Personalized e-Learning – a Goal Oriented Approach

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Abstract: - A major drawback of current e-learning systems is that they are too disconnected from learner's learning preferences and learning goals. There has been a high demanding for learner centric e-learning systems. Research on personalized e-learning is emerging in recent years. However, most of the current research is focused on user profile modeling, and learning styles research, etc. In this paper, we propose a novel goal oriented approach towards learner centric and personalized e-Learning. With this approach, learning goals are immersed into the courses or learning objects to bridge the gap between the individual learner's goal and the learning objects. Personalized learning path which satisfies the learner's goals can be generated for individual learners. A prototype system is demonstrated as the proof of concept.

Key-Words: - Personalized e-Learning, Goal oriented Modeling, Learner Centric

1 Introduction

e-Learning provides learners distributed learning that includes digital content, and is experienced through Internet-enabled technology interfaces. In recent years, the knowledge-based economy makes e-learning services an important concern of most major organizations.

In this era of rapid change, large amounts of new product, market, and competitive information are emerging. Employees are expected to learn frequently so as to compete effectively. However, employees usually have different skill sets and have different learning requirements. Traditional instructor-led training and on-line training cannot scale to meet these new learning challenges. E-learning, defined as Internet-enabled or Internet-enhanced learning, aims to provide the tools to create personalized learning path and to be able to dynamically readapt learning paths according to user feedbacks and environment changes in order to optimize the acquisition of needed competencies [1, 2].

Unlike on-line training where thousands of static pages of content were posted on the web, E-learning sites contain a variety of media and learning objects, from many different subject matter experts. Employees or learners will be able to choose what, when, where, how, and how much they are ready to undertake in their requirements. A learning object is a self-contained, tagged object. These learning objects will be targeted to learners when they need them and only to those who need them. Pre-assessments will identify the gap between what learners already know and what they need to know to effectively do their jobs. Post-assessments will confirm if they retained the knowledge. In short, e-learning provides individualized learning roadmaps for employees or learners to track learning progress based upon business objectives. E-learning is targeted to move from a content-centric model such as on-line training, to a rich, personalized, learner-centric model that will touch everyone associated with the enterprise, including partners and customers.

However, most of the existing e-learning systems are still in the style of "information transmission" [3]. One of the major limitations is that: ***E-learning systems are often too disconnected from the learner's current preferences and goals.*** For instance, E-learning systems often propose a learning path that does not reflect the current user's needs, interests, etc. E-learning researchers found that [2]:

- ***E-learning should be learner centric***: E-learning systems should put the user/learner at the centre, and also become a key component for managing individual knowledge. In particular, e-learning systems should help the learner in continuously assessing the state of their knowledge, and recommending an effective learning path.
- ***E-learning should be highly personalized***: E-learning systems should develop a very good knowledge of the learner in order to personalize the learning experience,

therefore maximizing the effectiveness of learning. In particular, e-learning systems should take into account the learner's learning style, interests, preferences, current activities and goals.

Providing knowledge intensive e-learning systems has remained a challenge. Recent advances in the field of intelligent agents have shown potential for providing personalized adaptive e-learning services in web based e-learning environments. Agent technologies are well suited to carry out the main activities involved in e-learning [1, 2, 4]. In fact, most of the e-learning systems are distributed systems. Those activities involved in e-learning systems require communications between distributed learning objects, sensing and monitoring of the environment and autonomous operations. E-learning agents have the ability to learn and reason. They are proactive, interactive, adaptive and autonomous. They are able to perform complex operations based on their goals, messages received and environment changes.

In general, e-learning is the delivery of education and training courses over the Internet and/or Intranet. It can be defined as a mixture of content (on-line courses or courseware) and communication (reaching online, emails, discussion forums). But it is not just about placing classes online to address *training* issues. E-learning encompasses training, education, information, communication, collaboration, knowledge management and performance management. It addresses *business* issues such as reducing costs, providing greater access to information and accountability for learning, and increasing employee competence and competitive agility. Therefore, E-learning is a critical element of any enterprise workforce optimization initiative.

Goal-oriented modeling method proposed in this research has the rich ability to model the pedagogical goals underlying the learning situation: in any given learning situation there are specific objectives defining what is to be learned and the desirable level of competence that is to be achieved. This affects which learning objects are relevant and how learning objects should be selected, and how they must be adapted for learner's preferences.

