Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

AN EFFECTIVE RESEARCH SUPERVISION MANAGEMENT VIA A MULTI-AGENT SYSTEM

OMAR ABDULLATIF JASSIM, MOAMIN A. MAHMOUD, MOHD SHARIFUDDIN AHMAD
[2]College of Computer Science and Information Technology, Center for Agent Technology,

Universiti Tenaga Nasional

E-mail: omar4049@yahoo.com, moamin@uniten.edu.my, sharif@uniten.edu.my

ABSTRACT

One of the challenges in research development is supervision management and its related activities. Inexperienced supervisors may have difficulties in recommending the appropriate research activities for their students and the students may not have the skills in research. Consequently, the main aim of this study is to develop a supervision management framework that incorporates a multi-agent system for managing research development. In developing the framework, the most important development stages are analyzed from the literature of research development process. The proposed framework consists of three phases which are Research Development Activities, Performance and Completion Measurement, and Tracking Activities. The components of the framework are discussed as possible implementation for a general application of research supervision management. The proposed framework is validated by 22 experts from Malaysian, Singaporean, and Jordanian universities. The validation results show that the proposed framework is useful to manage the supervision activities of research development.

Keywords: *Task Management; Supervision Management; Research Development Activities; Intelligent Software Agents*

1. INTRODUCTION

Educating our early career researchers is becoming more complex [1, 2]. This is due to the range and scope of the master and doctoral degrees, the fast moving nature of knowledge, internationalization, the demands of funding bodies and employers that are straining on the master and PhD supervisors. Supervisors may face difficulties on deciding the tasks that they must undertake to nurture efficient postgraduate research. The range and depth of knowledge that a supervisor holds indicate how they supervise and the type of researcher who emerges at the end of the process. Kamler and Thomson [3] argue that in an age of super complexity, when demands of academics and other employers are unpredictable, skills of the effective researcher, and thus their supervisors, are likely to become even more important.

According to Patterns and Trends in UK higher education [4], there is a percentage increase of 32% between 2002–03 and 2010–11 for students registering for postgraduate study. Indirectly, this increasing trend raises some management concerns about the challenges in research supervision and development activities affecting supervisors and students. Some of these challenges include miscommunication between supervisors and students, ambiguities of research development activities, lack of effective status tracking process of different research activities, and last but not least, lack of effective methods to measure students' performance that reflect their real progress [4, 5].

From the literature, we have not discovered any comprehensive research supervision systems that formally manages research activities except some segments of processes that implement research supervision management activities [6, 7, 8] and some software that monitor students' progress [9, 10, 11]. To fill this gap, we attempt to investigate and develop a system that handles comprehensive processes of research supervision management involving supervisors and students.

Consequently, the main aim of this study is to develop a supervision management framework that incorporates a multi-agent system for managing research development activities. Many researchers have employed agent based-systems as effective tools to improve task management [12, 13, 14].

In developing the framework, the most important development stages and activities are analyzed from the literature of research development process. We propose that the framework consists of three phases which are Research Development Activities, Performance and Completion Measurement, and

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Tracking Activities. The Research Development Activities phase proposes a number of activities to conduct a research. These activities consist of two layers, abstract and detail. The Performance and Completion Measurement phase works on measuring a student performance and expected completion date. The Tracking Activities phase presents the proposed activities to track and trigger a student's tasks.

This paper is an extension to our previous work in the same topic [15, 16, 17]. The objectives of this paper are: (i) To analyze the most efficient standard of research supervision activities, (ii) To develop a multi-agent framework that manages and tracks activities and measures performance, and (iii) To develop a prototype that manages the supervision process based on a multi-agent model. The outcome of this paper is a model that enables software agents to assist supervisors in managing and monitoring students' research progress. The significance of this outcome contributes to a more efficient supervision and more qualified researchers.

2. RELATED WORK

One of the main challenges in research development is research supervision [18, 19]. The main aim of a research supervision is to produce high quality researchers who will be able to conduct research based on the logical and academic research activities. However, new supervisors and researchers face difficulties in understanding and implementing various research activities. The differences between supervisors and students' levels of knowledge and skills further augment the difficulties of research supervision activities [1, 19].

Lubega and Niyitegeka [11] found that research supervision activities could be managed effectively using many methods such as E-mail, forums, and chat rooms. AlBar [9] develops an electronic system to manage supervision activities and improve communication between the supervision stakeholders. Romdhani et al. [10] develop a supervision system to manage research development activities that undergraduate students could follow. However, the proposed development processes are static for all students. The supervisor cannot adaptively change these processes. Yew et al. [6] mention that the supervision activities could be managed efficiently using agent-based systems such as expert systems. Ismail [7] argues that students have many challenges in research development such as skills deficiency. Therefore, the research development processes should be clear and understood by the students in order to minimize the difficulties of research development.

The related works show that there are no clear reviews of research supervision process proposed by researchers in order to design supervision activities based on dynamic rather than static processes. However, researchers agree that there are difficulties in designing and managing a research development process. Consequently, previous works have suggested various methods and systems to manage supervision activities. The electronic methods are naturally considered as efficient approaches to manage research supervision efficiently.

Software agents have been widely used to assist humans in complying with the schedules of a collaborative work process and task management applications [20, 21, 22]. Consequently, in this research, we exploit the software agent technology, due to its autonomous, reactive, proactive and social ability characteristics, in managing research supervision activities (23, 24, 25).

3. A RESEARCH SUPERVISION MODEL

In this section, we present our proposed model of an agent-based system for research supervision. We develop the model based on our a priori knowledge of the supervision process. As shown in Figure 1, the model consists of five main components: Student, Supervisor, Software Agent, System Administrator, and a Database. An agent is assigned to a new student once the student registers with the system. The agent regulates activities between the student and his/her supervisor and records these activities in the database. It is also able to scan the database to update its beliefs on changes. A student is able to interact with the agent and view and add information to the database, e.g. upload a progress report. A supervisor is able to interact with the agent and view and edit the database, e.g. comment and edit a progress report.

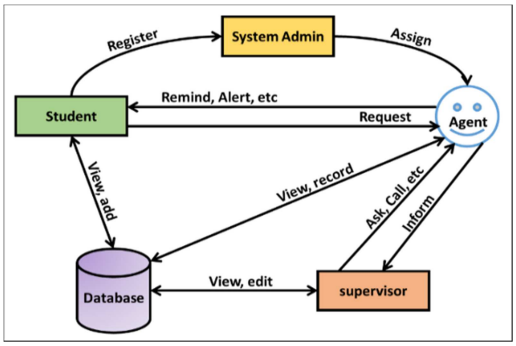


Figure 1: A Research Supervision Model

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4. A CONCEPTUAL MULTI-AGENT RESEARCH SUPERVISION MANAGEMENT FRAMEWORK

Our conceptual framework for an agent-based research supervision management, as shown in Figure 2, consists of a supervisor who creates and (1) follows the given stages, (2) discusses a new task with a student, and (3) delegates the tasks to the student's agent, which communicates with the student. The agent then performs several tasks; it (4) views the research processes' contents and specifies the given task to a particular stage and step. It also (5) measures the performance and the completion of the research work and (6) updates the student and the supervision team. In addition, the agent (7) monitors the student's achievement and performs some activities to (8) prompt the student to meet the tasks' deadlines. Figure 2 shows a framework for multi-agent research supervision management.

