Chapter 6

IEEE 802.15.4 WSN : GTS Mechanism

This Chapter details about the performance of the GTS allocation mechanism in IEEE 802.15.4. The analysis gives a full understanding of the behavior of the GTS mechanism with regards to Packet medium access delay, throughput and wasted bandwidth due to IFS. The impact of IEEE 802.15.4 parameters on the throughput, delay of a GTS allocation are analyzed which pave the way for an efficient dimensioning of an IEEE 802.15.4 cluster.

With the emergence of new Wireless Sensor Network (WSN) applications under timing constraints, the provision of deterministic guarantees may be more crucial than saving energy during critical situations. The IEEE 802.15.4 protocol [1] is one potential candidate to achieve predictable real-time performance for Low-Rate Wireless Personal Area Networks (LR-WPAN).

Timeliness is an important feature of the IEEE 802.15.4 protocol, turning it quite appealing for applications under timing constraints. Because of this attractive feature, it is used in real time for time constraint data delivery which is provided by Guaranteed Time slot mechanism.

6.1 GTS Mechanism Evaluation

The goal for any simulation model is to accurately model and predict the behaviour of a real system. Recently, several analytical and simulation models of the IEEE 802.15.4 [1] protocol have been proposed. Nevertheless, currently available simulation models [2] for this protocol are both inaccurate and incomplete, and in particular they do not support the Guaranteed Time Slot (GTS) mechanism, which is required for time-sensitive wireless sensor applications.

6.2 Related Work

NS-2, OMNeT++ and Opnet are widely used and popular network simulators which, among others, include a simulation model of the IEEE 802.15.4 protocol. Of course, each simulator has its own disadvantages and advantages, which is already discussed in chapter 3.The Network Simulator 2 (ns-2) [3] is an object-oriented discrete event simulator including a simulation model of the IEEE 802.15.4 protocol. The accuracy of its simulation results is questionable since the MAC protocols, packet formats, and energy models are very different from those used in real WSNs [4]. This basically results from the facts that ns-2 was originally developed for IP-based networks and further extended for wireless networks. Moreover, the GTS mechanism was not implemented in the ns-2 model. OMNeT++ (Objective Modular Network Test-bed in C++) [5] is another discrete event network simulator supporting unslotted IEEE 802.15.4 CSMA/CA MAC protocol only. Finally, note that while ns-2 and OMNeT++ are open source projects, the Opnet Modeler is commercial project providing a free of charge university program for academic research projects [6].

There have also been several research works on the performance evaluation of the IEEE 802.15.4 protocol using simulation model. Author in [7] compared the beacon enabled and non-beacon enabled modes with and without acknowledgement on OPNET simulator to analyse the loading effect on considered scenario by varying number of nodes. Author in [8] underline the suitability of 802.15.4 in wireless medical applications used in patient care applications through the network performance evaluation. Their focus is on interoperability and scalability. J. Zheng and M.J. Lee in [9] implemented the IEEE 802.15.4 standard on NS2 simulator and provided simulation-based performance evaluation on 802.15.4. It was a comprehensive literature that defines the 802.15.4 protocol and was mainly confined to the IEEE 802.15.4 MAC performances. This work has a minor evaluation on the performance of the peer-to-peer networks [10]. In [11] the authors have proposed an accurate OPNET simulation model, with focus on the implementation of the GTS mechanism. Based on the simulation model they proposed a methodology to tune the protocol parameters to guarantee better performance of the protocol by maximizing the throughput of the allocated GTS as well as minimizing frame delay.

Our work here focuses on simple 1-hop star network. It describes the wireless sensor networks in the IEEE802.15.4 to integrate the GTS mechanism in the MAC layer in order to improve the QoS. To achieve this performance evaluation, a simulation model for the IEEE 802.15.4 GTS mechanism within the implementation of the protocol under the OPNET simulator is used [11]. This simulation model has been recently made available publicly [12]. OPNET Modeler was chosen due to its accuracy and to its sophisticated graphical user interface. This model is used to carry out a set of experiments. The Focus is on extending this simulation paradigm by introducing additional settings and performance metrics.

6.3 The IEEE 802.15.4 Simulation Model

The simulation model implements physical and medium access control layers defined in the IEEE 802.15.4-2003 standard [1]. The OPNET Modeler [11] is used due to its accuracy and to its sophisticated graphical user interface. The OPNET Modeler is an industry leading discrete-event network modeling and simulation environment. The wireless module extends the functionality of the OPNET Modeler with accurate modeling, simulation and analysis of wireless networks. This module is one of the several add-on modules available from OPNET. The actual version of the simulation model only supports the **star topology** where the communication is established between devices, called inside the model *End Devices*, and a single central controller, called *PAN Coordinator*. Each device operates in the network must have a unique address. The structure of the IEEE 802.15.4 simulation model is presented in Figure 6.1.The structure of the IEEE 802.15.4 sensor nodes (*wpan_sensor_node*) used in the simulation model is composed of four functional blocks [13]:

