1) MOBILE COMPUTING-Introduction

Mobile Computing is a technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link.

The main concept involves −

- Mobile communication
- Mobile hardware
- Mobile software

Mobile communication

The mobile communication in this case, refers to the infrastructure put in place to ensure that seamless and reliable communication goes on. These would include devices such as protocols, services, bandwidth, and portals necessary to facilitate and support the stated services. The data format is also defined at this stage. This ensures that there is no collision with other existing systems which offer the same service.

Since the media is unguided/unbounded, the overlaying infrastructure is basically radio wave-oriented. That is, the signals are carried over the air to intended devices that are capable of receiving and sending similar kinds of signals.

Mobile Hardware

Mobile hardware includes mobile devices or device components that receive or access the service of mobility. They would range from portable laptops, Smartphone’s, tablet Pc's, Personal Digital Assistants.

These devices will have a receptor medium that is capable of sensing and receiving signals. These devices are configured to operate in full- duplex, whereby they are capable of sending and receiving signals at the same time. They don't have to wait until one device has finished communicating for the other device to initiate communications.

Above mentioned devices use an existing and established network to operate on. In most cases, it would be a wireless network.

Mobile software

Mobile software is the actual program that runs on the mobile hardware. It deals with the characteristics and requirements of mobile applications. This is the engine of the mobile device. In other terms, it is the operating system of the appliance. It's the essential component that operates the mobile device.

Since portability is the main factor, this type of computing ensures that users are not tied or pinned to a single physical location, but are able to operate from anywhere. It incorporates all aspects of wireless communications.

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2) Mobile Computing - Classification

Mobile computing is not only limited to mobile phones, but there are various gadgets available in the markets that are built on a platform to support mobile computing. They are usually classified in the following categories −

Personal Digital Assistant (PDA)

The main purpose of this device is to act as an electronic organizer or day planner that is portable, easy to use and capable of sharing information with your computer systems.

PDA is an extension of the PC, not a replacement. These systems are capable of sharing information with a computer system through a process or service known as synchronization. Both devices will access each other to check for changes or updates in the individual devices. The use of infrared and Bluetooth connections enables these devices to always be synchronized.

With PDA devices, a user can browse the internet, listen to audio clips, watch video clips, edit and modify office documents, and many more services. The device has a stylus and a touch sensitive screen for input and output purposes.

Smartphones

This kind of phone combines the features of a PDA with that of a mobile phone or camera phone. It has a superior edge over other kinds of mobile phones.

Smartphones have the capability to run multiple programs concurrently. These phones include high-resolution touch screens, web browsers that can access and properly display standard web pages rather than just mobile-optimized sites, and high-speed data access via Wi-Fi and high speed cellular broadband.

The most common mobile Operating Systems (OS) used by modern smartphones include Google's Android, Apple's iOS, Nokia's Symbian, RIM's BlackBerry OS, Samsung's Bada, Microsoft's Windows Phone, and embedded Linux distributions such as Maemo and MeeGo. Such operating systems can be installed on different phone models, and typically each device can receive multiple OS software updates over its lifetime.

Tablet PC and iPads

This mobile device is larger than a mobile phone or a PDA and integrates into a touch screen and is operated using touch sensitive motions on the screen. They are often controlled by a pen or by the touch of a finger. They are usually in slate form and are light in weight. Examples would include ipads, Galaxy Tabs, Blackberry Playbooks etc.

They offer the same functionality as portable computers. They support mobile computing in a far superior way and have enormous processing horsepower. Users can edit and modify document files, access high speed internet, stream video and audio data, receive and send e-mails, attend/give lectures and presentations among its very many other functions. They have excellent screen resolution and clarity.

The Benefits of Mobile Computing

There are many benefits to mobile computing including the ability to get directions, entertain you when bored, do business, and more, including:

- **Connectivity:** You can stay connected to all sources at all times.
- **Social Engagement:** You can interact with a variety of users via the Internet.
- **Personalization:** You can tailor your mobile computing to your individual needs.

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3) <u>Mobile Computing Vs Wireless Networking</u>

The terms "mobile" and "wireless" are often used interchangeably but in reality, they are two very different concepts applied to modern computing and technology.

Mobile is a word that is commonly used to describe portable devices. A mobile device is one that is made to be taken anywhere. Therefore, it needs an internal battery for power, and must be connected to a modern mobile network that can help it to send and receive data without attaching to a hardware infrastructure.

Wireless, on the other hand, does not mean mobile. Traditional computers or other non-mobile devices can access wireless networks. One very common example is the use of a localized browser product in a local area network (LAN), where the router takes what used to be a cabled interaction and makes it wireless. Other kinds of wireless networks called wide area networks (WAN) can even use components of 3G or 4G wireless systems made specifically for mobile devices, but that doesn‘t mean that the devices on these networks are mobile. They may still be plugged in or require proximity to a router or network node.

Mobile and wireless systems really accomplish two very different things. While a wireless system provides a fixed or portable endpoint with access to a distributed network, a mobile system offers all of the resources of that distributed network to something that can go anywhere, barring any issues with local reception or technical area coverage.

For another example of the difference between mobile and wireless, think of businesses that offer Wi-Fi hotspots. A Wi-Fi hotspot is typically a resource for someone who has a relatively fixed device, such as a laptop computer that doesn‘t have its own internal Internet access built in. By contrast, mobile devices already have inherent access to the Internet or other wireless systems through those cell tower networks that ISPs and telecom companies built specifically for them. So mobile devices don‘t need Wi-Fi - they already have their connections.

To some who are used to using both wireless and mobile networks, this distinction may seem very simple. However, the difference between providing mobile and wireless is likely to be something that gets explored more as new technologies continue to develop, and companies continue to offer more different kinds of interfaces to consumers.

Mobile is subgroup from wireless. We have wireless systems that are not mobile and we have technologies which are wireless but not mobile in sense of technologies deployed in mobile operators networks. We have fixed wireless (e.g. fixed WiMAX) and e.g. TETRA which is not technology deployed in mobile (operators) networks.

In communication engineering, wireless communication (both static and dynamic) is communication between Nodes/system without use of direct physical connection rather it is through a non conducting or dielectric media. Where as in mobile communication, communicating nodes moves within specified area and method of communication is wireless communication suitably.E.g.-Mobile Ad-hoc networks (MANETs).

Wireless Communication in itself is a very broad concept that is achieved using various inter-related technologies. Mobile Communication utilizes some of the technologies that are made available / possible by Wireless Communication. Some of the popular wireless technologies employed in Mobile Communication include: GPRS (General Packet Radio Service), LTE (Long Term Evolution), HSPA (High Speed Packet Access), GSM (Global System for Mobile Communication), EDGE (Enhanced Data GSM Environment), CDMA (Code Division Multiple Access) and its variants, etc.

Wireless refers to the method of transferring information between a computing device, such as a personal data assistant (PDA), and a data source, such as an agency database server, without a physical connection. However, not all wireless communications technologies are created equally, offer the same uses or are even mobile.

Mobile computing refers to computing devices that are not restricted to a desktop. A mobile device may be a PDA, a smart phone or a web phone, a laptop computer, or any one of numerous other devices that allow the

user to complete tasks without being tethered, or connected, to a network. Mobile computing does not necessarily require wireless communication. In fact, it may not require communication between devices at all.

Wireless communication is simply data communication without the use of a landline. This may involve a cellular telephone, a two way radio, a fixed wireless connection, a laser, or satellite communications. Here the computing device is continuously connected to the base network.

