Enhancement in Slotted CSMA/CA for Clock Synchronization

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Abstract

The virtual path is established between the source and destination by using AODV. The sensor nodes should be synchronous to each other to avoid the packet collision by using NTP (Network Time Protocol). If packet loss is less then packet retransmission can also be less. All the sensor nodes match their time with master node which is already deployed in the sensor network. The master node is synchronized with GPS (Global Positioning System). In the sensor network all the nodes are synchronized and slotted CSMA/CA is applied to the network. According to the slotted CSMA/CA which node wants to transmit the data they reserve the time slots. All the nodes get the different slots and transmit data according to the turn. The Proposed novel approach is implemented in NS2 and results are taken in the form of graphs which shows that proposed technique is more efficient and reliably than the existing techniques for slotted CSMA/CA.

Keywords
Slotted CSMA/CA, NTP, GPS, AODV

1. Introduction

Wireless Sensor Networks (WSNs) are composed of large number of low-cost and tiny sensors. It is a distributed and self-organized network where sensor nodes will locally carry out sensing, processing and transmitting operations in an autonomous and unattended manner. WSNs have broad applications such as military surveillance and tracking, environment monitoring and forecasting, healthcare etc.

Sensor networks constitute a substantial improvement over traditional sensors, which are deployed in the following two ways:

- Sensors can be positioned far from the actual phenomenon, i.e., something known by sense perception. In this approach, large sensors that use some complex techniques to distinguish the targets from environmental noise are required.
- Several sensors that perform only sensing can be deployed. The positions of the sensors and communications topology are carefully engineered. They transmit time series of the sensed phenomenon to the central nodes where computations are performed and data are fused.

Sensor nodes are deployed in environments where it is impractical or infeasible for humans to interact or monitor them. The WSN is constructed of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has generally various parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. A sensor node generally consists of sensors, actuators, memory, a processor and they do have communication ability. All the sensor nodes are allowed to communicate through a wireless medium. The wireless medium may either of radio frequencies, infrared or any other medium, of course, having no wired connection. These nodes are deployed in a random fashion and they can communicate among themselves to make an ad-hoc network [7]. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth.

1.1 CSMA/CA

CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) is a protocol for carrier transmission in 802.11 networks. Unlike CSMA/CD (Carrier Sense Multiple Access/Collision Detect) which deals with transmissions after a collision has occurred, CSMA/CA acts to prevent collisions before they happen. In CSMA/CA, as soon as a node receives a packet that is to be sent, it checks to be sure the channel is clear (no other node is transmitting at the time). If the channel is clear, then the packet is sent. If the channel is not clear, the node waits for a randomly chosen period of time, and then checks again to see if the channel is clear. This period of time is called the backoff factor, and is counted down by a backoff counter. If the channel is clear when the backoff counter reaches zero, the node transmits the packet. If the channel is not clear when the backoff counter reaches zero, the backoff factor is set again, and the process is repeated. Carrier sense multiple access with collision avoidance (CSMA/CA) in computer networking, is a network multiple access method in which carrier sensing is used, but nodes attempt to avoid collisions by transmitting only when the channel is sensed to be "idle". The basic idea behind CSMA/CD is that a station needs to be able to receive while transmitting to detect a collision. When there is no collision, the station receives one signal: its own signal. When there is a collision, the station receives two signals: its own signal and the signal transmitted by a second station. To distinguish between these two cases, the received signals in these two cases must be significantly different. In a wired network, the received signal has almost the same energy as the sent signal because either the length of the cable is short or there are repeaters that amplify the energy between the sender and the receiver. This means that in a collision, the detected energy almost doubles.

In a wireless network much of the sent energy is lost in transmission. The received signal has very little energy. Therefore, a collision may add only 5 to 10 percent additional energy. This is not useful for effective collision detection. We need to avoid collisions on wireless networks because they cannot be detected. Carrier sense multiple access with collision avoidance (CSMA/CA) was invented for this network. Collisions are avoided through the use of CSMA/CA's three strategies: the inter-frame space, the contention window, and acknowledgments. To solve the problem of Hidden terminal and exposed terminal, MACA and MACAW protocols had been proposed. In these protocols the CTS and RTS packets are used for allocation of the channel access. The problem of RTS and CTS packet collision exists in MACA protocols. This problem is been solved in MACAW protocol. The efficiency of slotted CSMA/CA protocol reduces in Ad hoc networks due to the self configuring nature of the network. In this network mobile nodes can leave or join the network when they want due which the clocks of the mobile nodes are not synchronized and it will leads to degrade the network performance. In this work, we focus on to solve the problem of clock synchronization in slotted CSMA/CA.

