Lesson 1.3: Introduction & Foundation

CSC450 – COMPUTER NETWORKS | WINTER 2019-20

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OUTLINE

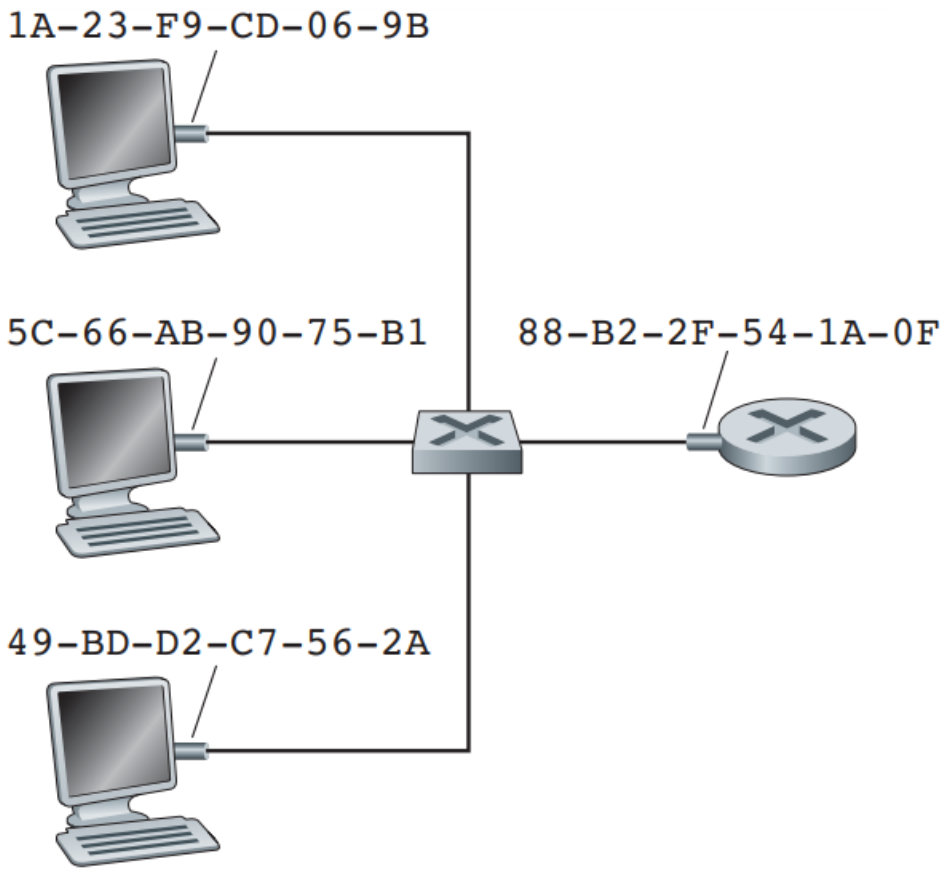
- Addressing.
  - Physical addressing.
  - Logical addressing.
- Network architectures.
  - Layering in networks.
  - Internet model.
  - OSI model.
  - Encapsulation.

ADDRESSING: INTRO

- Types of **network addresses**:
  - **Host** address.
    - **Application** layer - Uniform Resource Locator (**URL**) address.
  - **Logical** address.
    - **Network** layer - Internet Protocol (**IP**) address.
  - **Physical** address.
    - **Link** layer - Media Access Control (**MAC**) address.

PHYSICAL ADDRESSING

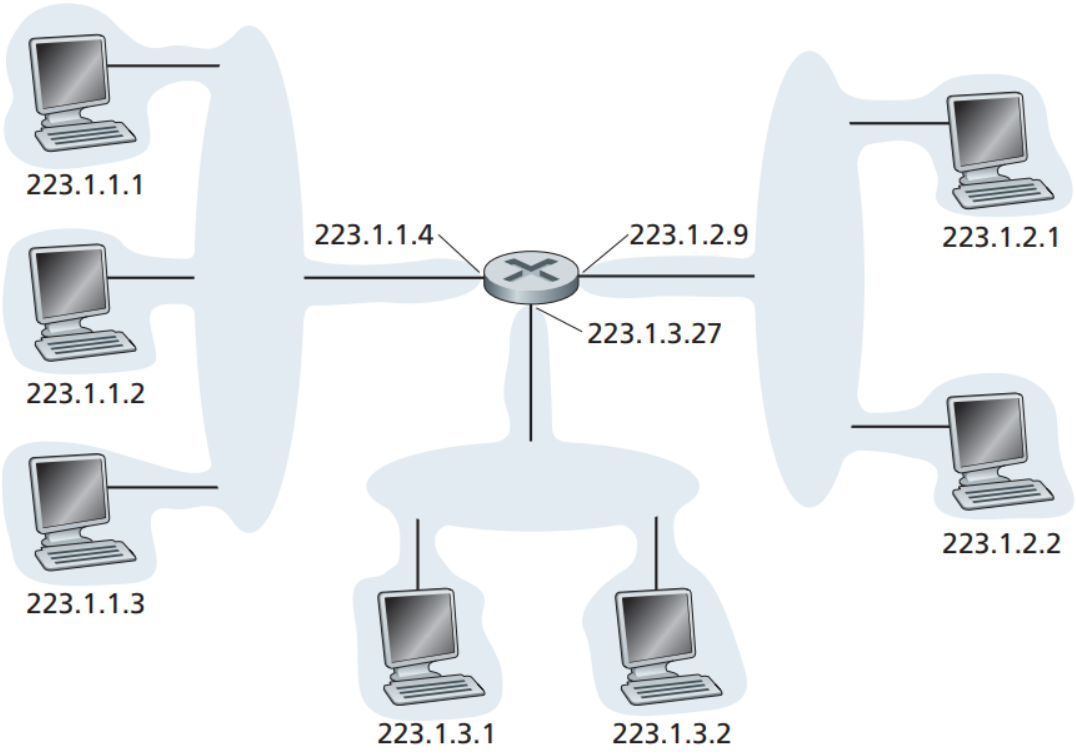
- Unique **media access control** (**MAC**) **address** is assigned to each **network interface controller** (**NIC**) residing at host/router.
  - **Physical** or **link-level** address.
- MAC address **characteristics**:
  - **6 byte** (*octet*) long.
    - 2^{48} (over 281 trillion) possible MAC addresses.
  - **Expressed** in **hexadecimal** notation.
    - Each byte is expressed as a **pair** of hexadecimal numbers.
  - **Resides** at the **network adapter ROM** (*hardware*).
    - Does **not change** if adapter moves to another network.
- **Address resolution protocol** (**ARP**) is used to **translate** between physical and logical addresses.