Mobile computing essentially refers to a device that is not always connected to a central network. This group of devices includes laptops, newly created smart phones and also PDA's. These products may communicate with a base location, with or without, a wireless connection

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4) **Applications of Mobile Computing**

In many fields of work, the ability to keep on the move is vital in order to utilise time efficiently. The importance of Mobile Computers has been highlighted in many fields of which a few are described below:

a. Vehicles: Music, news, road conditions, weather reports, and other broadcast information are received via digital audio broadcasting (DAB) with 1.5 Mbit/s. For personal communication, a universal mobile telecommunications system (UMTS) phone might be available offering voice and data connectivity with 384 kbit/s. The current position of the car is determined via the global positioning system (GPS). Cars driving in the same area build a local ad-hoc network for the fast exchange of information in emergency situations or to help each other keep a safe distance. In case of an accident, not only will the airbag Wireless Networks & Mobile Computing 10CS831 be triggered, but the police and ambulance service will be informed via an emergency call to a service provider. Buses, trucks, and trains are already transmitting maintenance and logistic information to their home base, which helps to improve organization (fleet management), and saves time and money.

b. Emergencies: An ambulance with a high-quality wireless connection to a hospital can carry vital information about injured persons to the hospital from the scene of the accident. All the necessary steps for this particular type of accident can be prepared and specialists can be consulted for an early diagnosis. Wireless networks are the only means of communication in the case of natural disasters such as hurricanes or earthquakes. In the worst cases, only decentralized, wireless ad-hoc networks survive.

c. Business: Managers can use mobile computers say, critical presentations to major customers. They can access the latest market share information. At a small recess, they can revise the presentation to take advantage of this information. They can communicate with the office about possible new offers and call meetings for discussing responds to the new proposals. Therefore, mobile computers can leverage competitive advantages. A travelling salesman today needs instant access to the company’s database: to ensure that files on his or her laptop reflect the current situation, to enable the company to keep track of all activities of their travelling employees, to keep databases consistent etc. With wireless access, the laptop can be turned into a true mobile office, but efficient and powerful synchronization mechanisms are needed to ensure data consistency.

d. Credit Card Verification: At Point of Sale (POS) terminals in shops and supermarkets, when customers use credit cards for transactions, the intercommunication required between the bank central computer and the POS terminal, in order to effect verification of the card usage, can take place quickly and securely over cellular

channels using a mobile computer unit. This can speed up the transaction process and relieve congestion at the POS terminals.

e. Replacement of Wired Networks: wireless networks can also be used to replace wired networks, e.g., remote sensors, for tradeshows, or in historic buildings. Due to economic reasons, it is often impossible to wire remote sensors for weather forecasts, earthquake detection, or to provide environmental information. Wireless connections, e.g., via satellite, can help in this situation. Other examples for wireless networks are computers, sensors, or information displays in historical buildings, where excess cabling may destroy valuable walls or floors.

f. Infotainment: wireless networks can provide up-to-date information at any appropriate location. The travel guide might tell you something about the history of a building (knowing via GPS, contact to a local base station, or triangulation where you are) downloading information about a concert in the building at the same evening via a local wireless network. Another growing field of wireless network applications lies in entertainment and games to enable, e.g., ad-hoc gaming networks as soon as people Wireless Networks & Mobile Computing meet to play together.

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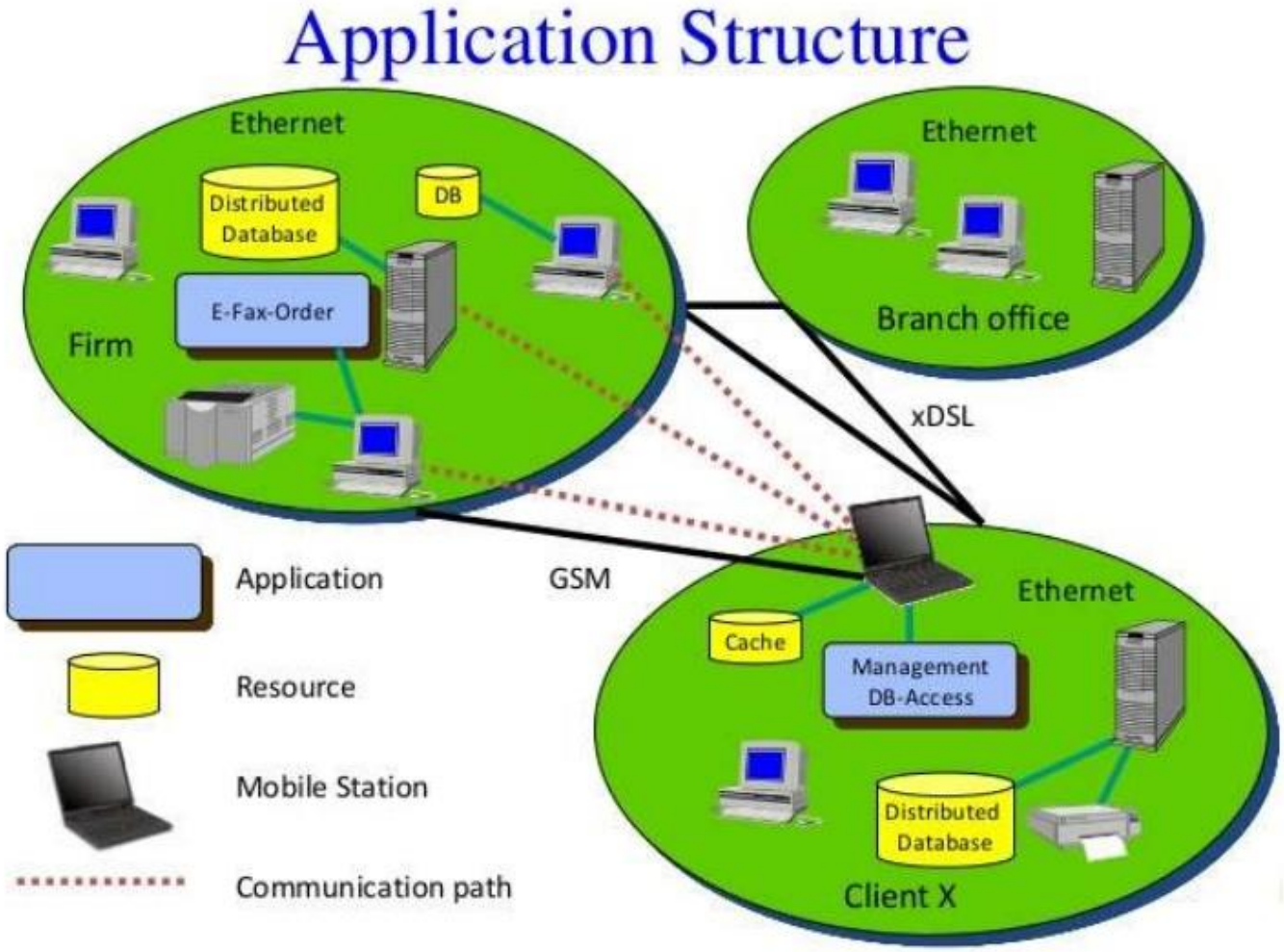
5) Characteristics Of Mobile Computing

1. **Portability** - The Ability to move a device within a learning environment or to different environments with ease.
2. **Social Interactivity** - The ability to share data and collaboration between users.
3. **Context Sensitivity** - The ability to gather and respond to real or simulated data unique to a current location, environment, or time.
4. **Connectivity** - The ability to be digitally connected for the purpose of communication of data in any environment.
5. **Individual** - The ability to use the technology to provide scaffolding on difficult activities and lesson customization for individual learners.
6. **Small Size - Mobile devices** are also known as handhelds, palmtops and smart phones due to their roughly phone-like dimensions. A typical mobile device will fit in the average adult's hand or pocket. Some mobile devices may fold or slide from a compact, portable mode to a slightly larger size, revealing built-in keyboards or larger screens. Mobile devices make use of touch screens and small keypads to receive input, maintaining their small size and independence from external interface devices. The standard form of a mobile device allows the user to operate it with one hand, holding the device in the palm or fingers while executing its functions with the thumb.
   Net books and small tablet computers are sometimes mistaken for true mobile devices, based on their similarity in form and function, but if the device's size prohibits one-handed operation or hinders portability, then it cannot be considered a true mobile device.
7. **Wireless Communication** - Mobile devices are typically capable of communication with other similar devices, with stationary computers and systems, with networks and portable phones. Base mobile devices are capable of accessing the Internet through Bluetooth or Wi-Fi networks, and many models are equipped to access cell phone and wireless data networks as well. Email and texting are standard ways of communicating with mobile devices, although many are also capable of telephony, and some specialized mobile devices, such as RFID and barcode.

