Network Architecture
Week 1

Module : Computer Networks

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Network Architecture Characteristics

- The term network architecture, refers to both the technologies that support the infrastructure and the programmed services and protocols that move the messages across that infrastructure
- 4 basic characteristics for networks in general to meet user expectations:

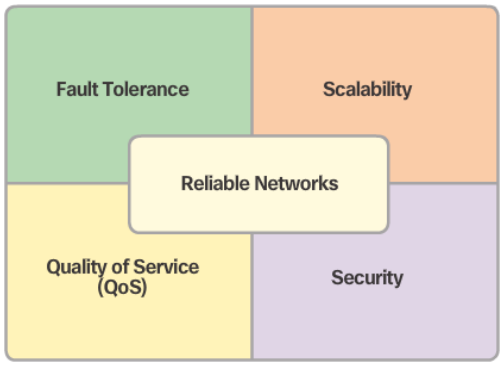
  - Fault tolerance,

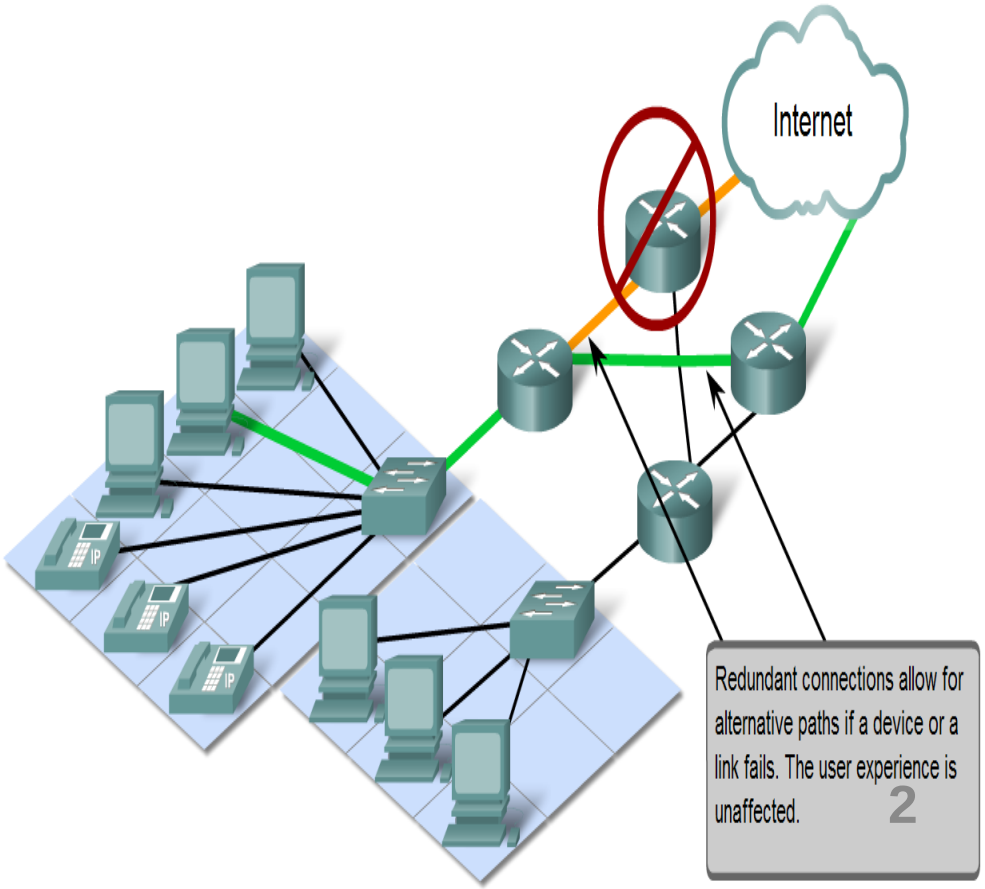
  - Scalability,

  - Quality of service (QoS)

