

COMPUTER ORGANIZATION AND ARCHITECTURE

Lecture 9

Data Communication and Networks

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INTRODUCTION

One of the functions of a computer is communication. This lecture is a review of how computers communicate. We will work on the methods of communication that computers use, the tools that they use when communicating, the types of networks and finally the devices that are used by networks.

Learning objectives

By the end of this topic, you should be able to:

1. Identify how data transmission occurs across a network
2. Identify and show the characteristics of various network topologies
3. Show the types of networks and the devices used in each

OVERVIEW

Throughout this lecture series, we have systematically moved from one category of hardware devices to the next. We now focus on the final category of hardware: communication. Communication is represented by the term network. What is a network then? A network could be defined as an interconnection of people or objects that come together with a specific goal in mind. Think of social networks. People come together because they are employees in the same organization, were in the same school, are family members and many more.

So exactly what is a computer network? A computer network is a collection of computers and additional hardware devices that ensure that computers can communicate with each other. We can ask then why would it be necessary for computers to communicate? Try to think of a world where computers do not communicate! It would not be possible to do shopping overseas and make payments with the click of a button. Even something as simple as communicating would take so much time. Computer networks allow businesses and other organizations to share devices, information, transfer money, buy goods globally, and even operate internationally [1].

Before we start looking at network characteristics, we first work on how data is transmitted in a network.

DATA TRANSMISSION

When a computer communicates with another, data is not sent randomly. Several rules exist on how data is to be sent from one computer to the next. Before we talk about how data is sent, we need to understand the various signals that exist.

Analogue signals: These are signals that are used by conventional phones and are mainly found in voice and music data.



Figure 1: Analogue signal

Digital signals: these are signals in digital form and are represented by 0s and 1s. The signals have two distinct states [4].

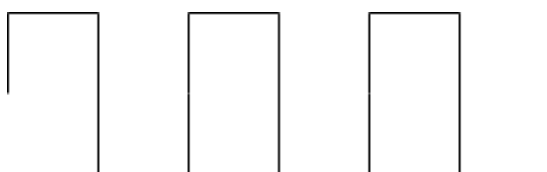


Figure 2: Digital Signals

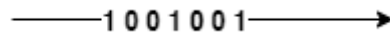
Sometimes data to be sent may be digital but for it to be transmitted it will use a medium that allows for analogue signals. In this case, the digital signals will need to be converted to analogue signals and when the signals reach their destination they are converted back to digital signals. Various hardware devices are in charge of the conversion.

Transmission Type

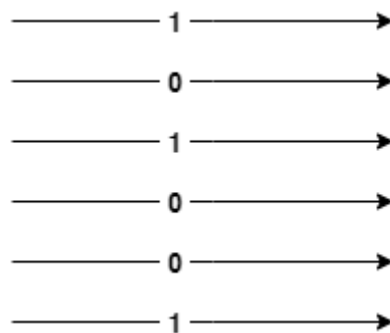
When data is ready to be sent out, it can either be sent using the serial or parallel transmission. If you remember that from lecture 6, we reviewed ways in which data can be read from the storage medium. This is the same as how it is sent during data transmission.

Serial Transmission: This is similar to how a queue works. One data is sent after the other. This occurs only on a single line of transmission. Think of a road that has only

one lane. Cars move by following one another and cannot pass/overtake the car in front of it. This is the same for serial transmission (figure 3). This is the most common way in which data is sent.



Parallel transmission: In parallel transmission, data is sent across several transmission lines. Groups of data are sent at the same time as shown in figure 4. While parallel transmission is faster, it is rarely used, and instead, serial transmission is used [4].



For serial transmission to be effective, several methods or mechanisms are applied to ensure that data sent can be reorganized on the receiving end. There are three ways in which this is done during serial transmission and is discussed below:

Synchronous transmission: In synchronous transmission, data is organized in blocks or groups of data which are then sent at specific intervals [4]. Synchronous means that the sending and receiving device is aware when data is sent and to be received. This is the most common way in which data is sent.

Asynchronous transmission: In asynchronous transmission, data is sent when it is ready to be sent. This is different from synchronous since the receiving device does not receive a notification that data is being sent. To take care of that, when data is ready to be sent, it is encoded with a start and stop bit which notifies the receiving device that the data being sent ends at a particular point. The asynchronous transmission then ends up being less efficient than synchronous transmission [4].

Isochronous transmission: Isochronous transmission is where data is sent when it is ready, but all the data must be delivered at the time it is needed [4]. A good example is when streaming a movie. The video part and the audio part may be sent separately,

however, both must reach at the same time to ensure that the movie plays in sync. Factors that go into play include having bandwidth necessary for the transmission needs to be reserved [4].