1. The **Physical Layer** consists of a wireless radio transmitter (***tx***) and receiver (***rx***) compliant to the IEEE 802.15.4 specification, operating at the 2.4 GHz frequency band and a data rate equal to 250 kbps. The transmission power is set to 1 mW and the modulation technique is Quadrature Phase Shift Keying (QPSK).
2. The **MAC Layer** implements the slotted CSMA/CA and GTS mechanisms. The GTS data traffic (i.e. time-critical traffic) incoming from the application layer is stored in a buffer with a specified capacity and dispatched to the network when the corresponding GTS is active. The non time-critical data frames are stored in an unbounded buffer and based on the slotted CSMA/CA algorithm are transmitted to the network during the active CAP. This layer is also responsible for generating beacon frames and synchronizing the network when a given node acts as PAN Coordinator.
3. The **Application Layer** consists of two data traffic generators (i.e. *Traffic Source* and *GTS Traffic Source*) and one *Traffic Sink*. The Traffic Source generates unacknowledged and acknowledged data frames transmitted during the CAP (uses slotted CSMA/CA). The GTS Traffic Source can produce unacknowledged or acknowledged time-critical data frames using the GTS mechanism. The Traffic Sink module receives frames forwarded from lower layers and performs the network statistics.
4. The **Battery Module** computes the consumed and the remaining energy levels. The default values of the current draws are set to those of the MICAz mote specification [14].

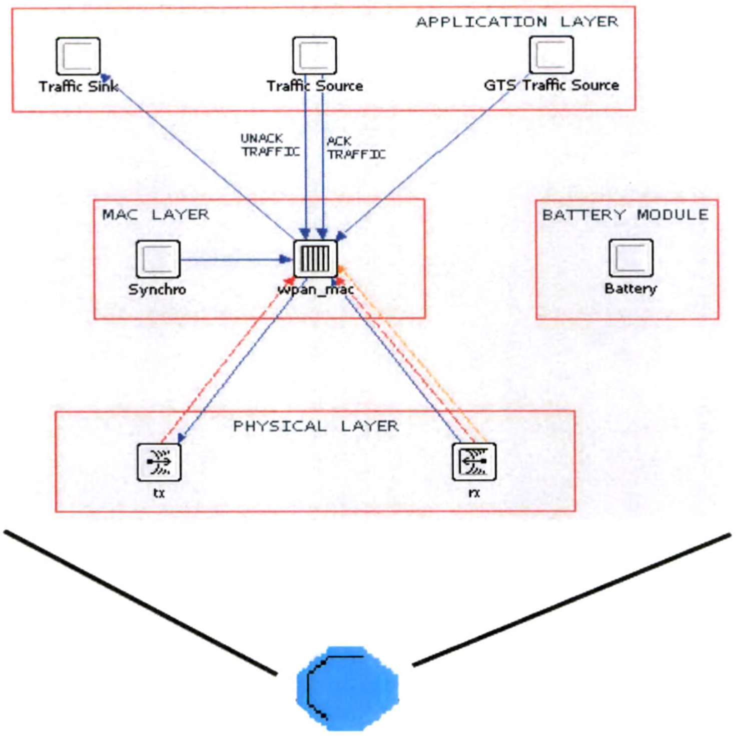

Figure 6.1: The structure of the IEEE 802.15.4 Simulation Model

The actual version of the simulation model is 2.0 and is not backward-compatible to the previous version 1.0, meaning that the devices conforming to version 1.0 are not capable of joining and functioning in a PAN composed of devices conforming to version 2.0 and vice-versa. The actual version 2.0 of the simulation model implements the following functions in accordance with the IEEE 802.15.4-2003 standard.

Support (implemented) features:

- Beacon-enabled mode
- Slotted CSMA/CA MAC protocol
- Frame formats (beacon, command, ack, mac_packet)
- Physical layer characteristics
- Computation of the power consumption (MICAz and TelosB (TmoteSky) motes supported) - Battery Module
- Guaranteed Time Slot (GTS) mechanism (GTS allocation, deallocation and reallocation functions)

- ℵ Generation of the acknowledged and unacknowledged application data (MAC Frame payload = MSDU) transmitted during the Contention Access period (CAP)
- ℵ Generation of the acknowledged or unacknowledged application data transmitted during the Contention Free Period (CFP)

The values of all constants and variables in this simulation model are considered for the 2.4 GHz frequency band width, a data rate of 250 kbps, which is supported by the MICAz or TelosB motes, for example. In this case, one symbol corresponds to 4 bits. For other frequency bands and data rates it is necessary to change appropriate parameters inside the simulation model (e.g. the header file *wpan_params.h*).

There are two types of nodes inside the simulation model:

- ℵ ***wpan_analyzer_node***: This node captures global statistical data from whole PAN (one within PAN).
- ℵ ***wpan_sensor_node***: This node implements the IEEE 802.15.4-2003 standard as was mentioned above.

6.4 GTS Mechanism

In Chapter 5, it is discussed that in IEEE 802.15.4 standard, Superframe is divided into active and optional inactive period. Each active period can be further divided into a Contention Access Period (CAP) and an optional Contention Free Period (CFP). The CFP is activated by the request sent from an End Device to the PAN Coordinator and provides real-time guarantees for time-critical data. Upon receiving this request, the PAN Coordinator checks whether there are sufficient resources and, if possible, allocates the requested time slots. This requested group of time slots is called Guaranteed Time Slot (GTS) and is dedicated exclusively to a given device. A CFP support up to 7 GTSs and each GTS may contain multiple time slots. The GTS allows the corresponding device to directly access the medium without contention with other devices inside the PAN. A GTS can only be allocated by the PAN coordinator and applied exclusively to data transfer between the device and its coordinator, either from the End Device to the PAN Coordinator (transmit direction) or from the PAN Coordinator to the End Device (receive direction). Each device may request one GTS in the transmit direction and/or one GTS in the receive direction. The allocation of the GTS cannot reduce the length of the CAP to less than *aMinCAPLength* (440 symbols). If the available resources are not sufficient, the

GTS allocation is denied by the PAN Coordinator. End Device to which a GTS has been allocated can also transmit during the CAP.

