MULTI PLAYER, INTERNET AND JAVA-BASED SIMULATION GAMES: LEARNING AND RESEARCH IN IMPLEMENTING A COMPUTERIZED VERSION OF THE "BEER-DISTRIBUTION SUPPLY CHAIN GAME"

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ABSTRACT

We describe the development and implementation of a Java-based, multi player, multi-group, distributed simulation and game. The Supply Chain game described here is based on the famous "Beer Distribution Game" (Sterman, 1989). Group, synchronous, distributed Java-based applications are both feasible and useful for gaming and management simulation processes in both learning and research capacities. Early results from actual running of the "Supply Chain game" are in line with data reported by Sterman (1989, 1992a,b). The Supply Chain game can be used as a teaching and research tool, generally in organizational processes and especially for e-commerce applications.

Traditional board games are location-bound, administration-laden, and less motivating or attractive because they require many manual calculations and transactions. Early LAN-based computerized implementations are still limited in a variety of ways. Our approach is Internet based and integrates several technologies: Both player and administrator interface with a Java applet. We used Java RMI (Remote Method Invocation) and JDBC (Java Data Base Connectivity) for the players synchronization and back-server SQL (Standard Query Language) database (Oracle) connection, respectively.

Supplemental materials, including movies of the game, are available at http://hulia.haifa.ac.il (a web site supporting this paper).

INTRODUCTION AND LITERATURE

Surfing the web constitutes a "pull" process. By using a browser and input devices (i.e., keyboard, mouse etc.) the surfer actively searches for the information. In contrast, "Push" is a different method to receive information: In a "push" environment, the user is passive while the provider plays a more central role. Active channels, Netcenter and portals are a few examples of push products.

The push and pull dichotomy serves well in understanding simulations and games. Traditional teaching systems are "push". Students have little or no control in the process. Games, on the other hand, are "pull". Here, learners are pulled into the learning process and encouraged to participate. Learners actually determine the learning process when they use simulations and simulation-games.

Simulation and simulation-games are experiential learning processes where knowledge is created by the transformation of experience (Saunders, 1997). Usually the process is cyclic. There are six basic underlying assumptions: 1) learning is defined by the process and not by the outputs; 2) learning is based on experience; 3) learning must include conflict; 4) learning is a process of adopting a discovered “world”; 5) feedback between the learner and the environment is required; 6) learning creates knowledge.

Over half of the companies studied were found to use simulations in their organizational training. (Training, 1994) Following are attributes of simulations that need to be considered when constructing simulations to be used in training:

- Realism: the more realistic the “game world” the more effective the simulation will be. (Redfern, Fairweather & Watson, 1996; Stumpf, Watson & Rustogi, 1994)

- The player’s experience needs to be added to the game reality. (Redfern, Fairweather & Watson, 1996; Lehaney et al., 1998)

Attributes related to the nature of the simulation:

- Simulations enable time compression. We can simulate a period of months in a few minutes. (Filipczak, 1977; Butterfield & Pendegraft, 1996; Faria & Dickinson, 1994; Gilgeous & D'Cruz, 1996; NSC, 1996)

- Feedback can be immediate. (Faria & Dickinson, 1994; Fripp, 1997)

- Simulations are an inexpensive training tool. (Gilgeous & D'Cruz, 1996)

- Simulations can be familiar since they are well spread. (Lehaney et al., 1998)

- Realism motivates (Manzoni & Angehrn, 1998)

- Realism adds new perspectives to uncertainty. (Gilgeous & D'Cruz, 1996)

- Simplification enables focus on the main issues (Keys, Fulmer & Stumpf, 1996; Butterfield & Pendegraft, 1996)

- Simulation permits inexpensive experimentation. (Faria & Dickinson, 1994; Gilgeous & D'Cruz, 1996; Fripp, 1997; NSC, 1996)

Conclusions and lessons from simulation-games:

- Participants make strong and stable connections between theory and reality (Redfern, Fairweather & Watson, 1996; Manzoni & Angehrn, 1998)

- Simulations teach analytical methods (Faria & Dickinson, 1994)

- Simulations provide unbiased results (Thavikulwat, 1995; NSC, 1996)

- Players tend to continue to search for relevant information, even after the game is over. (Manzoni & Angehrn, 1998)

- Lessons survive for longer time periods. (Manzoni & Angehrn, 1998)

COMPUTERIZED AND INTERNET ENABLED GAMES

Despite their utility, the main inhibiting reasons for not using simulations in the classroom are the logistics of games, the time consumed by simulations and the special difficulty in simulating social situations. Following is a discussion of how computerizing simulations and placing them on the Internet can provide added value.

