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SMART AGENTS IN THE BUSINESS INFORMATION SYSTEM

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Abstract. *Agent-based modeling stresses on a system's dynamic entities. Active objects, known as agents, must be recognized with agent-based modeling and their actions defined. Agents may be business-process, business-functional-unit, employees, tools, products, or business partners; anything is appropriate to the system. Connections are being established between them, environmental business parameters are set, and simulations are running. The entire dynamics of the system arise from the interactions or behaviors of many entities. In our paper, we simulate an agent-based Business Information System (BIS) and study the efficiency of the BIS system using smart software agents. The proposed agent possesses rational knowledge and reactive capabilities and interacts, including other agents, with the external business environment. We investigate whether smart software agents in certain circumstances can improve the performance of the Business Information System (BIS). The main contribution of this work is to simulate and evaluate business information system's performance using smart software agents. Furthermore, there may be a systematic view of the intelligent agents, assuming that a decision is a process involving evaluation, cognitive-signal generation, and cognition-response. Sales and Operations Planning (SOP) is chosen to demonstrate the impact of using smart software agent. NetLogo is used to design, implement and test the proposed agent on the SOP system as a multi-agent simulation and programming language.*
Keywords: Agent-based simulation, Multi-agents, Believable, Behavior, Business Information System (BIS), Sales and operations planning

1. **Introduction.** With the help of state-of-the-art technology, successful manufacturers are increasingly competing. These companies embrace the concept of electronics, mobile and smart manufacturing in the face of intense global competition and expanding customer requirements. With the integration of big data and de-centralized system, business partners must be able to share product design concepts, which minimize time to market and maximize production efficiencies [1]. Excellent smart solutions allow manufacturers to optimize productivity and efficiency [2]. Due to customized production, the shorter life cycle of products and different process engineering, today's global business is an essential requirement for manufacturing companies [3]. Information architecture must be scalable.

Software agents emerging in the information system structure are also a promising one. Software agents are entities that operate without their users' direct involvement and have some 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 offers an understanding of the integrated business information system, which has a rapid response to changing requirements

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and the ability to integrate different production processes [5]. Sales and operations planning application is chosen as a demonstration for one of the most significant business information systems that is used heavily in the manufacturing world. The SOP concerns both the scheduling of production and the management and control of warehouses [6,7].

We used a previous general, flexible, and robust architecture in this paper to build smart software agent requirements. The agent proposed is rationally knowledgeable and responsive and interacts with the outside world, including other agents [8]. However, the remainder of this paper is structured as follows. Section 2 discusses the related works. The sales and operations planning system is set out in Section 3. Simulation settings are provided for all entities, variables, scenarios, agent architecture, agent thinking mechanism and environment parameters in Section 4. In Section 5 the results are discussed, and in Section 6 the conclusions and future work are presented.

2. **Related Works.** Some associated works are briefly labeled in this section. Recent research achievements around the world are attempting to push agent technology onto the path to applications in manufacturing. 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 the concept of tolerance of a system by developing an agent-based model framework for two potential production systems. Such applications of agent-based modeling can illustrate the possible evolutionary line of given situations under different circumstances and geographical settings.

While in [11] the researchers proposed a comprehensive multi-factor reliance framework that applied some measurements to assessing network agent confidence.

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 in the simulation world into a two-dimensional supply network.

3. **Agent-Based Sales and Operations Planning System.** A business information system used by agents is the industrial production and planning app, named the sales and planning application [13]. For industrial or manufacturing systems, agents are not a cure. Like any other technologies, they have specific capabilities and are best suited to problems that are characteristic of modularity, decentralization, unpredictability, unstructured and complexity [9].

Sales and operations planning is a computer modeling technique that makes it possible to make demand-driven production plans [14] (see Figure 1). The sales order life cycle will be handled using multi-agents in its front and back end. Each SOP component is supervised and monitored using a discrete-agent.

3.1. **Intelligent software agent in SOP.** An agent is more than an object; it is a proactive object, a limited entity of the process. It does not have to invoke externally, but it autonomously monitors its environment and acts accordingly. This agent characteristic makes them particularly suitable for applications that can be broken down into standalone processes.

