

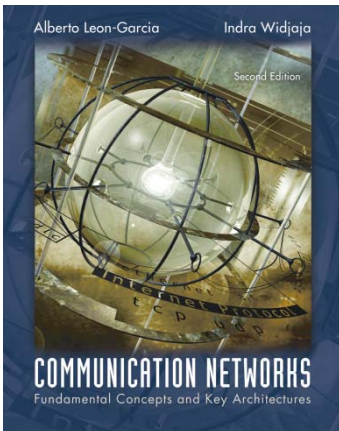
# CSE 3213: Communication Networks

## Winter 2010



**Course Web-Page:** [https://wiki.cse.yorku.ca/course\\_archive/2009-10/W/3213/](https://wiki.cse.yorku.ca/course_archive/2009-10/W/3213/)

**Instructor:** Foroohar Foroozan (foroozan@cse.yorku.ca)



**Office Hours:** TR 14:00-15:00 (CSE 2052)

**Prerequisite:** General Prerequisite.

**Textbook:** "Communication Networks:  
Fundamental Concepts and Key Architectures",

A. Leon-Garcia and I. Widjaja, McGraw Hill, 2004, 2nd edition.

**Other Material:**

"Data Communications and Networking", B. A. Forouzan, McGraw Hill, 2007, 4<sup>th</sup> edition.

"Computer Networks: A Systems Approach – Network Simulation Experiments Manual",  
E. Aboelela, Morgan Kaufmann, 2008, 2nd edition.



**Grading Scheme:**

|                            |           |      |
|----------------------------|-----------|------|
| Quiz 1, 2, 3, 4:           | 4 x 3 % = | 12 % |
| Lab Report 1, 2 ,3:        | 3 x 6 % = | 18 % |
| Midterm ( <b>Feb 24</b> ): |           | 30%  |
| Final:                     |           | 40%  |

**Missed Midterm/ Quizes:**

Missing a test will result in a score of zero – unless the official York [attending physician's statement](#) is filled out. (with the official physician's statement, the weight of the exam/quiz will be added to that of the final exam.)

Exact time of each Quiz will be announced on the course Web site, in advance.

**Lab Software:**

**OPNET IT Guru (Academic Edition)**

- ‘free’ **network simulation** software
- 6-month renewable licence
- lab-manual will be available after reading week
- labs to take place in March

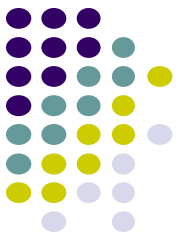


## Course Objective and Schedule:

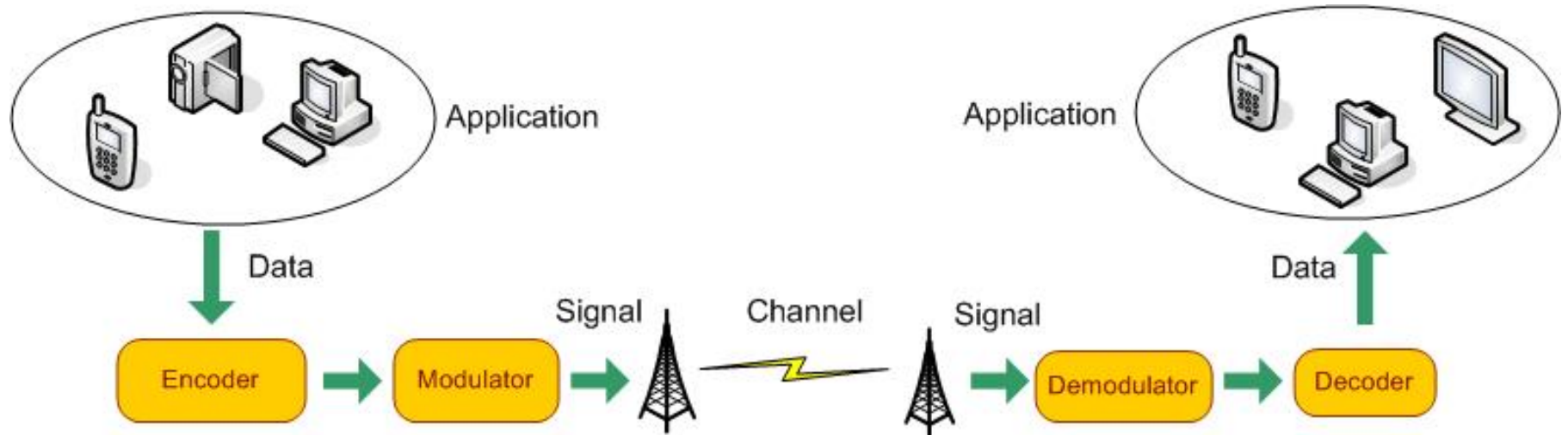
The course is an introduction to communications and networking. Topics covered include:

- **Message, Circuit, Packet Switching LANs, WANs**
- **Applications and Layered Architectures**
- **Digital vs. Analog Communications**
- **Characterization of Communication Channels**
- **Channel Capacity, Nyquist and Shannon Theorems**
- **Line Coding (RZ, NRZ, Bipolar, Manchester)**
- **Digital Modulation (ASK, PSK, FSK)**
- **Properties of Media and Digital Transmission Systems**
- **Error Detection and Correction**
- **Flow and Error Control**
- **Medium Access Control (Aloha, CSMA, Scheduling)**
- **LAN Protocols (Ethernet, Token Ring, Wireless LANs)**
- **Connecting LANs**
- **Network Layer and IP Protocol**





