# Basic Concepts

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ISAE-SUPAERO

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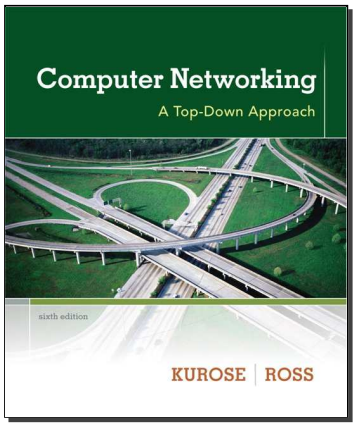
Textbook Chap. #1 Sections 1.1, 1.2, 1.3, 1.5



## Textbook




Computer Networking
A Top-Down Approach

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## Goal of this Lecture

- Understand what packet switching is
- Understand what circuit switching is
- Understand their differences
- Understand what a protocol

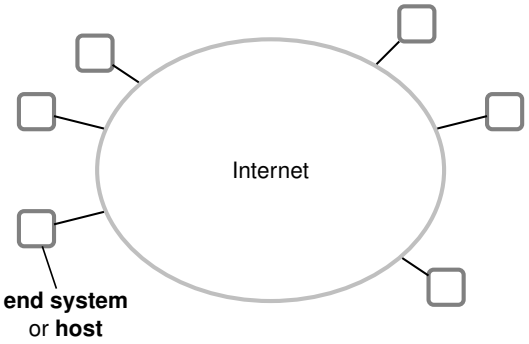


## Outline

- What is the Internet ?
- Types of network
- Types of service
- Protocols
- The Internet protocol stack



## What is the Internet ?



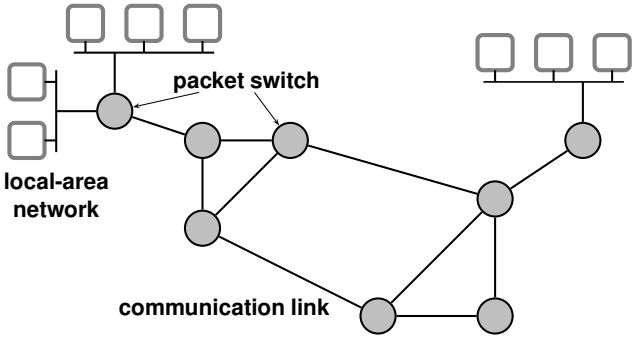



## End Systems

- End system or host ( )
  - a computer
  - a phone (more or less “smart”)
  - a server (well, that would also be a computer)
  - a camera (a.k.a., webcam)
  - a temperature sensor
  - a PDA
  - . . .
  - a car
  - a television set
  - a picture frame
  - a fridge
  - a watch
  - . . .
  - a pacemaker ?
  - (sun) glasses ?
  - . . .



## What is Inside the Internet ?






## Basic Concepts

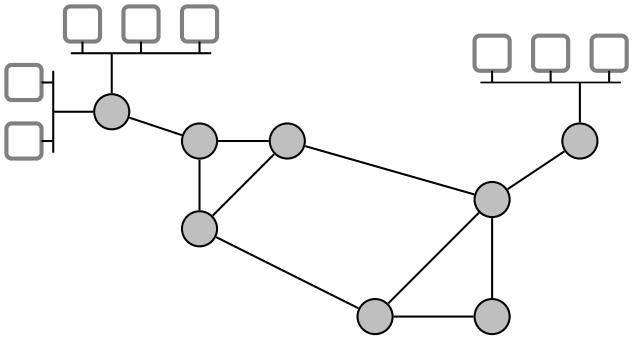
- The Internet uses packet switching
- Packet switch : a **link-layer switch** or a router
- Communication link : a connection between packet switches and/or end systems
- Route : sequence of switches that a packet goes through (a.k.a. **path**)
- Protocol : control the sending and receiving of information to and from end systems and packet switches

## Communication Links

- Various types and forms of medium
  - Fiber-optic cable
  - Twisted-pair copper wire
  - Coaxial cable
  - Wireless local-area links (e.g., 802.11, Bluetooth)
  - Satellite channel
  - ...