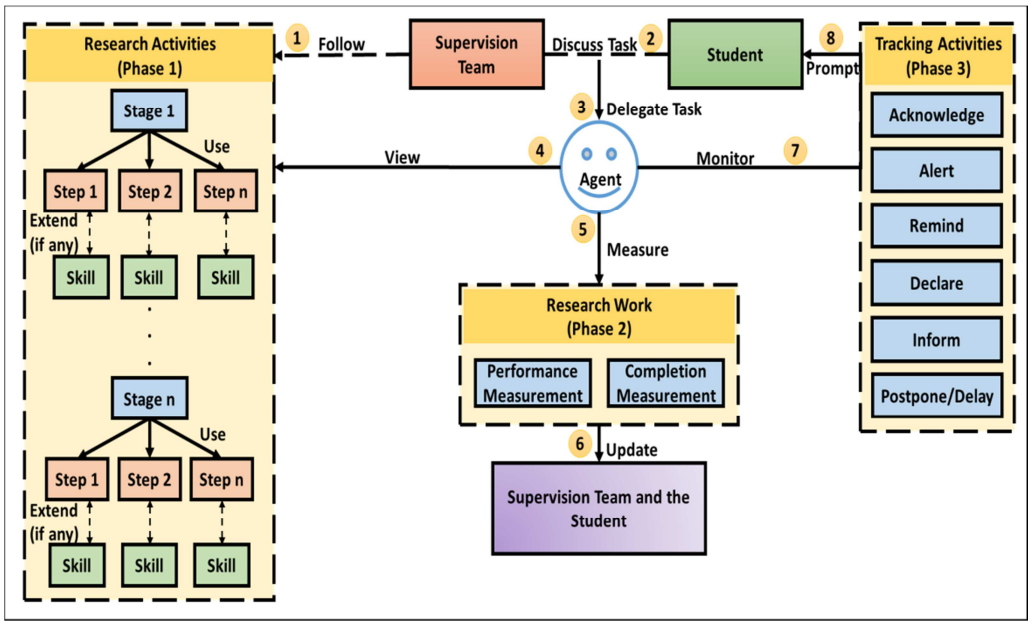


Figure 2: A Framework For Multi-Agent Research Supervision Management

4.1 The Research Development Activities Phase

The Research Development Activities phase consists of two layers; an abstract layer that all supervisors must follow, and a detail layer from which supervisors may select some or all of the activities according to a particular project's needs.

The literature reveals a host of activities for research development. We propose that these activities can be divided into two layers; abstract and detail. As shown in Figure 3, the abstract layer consists of six stages, and the detail layer consists of numerous steps. The stages are preliminary stage, review stage, data collection stage, data analysis stage, development stage, and testing and validation stage [26, 27, 28, 29, 30]. It is essential for a supervision team to mandatorily follow the abstract layer stages. However, several appropriate steps (and not all the suggested steps in Figure 3) can be adopted from the detail layer since the complexity varies from one research to another. The following sections discuss the details of the proposed stages and steps.

We show the validity of this framework by proposing the stages and steps that are selected for a Master research program, with the following requirements:

- The Master student is given 12 months to complete a dissertation based on the topic that is relevant to the Master program.
- The title of the research project selected by the student is "Development of a Hybrid Cloud Computing Model for Multi-campus Universities",
- The main aim of the thesis is to develop a cloud computing model for multi-campus universities to reduce the cost of current IT resources, and manage the services and information gathered among university workers to speed up the work activities.

Based on Figure 3 and our analysis and understanding of the research title and its

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

description, we suggest the following stages and steps for the research work.

- Preliminary Stage: In this stage, the research problems, objectives, questions, and motivations are identified based on the preliminary study.
- Review Stage: In this stage the literature are reviewed to identify cloud adoption directions. The tasks that belong to this stage are field history development, concepts definition, review and analyze the theoretical and practical works, and formulate the conceptual vision.
- Data Collection Stage: The data collection is based on two main methods which are quantitative using questionnaire and qualitative using interview.
- Data Analysis Stage: The quantitative and qualitative data analyses are the main tasks of this phase.
- Development Stage: The main task in this phase is model development.
- Testing Stage: In this phase, the validity of the proposed model is confirmed through an interview with an expert panel.

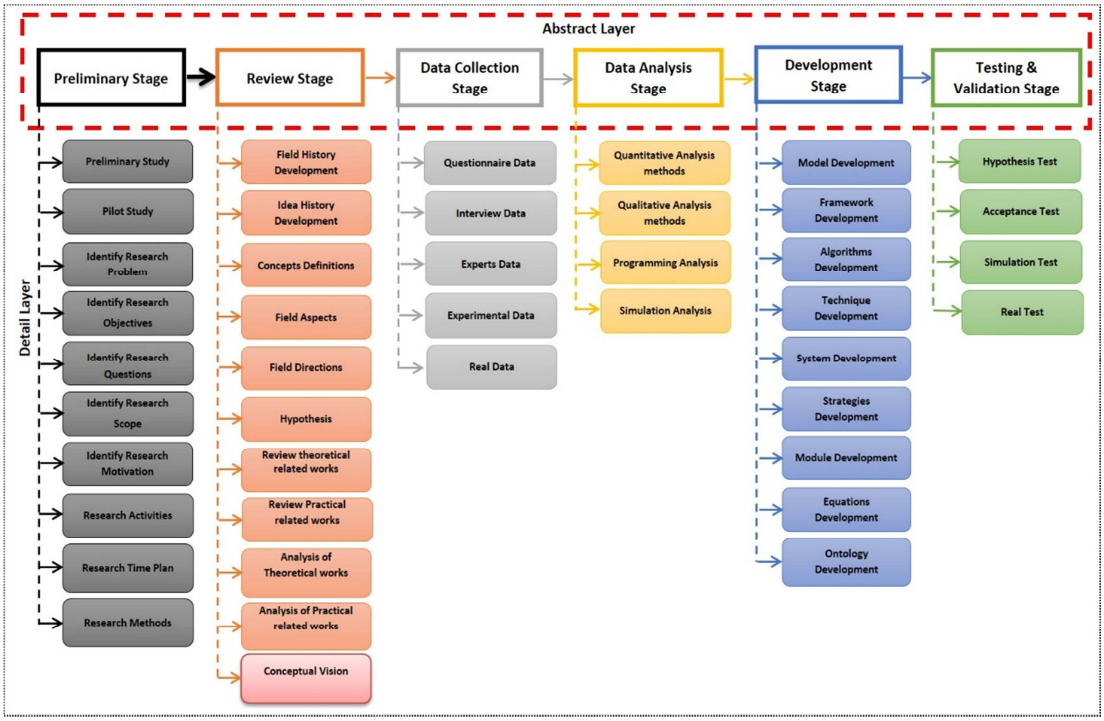


Figure 3: A Framework For Research Development Activities

4.2 Performance and Completion Measurement Phase

The second phase entails measuring a student performance and eventually the expected completion date.

Performance Measurement: A performance is measured by dividing the given time for a task by the real time taken to achieve that task. It is gauged as Meet Expectation (ME) if the result equals 1, Exceed Expectation (EE) if it is greater than 1, and Low Expectation (LE) if it is less than 1. The details of measurements are as follows,

Performance (PRF) representation is as follows**:**

$$PRF = \begin{cases} LE & PRF < 1 \\ ME & PRF = 1 \\ EE & PRF > 1 \end{cases}$$

The following formula measures the performance, PRF, of a specific completed milestone/step. If the performance of a milestone is PRF_M, Projected Milestone Period is P_M, Actual Milestone Period is A_M, then**,**

$$PRF_M = P_M / A_M$$

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

For example, to measure the performance of a milestone 2, let us assume,

$P_{M2} = 10$ days
$A_{M2} = 12$ days
Then ,
$PRF_{M2} = P_{M2}/A_{M2} = 0.83 \Rightarrow LE$

The following formula measures the overall performance, OPRF of all completed milestones/steps,

$$OPRF = \frac{\sum_{n=1}^{k} P_{mn}}{\sum_{n=1}^{k} A_{mn}} \quad Where\ n=1, 2, \ldots, k$$

For example, to measure the overall performance of three milestones, let us assume,

$P_{M1} = 10$ days; $A_{M1} = 8$ days
$P_{M2} = 13$ days; $A_{M2} = 12$ days
$P_{M3} = 15$ days; $A_{M3} = 15$ days
Then,
$OPRF = (10+13+15)/(8+12+15) = 38/35 = 1.08 \Rightarrow EE$

Completion Measurement: The completion is influenced by the performance, if the performance is high, the completion is imminent and vice versa. The details of measurements are as follows,

If Completion is CompM, Total Project Period is PR, then,

$CompM = PR * (1/OPRF)$

For example, to measure the completion of a project, let us assume,

$PR = 300$ days

From previous example,

$OPRF = 1.08$ Then
$CompM = 300 * (1/1.08) = 277.77$ days

4.3 Tracking activities phase

The last phase involves tracking different activities and produce appropriate housekeeping messages such as Acknowledge, Remind, Alert, Declare, Inform, etc. Section 5.4 discusses these activities in details.

5. THE ACTORS' FUNCTIONS

Having presented the proposed model and framework, we discuss the different functions of the main entities: Student, Supervisor, Software Agent and System Administrator.

5.1 Administrator Functions

An administrator has two basic functions which are as follows:

- Approve: Approves new membership.
- Unsubscribe: Unsubscribes current membership.

