# Networking Basics, Layering

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Fundamentals of Wired and Wireless Networks, Kameswari Chebrolu and Bhaskaran Raman, 09-13 May 2005

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# Communication: what and how?

- *Communication: The exchange of thoughts, messages, or information, as by speech, signals, writing, or behavior.*
- Requirements for communication
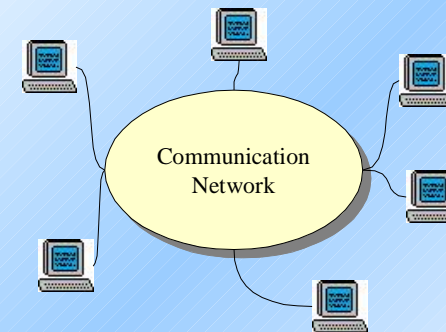  - Medium + Energy, Protocol

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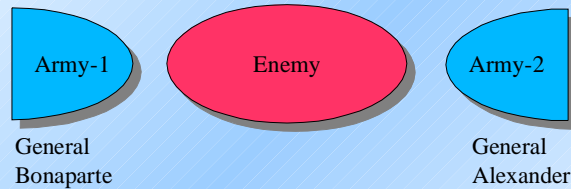
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# Communication networks

- Before the electronic age
  - Using doves/pigeons
  - Postal system
- Telegraph
- Telephone network
- Internet
- Cellular/Wireless

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# What is a Computer Network?



Communication Network

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## The Two-Army Problem

Army-1    Enemy    Army-2

General Bonaparte      General Alexander

The attack will succeed *if and only if* both armies attack the enemy at the same time

*What strategy to adopt?*

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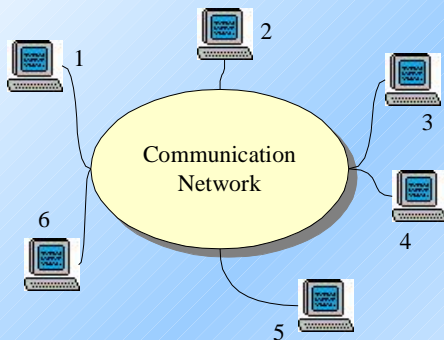
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## Designing a Protocol

- **What** information to send?
- **When** to send?
  - Define possible message sequences
- **How** to send?
  - Depends on the network available

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## Designing a Network

1
2
3
4
5
6

Communication Network

- Need naming
- Network topology:
  - All-to-all
  - Star
  - Intermediate, e.g.
- This is natural:
  - Roads, railway, airlines

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## Metrics for Protocol/Network Design

- Efficiency
  - Time, cost, energy, etc.
  - Throughput versus latency
- Reliability
- Security

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## Several Levels of Issues

- How do two computers communicate on a single link?
- How do several computers share a common medium?
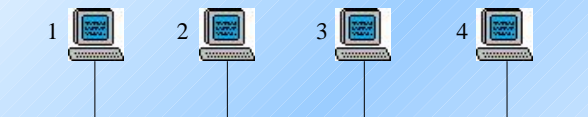- The notion of a network: when not all computers are connected to each other directly

## Communication on a Single Link

- Depends on the physical medium in use
  - Ethernet: converted to electrical signals
  - SONET: optical signals
  - Satellite, WLAN: RF modulation in some frequency
- This is domain of ECE communications

## Sharing a Medium

- Example: ethernet



- Notion of Medium Access Control (MAC) protocol
- Possibilities: central control vs. distributed control

## Medium Access Control (MAC)

- Time-division multiple access (TDMA)
  - Satellite link, T1, SONET
- CSMA/CD
  - Ethernet
- CSMA/CA (RTS/CTS optional)
  - Wireless LAN
- Other possibilities: FDMA, CDMA
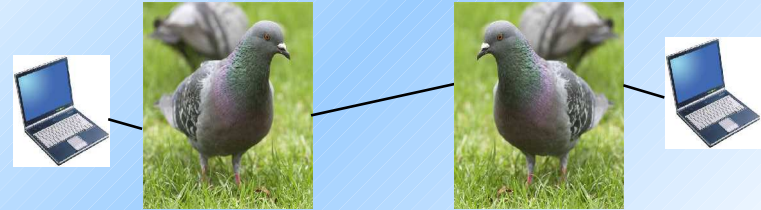  - GSM uses FDMA + TDMA + central control

## Beyond Direct Communication

- Notion of routing
  - Centralized vs. distributed routing
- Distributed routing:
  - Source routing vs. destination-based routing
- Destination-based routing:
  - Each "node" has a routing table
    - Send packets to node 5 via node 2
    - Send packets to node 6 via node 3
    - Etc.

