Using Case-Based Planning in Designing and Planning a Multiagent System

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Abstract: Designing and planning in multiagent systems (MAS) can be an example of planning problems, which has been recently known as a powerful processing tool in transactional and interactional environments. Case-based planning (CBP) which is an induction-based mechanism, has many applicational abilities in these problems. Intelligent tutoring system that have kept the most attention in the computational mechanisms of concept transition in recent decade, are the contexts that have attracted use of multiagent interaction as well. In this paper, we introduce a system structure that designs a multiagent system using case-based planning abilities to supply the intelligent tutoring system (ITS) necessities.

Key-Words: Multiagent system, Case-based planning, Intelligent tutoring system, UML diagrams

1 Introduction
In recent years, multiagent systems have been considered much in the artificial intelligent researches. An approach for planning is that multiagent system must use its previous experiments in different contents to encounter the situations similar to their current one. Essence of these worthwhile experiments is so that analysis methods are not able to respond modeling process of these experiments and use them. Even if a formal framework for dominating role of specific, previously experienced situations in human problem solving is available, sometimes the case-based approach might be the only practical way to solve problems [2].

In this paper, we attempt to design and plan an intelligent tutoring system using case-based planning principles in designing and planning of a multiagent system. Case-based planning task in this multiagent system is to determine agents based on their application and also determine their layout and sequence so that final produced solution from case-based planner is a sequence of agents in different time slots.

First, in this paper we study planning in multiagent system, then we review intelligent tutoring system and its units. In next section, we focus on case-based planning, its case structure, and adaptation mechanism. Then we consider application of multiagent system in intelligent tutoring system. After that, we focus on multiagent system and agents’ architecture and abilities for realizing an intelligent tutoring system. Finally, before conclusion section, we describe proposed system structure based on case-based planning that is used for planning an intelligent tutoring system regarding to multiagent approach.

2 Planning in Multiagent System
In recent years, multiagent systems have been considered much in the artificial intelligence society. Research in multiagent system contents involves researching in independent, rational and flexible behavior of some entities such as robots and software programs, and interaction and coordination of them in such different spaces such as robotics, information retrieval and management, education and simulation [1].

Planning for a single agent is a process of constructing a sequence of actions just considering goals, capabilities, and environmental constraints. However, planning in a multiagent system environment also considers the constraints that the other agents’ activities place on an agent’s choice of actions, the constraints that an agent’s commitments to others place on its own choice of actions, and the unpredictable evolution of the world caused by other unmodeled agents [1].

Thus, multiagent system must use its previously experiments in different contents in encountering similar
situations with the current situation; that analysis methods are not be able to respond these experiments modeling process and using them. Several studies have given empirical evidence for the dominating role of specific, previously experienced situations in human problem solving. This allows human beings to turn around the lack of formal frameworks to some domains. But even if a formal framework is available, sometimes the cased-based approach might be the only practical way to solve problems [2].

3 Review of Intelligent Tutoring Systems

Several definitions of making intelligent concept, types of applicational domains, architectures and ITS’ different units have been proposed for intelligent tutoring system [3]. We can divide intelligent tutoring system to several main units that are described in the following sections. Concept of interaction between these parts is illustrated in figure1.

![Intelligent Tutoring System](image)

**Figure 1. General scheme of ITS**

3.1 Learner Modeling

One of the most important tasks which are necessary in an intelligent tutoring system for making an isolated tutoring system, is to construct a knowledge learner model. The simplest model is overlay model, in which the learner knowledge is supposed as a subset of modified domain knowledge. In this modeling method we usually can not model the learner faults. Another approach of researchers in learner modeling is to make the bug libraries that try to model learner misunderstanding. Nowadays using artificial intelligence and machine learning abilities, some mechanisms have been introduced that can carry out this process with high efficiency and accuracy. One of the most important mechanisms is Belief, Desire and Intention (BDI) modeling in which all characteristics of these three components are extracted in an independent process or with training and learning procedure. Using learner modeling in cooperation environments is another new approach of learner modeling that has appropriate [3,4]. In addition to these models, there are other characteristics that are explicitly related to learning methods in learning procedure. Cognition, motivational and physiologic characteristics of learner are the methods that are used as an evaluable criterion for the way of understanding and interacting with learning environment.