Well-developed computerized simulations can remove many of these inhibitors. Computerizing games add value by controlling unintended errors, reducing cheating errors, increasing result precision, easing the administration chores, cutting down on setup and explanation time, teaching more by reducing the cognitive load, allowing the player to focus on decision making, enabling easy manipulation of the game parameters, and creating a more amenable infrastructure for evaluation and development research.

Internet computerized games allow even more advantages. Networked games place developers much closer to their costumers, enabling faster customization and parameter tweaking. Internet-based delivery allows international distribution of games, and international participation. Play itself is no longer limited to a single location. Internet-based delivery of simulations allows a-synchronic games, and enables the meeting of players from a variety of linguistic and cultural backgrounds.

THE HULIA GAME

The Supply Chain game simulates a four-link production/marketing chain comprised of a factory, a distributor, a wholesaler and a retailer. Members of the chain order products from upstream and receive orders from downstream. Each group (chain) attempts to maximize net profit, and competes with other chains. Reliably across repeated runs, the game results in negative feedback and time delays that cause oscillation, amplification and unrealistic decisions making in the group level (Senge, 1990). Players' excitement and motivation fuels learning.

The "Hulia" game is based on the "Beer distribution game". The name "Hulia" in Hebrew means both "a chain link" and "a special team". The game simulates the systems dynamics in a supply chain system. Each player performs the role of a single link in the chain. Chains (which are teams of players) compete with each other. Each competing chain has four links.

The beer distribution game was developed by the Systems Dynamics Group, of the Sloan School at MIT. Its manual version is fully described by Sterman (1989, 1992a, 1992b) and by Senge (1990). The game is a competition between groups. Each group tries to maximize net group profit. The Game simulates a distribution system. Each group consists of four role-positions: factory, distributor, wholesaler, and retailer. The participants send product orders up the supply chain, and push products down the supply chain (See Figure 1). There is a time lag between ordering and receipt. There is also a time lag between shipping and receiving of products. Each player has local information, information regarding his or her activities, but does not have global (system) information. Future demand is unknown to the members of the group. The game is played in multiple repeated simulated rounds or "days". Every simulated "morning" the retailer is informed of the daily demand. Players may not communicate anything except order quantities.

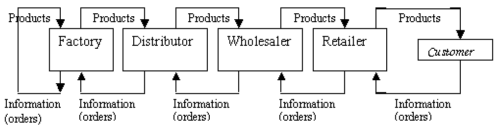

Figure 1: Hulia game chain

The Beer game has simple rules. At the beginning of most games players seem to think they have mastered the game and are sure to win. The players make one decision per day. The cost structure is such that players are lead to believe that they can succeed. However, they soon discover that the task is not so simple. In actual implementations, although the players have been asked not to pass information among themselves, it is very hard to stem the flow of chatter. The online "Hulia" game solves this problem. With the computerized game the players sit facing a screen and not around a round table. Playing over the Internet is even better because we can completely manipulate, control, collect and research the informal channels of information transfer. The Hulia game keeps logs of all the transactions including information flows.

Thousands of students have played this simulation since the 1960s, mostly in business administration programs. The reliable outcomes have been reported in the literature e.g., Sterman (1989), Sterman (1992), Senge (1990), and Goodwin & Franklin (1994). Performance and learning results of the Hulia game are consistent with results reported in the literature.

A TAXONOMY OF SIMULATION & BUSINESS GAMES

Business games simulate business process and business situations. Business games can be classified by pedagogical purpose, number of decisions, types of decisions, number of companies involved in the game, number of products, the amount of computerization, amount of interactivity, time frame for decision and more. Interface complexity, details complexity, and dynamics complexity are a set of three dimensions that categorize games according to Packer & Glass-Husain (1997). Many atomic or compound details characterize games with high detail- complexity. These games are more challenging and require more development time. Many game authors believe, erroneously, that higher complexity adds a realistic perspective to the game. Games with a complex underlying mathematical model are games with a high details complexity. Games with interface-complexity will be easier to learn and play.

The beer distribution game, administered as a board game, has high detail-complexity, very low interface complexity and medium level of dynamics complexity. Computerizing the game didn't change the mathematical model hence no change in the dynamic complexity but we did provide a more sophisticated interface, higher interface complexity and lower detail- complexity.

INTERNET COMPUTERIZED BEER DISTRIBUTION GAME - HULIA GAME

There have been past attempts to computerize the beer distribution game. The first development was a LAN version of the beer game. A LAN-based implementation limits the game to one location and requires use of a computer laboratory (Murray, 1996) Following the LAN attempt there were Internet CGI-based implementation attempts. CGI based games do not allow the execution of rapid decision making of the sort needed here, where players need each to produce a decision every minute. The currently available CGI beer game also has a less than friendly user interface. (http://jacobs.indiana.edu/beer/beerstarter.htm).

