LIST OF EXPERIMENTS

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EXPERIMENT NO.1

AIM: Study and Analysis of wired network.

THEORY: As technology advances in society the need for wired and wireless networking has become essential. Each of these types of networking has their advantages and disadvantages according to security. Wired networking has different hardware requirements and the range and benefits are different.

HARDWARE COMPONENTS: Before one can begin to setup a network they must first be sure they have a network interface card, commonly referred to as a NIC. A NIC is a device that connects a computer or other device to a network. For computers, the NIC is usually installed in an expansion slot and has a chip that handles the physical and data-link layers of network communications.

To establish your network you will need a few key components. If you plan to access the internet you will start your network off with a cable modem. This type of modem is designed to operate using your existing cable lines. Cable internet has a high bandwidth and can support most, if not, all applications you will be using. The second component is a router. A router is a device that routes data from one network to another network. A router is connected to at least two networks, commonly two networks or a network and its ISP's network. A router allows for everyone on the network to access the internet

The next component that you will need to setup a network is a hub or sometimes a switch. A hub is a device that connects the cables from computers and other devices such as printers in a network. Traditionally, hubs are used for star topology

networks, but they are often used with other configurations to make it easy to add and remove computers without bringing down the network.

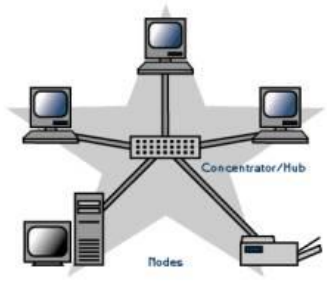
A hub can be either active or passive; simply forwarding messages or amplifying or refreshing the data. A switch is a device similar to a hub that enables the connection of multiple computers, access points, and other network enabled devices. The difference between a hub and a switch is that a switch filters the data that passes through it and a hub does not.

These components have all been modified and are capable of establishing wireless networks. A router can be purchased with wireless capability but a more efficient way of adding wireless to your network is to simply add wired access points. An access point will bride a wired network with a wireless network and can be hard wired in to your existing system. (Wi-Fiplanet.com) This option allows for the mobility of a wireless network.

Another key component is a print server. A print server is used to connect printers to a network to allow for network printing. The server will act as a buffer; storing the messaging and printing them in order of the queue. This device can drastically reduce the cost of networking because now everyone can use the same printer without having a printer attached to every computer.

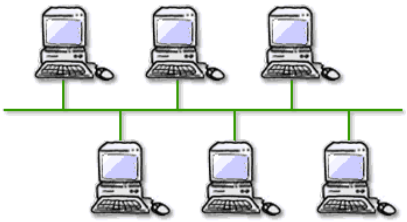
WIRED NETWORKS

Wired networks, also called Ethernet networks, are the most common type of local area network (LAN) technology. A wired network is simply a collection of two or more computers, printers, and other devices linked by Ethernet cables. Ethernet is the fastest wired network protocol, with connection speeds of 10 megabits per second (Mbps) to 100 Mbps or higher. Wired networks can also be used as part of other wired and wireless networks. To connect a computer to a network with an Ethernet cable, the computer must have an Ethernet adapter (sometimes called a network interface card, or NIC). Ethernet adapters can be internal (installed in a computer) or external (housed in a separate case). Some computers include a built-in Ethernet adapter port, which eliminates the need for a separate adapter (Microsoft). There are three basic network topologies that are most commonly used today.



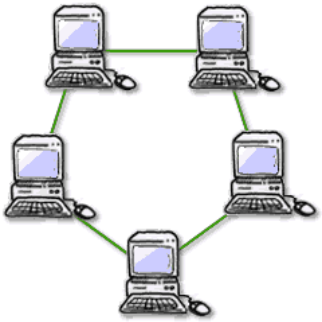
The star network, a general more simplistic type of topology, has one central hub that connects to three or more computers and the ability to network printers. This type can be used for small businesses and even home networks. The star network is very useful for applications where some processing must be centralized and some must be performed locally. The major disadvantage is the star network is its vulnerability. All data must pass through one central host computer and if that host fails the entire network will fail.

On the other hand the bus network has no central computer and all computers



are linked on a single circuit. This type broadcasts signals in all directions and it uses special software to identify which computer gets what signal. One disadvantage with this type of network is that only one signal can be sent at one time, if two signals are sent at the same time they will collide and the signal will fail to reach its destination. One advantage is that there is no central computer so if one computer goes down others will not be affected and will be able to send messages to one another.

The third type of network is the ring network. Similar to the bus network, the ring network does not rely on a central host computer either. Each computer in the network can communicate directly with any other computer, and each processes its own applications independently. A ring network forms a closed loop and data is sent in one direction only and if a computer in the network fails the data is still able to be transmitted.



Typically the range of a wired network is within a 2,000-foot-radius. The disadvantage of this is that data transmission over this distance may be slow or nonexistent. The benefit of a wired network is that bandwidth is very high and that interference is very limited through direct connections. Wired networks are more secure and can be used in many situations; corporate LANs, school networks and

hospitals. The biggest drawback to this type of network is that it must be rewired every time it is moved.

PERFORMANCE EVALUATION METRICS

Before we can proceed with performance evaluation, we must choose the different metrics that would help us in making comparisons. There could be different metrics to determine the performance like throughput, delay, jitter, packet loss. the choice of metric would depend upon the purpose the network has been setup for. the metrics could be related to the different layers of the network stack. for example, tcp throughput is based on the application layer, whereas ip round trip time is based on the network layer. for example, a network supporting multimedia applications should have minimum delay and jitter. packet loss might not be a critical issue for such network. however, packet loss might be a considerable factor for networks supporting textual data oriented applications, say someone downloading by ftp.

once the metrics have been chosen, one goes for their quantitative evaluation by subjecting the network under diverse conditions. for example, one could make step by step increments in bandwidth of the links, which in turn improve the throughput. however, the throughput might get saturated beyond the certain point. that is, further increase in bandwidth would not improve throughput. thus, the optimum value of bandwidth has been determined. The table below shows different metrics of evaluation, and categories they are appropriate for.

Category	Metric	Unit
Productivity	Throughput	Bytes per second
Responsiveness	Delay, jitter	seconds
Utilization	Channel utilization	Percentage of time busy
Loss	Packet drops, Retransmission count	Number
Buffer space	Queue size, overflow or underflow rate	Bytes

it might not be always possible or feasible to obtain best performance from a network due to various factors like high cost, complexity, compatibility. in such cases one would like to obtain optimum performance by balancing different factors.

Following are some of the performance measurement metrics:

- **LATENCY:** it can take a long time for a packet to be delivered across intervening networks. in reliable protocols where a receiver acknowledges delivery of each chunk of data, it is possible to measure this as round-trip time.
- **PACKET LOSS:** in some cases, intermediate devices in a network will lose packets. this may be due to errors, to overloading of the intermediate network, or to intentional discarding of traffic in order to enforce a particular service level.
- **RETRANSMISSION:** when packets are lost in a reliable network, they are retransmitted. this incurs two delays: first, the delay from re-sending the data; and second, the delay resulting from waiting until the data is received in the correct order before forwarding it up the protocol stack.
- **THROUGHPUT:** the amount of traffic a network can carry is measured as throughput, usually in terms such as kilobits per second. throughput is analogous to the number of lanes on a highway, whereas latency is analogous to its speed limit.

EXPERIMENT NO.2

AIM: Study and Analysis of wireless network.

THEORY: Wi-Fi- enabled devices are connected wirelessly and can connect to the internet via a wireless access point. wi-fi can function in geographical location and can be used where wiring and cable connection is not feasible.

HARDWARE COMPONENTS: The following hardware devices are required for connecting the wi-fi network.

ACCESS POINT

Access Point (ap) acts as a bridge between the wired network and wireless devices. it allows multiple devices to connect through it for accessing the network. an ap can also act as a router through which the data transmission can be possible from one ap to another.

WIRELESS NETWORK CARD

A wireless network card (wnc) is required on each device on a wireless network. a desktop computer would need an internal card, which will usually have a small antenna or an external antenna on it. these antennas are optional on most equipment and they help to increase the signal on the card.

