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Towards Understanding Open Source Software Testing: An Empirical Study

Tamer Abdou
Suez Canal University
Ismailia, Egypt
tamer.abdou@alumni.concordia.ca

ABSTRACT

For small-and-medium-sized enterprises (SMEs) committed to software-intensive activities, open source software (OSS) holds much promise. It is therefore unsurprising that there is increasing involvement of software development organizations in open source software development (OSSD). For the quality of OSS, there is need for sustained commitment to testing. This paper investigates whether the OSSD approach affects 'conventional' software testing, and the extent to which the practices inherent to the OSSD approach predict the criteria of adequate software testing. To do that, a quantitative model is proposed. This model relies on nine revisions of an OSS project, FindBugs, hosted by the SourceForge repository. The results suggest a strong correlation between the OSSD approach and the changes in the software testing structure. This has significant implications for businesses, as well as for people involved in OSSD and in software testing.

Keywords

Open Source Software Community, Test Completeness, Test Process Improvement, Test Reliability, Test Success, Test Validity.

1. INTRODUCTION

Software testing faces significant expenses. Some organizations allocate as much as 50-60% of their budget to testing activities [1] [2]. There are considerable costs and enormous efforts spanning the software testing lifecycle spent across IT organizations while adopting an open source software component to cope up with business changes. Within this context, the open source software implication on software testing has received attention.

Ajila *et al.* [3] stated that there is a strong correlation between open source software adoption and software development economics, from the perspective of productivity and more importantly, product quality. Moreover, Norman *et al.* [4] stated that the effort that testers and developers spend on making testing possible is 80%, and only 20% focuses on making testing meaningful.

The understanding of software testing relationship with open source software approach will help in creating effective development and testing management strategies to control and possibly reduce the software testing cost while preserving the benefits of open source software approach.

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The goal of this empirical study is to investigate the impact of the open source software approach on software testing and its four adequacy criteria.

Having the aforementioned goal in mind, this quantitative research is guided by the key research question:

How does open source software approach impact software testing and its four adequacy criteria?

In this study, open source software approach is characterized with its practices being *Interaction (INTER)*, *Selection (SELEC)*, and *Variation (VARI)* as key independent variables. Therefore, the study attempts to answer five consequent questions:

RQ_1 How does OSSD approach characterized by *INTER*, *SELEC*, and *VARI* practices impact software testing *Reliability (REL)* criterion?

RQ_2 How does OSSD approach characterized by INTER, SELEC, and VARI practices impact software testing Validity (VAL) criterion?

RQ_3 How does OSSD approach characterized by *INTER*, *SELEC*, and *VARI* practices impact software testing *Success (SUC)* criterion?

RQ_4 How does OSSD approach characterized by *INTER*, *SELEC*, and *VARI* practices impact software testing *Completeness (COM)* criterion?

RQ_5 How does OSSD approach characterized by *INTER*, approach characterized by *INTER*, *SELEC*, and *VARI* practices impact weighted software testing?

The fifth research question is investigated to support the results of this study by providing additional estimation through the examination of the impact on software testing characterized by four adequacy criteria *Reliability*, *Validity*, *Success*, and *Completeness*.

The rest of the paper is organized as follows. First, relevant background, the quantitative model, and hypotheses of the underlying work are provided. Next, the results for all nine revisions of *FindBugs* (http://findbugs.sourceforge.net/) are presented.

This is followed by a discussion and interpretation of the results and implications of the work for further research endeavors. Finally, concluding remarks are given.

2. BACKGROUND AND RELATED WORK

OSS quantitative models are based on measurement approaches which encompass tests, metrics and inspections. In these

approaches, direct measures are recorded and compared to a pre-established values to decide if the software component meets numerical required goals. Test process metrics allow managers to track, understand, control, and hence improve testing. For example, the number of test cases, defect density and other similar metrics give an insight about several aspects of the test process [5] [6]. Several maturity models and tools appeared in the last few years trying to evaluate OSS projects. The goal of these models is to help adopters to understand the features of the project, and to check the advantages and disadvantages of its adoption.

Testing was not considered to detect faults in requirements, design and implementation until 1984 [7]. In 1988 Beizer stated that "the act of designing tests is one of the most effective bug preventers known." This perspective of Beizer extended the definition of testing to faults prevention as well faults detection [8]. Other studies from [9] and [10] support the need of the controlled testing process early in the software lifecycle to reduce cost and effort.

This emphasizes the need for an optimal alignment between a software development approach, such as an open source software approach, and a software quality indicator, such as software testing. The purpose of this alignment is to allow enterprises for better software lifecycle management as well as a controllable software evolution process. The causal link will further help open source software community to reduce the debt of their software, which is realized only in subsequent releases. Inadequate testing of software could have enormous implications of an unstable, unreliable, and inefficient features, and hence on the economy.

3. QUANTITATIVE MODEL

This study involves evaluating the software testing of the open source software approach from the perspective of community. The study has been conducted to uncover the open source approach impact on software testing adequacy criteria. This study evaluates the impact of the open source approach practices characterized by *Interaction*, *Selection*, and *Variation* [11], on software testing in terms of its adequacy criteria: *Reliability*, *Validity*, *Success*, and *Completeness* [12].

The relationship between OSS testing and its adequacy criteria are represented by the following equation:

$$(OSSTesting : REL, VAL, SUC, COM) = f(INTER, SELEC, VARI) \quad (1)$$

The resultant testing score is calculated as a sum of the weighted dependent variables of Equation 1. A multiple regression analysis is applied to check whether the stated hypotheses are satisfied.

The aforementioned questions in section 1 answered within the guidelines of testing theory [12] and principles of software testing [13]. These research questions managed four software testing adequacy criteria to be the dependent variables in this study, and three OSSD practices to be the independent variables, as shown in Figure 1.

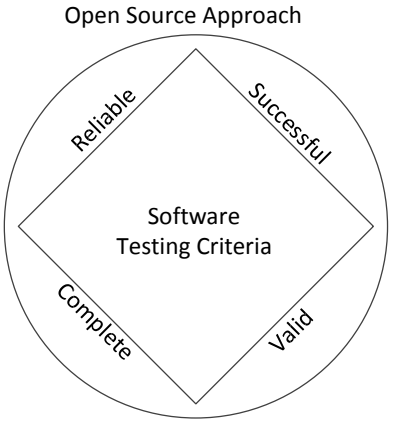

Figure 1. A conceptual model

Note that software testing as the resultant outcome, or weighted software testing is regressed for *INTERACTION*, *SELECTION*, and *VARIATION* as a final research question. The weighted software testing is the sum of weighted *COMPLETENESS*, weighted *RELIABILITY*, weighted *VALIDITY*, and weighted *SUCCESS*. This is because software testing is a function of its adequacy criteria. Open source software community will benefit from this integrative evaluation framework to comprehend the impact of open source software approach on individual termination criteria of testing as well as on the accumulated result: Weighted Software Testing.

3.1 Dependent Variables

The weighted software testing is the main dependent variable in this study. The other dependent variables that characterize software testing termination are *REL, VAL, SUC, and COM*, and are defined as follows:

Test Reliability (Y_1): The ability of testing to perform its required functions under stated conditions for a specified period of time, or for a specified number of operations [14].

Test Validity (Y_2): The ability of testing to confirm by examination and through provision of objective evidence that the requirements for a specific intended use or application have been fulfilled [15].

Test Success (Y_3): The ability of testing to pass assigned tasks and predicates that express the acceptability of the results [12].

Test Completeness (Y_4): The ability of testing to be officially completed based on a set of generic and specific conditions, agreed upon by the stakeholders [10].

These four variables have established origins in the software testing literature, including the theory of an ideal test [15], as well as related research [6] [16] [17] that integrated these software testing adequacy criteria in their studies. The aims of the software testing adequacy criteria is to provide reasonable confidence that a software will function 'acceptably' when test activities satisfy this criterion [18].

3.2 Independent Variables

The following independent variables allow for investigating the impact on the dependent variables in this study. The primary independent variable that drives software testing in this study is the OSSD approach.

We have identified two fundamental types of OSSD approach:

1. Community-oriented Approach, where open source practices are directed to improve the community structure of open source software.

2. Development-oriented Approach, where open source practices are targeting the improvement of the development process of open source software.

In this study, the main focus is on the first approach: Community-oriented Approach.

Three key variables, that characterize the open source software practices, are identified as *INTER, SELEC, and VARI*.

INTERACTION (X_1) is one of the key practices in open source software approach. The practice is characterized by the constant interaction between contributors as a community-oriented practice, and by the amount of interaction between modules through the development process.

The fact that the products are available at a low cost allows for obtaining a significant quantity of information for no cost. Moreover, this allows for having the process undergo a massive process of observations and better measurements.

The consequences of not engaging in this interaction are recognized in proprietary software. The number of forum posts is used in this study to measure the interaction of the contributors of the open source community.

SELECTION (X_2) is generally a mechanism that makes it possible to identify the best agents or behaviors [11]. From the point view of open source software approach, selection is the ability to identify which strategies are the best ones then decide which ones to be accepted and which to be rejected.

The number of downloads was used in this study to measure the extent of selection being contributed from the community level. This study conducts an analysis based on existing empirical data, which is a software system developed using open source software approach.

VARIATION (X_3) is another key practice in open source software approach in which the contributors in the open source community can influence the system by exchanging their mental models with the rest of the community. Contributors are able to use their experience and memory to model their process and behavior [11].

The team size thus creates a good amount of variation that can be measured from the perspective of open source community.

The study involved the measurement of software testing and its adequacy criteria after the end of each revision driven by open source software approach. Therefore, this research design is an interrupted time-series experimental design [19]. This design is a within-subjects design in which periodic measures are made, after independent variable is introduced, on a single group in an effort to determine whether a change in the dependent variable occurs [20].

3.3 Source of Data

The source of data for this study is the *SourceForge* Research Data Archive (SRDA) [21]. The SRDA is a repository of SourceForge OSS research data and allows the execution of SQL queries on tables exported from SourceForge. The data set of the software system's source code has been checked out from SourceForge. The need of this research design technique is targeted to uncover the impact of OSSD process on software testing adequacy criteria. The source code at each revision completion during the development lifecycle driven by OSSD approach was analyzed to assess this approach impact on software testing and its four adequacy criteria.

There are four types of scales: nominal, ordinal, interval, and ratio. These scales are commonly used in software measurement [22] but are also applicable to software testing [23]. This study integrates internal and external quality views on software product quality using source code properties and their relevant metrics. These metrics are listed for each of the dependent and independent variables.

The data used in this study contained source code attributes retrieved from each software revision marked by complete revisions of the selected open source software projects. All the selected case studies followed the open source software approach according to Open Source Initiative [24] and Open Source Foundation. A total of nine software revisions was collected for data analysis. The variables applicable to the evaluation of the impact of the open source software approach on software testing criteria were retrieved from existing and current open source software development and testing literature.

All data is extracted from incrementally developed software system that comply with the distribution terms of open source software provided by the Open Source Initiative (OSI) [24] [25].

3.4 Empirical Study Hypotheses

To have an answer to the research questions of section 1, fifteen hypotheses were investigated in this study. In particular, to answer RQ_5, the first three hypotheses of the following were proposed and checked.

$H_0$1 *Interaction* open source practice has no impact on the weighted software testing.

$H_1$1 *Interaction* open source practice has an impact on the weighted software testing.

$H_0$2 *Selection* open source practice has no impact on the weighted software testing.

$H_1$2 *Selection* open source practice has an impact on the weighted software testing.

$H_0$3 *Variation* open source practice has no impact on the weighted software testing.

$H_1$3 *Variation* open source practice has an impact on the weighted software testing.

4. THE METHODOLOGY

A research method is conducted to investigate the impact of open source software approach on software testing. More specifically, this section addresses the questions related to the extent open source software approach impacts software testing:

What are the changes to software test reliability, test validity, test success, and test completeness, and hence, the resultant weighted software testing?

First an overall quantitative method is presented along with a refinement to the research questions and hypotheses represented in section 1. Then, the research settings and case study data are illustrated as well as the tools and techniques used in applying this methodology. Finally, the study ends with a conclusion of how the data were collected and subsequently analyzed.

4.1 Research Design

The research design is conducted after assuming a hypothesis that leads to the impact of each of the illustrated independent variables on the dependent variables.

A Quantitative research is appropriate for this study, for the following reasons:

1. Quantitative research has been mainly concerned with quantifying a relationship or comparing two or more groups [26].
2. The aim of this study is to test the effect of some activities, which matches the same goal of quantitative investigations [27].
3. The methodology used in this study is dependent on the application of well-defined measures, which matches the same usage of quantitative methods [28].

The quantitative method is applied to existing data collected from open source software meta-repository: SourceForge.net, as declared in Section 3.3.

A conducted time-series experiment provides for explaining the impact of open source software approach on software testing adequacy criteria: *Reliability, Validity, Success, and Completeness.* This impact has been measured while controlling the software project management requirement's instability, and technology criticality.

As indicated, the study aims to fill the gap where the impact of open source approach on software test reliability, validity, success, and completeness have not been examined with empirical data and with applicable internal/external quality measures. These quality attributes have a direct effect on the software testing efforts, cost and overall testing effectiveness.

In order to achieve the prior aim, the following key research question is addressed:

To what extent, if any, does open source software approach impact software testing criteria?

The software test reliability, validity, success, and completeness are particularly important to software testing aspect within open source software systems in which testing activities span the whole software lifecycle from design, implementation, and even maintenance phases of software systems.

This study uses the following research methods' concepts based on the main goal revised in section 1:

1. The "building blocks" of the research theory: Measuring the influence of open source software approach characterized by *INTER, SELEC and VARI* on software testing.
2. Dependent Variables: Test reliability, Test validity, Test success, and Test completeness represent the phenomenon, which this study is trying to explain. Additionally, Weighted Software Testing is measured as the sum of the weighted average of the prior criteria that characterize software testing.
3. Independent variables: open source software approach is characterized by three key practices: *INTERACTION, SELECTION, and VARIATION* from two different perspectives (open source Community and open source Development), as summarized in Table 1. These independent variables represent the phenomenon that is hypothesized that influences this study. Each churn is typically represented as a new revision of a complete development cycle in the open source software approach.

Table 1. Practices and applicable metrics

	Open Source Community
INTERACTION	Forum-posts number
SELECTION	Downloads number
VARIATION	Team Size

4. Unit of analysis: This study analyzes selected open source software systems including their internal and external source-code attributes such as test construction, test coverage, code simplicity, and issue closure.

The objective of this research is to study the software testing during the open source software lifecycle at the submission time of the selected revisions. The software testing adequacy criteria are categorized further as shown in Figure 2 with identified attributes and their relevant metrics.

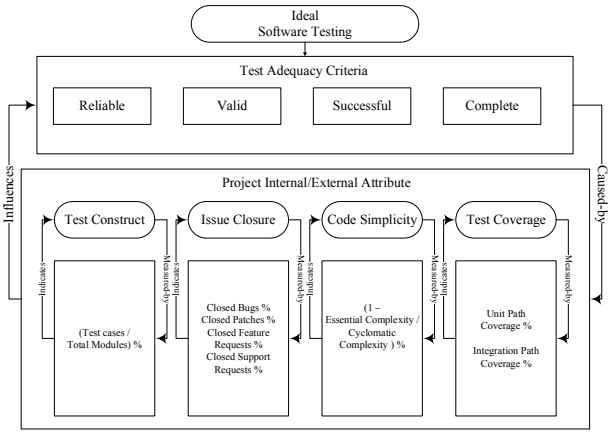

Figure 2. Software testing hierarchy

The selected set of metrics was used in earlier studies and by several researchers and practitioners for object-oriented development approach [29] [30], software test-process [31], and within open source software systems [32] [33] [34]. A map diagram shown in Figure 3 is depicted to guide this section of the analysis.

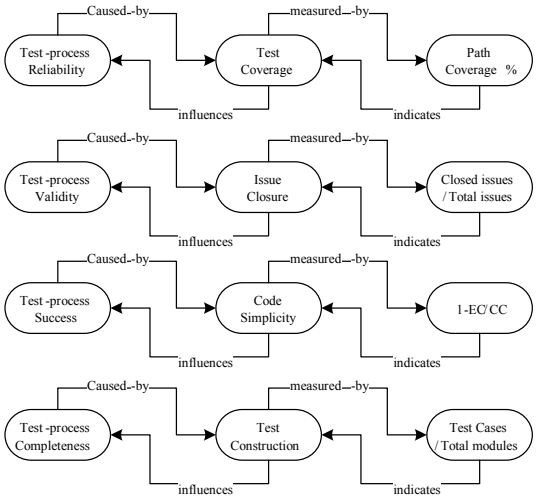

Figure 3. Software test-process adequacy criteria map

The aforementioned metrics, shown in Figure 3, are used to measure the selected project attributes based on earlier studies. Code Simplicity is represented by a combined McCabe Conditional metric which is the complementary percentage of the number of un-structured paths to the number of logically independent paths through the source code. Issues Closure is represented by the percent of corrective actions towards fixing bugs, feature requests, support requests, and patches [35]. Test Construction is represented by the number of test-cases to the number of modules within class files. Test Coverage is represented by the percent of tested unit and integration paths. The next section outlines the data analysis steps.

4.2 Criteria and Metrics

This step lists project attributes for dependent variables (software testing adequacy criteria), as shown in Figure 2. These metrics have been studied extensively [29] [30] [31] [32] [33] [34].

The values measured using metrics shown in Table 2, are multiplied by the weights derived using the Analytic Hierarchy Process (AHP) [36] of each project attribute.

Table 2. Software testing process dependent variables and relevant metrics

Testing Variables	Metrics
Success	Complexity measured in McCabe cyclomatic complexity
Validity	Corrective issues measured in corrective actions percentage
Completeness	Testing Coverage measure in Path coverage
Reliability	Unit Testing measured in Assert count per class

To compute the final value of each attribute from four different perspectives being the four test adequacy criteria as illustrated in the following equations:

$$Test\ Reliability = \sum_{i=1}^{n} W(Di,j) * M_i \quad ; j = 1 \quad (2)$$

$$Test\ Validity = \sum_{i=1}^{n} W(Di,j) * M_i \quad ; j = 2 \quad (3)$$

$$Test\ Success = \sum_{i=1}^{n} W(Di,j) * M_i \quad ; j = 3 \quad (4)$$

$$Test\ Completeness = \sum_{i=1}^{n} W(Di,j) * M_i \quad ; j = 4 \quad (5)$$

n = The number of project attributes, which is equal to 4 in this research model.

i = {Test Construction=1, Issue Closure=2, Code Simplicity=3, Test Coverage=4}

j = {Reliability=1, Validity=2, Success=3, Completeness=4}

M_i = Measure of i attribute.

D_{ij} = i weight for j test criterion.

Definitions for the weighted software testing and adequacy criteria have been illustrated, based on Good enough testing theory [12], and ISO/IEC standards. Object-oriented code metrics that are widely used by software engineering researchers and practitioners are selected to be our set of raw metrics, in order to compute the final set of metrics.

Each software testing criteria was quantified simply using the collected data from the source code at the end of every revision, and corresponding weights yielded from applying AHP process.

5. DATA ANALYSIS AND RESULTS

The quantitative study conducted in this research was used to determine whether and how the open source software approach impacts the software testing criteria. The open source software model can be statistically attributed to the changes in software testing in terms of test reliability, validity, success and completeness.

The analysis consists of a multiple regression analysis, which incorporates the following independent variables: the *INTERACTION*, *SELECTION* and *VARIATION*, from open source community perspectives.

The dependent variables were obtained from the literature of software testing, as shown in Section 4.1. *REL*, *VAL*, *SUC* and *COM* were computed, as shown in Section 4.2.

As part of these computations, project's internal attributes such as complexity and structuredness were analyzed and measured using selected metrics post the release time of each selected revision. The results presented in this section answered the five research questions introduced in section 1

The results also checked 15 null and alternative hypotheses required to for this study. An instance of these is mentioned earlier in section 3.4.

5.1 Software System Data Selection

From open source-software systems hosted by SourceForge meta-repository, a software system was deemed suitable for analysis based on criteria highlighted in section 4. A descriptive statistics of the selected case study aspects are tabulated in Table 3. The selection constraints were necessary to select the right software system and ensure that this will not contain missing essential values as well as missing multiple revisions as it would accurately allow the measurement to assessing the impact of open source approach on software testing criteria.

Table 3. Specific statistics of FindBugs OSS

Aspects	Findbugs
Total revisions reviews	9 revisions
Total development duration	56 months
Average iteration duration	7 months
Size of the product	76453 average-LOC
Average Team size	10 developers
Development status	Production/Stable
Open source license	Lesser GNU Public
Category	Software Development
Registration Date	2003-12-03
Intended Audience	Developers, Quality Engineers
Programming Language	Java
User Interface	Command-line, Eclipse

5.2 Data Normalization

Data was first transferred to Minitab 6.1 data analysis tool, then the following manipulations have been applied to the data set:

1. For all the four dependent variables: *REL*, *VAL*, *SUC* and *COM*, weighted values were created so all the dependent variables would be on the same scale. The weighted values are computed by multiplying the actual value by the weighted-average value with respect to its occurrence, as shown in Table 4.

Table 4. Weighted data for dependent variables

	Y_1	Y_2	Y_3	Y_4
	Reliability	Validity	Success	Completeness
Rev.1	27.86	27.89	29.66	30.80
Rev.2	27.88	27.92	29.68	30.83
Rev.3	27.77	27.81	29.57	30.71
Rev.4	27.93	27.96	29.73	30.88
Rev.5	27.85	27.89	29.63	30.79
Rev.6	26.84	26.90	28.63	29.73
Rev.7	25.57	25.66	27.26	28.30
Rev.8	27.27	27.34	28.98	30.11
Rev.9	27.25	27.32	28.95	30.08

2. For all three independent variables: *INTER*, *SELEC* and *VARI*, normalized values (z-scores) were created so all the independent variables would be on the same scale, as shown in Table 5.

Table 5. Normalized data for independent variables

	Community-Oriented		
	X_1	X_2	X_3
	Interaction	Selection	Variation
Rev.1	-1.09	0.90	2.42
Rev.2	-0.79	0.84	-0.11
Rev.3	-0.72	0.72	-0.11
Rev.4	-0.66	0.46	-0.11
Rev.5	-0.32	0.79	-0.11
Rev.6	-0.22	0.20	-0.11
Rev.7	0.85	-1.30	0.14
Rev.8	1.46	-1.31	-1.13
Rev.9	1.49	-1.30	-0.87

3. A time-series quantitative for-casting technique: Smoothing, was used to estimate the values of missing data. The Smoothing Method handles missing values by assuming a linear relationship. One missing value is replaced by the average of the observations before and after it. Multiple missing values are replaced by steps between the known values.

Table 6. Weighted average for dependent variables and computing the weighted software testing

Y_{1WA}	Y_{2WA}	Y_{3WA}	Y_{4WA}	Y (WST)
Y1*Avg	Y2*Avg	Y3*Avg	Y4*Avg	Y
762.07	764.45	863.68	931.67	2390.20
762.78	765.19	864.45	932.38	2392.42
759.69	762.14	861.18	928.80	2383.01
764.05	766.44	865.82	933.91	2396.31
761.76	764.58	862.97	931.21	2389.31
734.32	737.40	833.61	899.17	2305.34
699.45	703.25	793.71	855.85	2196.41
746.05	749.37	843.79	910.81	2339.21
745.42	748.75	843.03	909.93	2337.20

5.3 Descriptive Statistics

Descriptive statistics were conducted on the dependent and independent variables, as well as the values of the metrics that were used to compute the dependent and dependent variables, as presented in tables 7, 8, and 9.

Table 7. Descriptive statistics of dependent variables

	Y_1	Y_2	Y_3	Y_4	Y
Total Count	9.00	9.00	9.00	9.00	9.00
Mean	27.36	27.41	29.12	30.25	2347.71
StDev	0.77	0.75	0.81	0.84	65.20
Minimum	25.57	25.66	27.26	28.30	2196.41
Maximum	27.93	27.96	29.73	30.88	2396.31

Table 8. Descriptive Statistics of Independent Variables of 'FindBugs' Prior to Normalization

	Community-Oriented		
	X_1	X_2	X_3
Total Count	9.00	9.00	9.00
Mean	168.56	7901.33	10.44
StDev	29.80	5682.05	3.94
Minimum	136.00	458.00	6.00
Maximum	213.00	13001.00	20.00

Table 9. Descriptive statistics of independent variables of 'FindBugs' subsequent to normalization

	Community-Oriented		
	X_1	X_2	X_3
Total Count	9.00	9.00	9.00
Mean	0.00	0.00	0.00
StDev	1.00	1.00	1.00
Minimum	-1.09	-1.31	-1.13
Maximum	1.49	0.90	2.42

For instance, prior to normalizing the independent variables, the interaction measurements (X_{11}) from the open source community perspective, ranged from 136 to 213 with a mean of 168.56 and a standard deviation of 29.80. Subsequent to normalizing the independent variables, the mean will always set to 0.00 and the standard deviation will be 1.00, as shown in Table 9. For instance, after normalizing the independent variables, the interaction measurements range from -1.09 to 1.49, with respect to the open source community. The normality of the regressors and the dependent variable were adequate for performing the analysis.

5.4 Initial Analysis

On initial analysis, the assumptions of: linearity, normality, homoscedasticity, and absence of multicollinearity were evaluated before utilizing the regression analysis.

To assess linearity, scatter plots were examined and the assumption was satisfied. To assess normality, skeweness and kurtosis were measured, as shown in tables 10 and 11 for all the variables of the study. According to West *et al.* [37] normality was satisfied as skewness values were less than the absolute value of two, and kurtosis values were less than the absolute value of seven.

Table 10. Skeweness and Kurtosis coefficients for dependent variables

	Y_1	Y_2	Y_3	Y_4	Y
Skewness	-1.84	-1.86	-1.78	-1.81	-1.82
Kurtosis	3.53	3.62	3.35	3.47	3.5

Table 11. Skeweness and Kurtosis coefficients for independent variables

	Community-Oriented		
	X_1	X_2	X_3
Skewness	0.73	-0.7	1.95
Kurtosis	-1.28	-1.76	5.28

To assess whether the dependent variables have the same variance (Homoscedasticity) for all settings of the independent variables: Scatter plots of the standardized residuals against the fitted values of all the dependent variables have been generated. The assumption was satisfied as there were no systematic patterns throughout each scatter plot.

To assess whether independent variables are correlated with other independent variables (Multicollinearity): The variance inflation factor (VIF) has been assessed to indicate how much the variance of an estimated regression coefficient increases if the independent variables are correlated, as shown in Table 12.

Table 12. Variance inflation factors of independent variables

	Community-Oriented		
	X_1	X_2	X_3
VIF	22.438	18.248	2.160

One of the remedy methods to deal with high VIF value: more than 10, is to remove one of the independent variables with the highest VIF from the regression equation [38]. For instance, it can be noted from Table 12 that the VIF values for both X_{11} and X_{12} are greater than 10; therefore, one of these variables should be removed from the model. This remedy method has been applied and the results are shown in Table 13.

Table 13. Variance inflation factors of independent variables

	Community-Oriented		
	X_1	X_2	X_3
VIF		1.397	1.397

Also a correlation matrix has been used to assess multicollinearity between independent variables as shown in Table 14.

All the assumptions of linearity, normality, homoscedasticity, and multicolleniarity were verified before conducting the regression analysis using MiniTab 6.1 tool.

Table 14. Pearson correlation with p-values

Community-Oriented		
	X_1	X_2
X_2	-0.965	
***p*-value**	0	
X_3	-0.646	0.533
***p*-value**	0.06	0.14

5.5 Multiple Regression Data Analysis

This study utilized a multiple regression approach on the open source software related variables and changes observed in software test reliability, validity, success, and completeness to derive the best-fit model for analyzing the data set prescribed in the methodology presented in section 4. The results are explained in this section.

The calculation of actual values for software test reliability, validity, success, and completeness is completed using equations 2 : 5, section 4.2, for all the nine software revisions. All nine revisions were analyzed to produce the values for all the listed software metrics.

The open source software approach variables were then regressed over software test reliability, validity, success and completeness as well as the weighted software testing. The regression analysis results indicated that the open source software approach is statistically significant predictor of software testing and its four adequacy criteria.

The results in Figure 4 show that the community-oriented regression model predicted 87.1% of the changing proportion in the weighted software testing at a 95% confidence level.

The adjusted R-squared indicates the prediction percentage, which represents the weight of changeability in the dependent variable that can be explained by the predictors (independent variables) in the regression model [39].

6. ASSESSING RESEARCH QUESTIONS

The five research questions mentioned in the introduction, section 1 have been assessed and the answer has been analyzed. The following is an example on how this process accomplished for answering RQ_5.

RQ_5 How does open source software approach characterized by *INTER*, *SELEC*, and *VARI* practices impact Weighted Software Testing?

To assess the fifth research question, a multiple regression model was conducted, and that from the perspective of open source community.

$F_{2,5}(0.05) = 24.63, p < 0.05$ illustrates that at a significance level of 0.05, there is a sufficient evidence that this model is useful in explaining 87.1% of the weight change of the weighted software testing (*WST*) for this project.

Further analysis reveals that *SELEC*, and *VARI* are significantly linearly related to *WST* and is a useful predictor of weighted software testing.

The *p*-value of the *SELEC* variable, $0.001 < 0.05$, defines that for every one-unit increase in *SELEC*, the model predicts that *WST* will increase by 77.6, holding all other explanatory variables constant (*INTER* and *VARI*). Moreover, The *p*-value of the *VARI* variable, $0.005 < 0.05$, defines that for every one-unit increase in *VARI*, the model predicts that *WST* will decrease by 123, holding all other explanatory variables constant (*SELEC* and *INTER*).

With a fitted regression model as:

Y (*WST*) = $2314 + 77.6X_2 - 123X_3$, the null hypothesis is rejected. This means that the model is significant as a whole, and both the selection (*SELEC*), and the variation practices (*VARI*) offer a unique contribution to predict the weighted software testing

```
The regression equation is
Y (W.Testing) = 2314 + 77.6 X12 - 123 X13


Predictor      Coef  SE Coef       T      P    VIF
Constant   2313.74    11.09  208.67  0.000
X12          77.60    11.18    6.94  0.001  1.504
X13        -123.26    25.31   -4.87  0.005  1.504


S = 24.2769   R-Sq = 90.8%   R-Sq(adj) = 87.1%


Analysis of Variance

Source           DF     SS     MS      F      P
Regression        2  29035  14518  24.63  0.003
Residual Error    5   2947    589
Total             7  31982
```

(*WST*), as shown in Figure 4.

Figure 4. Community-oriented regression analysis of weighted software testing versus selection and variation practices

RQ_5 hypotheses were checked for statistical significance based on *Coef* and *p*-value values of the independent variables. The criteria for the hypothesis tests were based on degree-of-freedom of 7 and a confidence level of 95%. Moreover, the direction of the relationship between weighted software testing, and the independent variables were tested from an open source community perspective.

$H_0$13 *Interaction* open source practice has no impact on the *Weighted Software Testing*.

$H_1$13 *Interaction* open source practice has an impact on the *Weighted Software Testing*.

Since the presence of *INTER* variable in the regression results in an unacceptable VIF value, as shown in Table 12, *INTER* variable has been scoped out from this model.

$H_0$14 *Selection* open source practice has no impact on the *Weighted Software Testing*.

$H_1$14 *Selection* open source practice has an impact on the *Weighted Software Testing*.

According to the results obtained and shown in Figure 4, the alternative hypothesis $H_1$14 is accepted because the coefficient for *SELEC* has a *p*-value of 0.001 and a $|t|$ value of 6.94, which

is greater than the *t* critical value of 1.89. Since analysis has been tested at 95% confidence level, *p*-value< 0.05. The results led to the conclusion that there is a relationship between *SELEC* and *WST*. Moreover, the null hypothesis $H_0$14 is rejected, and the results indicate that change in *SELEC* is positively related to *WST* so that with a one-percent increase in *SELEC*, *WST* increases by 77.6%.

$H_0$15 *Variation* open source practice has no impact on the *Weighted Software Testing*.

$H_1$15 *Variation* open source practice has an impact on the *Weighted Software Testing*.

According to the results obtained and shown in Figure 4, the alternative hypothesis H115 is also accepted because the coefficient for VARI has a p-value of 0.005 and a |t| value of 4.9, which is greater than the t critical value of 1.89. Since analysis has been tested at 95% confidence level, p-value< 0.05. The results led to the conclusion that there is a relationship between VARI and WST. Moreover, the null hypothesis H015 is rejected, and the results indicate that change in VARI is negatively related to WST so that by a one-percent increase in VARI, WST decreases by 123%.

7. SUMMARY OF FINDINGS

From a community-oriented perspective, the research results indicate that both *SELEC*, and *VARI* variables that characterize the selection, and variation practices of open source software, with the exception of *INTER* practice, are significant predictors of software test reliability, validity, success, completeness and hence of the weighted software testing for our case study that has been developed using open source approach.

The community-oriented regression model explains approximately 87% of the change in software testing from the independent variables regressed.

In conclusion, the selection and variation practices do play a significant role in the way software testing and its comprising criteria integrated during the open source software development process. Note that software testing is an essential quality indicator that spans the software development lifecycle. Shaping the test structure of a software system while utilizing an open source approach may now be possible with given findings of this study.

The results of the fifth research question indicate a *SELEC*, and *VARI* changeability of 77, and 123 respectively. The significance of this is that a one percent change in *SELEC*, and *VARI* within the open source approach will result in an approximate 77%, and 123% change in the weighted software testing.

8. LIMITATIONS OF THE STUDY

There are certain limitations of the work presented in this paper.

The study was conducted on a single software system developed using the open source approach hosted by a single repository. The results obtained from the study presented here may likely be different from other open source systems with varied levels of open source maturity.

The data for the first revision of 'FindBugs' that make up the variables in this study was not recorded due to a bug prohibit the system from running tests from the JUnit testing framework. As a result, the data for test coverage metrics were not present for the first revision.

The missing data that makes up the internal or external variables has not been recorded. Instead, the data was derived using either a forecasting method (if the aim is to produce future data), or a smoothing method (if the aim is to find past data). These two methods are built in the tool that is being used in this study, Minitab 6.1.

The final data analyzed was statistically significant, at nine software revisions. It is possible that a larger sample may produce different results.

9. CONCLUSION AND FUTURE WORK

The study provides a statistically significant finding that open source practices within open source approach of software development and community impact software testing and its adequacy criteria positively. These conclusions are in alignment with open source practices goals. For instance, an open source software practice is targeted to decide whether to accept strategies or actions within the open source community and development for better results, and thereby for fewer buggy releases. Variation practice is followed to preserve the continuous product evolution of a software, and hence for in-deteriorated software.

Furthermore, it also raises some questions. For instance, why does the selection practice within the open source approach improve the software test reliability or the ease with which a practitioner can perform a required function under specific conditions for a specific time, or for a specified number of operations? The answer has not been determined, because the data used in this study is not adequate to allow that determination. However, it may be inferred that the selection practice allows the development team to focus on testing efforts through a higher coverage of unit testing, which also in turn allow to improve their ability to identify the unhealthy snippet of the program.

The results of this study strengthen the confidence of business management in adopting open source practices further as they continue to define the challenges of increasing software testing efforts and costs. The social impact of this study is its ability to provide business management with additional evidences that could be used to enhance the alignment between open source software practices and software test process objectives. The improved alignment could further strengthen the features of open source approaches through qualitative, productive, and cost-effective business services. Potential reduction in software testing efforts and cost is challenging for any organization, resulting from a required quality of software that is developed using open source approach.

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CMMI-DEV Experience in MEA: Characteristics and Lessons Learned

Ahmed Abd Elaziz
Software Engineering Competence Center (SECC)
Giza, Egypt
aaziz@itida.gov.eg

Marian Tadros
Software Engineering Competence Center (SECC)
Giza, Egypt
martadros@itida.gov.eg

Madiha Hasan
Software Engineering Competence Center (SECC)
Giza, Egypt
mad_abdalla@itida.gov.eg

ABSTRACT
The Capability Maturity Model Integration for Development (CMMI-DEV) provides guidance to improve the effectiveness, efficiency, and quality of product development work. It is a powerful process improvement model suitable for software, hardware, and system engineering organizations. The Software Engineering Competence Center (SECC) has a good experience working with this model inside and outside Egypt. This industrial paper shows the trend of CMMI-DEV usage worldwide and in the Middle East and Africa (MEA). Then it describes common characteristics and problems and gives recommendations and lessons learned that have been proven to facilitate improvement of software development processes in MEA organizations in alignment with the current strategic focus of many MEA countries.

Keywords
Software process improvement, CMMI, Best practices, Appraisals

1. INTRODUCTION
Software value is increasing tremendously and this is trending with the emergence of disruptive technologies as social, cloud, mobile, and cognitive computing, big data, Internet of things, and gamification. Egypt and many countries in Middle East and Africa (MEA) strategically target being positioned as software powerhouse contributing to the growth of national economies. This mandates software organizations to develop competitive high-quality products in shorter durations at lower costs. Doing so requires effective and efficient management and engineering processes.

The Capability Maturity Model Integration for Development (CMMI-DEV) is a set of best practices and an appraisal method developed by the Software Engineering Institute of Carnegie Mellon University and recently has been transferred to the CMMI Institute [1]. The CMMI-DEV helps development organizations achieve high performance through adoption of practices proven to be successful by so many organizations over many decades [2].

The Software Engineering Competence Center (SECC) of Egypt has supported the adoption of CMMI-DEV by many MEA organizations inside and outside Egypt. This industrial paper summarizes part of its experience describing some common encountered characteristics and problems and presenting recommendations and lessons-learned to successfully address them.

The rest of this paper is organized as follows: Section 2 provides statistics of CMMI-DEV activities in the MEA region. Section 3 gives a high-level description of the corresponding SECC activities. Section 4 describes experience acquired while serving beneficiary organizations and gives recommendations and best practices. Finally Section 5 states the work conclusion.

2. CMMI-DEV IN MEA
Thousand appraisals have been conducted all over the world in CMMI-DEV since 1990s. The Software Engineering Institute (SEI) and now the CMMI Institute have prepared semiannual reports for the CMMI maturity profile [3][4]. However there is no data available for the period before 2003. Also although these reports contain a lot of valuable information, they suffer from some inconsistencies in report format and numbers. Additionally some detailed information about the countries that had less than 10 appraisals are not mentioned. With some data manipulation and approximation to figures mentioned in the maturity profile reports generated since March 2004 till March 2014, Figure 1 demonstrates the number of countries worldwide and in MEA where CMMI-DEV appraisals have been conducted and Figure 2 shows the corresponding number of appraisals. Clearly, the demand on CMMI-DEV is increasing worldwide and in MEA.

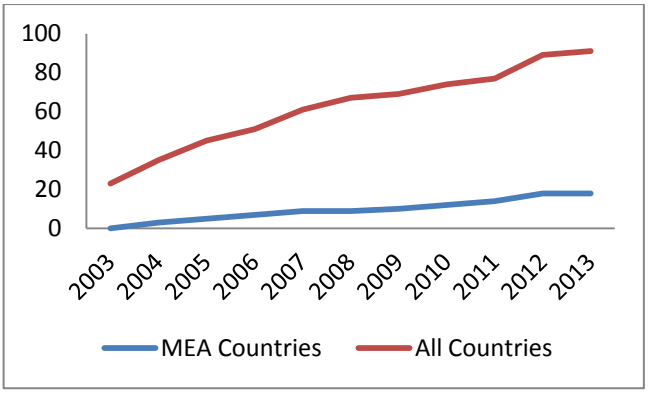

Figure 1. Countries where CMMI-DEV appraisals have been conducted

AMECSE'14, October 21–22, 2014, Giza, Egypt.

The figures show that the MEA countries where CMMI-DEV appraisals have been conducted represent 10 to 20% of all countries and the number is continuously increasing. Moreover concerning the number of appraisals, the MEA share is small and does not exceed 5%.

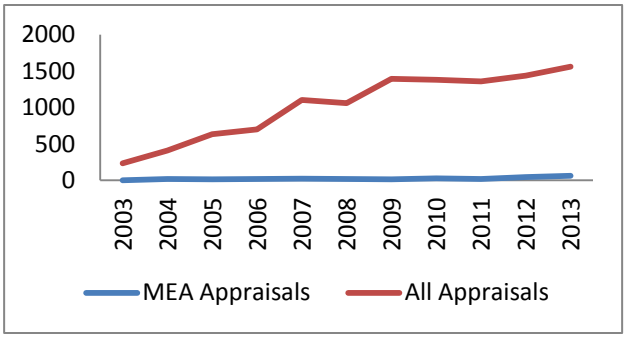

Figure 2. Number of CMMI-DEV appraisals in MEA and whole world

Figure 3 magnifies the MEA appraisals to clearly demonstrate the increasing trend.

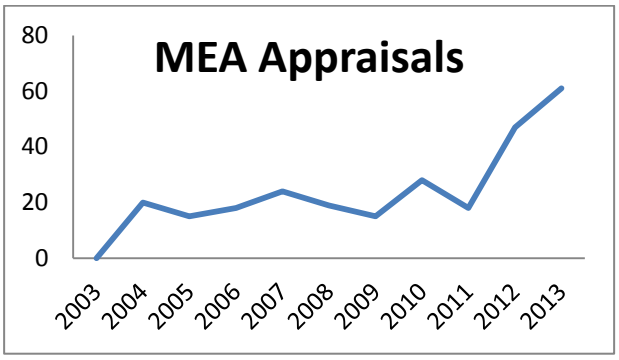

Figure 3. Number of MEA appraisals

Although many countries in the region perform CMMI-DEV appraisals, there is only one or very few appraisals conducted in most of these countries. This implies that many countries in the region are discovering CMMI-DEV and there is high potential for its adoption.

3. SECC IN MEA

Figure 4. MEA countries in red and green are where SECC has supported CMMI-DEV adoption and held appraisals

SECC as a partner to SEI and CMMI Institute has offered CMMI consultation and appraisal services starting from 2005. SECC has helped many organizations in MEA to fulfill CMMI-DEV requirements. Figure 4 depicts MEA countries where SECC has supported model adoption. Over 50 appraisals have been conducted. SECC has provided process improvement consultation and training to hundreds of MEA organizations based on CMMI-DEV and other models and approaches as Agile Scrum, CMMI-SVC, and Six Sigma. Beneficiary organizations belong to different software industry segments that include professional services, enterprise solutions, system integrators, and embedded software development. Private, public, and governmental organizations have been supported.

Service agreement types include direct agreement with the beneficiary, outsourcing agreement with a local partner to provide services to its customer, and cluster agreement with a local partner to provide services to a group of local beneficiaries. Table 1 gives specific considerations for the different agreement types.

Table 1. Specific considerations for different service agreement types

Agreement Type	Specific Considerations
Direct agreement with the beneficiary organization	Let the customer handle the logistics. State the acceptable level for the different logistic types (e.g. housing, catering, transportation, etc.). Incorporate non-disclosure, copyright, and security issues.
Outsourcing agreement with local process improvement partner	State the roles and responsibilities of local partner. Indicate whether partner is participating in offering consultation and if yes, the required qualifications of partner staff. Mitigate any safety issue.
Cluster agreement	Plan merging activities for many beneficiaries if feasible. For example, some training could be simultaneously offered to different beneficiaries. Optimize travelling trips to reduce cost. Prioritize for quick wins.

4. PROCESS IMPROVEMENT EXPERIENCE AND RECOMMENDATIONS

Hereunder are the most common characteristics SECC has seen, the most common problems encountered, and recommended practices to address them.

4.1 Common Characteristics

Most of the organizations SECC has worked with, share a group of characteristics that needs to be comprehended to improve processes and achieve organizational targets.

4.1.1 Small Team Size

The development team of the organizations is usually small ranging from 6 to 30 people in most cases. The organization size may be much larger, but others are working in non-developmental activities like data processing, multimedia, implementation, accounting, sales, and marketing.

Consequently it is not feasible to dedicate staff members for every single needed role, but rather some team members are allocated to do more than one role. Examples include:

- One of the testers acting as quality auditor.
- One of the developers acting as configuration controller.
- Project managers acting as quality auditors for other projects.
- Project manager acting as analyst.
- Developers acting as technical designers.
- Project managers and testers simultaneously working in more than one project.

Small team size also has impact on CMMI-DEV model interpretation. Examples include:

- Work of Product Integration Process Area is minimal as usually there are only one, two, or three developers in the project working as one team.
- One person – most probably the project manager – may prepare all the plans of the project so the consistency review of all plans is imbedded in the preparation itself.
- The project team members are usually located in the same physical place and depend heavily on oral communication. Hence, formality of commitment and review may not be needed in such settings.

4.1.2 Small Projects

Projects are small in terms of duration and staff. They typically range from 1 to 12 months and its development team from 1 to 5 developers. In addition many projects within the same organization or department inside the organization are similar in technology, requirements, and many other aspects.

In such cases the following should be considered:

- There is no need for detailed documentation. The duration of the project does not give enough time to write and review detailed documents which add no value to anyone. As the team size is small, members mainly depend on oral rather than written communication. This applies to plans, requirements, design, and reports. One successful tactic that shortens the documents and keeps the CMMI-DEV model satisfied is to group common and fixed parts in one or more documents and refer to it in the other project documents. For example, work environments, roles and responsibilities, and configuration environment could be defined in central documents and referred to in relevant project documents.
- Traceability between requirements and other work products could be small as typically few high and medium-level requirements may be traced in small projects.
- One project manager usually manages more than one project at the same time. It could be better to merge the plans of many projects in one document. Same applies to project monitoring documents and reports.
- Reusability saves time and money. It is recommended to build reuse library for technical and non-technical work.
- Automation is recommended. Many organization use project management, issue management, testing and other tools which enable automatic report generation that could be seen by different people having different authorities. Reports could also be customized based on the different people needs. Meetings are minimized in such cases and are only needed in emergent situations.

4.1.3 Missed Functions

In many organizations, some major functions that are essential for process improvement may be missing like quality assurance and configuration management. In such cases it is not recommended to start by establishing separate units for such functions. It may also be not feasible due to the organization size. Hence, it is recommended to start by assigning these tasks to individuals beside their original jobs. Later and after thorough examination the organization may decide to establish dedicated units or to continue with same staff assignment.

4.1.4 Resistance to Process Improvement

There is always strong resistance to process improvement, especially at start. Typical symptoms of resistance include debates from a lot of people, arguments about inapplicability of the process, claiming that the process delays the projects, and confirmation that CMMI-DEV is only for large organizations. Some recommended tactics to tackle this are as follows:

- Let people from all levels in the organization, not only the process improvement team, participate in the process improvement activities. They must participate in the discussions, identify their problems, set their priorities, and recommend solutions. This increases buy-in as they get the sense of owning the process they are required to follow, rather than getting the feeling of following a process created by an outsider.
- Do not speak CMMI language, but rather speak the organization's language. Do not use terms like "verification and validation" if they are not known to the organization, but rather use "testing and review" if more common.
- Start by brainstorming with the organization staff to identify and prioritize the major problems in the organization. Pick some of the major problems that could be quickly fixed and start with them to demonstrate quick win. The low hanging fruits of Figure 5 help a lot in increasing the buy-in.
- Do not put a far target like achieving CMMI-DEV ML3 as one's first goal. Instead have many close achievable targets like finishing the process definition, establishing project management activities, solving three of the major problems, etc. When one target is achieved, celebrate with the staff emphasizing that this is due to their dedicated effort.
- Be agile and do not stick to one approach. Even if one approach has succeeded many times in other organizations, it may not succeed in this particular organization. For instance, the use-case point estimation is well-known and successful, but some organizations prefer to develop their own estimation technique even if they follow object-oriented analysis and design where use case points are used.
- Help people understand terms as quality assurance, configuration management, size estimation, performance testing, etc. Have them formally trained on these topics if needed. When people learn and appreciate, they become eager to implement and improve.

4.2 Common Problems

After working with many organizations in the region, we realized some common problems in most of the organizations. Some of these problems are technical and some are related to project management. In addition we faced a safety problem sometimes. Hereunder the most common and important problems and how they were addressed.

4.2.1 Technical Problems

4.2.1.1 Scope Creep

Scope of projects is usually not clear and requirements change many times. This is due to using inappropriate methods to collect the requirements, absence of effective change management process, and uncontrolled open communication channels. The customer and/or organization CEO may contact one of the developers asking for one feature, the developer implements the feature, the project manager knows nothing, the project is delayed, and eventually the project manage is blamed. The following recommendations address this problem:

- Use appropriate requirements gathering and elicitation technique. Most of organizations document requirements and communicate it with the customer via email. Using prototypes and face-to-face discussions with the customer are much better. Partitioning the project into small stages or iterations as in agile approach is also good as it utilizes frequent communications with the customer to discuss outputs so as to avoid big bang delivery at the end.
- Establish an effective change management process. Identify the change impact, the decision authority, and how the change and decision are communicated.
- Control communication channels. Identify who contacts the customer and/or senior management. Instruct developers not to perform any task unless approved by the project manager.

4.2.1.2 Un-maintainable Systems

One of the technical problems usually seen is the spaghetti code that results in a system that could be working, but very difficult to maintain. CMMI-DEV mandates the existence of technical design. To address this problem:

- The relevant organization staff should attend training in technical design and architecture if feasible.
- Establish a process for the design taking the following into consideration:
    - Start simple then complicate. Early designs could be nothing more than high-level class diagrams and ERDs. By time more design components are added.
    - Review the source code and make sure it reflects the design.

4.2.1.3 Too Many Defects

Some delivered systems contain a lot of defects. This is due to absence of dedicated testing team or because of performing ad-hoc testing. To address this problem the organization should be asked to:

- Dedicate qualified persons for the testing activities.
- Train the testing staff on testing principles, processes, and tools.
- Prepare a testing plan identifying types of testing needed for the projects (e.g. functionality test, usability test, stress test, etc.), the tools needed, and the passing criteria for each testing type in addition to other planning elements like schedule, roles and responsibilities, etc.
- When needed, test cases have to be traced to requirements and coverage must be ensured.
- Use of a tool to handle test cases and bugs is highly recommended. There are many commercial and open-source tools available.

4.2.2 Project Management Problems

4.2.2.1 Missed Delivery Dates

Delivery dates are typically missed. This is due to the use of inappropriate estimation techniques. When a project starts, an expert usually estimates the project schedule using expert judgment that has no objective basis at all. Then the senior manager or the marketing team imposes another subjective date without any basis as well. To address this problem:

- Collaborate with the experience of the organization staff to identify appropriate technique that can be used to size their work. For example, use case points, number of screens, number of database tables, etc. Collect some data if feasible about past projects. Find the relation between the project size and its effort and duration and use it as the basis for the estimation of new project effort and duration.
- Start with simple techniques first. For instance, count use cases or screens and then classify them into simple, average, complex, or any other classification utilizing clear criteria. Incorporate other factors like project complexity and reuse.

4.2.2.2 Disputes and Conflicts

Responsibilities are not identified. Whenever the project faces a problem, the project staff starts to blame one another. Stakeholder management is an essential component in CMMI-DEV. Recommended practices to address this problem include:

- Study the organization structure, the project structure, and team member qualifications and help them identify clear roles and responsibilities.
- Special attention must be taken for small organizations and projects. For instance, if the project manager is the analyst of the project, requirement review cannot be part of his/her responsibilities. If one staff member is assigned as a quality auditor, he/she cannot audit part of the work he/she participated in. One possibility is to assign auditing development activities to one of the testers while assigning auditing everything else to one of the developers.

4.2.2.3 Late Discovery of Project Problems

Project risks are not discovered unless they are realized or become disastrous. Good project management requires handling problems before they occur and good handling of them when they occur, i.e., effective risk management. Good practices include:

- Start by brainstorming sessions with project managers and other team members asking about potential project problems. Analyze these problems and draft mitigation plans to avoid them and to minimize their impact if they

occur. Also draft contingency plans to be executed if problems are realized.
- Document all of this in a risk repository. Then ask project managers to do two things:
    - Review the risk repository at the start of the project or project phase to identify which risks their project may face and handle them.
    - At the end of the project or phase the project manager has to update the risk repository with problems faced. New risks might be added and/or some attributes of existing risks might be updated.

Establish a project tracking mechanism to track the project weekly or biweekly based on the project duration. A project tracking template and/or checklist are established to remind the project manager what to check in each tracking session. For example, the checklist might contain questions like:

- Are CPI and SPI calculated and analyzed?
- Are project issues and risks under control? Do they require interference from senior management?
- Did quality auditor audit the phases completed and their work products? Are audit NCs closed?
- Are baselines taken as planned?

4.2.2.4 Surprised Senior Management

Senior management frequently does not see project problems until too late. Project managers hide information hoping everything goes well until problems explode. To avoid this:

- Senior management has to see summary reports about the projects, monthly or at end of each project phase. It is recommended that the period between two consecutive reviews does not exceed three months and is not less than one month. These reports could be prepared by the project manager or automatically generated by an enterprise management tool.
- Quality auditors have to escalate late NCs to senior management.

4.2.3 Safety Problem

Although safety is not that common problem in the MEA region, it is an existing risk that should be addressed. To meet commitments and ensure the safety of SECC's staff, the virtual meeting technology was sometimes used to perform part of the work. SECC has conducted four appraisals using this technology and all of them were successful and accepted by the Software Engineering Institute (SEI).

In the mentioned cases the appraisals were conducted in another country that had some safety issues. The Lead Appraisers preferred not to go there to maintain their own safety. The company staff and all appraisal team members were there. Using good microphones, cameras, computers, internet connections, and chatting tools, the Lead Appraiser and the team could communicate easily and effectively as if they are located in the same place.

A successful appraisal must meet group of appraisal rules that are easily met in face-to-face appraisal. In remote appraisals same rules must be followed. The following points show some of these rules and how they were ensured:

- Confidentiality is essential in appraisals. To maintain it, the Lead Appraiser must ensure that there are no strangers in the interview room. Only appraisal team members and invited interviewees are permitted to be there. Good positioning of the camera in the interview room to show the biggest part of the room – and preferably the door – lets the Lead Appraiser see the whole room and who comes in and out. In one the appraisal a security cam was used which could be rotated and zoomed by the Lead Appraiser via the web. In other appraisals where simple web cam or laptop built in cam were used, the Lead Appraisal frequently asked one of the appraisal team members to rotate the camera in the room to ensure permitted people only are there.
- Thumb rule is used hundreds of time in the appraisal to take decisions. This requires good visibility from the Lead Appraiser to the appraisal team and vice versa. Good positioning of the camera helps a lot. When the Lead Appraiser does not see the thumb of one of the appraisal team, s/he is asked to move his hand in front of the camera to be seen to the Lead Appraiser. Camera settings may be changed or the appraisal team member may change his location to avoid repetition of the problem. The following figure is a snapshot from the screen the Lead Appraiser sees where s/he can see most of the room, the appraisal team members, the interviewees, and thumbs of the team members.

Figure 5. Appraisal Team as seen to the Lead Appraiser via Virtual Meeting Technology

- As one of the SCAMPI requirements, at least two members of the appraisal team must attend each interview. The Lead Appraiser is necessarily one of them. The whole appraisal team was asked to attend all the interviews. Sometimes when the Internet connection went down, the Appraisal Team was there and they

could continue the interview till the connection is enhanced and the Lead Appraiser is back again.

- Appraisal plan and appraisal disclosure statement (ADS) must be signed by both the Lead Appraiser and Appraisal Sponsor who are physically in two different locations. One of them signs first, scans the signed document, sends it by email to the other one who prints, signs, scans again, and send the paper signed by both of them to the other one.

Lessons learned include:

- Be ready with many communication and chatting tools. If the server of some tools goes down, another one is ready.
- Be ready with more than one Internet connection at each side.
- Some tools are not permitted in some countries or in some organizations.
- Have two screens at each side; one to see people and one to share a desktop to perform the work.
- Before performing the activity, especially for the appraisal, test the complete exact environment and make sure everything works well.

5. CONCLUSION

Demand on CMMI-DEV has been increasing worldwide and in the Middle East and Africa. Although the adoption scale in the MEA region is small, it is trending. Recently many MEA countries have adopted software development as one strategic focus area for the growth of their economies. The Software Engineering Competence Center (SECC) of Egypt has delivered CMMI-DEV based training, consultation, and appraisal services to hundreds of organizations in the MEA region.

This industrial paper has presented common characteristics and problems of many MEA organizations. Common characteristics include small team size, small projects, missed functions, and resistance to process improvement. Common problems include scope creep, missed delivery dates, disputes and conflicts, late discovery of project problems, un-maintainable systems, surprised senior management, too many defects, and sometimes safety issues. The paper has described recommendations and lessons learned that address these common characteristics and problems and that support effective and efficient process improvement in MEA organizations.

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Objective Visionary of CMMI Implementation: Pitfalls and Cost Benefits

Wael Philops
ITS, Nasr City Free Zone
wael.deif@its.ws

ABSTRACT
CMMI is an internationally recognized standard, developed by the Software Engineering Institute, whose objective is to allow the maturity-level evaluation of organizations concerned with software development. During its ten-year experience, ITS development center in Egypt adopted and followed the staged representation approach of the CMMI model that focuses on process improvement in a systemic and structured way, to reach a stage that allows generation of a framework for the next stage. Being accredited the maturity Level 5, ITS has developed a plan through which it has implemented CMMI levels. This paper discusses some aspects of ITS implementation plan for CMMI level 4 & 5 and the problems and pitfall against cost benefits.

Keywords
CMMI, Software Engineering, Software Development, CMMI Staged Representation Approach.

1. MOVING FROM CHAOS TO PROCESS ORIENTED RESULTS
When ITS management decided to adopt the CMMI model in the organization, it needed a program to be initiated and led by someone who is involved in the software development of the company products.

The real challenge in implementing CMMI in an organization is to gain the management and product teams commitment towards the change itself, so as to fulfill the organization's need of forming a group of the most experienced people on both managerial and technical levels (referred to by CMMI as SEPG (Software Engineering Process Group) or EPG (Engineering Process Group)). Therefore, the organization will be able to manage the change.

Each member of this group acts as a change agent of certain process and team. He/she is responsible for designing the process according to the CMMI requirements and for coaching different product team members to implement this process.

The group leader is assigned by the top management to clear roles, responsibilities and reporting mechanism.

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The first task of the group leader was to select the competent consultation entity that will help ITS to achieve the CMMI transformation plan. Below are some of the consultant's roles:

1. Assessing the current organization processes and product gap against CMMI requirements categorized by level and process area
2. Conducting spot checks
3. Conducting training on CMMI Model, Software Sizing techniques, SDLC, Measurements, etc.

Next step was to get clear business objectives from top management concerning the quality of products and customer satisfaction. Accordingly, the SEPG started to define the metrics scheme, with the traceability between the defined metrics and business objectives being tracked clearly as well as the data collection mechanism and the frequency of issuing metrics and targets1.

After identifying organizational business objectives according to proper measures and forming the SEPG, a process improvement plan was ready to be initiated by the SEPG leader in order to specify the following ten attributes:

1. Program sponsor
2. Program time frame
3. Major process gaps
4. Process needs
5. Process owners
6. Key performance indicators
7. Major deliverables and milestones
8. Spot checks by the consultant
9. Risk and contingency plan
10. Budget

The process improvement plan has to be reviewed with the SEPG and then approved by the top management and sponsor.

It was necessary for all the assigned process owners to take the CMMI overview course in detail to smoothly identify the process needs. Each owner had to maintain a process action plan which specifies the following:

1. Process subject matter expert (SMEs) and practitioners
2. Assigned tasks including but not limited to the following:
   a. Process writing
   b. Guidelines
   c. Templates
   d. Case study

[1] How to set targets and probability of success based on the organization past performance will be discussed later on.

e. Pilots
f. Coaching and training

3. Due date
4. Effort spent
5. Status

After agreeing upon the process by the process practitioners, it is ready for baseline and implementation. Normally, the process owner defines the process as is, implants some new practices that fit with the CMMI model and closes the gaps.

Training and coaching were the next challenges faced by ITS. It was difficult to change practitioners' mindset from legacy and chaotic behavior to be process oriented workflow. Only coaching and training are key to overcome this challenge and stabilize the process.

A stable process is the first key performance indicator which assures that the program is on the right track. An organization should not move to another stage unless process stability is achieved.

The process is stable when the entire project outcomes are uniform and spreading around the mean and within its tolerance (standard deviation or Sigma) after removing the special and common causes of process variation.

It is not necessary that the stable process meets the set targets but the outcome should be organized and meaningful. A uniform outcome tells the management that the organization follows a defined process with no more chaotic achievements and unorganized outcome.

In software industry, we can rely on 15 to 25 data points (projects) to check the stability of the process. There are also many statistical techniques for stability measurement, such as Westinghouse rules nos. 8, 4, and 1, control charts and Minitab tool which is the best tool to be used for such measurement.

If the process is not stable, the organization should not proceed with it and the SEPG should analyze the process variation to find out the root cause and start again with a new action plan.

An organization may take two years to stabilize the process according to various factors, like culture of change, size and availability of projects, continuous management commitment, multiple locations or sites etc.

One good practice that helps any organization to stabilize the process rapidly is to initiate the process change management tool and let practitioners suggest ideas and improve their processes. SEPG must come up with a tool for a process that manages the required changes and the implementation of such changes on the ground.

1.1 Samples of Stable Processes

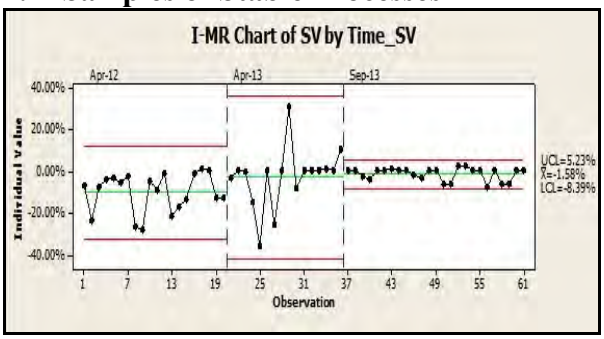

Figure 1: Schedule Variance (SV)

As per the above graph, we find that the Schedule Variance is improving over time, while the organization is still not capable of fulfilling its goals. The organization should analyze the data to determine whether it is a significant improvement or not.

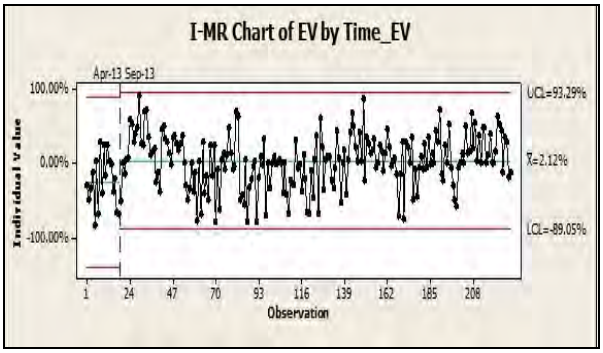

Figure 2: Effort Variance (EV)

As per the above graph, we find that the Effort Variance has a huge variation which makes the organization fails to fulfill its goals. Thus, it is necessary to take immediate actions to improve such variation even if the process is stable.

2. ACHIEVING A CAPABLE PROCESS

Moving to a more mature process required actions to be set by the organization regarding the data management. These actions were taken to control data sources and types that most of which are efforts and defects. Below are some of the required actions that were taken:

1. Selecting proper tools for effort and defects tracking
2. Selecting the proper statistical tool
3. Identifying the measurement team
4. Providing training to measurement team (process training, statistical techniques, probability, etc.)
5. Determining data collection mechanism
6. Encouraging employees to keep records
7. Avoiding using measurements to evaluate employees performance but to evaluate the process performance
8. Mapping every metric to match organization goals and objectives
9. Defining the mission of the measurement team and spreading that mission across the organization
10. Empowering the measurement team for data collection and validation
11. Implementing a parallel process for data validation and correction

12. Empowering the project management office
13. Reducing process change as well as accepting minor changes that will not affect the process behavior
14. Assigning a testing team to validate defects and related data
15. Formulating a data baseline policy

Setting values of organizational goals is one of the challenges that faced the management. It is difficult to set these values if the process is still chaotic and unstable.

