On the Conception of Intelligent Power Plants Based on Multiple Agent Systems

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Abstract. Lately, great efforts have been made to develop effective hybrid power systems, which consist of a mixture of renewable and conventional power plants, energy storage systems and power consumers. The very dissimilar characteristics of these elements, as well as the ever increasing performance requirements imposed to them, makes the design of control systems for power generation plants a remarkably challenging task. A promising approach to provide effective solutions to this problem is by applying the paradigms of Intelligent Agents and Multi-Agent Systems. In this paper, the definition of an Intelligent Multi-Agent System for Supervision and Control (iMASSC) is proposed to create intelligent power plants for either renewable or conventional power generation units. A Multi-Agent System with a generic structure is used instead of a single specific Intelligent Agent. This approach is more realistic in that it takes into account the complexity of current power plants. Later, the community of intelligent power plants, through autonomous and coherent collaboration, will achieve the objectives of the hybrid power system. Hence, the iMASSC model is expected to provide feasible solutions to the operation of modern intelligent hybrid power systems and smart grids.

Keywords: Intelligent agents · Multiagent systems · Intelligent power plants · Hybrid power systems

1 Introduction

Hybrid power generation systems, including both conventional and renewable power plants, aim to properly use both resources in an efficient and sustainable way to supply the ever growing demand of electric energy worldwide. However, the intermittency and non-predictability of some renewable energies make the operation of hybrid power generation systems a challenging task. Achievement of highly effective, reliable, and autonomous operation requires the deployment of intelligent control systems.

Power systems based on conventional power plants have been successfully operated with classical automation and control methodologies so far. The most common control system structure of a power system is that of a hierarchical system, where each power plant is commonly governed with a distributed control system running classical

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control algorithms [1]. This approach is enough to make most conventional power plants fully dispatchable, that is, to make them contribute to control power flows and voltage stability in the power system. However, most renewable power plants are intermittent and not dispatchable; their introduction in a power system can disturb power flows and voltage stability. Classical automation and control methodologies are not enough to control renewable power plants and their interaction with conventional power plants in hybrid power generation systems. Creating power plants, conventional and renewable, that behave as intelligent systems can provide effective solutions to the successful operation of hybrid power systems.

Artificial intelligence emerged and evolved to solve problems with a high degree of complexity [2]. In particular, the Intelligent Agent (IA), and Multi-Agent System (MAS) paradigms were created to perceive their environment, make decisions and act upon the environment. So, these artificial intelligence paradigms can provide solutions to industrial process control problems [3]. In particular, it is believed that the IAs and MASs paradigms can provide the means for power plants and hybrid power systems to behave as intelligent systems, that is, to operate in an autonomous, coherent and goal directed manner.

In this regard, this paper proposes the conceptual model of a generic MAS with which it is possible to create intelligent power plants, from either conventional or renewable power generation units regardless of their very dissimilar behavioral characteristics. Each intelligent power plant will have its own abilities and expertise to cooperate, negotiate or compete with the other plants in the community of intelligent power plants of a hybrid power system. The objectives and goals of the hybrid power system will be satisfied and achieved, respectively, through the autonomous, coherent and goal oriented behavior of the intelligent power plants.

This work is organized as follows. In Sect. 2 the paradigms of IAs and MAS are briefly described in their most general terms from the point of view of information technology. Section 3 presents relevant applications and design issues of MAS for operation and control of power systems and power plants, revealing the scarcity of literature about the design and development of MAS for power plants. In Sect. 4 the functional structure of an intelligent system for operation of power plants is revisited to outline the fundamental distribution of problem solving capabilities required for the agents, as well as, the basic pattern of data and information relationships among them. Section 5 introduces the intelligent multiagent system for supervision and control (iMASSC) for a power plant, either conventional or renewable. This MAS model, not a single IA model as others propose, provides the necessary framework to integrate different technologies in a systematic way to create intelligent power plants. Section 6 introduces the structure of a hybrid power system as a smart microgrid including a community of intelligent power plants. Section 7 lists the future work necessary to build iMASSC prototypes to undertake real-time proof-of-concept experiments within the context of an intelligent hybrid power system. Conclusions are stated in the last section.

