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Applications of Wireless Sensor Network in Smart Grid

[1] Huijun Xu

[1] Nanchang Institute of Technology, No. 289, Tianxiang Avenue, High-Tech Development Zone, Nanchang City, 330099, China

Tel.: +8615093187752, fax: +8615093187752

[1] E-mail: Yueguan2012@163.com

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Abstract: The smart grid has been the hot topic all round the world, which involves many advanced technologies. It is very important for improving the managing efficiency, energy-saving, safe performances and so on. However, for it comes down to many subjects, its development has also been limited, applications of it in the grid has still existed some shortcomings. As a part of the new kind of communication techniques, it is good for solving these technical problems to improve and develop the wireless sensor network. In this paper, we firstly analyzed the characteristics and structures of the smart grid and wireless sensor network, then brought out the applications of wireless sensor network in the smart grid, by which we provides some reasonable suggestions to the related workers when they establish the grid. *Copyright © 2013 IFSA*

Keywords: Wireless sensor, Smart grid, Communication.

1. Overview of Wireless Sensors and Smart Grid

Current society, the development of the power industry is very sluggish, a lot of problems, including low investment efficiency, weak flexibility and adaptability, low reliability, environmental damage, etc., are urgently needed to solve these problems. In Europe and some developed countries after discussion, agreed that the best way is the new technology and new framework on the basis of a "smart grid". After this concept was proposed, it has been widely accepted around the world, and in its vigorous development, form the mainstream of the next generation power grid development [1].

Conventional sensors used to obtain information technology with a relative unitary model. And smart grid applications are made and changed the pattern toward miniaturization, networking, integrated and intelligent new direction, the IT field in recent years is the main object of study. Wireless sensor network gathers sensor technology, communications technology, distributed information processing technology and embedded computing technology and other technology, and be able to accurately monitor object perception and a variety of information collected and sent observers.

Relying on the unique technical features, wireless sensor networks in military defense, urban management, environmental monitoring and health care, and many other fields widely used. Some people even use it for power automation remote meter reading, distribution network protection, substation automation, load forecasting, etc., so that the power system operation efficiency is greatly improved.

Currently, there are few reports mention the specific implementation of smart grid technology, but also involves a lot of literature concepts, development or architecture and so on. Only in efficient and reliable communication networks, smart grid to achieve interactive, open and rely on unique

technical characteristics, wireless sensor networks in military defense, urban management, environmental monitoring and health care, and many other fields widely used. Some people even use it for power automation remote meter reading, distribution network protection, substation automation, load forecasting, etc., so that the power system operation efficiency is greatly improved target [2, 3]. As an emerging field of communication technology, wireless sensor networks have many advantages, such as large coverage area, high fault tolerance, high precision, remote telemetry remote control, etc., in the development of smart grid plays an important role.

2. Research on Dynamics and Features of Wireless Sensor Network

2.1. Dynamics of Wireless Sensor Network

Wireless sensor network research began in the early 1970s, initially mainly used for military projects. Over the past decade, wireless sensor network is widespread concern in the world's major research institutions to ensure that the basic theory and its supporting technologies for rapid development. And the moment, he is gradually coming out from the experimental prototype, close to practical application, while the connotation and denotation has also been enriched and expanded.

Note, to ensure its basic theory and support the rapid development of technology. And the moment, he is gradually coming out from the experimental prototype, close to practical application, while the connotation and denotation has also been enriched and expanded.

In theory research, considering its size, self-organization, no partition, small volume, low cost, communications limited conditions, the researchers with a low power consumption as the core, in the network routing, topology control, network security, and continuously explore aspects such as data fusion, in order to prolong network life.

In practice, people are no longer adhere to the traditional old model, but application-centric, to take simple, feasible and proven technology, relying on wireless communication technology to achieve network monitoring systems is classified as wireless sensor network research category.

2.2. Main Features

2.2.1. Applying Relevance

Applications from different backgrounds, wireless sensor networks architecture, software systems and hardware systems are not the same, in practice, should be combined with each specific application requirements of its research, which is significantly different from the traditional wireless sensor network characteristics of the network world.