Setting goals values required the organization measurement team to apply simulation models, such as Monte Carlo simulator, against a reliable historical data which is validated and approved by the measurement team.

Accordingly, the goal value is settled with the probability of success (POS) and tangible tolerance that are accepted by the top management.

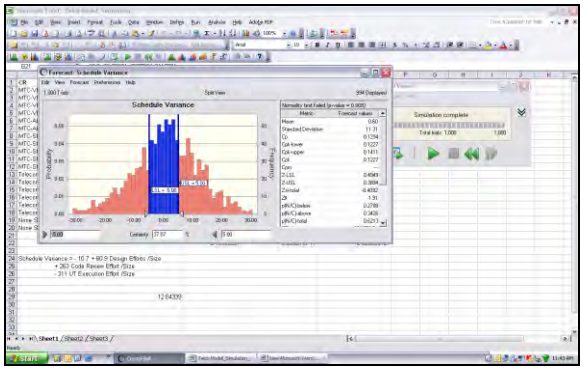

Figure 3: Setting Schedule Variance Goals 1

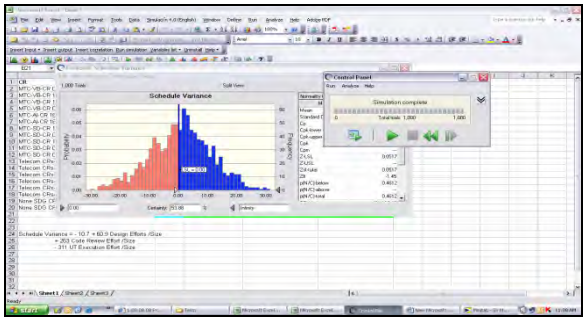

Figure 4: Setting Schedule Variance Goals 2

Another challenge is to find the proper performance model, i.e. if an organization wants to deliver the product to the customer on time it should use the schedule variance (Y) metric in measuring this goal.

Based on the same hypothetical analysis, measurement teams have to define a clear independent variable (X).

2.1 Defining Process Performance Model

A process performance model is a description of the relationships among a process attributes and its work products that is developed from historical process-performance data. This is calibrated using the process and product data collected during the project implementation. This helps in predicting results to be achieved after applying a process.

PPM depends upon one or more separate variables that can be used to predict the outcome (dependent variable). It is a mathematical model that is developed using empirical process performance data.

2.2 Identifying Goals of a Process Performance Model

The goal of a PPM is to track the actual steps of applying a process. In applying a PPM, it is important to consult an external observer who examines the way a process is implemented and determines the required improvements that make it more effective and efficient.

It is also necessary to establish rules, guidelines, and behavior patterns that would lead to the desired process performance. These may vary from strictly enforced rules to flexibly applied guidelines.

2.3 Identifying the Importance of the Model

There are core criteria according to which organizational goals are defined. Every project targets some relevant goals. These criteria are composed of both process and product related criteria. These goals must be in line with organization's business objectives.

Building the model helps the project manager to reach those goals, by controlling some variables addressed in the model.

2.4 Generating a Model

In order to build a PPM, it was necessary to use statistical and other analytic techniques in order to examine the historical data. This is to construct a model that can be used to predict future states. Initially, a PPM may not be very accurate. However, each time a process is applied, it is necessary to incorporate the process data output into the model to improve its accuracy in the next time. A clear example is the estimation model used by the project manager. When a primary project estimation model is used, the predicted results will not most probably be very accurate. Nevertheless, collecting the project estimates and incorporating them into the model enables you to predict results more accurately over time:

1. Gathering historical data from relevant projects.
2. Defining the Ys (dependent variables) and Xs (independent variables)
3. Running Regression Analysis test (in Minitab Program) for the collected data to find a line that best fits this data. Then, producing an equation to match the collected data. [To reach a regression line as "Y=a+bX"].
4. The model selected has to have some of the following criteria:
   a. The value of "R squared" value preferred to be 75 % or above.
   b. The difference between "R squared" and "R squared adjusted" must not to be very high (more than 10 %); that means that "R squared adjusted" is preferred to be not less than 65 %.
   c. "P" value has to be less than 0.05.

2.5 Implementing the Model within the Project

1. While planning the project, it was necessary to consider the metrics goals for the project and document them in the metrics plan. The goals had to be aligned with the business objectives of the organization. It could be a single number which may be the minimum or maximum value of the parameter as applicable, or can be a range that is acceptable to you.

2. The organization took up one of the goals that were most important and for which a process performance model is available, and then selected the most appropriate model when composing the project's defined processes.
3. There were two possibilities:
   a. If the results achieved are satisfying and in tune with the goals for the line of business, this means that the achieved value is 0.50 / FP
   b. If the project has a business need to achieve a lower pre-shipment defect density which is proportional to the post shipment defect density, then the value required to be achieved is 0.45 / FP.
4. In both cases, simulation techniques had to be used to determine the confidence level of the extent to which the project goals are achieved if the regular process of the organization is applied.
5. If the confidence level is satisfactory, it is required to determine the independent variable (design review effort /size) required to achieve the project goals with the level of confidence acceptable to the organization. This requires carrying out a simulation to come to the required value of the independent variable(s) through trial and error.
6. If the value of the independent parameter needs significant improvement, apply CAR (Causal Analysis and Resolution) techniques to identify means of improving the process to achieve those values.
7. While executing the project, you have to statistically control the value of the independent variable(s) through XmR Charts.

   X Chart is used to analyze the values of the independent variable(s). These values should lie within the control limits. It is necessary to apply CAR in case some data points are outside the control limits and if the sub-process is not capable (the LCL is below LSL "Goal").

   MR Chart is the moving range that represents the variance between two consecutive data points (the absolute value) and these values should be included within the control limits; in case of outliers do a CAR as well.
8. From time to time, using the already achieved values of the parameters, keep searching for the probability of meeting the relevant goals. If there is any slippage, take steps to get back on track. (Do CAR in case of outliers and if the sub-process is not capable).
9. Create a baseline for sub-process of data collected after CAR implementation and compare it to the previous data.
10. Check for quantitative improvements.
11. Reset goals (sub process goals) if required and repeat process.
12. If you have used a different process and have succeeded in meeting your project goals (CAR Outcome), this can now be used by other projects in the organization. You will have achieved process improvement proven by results (OID)!

2.6 Samples of PPMs

1. Schedule Variance = - 10.7 + 60.9 Design Efforts /Size + 263 Code Review Effort /Size -311 UT Execution Effort /Size
2. Schedule Variance = 10.6 + 6.25 Design Efforts + 21.5 Code Review Effort -97.1 UT Testing Preparation Effort -32.2 UT Testing Execution Effort
3. Defects injected in coding = 0.236 - 1.13 HL Design Review Effort/FP-4.14 LL Design Review Effort/FP-2.54 Requirement Analysis Efforts/FP
4. Effort Variance % = - 41.0 - 443 Rework eff./size + 1321 Code review effort /size

3. PITFALLS

3.1 Implementing the Practices Verbatim

Key practices are meant to be representative. Implementing the practices verbatim can be costly and may not reflect your organization's specific process needs very well. This approach can result in an overly proscriptive process that actually increases costs and slows release cycles. Expending funds to make "improvements" that turn out to be counterproductive is much worse than doing nothing at all. It can rapidly destroy the credibility of your process improvement implementation with management and with the software development staff.

3.2 Delaying Your Metrics Program and SEPG

The models lack an explicit measurable coupling between maturity levels and business results, such as cost and cycle time. The models do not require substantial process performance measurements until reaching the higher maturity levels. Consequently, in a beginning organization a process improvement effort often delay the implementation of a measurement program. Without measurements, an organization can achieve maturity level 3 without understanding the true costs and benefits associated with process improvement. Without a solid understanding of the return on investment (ROI) and its relationship to business results, it can be easy to lose sponsorship during a re-organization.?? Worse yet, without measurement, it is quite possible to implement practices that meet the goals of the KPAs (PAs) but are not cost-effective from a business standpoint. The basic problem is that the models provide qualitative KPA (PA) goals and typical practices to meet these goals. If your organization has an efficient implementation of the practices that meets the goals, you can realize improved business results. However, if your implementation is inefficient relative to your organizational needs, you may meet the goals, but at a cost that will outweigh any benefits. Process performance may be static or might actually degrade relative to business goals.

3.3 Opening Loop Management

Another consequence of deferring measurements is that even good process will underperform without active management. Management means feedback and control. With active management, actual process performance is continually checked against process capability. When they begin to diverge, management actions are used to drive the process back in

efficient operation. Without good measurements the process goes "open loop" and tends to degrade in performance over time.

3.4 Adhering Strictly to the Staged Representation

Often times, the staged improvement model is taken too literally. Inspections are a level 3 practice in the CMM. When implemented effectively and efficiently, inspections can be one of the best ways to quantitatively improve cost, product quality, and cycle time. Many organizations with a level 2 goal ignore inspections totally because they are a level 3 practice. There is certainly room to introduce a few higher maturity level practices early on if there is a good business case for them.

Sometimes, the staged improvement model may not be the best choice for an organization. If applied literally across a large organization, it can result in excessively long cycle times for improvements and repeated, costly false starts. Consider a 500-person software organization with 20 active development projects. In a strict application of the staged representation, we would try and get all projects practicing at maturity level 2 before moving any of the projects to level 3. This can take a very long time. Without the benefit of experience, an organization could roll out an inefficient implementation of a process across an entire organization, expending a considerable amount of time, money, and good will before it can be fixed.

One alternate approach is to select several pilot projects and move them rapidly to a high maturity level. Experience gained from these projects will make it less likely that there are organization wide false starts with ineffective improvements. Having a few projects operating at higher maturity level permits an accurate assessment of costs and benefits. Moreover, these projects will generate pull for other projects to upgrade their practices as well, overcoming organizational resistance to change.

The CMMI offers a continuous representation as an alternative to the traditional staged representation, but many organizations have a "staged" mindset left over from experience with the CMM and they are reluctant to experiment with it.

3.5 Emphasizing Documentation Rule

Both maturity models are fairly "document centric". There is a long list of required policies and procedures that need to be in place for each KPA (PA). These policies and procedures must be available during an assessment in order to provide evidence of the institutionalization of the practices. In the quest for a level, it is easy to generate a lot of policies and procedures that satisfy the KPAs (PAs) but are never used. This is a waste of time and money, and it squanders the credibility of the improvement process. Policies and procedures need to be short and they need to be used by everyone concerned. These procedures are often written to have minimal impact on existing practices in an attempt to shelter a busy development staff from unnecessary upheaval. The problem is that this pre-supposes there is no need for improvement. If the practices of most of the organization are not affected, how can there be a significant improvement? In this case, what is the point of the investment in model based improvement? If you really believe things are fine the way they are, you are better off doing nothing!

3.6 Maintaining Poor Organizational Alignment

The final failure mode concerns organizational responsibilities. The CMM recommends creating a Software Engineering Process Group (SEPG) chartered with the responsibility of defining and improvement the organization's software process. The CMMI talks about an Engineering Process Group (EPG), reflecting its broader focus. If the responsibility for deploying improved practices is given to the SEPG (EPG), and the project managers have the responsibility to get product out the door, it is possible to set up a situation where the SEPG (EPG) is busy putting practices in place and the project managers don't use the new practices on their projects. After all, project managers' goals are based upon shipping product. They have no incentive to take a chance trying new practices on their project. The result is frustration for all parties and a waste of organizational time and resources. The solution is that senior management must make continuous improvement everyone's responsibility.

Summary

It should be emphasized that there is nothing wrong with the models. They are just not prescriptive enough to avoid these problems. In some sense, the models are like a "necessary but insufficient condition" for improvement relative to business goals. Failing to meet the model goals indicates a high likelihood of consistently missing business objectives. Meeting the model goals can correlate with a higher likelihood of meeting business goals, provided the practices used to meet the goals are efficient and effective. There will be no correlation when the practices are not efficient and effective.

The net result can be the all-too-typical situation where an organization expends considerable effort moving up maturity ladder without making significant improvements in cost, quality, or cycle time. In some government contracting circles, this can be considered an acceptable cost of doing business because contract awards are often predicated on maturity level. In most other business, however, it collapses when someone in management notices that there are significant expenditures without measurable returns beyond a process maturity level.

4. COST BENEFITS

Examples of process/sub process being statistically managed:

Design review defect density, a sub process of Design review process which is part from the design process that is part from the SDLC in the organization.

Code Review Efforts, a sub process of Design review process which is part from the design process that is part from the SDLC in the organization.

PAs in which they reside respectively are:

Technical Solution

Verification

Examples of QPPOs (Y factors): A few QPPOs set for projects (these were seen to be implemented in all sampled projects) were:

a. SV
   Goal: -5%, USL: -10%, LSL: 0%
b. FTDD (CEP)
   Goal: 0.13, USL: 0.30, LSL: 0.07

c. FTTD (DNP)
Goal: 0.6, USL: 0.9, LSL: 0.25

The goals for the critical sub processes are mentioned below:

Table 1: Critical Sub Processes Goals

Critical Sub Process	Metric	Goal	LSL	USL
Design Review Defects Density	DDD	P1 0.23 P2 1.4 P3 1	0.1 04 0.3	0.6 2.4 2
Code Review Efforts	Code Effort %	P1 6% P2 5% P3 3%	4.5% 3.5% 4.5%	7.5% 6.5% 1.5

The basis of choosing the critical sub processes, determining its goals and specification limits and the steps involved in statistical management (of the critical sub process) in the projects in the OU are described below:

First, given the goals for Y, the Probability of Success (POS) of achieving the goals are determined by Probability Distribution functions. If the POS is less than a pre-determined threshold value, it would imply that there is a need to "compose the process". This is done by identifying the critical sub process which would then need to be modified to achieve the goals. This is done by considering the relevant PPMs. The various X factors in the PPM were analyzed for controllability, stage in the life cycle and, most importantly, a sensitivity analysis based, in some cases, on Tornado coefficients and in other cases, by considering the coefficients.

To determine the goals and specification limits for the sub process, Monte Carlo simulation was performed on the other x factors and moving the critical x factor value incrementally till the desired Probability of Success was obtained. If the critical sub process was found to be not capable (as was the case in all the projects that were appraised), a Root Cause Analysis was done to identify the root causes. Fish Bone was done in all cases. The identified root cause led to a decision on what modifications to do on the sub process.

Once the sub process was modified, it was statistically monitored. Control charts of the x factor were studied and tested for stability and capability. If not stable or capable, root cause analysis was again performed to determine special and common causes. Causes were removed and control charts analyzed again.

Likewise, the y factor was periodically monitored. Tests of hypothesis were also done to confirm if the y data had significantly improved over the past.

Examples of the critical sub processes were - (a) Design review defects density, a sub process of the design phase, which in turn is a sub process of the SDLC. This was found to be affecting the function test defect density (b) Code review efforts %, a sub process of the coding phase which in turn is a sub process of the DEV Life Cycle. This affects the function test defects density.

One can see that the processes above were statistically analyzed, both at the organization level and at the project level. Evidence of CAR was seen in instances where process stability and/or process capability were not achieved. Removal of common causes led to process improvement, which, in turn, led to process improvement proposals being made in the form of PRIME requests (OPM). Examples of action taken as a result of common cause removal were (a) enhancing the design review checklists (b) increasing usage of SPDB by awareness and training sessions.

Evidence of improvement in Process performance baselines as a result of OPM activities was also seen. Hypothesis tests were carried out to test whether the improvements were significant or not.

The statistical tests carried out, both while developing PPMs and identification of critical sub processes, were - Tests of Normality, Tests of homogeneity (2 sample t-test and ANOVA). Hypothesis testing was done in all cases with the p-value being looked at for statistical significance. Multiple Regression equations were developed. Minitab (for Statistical analysis) and Simulation (for Monte Carlo Simulation) were used.

Quality and process performance objectives being met:

Reduction in DD from 0.00196 to 0.00049

Reduction in Standard Deviation of MTTR is reduced from 18.26 to 7.43

SV mean improved from -3% to -1.5% also the STDEV improved from 9% to 3%

FTDD mean improved from 0.20 to 0.10 and STDEV from 0.14 to 0.10

Rework mean improved from 26% to 20% and STDEV from 19% to 15%

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Towards a Smart Applications Development Framework

Adrian Noguero
Tecnalia Research & Innovation
Spain
adrian.noguero@tecnalia.com

Angel Rego
Tecnalia Research & Innovation
Spain
angel.rego@tecnalia.com

Stefan Schuster
Tecnalia Research & Innovation
Spain
stefan.schuster@tecnalia.com

ABSTRACT
The number of smart devices (aka "Endpoints") is rapidly growing. Smartphones, tablets, wearables, along with smarter sensors, actuators and appliances are just a couple of examples. When all these devices are put into collaboration is when smart applications and smart spaces appear. Currently, a great effort is being invested in the development of the Internet of Things (IoT); however, Internet based technologies are not always the most appropriate solution for the implementation of this kind of applications, due to the big overheads introduced by the communication protocols and the big memory footprints of the associated server programs. This paper presents SMOOL (Smart Tool) a semantic publish/subscribe middleware that aims at providing a valid communications infrastructure for smart applications.

Keywords
Middleware, semantics, smart spaces, smart applications, Smart-M3, cyber-physical systems.

1. INTRODUCTION
Technical interoperability between embedded devices, such as sensors and actuators, has been for a long time an important issue to be solved. Past research efforts gave birth to communication standards, such as Zigbee or KNX. However, the dawn of the Internet of Things has raised the interoperability problem to the application (semantic) level. Moreover, the number of smart phones, smart TVs, wearables and tablets sold is rapidly growing. The availability of such smart devices enables the development of new smart applications that consume services provided by the environment, giving birth to Smart Spaces. However, the lack of a common language and well performing communication protocols are two important obstacles to fully exploit the concept of smart spaces. The main consequence of this scenario is that many of the functionalities provided by modern smart devices are often underused.

In this heterogeneous scenario, the development of smart applications that take advantage of the capabilities of the smart devices towards a common goal becomes a tremendous task, which requires not only managing complexity and heterogeneity, but also adapting the data models among similar devices from different vendors at application level. As a consequence, smart applications become expensive, niche and brand specific and their cost-to-return ration prevents their market penetration. Therefore, the implementation of design and development support tools could make smart applications economically sustainable, allowing their penetration in many different mass-markets, such as domotics, energy efficiency, entertainment, etc. Furthermore, as the envisaged number of devices that comprise a smart application is typically very large, the scenario becomes optimal for the experimentation with the IPv6 protocol and drawing meaningful conclusions.

This paper describes SMOOL, a middleware platform, implemented under the publish/subscribe paradigm, that aims at tackling the latter issues through the definition of (1) an open API and middleware services based on existing standards that provides a communication back-bone for smart applications, (2) a common and extensible data model for smart spaces that enables interoperability among vendors at application (semantic) level and (3) a set of design and development support tools that drastically reduces the development time of smart value added applications. The whole SMOOL solution takes into account legacy devices, implementing gateways for existing smart components and developing guidelines for other vendors to develop their own. This way the SMOOL middleware can be split into two main components: the SMOOL Infrastructure, which enables the technical interoperability of the devices at runtime; and the SMOOL Superstructure, which includes all the design and development tools associated with the Infrastructure, providing application (semantic) level interoperability. Last but not least, SMOOL addresses the economic sustainability challenge of mass-markets with an open business model approach, where cost-to-return becomes part of the solution.

The SMOOL middleware builds upon the Smart-M3 information sharing platform [1], result of the SOFIA research project. SMOOL infrastructure reuses the Smart Space Access Protocol (SSAP) developed in SOFIA; however, SMOOL extends the capabilities of the application development tools and greatly simplifies the API for new developers. The rest of the paper is organized as follows: section 2 analyzes some relevant related works, section 3 provides an overview of the internal design of the middleware, section 4 describes the API, section 5 covers the design and development tools, section 6 describes a use case application using SMOOL and, finally, section 7 draws some conclusions and presents the future research work.

2. RELATED WORK
Communication-enabling middleware is designed around two main communication patterns: client-server communications and publish-subscribe communications. The client-server paradigm is useful for centralized architectures and for systems where communications only occur between two elements of the network. Among the middleware technologies which support the client-server communications paradigm several standards can be found; for example, CORBA [2], Ice [3], Web Services, Java RMI [4] or OPC [5]. It is also possible to find in the literature other

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middleware architectures that extend or modify these technologies to develop middleware with more added value [6] [7] [8].

The publish/subscribe paradigm (or its previous version: producer/consumer) is more suitable for one-to-many and many-to-many communications. This kind of communications paradigm is found in applications where data exchange is more important than the interaction itself. Typical examples are distributed control systems and video streaming applications. These applications are less coupled than client-server applications. It is important to note, though, that the publish/subscribe middleware architectures have been designed on top of individual client-server communications; nevertheless, the user gets the feeling of a many-to-many communication. Several middleware standards can also be found for the implementation of a publish/subscribe communications paradigm, for example, DDS [9], Icestorm [10], SOFIA Middleware [11], the CORBA Event Service and the CORBA Notification Service [12] and the Java JMX [13]. In the same way as with client-server middleware, several super-layers have been developed on top of these technologies to provide higher added value [14][15].

Despite the matureness of the reviewed technologies, none of them has been able to overcome others. In the context of the Internet of Things, web services are the most promising technology; however, protocols used in the web services stack make them too heavy for communications based on low bandwidth communication media, such as Zigbee or Bluetooth, where adaptable communication protocols, such as the GIOP of the CORBA standard perform better.

Data models are used to define the way in which devices are represented in a smart application. This representation not only defines the devices themselves, but also the information they share with other devices and/or consume from other devices as well as the services.

Currently, ontologies in networked systems are used for service creation, provision, and execution to a various extent by using different description languages. Web Ontology Language for Services [16], Web Service Modelling Ontology [17] and Internet Reasoning Service [18] provide specific ontology building blocks for particular purposes of use. Conversely, METEOR-S [19] is an approach that targets the extension and integration of the existent Web Services and Semantic Web technologies. Each approach provides specific advantages that are missing in the others but none of them provides complete description support for service semantics.

Existing smart application ontologies lack of completeness; only one or a few qualities are considered, and the vocabulary and/or metrics are missing. Moreover, support for creating extensions at run-time is missing [20]. The SOFIA project [21] extended the use of ontologies by exploiting the semantic information for device identification in smart spaces. Similar results were also found in the eDIANA project, in the energy efficient building domain [22].

The usage of tools to support the design and development of smart and distributed applications is found regularly in the literature. There are many tools that rely on modelling technology. For example, the FORGE framework [23] is comprised of a set of tools that allow the users to create the source code of the applications from high level UML application models using MDE techniques. The FORGE framework also includes tools for distributed application analysis and deployment in the context of the CompOSE|Q middleware; but in this case, run-time monitoring is not supported. The configurable multiprocessor platform based on the TUTMAC UML 2.0 [24] is another example of a configurable middleware architecture with model-based tool support; however, again the supplied tool does not provide management capabilities. As part of their functionality, these two tools include code generation.

3. OVERVIEW OF SMOOL

3.1 The Publish/Subscribe Model

The SMOOL infrastructure is a data distribution middleware based on the publish/subscribe paradigm. Compared to the classic client/server applications, which are typically used for applications where interactions are established on a one-to-one basis, publish/subscribe architectures perform better when messages are to be distributed to multiple clients [25]. In other words, in publish/subscribe applications data is more important than the interactions themselves.

This is often the case of smart applications and pervasive computing systems. For example, when a new device enters a smart space subscribing to the data that is relevant for the device is much simpler than locating all the services provided by all the server devices in the area and selecting the ones that are useful for it. Moreover, the latter approach might lead to compatibility issues (e.g. similar services might define different APIs).

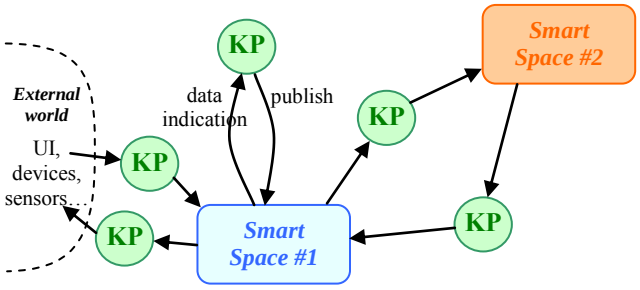

Figure 1. SMOOL infrastructure schema

Figure 1 describes the SMOOL publish/subscribe schema, in which the clients (so called Knowledge Processors or KPs) provide data to the smart space, often coming from sensor measures taken from the real world or decisions made by smart application users through smart devices, and consume this data to create added value data, interact with the real-world or even to share it across several smart spaces.

3.2 Semantic Middleware

Currently all the existing data distribution middleware solutions provide the users the capability to define application specific data models. These models are then used by the producers and consumers to define the information included in every data message distributed in the system. Thus, messages require some form of identification that allows consumers to recognize the type of the message to be able to use the information contained in it. As a result, both publishers and consumers need to know the message types that they will exchange before the application is deployed.

In the majority of cases this offline definition of data types is enough to create data centric distributed applications; however, in those cases where the number of potential application developers and device vendors is high and/or cannot be determined at design time, this approach may lead to application level incompatibilities.

To overcome this incompatibility issue, SMOOL introduces a semantic model that is used to mark each of the message types shared in a smart space. The semantic model is basically an ontology which defines the different message kinds, establishes semantic relations between the different message types and ensures application level compatibility. In addition, due to the extension characteristics of the ontologies, the semantic engine in SMOOL ensures backward compatibility of the applications even when new message types are added to the ontology.

Ontologies in SMOOL are used in two ways. On the one hand, the ontology is used to allow abstract subscriptions to data of many different types. For example, a KP may subscribe to the concept *Sensor* and will receive notifications whenever a message of the *Sensor* type or any subtype is published (e.g. *TemperatureSensor*). On the other hand, the SMOOL ontology is used by the design and development tools to automatically generate the data model code required by the KPs to produce/consume data of each message type.

3.3 Middleware Design

3.3.1 Semantic Information Broker (SIB)

SMOOL applications consist of a set of KPs that exchange data among them. Therefore, the KPs are the most important component of the SMOOL middleware infrastructure and define the end-points of the data in the smart applications. However, to implement the behavior of the smart space that dispatches the data messages to the subscribers a second component, so called Semantic Information Broker (SIB), is required.

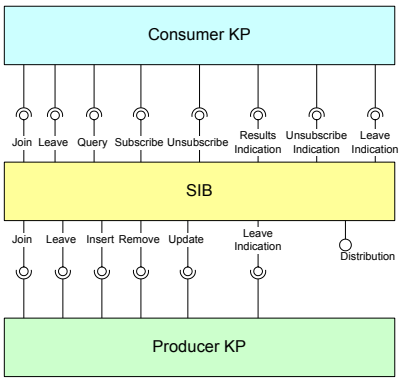

Figure 2. Interactions between the SIB and the KPs

As shown in Figure 2, the SIB provides several interfaces to the KPs that implement the publish/subscribe paradigm. For example, the KPs can connect to/disconnect from the smart space, represented by the SIB, using the *Join/Leave* services. In addition, producer KPs can also push data messages to the smart space using the *Insert/Remove/Update* services. Similarly, consumer KPs, can us the *Subscribe/Unsubscribe* services to link to the different message types and receive *Indications* whenever new data is produced. Additionally, consumer KPs may use the *Query* service of the SIB to asynchronously get the updates of a concrete data type or even a particular data message.

All the interactions between the KPs and the SIB are implemented using the Smart Spaces Access Protocol (SSAP) [1]. The SSAP defines the messages involved in each of the services mentioned before, describing the data structure to be included in each of them. The SSAP protocol is XML based, which is very convenient to share ontology-based semantic information as this information is already XML. As depicted in Figure 3, the SSAP module is the one that manages the interactions between the SIB and the KPs. This way, heterogeneous devices can talk the same language (SSAP), improving interoperability among devices from different vendors

The SSAP module connects to the Gateway module to send/receive the messages to/from the communications network. SMOOL is intended to be used with different communication technologies, and the Gateway module is the one that controls whether a message should be transmitted by the TCP/IP stack, Bluetooth, or any other communication technology/network.

The SSAP module is also linked to the Core module of the SIB. The Core module implements the smart space logic. It is responsible for (1) generating the responses to the SSAP messages, (2) user and permissions management, (3) storing the messages in the Semantic Engine module and (4) generating the indication messages for the subscribing KPs when data becomes available.

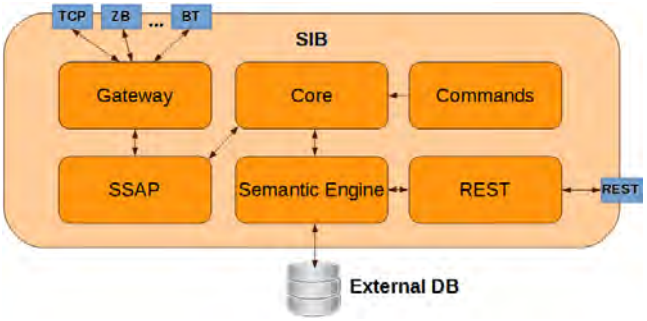

Figure 3. Internal structure of the SIB

The Semantic Engine module is responsible for updating and maintaining a model of the messages shared by the KPs in the smart space. In addition, the Semantic Engine module is also connected to a database to store persistent messages. Persistent messages are kept inside the smart space until the producer removes them (e.g. user preferences) whilst non-persistent messages are removed from the SIB after they have been dispatched or when a session finishes (e.g. messages).

The Commands module controls the lifecycle of the SIB. It can create new smart spaces and/or gateways and start and stop them according to the needs of the smart space administrator.

Finally, the REST module provides a REST interface to access the data currently stored in the smart space. The REST interface provides read-only access to the messages, and it is intended to be used to integrate SMOOL into higher level control and monitoring applications (e.g. cloud computing and big data systems).

3.3.2 Knowledge Processor (KP)

Knowledge Processors (KP) are the end points of the smart applications. These components implement the logic of the applications and produce/consume data to fulfill their tasks.

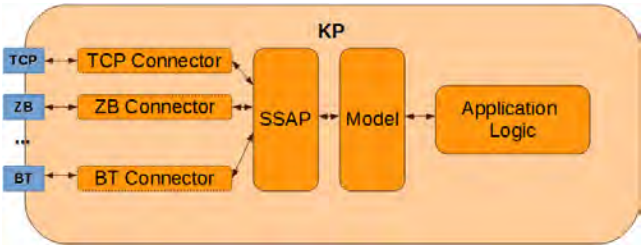

Figure 4. Internal Structure of the KP

The internal structure of a KP is depicted in Figure 4. It has already been discussed that the KPs need to access the smart space services to interact with it (see Figure 2) using SSAP messages. However, using SSAP messages directly is not an easy task and it may lead to errors. Thus, the KPs include a model layer, which converts programming objects representing ontology concepts to the required SSAP messages and vice versa.

Contrarily to the SIB, a KP will typically connect to the smart space using a single connector. Each connector is capable to access the SIB using a concrete gateway kind, for example, a KP should use the Bluetooth connector to access the SIB via the Bluetooth gateway. Therefore, developers must select which gateway module each KP will use to connect to the smart space (e.g. TCP/IP, Bluetooth, Zigbee, etc.).

3.3.3 Users and permissions management

One of the main improvements of SMOOL with respect to its predecessors is the intelligent user and permission management included the middleware. This feature allows the smart space administrator to activate a user management system and to define permissions to access the data inside the SIB. Additionally, SMOOL foresees the inclusion of a guest account for all external devices connecting to a space (e.g. a smart office may define users for the workers and use the guest account for visitors). User authentication provides a higher level of security and enables the definition of lower grain permissions, preventing users from accessing sensible data in the smart space.

After authentication users may publish and consume data in a smart space; however, the smart space administrator may define restrictions to the users depending on a set of permissions on the data available. This user management and permissions system has been inspired by user and permission management in Linux, defining three permission levels:

- Owner User. The permissions the producer user has on a particular data message. Typically, the producer user can update the produced message and even remove it from the smart space.
- User Group. The group of users that can receive a concrete message can be restricted through user group permissions. User groups may also have rights to update or remove a message in some collaborative smart applications.
- Others. These permissions will apply to the rest of the users in the smart space, including the devices connected as guests.

The implementation of the user management and permissions system is part of the SMOOL Core module of the SIB.

4. API DESIGN

4.1 API Overview

SMOOL provides a simple API to access the SSAP services of a smart space inspired in the APIs of other popular publish/subscribe middleware architectures, such as DDS [9]. The API is provided as a single library file that is included in the smart application project.

Following the KP design, the SMOOL API is also divided into layers as show in Figure 5.

The lower layers of the KP form the KP Interface (KPI). The KPI includes the layers of the KP libraries that are not modified from application to application. However, the SMOOL layer of the library is generated and compiled in a per application basis, including specific functions for producer and consumer KPs. In addition, the SMOOL layer includes factory functions to handle the ontology concepts relevant for each application. As it will be discussed in section 5, the SMOOL tools allow the smart application developer to choose the ontology concepts that each KP will produce and/or consume.

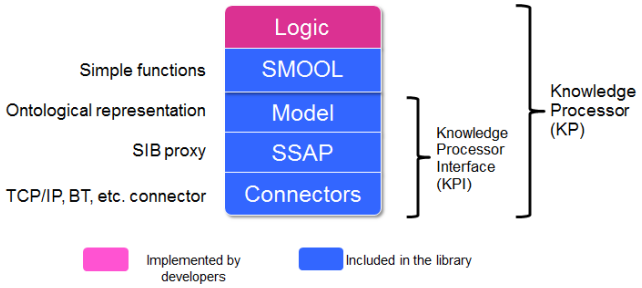

Figure 5. Layers of the SMOOL KP API

It is important to note that the KP libraries can be used in several different platforms and programming languages, such as J2EE, Android, C++, Javascript, etc. Therefore, the SMOOL tools need to implement different KPI generators for the different technologies supported by the tool.

KPs will connect to one of the gateways of the SIB using a specific communications connector (i.e. TCP/IP, Bluetooth, etc.). In order to use these connectors, the smart application developer will need to configure during KP generation process the connector that particular client will use to interact with the SIB.

4.2 SMOOL API Description

As it has already been explained, the SMOOL API is intended to be used in several different platforms and devices. Therefore, the API must be implemented on top of different technologies, slightly varying its look-and-feel across programming languages. However, its high-level design remains unmodified despite the programming language. In this section the high-level design of the API will be described from a KP developer perspective.

By providing a KP library for different platforms (Java, Android, C++, etc), any device can be easily integrated into an SMOOL environment, reducing drastically the cost of development time compared to an ad-hoc implementation.

Figure 6 describes the API as a flow graph including the steps developers must follow to successfully implement a SMOOL based smart application. The first step is to provide a meaningful and unique name for the current KP. The name of the KP will be used by the smart space to identify the smart space participant, and it will be shared with other participants. In addition, when authentication mechanisms are active, the KP name will also be used as the username in the current smart space. The second step involves connecting to a smart space through a SIB. This process can be done directly if the address of a certain SIB gateway is known; however, in many cases (e.g. mobile phone apps) it will be necessary to locate a SIB in the local network. The SMOOL API provides a set of methods to locate smart spaces, this process is known as SIB discovery. Once one or more SIBs have been discovered, the KP may connect to a smart space.

After a KP has successfully connected to the smart space the subscriptions must be set up. For each consumed concept the SMOOL API provides a *Subscription Class* intended to receive callbacks whenever a new message or a message update is published in the smart space. Subscriptions are handled by the

Consumer object of the SMOOL API, which manages the subscription process with the SIB. A consumer may subscribe to one or more concepts in the same session and for each of them a new Subscription object must be implemented, defining the logic to be executed when a new message is published, updated or removed from the smart space.

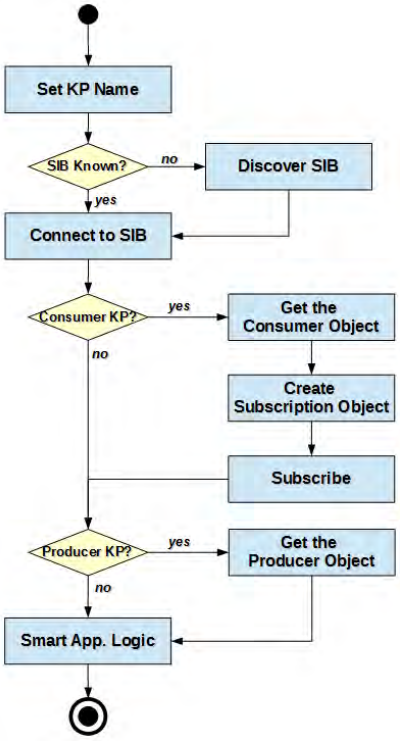

Figure 6. SMOOL API for developers

Finally, data producing KPs will use the Producer object to publish new data in the smart space or to update/remove data messages. In addition to the Producer, the SMOOL API provides factory objects to the applications that help creating SMOOL compatible messages. These messages can be then published and/or changed using the Producer object in the main logic flow of the smart application according to its functional requirements.

It is important to note that some KPs might produce and consume data at the same time.

5. TOOL SUPPORT

Specialized design and development tools contribute to reducing the time-to-market of the applications, augmenting the quality of the final software and reducing the number of bugs. This is especially true when a new technology is involved.

To reduce the learning curve of the SMOOL technology, the framework includes a set of helper tools that ease the adoption of the middleware concepts and provide support for the implementation and testing of smart applications. All the tools have been implemented as Eclipse plugins, fully integrated with the IDE, which makes them more usable for developers.

Currently, the SMOOL toolkit includes two main tools:

- KP generation wizard
- SIB control and monitoring user interface

5.1 KP Generation Wizard

The KP generation wizard guides the smart application developer during the configuration of the KPI for a particular smart device. As a result the wizard will generate a project inside Eclipse including all the KPI libraries and the top level SMOOL API.

As shown in Figure 7, the wizard features a form to configure several parameters of the new KP project:

- *Project Name*. The name of the project that will be generated inside Eclipse.
- *Project Type*. The type of KP project to be generated (e.g. J2SE, Android, Javascript, C++…). This parameter modifies not only the nature of the generated project, but also the KPI libraries and the structure of the SMOOL API.
- *Shared Concepts*. The data elements the current KP will produce and consume. It is possible to select several items from each list, and it is also possible to create new concepts extending existing ones.
- *Communications Layer*. Configures the connector this KP will use to access the SIB (e.g. TCP/IP, Bluetooth, etc.).
- *SIB name, address and port*. If provided an automatic connection function is generated for a concrete smart space in the current KP.
- *Automatically Discover SIB*. If checked (and supported by the communications technology) an automatic smart space discovery procedure is generated for the current KP.

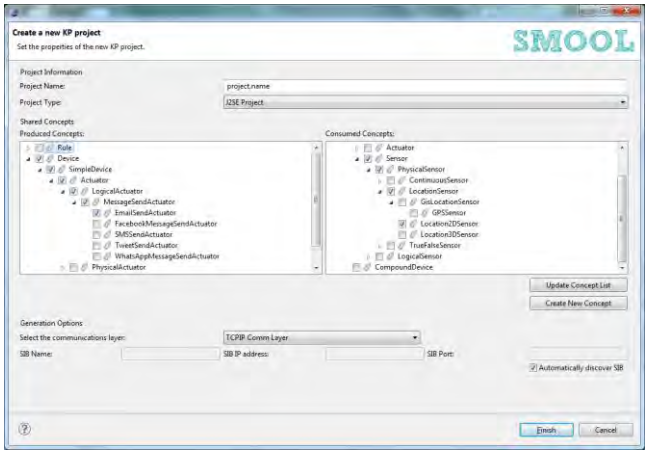

Figure 7. Screenshot of the KP generation wizard

After the generation process has been completed a new KP project will appear in the navigation panel of Eclipse IDE. Developers can then add the application specific logic to the KPs according to the functional requirements of the smart application.

5.2 SIB Control and Monitoring UI

The SMOOL toolkit also contains a specific user interface to create smart spaces and control the messages, subscriptions, etc. generated by the smart applications connected to it. The goal is to provide a means to debug the smart applications in a real smart space context.

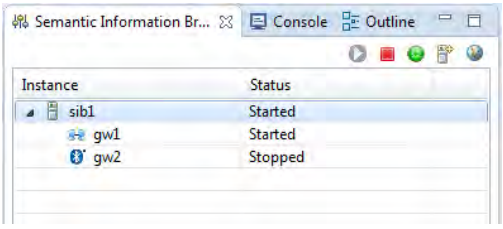

Figure 8. SIB management panel

The first tool is the SIB management panel, shown in Figure 8, which provides an interface to the Commands module in the SIB. The panel allows the smart space administrator to create different smart space instances and to define different gateways for each of the smart spaces managed by the SIB. The panel also provides specific mechanisms to control the lifecycle of the smart spaces (i.e. start/stop/restart the SIB).

Once the smart space is up and running, the SIB viewer panel enables the user to monitor the KPs connected to the smart space and their subscriptions, and to review all the messages inserted by SMOOL producers into the smart space (see Figure 9).

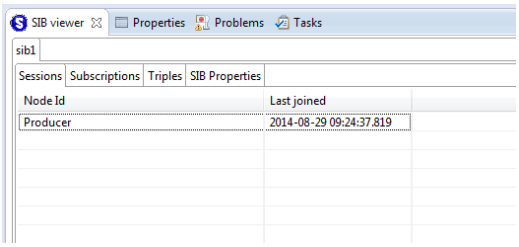

Figure 9. SIB monitoring panel

SIB management and monitoring tools are especially useful when debugging new smart applications because developers are capable to check in real time if the generated messages are being received/dispatched by the smart space correctly and even if the data being shared is correct or not.

6. SMOOL USE CASE APPLICATION

This use case aims to develop a multi-purpose and multi-device environment to access data generated by devices in a geo-located smart space. This information is gathered from different kinds of sensors and human interfaces (e.g. smartphone applications), and then presented to the system administrator for analysis and decision making. This ecosystem leans on the SMOOL middleware to connect sensors from different vendors and transfer the read measures over different protocols and networks (wired and wireless) to the smart space. By using SMOOL, Consumer applications automatically retrieve the data in a standard and vendor-independent format.

The proposed use case application represents a factory building where several physical parameters are to be monitored by the system administrator. Additionally, as a safety measure, all the workers of the factory must be localizable at all times. The main components of this use case application are (see Figure 10):

- The SMOOL SIB, which provides three different gateways to the clients to access the smart space and handles the publish/subscribe process.
- A set of wired sensors (from Phidgets [27]), connected via Ethernet, acting as data producers (i.e. temperature, light, distance, RFID tags, etc...)
- Wireless sensors (from Libelium [28]), connected through IEEE 802.15.4, acting as data producers. These sensors are also programmed to act as a security network, independent form the smart space. Thus, if critical events occur, or the SMOOL platform is damaged, the secondary network can still be used to send important information.
- Mobile devices (Android smartphones) acting as data producers and consumers. These devices send their physical location, outdoor and indoor, by using all available location providers (i.e. GPS, tower cell and WI-FI). In addition, smartphones can also act as data consumers by using the websocket gateway to the smart space data.
- A web application, implemented using a Javascript KP, and HTML5, websockets and openlayers technology, which acts as a data consumer. By accessing the main web page, a map is shown containing the position and data from the sensors, the information is updated in real time, since the websocket is listening to new sensor updates.

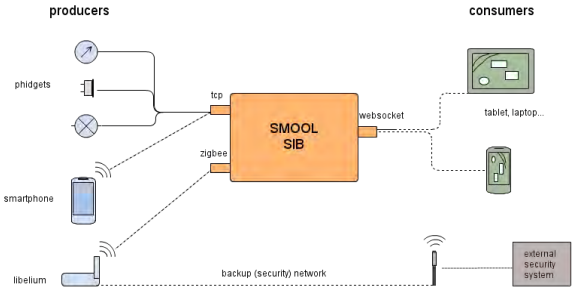

Figure 10. Use case application overview

Figure 10 shows the architecture of the use case application, where some devices are sending information to the smart space (i.e. producers), while other devices receive the information they are subscribed to (i.e. consumers). The wired and wireless sensors are deployed in some particularly critical locations of the installation. These devices periodically send the measures of different physical parameters to the smart environment for monitoring. In addition, sensors are configured to send their current position on start-up. RFID sensors deployed in the use case application are used for access control purposes. Android phones are carried by workers in order to provide their current location. Furthermore, some workers may also access the smart space to monitor the status of the sensors in real-time. Finally, the administrator's interface provided by the web application processes the consumed information and displays sensor locations and data on a map.

Figure 11. Use case application mock-up

A mockup model (shown in Figure 11) has been created to reproduce the real world scenario with physical sensors, positioning devices and smartphones. The mockup contains a simple control access system by using RFID, a temperature sensor, an environmental light sensor, a water tank level sensor, an indoor/outdoor location device (smartphone), and a disaster sensor.

The Javascript SMOOL KP in the web control panel is able to subscribe to the information produced by all these sensors and devices and display the current position and data in an OpenLayers map (see Figure 12). The web interface includes filters that allow the administrator to view just the sensors in a particular area, hide some sensors, as well as some management features (i.e. send messages to workers, monitor alarms, etc.). The web application can be customized to display different environments based on user privileges.

Figure 12. Screenshot of the Javascript SMOOL consumer

Since the web application data is fed by using Websockets technology (instead of AJAX), the response time from the sensor sending a new value to the value displayed in the map, is really fast. The bandwidth required for sensors to send the data, and for web clients to retrieve them is the smallest possible because the browsers (the "consumers") are subscribed just to the information they are interested in. A device can send information about temperature and pressure to the SIB, but a receiver subscribed only to temperature, would not get pressure data.

7. CONCLUSIONS AND FUTURE WORK

This paper has presented SMOOL, a middleware and tool framework for the design and development of smart applications which builds upon the Smart-M3 paradigm and the SSAP protocol [1]. The middleware is based on the publish/subscribe paradigm and introduces semantic technologies to ensure interoperability at application and data level. The source code of SMOOL is made available as open source software under the EPLv1.0 license [26].

Future work is envisaged in two directions. On the one hand the authors aim at augmenting the number of SMOOL compatible platforms by developing and adapting the KP libraries to more programming languages and platforms, including Objective-C and C#. On the other hand, authors are currently working in the development of a high-level smart application design, simulation and deployment tool for non-expert users that enables any person to easily deploy smart applications on top of SMOOL.

8. ACKNOWLEDGMENTS

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A Technique for Requirements Prioritization Based on Goals' Weights

Mukhtar Abd Elfttah Abo Elsood
Computer Science and Information Systems Department
Institute of Statistical Studies and Research,
Cairo University, Egypt
mukhtar646464@hotmail.com

Eman S. Nasr
Independent Researcher
Cairo, Egypt
nasr.eman.s@gmail.com

Hesham A. Hefny
Computer Science and Information Systems Department
Institute of Statistical Studies and Research
Cairo University, Egypt
hehefny@hotmail.com

ABSTRACT
Most, if not all, of the software projects developed can't implement the entire requirements within a given time and available resources. Hence Requirements Prioritization (RP) is needed during the requirements elicitation phase of software development to define the priorities given the available resources and constraints. There are many prioritization techniques available in the literature to prioritize software requirements. However, most of them work well on a small number of requirements, but when the number of requirements get large many of these techniques suffer from different shortcomings, such as scalability, uncertainty, time consumption, and complexity. In addition, most of these techniques don't take into consideration the effects of a project's required goals on the final alternatives' ranking. In this paper, we propose a new RP technique based on goals' weights, and derived from hybrid techniques in an attempt to enhance the problems of time consumption, scalability and complexity. These hybrid techniques are cumulative voting, Hierarchical Cumulative Voting and Analytic Hierarchy Process.

Keywords
Requirements prioritization, goals' weights, requirements engineering.

1. INTRODUCTION
Requirements prioritization (RP) is generally defined as the activity, carried out during requirements elicitation, during which the most important requirements for a software system can be discovered [1]. Firesmith [2] defines RP as the process to determine the implementation order of the requirements for implementing a software system, or the process to determine the order of importance of the requirements to the stakeholders. Hence, it could be claimed that RP represents the heart of software systems development. A project could be challenged due to less important requirements being implemented first, which causes big problems in all of a software system's life cycle. The big failure of the FBI's project in 2005 [3], with a loss of 170 million dollars, clearly highlighted the utmost importance of RP, and attracted attention for more research in requirements engineering (RE) in general. The FBI's project requirements document was about 800 pages, and it is argued that among the main reasons for the project's failure is that the researchers failed at that time to prioritize the requirements [4, 5]. According to many studies, e.g., [5, 6], the process of prioritizing requirements can help in, and provides support for, the following issues:

- Helping multiple stakeholders, whose opinions are conflicting, to decide on the important requirements for a system.
- Establishing a relative importance for each requirement that helps in ranking.
- Planning and selecting an ordered, optimal set of requirements for implementation in successive releases.

There are many prioritization techniques available in the literature to prioritize software requirements. We will highlight the most popular ones in Section 2 of this paper. However, according to more than one study [7], most of the RP techniques work well on a small number of requirements; many of them still suffer from different shortcomings such as scalability, uncertainty, time consumption, and complexity. According to many studies, e.g. [7, 8, 6] none of the prioritization techniques can be considered the best; the best prioritization technique usually depends on the situation. There is even no standard criterion for evaluating an RP technique, and that is why researchers attempting to conduct RP techniques' evaluations reach conflicting results, e.g. [9, 10].

One of the most popular definitions for RE is that it is a branch of software engineering concerned with the real-world goals, functions of, and constraints on software systems [7]. So, it could be claimed that all of the RE activities are used to ultimately serve the goals identified by the stakeholders. In spite of that, most of the RP approaches don't take into account the effects of the required goals into the final alternatives' ranking. In this paper, we propose a new RP technique based on goals' weights, and derived from hybrid techniques in an attempt to enhance reported problems of time consumption, scalability and complexity.

The rest of the paper is organized as follows. Section 2 gives an overview of the more familiar prioritization techniques in the literature and their deficiencies. Section 3 gives a brief overview about goals and a description of our proposed new technique, supported by an application of it on a hypothetical example. Finally, Section 4 gives the conclusion and future work.

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2. PRIORITIZATION TECHNIQUES

RP is a decision making problem that needs Multi Criteria Decision Making (MCDM) solutions. MCDM solutions are concerned with how to choose the best decision from different alternatives according to different criteria, which usually conflict. The basic idea for most RP techniques belongs to the scoring methods. The scoring methods are compensatory methods that generate relaive weights for the requirements. So; the requirements importance can be measured and ranked according to specific criteria with different scales. These scales have advantages and disadvantages. In this section we give an overview of the three basic types of measurement scales that are used widely in RP techniques; these types are nominal, ordinal and ratio scales [11, 12]. We will present the most famous techniques for RP within each type, highlighting the advantages and limitations of each technique.

2.1 Nominal Scale

In this type of scale; data is classified into categories and cannot be arranged in any particular order. The methods that belong to this scale can create different groups without any order for ranking as the group of colors. Where each group has assigned to a different priority; the requirements are assigned to these groups according its priority. One of RP methods that apply this scale is a Numerical Assignment (Grouping) technique. This technique divides the requirements into three groups: critical, standard, and optional. The worst problem in this technique is that; there are no differences in priority within each group. But this technique is considered very easy and scalable [11].

2.2 Ordinal Scale

In this type of scale; data is arranged in some order, but the differences between data values cannot be determined or meaningless. The methods that belong to this scale can create different groups with the order meaning as the group of favorite drinks (1- tea 2- coffee 3- milk etc). So; its techniques can support ranking, such as simple ranking, bubble sort and Binary Priority List (BPL) [6, 12],. BPL is an important technique that uses ordinal scale which its idea depends on comparison and ranking horizontal or vertical. We put any requirement into the first level then compare it with the next requirement. If it is more important put it up or if it is a low important put it down and so on for all requirements. According to Bebensee et al, [13, 14], the result is ranked requirements, as shown in Fig. 1. PBL technique is easy and reliable but it suffers from scalability issues especially for large requirements. Beside BPL technique does not take into account the dependencies between requirements.

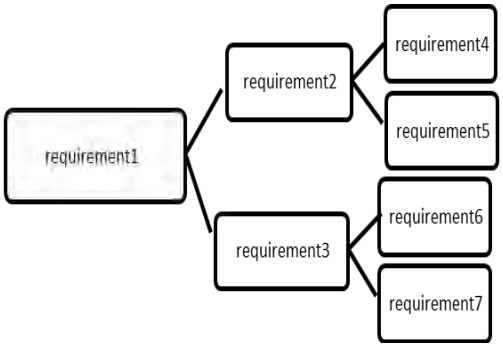

Figure1. PBL architecture.

2.3 Ratio Scale

In this type of scale; data can be ranked and Differences, relative ratios are meaningful for this level of measurement. The methods that belong to this scale can create different groups; with the order meaning and provide the relative difference between requirements such as methods in the following sub-sections.

2.3.1 Cumulative Voting (CV), the 100-Dollar Test

The idea of the 100-dollar technique is that each stakeholder is asked to assume s/he has $100 to distribute among the requirements [15, 10]. The result is presented on a ratio scale. The 100-dollar test is a very straightforward prioritization technique. A problem with this technique arises when there are too many requirements to prioritize. Another possible problem with the 100-dollar test (especially when there are many requirements) is that the person performing the prioritization miscalculates the points, and they do not add up to 100. This can be prevented by using a tool that keeps count of how many points have been used. The risk with such an approach is that stakeholders may be forced to not prioritize according to their actual priorities [16, 17].

2.3.2 Hierarchical Cumulative Voting (HCV)

The idea of HCV is like CV, but is classified into different levels of hierarchies. HCV was developed in an attempt to address the scalability issues in CV, as shown in Fig. 2 that illustrates the technique; it shows that in the high level there are a three groups (G1, G2, and G3). According to CV technique we must distribute 100$ between the three groups. In the next level, for group 1 which contain two requirements we must distribute another 100$ between the two requirements and so on for every group. Although HCV technique had present a good solution for scalability issue. But; when the no of requirements in the high level or its sublevel is exceeds. We need more levels to keep on the scalability that is causing a more time consuming [16].

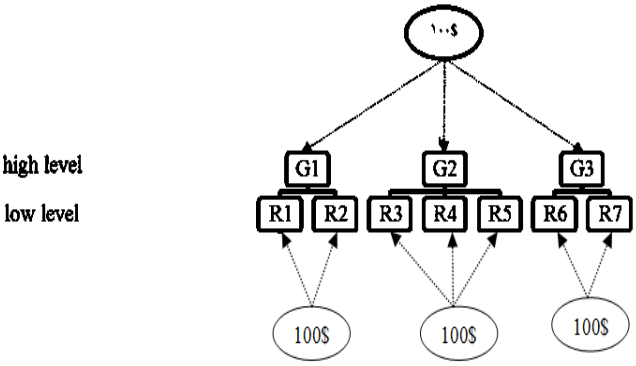

Figure 2. HCV.

2.3.3 Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), is introduced by Thomas Saaty (1980).to help the decision maker for best choice from alternatives with ranked relative weights. The idea that satty introduced is a pairwise comparison between all possible alternative pairs according to its criteria. Satty presented a measure scale to measure the relative importance between every alternatives pairs as shown in Table 1. Then design the weight matrix which result the ranked alternatives weights depending on calculation of eigenvector and eigenvalue [18, 19, 20]. However, AHP suffers from time consuming, scalability, redundancy, uncertainty, vagueness and inconsistency issues.

Table 1. The Saaty rating scale

Values	Definition	Explanation
1	Equal importance	Two factors equally importance to the objective
3	Somewhat more important	Experience and judgment slightly favor over the other.
5	Much more important	Experience and judgment strongly favor one over the other.
7	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Absolutely more Important.	The evidence favoring one over the other is of the Highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed

2.3.4 Fuzzy AHP (FAHP)

To overcome the limitations of AHP, such as the uncertainty and vagueness, FAHP was used. It is based on fuzzy set theory and fuzzy number. Which the idea of FAHP is the same as AHP depending on pairwise comparison but the representation of the alternatives importance by using three values. A fuzzy linguistic label can be represented by a TFN (triangular fuzzy number). A TFN is represented by 3 values (l, m, u), where l is the low value, m is the middle value and u is the upper value. There is no standardizing scale in FAHP. Other limitations of FAHP are still the same in AHP, such as scalability, time consumption, and redundancy [16, 11, 21].

3. GOALS/STRATEGIC PLANNING

3.1 What Are Goals?

According to Axel van Lamsweerde [9]:

> "a goal corresponds to an objective the system should achieve through the cooperation of agents in the software to be and in the environment".

Nowadays, a lot of organizations have diverse stakeholders who might be even around the globe. Those stakeholders suffer from some issues such as a difference in stakeholders' preferences and stakeholder's weights. Those stakeholders address the organization goals; Because of the hierarchy organizational structures for many originations the goals are different in each level. So the goals of different levels of abstraction can vary from high-level (strategic), down to low-level which the goals are related to time. As meaning; does the goals are suitable for all times or effected by the environments? In the sense explained; may be a goal is more important in the present time but in the future become less important [22].Where; The relations between goals and environments are diverse, such as laws, competition, diverse stakeholders, requirements constraints, and customer needs. Hence these different environments are related directly to the requirements that represent the base for any development. So if we need to achieve the goals correctly we must identify these requirements correctly too [23, 24].

3.2 The Requirement – Goal Role

Suppose that a project's goals are n goals, and the stakeholders are equally relative weight, then the organization project goals are divided into hierarchal levels as shown in Fig 3.

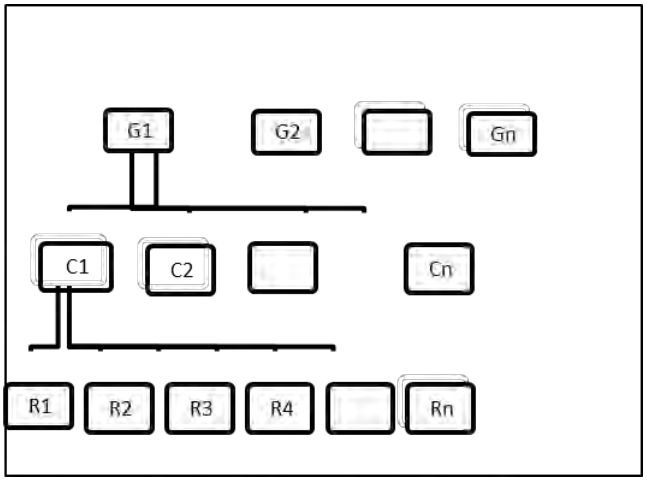

Figure 3. Hierarchal levels project.

Where,
G1, G2, G3… Gn are the project goals.
C1, C2, C3, C4… Cj are the criteria needed (attributes) for every goal.
R1, R2, R3, R4… Ri are the requirements for every criteria.
The goal weight is WG according to stakeholders, the criteria weight is WC according to goals and the requirement weight according to criteria is WR and WRG according to goals.

$$\text{WRG} = \frac{\sum_{x=1}^{n} WGx}{n} * \frac{\sum_{y=1}^{j} WCy}{j} * \frac{\sum_{z=1}^{i} WRz}{i} \quad (1)$$

3.3 The New Proposed RP Technique Based on Goals' Weights

The steps of the technique are as follows:

1- Assume that the stakeholder's weights are equal.

2- The stakeholder's determine the goals weights (G1, G2, G3, ..., Gn) according to our proposed scale from (0-9) as in Table 2, where

$$\sum_{z=1}^{n} G_z \neq 0$$

Table 2. (0-9) scale

Scale	Value
0	Not important at all
1	More less important
2	Less important
3	Low important
4	Low moderate important
5	Moderate important
6	High moderate important
7	High important
8	Very high important
9	Strategic important

3- For every goal the stakeholders assign the criteria weights (C1, C2, C3, …,Cj) using scale from (0-9) where

$$\sum_{z=1}^{n} C_z \neq 0$$

4- Design the Goals - criteria matrix according scale from (0:9) as follows:
Suppose X is the cross section between the row and the column so the Goals - criteria matrix design as follows:

$$\begin{array}{c} \\ C_1 \\ C_2 \\ : \\ C_j \end{array} \begin{array}{c} \begin{array}{cccc} G_1 & G_2 & .. & G_n \end{array} \\ \begin{pmatrix} x_{11} & x_{12} & .. & x_{1n} \\ x_{21} & x_{22} & .. & x_{2n} \\ : & : & : & : \\ x_{j1} & x_{j2} & .. & x_{jn} \end{pmatrix} \end{array}$$

5- For consolidation the criteria scales should be suitable for the comparison so we design a normalized decision matrix for criteria Cj according to every Goal Gn as the next normalization equation (1)

$$\text{Normalized matrix } (C\,G)_{jn} = \frac{C_j G_n}{\sqrt{\sum_{j=1}^{z} (C_j G_n)^2}}$$

for every G1,G2,..,Gn (2)

The result of the normalized matrix $(CG)_{jn}$ is the criteria weights according to the goals

6. Criteria weights = Cj weights * Gn weights for all values in the matrix

7. For every criteria calculate the arithmetic mean as equation (3)

$$C_j(\text{mean weight}) = \frac{\sum_{n=1}^{z} (Cj * G_n)}{z}$$

for C1, C2, ..., Cj (3)

8. The criteria weights according the goals = C_J (mean weight) Ranked.

9. Design the requirements - criteria matrix according scale from (0:9) as follows:

10.

$$\begin{array}{c} \\ R_1 \\ R_2 \\ : \\ R_I \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & .. & C_j \end{array} \\ \begin{pmatrix} x_{11} & x_{12} & .. & x_{1j} \\ x_{21} & x_{22} & .. & x_{2j} \\ : & : & : & : \\ x_{i1} & x_{i2} & .. & x_{ij} \end{pmatrix} \end{array}$$

11. Design a normalized decision matrix for requirements R_i according to every criteria C_j as the next normalization equation (4)

$$\text{Normalized matrix } (RC)_{ij} = \frac{R_i C_j}{\sqrt{\sum_{i=1}^{z} (R_i C_j)^2}}$$

for C1, C2, ..., Cj (4)

The result of the normalized matrix$(R\,C)_{ij}$ is the requirements weights according to the criteria

Requirements weights = R_i weights * C_j weights for all values in the matrix

12. For every requirement calculate the arithmetic mean as equation (5)

$$R_i(\text{mean weight}) = \frac{\sum_{j=1}^{n} R_i * C_j}{n}$$

for R1, R2, .. , Ri (5)

13. The requirements weights according the goals = R_i (mean weight) Ranked.

3.4 Example

Suppose a project has 3 goals one of these goals is buying an industrial machine with the following data:

Hint: For simplicity calculation we suppose the following relative goals and criteria weights but it is same as requirements weights calculation. This example only to explain how the algorithm is applied but in the future we will introduce a comparative study with respect to other techniques.

