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Robust Method of Power Saving Approach in Zigbee Connected WSN with TDMA

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Abstract: ***Wireless Sensor Network (WSN) is a network consists of individual nodes that are able to interact with their environment by sensing and controlling the physical parameters. In this network of wireless remote nodes Idle listening, Transmitting and Receiving are the major sources of power consumption. For investigating the power consumption several strategies are developed. In this paper, we are using IEEE 802.15.4 protocol for establishing the communication between these wireless sensor nodes. The IEEE 802.15.4 protocol is utilized as the communication protocols of Physical layer and MAC layer. The MAC layer provides the PSM by setting the two parameters Beacon Order (BO) and Super frame Order (SO) to achieve the low duty-cycle operation for the Zigbee network. Earlier, for reduction of the power consumption in wireless sensor networks we used the combination of Power Saving Mechanism (PSM) and Power control (PC) techniques in IEEE 802.15.4 protocol. We know that by using these techniques saves more power but lags in throughput. Because of the very large BO and small SO, obviously the throughput degrades. So to overcome this problem we add the TDMA protocol to this protocol. Then the results that will be obtained show the significant reduction in power consumption and increase in throughput due to the improved duty cycle.***

Keywords: Hybrid technique, PSM, PC, Power saving, Beacon Order, Super-frame Order, Zigbee, TDMA protocol

1. Introduction

Wireless sensor network is nothing but a communication mechanism. In this mechanism idle listening, transmitting and receiving are the main sources. In wireless sensor network applications, power consumption is mainly concerned. Consequently, several strategies have been proposed for investigating the power consumption of this kind of application. These strategies can help to predict the WSN lifetime, provide recommendations to application developers and may optimize the energy consumed by the WSN applications. By evaluating the power consumption, it is possible to estimate the application's lifetime, be aware of application's power consumption to adopt strategies to increase the network lifetime. Most of the energy is consumed in the wireless network interface, so many energy saving mechanisms work in this area [1].

In this paper, we proposed the reduction of power consumption at hybrid techniques and are implemented in IEEE802.15.4 protocol. The hybrid techniques are the combination of Power saving mechanism (PSM) and Power Control (PC) [2]. PSM is used for reduction of idle listening and also used in wireless networks like 802.15.4, 802.11 and 802.16. In PSM, the device enters into the sleep mode at some period of time then conserves the energy and also increases the network life time of entire network. PC is used for reduction of transmit power i.e. reduce the distance between transmitter and receiver then conserve the energy. In Earlier, by using these hybrid techniques gives better result for extent but lag in throughput. Eventually for getting the better result, a TDMA protocol is added with the 802.15.4 protocol to minimize the power consumption and to get the high throughput.

This paper is organized with seven sections. The first section provides an overview of wireless sensor networks related to power consumption. The second section will brief the survey on various power consumption techniques related to wireless sensor networks. Later, the third section will introduce the over view of PSM and PC techniques. After, the section will introduce the proposing system consisting of the hybrid power saving techniques, implemented on IEEE 802.15.4 protocol in combination with TDMA protocol. In the further section, the implementation of the proposed power saving techniques will be explained. In this sixth section, the simulated results using MATLAB will be provided. The final section gives conclusion regarding the implemented work.

2. Literature Survey

In recent years power management is the hot topic in WSN. This related work provides an overview of research work so far done by many researchers regarding the various issues of power consumption in WSN and various techniques adopted to minimize the power consumption.

Asama Alshaibi, Peter Vial and Montserrat Ros [1] have found that to increases the energy consumption, this paper gives an overview of several techniques used for wireless networks. We incorporated PSM and PC to gain the advantage of PSM (reduce idle listening) and PC (reduce receiving and transmitting power) and implemented them in the IEEE 802.15.4 protocol. The results show that the new hybrid technique saves more power than PSM and PC individually. Sidra Aslam et.al [2] have found that to increase the sensor node's lifetime, circuit and protocols have to be energy efficient so that they can make a priori reactions by estimating and predicting energy consumption. They presented and discussed several strategies such as power-aware protocols, cross-layer optimization, and harvesting technologies used to alleviate power consumption constraint in WSNs.

