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Towards Collaborative Master Student Talent Development with E-CARGO Model

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Abstract: Education for master student is being paid great attention by colleges and universities due to its special role in high quality service to the society and great support to academic research. Unlike the undergraduate students, master students have individually different career path and the talent development should be conducted accordingly. This study proposes a collaborative talent development model to develop the professional skill of master students. In such model, master students and undergraduate students take different but coupling development activities in several R and D projects. Hierarchical talent development is realized when mentors guide master students and master students guide undergraduate students. During the collaborative talent development, some projects may have insufficient resource allocation if related students are mistakenly allocated in multiple projects for a special time slot. When too much work is assigned to some students, they may work overtime, which is not good for either the software quality or the talent development. Two algorithms based on E-CARGO model are described in this study to indicate the project resource lacking risk and the student overworking.

Key words: Individually training, professional skill, undergraduate student training, career paths

INTRODUCTION

Education for master student is being paid great attention in China. On one hand, master students typically have higher professional capability and will contribute more for society and master student can support the mentors and universities to do some academic research work and speed the research significantly. Similar as the case in oversea universities (Patterson, 2009) the colleges and universities in China attach importance to their master student education and are willing to support the related education with sufficient budget and excellent mentors. On the other hand, due to the large impact of worldwide economic crisis, most Chinese undergraduate students are facing serious employment pressure and will try to apply for graduate education.

Unfortunately, the scale of master student enrollment keep at a high level and the financial support from universities turns out to be insufficient except those 211 works of key universities in China. As a result, lots master students don't have sufficient training experience and don't have expected professional capability in the competitive employment market. Some survey in China indicated that some undergraduate college students are easier to find their job than those graduated students from university.

In order to efficiently develop the professional skill of master student, study program can be well recognized (Berztiss, 1979). Some large companies such as Bell Laboratories may have related policies to extensively utilize master's programs at universities for the continuous education of their employees. Some researchers found that continuing studies at the master's level benefited hiring and retaining personnel and facilitated the dissemination of new technology through the organization (Lunetta, 1977). Programmers would acquire new knowledge from others; periodic influx into an organization of master's program is essential if the organization would like to retain technical soundness (Fisherr *et al*., 1978).

Multi-level education for master students was suggested by Pasko and Adzhiev (2009) and different major paradigms in computer graphics have been proposed. Pasko and Adzhiev (2009) also mentioned that the motivation of involving qualified students in the R and D process.

Aware about the impact of declining funding sources for courseware to classroom education for many institutions, Internet-based student software project management was proposed (Rodgers, 2005). The proposal turned out to be cost-efficient and could serve as alternative to a commercial, network-based project

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management environment. Related works have also been done by the authors on online education with Moodle-based E-learning system (Xu, 2008a, b, 2009).

Though involve master student in software projects or even R and D process will be an efficient method for the talent development, the students may face the techno-stress (Tu *et al*., 2005) and they should know some fundamental concept and skill before joining a large project (Mukherjee, 1997).

Collaboration is essential for software projects and several researches have been done to facilitate the collaboration, including the E-CARGO model proposed by Zhu (2006a, b). Zhu and Zhou (2008) also proposes related methods to support multi-agent system (Zhu, 2006b, 2007) and role transfer (Zhu and Zhou, 2006). The authors had ever adopted E-CARGO in SOA architecture and found that it facilitate the coupling decomposition significantly (Xu *et al*., 2008). E-CARGO may also be used in modeling some collaboration systems, as what the authors have done in establish a talent development system for undergraduate education (Yu *et al*., 2009).

Here, in this study, the authors would like to introduce the background of master student talent development in College of Computer and Information Engineering, Zhejiang Gongshang University, Hangzhou, China. The difficulties and the practice vision will be mentioned. After that, a collaborative model will be presented to deal with the problems and achieve the talent development goal. E-CARGO will be used as the modeling method to demonstrate the collaborative talent development model for master students.