Figure 2 shows the role of an intelligent software agent in the SOP. First, an agent accepts the sales order of the client. The agent will carry out material planning processes in the backend as a mobile and portable agent in collaboration with other agent types. The agent then dispatches daily production jobs to Job Shop, which performs scheduling and production in real time. On the other hand, to demand the raw materials, agents send

Figure 1. Sales and operations planning application

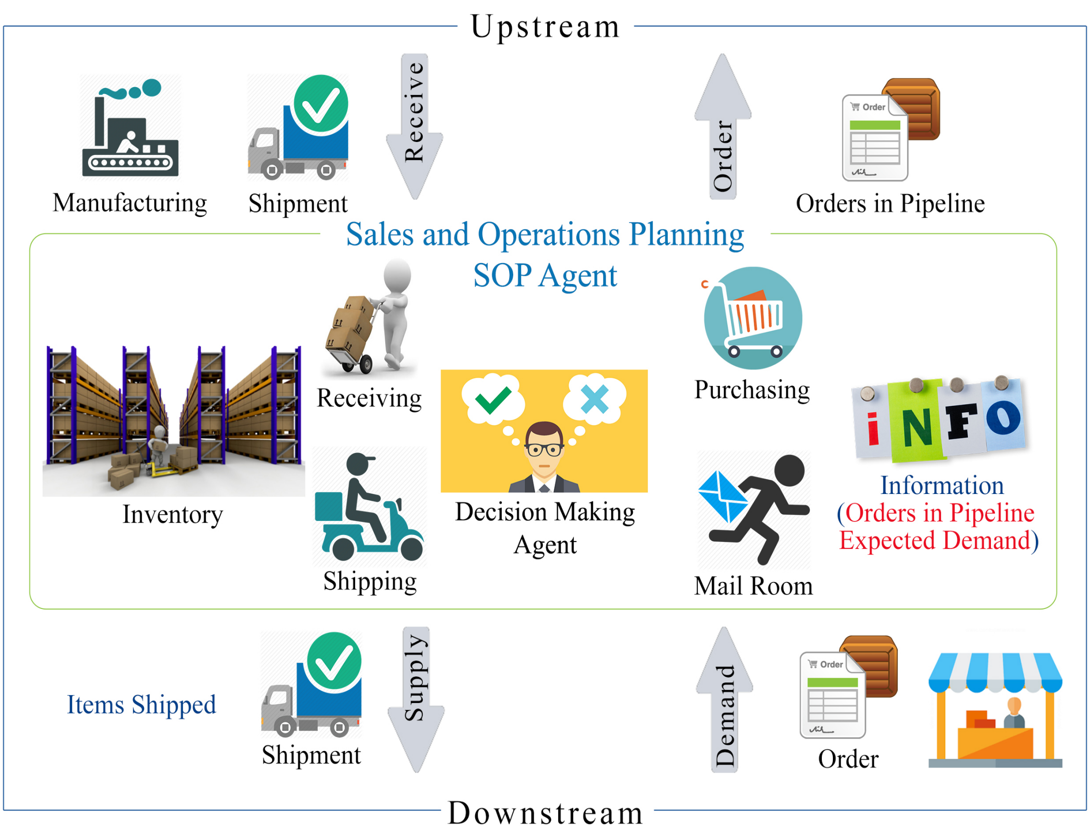

Figure 2. Agent-based SOP application boundaries

purchase orders to an appropriate supplier. Job Shop returns finished parts to the SOP-Agent after completing the production task, which can adjust some initial parameters such as lot size, lead time to meet the customer's sales order requirement.

3.2. **Proposed agent architecture.** As the mind is made up of many small components called agencies [15], that is simple, but the interaction between them leads to complex behaviors. We used this idea to build our agent architecture. The agent's configuration is mentioned in [16]. Figure 3 demonstrates the agent architecture.