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## Inter-Network (Internet)

- Connect different "networks"
- Pigeon-powered Internet takes flight



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## History of the Internet

- 1961-62: Packet-switching as a concept
- 1969: Four host computers on ARPANET
- 1972: E-mail application launched
- Network Control Protocol (NCP) used in ARPANET
- 1980s: LANs, PCs, Workstations
- Until 1985: Internet used by researchers/developers

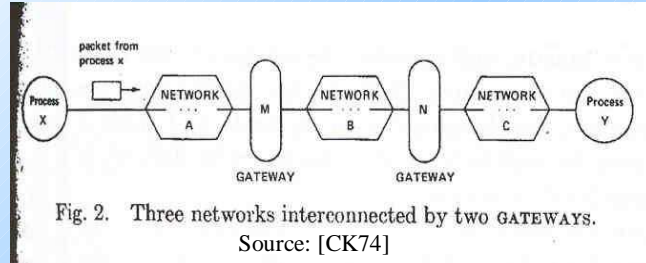Fundamentals of Wired and Wireless Networks, Kameswari Chebrolu and Bhaskaran Raman, 09-13 May 2005

## History (continued)

- Networks from DoE, NASA, NSF, AT&T
- NSFNET backbone was created
- Privatization: 1985-1995
  - 6 nodes (56kbps links) to 21 nodes (45Mbps links)
- Steady exponential growth for 15 years
  - In bandwidth, number of hosts, total traffic, etc.
- http://www.isc.org/ds/

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## Internet Design Goals

- Primary goal: Inter-networking



Fig. 2. Three networks interconnected by two GATEWAYS.
Source: [CK74]

- Sources of variability: addressing, MTU, delivery guarantees, delay/bandwidth, routing

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## Internet Design Goals

1. Communication in the presence of failures
2. Multiple types of service
3. Accommodate different networks
4. Distributed management
5. Cost effective
6. Dynamic host attachment, removal
7. Resource accounting

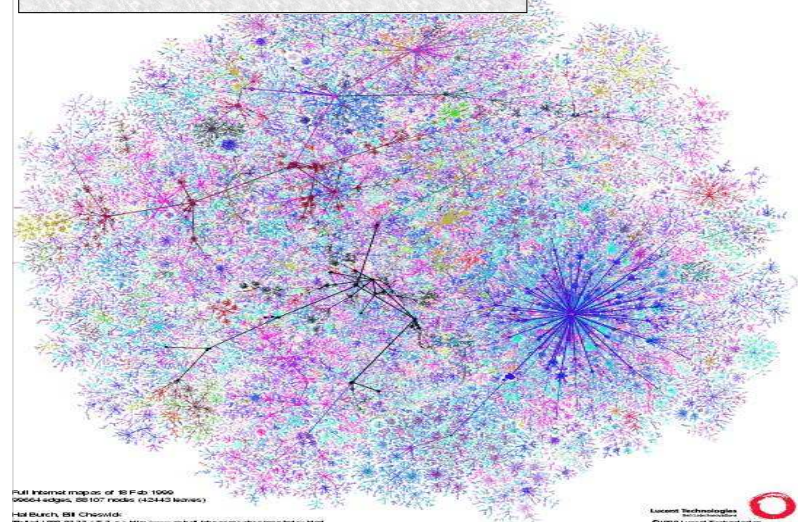Fundamentals of Wired and Wireless Networks, Kameswari Chebrolu and Bhaskaran Raman, 09-13 May 2005

## Internet Service Semantics

- Best-effort
- Packets may be:
  - Dropped
  - Delayed
  - Duplicated
  - Reordered
- Packets will NOT be *created*

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## The Internet, as of 1999

## OSI Layering

- What is layering?
  - *"Structuring technique which permits the network... to be viewed as logically composed of a succession of layers, each wrapping the lower layers and isolating them from higher layers"* [Zim80]

| Application |
| :---: |
| Presentation |
| Session |
| Transport |
| Network |
| Link-Layer-Ctrl Medium-Access |
| Physical |

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## Advantages of Layering

- Handle heterogeneity
- Software reuse, modularity
- Allows extensibility, new technologies

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## TCP/IP

- IP (Internet Protocol) is the network layer of the Internet
- Transport layer provides reliability, in-order delivery
  - TCP (Transmission Control Protocol) is the most common transport layer
- A lot of networking research (past and present) is centered around TCP/IP

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## Summary

- Communication networks:
  - Protocols
- Various levels of communication:
  - Single link: one computer to another (PHY/Link)
  - Shared medium (MAC/Link)
  - Indirect communication: routing (Network)
- The OSI layered reference model
- TCP/IP protocol suite

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