Planning and Management of the Production Factors based on the SCDIA Framework

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Abstract: - In this work, we propose a general reference model for the automation applications, which execute functions of planning and production factors management. Then, such model is applied for proposing a model that will support the SCDIA reference model as shown in [1].

Key-Words: - Industrial Automation, Multiagent Systems, Planning and Production Factors

1 Introduction

Originally, there was a proposal for a reference model for the development of intelligent distributed control systems based on agents (called SCDIA) [1], using a group of agents for distributing the functions of the supervision and control systems. With the SCDIA proposed at [1], it is not possible to integrate the enterprise, neither the execution of all industrial automation activities; nevertheless, as a continuity of its evolution, [3] proposes an integration design using the multiagents system. This design proposes a model with three abstraction levels. The agents of the first abstraction level are composed by the business objects. In the second level, there is a set of agents capable of carrying out all activities related to industrial automation (defined as "Automatic Intelligent Distributed System based on Agents-SADIA"). And the third level proposes the use of the SCDIA model. Also, [3] proposes the use of the Multiagents System model (MAS) for the Abnormal Situations Management Agent of the second abstraction level, and in [5] the model of MAS is proposed for the Failures Management Agent, as well in the second abstraction level.

The objective of this investigation is to develop the reference model of the Agent for Planning and Management of the Production Factors in the second abstraction level of the SADIA model, in which there is the intention of solving the problem concerning the automation of planning and management of the production factors.

2 Theoretical Aspects

2.1 Planning and management of the production factors

Production planning refers to the making of the general plan as well as the detailed plan for the negotiation object according to the requirements of the negotiation, models of the productive process, production mechanisms and/or negotiating rules, optimization methods, global state, predictions and/or estimates, amongst others. With the general plan, the production goals are determined on the base of time (the period of time is usually called planning horizon), indicating: what is going to be produced, which quantity, who requires the product and when it is being required. The detailed plan should show the activities sequence, which should be executed by the negotiating object throughout time, with the purpose of accomplishing the production goals, established in the general plan.

The management of the production factors refers to the control of the required resources inventory for the plan execution, terminated products stock control, and waste management.

Using the functional data flux model proposed in [2, 7], the main functions and tasks were determined. These should be executed by a system that supports production planning and production factors management, shown below:

- Order Processing: among its main tasks: a) Manages accepts and confirms the clients'

orders. b) Stores the products according to received orders.

- Production Planning: its functions represent the interface between the functions of the control system and the enterprise, through production planning, the information about current production and the production capacity. Some of the general functions for production planning are the following: a) Indicates the production plan for each negotiation object. b) Identifies the long-term raw material requirements. c) Establishes the delivery program for the terminated products. d) Indicates the products availability for sale.
- Production Cost Control: among its main tasks: a) Calculate and report the production costs, b) Obtain the costs of prime material, manual labor, energy and other costs.
- Material and energy control: Among its main functions are: a) Fulfill the matter and energy requirements necessary for production, according to the production plan. b) Assigning the material and energy. c) Optimize dynamically the inventory and materials management. d) Receive the material and entering energy supply and request the testing for assuring their quality.
- Facilitating: among its main tasks: a) Providing purchasing orders to the prime material, parts spare parts and other required materials suppliers. b) Monitoring the purchasing state and report to the requestor. c) Processing the entering receipts for their payment, right after the arrival and approval of the material.
- Products inventory control: includes: a) Managing the inventory of the final products, b) Minimize the quality gift (quality over the client requirements), c) Manage the terminated products dispatch, according to the delivery program.
- Product dispatch: include: a) Assign the terminated products, indicating the information about the client that will receive the product, the, product cost, the delivery date, time of delivery, transport or delivery way, and all the information related to product sale. b) Generate the orders for waste management, indicating the product type, waste management normative, responsible person, date and time, etc. c) Report the transportation costs for accounting of production costs.

See [4] for the details of all functions.

2.2 System of Intelligent Distributed Control Based on Agents (SCDIA)

The SCDIA is a multiagents platform specifically designed for control systems of distributed processes[1], which proposes the use of a group of agents, which represent the elements present in a processes control loop (see figure 1). This way, the platform proposes five fundamental agents whose functions within the MAS are described below.

