IMPROVING THROUGHPUT AND DELAY PERFORMANCE IN SENSOR NETWORKS USING MAC PROTOCOL

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Abstract : In sensor network, we focus on IEEE 802.15.4 WSNs and show that they provide a very low reliability in terms of packet delivery ratio when power management is enabled. We found that this behavior is caused by the 802.15.4 MAC protocol and therefore, throughout we will refer to it as the 802.15.4 MAC unreliability problem. Specifically, we found that this problem – which is originated by the CSMA/CA algorithm used for channel access – becomes critical when power management is enabled due to the default MAC parameters setting suggested by the standard. Indeed, the IEEE 802.16 standard allows some flexibility in choosing CSMA/CA parameters, as it defines a range of allowed values for each of them We focus on the average throughput and delay analysis. We carry out a transient analysis that is of particular interest when sensor networks are deployed to provide -coverage for real-time applications. We validate our analytical results against simulation results obtained through NS2.

IndexTerms - IEEE 802.16 MAC; Single-hop; Multi-hop; WIMAX technology; Wireless sensor network

I. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

Characterizing timing performance in WSNs has been investigated in different contexts. For single packet multi-hop communication, the end-to-end delay distribution has been analyzed in our previous work. For the traffic flow, several models have been developed to analyze probabilistic bounds on delay. As an example, the concept of Network Calculus is extended to derive probabilistic bounds for delay through worst case analysis. However, due to the randomness in and the low power nature of the communication links in WSNs, these worst case bounds cannot capture the stochastic characteristics of end-to-end delay. The communication capacity bounds for wireless networks or WSNs without duty cycle operation are investigated. However, the applicability of these models to WSNs is limited since in WSNs, the wireless channel utilization is often well below the transmission capacity as nodes are constantly forced into a sleeping state to preserve energy. The existing studies on event detection delay in WSNs are either focused on (1) the event discovery delay, i.e., the delay until the event is detected by an individual node, or (2) the delivery delay in a broadcast network.

Most of the analytical studies, instead, have investigated the stationary performance of the IEEE 802.15.4 contention-based access scheme, and they consider only a synchronized network where time is divided into time slots. More specifically the access scheme is by using discrete time Markov chains and queuing theory. They study the network performance in both saturation and non-saturation regimes, trying to characterize the conditions under which the network enters the saturation region.

In IEEE 802.15.4 sensors simultaneously generating reports to be sent to a sink node through single-hop transmissions. Their goal however is significantly different from ours, since no acknowledgments are considered and an average message delay distribution is derived. This implies that, more than 10% of the messages are lost due to collision when two sensors are considered and the initial contention window is 7. For event detection (e.g., detection of car accidents, fire, alarms), instead, a reliable message transfer is required, and the estimate of the message arrival time distribution at the central controller is needed, which greatly differs from the average message delay distribution computed.

The energy-efficient target coverage problem deals with the problem of covering a set of targets with minimum energy cost address the target coverage problem where the disjoint sets are modeled as disjoint set covers, such that every cover completely monitors all the target points.

They have addressed target coverage problem without considering connectivity. Simple coverage problem has been addressed like k-coverage problem and Q-coverage problem. None of these address the connected coverage problem. Present a centralized approximation algorithm and a distributed version of the algorithm to solve connected k-coverage problem. The distributed priority algorithm is more efficient in applications where the query is executed for less than a few hundred times.

IEEE 802.16 is a standard for low-rate, low-power, and low-cost Personal Area Networks (PANs)[5]. A PAN is formed by one PAN coordinator which is in charge of managing the whole network, and, optionally, by one or more coordinators which are responsible for a subset of nodes in the network. Ordinary nodes must associate with a (PAN) coordinator in order to communicate. The supported network topologies are *star* (single-hop), *cluster-tree* and *mesh* (multi-hop).

WiMAX is based on IEEE 802.16 specification and it is expected to deliver high quality broadband services

II. MODULES

2.1Network Model

Node types

The standard defines two types of network node.