    eg: consistent quality of video

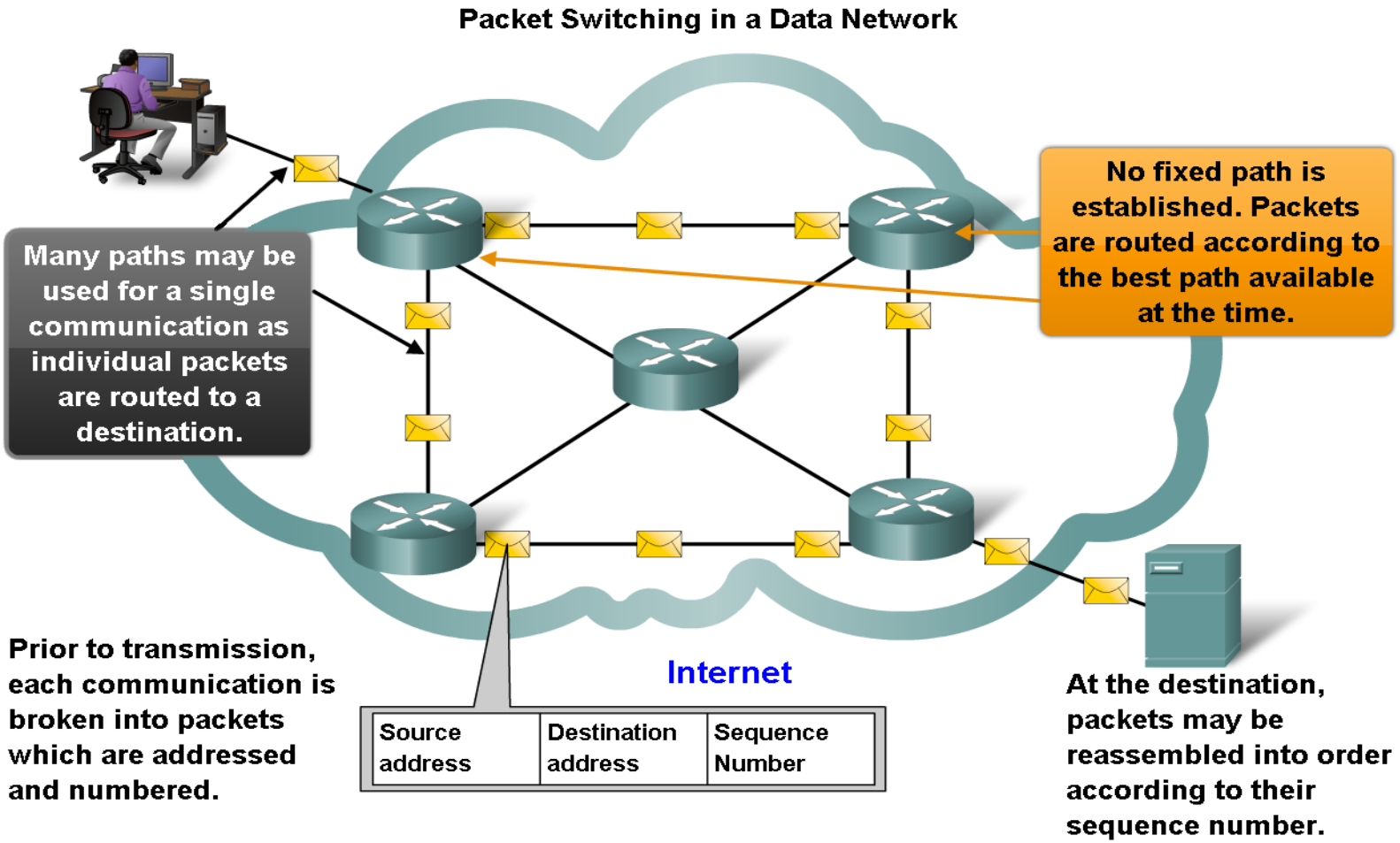
  - Security





Network Architecture Characteristics – Fault Tolerance

- **Packet switching helps improve the resiliency and fault tolerance of the Internet architecture**



Packet Switched Connectionless Network

- A packet switched connectionless network had the features necessary to support a resilient, fault tolerant network architecture

  - The need for a single, reserved circuit from end-to-end does not exist

  - Any piece of a message can be sent through the network using any available path

  - Packets containing pieces of messages from different sources can travel the network at the same time

- By providing a method to dynamically use redundant paths, without intervention by the user, the Internet has become a fault tolerant, scalable method of communications.

