NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Week 7: Introduction

EE3017/IM2003 Computer Communications

School of Electrical and Electronic Engineering

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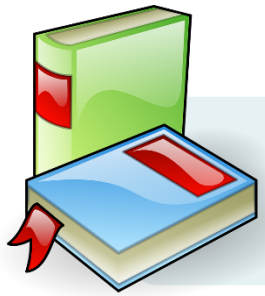
Part II Topic Outline
(Updated in January 2020)

Part II Topic Outline

Textbook



James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach, Pearson.

Note:

- *I am using Fifth Edition that was published in 2010 but any edition is fine.*

- Slides with the caption "**Notes: ….**":
  They contain explanatory notes and they will be tested in quizzes and exam as well.

Topic Outline

Introduction

- What is the Internet?
- What is a protocol?
- The Internet Protocol Stack
- The Open Systems Interconnection (OSI) Reference Model
- Why do we need protocol layering?

Recommended reading:
Section 1.1 What is the Internet?
Pages 28 to 35 of the recommended textbook
(Page numbers are based on 5th or 2010 Edition.)

Learning Objectives

Learning Objectives

By the end of this topic, you should be able to:

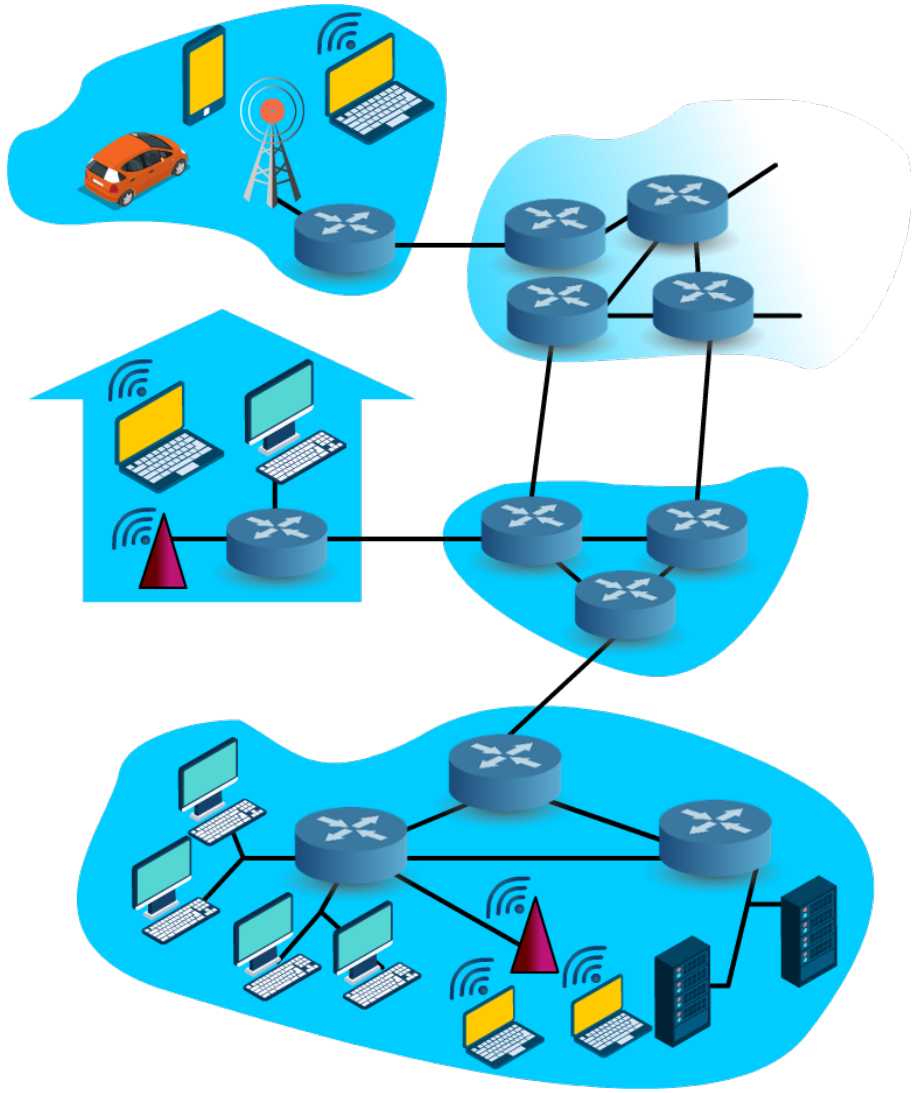
- Identify the basic components of the Internet.
- Describe what is a network protocol.
- Explain why are there many protocol layers.
- Describe the functions of the different protocol layers in the Internet Protocol Stack.
- Explain the differences between the Internet Protocol Stack and the OSI Reference Model.

What is the Internet?

What is the Internet made of?

Millions of connected computing devices:

- **Hosts = end systems**
  - Running network apps
- **Communication links**
  - Fibre, copper, radio, satellite
  - Transmission rate = bandwidth
- **Routers:** forward packets (chunks of data)



Legend:

PC
access points
wireless laptop
router
server
wired links
cellular handheld

Notes: What is the Internet made of?

Hosts/End Systems

- These are computing devices such as PCs, laptops, mobile phones, servers, workstations and gaming consoles that are connected to the Internet and run network applications.

Communication Links

- These are transmission media such as fibre optic cables, copper cables, and radio waves that are used to send the digital data between network devices (including hosts, routers and switches).