2.2.2. Data-Centric

The basic idea is to put the sensor as aware of data flow or data source, the wireless sensor network (WSN) as the corresponding sensor data or database space, apply for data management and processing as its target. Sensory data management and processing technology is to implement a data-centric core technology of sensor networks.

2.2.3. Self-Organizing, Self-Adaptive

Wireless sensor network node with self-organizing, adaptive characteristics that can be automated configuration management, the use of network protocols and topologies space can coordinate their behavior, automatically form an independent network, so it does not require any pre-network facilities do rely on, you can type in the detection area randomly deployed or artificial deployment.

2.2.4. Topology of Dynamic Changes

Wireless sensor network node with self-organizing, adaptive characteristics that can be automated configuration management, the use of network protocols and topologies space can coordinate their behavior, automatically form an independent network, so it does not require any pre-network facilities do rely on, you can type in the detection area randomly deployed or artificial deployment.

2.2.5. Multiple Hops Network Routing

Due to limited by node transmission power wireless sensor network (WSN), as the nodes and coverage for communication, need to use intermediate nodes to forward, this requires the network to have multiple hops routing. In addition, multi-hop wireless sensor network routing routing does not require specialized equipment, but by ordinary nodes done in collaboration [4].

3. Applications of Wireless Sensor Network (WSN) in the Device Status Repairing

Cause level of the power industry management level and asset operation maintenance there are many reasons, lag of equipment maintenance mode is one of the main reasons. Past, even in the present, device inspected, the most widely used method is to regular

maintenance, and many years of practical experience has proved that this method exists overhaul excess or inadequate maintenance, and many other defects. So, equipment maintenance should be a positive transition to the state overhaul, enhance the level of assets management and operation maintenance. Part of IBM Global Business Consulting business unit has specifically developed a set of standardized analysis summary for the smart grid, called the White Paper, which mentions, in order to make the power sector management and asset maintenance and operation level improved, the key is whether there a remote asset monitoring and control systems. Remote asset monitoring and control system using the sensing device to test the state of power equipment and data, on the basis of test results, the equipment condition assessment and judgment fault that may occur, for example, through the oil and transformer oil chromatographic detection, to determine whether there has been insulated cracking, and there may be a risk factor for the reminder to service personnel, according to the device to help optimize equipment maintenance personnel.

Must with the aid of sensors, the device status send to remote asset monitoring and control system, using communication network of equipment condition assessment, to determine whether or not need for repair or update equipment.

Most state sensor devices are installed inside the equipment, the environment is more complex, and the traditional communications carrier operation is not flexible enough, the installation is not very convenient. There fore, we can introduce the device state maintenance WSN technology, namely wireless sensor network technology, making it flexible, without wiring advantages into full play. As shown in Fig. 1, in order to monitor the temperature of the circuit breaker as an example, illustrates the application of WSN in equipment state overhaul.

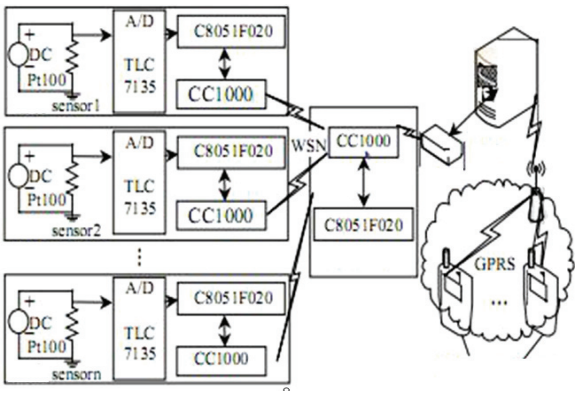

Fig. 1. Application of WSN in monitoring the temperature of circuit breaker.

