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Some Control Strategy relate to Congestion Control for Wireless Sensor Networks

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Abstract. Wireless sensor network that has wide promise and potential with various applications has aroused the common interesting of academic researchers and industrial circle. Firstly, this paper has mainly described the characteristic and the content of congestion control in wireless sensor network. Then, A careful analysis of the implementation of the congestion control algorithm involves technical difficulties and deficiencies were made, and all kinds of classic algorithms were made to comparative study. At the same time, the status of existing work's research and development were sum up. Finally, the future research directions of congestion control of wireless sensor network that the research field is in the initial developing stage were pointed out.

Keywords: wireless sensor networks, congestion control, load balancing, control strategy

1. Introduction

With the rapid development and increasingly mature technology of micro-electro-mechanism system (MEMS), wireless communications and modern networks merge into wireless sensor networks. So, Wireless sensor network (WSN) is a high degree of cross-disciplinary, highly integrated knowledge on network communication, and is a forefront research hot spot in the world. As a typical example of Pervasive Computing Applications, WSN has very broad application prospects [1], from military reconnaissance, peacekeeping and counter-terrorism, environmental monitoring, disaster relief to the traffic management, bio-medical and space exploration and so on. WSN has potential practical value in the very important areas [1, 2]. Now as a new field of study, sensor networks is regarded as a revolution of the perception and collection of information in 21st century. It has proposes a large number of challenging research topics in the basic theory and engineering techniques. Congestion control is one of the basic problems.

2. Congestion control strategy relate to WSN

The present WSN generally use Best Effort data transmission service model [3,4], therefore, congestion control and Best Effort service model closely linked. The main task of WSN congestion control is to improve the network environment, in accordance with the WSN data transmission services model in the network and data link layer, according to WSN's characteristics and its specific application environment, through the implementation of certain strategy; at the same time, it can further improve network throughput, which can ensure the load won't exceed the capacity of the transmission network.

WSN has the three basic characteristics: centralized data collection, multi-hop data transmission, and many-to-one traffic patterns. It means that the nodes is more close to the base stations need to send more data packets, and their traffic burden will be more serious. It may lead to serious packet collisions, network

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congestion, packet loss; in the most serious cases may even results in collapse congestion [5, 6], which this phenomenon is called the funnelling effect [7]. Load imbalance between nodes will aggravate the funnelling effect. The nodes, which have heavy load, will die soon because of the excessive consumption of energy. In this case, part of the node failure or death will further deterioration of network congestion level in turn, or cause the entire network premature death or paralyzed, this is a typical vicious circle.

The two criteria of performance measurement are often used in WSN simulation experiments: the life expectancy of network and the average flow of the biggest load nodes. Life expectancy is defined as experienced time interval when it is from the sensor network starts to work to the first node has consumed up its energy. The longer life expectancy of network will have the higher performance. The average flow of the biggest load nodes is used to measure the congestion level of the Network data flow. The higher the value is, the more serious network congestion situation will be.

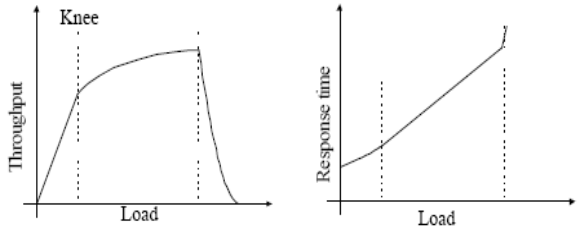

Fig. 1: Load of in network e.

The reference [6] uses figure 1 to describe congestion: when the network Load was small, it showed a linear relationship between the network throughput and the load, network delay slowly increased; After the network load exceed the Knee, the network throughput increased slowly, network delay grown faster; when the network load go over the cliff, the network throughput sharply declined, and the network delay raised sharply.

3. Load balancing strategies in WSN

The purpose of WSN congestion control is to improve the network throughput, reduce the time of data transmitted delay. Under this circumstances, node energy, communications bandwidth, network computing capacity and other resources is generally limited. It is possible to improve the network performance through the protocols design, route algorithm choose, data integration and load balancing, power control, sleep scheduling strategies and so on. At the same time, the various resources of WSN can be optimal allocated or distribution.

Load balancing is an effective technology to solve the WSN funnelling effect [7]. It is especially efficiency when the nodes are close to the base station; network congestion can be alleviated to a certain extent. At the same time, Load balancing can balance the node energy consumption and prolong the lifetime of sensor networks.

At present, there have obtained some research results about the load balancing in the WSN, such as: Shah and others [5] have used a kind of multi-path route mechanism, which has energy apperceive capability, make balance the load among the nodes. But the sensor network model, which they used, does not have the flow characteristics of many-to-one. Perillo and others [6] have used the optimize node transmission distance ways to achieve the load balancing, but all nodes in the sensor network model can communicate directly with the basic station. This case is obviously inconsistent with WSN's characteristics of the multi-hop. Gupta and others [7] have put forward an algorithm, which can balance load among the cluster heads, but the nodes must be organized into the WSN cluster structure in advance. Gao and others [8] have presented a scheme, which balance the route's load in the narrow geography distribution area. At the same time, they propose three kinds of greedy algorithm to achieve load balancing for different degrees load base on previous assumptions. It is pity that the WSN's geographical distribution of means is not consistent with that of reality mean.

Hsiao and others [9] have constructed the balancing tree for the wireless network which can achieve the load balancing at the highest level among the wireless nodes, but the flow characteristics of WSN and the

kinds of wireless networks is different. Dai and others [10] have set centralized algorithm. It looks the grid structure of central-node wireless sensor network as a static load-balancing tree, but in reality this type of network structure are rare.

