Channel Sharing based Medium Access Control Protocol for Wireless Nano Sensing Network

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Abstract

Recent advancement and grown up technologies has enabled the development and implementation of low-cost, energy efficient and versatile sensor networks. Sensor networks are built up with sensors that have the ability to sense physical or environmental property. Assumption can be made that Wireless Sensing Network (WSN) is able to sense environmental conditions at Nano and gaseous level. This architecture of Wireless Sensor Network is maintained by a sub-layer named Medium Access Control Layer that provides addressing and channel access control mechanism among multiple nodes of the network and makes these nodes capable to communicate with other nodes through a shared medium. The hardware that implements the MAC is referred to as a medium access controller. This paper finds the problems in selection of cluster nodes and transmitting data and also proposes an improved MAC protocol to minimize the problem.

Index terms— WSN, MAC protocol, terahertz communication, electromagnetic communication.

1 I. Introduction

ireless sensor network has increasingly become a research hotspot as the technology of wireless networks become gradually matured and supported by small, micro-mobile devices. WSN consists of a several number of sensor nodes ranging from few tens to thousands and base station or sink node. Each node is capable of storing, processing and relaying the data that are sensed. When Physical Layer is used for Signal transmission and reception by nodes within the network then there must be a point to point capability among these multiple networks nodes. However, this is insufficient for several reasons. In spite of using advance channel coding algorithm error can occur in bits or packets. The factors for this type of error are variations of link quality, interference etc. And it is particularly true for wireless nano sensor network. For this reason an additional control mechanism is needed above the physical layer. This additional layer is Medium Access Control Layer or MAC Layer.

2 II. Medium Access Control Protocol

Protocol means few rules and regulation. Network Protocol means some rules and convention for successful and efficient communication among network nodes. MAC protocol indicates some rules and convention for accessing the same channel by multiple nodes at the same time without collision for better performance and throughput. So the key task of a MAC protocol is to coordinate the process of sharing the same medium among multiple users with the objective of achieving certain performance goals.

3 a) Classification

4 Centralized MAC Protocol

In this type of Protocol the entire process is control and coordinates by a central network node. Remaining nodes are depending on this central node for accessing the channel. For example cellular network, satellite network etc.

5 Distributed MAC Protocol

This protocol not depended on central node for assigning channel to multiple network nodes. Instead they distributed these control mechanism among all nodes of the network.

6 III. MAC Issues for WSN Network

Nano network is densely populated network. These nano nodes have many construction limitation which are must be considered for designing MAC protocol. These limitations are as follows: 1. Nano devices are severely energy constraint machine because of their nano size. It is also difficult to provide energy harvesting technique to these nano devices for large energy support. 2. Due to the nano-scope dimensions of nano-devices and future nano-transistor, the expected number of transistors per nano processor might round up to the thousands [1]. Since nano network is densely populated network so large number of nano devices must be considered for designing an efficient and effective MAC protocol. 3. It is needed to build up an energy-efficient complexity-aware Medium Access Control protocol that supports the peculiarities of nano devices in the wireless nano sensor network.

7 IV. Design Issues for MAC Protocol

It is known graphene is one-atom-thick planner sheet of carbon atoms that are densely packed in honeycomb crystal lattice. Graphene-based nanoantennas have already been proposed and they will make possible to overcome the scalability problem when trying to miniaturize classical antennas to the Nano scale [2]. This material exhibits many peculiar characteristics that must be considered if we use these materials to construct nano nodes for nano network. Graphene based nano devices communicate through Terahertz band [3]. Now try to clear the reasons of using Terahertz band for communication among nano nodes. Graphene has shown promising electrical, mechanical and thermal properties over transistors, flexible/transparent electronics, optical devices and now terahertz active components.

8 a) Terahertz Communication

Nano networks are composed of huge number of nano nodes which have limited energy to communicate. So they are communicated in such a way that they can transmit a large number of bits at a time. Terahertz band provide this facility. It theoretically supports very large bit-rates, up to several hundreds of terabits per second for distances below one meter.

