# DISTRIBUTED CONTEXT AWARE DYNAMIC ADAPTATION MODEL FOR KNOWLEDGE ASSESSMENT IN E-LEARNING SYSTEM

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**ABSTRACT**

*The objective of the work is to propose a context driven dynamic adaptation model for knowledge assessment in E-Learning system through software as component. Most of the existing models deployed for Knowledge Management have focused on the contents of the assessment while giving less emphasis to the context with which the assessment services are to be rendered. A timed automaton has been proposed to accept the user requests for services navigating through the different rules resulting in a change in the behavioral states. The various states are then rewritten according to the runtime policy of application incorporating the uncertainties pertaining to the nature of services, content, time and policy changes. This context driven approach considers the nature of the application and its content along with the run time policy of different applications. An architectural framework with dynamic adaptation model has been implemented using PHP and MySQL Server and extensive testing has been carried out. Interesting inferences have been observed in terms of the session time and rewriting rules.*

*Keywords: Context-awareness, Dynamic Adaptation, Component Services, Timed Automaton, Architectural Framework, Degree of Toughness (DT), E-Assessment*

## 1.0   INTRODUCTION

Context awareness feature can be expressed in terms of location, time, environment and workspace in the decision making process. Context has been defined as "any information that can be used to characterize the situation of an entity" [1]. It can be classified with respect to the user as a novice, a savvy or an expert based on the nature of application. Adaptability deals with dynamically changing the functionalities of the computational entities in response to the changing operating conditions. Some of the examples of services which need quick and selective adaptation are gaming service, calculation request service, mailing service , E-learning, etc. Business services in the areas like healthcare, insurance and banking must be highly adaptable to meet the changing need of the customers. A brief overview of existing and relevant context aware architectures is presented below:

Bradley et al. [2] in their work have achieved context aware computing by representing the state of the system by a vector of feature values. The time, location and policy of the service provider are considered to determine the exact context based on which the adaptation engine starts with its predefined behavior. The adaptation module first identifies the current context that the learner is situated in, based on a number of variables which indicate the individual contextual factors like the physical address of the location, the type of location, and the time available in the work, as proposed by Jane et al.[3]. Tarak Chaari et al. [4] have proposed a new definition of context and established three dimensions for context namely services, content and presentation.

Most of the existing literatures on context aware system focus on the layered architecture. Anders et al. [5] have defined an adaptive context aware application with two levels and a simple response system using the context middleware as a complex and adaptive multiagent system. A layered context stack has been proposed by Wei Li [6] to collect, interpret, aggregate and analyze of sensor data to a useful high level context information. The parameters which constitute the context need not be considered on a single layer for computation purposes since some of the parameters have to be dealt only at the end session of the application. Hence, the concept of layered contexts comes to solve the un-timed occurrence of these parameters.

Mahmoud Hussein et al. [7] in their approach have proposed an adaptive context awareness model in which the context relationships are considered at the modeling level, thereby reducing the system development errors.

182

*Malaysian Journal of Computer Science.  Vol. 26(3), 2013*

They have separated the functionality and the context management to reduce the system errors.  Mare Dalmau et al. [8] have highlighted the importance of adding adaptation to the context which needs a well designed architecture that takes care of irrelevant and redundant information. Similar idea was proposed by Davy Peuveneers et al. [9] in a modular context management system, where the effect of removing unnecessary transformation and reasoning components were studied .The consistent program behavior ignoring context changes within the particular scope of the software system was considered in [10, 11]. Since context information is volatile, the composition of context dependent behavior is continuously subject to change.

In E-learning, there is a paradigm shift in assessment methodology from the conventional pen and paper based tests to a more dynamic interactive approach of adaptive tests. The goal is to provide a personalized learning experience tailored to the user's needs.  The deployed E-assessment software services can be reused if and only if they are context sensitive and highly adaptable. The adaptability in E-Assessment takes into consideration the learner's situation and their personal characteristics in generating a personalized learning experience. It facilitates a user's request for the required services taking into consideration the different types of contexts.  The abstraction level of context will vary since a context by itself may be a composite variable consisting of different contexts. In the case of knowledge assessment in E-learning, the context has been defined in terms of learner's state, educational activity state, the infrastructure state and the environmental state where the adaptation engine considers all the four states as input and produces educational activity as output according to Economides [12]. The various areas of orientation of Computer Adaptive Testing as given by Economides [13] are content, time, difficulty level, score,  presentation, media and format, communication and collaboration, feedback, control examinee characteristic and educational outcomes. A new approach that refines the results of the assessment in computerized testing by exploring the user's knowledge has been proposed by Lamboudis et al. [14].  They have proposed an approach in which the system waits for the user to check the validity of an answer and then proceeds to the next question. An exploration module is called to allow the user to have a second chance to provide the validity of the answer. The depth of exploration is an implementation decision to be taken by the designer. The earlier work proposed by Jane et al.[15] described a generic Context Aware and Adaptive Learning schedule (CALS) for selecting the appropriate learning material for learners based on their preferences and contextual features. The tool consists of four logical layers namely learner model, learning preference adaptation, contextual feature adaptation and learning object selection. This can be used in concordance with other models as in [16].

