ENERGY-BALANCED SCHEME AND CONGESTION CONTROL BASED ON THE HIERARCHY USING WIRELESS SENSOR NETWORKS

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Abstract

Wireless sensor network (WSN) consists of an outsized range of device nodes. The restricted resources and many-to-one communication model typically end in congestion and unbalanced energy consumption. Hence, the matter of congestion control with balanced-energy is kind of vital for the utilization of WSNs. In this paper, tends to gift a congestion management and energy balanced theme supported the hierarchy (CcEbH).The network model is first initialized into a gradual topology, by that these neighbor nodes of a node are expressly divided into three sets, i.e., an equivalent gradual nodes, the upstream nodes, and also the downstream nodes. And then,within the planned congestion shunning technique, the node can use other lower hierarchy neighbor nodes to forward information once its downstream node can be congested. After that, the congestion management mechanism can notice the congestion if a node via its queue length, forwarding and receiving rate, and inform its upstream nodes to seek out alternative next hop to unleash the congestion. Within the CcEbH, the balanced energy consumption strategy can balance the energy consumption of lower hierarchy nodes by using the node with the foremost remaining energy. The algorithm will effectively deal with the network congestion and unbalanced energy consumption.

Keywords: Wireless sensor network, congestion control, balanced energy consumption, Hierarchical topology

I. INTRODUCTION

In recent years, wireless sensor networks (WSNs) have attracted a great deal of attention to the development of the electronics and wireless communications technologies. A WSN is composed of hundreds or thousands of sensor nodes equipped With various components, e.g., sensing, energy supplying, data processing, and communicating units. Those nodes work together to detect the event of predetermined nature or obtain data about the environment, and transmit the sensed data to the sink or base station through wireless links [The sensor nodes with restricted power are often deployed in the areas where it is difficult to replace their power. This brings many constraints for designing protocols on WSNs. It is well known that the WSNs have shown great potential in many practical applications, such as military surveillance, target tracking and natural disaster relief, and so on. Generally, there are large amounts of data to be transmitted from the Source to the sink, which may frequently result in congestion due to the many-to-one data flow. Congestion is an undesired phenomenon due to serious reducing the network performance and the network lifetime, and causing wastage of the limited energy. So, the problem of congestion control in WSNs has been receiving more attention in the past decades and many congestion control protocols have been proposed for WSNs, see the survey papers . The key feature of these protocols is to decrease the data rate of the source or forward to the data flow to another spare neighbor node so as to attain releasing congestion. Thus, they usually use the shortest path to forward data, which may make the nodes run out of energy quicker than other nodes. Moreover, when they find the spare neighbor nodes, they just consider the hop count and the buffer occupancy of neighbor nodes. In order to cope with those problem simultaneously, this paper proposes the congestion control and energy-balanced schemes based on the hierarchy (CcEbH). Atthe initialization phase of network model, a hierarchical topology is constructed from the sink node, by which every node will know its own hierarchy. The sensed data is transmitted from the high hierarchy nodes to the low or same hierarchy nodes. By checking the queue length of the next hop node, the forwarding node will decide whether or not to continue to send packets to this next hop node at the congestion avoidance phase. In order to detect the congestion accurately, the CcEbH utilize a novel congestion detection method. The upstream node will employ other unloaded parent nodes or the same hierarchy neighboring nodes to receive packets after it knows the occurrence of congestion at the next hop node. In order to balance the energy consumption, the upstream node will take the low-hierarchy node with the most residual energy as the receiving node. In CcEbH, the node also uses the same hierarchy neighboring nodes to balance the energy consumption of the nodes located at the same level.