6) Structure Of Mobile Computing Application

Mobile Computing is a technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link



Programming languages are used for mobile system software. Operating system functions to run the software components onto the hardware. Middleware components deployment. Layered structure arrangement of mobile computing components is used. Protocols and layers are used for transmission and reception.

Programming Languages

The following are the programming languages used for Mobile Computing applications are:

Java - J2SE.

J2ME (Java2 Micro edition)

JavaCard (Java for smart card)

The Java enterprise edition (J2EE) used for web and enterprise server based applications of mobile services

C and C++

Visual C++

Visual Basic

Operating System

Symbian OS, Window CE, Mac OS are the operating systems used in Mobile computing applications. It offers the user to run an application without considering the hardware specifications and functionalities. It provides functions which are used for scheduling the multiple tasks in a system.

It provides the functions required for the synchronization of multiple tasks in the system. It uses multiple threads synchronization and priority allocation. Management functions (such as creation, activation, deletion, suspension, and delay) are used for tasks and memory. It provides Interfaces for communication between software components at the application layer, middleware layers, and hardware devices.

It facilitates the execution of software components on diversified hardware. It provides Configurable libraries for the GUI (graphic user interface) in the device. It provides

User application‘s GUIs, VUI (voice user interface) components, and phone API. It provides the device drivers for the keyboard, display, USB, and other devices.

Middleware

Software components that link the application components with the network-distributed components. It is used to discover the nearby device such as Bluetooth. It is used to discover the nearby hot spot for achieving device synchronization with the server or an enterprise server. It is used for retrieving data (which may be in Oracle or DB2) from a network database. It is used for service discovery at network. It is used for adaptation of the application to the platform and service availability.

Architecture of Mobile Computing Applications

Client/server architecture (and its variants) is often adopted for this kind of applications. However we have to take into consideration some specific aspects related to the mobile devices (clients), and their connectivity with servers.

Clients

There are many mobile device types, including RIM devices, cellular telephones, PDAs, Tablet, PCs, and Laptop PCs. These mobile devices can typically operate as thin clients or fat clients, or they can be developed so that they can host web pages

Thin Clients

Thin clients have no custom application code and completely rely on the server for their functionality. They do not depend as heavily on the mobile device‘s operating system or the mobile device type as fat clients. Thin clients typically use widely available web and Wireless Application Protocol (WAP) browsers to display the application content pages.

Fat Clients

Fat clients typically have one to three layers of application code on them and can operate independently from a server for some period of time. Typically, fat clients are most useful in situations where communication between a client and server cannot be guaranteed.

For example, a fat client application may be able to accept user input and store data in a local database until connectivity with the server is re-established and the data can be moved to the server.

This allows a user to continue working even if he/she is out of contact with the server. Fat clients depend heavily on the operating system and mobile device type and the code can be difficult to release and distribute. Fat clients can be implemented using one, two, or three layers of application code. However, if you only use one layer it is extremely difficult to isolate the individual areas of functionality and reuse and distribute the code over multiple device types.

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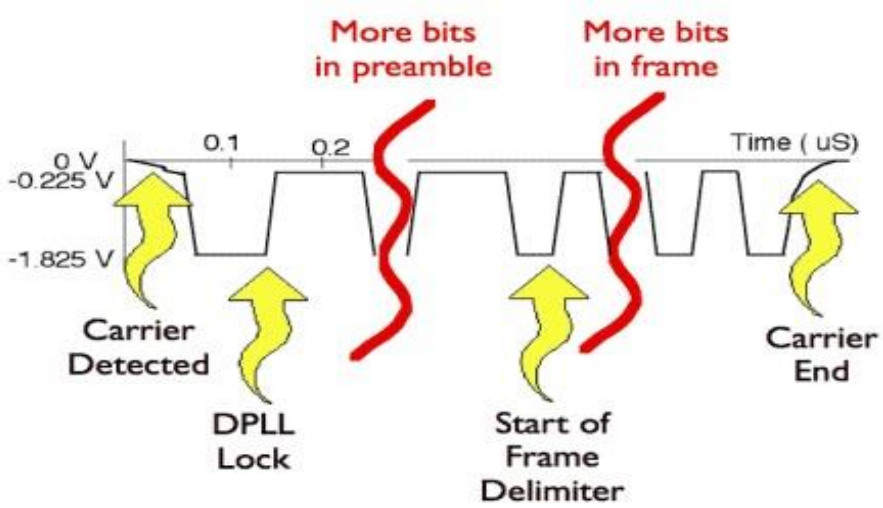
7) Mac Protocols

The Medium Access Control (MAC) protocol is used to provide the data link layer of the Ethernet LAN system. The MAC protocol encapsulates a SDU (payload data) by adding a 14 byte header (Protocol Control Information (PCI)) before the data and appending an integrity checksum, the checksum is a 4-byte (32-bit) Cyclic Redundancy Check (CRC) after the data. The entire frame is preceded by a small idle period (the minimum inter-frame gap, 9.6 microseconds (µS)) and a 8 byte preamble (including the start of frame delimiter).

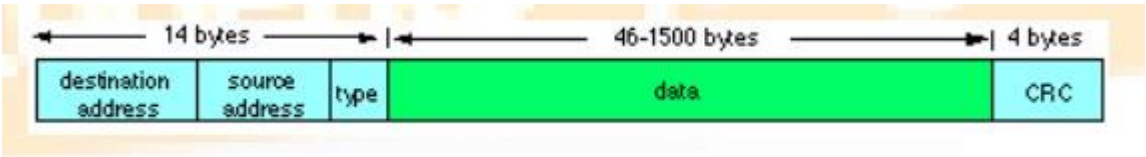
Preamble

The purpose of the idle time before transmission starts is to allow a small time interval for the receiver electronics in each of the nodes to settle after completion of the previous frame. A node starts transmission by sending an 8 byte (64 bit) preamble sequence. This consists of 62 alternating 1's and 0's followed by the pattern 11. Strictly speaking the last byte which finished with the '11' is known as the "Start of Frame Delimiter". When encoded using Manchester encoding, at 10 Mbps, the 62 alternating bits produce a 10 MHz square wave (one complete cycle each bit period).



The purpose of the preamble is to allow time for the receiver in each node to achieve lock of the receiver Digital Phase Lock Loop which is used to synchronise the receive data clock to the transmit data clock. At the point when the first bit of the preamble is received, each receiver may be in an arbitrary state (i.e. have an arbitrary phase for its local clock). During the course of the preamble it learns the correct phase, but in so doing it may miss (or gain) a number of bits. A special pattern is therefore used to mark the last two bits of the preamble. When this is received, the Ethernet receive interface starts collecting the bits into bytes for processing by the MAC layer. It also confirms the polarity of the transition representing a '1' bit to the receiver (as a check in case this has been inverted).

Header



The header consists of three parts:

A 6-byte destination address, which specifies either a single recipient node (unicast mode), a group of recipient nodes (multicast mode), or the set of all recipient nodes (broadcast mode).

A 6-byte source address, which is set to the sender's globally unique node address. This may be used by the network layer protocol to identify the sender, but usually other mechanisms are used (e.g.arp). Its main function is to allow address learning which may be used to configure the filter tables in a bridge.

A 2-byte type field, which provides a Service Access Point (SAP) to identify the type of protocol being carried (e.g. the values 0x0800 is used to identify the IP network protocol, other values are used to indicate other network layer protocols)

CRC

The final field in an Ethernet MAC frame is called a Cyclic Redundancy Check (sometimes also known as a Frame Check Sequence). A 32-bit CRC provides error detection in the case where line errors (or transmission collisions in Ethernet) result in corruption of the MAC frame. Any frame with an invalid CRC is discarded by the MAC receiver without further processing. The MAC protocol does not provide any indication that a frame has been discarded due to an invalid CRC.

