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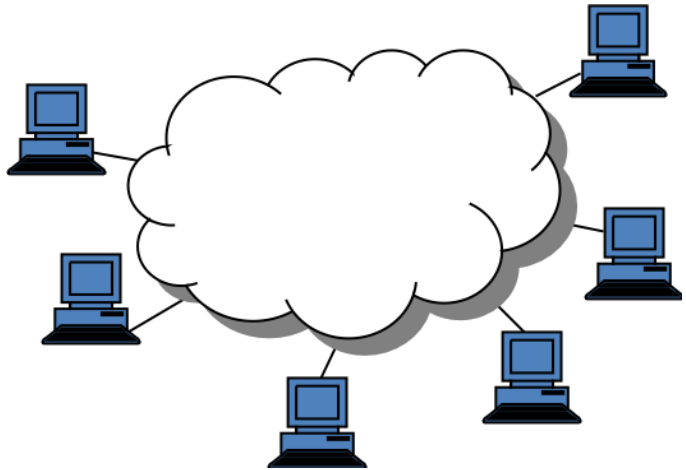
Technological Background

Gianfranco Nencioni



Most slides are based on early ones prepared by Prof. Erdal Cayirci

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Learning Questions

- What is a computer network?
- Which are the type of network?
- How is the communication in a network working?
- Which are the challenges that need to be addressed in a network?
- How are these challenges addressed?
- Which are the additional challenges of a **wireless** network?
- Which are the characteristics of different **wireless** networks (taxonomy and paradigms)?

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Outline

- Communication Networks
  - Networking
  - Protocol
  - Internetworking
- Wireless Network Challenges and Taxonomy
  - Ad-hoc Networking
  - Cellular Networking
  - Sensor Networks
  - Mesh Networks

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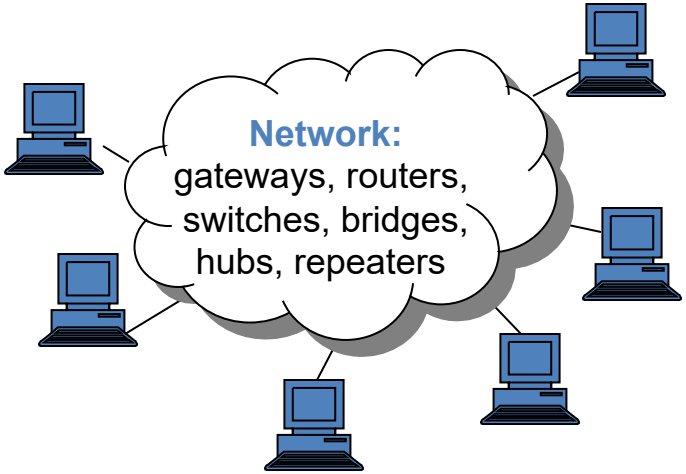
Communication Networks

Networking



- Body-area networks (BAN)
- Personal-area networks (PAN)
- Local-area networks (LAN)
- Metropolitan-area networks (MAN)
- Wide-area networks (WAN)

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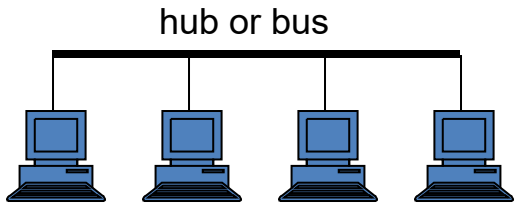
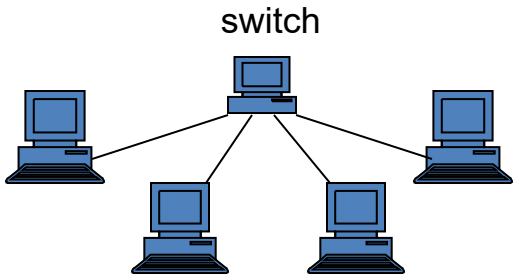
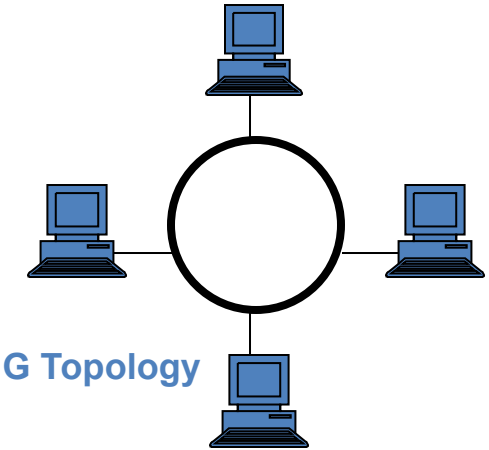
Network Topology