1- The relative goals G1= 0.4, G2=0.25, G3=0.35

2- The relative criteria and alternatives decision matrix

	C1=0.2 Style	**C2=0.35 Reliability**	**C3=0.3 Economy**	**C4=0.15 Low cost**
R1	7	9	9	8
R2	8	7	8	7
R3	9	6	8	9
R4	6	7	8	6

3- X^2_{ij} matrix

	C1=0.2 Style	**C2=0.35 Reliability**	**C3=0.3 Economy**	**C4=0.15 Low cost**
R1	49	81	81	64
R2	64	49	64	49
R3	81	36	64	81
R4	36	49	64	36

4- The normalized matrix according to equation 3:

	C1=0.2 Style	**C2=0.35 Reliability**	**C3=0.3 Economy**	**C4=0.15 Low cost**
R1	0.46	0.61	0.54	0.53
R2	0.53	0.48	0.48	0.46
R3	0.59	0.41	0.48	0.59
R4	0.40	0.48	0.48	0.40

5- The normalized decision matrix according the new relative criteria weight as follow:

$$C1 = G1 * C1 = 0.4 * 0.2 = 0.08$$
$$C2 = G1 * C2 = 0.4 * 0.35 = 0.14$$
$$C3 = G1 * C3 = 0.4 * 0.3 = 0.12$$
$$C4 = G1 * C4 = 0.4 * 0.15 = 0.06$$

6- The normalized decision matrix weights according the Ci

	C1=0.08 Style	**C2=0.14 Reliability**	**C3=0.12 Economy**	**C4=0.06 Low cost**
R1	0.46	0.61	0.54	0.53
R2	0.53	0.48	0.48	0.46
R3	0.59	0.41	0.48	0.59
R4	0.40	0.48	0.48	0.40

7- The requirements decision matrix weights = Ri * Cj

	C1=0.08 Style	**C2=0.14 Reliability**	**C3=0.12 Economy**	**C4=0.06 Low cost**
R1	0.0368	0.0854	0.0648	0.0318
R2	0.0424	0.0672	0.0576	0.0276
R3	0.0472	0.0574	0.0576	0.0354
R4	0.032	0.0672	0.0576	0.024

8- The arithmetic mean according to equation 1

R1= 0.0547
R2=0.0487
R3=0.0494
R4=0.0452

The final ranking related with the goals is R1 then R3 then R2 then R4

4. CONCLUSION AND FUTURE WORK

In this paper we gave an overview of a number of popular RP techniques available in the literature and their reported drawbacks. This was followed by giving an overview about goals, which is the basis of our new proposed technique. Then we presented our proposed new goal-based technique for RP, which is characterized by giving relative weights to requirements according to a project's goals, with a measuring scale that contains a zero weight to indicate unimportance for reaching more accurate results. In the future, we intend to continue working on enhancing our new goal-based RP technique to solve problems of uncertainty and data vagueness. In addition, further evaluation of the new technique will be done. We also intend to explore the dependency relations and the time effects for the stakeholder's preferences. The proposed technique needs for more researches to evaluate the accuracy, scalability and its reliability. Finally we need more research for analyzing the relationship between the goals completeness and the RP quality.

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Designing Low-Cost Technologies to Improve the Quality of Learning and Health Services in Future Egyptian Smart Cities – Three Case Studies

Shaimaa Lazem
City for Scientific Research
and Technology Applications
New Borg El-Arab City, Egypt
shlazem@acm.org

Asmaa Shoa'la
Faculty of Engineering
Alexandria University
Alexandria, Egypt
asmaashoala@gmail.com

Walaa M.Sheta
City for Scientific Research
and Technology Applications
New Borg El-Arab City, Egypt
wsheta@mucsat.sci.eg

Marwa Elteir
City for Scientific Research
and Technology Applications
New Borg El-Arab City, Egypt
maelteir@mucsat.sci.eg

ABSTRACT
The Smart City concept has been materialized incrementally since 2005, when the information systems were used to integrate the operation of urban infrastructure and services, such as buildings, electrical and water distribution, and public safety. Smart City concept goes a step further by focusing on the human capital and education as drivers of urban development. The paper classifies the working definitions of smart cities into three high-level categories representing three different visions for the role of the citizen in the Smart City. We additionally describe the output of two workshops carried out to design low-cost learning and health technologies. Lessons learned from the design of the proposed technologies are summarized.

Keywords
Smart City, Smart Technology, Smart Learning, Smart Health.

1. INTRODUCTION
The Smart City concept is a natural extension of the "information city". It has been materialized incrementally since 2005, when the information systems are used to integrate the operation of urban infrastructure and services, such as buildings, electrical and water distribution, and public safety. Smart City concept goes a step further by focusing on the human capital and education as drivers of urban, rather than singling out the role of Information and Communication Technologies (ICT) infrastructure. The concept of the Smart City has six main elements including: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance [1]. To take full advantage of ICT physical infrastructure in a Smart City, many complementary investments are required, including factors such as human capital and the provision of ubiquitous technologies with usable and reliable interfaces, which many development countries still lack. In this way, a Smart City becomes a complex environment, aimed at the welfare of its citizens.

Incorporating ICT into education and health in a Smart City has become an important issue in economically developed countries. However, the relatively low literacy in these countries represents a major barrier to provide effective Smart City services. Although global rates of illiteracy are decreasing, one in five adults still cannot read and write and many more do not possess the skills needed to receive e-service. In recognition of the impact of low literacy on Smart City, this paper is focusing on the development of low-cost user interfaces for people with low literacy skills.

Human-Computer Interaction (HCI) in the context of developing regions is often referred to as Human Computer Interaction for Development (HCID or HCI4D). HCI4D is an effort to design ICT to meet the unique needs of users in communities with limited resources and infrastructure [2]. As stated by Dodson et al. "HCID operates on the premise that poorly designed machines and poorly understood human behaviors can add, rather than alleviate, burdens on users in developing communities" [3]. Despite the economic agenda driving the adoption of the ICT in Egypt, little HCI4D research has been carried out on its use. Human-centered design [4] is needed to provide better understanding of the users' requirements in different national backgrounds and contexts. Computers and Internet are global technologies, but people work in national contexts, and react differently to the same action based on their culture.

In this paper, we focus on the design of human computer interface for Egyptian citizens with a special emphasis on the illiterates and low-literate citizens living in rural areas. The presented effort is part of a bigger framework that aims at addressing the cultural gap within the country itself. With more than 60% of Egypt's population lives in rural areas, the language barrier (Arabic contents and Arabic Domain Names), literacy rates, limited connectivity in addition to awareness, consist a strong barrier for development.

Working definitions for smart cities have been categorized into three high-level categories representing three different visions for the role of the citizen in the Smart City. We present three case studies for designing technologies that belong to the predominant category.

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The presented prototypes were developed in a series of winter and summer training workshops that were held in the City for Scientific Research and Technology Applications (SRTA-city), to teach undergraduate students about HCI [5] [6]. About 90 students were selected to participate in the workshops, based on their merits, from the Faculty of Engineering, Alexandria University, Egypt.

Students worked in teams to propose technological solutions for the challenges currently facing the Egyptian community. Challenges were described to them in relatively abstract forms (e.g., fighting adults' illiteracy using mobile phones). Students were given scientific publications for guidance.

The presented prototypes are the result of collaborative design effort between the first author and the students. The prototypes share the following main characteristics. They deal with the basic needs (e.g., learning and health) in the future Egyptian Smart City. They strike a balance between the cost of the technology, to facilitate its wide deployment, and quality user experience. The prototypes go beyond the traditional desktop interfaces. Moreover, a user research phase was conducted, including data gathering and analysis, so that students understand the needs of their users and appreciate the role of the context in shaping the technology design. Further research has been carried out to improve some of the prototypes.

The rest of the paper is organized as follows. In Section 2, Smart City definitions are reviewed and categorized. A low-cost physical interaction technology to motivate and engage junior students is proposed in Section 3. Section 4 proposes using interactive public displays for learning and health applications. We present an ambient system for taking patients' measurements in healthcare facilities in Section 5. Section 6 reflects on the design and development of the presented prototypes. We conclude the paper and outline our future work in Section 7.

2. SMART CITY DEFINITIONS

There's a lack of agreement upon a unique definition that can fit all the envisioned smart cities. About 100 definitions were proposed in the literature [7]. In this section, we review and categorize the definitions based on how they envision the citizens' role in the Smart City. We argue that the citizens' role informs the design and development of the technical systems deployed in the Smart City.

We reviewed the definitions listed in [7], and added more definitions from the literature that were not included. An initial sample of the definitions was examined and three high-level categories were defined (A, B, and C). The full definitions list was then coded by two independent raters. The percentage of agreement between the two coders is 79%. The inter-rater reliability coefficient (Cohen's Kappa) calculated with 95% confidence interval was 0.57 with standard error 8%, showing moderate agreement between the two coders according to [8]. Some of the reviewed definitions are summarized in Appendix A.

Table 1. Frequencies of occurrences for the three categories, where a full agreement exists between the two rates.

Category	# of Definitions
Category A	63
Category B	18
Category C	5

Category A - Citizen as a Service Recipient: In the first category, the city delivers efficient services to its inhabitants by adopting advanced infrastructure and smart computing technologies to optimize the city resources and provide quality of life. The city residents are the services' recipients. Category A can be seen as a baseline category, which includes most of the definitions.

"A city that monitors and integrates conditions of all of its critical infrastructures including roads, bridges, tunnels, rails, subways, airports, sea-ports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens." [9].

The Wi-Fi citizens' access network in Barcelona [10] is an example for Category A projects. It offers 250 free hotspots on public venues (in parks, museums, markets, public libraries, etc.); it accordingly increases the accessibility of e-services.

Category B - Citizen as a Participant: The unique feature that differentiates the second category is that it considers citizens as participants in the transformation of their city to a smart one.

"Amsterdam Smart City is a unique collaboration between the inhabitants of Amsterdam, businesses and governments in order to illustrate how energy can be saved, now and in the future" [11].

A good example for Category B applications is Barcelona's real time location-based information generated by citizens, who report problems like potholes and broken street lights or incidences [10]. Another example is the development of a tool for public urban planning. An online web-based application, "Model me", is used in Amsterdam, where the users/citizens post initiatives for development such as parking space sharing or the redevelopment of an office building [12].

Category C - Citizen's Empowerment: The third category views the citizens' development as the central focus of the Smart City. The key difference between categories A and C is that category A delivers services that fill the citizens' rudimentary needs (e.g., education, health, and economic development), while category C focuses on citizens' development beyond their basic wellness such as enhancing their innovation and creativity, improving their ability to learn, using technologies to prosper their lives, and strengthening their freedom of speech.

"A Smart City is a city that gives inspiration, shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish in their own lives. A smart city is an admired city, a vessel to intelligence, but ultimately an incubator of empowered spaces." [37].

In Barcelona, the Cibernàrium is a place that offers wide range of different activities with practical and innovative contents (from beginners to advanced training experts) to improve the citizens' professional profile. It works on keeping abreast of the latest technological solutions, acquiring IT skills, and learning how to use new technologies and internet tools [10].

In the following sections, we present three case studies for designing technologies belonging to category (A). The case studies aim at delivering quality low-cost learning and health

services that suits the high illiteracy ratio and the low-resources in the Egyptian community.

3. CASE STUDY I: INTERACTIVE MAT - USING PHYSICAL INTERACTION TO BOOST STUDENTS' ENGAGEMENT

According to the global competitiveness report issued recently by the World Economic Forum [14], Egypt is ranked 141 out of 144 countries with respect to the quality of primary education. Compared to 2012-2013 report, Egypt's rank has moved down by 47 places. Several reasons contribute to this severe reduction in the quality of primary education; including the high capacity of classes i.e., more than 100 students, untrained teachers, teaching methods that lack experimentation, defective curriculum, etc. One way to cope with this problem is to adopt ICT, which has proved its effectiveness in many countries [15]. Unfortunately, several challenges hinder the adoption of ICT in the public schools in Egypt. Among these challenges are the cost of delivering technology to each student, unavailable space in schools for deploying computer labs, and the lack of resident personnel with adequate computer skills.

Smart cities aim at promoting learning services. We thus propose establishing public learning spaces that host novel educational technologies and use edutainment to increase students' engagement and motivation. Such learning spaces can be set in schools and public spaces of the city. A key factor for the prevalence of such service is reducing its cost.

Edutainment is a known-concept [16] that aims at introducing the educational content to the students through games, which have the potential to transform the learning environment into enjoyable and engaging one. Using low-cost interfaces for edutainment applications was introduced in [16] and [17]. An information kiosk was designed to be fully contained behind a shop window. Street kids can access the computer using a technology that track their fingers on an inexpensive fabric externally mounted on the shop window.

Interactive Mat (IM) is a low-cost edutainment technology that uses an inexpensive webcam and low-cost paper to form an interactive playground. IM is designed to allow students to physically interact with educational games. We focus on the physical interaction as it contributes to students' physical as well as mental growth. There is a recent tendency to combine physical interaction and games as in Microsoft Kinect, EyeToy Play from Playstation2, and Nintendo Wii. The cost of these commercial systems is not adequate for wide-scale deployment in an over-populated country such as Egypt.

3.1 System Components

Figure 1 depicts a schematic diagram for the hardware components of the IM. The technology consists of a computer, a floor mat, and an inexpensive webcam. The floor mat represents the playground or the input space. It is structured as a nine-block grid (3×3) of low-cost thick paper. The camera is mounted on the ceiling so that its field of view encompasses the area covered by the mat. The student's position on the mat is tracked by the camera and mapped into one of the nine blocks. The played game is projected on the wall in front of the students.

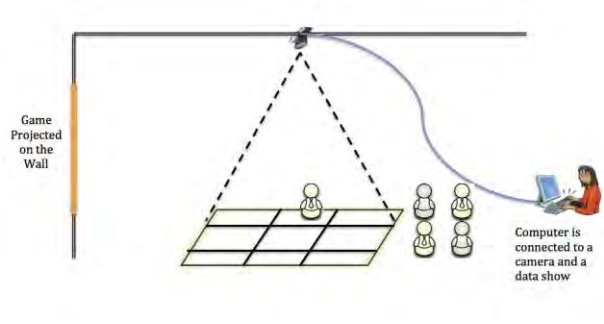

Figure 1. A schematic diagram for the Interactive Mat: the computer running the games is connected to a commodity camera for the position tracking, and a data show to project the game on the wall.

Interactive floors can be classified as sensor-based (e.g., [18], [19], and [20]) and vision-based floors. Vision-based interactive floors often use floor projection, where user interaction and display share the same physical space (e.g., [21] and [22]). The IM favored vision-based designs over sensor- based to avoid the damage that might happen to the sensor-based floors if left unsupervised to students. We did not choose floor projection technologies as it limits the display area for students during their play. Additionally, it requires the use of special materials on the floor, a set up that might be hard to achieve in the public schools without substantial cost.

The backend software is composed of the position tracking, the game server, and the database modules. The position tracking is implemented using an open source computer vision library i.e., Java CV. It tracks the position of the student on the mat and sends the corresponding block number to the game server. The game server is implemented using Java programming language. It handles the game logic and interface. The game sever is connected to a database server to store game questions, students' information and playing records.

3.2 Usage Scenarios

The IM could be used with several educational applications such as math and spelling games (Figure 2). The math game aims at improving the addition and multiplication skills of junior students. As shown in Figure 2 (top), the game main screen shows a question to the student with nine possible answers distributed on the nine blocks on the screen. The nine blocks are corresponding to the nine blocks of the floor mat. To answer the question, the student stands on the block corresponding to the right choice. The spelling game, Figure 2 (bottom), aims at increasing the Arabic spelling skills. The student is required to form a word that represents the picture shown to her/him. The student chooses the letters from the nine blocks shown on the screen by standing on the corresponding blocks of the floor mat.

The games were tested with children in pilot-scale experiments. The preliminary results indicated that children enjoyed the games and the competition to find the correct answers for the questions.

Figure 2. Games designed to operate using the Interactive Mat: a game to test students' math skills (top), and a game to test students' Arabic spelling skills (bottom)

3.3 Deployment on the Raspberry Pi

The initial versions of the game was developed using Java programming language and a commodity PC [5]. To further lower the cost, we explored deploying the arithmetic game on an ultra-low cost computer, the Raspberry Pi [23]. It is worth noting that the Raspberry Pi provides significant reduction in power usage and cooling costs i.e., few watts (<10) compared to 50 to 250 watts for PCs [24], which is important given the current electricity demand in Egypt. The direct porting of the game to the Raspberry Pi showed that the performance of the game in terms of the game startup time, latency, and smoothness of the interface suffers significantly. This was expected since the main processor in the Raspberry Pi is significantly less powerful i.e., ARM v6 architecture compared to the ones available in commodity PCs either from Intel or AMD.

We have carefully analyzed the performance of the game, the database and the tracking module to determine the main bottlenecks of the system and optimize their performance. Our experiments show that the game server and the position tracking are the main bottlenecks. The tracking module was implemented using JavaCV library, which uses JavaCPP as a wrapper to access the native OpenCV library, resulting in significant latency.

Our first optimization includes implementing the tracking module directly using C++ and OpenCV and running it as a separate process that communicates with the Java game through sockets. We have further optimized the performance of this component by using a smarter C++ compiler and forcing several ARM-aware optimization flags. Preliminary results show that using these optimizations, the latency of the tracking module becomes 168.6 msec/frame, which is accepted latency [25]. The other bottleneck is the game server. While the rendering performance falls within accepted range, 16 frame/sec, given the type of interaction in the game [26], the startup time and the latency of the game are very long i.e., 20.7 sec and 2.5 sec respectively.

For the startup time, we have realized that most of this time is spent in reading the images of the interface. By using appropriate image encoding and compression techniques, along with adopting a more optimized Java Virtual Machine, the startup time drops to 13 sec. For the latency of the game, we believe that most of this latency returns to the socket communication which we plan to optimize in our future work. Given the current status, we can conclude that we are able to deploy a working version from the proposed game on the Raspberry Pi.

We achieved this performance while utilizing only one of the available processors on the chip i.e., ARM CPU. The chip also includes a powerful graphics processing unit i.e., Video Core GPU which we did not utilize. Utilizing this GPU may open the door for deploying more compute-intensive applications, which we plan to investigate in the future work.

Although the main processor of the Raspberry Pi is an old generation of ARM i.e., ARM v6, our work shows that it is a capable device that using only one of its processing units can run a complex game composed of a computer vision component for position tracking, a game engine, and a database server. To implement them, experience in programming should be augmented by code optimization skills to efficiently utilize the resources of the target architecture.

4. CASE STUDY II: PUBLIC DISPLAY APPLICATIONS

Public displays are large-scale displays placed in public, semi-public, and private spaces like airports, schools, and homes [27]. The design of public display applications follows special guidelines that suit the context in which the technology is installed. For instance, simplicity of interaction with the technology, suitability for various populations, and permitting ad-hoc joining and leaving. In this section, we present two examples for using public displays to provide public learning and health services. We further discuss various techniques for interacting with public displays.

4.1 Using Public Displays and Mobile Phones to Improve Spelling Skills for Low-literate Adults

Reports from the Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS) indicate that the number of illiterates aged 10 years or more has exceeded 16 million in 2012 [28]. Illiteracy rate among youth aged 15 to 24 is 8.5%, and 62.3% of the adults aged 60 or more are illiterates. As for urban and rural areas, illiteracy rate among urban residents registered 17.7%, and 31% for rural residents. Measured by gender, illiteracy rate among females in rural areas is 40.4% compared to only 22.8% in urban areas, and 21.4% of males in rural areas are illiterates compared to 12.8% in urban areas.

These statistics establish the fact that elders, and rural area residents especially females will be likely excluded from technology-based services that requires basic reading and writing skills. A common example is illiterate requests help from strangers to use ATM machines for cash withdrawal or other services (e.g., charging her mobile phone). Such request violates the privacy of her personal information.

Despite the tremendous efforts in establishing anti-illiteracy classes, Egypt suffers from high illiteracy rates. Illiterate adults face many challenges that lead them to leave anti-illiteracy classes or do not go in the first place. They have limited free time due to their family responsibilities. Many of them, especially those with low socio-economic status, suffer from fatigue due to long working hours. There is a need to define the means by which ICT can fit into the context of illiterate adults' activities.

Mobile phones have high penetration rate in Egypt (119.69% as per May 2014 [29]). We thus explored using them to educate illiterate adults. We conducted in-depth interviews and observed several illiterates and low-literate adults from SRTA city to understand their usage of mobile devices.

Our interviews revealed that illiterates usually memorize the steps required for operating a certain function on the mobile rather than reading the menus. They often ask an educated friend or family member to store their important phone numbers on speed dial. Some of them add special characters (e.g., "****") as a prefix to the name to facilitate their search for it in the phone book. Moreover, they change their mobiles frequently as they usually buy used phones that have short lifetime. Furthermore, elder illiterates and low-literates strongly believe that their illiteracy prevents them from interacting with advanced technologies such as computers.

We proposed using interactive public displays to deploy learning applications for illiterate adults. Illiterates would use their mobile devices to interact with the displays, as we will further explain in Section 4.3. Public displays have an advantage over Interactive Voice Systems (IVR). This is due to the fact that information is visually represented. Public displays could be deployed where the information is actually needed by illiterate adults. The applications running on the display should be designed to be easily understood and operated.

An application was developed resembling a game that is used in traditional anti-illiteracy classes (Figure 3). The user has to select the characters that form a certain word displayed on the screen. The results from our pilot study were encouraging as the low-literate users enjoyed playing the game using a mobile phone. They indicated that the game was an excellent dictation exercise for them. We have also observed that playing the game in a shared manner created a subtle competitive learning environment that encouraged them to play.

4.2 Alternating Children's Diet Habits While Waiting at Pediatric Clinics

Egyptians are the fattest Africans and the 14th fattest country in the world with nearly 70% of its adult population and 15% of (school-age) children overweight or obese [30]. The prevalence of overweight in urban areas of Egypt was 45.3% and 39.6% among men and women, respectively, compared to 28% and 36.5% in rural areas, respectively [31]. We focus on using the mundane waiting time in public healthcare facilities to educate children about multiple nutrition and health issues in Egypt that affect their diet habits.

Interviews were conducted with 26 children and their parents in El-Shefa hospital located in Alexandria, Egypt. Interviewed children were between four and twelve years old. Figure 4 shows part of the children responses to the interview questions. The children were asked to choose the food they believe it's better for their health (top), and to choose healthy food among several food photos that are not necessarily familiar to them (bottom). Results demonstrated that not all children have sufficient knowledge about healthy food choices. Additionally, children favor food that tastes better over healthy food. (Results should be interpreted with caution since the sample was not large. We found, however, that the results were indicative given the obesity ratios mentioned above).

Figure 3. Game to improve adults' spelling skills

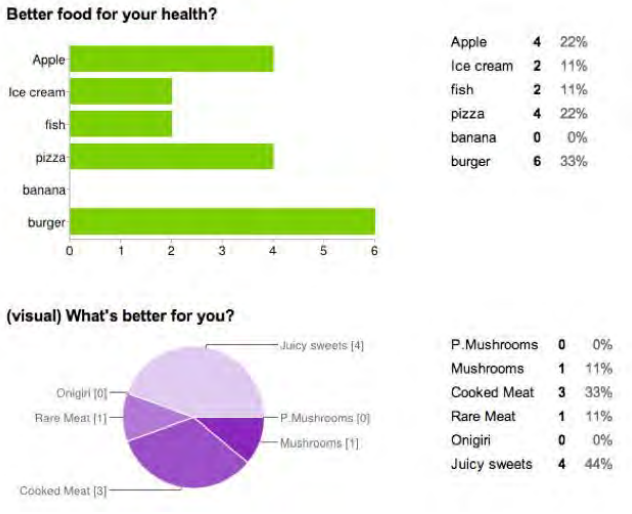

Figure 4. Children responses in a survey conducted to examine their understanding of healthy food

We further designed a multi-player game, “Food Avalanche”, that can be deployed on public displays in pediatric clinics. Public displays can be installed in the waiting rooms to present relevant health information and/ or health games. Children are thus engaged in a useful activity while waiting in the clinic. Figure 5 shows a snapshot from the Food Avalanche game. The game educates children about healthy food options. The child is presented with two choices; healthy and non-healthy food. Using trial and error and the mechanics of the game, the child learns what to avoid and what to pick.

4.3 Interaction with Public Displays

This section focuses on interaction with non-touch large displays. People interacting with public displays have different ages and literacy levels. Given the high illiteracy ration in Egypt, it is important to use a simple yet effective interaction technique so that illiterates benefit from the interaction with the displayed information.

Mobile phones can be used to access information on public displays using Dual Tone Multiple Frequency (DTMF) technique. Each button on the phone keypad has a unique tone. By connecting the phone to the computer running the public display application via audio connection, phone keypad tones can be interpreted by the application.

Figure 5. A snapshot from the Food Avalanche game

Alternatively, a special handheld device can be designed to replace the phone (Figure 6). The device consists of a microcontroller, a simple keypad with small number of buttons (could be phone-like), and a Bluetooth module for wireless communication with the display.

Additionally, interaction with public displays could be done using paid services. Services such as Twilio [32] allow for controlling public display applications from mobile phones using cloud communication, DTMF, and special API to communicate the signals to the applications.

Helping Band is a low-cost wearable bracelet-like device that aims at encouraging people (children, in particular) to interact with public displays. It could be used with the Food Avalanche game, for instance. The band rewards those who seek and provide help, when dealing with technology. Users who interact with the display wear the bands in their hands. Users perform the "fist-bump" gesture to indicate that they helped each other to deal with the information on the public display. The impact of the help is reflected on the public display by increasing the users' scores as a form of rewarding as shown in Figure 7.

The Helping band consists of simple components; an RF transceiver, a micro-controller (AVR), an Infra-Red (IR) Sensor, indication LEDs, and a battery. The public display is equipped with a Radio Frequency (RF) transceiver wireless module. Each band has a unique identification, it communicates with the public display through the RF wireless module. The module allows multi-point to point communication, where up to six users can interact with the public display at a time. When the two bands become close to each other (make the "fist-bump" gesture), the band identification numbers are sent to the public display.

Figure 6. A prototype for a handheld controller that uses Bluetooth to communicate with public displays.

Figure 7. Helping Band wearable device in use.

5. CASE STUDY III: AMBIENT TECHNOLOGY FOR WAITING ROOMS IN PUBLIC HEALTHCARE FACILITIES

Visiting public clinics and hospitals is an unpleasant experience for many Egyptians. In addition to the physical pain, they experience long waiting times (sometimes three-to-four hours in non-emergency cases) before receiving the service in a place that is usually crowded. Therefore, changing the psychology of Egyptians towards visiting healthcare centers has become a requirement for delivering quality healthcare services. Shortening the waiting time might be hard to achieve in some places due to the large crowd that is being served. Changing other environmental and procedural factors can significantly change the way patients perceive waiting time.

Mann [33] introduced several propositions concerning the psychology of waiting. He suggested that people experience the fear of “being forgotten” and thus their “anxiety” level is much higher while waiting to be served than it is while being served, even when the latter is longer. Therefore, waiting time could be perceived shorter by providing a fast immediate service to the patient when entering the waiting room. Health Mirror is a prototype for an ambient technology that is designed to be embedded in the hospital physical environment to satisfy the patient's sense of being welcomed. X-Stress is another embedded device that could be used in dental clinics.

As defined by Mankoff et al. “Ambient displays are aesthetically pleasing displays of information which sit on the periphery of a user's attention. They generally support monitoring of non-critical information.”... “Ambient displays have the ambitious goal of presenting information without distracting or burdening the user.” [34].

5.1 Health Mirror

The Health Mirror, (Figure 8), is a mirror designed to be installed as a part of the decoration of the entrance of the waiting room. Markers on the floor guide the patient to stand in front of the mirror. When the patient stands in a previously marked spot, the system measures the patient's height and weight. The patient is then encouraged to play a one-button game for 15 seconds using a button installed next to the mirror. The heart rate measuring sensor planted in the button will measure the heart rate while the patient plays the game. Having the three measurements, the system will display them on the mirror.

Patient's height is measured using a webcam, and a simple image processing method (e.g., background extraction). When the system is set, a picture of the surrounding place is taken as a reference background. When a patient enters the field of view of the camera and stands on the reference point on the floor, a change in the background occurs. The background change is proportional to the height of the patient. Using simple calculations, the system obtains the patient's height.

Weight measurement is done by converting the output from a load cell planted in the floor into a measurable electrical output. Analog-to-digital converter and filter modules are used to filter the noise in the signal. Using an Arduino micro-controller, the system maps the voltage difference provided by the load cell into the actual weight in Kilograms.

Figure 8. A prototype for the Health Mirror system. The patient sees her height, and weight information presented on the semi-transparent mirror. She could check her heart rate by putting her thumb on a button attached to the mirror.

The system measures the heart rate from the patient's fingertip (thumb) using two IR LEDs. One is used as a transmitter (IR diode) and the other is used as a detector (photodiode). The blood flow is used to track the heart beats of the patient. When the patient puts his/her fingertip on the sensor, the detector LED detects signal changes according to the blood flow in the finger. The output voltage of the detector can be either high or low according the flow of the blood through the body. The system amplifies the output voltage and sends the amplified signal to a microcontroller that converts this voltage into pulses and calculates the number of pulses per minute and the patient's heart rate, accordingly.

5.2 X-Stress: Stay Calm in Dental Clinics

X-stress is a device that could be used in the waiting rooms of dental clinics to let the patients' know their stress level and help them to stay comfortable. Picard and Scheirer designed a glove, "galvactivator", which measures the stress based on skin conductance and uses LEDs' intensity to indicate the stress level of the person wearing the glove [35]. X-Stress uses a similar technique for stress measurement. It additionally responds to the stress by providing palm massage for stressed patients. X-Stress is designed to be embedded in the arm of a chair as shown in Figure 9. It has the form of computer mouse with two electrodes placed in the right and left buttons to measure the skin conductance. The stress meter is an array of red, yellow, and green LEDs that indicate the patient's stress level. A vibrator motor performs soft palm massage for stressed patients.

Figure 9. X-Stress: the prototype is installed on the chair-like arm to monitor the patient's stress and provide palm massage.

6. DISCUSSION

We argue that Smart City applications in developing countries should be more inclusive for vulnerable users such as illiterates, and elders to reduce the digital divide in the city. Additionally, applications should leverage the high penetration of mobile devices and be-aware of their usage patterns. Interaction beyond the desktop is yet to be fully explored.

Some of the presented technologies in this paper (e.g., the components of the Health Mirror system) are not novel by themselves. The novelty, we argue, lies in fostering an interdisciplinary approach that integrates such technologies with the knowledge about the psychology of waiting in order to improve the quality of waiting experience in healthcare facilities.

Software development companies should be more open to learn about their target users in order to provide quality user experience. We adopted a user-centered approach to understand our potential users (e.g., low-literates and children) and the context of their activities (e.g., hospitals). We further used this knowledge to inform our designs. Coming from strict engineering background, students first resisted the user research part and even called it the "non-technical" part of the workshops. Their perspective about end-users, at least for some of them, has changed upon the workshops completion as expressed in their feedback.

"We had small private meetings with you [by you he means the first author] *each day, and you played the user role, for giving us feedback to our day-by-day work, by the end of the training we took that role. We imagined ourselves as the users, and it helped us produce better results."*

"...I thought that the challenging task was simply the final product ... and although this is crucial, it's definitely not everything .... this became evident when we did our fields inspections and surveys ... where we realize how anything to distract our Chemotherapy patient was absolutely essential .... so I must admit this caused a paradigm shift in me ,,, and I admit I started looking at the material covered in the lectures differently."

"...so we had to ease the transition between the usual way that people know and are familiar with, and the new way after introducing technology to the equation. if that transition isn't on a certain level of simplicity then this technology will be a huge failure, and people will be rushing back to the old-fashioned way."

7. CONCLUSIONS AND FUTURE WORK

A Smart City focuses on improving the quality of life for city residents in parallel to the development of the city physical and digital infrastructure. Working definitions of smart cities have been analyzed and categorized into three high-level categories. The categories represent three different visions for the role of the citizen in the Smart City; citizen as a service recipient (Category A), citizen as a participant (Category B), and the empowered citizen (Category C).

A number of low-cost technologies and their associated applications were introduced to improve the public learning and health services. The technologies serve the predominant category (A).

The presented prototypes were informally evaluated by the workshops' attendees. Mature versions from the children (Section 3) and adults' technologies (Section 4.1) were reviewed by a small sample of their target users. We plan to evaluate the presented technologies using rigorous experimentation techniques. We explore designing technologies and applications that suit categories B and C.

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APPENDIX
A. SMART CITY DEFINITIONS

Table 2: Sample of Smart City definitions listed in chronological order.

Definition	Ref.	Date	Category
"Smart City is referred as the safe, secure environmentally green, and efficient urban center of the future with advanced infrastructures such as sensors, electronics and networks to stimulate sustainable economic growth & a high quality of life."	[9]	2000	A
"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens."	[9]	2000	A
"A city whose community has learned to learn, adapt and innovate. People need to be able to use the technology in order to benefit from it."	[36]	2001	C
"A city where the ICT strengthen the freedom of the speech and the accessibility to public information and services."	[37]	2004	C
"...are territories with a high capacity for learning and innovation, which is built - in to the creativity of their population, their institutions of knowledge creation and their digital infrastructure for communication. .... [and are concerned] with people and the human capital side of the equation, rather than blindly believing that IT itself can automatically transform and improve cities."	[38]	2006	C
"A city well performing in a forward-looking way in economy, people, governance, mobility, environment & living, built on the smart combination of endowments and activities of self-decisive independent and aware citizens."	[39]	2007	B
"A Smart City is a city that gives inspiration, shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish in their own lives. A smart city is an admired city, a vessel to intelligence, but ultimately an incubator of empowered spaces."	[13]	2008	C
"Amsterdam Smart City is a unique collaboration between the inhabitants of Amsterdam, businesses and governments in order to illustrate how energy can be saved, now and in the future."	[11]	2010	B
"A city combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and livability."	[40]	2010	A
"A city connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city."	[41]	2010	B
"An urban area functioning and articulated by modern information and communication technologies in its various verticals, providing ongoing efficient services to its population."	[42]	2010	A
"The use of Smart Computing technologies to make the critical infrastructure components and services of a city - which include city administration, education, healthcare, public safety, real estate, transportation, and utilities - more intelligent, interconnected, and efficient."	[43]	2010	A
"Smart city" [refers to] a local entity - a district, city, region or small country - which takes a holistic approach to employ information technologies with real-time analysis that encourages sustainable economic development."	[44]	2011	A

"A city can be defined as "smart" when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."	[45]	2011	B
"A city that reflects a particular idea of local community, one where city governments, enterprises and residents use ICTs to reinvent and reinforce the community's role in the new service economy, create jobs locally and improve the quality of community life."	[46]	2014	B

SALE – An Innovative Platform for Semantically Enriching Next Generation Advertising Services

Haitham S. Hamza, Enas Ashraf, Azza K. Nabih, Mahmoud M. Abdallah, Ahmed M. Gamaleldin
SECC-ITIDA, MCIT
Giza, Egypt
{hhamza, inas, azkamal, mmabdallah, agamal}@itida.gov.eg

Shourok Alaa, Kamilia Hosny, Aya Khattab, Ahmed Attallah
ANSR Lab, Cairo University
Giza, Egypt
{salaa, khosny, akhattab, aattallah}@ansr.cu.edu.eg

ABSTRACT
The rapid expansion of wireless technologies has provided an ecosystem to support intelligent solutions in the domain of advertising. Allowing contextual information to be used creates opportunities to reach individuals and thereby increases the relevance of the delivered message. A major challenge for ubiquitous advertising is to match advertisements with consumer's profile, preferences, and context information. As a result, innovative solutions and emerging technologies such as Semantic Web and Service Oriented Architecture (SOA) become of great importance to address this issue. In this paper, we propose a Smart-M3 based platform called SALE (Semantic Advertising Platform for Egypt). The proposed platform provides an extendible easy to use approach to create semantic context-aware advertising services and applications. This is achieved through deploying semantic technologies to link users and advertising entities anonymously and to promote extendibility for context, preference and advertisement domains information. Using Service Oriented Architecture (SOA), SALE allows large number of end- user applications to be integrated and others to be built independent of the target platform that therefore will no longer need to support proprietary, large footprint middleware. The detailed architecture of SALE as well as a discussion on how SALE addresses ubiquitous advertising challenges is discussed throughout this paper.

Keywords
Ubiquitous advertising; SOA; Semantic middleware; Smart-M3; Ontology; Security; Interoperability; Extendibility.

1. INTRODUCTION
The ongoing evolution of services conducted over the Internet lead to the hype in the advertising business as an enabler for next generation personalized services [1]. The currently emerging ubiquitous computing environment caused humans to be "connected" most of the time to cope with the digital community they are part of either for business or entertainment purposes. This made it easier to reach everyone, everywhere and anyhow leading to flooding users with irrelevant information and notifications causing the user to lose interest of the received information. A thing that will consequently affect the whole advertising business [2]. This was a trigger to re-think the advertising business taking advantage of the technological advances and users' willingness to provide more information about themselves in return for personalized services that only matches their interests and needs as long as the security and privacy issues are efficiently handled.

Pervasive technologies provide a chance to come up with innovative solutions making use of user's preferences to design customized advertising campaigns of the user's interest [3]. Taking personalization into account and user's continuous mobility, the need for context-aware advertisement applications emerges. It becomes important to combine the context and profile information to provide users with interesting advertising experience serving their specific purposes through which they can control even which brand to send them [1]. User contextual information can be location, time, weather, or his physical and health conditions.

In order to match user context, profile and preferences with the advertisement, each should be modeled in a way that permits design of applications and personalized services seamlessly across various platforms. Here comes the role of Semantic Web. Semantic Web[4][5][6][7] is an extension of the current web not a replacement. It intends to make the data on the web machine understandable leading to the ability of machines to process the data automatically as well as to infer new data. Using Semantic Web technologies it becomes feasible to create a standardized formal description of a domain by capturing the domain knowledge in an Ontology. Ontologies help in creating a common understanding for a domain so that different independent applications can interoperate using the same vocabulary.

In this paper we present an architectural approach and a prototype implementation of a platform that enables the development of personalized advertising solutions across different platforms. Semantic Advertisement Platform for Egypt (SALE) is an innovative platform to handle the end-to-end delivery of advertisements introducing an easy to use approach to customize and build context-aware mobile advertising applications for advertisers as well end-users with reduced time-to-market [8] .

The proposed platform makes use of Smart-M3 interoperability platform [9][10][11] as the core semantic middleware. For extendibility and interoperability purposes, SALE deploys a SOA-semantic integration architecture as discussed in [12] (will be elaborated later).

To understand the architecture of SALE and how it addresses number of ubiquitous advertising challenges, more details need to be introduced and this is how the rest of this paper is organized.

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Section 2 summarizes the ubiquitous advertising challenges and the related work for solving them. Section 3 presents SALE generic architecture whereas SALE detailed features and usage scenario is presented in section 4. Sections 5, 6, and 7 elaborate SALE semantic core, SALE services interface, and SALE security layer respectively. Section 8 discusses how ubiquitous advertising challenges can be addressed using SALE as well as the proposed future work to enhance SALE performance and extend its features. The paper closes with a conclusion in section 9.

2. CHALLENGES AND RELATED WORK

2.1 Ubiquitous Advertising Challenges

Advertising in pervasive computing environments has gained increased importance over traditional online web advertising. This is because of the increased level of personalization and intimacy that these kinds of environments offer to the user [13] making it possible to deliver relevant advertisements in a more convenient manner. However, advertising in such environments faces lots of challenges. Seven common challenges were outlined by Ranganathan and Campbell [13]: (1) reaching the right people with the right ads, (2) delivering ads at the right time, (3) delivering ads in the best way, (4) serendipitous advertising, (5) providing a means for users to follow up on the ad, (6) collecting the ads revenues and (7) privacy and security. Four more challenges were added by Eriksson and Akesson [18]: (1) dynamic data exploitation, (2) advertising adjustment to user behavior and preferences, (3) context adaptation and (4) user-advertiser relationship.

As a result, it becomes necessary to develop an architectural solution to address these challenges across different technologies and platforms in a way that can be easily extended with new context, preference, and advertisement domains information. We can summarize that the aimed solution needs to fulfill some main requirements of being context-aware, user-preference aware, device independent, secure, extendible and is able to interoperate with various end-user applications.

In the following section, we will discuss the related work and some of the proposed solutions. As will be illustrated, most of the solutions are not offering the full set of requirements integrated into the same architecture. We claim that SALE is an integrated solution that offers context and user preference awareness, device independence and application interoperability thanks to deploying SOA concepts, extendibility thanks to using Semantic Web and ontologies to model context and advertisement data and finally security via authorization and authentication.

2.2 Related Work

A generic enabler framework for contextualized advertising is proposed in [1]. This is a generic abstract study aiming at providing a draft of the suggested layered architecture and its main components such as content and session management, social/reality mining and context component together with the advertising main logic component.

An agent-based framework for personalized advertising on mobile devices is presented in [2]. The framework is implemented using two types of agents namely; client and server agents. The client agent is owned by the user and runs on Android devices. The proposed solution employs Semantic Web technologies using a common ontology package shared between the client and the server agents. The ontology models each domain and it is used to create customized dynamic screens using Java reflection. The entered data is then sent to the server to fetch the appropriate ads. Advertisers' data and rules are stored in files that feed the knowledge base. A regular check is done to automatically update the knowledge base with any updates in the files such as adding new advertisers or even changing current advertiser rules. In this work, user context information is not a factor in the operation of ads filtering and matching.

A mobile commerce framework is proposed in [14]. The framework defines a set of functional layers that helps the designers and developers to effectively implement new m-commerce applications. The framework allows demographic information to be collected by the wireless network providers and the location information to be provided by the mobile service providers. Ads can be delivered via SMS or short paging messages. This solution however lacks filtering ads based on user interest and getting user feedback about the delivered ads and thus offer limited user-advertiser relationship. Moreover, the location information provider is not an integral part of the proposed framework and will require integration with a third party services to deliver location based ads.

A scalable context discovery platform is proposed in [15] as a key building block for mobile based services. The solution employs semantic technologies using context advertisement ontology. The architecture main block is the context gateway through which users advertise their context information. The context gateway is composed of two layers; the knowledge management layer that is responsible for message processing and semantic evaluation of the received data. The received data is saved in a semantic advertising database upon which the semantic matching handler performs the required queries. The second layer is network management layer that is responsible for routing the message either to the current knowledge manager or to a neighboring context gateway using a semantic routing handler.

Another SOA based architecture is proposed in [16]. The architecture is based on context-aware triggering system that enables device independent advertising services based on user preferences. The main building blocks of this solution are the service enabler, advertising enabler, session enabler, content enabler and context enabler. All enablers interact with the advertising enabler via a service broker. The content provided can be tagged by the advertiser with metadata, semantics and ontologies. However, semantic matching, reasoning and filtering are not integral parts of the architecture and thus limiting easy extendibility.

Our work aims at providing a way for enhanced effectiveness of ubiquitous advertising addressing the three main challenges pointed out by Leppäniemi et al. "*reach the right people with relevant content when it matters most to them*" [17]. Moreover, we aim at building an extendible and customizable platform that can be used for different advertising services in various domains. For this reason a semantic context-aware platform is built integrating most of the standalone concepts features discussed in this section and providing an integrated solution fulfilling the main requirements for ubiquitous advertising. The same SOA-semantic integration approach discussed in [12] is adopted for the sake of extendibility and interoperability but this time without the need for an Enterprise Service Bus (ESB). Given the fact of the constrained resources of devices used in ubiquitous advertising, Representational State Transfer (REST) services are used to implement the functionalities on mobile based clients due to its light weight and minimal network overhead.

Unlike [2], in our proposed architecture, the knowledge is represented semantically through RDF triples using a pre-defined ontology. The triples are then inserted into the knowledge base on

the fly with no need for intermediate storage and processing. Adopting Smart-M3 architecture and the subscription technique, automatic notifications are sent from the knowledge base for updated data and hence no need for regular checking to update the knowledge base.

Unlike [14], SALE performs semantic filtering and matching on context data as well as user preference data using pre-defined ontologies that can be extended for various context and preference information and various advertising domains. Moreover, SALE offers the user the ability to rate or block certain advertisers and hence maintain user-advertiser relationship

The following sections will detail SALE architecture and how SALE addresses the ubiquitous advertising challenges.

3. SALE GENERIC ARCHITECTURE

SALE aims at introducing a platform that is flexible enough to be used with wide range of scenarios and advertising applications across various end-user platforms. For this purpose, interoperability and extendibility are key features that need to be implemented. To achieve this, the SOA-semantic integration approach discussed in [12] is adopted. SALE generic architecture is depicted in Figure 1.

The semantic layer is implemented using Smart-M3 interoperability platform. Smart-M3 is an open source architecture that consists of two main components: semantic information broker (SIB) and a set of knowledge processors (KPs). SIB is the main storage for saving the application data semantically in RDF format according to a number of ontologies defined to model the advertising business domain as well as user profile, context and preferences (the details of system ontologies will be elaborated later in this paper). All the scenarios are then implemented through set of KPs that interact with the SIB to insert, update, or remove data. Finally, the smart application can provide an interface to its end-users through web or mobile applications that use a set of exposed services (REST services in case of SALE) to build meaningful and rich scenarios. The current implementations of Smart-M3 do not natively support security issues like message encoding and access control. This is why a security manager is added to raise the level of security while using un-secured SIBs. Extension points for quality of service blocks are provided but not yet implemented in SALE current version.

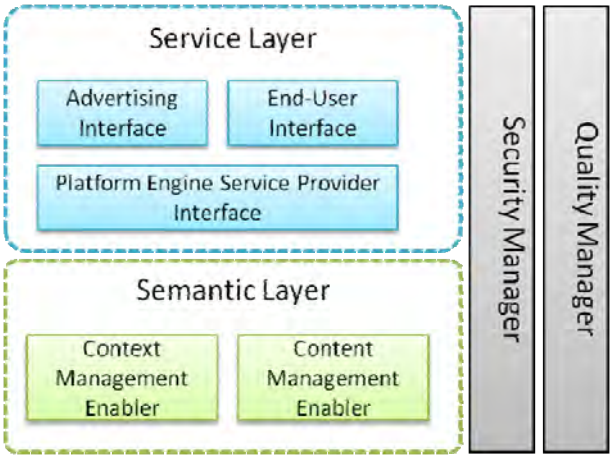

Figure 1 - SALE Generic Layered Architecture.

4. SALE FEATURES AND USAGE SCENARIO

This section illustrates SALE features through demonstrating one of SALE usage scenarios. SALE provides the opportunity to develop innovative location-based advertising applications in two modes; push mode and pull mode. Advertisers registered to the system are expected to build advertising campaigns, using a developed web portal in this example scenario, through which they select the publisher, advertisement details such as media, validity duration, advertising channel (mobile, web, etc.) and target segment to which the campaign is meant to be delivered.

In the current version of SALE, location and time are used as the consumer's context information. Application on consumer's device, Android application in this scenario, is expected to periodically update SALE with the current location of the user. In case of the push mode depicted in Figure 2, semantic matching between user's context, preferences, and advertisements is performed every time a context update is received. While in pull mode depicted in Figure 3, user can request offers for a certain purpose using free text search. Once the request is received, SALE matches the search text semantically to one of the advertiser's business domains using dictionary ontology and then makes use of Google places service to find nearby advertisers and match their offers to the user's request. We argue that these features address at least three of the discussed challenges [17]: (1) reach the ***right people***, (2) with ***relevant content***, (3) ***when it matters most*** to them. We add to this the reduced time to create and dispatch advertisement campaigns using various applications that can be built on top of SALE and the wider spectrum of users who can be addressed via various channels.

Moreover, SALE provides consumers with the option to block specific advertisers whose services are not liked by users though they lie within their interest domain. Such feature can be considered as a start to maintain user-advertiser relationship challenge addressed in [18].

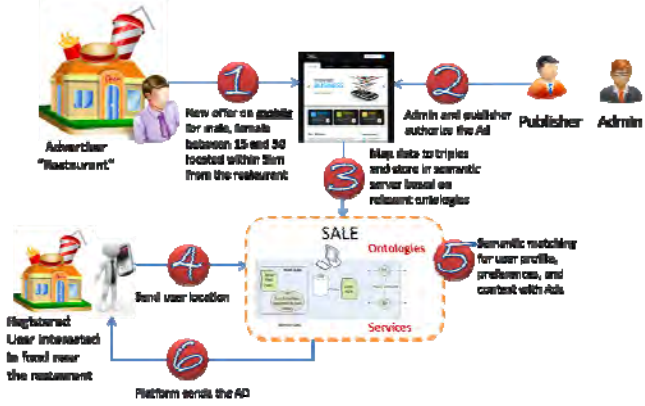

Figure 2 - SALE Usage Scenario - Push Mode

Figure 3 - SALE Usage Scenario - Pull Mode

Following are the main features exposed to application developers:

1. Profile management for advertisers and end-users. This includes services such as registration and account management.
2. Automatic context update to automatically update user context upon which ads will be delivered.
3. Advertisement management to handle creating, editing, deleting ads. Ads info is associated with the context to trigger advertisement broadcast.
4. Content storage and lookup to manage storing and fetching content and metadata.
5. Security services including (1) authentication to handle user login and protected data and (2) authorization to provide the user with the ability to rate or block advertisements from certain sources as well as manage advertisement broadcasting based on user authorization preferences.
6. Quality of Service to provide metrics collection and analysis.

These features are realized through the layered architecture depicted in Figure 1. The semantic core implements all SALE functionalities using Smart-M3 architecture. We consider the typical system architecture that consists of the SIB as the core storage for the environment information, set of KPs that interact with the SIB and cooperate to achieve the required application scenarios, and set of REST services that are exposed to end-user mobile or web applications. Since Smart-M3 architecture does not natively support security issues like message encoding and access control, we propose mechanisms as workarounds to raise the level of security in Smart-M3 based systems. The following sections elaborate the three main layers that implement SALE core functionalities.

5. SEMANTIC CORE AND KNOWLEDGE MANAGEMENT

SALE semantic core implements the basic functionalities offered by the platform. Ontologies play a major role in supporting information exchange within SALE. In order to model the ubiquitous advertising business domain, we introduce three ontologies to model (1) SALE actors' profiles and preferences, (2) advertisement data and (3) dictionary ontology that will be used to build synonyms knowledge graph on runtime. This section elaborates the details of each ontology, the composition and distribution of KPs and the knowledge flow between different components within SALE semantic core.

5.1 Advertisement Ontology

Modeling the advertisement with extendibility in mind is one of main goals of SALE as a generic platform. Given the large number of service providers and wide spectrum of business domains, it is important to make sure that the developed ontology can be extended with the specific details of the advertiser's business domain. Figure 4 illustrates the ontological definition of the advertisement. The advertisement data includes:

- Textual description for the advertisement
- Status whether it is ready, expired, or blocked. The advertisement passes two authorization stages; by the publisher and the system administrator. The publisher can authorize the advertisement or not based on the selected channels, advertiser's billing status, media content among other reasons. While the system administrator decision is based on technical reasons
- Offer concept, illustrated in Figure 5, is related to further details such as its type that defines whether it is a special offer or discount, validity, and offered item details including its type whether it is a product or service as well as its price
- Advertiser, publisher and media creator as defined in the profile ontology
- Target segment defining the audience for the advertisement campaign and their target context as illustrated in Figure 6
- Advertisement media defines media link and specs, the targeted channel, and the media status; whether it is ready to be sent, or is blocked

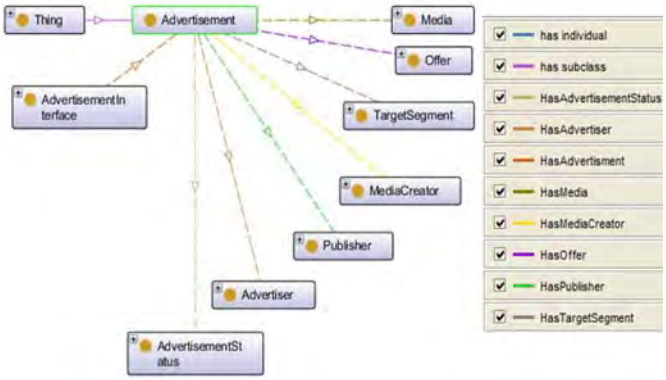

Figure 4 - The Ontological Definition for the Advertisement

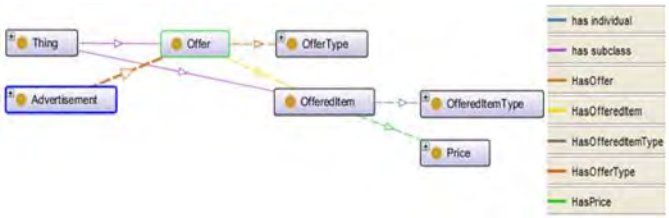

Figure 5 - Concepts Related to the Offer and the Offered Item

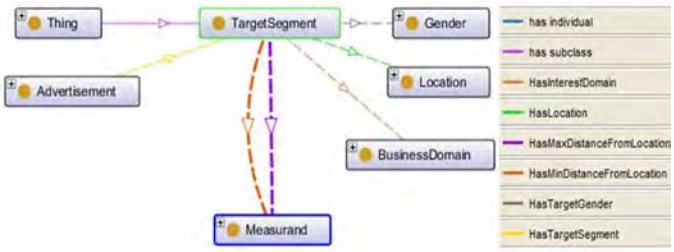

Figure 6 - Concepts Related to the Target Segment

5.2 Profile Ontology

The profile ontology models SALE main actors namely; end-user, advertiser, publisher, and media creator. The main classes of the profile ontology are the company and the person; company class defines advertisers, publishers, or media creators, while person class defines users. The company has identification data, friendly data (human readable name), contact data, and preferences (interest/business domains) as shown in Figure 7. The

person has identification data, friendly data, demographic data, contact data, context data, and preferences as shown in Figure 8.

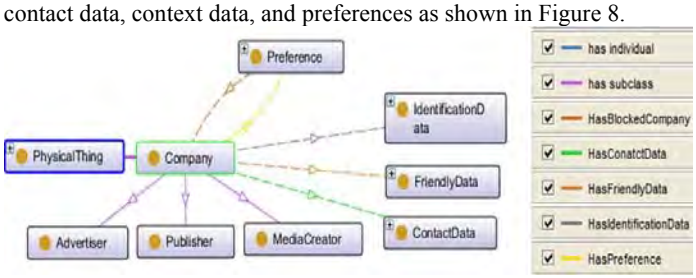

Figure 7 - Concepts Related to Company

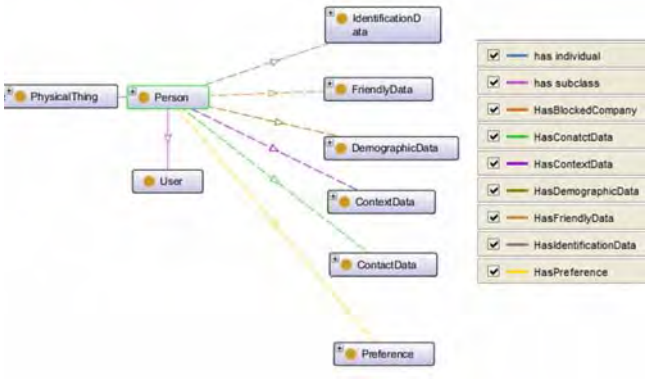

Figure 8 - Concepts Related to Person

5.3 Dictionary Ontology

Dictionary ontology is intended to be used to define the related words for each of the platform interest domains words. This is defined to serve the user's free text search for ads in the pull mode of operation of the system. As illustrated in Figure 9, this simple ontology consists of classes to define each word in the platform interest domain and tie it to related words which may give the same meaning. This ontology is used to create the synonyms knowledge RDF graph on runtime via linking to external web services. The dictionary ontology is designed as a proof of concept. It can be easily extended or replaced by other standard ontologies such as SKOS for more rich taxonomies.

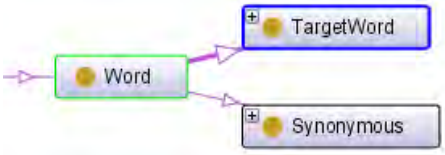

Figure 9 - Dictionary Ontology Classes

5.4 KP Design and Knowledge Flow

The design of KPs and knowledge flow mechanism plays an important role to promote system interoperability and extendibility [12]. It is crucial to keep the modularity and de-coupling of information producers and consumers in mind in order to further promote extendibility. Figure 10 illustrates the main components that build SALE functionality as well as the knowledge flow between different components. KPs are classified into producer, consumer, and aggregator. Producer KPs provide information to the SIB, consumer KPs only query information from the SIB and takes actions accordingly while aggregator KPs performs both actions.

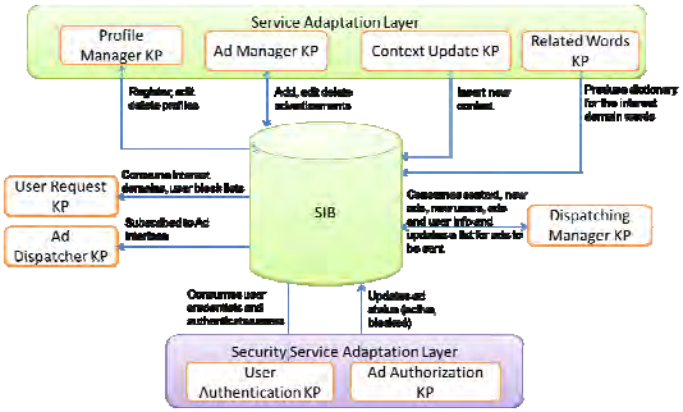

Figure 10 - Knowledge Flow and Component Interaction

1. *Profile Manager KP:* Aggregator KP responsible for registering new users, advertisers, publishers as well as editing and deleting profiles.
2. *Ad manager KP:* Aggregator KP responsible for adding, editing and deleting advertisement campaigns.
3. *Context Update KP*: Producer KP responsible for updating user context.
4. *Related Words KP*: Producer KP responsible for adding the dictionary of the platform interest domain words.
5. *Dispatching Manager KP*: Aggregator KP subscribed to context update, insertion of new user or advertisement. This KP is responsible for matching user profile and preferences, block list, context with advertisement information and accordingly updating a list of advertisements to be sent in the ad interface list that contains the advertisements and target user.
6. *User Request KP*: Consumer KP responsible for semantically matching user's request in SALE pull mode of operation.
7. *Ad Dispatcher KP*: Consumer KP that is subscribed to the advertisement interface. When a new ad is added to the interface, the KP sends the advertisement based on the required channel and removes the advertisement from the interface. This should include several dispatchers based on the channel; mobile, web, etc. It is expected to have listeners on the end-user side to receive the advertisements.
8. *User Authentication KP:* Consumer KP that checks users' credentials and authenticates access.
9. *Ad Authorization KP:* Producer KP that takes decision from publisher to activate or block certain advertisement. This can be extended later to be aggregator to consume the decision making parameters and automatically performs the authorization actions.

Different KP's are using Redland RDF storage for storing semantically formatted data.

6. SERVICES LAYER

SALE services interface implements a set of offered functionalities for application developers. These services were designed to be autonomous and loosely-coupled. In addition, the grouping of services into functional layers, illustrated in Table 1, makes it easy to maintain and change the services without worrying about the impact of this change on other layers.

Table 1 - Service Functional Layer Design

Service category	Service
Profile Management	addUserService
	unsubscribeUserService
	modifyUserDataService
	submitUserPereferencesService
	loginService
	setRegistrationIdService
Context Management	updateLocationService
Ads management	getInterestDomainsService
	viewActiveAdsService
Security management	getBlockListService
	blockAdvertiserService
	unBlockAdvertiserService

The reason we chose REST services is that it is a reduced subset of the usual web service stack. On a technical level, web services can be implemented on mobile devices. These devices are constrained with network bandwidth, memory and power. There is an overhead of headers and additional layers of SOAP elements on the XML payload. Therefore using a SOAP web services client in contrast to using RESTful web services client on mobile devices is more costly for the developer and the user.

7. SALE SECURITY LAYER

Security is a key issue in smart applications; systems should guarantee preserving user privacy and it should not allow any unauthorized entities to get access to any user or system information. Having the SIB as the main repository for all information, it is important to secure SIBs and secure all communications coming in and out of the SIB. Not all SIB implementations have built-in security features as the technology is relatively new and is still under continuous development. It is important to have workarounds to raise the level of security while using unsecured SIBs. As summarized in Figure 11, some of these workarounds are to be applied to the server side of the application while the others target the client side [19].

The following mechanisms are introduced as workarounds to raise the level of security in Smart-M3 based systems:

- SIB access restrictions through enabling firewall
- Securing the communication channels between the SIB and the applications through using HTTPS protocol to interface to the web applications and REST services
- Certifying the Android based clients
- Encrypting user credentials, and applying user authentication and authorization polices to properly access system information and services.

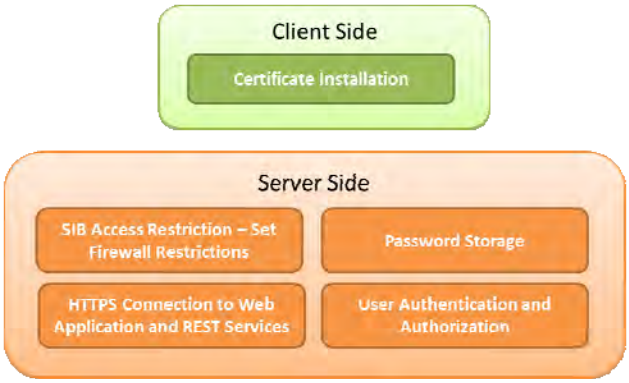

Figure 11 - Proposed Security Workarounds for Smart-M3 Application

8. DISCUSSION

8.1 Addressing Ubiquitous Advertising Challenges using SALE

This section discusses how the proposed platform addresses number of the common challenges facing ubiquitous advertising business via scanning over SALE features vs. the challenge we claim to address given that challenges related to revenue streams are outside the scope of this work.

1. *Reaching the right people with the right ads*: this is concerned with matching consumer's need with advertiser's offerings so only relevant ads are delivered to interested users. SALE offers a semantic matching approach thanks to using Smart-M3 architecture and the designed ontologies.
2. *Delivering ads at the right time*: this is concerned with the trigger for the semantic matching process. Currently, the matching process is triggered based on the user's proximity to the advertiser's location or on user request for offers. SALE provides an easy way to extend contextual information by performing minimal updates to the advertisement ontology as shown in Figure 12 and modifying the queries in the *Dispatching Manager KP*.

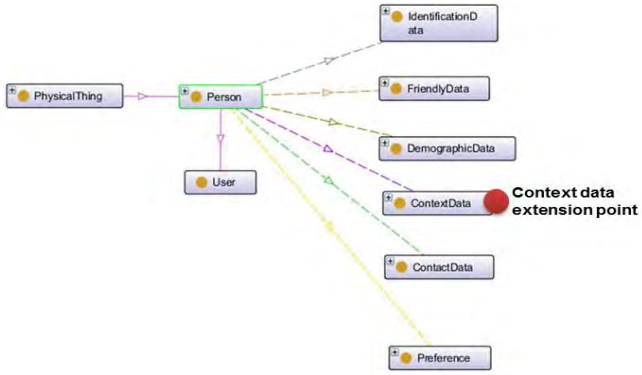

Figure 12 - Extending Profile Ontology with New Contextual Information

3. *Delivering ads in the best way:* this is concerned with "how" the ads will be delivered. The current release of SALE send to Android powered devices using Google Cloud Messaging (GCM). The advertisement ontology used within SALE semantic core offers another extension point as shown in Figure 13 in order to add

new delivery channels. In case of adding new channels, it is expected to implement the mechanisms for sending and receiving information form the new channel. This requires update to the *Ad Dispatcher KP*.

