Information Communication Technologies

Lecture 12. Internet Architecture

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Agenda

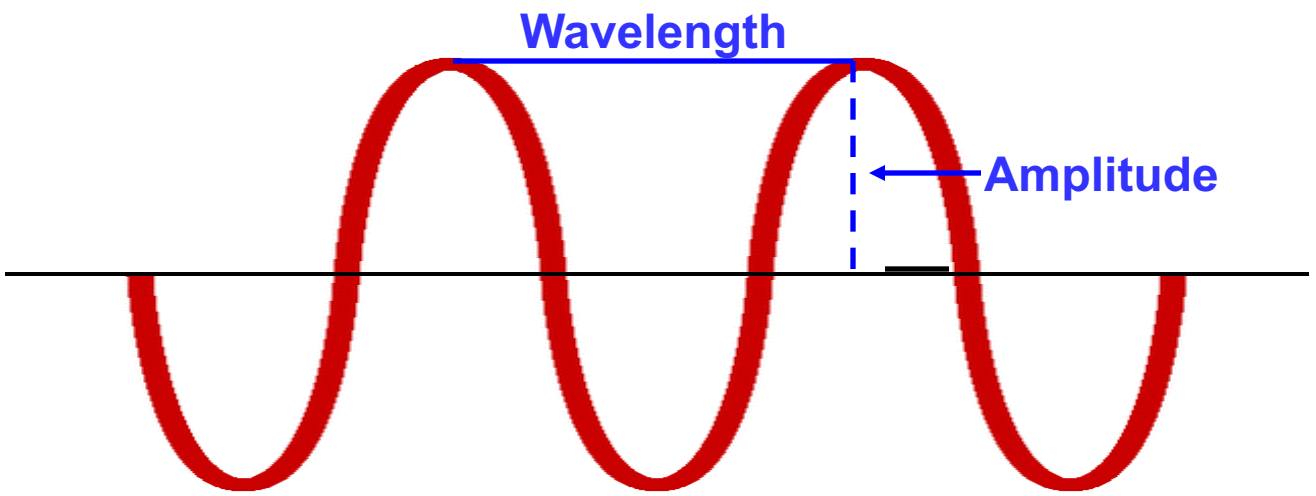
- Data Transfer Technologies
- Routers and TCP/IP
- Domain Name Service
- Connectivity
- Internet Service Providers

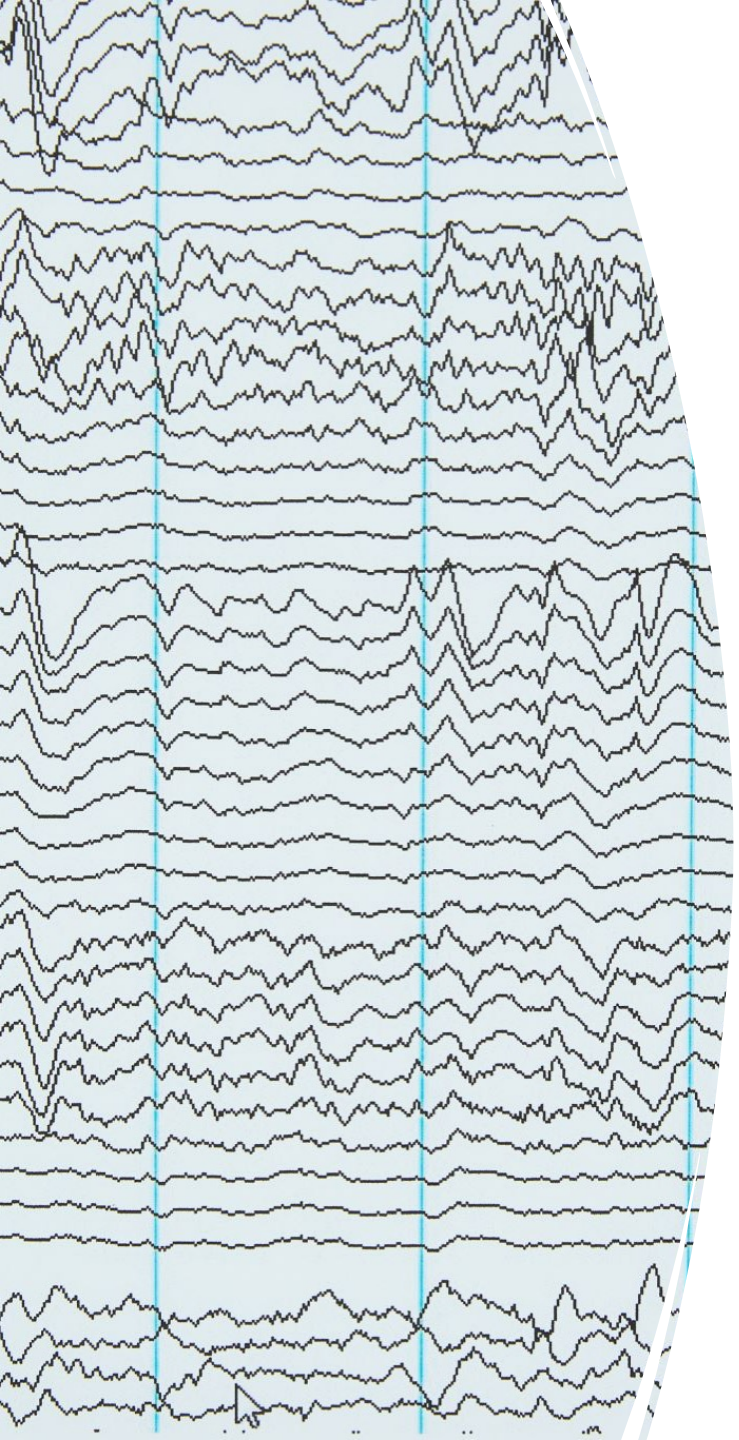
Communications

- ***Data communications*** is the process of transmitting and receiving data in an orderly way.
  - ***local communications*** (short distance)
  - ***telecommunications*** (long distance)
- ***Communications system*** - combination of hardware, software, and connecting links that transport data
  - efficiency of system depends on coding process and ***noise*** (interference that destroys the integrity of signals on a line)

Electromagnetic Signals

- Today's communications systems transmit messages and data in the form of electromagnetic signals (waves).
  - characterized by size and spacing
  - ***amplitude*** = height of wave
  - ***wavelength*** = distance between waves



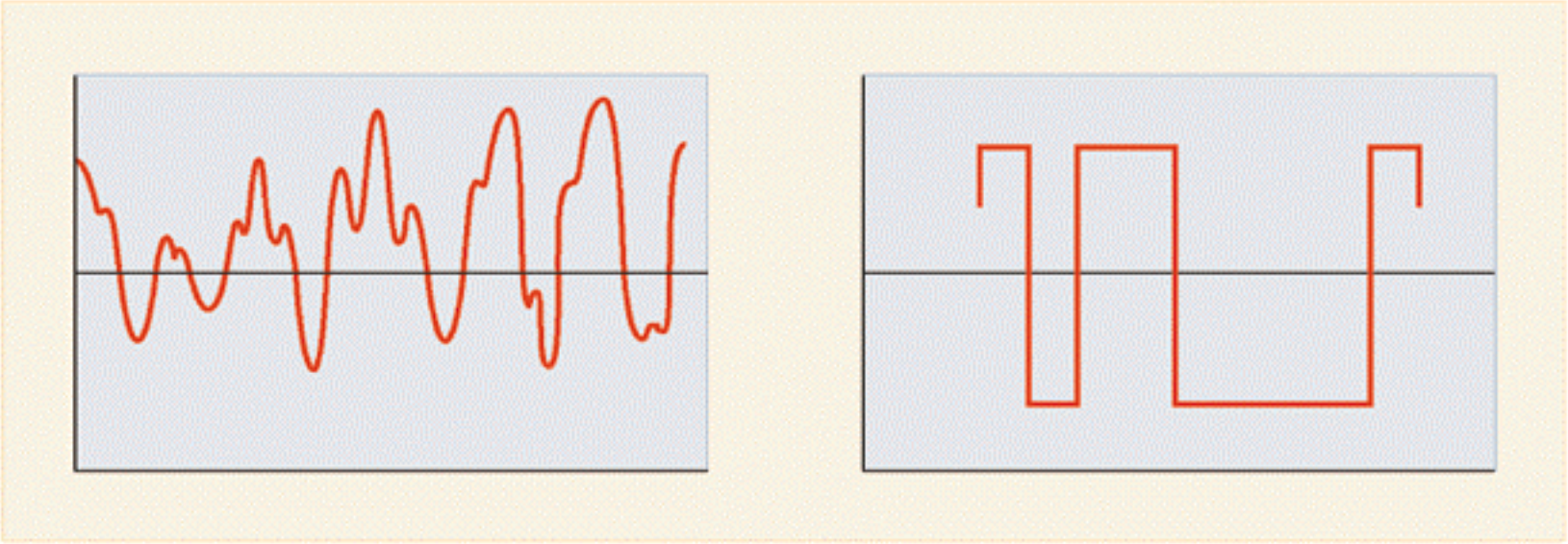


Communication Signals

- ***Frequency*** is the number of times per second the wave cycle repeats or “oscillates”
  - shorter wavelengths produce higher frequencies
- Waves can have different shapes called ***waveforms***.
  - analog signals have an unlimited range of values and a smooth curved waveform
  - digital signals represent discrete values and have a square or “stepped” wave pattern

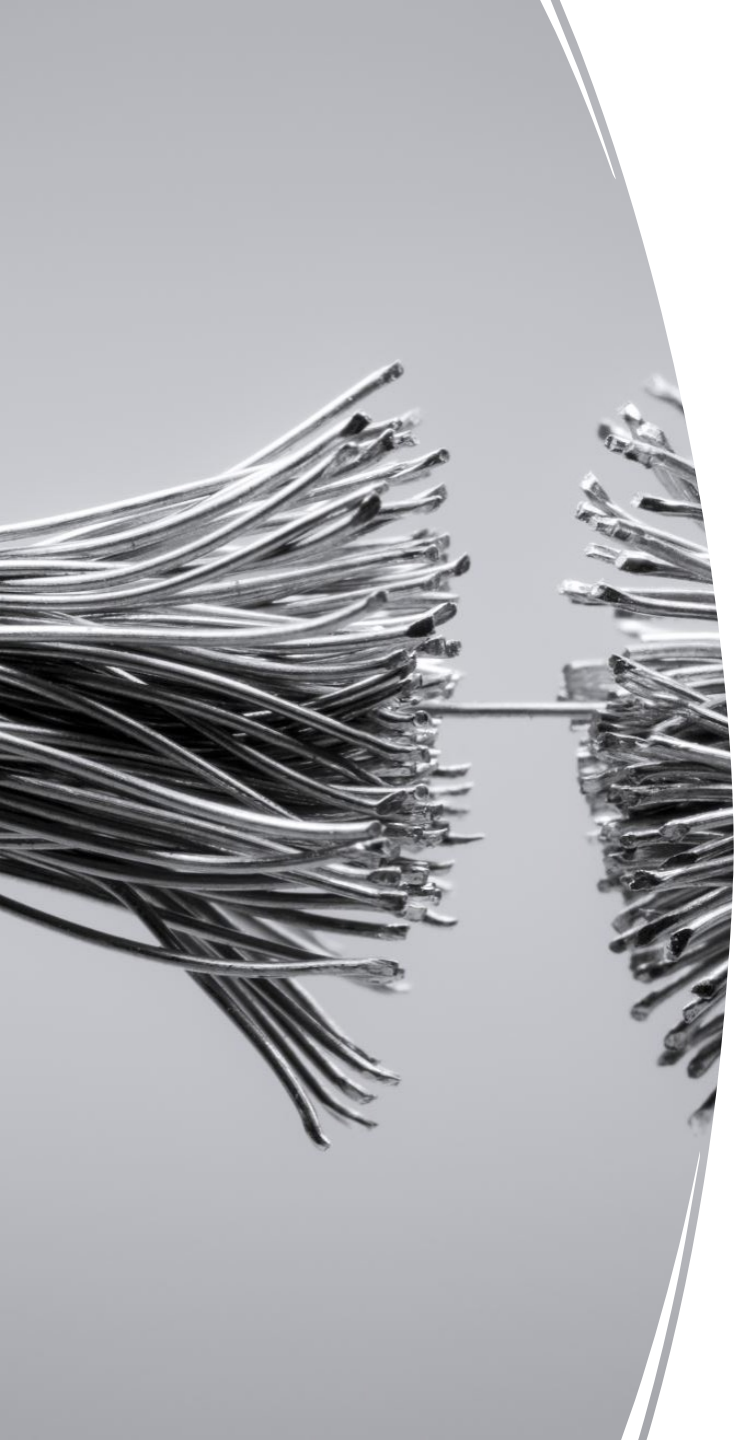
Communication Signals (continued)

- It is possible to convert analog signals into digital signals.
- Digital signals:
  - less susceptible to noise
  - require simpler circuitry
  - easier to clean



Analog wave pattern

Digital wave pattern

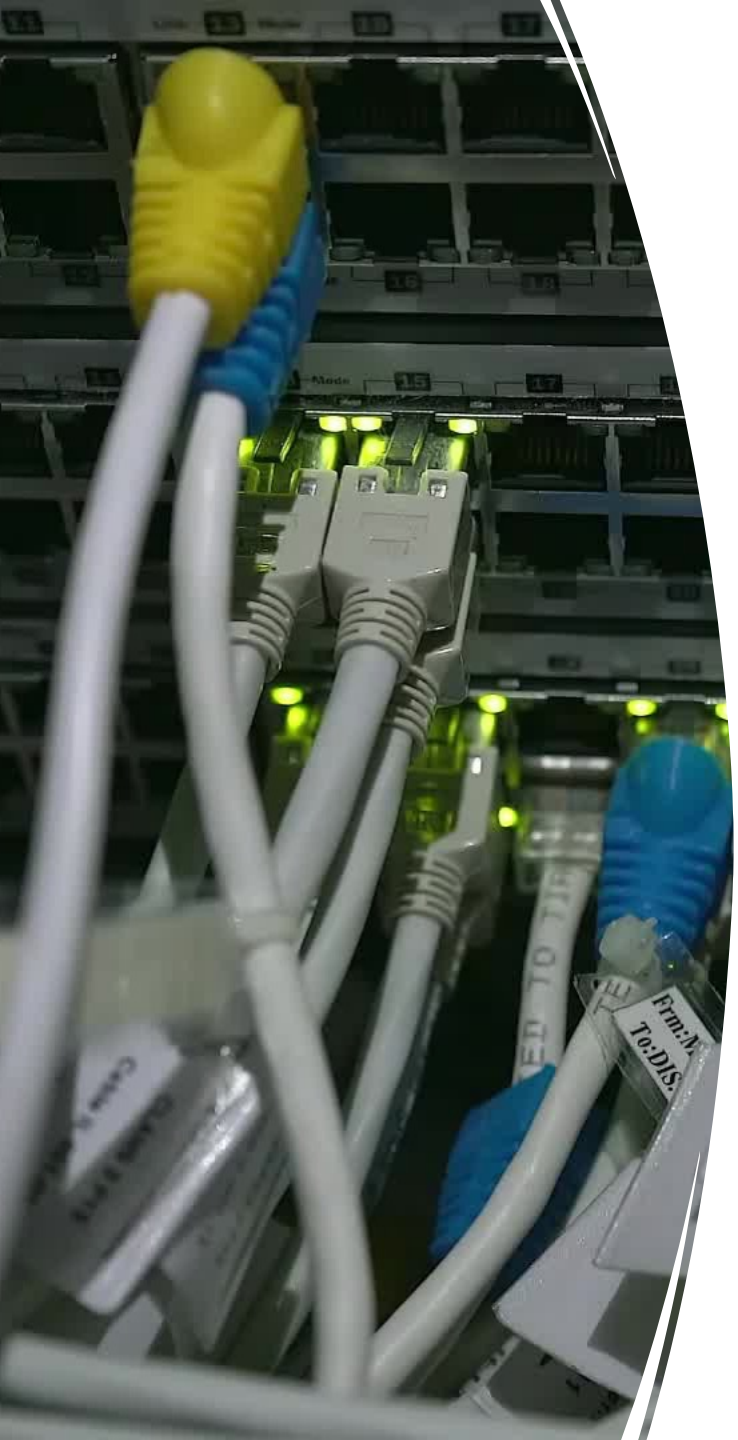


Communications

- ***Communications channel*** - a physical path or frequency for a signal transmission
  - telephone cables
- ***Communications medium*** carries one or more communications channels and provide a link between transmitting and receiving data.
  - twisted-pair cable
  - coaxial cable
  - fiber-optic cable

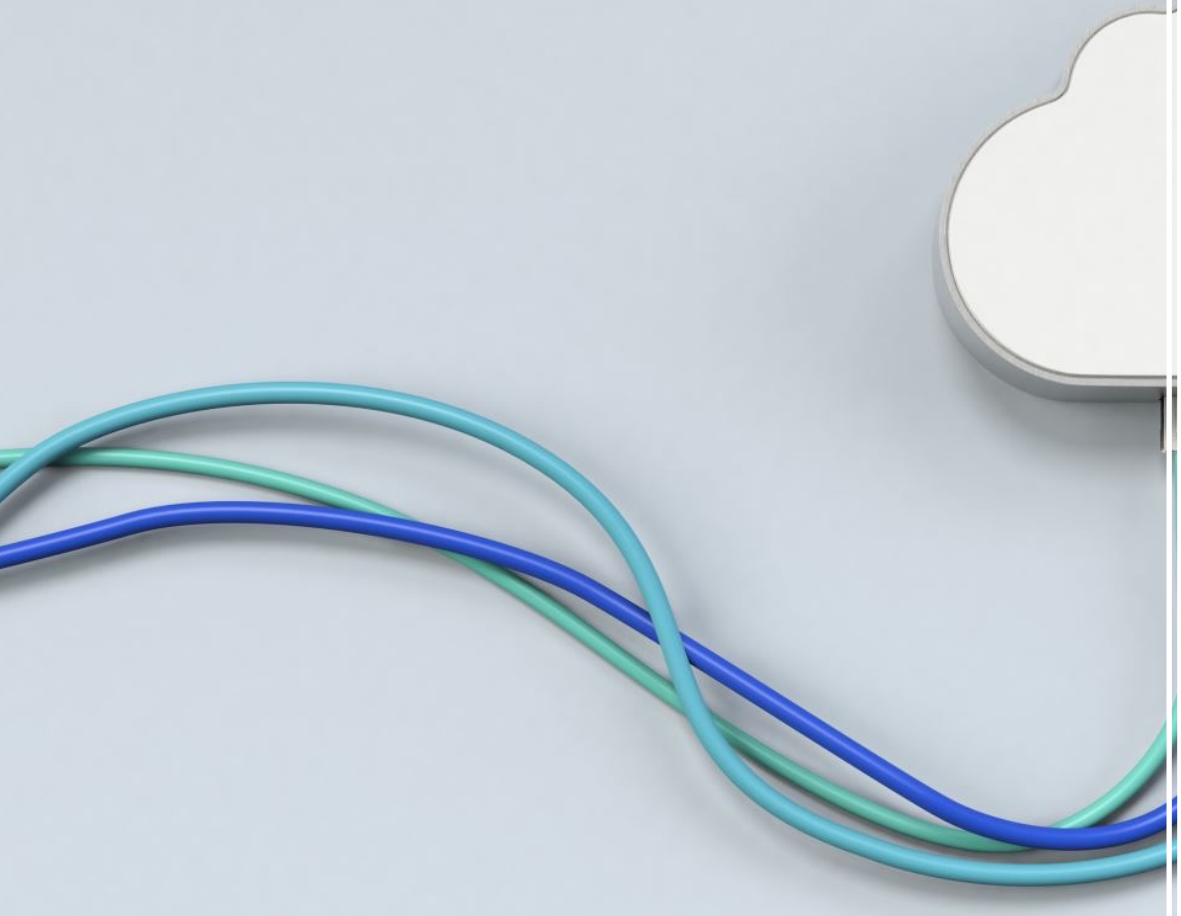
Communication Channel

- Communication Signals are transmitted through *Communication Channel*
  - What is a communication Channel
    - The term **channel** refers to a communications path between two computers or devices.
    - It can refer to the physical medium or to a set of properties that distinguishes one channel from another.