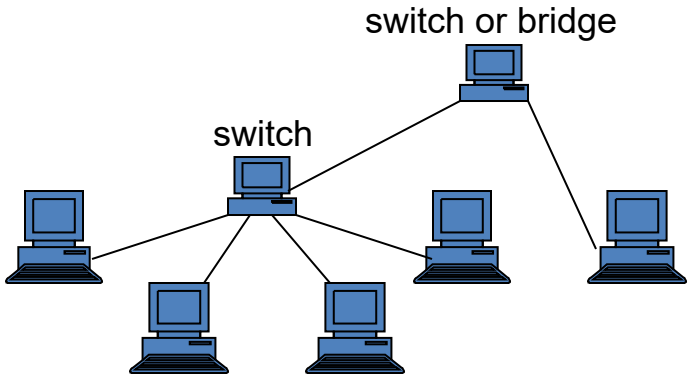
BUS Topology



STAR Topology

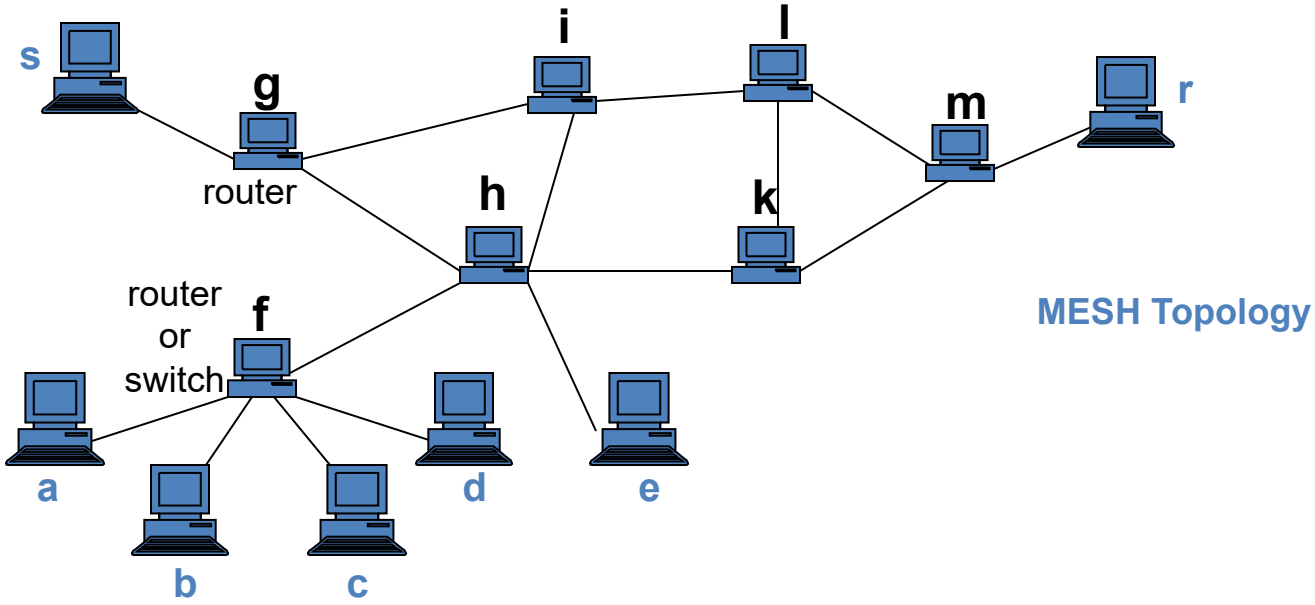


RING Topology

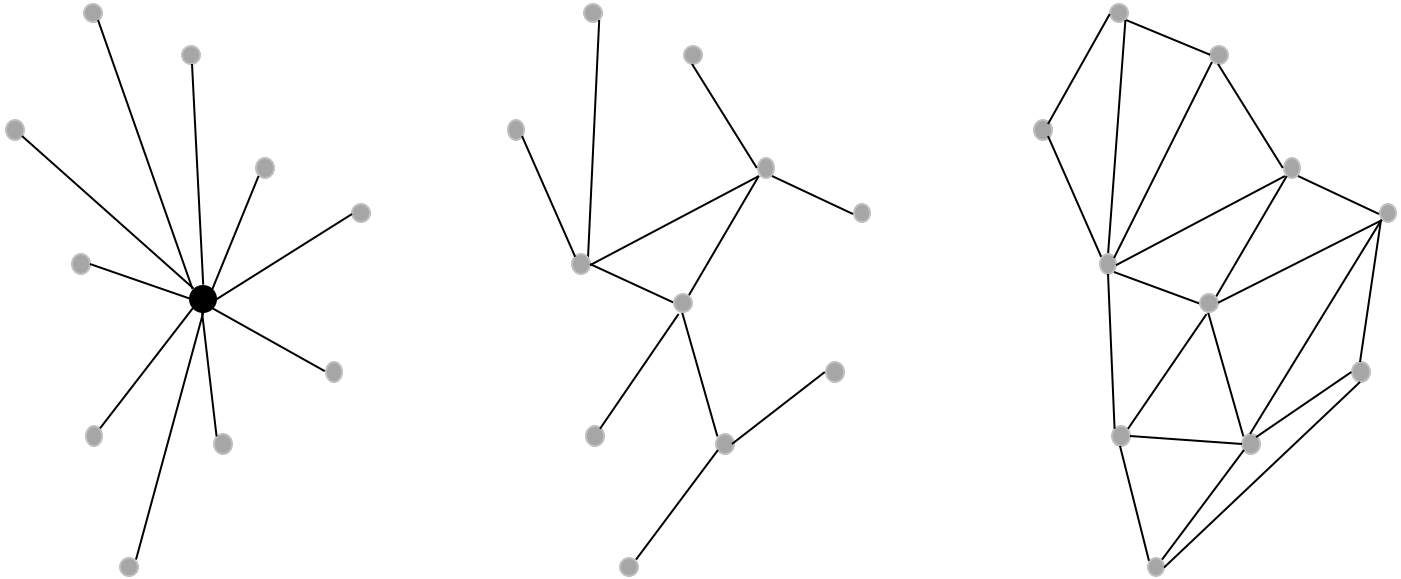


HIERARCHIAL or TREE Topology

Network Topology



Network Topology



a. Centralized **b. Decentralized** **c. Distributed**

Points of Failure / Maintenance
Fault Tolerance / Stability
Scalability /Max population

Ease of development /Creation
Evolution / Diversity

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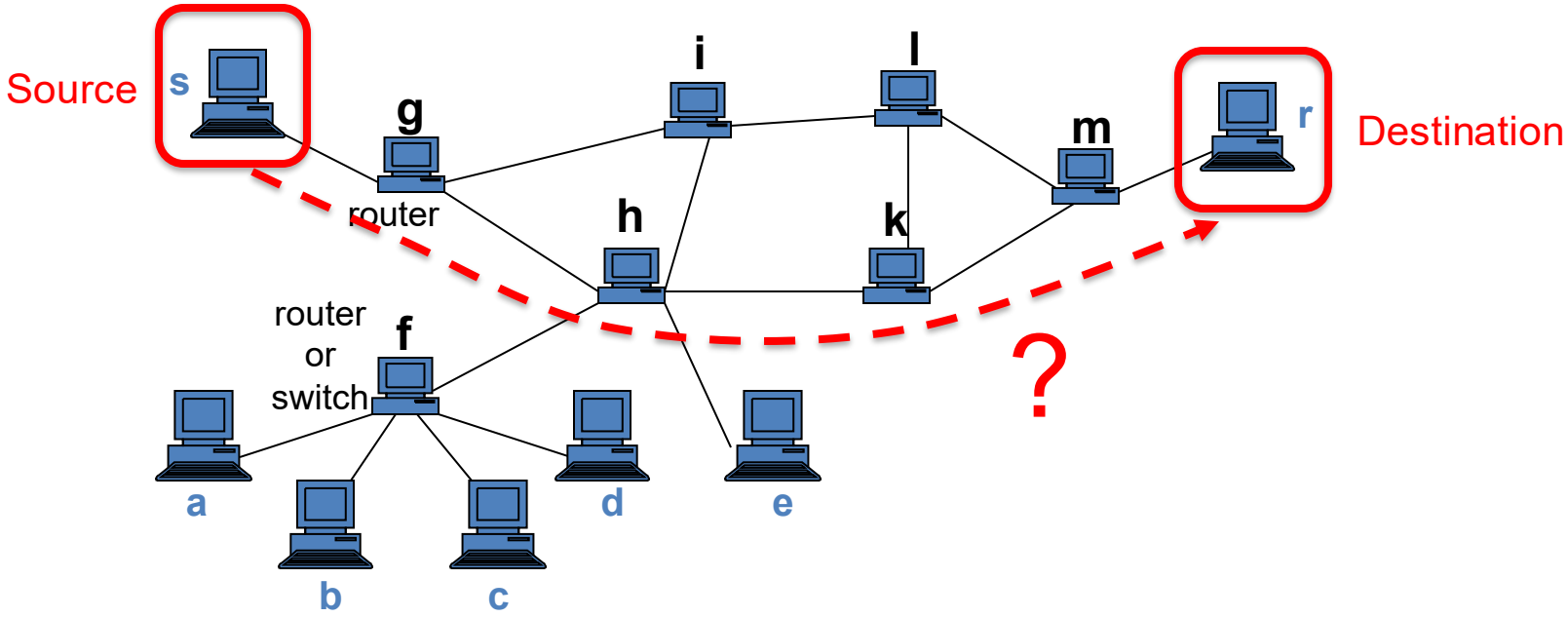
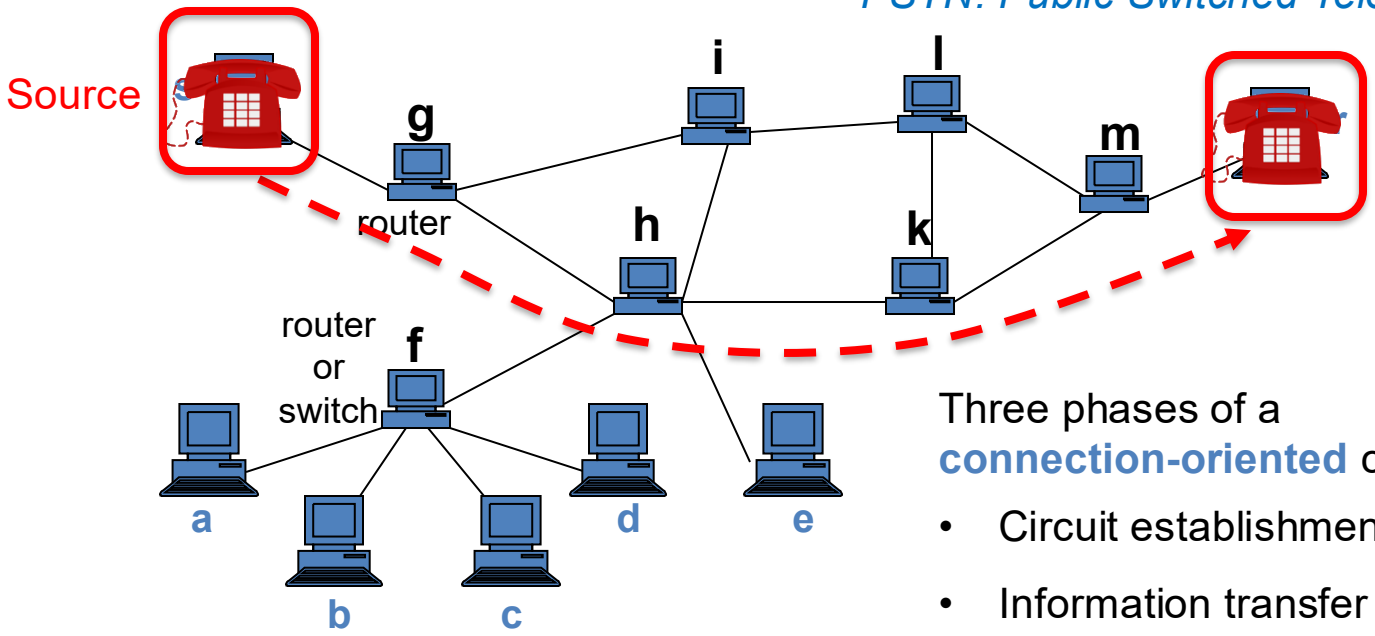
Networking



