A Web Deployed Multi-Agent Based Approach for Student-Lecturer Appointment Scheduling in Institutions of Higher Learning

A Web Deployed Multi-Agent Based Approach for Student-Lecturer Appointment Scheduling in Institutions of Higher Learning

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Abstract. Institutions of higher learning such as universities have been positively influenced by the internet which has facilitated learning and teaching. Likewise, this same internet can also support student lecturer appointments, but currently students and lecturers are faced with issues such as finding free timeslot, difficulty of students to meet supervisor and issues related to managing appointment operations. Therefore, this paper develops a multi-agent architecture and a web-based agent appointment scheduling system to support students and lecturers in managing appointment scheduling in universities. The agent-based appointment scheduling system was implemented as a web system integrated by multi-agents to facilitate students in finding available timeslot, resolving difficulty of students to meet supervisor and addressing difficult of managing scheduled appointment records by lecturers. The usefulness of the agent-based appointment scheduling system was evaluated by collecting data using questionnaire from randomly selected respondents. Furthermore, Statistical Package for the Social Science (SPSS) was employed to analyse the questionnaire data using descriptive and exploratory factor analysis. Findings from the survey reveal that the developed agent-based appointment scheduling system practically supports students and lecturers in scheduling appointments.

1. Introduction

One of the important activities in universities is the setting up and managing appointments between students and their respective lecturers [1]. However, at the moment, several computer systems are being utilized to manage appointment scheduling such as reminders, calendar, e-mail, web, word processing etc. [2-3]. According to Parchment and Sankaranarayanan [4] scheduling of lecturer's availability is challenging for students who are trying to set meeting time with the lecturer and lecturers who have to make themselves available even outside school hours. Appointments that are done manually set can be tedious and time consuming. The manual method of scheduling appointments for most universities between students and lecturers are done sometimes through application software with a central calendar or mostly through messaging applications [5]. In this approach, the lecturer whose time is being booked must check his/her web or mobile application regularly to find out what their schedule is, and to let the student know the available times [6]. To eliminate human error due to setting appointments manually, there is need for an autonomous approach to manage the appointment scheduling process easier [7].

In other to resolve the aforementioned issues, several techniques such as fuzzy logic, decision tree, agents etc. has been applied in prior studies [4, 8] to facilitate appointment management. Accordingly, this study integrates multi-agents to support appointment scheduling in institutions of higher learning. In computer science an agent is a computer program that can be seen as perceiving its environment through sensors and acting upon that environment through effectors [9]. Agents can be referred to as pre-defined program deployed to accomplish certain goals such as appointment scheduling [10]. In a multi-agent system, each individual agent has its own capabilities to manage and schedule appointments meetings for its assigned end user.

Multi-agents coordinate their activities and convey information to other agents on behalf of their linked users to find a solution that satisfies the end users' requirements such as finding suitable free appointment time slot for students and lecturers [8]. Thus, multi-agents are appropriate to facilitate scheduling. Besides, the deployment of multi-agents to automate task has been applied by prior studies [2, 4, 8, 10]. Therefore, this study integrates multi-agents to replace the manual appointment scheduling system into an autonomous agent based student lecturer appointment scheduling system. The developed agent based appointment scheduling system provides information between students and lecturers. Hence, students and lecturers can view appointment data and the developed system automatically sends reminders notification to students and lecturers on appointment through email and Short Messaging Service (SMS).

Accordingly, this study develops a multi-agent architecture to support students in making appointments as well supporting lecturers in managing their schedule based on the students' appointments. Practically, this study implements the agent based appointment scheduling system to help students and their respective lecturers in managing their appointment schedules autonomously. The structure of this paper is as follows. The theoretical background is presented in section 2 and methodology is presented in section 3. The results and discussion are presented in section 4. Conclusion, limitations and future works is presented in section 5.

