Smartening Production Process of Industrial Papers

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ABSTRACT
Followed by changing environment and global competition, performance of enterprises in allocating more market share to themselves has shaped to be a strategic issue for most of competitive enterprises including production companies. In that case suggestion of a new method or methods that increases the performance of production companies, especially in their production speed, can be critical factor these companies, including industrial paper companies. Thus, in these paper multi agent systems is suggested for enhancing production process of industrial papers. According to the obtained results, simultaneously considering all production factors using multi agent systems can lead to significant enhancement in production performance. This will also construct optimum quality control form at input, internal process and output stages. This paper presents how this methodology can improve the performance of industrial paper production significantly.

General Terms
Hardware agents

Keywords
Agent, multi agent system, performance, production process, industrial paper

1. INTRODUCTION
In a systematic perspective, in order of producing products and services, organizations absorb different inputs and with some operations on the inputs they yield final products or outputs. In other words, production process is a function of organizational goals. In organizational production and operation management processes, in order of planning, system design is a need. A requirement of System design is familiarity with different production and service systems. These production systems include just in time and agile. Advantage of just in time system is in continues enhancement in all functions of production processes and lean quality. Major, advantage of agile production systems is in organizing according to uniqueness in following changes and valuing to costumer.

According to constraints theory, for maximum usage of limited resources, all bottle-neck operations must be simultaneous and in parallel of each other. According to this theory, limiting cost and maximizing capacities is possible. But removing all bottle-necks in agile and just in time systems is impossible. So adopting a systematic method that can balance production process instead of balancing capacity is of great importance. This method must eliminate delay in sending production packages to next step. Implementing multi agent hardware systems is so efficient and can eliminate production bottle-necks in production processes. Making the production process more hardware based using multi agent systems is a new method. Until now, this method isn't used theoretically or experimentally in production process of industrial papers. Thus, papers objective is developing a new model. This model will implement multi agent hardware systems for optimization of production processes and enhancement of efficiency in production of Industrial papers. Paper is organized in four parts. First section is devoted to rudimentary review of production methods. Second part is a literature review of agents and hardware agents. Next part details the implementation of hardware agents in industrial papers production processes. And finally the last section will conclude and states some issues of the process.

2. LITERATURE REVIW
During the last decade agent technology revealed a high potential in solving distributed systems with high scale. Multi agent systems have been welcomed in many different fields, including social science, engineering, math and physics theories. Multi agent is the popular and largely accepted sub branch of distributed artificial intelligence. This is the outcome of rapid progress and maturity in hardware and software computing resources in massively computational demanding and distributed environments. Agent technology is based on notion of reactive, active, independent entities that evolve in a dynamic environment.

Multi agent system is a complex of different entities that cooperate in resolving a problem that it's individually resolving was impossible for them. In fact the reason of successful growth of multi agent technologies is in their ability in dividing systems into several agents and their cooperation in accomplishing expected goals. Agents are programmable entities that through sensors gather environmental information and using actuators effect on environment. Agents have many applications in communication systems, control systems, searching in data warehouses and combination of sensors. Compared with traditional systems agents have lots of features in a way that they are totally fit for dynamic large scale systems.

Concept of multi agent systems consists of a modeling approach that is well thought for reflecting systems with different entities and selected agents that reflect intelligence and possess independence and relatively relationship with environment and each other. Multi agent systems models are good reflection of geographically and functionally distributed entities. In fact multi agent technology increases the ability of analysis and scrutiny of problems in three following situations:

1) Problem be geographically distributed

2) Subsystems exist in a dynamic environment

3) Subsystems need flexible interaction with each other

As with increase in problem scale agents can be added to the problem state, agent based systems are flexible and scalable. Furthermore agent systems can work in series and parallel, so compared with undistributed systems they have better efficiency and pace. In another perspective failure of one agent is dispensable with other agents. This leads to enhanced reliability of these systems. Agents can share information, effect on environment and be time aware. In this case they can use different methods for information gathering, using their time consciousness and depended on the time they possess for response they use appropriate method of gathering information.

3. AGENT MODEL

This is a formulation that is used for hardware agents. It roots from BDI (belief, Desire, Intention) architecture. In this architecture every agent has some beliefs, desires and intentions. Beliefs are indicator of what agent believes is correct in the environment at the present moment. In a system desires are the collection of outputs that an agent is willing to send to environment. These desires may be accessible or not. Reaching Goal requires activities of rest of agents and it can be impossible. At the end attitudes and intentions are collection of activities that an agent must accomplish in order of reaching goals. So agent is a function for mapping inputs and updating intentions. It is also a function for mapping intentions to desires and finally mapping desires to intentions. Figure 1 is representative of an intelligent agent that is in interaction with environment.