5.2 Student Functions

A student has six functions as follows:

- Register: Registers with the system and assigns to an agent.
- Request/Respond: Requests, e.g. extension, from his/her supervisor or Responds to his/her supervisor.
- View Performance: Views his/her performance for every milestone and for all milestones.
- Submit New Task and Meeting: Submits new tasks and specifies meeting date after having met his/her supervisor.
- Submit Progress Report: Submits his/her progress report before a meeting.
- View Milestones: Views the research milestones that are created by his/her supervisor.

5.3 Supervisor Functions

A supervisor has ten functions which are as follows:

- Register: Registers a supervisor with the system.
- View Performance: Views his/her student performance for every milestone and for all milestones.
- View Milestones: Views the research milestones that are created by him/her.
- View Student information: Views his/her students' information.
- Create/Edit Milestones: Creates or edits milestones for his/her student.
- Ask/Respond: Asks his/her student or Responds to his/her students' requests.
- Verify New Task and Meeting: Verifies a new task and meeting date submitted by his/her student.
- Call for Special Meeting: Calls for special meeting usually about the research project.
- Approve/Terminate Student: Approves a new supervision request by a student or Terminates a student from his/her supervision.

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

- Cancel Meeting: Cancels a meeting for some reasons.

5.4 Agent Functions

A software agent has eight functions as follows**:**

- Acknowledge: Notifies a message's sender that the message is sent successfully and received by the recipient.
- Notify: Notifies supervisor/student about any update/action has been taken by student/ supervisor.
- Remind: Reminds a student regarding a task and the remaining time before the deadline**.**
- Alert: Alerts a student when a deadline is imminent. A penalty token is attached with an alert message. For example, "Please be informed that you have to submit your progress report in one hour, otherwise the meeting will be cancelled and this will affect your performance".
- Declare: Declares a message to a student and his/her supervisor when the student fails to meet a given deadline. For example, the agent declares that "The meeting is cancelled due to failure in submitting the assignment report**".**
- Inform: Provides communication between the student and his/her supervisor to share information about a particular matter**.**
- Cancel Meeting: Cancels a meeting that has been pre-set when the student fails to submit the progress report before the deadline**.**
- Measure Performance: Measures a student's performance of past tasks.
- Measure Completion: Measures the completion of a project.

Figure 4 shows a use case diagram of all actors and their functions.

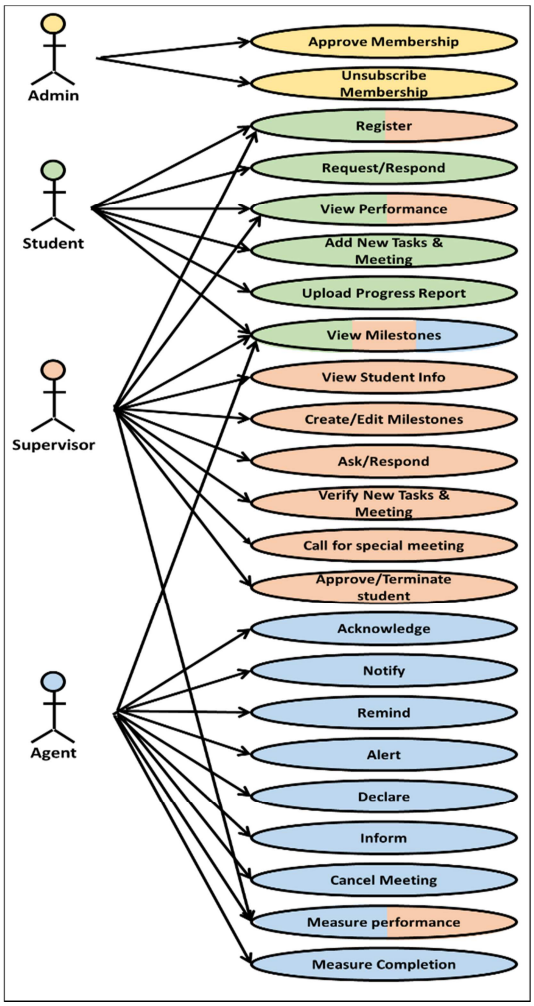


Figure 4: The Actors' Functions

6. VALIDATION VIA A RESEARCH PROCESS

To validate the framework and the functions, we present a scenario of a research supervision process involving a student, a supervisor and an agent, of a typical research activity. In this scenario, we assume that the student has met his/her supervisor and after the meeting,

- **Agent:** Reminds the student to add a new task and a next meeting date.
- **Student:** Submits New Task and Set Meeting Date.
- **Agent:** Notifies the supervisor about the recent action by the student.
- **Agent:** Acknowledges the student that the supervisor has been notified.
- **Agent:** Reminds the supervisor to verify the new task and the meeting date.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

- **Supervisor:** Verifies/Edits the new task and the meeting date.
- **Agent:** Notifies the student about the recent action by the supervisor.
- **Agent:** Acknowledges the supervisor that the student has been notified.
- **Agent:** Reminds the student to upload a progress report before the due date.
- **Agent:** Alerts (if the due date is very close) the student about the penalty if he/she fails to submit the progress report.

If the student fails to submit the progress report before the due date, e.g. 24 hours before the meeting time:

- **Agent:** Cancels the meeting.
- **Agent:** Declares that the student failed to submit the progress report.
- **Agent:** Measures the performance and the compilation and reveal the results to the supervisor and the student.
- **Agent:** Remind the student to set a new meeting date.

If the student manages to submit the progress report before the due date:

- **Student:** Submits Progress Report.
- **Agent:** Notifies the supervisor about the recent action by the student.
- **Agent:** Acknowledges the student that the supervisor has been notified.
- **Agent:** Reminds the student and the supervisor about the meeting date and time.

Figure 5 shows the sequence diagram for the above scenario if the student managed to submit on time.

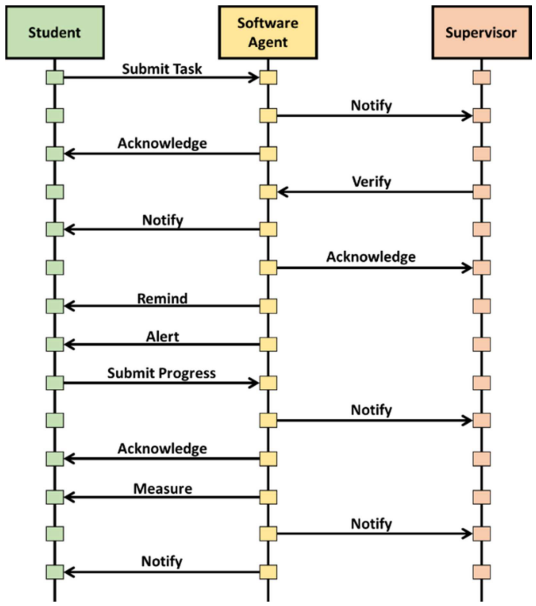


Figure 5: Sequence Diagram

7. VALIDATION OF MULTI-AGENT RESEARCH SUPERVISION MANAGEMENT FRAMEWORK (MARSMF)

According to NQC (2009), one of the most accepted methods of framework validation is the summative review method, which depends on discussing the model details with experts in the same field of research, and updating the model based on reviewers' feedbacks and recommendations. We use the summative experts' panel reviews to ensure the validity of the proposed MaRSMF. The expert panel of validation consists of 22 experts from Malaysian, Singaporean, and Jordanian Universities. The profiles of the Expert panel are attached in Appendix D1. The experts are selected based on their experiences, skills of research supervisions, and ICT background. All members of expert panel have good background of ICT domain for at least 5 years and they are involved in supervision activities for Master and PhD students.

The survey of experts panel are conducted based on two main parts; (1) MaRSMF validity for the purpose of research supervision management in Information Communication Technology (ICT) fields, and (2) structure and activities of MaRSMF (See Appendix D2 for further information about interviews).

Consequently, we collected the experts responses based on 5-likert scale; 1 for Strongly Disagree (SD), 2 for Disagree (D), 3 for Neutral (N), 4 for Agree (A), and 5 for Strongly Agree (SA).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

According to responses of the first part of survey shown in Table 1, the experts agree that the steps, stages and tasks of MaRSMF are adequate to complete a research process. The stages are adequate to represent the research development phases. The tasks that are related to each stage are adequate to represent the stages' aspects and directions. On the other hand, the overall response of experts shows that the proposed activities and processes of MaRSMF are clear. In other words, the formulated and developed activities and processes are easy to understand. Moreover, the experts agree that the activities of MaRSMF are applicable to manage the research development.

