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Reliable Communication Framework for Congestion Mitigation in Wireless Sensor Network Using Multiple Sinks : A Novel Approach

Dr.B.Sivakumar and S.Sowndeswari

Prof. & HOD, Dept. of TCE, Dr.AIT, Bangalore.
Sivabs2000@yahoo.co.uk
M.Tech(DCN) Dept. of TCE Dr.AIT , Bangalore.
sowndeswari@yahoo.co.in

Abstract

The proposed system exhibit the issues of congestion in WSN which usually takes place when the quantity of the sensor motes reporting data maximizes towards sink mote. This phenomenon will cause minimization of optimal throughput and loss of valuable data. The proposed system highlights a novel approach for mitigating the ill-effects of traffic congestion in the area of wireless sensor network. The proposed system has also introduced the concept of multiple sink to mitigate the congestion issue. Designed in NS2, the proposed system considers multiple sinks, which are facilitated for the traffic distribution among all the other sinks in order to mitigate congestion. While the majority of the prior research has aimed for congestion detection and avoidance, this work will more focus on congestion mitigation. The experimental framework is designed using IEEE 802.15.4 sensor networks and conducts various iterations of the experiments for validating the efficiency of the protocols used. The result shows that with continuous triggering of the sensor motes will lead to traffic congestion.

Keywords-component; Traffic Congestion, Congestion, Wireless Sensor Network, Multiple Sink

Introduction

The modern communication system has already witnessed the recognition of communication devices like smart phones, PDAs, RFID, and intelligent electronics like sensors, which are more or less frequently used in our day to day life applications. With the upcoming modernization of electronic gadgets and their respective sizes, it is now feasible to design a very miniaturization of electronics products [1] and it can be visualized that embedded systems in use can be maintained with scaled down Linux or windows operating system. Therefore, from this view point, the rise of wireless sensor network is the recent trend of Moore's Law [2] towards the miniaturization and open pervasiveness of computing devices. A typical WSN [3] consists of spatially distributed autonomous sensors to cooperatively monitor physical or environment conditions. Choosing the finest sensor motes and wireless communication link will require information of the systems and diversified problems associated with it. Power or unwanted energy draining is one prime issue in wireless sensor network considering the issue attributes like battery life, rate of sensor mote update and size. Various examples of minimal data rate sensor motes will consist of humidity, temperature, pressure, etc. Various examples of maximal data rate sensor motes will consist of acceleration, strain, and pulsation. Another prominent issue associated with the wireless sensor network is traffic congestion [4], which can be said as a phenomenon that can be pragmatic in unusual types of wired and wireless networks even in the existence of vigorous routing algorithms. The prime reason of congestion in wireless sensor network is principally due to dual factors e.g. at the time, when multiple sensor motes attempt to transmit data through the identical channel at a time or when the routing mores fails to forward the received data to the next routing sensor motes due to out of transmission range issue. Applications of WSNs in the areas of environment and habitat monitoring [5] require the sensor nodes to periodically collect and route data towards a base station or commonly known as sink. It is also known that every sensor motes can only be equipped with restricted amount of data storage, so if at any given routing motes, the data aggregation rate controls over the data forwarding rate, congestion starts to build up at this mote. It was also seen that such types of traffic congestion as well as loss of data usually takes place at the sensor motes which is located in the proximity of the static sink. Data loss at such sensor motes occurs because of the reason that at any given point of instance a sink can only communicate with one or a restricted quantity of sensor motes. Hence it can be seen that the cumulative network lifetime is another prominent issue with respect to environmental and habitat monitoring or any other types of application, where feasibility of massive traffic and power draining exists.

The proposed system is designed as an experimental simulation model for mitigating the effect of traffic congestion. In order to do this, the proposed system will be using the concept of multiple sinks which has created this simulation environment, which will eventually mean that the simulation area will be divided into multiple section with every unit section to be facilitated with separate sink. The feasibility of traffic congestion mitigation is high as the data traffic is dispersed among the multiple sinks. Experimented in network simulator NS2, the proposed system will aim to achieve minimum energy consumption, minimum data rate, minimum cost wireless system and furnished device level connectivity. In section 2, we give an overview of related work which identifies all the major research work being done in this area. Proposed system is discussed in Section 3 followed by implementation in Section 4. Section 5 discusses about implementation with result analysis.

