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A MULTI-AGENT SYSTEM USED IN GAS-OIL SEPARATION PLANT

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Abstract: *The separation process is a fundamental part of all hydrocarbon production. The main objectives for operators is to produce oil free from gas and water, remove all liquids from gas, and discharge produced water without disturbing the environment. The processes involved are in a state of considerable change, under pressures of all kinds: technological, environmental and economic. As a result modern methods and technologies are applied to minimize the cost and increase the profit. Recently, intelligent agents are more and more present in industrial fields. It is reasonable to use multi-agent systems (MAS) within industrial applications, as agents lend themselves to modular, decentralized, unstructured and complex applications, a new target field being, in this respect, that of the oil industry.In the current paper the author proposed a MAS applied in the framework of a separation plant in order to prove the importance of such advanced intelligence technique.*
Key-words: *agent; multi-agent system; gas oil separation*

1. INTRODUCTION

Petroleum production processes own the characteristics of complexity, multi-variables and uncertainty. Nowadays traditional production techniques in petroleum field have faced lots of limitations in modern environment. It is necessary to adopt advanced and appropriate methods to improve production techniques by reducing costs and increasing benefits. As a well solution for solving complex problems, multi agent system (MAS) is utilized by more and more researchers to deal with different difficult problems in petroleum production processes.

This paper presents an example of multi agent system applied in gas-oil separation plant. A specific process is simulated using intelligent agents. The authorhas designed the agents with Zeus Agent System, a framework that facilitates large-scale realization of the collaborative agent approach.

2. A REVIEW OF THE GAS OIL SEPARATION PROCESS

The separation of oil and water mixture is a well known process in the oil industry. A permanent problem encountered in this process is the inability to predict all possible scenarios concerning the conditions for accumulation of the mixture, the operating status of the equipment and systems involved in the process and chemicals used, which have a general and flexible.Inthe oil industry, the most common cases ofseparationare:

- ✓ Water-Oil separation, wherethe flow of oilismainly;
- ✓ Oil-Water separation, where water flow is mainly;
- ✓ separation of emulsions;
- ✓ separation of non-hydrocarbon oils.

Water-Oil separation, where main flow is mostly oil and Oil-Water separation, where water flow is mainly are encountered inoil refineries and chemical plants process where it is essential that hydrocarbons are not contaminated with water.

For water and oil case, there are two types of emulsions, depending on which is fluid continuous phase: oil in water emulsion, water in oil emulsions respectively. Emulsion separation is a process of increasing difficulty because of extreme variations of fluid components.

Separation of non-hydrocarbon oils is complicated bytherelatively highviscosityandsolubilityof vegetable oilsinbiodieselproduction plants. Systems required forthese separationsare substantiallydifferent fromthe systems usedinconventionalhydrocarbonoils.

Typically, oil water separation is done by gravity and other methods based on improved systems of gravity. If thecontinuous phaseisoil,it is recommended to apply anadditionalforceto help forcethe water separation.Intreatment plantsan electrical field is applied for electrostaticseparationof particles.

Sedimentation of solids particles in aclarifierorsettlingdeviceis defined bythe law ofStokes, whose simplified formis as follows [9]

In this calculation some assumptions are made:

- ✓ Particles are spherical.
- ✓ Particles are the same size.
- ✓ Flow is laminar, both horizontally and vertically.

In literature [1]are discussed different types of separators such as: gravity type separators, gravity type coalescing separators, inverted cone separators, skimmer separators and centrifugal separators.

3. INTELLIGENT AGENTS IN OIL INDUSTRY

The petroleum industry represents one of the most profitable industries being in continuous development. The main concern in this field is to better control and to optimize the oil production. Asset management and control of modern plants involve the automation of complex processes using advanced techniques. An intelligent approach will reduce maintenance expenses, improve utilization and output of manufacturing equipment, increase safety and improve the quality of products.

Intelligent agents represent a naturalabstraction mechanism with which to decompose and organize complex systems. Adoptingan agent-oriented approach means to decompose the given problem into multiple, interacting, autonomous agents that have particular objectives to achieve [3].

