Do Agents in Business Information System is Beneficial?

Eman Abu Maria[1], Khulood Abu Maria[2] and Mohammad A. Alia[3]

[1, 2, 3] Faculty of Science and Information Technology
Al Zaytoonah University of Jordan, Amman, Jordan
[1] eman.maria@zuj.edu.jo, [2] khulood@zuj.edu.jo and [3] dr.m.alia@zuj.edu.jo

ABSTRACT

Agent-based modeling focuses on the individual dynamic entities of a system. With agent-based modeling, active objects, known as agents, must be recognized and their actions defined. They may be business-process, business-functional-unit, employees, tools, products, or business partners, whatever is relevant to the system. Connections between them are established, business environmental parameters are set, and simulations run. The whole dynamic of the system emerges from the interactions of many entities or their behaviors. In our paper, we simulate an agent-based Business Information System (BIS) and study the efficiency of the BIS system using intelligent software agents. The proposed agent possesses rational knowledge and reactive capabilities and interacts with the external business environment, including other agents.

We investigate if intelligent software agent can improve the performance of Business Information System (BIS) in certain circumstances. The main contribution of this work is to simulate and evaluate the performance of Business Information System using intelligent software agents. Moreover, a systematic view of the smart agents can take place, assuming making a decision is the process involving assessment, cognitive-signal generation, and cognition-response.

Sales and Operations Planning (SOP) is being chosen to demonstrate the use of intelligent software agent impact. NetLogo is being used as a multi-agent simulation and programming language to design, implement, and test the proposed agent on the SOP system.

The SOP is simulated, and results are evaluated thoroughly. Our study shows that Business Information Systems with proper modeling of the agent can perform in many cases better than systems without agents. In conclusion, we shed light here on how intelligent software agent's decision-making process can be modeled using business rules and constraints. The primary hypothesis of our research is "using an agent in Business Information System is supportive?"

KEYWORDS

Agent-Based Simulation, Multi-Agents, Believable, Behavior, Business Information System (BIS), Sales and Operations Planning.

1. Introduction

Successful manufacturers are increasing competes with the help of state-of-the-art technology. In the face of forceful global competition and expanding of the customer requirements, these companies are embracing the concept of electronics, mobile, intelligent manufacturing. They need to implement advanced internal networks, private extranets, and on-line electronic marketplaces that help them to automate the internal business processes, streamline product development, and enable more powerful electronic business relationships with suppliers, partners, agents, distributors, warehouses and customers around the globe. Establishing a reliable network infrastructure is an essential first step to meet the worldwide communication demands of modern manufacturing. With the integration of big data, business partners must be able to share product design concepts, which minimize time to market and maximize production efficiencies [1].

Manufacturing networks must create a secure collaborative environment and ensure that all applications and processes operate in trustworthy levels. They must have the flexibility to easily integrate with external organizations and adapt to emerging manufacturing technologies. Excellent networking solutions allow manufacturers to maximize productivity and efficiency while establishing a foundation for continued success, improvement, and progress [2].

Due to the customized or personalized production, shorter product life cycle and various process engineering, today's global business is essential special requirements for manufacturing enterprises, such as rapid response to changing needs, reduction in both time and cost of the product realization activities [3].

Also, most of the manufacturing enterprises are often heterogeneous concerning computer platforms, operating systems, network capabilities, and custom and commercial software. Information architecture must be scalable. Internet technology and big data analysis will be ultimate to the infrastructure of manufacturing applications are a trendy one, software agents emerging in the information system structure also a promising one. Software Agents are entities that work without the direct involvement of their users and have some kind of self-control over their actions, behaviors, and internal states. Agents can cooperate with other agents or users through some agent-communication language or protocols. Agents can respond to their environment as a pro-active action; through exhibiting goal-oriented behavior in their dynamic environment [4].