Bandwidth/ пропускная способность

- ***Bandwidth*** - transmission capacity of a communications channel.
  - The capacity of a communications system depends on the bandwidth of the channel.

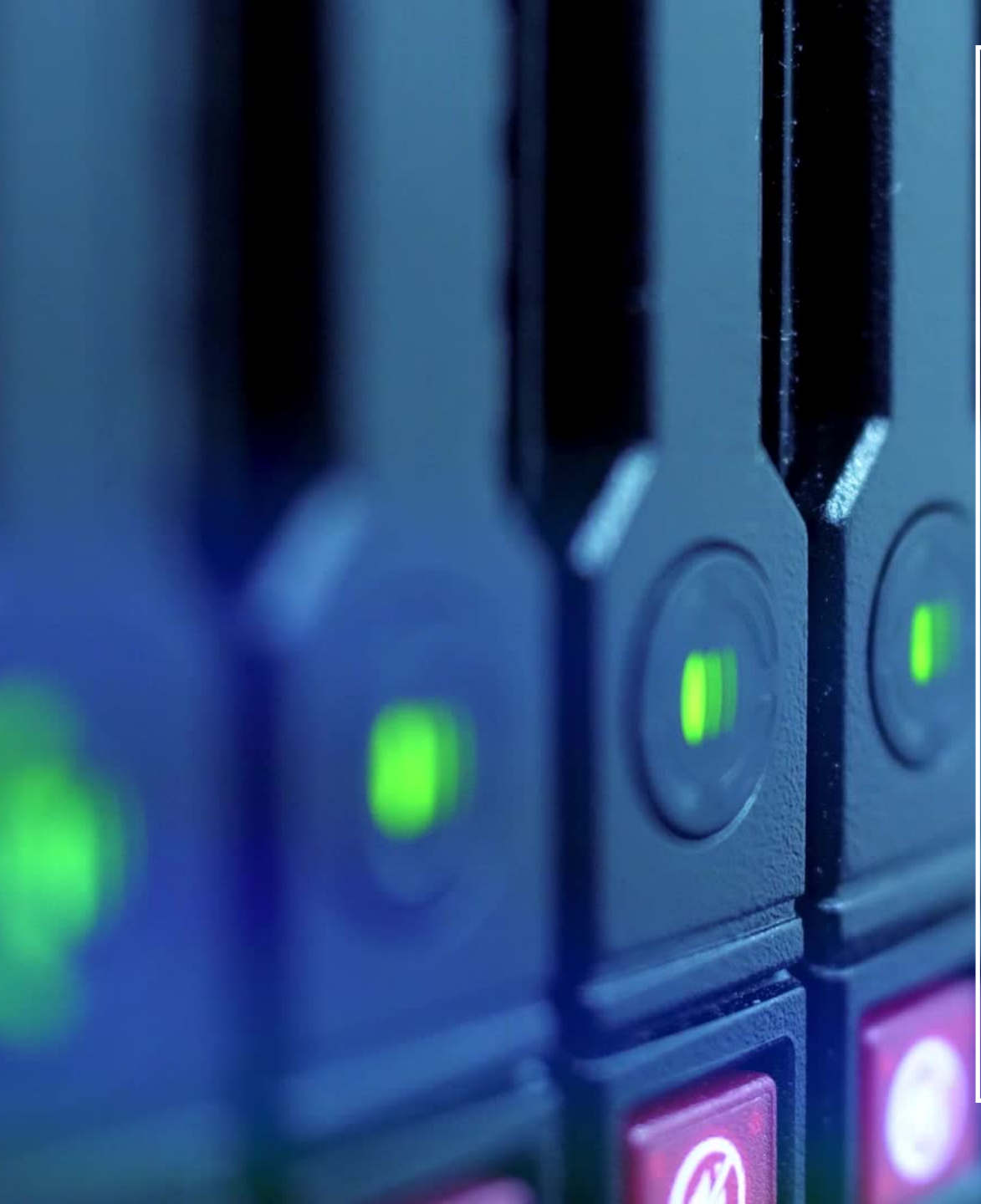


Bandwidth (continued)

- Broadband transmission (high capacity)
  - A type of data transmission in which a single medium (wire) can carry several channels at once.
  - E.g. Cable television
- Baseband transmission (less capacity than broadband)
  - A type of digital data transmission in which each medium (wire) carries only one signal, or channel, at a time.
  - E.g. Telephone

Data Transfer Rate

- ***Data Transfer Rate*** is rate at which data is transmitted
  - The speed with which data can be transmitted from one device to another.
  - Also known as *Throughput*
  - Data is either transferred in serial transmission or parallel transmission.
- When a communications channel is busy, it takes longer to send and receive data.



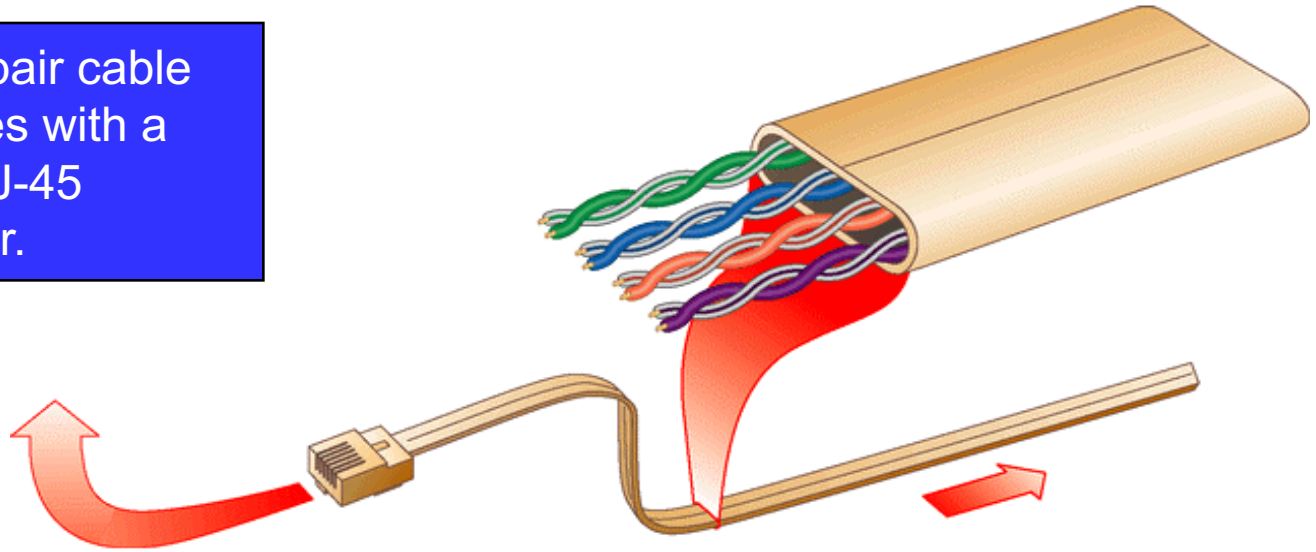
Data Transfer Rate (continued)

- ***Serial transmission*** - one piece of information follows another
  - modem and network communications
- ***Parallel transmission*** - all of the bits for an entire byte are sent at the same time
  - for sending data to a printer

Twisted-Pair Cable

- ***Voice-grade cable*** (Category 1 cable)
  - recommended for transmitting voice but not data
- ***Data-grade cable***
  - suitable for data transmissions
- Select a Category 5 unshielded or shielded cable with RJ-45 connectors to connect your network interface card to a network hub.

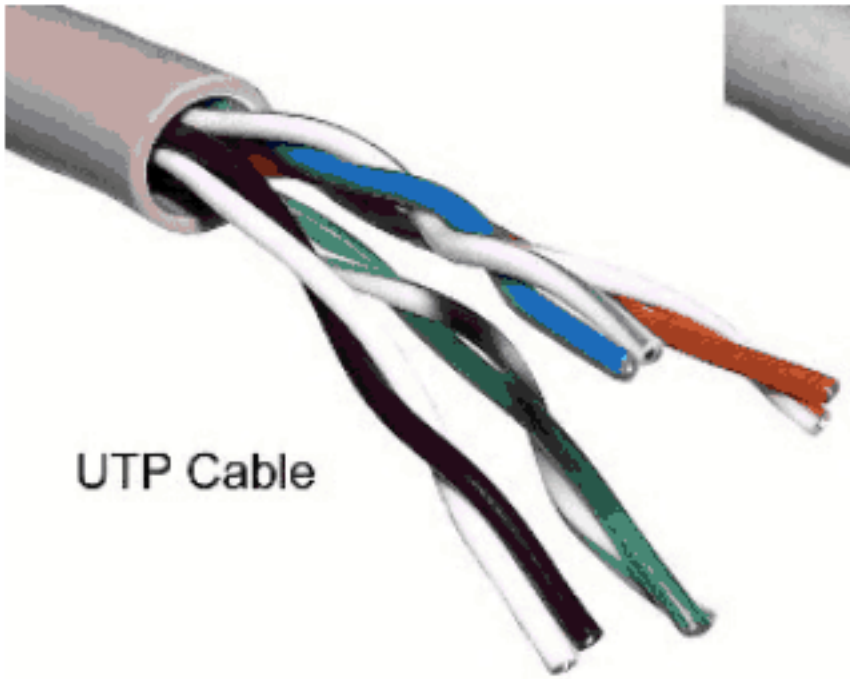
Twisted-pair cable terminates with a plastic RJ-45 connector.



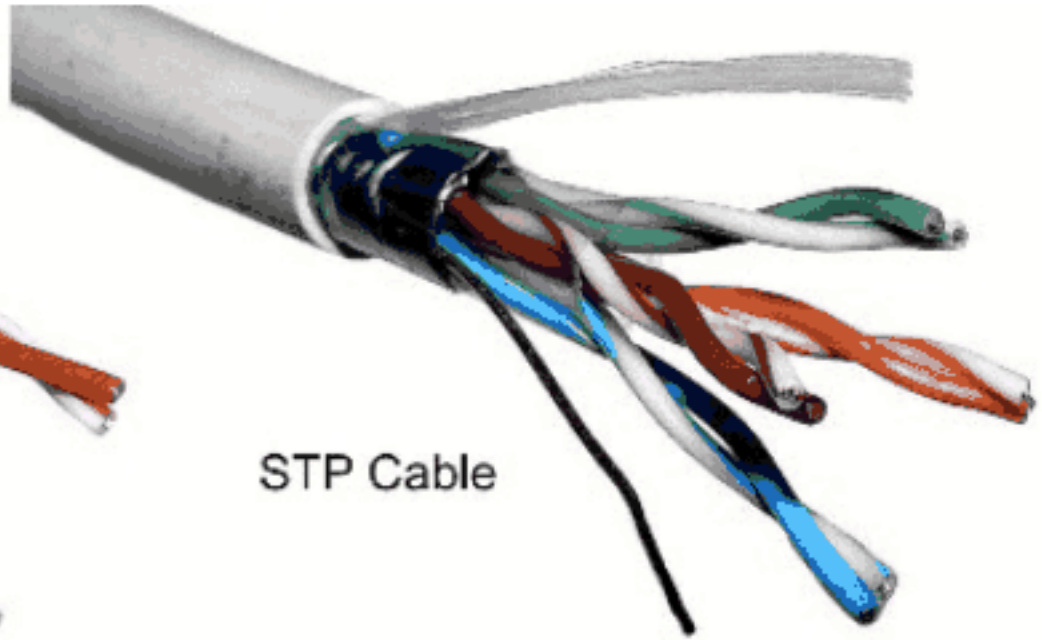
Twisted-Pair Cables

- Two types
  - Shielded twisted pair (STP) cable
  - Unshielded twisted pair (UTP) cable
- One wire carries the signal while the other wire absorbs signal interference
- Categories
  - Category 1 voice only (telephone wire)
  - Category 2 data to 4 mbps (Local Talk)
  - Category 3 data to 10 mbps (Ethernet)
  - Category 4 data to 20 mbps (token ring 16 mbps)
  - Category 5 date to 100 mbps (fast Ethernet)

UTP vs STP



UTP Cable

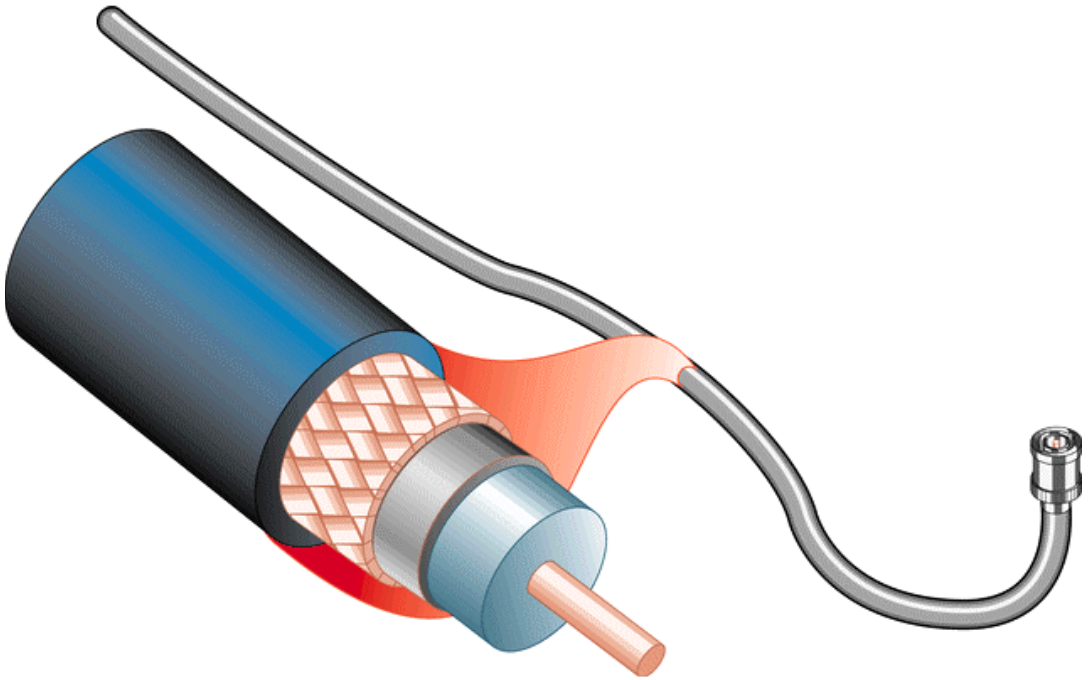


STP Cable

Coaxial Cable

- Coaxial cable - high-capacity communications cable consisting of a copper wire conductor
  - carries television signals

Coaxial cable contains shielding which increases bandwidth.

