
An Intelligent Service-Based Layered Architecture for eLearning and eAssessment

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ABSTRACT

The rapid advancement in ICT (Information & Communication Technology) is causing a paradigm shift in eLearning domain. Traditional eLearning systems suffer from certain shortcomings like tight coupling of system components, lack of personalization, flexibility, and scalability and performance issues. This study aims at addressing these challenges through an MAS (Multi Agent System) based multi-layer architecture supported by web services. The foremost objective of this study is to enhance learning process efficiency by provision of flexibility features for learning and assessment processes. Proposed architecture consists of two sub-system namely eLearning and eAssessment. This architecture comprises of five distinct layers for each sub-system, with active agents responsible for miscellaneous tasks including content handling, updating, resource optimization, load handling and provision of customized environments for learners and instructors. Our proposed architecture aims at establishment of a facilitation level to learners as well as instructors for convenient acquisition and dissemination of knowledge. Personalization features like customized environments, personalized content retrieval and recommendations, adaptive assessment and reduced response time, are believed to significantly enhance learning and tutoring experience. In essence characteristics like intelligence, personalization, interactivity, usability, laidback accessibility and security, signify aptness of proposed architecture for improving conventional learning and assessment processes. Finally we have evaluated our proposed architecture by means of analytical comparison and survey considering certain quality attributes.

Key Words: E-Learning, E-Assessment, Architecture, Data Mining, Intelligent Agent.

1. INTRODUCTION

Rapid development AI (Artificial Intelligence) and ICT led to significant advances in eLearning. Recent studies revealed that worldwide eLearning grew up to 56.2% as compared to

35.6% in 2011 and this figure is expected to be doubled [1]. Malaysia and Vietnam are the most rapidly growing eLearning markets with 17.3% annual growth rate. China has the highest adoption rate of eLearning where 14% of

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the college students are online students [2]. E-Learning systems are leveraging latest technologies like APIs, Cloud, Web services, HTML5 and MAS to increase overall utility and efficiency of these systems. AI concepts and methodologies are being adopted to develop intelligent, personalized, reliable and fault-tolerant systems for eLearning. Traditional eLearning systems suffer from significant shortcomings i.e. scalability, personalization, interoperability, coupling and performance issues [3-5]. Newer technologies like web services, cloud, semantic web, xAPIs and advanced methods like IR, KE, service matchmaking, and Query optimization can significantly contribute towards overcoming these issues.

Since last decade, intelligent agent-based eLearning systems have received significant attention of research community. Agent based technologies can facilitate learning processes in numerous ways including learner-system interaction, personalization, AI model generation for learning and simulation, resource optimization and a common infrastructure to absorb diverse range of software components [6-7]. Agent-based information system provides direct instructions or feed back to the students without human intervention [8].

Software agents as part of an MAS, need to communicate with other agents through a message passing mechanism [9]. Internal state and behaviors of member agents are not accessible by other member agents of MAS [10-11]. Agents can only discover and invoke services offered by other agents by means of middleware services [10,12]. These middleware services are provided by MAS platform in which agents are embedded. Member agents can interact using ACL (Agent Communication Language) while communication protocols define the rules of interaction among member agents of MAS [11]. However, this communication is not always local and homogeneous, as remote interaction with member agents of other MAS systems and non-agent software components is quite

likely condition [10]. Interoperability between heterogeneous member agents and heterogeneous MAS is considered as a major research challenge which has received significant attention from research community [12-18].

We have proposed an MAS-based multi-layered architecture supported by Web services. This architecture mainly comprises of two modules namely eLearning and eAssessment. Five constituent layers of eLearning module ensure the loose coupling and distributed nature of the system. These layers include Human interface, resource, MAS, dB controller, and DSRs (Data Storage Repositories) layers. eAssessment architecture also consists of five layers namely; Human interface, resource, FDL (Functional Description Layer), implementation and database layer. Detailed description of these modules is provided in subsequent sections. Section 2 provides related work in areas of MAS, SOA, personalized leaning and query processing. Section 3 provides general architecture with detailed description of the proposed system and underlying layers. Section 4 provides evaluations mechanism followed by conclusion in section 5.

2. RELATED WORD

MAS is a sub-discipline of DAI (Distributed Artificial Intelligence). MAS deals with diverse range of operations including distribution or decomposition of activities, communication, coordination and conflict resolution among agents [19]. A large number of MAS based solutions for eLearning can be seen in existing literature. An architecture by [20] has utilized agents for each subject including expression extraction and user interface. ACM CR classification hierarchy is used in this regard. In [21] authors introduced extension to MASHA (Multi Agent System Handling Adaptively) to MASHA-EL aimed at supporting eLearning. In this system students

or users using different devices are provided with a device agent and each learning website is linked with a teacher agent. An asynchronous web-based training system developed by Kawamura and Sugahara [22] utilizes client-server architecture and mobile agent technology to enhance scalability and robustness of the eLearning system. MAS-based solution for pushing eLearning content is proposed by Peng [23]. This two-layer architecture is accompanied by an organization scheme for eLearning content and a recommendation system for relevant content recommendations. A multi-layered architecture for eLearning and eAssessment was proposed by Arif et. al. [24]. This MAS based architecture comprises of five layers for each sub-module. MAS-member agents across these layers are responsible for resource utilization, communication and personalization. Another MAS-based architecture proposed by Wei and Yan [25] utilized information gathering and ontology agents for content management and virtual mentor agents for Learner-system interaction.

SOA (Service Oriented Architecture) is becoming a dominant technology largely adopted to realize organization business processes [26]. However, SOA is equally important for implementation of specialized eLearning services [27]. Service orientation complements Multi-agent paradigm in numerous ways. From eLearning point of view service orientation ensures flexibility, reuse, interoperability and loose coupling of eLearning systems while MAS caters for special learning needs of particular users and learning context can be intelligently customized according to requirement of particular uses. An adaptive context-aware eLearning middleware by Stoyanov et. al. [28] utilized MAS along with service orientation. A specification method for ODIS (Ontology Driven Information System) by Kawamura and Sugahara [22] aims at linking educational processes to their implementation while utilizing Service oriented architecture. An SOA-based design for collaborative learning environments [29]

utilized grid services to ensure interoperability, reusability and resource sharing. This design includes an MAS-based middleware for grid services. A Web service based architecture proposed by Wei and Yan [25] utilizes web services and intelligent agents for a flexible, personalized and light-weight system. A blackboard-based architecture by [30] aimed at provision of communication and integration support to service oriented MAS eLearning systems. This architecture provides an interactive three-layer platform for eLearning and e-Testing.