The business application evaluated in this paper proposes to comprehend the integrated business information system, which has a rapid response to requirements changing and the capability to integrate various manufacturing processes [5]. Sales and operations planning application is chosen as a demonstration for one of the most significant Business Information System that is used heavily in the manufacturing world. The SOP is concerned with both production scheduling and warehouse management and control. A material control system attempts to keep adequate warehouse levels to assure that the required materials are available when needed. The SOP is a fully integrated information system that consists of multiple items with complex bills of materials (BOM). The SOP is not useful for Job Shops that tightly link [6]. The primary objectives of the SOP system are as follows:

1. Ensure the availability of raw materials, components, and products for planned production and customer delivery.
2. Maintain the lowest possible level of the warehouse.
3. Plan manufacturing, purchasing activities, and delivery schedules.

The three significant SOP inputs sub-systems are the Master Production Schedule (MPS), the Product Structure Records, and the Warehouse Status Records. Without these essential inputs, the SOP system cannot function. The demand for end items is scheduled over some time-periods and record on a Master Production Schedule (MPS). The master production schedule expresses how much of each piece is wanted and when it is wanted? The MPS is developing from forecasts and customer sales orders, safety stock requirements, and internal order processes. SOP takes the master schedule for end items and translates it into individual time-phased component requirements. The product structure records, also known as a bill of material documents (BOM), contains information on every item or assembly required to produce end items. The warehouse status records include the status of all items in the warehouse, including on-hand warehouse and scheduled receipts. These records must be up to date, with each arrival, distribution, or withdrawal documented to maintain record integrity and consistency. Gross component requirements will be reduced by the available warehouse as indicated in the warehouse status records [7].

In this paper, we used a previous general, flexible, and robust architecture to build requirements of intelligent software agents. The proposed agent possesses rational knowledge and reactive capabilities, and interacts with the external world, including other agents. We are pointing to develop artificial mechanisms that can play the role decision-making process in natural life [8].

2. RELATED WORKS

In this Subsection, some related works are concisely labeled. We believe that it is essential to go through earlier studies before we start introducing our work in the next Sections — recent research accomplishments all over the world attempt to push agent technology on the way to manufacturing applications. The industry, on the other hand, becomes steadily conscious about the potential value when engaging agent-based software approaches within their manufacturing business world.

In [9] researchers studied the requirements associated with the existing industrial applications of investigating systems. They introduced a multi-agent software architecture as a promising solution for tackling the diversity of problems related to construction such as industrial agent-based systems.

The study of [10] proposed a notion of a system's tolerance by developing an Agent-based Model framework for two potential manufacturing systems. Such applications of agent-based modeling can illustrate the possible evolutionary line of given situations under different circumstances and geographical settings. Researchers have viewed these economic events along with their connected partners (such as suppliers, customers, government agencies, etc.) and the familiar surroundings in which they operated to be complex adaptive systems.

While [11] the researchers proposed a comprehensive reliance framework as a multi-factor model, which applied some measurements to appraise the trust of network agents.

What precisely differentiates this work from the previous researches in the same area is its after-interaction investigation and performance analysis that demonstrates the applicability of the proposed model in distributed multi-agent systems.

Researches in [12] presented a system dynamics model that describes how to build supply chains and networks. Their work expands a one-dimensional supply chain into a two-dimensional supply network in the simulation world. The outputs of system simulation verify the effectiveness of an agent-based supply chain management (SCM) model.

3. AGENT ARCHITECTURE

As the mind is made up of many small components called agencies [13] that have a straightforward function, but the interaction among them leads to complex behaviors. We used this idea for building our agent architecture. The configuration of the agent is mentioned in [2]. Figure 1 demonstrates the agent architecture.

