Part 2 : Network Model

Data Communication and Computer Network

VER 2023

Introduction

- A network is a combination of hardware and software that sends data from one location to another.
- The hardware consists of the physical equipment that carries signals from one point of the network to another.
- The software consists of instruction sets that make possible the services that we expect from a network

OSI

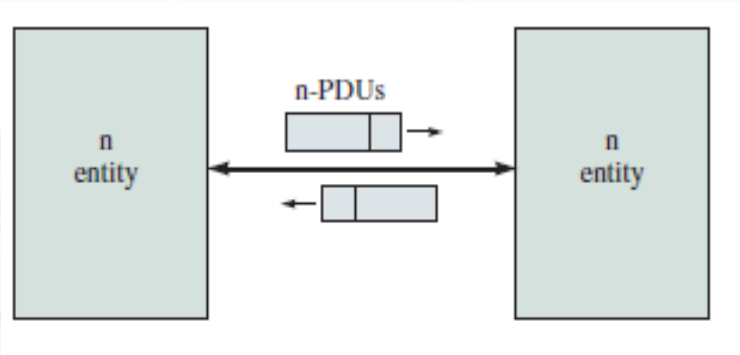
- International Organization Standard (ISO) developed a reference model for open systems interconnection (OSI).
- This model provided a framework for talking about the overall communication process and hence was intended to facilitate the development of standards.

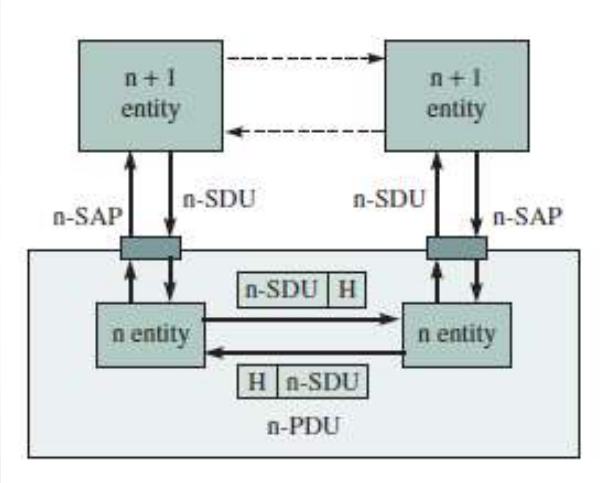
Benefits of the OSI Model:
- Reduces complexity
- Standardizes interfaces
- Facilitates modular engineering
- Ensures interoperable technology
- Accelerates evolution
- Simplifies teaching and learning