The main focus of this research work is to propose a highly adaptable assessment service that can be deployed as distributed software in a knowledge management framework. All the requested software services are described once and deployed as software component or services; the completeness and correctness of the services are monitored continuously. The proposed model of context aware adaptation model identifies four dimensions for the context variable applicable to the assessment application through which the rules of adaptation are derived. The users may also request the same set of services periodically with different content in different contexts due to which the policy rules should be changed and rewritten. The basic underlying assumption in the proposed model is that the question selection time and total time are equal for all the users.

The organization of the paper is as follows: Section 2 identifies the critical dimensions of the context variable selected in E-Assessment; Section 3 proposes a distributed architecture for dynamic adaptation applicable to E-Assessment focusing on the context with which the questions are to be selected over different sessions. Section 4 deals with mechanism of the rules that are   generated and rewritten for quick adaptation to increase the performance of the assessment with the help of the system behavior. Section 5 highlights the proposed adaptation model on the context driven web based assessment services in an E-Learning system.  Section 6 discusses the related performance and metrics of adaptation in E-Assessment system. Section 7 concludes the work with its limitation on applicability and scalability centered on the nature of deployment and the assessment capacity of size.

## 2.0   CONTEXTS IN E-ASSESSMENT AND THEIR DIMENSIONS

The assessment of academic performance nowadays is not only based on the answering ability but also on the context where the question contents are thrown up. The dimension variables like time, content, the type of the application and the run time policy decisions play an important role in deciding the performance of context aware computing systems as shown in Fig 1. The proposed model focuses on the dynamic adaptation of the assessment service for different contexts based on the needs of different types of learners.

183

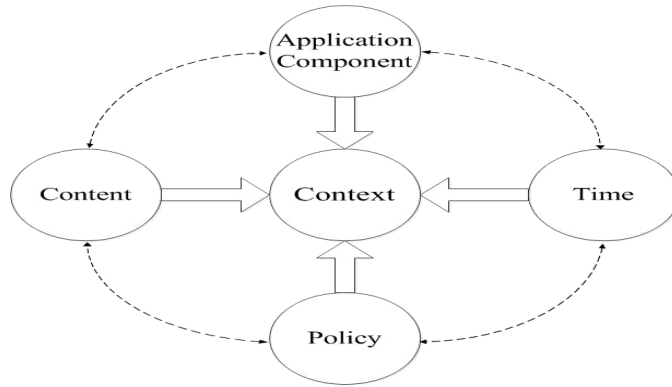Malaysian Journal of Computer Science.  Vol. 26(3), 2013

Fig. 1.  Dimensions of knowledge assessment

The dimensions are also dependent on each other as far as a single context variable is considered. For example, in  E-Assessment the percentage of questions correctly answered , the time taken for the test etc are some of the context variables in deciding the performance of the user whereas the gender, the knowledge of the user, their proficiency of the domain are some of the dimensions in that context. In web applications, each and every service may have a number of different contexts and each context may have multiple dimensions.

The number of components or services deployed in a typical application can be considered as a set of *Co*, the various context variables with which the application can be executed is treated as a set of *Cx* and the multiple dimensions of each context variable can be considered as the third set, *Cd*. The selection of the correct context variable is done by the adaptation engine based on rules to exploit the surjective functional mapping between the variables and the dimensions as shown in Fig 2.
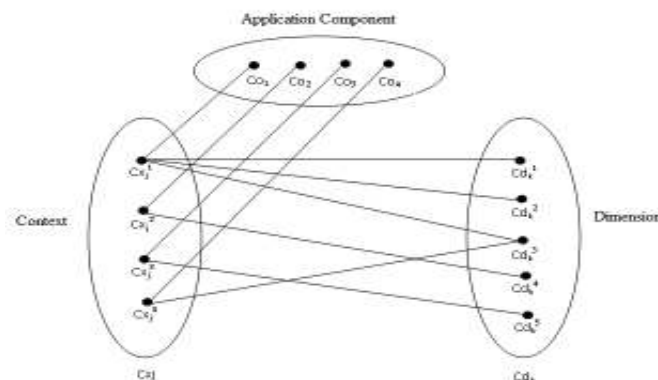


Fig. 2. Triangular surjective functional mapping component, context and dimension

The application components can be a domain set and the context variables are co-domain with the dimensions as the range set. The functional mapping is to be modeled based on the application with the number of elements in each and every set and the binary relationships between them as mentioned below:

$$Co_1 \longrightarrow Cx_j^1 \longrightarrow Cd_j^1 + Cd_j^2 + Cd_j3 \qquad (1)$$
$$Co_2 \longrightarrow Cx_j^2 \longrightarrow Cd_j^4 \qquad (2)$$
$$Co_3 \longrightarrow Cx_j^3 \longrightarrow Cd_j^5 \qquad (3)$$
$$Co_4 \longrightarrow Cx_j^4 \longrightarrow Cd_j^3 + Cd_j^5 \qquad (4)$$

For example, the first mapping conveys that the context in the application component $Co_1$ is one to one mapped with the context variable $Cx_i^1$ which in turn is connected with three dimensions $Cd_i^1$, $Cd_{i2}$ and $Cd_i^3$ of the same context $Cx_i^1$.