Telecommunication = communication over distance

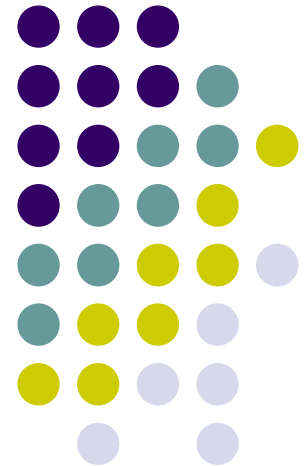
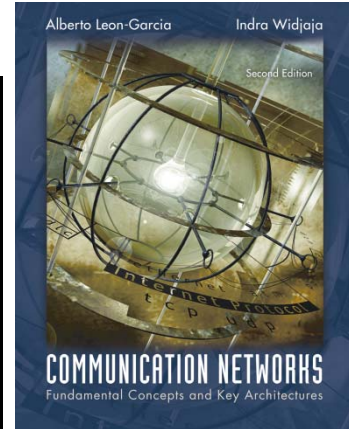


# Chapter 1

# Communication

# Networks and Services

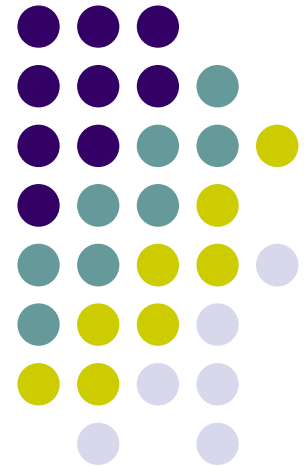
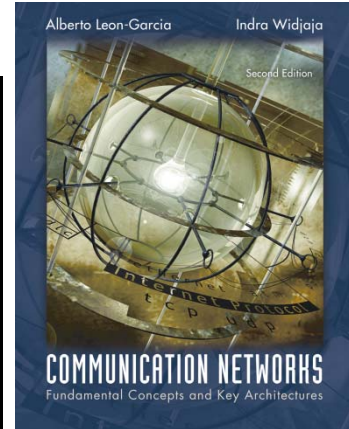
Network Architecture and Services  
Telegraph Networks & Message Switching  
Telephone Networks and Circuit Switching  
Computer Networks & Packet Switching



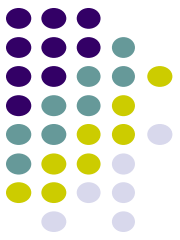
# Chapter 1

# Communication Networks and Services

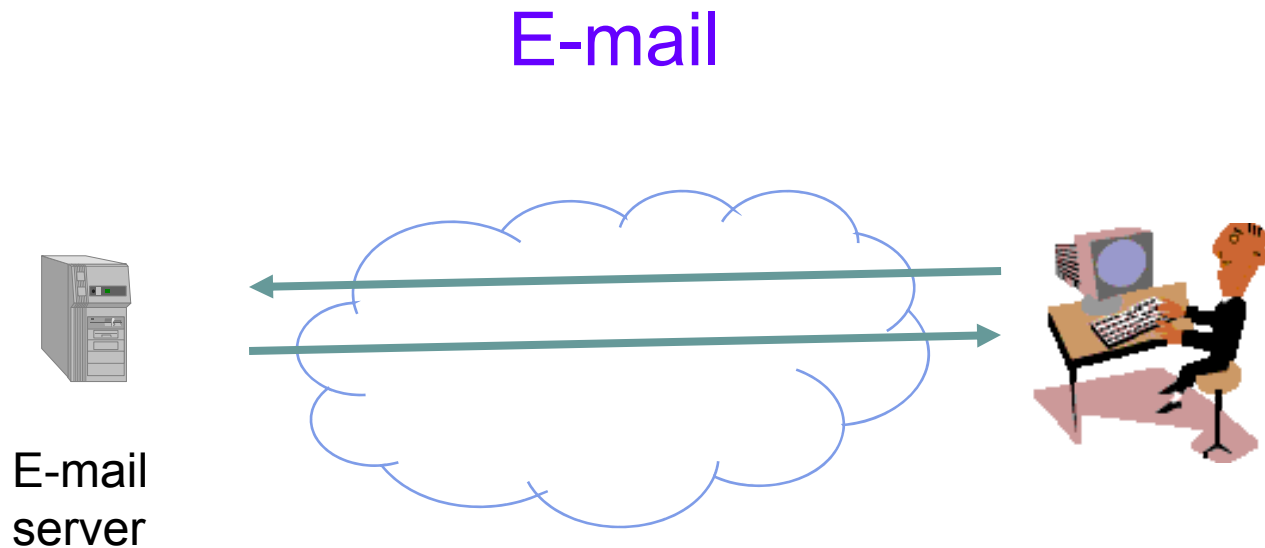
## *Network Architecture and Services*



# Communication Services & Applications

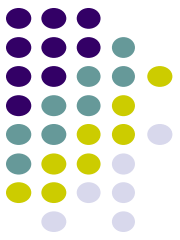


- A communication service enables the exchange of information between users at different locations.
- Communication services & applications are everywhere.