The first one is the full-function device (FFD). It can serve as the coordinator of a personal area network just as it may function as a common node. It implements a general model of communication which allows it to talk to any other device: it may also relay messages, in which case it is dubbed a coordinator (PAN coordinator when it is in charge of the whole network).

On the other hand there are reduced-function devices (RFD). These are meant to be extremely simple devices with very modest resource and communication requirements; due to this, they can only communicate with FFD's and can never act as coordinators.

Topologies

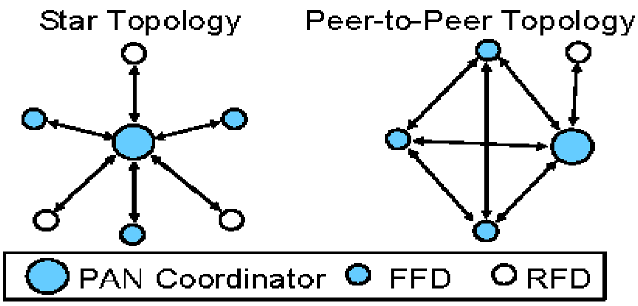

Figure 1: IEEE 802.15.4 star and peer-to-peer

2.2 Data Transport Architecture

Frames are the basic unit of data transport, of which there are four fundamental types (data, acknowledgment, beacon and MAC command frames), which provide a reasonable tradeoff between simplicity and robustness. Additionally, a superframe structure, defined by the coordinator, may be used, in which case two beacons act as its limits and provide synchronization to other devices as well as configuration information. A superframe consists of sixteen equal-length slots, which can be further divided into an active part and an inactive part, during which the coordinator may enter power saving mode, not needing to control its network.

Within superframes contention occurs between their limits, and is resolved by CSMA/CA. Every transmission must end before the arrival of the second beacon. As mentioned before, applications with well-defined bandwidth needs can use up to seven domains of one or more contentionless guaranteed time slots, trailing at the end of the superframe. The first part of the superframe must be sufficient to give service to the network structure and its devices. Superframes are typically utilized within the context of low-latency devices, whose associations must be kept even if inactive for long periods of time.

Data transfers to the coordinator require a beacon synchronization phase, if applicable, followed by CSMA/CA transmission (by means of slots if superframes are in use); acknowledgment is optional. Data transfers from the coordinator usually follow device requests: if beacons are in use, these are used to signal requests; the coordinator acknowledges the request and then sends the data in packets which are acknowledged by the device. The same is done when superframes are not in use, only in this case there are no beacons to keep track of pending messages.

Point-to-point networks may either use unslotted CSMA/CA or synchronization mechanisms; in this case, communication between any two devices is possible, whereas in “structured” modes one of the devices must be the network coordinator.In general, all implemented procedures follow a typical request-confirm/indication-response classification.

2.3 Data Flow of communication stack at the MAC level

2.3.1 Multiple sink with PAN coordinator

(i) Generating network beacons if the device is a coordinator: A coordinator can determine whether to work in a beacon enabled mode, in which a superframe structure is used. The superframe is bounded by network beacons and divided into aNumSuperframeSlots (default value 16) equally sized slots. A coordinator sends out beacons periodically to synchronize the attached devices and for other purposes.
(ii) Synchronizing to the beacons: A device attached to a coordinator operating in a beacon enabled mode can track the beacons to synchronize with the coordinator.
(iii) Supporting personal area network (PAN) association and disassociation: To support selfconfiguration, 802.15.4 embeds association and disassociation functions in its MAC sublayer. This not only enables a star to be setup automatically, but also allows for the creation of a selfconfiguring, peer-to-peer network [7].
(iv) Employing the carrier sense multiple access with collision avoidance (CSMA-CA) mechanism for channel access: Like most other protocols designed for wireless networks, 802.15.4 uses CSMA-CA mechanism for channel access.

2.3.2. Estimation of packet loss rate in IEEE 802.16

The estimation of packet loss rate in IEEE 802.16 is as shown in Figure 2. Where two function call for the estimation of the packet loss rate [8].

Function calls MAC functions have to be called from the application in order to initiate an action in the communication stack at the MAC level. MAC functions are prefixed with wpan_ and suffixed with either _request or _response. A sample construct of a call to a MAC function is: wpan_mlme_associate_request.