184

## 3.0 DISTRIBUTED ARCHITECTURE FRAMEWORK WITH DYNAMIC ADAPTATION

The architectural framework for dynamic adaptation in E-Assessment is given in Fig 3. The knowledge assessment in an E-Learning system has to be adaptable to reflect the incoming changes from various external bodies like the government educational policies, standards of syllabus, regulations in the specified curriculum and evaluation policies at the user profile which govern the quality of the education system. This is handled by the run time policy detector. To incorporate the change of the hour and to take an intelligent decision in the system, a collaboration of many software component services are needed. The adaptation manager holds a database of rules required to perform adaptation on the application. It monitors significant context changes in the application according to the current context and user preferences and also takes care of rewriting the rules. The proposed framework incorporates the key process activities through the time management, content analyzer and the session allocator. The selection of the session allocation is based on the summary of report submitted by the adaptation manager. The decision making section of the application uses adaptation rules and the goal of the session allocator is to determine which tasks from the current context of the user should be scheduled  to carry out the assessment procedure. During the execution of the application, the contents are analyzed with respect to the context to provide l information to the service allocator. The umbrella activities like reporting and violation message display components are also to be considered to deliver the application as a real product.  The correct message will be fed in the form of rules into the runtime policy generator. The proposed middleware component must then detect the events and activate the appropriate interfaces in the adaptation manager in the middleware.
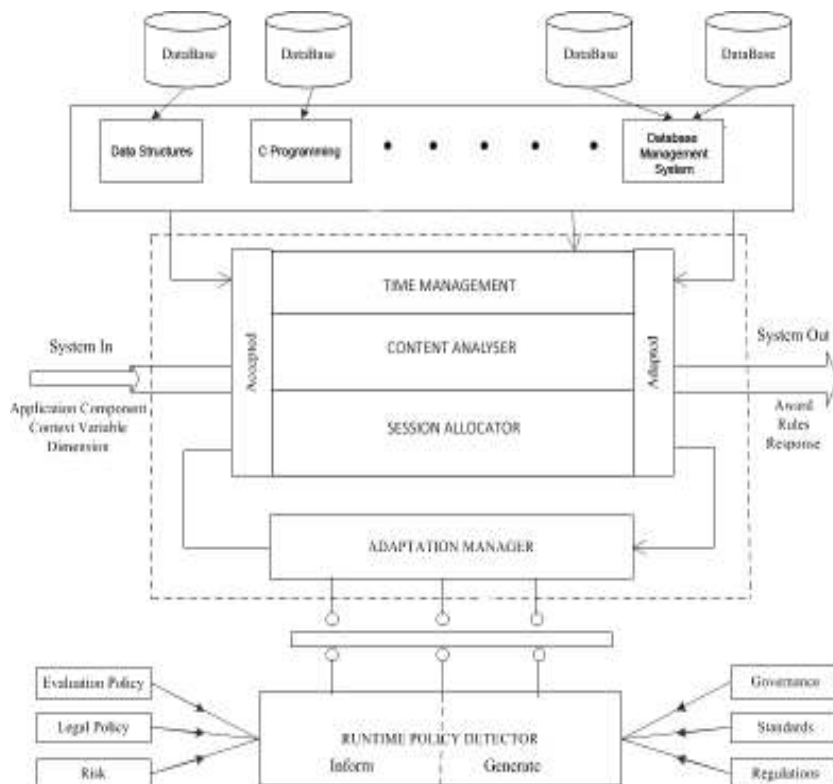


Fig. 3. Distributed architecture framework for dynamic adaptation

The adaptation engine can be computationally represented by a non deterministic finite state automaton NDFA which can be realized and executed from the middleware component. The individual states and transitions are monitored in the respective functional blocks given as an extended timed automaton.

185

The automata can be defined as $K = (\sum, Q, Q_s, T, R, P)$

where

$\sum$ is the set of inputs
$Q$ is the set of states, $Q_s$ is the final state; $T$ is the set of transitions
$R$ is the set of rules; $P$ is the set of adaptation policies
$T \rightarrow \{Q \times Q\}, R \rightarrow \{ P \times \sum \}$

The set $\sum = (U, C.D)$

where

$U$ is the user input & $U = choice(x,y,z)$
$C$ is the choice, where $c_i \in C$ and $C_i$ is finite and customizable,
$c_i \in D \; X \; U$ and
$D$ is the domain as $D(d_1, d_2, d_3, ..d_i...d_n)$ representing different domains like Data structures, C Programming , Database Management Systems and so on , for which context awareness is needed where $d_k \in D$ and $d_k \neq d_i$ .

Now,

$\sum = \{ (x,y,z), (c_1....c_n) , (d_{1.....} d_n) \}$
where $d_i \in D, d_i \neq d_j$
$c_i \in C, c_i \neq c_j$



Fig. 4. State transition diagram for adaptation

A detailed description of the adaptation rules is given in the following section.

