WiseMAC Protocol for Wireless Sensor Network-An Energy-Efficient Protocol

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Technology

In

Communication and Networking

By

Anuj Kumar

Roll No: 212ec5173

Department of Electronics & Communication Engineering

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Under the guidance of

Prof. Poonam Singh

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CERTIFICATE

This is to certify that the thesis entitled, "**WiseMAC Protocol For Wireless Sensor Network-An Energy Efficient Protocol**" submitted by ANUJ KUMAR in partial fulfilment of the requirements for the award of Master of Technology degree in **Electronics and Communication Engineering** with specialization in "**Communication and Networking**" during session 2012-2014 at National Institute of Technology, Rourkela (Deemed University) and is an authentic work by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other university/institute for the award of any Degree or Diploma.

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ABSTRACT

Wireless Sensor Networks are very useful in case of distance or unreachable areas. WSN are having large number of nodes (sensors) which are randomly distributed. These sensors are primarily used to process data and connected through wireless channel. The processing, transmission and reception and sensing the channel need power. This power is given to nodes by their batteries. So the problem in front of us is to reduce power consumption by these nodes. Some areas are very far and some areas are unreachable like valley or hill areas. Thus it is not possible in some cases to replace or change the battery. Our focus is to make a protocol which makes these nodes work with lesser battery power. There are so many MAC layer protocols which work for this purpose but they too are not energy efficient. These protocols are based on CSMA. Here in this report we have proposed WiseMAC protocol which is also based on CSMA but with preamble sampling. This protocol shows very good reduction in power consumption. For this we used some more schemes with the existing WiseMAC protocol, these schemes are more bit and extended more bit. Our WiseMAC protocol is an asynchronous protocol and works very well in case of adaptive traffic conditions. To make WiseMAC energy efficient we are here focusing to reduce preamble sampling duration and this done with reducing duty cycle and contention window of our proposed protocol. As we have implemented Adaptive WiseMAC protocol so we are focusing that this will help in body are network (BAN) for medical purposes. Although a lot of works have been done but still more work has to be done.

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INTRODUCTION

1.1 WIRELESS SENSOR NETWORK

In a Wireless sensor Network there are a number of sensor nodes which are distributed randomly over an area or a place or a location (e.g. buildings, farmer fields) in order to collect information and proceed it. These wireless sensors are connected and communicate with each other in a random and multi-hop fashion. They collect the information and pass it to the next hop (sensor). In this way the information is reached to the server and appropriate action took place. Wireless sensor network may also use the satellite in a case. There are lots of applications where we can use wireless sensor network like environmental monitoring, in home and building automation to industrial control. But the problem with sensor network is that when we are using them in outfields (e.g. valleys or hills area) is related to the battery. Because whenever the battery discharges we are not able to replace it or recharge it so to avoid or minimize this problem we have to focus on minimizing the energy extracted from a battery. In a sensor node there are three main functions which consume the energy most – (1) sensing, (2) computation, (3) radio operation. Radio operation means transmitting the collected information. The major part of energy loss comes from transmitting.

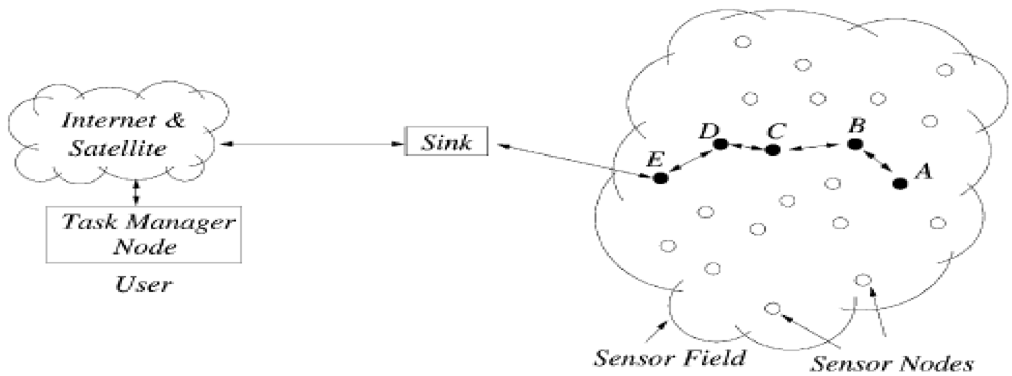


Figure 1 Wireless Sensor Network

This energy consumption can be reduced at protocols level. There has been a lots of protocols implemented for this purpose. But when we compare these protocols with WISE-Mac protocol we see the advantages of wise-mac over those. What wise-mac does it reduces the wakeup time of sensor nodes. Whenever a node is not in a sending or receiving mode wise-mac turns it in sleep mode to save energy [1].

Besides this a sensor node must be small in size, have less memory requirement, avoids collisions, use for single application, and also be able to tolerate a change in radio frequency and in environment conditions.

1.2 DIFFERENT MAC LAYER PROTOCOLS

In recent years, several energy-efficient MAC protocols are planned to boost the lifetime of sensor networks by reducing the energy consumed by idle listening and overhearing. The idle listening downside refers to a node listening to the channel even supposing there are not any radio transmissions to receive [8]. The overhearing downside refers to a node receiving a packet it's not supposed to receive. MAC protocols are primarily divided into 2 sorts. These are synchronous (or slotted) and asynchronous (or random access) MAC Protocols. Synchronous mac Protocols are referred to as Schedule-Based or Slotted MAC Protocol. Unnecessary power consumption takes place on synchronization message exchanges. Schedule based medium access protocols are generally need a mechanism to determine a non-conflicting schedule control which participant could use which resource at which time.

Schedule are often mounted or computed on demand. Time synchronization is required and time is split into slot. SMAC, T-MAC, SCPMAC are example of synchronous mac Protocols. Asynchronous mac Protocols are referred to as Contention-Based or Random Access mac Protocols. Here randomization is used. Nodes don't synchronize time and contend for access to the radio channel. To cut back idle listening, protocols during this category shift the costs from the receiver to the sender by extending the mac header (i.e., the preamble), it permits nodes to visualize or check the channel periodically and sleep most of the time. Low Power Listening (LPL) can also be referred to as Preamble sampling BMAC, XMAC, WiseMAC, and C-MAC are come in the category of asynchronous mac protocols. Among all of those mac protocols WiseMAC is one in all the foremost energy economical protocol utilized in Wireless sensor Networks.

1.3 Reason of Energy Waste in MAC

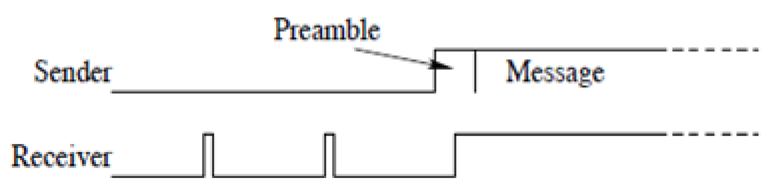
1. **Collision**: once a transmitted packet is corrupted it's to be discarded, and therefore the retransmissions of packets increase energy consumption.

2. **Control Packet Overhead**: transmitting and receiving control packets consumes energy too, and less useful information packets are often transmitted.
3. Idle Listening: continuously listening to the all the traffic further consumes energy of sensor nodes.
4. **Overhearing**: which means that a node picks up packets that are destined to different nodes will unnecessarily consume energy.

5. **Over emitting**: this is often caused by the transmission of a message once the destination node isn't prepared.

1.4 What is WiseMAC?

WiseMAC is predicated on the preamble sampling technique [1]. This system consists in often sampling the medium to visualize for activity. By sampling the medium, we tend to mean taking note of the radio channel fora brief length, e.g. the length of a modulation image. All detector nodes during a network sample the medium with identical constant amount TW. Their relative sampling schedule offsets are independent. If the medium is found busy, a detector node continues to listen till an information frame is received or till the medium becomes idle once more. At the transmitter, a wake-up preamble of size up to the sampling amount is additional before of each information frame to make sure that the receiver are going to be awake once the info portion of the packet arrives. The WiseMAC scheme has a very small periodic wakeup's and duty cycles which is very small in time to sense the carrier for a preamble signal, as shown in fig.2



WiseMAC: a short preamble in sync with the receiver's sampling schedule.

Figure 2 Preamble Sampling

The receiver does not go into the sleeping mode while sensing the medium at the time when it sense that medium is busy. The medium have been sampled by all the nodes in network with a period of time T. but they sample the medium at different time instances or we can say that the instances of taking samples are random and independent of each other.

If a node listen that the medium is busy while it is waking up then it continues to listen until it does not get the whole data packets or the medium becomes idle again [3]. Every node has their own wake up pattern and it is independent of each other, in order to get the pattern knowledge of their neighbor, the node send a preamble of time duration T. after receiving the preamble the receiving nodes send back its wake up pattern details to the sender node in a acknowledge packet. Which is now used to update the table contains by node. So in this way a node is now able to have knowledge of their neighbor's wake up pattern. This table now helps the node to know at which instances the neighbor nodes will be in their wake up mode and thus is able to minimize the preamble length of all the upcoming frames. Again the table is updated correspondingly.

So using this scheme we have very low power consumption in case when channel is idle. The main disadvantages of this WiseMAC protocol is that it's having very small throughput because of long wakeup preamble and also consumes very large power at the time of reception and transmission. The power consumption is not only due to the desired destination node but also by the nodes which are in listing mode and overhearing the transmission. Our further approach is to reduce this preamble length.

Advantages of WiseMAC:

1) The performance of WiseMAC is better than that of S-MAC in various traffic rates.
2) Because of low power consumption it provides a very long life to the battery.
3) In dynamic traffic it is having a very good throughput.
4) The external need of synchronization can be eliminated because it can handle the clock drift in good way.
5) Different protocols can be easily combined with it if necessary.

Disadvantages of WiseMAC:

1) Sleep, wake up and listing modes are not properly schedule in WiseMAC protocol results in power consumption to update the table again and again.
2) Sometimes the broadcast packets are buffered for neighboring nodes and delivered many times when they comes in wake up mode, so this will consume power.
3) It also suffers the hidden terminal problem, due to which it is facing problem of packet collision.

CHAPTER: 2

LITERATURE SURVEY

[1]Title: WiseMAC: An Ultra-Low Power MAC Protocol for Multi-hop Wireless Sensor Networks.

Publication: Amre El-Hoiydi and Jean-Dominique Decotignie, Computers and Communications 2007, Proceedings, ISCC 2007, Ninth International Symposium Volume 1, Issue, 28 June-1 July 2007 Page(s): 244 - 251 Vol.1

Paper Detail: This paper gives knowledge about energy efficiency property WiseMAC protocol on MAC layer in wireless sensor network. It further tells about the preamble techniques used for packet transmission and reception and visualize how it works.

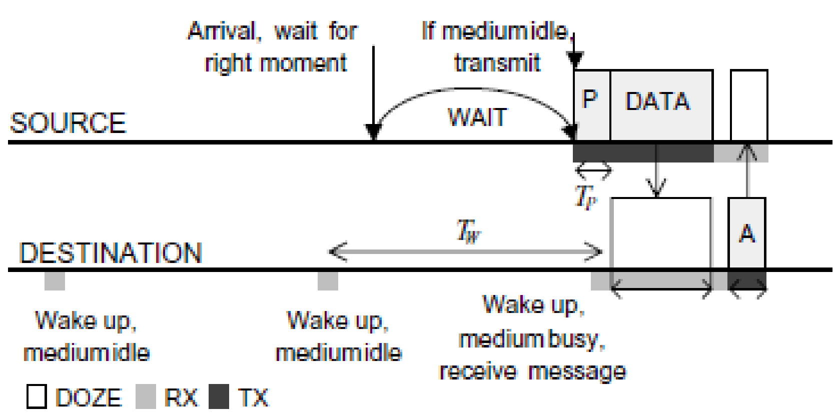


Figure 3 WiseMAC wake-up Preamble

Here WiseMAC shown as a protocol which is capable of reducing power consumption in reception and transmission at the time of overhearing. It is being described by the author that WiseMAC does not required setup signaling, synchronization and it is also adaptive in nature for change in traffic. When traffic is low it provides very small power consumption and when traffic is high it shows very high energy efficiency. You can also find a comparison of energy efficiency of different protocols like WiseMAC, T-MAC and S-MAC.