The experts also agree that the activities and processes of MaRSMF are useful for supervisors to plan their students' research development activities. Therefore, the challenges of research supervision and development could be avoided. In addition, the experts agree that the MaRSMF is helpful in tracing students' progress and measuring the students' performance which gives the students and supervisor better understanding of the students' research skills (i.e. weaknesses and strength). Consequently, the supervisor can monitor and develop the students' skills easily.

Table 1: Summary Of Interview First Part Responses

No.	Item	SD	D	N	A	SA	Mean	Agreement Level
1	The proposed model is clear and understood by readers.	0	0	1	14	7	4.27	High
2	The proposed model is applicable to research supervision domain.	0	0	3	14	5	4.09	High
3	The proposed model covers the whole research development process.	0	0	3	13	6	4.13	High
4	The proposed model is useful for supervisors to plan their students' research development activities.	0	0	1	17	4	4.13	High
5	The proposed model is helpful to trace students' progress.	0	0	2	15	5	4.13	High
6	The proposed model is helpful to measure students' performance.	0	0	5	11	6	4.04	High
7	The proposed stages are adequate to complete research development.	0	0	5	12	5	4.00	High
8	The proposed steps are adequate to achieve related stages.	0	0	4	14	4	4.00	High

According to responses of the second part of the interview, the experts agree that the overall activities, processes, and formulas of MaRSMF and MaRSMS are satisfactory. Table 2 shows the responses of the second part of the interview.

Table 2: *Summary Of Interview Second Part Responses*

No.	Item	SD	D	N	A	SA	Mean	Agreement Level
9	How would you rate your overall satisfaction at the presented framework?	0	0	1	21	0	3.95	High

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

In conclusion, the experts confirm that the proposed model is valid for the purpose of research supervision management in ICT field which assures the achievement of the objective of this research.

8. PROTOTYPING OF MULTI-AGENT RESEARCH SUPERVISION MANAGEMENT SYSTEM (MARSMS)

MaRSMS is prototyped using application service provider (ASP) as programming language in ASP.NET environment in order to develop all functional and non-functional requirements.

ASP is a business software that provides computer-based services to customers over a network. Software offered using an ASP model is also called On-demand software or software as a service (SaaS). The most limited sense of this business is that of providing access to a particular application program (such as customer relationship management) using a standard protocol such as HTTP. ASP programming language is selected due to several reasons which are as follows:

- Minimizes network traffic.
- Flexibility to view in any browser.
- High security - ASP code cannot be viewed from the browser.
- Ability to dynamically edit, change or add any content of a web page.
- Ability to access any data or database and return the results to a browser.

Figure 6 shows the main interface of MaRSMS which contains general information about the system's aims and some links allowing students, supervisors, and administrators to access their profiles.

Figure 6: Marsms Main Interface

9. TESTING AND RESULTS

This section explains the research supervision activities that are added to the system's database. In order to understand the main activities of MaRSMS implementation, the implication scenarios are discussed through explanation of the main MaRSMS interfaces.

Figure 7 shows the first step from a student's side. The student creates a new research plan by filling the proposed tasks of each research stage. For example, the student selects the preliminary study and pilot study tasks for basement stage development.

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

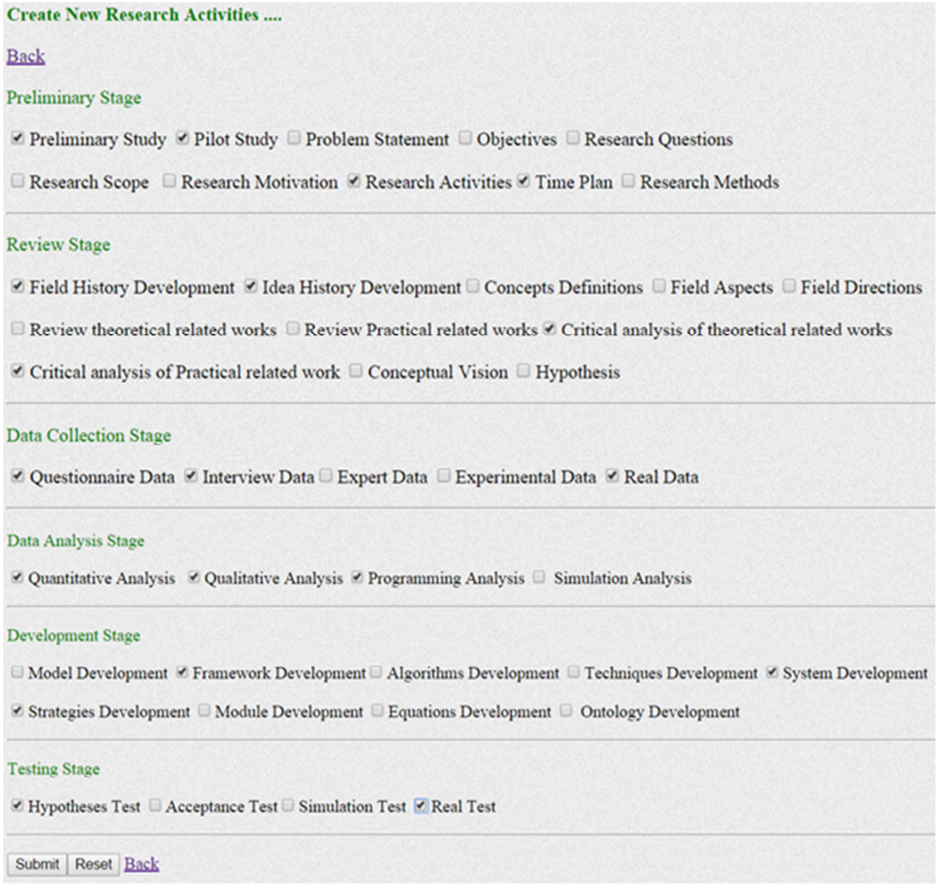


Figure7: Create New Tasks And Research Stages

Based on the added tasks of each stage from the student, the supervisor views the added tasks and assigns the estimated days to complete each research stage. Figure 8 illustrates the supervisor's function of assigning expected completion date for each stage.

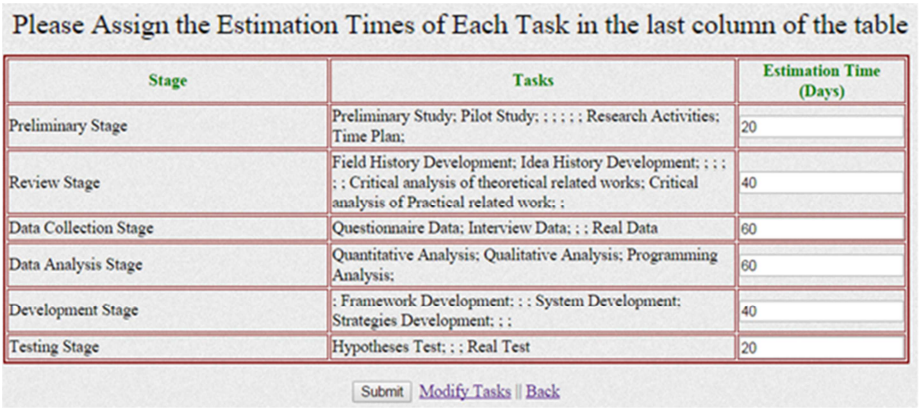


Figure 8: Assign Estimated Completion Days For Each Stage

However, the supervisor has the authority to update the tasks of any research stage. For example, Figure 9 shows the interface for updating research tasks of basement stage by the supervisor.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

