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# An Effective Approach for Tree Based Data Collection in Wireless Sensor Network

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***Abstract-*** In this paper authors describe about time and frequency division multiple access protocol (TFDMA). It is a new combinational MAC layer protocol for wireless sensor networks in which, the first effort to consider the working of both TDMA and FDMA schedules in the network full of constraints. Also, at the same time by allowing it to operate in an energy-efficient collision-free manner. However, TFDMA considers the multiple frequencies provided in the radio's of recent sensor node hardware platforms. Authors also show how TFDMA performs protocols providing high throughput and small bounded end delay suitable for new introducing types of sensor network applications such as real-time voice streaming etc.

***Keywords—*** Scheduling, Tree based network, TFDMA, Wireless Sensor Network, Data Collection

## I. INTRODUCTION

In a typical wireless sensor network (WSN) applications it's of interest to increase the network lifetime due to the battery limitations of the sensor devices. Being important source of energy consumption, wireless communication in WSN has received a lot of attention. The MAC protocols especially studied deeply with the objective of energy efficiency with respect to throughput, bandwidth utilization, fairness and latency were considered as the secondary objectives. A wireless sensor network is nothing but a network of tiny embedded systems, each of which composed of sensors (for light, temperature, etc.), a low-power communication device (radio transceiver), less amount of memory and processing capability as well as limited battery power supply. Traditional WSN applications like [1] [2] [3] have mostly focused on passive low-duty cycle sensing and monitoring, in-network data reduction and asynchronous operation designed to increase the sensor-net lifetime. Though, recently proposed applications of sensor networks in both mission-critical operations and wide-area surveillance such as real-time streaming for voice and low-rate video delivery [4] require high

Bandwidth utilization and throughput along with bounded end-to-end delay of a few milliseconds.
Hence, design of effective WSN medium access control (MAC) protocols has become a more challenging task providing the unique set of resource constraints in these networks which result in very different design tradeoffs than those in wireless ad hoc networks [5].

It is obvious that bandwidth is not the main concern in traditional low-duty cycle and low-date rate applications. Though, it becomes an important concern during certain periods of time when a large burst of packets is generated because of a change in the monitored conditions and requires to be transported in a reliable and efficient manner to a base station. Future applications such as intruder detection, structural health monitoring etc. need data transfer at a higher rate by utilizing the use of the limited bandwidth. Also, it becomes more common to use sensor nodes that run multiple concurrent applications that also results in higher data rate requirements. Converge cast, like the collection of data from a set of sensors toward a common sink over a tree based topology, is a fundamental operation in wireless sensor networks (WSNs) [5]. It is crucial in many applications to provide a guarantee on the delivery time as well as to extend the rate of such data collection. Classification of WSN includes three categories:
(1) Sensor nodes in the network which are divided into clusters, known as cluster-based classification.
(2) A chain of sensors is formed to serve as a network structure in which transmission of data is divided into multiple levels. This is called chain-based classification.
(3) All nodes are organized in the form of a hierarchical tree which is logically formed, called tree-based classification. Here, the leaf node senses and forwards the data to the intermediate node and their parent nodes.

## II. FEATURES AND ITS REQUIREMENT

a. A sensor node should not be costly.

 

b. Data gathering protocol like tdma, fdma, cdma ought to be economical enough to offer longer life-span to the network.
c. Nodes employed in this should be capable enough to make a network mechanically with none external configuration.
d. Sensor nodes ought to be ready to work along and mixture their knowledge in an exceedingly important method while not meddlesome or colliding.

## III. SYSTEM ARCHITECTURE

A sensor network is the collection of thousands nodes distributed in a very wide space. Nodes communicate each other through the Base Station (BS). Figure 1 shows a basic architecture of a sensor network in which sensor nodes are shown as small circles. Each sensor node basically consists of the five components:

i. Sensor Unit
ii. Analog Digital Converter (ADC)
iii. Central Processing Unit(CPU)
iv. Power Unit
v. Communication Unit.