TRANSMITTER

Transmitter is used for emitting the wireless signals and it also receive the connection requests where a wireless client will send the requests and receives the replies from the transmitter. in this case, the transmitter is the wireless router.

WI-FI NETWORKS

wi-fi (wireless fidelity) uses the ieee 802.11 standard. wi-fi has some other extensions like 802.11a, 802.11b, and 802.11g. wi-fi technology operating at a frequency of 2.4 ghz and uses radio communication.

ieee 802.11 standards

following are the different standards for wi-fi

- 802.11 is the wireless local area networks (wlans) standard. supports 1- 2 mbps.
- 802.11a is a high speed wlans standard for 5 ghz band. it uses an orthogonal frequency division multiplexing (ofdm) encoding scheme.
- 802.11b is a wireless standard for 2.4 ghz band. it supports 11 mbps. it uses only dsss (direct sequence spread spectrum).
- 802.11d is a international roaming. this automatically configures devices to meet local radio frequency (rf) regulations.
- 802.11e address the quality of service (qos) requirements for all ieee wireless radio interfaces.
- 802.11f defines inter-access point communications for multiple vendor-distributed wlans.
- 802.11g establishes an additional modulation technique for 2.4 ghz band. this supports speeds up to 54 mbps.
- 802.11h supports the spectrum management of the 5 ghz band.
- 802.11i define the current security weaknesses for both encryption and authentication protocols.
- 802.11n supports more throughput improvements. also provides speeds up to 500 mbps.

the basic difference between 802.11a,802.11b and 802.11g are given below

Parameter	802.11a	802.11b	802.11g
Standard approved	Sept 1999	Sept 1999	June 2003
Available bandwidth	300MHz	83.5MHz	83.5MHz
No. of overlapping channel	4	3	3
Frequency	5GHz	2.4GHz	2.4GHz
Typical Data Rate	23 Mbit/s	4.5 Mbit/s	19 Mbit/s
Maximum Data Rate	54 Mbit/s	11 Mbit/s	54 Mbit/s
Range	115 feet	115 feet	125 feet
Compatibility	None	None	backward compatible with b
Advantages	fast maximum speed, regulated frequencies prevent signal interference from other devices	lowest cost, signal range is good and not easily obstructed	fast maximum speed, signal range is good and not easily obstructed
Limitations	highest cost, shorter range signal that is more easily obstructed	slowest maximum speed, home appliances may interfere on the unregulated frequency band	costs more than 802.11b, appliances may interfere on the unregulated signal frequency

ADVANTAGES OF Wi-Fi

Following are the different benefits of wi-fi networks

- In wireless ad-hoc network mode, devices like consumer electronics and gaming applications can directly connect and exchange data with each other.
- Digital images can be transferred wirelessly from cameras and other devices.
- All connected devices within the range have access to internet and inter-networking.
- Wi-fi enables wireless voice-applications (vo wlan or wvoip).
- Wi-fi provides a secure computer networking gateway, firewall, dhcp server and an intrusion detection system along with other features.
- Cost of cabling and network deployment of local area networks is significantly reduced.
- Can be used at placed where wiring and cable lay-out is not feasible.
- Due to its cost effective nature, it can be used widely in different educational campuses and industries.
- Wi-fi device can function in any type of geographical location.

LIMITATIONS

Like any other types of technology, wi-fi has its set of drawbacks that are listed as follows:

- global inconsistency of spectrum assignments and operational limitations.
- overlapping of channels.
- limited range of equivalent isotropically radiated power in some areas.
- greater power consumption compared to lower bandwidth standards.
- limited battery life due to range and reach requirements.
- wi-fi network range is also limited.

EXPERIMENT NO.3

AIM: Study of open source software ns2 .compare ns2 with other simulation software's.

THEORY: Network simulation has become an integral part of most research works in the field of computer networks. Whether it is for understanding the behavior of existing protocols, or to determine the performance of a new protocol, one doesn't often get access to real network devices. this gap has been filled up by network simulation to a large extent.

network simulator version 2 (ns-2) is discrete event packet level simulator. the network simulator covers a very large number of application of different kind of protocols of different network types consisting of different network elements and traffic models. ns-2 is a package of tools that simulates behavior of networks such as creating network topologies, log events that happen under any load, analyze the events and understand the network. the aim of this first experiment is to learn how to use ns-2, to get acquainted with the simulated objects and understand the operations of network simulation. we will also look at how to analyze the outcome of a simulation.

BASICS OF TCL PROGRAMMING FOR NS-2

network simulation with ns-2 would involve the following general steps:

1. initialization and termination aspects of network simulator object
2. defining the network topology: nodes, links, queues, mobility of nodes, if any
3. defining the network traffic: creating agents and their applications
4. setting trace for network animator (nam) [optional]
5. tracing

in this section, we provide a brief overview of the most commonly used features of ns-2.

INITIALIZATION:

set ns [new simulator]

Description-

CREATING THE OUTPUT FILES

Create the trace files

set tracefile [open out.tr w]

$ns trace-all $tracefile

Description-

Create the nam files

set namfile [open out.nam w]

$ns namtrace-all $namfile

Description-

THE TERMINATION PROGRAM IS DONE BY USING A 'FINISH' PROCEDURE.

```
# Defining the 'finish' procedure'
proc finish {} {
    global ns tracefile namfile
    $ns flush-trace
    close $tracefile
    close $namfile
    exit 0
}
```

Description-

In ns we end the program by calling the 'finish' procedure

End the program

$ns at 125.0 "finish"

Thus the entire operation ends at 125 seconds.To begin the simulation we will use the command

Start the the simulation process

$ns run

Description-

DEFINING NODES, LINKS, QUEUES (TOPOLOGY)

Create nodes

set n0 [$ns node]

set n1 [$ns node]

set n2 [$ns node]

set n3 [$ns node]

set n4 [$ns node]

set n5 [$ns node]

Create links between the nodes

$ns duplex-link $n0 $n2 10Mb 10ms DropTail

$ns duplex-link $n1 $n2 10Mb 10ms DropTail

$ns simplex-link $n2 $n3 0.3Mb 100ms DropTail

$ns simplex-link $n3 $n2 0.3Mb 100ms DropTail

$ns duplex-link $n0 $n2 0.5Mb 40ms DropTail

$ns duplex-link $n0 $n2 0.5Mb 40ms DropTail

Set queue-size of the link (n2-n3) to 20

$ns queue-limit $n2 $n3 20

Description-

AGENTS AND APPLICATIONS

TCP :

The Transmission Control Protocol provides a communication service at an intermediate level between an application program and the Internet Protocol. It provides host-to-host connectivity at the transport layer of the Internet model. An application does not need to know the particular mechanisms for sending data via a link to another host, such as the required IP fragmentation to accommodate the maximum transmission unit of the transmission medium. At the transport layer, TCP handles all handshaking and transmission details and presents an abstraction of the network connection to the application typically through a network socket interface. It is a connection-oriented protocol that is used for the reliable transfer of data from one process to another process. It takes the help of the Port numbers for transmission. It uses flow control and error control mechanisms at the transport level. There are three phases in which TCP transmits the data between the sender and receive which as follow:

- **Connection Establishment –**
  It takes the help of 3 way handshaking mechanism for Connection Establishment which involves the exchange of SYN, ACK, and window size
- **Data transfer –**
  In this step, the transmission of data occurs
- **Connection termination –**
  Here the transmission of data gets terminated by sending a FIN packet to the receiver.

Services offered by the TCP are as follows :

- Process to Process or end to end Communication using Port numbers
- Transmits the data as a stream of bytes from source to destination
- It groups the data that comes from the application into packets called Segments. It also adds a header to each data segment and sends it to the network layer
- It offers Full Duplex communications
- Reliable Service: TCP uses an acknowledgment mechanism which makes it reliable
- It offers Flow control, Error control, and Congestion control too.

FTP over TCP

FTP or File Transfer Protocol is considered to be a standard network protocol. It has been in use for many decades. This protocol transfers files and sensitive data between the two devices connected over a network through the client-server model.

FTP allows you to exchange and manipulate files in the TCP/IP network. With FTP, user credentials can also be sent. However, the transferred files are not encrypted. Thus, files and information sent over FTP are vulnerable.