Circuit switching vs packet switching

Circuit Switching

PSTN: Public Switched Telephone Network

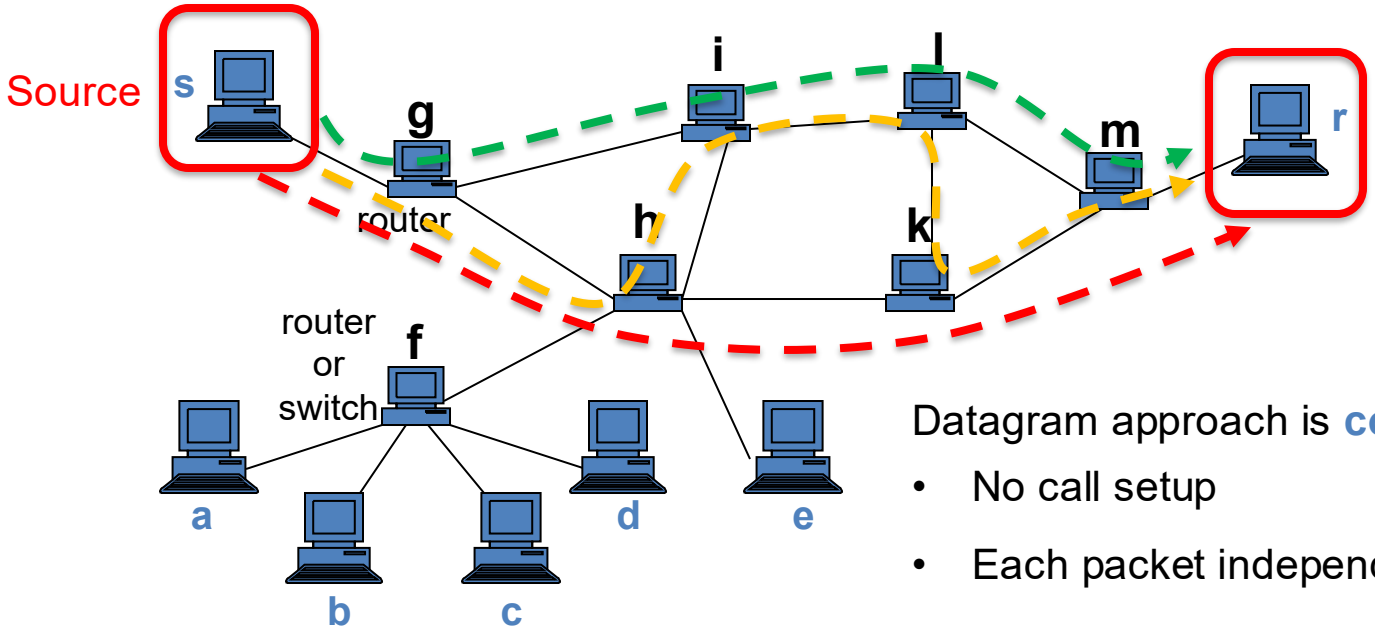


Three phases of a **connection-oriented** communication:

- Circuit establishment
- Information transfer
- Circuit disconnect

- Dedicated communication path
- Constant resource allocation (delay - jitter)
- Transparent, but inefficient

Packet Switching

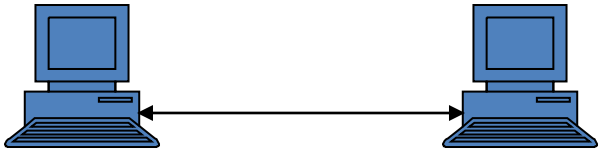


Datagram approach is **connectionless**:

- No call setup
- Each packet independent to the other

- *Packet*: block of data (+ *header*, control information)
- No dedicated path/resource

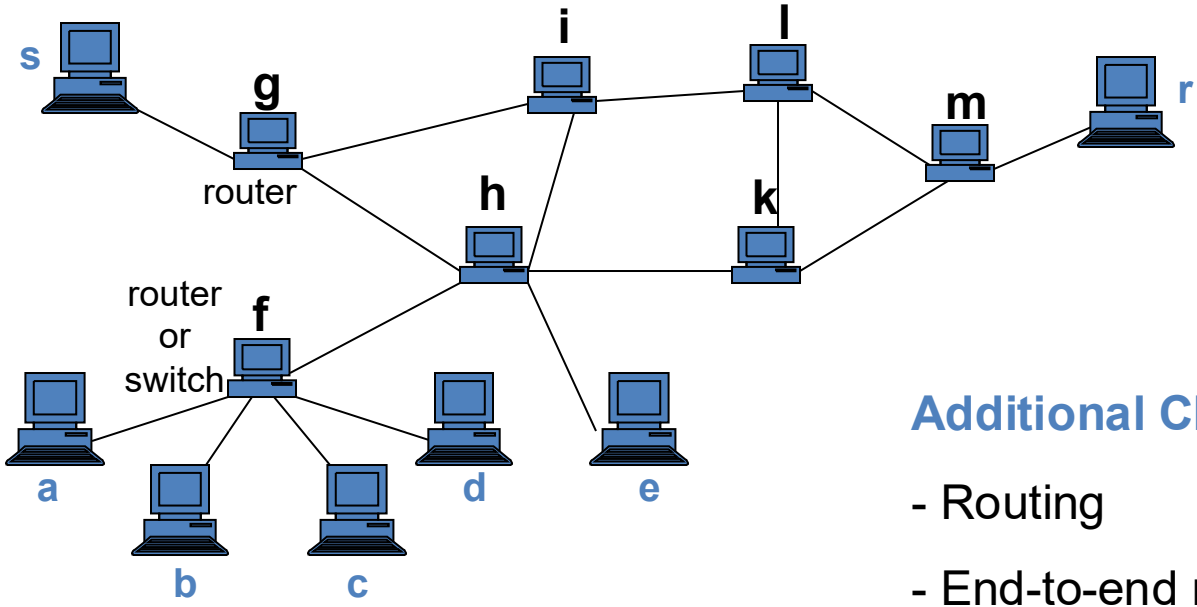
Link-Based Connection



Challenges:

- Representing 1s and 0s on the medium
- Fragmentation *Divide information unit in subunits*
- Error detection and correction (reliability)
- Flow control *Decide sending rate*
- Medium Access Control

Networking

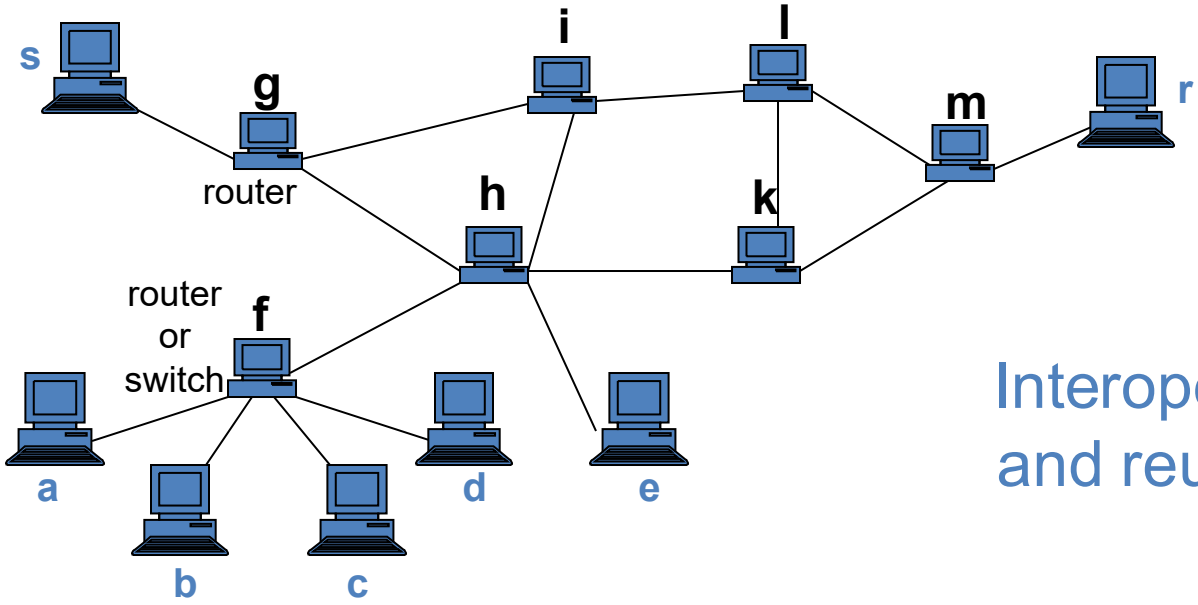


Need for protocols!

Additional Challenges:

- Routing
- End-to-end reliability
- End-to-end flow control
- Congestion control

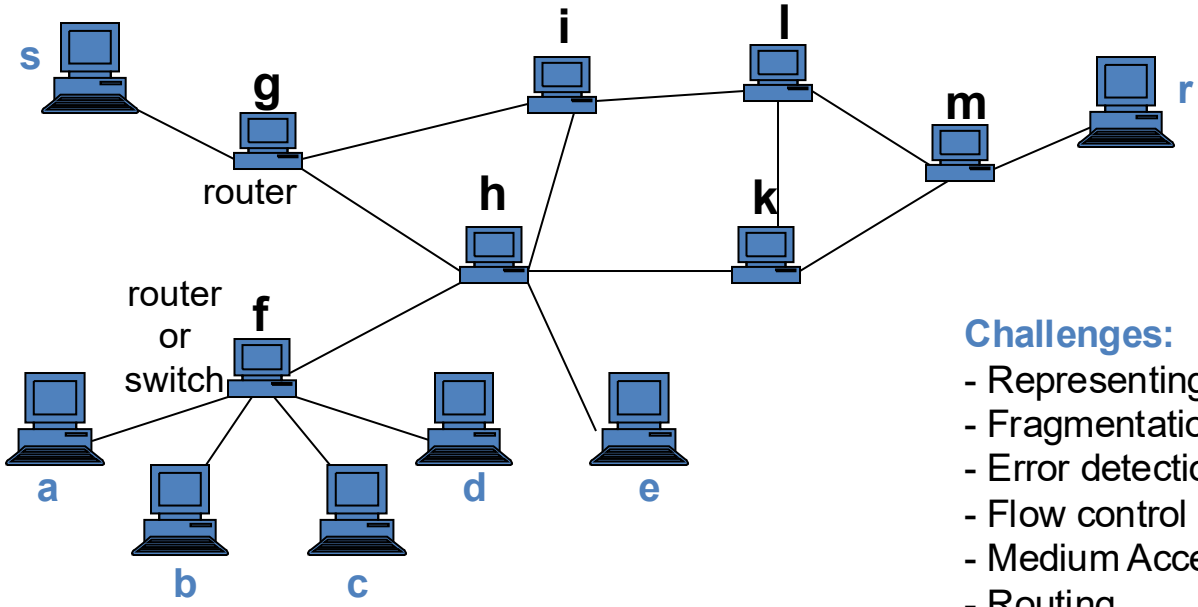
Protocols



Interoperability and reusability

Formal standards and policies comprised of rules, procedures and formats that define communication between two or more devices over a network.

