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博 士 論 文 概 要

論 文 題 目

Research on Multipoint Transmission Protocols for Wireless Sensor Network

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In recent years, wireless sensor networks (WSNs) have gained worldwide attention driven by advances in miniaturized hardware, and motivated by a vast array of potential applications. A WSN is composed by many low-cost sensor modules with limited memory, computing capability and energy resources. There are still many research challenges in WSN, especially in the aspect of multipoint transmission protocol. In many particular applications such as traffic control system, automatic guided vehicle system, etc., wireless sensor modules have to sense the target's state information such as speed, acceleration, rest power or fuel, position, etc., and then exchange the state information with all the other modules or infrastructure in real time. The multipoint transmission is required for data exchanging, and it is commonly performed in a mobile multihop pattern. However, designing such a transmission protocol based on the low-cost WSN module is a great challenge. The conventional protocols in low-cost solutions such as Zigbee over IEEE802.15.4 are not suitable for such a multipoint application of mobile WSN due to their low performance. Hence, proposing new protocol to achieve high energy efficiency and high transmission efficiency for multipoint transmission in WSN is the research target.

Firstly, energy is the most important concerns of WSN since sensor modules use batteries as the power supply in most cases. Conventional broadcast based protocols cost high power consumption although they are easy to be implemented for multipoint transmission by low-cost wireless sensor modules. Recent research indicates that the network lifetime of WSN can be significantly prolonged by reducing the redundant transmission data in the network. In this research, there are two research subjects to improve the energy efficiency of the network based on broadcast. One is to reduce the redundant broadcasting data from the source nodes. The other one is to decrease the amount of intermediate nodes' forwarding.

Secondly, transmission efficiency is another key issue for the protocol in WSN. In many applications for detection systems, there is a high requirement for the transmission delay. As a conventional media access control (MAC) layer protocol, time division multiple access (TDMA) is widely used in the WSN. However, it adopts the constant timeslot assignment which cannot adapt to the dynamic traffic flow of the network. It leads to much unnecessary waiting time when the traffic flow is less than the timeslot assignment. Therefore, a high efficient transmission is desired for the delay sensitive application of WSN by reducing the redundancy in time domain.

Chapter 1 [Introduction] This chapter briefly introduces the overview of WSN and the current research status of the transmission technologies for WSN. The research target of multipoint transmission is discussed as well. Finally, the objective and scope of the research is presented.

Chapter 2 [Energy efficient system data sharing protocol for multipoint transmission in WSN] In this chapter, an on-demand dynamic multihop data

sharing (On-Demand DMDS) protocol is proposed to improve the energy efficiency of network by reducing the redundant broadcasting in source node. Wireless sensor network (WSN) is energy restricted in most cases. Designing an energy-efficient and reliable transmission protocol for a mobile multihop WSN is a great challenge since the topology of the network changes rapidly. Some conventional multipoint transmission protocols, such as synchronous dynamic multihop data sharing (S-DMDS) protocol assign each node to broadcast data blindly. Hence, much redundant broadcast is generated and much unnecessary energy is consumed. The proposed protocol employs the on-demand mechanism to reduce the redundant broadcasting in source nodes. On-demand mechanism assigns node to broadcast data according to the real demand by detecting whether there is changed data that needs to be broadcast and how much changed data needs to be broadcast. Therefore, the amount of data broadcast to the network is significantly reduced. Furthermore, a neighbor node table and a report mechanism are introduced to prompt a node to check its neighbors' status in the mobile situation. The results show that under a constant arrival rate, On-Demand DMDS protocol reduces the total transmission data of the network to 12.7% and extends the network lifetime to 9.2 times at most, in comparison with the conventional multipoint transmission protocol S-DMDS protocol. As a summary of this chapter, a novel multipoint transmission protocol On-Demand DMDS is proposed and it is proved that the proposed protocol reduces the redundant broadcast data and improves the energy efficiency remarkably.

Chapter 3 [Multipoint relay with energy awareness for system data sharing protocol in WSN] A multipoint relay with energy-awareness (EA-MPR) for system data sharing protocol is presented in this chapter. It is abbreviated as EAMPR-SDS protocol. The proposed protocol aims to improve the energy efficiency of the network by optimizing the data forwarding in intermediate nodes. Because the redundant forwarding problem in conventional forwarding method causes low energy efficiency, the proposed protocol employs EA-MPR to reduce the redundant forwarding in the network. It assigns the sending node to decide which of its neighbors to forward the data on the basis of the information of 1-hop neighbors' rest energy as well as the 2-hop neighbor information. Therefore, instead of all the nodes in network, only a subset of nodes (MPR nodes) is selected to forward the data and still guarantee complete network connectivity. Furthermore, energy consumption of the MPR nodes is automatically balanced by the energy awareness mechanism. The simulation results prove that the redundant forwarding data in EAMPR-SDS is much less than that in On-Demand DMDS and S-DMDS which adopt conventional forwarding method. In comparison with the On-Demand DMDS, the total transmission data is reduced to 52.46% and the network lifetime is extended to 3.4 times at most. As a summary of this chapter, a new forwarding optimized protocol EAMPR-SDS is proposed

for the multipoint transmission protocol in WSN and it is proved that the proposed protocol efficiently reduces the amount of redundant forwarding and further improves the energy efficiency.

Chapter 4 [Hybrid MAC for high efficient multipoint transmission in WSN] A hybrid MAC is proposed on the basis of EA-MPR for multipoint transmission protocol in WSN. The new protocol is abbreviated as HMAC-EA-MPR-SDS protocol. It aims to improve the transmission efficiency of the conventional TDMA, which is adopted in the above multipoint transmission protocols, via reducing the redundancy in time domain. Conventional TDMA assigns a constant timeslot for all nodes to broadcast data. However, each node has different demand to occupy the timeslot since some of nodes have to forward other nodes' data and some of nodes just broadcast their own data. Conventional TDMA leads to much wasted timeslot and low transmission efficiency. In the HMAC-EA-MPR-SDS protocol, a short timeslot TDMA is introduced for each node to broadcast its own data. Meanwhile, the forwarding nodes (MPR nodes) are also selected. After that, a high speed access method (token chain) is proposed for the MPR nodes to forward data through the whole network efficiently. Hence, the proposed method can improve the access efficiency of network. Additionally, a restart mechanism is employed for dealing with dynamic topology and balancing the energy consumption of MPR nodes. The simulation results prove that HMAC-EA-MPR-SDS protocol can achieve a much less transmission delay and higher network scalability in comparison with all the above multipoint transmission protocols. For example, the transmission delay is reduced to 18.4% at most in comparison with On-Demand DMDS protocol. As a summary of this chapter, a novel hybrid MAC based on the EA-MPR is proposed for the multipoint transmission in WSN and it is proved that the proposed protocol can significantly reduce the transmission delay and it can achieve a high efficient multipoint transmission in WSN.

Chapter 5 [Conclusion] In this chapter, the conclusion is drawn and the future work of the research is presented.

This research concentrates on proposing multipoint transmission protocols for the mobile multihop WSN with energy efficiency and transmission efficiency. A novel on-demand mechanism is proposed to improve the energy efficiency by reducing the amount of redundant broadcast data in the source nodes. An optimized forwarding method EA-MPR is presented to improve the energy efficiency further by decreasing the amount of redundant forwarding as well as by balancing the energy consumption of the forwarding nodes. A new hybrid MAC based on EA-MPR is proposed to achieve a high efficient transmission by reducing the redundancy in time domain. These proposals are favorable contributions for the multipoint transmission applications of mobile multihop WSN.