Implementation Details:

WiseMAC gives many characteristics to the WSN. It is easier to work with WiseMAC because it does not required synchronization. It is very good in changing traffic condition. When traffic is low it provides very small power consumption and when traffic is high it shows very high energy efficiency. Battery's life increases because of efficient utilization of channel. Wise Mac can be combined with different protocols in various applications of WBANS.

This paper also provides you the simulation part so you can analyze the performance of the WiseMAC protocol. This paper follows to topologies one is regular lattice topology and another is sensor network topology. In first one the traffic or information is being proceed by in parallel while in second one the traffic or information is being proceed randomly though the sensors.

Understanding:

- ✓ With increase in traffic the power is consumed by the S-MAC and T-MAC increases, they consume 7 times more power than WiseMAC.
- ✓ The life time of a node when using WiseMAC as a protocol can be of five years when traffic rate is one packet per 100 seconds.
- ✓ WiseMAC shows highest efficiency when traffic increase because the length of the preamble becomes small.
- ✓ WiseMAC shows energy efficiency above of 80% while the rest of the protocols show the energy efficiency below of 50%.

[2]Title: Increasing Throughput for WiseMAC.

Publication: Philipp Hurni and Torsten Braun, IEEE/IFIP WONS 2008, Garmisch-Partenkirchen, Germany, January 23 - 25, 2008.

Paper details: This paper focuses on the extension of more bit scheme by working with the duty cycle of WiseMAC in high traffic condition. In this way the duty cycle becomes adaptive in nature. In this scenario when the traffic is high, all nodes will awake for a longer time compared to the normal condition and all nodes will not go into the sleeping mode until all the traffic will be processed. So in this way the more bit scheme is modified to a stay awake promise bit scheme.

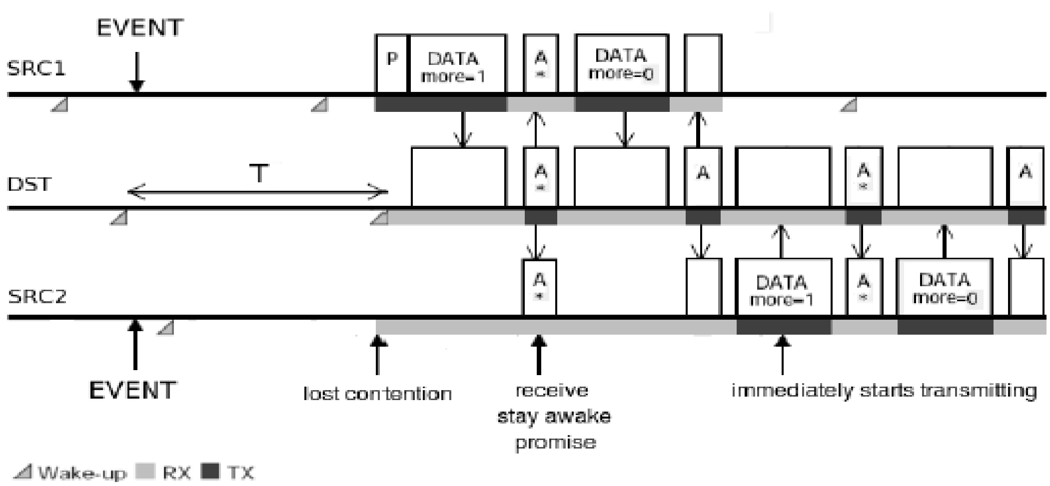


Figure 4 Extended more bit scheme

Implementation Details:

- In this paper the author comes with an example of 90 nodes in an area of 300metre x 300metre. Poisson model is used to generate the traffic at each node and sent towards a single sink.
- Paper uses shortest path routing. Each node comes up with a time interval of T=250 between two wakeups and duty cycle of 5%.

Advantages:

- Using this scheme WiseMAC shows better results in terms of suitability and energy efficiency compared to all other exiting protocols.
- Adaptability of duty cycle; this makes the WiseMAC protocol adaptive in case of different traffic conditions. Like in case of no traffic the energy consumption is very low. While in case of linear increase in traffic the WiseMAC change itself to the traffic condition by changing its duty cycle.
- The benefits of this scheme are throughputs, packets loss and delay.

Disadvantage:

- This scheme is very good when there is transmission of busts of packets but in case of single packet transmission it is failed.

[3]Title: Evaluation of WiseMAC on Sensor Nodes.

Publication: Philipp Hurni and Torsten Braun, Universität Bern, Switzerland, LNCS, IEEE, ACM, 2008.

Paper details: This paper will gives you a brief detail on more bit scheme in WiseMAC and also it focuses on the adaptability of its duty cycle in case of high traffic. The author compares the energy efficiency conditions for original and extended more bit scheme with the help of simulation.

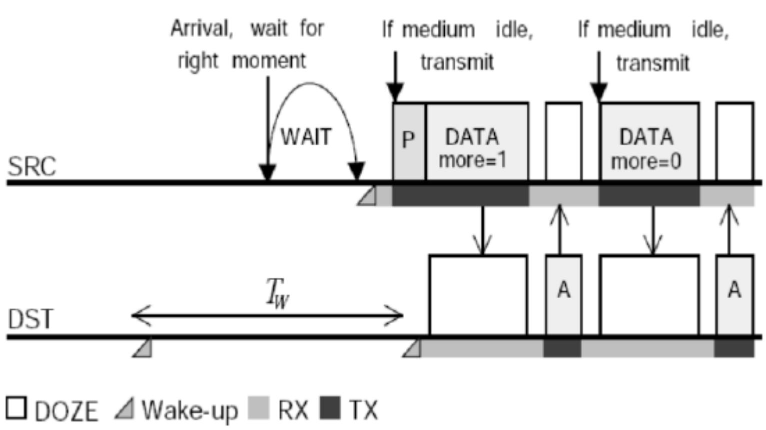


Figure 5 more bit scheme

Implementation details:

- The author uses OMNET++ simulator to show the performance of new scheme.
- Both the schemes are implemented on embedded sensor board (ESB).

Advantages:

- A comparison between WiseMAC and CSMA gives you an idea of that the life period of battery can be increased by approximately 120% in case of WiseMAC because in CSMA protocol the nodes are always in receiving mode and do not go in sleep mode.
- The extended more bit scheme gives you an increase throughput of about 20 % compare to the original scheme.

Disadvantages:

- This paper demonstrates only two schemes to improve throughput.

[4]Title: FM-UWB and WiseMAC-HA for Medical BAN Applications.

Publication:J. F. M. Gerrits, J. Rousselot, J. R. Farserotu, C. Hennemann, M. Hübner, J.-D. Decotignie, CSEM Scientific and Technical Report 2009.

Paper details: In this paper sensor node has been described with an application which is so called body area network (BAN). It has been shown that sensor nodes can also be used in medical field. Author also discussed about ultra-wide band communication system. It has been told that UWB system has a low specific absorption rate, low power consumption and can be work well with the exiting wireless network. To implement these requirements Swiss Center for Electronics and Micro technology (CSEM) has developed a dual-mode protocol, so called WiseMAC-High availability (HA).

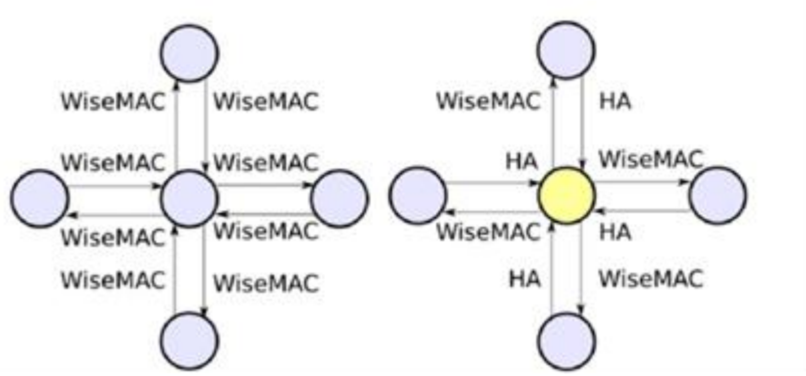


Figure 6 Possible Network Configuration of WiseMAC-HA

Implementation Details:

- In this for contention resolution a back off algorithm is used so that independent network can be implemented.
- Also gives a comparison between WiseMAC and WiseMAC-High availability (HA).

Advantages:

- This protocol exhibits low power consumption and low latency.
- It also offers flexibility and scalability.

Disadvantages:

- This protocol is only limited to the Body Area Network thus it do not find any other application in which it can be used.

[5]Title: Improving Unsynchronized MAC Mechanisms in WSN.

Publication: Philipp Hurni and Torsten Braun, IEEE/IFIP WONS 2008, Institute of Computer Science and Applied Mathematics, University of Bern, 2008.

Paper details: In this paper the Author has discussed how an unsynchronized power saving can be done and can be applied to the WSN. There are so many MAC protocols which do not require synchronization in wake-up pattern and in the same way the author has tried to improve these protocols at power level. Further this protocol has been tested in ad-hoc wireless sensor network to see the outcomes.

Implementation Details:

- In this scenario the nodes have been created in a multi –hop wireless ad-hoc sensor network and maintain 2 wake-up and 2 sleep periods in one cycle duration.
- Here the OMNET++ has been used for simulation purpose. This simulator uses the mobility network so that it can handle both the wireless as well as mobile networks within OMNET++.
- In this paper WiseMAC is implemented in a way that it will make a node in sleep or receiving mode periodically, and no need of synchronization other than updating the table.

Advantages:

- Thus author has combined his ideas with the previous work on unsynchronized MAC protocols for WSN. After reading and understanding this paper we come with an improvement in energy consumption, latency, and throughput.
- This paper shows an energy efficiency of WiseMAC protocol above 80%. This is further very large compare to other MAC protocols.

Disadvantages:

- This paper shows that with increase in traffic leads to the fairness problem in the network.

[6] Title: **On the Best Way to Cut a Body Area Network's Wires.**

Publication: Jérôme Rousselot, Jean-Dominique Decotignie, CSEM , Real-Time Software & Networking, CSEM Neuchâtel, Switzerland.

Paper Details: in this paper author has described that in sensor network we are eliminating the wire damage risk and also discussed that the wireless sensor network has been used in many areas. In wireless sensor network the nodes are connected by wireless data links. It's also evaluated the together functioning of physical layer and the MAC layer protocols. This further gives the detail about the power efficiency, latency and packet loss during transmission.

Implementation Details: WiseMAC protocol does one thing, it make the nodes in sleep mode most of the time. As we know that the wake up time of each node is asynchronous but periodic. WiseMAC reduces the cost of transmission and reception. As we are using WiseMAC we are definitely getting an advantage of power saving because unnecessary wake up of a node is being minimized by this protocol. The battery life increases and for years we do not need to change or replace a battery.

- This paper covered some health parameter like-core body temperature, pulse oximetry, activity and respiration.
- In the network there are four nodes organized in a star topology and each node is capable of collect all the data. Out of four three sensors create activity and respiration information and the fourth one is used to generate core body temperature.
- OMNET++ has been used here for simulation purpose.

Advantages:

- This paper is basically gives three solution to the BAN (Body Area Network). Low power WiseMAC protocol with a narrow band radio transceiver and an FM-UWB transceiver are two solutions. In third solution we combined an IEEE 802.15.4A UBW-IR PHY with WiseMAC protocol.

Disadvantages:

- This paper further focuses on the BAN application and all the performance of network using WiseMAC and WiseMAC protocols is restricted to this application of BAN.