2 Intelligent Agents and Multiagent Systems

Real time software systems are an essential ingredient in nowadays control technology. These systems were initially developed with methods created for non-real-time applications, such as real-time structured analysis and design [4] and real-time object-oriented design [5]. However, in order to deal with more demanding and large-scale systems, the agent paradigm was introduced to improve the ability to conceptualize, design and implement increasingly complex software systems [6]. An agent can be defined as an encapsulated software system situated in an environment, capable of perceiving it, perform information-related tasks and act upon the environment in order to meet the design objectives [7].

An agent can be called an intelligent agent (IA) when it has a high degree of operational autonomy. IAs can have beliefs, desires and intentions, as well as precise knowledge [8]. As shown in Fig. 1, the main characteristics of IAs are:

- Reactivity. React quickly to changes.
- Pro-activeness. Look to accomplish their objectives.
- Sociability. Communicate with each other to negotiate, cooperate or compete.
- Autonomy. Able to act by themselves without human supervision.
- Mobility. Are capable of moving to interact with other agents.

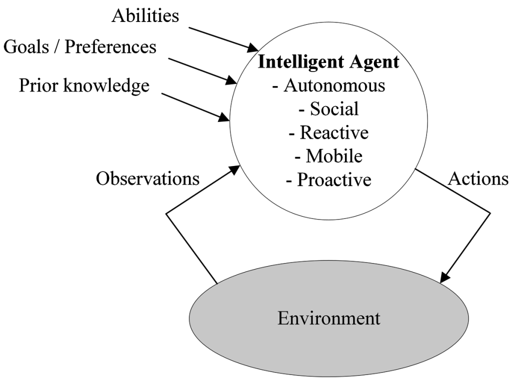

Fig. 1. Intelligent agent.

A Multi-Agent System or Multiagent System (MAS) is defined as a loosely coupled network (organization) of problem solvers (agents) that interact to solve large and complex problems that cannot be individually solved [9]. An agent in a MAS specializes in solving a particular aspect of the larger problem using its own suitable technique [10].

Intelligent agents are highly used in MAS since [11]:

- IAs solve problems that are too big for a single centralized agent.
- IAs interoperate with multiple existing systems to meet the changing needs.

- IAs provide solutions that effectively use spatially distributed information.
- IAs procure solutions with distributed expertise.
- IAs might implement solutions with enhanced performance with respect to computational efficiency, reliability, extensibility, robustness, maintainability, responsiveness, flexibility and reusability.

MAS are organizations of agents and intelligent agents where the interactions between the agents are given through a definition of roles, behavior expectations and authority relationships [12]. Generally, MAS are conceptualized in terms of their structure, i.e., the pattern of information and data exchange relationships, as well as the distribution of problem solving capabilities among the agents, as it is portrayed in Fig. 2. The organizational versatility is crucial since the organizations must be able to adapt to changing circumstances by altering the pattern of interactions among their agents to have the potential to be successful. An open organization is capable of changing dynamically: the information sources, communication links, and components could appear and disappear arbitrarily and unexpectedly. The components may be not known in advance or are able to change over time and may be highly heterogeneous. In open organizations, agents may find dynamically their collaborators depending on the task needs and on the available agents at a given time, forming teams pursuing common goals to achieve the global system coherence [13].