Picture : copyright CISCO

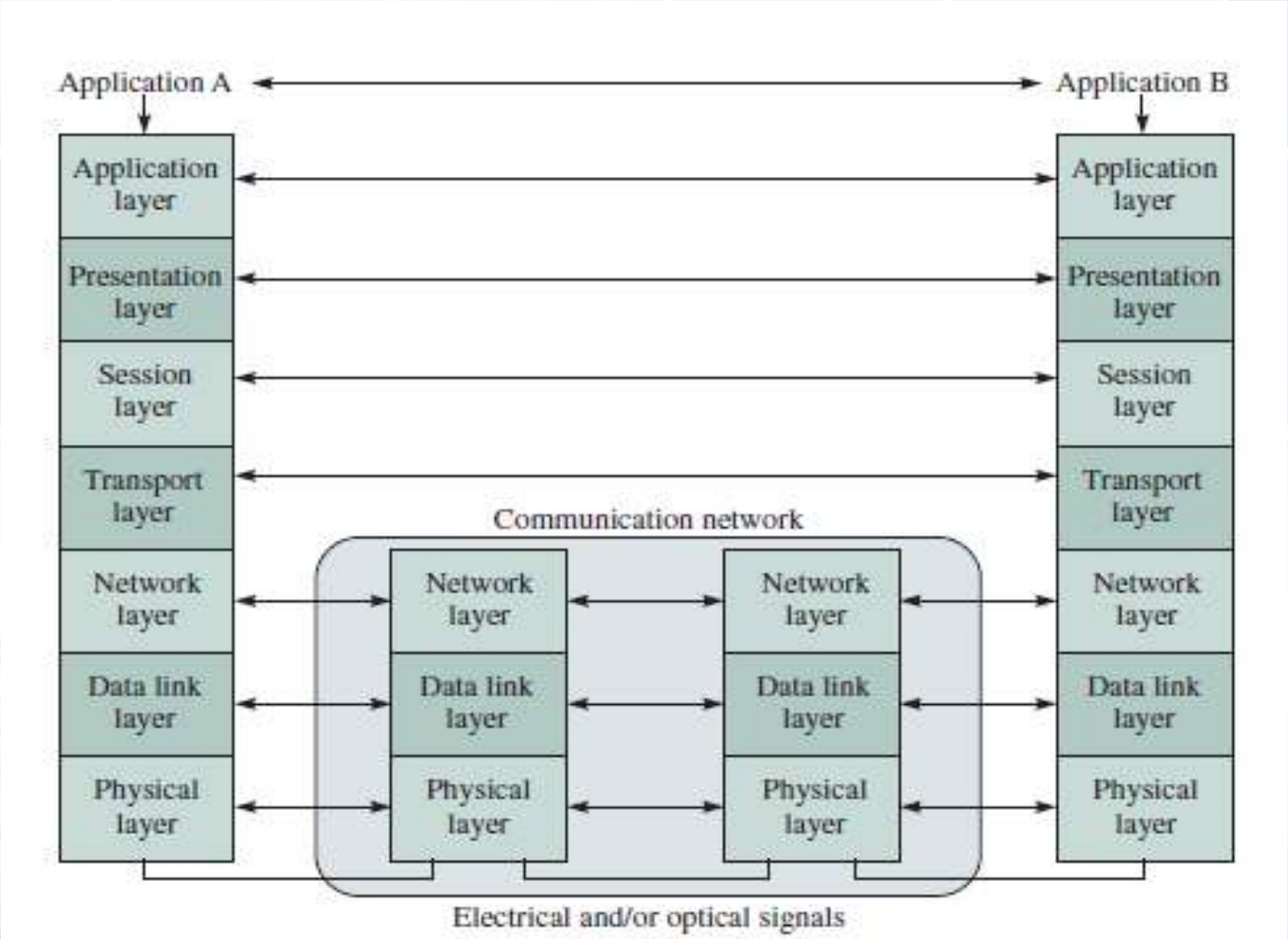
OSI

- Layer n entities communicate by exchanging protocol data units (PDUs).
- Each PDU contains a header (contains protocol control information), and usually user information in the form of a Service Data Unit (SDU).

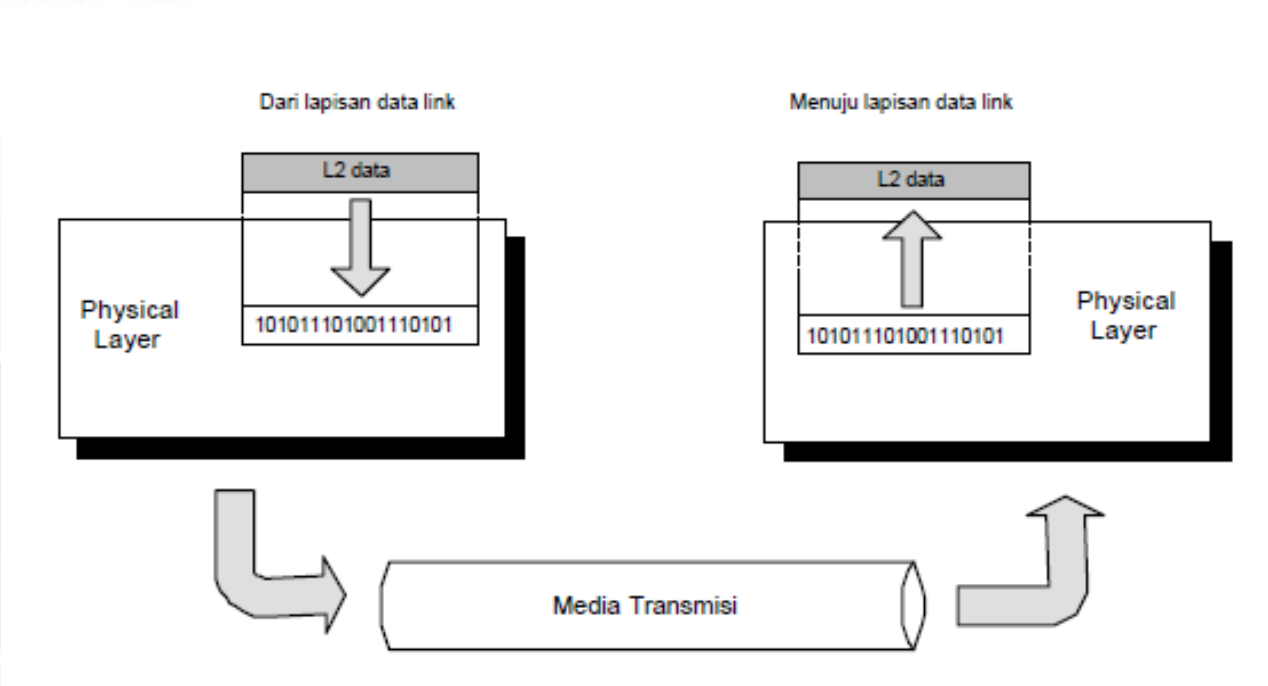




OSI


Application A
Application B
Application layer
Presentation layer
Session layer
Transport layer
Network layer
Data link layer
Physical layer
Communication network
Network layer
Data link layer
Physical layer
Network layer
Data link layer
Physical layer
Application layer
Presentation layer
Session layer
Transport layer
Network layer
Data link layer
Physical layer
Electrical and/or optical signals