II. RELATED WORK

Congestion control has been a hot area of research in WSNs. Congestion will occur when the traffic load exceeds the available capacity on the node level (buffer overflow) or link level (interference or contention) . The existing congestion schemes are roughly divided into traffic control and resource control. The former is suitable for transient congestion situation as in , while the latter is more effective in cases of persistent congestion circumstances. The main feature of the traffic control methods as in is to send a back-pressure message to the source nodes when the occurrence of congestion is detected. And then, the source nodes will decrease the rate so as to release congestion.However, the traffic control methods are not suitable for real-time applications, such as patient monitoring, security detection and so on. Therefore, there are many efforts to focus on the resource control methods as in. The resource control method will not decrease the data rate after the happening of network congestion. Instead, it will make use of the spare nodes to forward the redundant data so as to reduce the load of the congested nodes. Hence, for the resource control method, it is important to choose new next hop or construct the alternate path. Both HTAP and DAlPaS will choose new next hop for any node when congestion occurs at its original next hop.

In order to find all possible routes from the sources to the sink when an event occurs, the HTAP algorithm in building a source-based hierarchical tree after the end of the topology control scheme. When congestion is about to occur at a specific node, its upstream nodes will be informed to stop transmitting packets. And then, those upstream nodes will choose the available node with the same level (in comparison with the congestion node) and the least buffer occupancy as their next hop. After that, the upstream node will forward the excess packets through the new next hop. Through the above algorithm, the load on the congestion node is reduced and the congestion is released.

III. HIERARCHICAL TOPOLOGY

In this section, the hierarchical topology will be constructed. Suppose that the network model has one sink node and a lot of homogenous sensor nodes deployed uniformly over the target field. The sink node has infinite energy and other nodes have the same limited initial energy without a renewable energy budget. Besides, each node has a particular ID and all nodes have same communication distance.

A. Construction stages of hierarchical topology

The hierarchical topology formation can be divided into two stages: topology discovery and hierarchy updating. The former will form an initial hierarchical topology after the node deployment. The latter will update the hierarchical value of nodes so as to have less hops and delay to the sink. The above topology construction procedure is only made once at the initialization of the network model. The node will also update its hierarchy and neighbor table when its neighbor node will run out of their energy or its neighbor node has moved out its radio range.

Topology discovery stage: The phase starts from the sink node. The sink node broadcasts a hierarchy_discovery message with its hierarchy value 0 and ID. The node receiving the hierarchy_discovery message will consider the sink node as its neighbor node and set its hierarchy as 1 which is got by increasing the hierarchical value in the hierarchy_discovery message by 1.

Hierarchy updating stage: This stage will be carried out when any node receives a hierarchy_discovery message from neighbor nodes again. The node records the node ID in the hierarchy_discovery message into its neighbor table firstly. And then, it will compare its hierarchy with the hierarchical value in the hierarchy_discovery message. The node will change its hierarchy if its hierarchy value is greater than the value in the hierarchy_discovery by 2 or more. The node updates its hierarchy to the value which is higher than the hierarchical value contained in the hierarchy_discovery message by 1. And then, the node will broadcast a new hierarchy_discovery with its hierarchy and the node ID. In other circumstances, the nodes drop the hierarchy_discovery message and just record the node ID into its neighbor table.

B. The hierarchy updating for low power and mobile nodes

The powerless nodes and the mobile nodes may bring about the change of topology structure. In this work, we propose a method to deal with the powerless nodes and mobile nodes. When a node doesn't receive hello message from its neighbor node for a period of time, it will delete this neighbor node from its neighbor table. Similar deleting procedure will be also made when the residual energy of its neighbor node is less than 20% of total energy. The node checks its neighbor table after deleting a neighbor node with low power or moving out of its ratio range. If it has not lower-hierarchy nodes, it will increase its hierarchy by 1. And then, it will broadcast a hierarchy_discovery message with its new hierarchy value and ID. The nodes that receive the hierarchy_discovery message will update its neighbor table and execute the above process. When the node still has lower-hierarchy nodes, it will do nothing.

IV. CONGESTION CONTROL AND ENERGY-BALANCED SCHEME

In this section, based on the constructed hierarchical topology, the congestion control and energy-balanced algorithm (CcEbH), which includes three parts: Congestion avoidance method, Congestion control mechanism, and Balancing energy consumption strategy.