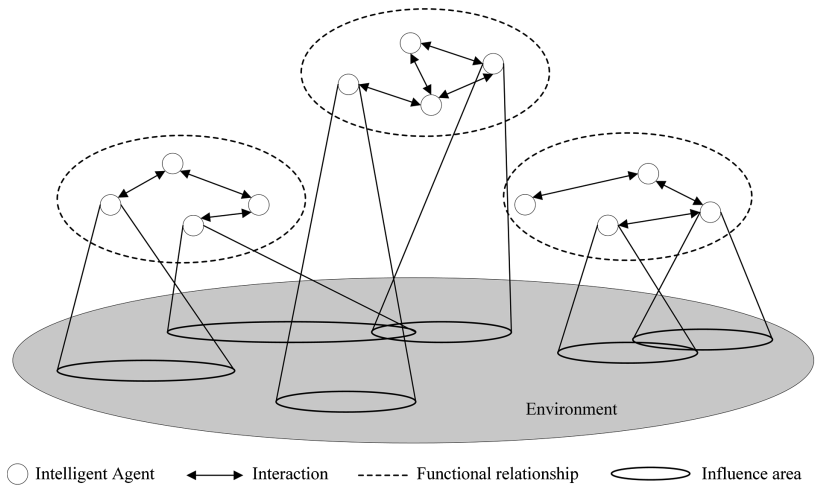

Fig. 2. Multiagent system.

The advantages of MAS based control systems over classical control systems are that they are scalable, flexible, plug and play, fault-tolerant, and suitable for distributed problems. Currently, development of MAS based control systems presents two major design and implementation challenges [14, 15]:

- Engineering design for definition, formulation, description, decomposition and allocation of the overall problem, followed by selection and integration of a suitable group of IAs.
- Engineering implementation to enable agents to achieve global problem-solving coherence; providing the means to communicate and interact, make decisions and take actions, and recognize and bring together disparate viewpoints and conflicting intentions.

The work reported in this paper is mainly concerned with providing answers to the engineering design of a generic MAS intended to create intelligent power plants from either conventional power plants or renewable power plants. Therefore, the process of definition, formulation, description, decomposition and allocation of the overall power plant control problem, followed by the selection and integration of suitable groups of IAs determines the scope of this paper. The engineering implementation of the proposed MAS will be reported in forthcoming papers.

3 Applications of MAS to Microgrids and Power Plants

In general, MAS have been applied to power engineering in many areas, i.e. diagnostics, distributed control, modeling and simulation, monitoring, decision making, automation, protection and maintenance scheduling [16]. There are examples of MAS applications in power systems and power plant control in [18]. Also, a scalable MAS is proposed for control of a large network of power generation, transmission, load and compensation sources in [20], and a multi-agent based power sharing scheme for hybrid power systems is presented in [30]. Regarding power plants, a MAS is applied to improve the heat rate of a fossil fuel power plant in [17] and a MAS to optimally control a power plant based on multiple objectives is designed in [19].

Due to their intrinsic characteristics, MAS have been mainly applied to control microgrids [22–24], which are becoming the new paradigm for structuring power systems. Microgrids are relatively small power systems that are usually integrated by distributed energy sources, loads, storage and control devices, and can operate interconnected or isolated from the main electric grid or power system. Operation and control of microgrids are challenging due to the variety and distribution of their components. For instance, a MAS distributed control implemented in the pilot microgrid of Kythnos Island in Greece is described in [29], a MAS that coordinates steady-state operation of distributed power and load, and provides black start-up capability in islanding operation is presented in [25], and a MAS that aims to achieve optimal energy exchange between power units in the microgrid, the main grid and the local loads is introduced in [26]. An analysis to extend MAS applications for control development in micro/smart grid hybrid systems is done in [27]. A recent survey of MAS applied to microgrid control is provided in [37].

There are several methodologies to design a MAS. The most common design procedure includes: (a) Specify the system and its objectives, (b) Analyze the roles of the agents, and (c) Design the interactions between the agents. The design of a MAS is expressed through its architecture that specifies the information and data exchange relationships, and the specific problem solving capabilities of the agents. Some examples are presented in [38, 39]. Largely, MAS architectures depend on the characteristics of the applications [40]. In particular, there are structures for energy generation and load control [41], forecasting, trading and planning [20], energy management, energy distribution, database management, monitoring [42] and so on [21, 43, 44]. MAS for microgrid operation might exhibit a three-layered architecture [16]:

- A top layer or message handling layer for receiving messages.
- An intermediate layer or behavioral level that defines the tasks to be carried out.
- A bottom layer or functional level for determining the actions agents must perform.