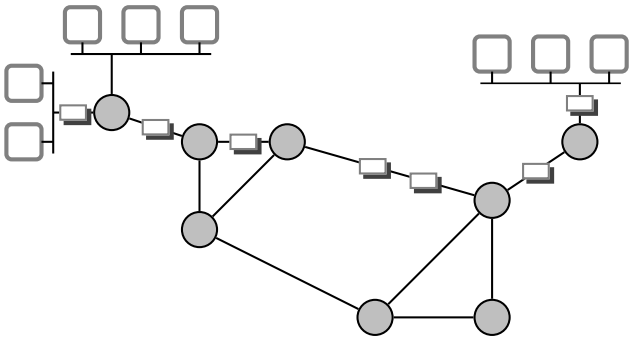


## Packet Switching



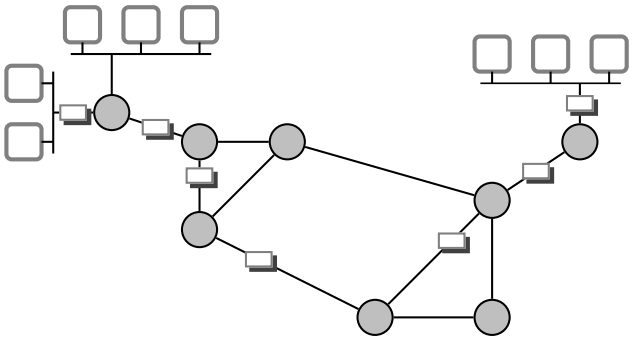


## Packet Switching





## Packet Switching



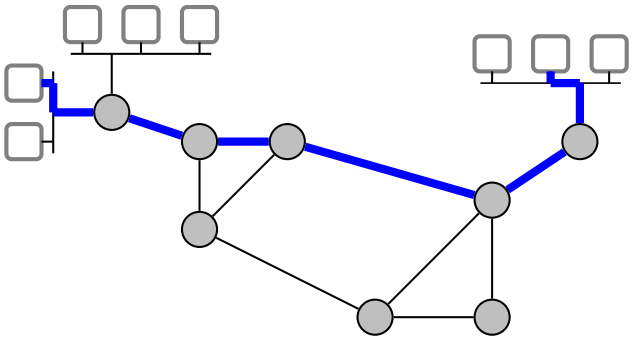


## Packet Switching

- The Internet is a **packet-switched** network
- Information is transmitted in **packets**
- Switches operate on individual packets
- A switch (router) receives packets and **forwards** them along to other switches or to end systems
- Every forwarding decision is taken on the basis of the information contained in the packet



## Circuit Switching





## Circuit Switching

- The telephone network is a typical circuit-switched network
- Requires a **connection setup** phase to reserve resources (links, buffers, switches, etc.)
- If setup succeed, the set of links selected are dedicated for the entire duration of the communication
- When finished, the network tears down the connection, freeing the corresponding resources (links, buffers, etc.)



## Circuit vs. Packet Switching

## Circuit vs. Packet Switching

- Circuit switching requires an expensive setup phase
  - however, once the connection is established, little or no processing is required
- Packet switching does not incur any setup cost
  - however, it always incurs a significant processing and space overhead, on a per-packet basis
    - ⋆ **processing cost** for forwarding
    - ⋆ **space overhead** because every packet must be self-contained



## Circuit vs. Packet Switching (2)

- Circuit switching admits a straightforward implementation of quality-of-service guarantees
  - network resources are reserved at connection setup time
- Guaranteeing any quality of service with packet switching is very difficult
  - no concept of a “connection”
  - and again, processing, space overhead, etc.



