Research on the AODV Routing Algorithm in Linear Topological Wireless Sensor Networks

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***Abstract* — With the rapid development of science and technology, 'pervasive computing' model has emerged accordingly. Linear-topological wireless sensor network (WSN) that based on power equilibrium appears in a new kind of data acquisition technology. This study mainly focuses on the reliability and security of data transmission, framework design and realization of network and so on, which is also the key of this research. Given that AODV(Ad Hoc On-Demand Distance Vector) routing technology is one of the core technologies of wireless sensor network technology, it's an urgent task to carry on the research of AODV routing algorithm in WSN(Wireless Sensor Network). This study of AODV routing algorithm in WSN is a relatively new field, which starts from the analysis its present situation, then uses the LETF standardized AODV routing algorithm as the basic condition to put forward AODV routing algorithm in linear-topological WSN based on power equilibrium, as well as AODV routing algorithm in mesh-based topological WSN based on judging threshold. While this paper mainly puts emphasis on the former, studying the advantages of wireless sensor network AODV routing algorithm over others. Besides, the study is making efforts to prolong the survival of wireless sensor network, to improve the expansibility and robustness of WSN and to lay solid foundation for the birth of better routing algorithm.**

Keywords - AODV routing algorithm;Power equilibrium; Wireless sensor network

I. INTRODUCTION

In the 21st century the calculation model of pervasive computing has been put forward as early as in 1988 and this is also the reason why it has aroused high social attention. Pervasive computing covers a lot of ground, including wireless communication technology, manufacturing technology of MEMS operating system, application oriented embedded operating system and its relevant software technology [1]. The AODV routing algorithm in linear-topological WSN based on power equilibrium is a typical application. People can obtain the information they needed conveniently through the wireless sensor network. The AODV routing algorithm in wireless sensor network is a kind of emerging technologies, but still cannot meet the actual needs, for it is still in its primary stage. The wireless sensor network is designed to collect data. How to transmit the data monitored by sensor nodes to the observation points more efficiently and reliably is one of the important purposes of studying wireless sensor network AODV routing algorithm. Compared with the traditional network, wireless sensor network has an obvious particularity and its applications have great differences as well. The factors that rapid development of MEMS and information technology, the plunge of computer cost have provide opportunities for wireless sensor network to develop. For instance, in business, wireless sensor network can help the household and office environment shift towards intelligence, laying solid foundation for more convenient and more comfortable environment; in the field of medical and health care, doctors can know about patient's state of illness and monitor various physiological statuses at any time, through remote control. If a bad condition appears, doctor can be informed and implement the rescue within the shortest time; in the field of environmental monitoring, the habitats of wildlife can be monitored; besides, wireless sensor network also plays a positive role in the monitoring of volcanic eruptions and early warning of forest fire. Overall, there is still a big gap between China's wireless sensor network (WSN) and that of developed countries. Therefore, we should carry out this cutting-edge technology that may change human's future life without delay. To a certain extent, this technology can promote national economic development and lay solid foundation for better participates in international competition[2].

II. AODV ROUTING ALGORITHM

AODV (Ad hoc On-Demand Distance Vector Routing) routing algorithm is a joint research made by Charles e. Perkins from the Nokia research center and Elizabeth M. Belding - Roryer from the University of California and other people. Besides, it has been formally announced by LETF MANET work team as the RFC standards of ad-hoc network Routing protocol as early as July 2003[3].