3.2 Reasoning and Tutor Model

Reasoning unit attempts to realize procedure of selection and arrangement of educational objects and concept transferring mechanism, by communicating between learner model predicate and domain knowledge. In this unit, tutoring system selects necessary courseware for learner from several possible statuses of system and gives it to learner in a appropriate way. To coordinate among believes, desires, intentions and learner learning methods, and in other hand, expert knowledge in learning task, learning tools essence, learning strategies and ..., reasoning procedure needs to be established in a continuous space instead of a discrete space and using intelligent mechanisms which are able to make a decision in a nondeterministic space. Variant mechanisms have been introduced for reasoning such as clustering methods, Bayesian reasoning, rule-based reasoning, and case-based reasoning [3, 5].

3.3 Assessment and Tuning

This unit is used for assessing intelligent tutoring system and learners’ operation and also adapting and coordinating tutoring system with learners and evaluating system users [3]. This unit and learner start to work at the same time. It simultaneously considers the acquisitive learner knowledge and his/her behavior, and evaluates modeling and reasoning procedure, and finally its results are used to adapt parametric items of modeling and reasoning units. Different mechanisms have been introduced for assessment, such as assessment using virtual learner, cooperative assessment (to cooperate several learners or tutors), behavioral assessment, assessment using several exams and considering number of referring to available resources in system (such as articles, texts, ...) and finally assessment and concluding about learning rate or level.

3.4 Learning Management System

All learners’ information are stored in this unit. This unit records the learner information and saves this information into his or her file since he or she enters to system. Learning management system (LMS) communicates with learner mutually and also the other units benefit from its recorded information according to their needs. This system includes operational sections such as registration, authentication, group management, file management and tutoring management [3, 4].

4 Case-Based Planning

Case-based planning has grown from a mere application of case-based reasoning to a promising approach to solve planning problems. Case-based planning is planning as remembering. It is based on the reuse of past experience,
namely the reuse of plans which have succeeded in past situations and the recovery from plans which have failed. This paradigm covers a range of different strategies for organizing and managing past and new plans (e.g. plans may be retrieved as concrete experiences or as generation traces).

On the contrary, the lack of formal frameworks does not seem to be a recurrent motivation for case-based planning. Indeed in that domains that human solve the problems, the only way to define a problem solution is to represent it extensionally, collecting cases. But even if a formal framework is available, sometimes a case-based approach might be the only practical way to solve problems [6].

The design of a case-based planner usually involves the solution of problems, which can be grouped in the following areas:

- **Plan Memory Representation.** Basically this is the issue of deciding what to store and how the memory would be organized in order to retrieve and reuse old plans effectively and efficiently.
- **Plan Retrieved.** This is the issue of retrieving one or more plans which solve problems similar to the current one.
- **Plan Reuse.** This is the issue of reusing (adapting) a retrieved plan in order to satisfy the new problem.
- **Plan Revision.** This is the issue of testing the new plan for success and repairing it if failure occurs.
- **Plan Retention.** This is the issue of storing the new plan in order to be useful for future planning. Usually, when the new plan fails, it is stored with the justification of its failure.

Plan retrieval, reuse, revision, and retention are the fundamental case-based planning tasks. Their interactions are described by the case-based planning cycle, a dynamic model that describes the case flow and how the system evolves (See figure 2) [6].

4.2 Adaptation

When an old plan is retrieved, it is reused to solve the new problem. Since each problem may be different from the previous ones, even slightly, usually the old plan must be adapted to the new problem, in order to solve it. Adaptation is one of the most difficult tasks in case-based planning and reasoning. There are many adaptation methods, such as derivational adaptation, transformational adaptation, and compositional adaptation [8].

5 Using Multiagent System for Realizing an Intelligent Tutoring System

As for various necessities of an intelligent tutoring system in interaction between users and available knowledge in tutoring system, various structures can be considered for it. From the first used methods are conventional sequential and object-oriented procedures that each according to existing necessities has its own advantages and disadvantages. Nowadays using agent-based architectures as the newest method, that has more coordination with such system has an important role in their development.