Callback functions When the MAC needs to invoke a function in the application, it calls a callback function. If the callback function is not implemented by the application, it will be replaced by an empty function from the library. Callback functions are prefixed with usr_ and suffixed with either _confirm or _indication. A sample construct of a callback to an application function is: usr_mlme_associate_indication.

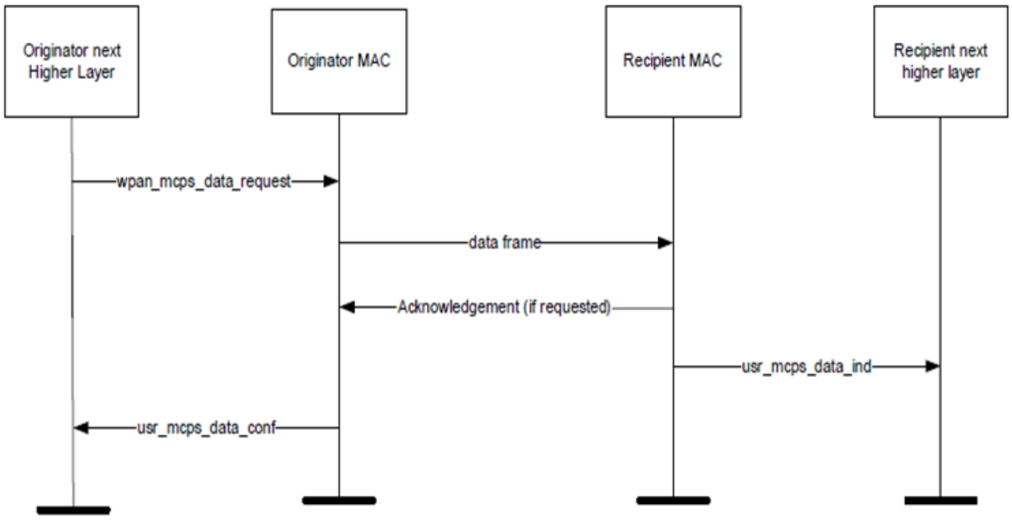

Figure 2: Data Flow Diagram of communication stack at the MAC level

III. Use Case Diagram

The model representing the message transfer is shows in Figure 3. A network site is wireless sensor network; by using routing protocol wireless sensor node will select and get a signal from a PAN. PAN is device who will give the signal as well as there is any overlapping signals are there that can be reduced. Congestion occurs means according to the time it will select routing calls and event it will be calculating by using IEEE 802.16. Radio propagation model is nothing but according to the radio signals ranges, what is the spreading from that will be select the destination. Each and every time it will check the radio propagation mode and justify the PAN.

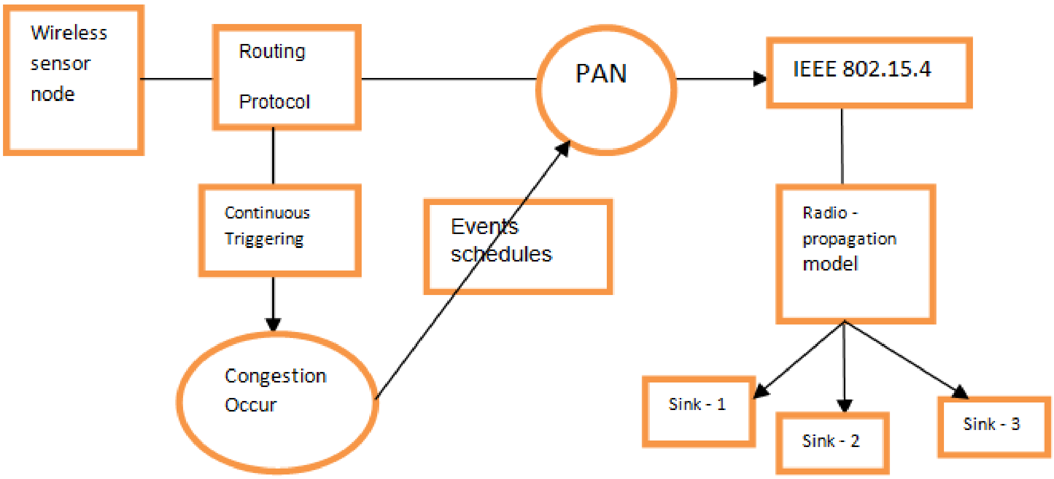

Figure.3: The model representating the message transfer from a sensor to central controller and destination

