

Broadband Technologies and Applications: A Tutorial

Presentation by

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Introduction

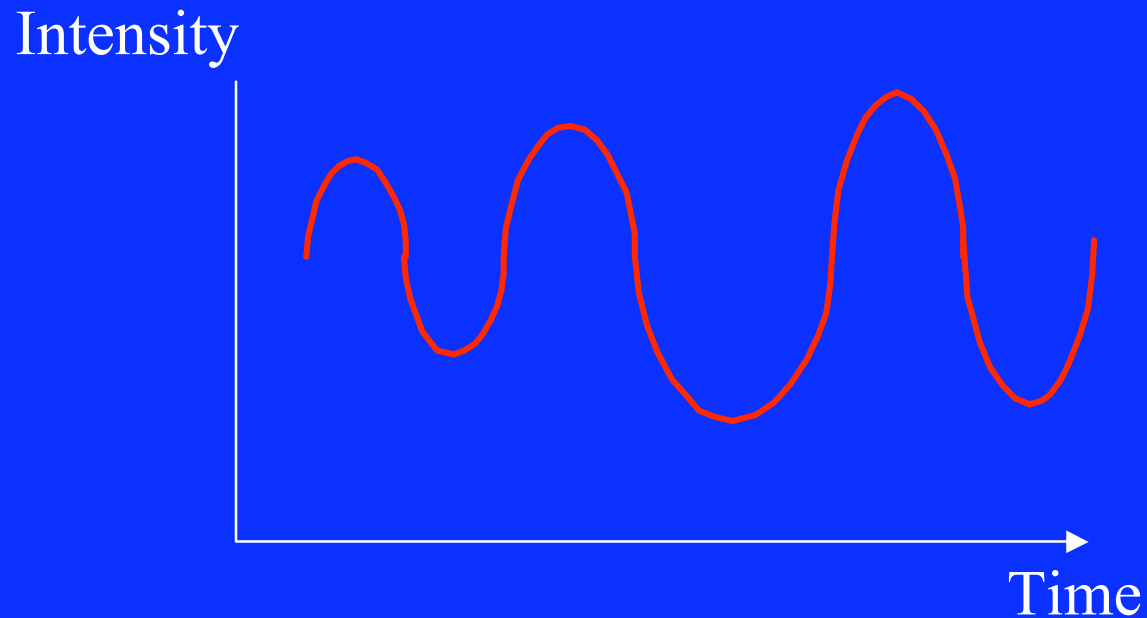
- Purpose:
 - To provide non-engineers with an overview of major trends in telecommunications technology and to reflect briefly on the policy and regulatory implications of those trends

Outline

- The Digital Revolution
- The Race for Broadband
- The Wireless Revolution
- The Role of the Internet, the Internet Protocols and “Intelligence at the Edge”
- Convergence and Its Implications