Routers

- Network devices that forward data packets along networks. They exchange information with other routers to set up a routing table in each router to decide how packets with different destination addresses should be forwarded. Hence, their main functions are packet forwarding and routing.

Notes: What is the Internet made of?

Switches

- They are different from routers and are normally used only in local area networks. They do not support network layer protocols and routing.

Wireless Access Points

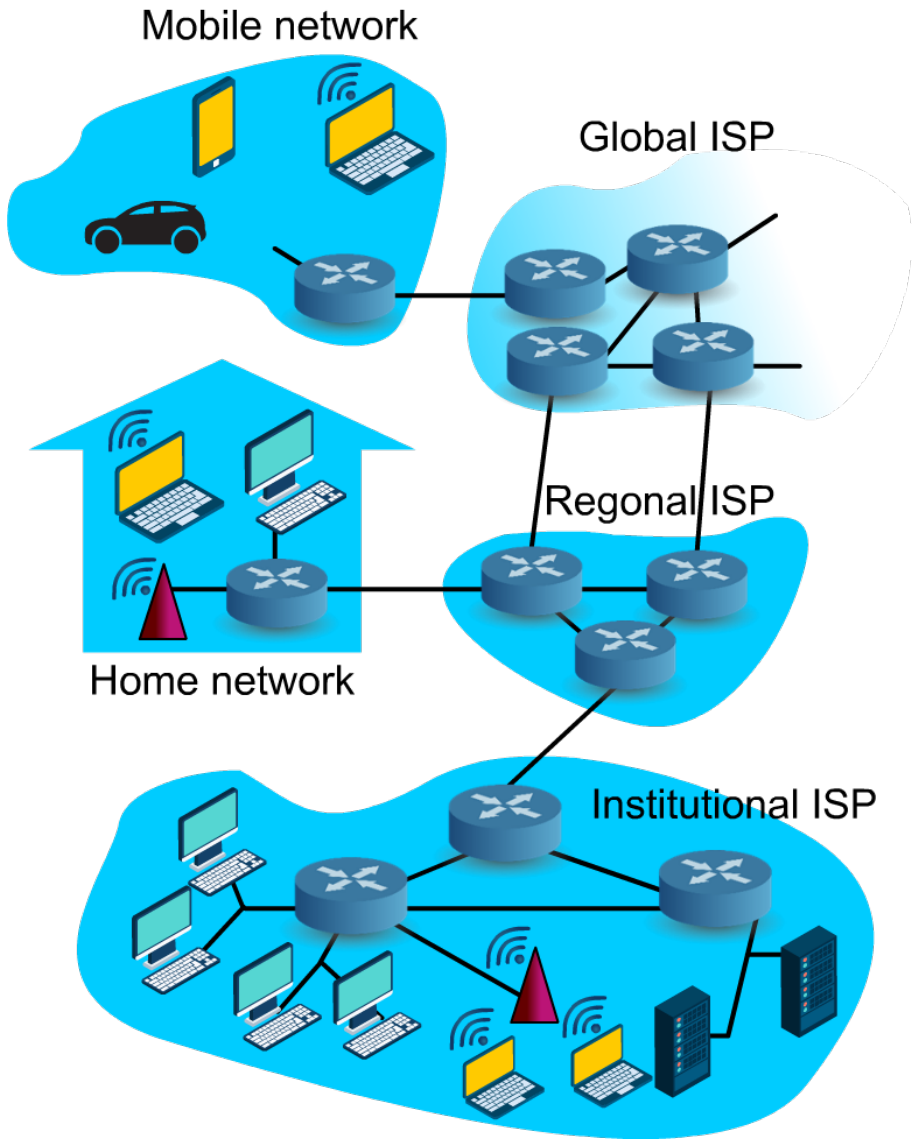
- Network devices that allow compatible wireless devices (e.g., laptop and smart phone) to connect to a wired network.

Internet Service Providers (ISP)

- Organisations that provide services for accessing and using the Internet; e.g. SingTel, Starhub, M1 and MyRepublic etc.

What is the Internet?

- **Protocols control sending, receiving of messages**
  - e.g. TCP, IP, HTTP, Skype, Ethernet
- **Internet: "network of networks"**
  - loosely hierarchical
  - public Internet versus private intranet
- **Internet standards**
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force
  - IEEE: LAN standards



Notes: What is the Internet?

- The Internet is a loose association of thousands of networks and millions of computers across the world that all work together to share information. These networks are owned by different organisations and institutions, and no single entity has full control of the Internet.

- On the Internet, the main lines carry the bulk of the traffic and are collectively known as the Internet backbone. The backbone is formed by the biggest networks in the system, owned by major Internet service providers.

- A private intranet is a private computer network that uses the same protocols and technologies as the Internet to securely share any part of an organisation's information or operational systems within that organisation.

- Network devices on the Internet, such as routers, run protocols to control sending and receiving of messages.

Notes: What is the Internet?

- The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It defines the standards for the Internet.

- A Request for Comments (RFC) is authored by engineers and computer scientists in the form of a memorandum describing methods, behaviours, research, or innovations applicable to the working of the Internet and Internet-connected systems. It is submitted either for peer review or simply to convey new concepts and information. The IETF adopts some of the proposals published as RFCs as Internet Standards.

- Most of the local area network (LAN) and selected wide area network technologies are standardised by the Institute of Electrical & Electronic Engineers (IEEE).

What is a Protocol?

What is a Protocol?

Protocols define format, order of messages sent and received among network entities, and actions taken on message transmission and reception.