Adaptability and learning ability are very important characteristics of an intelligent tutoring system. It means system is expected to be able to react properly in a new situation, and not to stick in logical deadlock. This is not acceptable that the user receives an improper answer after entering logical information to system, or system does not answer to user at all. So encountering new and not predicted situations is a problem that is met in the most of tutoring systems. We must use artificial intelligence to perform comparing and reasoning operation, and create case bases and etc., so that system responds properly to all created cases [9].

In a tutoring system, we may encounter huge amounts of simultaneous requests. If a supervisor has to monitor the system operation continuously, there is not any automation concept in real meaning. It means that if all users refer to this person directly or by setting time previously, they may receive more accurate respond. So being intelligent and adaptable is the most important method of a new case in memory too. Representation in case-based reasoning is to make decision about what will be stored in case, then find an appropriate structure for describing case structure, and to decide how case memory must be organized for efficient retrieving and reusing [7].

Three main parts of case structure are problem situation, solution and observed operation. A solution can imply a model, a method, an approach and a strategy in addition to its usual format. To achieve a better solution for current situation, we can add derivation trace and/or supportive argument beside stored solution in case in order to be ensured of produced solution operation’s accuracy.
reason to lead to agent-based systems. In addition, preformed researches and created standard mechanisms in interacting between agents have been caused to work perfectly in units and subunits of an intelligent tutoring system.

There are other agent’s abilities that can help designers in selecting agents as the technology of extension of ITS. For example, suppose that the system wants to work decentralizely. Therefore, a mutual communication between the system and user must be established, user connects to server, enters information and then receives proper output. In this way, all of processing, modeling and making output operations are performed in the server. But when the number of users becomes more than a specific number, server may not be able to perform computation for all users, and it is not desirable. We can describe the same problem for the time that user wants to keep databases under control; here we must transfer part of computation to user’s system. How can we do it? We must notice that agents perform all processing parts of agent-based systems. When we talk about transferring process to user system, we mean transferring agent to user’s system, it means the agent continues its work in user system. It will be used widely specially in user modeling unit. An agent is called mobile agent if it is able to move in network, return to server after giving service to users and transfer information to server. Using mobile agents, we can easily move many parts of processes to user system [10, 11].

5.1 Agents’ Structure

There are several units in intelligent tutoring systems that cooperate to lead a predefined goal, the same as other users’ communication based systems. To achieve this goal we consider intelligent tutoring system as a multiagent system so that each method of any intelligent tutoring system’s unit is supposed as an intelligent agent or another multiagent system. Therefore, when agent encounters a situation, all agents do not necessarily act; different agents may act in system based on different situations. Furthermore, we can extend system by adding more agents to increase system efficiency. In addition, these agents can cooperate with other agents in the system.

Agents in this system have the similar frames, with different attributes so that some agents may not have a value for some attributes.

In addition to the characteristics that are mentioned in previous section, our agents have other specifications. Each agent must recognize received messages from the other agents in the system, so that some agents active through receiving a KQML (Knowledge Query and Manipulation Language) message from another one and...
start to act [15]. Also agents must be able to sense changes and react properly against them. It means agents must have abilities to understand, induce, learn and cooperate with other agents.

Figure 3 shows the general architecture of system’s agents. Each agent has a special knowledge and action base according to its task. Communication manager determines and provides communication messages between agents in KQML standard, or establishes communication with users in some specific agents. Knowledge base and action base can be difference in different agents; therefore we illustrate some possible knowledge and actions that can be stored there in figure 3. Also architecture of our multiagent system is shown in figure 4.

5.2 Agents’ Abilities
The agents of our system have the following capabilities [12]:
They have authority, which indicates the real-world individual or organization that the agent represents.
They have autonomy, which are able to carry out tasks independently; this differentiates an agent from any other computing technique.
They have adaptability, so that they can learn and improve with experience. Each agent has a method for learning and adapting with new situations.
They have mobility to transfer a part of computation to user’s system, we mean transferring agent to user’s system; it means the agent continues its work in user’s system. For example in our system user modeling agent can transfer to learner’s system and performs modeling there.

An agent should be able to cooperate with its peers and also coordinate efforts in order to work in this environment. Agents need to be able to communicate with other agents and humans, so that we realize it through KQML standard.