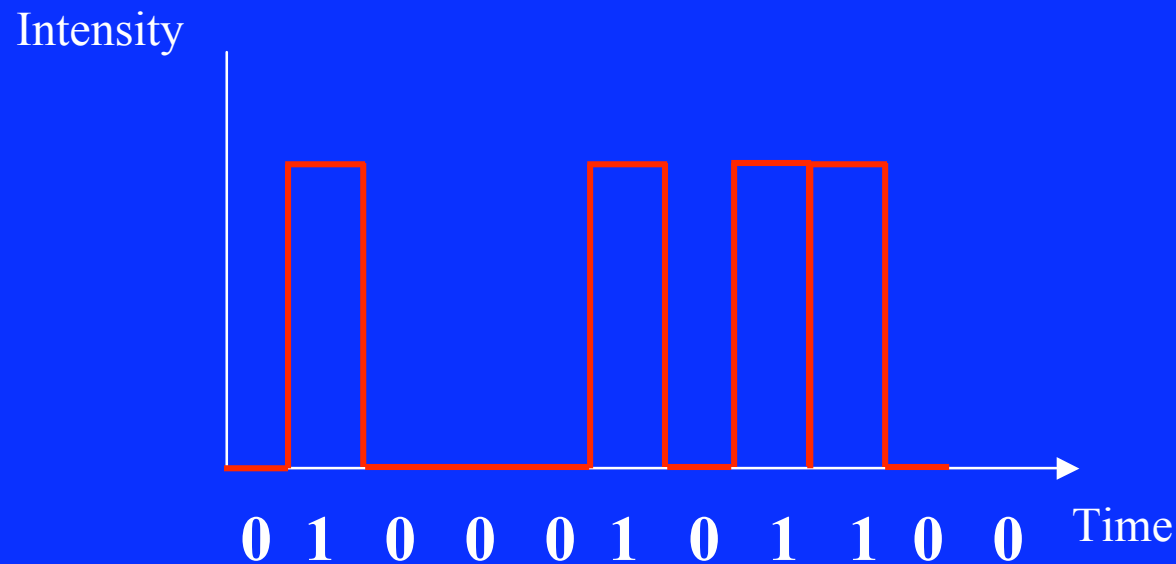
The Digital Revolution

- Analog Signal



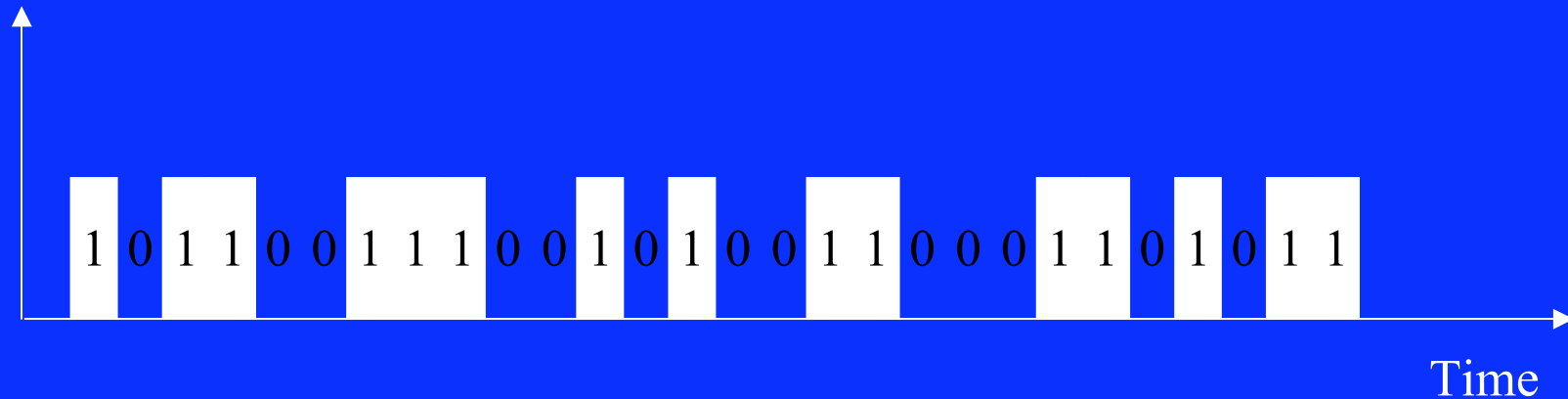
The Digital Revolution

- Digital Signal



The Digital Revolution

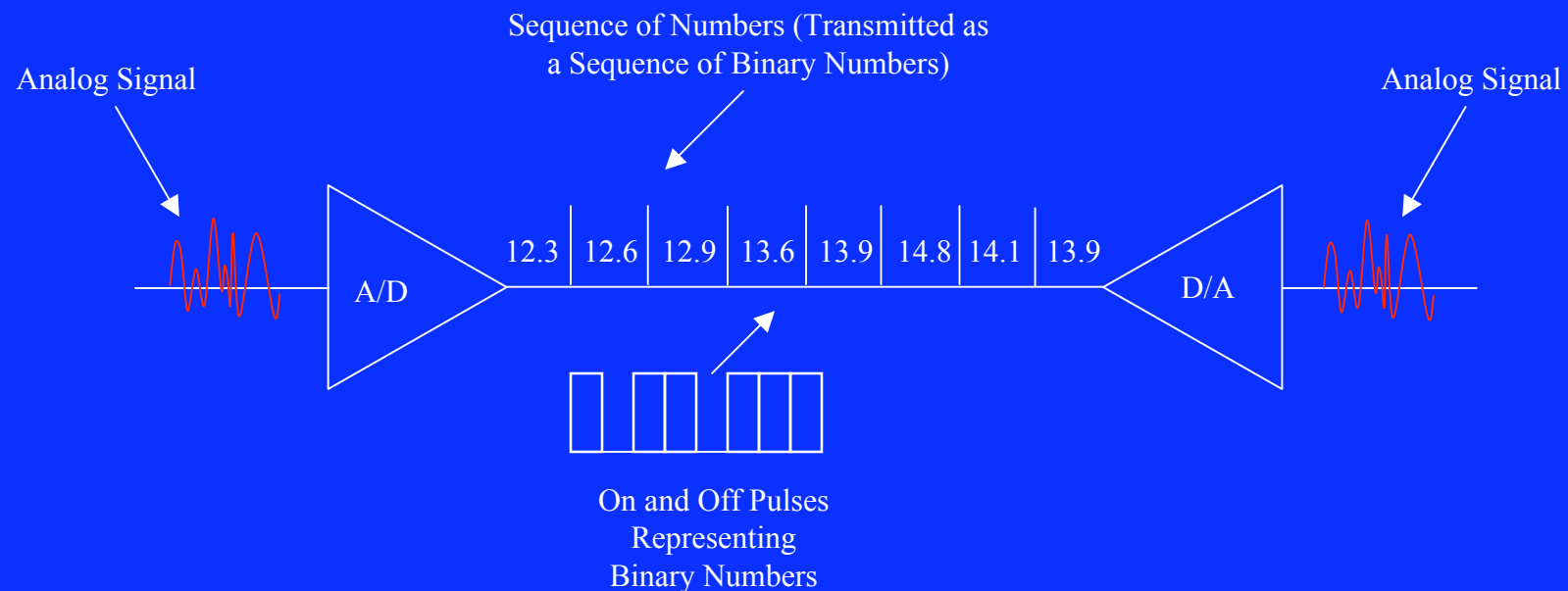
- Analog and Digital Networks



Digital Network: voice, data, image and video
information carried as a sequence of ones and zeros
represented by pulses of current or light or radio waves

The Digital Revolution

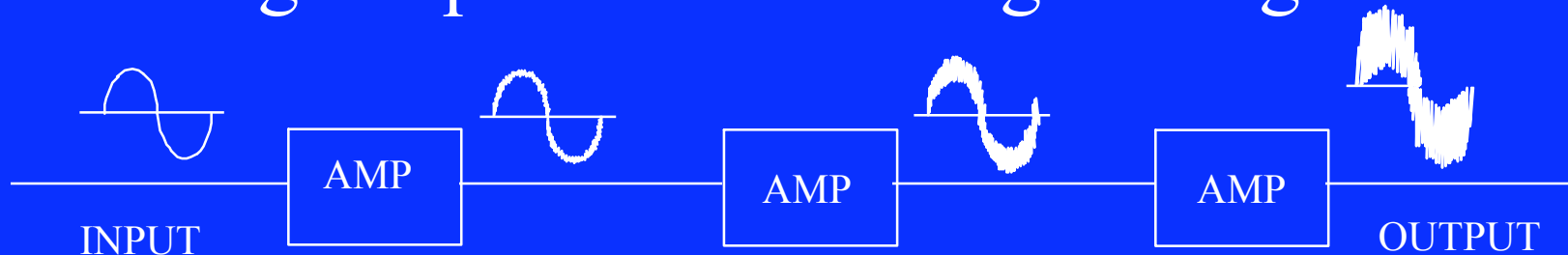
- Analog to Digital and Digital to Analog Conversion



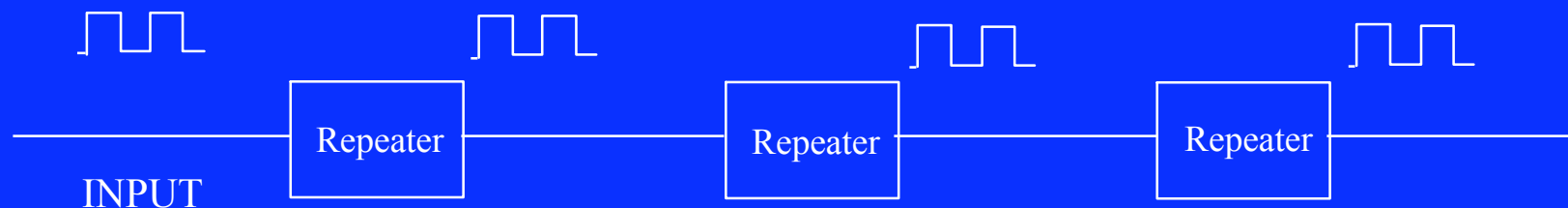
The Digital Revolution

- Why Digital?

- Analog Amplification vs. Digital Regeneration



Analog Amplification: Noise Accumulates



Digital Regeneration: “Perfect” Signal is Regenerated

The Digital Revolution

- Why Digital?
 - Digital Regeneration



-- Other Advantages (Examples):

- Ease of combining different kinds of signals (multiplexing)
- Rapid decline in costs and improvements in performance of digital devices (“chips”)
- Ease of encryption

The Race for Broadband

- What Is Bandwidth?
 - In simple terms, bandwidth is just a measure of how fast information can be transmitted
 - The larger the bandwidth, the more information that can be transmitted in a given amount of time
 - In the digital world, bandwidth is measured in bits per second
 - Analogous measures: vehicles per hour or gallons per minute

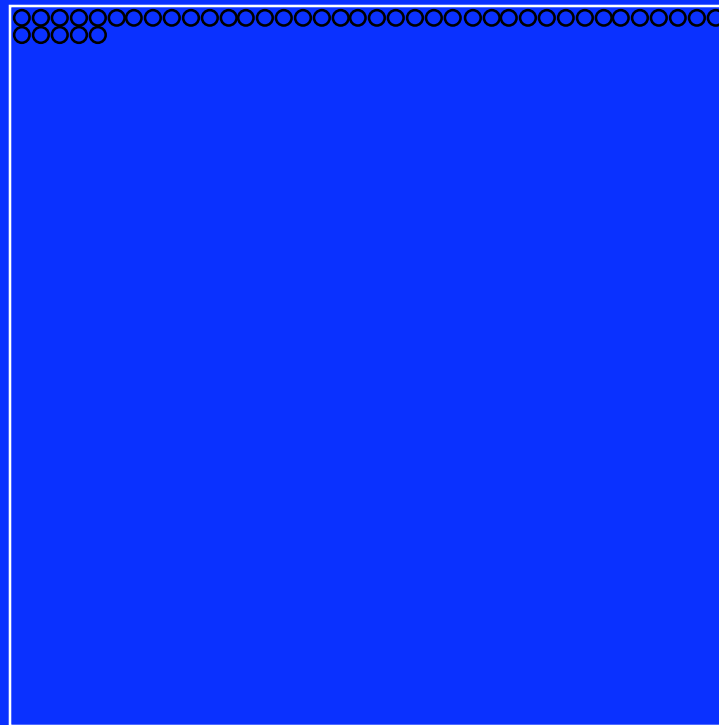
The Race for Broadband

- What Is Bandwidth?
 - To over simplify:
 - Voice requires only narrow bandwidths (narrowband)
 - Still images require wide bandwidths (wideband)*
 - Video requires broad bandwidths (broadband)

*For transmission of the image in a reasonable amount of time

The Race for Broadband

- Illustration of the Importance of Bandwidth



Computer Monitor

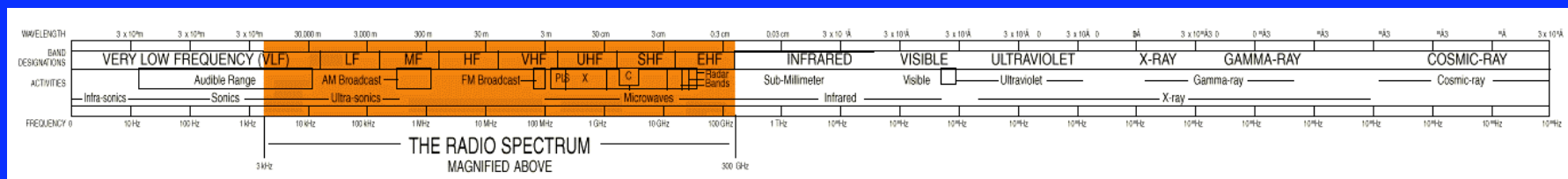
The Wireless Revolution

- What Is Spectrum?
 - “Spectrum” is a conceptual tool used to organize and map a set of physical phenomena
 - Electric and magnetic fields produce (electromagnetic) waves that move through space at different frequencies
 - The set of all possible frequencies is called the “electromagnetic spectrum”