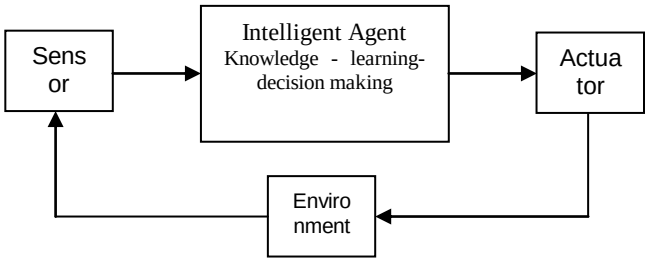

Figure1: intelligent hardware agent in interaction with environment

Using multi agent systems complex problems can be divided into simpler and smaller problems that can be adopted by different agents in the system. As a conclusion agent technology is appropriate for developing complex computer systems.

3.2 Agent communication

For reaching goals agents must communicate about their knowledge. Relationship between agents is possible through ACL (Agent communication language). For this purpose different communication protocols like TCP/IP, SMTP and HTTP are adopted.

Agents have especial features that distinguish them from standard programs. These features can be grouped in two collection of mandatory and arbitrary. Mandatory features include independence, decision making and goal based being of agents. Arbitrary features are abilities in replacing, interactivity, cooperation and learning.

3.3 Agent Technology

Agent technology is divided into unique agent and multi agent technologies. In unique agent systems an agent performs an activity for user or process. During operation it may communicate remotely with user or system internal resources. Mandatory features of unique agent systems are in their independence, decision making and goal based being. Furthermore they can possess some intelligence characteristics.

Agents in multi agent systems massively interact with each other, user and with system resources to reach to desired objectives. In order of goal achievement multi agent systems may use static or dynamic agents. Mandatory features of multi agent systems include independence, decision making, being goal based and cooperation and collaboration. In addition they may possess the abilities of learning and motion.

3.4 multi agent technology in distributed and parallel systems

In a distributed system, the whole system prepares an environment for development and process of activities. Various methods of parallel computing are done through these systems that are similarly used in relationship of user and computer (interface). The decision making about selection of appropriate method is by agent. In parallel process the user don't need to be concerned about selection of method.

3.4.1 Objectives of multi agent systems in parallel processes

Objectives of multi agent systems in parallel processes include:

- Using optimum resources through optimized parallel recourses.
- Advanced competency through optimized parallel processes or activities.
- Fitting all the system through agent's ability in learning
- Simpler system management and the ability of shifting loads for simplifying hardware

3.4.2 Advantages and disadvantages of using agents in parallel processing systems

- Synchronism of a multi agent system and shared activity technique is an appropriate complex for distributed model that is applicable in parallel process. A multi agent system consists of several specialized modules that cooperate in resolving problems.
- Agents are flexible and have the ability of learning. This flexibility can assist in performing dynamic load balancing strategy for input distribution and optimized activities. Learning ability leads to long term enhancement in strategic planning and scheduling.

- Agents are appropriate for efficient and distributed planning. So they are applicable in parallel process planning.
- Scalability is an important feature of distributed and multi agent systems

By the way using agents have some disadvantages that the major one of them are communication excessive load, agent basic knowledge management excessive load and the calculated time for teaching agents.

3.5 AGENT'S CAPABILITY

Programmable Hardware and internal array technique (FPGA) suggest more hardware flexibility features than their identical software implementations. Agent techniques in reconfigurable hardware permit experts to create high speed systems. In this paper a multi agent system is developed that is adaptive to environmental changes. Compared with its corresponding software equivalents these systems enhance the efficiency. The hardware agent architecture changes due to change in requested applications. In order of reaching desired goals, this system links a set of low level hardware agents with high level software agents.

Hardware agents have several features. First feature is their speed. Usually, hardware agents are 2 times faster than software agents. Other feature is lower power consumption. During monitoring phase, Hardware agents turn to standby mode. This enhances efficiency and reduces power consumption.

4. IMPLEMENTATION

4.1 Planning of multi agent system

If architectures adopt multi agent for execution of various activities in a complicated computational system then they will implement every group of activities with a single agent. Agents work in parallel with captured activities. As an agent accomplish its duty quits "done signal" and sends it with "turn on/off" signal to other successful agents. Then agent transfers the next value to next levels. In this model agents verify their request in interaction with environment as they are ready to receive more inputs. So, using reconfigurable hardware agents, agents are implemented in a multi agent system for production of industrial papers.

4.1 Automated sensors

One of the applications of hardware agents are in automated sensors field. Most of automated systems have sensors for gathering information and conditional situation. This systems use this information as feedback for controlling gauges. Capability and power of these systems in execution of an activity is dependent on quality of received information from sensor. As the quality of this information are dependent on quality of sensors.