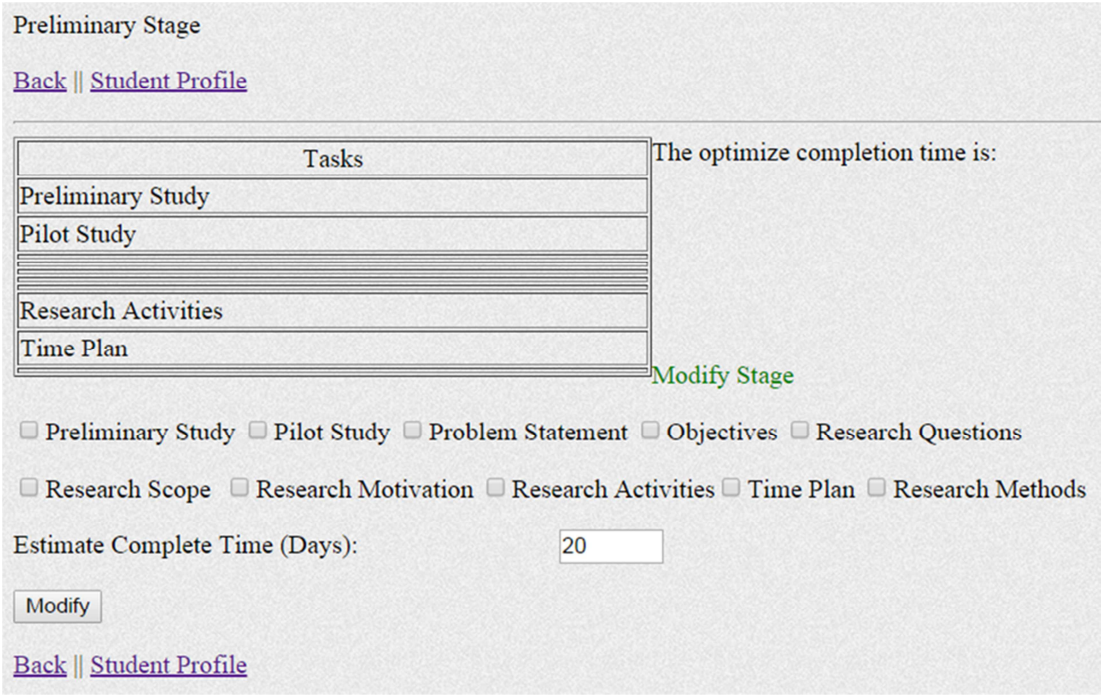
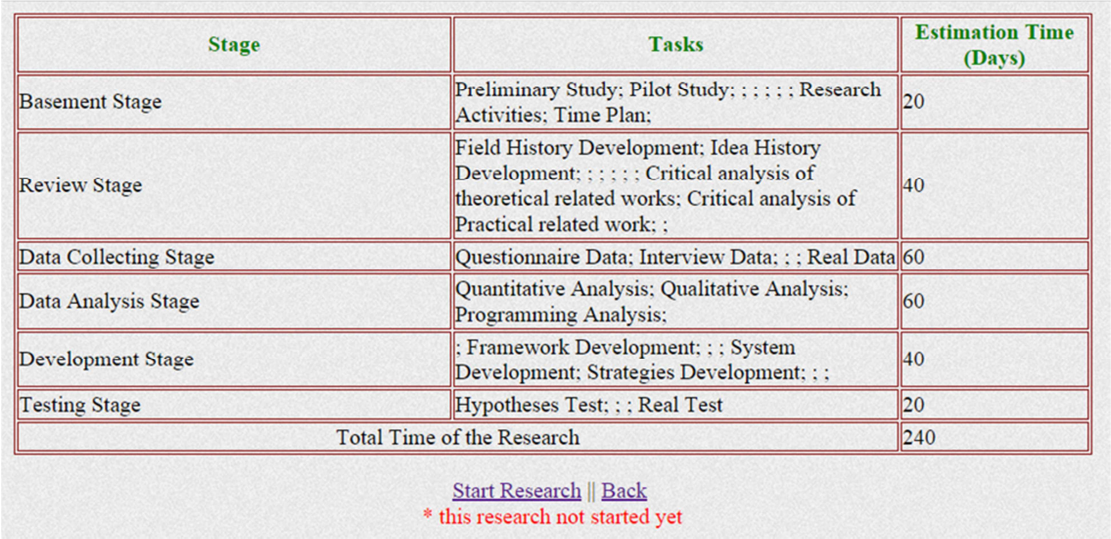


Figure 9: Update Research Tasks

Once a supervisor completes the activities of updating and assigning the expected completion date of the research stages, he/she and his/her student can view the report of the research development plan as illustrated in Figure 10.



Stage	Tasks	Estimation Time (Days)
Basement Stage	Preliminary Study; Pilot Study; ; ; ; ; ; Research Activities; Time Plan;	20
Review Stage	Field History Development; Idea History Development; ; ; ; ; ; Critical analysis of theoretical related works; Critical analysis of Practical related work; ;	40
Data Collecting Stage	Questionnaire Data; Interview Data; ; ; Real Data	60
Data Analysis Stage	Quantitative Analysis; Qualitative Analysis; Programming Analysis;	60
Development Stage	; Framework Development; ; ; System Development; Strategies Development; ; ;	40
Testing Stage	Hypotheses Test; ; ; Real Test	20
Total Time of the Research		240

Start Research || Back
* this research not started yet

Figure 10: Final Research Development Plan

The supervisor then initiates the research (Figure 11).

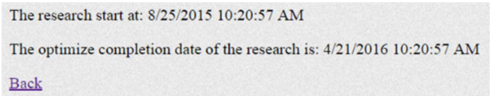


Figure 11: Research Starting

Subsequently, a call for meeting is made to discuss the first task that should be completed by his/her new student. Figure 12 illustrates the process of calling for the meeting. The supervisor selects the stage and task that will be discussed in the meeting, and sets the date and time of the meeting.

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

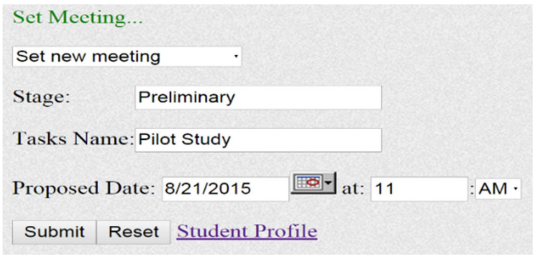


Figure 12: Set New Meeting

The agent in turn acknowledges and informs the student about the date and time for the meeting. The agent then keeps sending reminders if the meeting remaining days is more than two, and alerts if the meeting remaining days is less than two. The reminders and alerts pop up on the student main page (Figure 13).

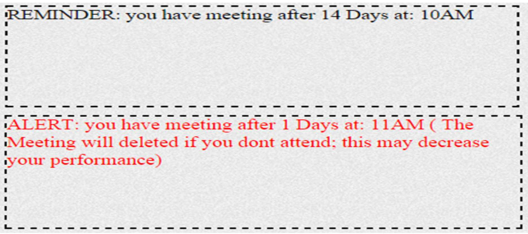


Figure 13: Meeting Reminders And Alerts

The student can send a request to his/her supervisor to reschedule the meeting by setting a new proposed date and time. Figure 14 shows the rescheduling request interface.

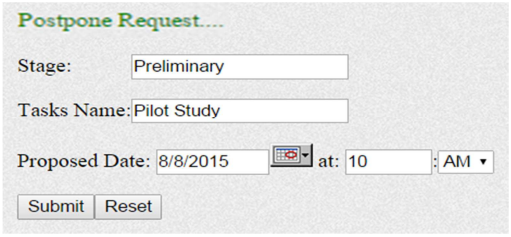


Figure 14: Meeting Postpone Request.

However, the supervisor has the authority to accept, reject, or update the proposed meeting date according to the student's request. The postpone acknowledgment is made through the agent and viewed by supervisor (Figure 15). It is necessary to mention that the supervisor can set absence declaration through the agent in case of student's absence in the meeting, i.e. cancel the meeting for this week and count the student's time.

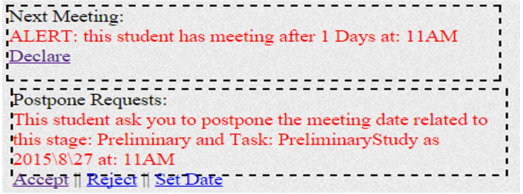


Figure 15: Response To Meeting Postpone

In order to increase the virtual communication performance through the agent, the student and the supervisor can exchange messages in the context of current research tasks. Figure 16 shows an example of a message exchange between a student and his/her supervisor.