TCP or Transmission Control Protocol is considered a communication standard that allows application programs and devices to exchange data and messages over a network. TCP follows the standards provided by the Internet Engineering Task Force (IETF).

TCP defines ways to establish and maintain a network connection through which the data is exchanged. Additionally, it determines how to break the application data into groups so the network can transfer the data and ensure successful delivery.

The best thing about TCP is that it is reliable, secure, and offers efficient data transfer.

TCP works with Internet Protocol (IP). IP is a principal communications protocol that dictates how the data should be sent to the internet from one network to another.

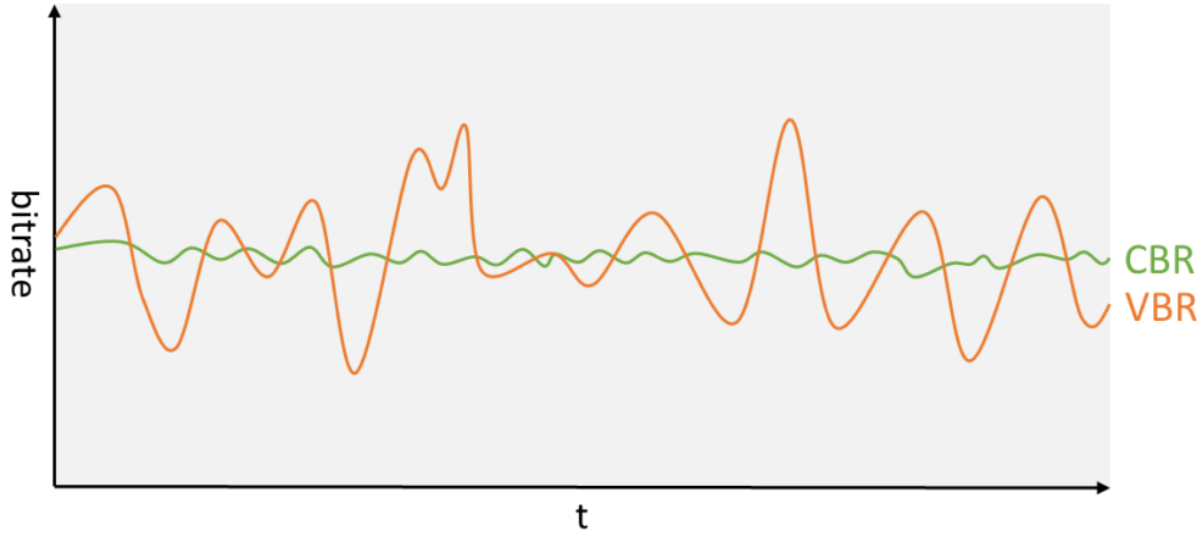
TCP and IP are the basic standards that define the internet rules and are considered the most used protocols by internet servers.

Constant Bit Rate (CBR)

It is a term often used with video encoders, to indicate that the encoder works in a constant bit rate, generating the same number of bits per a short period of time (usually 1 second or less).

CBR encoding schemes work well when the network bandwidth is known and limited and is quite common in live video sessions where latency must remain low. The compression created by CBR encoding schemes are great for sending media live over a network, but not as good when needing to store recordings as they tend to be larger than necessary.

WebRTC uses CBR by default when encoding camera sources.
The other popular encoding scheme is VBR.

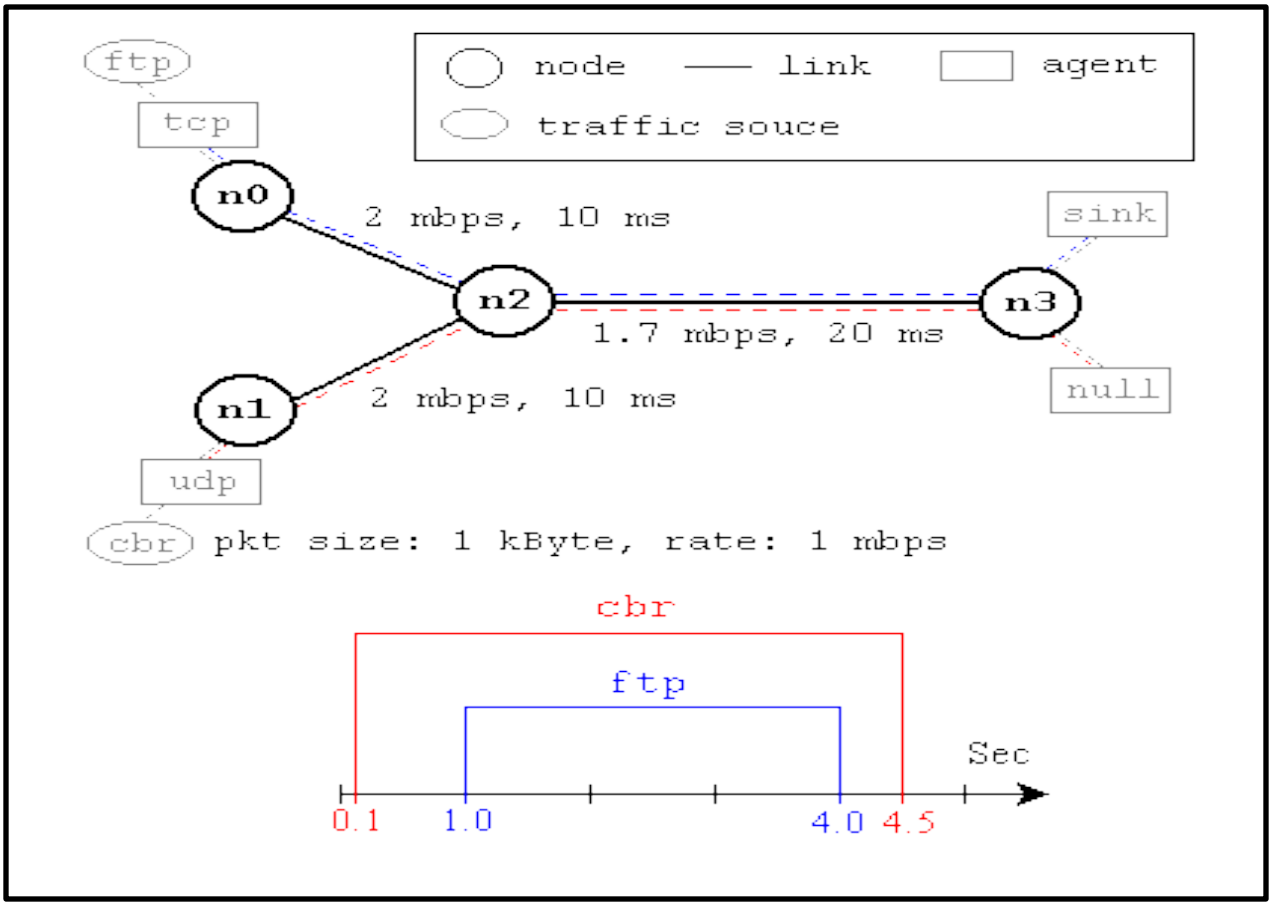


CBR over UDP Connection

This type of traffic implies data of UDP type and application traffic agent is CBR. Here , the former is a transport layer protocol and latter is application layer protocol. It offers transmission of data at constant bit rate and does not communicate in phases, and traffic moves in one direction from source to destination without any feedback from destination. It offers three basic characteristics mentioned below:

(a) Unreliable: The network is quiet unreliable as it does not set up communication in phases and does not rely on acknowledgements to recover the lost messages. The sender node does not take the responsibility of the successful delivery of data.