MAC addresses

LOGICAL ADDRESSING: INTRO (1)

- **Internet Protocol** (**IP**) **address** is assigned to each **interface** at a host/router.
  - Interface – **connection** between host/router and physical link.
  - **Logical** or **network-level** address.
- IP address **characteristics**:
  - **4 byte** (octet) long.
    - 2^{32} (around 4 billion) possible IP addresses.
  - **Expressed** in a **doted-decimal** notation.
    - Each byte is expressed as a **decimal** number.
  - **Hierarchical**.
    - **Network** prefix and **host** identifier.
  - Globally **unique**.
- **Domain name system** (**DNS**) is used to **translate** between logical and host addresses.



Interface IP addresses

LOGICAL ADDRESSING: INTRO (2)

- **Internet Protocol** (**IP**) **address** is assigned to each **interface** at a host/router.
  - Interface – **connection** between host/router and physical link.
  - **Logical** or **network-level** address.
- IP address **characteristics**:
  - **4 byte** (octet) long.
    - 2^{32} (around 4 billion) possible IP addresses.
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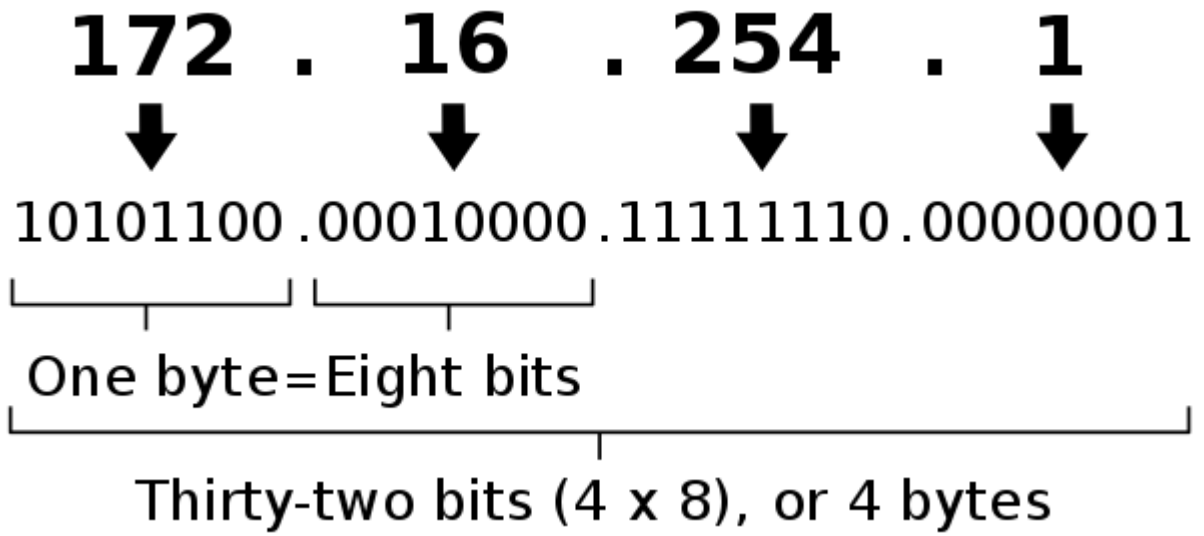


IP address representation

LOGICAL ADDRESSING: MASKS

- **Network mask** is used to **split** IP address into a **network prefix** and **host identifier**.
  - By applying **AND** operation on IP address and network mask.
- **Example**:

Host identifier

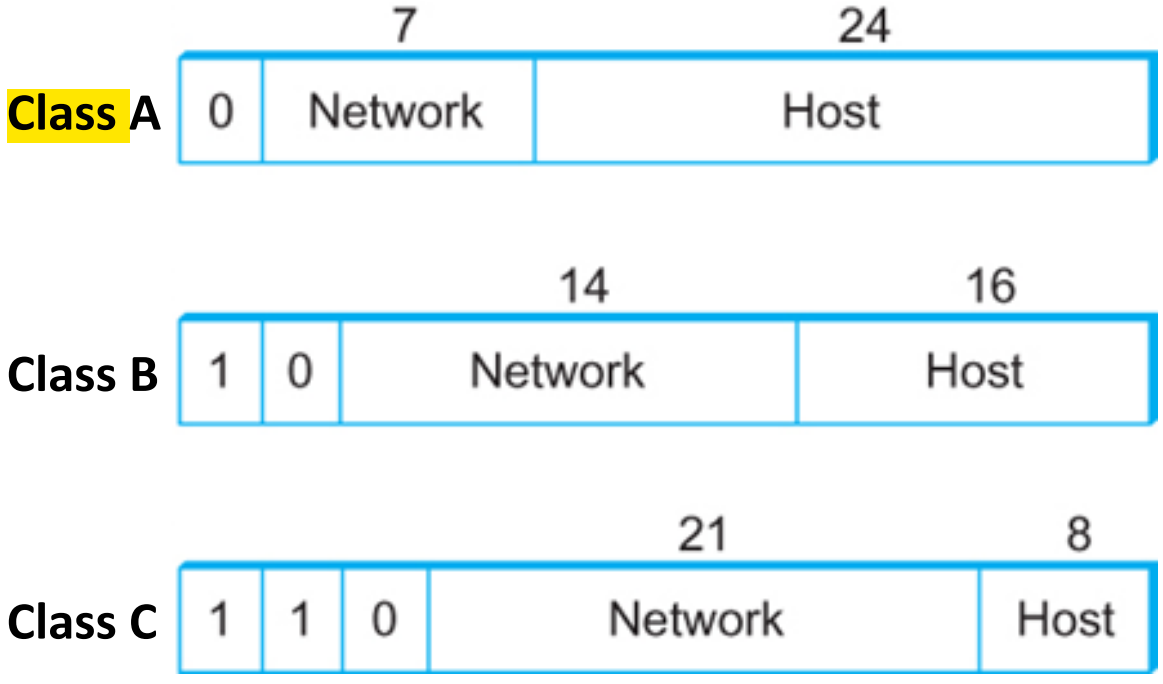
IP address:	*132.6.17.85*	->	10000100 00000110 00010001 01010101
Network mask:	*255.255.0.0*	->	11111111 11111111 00000000 00000000
			10000100 00000110 00000000 00000000