Physical Layer

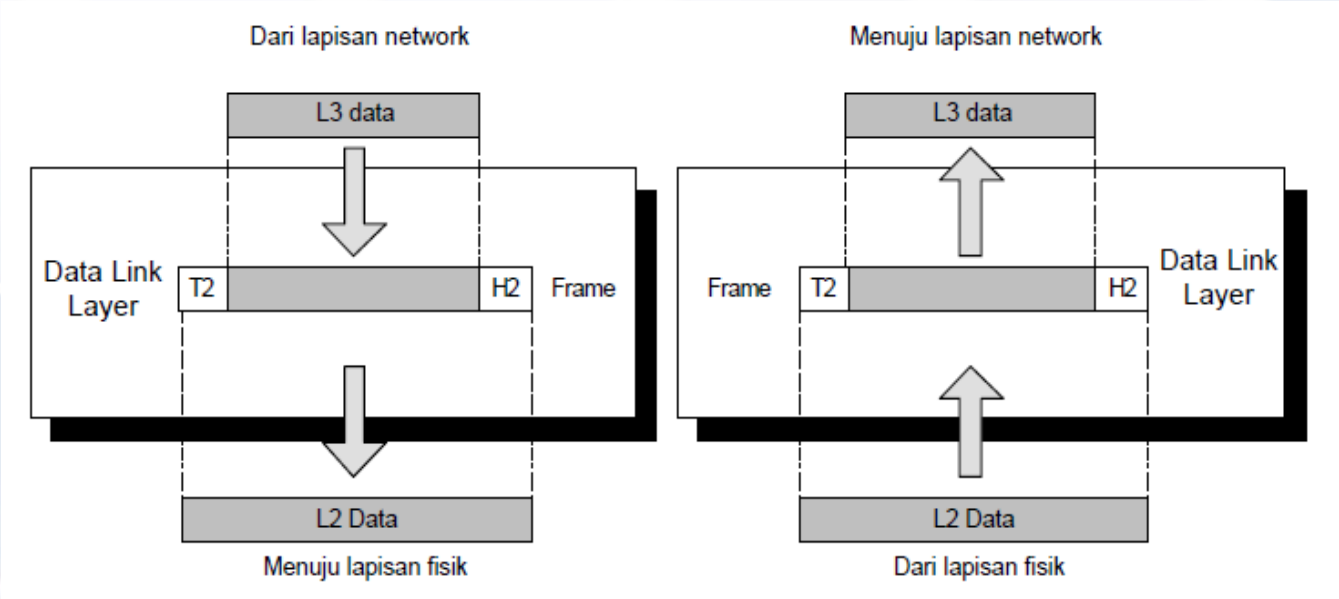


- When the formatted data unit passes through the physical layer (layer 1), it is changed into an electromagnetic signal and transported along a physical link.
- Upon reaching its destination, the signal passes into layer 1 and is transformed back into digital form.
- Representation of bits : The physical layer data consists of a stream of bits (sequence of Os or 1s) with no interpretation. To be transmitted, bits must be encoded into signals--electrical or optical. The physical layer defines the type of encoding (how Os and I s are changed to signals).

Physical Layer

- Physical topology : hybrid topology, mesh topology, star topology, ring topology or bus topology.
- Transmission mode : half-duplex mode, full-duplex (simplex) mode.
- Data rate : The transmission rate-the number of bits sent each second-is also defined by the physical layer. In other words, the physical layer defines the duration of a bit, which is how long it lasts.
- Synchronization of bits : The sender and receiver not only must use the same bit rate but also must be synchronized at the bit level. In other words, the sender and the receiver clocks must be synchronized.
- Line configuration : The physical layer is concerned with the connection of devices to the media. In a point-to-point configuration, two devices are connected through a dedicated link. In a multipoint configuration, a link is shared among several devices.