Giuseppe Anastasi et.al [3] has surveyed the main approaches to energy conservation in wireless sensor

networks and they have been devoted to a systematic and comprehensive classification of the solutions in the network. It mainly stressed on the importance of different approaches such as data-driven and mobility-based schemes.

Moslem Amiri et.al [4] has estimated lifetime bounds of a network of motes which communicate with each other using IEEE 802.15.4 standard. Different frame structures of IEEE 802.15.4 along with CSMA/CA medium access mechanism are investigated to discover the overhead of channel acquisition, header and footer of data frame, and transfer reliability during packet transmission.

Huan-Chao Keh et.al [5] has proposed an optimal sleep control mechanism. When the sensor nodes are set randomly in the entire network then determined the sleeping probability through the distance between the sensor node and the sink. This proposed mechanism will effectively reduce the frequency of the transmission of the sensor nodes more close to the sink and reach the loading balance of the whole network. However, the sleeping sensor nodes will process their sleeping schedule according to their own residual power and achieve the effectiveness of saving power.

Sandra Sendra et.al [6] have presented the main causes of energy loss in wireless sensor nodes and also they discussed about the main characteristics required to make a wireless sensor node and the factors to be considered when implementing a WSN or ad-hoc network and the energy wastage given by the electronic circuit. Finally, they show and compare several MAC and routing protocols that have been designed to optimize the power consumption.

F. Shebli, I. Dayoub and J.M. Rouvaen et.al [7] have proposed a method to calculate energy consumption within linear wireless sensor networks, according to the data flow rate, the number of nodes and the distance between them. Furthermore, they have succeeded in reducing energy consumption within linear sensor networks made up with nodes featuring differing data flow rates.

Yuhong Zhang and Wei Li et.al [8] have reported the results of the energy consumption of a WSN. By developing a stochastic model of the sensor node of WSNs and applying the stochastic method, they derived the explicit expression of the distribution of the number of data packets in a sensor node. Then determined several important performance matrices related to the sensor node's energy consumption. However, the energy consumption for transmitting the data packets depends on the rate at which data packets are generated, which means that transmitting high-density data requires the expenditure of more energy.

Najmeh Kamyabpour et.al [9] has presented a new approach for minimizing the total energy consumption of wireless sensor network applications based on the Hierarchy Energy Driven Architecture (HEDA). They identified the components of each constituent of HEDA and also extracted a model for each of the constituents and components in terms of their dominant factors (or parameters). They proposed a formulation for the total energy cost function in terms of their constituents.

Dimitrios J. Vergados et.al [10] has proposed a Scheduling Scheme for Energy Efficiency in Wireless Sensor Networks. The basic concept of this scheme is to try to maximize the time each sensor node remains in SLEEP mode, and to minimize the time spent in IDLE mode, taking into account not only the consumed power, but also the end-to-end transmission delay.

3. Overview of PSM, PC techniques and 802.15.4 protocol

In this paper we are using the PSM and PC techniques for reduction of power consumption and are implemented in 802.15.4 protocol.

3.1 Power Saving Mechanism (PSM)

It is used in common wireless networks such as 802.11, 802.16 and 802.15.4. In these networks, the node or sensor is allowed to sleep for a period of time switching when the network is not in use then consume the energy [6].

3.1.1 Algorithm:
PSM stimulates that the time be divided into beacon intervals, with the start of the beacon interval being synchronized at all the nodes. Each node remains awake for a short interval at the start of the beacon interval. This short interval is called the ATIM window. ATIM is the abbreviation of ad hoc traffic indication map. The power save protocol consists of the following steps:

a) At the start of beacon interval, the node X has packet to send to another node Y, then the node X transmits the ATIM REQ message to node Y by using ATIM Window.
b) If the node Y receives the ATIM REQ message from the node X then node Y responds immediately sending the ATIM ACK to node X.
c) If any node i.e. X or Y does not send or receive any REQ message then a node got sleep mode for the rest of beacon interval.
d) Any node that has transmitted or received an ATIM REQ message during ATIM Window will stay awake for the rest of beacon interval. Such node may transmit and receive data during rest of beacon interval.

If wireless interface at a host or a node is asleep during a beacon interval, and the host receives a packet to send to another node, the packet must wait until the next beacon interval. Thus, with the power save mechanism, delays comparable to a beacon interval may be incurred before a packet is transmitted from a node to its neighbor.