1. Literature Review

Yu Cheng et al. presented a theoretical analysis of the maximum throughput of a wireless mesh backhaul network that is achievable over a practical carrier sense multiple access with collision avoidance (CSMA/CA) medium access control (MAC) protocol. They resort to the multicommodity flow (MCF) formulation augmented with the conflict-graph constraints, a novel approach to take into account the collision overhead in the distributed CSMA/CAMAC. Such overhead due to random access has been ignored by existing MCF-based capacity studies, which assume impractical centralized scheduling and result in aggressive capacity planning, which is unachievable over the CSMA/CA MAC. This paper made the following three main contributions: 1) They developed a generic method of integrating the CSMA/CA MAC analysis with the MCF formulation for optimal network capacity analysis, which readily generates an upper bound of the network throughput; 2) Authors define a new concept of CSMA/CA clique and theoretically study its relationship to a CSMA/CA area in terms of throughput; and 3) using the CSMA/CA clique as a tool, they derive a lower bound of the network throughput achievable over the CSMA/CA MAC by clique-based MCF formulation. NS-2 simulation results are presented to demonstrate the tightness of the upper and lower bounds that are newly developed, compared to those based on the MCF formulation assuming a slotted system and centralized scheduling.

A. N. Alvi et al. described that IEEE 802.15.4 standard is specifically designed for low Rate Wireless Personal Area Network (LR-WPAN) with low data rate and low power capabilities. Due to very low power consumption with duty cycle even less than 0.1, the standard is being widely applied in Wireless Sensor Networks applications. It operates in Beacon and Non Beacon enabled modes. During Beacon enabled mode, it has Contention Access Period (CAP) and optional Contention Free Period. They have analyzed its performance during CAP where slotted CSMA/CA algorithm is used. The performance analysis includes channel access

busy, transmission failure chances along with reliability and throughput against all three frequency bands with load variation.

Jia Xu et al. proposed a revised cluster routing algorithm named E-LEACH to enhance the hierarchical routing protocol LEACH. In the E-LEACH algorithm, the original way of the selection of the cluster heads is random and the round time for the selection is fixed. In the E-LEACH algorithm, they consider the remnant power of the sensor nodes in order to balance network loads and changes the round time depends on the optimal cluster size. The simulation results show that proposed protocol increases network lifetime at least by 40% when compared with the LEACH algorithm. Although LEACH protocol prolongs the network lifetime in contrast to plane multi-hop routing and static routing, it still has problems. The cluster heads elected randomly, so the optimal number and distribution of cluster heads cannot be ensured. The nodes with low remnant energy have the same priority to be a cluster head as the node with high remnant energy. Therefore, those nodes with less remaining energy may be chosen as the cluster heads which will result that these nodes may die first. The cluster heads communicate with the base station in single-hop mode which makes LEACH cannot be used in large-scale wireless sensor networks for the limit effective communication range of the sensor nodes.

Naveen Chauhan et al In presented technique that uses Global Cooperative Caching for Sensor Networks (GCCS) to improve wireless sensor network performance. GCCS exploits cooperation among SNs and decisions regarding data items are depend. Grid based approach is used to utilize energy consumption. Then this technique is further enhancing to improve network performance. The proposed work is working well in real world situations.

Hairong Zhao et al. proposed to improve of setting up cluster and data transmission route. A timer is introduced to make sure of electing the optimal sensor node as cluster head in process of setting up cluster. During data transmission, using single hop and multi-hop hybrid routing to communicate can utilize energy more effectively and evenly. A simulation example is provided to demonstrate the usefulness of the algorithm which extended the network lifetime and reduced energy consumption greatly compared to LEACH algorithm.

Narottam Chand et al. presented in this paper cooperative caching scheme ZCS to improve performance the performance of wireless sensor networks. In this scheme, in a zone nodes share their data which shows limited nodes problems and limited query latency at a node to prolong lifetime of wireless sensor networks. A cache discovery process, distance based admission control, consistency check and utility based cache replacement policy is include by ZCS scheme. To improve hit ratio replacement policy is also used.

Lucas D. P. Mendes et al. has been presented that Cross-layer design has been widely used in wireless sensor networks, especially to improve the network lifetime, as can be seen in the literature. They combined a cross-layer solution to a transmission advertisement scheme to improve a slotted ALOHA-based wireless sensor network throughput and lifetime. This medium access method scheme has been chosen because it does not add protocol information to be transmitted with data bits, reducing

transmission overhead when compared to other medium access methods. Finally, the combination of a cross-layer design and the advertisement scheme has proven to increase the network throughput by more than 10% and to double the network lifetime.

2. Problem Formulation

In the sensor networks many techniques have been proposed to reduce energy consumption of the wireless sensor networks. The much efficient approach among all the approaches is clustering. In the approach of clustering, clusters are formed and cluster heads are chosen in each cluster. The cluster heads are chosen with the election algorithm. The cluster head is responsible for the data forwarding and data receiving in each cluster. The routes from source to destination through the clusters are formed with the reactive routing protocols. The slotted CSMA/CA scheme is used for the channel sensing and to avoid data packet collisions. In self configuring type of networks, it is chance that certain cluster head's clocks are not synchronized. Due to the non synchronization of the clocks, packet collision in the network can happen which degrades the network performance as shown in the figure 1.