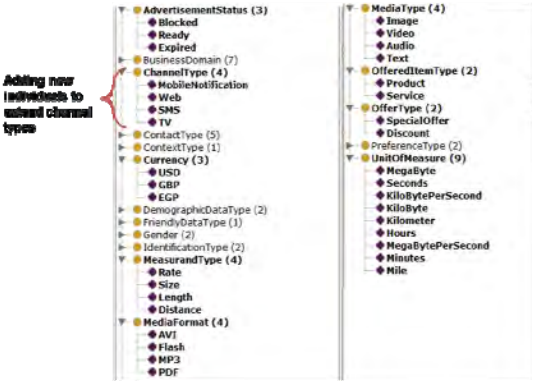

Figure 13 - Extending Advertisement Ontology by Adding New Individuals to Extend Channel Types

4. *Privacy and security*: this is concerned with maintaining a balance between personalization and privacy. Users are willing to provide more personal information as long as they guarantee two main things; first that this information is not revealed and second is that they do not receive unauthorized content. SALE provides multiple levels of privacy and security, this includes:
   i. *User authentication:* using identification data. Currently user name and password are used. However, adding extra authentication methodologies and techniques was one of the system design goals. This can be achieved by making minor modification to the identification data concept in the profile ontology as well as modifying the *User Authentication KP* and exposing the new techniques as a service to be used by end-user application.
   ii. *Content authorization:* this is achieved via the suggested workflow for publishing a new advertisement. Any new advertisement is subject to two levels of authorization by the publisher and the system administrator, thereby guarantee that consumers will not receive any spam content.
   iii. *Securing data in the knowledge base:* as discussed earlier, many techniques have been used in SALE to secure the stored information as well as data exchange between system components such as using firewalls, secure HTTPS connections, certification and data encryption.
5. *Maintaining consumer-advertiser relationship and real-time adjustment to user behavior and preferences:* this is related to receiving feedback from consumers about the received services. Two techniques are provided by SALE (1) the ability of the advertiser to send various types of media through which they can explicitly get feedback or tempt user to immediately buy their product or register to their services, (2) the ability of the user to block or unblock content from certain advertisers and hence adjusting user preferences information for the upcoming sematic matching process.

8.2 Future Work

As illustrated above, SALE has the potential to address most of the challenges of ubiquitous advertising. However, the trade-off between performance and multi-user access is a big challenge that faces SALE implementation. This is because the context matching procedure depends on an event driven approach using an event handler to perform the context matching for each context change event. Having multi-users in the system will cause invoking this handler at higher rates. Unless, we have a high performance server to host the SIB, this might cause performance degradation. A queuing system is used in order to organize and limit the simultaneous multi-user access to the SIB but this still comes with the cost of increasing the response time to each single Ad matching and dispatching task. As a result, enhancing the scalability and performance for multi-user access is considered one of the main research points to enhance SALE performance.

Thanks to using ontologies and SOA, other extensions can be easily implemented to extend the features of the current system such as:

- Extending the contextual information by performing updates to the current used ontology at the previously mentioned extension points.
- Enhancing the ads reachability by adding more communication channels such as SMS, email, etc.
- Implementing different mechanisms for sending and receiving information from other mobile devices as well as wearables.
- Extending the advertisement domains and dictionary ontologies to include rich details of each of the addressed domains.
- Supporting integration with social media like Facebook as a mean to provide more efficient way to login to SALE and to provide rich contextual information.

9. CONCLUSION

An innovative solution for next generation advertising services needs to deliver relevant content only to interested users. Semantics and context awareness are two key success factors for a proposed platform to overcome ubiquitous advertising challenges. This paper proposed and demonstrated, through real implementation, a semantic advertising platform to provide application developers with an easy to use platform to create personalized advertising solutions seamlessly across different platforms.

As illustrated above, SALE has been designed and architected to address common ubiquitous advertising challenges. Moreover, SALE promotes both interoperability and extendibility through using SOA-semantic integration architecture. Smart-M3 supports interoperability at the information level through using Semantic Web technologies to model, represent, and store information. It is also considered an enabler for extendibility because of the decoupled architecture of KPs making it easy to integrate more components and functionalities easily given that the same ontologies are adopted. We add to this the design of the ontologies used by SALE that offer multiple extension points to add more advertisement domains, advertisement data and metadata, as well as contextual information. Exposing the system functionalities using light weight REST services provides the required support to realize interoperability on the service and application levels making it feasible to design a wide spectrum of

application on different platforms using the loosely-coupled, platform independent service layer.

SALE is planned to be published as an open source platform that welcomes community contributions to create various usage scenarios as well as to solve the common issues causing the discussed limitations [8].

10. ACKNOWLEDGMENT

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Smart Metering for Domestic Water Flow – Challenges and Resolutions

Ayman M. Hassan
Benha Faculty of Engineering
Benha, Egypt
ayman.hassan@orange.com
ayman.mohamed@bhit.bu.edu.eg

Ali Abu-El-Magd
Embedded Software Architect
Orange Labs Cairo, Egypt
International Centers – P&S
ali.abuelmagd@orange.com

Ahmed El-Sanhoury
Principal Engineer, M2M & Energy
Orange Labs Cairo
International Centers – P&S
ahmed.elsanhoury@orange.com

ABSTRACT
In this paper, a smart metering system for domestic water flow meters is presented. The system comprises front-end readers that are attached to the legacy mechanical flow meters, and a cloud-based back-end system for data collection, monitoring and control. The paper focuses on the difficulties and challenges associated with the front-end segment, where tough requirements are imposed by utility companies. Careful firmware-hardware co-design is presented, with a main focus on the energy constraint. The processor selection and the architecture of the embedded firmware which achieves a system lifetime of 5 years yet allows daily communication is also demonstrated. Finally, the roadmap for mass production and deployment is considered.

Keywords
Smart Metering, Automatic Meter Reading, Target Detection, Battery profile.

1. INTRODUCTION
Egypt has a population of about 85 million, and receives an annual Nile water share of 55.5 billion cubic meters [1]. Around 85 percent of that water is used in agriculture, but a lot simply leaks away. According to [2] Egypt loses two billion cubic meters of water to evaporation, and three billion cubic meters to grass growing on the banks of the Nile and on river islands. Around 40 percent of the remaining water - used domestically and in industry (2.3 billion cubic meters) - is lost to leaking pipes and drains, while 2.5 billion cubic meters are used to generate electricity.

The domestic water sector in Egypt faces many challenges. Among the approximate number of flow meters deployed, which is approximately 20 million, more than 50 % of it either provide inaccurate readings or are completely defective. This results in calculating bills according to coarse estimation, which leads to inconsistent bills and delayed payments. Furthermore, pipe leaks, tampering and un-authorized joints add to the gap between production cost and revenues. A study is presented in [3] which gives an estimate the Non-Revenue Water to be 34%. Egypt invests 3 billion Egyptian pounds yearly in the sector of water and waste matter, so the sector losses from Non-revenue water exceed 1 billion pounds (2.7 Million pound per day!)

In this paper, we present and Automatic Meter Reading system for mechanical water flow meters used in domestic and industrial sectors. The system consists of a reader that is attached to the meter and is connected to a backend server through the cloud. Readers are battery-powered and are connected to the cloud through built-in GPRS modems. The backend system collects data from all meters and applies different data analysis needed for billing, tamper detection, leak detection, usage profile, and other utility-related parameters. Interoperability between system elements is achieved through Hardware-Firmware-Software co-design process.

The rest of the paper is organized as follows. Section 2 presents background on AMR systems, and similar work on water metering in specific. The architecture of the system, including hardware and firmware segments, is demonstrated in section 3. Special focus on the energy management task is discussed in details. Section 4 describes the backend part of the system, and introduces the concept of mediation layer and device abstraction. Finally, the conclusion and future activities for the industrialization phase of this system is presented.

2. BACKGROUND
Automatic meter reading (AMR) is a technology which automatically gathers data from energy, gas, and water metering devices and transfers it to the master station in order to analyze it for multi purposes. Data are read remotely, without the need to physically access the meter. The advantages include reducing peak demand for energy, supporting the time-of-use concept for billing, enabling customers to make informed decisions, and reducing the cost and increasing the accuracy of meter reading. AMR technologies may include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power-line transmission.

AMR for Water meters can also be used at the water source, well, or throughout a water system to determine flow through a particular portion of the system. The domestic water consumption is measured through mechanical flow meters which are generally located outdoors or within a man-hole. AMR for such meters is challenging as it implies attaching reading device (reader) to the meter. The reader should work properly under temperature, dust, rain and direct sunlight conditions, and should be completely autonomous. Generally, IP68 casing is required to ensure tolerability to such harsh conditions.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

The Global Smart Water Network can be categorized by technology into two segments:

- Smart Water Meters
- Monitoring and Control Systems.

Key Vendors for smart water meters include: Arad Group, Badger Meter Inc., Elster Group, Itron Inc., Neptune Technology Group Inc., Sensus USA Inc.

Relying on turn-key solutions for smart water metering has its advantages of fast roll-out and develop on past experience of the service provider. However, this approach has many drawbacks. Besides the high initial and operational costs associated with the turn-key solutions, those systems are designed for specific types of meters that should be equipped with special components to enable compatible reader interface [4]. The different types and vendors of meters installed in Egypt several years ago calls for more tailored solutions that could easily fit on various types of existing meters. Furthermore, the low-revenue small flow meters (1/2 inches and 3/4 inches) represent the majority of existing meters. Therefore, for any AMR system to be used under these conditions, it should be presented at ultra-low cost.

Another important evolution of the AMR that is expected to spread in the near future is the concept of Machine-To-Machine (M2M) operator [5]. The concept of M2M Operator is that the smart metering, like any other communications technology, could be introduced to utility companies as a "service". In this regard, the utility companies could ask the M2M operator for meter reading among many other services including: metering, billing, alerts, profiling, etc. This paradigm enables Telecom operators to invest in M2M business much more than availing the connection. In the meantime, utilities will hand-over all the technical related issues of the AMR to the operator, and will just pay per-service or per-meter.

For the reasons above, we at Orange Labs worked towards design and development of a complete water-flow AMR system with this view in mind. The front-end reader presented in this paper is totally designed in the lab and its cost ranges from 30 to 45 USD, which is less than half of its counterparts in the market. Further cost reductions and reduced-cost versions is planned after the first trial. Furthermore, the smart metering platform presented here is designed relying on Orange proprietary platform called (Intelligent Application Enabler) which is a mediation layer between devices layer and application layer. This architecture enables the back-end to be compatible with different meter types, including Gas and Electricity. The work presented in this paper is considered the first step towards introducing the concept of M2M Operator in Egypt.

3. SYSTEM ARCHITECTURE

This section describes the architecture of the AMR system for water flow. From the design view point, the system comprises three components:

- Reader Hardware
- Reader Firmware
- Backend Platform

Fig. 1 illustrates the architecture of the water AMR system.

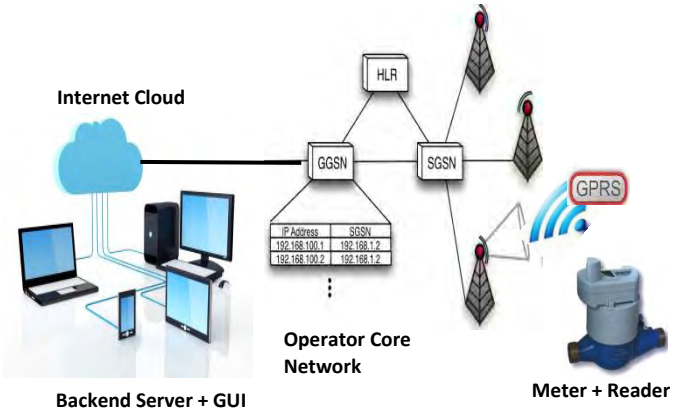


Figure 1. Block diagram of water flow AMR system.

The main requirements of the utility companies for an AMR system could be briefed in the following points:

1- Reading accuracy : 10 liters.
2- Reading time step : 15 minutes
3- Minimum reading rate : Once daily (96 readings).
4- Power source : Battery only.
5- Minimum lifetime : 5 years.
6- Tamper detection.
7- Reverse-flow detection.

The architecture of each module, and the design approaches to meet the above specifications is presented in the following sections.

3.1 Hardware Architecture

The reader module attached to the flow meter contains four main components: Sensing, processing, communication and battery. The sensing part is responsible for detecting a rotating target integrated in the meter. The target is a small sheet of metal attached to a rotary wheel that is mechanically attached to the turbine by a set of gears. The rate of revolution is directly proportional to the water flow rate. Furthermore, the direction of the target rotation indicates a forward/reverse flow. The detection of the target is done by magnetic coupling, which uses the idea of eddy current losses in the target.

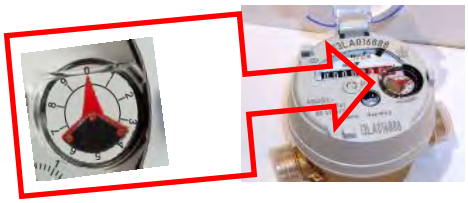


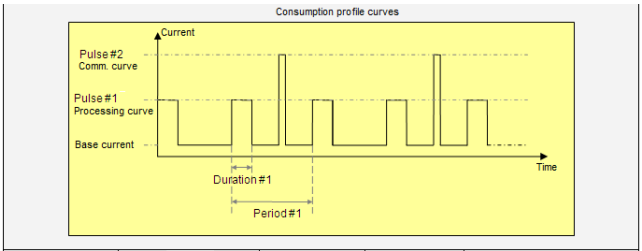
Figure 2. Target at water flow meter.

The processing section is responsible for reading the status of the sensing circuit and detects the existence and rate of target rotation. The processor keeps track of the target rotation and accumulates overall consumption during a predefined duration. The unit also keeps track of the tamper sensor and records any trial to detach the reader.

In order for the processor to accurately track target revolution and in the same time preserve battery, the processor takes only snapshots of the target position at a specified sampling rate. In

between those snapshots, the processor forces itself into the sleep mode where the power consumption is at minimum. The sampling rate is specified according to the maximum rate of target revolution, which is equivalent to the maximum water flow tolerated by the meter. The processor sampling rate is such that each revolution is sampled at least three times, so the target motion and direction is detected. Of course this rate differs from one meter to another, and it is a direct function of the maximum flow rate supported by the meter (designate by Qmax), which is the maximum allowed water flow in m3 per minute.

The battery section represents the power source for the whole system. The selection of the type and capacity of the battery is a key in meeting the utility requirements. The 5-years lifetime requirement needs very low self-discharge battery, which excludes rechargeable batteries from the selection list. Also the battery should be able to supply high-current pulses needed by the GPRS modem during the communication with the cloud server. Those pulses could be as high as 2-Amperes during the data exchange session occurring at least once daily. On the mechanical side, the battery should fit easily in the reader compartment, and should be of reasonable weight to avoid mechanical stress on the meter. The temperature range of the battery should be selected to cover hostile outdoor environment, with a wide operating temperature range. Fig. 3 indicates the current profile drawn from the battery. Upon specifying the amplitude and duration for each pulse, the amount of energy consumed from the battery per day is calculated, and hence the total capacity for a given lifetime could be reached.



		Current	Duration	Period	Notes
Base current		35 µA			
Pulse #1	Best case Processing	15 µA	24 h	24 h	24h/day in lowest processing consumption
Pulse #2	Best case Comm.	200 mA	20 s	24 h	Once per day for best communication session
Pulse #1	Worst case Processing	125 µA	24 h	24 h	24h/day in highest processing consumption
Pulse #2	Worst case Comm.	200 mA	80 s	24 h	Four times per day for worst communication session

Figure 3. Battery discharge profile.

The communication segment of the reader consists of a GPRS modem which is used to send water consumption data and receives commands and setting from the back-end. Each modem has a unique serial number that is used for authentication and provisioning of the meter at the back-end. To save battery and meet the system lifetime, the modem is switched-on once daily to communicate with the back-end server and just after the session ends, it is switched-off. Fig. 4 illustrates the block diagram of the reader, indicating the main blocks discussed.

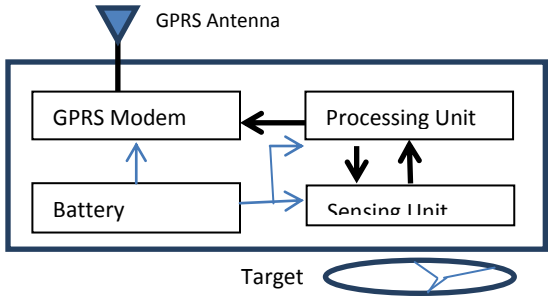


Figure 4. Block diagram of reader hardware units.

3.2 Software Architecture

A classical approach is elected for grouping firmware modules in layers that abstract the layer on top from the underlying hardware. The lowest layer is the target abstraction layer. It contains the modules that drive the uC peripherals used by the system. The layer on top of that is the board abstraction layer. It contains the modules that drive the different PCB circuit modules. The top most layer is the application layer containing all the system logic without any hardware dependency. The static architecture of the firmware, together with the device state machine are illustrated in Fig's. 5a, 5b.

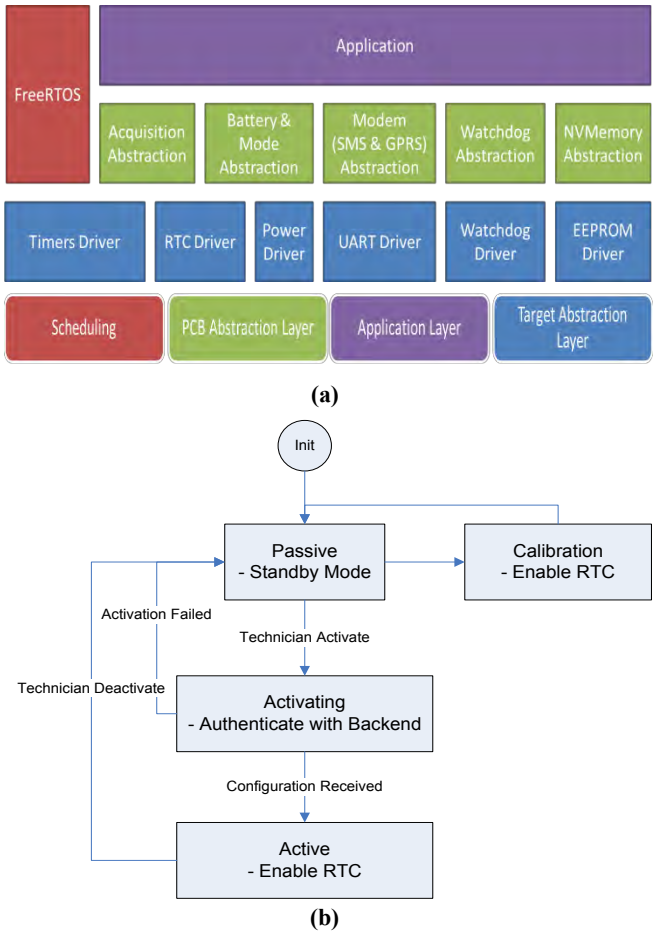


Figure 5. (a) Firmware static architecture of the reader and (b) reader state machine.

3.3 Acquisition Polling Rate

As shown in section 3.1, the acquisition polling rate is one of the main contributors to the system's power consumption. The minimum acceptable rate needs to be carefully calculated to ensure no flow pulses are missed.

If only two sensing elements are used for acquisition they need to be placed in such a way that guarantees an overlap in detection to enable the possibility of flow direction identification. In that case a simple algorithm similar to that of quadrature decoding can be used to count pulses and their direction. The four generated states must all be acquired to guarantee system integrity. Also there is a lot of added complexity on the placement of the sensing elements. In the case where three sensing elements are placed equidistantly the time it takes to enter and exit the target detection state of each sensing element depends on the size of the target. The other main factor deciding the polling rate is the maximum needle speed. This latter factor is a function of the Qmax as well as the amount of flow that one revolution of the needle represents K.

The fastest needle we are required to support represents a K of 0.01m3 and is on a meter with a Qmax of 100m3/h.

$$Target\ angular\ velocity = \frac{100}{(3600 * 0.01)} = 2.778\ revs/sec$$

The target size is close to one fourth of the revolution but we shall use one fifth to add a safety factor.

$$Polling\ Rate = Target\ angular\ velocity * 5 = 13.889\ sps$$

An additional power conservation technique is using an adaptive polling rate. If the water flow stops for some time the system could go into a lower power mode by sampling at a slower rate. Then boost the polling rate up to support maximum flow as soon as any state change is detected. This technique makes use of the fact that the change in water flow speed cannot be instantaneous. During the gradual speed up it will be easy to detect the state change at the lower sampling rate and then change the rate to allow full system readiness.

3.4 Operating Modes

The main strategy for power saving is to have both the Microcontroller and the GPRS Modem in their lowest possible power modes for as long as possible with respect to the times when they are running. There are two main functionalities required by the system: Meter Reading Acquisition and GPRS Modem Communication.

$$Functioanlity\ Duty\ Cycle = \frac{Active\ Time}{Period}$$

The modem communication periodicity is constrained by the industry norm of automated water meter reading. It is expected to happen once daily. This is excellent given that the session from network negotiation until HTTP response reception can be completed in less than 30 seconds. So we can keep the modem in the Shut Down power mode for the whole day except for the 30 seconds in the active mode. The consumption of shut-down as well as active power modes is indicated in Table 1.

$$Communication\ Duty\ Cycle = \frac{30}{24 \times 60 \times 60} \times 100\% = 0.035\ \%$$

Table 1. Modem power modes

Power Mode	Consumption	Usage
Active	30mA with 2A Bursts	-Modem Communication
Shut Down	35uA	-Waiting for Modem Communication

The acquisition periodicity is the inverse of the polling rate calculated earlier. Assuming a 16 sample per second rate the periodicity becomes 0.0625 seconds. For constraints related to the sensing technique used one sample requires 2.5 milliseconds to be acquired.

$$Acquisition\ Duty\ Cycle = \frac{0.0025}{0.0625} \times 100\% = 4\%$$

The flowchart of the acquisition section of the firmware is depicted in Fig. 6.

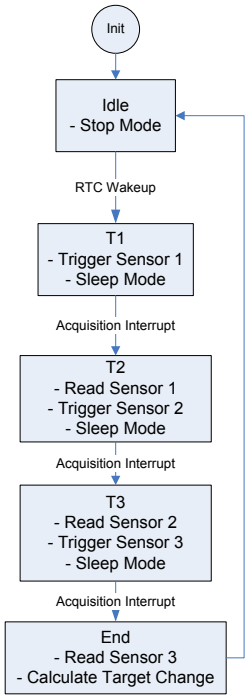


Figure 6. Flowchart of the acquisition section.

Identifying that the acquisition sample is mostly consumed waiting for the sensor to respond after activation, we can reduce the duty cycle even further. The controller can sleep between sensor trigger times to only be interrupted by the acquisition-complete interrupt. This should drive the overall duty cycle well below 1%. Table 2 shows the consumption of the microcontroller operated at different modes.

After applying the above mentioned optimizations, the break-down of the energy consumption from the battery is illustrated in Table 3.

Table 2. Microcontroller power modes

Power Mode	Consumption	Usage
Active @ 4MHz	500uA	-Modem Communication -Triggering Acquisition -Applying Acquisition Algorithm
Sleep	50uA	-Waiting for Acquisition Completion
Stop	3.5uA	-Waiting for next Acquisition cycle
Standby	1.5uA	-Waiting for Activation

Table 3. System energy breakdown

Functionality	Consumption (Ah/year, %)	Conditions
Communication Energy (Best Case)	0.41, 48%	One session per day – Best-case processing.
Communication Energy (Worst Case)	1.64, 79%	Four sessions / day - Best-case processing.
Processing (Best Case)	0.44, 52%	One Communication session per day
Processing (Worst Case)	1.4, 77%	One Communication session per day

3.5 Microcontroller Architectural Advantages

3.5.1 Direct Memory Access

Modern microcontrollers allow peripherals to have direct access to the RAM. When used right, this feature could greatly reduce code execution time and thus save power by letting the hardware do all the heavy lifting while other code can execute in parallel. In our case we communicate with the GPRS modem via UART peripheral. We build the string required to be sent to the modem and initiate transmission by pointing the UART to the beginning of our Tx buffer in memory and indicating the size. The HW does all the serial character by character transmission by iterating through our buffer while our instructions manage the sensing circuitry.

3.5.2 Internal Oscillators

We use two of the three internal oscillators made available by our microcontroller. A lower speed oscillator is used to clock our RTC and a higher speed oscillator is used as a system clock. The higher speed oscillator is factory calibrated and we use it to calibrate the lower speed oscillator during system startup. Using internal oscillator cuts device cost and decreases consumption but comes at some accuracy and drift risks. We also use the timestamp acquired from our backend system during communication time to correct for any drift on our RTC caused by the lower speed internal oscillator.

3.5.3 Comparator Peripheral

Having a comparator to use inside our microcontroller with configurable threshold reduced the complexity and cost of our PCB design by eliminating a component from the circuit. In addition it allowed for easier supply management from the battery as no additional biasing voltage would be required.

3.5.4 Independent Peripheral and Port Clocking

We rely heavily on putting our microcontroller in low power level states for reduced consumption. During the active state we are also very cautious by only enabling those peripherals and ports required by the current activity. The modular static architecture combined with the Cortex-M's feature of independent clock gating of each port made our job easier. For each module we created a resume and suspend routine that follow the following pseudo code.

Function Suspend_X:

- Configure all pins in Analog Input mode (Schmidt trigger OFF)

- Disable the used peripherals

- Disable the clocks going to the used peripherals

Function Resume_X:

- **Enable the clocks going to the used peripherals**
- **Configure the pins required by this module**
- **Start the required peripherals**

3.5.5 Development Tools

An energy efficient microcontroller by ST was chosen for our device, built around ARM's Cortex M-3 core. It brought the right balance between low power consumption and powerful 32-bit processing. Not to be tied to any proprietary development tools we elected to work with an open source toolchain. GNU's gcc was used as a cross compiler in addition to gdb for debugging. An eclipse based IDE was also selected for the same reasons.

4. IAE AND BACKEND PLATFORMS

The previous sections discussed the water AMR system from the frontend (meter) side. The data collected by all the readers attached to meters are sent through the GPRS modem to the application server for data analysis as previously mentioned. The backend system that is implemented in this system contains two main modules: The Intelligent Application Enabler (IAE) mediation layer, and the Application layer. In the coming sections we will present functions associated with both modules.

4.1 IAE Platform

The IAE is a generic platform developed by Orange [6] and allows M2M operator to create and manage end-to-end M2M services on behalf of its customers. The main functionalities of IAE could be briefed as follows:

- It is a mediation platform between devices and customer IT environment which enables data collection, message and device management services.
- It provides "network operations" capabilities such as messages exchanges supervision and devices network supervision.
- Based on this platform, M2M operator can provide or integrate complete M2M solutions addressing customer specific challenges.
- It allows the customer to ensure communication between their devices and their business applications.

The M2M operator can then deliver a purpose-built M2M end-to-end service beyond connectivity, encompassing terminal devices, network, and back-end applications. The high-level diagram of

IAE and its location within the cloud connected application server is shown in Fig. 7.

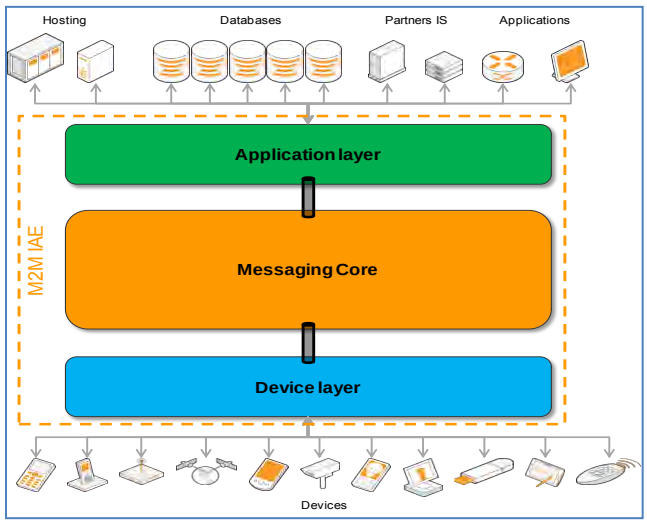
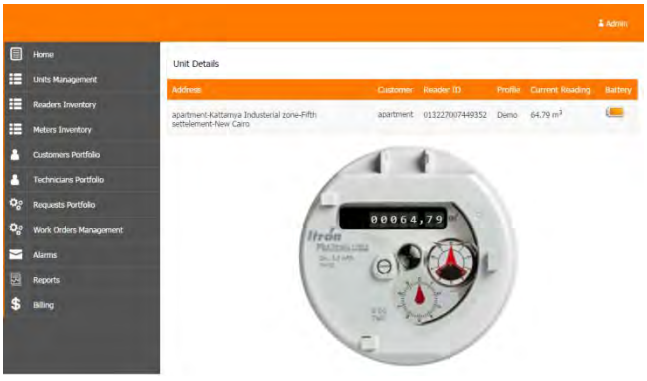


Figure 7. IAE platform architecture.

4.2 Smart Metering Application

The Smart Metering Application interface is a Java-developed application that interacts with the IAE layer and extracts meter information using standardized API's. The IAE abstraction layer makes the Application compatible with many types of devices and meters. The utility requirements are the main factor that defines the main functions and GUI for the designer. A typical page of the application layer is shown in Fig. 8 and is called "Meter Page". It illustrates the meter serial number, type and periodic value of the water consumption. Of course the application could be tailored according to specific utility needs, while keeping the device interface and the IAE intact.



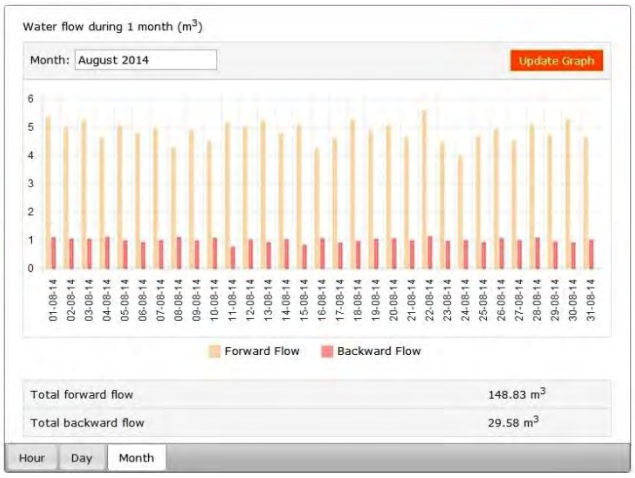


Figure 8. GUI snapshot of the smart metering solution.

5. CONCLUSION

An AMR system for measuring domestic water consumption is demonstrated. The system includes a reader that is attached to the water flow meters and a cloud-connected server hosting the back-end system. The reader main challenge is in energy conservation, under the battery operation and imposed lifetime. A careful hardware-firmware co-design process has been followed to meet the lifetime criterion.

The back-end system containing IAE mediation layer plus the application is also presented. The IAE enables the developers a device abstraction layer through predefined API's by which, the final application is device-independent.

The presented system architecture is an early effort to introduce the concept of M2M operator in Egypt, through availing meter reading as a service to the utilities. Orange Labs in Cairo is currently testing a first version of this system in a private utility company, and initial results are encouraging. A first test pilot for 50 meters is planned before the end of 2014.

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CMMI-SVC Potential in MEA

Ahmed Abd Elaziz
Software Engineering Competence Center (SECC)
Giza, Egypt
aaziz@itida.gov.eg

Marian Tadros
Software Engineering Competence Center (SECC)
Giza, Egypt
martadros@itida.gov.eg

Madiha Hasan
Software Engineering Competence Center (SECC)
Giza, Egypt
mad_abdalla@itida.gov.eg

ABSTRACT
This paper demonstrates the great potential of adopting the Capability Maturity Model Integration for Services (CMMI-SVC) in the Middle East and Africa (MEA). It introduces the CMMI-SVC concepts, brief history, and target benefits. It gives the adoption status worldwide and in MEA in particular. It describes three successful case studies that span different business domains and organization types. Each case study yields the specific model interpretation and implementation tactics. Lessons learned and recommendations to facilitate adoption are also provided.

Keywords
Process improvement, Service management, Service delivery, CMMI, Best practices, Appraisals.

1. INTRODUCTION
The service industry is a significant driver for worldwide economic growth and the Middle East and Africa (MEA) is no exception. Guidance on developing and improving mature service practices is a key contributor and urgent need to the service provider performance and customer satisfaction. The CMMI for Services (CMMI-SVC) model is developed to fulfill this need [1].

For any organization to deliver quality services, it has to focus on improving its processes. As depicted in Figure 1, processes hold people, procedures, and tools together.

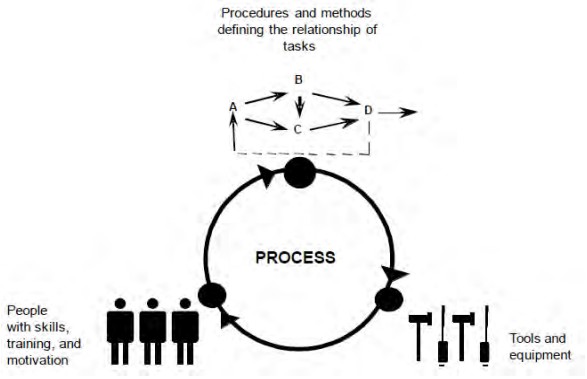

Figure 1. Processes hold people, procedures, and tools together [1]

AMECSE'14, October 21–22, 2014, Giza, Egypt.

CMMI-SVC is a process improvement model that can be adopted to solve any performance issue at any level of an organization in the service industry across many business domains. It covers the activities required to establish, deliver, and manage services.

As its name implies, CMMI-SVC targets not only IT services but the service business in general. It can be used to improve processes of finance, training, procurement, facilities management, customer helpdesk, housing, transportation, catering, public services, insurance, IT operations, software maintenance, network management, data security, data centers, and many other services.

Taking into consideration that services constitute the main bulk of today's business, CMMI-SVC is of utter importance to almost any organization and any business. CMMI-SVC draws on concepts and practices from CMMI-DEV and many service-focused standards and models including ITIL, ISO/IEC 20000, and COBIT [2].

The rest of this paper is organized as follows: Section 2 provides brief history of CMMI-SVC and samples of its successes. Section 3 gives the status of its worldwide adoption with special focus on MEA. Section 4 describes three case studies spanning different business domains and organization types. The implementation tactics supported by the Software Engineering Competence Center (SECC) are highlighted. Section 5 provides lessons learned and recommendations. Finally Section 6 states the work conclusion.

2. HISTORY AND BENEFITS
Figure 2 demonstrates the CMMI-SVC historical timeline. Roots of CMMI-SVC go back to 1930s when Walter Shewhart began work in process improvement with his principles of statistical control [1]. The journey then continued until the birth of CMMI-SVC in 2009.

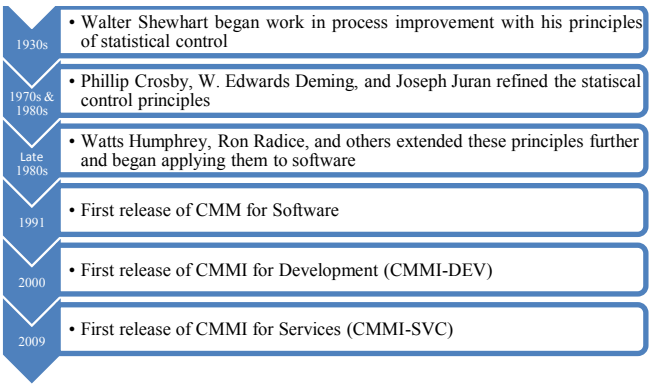

Figure 2. CMMI-SVC Timeline

The ultimate benefit of successful CMMI implementation is improved performance which means improved on-time delivery, productivity, quality, customer satisfactions, and return on investment, and reduced costs. Sample successes [3]:

- IBM Australia Application Management Services improved account productivity by over 20% and closed 95% of problems within the customer-specified timeframe.
- General Dynamics Advanced Information Systems reduced maintenance staff costs by 64% while doubling the size of the organization.
- General Motors improved the percentage of milestones met from 50% to 85%.
- Siemens Information Systems reduced its cost of quality from over 45 % to under 30% over a three-year period and increased its customer satisfaction index by an average of 42% in three technical areas.

3. CMMI-SVC WORLDWIDE

The Maturity Profile Report [4] released by the CMMI Institute has indicated that by March 2014, a total of 394 CMMI-SVC appraisals were conducted in 33 countries around the globe covering wide diverse of business domains.

3.1 Appraisal Distribution

Figures 3 and 4 depict the distribution of CMMI-SVC appraisals over countries and continents, respectively. Clearly countries and continents where service delivery receiving a strategic focus, have the biggest shares.

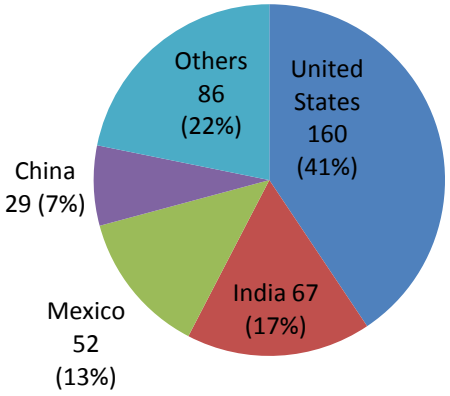

Figure 3. CMMI-SVC Appraisal Distribution over Countries

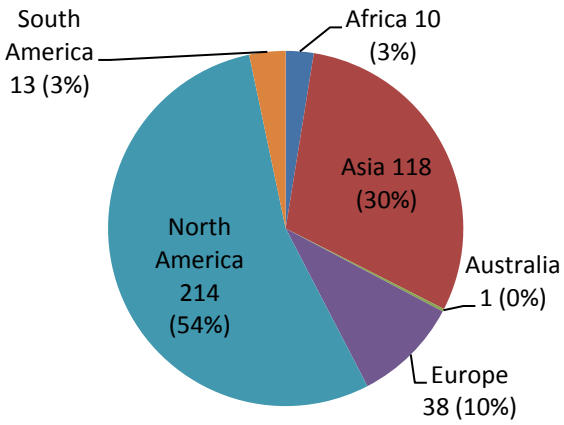

Figure 4. CMMI-SVC Appraisal Distribution over Continents

3.2 CMMI-SVC in MEA

Analyzing the data of latest Maturity Profile [4] and the published appraisal results [5], it is found that 11 CMMI-SVC appraisals were conducted in the Middle East and Africa by March 2014. The appraisals were conducted in 4 countries only: 4 in Egypt, 4 in Morocco, 2 in South Africa, and 1 in Turkey. These 11 appraisals were conducted in 7 organizations only as 1 organization performed 3 appraisals, 2 organizations performed 2 appraisals each, and 4 organizations performed 1 appraisal each.

The lines of business that have adopted CMMI-SVC are detailed in what follows.

3.2.1 Software Development and Maintenance Organizations

Such organizations develop software systems, deliver it to customer sites, then provide maintenance and support services to customers and users. Two organizations of this business line in two different countries have adopted CMMI-SVC to help them improve their processes.

3.2.2 Financial Organizations

Two financial organizations have adopted CMMI-SVC. One bank performed three appraisals to its IT unit. The unit is offering standard IT maintenance services and application maintenance to the bank departments. The second organization provides banking services to its customers via the Internet like ATM management, cards management, and money transfer. CMMI-SVC has been used to manage and deliver these services.

3.2.3 Healthcare Organization

One organization working in healthcare has used CMMI-SVC to manage and deliver services as primary care, hospitalization, medical visits, laboratories, etc.

3.2.4 Training Institute

One training institute has adopted CMMI-SVC to manage and deliver its professional training program. It performed maturity level 2 and level 3 appraisals.

3.2.5 Governmental Organization

One governmental organization has used CMMI-SVC to manage and deliver deployment, support, and training services for their inventory management software system.

4. INDUSTRIAL CASES

The Software Engineering Competence Center (SECC) supported successfully the adoption of CMMI-SVC in three Egyptian organizations of different types and representing diverse businesses. Hereunder these industrial cases are described detailing the model interpretation to suit the different needs and the implementation tactics. Names of the organizations are not mentioned and some insignificant details are slightly changed or removed to maintain confidentiality.

4.1 Software Development and Maintenance Organization

This is a private sector company that has developed broker software, sold it to many customers, and frequently updated its software and delivered the updated version to its customers. The software has been updated to fix bugs or to respond to an accepted change request. Whenever the software has been updated, the new version has been delivered to all customers via the Internet.

Initially the company asked for CMMI-DEV and contracted for it. When consultation started, the consultant realized that most of the company work is in maintaining one broker software system rather than in developing new systems or new modules of the system. The consultant recommended CMMI-SVC for the company and the management accepted this recommendation.

4.1.1 Context

The technical staff of the company was less than 10 people. The broker system was average in size and contained many modules. The product had received 4 to 6 change requests weekly, either modifications or bug fixing. Immediate response to changes especially bug fixing was highly required.

4.1.2 Implementation Approach

Starting with analysis of the gap between the organization work and CMMI-SVC requirements, group of problems were addressed. The top ones were:

- Inability to meet some customer needs due to misunderstanding of customer requirements.
- Ad hoc management of the maintenance work. There were no objective estimation, no schedule, no risk update, and no mechanism for handling project issues. Consequently many commitments could not be met.
- Implementation of many incomplete activities like collecting unobserved measures, taking baselines without audits to ensure their correctness, and performing some quality audits with no set criteria.

After the gap analysis, an action plan was created to address the organization problems and interpret the model within the organization context. The major points considered were:

- The part of the contract that entailed the maintenance period and SLA was considered as the service agreement.
- Each single customer request was considered as a service request.
- Due to the high frequency of requests, each month was considered a separate time slot.
- For each time slot (month), a maintenance plan was prepared at start.
- Work expected in a slot was estimated based on the work done in previous slots. In other words amount of requests expected in the starting time slot was calculated based on the amount of requests received in the previous slots. The average effort to respond to a request was estimated based on the number of requests received before and effort excreted to respond to them.
- The service manager started to use simple spreadsheets to manage the work issues and risks.
- At the end of each time slot, all activities of the period were reviewed. This was considered as the milestone review.
- At the end of each slot, quality auditing activities were performed to audit the whole work within that time slot instead of performing it with each single delivery. This was more feasible and applicable. Checklists were established for all audits.
- At the end of each slot, a baseline was taken to the work products created or updated during the month. Configuration audits preceded the baselines. The baselines recorded the updates and the customers receiving them.
- A process was established to biannually review the agreements with customers, analyze them, and update the process and work accordingly.

4.2 Training Organization

This is an organization that has provided an annual professional training program subsidized by the government and some private sector companies for fresh graduates to prepare them for work in a highly-technical field that has been strategically needed and supported by the Egyptian government.

4.2.1 Context

The organization has been running its program for more than 10 years. Its graduates have been trusted and promptly hired due to good reputation. The training cycle starts in summer vacation by announcing the schedule of registration for new students of the incoming intake. Due to the large number of students, an entrance exam is conducted followed by interviews to filter students. The accepted students are informed about the start date of the program. Students are distributed over different classes based on their requests and organization plan set as per the government strategy and work market needs. Students pass through frequent exams during the year. Students and instructors evaluate each other periodically. Whenever an instructor receives a low evaluation, his/her case is examined and appropriate action is taken.

The organization had implemented ISO before CMMI-SVC and consequently had many basics in place. The IT of the organization was implementing ITIL but it was not scoped in the CMMI-SVC work. The organization also had a group of qualified persons, some of them had good background of CMMI-DEV and many, in addition to top management, were eager to improve, challenge, and implement new methodologies.

4.2.2 Implementation Approach

This is a good success story as the organization successively has achieved maturity levels 2 and 3 in less than 3 years. The main points in interpreting the model were:

- The agreement between the organization and the government indicating number of students, specialties, and number of students in each specialty, was considered as the service agreement. There was one agreement every year.
- The registration of each student was considered as a separate service request.
- As ISO was used and the team was highly qualified, many CMMI requirements were in place already like planning and auditing.
- An annual plan was prepared and revisited every quarter to keep it up to date.
- Bimonthly the work was monitored and configuration audits were performed.
- The main asset was the training materials of the different courses. They constituted the main bulk of configuration items. As the training material could change from year to year, but were not allowed to change within the same year, a simple folder structure was enough to act as the configuration management tool.
- Evaluations of students and instructor were frequently reviewed and appropriate actions were taken.

4.3 Inventory Management Governmental Organization

This organization was a technical unit of one of the Egyptian ministries that has locations everywhere in Egypt. The organization has developed consequent versions of inventory management software system. The software has been deployed in some locations. On annual basis the organization has been receiving a plan from top authority with a list of new locations where the system has to be deployed.

4.3.1 Context

The technical staff of the organization was less than 20 persons involved in continuous development, deployment, support, and training. When the organization received the deployment plan, they established their own plan to deploy the system to the agreed locations and train the locations staff on the system.

The organization staff was highly qualified and was aware of process improvement. They already implemented CMMI-DEV and Six Sigma and achieved very good improvement with it.

4.3.2 Implementation Approach

The main points in interpreting the model in this context were:

- The annual plan received from the higher authority was considered as the service agreement.
- Each deployment and training required for each location was considered as a service request.
- A consolidated plan was prepared for all the locations. The plan was monitored monthly and status was reported to senior management and higher-level authority.
- Quality audits and configuration baselines and audits were done on the spot after each visit for deployment or training at each location.

5. LESSONS LEARNED AND RECOMMENDATIONS

Experience has shown many aspects that have to be considered when implementing CMMI-SVC. Important aspects include:

- Senior management commitment is a highly-critical prerequisite for CMMI-SVC implementation.
- Deep understanding of the underlying organization business and of staff experience is a key success factor in CMMI-SVC implementation.
- Flexibility in CMMI-SVC interpretation is essential to avoid bureaucratic useless activities.
- From the few appraisals conducted by SECC we realized that jumping from one maturity level to the next in CMMI-SVC needs about one year on average. Still more data is required to reach solid conclusion, but that is what we have so far.
- CMMI-SVC does not work in isolation from many existing models, but rather it integrates quite well. For instance, achieving the CMMI-SVC goals provides the necessary infrastructure required for COBIT. CMMI-SVC provides a powerful framework to implement ISO/IEC 20000 to manage service delivery and other service-related processes and operations. If the organization is building or updating its service system, CMMI-DEV comes to do the task via its engineering practices. ITIL explains the “how to do” and “who will do” of the “what to do” mentioned by CMMI-SVC. CMMI-SVC also adds powerful infrastructure to institutionalize the service delivery work and measure and benchmark the organization performance.
- Although still yet few, the success of CMMI-SVC implementation especially with governmental and training organizations demonstrates great potential as more and more MEA governments have been treating IT and IT-based services as strategic assets and have been given much attention to capacity building and e-government initiatives for the well-being of their citizens.
- Matching what was previously stated and reported by SEI and CMMI Institute, CMMI-SVC was successfully implemented in diverse business lines and organizations in MEA – not only IT and IT related organizations. All kinds of services can benefit from CMMI-SVC like hotel housing, restaurants and food catering, public and private transportation agencies, and health and life-insurance organizations.

6. CONCLUSION

CMMI-SVC is applicable for a very wide range of business domains. It has been implemented successfully in many countries and diverse organizations all over the world. The Middle East and Africa (MEA) is no exception although it has been demonstrated that the adoption scale is very little so far. CMMI-SVC could benefit MEA a lot in perfect alignment with many government initiatives that focus on service industry for economic growth and citizen well-being. Three case studies have been given to demonstrate that CMMI-SVC can help governmental and non-governmental organizations in diverse businesses as training, software maintenance, and inventory management, improve their

performance and be benchmarked on a reputable international scale using appraisals. Different model interpretations have been provided for different business needs. Lessons learned and recommendations have been given to facilitate model adoption.

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Prediction of Software Defect Severity based on Analysis of Software Repositories

Mostafa M. Ahmed
Dept. Information Systems
Assiut University
Assiut, Egypt
mostafa.kamel@aun.edu.eg

Abdel Rahman Hedar
Dept. Computer Science
Assiut University
Assiut, Egypt
hedar@aun.edu.eg

Hosny M. Ibrahim
Dept. Information Technology
Assiut University
Assiut, Egypt
hibrahim@aun.edu.eg

ABSTRACT

In software development projects bugs repositories become memory of the issues found in the past. There are a lot of factors related to bugs found in software; one of the main factors is wasting time to fix issues that are not important due to in experience of both developer and reporter. Identifying bug severity is an important task commonly used to avoid misclassification of the bug. This research explores the viability of using efficient data mining tools to predict the severity of a bug given only the summary of the bug. In this study we use open source repositories of the Eclipse repository and GNOM for modeling and predicting bug severities. This paper compares between different algorithms and using ROC graphs to simulate the results and evaluate the performance of the classifiers. The classifier can correctly predict up to 0.95 for GNOM and 0.837 for Eclipse.

Keywords

Defect severity prediction, bug repository, bug severity, tracking system, mining software repository, extended association rule mining, roc curve, evaluation method , multinomial naive baye, transformed weight normalized complement

1. INTRODUCTION

Software organizations are interesting with software testing in order to reducing the risk of problems which are occur-ring in the customer side caused by defects found through development life cycle. If defects are corrected before the system releases; more satisfaction from client the company will be getting. Defects are been stored in issue tracking system [1] to manage bug reports [2], monitor resolution of defects and to support decision making processes. One of the most important tracking systems is Bugzilla [3].

Bug track systems are the basis to identify useful patterns of software module defect occurrences, associations, modification, evolution and decay.

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For this reason software engineering research has been exploring bugs repositories as a powerful concept to understand, predict and plan software projects and improve the quality [4].

Bug report is represented as an individual record in a bug repository. Bug report has many fields that is include description that simulate the business scenario that causes the issue. A title represents a summary of the incident in one line. As well as, the project name. The other fields will be described later. These fields are normally provided by the original submitter.

Bug reports are queued through bug repositories according to two important factors: severity and priority. Severity is defined as how badly the issue impacts on the build. While the priority defines the important for fixing the bug based on time frame from developer's point of view. For example, if the company name is misspelled in home page of a website, then the priority is high and severity is low.

There are some words through bug report description that identify the severity of the bug. For example, crash which applied for critical or blocker issues. GUI and misspelling errors are led to low/enhancement issues. In case of bug report has a critical severity; it will be fixed faster.

Many reporters regularly raising issues as critical / blocker without mentioned of criteria found in Table 1 due to in experience of both developer and reporter. This affects in two side, the first side, that is the issue will be always solved in the first of the developer's queue. The second one, the reporter will be marked as an inexperience. Also, his is-sues will be ignored due to bad reputation. The two choices will affect in time and efforts assigned to the project plan negatively.

Therefore, there is a strong need to an effective tool to identify severity automatically. By using an efficient defect analysis mechanism on bug reports, the right severity is been identified. This mechanism uses the description provided from new coming issue. The new mechanism allows to save efforts, time and improving the quality of the software.

The invented approach investigates how to predict the severity of the new coming bug according to analysis of description automatically. By using text mining techniques based on GNOM [5] and Eclipse [6] bugs repositories. Analyses will be based on text description field found in bug report. Description field will be a suitable input for the classification model. Our basic idea is to design an approach to find the severity of new coming one using natural language mining techniques.

Based on a case study drawn from MSR conference researches [7, 8] on analysis of open-source community GNOME and Eclipse. These researches apply different algorithms and using area under

curve of ROC graphs [9] as an evaluation method. The study discusses what the weakness and strengths points in the new approach and comparing results with others solutions. The study tries to answer the following investigations:

1. Is the proposed solution has better results than other compared approaches? The study tries to apply the best algorithm to get accurate prediction of bug severity and compares the result to other previous works.

2. How the accuracy of the classifier is calculated? The study describes the evaluation criteria to adjust the accuracy and correctness of the applied algorithm.

The rest of paper is structured as follows: In Section 2 which gives a brief about Issue tracking system, bug report and bug life cycle. Section 3 talk about data classification, text mining, challenges which we try to compete it and his-tory of related work. Section 4 begin review of proposed methodology and applying the algorithm in training dataset, provide how to evaluate the classifier using true positive versus false positive rates and ROC graphs, through this section we try to solve challenges research presented before. After that, section 5 lists experiment result and provide comparison between proposed solution and other algorithms. Finally, section 6 discusses the results and points out future work.

2. BACKGROUND

As the study focuses on mining bug repositories, this section discusses what are the elements effect on issue track system and the studies which are dealing with mining bug repositories. Those studies concentrate on the mining technique employed, amount of analyzed data and algorithms which have been used.

2.1 Issue Tracking Systems

Issue tracking systems [1] is used to manage and maintain lists of bugs which are received from different actors in development life cycle. It works as a record for software application characteristics. It also opens connection channel between end users, developers, designers and testers. Each one discusses his point of view for the new coming issue and change the status of the bug [10]. Communications happen through different activities such as creating entirely new issues, reading existing issues, adding details to existing issues, or resolving an issue.

When a user of the tracking system makes a change, all related date will be recorded such as the action and who made it. Recording all change details facilitate maintaining a history of the actions taken. Each user of the tracking system may have issues assigned to him. He is responsible to find proper resolution to fix issue assigned to him. All issues generally presented to him in a list format. The user may have the option of re-assigning an issue to another user, if needed. The tracking system will authenticate its users before allowing access to the systems for security purpose. Tracking system often also contains a knowledge base containing information on each user, resolutions to common problems, and other such data.

Bug report represents major component for issue tracking which is called also a ticket. Ticket is created from technical support team, development team or testing team as a result of an incident. By creating a ticket a notification came to project manager or coordinator. Ticket has some de-tails about business scenario that causes unexpected behavior from software application. In next two sections, Bug report contents and bug life cycle will be described.

Issue ID	73489
Issue Title	ARMFIFG program insert invalid value i
Issue Describtion	run program on tested batch have a fra <Expected result> verify that file gene amounts
Severity	Major
Classification	Not a Bug
Entered By	moahmed [mostafa Kamel]
Found By	moahmed [mostafa Kamel]
Founder Role	QC tester
Phase Detected	6-System Test
Phase Injected	.....
Defect Category	.....
Defect Type	.....
Status	Closed
Assigned To	shali [Shaimaa Ahmed Mohamed Ali]
Priority	
Testing ActualEffort	0
Coding Actual Effort	0
Design Actual Effort	0
Impact Analaysis Effort	0
Environment Setting Effort	0
Impact Analysis	

Figure 1. Bug report structure

2.2 Bug Report Contents

A major component of issue tracking system is a bug re-port, which has specific information about incident and a set of fields. Some fields describe incident in natural language without any rules and there are some other fields that have predefined values. For example, description, impact analysis and issue title which represents free text fields in addition to, other predefined fields such as severity, project, founder Role, phase detected and phase injected as shown in Fig 1.

Title of the incident has the summary in one line for the problem that faces the reporter. Description represents a full scenario to regenerate the issue. Severity is defined as how important this issue is affecting on the software application Also, it has range of values such as critical / blocker, major, medium, minor and low. A clear guidelines to assign severity found in Table 1. Founder role represents who found this issue such as tester, end user, developer or analyst. Phase detected is defined as in which phase this issue is generated. The phase's values depend upon organization development cycle that may include requirement, design, coding, function test and user acceptance test. Phase

Injected represents in which phase issue come from. Classification represents resolution status which range among clear issue, setup, duplicate or not a bug issue. Finally, impact analysis which represents why this issue is generated and what are the changes to fix it.

Going through project time plan, fixing issues or rework time takes an important section and solving trivial or noncritical issues will affect progress of project or products that are forward/backward. Assigning the bug severity depend upon experience of the reporter as a manual process while clear guidelines exist on how to assign the severity of a bug which described in Table 1.

Table 1. Severity classes definitions

Severity	How much damage the bug does?
Blocker	Application freezes, crashes, or fails to start. Also, Data is corrupted.
Critical	Key feature does not work, , or returns incorrect results.
Major	Key feature looks terrible. A secondary feature returns incorrect results
Normal	Secondary feature is difficult to use, Minor feature does not work.
Minor	Secondary feature has a cosmetic issue.
Trivial	Minor glitches in images, not so obvious spell mistakes,… etc.
Enhancement	Improvement to the product based on feed-back from users.

2.3 Bug Life Cycle

Issue tracking systems have different states for a bug which is tracked through status assigned to it. At the moment an issue report is submitted, it gets a unique identifier by which it can be referred to in further communication. Let us assume that someone has just raise an issue report into the bug database. While the issue is being processed, the report runs through a life cycle as given in Fig. 2.

The position in the life cycle is determined by the state of the issue report. Initially, every single issue report has a state of New Issue. It is then checked for validity and uniqueness by coordinator. If it passes these checks, the proper developer / designer will be assigned. Identifying nature of the issue is crucial in when selecting proper developer and finding the resolution of issue. Status of the report becomes "Assigned". At this point, the issue report is also assigned a priority the higher the priority, the sooner it is going to be addressed.

The developer now works on the issue; the state of issue is then changed to Under Investigation. If developer finds a problem in source code, system design or application configuration and comes up with a resolution. The status will be resolved, otherwise the issues will be closed. At this stage, developer records the defect category. As the problem is now fixed, two more steps remain: the testers must confirm the success of the fix (resulting in under testing state). If the tester found issue is fixed, report will go to state Closed. Otherwise issue will go back to Under Investigation state.

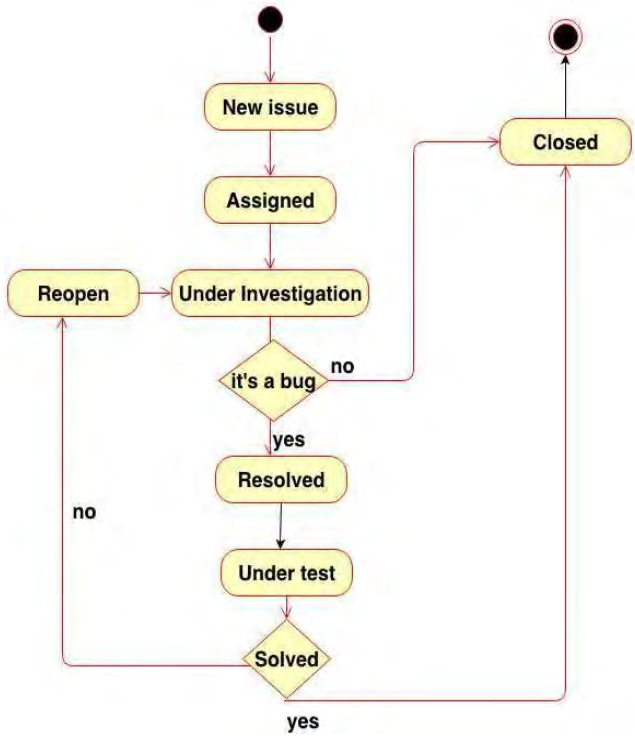

Figure 2. Bug life cycle

3. DATA CLASSIFICATION

Data surround us through scientific, demographic, financial and marketing fields. People have no time to look at these data. Human attention has become the important resource. Researches invented techniques to automatically summarize data, and discover hidden patterns from large amount of data to transform them into useful information which called mining techniques. There are different data mining techniques for recognizing patterns from the data, e.g., classification, association rule mining and clustering [11]. Data mining classification techniques classify the data according to some predefined categorical labels.

Classification is the process of building a model by learning from a dataset. Classification is a two-step process, learning and classification. In the first step a classifier model is built by determining the characteristics of each class from the given training dataset which consists of training instances with associated class labels [12]. For example, suppose $X(x_1, x_2, x_3,...x_n)$ is a training instance where x_1, x_2, x_3,...x_n represent the features (attributes) and n is the number of features.
Each training feature provides a piece of information to the classifier that helps in determining the characteristics of the class. For each X_I there is a special attribute (class label) which represents its class Y_I . This step can be viewed as learning of a function $y = f(x)$ where *y* is the predicted class label and *f(x)* may be some rules or mathematical formulae. In the second step, the function is used to predict the class label *y* for new instances. In case of a rules-based classifier, rules are used to characterize the new instance in an appropriate class. In case of mathematical formula, feature values are plugged into the equation to find its class label.

Accuracy of the classifier is the percentage of test samples correctly classified by the learned classifier model. The dataset that is used for testing or validating the classifier is unseen data (not used for training). In the validation process, we know the actual class labels of the test data but the classifier is not aware of them. Although a number of classification algorithms are available e.g., Naive Bayes, Support Vector Machine (SVM), Decision Trees and Neural Networks. In the following subsections we describe Naive Bayes and K-Nearest Neighbors. These two classifiers have been used by various researchers for text classification and have shown promising results [13].

3.1 Text Mining Approach

Automatic text classification or text categorization, a subtopic in machine learning, is becoming increasingly important with the ever-growing amount of textual information stored in electronic form [14, 15]. It is a supervised learning technique, in which every new document is classified by assigning one or more class labels from a fixed set of pre-defined classes. For this purpose a learning algorithm is employed that is trained with correctly labeled training documents [16]. The documents are generally represented using a ”bag of words” approach, where the order of the words is ignored and the individual words present in the document constitute its features. The features present in all the documents make up the feature space. Since the number of words can be very large, the resulting learning problems are generally characterized by the very high dimensionality of the feature space, with thousands of features. Hence the learning algorithm must be able to cope with such high-dimensional problems, both in terms of classification performance and computational speed.

3.2 Challenges

To satisfy such a strong need to predict bugs severity, in this paper, researchers propose a new approach that applies text mining on natural-language found in description of bugs. The study faces a lot of problems found with processing natural-language. Researchers discuss the challenges that face the study to produce such effective approach as follow:

1. Designing an algorithm with accuracy exceeds (Area under ROC evaluation method) for compared algorithms to deal with Textual-Data which include natural text and related problems such that synonyms (two words have the same meaning), ploynyms (the same word has more than one meaning) and stopper words (The, a, an ?etc).
2. Which field in the bug reports serves as the best prediction basis?
3. Training period and evaluation measures: How many samples must be collected before one can make a reliable predictor? How effective is our model at classifying severity of a given for a given Bug Report.
4. Difference between the improvements the paper suggest and others´ solution.

3.3 Related Work

As the bug database grows, it becomes a projects memory of the group-listing all the problems as they occurred in the past, and how they were addressed. This memory can be a valuable resource when it comes to assess the project’s future. The analysis of defects in Bug repositories can provide feedback for defect prevention in later iterations, researchers to benefit from, a lot of researchers use defect analysis as a powerful concept to improve the quality [17]. The key solution to increase productivity in software projects by learning from history.

Kanwal and Maqbool [18] built a text approach using SVMs to prioritize the newly coming issues. They used bug report features (online summary) to prioritizing bugs. Ac-curacy of the classifier increased when training features were combined. Runeson [19] predicts duplicated bug reports by finding the similarity of bug reports using the vector space model. Results show that 2/3 of the duplicates can be found using this technique.

Cathrin [20] built a classifier that is automatically predicts fixing effort. She used training dataset from the JBoss project. Classifier depended upon KNN [21] approaches by using on line summary of bug report. She made a new evaluation method to measure accuracy of her prediction which was called average absolute residual. Evaluation method represented the differences between the predicted effort pi and actual effort ei. The prediction lies within 50 % of the actual effort value.

Shuji [22] build a model to detect defect correction effort based on extended association rule mining; they defined defect fixing effort as a variable and appropriate association rule mining to treat with such variables. Data used are supported from Japan’s Ministry of Economy, Trade and Industry (METI), use Support and Confidence as Evaluation factors. Results for their approach expressed as correction effort based on development stage for example, Defects detected in coding and unit stages will be easy to correct(7% of mean effort) when they are coming with validation of input data.

Emad and Walid [23] have developed an approach for predicting re-opened defects through Eclipse projects, their study depend upon some factors such as work habits dimension like: day which issue is closed, the bug report features dimension like: components, the bug correction dimension like: time needed to fix bug. They evaluate their model with 62.9% precision and 84.5% recall when predicting whether a bug will be re-opened.