While the three transmission types focus on the serial method of transmission, the next focus on the direction in which data is sent, regardless of whether it is serial or parallel.

Simplex transmission: In simplex transmission, data is sent only in one direction. Think of radio broadcasting where a user can only receive a signal but cannot send it out. This method is not common as for the communication to happen, data needs to be sent and received.

Half-duplex transmission: This is where data can only travel in one direction at a given time. This means that channel or transmission path can either send at a given time or receive. When data is being sent, then the channel can only send and when receiving it can only receive. A good example is a walkie-talkie where only one person can talk at any given time. Another example is the fax machine.

Full-duplex transmission: This transmission allows for sending and receiving data at the same time. Data can both in both directions simultaneously. This is the most common method of transmission during networking or when using the internet.

NETWORK CHARACTERISTICS

When thinking of a network, various characteristics define each. These characteristics are based on the way the network works, its connections and its size. We discuss each of these characteristics below.

Wired vs Wireless

A network is considered wired, wireless or a mix of both. A wired network is one where all the hardware devices including the computers are physically wired within the network. A wireless network is one where signals are sent through the air instead of using physical cabling. Most networks will have a combination of a wired and wireless network, resulting in a mixed network.

Topology

A topology can be defined as the physical layout of something. In the case of a network, topology refers to the physical layout of a computer network. How the components (computers and other devices) are arranged on the network. Several network topologies exist.

1. Star Topology

This is a network topology where the computers and other peripheral devices are connected to a central node such as a switch or router. The central node oversees communication within the network. This of course means that if the central node goes down then the entire network is disabled. On the other hand, it also means that if one of the computers is unable to connect to the rest of the network, it is easy to troubleshoot.

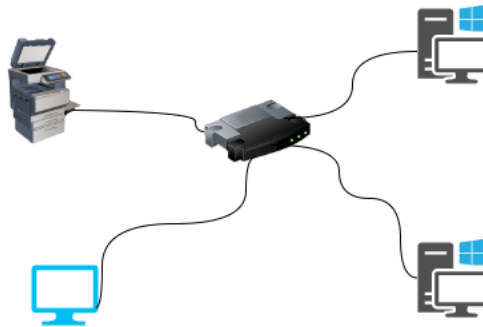


Figure 3: Star topology

2. Bus Topology

This is a network topology where the computers and other peripheral devices are connected to a central cable. Terminators are placed at the end of the central cable in a bus topology. All the communication happens within the central cable and if the cable goes down then the entire network will go down. It can be difficult to troubleshoot within the bus topology as compared to the star network especially when the whole network goes down.

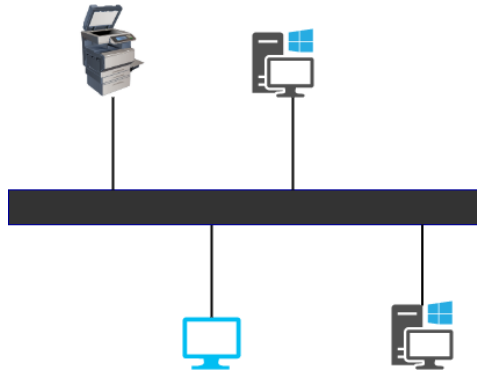


Figure 4: Bus Topology

3. Ring Topology

This is a network topology where the computers and other devices connect to two other devices along the network to form a ring. For communication to happen a token is passed around to the receiving computer or device (node) that then uses it to communicate. For another computer to communicate, they must wait until the computer that was transmitting to finish before they can receive the token. The ring topology is a relatively easy network to install and expand. If one workstation shuts down or goes off, then the entire network goes down.

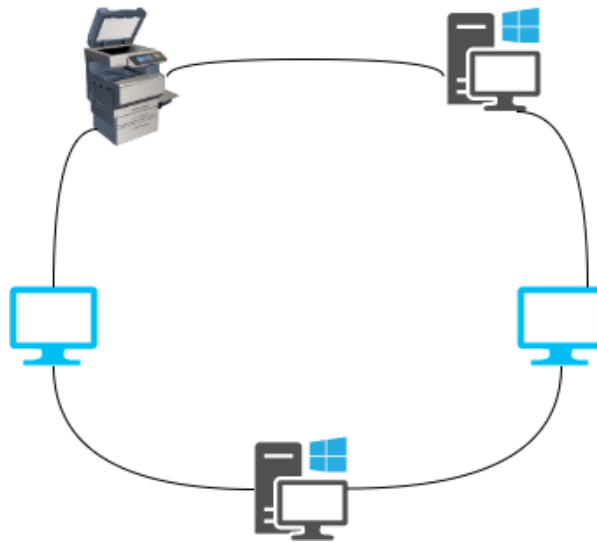


Figure 5: Ring Topology

4. Hybrid Topology

This is a combination of more than one of the network topologies. For instance, an organization can easily decide to have star topologies supported by the bus topology.