Data integration is adopted for overcoming these defects. This is done through integrating information of two or more independent sensors. FPGA technology and other adjustable hardware, make hardware implementation possible. This leads to more flexibility, before advent of hardware agents; it was possible only with software agents. Implementing agent techniques in adjustable hardware gives the opportunity of making fast systems that enhance the ability of parallelism compared with software agents. Agent based systems must constantly adapt their behavior in response with environmental changes. In this way, they will be able to satisfy environmental needs and remain efficient and effective. For this purpose, agents can be implemented in various ways. This gives their belief systems the ability that through time and with interaction with environment and other agents, evolve and progress themselves. Integration of data/sensor through hardware agents was developed by Naji and et al in 2004. They used hardware agents in an example for integration of data. The ability of system in execution of activity is dependent on quality of received information. And this is dependent on quality of sensor. Combination of sensors through integration of received information gives a significant help for quality of received information. Combination of information can increase the reliability and precision of received information in a good amount.

4.2 Research model

According to Figure 2, multi agent system is formed from four agents from M_1 to M_4. These agents are formed from Agents A_1 to A_{10}. Environmental inputs of I_1 to I_{27} are fed to system. According the production method of products they are controlled through agents.

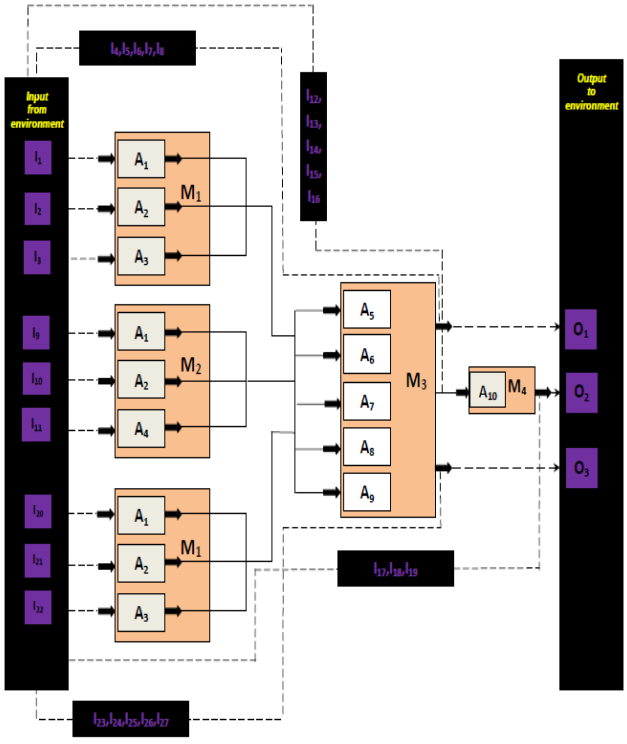

Fig.2 conceptual model according to hardware multi agent system for industrial paper production process

According to BDI (belief, Desires and intention) architecture, in this paper B is the standards that are adopted for agent's inputs. These standards are as follows:

As for all agents wanted standards are available, so fuzzification of model is not necessary, because operation of all

agents is similar. But their inputs are different. D for all Agents is:

1. Measures the quality of waste papers according to the degree of being Brown or inked.

2. Identify useless material in production process.

3. Anticipate the humidity of papers from 2 to 10 percent.

4. Anticipates the ash from 6 to 20 percent.

5. Anticipate thickness of paper.

6. Identify the location of papers borders.

7. Anticipate the density amount in all production processes.

8. Executes the sampling and analysis intelligently in all production process sections.

So, by adopting the mentioned goals in production process, agents yield the output with desired quality. I is the process that converts B to D. according to production process, the products pass the following steps:

1. Dough section(dough production, HD two level cleaning system, elementary screen, distinguishing long and short fibers, cleaner of short and long fibers, delicate screen of long fibers, dough condensation, perfecting long fibers, ejection of expulsion)

2. Recessive papers and retrieving fibers section.

3. Paper machine (Box, press, dryer, cannon pulley, rebounder)

4.2 Detailed conceptual model

Conceptual model in figure 2 consists of 3 separate sections. Independent function of that is as follows:

1. input 1 (it consists of 3 inputs I_1 , I_2 , I_3) enters the production process and in this stage is controlled by 3 agents (A_1, A_2 , A_3) and if there isn't any difference between adopted standard, it will shift to next production step and will be controlled by 5 agents (A_5, A_6, A_7, A_8, A_9). After standardization according to desired amounts, 5 constant inputs (I_4, I_5, I_6, I_7, I_8) will be added to that and results P_1 product. Coding of conceptual model is done with C# language.