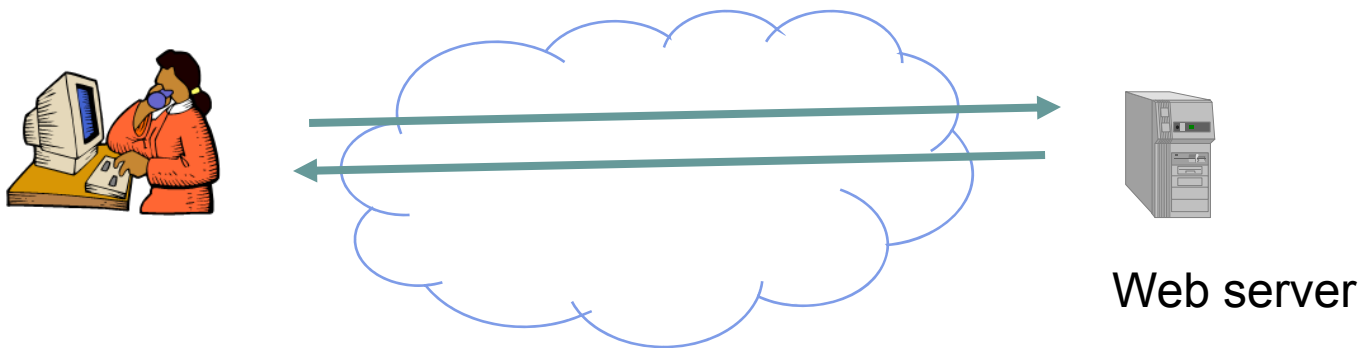
Exchange of text messages via servers

# Communication Services & Applications



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## Web Browsing



Retrieval of information from web servers

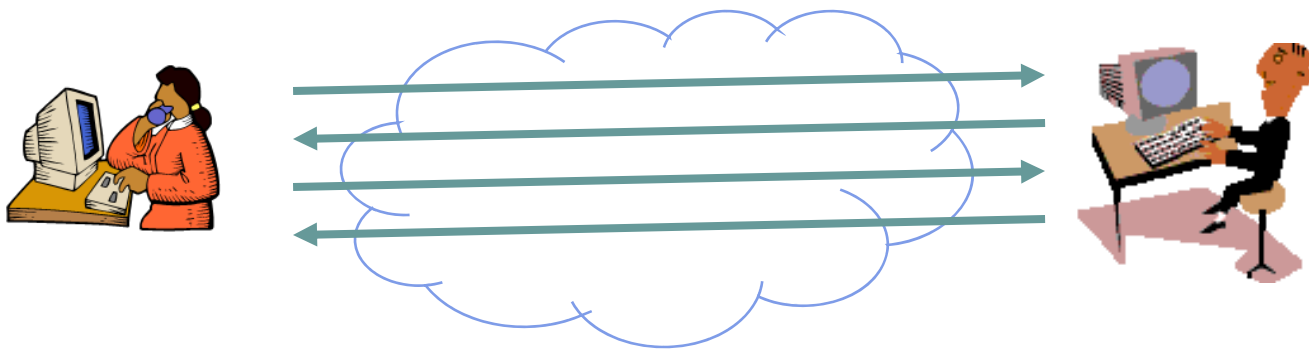


# Communication Services & Applications



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## Instant Messaging



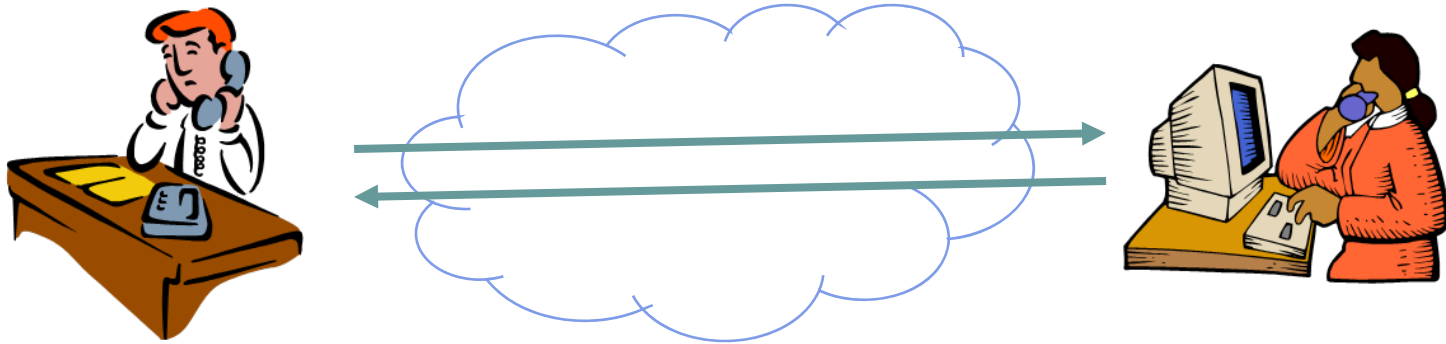
Direct exchange of text messages

# Communication Services & Applications



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## Telephone

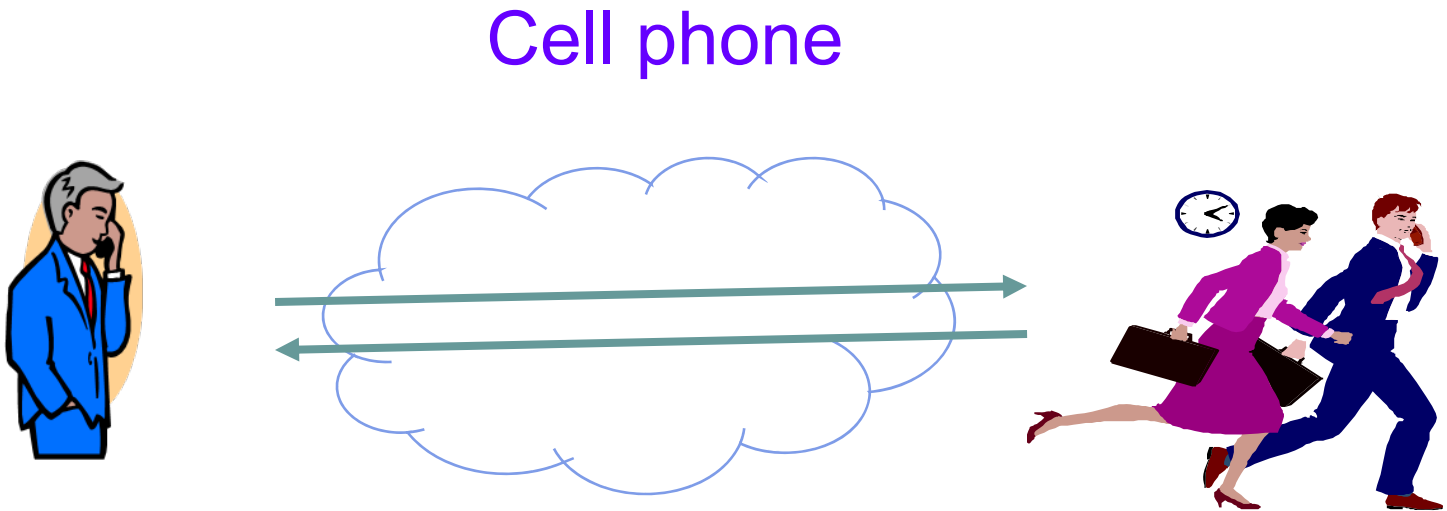


Real-time bidirectional voice exchange

# Communication Services & Applications

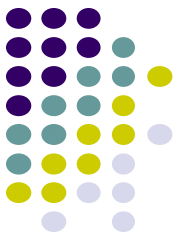


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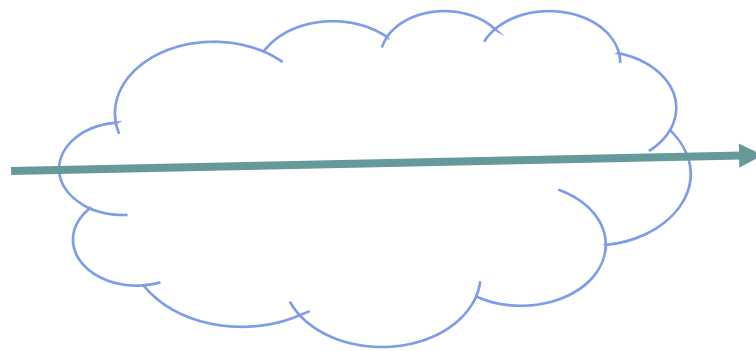
Real-time voice exchange with mobile users

# Communication Services & Applications



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## Short Message Service