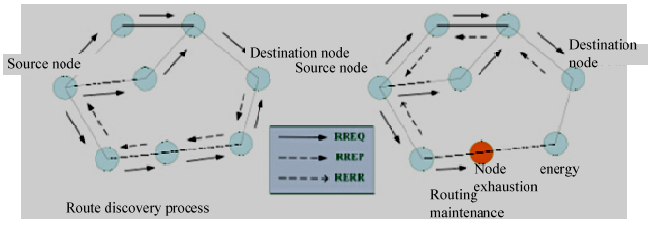

Figure 1. Source node request process

Figure 1 is the schematic diagram of source node request process. In essence, the AODV routing algorithm is the combination of DSR and DSDV, by absorbing their advantages and getting rid of their deficiencies. Generally speaking, the AODV routing algorithm can be divided into three aspects, including route request, route reply and route error. If the source node has difficulty in transmitting data, it will start another route on its own without other operations. To put it another way, the network will automatically send a route request to RREQ and AODV to response to RREQ through affecting the intermediate nod. Furthermore, in the process of data transmission, when detecting the appearance of route that responsible for data transmission or breakdown that stops the nod from reaching effective destination, the intermediate nod will send the error message to source node. After receiving the error request, the source node will detect the error automatically and make find another effective route according the specific situation of PERR [4]. Take Shallow geothermal energy as an example, as shown in Figure 2.

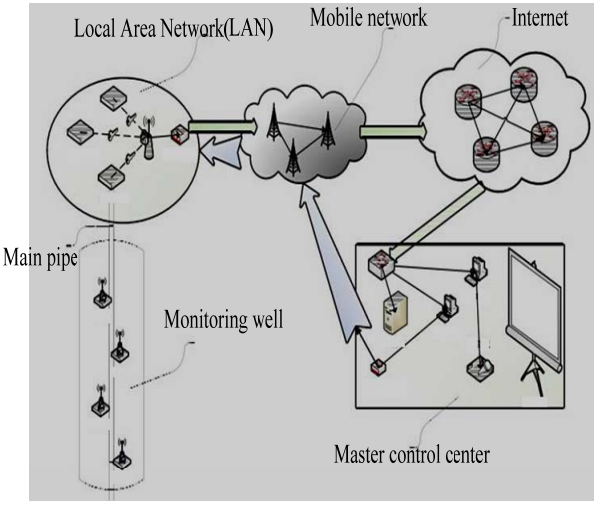

Figure 2. Shallow ground temperature monitoring network

Figure 2.Shows the shallow ground temperature monitoring network. As a new kind of strategic resources, shallow geothermal energy has gained high attention from countries and governments. The development and utilization of shallow geothermal energy is a reflection of practicing the scientific outlook on development and has played an important role in helping adjust the energy structure in China[5]. To a certain extent, the development and construction of intelligent monitoring network of shallow geothermal energy can save manpower and material resources. Moreover, the effective development and utilization of this energy is of great social and economic value. It covers the mobile communication network, Internet and wireless sensor networks, among which the mobile communication network and the Internet act the role of conveying information and forwarding instructions in the development of shallow ground temperature monitoring network while the wireless sensor network mainly responsible for collecting information. The sensor node is set in monitoring well so that the advantages of wireless networking can manifested maximum and the difficulties in underground wiring work are overcame.

III. Analysis of AODV routing algorithm in linear-topological WSN based on power equilibrium

In the applications of wireless sensor network, that all monitoring data collected are transmitted to the collection point is one of the crucial contents of linear-topological wireless sensor network. However, the wireless sensor network is limited in its bearing capacity and cannot transmit the data to sink node directly without using other ways because of its deficiencies in technology. In view of this, the design of a suitable WSN routing protocol can not only create conditions for efficient operation and data security, but also provide a solid theoretical basis for studying AODV algorithm. Different from traditional network, the wireless sensor network cannot simply take the shortest path as the design goal of AODV routing protocol [6]. Based on the whole, considering the deficiencies in technology of wireless sensor network, we should put energy efficient in the first place, for this is a precondition for normally running of the system and all nodes. See from the whole field of AODV routing algorithm in WSN and related information about routing algorithm, protocols of linear-topological AODV routing algorithm analysis in WSN based on power equilibrium emerge one after another. However, the linear-topological WSN based on power equilibrium is the most efficient way, because of its own unique advantages. For instance, the applications of WSN in forest, river and road, etc, have fully showed its characteristics of line or chain structure.