In a three-level MAS for a typical autonomous electricity network, there are distributed energy resource agents, database agents, control agents and user agents [45]. The first level controls the distributed power and load for proper energy management and reliable operation. The second level optimizes power quality and reduces fluctuations. The third level manages and schedules multiple microgrids based on market and scheduling needs [35]. A three-layer MAS made of main grid agents, microgrid agents and component level agents based on a hierarchical coordinated control strategy is proposed in [30]. A MAS architecture with two-layer control strategies in which distributed energy resources and loads are classified, and three types of agents are considered: a regional agent, a local agent and a service agent, for both, grid-connected and isolated modes, is presented in [31]. A MAS with decentralized control architecture for autonomous operation of a microgrid with power electronic interfaces is presented in [32]. A real-time intelligent control and structure based on MAS for microgrids is proposed in [33]. A microgrid energy management framework based on agent-based modelling to increase system performance is proposed in [34]. A MAS architecture for controlling distributed energy resources, where agents are grouped depending on their effect on the environment is presented in [28]. A framework to control active power and frequency to improve stability of a microgrid is presented in [35] and a framework for integration of a microgrid into the grid is presented in [36].

All previous review reveals that most MAS have been designed and implemented to advance and facilitate operation of microgrids. There is a shortage of technical literature about the design and development of MAS for power plants. If prevailing, this state of things will lead to an unbalance in the development of intelligent power systems, smart grids, intelligent hybrid systems, smart microgrids and so forth. Development of intelligent power plants, either conventional or renewable, is crucial to prevent the aforementioned dilemma, and the use of MAS to develop intelligent power plants is the most attractive and promising approach.

4 Intelligent Multiagent System for Supervision and Control of Power Plants

An intelligent system, based on the MAS paradigm, for autonomous operation of fossil fuel power units was proposed in [46]. The two-level hierarchical functional structure of the intelligent system was proposed after three major milestones: (a) The general structure model for industrial batch-process automation [47], (b) The four basic intelligence functions to implement intelligent systems [48], and (c) The principle of increasing precision with decreasing intelligence [49]. System goals were identified using power plant process engineering concepts, and intelligent control systems engineering concepts were used to identify main tasks, as well as to functionally decompose the system. Then, the software engineering agency concepts were used to identify and group agents according to knowledge and purpose interactions. Details of the process followed to define the intelligent system structure can be found in [50].

Now, the structure model of the intelligent system for operation of conventional and renewable power plants is proposed to be also realized as a multi-agent system, yielding the Intelligent Multi-Agent System for Supervision and Control (iMASSC) of power plants. The proposed iMASSC organization is an open superset of functionally grouped agent clusters in a two-level hierarchical system, as it is shown in Fig. 3. The term organization is preferred to emphasize the soft nature of the system structure over a rigid inflexible architecture. The upper level of iMASSC, which is mainly characterized for knowledge-driven processes, performs the supervisory functions needed to provide self-governing operation characteristics, while the lower level of iMASSC, which is mainly characterized for data-driven processes, performs the fast reactive behavior functions necessary for real-time control and protection.

Agents are loosely clustered taking the intelligence functions as guidelines. In that way, the control cluster takes account of the sequence control, regulatory control, protection, and input-output handling agents. The self-awareness cluster is introduced to group the system operating state determination, fault diagnosis, and test assistance agents. The world modeling cluster comprehends the learning, model building, and adaptation agents. The value judgment cluster comprehends the online performance monitoring, control tuning, and reconfiguration agents. The memory cluster is introduced to include the data and knowledge processing agents, as well as the system knowledge and data bases agents. The behavior generation cluster groups the process optimization, sequence generation, and set-point generation functions.

