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Implementation of Supply Chain Simulation Model

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Abstract

The key to increase the performance of Indonesia's national logistics is to improve the system of logistic processes, as well as its Human Resources (HR) quality. In Higher education, one of the efforts to improve HR's quality in the field of logistics is by giving students the knowledge of a simulation game, for instance using beer game. This game brings experience to the players (students) in managing distribution planning of goods from one manufacturer to the retails or end users, as well as the understanding of impact of bullwhip effect in the supply chain area. The contribution of this paper is to create a supply chain simulation model that can provide players (students) more experience in handling many supply chain scenarios. Supply chain simulation proposed in this paper is limited in design. It also used two methods, namely single moving average forecasting method and Economic Order Quantity Method (EOQ).

Keywords: simulation;supply chain;bulwhip effect;

1. Introduction

Supply chain is a system of networks from various organizations, working together and forming a distribution mechanism of the production of goods and services to their customers. According to logistic experts' conclusion, one of the problems that cause low performance Indonesia's national logistics is the Human Resource. Thus, the key to increase the performance of Indonesia's national logistics is to improve the logistic process system (unloading and loading, packing process, sorting, and etc) and the expertise of professional human resources. Currently, the human resources needs of logistics is still very limited, but the labor market is in dire need of expertise human resources professionals.

One of the efforts to improve human resources' quality in the field of logistics is by giving college students the knowledge of a simulation game, for instance using beer game. Beer game is a simulation of logistic and supply chain game. This game brings experience to the players (students) in managing distribution planning of goods from one manufacturer to the retails or the end user (customers). Also the understanding of the impact of "bullwhip effect" in the supply chain area. Bullwhip effect is a

phenomenon of the greater demand on upstream channel than downstream channel. It caused by the weak flow of information and coordination among supply chain members. Bullwhip effect has an impact on the high logistics processes cost in an industry.

The contribution of this paper is to create a supply chain simulation model that can provide players (students) to earn more experience in handling many supply chain scenarios. This research developed the supply chain simulation model based on supply chains of three chosen industries (paint industry, beverage industry, and tobacco industry).

This paper is a justification of implementation phase for the of supply chain simulation model. This phase is developed based on the research on supply chain information systems conducted by Hevner et.al [1]. Implementation of this supply chain simulation model explains the plan and design of a supply chain based on three industries mentioned above.

2. Supply Chain Management and Bullwhip Effect

Synchronization and coordination towards upstream and downstream channels are important issue in supply chain management. An Enterprises has to maintain the effectiveness of a supply chain among its members. Flow of goods, information, and finances, should be coordinated among its members. Otherwise, the bullwhip effect will arise among the supply chain. The existence of the bullwhip effect will cause inefficiencies in the supply chain, such as the increase of inventory in each channel supply chain, as well as the increase of inventory cost.

Information distortion on the supply chain is one of the major problems in creating supply chain inefficiencies. In general, the information about consumer demand for a product is relatively stable over time. However, there is much more fluctuative orders from the store to the distributor and from the distributor to the factory, compared to consumers' demand.

3. Simulation and Role Play

A more innovative instructional design is required for a better understanding of complex problems, for instance, using simulation. Simulation is defined as a simple model, dynamic and accurate in representing the real system which used to learn system context [2]. Sutcliffe (2007) stated that a simulation would become role-plays that improve its user to do the apropiate act for their own role in system [3]. Previous researches concluded that in term of simulation, the decision is not merely on how to make the best simulation technology, but how to design and facilitate the role play so that it can give a deep insight for user. Simulation can be used to increase the creativity and knowledge for its users [4].

A designed supply chain simulation is a device that can help users to get the experience and understand of how the bullwhip effects occur and how to resolve them. Specifically, in the context of student-center learning (SCL), Clark et. al. (2009) and Pea (1985) in Jonassen and Land (2012) stated that simulation demonstrates the learners about how a model works. It helps the learners to understand the tacit knowledge and get the feedback from the technology that can be used to increase, add, or expand their thinking process or their perspective. It also used to manipulate or reconstruct the learners' understanding of the learners about a system [5].

4. Supply Chain Simulation Model

In the research that has been undertaken, supply chain simulation consist of four sections, which available in simulation software of supply chain, as can be seen in Fig. 1. The four sections of supply chain simulation model are:

- Early initialization. It represents the initial conditions of each actor and the game to be played.
- Scenario. It shows how the supply chain simulation work, at the time the game is played
- The device. It shows the facilities given to a player or administrator that involve database and processes performed by the system itself.
- Role Play. It explains the rules of each scenario and the facilities provided by the facilitator to the players.