The human-like characteristics of agents determine a high abstraction level which may simplify the modeling and implementation of systems for complex domains.

A multi-agent system consists of a number of agents, each one capable of interacting with the others. In general, these agents act on behalf of owners with very different goals and motivations. They therefore require the ability to cooperate, coordinate, and negotiate with each other [6].

Different multi-agent architectures are designed for handle continuous processes like those in petroleum industries. Agents are responsible for managing data production and analysis and the production equipment. Two types of agents can be used in this case: control agents and supervisory agents.

Control agents are agents designed to execute the control of systems and of the components of production plant. The task of supervisory agents is to integrate knowledge and data from different repositories with information provided by the control agents with the objective of solving complex problems. Supervisory agents can exchange information with control agents to solve eventual unexpected situations. Multi-agent systems are successfully applied in fault diagnosis. An agent-based architecture may contain the following agents: a monitoring and diagnosis agent, data manager agent, decision agent, user interface agent etc.

Monitoring agent contain the algorithms used to detect and identify the fault. Decision agent communicates with monitoring agent and performs mapping of the evidences using fusion strategies to extract meaningful results. User interface agent facilitates the queries addressed to data manager agent and displays the results to the user.

The production planning represents a key activity in the petroleum industry, reason why the necessity of applications that provide support to this activity. Various multi-agent systems are developed for the production planning in industrial automation (specifically, in continuous processes).

In the next section the author presents a multi-agent system used in a gas-oil separation plant.

4. COOPERATIVE MULTI-AGENT SYSTEM FOR GASOIL SEPARATION

General scheme of a park of separators and tanks, adapted from [1] and [5] is presented in figure 1.

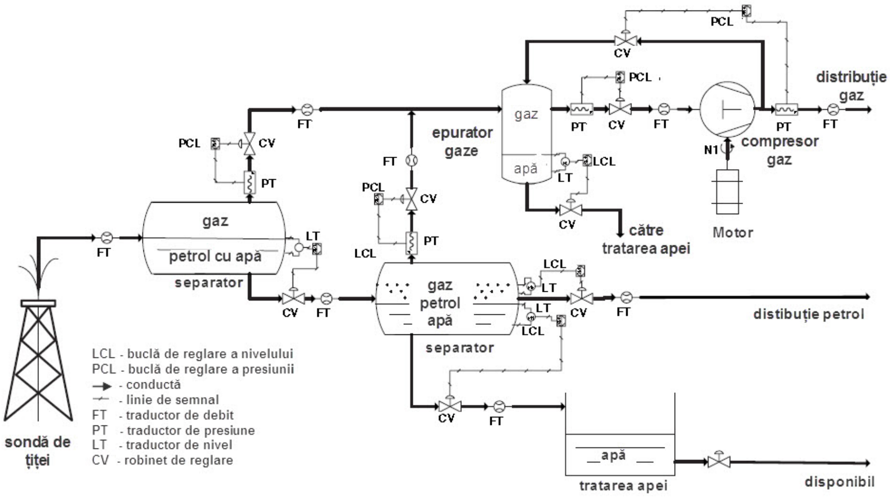

Fig. 1. Park of separators and tanks

Crude oil is produced from the wells in the first-stage separator. The gas leaving the first stage separator and is sent to treating.

The oil leaves the first stage separator and it's sent to the second stage of the separation. In the second stage of separation is removed water and then the oil is sent to storage.

In the separation process, it is absolutely necessary to heat the oil at a temperature that will ensure proper separation of the two phases – oil and water - because it is paraffinic and it has a high freezing point.

The model considered assumes that there are three software agents:

- ✓ Process Agent – corresponds to the two phases separation of the fluid: oil and deposit water through a process of heating fluid with hot water,
- ✓ Tank Agent–represents the agent responsible with the heating unit that provides hot water necessary during the separation process,
- ✓ Pump Agent – the supply agent that provides water (fluid) to either the heating unit or to the process.