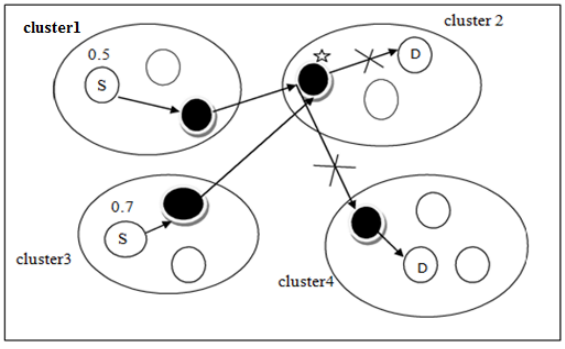

Fig 1: A network without synchronous nodes and packet collision

Figure 1 shows the whole scenario of sensor network without synchronous of sensor nodes. In this figure here two nodes are the source and two destination, they followed the same path for data transfer. Cluster 1's source send the data to cluster 4's destination and cluster 3's source send the data to cluster 2's destination. Here the clock synchronous is not present between the sensor nodes. Cluster 1's and cluster 2's source send their data to their respective cluster heads. Now their cluster heads forward the data to next cluster head according to the routes. Here both sources have same route for transfer their data. When the data reaches to the cluster 2's head from both sources at same time here data packets are collide to each other, the data packets are loosed and it do not reach to their respective destinations. The packet retransmission is necessary to complete the communication.

3. New Proposed Technique

In the sensor network the path is established by AODV routing protocol between source and destination. The source node sends the information to the cluster head for their transmission to discover the route between sources to destination. Here the whole sensor network is divided into clusters. In the network all the sensor nodes and cluster heads are synchronous to each other by using the NTP. Figure 2 shows the flow chart of proposed technique. All the sensor nodes match their time with master node which is already deployed in the sensor network. The master node is synchronized with GPS (Global Positioning System), and then master node send the information to all the cluster heads and cluster heads distribute this information to all cluster members. Now in the sensor network all the nodes are synchronized and slotted aloha is applied to the network. According to the slotted aloha

which nodes want to transmit the data they reserve the time slots. All the nodes get the different slots and they transmit their data according to their turn. The packet loss will be reducing with the new proposed technique and network throughput will be enhanced and energy will be consumed less as compared to the existing techniques.

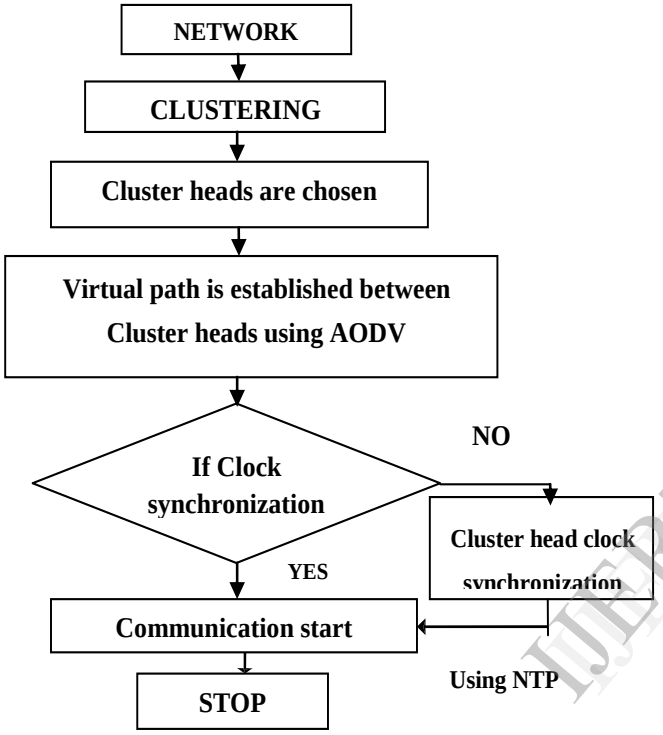

Figure 2: Flow Chart of Proposed Technique

4. Results and Discussion

The wireless sensor network is deployed in the area with the 16 sensor nodes and one base station. The whole network is divided into the four clusters, with one cluster head in each cluster. The cluster head is chosen with the election algorithm. NS2 is used for the simulation and results are shown in form of graphs.

In the figure 3, energy consumption of previous and new technique is shown. The red lines show the energy of previous technique. The green line shows the energy consumption in the new proposed technique. The clocks in the previous technique are not synchronized and fixed path are from source to destination. Due to these two reasons retransmission of the packet are required when packet loss is there in the network. In the new technique clocks are synchronized with master clock and slotted CSMA/CA is used for channel sensing.

