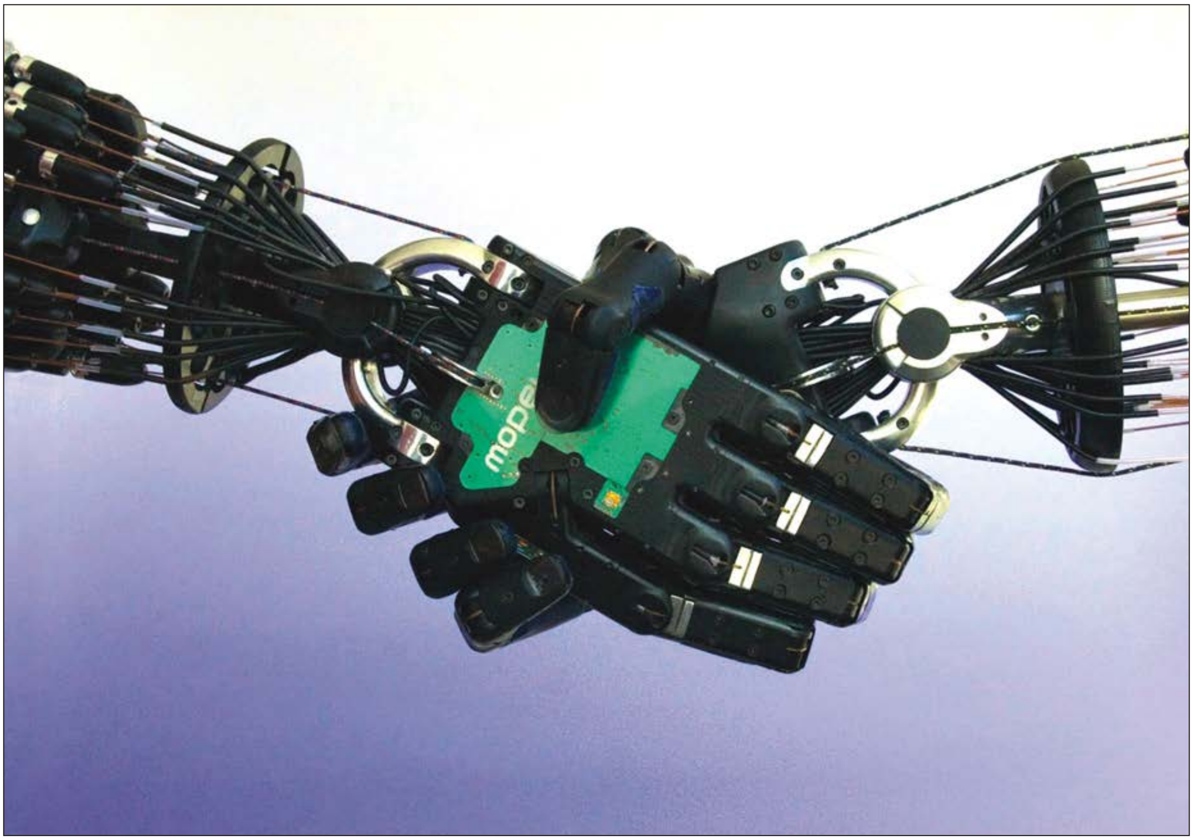

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A Normative Multi-agent Framework for Dynamic Task Assignment and Delegation

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ABSTRACT

The problem of task overload is a major concern for many organizations. This problem is partly due to the continuous enhancement of the organizations' processes that gradually becomes very complex and requires more resources to handle them. Consequently, this paper attempts to resolve this issue by studying and analyzing a workflow problem of an academic faculty in completing the preparation of examination papers within a stipulated deadline. Due to task overload problems, some members of the faculty are unable to submit the documents on time. To mitigate this problem, we propose a multi-agent framework incorporating norms to implement task assignment and delegation. We simulate the system to test the practicality of the normative multi-agent framework and the outcome shows promising results.

Key words: Component, multi-agent systems, normative systems, task assignment, delegation

INTRODUCTION

Processes and workflows in an organization involve tasks that require cooperation and collaboration. There are tasks in a stage of the workflow that are dependent on the previous stage. Failure to complete the activities at a certain stage can cause delays and may lead to failure in meeting critical deadline. To ensure that the workflow runs smoothly, organizations impose specifics rules and guidelines to govern the processes (Skarbek, 2012; Ahmad, 2004). In addition to these rules and guidelines, some organizations also rely on norms in coordinating the tasks (Castelfranchi *et al*., 2000). Norms represent the soft constraints or unwritten rules that regulate the behaviors of role actors in an organization (Barka and Sandhu, 2000).

In many organizations, various plans are executed to avoid delays in task completion. One of the strategies is to decompose and delegate the tasks (Barka and Sandhu, 2000; Ahmad *et al*., 2009). However, in an organization where an individual may be responsible for a few roles and has to complete many tasks, the process of delegating tasks may not be trivial. In many organizations, individuals are organized and grouped based on roles. Based on the assigned role, their tasks and responsibilities vary. As the organization grows, the assigned roles might correspondingly grow and become more complex. In line with this concept, role and task delegation are useful in ensuring that the organizational goal is achieved. In large organizations, the delegation of roles and tasks are complex especially when multiple roles are involved. This creates problems of coordination between different tasks and allocation of resources, which are examples of challenges in this area. Among others, solutions from the literature use norms to address the coordination problem of delegating resources and tasks allocation in organizations (Ahmad *et al.*, 2009; Conte *et al.*, 1999).

Consequently, this paper discusses how norms can be exploited to resolve such coordination problem. We select the domain of Final Examination Paper Preparation (FEPP) for the Diploma Programs at the Faculty of Computer and Mathematical Sciences of Universiti Teknologi Mara (UiTM) for this research project. This involves the discussion on the roles of norms as soft constraint or unwritten rules and guidelines in regulating individuals' behavior to complete their tasks in a selected domain. We then model task delegation process in a normative multi-agent environment and simulate the dynamism of task delegation to achieve some organizational goal.