DM (Data Mining) and AI communities leverage IR (Information Retrieval) and IE (Information Extraction) techniques to guide users in personalized ways [31,32]. Personalized recommendations are significantly important in context of eLearning environments. Recommender systems employ these techniques to exploit user-generated opinions in a complex and powerful manner [33]. These systems utilize different filtering mechanisms for IR i.e. content-based filtering, collaborative filtering, knowledge-based filtering, demographic filtering and hybrid filtering [34-36]. Retrieval of relevant content and instructional resources is considered a tedious and time consuming task in e-Learning environments. Several studies have emphasized on learner-centric content retrieval and recommendation [19,37-41]. An MAS based design by Thukra et. al. [19] aims at automatic retrieval and organization of relevant content. Information gathering and ontology agents have been proposed to retrieve and organize relevant content while virtual mentor agents cater learner's interaction with the system. Challenges of personalized and inclusive e-learning scenarios have been highlighted by Santos and Boticario [39]. A learning path recommendation mechanism by Kurilovas et. al. [37] utilizes swarm based approach for different learner groups [38] proposed a SCORM (Sharable Content Object Reference Model) based architecture for content retrieval from repositories. This works utilizes pedagogical patterns for learner-centric content creation

and recommendation. In [40] authors proposed a personalized event recommendation mechanism based on ontologies and spreading algorithm. Another eLearning recommender systems by DeMaio et. al. [41] utilizes formal concept analysis and knowledge modeling techniques with an emphasis on RSS feeds [42]. Presented a set of guidelines to recommend personalized educational content to the learner. These guidelines have been derived by an integration of three distinct methodologies including user-centric design, eLearning lifecycle and adaptive feature evaluation. A recommender engine proposed by Bodea et. al. [43] utilizes an ontology-based clustering approach to generate personalized recommendations. Neves et. al. [44] suggested leveraging user interaction data for recommendations.

Query processing and optimization in distributed eLearning systems is a complex task. Efficient and optimized query execution reduces the overall response time of system, consequently reducing implementation cost [45]. Identified influential factors for distributed query optimization in eLearning environment. This study also suggests some strategies to optimize query execution. Wadjinny and Chiadmi [46] has focused on finding efficient and feasible query plans for data retrieval from digital libraries. Limited query capability is a significant drawback in heterogeneous environments. This problem was addressed by [47] through a formalism for modeling source capabilities and an algorithm to create query plans for data sources. A cost models helps in suggesting the optimized query plan. Evolutionary techniques have also been suggested to optimize database queries [48]. A hybrid algorithm comprising of genetic algorithm and learning automata is used to overcome join ordering problem related to database query optimization. Arsova and Arsov [49] suggested to use algebraic laws for query optimization in relational databases. A query optimization strategy proposed by Xu et. al. [50] utilizes domain ontology to investigate is-a, part-of and equivalent class-

relations. This ontology works as a middleware between users and information systems. Finally an optimization method for eLearning video Database, utilizes vertical class partitioning method for efficient query processing [51].

3. DESCRIPTION OF PROPOSED ARCHITECTURE FOR ELEARNING AND EASSESSMENT

This system is aimed at providing the integrated environment for eLearning and eAssessment. Separate modules have been designed for eLearning and eAssessment. This multi-layered architecture for eLearning includes five layers namely Human interface, resource, MAS-WS, dB controller, and DSRs layers. The detail of the architecture is described in next section. eAssessment module also consists of five layers namely; Human interface, resource, FDL, implementation and database layer. Detailed description of these layers is given in section 3.2.1.

3.1 Proposed Architecture for eLearning

This multi-layered architecture includes five layers namely Human interface, resource, MAS-WS, dB controller, and DSRs. Multiple MAS member agents and web services across these layers are responsible to accomplish specific operations including resource utilization, personalization, content retrieval and delivery, user profiling, interoperability and security. Fig. 1 describes this architecture for eLearning followed by detailed description of the architecture.

3.1.1.1 Human Interface Layer

There exist three main roles in this layer, Learner (student), instructor and administrator. This layer is responsible for their interaction with the system. This layer also delivers intelligence by introducing PA (Personal Agent) into it. PA is responsible for receiving input from user,

communication with local resource agent, and provision of retrieved content and information to the user.

3.1.1.2 Resource Layer

In resource layer there are two resource agents namely IRA (Instructor Resource Agent) and LRA (Learner Resource Agent). This layer enables instructors and learners to find relevant material conveniently through resource agents. The resource agent is responsible for communication with the dB controller layer and information retrieval from the user profiles dB key advantage of using resource agent is the minimal computation time and increased performance. The interaction of users to different components of the system is facilitated by resource agent as described in Fig. 2.

3.1.1.3 MAS-WS Layer

This layer consists of seven different agents and web services responsible for certain tasks related to user

interaction, accessibility, interoperability, personalization, security and adaption. A brief description of each agent and service is given in Table 1.

3.1.1.4 dB Controller Layer

The dB controller layer comprises of five distinct agents namely recommendation, eContent, accessibility, user and practice agents. This layers is mainly responsible for access and communication with the DSRs. A brief description of each agent and service is given in Table 2.

3.1.1.5 Data Storage Repositories

This layer contains four databases including user profile dB, and content dB, recommendation dB, along with a local service registry. User profile dB stores information of registered users. User agent at dB controller layer is responsible to add and retrieve user information from user profile dB. Content dB is used to store all learning content either retrieved from web sources, or written by

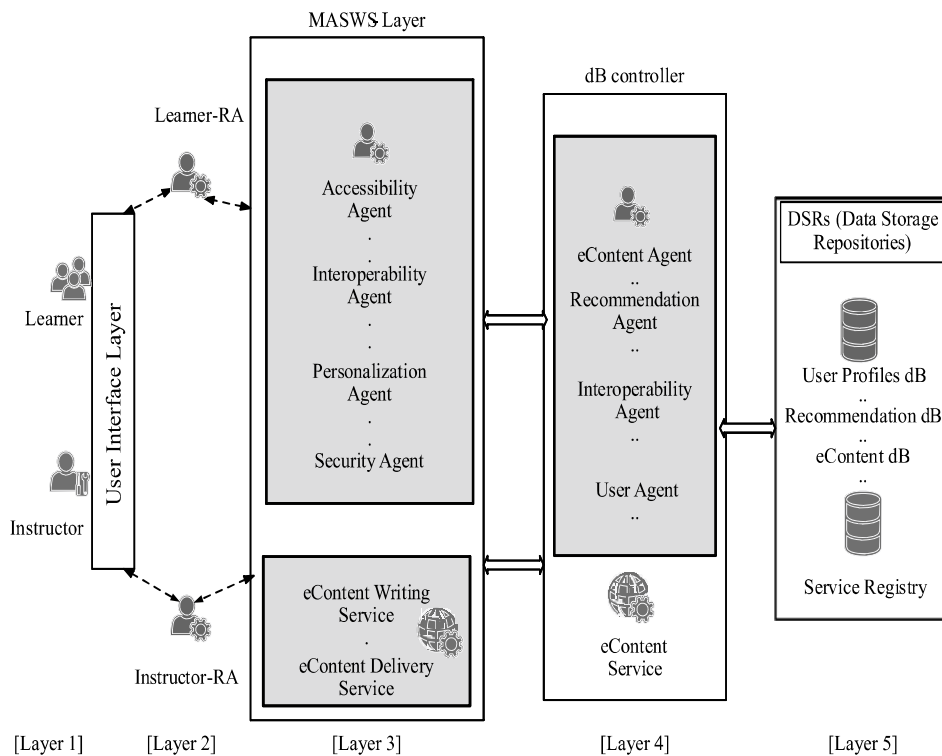


FIG. 1. MULTI-LAYERED GENERAL ARCHITECTURE FOR ELEARNING

instructors. Recommendation dB stores recommendations for a particular learning group or community. Service registry provides an infrastructure for discovering and binding web services.