Protocols



Protocol Layering

Divides the protocol design task into smaller steps

- Protocol stack
- Basis of protocol design

Challenges:

- Representing 1s and 0s
- Fragmentation
- Error detection and correction
- Flow control
- Medium Access Control
- Routing
- End-to-end reliability
- End-to-end flow control
- Congestion control

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Standardization Organizations

- **IETF** (Internet Engineering Task Force)
  - *Internet communication protocol*
- **IEEE** (Institute of Electrical and Electronics Engineers)
  - *Wireless and wired communication*
- **ITU** (International Telecommunication Union)
  - *Telecommunication protocols and PSTN*
- **ETSI** (European Telecommunications Standards Institute)
- **ISO** (International Organization for Standardization)
- **3GPP** (Third Generation Partnership Project)
- **5GPPP** (5G Infrastructure Public-Private Partnership)

Open Systems Interconnection (OSI) Layers

• Application	applications
• Presentation	eliminating the problems due to differences in syntax
• Session	establishing, managing and terminating sessions
• Transport	reliability, flow and congestion control
• Network	addressing, routing
• Data Link	MAC, synchronization, error control, flow control
• Physical	representing 1s and 0s on the medium

Open Systems Interconnection (OSI) Layers

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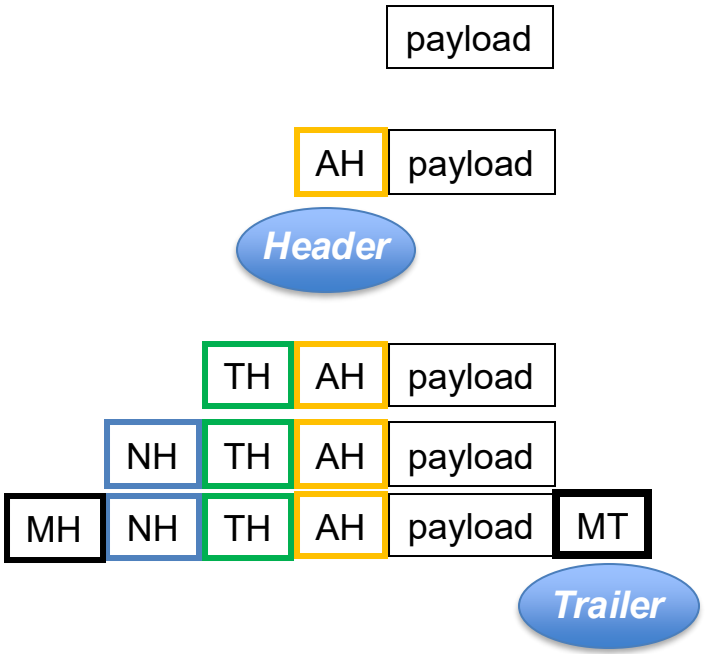
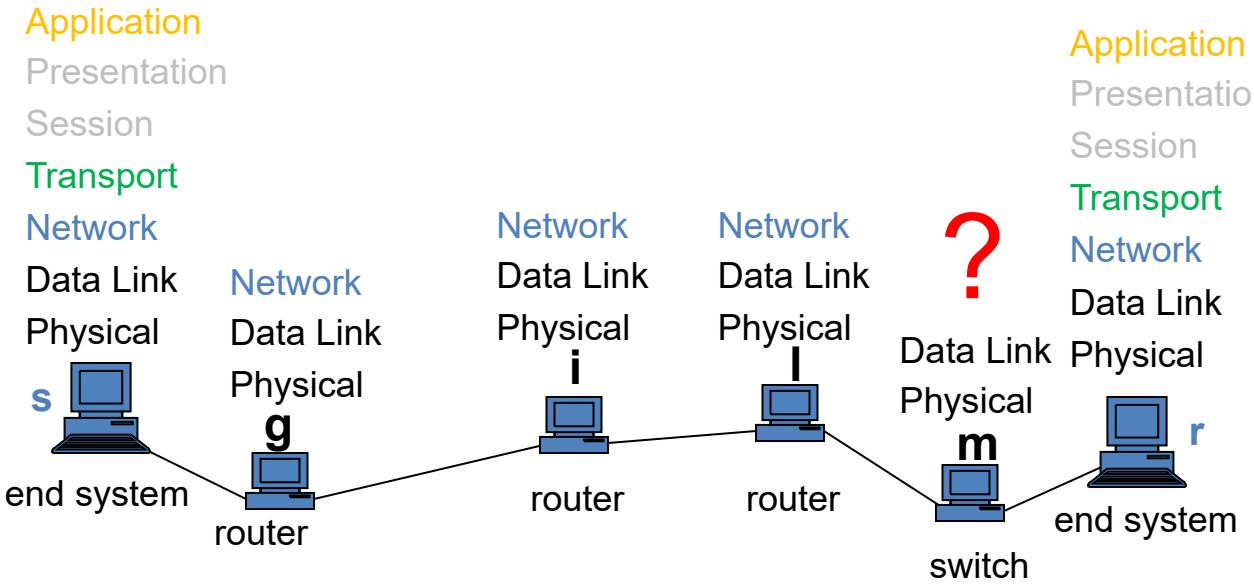
- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical



- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical

encapsulation **dencapsulation**

Open Systems Interconnection (OSI) Layers



Networking Equipment

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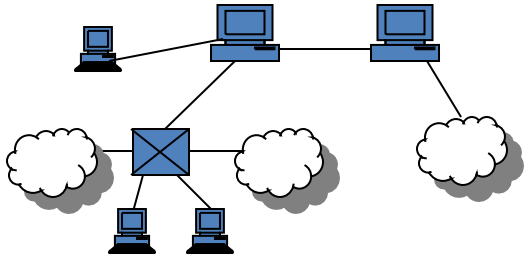
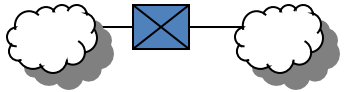
- Network

router

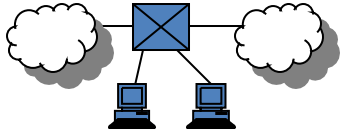


- Data Link (MAC)