Zaman and Adams [24] who have analyzed the features of different types of bugs such as security and performance bugs to get useful information for their behavior in terms of the bug fix time, the number of developers assigned and the number of files impacted. Their Results show that security bugs are more complex, required more developers with experience, and large number of files affected but took less fix time than performance and other bugs. Similarly, performance bugs need more experienced developers than the other bugs.

Lamkan and Demeyer [25] predict severity of bug report using classification model for serve and non-serve issues. They used online summary field of bug report for prediction based on SVM, Naive Bayes, Multinomial Naive Bayes and Nearest Neighbor Classifiers which make better performance in results. Results were evaluated using ROC (receiver operating characteristic) curve [9]. Performance of Multinomial Naive Bayes was found to be better than that of other classification algorithms.

4. PROPOSED METHODOLOGY

Naive Bayes is a learning algorithm that is frequently employed to tackle text classification problems. It is computationally very efficient and easy to implement. There are two event models [26] that are commonly used: the multivariate Bernoulli event model and the multinomial event model. The multinomial event model frequently referred to as multinomial naive Bayes or MNB for short generally out-performs the multivariate one, and has also been found to compare favorably with more specialized event models [27]. However, it is still inferior to the state-of-the-art

support vector machine classifiers in terms of classification accuracy when applied to text categorization problems [28, 29, 30].

However, recently a new algorithm has been proposed, called" transformed weight-normalized complement naive Bayes" (TWCNB) [31], that is easy to implement, has good running time and is claimed to be nearly as accurate as sup-port vector machines [32]. TWCNB is a modified version of MNB that is derived by applying a series of transformations relating to data and MNB itself.

4.1 Feature Generation

As in mentioned before about "bag-of-words" approach each issue report is represented as a set of words and the number of times each word occurs in the document. In other words, each issue report has the words as its attributes or features and each attribute can take on an integer value counting the number of times the particular word occurs in the issue report. The set of words (also called" dictionary") is generated from all the issues reports present in a dataset. For a particular dataset, we first determine its dictionary by reading all the reports present in it. Then, for each report, we record the number of times each of the words in the dictionary occurs in it including those that did not occur by giving them a value one.

There are several ways of determining the word weight. Let f_{ij} be the frequency of word *i* in document *j*, *N* the number of documents in the collection, *M* the number of distinct words in the collection, and n_i the total number of documents have word i in the whole collection. The simplest approach is Boolean weighting, which sets the weight a_{ij} to 1 if the word occurs in the document and 0 otherwise. Another simple approach uses the frequency of the word in the document, i.e., $a_{ij} = f_{ij}$. A more common weighting approach is called *TF.IDF* (term frequency - inverse document frequency) weighting as given in equation [1].

$$a_{ij}=f_{ij}\times\log\frac{N}{n_i} \qquad (1)$$

A slight variation of the *TF.IDF* weighting, which takes into account that documents may be of different lengths, as given in equation [2].

$$a_{ij}=\frac{f_{ij}}{\sum_{i\to 1}^{M} f_{ij}^2}\times\log\frac{N}{n_i} \qquad (2)$$

4.2 Review of Multinomial Naive Bayes

Let us now discuss how multinomial naive Bayes computes class probabilities for a given document. Let the set of classes be denoted by C. Let N be the size of our vocabulary. Then MNB assigns a test document D_j to the class that has the highest probability

Prob(c | D_j), which, using Bayes S rule, is given by Equation 3.

$$Prob(c|D_j)=\frac{Prob(D_j|c)*Prob(c)}{Prob(D_j)} \qquad (3)$$

The class prior Prob(c) can be estimated by dividing the number of documents belonging to class c by the total number of documents. Prob(Dj | c) is the probability of obtaining a document like D in class c and is calculated as given in Equation 4.

let T_1, T_2 ... T_m be the sequence of lexical terms in D_j . We will assume that the occurrence of a term T in the I_{th} place of D_j depends only on the category c and, given c, is conditionally independent of all the other terms in D_j and of the position I. Calculation will be as given in Equation [4] where Prob(T_{ij} |c) means the probability that a randomly chosen word token in c is the word T_{ij} and m is the number of words in D_j .

$$Prob(D_j|c)=\prod_{i=1}^{m} Prob(T_{ij}|c) \qquad (4)$$

By estimating Prob(T_{ij} |c) and Prob(c) using the training set and calculated as the relative frequency of T_{ij} in documents of category c as given in equation [5].

$$\text{Prob}(T_{ij}|c)=\frac{1+f_{ic}}{N+\sum_{x\to 1} f_{xc}} \qquad (5)$$

Where f_{ij} is the count of word i in category c and f_{xc} is the frequency of word x given in training belong to class c.

4.3 Transformed Weight Normalized Complement Naive Bayes

As mentioned before, TWCNB [31] has been built based on MNB and is very similar to it. One difference is that the TF.IDF transformation is part of the definition of the algorithm. But the key difference is that TWCNB estimates the parameters of class c by using data from all classes apart from c (i.e. it uses the complement). To this end Equation 6 is called word weight rather than probability and redefined in the following way:

$$a_{ic}=\log\frac{1+\sum_{k=1}^{|C|} f_{ik}}{N+\sum_{k=1}^{|C|}\sum_{x=1}^{N} f_{xc}}, \quad k\neq c \wedge k\in C \qquad (6)$$

The word weights are then normalized for each of the classes so that their absolute values sum to one and the classification for test document D_j is given by Equation 7.

$$\text{Class}(D_j)=\text{argmax}_c[\log(\text{Prob}(c))-\sum_{i=1}^{n}(f_{ij}.a_{ic})] \qquad (7)$$

Because of the value of log(Prob(c)) is usually negligible in the total, can be simplified as given in Equation 8

$$Class(D_j)=argmin_c[\sum_{i=1}^{n}(f_{ij}.a_{ic})] \qquad (8)$$

The parallels between MNB and TWCNB can easily be observed if we look at the classification rule for MNB given

in Equation 9

$$Class(D_j)=argmax_c[\log(Prob(c))-\sum_{i=1}^{n} f_{ij}\log\frac{1+f_{ic}}{N+\sum_{x=1}^{N} f_{xc}}], \quad (9)$$

For multi-label datasets, a classifier S performance is often measured using the precision-recall break-even point, for which we need some kind of document score representative of how likely a document is to belong to a class. Normally, a different classifier is trained for every class: it learns to predict whether a document is in the class (positive class) or not (negative class). This approach is also known as S one versus rest T. Although this method can be used with MNB, it

does not work when used with TWCNB. Unlike MNB, where

Equation 2 can be used directly in conjunction with the one-

Versus rest method, TWCNB's scores (given in Equation 7 and

Equation 8) cannot be used directly because they are not comparable across different test documents due to the missing normalization step. Hence a different method is used in [31], as described in the appendix of that paper. This method can be called all vs rest.

Based on the all-vs-rest approach, TWCNB's score [31] is calculated as follows :

$$docSore(D_j)=\sum_{i=1}^{n}(f_{ij}.a_{iA}-f_{ij}.a_{iR})$$

In the above, a_{iA} is the word weight with data from all the classes, and a_{nR} is the word weight obtained from the "rest" (i.e. all documents not pertaining to the class that we are computing the score for). Table 2 gives a brief for mapping words.

4.4 Applying TWCNB Algorithm on Bug Repository

The bug reports we studied originated from GNOM where the severity varies from Trivial, Minor, Normal, Major, Critical to Blocker. There exist clear guidelines on how to as-sign the severity of a bug listed in Table 1. GNOME is a mining challenge for MSR [1]. Actually bug reports found in

Table 2. Mapping words

Terms	Mapping Items
N	Total number of issues
n	Total number of words in issue report
M	Total number of distinct words
n**i**	number of times word i occurs
a**ic**	word's i weight in class c
a**iA**	word i's weight with data from all the Classes
a**iR**	the word weight obtained from the rest classes that not include mentioned one
f**ij**	frequency of word i in issue j
D**j**	j training issue

[1]MSR: Mining Software Repository Conference http://msr.uwaterloo.ca/msr2010/challenge

GNOME repository contain bad steps, scenarios and data due to the reporter is a user of Mozilla Products (which GNOM Owner). Reporter does not have any technical experience and thus make the classification be quite difficult. The same thing for Eclipse bug repository.

Important information specifying bug is entered in through title and description fields of the bug report. Title contain more important keywords to the problem found in software.

While description has steps to reproduce the bug. Thus, merging them when measuring bugs scores. The following are steps will be applied to implement our approach:

1. Selecting training dataset and apply the classifier to training set.
2. Begin evaluation phase on evaluation set.

4.5 Selecting Training Dataset and Apply the Classifier to Training Set

For GNOM Bugs training set, we have about 400,000 bug reports as found in Table 3 and for selecting mapping between all those categories for bad reports contents, we have two main categories Serve (critical and major issues) and Non Serve (minor and low issues) categories. for GNOM bugs repository we remove issues with normal and enhancement severity to be as compared paper.

Table 3. Complete reports categorization for GNOM & ECLIPSE

Product	Component	Non-serve	Serve
Evolution	Calendar	519	1914
Evolution	Mailer	5681	2107
Metacity	General	230	210
Nautilus	CD-Burner	220	400
GNOME	Panel	400	1006
GStreamer	Core	93	352
Eclipse	SWT	696	3218
Eclipse	User Interface	1485	3351
Eclipse	Debug	327	485
CDT	Debug	60	205
GEF	Draw2D	36	83
JDT	User Interface	620	790

Applying the classifier TWCNB as a categorization method can be easily adapted to new coming issue which is summarized as:

1. Preparing data to be suitable for Algorithm as follow:

   A. Clean Data: Misspellings were common in the fault logs. A common error in the input data was words concatenated together where spaces should have been used to separate the words, e.g. "fixedthe" we overcome this issue by provide spell checking feature was employed.

   B. Stemming Process: Prefix and Suffix of the words cause some confusion and miss understanding of the words to overcome this issue we develop stemming algorithm to clear the words from suffix and prefix of the words such as : pre, tion, lly...etc.

   C. Stop Words: there are some stop words such as: the, a, an...etc which found frequently in issues and does not cause any difference in the meaning and for thus we

develop an algorithm to clean the description from those words.

2. Transform tested issues using words weighted method as given in Equation 6.
3. Then measure the scores for new issue against each severity as given in Equation 10.
4. Issues severity's scores are sorted and highest score is chosen.
5. Mapping Issue's severity to mapping severities function.

4.6 Parameter Setting

In order to evaluate the performance of the classifiers TWCNB, we replay the history of the issue tracking system. By considering classification techniques using two classes for five known severity mapping. Formally, each instance I is mapped to one element of the set Serve and Non serve of class labels. A classification model maps from instances to predicted classes. Given a classifier and an instance, what are the possible outcomes for the classifier? if the predicted match with predefined severity then it will be true predict, otherwise it will be false predict. There are some expressions to ensure the validity of the evaluation method:

1. TPR (true positive rate): The percentage of all bug reports that actually predicted as T as follow:

$$TPR(T) = \frac{\#\ bugs\ \ correctly\ \ predicted\ \ as(T)}{\#\ bugs\ \ of\ \ severity(T)}$$

2. FP Rate (also called false alarm rate) of the classier is:

$$FP\ rate(T) = \frac{\#\ bugs\ \ incorrectly\ \ classified\ \ as(T)}{\#bugs\ \ predicted(T)}$$

Having a confusion matrix, sketched in Table 4 This matrix represents all possible outcomes when making predictions of the severity

According to the table 4 we calculate FP rate and TP rate for each severity as follow:

$$TPR = \frac{TP_{serve}}{TP_{serve} + FP_{non\ serve}}$$

Table 4. Confusion matrix

	True Classes		
		Serve	Non Serve
Predicted Classes	Serve	T P serve	F P non serve
	Non Serve	F P serve	T P non serve

$$FPR = \frac{FP_{serve}}{TP_{serve} + FP_{non\ serve}}$$

$$Accuracy = \frac{TP_{serve} + TP_{non\ serve}}{\#\ of\ instaces\ in\ Dataset}$$

To evaluate the performance of the classifier we use Receiver Operating Characteristics (ROC) graphs [9] that are useful technique for organizing classifiers and visualizing their performance. The ROC curve for a binary classification problem plots the true positive rate as a function of the false positive rate. The points of the curve are obtained by sweeping the classification threshold from the most positive classification value to the most negative. For a fully random classification, the ROC curve is a straight line connecting the origin to (1, 1). Any improvement over random classification results in an ROC curve at least partially above this straight line. The AUC is defined as the area under the ROC curve.

Consider a binary classification task with m positive examples and n negative examples. Let C be a fixed classifier that outputs a strictly ordered list for these examples. Let $\{x_1 . . . x_m\}$ be the output of *C* on the positive examples and $\{y_1, y_2, . . . , y_n\}$ its output on the negative examples and denote by 1_X the indicator function of a set X. Then, the AUC, A, associated to C is given in equation 11 which is the value of the Wilcoxon-Mann-Whitney statistics [33].

$$A = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} 1_{x_i > y_j}}{m \times n} \qquad (11)$$

Thus, the AUC is closely related to the ranking quality of the classification. It can be viewed as a measure based on pair wise comparisons between classifications of the two classes. It is an estimate of the probability Pxy that the classifier ranks a randomly chosen positive example higher than a negative example. With a perfect ranking, all positive examples are ranked higher than the negative ones and A = 1. Any deviation from this ranking decreases the AUC, and the expected AUC value for a random ranking is 0.50. Pseudo code to calculate AUC as follow:

Inputs L , the set of test instances; f (i), the classifier estimate that instance i is positive; min and max, the smallest and largest values returned by f ; increment, the smallest difference between any two f values.

1. for t = min to max by increment do
2. FP = 0
3. TP = 0
4. for i to L do
5. if f(i) is greater than t then This example is over thresh-old
6. if i is a positive example then TP = TP + 1
7. else then FP = FP + 1
8. Add point (FP /N, TP /P) to ROC curve

5. EXPERIMENT RESULTS

In this section we introduce results by applying TWCNB on two bug repositories (GNOM and Eclipse) and comparing the results to other algorithms found in [7, 8]. Comparison will be listed in

Table 5 which evaluates the performance of the classifier through Area under (ROC).

As found in comparison listed in Table 5, there are better improvements in predicting GNOM issues which range from (0.90 to 0.95) for TWCNB comparing to (0.71 to 0.92) for other algorithms and in case of Eclipse range from (0.69 to 0.837) for TWCNB comparing to range from (0.55 to 0.83) for other algorithms. One of the weakness found in compared papers [7, 8] is that there are no entry for time spent in the whole experiment. Papers represent time only two component and do not specify the machine specification (which ran the whole experiment).

5.1 Measuring System Accuracy

Through our study, we use Cross Validation technique [34]. Cross validation is a model evaluation method that is better than simply looking at the residuals. Residual evaluation does not indicate how well a model can make new predictions on cases it has not already seen. Cross validation techniques tend to focus on not using the entire data set when building a model. Some cases are removed before the data is modeled; these removed cases are often called the testing set. Once the model has been built using the cases left (often called the training set), the cases which were re-moved (testing set) can be used to test the performance of the model on the unseen data (i.e. the testing set). As shown in Figure 3 , 4 learning curve for ”Evolution -Mailer” and ”JDT-UI” components for the TWCNB classifier.

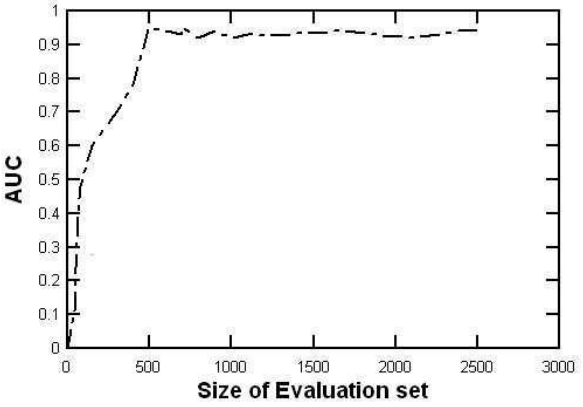

Figure 3. Learning curve of learning curve of Evolution - Mailer

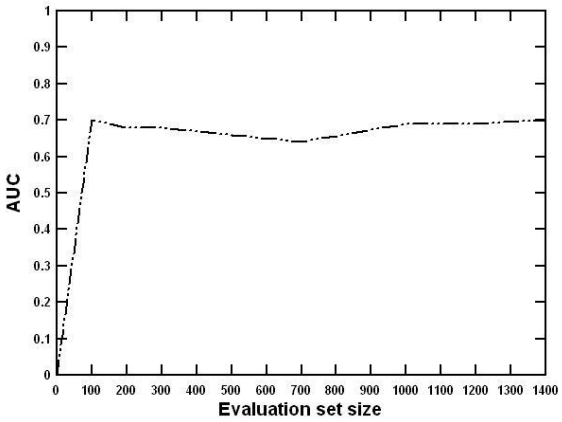

Figure 4. Learning curve of learning curve of JDT/UI

6. DISCUSSION AND FUTURE WORK

This paper presented a solution for prediction of defect severity by using an efficient text mining algorithm to facilitate the job and compare this to four algorithms [8] using ROC graphs to simulate the results. One of them matches with our proposed solution, by exploring in experiment' results we found that TWCNB has a wide performance if it's compared with MNB. For example in GNOM Mailer component; proposed solution gives 0.95 whereas MNB give 0.89 for AUC. This is from one side, from the other side proposed solution give results better than MNB as listed in Table 5 for the following components {Evolution - Calendar, GNOME - Panel, Metacity - General, GStreamer - Core and GEF - Draw2D}. There are draw for {Eclipse - SWT and CDT - Debug} components. Proposed solution has an increase accuracy rate for most of GNOM repository's components. For Eclipse repository we have one component that exceeds the accuracy of other compared algorithm. There are two components have the same accuracy for Eclipse components. The total results refers that proposed solution got almost accuracy for the both repositories.

6.1 What are the Weaknesses of Other Algorithms Results?

Existing researches [7, 8] that have investigated predicting bug severity depend upon exclude normal severity from data set and didn't not consider that a wide range of the issues came as normal. our claim depend upon instead of using two mapping severities we can use three mapping categories for serve, non serve and normal and thus can be presented in next builds. the second claim about performance of the classifier according to time spent, through the compared researches we got that only two components have a clear measure of the experiment but other components do not have. and thus make a confusion for the relationship between the accuracy of the classifier using AUC and time spent for doing the experiment.

6.2 Future Work

We expect to process in the future some enhancement to Bug tracking System such as:

1. Automatic User expertise Prediction: which can pre-dict the expertise of the Reporter and hence can have more options and find help as the level of the expertise can have.

2. Automatic bug assignment: which can predict the best one to solve the new coming issue from analysis of the source code and description found in the report?

3. Identifying the security issues based on analysis of soft-ware repository.

Table 5. Comparison between algorithms and proposed solutions using AUC

Product – Component	Compared algorithms				Proposed Solution
	NB	NB Mult	1-NN	SVM	TWCNB
Evolution – Mailer	0.84	0.89	0.73	0.87	0.95
Evolution – Calendar	0.86	0.90	0.78	0.86	0.92
GNOME – Panel	0.89	0.90	0.78	0.86	0.93
Metacity – General	0.72	0.76	0.69	0.71	0.94
GStreamer – Core	0.74	0.76	0.65	0.73	.90
Nautilus – CDBurner	0.93	0.93	0.81	0.91	0.91
Eclipse – SWT	0.74	0.83	0.62	0.76	0.83
JDT – UI	0.69	0.75	0.63	0.71	0.70
Eclipe- UI	0.70	0.80	0.61	0.79	0.70
Eclipse – Debug	0.72	0.76	0.67	0.73	0.69
GEF - Draw2D	0.59	0.55	0.51	0.48	0.82
CDT – Debug	0.68	0.70	0.52	0.69	0.70

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The Adapted V-Model, A Practical Approach to Agile Testing

Yasser Ghanim
Software Engineering Competence Center
ITIDA, B121
Smart Village, Giza, Egypt
yghanim@itida.gov.eg

ABSTRACT

Agile methods largely remove the distinction between phases and roles with no predefined order of steps. Some agile approaches such as Test-Driven Development (TDD) switch the traditional order of coding and testing and largely remove the boundary between the two implying that testing is becoming more a technical responsibility of the developers! Testers are complaining of loss of identity and scope within agile teams. In parallel some modern non-agile testing approaches such as Risk-based testing also open the boundaries between testing and analysis and suggest more involvement of testers in business and system analysis and also system architecture. This paper suggests a practical approach that aligns the modern testing approaches with agile approaches and sets a clear framework for such alignment. Scrum will be taken as a representative for Agile. The paper devises an adapted version of the V-Model for Scrum. The proposed approach is developed based on the Testing Process Improvement Guide (TPIG) developed by the Software Engineering Competence Center.

Keywords

Agile, Testing, Process Improvement, SCRUM, ISTQB, V-Model, TPIG

1. INTRODUCTION

In 2001, a group of individuals agreed on a common set of values and principles which became known as the Manifesto for Agile Software Development or the Agile Manifesto [1], [2]. The Agile Manifesto contains four statements of values:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

The Agile Manifesto argues that although the concepts on the right have value, those on the left have greater value.

Testing and development are tightly related, and thus testing varies between the different development lifecycles. Testers must understand the differences between testing in traditional lifecycle models (e.g., sequential such as the V-model or iterative such as RUP) and Agile lifecycles (e.g. Scrum, XP, Pair Programming…etc) in order to work effectively and efficiently.

In another direction, testing has become a well-established discipline with the emergence of many testing standards and models. The main concern of testing is assessing product quality and isolating defects. This is an agreed goal whether in traditional or Agile setups. Traditionally, testing was viewed as the safety net applied toward the end of the development lifecycle to protect the end user from potential product failures (product/quality risks). Testers were advised to plan for testing as an independent activity from product construction (design and coding) and to provide separate testing role/function for objective and independent evaluation. However the Agile methods largely remove the distinction between roles and functions inside the development team. Even when cross-functional teams are formed, team members are not assigned distinctive roles but are rather referred to as The Team (as per the Scrum methodology) Some aggressive quality-oriented agile approaches such as Test-Driven Development (TDD) in the XP methodology switch the traditional order of coding and testing and largely remove the boundary between them. Jonathan Kohl, a known blogger and lecturer on software testing writes on his blog: "*I welcomed Agile Development, and have championed it now that I've experienced it. I didn't feel a threat to my job as a tester, but I knew things were going to change. The only thing that bothered me was a new impression towards testers that seemed to be emerging. The attitude sounded like: we're doing testing now thank you very much, so we don't know where you will fit in Agile projects"*. [3]. One main aim for this paper is to show where testers fit in agile projects.

In parallel, some modern testing approaches soften the boundaries between testing and business/system analysis. The modern approach of risk-based testing assigns greater business analysis responsibility to testers and gives them more exposure and involvement in system analysis and also system architecture.

The paper discusses a practical approach that aligns modern testing approaches and techniques with the agile approaches and devises a clear process framework for such alignment in the form of a modified V-Model for agile. The widely accepted ISTQB syllabus and its Fundamental Test Process will be taken as reference for modern testing approaches. Scrum which is the most widely spread agile approach will be taken as a representative for Agile methodologies. The paper falsifies the hypothesis that testing as a role is demolishing or receiving smaller weight in agile teams. In contrary the paper assigns higher weight to skilled testers within agile development.

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2. INDUSTRY ANALYSIS

This section shows how both testing and scrum certifications and trainings are sought by the software engineers in Egypt as an indicator for the industry shift toward modern testing as well as agile methodologies. The paper observes an increasing demand on proper alignment between modern testing and agile development. Testing training and certification have witnessed great growth in Egypt in the past five years. We will base our analysis on the ISTQB training and certification in Egypt as ISTQB has become the most used reference for SW testing.

Since the first ISTQB training arranged by SECC in 2009 to a limited number of test engineers, hundreds of testers are now certified against the different ISTQB levels. The growth reflects the needs for modern and systematic testing approaches to deal with the ever increasing business and technical complexity. In response to this, SECC founded the Egyptian Software Testing Board (ESTB) which is the local arm of ISTQB in Egypt.

For Agile, demand is also evident. More companies and individuals are seeking agile services and training. Testers are now required to align with companies requirements to work within agile teams.

This section depicts the growth/trend in seeking both ISTQB and Scrum courses and certifications. Data is based on SECC records. It is to be noted that all data are collected till end of August 2014 which means 2014 figures are subject to increase.

2.1 Testers Demand on Testing Certification

Nearly two thousand test professionals from all levels have taken the ISTQB foundation level exam in Egypt through the ESTB (additional unknown number might have taken the exam online, but it is expected to be marginal.) Little more than half this number succeeded in obtaining the certificate.

Figure 1. ISTQB Certification in Egypt

In parallel, SECC is offering training in a number of selected testing topics offered in greater depth than the ISTQB standard training. Testers demand on testing courses offered by SECC is shown in this chart:

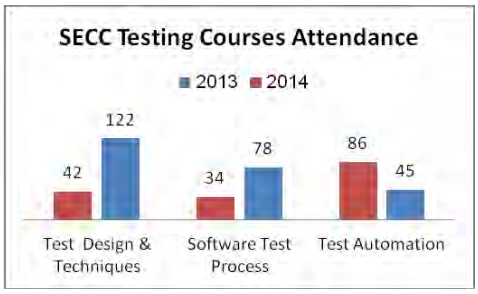

Figure 2. SECC Testing Training Courses

It is interesting to see that Test Automation is ranked as number one testing course in 2014, with the big role Test Automation plays in agile development as the paper discusses below.

2.2 Demand on Agile Certification

In the other dimension of Agile/Scrum training and certification, agile professionals' demand on the relevant courses and certifications offered by SECC is shown below:

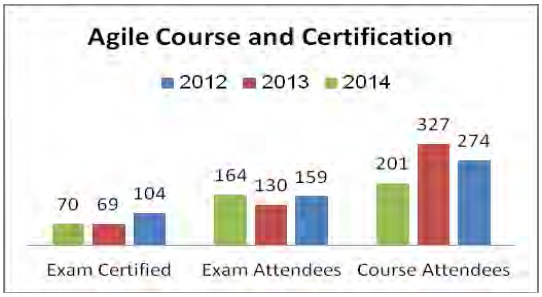

Figure 3. SECC Agile Courses and Certificates

For companies seeking agile services, SECC records shows that since mid 2012 SECC provided Agile consultation service to around 30 Egyptian software houses including some of Egypt's leading software houses with 200+ professionals.

SECC training records do not show the percentage of testers among the agile trainee and certificate seekers. However the ISTQB provides some useful data on the percentage of testers interested in Agile.

Among the software professionals interested in Agile, more testers are becoming interested in Agile Testing. As per the research conducted by the ISTQB in May 2014, 64% of the surveyed test engineers are interested in Agile Testing certification. The following question was asked to test engineers and test managers: "would you be interested in Agile Tester Certification?" The answers were as follows with 64% of test engineers and 63% of test managers answering with yes:

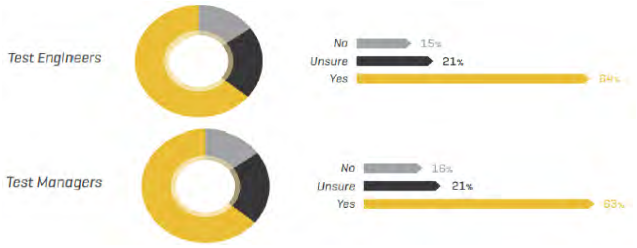

Figure 4. ISTQB Testers Survey

We can conclude that Agile development in general and Agile testing in specific are dragging more inertest and witnessing an increasing demand by software engineers including test engineers. In parallel modern testing whether within traditional or agile contexts is also a hot topic, and test engineers understand the need for more systematic and more aggressive testing approaches to deal with the quality challenges posed by the complex modern applications and complex business needs. The paper concludes high urgency and importance within the software industry in Egypt for aligning modern testing frameworks with Agile development. Reasonable assumption can lead to extending this conclusion to the software industry abroad.

3. TESTING IN TRADITIONAL DEVELOPMENT (THE V-MODEL)

The V-Model is the basis for many other SW Development and Testing models such as CMMI, TMMI and ISTQB. It provides the view of testing as a process that runs in parallel with development. It also relates the test execution phases known as test levels to product construction phases allowing for more systematic test preparation and also test participation in construction (through reviews and static verifications).

The V-Model was traditionally considered as a Water-fall model. However, it can easily be applied to iterative development. For agile, this paper proposes (in the coming sections) an adapted version of the V-Model that supports collaborative development.

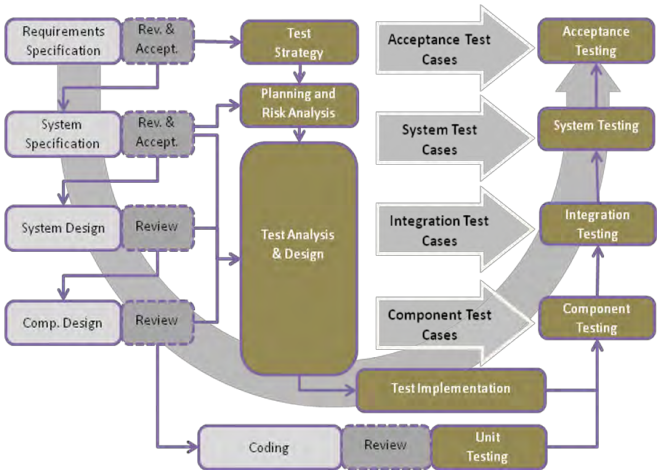

Figure 5. V-Model

4. UNDERSTANDING TESTING IN AGILE

Do testers really have to work differently in agile projects? What challenges meet them? And how can they adapt to agile testing?

4.1 Tester's Challenges in Agile Projects

The first main difference between traditional and agile development is the idea of short iterations (sprints in Scrum). Testing is no longer an independent phase at the end of the project. Iterations must result in working (possibly shippable) product increments, which means well-tested components.

Testing iteratively poses challenges to testers which include (for instance): testing is no longer done in isolation and testers have to closely coordinate with the developers, handling regression testing which leads to increasing testing load over iterations, and dealing with technical-oriented activities such as test automation.

Table 1. Responsibilities in Traditional Teams

Activity/ Work Product	**Traditional Development**		
	Analyst	**Developer**	**Tester**
Business Req.	Develop	-	Understand
Acceptance Criteria	Support	-	Develop UAT Test Cases
System Req.	Develop	Understand	Understand
Test Cases	-	-	Design Test Cases
Coding / Unit Testing	-	Code / Unit Test	-
Test Automation	-	-	Automate Test Cases
Test Execution	-	Debugging & Bug Fixing	Execute Test Cases
Completion	-	Deliver Builds	Evaluate Exit Criteria

Another main difference is that the question of roles and responsibilities turns into a question of skills and experience. Agile sets no sharp distinction between roles and requires no specific team structure. It follows the whole-team approach where the team shares responsibility over project success.

The traditional separation of interests between quality and delivery is eliminated in agile. A single "done" definition is provided which embeds quality targets into the completion criteria for everyone. No team member can claim completion of tasks if the user story is not done according to the done criteria and is not yet "possibly shippable" to the customer.

The traditional dispute between quality and delivery interests owned by two distinct roles: delivery-oriented people (namely developers and PMs) and quality-oriented people (namely testers), is no longer valid. Accountability for both delivery and quality is equally shared. It is now a question of sufficing the necessary skills needed to achieve the "done" target than allocating different responsibilities to different roles.

So, the biggest challenge for testers when joining agile teams is to understand their participation in the other two areas and the amount of skills they need to acquire in the other skill sets.

The same thing applies to others. In agile teams (and supposed to be in traditional setups as well) quality is everybody's responsibility! As far as testing is concerned, everybody got to have a minimum level of testing and quality assurance skills.

We can categorize the skills needed within agile teams into three main categories and propose a minimum set of shared core skills by all agile team members to cover the essentials of each of the these areas and allow for more collaborative efforts toward a well-engineered and defect-sanitized product:

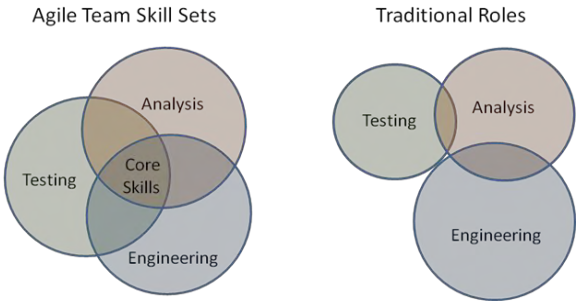

Figure 6. Testers Roles in Agile Vs. Traditional

Core skills include basic knowledge of the business domain, system analysis concepts, and general architecture and design understanding. For testers and developers some basic coding (scripting) skill is needed for testers, and some test design techniques skill is required for developers. Testers might need to understand the impact of certain design patterns on system testability and other quality characteristics.

4.2 Risk-based Testing and Agile

Risk-based testing is one of the important modern analytical testing strategies. It introduces a new philosophy to the testing

lifecycle. Traditional testing approaches depend on enumerating software requirements and designing test cases for the best requirement coverage. Requirements are treated equally and test execution is usually arranged based on First-In-First-Out basis with testing effort proportionate to development effort.

A product/quality risk means a potential failure (or failure category) that has direct impact to end user. Risk-based testing is defined by the ISTQB as an approach to testing to reduce the level of product risks and inform stakeholders of their status, starting in the initial stages of a project. It involves the identification of product risks and the use of risk levels to guide the test process [5]. This means the more harmful defects will receive more effort and more aggressive approach to detect and thus have a smaller chance to escape to the operational environment. Moreover, components with higher risk levels are supposed to be developed earlier in the project so they may be stabilized enough before the final deadline is reached.

The paper proposes an important intersection between risk-based testing and agile development as will be discussed later.

4.3 Test-First Development and Test-Driven Development (TDD)

4.3.1 Test-Driven Development (TDD)

TDD means writing automated test drivers (scripts) which represent a unit test case ahead of development so that developers will start writing code against it with the objective of getting the tests passed. Tests must start as failed with the absence of the corresponding code. As the unit code is developed tests start to pass. After passing their tests code units are refactored to improve their non-functional aspects keeping the tests passed. All unit tests must remain successful as any change occurs to any unit (see the continuous integration section below.)

TDD is largely considered as design and engineering practice rather than a quality control practices. However, in TDD quality is built in the product units from the beginning and testers can play an important role.

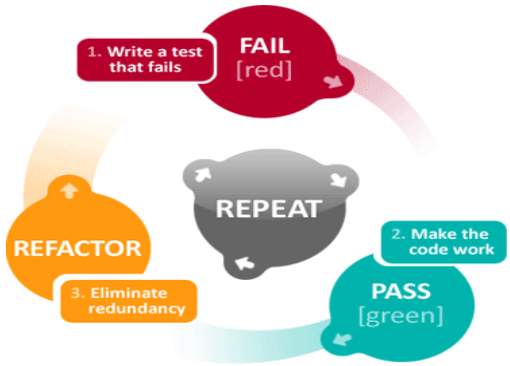

Figure 7. Test-Driven Development Cycle

In Agile development product modularity and maintainability is desirable to allow for more modifiable and change friendly code. Smaller parts of the product should independently function and provide value to end users. That means a code unit such as a class or a service will have clear user value than was in traditional development which reduces the distance between system testing and unit testing. Units are no longer purely technical with no clear traceability to system test cases, and testers can very well help in specifying and designing unit tests. Testers will start their test case specification on the unit level taking into consideration the functional role of these units. Testers can proceed (based on their skills) in automating and scripting such tests and handing them to the developers. The practice helps developers understand the value and business context of their code units, as well as it helps testers to understand product architecture and code structure.

The TDD (if well collaborated between testers and developers) enforces code granularity with strong business alignment which largely enhances product maintainability and changeability than if done by developers alone.

4.3.2 Test-First Development

Test-first development is the manual version of TDD where test cases are not automated. It is a less aggressive approach and does not lead to the same level of modularity, but at least it ensures developing against very clear and detailed targets and criteria. In this approach test cases are written against user stories rather than individual classes. Test cases are considered as detailed examples for clarifying the user story requirements to developers.

Specifying test cases in this approach starts before but can overlap with development. Testers start by writing positive (happy scenario) test cases. As developers are busy developing against these positive tests, testers continue specifying the negative and exceptional test cases which can then get addressed as another round of developing the target user stories.

The test-first technique works very well with the test condition techniques discussed below in the proposed approach.

5. THE PROPOSED APPROACH; THE TPIG AS A VEHICLE

The proposed approach uses the Testing Process Improvement Guide (TPIG) developed by SECC as a vehicle for applying the modern testing concepts and techniques suggested by the ISTQB to Agile development. It proposes an adapted version of the V-Model (the underlying model behind the ISTQB and TPIG) that will be described in the coming sections after explaining the underlying techniques.

5.1 The Testing Process Improvement Guide

The Testing Process Improvement Guide (TPIG) designed by SECC helps software houses in Egypt adopt modern testing approaches and build well-founded testing capabilities to gain a competitive edge with reference to product quality [6].

An important objective was to design a guide that helps companies align testing efforts with business objectives and product risk. TPIG achieves this by providing companies with an out-of-the-box and ready-to-implement process that is based on internationally proven standards and techniques such as ISTQB and TMMI. Another important benefit of the TPIG is that it also helps companies maximize return on investment in training and certifying testing teams by having a process definition that is well aligned with the common certification schemes (ISTQB). Similarly it helps testers to utilize the knowledge they gained in training and certification in applying mature testing processes with strong focus on business objectives. Thus TPIG closes the bridge between theory and implementation and between personal career interests and organizational business objectives. Hence it is a highly practical guide.

The TPIG is built in a flexible way for easy adaptation to any development methodology. It has proven success records in both traditional and agile environments.

5.2 TPIG and Risk-Based Testing

The TPIG is built around the Risk-Based Testing approach. The following TPIG procedures reflect this approach:

Table 2. TPIG and Risk-Based Testing

Test Strategy	Identify the generic product risks
Product Risk Assessment	Assess risk based on risk impact and probability.
Test Estimation	Risk profiling by mapping risks and assigning risk points to test objects.
Test Planning	Identify testing approach and techniques. Define exit criteria.
Design System Test Cases	Select test design techniques that match risk level
Test Phase Exiting	Calculate residual risk and compare to targets.
Prepare Test Summary Reports	Report based on risk resolution and residual risk level. Provide assessment of test objects viability for operations.

There is an important intersection between risk-based testing and agile. Test objects in traditional development become user stories where user stories are prioritized in the backlog considering the product risk level as one of the prioritization parameters. Other parameters may include urgency to business or dependency on other user stories. Testers can contribute their risk-assessment skills in this stage.

Product risks are very often measured based on their impact and probability. Impact means severity of the problem to the end user. The higher a failure impacts users' interests, the higher the effort testers must incur to prevent it. Measuring risk impact depends mainly on the type of the application and its operational environment. Analysis is needed to understand the role played by each function and its business sensitivity within the business domain. Such analysis requires domain experience (business analysis) and adds a lot of depth to understanding the business domain by the whole team. Such understanding is very important to testers as well as business and system analysts. It is an important intersection between testing and business analysis.

Analyzing non-functional risks such as performance and security require architectural knowledge and understanding technology impact on these quality characteristics. Proposed Architectural solutions can be compared for their ability to reduce non functional product risks.

Risk probability means the likelihood of certain functional or non-functional failures. The higher the probability the higher the effort to be allocated to detecting and fixing this failure. Failures with less probability will still get adequate attention which will normally be less than the more likely failures. It is common experience that failures' probability is proportionate to code complexity. Code and design complexity cause the probability to differ between two risks of equal impact. Probability may also be determined based on requirement complexity (e.g. calculations and mathematical equations are more likely to have mistakes made by analysts and developers.)

To understand the probability level of each risk, testers as well as analysts and developers must perform complexity analysis of the different system functions from both business and technical perspectives. The later will have to be done late in the development lifecycle when the technical architecture and design are available. Here come two more intersections with both business analysis and system architecture.

Risks are then assigned to test objects to create a complete risk profile of the application. Such risk profile will then be the basis for most of the decisions taken by test leads starting from selecting the proper testing approach, to test estimation, to evaluating test results and approving test exit. Drawing risk profiles requires good understanding of the proposed software which intersects with system analysis. A new intersection between testing and development.

Adequate resolution of risks (often called minimizing residual risk) is to be part of testing exit criteria and hence part of the done definition of any user story. Acceptance of user stories by Product Managers and Customers largely depends on the team success to reduce the probability of the identified risks below a safe threshold (probability can never get to zero). Assessment of the residual risk level and comparison to accepted thresholds is a skill contributed by testers.

So we can conclude that risk-based testing supports the collaborative development encouraged by the agile methodologies and adds more rigor to a number of agile practices. We can list the following intersections between testing and the other disciplines within the agile teams:

Business Analysis
Product risk identification and assessment workshops where both functional and non-functional risks are enumerated and studied for their impact.

System Analysis
Requirement complexity is assessed for evaluating product risk probability.

Product risk mapping and evaluation of their applicability to user stories.

System Architecture
Product risk probability is revised based on architectural decision. Architecture is selected/optimized for risk level minimization.

Release Planning
Stories are prioritized and allocated to releases and sprints with risk taken in consideration.

Story Completion
The done criteria of the user stories include reducing product risk probability and having residual risk below thresholds defined in the testing exit criteria.

The whole Risk-Based Testing approach improves the whole team understanding of both the problem and solution domain and builds a shared vision.

5.3 Risk Assessment and Mapping in TPIG

Risk assessment in TPIG starts by holding risk identification workshops. Brainstorming that involve business-oriented, quality-oriented and technology-oriented members is conducted which leads to big deal of coverage of functional and non-functional risks. Risks related to past experiences, architectural and technology decisions, sociopolitical environment …etc. which are often overlooked are highly likely to get captured

through these workshops. Risks are then analyzed for probability and impact to receive score that reflects the risk level.

The following TPIG sheet records the identified risks (both functional and non-functional) as the column headers with their relevant scores beneath them.

			Functional Risks **							Non-Functional						
ID	Test Object	Basic Object Functionality *	Product Risk 1	Product Risk 2	Product Risk 3	Product Risk 4	Product Risk 5	Product Risk 6	Product Risk 7	Product Risk 8	Product Risk 9	Product Risk 10	Risk Assessment Score	Effort Level	Object Size Points (Development)	Testing Risk Points
		5	6	6	9	9	9	9	9	9	9	9	267	%	Unit?	TRP
1	Object 1												0	0		0.00
2	Object 2												0	0		0.00
3	Object 3												0	0		0.00
4	Object 4												0	0		0.00
5	Object 5												0	0		0.00
6	Object 6												0	0		0.00
7	Object 7												0	0		0.00
8	Object 8												0	0		0.00
9	Object 9												0	0		0.00
10	Object 10												0	0		0.00

Figure 8. TPIG Risk Analysis and Mapping Sheet

Risks are then mapped to test objects (or user stories) recorded as rows labels. Risk-Object mapping includes a big deal of system analysis and understanding of the proposed solution as discussed before. The team has to evaluate the level of impact on each object and assign a rank from 0 to 3.

Based on this mapping the TPIG devises and test estimation method called Risk Point estimation that adjust varying testing depth to each object based on risk. Discussing the risk point estimation method in detail is out of scope for this paper.

5.4 Test Conditions as an Analysis Tool

Test Condition is defined by the ISTQB as "*An item or event of a component or system that could be verified by one or more test cases, e.g. a function, transaction, feature, quality attribute, or structural element.*" [5]

Test condition identification is an interim step between requirement understanding and test case derivation. Requirements are often represented in the unstructured form of textual description as in business requirements or user stories, or in a lightly-structured form as in use cases and operational scenarios. Unstructured requirements are often not concise enough and have room for ambiguity, omissions and under specifications as well as inconsistency, redundancy and over specifications. Requirement reviews may lead to considerable reduction in requirement anomalies. However, big percentage of these anomalies escapes review to reach the code. The less structured the requirement representation is the higher the chance for requirement anomalies. Structured representation may include lists, ranges, boundaries, equations, logical conditions, process diagrams…etc. Requirements that involve mathematical equations may not be expressed in textual format but should be specified using concise operations (e.g. <, >, <=, >= …etc.).

Deriving test cases from unstructured requirements is very heuristic and may lead to poor requirement coverage. Coverage cannot be guaranteed nor calculated for unstructured requirements. There is always a room for false assumption or between-the-lines inferences. Moreover systematic test design techniques cannot work on unstructured inputs. For a technique to apply systematic steps to derive test cases, requirements must be provided in a pre-defined structure that can be interpreted by the techniques. For example input data ranges with clear boundaries can be used as input for the Boundary Value Analysis (BVA) technique.

Having this said, Test Condition is a powerful approach to bridge the gap between requirement and test case and allow for the application of systematic Black-Box Techniques.

A test conditions usually takes the form of an attribute that has one or more mutually exclusive alternatives. For example a user account can be either: open, closed or suspended. An insured person could be either under 18 (Age <18) or from eighteen to sixty (18 =< Age <= 60), or older than sixty (Age > 60) where the "=" operation is clearly assigned to identify the exact boundary between age ranges. Without such level of specification there is always a chance for omitted account types (e.g. a closed account can be either expired or terminated), or ambiguous specifications of boundaries (18 is part of which range? Should the system accept ages up to a maximum value such as 99?) Test conditions leaves very little room for ambiguous or unconcise requirements. A number of black-box techniques can apply on test conditions such as Equivalence Partitioning, Boundary Value Analysis, and Decision Table.

Table 3. Test Condition Attributes

Test Condition Attribute	Description
Condition Name	Describe the general rule name such as Customer Age Bands or Account Type
Test Object	The system object (Screen, Service, Interface…etc.) on which the rule apply.
Requirement Reference	The user story, use case, or requirement item from which the condition is derived.
Condition Type	Conditions can be Boolean (True, False), Ranges, distinct values, or a constraint.
Alternatives	These are the different (mutually exclusive) cases for the conditions. Each condition can be an input range or a distinct value.
Expected Outcomes	The expected system behavior per alternative.
Related conditions	Other conditions that must be considered before determining the exact system behavior. E.g. the result depends on both customer age and account type.
Priority	Help determining the priorities of the derived test cases.

With the above examples of test conditions we can see that such level of structured specification although intended to serve test case design can also serve as an analysis technique on its own merits. Expressing requirements in such very detailed, concise, consistent, complete (…etc.) manner requires answering many questions and validating many assumptions. Should we consider age 18 part of the first or second age band? Should we have three or four account types? Should we reject age after certain limit? And so on. The one who can answer such questions is supposedly the customer or his representative such as the product manager. Such work can be very justifiably described as analysis work

rather than testing work with considerable business and system analysis skills involved.

Test condition specification provides big intersection between analysis and testing, and also big collaboration point between testers and developers. It is a powerful approach in any project setup whether traditional or agile.

However, in traditional setups such practice is rarely recognized as analysis effort, and little coordination is done between testers and developers in both producing and consuming test conditions as they are often considered part of the test process that is invisible to the developers. They cannot be validated by the customer to whom the tester has no access!

In Agile, test conditions can be recognized as full-fledged analysis activity that elaborates on user stories and allows testers to act as complete analysts who interact with the product manager as well as the customer. Test conditions are validated by all stakeholders and are no longer inputs to test design only but rather consumed by the whole team to provide a solid shared ground for design and coding. Design aspects such as "should the age field allow for more than two digits" can be discussed and made between developers and testers during test condition specification. There are many design aspects that can impact how test conditions are specified. The same set of requirement can be designed for better testability and more optimized tests impacting how test conditions and test cases are specified. A workflow system that has a generic toolbar that appear in all screens will be tested in a different way and with different number of test cases than a customized toolbar that changes from one screen to another. Validations that are done on a field-by-field basis require different test cases than aggregated validations at form submission, and so on.

5.5 Test Conditions and Test-First Approach

A more aggressive augmentation to this approach would be the use of the **Test-First** approach discussed earlier. In this approach the analysis role of the agile tester gets extended to include the test cases as well. The test cases serve as examples on the test conditions for the developer. The whole set of test preparation work products (test conditions and test cases) become the basis for the development work and provide the lowest possible level of analysis details that can ever be furnished to developers. Test execution becomes a matter of re-assurance while most defects are avoided from the beginning.

5.6 Regression Testing and Test Automation

Regression testing is highly related to change. Code changes may introduce risks to already tested and stabilized components. Even with loosely coupled product architecture, both business and technical impacts are never eliminated. Business impact means inter-related requirements with change on one requirement entails revision to the other. Technical dependency results from shared code resources. Regression is a big burden on testers as it requires rerunning previously passed tests.

In Agile, regression risks are higher as change is introduced all the time. Even if no user stories are modified after being developed, the fact that some dependency exist between user stories, require retesting previously completed stories with each new iteration. That means the more that we proceed with new iterations the more we will have old user stories possibly subject to regression. That makes the regression suite grow over time to an extent that could consume a whole iteration and the team velocity will get much slower by the time. The only solution to this situation is Test Automation (TA). Testers (and developers) are supposed to automate test cases (of all test levels) as they execute them for the first time (often manually) so little manual regression testing will be spent in future iterations.

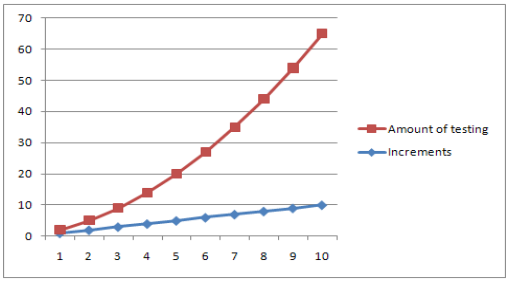

Figure 9. Testing Effort Growth per Iteration [7]

As mentioned later in the Continuous Integration section, TA suites whether for unit, integration or system tests can be included in the continuous integration process. So regression results can be reported to developers instantly (or daily) after code submissions.

The TPIG product suite provides guidance for TA planning as well as designing TA suites and frameworks [8]:

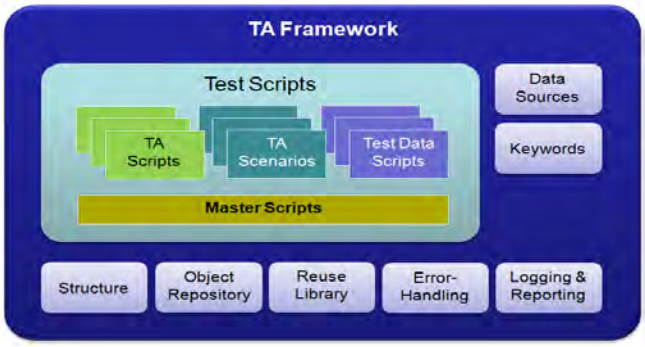

Figure 10. TPIG Test Automation Framework

Test Automation requires considerable planning and preparation and often meets technical challenges such as custom controls and complex programming interfaces. This makes Test Automation an important area for collaboration between developers and testes. It is possible that developers focus on unit test automation while testers focus on UI/System Test automation. But the more collaborative approach would be to work jointly toward all types and levels of test automation, resulting in a more efficient and well designed automation suite and hence a more efficient continuous integration suite.

5.7 The Adapted V-Model for Scrum

Many perceive the V-Model as a competing model to Agile development, very few proposals were made to align the V-Model to agile methodologies (e.g.: an article by Mr. Monteleone, President of Monteleone Consulting in 2013 on modernanalyst.com [9]) However, such proposals were mainly high level and don't adopt the ISTQB Fundamental Test Process.

This paper proposes an adapted version of the V-Model for Scrum that aligns test preparation and test execution activities (as defined by the ISTQB) with the activities proposed by the Scrum methodology. The adapted V-Model for Scrum highly integrates the test preparation activities into the product construction (Analysis/Design/Coding) activities.

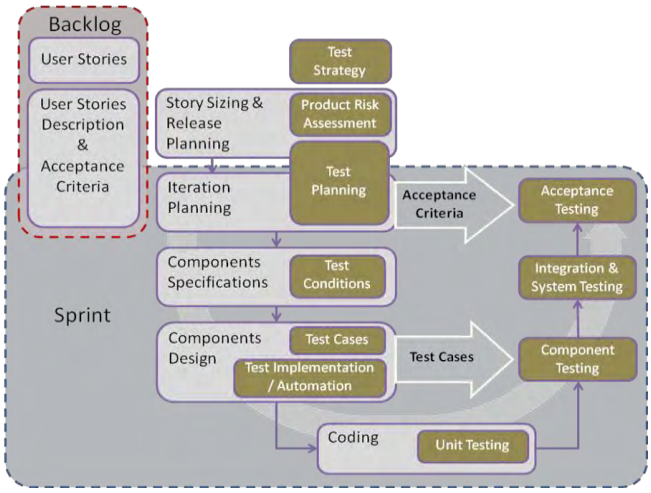

Figure 11. Adapted V-Model for Scrum

In the adapted V-Model, product components are specified, designed and coded with the whole team working hand in hand. Testers participate in the daily stand-ups, get involved in the architectural and engineering discussions, and start acquiring more engineering knowledge. Testers' quality concerns get incorporated into product and components design from the beginning. Reviews (formal or informal) become a culture with the whole team providing useful inputs.

Dealing with defects becomes more proactive. More defect prevention takes place than defect detection and testers' effort shifts more toward preventive techniques. The agile techniques of Test-First and TDD can be easily applied by basing coding on test case design (Test-First) or on automated tests (TDD) where in both cases testers guide the development effort, not the other way around, and quality is built-in from the beginning.

5.8 The Mini-Waterfall Trap!

A sprint is not a mini-waterfall, as taught by Agile Coaches! Waterfall implies sequential steps with little collaboration. A sprint follows a lean approach where task sequencing is based on inherent dependencies rather than pre-defined phases. Stories might get completed at different points of times during the sprint. Some activities might be shared between stories and some are not. Testers and developers work in parallel toward completing all activities. There are almost no activity within the sprint that does not require the involvement of both skill-sets of testing and development. One more practice that helps eliminate the mini-waterfall pattern is Continuous Integration.

5.9 Continuous Integration

Continuous Integration (CI) streamlines the transition between coding and testing and allows for parallel activities with almost zero lead time between coding/fixing and testing/retesting. In contrary to daily or sometimes weekly builds between development and testing as in the more traditional setups, builds are made available to testers as new code unit is submitted. In CI, configuration management, compilation, software build, unit testing, and deployment are wrapped into a single, automated, repeatable process [10]. Even integration and regression testing can get included through Test Automation.

Combining automated unit tests with CI makes code submissions and builds instantly verified and corrected by the submitting developer. Build verification and entry criteria to testing become largely automated and build frequency can be very high with little risk to quality.

Following developers' coding, debugging, and check-in of code into a shared source code repository, a continuous integration process consists of the following automated activities [10]:

- Static code analysis.
- Compilation, linking, and generating executable files.
- Unit testing and checking code coverage.
- Deployment into test environment.
- Integration testing
- Regression testing.
- Report results and status to the team.

Continuous Integration frees testers from focusing on Build Verification Tests (BVT), smoke tests, and solving build problems to focusing on defining an effective CI strategy. They can add to the design of CI processes by adding automated integration and system test cases. Testers can also contribute by providing requirements for static code review for the non-functional aspects of the code such as performance and security.

5.10 The Adapted V-Model for Scrum – Collaborative Version

The following diagram shows a more improved version of the adapted V-Model for scrum which emphasis the collaborative approach:

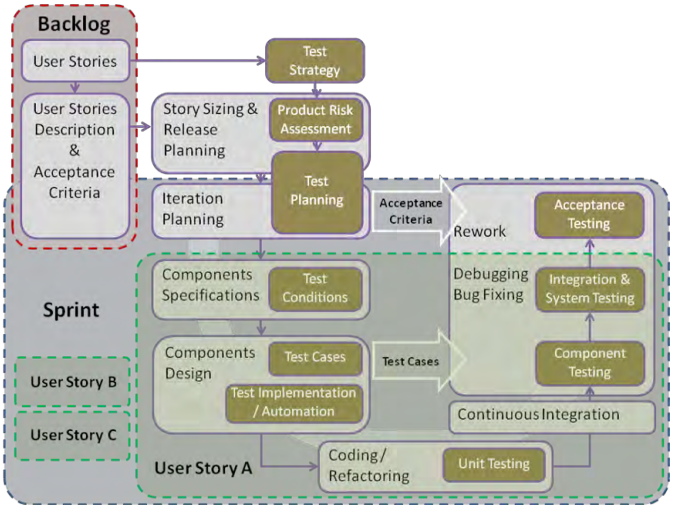

Figure 12. Adapted V-Model – Collaborative Version

In this version of the adapted V-Model, working on user stories overlap and the mini-waterfall is avoided. Testing is highly integrated with development. Testers and developers are closely coordinating their micro-steps. Potential collaboration includes, but not limited to the activities' listed in the following table:

Table 4. Tester-Developer Collaboration

Activity/Work Product	**Tester**	**Developer**
Component Specification	Support/Develop Customer/Product Manager Coordination	Develop
Test Conditions	Develop	Support and Review

Test Cases	Develop	Review
Test Automation Suite	Develop	Support/Develop
Component Design	Reassess Product Risks Improve Test Cases	Develop
Automated Unit Tests	Support/Develop	Develop
Code	Improve Unit Tests	Develop Improve Unit Tests Refactoring
Component Testing	Execute	Debug/Fix
System & Integration Testing	Execute Analyze Dependency and Regression	Debug/Fix Support Analysis
Acceptance Testing	Customer/Product Manager Coordination	Rework

5.11 Tester Responsibilities in the Agile TPIG

We can summarize tester's responsibilities as proposed by this paper in the Agile version of the TPIG and the adapted V-Model compared to traditional development as follows:

Table 5. Tester Responsibilities in Agile TPIG

Activity/ Work Product	**Traditional**	**Proposed Agile Approach**
Business Req./ User Stories	Understand	Review User Stories Ensure Functional/Non-Functional specification
Test Strategy	Develop	Develop
		Identify Product Risks
Acceptance Criteria	Develop UAT Test Cases	Review Acceptance Criteria
Project/Release Plan	Commit!	Assess/Map risks to user stories Risk Point Estimation Contribute to user stories priorities and sequence
Test Plan	Develop	Develop as part of Release/ Sprint Plan
System Req.	Understand	Develop Test Conditions
Test Cases	Design Test Cases	Design Test Cases
Coding / Unit Testing	-	Design Unit Tests Guide coding (TDD)
Test Automation	Automate Test Cases	Automate Test Cases
Test Execution	Execute Test Cases	Execute Test Cases Participate in designing Continuous Integration suites.
Completion	Evaluate Exit Criteria	Calculate Residual Risk Satisfy the "Done" definition

We can see that this approach assigns testers greater responsibilities than thought before which means the weight assigned to professional and skilled testers in agile is very high and can even be higher than traditional development.

6. BENEFITS OF THE PROPOSED APPROACH

In general, the early involvement of testers in the development cycle, their clear participation in the Business/System analysis activities, and the close collaboration in the design/coding activities, leads to quality being built in product from the beginning rather than assessed and controlled at the end. The essence of the V-Model is early testing and early defect detection and removal which are highly evident in the proposed approach. The "throw-over-the-wall" syndrome where one role passes its ill-completed output to the next role is eliminated (such behavior was often responsible of another syndrome known as the "squeeze-against-the-wall" where testers often get stuck with over squeezed testing time and a non-movable delivery wall!) The final result is assumed to be reduced Defect Density (DD), reduced Cost of Quality (COQ), and improved Defect Removal Rate (DRR). More measures include improved Testing Schedule Variance (SV) and Testing Cost Variance (CV).

Little empirical data is available on the DD and COQ measures. However, in the number of agile companies that implemented the TPIG approach considerable DRR improvement was measured with also high SV and CV improvements. The DRR is calculated as follows:

DRR = Pre-Release Defects / (Post Release Defects + Pre-Release Defects)

The following graph is based on real TPIG implementation at SECC customers during the first round of TPIG implementation in 2010/2011. It shows considerable improvement in three different measures (DRR, SV and CV).

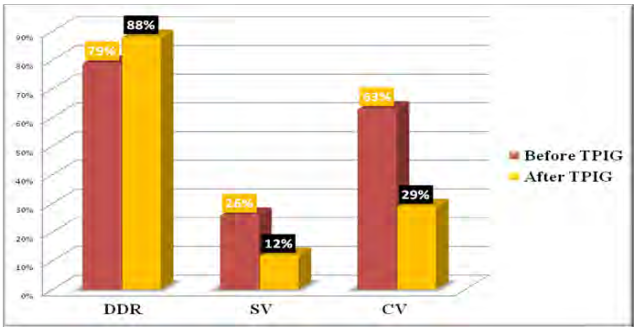

Figure 13. TPIG for Agile Improvements

The Figure shows around 9% DDR improvement before and after the adoption of the proposed approach which means 9% of the overall product defects (around 42% of the production defects) are now discovered by testers rather than users. A great quality gain based on a single process improvement initiative.

For the COQ measure, the ASQ (asq.org) defines it as follows:

COQ = Prevention Costs + Appraisal Costs + Failure Costs (Internal and External)

Based on the empirical analysis performed by SQS Company in Europe over 5000 projects completed in the past fifteen years, the defect failure cost is reduced by at least 50% by moving defect detection from production to testing.

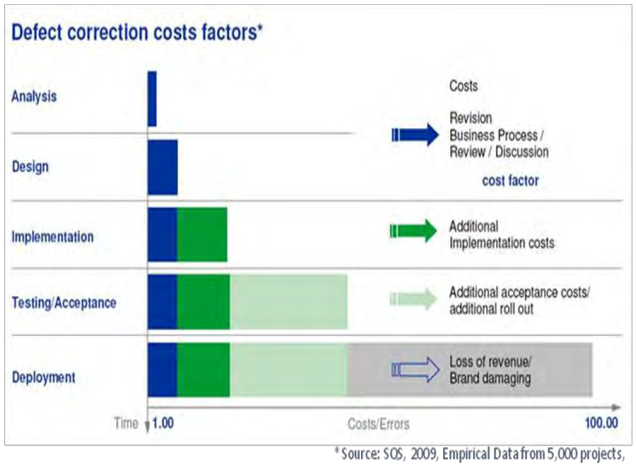

Figure 14. SQS Cost of Defect Curve

Combining this with the 9% DDR improvement shown in the above case study and assuming 100 EGP average cost per production defect, and 50% cost reduction in pre-production defects, the following results are gained for each 100 defects:

a) Before TPIG Implementation:

Failure Cost of Production Defects = 21 * 100 = 2,100

Failure Cost of Pre-Production Defects = 79 * 50 = 3,950

Total Failure Cost = 2,100 + 3,950 = 6,050

b) After TPIG Implementation:

Failure Cost of Production Defects = 12 * 100 = 1,200

Failure Cost of Pre-Production Defects = 88 * 50 = 4,400

Total Failure Cost = 1,200 + 4,400 = 5,600

Failure Cost Saving:

Failure Cost Saving per 100 defects = 6,050 – 5,600 = 450

Failure Cost Saving Percentage = (450/6,050)*100 = 7.4%

The 7.4% figure is the absolute minimum as it assumes the DDR improvement is based on defect detection during the test execution phase only. Considering improved defect prevention (early detection) the ratio can grow to anywhere between 7.4 and around 14% (detection cost during analysis is only 1% of the production cost)

Further reduction could be calculated should we have data related to Defect Density (DD). Defect correction (debugging and bug fixing) as part of failure costs is reduced through the reduction of defect density in the product as a direct result of early defect detection.

