CREAT: Cluster Based Routing Using Energy Aware Technique for Wireless Sensor Network

SUBMITTED BY:

Atif Sattar
(01-244092-035)
MS (Telecom &Network)

Supervised By: Sohail Jabbar

DEPARTMENT OF COMPUTER SCIENCE
BAHRIA UNIVERSITY
ISLAMABAD
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Dated: --------------------

Final Approval

This is to certify that we have read the thesis submitted by **Atif Sattar, Enrollment # 01-244092-035**. It is our judgment that this project is of standard to warrant its acceptance by the Bahria University, Islamabad, for the Degree of **MS in Telecommunication and Networks**.

Project Evaluation Committee

External Examiner: ___________________________

Internal Examiner: ___________________________

Supervisor:
Sohail Jabbar ___________________________
Bahria University, Islamabad.

Dedicated to my Parents and Teachers

A Dissertation Submitted To

Department of Graduate Sciences and Applied Sciences,

Bahria University, Islamabad

As a partial Fulfillment of Requirements for the Award of the Degree

Of

MS in Telecommunication and Network

Declaration

I hereby declare that this Thesis "**CLUSTER BASED ROUTING USING ENERGY AWARE TECHNIQUE FOR WIRELESS SENSOR NETWORK**" neither as a whole nor as a part has been copied out from any source. It is further declared that I have done this research with the accompanied report entirely on the basis of my personal efforts, under the dexterous guidance of my teachers especially my supervisor Mr. Sohail Jabbar. If any of the system is proved to be copied out of any source or found to be reproduction of any project from any of the training institute or educational institutions, I shall stand by the consequences.

Atif Sattar
Enrollment # 01-244092-035

Acknowledgement

Praise be to God (Allah), the Cherisher and Sustainer of the Worlds (Rabbul Aalameen), Most Gracious (Al-Rehman), Most Merciful (Al-Raheem) and Master of the Day of Judgment, whose bounteous blessings enable us to pursue and perceive higher ideas of life. He is he, who sent his prophets for the guidance of Human beings and Ginns. Darood and Salaam upon his last prophet, Muhammad (Peace be upon him), his family and his companions, who has the ultimate and eternal way of complete success for this world and the hereafter in the form of Quran: the ultimate manifestation of ALLAH's grace to man, the ultimate wisdom, and the ultimate beauty of expression: in short, the word of God. After this i must mention that it was mainly due to my family's moral and financial support during my entire academic career that enabled me to complete my work dedicatedly. I would like to thanks to my respected teacher's and especially consider it a proud privileged to express my gratitude and deep sense of obligation to my reverend supervisor Mr. Sohail Jabbar for his dexterous guidance and kind behavior during my thesis work. The guidance of Engr. Dr. Abid Ali Minhas and Mr. Amjad Arfin are really appreciable throughout my research work. I would like to thank my brother, and sisters who encouraged me at those moments when I got exhausted. I also would like to say gratitude to my truly friends especially "the prayer (Nemaaz)" that helped me in every difficulty. I once again would like to admit that I owe all my achievement to my most loving parents who mean most to me, for their prayers are more precious than any treasure on earth. May they be live long with special and unlimited blessing of Allah (Subhana hu Wata'ala). Ameen.

Atif Sattar
Enrollment # 01-244092-035

Project In Brief

Project Title: CLUSTER BASED ROUTING USING ENERGY AWARE TECHNIQUE FOR WIRELESS SENSOR NETWORK

Undertaken By:

Atif Sattar
(01-244092-035)

Supervised By:

Sohail Jabbar
Bahria University,
Islamabad.

Start Date:

April 2011

Completion Date:

December 2011

Tools & Technologies:

NS-2
Scientific workplace
Microsoft Word
Microsoft Power point
Gnu-plot
MS Paint
Adobe Acrobat Professional 6.0

Operating System:

Windows 7

System Used:

Intel Core i-3(Genuine)
RAM 3 GB DDR-3

320 GB Hard Disk

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ABSTRACT

Wireless sensor nodes have four major parts which are microcontroller, Memory, Antenna and a battery. Wireless sensor network (WSN) nodes are highly dependent on batteries in many computational applications. Due to its unattended and far distant deployment, replenishment of battery is almost impossible. So, any designed application and algorithm for this energy constraint technology of wireless sensor network should be energy aware. Communicating the sensed data from the source node to the base station that is generally known as routing is the core functionality in this deployed network and for minimum utilization of a battery we need an optimal path from source to destination. Lessening the broadcasting, decreasing computation and packet overhead add better role in the energy conservation. In this research work, we targeted this issue of energy conservation for the routing functionality in WSN from the aforementioned energy conservation factors. Our proposed algorithm, CREAT (Cluster Based Routing Using Energy Aware Technique for Wireless Sensor Network) has achieved this goal of prolonging the network life time by lessening the broadcasting, decreasing the computation and by adapting the novel way of transferring the cluster head to the most suitable node in the cluster. It is intuited from the initial derived results through the simulation in NS2, that Energy aware routing (CREAT) algorithm performs better in overall network life time, end to end delay and Network Energy Consumption.

INTRODUCTION

Chapter 1

Introduction

1.1. Wireless Sensor Network

Wireless sensor networks are Broadly Used in many sort of fields. Wireless node can sense data process it and transmit it to the desire location. Wireless sensor node consists of transceiver, base station and a tiny sensor device. Energy control is the main goal in WSN. Wireless sensor network comprise in a narrow transducer with diverse location. It monitored the data like temperature, humidity, wind speed and its direction. Usually, wireless sensor networks are used in real time applications.

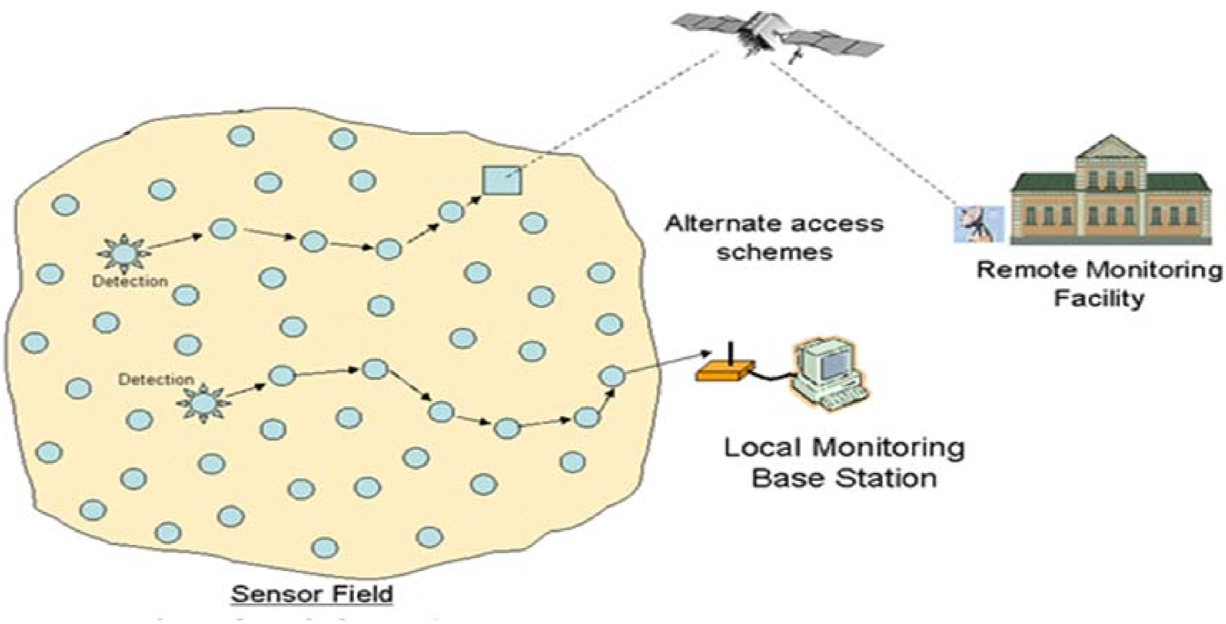


Figure 1: Structural diagram of wireless sensor networks [2]

1.2 Topology

In networks communication, a topology is a usually illustrative description of the arrangement of a network, including its nodes and connecting lines.

1.2.2 Types of topologies

There are different types of network topologies that can be used in wireless sensor networks. Different topologies deployed in wireless sensor networks. Ring Network is a network topology in which a node connected to his next node through a single pathway and making like a ring is called ring topology. In ring network there is no need to power on of all the nodes for communication also does not need network server to control the connectivity between computers. It is slower than Ethernet and also much expansive. Ring topology regenerates the data packets for longer distance rather than bus and star topology. Star topology nodes are connected through a hub. In star topology failure of the central hub is the failure of the data. Easy way of communication and in mesh topology nodes are connected to every other node this topology is much expansive. Two kinds of mesh topologies mesh full and partial mesh. In fully mesh is expansive and it has redundancy but partial mesh less expansive and has less redundancy. A junction of two or more network topologies is called hybrid topology. Mesh has more secured than other networks. Mesh is more complex while implement the network. Fault identification also easy in mesh network. Tree topology network nodes are connected like a tree or a hierarchy.

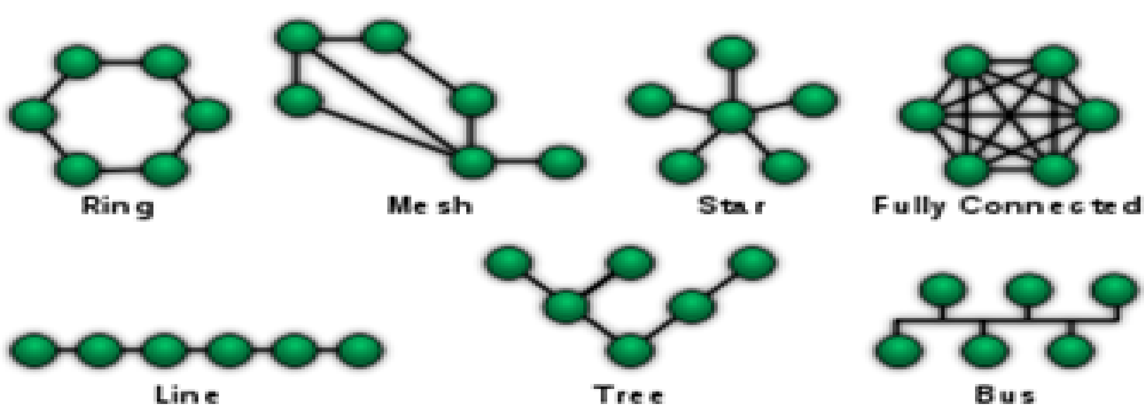


Figure 2 Network topologies [3]

1.3. Application of Wireless Sensor Network

Now a day, WSN are widely used in remote areas. Farmers using this technology measuring temperature measuring, wind speed, water availability and soil in fields. Wireless sensor nodes also used in many Industrial environments like process monitoring and machine condition monitoring. Wireless sensor nodes used in military applications like protection of sensitive areas, any kind if movement near border area. In medical field operation monitoring and surgery. WSN used in fire detection, animal habits monitoring and disaster relief applications. In industrial area wireless sensors are used in machine monitoring and maintenance. Green house monitoring and land slide detection.

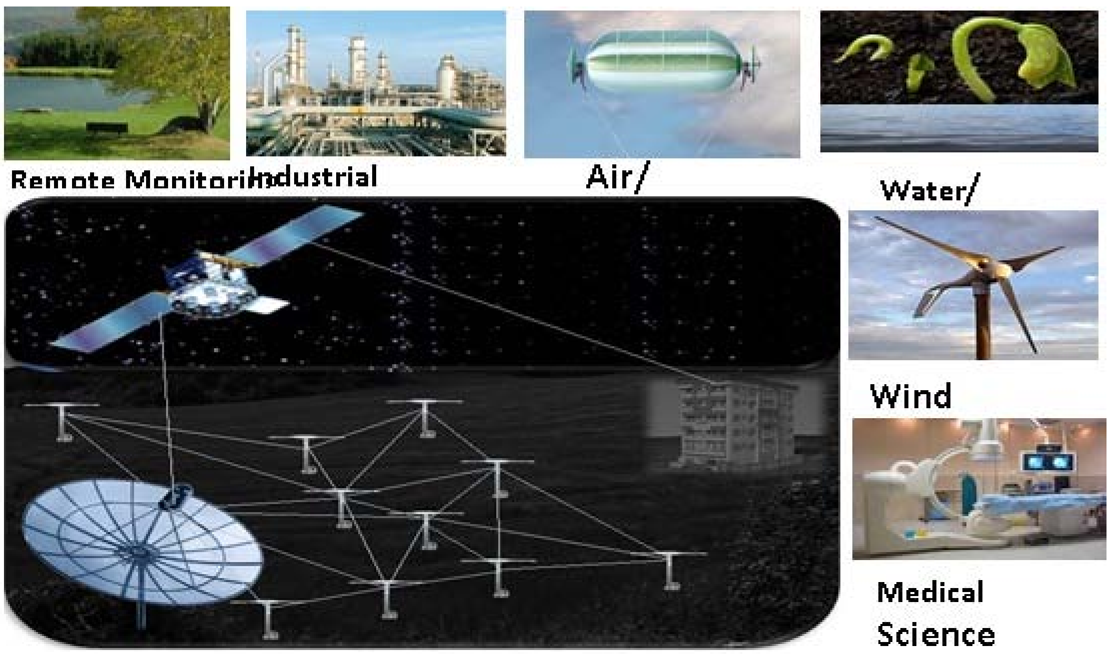


Figure 3: Application of WSN

With the passage of time WSN are growing fast in both hardware and software fields. Sensor nodes are deployed in many sorts of field like, also in environmental resources. Today, in agriculture manner many multinational companies even government is also deployed these technologies depending on conditions. Following picture shows the structure of WSN network connected with internet cloud through gateway.

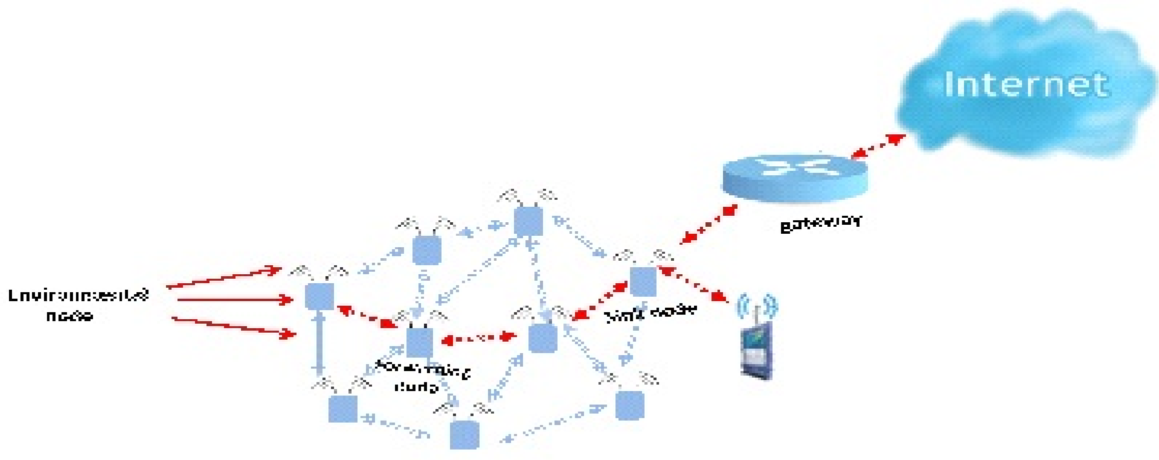


Figure 4: Wireless Sensor Network

1.4. Issues in Wireless Sensor Network

There are two types of issues in wireless sensor networks software base and the hardware base. By using battery backup we reduce the energy problem and power management but this is not the proper solution. Our software must be easily deployed in real world environment. It should be auto intelligent to control the traffic and avoid from the deadlock situation. Also consume the minimum energy. Load is balanced and it provides the privacy and security.

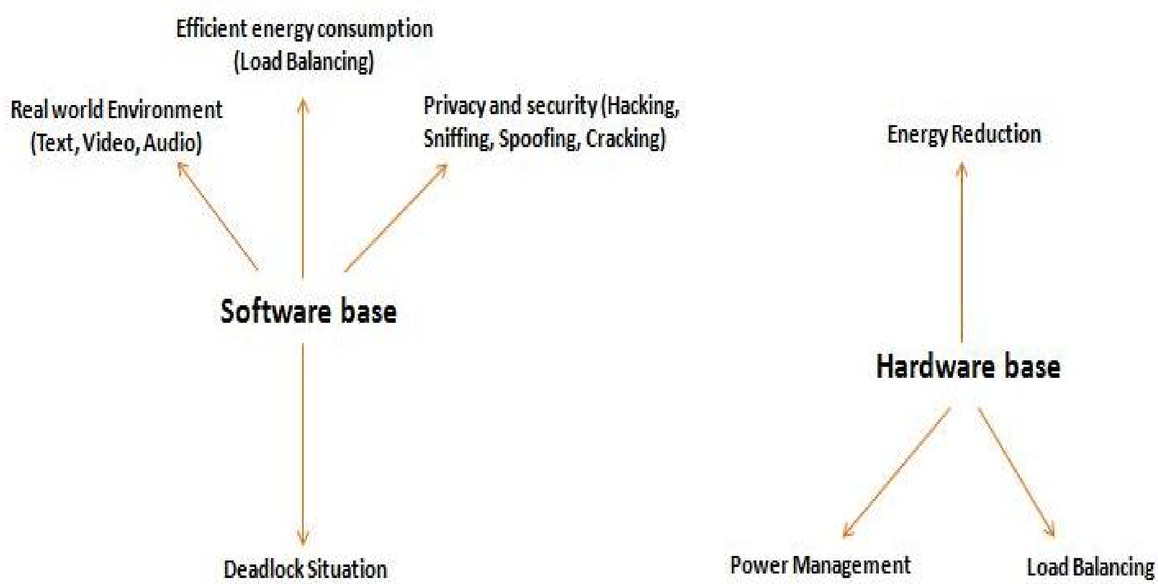


Figure 5: Types of WSN Issues

Commanding node distribute the work among nodes is called load balancing in this way more work is done by the same amount of time. There are two methods of load balancing software base and hardware base or by using the both way. Sometimes more real time data needed to be computation so load distribution is required at that time for efficient work. If there are 10 computational nodes and 92% work is done by only 2 of them so they are not working efficiently. In wireless sensor networks sensor devices get the real time data and send it to the commanding node. Commanding nodes are either fix or it can be a mobile device. The nodes whoever far away from commanding node can consume more power because of routing nodes (Traffic). The minimum energy is consumed if there is an optimum path and load is balanced. If Load is balanced it increases the redundancy. There are several load balancing issues in WSN. Source to destination path should be optimal. If our path is optimal and the load is balanced it consumed minimum energy and also congestion is lower. Efficient utilization of time also a load balancing issue. Load balancing increase the optimization problem because of many nodes. Efficient utilization of time to reduced its processing time. Energy consumption lesser while load balancing. Traffic control when cloud comes on the node. Load balancing is use for distribution of heavy workload between the nodes. Minimum energy is consumed while load balancing. No data deadlock situation if load is balanced. More real time data is computed that’s why load balancing is use. By doing load balancing we control the heavy load of traffic in real time communication also energy is efficient. In the figure we reduce the load and energy both at the same time we control the traffic by clustering which can use data stack to reduce energy consumption. The other way is data distribution through multiple paths for load balancing.