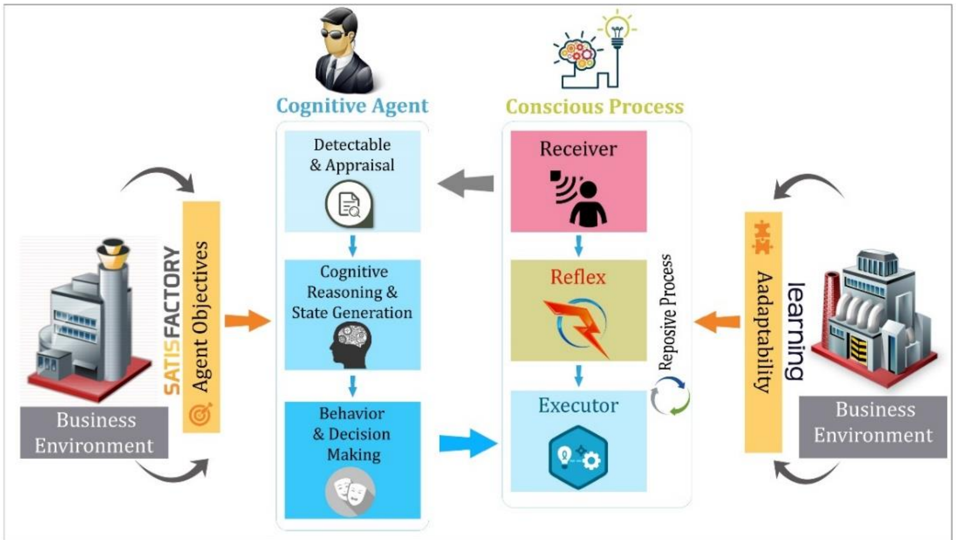

Figure 1. Agent model [2]

4. SALES AND OPERATIONS PLANNING OVERVIEW

Business Information System with which agents are applied is an industrial production and planning application named Sales and Operations Planning. The primary goal of the SOP is to keep stock value to the minimum. The SOP applies to discrete and dependent demand systems, allocating items in the warehouse when they are required. The system must be time-phased so that predetermined materials arrive at the point in time when they need. Time phasing results in reduced warehouse levels, since holding costs are a factor in determining ordered raw material or work-in-progress [14].

Agents are not a cure for industrial or manufacturing systems. Like any other technology, they have specific capabilities and are the best use for problems which are characteristics as modular, decentralized, unpredictable, ill-structured, and complex [9]. SOP application is a real-time application, and it is curious to understand for researchers how to care about agent-based real use [15].

Sales and Operations Planning is a computer modeling technique that allows demand-driven production plans to be made [16] (see Figure 2). The sales order life cycle will be handled using multi-agents in its front and back end. Each SOP components is supervised and monitored using a discrete-agent.

Figure 2. Sales and operations planning application

4.1. Sales and Operations Planning Benefits

There are many benefits and capabilities, which are crucial for all business information systems used nowadays. SOP benefits to the industrial organization [8] [14] are as follows:

1. Reduce warehouse Levels and Component Shortages.
2. Reduction in Excess warehouse.
3. Improve Productivity and Quality.
4. Improve Production Schedules.
5. Reduce Manufacturing Cost and Lead Times.
6. Less Scrap and Rework.
7. Improve Calculation of Material Requirements.
8. Reduce Purchasing Cost.
9. Improve Supply Schedules.
10. Improve Shipping Performance.
11. Improve Communication and Plant Efficiency.
12. Reduce Overtime.
13. Improve Customer Service.
14. Improve Competitive Position.

4.2. Intelligent Software Agent in SOP

As agents are pro-active objects and share the benefits of modularity that have led to the widespread adoption of pro-active object technology. They are best suited to applications that fall into natural modules. To see this more clearly, recall that an agent has its own set of state variables. Some subset of the agent's state variables is connected to some subset of the business variables. An agent is more than an object; it is a pro-active object, a bounded process entity. It does not need to invoke externally, but autonomously monitors its environment and takes actions, as it deems appropriate. This characteristic of agents makes them particularly suited for applications that can be decomposed into stand-alone processes, each capable of doing useful things without continuous direction by some other process. SOP industrial entity is a good candidate for the agent-hood. The agent is best to integrate into one of the following areas:

1. Job Shop Production.
2. Complex Products.
3. Assemble-to-Order.
4. Discrete and Dependent Demand Items.

Intelligent software agent role in SOP is demonstrated in Figure 3. First, an agent accepts the customer's sales order. In the backend, the agent will be performing material planning process as a mobile and portable agent with collaboration with other types of agents. Then the agent dispatches daily production jobs to Job Shop that carries out real-time scheduling and production. On the other hand, agents send purchase orders to a suitable supplier for demanding the raw materials. After completing production task, Job Shop returns finished parts to the SOP-agent that may adjust some initial parameters like lot size, lead-time to meet the requirement of sales order placed by the customer.