Temperature sensor node sensing head is the main part of thermistor Pt100, through A/D chip TLC7135 of thermistor voltage for testing, then use C8051F020 MCU chip temperature is calculated. Will detection in WSN control method with the result of the communication chip CC1000 sent to gathering node, a collection of nodes and then to package the data received, the use of gateway protocol conversion, using Ethernet to all the data sent to the remote asset monitoring system from remote monitoring system for the analysis of the data received and to assess the operational status of the device, if the device fails, you need to repair or replace, put the details of the equipment needs to be repaired with the GPRS network platform to send information to a mobile field staff who work management equipment, so that field staff respond quickly to enhance repair education, reducing operating costs.

4. Application of the Wireless Sensor Networks in Smart Metering and Smart Home

In traditional electric energy metering, main purpose is to complete for the calculation of electricity, unsophisticated enough on customer measurement data, the data is not fully utilized Instead, smart metering management system personally for residential customers in the industrial or commercial users to install smart table, a more comprehensive and detailed measurement information collected, actively cooperate with the TOU measures, peak load to be suppressed in order to ease the sharp peak load growth situation; and real-time control of the load situation can guide grid construction, saving construction costs, reduced power grids; smart metering management is also beneficial to the effective positioning grid enterprises [5]. In addition, the introduction of smart metering technology, was also helpful to strengthen the demand side management, through the video, let the customer see the actual cost of energy consumption, and make corresponding adjustments, such as shut down some equipment, transfer from high energy consumption time to low prices. This approach can effectively reduce the cost of consumers.

Smart home systems and smart metering has a quantity, short communication distance, WSN is completely can be applied in it. In one area, the use of wireless sensor networks collect metering situation, and then through the power communication network will be collected from the case is sent to the measured energy metering management system and returns the real price. Embedding sensor nodes in the intelligent home appliances at the same time, with the help of WSN receive price information transmitted via by smart meters, between various intelligent home appliances through the WSN in consultation, decided to appliance of opening and closing [6]. In addition, wireless sensor networks, the Internet and other wireless networks are connected together to form smart home remote monitoring system, shown in Fig. 2.

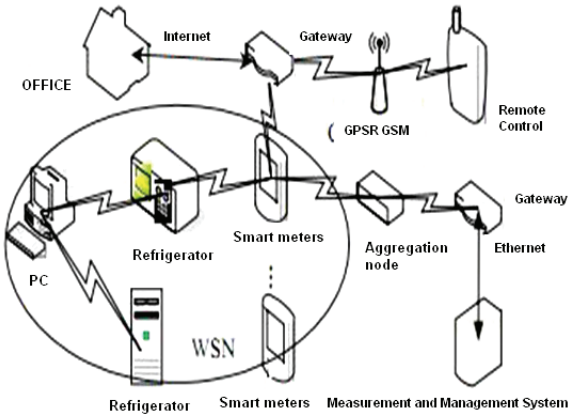

Fig. 2. Smart home remote monitoring system formed by WSN, internet and other wireless network.

5. Applications of Wireless Sensor Networks in Collapse Prevention in Grid

5.1. Application Background

Smart grid to grid security, increased reliability as a primary objective, causing power blackouts of many factors, natural disasters destroy them is an important factor. In 2008, for example, the snow disaster in southern China in most areas severely damaged the electrical infrastructure, causing widespread power outages. From overall analysis shows that damage to power facilities and caused power outage, or because of changes in the emergence of irregular grid malfunction protection, could lead to blackouts. Electric power communication network is destroyed large scope blackout of 2008, another main reason, on the one hand, electric power facilities monitoring and early warning system failure, can't take timely measures to disaster prevention and mitigation, on the other hand longitudinal channel is damaged to the normal operation of the main protection not, make the serious loss protection performance. But most of the existing electric power communication network is wired communication mode, easy to failure under the violation of the natural disasters, a wireless communication network is mainly rely on base stations to achieve the forwarding of information, meet with natural disasters, often appear the phenomenon such as base station or losing electricity pour tower, the wireless network will also fail [7]. Therefore, the use of WSN with the self-organizing, adaptive, multi-hop and other advantages to build new power communication network, is to deal with the grid catastrophe effective means.