ADC is a translator that tells the CPU what the sensor unit has sensed, and also informs the sensor unit what to do. Communication unit's task is to receive command or query from, and transmit data from CPU to outside world. CPU is the most complex unit. It interprets the command or query to ADC, monitors and controls power if necessary, processes received data, computes the next hop to the sink, etc. There is also several alternative application specific elements beside these.[6]

In this research paper we introduce a combined form of fdma and tdma which can be termed as TFDMA. According to the characteristics of high reliable and low power periodical data collection on a large scale metallurgical industry wireless sensor network (WSN), we present a TFDMA MAC protocol. This protocol depends on a cluster-based gradable topology and uses a synchronization mechanism with dynamic time-stamp adjusting. During this protocol, we have a tendency to use a time-slot allocation TDMA supported broadcasting in initial and adopt dynamic timestamp adjusting time synchronization technology for every node among a cluster, that might effectively decrease the information collision caused by random competition and scale back the synchronization price in ancient TDMA protocol. and that we adopt FDMA protocol between the clusters to order to deploy a large-scale WSN with very little delay increase. The experiment result has verified that this protocol might prolong the networks life-time by concerning Bastille Day compared with the normal TDMA protocol, and it additionally demonstrates that the protocol might guarantees the need of energy potency, accuracy, strong and reliability. The protocol might even be applied to alternative WSN systems.

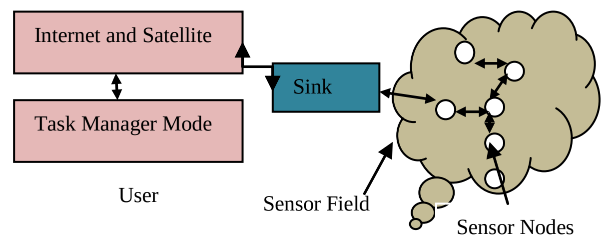


Fig 1: Architecture of WSN

Here, in this paper we have a tendency to use a composite theme that is centrally controlled protocol [6]. The system is assumed to be created of energy-constrained detector nodes that communicate to one close to by high-powered base station (< 15%). A pure TDMA theme dedicates the total information measure to one detector node; a pure FDMA theme allocates minimum signal information measure per node. Despite the actual fact that a pure TDMA theme minimizes the transmit-on time, it's not forever most well-liked thanks to the associated time synchronization prices. thus so as to beat the disadvantage caused in each we have a tendency to introduce TFDMA which mixes the advantage and dealing of each by providing single channel frequency to send and receive information at intervals a given time-slot.

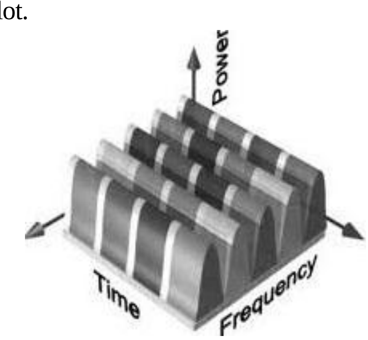


Fig.2: Hybrid of FDMA & TDMA

## IV. PREVIOUS WORK

In the previous researches we are using various types of scheduling like TDMA scheduling where we are basically focused on finding a TDMA schedule that minimizes the total time required to complete a converge cast in WSN. The aim is to guarantee a bound on converge cast latency. But we addressed the basic limitations due to interference and half-duplex transceivers on the nodes. TDMA is not able to cope up with variable amounts of data.

