A Demand-Response Scheme Using Multi-Agent System for Smart DC Microgrid

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ABSTRACT

This article describes a framework for load shedding techniques using dynamic pricing and multi-agent system. The islanded microgrid uses solar panels and battery energy management system as a source of energy to serve remote communities who have no access to the grid with a randomized type of power in terms of individual load. The generated framework includes modeling of solar panels, battery storage and loads to optimize the energy usage and reduce the electricity bills. In this work, the loads are classified as critical and non-critical. The agents are designed in a decentralized manner, which includes solar agent, storage agent and load agent. The load shedding experiment of the framework is mapped with the manual operation done at Kisiju village, Pwani, Tanzania. Experiment results show that the use of pricing factor as a demand response makes the microgrid sustainable as it manages to control and monitor its supply and demand, hence, the load being capable of shedding its own appliances when the power supplied is not enough.

KEYWORDS
Demand-Response Scheme, Dynamic Pricing, Load Shedding, Multi Agent System, PV, Smart Microgrid

1. INTRODUCTION

The aging grid technologies coupled with the need for a greener energy system have urged the development of the smart grid. Information and Communication Technologies (ICT) are the heart of the smart grid. The smart grid is considered as a system of systems that engenders a plethora of advanced and smart applications such as distributed intelligence, smart metering infrastructure, demand response schemes, and self-healing (Bayindir, Colak, Fulli, & Demirtas, 2016). According to (Zaballos,
Vallejo, & Selga, 2011), the smart grid is an electricity network that can intelligently and smartly integrate the actions and users connected to it (generators, consumers, transmitters, distributors and those that do both) so as to efficiently deliver sustainable, economic and secure electricity supplies.

Developing countries are facing arduous challenges to modernize the aging grid due to, among others, poor ICT infrastructure unregulated energy market. For instance, the Tanzania Electric Supply Company (TANESCO), which is the sole supplier company of the electricity in Tanzania, the transmission side, is the part, which has been implemented in the process of monitoring and controlling with smart grid and lesser extent to the primary distribution side of the grid system. There is still a need to automate the control of electric power to increase efficiency in all aspects of the electric power system, optimize cost to consumers and reduce the number of staff and human errors. In addition, the use of renewable energies such as solar and the wind is more valuable in the utilization and provision of electricity in places without access to the national grid. When the smart network system has been integrated with renewable energies as a source of power, this is referred to the as smart microgrid. According to Kihwele & Kyaruzi, (2004), microgrid system is capable of rapidly detecting, controlling, managing, analyzing and responding to various perturbations in the network by integrating advanced control methods such as agent-based systems.

The control and management of distributed energy systems using multi-agent systems in the smart grid have been seen to work effectively in the provision of autonomous actions. The study by Jiang, (2006) discussed that agent-based system can be applied in the management of distributed energy systems including demand-side management, storage, and generation. Another use of multi-agent systems has been implemented in the simulation of discrete event emergency medical services in London hospitals, (Anagnostou, Nouman, & Taylor, 2013). Other sectors by which multi-agent systems can be applied are e-health, transportations, and infrastructure.

In microgrid systems, the role of control is important for reliable communication, efficiency operations, and autonomous actions. The level of control and monitoring in microgrid depends on different aspects incorporated such as latency, memory consumption, security issues and power management. Normally, the microgrid can be either operates in synchronous mode (connected to the grid) or asynchronous mode (islanded). Figure 1 described the Direct Current (DC) microgrid concept based on an islanded mode with solar as a renewable source of energy. Some advantages of microgrid systems are increasing reliability, money saving, revenue generation and aiding economic growth.

Figure 1. DC Microgrid control system
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