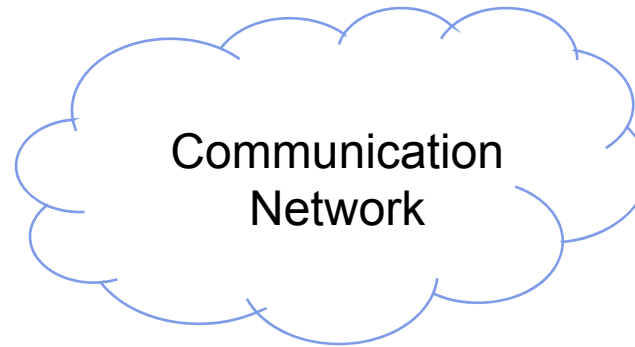
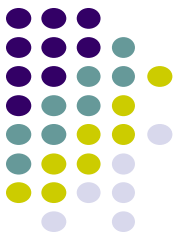
Fast delivery of short text messages

# Services & Applications



- Service: Basic information transfer capability
  - Internet transfer of individual block of information
  - Internet reliable transfer of a stream of bytes
  - Real-time transfer of a voice signal
- Applications build on communication services
  - E-mail & web build on reliable stream service
  - Fax and modems build on basic telephone service
- New applications build on multiple networks
  - SMS builds on Internet reliable stream service and cellular telephone text messaging

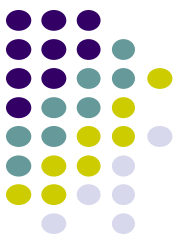
# What is a communication network?



- The equipment (hardware & software) and facilities that provide the basic communication service
- Virtually invisible to the user; Usually represented by a cloud
- Equipment
  - Routers, servers, switches, multiplexers, hubs, modems, ...
- Facilities
  - Copper wires, coaxial cables, optical fiber
  - Ducts, conduits, telephone poles ...