In this paper, we explore the potential of proposed goal-oriented modeling methodology and goal autonomous agents in an e-learning environment. The challenge is: how to model the agents' knowledge, goals, behaviors, etc. so that the agents can provide knowledge intensive learning, in other words, personalized adaptive learning services to help learners to achieve their learning goals. In the following, we describe an e-learning scenario to show how the proposed methodology can be used to model and develop the agent-based e-learning systems.

2 Problem Scenario

In this case study, we focus on two sub-goals of the e-learning systems, the personalized learning path generation and learning object delivery. We assume that the roles of a project are known; the learners have been decided; the pre-assessment is a list of questionnaires. Furthermore, the post-assessment for each course is prepared by the course providers. The scenario for this case study is described as the following:

A company needs to train an Oracle developer to be a database administrator (DBA) for a coming project via e-learning services. This is because with e-learning services, the employee can learn the courses in the company and he can still be on duty for some other projects. The other reason to select an e-learning service is that they hope the e-learning service can provide a personalized training for the employee since he has many years of experience in Oracle database development. So the duration for the training could be reduced.

In this scenario, we want to provide a personal e-learning assistant to assist the employee, i.e. the learner, for the Oracle database training. The requirements are that 1) the agents should provide the courses based on the company's budget, duration restriction and the learner's technical expectation; 2) the agents should provide a personalized learning path to meet the learner's current technical skills.

3 A Novel Goal-Oriented Approach

Goal orientation is an increasingly recognized paradigm for agent modeling and development. Goal-net Methodology is proposed to model complex goals of agents in an open distributed and dynamic changing environment [5, 6]. Goal Nets model both the learner's goals and the learning objects. The novelty of the proposed approach is that the learner's goals are immersed into learning objects which bridges the gap between learning's goals and learning objects.

3.1 Goal Net Model

A Goal Net [5] is a composite goal hierarchy which is composed of goals (alternatively known as states) and transitions**Error! Reference source not found.**. The goals are used to represent the states that an agent

needs to go through in order to achieve its final goal. The transitions connect one goal to anther specifying the relationship between goals it joins. Each transition must have at least one input goal and one output goal. Each transition is associated with a *task list* which defines the possible tasks which might be performed by the agent in order to transit from the input goal to the output goal. A complex system can be recursively decomposed into sub-goals and sub-goal-nets. In such a manner, the system can be easily modeled and simplified.

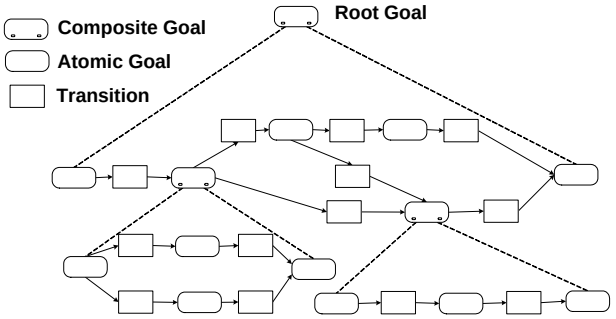
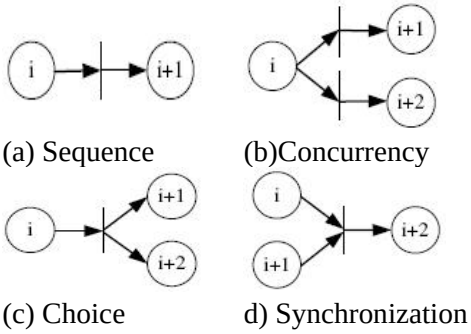


Fig. 1 Goal-net Model

A Goal-net is hierarchically structured as shown in Figure 1. The root composite goal at the highest level of the hierarchical structure represents the overall goal of the agent and the composite goals in lower levels of the hierarchical structure represent sub-goals of the agent.

- A *goal net* is a hierarchical net. It contains a set of goals, transitions and arcs organized into a network to achieve an overall goal.
- A *goal* is a tuple containing a set of variables that define the profile of the goal, a set of application variables and a set of internal functions.
- A *composite goal* is a goal which contains additional information on the initial and target goals of the sub-goal-net it represents.
- A *transition* is tuple containing a set of variables that define the profile of the transition, a set of application specific variables and a tasklist which consists of a finite set of tasks each, in turn, consists of a finite set of functions.
- An *arc* is a tuple containing a set of variables which define the profile of the arc, a link to the input state/transition and a link to the output transition/state.