- Observation Agent: it is in charge of obtaining the necessary information in order to determine the state of the process, executing the tasks of collection, consolidation and data processing. Combines data coming from different sources for offering information about the state of the process.
- Controller Agent: it is an agent, which evaluates the information of the process and takes decisions in order to allow the permanence of a desirable sate and the ideal productivity, quality and security conditions.
- Acting Agent: converts the taken decisions by the controller, coordination or specialized agents, into actions that produce the changes necessary into the process for reaching the objectives.
- Coordinating Agent: supervises the control loop, plans the control schemes and decision making, produces changes in the controllers commands, including changes in the behavior of he control loop agents under its supervision. Coordinates the activities of the agent's community.
- Specialized Agent: it is an agent, which performs a specific function that supports the system, for example pattern recognition, statistic calculations, failure diagnosis, estimations, predictions, etc.

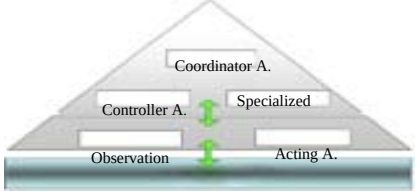

Figure 1. System of Intelligent Distributed Control Based on Agents

Even though this architecture is easily identified with the activities realized in processes control system, it can be extrapolated for representing functions in types of systems, as for example the model of the Failure Management Agent [5] and the Abnormal Situation Management Agent [3].

3 Reference model of a MAS for production planning and management of the production factors.

A support system for the production planning and management of production factors should generate and execute the necessary action sequences in order to satisfy the requirements of ach one of the requested services. The sequence of actions (detailed plan) involves the assignment of resources throughout time, until the full execution of the whole plan. This system should as well supervise the plan execution, and dynamically modify the executing plan in any case of deviation (re-planning). Figure 2 shows the proposal for a functional separation of three blocks.

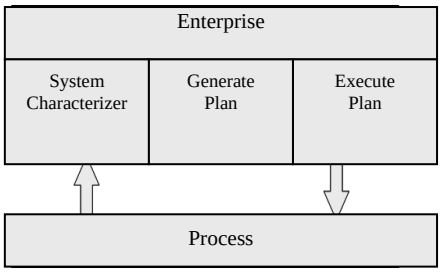

Figure 2. Functional Diagram of the Planning and Production Factors Management System.

Each block in the system is composed by different modules interacting with each other, following a sequence determined by the negotiation rules, according to the reference model shown in Figure 3.

System Characterizer: Two modules compose this block: Determine the global state (It is in charge of obtaining and processing all the required information for plan making. In general, the variables used are the following: Current Demand, Estimated Demand, State of Production demand, Production Capacity, Compromised production capacity, Unattended production capacity, Available production capacity, Income Indicator, Resources availability, Products availability for sale and/or usage of other negotiation objects), and manage the negotiation requirements (In the productive process, the negotiation objects can assume the role of requirement for generating objects, services offering object or both roles objects).

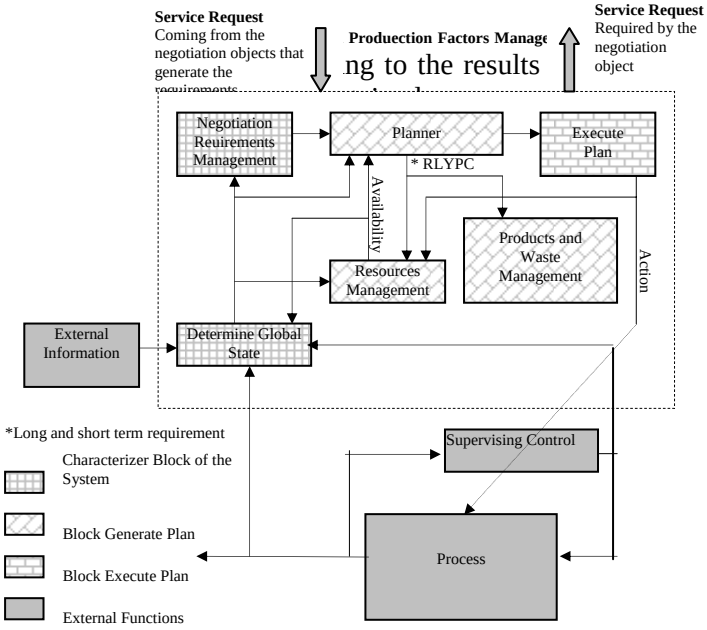

Figure 3 Reference model for Production Planning and management.