5.2. Applications of WSN in Icing-Disaster Monitoring and Forecasting System

With ice disaster monitoring content and objectives of the monitoring system for reference, choose appropriate sensor node, combined with the specific geographical environment characteristics and tower type, in the case of does not exceed the system coverage, based on the principles of optimal cost, do science reasonable arrangement of sensor nodes. Sensor networks with multiple routing this characteristic, the tower on the monitoring data according to the characteristics of the monitoring results to the monitoring center. Fig. 3 is a set of WSN was used to construct the ice disaster monitoring and early warning system.

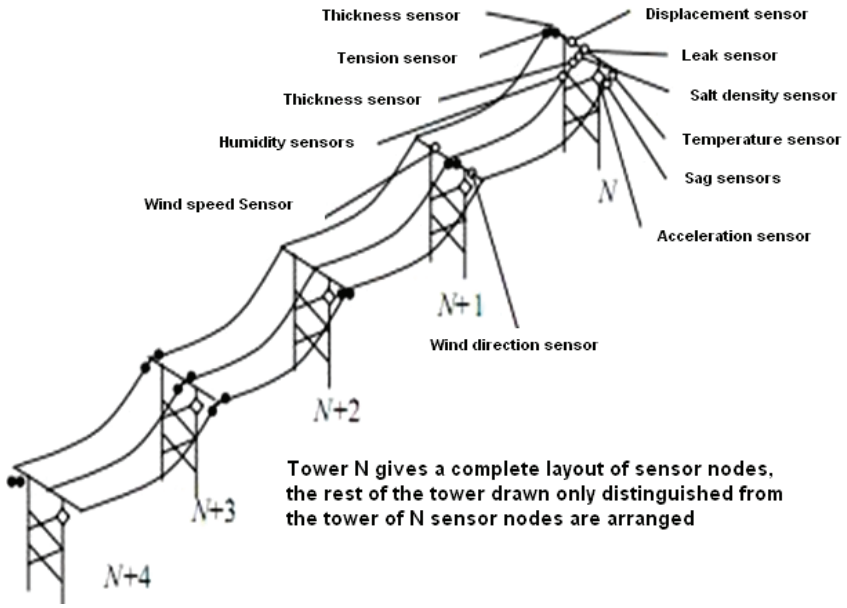

Fig. 3. Icing-disaster monitoring and forecasting systems.

If the metaphor of a transmission corridor "narrow ribbon", combined with the sensor node layout scheme to be considered, Layer 2 topology is more appropriate monitoring and early warning systems in sensor networks, in this architecture, the sensor nodes are divided into a number of clusters, each cluster with at least one cluster head, the cluster is the first layer, the second layer is between the clusters. Clearly, in the monitoring and early warning systems in sensor networks, with a tower on the sensor nodes can be grouped into a cluster, called local communication cluster, a cluster inevitable local communication with a cluster head, which is mainly responsible for the cluster integrate the data of each node and forwards [8]. Each tower cluster head node formed between the two layers, called the Tower between layers, this layer is mainly responsible for a cluster head node data processing and transmission, routing tables between their respective maintenance, and is responsible for forwarding paper, the use of "relay" method to send data to the transformer substation. Fig. 4 is a sensor network monitoring and early warning system, a two-layer architecture diagram (sensor not fully given).

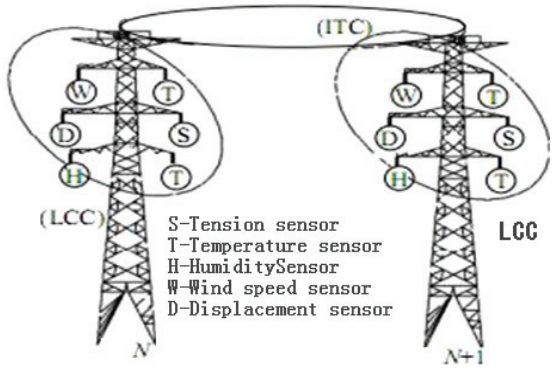

Fig. 4. 2 Layers architecture diagram of monitoring and forecasting system WSN.