Network prefix

Network prefix: *10000100 00000110* -> **132.6**
Host identifier: *00010001 01010101* -> **17.85**

LOGICAL ADDRESSING: CLASSES

- Originally, **IP addresses** were divided into **classes**:
  - **Class A**:
    - **8** bit for **network** prefix, **24** bit for **host** identifier.
    - Address **range**: *0.0.0.0 – 127.255.255.255*
    - Network **mask**: *255.0.0.0*
  - **Class B**:
    - **16** bit for **network** prefix, **16** bit for **host** identifier.
    - Address **range**: *128.0.0.0 – 191.255.255.255*
    - Network **mask**: *255.255.0.0*
  - **Class C**:
    - **24** bit for **network** prefix, **8** bit for **host** identifier.
    - Address **range**: *192.0.0.0 – 223.255.255.255*
    - Network **mask:** *255.255.255.0*
  - **Class D & E**.



IP address classes

LOGICAL ADDRESSING: SUBNETS

- **Sub-netting** – process of **dividing** large **blocks of addresses** into several **contiguous sub-blocks** to create **smaller** physical networks.
  - Each **sub-block** is a **subnet**.
- **Subnet mask** is used to allow **sharing** single **network number** among **multiple hosts**.
  - All hosts on the same **physical network** share same **subnet number**.
- **Example**:

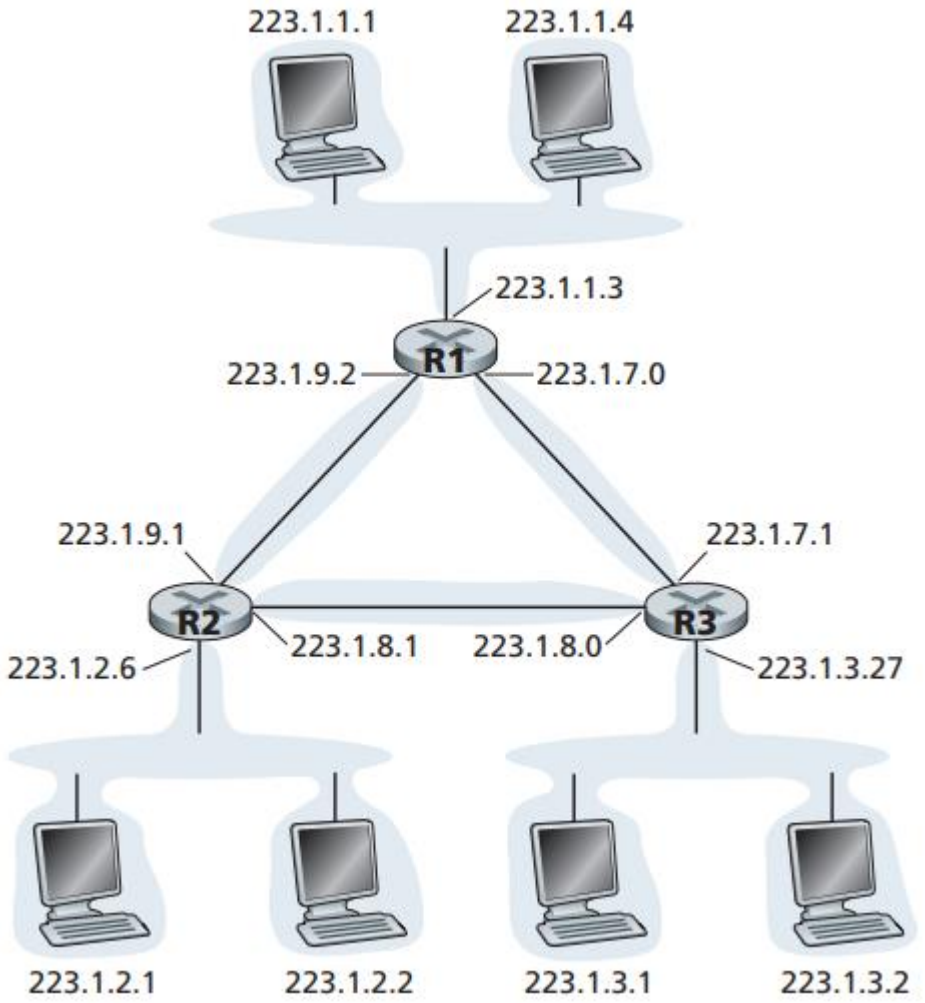
  Subnet: *223.1.1.0/27*

  Subnet index: */27*

  Indicates that left 27 bits define subnet address.