2. Theoretical Background

2.1. Overview of University Appointment Scheduling

Appointment is an arrangement to meet someone at a particular time, day, and location. In university context relating to students and lecturers, appointment management mainly includes consultation setup, appointments and/or consultation management for lecturers and student appointment reservation [1]. Currently, universities manage appointment by using sign-up sheets and software systems. Also, some lecturer manually inputs appointments in calendar so as to be reminded by the system. Most lecturer provide a manual sheet for students to fill. As such students have to go to the department office in advance to fill the booking sheet for appointment reservation [3]. In this approach, students might also be asked to check back the following day pending availability of lecturer or supervisor. Likewise, another appointment approach is by assigning a fixed time where the lecturers and student both agree on a particular consultation time through phone call or chat on social media application as well through SMS [8].

Nevertheless, these current approaches are faced with a few limitations, where in the current approach students have to go to the department in advance to book the appointment or message the lecturer who might not be available or online at the moment [11]. Hence, these current approaches cannot manage the appointment time and control the number of appointments properly. For instance, many students may come at the same time, the lecturer may exceed the consultation time because of overfull volume of appointments [12-13]. Evidently, these methods do not adapt to changes or cancellation of scheduled appointments. Hence, there is need for an approach to address the limitations of the current approach.

2.2. Appointment Scheduling Process in Universities

This sub-section depicts the appointment process as shown in Figure 1.

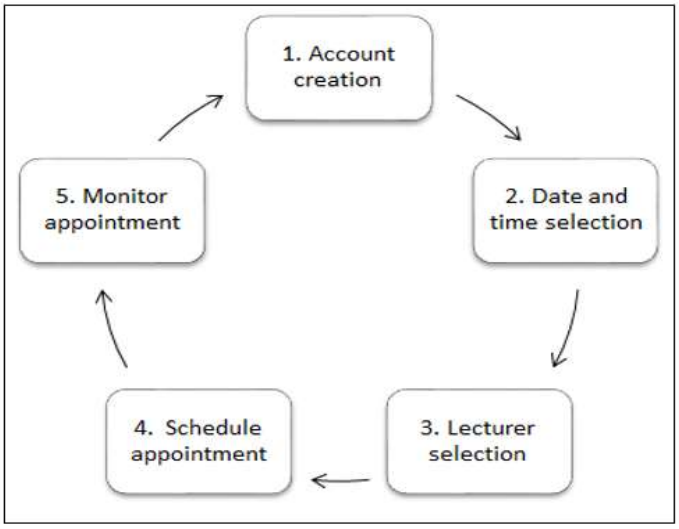

Figure 1. Appointment scheduling processes.

Figure 1 shows the process that outlines the phases of activities carried out by students and lecturers in making appointment scheduling. In the first phase, the student will create an account and the student details will be stored in the database [14]. In the second phase the date and time for the appointment will be selected followed by lecturer selection, next the students' selects his or her lecturer name and proceed to making the appointment after which the appointment is to be scheduled and monitored accordingly. In the last phase scheduled appointment will be monitored by the student or lecturer in case of possible changes [14].

2.3. Multi-agents for Appointment Scheduling

An agent is software that acts or brings about a certain result. It is one who is empowered to act for another [2]. Thus, agent is a software entity, which is autonomous to accomplish its design objectives, considered as a part of an overall objective [12], through the procedure of communication and coordination with other agents [15]. Table 1 depicts the characteristics of multi-agents and based on these features' agents are suitable to be integrated to facilitate appointment scheduling of students and lecturers.

Table 1. Characteristics of multi-agents.

Characteristics	Description
Reactive	Agents can perceive change in surrounding environment and respond in a timely way.
Co-operation	Agents utilize standard protocols to cooperate and collaborate in achieving their pre-defined goals.
Independent	Agents possess the ability to adapt and learn from its environment to take decision in fulfilling its goals.
Goal-Oriented	Agents are always aware of their ability and performance.
Communication	An agent does communicate with other agents to share data to achieving their pre-defined goal.

Temporarily Continuous	Agents focus on a particular purpose and is continuously executed until the task is accomplished.
Self-Learning	Agents change their behaviour to adapt towards evolving user requirements.
Mobility	Agents are able to migrate travel throughout computer systems in order to carry out their tasks.

2.4. Related Works

Table 2. Prior studies related to student-lecturer appointment scheduling.