Agent clustering is introduced to simplify the representation and to indicate that the agents in a cluster use closely related system knowledge or data, and have mutual commitments and beliefs. In reality, all agents may coexist as parallel processes with random access to system information. As required for an open system, iMASSC exhibits organizational adaptability mediated by the supervisory execution manger agent and the direct execution manager agent. In principle, the iMASSC organization can adapt to changing circumstances by activating or deactivating agents, incorporating new agents or dismissing old agents, or modifying the pattern of interactions among the current agents. The iMASSC agents should dynamically find their collaborators based on the system requirements at hand and on which agents are present in the organization at any given time. Clusters should be formed adaptively as required.

The system functional decomposition into agents in Fig. 3 is not exhaustive in any way; it shows what is considered a basic set of tasks that should be taken into account to achieve a more general design toward truly intelligent control systems, and how they should be organized. In the spirit of an open system, this set of tasks may be augmented, or decreased, as required by the application at hand. Agents in Fig. 3 are briefly described as follows.

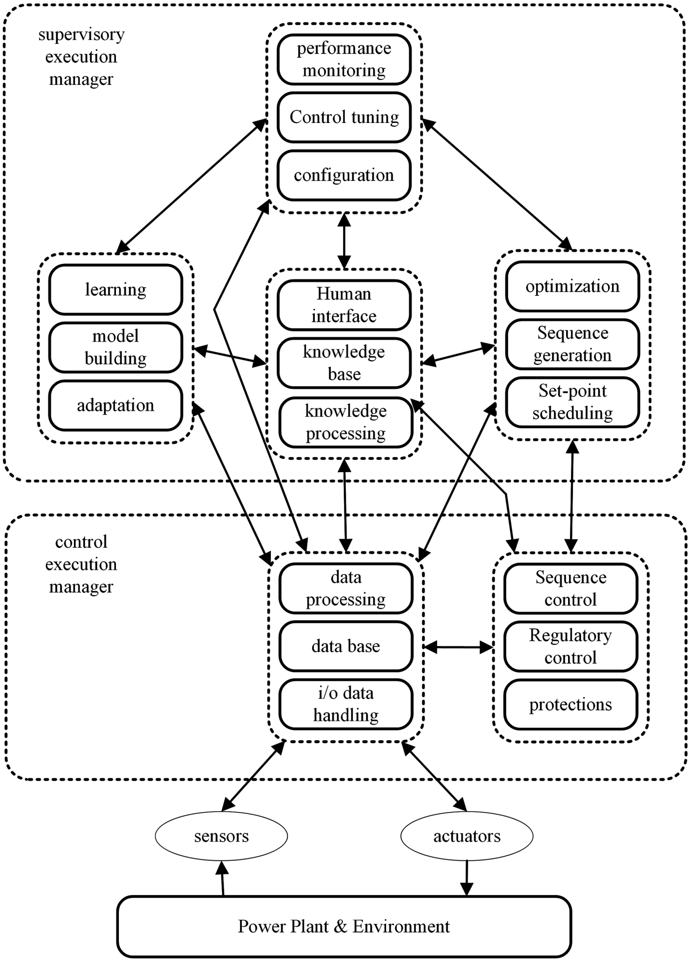

Fig. 3. iMASSC organization.

- Input/output signal handling. Constitute the interface between the control system and the plant instrumentation. Basically, it is responsible for entering and sending contact signals, as well as continuous signals, from and to the process instrumentation at regular intervals or under demand. In a more advanced application it should also implement the dialogs with new intelligent instrumentation. Also can take care of simulating a virtual environment for the entire system by halting actual inputs and imposing arbitrary input values.
- Protection and interlocking. Monitor critical variables to prevent the process entering unsafe operating regions, or shutdown total or partial process when already in unsafe conditions. These functions depend heavily on the physical characteristics, equipment configuration, and protection requirements at different operation stages of the process.