Figure 3. Agent-based SOP application boundaries

4.3. Agent-Based Simulation

Analyzing business information systems through simulation models is much more affordable; it requires a lighter amount of resources. Agent-based simulation aims to model the SOP system with agents supervisory. The proposed agent will be a supervising, monitoring, and controlling agent, which is responsible for improving the efficiency of the system. The SOP decision maker agents control the critical variables of the system. The decision is taken based on the information about the up- and down-stream levels of each data received at the decision points (from the data agents distributed all over the system).

Agent, at first, accepts the customer's sales order and performs material requirement planning process, which results in material scheduling and delivery date. Then agent monitors daily planned order to the production model that carries out real-time production programming. At the same time, the agent sends purchase orders to the supplier for buying raw materials. After completing production task, production model returns the relevant information about finished parts. Once the customer adds or modifies orders, the agent updates data automatically to respond to the changes in customer demands. The agent receives information from the business environment and decides in-line. The business environment is being affected by the decisions made by SOP-agent. Therefore, Agent always faces a new condition to resolve. The current business environment also encourages or punishes the agent by the result of the decisions taken by rank the outcomes of the actions as good or bad one. A rational choice is to consider as an optimum solution to maximize the reward subject to a set of constraints. The ability to avoid wrong decisions and find the best solution can be improved. Dynamic systems are standard practice to assume that decisions are made according to a rule base or a guidance table or a graph. Rationality is considered independent of agents as the decision maker is always trying to maximize its explicit profits and reduce the cost by taking decent decisions.

4.3.1. Simulation Scenarios

The SOP simulation requires the development of a NetLogo environment, providing SOP-agents. Agent lives in a simulated world with a set of objects, which behave similarly, and in which the agent has to make sure their primary goals are satisfied. Agent main goal is to look after the warehouse level, reach customer acceptable delivery date, and the end to achieve high customer satisfaction. To satisfy these primary goals, the agent needs to arrange business empirical goals priorities.

System simulation interface has a set of sliders, which influence generic parameters of the business circumstances, and influence SOP-agent by changing its initial business environment from normal to risky that it will work under it. Agent main goals and standards also can be initialized. These influence the behavior of the SOP-agent exclusively. Simulation has an initial setting that can be altered to reflect the business conditions for the agent to work under and take a suitable series of actions to manipulate the dynamic business environment. Most aspects of the SOP-world change at every step of the simulation, like the sales orders number, priority and the searching cost of the suppliers all handled in NetLogo by using the random function. With random numbers, we able to control the maximum value of these numbers, control how risky or easy the business conditions of the agent becomes, hence, maximizing (or minimizing) the complexity of the SOP business environment.

4.3.2. Simulation Entities

The simulation has the following Entities:

1. **Warehouse Entity:** It is the agent focus point. It declines in status over time. It can only be improved when an agent manages it. Managing warehouse material, sales, purchasing, and production orders will enhance the condition of the warehouse.
2. **Sales Object:** It offers new customers Sales Orders with a new randomly calculated number.
3. **Purchasing Entity:** Agent must manage the required purchase orders. At purchasing, the agent has to pay for orders and learn to purchase. Costs and purchasing capacity improvement are recalculated randomly every run.

4. **Supplier Entity:** Agent should improve its supplier's information level (for alternative suppliers and agent knowledge) at the very moment, and receives the reward in terms of enhancing its purchasing process.

The key performance indicators (KPI) for the simulations are:

- Warehouse level or value (Main Goal).
- Sales orders level.
- Suppliers information level.
- Purchasing orders level.

Agents live in the simulation environment with their own set of objects, which behave similarly, and in which the agents have to make sure that:

- Their warehouse status does not decay completely.
- They do not run out of cash (all business process will stop).