Human Protocols

- "What's the time?"
- "I have a question"
- Introductions

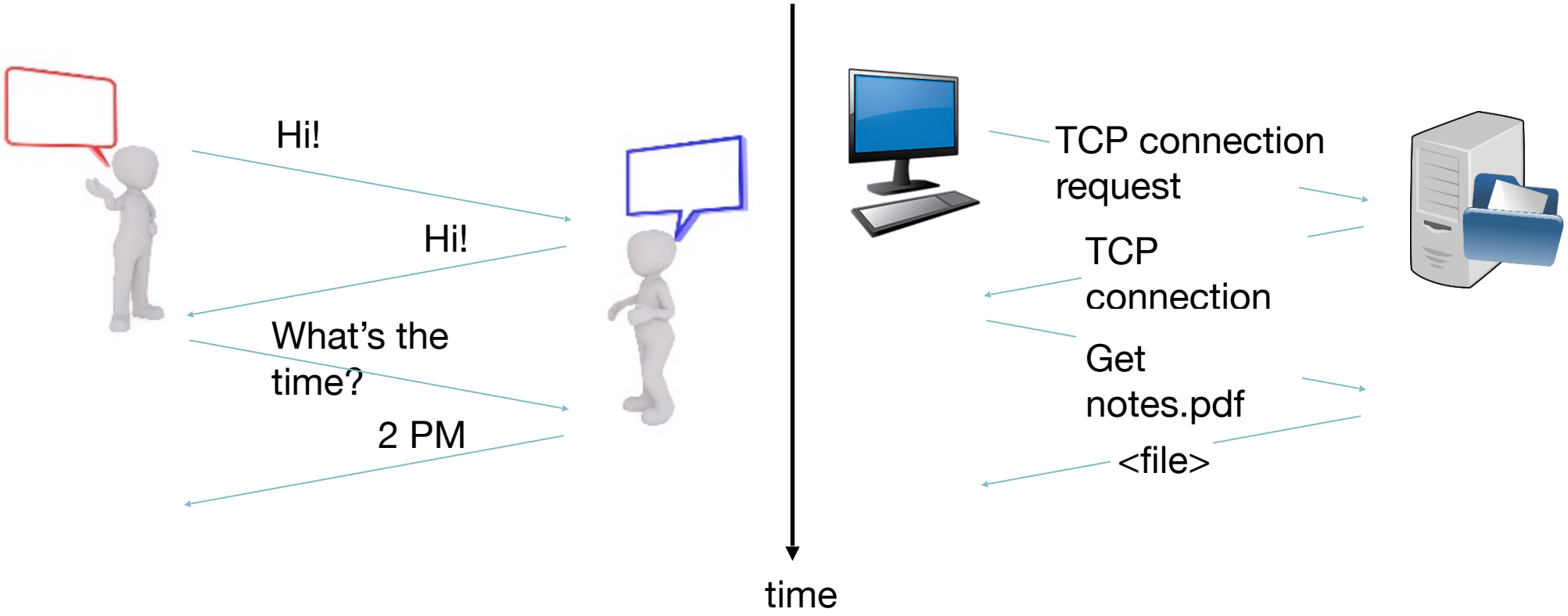
- … specific messages sent
- … specific actions taken when messages received, or other events

Network Protocols

- machines rather than humans
- all communication activity in Internet governed by protocols

What is a Protocol?

A human protocol and a computer network protocol:



Other human protocols?

Notes: What is a Protocol?

- When computers communicate with each other, there needs to be a common set of rules and instructions that each computer follows. A specific set of communication rules is called a protocol. Because of the many ways computers can communicate with each other, there are many different protocols.

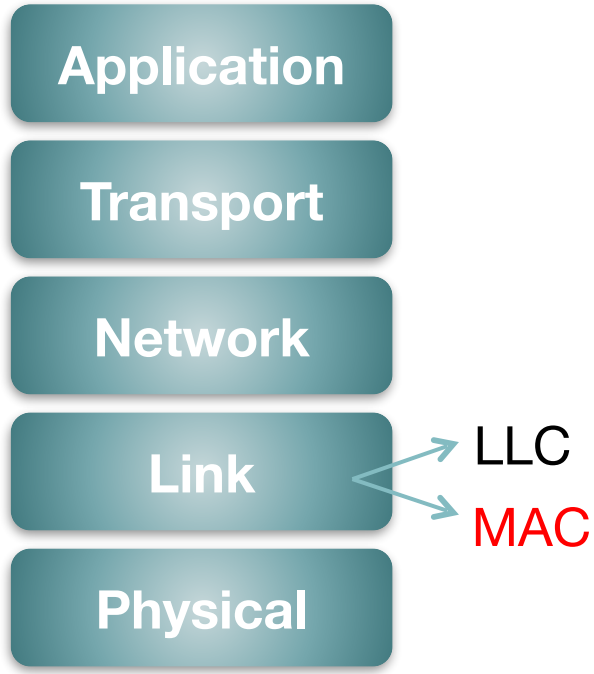
- Normally protocols define the message format, order of messages sent and received among network entities, and actions taken on message transmission and reception.