[7] Title: **Energy Saving in MAC Layer of WSN: a Survey.**

Publication:A Roy and N Sarma, “National Workshop in Design and Analysis of Algorithm (NWDAA)”, Tezpur University, India, 2010”.

Paper Details: In this paper author has defined some MAC protocols which are energy efficient for wireless sensor network and tried to improve their methods of energy improvement. Paper further tells about wireless sensor network and different MAC protocols and also tells about the different reasons of energy wastage and try to focus on them. Finally it provides the comparison between different MAC layer protocols on the basis of energy consumption. Here are the MAC protocols which are being defined under this paper:

Sensor-MAC (S-MAC), Timeout-MAC (T-MAC), Berkeley-MAC (BMAC), X-MAC, convergent-MAC (C-MAC), WiseMAC

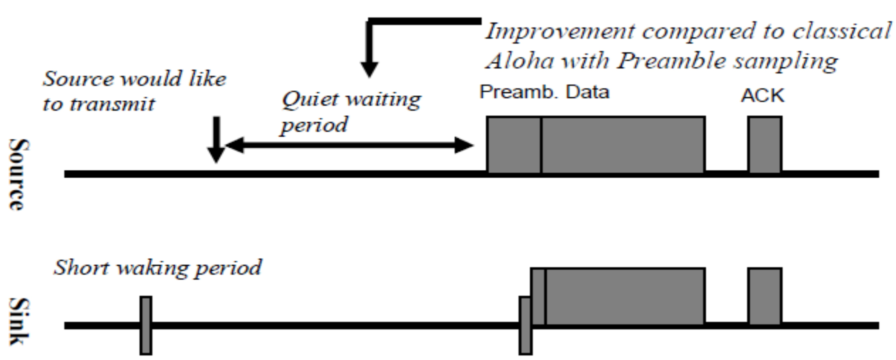


Figure 7 WiseMAC protocol

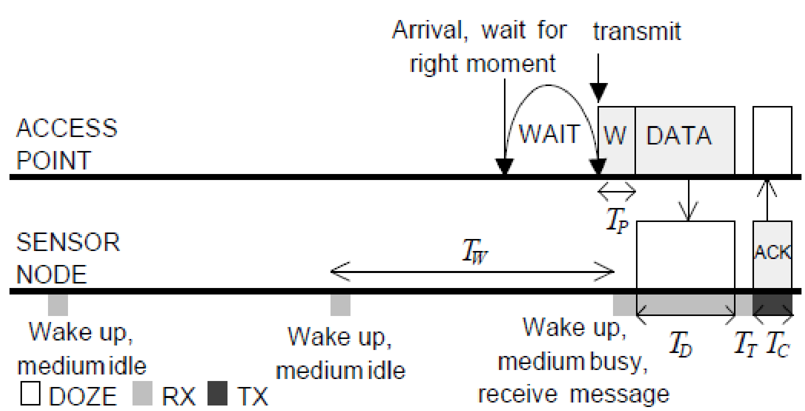
Understanding:

- Different MAC layer protocols have been compared here on the basis of their energy efficiency. This paper is only a survey of different Mac layer protocols and it shows that energy efficiency is also application dependent.

[8]Title: **An Ultra-Low Power MAC Protocol for the Downlink of Infrastructure WSN.**

Publication: A. El-Hoiydi and J.-D. Decotignie, CSEM, Swiss Center for Electronics and Micro technology, Computers and Communications, 2004. Proceedings. ISCC 2004. Ninth International Symposium Volume 1, Issue, 28 June-1 July 2004 Page(s): 244 - 251 Vol.1.

Paper Details: this is a proposal paper for WiseMAC protocol which defies that WiseMAC is an ideal protocol for downlink network. This paper also discusses about the multi-hop sensor network. This WiseMAC protocol is further compared with an autonomous network protocol called Zig-Bee which comes under IEEE 802.15.4 standard. Zig-Bee is a power management protocol. When we compare these two protocols we see that WiseMAC provides lower power consumption for same delay.



Implementation Details:

- WiseMAC and Zig-Bee are compared on the basis of Power and delay, varying traffic condition and also scalability factor.

Advantages:

- WiseMAC consume less power compare to Zig-Bee.
- WiseMAC shows a very good performance under low and high traffic conditions.
- For the same delay in WiseMAC provides less power consumption.

Disadvantages:

- When we compare these two protocols we do not concern about throughput of network.

[9] Title: **Wise-MAC: An Ultra-Low Power MAC Protocol for the Wise NET WSN.**

Publication:A. El-Hoiydi, J.-D. Decotignie, C. Enz and E. Le Roux,ACM 1-58813-707-9/03/0011, November 5–7, 2003, Los Angeles, California, USA.

Paper Details: It is just like an abstract paper for WiseMAC. It has been told that WiseMAC is based on CSMA and preamble techniques are used to minimize the power consumption. Frame structure and preamble sampling are also discussed. Medium reservation technique is also discussed here in order to prevent collision between different nodes who want to send data to the same destination. The frame contains wake-up preamble, bit synchronization preamble, start frame delimiter and at last MAC protocol data unit as shown below.

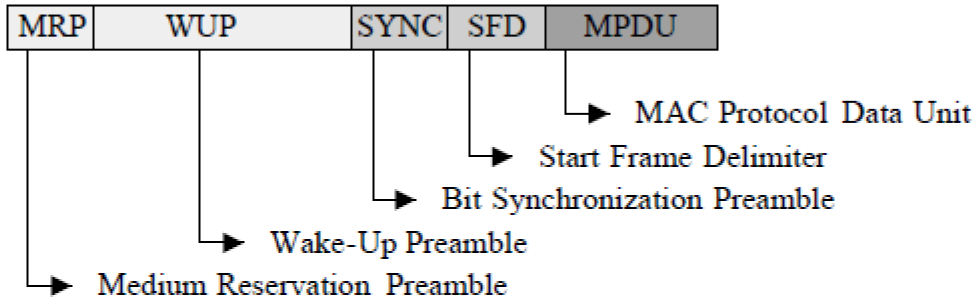


Figure 8 Frame Structure of WiseMAC

Implementation Details:

- In this paper all the simulations are carried on the GloMoSim platform.
- Simulation has 9x9 lattice multi-hop network MPDU frames with a length of 64 bytes. The bit rate is of 25 kbps and the wake up period is about 200 ms.

Advantages:

- WiseMAC is capable to handle and process random, periodic and heavy traffic.
- WiseMAC is scalable and provides mobility.

Disadvantages:

- Frame structure is not defined in a detail manner only preamble part is shown.

[10]Title: **Evaluation of WiseMAC and extensions on wireless sensor nodes.**

Publication: Philipp Hurni and Torsten Braun, Markus Anwander, LNCS,IEEE,ACM, Telecommun Syst. , 2009.

Paper Details: This paper covers the basic properties and schemes of WiseMAC implementation. Further with the help of simulation these properties have been evaluated. It uses a real sensor hardware and implementation has been done to improve or show the traffic adaptability of WiseMAC. a more bit fragmentation scheme has been proposed for WiseMAC under heavy and packet busts conditions.

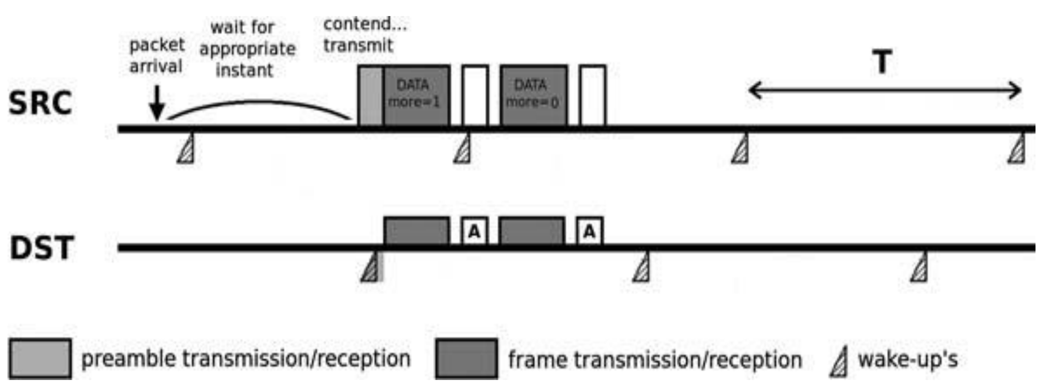


Figure 9 More Bit Scheme

(This scheme set the flag in a unicast MAC frame whenever a sender has more packets (data) to send. This is called more bit scheme and it tells the receiver that after receiving the data it will not make itself turnoff and will be continuing in listing mode and if there are packets it will be in receiving mode.)

Implementation Details:

- Here OMNET++ simulator is used to simulate the topology with 90 nodes over an area of 300m*300m.
- This simulation shows that higher throughput can be achieved by using extended more bit scheme but it consumes high energy. But if are considering the ratio of throughput to the

energy we see that extended more bit scheme is better than more bit scheme in high traffic conditions.

- Embedded sensor board is used for implementation of more bit and extended more bit scheme.

Outcomes:

- The life time of WiseMAC nodes with that of normal CSMA nodes is about 120% more this is because CSMA keeps all the nodes in receiving mode which leads to an extra power wastage.
- The outcomes of this experiment show the comparison between WiseMAC and the normal Mac schemes.

[11] Title: PW-MAC: An Energy-Efficient Predictive-Wakeup MAC Protocol for WSN.

Publication: Lei Tang, Yanjun Sun, Omer Gurewitz, David B. Johnson, INFOCOM, 2011 Proceedings IEEE,Department of Computer Science, Rice University, Houston, TX, USA.

Paper Details: This paper contains PW-MAC (Predictive-Wakeup MAC) which is a new energy-efficient MAC protocol. This protocols work on an asynchronous duty cycle. It forces the sender to wake-up just before it find the desired receiver is going to be in wakeup mode, so in this way the wake-up time of sender is reduced and hence we are able to utilize the energy efficiently.

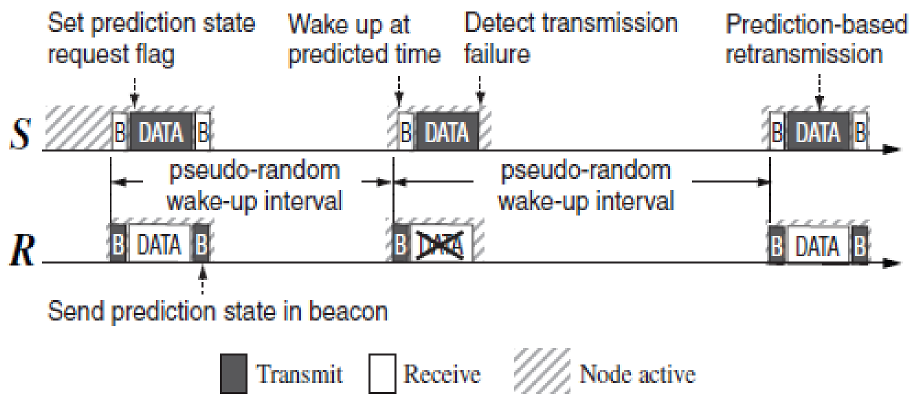


Figure 10 Predictive-Wakeup

As shown in the diagram sender S set the prediction state request flag to find the wake-up state of receiver and receiver wake-up just before the receiving a packet. Sometimes failure occurs because of pseudo-random wake-up time of receiver and hence sender has to send the packet again.

Implementation Details: in this paper PW-Mac is compared with WiseMAC. PW_MAC is implemented in tiny OS. The following matrices are measured in testing

- Data packet delivery ratio.
- Duty cycle.
- Packet latency.

Outcomes:

- PW-MAC provides us a high energy efficiency when traffic is high and packets are dropped or in case of collision of data packets.
- The delivery latency of PW-MAC is 5% less than that of WiseMAC.
- PW-MAC gives you a very good energy efficiency at transmitter and receiver end.