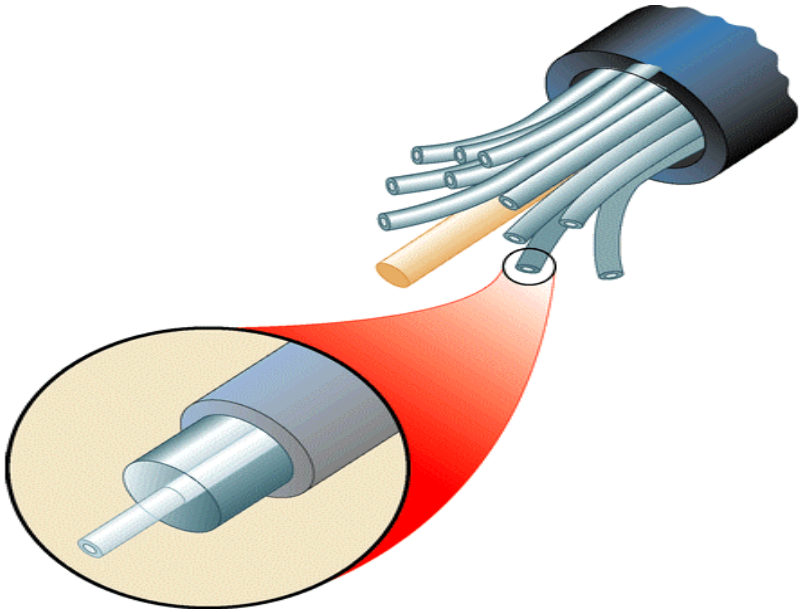


Coaxial Cable

- ***Coaxial cable***:
  - has excellent bandwidth
  - more expensive
  - more difficult to work with than twisted-pair
- Fiber-optic cable is replacing coaxial and twisted-pair cable where high bandwidth is required.

Fiber-Optic Cable

- ***Fiber-optic cable*** is a bundle of extremely small tubes of glass called optical fibers surrounded by layers of plastic, that transmits data using light rather than electricity
  - thinner than human hair



Fiber-Optic Cable (continued)

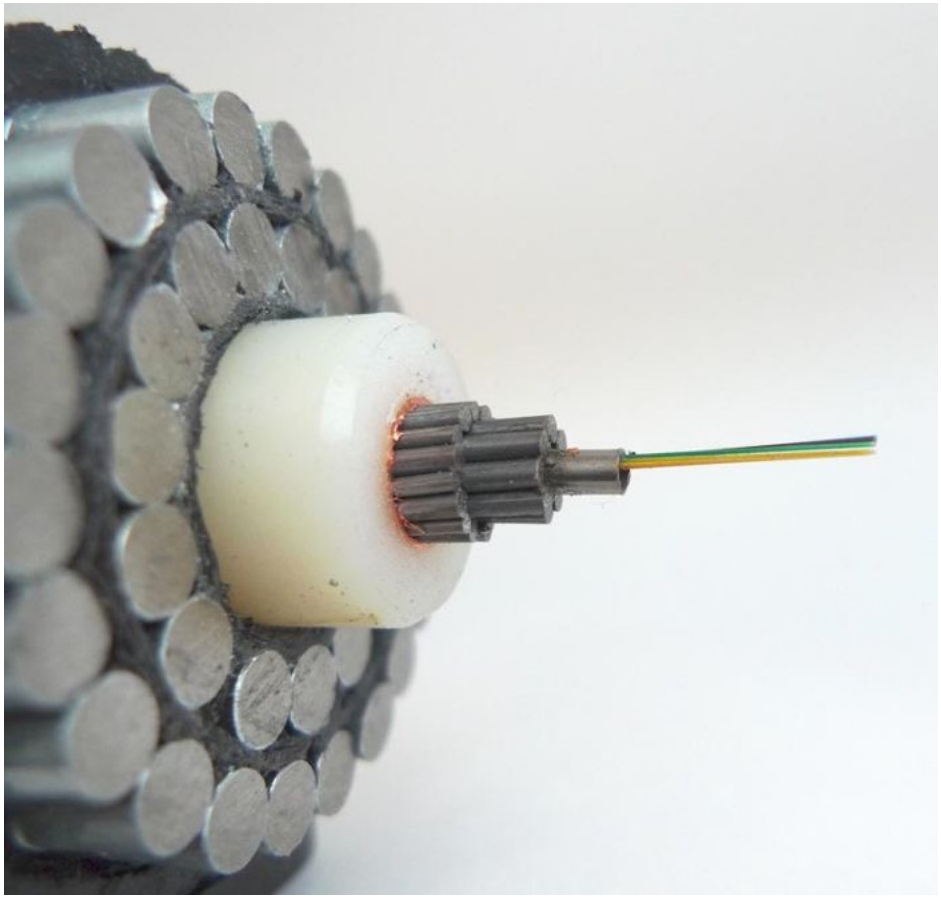
- ***Fiber-optic cable***:
  - new development
  - does not conduct or transmit electrical signals
  - miniature lasers send pulses of light
  - each fiber is a one-way communications channel
  - light signals encounter little resistance

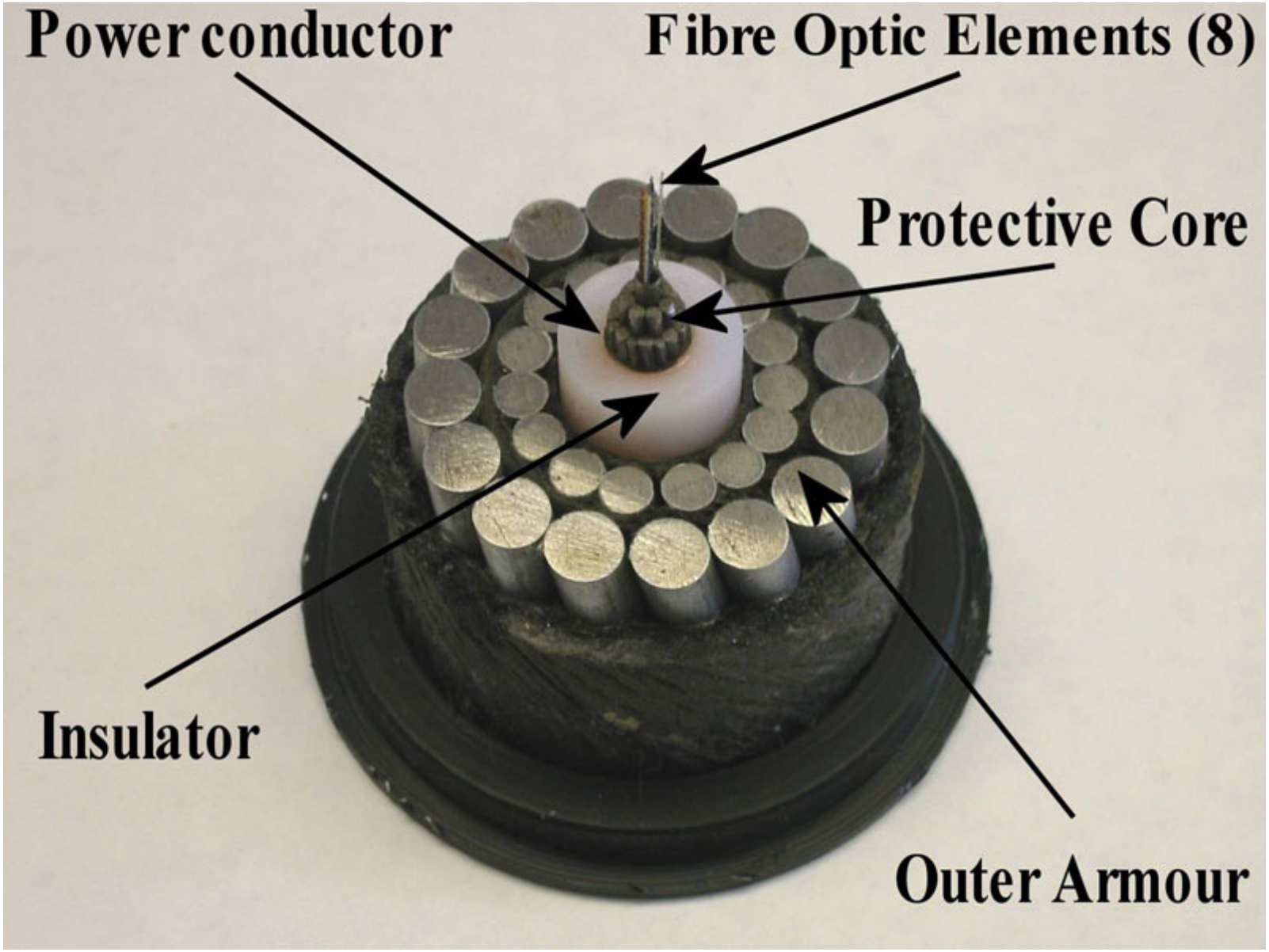
Fiber-Optic Cable (continued)

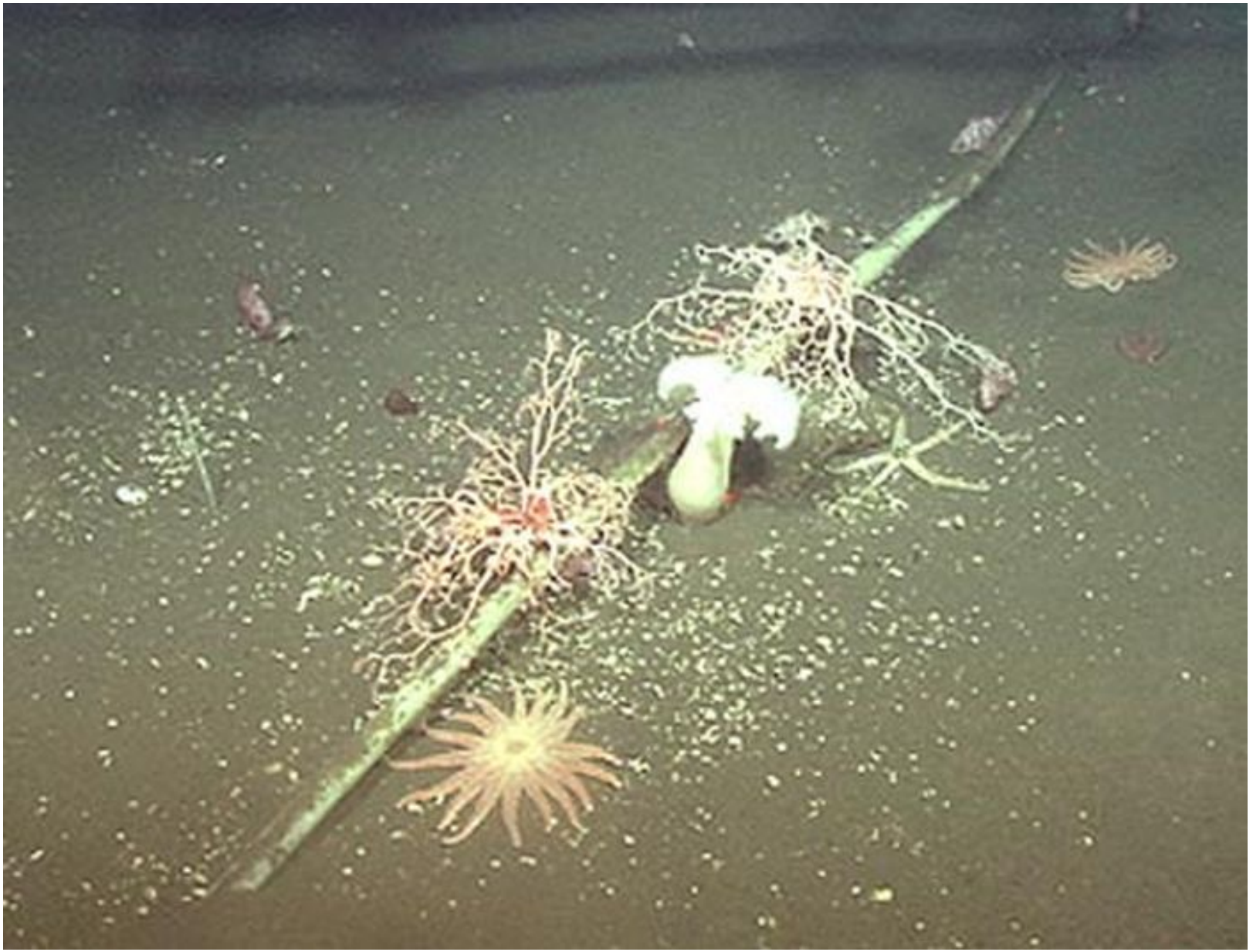
- ***Single-mode cable***
  - very narrow core
  - transmission speeds exceed 50 gigabytes per second
- ***Multi-mode cable***
  - wide, 50-100 micron core
  - easier to install
  - choice for computer networks

TAT-14 Cable System
Sprint Network Administration System

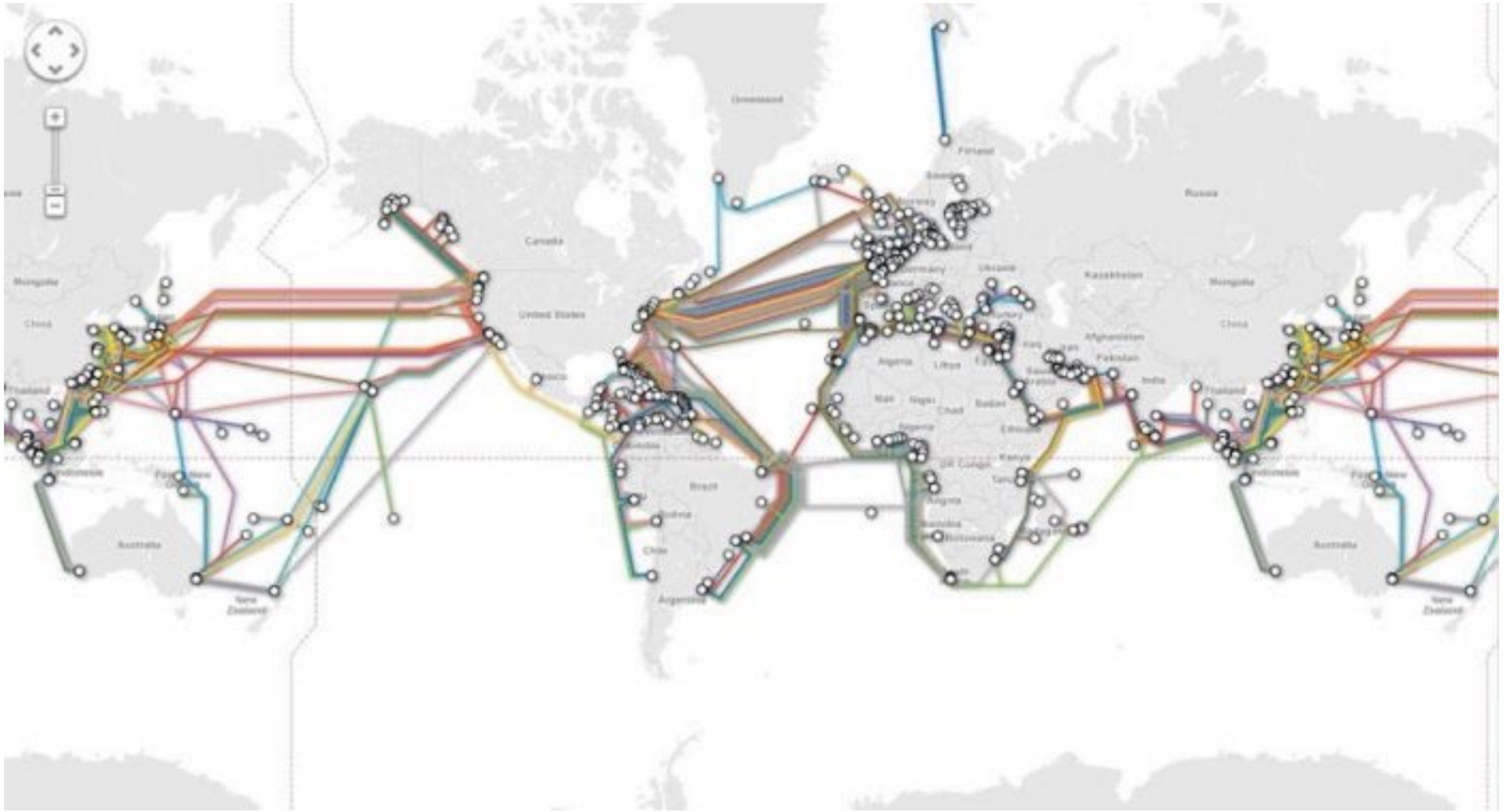
- The TAT-14 transatlantic cable system is in full service, connecting the United States to the United Kingdom, France, The Netherlands, Germany, and Denmark by 10 Gbs Direct Wave Access (DWA) or STM-16, STM-4, and STM-1 interfaces.
- The cable system is comprised of four fiber pairs configured for 47 x 10Gbs DWDM channels of which 10 are utilized for dual, bi-directional SDH rings.




