A SMART WIDE-AREA MONITORING SYSTEM BASED ON COGNITIVE RADIO

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ABSTRACT

The current architecture of electric power grid is undergoing a fast change by focusing on high reliability and flexibility to meet the needs on two-way communications between power utilities and customers. Nowadays, because of the limited wired and wireless spectrum resources, the traditional communication infrastructure for the monitoring system can hardly fit the high demand of connections among distributed elements in the smart grid. This paper firstly provides the architecture of the wide-area monitoring system for smart grid by applying cognitive radio techniques. Then the paper describes the novel smart wide-area monitoring system based on cognitive radio for the feasible applications.

INTRODUCTION

At present, the global warming and rising cost of energy drives the electrical power industry meeting the challenge by facing smart grid (SG) technologies [1]. The rapid change in SG infrastructures includes renewable energy sources, energy demand management, intelligent architecture, etc. To integrate such concerns on high efficiency, the current power grid system needs a flexible and reliable approach to establish two-way communications between power utilities and customers. Nowadays, SG is emerging as a convergence of information and communication technique with power engineering to allow pervasive control and monitoring [2]. On the other hand, because he current inflexible low-speed communication architecture serves as a barrier to deployment of new techniques applied for SG, power transmission and distribution systems still suffer from the fact that the wide-area monitoring systems and central control systems are too slow [3]. Based on these demands of SG communication architecture, this paper presents a smart wide-area monitoring system via applying cognitive radio (CR) technologies such as spectrum sensing and sharing methods.

PROBLEM FORMULATION

State Grid Corporation of China (SGCC) has started pushing an 11-year plan named “Strong and Smart Grid” since 2009. The new approaches of SG applied on the grid can bring the grid owners obvious benefits, compared with the methods applied on the customer side, though he new approaches of SG applied on the grid can bring the grid owners obvious benefits, compared with the methods applied on the customer side. This is the reason why the current SG research in China mainly focuses on the applications of IEC 61850 standards to the power grid [4], especially at the transmission and distribution substations side, leading to the potential motivation of improving the smart wide-area monitoring system.

In this paper, we propose a smart wide-area monitoring system of SG based on CR. One of the key issues to meet the challenge of cost-efficient demands is to build a flexible communication system. This high-speed system is able to collect the data from unpredicted locations upon the existing infrastructure. Based on the dilemma that the power utilities are always lack of spectrum resources, this paper chooses CR as the feasible solution for the wide-area monitoring system, following the investigation of the limitations of current communication technologies. The feasible application of this monitoring system is also explored on top of the existing monitoring system infrastructure of Shanghai grid.

COMMUNICATION TECHNIQUES FOR SG

Traditional Communication Infrastructure

The infrastructure of communications over SG is traditionally composed of three layers- application layer, communication layer and power layer. The power layer includes all the devices of generation, transmission, distribution and customers. The application layer of SG has interoperable functions, which supports new applications on the power supplier side, distribution and transmission side, and consumer side. The fundamental characteristics of SG are composed of the applications included in this layer comprise. However, the current power grid is criticized for several drawbacks in the communication layer, which impede the development of SG over the application layer. These drawbacks can be solved by applying the new communication layer with SG infrastructure.

As the central system of SG, the communication layer enables high reliability and intelligent self-awareness, which supports interoperability and processing ability by establishing a high-speed two-way communication path, by both private and public methods. All kinds of communication technologies can be applied in this layer, such as digital subscriber line (DSL), synchronous digital hierarchy (SDH), Ethernet passive optical network (EPON), power line communication (PLC), cellular networks, worldwide interoperability for microwave access (WiMAX), long term evolution (LTE), RF Mesh, WLAN and Zigbee, etc. From another perspective, a smart monitoring system can be offered remotely in a public network instead of existing private communication infrastructure.

However, none of these techniques can fully meet the featured requirements of a wide-area monitoring system

for smart grid, which are mainly economical efficiency and communication flexibility. For those wired technologies, the data transmission is robust but the building cost is high, and expanding the wired system at the distribution side is relatively inflexible. On the other hand, wireless technologies with low robustness can be supplementary methods for the existing backbone network, but these techniques are either spectral resource required (cellular) or of low speed and short transmission range WLAN/Zigbee). Therefore, the current communication architecture with techniques mentioned above is lack of compatibility for both transmission and distribution network, which is the basic requirement of an SG monitoring system.

Three-tier Communication Structure

There is a three-tier hierarchical structure in the communication layer, including a wide-area network (WAN), a neighbourhood area network (NAN) and a home-area network (HAN) [5], shown in figure 1. Therefore, the SG communication infrastructure is envisioned to be a multilayer structure, extending across the entire SG from the generations to the consumers. Smart devices are able to connect to the NAN, enabling the customers to be aware of electricity usage costs. In this way, they can adjust their consuming behaviours. In particular, HAN communicate with various industrial, commercial and residential consumers to provide important service. Thereby, the smart monitoring system inside this three-tier communication structure needs a robust reliable communication approach of high transmission rate and low latency.

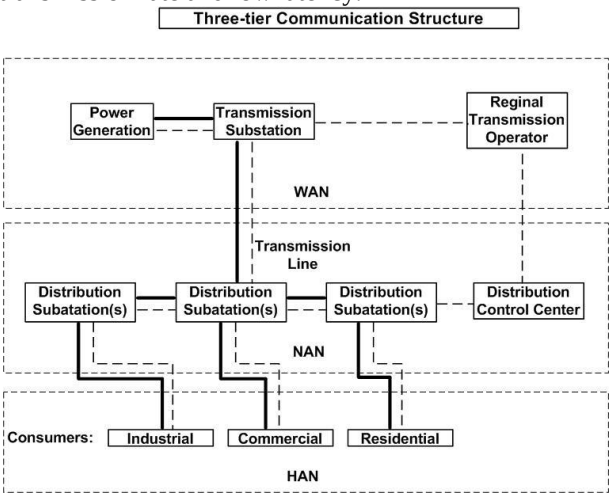

Figure 1. Three-tier Communication Structure

Cognitive Radio

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In our proposed novel broadband cognitive radio approach, an opportunistic communication of high data rates by utilizing spectrum holes in the licensed band is achieved. This cost-efficient cognitive communication architecture can be easily established on top of the existing wired backbone networks to widely monitor the power system status.

FEASIBLE APPLICATIONS

CONCLUSIONS

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REFERENCES

[1] C.H. Hauser, D.E. Bakken and A. Bose, 2005, "A failure to communicate: next generation communication requirements, technologies, and architecture for the electric power grid", IEEE Power and Energy Magazine, vol. 3(2), 47-55.

[2] H. Farhangi, 2010, "The path of the smart grid", IEEE Power and Energy Magazine, vol. 8 (2), 18-28.

[3] S.M. Amin and B.F. Wollenberg, 2005, "Toward a smart grid: power delivery for the 21st century", IEEE Power and Energy Magazine, vol. 3 (5), 34-41.

[4] S. Chen, et al., 2009, "Survey on smart grid technology", Power System Technology, vol. 33 (8), 1-7.

[5] R. Yu, et al., 2011, "Cognitive radio base hierarchical communications infrastructure for smart grid", *IEEE Network*, vol. 25 (5), 6-14.