bridge



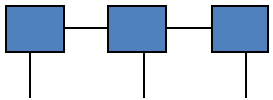
switch



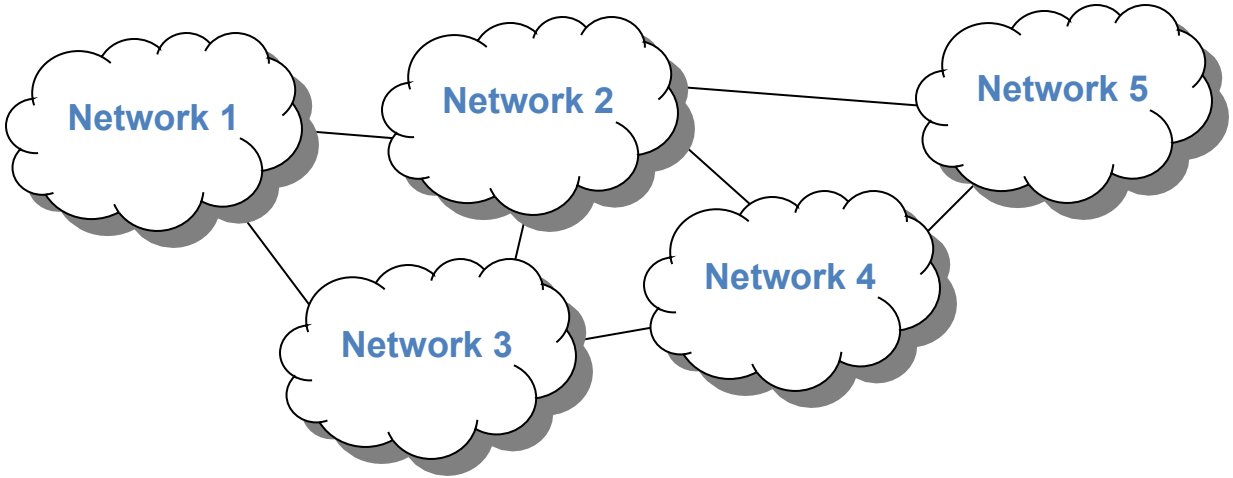
- Physical

repeater

hub



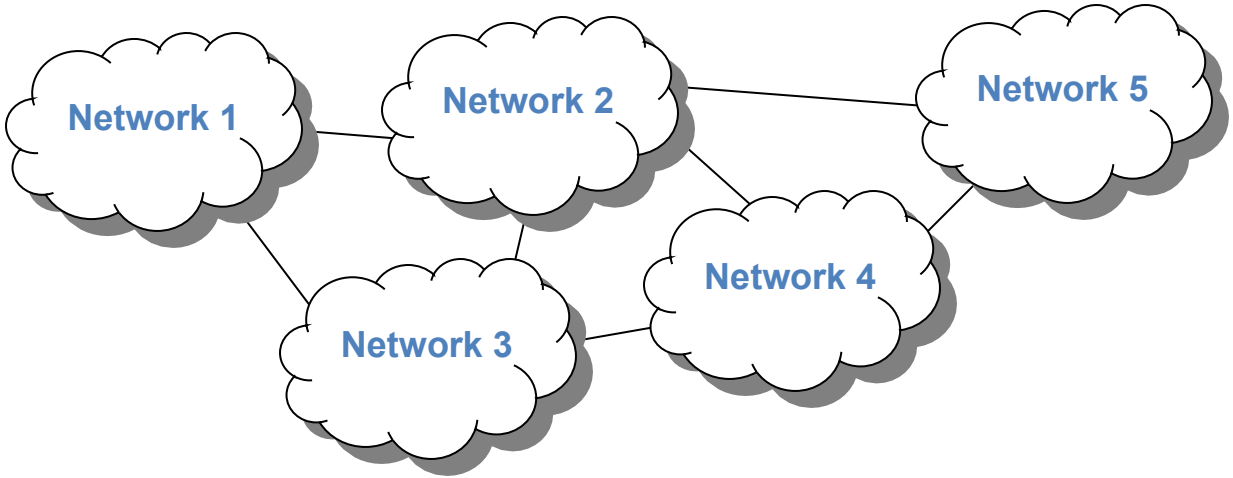
Internetworking



Interconnection of networks

- Hierarchical: LAN - MAN - WAN
- Each network maintains its identity
- End systems and network equipment (aka intermediate systems by ISO)

The Internet



Internet Protocol Suit

Internet Protocol Suit

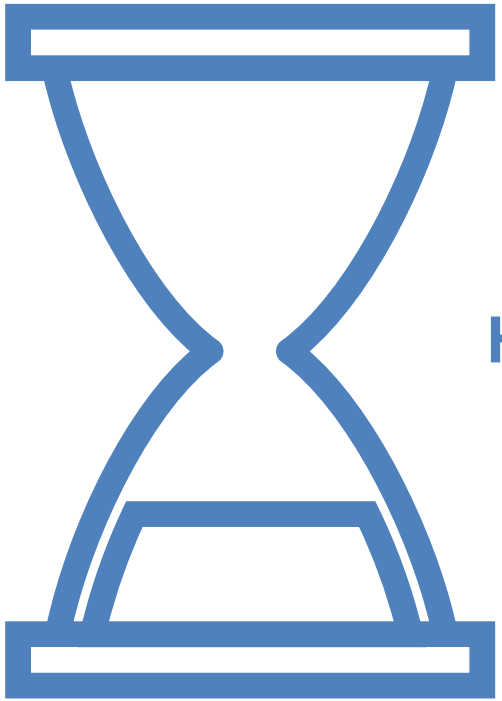
Application

Transport

Network

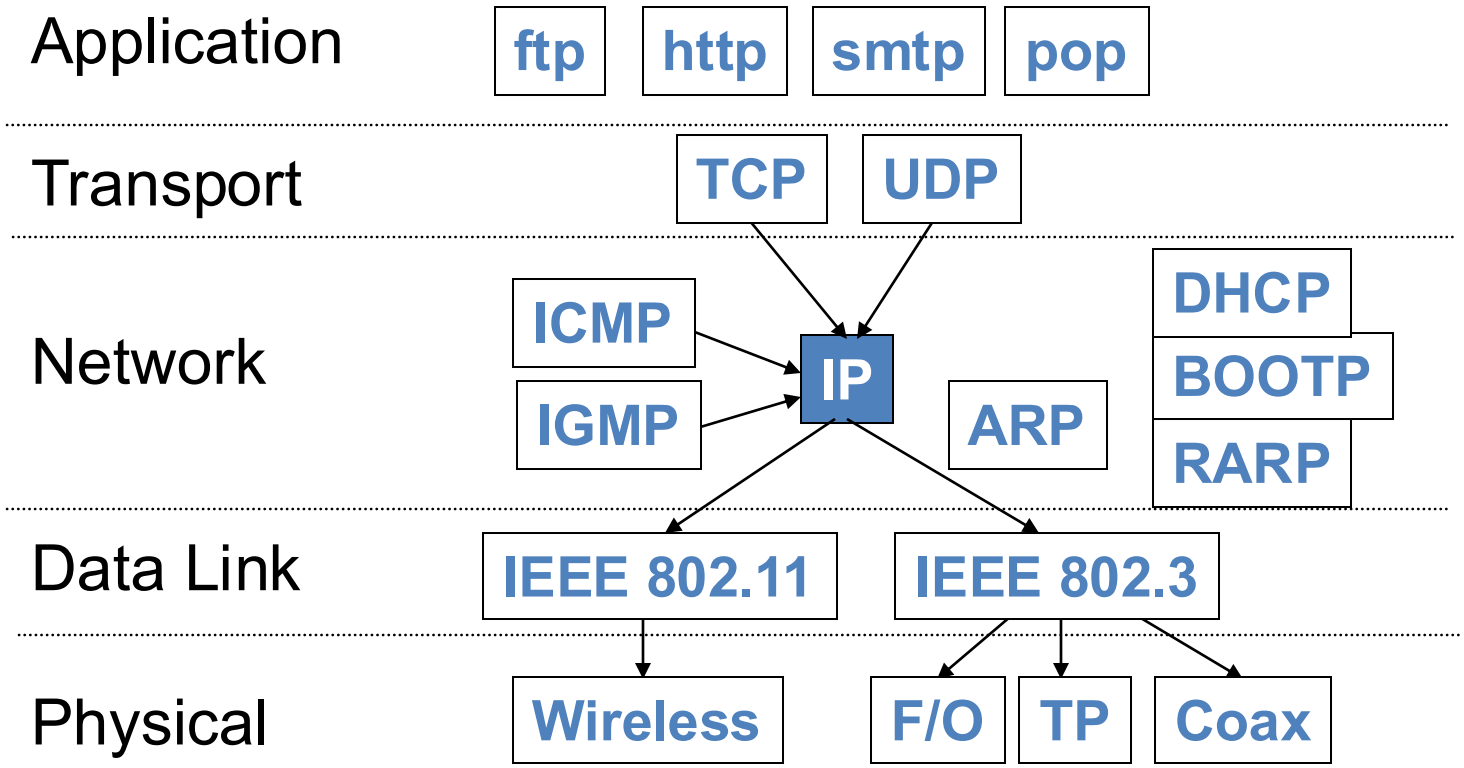
Data Link

Physical



Hour glass!

Internet Protocol Suit



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Wireless Network Challenges and Taxonomy

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Wireless Network Challenges

- Wireless Channel
  - High Interference
  - Limited coverage
  - Error prone
  - User mobility
  - Variability
- This challenges are not only physical, but have impact on other layers: multiple access control, error control, network layer, and transport layer.