An agent commences its goal pursuit from the root state; it then goes through the hierarchical structure to reach its final goal. Goal-net can represent four basic temporal relationships between states: sequence, concurrency, choice, and synchronization which are shown in Figure 2.



(a) Sequence (b)Concurrency

(c) Choice d) Synchronization

Fig. 2 Goal-net Transitions

In case of concurrency agent need to make decision about the next state to choose, Goal selection algorithm is the decision making function for selecting the next goal in Goal Net.

3.2 Learning Object with Goals

Suppose there are three related course providers in the e-learning grid. All the e-learning providers provide Oracle courses for DBA training. However, the course organization, price, duration, volume of the technical contents are all different from each provider. And they might be changed by the service provider at anytime in a dynamic environment. Table 1 lists the details of the courses provided by the three course providers.

Course Provider	Course	Price (S$)	Duration (hrs)	Technical Grade
Provider 1	Quick DBA	1100	5 * 8 = 40	3
Provider 2	PL/SQL	400	5 * 8 = 40	1
	DBA fundamental I	650	5 * 8 = 40	3
	DBA fundamental II	400	5 * 8 = 40	4
	Performance Tuning	400	5 * 8 = 40	6
Provider 3	DBA I	700	5 * 8 = 40	2
	DBA II	500	5 * 8 = 40	4

Table 1 The courses list

The courses exist in the form of learning objects on an e-learning grid. A course provider stores a learning object on multiple e-learning grids to increase the quality of service. A course is usually split into one or more learning objects (LOs) to increase reusability and flexibility. Each e-learning provider has metadata to describe the courses it provides. The metadata includes the information about price, duration, prerequisite courses, and the information of the learning objects, etc. For example, the course *PL/SQL* is split to two LOs, *Standard SQL* and *PL/SQL*. Every course provider provides a series of courses to meet a certain requirement. In order to provide personalized learning service the learning assistant agents should be able to compose the courses from the three learning providers.

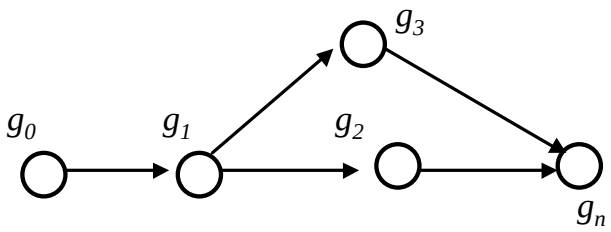


Fig. 3 The course relationships

The courses have relations with other courses in terms of prerequisites. For example, in the Oracle database courses, one of the prerequisites of the course *DBA Fundamental I* is the course *PL/SQL*. The learning paths for individual learners will be generated based on the relationships. For example, a course relationship diagram is shown in Figure 3. The node g_n is the course a learner wants to learn while g_0, g_1, g_2 and g_3 are the courses the learner must learn before he can learn g_n. In our system, each course is regarded as a goal. So, in order to learn the course g_n, that is, reach the goal g_n the learner must reach the goals g_0, g_1, g_2 and g_3 respectively.

According to the metadata of the courses from the three course providers, we know the Oracle courses have the following relationships respectively as shown in Figure 4.

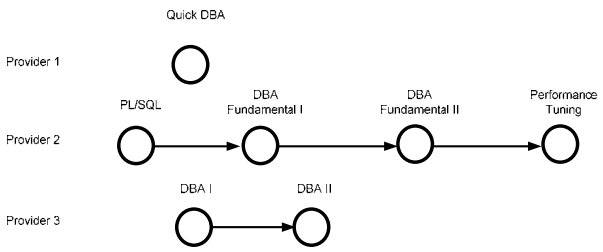


Fig. 4 The Oracle course relationships

In the next section, we show the detailed Goal Net design for modeling the learning path generation agent and course delivery agent.