We have also researched on the Self Stabilizing (SS-TDMA) protocol which uses a fixed schedule throughout the lifetime of the network. Nodes know their location and collision free schedule can be made according the location information. Author show that SS-TDMA can result in acceptable performance[7], but their constraints on the location of the nodes renders it impractical in many deployment scenarios. The other approach taken by van Hoesel et al. in the LMAC protocol [8] is to assign nodes an unused slot number within a two-hop neighborhood to ensure collision-free transmission. The drawback of LMAC is that nodes must always listen to the control sections of all slots in a frame even if slots are unused. In addition, LMAC is not suitable for large-scale network for that in large-scale network, the number of nodes' two-hop neighbors is too much which cause schedule collision. Similarly, we studied another scheduling named as FDMA[10]. FDMA has various limitations in the real time environment some of them were; firstly, the complex FDMA is constantly active independent of the data rate, which is inefficient from power consumption point of view, while OFDM combined with data packet scheduling allows to hibernate during certain time intervals. Secondly, the fast channel feedback information and adaptive sub-carrier assignment is complicated.

In all approaches which were previously been used in order to gather data in tree based network have some or the other limitations therefore in this research we consider a combined approach named as TFDMA.

## V. PROBLEM STATEMENT

In most of the WSN applications, there is always a data collection stage that involves collection of the data at each sensor node and its subsequent transmission to the sink node. Due to battery power at each hop, and at times non-rechargeable battery feature of the sensor nodes, power efficiency and also the saving of it at the same time for further works is a serious design consideration in each phase when designing sensor networks. Some works focuses on proposing efficient data processing algorithms in each node like FDMA, TDMA algorithms, while others focus on proposing efficient data transmission protocols in sensor networks. Some of the processing algorithms already proposed as follows; In TDMA scheduling we failed to collect a large amount of data and also due to time constraint important data may be delayed whereas in FDMA is not applicable in the context of sensor network since sensor nodes are often under constraint to transmit only on one frequency once the frequency is set before deployment. For instance, MICA motes of UCB [9], the most popular sensor nodes equipped with radio feature, operate on a fixed frequency during the lifetime of network. CDMA requires expensive operations for encoding or decoding a message which is being sent and is not preferred for sensor network because it lacks the special hardware required for CDMA and that have limited computing power. Either FDMA or CDMA &other schedules needs to extend the functionality of its sensors hardware, which complicates the hardware design and the node's hardware becomes too costly as well[10] .The hardware expensiveness is undoubtedly uneconomical & in most of the ways cannot be afforded due to high cost told above especially for large-scale wireless sensor network. Therefore, the problem is how to avoid data interference and improve energy utilization efficiency with a reasonable TFDMA schedule in a large-scale wireless sensor network.

## VI. OUR APPROACH

The communication period in TFDMA depends upon the fixed-length TDMA cycle containing number of frames consisting of the time slots. Each frame is equivalently divided into several fixed time slots where a slot duration is the time which is required to transmit a maximum amount of the packet. In addition, a decided number of consecutive slots in each cycle from its beginning forms the scheduled slots while the other remaining slots of that cycle are its contention slots. The base station is responsible to assign an required amount of frequency approximately as well as specific time slot(s) to each node by the help of an algorithm which will be described later. By the help of this algorithm scheduled node will be able to communicate in an energy-efficient collision-free manner turning off its radio content when it is not necessarily needed. All scheduled nodes employ LPL we incorporate a concept of LPL (low power listening), the nodes are in LPL [11] form to measure the topology changes and if there is a topology packet coming their way they wake up and make necessary changes; on contention slots during which they select one slot in a randomized manner to send a WAKEUP message to the base station (using flooding if specific routes are not present). On the other hand, all of the unscheduled nodes which have just joined the network, only operates in contention slots. Slots sending the WAKEUP message in a similar way. If a node finds a WAKEUP message from any other node in its one-node distance, it adds the sender to its neighbor list. The updated neighbor list will be included in the next WAKEUP messages sent by that node. Having received the WAKEUP messages sent by the nodes, the base station is able to design the schedule and send it to each node in a SEQUENCED message. Consequently, every node will send DATA messages to its parent using the assigned slot and frequency the way in which the network throughput becomes maximum and the overall uplink delay becomes minimum. By making use of the TFDMA channel access technique, the sink node broadcasts a schedule packet-nodes informing other packet-nodes about their time slots as well as their channel frequencies for exchanging messages.