In addition to the above quantitative improvements the following qualitative improvements are assumed in different areas:

Management Benefits

1. Time-to-Delivery is improved by taking the test-rework-retest cycles to the minimum.
2. A unified understanding of scope and requirements improves collaboration and reduces conflicts among the team, and requirement assumptions are largely eliminated.
3. Testers' analytical skills are leveraged for the benefit of the whole team. There is little room for ambiguous, incomplete, inconsistent or non-testable requirements.
4. Test-First and TDD lead to better traceability of requirements to code units.
5. Risk assessment during story writing leads to better priorities. It allows the product manager to wisely set a proper release plan to maximize risk mitigation and minimize residual risk at interim or final product releases.

Analysis Benefits

1. Test conditions, positive/negative tests with clear expected result, test design techniques, requirement coverage measures, all augment business and system analysis by additional analysis levels that result in clean specifications with small chance for defects and false assumptions.
2. The practice of risk assessment and risk mapping is another addition to analysis. For example, identifying localization issues (multi language support, currency exchange…etc.) during risk assessment workshops will lead to additional rounds of analysis for these areas and hence the development of more complete and accurate requirements.

Engineering Benefits

1. In addition to providing complete and concise input to developers, agile testers develop better understanding of system architecture and design and their impact on the different quality aspects (functional or non-functional). This will lead to improving architecture and design over time and taking more enlightened engineering decisions.
2. Trade-offs between architectural and design alternatives better considers impact on quality attributes which can stem from the team accumulated experience in resolving functional and non-functional product risks.
3. Testers may start contributing to design reviews and static code analysis. They can also provide a lot of functional value to unit tests by making them more purposeful.

7. CONCLUSION

Modern testing concepts, approaches and techniques are not in conflict with agile methodologies. In contrary they can perfectly fit within agile development and foster the fulfillment of the agile values and principles. Approaches such as risk-based testing and test condition strongly support agile teams and allow for more collaborative effort toward analysis, engineering and quality control. It also supports developing shared vision and common understanding between the team members and other stakeholders. Tangible management benefits are also achieved in avoiding the mini-waterfall trap and reducing team conflicts.

The V-Model which is a dominating model behind many other development process models such as the CMMI for Dev. can be

adapted to agile methodologies to carry on its very same benefits as in traditional development. The V-Model will serve as carrier of the modern testing techniques (risk-based, test conditions, Black-box techniques…etc.) to the world of agile development. Effort has already been made in implementing the adapted V-Model model through SECC Testing Process Improvement Guide (TPIG). Case studies that prove the benefit of the approach are already established and some data are gathered and analyzed to prove the case. More data are still to be collected for the different testing measures such as the DDR, DD and COQ.

Last but not least, testing is not a downgraded role in agile. The misconception that agile teams do not need specialized testers is to be cleared. Testers play very powerful role in agile but with some adaptation and skill development toward business analysis and engineering. Testers need also to utilize their analytical skills for the whole team benefit, as well as providing support to product engineers which will require acquiring/developing some understanding of product architecture and design. Scripting skills are strongly needed for test automation in addition to testing the non-functional test types such as performance.

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Software Productivity from an Industrial Perspective

Samer I. Mohamed
October University for Modern Sciences and Arts
Faculty of Engineering
Electronics and Communication Department
Giza, Egypt
saibrahim@msa.enu.eg

ABSTRACT
Software development productivity is one of the major and vital aspects that impacts software industry and time to market of many software products. Although many studies have been conducted to improve the productivity measurements within software engineering research domain, productivity is still an issue in current software development industry because not all impacting factors and their relationships are known [1]. This paper sheds a light on some of these factors and assesses their impacts as seen by random sample of industrial software SMEs. It also elaborates the main best practices that help in improve the software productivity based on real industrial projects. The resulting list of factors and best practices can be utilized to guide further productivity analysis and taken as basis for building improved and more optimized productivity models.

Keywords
Software productivity, Volatility, Technical factors, non-technical factors, Best practices, SMEs, SMART requirements.

1. INTRODUCTION
Software development industry nowadays becomes one of the main industries that contributes on the evolution of the computer-based systems. Many organizations currently investing huge amount of money to improve their productivity and time to market to gain larger market share and increase their operational margin. Productivity in software development has been an important research area for several decades now where successful organizations focus their R&D to improve.
There are many different measures for software productivity within the literature. The most common and traditional approaches are the lines-of-code (LOC) and function points (FP), i.e., the amount of LOC or FP produced per hour by a developer [2]. Based on this, there is a large amount of studies on various aspects of productivity. The two mentioned measures and several more dimensions have been analyzed and detailed within the literature.

Our contribution through this paper, is the introduction of a balanced and mixed approach for both the industrial and theoretical perspectives of those factors that impact the software productivity. Although the software engineering literature in that area often has a strong emphasis on mainly technical factors such as the software size or the product complexity. However, there are other non-technical factors that impact software productivity as has been proved by Brodbeck [3] who has shown that more than a third of the time a typical software developer is not concerned with technical work.
The paper is organized as follows: section II gives a background for the early studies done on software productivity as a concept; section III introduces the case study targeted by this paper; where case study description, details, results, and recommendations are detailed; section IV is the conclusion of this study.

2. BACKGROUND
Software development is a great expense for most organizations, thus, software development productivity can have a significant impact on the organization's ability to compete and survive. Currently, most software development organizations are not optimized. There is an increasing demand for software especially for embedded systems. However, without improved efficiency, it will be difficult to take advantage of these opportunities in a cost-effective manner.

Tools will not be the only facility to succeed; but a need for a process that ensures quality software can be produced consistently and efficiently has an important effect. Like the various automobile manufacturers, different development organizations today typically have access to roughly the same production tools and technologies. The organizations that have a process for leveraging them most successfully are the ones with the highest productivity and the lowest production costs and the best one to compete.
There are extensive researches in the measurement of the development productivity. Humphrey and Singpurwalla [4] use the statistical techniques of time series analysis to predict the productivity of software development with reasonable accuracy. Blackburn et al. [5] imparts a global survey of software developers on improving speed and productivity of software development. The most famous model that involves productivity is COCOMO by Boehm [6, 7]. It is a cost-estimation model in which the productivity of the developers obviously plays a decisive role. Lakhanpal [8] concentrated on characteristics of groups and their influence on productivity. Brodbeck describes in [9] that in a survey, the projects with a higher communication effort also were more successful.
Even the intensity of internal communication is positively correlated with project success. This is in contrast to common software engineering belief that high communication effort hampers productivity. Wohlin and Ahlgren have described factors and their impact on time to market in [10]. They use 10 different factors in their study, mostly factors that are covered by the different publications. They also include product complexity, methods, tools and requirements stability that could be considered as technical factors.
Blackburn, Scudder, and VanWassenhove [11] studied the factors and methods that improved productivity in Western European companies. They found project duration and team size to be significant. Chatzoglou and Macaulay [12] interviewed participants of over a hundred software projects about several factors and their influence on productivity. They found that

experience, knowledge and persistence of the team members is considered important. Also the motivation of the users and their communication with the rest of the team play a role. Finally, the available resources, tools and techniques used and the management style are important factors

These studies focus mainly on the measurement of the productivity, there are unfortunately very few investigations on the elements that influence the productivity.

3. CASE STUDY

3.1 Case description

The Case is based on an industrial survey performed among group of 50 software engineers and Subject Matter experts (SMEs) from different industrial domains within software development field. The selected sample of SMEs takes into consideration different diversity aspects within technology, industrial domain, SME job level, application domain, project types and software development models. This is basically to ensure unbiased outcomes and normal weight distribution of the different factors that impact software productivity within software development spectrum.

3.2 Case Details

The survey presented in this case study has different types of questions varies between multiple choice questions MCQ and open type questions where interviewee has to put his own answer. Although 95% of the questions are MCQ but the remaining 5% was needed to assess interviewee judgments on some productivity factors and best practices.

The survey main objectives are basically:

- Gather basic information about interviewee and projects types.
- Assess time wasted in non-productive tasks compared to other productive ones.
- Evaluate those factors that impact the total productivity from interviewee perspective.
- Identify those best practices to improve the software productivity either adopted or proposed by the interviewee.
- Measure the impact of external and non-technical factors on productivity.

The design of the survey was done to assess ratio and impact of different factors impacting the productivity either technical or non-technical aspects.

Technical aspects like requirements volatility, tooling, technical training, rework due to poor quality and bug fixes, innovation support, project duration, application complexity, technical experience, status updates/admin impact, and modern programming practices has been assessed.

Non-technical aspects like appreciation and motivation, team cohesion, software size relative to application size (diseconomy of scale), turnover/attrition, work location, environmental effect like noise/lighting effect, defensive management, team size and roles and responsibilities clarity has been assessed and compared against technical aspects.

Each factor impact on productivity from the above listed ones has been assessed in range from low level to very high level.

Survey also has identified the best practices to improve the software productivity and the adoption methodology ranging from unknown level to standard level as follows:

- Desks away from loud employees like managers, support, sales that are always on the phone.
- Deal with SMART requirements.
- Improve estimation accuracy.
- Use short task schedule.
- Being part of small and well organized project team.
- Use prioritized task list.
- Less context switching between multiple projects, or because of changing specs.
- Make sure to allocate time for Refactoring and optimization before QA gets to it.
- Code reviews.
- Reusability.
- Technical training.
- Pairing between developers through development.
- Adopt minimal constrains validation.
- Improve communication between Business Side and developers.
- Eliminate scope creep.
- Co-operative work environment.
- Have a system for distributing tasks.
- Increasing code knowledge.
- Prevents customer-architect misunderstandings by supporting agile development processes with prototyping, short iterations, and other practices that promote early and frequent customer interaction.
- Prevents architect-developer misunderstandings by enforcing policies such as requiring that a test case be written for every use case, forcing developers to think about each requirement from different perspectives.

3.3 Case Results

In this section we will show the outcomes from the productivity survey and how these outcomes related to previous analytical studies in this field [13].

These outcomes will be classified into two main categories:

I) Impact of different factors on software development productivity either technical or non-technical aspects.

II) Best practices adopted by developers either related to technical or process/project-related aspects.

Table 1. shows the impact of technical factors on software productivity. Each factor range between ‘Low’ and ‘High’ through ‘Average’ values.

Table 1. Impact of technical aspects on software productivity

Factor/criteria	Low (%)	Average (%)	High (%)
Volatility	0	27	73
Tooling/training	13	33	54
Rework	40	33	27
Status updates	27	40	33
Innovation	27	20	53
Project duration	13	60	27
App. complexity	13	47	40
Technical experience	7	20	73
Modern programming practices	0	13	87

Data of table 1. are illustrated graphically in figure 1.

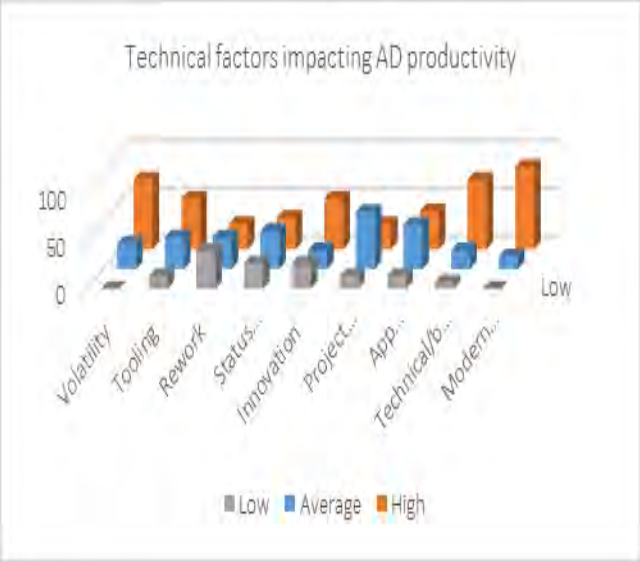

Figure 1. Technical factors effect on software development productivity

Table 2. shows the impact of non-technical factors on software productivity. Each factor range between 'Low' and 'High' through 'Average' values.

Table 2. Impact of non-technical aspects on software productivity

Factor/criteria	Low (%)	Average (%)	High (%)
Appreciation	0	20	80
Team cohesion	0	13	87
Software size	0	60	40
Turnover/attrition	0	20	80
Work location	7	7	86
Environmental effect	20	27	53
Defensive management	0	13	87
Team size	20	67	13
Roles and Responsibilities clarity	0	0	100

The data from table 2. Also presented graphically in figure 2.

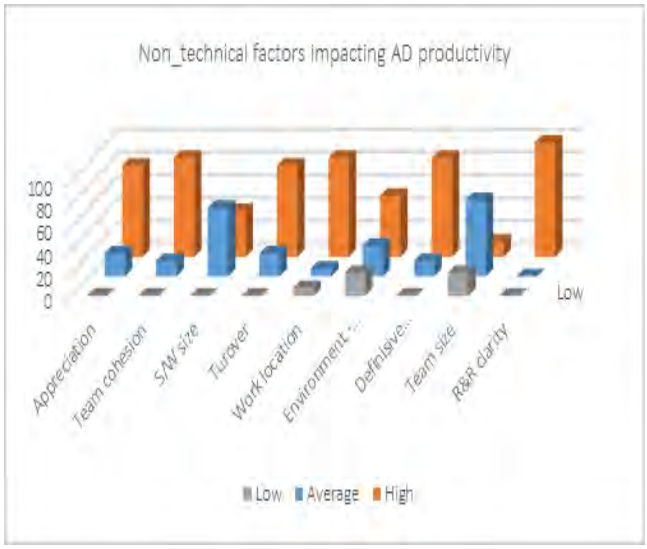

Figure 2. Non-Technical factors effect on software development productivity

Best practices adopted by software developers also have an impact on the productivity as provided by the results/outcomes from the survey. These results are classified into main classes. The first class related to technical best practices while the second one related to project/process best practices.

Table 3. shows the impact of adopting different types of technical best practices on software productivity. Each practice range as detailed earlier between 'Not available' and, 'Standard' where practice is used as standard use, 'Training needed' where practice is used but need more development/improvement to be materialized, 'Has major value' where the practice has practical value on software productivity.

Table 3. Technical best practices impact on software productivity

Best practice	Not available (%)	Standard (%)	Training needed (%)	Major value (%)
SMART requirements	60	27	13	0
Use Refactoring	67	33	0	0
Code reusability	13	33	27	27
Code reviews	13	80	7	0
Increase code knowledge	13	87	0	0
Agile development	33	53	7	7
Test case per use case	53	47	0	0
Technical training	0	7	27	66
Pairing	0	53	20	27
Have Business experience	0	20	40	40
Minimal constrains validation	0	13	67	20

The data from table 3. Are illustrated graphically in figure 3.

Figure 3. Technical best practices effect on software development productivity

Table 4. shows the impact of process/project best practices on software productivity. Each practice range as detailed earlier between 'Not available' and 'Standard'.

The data from table 4. Also presented graphically in figure 4.

Table 4. Impact of process/project practices on software productivity

Best practice	Not available (%)	Standard (%)	Training needed (%)	Major value (%)
Desks away from noise	73	27	0	0
Less project switching	13	87	0	0
Communication improvement	40	33	27	0
Scope creep elimination	0	100	0	0
Improve estimation accuracy	13	73	13	0
Use task distribution system	33	67	0	0
Use prioritized task list	13	87	0	0
Co-operative environment	0	53	20	27
Small project team	0	60	20	20
Short task schedule	0	33	33	34

Figure 4. Process/project practices effect on software development productivity

3.4 Case Results Analysis

Analyzing the results of this case study/survey, we conclude the following points as follows [14]:

With respect to technical factors, here are the analytical outcomes:

- Requirements volatility has major negative impact on productivity especially through the system design and development.
- Use state of the art tooling on different process, project, technical or technological levels will highly affect positively the software productivity through automation.
- Technical training is vital for productivity improvement and has high impact to improve the productivity.
- Rework due to poor quality or bug fixes impact productivity negatively but with lower weight/impact.
- Spending much more time on doing status updates/or admin work impacts productively negatively with average weight.
- Innovation support from the upper management has high positive impact on improving the software productivity.
- Project duration has average impact on the software productivity if it's within allowable limits (1 to 2 years). Productivity for those project with duration more than 2 years decay with time as developer's interest and motivation reach a saturation levels.
- Application complexity is directly correlated with the software productivity, but most of the interviewees see this has average impact only because the impact will be high at project start then decay with learning curve improvement along with project lifetime.
- Having business and technical experience with the application domain/field will help indeed to improve the development productivity and increasing code knowledge.
- Adopting modern programming methodologies have very high positive impact on improving software productivity [15].

With respect to non-technical factors, here are the analytical outcomes [16]:

- Appreciation and saying THANK YOU has the magical impact on the developer's spirit and motivation level, the thing that improves the software productivity [17].
- Team cohesion and healthy work environment have very high positive impact on software development productivity.
- Software size has neutral impact on the software productivity especially with adopting the latest state of the art methodologies and modern programming practices and tooling.
- Turnover/attrition has high negative impact on the software productivity because it's directly correlated to the productivity of the team in general and developer's spirit in particular.
- Having work location nearby home has a major impact on the developer productivity, the nearer the work location the more productivity outcomes and vice versa because of time/efforts waste due to lengthy transportation.
- Work environment conditions (Noise, lighting, seating, fresh air, others) have average impact on the productivity.
- Relationship between management and employees has high impact on the employee productivity, defensive management is negatively impacting resultant productivity and vice versa for supportive management.
- Working in a team or small groups indeed has major impact on productivity as explained in the team cohesion factor, but the team size also has an average impact on the productivity depending on the team size itself. If the team size up to five, then healthy communication and controllable/manageable deliverables can be maintained. Increasing the team above five will drastically impact communication in between developers and accordingly the resultant software productivity [18].
- Having clear roles and responsibilities for all stakeholders within the project will maintain healthy communication and clarify the boundaries between interacting roles, the thing that minimize the root cause for any conflicts or major escalations. This will definitely will improve the net productivity

With respect to technical best practices, here are the analytical outcomes [19]:

- Deal with SMART requirements through the full development life cycle starting from elicitations towards testing through design and development has vital role to ensure a match between what is requested by the client and what is implemented by the development team. Although most of the interviewees see that adopting this practice is not available in many projects due to variations in maturity levels of the different stakeholders, but still acknowledge its vital value [20].
- Code refactoring/reusability is one of the other important aspects in modern programming practices to best reuse/re-structure the exiting code core without changing the external interface with the integrated systems. Survey shows that this practice has major value on improving the system performance/maintainability but not available for new development projects where time constrains exists [21].
- Code reviews is one of the important aspects in software development and adopted as standard by most of the interviewees through pairing approach. This ensures better quality and early bug detection which improves the rework cost and enhance net productivity and accordingly the time to market [22].
- Agile development is one of the modern techniques for software development that adapts with the current market demand dynamics and fulfill the increase demand on new products with minimum time to market especially for mobile and small scale products. This practice is used as standard between most of the interviewees currently to adapt with market trends [14].
- Testing is one of the main components in the development life cycle. Incorporating the testing early

in the design phase or even in the elicitation phase is very important to ensure every developed component/use case has its own test case. Adopting this as standard will lead to better quality, less rework costs, high productivity.

- Technical training and ongoing courses that adapt with the latest state of the art technologies is of a great need between most of the interviewees because it keeps them with the technological rapid advances and keeps the momentum for improving the business and technical experience.

With respect to process/project best practices, here are the analytical outcomes [23]

- Controlling the noise level in most of the organizations is very hard although its importance to facilitate a noise controlled climate for the software engineers. Most organizations currently balance between increasing number of meeting rooms versus the open space work locations depending on the development approach (ex. Agile development requires special arrangement for seating). Most of the interviewees see that 10-20% of their time almost wasted due to high noise level within the work place.
- Project management and alignment has an important role to facilitate structured and well organized climate for the development team to deliver starting from requirements specification towards project delivery, and to isolate any road blocks or management issues that waste their time. Switching between projects is mixed blessing as seen by most of the market leaders and management where it could motivates the engineers while impacting the net productivity because of additional overhead to gain the knowhow and learning curve.
- Communication consumes basically considerable amount of anyone time, while it takes around 90% from the project managers, it also consumes between 10-30% of developer bandwidth. Thus improving the way of communication both internally between team members and externally with the project stakeholders has vital role and directly correlated with the team productivity in general and software engineer in specific [24].
- Scope creep is one of the aspects that lead to project failures and client dissatisfaction. Thus eliminating the scope creep is one of the standards adopted by many organizations to ensure project successful delivery.
- Improving the process and using more automation is vital to minimize the unnecessary overhead and admin work especially this related to estimation process and other progress/reporting tracking tools. Although it's important for the PM to track the project progress and prioritize the task list for the team, S/he needs to control the additional overhead that impacts productivity via tooling and improved process.
- Working in a team is much better compared with working individually if it's performed within controllable ranges. Groups of 3 to 5 engineers is the optimum within software development teams from communication, cooperation, controllability, and delivery perspectives [25].

With respect to %time wasted in non-productive tasks relative to other productive ones, here are the analytical outcomes

- Meeting/talks (Technical) consumes around 20-30%.
- Presentations (Business related) consumes 5%.
- Project management/organization consumes 5%.
- Application development consumes 50%
- Others (ex. Coffee, Lunch) consumes 10%
- Most of S/W engineers consumes around 75% of their annual leaves.
- Only 25% of the S/W engineers spend overtime hours outside of their normal working hours.

3.5 Case Recommendations/Proposed Actions

From the analytical outcomes detailed in earlier sections, we come up with list of recommendations and actions to better improve the software development productivity for any software development organization in general and software engineer in particular [26].

- Minimize the requirements volatility via adopting proper change/release management process, proper requirements management tools and modern/agile development methodology.
- Increase automation and tooling that eliminate manual and unnecessary overhead. Open source tools spread over the web have vital value and provide quick solutions for many problems with min/no costs.
- Organizations need to invest in their teams via technical training, R&D support, and innovation funds.
- Healthy relationship between the management and employees/engineers is the quick win for improving the net outcomes from the factory. This can be expressed in many ways simply via THANK YOU.
- Facilitate nearby location to home with multiple sites and WFH (Work From Home) facility will help in first minimize transportation time/efforts and improve the productivity.
- Organizations need to balance between the work from office and WFH days to maintain healthy communication and minimize the wasted times/efforts.
- Clear R&R is vital for the whole deliverables of any organization in general and software engineers in specific, where boundaries and interface with external world identified. This will enable the engineer to understand clearly what to do and what to avoid lead to better outcomes and minimal issues/escalations.
- Using modern programing practices like code refactoring/reusability, reviews, SMART requirements, agile development, pairing, and minimal constrains validation are important form the technical perspective to improve the quality, controllability and productivity.
- Adopting better process and project management policies like eliminate scope creep, facilitate cooperative environment, short task schedule, small project teams, prioritized list of tasks, distribution task tools, and desk

away from noise sources will help in minimize the overhead and eliminate any sources of distractions.

- Organizations need to consider with same weights both the technical and non-technical aspects/sides of the factors impacting the productivity as they have almost if not exactly similar, matching effect on the productivity.

4. CONCLUSIONS

In software development literature, productivity is a complex concept that needs to be tackled depending on the software project factors. There are technical and non-technical factors which has a considerable effect on the software productivity. This papers shed a light on the main factors both technical and non-technical that impact software productivity. It also explores the different best practices adopted by software engineers and shows its effect as seen by the industrial software engineers in different domains. List of recommendations and corrective actions has been provided as way for continual improvement.

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Making Smartphones Smarter while Profiting from the Cloud

A global approach from design to deployment of Mobile Cloud Applications

Leire Orue-Echevarria, Gorka Mikel Echevarria, Juncal Alonso, Stefan Schuster
TECNALIA
Spain
{leire.orue-echevarria, gorka.echevarria, juncal.alonso, stefan.schuster}@tecnalia.com

ABSTRACT

Mobile Cloud Computing (MCC) is the usage of cloud computing in combination with mobile devices. Access to services deployed in the cloud from mobile devices has grown exponentially in recent years due to the increase of the processing capacity of smartphones in combination with improved telecommunications networks. Even though MCC is not something new, the complexity of the applications intended to run on mobile devices has increased tremendously and in many cases there are problems to run those applications with acceptable quality levels.

This paper arguments on the need to provide a set of methods and tools that will aid MCC application developers in the design, development and deployment of MCC applications in their quest to satisfy the highest performance requirements reducing the battery power consumption, minimizing the data transferred, and, at the same time, ensuring the required data privacy, availability and data consistency at runtime by providing offloading components.

Keywords

Mobile Cloud Computing. Offloading. Dynamic reconfiguration. Mobile Applications. Cyber-foraging. Task partitioning.

1. INTRODUCTION

Recently, cloud computing has changed software infrastructures and business models of Internet services with technologies to provide and manage a huge amount of resources of computation and data storage over the network at relatively low costs. On the other hand, the popularity of smart devices and mobile networks has substantially changed the way people access computers and network services.

The rising popularity of mobile devices is also reflected on the increasing number of offerings of applications in various categories such as entertainment, health, games, business, social networking, travel and news, whose revenue is expected to reach more than 25 billion dollars by 2015. According to Markets&Markets [1], the global market is expected to reach a CAGR of 29.6% from 2010 to 2015. There currently exist several applications, such as location-based social networking that use the various sensors data of the phone. Applications that use the GPS reading are expensive in terms of energy and limit the service to be provided to the user. This situation becomes extreme when considering applications such as image processing video games, augmented reality or wearable computing. In these applications, the demand of high computational capacities (e.g. battery capacity, CPU, storage and network) raise greatly which discourages developers to implement such mobile applications. However, taking a look at the trends of mobile phone architecture and battery, it is very unlikely that these constraints will change in the near future. This is, in fact, not merely a temporary technological deficiency but intrinsic to mobility [2] and a barrier that needs to be overcome in order to realize the full potential of mobile computing.

Today we do enjoy mobile applications connected to the cloud, such as Apple iCloud, Google's Gmail for Mobile, and Google Goggles. However, in those cases, the mobile devices exist purely as thin clients that connect to a remote proxy providing complex services. Although these apps are becoming popular, they can perform well only under high speed connectivity. However, it is not practical to assume fast connections, affordable data access fees or good response times in most places of the world. This is true for most developed countries. In contrast, short range communication consumes less energy, and this is a key factor since mobile devices usually operate on a limited energy source. Satyanarayanan [3] predicts that, considering the current trajectory of Internet evolution, although bandwidth is likely to improve with the advent of 4G (LTE, WiMAX and so on), latency is not. Thus, taking into consideration data access fees, latency and bandwidth issues [4], as well as high demands of energy deriving from the use of 3G, the cloud could be a good alternative. The problem related to solve these shortcomings of smartphones is currently being addressed in the research industry. The motivation behind this research is to connect resource-constrained mobile devices to nearby resource rich powerful clouds [3] [4] [5] [6]. The basic idea is to let devices leverage computation and energy on cloud servers to execute (part of) mobile code that requires heavy use of computing or network resources. Mobile cloud computing is opening a new world where smartphones equipped with various network connections and a wider range of sensors are increasing their functionalities with the help of the computational power of the clouds. Mobile cloud computing can accommodate a much wider range of complex applications which cannot run solely on smartphones, such as augmented reality, m-learning or vision-, graphics-based ones [7]. As another advantage, mobile cloud computing may relax the design constraints of smartphone hardware which, due to the considerations of size, costs and battery capacity, have been strictly imposed on hardware features like CPU, storage and network [8].

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While the combination of cloud computing and mobile computing, named mobile cloud computing (MCC), started to show its effects with many seemingly innovative smartphone applications and cloud services appearing in today's market, the real potential of mobile cloud computing is far from being fully explored. As stated in [9] at a first glimpse, it may appear that today's smartphones are already powerful enough to support the new software applications that are appearing that augment human perception or cognition, without need for cloud offload. API's have been created for this purpose. Some examples include Google's Voice Search [10] or Apple's Siri [11]. Both perform voice recognition to allow hands-free control of a smartphone. Other examples of applications that that run on resource-limited mobile devices, such as computer vision applications are described in the survey by Lowe [12].

However, upon closer examination, the situation is much more complex and subtle. [9] provides an example related to computer vision and face detection, where the computational requirements vary depending on the operational conditions. In this situation, the capabilities of mobile devices are quickly outdone by the computational demands. [9] continues further with the example and provides a potential solution by performing two simple changes, improves a lot which the situation. These two changes are: increasing the number of possible faces from just a few close acquaintances to the entire set of people known to have entered a building, and reducing the constraints on the observation conditions by allowing faces to be at arbitrary viewpoints from the observer.

As justified in [9], similar trade-offs apply across the board to virtually all applications of this genre, not only in terms of computational demands but also in terms of dataset sizes. In continuous use under the widest possible range of operating conditions, providing near real-time responses, and tuned for very low error rates, these applications have ravenous appetites for processing, memory and energy resources.

The two principal factors that determine and impact on the quality of user experience in mobile cloud computing today are the quality of mobile networks and security concerns.

Users have to yet to experience a mobile application that fulfils their requirements on quality of service and quality of experience. This difficulty strives on the tight dependency of the mobile application on the conditions of a mobile network such as latency or bandwidth. In some cases, several issues such as performance problems arise when executing an application over a wireless network as the client and the server need to communicate over an unreliable network and exchange large amounts of data. In other cases, the applications are so resource-demanding that they cannot be executed even on high-end mobile devices due to their high performance requirements. A potential solution could be dynamic cyber-foraging, apart of course, from improving the quality of mobile networks and the device capacities and capabilities. Cyber-foraging [13] is the leverage of external resource-rich surrogates to augment the capabilities of resource-limited devices in order to 1) Increase computational capability, 2) Conserve battery on a mobile device, 3) Access remote or shared data, 4) Provide better application fidelity. Cyber-foraging can be done mainly in two manners, namely 1) Code/Computation Offload and 2) Data Staging.

Offloading enables mobile applications to use external resources adaptively, i.e. different portions of the application are executed remotely such as on the cloud, based on resource availability following a dynamic workload partitioning scheme.

However, up until now, the pursued offloading approaches focus mostly on static techniques, leaving aside context information (e.g. resource availability, network conditions, battery life, and so on), vital for a more dynamic and elastic approach.

Systems with context-awareness are able to use contextual information to change and automatically reconfigure their configurations to adapt to the context [14]. This behaviour is very useful in the case of mobile systems, since these deal with an execution environment that is subject to constant change. In the case of mobile cloud computing, context awareness can be used in forming resource clouds as well as processing information. Consider a mobile device connected to a remote cloud service through the Internet. As the context of the user changes, this prompts invocation of different cloud services based on the current context. As explained in [15], with this kind of context-awareness, a service would not be tied up to a user. Instead, when a mobile user invokes a cloud service, the request is accompanied by his/her context information, and the most suitable service is selected based on that information. Therefore, context is used to provide customized and personalized services. Offloading could benefit from context-awareness.

Mobile cloud applications make use of services such as storage or computation from cloud service providers that may be geographically distributed. Users trust service providers with their personal data, whilst taking the risk of exposing the data to eavesdroppers in the network. Security and privacy become therefore key concerns in this situation. However, for cloud providers, to ensuring that the data is totally secure in such highly distributed and replicated infrastructures is costly and presents several challenges.

Another important issue that is avoiding mobile cloud applications from its definitive take off is device fragmentation [16], which does not allow to "write once run everywhere" and the lack of tools and programming models that aid the developers in the decision of cyber-foraging, with a special attention on static and dynamic offloading of components between the cloud and the mobile device. Application task balancing schemes, code and computation offloading mechanisms based on the network and the cloud provider conditions, high performance, scalability and trust models are among the active research topics for improving the software infrastructure.

On the application side, it is difficult for developers to produce innovative mobile cloud applications due to the lack of experience, programming tools, paradigms and examples. Traditional client-server models have been successfully used for desktop users to leverage distributed applications over the Internet. Current mobile platforms embrace these models too, but fail to cope with the variability of mobile cloud computing environments. Thus, a dedicated solution is needed in the age of mobile cloud computing dealing with specific performance and security issues, allowing application developers and users to profit from existing cloud computing services. First, application partitioning at design and run time should enable dynamic adaptation to the available resources both in mobile devices and cloud infrastructures. Second, the users have to trust the service providers with their personal data. Finally, in addition to sharing data conveniently and securely, "offloadable" components of applications may be migrated or distributed from one device to

another to encourage close collaboration. This position paper presents a possible solution to overcome these shortcomings.

2. FROM DESIGN TO DEPLOYMENT

2.1 Current Situation and Challenges

Developing and deploying mobile cloud applications is complex. There is simply no "one-size-fits-all" solution. Not only do development teams have to design, develop and validate the functionality of the mobile cloud application, they also have to consider their performance under high load conditions as well as across multiple devices, carriers, operating systems and geographies. This requires teams to adapt existing methodologies and processes to ensure consistent behaviour across many environments.

Major challenges include:

- Task balancing, emulator-based or real device testing solutions
- Security awareness by design
- Coping with varying bandwidth, network and user loads
- Identifying optimization opportunities for mobile application clients and infrastructure to ensure that applications remain responsive under challenging mobile network conditions and increasing load
- Post-release monitoring at runtime and be able to reconfigure and offload the application components dynamically.

In addition to that, the programming models that have been used so far for mobile applications need to be extended and improved, as it takes a step further in the distributed computing, by establishing dynamically the running environment (smart device or cloud) for specific components depending on execution conditions. The main objective is to achieve the efficient (performance, battery consumption, data transfer rate) and secure usage of mobile and cloud computing resources. The application model to be developed shall present a significant novelty over traditional programming models (client-server or model-view-controller for web applications). This model will have to guide the application design around the variability inherent in mobile cloud computing. The applications will exhibit seamless mobility of data and computation. Application developers will have the illusion that they are programming for much more powerful devices than the current flagship smart phones. The end users will have the perception of always-available access to applications and data, i.e. that their applications run completely locally on their mobile devices. As the conditions of the mobile cloud environment change, the applications will dynamically adapt to provide the best user experience. It will be crucial to test that this complex dynamic execution effectively provides tangible benefits to both the end user and the provider.

The biggest challenge whatsoever is the partitioning scheme, which consists in configuring a software component on the smartphone or on the cloud provider at runtime, depending on system conditions. To achieve this, it will be necessary to implement complex but fast and efficient algorithms that will take as inputs many variables, related to the user, smartphone, server or network status from which the decision of which components will run in one environment or another will be taken. The performance penalty of partitioning must be small since it is executed at run-time. Moreover, the number of possible application partitions is very large because partitioning can employ several levels of granularities. Choosing the right granularity of partitioning is an important consideration. Automatic partitioning of application code without developer intervention is even more challenging. It requires estimating the behaviour of an application in relation to input parameters and execution outcomes.

Nonetheless, both the cloud provider performance and the network quality need also to be evaluated in order to make runtime decisions that dynamically recompose the application. In the case of the network monitoring it is very important to measure the traffic between the app in the mobile device and each of the cloud services used in order to maximize the network bandwidth. Regarding cloud provider performance, real time metrics are required to establish the best combination of resources allocation.

2.2 Approach

The solution presented in this position paper focuses on the development of mobile cloud applications, that is, applications that run partly on the cloud and partly on a mobile device such as a smartphone. Offloading, cyber-foraging or augmented execution refers to a technique used to overcome the limitations of mobile phones in terms of computation, storage, memory and battery. Offloading enables mobile applications to use external resources adaptively, i.e. different portions of the application are executed remotely such as in the cloud, based on resource availability (dynamic workload partitioning scheme).

In order to be able to develop such mobile cloud applications and to take the most of offloading, methods and tools to be used both at design, development and at run time, that is, when the applications have been already deployed, are needed.

These tools shall aim to:

- reduce development effort: the developer will have tools supporting him in the decision of what to offload at design time,
- reduce maintenance time (for performance improvement issues for instance),
- increase user satisfaction: the application is able to reconfigure itself based on external conditions.

Eclipse is a common and widely used IDE to create mobile applications. Thus, in order to foster the adoption of such a development framework, the proposed solution should be Eclipse-based by means of plug-ins. However, this is only suitable at design time. At runtime, on the other hand, a middleware component needs to be offered. This component will be responsible of monitoring the execution conditions of the application both at device and cloud level and executing the algorithms responsible of redistributing the "offloadable" runtime components when needed

The main objective of these tools at design time will be explicitly to:

- Recommend which tasks / functionalities should be programmed to be placed on the device and which ones on the cloud. This division of tasks shall be preceded of a categorization, a taxonomy, based on certain parameters such as how often that certain functionality calls the database, where the data is going to be stored or the criticality of a certain task under certain circumstances (and their probability). This taxonomy and accompanying algorithms will be an important input at design time.

- Define which data will be stored where and the security and privacy level that they shall require based on how sensitive the data is (personal email address, health conditions, credit card numbers, etc.).
- Define the network conditions and thresholds upon which the task division performed at design time is no longer valid and a new task balancing is needed to be performed at run-time.
- Ensure fault tolerance and recovery.
- Determine, based on a stereotyping of different cloud providers, which cloud provider is the best one for the MCC application.

At runtime, network and cloud applications are monitored to analyse the situation of the execution environment (done periodically or when needed) with respect to the application's and overall system's performance, the estimated impact on user experience, the possible risks on availability, security and privacy of data, and also taking into account the evolving needs of the application (e.g., information processing needs). The results of these analyses will be used to dynamically adapt the distribution of tasks (to the devices or the cloud) and eventually provoke the reconfiguration, redeployment or replacement of the different components and services involved.

The middleware component will have to support seamless communication, offloading and synchronization between the mobile device and the cloud. Middleware will run on the device and on the cloud as a background daemon. It will handle the establishment of a session, authentication and authorization too. In this way, multiple applications running on the same device can take advantage of the same middleware components. The middleware component will monitor (application, system, and network) so that it can make decisions on how the different application components (or layers) should be distributed; and, even act if they need to be redistributed or reconfigured during their execution. The cloud and device middleware components will have different objectives. The middleware on the device will have monitoring features to overview network quality (e.g. bandwidth, round trip time), as well as "decision" features to actually support the offloading of part of whole app's execution on the cloud. The cloud middleware, instead, has to support the mobile middleware in offloading, executing the code and reporting back the outcomes.

2.3 Solution

For design/development phases tools assembled as specific plug-ins for widely used IDEs[9] (e.g., Eclipse) and SDK's (e.g. Apache Cordova. PhoneGap, is the commercial distribution of Apache Cordova and one of the widest SDK used by developers. IBM Worklight also underlies over Apache Cordova) should be offered, so to minimize the learning curve for developers. The authors foresee the following tools and components, which will be based on HTML5 in conjunction with Javascript, a technological combination which seamlessly supports cross-platform and hybrid applications:

- A plugin for the high-level design of the application architecture and the establishment of rules and parameters needed for the deployment.
  This plugin will consist of a wizard where it will be possible to specify the cloud stereotype it will run on. This plugin will also contain the different criteria and recommendations of where to place each task, be it on the cloud or on the mobile.

Besides the wizard, the plugin will offer a graphical interface on which it will be possible to include three types of components: components that run on the cloud (always), components that run on the mobile (always) and "offloadable" components (components that run in one environment or in the other depending on the conditions).

In the case of "offloadable" components, a menu will be used to specify where they will run by default and the rules to determine the change from running in the client to the server or vice versa.

These rules are based on values of aspects such as:

  - network traffic
  - if there is network connection
  - device conditions (resources: battery level, memory, processor ...)
  - load on the cloud provider
  - others

- A plugin for developing components to run on the device. This will be different depending on the OS (Android, iOS, BlackBerry OS, HTML5…) of the target platform, but initially only HTML5 will be considered. The idea is to try to integrate the plugin with existing commercial development frameworks such as Appcelerator, PhoneGap or others, so as to also provide support for other mobile OS.
- A plugin for developing components to run on the cloud. It will be a proper development environment for the platform which will host the deployment.
- A plugin for developing "offloadable "components. It could be an environment for developing code that would run on both the server and the devices.
- A plugin to deploy the application in the cloud. This plugin permit to select the provider where to deploy the "server components" and "offloadable components" and to perform the action. The plugin will also allow uploading the "client components" either to the same provider or to another provider as these components have to be downloaded to the mobile for the first execution and / or when there are updates. In the case of HTML5, it is also necessary to upload the code so it can be accessed through browsers.

Possibly the most important part of this tool and methodology set will be two customizable and generic middleware components that will monitor the execution conditions on the phone and on the cloud, determine whether it is necessary to reconfigure the application or not, and providing mechanisms for re-configuring the application if needed.

The two middleware components are

- Elastic Mobile Middleware (EMM), which will be executed at mobile device level and will be responsible of receiving those application requests to be served by "offloadable" components and decide whether they will be served locally or remotely depending on values of established rules (available memory, network latency, response time, battery load ...), and on policies at deployment time (one policy could specify for example if a component of a specific type has to be executed at mobile or at cloud level depending on certain privacy or security concerns).

- Elastic Cloud Middleware (ECM), which will be executed at a cloud provider. It will centralize the requests from EMM and redirect the execution to "offloadable" components on the server. Then it will return the result to EMM.

The following figure depicts the high-level architecture of the proposed solution:

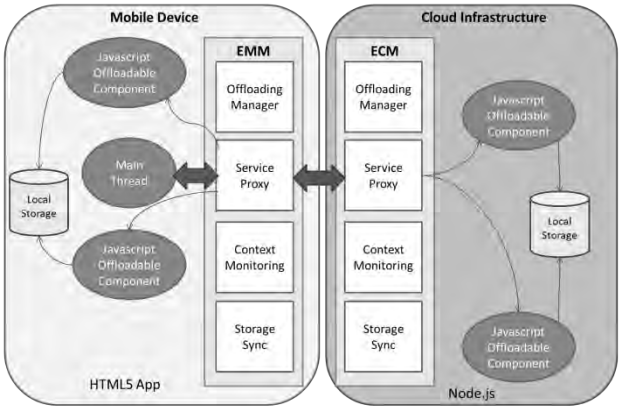

Figure 1: High-level architecture of the proposed solution

As shown in Figure 1, both parts of the middleware will be composed of the following components:

- Context Monitoring Component: component in charge of monitoring the execution conditions both at device and cloud level. In addition to providing data to Offloading Manager, this component will allow to exploit this information by storing it in a cloud database.
- To achieve this end, both EMM Monitoring Component and ECM Monitoring Component will be coordinated and will behave as follows: EMM Monitoring Component will collect data for the metrics defined at mobile level and will send them asynchronously to the ECM Service Proxy, that will delegate the processing to ECM Context Monitoring Component that will store the data, along with the values retrieved at server level.
- The storage of monitoring values at execution, both at device and cloud levels, will allow exploiting them and providing valuable integrated information on the application's behaviour. This information will be accessible via web, so the application administrator will be able to access it from any device with internet access and perform corrective actions if necessary.
- Offloading Manager: this component will take values coming from Context Monitoring component as inputs to determine if an "offloadable" component will be executed at local or at remote level and if so to perform the offloading action.
- Storage Synchronization Component: since execution may flow up and down, this component will maintain synchronized the operational data stored at both levels.
- Service Proxy: this component will receive the requests to be served by "offloadable" components and after analysing the runtime conditions (through Context Monitoring Component and Offloading Manager) will delegate the execution and will return the results. This component also will be in charge of establishing the communication between both environments (local and cloud). The centralization of communications between the two middleware instances will help to coordinate both ends and ensure the coherence in the flow of information.

The other main key components that will take part to build the solution will be:

- Local storage: as the solution will be focused on hybrid applications, and will be using HTML5 storage mechanisms. This technology is not suitable for data intensive mobile apps, but can be used to store locally (at device level) those essential data that permit the application to work offline. If there are needs of massive storage, the solution will offer the possibility of using high capacity storage solutions offered by cloud providers in combination to HTML5 storage (that could be viewed in these cases as some kind of cache). This way it will be possible to take advantage of the cloud infrastructure while allowing also the mobile applications to work offline.
- Javascript "offloadable" components: a set of components established at design time that due to their special characteristics (mainly need of computational resources) will be executed at device or cloud level depending on contextual information.

3. CONCLUSIONS

All analyses indicate that the use of smart mobile devices will continue its unstoppable growth in the coming years. It is also expected that the number of applications that can be accessed through these smartphones will increase exponentially.

However, despite the technological advances on these mobile devices, there are still significant challenges ahead to achieve acceptable access service levels on certain software applications.

The heterogeneity of mobile devices, changing conditions in communication networks, coupled with the increasing complexity of computing needs, make it imperative to combine the processing capabilities of smartphones with cloud-hosted servers' capacities (aka mobile cloud computing).

Since time ago, there exist software solutions accessed through mobile devices which make use of cloud services, but today there are still important shortcomings in providing dynamic solutions making use of computing and storage capabilities on both sides (smartphone and cloud servers) depending on contextual conditions .

This is a challenge that needs a satisfactory answer as soon as possible, so the mobile world can evolve and take the most from the Cloud Computing. For this purpose, it is necessary to elaborate new methodologies and tools to design, develop and run applications with components whose execution may fall well in the smartphone or on the cloud, according to changing environmental conditions.

These conditions can be related to smartphone's characteristics such as processing or storage capacity or battery level at a given time, can be related to the network service provided, or to other circumstances such as number of concurrent users or even privacy conditions when running the application that may require the execution and/or storage in the smartphone or in the cloud.

This paper presents an initial approach to design, develop and deploy Mobile Cloud applications taking the most of offloading, reducing developing and maintenance costs and increasing user satisfaction. The solution will be Eclipse based (by means of Eclipse plug-ins) for the design time and offering a middleware for the run-time and will be focused on providing new ways of implementing the offloading model. This will be carried out by providing a set of methodologies and tools that will allow the maximum exploitation of available resources through the combination of mobile devices and cloud computing.

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Improving Semantic-Based Application Development Experience by SOFIA ADK and RedSIB Integration

Azza K. Nabih
SECC-ITIDA, MCIT
Giza, Egypt
azkamal@itida.gov.eg

Mahmoud M. Abdallah
SECC-ITIDA, MCIT
Giza, Egypt
mmabdallah@itida.gov.eg

ABSTRACT
In a very busy and fast growing world we are living in, people are seeking for the highest level of automation in their lives. Services should be smart and it is necessary to consider features like proactiveness and context awareness. They are required to adapt to the user's needs and situations and to be able to take wise decisions on behalf of the user. Developing such systems is challenging but they represent a main asset for companies and industries to be innovative and raise their competitiveness level. Furthermore, this kind of smartness in systems is an enabler for more emerging computing paradigms such as Internet of Things, Pervasive Computing, and solutions directed to solving societal challenges. M3 is a reference concept architecture that employs semantic web technologies to allow seamless integration of devices, users, and services, enabling realization of such smart systems that utilize all possible information available and accessible from a shared information repository. M3 technology is progressively maturing. Many implementations for the architecture exist, yet many challenges are still unsolved. This paper presents the integration of two M3 implementations; SOFIA ADK and RedSIB in order to improve the developer experience in using M3 technology. M3 challenges and future work required are also discussed paving the way to go forward with this promising technology.

Keywords
Semantic Technologies; Smart-M3; SOFIA; RedSIB; RDF; Ontology; Semantic Web; SIB; KP; Smart System.

1. INTRODUCTION
No one can deny the role of technology in improving our lives. Technology represents the main tool to provide innovative solutions for every concern that may arise. There is a world trend to automate everything and better utilize the resources (e.g. water, energy …) by employing the technology to build smart systems that are able to be proactive, context aware, and can take wise decisions on behalf of the users. Such smart systems are enablers and core components of emerging classes of computing paradigms such as Internet of Things, Pervasive Computing, and solutions directed to solving societal challenges [1] [2].

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M3 architecture is proposed as a candidate solution to meet the requirements of these modern smart systems [3]. M3 is a middleware architecture to share semantic information about the physical world in order to make it available for smart services [1]. The abbreviation M3 means multi-device, multi-vendor, multi-domain to highlight the flexibility of the technology. All system actors whether they are human or machines are able to publish their information for other actors through simple shared information brokers. The platform has a centralized architecture allowing seamless integration with other systems, services, and program modules through information sharing [4].

Smart-M3 [5] is the first open source implementation of the M3 architecture. Smart-M3 was released as open source platform at the NoTA conference on October 1, 2009. The platform was adopted by ARTEMIS project SOFIA and has been further developed within several communities [6]. The architecture employs Semantic Web technologies to support information interoperability. In addition, it provides a mechanism for subscribing to changing data within the shared information repository, hence taking appropriate actions accordingly [7].

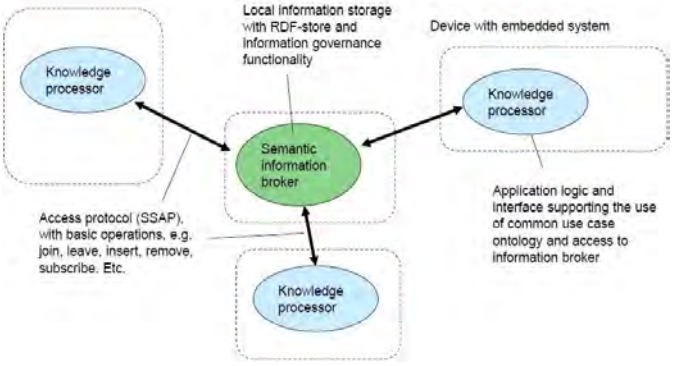

Figure 1. Smart-M3 architecture [8].

Smart-M3 consists of two main components as depicted in Figure 1: semantic information broker (SIB) and knowledge processors (KPs). The shared information is semantically stored according to appropriate domain Ontology in one or more SIBs. In the simplest case, one SIB will store all information. Collaboration of KPs forms the application as depicted in Figure 2. The KPs co-operating in different scenarios are loosely coupled. The Smart Space Access Protocol (SSAP) is the protocol that the KPs use to access the SIB [9].

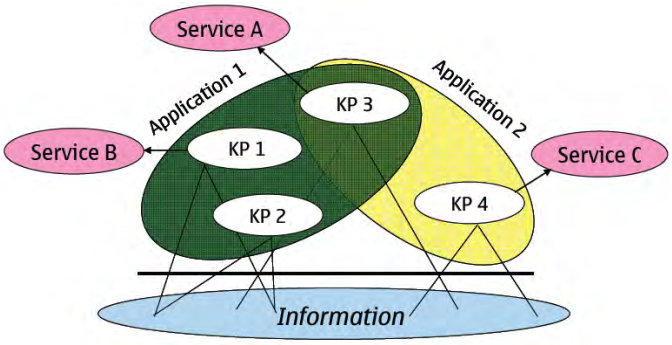

Figure 2. Notion of application [9].

The use of common Ontology [10] allows all actors (human and machines) to mutually understand the semantics of information and cooperate with each other through the SIB. Smart-M3 is Ontology agnostic, hence it allows the developers to consider the best information model that satisfy the requirements of the addressed application domain.

Several Knowledge Processor Interfaces (KPI) are developed in popular programming languages allowing the developers to write their own KPs using any of the supported languages (C, C#, java, PHP, java script, python) [1][6].

Smart-M3 platform is experimentally demonstrated in many application domains ranging from small to large scale projects. The platform shows promising results and has many strengths. Main strengths of the platform are:

- Easy exchange of global and local information, hence allowing cross-domain interoperability. This is achieved mainly through using Semantic Web as the core technology for information sharing.
- Modularity and extensibility as the architecture is based on the concept of independent agents (KPs) that are loosely coupled and communicate with each other through inserting and querying the shared information into the SIB.
- It is an open source architecture, so it can be adopted even in small enterprises without adding additional costs except for the initial learning and migration phase to adopt the technology into the business.
- The application logic can be implemented using different programming languages as there are support for many KPIs in many widely used languages.
- Smart-M3 has a good community that takes care of the technology and handles issues raised from deployment of the technology into real projects.

There are many challenges associated with the current implementations of Smart-M3 architecture that should be tackled in order to have an impact on the market. The paper will discuss and summarize most of these challenges that were met when deploying the architecture in real systems. It will illustrate a trial that was done to improve the Smart-M3 based development experience through integrating two Smar-M3 implementations and will present the evaluation for the integrated scenario.

The rest of the paper is structured as follows. Section 2 discusses the challenges of Smart-M3 platform based on real deployment of the platform in some real case studies. Section 3 presents the efforts done by the community to tackle these challenges. Section 4 discusses a proposed integration between two existing implementations; the SOFIA ADK and RedSIB along with the evaluation and limitations of the integrated solution, and, finally, Section 5 concludes the paper and gives directions for future work.

2. SMART-M3 IMPLEMENTATION CHALLENGES

Smart-M3 architecture is used in several application domains and is experienced in several projects with many of them funded by the EU Commission that has a great role to motivate and encourage new technologies, innovation, and research around the world. Smart-M3 based applications ranged from small scale to large scale systems and include for example: context-aware applications, smart environments (room, home, city, office, hospital …), resource management and utilization, social media, and mobile computing. Many of these experiments were presented and demonstrated in the proceedings of the Open International M3 Semantic Interoperability Workshop that was held on November 2013 to discuss the state of the Smart-M3 technology [6].

Egypt also has a role in employing Smart-M3 architecture and evaluating such platform in two of its projects which have been done as part of the RECOCAPE EU funded project [11]. Namely, SECC; the Egyptian partner in the project has completed its two pilot projects Energy-Aware Smart Building project [12] which aimed to develop a smart home system with the ability of applying energy saving polices and Semantic Advertising Platform for Egypt (SALE) project [13] that targeted developing a smart advertising platform which exploits semantic technology using Smart-M3 as a core component in the architecture.

In addition, SECC conducted consultation services on Smart-M3 technology and encouraged the Egyptian companies to deploy and improve their business through employing this promising technology. SECC in cooperation with United Ofoq Company has experienced the deployment of Smart-M3 platform in their applicant module that represents a basic module in their ERP system.

Through these experiences with the Smart-M3 technology, many challenges are met. Some of them are reported by the world wide community [6] and additional ones are from SECC experience in using the technology. It is important here to highlight that the two main Smart-M3 implementations experienced in SECC projects are the Sofia ADK and RedSIB.

The challenges reported by the world wide community are [6]:

1) Lack of reasoning and inference of new data. This includes both the Ontology based generic reasoning and the SIB rules engine domain specific reasoning.

2) Lack of Smart-M3 support for plug-in extensions [14]. These plug-in extensions are needed to support functionalities like: Information filtering, domain specific features, ease access of multi-SIBs through a simple interface, profiling functionalities (memory, performance…), Dynamic and run-time configuration of the SIB, and garbage collection

3) Lack of access control, examples are join access control that determines who can join the system, and information access control which determines who can access which information in the system.

4) Lack of advanced operations like enforced locking of sub-graphs.

5) Lack of reliability and recovery procedures

6) Support of more communication protocols between the SIB representing the shared information storage and the KPs running on distributed processing elements.

7) Support for low resource devices.

8) Lack of detailed documentation to understand M3 evolution and the motivations of the different available Smart-M3 implementations.

9) Lack of bug reporting facilities.

Additional challenges reported by SECC, Egypt are:

1) Upgrade and integration of companies legacy systems; mostly dependent on relational database technologies, into semantic based solutions using Smart-M3.

2) Performance especially in case of large size data sets.

3) Lack of performance profiling and comparison between the different Smart-M3 implementations. In addition, performance comparison of these Semantic-based solutions and the legacy database solutions.

4) Lack of extensibility measures for the platform in order to know the maximum allowed users, nodes, or applications that can interact through the platform.

5) Lack of security support on the data inside the SIB.

6) Incomplete Arabic support.

7) Lack of standard Ontologies that can be used to build semantic based solutions for the different application domains.

8) Incomplete support for standard SPARQL queries which make solutions developed using the various Smart-M3 implementations incompatible.

9) Nondeterministic behavior of subscription and subscription handling in some cases like calling the subscription handlers with high frequency such as in the case of multi-users or high rate of information change. Also, subscription causes non-deterministic behavior in case of Arabic data and data with special characters.

10) Not all Smart-M3 implementations support persistence storage.

11) Smart-M3 implementations doesn't support multi-platforms (Windows, Linux…).

12) Lack of complete and rich development framework for Smart-M3 based solutions. Most required features reported based on real deployment of the platform into business are: Ability to import Ontologies (one or more, or an Ontology that may import other Ontologies) and perform validation of the inserted triples versus these Ontologies. Also, the support for automatic code generation. In addition, there should be facilities to support backup, restore, and administration facilities for the data in the SIB.

13) Lack of support of some Smart-M3 open source implementations.

Much work is done to tackle these challenges and improve the developers' experience in using Smart-M3 architecture. The target of all efforts is to raise the Smart-M3 technology maturity and make it a main competitor in the market. Community efforts to handle Smart-M3 technology challenges will be discussed in the below section.

3. COMMUNITY EFFORTS TO HANDLE SMART-M3 TECHNOLOGY CHALLENGES

The initial M3 implementation was the Piglet SIB which is developed in Python. Starting from this, different contributions are done to evolve the Smart-M3 technology and improve the developers' and users' experience in the technology.

SOFIA ADK was one of the valuable contributions tackling many of the Smart-M3 challenges [15]. It focused on the implementation of a development framework aiming to hide the Ontology details from the developer, assisting automatic code generation of the application data model by transforming Ontologies into model APIs, and it provides the possibility of programming into java by automatically including java KPI libraries. SOFIA ADK helps developers to focus on the application logic without bothering them with communications, discovery, or semantics [8]. The SOFIA ADK approach is shown in Figure 3. This effort was accomplished by Tecnalia, Spain which also contributed to improve the developer experience by providing a layer for automatic code generation of the application logic by using models which directly maps into code. Tecnalia also introduced SMOOL as an extension to SOFIA ADK aiming to provide in this way a full-fledged framework for smart space applications design and development [16] [17]. SMOOL is still at an early stage of development and it supports only a single fixed Ontology at the moment.

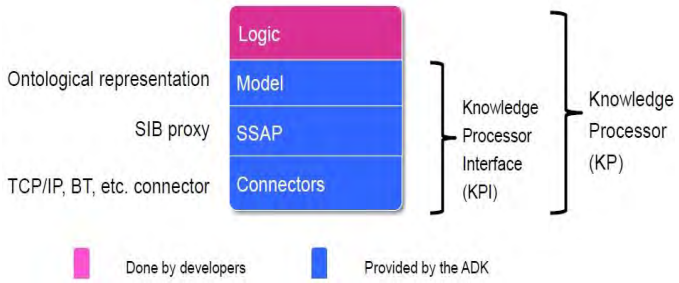

Figure 3. SOFIA ADK approach [8].

An alternative implementation to SOFIA ADK SIB was developed in C and is launched as an open source platform on October, 2009. This SMART-M3 implementation was also developed within the SOFIA project. Later in 2012, a more powerful alternative is launched and is called the RedSIB. In RedSIB, SPARQL is adopted as a more powerful Semantic based query language. RedSIB aims at improving scalability, performance, and robustness of the Smart-M3 based systems.

RedSIB targets Linux based platforms, hence a new SIB alternative was developed [6] with the target to be platform independent, and this was the OSGI SIB.

As an effort to support low resource devices, VTT created RIBS as another Smart-M3 implementation alternative. They also focused on the performance and security issues in their solution.

SmartSlog is also developed as an Ontology driven SDK, it supports code generation only in C and is suitable for low capacity devices [16].

As part of handling the Smart-M3 challenges related to the lack of support for the technology, efforts are done to build Smart-M3 communities to be responsible for discussing the technology issues and share the knowledge, ideas, and efforts to improve the technology. There was a community previously established as part of SOFIA project activities (www.sofia-community.org) also another community established by VTT to share information about M3 technology (www.open-m3.org). Both communities failed to attract developers and users, as a result there was no more active organizations to host and to put efforts into them.

The available active communities currently available is the SourceForge project website which is an active place for the distribution and development of RedSIB implementation of Smart-M3 also FRUCT.org community [18] which is also active on Smart-M3.

In order to face some of the above mentioned challenges this paper proposes the integration of SOFIA ADK and RedSIB. Next section shows how this integration can overcome some of the issues existing in the two separate solutions and can significantly improve the Smart-M3 development experience.

4. SOFIA ADK AND REDSIB INTEGRATION

SECC, Egypt experienced Smart-M3 in many of its projects and consultation services to the Egyptian companies. Mainly, SOFIA ADK and RedSIB implementations were used and evaluated. They were selected because they are the two open source alternatives, supporting java development, and not restricted to resource constrained devices but can be used for any application domains.

Table 1. summarizes the pros and cons of the SOFIA ADK. SOFIA ADK is good in automatically including java KPI libraries, automatic generation of the model layer through transforming the imported Ontologies into model APIs, and integrating SIB simulation into Eclipse which is the platform used for SOFIA ADK. All these features make SOFIA ADK a rich development framework. Utilizing the generated model APIs and using them to insert the semantic triples into the SIB enables the verification of the inserted data and prevents the systems from inserting invalid triples that don't follow the selected Ontology to be used for the KP operation. Modifications to the Ontology is simple as it is only a step of importing a new Ontology to be used for the new KP logic. This doesn't affect the code written for the old non modified concepts and this doesn't affect the triples already inserted in the SIB at all. Unfortunately SOFIA ADK support is not currently available, and there are limitations mostly due to the fact that the ADK is a research project result, not a product. In addition, it doesn't support saving Arabic data into the SIB which is expected to be a general problem with all non-English characters. Furthermore, it was found that SOFIA ADK doesn't support importing an Ontology that internally imports other Ontologies, and it was found also that it doesn't generate the corresponding APIs for the Ontology properties that have more than one domain. Moreover, it supports only importing a single Ontology for each KP, while some KPs may need to use concepts from more than one Ontology.

Table 1. SOFIA ADK pros and cons.

Pros	Cons
Complete and rich development framework	ADK development has stopped
Validation for triples versus the input Ontology	Volatile SIB
When modifying Ontology, just we need to re-import the new Ontology.	No Arabic support
	Poor SIB performance
	Doesn't support importing an Ontology that imports other Ontologies
	ADK doesn't generate APIs when the Ontology contains properties having multiple classes in their domain
	KP project doesn't support multiple OWL Ontologies

On the other hand, RedSIB reported good results for being active within the community having an active SourceForge project to maintain its development and evolution. RedSIB provides a persistent storage for the data in the SIB, and it is found to provide support for Arabic data when used to implement various smart applications within SECC. The RedSib is continuously improved by its active community on SourceForge and this can make it an effective and competitive alternative relative to other Semantic and non-Semantic based solutions after reaching a mature state of development. But, RedSIB currently suffers from poor development framework which adds overhead on the developers to include KPI libraries themselves, to have knowledge of the semantics as they are supposed to write each piece of code themselves, both for the model and logic layers of the application. Moreover, there is no validation on the inserted triples as it is the developers' role to decide the format of the inserted triples without depending on a validation layer that ensures the compliance of the inserted triples with the intended Ontology to be used. The performance also is found to be not that good to meet the requirements of many business domains. We hoped that next versions will improve performance as it is VTT research center in Finland and University of Bologna in Italy mission to provide solutions for the performance and security problems of this Smart-M3 implementation. Table 2 summarizes the pros and cons of RedSIB.

Table 2. RedSIB pros and cons.

Pros	Cons
Under active development	Existing KPIs doesn't provide rich development framework
Provide persistency storage	There is no validation on the inserted triples to match the

Pros	Cons
	Ontology concepts
Arabic support	Performance in the search was not good enough for some business domains
Performance continuous improvement	
Security and privacy continuous improvement	

Based on the previous evaluation for the two alternatives, we decided to introduce an integration between SOFIA ADK and RedSIB in order to make use of the benefits supported by each platform while overcoming some of its limitations. Following is an explanation for the approach, evaluation for its results based on real application development experience using this suggested solution, along with a summary for its limitations.