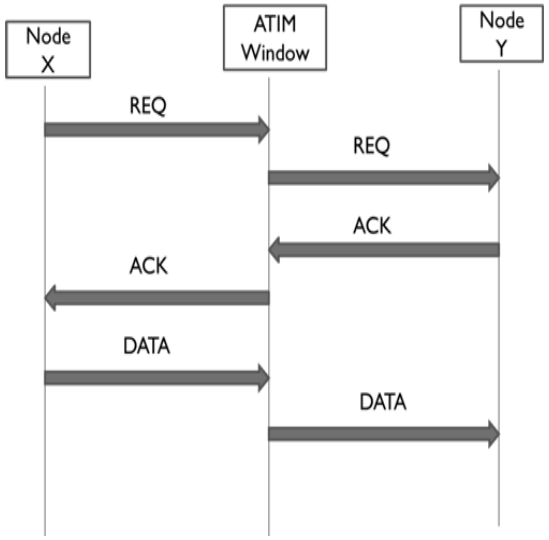

Figure 1: PSM algorithm

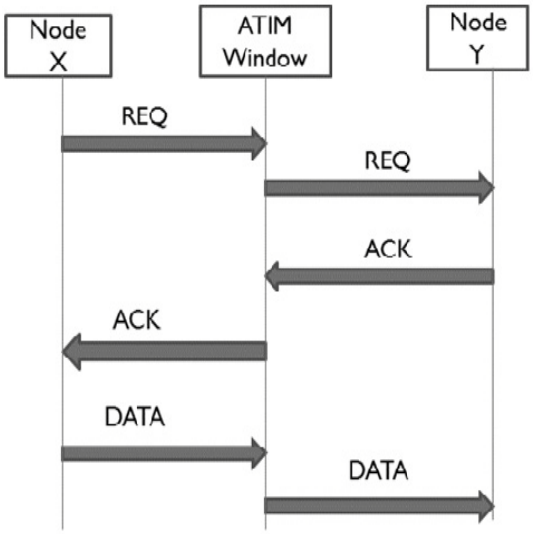

Figure 2: PC algorithm

If a packet must be forwarded on multiple hops, the delay can increase in proportion to the number of hops. All nodes remain awake during the ATIM window, which can result in significant energy consumption. For instance, if ATIM window duration is 20ms with the beacon interval being 100ms, then each node may sleep for at most 80% of the time.

3.2 Power Control (PC):

It is used to change the transmit power according to the distance between the transmitter and receiver to reduce the consumption of energy.

3.2.1 Algorithm:

The energy consumption during the ATIM window can be reduced by reducing the duration of the ATIM window [6]. However, a shorter ATIM window allows less time for exchanging the ATIM request packets. If a node is not able to send an ATIM request to another host (due to contention during the ATIM window) then the packets at the host will incur longer delay. Alternatively, energy consumption may be reduced by using a larger beacon interval. However, in this case, delay in delivering the packets will increase. Thus, the suitable choice of the ATIM window and the beacon interval depends on the delay requirements, as well as the frequency with which the nodes in power save mode need to transmit packets.

We combine these two techniques (PSM and PC) together to have the advantage of sleep mode and the advantage of the power control. By using these hybrid techniques i.e. PSM and PC gives better result for extent but lag in throughput. Fig.4 shows the combination of PSM and PC. Eventually for getting the better result, a TDMA protocol is added with the 802.15.4 protocol to minimize the power consumption and to get the high throughput.

3.3 IEEE 802.15.4 Protocol

IEEE 802.15.4 protocol is used for establishing the communication between wireless sensor nodes. The IEEE 802.15.4 protocol is utilized as the communication protocols of Physical layer and MAC layer. The MAC layer provides the PSM by setting the two parameters Beacon Order (BO) and Super frame Order (SO) to achieve the low duty-cycle operation for the Zigbee network.

The beacon interval (BI) which is also known as super frame length and the length of active part called super frame duration (SD) is defined as follows:

BI = a Base Super-frame Duration × 2BO, $0 \leq BO \leq 14$.

SD = a Base Super-frame Duration × 2SO, $0 \leq SO \leq 14$.

Where, a Base Super-frame Duration, the number of symbols forming a super frame when the super frame order is equal to 0, is 960 symbols.