3.1.2 Educational Evaluation Engine

Our educational evaluator engine provides enhanced functionalities for content evaluation and search. We apply the text mining and query optimization techniques for this purpose. Detail of query optimization process is described in section 3.1.8 this educational evaluator engine helps instructors to find the plagiarism in the assignments using different text mining algorithms.

3.1.3 Recommendation Engine

A recommender system suggests the relevant content to its users on the basis of his past preferences or preferences of his community [44]. The preferences of a

learning community or group could be established leveraging user profiles or common access patterns. Design of recommender systems can be seen as two constituent modules including *learning module* and *advisory module*. Learning modules identify past patterns of access and deduces an individual or common access model from these patterns. These modes are then utilized by advisory module for content recommendation. From implementation point of view, different techniques including association rule mining, data clustering, and filtering mechanism can be used.

Log files of the web-servers contain useful information regarding user's access to the website or web application. Although navigation histories of users can be traced through these web logs, knowledge extraction from them is not a trivial task. A priori cleaning and transformation phase needs to take place before employing data mining algorithms [52].

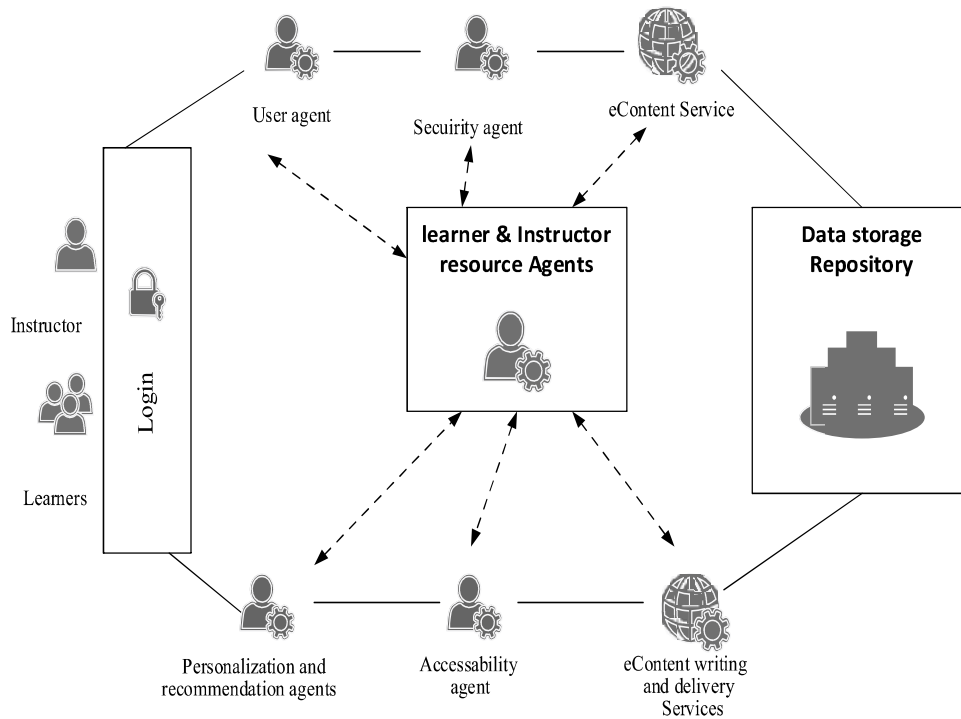


FIG. 2. LEARNER AND INSTRUCTOR RESOURCE AGENTS

Our proposed recommendation system is based on association rule mining. Web- server log files keeping record of the user’s access are translated into known learning activities and then clustered into different sessions. Then these sessions are modelled as transactions. We have applied association rule mining on these transactions to determine the associations between actions, URLs and their sequences. However, this results in significantly large number of association rules. Specific filtering mechanisms can help in reducing the set of association rules. For example rules associating two directly linked URLs are not much anticipated, so they need to be eliminated. Moreover, we give more weightage to such rules that have some consequent action signifying a successful termination. We can label several actions as “successful” or “failed” using user profiles.

Whenever recommender agents activate by a triggering event, association rules are checked with rule antecedents to detect matches between events or sequence of events. Consequent of the rules is recommended whenever a match is found. In case of several matches, recommendations are ranked and only high ranked recommendations get suggested. The working of the recommendation agent is illustrated in Fig. 3.

The IA (Interactive Agent) is responsible for front-end operation i.e. transferring learner queries, and delivering personalized content to the user. Personalization agent is responsible for receiving user feedback, adjustment of difficulty parameters for course content and updating learner abilities. Recommendation agent aims at selecting suitable learning material for learner from the eContent db. If relevant content is not available in Content dB then

TABLE 1. TABLE STYLES

Agent	Description
Accessibility agent	Responsible for access to dB controller agents
Interactive agent	Responsible to deliver an interactive platform enabling users to modify contents and objects according to their preferences.
Interpretability agent	Responsible to provide communication facilities among member agents of layer and other non-agent components of the system.
Personalization agent	Responsible to provide personalization features including learning plans, personalized content and assessment.
Security agent	Responsible for controlled and restricted access to the system by authorized users only.
eContent writing service	Responsible for acquiring content from users, and transferring it to eContent service
eContent delivery service	Responsible for delivering content to users. This content is written by eContent agent and saved in eContent dB.

TABLE 2. TABLE STYLES

Agent	Description
Recommendation agent	Responsible for suggesting relevant content through a recommendation engine.
eContent agent	Responsible to receive user requests, retrieve data from eContent dB and deliver that information to users through resource agent
User agent	Responsible to keep track of user records and activities.
Interpretability agent	Responsible to provide communication facilities among member agents of the layer and other non-agent components of the system
eContent service	Responsible for interaction with DSRs and content providers. This service is also responsible for receiving Content from eContent writing service and delivering content to eContent delivery service.

content exploration is continued over internet through eContent service. This service retrieves relevant content from internet and save it into Content db. Personalization agent and user agent work together to customize eLearning content according to user's knowledge and expertise. When content is customized according to the needs of learner, eContent delivery service transfers this content to the interactive agent and ultimately content is delivered to the user.

