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Congestion Control in Wireless Sensor Networks: Survey & Discussions

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ABSTRACT

Wireless sensor networks are composed of a large number of sensor nodes distributed randomly in a particular area, which can be used for sensing data, information transmission, event monitoring and so on. However, most nodes in the network are powered by batteries and can only provide limited lifetime. Once the node is depleted of energy, it immediately enters a state of death. The energy conservation in WSNs represents a big challenge that must be taken into account during design any protocol for these networks. Since the nodes in the network are provided with limited power batteries and the depletion of nodes' energy will limit the lifetime of the whole network, therefore, it is necessary to consider the energy consumption of the sensor nodes during any protocol design for WSNs. In this paper we discuss about the congestion control and their effects in sensor networks.

Keywords: Mobile sink, Mobility management, Energy efficiency, Wireless sensor Networks, Routing, Life time.

INTRODUCTION

With the development of communication network, communication environment is becoming more and more complicated, make traditional communication technologies no longer suitable, and provides many more potential applications of Artificial Intelligence (AI). Intelligent sensor network is widely used in many applications, these applications include industrial field monitoring, ecological environment protection, intelligent traffic information collection, intelligent health monitoring, and location services [2]. As the wireless sensor network (WSN) becomes pervasive, lots of recent research works tend to focus on application specific properties. Among them, real-time communication remains one of research challenges depending on application types such as event-driven, continuous, and query-driven types.

In WSN, the high data correlation among the sensor readings especially in the dense sensor network, the correlation can be exploited to maintain the power and prolong the WSN lifetime by making sleep/active schedule. In this section, we explore several approaches that extend the network lifetime by making efficient sleep/active scheduling [4]. WSNs have been extensively employed to sense the diverse kind of data. The various challenging applications of the WSNs as has been discussed, demand from sensor nodes to support the not only the energy-efficient communications paradigms but also the delay sensitive support. For this purpose, the energy-efficiency in WSNs have been regarded as the main motive for designing any communication protocol. The energy conservation in WSNs can be applied to various design patterns.

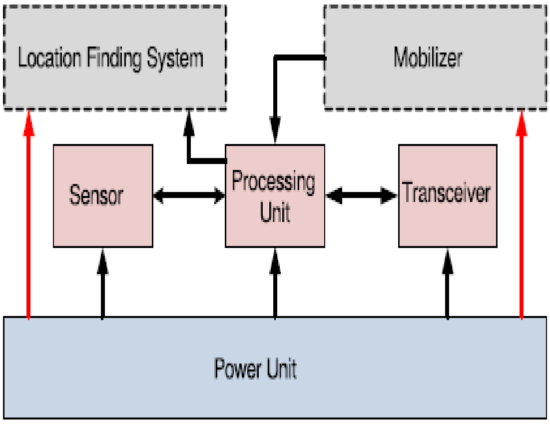

Fig 1: The architecture of the sensor node consists of power unit, sensor, processing unit, transceiver, location finding system, and mobilizer [12].

Unlike conventional wireless communication networks (MANET, cellular network, etc.), WSN has inherent characteristics. It is highly dynamic network and specific to the application, and additionally it has limited energy, storage, and processing capability. These characteristics make it a very challenging task to develop a routing protocol. In most of the scenarios, multiple sources are required to send their data to a particular base station. The nodes near to the sink deplete more energy and hence eventually die. This causes partitioning of the network; consequently, the lifetime of the network gets to reduce. This phenomenon is known as hotspots or energy hole problem. A mobile sink is used in the network to overcome this problem. The network with mobile sink implicitly balances the load among the sensor nodes and reduces the chance of hotspots. It can help to achieve the uniform energy consumption and prolong the lifetime. On the other hand, some problems are associated with the mobile sink. The mobile sink is frequently required to send its current position information across the network. This process causes a significant energy consumption overhead. In addition to that, the mobile sink makes the sensor network dynamic in nature. Hence, it is not feasible to find the routing path prior to its requirement [9].