The behavior of the suggested automata with its states is shown in Fig 4 as a state transition diagram. The adaptation model has various states and transition from one state to another depends on the user's input. The user input is obtained so that the corresponding choice of domain will be selected to generate the rules pertaining to the domain in the run time. The user starts by selecting the domain that he wants to take up the test.

186

The system checks for the validity of the domain. If the domain is valid (exists *i* the database), the system checks the policy and starts the session if the policy holds good. The system begins with the analysis of the input patterns following which the adaptation rules are generated. The system continues with the adaptation procedure until the time duration of the assessment elapses or the questions for the prescribed marks have been attempted, whichever occurs first.

## 4. 0  ADAPTATION RULES AND REWRITING

The performance of the proposed context aware online adaptation model for knowledge management depends on the sensitivity and selectivity of the application over its context changes. Since the application is inherently time sensitive, the time taken for the context and its dimension switch over should be minimum. To minimize the challenge of time constraint, a rewrite based technique is incorporated.  The rules that are to be generated and rewritten can be realized as shown below:

**Rule R**:  Get (user id, domain, time setting and choice level) from user as input. Then, the control goes to "store-domain" state shown in its behavioral automaton.

$$\text{Read} \xrightarrow{\text{Domain\_id, User\_id, User\_choice}} \text{Store}$$
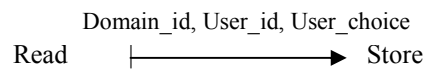
**Rule S**:  This rule is meant for checking the validity of the selected domain. If the domain is valid i.e., found in domain listing, then the system moves to "wait" state, else to the previous "read" state.

$$\text{Store} \xrightarrow{\text{Domain, Domain listing}} \text{Wait}$$
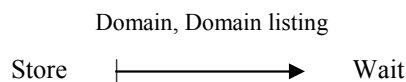
**Rule W**:  The system Finite State Machine (FSM) model waits for a specified period of time and goes to state "check policy".

$$\text{Wait} \xrightarrow{\text{System time, Setting}} \text{Check Policy}$$
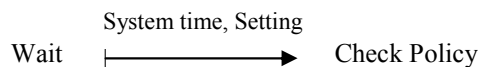
**Rule C**:  The policy rules are checked and if there is a violation on the context or its dimension, the system model goes to state *R*. Else, the session begins and it goes to the state named , "analyze".

$$\text{Check Policy} \xrightarrow{\text{User id, Domain Id}} \text{\{Read Input, break; Analyze\}}$$
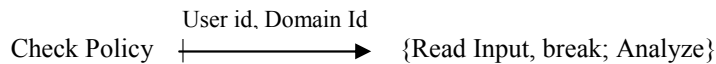
**Rule A**:  By this rule, the model enters into state of  "analyze" based on the  *DT* choice level and input given by the user  for a specified number of  times. Based on the policy rules, it moves to state *G*.
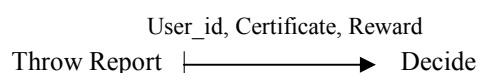
$$\text{Analyze} \xrightarrow{\text{User \_choice}} \text{Generate Rules  \& Award Marks}$$
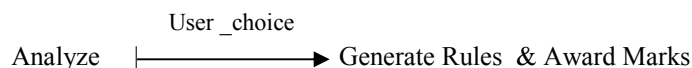
**Rule G:** New rules are generated based on  the user choice and  through implementing the generated rules , it goes to state *T* to check if the time of the test has elapsed. If the time has not elapsed, the rules are changed and also a check is made to ensure that the user has not attempted any other trial for the maximum prescribed marks.
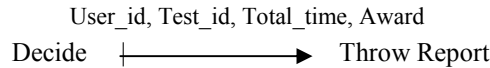
$$\text{Generate Rules \& Award Marks} \xrightarrow{\text{Reward, Time}} \text{Manage Time}$$
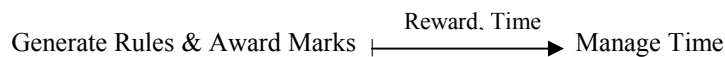
**Rule M:** The time utilized so far is checked with the time duration of the test. If the time has elapsed, then it goes             to State *T*.  Otherwise it continues with the test with the new set of rules.

$$\text{Manage Time} \xrightarrow{\text{System time}} \text{Throw Report}$$
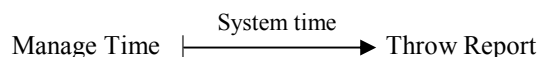
**Rule T**: Initiates the state *D*. Once reports are generated in *D*, the session ends.

$$\text{Throw Report} \xrightarrow{\text{User\_id, Certificate, Reward}} \text{Decide}$$

187

Malaysian Journal of Computer Science.  Vol. 26(3), 2013

**Rule D:** Generates the reports and goes to state *T*.

<div align="center">

User_id, Test_id, Total_time, Award

Decide  $\longmapsto\!\!\!\!\longrightarrow$  Throw Report

</div>

The rules which are the reflections of the policies for the acceptance of the user input, checks the validity and acts as per the run time inputs given by the users.   The rule based system moves from one rule to another rule based on the input and context and tries to rewrite the same rules over different sessions but with different dimensions. The lists of attributes are stored as records in the MySQL database and the rules are coded in PHP.