? Nano nodes require a simple communication scheme for their limited energy. Since terahertz band have very large bandwidth that helps to design a very simple communication scheme for nano nodes. ? Terahertz waves can carry more information than radio/microwaves for communications devices. ? They also provide medical and biological images with higher resolution than microwaves, while offering much smaller potential harm of exposure than X-rays. Because of these reasons, terahertz band is used as communication medium for nano nodes in the nanonetwork.

9 V. MAC Protocol for Electromagnetic Communication

This protocol is divided into three stages namely Selection of Master Node, Handshaking process, and Data transmission Process. [4] Fig. **??**: Clustered Nano Devices

10 a) Selection of Master Node

Initially, assumption is made that the nano nodes are combined to form a network. A node which is equidistant from the rest of the nodes is selected as master node among remaining nodes. Ambiguity is removed by the metric helps that were in the conventional mechanisms and lessen the possible collision.

The selection of the node M must be announced to the other nodes so as to ignite the communication. The nodes are now equally distributed and each tries to send its packets to M. It is the responsibility of the node M to allocate the channel to the requested device for a certain period of time, depend on the devices priorities or the urgent transmission of the data. However, this method works if the number of nodes in the scenario falls within 50.

If the number exceeds 50, then an alternative method is applied where the nano devices are divided into clusters. Nodes are partition into a several number of small groups called clusters for supporting data aggregation through network. A coordinator is assigned for each cluster which is defined as cluster head (CH), and member nodes. Clustering provides a two-tier hierarchy in which CHs form the higher tier while member nodes form the lower tier [5] . Figure **??** illustrates data flow in a clustered network.

The member nodes inform their data to their corresponding CHs. These data are aggregated by CHs and report them to the central base through other CHs. Because CHs often transmit data over longer distances, they waste more energy compared to member nodes of the network. In order to select energy-plentiful nodes to serve as cluster heads (CHs), the network may be reclustered periodically and distribute the load uniformly on all the nodes. Clustering decreases channel contention besides achieving efficiency of energy. Hence, to subdue disconnected regions and distribute energy consumption across all nodes of the network periodic clustering is so important. Periodic re-clustering is also important for creating dynamic clustering of nodes and for better throughput of the network under greater load. There are two following types communication mechanism:

? Intra Cluster Communication and

11 ? Inter Cluster Communication

An important design challenge is scheduling intra-cluster and inter-cluster transmissions. Time division multiple access (TDMA) is best for intra-cluster transmissions, Since clustering is typically employed in applications where data aggregation is performed. This is because a CH can set the TDMA schedule and inform its cluster members about it. The problem is how to prevent the TDMA intra-cluster transmissions from colliding with transmissions in neighboring clusters or with inter-cluster frames, especially when CHs communicate with each other using longer ranges.

After the selection of the master node, data is transmitted by broadcasting TDMA frame to all the nodes in the network. Here raises another scenario where few other nodes are to be added in to the network. If this happens the selection of master node is to be rescheduled by iterating the above procedure. Since the master node is repeatedly subjected to change whenever new nodes are added to the network, energy dissipation is reduced. The number of nodes to be added is also a considerable constraint to achieve scalability. If the number of additional nodes is less than 10 then the above mentioned technique can be applied if the number exceeds 10 then again we have to roll back to the Clustering mechanism which is described in detail in the above sections.

12 b) Handshaking Process

The handshaking process is divided in two sub stages, the handshaking request and the handshaking acknowledgment.

The handshaking request is triggered by any nano-device that has information to be transmitted and which has enough energy to complete the process. A transmitter generates a Transmission Request (TR) packet, which contains the Synchronization Trailer, the Transmitter ID, the Receiver ID, the Packet ID, the transmitting Data Symbol Rate (DSR) and the Error Detecting Code (EDC). The DSR field specifies the symbol rate that will be used to transmit the data packet. The strength of RD TS-OOK against collisions increases when different users transmit at different rates. In the PHLAME protocol, every transmitting node randomly selects a symbol rate from a set of co-prime rates, which minimizes the probability of having catastrophic collisions. The EDC field is used to detect transmission errors as a conventional checksum field. The TR packet is transmitted using a Common Coding Scheme (CCS), which specifies a predefined symbol rate and channel coding mechanism. By using the same symbol rate, catastrophic collisions might occur. However, the TR packets are very short and the EDC field should suffice to detect simple errors in the majority of cases. Finally, the transmitter waits for a timeout before trying to retransmit the TR packet when no answer is received.