A. Congestion avoidance method

In a particular area, when many nodes attempt to transmit data to one node simultaneously, the congestion may happen at this node. Thus, in order to reduce this kind of congestion at the downstream nodes, the following congestion avoidance method is proposed in CcEbH for the upstream nodes. Before an upstream node sends data, it will check the buffer occupancy of the next hop node. When this buffer occupancy is greater than the queue length of the upstream node by 20% of total buffer size, the upstream node will choose other suitable downstream node to receive data. By means of the neighbor table, the node with the most remaining energy in the lower-hierarchy neighbor nodes is prior. In the case that this upstream node has only one lower-hierarchy neighbor node, the congestion avoidance method will not work.

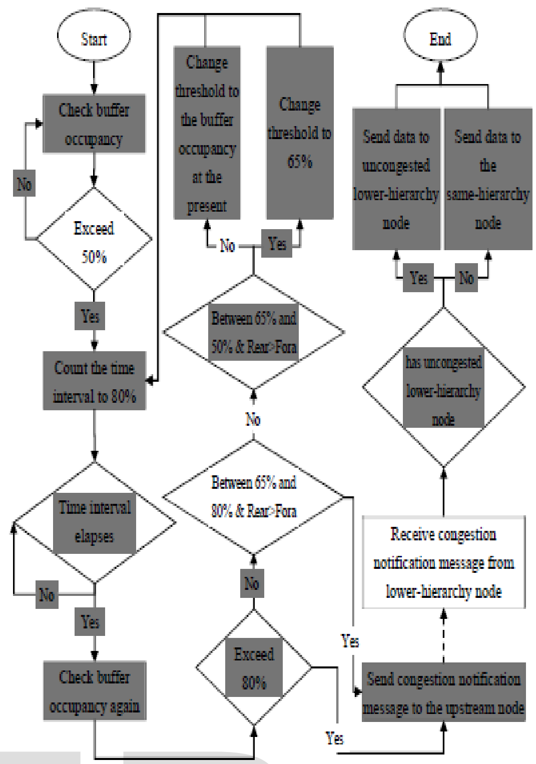

Fig 2 The flow chart of congestion control mechanism

B. Congestion control mechanism

Although the above congestion avoidance method can decrease the probability of congestion to some content, it cannot eliminate network congestion completely. Hence, in CcEbH, the following congestion control mechanism is proposed, which includes congestion detects and congestion release. This mechanism is a resource control method and can release persistent network congestion effectively. Congestion detects phase: When the buffer occupancy of a particular node reaches congestion detect threshold, e.g., 50% of the buffer size.

C. *Balanced energy consumption strategy*

It is well known that the unbalanced energy consumption is an inherent problem for WSNs with multiple hop routing and many-to-one traffic flow. Moreover, the sensor nodes closest to the sink tend to deplete their energy faster than other sensor nodes, which lead to the energy-hole problem and decrease the network lifetime. In order to maximize the network lifetime, the nodes within the radio range of sink node should deplete their energy roughly at the same time. In CcEbH, we use the neighbor nodes in the same hierarchy or lower hierarchy to balance the energy consumption

The balanced energy consumption strategy not only concentrates on the balancing energy dissipation of innermost hierarchy nodes, but also contributes to balance the energy consumption of the intra-hierarchy node. The innermost hierarchy nodes are the type of nodes that the hierarchical value is 1, while the intra-hierarchical nodes is the nodes located in the same hierarchy.

V. CONCLUSION AND FUTURE WORK

In this work, we have proposed a congestion control and energy-balanced scheme based on the hierarchy topoly for WSNs (CcEbH), in which the congestion avoidance method and the congestion control mechanism have been also given to decrease the probability of congestion occurrence. The proposed strategy can balance the power consumption of the low hierarchy nodes by computing the node to forward the packets to the lower-hierarchy node with the most residual power firstly. This strategy also takes advantage of the neighboring nodes that have the same hierarchical value to balance the energy dissipation of all the downstream nodes at the same level.

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