Related Work

In previous research work, numerous innovative congestion control protocols have been implemented in the area of wireless sensor network. One of the prominent work out of it is CCF (Congestion Control and Fairness) uses packet service time to deduce the available service rate and therefore detects congestion in each intermediate sensor node [6]. Congestion information, that is packet service time in CCF, is implicitly reported. CCF controls congestion in a hop-by-hop manner and each node use exact rate adjustment based on its available service rate and child node number. CCF guarantees simple fairness. That means each node receives the same throughput. However, the rate adjustment in CCF relies only on packet service time which could lead to low utilization when some sensor nodes do not have enough traffic or there are a significant packet error rate (PER) [7]. In CODA, congestion is detected in each sensor node based on measurement of queue length. The node that detects congestion sets a CN (congestion notification) bit in the header of each outgoing packet. Once the CN bit is set, neighboring nodes can overhear it and stop forwarding packets to the congested node so that it can drain the backlogged packets. This non-smooth rate adjustment could impair link utilization as well as fairness, although Fusion has a mechanism to limit the source traffic rate and a prioritized MAC algorithm to improve fairness. Siphon also infers congestion based on queue length in intermediate nodes, but it uses traffic redirection to weaken congestion. There is no rate adjustment in Siphon. Congestion Detection and Avoidance (CODA) detects congestion based on buffer occupancy as well as wireless channel load. CODA designs both open loop and closed-loop rate adjustment, and the algorithm used to adjust traffic rate works in a way like additive increase multiplicative decrease (AIMD) [8].

R.Then Malar [9] presented the novel upstream congestion control protocol for WSNs, called Priority based Congestion Control Protocol (PCCP).The PCCP employs packet-based computation to optimize congestion control for a WSN. Muhammad Mostafa Monowar et.al [10] present Prioritized Heterogeneous Traffic-oriented Congestion Control Protocol (PHTCCP) which ensures efficient rate control for prioritized heterogeneous traffic. The protocol uses intra-queue and inter-queue priorities for ensuring feasible transmission rates of heterogeneous data. JANG-PING SHEU [11] in wireless sensor networks, congestion occurs when the traffic load being offered exceeds the available capacity of sensor nodes. In most applications, every sensor node will send the event it has sensed to a sink node. C. Wang et.al [12] present a novel upstream congestion control protocol for WSNs, called Priority based Congestion Control Protocol (PCCP). Unlike they exist PCCP innovatively measures congestion degree as the ratio of packet inter-arrival time along over packet service time. They also demonstrated that PCCP achieves efficient congestion control and flexible weighted fairness for both single-path and multipath routing as a result, this leads to higher energy efficiency and better QoS in terms of both packet loss rate and delay. G.Srinivasan and S.Murugappan [13] has exhibited their research, which shows that in Wireless Sensor Networks (WSN) the packet loss occurs due to congestion. The sink node which is called special node collects information from other nodes. There are various congestion control algorithms are currently used. Also in WSN congestion detection and congestion control are the major research areas. Wei-wei

FANG et.al [14] present Congestion in wireless sensor networks (WSNs) not only causes severe information loss but also leads to excessive energy consumption to address this problem, for that they consist a novel scheme for congestion avoidance, detection and alleviation (CADA). Bret Hull et.al [15] examine three techniques that span different layers of the traditional protocol stack: hop-by-hop flow control, rate limiting source traffic when transit traffic is present, and a prioritized medium access control (MAC) protocol. They have also implemented these techniques and present experimental results from a 55-node in-building wireless sensor network and demonstrate that the combination of these techniques, Fusion, can improve network efficiency by a factor of three under realistic workloads. Mehmet C. Vuran [16] comprehensively investigates the interactions between contention resolution and congestion control mechanisms in WSN. An extensive set of simulations is performed in order to quantify the impacts of several network parameters on the overall network performance. Pavlos Antoniou et.al [17] describe swarm intelligence is successfully employed to combat congestion by mimicking the collective behavior of bird flocks, having the emerging global behavior of minimum congestion and routing of information flow to the sink, achieved collectively without explicitly programming them into individual nodes. Majid I. Khan [18] proposed scheme utilizes the sink mobility and an in-network storage model that is used to set up mini-sinks along the mobility trajectory of the sink. They have also proposed scheme data only has to travel a limited number of hops to reach the nearest mini-sink which helps to improve the energy consumption of the sensor nodes. Muhammad Mostafa Monowar [19] describes in this paper an efficient scheme to control multipath congestion so that the sink can get priority based throughput for heterogeneous data. They have used packet service ratio for detecting congestion as well as performed hop-by-hop multipath congestion control based on that metric. Chieh-Yih Wan [8] presents the detailed design, implementation, and evaluation of CODA using simulation and experimentation. They define two important performance metrics (i.e., energy tax and fidelity penalty) to evaluate the impact of CODA on the performance of sensing applications. They have also discussed the performance benefits and practical engineering challenges of implementing CODA in an experimental sensor network testbed based on Berkeley motes using CSMA.