Data Link Layer

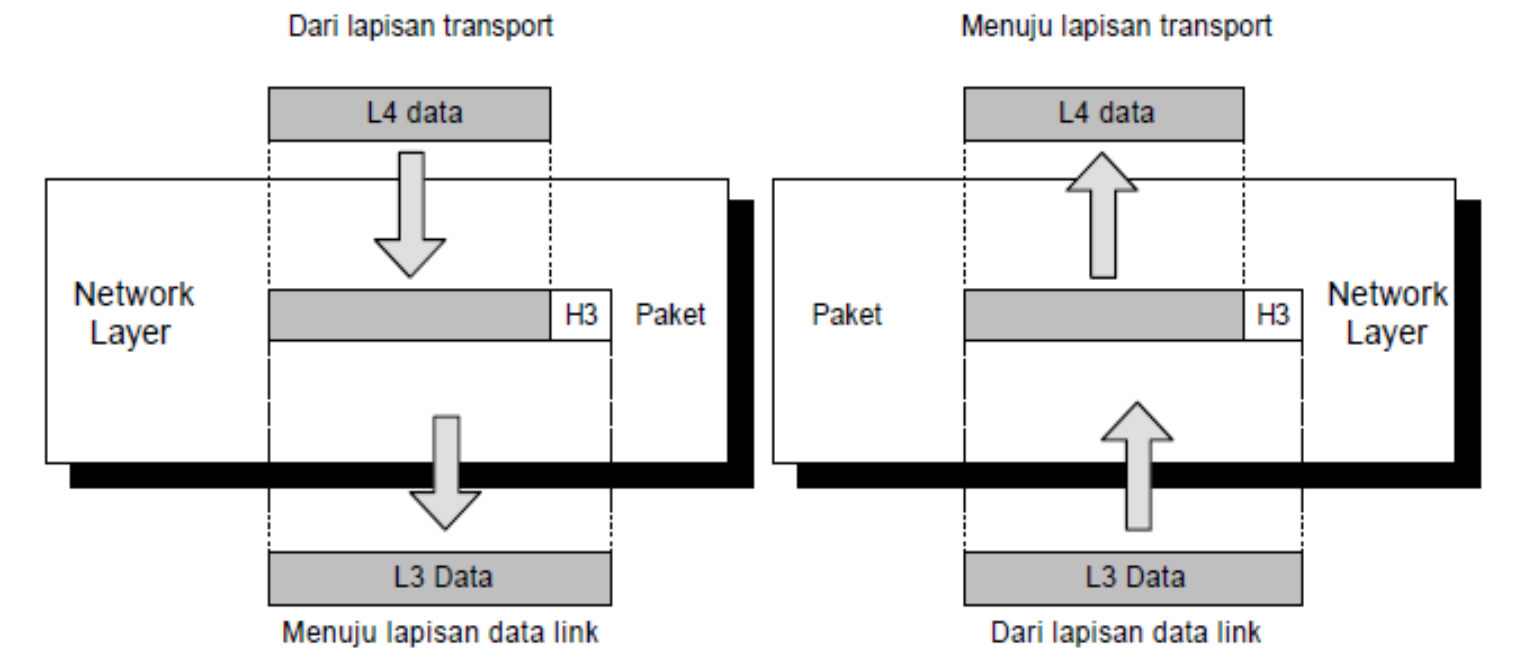


- Framing : The data link layer divides the stream of bits received from the network layer into manageable data units called frames.
- Physical addressing : If frames are to be distributed to different systems on the network, the data link layer adds a header to the frame to define the sender and/or receiver of the frame. If the frame is intended for a system outside the sender's network, the receiver address is the address of the device that connects the network to the next one.

Data Link Layer

- Flow control : If the rate at which the data are absorbed by the receiver is less than the rate at which data are produced in the sender, the data link layer imposes a flow control mechanism to avoid overwhelming the receiver.
- Error control : The data link layer adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames. It also uses a mechanism to recognize duplicate frames. Error control is normally achieved through a trailer added to the end of the frame.
- Access control : When two or more devices are connected to the same link, data link layer protocols are necessary to determine which device has control over the link at any given time.

Network Layer

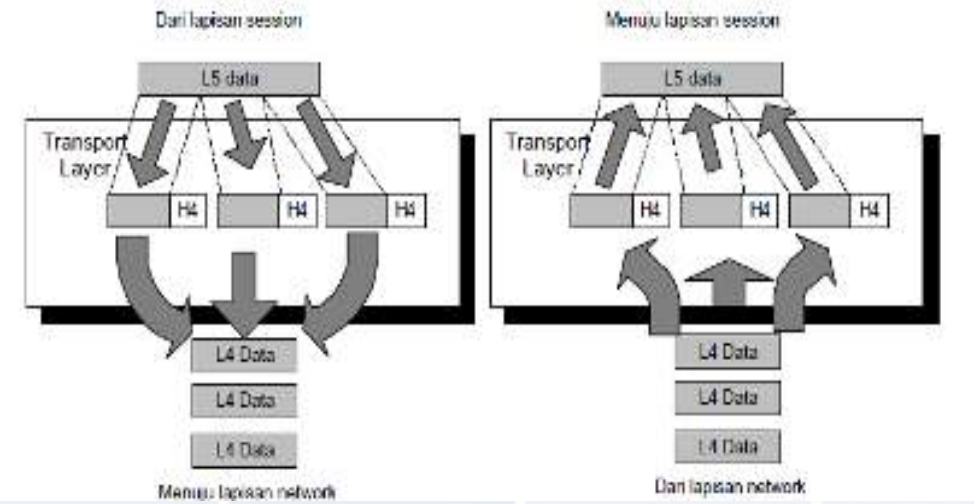


- The network layer is responsible for the source-to-destination delivery of a packet, possibly across multiple networks (links).
- If two systems are connected to the same link, there is usually no need for a network layer. However, if the two systems are attached to different networks (links) with connecting devices between the networks (links), there is often a need for the network layer to accomplish source-to-destination delivery

Network Layer

- Logical addressing : The physical addressing implemented by the data link layer handles the addressing problem locally. If a packet passes the network boundary, we need another addressing system to help distinguish the source and destination systems. The network layer adds a header to the packet coming from the upper layer that, among other things, includes the logical addresses of the sender and receiver.
- Routing : When independent networks or links are connected to create *intemetworks* (network of networks) or a large network, the connecting devices (called *routers* or *switches) route or switch the packets to their final destination. One of the functions* of the network layer is to provide this mechanism.