The objectives of this work are (1) To analyse and develop existing multi-agent systems and the delegation of roles in FEPP systems, (2) To develop and implement a framework for the delegation of roles in cooperative agents for a multi-agent system based on the concept of normative governance and (3) To assess the performance of the cooperative agents in multi-agent systems.

The achievement of these objectives would provide the answers to the following research questions:

- Is the inclusion of the principles of normative governance of individual and society clusters in the delegation of roles in multi-agent systems a valid proposition?
- How one does developed a framework for the delegation of roles based on the above principles?
- Does the inclusion of such principles in multi-agent systems improves agent performance?

This research contributes to the multi-agent workflow process by improving the availability and quality of task performances. The improvement is realized through the use of agents in identifying task overload situation and attempt to reduce the problem through task delegation.

Our contribution in this paper is two-fold. Firstly, we propose a framework for task delegation using software agents. Secondly, we incorporate a normative framework that provides clear indication to humans on the urgency of their scheduled tasks.

RELATED WORKS

In multi-agent systems environment, norms are deployed to facilitate agents' actions which subsequently improve their coordination and cooperation. Norms have been said to increase the predictability of multi-agents' behavior via the compliance of agent actions to the norms. Many frameworks have been developed that show how norms facilitate and regulate agents' rational behavior in multi-agent systems (Ahmad *et al.*, 2009; Conte *et al.*, 1999; Rao and George, 1995; Lopez and Marquez, 2004). They are modeled according to the BDI (Belief-Desire-Intention) architecture. Such agents have the advantage of making decisions similar to human's decision-making (Thangarajah *et al.*, 2008). For example, if an agent needs to choose a task to prioritize, its rational behavior should enable it to choose between a normative goal and its individual goals which are based on its beliefs of the environment.

An autonomous agent with norms is called a normative autonomous agent. Such agent is able to adopt some norms (i.e., norm instances) and select which norms to comply with (i.e., intended norms) and which norms to reject (i.e., rejected norms) (Savarimuthu *et al*., 2005). Conte *et al*. (1999) propose that objects that enter the agent's mental process and interact with its beliefs, aims and plans represent norms. Consequently, the agent is able to decide either to follow or violate a norm and react to norms violation. Normative agents are 'aware' of the enacted norms so much so that they are able to either obey or violate the norms in specific situations (Conte *et al*., 1999), thus enabling them to complete a task within the given duration.

Ahmad *et al*. (2009) developed a normative multi-agent framework called the Obligation-Prohibition-Recommended-Neutrality-Disliked (OP-RND) framework to regulate rules and norms effectively. Their agents perform tasks from a set of pre-compiled tasks based on their beliefs of the reward and penalty associated with the selected tasks. In their work, Obligation, O, is a command imposed by some authority agent. In such environment, an agent is obligated to perform an action, gets rewarded for doing it or penalized for leaving it. They defined Prohibition, P, as a command, which an agent has to avoid an action, hence gets rewarded for leaving it or penalized for doing it. They consider Obligation and Prohibition (OP) as rules imposed by the authority in a normative environment due to absolute consequences (reward or penalty) upon conformation or violation of some action (Barka and Sandhu, 2000). In our work, we exploit the OP-RND normative framework to incorporate it with the workflow and to eventually enhance the system performance.

CASE STUDY

This study is based on the selected domain of Final Examination Paper Preparation (FEPP) process for the Diploma Programs at the Faculty of Computer and Mathematical Sciences of Universiti Teknologi Mara (UiTM). Since the Diploma of Computer Science program is offered in several branch campuses, the common process of FEPP is implemented throughout the faculty. Coordinators for the courses are selected by the Dean among the UiTM's branch campuses that offer the faculty's courses. These coordinators coordinate and prepare the examination questions of assigned courses in 'camera-ready' form before sending them to the examination office at the faculty's main branch. The selection of a branch campus for a particular course's examination paper preparation is done based on the number of experienced lecturers teaching the course. The appointment for each branch campus is valid for two years. The hierarchical relations for the FEPP process are shown in Fig. 1.

The FEPP process starts at the beginning of a new semester. The Dean via the Deputy Dean (Academic) instructs all lecturers to prepare sets of final examination papers. At each of the branch campus, the Program Coordinator (PC) receives the preparation instruction for all the courses under his/her responsibility. He/She extends this instruction to the Course Coordinators (CC). Since each course is offered in more than one branch campuses and to ensure the quality of the questions prepared, the CC informs all Branch Course Coordinators (BCC) at other branch campuses to prepare a set of final examination paper (for a course) as a contribution set. This set consists only of raw questions and solutions and is not formatted as required of the final examination paper. From the contributions sets received from all the branch campuses, the CC and the Moderation Committee finalize three sets. These three sets are then sent to the faculty's main branch before

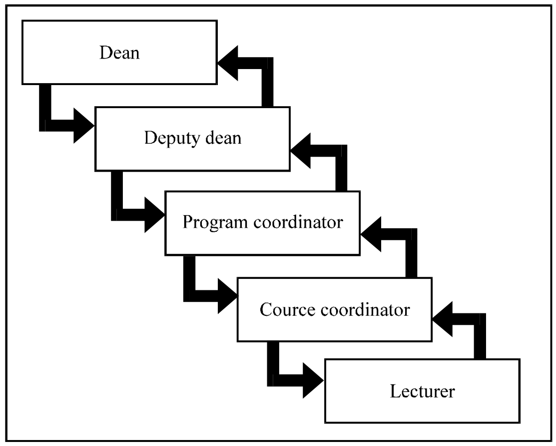

Fig. 1: Hierarchical relations for FEPP process

they proceed to the next step at the examination department. The preparation for other courses' examination papers follows the same instructional and assignment structure.