The PAN Coordinator may accept or reject the GTS allocation request from the End Device according to the value of the user defined attribute ***GTS Permit***. The End Device can specify the time when the GTS allocation and deallocation requests are sent to the PAN Coordinator (***Start Time*** and ***Stop Time*** attributes). This allocation request also includes the number of required time slots (***GTS Length*** attribute) and their direction, transmit or receive (***GTS Direction*** attribute).

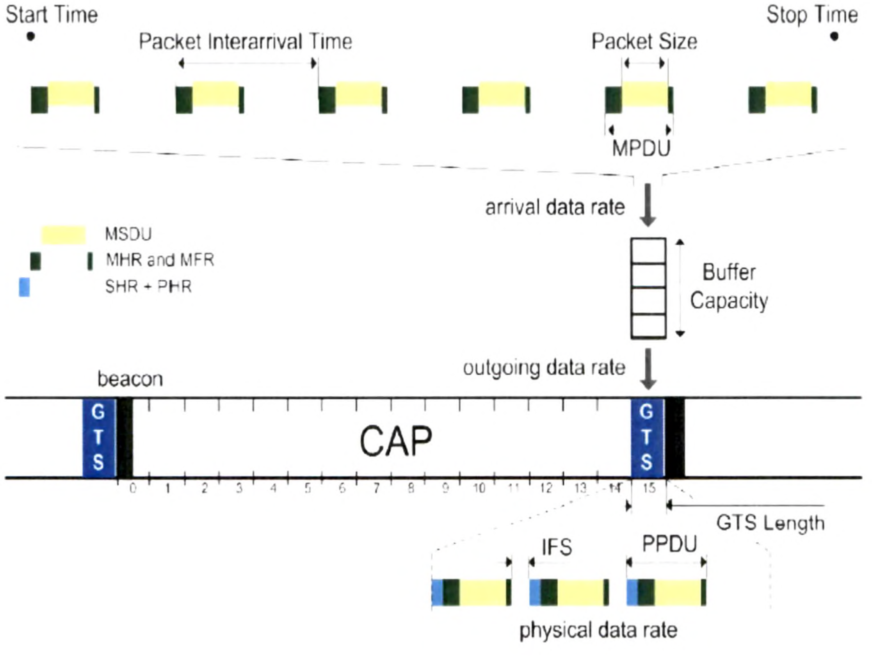

Figure 6.2 : Packet flow structure in GTS enabled mode [15]

The GTS mechanism packet flow structure is shown in Figure 6.2. When the requested GTS is assigned to a given device, its application layer starts generating data blocks that correspond to the MAC frame payload (i.e. MAC Service Data Unit (MSDU)). The size of the frame payload is specified by the probability distribution function of the ***MSDU Size*** attribute. The probability distribution function, specified in the ***MSDU Interarrival Time*** attribute, defines the inter-arrival time between two consecutive frame payloads. Then, the frame payload is wrapped in the MAC header and stored as a frame in the buffer with a given capacity (***Buffer Capacity*** attribute). The default size of the MAC header (*MAC_HEADER_SIZE*) is 104 bits, since only 16-bit short addresses are used for communication (according to standard specification). The maximum allowed size of the overall frame (i.e. frame payload plus the MAC header) is equal to *aMaxPHYPacketSize* (1016 bits). The generated frames exceeding the buffer capacity are dropped. When the requested GTS is active, the frames are removed from the buffer, wrapped in the PHY headers and dispatched to the network with an outgoing data rate equal to physical data rate *WPAN_DATA_RATE* (250 kbps).

Consecutive frames are separated by inter-frame spacing (IFS) periods. The IFS is the minimum interval that any device must wait before sending another frame. Determination of IFS is depicted in Figure 6.3. The IFS is equal to a short inter-frame spacing (SIFS) of 48 bits, for frame lengths smaller than *aMaxSIFSFrameSize* (144 bits). Otherwise, the IFS is equal to long inter-frame spacing (LIFS) of 160 bits, for a frame length greater than *aMaxSIFSFrameSize* bits and smaller than *aMaxPHYPacketSize* (1,016 bits) [1].