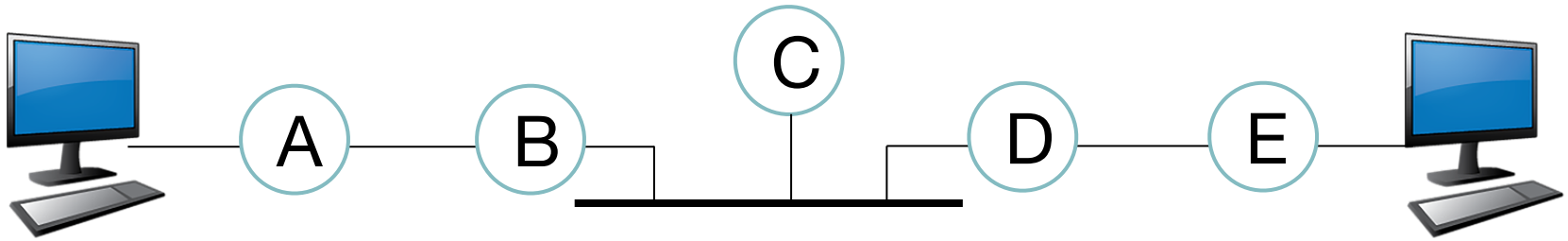
- Some of the commonly known protocols are:
  - Transmission Control Protocol (TCP)
  - Internet Protocol (IP)
  - HyperText Transfer Protocol (HTTP)
  - File Transfer Protocol (FTP)
  - IEEE 802.3 Ethernet or Carrier Sense Multiple Access/Collision Detection (CSMA/CD) Protocol

The Internet Protocol Stack

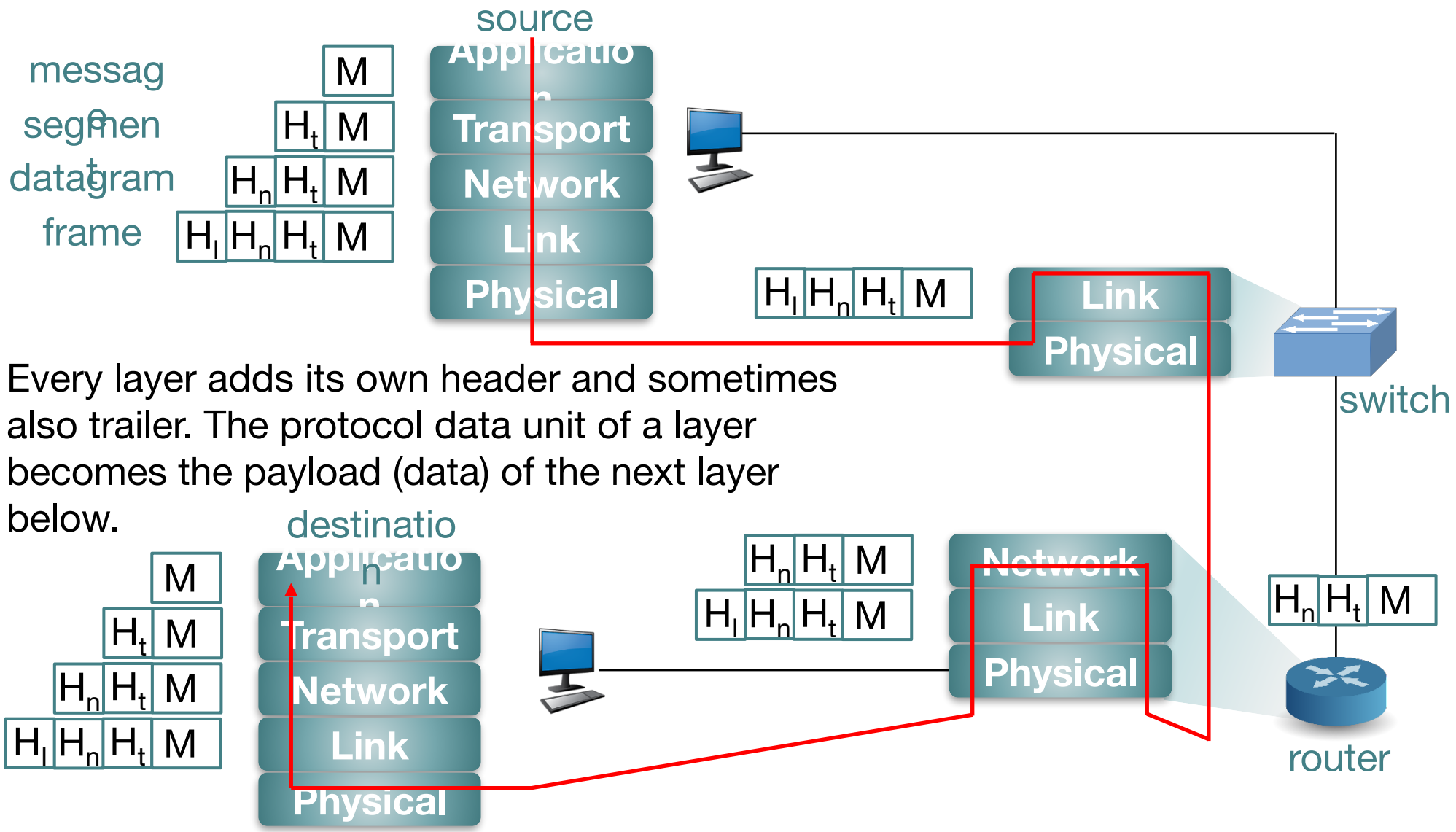
Internet Protocol Stack

- **Application**: Supporting network applications.
  - FTP, SMTP, HTTP
- **Transport**: Process-process data transfer
  - TCP, UDP
- **Network**: Routing of datagrams from source to destination.
  - IP, routing protocols
- **Link**: Data transfer between neighbouring network elements.
  - PPP, Ethernet
- **Physical**: Bits “on the wire”.