The Wireless Revolution

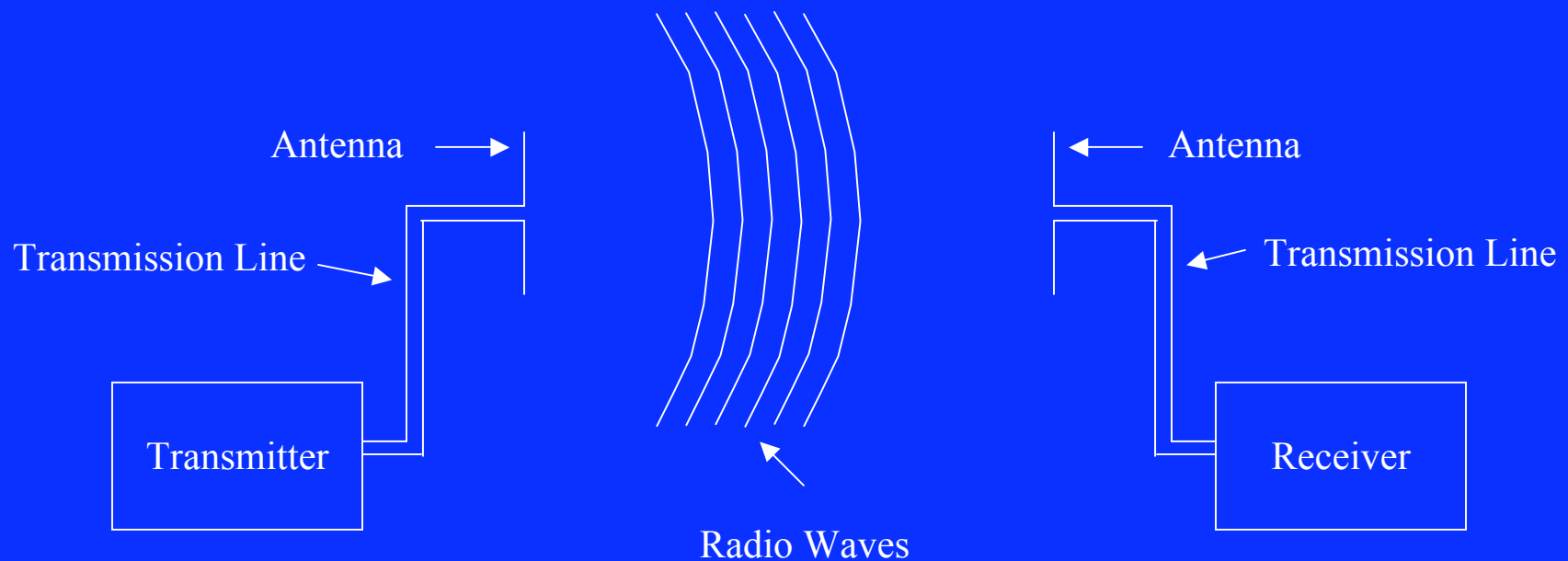
- What Is Spectrum?
 - The subset of frequencies between 3,000 Hz and 300 GHz is known as the “radio spectrum”
 - Note that radio waves do not require a medium *per se*, that is, radio waves can travel through a vacuum (e.g., outer space)

Electromagnetic Spectrum



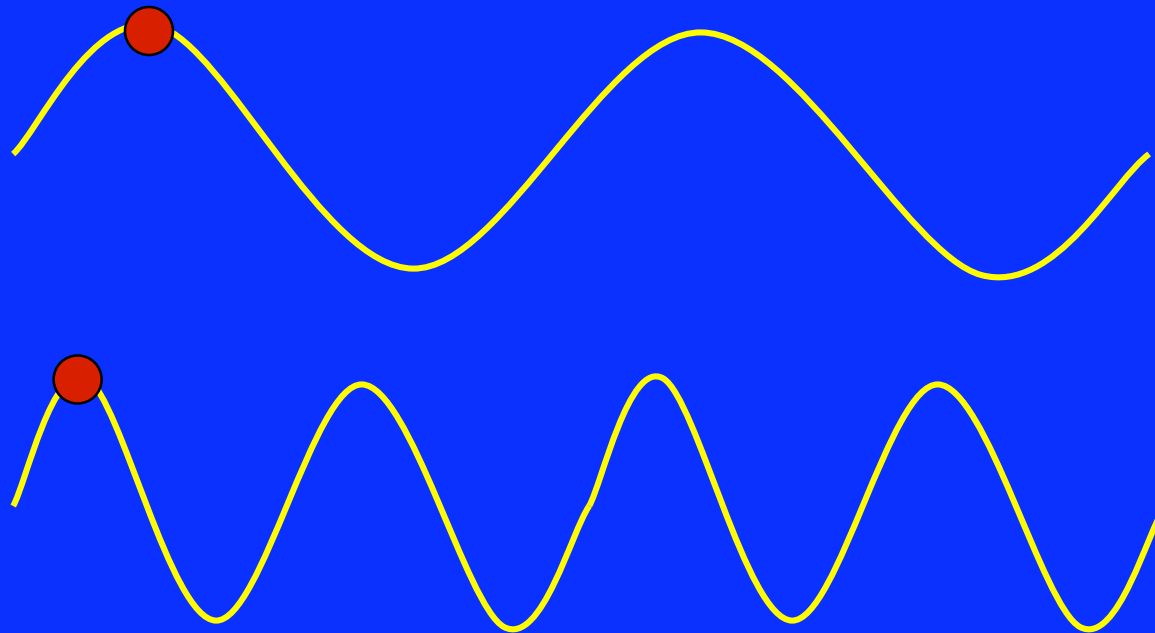
The Wireless Revolution

- A Radio Communications Link



The Wireless Revolution

- Relationship Between Frequency and Wavelength

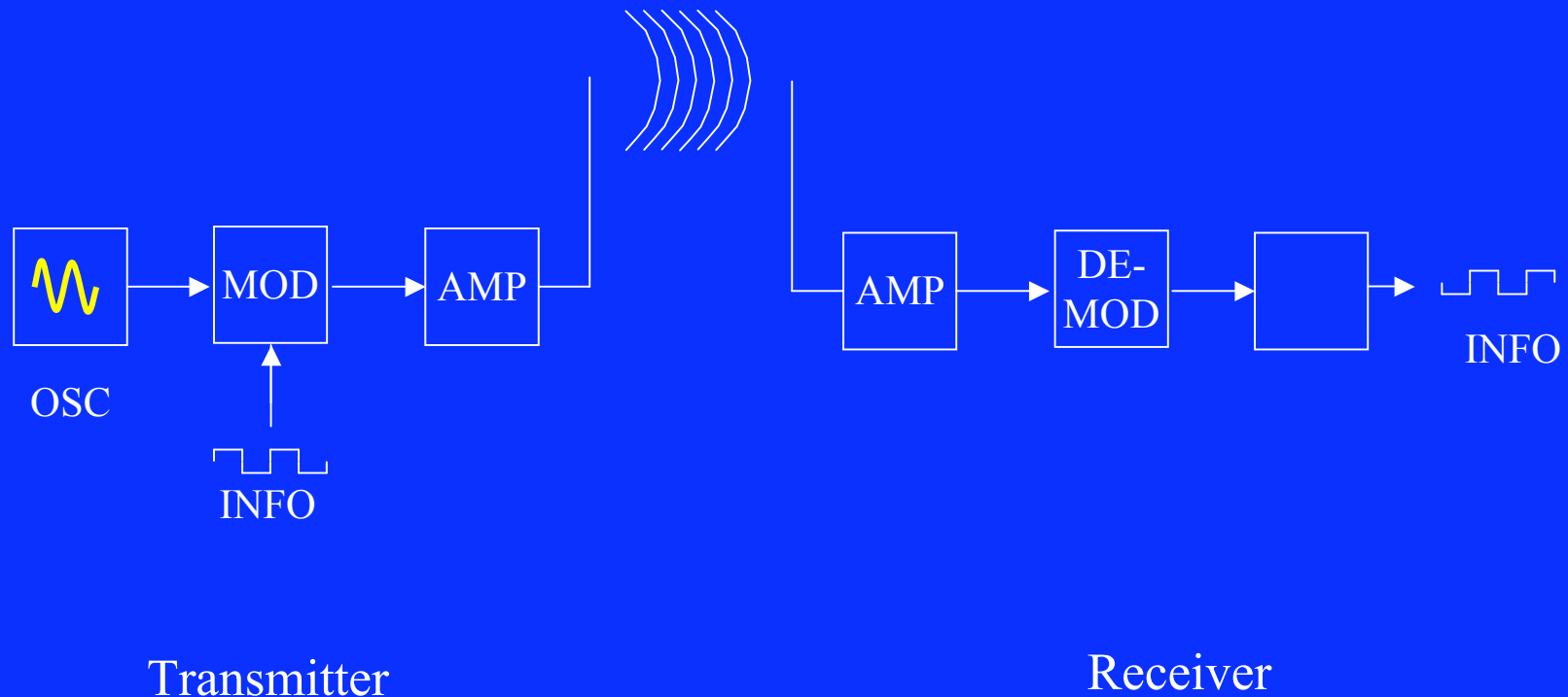


The Wireless Revolution

- Characteristics of Different Frequencies
 - Some Factors Vary with Frequency
 - How fast the wave weakens with distance
 - Size of efficient antennas
 - Ability of the waves to penetrate buildings
 - Ability of the waves to penetrate through trees and other vegetation
 - Reflectivity of various objects to the waves