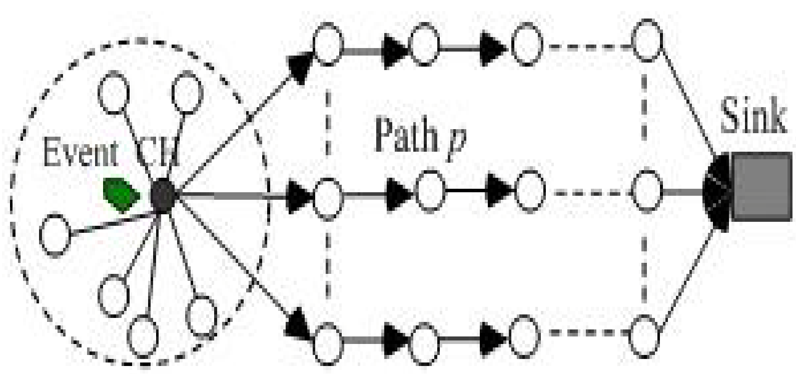


Figure 6: Load Balanced with multiple paths [4]

1.5. WSN Hardware Profile

1.5.1. What is Mote

Actual meaning of mote is a tiny speck as shown in the following figure. A mote consists of RF module and processor. Wireless sensor node have used for many applications from the years. Advance work in Wireless sensor node was started since 1998 in Berkeley. Berkeley and Intel introduce network embedded system technology and then smarter sensor in silicon having capability low power, small in size, self-configuring and support multi-hop wireless communication.

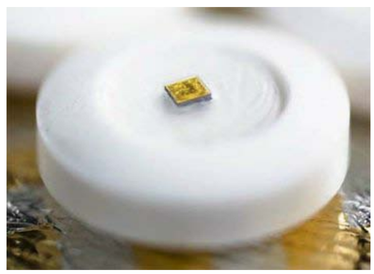


Figure 7: Tiny Mote

Sensor nodes have many usages, application specific. Wireless sensor node hardware designed to be extensible and modular. Wireless sensor node designed to be small in size and power efficient with maximum range transceiver rang. Following figure shows the hardware cycle of wireless sensor.

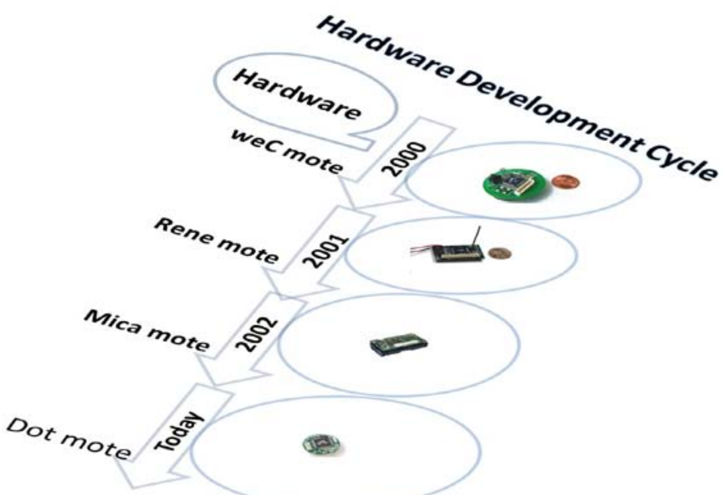


Figure 8: Motes development cycle

1.5.2. Some examples of sensor nodes

Manufacturers make sensor nodes for different purposes. Famous one is mica manufacture by Berkeley mostly used for experiments and available in market. Some sensor nodes inject in human body having personal information and for shopping purpose. Manufacturers make more money by selling their products in market. Our main focus is on mica and its architecture. Parts of sensor nodes shown in **Table 1**.

Table 1: Sensoe node parts

Pieces of hardware	Working
Radio motes	Processing, Connectivity
Sensing Board	Environmental Data Gathering
Programming Board	Gateway, Development

1.5.3. What is MICA

Most commonly used sensor node is mica easily available in market. For experiments developers and researchers are used mica. It consumes low power and long transceiver range. Know a day’s mica mostly used by researchers and developers. There are some other manufacturers in the following table.

Table 2: Motes are easily available in market are shown in Table 2

Mote Type Year	*WeC* 1998	*René* 1999	*René 2* 2000	*Dot* 2000	*Mica* 2001	*Mica2Dot* 2002	*Mica 2* 2002	*Telos* 2004
								
Microcontroller								
Type	AT90LS8535		ATmega163		ATmega128			TI MSP430
Program memory (KB)	8		16		128			60
RAM (KB)	0.5		1		4			2
Active Power (mW)	15		15		8		33	3
Sleep Power (μW)	45		45		75		75	6
Wakeup Time (μs)	1000		36		180		180	6
Nonvolatile storage								
Chip	24LC256				AT45DB041B			ST M24M01S
Connection type	I^2C				SPI			I^2C
Size (KB)	32				512			128
Communication								
Radio	TR1000				TR1000	CC1000		CC2420
Data rate (kbps)	10				40	38.4		250
Modulation type	OOK				ASK	FSK		O-QPSK
Receive Power (mW)	9				12	29		38
Transmit Power at 0dBm (mW)	36				36	42		35
Power Consumption								
Minimum Operation (V)	2.7		2.7		2.7			1.8
Total Active Power (mW)	24				27	44	89	41
Programming and Sensor Interface								
Expansion	none	51-pin	51-pin	none	51-pin	19-pin	51-pin	10-pin
Communication	IEEE 1284 (programming) and RS232 (requires additional hardware)							USB
Integrated Sensors	no	no	no	yes	no	no	no	yes

1.6. Node Architecture

A node consists of sensor, sensor board, power supply and memory. Sensor node sense data process it and send it to memory or base station. Transceiver has limited range to transmit or receive the signals. Sensor node has limited power resources. Following figure shown the typical architecture of sensor node components.

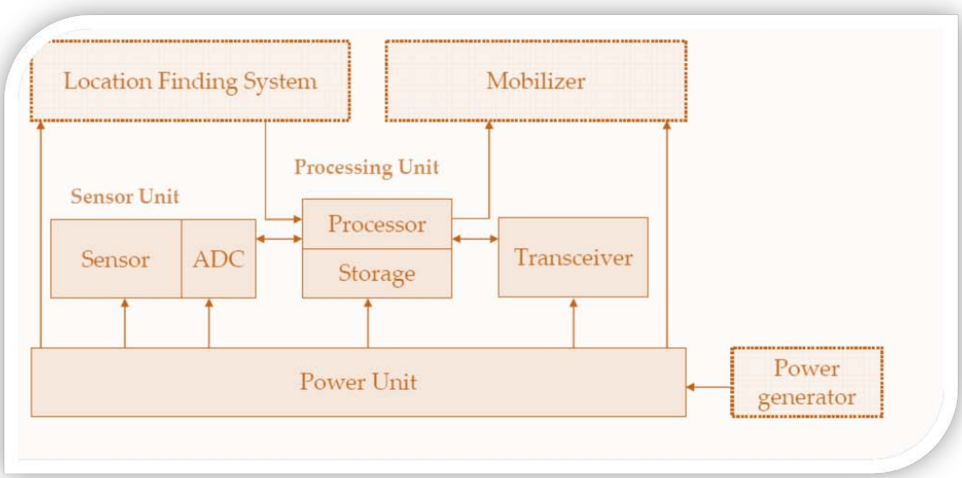


Figure 9: Components of a sensor node

Following are the details, working of typical sensor node components.

1.6.1. Controller

It collect data from transceiver and from sensors, process it and forward it, also called processing unit. Functionality of the processing unit depends on the task and on implemented architecture. Controller must have the ability to consume minimum power, tiny in size and easily programmable. Following are some designed microcontroller of mica mote.

2nd generation wireless sensor (Berkeley lab, Atmel atmega103/128L).

- 4 MHz and 8 bit CPU
- 128 KB instruction memory
- 4 KB SRAM and EEPROM
- 4 Mbit flash
- RFM TR1000 radio (916/433 MHz)
- 51 pin connector

3rd generation wireless sensor MICA2

- New radio CHIPCON 1000
- Standalone boot loader processor
- Wireless remote programing
- Serial flash 512 kb

3rd generation wireless sensor MICA2 DOT

- Similar features to mica2
- Six analog inputs, digital bus
- Integrated battery and temperature, status LED, voltage sensors.
- 3v coin cell battery

1.6.2. Memory

MICA has three type memories Flash, EEPROM memory, and Random Access Memory RAM. Flash memory is suitable when digital data required. WeC and Rene microcontroller (AT90LS8535) having 8 KB programmable memory, 0.5 kb RAM, active power is 15 mW and sleep power is 45 micro watts. Rene2 and Dot microcontroller (ATmega163) 16 KB programmable memory, 1 KB RAM and 15 mW active power. Mica2 Dot and MICA2 having 128 KB programmable memory and 4 KB RAM. Telos programmable memory is 60 KB and 2 KB RAM.

1.6.3. Communication Device

Transceiver used for transmitting and receiving the signal. In MICA RFM TR 1000 ASK, 1 to 300 ft range. In MICA2 new CHIPCON 100, transceiver range is 500 to 1000 ft and 38.4 K baud rate, linear RSSI, Good noise immunity, It auto configuration device like software programmable frequency and within bands, output power programmable In Telos and MICAz (IEEE 802.15.4 CC2420) radio, 250kbps and 2.4 GHz ISM band. Following figure shown clear evolution of radio stack.

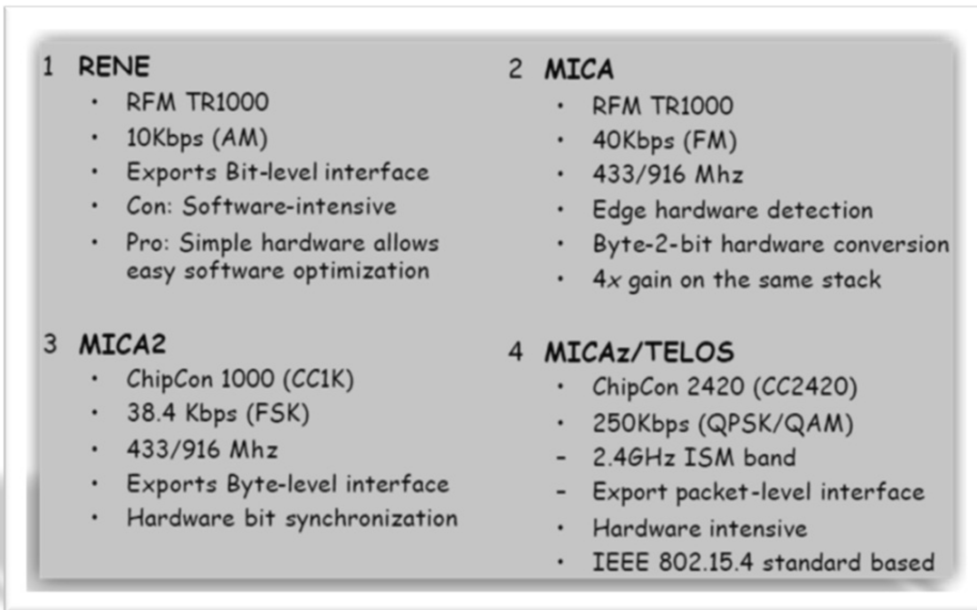


Figure 10: Radio Evolution

1.6.4. Sensor

A device that collects information from real world environment, information is in the form of signals. A general electronic sensor has primary transducer and secondary transducer. A transducer is defining as it converts one form of energy into other form. Primary transducer converts real world data into electrical signals and secondary transducer converts electrical signals into digital or analog signal. There are further subtype of primary transducers are conventional transducers, microelectronic sensors and light sensors. Sensors are many types, some sensors are active type and some are passive type in passive type they are Omni-directional and narrow beam sensors. Following table shown some example of sensors and their working.

Table 3: sensors and their working

Conventional Transducer	
Name	**Use For**
Thermocouple	Temperature Difference
Compass / Magnetic	Direction
Microelectronic Sensors	
Phototransistor / Photodiode	Photon energy or light, Infrared detectors, Intrusion Alarm
Piezoresisitve pressure Sensor	Air pressure
Micro Accelerometers	Vibration, Velocity of car crash etc.
Chemical Sensors	Explosives
DNA arrays	Match DNA sequence
Light Sensors	
Photodiode	Light → ΔI
Photoconductor	Light → ΔR

1.6.5. Power Supply

Let's assume lithium-ion batteries because they are frequently used in sensor networks. These batteries comprised of an electrolyte, cathode and an anode as shown in the following figure.

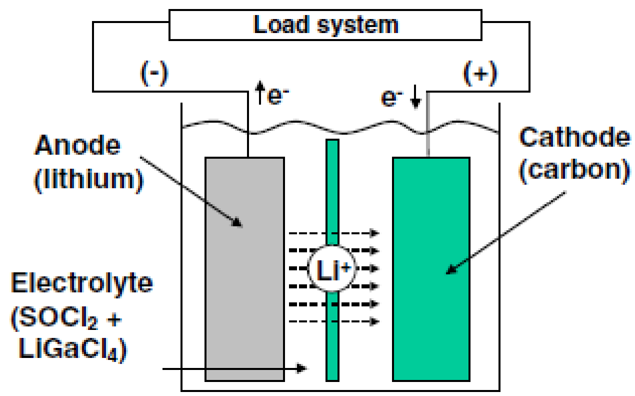


Figure 11: Paper power supply on study

Usually sensor nodes are in three mode for long time operations sleep, active and wakeup mode. In sleep mode it sleeps most of the time but not all time. Telos consumed 2.4 μA and MICAz consumed 30 μA while in sleep mode. In wakeup mode it briskly start working, while in wakeup mode Telos consumed 290ns typical, 6ms max and MICAz consumed 60μs max. Minimize processing and return to sleep it is on active mode. It is called low duty cycle. Transceiver also consumed power while in transmitting or receiving mode.

1.7. Profile of MICAz Mote

MICAz is belongs to CHIPCON2420 crossbow family usually known as CC2420. It consumes low power and easily programmable. It has 2.4 GHz ISM band, 250 kbps QPSK/QAM. Export packet level interface & hardware accelerated IEEE 802.15.4 RF transceiver having 16 channels. CC2420 having fast data rate, low voltage 1.8v low supply, automatic decoding, 128 byte full packet support buffer. The other one is TI MSP430 ultra-low power, 1.8v operation, 1.6 μA sleep and 460 μA active, operating system TinyOS. Following figure shown pin out description of MICAz CC2420.

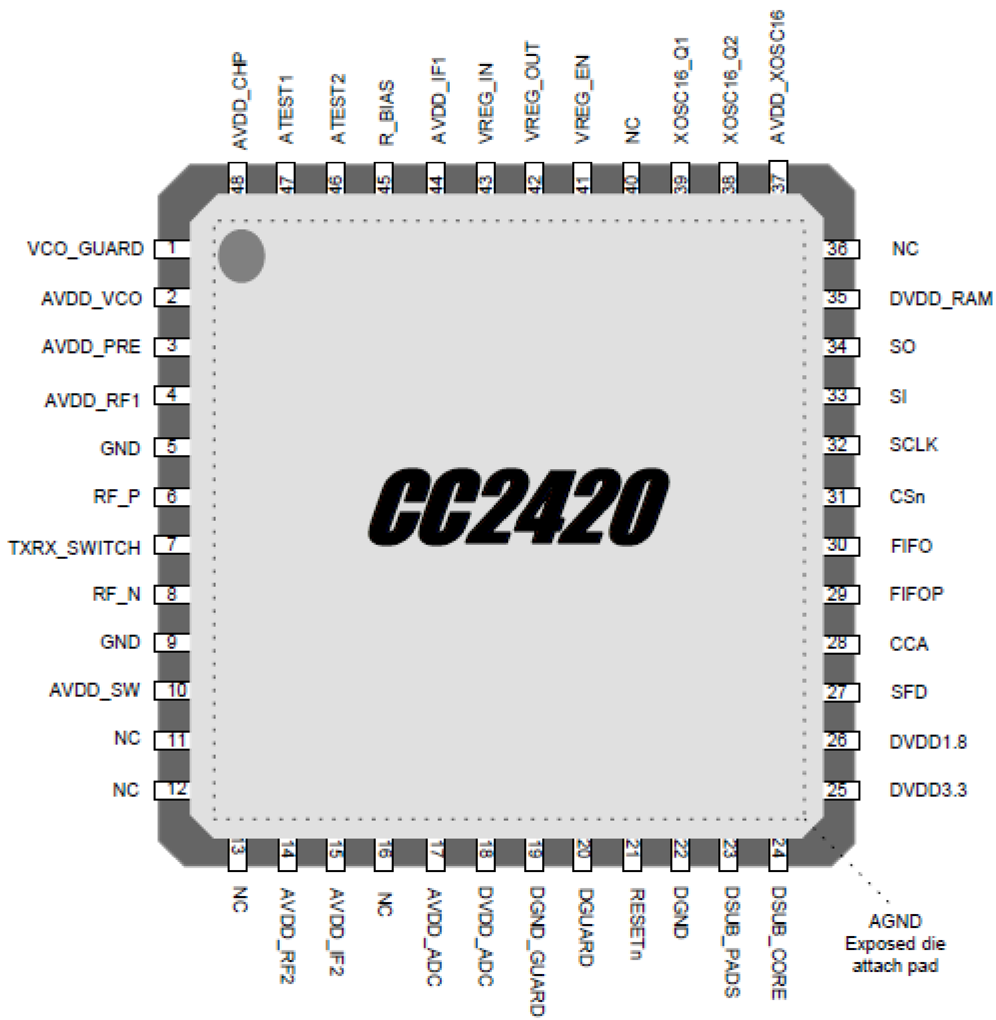


Figure 12: CC2420 Architecture

Following table shown pin out detail.