(b) Unidirectional: As no acknowledgements are transmitted from receiver, only one way communication is done i.e. on the forward link. The destination does not send any data packet to the receiver, therefore it offers unidirectional traff



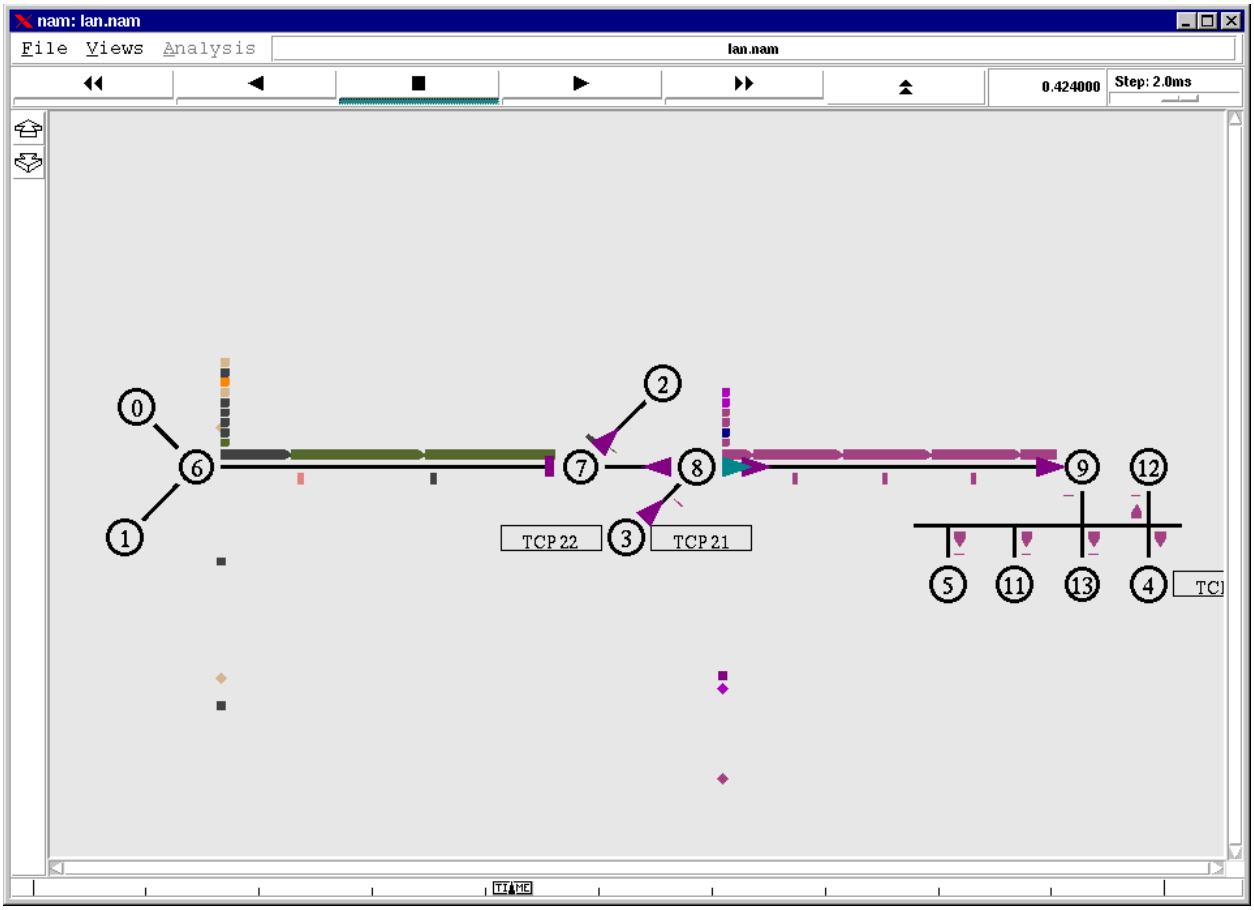
Scheduling Events

Event scheduling is the activity of finding a suitable time for an event such as meeting, conference, trip, etc. It is an important part of event planning that is usually carried out at its beginning stage.

In general, event scheduling must take into account what impact particular dates of the event could have on the success of the event. When organizing a scientific conference, for example, organizers might take into account the knowledge in which periods classes are held at universities, since it is expected that many potential participants are university professors. They should also try to check that no other similar conferences are held at the same time, because overlapping would make a problem for those participants who are interested in attending all conferences.

Network Animator (NAM)

Nam is a Tcl/TK based animation tool for viewing network simulation traces and real world packet traces. It supports topology layout, packet level animation, and various data inspection tools.
Nam began at LBL. It has evolved substantially over the past few years. The name development effort was an ongoing collaboration with the VINT project.
Currently, it is being developed as an open source project hosted at Sourceforge.



Tracing

NS-2 simulation can produce visualization trace as well as ASCII file corresponding to the events that are registered at the network. While tracing ns inserts four objects: EnqT, DeqT, RecvT, and DrpT. EnqT registers information regarding the arrival of packet and is queued at the input queue of the link. When overflow of a packet occurs, then the information of the dropped packet is registered in DrpT. DeqT holds the information about the packet that is dequeued instantly. RecvT hold the information about the packet that has been received instantly.

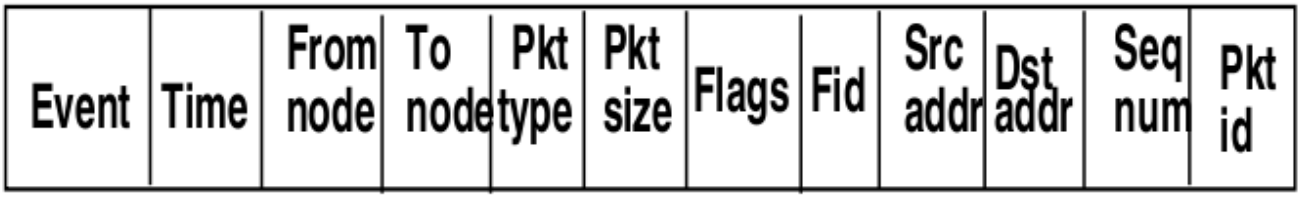


Figure-01: NS-2 trace file format (wired networks)

Structure of Trace Files

The following describe about the structure of the trace files produced for wired networks.

The first field is event.It gives you four possible symbols '+' '-' 'r' 'd'. These four symbols correspond respectively to enqueued, dequeued, received and dropped.

1. The second field gives the time at which the event occurs
2. The third field gives you the input node of the link at which the event occurs
3. The fourth field gives you the the output node at which the event occurs
4. The fifth field shows the information about the packet type.i.e whether the packet is UDP or TCP
5. The sixth field gives the packet size
6. The seventh field give information about some flags

7. The eight field is the flow id(fid) for IPv6 that a user can set for each flow in a tcl script.It is also used for specifying the color of flow in NAM display
8. The ninth field is the source address
9. The tenth field is the destination address
10. The eleventh field is the network layer protocol's packet sequence number
11. The last field shows the unique id of packet

Following are trace of two events:

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

OUTPUT

Description-

EXPERIMENT NO.4

AIM: Study and Analysis of wireless network.

THEORY: Wi-Fi- enabled devices are connected wirelessly and can connect to the internet via a wireless access point. wi-fi can function in geographical location and can be used where wiring and cable connection is not feasible.

BLUETOOTH NETWORK

The name Bluetooth was named after 10th century Viking king in Denmark Harald Bluetooth who united and controlled Denmark and Norway. Bluetooth is a low power, low cost, and short range radio network standard. It supports unlicensed Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band. It is complementary to the Wi-Fi network specified by IEEE 802.11b/g/a standard. Bluetooth uses a frequency hopping scheme to provide robust wireless communication. As a cable replacement, Bluetooth is widely used in cell phone, PDA, laptop, headset, and printer, etc. to form a Personal Area Network (PAN) and provide universal access. Bluetooth uses a radio technology called frequency-hopping spread spectrum

BLUETOOTH VS WI-FI

Bluetooth and Wi-Fi technologies have some similarities because both are wireless technologies and used to communicate with other devices.

Parameters	Bluetooth	WiFi
Year of development	1994	1991
IEEE Standard	802.15	802.11
Power Consumption	Low	High
Cost	Low	High
Bandwidth	Low (800 Kbps)	High (11 Mbps)
Range	10 meters	100 meters
Frequency	2.4 GHz	2.4 GHz
Network	Personal Area Network (PAN)	Wireless Local Area Networks (WLAN)
Hardware requirement	Bluetooth adaptor on all the devices connecting with each other	Wireless adaptors on all the devices of the network, a wireless router and/or wireless access points
Specifications authority	Bluetooth SIG	IEEE, WECA
Primary Devices	Mobile phones, mouse, keyboards, office and industrial automation devices	Notebook computers, desktop computers, servers
Ease of Use	Fairly simple to use. Can be used to connect up to seven devices at a time. It is easy to switch between devices or find and connect to any device.	It is more complex and requires configuration of hardware and software.