UiTM's unique FEPP entails several processes, which are considered as norms. These norms form the basic foundation for the FEPP framework. At the beginning of each semester, every lecturer is aware that they have to prepare questions for the final examination:

- The duration for preparing examination questions depends on instruction from higher management, which might be issued on the first day of the semester or later
- The CC must also get the examination sets from other branches through the BCC of other branches (society cluster's norm)
- The BCC/CC divides the task of preparing the questions based on the syllabus and format among other lecturers (L) who teach the same subject
- The BCC/CC gets the examination questions from L and compiles them
- The BCC may submit the examination sets directly to the CC (without sending through the PC)
- The BCC may submit the examination set through the PC, who submits to CC
- If only one lecturer, who is also a BCC/CC, teaches the course, he/she prepares it alone
- If more than one lecturer teaches one course, the BCC/CC delegates the task among the other lecturers

While some of these norms are entrenched within the processes of the FEPP framework, some other norms could be improved, especially in the process of task assignment, delegation and examination paper submission.

FINAL EXAMINATION PAPER PREPARATION (FEPP) FRAMEWORK

Due to the many number of preparation tasks (i.e., two or three courses) that each lecturer receives from his/her Course Coordinators, they may not be able to avoid delays in completing their tasks. However, since they are required to submit their papers before the deadline, they are obliged to collaborate among themselves. To model such collaboration, our framework considers the relations between software agents and their human counterparts with other humans and their agents. An overview of our framework is shown in Fig. 2. Figure 3 shows

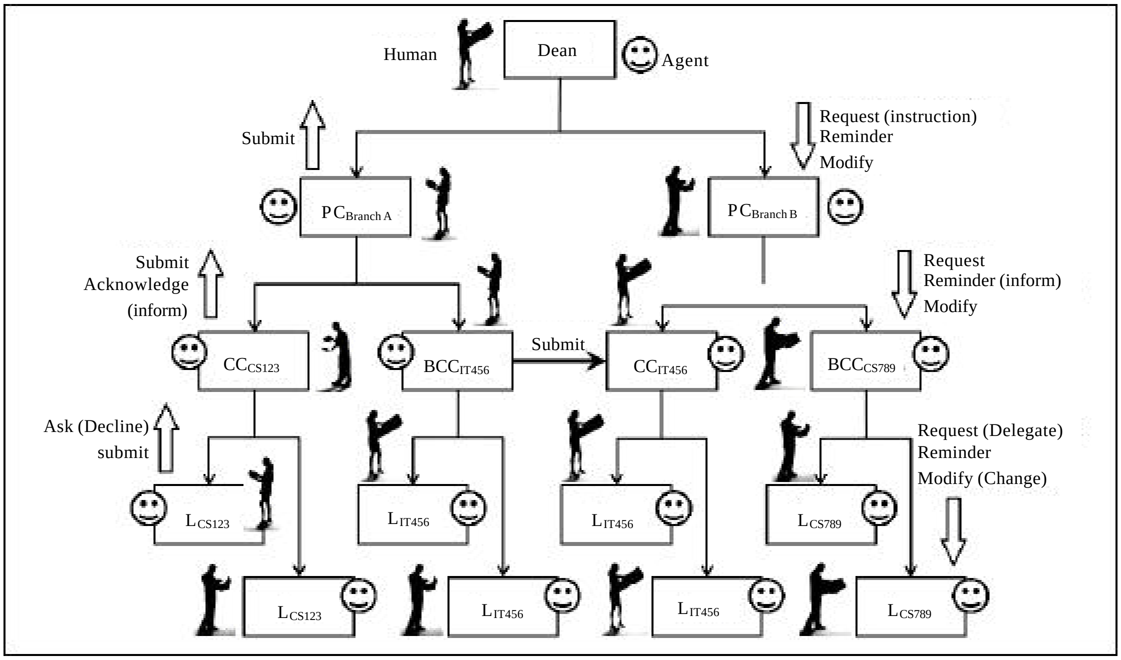

Fig. 2: Agent-based FEPP framework

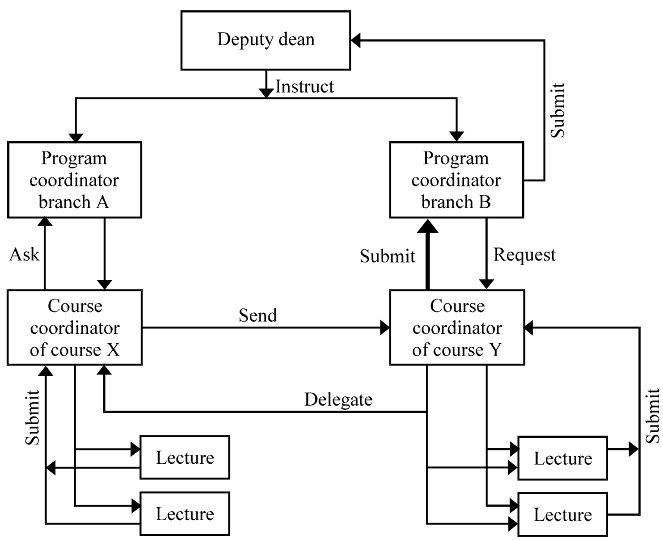

Fig. 3: An instance of the agent-based FEPP framework

an instance of the framework for a particular course's examination preparation. We call the group of lecturers who prepares a particular course's examination paper as a society cluster.