DoD (U.S Department of Defense) demands that all simulations support the HLA (High Level Architecture) standards. HLA enables simulations to share resources and information. Business simulations and simulation-games do not have such a standard. Development of simulations with standard programming languages, databases and synchronization tools will stimulate the sharing of resources and information.

Development objectives for the Hulia game include:

- Run on all types of hardware and operating systems.
- The Internet should be the communication channel between the players. Games should be accessible anywhere.
- Multimedia components will be part of the game.
- All the play will be recorded in a central database, collecting raw data for further research.

According to these points we chose the following architecture for the game. The server has three main components; an http server, a database and a synchronization demon. Players and game administrators connect to the server using their browser. The server is currently a Windows NT server 4.0. Hulia is built in a flexible way permitting transfer to any operating system. The http server is Netscape Enterprise 3.6 serving both the static pages, the Java applets and the CGI programs.

The static HTML (Hyper Text Markup Language) pages include the opening screens, data entry forms and user manual. Java applets are the main game component. The game administrator may change and update the game parameters using a CGI interface. All the game transactions are processed and stored in a relational database: We use Oracle 8.0. The players connect directly to the database using a JDBC interface. We are using a thin JDBC driver because we want to keep the game 100% pure Java.

The entire interface is parameterized to allow customization. Simultaneous participation by players from widely dispersed locations can take part even while using different languages and interfaces. The rules of the game can be easily altered between, and even within, sessions. All parameters, including prices, timing, delays, and demand levels are manipulatable online via a CGI (Common Gateway Interface) interface. Having tried out various synchronizing engines we conclude that the Java RMI and Java RMI callback is currently a stable engine for this propose.

The administrator updates the game parameters using a CGI interface that connects to the database using a perl DBI/DBD (Data Base Interactivity/ Data Base Driver) method. Rules of the game oblige the entire group to finish operations on any given day before members of the group are able to continue to the next day. We track this with a Java-based synchronization daemon.

Java based synchronization demon can be built using different Java approaches. It can be done using sockets or Java RMI. We initially tried to build the daemon using sockets due to the high message traffic, the necessity of handling the sockets manually. However, due to sockets instability we decided to move to Java RMI.

Java RMI, like CORBA (Common Object Request Broker Architecture), handles the communication between objects. When you create server encapsulations with RMI (or CORBA), the TCP (Transmission Control Protocol) daemon creates client objects that actually handle the connection. In this design, the TCP daemon acts like a factory; it produces the objects that handle the connections. When you establish a connection using RMI you connect directly to an object. There is no new object created on the daemon side. This makes it a little more difficult to create multiple-client objects. We solve this problem by creating an object that creates connection-handling objects. The factory object then creates a new connection handling object and passes the enrolled client a reference to the new connection handler. The RMI object must be digitally signed or served by secure web pages. We chose to use a secure web server. Clients in the game open a "listener" on the client side to receive messages pushed by the daemon. According to the Java sand box specifications, Java applets are not allowed to open listeners unless the user permits them. As Netscape and Microsoft Internet Explorer use different RMI security schemas, we built the game to operate under Netscape's RMI security schema – hence the game requires Netscape 4.5 or a later version.

Players see and interact primarily with a Java applet. The applets provide the user a choice of three active panels: an online profit/loss statement, an online graph of past decisions (Figure 2) and a picture of the activity cycle (Figure 3).

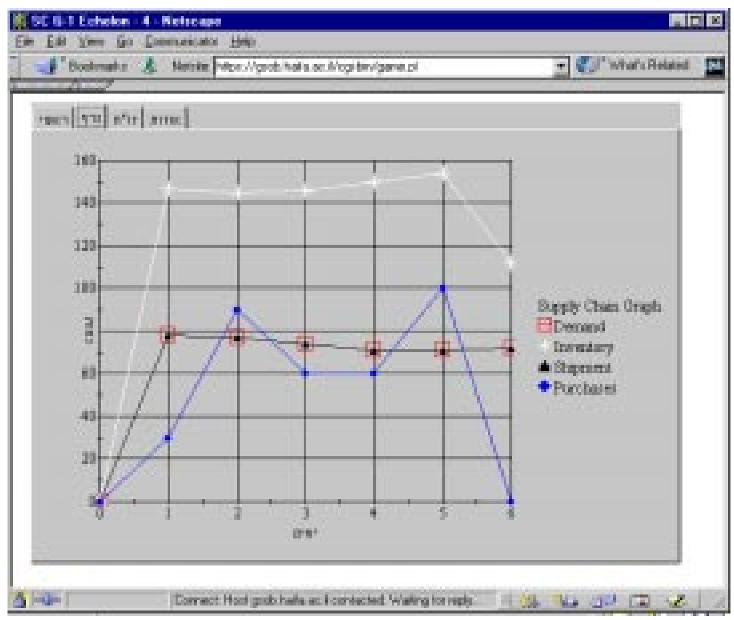

Figure 2 Screen shot of an online graph - Hulia Game

The activity cycle is the main activity and decisions panel. Each day the player makes (clicks on) six steps (See Figure 3): 1) Receive demand; 2) Receive orders; 3) Prepare for shipping; 4) Ship to customers; 5) Order products (make the decision); 6) Call it a day. The administrator applet lets the administrator monitor the state of each group, in number or graph format. All the interface labels are stored in separate text files enabling multiple language versions of the game. The language files are uploaded by each player, i.e. each group member can use a different language.