This then helps to use the advantages of each topology to mitigate the disadvantages of the other topology.

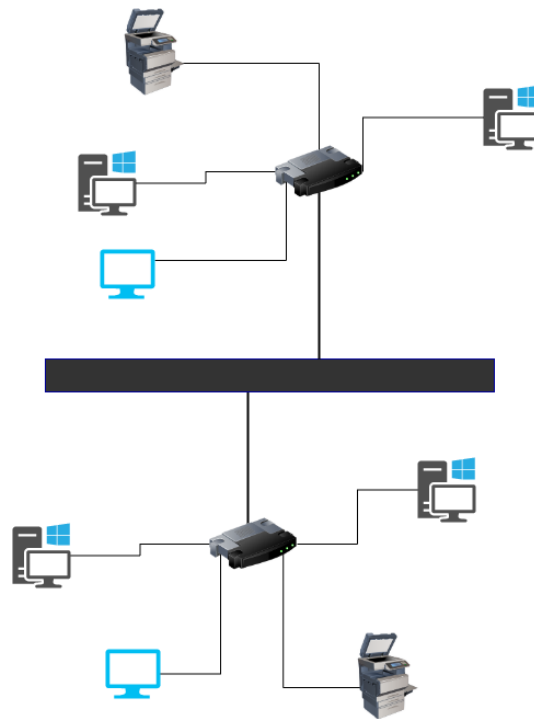


Figure 6: Hybrid Topology

Architecture

This characterizes the logical representation of the network and in more regard how the computers can communicate. Two main architectures exist:

1. Client-Server

This architecture includes clients (computers and other peripheral devices that use resources on the network) and servers (allow for access of resources by clients) [4]. Remember we defined a server during the first lecture as a computer that allows for management of resources. This is one of the most common architectures.

2. Peer-to-Peer

This architecture involves the computers and other peripheral devices sharing resources equally without the presence of a central device. This is a common architecture in a home network.

Size and Coverage

Networks are characterized by their size and the area that they cover. These networks have a variety of topologies, can be wired or wireless and can contain any architecture. These are discussed below

Local Area Network (LAN): This network covers a small geographical area such as a home or office building [4]. It could also cover a school. This type of network is used to facilitate communication and share resources.

Metropolitan Area Network (MAN): This network covers a larger geographical area than the LAN such as a town or country. Some MAN networks do cover large universities.

Wide Area Network (WAN): This network covers a very large geographical area. A WAN mainly connects two or more LANs [4]. For instance, the internet could be considered the largest WAN globally.

NETWORK MEDIA

For computers and other peripheral devices to communicate they must use networking media. This media refers to wired or wireless media.

Twisted Pair Cable

This is a wired media cable that is made up of pairs of thin strands of insulated wire twisted together [4]. This is the cheapest type of cable and is the most common type of cable used during networking. This type of cable can be used for both analogue and digital transmission [4] such as the old telephones found in homes.



Figure 7: "Top 40 Innovations: Tightly Twisted LAN cables" by CommScope is licensed with CC BY-NC-ND 2.0.

Coaxial Cable

A coaxial cable is made up of a thick centre wire (1) that is insulated (2) then covered with braided wire (3) and finally insulated (4) on the outside. The braided wire is used to prevent electromagnetic signals from entering the cable [4]. This cable is found in most homes as it is used to transmit signals from an aerial or satellite dish to the TV.

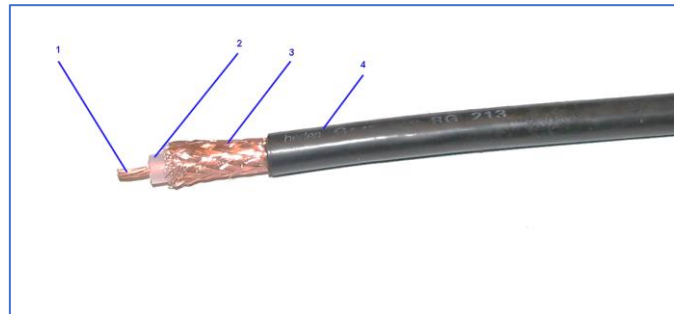


Figure 8: "File: Rg213 1.jpg" by User Appaloosa on de. wikipedia is licensed with CC BY-SA 3.0.