TALENT DEVELOPMENT SITUATION FOR MASTER STUDENTS

There are two major goals in master student education: one is to develop their professional software development skills including complex system requirement analysis, large system design and software validation. Another is to develop their management skill including large project scheduling, team communication, cost estimation, project tracking and evaluation.

There are nearly 100 teachers in our college and they lead several strong mentor groups. The master students are expected to join some real projects to enhance their professional skills by finishing the software design, component development and software testing.

With the support from mentors, the master students have been provided with sufficient research resource and each of them has their own computer and fixed office space. However, the undergraduate students don't have sufficient chance to join the R and D projects and only some excellent ones may join the research team. Typically the ratio of teacher, master student and undergraduate students is nearly the same in a typical research group in our college. In such situation, the master students don't have much chance to develop their management skill as there are only few undergraduate students they can direct. Besides, they don't have time to enhance their professional development skill as they should spend much time to finish detail wok such as coding, unit testing and some functional test.

This study is to propose an effective and efficient model to enhance the professional skill development of master students. In order to achieve this goal, more undergraduates should be arranged to join the research group but they must attend the research via a WEB-based collaborative system due to the limitation of equipment provided in our college.

COLLABORATIVE SKILL DEVELOPMENT FOR MASTER STUDENTS

Role-based collaboration model E-CARGO (Fig. 1) is introduced by Zhu (2006a, b) to establish the development/business environment as a role net. Each role provides a certain services and applies a certain services in the proposed role net.

Role based collaboration and its kernel mechanism were introduced by Zhu (2006b). E-CARGO is helpful to build a more efficient collaborative system, e.g., roles can be regarded as agent dynamics in multi-agent systems (Zhu, 2007). Role transfer in emergency management systems and related solution has been proposed by Zhu and Zhou (2008) which is also a regular activity in education management and can be adopted in resource replacement when there is lack of some key resource.

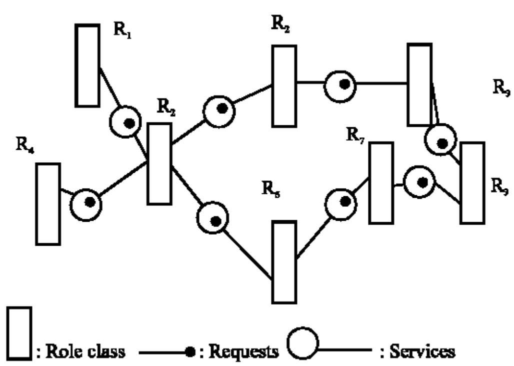

Fig. 1: Demonstration of E-CARGO role net (Zhu, 2006a; Zhu and Zhou, 2006)

There are kinds of relationships in collaborative talent development program for master students, including the relationships among students, between students and mentors, between different mentors and among R and D groups, equipment and projects. According to the E-CARGO model, all the personnel can be modeled as agents, positions such as student, professor, technician and staff can be modeled as roles and the tasks in R and D projects can be modeled as services, the equipment and the deliverables can be modeled as class/object data. The detail definitions are provided as follows.

Definition 1: Role. A role is the service template. A role is defined as:

r::=<id, ca, ratio, S>

Where:

id = The identification of the role r

ca = The catalog of role, there are four different roles considered in this research work, including mentors, graduated students, senior undergraduate students and junior ones

ratio = The ratio of available time role r should contribute to the R and D projects

S = A set of services provided by role r

As shown in Table 1, there are mentors, master students, senior undergraduate students (excellent undergraduate student at the lab.) and junior undergraduate students (virtually attend the R and D project via WEB system).

R and D projects are led by mentors and managed by master students. The mentors and master students serve as the instructors to provide advice and technique support when the group is in trouble, while the master students will serve as daily instructors and provide direct and detail technique instruction to the team and they will gather and check the status of the innovation, verify and validate the innovation work.