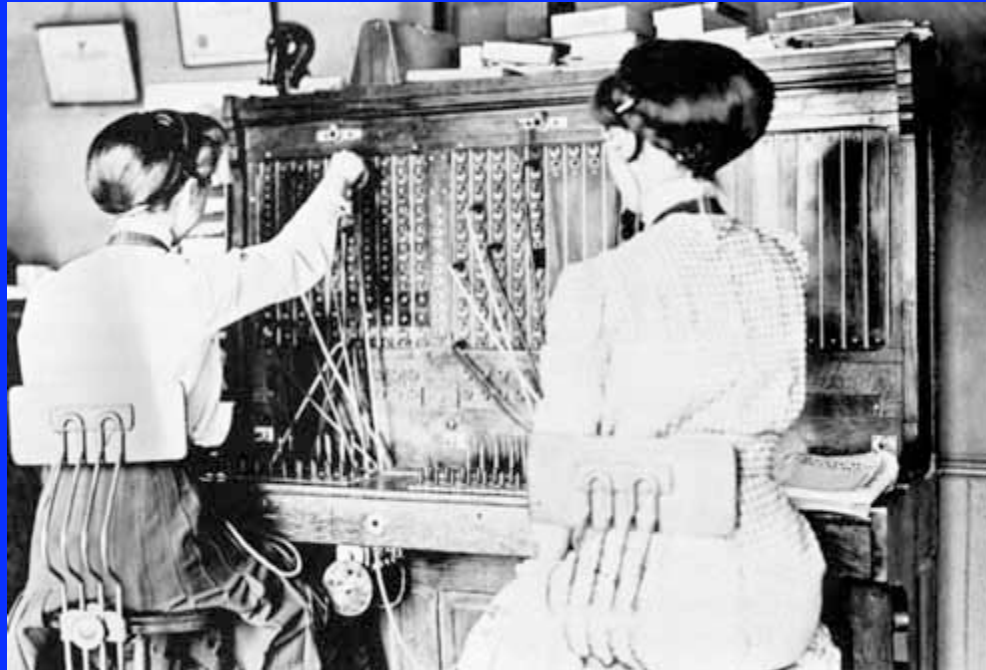
The Wireless Revolution

- Modulation and Demodulation
 - Transmitter and Receiver – Basic Building Blocks



The Role of the Internet

- Telephone Switching

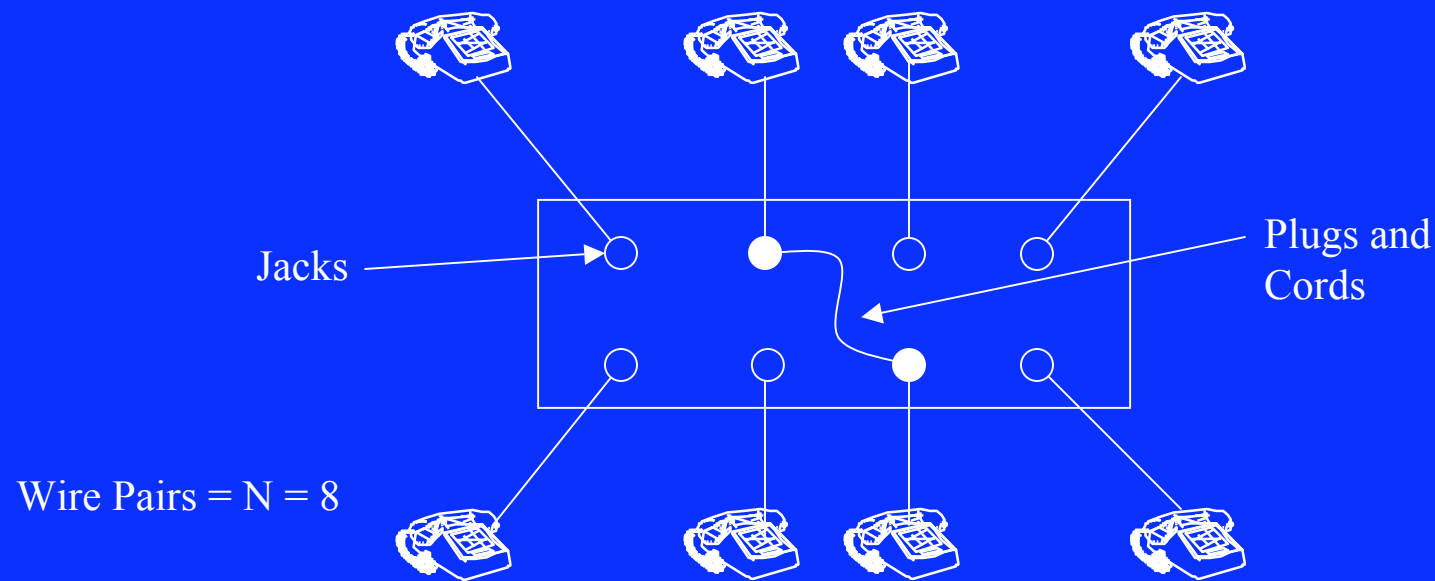


Laura Robbins and Maud Ware at telephone switchboard 1910

Source: [bchs.kearney.net/ BTales_198302.htm](http://bchs.kearney.net/BTales_198302.htm)