A. Distributed network and self-organizing network

Having not a certain control center, the nodes in wireless sensor network mostly are set in the test area in a random or manual way. All nodes are equal and they can make up the network automatically by mutual perception between each other[7]. This belongs to the category of distributed algorithm. And the join or withdraw of nodes will not affect the normal use of network.

B. Relatively poor safety and reliability and the limited bearing capacity of nodes

Figure 3 is the power consumption scale map of wireless sensor network AODV. As is shown, the power consumption of sending is the highest and followed by that of receiving. Because of its small size and relatively low price, the senor nodes may have deficiencies in the capacity of data-processing and storage. From a general perspective, node power supply source is a tiny cell, so there are some difficulties when replacement. In another ways, nodes in wireless sensor network generally rely on radio for operation, which may cause security risk, to a certain extent. For instance, a bad weather will create opportunities for malicious signal interference.

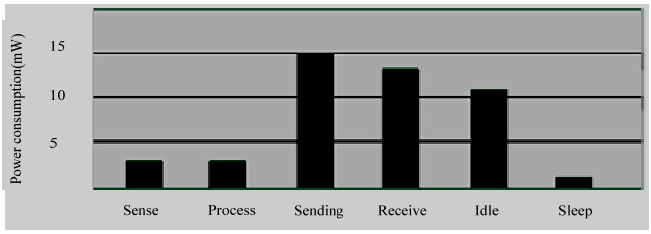

Figure 3. Power consumption scale map of wireless sensor network AODV

C. The dynamic linear topology

Generally speaking, the dynamic linear topology is a technology of great challenge that comes from the variation of environment and uncertainty of target monitoring. It may die in certain nodes because of excessive loss and energy consumption[8]. There is a possibility that the dynamic linear topology is caused by the maladjustment of some new nodes, which may greatly change the dynamic reconfiguration ability of wireless sensor network.

D. Relativity of Application

Throughout the whole application field of wireless sensor network, customers generally pay attention to one of parameters index of monitored object while ignore the whole study of data. The parameters being focused on differ when it comes to different applications, which also put forward higher requirements to the network system. Therefore, wireless sensor system cannot be the same as traditional network which acts as a platform for communication protocol. It has to design and create innovations for each application, in order to create favorable conditions for realizing scientific and efficient security system, especially for the characteristics of linear topological WSN based on power equilibrium which also be applied in the study of general wireless sensor[9]. At the same time, the simple topological structure and simplicity of routing paths have created favorable conditions for it.

Combine the features of AODV routing algorithm in linear-topological WSN with the data in Table 1, the following aspects can be taken into consideration when designing AODV routing algorithm in WSN:

(a) Energy efficiency. When choosing AODV route in linear-topological WSN, the minimum energy consumption value of nodes and even the average energy consumption value of each node should be taken into consideration, in order to make the most use of each node.

(b) Expansibility. Energy exhaustion or damage of nodes should be taking into consideration when designing the AODV routing algorithm in linear-topological WSN, in order to avoid the changes in network structure[10]. Therefore, this requires that, in the beginning of design, node expanding should be taking into consideration strictly, in order to better adapt to changes in network structure.

(c) Robustness. In common sense, the wireless sensor network needs spacious outdoor environment as a precondition, for the full play of the utility of node is closely related to environmental factors. Without this precondition, the communication paralysis may occur. Therefore, when designing the AODV routing algorithm in linear-topological WSN, a buffer time should be given if error occurs to fundamentally eliminate bad influence that comes from the unreliability of sensor.

(d) Quick convergence. To some extent, topological structure of network and overall energy of network have an influence on the wireless sensor network. Therefore, features that the security of protocol, the flexibility and conciseness of the network should be taken into consideration when designing the AODV routing algorithm in wireless sensor network[11].