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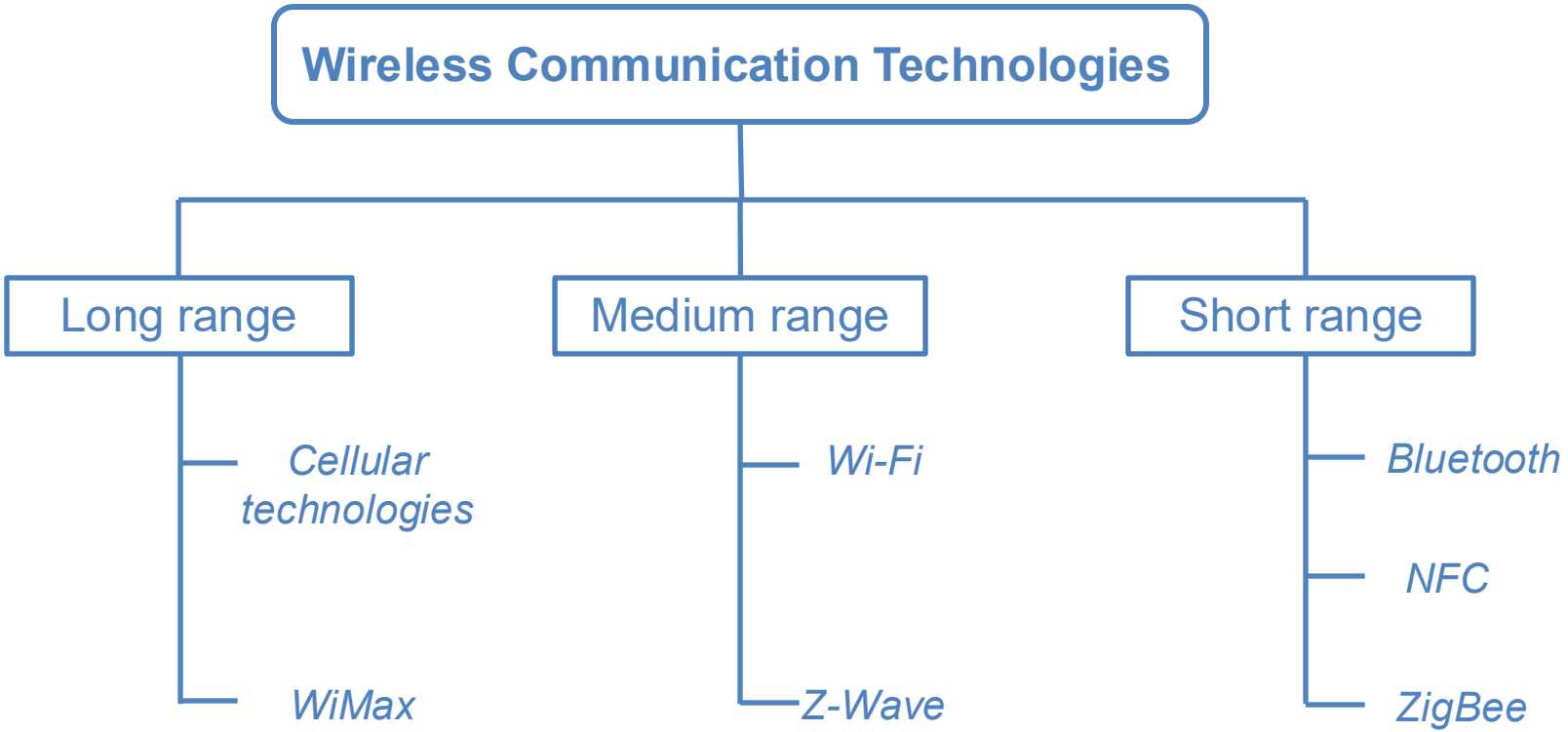
Taxonomy



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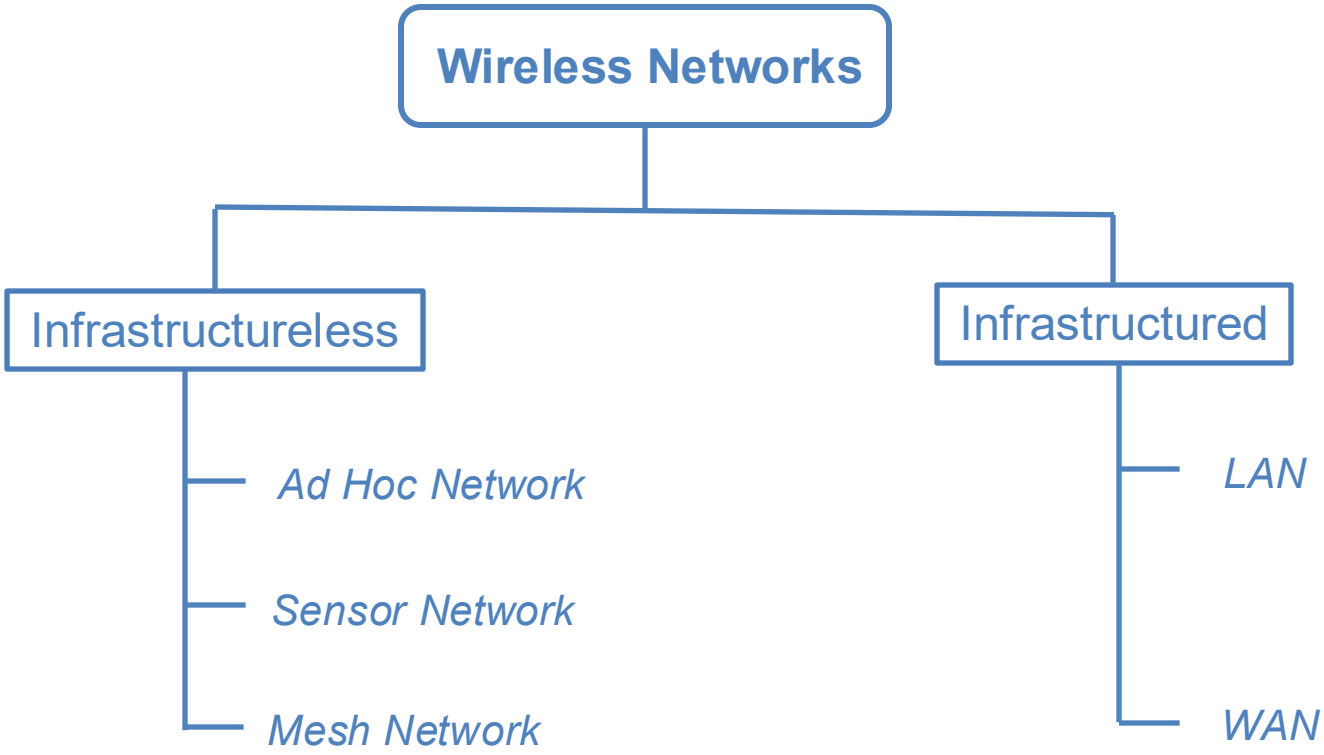
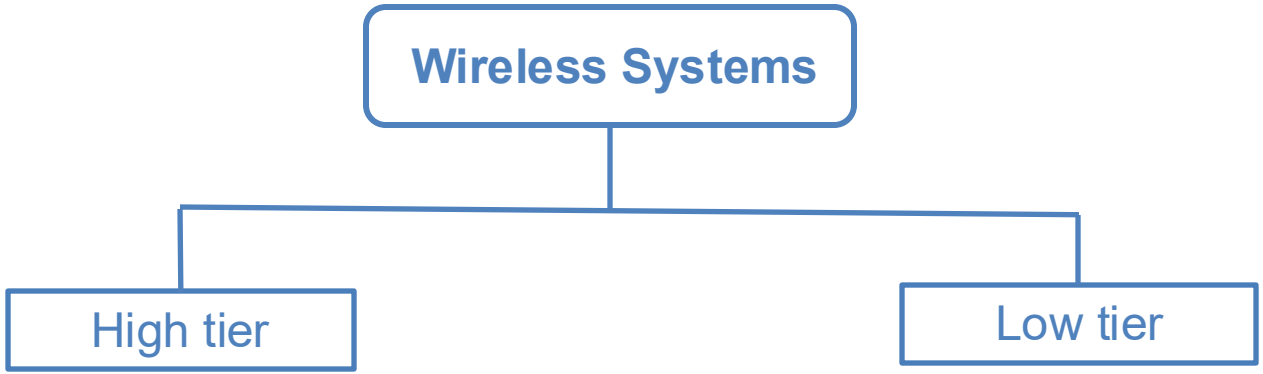
Taxonomy



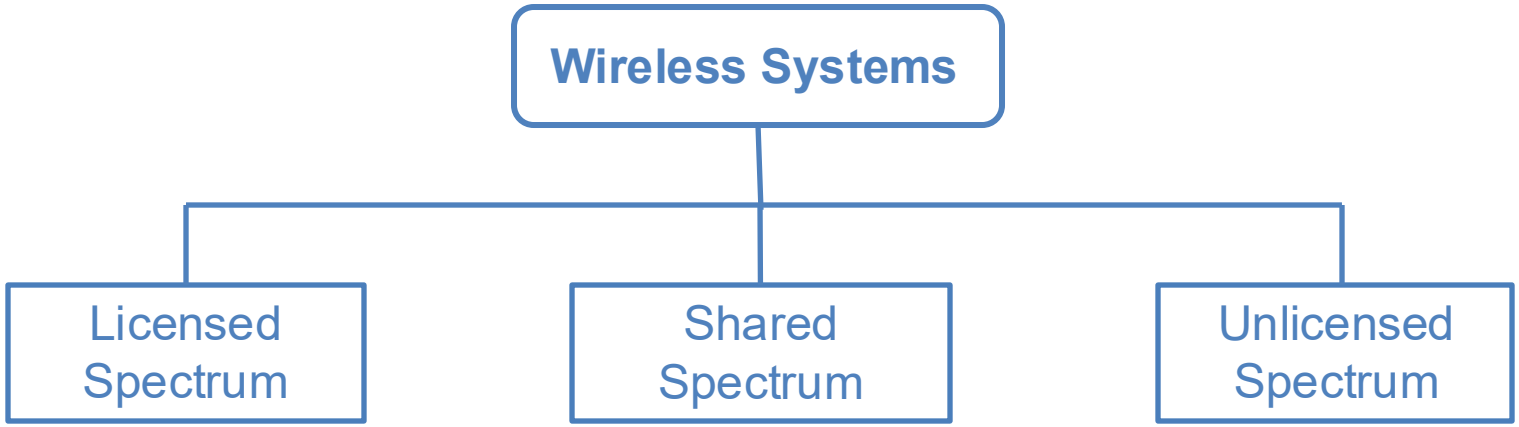
Taxonomy



- Designed for both pedestrian and vehicular speeds
- Coverage of large geographical areas

