International Journal of Latest Trends in Engineering and Technology
Special Issue IC3NS 2018, pp. 001-004
e-ISSN:2278-621X

A REVIEW ON APPLICATIONS AND CHALLENGES IN WSNS TO DEVELOP A SMART CITY

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Abstract-The augmenting demand of clean, abundant and sustainable electricity in every sector makes the comprehensive change imperative in power sector to cope with it, which is anticipate to proliferate in next few decades. So the existing power grid needs to become smarter to deliver a reliable, cost effective and customer friendly services. Due to the low cost and collaborative nature of wireless sensor networks, eloquent changes can be corporate in existing grid system to deal with the envisaged electricity crunch in future.
In this paper we focus the various applications of wireless sensor networks in smart grid including generation, transmission and utility side. In addition, the major challenges, which thwart the operability of wireless sensor network like harsh environment, infrastructure, and security, are highlight. Further, the concept of using smart city in our country like India, which is still a developing country, has been outlined.

1. INTRODUCTION

The intricate and nonlinear nature of existing electric power distribution networks and the increasing electricity demand in most countries has caused severe network congestion problems in present time [1]. The existing power distribution networks face the challenges in effectual fault detections, automation, monitoring, and communications [2]. These factors, together with the over stimulated situation, increase the possibility of system to breakdown. Because of the day-by-day augmenting demands for clean, sustainable and abundant electric energy together with the above-mentioned aspects, smart grid concept has come into light [1]. Smart Grid is the modernized version of the existing electricity distribution system so that it monitors, secures and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage network and distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their thermostats, appliances electric vehicles and other household devices. Smart grid technology includes electric transmission and distribution networks and the information and communications system. The Smart Grid absorbs the Energy, IT and Telecommunication Technologies [3].

2. KEY OBJECTIVES OF SMART GRID

The following points highlight the features of a secure and potent smart grid technology.

• Atomized-healing: The grid rapidly diagnoses, analyzes, proactively takes action, and restores

• Empowers and incorporates the consumer: Ability to integrate consumer equipment and behavior in grid design and operation

• Tolerant of attack: The grid evades and is passive to cyber/physical-threats

• Provides power quality needed by 21st-century users: The grid provides quality power concordant with consumer and industry needs

• Encompasses a wide variety of supply and demand: The grid encompasses manifold resources, including demand response, power, wind, photovoltaic, combined heat and end-use efficiency

• It is fully enabled and is supported by competitive electricity markets [3].

The challenges and needs for future smart transmission grids can be summarized into following aspects.

Table 1: Challenges and needs for WSN in smart grid

1	Environment Challenges	Climate Change Pollution Exhausting Natural resources Natural Catastrophes Geographical Challenges etc
2	Customer and Market Needs	Energy Price and Production cost Energy quality and sufficiency Customer driven services Regulations and policies etc
3	Infrastructure Challenges	Aging networks Insufficient investment

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		Increasing electricity demand Economics and reliability etc
4	Innovative Technologies	Materials Power electronics Energy Storage Communication Computation and Control
5	Security requirements	Secrecy Integrity Availability
6	Attack Taxonomy	Device issues Networking issues
7	Other Technical issues	Harsh environmental conditions Resource limitation of sensor nodes Reliability Latency requirements Packet errors Variable link capacity QoS requirements

Recent up gradation in embedded systems and wireless sensor networking made it possible to execute low-cost monitoring and detection of systems for smart grids [4]. These systems collect information from wireless sensor nodes, which monitor critical smart grid equipments and are used to monitor and respond in a forehanded way to the changing conditions. Hence, WSNs have been known as an efficient and reliable technology for various smart grid applications [1, 5, 6]. The collaborative operation of WSNs brings significant advantages over existing communication technologies, including fast deployment, low cost, flexibility, and cumulative intelligence via parallel processing. It is lucid from the recent advancement of WSNs, which has made it feasible to realize low-cost embedded electric utility monitoring, and diagnostic systems. In these systems, wireless sensor nodes are installed on the critical equipment of the smart grid, which performs many actions, and monitor the parameters critical to each equipment's condition. Such information fits the smart-grid system to react to the changing conditions in a fast and timely manner. In this regard, WSNs play a very vital role in creating a highly secure and automatic healing smart electric power grid that rapidly reacts to online events with appropriate actions [4, 7].

Some of the conventional and visualized applications of WSNs in smart grids include load management and control, wireless automatic meter reading (WAMR), remote monitoring, , electric fault detection, equipment fault diagnostics and distribution automation.

However, harsh and intricate electric-power-system environments pose great challenges in the reliability of WSN communications in smart-grid applications.

Table 2: Wireless sensor network applications in smart grid environments

Applications	Power Grid side	Consequences of using WSN
Wireless automatic meter reading	Consumer side	Decreased utility operational cost and prevention of meter tampering
Residential energy management	Consumer side	Shifts the demand to off peak hours by providing real time feedback of energy consumption
Automated panels management	Consumer side	More efficiency by with integration of sensor nodes into the system.
Building automation	Consumer side	Control various appliances' energy consumption and prevent redundant energy use.
Demand side load management	Consumer side	Provides a variety of energy services from low-risk energy sources
Process control monitoring	Consumer side	Efficient production process by continuous monitoring
Properties control monitoring	Consumer side	Control of physical properties in production process
Equipment management and control monitoring	Consumer side	Predictive maintenance
Equipment fault diagnostics, Overhead transmission line monitoring, Outage detection, Underground cable system monitoring,	T&D Side	Reliable performance of equipments