Author Name	Contribution	Problem Addressed	Approach
Al-Yarub and Al-Araimi [5]	Implemented a smart appointment system for university faculty.	The author aimed at resolve issues related to setting appointment between students and lecturers.	Deployed a smart appointment system using visual basic codes and android operating system.
Parchment and Sankaranarayanan [4]	Proposed an intelligent agent-based student-staff scheduling system.	The system utilized autonomy and mobility to schedule appointments for lecturers.	Adopted JADE java aglet.
Mussawar and Al-Wahedi [16]	Designed a web-based intelligent appointment system.	Attempted to address issues in scheduling meeting.	Integrated agent-based modelling and multiagent decision making.
Wahab and Helmy [1]	Developed an intelligent agent based scheduling of student appointment- android environment.	Resolved appointment issues linked to student and lecturer meeting.	Developed a web-based appointment system using Hypertext Preprocessor (PHP) MYSQL with intelligent system techniques.
Shakshuki and Koo [8]	Infused software agents to develop a meeting scheduler.	Utilize agent to manage, negotiate scheduling tasks, meetings, events, appointments for end-users.	Implemented a prototype system using java programming.
Kawamura et al. [15]	Implemented meeting scheduling system based on multi-agent-based approach.	Aimed at creating a schedule that is fair and is suitable to all parties involved.	Employed Java mobile agents to implement the prototype.
Ahmad et al. [3]	Implemented an e-appointment scheduling to handle appointment for students and lecturers.	Aimed at facilitating students and lecturers in addressing scheduling problems.	Deployed constraints logic programming and PHP to implement the system.
Shakshuki et al. [11]	Designed an agent-based meeting scheduling system to for negotiation strategies.	Helped resolve numerous meetings in end user schedule by creating negotiation strategies to address meeting conflicts.	The concept was demonstrated by programming a prototype using java programming and MySQL for database.

Table 2 reviews prior studies related to student-lecturer appointment scheduling. Each of the study aimed to address appointment scheduling problems faced by end user. However, the review indicates that none of the studies was able to manage appointment scheduling and also provide automated reminder to users. Hence, there is need for an approach that can address the aforementioned limitations.

3. Methodology

This section presents the developed system architecture model designed to depict how multi-agent facilitate appointment scheduling management. Besides, the system architecture is developed to implement the proposed web based agent appointment scheduling system. Accordingly, Software Development Life Cycle (SDLC) methodology was used to develop the web based agent appointment scheduling system. SDLC defines a proper detailed process to specify, implement and test/debug agent-oriented software systems. It offers a set of detailed guidelines that includes examples and heuristics, which help better understanding what is required in each step of the development [10].The web based agent appointment scheduling system was developed using PHP MYSQL similar to prior studies [1, 3] to assist the agents in providing support to students and lecturers in managing appointment scheduling. SDLC methodology adopted involves requirement analysis, system design, implementation, testing and evolution. Thus, Figure 2 shows the agent based system architecture for the appointment scheduling system based on nine agents (five agents for student, three agents for lecturer or supervisor and one agent for system administrator) collaborating to achieve appointment scheduling between students and lecturers. Likewise, the architecture comprises of the administrator who manages the entire system operations. The administrator also approves and maintains students and lecturers' operations.