Congestion is a phenomenon that often exists in the network. It refers to the phenomenon that the amount of data transmitted by the network and the load of the router in the network exceeds the rate at which it can be transmitted, causing the data of the buffer to over flow. This phenomenon first appeared in the Internet. With the development of optical fiber communication and the development of microprocessor technology, the communication capacity and the data forwarding capability of the router have been increased by orders of magnitude. Therefore, the congestion of the wired network is greatly mitigated. However, the wireless network is another situation. Due to the tremendous growth of sensing devices, and the variety of the perceived data, the scale grows faster, which leads to network congestion being more common in wireless networks. However, it appears more frequently in wireless sensor networks. This is because the sensor nodes in the wireless sensor node network have less storage capacity, and the processing capacity of the nodes is limited. More importantly, the sensor network is mainly for the monitoring of events.

Due to the suddenness and mass occurrence of events, when an event occurs, it will often cause related events to occurs, so that the data to be transmitted is often sudden and massive. Therefore, congestion is easy to occur, and when congestion occurs, the important data is need to be transmitted. When there is no emergency event, its data is ordinary data. When a congestion occurs, it will cause significant damage to the application. To address the network congestion, a number of congestion control schemes for WSNs have been proposed. Most schemes either perform rate control to reduce the data generation rate at source nodes or compress the samples at the intermediate relay nodes in a lossy way. By reducing the amount of data to be transferred, these schemes can effectively avoid or mitigate the network congestion. In the meantime, however, the estimation error for the monitored physical state can be largely increased due to the information loss during the congestion control. These congestion control approaches can be paradoxical with regard to the data accuracy since they indeed try to improve the estimation accuracy in a way that degrades data accuracy [1].

The amount of data loaded by the sensor node is too large and the data need to be processed can cause many challenge issues for wireless communications. One of the important challenges issues is congestion in wireless sensor networks (WSNs). In WSNs, a large number of low-cost, Feature rich sensor nodes are deployed in area that need to be monitored to sense of the network monitoring area. Due to the limitation resources of sensor nodes, the congestion occurs when the node's traffic load exceeds it's the available capacity. Congestion may cause serious problems such as high packet loss and energy consumption, and low throughput, which is extremely deleterious impact on the performance of WSNs.

The rest of this paper is organized as follows in the first section we describe an introduction of about the congestion control. In section II we discuss about the performance metrics for the wireless sensor networks, In section III we discuss about the related work, In section IV we mention the problem statement followed by the rich literature review. Finally in section V we conclude and discuss the future scope.

II PERFORMANCE METRICS

The efficacy of the proposed protocol has been demonstrated by using the standard performance metrics like control packet overhead, energy consumption, end-to-end latency, packet delivery ratio and network lifetime [9].

- Control packet overhead:- It is the energy consumption at each sensor node due to the transmission and reception of control packets. These packets are not data. The control packets are used in neighbour discovery, route construction, cluster formation, maintenance process, and so on. This metric is called an overhead because the packet transmission and reception, other than data, is a burden to the network.

- Energy consumption:- It is the total energy consumption at each sensor node due to transmitting, receiving, listening, processing and sleeping. The routing protocol computes the energy consumption based on the energy model. This metric indicates as to how efficiently a protocol works in the network.

- End-to-End Latency:- The end-to-end latency is measured as the time taken for a data packet to transmit over a network from source to sink. It considers all types of delay such as queuing delay, route discovery delay, processing delay and so on. This metric indicates the robustness of the routing protocol.

- Packet delivery ratio:- It is measured as the ratio of the data packet received at the sink to the data packet sent by the sensor nodes. It defines the successful delivery of the data. The protocol with the better delivery ratio is considered to be consistent. This metric also signifies the reliability of the routing protocol.\

- Network lifetime:- This metric indicates the duration for which the sensor network is fully functional. It depends on different applications. The lifetime of the network can be a time span when the first sensor dies, a percentage of sensors die, the network partitions, or the loss of coverage occurs.