Transport Layer



- The transport layer is responsible for process-to-process delivery of the entire message.
- A process is an application program running on a host. Whereas the network layer oversees source-to-destination delivery of individual packets, it does not recognize any relationship between those packets. It treats each one independently, as though each piece belonged to a separate message, whether or not it does.
- The transport layer, on the other hand, ensures that the whole message arrives intact and in order, overseeing both error control and flow control at the source-to-destination level

Transport Layer

- Service-point addressing : Computers often run several programs at the same time. For this reason, source-to-destination delivery means delivery not only from one computer to the next but also from a specific process (running program) on one computer to a specific process (running program) on the other.
  - The transport layer header must therefore include a type of address called a *service-point address (or port address). The network layer gets each packet to the correct* computer; the transport layer gets the entire message to the correct process on that computer.
- Segmentation and reassembly : A message is divided into transmittable segments, with each segment containing a sequence number. These numbers enable the transport layer to reassemble the message correctly upon arriving at the destination and to identify and replace packets that were lost in transmission.

Transport Layer

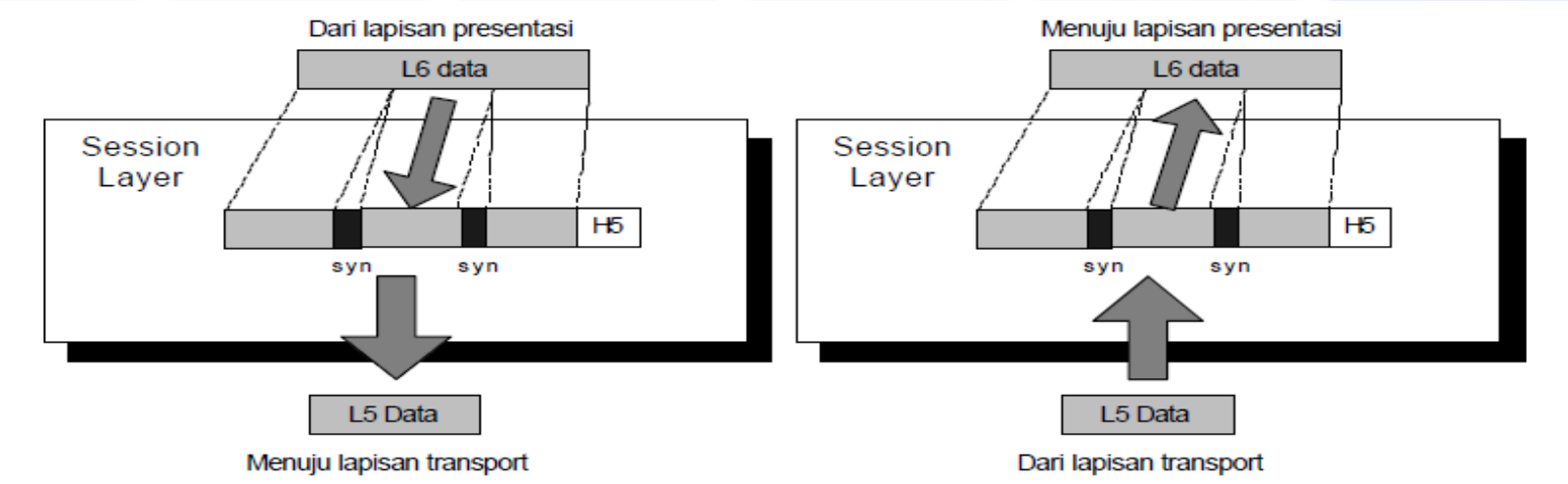
- Connection control : The transport layer can be either connectionless or connection oriented. A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine. A connection oriented transport layer makes a connection with the transport layer at the destination machine first before delivering the packets. After all the data are transferred, the connection is terminated.
- Flow control : Like the data link layer, the transport layer is responsible for flow control. However, flow control at this layer is performed end to end rather than across a single link.
- Error control : Like the data link layer, the transport layer is responsible for error control. However, error control at this layer is performed process- to-process rather than across a single link. The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error (damage, loss, or duplication). Error correction is usually achieved through retransmission.

Session Layer

- Dialog control. The session layer allows two systems to enter into a dialog. It allows the communication between two processes to take place in either half duplex (one way at a time) or full-duplex (two ways at a time) mode.

- Synchronization. The session layer allows a process to add checkpoints, or synchronization points, to a stream of data.
  - For example, if a system is sending a file of 2000 pages, it is advisable to insert checkpoints after every 100 pages to ensure that each 100-page unit is received and acknowledged independently. In this case, if a crash happens during the transmission of page 523, the only pages that need to be resent after system recovery are pages 501 to 523. Pages previous to 501 need not be resent.