The agents for process control create the control plan (management) in real time in order to achieve the proposed goals. The planning process is characterized as a distributed and cooperative planning where each agent creates its own plans which are later adapted to the plans of the other agents through a negotiation process.

The author has developed the agents with Zeus Agent Building Toolkit, which is a toolkit for constructing collaborative multi-agent applications. ZEUS is a culmination of a careful synthesis of established agent technologies to provide an integrated environment for the rapid development of multi-agent systems. ZEUS defines a multi-agent system design approach and supports it with a visual environment for capturing user specification of agents that are used to generate Java source code of the agents [8].

The application implemented in this paper contains besides the above-mentioned agents, other three utilitarian agents that are necessary for a proper functioning of the proposed multi-agent system: ANS agent, Facilitator and Visualiser[7].

Ontology of this application is related to indicators associated with each agent. Each fact has an attribute with which the indicator can be measured (Fig. 2).

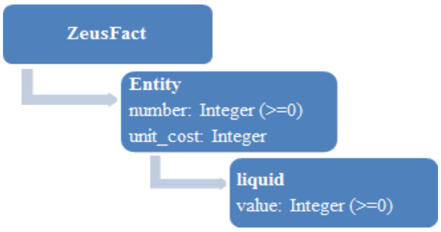

Fig. 2. The ontology of multi-agent system

The proposed network architecture allows each agent to communicate with all the other agents. For a robust behavior of the system, there must be a good coordination of the agents, and that is to be achieved by using coordination protocols provided by Zeus environment.

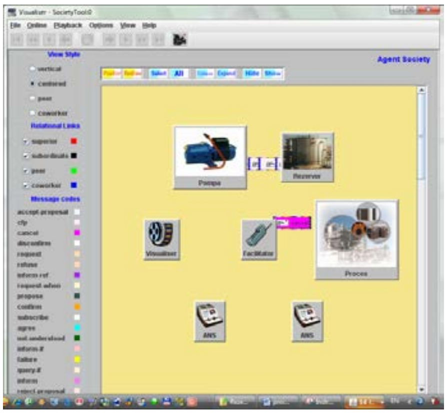

Fig. 3. Communication between agents

Tank Agent interacts with all the other agents, establishing two types of relation: a superior relation with the Pump Agent and a subordinate relation with the Process Agent. The Tank Agent uses FIPA Contract Net Protocol Manager coordinating protocol, and Growth Function strategy, as a strategy of initiator (tick "Initiator"). Tank Agent also uses FIPA Contract Net Protocol Coordination Contractor, and Decay Function strategy, as the respondent’s strategy (tick "Respondent").

Pump Agent interacts with all the other existing agents, having a subordinate type of relation with the Tank Agent. Pump Agent uses FIPA Contract Net Protocol Coordination Contractor, using as the respondent’s strategy (tick "Respondent") Decay Function strategy.

Figure 4 presents the negotiation between agents.