IV. Simulation Environment

It is assumed that 50 mobile nodes move over a square area of 300 × 1500*m*2. Each simulation has been run for 900 seconds of simulation time. The propagation channel of *two-ray groundreflection model* is assumed with a data rate of 2 Mbps. The environment noise level of -83 or -90 dBm is modeled as a Gaussian random variable with the standard deviation of 1 dB. Noise level of -90 dBm is considered ignorable and interference from other transmitters dominates. On the other hand, noise level of -83 dBm is used to simulate a harsh communication environment.

V. Results And Discussion

Fig.4 shows the comparison of packet delivery ratio between first sink and second sink (i.e. between two destinations), at the first sink of 50^{th} node packet delivery ratio can be 81 percent and the same time and node the second sink packet delivery ratio is 94 percent. Here packet delivery ratio can be increase from sink1 to sink 2. When compared with IEEE 802.15.4 and IEEE 802.16 the packet delivary ratio can be very high in IEEE 802.16 compared to IEEE 802.15.4, this can be show in fig 5.

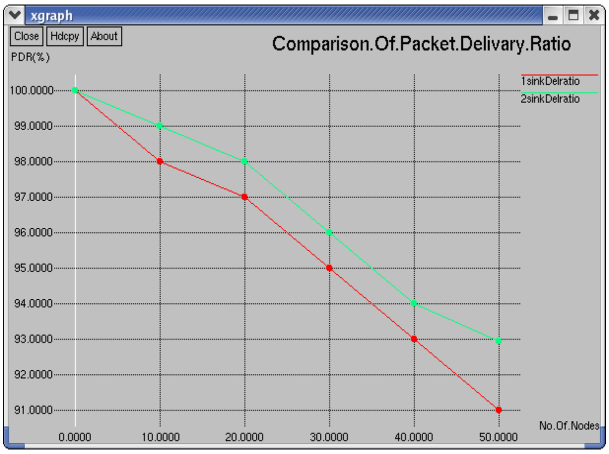

Figure 4: Comparision of packet delivery ratio

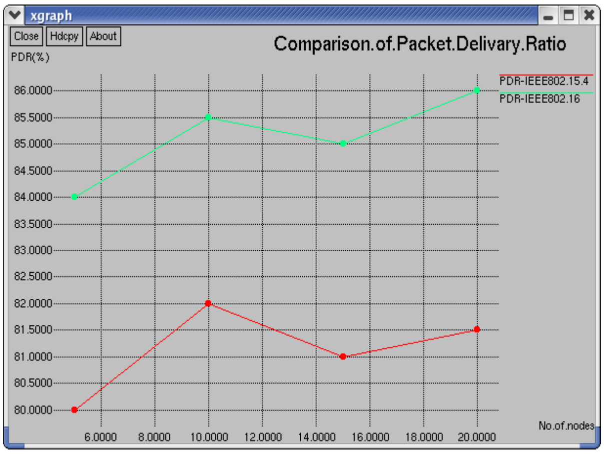

Figure 5: Comparison of packet delivery ratio

Fig.6 represents the data sent with average neighbours, this can be calculating between average neighbor and data (bytes per second). Here neighboring nodes can be improved from 2 to 10 corresponding data can transferred be increased from 10 to 23.