Personalization Agent is responsible for evaluating learner abilities and this evaluation by PA is used by recommendation agent in suggesting relevant content. Fig. 3 depicts the recommendation process and correlation of different components of recommender system. We have applied information function to calculate the degree of matching for content recommendation to learners.

$$I_j(\theta) = \frac{(1.7)^2}{\left[e^{1.7(\theta - b_j(\text{tuned}))} \right] \left[e^{1.7(\theta - b_j(\text{tuned}))} \right]^2}$$

Here θ represents updated learner capabilities projected after n preceding content and $P_j \theta$ denotes accurate response probability to j th course content for learner's capability θ . Lastly b_j (tuned) represent the level of difficulty of the j th course content. Relevant contents are recommended on the basis of grading of information function value. It means content with higher information function value has highest priority to be recommended for a learner with specified capability level.

3.1.4 Thematic Learning

Collaborative learning enables users to communicate with each other by means of chat rooms, email groups,

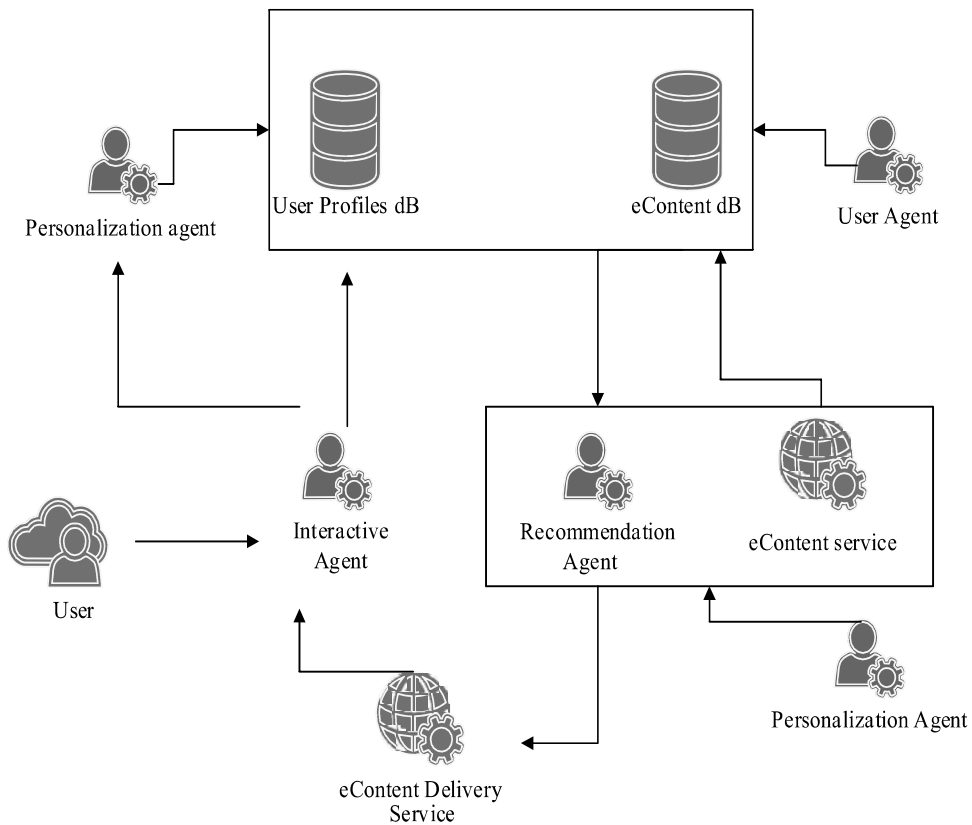


FIG. 3. RECOMONDATION AND CORELATION OF DIFFERENT COMPONENTS

discussion forums, and blogs. This mode of learning is aimed at discussion and sharing of study related issues [53]. Thematic learning is a type of collaborative learning in which an interesting theme is created, and peers are invited to investigate that theme together. Our proposed architecture includes a thematic learning module (Fig. 4) which encourages students to self-explore and collaborate in grasping the specified themes.

3.1.5 Data Collection Module

Data collection module is an important part of our system that collects relevant data from different online sources, like digital libraries, blogs and educational web sites. eContent service retrieves the required content from internet and which is further categorized and saved to local content library. Personalization agent directs eContent service about the required content. After retrieval of content, User agent and personalization agent work together to customize this data according to user's needs.

3.1.6 User Profile Module

In e-learning systems, user profiling mechanism is of great concern as profiling makes it possible to present search results which suit ender user's expectations and needs. Our system uses a local database to store the user information i.e. registration, results, interests and background. A personal agent is created for each user initiating his session. This personal agent remains active during user's interaction with the systems and performs specialized tasks like user account management, gathering, evaluating and sorting search results.

3.1.7 Log Recording Module

The log recording module is designed to record the student's feedbacks and behaviors. In fact this module keeps track of the student satisfaction level. However, in case of a question concerning academic issues, knowledge extraction module fetches numerous possible answers to the question. User interface let students to choose the relevant answer. The sequence of problems will be saved to answer similar questions in future.