### A. Scheduling using TFDMA algorithm:

 

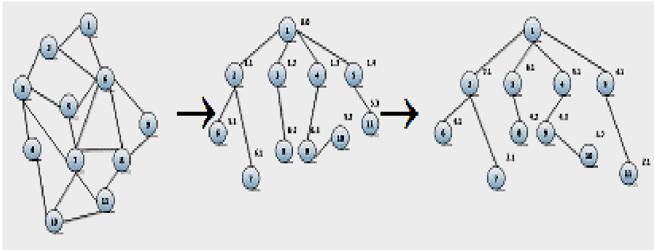

Fig 3: Operation of Scheduling Algorithm.[The Numbers shown here are the Assigned Time Slot and Frequency Respectively]

This scheduling algorithm is applied on a tree having the base node as its root. As each node Mi is traversed, it is assigned a default time slot and a frequency. Then there is a possibility of an interference with any of its same level previously-visited node (neighbors) is checked. If a interfering node Mj is found for Mi, then the algorithm checks whether Mi and Mj are siblings. If so found, then Mi will be assigned a different time slot than that of Mj. If they are not siblings then Mi will be assigned a different frequency than that of Mj , allowing both Mi and Mj to send data & information to their parents at the provided time slot but in different channels or frequency. When tree starts with a new height (level) of nodes the default time slot number will be increased by +1. Once all nodes are processed according to the above characteristic, the entire time slot assigned will be changed such that the slot number assigned to every node is

Smaller than that of its aren't (time slot(children)<time slot(parent)). This inversion is done as following :

Vnew = Vmax − Vcurrent + 1

Where Vnew→ New changed assigned time slot,

Vcurrent→Current slot number assigned to the nodes

Vmax→Total number of assigned slots.

Algorithm 1: TFDMA approach:

```
Ensure: A scheduled Tree of the Given Network :
ENQUEUE (A,S)
 while A is not empty do
 t ← DEQUEUE (A)
 timeSlot[t] ← current TimeSlot
 F_SINK () /*For assigning channels */
 for all Visited same level hop neighbor v of t do
Ensure: A scheduled Tree of the Given Network :
ENQUEUE (A,S)
 while A is not empty do
 t ← DEQUEUE (A)
 timeSlot[t] ← current TimeSlot
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 F_SINK () /*For assigning channels */
 for all Visited same level hop neighbor v of t do
Ensure: A scheduled Tree of the Given Network :
ENQUEUE (A,S)
 while A is not empty do
 t ← DEQUEUE (A)
 timeSlot[t] ← current TimeSlot
F_SINK () /*For assigning channels */
 for all Visited same level hop neighbor v of t do
 if parent[v] == parent[t] or #Channel >= available channels then
 if timeSlot[t] = timeSlot[v] then
 timeSlot[t] ← timeSlot[v] + 1
 else
 if timeSlot[t] =timeslot[v] and
channel[t]=channel[v] then
 channel[t] ← channel[v] + 1
 For ended
 for all unvisited edge e of t do
 let w be the other untraversed endpoint of edge e
 parent[w] ← t
 height[t] ← height[w] + 1
 For ended
 While closed
```

Algorithm2: TFDMA using F_SINK():

```
Calculation of the range Ri = Fi/Ki
For each Qi , Ci where  i ←1 to j
Assign Ri
If Qi receives the last packet then
Withdraw the frequency and add it to the free space.
for ended
Requesting a new Fi allotment
If available from free space, Assign from it.
```