The operation of the framework is based on the symbiosis between humans and their agents. Humans mainly perform the offline task of examination paper preparation while their agents continuously monitor the states of the environment to which they autonomously respond. Specifically, the agents perform common mundane actions such as alerting humans to complete the task, reminding imminent deadlines, forwarding completed documents to the right destination and all other actions that are necessary to achieve the FEPP's goal. With such functions given to the agents, the humans can ignore the deadlines of documents' submissions and their destinations. Alerting service provided by the agents ensures continuous reminder of the deadlines. The agents then submit the documents automatically to the intended recipients when humans upload the documents to his/her folder. All these events are recorded in an event log file as part of the agents' environment for tracking the process flow.

INCORPORATING NORMS IN DELEGATION

In the examination paper preparation process, the norm is to complete the preparation and submit the paper before the deadline. However, task overload problems cause norms violation when some examination papers are not submitted by the deadline.

With task delegation and norms incorporated in a multi-agent system, such problem could be avoided. We exploit Ahmad *et al.* (2009) work on the OP-RND normative framework, which suggests that a rule is a mutually exclusive state of Obligation, O and Prohibition, P, imposed on an agent. Figure 4 shows an abstraction of the OP-RND framework from Ahmad *et al.* (2009).

The domain discussed in (Ahmad *et al.*, 2009) is suitable for our main objective of enhancing the performance of FEPP's workflow. Consequently, we incorporate their normative framework in our domain with some required modifications which are appropriate to our work. While the FEPP process entails similar conditions and parameters associated with the deadlines, we incorporate the idea of rewards and penalties that are imposed for norm compliance and violation. There are two reasons for deploying the OP-RND framework:

- The OP-RND framework provides a clear delineation or boundary of normative performance of humans and agents based on the Recommended, Neutrality and Disliked periods
- The RND periods can be specified or adjusted according to the abilities of the performers given all the necessary resources

If α is an agent, δ is an action, Ω is a reward, Π is a penalty, Γ is neutral (no reward and no penalty) then according to (Ahmad *et al.*, 2009):

- O is a state in which an agent must perform an action and is rewarded for doing it but penalized otherwise:

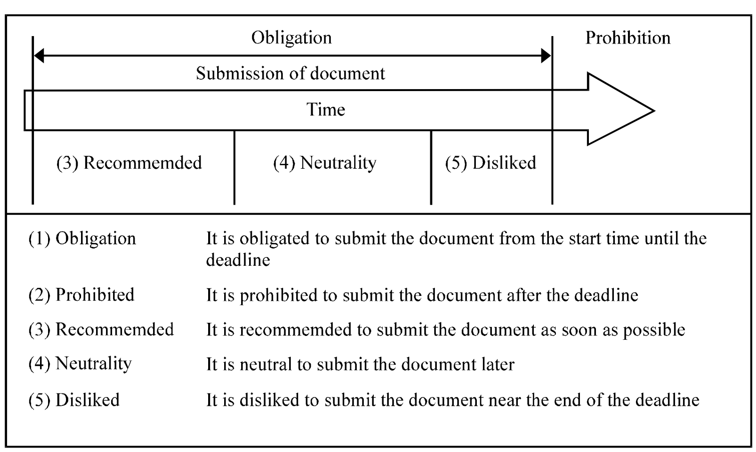

Fig. 4: OP-RND framework (Ahmad *et al.*, 2009)

$$O: perform(\alpha, \delta) \rightarrow \Omega(\alpha) \wedge avoid\ (\alpha, \delta) \rightarrow \Pi(\alpha)$$

- P is a state in which the agent must avoid an action and is rewarded for leaving it but penalized otherwise:

$$P: perform(\alpha, \delta) \rightarrow \Pi(\alpha) \wedge avoid\ (\alpha, \delta) \rightarrow \Omega(\alpha)$$

A norm is a mutually exclusive state of Recommended, R, Neutrality, N and Disliked, D, where:

- R is a state in which the agent is rewarded for performing an action but is not penalized otherwise

$$R: perform(\alpha, \delta) \rightarrow \Omega(\alpha) \wedge avoid\ (\alpha, \delta) \rightarrow \Gamma(\alpha)$$

- N is a state in which the agent is neither rewarded nor penalized for performing or avoiding an action

$$N: perform(\alpha, \delta) \rightarrow \Gamma(\alpha) \wedge avoid\ (\alpha, \delta) \rightarrow \Omega(\alpha)$$

- D is a state in which the agent is rewarded for avoiding an action but is not penalized otherwise

$$N: perform(\alpha, \delta) \rightarrow \Gamma(\alpha) \wedge avoid\ (\alpha, \delta) \rightarrow \Omega(\alpha)$$

Normative governance in FEPP framework: Due to the task overload problem, the FEPP workflow occasionally encounters delays. Since the lecturers need to collaborate in preparing the contribution sets in limited time, failure to complete the task leads to failure to meet the deadline. Hence, this overload problem of the FEPP and personal goals (i.e., other responsibilities of the lecturers) demand the delegation of tasks with normative governance.

The implement the normative governance, we incorporate the OP-RND in the FEPP framework at the lecturer's level. To concur with the OP-RND framework's terms, we called the examination paper submission as the normative goal, G_N, which needs to be achieved by the given deadline. At the same time there are other goals, which we called the personal goals, G_P, based on each individual lecturer's obligation such as performing administration tasks, marking quiz papers, attending meetings and so on. In this case, both G_N and G_P need to be arranged within two weeks based on the OP-RND framework (Joeris, 2000).