Literature survey in brief:

Name of paper	Abstract
WiseMAC: An Ultra-Low Power MAC Protocol for Multi-hop Wireless Sensor Networks[1]	This paper gives knowledge about energy efficiency property WiseMAC protocol on MAC layer in wireless sensor network. It further tells about the preamble techniques used for packet transmission and reception and visualize how it works.
Increasing Throughput for WiseMAC[2]	This paper focuses on the extension of more bit scheme by working with the duty cycle of WiseMAC in high traffic condition.
Evaluation of WiseMAC on Sensor Nodes[3]	This paper will gives you a brief detail on more bit scheme in WiseMAC and also it focuses on the adaptability of its duty cycle in case of high traffic. The author compares the energy efficiency conditions for original and extended more bit scheme with the help of simulation.
FM-UWB and WiseMAC-HA for Medical BAN Applications[4]	In this paper sensor node has been described with an application which is so called body area network (BAN). It has been shown that sensor nodes can also be used in medical field. Author also discussed about ultra-wide band communication system
Improving Unsynchronized MAC Mechanisms in Wireless Sensor Networks[5]	In this paper the Author has discussed how an unsynchronized power saving can be done and can be applied to the WSN.
On the Best Way to Cut a Body Area Network's Wires[6]	In this paper author has described that in sensor network we are eliminating the wire damage risk. It's also evaluated the together functioning of physical layer and

	the MAC layer protocols.
Energy Saving in MAC Layer of Wireless Sensor Networks: a Survey[7]	In this paper author has defined some MAC protocols which are energy efficient for wireless sensor network and tried to improve their methods of energy improvement.
Wise-MAC: An Ultra-Low Power MAC Protocol for the Downlink of Infrastructure Wireless Sensor Networks[8]	This is a proposal paper for WiseMAC protocol which defies that WiseMAC is an ideal protocol for downlink network. This paper also discusses about the multi-hop sensor network. This WiseMAC protocol is further compared with an autonomous network protocol called ZigBee which comes under IEEE 802.15.4 standard
Wise-MAC: An Ultra-Low Power MAC Protocol for the WiseNET Wireless Sensor Network.[9]	It is just like an abstract paper for WiseMAC. It has been told that WiseMAC is based on CSMA and preamble techniques are used to minimize the power consumption. Frame structure and preamble sampling are also discussed.
Evaluation of WiseMAC and extensions on wireless sensor nodes[10]	This paper covers the basic properties and schemes of WiseMAC implementation. Further with the help of simulation these properties has been evaluated
PW-MAC: An Energy-Efficient Predictive-Wakeup MAC Protocol for Wireless Sensor Networks[11]	This paper contains PW-MAC (Predictive-Wakeup MAC) which is a new energy-efficient MAC protocol. This protocols work on an asynchronous duty cycle. It forces the sender to wake-up just before it find the desired receiver is going to be in wakeup mode, so in this way the wake-up time of sender is reduced and hence we are able to utilize the energy efficiently.

CHAPTER: 3

PROPOSED WORK

3.1 Existing System:

We have discussed so far and many times that WiseMAC is an energy efficient protocol and with addition techniques or schemes like more bit and extended more bit schemes it shows wonderful performance in Wireless sensor Network. This protocol works on MAC layer and can be combined with other protocols according to the application. This was initially implemented for multi-hop wireless sensor network. As we know that in WSN there are a large number of sensor nodes which are used for transmitting and receiving the data packets and further connected to the server. All the nodes create a random topology to make a wireless connection to each other. Sensors have a battery, a microprocessor, and memory. They must be small in size so that they consume less battery power and work for a long time without replacement of battery. Because we are using nodes in wireless network so there is always be traffic which passing through almost all the nodes so in case of processing the data packets the nodes consume energy from battery. So energy conservation becomes more important issue in WSN.

As we know that the main reason of energy consumption are transmission and listening to the medium. Many MAC layer protocols like S-MAC, T-MAC, and B-MAC have been implemented to reduce the energy consumption by the nodes in WSN, at the time of transmitting and over hearing the channel. The idle listening means when there is no transmission in network all the nodes sense the medium and by overhearing we means that a node sensing a packet which is not directed to it.

The WiseMAC use preamble sampling technique. In this technique the medium is sampled in regular manner to identify if the channel is busy. All sensor nodes sample the medium randomly but for equal time duration and if they find channel busy they all come in listening mode to receive a data packet and again they go in sensing modes. Using this scheme or technique we are getting very low power consumption when channel is idle but in case of transmission and listening mode power consumption is still there.

3.2 Proposed Work:

3.2.1 Statement of problem

Wireless Sensor network provides a powerful combination of distributed sensing, computing and communication. WSN also provides flexibility and mobility but faces some problems one of them is energy consumption by nodes. In order to reduce power consumption we have to go through all the layers from physical up to application but MAC layer plays an important role in all among them.

It is always desirable to have less power consumption in WSN. But reducing the power consumption affects the throughput in original WiseMAC. So we have to do some modification in WiseMAC to keep in mind that these modification will affects some other parameters or properties.

3.2.2 Features

Increase in traffic will definitely affects the working conditions of WiseMAC. It's come with the problem like idle listening and overhearing. So our modification must be accordingly. Increase traffic comes with increase in battery utilization so if we are not using a good scheme we will be running out with battery power. Low traffic and high traffic both have their own problems but the propose protocol is adaptable in variable traffic conditions and results in high energy efficiency.

3.2.3 Scope

We are working on the modification of exiting WiseMAC protocol which make it energy efficient and provide a long life to the network. So we have taken WiseMAC protocols to make some modification by analyzing its working and scheme it uses and one way of doing this is to put the sensors in power saving mode so that they consume less power.

3.2.4 Objective

My main objective is to reduce power consumption by sensors in WSN using WiseMAC protocol. We have to do some work with exiting WiseMAC protocol to make it energy efficient.

We are trying to do this by reducing the wake up time, over hearing and collision. Our protocol must use adaptability in high and low traffic conditions. Another objective is to reduce the packet delivery time. This proposed protocol should increase the life time of nodes.

3.2.5 Goals

Reduction in Power consumption is always being the main theme of my research work. There are so many protocols which work in BAN but we want a high energy efficient protocol with variable traffic conditions and less delay. So I am hoping that my proposed protocol may be used efficiently in Body Area Network (BAN)

3.2.6 Constraints

In wireless sensor network to implement the proposed protocol I have consider some constrains such as processing power of node, Transmission range, Transmission bandwidth and Routing protocol. There are other techniques or parameters to reduce the energy consumption at MAC layer, but we are focusing at only three parameters that are energy efficiency, latency and throughput.

CHAPTER: 4

RESEARCH METHODOLOGY

4.1 Basic methodology used for the original WiseMAC protocol

1. **Sampling the medium:** here sampling means to sense the medium periodically for a very short time. All sensors do the same thing at different time instants or you can say that it is random. If the medium is found busy, node sense the medium continuously until it get the data frame and if the medium is idle node goes into the sleep mode. A wake up preamble is added at the front of each and every frame. The size of preamble is equal to the sampling period. In this way we are getting good power reduction.

2. **Minimize Wake-up Preamble:** Earlier the long wake up preamble has the problem of throughput and more power consumption but with the more bit and extended more bit schemes we getting extra advantages. With these schemes we are focusing on reducing the preamble length so that a node wake up less and consume less power from battery.

3. **Keep Sampling Table:** Our aimed protocol is basically targeted reduction in the preamble size in the way that now the acknowledgement packet not only contains acknowledgement to the transmitter but also contains some information about its sampling instances. So with the help of this the neighboring nodes update their relative sampling table. With help of this table nodes work intelligently and transmit only at the right instant.

4. **Collision Avoidance:** sampling randomization is very useful what we going to discuss. Whenever more than one node try to send data to the same destination this preamble sampling helps to avoid the collision which added a random time in front of data packet.

4.2 Methodology used for adaptive Contention Window

WiseMAC is basically works on non-persistent-CSMA technique which work well when we added some new ways to moderate it like preamble sampling. This will reduce power consumption, produce better throughput and provide less delay in case of moderate traffic conditions and this is because of contention window in CSMA which helps us to make a use of it in adaptive traffic conditions. We will discuss it further.

Mathematical parameters

αf =number of transmission failures

αs= total successful transmissions with one or more transmission-attempts.

PrT_f =Transmission failure probability due to collision

Mathematically, we can present it as

$$PrT_f = \alpha f / (\alpha f + \alpha s)$$

4.3 Algorithm for Adaptive Contention Window:

1. First of all we have enough data available for this algorithm because every n seconds algorithm check for number of transmitted packet and step forward only when they are sufficient for condition.

2. In this step at any time instant a probability (PrTf) is calculated based on transmission of failure and success.

3. Less PrTf shows a node with increase contention window if all other nodes do the same and even in the second round there is an increased PrTf then it shows that it because of this common sensor node and it is the culprit. So algorithm does one thing it allows that node not to change its contention window but allows other nodes to adjust their window. So in this way the network will be stable and adjust itself accordingly.

4. In CSMA based WiseMAC protocol less CW leads to small PrTf and large CW leads to large PrTf. There are so many nodes in the network and each and every node try to increase its CW to a large size so it is not possible to get this much of CW in a single step.

5. Contention window finding can be done in the following way:

$\Delta CW = \gamma * (CWtarget - CWcur) / CWcur$

$CWcur = CWcur + \Delta CW$

Where γ is a scaling factor

4.4 Algorithm for Dynamic Duty Cycle:

1. Step first is same as for the above algorithm, its check for enough number of transmitted packets and this happens after every T seconds.
2. Now its turn to segregate the different traffics depending on which kind of traffic it is like audio, video, non-real time and temperature (real time).
3. This segregation is called type of service (ToS) and it is used to determine which kind of traffic has more number of packets.
4. So according to this segregation we are now able to find which kind of tariff has more number of packets and it is called dominating traffic. Now the duty cycle is adjusted according to this traffic.

CHAPTER: 5

PROJECT DESIGN

5.1 SOFTWARE REQUIREMENT SPECIFICATION

WiseMAC protocol properties in WSN have been analyzed here. There are so many simulators which can be used for this kind of simulation but here NS-2 has been used. Following are the list of hardware and software which are necessary for this project simulation.

5.1.1. Operating Environment

System Specifications

- **Hardware Specifications**

a) Processor Type : Pentium -4
b) Speed : 2.4 GHz
c) Ram : 2 GB RAM
d) Hard disk : 20 GB HD

- **Software Specifications**

a) Operating System : Linux – red hat 5.0
b) Programming Package : C++, TCL
c) Tool Used : Oracle VM Virtual Box
d) Version : NS-2 (version 2.29)

System Architecture:

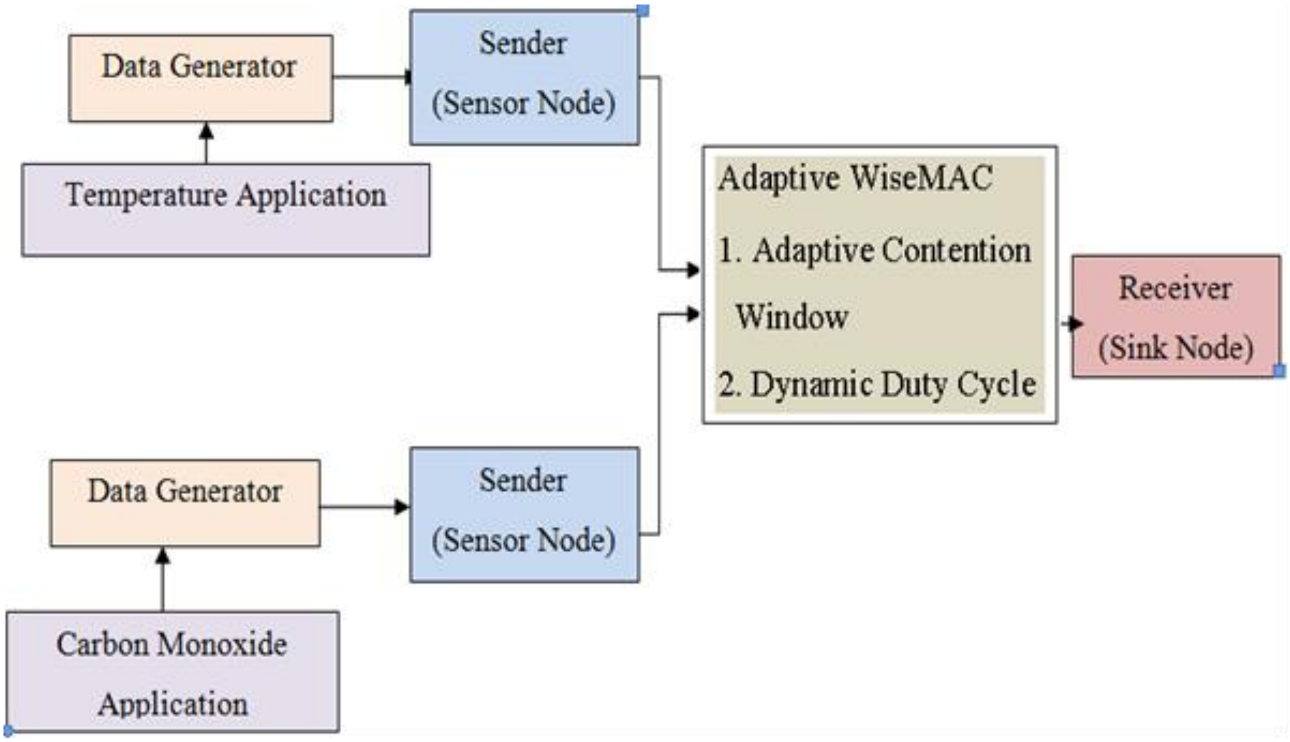


Figure 11 system architecture

Flow chart for Adaptive Contention Window MAC Algorithm:

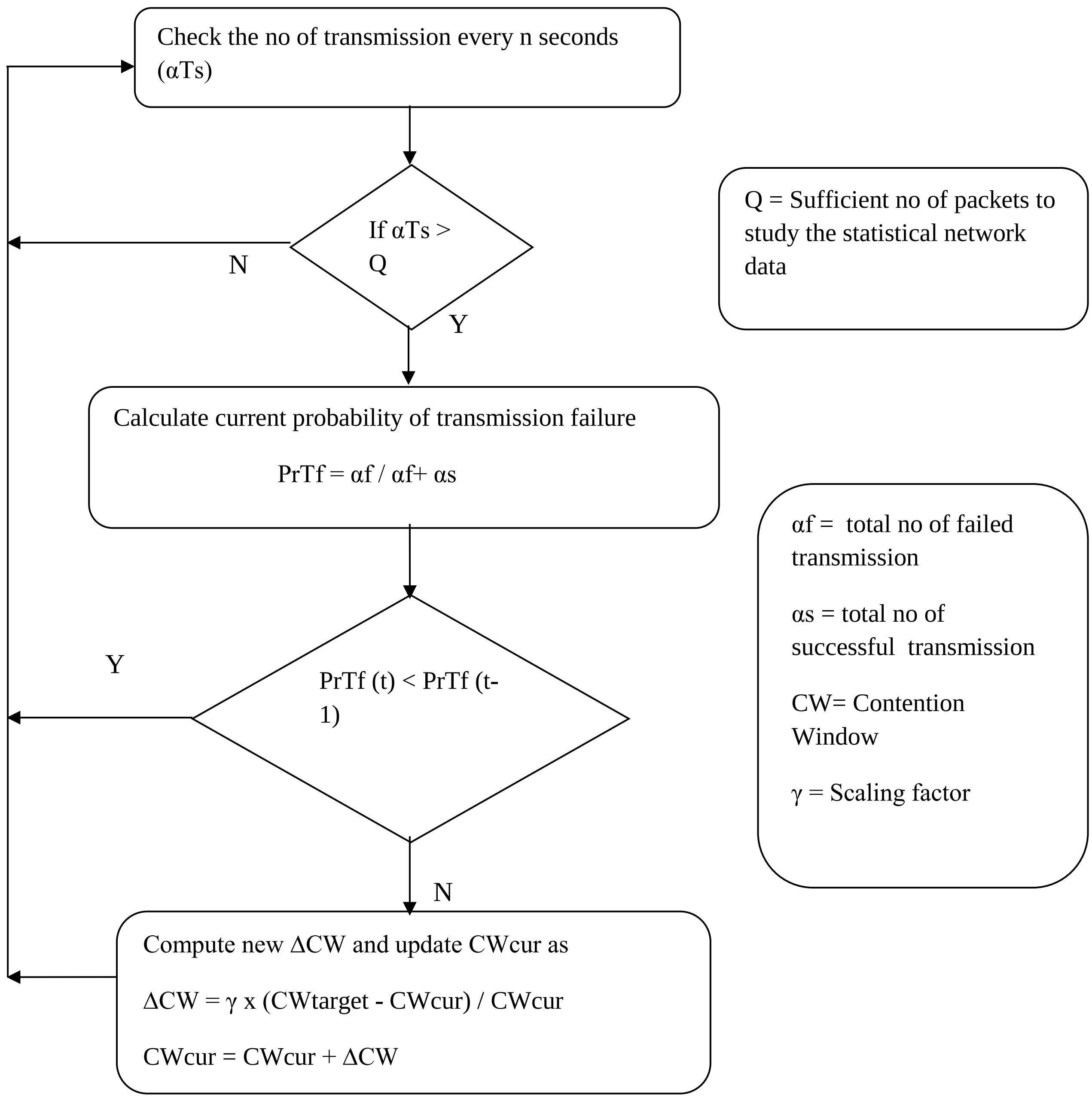


Figure 12 Flowchart for adaptive contention window

5.1.2 External Interface Requirements

5.1.2.1 User Interfaces

NS-2 simulator comes with an additional feature so called Network Animator (NAM). This helps in visualizing the scenario so created in simulator. In this nodes are donated by a circle and one can watch the packet transmission and dropped packets. NS-2 has another feature called X-GRAPH which is used to show different graphs generated according to the created scenario. Here below one example of NAM is shown.

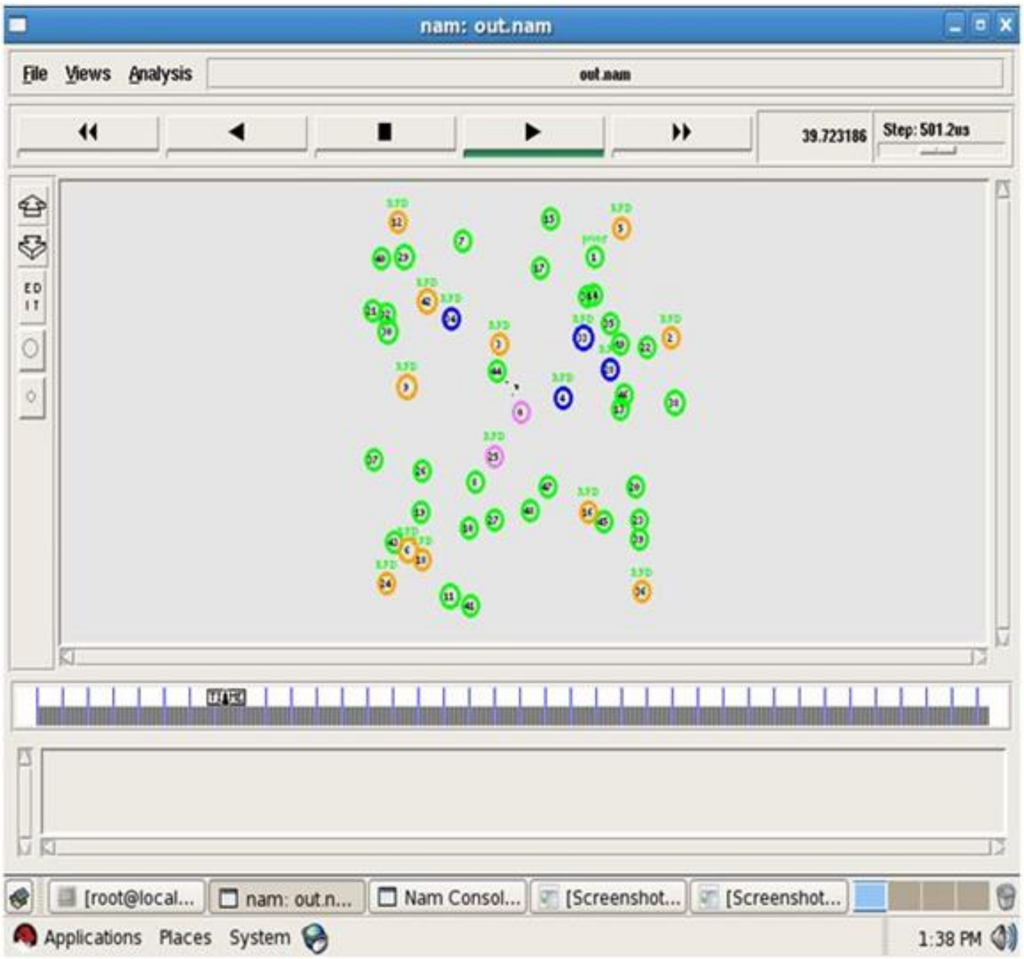


Figure 13 Data Transmission scenario of adaptive WiseMAC

All the script is written in tcl language. After the execution of this simulation some trace files are generated which are helpful to watch what is going on in the created scenario, means the delivery time which node is transmitting and which one is receiving.

CHAPTER: 6

IMPLEMENTATION

6.1 Simulation Background:

6.1.1 Software Details of NS2

NS2 is a free for users but it is bit difficult to install and use it. Once you get hand on it, it will work in good way for simulation purposes. One can install it either UNIX platform or windows. Installing it on windows requires Cygwin software to be installed previously on the system. Cygwin provides you Linux like feel. NS2 has two languages one is C++ and second is TCL. C++ is used for compilation while TCL is used to create objects and script. Although C++ is faster than TCL because C++ is a compiler while TCL is an interpreter but adding new things in script makes Tcl language friendly with user because it is easy and fast to add new things in Tcl language. You can download NS package from any free site online. Once you install it on Linux platform you can start you simulation process. Below are the files which one can find in the NS package.

- NS release 2.30,
- Tcl/Tk release 8.4.13,
- OTcl release 1.12, and
- TclCL release 1.18.

6.2 Architecture of NS2

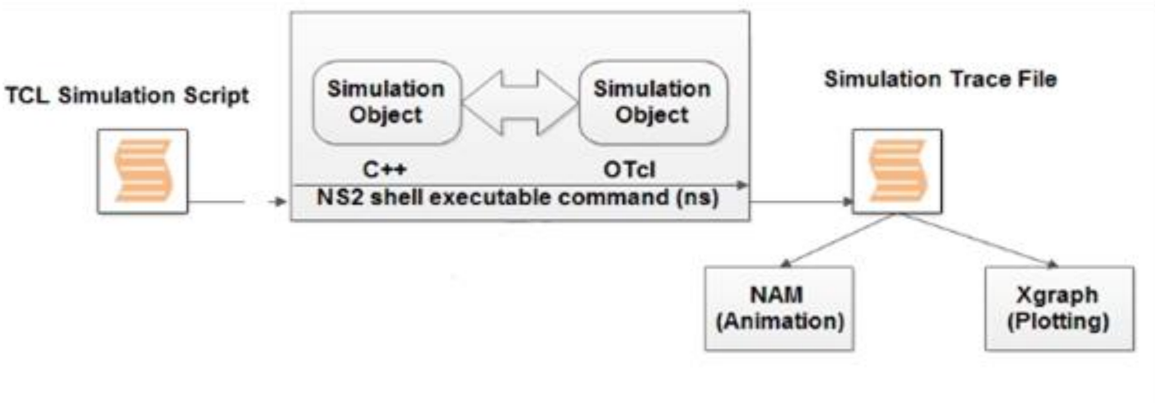


Figure 14 Basic Architecture of NS-2

The above figure is showing the basic structure of NS-2. It has a TCL simulation script which comes for execution in NS-2 shell. A written script is prepared by the user which is used as a input arguments in NS-2. When this file is executed a trace file is generated and it is used to plot graph and animation (NAM). NS-2 has two languages c++ and Otcl (object oriented language). C++ is used for internal purpose of simulation script. Otcl is used to assemble and to configure the objects in the simulation.