Power conductor
Fibre Optic Elements (8)
Protective Core
Insulator
Outer Armour




WARNING
SUBMARINE
CABLE
Google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Indonesia
Australia
New Zealand
Algeria
Libya
Mali
Niger
Chad
Sudan
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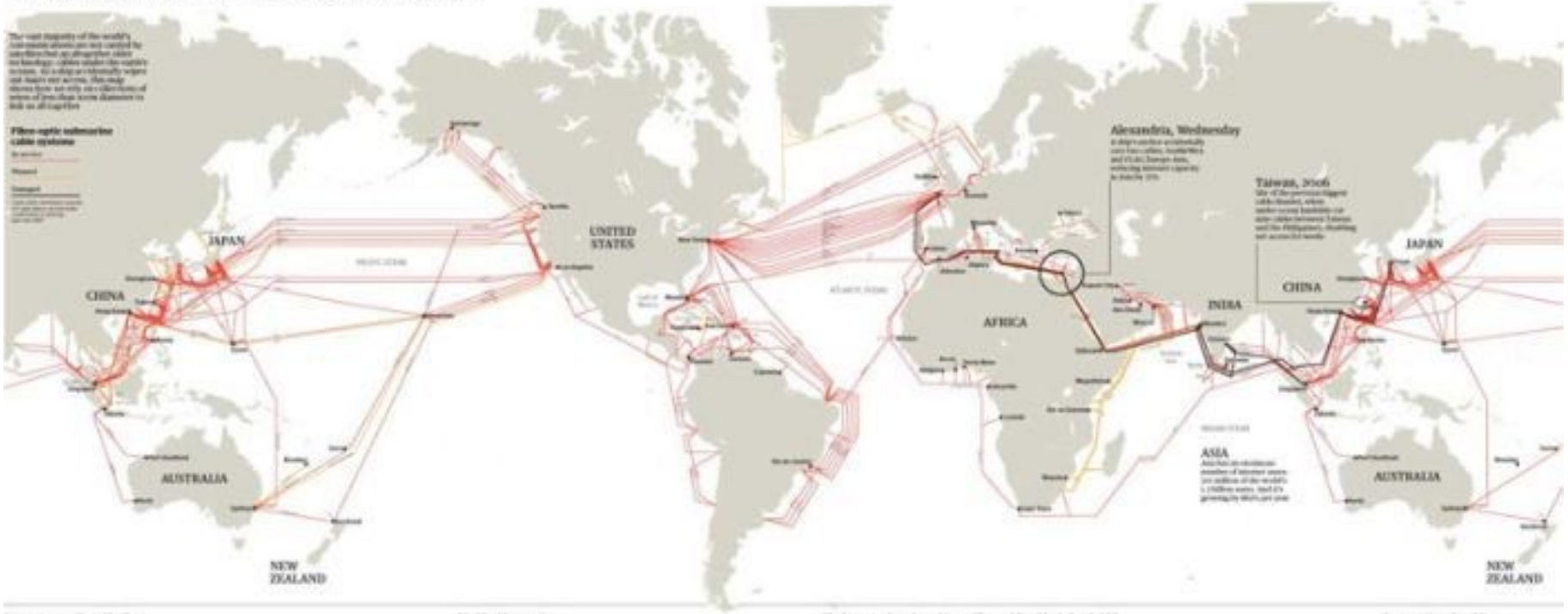
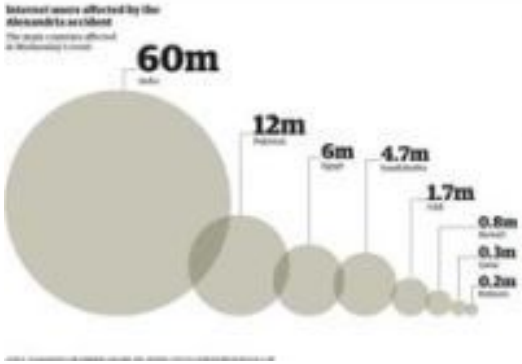
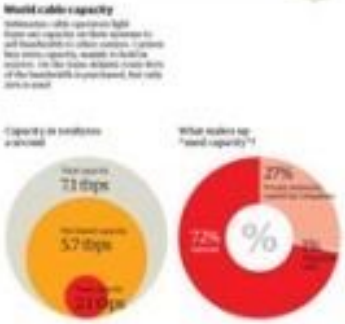
Namibia
Botswana
Ukraine
Germany

The internet's undersea world







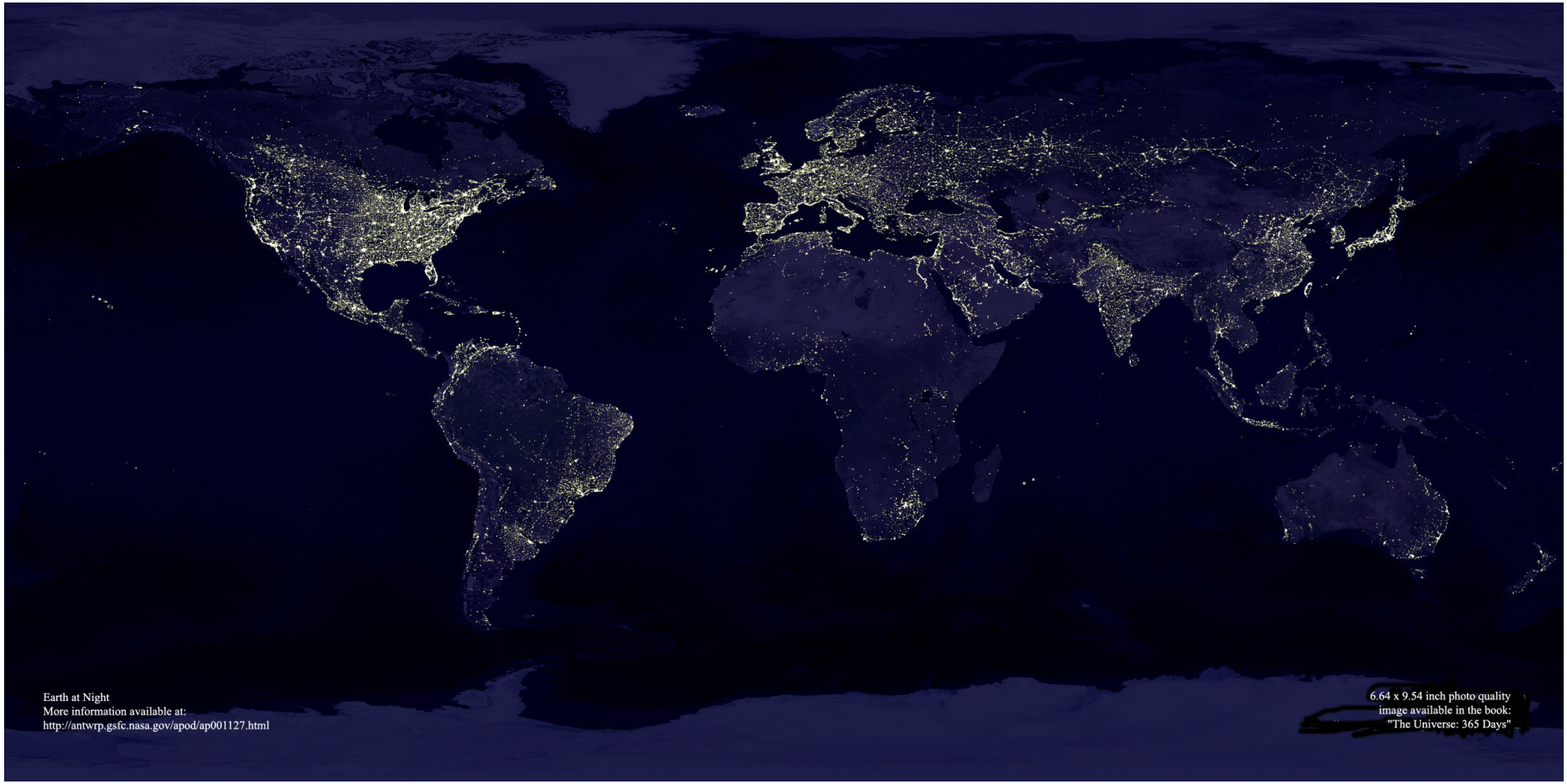
CS Cable Innovator

- 1995 Finland (145m*24m), 8500 t fiber optic, 42 day of work (60).

Национальная информационная супермагистраль

Рис. 1 Структура сети связи АО «Казахтелеком»

Национальная Информационная Супермагистраль

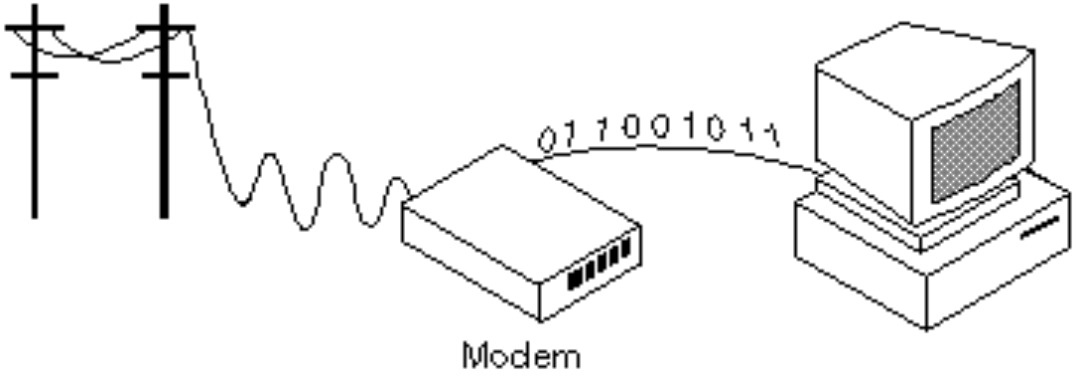

Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap001127.html
6.64 x 9.54 inch photo quality
image available in the book:
"The Universe: 365 Days"

The Internet and Intranets

- An ***intranet***, a mini-Internet within an organization, uses TCP/IP protocols and Internet software to handle data communications.
  - Web pages
  - Internet mail
- The Internet employs ***packet switching*** technology:
  - divides message into smaller units called ***packets***

Circuit Switching

- Circuit Switching
  - A type of communications in which a dedicated channel (or circuit) is established for the duration of a transmission.
  - Used by Telephone system
- Modem is used for convert digital pulses to analog signal
  - modulator-demodulator
  - used over analog line

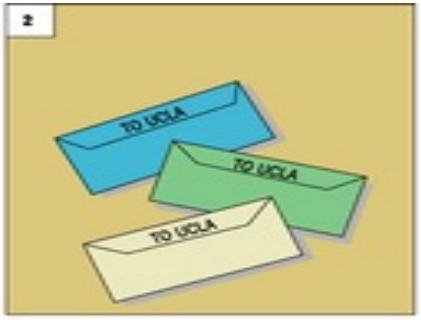


Packet Switching

- The advantage to packet switching is the efficient use of available bandwidth.

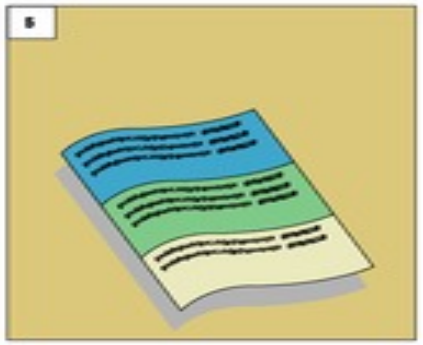
1. A message is divided into packets.

2. Each packet is addressed to its destination.

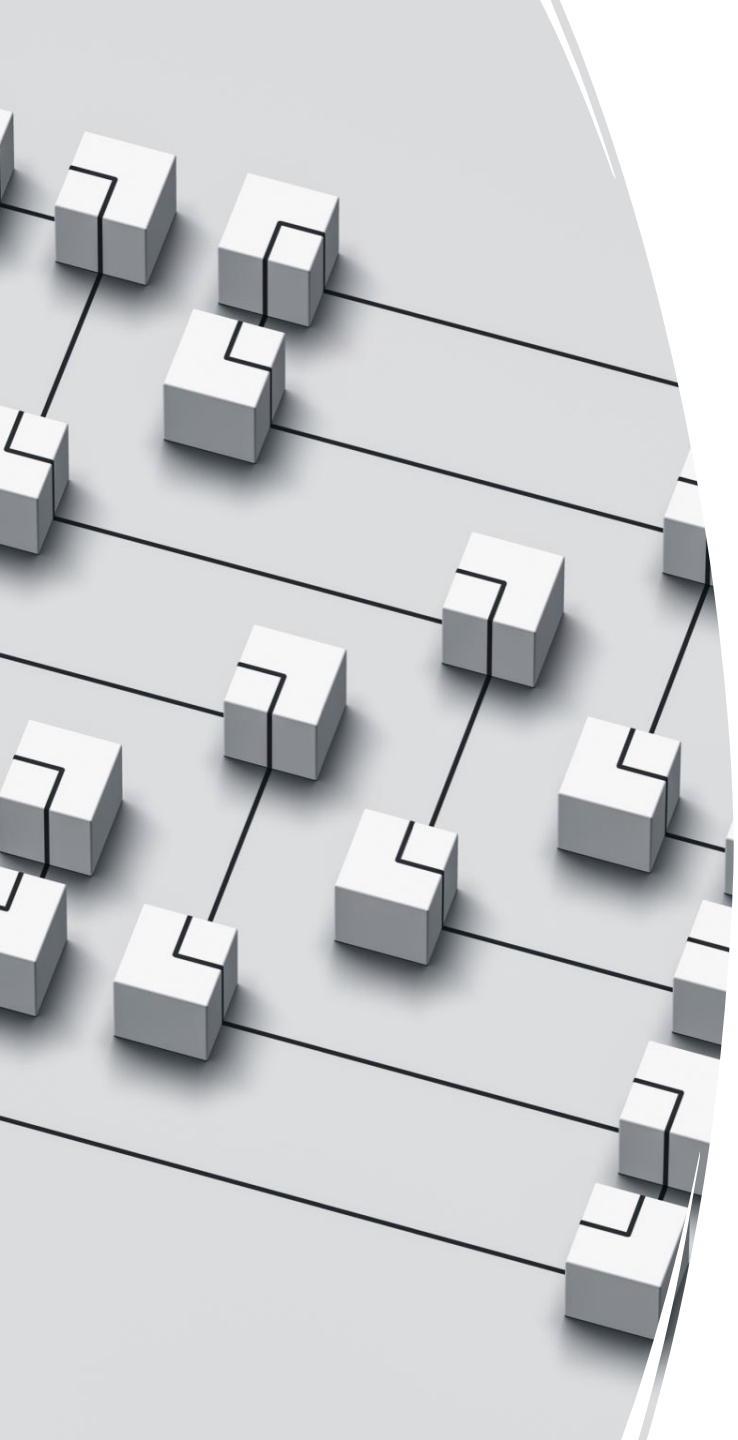


3. A packet might travel the shortest path to its destination.

4. If a route is congested or inoperable, packets can be rerouted to other links.



5. When the packets arrive at their destination, they are reassembled.

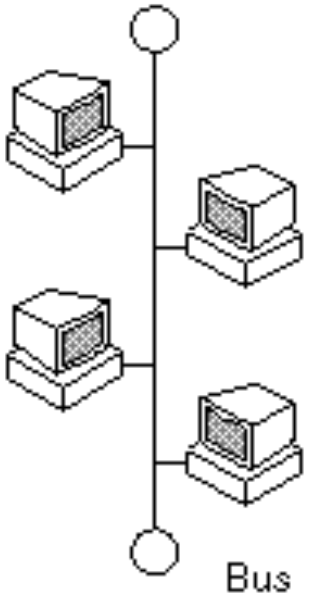


Communication System Topologies

- ***Topology***
  - The pattern or path of the interconnections in a communication system
  - Networks can use a single topology or a mixture of topologies
- There are three principal topologies:
  - Bus topology
  - Ring topology
  - Star topology

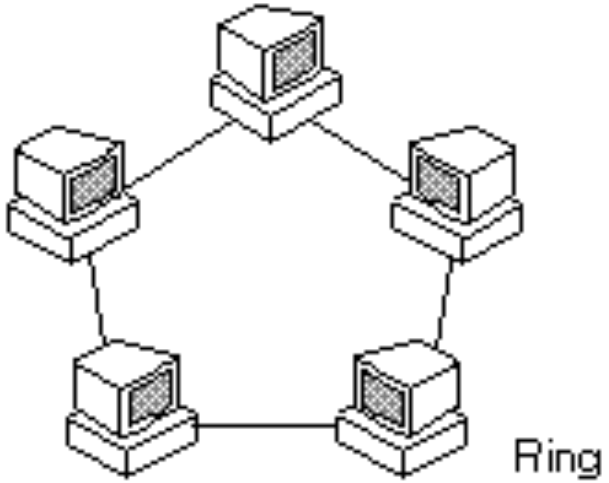
Bus Topology

- ***Bus topology*** - provides a common or shared communications pathway
  - All devices are connected to a central cable, called the bus or backbone. Bus networks are relatively inexpensive and easy to install for small networks. Ethernet systems use a bus topology.
  - Used by cable TV companies
  - String cables from house to house
  - No one user gets to use full bandwidth



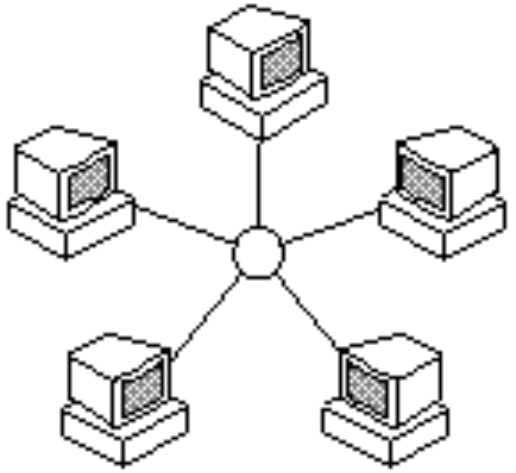
Ring Topology

- ***Ring topology*** - connects devices in a continuous loop
  - All devices are connected to one another in the shape of a closed loop, so that each device is connected directly to two other devices, one on either side of it. Ring topologies are relatively expensive and difficult to install, but they offer high bandwidth and can span large distances.
  - Used in local area networks