The OP-RND normative framework implements the normative governance for our agent-based FEPP framework as follows:

- We propose the Recommended Period, P_R, for an agent, α, to motivate or urge a lecturer, L, to complete his/her task, T, within the Recommended period slot ($P_R = S_1$), to get a reward, Ω

$$P_R: Complete\ (L, (T \leq S_1)) \rightarrow get(\alpha, \Omega)$$

- We propose the Neutrality Period, P_N, for an agent, α, to alert a lecturer, L, to complete his/her task, T, within the Neutrality period slot ($P_N = S_2$), to avoid a penalty, Π, but no reward

P_N: Complete (L, ($S_1 \leq T \leq S_2$))→get(α, Γ)

- We propose the Disliked Period, P_D, for an agent, α, to inhibit a lecturer from such delay in the future that effectively subject the FEPP to high risks as this process is associated with students' examination schedule. In this period, the lecturer completes his/her task, T, within the Disliked Period slot ($P_D = S_3$) and incur a penalty, Π

P_N: Complete (L, ($S_2 \leq T \leq S_3$))→get(α, Π)

In this work, the reward and penalty actions are given points (+1, 0, -1). Completing the task in the following periods, incur the corresponding points:

- In the Recommended Period, P_R, a lecturer receives +1 point, reward (Ω = +1)
- In the Neutrality Period, P_N, a lecturer receives 0 point, Neutrality (Γ = 0)
- In the Disliked Period, P_D, a lecturer receives -1 point, Disliked (Π = -1)

Figure 5 shows the three periods, the green area represents the recommended period, in which a lecturer receives +1 point. The blue area represents the neutrality period, in which a lecturer receives 0 point and the red area represents the disliked period, in which a lecturer receives -1 point. The figure also shows the black area, the Prohibited Period (P_P), which this research attempts to resolve.

Normative process with delegation: We use the norms with delegation in our framework as an interesting prospect to improve the cluster's predictability. Since time is very important for the lecturers, they need to help each other by cooperating between the group members to gain time and get the rewards.

Since we have two weeks for each lecturer to submit his/her tasks, the agent always recommend submitting in earlier time. Therefore, if the lecturer has more than three tasks (i.e., preparing examination papers for four courses), he/she should request the CC to delegate one of the courses:

delegate (L, T)⇔T>3

His/her agent calculates the duration, μ, for preparation from the moment the request is made to the CC to request for delegation or to increase his/her efforts, F, by doing his/her best to submit in the Recommended or Neutral period:

μ: calculate (α, (T>3)⇒suggest (α, (delegate (L, T)∨increase(L, F))

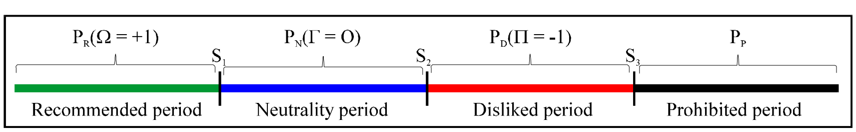

Fig. 5: Normative periods

FEPP-OP-RND FRAMEWORK MAPPING

According to the OP-RND framework, we need to set the duration of each of the Recommended, neutrality and disliked periods for task submissions. UiTM sets the Obligation for completing the final examination paper preparation to 15 days (Ahmad *et al.*, 2009). We propose the first six days (S_1 = 6 days) as the Recommended period. Assume that a lecturer gets the maximum average of the tasks (e.g., three tasks). If he/she gets more than three, his/her agent will request for delegation. Hence, he/she can complete each task in two days and submit all the three tasks in six days. Therefore, he/she can submit in the Recommended period and get the reward point.

We propose the second six days (S_2 = 6 days) as the Neutrality period, considering that the lecturer has to complete some other tasks (i.e., their personal goals) together with the FEP and he/she still has time to submit before the Disliked period. We propose the Disliked period within the last three days (S_3 = 3 days) before the submission deadline. As for the Prohibition period, it is set immediately after the deadline. Figure 6 shows the mapping of our FEPP Framework to the RND periods.

The norms obligation in our multi-agent system gives the expected time to complete the task for humans and this is based on the number of tasks received by the agent by using the formula below to calculate the number of tasks:

$$X_i = \sum_{i=0}^{n} Y_i$$

where, i = 1..., n, X_i is the task counter and Y_i represents the number of preparation tasks that a lecturer has been assigned to from a Course Coordinator.

For each lecturer, a counter counts the number of tasks he/she gets when a Course Coordinator assigns the tasks to the lecturers. The agent calculates the maximum number of days for each task based on the normative periods and on this basis determines the number of days needed by the lecturer to complete the task by relying on the following formula:

$$V_Q = X \times Q$$

where, Q is the number of days for each task (average achievement) and V_Q is the value of V based on Q. where V is the expected number of days. Then:

$$Q = V_Q/X$$

If R is the actual value of average achievement by a lecturer, V_R is the value of V based on R, then:

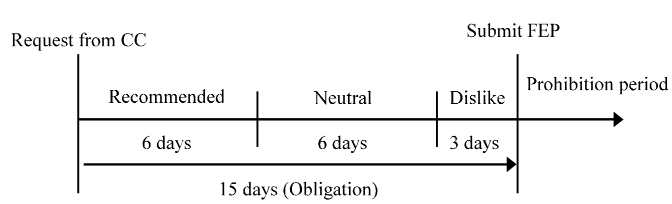

Fig. 6: FEPP mapping with OP-RND framework

$$V_R = X \times R$$

$$R = V_R/X$$

From Q and R:

$$Q \geq R \Rightarrow get(L, \Omega)$$

where, the value of Q is less than or equal to R, the lecturer gets a reward:

$$Q < R \Rightarrow lose\ (L, \Omega)$$

otherwise the lecturer loses the reward, for example, if a lecturer has three tasks and the reward period based on the framework is 6 days. Then:

- $V_Q = 6$ days
- $X = 3$ tasks
- $Q = V_Q/X$
- $Q = 6/3 = 2$

Assume that the lecturer completes the preparation in $V_R = 5$ days. Then:

- $V_R = 5$ days
- $X = 3$ tasks
- $R = V_R/X$
- $R = 5/3 = 1.66$

Since Q>R, then the lecturer gets a reward.

