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Research Article

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Study intelligent online monitoring system for smart grid base WSNs

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ABSTRACT

The collaborative and low-cost nature of wireless sensor networks (WSNs) brings significant advantages over traditional communication technologies used in today's electric power systems., how to device status data with secure, cost-effectively sent to the monitoring center for analysis, is an important topic in the field. In this paper, firstly finds the several key characteristics of wireless sensor networks communication link; then analyzing relations between RSSI and receives package ratio. The main idea is obtaining the RSSI value through forward link and reverse link then calculate the success to send a packet which need the minimum energy. From these, the REEOA route metric algorithm is provided. Algorithm is applied to intelligent online monitoring system, Experiments show that the wireless sensor network for intelligent substation on-line monitoring system to provide valuable reference.

Key words: Smart Grid; Online monitoring; wireless sensor networks; link quality evaluation

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INTRODUCTION

The smart grid is comprised of many networks (domains) with various boundaries that have to be interconnected to provide end-to-end services. Wireless sensor network (WSN) is the cutting-edge research focus in the current field of information technology. It has great scientific significance and broad application prospects. With the development of manufacturing processes and further research related to communication protocols, it takes an increasingly important role in the power system. Smart grids are a relatively complex integrated system [1] [2].

The wireless sensor networks [3] can be defined as an autonomous, ad hoc system consisting of a collective of networked sensor nodes designed to intercommunicate via wireless radio. Typically, these nodes coordinate to perform a common task. The key technology based on resource limited is still the bottleneck for WSN to be mature. Designing WSN application algorithm with lower energy cost under microwave wireless communication is an effective way to solve the bottleneck above. Such energy-efficient strategies based on resource limited involve many aspects such as density control, energy consumption distribution estimation and node deployment, wireless communication security, cross layer design of wireless communication protocol and so on. Although the main power consumption term in a traditional wireless system is due to the energy required for actual transmissions, this may not be the case in energy-limited wireless sensor networks [4]. In fact, in some cases it is the circuit energy needed for receiver and transmitter processing that is dominant. Network lifetime maximization involves all levels of sensor network hierarchy, from hardware/software design to communication protocols. Recent efforts dealing with communication-related energy costs mainly focus on two separate but equally important fronts: energy-efficient routing and sleep scheduling. In order to improve the energy-efficiency at the local sensors in an energy-limited wireless sensor network of the above type, in this paper we propose a new [5].

The remainder of this paper is organized as follows. In Section II, we discuss related work in this area. Section III introduces a REEOA algorithm to extern the lifetime maximization. In Section IV, includes simulation results and a discussion of various scenarios In Sections VI, presents our conclusions.

1. RELATED WORK

The electric power industry is undergoing a transformation that will drive gradual, long-term change in the processes and infrastructure for generating, transmitting and distributing power. In general wireless sensor network, each wireless sensor node has to receive packages from other sensor nodes and select adjacent sensor nodes to send data out according to the header of each package. This change will incorporate renewable generation, new T&D technologies, and increased levels of automation and control, and upgraded sensors, analytics, data, and information to enable more reliable, efficient power [6]. Communications is such a fundamental element of the Smart Grid, the appropriate design for physical, data and network communications layers are today a topic of intense debate. Unfortunately, Smart Grid is today fast enough, the computation needed for such real-time. But control is still very complex and poorly understood. For instance, DR and load shedding can potentially yield [7]. Routing metric method can reflect router decisions, based on the different routing decisions the node routing table entry will be different. Research activities related to the reliability of WSNs, such as wireless channel modeling and link-quality characterization, in harsh environments are extremely important when designing and deploying a reliable WSN in the smart grid. These channel models provide power system designers the ability to predict the performance of the communication network for a specific propagation environment, channel modulation, and frequency band. Although there exist radio propagation measurements in urban areas, office buildings, and factories link-quality characterizations in power generation, distribution, and industrial facility environments are yet to be efficiently studied and addressed[8]. Although there are proposed many complex communication protocols， and routing algorithms for wireless sensor network, the complexity, high cost, and handshake challenges must be solved in hardware implementation. Nowadays, the PC is powerful enough for controlling, scheduling, and routing transmission path within the wireless biomedical sensor network (WBSN) system. The proposed WBSN system architecture is separated into communication and control paths for biomedical applications. In this paper, we consider the energy efficiency issue for selective single-relay cooperative schemes. Compared with multi-node cooperative schemes, single-relay cooperation requires neither cooperative beam forming nor distributed space time coding, where only the “best” relay out of a set of candidates participates in the data transmission.

2. WSNS COMMUNICATION LINK MEASUREMENT

In order to test the actual communication link, this paper made the following relevant test:

3.1. Hardware and software platform of experiment

Hardware platform of experimental is the Micaz node developed by Crossbow Company; its working band is the 2.4-2.4835 GHz ISM band. The module has DSSS radio which has the 250kbps maximum data transfer rate; its communications module is high-performance wireless chip CC2420 [9] which compatible with IEEE 802.15.4 specifications. Its processor is AT mega128, which has a low-power, high-speed processor. The base station model is MIB510.