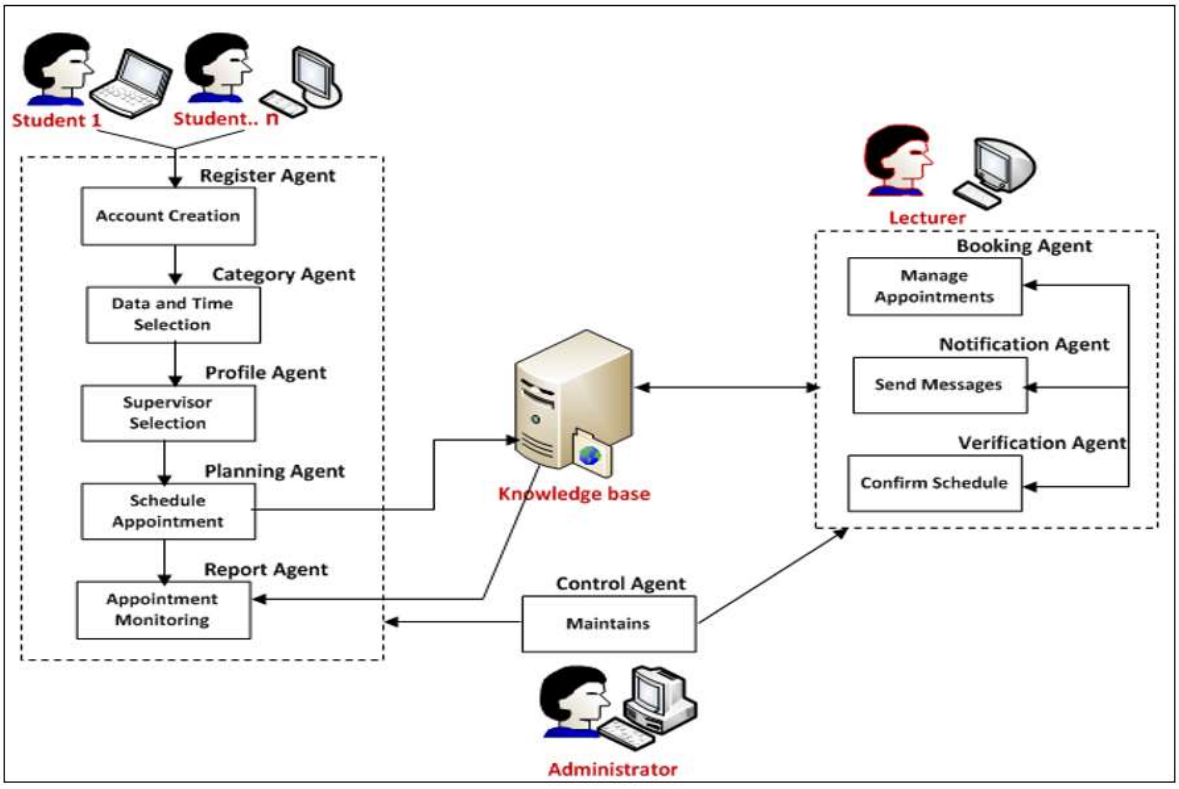

Figure 2. Multi-software agent system architecture.

3.1. Appointment Scheduling Process

The developed multi-agent based system architecture shows that there are five processes in making appointment scheduling between the students and lecturer. Accordingly, each of the process is briefly described below;

3.1.1. Account Creation

This is the first process in which the students are required to register and create an account. The student uses the created account details to login and gain access to his or her account and proceeds to make appointment booking to visit his or her lecturer.

3.1.2. Date and Time Selection

In this process the date and time for the appointment is to be selected followed by supervisor selection in which the student selects the lecturers' expert domain and the system displays the available lecturer's available data and time for the student to select and make booking.

3.1.3. Supervisor Selection

In this process the students' selects his or her supervisor to proceed to making the appointment. The system displays the lecturer's details and available date and time when appointment booking can be made by the students.

3.1.4. Schedule Appointment

This process involves the scheduling of the appointment after the student has selected the date and time based on the availability of the selected lecturer.

3.1.5. Monitor Appointment

In the last phase the appointment has been scheduled and will be monitored by the student and lecturer. Also, the already scheduled appointment details can be updated by the student or lecturer.

3.2. Deployed Multi-agents for Appointment Scheduling

The nine agents deployed in the developed multi-software agent system architecture (see Figure 2) are presented in Table 3. Where each of the individual agents works autonomously with each of the five appointment process and other system components to ensure the students and lecturers as well as the administrator can manage appointment schedules.

Table 3. Characteristics of multi-agents.

Agents	Functionality
Register agent	This agent manages account creation and the registration process done by the student when he or she creates a new account, which is required for students using the system.
Category agent	This agent manages date and time selection. It helps in arranging the date and time in the right format for the students in relation to the expert research area the lecturer belongs to, hence this agent categorize all lecturers in different specialization.
Profile agent	This agent is deployed during supervisor selection by displaying the necessary details of the supervisor. This agent further retrieves the general profile of the lecturer to students who want to view the lecturers' information.