Circuit Switched Connection-Oriented Network (e.g. PSTN)

- Nevertheless, there are some advantages of using Circuit Switched Connection-Oriented Network

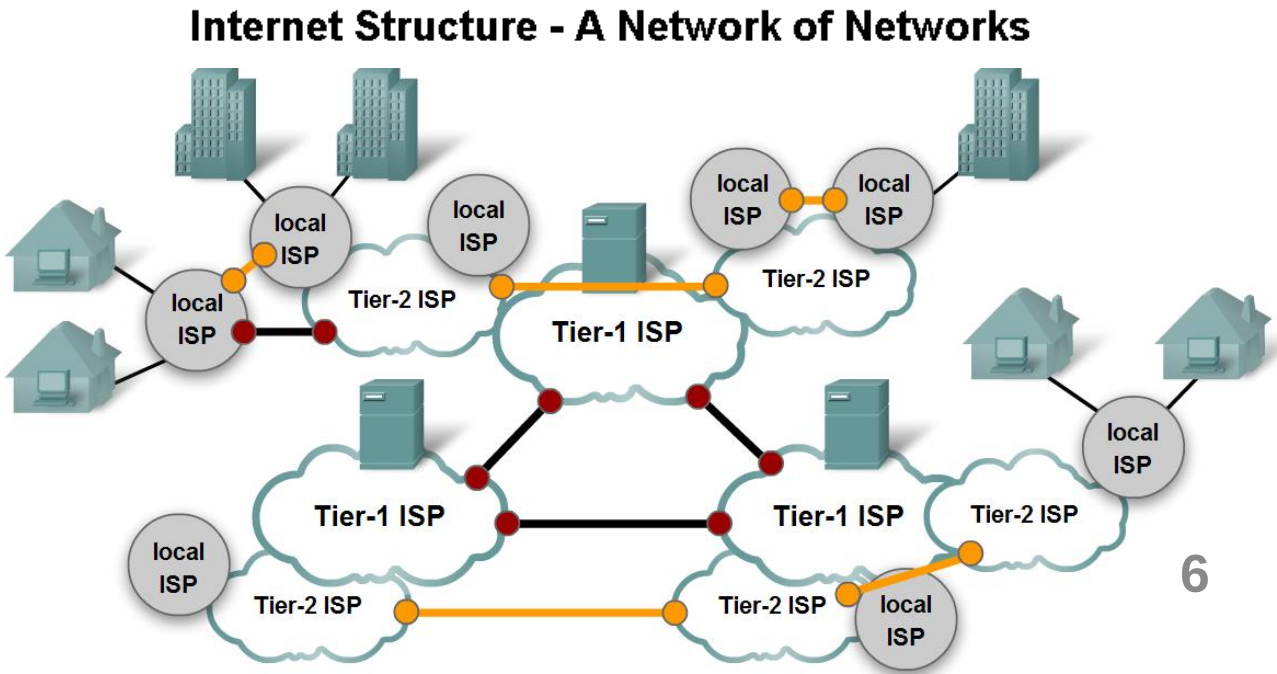
  - Resources at the various switching locations are dedicated to providing a finite number of circuits, the quality and consistency of messages transmitted across a connection-oriented network can be guaranteed

  - The provider of the service can charge the users of the network for the period of time that the connection is active

Network Architecture Characteristics - Scalability

- Certain characteristics of the Internet help it scale to meet user demand
  - –Hierarchical
  - –Common standards
  - –Common protocols
- There is no single organization that regulates the Internet, the operators of the many individual networks that provide Internet connectivity cooperate to follow accepted standards and protocols

The adherence to standards enables the manufacturers of hardware and software to concentrate on product improvements in the areas of performance and capacity, knowing that the new products can integrate with and enhance the existing infrastructure



Providing Quality of Service (QoS)

