# Research Supervision Management Via A Multi-Agent Framework

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KEYWORD

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

ABSTRACT

*In this paper, we propose an agent-based framework to enhance, control and manage the research supervision process. The proposed framework consists of three phases which are Research Development Activities, Performance and Completion Measurement, and Tracking Activities. The Research Development Activities phase proposes a number of activities to develop a research. 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. Four actors constitute the proposed framework which are, a supervisor, a student, a system administrator and a software agent. Each actor has a role and is authorized to perform specific functions. We discuss the components of the framework as possible implementation for a general application of research supervision management.*

## 1. Introduction

The rate of students' enrolment for postgraduate studies is rapidly increasing [Higher Education in Asia, 2014] [Trends in Higher Education, 2014] [Patterns and trends, 2012]. According to Patterns and Trends in UK higher education [Patterns and trends, 2012], 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 tracking processes for status of different research activities, and last but not least, lack to effective methods to measure students' performance that reflect their real progress.

From the literature, we have not discovered any comprehensive research supervision system that formally manages research activities except some segments of processes that implement research supervision management activities [Yew, 2011] [Ismail et al., 2011] [Swansonet al., 2011] and some software that monitor students' progress [AlBar, 2012] [Romdhani et al., 2011] [Lubega et al., 2008]. To fill this gap, we attempt to investigate and develop a system

that handles comprehensive processes of research supervision management involving supervisors and students with the following capabilities:

- Track the Stages of Research Activities: Tracking the various research activities such as Literature Review, Modelling, Designing, etc., that are undertaken by students. Such tracking reduces the burden of having to remember many research issues (cognitive load).
- Measure Students' Performance: An outcome of this performance measure is a student's progress within a certain period.
- Gauge Students Completion: This estimates when a student would finish his/her research work.
- Housekeeping activities: Such as alert, acknowledge, remind, declare, warn etc., directed to both the supervisors and students.

We postulate that adaptive IT techniques could deliver effective solutions to supplement and enhance the performance of research supervision management activities. Specifically, based on the desired system abilities mentioned above, we propose to utilize intelligent software agents to assist supervisors in managing and monitoring those activities. This paper presents our initial findings of the work-in-progress of this research.

This paper is an extension to our previous work [Jassim et al., 2015A] [Jassim, 2015B] [Mahmoud et al., 2015]. The objective of this project is two-fold: (i) To analyze the most efficient standard of research supervision activities, (ii) To propose a research supervision management framework based on multi-agent systems (MAS). 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

Many researchers have employed agent based-systems as effective tools to improve task management [Hsieh and Lin, 2015] [Itaiwi et al., 2012] [Ahmed et al., 2011]. However, in the domain of research supervision management, the literature do not seem to provide ample support for agent technology application in such domain. Some fragmented attempts have been made on using electronic versions of the domain process but with limited capabilities.

Pearson and Kayrooz [Pearson and Kayrooz, 2004] argued that research supervision is a facilitative process requiring support that involves providing educational tasks and activities which include: progressing the candidature, mentoring, coaching the research project and sponsoring students' participation in academic practices. A defining question which draws the line between facilitation and enculturation model is: "how much responsibility should a student or a supervisor take for arriving at the destination?" Mentoring is a powerful concept in this arena [Pearson and Kayrooz, 2004] [Brew, 2001].

AlBar [2012] proposed an Electronic Supervision System Architecture to build an educational collaborative environment between supervisors and teachers which include several kinds of tasks to perform such as skills development, experience sharing, group meeting and tasks, and discussing about teaching and administrative strategies. Romdhani et al. [2011] presented a student project performance management system developed as an integrated and collaborative online supervision system for Bachelor final year and dissertation projects. The system activities are:

- Development of project proposal.
- Development of the problem description.
- Following the objectives.
- Presenting and analysing the data.
- Drawing conclusions and identifying future work.
- Presenting and defending the work orally.
- Development of the final version of the report.

Yew et al. [2011] proposed a conceptual framework that integrates supervision process, knowledge management (KM) activities, and enabling information technology (IT) for designing such research supervision as a KM System. Swanson and Watt [2011] conducted theoretical reviews on supervisors and postgraduate responsibilities in research in order to provide efficient monitoring of supervision activities. Lubega and Niyitegeka [2008] presented a pedagogical model for E-supervision that is facilitated by the available technology instead of traditional supervision activities such as e-mails, discussion boards, forums, telephony, chat rooms, Wiki, blogs and e-research group.