***How are communication networks designed and operated?***

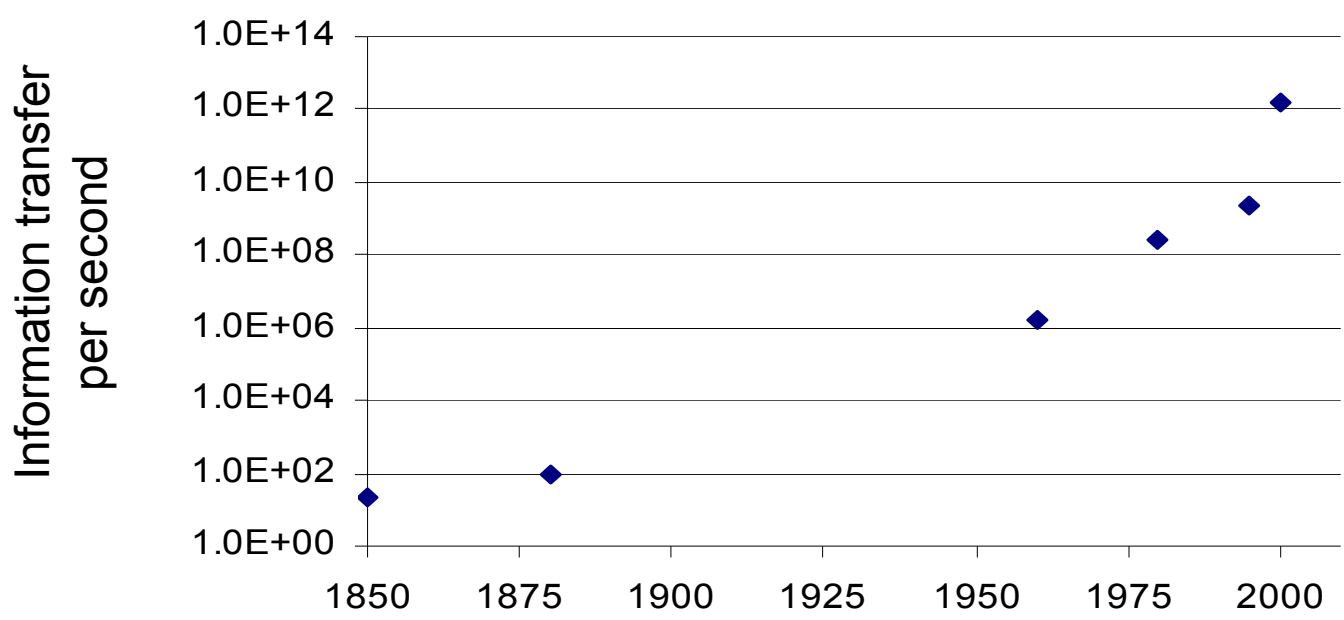
# Communication Network Architecture



- *Network architecture*: the plan that specifies how the network is built and operated
- Architecture is driven by the network services
- Overall communication process is complex
- Network architecture partitions overall communication process into separate functional areas called *layers*

Next we will trace evolution of three network architectures: telegraph, telephone, and computer networks

# Network Architecture Evolution



?

Telegraph networks

Telephone networks

Internet, Optical & Wireless networks

Next Generation Internet



# Network Architecture Evolution

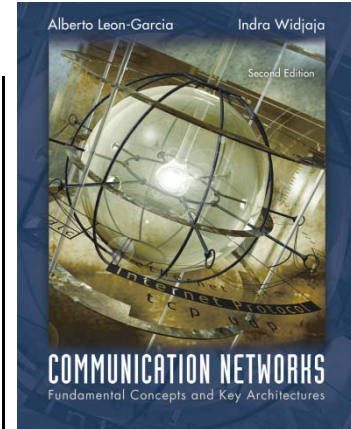


an indicator of the progress in comm. technology is the speed at which data can be transmitted measured in [bps]

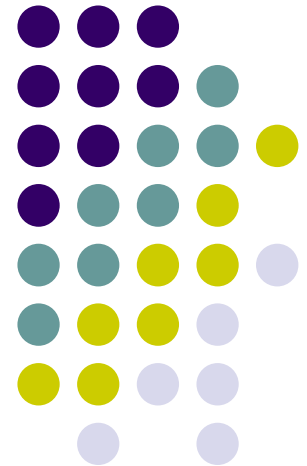
- Telegraph Networks [**20 bps**]
  - Message switching & digital transmission
- Telephone Networks [**64 kbps**]
  - Circuit Switching
  - Analog transmission → digital transmission
  - Mobile communications
- Internet [**n\*Gbps**]
  - Packet switching & computer applications
- Next-Generation Internet
  - Multiservice packet switching network

# Chapter 1

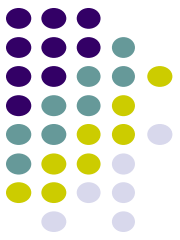
# Communication Networks and Services



## *Telegraph Networks & Message Switching*



# Telegraphs & Long-Distance Communications



## Approaches to long-distance communications

- Courier: physical transport of the message
  - Messenger pigeons, pony express, FedEx
- Telegraph: message is transmitted across a network using signals
  - Drums, beacons, mirrors, smoke, flags, semaphores...
  - Electricity, light
- Telegraph delivers message much sooner

# Telegraphs Networks : Message Switching



**Electric Telegraph** wires were stretched from one point to another; electric current is either allowed to flow through the wires or is broken by switch called **telegraph key**

electric current is used to activate a **sounder** which makes clicking sounds – short / long times between clicks are decoded into letters from the alphabet

**Morse Telegraph** text message is encoded into a sequence of dots and dashes [1837]

- dots and dashes are converted into short and long pulses of electric current
- **digital transmission system** – relies only on 2 signal-levels