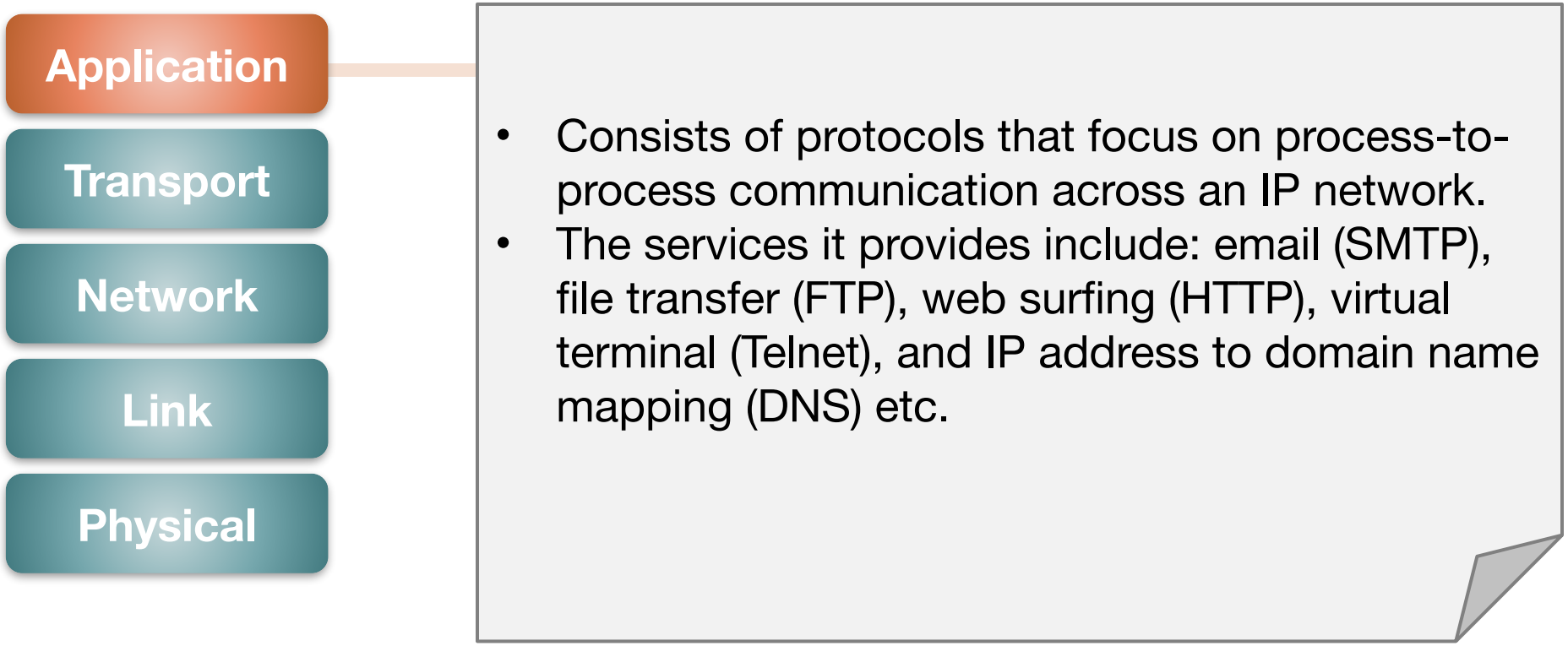
Encapsulation



Every layer adds its own header and sometimes also trailer. The protocol data unit of a layer becomes the payload (data) of the next layer below.

Notes: Internet Protocol Stack

- This is also commonly referred to as TCP/IP protocol stack/suite.
- A protocol stack/suite is a set of communication protocol layers that work together.



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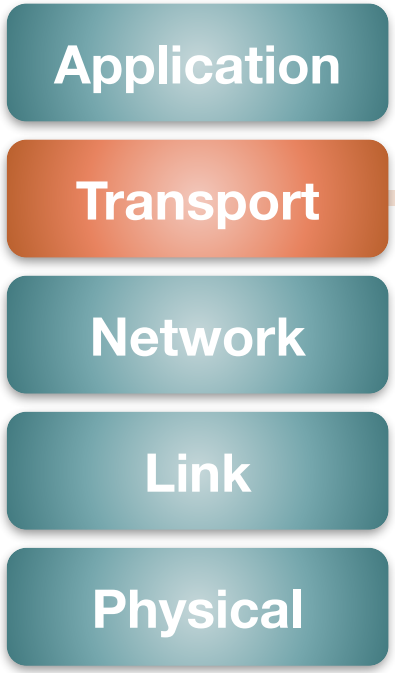

- Responsible for end-to-end communication over a network. It provides logical communication between application processes running on different hosts.
- Also responsible for the management of error correction, providing quality and reliability to the end user.
- The two most widely used Transport Layer protocols are TCP and User Datagram Protocol (UDP).