## Circuit vs. Packet Switching (3)

- Circuit switching allows only a limited sharing of communication resources
  - once a connection is established, the resources are blocked even though there might be long silence periods
  - i.e., circuit switching is an inefficient way to use the network
- Packet switching achieves a much better utilization of network resources
  - it is designed specifically to share links



## Virtual Circuits

- Idea : combine the advantages of circuit switching and packet switching
- There is a connection setup phase
- The connection does not create a physical circuit, but rather a “virtual circuit”

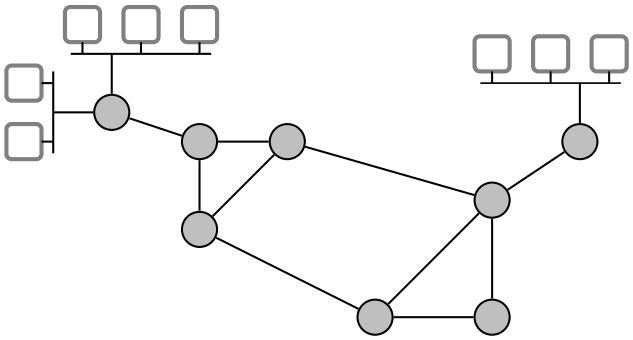


## Virtual Circuits

- Information is sent in packets, so links can be shared more effectively
- Packets carry a **virtual circuit identifier** instead of the destination address
  - **Important observation :** at any given time there are much fewer **connections** than **destinations**
    - ⋆ much faster per-packet processing (forwarding)
    - ⋆ lower per-packet space overhead