BLUETOOTH – POWER CLASSES

Class	Maximum Permitted Power	Operating Range
Class 1	100mW (20dBm)	100 meters
Class 2	2.5mW (4dBm)	10 meters
Class 3	1mW (0dBm)	1 meter

In this case, if you wish to communicate over the 100m range, you will need a class 1 Bluetooth device at both ends. But if you wish to communicate over the 10m range, you can have a class 1 or class 2 device at both ends.

BLUETOOTH - VERSIONS

Many Bluetooth specification versions have been released since Bluetooth technology was finally introduced in 1998. **Versions 1.0** and 1.0B had too many problems and restraints for manufacturers to successfully develop Bluetooth devices. The main issue was the lack of interoperability among devices.

- **Bluetooth 1.1** : The Bluetooth Core Specification version 1.1 is the most successful operating version of Bluetooth technology. Bluetooth 1.1 corrected many of the problems found in the earlier versions. As a result, the devices using Bluetooth 1.1 have much more interoperability.
- **Bluetooth 1.2** : Many new Bluetooth devices, like the latest cell phones, are being sold with the newer Bluetooth specification version 1.2. It has backward compatible with Bluetooth 1.1, adaptive Frequency Hopping - helps reduce radio interference by eliminating the use of crowded frequencies in the hopping sequence, faster transmission speeds (1 Mbps) etc.
- **Bluetooth 2.0** : Version 2.0 + EDR (Enhanced Data Rate) was announced by the Bluetooth SIG in June 2004 and began appearing in Bluetooth devices in late 2005. It delivers data transfer rates up to three times faster than the original Bluetooth specification.
- **Bluetooth 2.1**: Bluetooth Core Specification Version 2.1 is fully backward compatible with 1.2, and was adopted by the Bluetooth SIG on July 26, 2007. It supports theoretical data transfer speeds of up to 3 Mb/s. This specification includes two features, such as, Extended inquiry response (EIR) and Sniff subrating
- **Bluetooth 3.0** : The 3.0 specification was adopted by the Bluetooth SIG on April 21, 2009. It supports theoretical data transfer speeds of up to 24 Mb/s. Its main new feature is AMP (Alternate MAC/PHY), the addition of 802.11 as a high speed transport.

- **Bluetooth 4.0 :**

  Bluetooth 4.0 is an optimized version of the proprietary wireless Bluetooth technology standard for data exchange over short distances. Bluetooth 4.0 enhances Bluetooth technology while maintaining compatibility with classic Bluetooth-capable-devices.

  Bluetooth 4.0 uses low energy technology, allowing manufacturers to include Bluetooth in small battery operated devices. This new energy specification is a key benefit for developers and consumers of handheld and compatible devices.

- **Bluetooth 5.0 :**

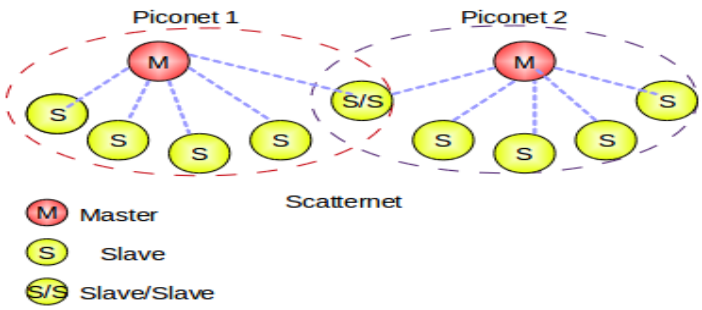
  Bluetooth 5.0 is the latest version of the Bluetooth wireless communication standard. It's commonly used for wireless headphones and other audio hardware, as well as wireless keyboards, mice, speakers, trackers, and game controllers. Bluetooth is also used for communication between various smart home and Internet of Things (IoT) devices.

How does Bluetooth work ?

- Bluetooth is a standard for tiny, radio frequency chips that can be plugged into your devices
- These chips were designed to take all of the information that your wires normally send, and transmit it at a special frequency to something called a receiver Bluetooth chip
- Bluetooth chip is designed to replace cables. Information normally carried by the cable, is transmitted at a special frequency to a receiver Bluetooth chip
- These devices can form a quick ad-hoc secure "piconet" and start communication
- A piconet starts with two connected devices, and may grow to eight connected devices

- All Bluetooth devices are peer units and have identical implementations. However, when establishing a piconet, one unit will act as a Master and the other(s) as slave(s) for the duration of the piconet connection

NETWORKING OF BLUETOOTH



Bluetooth technology provides both **point-to-point** and **point-to-multipoint** connection. In point-to-multipoint connections, the channel is shared among several Bluetooth units. In point-to-point connections, only two units share the connection. Bluetooth protocols assume that a small number of units will participate in communications at any given time. These small groups are called **piconets** , and they consist of one master unit and up to seven active slave units. The master is the unit that initiates transmissions, and the slaves are responding units. This type of Bluetooth network can have only one master unit. If several piconets overlap a physical area, and members of the various piconets communicate with each other, this new, larger network is known as a **scatternet** . Any unit in one piconet can communicate in a second piconet as long as it serves as master for only one piconet at a time..

Figure-01: Illustration of Bluetooth Piconets & Scatternet with Slave/Slave node

EXPERIMENT NO.5

AIM: Study of Mobile IP.

THEORY: Mobile IP is a communication protocol (created by extending Internet Protocol, IP) that allows the users to move from one network to another with the same IP address. It ensures that the communication will continue without user's sessions or connections being dropped.

Terminologies:

- **Mobile Node (MN):**

  It is the hand-held communication device that the user caries e.g. Cell phone.
- **Home Network:**

  It is a network to which the mobile node originally belongs to as per its assigned IP address (home address).
- **Home Agent (HA):**

  It is a router in home network to which the mobile node was originally connected
- **Home Address:**

  It is the permanent IP address assigned to the mobile node (within its home network).
- **Foreign Network:**

  It is the current network to which the mobile node is visiting (away from its home network).
- **Foreign Agent (FA):**

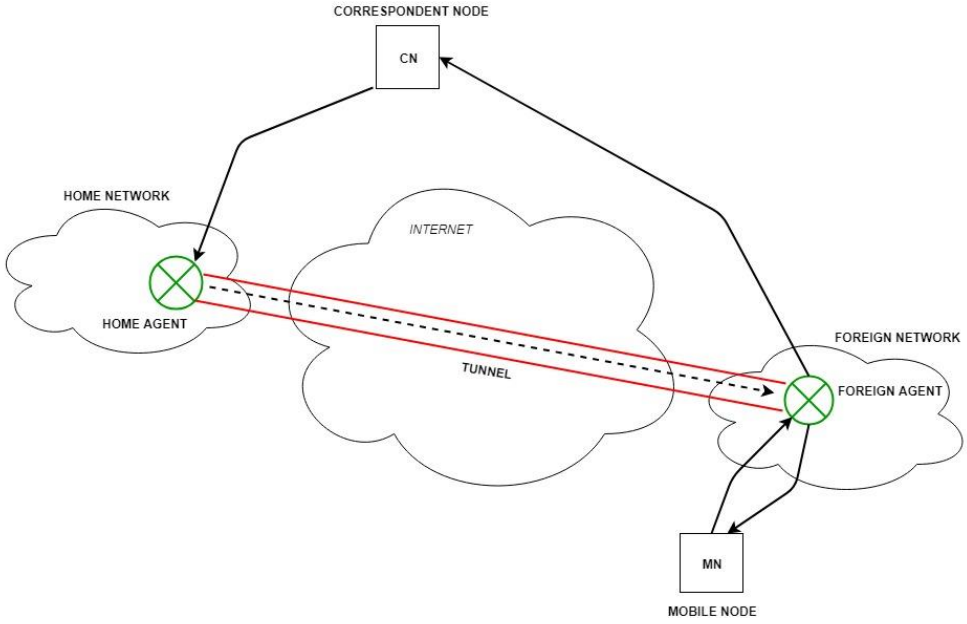
  It is a router in foreign network to which mobile node is currently connected. The packets from the home agent are sent to the foreign agent which delivers it to the mobile node.