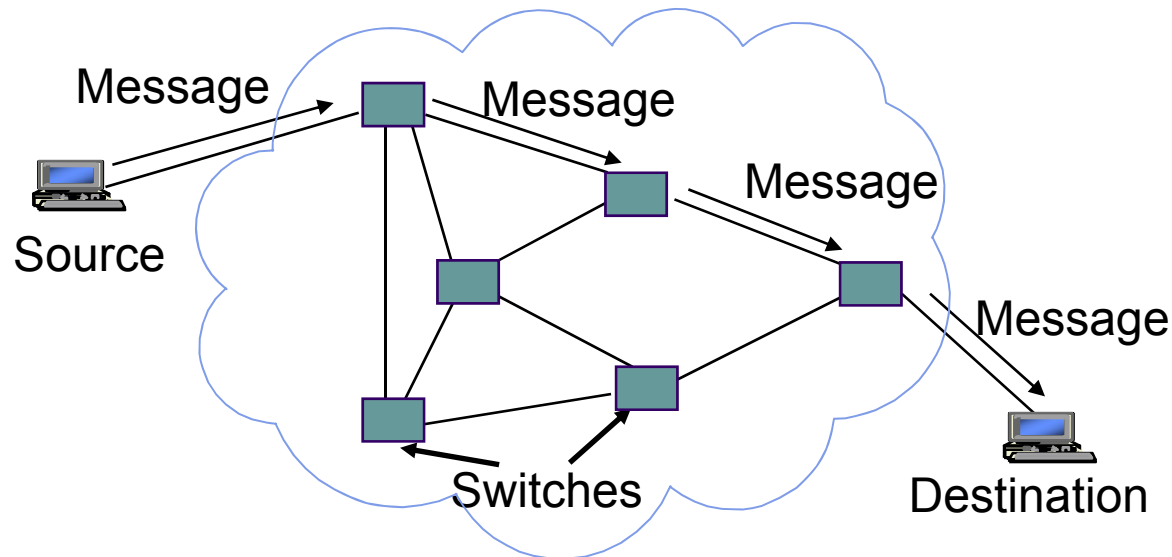


|   | Morse Code |   | Morse Code |   | Morse Code |   | Morse Code  |
|---|------------|---|------------|---|------------|---|-------------|
| A | - · -      | J | - · - - -  | S | - · - · -  | 2 | - · - - - - |
| B | - · - - -  | K | - · - - -  | T | - - -      | 3 | - · - - - - |
| C | - · - - -  | L | - · - - -  | U | - · - - -  | 4 | - · - - - - |
| D | - · - - -  | M | - - -      | V | - · - - -  | 5 | - · - - -   |
| E | -          | N | - - -      | W | - · - - -  | 6 | - · - - -   |
| F | - · - - -  | O | - - - - -  | X | - · - - -  | 7 | - · - - -   |
| G | - · - - -  | P | - · - - -  | Y | - · - - -  | 8 | - · - - -   |
| H | - · - - -  | Q | - · - - -  | Z | - · - - -  | 9 | - · - - -   |
| I | - · -      | R | - · - - -  | 1 | - · - - -  | 0 | - · - - -   |

# Electric Telegraph Networks



- Electric telegraph networks exploded
  - Message switching & Store-and-Forward operation
  - Key elements: Addressing, Routing, Forwarding



# Elements of Telegraph Network Architecture

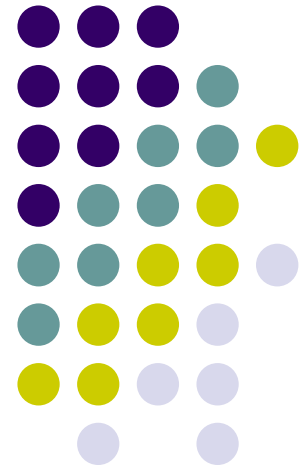
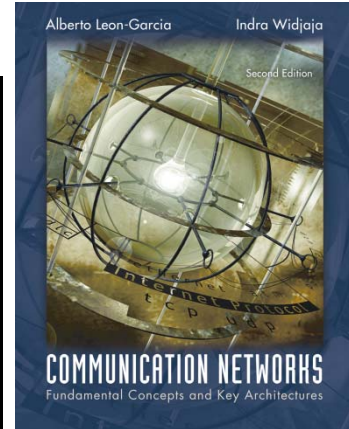


- Digital transmission
  - Text messages converted into symbols (dots/dashes, zeros/ones)
  - Transmission system designed to convey symbols
- Multiplexing
  - *Framing* needed to recover text characters
- Message Switching
  - Messages contain source & destination *addresses*
  - *Store-and-Forward*: Messages forwarded hop-by-hop across network
  - *Routing* according to destination address