C++ is basically used to define the detailed protocol implementation part of NS-2 and related to the flow of packets. So if someone wants to add something in the protocol's rules then one should go with C++. Configuration and further setup are done with the help of Otcl. It works slowly but good for simulation purposes.NS-2 has compiled objects of C++ which can be used for Otcl interpreter. The C++ and Otcl are together called TclcL.

Objects in Otcl are called handles. It is just like a string in this domain and it does not contain any functions rather all the functions are covered under C++ objects. A user interacts with the handle in Otcl. It has its own defined variable and procedure for interaction. The outputs of NS-2 are either files or animation or can be a plot. As we have said earlier we have two other facilities with NS-2, one is X-graph and another is NAM (network animator).

6.3 Files and Lists

Below are the commands which will help you to open and read files and also you can also obtain elements of list:

settestfile [open test.dat r]

gets $testfile list

set first [lindex $list 0]

set second [lindex $list 1]

settestfile [open test.dat w]

puts $testfile "testi"

6.3.1 Creating Topology

For simulation one must have network structure or topology in technical terms. So now one has to create topology which contains large number of nodes and connections. The following command helps us to create nodes and links.

set ns [new Simulator]

6.3.2 Nodes

The following command is used to create a new node in the network.

set n0 [$ns node]

set n1 [$ns node]

set n2 [$ns node]

set n3 [$ns node]

By these commands we have created four nodes in the network. Node1, node2, node3, node4 are there name. If network do not have router then our simulation must have traffic agents like TCP or UDP and traffic source like FTP or CBR etc. these traffic agents and source must be configured by using NS script. Thus a source is attaché t the node with help of traffic agent.

6.3.3 Agents, applications and traffic sources

TCP and UDP are always the first choice for traffic packets. We use either TCP or UDP. If we are using TCP then there so many types for TCP as:

Agent/TCP –TCP sender with a Tahoe

Agent/TCP/Reno –TCP sender with a Reno

Agent/TCP/Sack1 – TCP with selective acknowledgement

The most common applications and traffic sources provided by ns2 are:

Application/FTP – produces bulk data that TCP will send

Application/Traffic/CBR – generates packets with a constant bit rate

Application/Traffic/Exponential – during off periods, no traffic is sent. During On periods, CBR is used to generate the pakets. The length of both on and off-periods is exponentially distributed.

_Application/Traffic/Trace – Traffic is generated from a trace file, where the sizes and inter-arrival times of the packets are defined.

One can create traffic for oneself using these commands as:

For Node0:

```
set udp0 [new Agent/UDP]

$ns attach-agent $n0 $udp0

set cbr0 [new Application/Traffic/CBR]

$cbr0 attach-agent $udp0

$cbr0 set packet_size_ 1000

$udp0 set packet_size_ 1000

$cbr0 set rate_ 1000000
```

An FTP application using TCP as a transport protocol can be created and attached to node n1 in much the same way:

```
set tcp1 [new Agent/TCP]

$ns attach-agent $n1 $tcp1

set ftp1 [new Application/FTP]

$ftp1 attach-agent $tcp1

$tcp1 set packet_size_ 1000
```

6.3.4 Traffic Sinks

In order to terminate the traffic one required traffic sink this can be either TCP sink or UDP sink. TCP sink is in agent/sink class while UDP is in agent/null class.

The following command is used to Attach UDP sink to node n2 with udp0:

```
set null [new Agent/Null]

$ns attach-agent $n2 $null

$ns connect $udp0 $null
```

The following command is used for TCP:

```
set sink [new Agent/Sink]

$ns attach-agent $n3 $sink

$ns connect $tcp1 $sink
```

Another way to connect source and destination:

```
$ns create-connection <srctype><src><dsttype><dst><pktclass>
```

For example, to create a standard TCP connection between n1 & n3 with a class ID of 1:

```
$ns create-connection TCP $n1 TCPSink $n3 1
```

One can very easily create several TCP-connections by using this command inside a for-loop.

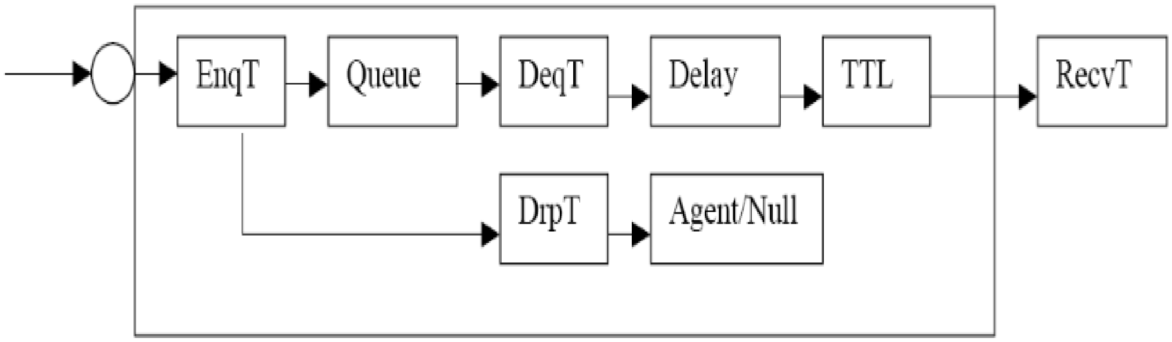
6.3.5 Traces

All events from the simulation can be recorded to a file with the following commands:

```
settrace_all [open all.dat w]

$ns trace-all $trace_all

$ns flush-trace

close $trace_all
```

First command is used to open output file and handle is attached with it. In second command a trace file is created for it which is used to keep records of activities happening in the network. After this the trace file has to be flushes and it is done with the third command above. Last command is used to close the trace file.

.



A trace file has the following format:

+ 1.84375 0 2 cbr 210 ------- 0 0.0 3.1 225 610

- 1.84375 0 2 cbr 210 ------- 0 0.0 3.1 225 610

r 1.84471 2 1 cbr 210 ------- 1 3.0 1.0 195 600

r 1.84566 2 0 ack 40 ------- 2 3.2 0.1 82 602

+ 1.84566 0 2 tcp 1000 ------- 2 0.1 3.2 102 611

- 1.84566 0 2 tcp 1000 ------- 2 0.1 3.2 102 611

+: enqueue

-: dequeue

d: drop

r: receive

1st field: events type

2nd field: simulation time

3rd and 4th field: source and destination nodes

5th field: packet type

6th field: packet size

7th field: flag field

8th field: flow id

9th and 10th field: source and destination addresses

11th field: sequence number

12th field: packet id

$ns create-trace type file srcdest

The above command is used to create trace object between source and destination.

_Enque – a packet arrival (for instance at a queue)

_Deque – a packet departure (for instance at a queue)

_Drop – packet drop

_Recv – packet receive at the destination

6.4 Built-in Traffic Generators in NS2

In NS there is a default traffic generator which will help you when you are not able to generate traffic.

In NS2, there are four main traffic generators:

• Constant Bit Rate (CBR): Send a fixed size payload to the attached agent. By default, the Interval between two payloads (i.e., the sending rate) is fixed, but it can be optionally randomized.

• Exponential On/Off: Send fixed size payloads for every randomized interval to an attached agent during an ON period. Stop sending during an OFF period. ON and OFF periods are exponentially distributed, and are alternated when one period terminates.

• Pareto On/Off: Similar to the Exponential On/Off traffic generator. However, the durations of ON and OFF periods follow a Pareto distribution.

• Traffic Trace: Generate traffic according to a given trace file, which contains a series of inter-burst transmission intervals and payload burst sizes.

Implementing Adaptive Contention Window (ACW) in Ns2

1. Create a WSN topology in NS2 environment with the desired number of sensors.
2. Accept the traffic after every Q sec from the inbuilt traffic generators of NS2.
3. Accept the traffic as Real time, Non Real Time and Best effort (Refer TOS of IP datagram of DARPA [21]).
4. Adjust the contention window as per scaling factor and 802.11e EDCA parameters.
5. Run AWK and PERL file for End-to-End delay and Throughput.
6. Compare the results with the other MAC protocol.
7. Vary the number of nodes to see its impact on throughput and end to end delay

6.5 Experimental setup

The simulation is done on NS-2.29 and a random topology is taken. The topology look like as below. Here in the simulation wireless sensor data and carbon monoxide data generator sensor is considered.

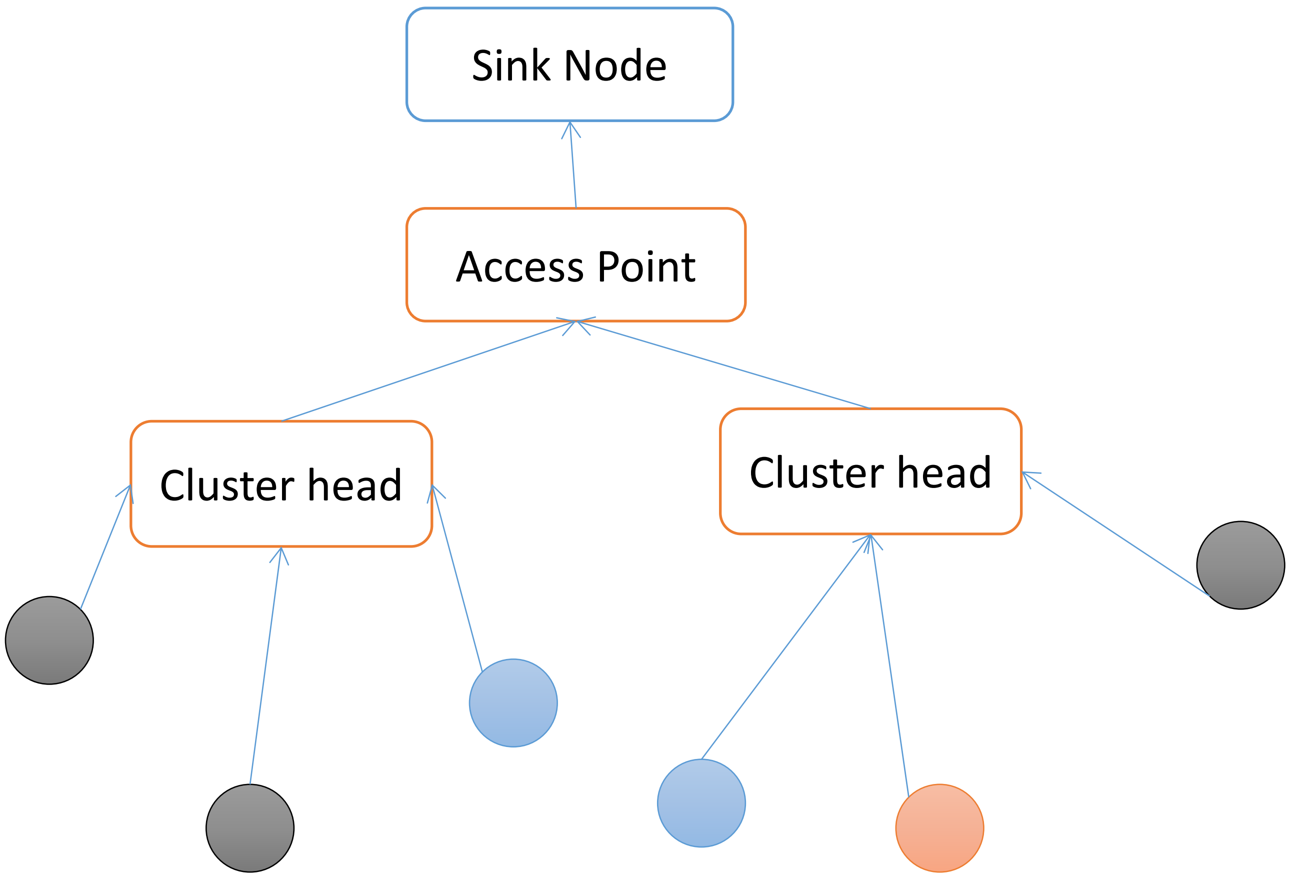


Figure 15 Experimental setup

Common Node: Common nodes are the nodes which normal in network. These have to sense the data, collect it and forward it.