3.3 Learning Path Generation

The goal of the learning assistant agent is to assist a learner to complete the DBA courses. To provide a personalized assistant to the particular learner, the agent must get the results of pre-assessment. The collected pre-assessment information will be used to select the learning objects (LOs) of a course particularly for the individual learner. To complete the DBA training, the learner must complete the courses provided by any of the three learning providers. However, we need to compose the courses from the three learning providers, so that we can have more ways to finish the courses based on different requirements from individual learners. So all the courses from the three learning providers will be considered together and each course becomes a sub-goal towards the final goal, *complete the DBA courses*. When a learner requests service, the agent should obtain the learner's current skills or the results from pre-assessment and then obtain the requirement or constraints about the courses from the learner to decide the learning path for him. After the learner finishes the courses, the agent should conduct a test for the learner to evaluate his achievement.

According to the metadata of the courses, course provider 1 provides only one course *Quick DBA*; course provider 2 provides four courses and they must be taken in order of *PL/SQL*, *DBA Fundamental I*, *DBA Fundamental II*, and *Performance Tuning*; course provider 3 provides two courses and they must be taken in order of *DBA I*, and *DBA II*. After investigation of the courses provided by the three learning providers, we have new knowledge about the courses: 1) after the course *PL/SQL* is taken from the course provider 2, the learner can take the course *DBA I* from the course provider 3 or take the course *Quick DBA* from the course provider 1; 2) after the course *DBA Fundamental I* is taken, the learner can take the course *DBA II* from the course provider 3; and 3) after the course *DBA I* is taken, the learner can take the course *DBA Fundamental II* from the course provider 2. After the required courses are completed, the learner needs to take a test for a post-assessment. Then the training is finished. So by doing this, the learner can connect to different learning course provider from one course to the next course. The prerequisite relationships among courses become transitions among the sub-goals.

Then we have the Goal Net as depicted in Figure 5.

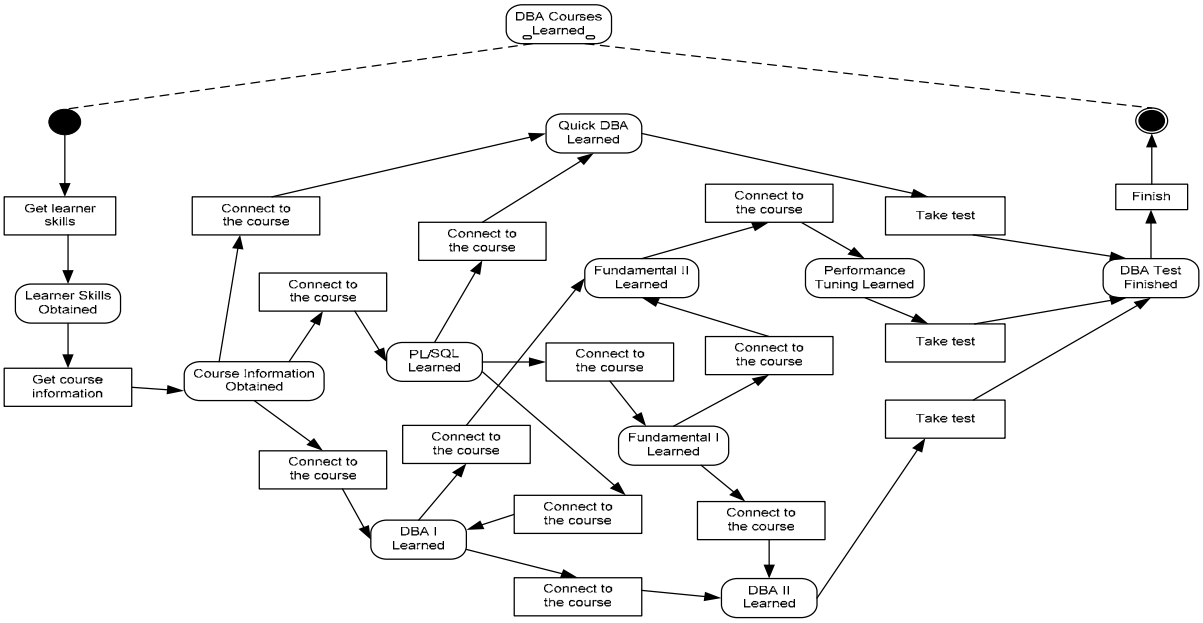


Fig. 5 The Goal Net for the learning path generation agent

4 Proof of Concept

After the e-learning problem is modeled with the Goal Net, multiple e-learning agents are identified and thus a multi-agent e-learning system is generated. Figure 6 gives a multi-agent e-learning system architecture.