It can be seen that the majority of the work has been done towards solving the issues of congestion in wireless sensor network, but till data, no such benchmarked work can be recognized. It can be visualized as a continuous research process as topology and applications of wireless sensor network are something which will continuously be of dynamic type, still we are in the infancy stage to solve this issues.

Proposed Architecture & System

The prime aim of this proposed research is to design an analytical evaluation framework deploying wireless sensor network for efficient dispersing of data traffic in order to achieve an effective prevention against congestion using multiple sinks. The scalability of sensor networks is seen to increase with the introduction of the multiple sinks, which is the prime notion behind this work. The proposed system also consists of designing a simulation area for deploying wireless sensor network. The parameters to be considered for the node deployment will be number of sensor nodes, node density, number of sink nodes, sensing and transmission range etc. The proposed work also defines the provisioned events like initialization of personal area network location, various local coordinates as well as sensor motes, and initiating from various applications.

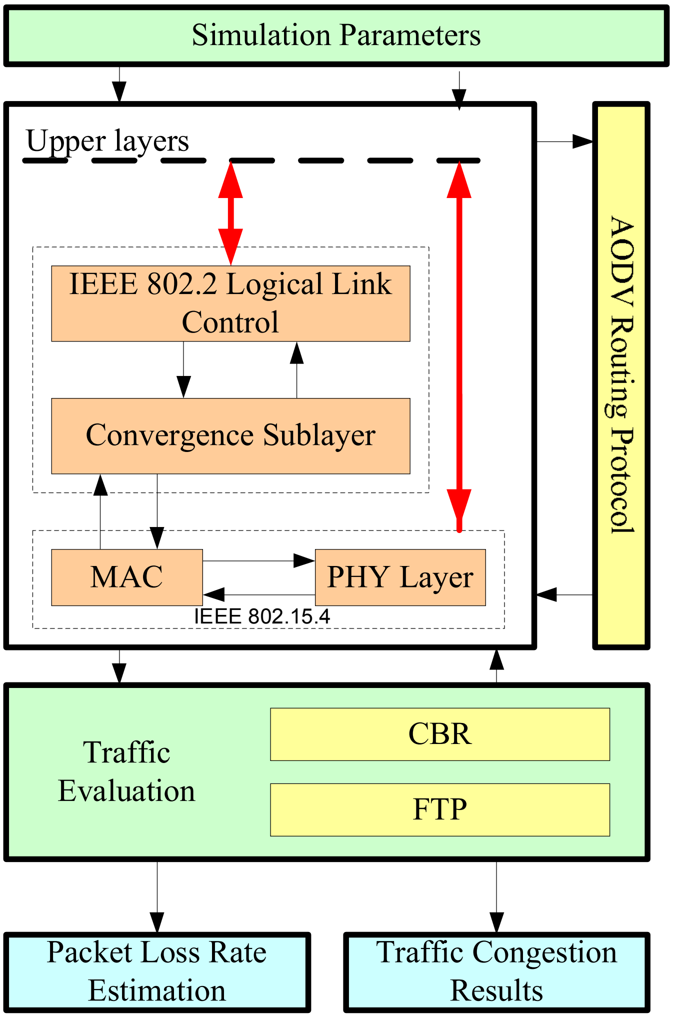

Figure 1. A Novel Architecture

The work also describes the transmission or communication propagation model, antenna model, traffic prototype, interface queue, link and sensor mote failures, as well as link breakage system super frame structure in beacon enabled mode, radio transmission range, and animation configuration. The proposed work will be experimented with different traffic sets (CBR, FTP) performance which will be analyzed in a single sink environment. The experiment will be conducted with an increase of sink nodes along with analyzation of events responsible for packets received and dropped by estimating packet loss rate due to sink failure. To achieve this aim, the routing protocol of AODV is considered as it creates no extra traffic for communication along existing links obeying IEEE 802.15.4 standard for minimal data rate wireless connectivity amongst comparatively uncomplicated devices that utilize comparatively minimal energy. The main target of the logic will be to avoid congestion.