Table 1: Roles and responsibilities for talent development

Role	Responsibility
Mentors	1. Instruct the R and D project, 2. Provide advice, or 3. Provide technique support.
Master students	1. Provide direct technique instruction, 2. Gather the status of R and D group and report to the instructors, 3. Finish system analysis and product design and 4. Verify and validate the research work
Senior undergraduate students	1. Assist the master students to finish the tasks, 2. Finish the component design and development and 3. Write some technique reports
Junior undergraduate students	1. Finish detail coding and testing, 2. Learn from the senior undergraduate students and master students to fulfill the R and D tasks.

The role and responsibilities may be adjusted according to different case

While senior undergraduate students, who are a few of excellent undergraduates, will have seats and computers in the lab, junior undergraduate students must join the R and D project virtually from WEB system. The ratio of four roles can be 1:1:1:5. In such way, there will be enough undergraduate students to finish detail development tasks and master student may spend more time on system analysis, product design and product validation, they may have chance to attach project management, including effort estimation on the tasks to be done by undergraduates, schedule optimization, task coordination, group communication and etc.

Unlike the innovation program presented in our former research (Yu *et al*., 2009), senior undergraduate students are the key but not major part in the R and D project. They will assist master student to finish the system analysis, design and validation, they also do lots component development and testing work. The junior ones must finish some components development tasks and finish related testing on the modules. They may learn the methods, tools and other knowledge or skills from the senior ones or master students, which will benefit their future work.

All these people's positions can be modeled as roles in the E-CARGO model and the related responsibilities can be modeled as services.

Definition 2: Agent. An agent is a role player (i.e., people). It can refer to a mentor or students and it is defined as:

ag::=<id, name, rid, av>

Where:

id = The identification of the agent ag

name = The name of the agent ag

rid = The role the agent belong to

av = The total available time of agent ag may contribute to the R and D projects

Definition 3: Service. A service is a responsibility of a role. It is defined as:

s::=<id, r, category, input, output, target_role>

Where:

id = The identification of the service

r = The role who provide the service

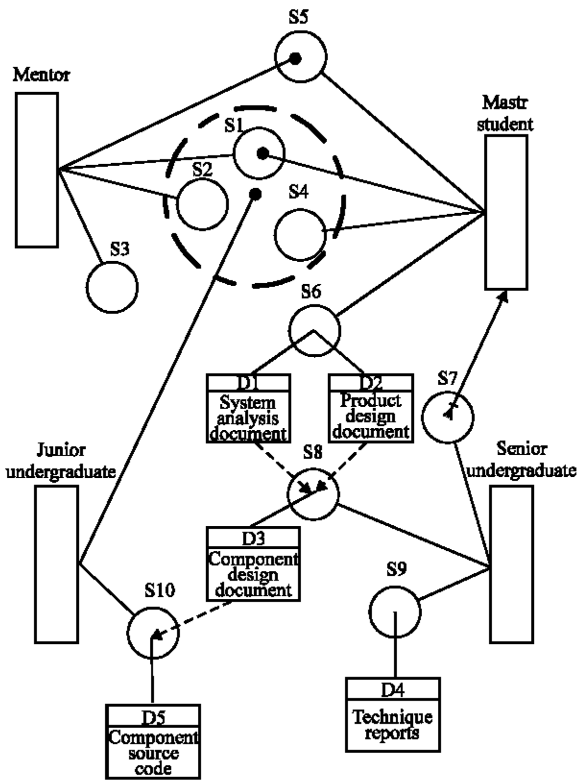

Fig. 2: Role net in our master talent development program

type = The category of the service, for example the instruction and advice can be grouped into one category though instruction focus on technique and advice focus more on methodology
input = The input data set
output = The output data set
target_role = The target role which current role will be transferred to

As shown in Fig. 2, there is four roles in table, include mentor, master student, senior undergraduate and junior undergraduate student.