- The packet-switched network architecture does not guarantee that all packets that comprise a particular message will arrive on time, in their correct order, or even that they will arrive at all.
- Networks also need mechanisms to manage congested network traffic.
- Networks does not have infinite resources, therefore QoS is necessary.
- Constraints of resources:

  - Technologies

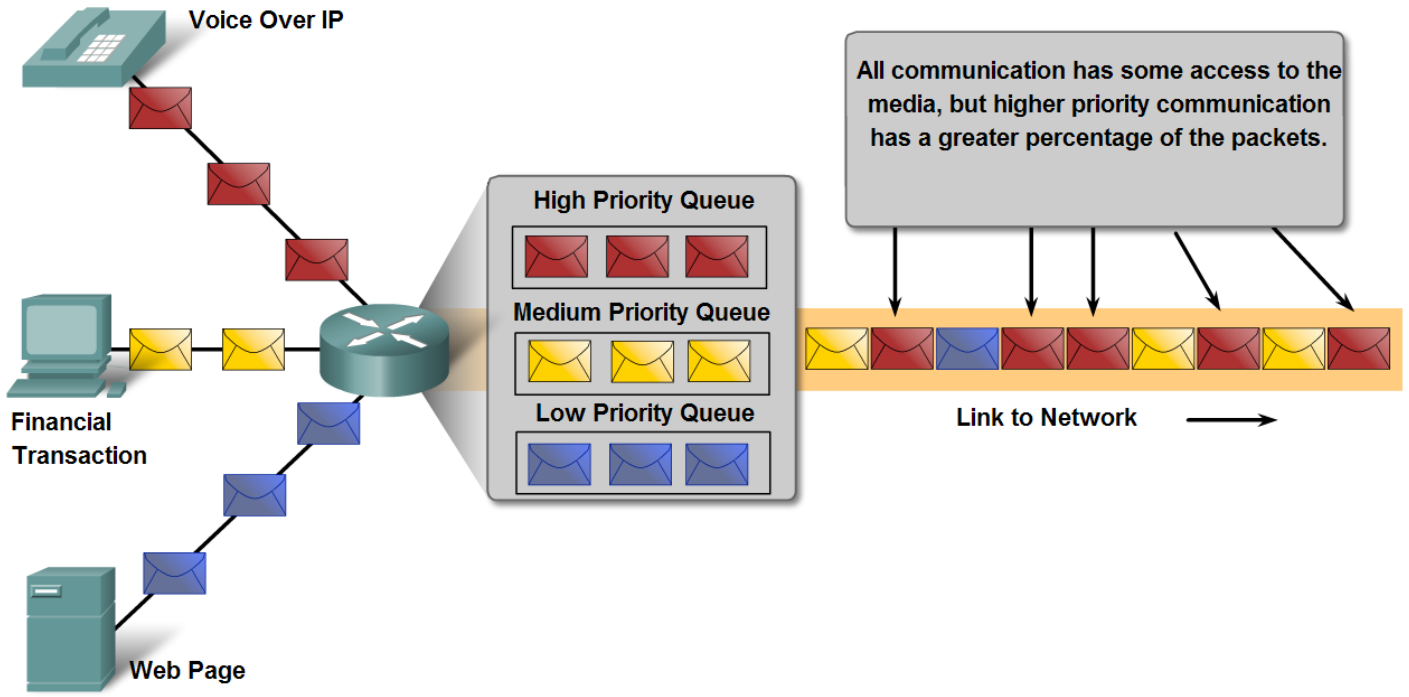
  - Costs,

  - The local availability of high-bandwidth service

Network Architecture Characteristics: Quality of Service (QoS)

In order to maintain a high quality of service for applications that require it, it is necessary to prioritize which types of data packets must be delivered at the expense of other types of packets that can be delayed or dropped