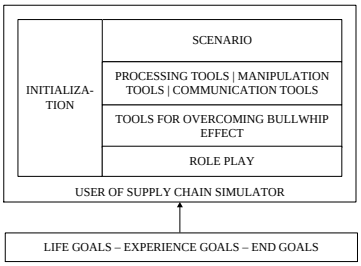


Fig. 1. Model of Supply Chain Simulation [6]

5. Implementation of Supply Chain Simulation

There are three goals that can be learned by the players from this supply chain simulation. It is explained as follows:

- Life Goals: each player gains experiences in formulating strategy to avoid the increase of the bullwhip effect in the supply chain.
- Experience Goals: each player gain experience in carrying out its role, both as a retailer/distributor/ wholesaler/factory. So the players understand how the bullwhip effect arise, as well as how to overcome the bullwhip effect.
- End Goals: every player understands the cause of the bullwhip effect, what to do if it happens, as well as how to use the tools/methods that can prevent the bullwhip effect.

5.1. Identification of Supply Chain Simulation User

At least, there are two main actors involved in supply chain simulation, namely Factory and Retailer. For the maximum, this simulation can involves four main actors, namely Factory, Distributor, Wholesaler, and Retailer. Those actors are also called as learners. Each game involves a facilitator that determine the initial condition for the learners. Thus, a facilitator set the initial condition early at the beginning of the game. If supply chain simulation is used in an educational institution or industry, then a lecturer or mentor can be served as a facilitator for the game.

5.2. Early Initialization

Initial condition in the game when it is played, are as follows:

- Industry type settings, which is related with the determination of the supply chain: 1 channel (Factory – Retailer), 2 channel (Factory – wholesaler – Retail) or 3 channel (Factory – Distributor – Wholesaler – Retail) and its production system (make to stock or make to order) and the unit price of the product
- Data setting about the conditions of the feast day: Eid Al-Fitri and new year
- Storyboard: Paint company, tobacco company, beverage company
- Storyboard Data:

Factory : The amount of, labors, engines capacity, raw materials kept in the warehouse.
Wholesaler : Warehouse capacity.
Distributor : Warehouse capacity.
Retail : Customers' demand.

5.3. Preparation of Scenario

Based on a model that has been made, the prepared scenario is about how the supply chain simulation running at the time during the game session. The implementation will only adopt two scenarios in one game.

Scenario 1: The bullwhip effects, are as follows:

- Trigger bullwhip effect setting:
  - Lack information: Demand and retail sales are made in a relatively stable condition;
  - The flow of goods from manufacturing to a wholesaler/distributor is made fluctuatively (Each player is only allowed to exchange information on the number of orders only).
  - Data forecasting is based on incoming orders in each stage of the supply chain

Scenario 2: Overcoming the bullwhip effects are as follows:

- Provision of the device as a tool to calculate demand and orders for each channel
  - Demand : Forecasting Method
  - Order : Economic Order Quantity Method (EOQ)

5.4. Identification of Tools

The tools required for supply chain scenarios on the simulation are as follows:

- Processing tools, Single Moving Average Forecasting Method and EOQ
- Manipulation tools: affected by any information and actions of each player:
  - Historical data demanded in the 2 years that are used for forecasting according to the type of industry and its products
  - Data related to factory, wholesaler, distributor and retail.
- Communication tools; each player is provided with communication tools, i.e.:
  - Share information tools about orders that are stored in a single database.
  - Chat dialogue as a means of communication among the players.

5.5. Preparation of Role Play

Role Play is the rule of each scenario and tool facilities provided by the facilitator to the players. Role play of supply chain simulation are:

- Simulation is played by at least two persons and one person as facilitator.
- A facilitator has the authority to choose the industry to be played in the supply chain simulation.
- Each player has a unique ID.
- Storyboard display will appear on each player according to the role.
- Each player must meet the number of incoming requests.
- Total stock of final goods of each channel will be calculated at the end of the game.
- The player who has the fewest number of stock inventory declared the winner of the game.
- The duration of the game: Scenario 1; 60 minutes to represent the 31 days and scenario 2; 30 to 45 minutes to represent the 31 days (depending on the length of the supply chain).

6. Supply Chain Simulation Application Design

Business process in supply chain simulation is a series of activity illustrating the input phases, process and output. This relates from the initial process up to the end of supply chain simulation game process. Business process of supply chain simulation area as follows (see Fig. 2).

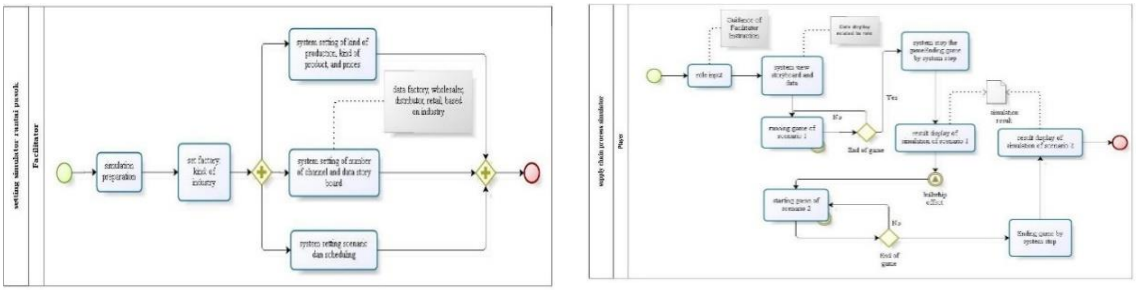


Fig 2. Business process of supply chain simulation

6.1. Business rules

Business rules are statements that define or constraint some business aspects. Based on the role play that has been defined, then the business rules for the supply chain simulation are as follows:

Table 1. Business Rules of Supply Chain Simulation

ID	Rule Definitions	Rule Types	Static/Dynamic
BR-01	Simulation played by at least two persons and one person as facilitator	Constraint	Dynamic
BR-02	Facilitator has the authority to choose/to play in the simulation	Fact	Dynamic
BR-03	Each player has a unique ID	Fact	Static
BR-04	Storyboard display will appear on each player according to the role	Action enabler	Static
BR-05	Each player must meet the number of incoming requests.	Action enabler	Dynamic
BR-06	Total stock of goods of each channel will be calculated at the end of the game.	Computations	Dynamic
BR-07	The duration of the game: 50 minutes to represent the 31 days.	Computations	Static

6.2. Design that uses the Unified Modeling Language (UML)

The application design of supply chain simulation with object oriented basis can be done using the UML with Node.js, JavaScript, and Angular JS application. Based on the case diagram (see Fig. 3 (a)); it explains how a user's can do among other actors playing. Also, the user can view statistics on costs in the form of graphs, and see the ranking with the lowest cost value. Class Diagram is divided into two parts (See Fig. 3 (b)), covering the class main in the front end part and the rest of back end on the server side.

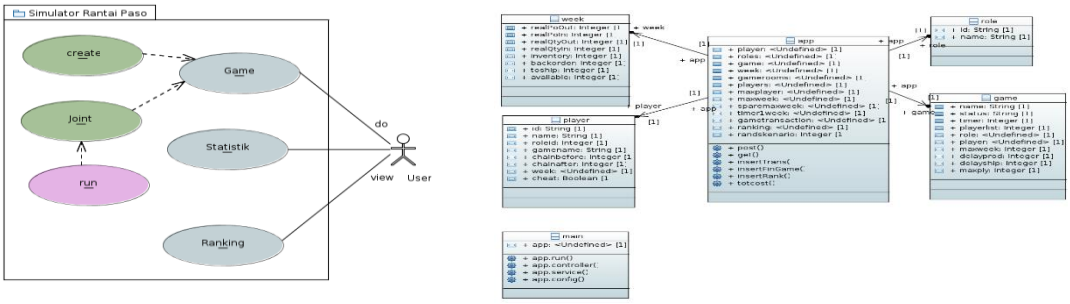
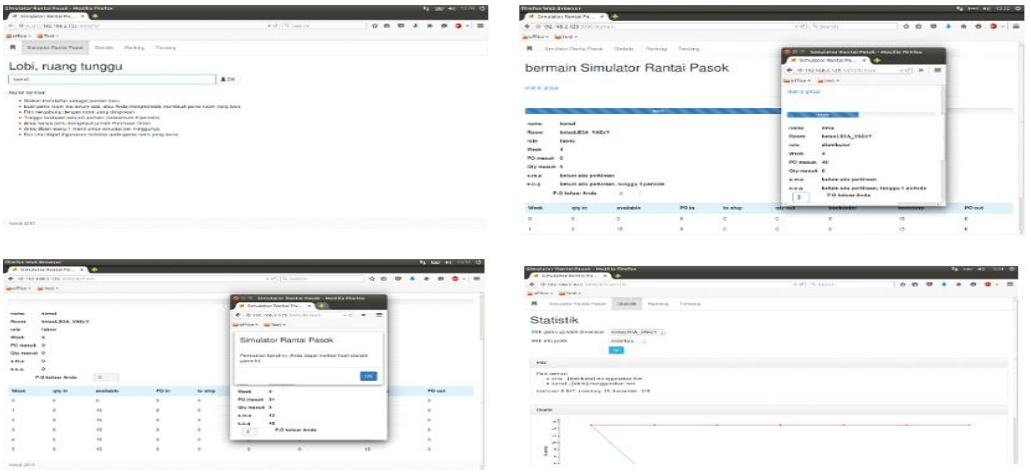


Fig 3. (a) Use Case Diagram (b) Class Diagram Suppy Chain Simulation

6.3. User Interface of Application

User interface that were made are as follows:



ig 4. User Interface Supply Chain Simulation Application

7. Conclusion

Based on the above discussion, it can be concluded that the implementation of supply chain simulation model provides experience to students in make design and students is knowing the bullwhip effect occurence and how to solve it. However simulation supply chain design in this paper processing tools are limited and tools still simple, only two methods of suppoting tools used to overcome the bullwhip effect, namely: single moving average forecasting method and EOQ.

7. Acknowledgement

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