  Subnet mask: *11111111 11111111 11111111* ***111***00000

  255.255.255.224



Subnets interconnection

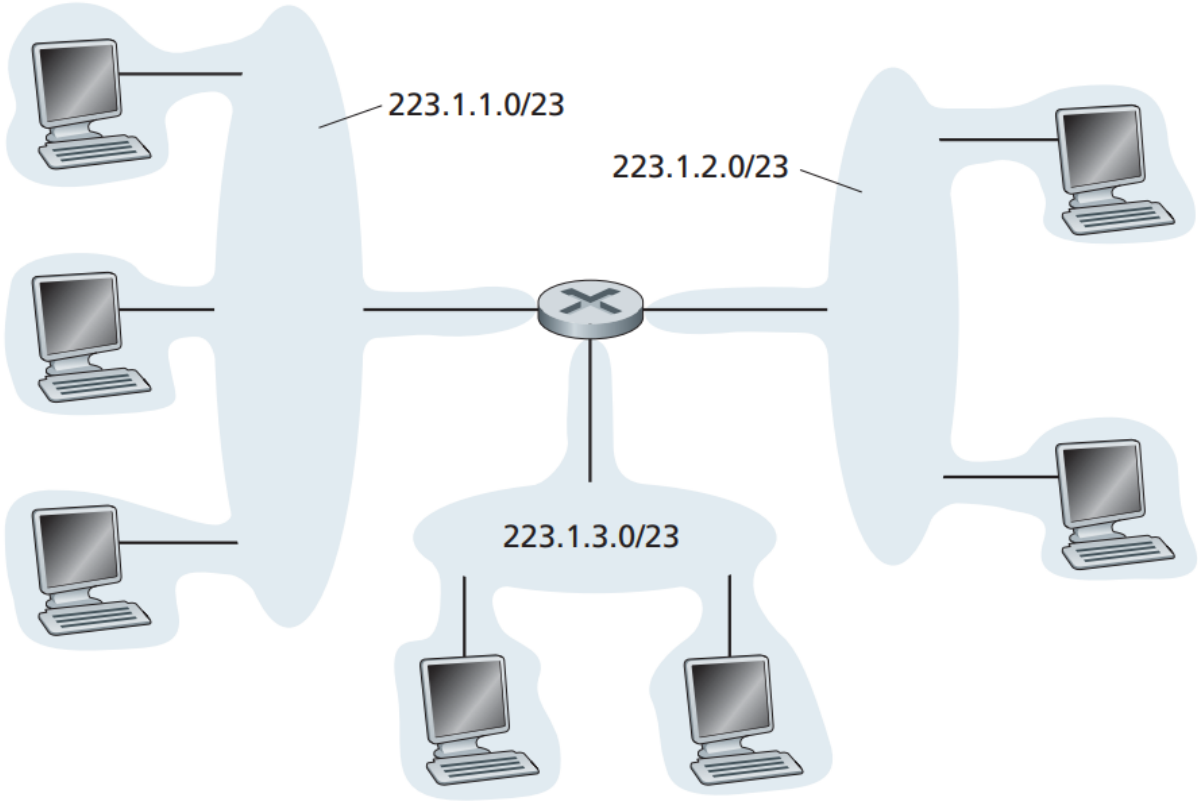
LOGICAL ADDRESSING: CLASSLESS (CIDR)

- **Classless inter-domain routing (CIDR)** is a current Internet **addressing method**.
  - **Generalizes** notion of **subnet** addressing.
    - Allows **arbitrary** length subnet addresses.
  - Address **format**: *a.b.c.d/x*
    - *a, b, c, d* – **octets** of IP **address.**
    - */x* – number of bits in **subnet** portion.
      - **Network prefix**.

- **Example**:
  - *200.23.16.0/23*

11001000 00010111 00010000 00000000

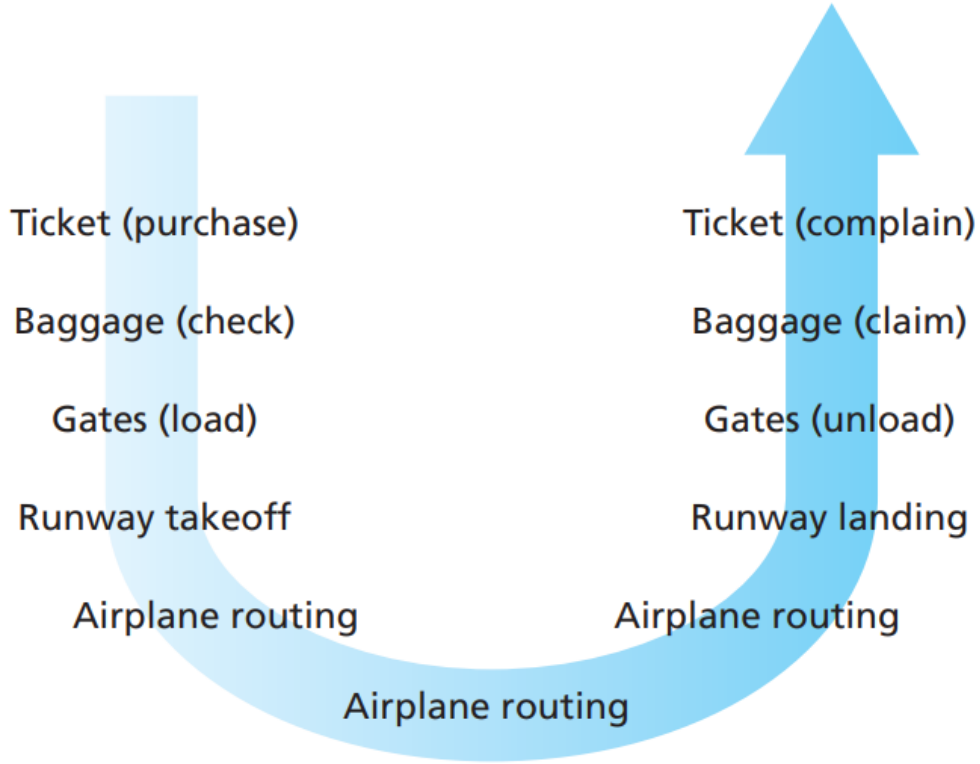
  - Maximum number of hosts under subnet = 2^n-2
    - n = # of bits for host part