TABLE I ROUTING ALGORITHM of MERR, LEACH, EEUC and PSO

	Scenario 1 Energy consumption when ten percent of nodes have died	Scenario 1 Energy utilization of WSN	Scenario 2Energy consumption when ten percent of nodes have died	Scenario 2 Energy utilization of WSN
MERR	35.117208	70.23%	29.274266	58.55%
LEACH	18.523864	37.04%	4.448789	8.89%
EEUC	44.709931	89.42%	36.521815	73.04%
PSO	46.175495	92.35%	37.240967	74.48%

IV. CLASSIFICATION OF DIFFERENCE FEATURES OF ROUTING ALGORITHM IN WSN

The routing algorithm in WSN has big difference with the traditional algorithms that is the former has strong characteristics while the latter has no obvious characteristics. This paper deeply studies the application fields of wireless sensor network and has a simple classification of the routing algorithm according to its configuration pattern, structural features and time of building route.

A. The first classification

According to whether the node has hierarchical structure in the linear-topological wireless sensor network and whether the nodes differ in their function, the routing algorithm protocol can be simply divided into planar routing protocol and hierarchical routing protocol. It can be easily seen in the planar routing protocol that nodes are equal in their status and function and have mutual interaction. Nodes actively transmit the data collected to sink node, or the sink node send the request to look for according to the need of route. Plane node is outstanding in its simple algorithm, convenient operation and good robust performance, but lack of scientific and systematic management in the communication resources. Moreover, it cannot fast response to the dynamic network and its expansibility needs more improvements. Different from planar routing protocol, hierarchical routing protocol divides the wireless sensor network into several clusters, each with a head node and several member nodes. What's more, head nodes of each cluster are ranked from low to high [12]. The head node of cluster not only has to finish its own tasks, but also undertake other head nodes' assignments, including the task of data transmission. During this process, energy consumption is very high and the reliability and Security of the network cannot be guaranteed[13].

B. The second classification

According to the time of building route and the finding methods of route, the routing algorithm protocol can be divided into active routing protocols, source-initiated on-demand driven and hybrid routing protocols. Taking the broadcast routing information of nodal period as basic conditions, the former starts researching work according to its own need and then choose the routing path. This protocol is outstanding in its real-time and security, while it is demanding when considering the high energy consumption of periodic broadcast. Source-initiated on-demand driven turns out to be passive, for it only starts researching work according to its own need when there is no purposes in its own routing information[14]. Compared with other routing protocols, Source-initiated on-demand driven is low in energy consumption and saves the network resources, but it takes too much time. Hybrid routing protocols combines characteristics of both and chooses active routing when the liner topology changes a lot, or it takes the Source-initiated on-demand driven and finally get the balance of the network resources and time.

C. The third classification

Because of its diversity, routes naturally choose their paths differently. However, according to the various characteristics of the routes, the routing algorithm protocol can be simply divided into geographical routing protocol and non-geographical routing protocol[15]. The former goes on its research work according to its own requirements. Bases on the above, it gets its geographical information, which certainly need the auxiliary of other technologies, such as GPS, etc.

Figure 4 shows the chain topological structure and plane topological structure. Linear-topological wireless sensor network has many classification methods, each having their own standards. The AODV routing algorithm in linear-topological WSN is the key part of the research. This study has a discussion of existing problems in chain topological structure and plane topological structure, in order to create conditions for the wider application of routing algorithm in WSN which is also the original purpose of this research [16].

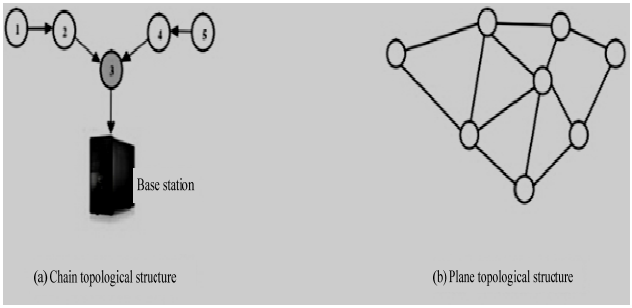

Figure 4. Chain topological structure and plane topological structure

V. CONCLUSIONS

Starting from the characteristics of WSN, this paper has a deep study of AODV routing algorithm in linear-topological WSN based on power equilibrium, such as the distributed network and self-organizing network, dynamic linear topology and relativity of application. Besides, this study puts forward that the equilibrium of each node, expansibility and quick convergence can be taken into consideration when designing routing algorithm in WSN. All these may help the

AODV routing algorithm in linear-topological WSN be applied in more fields and make the most of its functions.