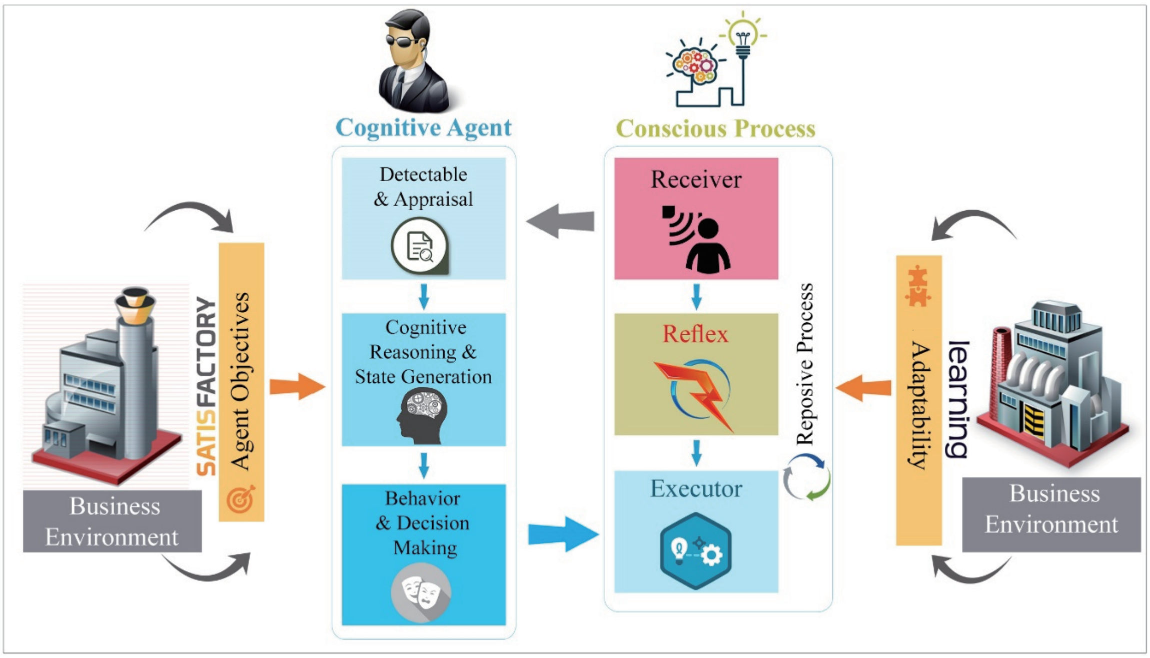

FIGURE 3. Agent model [16]

4. **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 monitoring and controlling agent responsible for enhancing the system's efficiency. The decision-maker agents of SOP control the system's critical variables. The decision shall be taken by information on the upstream and downstream levels of each data received at the decision points (data gathering agents distributed throughout the system). The business environment is affected by SOP-Agent's decisions.

Consequently, agent is always faced with a new condition to resolve. The current business environment also encourages or punishes the agent by ranking the results of the actions as good or bad as a result of the decisions taken. A rational choice is to consider as an optimal solution for maximizing the reward under a set of constraints. It is possible to improve the ability to avoid wrong decisions and to find the best solution.

4.1. **Agent-based simulation settings.** 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. With random numbers, we are able to control the maximum value of system performance measures.

4.2. **Simulation entities.** The simulation has the following entities.

1) **Warehouse Entity:** It is the focus point of the agent. Over time, it declines in status. It can only be improved if an agent manages it.

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. The agent must pay for orders and learn to purchase at the time of purchase.
4) **Supplier Entity:** Agent should improve the information level of its supplier.

The key performance indicators for the SOP simulations are warehouse level, sales orders level, suppliers' information level, and purchasing orders level.

4.3. **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 examines and scans the prospects of goals, using attitudes as a guideline that leads to the creation of mental agent status.
- **Goals Evaluation and Ranking:** Appropriate goals are taken more seriously than less likely goals.
- **Goal Filtering:** This leaves us with a priority list of objectives.
- **Take Action:** Highest priority is given to behavior.

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

Figure 4. The rational thinking mechanism of SOP-Agent

5. Experiments and Results.

We implement the simulation for the proposed agent in this section. The primary goal is to find out how to use smart software agent to improve SOP performance. We run the simulation ten times to achieve a satisfactory result, one in a normal and risky business environment.

5.1. Results analysis.

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

Since randomness plays an important role in simulating discrete events, a different set of the environment is used to perform simulation runs ten times. The simulation test, therefore, fails if the agent runs out of cash or if the warehouse level drops to zero. As the agent performs different actions or events, the system state parameters are changed as a subsequence of rational agent behavior.

5.2. Normal business configuration.

After completing 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 for 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 results of the simulation experiments, the performance of the proposed agent in the regular business information system of the SOP is acceptable; although it has extreme difficulties in keeping its main objective status (warehouse level) within preferred values, it also fails to maximize its capacity level while cash level is acceptable. The charts for typical SOP-Agent runs are described in Figures 5(a), 5(b), 5(c) and 5(d). The SOP-Agent's primary objective is stable (fewer fluctuations); it is an overall positive trend.