The link layer CRC therefore protects the frame from corruption while being transmitted over the physical medium (cable). A new CRC is added if the packet is forwarded by the router on another Ethernet link. While the packet is being processed by the router the packet data is not protected by the CRC. Router processing errors must be detected by network or transport-layer checksums.

Inter Frame Gap

After transmission of each frame, a transmitter must wait for a period of 9.6 microseconds (at 10 Mbps) to allow the signal to propagate through the receiver electronics at the destination. This period of time is known as the Inter-Frame Gap (IFG). While every transmitter must wait for this time between sending frames, receivers

do not necessarily see a "silent" period of 9.6 microseconds. The way in which repeaters operate is such that they may reduce the IFG between the frames which they regenerate.

Byte Order

It is important to realise that nearly all serial communications systems transmit the least significant bit of each byte first at the physical layer. Ethernet supports broadcast, unicast, and multicast addresses. The appearance of a multicast address on the cable (in this case an IP multicast address, with group set to the bit pattern 0xxx xxxx xxxx xxxx xxxx xxxx) is therefore as shown below (bits transmitted from left to right):

```
0                    23 IP Multicast Address Group  47
|                    |<--------------------------->|
1000 0000 0000 0000 0111 1010 xxxx xxx0 xxxx xxxx xxxx xxxx
|                    |
Multicast Bit                0 = Internet Multicast
```

1 = Assigned for other uses

However, when the same frame is stored in the memory of a computer, the bits are

Ordered such that the least significant bit of each byte is stored in the right most position (the bits are transmitted right-to-left within bytes, bytes transmitted left-to-right):

```
0                    23                    47
|                    |                     |
0000 0001 0000 0000 0101 1110 0xxx xxxx xxxx xxxx xxxx xxxx
     |               <--------------------------->
     Multicast Bit        IP Multicast Address Group
```

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8) Wireless Mac Issues

The three important issues are:

1. Half Duplex operation –> either send or receive but not both at a given time
2. Time varying channel
3. Burst channel errors

1. Half Duplex Operation

In wireless, it‘s difficult to receive data when the transmitter is sending the data, because: When node is transmitting, a large fraction of the signal energy leaks into the receiver path. The transmitted and received power levels can differ by orders of magnitude. The leakage signal typically has much higher power than the received signal -—Impossible to detect a received signal, while transmitting data‖. Collision detection is not possible, while sending data. As collision cannot be detected by the sender, all proposed protocols attempt to minimize the probability of collision - Focus on collision avoidance.

2. Time Varying Channel

Three mechanisms for radio signal propagation

Reflection – occurs when a propagating wave impinges upon an object that has very large dimensions than the wavelength of the radio wave e.g. reflection occurs from the surface of the earth and from buildings and walls

Diffraction – occurs when the radio path between the transmitter and the receiver is obstructed by a surface with sharp edges

Scattering – occurs when the medium through which the wave travels consists of objects with

The received signal by a node is a superposition of time-shifted and attenuated versions of the transmitted signals the received signal varies with time .The time varying signals (time varying channel) phenomenon also known as multipath propagation. The rate of variation of channel is determined by the coherence time of the channel Coherence time is defined as time within which When a node‘s received signal strength drops below a certain threshold the node is said to be in fade .Handshaking is widely used strategy to ensure the link quality is good enough for data communication. A successful handshake between a sender and a receiver (small message) indicates a good communication link.

3. Burst Channel Errors

As a consequence of time varying channel and varying signals strengths errors are introduced in the transmission (Very likely) for wire line networks the bit error rate (BER) is the probability of packet error is small .For wire line networks the errors are due to random For wireless networks the BER is as high. For wireless networks the errors are due to node being in fade as a result errors occur in a long burst. Packet loss due to burst errors - mitigation techniques

Smaller packets

Forward Error Correcting Codes

Retransmissions (Acks)

Location Dependent Carrier Sensing

Location Dependent Carrier Sensing results in three types of nodes that protocols need to deal with

Hidden Nodes: Even if the medium is free near the transmitter, it may not be free near the intended receiver

Exposed Nodes: Even if the medium is busy near the transmitter, it may be free near the intended receiver

Capture: Capture occurs when a receiver can cleanly receive a transmission from one of two simultaneous transmissions

Hidden Node/Terminal Problem

A hidden node is one that is within the range of the intended destination but out of range of sender Node B can communicate with A and C both A and C cannot hear each other When A transmits to B, C cannot detect the transmission using the carrier sense mechanism C falsely thinks that the channel is idle

Exposed Nodes

An exposed node is one that is within the range of the sender but out of range of destination .when a node‘s received signal strength drops below a certain threshold the node is said to be in fade .Handshaking is widely used strategy to ensure the link quality is good enough for data communication. A successful handshake between a sender and a receiver (small message) indicates a good communication link.

In theory C can therefore have a parallel transmission with any node that cannot hear the transmission from B, i.e. out of range of B. But C will not transmit to any node because its an exposed node. Exposed nodes waste bandwidth.

Capture

Capture is said to occur when a receiver can cleanly receive a transmission from one of two simultaneous transmissions both within its range Assume node A and D transmit simultaneously to B. The signal strength received from D is much higher than that from A, and

D‘s transmission can be decoded without errors in presence of transmissions from A.D has captured A. Capture is unfair because it gives preference to nodes that are closer to the receiver. It may improve protocol performance.

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9) Fixed Assignment Schemes

TDMA

Time Division Multiple Access (TDMA) is a digital wireless telephony transmission technique. TDMA allocates each user a different time slot on a given frequency. TDMA divides each cellular channel into three time slots in order to increase the amount of data that can be carried.

TDMA technology was more popular in Europe, Japan and Asian countries, where as CDMA is widely used in North and South America. But now a day’s both technologies are very popular through out of the world.

Advantages of TDMA:

- TDMA can easily adapt to transmission of data as well as voice communication.
- TDMA has an ability to carry 64 kbps to 120 Mbps of data rates.
- TDMA allows the operator to do services like fax, voice band data, and SMS as well as bandwidth-intensive application such as multimedia and video conferencing.
- Since TDMA technology separates users according to time, it ensures that there will be no interference from simultaneous transmissions.
- TDMA provides users with an extended battery life, since it transmits only portion of the time during conversations.
- TDMA is the most cost effective technology to convert an analog system to digital.

Disadvantages of TDMA

- Disadvantage using TDMA technology is that the users has a predefined time slot. When moving from one cell site to other, if all the time slots in this cell are full the user might be disconnected.
- Another problem in TDMA is that it is subjected to multipath distortion. To overcome this distortion, a time limit can be used on the system. Once the time limit is expired the signal is ignored.

CDMA

Code Division Multiple Access (CDMA) is a digital wireless technology that uses spread-spectrum techniques. CDMA does not assign a specific frequency to each user. Instead, every channel uses the full available spectrum. Individual conversations are encoded with a pseudo-random digital sequence. CDMA consistently provides better capacity for voice and data communications than other commercial mobile technologies, allowing more subscribers to connect at any given time, and it is the common platform on which 3G technologies are built.