The agent compares it with the UiTM's norms Obligation period by using the Boolean operator '≥' (greater than or equal) and '≤' (less than or equal) on the above formula, Table 1 shows the UiTM's Obligation norms.

TESTING THE NORMATIVE FRAMEWORK

We implement the normative OP-RND framework with Delegation in our system using Win-Prolog and its extended module Chimera (Joeris, 2000). When the FEPP starts to exchange messages between the agents and requests to prepare the final examination paper, for each task, the agent calculates and shows the R, N or D periods in which the submission is possible so that it helps the human to increase his/her ability to submit at an earlier period. The message appears to the humans as in Fig. 7.

Table 1: UiTM Obligation norms

Period	Norms
V≤6	Recommended
V≤12	Neutrality
V≤15	Disliked
V>15	Prohibition

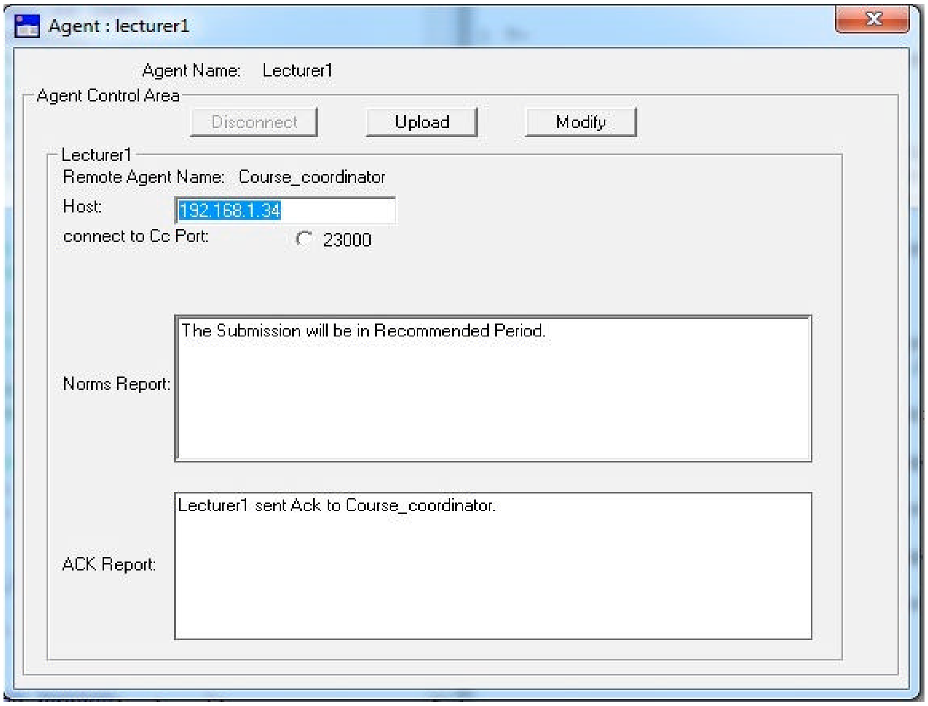

Fig. 7: Norms report 1

If the lecturer has two tasks, the agent allocates each task the maximum time to complete it, which is five days. So for two tasks, the lecturer needs 10 days to complete them and that allows him/her to complete in the Neutrality period. Therefore, the agent informs the lecturer to increase his/her ability to complete it in less than six days to be in the Recommended period (Fig. 8). If the lecturer has three tasks, he/she needs 15 days to submit the FEP. Then, the agent indicates to the lecturer to submit in the Recommended to gain reward or Neutrality period to avoid penalty as in Fig. 9.

The lecturer submits in the Prohibited period if he/she has more than three tasks because he/she needs more than 15 days. In this case, the agent requests for delegation and changes the status from Prohibited period to Request for Delegation as shown in Fig. 10.

ANALYSIS OF RESULTS

Table 2 below shows the number of preparation tasks assigned to each lecturer, (L1-L3), before and after the delegation for seven simulation runs, (S1-S7). The intersections of columns L1-L3 and rows S1-S7 (where L is a lecturer and S is a simulation run) are the number of preparation tasks assigned to the corresponding lecturers (both before and after delegation). For example, at S6, L1 and L3 are assigned four tasks before the delegation.

Table 3 below shows the number of successful submissions from each lecturer before and after the RND for seven simulation runs (S1-S7 from Table 2). The intersections of rows and columns are the number of successful submitted tasks in the corresponding periods for each lecturer, LI, L2 and L3 based on Table 2 (both before and after RND). Each column contains seven runs, for example, L1 during the seven runs has submitted twice in the Recommended, Neutral, Disliked periods and once in the Prohibited period.