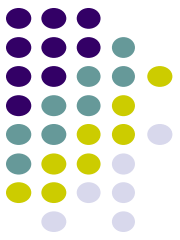
# Chapter 1

# Communication Networks and Services

## *Telephone Networks and Circuit Switching*

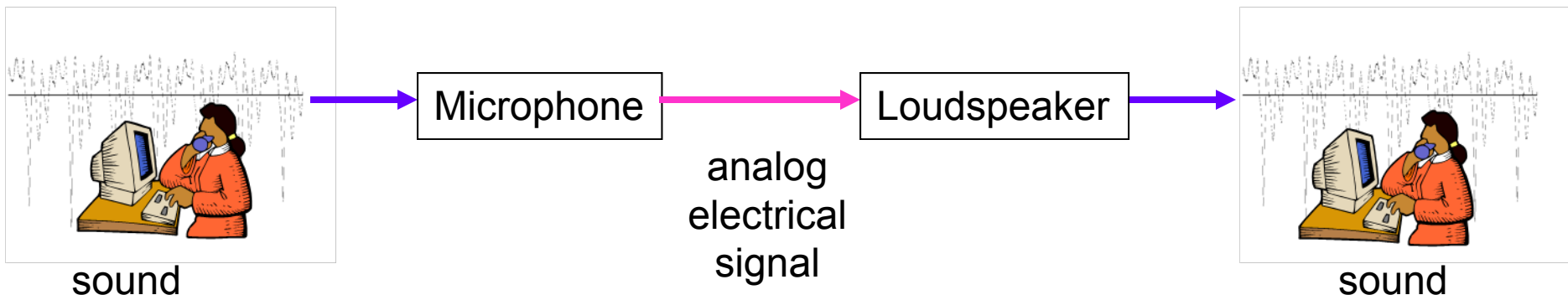


# Bell's Telephone



- Alexander Graham Bell (1875) working on harmonic telegraph to multiplex telegraph signals
- Discovered voice signals can be transmitted directly
  - Microphone converts voice pressure variation (sound) into *analogous* electrical signal
  - Loudspeaker converts electrical signal back into sound

- Telegraph vs. Telephone**
- telegraph was rather slow and (in some cases) required an expert operator with knowledge of Morse code and
  - telephone terminal was very simple and did not require any expertise - targeted as a direct service to end users

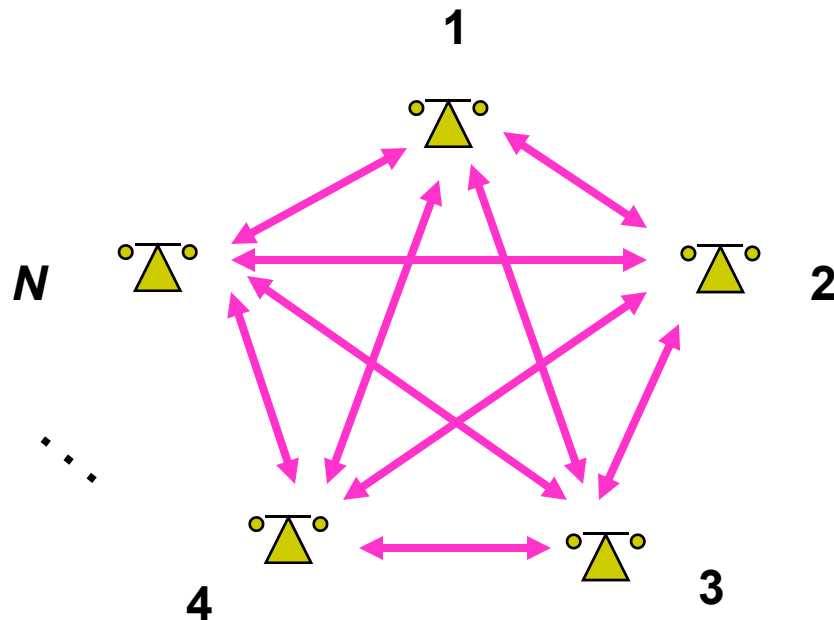






# The $N^2$ Problem

- For  $N$  users to be fully connected *directly*
- Requires  $N(N-1)/2$  connections
- Requires too much space for cables
- Inefficient & costly since connections not always on

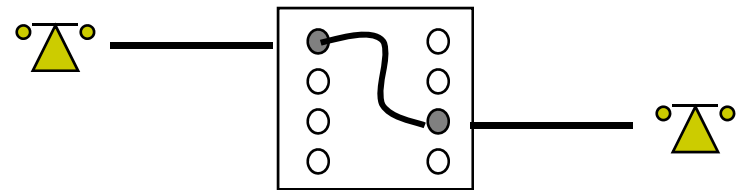
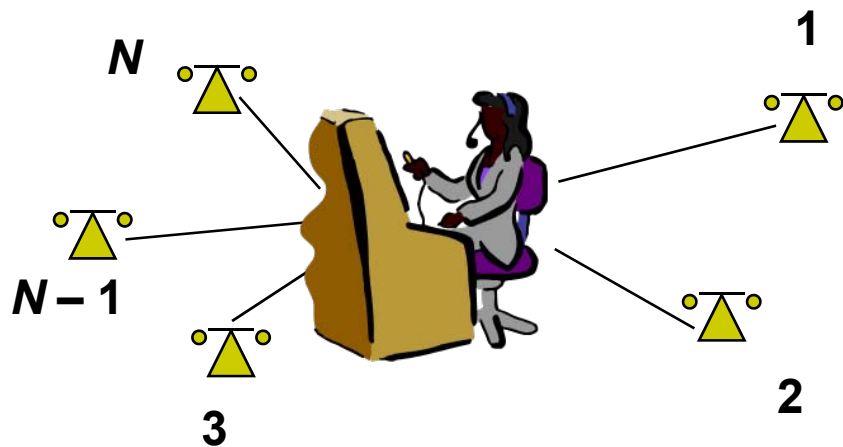


$$N = 1000$$
$$N(N-1)/2 = 499500$$



# Circuit Switching

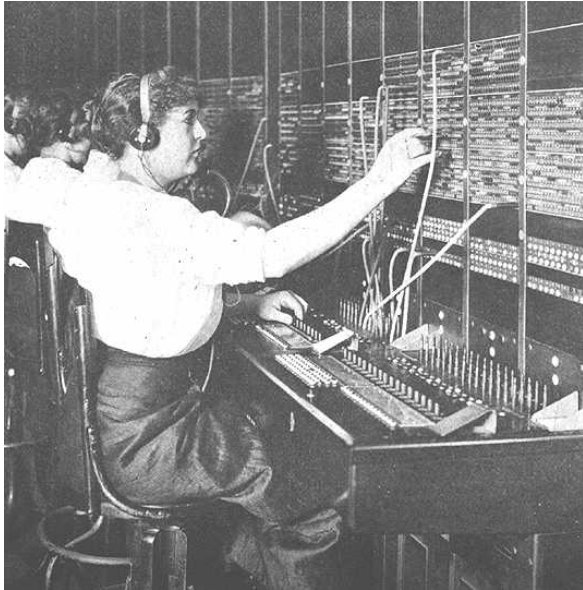
- Patchcord panel switch invented in 1877
- Operators connect users on demand
  - Establish *circuit* to allow electrical current to flow from inlet to outlet
- Only  $N$  connections required to central office