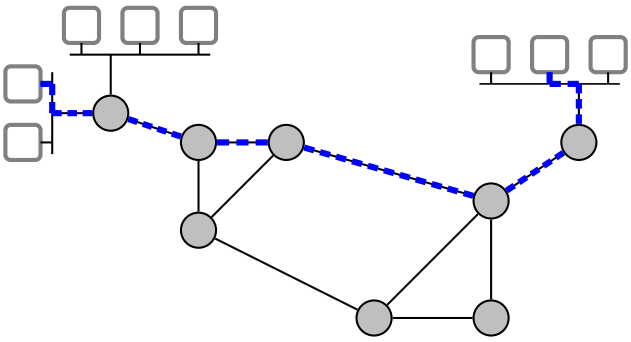


## Virtual Circuit



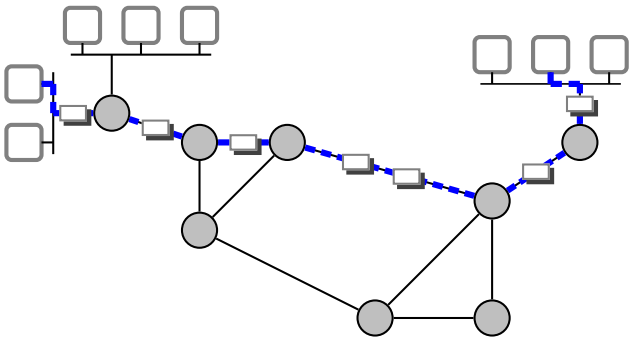


## Virtual Circuit

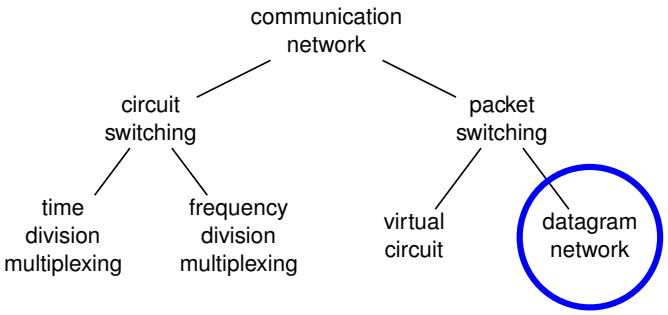




## Virtual Circuit

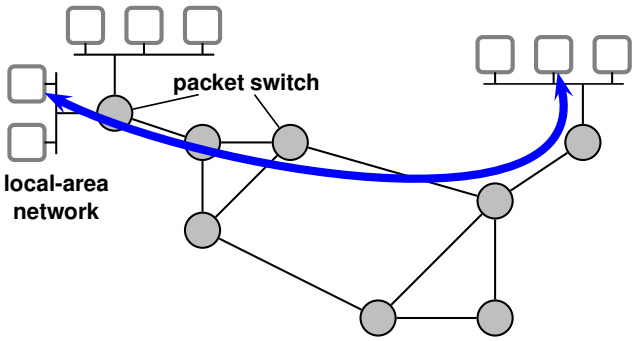


## Taxonomy of Networks






## Service Perspective




- What kind of service does the Internet offer to end systems ?



## Type of Service

- Two end systems can communicate through the Internet, but exactly what kind of communication service is that of the Internet ?
- Connectionless, "best effort"
  - the network accepts "datagrams" for delivery—this is conceptually similar to the postal service
  - "best effort" really means **unreliable** though not malicious
- Connection-oriented, reliable
  - virtual duplex communication channel ($A \leftrightarrow B$)—conceptually similar to a telephone service
  - information is transmitted "reliably" and in order



## Type of Service (2)

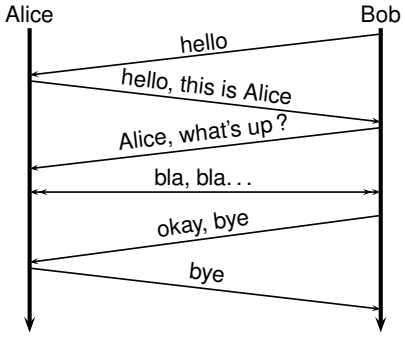
- How reliable is a "reliable" service ?
- The term "reliable" means that information will eventually reach its destination if a route is viable within a certain amount of time
- The network makes absolutely no guarantees on **latency** (i.e., the time it takes to transmit some information from a source to a destination)



## Communication Protocols

- End systems as well as packet switches run **protocols**. What is a protocol ?

  E.g., let's consider a phone call : Bob calls Alice






## Communication Protocols

- Phases of the protocol
  - **handshake :** establishes the identities and/or the context
  - **conversation :** free-form exchange
  - **closing :** terminates the conversation
- This protocol assumes a connection-oriented medium
- The protocol involves two parties (Alice and Bob)
- ...



## Communication Protocols (2)

- Another example : air traffic control
  - ... United 971, turn left heading 2-7-0
  - left to 2-7-0, United 971
  - ... AF 1575, contact Orly approach at 119.20
  - ...
  - ... AF 1575, contact Orly approach at 119.20
  - 1-1-9 point 2-0, AF 1575, bye
  - ... Center, request, Delta 800
  - ... United 971, climb and maintain flight level 3-7-0
  - flight level 3-7-0, United 971
  - ... Delta 800, go ahead
  - requesting flight level 3-5-0, Delta 800
  - Delta 800, unable at the moment

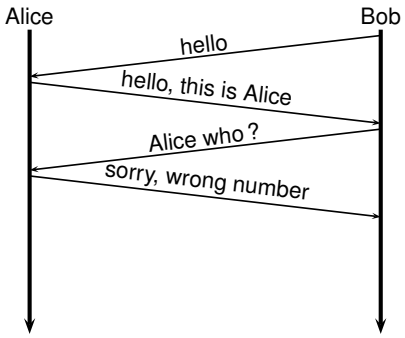


## Communication Protocols (2)

- A connectionless protocol
- Multi-party communication
- Medium access control (MAC) protocol
- Interleaved communication
- Acknowledgements
- Timeout and retransmission

