Opportunities and Challenges on Pervasive Computing in Smart Grid

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1. Background and experience of the participant in this field

The participant is an Associate Professor in the Department of Electrical and Computer Engineering at the University of British Columbia in Vancouver, Canada. His research areas include protocol design, optimization, and resource management of communication networks, with applications to the Internet, wireless networks, RFID systems, and smart grid [1]-[3]. The participant is an Associate Editor of the *IEEE Transactions on Vehicular Technology*. He is the Symposium Co-chair of the *IEEE Global Communications Conference (Globecom'11)*, *Wireless Communications Symposium*. He serves as technical program committee member in various conferences, including *IEEE Infocom*, *International Conference on Communications* (*ICC)*, and *Globecom*.

2. Vision of the participant

The electric power grid system is currently undergoing major upgrade and enhancement. The smart grid aims to incorporate novel power engineering techniques and advanced information and communications technology to support a variety of energy services and functionalities for the utilities and the customers. By exploiting the two-way communications capabilities between the utilities and the customers, it becomes possible to replace the current power system with a more intelligent infrastructure. Some of the distinguishing characteristics of the smart grid include [4][5]:

- Increased use of digital information and control technology to improve reliability, security, and efficiency of the electric grid;
- Dynamic optimization of grid operations and resources, with full cyber security;
- Deployment and integration of distributed resources and generation;
- Deployment and integration of demand response;
- Deployment of smart technologies for metering, communications concerning grid operations and status and distributed automation;
- Integration of smart appliances and consumer devices.

To support the above features, there will be a large amount of data exchange between different entities. There will also be an increased use of digital information, control technology, and pervasive computing to improve reliability, security, and efficiency of the electric grid.

Unlike existing computer or wireless networks, the smart grid is a complex network interconnecting with a large number of heterogeneous devices and systems with various ownerships and management boundaries [6]. Such complexity adds the difficulty to design the communications network for the smart grid which is essential to exchange information and share resources among different devices and appliances.

3. Evidence that pursuing this vision will lead to major advances in the field

The development of the smart grid is still in an early phase. A variety of technological innovations from different fields and disciplines such as pervasive computing, power engineering, system control, and communications are required to enable the smart grid.

Within each household, home area networks (HANs) will be used to interconnect various intelligent appliances, environmental sensors, load control devices, and energy display devices. The gateway through which HAN will be accessed is a *smart meter*, equipped with ZigBee on one end, and other communication technologies (e.g., 802.11, WiMAX) on the other. The smart meters can exchange vital data related to maximum demand request, service quality, and sensory data information. With millions of users/customers, there will be data exchange (e.g., pricing information) between the user and the utility company. The potential open issues:

- Design of security protocols for the HANs and smart meters. This should prevent malicious users from tampering the smart meters;
- Design of efficient demand response algorithms, which scale for millions of users. Some of the conventional distributed optimization-based algorithms (e.g., sub-gradient algorithms) may suffer from long convergence time.

Within the transmission infrastructure of the smart grid, different entities (e.g., transformers, transmission lines) will be equipped with sensors, which can detect any anomaly defects (e.g., temperature of the transformer exceeds some threshold). The open issues include gathering of real-time measurements in various locations of the grid in order to provide continuous and reliable state estimation and ensure reliable and resilient operation of the grid and its subsystems. Issues such as interface design, reliability, as well as security also need to be addressed.

References

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