Table 4: pin out detail

Pin	Pin Name	Pin type	Pin Description
-	AGND	Ground (analog)	Exposed die attach pad. Must be connected to solid ground plane
1	VCO_GUARD	Power (analog)	Connection of guard ring for VCO (to AVDD) shielding
2	AVDD_VCO	Power (analog)	1.8 V Power supply for VCO
3	AVDD_PRE	Power (analog)	1.8 V Power supply for Prescaler
4	AVDD_RF1	Power (analog)	1.8 V Power supply for RF front-end
5	GND	Ground (analog)	Grounded pin for RF shielding
6	RF_P	RF I/O	Positive RF input/output signal to LNA/from PA in receive/transmit mode
7	TXRX_SWITCH	Power (analog)	Common supply connection for integrated RF front-end. Must be connected to RF_P and RF_N externally through a DC path
8	RF_N	RF I/O	Negative RF input/output signal to LNA/from PA in receive/transmit mode
9	GND	Ground (analog)	Grounded pin for RF shielding
10	AVDD_SW	Power (analog)	1.8 V Power supply for LNA / PA switch
11	NC	-	Not Connect
12	NC	-	Not Connect
13	NC	-	Not Connect
14	AVDD_RF2	Power (analog)	1.8 V Power supply for receive and transmit mixers
15	AVDD_IF2	Power (analog)	1.8 V Power supply for transmit / receive IF chain
16	NC	-	Not Connect
17	AVDD_ADC	Power (analog)	1.8 V Power supply for analog parts of ADCs and DACs
18	DVDD_ADC	Power (digital)	1.8 V Power supply for digital parts of receive ADCs
19	DGND_GUARD	Ground (digital)	Ground connection for digital noise isolation
20	DGUARD	Power (digital)	1.8 V Power supply connection for digital noise isolation
21	RESETn	Digital Input	Asynchronous, active low digital reset
22	DGND	Ground (digital)	Ground connection for digital core and pads
23	DSUB_PADS	Ground (digital)	Substrate connection for digital pads
24	DSUB_CORE	Ground (digital)	Substrate connection for digital modules
25	DVDD3.3	Power (digital)	3.3 V Power supply for digital I/Os
26	DVDD1.8	Power (digital)	1.8 V Power supply for digital core
27	SFD	Digital output	SFD (Start of Frame Delimiter) / digital mux output
28	CCA	Digital output	CCA (Clear Channel Assessment) / digital mux output
29	FIFOP	Digital output	High when number of bytes in FIFO exceeds threshold / serial RF clock output in test mode
30	FIFO	Digital I/O	High when data in FIFO / serial RF data input / output in test mode
31	CSn	Digital input	SPI Chip select, active low
32	SCLK	Digital input	SPI Clock input, up to 10 MHz
33	SI	Digital input	SPI Slave Input. Sampled on the positive edge of SCLK
34	SO	Digital output (tristate)	SPI Slave Output. Updated on the negative edge of SCLK. Tristate when CSn high.
35	DVDD_RAM	Power (digital)	1.8 V Power supply for digital RAM
36	NC	-	Not Connect
37	AVDD_XOSC16	Power (analog)	1.8 V crystal oscillator power supply
38	XOSC16_Q2	Analog I/O	16 MHz Crystal oscillator pin 2
39	XOSC16_Q1	Analog I/O	16 MHz Crystal oscillator pin 1 or external clock input
40	NC	-	Not Connect
41	VREG_EN	Digital input	Voltage regulator enable, active high, held at VREG_IN voltage level when active
42	VREG_OUT	Power output	Voltage regulator 1.8 V power supply output
43	VREG_IN	Power (analog)	Voltage regulator 2.1 to 3.6 V power supply input
44	AVDD_IF1	Power (analog)	1.8 V Power supply for transmit / receive IF chain
45	R_BIAS	Analog output	External precision resistor, 43 kΩ, ± 1 %
46	ATEST2	Analog I/O	Analog test I/O for prototype and production testing
47	ATEST1	Analog I/O	Analog test I/O for prototype and production testing
48	AVDD_CHP	Power (analog)	1.8 V Power supply for phase detector and charge pump

1.8. Sensing Boards

MICA in sensor nodes having a large family and can easily embedded in sensing boards. MTS 300 and MTS 310 sensor board both have light, temperature, microphone and sounder. MTS 300 just have tone detection circuit and MTS 310 has 2 axis accelerometer and Magnetometer. Both are flexible and compatible with MICA, MICA2 and MICAz. Following figure shown both sensing boards.

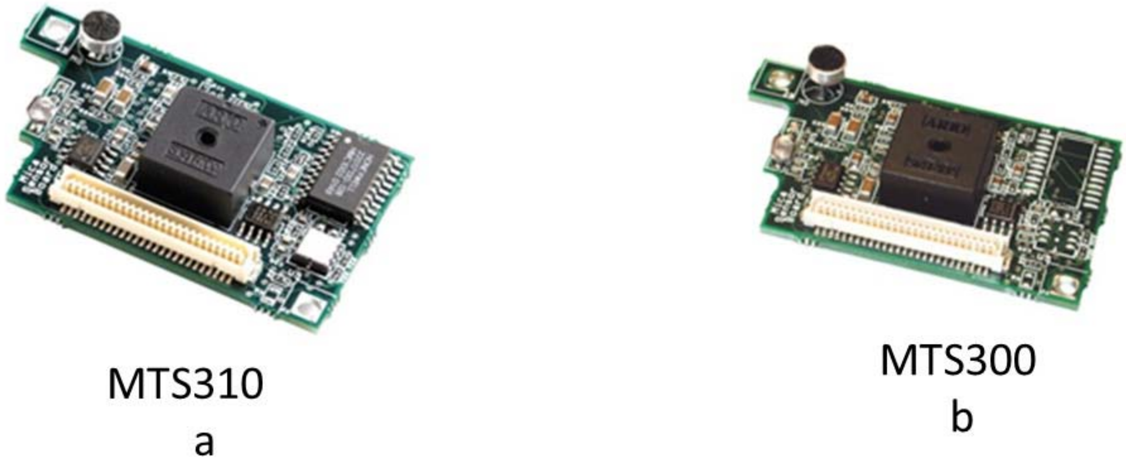


Figure 13: Sensing Board

Following table shown some sensing boards and their descriptions **Table**

Table 5: sensing boards and their descriptions

Sensing Board	Descriptions
MTS101	Basic Sensor Board
MTS300/310	Multi Sensor Board
MTS400/420 (MICA2)	GPS and Environmental monitoring
MTS510 (MICA2 Dot)	Microphone / Light
MDA 300/500	Date acquisition board

1.9. Evolution in Architecture of MICA mote Series

MICA MTS310 on board module descriptions.

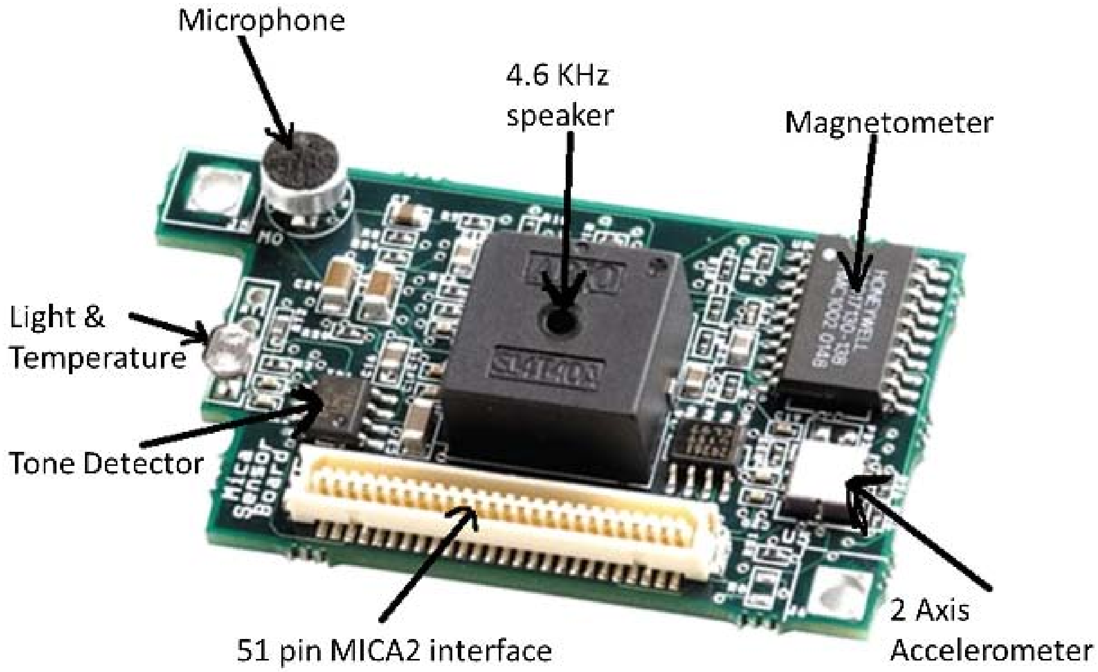


Figure 14: MICA MTS310 on board

1.9.1. MICA mote

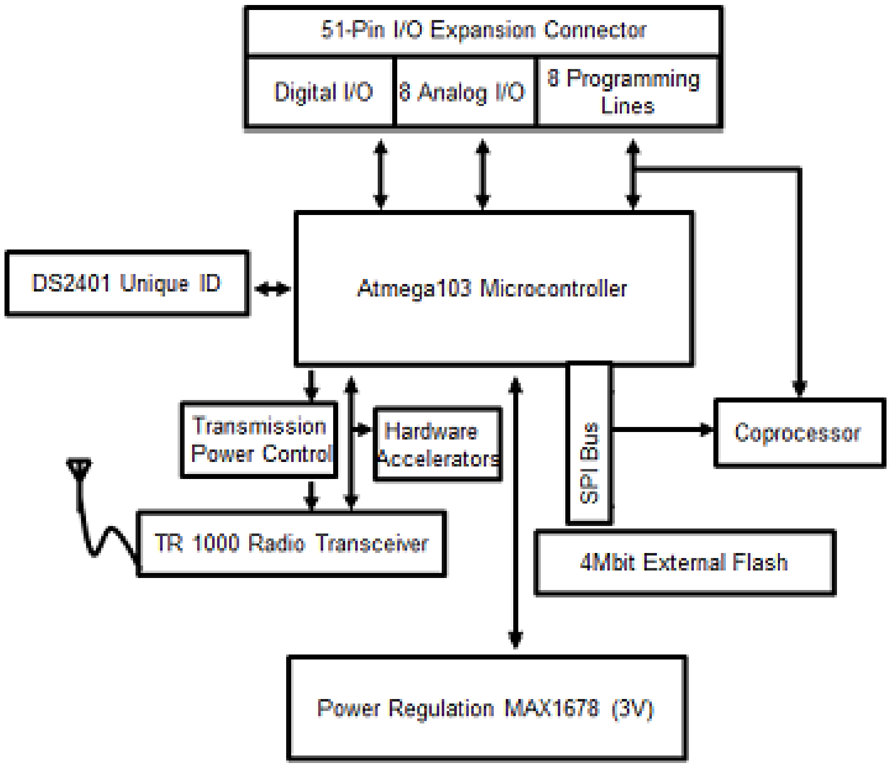


Figure 15: MICA Architecture [14]

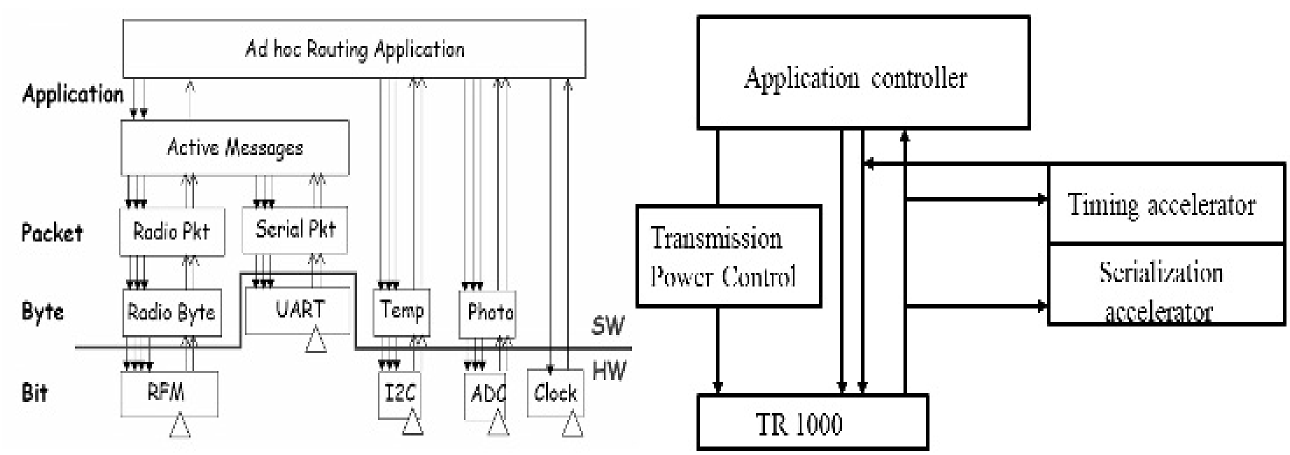


Figure 16: MICA radio sub-system Architecture [15]

Above figure 16 shows the complete Architecture of MICA [15] and figure 16 shows complete radio sub-system architecture.

1.9.2. MICA2 mote

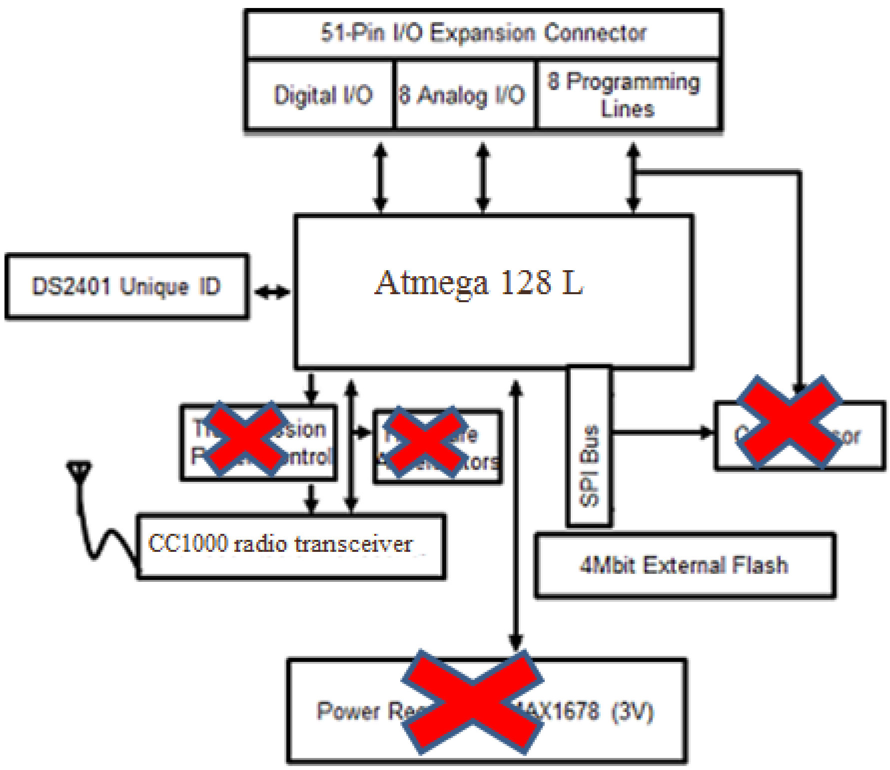


Figure 17: MICA2 Architecture[17]

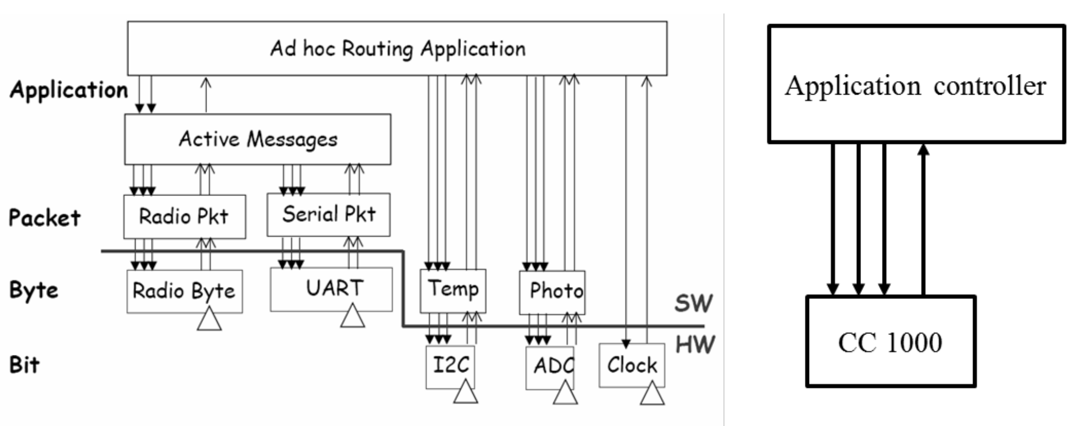


Figure 18: MICA2 radio Sub System Architecture

1.9.3. MICAz mote

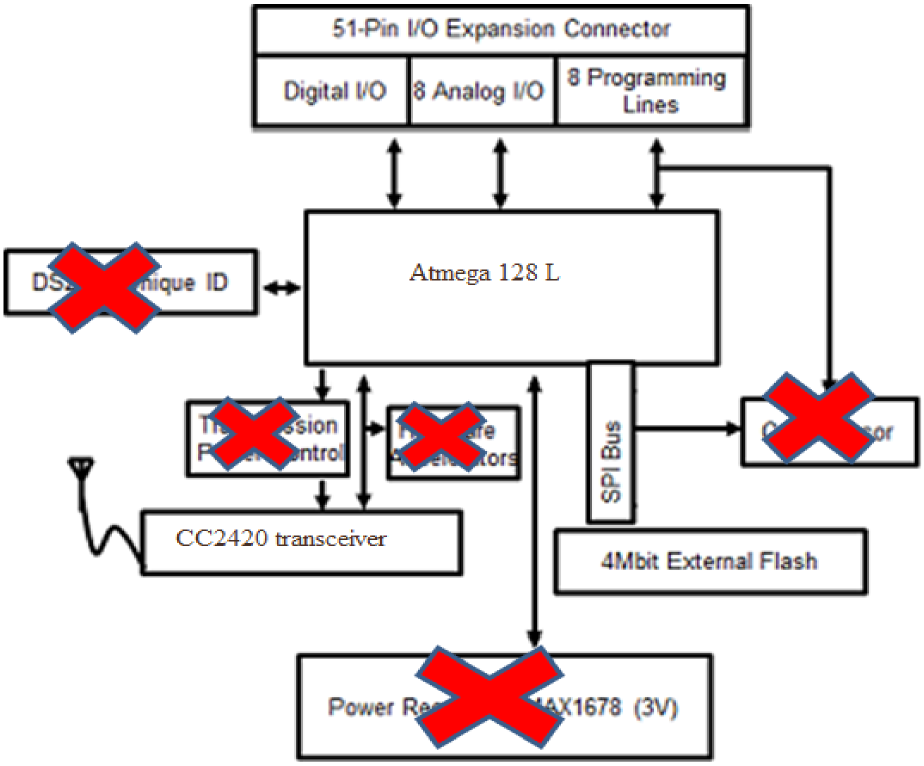


Figure 18: MICAz Architecture [16]

