ENHANCING INTELLIGENCE OF BUSINESS SIMULATION GAMES

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KEYWORDS

Business simulation games, intelligent agents, simulation scenarios.

ABSTRACT

Developing computer simulation games incorporates different computing aspects such as computer graphic, artificial intelligence, simulation itself, software engineering, etc. This paper is focusing on building intelligence into business simulation games by embedding intelligent agents into its software. Agents are proposed to generate simulation scenarios; define initial conditions of the game and/or respond to players' decisions by changing an economical environment according to the goals set by a game leader, and the agent's behavioural rules. Other applications of intelligent agents such as when an agent simulates a tutor or acts as a virtual player are also discussed in the paper.

INTRODUCTION

Computer business games with built in capability to change its parameters permit educators to generate different simulation scenarios, each playable as an independent game. A game manager decides about the complexity level of designed scenario dependent on the specific goals of the course and background of the participants' knowledge. Usually, the process of scenario development and subsequent control over it during the game session is carried out manually. Due to the wide range of the game parameters it is not easy to perform this task. Here, a human factor can lead to inconsistencies in designed scenario or a high probability of run-time errors. Application of software agents to perform some tasks of the game manager would be advisable. An agent could also be a tutor for the game participants and give explanations or advices if necessary, or play the role of a virtual opponent to the players.

BUSINESS SIMULATION LABORATORY

A computer business simulation game may be interpreted as a sequential decision-making experience with reality, which is simulated and animated on the computer. Trainees can see the impact their decisions have upon the problem situation and future events, and can react to these effects and make new decisions (Merkuryeva G., 2000). The business simulation game as a teaching-learning aid may be considered as:

- a simplified mathematical abstraction of a situation related to a real business world,
- a set of case studies with an added feedback and time dimension,
- and a business simulation laboratory.

The business simulation laboratory generates a learning process through business simulation providing:

- simulation of situations related to a real world business,
- experimentation with different decisions,
- quantitative evaluation of decisions and their consequences,
- modelling of business dynamics in time,
- time reversal, i.e. going back and playing again.

In business simulation games a player is intended to act as a manager or a head of department of a fictitious company. The player is provided with great amounts of initial data and information received during the game session, such as sales figures, market forecasts, and financial statements. This is an excellent approach for "learning by doing". Here, game participants can apply knowledge and get experience to solve problems or share it with other participants during the seminar, under the support of the course educator.

A feedback and time dimension added by using simulation provides:

- the possibility to see the impact that decisions have on future events in the reports fed back to the decision maker by the game process. It means that in a very brief time the manager is given a chance to study both long and short term results of his/her decisions;
- possibilities to react to these effects and make new decisions in the light of the altered circumstances, just as in the real business world, later decisions are adjusted by the effects of those that have been made before.

INTELLIGENT AGENTS

The classical definition of an agent presumes that it is an entity capable of information processing at various levels of sophistication and able to affect the world in which it operates (Russel S., Norvig P., 1995). In

Proceedings 20th European Conference on Modelling and Simulation
Wolfgang Borutzky, Alessandra Orsoni, Richard Zobel © ECMS, 2006
ISBN 0-9553018-0-7 / ISBN 0-9553018-1-5 (CD)

other words, agents include data as well as methods of this data processing and methods of interacting with the environment provided by a certain interface. Behaviour of such agents depends on production rules like in expert systems. With sensors agents can communicate with the game environment and other agents. If the agent is intelligent it takes the best possible action in a situation (Russel and Norvig, 1995).

It is assumed (Luger, 2005; Fay, 2000), that intelligent agents have to perform the following tasks:

- to get and interpret information from the environment,
- to convert strategic goals to operational level decisions,
- to impact the game environment,
- to recognise the strategic goal achievement measure and activity success.