Totally, there are 10 services provided by the related roles and there are 5 data objects are produced by the service or referred within the service. To be mentioned here, there is a virtual service grouped by S1, S2 and S4, which refers to the instruction and advice service from mentors, master students or even senior undergraduates. S7 is a special service which is used to transfer the role senior undergraduate to the role master student.

There is also a three layered instruction services in the talent development system, include the instructions from mentor to master students, from master students to senior undergraduates and then to junior undergraduates.

Table 2: Data objects in the system

Data object	Produced by	Referred by
D1: System analysis document	Master student (S6)	Senior undergraduate (S8)
D2: Product design document	Master student (S6)	Senior undergraduate (S8)
D3: Component design document	Senior undergraduate (S8)	Junior undergraduate (S10)
D4: Technique reports	Senior undergraduate (S9)	
D5: Component source code	Junior undergraduate (S10)	

Table 3: Service provided by the roles

Service	From role (to role)	Type	In	Out	To
S1: Instruction	Mentor (MS, SU, JU)	Guide			
S2: Advice	Mentor (MS, SU, JU)	Guide			
S3: Technique support		Sup.			
S4: Technique Instruction	MS (SU, JU)	Guide			
S5: Status report	MS (Mentor)	Work			
S6: System analysis and product design	MS (SU)	Work		D1 D2	
S7: Role transfer	SU	Trans			MS
S8: Detail design	SU	Work	D1 D2	D3	
S9: Technique report	SU	Work		D4	
S10: Coding	JU	Work	D3	D5	

Table 2 lists all the related data objects in the software development, including system analysis document, product design document, component design document, technique reports and source code of each component. Table 3 introduces the characteristics of related 10 services, including their provider, responsibility, related data object and possible target role.

Definition 4: Task. A task is a special service, which refers to the collaboration of roles. It is defined as:

task::=<id, Rpt, P, v>

Where:
id = The identification of the R and D tasks task
Rpt = A set of roles of the R and D project
P = Plan of the R and D task, as a set of matched pair of the date, agent and period, it is defined as:

P::= {<d, a, period>}

which express assign the agent a at the period on date d. Period can be a serial of number indicating the available time. For instance, 1, 2 and 8 can be used to refer to the first, second and eighth hours during the working time.

v = Value of the task, which is determined by the mentors and the master students

Definition 5: Project. A project contains a set of tasks. It is defined as:

pr::=<id, Rpt, Task, S >

Where:

id = The identification of the R and D project pr
Rpt = A set of roles of the R and D project
Task = A set of tasks in the R and D project
S = The schedule of the R and D project, as matched pair of the begin date and deadline, it is defined as:

S::= < begin, end>

which expresses that the project will be started on date begin and should be finished on date end.

Definition 6: Talent Development System. The master student talent development system can be defined as:

tds::=<ROLES,AGENTS,SERVICES,TASKS,PROJECTS>

Where:

ROLES = All the positions
AGENTS = All involved personnel
SERVICES = The services provided by the roles
TASKS = All the tasks
PROJECTS = All R and D projects

CORE ALGORITHMS FOR COLLABORATIVE TALENT DEVELOPMENT PROGRAM

There are lots algorithms for talent development program, including the algorithms to support layered guideline services between mentors, master students and undergraduates, the algorithms to optimize the roles ratio.

During the talent development for master students, sufficient resource should be ensured for each R and D projects, besides, the resource should be available during the time so that no overwork will happen. In such way, the quality of talent development can be obtained.

Here, the related algorithms will be designed to check if the project is healthy based on the E-CARGO model.