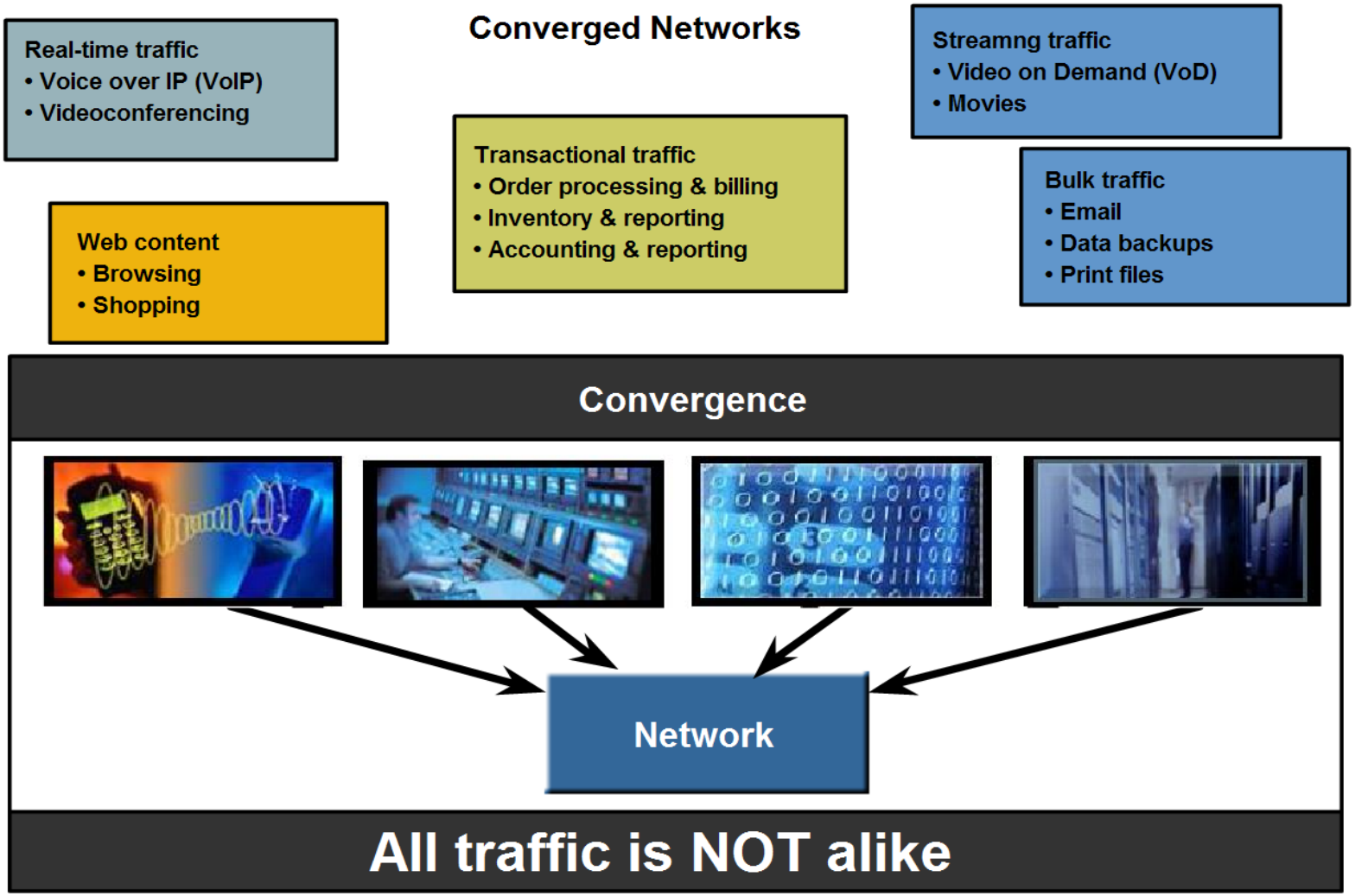
Using Queues to Prioritize Communication



Queuing according to data type enables voice data to have priority over transaction data, which has priority over web data.

Network Architecture Characteristics - QoS

- QoS mechanisms work to ensure quality of service for applications that require it.