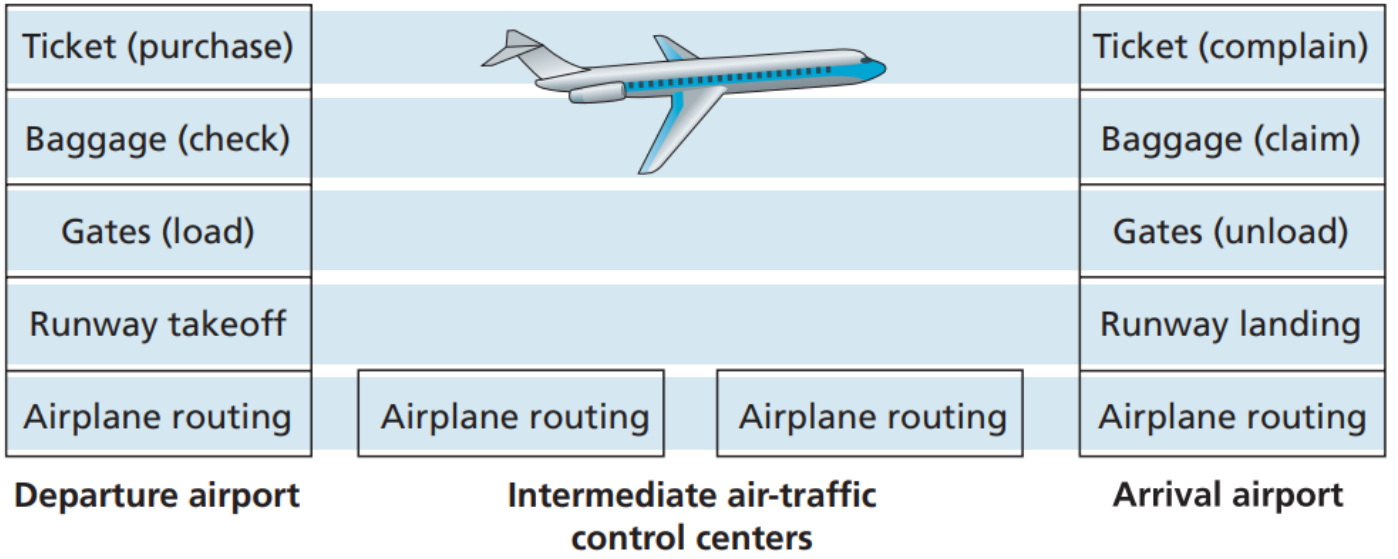
Subnet addresses

NETWORK ARCHITECTURES: LAYERING

- Airline system example.



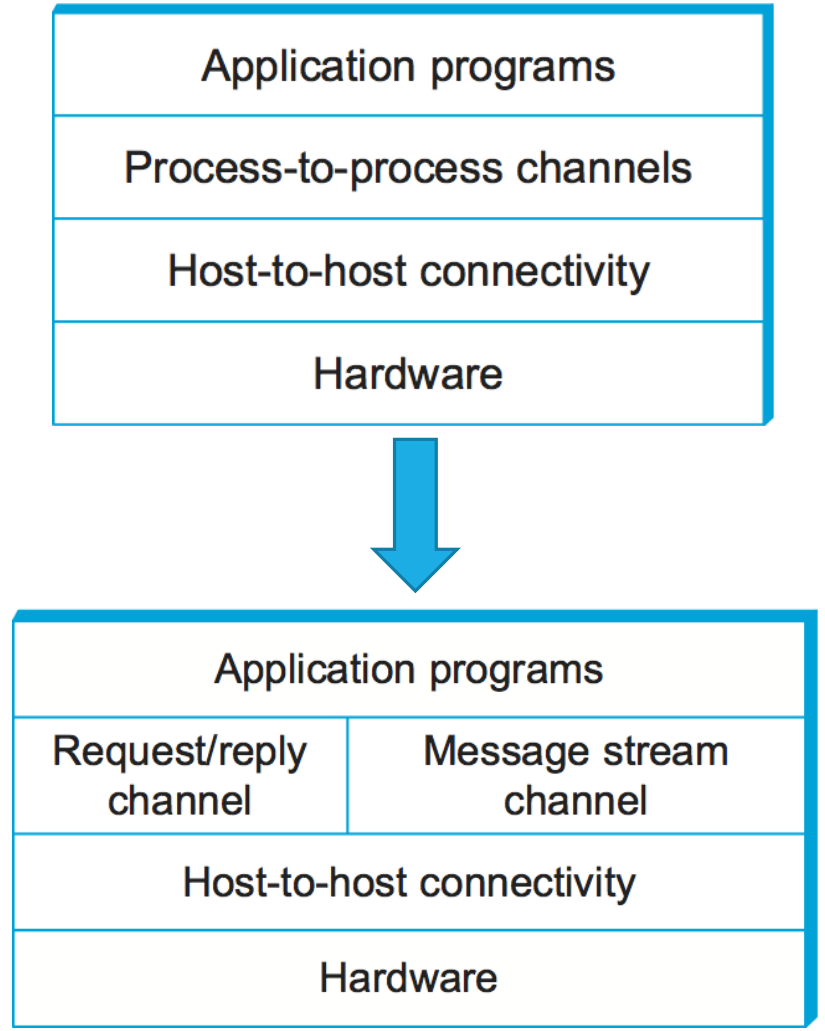
Actions in airplane trip



Layering of airline functionality

LAYERING IN NETWORKS (1)