Planner agent	This agent manages the entire process of scheduling appointment by co-ordinating the scheduling in relation to when the lecturer is available or on leave.
Report agent	It monitors the appointment process. Once a new appointment has been made, this agent sends notification through emails to the student who made the booking. Report agent also notifies the lecturer.
Booking agent	It ensures booking is done accordingly by collection all the information entered by the student when they want to make appointment to see their respective lecturers.
Notification agent	This agent is responsible for sending automated messages and notifications such as reminder to the lecturer and student regarding their scheduled appointment.
Verification agent	This agent mainly verifies and validates scheduling appointment information to prevent multiple scheduling appointment being booked in a single time and date. Also, this agent removes any time that has been booked by any student from the appointment search page.
Control agent	It works from the knowledge base to monitor appointment process. This agent mostly executes all the database functions such as search, update and delete actions in relation to appointment scheduling.

3.3. System Implementation

This phase involves the coding, deploying and running of the web based agent appointment scheduling system in XAMPP server locally to test the practically of the system to confirm the system is operational. This phase ensures that the web based agent appointment scheduling system can support students and lecturers towards appointment scheduling. The system was programmed using PHP similar to prior study [1, 3], for the agent and MYSQL for knowledgebase development as carried out by Shakshuki et al. [11] in their studies. The system was developed by applying concepts of multi-agent. The developed system uses the outputs from the previous phase to determine how the agents in the system communicates and collaborates in supporting appointment scheduling. The interface of the implemented web based agent appointment scheduling system is shown in Figure 3.

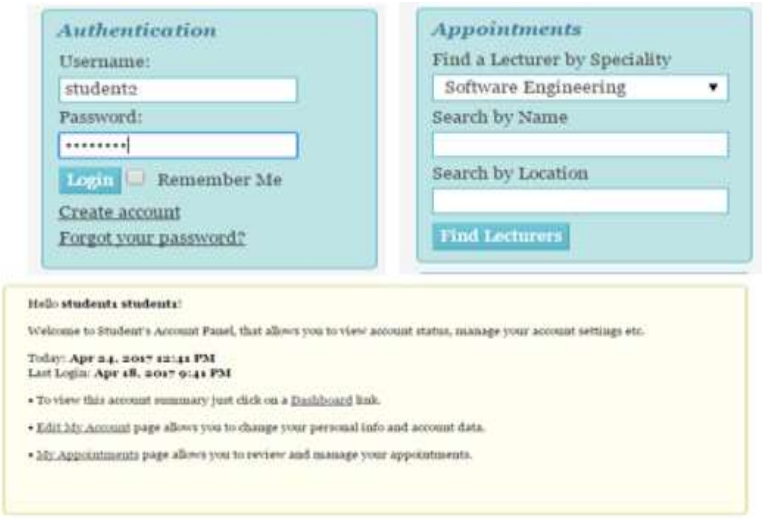

Figure 3. Web based agent appointment scheduling system.

4. Results and Discussion

This section presents the data collection, analysis and findings from questionnaire session. Data was collected from respondents mainly students and a few lecturers within Malaysia universities using paper based questionnaire to evaluate the applicability of the implemented system in regard to facilitating appointment scheduling among students and lecturers in their respective universities. Next, Statistical Package for Social Sciences (SPSS) version 23 was utilized to analyze collected data based on descriptive and exploratory factor analysis. The data was collected from 102 respondents. The developed system was demonstrated to each respondent after which the respondents filled the questionnaire to assess the usefullness of the system as regards to appointment scheduling between the students and their respective lecturers.

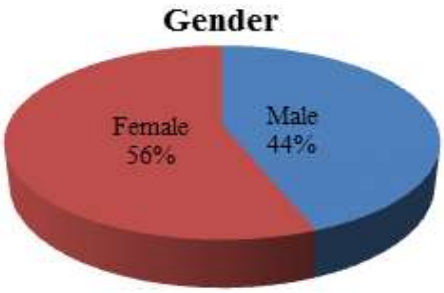

Figure 4. Gender distribution for the questionnaire respondents.

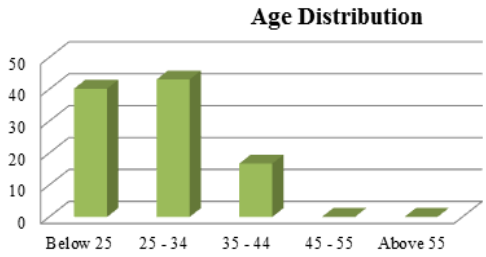

Figure 5. Age distribution for the questionnaire respondents.