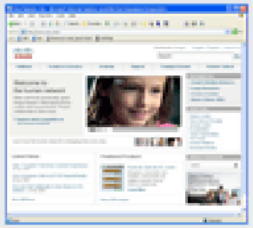
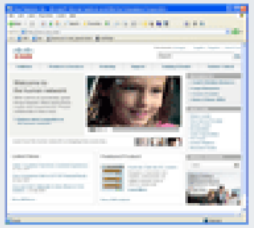


Network Architecture Characteristics - QoS

Quality of Service Matters

Communication Type	Without QoS	With QoS
Streaming video or audio	 Choppy picture starts and stops.	 Clear, continuous service.

Vital Transactions	`Time : Price`
	`02:14:05 $1.54`
	Just one second earlier...
		`Time : Price`
		`02:14:04 $1.52`
		The price may be better.

Downloading web pages (often lower priority)	 Web pages arrive a bit later...	 But the end result is identical.

Providing Network Security

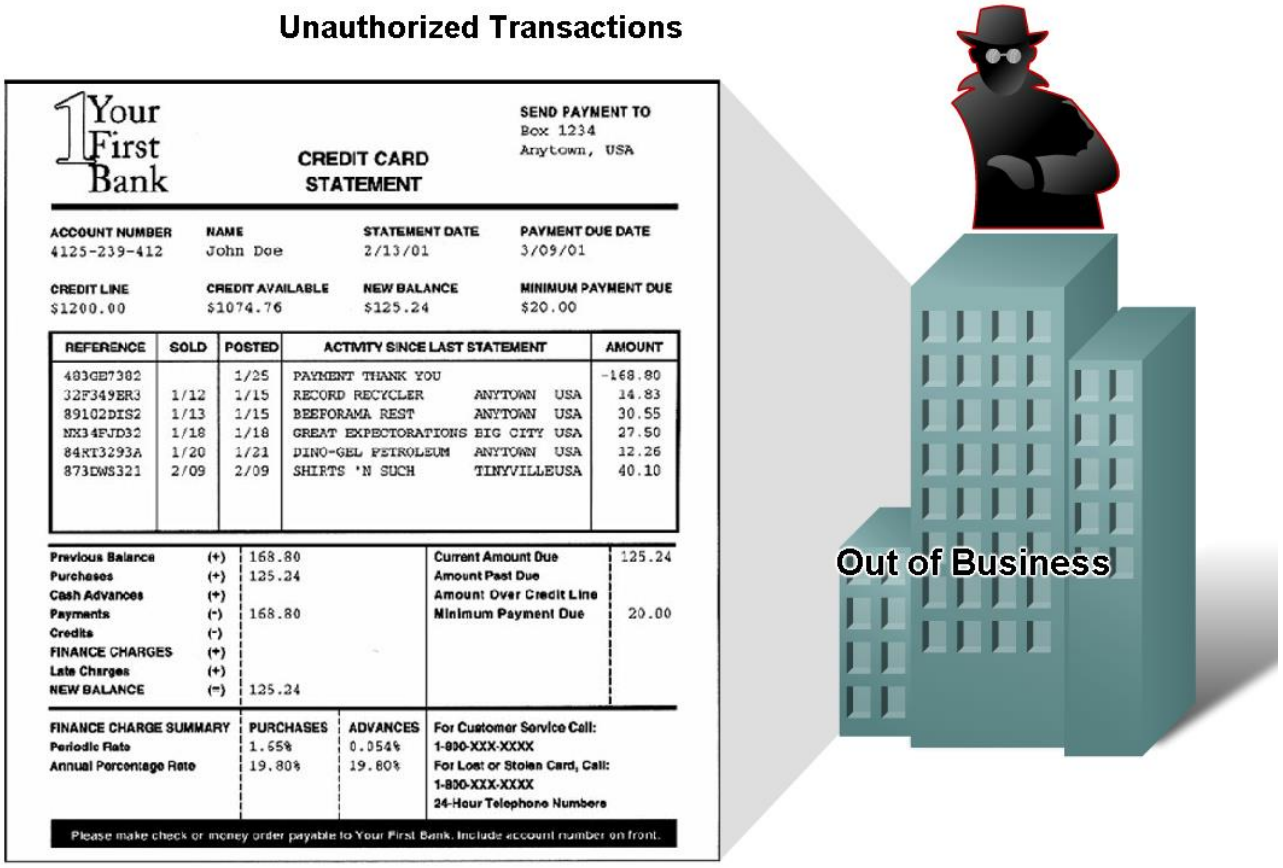
- Unauthorized use of communication data might have serious consequences
- 2 types of network security concerns that must be addressed to prevent serious consequences:

  - Network Infrastructure Security - physical securing of devices that provide network connectivity and preventing unauthorized access to the management software that resides on them

  - Content Security - protecting the information contained within the packets being transmitted over the network and the information stored on network attached devices

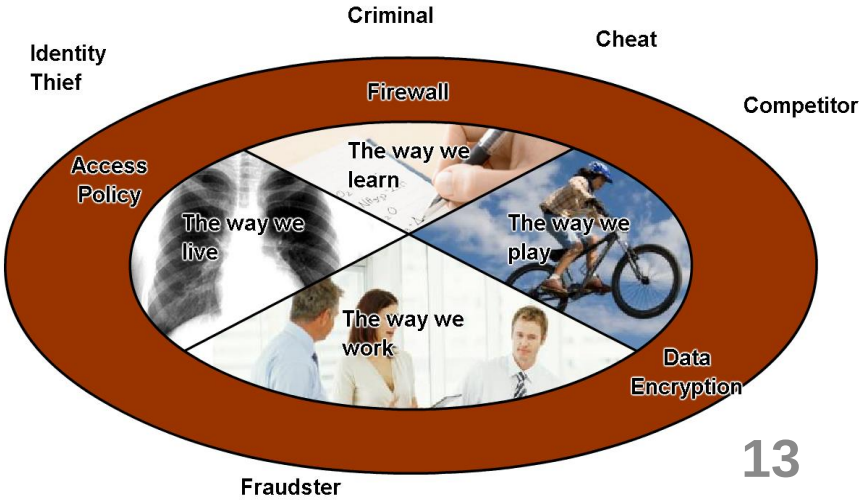
Network Architecture Characteristics - Security

- **2 Types of security – infrastructure & content**



Network Architecture Characteristics - Security

- 3 Primary goals of Network Security
  - Preventing theft of information
  - Preventing unauthorised changes of information
  - Preventing Denial of Service (DoS)
- Basic measures to secure data networks
  - –Ensure confidentiality through use of
    - •User authentication
    - •Data encryption
  - –Maintain communication integrity through use of
    - •Digital signatures
  - –Ensure availability through use of
    - •Firewalls
    - •Redundant network architecture
    - •Hardware without a single point of failure



Importance of Bandwidth

Why bandwidth is important:

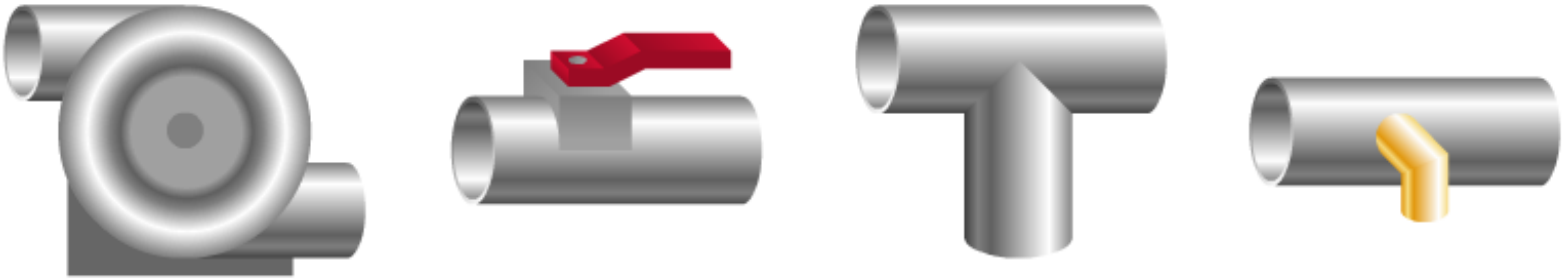
- Bandwidth is limited by physics and technology
- Bandwidth is not free
- Bandwidth requirements are growing at a rapid rate
- Bandwidth is critical to network performance

Bandwidth is defined as the amount of information that can flow through a network connection in a given period of time.