Presentation Layer

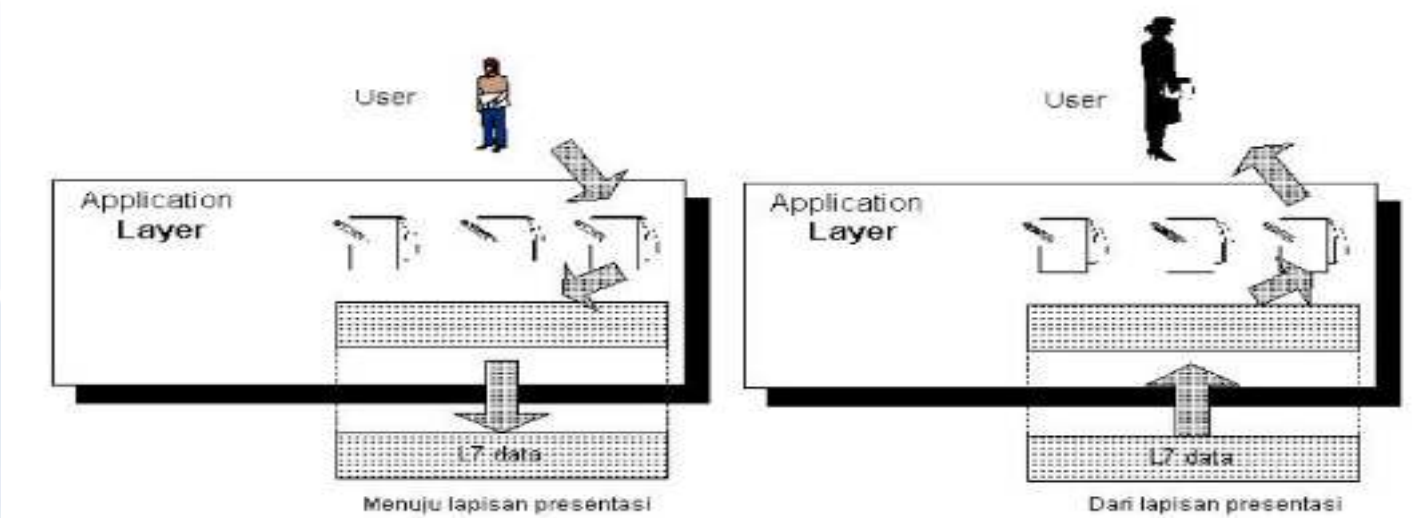


- Translation : The processes (running programs) in two systems are usually exchanging information in the form of character strings, numbers, and so on. The information must be changed to bit streams before being transmitted. Because different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.
  - The presentation layer at the sender changes the information from its sender-dependent format into a common format. The presentation layer at the receiving machine changes the common format into its receiver-dependent format.

Presentation Layer

- Encryption : To carry sensitive information, a system must be able to ensure privacy. Encryption means that the sender transforms the original information to another form and sends the resulting message out over the network. Decryption reverses the original process to transform the message back to its original form.
- Compression : Data compression reduces the number of bits contained in the information. Data compression becomes particularly important in the transmission of multimedia such as text, audio, and video.

Application Layer



- The application layer contains protocols that allow users to access to network. Popular ones include those described in Table.
  - Note that the application layer protocols do not include the end-user application programs, such as electronic mail, web browsers, and office applications since these reside in the user's computer as software application.
- For example, the application layer protocols could support electronic mail (known as e-mail) via SMTP (Simple mail Transfer Protocol), remote login with TELNET, Internet access via HTTP, file transfer using FTP, and network management through SNMP(Simple Network Management Protocol).

Examples of Protocol Operating at the application layer

Protocol	Abbreviation	Function
File Transfer Protocol	FTP	Transfer Files Between two remote machines.
Terminal Networking	TELNET	TCP/IP's client/server process for remote login.
Hypertext Transfer Protocol	HTTP	Downloads documents for a remote server when using a web browser.
Simple mail Transfer protocol	SMTP	Used to transfer electronic-email messages between hosts.
Network File System	NFS	Used to make a file system on a remote transferring the files.

Examples of Protocol Operating at the application layer

Protocol	Abbreviation	Function
Wide Area Information Service	WAIS	A content-search service that finds the name of a file given some information about the contents.
Real-time Transfer Protocol	RTP	Designed to transmit audio and video over the internet with little latency.
Domain Name System	DNS	Identifies each host on the Internet with a unique name called a domain name, for example, “photonicscomm.com.”
Trivial File Transfer Protocol	TFTP	Intended for file transfer applications that do not require complex interactions between client and server.
Simple Network Management Protocol	SNMP	Provides a set of fundamental operations for monitoring and maintaining and internet.