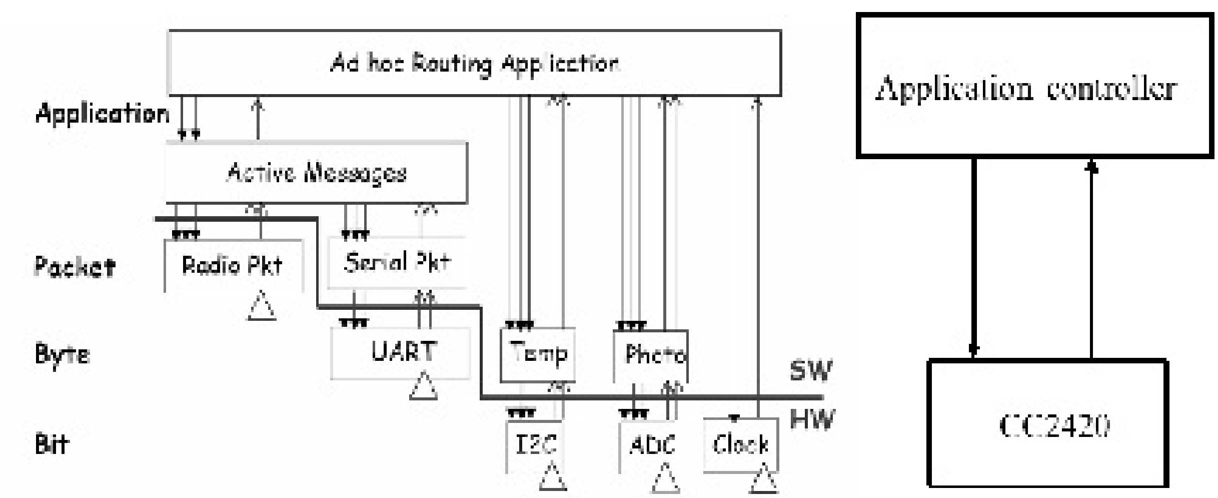


Figure 19: MICAz radio Sub System Architecture [16]

WIRELESS SENSOR NETWORK ROUTING PROTOCOLS

Chapter 2

Wireless Sensor Network Routing Protocols

2.1. What is Routing

The process of selecting the paths from source to destination is called routing. Routing can be user given (fixed) or node identified (dynamic). Routing can be single path or multipath. If there are many receiving nodes it may called multipath routing or if there is single node for receiving data is called unipath.

Routing protocols typically have two routing strategies; reactive approach (source initiated, on-demand driven) and proactive approach (table driven). There also exists hybrid routing protocols that integrate both routing strategies. One typical problem with reactive and proactive routing protocols is they have scalability problems with increasing network sizes in the order of a few hundred nodes. In addition, they may not adapt to network conditions as well as a hybrid.

On-demand or reactive protocols only create routes when the source node requests it [23]. When a node broadcast he message its neighboring nodes received message and send back ack. The route discovery will end once the routing table is maintained and updated by all nodes. The discovered route will then be maintained until it is no longer valid or not desired. Proactive protocols attempt to maintain routes. Proactive protocols, because they maintain tables for storing routing information. Whenever a change in network topology occurs these changes are propagated through the network by means of broadcast or flooding. These updates are vital to manage a consistent view of the network topology.

Zone Routing Protocol [24], implementation and some of its key routing strategies are described in a later section. Figure 3.2 shows a list of the current routing protocols compiled by Halverson and Lindberg in [25]. The protocols are categorized in accordance with the different characteristics as defined earlier. Protocols that do not fit into the classification are placed under “other”. There are security protocols that address various aspects of security threats. Some of these are standalone protocols while others would work together. Following figure show the types of routing.

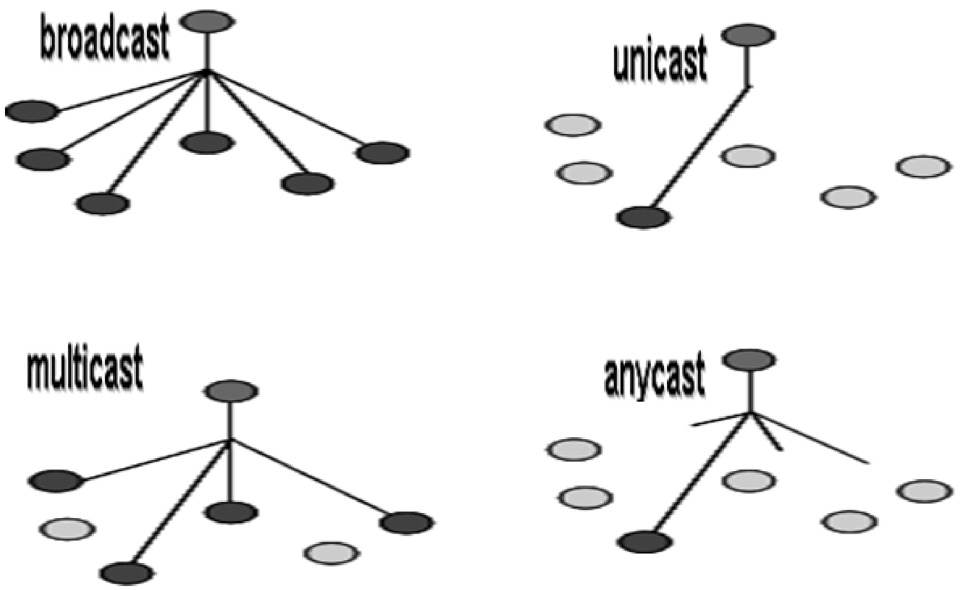


Figure 20: Routing Schemes

2.2. Routing in WSN

WSN is not have predefined infrastructure that’s why selection of best routing path is a big challenge in WSN. There are lot of routing algorithms given by scientist and researchers with the passage of time. The best shortest path is the best routing path for WSN.

2.3. Routing Algorithm

For implanting or working with routing protocol understanding with routing protocols is more important before it used. How the implemented protocol is running and how its complexities remove after design it. Some of conventional routing algorithms are link state, distance vector and source routing.

2.3.1 Distance Vector

The RIP specifications in RFC 1058 [11] provide a informative discussion with distance vector, or Bellman-Ford, algorithms. Each router informs its neighbors for routing table. Routing Information Protocol (RIP) is a much known algorithm. Each node from source to destination each node to node distance is calculated.

2.3.2 Link State Routing

Each route maintain its path and update the route for every time overall the network. When route is changed over the network it simply flood the advertisement (LSA) over the network for status changed. The link state routing is reliable and easier in use. Its also easier in debugging. OSPF [15] and Intermediate System-to-Intermediate System (IS-IS) are link state routing protocols.

2.3.3 Flooding

In flooding any node initiate the message and broadcast it over the network. Doing so many messages flooding cause network lifetime so short and so many broadcast increased the overhead on the network. Each node broadcast the message on each turn. Flooding is a very simple and reliable routing protocol because when a node broadcast a message it successfully delivered at its destination no matter what is route and how many packet is broadcast and forward over the network.

2.3.4 Source Routing

If the source of the packet is fixed and it uses the same route is called source routing. If the sender fixed the same route as before packer is delivered is called namely strict and if the there is no location specify before packet broadcast on the network is called loose routing both are the types of source routing. This usually solved by maintaining a routing table of the given network. Examples of routing protocols that rely on source routing are DSR [21] and AODV [22].

2.4 CHARACTERISTICS OF ROUTING PROTOCOLS

Research in WSN network has led to a number of routing algorithms and protocols. It cannot be possible to elect which protocol is better than by others under specific conditions. For better performance and results selection of better protocol is most important, if it's not better it may cause of poor results For better selection of routing protocol this section make us understand for weaknesses, characteristics, advantages and requirement of routing protocols. Figure 21 provides an overview of the protocol classes.

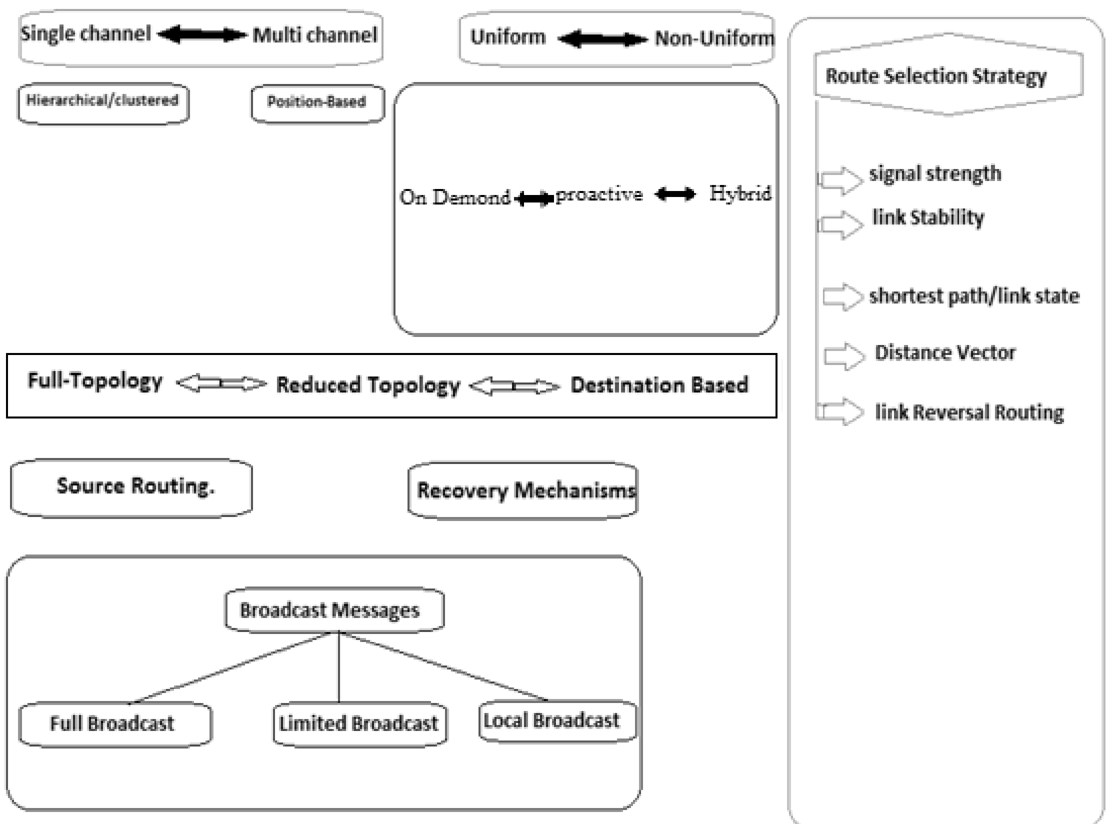


Figure 21: Protocol Class Overview

2.4.1 Single Channel versus Multi-channel Protocols

In most network simulations, it is often necessary to define a layer 2 interaction and many layers 3 channel. When data transfer with physical layer some methods are used how data transfer from source to destination usually two types TDMA and FDMA technique used for it.

2.4.2 Unicast versus Multicast

In unicast routing each packet is transmitted to a single destination whereas in multicast routing each packet is transmitted simultaneously to multiple destinations. Therefore multicast transmission is very efficient where we have a limitation of resources i.e. bandwidth and energy. In sensor networks we have also limited resources in particular energy is the main limitation therefore multicast protocol can help us to save these kind of limited resources.

2.4.3 Uniform versus Non-Uniform Protocols

Another protocols is for network if the nodes are not assign specific tasks is called uniform nodes and if the nodes are assign as specific task and work as centralized based is called non-uniform protocol.

2.4. 4 Hierarchical Topology

Instead of random disposition of networks, clusters are used to introduce some structure into the network. There is usually a dedicated node selected as a group leader, also called a cluster head. Cluster nodes join their cluster head by received signal strength and complete the cluster. There are known drawbacks to cluster networking, especially with very stable clusters. Another key issue is that consumption of energy by the Cluster head is increased but simple node consumed a very low energy.

2.4.5 Position-Based Protocols

Position-based algorithms require route discovery and no routing table overhead during this process. But a key requirement is positioning the nodes location. Each node knows it location and its neighboring node position. As a result of the extra overhead information that is required to maintain the position information, Global Positioning System (GPS).

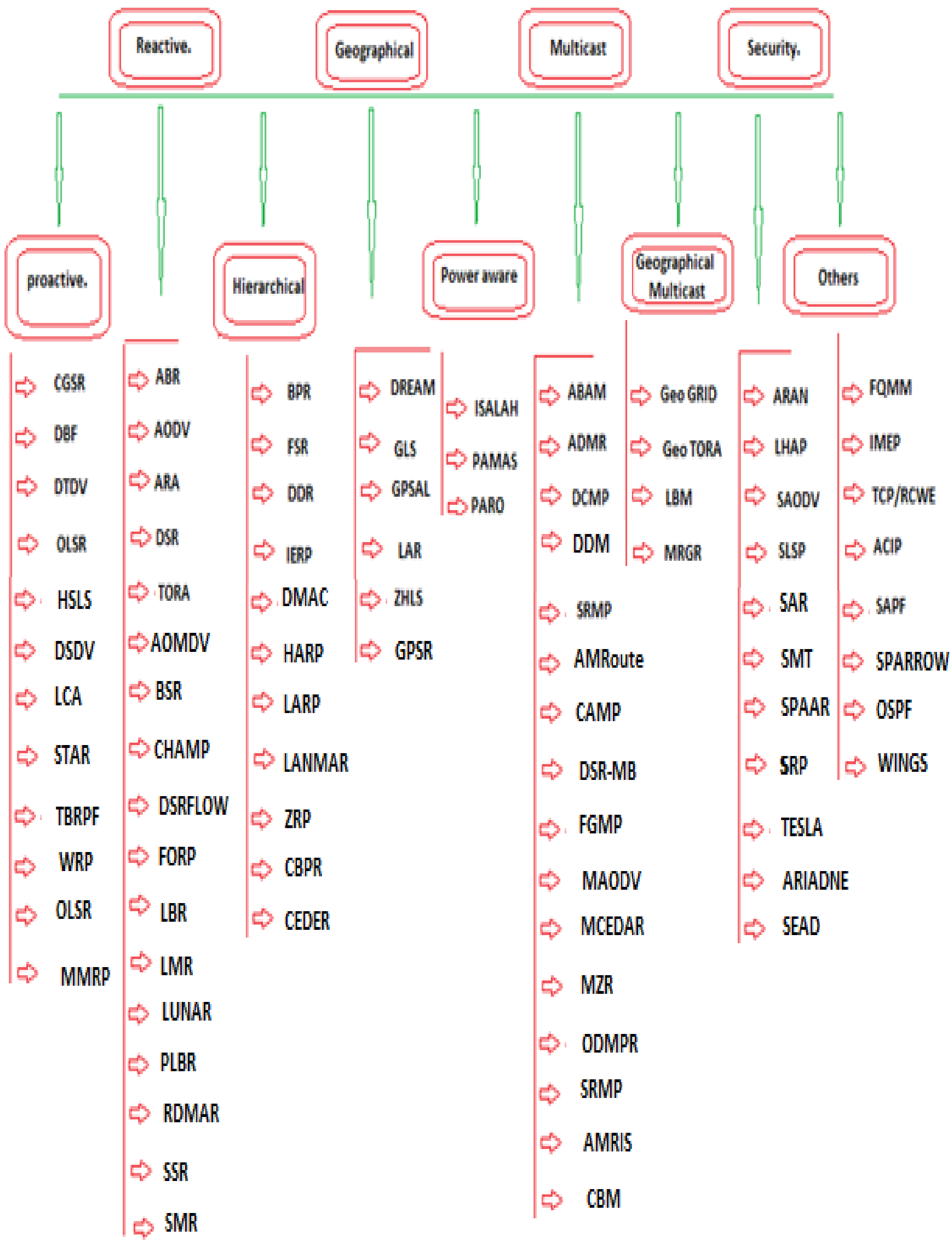


Figure 22: Overview of Routing Protocols

LITERATURE SURVEY

Chapter 3

Literature Survey

3.1. Background and Motivation

[Heinzelman 2000] LEACH (Low Energy Adaptive Clustering Hierarchy) in which BS is fixed and all the sensor nodes are homogenous because all the sensor nodes having same configurations like energy, computation power and memory. In LEACH one node designed as cluster head and other nodes as its member nodes. Cluster member's sense data and send it to their CH in TDMA mode. CH aggregates the received data and forwards it to BS directly. CH elected in every round through randomized rotation process. The node that elected CH once never elected as CH again. In LEACH residual energy is not considered for CH rotation. LEACH conserves energy through Aggregation and adaptive clustering.

LEACH is a periodic process new CH is elected on each round. In LEACH Advertisement, Setup and Steady-State three phases per round. Election and membership process in advertisement. Second is schedule creation and the last one is data transmission. CH can be chosen (randomly). If $n < T(n)$, then that node becomes a CH. Nodes membership based on RSSI and Eb/No. Each node assign a time and done it task within that time. CH received data from nodes aggregate it per round and send it to BS. CH to BS direct longest path consumed more energy. Randomly selected CH, not based on residual energy. Election of new CH on each round. Not support for multipath. No data reliable transfer to BS if CH dies.

In V-LEACH protocol [Bani 2009], vice cluster head is used instead of a new cluster head. V- LEACH working is same as LEACH but role of Vice-CH just advertisement of vice cluster head added. When node goes to die achieve its dead level it transfer the role to it V-ice-CH. Acquired data from member nodes reliable transfer. Extra overhead when role transfer to vice-CH. Life time of the Vice-CH is very less. Not hierarchical, maximum E2E delay.