As mentioned in (Stenmark, 1998), agents must have certain properties. An agent should be:

- *Autonomous.* The agent must have control over its own behaviour and be able to work and launch actions independent of the user or other actors.
- *Reactive.* The agents can detect changes in the environment and react to those in a timely matter by answering to events and initiate actions.
- *Communicative.* The agent is able to interact and communicate with users and other agents.
- *Goal-driven.* Agents have a purpose and act in accordance with that purpose until it is fulfilled.

Other aspects often mentioned are following: *dynamic* (agents should be able to operate depending on time and space), *adaptive* (agents learn and change their behaviour based on previous experiences), *temporal continuous* (agents should not be started or stopped for explicit tasks but rather be a continuously running process), and/or *mobile* (agents should be able to move from one machine to another one, and across different architectures and platforms).

According to (Jacobi at al, 2004), at the beginning an intelligent agent can be created with a minimum of background knowledge presented in the form of rules, and then by learning an appropriate "behaviour" becomes more experienced. Initially, an agent has its attributes, methods, behavioural rules and a "blank" learning component. *Attributes* could include various assets in terms of personnel, equipment and capability. *Methods* are doctrinal base ways of operation. *Behavioural rules* provide boundaries and constraints for an agent as well as define its behaviour. Initial setting of a *learning component* may come from a historical precedent in case of training system, or intelligent data as in the case of a planning system. The agent interacts with the environment as well as with other agents. A generic agent structure is shown in Figure 1.By acquiring knowledge from different sources, an agent gradually learns how to better achieve the desired objective. Thus, incremental learning agents become more competent. From accumulating knowledge about different situations, the agents can handle them increasingly successfully.

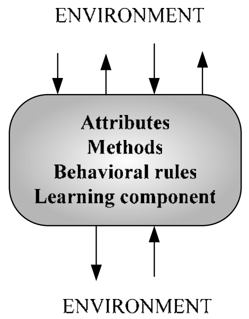

Figure 1: Generic Agent Structure

Agents are assumed to have at their disposal different resources (Jacobi et al, 2004), i.e.:

- inputs from the environment that give partial, noisy information;
- the ability to process input information and use it to update a real world model;
- learning mechanisms that dynamically affect the model;
- communication capabilities to interact with other agents.

AGENT-BASED SIMULATION

Agent-based simulation is an approach to model systems comprised of autonomous, interacting agents (Macal and North, 2005). It can be successfully applied in different areas such as ecology, sociology, economics, traffic simulation, etc. Agent-based modelling is used to model markets (here an agent represents a potential customer), supply chains (an agent represents a specific company), population (when an agent simulates a family, a citizen, or a voter), etc. Agent-based models provide an insight into the general behaviour of the system assuming the behaviour of its elements, without having any global knowledge about the system (Borshchev and Filippov, 2004). To model complex systems, the multi-agent approach is used. Each agent is defined by a set of rules according to which it may interact with other agents. This interaction then generates the overall system behaviour.

In contrast to the process-based approach that provides traditional simulation, agent-based simulation takes the agent perspective (Macal and North, 2005). This means that, in addition to standard model building tasks, the practical agent-based modelling requires:

- Identifying agents and getting insights into their behaviour,
- Identifying relationships between agents and getting insights into agent interaction,
- Getting agent-related data,
- Validating the agent behaviour models (in addition to the model as a whole), and

- Running the model and analysing the output from the standpoint of linking the micro-scale behaviour of agents to the macro-scale behaviour of the system.

Agent-based simulation can either provide a superstructure for modelling components based on other traditional modelling techniques, or the agent-based models can be independent. Since business games are models of an economic system, agents can be successfully applied here too.

BUSINESS SIMULATION SCENARIOS STUCTURING SCHEMES

In general, a scenario can be defined as a set of possible sequences of future events – not a forecast but one possible future. In the case of business simulations it may be interpreted as a structured record of the economic events that correspond to changes of conditions in the system and its elements over time. According to (Kononov, et al. 1999), a scenario usually describes the behaviour of the system, the process of changing its parameters and identifying the conditions of the system behaviour, as well as depicting how the system's components interact with each other. The synthesised scenario allows reflecting adequately the process of system behaviour, developing its organisational strategy and implementing reactions to changes in a real situation, generating strategic plans of action, providing qualitative analysis of consequences of actions, and also predicting loss, possible damage and undertaken risk.