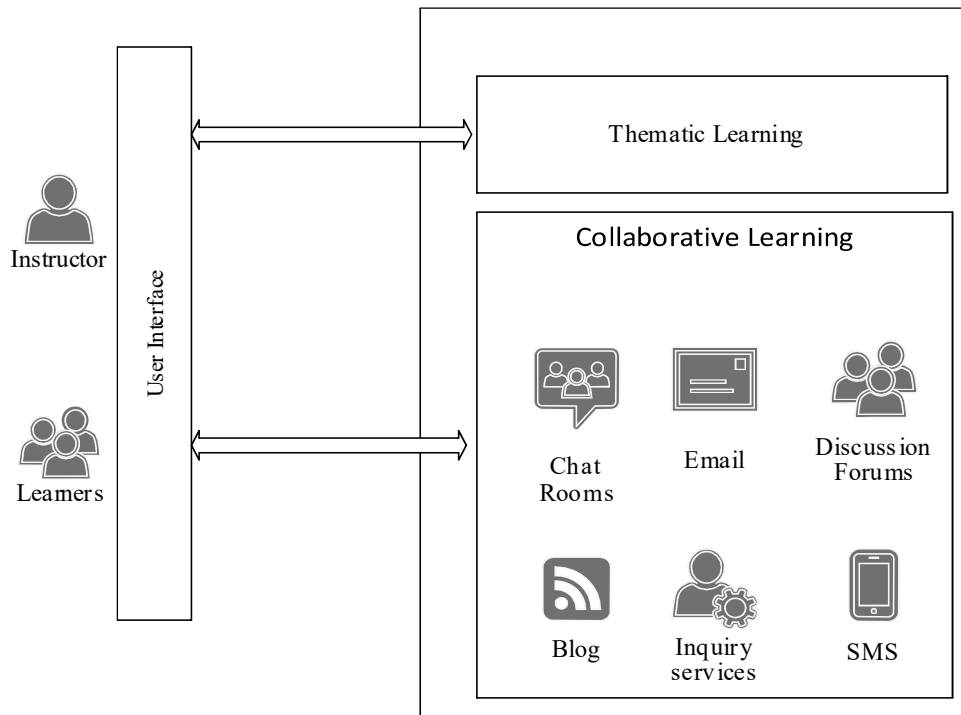


FIG. 4. REPRESENTS THE PROCESS OF THEMATIC LEARNING

3.1.8 Query Optimization

Efficient and optimized query execution is essential to reduce the overall response time of system. Our proposed architecture suggests query optimization process during lectures. Queries are generated through blogs, discussion forums, emails, SMS, and through phone calls. After collection of queries, lecture related queries are separated through filters. Then sentence matching algorithm is applied for query optimization followed by answer explorations from the content dB. If the answer exists in the dB, then result will be immediately displayed. If the answer does not exist, then user profile is evaluated to determine learner’s capabilities. Then query is processed

and answer is searched through digital library or other search engines by employing eContent service. The complete flow of the query optimization process is given in Fig. 5.

3.2 Proposed Architecture for eAssessment

The proposed system assists learners incorporating web based eAssessment system. The system intends to eliminate insufficiencies that are present in already existed eAssessment systems. Learner’s knowledge is investigated through various types of tests and levels of difficulties. A salient feature of the proposed system is to facilitate users for content selections and for improving

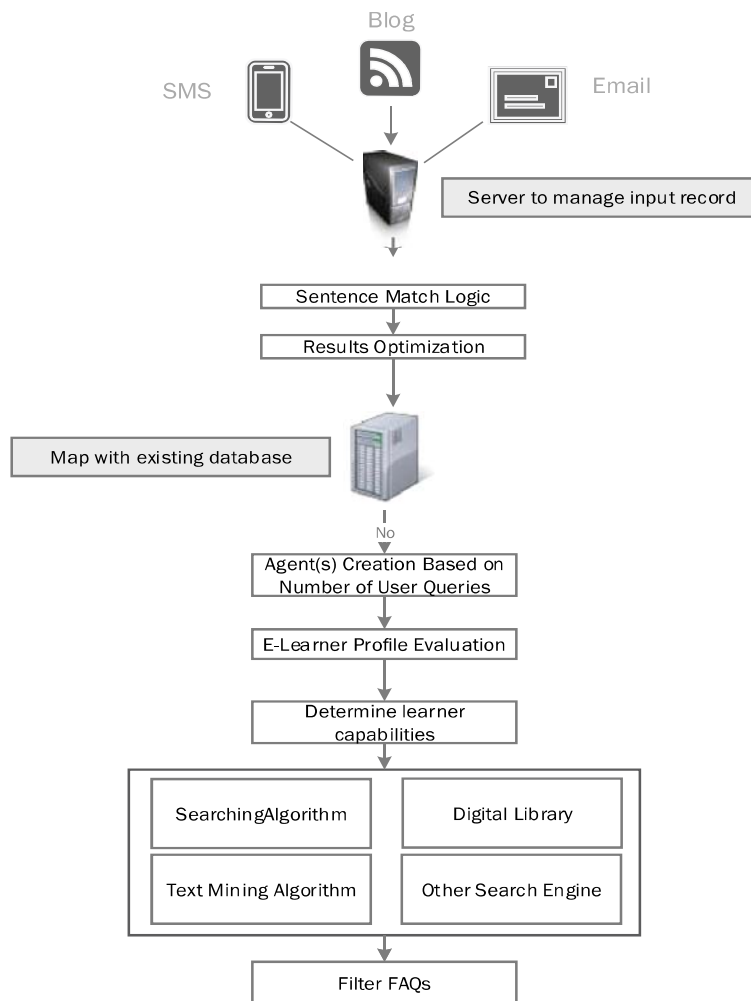


FIG. 5. QUERY OPTIMIZATION DURING LECTURE

his knowledge and abilities. The records of users are also stored for improved management of their preferences. This system enables Third parties to access the successful users and offer appointment through the system. Our system follows client-server model for eAssessment that offers online quizzes of various types considering different level of difficulty.

3.2.1 eAssessment Architecture

eAssessment architecture is the second module of our system. This architecture constitutes five layers including human interface, resource, FDL, implementation and database DSRs layers as illustrated in Fig. 6. Detailed description of these layers is provided in subsequent sections.

3.2.1.1 Human Interface Layer

The user and admin interfaces have been created to interact with the system. Through the admin panel, admin manages users of the system and various tests for learner

assessment. Admin has rights to view the profiles of users and their test performances with the help of graphical and tabular views. System also provides the facility of interaction between admin and third party. User interface provides a number of useful functionalities. eAssessment is the most important feature that assists the user for selection of easy and medium level tests and then difficult level can be selected. Secondly, users are capable of analyzing their performances through an interface that provides the facility of checking the results of previous tests whether there is self-improvement or not. Unregistered users have access to the selective tests for practice and self-evaluation. Different options like text format (bold, italic) and system background can be adjusted according to the choice of user.

3.2.1.2 Resource Layer

The second layer is for admin and user and also deals with the third party that can assess the performance of users or students. Upon creating profiles, user names

