Laboratory-Scale Microgrid Test-Bed – Intelligent Multi-Agent Based Distributed Control

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ABSTRACT

The structure of conventional electric power system is changing its course from few centralized entities to numerous distributed energy systems, leading to technological challenges in three key aspects - sustainability, flexibility, and reliability. Penetration of renewable energy resources into the power system seem to magnify these challenges, and require tremendous efforts to develop new control and protection methodologies, information and communication systems, market policies, etc. Various interest groups including the government, electric utilities, academic and research institutions, as well as consumers are actively working towards the goal of a new intelligent grid -- 'smart grid'.

This research focuses on the development of operation and control scheme for a laboratory-scale hardware-in-the-loop microgrid system. The main features of this microgrid system include integrated renewable energy systems, battery storage, smart loads to realize demand-side energy management for various load patterns, advanced digital relays, as well as smart energy metering devices interfaced through various communication channels and protocols. Conventional generating units synchronized to an AC bus are coupled to storage and PV system through a DC bus.

In real-life microgrid systems, various synchronous, asynchronous and static sources of power generation are dispersed geographically but relatively close to the demand side. An implementation of the conventional power grid control and operation methods would presumably demand very high speed central processing platforms to perform extensive computations required for such dispersed system. On the other hand, distributed control methods allocate these number crunching operations to asynchronous, autonomous control platforms, which operate in harmony to provide reliability, flexibility and resiliency

in the microgrid environment. Therefore, the distributed approach for control using Multi-Agent System (MAS) concepts becomes the primary focus of this research. Various agents in MAS platform offer advantages of being autonomous or self-organized, social, and pro-active as opposed to the existing distributed control systems. The framework for MAS is designed using Java Agent DEvelopment (JADE), a FIPA-standard compliant and open source java based platform.

The need for inter-operability between different vendors is also arising as a result of growing activities and interactions between customers, market operators and utilities. The OPC (OLE for Process Control) Classic specifications, inherited from Object Linking and Embedding (OLE) – a proprietary technology developed by Microsoft, offer a complete range of solutions for process data access (DA), alarms & events (A&E), and historical data access (HDA) from different proprietary PLC and SCADA systems. In this research, the OPC DA (Data Access) Server is employed to act as an interface between PLC systems tied to the microgrid hardware layer and open source JADE platform, residing on computer platforms.

The IEEE 1547 Standard for Interconnecting Distributed Resources with Electrical Power Systems, is used as a reference for microgrid operation during seamless islanding phenomenon in the event of faults or power quality violations, as well as for load and energy planning.