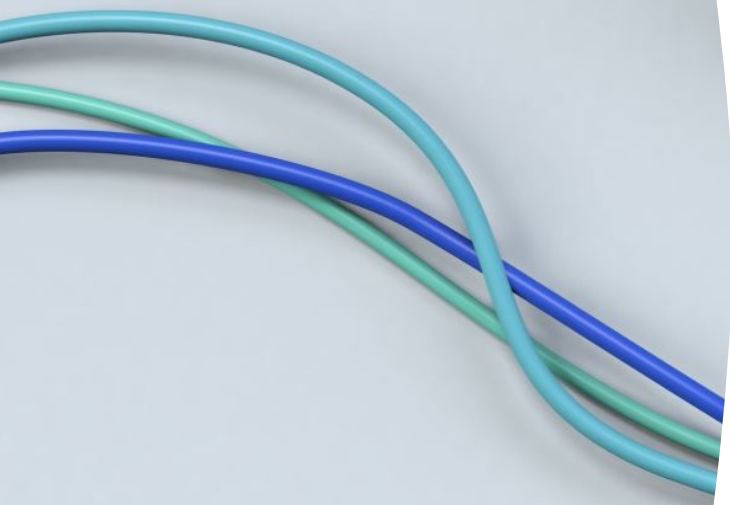


Star Topology

- ***Star topology*** - communications lines fan out from a central location
  - All devices are connected to a central hub. Star networks are relatively easy to install and manage but bottlenecks can occur because all data must pass through the hub.
  - every connection is dedicated to one user
  - expensive

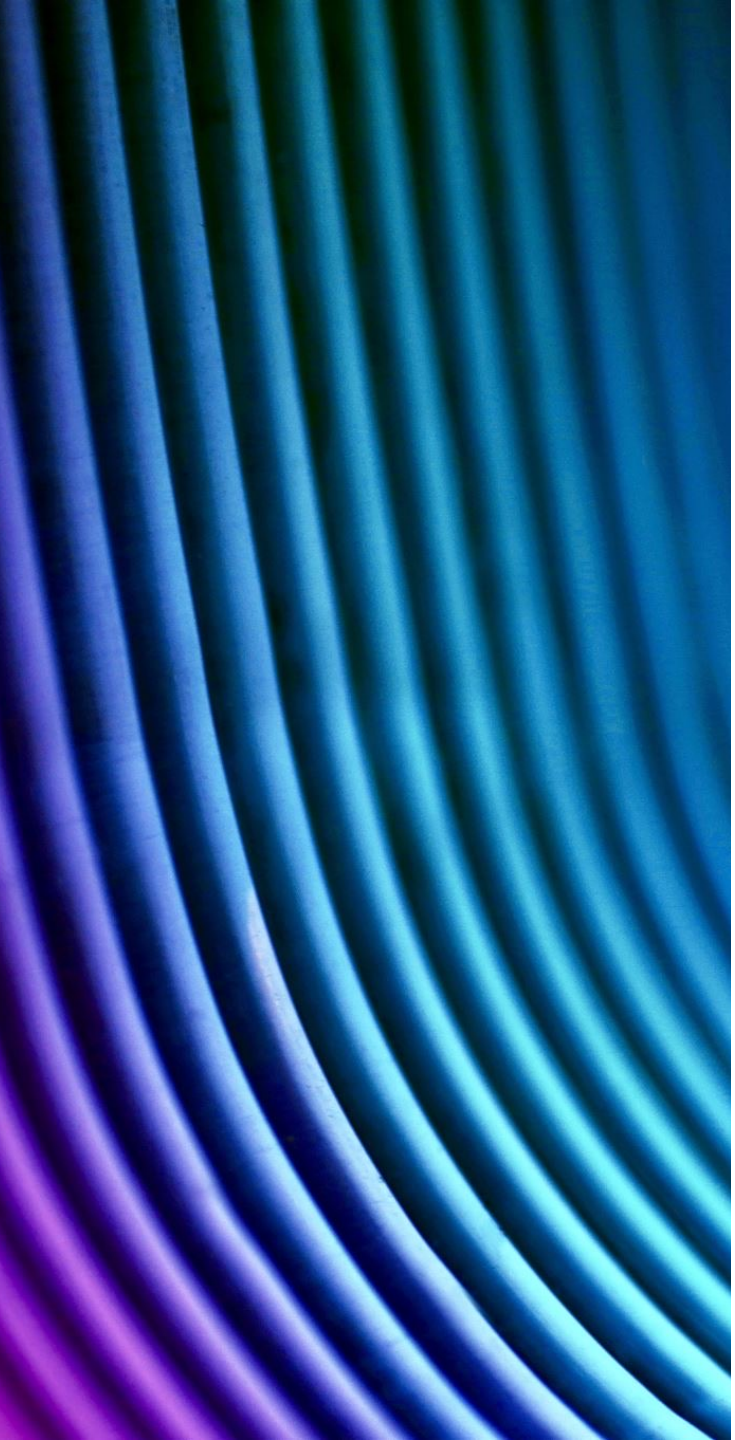


Star



Radio and Infrared Links

- It is possible to communicate without using wires.
- ***Radio waves*** - provide wireless communications
  - cellular phones
  - requires FCC license
- Radio communications link uses a ***transmitter*** to send the signal and a ***receiver*** to pick up the signal.
  - slower than cables
  - susceptible to interference



Radio and Infrared Links (continued)

- ***Infrared transmissions*** use a frequency rate below the visible light of spectrum.
  - an example of ***line-of-sight communication*** wireless mouse
    - transmitter that sends signal must have an unobstructed path to receiver

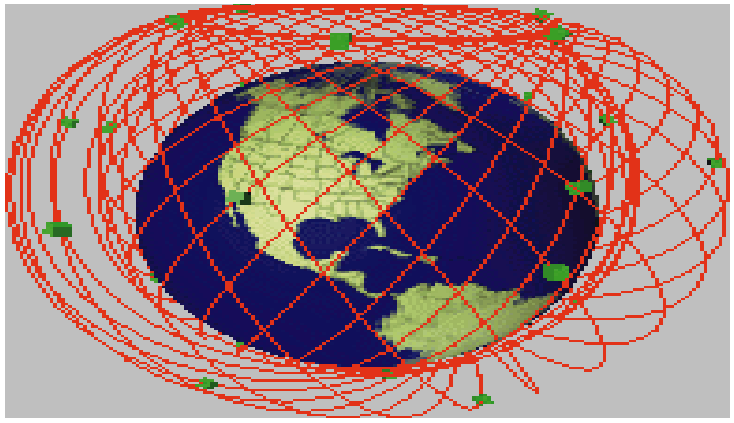
Microwave Links

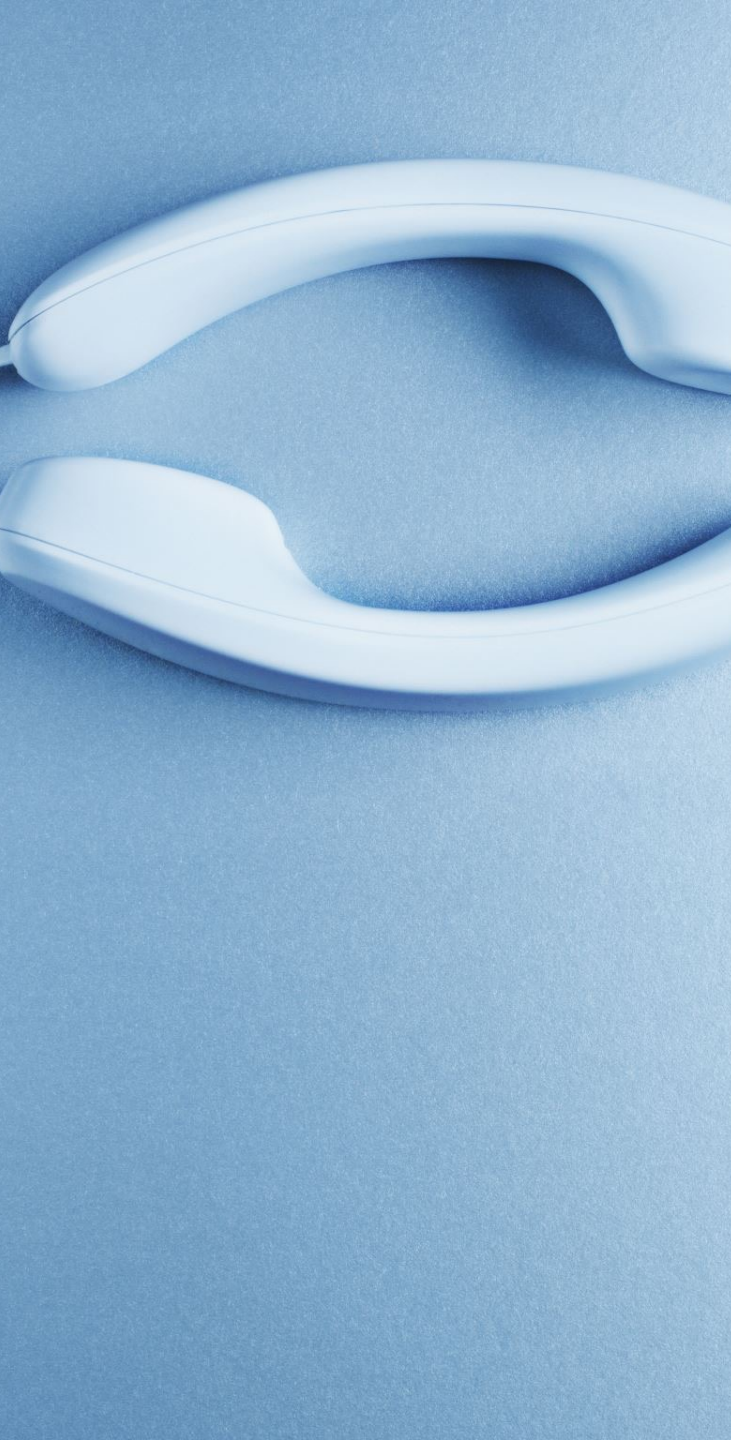
- ***Microwave*** - an electromagnetic wave with a frequency of at least 1 gigahertz (GHz)
- ***Microwave transmission*** sends a high-frequency signal from a transmitting station to a receiving station.
  - stations must be within 30 miles due to the earth's shape
- Many communications systems transmit microwave signals between a land-based ***ground station*** and a satellite.

Satellite Links

- ***Direct Satellite Services:*** digital satellite system, a network of satellites that broadcast digital data.
- A telecommunications satellite contains a ***transponder*** (receives signal, amplifies signal, and retransmits signal).
- Transmissions from a satellite transponder are sent to satellite dishes.
- ***Satellite dishes***
  - catch" transmissions on parabolic surface
  - reflects these signals to a feedhorn
- ***Feedhorn*** - small metal probe that is a microwave antenna

Low-earth orbit communications system





Telephone System

- The telephone network uses ***circuit switching*** technology.
  - temporarily connects one telephone to another for the duration of the call
  - can be used for Internet access
- The telephone communications system uses a tiered network to transport calls.
- The telephone network offers a variety of services for voice and data communications.

Telephone System (continued)

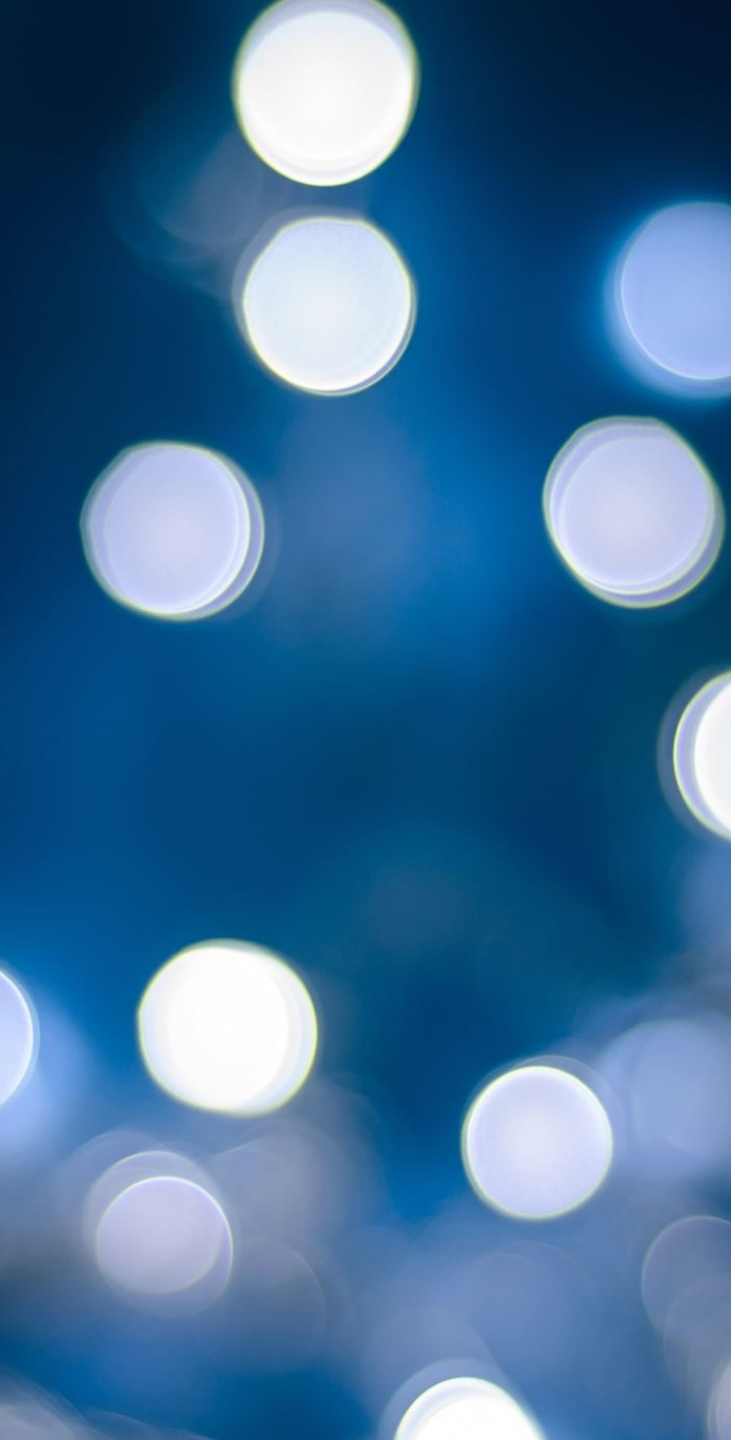
- ***POTS*** (plain old telephone service) is an analog service.
- ***Voiceband modem*** - converts digital pulses into analog tones to send digital computer data over a POTS line
- ***Modulation*** - change characteristics of a signal – digital to analog
- ***Demodulation*** - change signal back to original state – analog to digital

Telephone System (continued)

- Primary advantage of the telephone system for computer communications is inexpensive access.
- A ***DSU*** (data service unit) is required on your computer to send computer data over a digital line.
- ***ISDN*** service transports data digitally over ***dedicated lines*** – permanent connections between two locations.
  - basic (64 kbps)
  - enhanced (128 kbps)

Telephone System (continued)

- ***ADSL service*** - supports data rates up to 9 Mbps when receiving and up to 640 Kbps when sending
  - ISDN and ADSL affordable for individuals and businesses
- ***T1 service*** - provides 1.5 Mbps send and receive capacity over a dedicated line
- ***T3 service*** - uses fiber-optic cables to provide service with a capacity of 45 Mbps



The Cellular Phone System

Cellular phone systems have been pressed into service for data communications as well as voice.

- mobility is the advantage
- disadvantages
  - high cost
  - reliability
  - lack of security, interference

You should encrypt confidential data before sending it over cellular phone system.

The Cellular Phone System (continued)

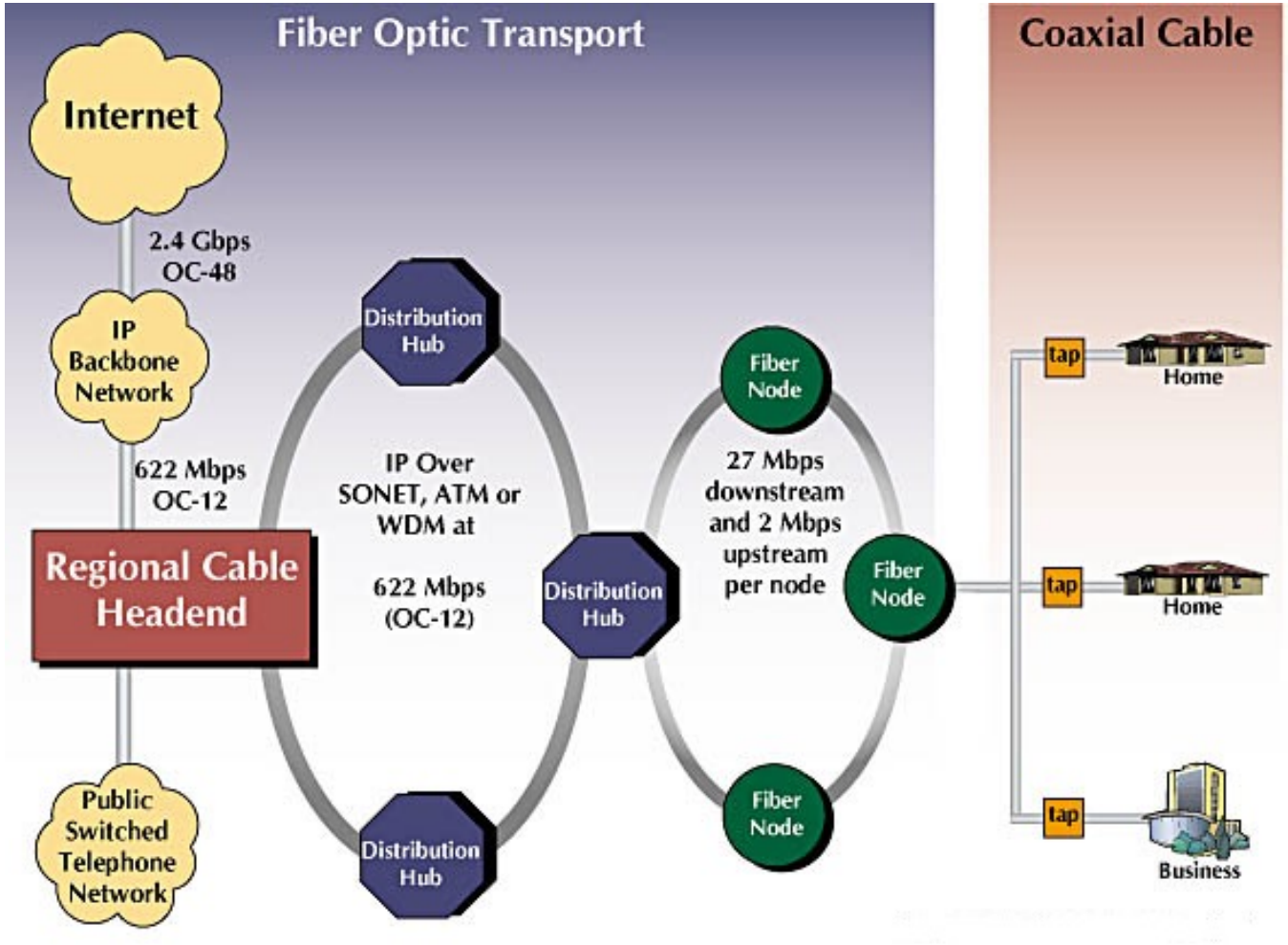
- You can send and receive data over the cellular phone system using a number of devices:
  - cellular phones
  - modems
- Cellular modems are similar to voiceband modems but function in cellular environments.
  - available as PCMCIA cards
- Transmitting data over the cellular phone system is slow and less reliable.