- Designed for pedestrian speeds
- Short coverage range

Taxonomy

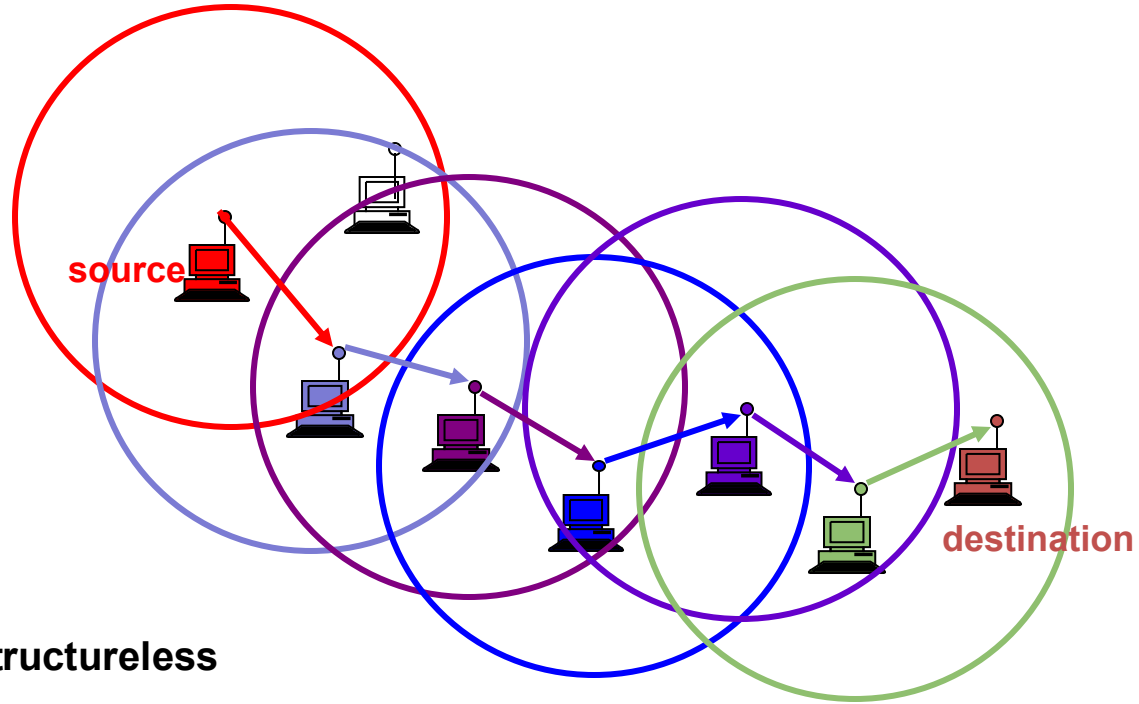


- Exclusive use
- Classical cellular network

- Shared exclusive use
- Authorized Shared Access (ASA)

- Shared use
- Multiple technologies: WiFi, Bluetooth, …

Ad-Hoc Networking



- **infrastructureless**
- **multihop**

Ad-Hoc Networking Applications

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- Temporary network deployment
- Disaster relief operations
- Smart buildings
- Cooperative objects (COs)
- Health care

Ad-Hoc Networking Challenges

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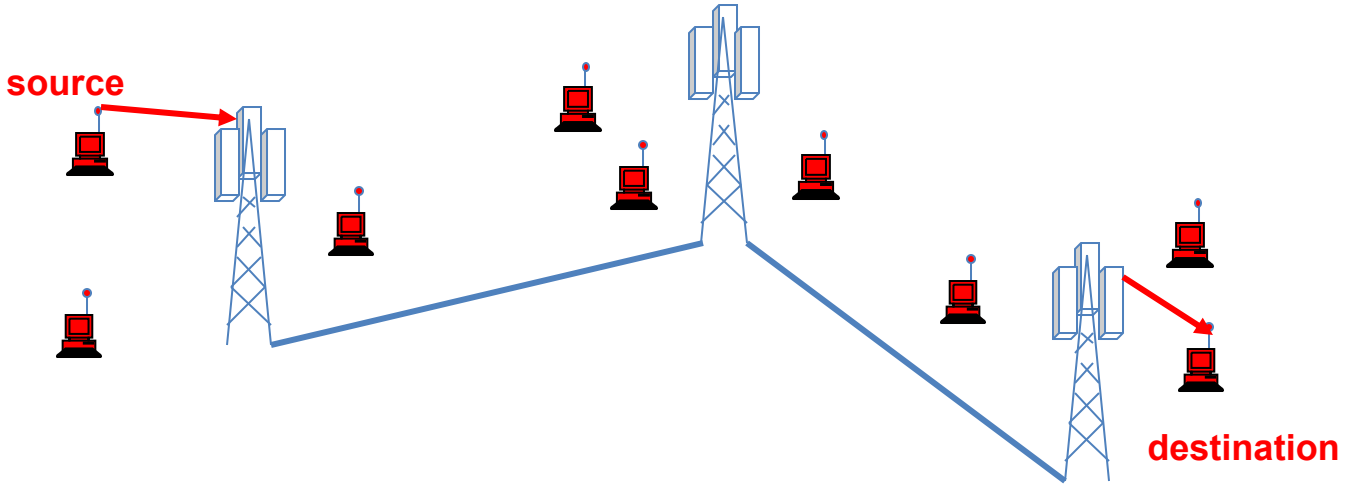
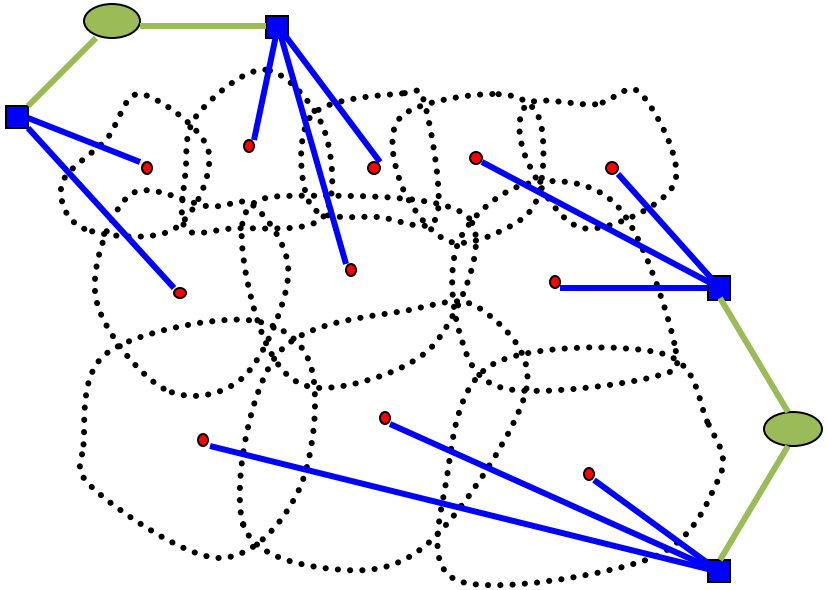
- Wireless medium
- Interference, Hidden Terminal and Exposed Terminal
- Mobility, Node Failures, Self-forming, Self-configuration, Topology Maintenance, Routing and Self-healing
- Node Localization and Time Synchronization
- End-to-end Reliability and Congestion Control

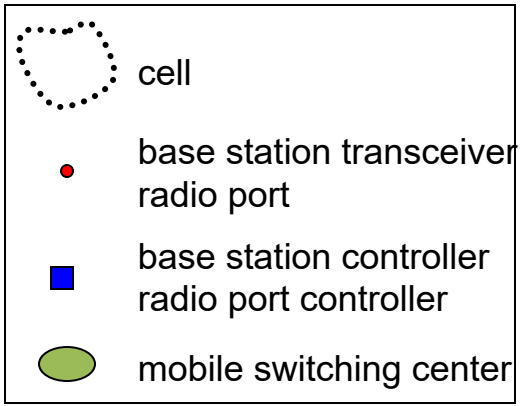
Cellular Networking



- **infrastructured**
- **single hop**

Cellular Architecture





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Ad-hoc vs Cellular Networking

	Ad-hoc Networking	Cellular Networking
Infrastructure	There is *no infrastructure*.	There is a *fixed infrastructure*.
Topology	The backbone nodes may be mobile. Topology *may change often* due to mobility and/or node failures.	The nodes in the infrastructure are fixed. Terminals can be mobile. However, the topology of the infrastructure *seldom changes*.
Nodes	The terminal nodes used by the users *can also relay* the traffic of the other nodes.	The nodes in the infrastructure convey the data between the source and destination. Their usage as a terminal station or a host computer is not mundane. The terminal nodes generally *do not relay* the other's traffic.
Links	The links are *mostly wireless*. An end-to-end connection can be through multiple wireless links, i.e., hops.	The terminal nodes access to the infrastructure via a wireless link. The links in the infrastructure can be *wireless or non-wireless*.

Ad-hoc vs Sensor vs Mesh Networks

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- There are many points of view:
  - Sensor and Mesh Nets as Ad-hoc Nets application
  - Three different networking paradigms

- **Important**: to know similarities and differences!