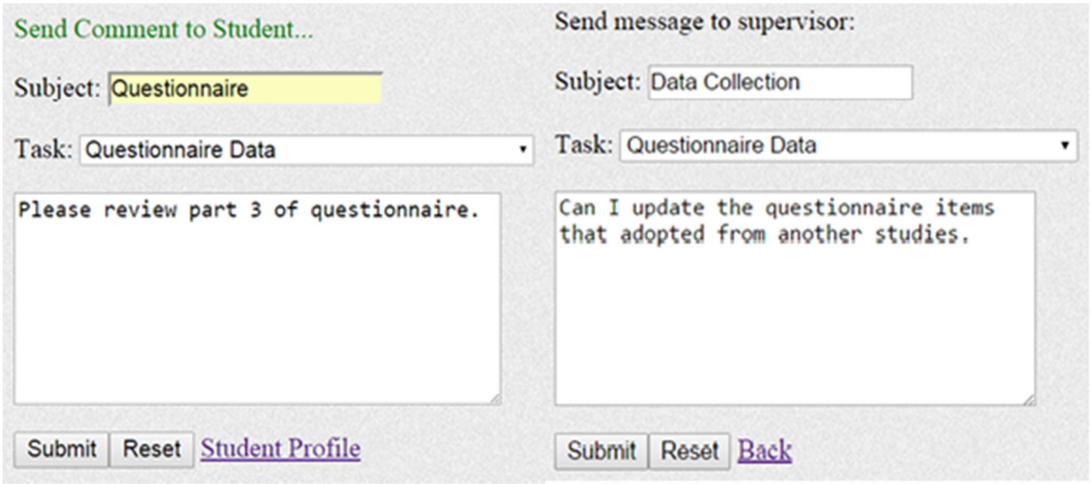


Figure 16: Messages Exchange

The messages that are sent from the student to the supervisor and vice versa are managed and recorded by the agent and displayed on the main page of students and supervisor (Figure 17).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Supervisor Page

Subject	Message	Task	Date
Data Collection	Can I update the questionnaire items that adopted from another studies.	Questionnaire Data	8/26/2015 6:53:53 AM

Student Page

Last Message:
The Last Message is: Please make a chart of the milestone for the entire project; This Message related to stage: Milestone and task: Time Plan...

Figure 17: Messages Display

As shown in Figure 18, the student can view the messages sent by his/her supervisor.

Supervisor Messages

Subject	Message	Task	Date
Questionnaire	Please review part 3 of questionnaire.	Questionnaire Data	8/25/2015 10:37:38 AM
Introduction	Try to include more literature on the theoretical framework.	Preliminary Study	8/25/2015 10:08:57 PM
Data analysis	Provide the mean and variance of the distribution of the collected data in section 3.	Research Activities	8/25/2015 10:11:02 PM
Milestone	Please make a chart of the milestone for the entire project	Time Plan	8/25/2015 10:13:40 PM

Main Page

Figure 18: Messages From Supervisor

After the discussion in meetings and the comments provided by the supervisor, the student completes the given task and once it is ready, he/she submits the task's report to his/her supervisor (Figure 19).

Submit Task to Supervisor

Task: Preliminary Study

Task Description:

This task is completed as the following.

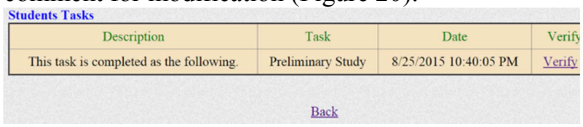
Submit Reset Back

Figure 19: Messages From Supervisor

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

The submitted task by the student is managed by his/her agent and viewed by his/her supervisor; the supervisor in turn may accept the task as it is or comment for modification (Figure 20).


Students Tasks

Description	Task	Date	Verify
This task is completed as the following.	Preliminary Study	8/25/2015 10:40:05 PM	Verify

Back

Figure 20: Completed Task Report

Once all tasks of any stage are completed, the supervisor declares the end of that stage and the agent automatically moves to the next stage. At this point, the agent computes the stage performance. Figure 21 presents the interface for stages ended by a supervisor.

Stage	Tasks	Finishing
Preliminary Stage	Preliminary Study; Pilot Study; ; ; ; ; ; Research Activities; Time Plan;	Already Finished
Review Stage	Field History Development; Idea History Development; ; ; ; ; ; Critical analysis of theoretical related works; Critical analysis of Practical related work; ;	Already Finished
Data Collection Stage	Questionnaire Data; Interview Data; ; ; Real Data	Already Finished
Data Analysis Stage	Quantitative Analysis; Qualitative Analysis; Programming Analysis;	Finish
Development Stage	: Framework Development; ; ; System Development; Strategies Development; ; ;	Finish
Testing Stage	Hypotheses Test; ; ; Real Test	Finish

Back

Figure 21: Completed Stages

Finally, the supervisor or the student can view the progress status. Figure 22 shows the interface for the performance and stages completion gauge which are computed according to formulas that are explained in the previous section. According to the example in Figure 22, the student completes all research stages before the due dates. Thus, the performance is satisfactory.


Progress Status.....

Stage	Preliminary	Review	Data Collection	Data Analysis	Development	Test
Completion %	8.33%	16.67%	25%	25%	16.67%	8.33%
Evaluation Status	On time	On time	On time	On time	On time	On time

Stage	Estimated Days	Real Needed Days	Performance Gauge	Step Performance
Preliminary Stage	20	16	Exceed Expectation	1.25
Review Stage	40	35	Exceed Expectation	1.14
Data Collection Stage	60	31	Exceed Expectation	1.94
Data Analysis Stage	60	56	Exceed Expectation	1.07
Development Stage	40	36	Exceed Expectation	1.11
Testing Stage	20	15	Exceed Expectation	1.33

Back

This report summrizes the student performance of research development

Research Progress Report
Comparison of Estimation and real time Completion

Preliminary Stage--Review Stage--Collection Stage--Analysis Stage--Developing Stage--Testing Stage--
Estimated Days Number = 240 Real Days Number = 189
*All Resreach Stages Completed

The research Completed within the estimated time ..

Stage	Estimated Days	Real Needed Days	Performance Gauge	Step Performance
Preliminary Stage	20	16	Exceed Expectation	1.25
Review Stage	40	35	Exceed Expectation	1.14
Data Collection Stage	60	31	Exceed Expectation	1.94
Data Analysis Stage	60	56	Exceed Expectation	1.07
Development Stage	40	36	Exceed Expectation	1.11
Testing Stage	20	15	Exceed Expectation	1.33
Overall Performance			Exceed Expectation	1.27

Student Profile

Figure 22: Performance And Completion Reports

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

To clarify the performance and completion computation that are achieved by the agent, we show the example in Figure 23. In this scenario, the student is late at some stages of development (i.e. Data collecting stage) but the overall research completion time is considerable.