The software platform of experimental is TinyOS [10]. TinyOS is a free and open source software component-based operating system and platform targeting wireless sensor networks. TinyOS is an embedded operating system written in the nesC programming language as a set of cooperating tasks and processes. It is intended to be incorporated into smart dust. TinyOS started as collaboration between the University of California, Berkeley in co-operation with Intel Research and Crossbow Technology, and has since grown to be an international consortium, the TinyOS Alliance.

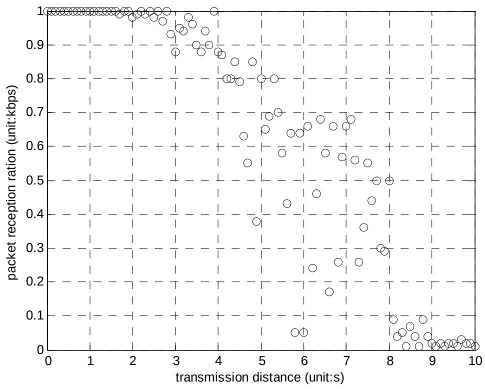

Fig. 1: The relationship between d and prr from A to B

3.2. Measurement of communication link

The test environment is Outdoor 500-kV substation, communications links were measured using different distances between nodes. Experiment uses 20 MicaZ nodes, which are divided into 10 groups. Each group has two nodes:

respectively, sending node and receiving node. And do the following requirements: 1 The Micaz node connected with base stations as receiver named node A; The Micaz node which send data to node A named node B. From above test: In the same distance, the relationship between packet reception ratio and the distance for forward link and reverse link.

From test results we can be obtained following conclusion: d <4m, link quality is very good, packet reception ratio is normally more than 85%; d> 4m and d <8m, the nodes of the packet reception ratio start to decrease, and the great changes without law; this area can be defined as transition zone; d> 8m, the packet reception ratio is poor, so when choosing the path as much as possible to avoid such path.

3. RUTINHG MTRIC PROPOSED

In allusion to the problem that actual network communication exits transitional zone and non-symmetry, in order to select a relatively reliable routing path, but only from the packet reception ratio cannot determine the actual communication link situation, In order to induce REEOA, this paper has made the following statement: Theodore S analysis the underlying link for wireless sensor network communication model of lognormal shadow:

$$PL(d) = PL(d_0) + 10\beta \log(\frac{d}{d_0}) + X_\sigma$$

Where: $PL(d)$ specific location for the path loss, d0 is the reference distance, β is the path loss index, σ is the standard deviation. X_σ is zero mean Gaussian random variable. From (1) can be received by the receiver of the power:

$$P_{recv} = P_{trans} - PL(d)$$

By equation can be calculated signal to noise ratio in the receiving node (SNR) as:

$$SNR_{(dbm)} = P_{recv(dbm)} - N_{(dbm)}$$

N is the platform noise. Based non-coherent modulation FSK, so the bit error rate formula is:

$$P_e = \frac{1}{2}\exp^{-\frac{1}{2}SNR}$$

In the wireless network, paper [10] analyzed the transmission between adjacent nodes in the delivery rate is on the SNR (signal-to-ratio) function; the expression is:

$$f(\lambda) = (1 - \frac{1}{2}\exp^{-\frac{\lambda}{2}\frac{B_N}{R}})^{8\rho F}$$

When a node sends a packet every time, energy consumption can be expressed as:

$$E^{tx}(P^{tx}) = \frac{8F}{R}\left(P^{cir} + \frac{P^{tx}}{\eta(P^{tx})}\right)$$

Now under the premise of ensuring the reliability of the network to save energy problems can be abstracted as the following optimization problem:

$$\text{Min:} \quad \sum_{i=1}^{H}\left\{E^{tx}(P_{li}) + E^{ack-rx}\right\} \qquad (1)$$

$$\text{Subject:} \quad \prod_{i=1}^{H} P_s(G_i, l_i) \geq Q_s$$

Since equation (1) non-linear solution of the problem is difficult to calculate the optimal solution directly. But with a recursive method to achieve the optimal solution, namely: First, set the network node an initial power level, using the recursive method to increase links among nodes of the power level until the end to meet the reliability requirements. Intermediate nodes for the link how to increase the power level, the paper made the following explanation:

Recursive method using equation (1) is equivalent to the maximization problem:

$$\text{Max} \quad : \quad \sum_{i=1}^{H} h_i(l_i) \qquad (2)$$

$$\text{Subject} \quad : \quad \sum_{i=1}^{H} l_i \le N, l_i \in \{1, 2, ..., L\}$$

Among which, obtained optimal solution $\{l_i^*\}$ by the recursive method, after a recursive algorithm and each node up to an additional power level; set as n times, n +1 times the optimal solution recursive operations were $\{l_i^*(n)\}$, $\{l_i^*(n+1)\}$;So, the recursive algorithms to the two following relations exist:

$$\sum_{i=1}^{H} h_i(l_i^*(n+1)) = \max\{h_j(l_j^*(n)+1)\} + \sum_{i=1, i\neq j}^{H} h_i(l_i^*(n))$$

Through the above analysis, from the recursive computation, just to find the nodes meet the following conditions: in the end to end link, if a power series for each additional, to deliver the fastest rate of increase.