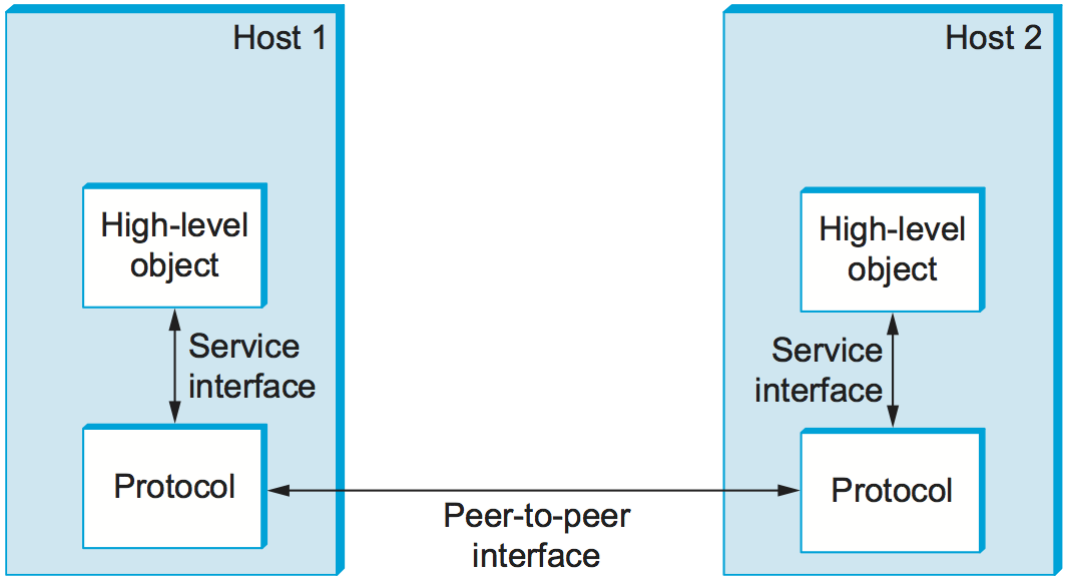
- Computer network **architectures** are organized in **layers**.
  - Each **layer** is composed of **protocols**.
    - Each **protocol** belongs to a **single layer**.
- Protocols at each level serve two main functions:
  - Provide communication services between layers.
  - Provide common functionality within the layer.
    - Layers on different machines can process same message.
- No direct layer-to-layer communications.
  - Protocol passes message down to the physical layer.
  - Physical layer protocols can send messages directly.



Sample network layers

LAYERING IN NETWORKS (2)

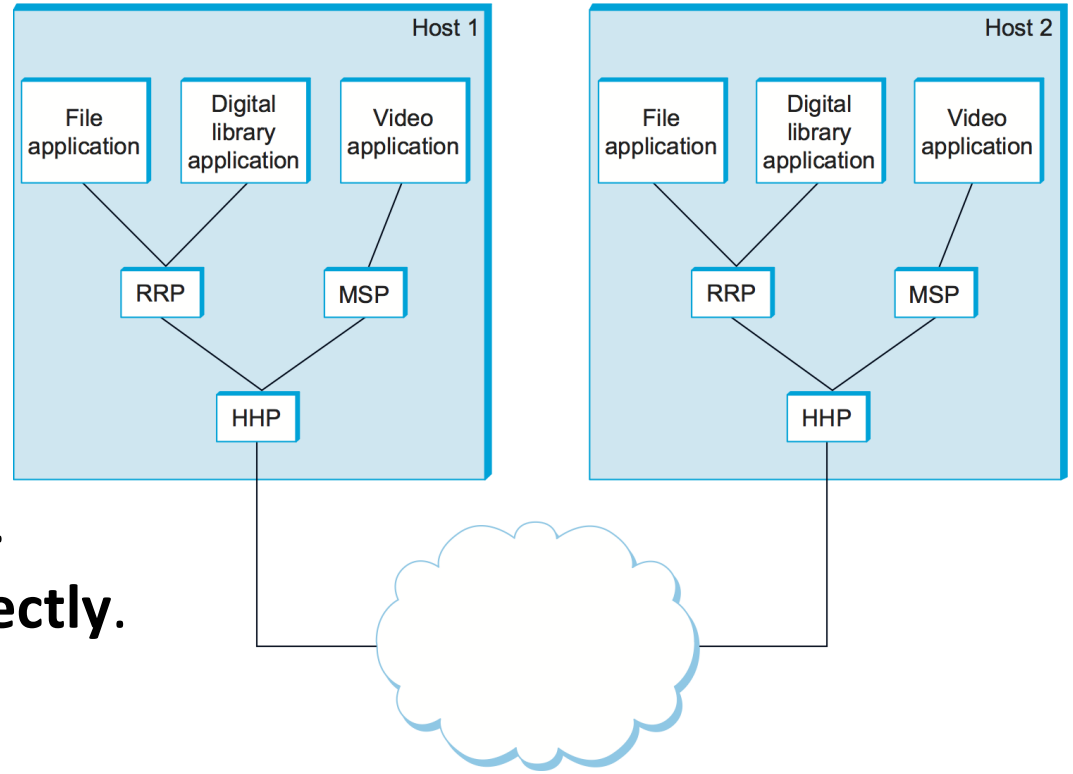
- Computer network architectures are organized in layers.
  - Each layer is composed of protocols.
    - Each protocol belongs to a single layer.
- **Protocols** at each level serve two main **functions**:
  - Provide **communication services** between layers.
  - Provide **common functionality** within the layer.
    - Layers on **different machines** can process **same message**.
- No direct layer-to-layer communications.
  - Protocol passes message down to the physical layer.
  - Physical layer protocols can send messages directly.



Protocol functions

LAYERING IN NETWORKS (3)

- Computer network architectures are organized in layers.
  - Each layer is composed of protocols.
    - Each protocol belongs to a single layer.
- Protocols at each level serve two main functions:
  - Provide communication services between layers.
  - Provide common functionality within the layer.
    - Layers on different machines can process same message.
- **No** direct **layer-to-layer** communications.
  - Protocol passes **message** down to the **physical layer**.
  - Only **physical layer** protocols can send messages **directly**.



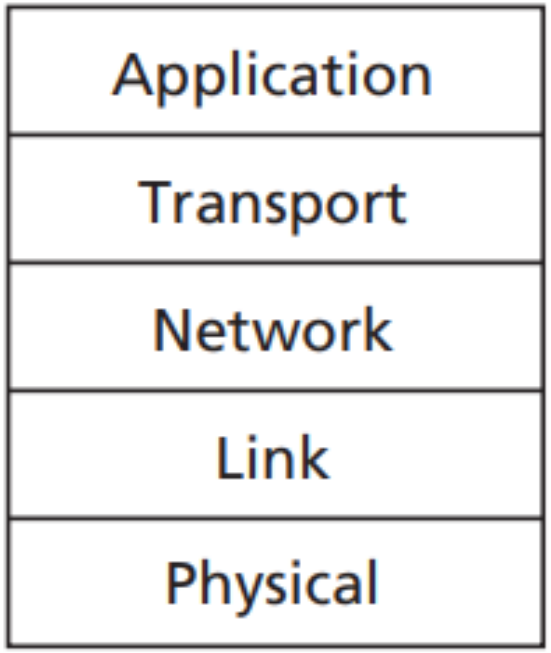
Layer communications

LAYERING IN NETWORKS (4)

- **Collectively** protocols of various layers are called **protocol stack**.
  - Also referred as **network model** or **network architecture**.
- **Main** computer network **protocol stacks**:
  - **Internet** (**TCP/IP**) architecture.
  - **Open Systems Interconnection** (**OSI**) architecture.