6 Case-Based Planning Application in a Multiagent System for Realizing an Intelligent Tutoring Environment
Case-based planning task in this system is to determine agents based on their application and efficiency, and also determine agents’ layout so that final solution of case-based planner is sequence of agents in different time slots.

Input of this system is the problem given to case-based planner so that current situation is presented as several attribute-value pairs. We aim to design and plan an intelligent tutoring system for a learner or a tutoring environment. Therefore, system encounters with two types of problem and then two different situations, based on user’s intention. Thus, system’s input in the first situation (designing an intelligent tutoring system for a learner) can be consist of general information and characteristics of learner, and in the second situation (designing an intelligent tutoring system for a tutoring environment) it can be consist of general information about the environment, its learners, its facilities, and so on.

Traditionally a planning problem is represented by case attributes that describe goals, first situations and possible failure. Plans are solutions. Output of case-based planner (final solution of current situation) is a sequence of time slots in which one agent or more is acting. Consequently, we use UML standards to represent the system output and represent the output with a use-case diagram, including main agents used in the given intelligent tutoring system, a class diagram including agents’ actions in suggested system, and a sequence diagram including sequence of acting agents.

Finally, to find the solution of current problem (proposed system), system must find out available correspondences of stored cases in system that have been presented as time sequences of agents, and then adaptation is performed by finding the best frames (agents) for each time slot. So the most similar case to the new case is retrieved first and then for adapting solution of retrieved case for new situation, a set of adaptation rules is used that each of them is applied in the value of an attribute. Therefore number of applied adaptation rules on the solutions of retrieved case is less than or equal to number of attributes in solution frame.

6.1 An Example of Cases
We give an example of inputs and outputs of our system. Since current situation is as input of our system, figure 5 illustrates current situation of new problem (figure 5a) and the situation of its relative retrieved case from cases library (figure 5b).

<table>
<thead>
<tr>
<th>Retrieved Case</th>
<th>New Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Situation</strong></td>
<td><strong>Situation</strong></td>
</tr>
<tr>
<td>Age: 23</td>
<td>Age: 23</td>
</tr>
<tr>
<td>Sex: Female</td>
<td>Sex: Female</td>
</tr>
<tr>
<td>Scientific Degree: Engineer</td>
<td>Scientific Degree: Researcher</td>
</tr>
<tr>
<td>Career: Learner</td>
<td>Career: System Analyzer</td>
</tr>
<tr>
<td>Work Place: governmental office</td>
<td>Work Place: governmental office</td>
</tr>
<tr>
<td>Connective Line: 56K</td>
<td>Connective Line: 2M</td>
</tr>
<tr>
<td>Spending Time: 30 hours</td>
<td>Spending Time: 20 hours</td>
</tr>
<tr>
<td>Assessment: By Tutor</td>
<td>Assessment: By User</td>
</tr>
<tr>
<td>Style: More Active</td>
<td>Style: More Reflective</td>
</tr>
</tbody>
</table>

Figure 5. Case structure. Sign ‘*’ means differences between case.
retrieved case regarding to the example (figure 5). Final use case diagram is shown in figure 6b and its sequence diagram is shown in figure 7b regarding to the illustrated situations in figure 5.

7 Conclusions and Trends
Agents with many characteristics such as authority, adaptability, intelligency, learnability, mobility and cooperation ability can be applied to construct some intelligent system. Regarding to widespread of available parameters to design and implement an intelligent system and various regards to their implementation, planning operation plays an important role in this process. Intelligent tutoring systems attempts to realize theoretic basis and available theories in educational technology area by using computational intelligence abilities and intelligent structures. In this paper, we review case-based planning characteristics and also attempt to introduce a multiagent system based on it to create intelligent tutoring systems that use agents’ technology in their structure. Finally, proposed system’s efficiency process in the paper has been represented by presenting an example.

To improve quality of cases’ selection and adaptation in case-based planner, we can save the relations between agents which lead to their selection in each case’s
Figure 7a. Sequence diagrams of retrieved case

Figure 7b. Sequence diagrams of adapted case
solution to use these relations during cases adaptation as additional and verbal information to find the best agents. To improve quality of multiagent system, agents in each category (each method of every unit) can collaborate each other for carrying out a task.

References