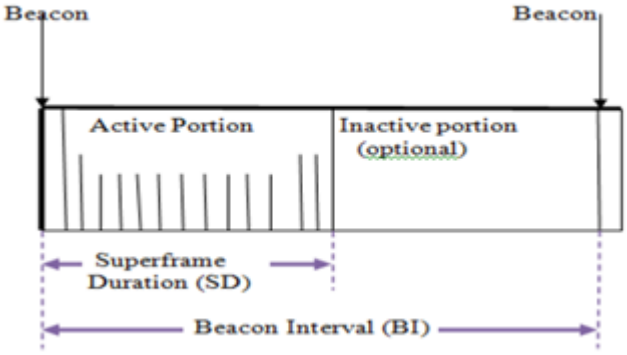

Figure 3: Beacon interval and Super frame structure

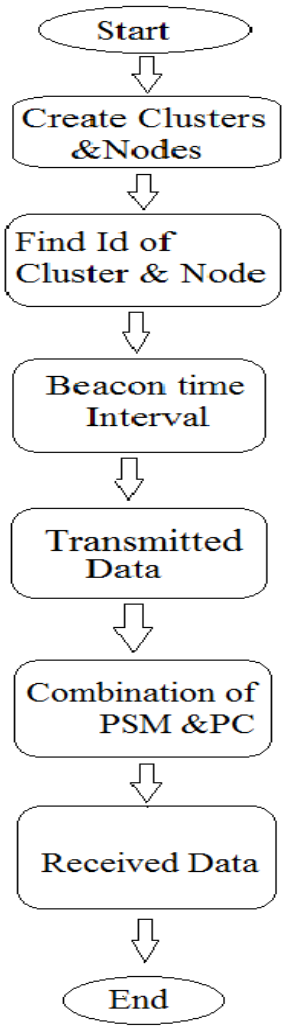

Figure 4: combination of PSM and PC

4. Proposed System

In this paper, we proposed the hybrid power saving techniques with TDMA for the reduction of power consumption in wireless sensor network. First of all for communicating the two mediums are considering the sensor node. Sensor node consists of four main components at fig.4 a sensing units, processing unit, transmission unit, and power unit. They may also have application-dependent additional components such as position/location finding systems, power generator, and mobilizer. Fig.5 shows the sensor node architecture.

- **Sensing unit,** are usually composed of two subunits: Sensors and ADC (Analog to Digital Converter). The Analog signals produced by sensors based on the observed phenomenon are converted by ADC to digital signal and fed into the processing unit to be processed.
- **Processing unit,** generally associated with storage unit, manages the procedures that make the sensor node collaborate with other nodes to perform the assigned sensing tasks.
- **Transmission unit** that connects the sensor node to the network.
- **Power unit** may be supported by a power scavenging such as solar cells. Since most of the sensor network routing techniques and sensing tasks require knowledge of location with high accuracy, thus it is common that a sensor node has a position/ location finding system.
- M**obilizer** is needed to move sensor node to carry out the assigned tasks.

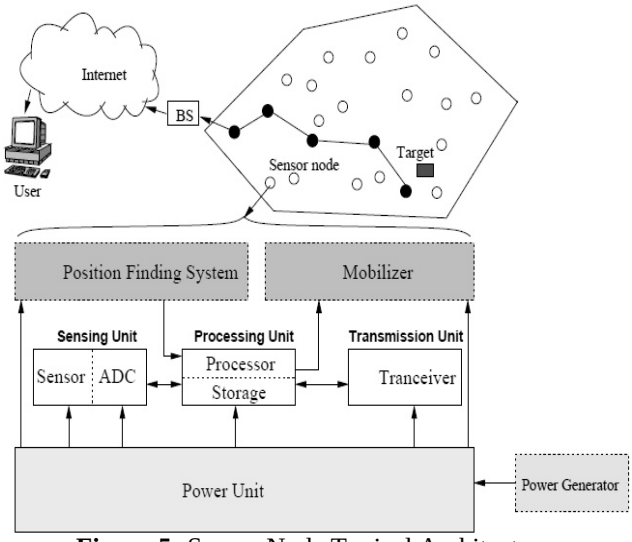

Figure 5: Sensor Node Typical Architecture

5. Implementation

In this paper, earlier Asama Alshaibi et.al [1] proposed the hybrid power saving techniques for reduction of power consumption. Here the hybrid techniques are nothing but Power Saving Mechanism (PSM) and Power Control (PC) and are implemented in IEEE 802.15.4 protocol. These two techniques reduced more power individually for extent but by using these techniques reduced more power consumption but lag in throughput. Fig.4 shows the combination of PSM& PC.