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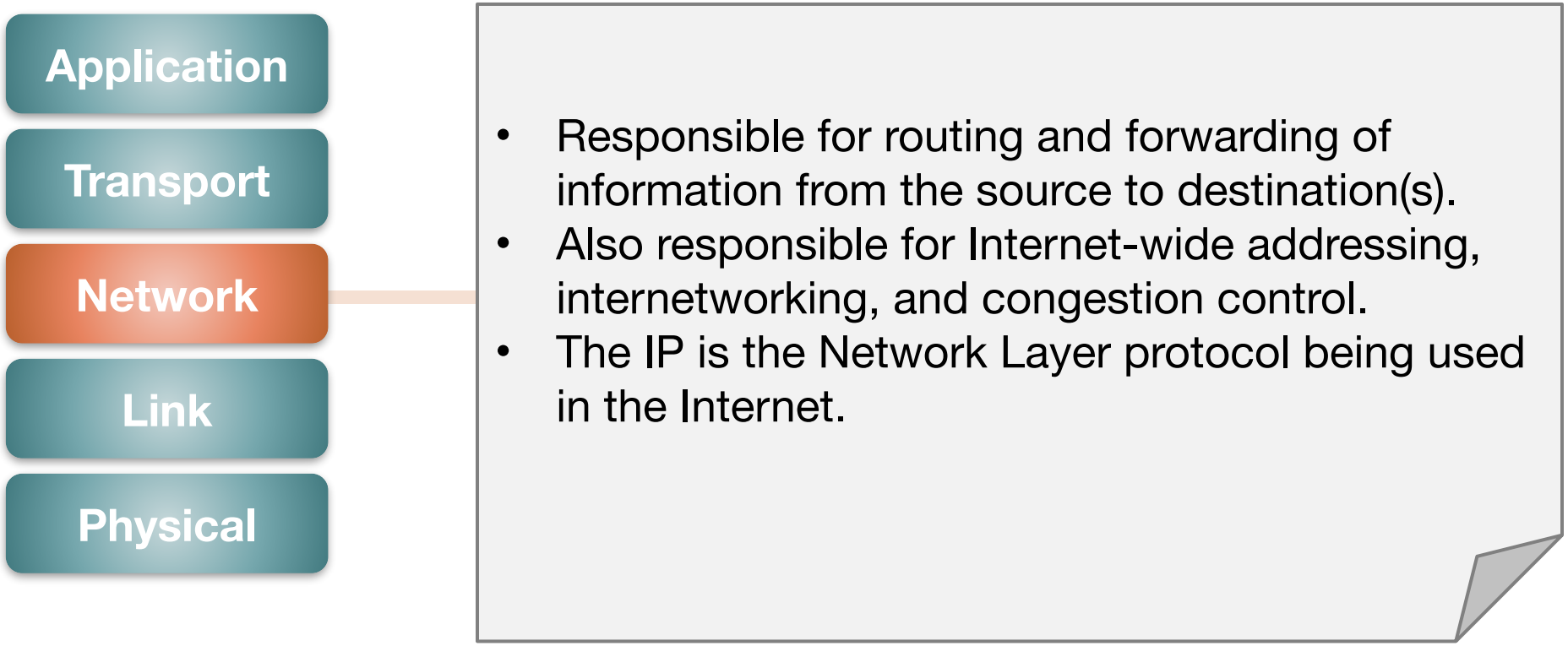

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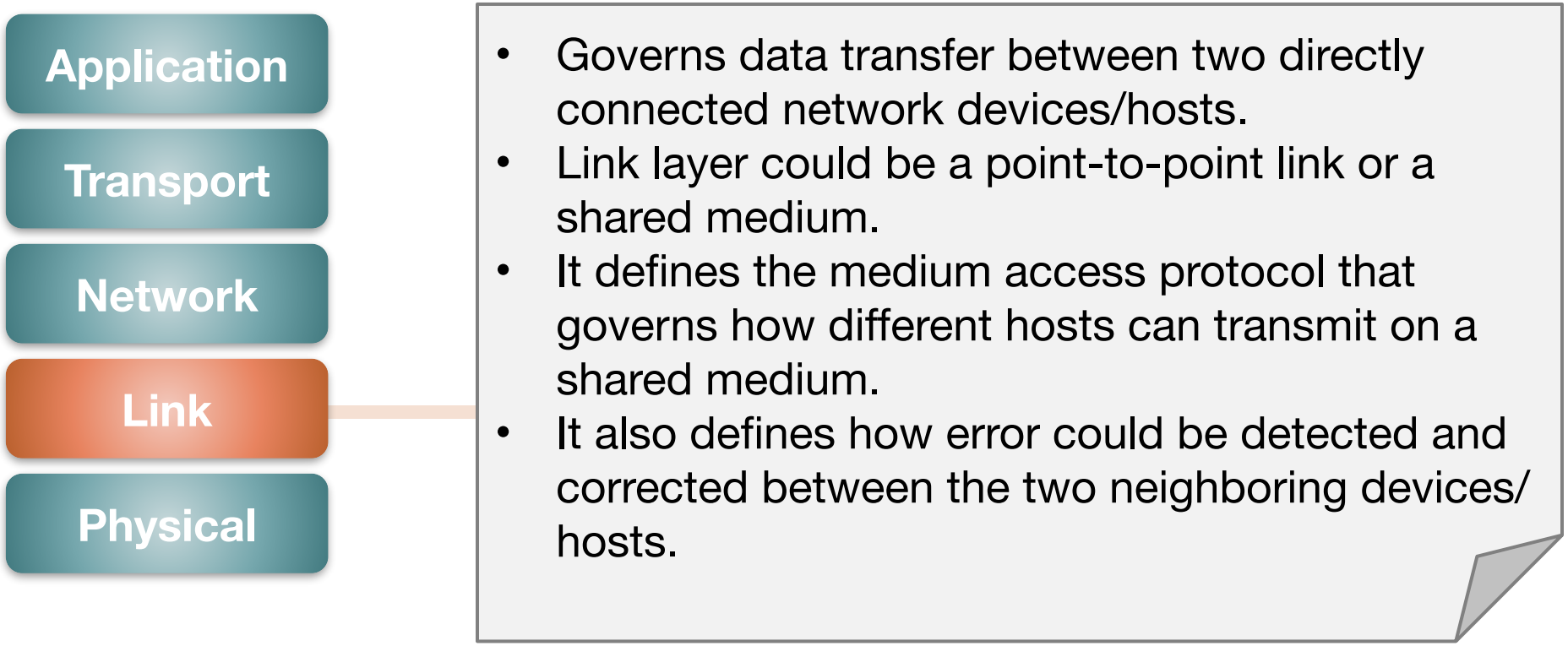