In TL-LEACH [Loscrì 2005] provide two level of hierarchy by including one more primary cluster-head between the BS and the secondary cluster-head and localized control for data transfer. TL-LEACH can understand in four steps. In step one every node decides if want to be in current round, same as in simple LEACH. Primary CH is working at top level, it select secondary CH and simple nodes CSMA method is used at this step.

In step two secondary CH first select their primary CH and as its forward node and also simple node. Simple node joins secondary CH by received signal strength.

In third step, primary CH knows about all the nodes in its group including secondary CH and simple nodes. CSMA code is choosing at each primary CH level for secure transmission. Randomized rotation of primary and secondary CH selection and self-configuring cluster formation in TL-LEACH.

In last step clusters are created and every node in primary CH start communicates in TDMA way, which is decided by primary CH. Every simple node send data to its secondary CH and secondary CH aggregate this data and send it to primary CH while this procedure simple node goes on sleep mode. No fault tolerance at primary cluster-head level. More energy is consumed in rounds, Extra overhead, not better for short network.

In [5], Ziyadi et al. describes about WSN are used to fetch and transmit real time data and information. Energy is the main problem in these kinds of network, deployed in remote areas and it's nearly difficult to change the batteries. So network have time and energy efficient it consumed the minimum energy. Ant colony optimization based clustering (ACO-C) is proposed for efficient energy each node works as an artificial agents like a real ant. ACO provide the shortest best path from source to destination. Applying the cost function to the base station side more effectively distribute and minimize the aggregating load and the transmission distance. A population based approach helps to minimize the distance between the cluster node and the clusters which is also known as dynamic optimization problem. In the dynamic optimization problem all ants work together to solve the problem. Authors also compare ACO-C with LEACH, LEACH-C and PEGASIS famous algorithms. LEACH in which some sensor nodes are selected for cluster heads and CH distribute the task to its members. In LEACH cannot get desire amount of cluster heads. After that LEACH-C (Clustering) was proposed to get that inability. ACO-C also compare with PEGASIS, working as a chain rule in which node contact with one single next node but this is not a proper energy efficient way. Initially, in ACO-C all nodes ack energy. Base station selects the nodes that have maximum energy with the help of cost function. Number of nodes in unit time and no of data packet received in unit time. ACO-C is better because node life time is longer than old algorithms with the same cost function. This achievement gets due to the optimized allotment between cluster head and the clusters showing in figure 23.

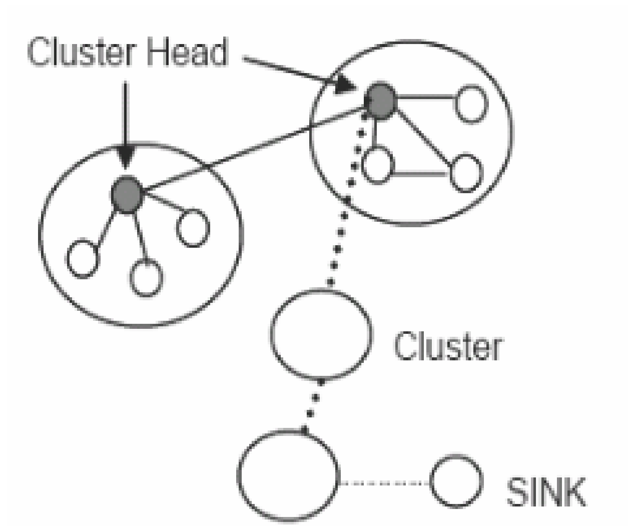


Figure 23: Cluster head with cluster members [11]

Authors take one hundred alive nodes along x-axis and eight hundred seconds along y-axis. All nodes alive for first two hundred seconds than long distance nodes are working down and for minimum energy consumption and prolong the network time. So results show ACO-C is better than previous famous algorithms. Using a population based approach wastage the whole colony. Author cannot make the network time and energy efficient at the same time continuously. If cluster heads are not in center position of each cluster than whole network may not be equally distributed. Life time of the network is not efficient for Multi hop routing.

In [6], Wei shen et al. investigated the energy awareness problems which play a vital role in WSN performances. In WSN a node depend on a power in some cases battery backup can be provided easily but battery backup can be difficult at the same time.

EPACOR is proposed solution. A routing algorithm is work like a backbone in energy prediction. EPACOR compare with other two famous algorithms. "Minimal spanning tree (MST) and least energy tree (LET). In EPACOR a shortest path is selected based on energy prediction. This algorithm has the energy lifetime of each node. Remaining energy will be calculated on each node, when the task is done by the selected path. The predication of learning mechanism has embedded about energy consumption in EPACOR algorithm with respect to its neighbors. EPACOR is depending on ant colony system (ACS) it choose the best optimal path with maximum channel capacity to the sink. To avoid from the loops node id will be save. They also used global pheromone update rule in it only best ant allow to release the pheromone on each iteration and the other one is local pheromone update rule, all ants release pheromone on each node. EPACOR also observe that nodes at long distance consume more power so it selects the path having short distance nodes.

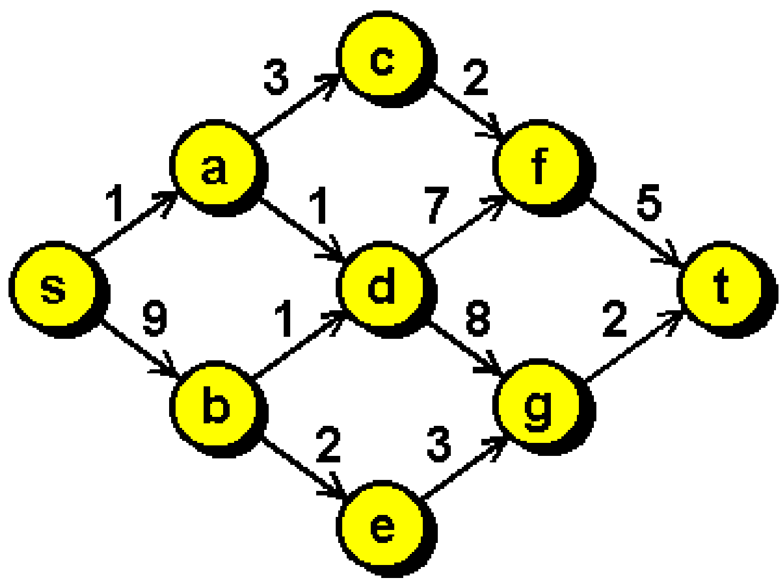


Figure 24: Selection of shortest path [12]

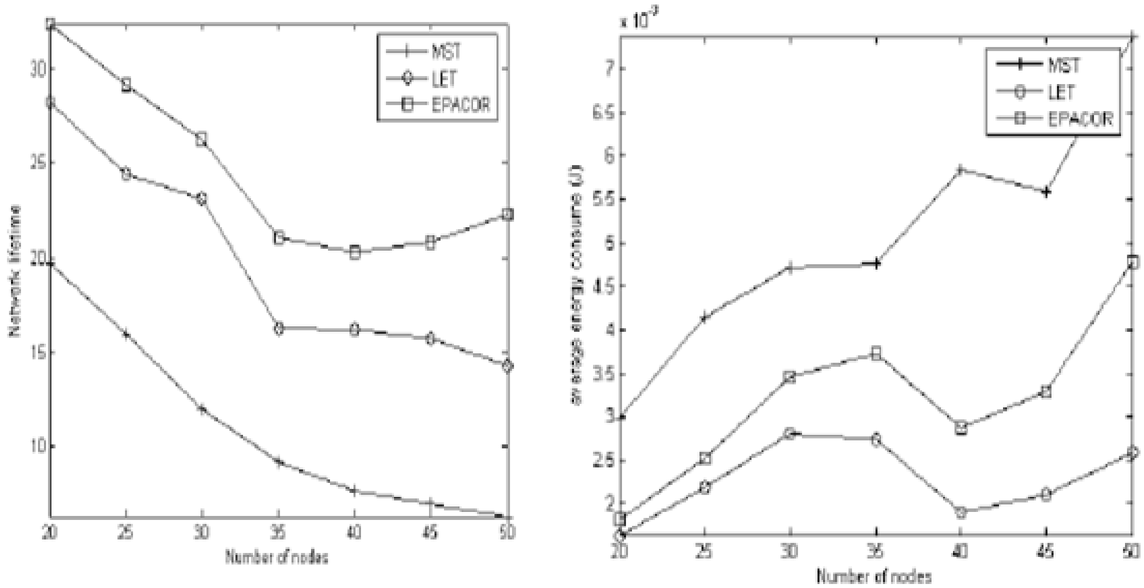


Figure 25: DGCs graph [6]

Lifetime and the total no of nodes are network parameters. They compare EPACOR with MST and LET. To measure the life time of the network authors use data gathering cycles (DGCs). Initially 2kb packet is assign and 0.2 joule energy is consumed by each node. Results show the average values of 30 simulations are on the graph. First graph shows the life time of the network over 50 different topologies which are randomly selected and from second graph average energy on the y-axis and different randomly selected 50 topologies on x-axis. MST results show that initially it consumed the maximum energy which is not better for the network and also lifetime of the LET is not much better for the network. EPACOR consumed minimum energy and with the good network lifetime. Lifetime of a network is a critical issue. WSN nodes have limited energy resource but authors done their experiments with single fixed node. They take the energy of the sink node is unlimited.

In [7], Dorigo et al. describes new approaches which has inspired a social behavior of insects particularly ants. Ants are more socialized and naturally intelligent. The general optimization technique which is inspired from ants called ant colony optimization. The ants sediment pheromone on the ground to lead the best shortest path towards destination. ACO provide the solution of many real world problems like TSP and assignment.

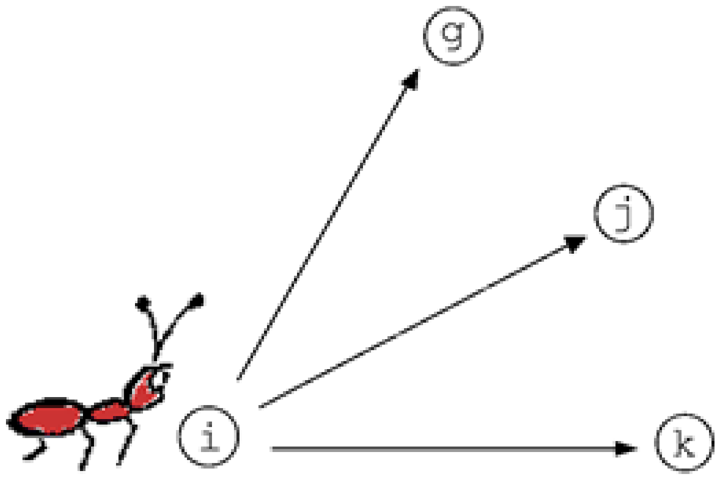


Figure 26: Probability if j is not visit before so (i, j) [7]

In the above figure ant choose the next city by using stochastic mechanism approach. If j is the next visiting city from i and j is not visited before. Edge to edge pheromone probability inspired the ant for visit. ACO attracts the attention of scientist and researchers in wireless sensor networks. It is first invented in 1990's and still it needs a lot of attraction of scientist and researchers.

In [8], Junlei Bi et al. discussed about WSN has limited resources, limited power and has limited channel capacity. So being a limited channel capacity load balancing is a big problem. Same as single ant has limited pheromone capacity but working in a group ants done their complicated task easily. In WSN providing a QoS and minimum energy consumption is a big deal. ACOLBR authors enhance the QoS and prolong the network lifetime. They also compare ACOLBR with other two famous algorithms AGRA AND M-IAR. "An ant like game routing algorithm (AGRA) not fit for congestion control. A multimedia enabled improved adaptive routing algorithm (M-IAR) is a multi-hop routing protocol geographical location of the nodes. If geographically node location is changing its failure the network also has poor scalability. ACOLBR has good scalability, end to end delay and load balanced. In ACOLBR, using MST intra cluster is built. It is hierarchical routing tree in it cluster members send collected data to cluster head and cluster head send data to its base station. Secondly, in inter cluster routing ACO algorithm is used to find the best optimal path and some close to optimal paths called suboptimal paths. In inter cluster routing first select the optimal path and send data but when data is greater than the channel capacity inter cluster routing used suboptimal paths for load distribution. In ACO they divided ants into two categories forward ants used local pheromone update rule and backward ants used global pheromone update rule. ACOLBR setup a multiple paths for better load balancing and congestion control.

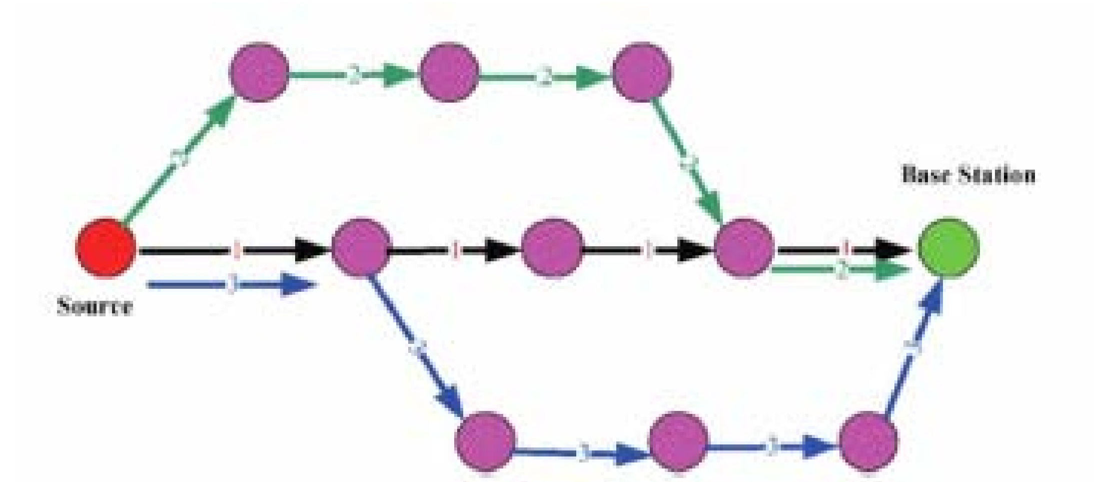


Figure 27: Diagram of the optimal and suboptimal paths [8]

Number of nodes alive in unite time, End to end delay in unite time, ACOLBR Compare these parameters with AGRA and M-IAR. Delay in delay occurs if using more than one suboptimal path also more energy will be consumed in suboptimal paths.

In [9], authors investigate about dynamic environment problems. When nodes are changing their location in WSNs, the geographical information of each node will be incompatible for algorithm. It is also a big deal for ACO when nodes are dynamically changing their location. Authors proposed their solution by applying three approaches. Population based ACO (P-ACO) is first approach to solve the problem in Ad-hoc networks. In population based ACO they divide ants in age wise groups and the task assign to next group who have minimum load. The second approach is PAdapt having three specifications. First one is called alpha and used for solution constructions. The second one is called beta and used for visibility measure and the last one is having strategy for out-dated search experience. The third approach is greedy ants, used to select the CH at the highest visibility strategy with greedy update. Both P-ACO and greedy ants have best iteration information updated. The pheromone information in ACO is iterative manner so each ant updates their pheromone information at the end of its each iteration. So ACO provide the dynamic problem solution. Initially, ad-hoc network is undirected graph. The nodes with minimum load will be selected as CH with having shortest distance with its members. CH's mostly have maximum load and the resources of the network is limited so the problem of load balancing is occur. ACO provide the solution of load balancing and provide the solution for dynamic based clustering. Reactivity, LBF at recovery and best LBF is the performance parameters with respect to gain over control in percentage. They take alpha parameter for solution construction, beta parameter for visibility measure and for out-dated search experience. It is not a good way to give a same task to the different behavior of ants, like a group of greedy ants. They also use the repair heuristic application it takes more time which is not suitable for WSNs.

In [10], chang et al. investigate that routing path should be optimal shortest and having load balanced network. Minimum energy consumption and minimum delay in time is a big problem for WSN network should be minimum energy consumption. Authors describe the energy aware load balancing schemes which is based on two levels. One is maximum capacity path (MCP) and the second one is maximum capacity path with path switching (MCP-PS). In MCP nodes are finding the best shortest path with maximum data rate transferred. In MCP-PS the nodes share the data by its next node for load balancing. The life time of first node is not too much small to preserve the energy for entire network. In dynamic multipath routing algorithm nodes are having multipath to transfer their data but it select only the shortest optimal path with maximum available energy. Network is undirected the time of deployment. In MCP, initially they construct a layered network. In this layered network each sensor node selects the shortest optimal path with high data rate transferred. They enhance the lifetime of the network in MCP. The second problem is how to balance the load on network than they proposed maximum capacity path with path switching algorithm. In the following figures fig (a) show that network is undirected and unstructured and fig (b) show layered network.

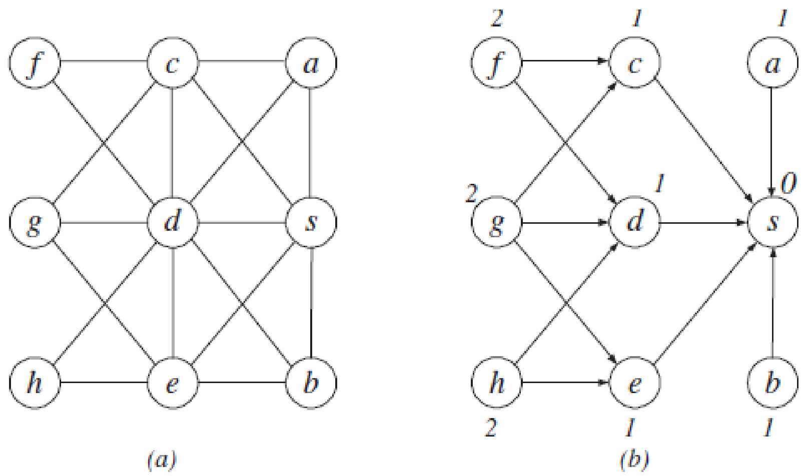


Figure 28: MCP Layered [10]

After construction of the layered network maximum capacity path is selected. The path is selected with having maximum energy for example in the following Figure.