We discovered that only fragments of efforts have been made that address the issues of research supervision management, as reviewed above. While we do not claim that the review is exhaustive, there seems to be a serious lack of comprehensive models or systems for research supervision management. Consequently, this paper attempts to tease out a comprehensive model for research supervision management based on the multi-agent approach.

Software agents have been widely used to assist humans in complying with the schedules of a collaborative work process [Ahmed M et al., 2011] [Ahmed M et al., 2010] [Itaiwi et al., 2011] and task management applications [Lacouture, 2012]. Consequently, in this research, we exploit the software agent technology due to its autonomous, reactive, proactive and social ability characteristics [Mahmoud et al., 2014] [Mahmoud et al., 2013].

# 3. A Conceptual Multi-agent Research Supervision Management Framework

Initial investigation from the literature reveals six main stages that constitute research development processes which are Basement Stage [Mmuya, 2007] [Blasius, 2001]; Review Stage [Krauss et al., 2009]; Data Collecting Methods [Marshall & Rossman et al., 2006], Data Analysis [Wögerer, 2005] [Waters, 2002] Development Stage [French et al., 2012], and Testing Stage [Wilcox, 2012]. Based on our analysis of these six stages, we synthesize a conceptual framework for an agent-based research supervision management that espouses the six stages.

Figure 1 shows each of these stages that involves numerous steps which are applicable to diverse research scopes. Based on the nature and characteristics of a research, the supervision team selects some of these steps which are applicable to the particular research scope.

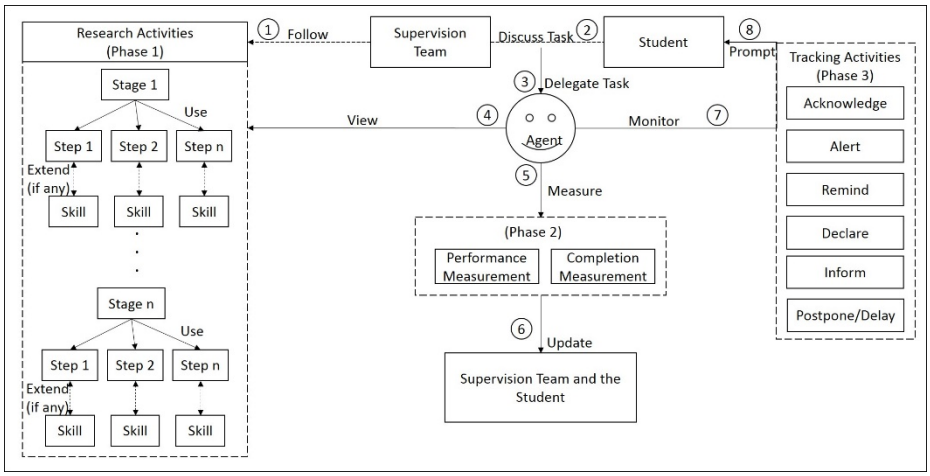


Figure 1: A Framework for Multi-agent Research Supervision Management

As shown in Figure 1, a supervisor or a supervision team (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.

In general, the presented framework consists of three main phases which are Research Development Activities, Performance and Completion Measurement, and Tracking Activities.

## 3.1. Research Development Activities

The literature reveal several activities for research development. We propose that these activities can be divided into two layers; abstract and detail. As shown in Figure 2, the abstract layer consists of six stages, and the detail layer consists of numerous steps. The stages are basement stage, review stage, data collecting stage, data analysis stage, development stage, and testing and validation stage [Blasius, 2001] [Krauss et al., 2009] [Marshall & Rossman et al., 2006] [Waters, 2002] [Thabane et al., 2010].

A supervision team must absolutely follow the abstract layer stages. But it is able to pick up appropriate steps (and not all suggested steps in Figure 2) from the detail layer since the complexity varies from one research to another.