For obtaining better result by using 802.15.4 with TDMA, to implement this technique first of all we defined the cluster ID & members and also nodes. And then decides the beacon interval and data length i.e. how much data is transmitting and receiving and also distance between them. After we are transmitting the data at the combination of PSM & PC then we obtain the result as lag in throughput. So overcome these problem, we are adding the TDMA to 802.15.4 protocol then we obtain the better result such as high throughput and reduction of more power consumption. Fig.6 shows the combination of PSM & PC with TDMA.

In this implementation part first of all we are finding the clusters and nodes for communicating at PSM and PC. In PSM the communication done slowly compare to PC. The power control scheme is the one of the protocols that is used to save energy at nodes or sensors. As it is mentioned in the introduction section, before transmitting or receiving any data, a handshake must take place between sender and receiver. This process is done by using MATLAB 2012.

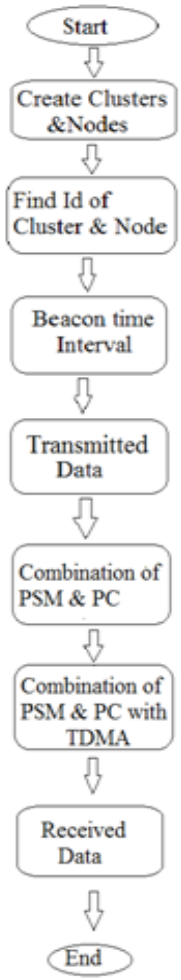

Figure 6: combination of PSM and PC with TDMA

6. Simulation Results

The simulation results is presented in this paper, have been obtained by using the matlab-2012 software In this thesis, for reduction of the power consumption in wireless sensor networks, we adopted the method of hybrid power saving technique i.e. a combination of Power Saving Mechanism (PSM) and Power Control (PC).These two techniques are implemented in IEEE 802.15.4 protocol.

Efficient power saving is observed by implementing this technique but with a drawback of decrease in throughput. So to overcome this drawback, the hybrid power saving technique is enhanced by adding a TDMA protocol in IEEE 802.15.4 protocol. Then the results are obtained showing significant reduction in power consumption and increase in throughput. Fig 7, 8, 9 are the combination of PSM and PC results and fig 10, 11, 12, 13are the combination of PSM and PC with TDMA results are Comparing one to another we obtained that the significant reduction in power consumption and high throughput.

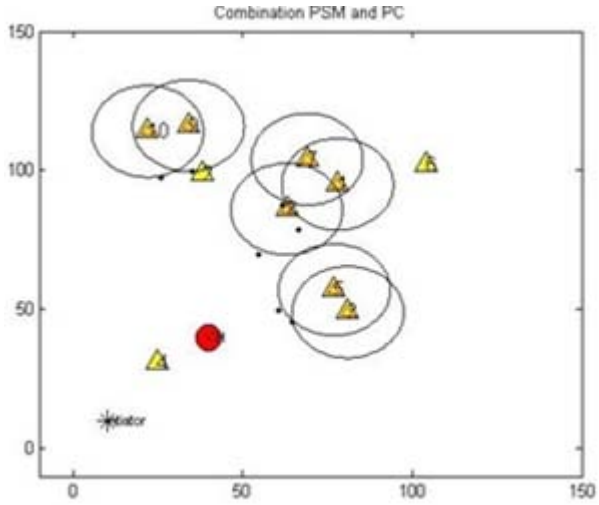

Figure 7: Combination of PSM & PC

Fig.7 shows the information about the connecting the nodes and channels and also transmitting data at the combination of PSM & PC.