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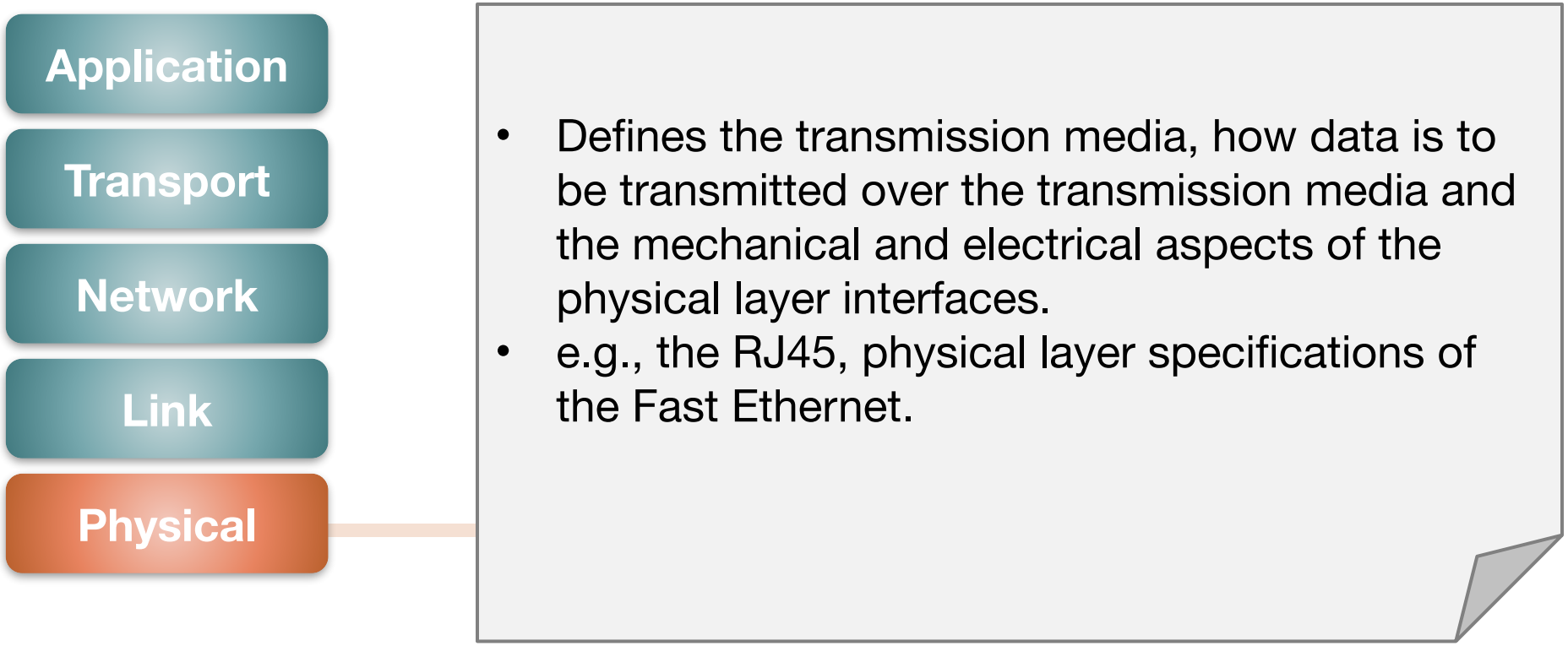


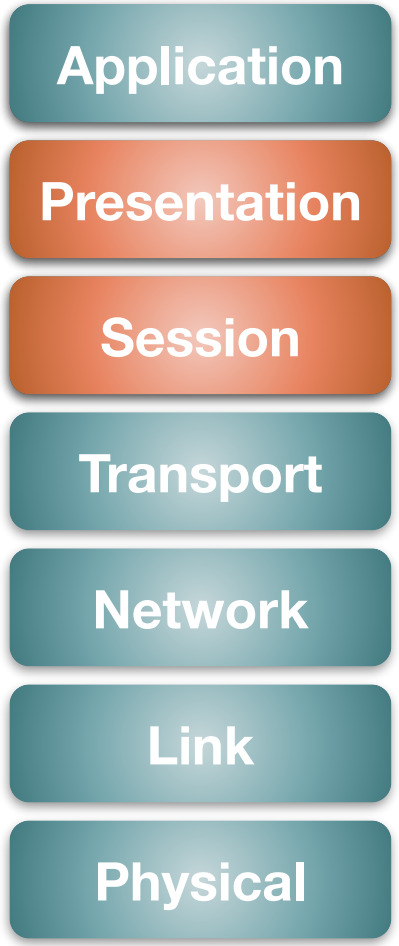
The Open Systems Interconnection (OSI) Reference Model

Open System Interconnect (OSI) Reference Model

- **Presentation**: Allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions.