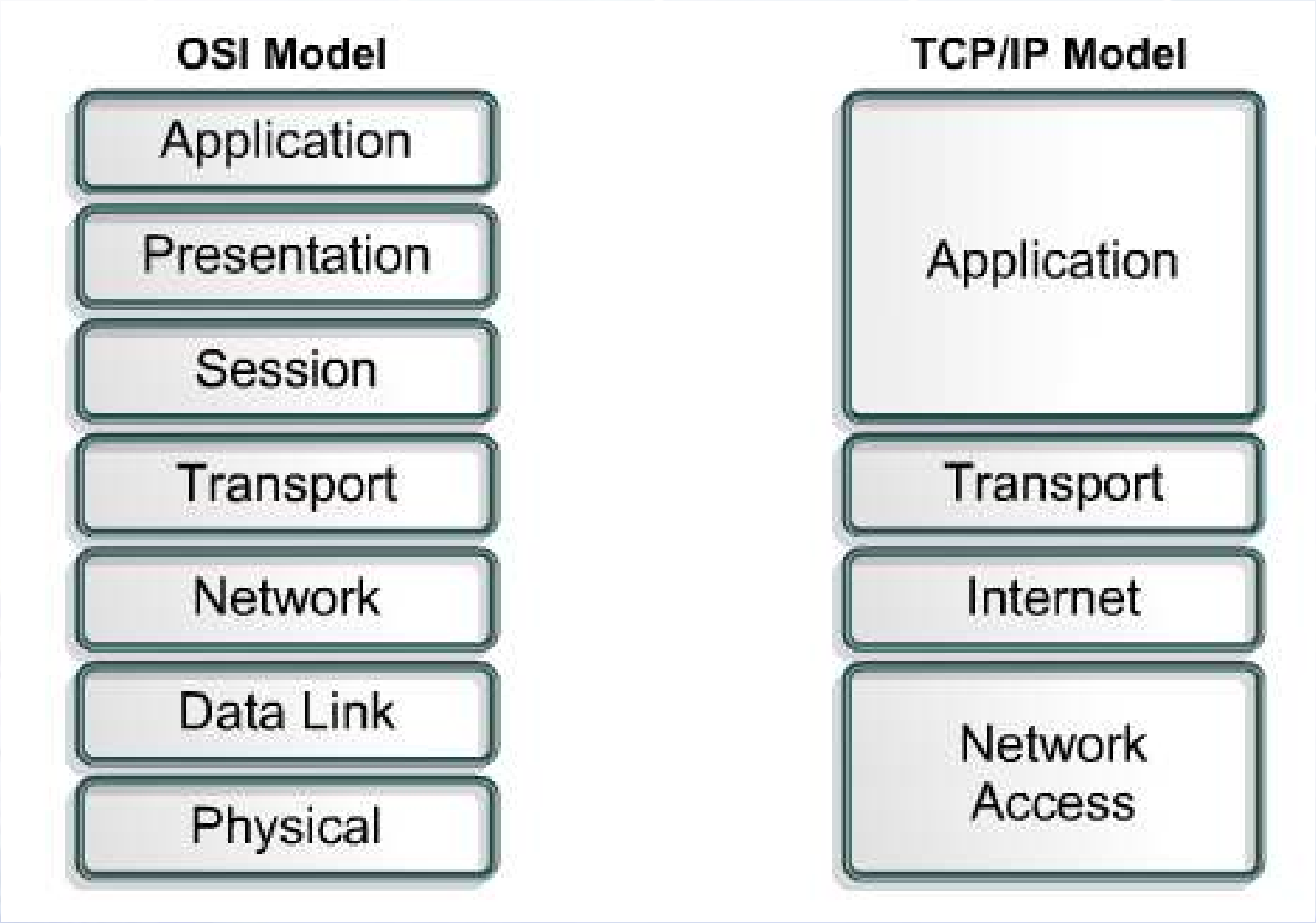
Summary of OSI

	User apps program			
Responsibility of host system	Layer 7	Application	Provides general services related to applications (e.g., file transfer, user access).	**Support user applications**
	Layer 6	Presentation	Formats data (encodes , encrypts, compresses)	
	Layer 5	Session	Maintains dialog between communicating devices)	
	Layer 4	Transport	Provides reliable end-to-end data transmission.	
Responsibility of network	Layer 3	Network	Switches and routes information units.	Govern the communication facilities
	Layer 2	Data link	Provides data exchange between devices on the same medium.	
	Layer 1	Physical	Transmits bit stream to physical medium.	