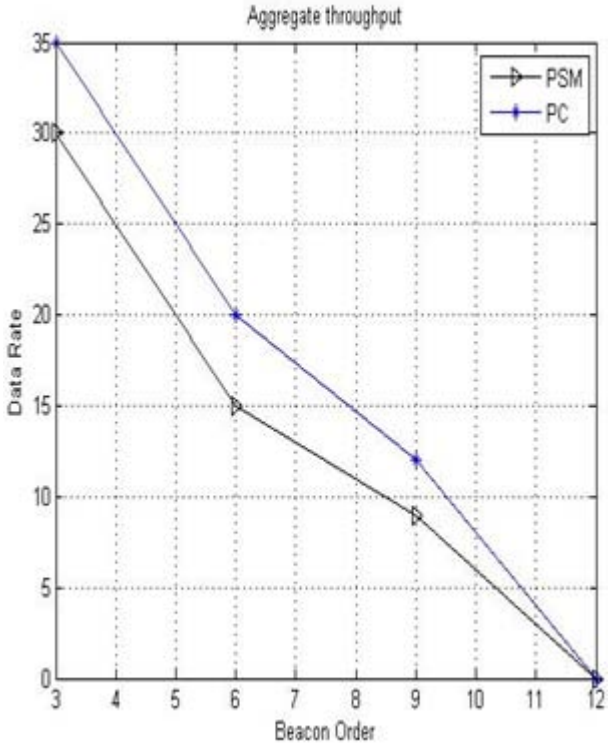

Figure 8: Aggregate Throughput at PSM & PC

Fig.8 shows the information about the aggregate throughput at combination of PSM & PC. Here when the BO is increases data rate is decreases.

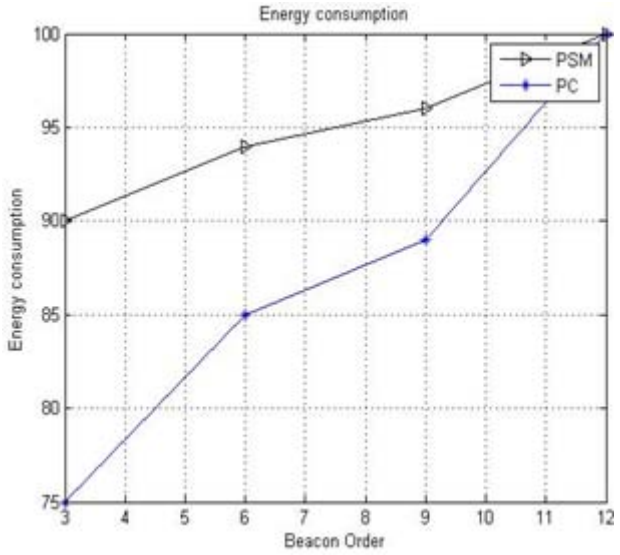

Figure 9: Energy Consumption at PSM & PC

Fig.9 shows the information about the energy consumption at combination of PSM & PC. Here BO is increases remaining energy is decreases.

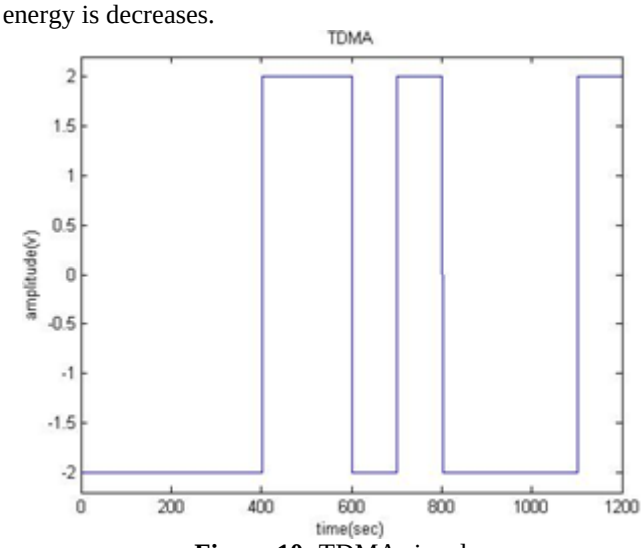

Figure 10: TDMA signal

Fig.10 shows the information about the transmitting the data in preferred time slot i.e. within slot data is transmitting.