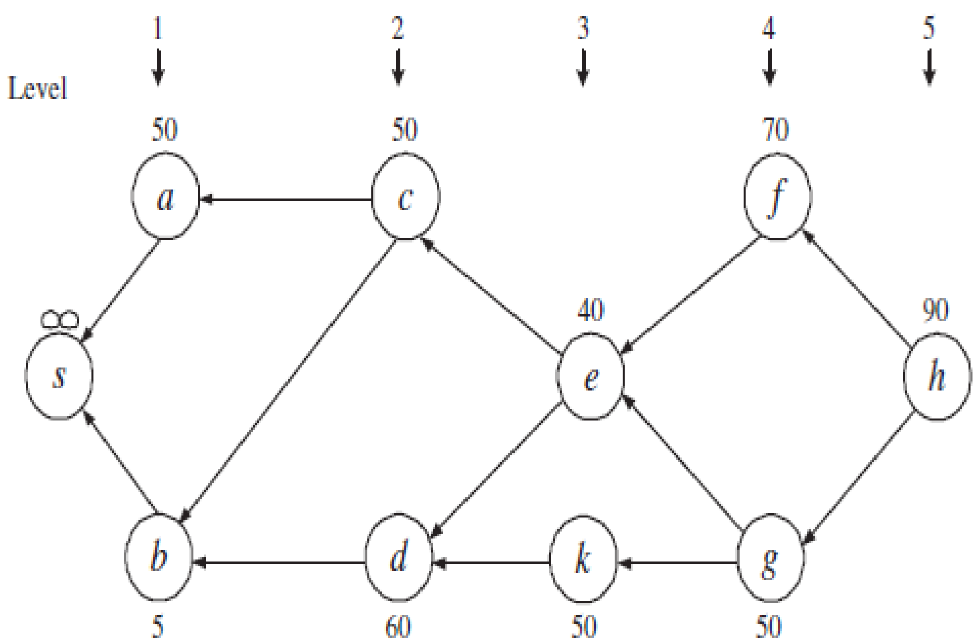


Figure 29: Path selected in the layered network [10]

MCP-PS algorithm is used to share the data by its next node in order to share the traffic and for saving the life time of first node. Number of turns with respect to area of 100 nodes by using different topologies. MCP-PS don’t have shortest path and consume more energy than MCP because of more data is transferred to its neighboring nodes. Extra no of turns used for path switching which is not the good way for data transferred.

3.2. Limitation of Existing Relevant Literature

Ru Huang at el. introduce “prediction mode based routing algorithm” to obtain the required energy awareness and data rate structure. Authors used series model ARMA to analyzed data traffic and load factor. For efficient energy ants pheromone rule is applied. If the structure is not reliable energy is not efficiently consumed. In results maximum energy peak level have been used that cause inconsistency into the results. Energy is not efficiently distributed in most of the networks. Network consumes maximum energy. Base station control all the traffic and energy.

3.3. Objectives

Wireless sensor networks work with real time communication it means, lot of data needs to be process and need more energy. Wireless sensor network also need best shortest optimal path for routing. Researchers proposed many routing protocols and energy aware algorithms but wireless sensor network still need energy aware and load balancing. It should be consumed minimum energy with maximum data. CREAT based clustering algorithm provide minimum energy and load balanced environment. It also provides scalability, network life time and network efficiency. With CREAT we gain minimum e2e delay and minimum computational delay. Our algorithm have good packet delivery ratio.

PROPOSED SOLUTION

Chapter 4

Proposed Solution

4.1. Proposed solution

We have proposed Customized, Energy aware routing (CREAT) algorithm which provide the solution of optimal routing, load balancing and minimum energy Consumption. It increases the network life time. It also removes the congestion problem and fault tolerance. CREAT is an energy aware algorithm. Random deployment of each node make more complex in very dense environment but table management of neighbour nodes and clustering provide easy way to communicate nodes with each other's.

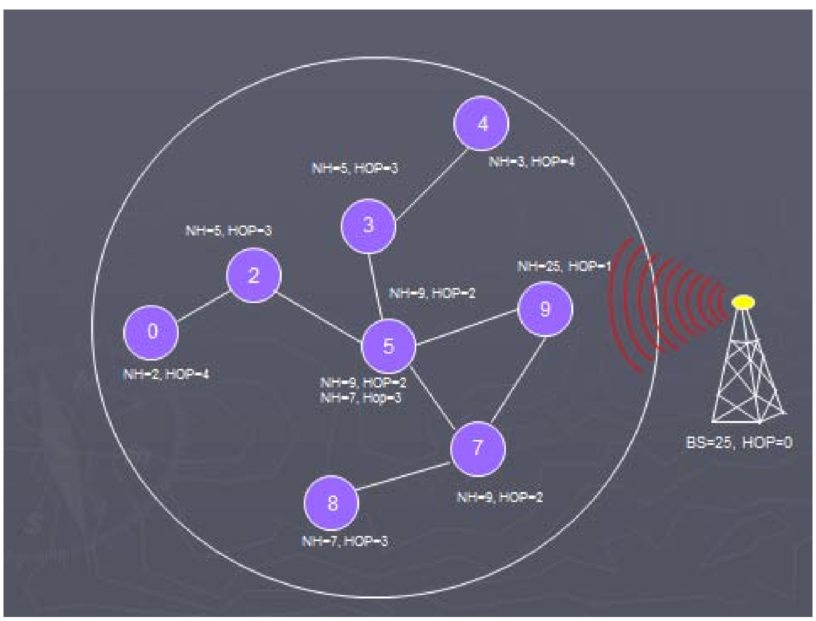


Figure 30: Proposal Diagram

In CREAT all nodes have their neighbor nodes information but they used minimum hop count path and maintain their neighbor table. First BS broadcast the message every node receive that message and create neighbor table of its neighboring nodes. Predefined cluster heads broadcast joining message when all path count with minimum and maximum hop. We reduce maximum broadcast that cause the minimum energy consumption. Also each node used multipath that made our algorithm more efficient and enhanced the packet delivery ratio. Following is the simple diagram regarding the architecture of our proposed solution.

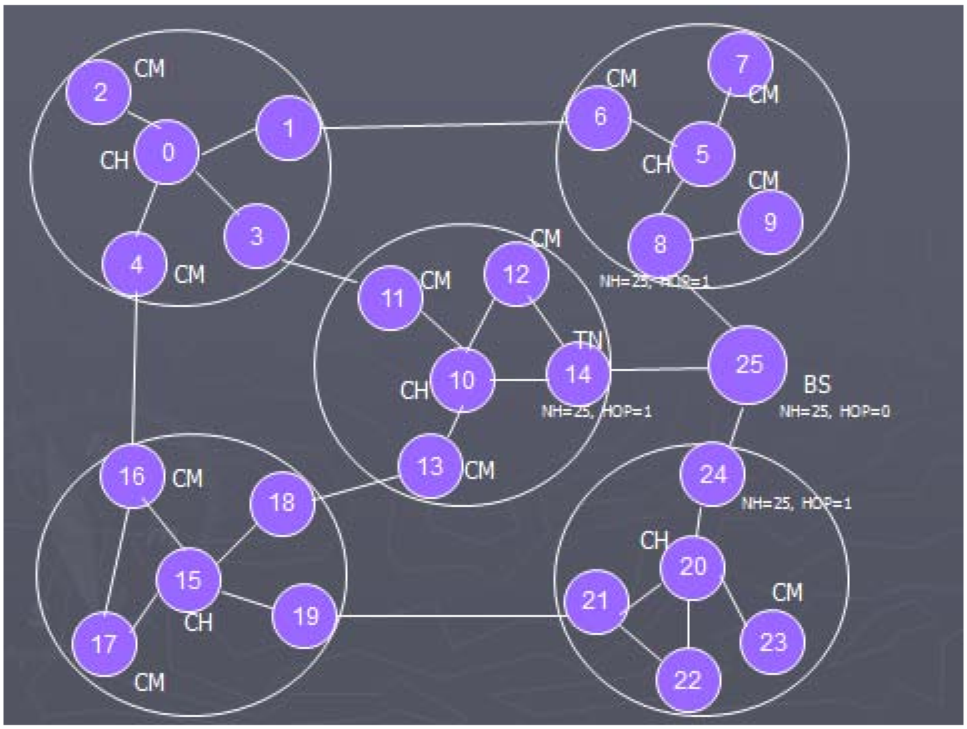


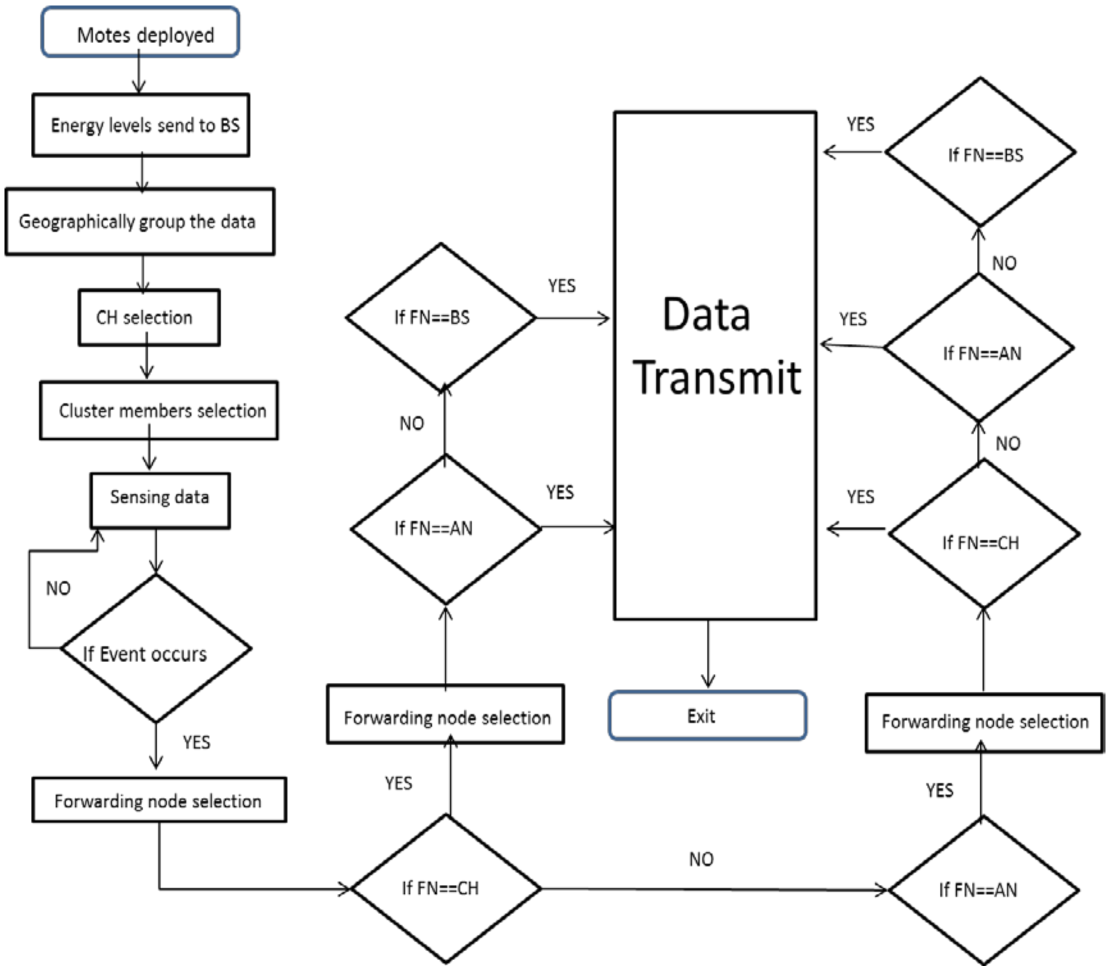
Figure 31: Proposed solution diagram

Minimum broadcast made less computational delay and decrease the packet overhead on each node which made our algorithm more efficient. Transit node share the load with cluster head and cluster members, transit node received packet and forward it to minimum hope. Less beacon message exchange and by doing load balancing we get improved life time of the network. Minimum end 2 end delay occurs due to 20 packet/s timer based strategy over the network. On each cluster four nodes communicate on each per second remaining are on queue and wait for timer on than other four nodes communicate and remaining are waiting for their turn. This cause increased in packet delivery ratio, lower e2e delay and increased the network lifetime.

CM sense data and send it to their cluster head cluster head forward it with transit node. Transit node receive packet and send it to its next hope, unless packet delivered to base station. Our network is fault tolerance; each CM node assigned threshold when it reached at that level it broadcast the message to its neighboring nodes to update their paths. They update it from their neighbor tables and start using available path.CH have multipath for fault tolerance. Threshold based CH rotation also help in fault tolerance.

Each node have dead threshold level transit node also assigned that level when node achieved that level it send broadcast to its neighbor nodes to update their path, transit node also received that broadcast and update its path from table. Following is the flow chart of our proposed solution.

4.2. Flow Chart



Flow chart of proposed solution

SIMULATION DETAILS

Chapter 5

Simulation Detail

5.1. Simulation

Is the process, design a model of real system and running experiments to know the behavior of network. By using simulator we precisely understand the system. Simulation mostly used in research works and for experiments. Using a simulator Is a very cheap method. There are many simulators for wireless sensor networks. We are using NS-2 for exact results and parameters.

5.2. Simulation Environment of NS2

A simulator that simulates the behavior of networks, ns-2 was design in C++. It provides OTcl simulation interface. NS-2 creates several files to understand the behavior of system. We can set nodes, links and terminated in tcl scripts.

5.2.1. How to Install NS-2

Following are the steps how to install NS-2 in Fedora. Also we can install NS-2 in window operating system by using Cygwin or VMware.

- Download ns-2 from //isi.edu/nsnam/dist/ns-allinone-2.27.tar.gz[link] or copy it in home folder.
- Now open command terminal and write in terminal, shown the following.

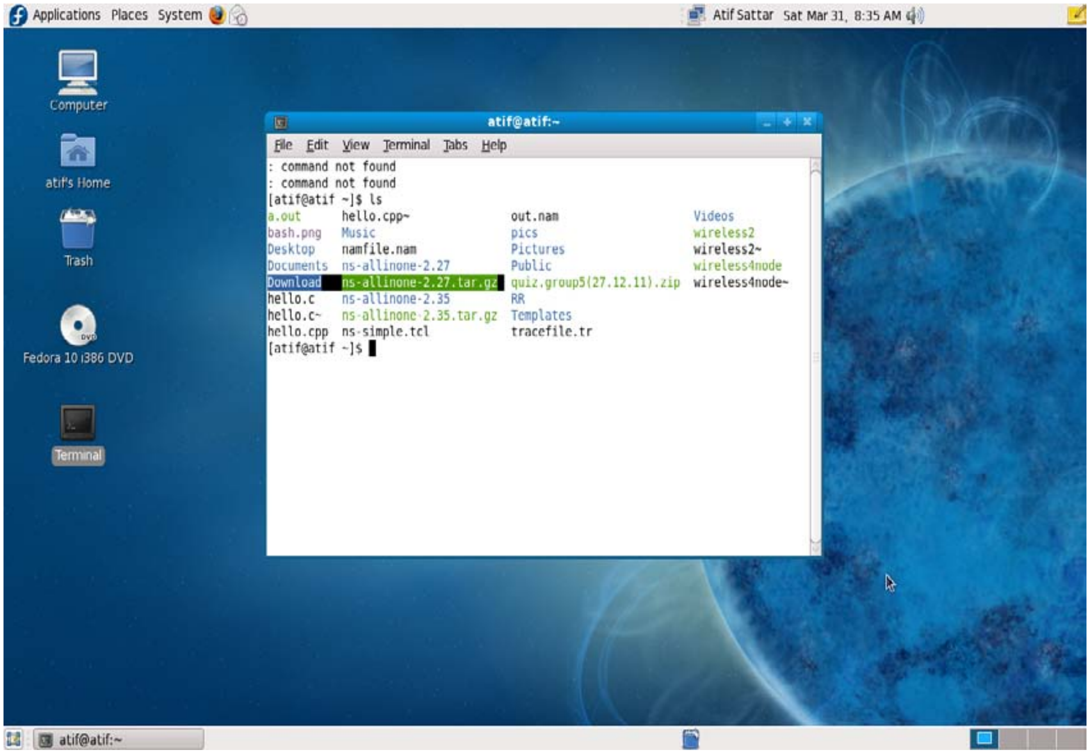
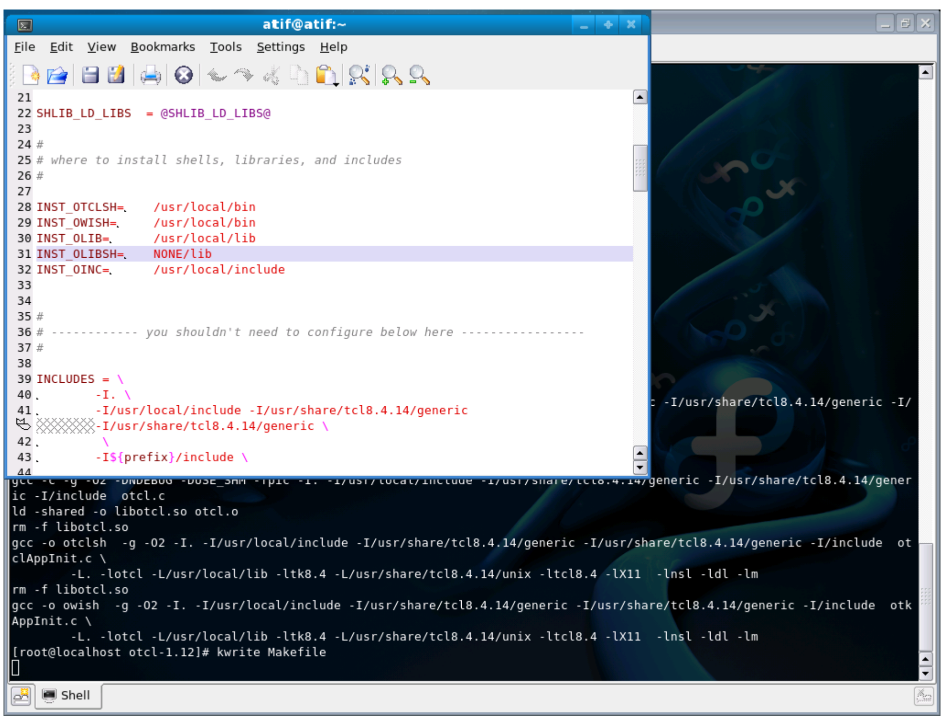


Figure 32: NS-2 tar.gz Extraction

- Write “tar zxvf ns-allinone-2.27.tar.gz” to extract the folder.
- Write “Cd ns-allinone-2.27.tar.gz” in terminal for installation. Write. /install for installation. Following picture shown the installation.