- Continuous regulatory control. Evaluates control algorithms for driving the continuously varying signals in the process according to predefined references.
- Sequence control. Allows the transition between the various operating states of the process. Enables/disables the continuous control functions as required.
- Operating state determination. Evaluates key signals to declare the operating state of the FFPU. This information is to be used by other functions in decision-making and evaluation of permissive conditions.
- Fault diagnosis. Identifies features of faults before occurring, and determines the causes when already occurred. Generates information for fault accommodation.
- Test assistance. Sets and verifies all necessary conditions to perform operation tests from a given catalog of tests.
- Process optimization. Determines the optimal operating conditions by solving optimization problems based on physical principles.
- Operation sequence scheduling. Performs time-sequenced decisions for automatic plant operation, for instance, unit scheduling of power generation based on AGC demands and physical conditions of equipment at the FFPU.
- Set-point scheduling. Generates set-points for the continuous control functions, and limits and threshold values for the sequence control and protection functions according to the different operative stages and optimization routines.
- Performance monitoring. Evaluates behavior of process under control to generate meaningful performance indications for adaptation and optimization.
- Control tuning. Based on performance values decides whether the current control configuration needs to be tuned or not. Performs tuning by updating parameters and knowledge of the direct control scheme if enabled by the human supervisor.
- Control reconfiguration. Based on performance values decides whether a change on the current control configuration should be done or not. Suggest a different control strategy from a given catalog and sets conditions for switching if enabled by human supervisor.
- Learning. Allows the supervisor to build and modify the knowledge and data bases for inferences and decision-making required at both the supervisory and direct control levels based on observations of the input-output behavior of both the process and the control system itself.
- Model building. On line modeling feature to account for plant and environment changes, provides information to be used by the adaptation mechanisms.
- Adaptation. In a broad sense provides the mechanisms to deal with changes in the plant and its environment at the supervisory level, such as updating the operating sequences and nonlinear characterizations required for wide range operation.

What is relevant in the iMASSC structure is the decomposition of the supervision function shown in Fig. 3 into several other tasks, in the form of agents, to provide the control system with the capability to satisfy increasing performance demands keeping the complexity of the system within manageable terms. Also, the software agency concept provides the necessary mindset to integrate very dissimilar technologies in a systematic and harmonious way to achieve a practical and effective system; by making use of the best characteristics each technology has to offer. These models can be advantageously applied to the operation of hybrid power systems.

5 Hybrid Power Generation with iMASSC Equipped Plants

Taking into account the kind of functions to be performed by the intelligent agents in a power plant equipped with iMASSC it is clear that intelligent power plants can be created. Basically, such power plants will perform the four basic functions of an intelligent system: sensory processing, world modeling, value judgment, and behavior generation. Figure 4 depicts a block diagram of a generic power plant, either conventional or renewable equipped with iMASSC. Note that the customary functions of current control systems, such as input/output signal handling, protection and interlocking, continuous feedback control and sequence control constitute the bottom hierarchical level of iMASSC, so little or no change is actually performed at this level in power plants. Nevertheless, all data gathered at this level is available to the top supervisory level of iMASSC. It is this supervisory level which introduces the functions that will provide the power plant with the abilities or characteristics of an intelligent system. While the bottom level functions mainly provide for quick real-time reactiveness of the power plant, the top level functions mainly provide for the goal-oriented behavior and social skills of the power plant.

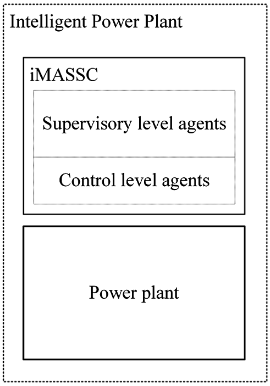

Fig. 4. Intelligent power plant equipped with iMASSC.