There are different scenario development methods (Kulba, 2004). They could be classified as follows:

- formalized that result in an automated procedure;
- partly formalized, i.e. based on an automated procedure but adjusted by experts;
- or, non-formalized, i.e. based on expert opinion.

Several scenario representation forms exist: signed graphs (Kulba, 2004), structures like the one presented in Figure 2, frames (Luger, 2005), and decision trees (Kindley, 2002). Scenarios contain different components (Luger, 2005; Stankenburg and Dam, 1999), i.e.

- composition of the company;
- definition of *environmental conditions*;
- definition of *initial conditions* that should be valid in order to run a specific scenario;
- definition of stimuli during scenario or *sequence of scenes* that the scenario is divided into, i.e. which events shall occur at what time during the scenario;
- definition of *results* that are valid if scenario is completed;
- definition of *hypotheses* or the "things" that support the content of the scenario.

An example of scenario representation is given in Figure 2. Here, the initial conditions of the scenario are interpreted as assets and liabilities of the company to start with, i.e. a number of operational plants and their capacity, stocks of raw material and finished products, bank loans, etc. As business simulations present experimental tools to modelling production of goods or services, the corresponding infrastructure can be interpreted as hypotheses. Game participants perform different roles in the scenario, for instance as managers of different departments in a company. During the game, participants have to achieve a certain level of the development that actually defines the result in the scenario scheme. Finally, a dynamic game can easily be divided into several periods, defining a sequence of scenes.

Scenario: Bicycle: production and trading *Properties*: Product Markets Raw Materials Reports Overviews *Roles:* Customers C=Companies Vendors *Initial Conditions:* C have money C have assets Customers ask for products *Results:* C operate successfully C go bankrupt Customers are satisfied Customers are not satisfied	*Scene 1:* C make market analysis C make strategic decisions } for each Market *Scene 2:* C make tactical decisions } for each Market C make operational decisions } according to existing Assets *Scene 3:* C analyse Reports C analyse Overviews IF results are not satisfactory THEN C adjust the business strategy AND C improve their tactics AND GOTO *Scene 2* *Scene 4:* IF time is not over THEN C make decisions AND GOTO *Scene 3* *Scene 5:* End of the game

Figure 2: Example of a Scenario

ENHANCING BUSINESS SIMULATION GAME WITH INTELLIGENT AGENTS

As an example of a business computer simulation game, the International Logistics Management Game (ILMG) is selected. According to the classification in (Eilon, 1963), it can be defined as a total enterprise (or general management), interacting, computer- and internet-based game for teaching purposes. The ILMG game provides a virtual economic environment controlled by the Game Management in a multitude of ways (Grubbström et al. 2005). Scenarios in the game are introduced to simulate real world situations and force trainees to acquire skills and experience in managing different functions of the company in various situations.

Simulation Game Management

Game participants operate as different corporations within international markets producing goods or services and competing in the same market. They have to make different strategic and operational decisions within a scenario framework defined by the Game Management in order to improve their company performance and to achieve the following goals: earn profit, capture substantial market share, and achieve high customer satisfaction. The corporation can make the following strategic decisions (Grubbström and Bikovska, 2006): Establish and locate a new plant or distribution centre, open a new market to sell products, adopt a new product. The following are examples of operational decisions: production batch sizing and scheduling, product pricing and advertising, arranging transportation of finished goods from one region to another, or raw material procurement. The structure of the game software is given in Figure 3.