4.3.3. Agent Thinking Mechanism

The rational thinking mechanism of SOP-Agent states as follows:

- **Initial State:** agent receives its initial states and system setting.
- **Perception:** Agent perceives current business Environment parameters.
- **Goal Scanning:** Agent looks at the prospects of goals and scans them, using attitudes as a guideline, which lead to creating agent mental state.
- **Goals Evaluation and Ranking:** appropriate goals are taken into consideration more seriously than less likely targets.
- **Goal Filtering:** this leaves us with a list of goals in order of priority.
- **Take Action:** behavior is taken according to the highest priority.

The agent has goals, which have been organized in order of priority using its evaluation mechanism, and it has a mental state, which has been formed (see Figure 4).

Figure 4. The rational thinking mechanism of SOP-Agent

5. Experiments and Results

In this subsection, we implement SOP system simulation for the proposed agent architecture. The goal is to find how using intelligent software agent improves the performance of SOP performance. The central hypothesis of the study will be analyzed and justified. To reach a satisfactory result, we run the simulation ten times, one under normal and risky business environment.

5.1. Results Analysis

We start our simulation experiments by answering the following questions:" Do agents in the business information system is beneficial?"

As randomness plays a significant role in discrete-event simulation, the simulation runs are performed ten times using a different environment setting. Hence, the simulation test fails if the agent runs out of cash, or if the warehouse level drops to zero (simulation stopping condition). As the agent performs different actions or events, the system state parameters are changed as a subsequence of rational agent behavior. We will simulate two environmental scenarios. The first run will be under normal business environment, while the other experiments will be under a risky business environment.

5.1.1. Agent-Based Simulation under Normal Business Environment

After performing ten runs under the healthy business environment (see Table 1), the results are as evident in Table 2.

Table 1. Business normal settings

Business Ordinary Environment Settings	Max. Value of Random Number Generators
Max. Suppliers Searching Data	15
Max. Searching Cost	7
Max. Customers Job Orders	15
Max. Stock Decline	7
Max. Procuring Orders	15
Max. Procuring Decline	7

Table 2. SOP-Agent simulation results under normal business environment

Experiment No.	Warehouse Level	Cash Level	Sales Orders Capacity	Procuring Orders Capacity
1	60.2	80.2	70.3	45.1
2	63.8	90.8	60.3	62.2
3	90.4	88.7	66.8	66.2
4	78.2	96	79.2	70.1
5	80.2	93	71.4	62.6
6	79.2	60.2	80.2	55.8
7	88.2	66.2	65.3	69.8
8	90.8	87.9	79.2	60.2
9	80.1	80.3	59.2	70.5
10	50.4	100	55.5	63.7

After evaluating the simulation experiments results, the performance of the proposed agent in the SOP business information system is acceptable; although it has great difficulties keeping its main goal status (warehouse value) within preferred values, it also fails to maximize its procuring capacity level while Cash level is acceptable. The charts for typical runs of SOP-agent is described in Figures 5, 6, 7 and 8. The SOP-Agent's primary goal is stable (fewer fluctuations); this general trend is a positive one.