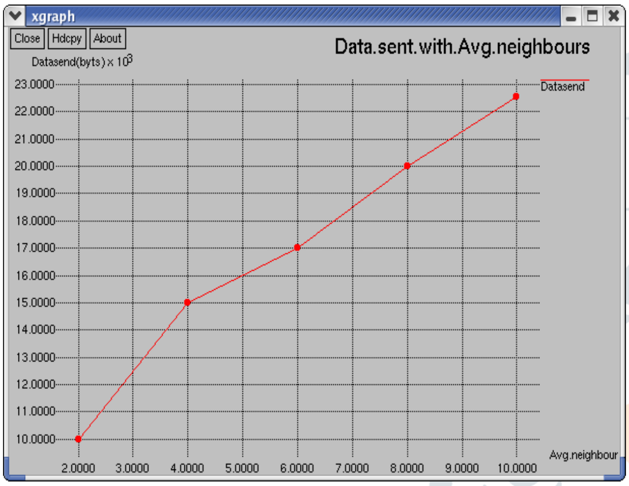

Figure 6: Data sent with average neighbours

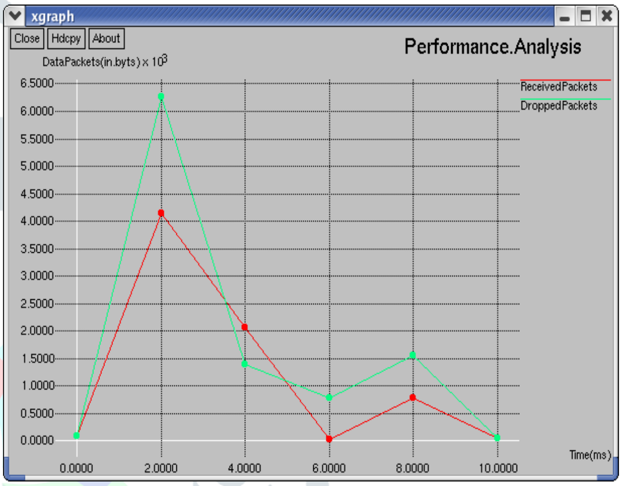

Figure 7: Performance analysis

From the Fig.7 gives the performance analysis between packets, here analysis can done between received packets and dropped packets. In this analysis at one point only dropped packets are high (i.e.2ms) and average performance of received packets be high. This can be calculation by using the below table-4.1

Send packets	Received packets
88	89
6259	4149
1394	2075
776	32
1548	790

Table 1: the performance analysis between packets

Fig.8 shows the traffic comparison, in our case considered the three traffics like CBR, TCP and POISSION. This traffic can calculate by the number of packets transmission (throughput) per second. While in TCP the traffic is very high when compared to other types and the CBR traffic is very low compared other traffics. So the best type of traffic is CBR for our consideration network.