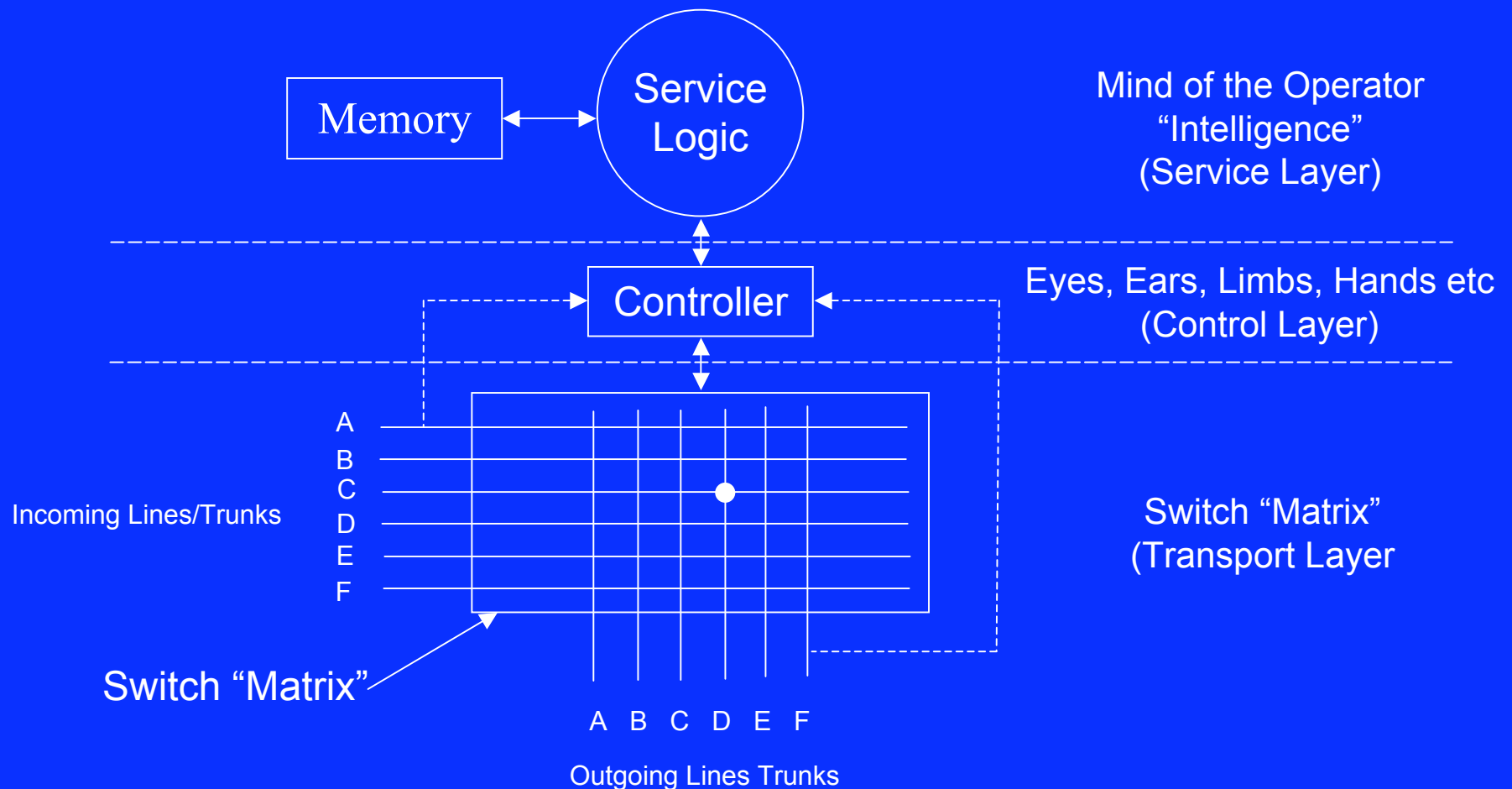
The Role of the Internet

- A Telephone Switchboard



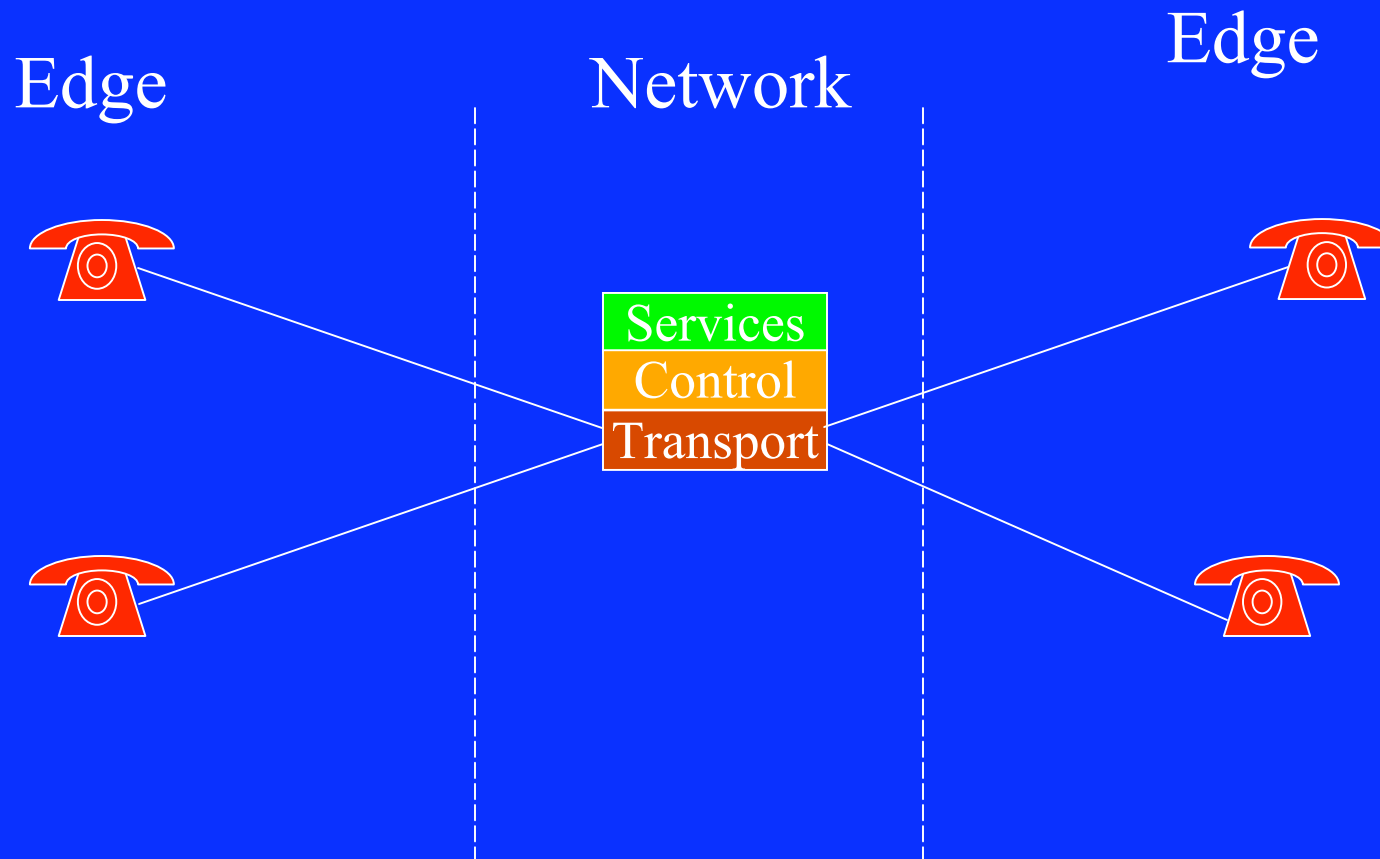
The Role of the Internet

- A Simple Telephone Switch – Manual or Automatic



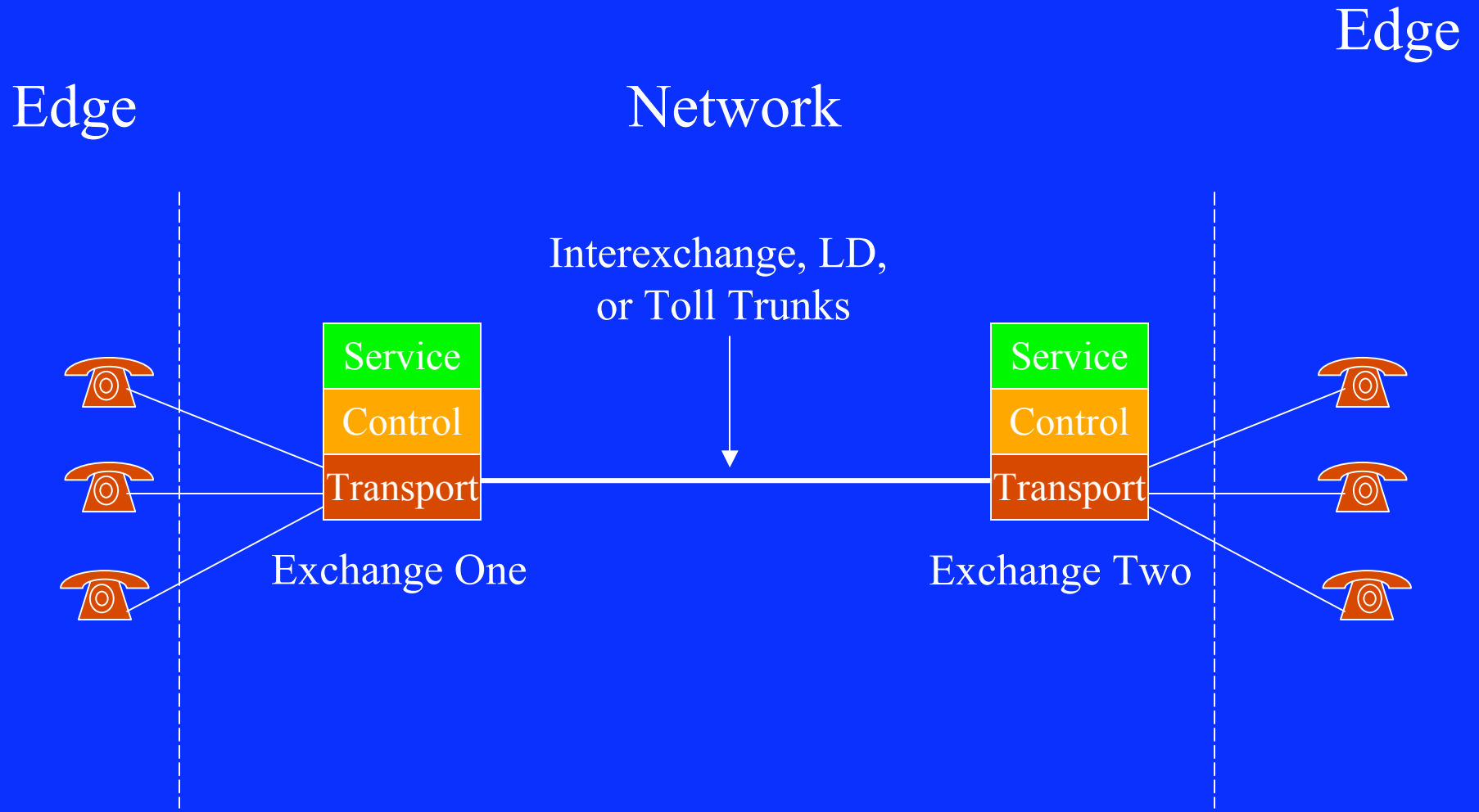
The Role of the Internet

- A Telephone Exchange



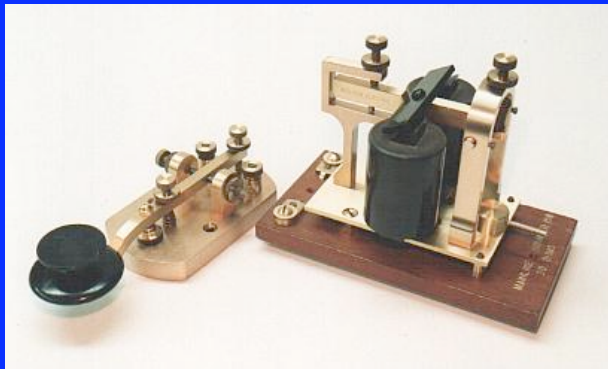
The Role of the Internet