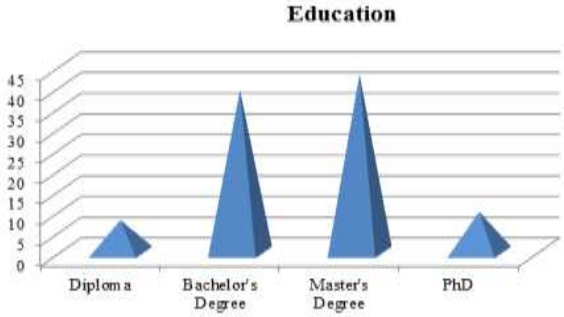

Figure 6. Education distribution for the questionnaire respondents.

4.1. Analysis of Demographic Data

The demographic profile of respondents involved in evaluating the implemented system is shown in this section. Results from Figure 4 show the gender distribution of the respondents that were involves the evaluating the implemented system. The results show that 56% were female and 44% were male. Similarly, results from Figure 5 show the age distribution of the respondents that were involves the evaluating the implemented system. Results from Figure 5 indicate that 43.1% are within the age of 25-34, whereas 40.2% are below 25 and lastly 16.7% are around the age of 35-44. Also, results from Figure 6 show the education distribution of the respondents that were involves the evaluating the system. Results from Figure 6 show that 43.1% are master's degree holders, whereas that 39.2% are bachelor's degree, 9.8 % are PhD holder and lastly 7.8% posses' diploma degree.

4.2. Descriptive, Reliability and Validity Analysis

This sub-section present results from the questionnaire items employed to test the applicability of the implemented system based on the questions which are measured with a 5-point Likert scale ranging from completely dissatisfied as "1" and completely satisfied as "5". Additionally, descriptive analysis was employed to provide an overview of the respondents' perception of usefulness of the implemented

system in relation to the questions. Table 4 presents results for the mean and Standard Deviation (SD), reliability Cronbach's alpha (α) and validity correlation coefficient (r) value for measuring the validity of the system.

Table 4. Descriptive analysis.

Questionnaire Items	Mean	SD	α	r
Usability of the system	4.45	0.654	0.757	0.387
Easy to navigate	4.51	0.625	0.737	0.542
Easy to learn	4.70	0.523	0.775	0.533
Encounter difficulty	4.45	0.791	0.729	0.733
Account creation sufficiency	4.39	0.720	0.731	0.611
Date/time selection efficiency	4.43	0.777	0.737	0.691
Efficiency of lecturer selection	4.68	0.548	0.754	0.545
Schedule appointment speed	4.63	0.561	0.743	0.531
Monitor appointment speed	4.49	0.641	0.750	0.595
Efficient in the real use	4.48	0.576	0.749	0.556
Its overall performance	4.60	0.567	0.752	0.345
System response time	4.51	0.558	0.761	0.328
System speed and response	4.56	0.499	0.765	0.504
Trust of the system	4.52	0.540	0.752	0.412
Accuracy of system scheduling	4.52	0.558	0.751	0.387
Overall system acceptance	4.64	0.483	0.771	0.542
Appointment reminders	4.51	0.656	0.767	0.533

Table 4 depict the results from descriptive analysis where the mean scoring guide is 0.00-2.49 = low 2.50-3.49 = moderate 3.50-5.00 = high as suggested by Jnr et al. [18]. The descriptive analysis results reveal that the mean value for all items is more than 2.5. Results from Table 4 indicate that each item overall mean is above 4.00 at a scale of 5, where item 3 has the highest mean of 4.70 and the standard deviation of each item is low showing that the values do not deviate far from 1. Hence, the implemented system was accepted and deemed useful by the respondents in regard to appointment scheduling between students and their lecturers. Additionally, SD is less than 1 for all items showing that the replies from the respondents are close and not widely dispersed. This indicates that all questionnaire items are accepted by our respondents in terms of the usefulness of the implemented web-based agent appointment scheduling system. Next, the reliability of the items are measured based on Cronbach's alpha, where Jnr et al. [18] suggest that ">0.9 – Excellent, > 0.8 – Good, > 0.7 – Acceptable, > 0.6 – Questionable, > 0.5 – Poor and < 0.5 – Unacceptable". Results from Table 4 reveal that the questionnaire items have an acceptable reliability since all the "α" values are higher than 0.70 benchmark score. Thus, the implemented system is acceptable by the respondents and applicable for appointment scheduling management process.