4. SYSTEM TEST AND PERFORMANCE EVALUATION

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes.

This paper uses the node id No. 20 as the source node, No. 40 as the destination node. From the simulation experiment, we can make the network throughput curves (Figure 1, Figure2)

$$Loss(j) = \frac{NumberDrops(j)}{NumberTimes(j)}$$

$$En(j) = \frac{\sum_{i=0}^{n} \text{RemainEnergy}_i(j)}{TotalEnergy}$$

Figure 2 shows that from the source node S to destination node D, the average end to end throughput graph; as pre-set conditions, in theory, end to end throughput can up to 25kbps. However, due to Hello, and ACK control packet, the actual throughput was lower than the theoretical value; REEOA-AODV and ETX-AODV take into account the actual traffic situation in the bottom of the communication link, then selecting a relatively reliable link. REEOA-AODV considers the lower-link communication characteristics of the non-symmetry, so its throughput is even higher than the ETX-AODV.

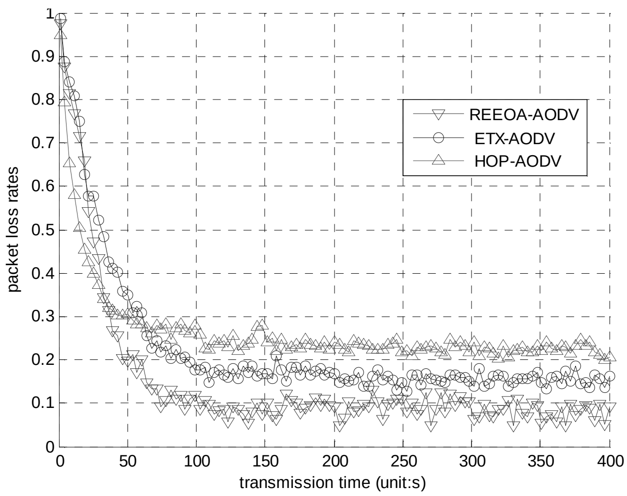

Fig. 2: End to end packet loss rates T vs. simulation time

Figure 3 shows that the simulation results of the experiment: When the end to end route is established, because HOP-AODV use the minimum hop count metric method, without considering the actual low-level communication link, Thus, when the transmission of data, the underlying need to re-transmit data, so that the network consumes more energy. REEOA-AODV, ETX-AODV consider the reliability of the underlying link in the establishment of a relatively reliable routing path, comparing the ETX- AODV, requires less retransmission, thus reducing the energy overhead. REEOA-AODV compare with HOP- AODV need fewer probe packets to judge the status of the link, so REEOA-AODV consumes less energy.

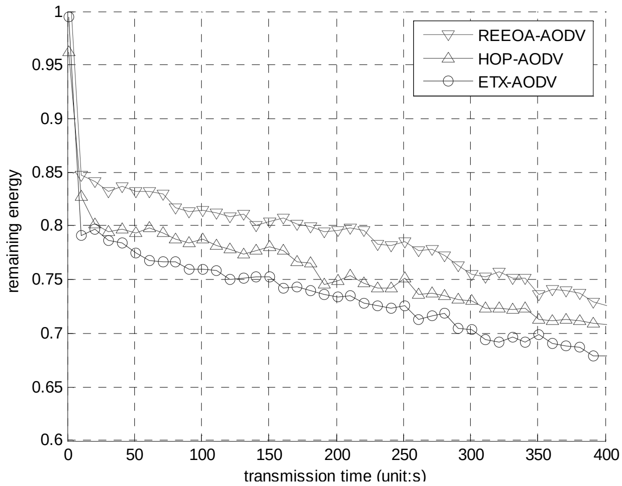

Fig.3: Remain energy En vs. simulation time t.

CONCLUSION

In this paper, firstly, overview existing wireless networks, several typical routing metrics, analyzes their advantages and disadvantages respectively; secondly, a statistical characterization of the wireless channel in different electric-power-system environments has been presented. Field tests have been performed on IEEE 802.15.4-compliant sensor nodes to measure background noise, channel characteristics, and attenuation in the 2.4-GHz frequency band. Thirdly, by modifying the original AODV protocol, REEOA is applied to AODV routing protocol. REEOA is applied to AODV routing protocol. Future work includes developing adaptive and cross-layer communication protocols for smart grid applications. Experimental results show that, in end to end throughput, remaining energy, performance of REEOA -AODV protocol is better than the original based on Hops, ETX of the AODV protocol. Thus, REEOA algorithm is suitable for practical applications of wireless sensor networks, providing a valuable reference for analyzing and designing of the practical application of wireless sensor networks.

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