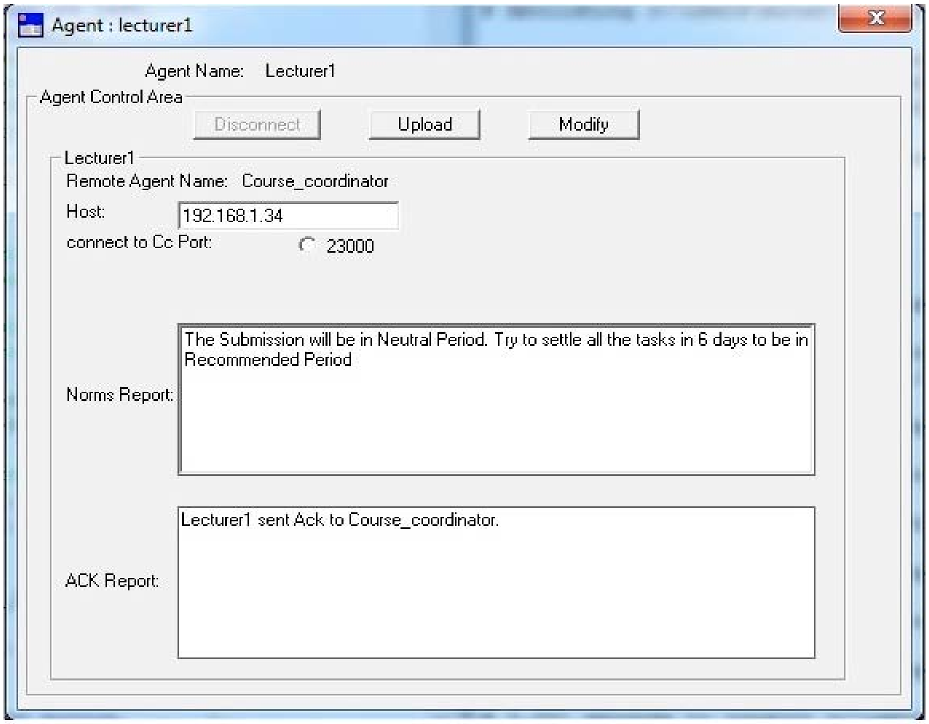

Fig. 8: Norms report 2

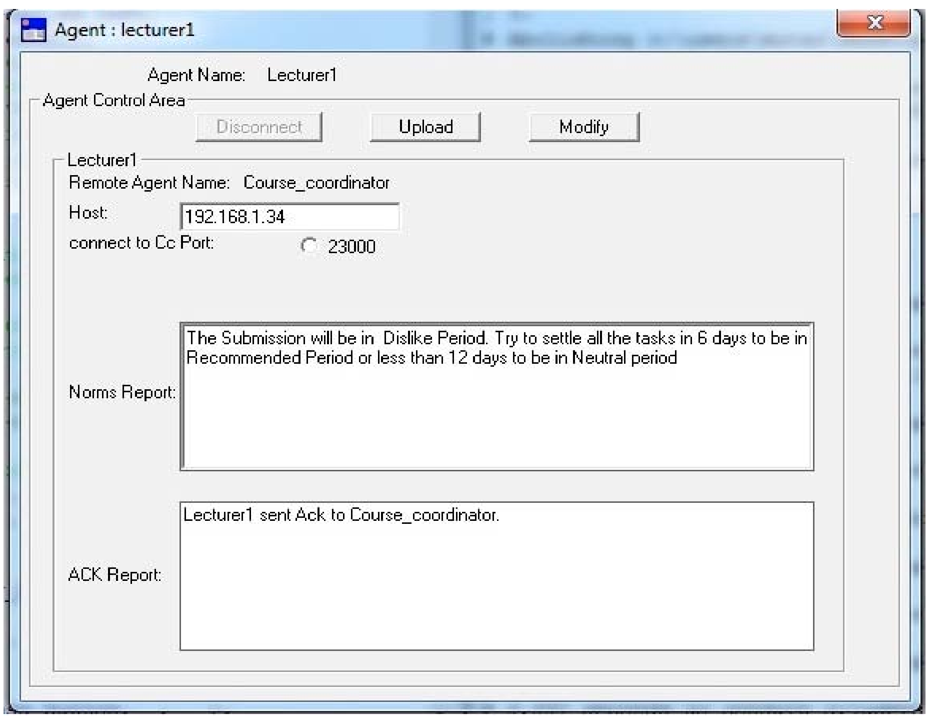

Fig. 9: Norms report 3

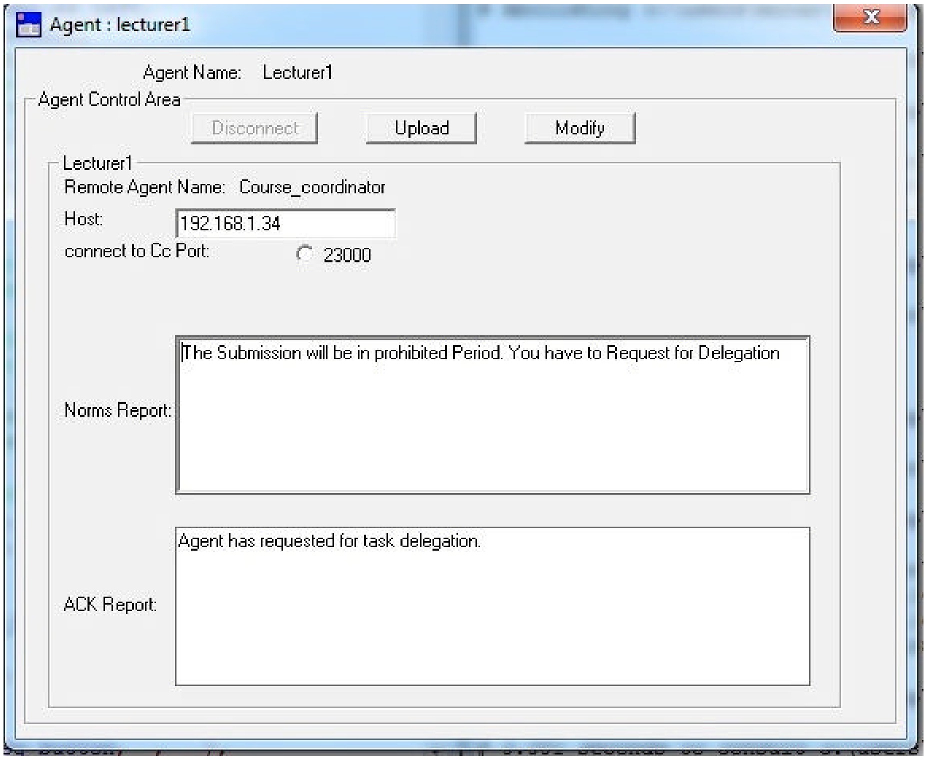

Fig. 10: Norms report 4

Table 2: Distribution of tasks before and after delegation

	Before delegation				After delegation		
Sim. run	L1	L2	L3	Sim. run	L1	L2	L3
S1	3	2	3	S1	3	3	3
S2	3	3	3	S2	3	3	3
S3	3	2	2	S3	3	2	2
S4	2	1	1	S4	2	1	1
S5	2	2	3	S5	2	2	3
S6	4	3	4	S6	4	3	4
S7	3	3	4	S7	3	3	4