III RELATED WORK

In this section, we present an overview of existing congestion control schemes proposed for wireless sensor networks and several works that propose to reduce data transmission rate through data compression in wireless sensor networks.

[1] In this paper, they analyze the impact of congestion control on the data accuracy and propose a Congestion-Adaptive Data Collection scheme (CADC) to efficiently resolve the congestion under the guarantee of data accuracy. CADC mitigates congestion by adaptive lossy compression while ensuring a given overall data estimation error bound in a distributed manner. Considering that for a CPS application different data items may have different priorities, they also propose a weighted CADC scheme such that the data with higher priority has less distortion. They further adapt CADC to guarantee the accuracy of specific aggregate computations. Extensive simulations demonstrate the effectiveness and efficiency of CADC. [2] scheme to mitigate the congestion in wireless sensor networks,while guarantees the quality of collected data. Different from the previous scheme, the DRCDC scheme avoids or mitigates congestion in both temporal and spatial based information entropy theory. In temporal, the data is collected at equal intervals, so that the temporal entropy of each sensor node is minimized, thereby reducing the average entropy of the matrix, and ensuring the quality of the collected data. In spatial, reducing the generated rate of the congestion nodes, and appropriately increase the generated rate of the uncongested node, so the generated rate is adaptively adjusted according to the environment in which each node is located, thereby congestion has been better mitigated. [3] This paper proposes a real-time video streaming routing protocol with an adaptive traffic shaping data rate over next-generation of WMSN. It evolves a novel algorithm for accomplishing adaptive traffic shaping of multimedia streaming and it utilizes the multipath forwarding with dynamic cost calculation for selecting next hop. The finding in the experimental results shows that the proposed mechanism guarantees high QoS performance in terms of delivery ratio, less end-to-end delay, optimal complexity, smooth routing reliability and fidelity criteria of the multimedia streaming compared to the baseline routing protocols. [4] This article suggests a Sensor Activity Scheduling (SAS) protocol for lifetime improvement of WSNs. SAS works in a periodic way. It exploits the spatial correlation among sensed sensor data in order to produce the best sensor activities schedule in WSNs. SAS composed of three phases: data collection, decision-based optimization, and sensing. SAS measures the similarity degree among the sensed data that collected in the first phase. It makes a decision of which sensors stay active during the sensing phase in each period and put the other nodes into low power sleep whilst keeping a good accuracy level to the received data at the sink to conserve the power and enhance the lifetime of the WSN. [5] In this paper, they use Bloom filter to minimize the prediction errors. They apply Savitzky-Golay filter to train a sequence of confidence windows. The purpose is to smooth the prediction process from being disturbed by load fluctuations. They present a new self adjust hybrid model (Proactive and Reactive Model) for load prediction guided by trained confidence windows. This will address excess bandwidth and long route request delay of proactive and reactive routing protocols. Self-adjust hybrid model (SH Model) provides a framework for other protocols. The significant gain in prediction accuracy makes the new SH Model very attractive to predict Congestion Control performance and also they propose path observation based physical routing protocol named POPR for WANET. [7] In this article they propose approximation (APPX) as another knob for close looped power management, to complement power knobs with performance and energy gains. They design a power management framework, APPEND+, that can switch between accurate and approximate modes of execution subject to system throughput requirements. APPEND+ considers the sensitivity of the application to error to make disciplined alteration between levels of APPX such that performance is maximized while error is minimized. They implement a power management scheme that uses APPX, DVFS, and PG knobs hierarchically. [8] in this paper, they present the up-to-date research approaches and discuss the