## Communication Protocols (3)

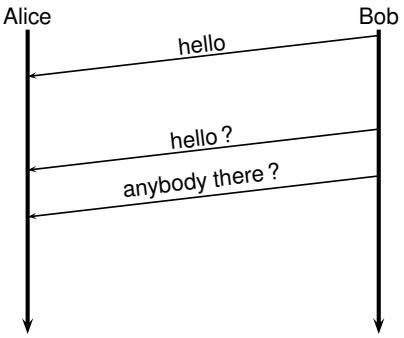
- Let's revisit the phone-call protocol






## Communication Protocols (4)

- Another run of the phone-call protocol





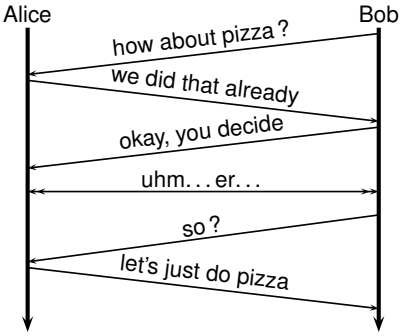

## Communication Protocols : Principles

- A protocol is a lot like a program
  - in fact, it is a **distributed program**, where different processes can send messages to each other
- It is an **executable** specification
- It must be **unambiguous**
- It must be **complete**
  - i.e., it must include actions and/or responses for all possible situations and all possible messages
- A network protocol must also define all the necessary **message formats**



## Communication Protocols (5)

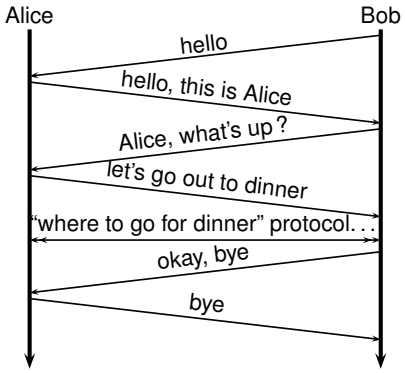
- Another protocol : deciding where to go for dinner






## Protocol Layering

- Bob calls Alice to decide where to go for dinner






## Protocol Layering

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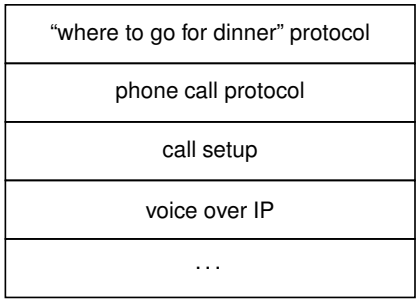




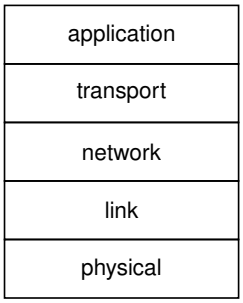

## Internet Protocol Stack

- The same layering principle applies to Internet hosts
- When two hosts communicate they have "to speak the same language"
- Each layer specifies its own language
- Each Internet component focuses on a specific layer
  - A router "speaks" at a given layer while an user application "speaks" at another level

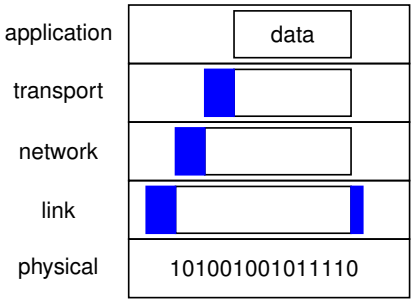


## Internet Protocol Stack

- There exists three main layering models sliced into four, five and seven layers
- The most used today is the five layers model presented below



## Internet Protocol Stack (2)






## Internet Protocol Stack (3)

- **Application** (e.g., HTTP, SMTP, and DNS)
  - application functionalities
  - application messages
- **Transport** (e.g., TCP and UDP)
  - application multiplexing, reliable transfer (TCP), congestion control (TCP)
  - datagrams (UDP) or segments (TCP)
- **Network** (IP)
  - end to end datagram, best-effort service, routing, fragmentation
  - packets (IP)
- **Link** (e.g., Ethernet and PPP)
  - point-to-point or local broadcast communication
  - frames (or packets)
- **Physical**