INTERNET MODEL (1)

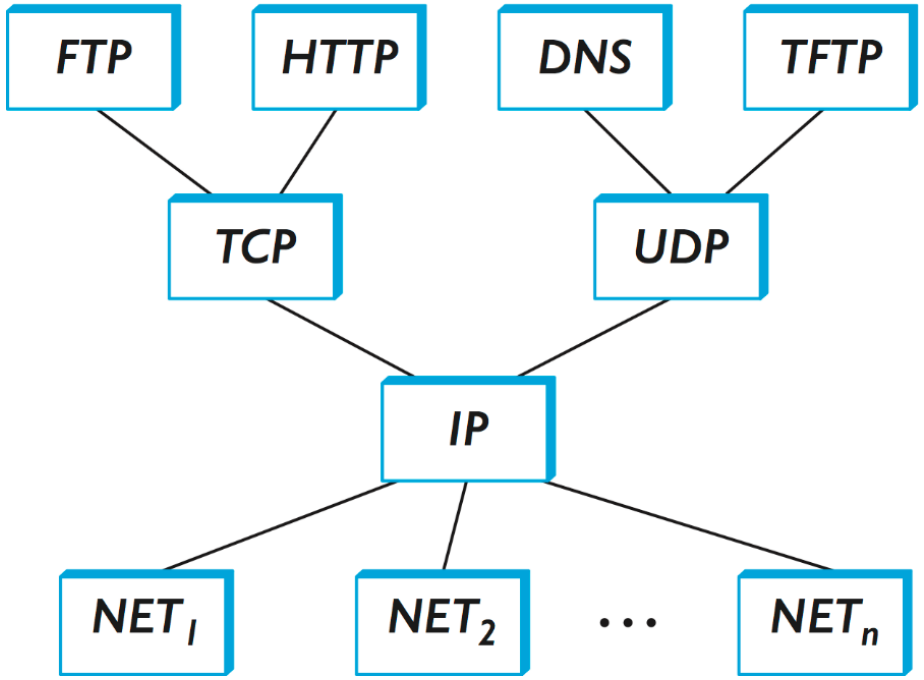
- **Internet** (**TCP/IP**) model layers:
  - **Application** layer.
    - Protocols: **HTTP, SMTP, DNS, FTP.**
    - Unit of data: **message**.
  - **Transport** layer.
    - Protocols: **TCP, UDP.**
    - Unit of data: **segment**.
  - **Network** layer.
    - Protocols: **IP**.
    - Unit of data: **datagram**.
  - **Link** layer.
    - Protocols: **Ethernet**, **Wi-Fi**, **DOCSIS**.
    - Unit of data: **frame**.
  - **Physical** layer.
    - Protocols: **copper wire**, **fiber optics**, **radio waves**.
    - Unit of data: **bits**.



Internet model

INTERNET MODEL (2)

- **Protocol graph** view of Internet model.