- **Session**: Synchronisation, checkpointing, recovery of data exchange.

- Internet stack “missing” these layers!
  - These services, if needed, must be implemented in application.
  - Needed?



Notes: Open System Interconnect (OSI) Reference Model

- The OSI model is a conceptual model defined by International Organisation for Standardisation (ISO) for computer networking.
- It characterises and standardises the communication functions of a telecommunication or computing system without regard to their underlying internal structure and technology.
- In addition to the 5 layers defined in the TCP/IP Protocol Suites, it also defines a Presentation Layer and a Session Layer.

Presentation

Session

- Responsible for transforming data into the form that the application layer can accept; e.g., transforming an image from JPEG to GIF if the application only accepts the GIF format.
- Formats and encrypts data to be sent across a network, providing freedom from compatibility problems.
- In the case of TCP/IP Protocol Stack, the functions of this layer are implemented in the application itself.

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Presentation

Session

- Manages and terminates connections between applications.
- Sets up, coordinates, and terminates conversations, exchanges, and dialogues between the applications at each end.
- Deals with session and connection coordination. In the case of TCP/IP Protocol Stack, the functions of this layer are implemented by the application itself.

Why do we need protocol layering?

Why do we need protocol layering?

Layering make them easy to understand and design

Modularisation eases maintenance, updating of system

- Change of implementation of layer's service transparent to rest of system
- e.g., change in protocol or procedure doesn't affect rest of system

Any harmful effects?

Notes: Why do we need protocol layering?

- Protocol layering simplifies networking designs by dividing them into functional layers, and assigning protocols to perform different tasks.
  - It produces simple protocols, each with a few well-defined tasks. These protocols can then be assembled into a useful whole.
    - Individual protocols can be removed or replaced as needed for particular applications.
      - It facilitates the discussion and teaching of a complex networked system.
    - It eases the maintenance and upgrading of selected functions in a networked system without affecting the other parts.
  - It allows different parts to be standardised and implemented quickly.
- It also allows different companies and individuals to specialise in selected layers and functions.

Notes: Any disadvantages of layering?

- Potential duplication of functions in different layers.
- Increased overheads as each layer introduces some overheads.
- Higher level layers cannot see what is in the lower layers; hence, cannot debug and pinpoint problems.
- Higher level layers cannot control all aspects of the lower layers; as such, cannot optimise the entire data transmission process.
- With technology advancement, high level of integration can be achieved with functions of different layer implemented in a single-chip; layering may hinder integration and development of single-chip solutions.

Course Overview based on the TCP/IP Protocol Stack

- **Application**: Supporting network applications.
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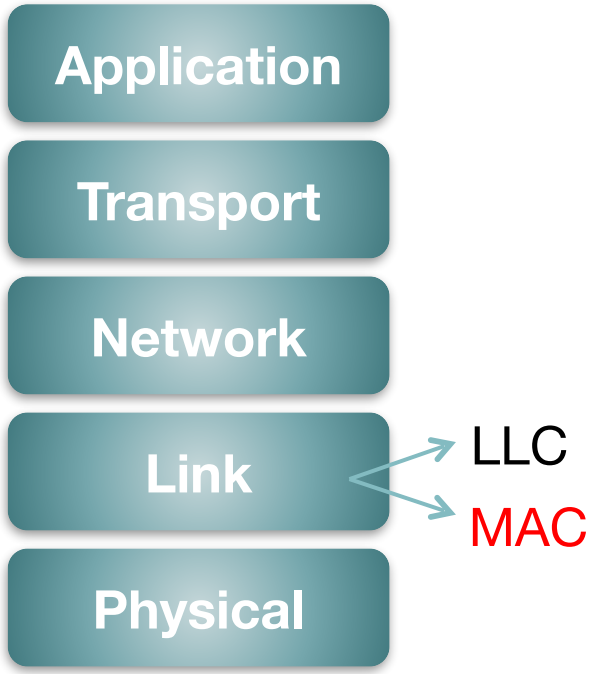
- **Transport**: Host-host data transfer
  - TCP, UDP
- **Network**: Routing of datagrams from source to destination.
  - IP, routing protocols
- **Link**: Data transfer between neighbouring network elements.
  - PPP, Ethernet
- **Two Sub-layers**:
  - Logical Link Control (LLC): Provide services to link layer; unacknowledged connectionless service
  - Medium Access Control (MAC): coordinating the access to the shared medium.
- **Physical**: Bits sent on the “wire” or “wireless”.



Summary

Summary

Key points discussed in this topic:

- The Internet can be described by the basic hardware and software components that make up the Internet.
- The internet is also described as an infrastructure that provides services to applications.
- An Application Programming Interface (API) specifies how a software piece running on one end system asks the Internet infrastructure to deliver data to a specific destination software piece on another end system.
- A protocol defines the format and the order of messages exchanged between two or more communicating entities, as well as the actions taken on the transmission and/or receipt of a message of other event.

Summary

Key points discussed in this topic (cont'd):

- Protocol layering is a good way to divide a complex system into manageable smaller sub-systems, which could be designed and updated independently of other subsystems.

- The Internet Protocol Stack consists of five layers:
  - Application
  - Transport
  - Network
  - Link
  - Physical

- The ISO/OSI reference model has two additional layers: Presentation and Session.