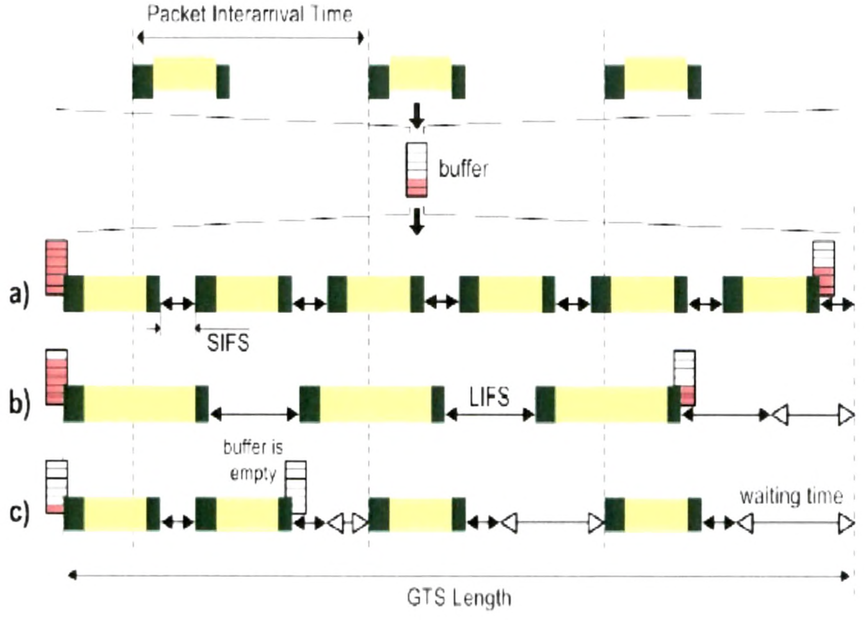

Figure 6.3: The utilization of the transmission time inside the GTS [15]

The MAC header in this model is 104 bits. To analyse the impact of IFS on the GTS performance, random packet sizes were determined at the input; 40 bits, 65 bits, 258 bits, 724 bits, 811 bits and 912 bits. The 40 bits and 65 bits packet sizes were chosen to invoke the SIFS, whereas the others will use LIFS.

Following Table 6.1 and 6.2 show the description of user defined attributes.

Attribute name	Value	Description
GTS Permit	[enabled/ disabled]	Enabled if the PAN Coordinator accepts GTS request from End Device. Disabled otherwise.
Start Time	Sec	The absolute simulation time in seconds when the application layer will start its GTS data generation. Setting the value to Infinity will simply disable data generation.
Stop Time	Sec	The absolute simulation time in seconds when the application layer will stop its GTS data generation. Setting the value to Infinity will make the application layer generate GTS data until the end of the simulation.
Length	0-15 slots	The length of the GTS in superframe slots within one superframe.
Direction	Transmit/receive	The direction of the transmission from the End Device point of view: ➢ transmit: End Device → PAN Coordinator ➢ receive: End Device ← PAN Coordinator
Buffer Capacity	Bits	The capacity of the FIFO buffer for storing the traffic arriving from the application layer before dispatching to the network.

Table 6.1 GTS setting

Attribute name	Value	Description
MSDU Inter arrival Time	Sec	The inter-arrival time in seconds between two consecutive MSDUs.
MSDU size	Bits	The size in bits of the generated data unit i.e. MSDU. The value can be from the interval (0, aMaxMACFrameSize). The values out of this interval are automatically set to boundary values. aMaxMACFrameSize is the maximum size that can be transmitted in the MAC Frame Payload and is equal to aMaxPHYPacketSize - MAC_HEADER_SIZE (i.e. 1016 - 104 = 912 bits)
Acknowledgement	Disabled/enabled	Enable if the generated data should be acknowledged.

Table 6.2 GTS Traffic Parameters

6.5 Parameter Analysis

To evaluate GTS Mechanism following parameters are consider: GTS Throughput, Packet Medium Access Delay and Wasted Bandwidth.

6.5.1 Throughput Analysis:

Defining the maximum throughput of GTS [16] is the maximum bandwidth for data transmission, the guaranteed bandwidth of a GTS is, (Eq1).

$$R = \frac{2^{IO}C}{16} - \frac{T_{idle}}{BI}C = \lambda \cdot DC \cdot C - W_{idle} \qquad \text{------------------ (1)}$$

With $\lambda = 1/16$,

DC = duty cycle = $2^{IO} \leq 1$ where IO=SO-BO

C = 250 kbps,

$W_{idle} = W_{overhead} + W_{wasted}$

The maximum throughput can be expressed as follows:

$$Th_{max} = \frac{Tdata}{BI} \cdot C \qquad T_{data} = T_s - T_{idle} \qquad \text{------------------ (2)}$$

$$T_s = \frac{SD}{16} = abaseSuperframeDuration * 2^{(SO-4)} \qquad \text{------------------ (3)}$$

$$T_{idle} = T_{overhead} + T_{wasted} \qquad \text{------------------ (4)}$$

T_{idle} is the sum of idle time spent inside a GTS

$$T_{overhead} = T_{IFS} + T_{ACK} \cdot \prod ACK \qquad \text{------------------ (5)}$$

T_{IFS} is the frame interval time when the data frame transmission wasted. T_{ACK} is time when wait for Acknowledgment frame, where $\prod ACK = 1$ for an acknowledged transaction and $\prod ACK = 0$ for an unacknowledged transaction. The value T_{wasted} is greater than zero if the length of a GTS is longer than the transaction time.

Hence, for a given SO the maximum throughput is related to the maximum time effectively used for data transmission inside a GTS. The transmission frame interval is affected by the arrival of data frames, T_{wasted} is affected by the size of buffer capacity. If data is small compared to GTS slot size, throughput decreases due to wastage of remaining bandwidth. So it is necessary to design the Superframe Structure in such a way that wasted bandwidth is reduced. This can be an important factor only for WSN application where a small data is to be transmitted at a regular interval of time, sometimes only signal that contained data in terms of bit.