## 5.0   E- ASSESSMENT STRATEGY AND IMPLEMENTATION

Assessing the performance using an evaluation strategy is an important part of E-learning.  Adaptive testing is a form of computer-based assessment that adapts to the students' ability level. The main objective of adaptive assessment is to conduct an optimal test for all the students. In conventional tests, the same sets of questions are administered to all the waste their time attempting questions which are either very trivial or very difficult to their ability. Students get frustrated when the difficulty of the questions is higher than their ability level and bored if it is lower than their ability. But in the procedure of adaptive testing, the questions will be generated based on the individual ability of the student. This will result in generating different sets of questions for different students, keeping their enthusiasm to face the test steadily. If the student gets correct answer for a question, the computer will then select the next question from a higher difficulty level; otherwise the next question will be from a lower difficulty level. Students proficiency in a subject will be assessed with a fewer questions than in conventional tests. A finer discrimination in all ranges of performance is possible in adaptive strategy. This will improve the effectiveness of the assessment. An adaptation model on the context driven web based assessment services in an E-Learning system has been developed and tested.

The interesting aspect of this model is that it allows the student to initially opt for the DT of the questions soon after he logs into the system of examination. If he opts for the $k^{th}$ DT ($k=1, 2, 3, 4, 5$) the system will start displaying the questions randomly for which the candidate answers. The following is the algorithm covering all the four cases of inputs and contexts:

**Case 1**: If the candidate answers the first three questions of the $k^{th}$ DT correctly, the system will shift to $k+1^{th}$ DT provided $k \neq 5$. When $k = 5$, the system continues to ask questions from the same level.
**Case 2**: In case the candidate answers all the three questions of the $k^{th}$ DT incorrectly, the system will shift to $k-1^{th}$  DT provided $k \neq 1$. It follows from the earlier logic the system continues to display from the $1^{st}$ DT irrespective of the number of wrong answers (WA) provided.
**Case 3**: This case relates the situation where the examinee answers either one or two questions correctly out of the first three questions from the $k^{th}$ DT. The system exhibits one more question from the same DT. Thus the examinee encounters a total of four questions. A total of three correct answers (CA) shift to $k+1^{th}$ DT, provided $k \neq 5$; otherwise to $k-1^{th}$ DT provided $k \neq 1$.
**Case 4**: In case examinee answers two questions correctly out of the first four questions from the $k^{th}$ DT, one more question from the same DT is given. A total of three correct answers out of five for the given questions, shifts to $k+1^{th}$ DT; otherwise to $k-1^{th}$ DT. However shifting to a higher or lower DT does not take place when $k=5$ or $k=1$ respectively.

### 5.1 Evaluation Procedure

The marks for a question in each DT are given in Table1. The tableshows that the increment of the marks are corresponding to the DT.

<div align="center">

Table  1. Marks associated with each context dimension (DT)

| DT | 1 | 2 | 3 | 4 | 5 |
|------|-----|-----|-----|-----|-----|
| **Mark** | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 |

</div>

The maximum marks and the duration of the examination can be set according to the needs of the subject. The test will be terminated either on the expiry of the time frame or when the examinee has attempted questions for

188

the prescribed maximum marks, whichever occurs first. The score and the number of DT – wise questions asked and answered get displayed at the end of the test.

**5.2 Question Bank Creation**

A question bank consisting of multiple choice questions for C-Programming language was created by collecting questions from the course experts. A conventional test (where each of the questions in the question bank has to be answered by all the students) was given to a group of students. Calibration was done with the proportion of the examinees who answered each question correctly to the total population, based on which the questions were initially classified into various levels of DT ranging from 1 to 5 (1–very easy and 5 – very difficult) as shown in Table 2.

Table 2.  Initial classification of questions into context dimensions (DT)

| DT | % Answered Correctly | No. of Questions |
|---|---|---|
| 5 | 0 – 10 | 26 |
| 4 | 11 – 29 | 80 |
| 3 | 30 – 49 | 97 |
| 2 | 50 – 69 | 79 |
| 1 | 70 – 100 | 78 |

Each question in the question bank is tagged with a DT. The DT of a question has to be updated periodically, after broad spectrums of students undergo the tests and the question has been asked sufficiently a large number of times.