It is seen that the IEEE protocol of 802.15.4 basically attempt to facilitate the basic minimal layers of network of category of wireless personal area network, which concentrated on cost effective, minimal speed pervasive computing among the wireless devices with respect to each other and the majority is concerned on network layers of OSI model. The discussion on the network layers is completely based on OSI model; although only the bottom layers are termed as standards, interaction with upper layers is intended, possibly using a IEEE 802.2 logical link control sub layer accessing the MAC through a convergence sub layer. Implementations may rely on external devices or be purely embedded, self-functioning devices. Another prominent layer is physical layer, which eventually facilitates the information communication service along with the interface to the physical layer management entity, which provides admission to each layer management function and preserve a repository of information on connected personal area networks. Finally, medium access control facilitates the communication of MAC frames by utilizing the physical channel. Apart from the data services, it also facilitates a management interface and itself manage admission to the physical channel and network beaconing. It also manages validations of frame, assures time slots and handles node associations. Lastly AODV routing protocol will be deployed and the entire architectural model will be tested on two types of traffic patterns (CBR, FTP). Finally, an output of Packet Loss Estimation as well as Traffic Congestion Results will be obtained.

Implementation and Performance Analysis

The proposed system is designed on Linux platform using network simulator (NS2), which is an object-oriented, discrete event driven network simulator developed at UC Berkeley. The experiment is conducted in various scenarios where the effect of minimizing source traffic by the representative node collection is analyzed in the initial set of experiments. A cumulative set of N sensor nodes is assumed to be uniformly distributed in a 200 m x 200 m square simulation area. One of the prime stages in the congestion avoidance in the proposed system is to determine the threshold of congestion where the congestion control mechanism can be initiated. It is comparatively easier to initialize a threshold for the buffer than for the communication channel, as the buffer is found to be vastly dependent on system capacity. For this purpose, the next consecutive set of the experiment is conducted on simple specific node traverse topology. During the simulation, it can be expected to explore that a utilization factor on the channel is above 75% where the channel saturates and also experience from different recurrent collisions among the neighboring nodes itself.

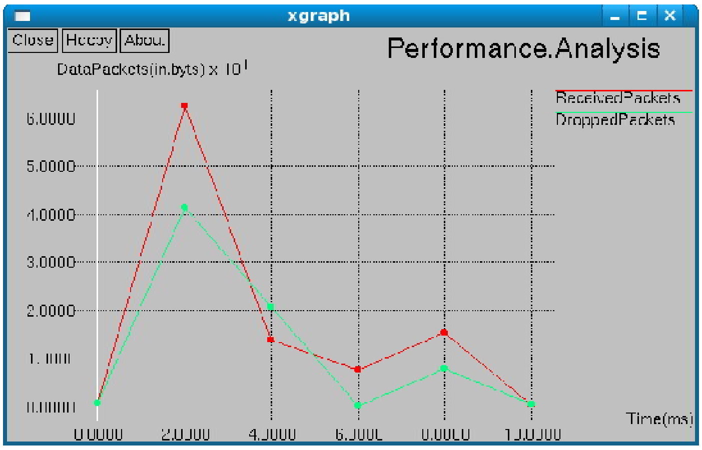

Figure 2. Performance Analysis

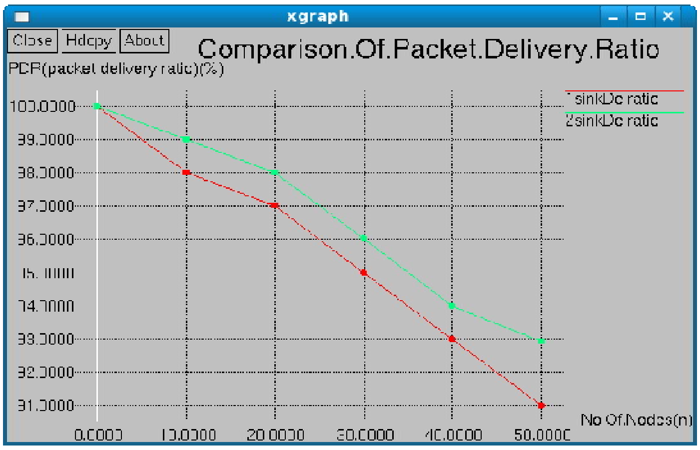

Figure 3. Comparative Analysis of Packet Delivery ratio.

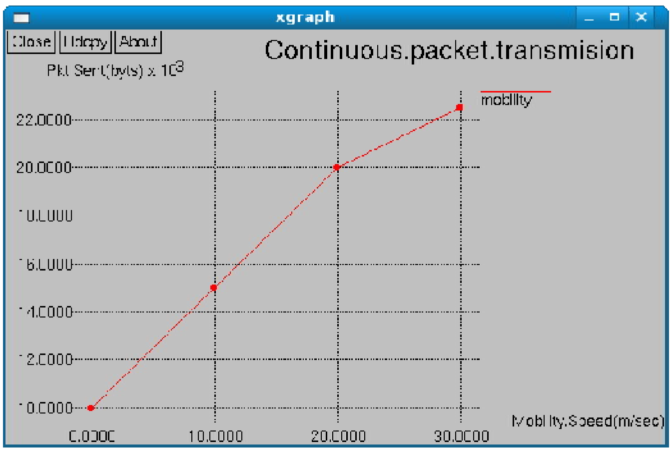

Figure 4. Performance analysis results for continuous packet transmission.