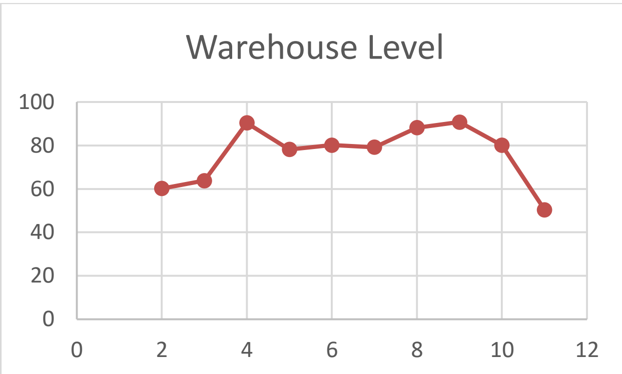

Figure 5. Main goal satisfaction

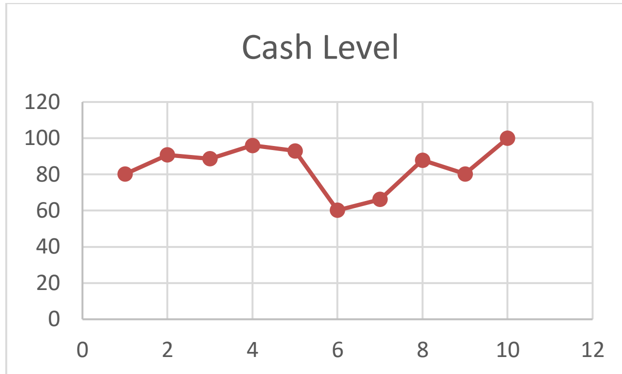

Figure 6. Cash level status

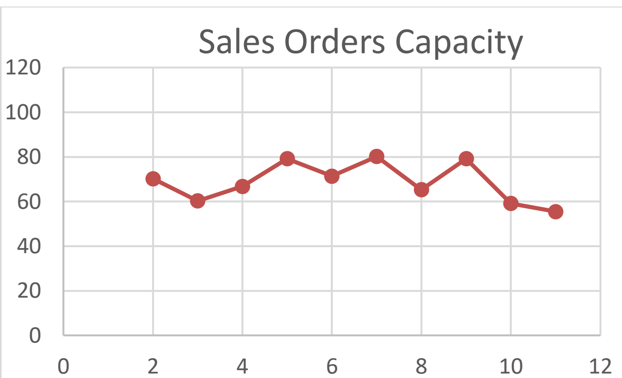

Figure 7. Sales orders capacity

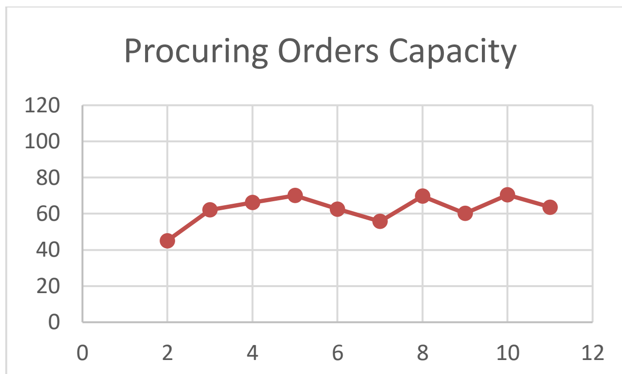

Figure 8. Procuring orders capacity

5.1.2. Agent-Based Simulation under Risky Business Environment

In a risky business environment, we minimize average values of the random numbers that are generated from the Customer Sales-Order, Suppliers Procuring-Orders, Agent's Sales Order Capacity, and Procuring Order Capacity (see Table 3). We need to test how the agent will act in such a risky environment with minimum income and reasonable expense. The simulation runs ten times, and the results are shown in Table 4. The simulation runs various times with these settings. As apparent, Suppliers Available Data, Incoming job orders from customers or distributors, and Suppliers alternative and materials purchasing orders are set Low. Also, notice that Searching declines variable values is set high.

Table 3. Risky business settings

Business, Risky Environment Settings	Max. Value of Random Number Generators
Max. Suppliers Searching Data	10
Max. Searching Cost	12
Max. Customers Job Orders	8
Max. Stock Decline	12
Max. Procuring Orders	10
Max. Procuring Decline	12

Table 4. SOP-Agent simulation results under risky business environment

Experiment No.	Warehouse Level	Cash Level	Sales Orders Capacity	Procuring Orders Capacity
1	96.3	70	81.3	79.2
2	80	65.2	94.9	60.2
3	100	59.1	60.3	90.4
4	60.3	75.3	80.2	70.3
5	98	90.2	79.1	90.6
6	70.5	77.2	60.3	80.5
7	97.2	66.5	90.2	80.1
8	93.3	75.6	79.4	60.3
9	98.2	73.1	63.1	85.3
10	80.6	60.8	79.2	60.4

From the tables above, the performance of the SOP-agent is surprisingly well, although it has great difficulties keeping warehouse value between its preferred values, and it fails to maximize Sales Orders Capacity quite often. When SOP-agent feels wrong about perceived events, it keeps trying to improve this, but as managing the inventory has a higher priority than serving customer sales orders. However, at this moment, SOP-agent behavior is acceptable in normal and risky business conditions. The charts for typical runs of SOP-agent describe in Figure 9,10,11 and 12.