Cluster Head: The Cluster head (CH) is the node which capable of handles more traffic compare to common nodes.

Access Point:

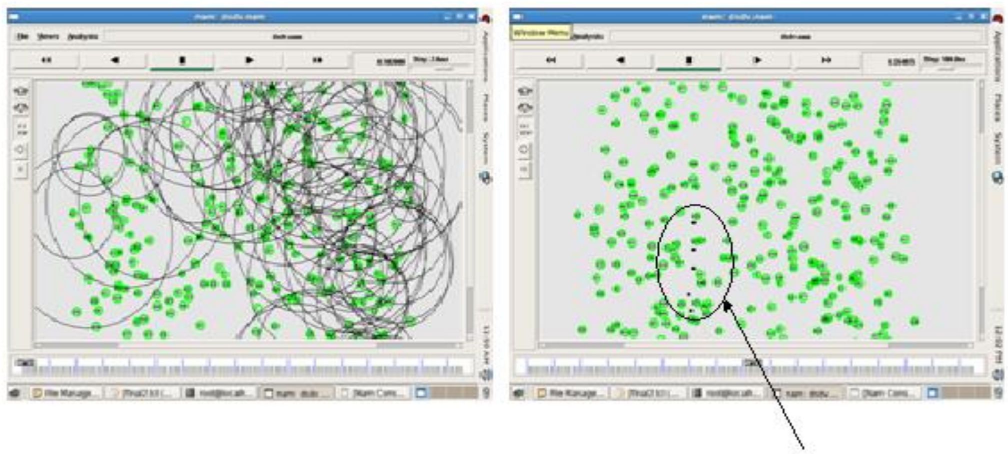
Base Station / Sink Point: Base station is the access point where all the data is targeted. It collects all the information and relevant action took place according to the situation.

Simulation Parameters:

Number of Nodes	10-100
Topology Size(Area)	300m×300m
Initial Energy	1000J
Simulation Time	1000s
Communication Range	50m
Carrier Sensing Range	100m
Bitrate	19.2kbps
Carrier Frequency	868MHz
Sleeping power	5µW
Transmit power	12mW
Receiving power	4.5mW
Receive to transmitState transition delay	12µs
Transmit to Receive State transition delay	12µs
Sleep to Receive State transition delay	518µs
Packet size including header	160bits
Packet queue length	15

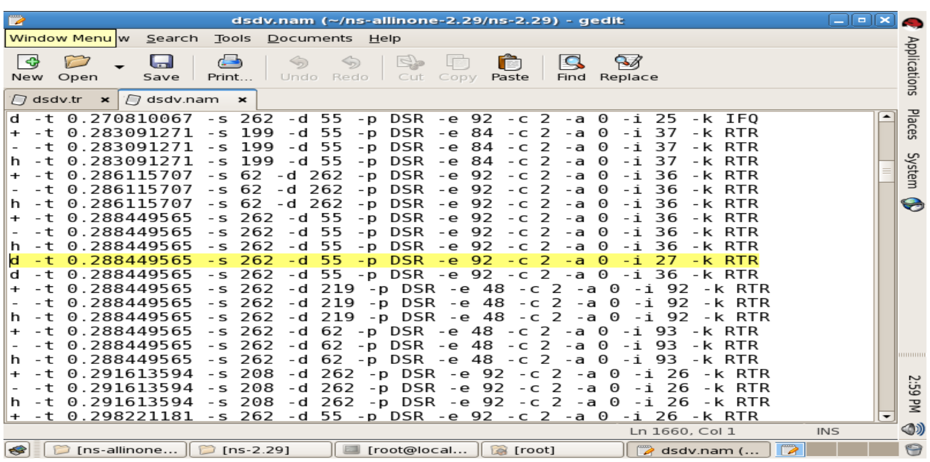
6.6 Network Animator output of NS2

The following are the NAM outputs of NS-2. When we run a simulation typing NAM in command window we get a popup window look like as below one. The green small circles are nodes in our random network. Some packets are dropped and shown by and arrow. You can also see large black circles which represents data transmission. There is a simulation time which is given in the above table.



Packet drop

Figure 16 NAM output scenarios



```
d  -t 0.270810067 -s 262 -d 55  -p DSR -e 92 -c 2 -a 0 -i 25 -k IFQ
+  -t 0.283091271 -s 199 -d 55  -p DSR -e 84 -c 2 -a 0 -i 37 -k RTR
-  -t 0.283091271 -s 199 -d 55  -p DSR -e 84 -c 2 -a 0 -i 37 -k RTR
h  -t 0.283091271 -s 199 -d 55  -p DSR -e 84 -c 2 -a 0 -i 37 -k RTR
+  -t 0.286115707 -s 62  -d 262 -p DSR -e 92 -c 2 -a 0 -i 36 -k RTR
-  -t 0.286115707 -s 62  -d 262 -p DSR -e 92 -c 2 -a 0 -i 36 -k RTR
h  -t 0.286115707 -s 62  -d 262 -p DSR -e 92 -c 2 -a 0 -i 36 -k RTR
+  -t 0.288449565 -s 262 -d 55  -p DSR -e 92 -c 2 -a 0 -i 36 -k RTR
-  -t 0.288449565 -s 262 -d 55  -p DSR -e 92 -c 2 -a 0 -i 36 -k RTR
h  -t 0.288449565 -s 262 -d 55  -p DSR -e 92 -c 2 -a 0 -i 36 -k RTR
d  -t 0.288449565 -s 262 -d 55  -p DSR -e 92 -c 2 -a 0 -i 27 -k RTR
d  -t 0.288449565 -s 262 -d 55  -p DSR -e 92 -c 2 -a 0 -i 36 -k RTR
+  -t 0.288449565 -s 262 -d 219 -p DSR -e 48 -c 2 -a 0 -i 92 -k RTR
-  -t 0.288449565 -s 262 -d 219 -p DSR -e 48 -c 2 -a 0 -i 92 -k RTR
h  -t 0.288449565 -s 262 -d 219 -p DSR -e 48 -c 2 -a 0 -i 92 -k RTR
+  -t 0.288449565 -s 262 -d 62  -p DSR -e 48 -c 2 -a 0 -i 93 -k RTR
-  -t 0.288449565 -s 262 -d 62  -p DSR -e 48 -c 2 -a 0 -i 93 -k RTR
h  -t 0.288449565 -s 262 -d 62  -p DSR -e 48 -c 2 -a 0 -i 93 -k RTR
+  -t 0.291613594 -s 208 -d 262 -p DSR -e 92 -c 2 -a 0 -i 26 -k RTR
-  -t 0.291613594 -s 208 -d 262 -p DSR -e 92 -c 2 -a 0 -i 26 -k RTR
h  -t 0.291613594 -s 208 -d 262 -p DSR -e 92 -c 2 -a 0 -i 26 -k RTR
+  -t 0.298221181 -s 262 -d 55  -p DSR -e 92 -c 2 -a 0 -i 26 -k RTR
```

Figure 17 NAM file

Explanation of NAM file:

'+' event puts the packet onto the transmission queue

'–' event removes the packet from the queue h- Sends the packet to the next hop

t- Time

s- Transmitting node id

d- Destination node id

p- Packet type

e- Size of transmission

c- Conversation

a- Packet color attribute id

k- Packet type

6.7 Trace file output:

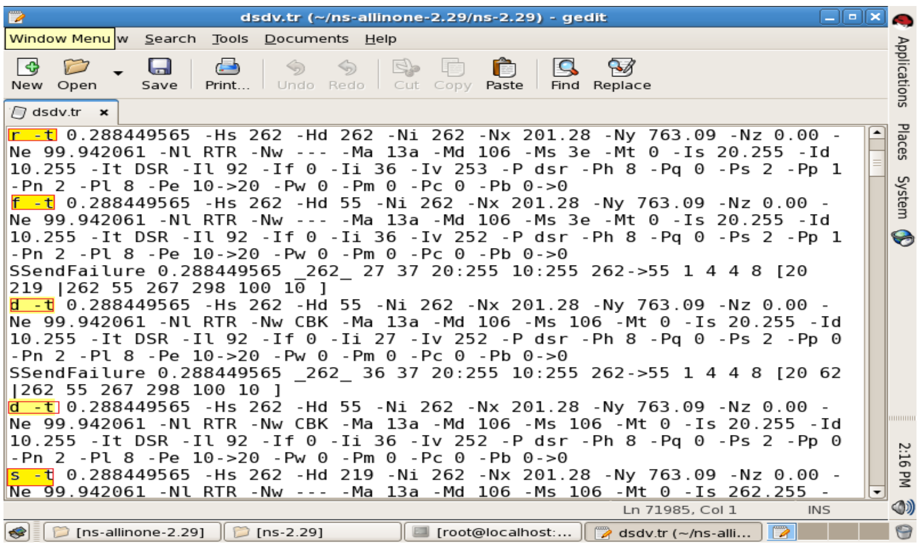


Figure 18 Trace file after simulation

Below are the descriptions of trace file notations:

1st field of trace file:

s- Send

r- Receive

d- Drop

f- Forward

2nd field of trace field

-t- time

-t*- global setting

For nodes field:

-Ni: node id

-Nx: node's x-coordinate

-Ny: node's y-coordinate

-Nz: node's z-coordinate

-Ne: node energy level

-Nl: trace level, such as AGT, RTR, MAC

-Nw: reason for the event. The different reasons for dropping a packet are given below:

"BSY" BUSY

"TTL" TTL has reached zero.

"TOUT" packet has expired.

"CBK" CALLBACK

"IFQ" no buffer space in IFQ.

"ARP" packet is dropped by ARP

The main goal of our experimentation described here is to measure throughput and end to end delay of the proposed MAC protocol and compare it with the static duty cycle based S-MAC and T-MAC. We have developed our sensor networks simulator based on NS2. The traffic classification, priority assignment, priority-based back-off, sleeping and idle listening are simulated as different states in the simulator.

6.8 Results

Performance Parameters for Simulation and Results

This is measured taking number of nodes in counting or in measurement.

6.8. 1 Throughput:

it is the maximum rate at which each node can send packets to each other in the WSN network.it is measured in bits/sec or bps or may be data packets per timeslot or per second. It is depend on number on nodes as the number of nodes increase the hop count decrease and hop progress increase. A large number of nodes will definitely decreases the throughput.