Generate Plan: Three modules compose this block: Planning (It is in charge of elaborating the general plan and the detailed plan of the negotiation object according to the negotiation requirements, models of the productive process, production mechanisms and/or negotiation rules, optimization methods, global state, and/or estimations, and other aspects. The general plan refers to determining the production goals of the negotiation object in function of time, indicating: what is going to be produced, which quantity, who requires the product and when it is expected. The detailed plan should show the activities sequence that the negotiation object should execute throughout time, in order to accomplish the production goals, which have been established in the general plan. The detailed plan should at least establish: The adjustments (set point), The request, the assignment and mechanisms for resources delivery and reception, The detailed program for product delivery, The specification of the mechanism or strategy to be followed for realizing each one of the production tasks), Resources administrator (It is in charge of the inventory control of the resources required for the execution of the plan), and Product and Waste administrator (It is in charge of controlling the terminated products stock. It should as well manage

the consequential wastes resulting out of the productive process).

Execute Plan: The module Execute Plan composes this block (It is in charge of executing the detailed plan).

4 Reference Model for production planning and production factors management based on SCDIA

4.1 Actors

Based on the functions that must be carried out, we identify and obtain the actors for the problem of planning and management of production factors (see table 1).

Table 1 Actors of the system for planning and management of the production factors.

Actor	Description
Characterizer	Receives the state of internal and external variables to the process and determines global state.
Negotiator	Sends, receives and processes the negotiation requirements.
Planner	Makes the general plan of the negotiation object taking in account the negotiation requirements, the global state, the estimations and/or predictions, etc.
Programmer	Makes the detailed program of the negotiation object based on the general plan, production mechanisms or negotiation rules, optimizing methods, global state, etc.
Resources Administrator	It is in charge of controlling inventory of the management resources and the management for their acquisition and assignment within the process.
Products Manager	It is in charge of the management, storage and distribution of the terminated products
Wastes Manager	It is in charge of the management of wastes according to the Hygiene, Environmental and Security rules
Predictor	Makes the estimation of variables required by the planner and the resources administrator
Executor	Executes production plan and notifies its execution state

With the actors identified the agents that support the management and production factors management are also identified, with the functionalities that allow the accomplishment of their activities. These functionalities could be distributed in the SCDIA general reference model. This way, the problem can be treated as if it was a control problem with feedback, distributing the functionalities of the actors in the following agents:

- Observation Agent: This agent develops the functions of the characterizer agent; this way the MAS obtains the state of the internal and external variables to the process for processing and so obtaining the global state (state of the surroundings).
- Coordinator Agent: it carries the functions of the planning actor and the programmer actor. This agent can obtain the general production plan and the detailed production plan, and in case it is necessary it must get a new general production plan (dynamic planning) and a new detailed production plan. This agent should as well generate the requests of services by the specialized negotiation object.
- Acting Agent: this agent processes the detailed plan, but if the actions to be executed by the plan are simple, the controller agent can directly execute these.
- Controller Agent: this agent should process the detailed plan and supervise continuously its execution in order to detect on time any deviation and take the respective actions. During the supervision of the plan, the agent evaluates the performance of the objects. In case the performance of the object is lower than expected, the controller agent must notify to the coordinator agent so it can obtain a new general production plan.
- Specialized predictor Agent: Carries out the functions of the predictor actor. Supports the coordinator agent for making the general plan and to obtain the detailed plan of the negotiation object. This agent is able to predict and validate all the restrictions, so that the coordinator agent uses this information for elaborating or validating the plan, or even for compromising in the production goals.
- Specialized Negotiation Object: The agent receives the requests coming from the requirement generating objects, and based on the global state, information coming from the predicting actor, and the negotiation mechanism, processed each request. This agent also receives and manages the requests mad by the agent coordinator of the negotiation associated to it, for this it determines the negotiation

mechanism for contracting the required services to the offering objects.

- Specialized Resources Manager Agent: it is in charge of controlling the resources inventory and the management for the making of the purchasing order and the resources assignment within the process.
- Specialized Products Manager Agent: it is in charge of the management, storage and distribution of the terminated products.
- Specialized Waste Manager Agent: it is responsible for the management of the wastes generated during the productive process.

In Table 2, each actor is shown with its respective SCDIA agent in which the functions are distributed.

Table 2 Relationship Actors – Agents.

Actor	**Agent**
Characterizer	Observation
Planning	Coordinator
Programming	Coordinator
Executor	Controller, Acting
Negotiator	Specialized Negotiator
Resources Manager	Specialized Resources Manager
Products Manager	Specialized Products Manager
Waste Manager	Specialized Waste Manager
Predictor	Specialized Predictor

Table 3 shows the tasks that must be carried out by each of the agents.