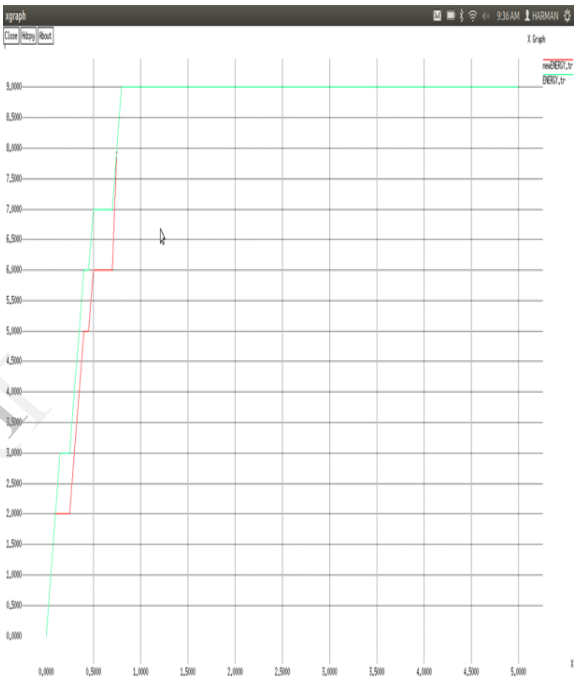

Fig 3: Energy graph

The figure 4 illustrated the throughput of the new and previous technique. The green line shows the throughput of the network in previous technique. The throughput of the new technique is shown in red line. The efficiency of the slotted CSMA/CA is enhanced with the clock synchronization. The throughput the network is enhanced through the use of new proposed technique because the packet loss in the network is reduced.

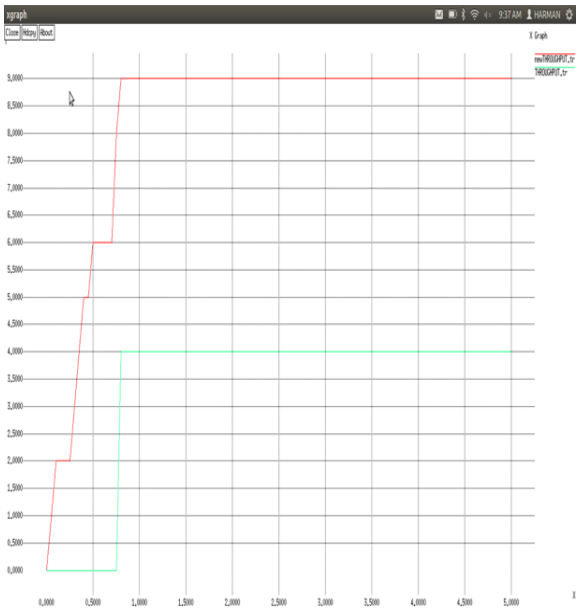

Fig 4: Throughput graph

The packet loss graphs are shown in the figure 5. The packet loss is more in the previous technique. In the previous technique clocks of the cluster heads are not timely synchronized. This is the reason that the packet loss is higher is more in the previous technique. The packet loss in the new technique is reduced, because the clocks of the cluster heads are synchronized with the master clock.

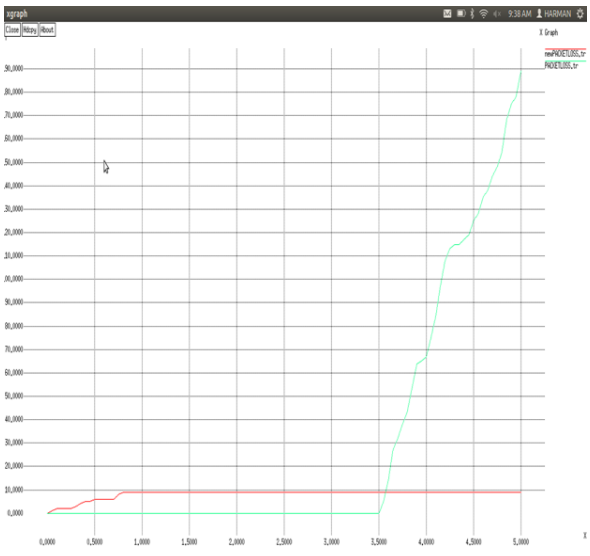

Fig 5: Packet loss graph

5. Conclusion

In this paper, we conclude that clustering is the efficient approach for reducing energy consumption in wireless sensor networks. The Slotted CSMA/CA is used for channel sensing and to avoid data packet collision. In this work, we made enhancement in Slotted CSMA/CA for the clock synchronization. This enhancement is based on the NTP protocol.

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