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important features related to real-time communications in wireless sensor networks. As for grouping, they categorize the approaches into hard, soft, and firm real-time model. Furthermore, in all these categories, research has been focused on MAC and scheduling and routing according to research area or objective in second level. Finally, the article also suggests potential directions for future research in the field. Even though it is not easy to provide real-time communication in WSN when it comes to take harsh environments into account, the demands for real-time delivery are more increasing. In order to meet this demand, various approaches based on hard and soft real-time model were taken. [9] In this paper they proposed rendezvous-based routing protocol, which creates a rendezvous region in the middle of the network and constructs a tree within that region. There are two different modes of data transmission in the proposed protocol. In Method 1, the tree is directed towards the sink and the source node transmits the data to the sink via this tree, whereas in Method 2, the sink transmits its location to the tree, and the source node gets the sink's location from the tree and transmits the data directly to the sink. The proposed protocol is validated through experiment and compared with the existing protocols using some metrics such as packet delivery ratio, energy consumption, end-to-end latency, network life time. [10] In the present paper authors have proposed a congestion control protocol for WSNs with medical applications. The best scenario for the proposed protocol is that sensor nodes show the patients who are not able to move and bedridden in a special ward of a hospital or private clinic, who also suffer from heart attack or brain death. This protocol proposes a new active queue management method to calculate packet loss probability, which integrates the RED method and Fuzzy PID approach. Also a FLC estimates the output transmission rate of the each node and then assigns a suitable transmission rate of each node. On the whole, the simulation results suggest that, considering parameters such as packet loss ratio and end-to-end delays, the proposed protocol could perform better than CCF, PCCP and OCMP protocols. [11] In this paper, they address this point and indicate the necessity of surveying the scattered works on deep learning applications for various network traffic control aspects. In this vein, they provide an overview of the state-of-the-art deep learning architectures and algorithms relevant to the network traffic control systems. Also, they discuss the deep learning enablers for network systems. In addition, they discuss, in detail, a new use case, i.e., deep learning based intelligent routing. They demonstrate the effectiveness of the deep learning-based routing approach in contrast with the conventional routing strategy. [12] In this paper, they propose an energy-efficient routing protocol for heterogeneous WSNs to support the delay sensitive, bandwidth hungry, time-critical, and QoS-aware applications. The proposed QoS-aware and heterogeneously clustered routing (QHCR) protocol not only conserves the energy in the network, but also provides the dedicated paths for the real-time and delay sensitive applications. The inclusion of different energy-levels for the heterogeneous WSNs also provides the stability in the networks while minimizing the delay for the delay-sensitive applications.

IV PROBLEM STATEMENT

The main purpose of this paper is to design a data distribution scheme to mitigate network congestion, reduce network packet loss rate, reduce network transmission delay, and ensure data quality of collected data [2].

(1) Improve the network lifetime. The network lifetime is related to the node with the most energy consumption in the network. When the energy stored in one node is exhausted, the node cannot work normally, which will cause the network to fail to achieve its normal function, that is, the network is paralyzed. Definition ` is the network lifetime.

(2) Reduce network packet loss rate. There are two main reasons why packets are lost in transmission: The first one is due to noise interference in the transmission link, which causes the packet to be lost. The second is due to the packet storage queue

is full in the network, resulting in packet loss caused by the data packet cannot be forwarded. Congestion caused by the first case is difficult to avoid. The retransmission mechanism is usually used to ensure its reliability. The data packet is retransmitted until the target node successfully receives the data packet or retransmits it to the maximum number of times.

(3) Reduce the maximum delay of network transmission. The delay of the network refers to the time elapsed from the generation of the packet until it is received by the sink. The delay of the network is mainly composed of the time when transmitting in the link and the waiting time in the sending queue.

V CONCLUSION AND FUTURE SCOPE

WSN is composed of a huge number of tiny devices which are capable of sense, process, store, and communicate with limited capabilities. Each sensor node is equipped with a limited battery life. Each node gathers the sensed data from the surrounding environment and then transfers the data to a sink across transmission media. One important energy saving approach is to produce the sensors activities schedule so as to decrease the number of active nodes by turning off unnecessary nodes whilst keeping the suitable level of data accuracy at the sink node. Energy-efficient data routing is a major research challenge in wireless sensor networks. In this paper we presents the comparative study for the wireless sensor network to improve the performance in the terms of throughput, energy, and life time of the node, in the future we plan to implement an efficient approach for this problems and improve the quality of services for the wireless sensor networks.

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