Cable Television System

- Cable TV companies have installed miles of high-bandwidth coaxial cables.
  - carrying capacity far exceeds POTS lines
- A ***cable modem*** is a device designed to demodulate a signal from the cable and translate it back to Internet data.

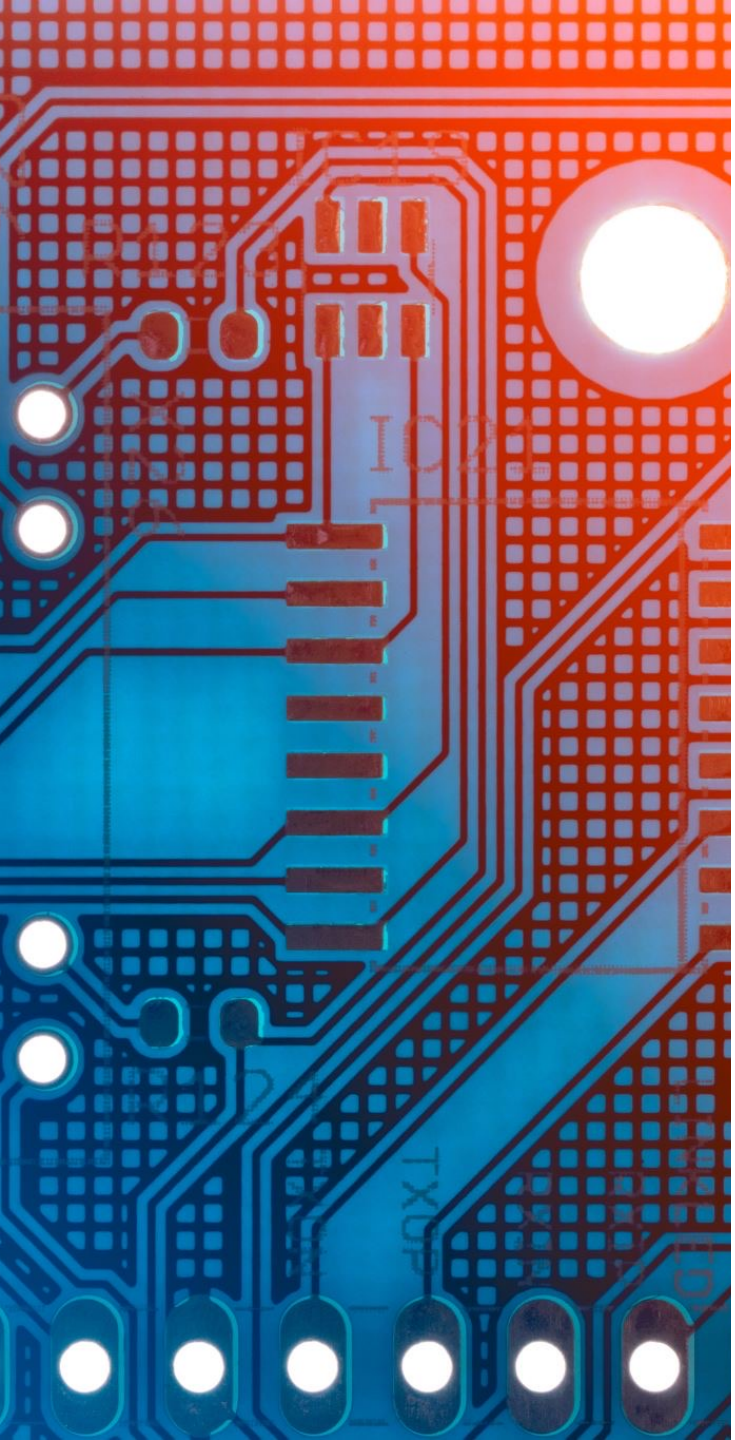
Cable Modem

- Cable Modem
  - A modem designed to operate over cable TV lines



Direct Satellite Service

- ***Direct satellite service*** (DSS) uses a geosynchronous or low-earth orbit satellite to send television, voice or computer data directly to a satellite dish.
  - DirecPC was one of the first
  - transmits in one direction – ***downstream***
  - requires a standard modem and phone line for ***upstream*** transmission



Communications (continued)

- Digital Service Unit
  - Also known as a Channel Service Unit
  - that connects a terminal to a digital line
  - performs protective and diagnostic functions for a telecommunications line
  - used in T1, T3 ,DSL & ISDN lines

Communications (continued)

- ISDN (Integrated Services Digital Network)
  - communications standard for sending voice, video, and data over digital telephone lines or normal telephone wires
  - supports data transfer rates of 64 Kbps - 128 Kbps
  - B-ISDN support data transfer rates of 1.5Mbps

Communications (continued)

- ADSL (Asymmetric Digital Subscriber Line)
  - Makes use of existing copper telephone lines
  - Downstream data transfer from 1.5 to 9 Mbps
  - Upstream data transfer from 16 to 640 Kbps

Communications (continued)

- T1 carrier lines
  - A dedicated phone connection supporting data rates of 1.54 Mb/s
  - consists of 24 individual channels, each of which supports 64Kbits per second.

Communications (continued)

- T3 carrier lines
  - a dedicated phone connection supporting data rates of about 43 Mbps
  - consists of 672 individual channels, each of which supports 64 Kbps.
  - used by ISPs to connect to backbone

Communications (continued)

- Cellular Phone System
  - refers to communications systems, that divide a geographic region into sections, called cells.
  - Each connection, or conversation, requires its own dedicated frequency, and the total number of available frequencies is about 1,000.

Ethernet and Token Ring LANs

- Most LANs use packet switching technology.
- ***Network access method*** - a set of specifications that defines how data will be physically transmitted
  - determined by type of network interface card and cables
  - popular network access methods include Ethernet and Token Ring

Ethernet

- ***Ethernet***
  - A local-area network (LAN) protocol developed by Xerox Corporation
  - Uses Bus or Star Topology
  - Supports data transfer rate of 10/100 Mbps
  - CSMA/CD access method to handle simultaneous demands.

Ethernet and Token Ring LANs (continued)

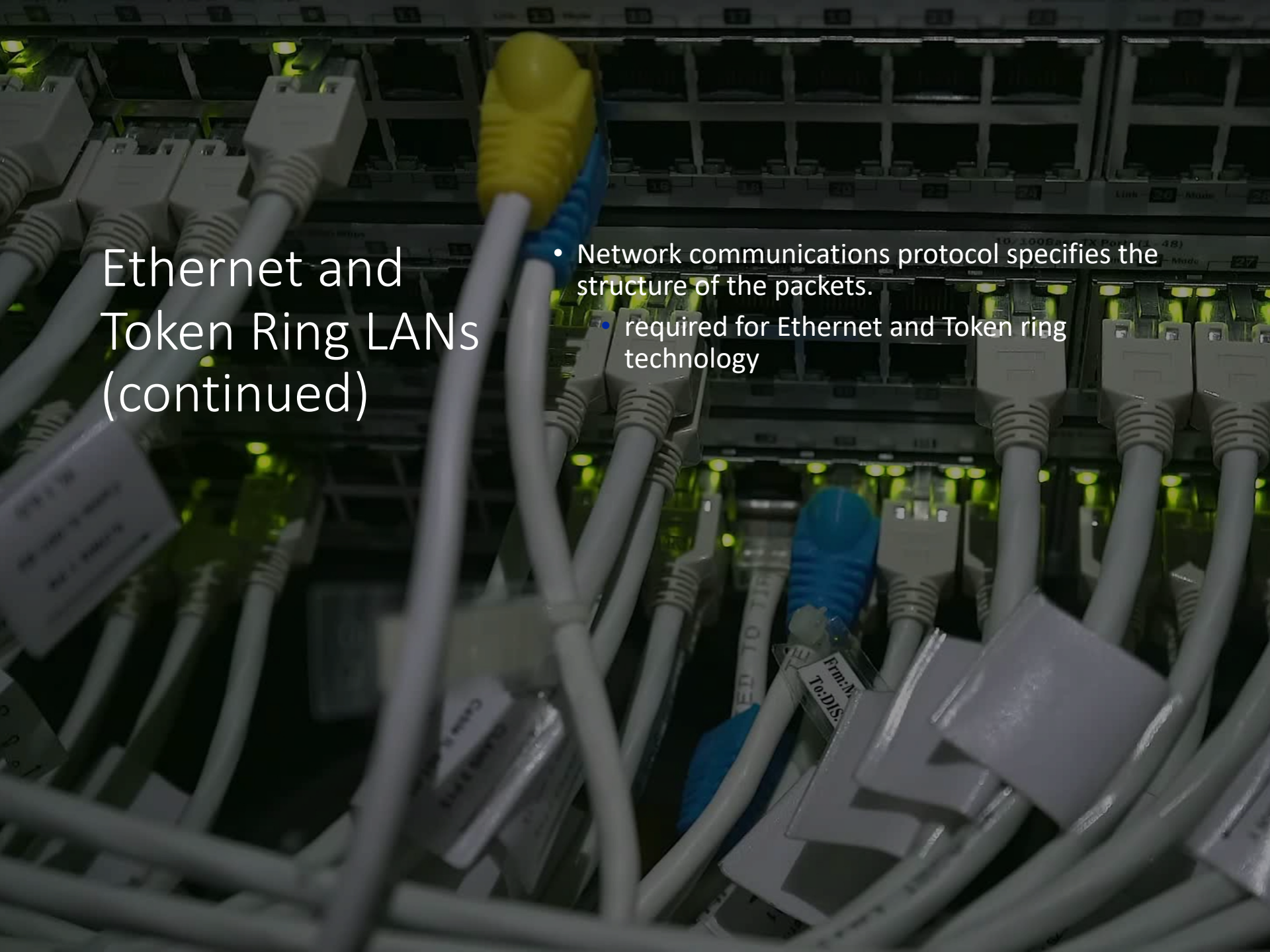
- On an Ethernet network, before a network interface card sends a packet, it checks to see if network is busy.
- When two devices on an Ethernet network send packets at the same instant, it's called a ***collision***.
- Ethernet networks use ***CSMA/CD,*** a method to deal with collisions.

CSMA/CD

- Carrier Sense Multiple Access / Collision Detection
- Set of rules determining how network devices respond when two devices attempt to use a data channel simultaneously
- Enables devices to detect a collision.
- After detecting a collision, a device waits a random delay time and then attempts to re-transmit the message. If the device detects a collision again, it waits twice as long to try to re-transmit the message. This is known as exponential back off.

Ethernet and Token Ring LANs (continued)

- When messages collide, both stop sending and wait a random period of time before attempting to send again.
- Token ring, the second most popular network access method, transmits data at 4 or 16 megabits per second over twisted-pair wire.
  - uses ring topology
  - uses ***token*** (special message) to prevent collisions

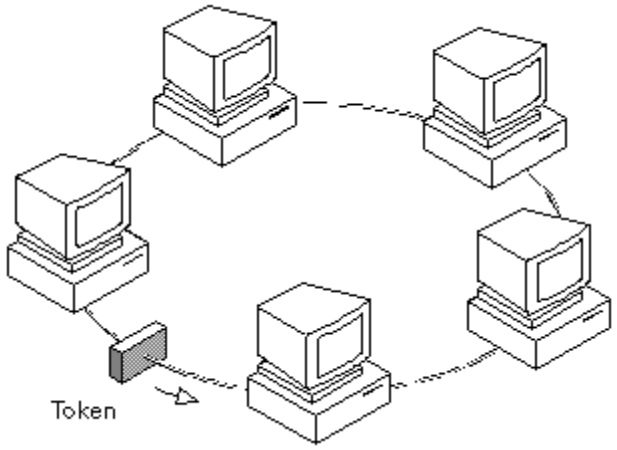


Ethernet and Token Ring LANs (continued)

- Network communications protocol specifies the structure of the packets.
  - required for Ethernet and Token ring technology

Token Ring

- Based on Ring Topology



- Makes use of Tokens
  - A token is a special series of bits that travels around a token-ring network.
  - The token acts like a ticket, enabling its owner to send a message across the network

Ethernet and Token Ring LANs (continued)

- A single network can use more than one communications protocol.
- People sometimes refer to their network by the server type, rather than the network access method.
- A single network can have several types of servers.

LAN Protocols

IPX

- Internetwork Packet Exchange, a networking protocol used by the Novell NetWare operating systems.
- Similar to IP

SPX

- Sequenced Packet Exchange, a transport layer protocol used in Novell Netware networks
- Similar to TCP

LAN Protocols (continued)

- NetBIOS
  - Network Basic Input Output System, an application programming interface (API) that adds special functions for LAN
- NetBEUI
  - NetBios Enhanced User Interface

Building a Low-Cost LAN

At least two computers

One network interface card for each computer

10BaseT hub with five ports

10BaseT cables (***network patch cables***) long enough to reach hub

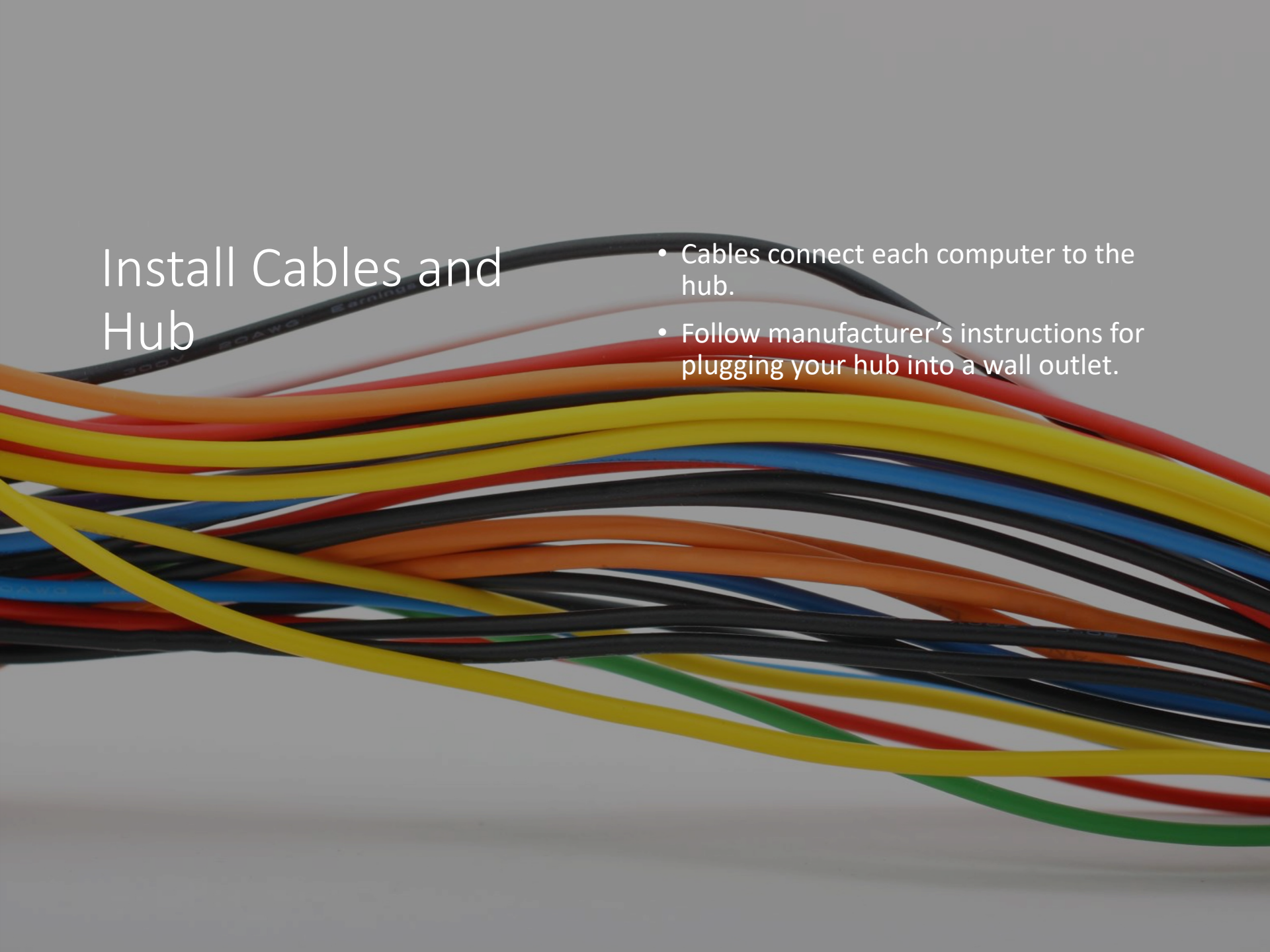
Philips-head screwdriver

Install Network Cards

- Put network card in each computer.
  - follow manufacturer's instructions
- Ground yourself.
  - use grounding straps or touch metal before you reach inside computer
- Locate unused expansion slot and plug in network card.