**5.3  Implementation**

Application has been developed using PHP software as the front end and MySQL at the back end database server to implement the proposed context aware online adaptation model for knowledge assessment in E-Learning  The test was administered to nearly 500 under graduate and post graduate engineering students.  The context dimension, its depth and the adaptation time are noted to determine the performance of the rule rewrite based implementation. The sample code for adaptation in online assessment corresponding to case 1 in the case study is given in Fig 5. The variable correctness_count denotes the number of questions answered correctly in a particular context dimension (DT) and if it is equal to 3 and if the DT level is less than 5, the level of the dimension is incremented.

```
        if($correctness_count=3 && $_SESSION['dt']<5)
    {
    $_SESSION['dt']++;
    $query="update test_log set flag=0 where student_id='" .
$_SESSION['student_id'] . "' and
        test_date='". $_SESSION['test_date'] ."' and test_id='" . $_SESSION['test_id']
. "' and
        college_id='" . $_SESSION['college_id'] . "'";
      mysql_query($query,$conn);
   }
                …
                …
                …
    header("Location:start_test.php");
                exit;
          }
      }
```

Fig. 5. Sample PHP script

189

Malaysian Journal of Computer Science.  Vol. 26(3), 2013

The frequent change in the contexts and the corresponding dimension are monitored over the sessions for adaptation rules to be applied as and when needed. The context sensing and switching performance are tabulated as in Table 3. If the user provides a correct answer to a question, the correctness value is set to 1; otherwise to -1. The DT column specifies the difficulty level of the question attempted.

Table 3. Context sensing-switching-closing analysis

| Log_id | Session_id | Question_id | Start Time of a question | End Time of the question | Actual Answer of the question | User's Answer | Correct_ness | DT |
|---|---|---|---|---|---|---|---|---|
| 40640 | 09mca50 | 378 | 7/2/2011 10:48 | 7/2/2011 10:52 | b | a | -1 | 1 |
| 40641 | 09mca02 | 375 | 7/2/2011 10:49 | 7/2/2011 10:49 | b | c | -1 | 1 |
| 40642 | 09mca26 | 18 | 7/2/2011 10:49 | 7/2/2011 10:49 | a | d | -1 | 2 |
| 40643 | 09mca27 | 75 | 7/2/2011 10:49 | 7/2/2011 10:49 | b | b | 1 | 2 |

Let $\tau$ be the time taken to answer a question. Let $t_0$ be the start time of the test. The minimum time taken for the 1st adaptation is given by

$$t_0 + 3\,\tau \tag{5}$$

But the time taken to answer the question depends both on the knowledge as well as the DT level. Let $\psi$ denote the knowledge level of the candidate. Therefore the time taken to answer a question at DT level $i$ is given by

$$t_i = (DT)_i\,\psi_i\,\tau \tag{6}$$

The above equation when considering the maximum allowed three inputs with an average time delay $\tau$ becomes,

$$t_0 = (DT)_i\,\psi_i\,3\tau \tag{7}$$

## 6.0 PERFORMANCE ANALYSIS

Data collected using the online adaptive assessment model in E-Learning system is shown in Table 4 .The session in the table starts with the user choosing DT 1 as his choice. The time taken to answer each question and the correctness of the response is monitored. Based on the correctness of the answer, the mark that is corresponding to the DT level of the question is allotted. The total mark is the sum of the marks scored for all the questions in a session.

Table 4. System performance data collected for online adaptation per session

| question id | Question Start Time | Question End Time | Actual Answer | User's Answer | Correct_ness | DT level of the Question | Mark Scored | Time Taken to answer( in seconds) |
|---|---|---|---|---|---|---|---|---|
| 26 | 11:07:42 | 11:07:54 | b | b | 1 | 1 | 0.2 | 00:12 |
| 33 | 11:07:54 | 11:08:05 | c | c | 1 | 1 | 0.2 | 00:11 |
| 8 | 11:08:05 | 11:08:11 | c | c | 1 | 1 | 0.2 | 00:06 |
| 339 | 11:08:11 | 11:09:06 | d | d | 1 | 2 | 0.4 | 00:55 |
| 70 | 11:09:07 | 11:09:39 | a | a | 1 | 2 | 0.4 | 00:32 |
| 21 | 11:09:39 | 11:09:49 | b | c | -1 | 2 | 0 | 00:10 |
| 204 | 11:09:49 | 11:10:13 | c | c | 1 | 2 | 0.4 | 00:24 |
| 314 | 11:10:13 | 11:10:57 | a | c | -1 | 3 | 0 | 00:44 |

190

| 268 | 11:10:57 | 11:12:03 | c | a | -1 | 3 | 0 | 01:06 |
| 261 | 11:12:03 | 11:14:01 | c | c | 1 | 3 | 0.6 | 01:58 |
| 355 | 11:14:02 | 11:14:17 | b | d | -1 | 3 | 0 | 00:15 |
| 321 | 11:14:17 | 11:14:37 | a | a | 1 | 2 | 0.4 | 00:20 |
| 82 | 11:14:37 | 11:14:50 | d | d | 1 | 2 | 0.4 | 00:13 |
| 309 | 11:14:50 | 11:18:20 | a | b | -1 | 2 | 0 | 03:30 |
| 18 | 11:18:20 | 11:18:32 | a | a | 1 | 2 | 0.4 | 00:12 |

The adaptation response over switching between contexts is shown in Table 5. The total mark scored by the candidates, the time taken to complete the test and the average time taken by students to provide a correct/incorrect response to  questions  at each difficulty level are calculated.