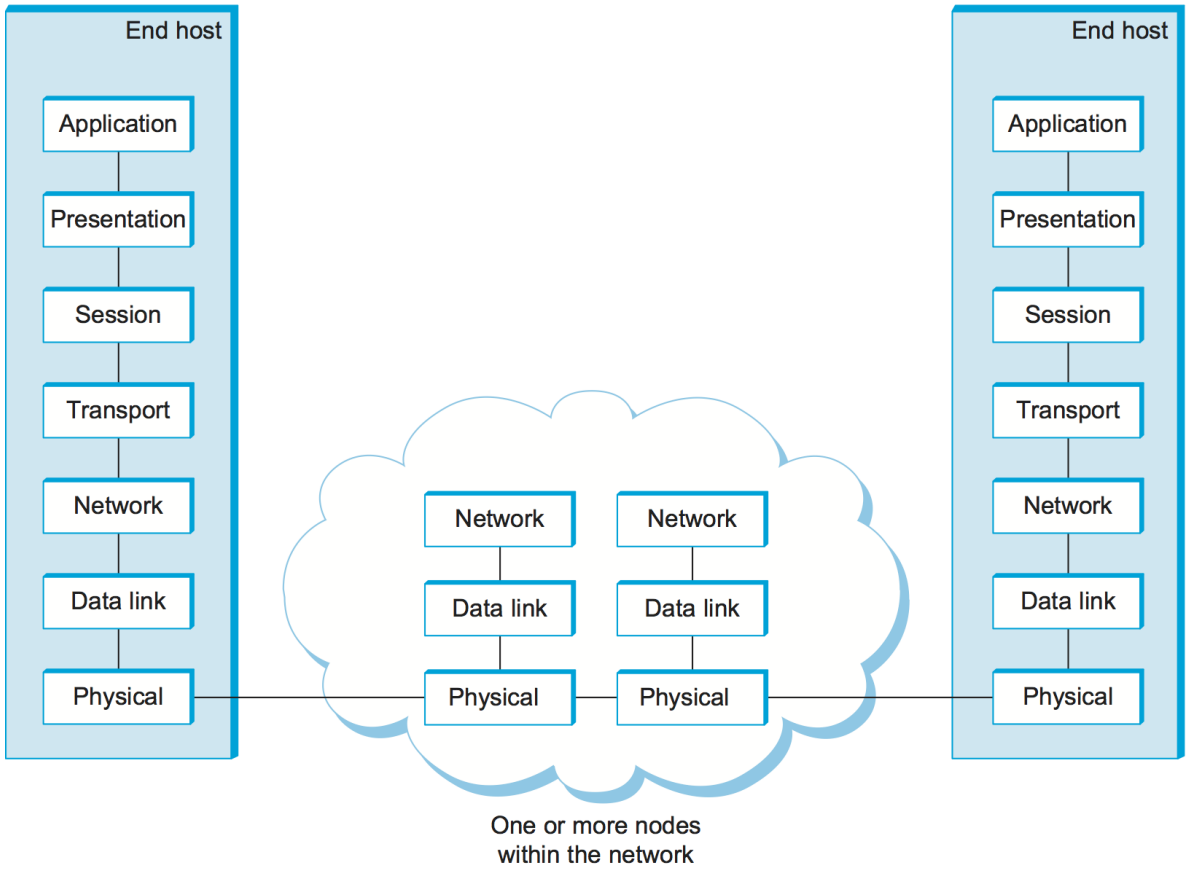


Internet model protocol graph

- **IP protocol** is a **focal point**.
  - Defines a **common method** for **exchanging** packets among a wide collection of networks.

OSI MODEL

- **Open Systems Interconnection** (**OSI**) architecture.
  - "Pre-Internet" 7-layer model.
- Two **addition** layers:
  - **Presentation** layer.
    - **Interpret** the **meaning** of the exchanged data.
      - Compression, encryption.
  - **Session** layer.
    - **Delimiting** and **synchronization** of data exchange.

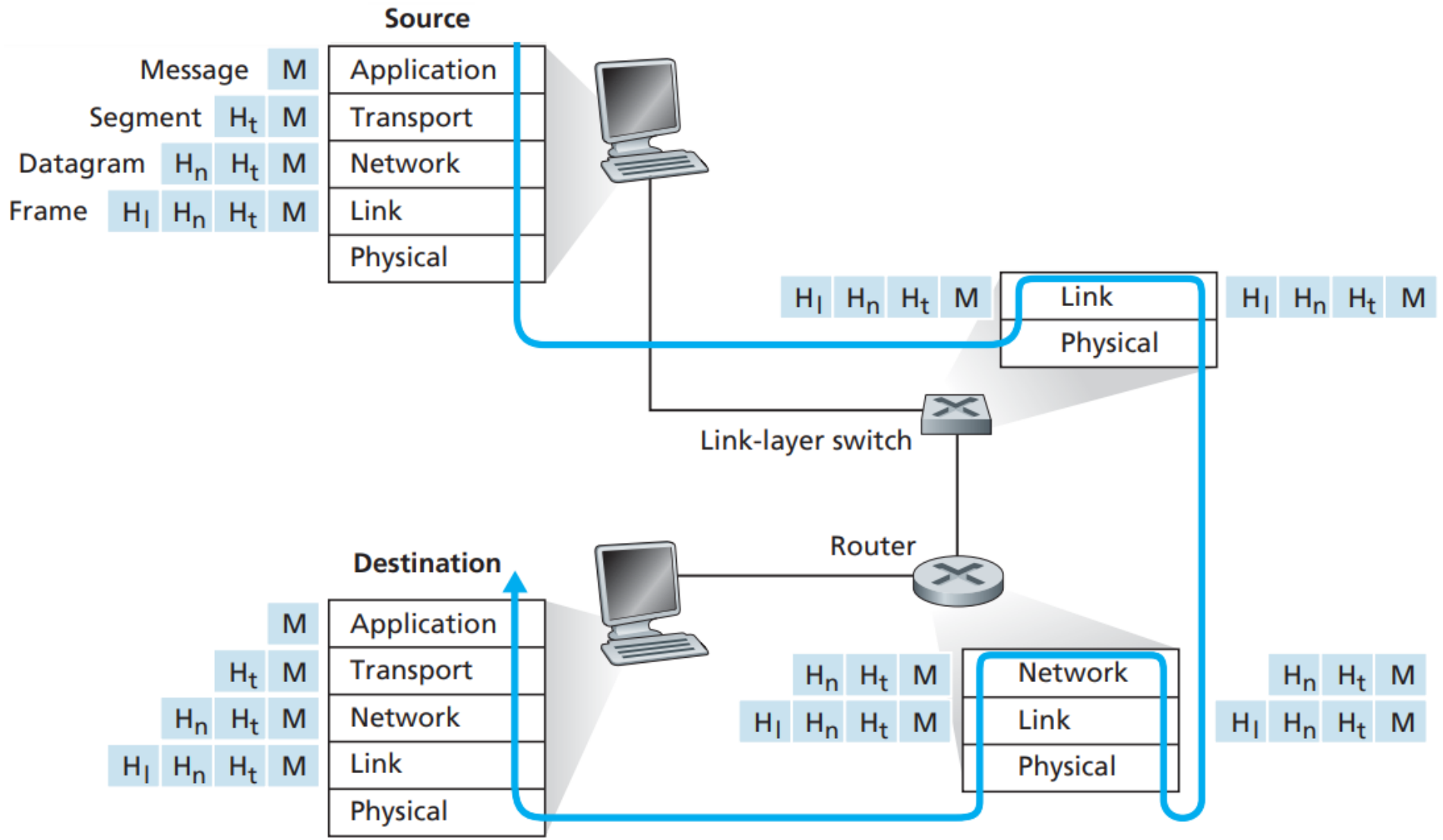


OSI model

ENCAPSULATION (1)

- **High-level** messages are **encapsulated** in **low-level** messages.
  - Each **lower level** protocol **wraps** message with its own **header**.
    - Coming to **physical layer** message contains **multiple headers** and a **payload** (*message body*).
- **Header** – small **data structure** attached to the **front** of the message.
  - Contains **identifier** that encodes to which **protocol** message belongs.

ENCAPSULATION (2)



Message encapsulation

SUMMARY

- Addressing.
  - MAC address.
  - IP address.
  - Masks.
  - Subnets.
  - CIDR.
- Layering.
  - Internet model.
  - OSI model.
  - Encapsulation.