6.6 Simulation Setup

The Simulation setup consists of a simple star network containing one pan coordinator and one associated end device which is GTS enabled. This configuration is sufficient for the performance evaluation of the GTS mechanism, since there is no medium access contention [17]. Thus, having additional devices would have no influence on the simulation results. Simulations for two different SO and BO values (varying duty cycles) are run to thoroughly study the performance impact.

For the sake of simplicity, and without loss of generality, assume the allocation of only one time slot GTS in transmit direction. The first simulation considers 100% duty cycle (i.e. SO = BO). In what follows, the change of the SO means that the BO also changes while satisfying SO = BO. This means that the optional inactive portion is not included in the superframe.

The statistical data is computed from a set of 1,000 samples. For the GTS allocation mechanism, the simulation time of one run is equal to the duration of 1,000 superframe periods, and consequently the simulation time depends on the SO. The 912 bits is the maximum allowable bits not to exceed aMaxPHYPacketSize (1,016) for 1 frame.

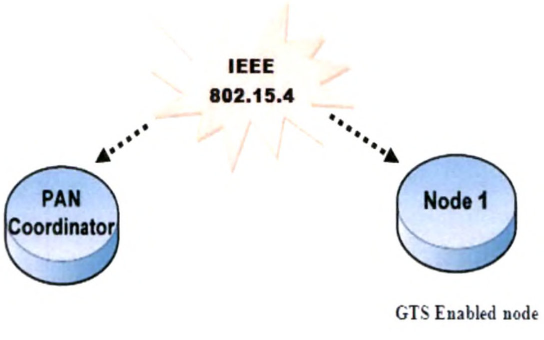

Figure 6.4: Simulation model

Figure 6.4 shows the implemented GTS Simulation model. For the parameter evaluation of the GTS Mechanism, GTS is set to 1 time slot and acknowledgement traffic is disabled.The buffer capacity is then dimensioned to 1 Kbits and 4 Kbits for each simulation and simulation time is 10 sec. 4 kbits is the real buffer size in MicaZ [14] architecture. Table 6.3 shows the attributes taken under simulation consideration.

Parameters	**Values**	**Units**
Packet size	40,65,258,724,811,912	Bits (constant type)
Packet Interarrival Time	0.001824	Sec
Buffer size	1 K, 4 K	Bits (constant type)
Distance	25	Meters
Transmission band	2.4	GHz
Transmission Power	1	Miliwatt

TABLE 6.3 SIMULATION PARAMETERS

6.7 Simulation Results and Discussion

This section evaluates the impact of SO, duty cycle, the inter-arrival time, the buffer capacity and the packet size on the data throughput of the allocated GTS, Packet Medium Access Delay, Wasted Bandwidth of the transmitted GTS frames.

6.7.1 Impact of Buffer size on GTS Throughput [1]

By varying the buffer size for 1 K and 4 K, the GTS throughput is observed [18]. From the Figure 6.5(a) and (b), it is observed that 912 packet size fails to transmit in all SO when the buffer size is 1 Kbits. This is because the 1 Kbits buffer capacity is not sufficient to hold the packet size. For lower SO values, superframe is very small so only 40 bits packet size, we get the GTS throughput. Therefore, 40 bits can conform for small SO values.

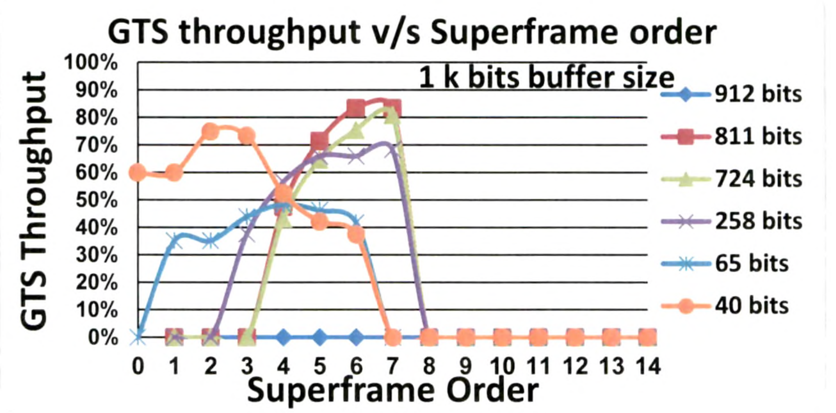

Figure 6.5(a): GTS throughput v/s superframe order for 1 k buffer capacity

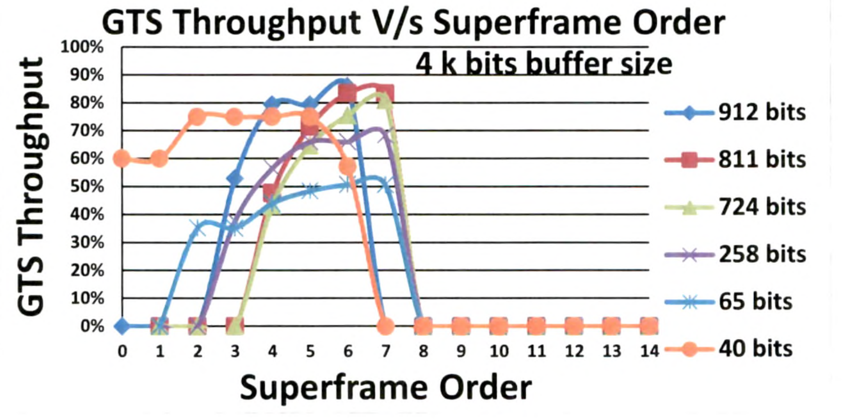

Figure 6.5(b): GTS throughput v/s superframe order for 4 k buffer capacity

[1] Published a paper, Ms. Sonal J. Rane "THROUGHPUT OPTIMIZATION IN IEEE 802.15.4 USING GTS MECHANISM", International Journal of Latest Research in Science and Technology, Volume 2, Issue 1: Page No.544-547, January-February (2013), ISSN(Online): 2278-5299