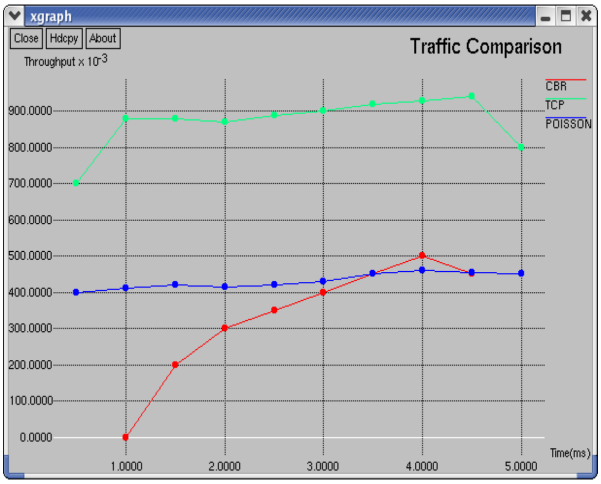

Figure 8: Traffic comparision

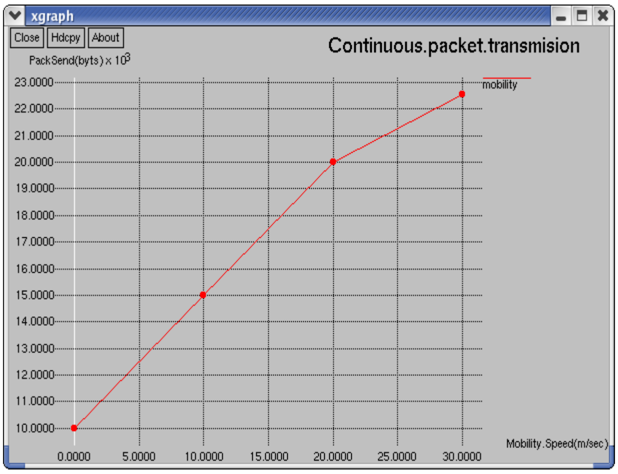

Figure 9: Countinuous packet transmission

Fig.9 gives mobility of the continuous packet transmission, where goes on increasing data with speed and it give the better mobility.

Fig.10 represents the average throughput, it gives the how many packets send from sink to destination, and here average throughput is very high in IEEE 802.16.

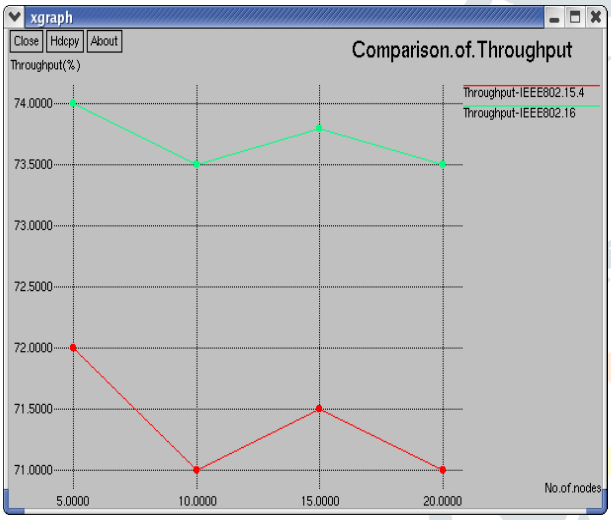

Figure 10: comparison of throughput

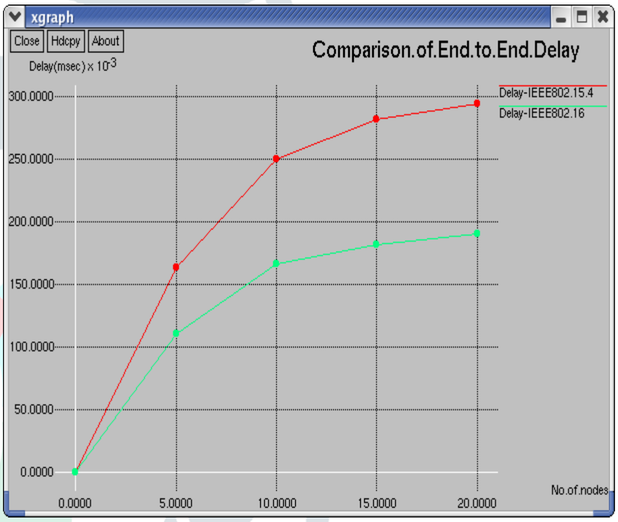

Figure 11: Comparision of end to end delay

Fig.11 gives the delay analysis between packets. In IEEE 802.16 delay can be reduced to nearly 50percentage when compared to IEEE 802.15.4.

VI. Conclusion And Future Scope

We studied the performance of a IEEE 802.15.4-based WSN for event detection. We carried out a transient analysis ofthe system when *k* sensors detect the event and attempt tosend their report to a central controller. We validated ourmodel using *ns2* simulations. Through the proposed model, wederived the delay distribution of each detection report delivery,and the probability that only *m* out of *k* reports reach thecentral controller within a given time constraint.

Our future work depends on signal strength; network uses thresholds to determine whether one frame is received correctly by the Sink. One signal strength threshold (CSThresh) to determine whether one frame is detected by the Sink. If the signal strength of the frame is less than CSThresh, this frame is discarded in PHY module and will not be visible to MAC layer. It has another threshold (RxThresh) for the signal strength of one frame received by the receiver. If one frame is received and received signal strength is stronger than RxThresh, the frame is received correctly. Otherwise, the frame is tagged as corrupted and the Mac layer will discard it.

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