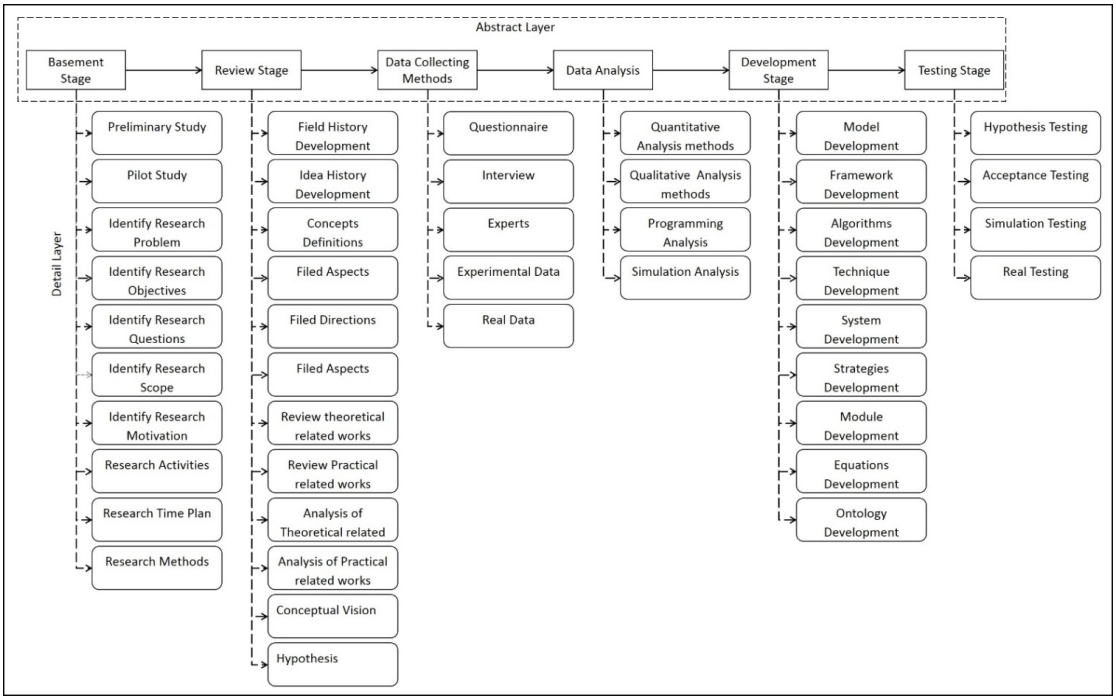


Figure 2: Research Development Activities

## 3.2. Performance and completion measurement

The second phase entails measuring a student's performance of past tasks and measuring the expected completion date. The completion is influenced by performance, if the performance is high, the completion is imminent and vice versa. The 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. However, the details of measurements are beyond the scope of this paper.

## 3.3. Tracking Activities

This phase involves two activities. The first records different tasks and messages between a student and his/her supervisor. The second activity activates and monitors the student's efforts to achieve his/her task within a given deadline. We suggest six actions for this activity as follows:

- Acknowledge: The agent notifies a message sender that the message is sent successfully and received by a recipient.
- Remind: The agent reminds the student regarding a task and the remaining time before the deadline.
- Alert: The agent alerts the student when a deadline is imminent. A penalty token is attached with an alerting 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: The agent declares a message to the student and his/her supervisor when the student fails to comply with a given deadline. For example, the agent declares that "the meeting is cancelled due to failure in submitting the assignment report."
- Inform: This function provides communication between the student and his/her supervisor to share information about a particular matter.

- Postpone/Delay: The student or the supervisor may request to postpone/delay a meeting due to some emergency issues.

# 4. 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.

- Administrator Functions: An administrator has two basic functions which are as follows:
  - Approve: Approves new membership.
  - Unsubscribe: Unsubscribes current membership.

- Student Functions: A student has six functions as follows:
  - Register: Registers with the system and assigned to an agent.
  - Request/Respond: Requests, e.g. extension, from his/her supervisor or Respond 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.

- 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 Respond 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.
  - Cancel Meeting: Cancels a meeting for any some reasons.

- 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 comply with 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 preset when the student fails to submit the progress report before the deadline.
  - Measure Performance: Measures a student's performance of past tasks. 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. However, the details of measurements are beyond the scope of this paper.
  - Measure Completion: The completion is influenced by the performance, if the performance is high, the completion is imminent and vice versa. The details of measurements are beyond the scope of this paper.

Figure 3 shows a use case diagram of all actors and their functions.