In these graphs, the corresponding packet size has reached its saturation throughput when the curve reaches its maximum peak value and plateaus. Throughput gradually decreases after reaching certain SO. The higher the SO, the larger the SD is. This creates unproductive service in time slot window duration with the corresponding buffer size and packet generation. This can be observed for SO beyond 7. Also higher SO values are not suitable for WSN application as Higher SO values, SD will be higher. This will provide more time duration to transmit the data but simultaneously delay will increase and throughput will decrease. At the lower SO, the duration of the superframe is very small so that only a packet size of 40 bits can conform.

6.7.2 Impact of Duty cycle on global statistics throughput.

Now consider Global statistics throughput, with and without inactive period. When only active period (100 % duty cycle) is considered, more throughput is achieved compared to considering inactive period (BO=SO+1) (Figure 6.6).

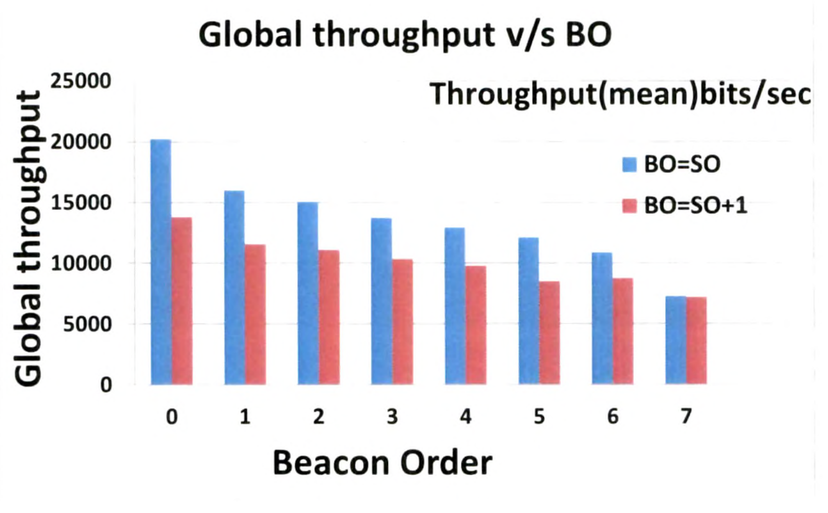

Figure 6.6: Global Throughput v/s BO

As the inactive part increases, the throughput drops significantly. This is because as we increase inactive period, that may save power consumption but data transmission does not take place, which will decrease the global throughput.

For the high SO values we get less GTS throughput and higher than 7 values, we don't get any throughput. This is because as SO values of the superframe increases, the active period increases (for 100% duty cycle) which also increases transmitted packet, but simultaneously delay will increase and overall global throughput will decreases.

6.7.3 Impact of Buffer size on Packet Medium Access Delay

This section evaluates and compares the Packet Medium Access Delay during one time slot of GTS when inter-arrival time is set to 0.001824 s for different values of the SO and for different packet and buffer sizes.

