Development of Business Game Simulator for Supporting Collaborative Problem-Based Learning

Chung Cheng Tseng¹, Chung Hsien Lan², and K. Robert Lai¹

¹Department of Computer Science and Engineering, Yuan Ze University, Taiwan
²Department of Information Management, Nanya Institute of Technology, Taiwan

cct0403@saturn.yzu.edu.tw, chlan@nanya.edu.tw, and krlai@cs.yzu.edu.tw

Abstract

This paper presents a business gaming simulator via fuzzy constraints-directed approach for supporting collaborative problem-based learning. In this gaming simulator, the structure of the problem is displayed as decision networks to allow students to explore “what-if” hypotheses. Additionally, a fuzzy constraint-directed agent negotiation mechanism is also provided to mimic more closely with the spirit of real-world problem-solving for collaborative strategic planning and decision making. To delineate the ideas of the proposed framework for supporting PBL, we have developed a prototyped business simulator, MANAGER, and applied it successfully in the beer game for supporting collaborative PBL.

1. Introduction

Problem-based learning (PBL) is a student-center collaborative learning approach[1] helping learners to collaborate in small groups to solve complex and ill-structured real-world problems. During the learning process, learners bring together collective skills for acquiring, communicating, integrating information and reflecting on their experiences to develop solutions to the problem, and thus they should learn useful knowledge of problem-solving more effectively. Additionally, since PBL emphasizes learners constructing knowledge in collaborative groups[2], the role of instructor is no longer considered only as the content (Knowledge) provider; he (or she) has to be a facilitator of collaborative learning as well.

Game-based learning is a type of problem-based learning in which the problem scenario is scripted in the context of games[3]. A game is a set of activities involving one or more players. It has goals, constraints, payoffs and consequences. In some game-based learning environments, student can play one or more roles to feel the essence of problem-solving and achieve their learning goals more efficiently. Thus, role-play game has been viewed as an effective instructional strategy for promoting active interaction and learning. Although most of business game simulators are meant to follow PBL as their pedagogical basis, they are unable to fully satisfy the setting of PBL mainly due to: (1) the lack of an effective framework to facilitate students to exteriorize their thinking process and (2) the lack of an efficient coordination mechanism to facilitate students developing the solutions in collaborative PBL.

To address these issues, this paper presents an agent-based business game simulator for supporting collaborative problem-based learning via fuzzy constraints-directed approach. In this PBL environment, the problem is formulated and analyzed as a distributed fuzzy constraint satisfaction problem (DFCSP) by identifying the relevant facts and relations from business operational models. Business problems or scenarios are easily modeled as a set of fuzzy constraint networks representing the entities in a business environment. The models of problem, represented graphically by multiple levels of decision networks, can not only reduce the complexity of the problem, and also assist students to learn the dynamic process of decision making. To support PBL, our system also allows students to explore “what-if” hypotheses by modifying the domain of objects in the decision network. The detailed computation is then performed automatically by constraint-based inference engine embedded inside the simulator. The results of hypotheses are then displayed in the decision networks. In this setting, the learning processes of various problem-solving skills are closely related to the decision networks. Instructor can give appropriate online instructions to the students by observing the problem-solving process. Decision networks also can be used to help the students to develop the solutions more effectively. Additionally, built-in fuzzy constraint-directed agent negotiation mechanism can mimic closely with the real-world problem-solving scenario of collaborative strategic planning and decision making, but also provides a practical and efficient method to reach an agreement of solution that benefits all agents with a high satisfaction degree of constraints.

2. System Architecture

Mimic Autonomous Negotiation Agents in Gaming Environnement (MANAGER) is an open simulation platform for collaborative problem-based learning[4].
Figure 1 represents the system architecture of MANAGER.

In Figure 1, **Business Scenario Description Module** transforms the business scenario, including the description of business situations, disciplines, facts and relations, into fuzzy constraint networks via a Fuzzy Constraint Description Language, *Khayyam* [5].

During the process of a business game, **User Interface Module** provides an environment for supporting collaborative problem-based learning among a group of agents (i.e., students). Students make and evaluate the hypotheses by modifying the object domains or constraint assertion in their respective **Decision Network**, as shown in Figure 2. In the decision network, a circle represents an object, and a rectangle with round corner indicates a constraint. At the same time, instructor can also monitor the problem solving process of each student through Decision Network. If some student appears to be getting stuck or off track, instructor can pose open-end questions and giving hints through **Message Module** which has the function of instant messaging. Students also can ask the instructor for giving more information, or talk to other students through this module. In **Game Console**, students and the instructor are able to adjust the parameters of gaming environment.

By simply doing domain modification or adding/deleting constraints along with system built-in constraint-based inference engine, the learners can explore a wide range of “what-if” hypotheses through **Problem Solving and Negotiation Module**. Inconsistent assignments and constraint violations are displayed in **Decision Networks**. In addition, a fuzzy constraints-directed agent negotiation model will coordinate the conflicts among the agents within the business environment to satisfy the inter-agent constraints. **Log Module** will keep all activities and important data during the process of problem solving and decision making. Log data can be accessed by clicking relevant objects and constraints. Log module provides important references for student assessment and instructional development.