VI. ACKNOWLEDGEMENT

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REFERENCE

[1] M.Mahmudimanesh, N.Suri, "Robust compressive data gathering in wireless sensor networks with linear topology", 2014 IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS), 2014: 179-186.

[2] R. Montemanni, P.Mahdabi, "A Linear Programming-based Evolutionary Algorithm for the Minimum Power Broadcast Problem in Wireless Sensor Networks", Journal of Mathematical Modelling and Algorithms, 2011, 10(2):145-162.

[3] C.J. Jiang, W.R. Shi, M. Xiang, "Energy efficient clustering protocol of wireless sensor network based on PSO",http://dict.youdao.com/search?le=eng&q=%E8%AE%A1%E7%AE%97%E6%9C%BA%E5%B7%A5%E7%A8%8B&keyfrom=dict.topComputer Engineering, 2010, 36（8）:15-17.

[4] Y. Liang, H.B. Yu, P. Zeng, " Routing protocol of wireless sensor network based on PSO and clustering",Control and Decision, 2006, 21(4)453-456.

[5] C.F Li, H.G Chen, " Routing protocol of wireless sensor network based on unequal clustering", Chinese Journal of Computers, 2007, 30(1):27-36.

[6] J. Skulic, A. Gkelias, K.K. Leung.Delay analysis of network coding in linear wireless sensor networks",2013 IEEE Conference on Wireless Sensor (ICWISE), 2013:25-29.

[7] B.K. Cetin, N.R.Prasad, R. Prasad, "A novel Linear Programming formulation of maximum lifetime routing problem in wireless sensor networks",International Journal of Autonomous and Adaptive Communications Systems, 2013, 6(2):191-204.

[8] X.L. Zhou, M. Wu, J.B. Xu, " BPEC: the distributed clustering algorithm by energy perception in wireless sensor network",Journal of Computer Research and Development, 2009, 46(5): 723-730.

[9] L.M. Wang, J.F. Ma, "The control method of intrusion-tolerant topology in wireless Sensor network based on renewable technology", Journal of Computer Research and development, 2009, 46(10): 1678-1685.

[10] K.H.KrishnaY.S.,Babu, T. Kumar, "Wireless Network Topological Routing in Wireless Sensor Networks",Procedia Computer Science, Proceedings of International Conference on Communication, Computing and Virtualization, ICCCV 2016,79:817-826.

[11] L.M. Sun, B. Li, X.Y. Zhou, "Congestion avoidance technology in wireless sensor network", Journal of Computer Research and Development, 2008, 45(1):63-72.

[12] Y.D. Xuan, Z. Zhao, Z. Fang, L.D. Du, D.Q.Geng, Y.H. Shi, "The design of monitor system for the elder based on wireless domain network technology", Journal of Computer Research and Development, 2011, 48(22):355-359.

[13] D.A.A. Raj, P. Sumathi, "Analysis and comparison of EEEMR protocol with the flat routing protocols of wireless sensor networks",2016 International Conference on Computer Communication and Informatics (ICCCI), 2016.

[14] F.JSun, Z. Wang, "The research on routing algorithm of wireless chain network based on single lamp monitoring", Computing Technology and Automation, 2012, 30(4):85-88.

[15] B.El Maroufi, M.D. Rahmani, M.Rziza, "Congestion avoidance in AODV routing protocol using buffer queue occupancy and hop count", Proceedings of the Mediterranean Conference on Information & Communication Technologies, MedCT 2015: LNEE 381:193-200.

[16] I.Jawhar, N.Mohamed, D.P. Agrawal, "Linear wireless sensor networks: classification and applications", Journal of Network and Computer Applications, 2011,34(9):1671-1682, Sept.