- A Telephone Network



The Role of the Internet

- The Telegraph and Message Switching



Telegraph Key and Sounder



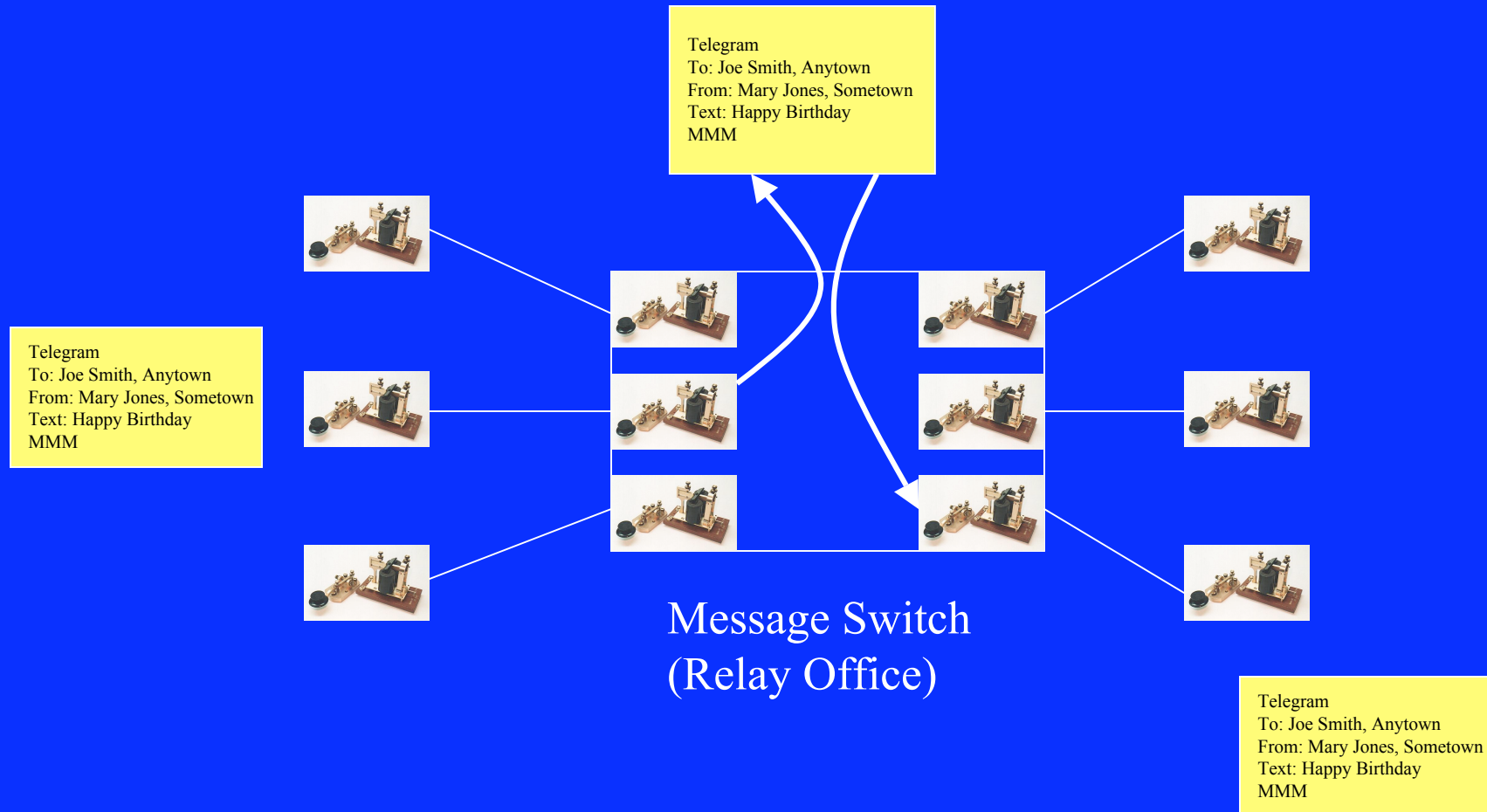
Telegraph Relay Office

Telegraph Key and Sounder Image from: www.jerry-howell.com/Telegraph.html

Telegraph Relay Office Image from: <http://www.coloradoplains.com/otero/souvenir/page23.htm>

