Wireless Sensor Networks in Power Supply Grids

V. Wolmarans and G.P. Hancke
venita@tuks.co.za; gerhard.hancke@up.ac.za
Department of Electrical, Electronic and Computer Engineering
University of Pretoria
Tel: +27829730413
P.O. Box 773, Derdepoortpark, 0035, South Africa

***Abstract*—The integration of wireless sensor networks into power distribution grids creates the potential to efficiently regulate and manage energy resources. The automation of electric systems is an important function for electricity supply companies and reduces operating cost and increases efficiency. The applications created by wireless sensor networks are wide-ranging and beneficial for both utility companies and power consumers. There are many issues that have to be dealt with concerning the integration of wireless sensor networks into the power distribution grid and these issues have to be addressed in an application-specific manner.**

***Index Terms*—Wireless Sensor Networks, Electric System Automation, Supervisory control and data acquisition, Automatic meter reading.**

I. Introduction

THE need for a high-performance data communication network for electric utility companies to monitor the real-time performance and operating conditions in the power grid have become a requirement for competitiveness, profitability and customer satisfaction [1].

Energy has also become an increasingly expensive commodity and demand-side management of energy resources does not only make business sense, it more than justifies the implementation of supervisory control and data acquisition (SCADA) systems.

Wireless sensor networks (WSNs) are a collection of wireless nodes with sensing capabilities, which are in some way distributed in a bounded area and are used to monitor either physical or environmental conditions. These nodes can communicate with one another and use each other as a path through the network in order to communicate with some sort of gateway or sink. [2].

The system requirements for electric system automation and monitoring have characteristics which can be provided for by WSNs, especially in terms of last-mile connectivity and there are many advantages to the implementation of WSNs above other types of wireless networks. The possible applications that can be provided by WSNs are wireless automated meter reading (WAMR), electric systems monitoring in different economic sectors, value-added services and the management of power distribution and administration.

II. Future Research for Integration

There are many issues that need to be addressed relating to the integration of the WSNs into the power distribution grids. The technology behind WSNs has the intrinsic characteristic of being application specific. For each of the different applications; technology, protocols, distribution of sensors, required coverage, possible interference, quality of services and other issues need to be individually addressed.

Future research will be aimed at solving these problems in each of the different implementation areas that will be discussed. A methodical investigation will be undertaken to determine the suitability and compatibility of these systems with a power distribution network. The optimal communications protocol in the WSN for electric system automation will be investigated, keeping constraints, such as electromagnetic interference (EMI) into consideration.

The requirements, advantages and disadvantages, constraints and limitations will be investigated and defined for the system as a whole. A model will be created for the successful implementation of WSNs as WAMR and SCADA in the power grid.

Even though the use of WSNs creates many difficulties in the system, there are however advantages that solicit the use of these networks in the power distribution grid. [1].

III. Implementation Areas

A. Wireless Automated Meter Reading

The majority of electricity and other utility meters are mechanical and have to be read manually by a meter reader. The process of meter reading, administration and billing can be greatly simplified by automating this meter reading process. The infrastructure that will be necessary for wired automatic meter readers is however very extensive. The solution therefore lies in the wireless domain.

Using wireless automatic meter readings, the electricity supplier will be able to make either periodic readings, or event-based readings. This idea can be expanded to automatically allow the consumer to request usage information from the supplier through an internet-based information system. This can greatly decrease operating costs for the supplier, by decreasing the need for human intervention in the system.

B. Supervisory Control and Data Acquisition

Supervisory Control and Data Acquisition (SCADA) plays and important role in any utility provider's efficiency and customer satisfaction. Wireless Sensor Networks can be directed towards SCADA goals in different parts of the economic sector.

1) Residential and Commercial Sector: About 17% of the annual electricity usage and 35% of the maximum electricity demand in South Africa is directed towards the residential sector [3]. The efficient monitoring and management of the residential sector energy supply is also very important in terms of public opinion of the utility company.