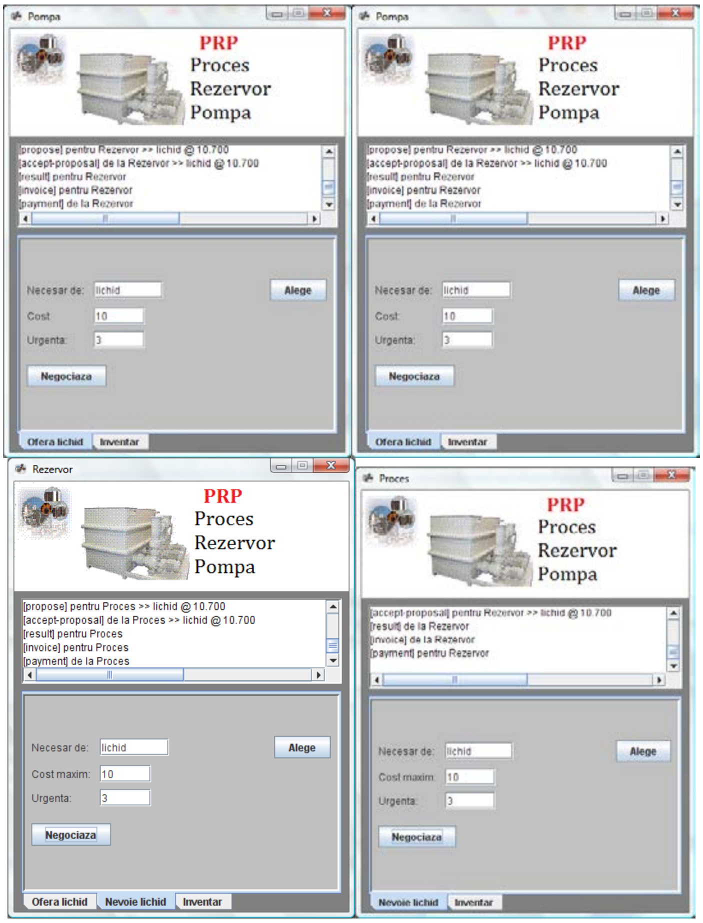

Fig. 4. Application results

The present simulation of process is based on the following assumptions:

- ✓ the process requires liquid,
- ✓ tank ensures liquid, but it also needs it in order to maintain the required liquid stock,
- ✓ pump provides fluid,
- ✓ direct transaction between the pump and the process can be achieved only through the tank

After negotiations, the pump provided fluid to the tank and the tank supplied fluid to the process.

Figure 5presents somestatistical resultsregarding agents’ communications (pump, tank, process and utilitarian agents) during the oil separation process.

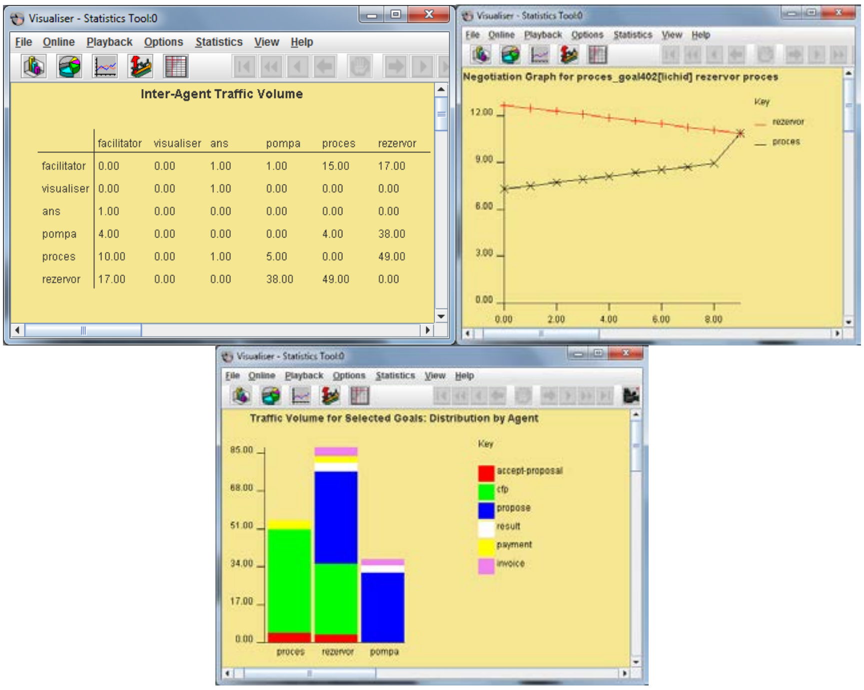

Fig. 5. Statistical results

5. CONCLUSIONS

The application presented in this paper indicates that agent approach in oil industry representsa challenge for engineering. Agents are common in production planning, supervisory and control process, diagnosis, transport process and others. Characteristics of intelligent agents such as autonomous, proactive, reactive, social, flexible and robust transform them in viable solutions for solving complex problems from petroleum field. The ability to learn enables agents to improve their performance over time and also improve the system performance which includes them.

Multi-agent systems provide the modularity that is needed in gas oil separation process and the agents' social ability makes them capable of meeting different restrictions and goals through negotiation and collaboration.

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