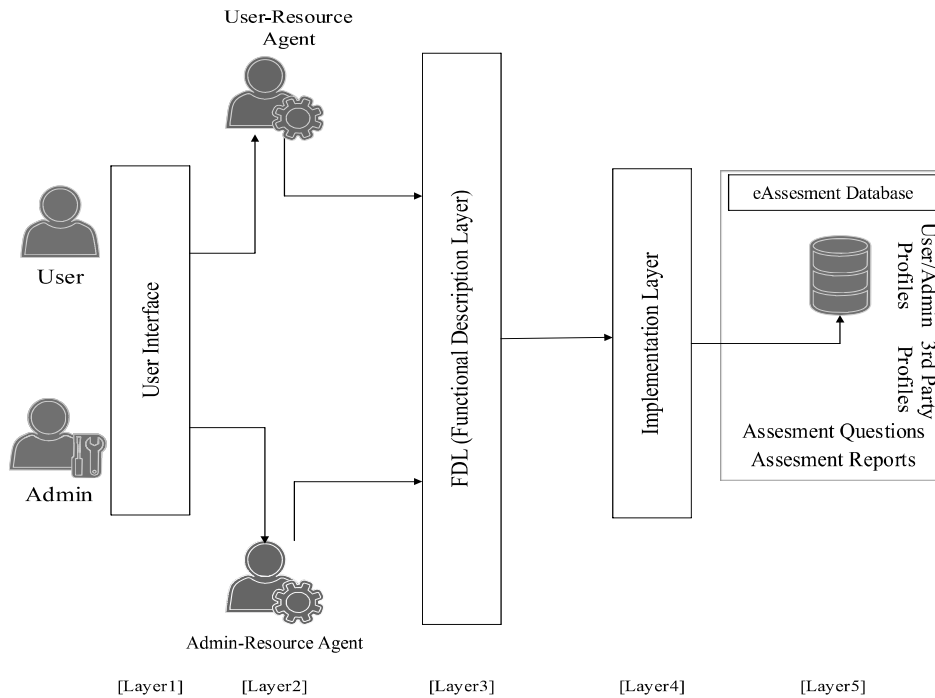


FIG. 6. PROPOSED ARCHITECTURE FOR EASSESSMENT

and passwords are assigned to users. When a user will login, a personal agent is automatically created. If a user wishes to know that how many users have scored better than him or less than him, the system will provide list of the names of all such users. Interaction between users and system is possible through login or without login. But login and without login, the users will have different type privileges to access the tests. Without login, only easy level tests can be accessed but through login any test level can be accessed and also profile will be updated automatically upon performing tests. The operational mechanism of different resource agents for multiple stake holders is described in Fig. 7.

3.2.1.3 FDL Layer

This layer is about testing control mechanism and provides the facilities of adding questions, setting the

positions and display of questions, changing the mode or order of questions, setting number of question to display and viewing the scores at the current page or altogether at the end of test. Questions for different test levels can be uploaded by tutors or users. The facility of third party test can also be added.

3.2.1.4 Implementation Layer

This layer implements test control strategies. It deals with loading of questions according to easy, medium or difficult test level. Selected questions will be hidden, next page will be loaded and answers will be calculated that can be emailed to admin and student or not after evaluation and results will also be stored in database.

3.2.1.5 Data Storage Repositories Layer

This layer is shared with eLearning module and comprises of user profile dB and test dB. User profile dB stores

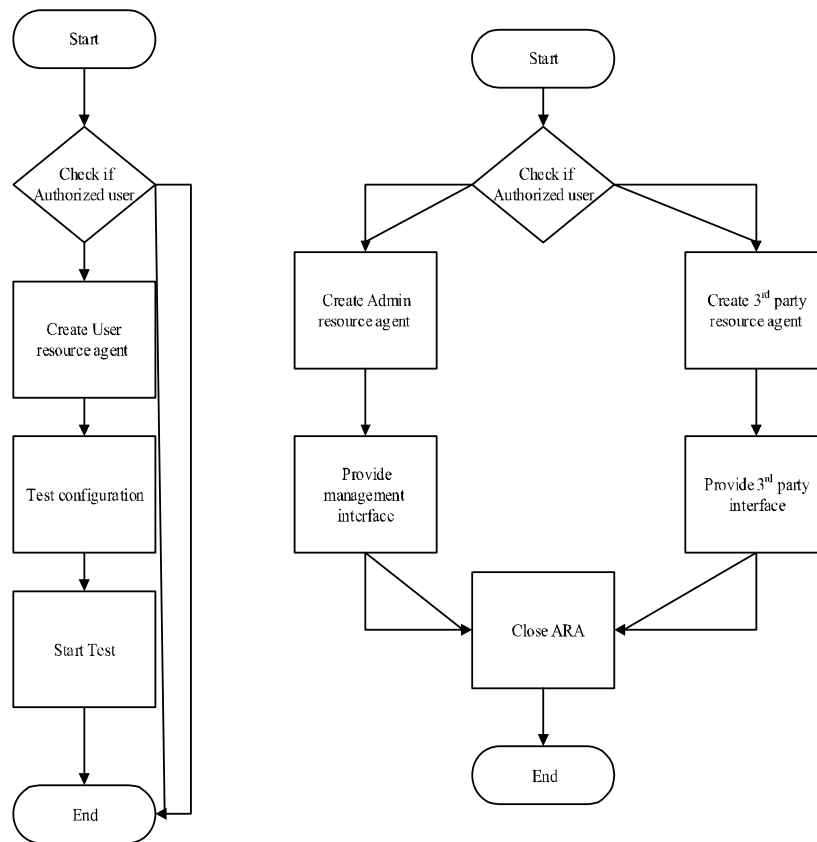


FIG. 7. WORKING OF RESOURCE AGENTS FOR MULTIPLE STAKEHOLDERS

information of registered users which is used for assessment and evaluation of learner's capabilities. Moreover, test results of individual learners are also stored in user profile dB. Test dB includes all questions related to practice, easy, medium and advanced level tests. These questions are randomly selected according to the type of test being attempted. Instructors and third parties are enabled to utilize eContent writing service to add desired question into Test dB.

3.2.2 Learner Assessment Process

eAssessment modules includes three types of tests (easy, medium, advanced) for learner evaluation and assessment. The easy level comprise of five tests. User need to pass at least 3 tests out of them. The medium level includes 3 tests and user need to successfully pass at least 2 tests in order to be declared as pass. While advanced constitutes a single test which is mandatory to pass that difficulty level. Fig. 8 elaborates the assessment process in a form of algorithm. A prior learner capability evaluation allows selective students with a certain level of knowledge, to attempt advanced level test. Testing time is calculated as bonus if a student is succeeded in passing the test in minimum possible time.

3.2.3 Control and Test Process

Algorithm has been divided into two parts:

- (i) First part of algorithm works for simple e-test system.
- (ii) Second part of algorithm works in official exam e-test system.

Some changes have been made to this phase in order to make it more effective. The email system has been separated from the test as emails will be sent only to those students who get more scores than a specific threshold. However student reports can be observed through a view.

The 'question hides' option has been added to flow chart as upon selecting an answer from student , the answer will be hidden to reduce question memorization. This feature has been added to avoid the memorization overhead. Two new concepts have been introduced to minimize the mechanical memorization. The material for enhancing the test skills about wrong answers is also suggested by advising to visit specific venues to explore answers and improve learning. We have customized an existing approach at this stage for increasing its efficiency.