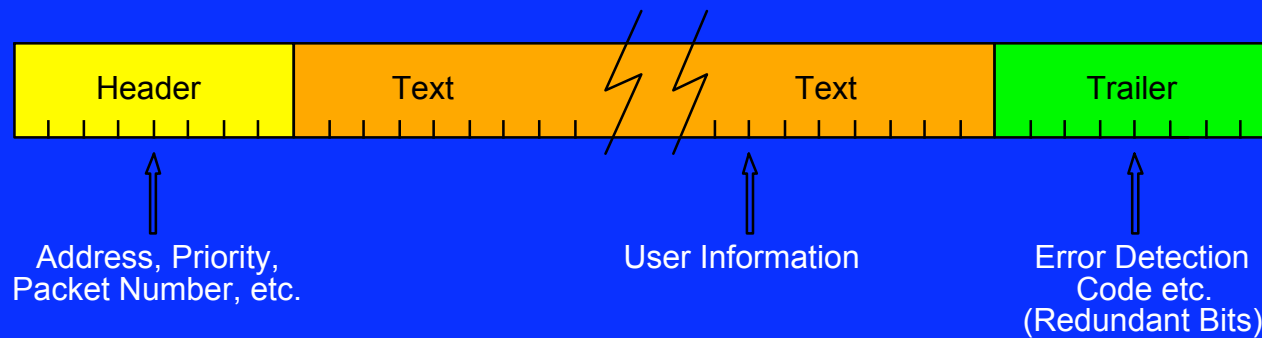
The Role of the Internet

- A Message Switch



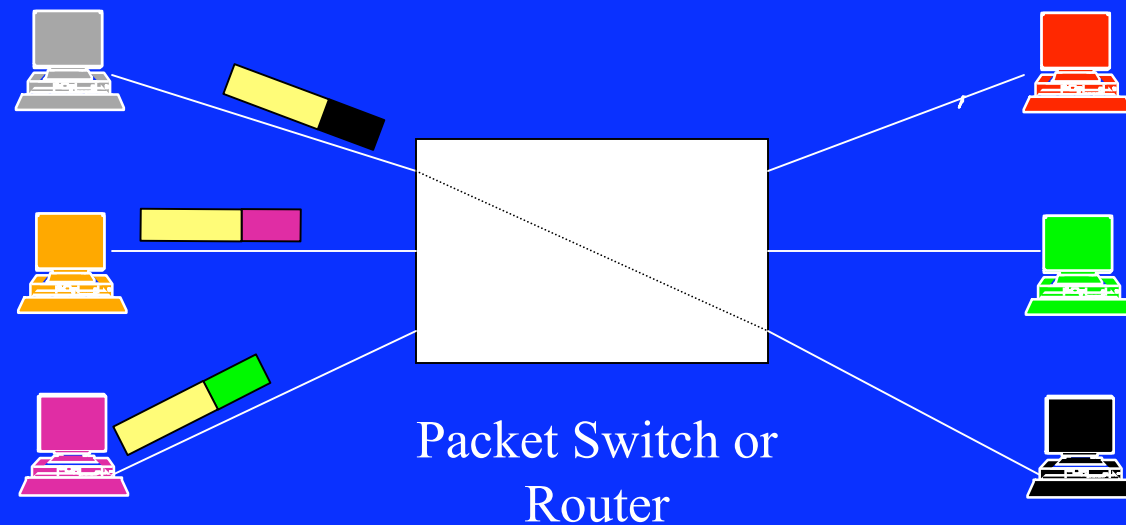
The Role of the Internet

- A Packet of Information



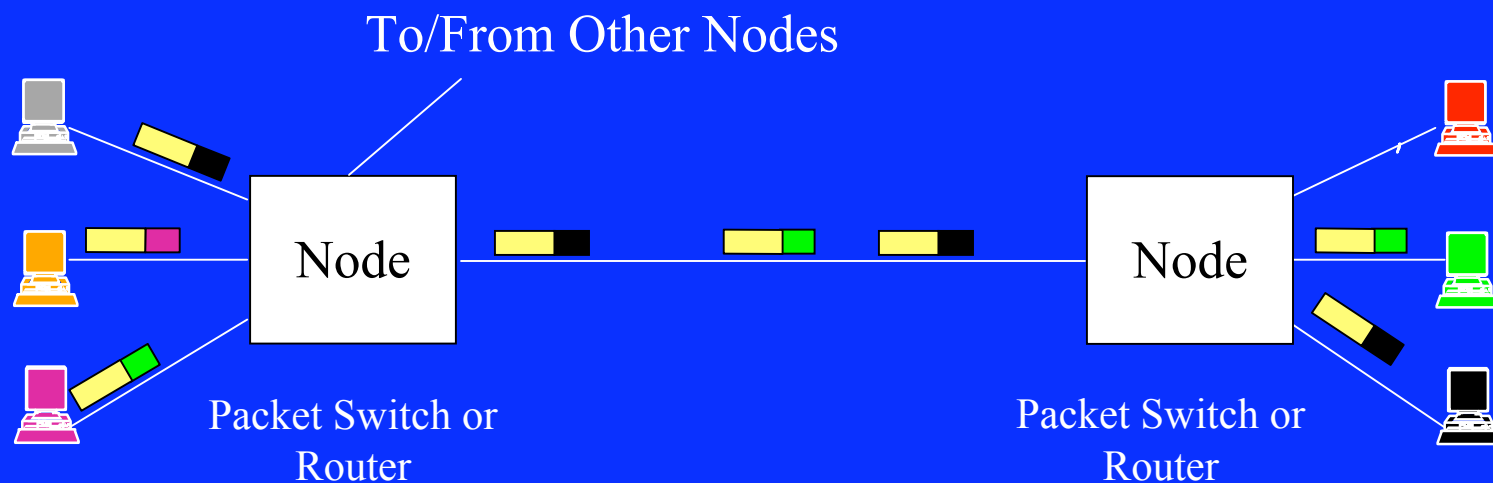
The Role of the Internet

- A Packet Switch or Router



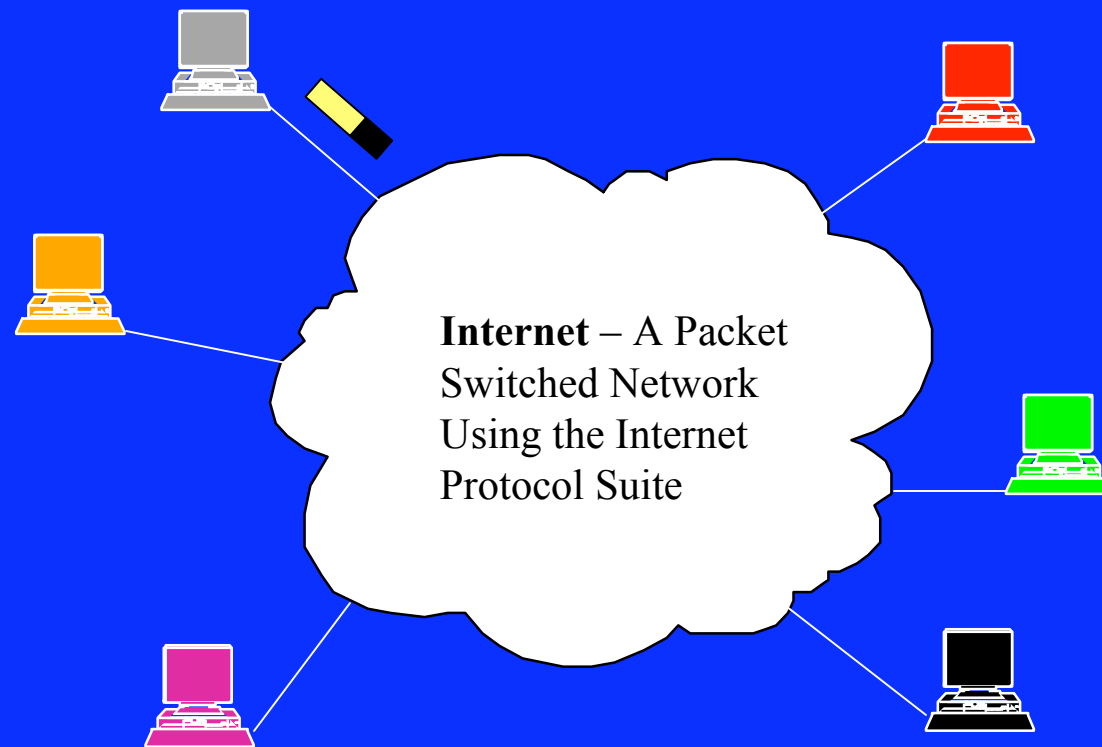
The Role of the Internet

- A Packet Switched Network



The Role of the Internet

- The Internet As a “Cloud”



The Role of the Internet

- A Note on Latency and Quality of Service (QoS)
 - In simple terms, latency just refers to delay
 - Latency is the amount of time it takes information (e.g., a packet) to travel from source to destination

The Role of the Internet

- In a packet switched network, latency is associated with congestion produced by the inability of packet switches to process packets fast enough and/or by the lack of adequate transmission capacity (bandwidth) between packet switches
- In combination, latency and bandwidth define the speed and capacity of a network
- Low latency is critical in voice communications and certain “real-time” data communications applications (e.g., interactive games)

The Role of the Internet

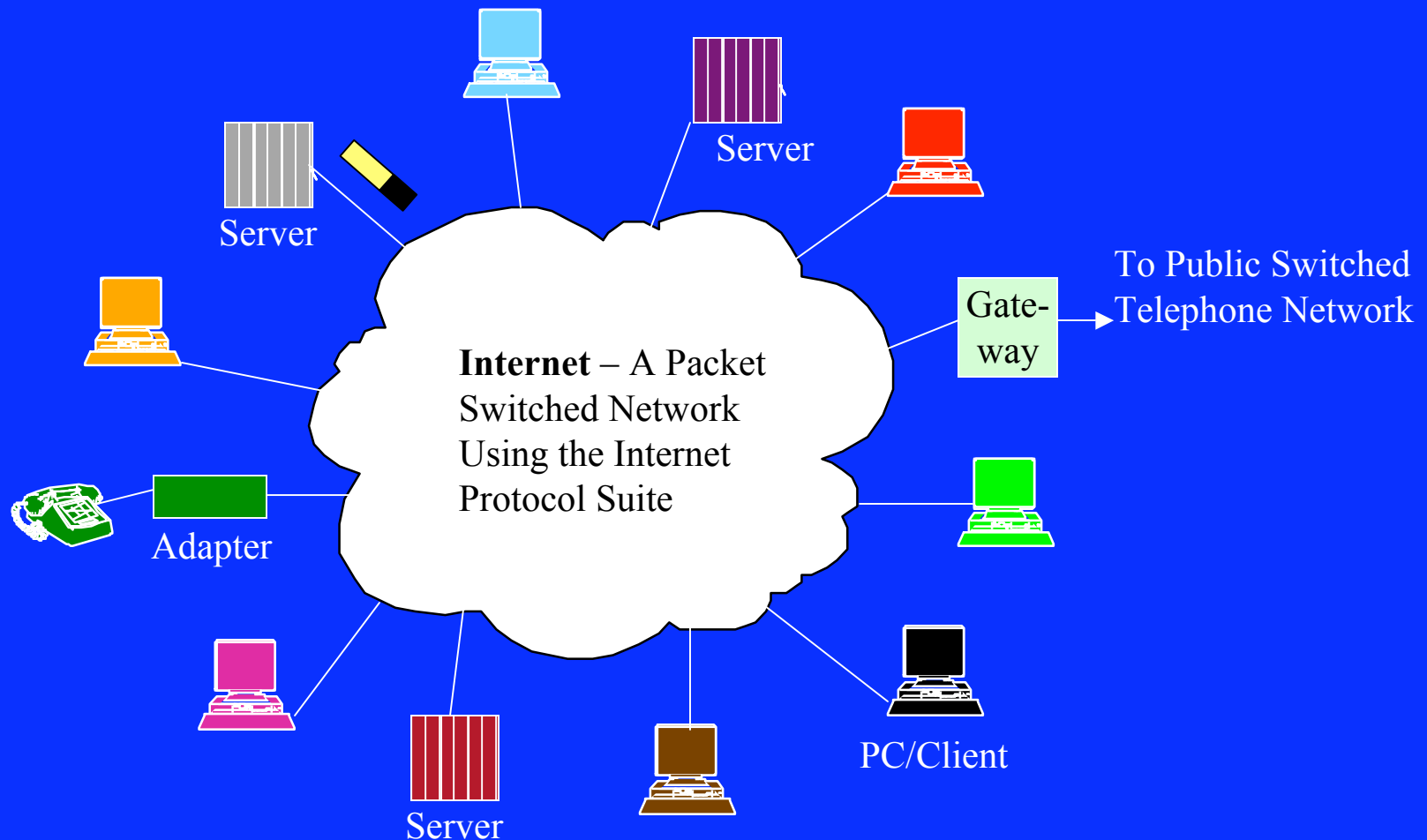
- Architecture of the Traditional Public Switched Telephone Network
 - Circuit switching
 - “Dumb” terminals with limited capabilities
 - “Intelligence” residing in switches, intelligent peripherals, service control points, etc. interior to the network
 - Services created inside the network