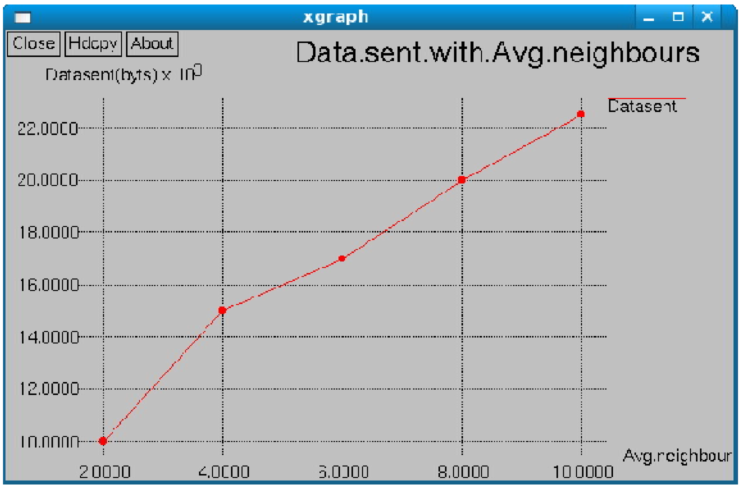

Figure 4. Performance Analysis for data sent with average neighbors.

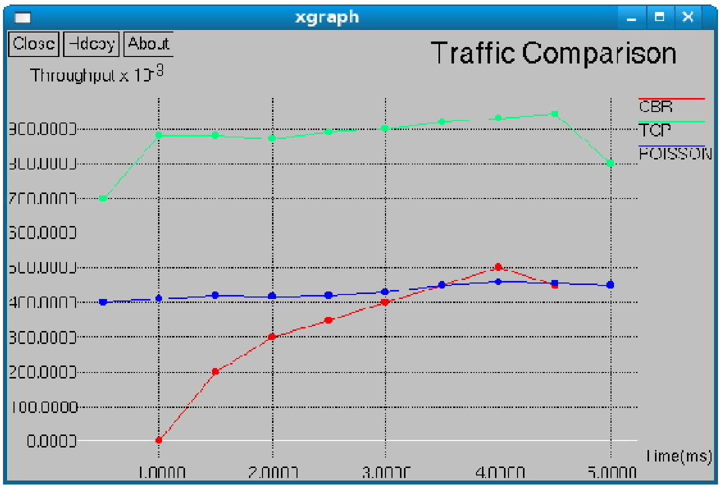

Figure 6. Traffic Comparison

Therefore, the next set of the network simulation is carried out considering the duration which is required for the wireless network in order to take some actions for escalating the congestion factor, where the utilization factor on the channel will be above 75%. The last experimentation scenario is considered for manual transmission. It was seen that event can be captured from at least 10 hops away from the target base station. Therefore, in short, it can be said that the proposed research work has considered 5 experimental scenario, where

In the first experimental scenario, the wireless network is designed with one, two and four sink nodes with performance analyzed using factors of packets received and packets dropped (Figure 2). In the last scenario, different types of traffic including constant bit rate and file transfer protocol is evaluated for the performance on a single sink scenario (Figure 6).

Conclusion & Discussion

The proposed system highlights one novel approach of minimizing as well as controlling the congestion in the scenario of wireless sensor networks using multiple sinks. In the area of wireless sensor network, the data aggregation technique based on single will actually lead to inadequacy because of non-equilibrium in power utilization. Not only this, it also stimulates issues regarding scalability and overload at the location of sink as it has many to one pattern. An optimal feasibility is to organize multiple sinks which could highly minimize the mean quantity of hops which a message has to pass through previous being received and processed by sink, as information will be always be transmitted to the nearest sink. In case the quantity of the information in the network is extremely massive, the information is send in the slots which is assigned for the particular section of the data in such a ways that the congestion is prevented in the process of transmitting data. As data will be collected at the nodes which are in proximity to the sink than it will be compressed and then forwarded to the consecutive level and such technique is highly optimal and efficient for transmitting data to sink without any loss or presence of congestion.

Our future plan includes providing failure recovery mechanism for sink failure and energy efficiency.

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