Advantages of CDMA

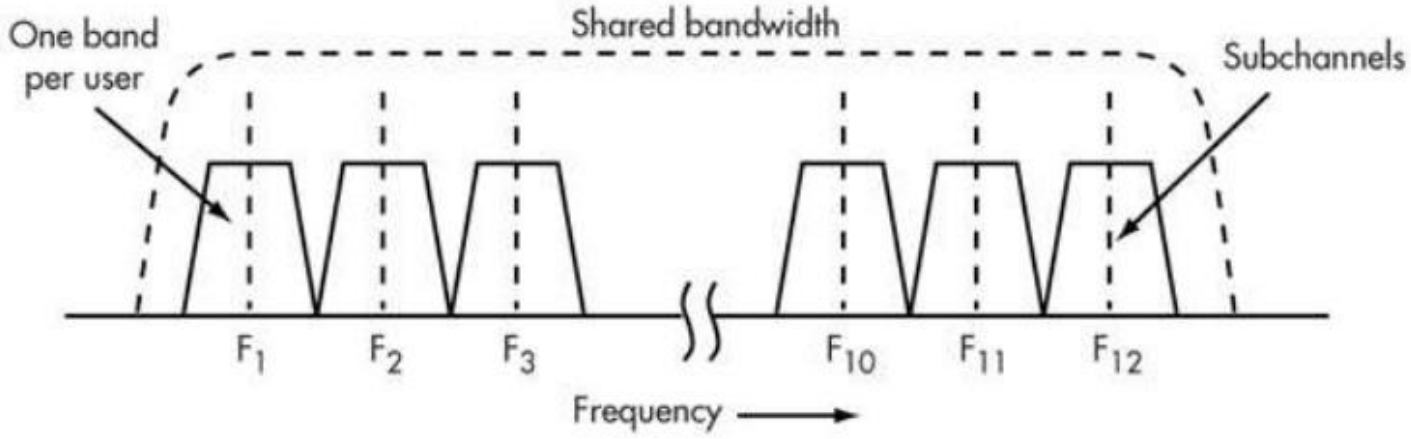
- One of the main advantages of CDMA is that dropouts occur only when the phone is at least twice as far from the base station. Thus, it is used in the rural areas where GSM cannot cover.
- Another advantage is its capacity; it has a very high spectral capacity that it can accommodate more users per MHz of bandwidth.

Disadvantages of CDMA

- Channel pollution, where signals from too many cell sites are present in the subscriber. s phone but none of them is dominant. When this situation arises, the quality of the audio degrades.
- When compared to GSM is the lack of international roaming capabilities.
- The ability to upgrade or change to another handset is not easy with this technology because the network service information for the phone is put in the actual phone unlike GSM which uses SIM card for this.
- Limited variety of the handset, because at present the major mobile companies use GSM technology.

FDMA

FDMA is the process of dividing one channel or bandwidth into multiple individual bands, each for use by a single user. Each individual band or channel is wide enough to accommodate the signal spectra of the transmissions to be propagated. The data to be transmitted is modulated on to each subcarrier, and all of them are linearly mixed together.



FDMA divides the shared medium bandwidth into individual channels. Subcarriers modulated by the information to be transmitted occupy each sub channel.

The best example of this is the cable television system. The medium is a single coax cable that is used to broadcast hundreds of channels of video/audio programming to homes. The coax cable has a useful bandwidth from about 4 MHz to 1 GHz. This bandwidth is divided up into 6-MHz wide channels. Initially, one TV station or channel used a single 6-MHz band. But with digital techniques, multiple TV channels may share a single band today thanks to compression and multiplexing techniques used in each channel.

This technique is also used in fibre optic communications systems. A single fibre optic cable has enormous bandwidth that can be subdivided to provide FDMA. Different data or information sources are each assigned a different light frequency for transmission. Light generally isn‘t referred to by frequency but by its wavelength (λ). As a result, fiber optic

FDMA is called wavelength division multiple access (WDMA) or just wavelength division multiplexing (WDM).

One of the older FDMA systems is the original analog telephone system, which used a hierarchy of frequency multiplex techniques to put multiple telephone calls on single line. The analog 300-Hz to 3400-Hz voice signals were used to modulate subcarriers in 12 channels from 60 kHz to 108 kHz. Modulator/mixers created single sideband (SSB) signals, both upper and lower sidebands. These subcarriers were then further frequency multiplexed on subcarriers in the 312-kHz to 552-kHz range using the same modulation methods. At the receiving end of the system, the signals were sorted out and recovered with filters and demodulators.

Original aerospace telemetry systems used an FDMA system to accommodate multiple sensor data on a single radio channel. Early satellite systems shared individual 36-MHz bandwidth transponders in the 4-GHz to 6-GHz range with multiple voice, video, or data signals via FDMA. Today, all of these applications use TDMA digital techniques. Wireless medium makes the MAC design more challenging than the wire line networks.

SDMA

Space-division multiple access (SDMA) is a channel access method based on creating parallel spatial pipes next to higher capacity pipes through spatial multiplexing and/or diversity, by which it is able to offer superior performance in radio multiple access communication systems. In traditional mobile cellular network systems, the base station has no information on the position of the mobile units within the cell and radiates the signal in all directions within the cell in order to provide radio coverage.

These results in wasting power on transmissions when there are no mobile units to reach, in addition to causing interference for adjacent cells using the same frequency, so called co-channel cells. Likewise, in reception, the antenna receives signals coming from all directions including noise and interference signals. By using smart antenna technology and differing spatial locations of mobile units within the cell, space-division multiple access techniques offer attractive performance enhancements.

The radiation pattern of the base station, both in transmission and reception, is adapted to each user to obtain highest gain in the direction of that user. This is often done using phased array techniques. In GSM cellular networks, the base station is aware of the distance (but not direction) of a mobile phone by use of a technique called "timing advance" (TA). The base transceiver station (BTS) can determine how distant the mobile station (MS) is by interpreting the reported TA.

This information, along with other parameters, can then be used to power down the BTS or MS, if a power control feature is implemented in the network. The power control in either BTS or MS is implemented in most modern networks, especially on the MS, as this ensures a better battery life for the MS. This is also why having a BTS close to the user results in less exposure to electromagnetic radiation.

This is why one may actually be safer to have a BTS close to them as their MS will be powered down as much as possible. For example, there is more power being transmitted from the MS than what one would receive from the BTS even if they were 6 meters away from a BTS mast. However, this estimation might not consider all the Mobile stations that a particular BTS is supporting with EM radiation at any given time.

In the same manner, 5th generation mobile networks will be focused in utilizing the given position of the MS in relation to BTS in order to focus all MS Radio frequency power to the BTS direction and vice versa, thus enabling power savings for the Mobile Operator, reducing MS SAR index, reducing the EM field around base stations since beam forming will concentrate rf power when it will be actually used rather than spread uniformly around the BTS, reducing health and safety concerns, enhancing spectral efficiency, and decreased MS battery consumption.

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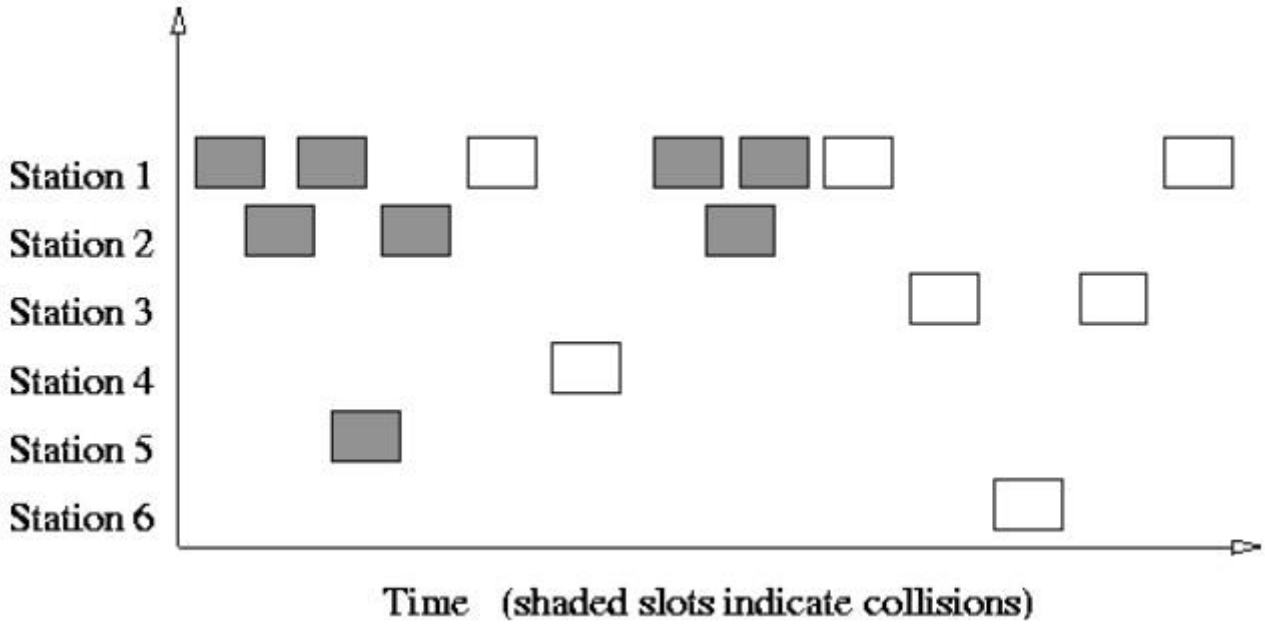
10) Random Assignment Schemes