- Now set the paths in bashrc file as shown

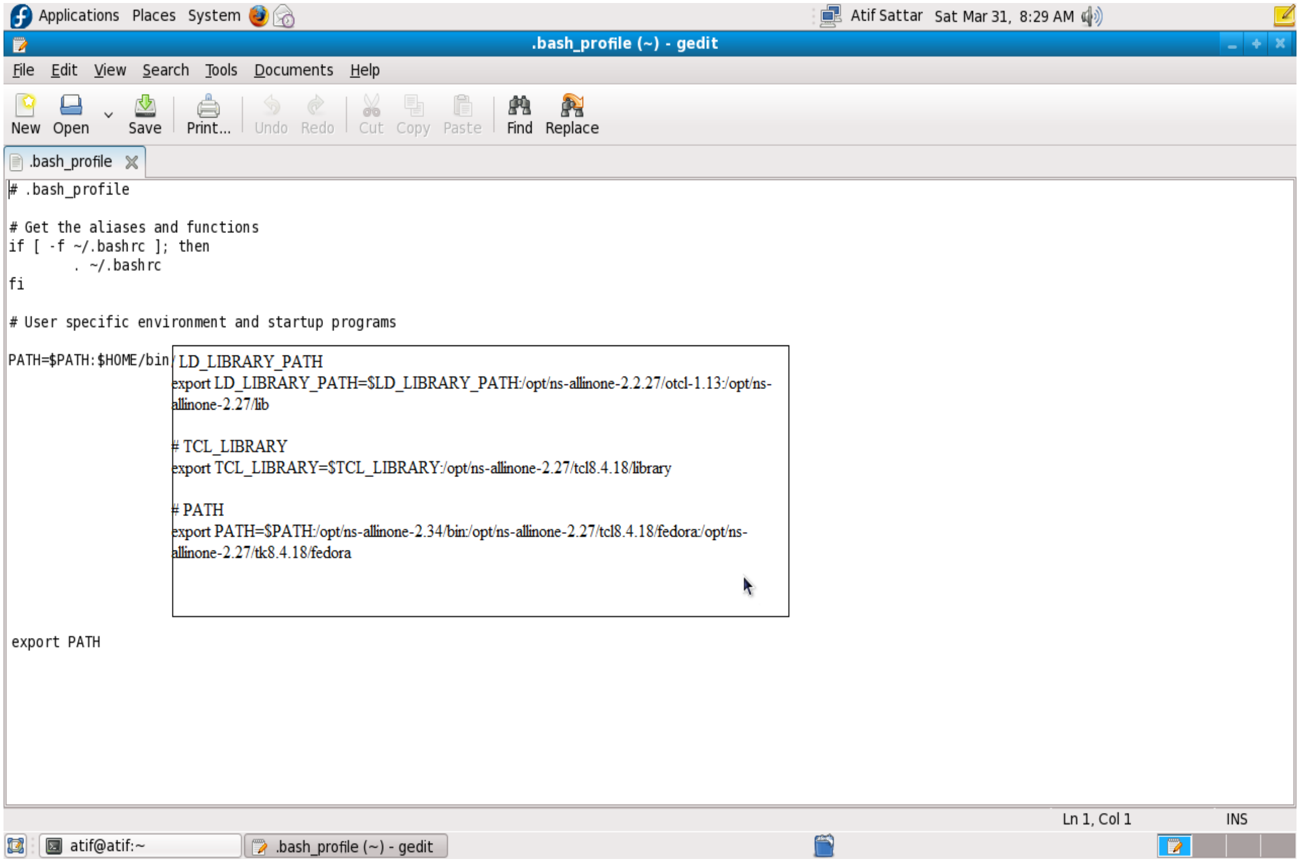


Figure 33: Set Library path

- Installation process in complete, if u write simple ns in command terminal the percentage(%) sign will appear this show successfully installed NS-2.

5.2.2. How to Run NS-2

Following shows how to run programs in NS-2.

- Create ns-simple.tcl file. Set number of nodes, protocol, routing algorithm and location etc. Set network links, half duplex or full duplex and bandwidth.

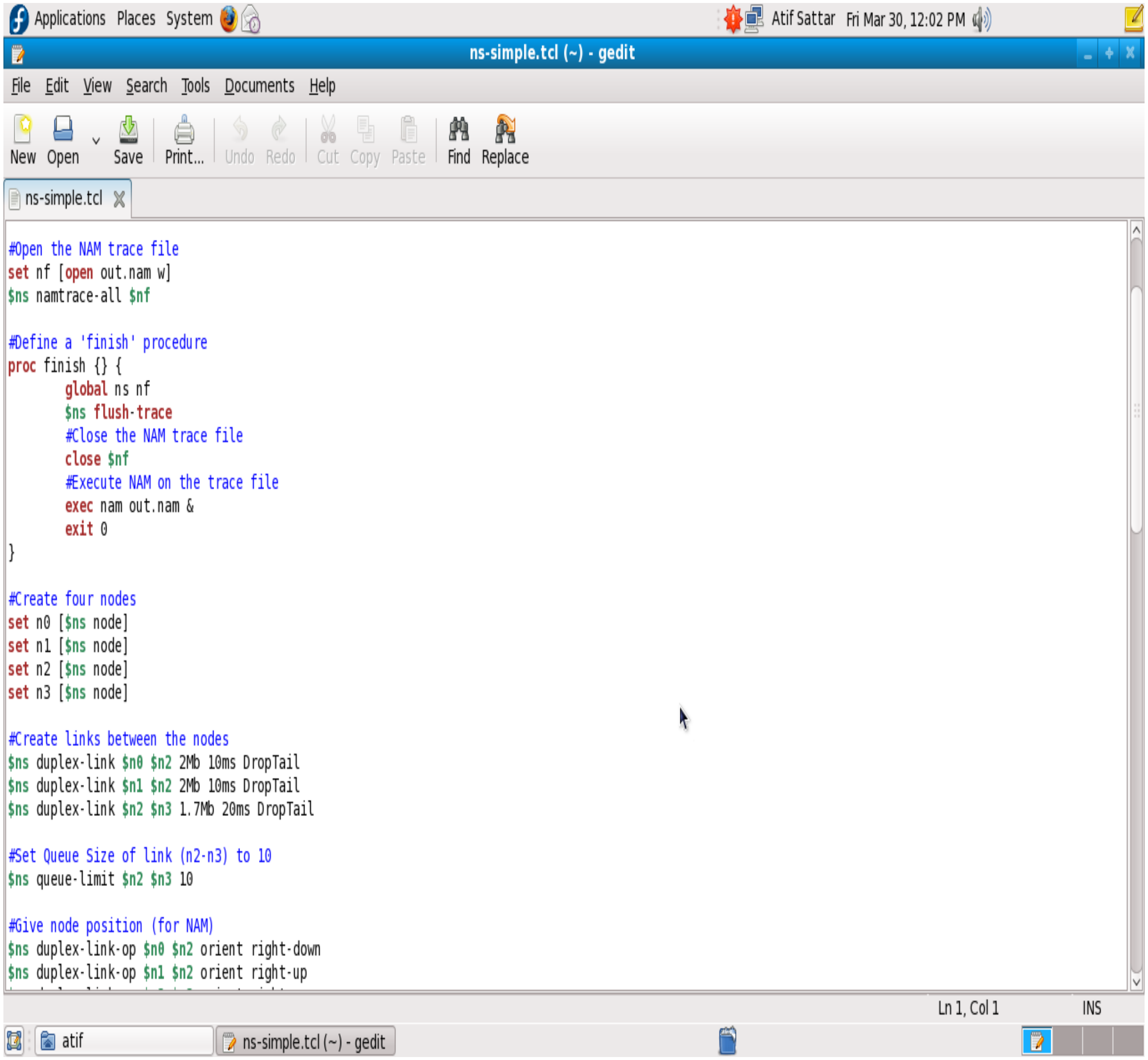


Figure 34: Tcl file

- C++ classes based on tcl scripts.
- When run .tcl files it automatically generate network animator (NAM) and trace files like in following figures.

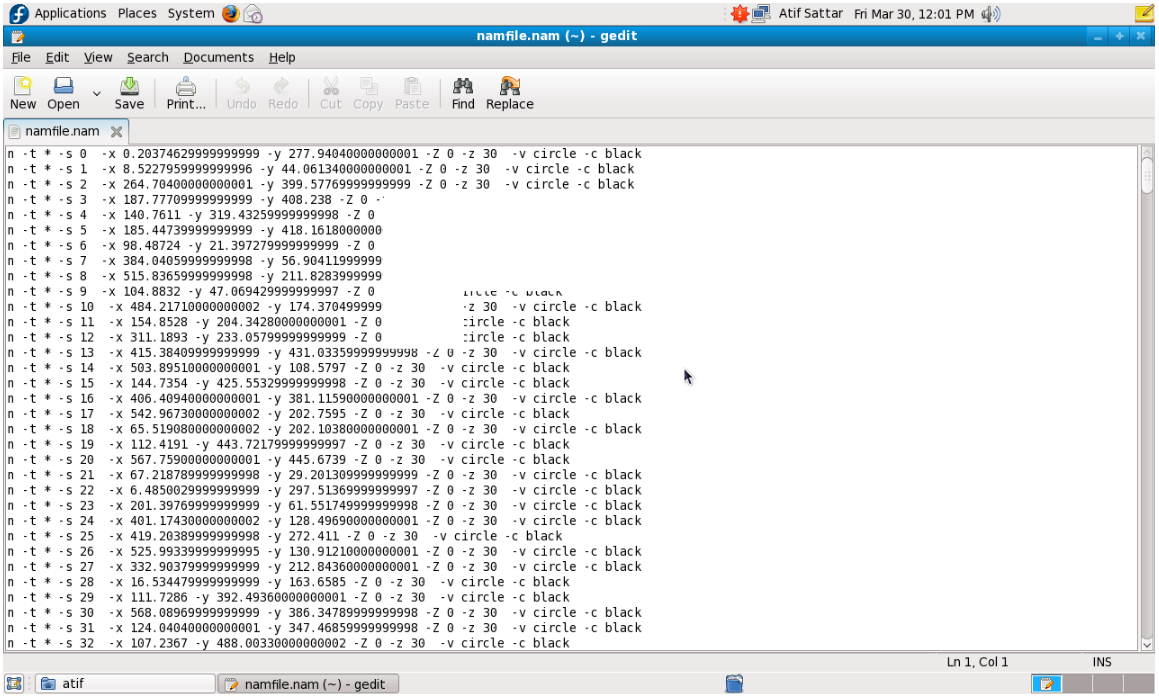


Figure 35: Trace file

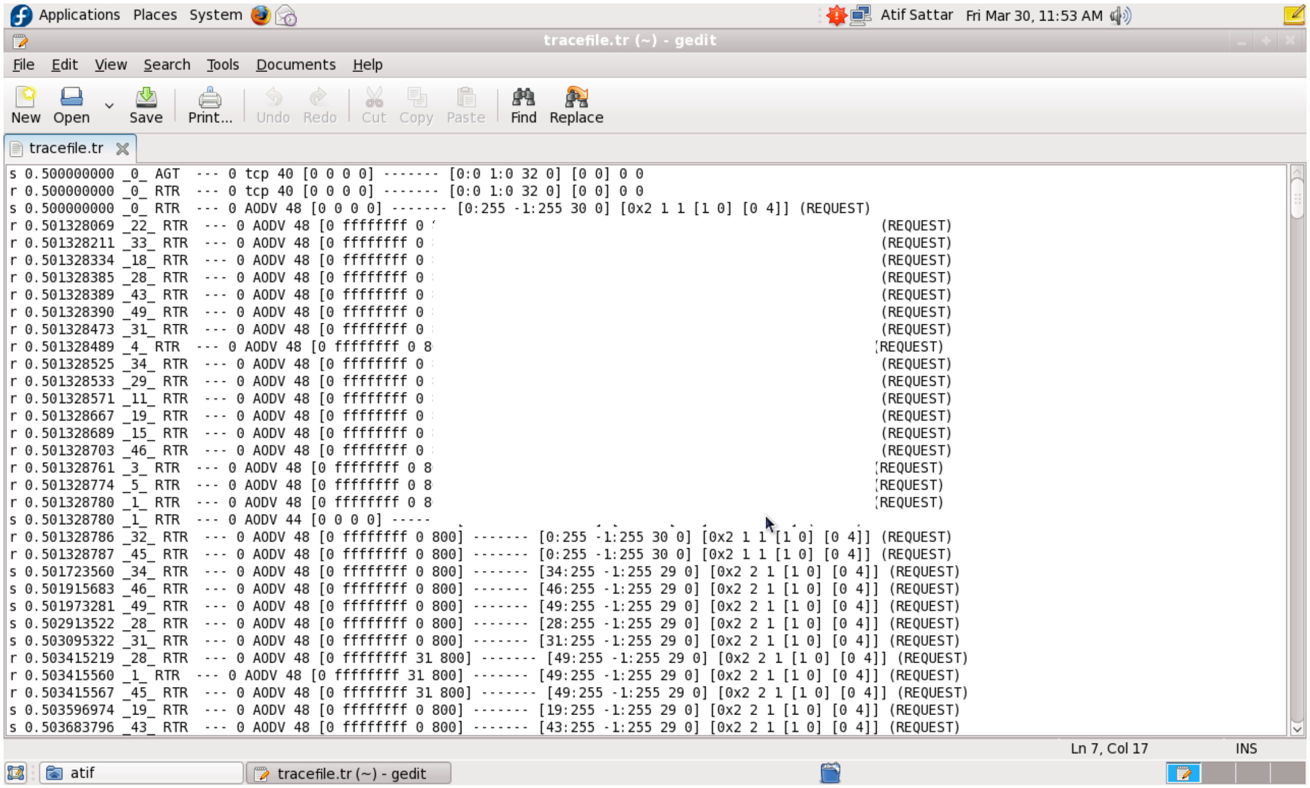


Figure 36: Trace output file

- Following figure shown successfully run the program.

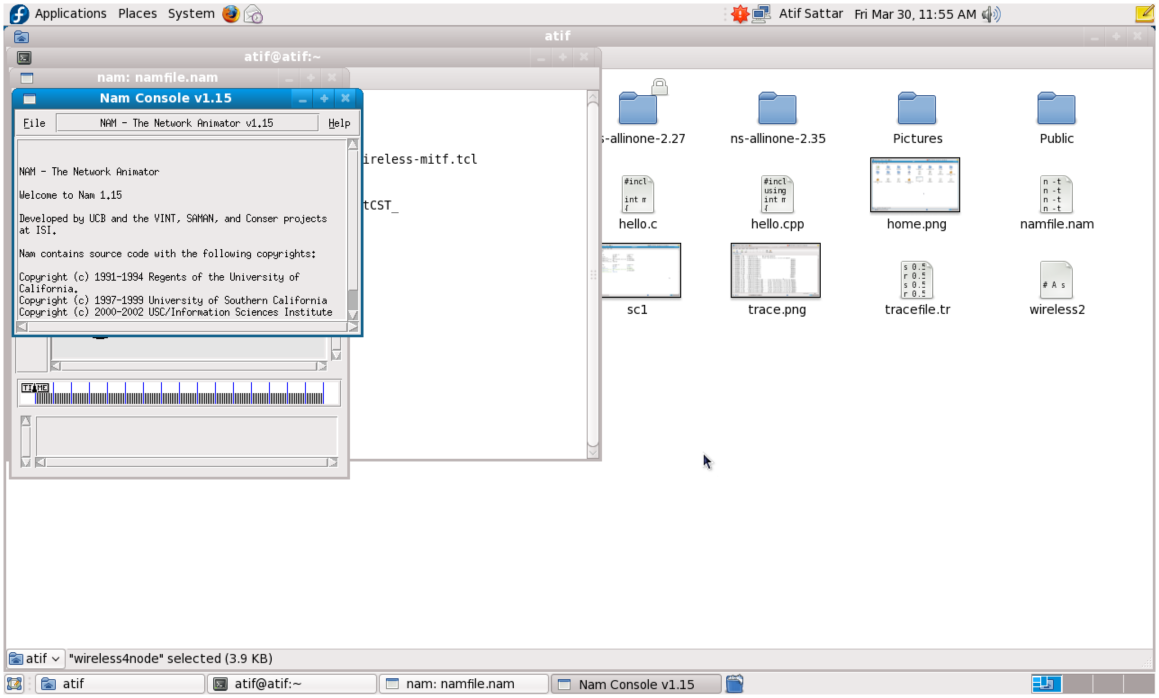


Figure 37: NAM file

5.2.3. NS-2 tracing

Observing behavior by tracing (events)packet received, packet drop etc.

```
+ 0.1 1 2 cbr 1000 ------- 2 1.0 5.0 0 0
- 0.1 1 2 cbr 1000 ------- 2 1.0 5.0 0 0
r 0.114 1 2 cbr 1000 ------- 2 1.0 5.0 0 0
+ 0.114 2 3 cbr 1000 ------- 2 1.0 5.0 0 0
- 0.114 2 3 cbr 1000 ------- 2 1.0 5.0 0 0
r 0.240667 2 3 cbr 1000 ------- 2 1.0 5.0 0 0
```

Time

Source/Destination Address, Port

5.2.4. NS-2 GUI Tools

Sample program 40 nodes 10 nodes are moveable.

Figure 38: Ns-2 Nam

Following figure shown the graphical representation of sample program

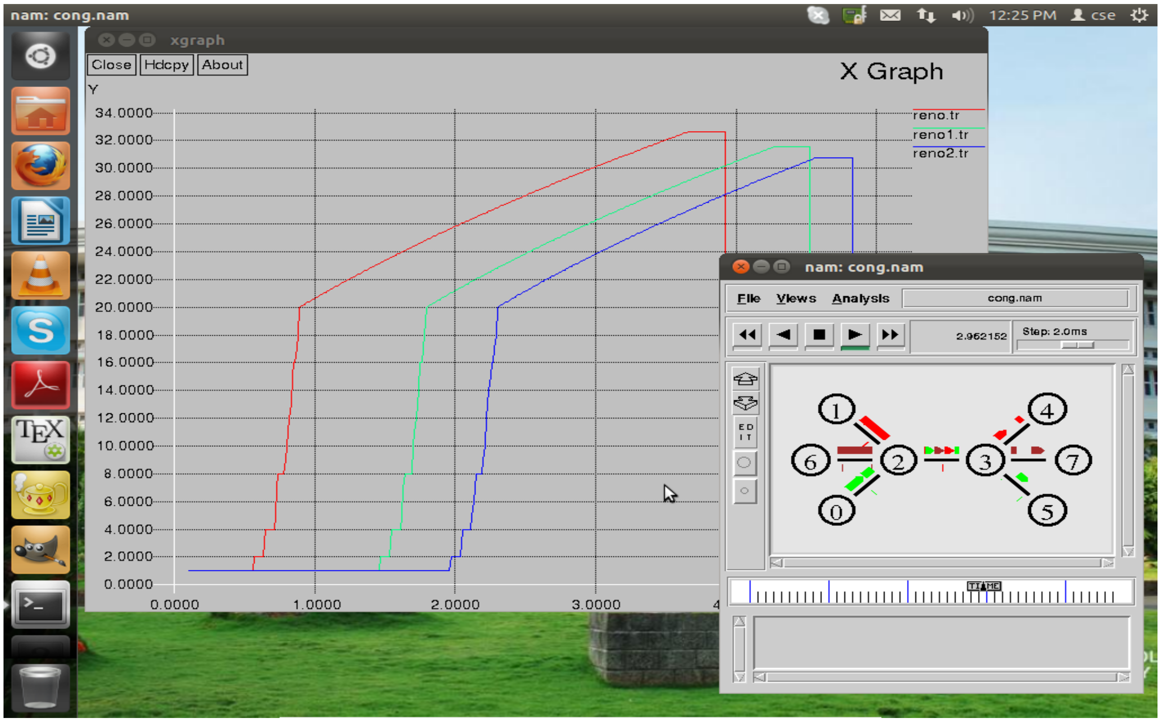


Figure 39: GNU plot Xgraph

5.3. C Language

C++ classes used in Tcl script file. We also call classes globally, separately.