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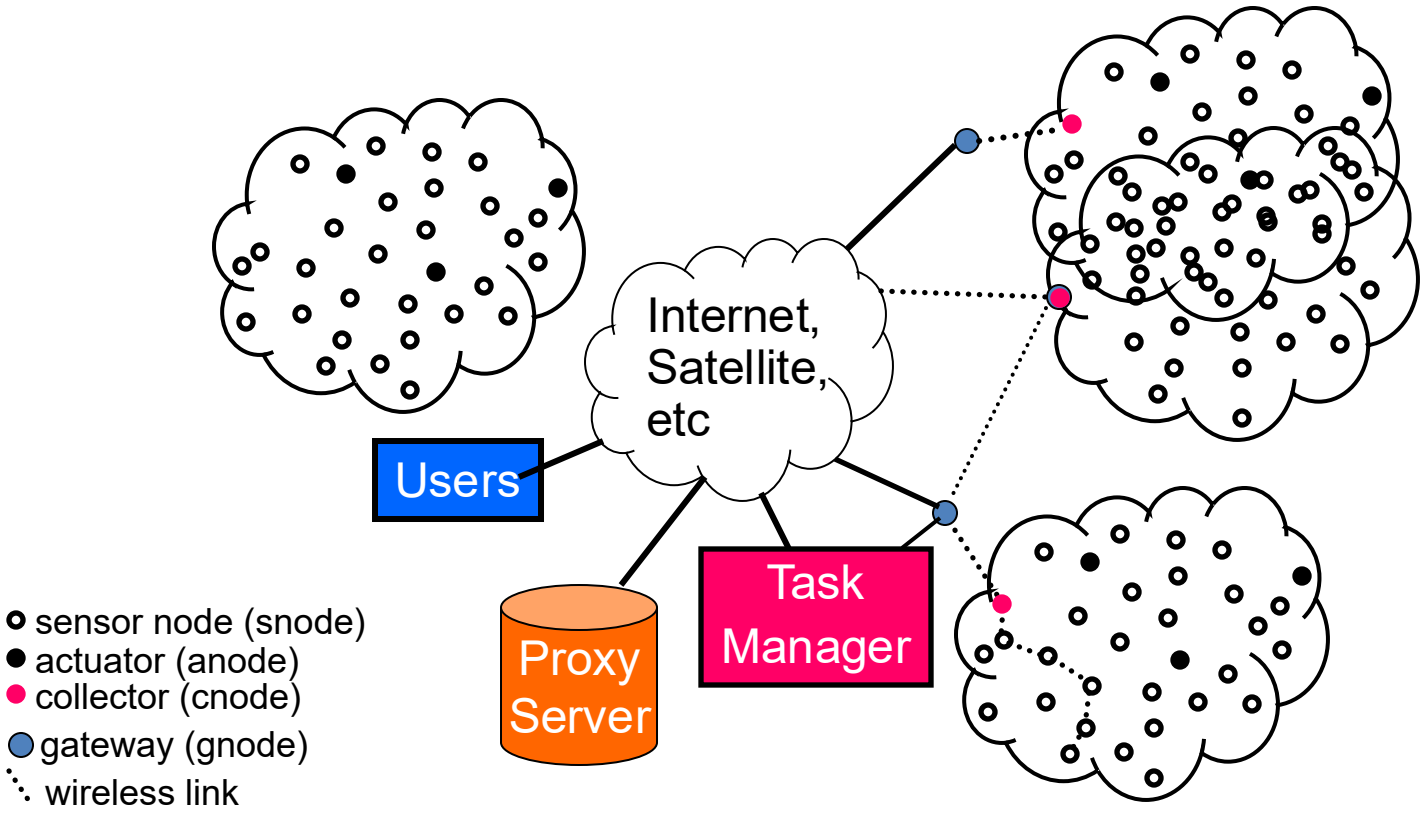
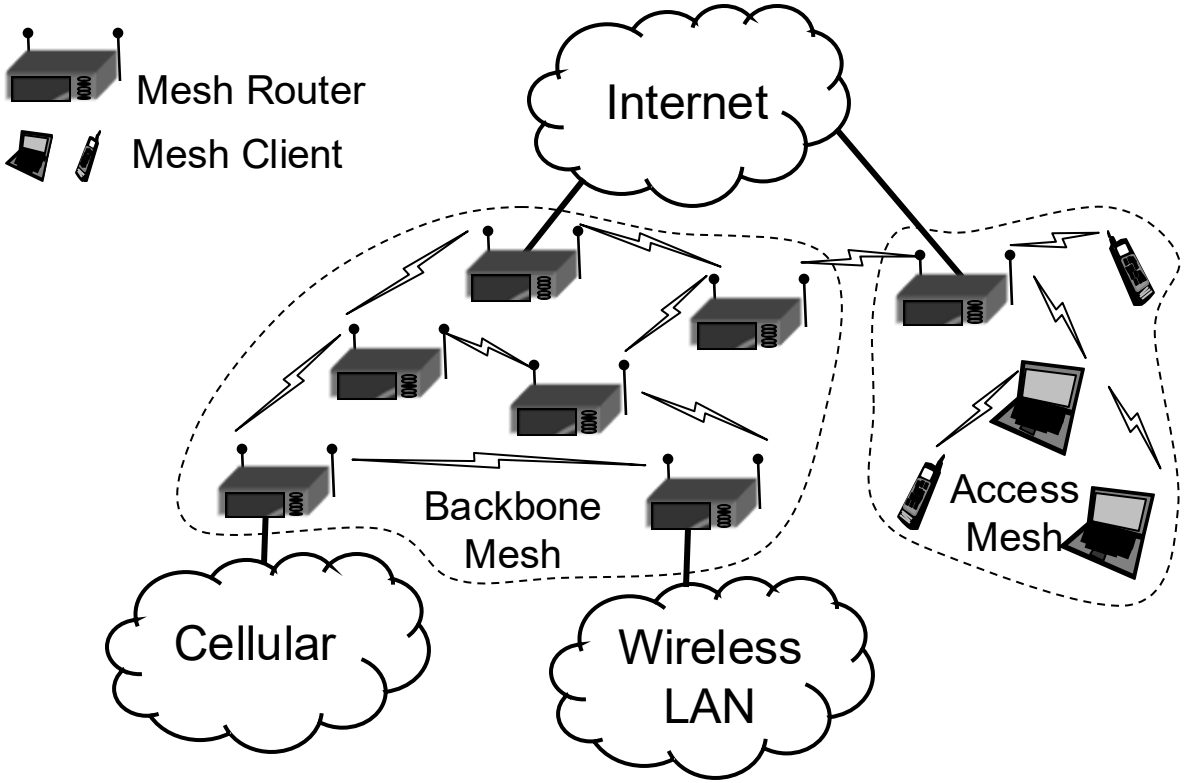
Sensor (& Actuator) Networks



Factors Influencing the Design

- Environment
- Fault Tolerance
- Scalability
- Production Cost
- Hardware Constraints
- Sensor Network Topology
- Power Consumption

Mesh Networks



Mesh Network Applications

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- Broadband home networking
- Community and neighborhood networking
- Enterprise networking
- Transportation systems
- Building automation and control networks

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Comparison of the Design Factors

Factor	Ad Hoc	Mesh	Sensor & Actuator
Wireless medium	ISM	ISM	ISM, acoustic, low lying antenna
Networking regime	random one-to-one	Random one-to-one, gateway nodes	one-to-many, many-to-one, many-to-many
Traffic	random, multimedia	Random, multimedia	temporally and spatially correlated, data
QoS requirements	bandwidth, delay, jitter, reliability	bandwidth, delay, jitter, reliability	power consumption, delay, reliability
Mobility	Mobile	typically fixed	generally fixed, network mobility
Fault tolerance	typically no critical point of failure	critical points of failure	critical points of failures, high fault-tolerance requirements
Operating environment	typical day-to-day environment	typical day-to-day environment	hostile and harsh, often unreachable
Power efficiency	not very critical	not critical	very critical
Scalability	order of hundreds	order of tens	order of thousands
Hardware constraints	laptops, PDAs	no constraint	tiny, low processing and memory capacity
Production cost	no hard constraints	no hard constraints	must be cost effective

Networking Tools

- Wireshark:
  - Free and open-source packet analyzer
- Tcpdump
  - CLI packet analyzer
- Cisco Packet Tracker
  - Cross-platform visual simulator
- GNS3
  - Network software emulator
- Unix (and not only)Tools
  - ICMP-based: ping, traceroute
  - Iperf: network performance measurements
  - Netstat, nslookup, ifconfig, nmap
- PRTG
  - SNMP-based Intermediate-device performance monitoring

Summary & Learning Material

- Communication Networks
  - Networking
  - Protocol
  - Internetworking

3.1–3.4
4.1–4.3
4.4

IMPORTANT!

- Wireless Network Challenges and Taxonomy
  - Ad-hoc Networking
  - Cellular Networking
  - Sensor Networks
  - Mesh Networks
- *Motivation*

Ch.1

First Quiz!

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Kahoot!

GET IT ON Google Play

Download on the App Store

https://kahoot.it/