Figure 9. Main goal satisfaction

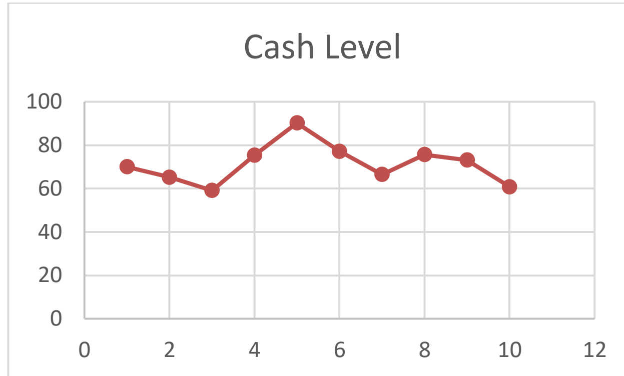

Figure 10. Cash level status

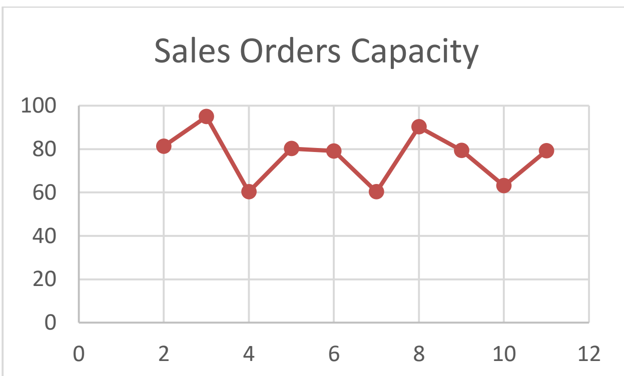

Figure 11. Sales orders capacity

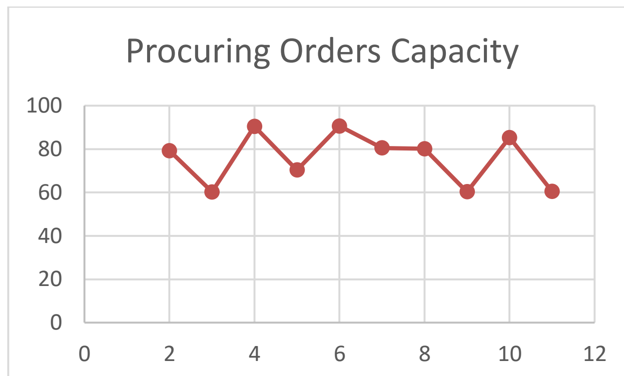

Figure 12. Procuring orders capacity

6. CONCLUSION

To recapture, the primary goal of this work is to try to investigate the role of intelligent software agents in the Business Information System. The concept of instrumentalism was explained, and put into practice, which enabled us to grasp the idea of agents, and led us to the conclusion that we can honestly say these agents are intelligent and beneficial to business information systems such as SOP.

At the beginning of this research, we had a limited idea as to what was required for an agent and how it would work. Our overall complex idea on what we have done was derived from what was understood from the literature and what was gradually built during our agent-based simulations. Progress was only made when our ideas were significantly simplified, and an open-mind was adopted to determine how the system should work.

The proposed agent is supposed to resemble some of the human behaviors. During implementation, we could notice that decision-making process and agent mental or thinking process on the SOP performance measures.

We selected a business planning application "SOP application," in which agents had to manage system warehouse object while maintaining other goals as well. In the constructed simulation, agents are tested in a real-time situation, thus making it easy to compare the performance of agents under different circumstances in real-time. Several experiments are conducted with varying variables of business settings.

The conclusions from simulation experiments are we successfully simulate software agents in the business information system. The simulation environment can be used as a framework for other simulations.

We are very confident that agents can be very beneficial in many applications in an information system. We consider this work, a bold step toward a subject that is promising in BIS or ERP field. Our message is that agents, when coupled with a business information system can enhance the decision-making process and systems outcomes.

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