Table 3: Distribution of submissions before and after RND

	Before RND					After RND			
Normative period	L1	L2	L3	Percentage	Normative period	L1	L2	L3	Percentage
R	2	2	1	23.81	R	3	2	2	33.33
N	2	3	1	28.57	N	2	3	3	38.10
D	2	2	3	33.33	D	2	2	1	23.81
P	1	0	2	14.29	P	0	0	1	04.76
No. of runs	7	7	7	100.00	No. of runs	7	7	7	100.00

Before RND (R = 23.81%, N = 28.57%, D = 33.33%, P = 14.29%), After RND (R = 33.33%, N = 38.10%, D = 23.81%, P = 4.76%). The R percentage (23.81%) is calculated as follows: The successful submissions for 3 lecturers as shown in Table 3 = 2+2+1 = 5, Total submissions for 3 lecturers = 7+7+7 = 21, Percentage value of achievement = (The successful submissions/Total submissions)*100 Percentage value of achievement = (5/21)*00 = 23.81%

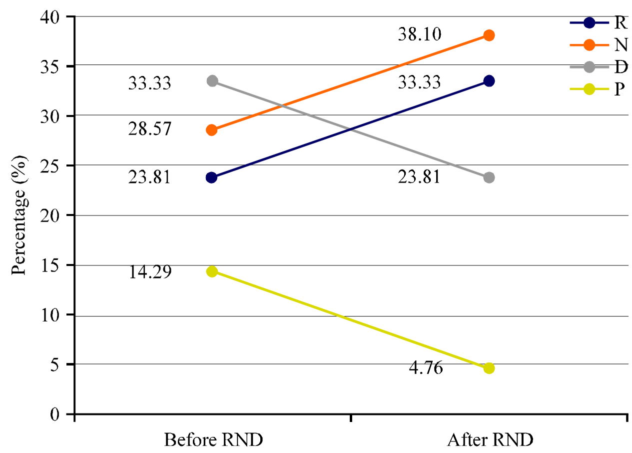

Fig. 11: Percentage of submissions before and after RND

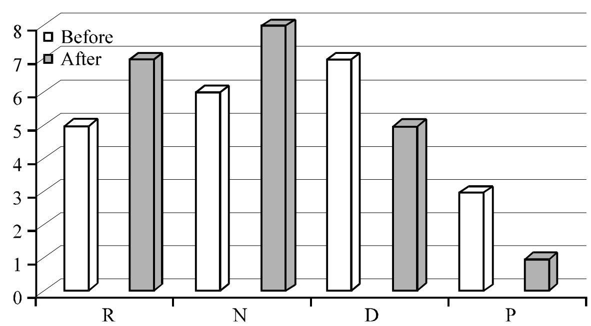

Fig. 12: No. of submissions in each period for 3 lecturers before and after RND

We calculate the percentage value of successful submission as follows:

$$\text{Percentage value} = \frac{\text{The successful submissions}}{\text{Total submissions}} \times 100$$

As shown in Table 3, the distribution of submissions before and after RND shows that submissions in the Recommended periods are achievable in five tasks before RND for three lecturers, in contrast to seven submissions achieved by the same three lecturers after RND. Within the Neutrality period, the achievement increases from six submissions before RND to eight submissions after RND. While in the Disliked and Prohibited period, lecturers managed to decrease the submissions from seven to five and from three to one, respectively.

Figure 11 shows the percentage of submissions for each period before and after RND. The percentage of submissions in the Recommended period increases from 23.81 to 33.33%. In the Neutrality period increases from 28.57 to 38.10%, while in Disliked period it decreases from 33.33 to 23.81% and in Prohibited period, it decreases from 14.29 to 4.76%.

Figures 12 shows the number of submissions in each period for three lecturers before and after RND.

CONCLUSION AND FURTHER WORK

Educational institutions face numerous administrative problems in meeting academic obligations and assigning workload to lecturers for examination paper preparation is no exception. While other AI techniques have been applied to resolve task scheduling problems, we have contributed here a novel technique of conflict resolution involving the distribution of workload in examination paper preparation. In this technique, a multi-agent system is deployed to enable intelligent software agents to assist humans in augmenting the workflow process by performing mundane tasks of message and document passing between agents for humans and within a society. Clusters of such individuals and societies operate and collaborate to determine a fair distribution of workload by delegating tasks to lightly loaded individuals.

We incorporate a normative framework that provides clear indication to humans on the urgency of their scheduled tasks. In this framework, humans are well-informed about the status of their deadlines when their agents alert and remind them of impending deadline breach based on the three normative periods allocated for each task.

We also demonstrate the role of norms in coordinating agents' behavior in a multi-agent system. In the context of FEPP, the integration of norms with a multi-agent system helps to improve humans' collaboration and teamwork quality in performing their tasks which is submitting completed examination papers within the stipulated deadline. The utilization of norms and effective delegation strategy enables the system to produce a fair distribution of workload by delegating tasks to lightly loaded individuals. However, while agent-based technology such as this could provide humans with the tool to improve performance by providing information and performing the necessary actions, the ultimate success is only achieved by the due diligence of humans in completing their part of the work within the stipulated deadline.

In summary, results from the study provide some evidence on the significance roles played by norms within a multi-agent syste m especially for the coordination and regulation of agents' behavior. In our future work, we shall investigate the emergence of emotions within the normative workflow process and identify emotive functions to further augment the performance of humans and agents.

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