For enhancing the knowledge and level of skill, we suggest students personalized content. Ajax based system has been developed for ensuring speedy access and better

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Input: username, password, test choice, test criteria
Output: result of the test (pass or Fail)
Method:
Begin:
Test ← Empty
Difficulty level (easy|| medium||difficult)
If (test level= easy)
    While(c<3)
    {
        Select ran_test()
        Perform test ()
        Cal initial_res()
        If (initial result=pass)
            Test=Test+1
        Else return (fail) }
    End while
If(test level= medium)
    While(c<2)
    {
        Select ran_test()
        Perform test ()
        Cal initial_res()
        If(initial result=pass)
            Test=Test+1
        Else return (fail) }
    End while
If(test level = advanced && (level 1 && level 2 = passed))
    {
        Perform_test()
        Calcinitial_test ()
        If (init_res=pass)
            Test=Test+1
        Else return (fail)
    }
    Cal final_test ()
    If( final test= passed)
        Return (pass)
    Else return (fail)
    
```

FIG. 8. LEARNER ASSESSMENT PROCESS

response time during test. Timely response, question loading and processing time are of grave concern while attempting a test. Fig. 9 describes control and test process in the form of an algorithm.

3.2.4 Notification Mechanism

Our system is also convenient for official exam scenarios. Besides, based on the results of the test, system takes decision about sending email to users. Likewise, threshold for passing grades of the test has also been specified. Additionally, system collects the user data about current session and notifies to both the admin and students by sending emails. Upon updating database and results, results can easily be visualized on system. Fig. 10 describes the notification mechanism.

3.2.5 Profiling Mechanism

The profiles of the learners (students), administrators and third parties are stored in to user profiles dB. User agent is responsible to store and retrieve data from this database. Different users have different privileges to access, write or store data into user profile dB. Administrations and third parties have privileges to access the record of all learners; however third parties

```

Input: username, password, test choice, test criteria
Output: Result of the test (pass or fail)
Method:
Begin:
Test ← Test start
If (current_time < time_limit)
{
Select answer // finish // navigate forward or backward // time check
If (click_finish) // (current_time => time_limit)
Submit_test()
Cal_scr ()
Display_scr()
Display_wrong_answer()
Sugest_content()
If (Scr => tHR)
Return (pass)
Else (fail)
}
Else (terminate)
    