Pure Aloha

With Pure Aloha, stations are allowed access to the channel whenever they have data to transmit. Because the threat of data collision exists, each station must either monitor its transmission on the rebroadcast or await an acknowledgment from the destination station. By comparing the transmitted packet with the received packet or by the lack of an acknowledgement, the transmitting station can determine the success of the transmitted packet. If the transmission was unsuccessful it is resent after a random amount of time to reduce the probability of re-collision.



Slotted Aloha

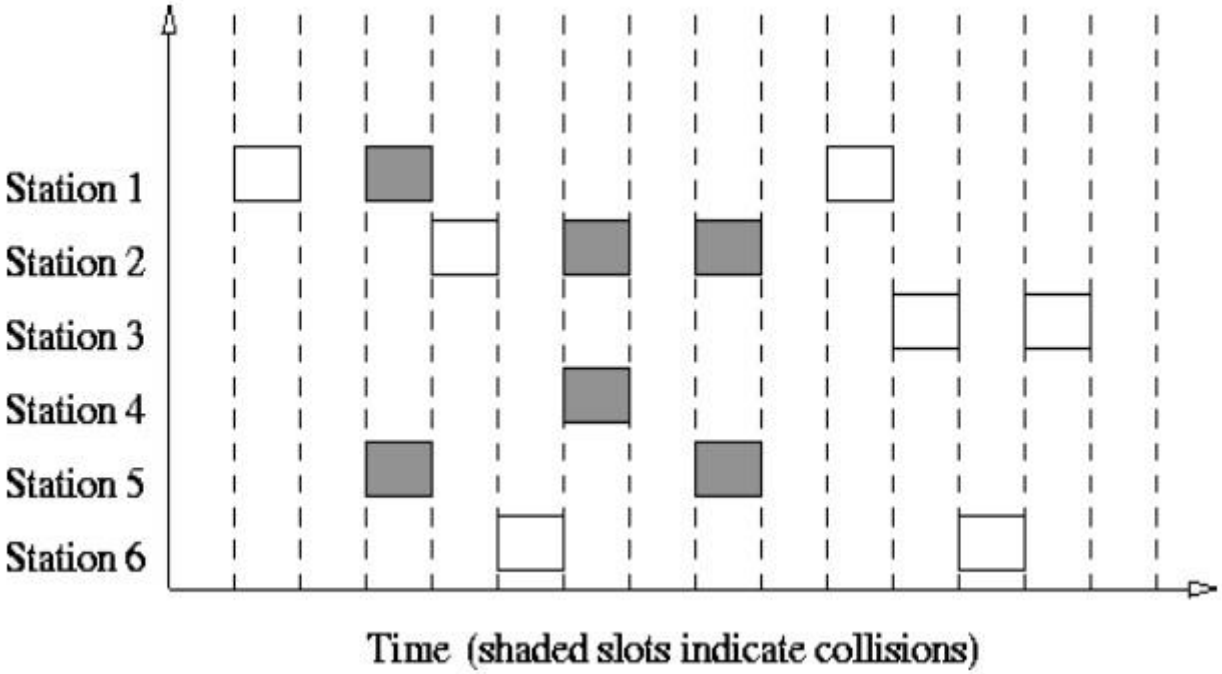
The first of the contention based protocols we evaluate is the Slotted Aloha protocol. The channel bandwidth is a continuous stream of slots whose length is the time necessary to transmit one packet. A station with a packet to send will transmit on the next available slot boundary. In the event of a collision, each station involved in the collision retransmits at some random time in order to reduce the possibility of recollision.

Obviously the limits imposed which govern the random retransmission of the packet will have an effect on the delay associated with successful packet delivery. If the limit is too short, the probability of recollision is high. If the limit is too long the probability of recollision lessens but there is unnecessary delay in the retransmission. For the Mars regional network studied here, the resending of the packet will occur at some random time not greater than the burst factor times the propagation delay.

Another important simulation characteristic of the Slotted Aloha protocol is the action which takes place on transmission of the packet. Methods include blocking (i.e. prohibiting packet generation) until verification of successful transmission occurs. This is known as "stop-and-wait". Another method known as "go-back-n" allows continual transmission of queued packets, but on the detection of a collision, will retransmit all packets from the point of the collision.

This is done to preserve the order of the packets. In this simulation model queued packets are continually sent and only the packets involved in a collision are retransmitted. This is called "selective-repeat" and allows out of order transmission of packets. By making a small restriction in the transmission freedom of the individual stations, the throughput of the Aloha protocol can be doubled.

Assuming constant length packets, transmission time is broken into slots equivalent to the transmission time of a single packet. Stations are only allowed to transmit at slot boundaries. When packets collide they will overlap completely instead of partially. This has the effect of doubling the efficiency of the Aloha protocol and has come to be known as Slotted Aloha.

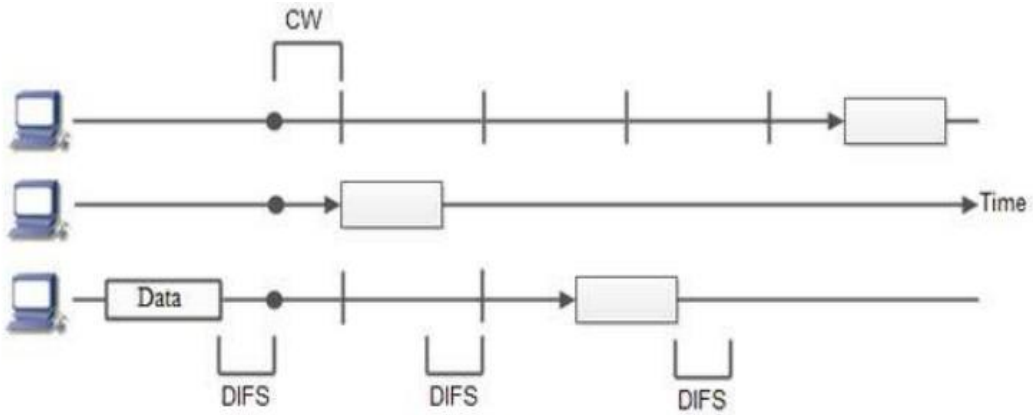


CSMA

CSMA is a network access method used on shared network topologies such as Ethernet to control access to the network. Devices attached to the network cable listen (carrier sense) before transmitting. If the channel is in use, devices wait before transmitting. MA (Multiple Access) indicates that many devices can connect to and share the same network. All devices have equal access to use the network when it is clear.

In other words, a station that wants to communicate "listen" first on the media communication and awaits a "silence" of a preset time (called the Distributed Inter Frame Space or DIFS). After this compulsory period, the station starts a countdown for a random period considered. The maximum duration of this countdown is called the collision window (Window Collision, CW). If no equipment speaks before the end of the countdown, the station simply deliver its package. However, if it is overtaken by another station, it stops immediately its countdown and waits for the next silence. She then continued his account countdown where it left off.