As known, a hybrid power system (HPS) incorporates diverse types of power generation sources, usually including renewable sources (wind turbine generators, solar photovoltaic panels, solar thermal plants, geothermal power plants, hydroelectric power plants, etc.), energy storage systems (fuel cell systems, solid state batteries, flywheels, compressed air systems, pumped hydropower, etc.), as well as the more conventional power plants burning some sort of fuel (biomass power plants, diesel motor generators, combustion turbine generators, coal burning power plants, fossil fuel power plants, etc.).

In general, each type of power generation source is an energy conversion system that has its own and defining characteristics regarding supply of primary source of energy, most favorable environmental conditions for more efficient operation, speed of conversion and transient response characteristics, range of electric energy that can be obtained, etc. Therefore, each type of energy conversion system requires control systems specifically designed for it. Nevertheless, all of the power plants must be able to participate and behave properly to provide the electric energy required by the users or loads, that is, power plants of all kinds must have a degree of intelligence enough to follow the guidelines set to get in, generate power and get out of a community of power plants. To carry out the later a smart facilitator or coordinator of operations might be useful. In the proposed structure any system is able to socialize with any other system, nevertheless the coordinator will set goals for their production, pursuing the optimal response of the whole system to the objectives previously set.

A hypothetical hybrid power system is depicted in Fig. 5 to illustrate the structure of a community of intelligent power plants, loads and energy management system. An Intelligent Multiple Agent System for Supervision and Control (iMASSC) is required to create an intelligent power plant from each conventional or renewable plant or energy storage system. An Intelligent Multiple Agent System for Load Control (iMASLC) is required to create an intelligent load or set of loads at the convenience of the power system. An Intelligent Multiple Agent System for Energy Management (iMASEM) is required to create an intelligent Energy Management System for the Hybrid Power System. At the time of writing this paper only the structure of iMASSC has been completely defined. The structures of iMASLC and iMASEM are currently under development and require further elaboration.

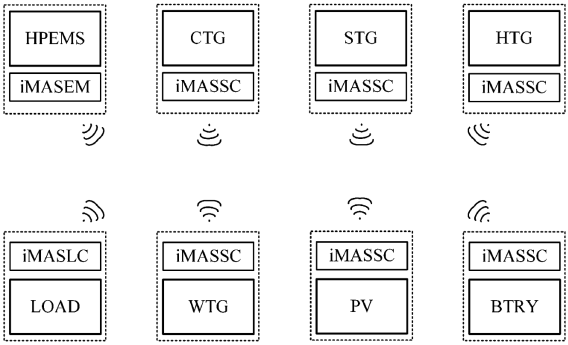

Fig. 5. Hybrid power system with intelligent power plants.

The proposed structure of a hybrid power system as a community of intelligent systems can be realized once the power plants in the system are made intelligent through iMASSC. Each intelligent power plant has its own abilities and expertise to participate, either cooperating, negotiating or competing with the other plants in the community, using the guidelines set for those aims. A key guideline is that the hybrid power system must provide the required power demanded by the loads in an optimal way at any moment. With such guidelines the community of intelligent power plants will show a coherent and goal oriented behavior. Also, the structure is flexible, in the sense that the intelligent power plants can decide whether or not to participate in the activities of the community depending on a variety of reasons, such as environmental conditions, financial issues, physical health circumstances, maintenance and repair programs, etc. Henceforth, to proceed in an orderly manner to ensure the availability, reliability and profitability of the hybrid system, the need for intelligent multiagent systems for energy management and load control was also pointed out, and will be complementary reported after further elaboration.

6 Future Work for iMASSC Development

Development of full iMASSC functionality can be a life-long multidisciplinary project requiring strong and tight collaboration of experts from many fields. Thus, to keep development within bounded time and resources, and to demonstrate the feasibility of the proposed approach, focus should be paid into the development of the essential functions of iMASSC required to create power plants that can be considered to be intelligent systems, that is, to create intelligent power plants. In this regard, there are many challenges and opportunities along the iMASSC research line.

