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## Multi-Agent Systems for the Dependability of Microgrids

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**Short Abstract:** The electrical grids are very complex systems, presently in full evolution. With the increasing penetration of the renewable energies, the centralised production goes to a distributed one. In this context, the interest of the microgrids rises especially by the specific services that it can provide. Ensure the stability and the dependability of a microgrid is a difficult task particularly in islanding. The microgrid is a mix of different types of elements and his structure may evolve. The multi-agents systems technique can be an interesting way for the control of each device and the real time decisions.

**Key words:** Multi-Agent Systems – Microgrid – Distributed Generation – Dependability – Renewable Energies.

### 1- From main grid to microgrids

The power grid is considered one of the most complex systems man-made. In its classical version, the grid is composed by large size power plants, power lines (transport and distribution), substations and a very large number of costumers (loads). The system operator ensures the grid stability using the load balancing mechanism based essentially on the RMS voltage and the frequency drop. If the frequency decreases, the quantity of the real power supplied by the power plants must increase (the loads needs more power); if the voltage decrease, the power factor is too small, so a compensation of the reactive power is required. In this kind of grid, the energy flow is unidirectional: from the power plants to the loads.

With the expansion of the renewable energies, the structure of the grid change and its complexity increase. The power plants based on wind turbines or photovoltaic panels are smaller and dispersed on large areas. The energy production passes from a centralised template to a distributed one and the energy flow become bidirectional on several segments because the same

power lines are used to take up energy from renewable generators and to supply costumers. To highlight the bidirectional connections and also the complexity of the future smart grid, some authors speak about an internet of energy [TG1].

The integration of this distributed production in the grid can be facilitate by the establishment of microgrids based on geographical location, microgrid composed by small power plants, loads and storage facilities that share the same connection point with the grid.

In this case, the main grid will perceive the microgrid as an entity, without having to directly manage each of its components.

One of the important characteristics of the microgrids is the islanding capability: if a failure is detected on the grid, the microgrid can be disconnected, become autonomous and continue to supply nearby loads. When the failure disappears, the connection is restored. Ensure the stability of the microgrid in islanding is a difficult task because the available power is reduced compared to the loads, so the start-up of an induction motor, for example, can be considered as an incident for the microgrid.

Our work focuses on the islanded state in order to guarantee a microgrid that operates in a healthy way for the longest possible time and can be quickly restored. Effective and rapid restoration of power system can significantly improve system reliability.

Each component of the microgrid has to accomplish a specific task: power generation, storage or consumption but these actions must be coordinated to ensure stability in islanding. A distributed control system based on a communication network must be implemented and each part of the microgrid will be managed by a software agent.

## 2- Multi Agent Systems

The development of the distributed artificial intelligence (DAI) was the starting point for the study of multi agent systems that began around 1980.

An agent is defined as an autonomous entity that can be viewed as perceiving and acting upon its environment. Generally, the agents are considered software entities, but some authors have tried from the beginning to give more openness to the concept [S1] considering other kinds of intelligent and more complex entities.

In this case, a Multi-Agent System (MAS) can be seen as a set of agents, which interact each other, located in a common environment or participating to an organisation.

Some of the important characteristics of the MAS are: autonomy (no need of human intervention), sociality (capacity to interact with other agents), reactivity (perceiving and acting) and pro-activity (capacity to take initiatives to perform its task).

## 3- MAS in Smart Grids

In the power grids, MAS has been studied and applied in a variety of applications, such as market operation, grid restoration, substation automation, grid monitoring and diagnosis. Some examples will be given and discussed.

With the liberalization of the energy market, the importance of the economic point of view increases and MAS may be implied in the Smart Grids energy management on this basis [NU1]. Each agent is in charge of one part of the system (figure 1): a load (LAG), a storage facility (BAG), a power plant (GPAG, GTAG), it can deal with the characteristics of his own subsystem and with the energy prices provided by the Smart Grid Controller (SGC). In this configuration each agent interacts only with the SGC, strongly limiting their sociality and pro-activity

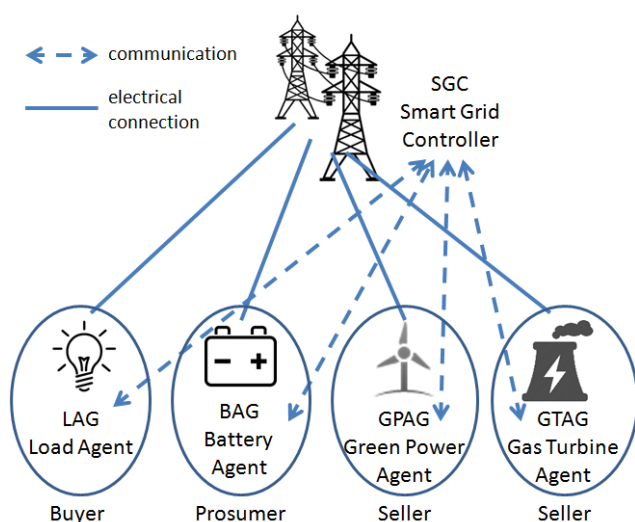


Figure 1: Smart Grids management with market point of view

The economic objective can be used to guide the energy flow in the grid but it is not enough to assure its stability.

The MAS was also proposed for the faults management in a distribution grid: detect the fault location, isolate the fault, and restore power to de-energized areas [KP1]. To achieve those

tasks, 3 kinds of agents are proposed:

- facilitator agent (FA) - acts as a grid manager to ensure the network reconfiguration

- bus agent (BA) - measures the power flow and the voltage and manage the circuit breakers for each connection bus. When the fault occurs, the BA negotiates with its neighbours to find the best connections to make.

- load agent (LA) knows the load requirements (active power, priority...), can exchange messages with the corresponding BA and is able to connect or disconnect the load.

This structure works only with centralised production. For the distributed one, other kinds of agents are necessary to manage the production and the storage. If a microgrid is considered, the tasks of the FA must be adapted also for islanded mode.

In the final paper, we will present our point of view on the implementation of MAS in microgrids, highlighting the specific characteristics: size of the system (in terms of power and number of units), evolutionary structure, sensitivity to environmental conditions (weather),... We will also point the interactions between entities in terms of energy and information and the infrastructure that must be able to support the MAS.

## 4- Conclusion

In the current conditions (market deregulation, increased penetration of renewable energy), the power grids are led to evolve towards Smart Grids. This evolution can be facilitated by the organisation of low power elements in microgrids. The multi agent system is a powerful tool well adapted to the distributed structure and the behaviour of the microgrids.

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