**Figure 2.** The decision network of MANAGER

### 3. An illustrative example

**3.1. Goals of a Beer Game**

The following example illustrates the application of MANAGER for supporting a well-known business game, the Beer Game [6]. A well-know phenomenon, when we play the beer game, is the bullwhip effect [7]. The essence of bullwhip effect is that small variance in the demands of downstream customers may cause very high variance in the procurement quantity of upstream suppliers. Thus, in the beer game, how to effectively eliminate the bullwhip effect in the supply chain is a critical issue to be dealt with, including: (1) Students have to keep their inventory as low as possible while avoiding backlog. (2) In addition, they have to minimize the cost of the whole supply chain. (3) Furthermore, each player needs to make profit as well. In order to achieve these goals, students have to consider their orders and supply strategies as well as coordinate with others. There are a wide range of strategies to be explored for coordinating order and supply. Some strategies are introduced under uncertain environment as well. Therefore, students need to learn different strategies (hypotheses), and develop the solutions collaboratively in the process of the beer game.

**3.2. Example for supporting PBL**

Assuming that the students who play the roles of retailer and wholesaler are collaborating to solve the problem of bullwhip effect. Also, initially an inadequate order policy has been made in the previous stages, the inventory of wholesaler (the domain of object “Current Stock Amount”) is now at 400 boxes. Accordingly, the inventory cost (the domain of object “Stock Cost”) will be at 400 dollars as well because
the unit cost of inventory (the domain of object “Stock Unit Cost”) is 1 dollar / per box. A warning color appears at the capital because the capital (the domain of object “Capital”) is already -200 dollars and the wholesaler will go into bankruptcy if nothing is sold at this stage. If the wholesaler wants to reduce the quantity of inventory, the order policy of wholesaler is to order nothing. The supply policy of wholesaler is planned to sale the half of inventory in order to reduce the quantity of inventory in addition.

At the same time, the retailer tries to fulfill 60 boxes of order from customers. However, retailer has to inquiries quotation of 30 boxes from wholesaler because the quantity of inventory (30 boxes) is insufficient for the demand of customers. But the wholesaler will offer the quotation for 200 boxes of beers. In order to set an appropriate price, the expense and expected revenue are considered. The expense (the domain of object “Expense”) is the sum of backlog, inventory, delivery and purchase cost. The cost of purchase (the domain of object “Purchase Cost”) is changed to 0 because of the order policy in the previous step. Besides, the cost of backlog (the domain of object “Backlog Cost”) is also 0. The quantity of goods delivery (the domain of object “Goods Delivery”) is modified into “200”, the delivery cost is changed to 140 dollars due to the constraint “ComputeDeliveryCost”. Besides, the quantity and cost of inventory (the domain of object “Current Stock Amount” and “Stock Cost”) are also changed due to the constraints “ComputeStockAmount” and “ComputeStockCost”. Therefore, the expense of wholesaler is 340 dollars. If wholesaler wants to make profit, the selling price (the domain of object “Incoming Order Price”) needs to be higher than 1.7 dollars. But according to the wholesaler’s desired profit, the domain of object “Revenue” is modified into “2000”. Thus, wholesaler quotes 11.7 dollars for one boxes of beer to retailer.

When the quotation from wholesaler is received, retailer observes that the expense is changed into 2382 dollars. But suggested retailer price (the domain of object “Incoming Order Price”) is 20 dollars / per box in the supply chain. Therefore, the result of revenue which is difference between the income (1200 dollars) and the expense (2382 dollars) is -1182 dollars. The capital of retailer is changed from 1200 dollars into 18 dollars in this stage. In order to assist wholesaler to solving the problem of inventory, the instructor instructs retailer to purchase more goods through the Message Module. The hypothesis of order policy for retailer is to purchase goods as more as possible while avoiding excessive loss. Thus, the retailer has to decide the desired quantity to negotiate. The accepted value of loss for retailer is modified to be an interval value between 0 and -600. Thus, the domain of object “Placed Order Quantity” is computed to be an interval value between 100 and 150 accordingly and the concession quantity for each round of negotiation is 5.

The wholesaler also decides the desired quantity in order to negotiate with retailer. According to the desired revenue, the domain of object “Revenue” is modified to be “200”. Thus, the domain of “Incoming Order Quantity” becomes 50 boxes. So, the domain of object “Incoming Order Quantity” is modified to be an interval value between 50 and 200 and the concession quantity for each round of negotiation is 5. Through agent negotiation, they reach agreement at quantity 125 boxes. Thus, the inventory quantity of wholesaler is 275 boxes and the revenue is become to 1100 dollars. The Wholesaler has enough capital (1300 dollars) to cope with the inventory cost in the next 4 stages. On the other hand, the capital of retailer is decreased to 895.5 dollars due to the loss (-304.5 dollars) in this stage. The inventory quantity of retailer will be increased to 125 boxes at the next 2 week.

4. Conclusions

This paper has presented a business game simulator via fuzzy constraints-directed approach for supporting collaborative problem-based learning. The usefulness of our system was demonstrated through the beer game in supporting collaborative PBL.

References