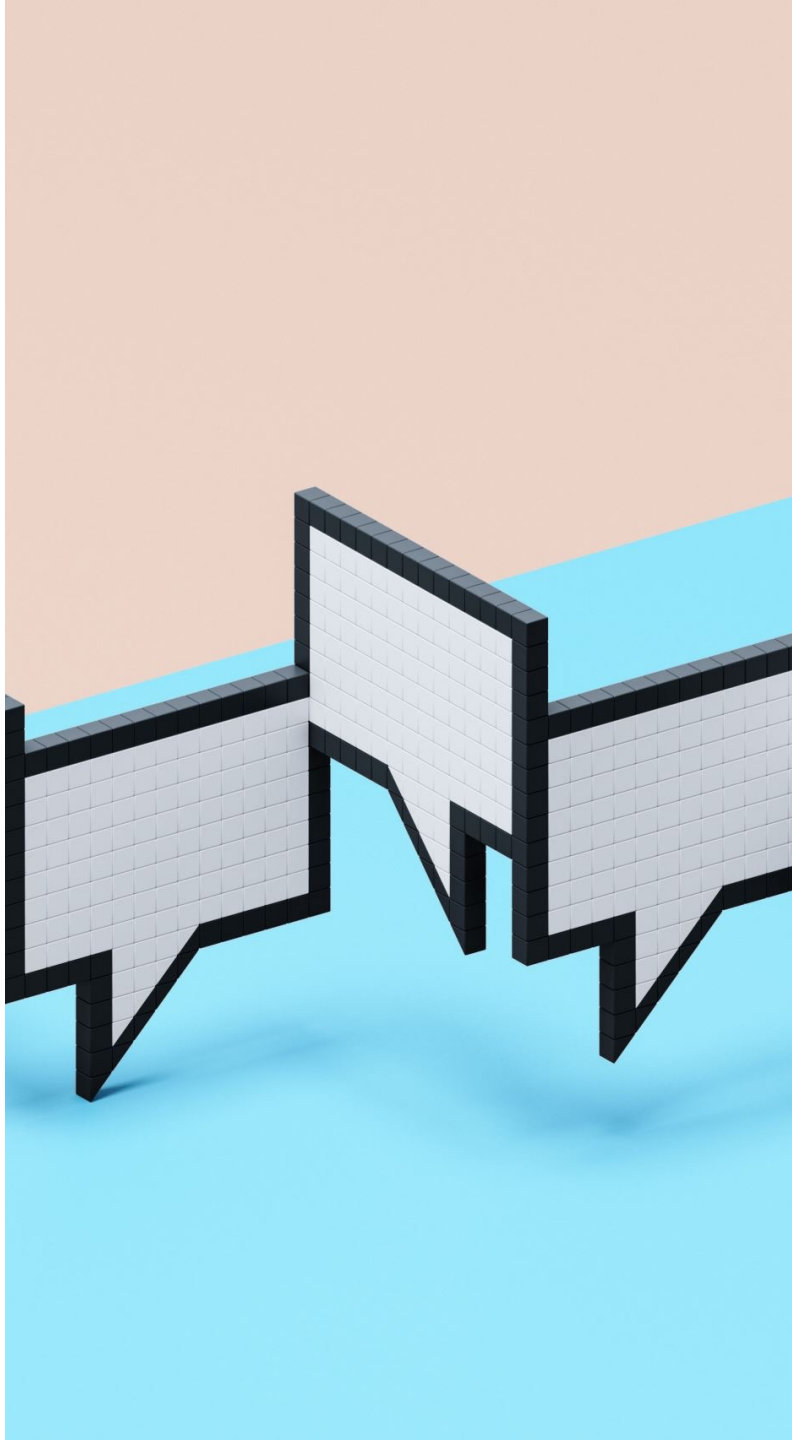
Install Cables and Hub

- Cables connect each computer to the hub.
- Follow manufacturer’s instructions for plugging your hub into a wall outlet.



Activate Network Software

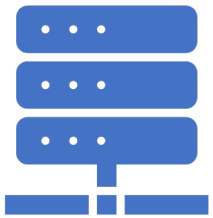
- Windows will detect the network cards and display a wizard – a series of dialog boxes to guide you through the rest of the installation.
  - select Client for Microsoft Networks protocol



Internet Architecture

- Routers and TCP/IP
- Domain Name Service, ***DNS***
- Internet Service Providers, ***ISP***

Routers and TCP/IP



Internet Protocol(I P)

specifies the format of packets, also called datagrams, and the addressing scheme.

The current version of IP is IPv4

A *host* is any computer on a network

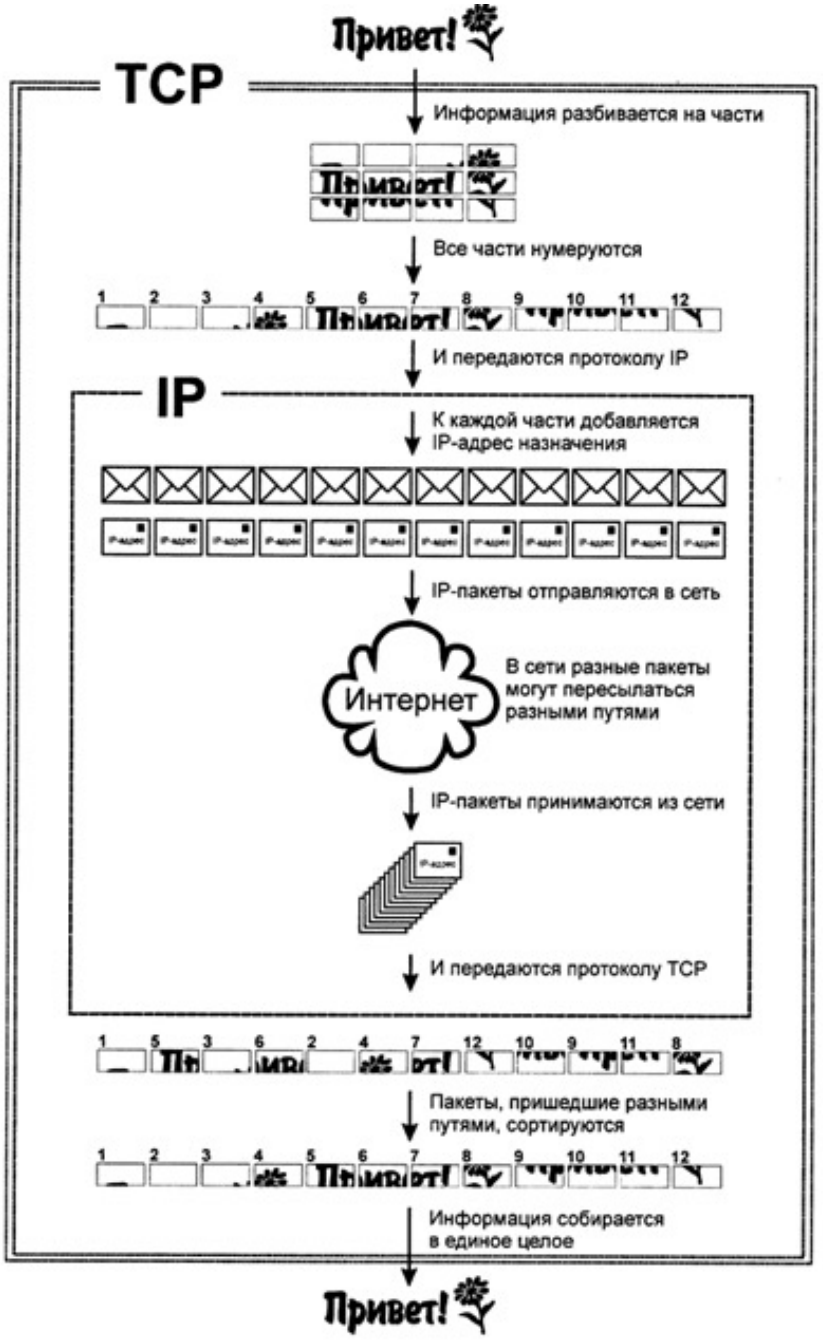
Routers and TCP/IP (continued)

Each host on the Internet has a unique IP address

- Written as four numbers between 0 and 255
- Separated by periods, 128.2.35.186
- Four bytes long

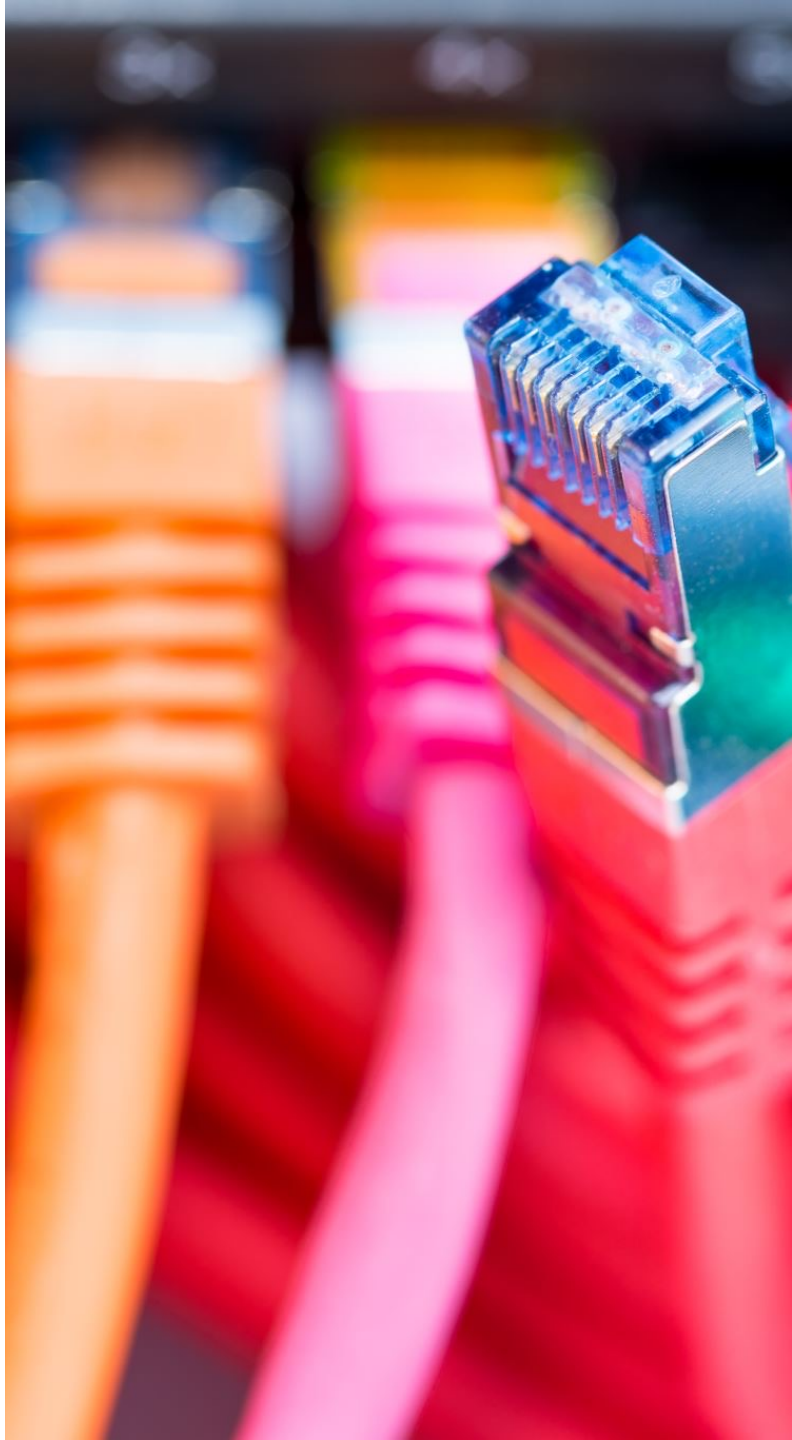
TCP (Transmission Control Protocol)

- TCP enables two hosts to establish a connection and exchange streams of data.
- guarantees delivery of data


Привет!
TCP
Информация разбивается на части
Все части нумеруются
1 2 3 4 5 6 7 8 9 10 11 12
И передаются протоколу IP
IP
К каждой части добавляется IP-адрес назначения
IP-адрес
IP-пакеты отправляются в сеть
Интернет
В сети разные пакеты могут пересылаться разными путями
IP-пакеты принимаются из сети
И передаются протоколу TCP
1 5 3 6 2 4 7 12 10 9 11 8
Пакеты, пришедшие разными путями, сортируются
1 2 3 4 5 6 7 8 9 10 11 12
Информация собирается в единое целое
Привет!

Routers and TCP/IP (continued)

- ***Router***
  - A device that connects any number of LANs.
  - Hop is an intermediate connection in a string of connections linking two network devices.
  - PING or traceroute utilities to trace the hops
- Keeps a list of IP addresses, corresponding LAN addresses for host on that network
- When a router receives a packet it either delivers it or passes it on to another router
- A ***hop*** is a packet going from router to router
- Packets can travel via network ***backbones***, high capacity communication lines



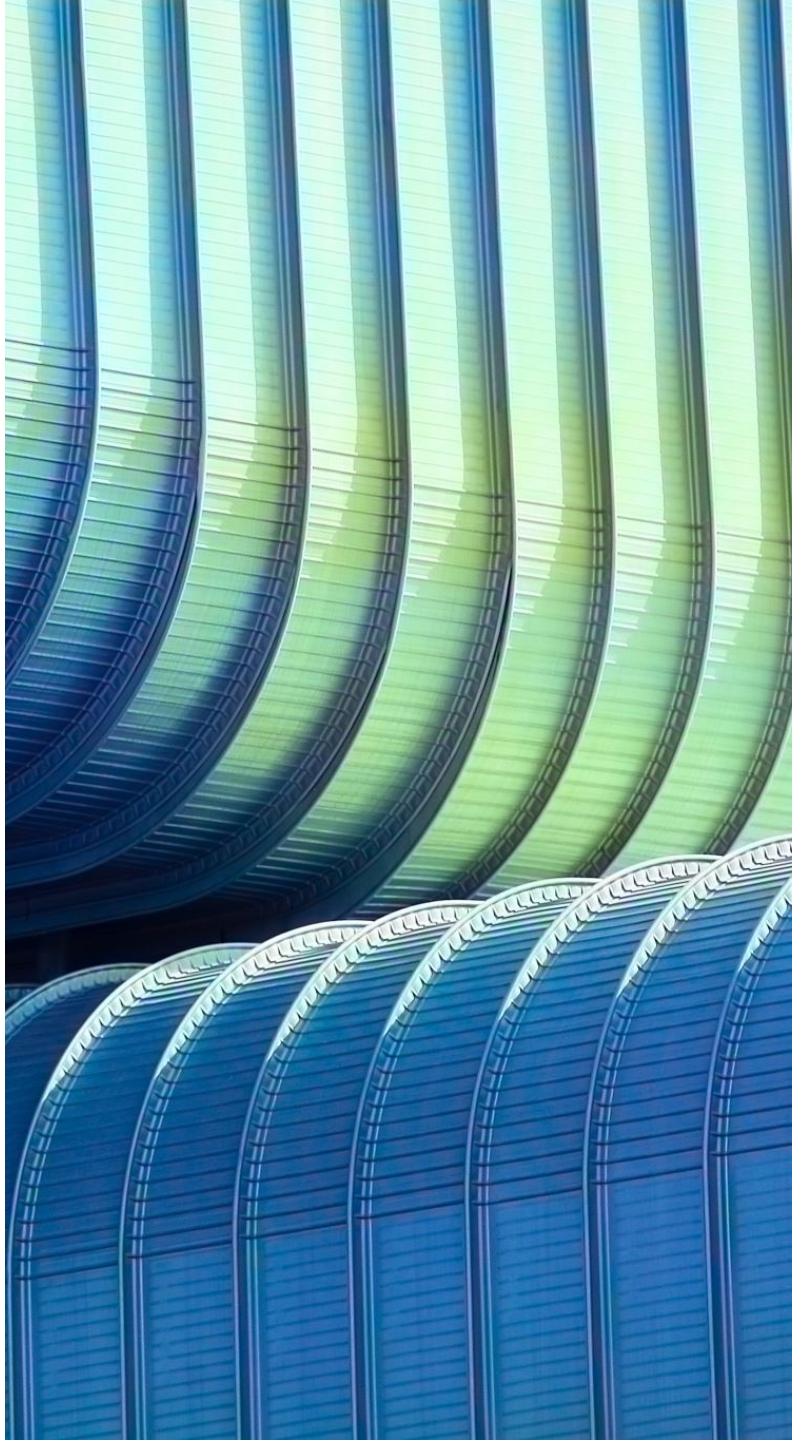
Transmission Control Protocol

Transmission Control Protocol, ***TCP***, uses another layer of protocol to insure packets are not lost in transmission

TCP confirms receipt of all packets

If some packets are lost, retransmits lost packets

This protocol has grown the Internet



Domain Name Services

Domain Name Service

- Domains are defined by the IP address
- Domain Name
  - name that identifies one or more IP addresses
  - E.g.: carnegietech.org

Domain Name System (DNS) server translates domain names into IP addresses.