```

FIG. 9. TEST PASS ALGORITHM

have limited access to user data in order to protect privacy of users. Administrations are able to perform management and coordination tasks over user profiles.

3.3 Proposed System Characteristics

Table 3 describes the key characteristics of our system.

4. EVALUATION

In this section, we have performed an analytical comparison of performance metrics, followed by a survey to evaluate learner’s satisfaction and conformance of meeting with certain quality attributes. Performance of the proposed system is compared with Client/Server [54], RS [52], Mobile learning [55] and eLearning DM [56]. The results of this comparison reveal that the proposed system is able to outperform other state of the art methods.

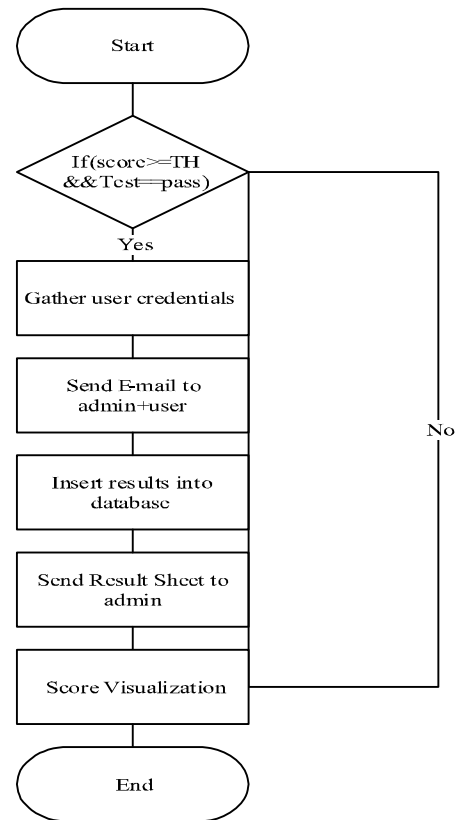


FIG. 10. NOTIFICATION MECHANISM

During evaluation, users were enabled to issue repeated system calls in client/server setting. Learner request is transferred from user stations to a processing server. Then server sends back results over the same route. In case of unwanted results, the cycle is repeated again with other processing servers. Significantly large set of data acquired through these servers is processed locally to extract required content.

Client/server settings have different communication mechanism as compared to MAS-based systems. Table 4 enlists the client/server and MAS-based model notations. In client/ server setting, a client makes a remote call to a server for content retrieval. Client requirements are then translated into numerous client/ server transactions.

TABLE 3. SYSTEM CHARACTERISTICS

Characteristics	Description
Flexibility, Dynamicity	Web services and MAS make the system more dynamic, Flexible and distributed.
Personalized learning	System will assist the user in selection of specific tutorials and topics. This assistance will be personalized for each user.
	Test stages have been divided into several sub stages due to the reason that there are different levels of students with different knowledge level
Resource optimization	A resource Agent layer ensures prompt resource delivery and optimized utilization of resources.
Feed back	Users can suggest relevant content which will be added into system after proper evaluation
Availability	Tutorials are available online to help users in preparation of different types of tests. This E-Test system is made freely available
Responsiveness	This system is AJAX based, making it fast and responsive. Query Optimization mechanism ensures reduced system response time.

TABLE 4. CLIENT/SERVER AND MAS NOTATIONS

Client/Server , RS, E-Learning, M-Learning Model Notations	
Symbol	Description
N	Number of server
t_{ci}	Transfer time from client to server i
t_{iq}	Time taken to process query at server i
R_{ci}	Transmission rate of link from client to server i
P_i	Probability of finding relevant information at server i
M_i	Size of data returned to client from server i
Proposed Architecture Notations	
t_{ai}	Processing time of intelligent agent at server i
t_{si}	Time needed for agent serialization at server i
t_{pi}	Time to process agent at server i
t_{dt}	Time needed for de serialization at server i and restart
$t_{m_i,t+1}$	Time to move intelligent agent from server i to server i+1
S_i	Size of intelligent agent after visiting server i
P_i	Probability of finding relevant information at server i by intelligent agents
$R_{i,i+1}$	Transmission link from server i to server i+1

Therefore the TC (Total Time) can be calculated as:

$$TA = \sum \left(2t_{ci} + \left(P_i * \left(t_{iq} + \frac{M_i}{r_{ci}} \right) \right) \right)$$

To optimize the data transfer using a particular compression method, it is necessary to extend the system with a compression server to compress M. but the e learner use same compression function.

Our proposed model tries to reduce large number of communication flows by employing member agents in MAS environment. This is realized by launching an agent from user station into the network. This agent is responsible for communication with multiple servers and acquisition of relevant content. All relevant contents collected from specific servers are moved with agent. This significantly impacts the size of agent. In performance context, size of agent and migration time required to switch between servers are two important parameters. Agent migration between two servers has to follow a sequence of steps including agent serialization, transfer, and de-serialization.

In MAS-based setting, an agent A_c initiates as a result of learner's request for specified content. This agent visits a server i to acquire the relevant data in case of availability.

Then it moves to next server accompanied by data collected from previous server. Using this scheme, total migration time (TA) can be calculated by using the following Equation.

$$TA = \sum \left(t_{ci} + \left(P_i * \left(t_{ai} + t_{mi,i+1} \right) \right) \right)$$

Here t_{ai} is the total processing time required at server i .

$$t_{ai} = t_{si} + t_{pi} + t_{dt}$$

S_i denotes size of the agent, which might increase after visiting server i .

$$S_i = \sum S_j$$

$t_{mi,i+1}$ is the time required to move A_c of size S_i from the server i to the server $i+1$ over the channel between server i to server $i+1$ with transmission rate R .

$$t_{mi,i+1} = S_i / R_{i,i+1}$$

To reduce the size of data being moved with the system, A_c compresses the data acquired from each server and after acquiring all relevant data, this compressed set of data is brought back to user station. Here after decompression, relevant data is delivered to the user. Results from analytical comparison have been illustrated in Fig. 11.

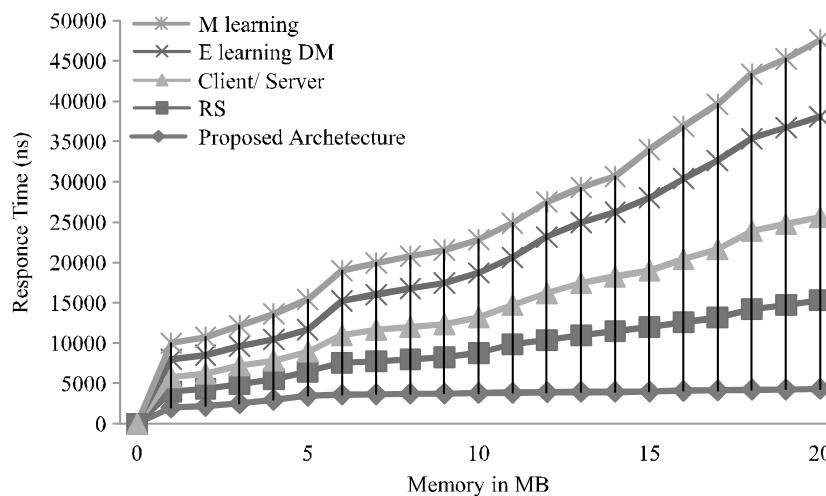


FIG. 11. ANALYTICAL COMPARISON OF THE SYSTEM WITH STATE-OF-THE-ART TECHNIQUES AND METHODS

A survey comprising of closed-ended questions was conducted to determine the efficacy of the proposed system against certain quality features. We believe that learners and instructors already familiar with eLearning mode of delivery can evaluate an eLearning platform better than students of traditional learning environment. For this purpose a group of 40 students and professional was selected from two virtual universities of Pakistan. Universities, “Virtual university of Pakistan” and “Comsats Virtual campus” are public sector universities with web and multimedia based learning mode. Learners

from these universities were asked evaluate this system according to the questions given in Table 5.

The answers of these questions helped in assessment of the learner satisfaction, fulfillment of educational needs and efficacy of system against certain quality attributes related usability. Results of this survey (Fig. 12) revealed that learner’s overall perception against our proposed systems is positive. However improvements in certain features like accessibility and user interface have been suggested to enhance the usability of the system.

TABLE 5. SYSTEMS’S EVALUATION BY LEARNER’S PERCEPTION OF THE SYSTEM

Participant's Perception Regarding Proposed Architecture						
Evaluation Feature	Question	Strongly Agree (%)	Partially Agree (%)	Neutral (%)	Partially Disagree (%)	Strongly Disagree (%)
Usability	Are system's options logically grouped and labeled?	27.5	27.5	20	17.5	7.5%
	Is the functionality clear from each option?	25	32.5	15	17.5	10
Interactivity	Does the system offer multiple interaction and communication opportunities among learners, to instructors, and to content?	35	42.5	7.5	12.5	2.5
	Is the user of the system provided with enough information to know where in the system he/she is?	27.5	50	12.5	5	5
Accessibility	Are accessibility issues sufficiently addressed?	17.5	37.5	17.5	15	12.5
Assessment	Does the eAssessment system sufficiently address the assessment criterion	22.5	37.5	15	15	10
adaption	While considering personalization, does this system adapt to individual's educational needs?	25	47.5	10	10	7.5
Learners satisfaction	To what extent this system is able to satisfy learner's educational needs?	22.5	42.5	12.5	12.5	10
Redundancy	Are learning objects conveniently generated and reused?	12.5	37.5	32.5	12.5	5

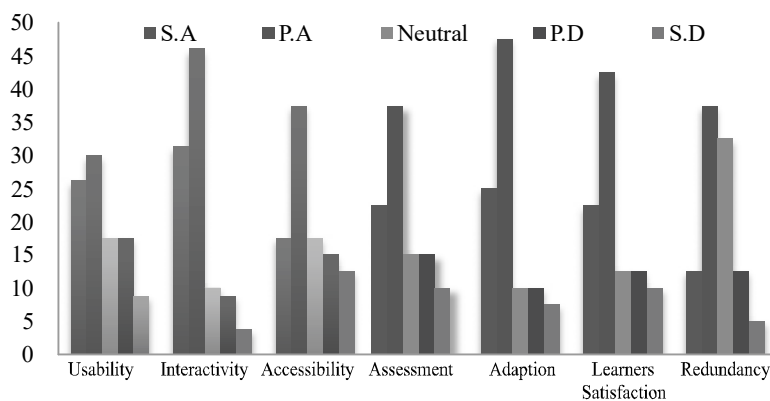


FIG. 12. RESULTS OF EVALUATION BY LEARNER'S PERCEPTION

5. CONCLUSION

This study provides an intelligent eLearning and eAssessment architecture based on MAS and Web service paradigms. Proposed architecture includes separate modules for eLearning and eAssessment where each module comprises of five distinct layers. MAS member agents and web services across these layers are responsible for certain tasks including resource utilization, personalization, user profiling, content retrieval and delivery, interoperability and security. A recommender system based on data mining techniques and query optimization mechanism are also constituent components of proposed architecture. The overall aim is to improve learning and assessment processes through an intelligent personalized eLearning system leveraging cutting-edge technologies like MAS and web services. Evaluation of the proposed systems against multiple evaluation features revealed that our systems is able to outperform by certain quality attributes. In future we are planning to extend our architecture to full adoption of SOA for maximum flexibility, heterogeneity and global accessibility. Semantic web, ontologies and RDF are getting significant attention from research community. We are planning to use semantic annotations and ontologies in content design, preparation and organization to improve overall effectiveness of the system.

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