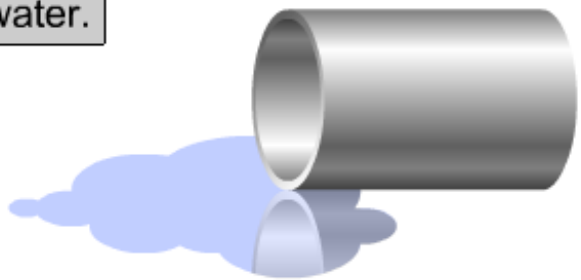
Bandwidth Analogies

Bandwidth is like the width of a pipe.

Network devices are like pumps, valves, fittings, and taps.



Packets are like water.

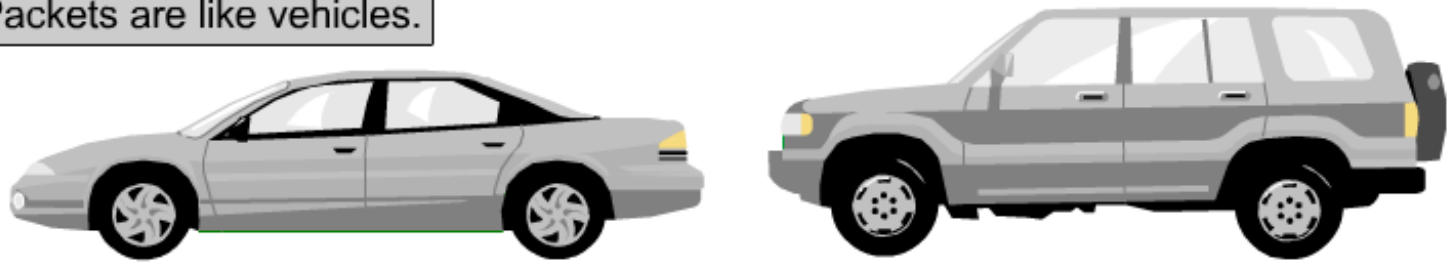


Bandwidth Analogies

Bandwidth is like the number of lanes on a highway.

Network devices are like on-ramps, traffic signals, signs, and maps.

Packets are like vehicles.



Measurement

Unit of Bandwidth	Abbreviation	Equivalence
Bits per second	bps	1 bps = fundamental unit of bandwidth
Kilobits per second	kbps	1 kbps = 1,000 bps = 10^3 bps
Megabits per second	Mbps	1 Mbps = 1,000,000 bps = 10^6 bps
Gigabits per second	Gbps	1 Gbps = 1,000,000,000 bps = 10^9 bps
Terabits per second	Tbps	1 Tbps = 1,000,000,000,000 bps = 10^{12} bps

In digital systems, the basic unit of bandwidth is **bits per second (bps)**. Bandwidth is the measure of how much information, or bits, can flow from one place to another in a given amount of time, or seconds.

Throughput

Throughput refers to actual measured bandwidth, at a specific time of day, using specific Internet routes, and while a specific set of data is transmitted on the network. Unfortunately, for many reasons, throughput is often far less than the maximum possible digital bandwidth of the medium that is being used. The following are some of the factors that determine throughput:

- Internetworking devices
- Type of data being transferred
- Network topology
- Number of users on the network
- User computer
- Server computer
- Power conditions

http://www.broadbandspeedtest.ie/

Data Transfer Calculation

Best Download

$$T = \frac{S}{BW}$$

Typical Download

$$T = \frac{S}{P}$$

BW	Maximum theoretical bandwidth of the "slowest link" between the source host and the destination host (measured in bits per second)
P	Actual throughput at the moment of transfer (measured in bits per second)
T	Time for file transfer to occur (measured in seconds)
S	File size in bits

Key takeaways so far….

- 4 basic characteristics of network architecture
  - Fault tolerant
  - Scalable
  - Quality of service (QoS)
  - Security
- Difference between Bandwidth and Throughput