Implementing SCADA monitoring nodes in the residential sector can decrease the frequency of power failure by alerting the electricity supplier of potential problems in the supply grid. When outages occur, the SCADA nodes can also alert the electricity supplier and thereby decrease outage times.

The electricity supplier can go as far as installing nodes in the home distribution boxes to monitor the use of electricity in homes. This information can be utilized in demand-side management programs. The same principle can be applied for users in the commercial sector in terms of usage monitoring and data acquisition.

2) Industrial and Mining Sector: For the industrial and mining sector, more sophisticated SCADA systems can be deployed. Many of the processes in these sectors are energy dependent and also very energy intensive. With an appropriate internal WSN, the energy demand and usage for these processes can be regulated and observed in an efficient manner.

The energy supplier can make use of this information for demand-side management of energy-resources. Proposing to the industry to run certain processes only during off-peak times and negotiating a better tariff for such an accommodation is one such example.

C. Value-added Services

WSNs create the potential for value-added services. These networks and nodes have the advantage of having configurable capabilities. The energy supplier will have the means to configure nodes by different economic zones, and even by type of business. This will give the supplier the potential for many value-added services specific to the type of business.

One of the value-added services that the utility company can provide is usage-based billing. The energy-supplier can for example charge different tariffs according to off-peak and peak-time usage. The supplier can provide the user with detailed billing and information about energy-consumption.

D. Management of Power Distribution

The management of power distribution is a very important subject in the area of energy conservation. WSNs can be greatly utilised in the area of demand-side management.

Demand-side management requires the utility company to have processes in line that reduces the use of power or redistributes the power usage into off-peak times. The power-consumption patterns need to be shaped to an average usage. This means that peaks in consumption have to be flattened or smoothed into the consumption valleys, as shown in figure 1. It effectively focuses on the reduction of maximum energy demand.

With WSNs, the usage of energy can be monitored more efficiently by both the energy supplier and the user. Portfolios

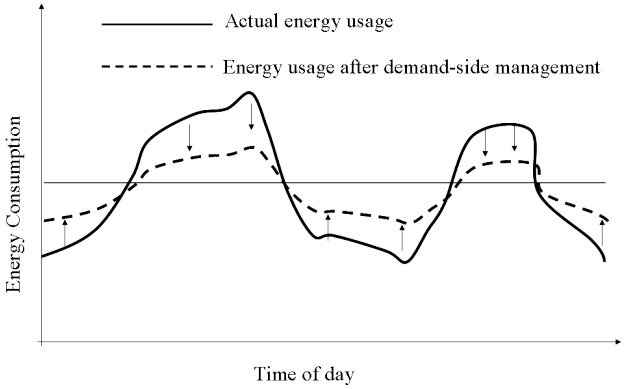

Fig. 1. Demand-side management with peak flattening and valley filling

can be negotiated according to the need of the user and service-lease agreements and tariffs can be efficiently controlled.

WSNs can be designed with the capability to remotely connect and disconnect services. In times when demand is higher than supply and load-shedding need to be implemented, users can define critical devices and processes against non-critical devices. The energy supplier can then disconnect only non-critical devices and processes to reduce demand.

IV. Conclusion

There are many advantages and applications to the implementation of WSNs in the power distribution grid. WSNs creates many possibilities for the improvement of the services that utility companies provide in all economic sectors. Although WSNs can greatly automate and simplify the electricity supply system, many technical issues concerning the implementation of WSNs are still unaddressed.

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Venita Wolmarans received a B.Eng. (Hons) degree in Computer Engineering in 2007 from the University of Pretoria. She is currently working towards a M.Eng. in Computer Engineering under the Centre for Teletraffic Engineering in an Information Society (CeTEIS) at the University of Pretoria.

G.P. Hancke is Professor in the Department of Electrical, Electronic and Computer Engineering, University of Pretoria. His research interests are in wireless sensor and actuator networks.