Conductor temperature and dynamic thermal rating systems Overhead and underground fault circuit indicators Cable, conductors and lattice thefts Conductor temperature and low-hanging conductors Insulators Fault detection and location		
Animal and vegetation control	T&D Side	Reduce blackouts and short circuit problems by expanded, safe and reliable operations
Real-time generation monitoring	Generation Side	Energy storage possible with real time generation monitoring
Remote monitoring of wind farms	Generation Side	Wise monitoring from external conditions like external pressure, temperature values, orientation of wind and bird collision etc
Remote monitoring of solar farms	Generation Side	Monitoring of adverse conditions like radiation, temperature value, DC voltages and whether conditions
Power quality monitoring	Generation Side	Low cost, reliable and efficient data communication system for power quality monitoring
Distributed generation	Generation Side	Improve the power management process by correcting the distributed generators' reference signals

3. WIRELESS SENSOR NETWORKS IN SMART CITIES

Indian cities are among the fastest growing metropolises in the world. It is seen that with the growth of the economy, the population is consistently increasing in the big and medium sized cities. The big chunk of population of India lies in urban areas; therefore, it has become compulsion to develop these environments. Smart City solutions are best serving the needs of citizens to live a secure, easily assessable and happy life. The development of sensing and communication technologies such as wireless sensor networks (WSNs) is making it feasible to monitor living environments and our cities. Due to the very small size of the sensor nodes, and their capabilities of transmitting data remotely, they can be deployed at locations that are hard or impossible to access. In smart cities, the number of nodes are no less than human population. These nodes are deployed to collect various information for many smart city applications. Due to dramatic decrement in cost of simple and complex sensors, collection of data is preferred by deploying wireless sensors. To improve the effect of urban quality of life and to maintain the quality of services of smart cities applications, online data without error and without any prominent latency is required. Along with the advantages, there are some challenges in terms of energy limitation, scalability, delay, and throughput and control overheads [10].

Few applications of wireless sensor network have been depicted in smart city concept. Intelligent transportation system: To reckon the number of cars approaching an intersection, monitoring of parking spaces availability in the city. Structural health: Monitoring of vibrations and material conditions in bridges, buildings, and historical monuments. Noise Urban Maps: Sound monitoring in bar areas and centric zones in real time. Smartphone Detection: Detect iPhone and Android devices and in general, any device, which works with Wi-Fi or Bluetooth, interfaces. Electromagnetic Field Levels: Measurement of the energy radiated by cell stations and Wi-Fi routers. Traffic Congestion: Monitoring of vehicles and pedestrian levels to optimize driving and walking routes. Smart Lighting: Intelligent and weather adaptive lighting in streetlights. Waste Management: Detection of rubbish levels in containers to optimize the trash collection routes. Smart Roads: Intelligent Highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams. Water Distribution Systems: Efficient distribution of water in residential areas as well as public infrastructure like public parks etc. Indoor monitoring: Reduction in energy consumption, monitoring indoor temperature, to detect any fault in electronic appliances etc. Environmental monitoring: By monitoring the quality of air, quality of water, and other parameters such as humidity, and ambient carbon dioxide level, as well as other harmful gases.

4. CHALLENGES RELATED TO SENSING IN SMART CITY

WSN subjects many challenges in smart city concept, which are summarized as followed.

Addressing and coordination issues between sensor nodes: When millions of nodes are deployed, how can they be efficiently managed? Although 6LoWPAN enables IPv6 addressing support on IEEE 802.15.4, efficient coordination (in terms of routing, for instance) between such a high number of devices is a big fuss.

Security: Enabling technologies for sensing applications have a number of issues, which have to be considered within the scenario of smart cities. These networks will be predisposed to cyber-attacks and cyber-vandalism [11, 12].

Data ownership and privacy: The main challenge in implementing the smart city concept that who will own the all data collected by these sensing applications. For example, if the electricity utilities own the right to access an individual's energy consumption data, should that data be used without the permission of the individual?
Trust: Individuals cannot trust the entities responsible for collecting and storing their data. For example, the Cloud can be considered a central information system where the company, which owns the infrastructure, typically controls access to data. These companies cannot be trusted completely.
Social Issues: Residents have always been actively involved in a city. For example, there are collaborative initiatives where people come together and help keeping the city clean by promoting no littering, etc. Smart cities (with all the automated processes and sophisticated technology) will create some sort of disconnection between the people and the city. Then there is the challenge of education as well. Average person is not educated enough to use and understand all these systems.
Centralized control: It is evident that we are moving towards a centralized control scheme, where all services are being progressively aggregated, to be managed by one huge central system. This translates to complete control by the governing bodies, which can be used to illegal tracking people or sabotage someone's privacy. This is related to the trust and privacy issues previously mentioned.
Costs incurred in upgrading current cities: It will not be quite frugal to upgrade current cities to make them smart cities. As smart cities are heavily dependent on communication and other infrastructures, it will certainly be very cost increasing to update all the current systems [12].

5. CONCLUSION AND FUTURE WORK

This paper highlights major advantages of using wireless sensor network in smart grid environment. It focuses on the major issues like environmental and other related issues while implementing the sensor network. It also presents the concept of using smart city technology in our country like India, which is still a developing country. Smart city technology includes the implementation of wireless sensor network. In our work, we have also discussed the various techniques used for link designing between substation and control center and various challenges included in application of smart city concept. The research study from this paper can be applied further for complex and operative smart grid and smart city scenario. Since the current proposed work is not sufficient, further research can be done to make the smart grid and smart city scenario more efficient and reliable.

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