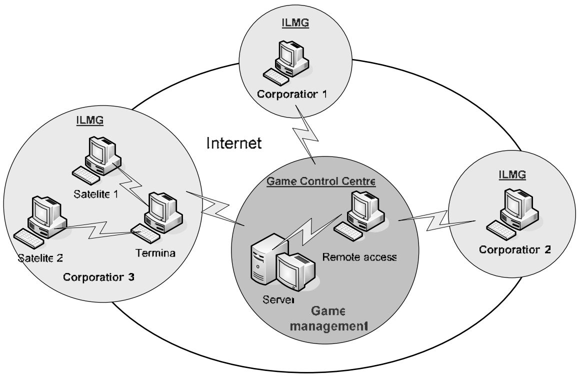

Figure 3: ILMG Software Structure

Decisions entered by participants are transferred through Internet to the Game Control Centre, then processed there, and their consequences in the form of different reports are transferred back to terminals. The Game Management can view the data of all users and apply necessary scenario alterations. Online game sessions, when participants do not have to physically be in a classroom, can be considered as an advanced feature of the game.

Introducing Intelligent Agents

Intelligent agents can be introduced in the game in different ways (see Figure 4): (a) agents may perform tasks of the Game Manager related to the development of the game scenario, (b) play a participant role, (c) and perform a tutor function in the game.

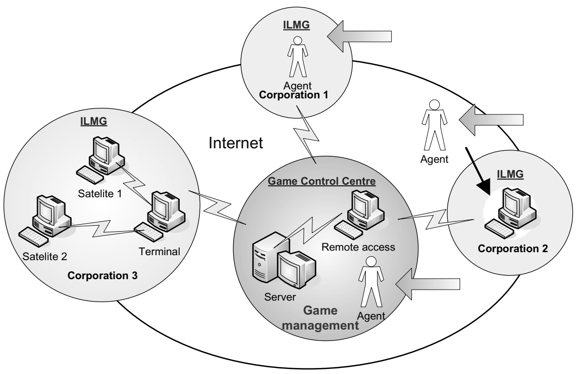

Figure 4: Embedding Intelligent Agents into the Game Structure

The development of a scenario in ILMG encompasses building a "script" before the game starts, i.e., defining a specific set directions or instructions to be followed by users as well as defining a set of environmental parameters and an initial company's state; as well as monitoring the run and making necessary alterations in scenario during the game session. The ILMG scenario can be created corresponding to the needs of a specific training and the participants' knowledge background. The decision environment and the reports could be made as complex as in a real life or could be simplified as necessary. Initial conditions of the game and company state are set up by changing different parameters that can be divided to several groups (see, Figure 5): regional parameters, regional-related production parameters, technical coefficients of products, market related parameters, financial parameters, etc.

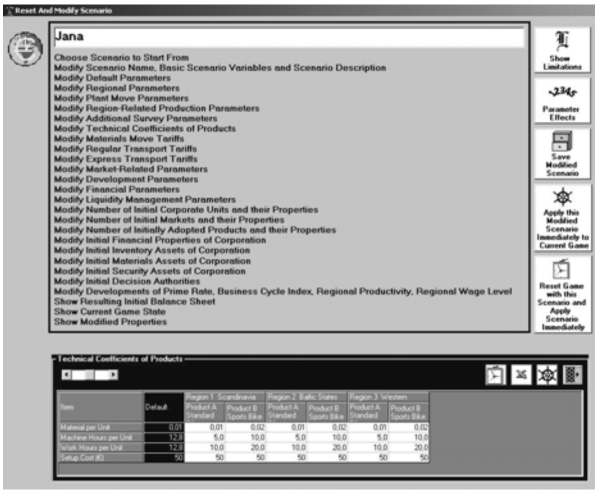

Figure 5: Scenario Window in Game Control Centre

Some session parameters (i.e. prime rate, business cycle index of the region, regional productivity index, and regional wage level) can be easily edited during the game that allows changing an economical environment to simulate different situations.