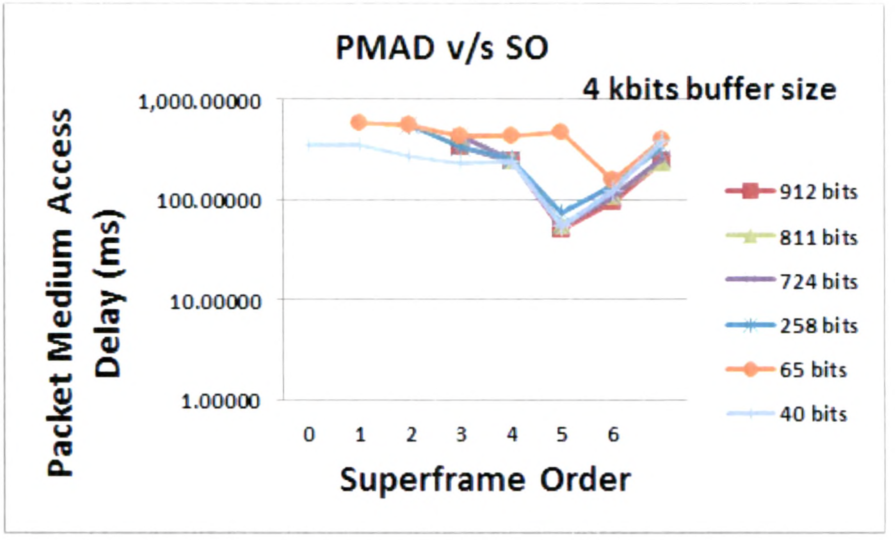

Figure 6.7 (a): PMAD v/s superframe order for 4 k buffer capacity

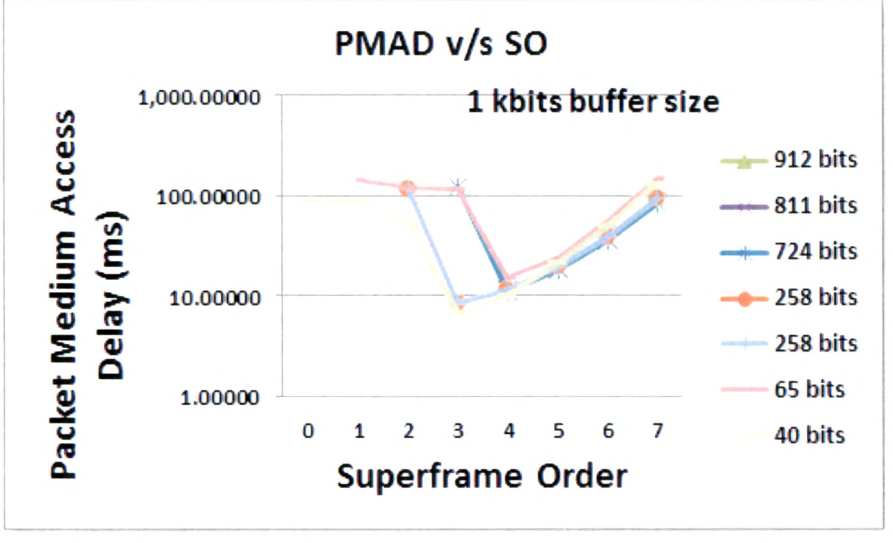

Figure 6.7 (b): PMAD v/s superframe order for 1 k buffer capacity

When SO increases, 0.001824 s inter-arrival time records a bigger range of Packet Medium Access Delay (PMAD) for both the cases (1kbits and 4kbits). This indicates the significant relationship of inter-arrival time, packet size and buffer size. As shown in Figure 6.7(a) and (b) initially PMAD is somewhat stable and then starts to decrease slightly. The point at which the PMAD decreases slightly indicates that the PMAD contribution originates from the long SD produced by the SO. The PMAD measurement is similar for the same SO regardless of the buffer size until it reaches that slightly decreased point. Also for higher SO values, all frames stored in the buffer and transmitted during one GTS and the delay grows with SO. For higher values of SO, delay will increase.

Readings for the PMAD for SO values at which SO is less than that decreased point, is not the same for each buffer size compared to the same scenario for inter-arrival of 0.001824s. Thus, with a high arrival rate, buffer size plays an important role towards packet end-to-end delay. For real-time traffic, the end-to-end delay is to be limited to a maximum of 250 ms.

WSN applications present real-time requirements such as bounded PMAD and high QoS sensitivity[16]. For instance, in voice communication, interactive voice requires PMAD latency of 250 ms or less, beyond which users notice a drop in interaction quality [19]. Similarly, video streaming over WSN requires a BER lower than 10^{-4} [20]. Inline with this, the IEEE 802.15.4 standard [1] provides GTS for resource reservation for those applications that have bandwidth requirements or low delay constraints.

6.7.4 Impact of the Superframe Orders on Wasted Bandwidth

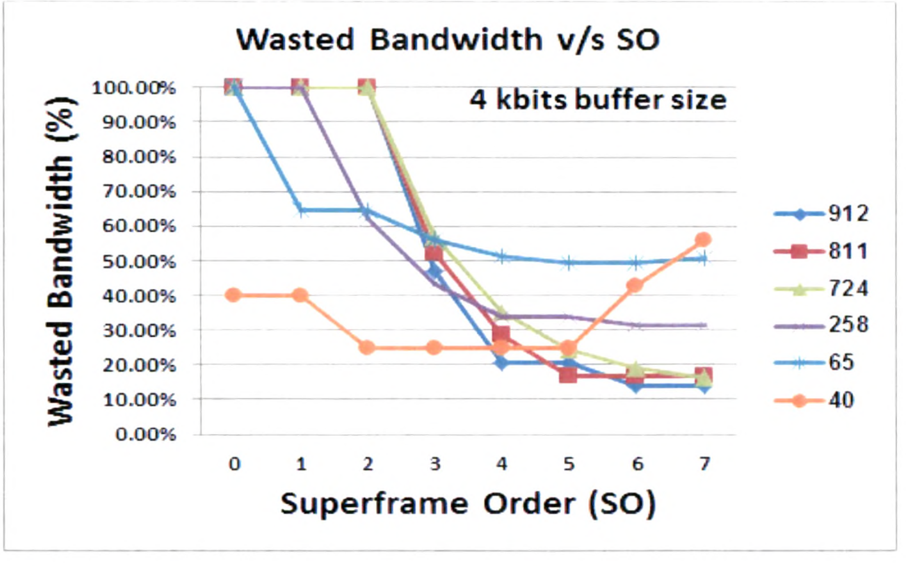

Figure 6.8: Wasted Bandwidth v/s superframe order for 4 k buffer capacity

Since the frames are transmitted without acknowledgement, the wasted bandwidth can only result from IFS or waiting for a new frame if the buffer is empty, as depicted in

Figure 6.3. Observe in Figure 6.8 that the wasted bandwidth is high for low superframe orders. This is due to the impact of IFS, since the time slot durations are too small to send high amount of data.