Algorithm 1: For project risk checking

```
   Input: TASKS, PROJECTS; // PROJECTS is the projects to be
handled; TASKS is the tasks to be finished.
   Output: risk-projects contain a set of project which has risk in resource;
agentRepository contains the usage of agent in these R and D projects.
   Truncate agentRepository;
   Truncate risk-projects;
   FOR(each ipr in PROJECTS) { // project ipr
   FOR(each itask in ipr.Task) {
   FOR(each iplan in itask.P) {
   //Check if the agent iplan.a at iplan.period on iplan.d has been already
assigned with other tasks. If not, the assignment will be updated in the local
repository.
   agentvalid= checkagentavailable(iplan.a,iplan.d, iplan.period);
   IF (not agentvalid)
      risk-projects.insert(<ipr, itask, iplan>);
   ELSE
   agentRepository.insert(iplan.a,iplan.d, iplan.period);
      }
   }
}
```

Algorithm 1 checks if the project is risk with insufficient resource due to resource conflict. However, the algorithm can be enhanced with detail date checking so as to identify the conflict on a special date. The algorithm *checkagentavailable* is not detail described as it is not core algorithm regarding to the collaboration.

Algorithm 2: For overwork checking

```
   Input: AGENTS, agentRepository; // AGENTS is the agents involved
in the R and D project; agentRepository contains the usage of agent in these
R and D projects.
   Output: risk-agents contain a set of overworked agents.
   Truncate risk-agents;
   Sort agentRepository in the order of agent, date and period;
   iagent = ‘’, sumtime=0;
   FOR(each iar in agentRepository) {
   IF(iagent = iar.a)
   sumtime=sumtime+length(iar.period);
   ELSE IF(iagent = ‘’) {
   iagent = iar.a;
   sumtime=length(iar.period);
   }
   ELSE {
   FOR(each sagent in AGENTS)
   IF(sagent.id = iar.a) {
   availableTime = sagent.av;
   break;
   }
   IF (availableTime < sumtime)
      risk-agents.insert(<iar.a,availableTime, sumtime >);
      iagent = iar.a;
      sumtime=length(iar.period);
   }
}
```

Algorithm 2 checks if the agents are overworked due to volume limitation of them. The algorithm length in this algorithm is to get the total working hours required to finish a certain task.

Figure 3 demonstrates the web page of the prototype. Xiao who works as IA has 20% overtime working and there are conflict assignments to Xiao on 2010-4-15 from 8:00 to 12:00.

Fig. 3: Web page of the conflict analysis prototype

DISCUSSION

Research and practice on master student talent development is a hot topic in education domain. Here, we would like to compare our research and practice with some others.

Gao *et al*. (2009) studied the relationship between university innovation education and college students enterprising, the results supported that more practice will enhance the innovation skill. The initial practice in our college supports their declaring, but we are afraid that too much practice will reduce the other study activities and we are going to increase the practice ratio step by step.

Besides, Silliman *et al*. (2006) presented the software development practice in international student collaboration. Ni and Zhou (2006) presented an international distance learning system based on the internet and general purpose technology (Ni and Zhou, 2006). The students communicate in Chinese via the WEB-based collaborative project portal. We're not sure if the efficiency will be remained when they communicate in English. The communication language may be an obstacle to extend the practice to International collaborative talent development.

Perrin *et al*. (2008) introduced several practice of integrating graduate and undergraduate education with real world projects, which is the most close research with us.

Our work in this study extended the related research and practice in our college, the master students and undergraduate students were integrated onsite and offsite via WEB collaborative system. Besides, the collaborative model was demonstrated in E-CARGO model. Further quantitative research is enabled with such demonstration. In this study, resource lacking and overworking is checked with proposed algorithms. We will enhance the framework with the suggested algorithms to improve the master students' talent development in our college.

In next phase of present research, we're going to evaluate the benefit of hierarchical talent development between master students and undergraduate students.

CONCLUSION

The issue and goal of master student's talent development in a Computer Science major has been introduced. A collaborative talent development model is demonstrated with E-CARGO model. Related algorithms have been designed to check if the group is healthy, which will sufficient undergraduate students and the tasks can be finished in time. The feedback from mentors and master students shows that the initial practice with suggested model is effective and efficient.

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