The Role of the Internet

- Architecture of Networks Based Upon the Internet Protocol (IP)
 - Packet switching
 - “Dumb” network
 - “Intelligent” terminals (e.g., PCs) with a rich set of capabilities
 - Services created in terminals/servers at the edge of the network

The Role of the Internet

- “Intelligence” at the “Edge” of the Network



The Role of the Internet

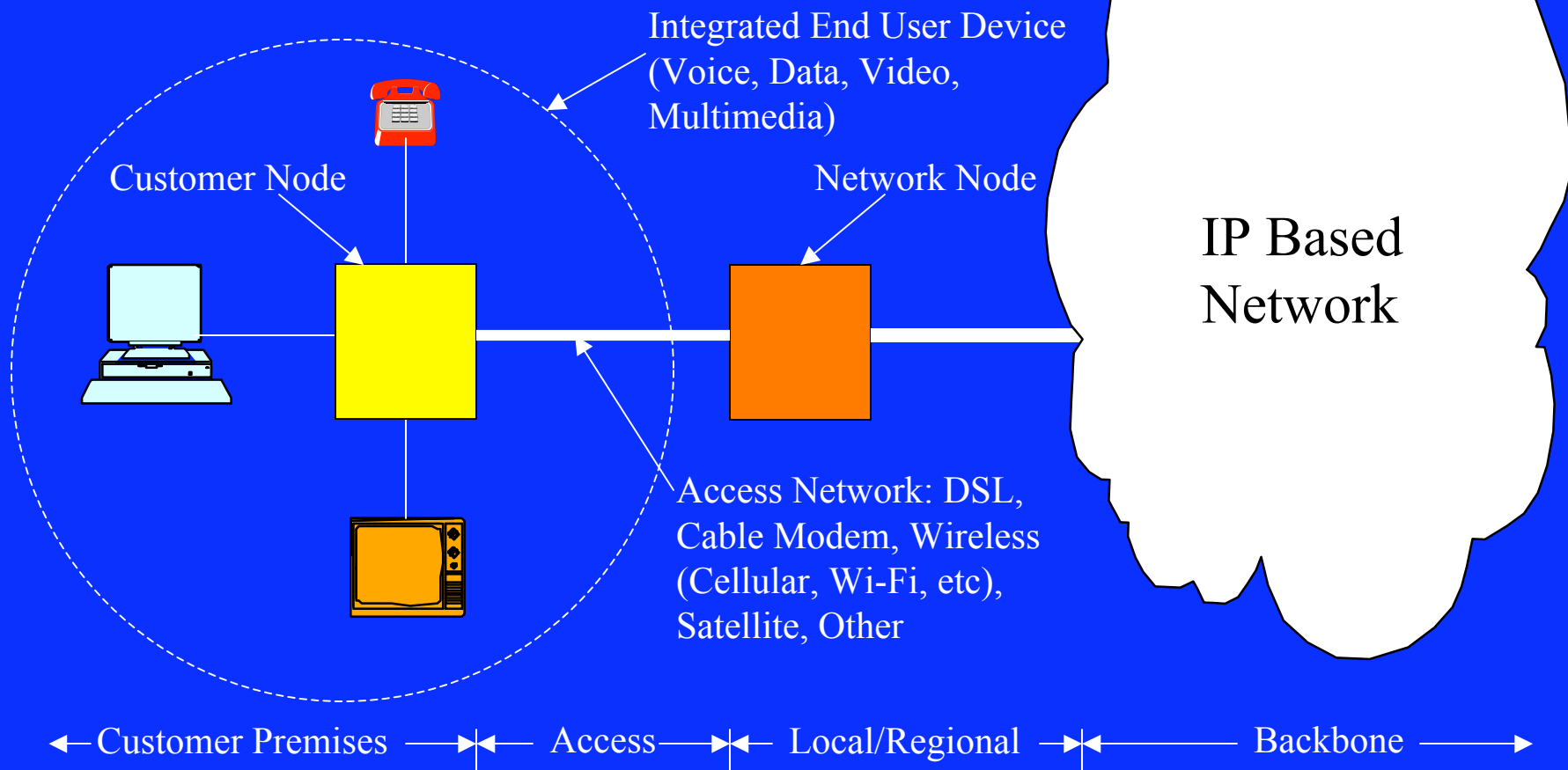
- Network Trends/Goals from a Technological Perspective:
 - All applications -- voice, data, image, video, multimedia -- conveyed on an all digital, packet-switched, broadband, low latency network or “platform”
 - A “network of networks” platform that uses common, open, non-proprietary standards and protocols (e.g., the Internet Protocol -- IP)

The Role of the Internet

- Network Trends/Goals from a Technological Perspective: (Cont'd)
 - Extension of this platform using wireless technology to allow users to communicate anyplace, anytime, in any mode or combination of modes.

The Role of the Internet

- Integrated Network with Integrated Access



Convergence

- Traditional “Silos” of Service/Regulation

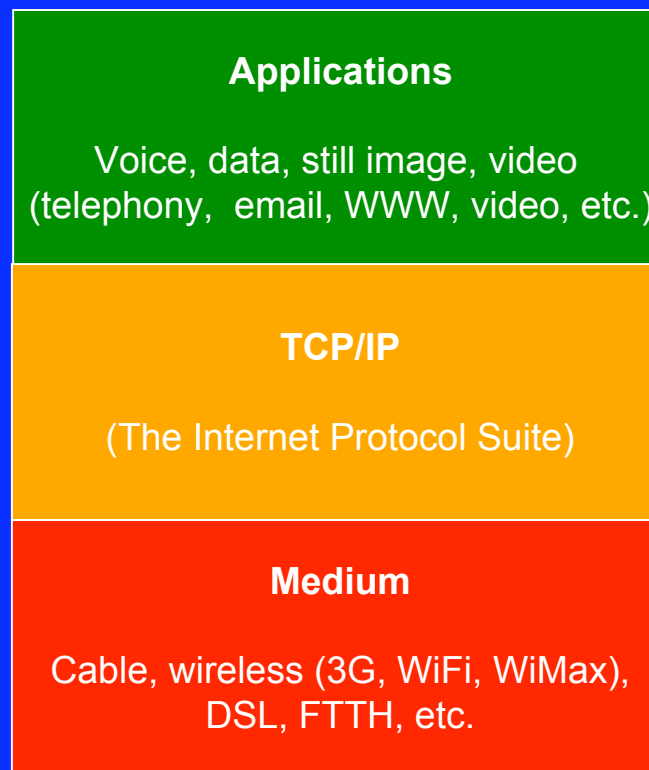


Note: Titles refer to the Communications Act of 1934 (as amended); Bureaus refer to organizational units within the FCC

Sources: Newman, Whitt, Sicker, others

Convergence

- Converged Networks Services



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