As showed in this figure, a multi-agent e-learning system contains agents identified using the Goal Net. The learning object servers store all the learning objects of courses, course metadata, and manage all the courses. It provides services to add new learning objects, delete learning objects or modify learning objects. So the availability of a learning object on a learning object server is dynamic. The course delivery agents need to access the learning object servers to retrieve required learning objects dynamically.

The multi-agent e-learning system shown in Figure 6 can handle many learners concurrently. When the e-learning service agent serves a learner, it will dispatch the work to the lower level agents: the learner agent and the learning agent who will dispatch the work further to their child agents, learning path generation agent and course delivery agent respectively. After the e-learning service agent dispatches the work, it can accept the next learner. Each agent also can pursue another goal when its current goal pursuit is waiting for the feedback from other agents.

The Goal Nets designed for this case study were developed using the Goal Net Designer and they were save in the knowledge base. We used relational database Oracle as the knowledge base of the agents. We also used it as the learning object servers to simulate the course providers.

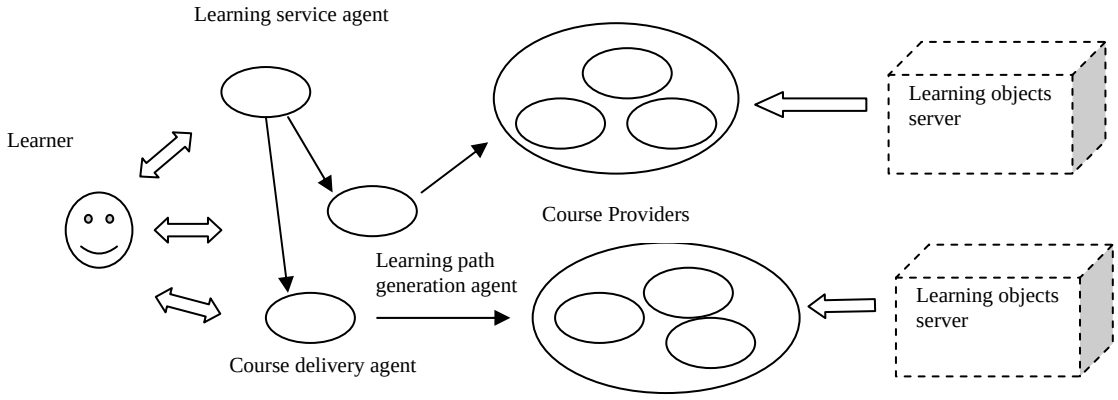


Fig. 6 The e-learning system architecture

The agents are developed using the agent framework with the Agent Creator. The Agent Creator was developed on top of the JADE. We selected JADE as development tool in our current prototype e-learning system because it supports agent management, agent communication and ontology server implementation. And it also complies with many industry standards.

The system structure is depicted in Figure 7.

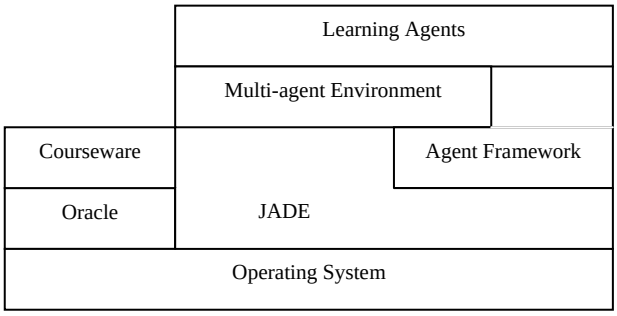


Fig. 7 The system development structure

5 Conclusion

In this paper, we have explored goal oriented modeling and the usage of the goal autonomous agents for personalized e-learning. The e-learning system modeled by the proposed goal oriented modeling methodology is highly personalized and learner centric. It facilitates the personalized learning path generation and learning objects delivery. A multi-agent e-learning system architecture was developed. Although the multi-agent e-learning system presented in this paper is in its prototype system stage, the goal oriented modeling methodology proposed in this research has been proven practical. The prototype system shows that the e-learning service agents are able to use flexible learning/reasoning mechanisms for providing learners personalized services that help learners to achieve their learning goals in real time.

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