- **Correspondent Node (CN):**

It is a device on the internet communicating to the mobile node.

- **Care of Address (COA):**

  It is the temporary address used by a mobile node while it is moving away from its home network.



Working:

Correspondent node sends the data to the mobile node. Data packets contains correspondent node's address (Source) and home address (Destination). Packets reaches to the home agent. But now mobile node is not in the home network, it has moved into the foreign network. Foreign agent sends the care-of-address to the home agent to which all the packets should be sent. Now, a tunnel will be established between the home agent and the foreign agent by the process of tunneling.

Tunneling establishes a virtual pipe for the packets available between a tunnel entry and an endpoint. It is the process of sending a packet via a tunnel and it is achieved by a mechanism called encapsulation.
Now, home agent encapsulates the data packets into new packets in which the source address is the home address and destination is the care-of-address and sends it through the tunnel to the foreign agent. Foreign agent, on other side of the tunnel receives the data packets, decapsulates them and sends them to the mobile node. Mobile node in response to the data packets received, sends a reply in response to foreign agent. Foreign agent directly sends the reply to the correspondent node.

Key Mechanisms in Mobile IP:

1. **Agent Discovery:**
   Agents advertise their presence by periodically broadcasting their agent advertisement messages. The mobile node receiving the agent advertisement messages observes whether the message is from its own home agent and determines whether it is in the home network or foreign network.
2. **Agent Registration:**

   Mobile node after discovering the foreign agent, sends registration request (RREQ) to the foreign agent. Foreign agent in turn, sends the registration request to the home agent with the care-of-address. Home agent sends registration reply (RREP) to the foreign agent. Then it forwards the registration reply to the mobile node and completes the process of registration.

3. **Tunneling:**

   It establishes a virtual pipe for the packets available between a tunnel entry and an endpoint. It is the process of sending a packet via a tunnel and it is achieved by a mechanism called encapsulation. It takes place to forward an IP datagram from the home agent to the care-of-address. Whenever home agent receives a packet from correspondent node, it encapsulates the packet with source address as home address and destination as care-of-address.

Route Optimization in Mobile IP:

The route optimization adds a conceptual data structure, the binding cache, to the correspondent node. The binding cache contains bindings for mobile node's home address and its current care-of-address. Every time the home agent receives a IP datagram that is destined to a mobile node currently away from the home network, it sends a binding update to the correspondent node to update the information in the

correspondent node’s binding cache. After this the correspondent node can directly tunnel packets to the mobile node.

EXPERIMENT NO.6

AIM: Study of OPNET tool for modeling and simulation of different cellular standards.

THEORY: To enhance comprehensive environment to develop and support various communication network model and distributed system.OPNET is an efficient discrete event simulator to simulate the behavior and performance of any network. We offer OPNET network simulator final year projects to implement the various network communications. We assure simulation for routing, multicast routing protocol, over wired, wireless network and TCP which programmed by C++ and OTCL.

Characteristics of Network Simulator: We adopt various network simulator characteristics for opnet are,

- Traffic specification among nodes.
- Customized text based applications.
- Link specification among nodes.
- Specify protocol to handle network traffic.
- Programming oriented tools.
- Nodes specifications.
- Visualize network graphic applications.

Types of Network Simulator: We categorized network simulator into following types based on students projects are as,

- **Open Source Simulator** We ensure open source simulator which provides free source code to user and affiliated packages.
- **Commercial Simulator** By commercial simulator we can't get source code software as affiliated packages with free of cost.

Languages Used In Network Simulator: We use following languages to implement various network simulator are,

- **C++** By using C++ we can run fast and suitable to implement protocol.
- **OTCL** By using OTCL we can run slower and modified quickly and ensure simulation configuration.

- **Network Simulator Method:** We implement network simulator by two methods which are as follows
- Analytical simulation.
- Discrete event simulation.

- **OPNET Methods** We provide various methods are
- **OPNET Modeler** We use opnet modeler as finite state machine with analytical model combination. We provide graphical user interface (GUI) which is a main characteristics of modeler.
- **Network Testbed** We operate network testbed as client server pair, Traffic G and Traffic S to reduce the scheduling granularity.

Network Simulator Representation: We represents network by opnet model and architecture.

Experiments Simulator We perform simulator experiments for FTP session and CBR traffic. We proposed more than 80+ projects in opnet simulation under various network communication in an optimistic way.

Types of wireless network:

- WWAN
    - 2G cellular
    - Cellular digital packet data
    - GSM
    - mobitex
- WPAN
    - Bluetooth
    - IR
- WLAN
    - 11

- HiperLAN

Requirements on wireless network security:

- Authentication.
- Accountability.
- Non repudiation.

Research on wireless network:

- Cross layer design.
- Define new technologies like ultra-wideband, software radio.
- Design more localized algorithms.
- Building working networks out of current fundamentals.
- Hybrid ad hoc networks, heterogeneous sensor and ad hoc networks.
- Sensor network issues such as reliability.

EXPERIMENT NO.7

AIM: Implement Code Division Multiple Access (CDMA).

THEORY: CDMA is a channelization protocol for Multiple Access, where information can be sent simultaneously through several transmitters over a single communication channel.
It is achieved in below steps:

- A signal is generated which extends over a wide bandwidth.
- The code which performs this action is called spreading code.
- Later on, a specific signal can be selected with a given code even in the presence of many other signals.

It is mainly used in mobile networks like 2G and 3G.

How does CDMA work?

To see how CDMA works, we have to understand orthogonal sequences (also known as chips).

Let N be the number of stations establishing multiple access over a common channel.

Then the properties of orthogonal sequences can be stated as follows:

1. An orthogonal sequence can be thought of as a 1xN matrix.
   Eg: [+1 -1 +1 -1] for N = 4.
2. Scalar multiplication and matrix addition rules follow as usual.
   Eg: 3**.**[+1 -1 +1 -1] = [+3 -3 +3 -3]
   Eg: [+1 -1 +1 -1] + [-1 -1 -1 -1] = [0 -2 0 -2]
3. **Inner Product:** It is evaluated by multiplying two sequences element by element and then adding all elements of the resulting list.
   - Inner Product of a sequence with itself is equal to N
     [+1 -1 +1 -1]**.**[+1 -1 +1 -1] = 1 + 1 + 1 + 1 = 4
   - Inner Product of two distinct sequences is zero
     [+1 -1 +1 -1]**.**[+1 +1 +1 +1] = 1-1+1-1 = 0

The analogy behind **code-division multiple access** says there are four people and two out of them are talking with each other in some language what other two don't know and the same goes for those two also. For example, two of them talking in Punjabi and two in Bengali. Those two talking in Punjabi has no idea about Bengali and same for Bengali guys too. So, there is no interruption in their respective communication. The same analogy has been used for **CDMA**.

We discuss the concept with the help of an example,

Say there are four stations: **A, B, C, D**
Each station has assigned a code say $\mathbf{C_1, C_2, C_3, C_4}$
Each of them sending their respective data say $\mathbf{D_1, D_2, D_3, D_4}$
All of them throws their data multiplying with the code

Thus data on the channel is
$\mathbf{C_1D_1 + C_2D_2 + C_3D_3 + C_4D_4}$

The receiver who wants to retrieve simply multiplying the data with its code and divide by the number of the station.