Table 5. Adaptation response on switching context dimension

| Session Id. | Total Mark scored (out of 15) | Total Test time(in sec) | DT1 | | DT2 | | DT3 | | DT4 | | DT5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CA Avg Time | WA Avg Time | CA Avg Time | WA Avg Time | CA Avg Time | WA Avg Time | CA Avg Time | WA Avg Time | CA Avg Time | WA Avg Time |
| 09mca01 | 4.8 | 1556 | 9.667 | 0.000 | 26.000 | 110.000 | 318.000 | 49.250 | 0.000 | 0.000 | 0.000 | 0.000 |
| 09mca02 | 12.4 | 1598 | 46.430 | 25.500 | 15.220 | 0.000 | 27.810 | 31.570 | 215.000 | 60.250 | 0.000 | 0.000 |
| 09mca03 | 8.4 | 1999 | 83.500 | 45.750 | 61.250 | 40.500 | 39.167 | 64.667 | 56.000 | 139.750 | 0.000 | 0.000 |
| 09mca04 | 3.8 | 1054 | 7.385 | 19.455 | 7.333 | 13.333 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 09mca06 | 7.8 | 1940 | 50.000 | 42.500 | 116.000 | 71.000 | 44.500 | 99.000 | 112.333 | 66.500 | 0.000 | 0.000 |
| 09mca07 | 8.4 | 1885 | 26.111 | 0.000 | 70.111 | 80.625 | 38.200 | 27.667 | 0.000 | 50.000 | 0.000 | 0.000 |
| 09mca08 | 5.8 | 897 | 12.333 | 25.474 | 10.143 | 15.556 | 0.000 | 5.667 | 0.000 | 0.000 | 0.000 | 0.000 |
| 09mca09 | 8.4 | 2066 | 44.333 | 80.000 | 49.000 | 48.500 | 136.667 | 39.500 | 64.667 | 105.000 | 149.000 | 0.000 |
| 09mca10 | 1.2 | 1586 | 28.500 | 52.407 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 09mca11 | 11.2 | 976 | 35.667 | 0.000 | 28.000 | 53.000 | 36.500 | 29.333 | 16.667 | 87.500 | 53.667 | 0.000 |

- CA  Avg time – Time taken  ( in seconds) taken to answer the questions correctly at  a DT
- WA  Avg time - Time taken  ( in seconds) taken to answer the questions incorrectly at  a DT
- Tot_time  - The total time ( in seconds) taken to complete the test

The average time taken to answer all the questions correctly by different online users over multiple sessions with different context dimensions are shown in Fig 6.
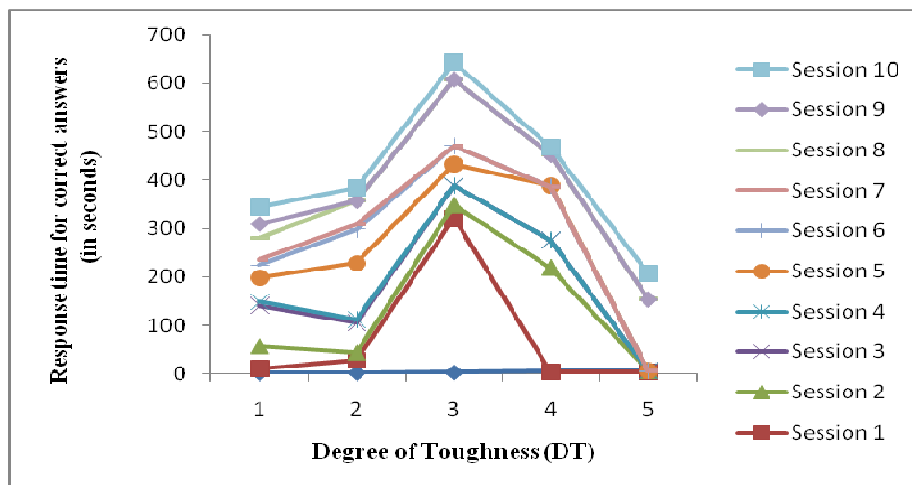


Fig. 6. Average response time over different DT levels

191

Malaysian Journal of Computer Science.  Vol. 26(3), 2013

**Basic rules:** Rules: G→ T , T→ G, G→A, A→G , G→M , T→ D, M→T
(G: Generate, T: Throw Report, A: Award, M: Manage Time, D: Decide)

The performance of the proposed rewrite method over different input patterns in multiple sessions are presented in Table 6.