4.1 Approach

We thought of a new approach that uses SOFIA ADK after replacing its volatile SIB with the RedSIB. For this, SOFIA ADK will provide a platform to import the Ontology specific to the KP under development, and automatically generates its model APIs. These APIs are then used to insert the required data communicated within the application. This will ensure the usage of the correct concepts as the insert APIs themselves are originally generated based on the input Ontology. Figure 4 shows the code used to connect the SOFIA ADK KP to the RedSIB which is initially installed and configured on an Ubuntu server having an IP to which KPs are to be connected.

```
//Defines
public static String SIB_HOST = "1.1.1.103";
public static String SIB_Port = "10010";
public static String SIB_Name = "X";

//Needed for ADK APIs
static SmartModel model;


public void init_ADK() {

    //Initialization to support ADK connection to SIB
    Properties p = new Properties();
    p.setProperty("HOST", Defines.SIB_HOST);
    p.setProperty("PORT", Defines.SIB_Port);

    SIBDescriptor sd = new SIBDescriptor("X", "TCP/IP", p);
    try {
        model = ModelManager.getInstance().createModel("ApplicantCV", sd);
        // Connect and (true)insert the ontology in the SIB
        model.connect();
    } catch (KPIModelException e) {
        e.printStackTrace();
    }

}
```

Figure 4. Initializing the connection of SOFIA ADK KP project to RedSIB.

Not all operations are found to be compatible between the SOFIA ADK and RedSIB. Mainly query, and hence edit and delete operations are found to be unresponsive due to incompatibility of the SPARQL queries generated by the ADK APIs and those supported by the RedSIB. To overcome this, external KPI libraries are included to the project and are used to complete the other operations failed to be done by SOFIA ADK. Connection through normal KPIs is done as shown by the code snippet in Figure 5.

SOFIA ADK APIs are then used for the insert operations and validating the newly inserted triples into the RedSIB, hence preventing any developers' mistakes to insert invalid triples. External KPIs are used for the query, update, and delete operations as well as subscription and subscription handling whenever changes occur to any of the inserted concepts into the RedSIB.

```
//Defines
public static String SIB_HOST = "1.1.1.103";
public static String SIB_Port = "10010";
public static String SIB_Name = "X";

//Needed for other KP accessing the SIB
KPICore kp;
SSAP_XMLTools ssap;
boolean joined = false;
String xml;
boolean ack;

public void init_Redsib() {

    // Join SIB
    kp = new KPICore(Defines.SIB_HOST,Integer.parseInt(Defines.SIB_Port),Defines.SIB_Name);
    ssap = new SSAP_XMLTools();
    xml = kp.join();
    ack = ssap.isJoinConfirmed(xml);
    if(!ack)
    {
        System.out.println("Cannot Join the SIB\n host =" + Defines.SIB_HOST + "\nport =" + Defines.SIB_Port);
    }
    else
    {
        System.out.println("Joined the SIB\n host =" + Defines.SIB_HOST + "\nport =" + Defines.SIB_Port);
        joined = true;
    }

}
```

Figure 5. Initializing the connection of normal KP to RedSIB.

4.2 Evaluation

The integrated solution makes use of the benefits provided by the RedSIB which were limitations in the SOFIA ADK. The solution mainly focuses on resolving the following challenges: Ensuring validation of the triples inserted by a specific application versus the input Ontology, persistence storage of the data into the SIB, Arabic support, and the active community participating to improve performance, security, and privacy of the architecture. Yet, this solution is still suffering from the limitations of the SOFIA ADK and its inability to import an Ontology that imports other Ontologies or importing more than one Ontology. Also, it suffers from the failure to generate APIs for the properties having more than one domain. Moreover, the integrated solution still have some overhead on the developers when performing some operations due to the incomplete compatibility between the SOFIA ADK APIs and the operations supported by the RedSIB. This makes SOFIA ADK operations effective only in case of inserting triples into the SIB, but other operations are needed to be handled by the developer using available external KPIs.

5. CONCLUSION AND FUTURE WORK

Smart-M3 is proved to be a promising architecture that can be used in many application domains. Many implementations are done to realize the architecture, yet many challenges are needed to be addressed in order to improve the user experience in using this new technology.

This paper introduced the Smart-M3 architecture, its challenges, and the work done by the community to tackle these challenges. The paper also introduced a new approach to integrate two different implementations of the Smart-M3 in order to improve the development experience and provide a more practical and

easier development framework. The proposed development framework integrates both SOFIA ADK and RedSIB to make use of the advantages of both platforms while overcoming their disadvantages as possible. The paper evaluates each implementation separately based on practical deployment of the solution into real projects, then the new approach is presented and evaluated. Although the proposed solution doesn't completely address all the challenges, it is proved to be better than using any of the implementations as a standalone solution.

In addition to the specific problems reported by the integrated solution, there are still many unaddressed challenges for the Smart-M3 technology itself, to which more efforts are to be directed in order to raise its maturity as a new alternative architecture for the smart systems. The most important is to introduce a complete open source development framework that provides full support for the SPARQL queries, support both English and non-English data, has persistent storage, efficiently support subscription and subscription handling even to high rate of data changes, supports automatic code generation on both model and logic layers, provides high level performance, reliability, and security, and also reasoning and inference of new data will be a good asset to be included in the framework. Moreover, there should be work directed to developing a more public SIB that can be easily customized to fit the different application domains. There should be benchmarking to evaluate the performance, security, scalability, and robustness of the different Smart-M3 implementations. Finally, there should be communities that support not only the code sharing, but also the different types of documentations like specifications, user guides, design patterns, case studies, papers, Ontologies, applications, and libraries.

6. ACKNOWLEDGMENTS

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Framework for Agile Business Solutions (FABS®)

Bassem R. Selim
Research Manager
68 Makram Ebaid St.
Nasr City, Cairo, Egypt
bassem@unitedofoq.com

Mohammed I. Abdel-Razik
FABS Core Technical Team Lead
68 Makram Ebaid St.
Nasr City, Cairo, Egypt
mibrahim@unitedofoq.com

ABSTRACT
This paper presents the Framework for Agile Business Solutions (FABS®) of the United OFOQ Company. FABS® allows for building and maintaining end-to-end business oriented solutions in minimal time needed, in comparison with other tools in the market. FABS® generated solutions are natively Cloud supported, ready for SaaS business model, integrated with Social Media meanwhile, provide end users seamless capacity to create his own personalized. Therefore, this paper will discuss the idea behind FABS®, the components of FABS®, how to use FABS® and success stories of FABS®.

Keywords
Agile, Cloud, Online, Application Building, Framework, Software Integration, Open Source Software, Work Flow, Business Process.

1. INTRODUCTION
Developing web applications has witnessed many stages. Firstly, it began with the hand-coded Hyper Text Markup Language (HTML) [1]. However, any change into HTML contents either need the content author or a great html expert on the minimal or no user interaction at all [1]. Thus, a new concept called the Common Gateway Interface (CGI) was presented to provide more functionality to user input and allowed to add dynamic contents to HTML pages [2]. Then, for more dynamic contents handlings and high-traffic web applications, more complex frameworks that can extend web server functionality like Perl was presented [3]. Moreover, some web servers provided the functionality of handling dynamic contents by executing some written code like Apache Tomcat [4] server and Java [5]. On the other hand, the concept of fully integrated server language is presented along with great server languages like ColdFusion [6], PHP [7] and Active Server Pages (ASP) [8].

Moreover, web evolution led us to the great concepts of (i) Convention over configuration [9] and (ii) Don't repeat yourself (DRY) [10].

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Consequently, a variety of great web frameworks are presented to ease development process and increase efficiency, productivity and make tasks like security, caching handling, Database access, mapping and configuration much easier to perform. Examples of this include JSF frameworks like (ADF [11], Primefaces [12]), Microsoft ASP.NET [13], JavaEE (Servlets) [14], WebObjects [15], web2py [16], OpenACS [17], Catalyst [18], Ruby on Rails [19], Grails [20], Django [21], Zend Framework [22], Yii [23], CakePHP [24] and so many others.

Finally, a new trend appeared to reduce the applications development and cost to minimal while increasing the usability, functionality, scalability and business value. This trend is applications builder frameworks that enable developers to use already made templates to build business applications in minimal time and effort. A few of these frameworks are Oracle APEX [25], IBM BlueMix [26] and Microsoft Sharepoint portal [27].

Although this great evolution made a huge progress in web development, their target remains the developers, coders or programmers. Therefore, FABS® brings the new wave of evolution, where the business user is the target for developing business solutions not the programmer.

The rest of this paper is organized as follows. Section 2 presents FABS® philosophy and architecture. Next, FABS® world is explored in section 3. Then, FABS® success stories are stated in section 4. Finally, conclusions are given in Section 5.

2. FABS® PHILOSOPHY
FABS® philosophy can be summarized in one phrase "Let Business People Innovate". It lets business people, in a rapidly changing market, to transfer their business know-how to a state-of-the-art solution in a fast-time-to-market way along with persisting freedom, and reaching the highest level of customer satisfaction with low total cost of ownership (TCO). FABS® achieves that through presenting an online framework used to rapidly build, customize and maintain end-to-end business applications.

This framework allows business people to build modern applications online with no code, in a highly accelerated time-to-value. Moreover, it provides flexibility in building and maintaining end-to-end different-size solutions in much less time than that needed to build those using traditional tools (see Figure 1 and Table 1). On the other hand, those solutions are business oriented; natively support cloud and social media, integrable with the various software technologies with rich and highly customizable GUI (see Figure 2). In the next section FABS® framework will be introduced in more details.

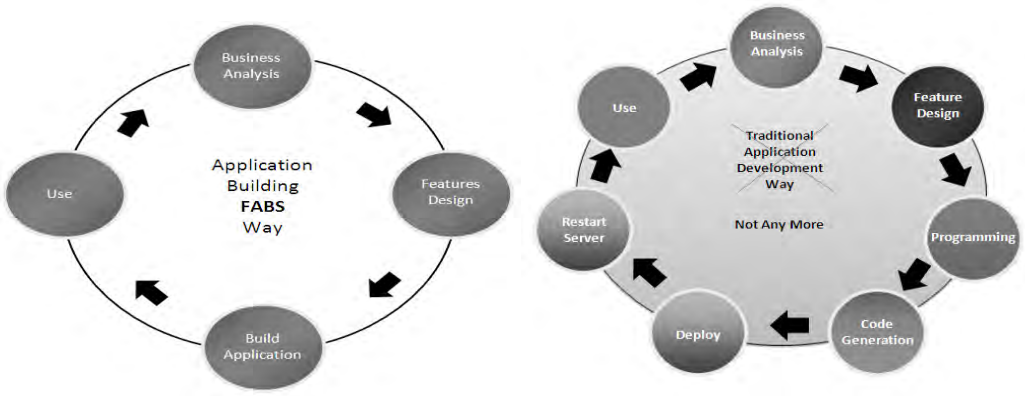

Figure 1. FABS® application development vs. traditional application development

Table 1. FABS® comparison with other framework builders

	FABS®	**APEX** [25]	**Blue Mix** [26]	**SharePoint**[27]
Targets	Business end users, implementers	PL/SQL developers and implementers	Developers	ASP.Net developers and implementers
Scalability	Need no more hardware, cloud based	It can be cloud based, or increase the number of Oracle DB servers	Cloud based	More servers are needed
Required Knowledge	Business knowledge only	PL/SQL knowledge	Any programming language	ASP.Net
Installation	No installation is needed	Runs anywhere ORACLE DB is installed	No installation is needed	Need specific implementer to install
Integration with other frameworks	Easily done through WS and other FABS option	Integrable with Oracle products	You can install or add more tools	Integrable with Microsoft products
TCO	Minimal	Oracle DB license	High	High
Upgrade	Any component in the framework is replaceable based on business needs	Based on Oracle products	Based on prices and other versions	Based on Microsoft products
Open Source Compatibility	Very compatible	Based on Oracle products	Based on available cloud products	Based on Microsoft products
UI	Moderate	Rich	User build it	Rich

3. FABS® WORLD

FABS® can be viewed from multiple angles. In the next few subsections a few angles will be visited.

3.1 FABS® Functional Architecture

FABS® functional architecture is divided into four main sections (i) servers and frameworks, (ii) FABS® engine, (iii) FABS® GUI tools and (iv) FABS®-Based business solutions (see Figure 3). In the next few subsections we will explore these sections in more details.

3.1.1 Servers and Frameworks

FABS® back-end is built over powerful ranked niche tools and frameworks, harmonizing together. It was built using agile philosophy and based on Free Open Source Software (FOSS) and standard frameworks (see Figure 3). Therefore, each component in FABS® framework is replaceable and scalable in a highly responsive manner. Hence, FABS® kills IT-vs-Business gap to let business people focus on business rather than technical aspects.

3.1.2 FABS® Engine

FABS® engine consists of many core tools that work behind the scene to enrich business user experiences. One of the most important tools is *Entity Manager* which is responsible for handling both metadata and business data from the presentation layer to the data layer and vice versa. Another important tool is the *Cashing Manager* who caches the metadata for later use to enhance the performance and increase memory management. An additional tool is *Security Manager* that provides security for both metadata and business data for all Create, Read, Update and Delete (CRUD) operations. Extra important tool is *Multi-Tenancy Manager* that handles the active tenants to work securely, efficiently and isolated from each other. Furthermore, there are many other important tools like *Import and Export Data Manager*, *Routing, Collaboration, I18n, Builders* and many more (see Figure 3).

3.1.3 FABS® GUI Tools

FABS® provides multiple GUI tools to provide the business user the ability to build and customize his/her business solution in an easy manner. FABS® GUI tools can be categorized into four categories (i) application builders, (ii) administration, (iii) configuration and (iv) services which will be explored in the following subsections.

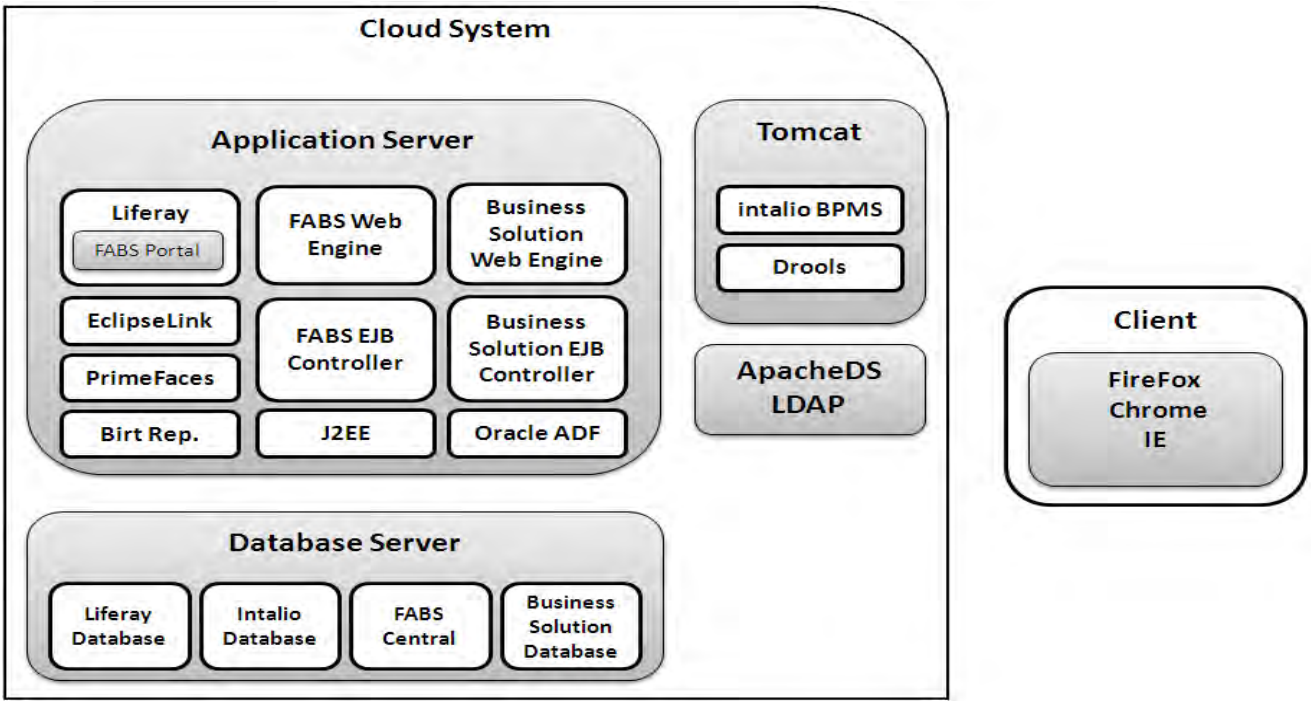

Figure 2. FABS® physical architecture

3.1.3.1 Application Builders

FABS® builders are tools to enable implementer or business user to build or modify his/her business solution with the need to write no code, deploy new applications or restart the application server.

One of the most important FABS® builders is "*Page Builder*" since page concept in FABS® is extremely important. The page contains two or more related potlets that are communicating with each other and presenting complete business functionality in different layouts. Consequently, all FABS® builders are pages.

Another important builder is "*Screen Builder"*. Through this builder business user can build the screens he/she wants and assign different CRUD functionality to it among other functionalities such as control validations, control types, controls sizes or screen GUI with absolutely no code. To enhance usability of this builder it provides different types of screens builders such as "*Form Screen"* and "*Tabular Screen".*

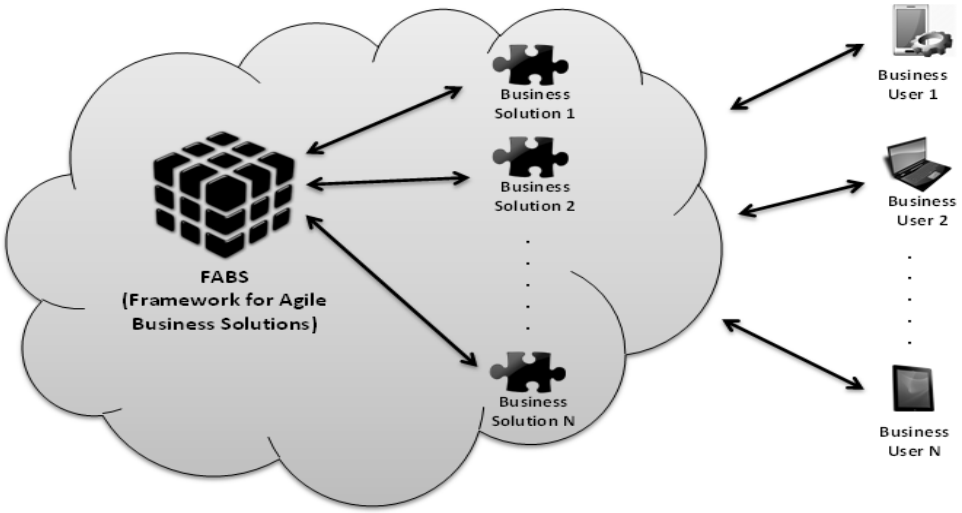

Figure 3. FABS® cloud system

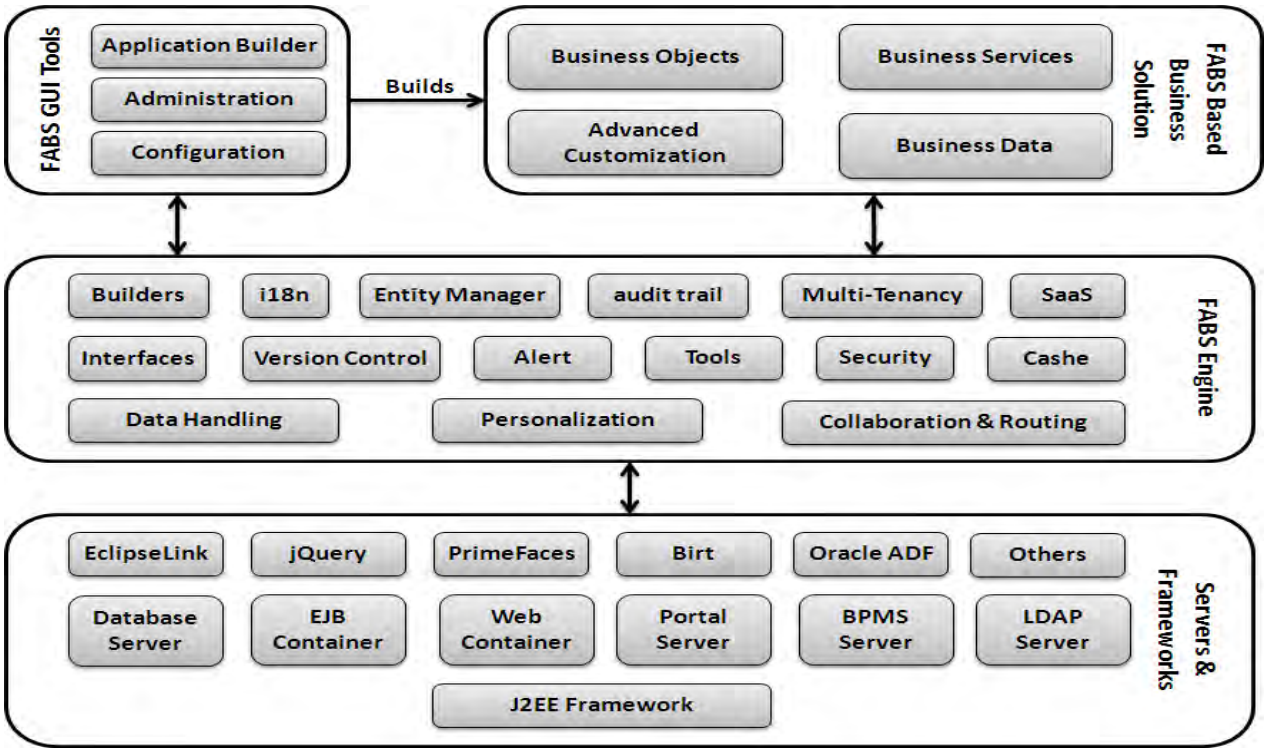

Figure 4. FABS® architecture

One more builder is "*Menu Builder"* that allows business user to build different menu hierarchies based on different roles. Other available builders are "*Business Process Builder"*, "*Report Builder"*, "*Wizard Builder", "Alert Builder", "Chart Builder"* and "*Business Entity Builder*".

3.1.3.2 Administration

FABS® provides business user with easy-to-use tools to administrate FABS®-based business solution. One of the most important tools is *User Manager* which end user can add, edit or remove user and provide the basic information for him/her like email, password, first and second language. Another important tool is *Menu-Role Manager* to define certain menu to certain roles. An additional tool is *User-Role Manager* to assign defined user to certain roles.

3.1.3.3 Configuration

Configuration tools are a way to help FABS® knows certain information about tenants, LDAP server, process server, web services server or any other important information.

3.1.3.4 FABS® Services

From day one FABS® is ready to present multiple services as Software-as-a-Service (SaaS). One of the most important services that are provided by FABS® is "*Alert"*. The FABS® alert service enables the user to send business information, notifications or events based on certain times or events via different communications channels like email or SMS. One more service is "*Form Designer"* that enables the business user to create business templates that can be filled and send automatically via previous setup. An additional important service is "*Server Job*" that enables user to perform non GUI long functionalities, like calculating monthly payroll, with no need to affect the running application performance. Further important service is "*Translation"* that enables business user to provide a translation in any language he/she wants not just to the Meta data but also the business data. The data are shown in the user first language preference. Moreover, FABS® provides different "*Analytical Tools"* tools that diverse on functionality and levels (i.e. OLAP, Charts, and Reports). Furthermore, FABS® presents powerful SOA, business process and workflow engine supporting (BPEL, BPMN, Human Task, Business Rules). Also, there are different "*Audit"* tools to enable the business user to track the system data and actions on different levels. Finally, FABS® provides security on many levels and layers like (HTTPS, LDAP, RBACK, SSO, data encryption). In the last section, a few of FABS® success stories will be explored in more details.

3.1.4 FABS®-Based Business Solutions

It is the resultant product built by the business user through FABS® builders and tools. Once the application is built and configured it is ready to be used with absolutely no need for any kind of installation or deployment. Section 4 will list two of FABS®-Based Business Solutions *OTMS* and *Legal System* in more details.

3.2 FABS® Physical Architecture

This view explains the physical components of FABS®. These components can be categorized into (i) application server, (ii) process server, (iii) LDAP, (iv) database server, (v) client and (vi) cloud system. All these categories, which will be detailed in the following subsections, can be installed into different servers with different operating systems with no integration problem at all (see Figure 4).

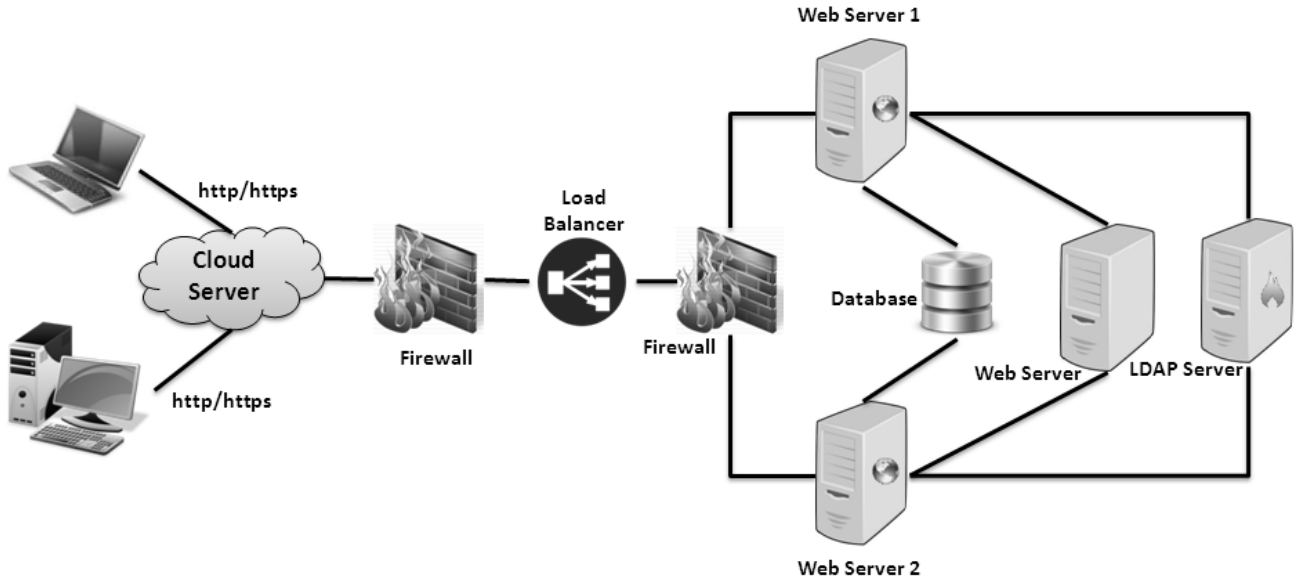

Figure 5. FABS® Network Architecture

3.2.1 Application Server

FABS® works on any application server supports J2EE framework like Glassfish or Web Logic. On the other hand, portal server can be installed on the same application server, which FABS® is installed on or a different application/web server.

3.2.2 Process Server

It is the server that runs and configures business processes. It is integrated with FABS® through different configuration tools.

3.2.3 LDAP

It is the location where the user and roles are created and stored beside FABS® central DB. It is integrated with FABS® through different configuration tools.

3.2.4 Database Server

FABS® runs on any relational DB (i.e. MySQL, SQL Server, Oracle DB... Etc.) based on the business needs. On the other hand, FABS® needs the following databases to be configured (i) one for portal server, (ii) one of business solution data and metadata (iii) one for process servers (iv) and one for multi-tenancy configurations.

3.2.5 Client

All what clients need to work on FABS® or FABS®-based business solution is application url and browser that support Java script (i.e. Firefox, Chrome, and IE) from desktop, laptop or smartphone. There is no any other requirement required from the user.

3.2.6 Cloud System

It is the operating system(s) that holds all previous servers on cloud environment. On the other hand, FABS® runs on Linux and windows equally, but not tested on the Mac environment yet.

3.3 FABS® Network Architecture

Finally, FABS® Network Architecture is presented which is simple (see Figure 5).

4. FABS® SUCCSS STORIES

4.1 OTMS

OFOQ Talent Management System (OTMS) is one of the most important success stories for FABS®. Basically, OTMS is a human resources management solution which is built by FABS®. Therefore, OTMS is utilizing the top notch portlets concepts and online business process features, which are provided by FABS®, to automate the human resources activities within the organization.

Consequently, OTMS adds value over the normal business functions, to easily enable business users to set up their own favorite and customized pages and functions with a totally user friendly experience resulting in a ranked as Tier one HR System in Egypt (see Table 2 for a brief list of OTMS customers).

4.2 Legal System

Another success story for FABS® is the Legal System which is specialized in Egyptian banks legal affairs automation. The Legal System is considered the first of its kind in the Egyptian market from implementation and features point of view. Like OTMS, Legal System is utilizing the top notch portlets concepts provided with FABS®. In addition to that, it benefits from other FABS® services like Alert and Chart. Legal System is implemented successfully in Suez Canal Bank and is going to be implemented on Egyptian Arab Land Bank soon.

5. CONCLUSION

FABS® is a promising framework used to create and customize end-to-end agile cloud business solution in easy and fast time-to-market manner using cloud system.

FABS® targets business analysts, business applications implementers and end-users with no programming work required.

FABS® is adapting Free Open Source Software (FOSS) concept. However, it can be customized to work with famous applications, servers and databases like ORACLE Weblogic and ORACLE database.

Finally, FABS® is an evolving framework and it still has a lot to present in the few incoming years.

Table 2. Brief list of OTMS customers

Customer Name	Customer Industry	Implementation Type	Country
Rashid Al Rashid (RAR)	Investment	Perpetual	KSA
Porta	Packaging	Perpetual	Egypt
Alstom	Power Generation	Perpetual	Egypt
Sea Drill	Drilling	Perpetual	KSA
Abo Dhabi Islamic Bank (ADIB)	Banking	Perpetual	Egypt
UTOPIA Pharmaceutical Company	Pharmaceutical	Perpetual	Egypt
Nalco Egypt company	Power and Energy	SaaS	Egypt
The Bakery Shop (TBS)	Bakery	SaaS	Egypt
Al Wehda Bank	Banking	SaaS	Libya
BNP Paribas Sahara	Banking	Perpetual	Libya

6. ACKNOWLEDGMENTS

Thanks to all previous and current FABS members who made these entire true.

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An Energy-Efficient Climate Control Solution for Smart Buildings Based on Predicted-Mean-Vote Criteria

Wael Farag
Faculty of Engineering
Cairo University
Cairo, Egypt
wael.farag@nmatec.com

Omar Afify, Shady Ahmed, Omar Gamal
NMA Technologies, Inc.
Cairo, Egypt
{omar.afify, shady.abdel-aal, omar.el-shageaa} @nmatec.com

ABSTRACT
In this paper, the climate control solution "ClimaCon" is proposed. ClimaCon is an external extension to any HVAC system. It aims to reach the best thermal comfort for individuals in several zones with the least possible energy consumption. The Solution basically consists of a closed-loop controller, using Raspberry PI (RPI), to control the HVAC actuators and the VAV unit [1] while getting the feedback signals through wireless sensing nodes present across different places in the controlled zone. The performance of the controller is tested through extensive simulation using the MATLAB based Hambase module [2]. The controller proves the ability to maintain the thermal comfort of individuals in the zone during energy saving profiles with excellent performance over twelve different use cases.

Keywords
Ubiquitous computing, Climate Control, Building Automation, Internet of Things.

1. INTRODUCTION
It has been known for a long time that the thermal comfort of a human being is not dependent only on air temperature but it is a function of several parameters [2]; mean radiant temperature, relative air velocity, activity level, and clothing. We take this facts into consideration and by installing a control unit into the central air conditioner of any building, we try to achieve the best combination of these parameters to reach the best thermal comfort of individuals in several zones with the least possible energy consumption, the data is collected from the zone using several nodes [3][4][5][6] put in different places inside each zone and then sent to the controller. The data is processed by the controller to analyze the situation inside each zone and then predict the new values of the outputs to reach the set points of the temperature and humidity. The controller offers to the user three modes of comfort to choose from beginning with energy saving mode which cares more about saving energy then moderate mode which tries to reach more thermal comfort to the individuals and the last mode which is the high comfort mode which offers the best thermal comfort for the individuals.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

In the following parts of the paper we proceed by explaining briefly our solution, and then we describe the controller used, sensing nodes, inputs and outputs modules, the different modes offered by the controller reaching the simulation results when the controller is put into test.

2. THE CLIMACON SYSTEM

2.1 System Overview
ClimaCon System mainly consists of three parts; sensors nodes, coordinator and controller.

The sensors nodes collect the data through the temperature, humidity and air quality sensors; they communicate with the system through Zigbee [3].

The coordinator is the interface between the Zigbee domain (nodes side) and the Ethernet domain (controller side).

The controller runs the program which collects the data from all different nodes and/or zones; applies the control and fault detection algorithms; calculates outputs and sends them to the specific node.

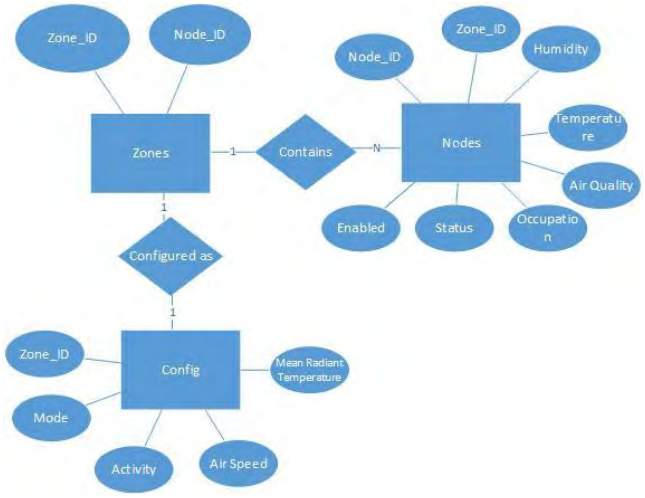

Figure 1. Entity relationship diagram

The three main entities are shown in the entity relation diagram are (Figure 1):

Zones: identify the different zones with the nodes connected to each.

Nodes: contains the attributes read by the sensor's nodes (temperature, humidity, air quality in addition to some attributes that identify the status of the node)

Configuration: contains some parameters needed by the control algorithm. These parameters need to be configured by the user for each zone; such as the expected level of activity and the air speed.

2.2 PMV and PPD

Our solution is concerned in keeping track of the thermal comfort on the individuals inside the controlled zone, to do that we must keep track of some parameters affecting the thermal comfort of human beings. These parameters are introduced in the comfort equation by Prof. P.O. Fanger [7] and then to quantify the degree of discomfort an index is devised [7] which gives the Predicted Mean Vote (PMV) from tables given in [2] page 7 or from the equation taking into account the following parameters:

- **Metabolism**, W/m^2 (1 met = 58.15 W/m^2)
- **External work**, met. Zero for most metabolisms.
- **Thermal resistance of clothing**, clo (1 clo = 0.155 m^2 K/W), the ratio of the surface area of the clothed body to the area of the nude body.
- **Air temperature**, °C
- **Relative air velocity**, m/s
- **Water vapor** pressure, Pa
- **Convective heat transfer coefficient**, W/m^2K and surface temperature of clothing.

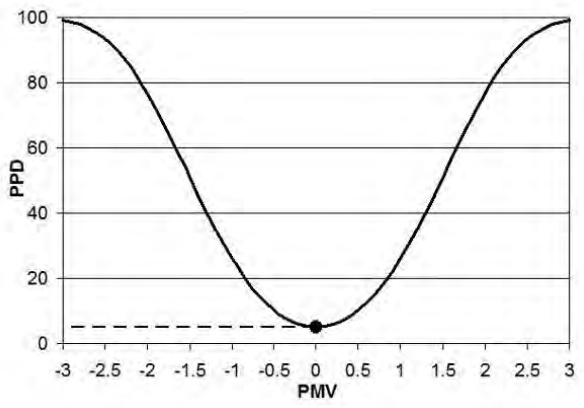

Figure 2. The relation between PPD (Predicted Percentage of Dissatisfied) and PMV (Predicted Mean Value)

The Predicted Percentage of Dissatisfied (PPD), may then be estimated from Fig.1 and when the PMV reaches zero the least percentage of dissatisfied (PPD) is located (5%)

2.3 Temperature and Relative Humidity Set Points

According to the (PMV) and (PPD) equations a study is made to find the perfect temperature and humidity for each activity and clothing values, the relative humidity in the study is set with constant value (45%) and the temperature set point will differ according to different combinations of activity and clothing. The study is shown in table 1

Table 1. Temperature Set Point study for different combinations of activity and clothing

Activity description	Clothing description	Temperature Set Point	Corresponding PPD
Lying down	summer clothing	28.7	5
Lying down	working suits	27.4	5
Lying down	Winter	26.6	5
Lying down	European Winter	24.5	5
Sitting quietly	summer clothing	26.5	5
Sitting quietly	working suits	25	5
Sitting quietly	Winter	24	5.1
Sitting quietly	European Winter	21	5
Sitting sedentary	summer clothing	25	5.1
Sitting sedentary	working suits	23	5.1
Sitting sedentary	Winter	22	5
Sitting sedentary	European Winter	19	5
Moving Light Activity	summer clothing	22.5	5
Moving Light Activity	working suits	20	5
Moving Light Activity	Winter	18.7	5
Moving Light Activity	European Winter	15	5
Moving Medium Activity	summer clothing	20	5
Moving Medium Activity	working suits	17	5
Moving	Winter	16	5.1

Medium Activity			
Moving Medium Activity	European Winter	11	5
Moving High Activity	summer clothing	13.5	5
Moving High Activity	working suits	10	5
Moving High Activity	Winter	7.2	5
Moving High Activity	European Winter	1	5

According to the predefined value of activity and clothing set by the user, the controller will work to reach the corresponding set point temperature to obtain the best PPD in all different cases.

2.4 Raspberry Pi Controller and Its Different Modes

We used a raspberry pi controller (RPI); it is one example of Plug Computers operating on Linux with 700 MHz low power ARM1176JZ-F applications processor, 512 MB of RAM and a 100MB Ethernet port.

The RPI runs the controller program which continuously read/write data from/to the router which in turn reads/writes from/to the Nodes as necessary. It also holds the Database where the collected data is stored.

Now we will list all the control input and output signals to introduce the reader to the parameters that affect the decision making of the controller and the controlled actuators; the inputs are measured and sent to the controller through several nodes installed in different places in each zone and here are the inputs and outputs of the controller:

Table 2. Inputs and outputs of the controller

Inputs	Outputs
- Zone Sensed Temperature [Tz] - Zone Sensed Relative Humidity [RHz] - Zone Sensed PIR Occupancy [Oz] - Zone Sensed Air Quality [AQz]	- Zone VAV Damper Position [DP_z] - Zone Humidifier Status [HF_z] - Zone Heater Status [HT_z] - Zone Blower Speed Fan [SF_z] - Zone Evacuation Blower [EB_z] - Zone Alarm Beeper Alarm - Zone Status LEDs (Green, Orange Yellow, Red)

On the controller two different algorithms run concurrently so we can assume the presence of two different controllers; “Air quality controller” and “Energy saving and Comfort controller”.

The first controller (air quality controller) has the higher priority. It is responsible for calculating the optimal HVAC output values (DPz, SFz, EBz, Beeper) it checks the air quality of the room and gives the output values to achieve the most healthy air quality and this controller is activated if and only if the air quality sensor gives the indication that the air inside the zone is highly polluted or severely polluted at this case the output values are taken from this controller as it has the highest priority.

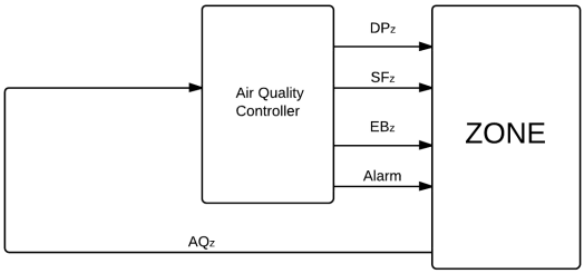

Figure 3. Air quality controller diagram

If the air quality sensor indicates that the air inside the zone is clean the air quality controller is skipped and the second controller are put into action and we take its outputs to be the new outputs of the actuator. First “The Energy saving and comfort controller” checks the occupancy in the zone if the zone is unoccupied the controller works to keep the PPD between (25% to 30%) (Energy saving sub controller) but if the room is occupied the comfort controller offers three different modes for the user to choose from them; High comfort mode (PPD value is kept between 6% to 8%), Balanced mode (PPD value is kept between 6% to 14%), Energy saving mode (PPD value is kept between 6% to 20%)

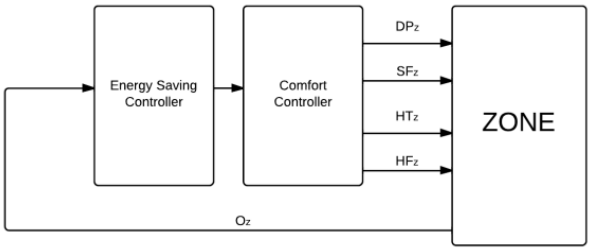

Figure 4. Comfort controller diagram

2.5 Fuzzy Logic of the Outputs

The controller updates the outputs’ values according to certain fuzzy logic for each output; we will discuss now the fuzzy logic of each output and also introduce the temperature and humidity fuzzy logic:

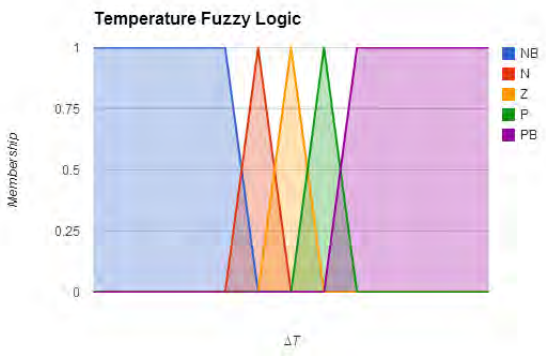

Figure 5. Temperature fuzzy logic diagram

Delta temperature = desired Temperature (according to the study) - sensed Temperature
-Less than -1.5Negative Big (NB)
-Between -3 and 0 Negative (N)
-Between -1.5 and 1.5 Zero (Z)
-Between 0 and 3 Positive (P)
-Greater than 1.5 Positive Big (PB)

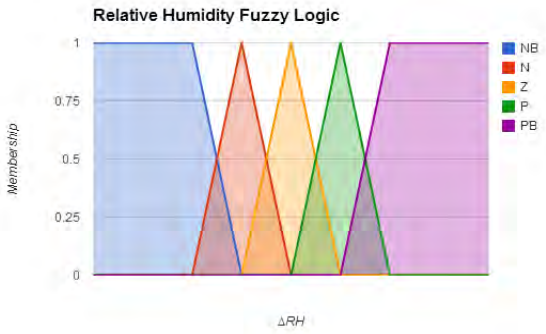

Figure 6. Relative humidity fuzzy logic diagram

Delta Relative Humidity = desired Relative Humidity (45 %) - sensed Relative Humidity
-Less than -10Negative Big (NB)
-Between -20 and 0 Negative (N)
-Between -10 and 10 Zero (Z)
-Between 0 and 20 Positive (P)
-Greater than 10 Positive Big (PB)

2.5.1 Outputs fuzzy logic:

(1) VAV Damper Position [DP_z]

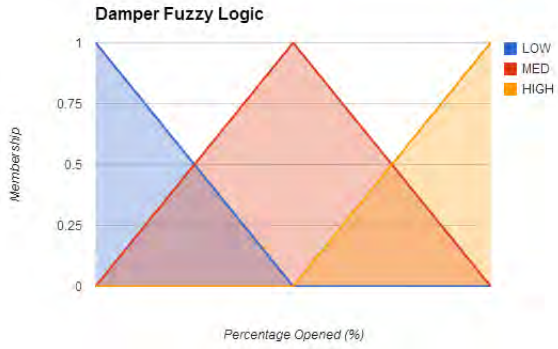

Figure 7. Damper fuzzy logic diagram

Table 3. Damper fuzzy logic values

	NB(ΔRH)	**N(ΔRH)**	**Z(ΔRH)**	**P(ΔRH)**	**PB(ΔRH)**
NB (ΔT)	HIGH	HIGH	HIGH	HIGH	HIGH
N (ΔT)	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Z (ΔT)	LOW	LOW	LOW	LOW	LOW
P (ΔT)	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
PB (ΔT)	HIGH	HIGH	HIGH	HIGH	HIGH

(2) Heater [HTz]

Table 4. Heater fuzzy logic values

	NB (ΔRH)	**N (ΔRH)**	**Z (ΔRH)**	**P (ΔRH)**	**PB (ΔRH)**
NB (ΔT)	OFF	OFF	OFF	OFF	OFF
N(ΔT)	OFF	OFF	OFF	OFF	OFF
Z(ΔT)	OFF	OFF	OFF	OFF	ON
P(ΔT)	ON	ON	ON	ON	ON
PB (ΔT)	ON	ON	ON	ON	ON

(3) Supply Fan [SFz]

Table 5. Supply fan fuzzy logic values

	NB (ΔRH)	**N(ΔRH)**	**Z(ΔRH)**	**P(ΔRH)**	**PB (ΔRH)**
NB(ΔT)	HIGH	HIGH	HIGH	HIGH	HIGH
N (ΔT)	MEDI	MEDIU	MEDIU	MEDIU	MEDI

	UM	M	M	M	UM
Z (ΔT)	LOW	LOW	LOW	LOW	LOW
P (ΔT)	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
PB(ΔT)	HIGH	HIGH	HIGH	HIGH	HIGH

(4) Humidifier and Dehumidifier [HFz]

Table 6. Humidifier and dehumidifier fuzzy logic values [H: Humidifier ON - D: Dehumidifier ON - O: Both OFF]

	NB (ΔRH)	**N(ΔRH)**	**Z (ΔRH)**	**P (ΔRH)**	**PB (ΔRH)**
NB (ΔT)	D	D	D	O	O
N (ΔT)	D	D	D	O	H
Z (ΔT)	D	D	O	H	H
P (ΔT)	D	O	H	H	H
PB (ΔT)	O	O	H	H	H

(5) Evacuation Blower [EBz]

Table 7. Evacuation blower fuzzy logic values

	NB (ΔRH)	**N (ΔRH)**	**Z (ΔRH)**	**P (ΔRH)**	**PB (ΔRH)**
NB (ΔT)	MED	LOW	OFF	OFF	OFF
N (ΔT)	MED	LOW	OFF	OFF	OFF
Z (ΔT)	OFF	OFF	OFF	OFF	OFF
P (ΔT)	OFF	OFF	OFF	OFF	OFF
PB (ΔT)	OFF	OFF	OFF	OFF	OFF

2.6 MATLAB Simulation and Results

2.6.1 Different seasons' results:

To put our controller into test we used Simulink to run our tests. As a first phase we chose recorded data from random four days from Egypt's history, the data from each day is 24 samples from each day to the temperature and relative humidity. In other words sample every hour from that day. We meant to choose four days from the four seasons to test the ability of the controller in different seasons and different temperatures and to simulate the presence of a building with different zones we used Hambase module [8]

We ran over twelve simulation cases; three simulations for each chosen day, we chose the high comfort mode for all simulations to work on the hardest cases, we will show you now the results of sample simulation from each day:

Case (1): 2nd of August 1985 "Summer" the zone is assumed to be an office, occupied all day long, air quality clean, activity of the individuals is "Sitting sedentary" and clothing is "working suits", temperature set point from the study is 23°C and humidity set point is 45%

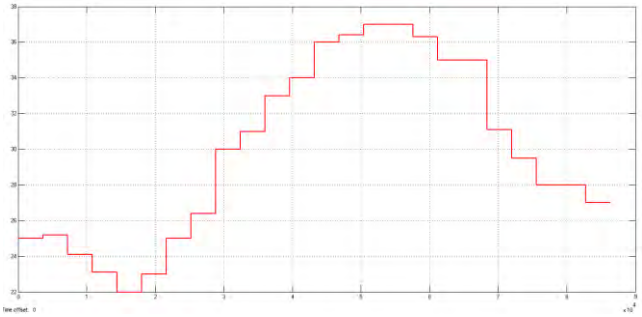

Figure 8 Case(1) outside temperature

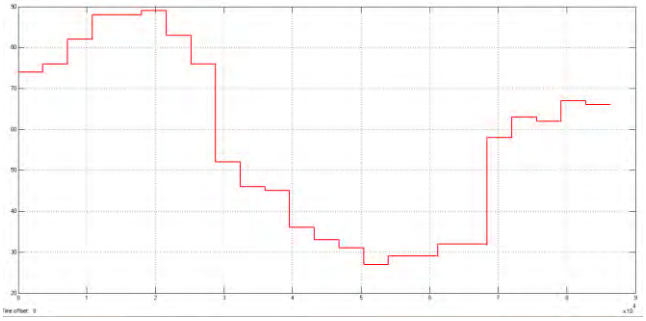

Figure 9. Case(1) outside relative humidity

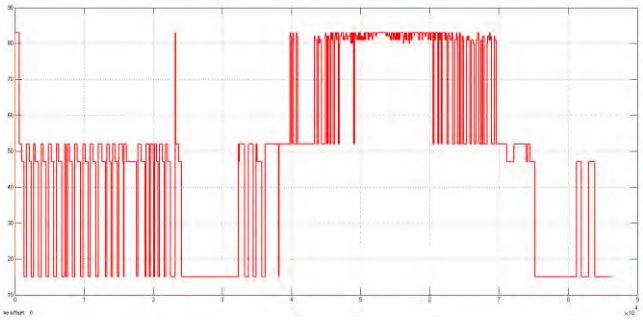

Figure 10. Case(1) VAV unit damper opening percentage

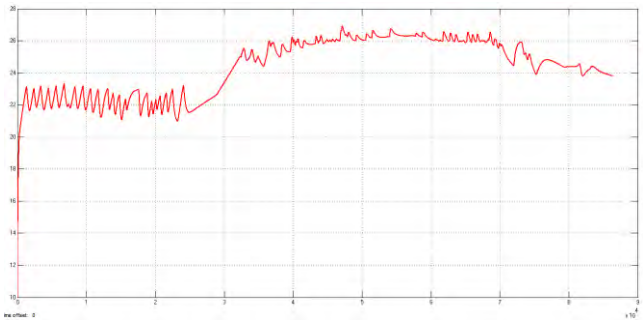

Figure 11. Case(1) zone temperature

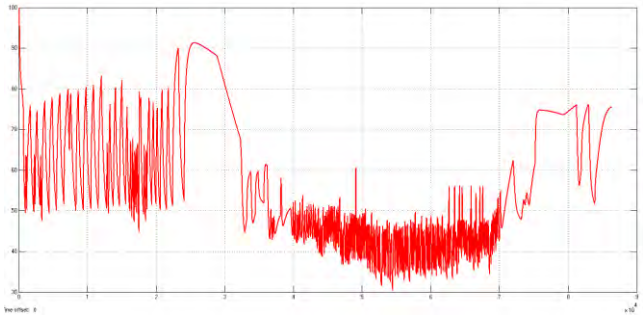

Figure 12. Case(1) zone relative humidity

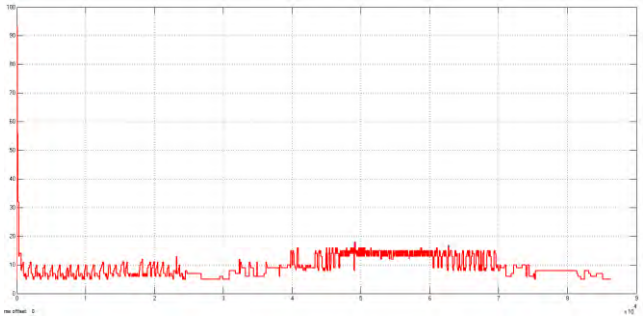

Figure 13. Case(1) individuals PPD

Case (2): 23rd of September 1993 "Autumn" the zone is assumed to be an office, occupied all day long, air quality clean, activity of the individuals is "Sitting sedentary" and clothing is "working suits", temperature set point from the study is 23°C and humidity set point is 45%

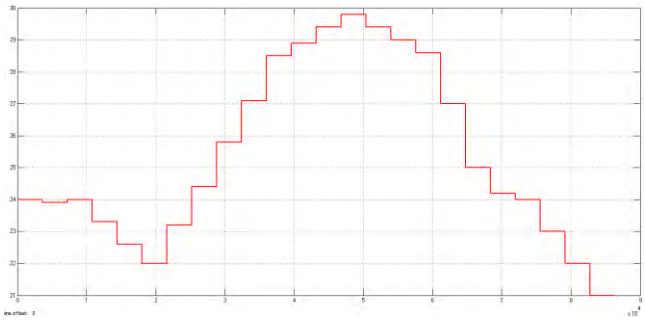

Figure 14. Case(2) outside temperature

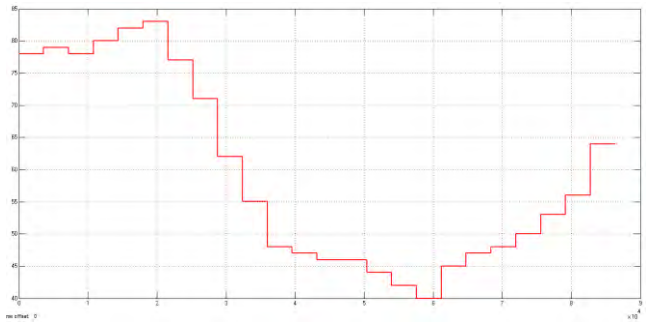

Figure 15. Case(2) outside relative humidity

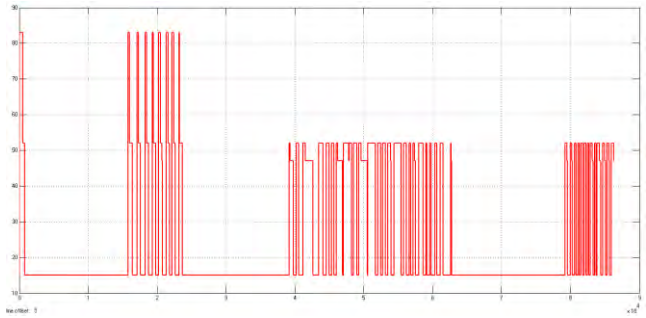

Figure 16. Case(2) VAV unit damper opening percentage

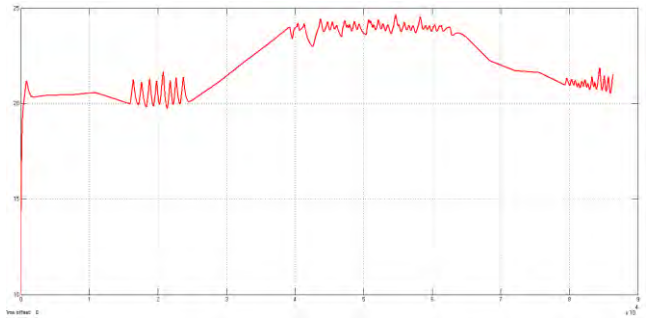

Figure 17. Case(2) zone temperature

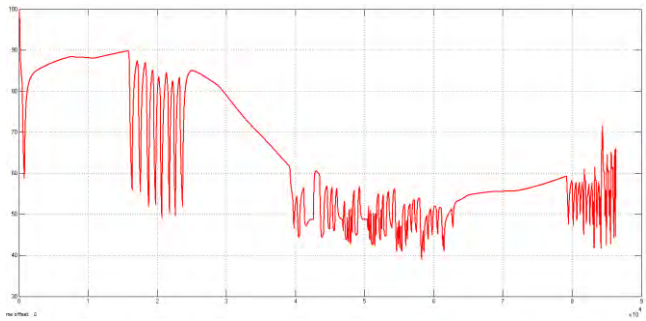

Figure 18. Case(2) zone relative humidity

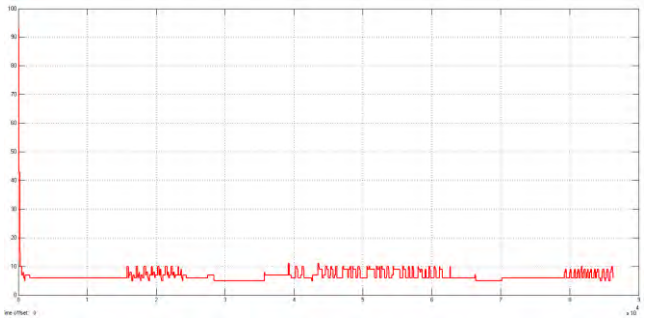

Figure 19. Case(2) individuals PPD

Case (3): 1st of January 1988 "Winter" the zone is assumed to be an office, occupied all day long, air quality clean, activity of the individuals is "Sitting sedentary" and clothing is "European Winter", temperature set point from the study is 19°C and humidity set point is 45%

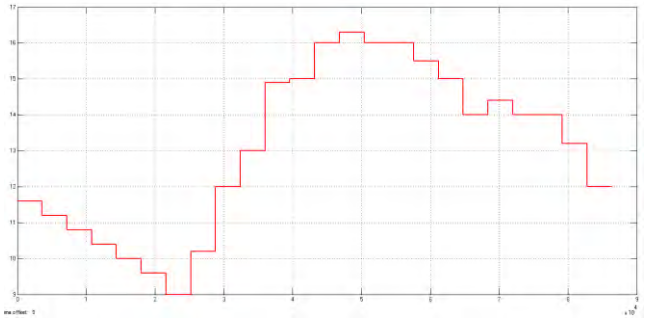

Figure 20. Case(3) Outside Temperature

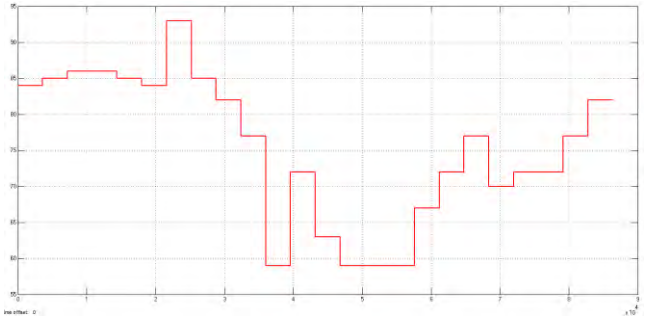

Figure 21. Case(3) outside relative humidity

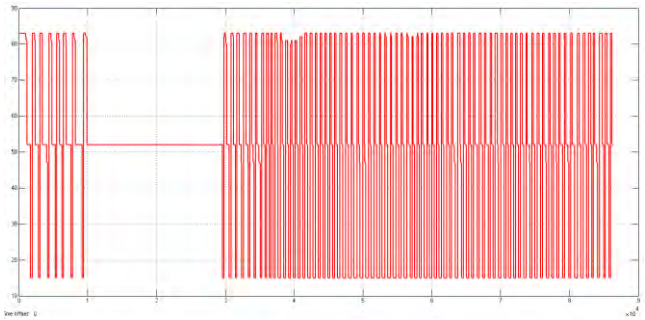

Figure 22. Case(3) VAV unit damper opening percentage

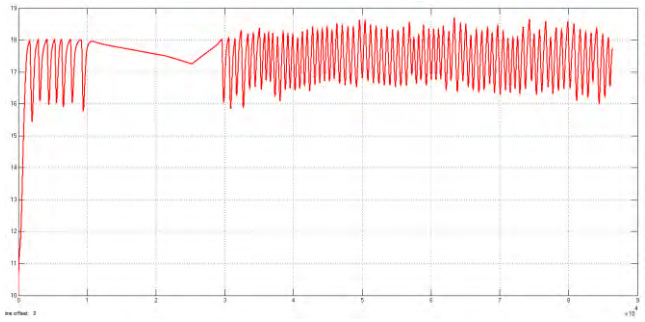

Figure 23. Case(3) zone temperature

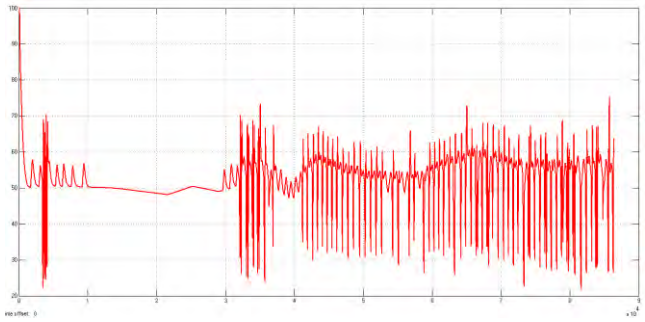

Figure 24. Case(3) zone relative humidity

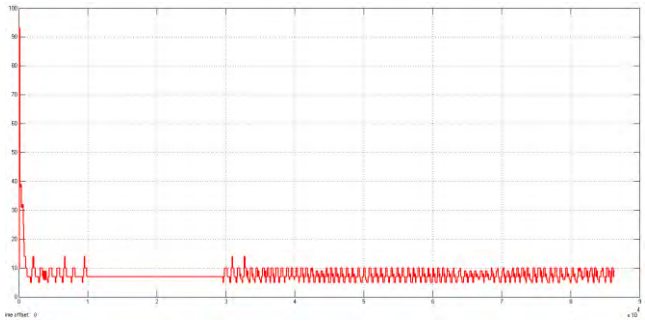

Figure 25. Case(3) individuals PPD

Case (4): 1st of April 1990 "Spring" the zone is assumed to be an office, occupied all day long, air quality clean, activity of the individuals is "Sitting sedentary" and clothing is "Working suits", temperature set point from the study is 23°C and humidity set point is 45%

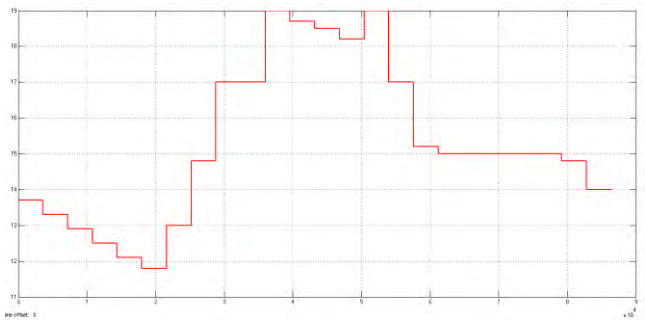

Figure 26. Case(4) outside temperature

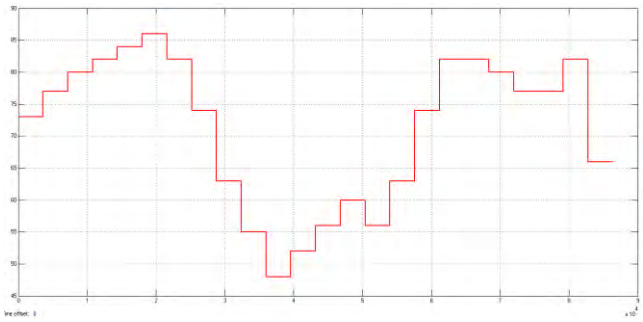

Figure 27. Case(4) outside relative humidity

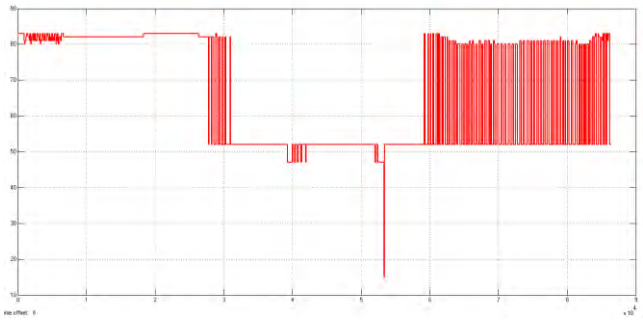

Figure 28. Case(4) VAV unit damper opening percentage

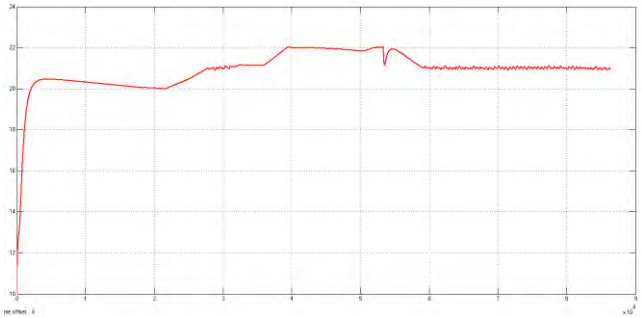

Figure 29. Case(4) zone temperature

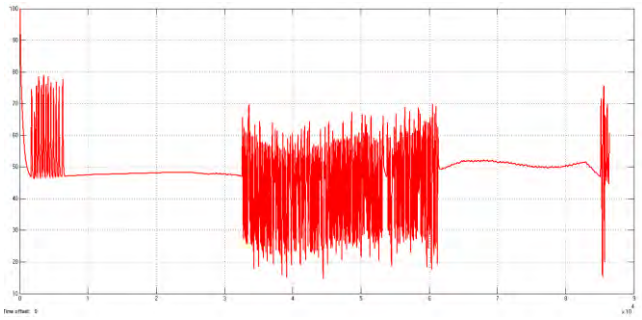

Figure 30. Case(4) zone relative humidity

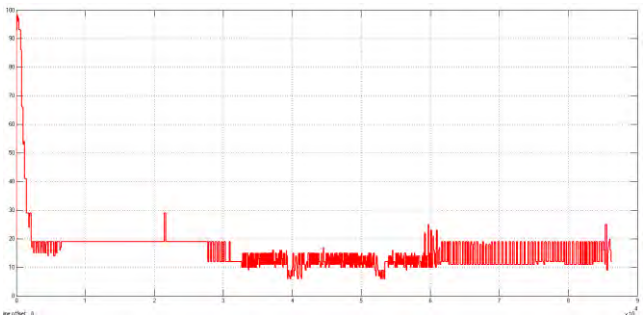

Figure 31. Case(4) individuals PPD

2.6.2 Energy saved in different modes:

After performing the previous simulation to test the response of the controller through different cases in different seasons we took the same summer and winter cases and performed simulations for all possible modes to compare the energy consumption through different modes and test the ability of the controller to save energy and here are the results:

Table 8. Energy consumption in the three modes

Case	Mode	PPD range	Energy consumption
Summer	Energy Saving	6% to 20%	14 KWH
Summer	Moderate	6% to 14%	15.5 KWH
Summer	High Comfort	6% to 8%	24 KWH
Winter	Energy Saving	6% to 20%	18 KWH
Winter	Moderate	6% to 14%	32 KWH
Winter	High Comfort	6% to 8%	49 KWH

From the above table (Table 8) we can see how the energy consumption varies from one mode to another and how the controller in the energy saving mode was able to save 10 KWH in summer case 31 KWH in winter case compared to the High Comfort mode which is highly similar to the thermostat method of control. Further simulation cases should be put into test putting different scenarios for the zone occupancy as we assumed in all cases that the zone is occupied all day long which will give more realistic results and mush more energy saving.