FIGURE 5. (a) Main goal satisfaction, (b) cash level status, (c) sales orders capacity, and (d) procuring orders capacity

5.3. **Risky business configuration.** We minimize average values of the random numbers generated from the customer sales-order, suppliers procuring-orders, agent's sales order capacity, and procuring order capacity in a risky business environment (see Table 3). We need to test how the agent will act with minimum income and reasonable expenses in such a precarious situation. The simulation runs ten times, and Table 4 shows the results.

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

The performance of the SOP-Agent is surprisingly good from Tables 3 and 4, although it has great difficulties in keeping the level of the warehouse between its preferred values, and it fails to maximize the capacity of sales orders quite often. If SOP-Agent feels wrong with perceived events, it continues to try to improve this, but as inventory management has a higher priority than serving customer sales orders. Figures 6(a), 6(b), 6(c) and 6(d) describe the charts for typical SOP-Agent runs.

6. **Conclusions.** 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

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

FIGURE 6. (a) Main goal satisfaction, (b) cash level status, (c) sales orders capacity and (d) procuring orders capacity

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. Some of the human behaviors should resemble the proposed agent. We could notice that decision-making process and mental or thinking agent process on the performance measures of the SOP during implementation.

Simulation experiments conclude that in the business information system we successfully simulate software agents. For other simulations, the simulation environment can be used as a framework. 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. In the future, our work will encourage the use of the smart agent in ERP Blockchain. The next question is "Are the Blockchain beneficial business information system agents?" as one of the promising technologies of decentralization.

REFERENCES

[1] L. Monostori, J. Váncza and S. R. T. Kumara, Agent-based systems for manufacturing, *CIRP Ann. – Manuf. Technol.*, vol.55, no.2, pp.697-720, 2006.

[2] M. Rolón and E. Martínez, Agent-based modeling and simulation of an autonomic manufacturing execution system, *Comput. Ind.*, vol.63, no.1, pp.53-78, 2012.

[3] R. Rajnoha, J. Kádárová, A. Sujová and G. Kádár, Business information systems: Research study and methodological proposals for ERP implementation process improvement, *Procedia – Soc. Behav. Sci.*, vol.109, pp.165-170, 2014.

[4] A. Thendral and C. Srimathi, Agent-based system in CRM application, *Int. J. Res. Rev. Comput. Sci.*, vol.2, no.3, pp.739-743, 2011.

[5] S. Prawesh, *Applications of Agent-Based Approaches in Business (A Three Essay Dissertation)*, Ph.D. Thesis, University of South Florida, 2013.

[6] M. Nolte, *The Impact of Sales and Operations Planning Implementation on Supply Chain and Financial Metrics*, 2015.

[7] S. Noroozi, *A Framework for Sales and Operations Planning in Process Industries*, Ph.D. Thesis, Linköpings Universitet, 2014.

[8] M. A. Shirazi and J. Soroor, An intelligent agent-based architecture for strategic information system applications, *Knowledge-Based Syst.*, vol.20, no.8, pp.726-735, 2007.

[9] A. Brighenti and M. Capobianco, *Multi-Agent Systems for Industrial Diagnostics*, 2016.

[10] N. Bichraoui, B. Guillaume and A. Halog, Agent-based modelling simulation for the development of an industrial symbiosis – Preliminary results, *Procedia Environ. Sci.*, vol.17, pp.195-204, 2013.

[11] B. Khosravifar, J. Bentahar, M. Gomrokchi and R. Alam, CRM: An efficient trust and reputation model for agent computing, *Knowledge-Based Syst.*, vol.30, pp.1-16, 2012.

[12] J. U. Min and H. Bjornsson, Agent-based supply chain management automation, *The 8th Int. Conf. Comput. Civ. Build.*, pp.1001-1006, 2000.

[13] Q. Liao, T. C. Khong, W. Y. San, J. Wang and C. Choy, A web-based material requirement planning integrated application, *Proc. of the 5th IEEE International Enterprise Dstributed Object Computing Conference*, 2001.

[14] K. A. Maria and R. A. Zitar, Emotional agent modeling (EMAM), in *Gaming and Simulations: Concepts, Methodologies, Tools and Applications*, 2010.

[15] K. A. Maria and R. A. Zitar, Emotional agents: A modeling and an application, *Inf. Softw. Technol.*, 2007.

[16] K. A. Maria, A. A. Nagham, T. Kanan and E. A. Maria, Using cognitive agent in manufacturing systems, *J. Theor. Appl. Inf. Technol.*, vol.95, no.10, 2017.