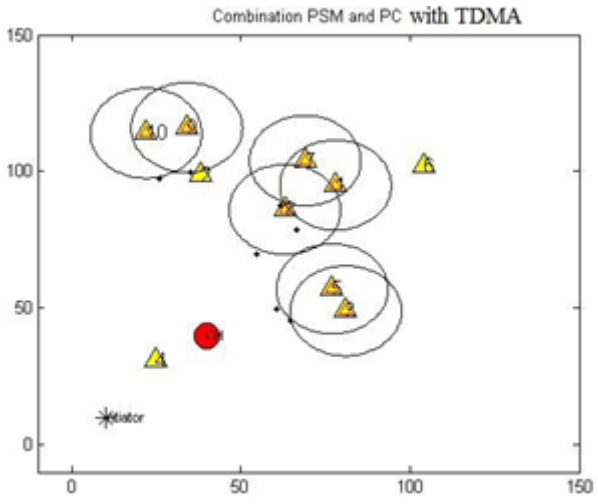

Figure 11: Combination of PSM & PC with TDMA

Fig.11 shows the information about the connecting the nodes and channels and also transmitting data at the combination of PSM & PC with TDMA

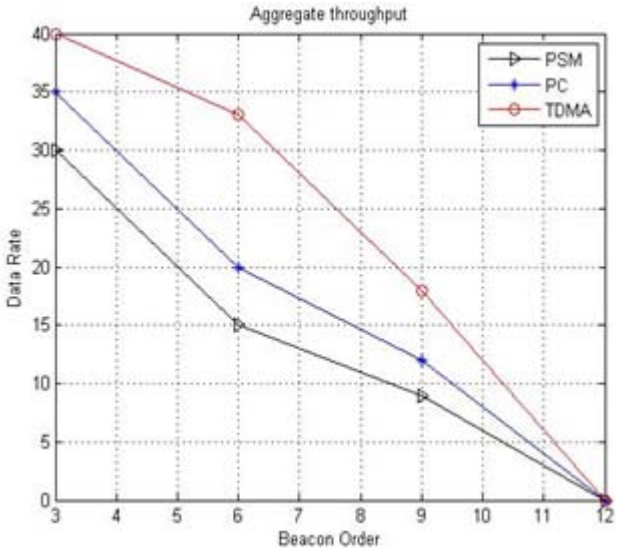

Figure 12: Aggregate Throughput at PSM & PC with TDMA

Fig.12 shows the information about the aggregate throughput at combination of PSM & PC with TDMA. Here when the BO is increases data rate is decreases than PSM & PC.

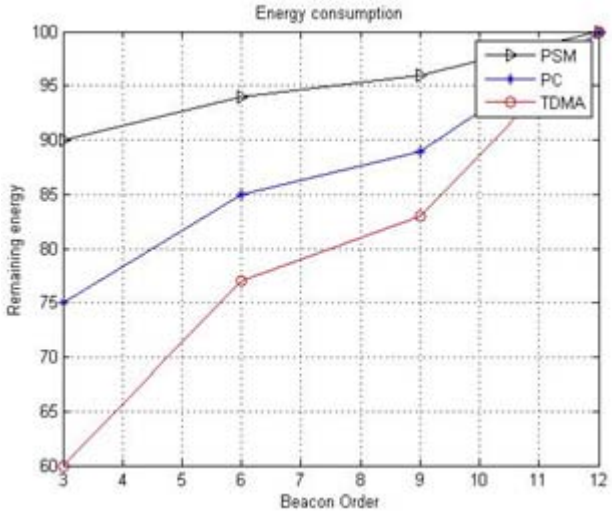

Figure 13: Energy Consumption at PSM &PC with TDMA

Fig.13 shows the information about the energy consumption at combination of PSM & PC with TDMA. Here BO is increases remaining energy is decreases than PSM & PC.

7. Conclusion

In this thesis, a robust hybrid power saving mechanism has been implemented to reduce the limitation of power consumption in wireless sensor networks. Here we are using IEEE 802.15.4 protocol for establishing communication between wireless sensor nodes. We know that the individual methods like PSM and PC techniques are used for reducing the power consumption. But the combination of PSM and PC techniques saves more power than individual i.e. the combination of PSM and PC gives improved performance in terms of conserving power but lag in throughput. So to

overcome this problem we included the TDMA protocol to the IEEE 802.15.4 protocol. By adding TDMA protocol we obtained an extent result compare with combination of PSM and PC i.e. significant reduction in power consumption and improvement in throughput.

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