The waiting time random has the advantage of allowing a statistically equitable distribution of speaking time between the various network equipment, while making little unlikely (but not impossible) that both devices speak exactly the same time. The countdown system prevents a station waiting too long before issuing its package. It's a bit what place in a meeting room when no master session (and all the World's polite) expected a silence, then a few moments before speaking, to allow time for someone else to speak. The time is and randomly assigned, that is to say, more or less equally.



Sharing time with CSMA method.

Again, this is what we do naturally in a meeting room if many people speak exactly the same time, they are realizing account immediately (as they listen at the same time they speak), and they interrupt without completing their sentence. After a while, one of them speaks again. If a new collision occurs, the two are interrupted again and tend to wait a little longer before speaking again.

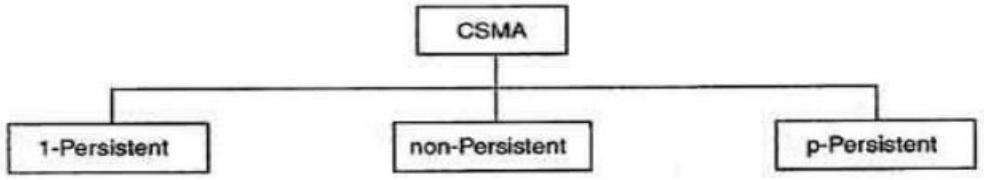
CSMA protocol was developed to overcome the problem found in ALOHA i.e. to minimize the chances of collision, so as to improve the performance. CSMA protocol is based on the principle of 'carrier sense'. The station senses the carrier or channel before transmitting a frame. It means the station checks the state of channel, whether it is idle or busy.

Even though devices attempt to sense whether the network is in use, there is a good chance that two stations will attempt to access it at the same time. On large networks, the transmission time between one end of the cable and another is enough that one station may access the cable even though another has already just accessed it.

The chances of collision still exist because of propagation delay. The frame transmitted by one station takes some time to reach other stations. In the meantime, other stations may sense the channel to be idle and transmit their frames. This results in the collision.

<u>There Are Three Different Type Of CSMA Protocols</u>

- I-persistent CSMA
- Non- Persistent CSMA
- p-persistent CSMA



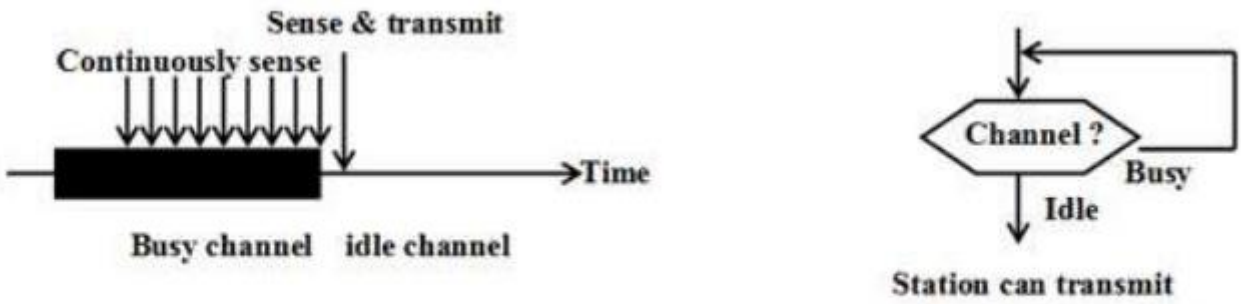
Types of CSMA

I-persistent CSMA

In this method, station that wants to transmit data continuously senses the channel to check whether the channel is idle or busy. If the channel is busy, the station waits until it becomes idle. When the station detects an idle-channel, it immediately transmits the frame with probability 1. Hence it is called I-persistent CSMA. This method has the highest chance of collision because two or more stations may find channel to be idle at the same time and transmit their frames. When the collision occurs, the stations wait a random amount of time and start all over again.

Drawback of I-persistent

The propagation delay time greatly affects this protocol. If after the station I begins its transmission, station 2 also became ready to send its data and senses the channel. If the station I signal has not yet reached station 2, station 2 will sense the channel to be idle and will begin its transmission. This will result in collision.



1-persistent CSMA

Even if propagation delay time is zero, collision will still occur. If two stations became .ready in the middle of third station's transmission, both stations will wait until the transmission of first station ends and then both will begin their transmission exactly simultaneously. This will also result in collision.

Non-persistent CSMA

In this scheme, if a station wants to transmit a frame and it finds that the channel is busy (some other station is transmitting) then it will wait for fixed interval of time. After this time, it again checks the status of the channel and if the channel is free it will transmit. A station that has a frame to send senses the channel.

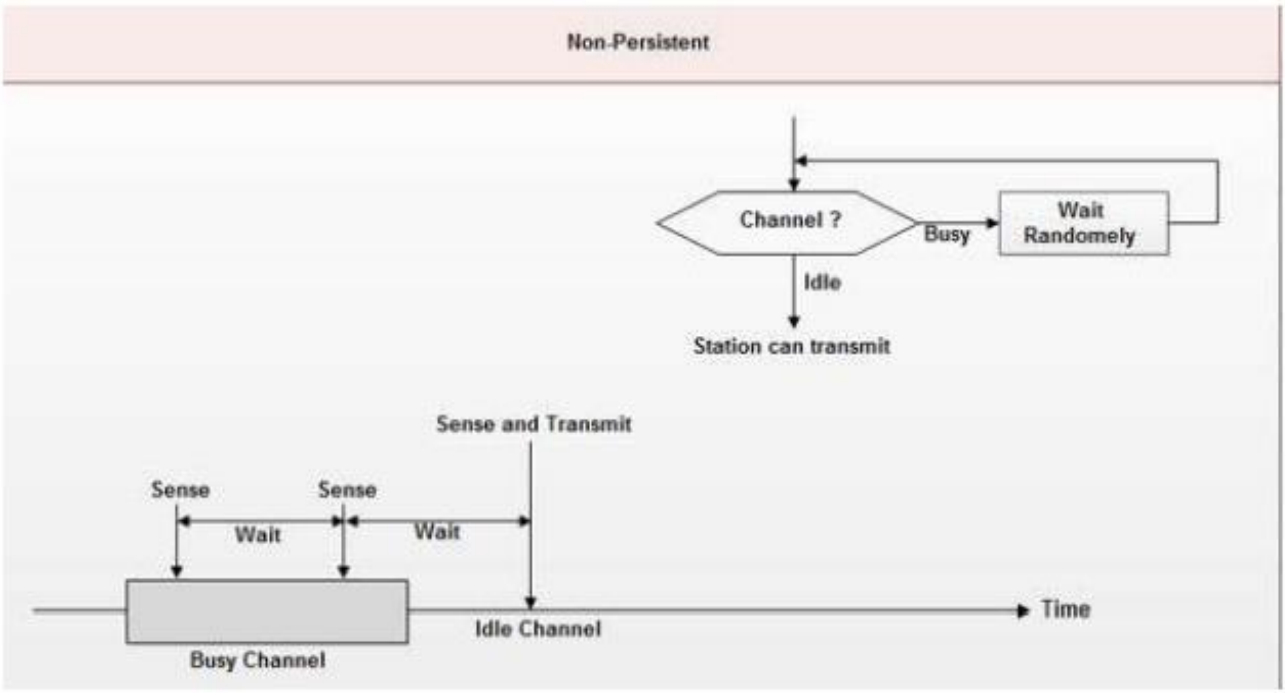
If the channel is idle, it sends immediately. If the channel is busy, it waits a random amount of time and then senses the channel again. In non-persistent CSMA the station does not continuously sense the channel for the purpose of capturing it when it detects the end of previous transmission.

Advantage of non-persistent

It reduces the chance of collision because the stations wait a random amount of time. It is unlikely that two or more stations will wait for same amount of time and will retransmit at the same time.

Disadvantage of non-persistent

It reduces the efficiency of network because the channel remains idle when there may be stations with frames to send. This is due to the fact that the stations wait a random amount of time after the collision.