Now, this is possible because of the coding theory. Let's see the how codes are generated, encoding and decoding of data bit and rules of addition and multiplication

Code generation:

Code generation is done by Walsh table

Walsh table is a kind of recursive table which is represented by

$$W_{2N}=\begin{bmatrix} Wn & Wn \\ Wn & \overline{Wn} \end{bmatrix}$$

Where W1= [1]
2N=No of stations
So, for 2 stations

$$W_2=\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

Code for first station is [1 1] //vector
Code for second station is [1 -1] //vector

Additions and multiplications are vector scalar type
Say [1 0]*[-1 1]=(1*-1)+ (0*1)]=-1+0=-1

Encoding and decoding of data

- If a station is sending bit 0, it's encoded as -1
- If a station is sending bit 1, it's encoded as 1
- If station is idle, it's encoded as 0

Example with 2 stations

Say, Station A sends 1, B sends 0
Code of A: [1 1]

```
#include <bits/stdc++.h>
using namespace std;

class CDMA {
  public:
  int** wtable;
  int** copy;
  int* channel_sequence;

  void setUp(int data[], int num_stations) {
        int n=num_stations;
        wtable = new int* [n];
```

```
        for(int i=0;i<n;i++)
                wtable[i]=new int[n];

        copy = new int* [n];
        for(int i=0;i<n;i++)
                copy[i]=new int[n];

        buildWalshTable(num_stations, 0, num_stations - 1, 0, num_stations -
1, false);

        showWalshTable(num_stations);

        for (int i = 0; i < num_stations; i++) {
                for (int j = 0; j < num_stations; j++) {
                        copy[i][j] = wtable[i][j];
                        wtable[i][j] *= data[i];
                }
        }

        channel_sequence = new int[n];

        for (int i = 0; i < num_stations; i++) {
                for (int j = 0; j < num_stations; j++) {
                        channel_sequence[i] += wtable[j][i];
                }
        }
  }

  void listenTo(int sourceStation, int num_stations) {
        int innerProduct = 0;
        for (int i = 0; i < num_stations; i++) {
                innerProduct += copy[sourceStation][i] * channel_sequence[i];
        }

        int k=innerProduct/num_stations;

        if(k==1)
                cout<<"The data received from station "<<sourceStation+1<<"
is: "<<k<<endl;
```

```
        else if(k==-1)
                cout<<"The data received from station "<<sourceStation+1<<"
is: 0"<<endl;
        else
                cout<<"Station "<<sourceStation+1<<" is idle, it didn't send
any data\n";
  }

  //building walsh table
  int buildWalshTable(int len, int i1, int i2, int j1,int j2, bool isBar) {
        if (len == 2) {
                if (!isBar) {
                        wtable[i1][j1] = 1;
                        wtable[i1][j2] = 1;
                        wtable[i2][j1] = 1;
                        wtable[i2][j2] = -1;
                }
                else {
                        wtable[i1][j1] = -1;
                        wtable[i1][j2] = -1;
                        wtable[i2][j1] = -1;
                        wtable[i2][j2] = +1;
                }
                return 0;
        }

        int midi = (i1 + i2) / 2;
        int midj = (j1 + j2) / 2;

        buildWalshTable(len / 2, i1, midi, j1, midj, isBar);
        buildWalshTable(len / 2, i1, midi, midj + 1, j2, isBar);
        buildWalshTable(len / 2, midi + 1, i2, j1, midj, isBar);
        buildWalshTable(len / 2, midi + 1, i2, midj + 1, j2, !isBar);

        return 0;
  }

  void showWalshTable(int num_stations) {
        cout<<".............Displaying walsh table.....................\n";
        //cout<<endl;
```

```
        for (int i = 0; i < num_stations; i++) {
                for (int j = 0; j < num_stations; j++) {
                        cout<<wtable[i][j]<<"  ";
                }
                cout<<"\n";
        }
        cout<<"-------------------------------------------------------\n";
  }
};

int main() {
  cout<<"------------------------------CDMA Implementation----------------------
-\n";

  int num_stations;
  cout<<"Enter no of stations\n";

  cin>>num_stations;
  //data bits corresponding to each station
  cout<<"Press 1 if station is sending bit 1\n";
  cout<<"Press -1 if station is sending bit 0\n";
  cout<<"Press 0 if station is idle\n";
  int* data=new int[num_stations];
  for(int i=0;i<num_stations;i++){
        cout<<"enter for station "<<i+1<<endl;
        cin>>data[i];
  }

  CDMA channel;

  channel.setUp(data, num_stations);

  // station you want to listen to
  cout<<"Enter station no you want to listen to\n";
  int sourceStation;
  cin>> sourceStation;

  channel.listenTo(sourceStation-1, num_stations);
  return 0;
}
```

EXPERIMENT NO.8

AIM: Write necessary codes to simulate a Wi-Fi Network using ns-2

THEORY: Wireless networks are computer networks that are not connected by cables of any kind. The use of a wireless network enables enterprises to avoid the costly process of introducing cables into buildings or as a connection between different equipment locations.

Advantages of wireless network:

- Very flexible with reception area.
- Ad-hoc networks without previous planning possible.
- No wiring difficulties.
- More robust against disasters like: earth quake, fire.
- Qyite cheap networking infrastructure possible.

```
#Example of Wireless networks
#Step 1 initialize variables
#Step 2 - Create a Simulator object
#step 3 - Create Tracing and animation file
#step 4 - topography
#step 5 - GOD - General Operations Director
#step 6 - Create nodes
#Step 7 - Create Channel (Communication PATH)
#step 8 - Position of the nodes (Wireless nodes needs a location)
#step 9 - Any mobility codes (if the nodes are moving)
#step 10 - TCP, UDP Traffic
#run the simulation

#initialize the variables
set val(chan)           Channel/WirelessChannel    ;#Channel Type
set val(prop)           Propagation/TwoRayGround   ;# radio-propagation
model
set val(netif)          Phy/WirelessPhy            ;# network interface
type WAVELAN DSSS 2.4GHz
set val(mac)            Mac/802_11                 ;# MAC type
set val(ifq)            Queue/DropTail/PriQueue    ;# interface queue type
set val(ll)             LL                         ;# link layer type
set val(ant)            Antenna/OmniAntenna        ;# antenna model
set val(ifqlen)         50                         ;# max packet in ifq
set val(nn)             6                          ;# number of
mobilenodes
set val(rp)             AODV                       ;# routing protocol
```

```
set val(x)  500   ;# in metres
set val(y)  500   ;# in metres
#Adhoc OnDemand Distance Vector

#creation of Simulator
set ns [new Simulator]

#creation of Trace and namfile
set tracefile [open wireless.tr w]
$ns trace-all $tracefile

#Creation of Network Animation file
set namfile [open wireless.nam w]
$ns namtrace-all-wireless $namfile $val(x) $val(y)

#create topography
set topo [new Topography]
$topo load_flatgrid $val(x) $val(y)

#GOD Creation - General Operations Director
create-god $val(nn)

set channel1 [new $val(chan)]
set channel2 [new $val(chan)]
set channel3 [new $val(chan)]

#configure the node
$ns node-config -adhocRouting $val(rp) \
  -llType $val(ll) \
  -macType $val(mac) \
  -ifqType $val(ifq) \
  -ifqLen $val(ifqlen) \
  -antType $val(ant) \
  -propType $val(prop) \
  -phyType $val(netif) \
  -topoInstance $topo \
  -agentTrace ON \
  -macTrace ON \
  -routerTrace ON \
  -movementTrace ON \
  -channel $channel1

set n0 [$ns node]
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]
set n4 [$ns node]
set n5 [$ns node]

$n0 random-motion 0
$n1 random-motion 0
$n2 random-motion 0
$n3 random-motion 0
$n4 random-motion 0
```

```
$n5 random-motion 0

$ns initial_node_pos $n0 20
$ns initial_node_pos $n1 20
$ns initial_node_pos $n2 20
$ns initial_node_pos $n3 20
$ns initial_node_pos $n4 20
$ns initial_node_pos $n5 50

#initial coordinates of the nodes
$n0 set X_ 10.0
$n0 set Y_ 20.0
$n0 set Z_ 0.0

$n1 set X_ 210.0
$n1 set Y_ 230.0
$n1 set Z_ 0.0

$n2 set X_ 100.0
$n2 set Y_ 200.0
$n2 set Z_ 0.0

$n3 set X_ 150.0
$n3 set Y_ 230.0
$n3 set Z_ 0.0

$n4 set X_ 430.0
$n4 set Y_ 320.0
$n4 set Z_ 0.0

$n5 set X_ 270.0
$n5 set Y_ 120.0
$n5 set Z_ 0.0
#Dont mention any values above than 500 because in this example, we use X
and Y as 500,500

#mobility of the nodes
#At what Time? Which node? Where to? at What Speed?
$ns at 1.0 "$n1 setdest 490.0 340.0 25.0"
$ns at 1.0 "$n4 setdest 300.0 130.0 5.0"
$ns at 1.0 "$n5 setdest 190.0 440.0 15.0"
#the nodes can move any number of times at any location during the
simulation (runtime)
$ns at 20.0 "$n5 setdest 100.0 200.0 30.0"

#creation of agents
set tcp [new Agent/TCP]
set sink [new Agent/TCPSink]
$ns attach-agent $n0 $tcp
$ns attach-agent $n5 $sink
$ns connect $tcp $sink
set ftp [new Application/FTP]
$ftp attach-agent $tcp
$ns at 1.0 "$ftp start"
```

```
set udp [new Agent/UDP]
set null [new Agent/Null]
$ns attach-agent $n2 $udp
$ns attach-agent $n3 $null
$ns connect $udp $null
set cbr [new Application/Traffic/CBR]
$cbr attach-agent $udp
$ns at 1.0 "$cbr start"

$ns at 30.0 "finish"

proc finish {} {
 global ns tracefile namfile
 $ns flush-trace
 close $tracefile
 close $namfile
 exit 0
}

puts "Starting Simulation"
$ns run
```