The handshaking acknowledgment is triggered by the receiver of the TR packet, which uses the CCS to decode the received bit streams when listening to the channel. If a TR packet is successfully decoded, the receiver will check whether it can handle an additional incoming bit stream. In our scenario, we consider that due to the energy limitations of nano-devices after the transmission or active reception of a packet, a device needs to wait for a certain recovery time in order to restore its energy by means of energy harvesting systems. This time is much longer than the packet transmission delay and poses a major limitation to the network. If the handshake is accepted, a Transmission Confirmation (TC) packet is sent to the transmitter using the CCS. The TC packet contains the Synchronization Trailer, the Transmitter ID, the Receiver ID, the Packet ID, the transmitting Data Coding Scheme (DCS) and the Error Detecting Code. The DCS is selected by the receiver in order to guarantee a target Packet Error Rate (PER), which depends on the perceived channel quality and can be estimated from the pulse intensity or the perceived noise. In particular, the DCS determines two parameter values. First, it specifies the channel code weigh t, i.e., the average number of logical ”1”s in the encoded data. By reducing the code weight, interference can be mitigated without affecting the achievable information rate. Second, the DCS specifies the order of the repetition code that will be used to protect the information.

13 c) Data Transmission Process

At this point, the data is transmitted at the symbol rate specified by the transmitter in the DSR field, and encoded with the weight and repetition code specified by the receiver in the DCS field. The DP contains a Synchronization Trailer, the Transmitter ID, the Receiver ID, and the useful Data. The Error Detecting Code has been removed from the packet since by using different symbol rates, catastrophic collisions are highly unlikely, and randomly positioned error scan be fixed by means of the chosen channel coding scheme. If the DP is not detected at the receiver before a time-out, TDP out, the receiver assumes that the handshaking process failed.

14 Fig. 2 : Transmission of Packets

This stage is concerned with the communication of other devices with the node M. Any node that requires the channel sends a control packet with fields containing destination address, source address, priority bit, to the node m. Priority bit number is a single bit field that represents the priority of the device. If the bit is set to 0 then the device can be scheduled sequentially. If the bit is 1, then the device has an emergency channel requirement. Scheduling of these devices is done through queuing at the master node by using Round Robin algorithm (that assumes all the devices of equal priority). After queuing, M starts allocating the channel on the FCFS basis. In some cases, if a node is to be allocated with the channel immediately then it sets it priority bit to 1 and hence the requested channel is allocated. If MN wishes to grant the channel to the node A, it first sends a REQUEST signal to the receiver B. If the receiver is free, then it sends an acknowledgement (ACK) signal to MN allowing the communication. MN in turn sends the same ACK signal to the requested device A. Hence the sender is allocated with the channel and the transmission of the packet takes place. After receiving all the packets B sends the acknowledgement to the master node indicating that the transfer is successful. In order to avoid collisions between the data packets and ACKs, the sender mentions the packet count in the first packet and receives an ACK from MN after all the packets arrive at the receiver. If the ACK is not received at the sender node within a stipulated time, indicating an error in transmission then all the packets are resent. Since the channel is allocated for transmission between two devices there will be no collisions from other nodes and hence reliability is achieved.

Energy Efficiency can be taken as a measure of the extent to which collisions are reduced. Since there are no collisions, the energy required to retransmit the packets can be eliminated totally. The other area where energy is conserved is selecting an equidistant method for the selection of master node all the nodes will require equal amount of energy to transmit the control packet. Whenever the nodes are added in to the network the master node is changed where energy dissipation is reduced. Considering all these factors energy will be saved or consumption of energy is reduced to a great extent.

15 d) Packet Structures

Two types of Packet structures are involved here: Control Packet, Data Packet

16 ? Control Packet

Control Packet is a dummy packet, free of the data that helps in allocation of the channel to the requested device. The fields included in its structure are Destination Address, Source Address, Priority bit and Synchronization trail.

17 Fig. 3 : Control Packet

The preamble bits present in the packet are used for the synchronization of the Nano machines to enable communication. The conflict arises as to which address has to be mentioned in the DST ADDRESS field. Is it the master node address or the destination node address?