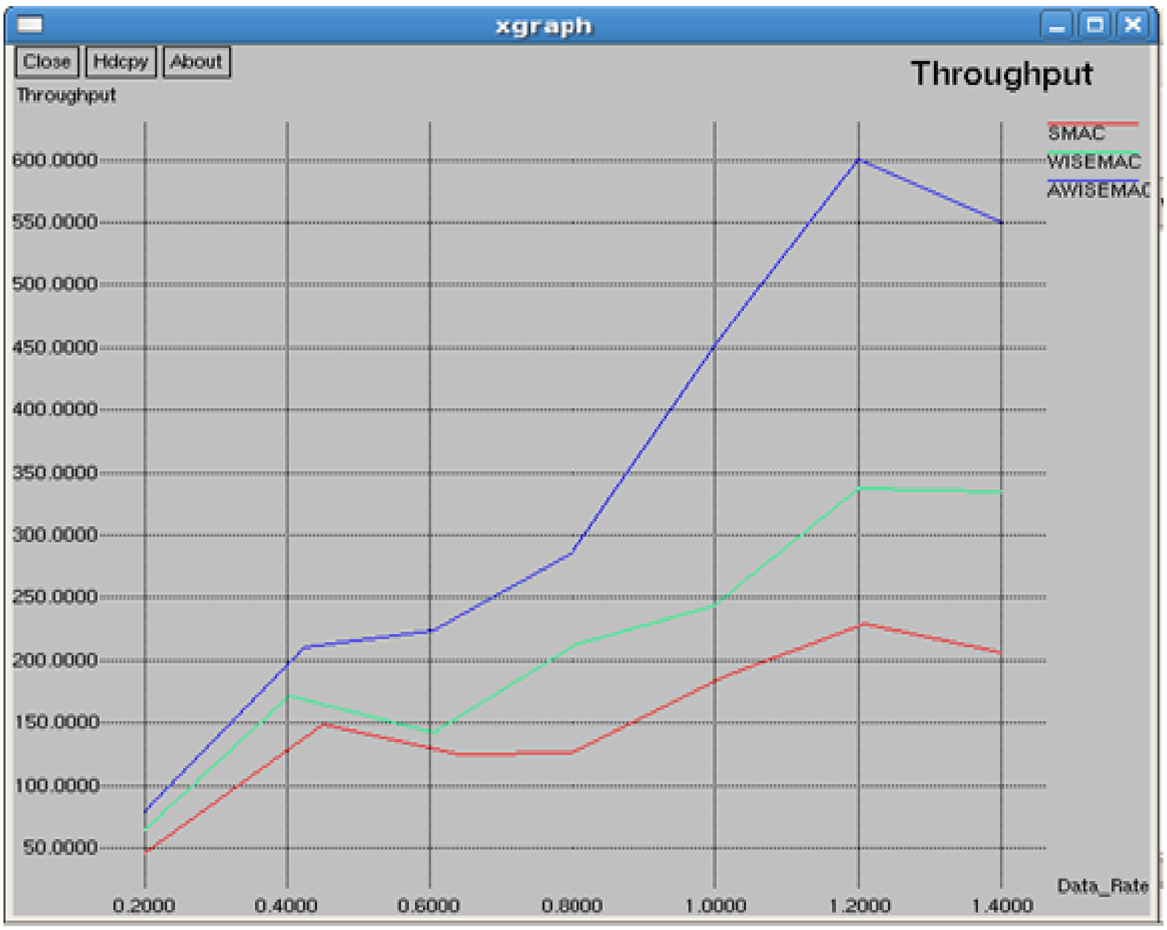


Figure 19 Throughput

Fig. explains the throughput-dynamics for different traffic classes. In our proposed MAC protocol we first classify the traffic into different classes depending on the type of service (ToS). Subsequently, it adjust it's the contention windows depending on the traffic classes Thus, as shown in Fig., depicts a comparative study of the wireless throughput between our protocol, SMAC and WiseMAC. On an approx we can say that SMAC and WiseMAC respectively achieve a throughput of 50 Kbps and 65 Kbps and our protocol, achieves an average throughput of 85 Kbps.

6.8.2 Packet Delivery Ratio:

It is defined as the number of data packets delivered to the destination node to the number of data packets transmit from the source node. The graph below shows the packet delivery ratio. So we have to count number of data packets transmitted and number of packets delivered and this is done by our NS-2 in which trace file is generated to show the packets detail. The graph contains the comparison between SMAC, WiseMAC and AWiseMAC (Adaptive WiseMAC).

Figure 20 Packet delivery ratio

6.8.3 End to End Delay:

It is defined as the time difference between transmission and reception of the accurate data packets. The different protocols further compared here but here AWiseMAC has some limitation and it is not showing comparably good end to end delay.

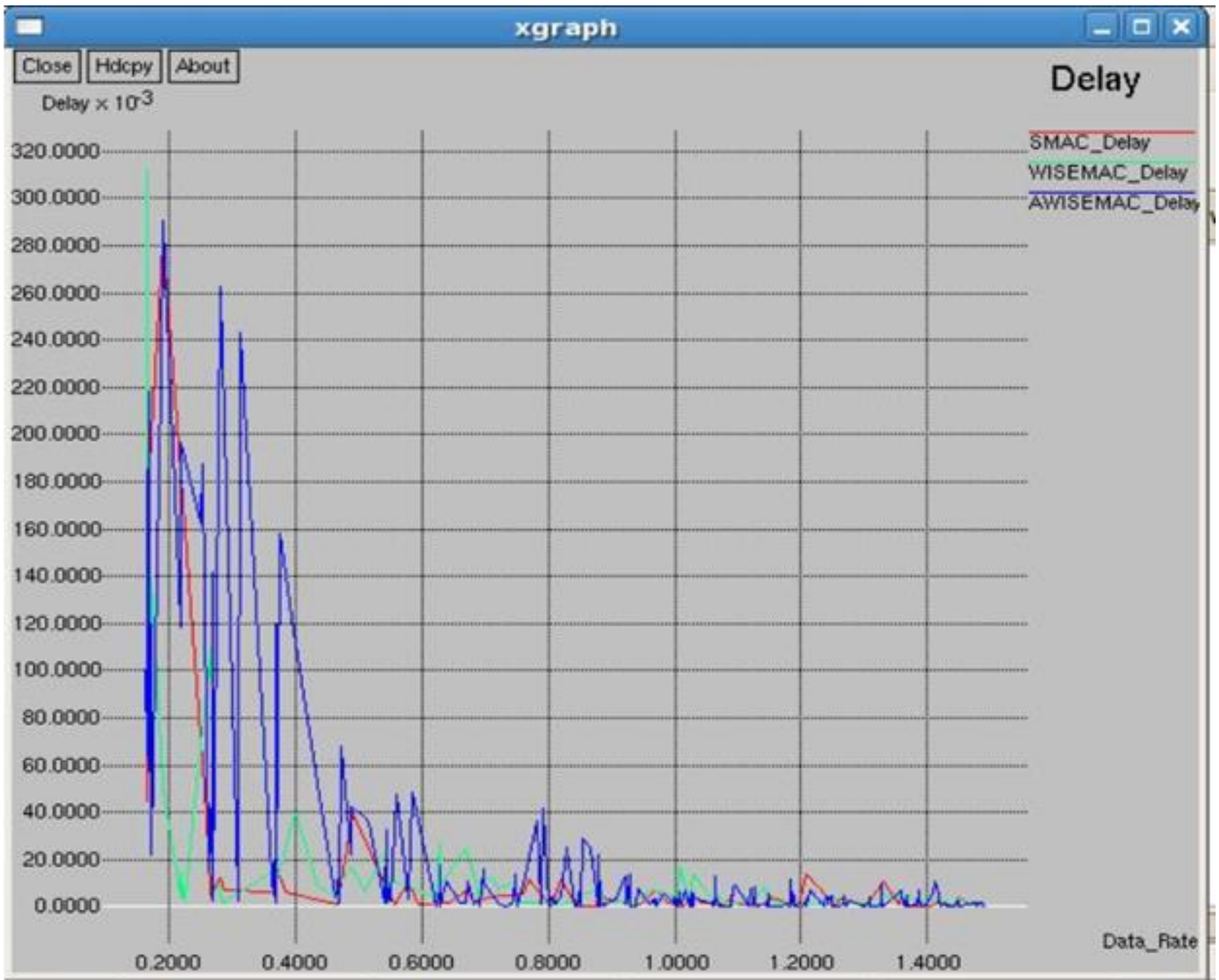


Figure 21 End to End Delays

6.8.4 Energy Efficiency:

The aim of our project is to make existing WiseMAC protocol Energy efficient and now this is showing in below graph.

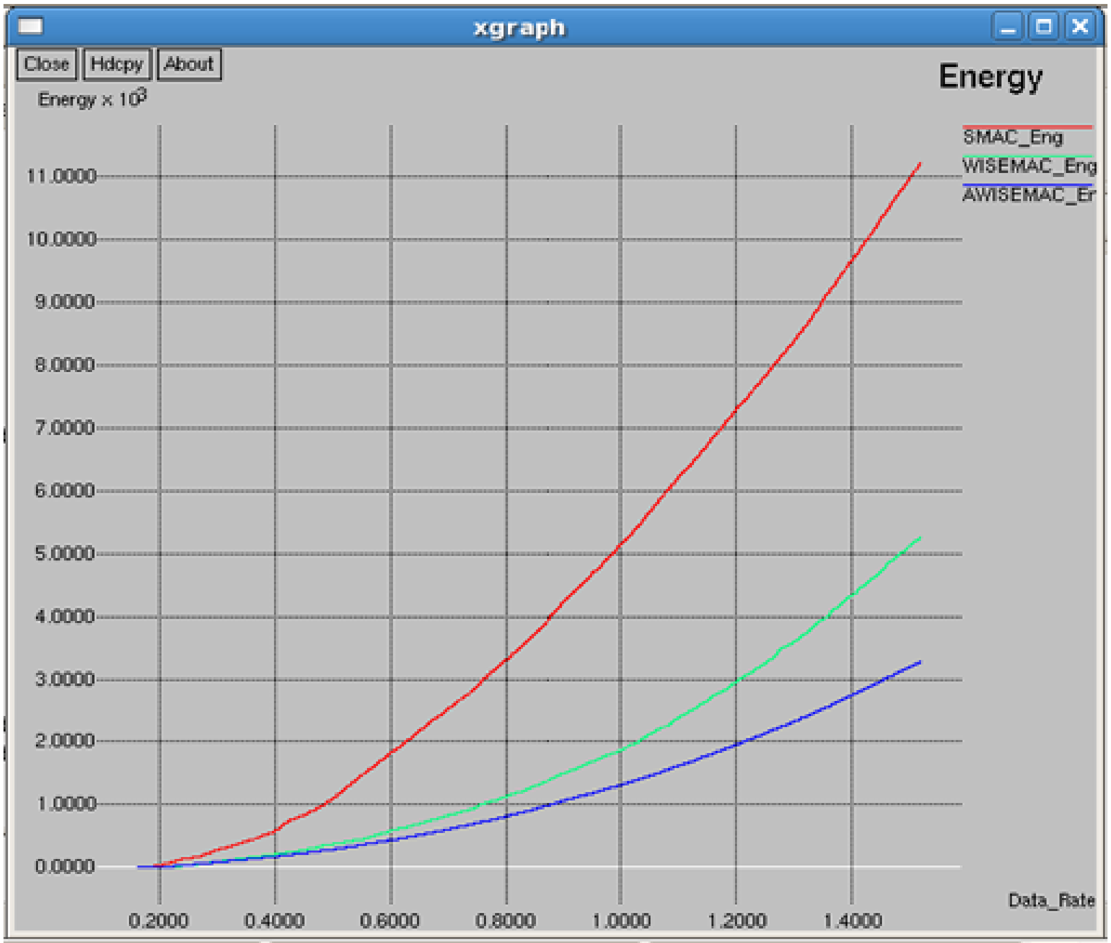


Figure 22 energy efficiency

CHAPTER: 7

CONCLUSION AND FUTURE SCOPE

Reduction in energy consumption is always the main point of discussion in Wireless Sensor Network and this whole work is dedicated to this. Beside energy consumption, throughput and end to end delay are also the center point of our discussion. WiseMAC protocol is an extension to the basic CSMA with preamble sampling and this technique helps to reduce the power consumption but it has limitation to the throughput.

In these days different protocol MAC protocol are widely used in health monitoring. WiseMAC is one of them; this is the main reason of frequent enhancement in existing WiseMAC protocol. Adaptive WiseMAC will consider and compare three main parameters of energy efficiency that are Delay, Power consumption and Throughput in wireless sensor network. We propose some modification to the original Wise-MAC to enhance the performance especially in terms of energy efficiency and power consumption in wireless sensor networks. We hope that in future the proposed protocol may be used for different applications in Wireless Body Area Network for health monitoring.

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