In order to solve the dynamic character of the sensor network tree structure in the reference, [11, 12] the researchers have presented dynamic query-tree energy balancing (DQEB) series of protocol to adjust the tree's structure and balance the network's energy consumption. However, it is at the huge power consumption cost to change the structure of tree. In order to eliminate the question of data access in WSN, which is caused by the traditional method of data storage. The literature [13] have adopted the load-balancing data access based on ring to ensure all of nodes consume evenly energy in the whole process, which is from data storage to inquire data. It prolongs lifetime of the WSN to a certain extent. However, the data access and inquire data algorithms based on ring is only suitable for event-centric WSN.

The load-balancing network (LBN), which is proposed in literature, [14] belongs to distribution algorithm. LBN's basic idea is: WSN is a "supply and demand" data network, base station is the only ultimate data demander, and the sensor node is the data producer and transporters, data demander "buy" the data from the data producer. It is indispensable to make balance between "supply" and "demand", in other words, between the base station and node, node and node. The base station and nodes will be organized into a load balancing network, rather than a balanced tree. So can the network balance the energy consumption when it carries data collect. It can prolong the network lifetime and effectively alleviate network congestion. But LBN only suitable for mostly immobility data collection sensor networks, which its topology is infrequently changed.

4. Other congestion control strategy in the WSN

Apart from the above the main strategies have emerged in recent years, there have many new routing protocols and design scheme appeared relative to the wireless sensor network, these study are gradually thorough and practicality. For example, the literature [15] uses graph theory to optimize traffic flow in select sampling datagram routing. The literature [16] ties up MAC layer and routing layer protocol, and use cross-layer optimization techniques to further reduce power consumption. In the literature [15, 16], the routing can adaptively adjust topology in sensor networks, which is randomly deployed, and let the redundant point frequently sleeping.

In addition, the following protocols algorithms are relate to congestion control strategy.

SPEED [17] is stateless non-deterministic geographic forwarding protocol (SNGF), which belongs to distribution routing strategy, with the provision of soft real-time end-to-end routing capabilities. SPEED has cyclical trigger and threshold trigger two kinds of work mode, which can access geographic information and load conditions through exchange information between neighbour node, and prefer chooses a lighter load and better performance neighbour nodes as the next hop, effectively reducing the network load and realizing congestion control. SPEED has certain scalability.

Berkeley-MAC (B-MAC) [18] protocol uses channel assessment to ensure the reliability of data transmission in the data link layer, and use low power interception technology to reduce idle listening to achieve low-power communications. Channel appraisement is adopted weighted sliding average index algorithm to derive the average channel noise through received Receives Signal Strength Index (RSSI), and then the derived the average channel noise is compared with the minimum RSSI value in a short time to determine the channel state. B-MAC protocol provide a series of bi-directional interface for upper layer, for example, set Preamble Length and so on. By setting these interfaces, MAC protocol can be applied to many different types of network traffic. In order to solve the problem of network congestion, B-MAC protocol by using the back-off algorithm to allocate channels, which is include initial avoidance and the congestion avoidance two stages, these function can be set up through application program. This kind of avoidance algorithm is similar to the principle of AIMD congestion control algorithm.

Particularly, it must be point out that the data transmission between nodes is based mainly on not end-to-end, a large number of redundant data. These must use the data aggregation or data fusion to resolve network congestion in the transmission process. In some special cases, it is also the existence of end-to-end data

transmission, such as voice, image or video, real-time data, it can implement the congestion control strategy through concerned about transmission delay, bandwidth and other parameters. Literature [19] based on none end-to-end transmission pattern proposed a reliable transmission strategy ESRT, and it solves the problem of network congestion through reliability and energy consumption coordinated control. Literature [20-22] establishes the priority based on the end-to-end data transmission mode in accordance with criticality of data, and realizes congestion control by distributing different network resources and implementation of scheduling strategy.

5. The problems faced

This paper summarizes the most representative work in the study of current WSN congestion control strategy, careful analysis of the advantages and disadvantages of various algorithms. Besides, the main problems will be presented in the research process of the congestion control scheme. To solve these problems, further research needed to be done.

1、Now, many research papers present the congestion control algorithm is only rest on the phase of theoretical research without considering various difficulties in the practice. So, the congestion control algorithms is lack of practicability；2、Most researcher assume that the node have the same structure. But in fact, even if all of the sensor network nodes have the same emission power, the transmission range of each node is different, due to the different of antenna quality, topography and some other factors. Now, the researchers have noticed that the big difference [21-23]. So, the model is too idealistic, without considering all kinds of varying factors in practical application； 3、Experiments and applications are the most effective trustworthiness circumstances for algorithm, but WSN has not yet completely entered the practical stage. Most of the congestion control algorithms were merely analyzed in theory and simulated in small-scale network because of the cost, technology and so on. All of theoretical analysis is based on the model, which it is idealized. So, lack of practical technical verification platform and the research results is not trustworthy；4、To reduce or even eliminate funnelling effect, which is result from network congestion, the researchers used distribution congestion control algorithm, hierarchical network design, data fusion, and other mechanisms to solve the problems. But the strategy of congestion control is single without take into account the comprehensive performance of WSN.

6. Conclusion

Compared with the traditional data communications network, WSN have distinctive features in network structure and application requirements. Because it is lack of pervasive unified architecture of WSN nowadays. There still exist some problems such as the simulation model is idealistic, and the network's comprehensive performance scarcely take into account, and the research results is not trustworthy, and so on. This paper thoroughly described WSN's congestion control performance evaluation system, analysis typical WSN congestion control strategies and protocols in detail, discussed the challenges which the congestion control algorithms is applied in WNS, point out that more practical congestion control scheme must be design according to application background in the future. This topic provides the necessary theoretical foundation for further study the communication protocol and congestion control mechanisms of WSN.

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