5.3. Set up Cable Wide-area Intelligent Protection for Cataclysm

Line pilot protection channel easily damaged by natural disasters, resulting in the communication channel is disconnected, resulting in protection of exit. Since longitudinal protection in a short time to restore the communication channel is unlikely, due to the main line in order to avoid withdrawal protected outage affected locations in wireless sensor networks using automatic network set up a temporary information can be collected channel, although the time of performance, WSN collected information is not necessarily meet the requirements of pilot protection, but can use it for a limited build wide area intelligent protection among the disaster as a temporary primary protection grid to run in order to ensure grid security and stability [9].

6. Applications of WSN in Distributed Busbar Protection

As an important component of the power system, one the bus can work the normal operation of the power system has a direct impact. Busbar protection is mainly used to protect the safe operation of the bus, generally only important in large power plants or substations for specialized installations, and the high cost of traditional bus; easily be distributed capacitance control signal affected; current transformer secondary relatively large load circuit; busbar protection device malfunction, will link all branches are disconnected, causing widespread power outages; addition, there is not enough flexibility in the secondary wiring complexity and other defects. Because the cost is higher, when the bus fails, generally do not have a dedicated bus protection, but by the corresponding generators protective isolation, power distribution network is to ensure the quality of the key people on the bus protection installation is increasing high. Distributed bus protection without setting specific protection devices, mainly through a communication network to complete each line protection action information exchange, both to solve the inherent flaws, but also saves costs for distribution network.

Communication network is a distributed bus protection can be achieved prerequisite. Most communication networks are used in a cable carrier, require cabling, networking is not flexible enough. The use of wireless sensor networks to build distributed bus protection, and more outgoing busbars, connection and inter-changeable characteristics consistent distance is too short. WSN is a multi-hop routing, bus outlet more frequently, the information transfer time is too long, it may not satisfy the protection requirements of speed and mobility, therefore, appropriate to adopt the two-layer communication architecture, using it can improve communication efficiency.

7. Conclusions

Building a flexible, economical and safe new generation of smart grid has been widely recognized around the world, along with the development of smart grid construction progress of the application of wireless sensor network arena will be broader. According to the actual situation and take effective measures to secure wireless sensor networks, topology control and routing algorithms, energy management and other issues, will also step with the construction of smart grid deep gradually be resolved.

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Reference

[1]. S. Qiang Zhang, Yugeng Sun, Ting Yang and Zhenhui Cui, Applications of wireless sensor networks in smart grid, *Chinese Power*, Vol. 43, Issue 6, 2010, pp. 31-36.

[2]. S. Xide Wu, Research on application of wireless sensor networks smart grid, *Netizen World*, Vol. 23, Issue 1, 2012, pp. 59-60.

[3]. S. Xide Wu, Study on applications of wireless sensor network in smart grid, *Netfriends*, Vol. 23, Issue 1, 2012, pp. 59-60.

[4]. S. Jingang Yi, Degui Xiao, Discussion of routing protocols of wireless sensor network, *China Science and Technology Review*, Vol. 28, Issue 9, 2013, pp. 322-324.

[5]. S. Kai Xie, Yongqi Liu and Zhizhong Zhu, Smart grid facing the future, *China Power*, Vol. 41, Issue 6, 2008, pp. 109-112.

[6]. S. Guanghui Gou, Fumin Wen, Study and development of wireless sensor networks applied in smart grid, *Electromechanical Technology*, Vol. 18, Issue 4, 2012, pp. 98-101.

[7]. S. Yangguang Wang, XianggenYing and Dahai You, Study on wireless sensor networks for smart grid, *Power System Technology,* Vol. 34, Issue 5, 2010, pp. 117-121.

[8]. S. Kai Xie, Yongqi Liu and Zhizhong Zhu, Smart grid in the future, *Chinese Electricity,* Vol. 41, Issue 6, 2008, pp. 19-22.

[9]. S. Bin Liao and Hongxiang Chou, Standardized smart grid to enhance grid security, *Shanghai Electric Power*, Vol. 19, Issue 6, pp. 55-58.