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# AGENT BASED APPLICATIONS IN DISTRIBUTED SYSTEMS

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***Abstract:*** *The common models of control systems are based on predictable events and use deterministic algorithms; however the systems act in uncertain and complex environments and have to be able to rapidly respond to changing conditions by optimizing multiple constraints . This paper presents some of the researches done in the distributed and cooperative systems: agent-based architecture approaches to the development of distributed applications.*
***Keywords:*** *Distributed Computing, Distributed Artificial Intelligence, Multi-Agent Systems.*

## 1. INTRODUCTION

In *decentralized* systems the competencies can be carried out by multiple entities named *agents* characterized by *autonomy*; this is the ability to operate independently of the rest of the system and to create and control the execution of its own plans instead of being commanded by other entity like in hierarchical control. Other properties was investigated namely *self-similar* - all objects contain a set of similar components and share a set of objectives and visions ( concept based on the mathematical fractals ), *self-optimized* which means that continuously increase its performance or *self-organized* like in biological systems where an entity can reorganize itself.

## 2. AGENTS AND MULTI-AGENT SYSTEMS

An *agent* is a self contained problem solving entity ( usual software, but can be also implemented in hardware ) [5], therefore a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives; in [15] was introduced *„a weak notion of agency”* referring to properties like *autonomy*, *social ability*, *reactivity*, and *pro-activeness* and also *“a strong notion ”* (citing Shoham) using mentalistic notions, such as knowledge, belief, intention, and obligation. Important studies was done towards agents *learning* and *mobility* .

Artificial Intelligence was primary concerned with *intelligence* of agents, but in last decades was extended few main streams of Distributed AI: parallel problem solving (multiprocessor, clusters), Distributed Problem Solving (DPS) and *Multi-Agent Systems*

(MAS). DPS study the posibilties to modularize a given task efficiently, how the work can be divided among the number of modules that cooperate, dividing and sharing the knowledge about the problem and developing a solution; in contrast *MAS* is based on the idea that intelligence should emerge from the interactions among components without constructing it explicitly into them [Jennings]; global control and globally consistent knowledge may not exist in multi-agent systems, but the agents are asumed to be self-interested, trying to achieve their own goals and maximizing their own personal payoff. In contrast CDPS agents have a common goal and attempt to maximize the system's global payoff. Further a MAS can solve multiple problems in parallel and agents can execute antagonistic tasks.

A multi-agent system (MAS) have some characteristics [7]: *each agent has incomplete information or capabilities for solving the problem and, thus, has a limited viewpoint; there is no system global control; data are decentralized; and computation is asynchronous*.

*Self-organization* is a process in which the internal organization of a system, normally an open system, increases in complexity without being guided or managed by an outside source. Self-organizing systems typically (though not always) display emergent properties.

*Emergence* is a notorious philosophical term refering to a global property of a complex system that results from the interactions and relationships among its agents, and between the agents and their environment. These characteristics represent stable patterns of the organization that are qualitative and exert a strong influence back on the individuals and their relationships. Properties of a complex system are emergent just in case they are neither properties had by any parts of the system taken in isolation nor resultant of a mere summation of properties of parts of the system.

A relatively novel concept refers to s*warm intelligence* attempting to design algorithms or distributed problem-solving devices inspired by the observation of the behavior of swarms. Many such algorithms have been proposed in literature [4] and are made up of simple entities that cooperate through self-organization without any form of central control.

One technique is *Particle Swarm Optimization* (PSO) developed by Eberhardt and Kennedy: behavior of each agent inside the swarm can be modeled by composition of simple vectors and rules: to step away from the nearest agent, to go toward the destination and to go to the center of the swarm. Already famous *Ant Colony Optimization* (ACO) is a computational paradigm (introduced by Marco Dorigo in 1992) using a probabilistic model (pheromone *model)* to generate solutions to the problem under consideration, algorithm updates *pheromone values* in such a way that the probability to generate high-quality solutions increases over time.