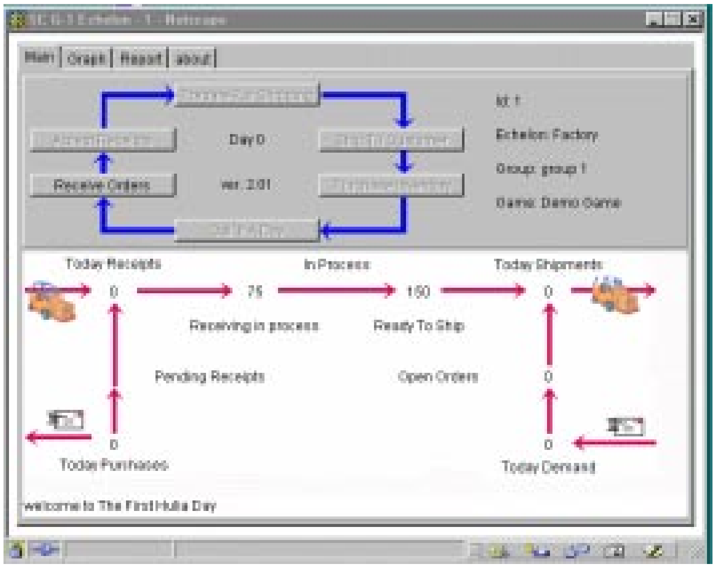

Figure 3 Screen shot of the Hulia Game

Each member of a group/chain interacts directly with the database. There are no direct data connections between the players. Database interaction requires processing of many SQL statements in a short time. Databases cannot handle such a load. The congestion may result in multiple stability problems. The solution for the SQL statements was to write the logic of the game not only in the applet code but also as PL/SQL (Procedure Language) procedures so that the player opens only one SQL statement each day.

CONCLUSIONS

The Beer game is a universally acclaimed business game, used by students worldwide. As a business game it has all the advantages of simulations and simulation-games. The Hulia game described here builds on these advantages while adding elements of computerization, and Internet based communication.

The Hulia game simulates a group decision-making process. The computerized logs of the game allow the conduct of various experiments with unobtrusive yet meticulous and documented observation. We plan to harness this tool to the study of the influence of communication channels' bandwidth, synchronicity and participation on group decision making process (Rafaeli, 1988), the subjective demand for and value of information, and decision maker reliance on recommender systems.

Playing requires a computer, Netscape 4.5 or higher and Internet connectivity without packets filtering. The game administrator needs only the same hardware as players. Administrators define game parameters prior to the game, or use one of the pre-defined games. The administrator is also responsible for making the user guide and running the post game discussion session.

The server consists of a Windows NT 4.0 Server, Oracle 8.0 database, Internet connectivity and a proprietary synchronization demon.

The design and development phases required over half a man-year. We used very recent programming approaches and needed to contend with learning curve and first-use issues. During the development phase we tried to find approaches that were stable enough for mass playing. We believe that we succeeded. Several classes of 30 or 40 students have played the game with very favorable feedback. Although some of our colleagues had doubts about playing the simulation over relatively limited-bandwidth networks, we succeeded in running the game with players using relatively slow 33.6KBS (Kilobits per Second) modems.

We are currently conducting empirical studies of game logs and subtle manipulations of actual games. We expect the data to reflect on e-commerce through an assessment of communication channels (bandwidth), the subjective demand for- and value of information, and decision maker reliance on recommender systems. And, as game administration allows control and measurement of communication between players, we plan to investigate the nature of this communication.

Multi Player, Internet and Java based simulation upgrade games to a new level. Games are easier to play and administer, they enable innovations such as multi national games, as well as provide a new infrastructure for research and experiments. Let's meet at http://hulia.haifa.ac.il for a game.

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BIOGRAPHY

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Gilad Ravid (B.Sc. Technion, Israel, M.B.A., Hebrew University of Jerusalem, Israel) is a Ph.D. student in MIS at the Graduate School of Business Administration, University of Haifa, Israel. This paper describes a research tool he developed as part of his doctoral research. He is currently exploring empirically the results of such games. He lectures at the Hebrew University in Jerusalem, Open University of Israel and Rupin Inst., Israel, in the areas of information systems, the web and e-commerce. He also works at the Open University of Israel as web production manager.

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