# Telephone Networks



**Connection-Oriented Service!** – connection has to be set up before the actual transfer of information can take place

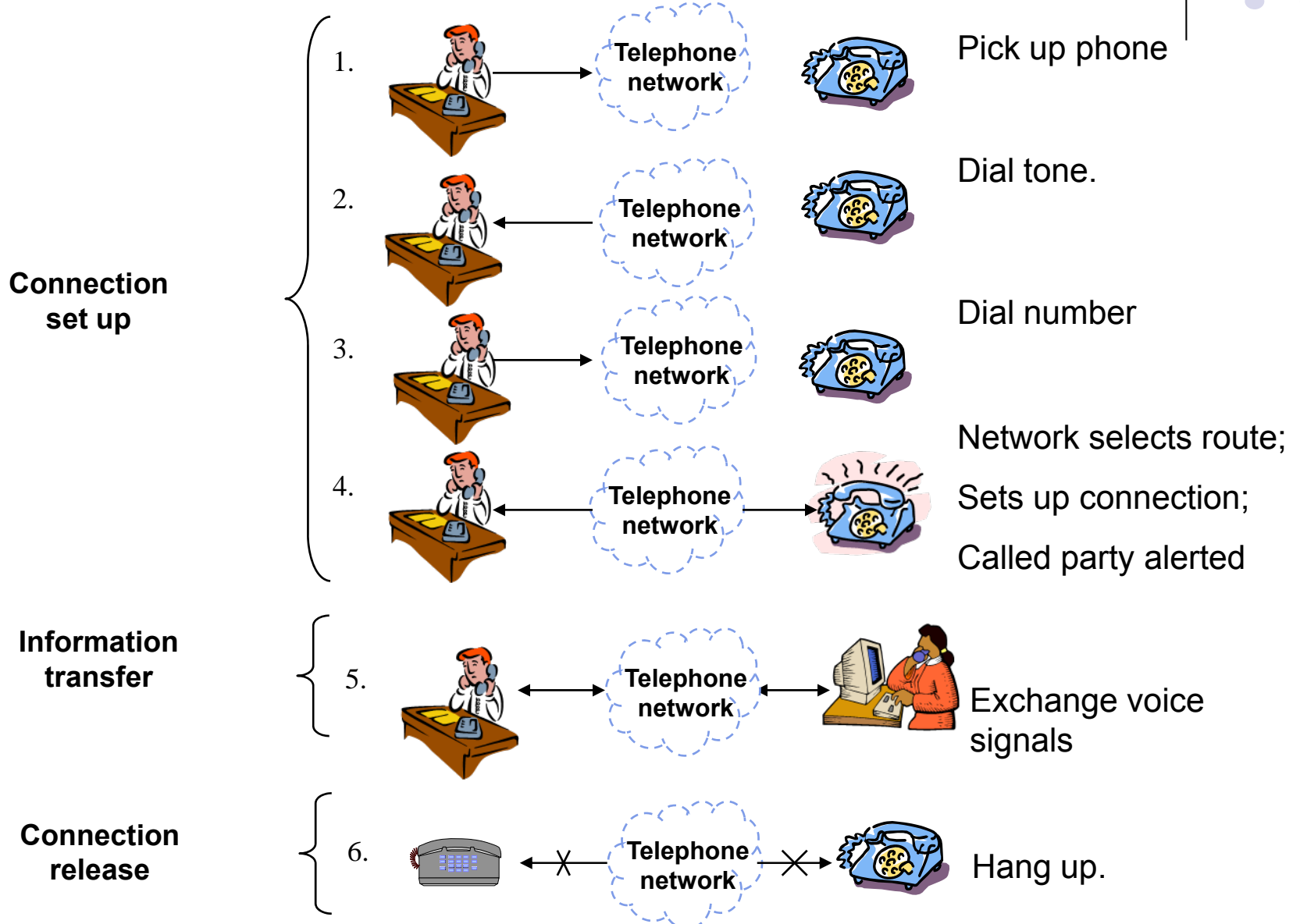


“intelligence” inside the network

**Digital Telephone Systems:** evolution began with the invention of the transistor and integrated circuits

- (1) analog voice is converted into digital signal  $\Rightarrow$  better transmission
- (2) digital switches  $\Rightarrow$  faster switching and advanced reservation of resources

# Three Phases of a Connection



# Elements of Telephone Network Architecture



- Digital transmission & switching
  - Digital voice; Time Division Multiplexing
- Circuit switching
  - User signals for call setup and tear-down
  - Route selected during connection setup
  - End-to-end connection across network
  - Signaling coordinates connection setup
- Hierarchical Network
  - Decimal numbering system
  - Hierarchical structure; simplified routing; scalability
- Signaling Network
  - Intelligence inside the network