Also, the devices request for GTS allocation through the GTS request command by specifying the number of slots needed and direction of GTS transmission (from or to the coordinator). The GTS slots are allocated in every superframe so they consume a significant bandwidth of the superframe duration. Therefore, inefficient allocation of GTS can lead to significant loss of bandwidth and degradation of the overall system performance [7].

As discussed in chapter 5, Superframe structure is divided in 16 slots and PAN coordinator allocates the GTS slots to the standard slot duration i.e., SD/16 in superframe. Because of a small fraction of the allocated slot is used for data transmission, the remaining bandwidth is wasted in every GTS slot in every superframe for the application which consists low average packet arrival rate and low data payload. So for this, a proposed method having a modified superframe structure is used which main intense is to save the wasted bandwidth so that it will optimize the throughput.

In standard IEEE 802.15.4, T_S is defined as

$$T_S = SD/16.$$

While in new proposed method slot duration is considered half of the standard value,

$$T_S = SD/32.$$

Now one GTS allocation means it contains half time duration to transmit the data. This method can be applicable for the application which consist low average packet arrival rate and low data payload.

The proposed method is carried out in Matlab by modifying the superframe duration. The following Table 6.4 consists of the simulation parameters varied in simulation and measured parameter (Wasted Bandwidth), considering standard and modified structure.

SO	BO	Superframe Duration(SD)	Beacon Interval(BI)	Duty Cycle (%)	Time Slot Duration (TS)		Wasted Bandwidth	
					For Standard IEEE 802.15.4	For Modified Proposed Method	For Standard IEEE 802.15.4	For Modified Proposed Method
1	1	30.72	30.72	100	1.92	0.96	10.4167	4.6875
2	2	61.44	61.44	100	3.84	1.92	13.0208	5.20833
3	3	122.88	122.88	100	7.68	3.84	13.0208	6.51042
4	4	245.76	245.76	100	15.36	7.68	13.0208	6.51042
5	5	491.52	491.52	100	30.72	15.36	13.3464	6.51042
6	6	983.04	983.04	100	61.44	30.72	13.4603	6.67318
7	7	1966.08	1966.08	100	122.88	61.44	13.4847	6.73014
8	8	3932.16	3932.16	100	245.76	122.88	13.4725	6.74235

Table 6.4 Simulation Parameters and resultant parameter

Figure 6.9 shows the graphs comparing wasted bandwidth for different SO values in standard IEEE 802.15.4 and modified proposed method.

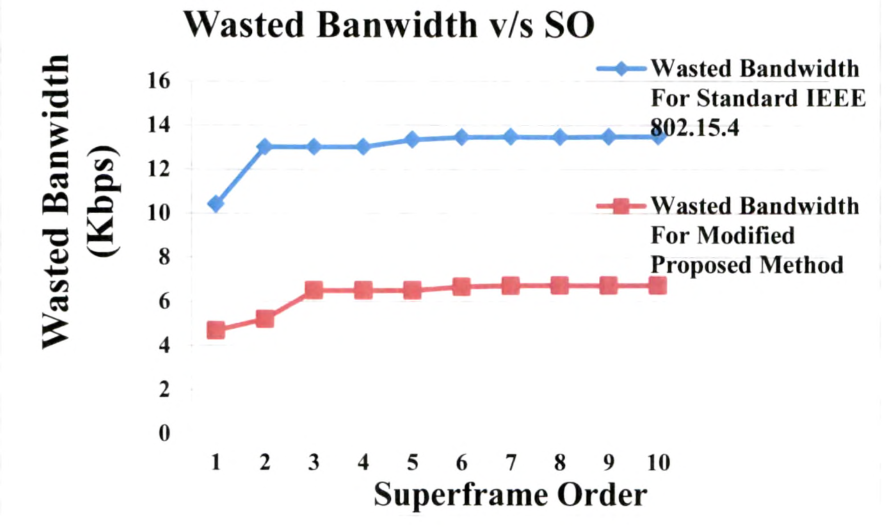

Figure 6.9: Comparisons of Wasted Bandwidth Results

From the Figure 6.9 it can be seen that in proposed method wasted bandwidth decreases compare to the standard IEEE 802.15.4. It is already discussed that the GTS allocation mechanism presents a worst behavior in terms of maximum throughput for different superframe orders due to a high amount of wasted bandwidth in large GTSs. Therefore, as wasted bandwidth decreases we get optimum throughput for a given GTS allocation. This can be used in the applications to wide variety of WPAN applications such as home automation, remote sensing where the devices in the network have a low average packet arrival rate, small payload and requires minimal dedicated bandwidth for contention free transmissions.

Summary:

In this chapter GTS (local) throughput and Global throughput for the WSN beacon enabled mode are evaluated for GTS Mechanism. The evaluation is performed using IEEE 802.15.4 OPNET simulation model. The maximum utilization of the allocated GTS is achieved for superframe orders SO= [2, 3, 4, and 5]. As inactive period increases, throughput decreases which is influenced by processing, transmitting, propagation, and queuing delays. The throughput can be increased by decreasing wasted bandwidth which occurs because of a fraction of the slot can be used during transmission of data. This can be resolved by splitting the slots which make superframe structure with 32 slots. This method can be applicable only for small data transmission which can accommodate with this new slot duration. If data is large which cannot accommodate with this modified slot duration then modified method may not give optimum solution.