First of all, development of a prototype of iMASSC should be attempted and simulation experiments with a power plant model must be carried out to improve effectiveness. Realization of an iMASSC prototype requires a careful selection of the functions to be developed. As a key requirement at least one function of each one of the four basic intelligence function clusters must be selected to implement the supervisory level of iMASSC. Then, the necessary feedback control, sequence control and protections should be included in the control level of iMASSC. Various challenges need to be solved at this stage. For instance, a hardware-software platform to develop intelligent multiagent systems has to be integrated. This platform should include at least a library of low-level functions to provide for the functionality of the platform, an agent description language to specify the agents and to translate them into executable code, and a language for common knowledge representation across all applications to allow for information exchange among agents. Once the iMASSC prototype is developed simulation experiments must be designed and implemented to demonstrate its intelligent behavior. These experiments can include solving the operation problem for a wide range of changing conditions in the power plant environment, using effectively the information stored in the knowledge base by all functions, arrive to operation solutions with participation of all agents, enhance performance of power plants, etc.

Later, various iMASSC prototypes have to be developed for conventional and renewable generation units to integrate a hybrid power system with intelligent power plants. Nevertheless, to make the hybrid power system practicable, additional intelligent MAS are necessary to be developed. At least an intelligent multiagent system for energy management (iMASEM) and an intelligent multiagent system for load control (iMASLC) are required. Energy dispatch is a crucial problem concerning the mixture of conventional and renewable power generation, and its optimal market-based solution is still open. Also, control on the load side faces multiple factors that must be wisely conciliated to obtain win-win solutions. Closely related to these problems is the definition of suitable performance indexes to measure and compare solutions with multiple competing objectives. Currently, a PC-based distributed platform to simulate a hybrid power system with intelligent power plants is being integrated. Once the hybrid power system development platform is developed, system wide simulation experiments will be carried out. Main experiments will include communication and data security, voltage stability and power flows, system reliability and resiliency, and system autonomy and coherence.

7 Conclusions

This paper introduces conceptual models of a supervision and control system to create intelligent power plants and the structure of a hybrid power system as a community of intelligent power plants. These models are intended to contribute novel solutions to the design of control systems for modern electric power systems, which are nowadays composed from either conventional or renewable power generation units. The proposed models define a reference framework to keep complexity of control systems within manageable bounds. This allows to create goal oriented and coherent communities of power plants, with very dissimilar behavioral characteristics. Therefore, power plants and hybrid power systems consistently achieve highly reliable, effective and autonomous operation. The difference with other approaches is that a Multi-Agent System is applied to each power plant instead of a single Intelligent Agent, providing a framework to create large-scale intelligent power systems.

The presented model of a supervision and control system to create intelligent power plants is based on the paradigms of intelligent agents and multiagent systems from the fields of software engineering and artificial intelligence. The simple typical structure of a multiagent system was extended using the concepts of batch process control, the basic intelligence functions and the principle of increasing precision with decreasing intelligence for intelligent systems, to propose the intelligent multiagent system for supervision and control (iMASSC). Hence, iMASSC creates intelligent power plants when specifically applied to either conventional or renewable power generation units.

The proposed structure of a hybrid power system as a community of intelligent systems can be realized once the power plants in the system are made intelligent through iMASSC. Each intelligent power plant has its own abilities and expertise to participate, either cooperating, negotiating or competing with the other plants in the community, using the guidelines set for those aims. A key guideline is that the hybrid power system must provide the required power demanded by the loads in an optimal way at any moment. With such guidelines the community of intelligent power plants will show a coherent and goal oriented behavior. Also, the structure is flexible, in the sense that the intelligent power plants can decide whether or not to participate in the activities of the community depending on a variety of reasons, such as environmental conditions, financial issues, physical health circumstances, maintenance and repair programs, etc. Henceforth, to proceed in an orderly manner to ensure the availability, reliability and profitability of the hybrid system, the need for intelligent multiagent systems for energy management and load control was also pointed out, and will be complementary reported after further elaboration.

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