3. CLIMACON MOBILE APPLICATION

Another addition to our solution is a mobile application to make it simpler to connect to our nodes wirelessly through the mobile. The application accesses the database to set and get the values from the nodes.

As you enter the application, the mobile will access the database which contains all the values read from the nodes in different zones. There are two main pages, one is for users and admins and the other is for admins only. Users can only monitor the readings from different zones (Temperature, humidity, it feels like, air quality, occupancy and status) but admins can:

- Set the degree of comfort
- Monitor the energy consumption
- Set the alarms

- Detect any failures in the system
- Shutdown a certain zone if there was any error
- View the occupancy of all the zones

4. CONCLUSION

After performing several tests on Simulink we can see that the controller succeeded in keeping the PPD of individuals inside the zone in the expected ranges maintaining the thermal comfort of individuals in the zone. The ClimaCon system is now ready for real life test on real building to get more realistic results.

5. REFERENCES

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Big, Open, Data and Semantics for Real-World Application near You

Biplav Srivastava
Distinguished ACM Speaker, IBM Research
New Delhi, India

OVERVIEW

State-of-the-art Artificial Intelligence (AI) and data management techniques have been demonstrated to process large volumes of noisy data to extract meaningful patterns and drive decisions in diverse applications ranging from space exploration (NASA's Curiosity), game shows (IBM's Watson in Jeopardy™) and even consumer products (Apple's SIRI™ voice-recognition). However, what stops them from helping us in more mundane things like fighting diseases, eliminating hunger, improving commuting to work, or reducing financial frauds and corruption? Consumable data!

In this talk, Biplav will demonstrate and discuss how large volumes of data (Big), made available publicly (Open), can be productively used with semantic web and analytical techniques to drive day-to-day applications. One important source of this type of data is government open data which is from governments and free to be reused.

Big Open Data is leading to early examples of "open innovations" – a confluence of open data (e.g., Data.gov, data.gov.in), accessible via API techniques (e.g., Open 311), annotated with semantic information (e.g., W3C ontologies, Schema.org) and processed with analytical techniques (e.g., R, Weka) to drive actionable insights. The talk will illustrate how this can help bring increased benefits to citizens and discuss research issues that can accelerate its pace. It is increasingly being adopted by progressive businesses and governments to drive innovation that matters.

Keywords

Big Data, Open Data, Semantic Web, Innovation.

ABOUT THE SPEAKER

Dr. Biplav Srivastava, Senior Researcher & Master Inventor, IBM Research and an ACM Senior Member and Distinguished Speaker, is based out of New Delhi, India. His research deals with enabling people to make rational decisions despite real world complexities of poor data, changing goals and limited resources. His expertise is in Artificial Intelligence, Services and Sustainability, where he has proven track record of high-quality innovation in the global business environment. Biplav's current focus is on open APIs and data, and their real world usage in enterprise integration. As part of this, he represented IBM at W3C's working group on Government Linked Data and is active in open data and AI circles. Previously, he had explored influential web services techniques in this space.

Biplav received Ph.D. in 2000 and M.S. in 1996 from Arizona State University, USA and B.Tech.in 1993 from IIT-BHU, India, all in Computer Science. He has 19 years of experience in industrial and academic research as well as commercial, deadline-oriented, software development in both India and US. He has 100+ research papers published including all top fora in his fields, 30 US Patents issued and 40+ applications. Biplav actively participates in professional services globally including running the 'AI in India' virtual Google group, organizing conference tracks, workshops and as a Program Committee member for more than 50 events. More details can be found at: http://www.research.ibm.com/people/b/biplav/.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Low Cost Devices & Cloud Computing Accelerating Use of Technology by Micro and Small Businesses in Developing Countries

Clement Uwajeneza
Aficta Board Member, Founder and
Managing Director, AxIS
Rwanda

OVERVIEW

Discussion on how low cost, connected devices (feature phones, handheld POS, low cost Android phones and tablets) combined with hosted applications are allowing micro and small businesses in developing countries to adopt technology and to provide technology-based services.

Showcasing some successful cases from Rwanda.

Keywords

Connected Devices, Android, Phones, Tablets, Cloud Computing.

ABOUT THE SPEAKER

Clement Uwajeneza founded AxIS to become one of the most successful and recognized ICT firms in Rwanda.

Considered as a pioneer in the ICT private sector landscape in Rwanda, Clement has participated in building institutions supporting and advocating for the sector. He is co-founder and board member of the Rwanda ICT Chamber, co-founder and Chairman of the Rwanda Software Developers Association, founding Member of the kLab Innovation Space and Chairman of the board of RICTA, a community owned company that manages the .rw and focuses on promoting and enabling the local Internet.

Clement's passion and commitment to sharing knowledge has led him to take lecturing positions in leading universities in Rwanda as Lecturer in Management Information Systems at the School of Finance and Banking and Teaching Assistant for Computer Science at Carnegie Mellon University Rwanda. Clement also spares time to mentor young entrepreneurs and start-ups in business and technology as a kLab mentor.

Clement Uwajeneza graduated in 2005 with a M.Sc. (Eng.) in Management and Information Systems from Polytech Montpellier in France. Before going back home in 2006, he worked at IBM France as Software Engineer.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Opportunities for Government, Business and Research from Open Data

Gavin Chait
Lead Consultant, Whythawk
Oxford, United Kingdom

OVERVIEW

Data are useful when shared.

Conversely, disease does not stop at the border. Health policy and research does.

Imagine bringing together planning information, business valuations and econometric data from local council databases, and combining this with telemetry of pedestrian movements. Imagine using this data to create a live view of the economic value of your local economy which attracts new products, services and investors.

Too often, what stands in the way of coordinated public health response, or new business opportunities, are data locked in research institutions or government departments and unavailable for further study. Not only does this lead to adverse outcomes but it also limits the potential for governments to promote research excellence and extract value from research they usually pay for.

From leveraging research insight to produce meta-analysis studies which improve health outcomes, to integrating data from different government departments to drive efficiency and reduce costs, to new data insights which improve investment and create new business opportunities, shared data can drive change.

Open Data initiatives ensure that public data are freely available in open, electronic, and reusable formats. Open access policies and data publication systems promote meta-analysis studies and new potential.

Join Gavin Chait on a journey into the opportunities which open data can create, and the technical requirements for getting there.

Keywords

Shared Data, Open Data, Government, Business Opportunities.

ABOUT THE SPEAKER

Gavin Chait is Whythawk's Lead Consultant. He was the commercial lead of open data projects at the Open Knowledge Foundation, and led the implementation of Edo State, Nigeria's first open data portal (a World Bank project), the Pakistan Education Data Portal for HTSPE (a DFID project) and numerous other open data projects around the world. Most recently, he has been working with the World Bank on developing technical guidance for National Statistical Offices on open data systems.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Web Entrepreneurship – A Kenyan Approach

Kennedy Kirui
Consulting Lead, iHub
Kenya

OVERVIEW

The Kenyan tech ecosystem has always had its fair share of attention globally and has even been dubbed the "Silicon Savannah" leading to comparisons to Silicon Valley. How has the journey been for techies in Kenya trying to make money on the web?

From offering web site development services to content development go through the journey of web entrepreneurship in Kenya. Learn how it all started, the tough journey & obstacles faced plus get to know how entrepreneurs in Kenya are currently making money on the web.

Keywords

Web Development, Web Entrepreneurship, Silicon Savannah.

ABOUT THE SPEAKER

Kirui is passionate about leveraging technology to solve the day to day challenges that different individuals and organizations face. Kirui has previously worked as a software developer and a project manager. He is passionate about mentoring the next generation of technologies and taking the tech ecosystem in Kenya to the next level.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

From IoT to Personal Data: Opportunities for Data Innovators

Marko Balabanovic
Innovation Director, Connected Digital Economy Catapult
London, United Kingdom

OVERVIEW

The Catapult centers are a major new intervention in the UK's innovation landscape. I will show how the Digital Catapult is unlocking challenges to accelerate data innovation companies. As we move into the new economies of the Internet of Things we'll see massive growth in the volume and diversity of data. The already serious challenges facing innovators around personal data, privacy and trust will become ever more complex, especially in areas such as personal health tracking and wearables or city sensor networks. Companies navigating this new world need very multidisciplinary teams to compete globally. I'll be showing how the platforms, testbeds and labs that the Digital Catapult creates will create new collaborations to overcome these challenges.

Keywords

IoT, Personal Data, Privacy, Trust, Innovation.

ABOUT THE SPEAKER

Marko is a creative technology leader with over 20 years of experience developing innovations in academia, corporations and startups. Most recently Marko led the technology team at the fast-growing London Startup State, launching a global opinion network. Previously, Marko was head of innovation at lastminute.com and Travelocity, improving innovation culture across the European organization as well as forming the lastminute.com labs team to develop novel products.

Prior to lastminute.com, Marko led the development team at Cellectivity and product design at Betfair. Specialisms have included personalization, machine learning and interaction design, including some of the early work on recommender systems during a computer science PhD at Stanford, and stints at Xerox and Ricoh R&D labs in Cambridge and Silicon Valley.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Overview of the Technology Trends in the Financial Industry

Mohamed Gad
Chief Architect, ITS
Egypt

OVERVIEW

Discuss the technology trends that will shape and heavily impact the future of the financial industry and its applications.

Keywords

Technology Trends, Financial Industry, Financial Applications.

ABOUT THE SPEAKER

More than fifteen years of experience in the IT field; covering Development, Requirement Analysis, System Design, Business Analysis, Implementation, Development Management, Implementation Management, Project Management, Systems Integration, Proposal Response Management, Pre Sales, Business Consulting, Process Re-engineering, Sales, Business Development and Product Management of different business solutions In the financial Business Industry.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Talent Development Strategies in Software Industry

Ragi Mahmoud
Corporate Manager, ITS Academy
Egypt

OVERVIEW

The presentation will highlight the role played by ITS Academy to develop new and existing talent to keep pace with emerging technologies and stay on the cutting edge of technological advances.

Keywords

Talent Development, Strategies, ITS Academy, Software Industry.

ABOUT THE SPEAKER

Ragi M Mahmoud has more than 20 years of Human Resources Development experience in a number of multinational and global organizations. Ragi earned his Master's degree in Human Resources from the University of Louisville (USA) and earned a number of professional certifications from international bodies representing the industry. Ragi has also been a member in the Association for Talent Development for the past 14 years.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Data is the Currency of the Future

Tarek Elabbady
Senior Director, Microsoft Advanced Technology Labs
London, United Kingdom

OVERVIEW

Data buzz words are everywhere… big data, deep learning, open data, Internet of things… etc. The reality is we are swimming our way towards the data-age, and these buzz words are just the splashes.

We are transitioning from the information age to the data age. As individuals, enterprises, or governments we are constantly generating data in large quantities. We are generating data at home, at work or on the road. The data is there, whether we decide to do something about or not is a different subject. It is up to us to view this flow of data as an opportunity or as a risk to our privacy and quality of living. Should we be alarmed with the data in our lives, or capitalize on it at the personal level, at the national level, and at the global level. For example, should we still call our venue today a software engineering conference or data engineering conference; this is what this talk is trying to address.

The speaker will review global trends suggesting that we may have no option but to embrace the new data-driven way-of-living. He will use examples of the potential value data can present to local manufacturing, utilities, and how it can contribute directly to the local Egyptian economy, offering new employment opportunities. As he suggested in his title, we should look at the data as the currency of the future, develop data sensitive culture, and establish an environment of trust that can give people and enterprises control over their data.

Today, doing more for less (DMFL) is the trend driving business changes in the west and quickly becoming a global mission. DMFL is reflected on new policies, and government regulations. Many of the large multinationals embraced it in their strategies defining new models for their business around the opportunities presented in data-centric environments. Whether they adopt a theme driving its value from operation efficiencies or enhance productivity, these new models all have data modeling, data inference, and prediction in their hearts.

Finally, the speaker will bring the conversation home, when he explores with the audience the implications of this new data age on the software engineering profession; presenting a general view of the modern application development environments, computing models and related tools, the convergence of device platforms, and the emergence of agile processes driving the development of new products, are all properties defining the future of software engineering.

Keywords

Big Data, Open Data, IoT, Doing More for Less (DMFL), Data Engineering, Agile Process.

ABOUT THE SPEAKER

Born and educated in Egypt, Elabbady received his PhD in electrical engineering from Purdue University in 1994, where he studied modeling of electromagnetic fields and signal processing. While at Purdue, he received the Geddes-Hauptman award for outstanding researcher at Purdue Electrical Engineering Dept., 1993.

After receiving his MBA from the University of Washington in 1999, Tarek joined Microsoft in the Windows group where he led a variety of the Windows development programs. His contributions included audio/video home networking, supporting networking technologies and hardware software interfaces. His most notable contribution was to the foundation of the Microsoft Windows Media Center division in 2002.

In 2005, Elabbady moved back to his home country, Egypt, to establish the first Microsoft Advanced Technology Lab (ATL) in the Middle East and Africa. Today Advanced Technology Labs are also located in Germany, Israel and Brazil and are home to skilled teams that cover interests in applied research, software development and business innovation.

In 2010 Tarek was appointed as the Senior Director of Microsoft Advanced Technology Labs and is now located at Microsoft Research Cambridge, UK from where he directs the Advanced Technology Labs.

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Upside-Down: Why the Cloud Changed the Rules of Software Development

Yves Christol
VP Software Development at Orange
Labs, Products & Services
Paris Area, France

OVERVIEW

Discuss why the cloud changed the rules of software development. To fully leverage this disruption, you have to put your all organization upside-down, but it's worth the effort.

Keywords

Cloud, Software Development, Upside-Down.

ABOUT THE SPEAKER

Software engineer, Yves developed webphone prototypes and internet payment services in the late 90's at France Telecom, Research & Development.

He moved then to marketing roles in internet micropayment, first, and mobile phones then, where he managed the Orange requirements to the industry for several years.

Back to the software since 2008, he's now driving the software development teams at Orange Labs, and he's trying to figure out what transformations are needed to adapt to this new software world.

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User Stories for Agile Business: INVEST, Carefully!

Tamer Abdou
Suez Canal University
Ismailia, Egypt
tamer.abdou@alumni.concordia.ca

Pankaj Kamthan
Concordia University
Montreal, Canada
kamthan@cse.concordia.ca

Nazlie Shahmir
WestJet Airlines Ltd.
Calgary, Canada
nshahmir@westjet.com

ABSTRACT
In many agile methodologies, software requirements are expressed as user stories. The success of a software project depends strongly on the practices of software requirements engineering. INVEST is a mnemonic acronym that is used often to guide the quality of user stories. In this paper, the advantages as well as inherent limitations of INVEST are highlighted. A comprehensive approach for the quality of user stories is proposed. This approach is model-based, context-sensitive, and knowledge-equipped.

Keywords
Agile Methodology, Conceptual Model, Software Engineering Economics, Software Project Assessment, Software Quality, Stakeholder.

1. INTRODUCTION
In the past decade, there have been a number of noteworthy changes in industrial software engineering, one of which is a movement towards agility. Indeed, agile methodologies have been deployed for a variety of application domains, for varying team sizes, in different locales. However, the deployment of agile methodologies, including those by small-and-medium-sized enterprises (SMEs), has come with its share of successes, as well as challenges and failures (Figure 1).

It is known that the success of a software project is related intimately to the quality of a software system. The quality of a software system, in turn, is related closely to the quality of software requirements (Figure 2). The quality of software requirements, again in turn, is related intrinsically to the practices of software requirements engineering [1].

In many agile methodologies, the approach to software requirements engineering is usually human-centered and scenario-oriented, and realized in the form of use cases or user stories [1].

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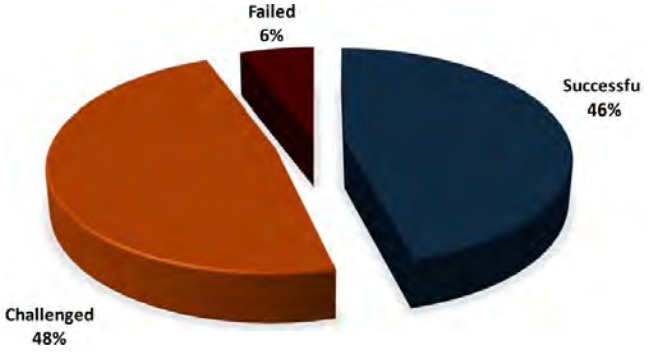

Figure 1. Outcomes of Agile Projects in SMEs. Source: The CHAOS Manifesto, Standish Group International, Inc., 2013.

Figure 2. Role of Requirements in Software Project Failures. Source: ESI International Survey of 2000 Business Professionals, 2005.

Indeed, there is explicit support for user stories in Extreme Programming (XP) and Scrum, in their customizations and descendants, as well as in certain other agile methodologies [1] [2]. The ISO/IEC/IEEE 26515 Standard defines a user story as "a simple narrative illustrating the user goals that a software system will satisfy". There have been initiatives to partially structure user story statements [2].

2. GAINS OF INVESTING
There are a number of advantages of INVEST, including the following:

- INVEST is a mnemonic acronym that stands for user stories that are *Independent*, *Negotiable*, *Valuable*, *Estimatable*, *Small*, and *Testable* [2] [3]. It is brief and easy to understand.
- INVEST reflects the nature of agile methodologies well. For example, INVEST makes estimation, negotiation, and testing, first-class concerns in authoring user stories.
- INVEST has been used widely in industry for assuring the quality of user stories [1] [2] [4].

3. LOSSES OF INVESTING

There are a number of inherent limitations of INVEST, including the following:

- INVEST ignores conventional literature on the quality of software requirements engineering [1] [4] [5], including the ISO/IEC/IEEE standards from the late 1990s and early 2000s.
- INVEST mixes different levels of abstractions. For example, independence is a product-level concern for multiple user stories, while negotiability is a project-level concern for a single user story.
- INVEST excludes certain crucial quality attributes, such as consistency, readability, and understandability.

4. A META-MODEL APPROACH FOR THE QUALITY OF USER STORIES

In a comprehensive approach for understanding the quality of user stories, a number of relevant elements belonging to the underlying software ecosystem need to be considered. *Usopica* is such a theoretical approach with practical implications for achieving user stories of quality as desired by its stakeholders (Figure 3).

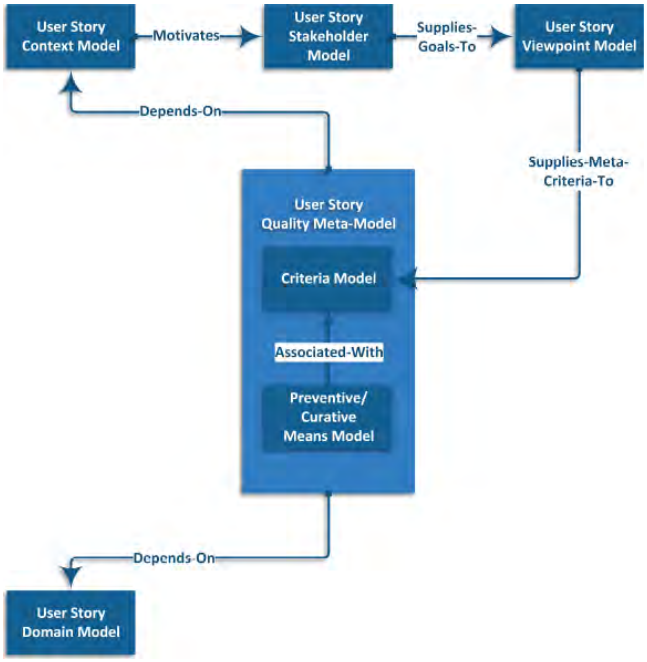

Figure 3. A Meta-Model for the Quality of User Stories.

Usopica has a number of defining characteristics, including the following:

- **User Story Domain Model.** To create an understanding of the domain of user stories. For example, such domain knowledge includes the terminology related to user stories.
- **User Story Context Model.** To lend an understanding to the context of user stories. For example, such context includes the nature of business, the nature of the software system, and the nature of its users.
- **User Story Stakeholder Model.** To identify appropriate stakeholders and elicit their goals. For example, stakeholders of a user story include customers, business analysts, project managers, software designers, and software testers.
- **User Story Viewpoint Model.** To use the User Story Stakeholder Model for devising the viewpoints relevant to the stakeholders in question. For example, axiology, epistemology, and utility are such viewpoints.
- **Criteria Model.** To provide meta-criteria for quality, and, based on it, criteria for quality. For example, meta-criteria for quality for a user story could be based on semiotics [5].
- **Means Model.** To associate suitable means with the criteria for quality. For example, such means could take the form of guidelines, patterns, or anti-patterns. These means could be used as a basis for inspecting the quality of user stories.

To summarize, *Usopica* acknowledges that a consideration for the quality of user stories should not be isolated from the environment in which the user stories exist.

5. CONCLUSION AND FUTURE WORK

For the success of a software project, as well as to avoid an excessive accrual of analysis debt [6], a sustained commitment to the quality of user stories is imperative.

In the practice of many agile methodologies, the question of assuring the quality of user stories arises naturally and needs to be answered systematically. To be broadly-applicable, an approach for addressing the quality of user stories should rest on an established theoretical foundation in software requirements engineering and quality engineering.

A sustained commitment to the quality of user stories can benefit significantly from an appropriate deployment of current information technology (IT). However, for a business, such an endeavor must also be economically and strategically viable. In that regard, the integration of *Usopica* with an agile project management system, preferably available as open source software (OSS) and a return on investment (ROI) analysis of such an initiative, suggest potential directions for future research.

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Test Automation New Era

Amr Gamal
ITS
Cairo, Egypt
Amr.gamal@its.ws

Ethar Mahmoud
ITS
Cairo, Egypt
Ether.mahmoud@its.ws

ABSTRACT
Automated Software Testing is the application and implementation of software technology throughout the entire software testing lifecycle (STL), with the goal of improving STL efficiency and effectiveness.

Keywords
Test Automation, Streamline, Effortless.

1. INTRODUCTION
Automated Software Testing efforts can support all facets of the testing lifecycle. It enables the inclusion of the various software testing phases. It supports production, and software standard assessment and verification. Moreover, automated tests can run on multiple computers and can be developed using different programming languages.

Automation can help expedite and streamline testing efforts. If implemented correctly, it can help save time, reduce costs, and raise the quality of your software product.

ETHIX-TA is a standalone tool with LESS interaction with development tool. It is an efficient tool which will help the majority of test engineers to record, run and maintain the automated scripts throughout friendly interface.

Welcome to **ETHIX-TA**; the tool for running automated scripts that is built on the latest technology platforms available from Microsoft. This development process provides testing scripts for banking applications in order to achieve reliable and cost-effective applications.

2. FEATURES
- Create an interface to facilitate the execution of scripts and data setup.
- Create new script with minimum effort.
- Compose scenarios to test the integration between different modules and products.
- Group and manage the test script according to their functionality.
- Complete audit trail for all actions.
- View all running logs in user-friendly interface.
- Easily running benchmark scripts through ETHIX-TA.
- Authenticate the user login either by user name and password or by windows authentication.
- Run each script multiple times with different data.

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Arabic Real Estate Semantic Specific Domain Search Engine

Moustafa Basha
Software Engineering
Research and Development
Giza, Egypt
basha.moustafa@gmail.com

Yasser Orabi
Real Estate Domain Expertise
Business Development
Cairo, Egypt
y.eloraby@egyptsquare.com

Hussien Ibrahim
IT Expertise and Project
Management
Cairo, Egypt
hussein.ibrahim77@gmail.com

ABSTRACT
The Project is trying to make a specified domain search engine, initially for Real estate domain. The purpose is to use the technology of NLP and semantic web in order to refine the search result of Real estate seekers and give the seekers more valuable and realistic data.

Our search engine has implemented to crawl in specific real estate portals and to index it in a semantic web contents using a simplified specific domain Natural Language Processing algorithm to extract more information about the real estate unit.

The extracted properties are used by the user to filter the search results to more refined information.

The user himself is a subject in a semantic web who has specific properties reflected in his/her desired search and his/her search pattern.

The project will gain use of the user gathered information to make a targeted push ads suitable to his/her properties (i.e. live style, culture, age …).

The project has been implemented as a mobile application which is mainly using the location based service facilitated by smart phones to collect more information and to provide better service about searching in current location.

The project will also be implemented as a web service for better accessing and view.

Keywords
Arabic NLP, Semantic Web, Specific domain search engine, SALE Platform, Smart-M3, Semantic Information Broker (SIB).

1. INTRODUCTION
Specified search engines will take place due to the huge amount of data for various domains and the difficulties to analyze it by generic search engines (i.e. Google, Bing). The information seekers want more refined results and want the machine to understand more about what they are seeking for.

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Searching for specified items on Internet shall take in consideration more data about the seekers such as, location, culture of this location and the meaning behind the expressions and terms are used which could contains a slang words.

On other hand, the current contents on Internet are not machine friendly contents. Thanks to Semantic Web which will take lead to solve this problem although it will need a huge effort to convert current unstructured data contents into semantic web contents.

The project has been implemented using SALE platform [1] which is based on Smart-M3 an open source semantic information broker [2].

2. TECHNICAL DETAILS
2.1 Overview
The following subsections describes the different phases of technical aspects of the project.

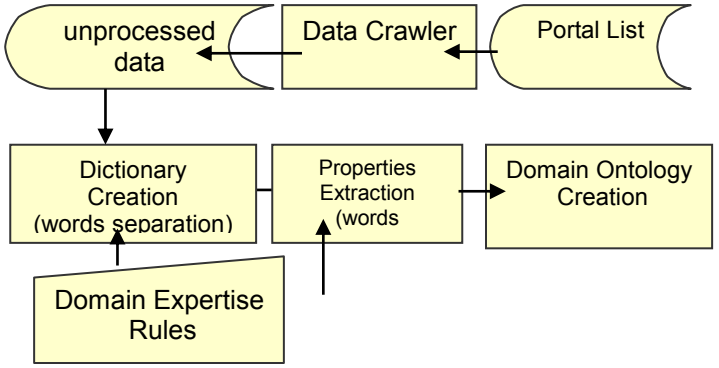

Figure 1. The phases of technical aspects of the project.

2.1.1 Dictionary Creation
Dictionary creation phase is done in half-autonomous way. The crawled unstructured data (i.e. descriptions, details).

2.1.2 Property Extraction
Property extraction phase is a pre-processing needed to be done in non-frequent bases. The property extraction pre-processing is done only for unstructured data (i.e. description of the Real estate subject), the target of this phase is to collect statistical information for the words used in the domain, the different forms of the same word and, the relation between words and each other. The first and second target is helpful to collect and update the domain dictionary especially for a rich language such as Arabic slang. The relation between different words helps to extract the more properties of specific subject from unstructured contents.

2.1.3 Subject/Resource Description

We illustrates more descriptive keywords to construct our RDF representation to give more information about the Subject.

Example:

"شقة حديقة على طريق السخام الدور الرابع إيجار"

The subject in the previous example is "شقه" which can be written with "ه" or "ة", the first object is "إيجار" and the relation between the subject and the object in this example is "لـ" which also could be implicitly mentioned "شقة إيجار في". Our preposition is to add more descriptive keywords to regular RDF representation which is working before adding the RDF triples.

As an example of our added descriptive language is the following keywords:

Modifiers which is to modify the object such as " إيجار السي حاسه 2000 تمبر" the modifier here is "إيجار السي" which could be another modifier value such as "ضد افي" The gain use of putting such descriptive keywords is to put language rules in terms of specific machine understandable keywords. Rules such as *Default* or *Promotion* can be added by domain expertise ex. In case of not mentioning any *modifiers* a default value could be taken place.

Synonyms which indicate equally meaning such as " على طريق" and "خديقه" and "جديقه". So the property can also have a synonyms and not only the RDF subject/resources.

2.2 Operation

The crawled data passes through a process to convert the structured and unstructured data into RDF triples using domain ontology created from previous phases and stored it in the SIB.

The stored data is reinvoked by the Real estate seeker using parametric search beside a filtering option appears to the seeker with the available filtering options deeply per-extracted from unstructured data (i.e. the human written description of the real estate unit).

2.3 Implementation

The current implementation of the project is as Android mobile application and the web site development is under progress.

We're using the SALE platform for push ads and user subscription options and as a REST interface between our application and Smart-M3 SIB after adding our specific new REST APIs.

The implementation as whole is using Java language in both front-end (the android mobile application) and back-end.

3. RELATED WORK

A close ideas to insert a metadata together with the uninstructed contents has been used as an annotations to describe and to simplify analysis of the natural language [3], this way has been used in START natural language question answering system [4]. other languages has been made to write the RDF triples in easier way adding some descriptive keywords which is human suited rather than RDF XML representation and make availability of adding synonyms properties as in Adenine language [5] founded by Haystake project [6].

4. CONCLUSION

Our illustration is taking the practical path of making a specific annotation way and trying to simplify processing needed by priory auto extracting the subject/property relations and adding our own keywords as a human friendly language to represent the RDF triples. This language is strongly needed by domain expertise as a human friendly way to put his rules and to refine dictionary and subject's properties.

The same concept can be applied for any other specific domain search engines.

5. ACKNOWLEDGMENTS

Our thanks to SECC team who allows us to introduce our idea in SALE Hackthon and to give us a hand to know more about Semantic Web and SALE platform.

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"Quick Guide": Guided Navigation Technique for Indoors Emergency Situations Using RFIDs and Path Finding Algorithms

Asmaa Shoala
Faculty of Engineering
Alexandria University, Egypt
asmaashoala@gmail.com

Kamal Bassuony
Faculty of Engineering
Alexandria University, Egypt
kamal.bassuony@outlook.com

Ahmed Saeed
Faculty of Engineering
Alexandria University, Egypt
Eng.a_saeed@yahoo.co.uk

Mohamed Ahmad
Faculty of Engineering
Alexandria University, Egypt
Mohamed13e07405@alexu.edu.eg

Mohamed El-Kielany
Faculty of Engineering
Alexandria University, Egypt
elkielanymohamed@yahoo.com

Shaimaa Lazem
City for Scientific Research and Technology Applications, Egypt
shlazem@acm.org

ABSTRACT

This poster proposes a low-cost indoors response system that leverages social collaboration to provide help for patients, children, or elders in emergency situations. The proposed system uses public displays and wearable technologies. A simple prototype was developed to simulate and test the system. We plan to improve the system in order to be used in medical services.

Keywords

Wearable Device, Indoors Navigation System, Public Displays.

1. INTRODUCTION

Promoting the collaborative spirit and enabling people to help each other is an important aspect to provide safe community. Help is particularly important for those who suffer from medical conditions such as diabetes and/or high blood pressure. It is even more urgent when the sick person is a child or an elder. Developing an indoors emergency response technique using ubiquitous technologies was one of the challenging research problems that were explored in The Second Winter School on Human-Computer Interaction (HCI) [1]. The abstract presents an innovative design that was designed in 10 days.

"Quick Guide" is a low-cost indoors guided navigation system that fosters and encourages people to help each other in emergency situations. When a person needs help; the help request is announced, and the shortest path the responder can take to reach that person are offered by the system. The interface is intuitive and usable by different ages and literacy levels. This system can be installed in public buildings such as malls or hospitals. It mainly consists of public information displays, wearable devices, and RFID (Radio Frequency Identification) tags [2].

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2. USAGE SCENARIO

Figure 1 shows a possible usage scenario for the proposed system. Assume that a mother and a daughter with diabetes are shopping in a mall. They walk separately to shop at different shops. The daughter is wearing the wearable device that monitors her blood sugar. If her blood sugar level is low, the wearable device issues a help request either automatically or with a button press.

The public information displays will show that there is a help request in a certain place. Anyone could respond this request by picking a navigation device that is attached to the display. At every junction in the building, the navigation device reads the installed RFID tag and the right direction will be displayed to the responder on the device screen.

3. DESIGN

Public displays can be installed in public buildings such as malls or hospitals to present health, educational or other type of relevant information depending on the context in which the display is installed. Wearable help devices and navigation devices are placed close to the public information displays. The public displays are distributed in the building and connected together, thus the help requests can propagate. RFID tags are installed at every junction point in the building.

The wearable help device could be picked by anyone who's afraid from being in an emergency situation such as children or sick elders. It is a simple device with one button, on which the requester presses if she/he needs help. The public displays will show that there's a help request in a certain place within the building.

The public display is equipped with a Near Field Communication (NRF) wireless module with 60 meters range; it's the point of connection between the wearable help devices and the displays. This module allows multi-point to point communication, where up to six users can request help at a time near the same display. These requests then propagate to the other displays.

RFID tag is a low-cost (about 15 L.E.) and long-life tag, as it doesn't need a power source. The tag has a unique identification number (ID), which is read by RFID reader via Universal Asynchronous Receiver/Transmitter (UART) [3].

Another simple device is associated to the public display is the navigation device. This device consists of the RFID reader, AVR microcontroller and small LCD to display the navigation directions.

If someone wants to respond to a request, she/he will pick the navigation device. At every junction point, the navigation device will read the tag installed at that point to know the right direction in the shortest path that leads her/him to the requester. The right direction is determined from path finding algorithms.

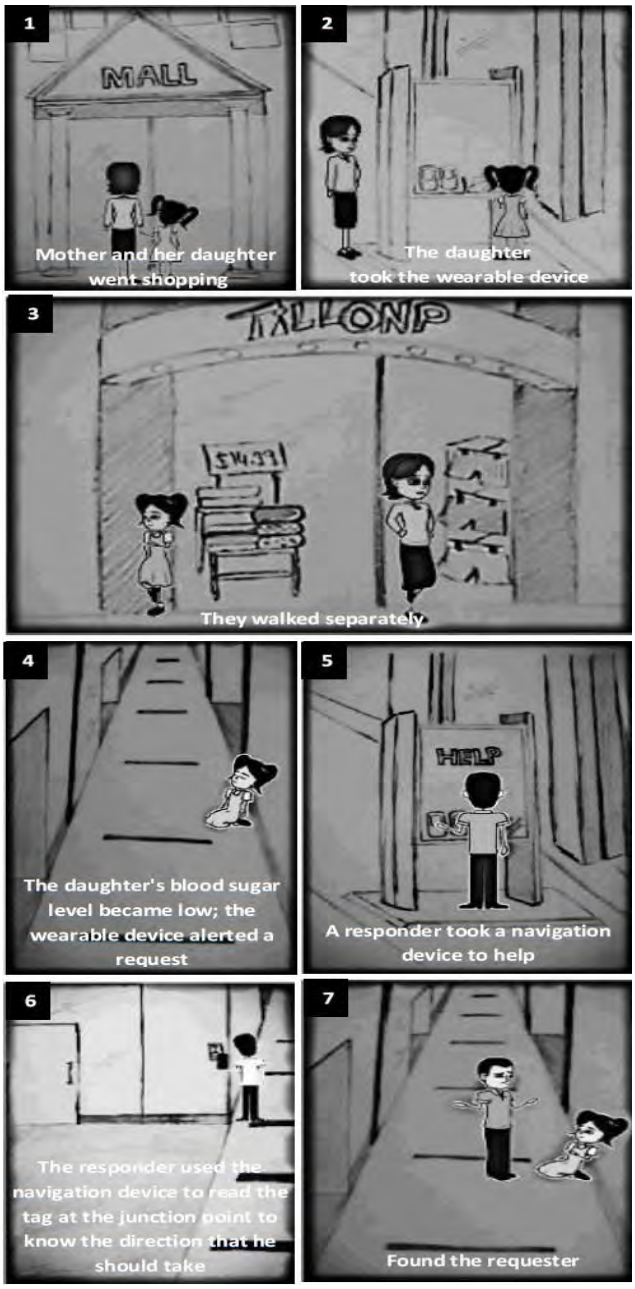

Figure 1: Usage Scenario for the Quick Guide System

Route finding is a Java application that is implemented using path finding algorithms to determine all possible routes between the responder and the requester; they determine the shortest path as well. This application takes the map of the building (nodes: rooms/shops/junction points, edges: corridors, weight: length of the corridors), the position of the requester (the nearest junction point) and the position of the responder as an input.

Initially all the shortest paths between every junction point and other nodes are stored on the microcontroller of the navigation device to reduce the response time of the system.

4. PROTOTYPE

As shown in Figure 2, a car is used for testing the navigation technique; it's equipped with the navigation device to model the responder. The car moves from position A to position B. At each junction point, the car reads the tag and accordingly moves to the right direction.

Figure 2: Quick Guide Prototype

5. FUTURE WORK

Enhancing the wearable device, so that it can measure human medical aspects, like the heart rate and the blood pressure in order to automatically detect emergency situations and send help requests. We plan to install and test the prototype in a public building. Experiments will be conducted to examine people's acceptance and usage of the proposed devices.

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SALE: Semantic Advertising Platform for Egypt

Haitham S. Hamza, Mahmoud M. Abdallah, Enas Ashraf, Azza K. Nabih, Ahmed M. Gamaleldin
SECC-ITIDA, MCIT
Giza, Egypt
{hhamza, mmabdallah, inas, azkamal, agamal}@itida.gov.eg

Shourok Alaa, Kamilia Hosny, Aya Khattab, Ahmed Attallah
ANSR Lab, Cairo University
Giza, Egypt
{salaa, khosny, akhattab, aattallah}@ansr.cu.edu.eg

ABSTRACT
In this poster, we will describe SALE platform. SALE is an advertising platform based on Semantic Web [1] and Service Oriented Architecture (SOA) technologies. It is used to create semantic context-aware advertising services and applications. Smart-M3 [2] interoperability platform provides SALE with the semantic web information sharing infrastructure. The poster will demonstrate its architecture, usage scenarios and its advantages. Also, the poster will give an overview about the SALE community that targets promoting Semantic Web technology and enriching the features of the platform.

Keywords
Semantic Web, SOA, Context, Semantic middleware, Smart-M3, Ontology, Interoperability, Extendibility.

1. INTRODUCTION
The efficiency of any marketing campaign is dramatically increased when the advertisements are designed to reach the target persons. Building context aware mobile advertising applications that serve different customers and business domains is a challenging task. Software developers will face the interoperability and extendibility amongst other challenges. SALE offers a generic solution that is customizable to address these issues and helps the software developers to build applications for advertisers as well as end-users.

2. SALE ARCHITECTURE
A layered architecture is used to implement SALE platform. Semantic middleware is the lowest layer and is composed of the SIB (Semantic Information Broker) and KPs (Knowledge Processors). The SIB is used to store all data of the system using semantic representation. The different KPs (knowledge processors) process the semantic data to provide the user with smart services. Directly above this layer lies the service layer which provides the end-user applications with a REST interface to the knowledge stored on the SIB through KPs. Also external web services like Google places are used to enrich the application.

The top layer is the application layer which provides the end-user with a mobile client, and the advertisers and administrators with web interface.

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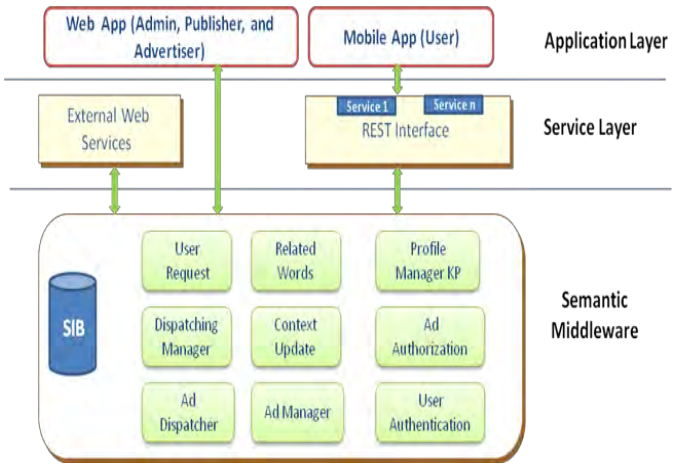

Figure 1. SALE Architecture

3. SALE USAGE SCENARIO
The following example describes the usage of SALE platform capabilities in one of the business domains. The advertiser here is a restaurant that targets its customers with customized offers based on the context provided including customer preferences and the current location. Currently, SALE-based applications could be used in two modes Push mode and Pull mode.

3.1 Push Mode

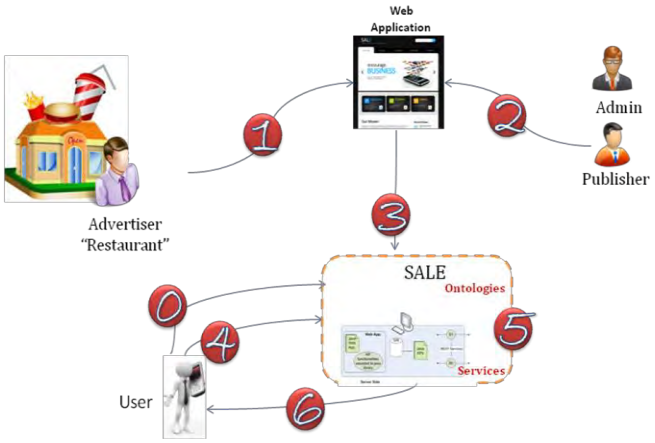

Figure 2. SALE Usage Scenario: Push Mode

In the push mode, SALE provides the basic service to the users as described in the steps below:

0. The user joins the system and puts his/her personal data and preferences in the system platform using the mobile application.
1. The advertiser (the restaurant) selects a new offer, e.g. for male, female, located within 3 km from the restaurant.
2. The publisher and the system administrator approve the advertisement to be published.
3. The web application converts the data to triples and saves them on semantic server based on relevant ontologies.
4. The mobile application sends the user location periodically to the server.
5. The platform makes semantic matching for user profile, preferences, and context with stored offers to extract the most relevant advertisements to the user.
6. The platform sends the relevant advertisements to the user.

3.2 Pull Mode

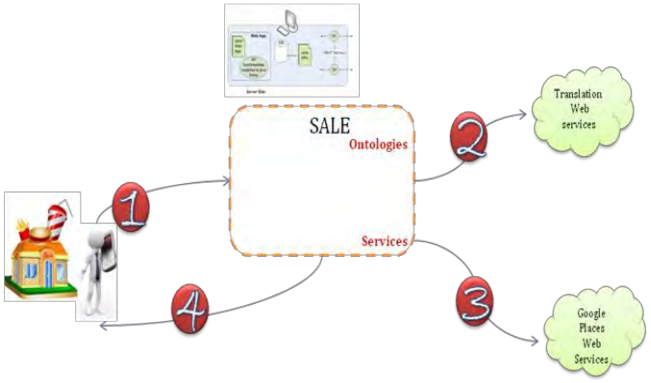

Figure 3. SALE Usage Scenario: Pull Mode

In the pull mode, SALE provides an alternative service to the users as described in the steps below:

1. Registered user types a free text request like "EAT" in a text area in the mobile application. Then the mobile application sends user request and location to the platform.
2. The platform connects to external web sites to semantically match the user request to a predefined domain in the platform ("EAT" with the platform domain "FOOD").
3. The platform connects to Google places web services to get landmarks near user location. After that, the platform finds the advertisers registered in SALE from these landmarks.
4. The platform sends offers from restaurants registered in SALE to the user.

4. SALE COMMUNITY

Open source community [3] was established to promote SALE and Semantic Web technology, and to open the door for increasing the features provided by the platform. The community will allow the software practitioners to learn about SALE architecture through webinars and technical content as well as downloading open source version of the SALE platform. Several activities like Hackathons and students graduation projects will be sponsored to enrich the SALE platform features.

Moreover, this community will help the software practitioners to utilize SALE as infrastructure to develop new applications, integrate SALE with enterprises tool (CRM) or deploy in different places.

5. ACKNOWLEDGMENTS

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ScrumMaster Role and Responsibilities in Agile Environment

Ahmed Mahmoud Hammad
SECC-ITIDA, MCIT
Giza, Egypt
ahammad@itida.gov.eg

OVERVIEW

This tutorial starts with a brief review on Scrum, and then explains in details ScrumMaster focus and responsibilities. It covers also the required qualifications and skills to fulfil its role competently.

The tutorial then makes an open discussion and recommendations on which existing roles in the team could migrate to ScrumMaster, and discuss advantages and challenges of each role.

The tutorial also explains the facilitation for various Scrum meetings and how it is important for the ScrumMaster to contribute to his local community.

Keywords

Agile, Scrum, ScrumMaster, Product Owner.

ABOUT THE SPEAKER

Hammad trains and coaches teams on Agile, Scrum, extreme programming, and Kanban. Ahmed also trains and coaches teams to help them get certifies in CMMI using Agile methodologies.

Ahmed is working at SECC as a Quality Expert for more than 7 years, consulted many small, medium and large organization in software process improvement and how to improve analysis, architecture, design, programming and testing practices.

Ahmed is actively researching and developing Agile and software engineering offerings to support the software industry in Egypt.

Ahmed worked for 14 years in software organizations such as Sakhr, Harf and QuickTel as a programmer, project manager and technical manager. As a result, he has extensive software development and management experience in desktop applications, database applications, web applications, mobile applications, and embedded applications. This helps him to guide software process improvement with deep understanding to the technical and management challenges.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Test-Driven Development for Skeptics

Ameer Gaafar
ITIDA
Smart Village, Building B121
Giza, Egypt
ahgaafar@itida.gov.eg

OVERVIEW

Test-Driven Development is gaining traction as an approach to software development that reduces both defect density and development effort. Unfortunately, TDD does not enjoy its renowned international status in our region. A recent survey indicates that TDD is among the least adapted Agile practices in Egypt! In this tutorial, attendees will be introduced to TDD, how and why it works, and will provide tips on how to adopt it safely in various environment. Attendees will also watch or get to try an actual TDD session and see how the approach provides a hospitable and safe environment for innovation and creativity.

The tutorial will also shed light on the important metrics that can be harvested from a TDD environment, and how these metrics can help individuals and teams perform effective reflection on their past performance and come up with actionable improvement plans.

The session will also related TDD to its larger agile context and demonstrate how it fits within iterative SDLC, lean thinking, and how it can be effectively used with other Agile techniques such as pair programming.

Keywords

Test-Driven Development, TDD, Agile, Lean, iterative development.

ABOUT THE SPEAKER

Ameer Gaafar has been leading and coaching software development teams for over 15 years. He successfully performed roles combining development leadership, delivery management, customer interfacing, and strategic alignment in software development organizations. Ameer's skills and knowledge repository include Institutionalization of agile methodologies, software architecture, enterprise systems integration, service-oriented architecture, domain-driven design, and domain specific languages.

Ameer currently works as an agile coach and software development expert with ITIDA, Egypt. As an agile coach, he helps teams and software firms in adopting agile mindset and practices. Ameer frequently lectures on topics related to agile design, evolutionary architecture, TDD, and design patterns. In addition, he works closely with several clients towards modernizing their current software architecture and creating cloud offerings.

Earlier in his career, Ameer progressed from a software developer all the way to software development head for over five years. During this time, he developed and led the development and evolution of several business critical ERP, supply chain, CRM, and digital asset management products.

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Sustainable Legacy Code Refactoring – A Systematic and Stepwise Approach

Amr Noaman Abdel-Hamid
Principal Consultant, Agile Academy
Sharjah FreeZone
United Arab Emirates
amr@agileacademy.co

OVERVIEW

One of the most painful activities in software development is maintaining extremely poor legacy code! Moreover, teams transitioning to Agile suffer from challenges like moving towards shorter iterations with shorter time for regression testing, trying to cover poor code with automated tests, prioritizing which refactorings to apply on which code, and convincing managers with the value of refactoring.

In this session, I will present a simple, sustainable, and stepwise approach to refactor legacy code. This approach divides the refactoring effort into three stages: (1) Quick-wins; simple and least risky enhancements. (2) Divide-and-conquer the code into modules with identified and clear interfaces. (3) Inject-quality-in the code by wrapping modules with automated tests. I will give an overview of several experiments and case studies applying this approach and will present some interesting observations and insights. Finally, I will go through the roadmap and demo refactoring a piece of spaghetti and cluttered code. I will also demo the use of several famous tools which enable safe and efficient legacy code refactoring.

This topic is based on several experiments done over the course of 3 years and was first presented as an experience report at the Agile Conference 2013 at Nashville; then at Agile2014 at Orlando, USA, and finally at AgileAfrica 2014 at Johannesburg, South Africa.

Keywords

Software Maintainability, Legacy Code, Continuous Refactoring, Sustainable Development.

ABOUT THE SPEAKER

Amr Noaman Abdel-Hamid is an agile coach, trainer and practitioner who's passionate about spreading agile and lean thinking in Egypt and the Middle East. Amr is a co-founder of Agile Academy, the only accredited training organization by the International Consortium of Agile (ICAgile.com) in Egypt and the Middle East.

Amr is one of the leading contributors to the agile community in Egypt since 2009. Throughout the last 5 years, while working with the Software Engineering Competence Center (SECC), Amr initiated the biggest Agile Adoption program in Egypt to help teams and organizations deliver software at their maximum potential. Through this initiative, Amr has trained more than 500+ professionals and coached many teams from a wide range of public and private organizations in Egypt and the Middle East such as Vodafone, Orange, Valeo, and ITWorx.

Amr is a frequent speaker at national and international conferences and forums, such as the Agile Conference, Scrum Global Gathering, PMI Global Congress, and a keynote speaker at AgileAfrica. Amr has co-authored the Process Increments method, an agile method for Software Process Improvement. He is also an author of several industrial reports and articles, and writes frequently at his blog: amr.agileegypt.org. You can reach Amr through email, Linked-in, or twitter @amrnoaman.

AMECSE'14, October 21–22, 2014, Giza, Egypt.

Safety-Critical Software Systems, What is Special?

Hossam Yahia
Software Safety Expert at Valeo
Smart Village, building F22
Cairo, Egypt
hossam.yahia@valeo.com

OVERVIEW

This tutorial is focusing on identification of the key special activities that have to be done for software development of safety critical systems.

The demand for software intensive systems in safety-critical applications is now increasing and putting a lot of constrains on the quality and reliability of embedded software.

The tutorial introduces to the different safety standards in different domains such as automotive, avionics, space, nuclear, railways, and industry automation.

It discusses the different categories for safety criticality defined for every domain highlighting as well the main differences in safety strategies for each domain.

The tutorial discusses as well special activities that are requested during safety-critical software development, like safety analysis, software components qualification, software tools qualification, dependent failures analysis, and freedom from interference analysis.

It works as a preface to the modern technologies used in developing safety-critical systems, like Model-Based Development including semi-formal and formal modeling, testing strategies like Model-In-the-Loop testing, Software-In-the-Loop testing, and Hardware-In-the-Loop testing.

Discussion slots are planned for free discussions related to any of the above topics.

The second part of the tutorial introduces to a new safety concept that was developed by Prof. Nancy Leveson, professor of aeronautics and astronautics in MIT, in her latest book "Engineering a safer world". The concept called, Systems-Theoretic Accident Model and Processes (STAMP), is a new approach to model accidents based on systems model that consider safety as an overall system emerging property rather than a property of every system component.

The approach used for safety analysis based on STAMP, called "System Theoritic Process Analysis (STPA), is also introduced.

STAMP and STPA have been already piloted in many military, aerospace, automotive, nuclear, and other applications that show the efficiency of the approach and identify also the possible future improvements to it.

The Tutorial closes with an open discussion regarding the Egyptian market and the industries that can make use of the worldwide need on software intensive systems for safety critical applications, and the paradigm shift needed for the Egyptian companies in order to access this domain.

Keywords

Functional safety, Software safety, ISO26262, Safety-critical systems, STAMP, STPA.

ABOUT THE SPEAKER

With a total of 11 years of experience, Hossam has received his Msc from Nile University in 2014 in Software Engineering, Communications and Information Technology. He received his Bsc from Cairo University in 2003 in Electronics and Electrical communications. His main experience is in the automotive embedded software domain with almost 9 years of experience.

Hossam has started working on automotive software functional safety since 2008; he has completely specialized in this area in 2010. Starting Jan 2012, he has been nominated as a Valeo expert in software safety.

Hossam has five publications in the area of software safety in different international conferences. His master thesis was focusing on automated software safety analysis based on formal modeling for the software source code based on CRSM formal language.

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Agile Software Development Practices

Ibrahim El-Etr
Orange Labs Cairo
B147, NTI Building, 3rd Floor
Smart Village, Giza, Egypt
ibrahim.eletr@orange.com

Mohamed Ragab
Orange Labs Cairo
B147, NTI Building, 3rd Floor
Smart Village, Giza, Egypt
mohamed.ragab@orange.com

OVERVIEW

Software development is considered a young discipline compared to other established industries. Many challenges face software development teams, resulting in low success rate for software project. Misguided use of practices copied from other fields cause more harm than good. Over the past two decades a set of software development methodologies have evolved and proved success in the field.

Applying agile software development practices is quite a challenge and it goes beyond what one may learn through reading material or attending training courses. It is about the deep understanding that it is not a flip of a switch over night, but rather a journey of disciplined empirical experimentation. Changing the mindset of each participant in the software development lifecycle. Selecting and evolving the best suited managerial and engineering techniques to deliver value to the customer.

The tutorial aims to provide a decent introduction to the landscape of Agile development methodologies. It then covers deeper day to day Engineering practices that are necessary for fulfilling the promise of Agile Development. It then covers some of the challenges, pitfalls and traps that hinder teams during adoption of Agile development methods

The tutorial addresses the challenges an organization may face while moving their software production arm towards agility. How to build self-organizing teams, how to eliminate unnecessary waste, how to bring management to the buy-in state, how to move to new team structure and answer employees worries. The presenters are going to share their experience in Orange Labs Cairo trying to find answers to these questions.

Keywords

Software development, agile process, scrum, extreme programming, lean organization, self-organized teams, product management.

ABOUT THE SPEAKER

Ibrahim is currently the Head of Program Management in Orange Labs Cairo, and a MBA student in the German University in Cairo. Ibrahim joined Orange Labs as the Head of Software Development in 2006. Ibrahim has 8 years of solid management experience, leading several teams to deliver several portfolios of software products to market. He has over 21 years of software development experience associated with highly diversified portfolio of international companies in different culture environments such as Orange, Telepin, Airwide solutions, Mitel networks, Nortel networks, and Newbridge (Alcatel Lucent). He spent the first 15 years of his career working for startup companies including owning his own business. Entrepreneurship is part of his DNA and he brings that outlook and method of work to every team he works with.

Mohamed Ragab is currently the Head of Technology, and an Agile Development Coach in Orange Labs Cairo. He joined Orange Labs as a Senior Software and Service Architect in 2009. Mohamed has more than 15 years of experience building software systems in a wide range of industrial domains, in small local companies as well as large multi-national organizations. Mohamed has experience delivering projects with small collocated teams of a few developers to large distributed teams with a few hundred developers on board. Mohamed's expertise is in the Java platform, Open Source technology stacks, software development infrastructure and automation, and Agile Development Methodologies.

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Agile Software Requirements Specification for Successful Software Development

Kassem Saleh
College of Computing Sciences and Engineering,
Department of Information Sciences
Kuwait University
Box 5969, 13060 Safat, Kuwait
Kassem.saleh@ku.edu.kw

OVERVIEW

This tutorial will provide an overview of both the theoretical and practical backgrounds needed for the agile development of software requirements specifications. The topics that will be covered in the tutorial include: software requirements and its context and importance, the software requirements body of knowledge and competencies for requirements engineers, the agile software development and agile manifesto, the agile requirements engineering processes and activities, user stories, stakeholders, user personas and user experiences, agile estimation and team velocity, agile requirements discovery and elicitation, use case development in the agile method, non-functional requirements development, and finally, acceptance testing.

Keywords

Agile software requirements, non-functional requirements, software development.

ABOUT THE SPEAKER

Dr. Kassem A. Saleh received his BSc, MSc, and PhD in Computer Science from the University of Ottawa in Canada in 1984, 1985 and 1991, respectively. Dr. Saleh worked as a software design engineer at Northern Telecom in 1984 and then as a computer systems specialist at Mediatel, Bell Canada, from 1985 to 1991. He is currently a Professor in Information Sciences at Kuwait University. Kassem was on the faculty of Concordia University during 1991-1992, Kuwait University from 1992 to 2000, and American University of Sharjah from 2000 to 2007. Dr. Saleh is also a Certified Information Systems Security Professional (CISSP) since 2005, and a Certified Software Development Professional (CSDP) since June 2014. He is a senior member of IEEE and a professional member of the ACM. His research interests include software engineering, requirements engineering, communications protocols, information security, environmental informatics and IT Management and Technology Transfer. Dr. Saleh has published more than 130 refereed journal and conference papers and has presented numerous tutorials and lectures at international conferences and universities worldwide. Dr. Saleh has authored a textbook titled Software Engineering in 2009. The Journal of Systems and Software has ranked Dr. Saleh among the top scholars in the field of systems and software engineering in seven of its annual assessments published from 1996 to 2003. Dr. Saleh is currently editor-in-chief of the Journal of Software.

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IEEE SWEBOK 2014 (Software Engineering Book of Knowledge)

Maged Koshty
Managing Director, ExpertWave
10H/5 Ahmed AbdElAzim St.
New Maadi, Cairo, Egypt
maged@expertwave.com

OVERVIEW

SWEBOK V3.0 is the most recent completely revised and updated version of the internationally respected Guide to the Software Engineering Body of Knowledge from IEEE Computer Society published in 2014. The SWEBOK Guide characterizes the contents of the software engineering discipline, promotes a consistent view of software engineering worldwide, clarifies software engineering's place with respect to other disciplines, provides a foundation for training materials and curriculum development, and provides a basis for certification and licensing of software engineers.

Newly imagined as a living, changing document, and updated as technology and the engineering profession changes over time. In this tutorial, we will highlight major changes in 15 Knowledge Areas that has been reflected in the SWEBOK, presenting different usage of the guide in major educational institutions worldwide such as SCP (SWEBOK Certificate Program). We will also review IEEE certifications based on the SWEBOK such as CSDP (Certified Software Developer Professional) and CSDP (Certified Software Developer Associate).

Keywords

IEEE SWEBOK Software Engineering Education universities.

ABOUT THE SPEAKER

Maged Koshty is the only IEEE Software Engineering Certified Instructor in the EMEA region and the managing director of ExpertWave specialized in Software Engineering and project management development, training and consulting. Maged has worked for major companies like Apple and Corel in Canada and ITWorx in Egypt and has over twenty five years of hands-on experience in developing software projects for international companies worldwide.

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Service Oriented Architecture: Practical Approach for Small and Enterprise Systems

Mustafa Gamal
SECC - ITIDA
Giza, Egypt
mugamal@itida.gov.eg

OVERVIEW

Software Oriented Architecture (SOA) is a powerful architecture pattern that enable modifiability, testability, and reusability. On the other hand SOA is joined with a heavy stack of technologies. Which lead to be thought by researchers, Software Developers, Designers and Architects as an architecture pattern suitable only for Large Enterprise systems. This tutorial will propose a lite SOA approach that enables software developers to design lightweight system benefiting from the power of SOA without the efforts related to adopting all its technology stack. Also they will know how to support business agility with SOA. Researchers will learn how to exploit their work to community or business. Also will have an overview of how to get benefit from SOA principles to leakage the power of cloud to speed up processing of heavy computation problems by distributing it over multiple cloud processing units.

Best candidate for this session are software developers of all types, researchers that uses software development as part of their work, and business owners with a software development background.

Keywords

SOA, Service Oriented Architecture, Software Development, Software Design, Software Architecture

ABOUT THE SPEAKER

Mustafa Gamal, Research and Development Consultant at the Software Engineering Competence Center has 13+ years of experience in the field of software development and training both inside and outside Egypt. He worked as an architect, and software developer for desktop, web and cloud based applications as well as SOA and workflow based systems.

Mustafa has a master degree in Cloud Based Applications Architecture and Design with three published papers in the same field. He believes in connecting research to business applications to provide most optimized solution for each unique business problem. Mustafa's experience includes training in the field of software development from different aspects for about 9 different programming languages as well as coaching the trained teams in their software development projects.

One of his most featured projects as software architect is the Emergency Management System for the Saudi Red Crescent SRCS. The system is designed and implemented to manage the ambulance lifecycle of the Saudi ambulance service. It integrates with mobile and phone networks to manage and save calls. Also it detects phone caller address to help merging similar calls and detect false calls. In addition the system integrates GPS and GIS systems for best performance on managing emergencies.

Mustafa holds a master degree in Software Engineering from Faculty of Engineering, Helwan University. His research work was in developing architectural model that uses Service Oriented Architecture methods and disciplines to develop Software as a Service applications hosted over cloud infrastructure.

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