To resolve this, inclusion of another field known as the CPB is the Control packet bit which distinguishes the control packet from the data packet. If the packet is a control packet then the bit CPB is set to 1, otherwise the packet is taken to be a data packet. Now the packet whose bit is set to 1 will be sent to the master node thereby requesting the channel.

18 ? Data Packet

Data packet structure represents the original data to be transferred with the following form the structure consists of a trail part and the data part. The data to be transferred is encoded in the data field and then transmitted. From previous discussion, it is learned that catastrophic collision is reduced by transmitting data from different transmitter using different transmission rate or symbol rate. This is the main limitation of this protocol. It is also known that symbol rate is selected randomly by nano devices and it is a co-prime number. So if the transmitted symbol rate is small enough then the data packet with this symbol rate journey the transmission medium long time. With high symbol rate data are transmitted more quickly through transmission medium.

Data packet with long time in transmission medium has high probability of affecting with noise and attenuation. This is a major problem of PHLAME. So a solution is been proposed for this problem that try to design a new MAC protocol for wireless Nano sensor network.

19 VII.

20 Proposed Algorithm

A brief description of the above mentioned procedure is given below in the form of an algorithm:

A Nano network is formed with 'n' no. of nano nodes in it. Election of the master node is done based on the value of n. If n<50 then we use EQUIDISTANT metric method. If n>50 then clustering is applied. Protocols for inter-cluster and intra-cluster communications like HEED are employed for the selection of master node. Now the nano device requests the master node to allocate the channel. The nano device will send a control packet to the master node. The master node will know that it is a control packet by setting the CPB to 1. Queuing is done at the master node which consists of all the nano-devices that request the allocation of channel. The queue scheduling followed here is Round Robin Scheduling. If a nano device needs the channel prior to all then the PB bit will be set to 1. After the queue of the devices, the first node in the queue will be allocated with the channel. Now the channel is used only by the two devices that have been mentioned in the control packet. After the data transmission is completed the master node takes back the control of the channel and reallocates it to the next device on the queue.

21 VIII. Proposed Solution

Due to different symbol channel information may be added with more noise and attenuation. So this problem is solved by using same higher symbol rate or transmission rate. But if more than one device wants to transmit at the same time then the information from different source may overlap in transmission medium. So if the use of same symbol rate is required, then use of different channel for transmission is a must, i.e., divide the main channel into multiple channel.

In this case FHSS (Frequency Hopping Spread Spectrum) or FDM (Frequency Division Multiplexing) can be used for dividing the allocated frequency into multiple channels.

In FHSS, signals are not transmitted in one frequency channel. Same signal transmitted with different frequency channel. so if FHSS is used in nano network then signal with same symbol rate can be passed through transmission medium without high noise, attenuation and overlapping as signal transmitted in this scheme through different frequency channel with same higher symbol rate or transmission rate.

In FDM, it is possible dividing the channel into multiple channels which are used by different nano device for data transmission. Since nano network use terahertz band for operation so it can easily divide the main frequency channel into multiple channel that is enough for source station to transmit data to destination.

When one node wants to transmit data to destination node it selects one channel to transmit. In that time if there is any other node to transmit information, then it senses the channels to find any free channel. The channel which is busy to transmitting data of first node is not used to transmit data of current node. Busy channel distinguishes the node for accessing it for data transmission.

If all channels are busy to transmit data from source to destination then there is a problem if any node wants to transmit in that time. There is no free channel for transmitting data. So In this case we can use channel sharing procedure. In Channel sharing scheme one channel can be used by many sources at the same time without data overlapping. Channel which starts transmitting information first is selected as sharing channel.

22 IX. Conclusion

In order to maintain Medium Access Control protocol, several issues must be considered. Design issue is one of the major. Different communication process such as terahertz communication is also considered. In this paper, the proposed solution is given based on some basic issues. The given access protocol is basically channel sharing based. So, in this scheme, one channel is allowed to be used by several sources at the same time whereas no data is overlapped. This can be an effective way to perfectly handle the MAC protocol issues. [1] [2]

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Figure 1: Fig . 4 :

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