P-persistent CSMA

This method is used when channel has time slots such that the time slot duration is equal to or greater than the maximum propagation delay time. Whenever a station becomes ready to send, it senses the channel. If channel is busy, station waits until next slot. If channel is idle, it transmits with a probability p.

With the probability q=l-p, the station then waits for the beginning of the next time slot. If the next slot is also idle, it either transmits or waits again with probabilities p and q. This process is repeated till either frame has been transmitted or another station has begun transmitting. In case of the transmission by another station, the station acts as though collision has occurred and it waits a random amount of time and starts again.

Advantage of p-persistent

• It reduces the chance of collision and improves the efficiency of the network.

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11) Reservation Based Schemes

Polling

Polling is the process where the computer or controlling device waits for an external device to check for its readiness or state, often with low-level hardware. For example, when a printer is connected via a parallel port, the computer waits until the printer has received the next character. These processes can be as minute as only reading one bit.

Polling is sometimes used synonymously with busy-wait polling. In this situation, when an I/O operation is required, the computer does nothing other than check the status of the I/O device until it is ready, at which point the device is accessed. In other words, the computer waits until the device is ready. Polling also refers to the situation where a device is repeatedly checked for readiness, and if it is not, the computer returns to a different task. Although not as wasteful of CPU cycles as busy waiting, this is generally not as efficient as the alternative to polling, interrupt-driven I/O.

In a simple single-purpose system, even busy-wait is perfectly appropriate if no action is possible until the I/O access, but more often than not this was traditionally a consequence of simple hardware or non-multitasking operating systems. Polling is often intimately involved with very low-level hardware. For example, polling a parallel printer port to check whether it is ready for another character involves examining as little as one bit of a byte.

That bit represents, at the time of reading, whether a single wire in the printer cable is at low or high voltage. The I/O instruction that reads this byte directly transfers the voltage state of eight real world wires to the eight circuits (flip flops) that make up one byte of a CPU register. Polling has the disadvantage that if there are too many devices to check, the time required to poll them can exceed the time available to service the I/O device. ≠

Algorithm

Polling can be described in following steps:

- The host repeatedly reads the busy bit of the controller until it becomes clear.
- When clear, the host writes in the command register and writes a byte into the data-out register.
- The host sets the command-ready bit (set to 1).
- When the controller senses command-ready bit is set, it sets busy bit.
- The controller reads the command register and since write bit is set, it performs necessary I/O operations on the device. If the read bit is set to one instead of write bit, data from device is loaded into data-in register, which is further read by the host.
- The controller clears the command-ready bit once everything is over, it clears error bit to show successful operation and reset busy bit (0).

Types

A polling cycle is the time in which each element is monitored once. The optimal polling cycle will vary according to several factors, including the desired speed of response and the overhead (e.g., processor time and bandwidth) of the polling.

In roll call polling, the polling device or process queries each element on a list in a fixed sequence. Because it waits for a response from each element, a timing mechanism is necessary to prevent lock-ups caused by non-responding elements. Roll call polling can be inefficient if the overhead for the polling messages is high, there are numerous elements to be polled in each polling cycle and only a few elements are active.

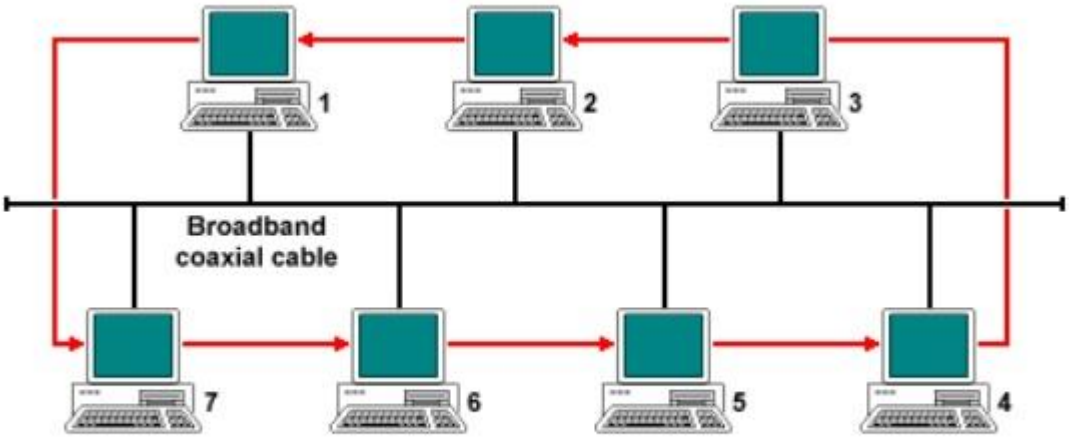
In hub polling, also referred to as token polling, each element polls the next element in some fixed sequence. This continues until the first element is reached, at which time the polling cycle starts all over again.

Polling can be employed in various computing contexts in order to control the execution or transmission sequence of the elements involved. For example, in multitasking operating systems, polling can be used to allocate processor time and other resources to the various competing processes. In networks, polling is used to determine which nodes want to access the network. It is also used by routing protocols to retrieve routing information, as is the case with EGP (exterior gateway protocol).

An alternative to polling is the use of interrupts, which are signals generated by devices or processes to indicate that they need attention, want to communicate, etc. Although polling can be very simple, in many situations (e.g., multitasking operating systems) it is more efficient to use interrupts because it can reduce processor usage and/or bandwidth consumption.

Token Bus

Token Bus is described in the IEEE 802.4 specification, and is a Local Area Network (LAN) in which the stations on the bus or tree form a logical ring. Each station is assigned a place in an ordered sequence, with the last station in the sequence being followed by the first, as shown below. Each station knows the address of the station to its "left" and "right" in the sequence.



A Token Bus network

This type of network, like a Token Ring network, employs a small data frame only a few bytes in size, known as a token, to grant individual stations exclusive access to the network transmission medium. Token-passing networks are deterministic in the way that they control access to the network, with each node playing an active role in the process. When a station acquires control of the token, it is allowed to transmit one or more data frames, depending on the time limit imposed by the network.

When the station has finished using the token to transmit data, or the time limit has expired, it relinquishes control of the token, which is then available to the next station in the logical sequence. When the ring is initialised, the station with the highest number in the sequence has control of the token. The physical topology of the network is either a bus or a tree, although the order in which stations are connected to the network is not important.

The network topology means that we are essentially dealing with a broadcast network, and every frame transmitted is received by all attached stations. With the exception of broadcast frames, however, frames will only be read by the station to which they are addressed, and ignored by all other stations. As the token frame is transmitted, it carries the destination address of the next station in the logical sequence. As each individual station is powered on, it is allocated a place in the ring sequence (note that in the diagram above, station two is not participating in the ring). The Token Bus medium access control protocol allows stations to join the ring or leave the ring on an ad-hoc basis. Token Bus networks were conceived to meet the needs of automated industrial manufacturing systems and owe much to a proposal by General Motors for a networking system to be used in their own manufacturing plants -Manufacturing Automation Protocol (MAP).

Ethernet was not considered suitable for factory automation systems because of the contention-based nature of its medium access control protocol, which meant that the length of time a station might have to wait to send a frame was unpredictable. Ethernet also lacked a priority system, so there was no way to ensure that more important data would not be held up by less urgent traffic.

A token-passing system in which each station takes turns to transmit a frame was considered a better option, because if there are n stations, and each station takes T seconds to send a frame, no station has to wait longer than T seconds to acquire the token. The ring topology of existing token-passing systems, however, was not such an attractive idea, since a break in the ring would cause a general network failure.

A ring topology was also considered to be incompatible with the linear topology of assembly-line or process control systems. Token Bus was a hybrid system that provided the robustness and linearity of a bus or tree topology, whilst retaining the known worst-case performance of a token-passing medium access control method. The transmission medium most often used for broadband Token Bus networks is 75 Ohm coaxial cable (the same type of cable used for cable TV), although alternative cabling configurations are available. Both single and dual cable systems may be used, with or without head-ends.

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