Fibre-Optic Cable

This is the newest and fastest cable of the two discussed above. This cable contains multiple (several hundred) clear glass or plastic fibres [4]. The fibres are about the width of a human hair and use light pulses to carry data. The fibres can only carry data in one direction. This cable is the fastest but also the most expensive cable.

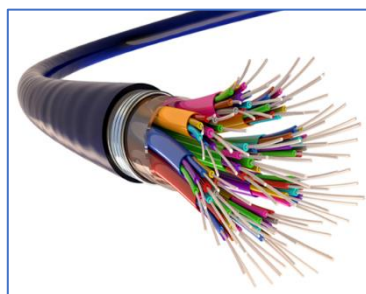


Figure 9: Figure 3: Fiber Optic Cable by Unknown Author is licensed under CC BY-SA-NC

Cellular Radio

This is wireless media that transmits radio signals from cellular towers. The cellular towers cover a honeycomb-shaped region that overlaps with other cellular towers. This is a type of media is used by cell phones and when someone makes a call, the cell phone will connect to the nearest cell tower. Assume the person is moving, then the signal will be picked from the next tower and so on until they end the call.

Microwave and Satellite

These two are mainly synonymous with microwave stations picking signals from other microwave stations or a satellite in orbit. Microwave stations are found on earth while satellites are found in space or rotating around orbit. Microwave stations are placed on tall buildings or raised ground such as hills as they require line of sight to be able to communicate with each other [4]. While the satellites were initially created to facilitate microwave signals to the base stations, they can now transfer data to specific devices like a satellite phone.

NETWORKING DEVICES

Several networking devices exist, and their use depends on the type of network, the size of the network and the type of architecture. We discuss three devices below:

Network Adapter

This is the adapter found within a computer that allows it to join a network or access the internet. It is also called a network interface card. For older computers that do not have a network adapter, a modem (modulator-demodulator) can be used to connect a computer to a network using a cellular line or a telephone line.

Switch/Router and Hub

These devices are used in networking especially with the star network as a central node. A **switch** contains ports where twisted-pair cables are connected to computers. A switch can identify devices that are connected to it [4].

A **hub** is also a central device that is used to transmit data. Unlike a switch, a hub is not able to tell apart the devices and will therefore transmit the data to all the devices.

A **router** can enable the transmission of data to both a wired and wireless environment, unlike the hub and switch that primarily deal with wired networks. A router can tell apart the devices and computers can either connect to it using a cable or through a wireless card.

NETWORKING PROTOCOLS

Protocols are rules that tell the computer what to do. Networking protocols guide a computer on how to communicate within a network. Several protocols exist. We review some of the common ones.

TCP/IP

TCP/IP stands for Transmission Control Protocol/Internet Protocol. TCP oversees the delivery of data while IP oversees any addressing and routing needs [4]. TCP/IP uses **packets** (small units of messages that contain sender and receiver information) to send information. Remember we spoke about IP addresses during the second lecture, well IP has various versions from IPv4 to IPv6 (version 4 to version 6) which determines how IP addresses work.

Ethernet (802.3)

This is the most commonly used protocol for wired networks and is mainly used in LAN networks. Devices that use the ethernet protocol generally have an ethernet port that allows for communication. Ethernet is used together with twisted pair, coaxial or fibre optic cables.

Wi-Fi (802.11)

This stands for Wireless Ethernet and is the most common standard used for wireless networks. The standard is easily built to connect to an ethernet network hence the name. Nowadays Wi-Fi is built on most portable devices.

Cellular

These are the standards that are used for cellular communication especially when accessing the internet. Most of the standards currently used are 3G (third-generation), 4G (fourth generation), and 5G (fifth generation). These standards use packets to transmit data. Speeds vary with 5G having the highest speed. This is also true for power consumption of the standards with 5G having the highest power usage.

SUMMARY

During this lecture, we have reviewed various networking terminology. We started with the data transmission characteristics that focused on transmission timing, types of

signals and transmission types. Next, we have reviewed network characteristics while reviewing the various types of networks. We then have done a review of networking media and devices. Finally, we have reviewed the types of protocols that support networking.

DISCUSSION TOPIC

One of the commonly used networking protocols for wireless is Wi-Fi. Unlike the cellular network that has made leaps and bounds, Wi-Fi might be considered as lagging in terms of speed. Do a review of any future technological predictions of the direction in which the Wi-Fi protocol is headed to make computers communicate faster. What do the end-users need to do to ensure faster Wi-Fi communication?

REFERENCES

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