Table 3 Tasks of the MAS for Planning and Management of the Production Factors

Agent	Task	
1. Observation	T1.1	Obtain state of internal variables
	T1.2	Obtain state of external variables
	T1.3	Data Request AGD[1]
	T1.4	Determine current global state
	T1.5	Determine indicators for management of the general plan
2. Specialized Negotiator	T2.1	Make negotiation offer
	T2.2	Analyze negotiation result
	T2.3	Make negotiation requirement
	T2.4	Select best offer
3. Coordinator	T3.1	Evaluate global state
	T3.2	Define service request
	T3.3	Obtain general production plan
	T3.4	Detect deviations on the general plan
	T3.5	Modify the genera production plan
	T3.6	Evaluate state and resources availability
	T3.7	Evaluate state and products availability
	T3.8	Evaluate waste state
	T3.9	Evaluate Production mechanisms
	T3.10	Obtain detailed production plan
	T3.11	Determine deviation on detailed plan
	T3.12	Adjust detailed production plan
4. Controller	T4.1	Determine state and results of detailed plan
5. Specialized Resources Manager	T5.1	Generate request for resource acquisition
	T5.2	Generate order for resource assignment
	T5.3	Resource entrance into the system
	T5.4	Control on level of resources inventory
6. Specialized Products Manager	T6.1	Generate order for the assignment and product dispatch
	T6.2	Control on products inventory
7. Specialized Waste Manager	T7.1	Determine mechanism for Waste
	T7.2	Generate order for waste
8. Acting	T8.1	Execute action of the detailed plan
9. Specialized Predictor	T9.1	Estimate future production capacity
	T9.2	Estimate demand (requirement to be received)
	T9.3	Estimate restrictions
	T9.4	Estimate date of resources income

The coordination model describes the MAS communication scheme; that is, the conversation, protocols. In order to describe the conversation the sequence diagram UML is used. For the problem of

planning and managing the production factors some of the conversations defined are: a) Design general production plan, b) Modify general production plan in case of low performance, c) Receive negotiation requirements, d) Make negotiation requirement, e) Design detailed plan, etc. Figure 4 presents the UML sequence diagram of the conversation: Design detailed plan.

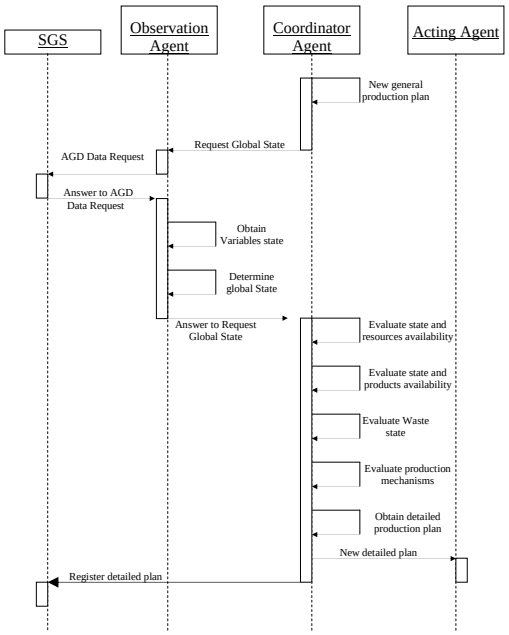

Figure 4. UML Sequence diagram of the conversation: Design detailed plan

4 Conclusion

This work has presented a reference model which embraces the most general functions that must be carried out by a system for supporting the planning of the production and the management of the production factors, mainly based on the ANSI/ISA-S.95.00.01-2000 [2] Standard. With a base on the reference model, a new model is proposed for a supporting system for the planning and management of production factors based on the SCDIA reference model.

The proposed model can be implemented for supporting the tasks of planning and management of production factors of the production processes which could be continuous, continuous by lots and discrete, distributing the tasks and objectives in the different agents of the model. This combined with the properties that characterize the agents, turn into the advantages presented in this Project. This way, the proposed MAS is a distributed model, as the agents are autonomous and there is no centralized supervising system. On the other hand, the MAS could have emerging behaviors, derived from the requirements the environment which it is necessary adjust. The emerging behavior is a current investigation topic in the MAS area.

This system completes the agents design proposed in the second abstraction level of the SADIA reference model (Automatic Distributed Intelligent System based on Agents) [3].

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