EXPERIMENT NO.9

AIM: Study of Wireless Markup Language (WML).

THEORY: The topmost layer in the WAP (Wireless Application Protocol) architecture is made up of WAE (Wireless Application Environment), which consists of WML and WML scripting language.

- WML stands for **W**ireless **M**arkup **L**anguage
- WML is an application of XML, which is defined in a document-type definition.
- WML is based on HDML and is modified so that it can be compared with HTML.
- WML takes care of the small screen and the low bandwidth of transmission.
- WML is the markup language defined in the WAP specification.
- WAP sites are written in WML, while web sites are written in HTML.
- WML is very similar to HTML. Both of them use tags and are written in plain text format.
- WML files have the extension ".wml". The MIME type of WML is "text/vnd.wap.wml".
- WML supports client-side scripting. The scripting language supported is called WMLScript.

WML Versions:

WAP Forum has released a latest version WAP 2.0. The markup language defined in WAP 2.0 is XHTML Mobile Profile (MP). The WML MP is a subset of the XHTML. A style sheet called WCSS (WAP CSS) has been introduced along with XHTML MP. The WCSS is a subset of the CSS2.

Most of the new mobile phone models released are WAP 2.0-enabled. Because WAP 2.0 is backward compatible to WAP 1.x, WAP 2.0-enabled mobile devices can display both XHTML MP and WML documents.

WML 1.x is an earlier technology. However, that does not mean it is of no use, since a lot of wireless devices that only supports WML 1.x are still being used. Latest version of WML is 2.0 and it is created for backward compatibility purposes. So WAP site developers need not to worry about WML 2.0.

WML Decks and Cards:

A main difference between HTML and WML is that the basic unit of navigation in HTML is a page, while that in WML is a card. A WML file can contain multiple cards and they form a deck.

When a WML page is accessed from a mobile phone, all the cards in the page are downloaded from the WAP server. So if the user goes to another card of the same deck, the mobile browser does not have to send any requests to the server since the file that contains the deck is already stored in the wireless device.

You can put links, text, images, input fields, option boxes and many other elements in a card.

WML Program Structure:

Following is the basic structure of a WML program:

```
<?xml version="1.0"?>
<!DOCTYPE wml PUBLIC "-//WAPFORUM//DTD WML 1.2//EN"
"http://www.wapforum.org/DTD/wml12.dtd">

<wml>

<card id="one" title="First Card">
<p>
This is the first card in the deck
</p>
</card>

<card id="two" title="Second Card">
<p>
Ths is the second card in the deck
</p>
</card>

</wml>
```

The first line of this text says that this is an XML document and the version is 1.0. The second line selects the document type and gives the URL of the document type definition (DTD).

One WML deck (i.e. page) can have one or more cards as shown above. We will see complete details on WML document structure in subsequent chapter.

Unlike HTML 4.01 Transitional, text cannot be enclosed directly in the <card>...</card> tag pair. So you need to put a content inside ... as shown above.

WAP Site Design Considerations:

Wireless devices are limited by the size of their displays and keypads. It's therefore very important to take this into account when designing a WAP Site.

While designing a WAP site you must ensure that you keep things simple and easy to use. You should always keep in mind that there are no standard micro browser behaviors and that the data link may be relatively slow, at around 10Kbps. However, with GPRS, EDGE, and UMTS, this may not be the case for long, depending on where you are located.

The following are general design tips that you should keep in mind when designing a service:

- Keep the WML decks and images to less than 1.5KB.
- Keep text brief and meaningful, and as far as possible try to precode options to minimize the rather painful experience of user data entry.
- Keep URLs brief and easy to recall.

- Minimize menu levels to prevent users from getting lost and the system from slowing down.
- Use standard layout tags such as <big> and <b>, and logically structure your information.
- Don't go overboard with the use of graphics, as many target devices may not support them

EXPERIMENT NO.10

AIM: Study of Wireless Markup Language (WML).

THEORY: The <template> is used to apply <do> and <onevent> elements to all cards in a deck. This element defines a template for all the cards in a deck and the code in the <template> tag is added to each card in the deck.

You can override a <do> element of a template by defining another <do> element with the same *name* attribute value in a WML card.

The <template> element supports the following attributes:

Attribute	Value	Description
onenterbackward	URL	Occurs when the user navigates into a card using a "prev" task
onenterforward	URL	Occurs when the user navigates into a card using a "go" task
ontimer	URL	Occurs when the "timer" expires
class	class data	Sets a class name for the element.
id	element ID	A unique ID for the element.

Following is the example showing usage of <go> element.

```
<?xml version="1.0"?>
<!DOCTYPE wml PUBLIC "-//WAPFORUM//DTD WML 1.3//EN"
"http://www.wapforum.org/DTD/wml13.dtd">

<wml>
  <template>
    <do name="main_menu" type="accept" label="Chapters">
      <go href="chapters"/>
    </do>
    <do name="menu_1" type="accept" label="Chapter 1">
      <go href="#chapter1"/>
    </do>
    <do name="menu_2" type="accept" label="Chapter 2">
      <go href="#chapter2"/>
    </do>
    <do name="menu_3" type="accept" label="Chapter 3">
      <go href="#chapter3"/>
    </do>
```

```
  <do name="menu_4" type="accept" label="Chapter 4">
    <go href="#chapter4"/>
  </do>
</template>

<card id="chapters" title="WML Tutorial">
  <p>
    Select One Chapter:<br/>
    <anchor>
      <go href="#chapter1"/>
      Chapter 1: WML Overview
    </anchor><br />

    <anchor>
      <go href="#chapter2"/>
      Chapter 2: WML Environment
    </anchor><br />

    <anchor>
      <go href="#chapter3"/>
      Chapter 3: WML Syntax
    </anchor><br />

    <anchor>
      <go href="#chapter4"/>
      Chapter 4: WML Elements
    </anchor><br />
  </p>
</card>

<card id="chapter1" title="WML Tutorial Ch1">
  <p>
    <em>Chapter 1: WML Introduction</em><br/>
    ...
  </p>
</card>

<card id="chapter2" title="WML Tutorial Ch2">
  <p>
    <em>Chapter 2: WML Environment</em><br/>
    ...
  </p>
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<card id="chapter3" title="WML Tutorial Ch3">
  <p>
    <em>Chapter 3: WML Syntax</em><br/>
    ...
  </p>
</card>

<card id="chapter4" title="WML Tutorial Ch4">
  <p>
```

```
    <em>Chapter 4: WML Elements</em><br/>
    ...
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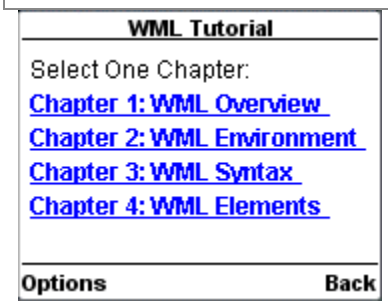

Program :

Output :