## VI. EXPERIMENTAL RESULT

In all of our experiments, a sensor field with each side measuring x-meters is considered. A number of M identical hops, ranging from 55 to 299 in the increment of 50, are randomly deployed in thie sensor field such that the avg node density is kept at $\lambda$ = 55/1652 nodes per meter square, a parameter which we borrowed from forwarded diffusion [12, 13]. Furthermore, there are sinks randomly deployed in the field and sources are randomly chosen among the nodes, subject to the conditions that SR=10% of M and the sources have to be interconnected to each other . Each node is assumed to have a radio range of approximately 45 meters. To sense the periodic transmissions, each source generates data reports of size fixed packets at 138 bytes in constant intervals of DR = 1 packet/second. The data are collected at the root, if they exist, and then they are sent to the sinks. We provide each source with an initial energy that is randomly chosen between 11 to 20 Joules. In all of our experiments, all nodes are given an initial energy that is greater than that of any event source(initial energy>event source energy) such that if they are not present in the network, due to energy depletion during transmission, does not affect the functionalities of any participating node during data collection. Lastly, the idle time power, receive time power and transmit power dissipation are set at 39, 399 and 679 mW respectively. We assume a negligible energy cost to process and aggregate incoming data reports. If the two nodes are within each other's communication then they are assigned the same time slots, they share the same frequency. Since TFDMA operation does not only depend on the number of available frequencies and channels, its performance remains unaffected by a varying number of them. Figures 4and 5show the perfect performance of TFDMA which is interference-free and collision free even when there are only 2 frequencies available. In order to achieve high performance of this we need to increase the number of required time slots. This is because when a new frequency channel is needed to be assigned to a node knowing that the maximum number of available frequencies is already reached, the node is assigned a new time slot in order to avoid the potential interferences. Consequently, fewer number of available frequencies results in a larger number of time slots [14].

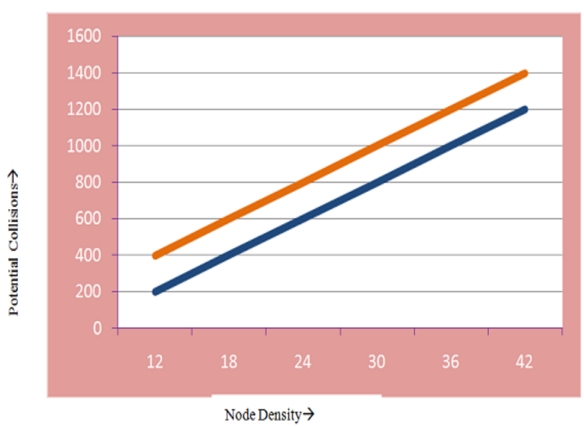


Fig.4: Diagram showing Potential conflicts vs. Node Density.

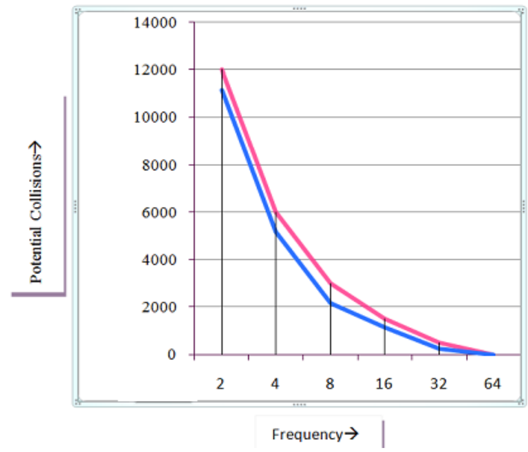


Fig.5 : Diagram showing Potential Collisions vs. Frequency

## VII. CONCLUSION

In this paper, we proposed and studied TFDMA protocol, which is a combination of TDMA &FDMA MAC protocol for wireless sensor networks. To the best our knowledge, TFDMA is the first sensor-net MAC protocol that schedules the network nodes in a way that eliminates collisions and interferences, providing us with a small bounded end-to-end delay and high throughput while taking an advantage of multiple frequencies available in current sensor node. Although the functionality of TFDMA does not depend on the type of its synchronization service, we believe that it best performs best in the presence of a hardware-based out-of-band time. The small bounded end-to-end delay and high output achieved by TFDMA as well as its energy efficiency due to minimization of idle listening, elimination of overhearing and its collision free operation make it a more appropriate protocol for the newly emerging sensor network applications.

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