Furthermore, results from Table 4 shows the validity, based on Jnr [19] the strength of relationship, correlation coefficient strengths ranges from 0.1 to 0.29 OR -0.1 to -0.29 as Weak, 0.30 to 0.49 OR -0.30 to -0.49 as Moderate and 0.50 to 1.0 OR -0.50 to -1.0 as Strong. Results from Table 4 depict the correlation analysis, where the Pearson correlation coefficient (r) (must be between -1 to +1), p is the probability significance (that must be less than 0.01 to be valid). The results from Table 4 indicate that the Pearson's correlation (r) value was from 0.3 to 0.7 showing a weak to strong correlation signifying that the items are statistically significant at $p = 0.000$, thus confirming the quality of the items and validating that implemented agent appointment scheduling system.

4.3. Exploratory Factor Analysis

The questionnaire items were explored using Exploratory Factor Analysis (EFA) to assess if the items influence respondent's perception towards the applicability of the implemented system as seen in Table 5. Therefore, the items factor analysis and total variance explained that best describes the usefulness criteria of the system are presented in Table 5. Respectively, Anthony Jr et al. [20] suggested that the factor loadings of items should be greater than 0.5.

Table 5. Exploratory factor analysis.

Questionnaire Items	Factor Loading	Total Variance	% of Variance
Usability of the system	0.614	3.904	22.964
Easy to navigate	0.694	1.997	11.748
Easy to learn	0.830	1.869	10.997
Encounter difficulty	0.794	1.538	9.048
Account creation sufficiency	0.774	1.165	6.853
Date/time selection efficiency	0.719	1.047	6.156
Efficiency of lecturer selection	0.837	1.030	6.061
Schedule appointment speed	0.800	0.851	5.004
Monitor appointment speed	0.754	0.735	4.324
Efficient in the real use	0.768	0.649	3.816
Its overall performance	0.663	0.527	3.100
System response time	0.747	0.502	2.953
System speed and response	0.840	0.389	2.290
Trust of the system	0.727	0.248	1.460
Accuracy of system scheduling	0.672	0.228	1.343
Overall system acceptance	0.759	0.191	1.122
Appointment reminders	0.558	0.129	0.760

Thus, results from Table 5 indicate that all items are above the threshold of 0.50. Also, the total variance explained for all items were greater than 0.1 as recommended by Anthony Jr et al. [20]. In addition, results from Table 5 indicate that the factor loading of all items are all above the 0.5 benchmark score, with item 13, speed and response of the system having the highest value of 0.840 and item 17 appointment messages reminders with the lowest value of 0.558. Furthermore, results from Table 5

suggest that all item total and percentage of variance ranges from item 1 with 3.904 (22.964) which measures the usability of the systems to item 17 appointment message reminders with a value of 0.129 (0.760). The results of the EFA thus validate the usefulness criteria for confirming the web based agent appointment scheduling system.

5. Conclusion, Limitations, Future works

This study developed system architecture model designed to illustrate how multi-agent facilitate appointment scheduling management. Besides, the system architecture is developed to implement the proposed web based agent appointment scheduling system, after which questionnaire was used to evaluate the implemented system. The implemented system support students and lecturers in making decision on how they can manage their appointment scheduling. Moreover, the system is implemented as a web based tool, thus it can assist lecturers and students by bridging a gap of communication and collaborative hence acting as a significant tool to improve academic performance. The limitation of this study is aligned towards the fact that data was collected from student and lecturers in Malaysia universities only. Hence the results from this study cannot be generalized to other countries. Secondly, the agent algorithms were not presented in this study. Hence, in future the sample size will be increased, and more data will be collected from more respondents within universities in other regions. Lastly, the agent algorithms would be designed to further show how the multi-agents facilitate appointment scheduling.

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