Agent Supporting the Game Manager

An agent can perform tasks of the Game Manager (Figure 6) related to the development of the game scenario, i.e. to define initial conditions of the game according to a composed story or developed case study, monitoring the game session, and making necessary changes in scenario.

It is well-known from experience that the human factor significantly can create inconsistencies in the designed scenario which, with a high probability, may lead to serious mistakes in the game. Intelligent agents would have the capability to increase the quality of the game scenario and the reliability of its software. Production rules embedded in the game software are used to set up parameters of the economical situation according to defined policies.

Here, from Figure 2 parameters of economical environments and company initial states presents agent attributes, methods as well as behavioural rules are represented by scenes, and an initial learning component is an empty knowledge base.

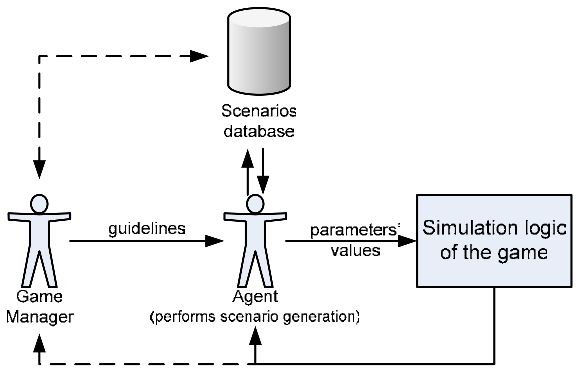

Figure 6: Agent Performs a Scenario Generation

In order to generate production rules, inductive learning algorithms can be used. Monitoring of the game scenario is based on the dynamic comparison of parameters of the economic environment and state of the companies in the game with scenes defined by the scenario introduced.

Agent as a Virtual Player and a Tutor

If a business game of this type is used for individual training, the agent could substitute another competitive company and be introduced to simulate its behaviour. The structural scheme of an agent-based simulator is given in Figure 7. In ILMG, this opportunity has been introduced as a standard (ILMG Dummy).

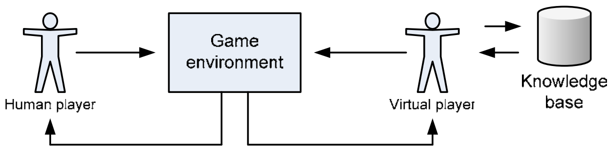

Figure 7: Virtual Player within the Game

When the agent plays a tutor role, it may define weak points in the players' activities, give necessary explanations in the form of causal relationships, and may suggest possible ways to solve the problems or if the participants need any support in their decision analysis. If the number of participants is large, it may not be so easy to manage the game due to its online mode and lack of time to make a deeper analysis of the current situation. The corresponding scheme of Agent-Tutor and Trainee interactions is given in Figure 8.

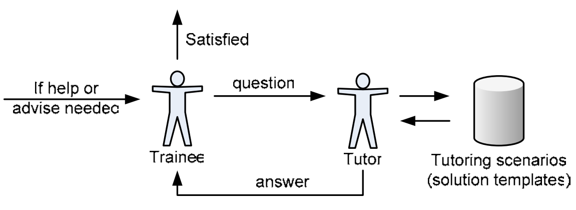

Figure 8: Proposed Agent-tutor and Trainee Interaction

CONCLUSIONS

Intelligent agents have found a wide range of applications in different fields. In this paper possible applications of intelligent agents in order to enhance intelligence of business computer simulation games are discussed. Main functions and roles of agents in the ILMG Game are introduced. Here, intelligent agents support the generation of simulation scenarios of the game session as well as perform a tutor task, or play the role of a virtual opponent. For the first agent application, business simulation scenario structuring schemes to define a suitable one are analysed in the paper. Future directions of the research can be finding of appropriate agents' learning approaches and methods as well as their practical realization.

ACKNOWLEDGMENT

This work has been partly supported by the European Social Fund within the National Programme "Support for carrying out doctoral study programs and post-doctoral research" project "Support for the development of doctoral studies at Riga Technical University".

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