Like real ants virtual agents [13] perceive the environment in local area around their current position, they are able to read the pheromone and the heuristic value of each edge adjacent to their current node. Each agent tries to assemble a complete and valid solution of the problem by passing a necessary amount of nodes in the graph. The individual agents are not trying to construct highquality solutions. In each iteration the agent is at first perceiving its surrounding environment via the methods *getAdjacentNodes*, *getPheromoneValues* and *getHeuristicValues*. Then it chooses the next edge based on the sensed values and its internal memory. Note that this is an autonomous step which can be considered as somewhat intelligent. Finally it updates the pheromone weight on the chosen edge and moves to the next node. This procedure is repeated until a complete solution was generated.

```
procedure VirtualAgent()
  resetMemory(M)
  currentNode = Nest
while (solution not complete)
  N = getAdjacentNodes(currentNode)
  P = getPheromoneValues(N)
  H = getHeuristicValues(N)
  edge = chooseEdge(P, H, M)

  updatePheromoneConcentration(edge)
  currentNode = getNextNode(edge)
  updateMemory(currentNode)
end while
end procedure
```

**Functionality of a virtual agent in pseudo-code [13]**

Agent-based approaches have been applied in many areas: multi-robot systems (swarm of mobile robots able to self-organize), air traffic controls, electricity infrastructure control, communications network congestion, collaborative driving (vehicles which collaborate in order to navigate through traffic), complex simulations, e-commerce (e-auctions, e-procurement).

## 3. DISTRIBUTED COMPUTING IN THE POWER INDUSTRY

The agent based technologies support modularity, decentralization, dynamic and complex structures. Other characteristics [5] refer to: *robustness*, *reliability* and *natural* representation of a domain.

Some researches investigated the multi-agent systems technology in power engineering; the use of MAS has been proposed for market simulation [9], power system restoration, condition monitoring, substation automation, protections or the control of microgrids.

An example of multiagent system was presented in [3] based on a dual-level structure. This schema perform a small number of activities that have to be performed in a distribution substation: communicating, switching device handling and decision making. The fault isolation and then the power restoration problem are distributed among the agent communities. The first level considers the implementation of collaborating software agents (agent communities) located at significant network nodes; the second level concerns the formation of the above groups in the substation environment. The system contained some types of software agents: *AE* (*Agent Expert*) assign the task to handle different situations; equipped with appropriate knowledge representation, beliefs about its environment and explicit intentions; *AI (Agent Inter)* is responsible for providing AE connections with physical layer-for example have knowledge to operate the programmable controllers or syncronization of the system, *AC* (*AgentCom*) responsible for communication among agent communities. Individual agents are introduced with explicit tasks: operate the circuit breaker (CBs) according to the messages they receive from AgentsCom, inform the control operator about the location of the fault, send informative message containing the state and load conditions of the CBs. The location of those agents is the distribution line terminals (therfore named *Terminal Agents*).

In [14] a multi-agent system is proposed to restore service through system reconfiguration. The system tries to achieve four objectives: restore loads as soon as posible, restore key loads with higher priority, restore as much load as possible, operate as few switches as possible.The agents only communicate with neighboring agents. A neighbor is an agent that monitors a power system component directly connected to the locally monitored component in the power flow. There are three types of agents: load agents, switch agents, and generator agents.

Distributed Generation (DG) of electricity is providing an increasing part of the world-wide energy supply. DG consists of different sources of electric power connected to the distribution network or to a customer site. Distribution network are expected to evolve from a hierarchically controlled structure into a network of networks in which a vast number of system parts communicate with and influence of each other. Centrallized control of such a complex system will reach the limits of scalability and communication overhead. A solution may be a market-based control, many control agents competitively negotiaite and trade on an electronic market to optimally achieve their local control action goal. Use of market based control in the electricity infrastructure opens the possibility for distributed coordination in addition to the existing central coordination.

## 4. CONCLUSIONS

This paper present recently approaches in power industry and control design; based on autonomy and cooperation of components towards a global self-organization behavior, agents seem to be good candidates for domains that require permanent adaptation to changing environment or demands such as *life-cycle activities* (engineering, product planning, scheduling and control, diagnosis) or *enterprise integration* (supply chain management) .The real challenge of this models are coordination between the agents to achieve stability and robustness; the MAS simulations can be quickly used in real processes because the software agents can be direct transfered in real components; the MAS architectures are scalable and support a *plug-and-operate* approach, very appreciated in system maintainability.

However there are problems to be considered when agents are being introduced. The global optimization may be reduced, because the decision making is local and autonomous, without a global view of the system. Changing the classical control device are expensive and new standards demand generally adopted (see IEC-61850 [1]).

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