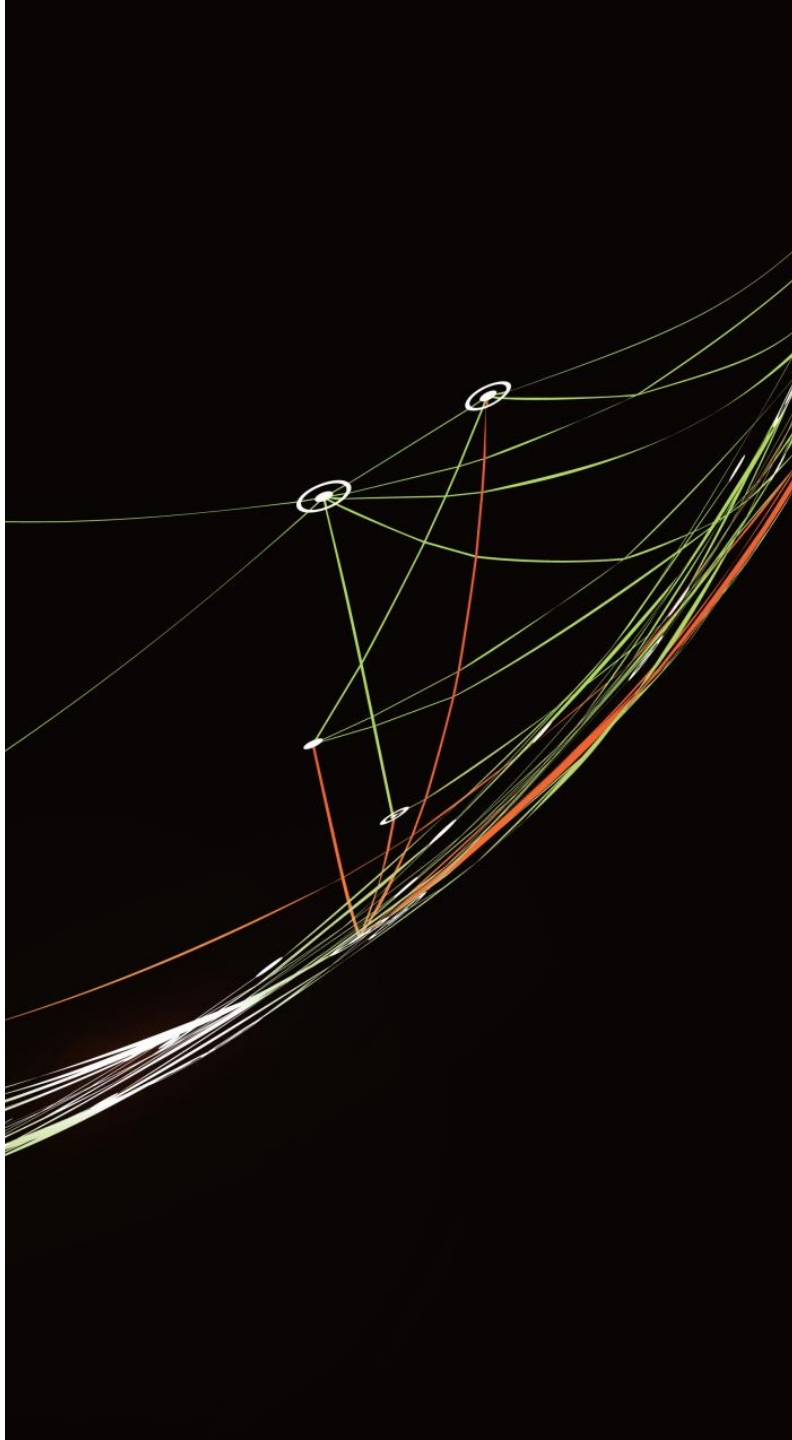
DNSs network with each other to provide IP address information

Internet Service Providers (ISPs)

- ISPs are companies who provide their customers with Internet services.
  - Some cater to individuals
  - Some cater to businesses
  - Provide hosting services
  - E-mail
  - Content providers - AOL

Internet Architecture (continued)

- xDSL
  - digital subscriber line
  - operate over existing copper telephone lines
  - Different types of DSL technologies
- ADSL
  - asymmetric digital subscriber line)
  - Downstream rate 1.5 to 9 Mbps
  - Upstream rate 16 to 640 Kbps
- G.Lite
    - also known as Universal ADSL
    - Uses Digital Loop Carrier
    - Downstream rate 1.5Mbps
    - Upstream rate 512Kbps



Internet Architecture (continued)

SDSL

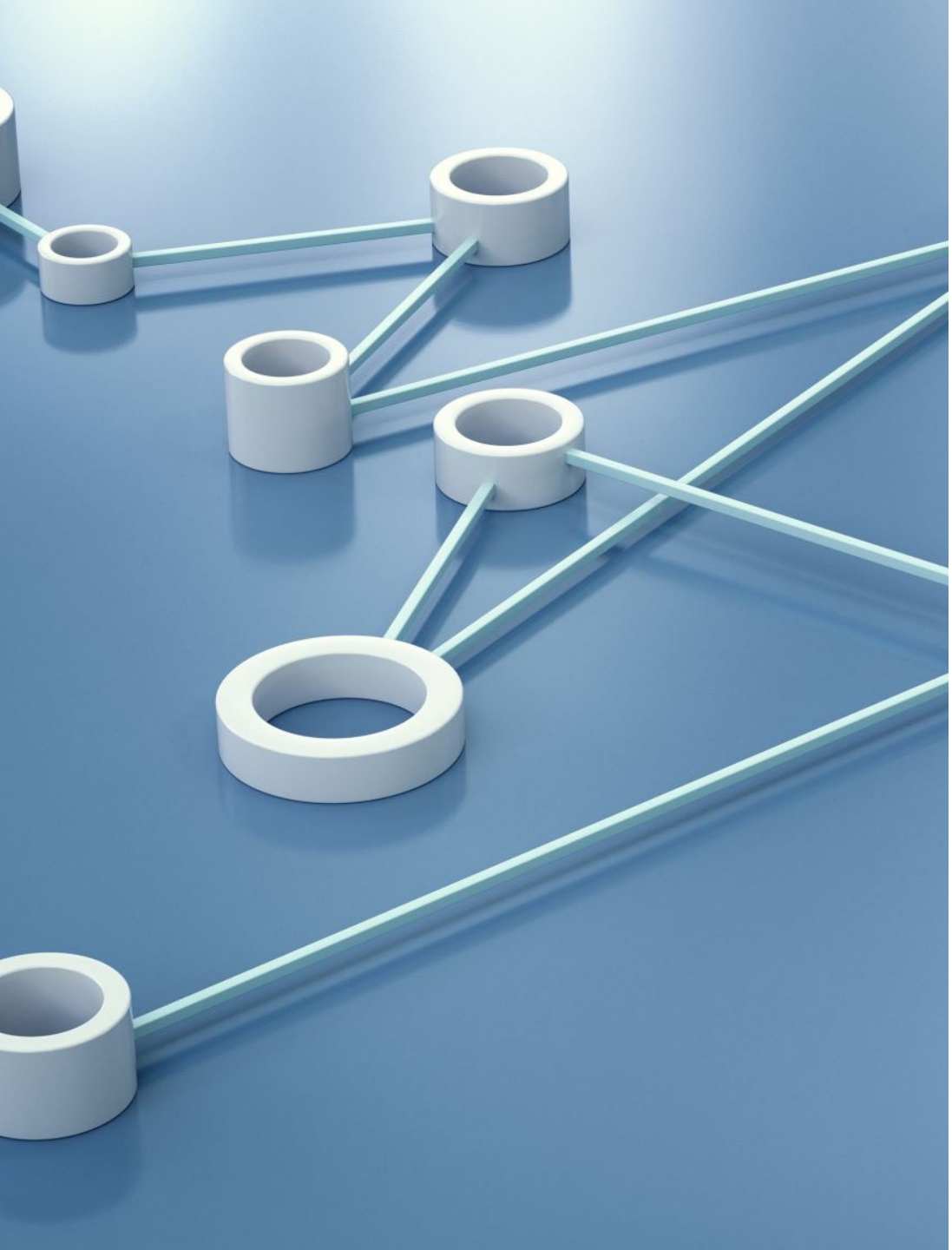
- symmetric digital subscriber line
- upstream and Downstream support same data transfer rate 3Mbps

VDSL

- very High Speed Digital Subscriber Line
- transmits data in the 13 Mbps – 55 Mbps range
- usually between 1000 and 4500 feet

Internet Architecture (continued)

- SONET
  - Synchronous Optical Network
  - establishes Optical Carrier (OC) levels
  - OC-1 = 51.85 Mbps
  - OC-3 = 155.52 Mbps
  - OC-12 = 622.08 Mbps
  - OC-24 = 1.244 Gbps
  - OC-48 = 2.488 Gbps



Communication Protocols

- A ***communications protocol*** is a set of rules that ensures the orderly and accurate transmission and reception of data.
  - Used to prevent noise interference communication protocols are used.

Communication Protocols (continued)

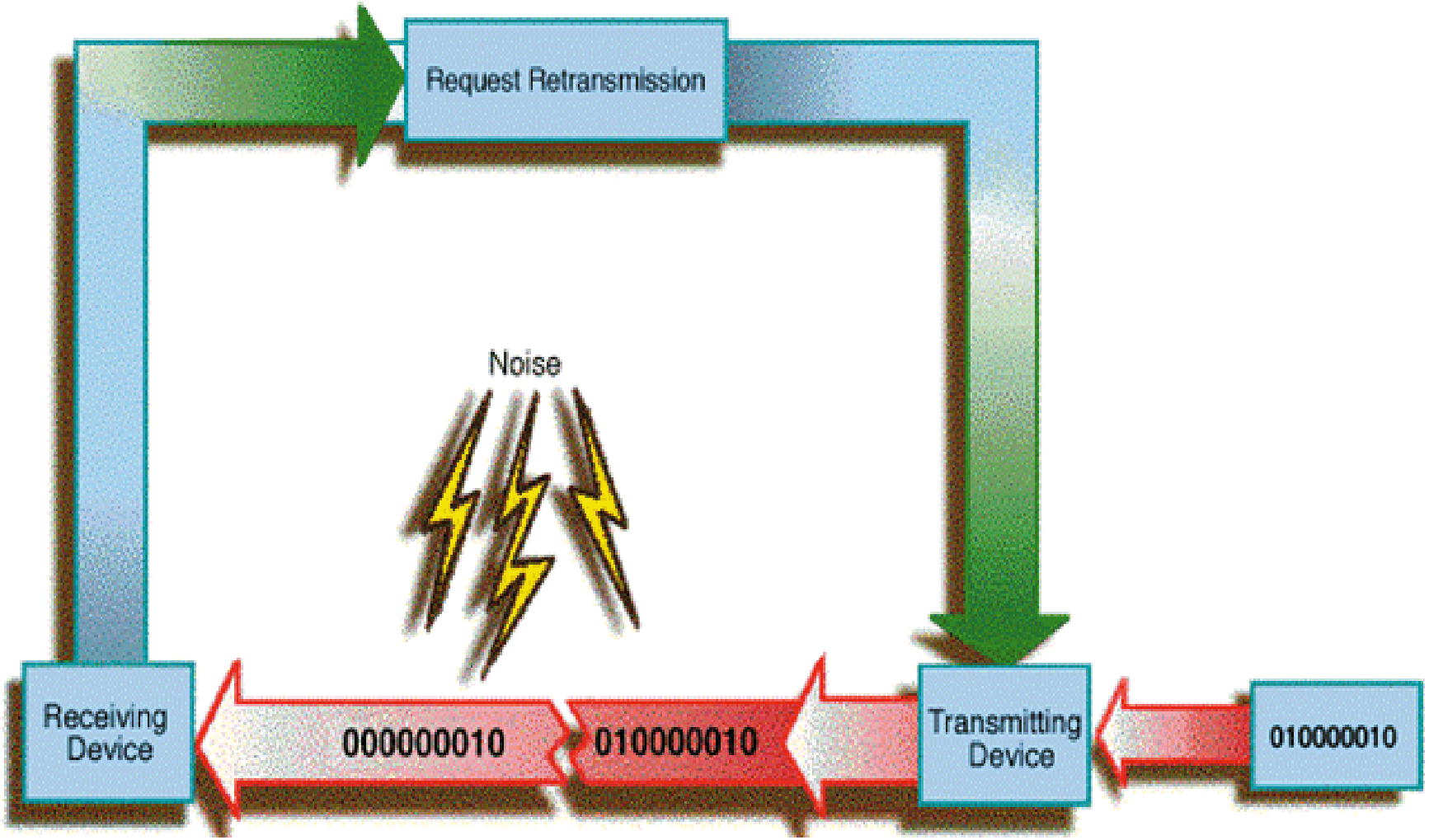
- Protocols are agreed-upon format for transmitting data between two devices. The protocol determines the following:
  - the type of error checking to be used
  - data compression method, if any
  - how the sending device will indicate that it has finished sending a message
  - how the receiving device will indicate that it has received a message

Error-Checking Protocols

- To ensure accurate delivery of data Error checking is used.
- ***Parity checking*** refers to the use of parity bits to check that data has been transmitted accurately. The parity bit is added to every data unit (typically 7 or 8 bits) that are transmitted. The parity bit for each unit is set so that all bytes have either an odd number or an even number of set bits
  - ***parity bits*** - describe the numbers of 0s and 1s in a sequence of data
  - ***even parity*** - number of 1 bits must be even
  - ***odd parity*** - number of 1 bits must be odd

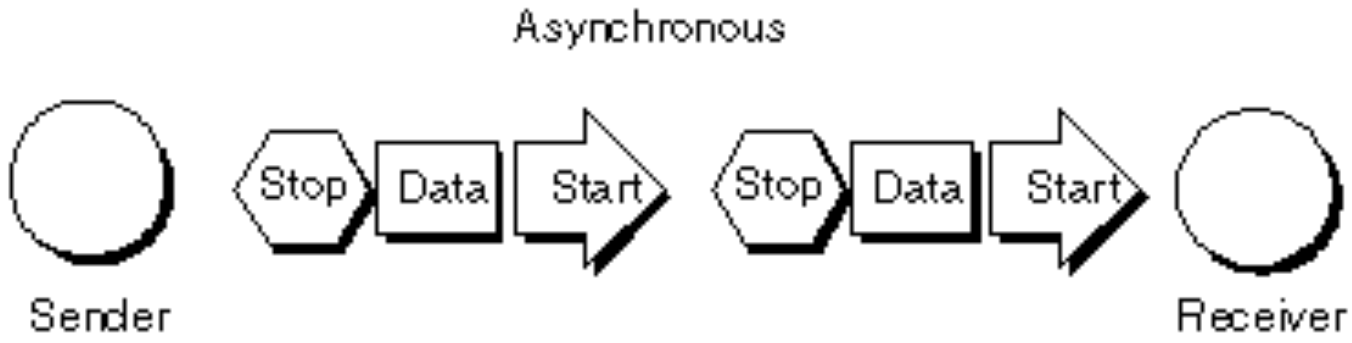
Error-Checking Protocols (continued)

Parity helps a communications system determine whether data has been corrupted during transmission.



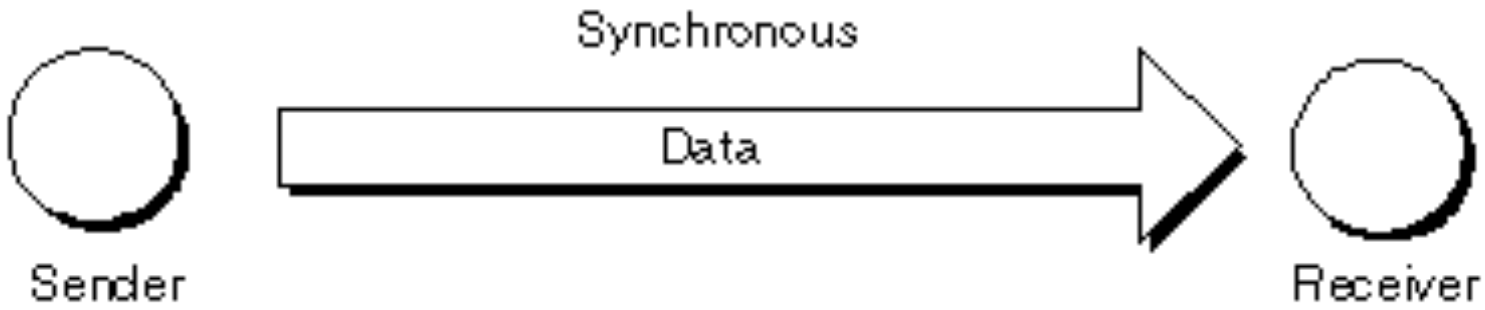
Serial Communication

- Serial communication uses Asynchronous and Synchronous transmission
- ***Asynchronous Transmission***
  - Communications in which data can be transmitted intermittently rather than in a steady stream.
  - Accomplished through a special start bit and stop bit at the beginning and end of each piece of data.
  - Transmits data as one or more series of bytes called a ***block***



Serial Communication (continued)

- ***Synchronous Transmission***
  - The sender and receiver are synchronized by a clock
  - Occurring at regular intervals
  - Usually synchronous and is governed by the microprocessor clock
  - E.g: Bus signals can occur only at specific points in the clock cycle.



Signal Direction

- ***Simplex communication*** - communication in one direction where one party is the transmitter and the other is the receiver (e.g. radio transmitter).
- ***Half-duplex communication*** - communications where only one party can transmit at a time. E.g: CB radio
- ***Full-duplex communication*** - transmission of data in two directions simultaneously. E.g: Telephone
- ***Echoplex communication*** - communication sent and echoed back to check accuracy

End of lecture 12