2. Input 2 (consists of 3 inputs of I_9, I_{10} , I_{11}), will enter in production process and in this stage is controlled by 3 agents (A_1, A_2 , A_4), if there is no difference from adopted standards it will enter to next production unit and will be controlled by 5 agents (A_5, A_6, A_7, A_8, A_9) after standardization with desired values, 5 input constants (I_{12} , I_{13}, I_{14}, I_{15},I_{16}) will be added to that and results are halfway product of $P_{2\text{-}1}$. As product is halfway, using A_{10} Agent, and after standardization, 3 constant inputs of (I_{17}, I_{18},I_{19}) will be added to that and results P_2 product.

3. Input 3(consists of 3 inputs of I_{20} , I_{21} , I_{22}), enters the production process and in this stage is controlled by 3 agents(A_1, A_2 , A_3). If there is no difference between adopted standards it will shift to next step and will be controlled by 5 agents (A_5, A_6, A_7, A_8, A_9). After standardization with desired values, 5 constant inputs of (I_{23}, I_{24} , I_{25}, I_{26},I_{27}) will be added to that. It results P_2 product.

4.4 Conceptual model components Standards

According to studies of production processes of replacement Craft Paper, Duplex cartoons and with top Paper , desired standards(tables 1,2,3) are according to the following:

1. I_1 , I_2 , I_3 standards that must be analyzed by A_3, A_1, A_2 orderly sequenced as : The Upper , Middle and lower layers. Orderly, these layers mustn't exceed20%, 10% and 70%.

A_5, A_6, A_7, A_8, A_9, must approximate orderly: 1) Basic weight from 90 to 300 grams 2) humidity from 2 to 10%, 3) ash from 6 to 20% 4) paper thickness from 3 to 5 millimeter. 5) Density extremely must be less than 0.8 CM/m^3. As an example C# code of conceptual model for A_1 agent is defined as follows:

```
private bool A1(Double I1)
if (I1 > .2)
IL1.Text;"upper layer is more than 20%"=
return false;
else
return true;
```

2. I_9, I_{10}, I_{11} standards that must orderly be analyzed by A4, A_1, A_2 are as follows: upper, middle and lower layers are orderly 60, 60 and 20% at maximum.

A_5, A_6, A_7, A_8, A_9 must evaluate orderly 1) basic weight of 90 to 300 Grams 2) humidity of 2 to 10% 3) ash from 6 to 20% 4) Paper thickness from 1 to 3 millimeter and 5) maximum density of 0.8 gram/cm^3

A_{10} agent must control maximum 5% diversion degree of paper to recover it to its desired condition.

3. I_{20} , I_{21} , I_{22} standards are analyzed by A_1, A_3, A_2 are: upper, middle and lower layers that at maximum orderly are 15 , 15 and 70 percents.

A_5, A_6, A_7, A_8, A_9 orderly evaluate: 1) basic weight of 90 to 300 grams 2) moisture from 20 to 10% 3) ash from 6 to 20% 4. Paper thickness from 1 to 3 millimeter 5) maximum Density of 0.8 gram/Cm^3

4.6 implementation results

This model's test is implemented in two hardware systems and in two different software modes. First mode is structured in series (serial). Second mode is structured in parallel using multi agent that is main notion of this paper. Results are depicted in the following tables.

Table 1. Speed comparison of serial and parallel production systems

Systems	CPU	Runtime (parallel)	Runtime (serial)	Speedup
Windows 7 Ultimate	Dual-Core 2.2GHZ	31250 Micro second	181230 Micro second	5.8
Windows XP	Dual-Core T4200	88002 Micro second	563218 Micro second	6.4

According to acquired results, run time of parallel implementation mode using multi agent system is much less than serial mode. In two systems Parallel mode was compared with serial mode. The amount of speed up of parallel to serial in first system was 5.8 and in second one was 6.4.

Implementation of mentioned software multi agent system in reconfigurable hardware is tasted in former works and simulation results using ISI tools of Xilinx Company using FPGA Virtex series microprocessors reveals and speed up of 1o times of its similar software implementations. It means speeds of 58 to 64 times of serial modes are reachable. This is a significant increase and can heighten performance of all system.

5. CONCLUSION

Using interaction of intelligent components in order of reaching whole system's goals, Multi agent systems, due to their learning ability make appropriate decisions. In this paper a multi agent system were designed for enhancements of outputs quality, pace and performance of industrial paper production process and for minimizing the waste. This system evaluates inputs density, papers thickness and positioning of paper lines thorough all production lines. This system executes all of that in parallel and simultaneously. It also identifies the appropriate sampling type with minimum error and maximum speed. According to conceptual model simultaneous implementation of all desired standards is controllable.

Testing model in two different structural and functional methods of serial and multi agent parallel both in software and hardware implementation mode led to following conclusions: execution time in multi agent parallel is several times shorter than similar process in serial mode and hardware implementation of a software multi agent significantly increase the system speed. Simultaneous Considering different aspects, due to increase of accuracy and speed of performance, current model can enhance other industrial processes as well as it did in industrial paper production process.

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