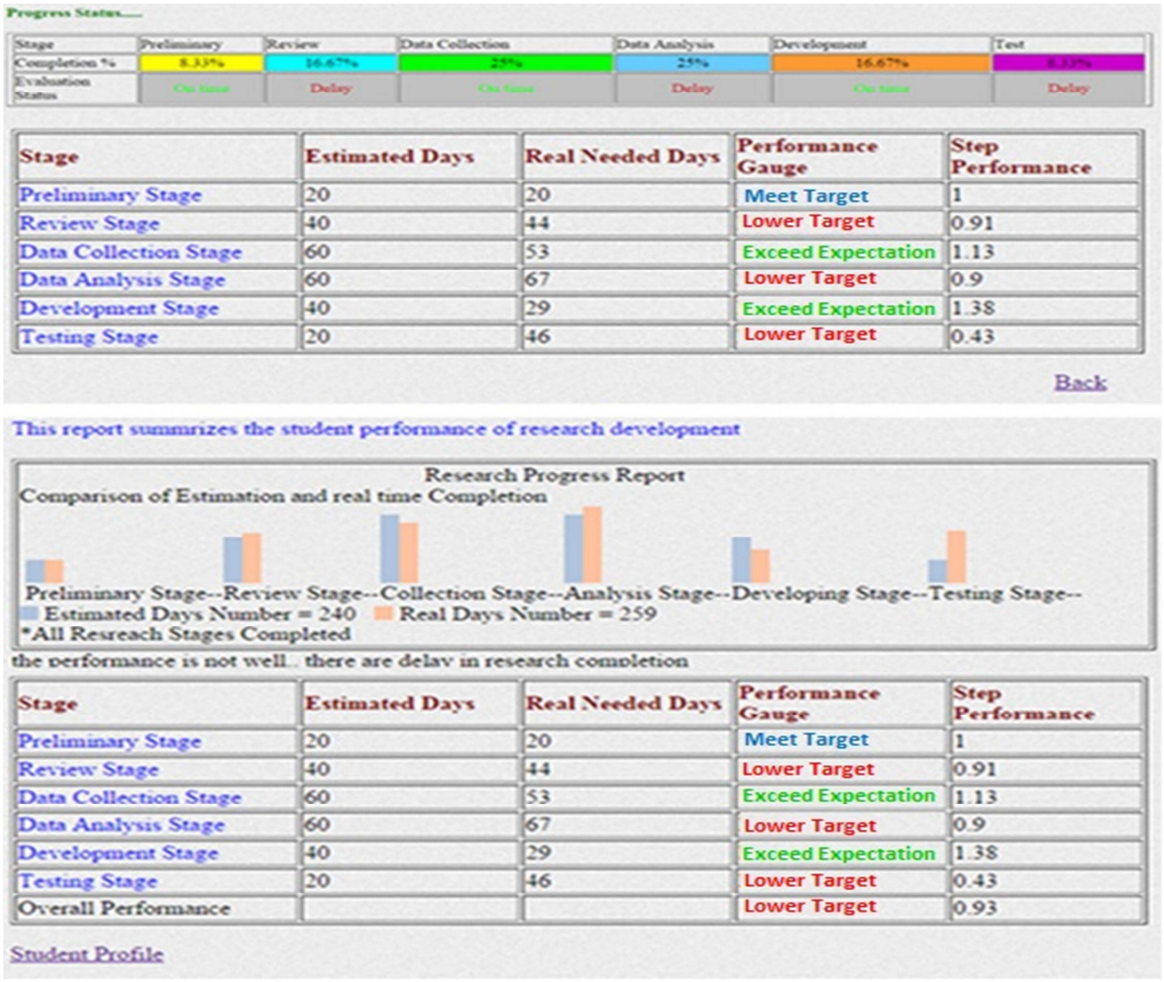
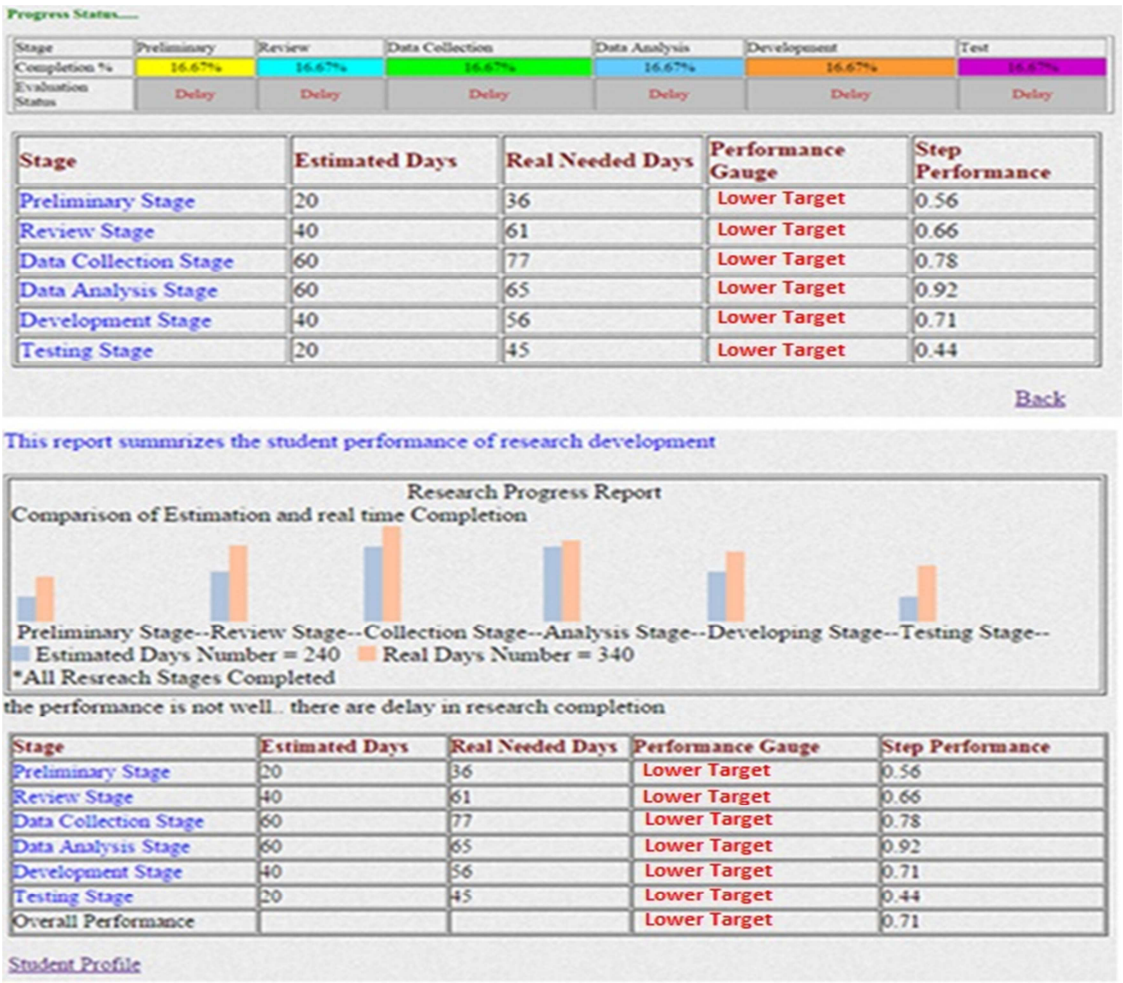


Figure 23: Example #1 On Performance And Completion Reports

On the other hand, in the scenario shown in Figure 24, the student is late in several stages development and the overall research completion time is overdue.

Journal of Theoretical and Applied Information Technology
15th July 2016. Vol.89. No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195


Progress Status.....

Stage	Preliminary	Review	Data Collection	Data Analysis	Development	Test
Completion %	16.67%	16.67%	16.67%	16.67%	16.67%	16.67%
Evaluation Status	Delay	Delay	Delay	Delay	Delay	Delay

Stage	Estimated Days	Real Needed Days	Performance Gauge	Step Performance
Preliminary Stage	20	36	Lower Target	0.56
Review Stage	40	61	Lower Target	0.66
Data Collection Stage	60	77	Lower Target	0.78
Data Analysis Stage	60	65	Lower Target	0.92
Development Stage	40	56	Lower Target	0.71
Testing Stage	20	45	Lower Target	0.44

Back

This report summrizes the student performance of research development

the performance is not well.. there are delay in research completion

Stage	Estimated Days	Real Needed Days	Performance Gauge	Step Performance
Preliminary Stage	20	36	Lower Target	0.56
Review Stage	40	61	Lower Target	0.66
Data Collection Stage	60	77	Lower Target	0.78
Data Analysis Stage	60	65	Lower Target	0.92
Development Stage	40	56	Lower Target	0.71
Testing Stage	20	45	Lower Target	0.44
Overall Performance			Lower Target	0.71

Student Profile

Figure 24: Example #2 On Performance And Completion Reports

10. DISCUSSION

As the results shown in Figure 7, 8, 9, 10 and 11, supervisors using this system are able to create the milestones of a new project effectively and timely. In addition, the duration of the project and each milestone will be specified which enable software agents to take over and monitor the progress. While Figures 12, 13, 14, and 15 show how meeting can be set efficiently by using system interfaces and software agents role in reminding and alerting a student to submit the progress report before the meeting.

Figures 16, 17, 18, and 19 show how communication can be handled and recorded by the system to keep tracking the progress of development. Figure 20 and 21 reveal each task submission process and the list of completed tasks. Finally, Figures 22, 23, and 24 show how the agent exposes the performance level and the expected completion date of a project that potentially help students and supervisors to evaluate the performance and subsequently take necessary actions.

While this system provides number of useful techniques, processes and actions such as research development activities that secure systematic development, interfaces and database that mitigate communication, and multi agent systems to remind, alert and keep tracking a research development progress. Other systems presented by literature only provide communications such as E-mail, forums, and chat rooms [11]. For example AlBar [9] develops an electronic system to improve communication only between the supervision stakeholders. Romdhani et al. [10] develop a supervision system to manage research development activities only that undergraduate students could follow. However, the proposed development processes by Romdhani et al. [10] are static for all students. The supervisor cannot adaptively change these processes.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

11. CONCLUSION AND FURTHER WORK

The significant findings from the literature review show that research development activities could be managed through six main stages; preliminary stage, review stage, data collection stage, data analysis stage, development stage, and testing stage. Each stage contains several tasks that could be selected by a supervisor and a student according to the research's requirements. For example, the preliminary stage can include several tasks (i.e. preliminary study, pilot study, research problem, research objective, research questions, motivation, scope, time plan, and research approaches or methods).