RESULTS AND DISCUSSION

Chapter 6

Results and Discussion

6.1. Results and Discussion

We have proposed and simulated our algorithm in NS-2. In NS-2 we obtained more accurate results for our proposed algorithm CREAT. Minimum broadcast and multipath is made our results more efficient also rotation of cluster head and minimum hop count made it energy efficient routing. Figure shows better performance.

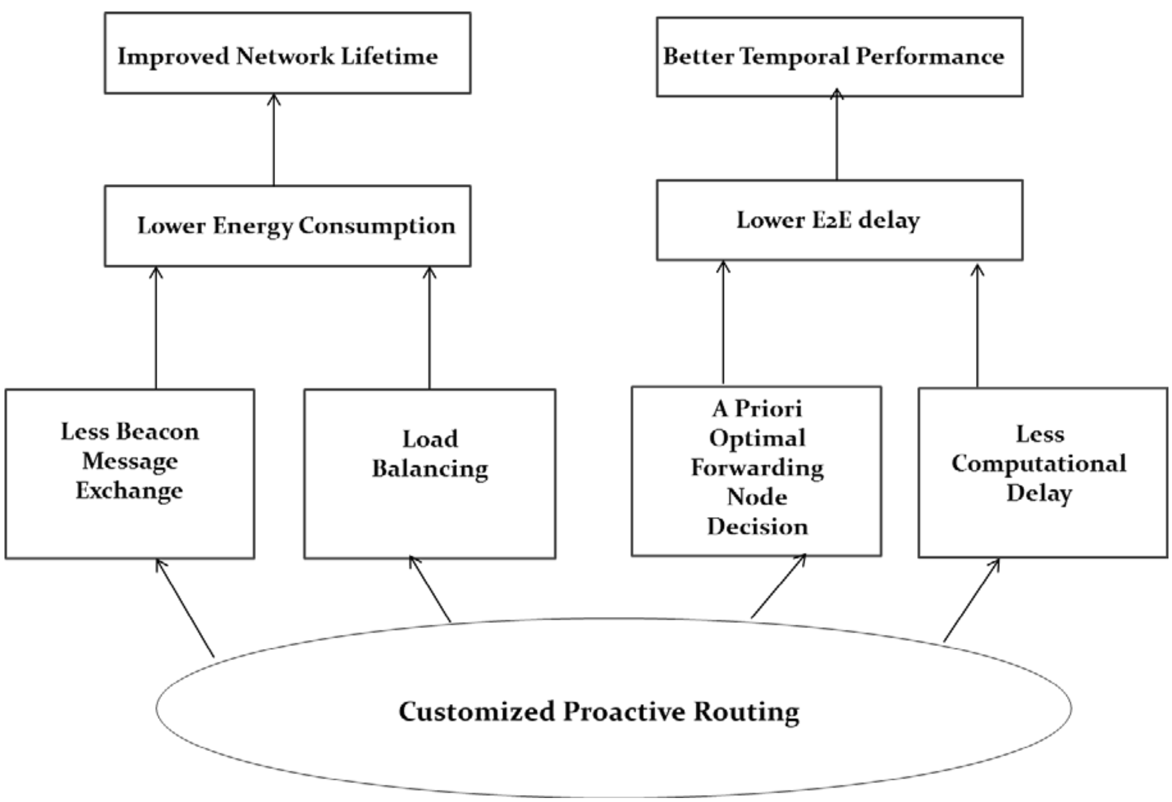


Figure 40: Effect of CREAT Components on Network Life Time

Following are the performance parameters shown in the table.

Table 6: Simulation Parameters

Queue Length	50
Total no of nodes	500
X and y axis co-ordinates	300*300
Simulation time	300
Initial energy	15j
Transmission range	50m
Transmission power	0.6
Receive power	0.3
Data rate	4 packet/s
Traffic flow	100
Propagation model	Two ray ground

A. Network Life Time

Time of death of 1st node defines the network life time as shown in figure for 100 nodes 1st node dies at 210 seconds and for 500 nodes 1st node dies at 190 seconds 50% network still in working, in both environments this also shows efficiency and scalability of our algorithm in a very dense environment. Life time of the network also cause better throughput and better packet delivery ratio as shown in Figure 41 and Figure 42.

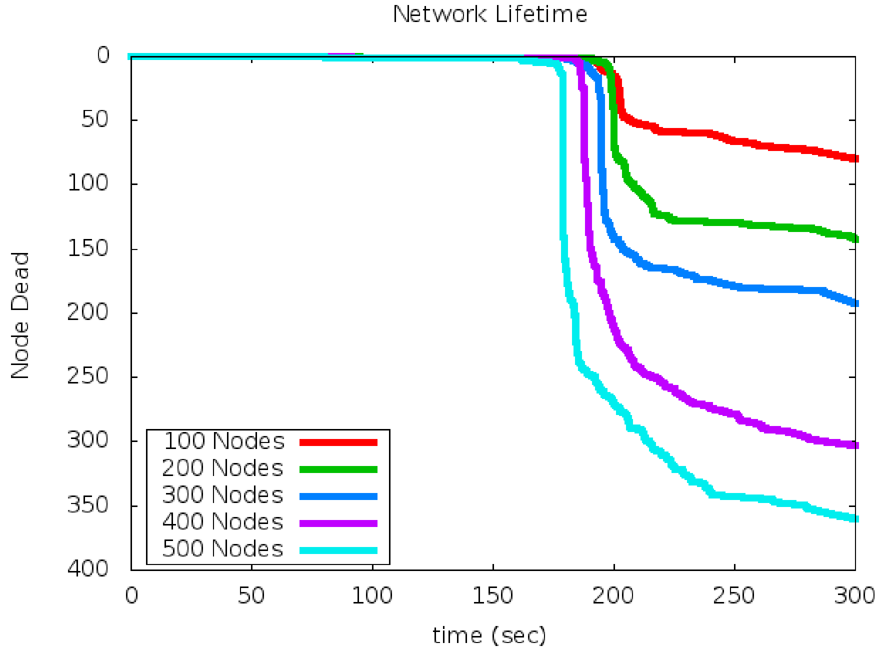


Figure 41: Network Life Time at different Network Density

In a very dense network half of the node dies and link route breakage but multipath available that's why for 100 nodes at 210 seconds most of the nodes die but multipath is available throughput is going down.

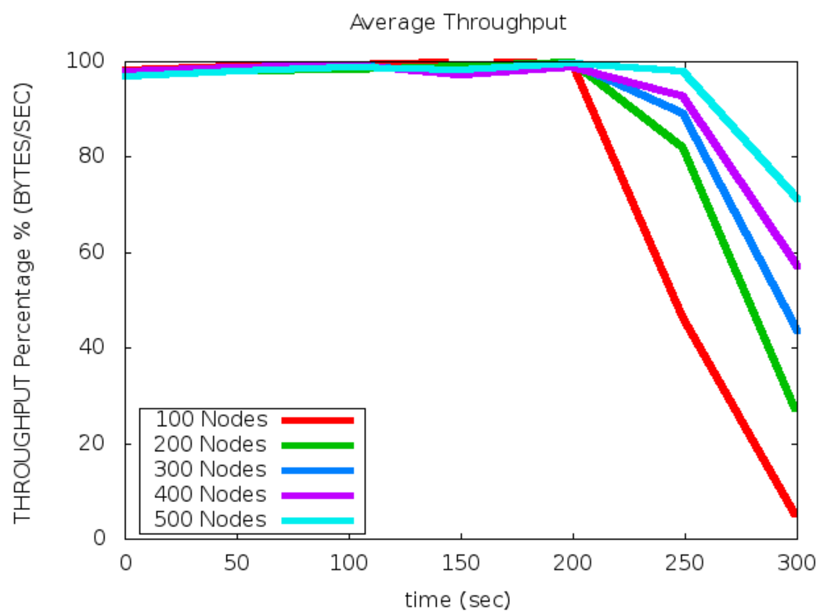


Figure 42: Network Throughput percentage at different Network Density

B. End-to-End Delay

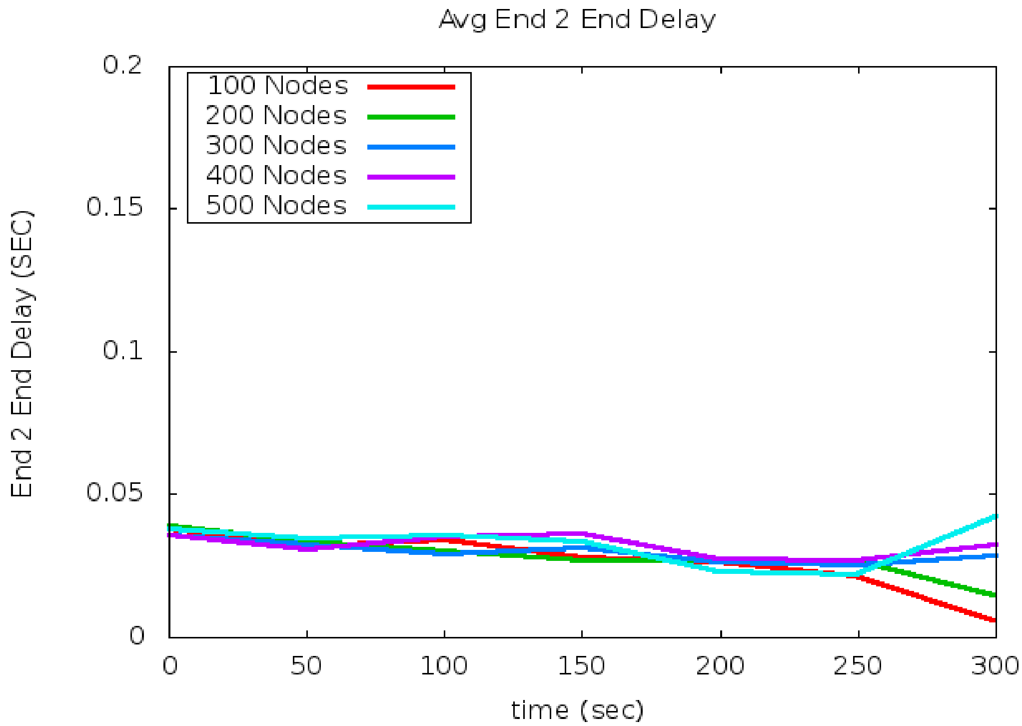


Figure 43: End to End Delay at Different Network Density

Source to sink packet receive process on each node and transfer this computational delay is very less and minimum hop count is also cause to minimize the e2e delay. From each cluster 4 packet/s compute and transfer so as 20 packets/s compute and delivered to BS from the whole network no-matter our network is very dense like for 500 nodes and for 100 nodes e2e delay and computational delay is very less. As shows in Figure 43 for 100 network path is not available for packet delivery that's why average e2e delay is minimum and going down but for 500 nodes many nodes die but multipath is available and packet delivery is going through multipath is the reason average e2e delay is going up.

C. Network Energy Consumption

Performance efficiency of the network shown in the following Figure 43 and Figure 44. Results show the performance of energy consumption in a low, medium and a very dense network.

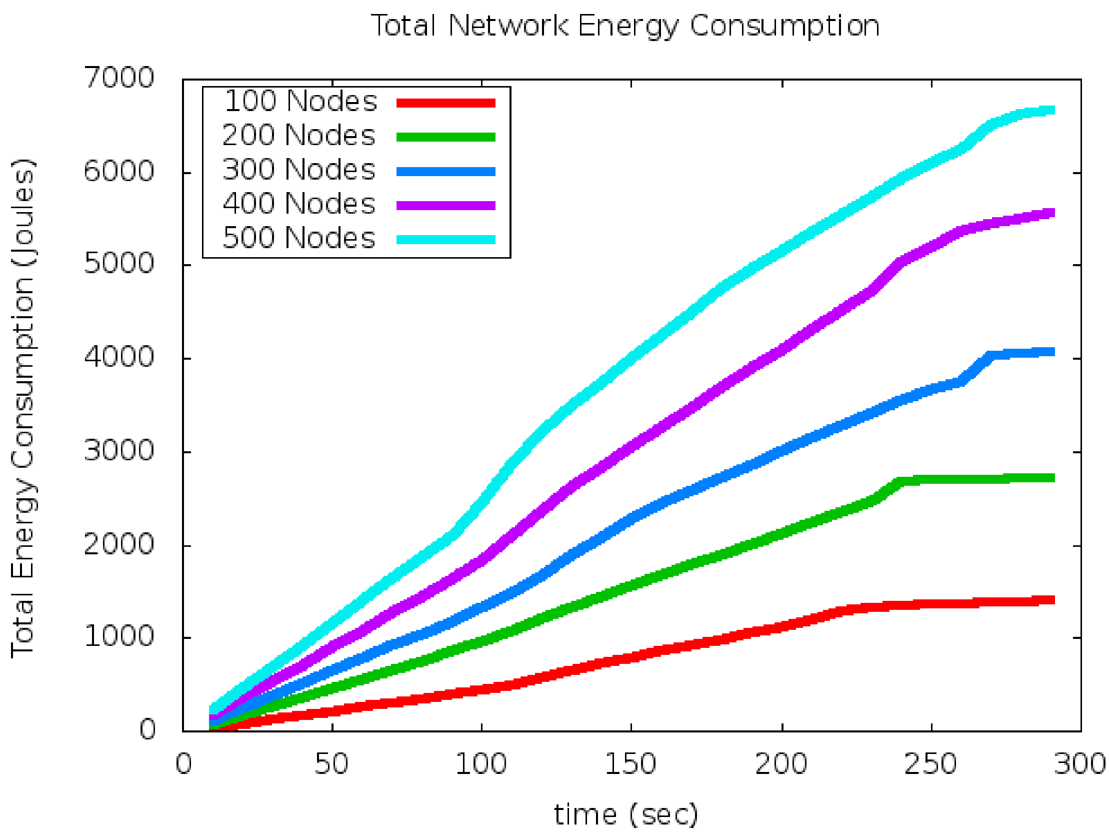


Figure 44: Total Network Energy Consumption at Different Network Density

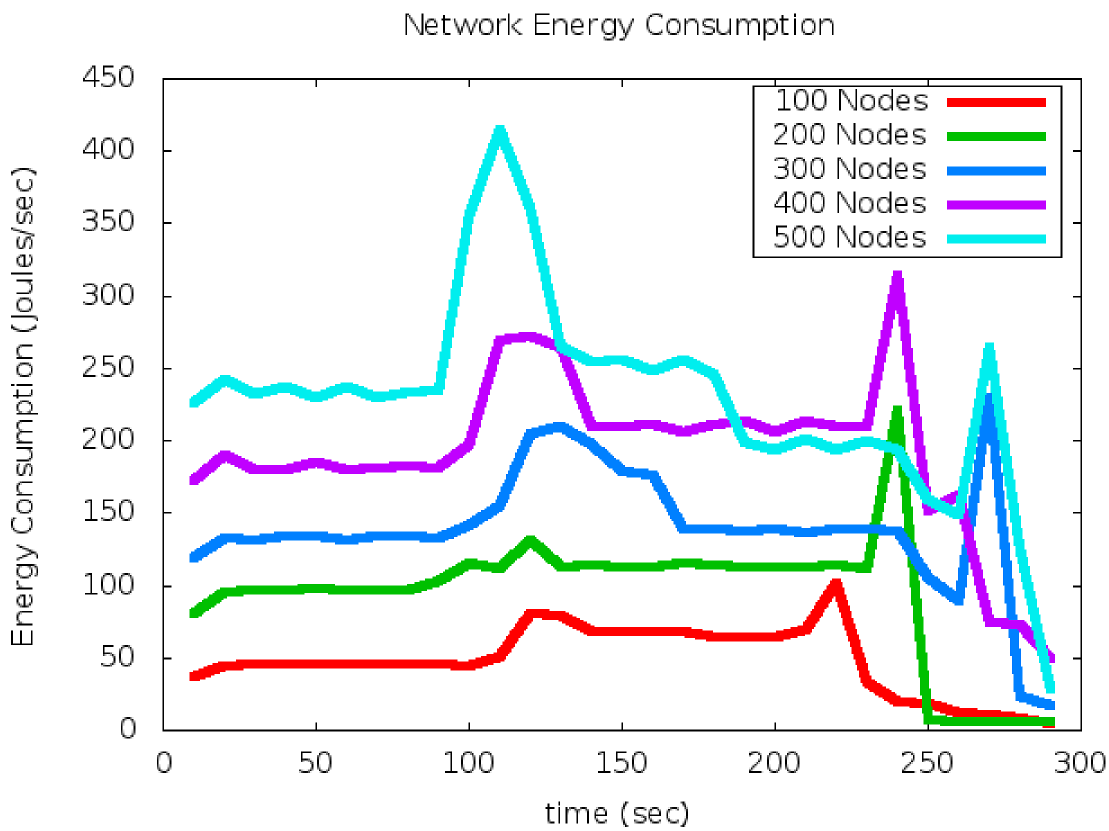


Figure 45: Network Energy Consumption at Different Time in Low, Medium and Highly Dense Network

CONCLUSION

Chapter 7

Conclusion

7.1. Conclusion

Researchers and developers has proposed many routing algorithms, protocols to prolong the network lifetime. Our energy aware algorithm (CREAT) is more affective as compared to old ones. Our algorithm increases throughput of the network, decreases end to end delay and along with it the distribution of energy utilization is uniformed. Clustering is more effective and gets better results. It increases network lifetime. CREAT algorithm gives the better understanding to establish the cluster head in WSN. In our algorithm we minimize the broadcast and add the cluster rotation which enhanced CREAT performance and more energy efficient. Minimum computational delay and e2e delay also add life to the network.

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