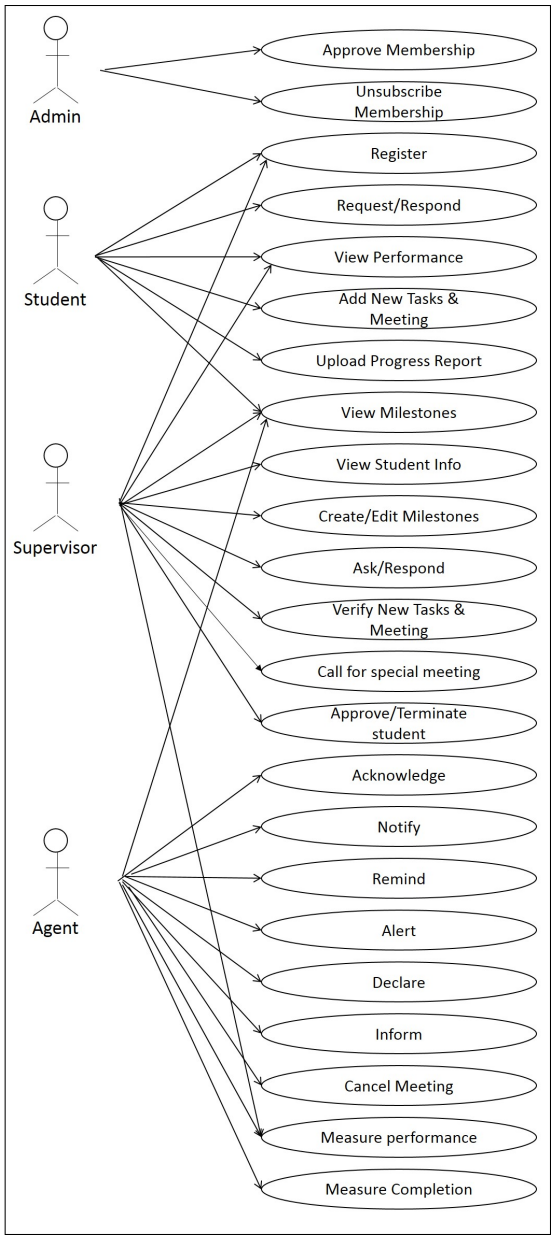


Figure 3 The Actors' Functions

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

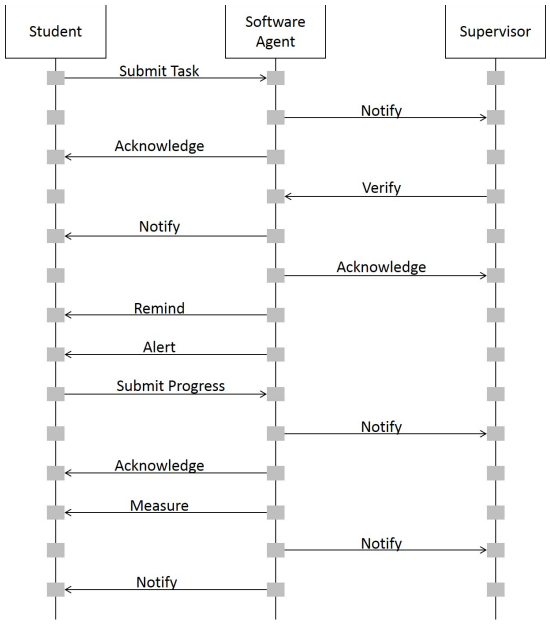


Figure 4 The Sequence Diagram

# 6. Conclusion and Further Work

In this paper, we present our initial findings on our research to develop a comprehensive framework for research supervision management utilizing the multi-agent system's approach to enhance the supervision quality, accurately reveal a student's progress status, and track the activities of a student and his/her supervisor.

Accordingly, the proposed framework introduces three phases; Research Development Activities, Performance and Completion Measurement, and Tracking Activities. Research Development Activities phase proposes 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 second phase entails measuring a student performance and eventually the expected completion date. There are three possible results, Exceed Expectation (EE), Meet Expectation (ME), or Low Expectation (LE). The last phase involves tracking different activities and produce appropriate housekeeping messages. We suggest six actions which are Acknowledge, Remind, Alert, Declare, Inform, and Postpone/ Delay.

In addition, we introduces four types of actors that constitute the proposed framework, a supervisor, a student, a system administrator, and an intelligent software agent. We also present and define the functions of each actor. Our analysis of a typical scenario of a research supervision process reveals that the framework and the actors' functions offer a significant contribution to ease the challenges of research supervision tasks.

In our future work, we shall study the required MAS aspects that animate tasks, e.g. interaction, collaboration, delegation, learning, etc. Subsequently, we shall build an agent-based system simulation model to test the proposed framework and validate its efficiency.

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