Table 6. Rule rewrite vs input pattern

| Session/ Roll No. | Test Start time | Test End time | DT in the answering pattern | Total Test Time (in sec) | Rules Rewriting Time (in sec) | No. of Rules rewritten |
|---|---|---|---|---|---|---|
| S1/09mca01 | 11.07:42 | 11:33:40 | 1-2-3-2-3 | 1556 | 29 | 8 |
| S2/09mca02 | 10:49:21 | 11:16:53 | 1-2-3-2-3-4-3-2-3 | 1598 | 147 | 19 |
| S3/09mca03 | 10:50:32 | 11:23:53 | 1-2-3-4-3-4 | 1999 | 197 | 18 |
| S4/09mca04 | 10:51:20 | 11:08:51 | 1-2-1-2-1 | 1054 | 182 | 26 |
| S5/09mca06 | 10:50:13 | 11:22:35 | 1-2-3-4-3-4 | 1940 | 250 | 17 |
| S6/09mca07 | 10:52:43 | 11:24:14 | 1-2-1-2-3-2-3-2-3-4 | 1885 | 43 | 16 |
| S7/09mca08 | 10:52:51 | 11:07:49 | 1-2-1-2-1-2-3-2-1 | 897 | 210 | 22 |
| S8/09mca09 | 10:51:37 | 11:26:04 | 1-2-1-2-3-4-5-4 | 2066 | 180 | 15 |
| S9/09mca10 | 11:18:01 | 11:34:24 | 1 | 1586 | 1586 | 19 |
| S10/09mca11 | 10:50:12 | 11:06:29 | 1-2-3-2-3-4-5 | 976 | 61 | 11 |

The adaptation time and rule rewrite time are shown in Fig 7 and Fig 8 respectively.
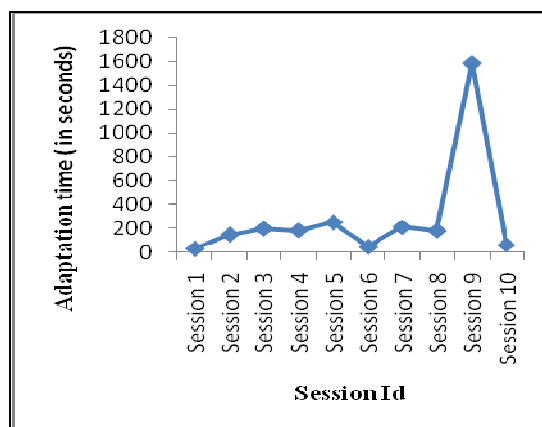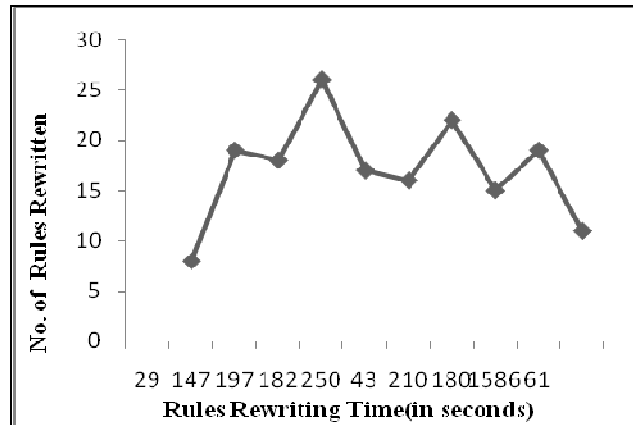


Fig.7. Adaptation time over multiple sessions

192

Fig. 8. Time for rules rewriting

## 7.0  CONCLUSION

A context aware distributed online adaptation model for knowledge assessment in an E-Learning system is proposed with its framework as a middleware component. The context variables and their functional mappings with their various dimensions are considered in designing the system. The context sensing and switching actions have been carried out by considering the runtime policies in the rule based rewriting sub system. The current standards, regulations, and risks along with the various policies are taken into account as the input to the adaptation manager component. The needed interfaces are declared and deployed to inform and generate the computational rules for the system. The context awareness has been incorporated as a set of multiple rules which are to be rewritten not only when the end user changes his or her input  as a content driven but also when the system average response time elapses as a time triggered application. The performance of the model is enhanced by carefully generating rules at run time which are based on the user as well as the system that triggers a switching during adaptation phase. The online assessment is computationally modeled with an automaton to make it adaptable based on the major external policy changes. A case study has been carried out to implement the proposed framework components for nearly 500 Engineering students in an institution and the middleware was deployed to monitor the context changes and the adaptation time over multiple sessions. The application which is an information processing and decision making component dynamically interacts with the time management and session allocation modules written in PHP as the user end with multiple databases in MySQL at the backend.

The system performance in terms of its functionality and the adaptation capability in terms of numbers of rules generated and rewritten are shown. From the observations, it is found that a student who has completed the entire assessment within 897 seconds in which the first context switching comes at 210 seconds where a total of 22 rules have been rewritten. In another scenario, only 8 rules have been rewritten for a total session time of 1556 seconds out of which 29 seconds as system rewrite time. It has been inferred from the performance charts that the system behaves non-linearly with respect to the total session time and rules rewrite time because of the laziness and eagerness of the individual student in answering the questions.

The proposed work is to be extended to all the departments as contexts and covering different subject domains as dimensions for more number of students in future. The limitation of the proposed is the synchronization issues when system crashes. The high availability and secured transmission of answers over the distributed network are the next challenges in the future work. The online question creation, and information transmission after identity management are some of the limitations in the case of large scale deployment in an educational data grid environment. The same work can also be deployed as a number of virtual services with all key process activities and virtual networks with virtual resources like hardware and software as services as an Exam-In-Cloud mission in future.

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194

Malaysian Journal of Computer Science.  Vol. 26(3), 2013

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195

Malaysian Journal of Computer Science.  Vol. 26(3), 2013