A software agent manages the communication between a supervisor and a student through several activities such as acknowledgement, reminders, alerts, and declarations. Moreover, a student has several tasks to complete such as research tasks; according to an identified development plan, sends messages to his/her supervisor; and follow up the comments and guides provided by his/her supervisor and agent. Additionally, a supervisor also has tasks to complete such as provide comments for his/her student to support tasks and stages development, identifies and updates meeting dates, answers students' messages, and verifies completed tasks and stages.

The various activities of research supervision framework are validated through a survey conducted on 22 experts from Malaysian, Singaporean, and Jordanian universities (i.e. research supervisors in ICT fields). The experts mentioned that the proposed framework activities are adequate, clear, and applicable to manage the research supervision activities in the ICT domain. Consequently, the proposed framework was prototyped as a multi-agent system for research supervision management. The prototyping implementation clarifies the implication scenarios of research supervision management activities which support the proposed framework validation. The prototype results show that the multi-gent system can manage the supervision activities and measure the students' research performance.

In our future work, we shall improve the current research outcome by developing a comprehensive virtual environment of research supervision development using a multi-agent system. There are many suggestions to address this issue which are; (1) allow supervisors and students to manage their meetings and communication using electronic methods such as video conversation, audio and video messages, and online text chatting, (2) allow students to record full tasks and stages records rather than brief reports, and (3) measure students' performance of tasks and stages development in real time and analyze the performance in order to provide automatic recommendation by an agent, i.e. explain students skills weakness and how to improve it.

ACKNOWLEDGMENT

This project is sponsored by Universiti Tenaga Nasional (UNITEN) under the Internal Research Grant Scheme No. J510050546.

REFERENCES

[1] Lee, A. M. (2007). Developing effective supervisors: Concepts of research supervision. South African Journal of Higher Education, 21(4), 680-693.

[2] Mahmoud M. A., Ahmad M. S., Raveentharan J., Kulasegaran Y., and Jassim O. A. A Multi-agent Framework for Funded Research Supervision. The International Symposium on Agents, Multi-Agent Systems and Robotics (ISAMSR 2015) IEEE, 2015.

[3] Kamler, B., & Thomson, P. (2014). Helping doctoral students write: Pedagogies for supervision. Routledge.

[4] PTHE. Patterns and trends in UK higher education 2012.

[5] THE:Trends in Higher Education, The Association of Universities and Colleges of Canada, 2011. http://www.aucc.ca/wpcontent/uploads/2011/05/trends-2011-vol1-enrolment-e.pdf.

[6] Yew, K. T., Ahmad, W. F. W., & Jaafar, J. (2011, September). A framework for designing postgraduate research supervision knowledge management systems. In National Postgraduate Conference (NPC), 2011 (pp. 1-6). IEEE.

[7] Ismail, A., Abiddin, N. Z., & Hassan, A. (2011). Improving the development of postgraduates' research and supervision. International Education Studies, 4(1), p78.

[8] Chiappetta-Swanson, C., & Watt, S. (2011). Good Practice in the Supervision and Mentoring of Postgraduate Students.

[9] AlBar, A. M. (2012). An Electronic Supervision System Architecture in Education Environments. European Journal of Business and Management, 4(8), 140-148.

[10] Romdhani, I., Tawse, M., & Habibullah, S. (2011). Student Project Performance Management System for Effective Final

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Year and Dissertation Projects Supervision. In London International Conference on Education, LICE.

[11] Lubega, J. T., & Niyitegeka, M. (2008). Integrating E-Supervision in Higher Educational Learning. Strengthening the Role of ICT in Development, 4, 351-358.

[12] Itaiwi A. K., Ahmad M. S., Hamid N. H. A., Jaafar N. H., Mahmoud M. A., A Multi-agent Framework for Dynamic Task Assignment and Delegation in Workload Distribution, International Conference on Computer & Information Sciences, 12 June 2012.

[13] Ahmed M., Ahmad M. S., and Yusoff M. Z. M., "A Collaborative Framework for Multi-agent Systems." International Journal of Agent Technologies and Systems (IJATS), 3(4):1-18, 2011.

[14] Ahmed, M., Ahmad, M. S., & Yusoff, M. Z. M. (2011). A review and development of agent communication language. electronic Journal of Computer Science and Information Technology, 1(1).

[15] Jassim O. A., Mahmoud M. A., Ahmad M. S., A Multi-agent Framework for Research Supervision Management. Distributed Computing and Artificial Intelligence, (DCAI' 15), Spain, 3th-5th June, 2015. In Springer's Advances in Intelligent Systems and Computing, Springer International Publishing, Volume 373, 2015A, pp 129-136.

[16] Jassim O. A., Mahmoud M. A., Ahmad M S., A Framework for Research Supervision, Information and Knowledge Management, international knowledge sharing platform Vol 5, No 7, pp. 1-9, July 2015B.

[17] Jassim, O., Mahmoud, M., & Ahmad, M. S. (2015C). Research Supervision Management Via A Multi-Agent Framework. ADCAIJ: Advances in Distributed Computing and Artificial Intelligence Journal, 3(4), 24-35.

[18] Wisker, G. (2012). The good supervisor: Supervising postgraduate and undergraduate research for doctoral theses and dissertations. Palgrave Macmillan.

[19] Ward, A. E. (2013). Empirical study of the important elements in the researcher development journey. Knowledge Management & E-Learning: An International Journal (KM&EL), 5(1), 42-55.

[20] Ahmed M., Ahmad M. S., Yusoff M. Z. M., Modeling Agent-based Collaborative Process, The 2nd International Conference on Computational Collective Intelligence Technology and Applications (ICCCI 2010), pp. 296-305, ISBN:3-642-16692-X 978-3-642-16692-1, 10-12 November, 2010A Taiwan.

[21] Ahmed M., Ahmad M. S., and Yusoff M. Z. M.,, Mitigating Human-Human Collaboration Problems using Software Agents, The 4th International KES Symposium on Agents and Multi-Agent Systems – Technologies and Application (AMSTA 2010), pp. 203-212, Gdynia, Poland, 23 – 25 June 2010B.

[22] Itaiwi A. K., Ahmad M. S., Hamid N. H. A., Jaafar N. H., Mahmoud M. A., A Framework for Resolving Task Overload Problems Using Intelligent Software Agents, 2011 IEEE International Conference on Control System, Computing and Engineering, ICCSCE11,2011.

[23] Mahmoud M. A., Ahmad M. S., Ahmad A., Mustapha A., Yusoff M. Z. M. and Hamid N. H. A. Building Norms-Adaptable Agents from Potential Norms Detection Technique (PNDT). International Journal of Intelligent Information Technologies (IJIIT), 9.3 (2013).

[24] Mahmoud M. A., Ahmad M. S., Ahmad A., Yusoff M. Z. M., and Mustapha A, A Review of Norms and Normative Multiagent Systems, The Scientific World Journal, pp. 1 - 23, 2014.

[25] Mahmoud, M. A., Ahmad, M. S., Yusoff, M. Z. M., & Idrus, A. Automated Multi-agent Negotiation Framework for the Construction Domain. InDistributed Computing and Artificial Intelligence, 12th International Conference. Springer International Publishing, pp. 203-210, 2015.

[26] Thabane, L., Mbuagbaw, L., Zhang, S., Samaan, Z., Marcucci, M., Ye, C., ... & Goldsmith, C. H. (2013). A tutorial on sensitivity analyses in clinical trials: the what, why, when and how. BMC medical research methodology, 13(1), 92.

[27] Blasius, J. (2001). Nicholas Walliman, with Bousmaha Baiche: Your research project. A step-by-step guide for the first-time researcher. KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie, 53(3), 607-608.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[28] Krauss, S. E., Hamzah, A., Omar, Z., Suandi, T., Ismail, I. A., Zahari, M. Z., & Nor, Z. M. (2009). Preliminary Investigation and Interview Guide Development for Studying how Malaysian Farmers Form their Mental Models of Farming. The Qualitative Report, 14(2), 245-260.

[29] Marshall, C., & Rossman, G. B. (2014). Designing qualitative research. Sage publications.

[30] Downing, S. M. (2004). Reliability: on the reproducibility of assessment data.Medical education, 38(9), 1006-1012.