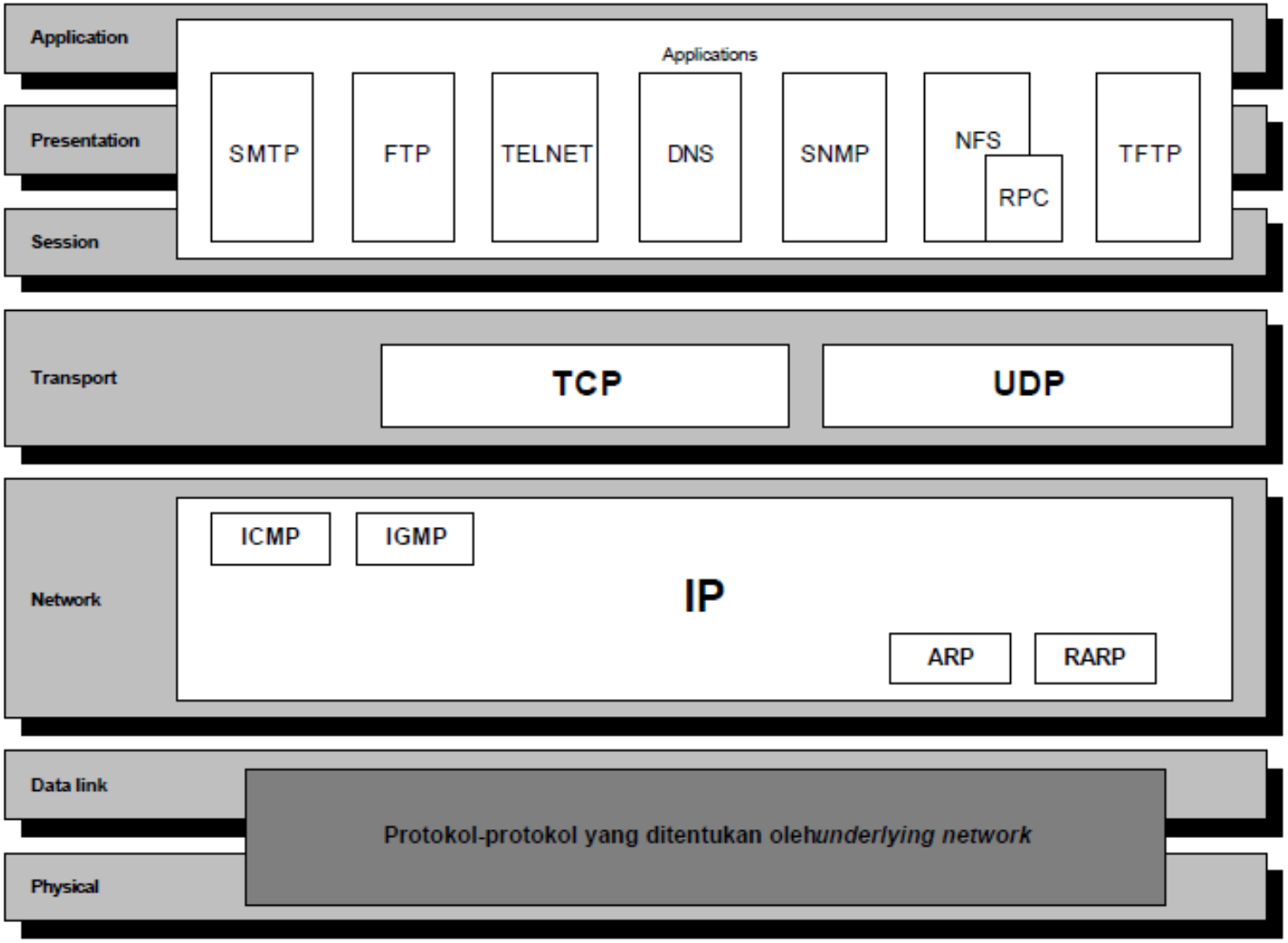
TCP/IP

- Next figure shows the layers of the TCP/IP protocol suite and how they relate to the OSI model.
- The application layer is equivalent to the combined OSI session , presentation, and application layer. TCP/IP has two protocols and the transport layer: the User Datagram Protocol (UDP) and the important Transmission Control Protocols (TCP) .
- The fundamental Protocols at the internet layer is the internet Protocols (IP), which is supported by three other protocols (ICMP,ARP, and RARP).
- Note that the TCP/IP suite does not define any specific protocols at the data link and physical layers. At these layers TCP/IP supports at all standard and proprietary protocols of the underlying network, whether from a LAN, a MAN, or a WAN. Sometimes these layers are jointly called the network access layer in the TCP/IP suite.

OSI vs TCP/IP


OSI Model
Application
Presentation
Session
Transport
Network
Data Link
Physical
TCP/IP Model
Application
Transport
Internet
Network Access

TCP/IP



- Developed prior to OSI model.

The Application Layer

- To illustrate these protocols, let us look at the following three example: an e-mail exchange between two users and web browsing,
  - The client/server view of an e-mail exchange between user A on one network and user B on another. Here user A prepares a message with the help of an-email client application residing in a local computer. Generally, a mail server is always running and ready to handle messages. Thus in an e-mail client/server application a user can send anything from short notes to long and complex files without having concern about whether the receiving host is prepared at that moment to receive these massages.
  - The e-mail client typically queues mail to be sent in a separate application located in a local e-mail server. This server sets up communication with remote hosts, stores and delivers messages locally, and transmit mail to destination e-mail servers.
  - At the destination the mail is stored in the private mailbox of the user to be read immediately or at a later time. SMTP defines the specifications for this process

The Transport layer

- The transport layer offers two basic type of services. :
  - The first of there first of these is the Transmission Control Protocol (TCP), which is a connection-oriented protocol. This server provides a reliable connection for information exchange between different hosts. Typically, when using a connection-oriented protocol, the network will guarantee that all packets are using the same network.
    - Examples of upper-level protocols using TCP are FTP, SMTP, and HTTP.

The Transport layer

- The user datagram protocol (UDP) is the transport layer's second type of protocol. This service is very basic since it simply offers a best-effort connectionless transfer of individual massages. The term best effort means that no error checking or tracking is done. A connectionless protocol transfer of individual massages. The term best effort means that no error checking or a destination is done. A connectionless protocol transmits its data onto the network with a destination address and assumes it will ge t to the recipient.
  - As such, it provides no mechanism for error recovery or flow control. Since multiple paths can exist when using this service, the service will likely deliver the packets in a different sequence from that in which they were sent. Thus the application at the destination is responsible for rearranging the packet intro the correct order.
  - Example of upper-level protocol using UDP are trivial File Transfer Protocol (TFTP), network file system (NFS), and broadcast or multicast.

The Internet Layer

- The internal layer deals with transferring information across one or more networks using routers. A router is a device that intelligently forwards packet from one network to another.
- There are four protocols at this layer. The most important one is the Internet Protocol (IP). The other peripheral protocols are the Internet Control Message Protocol (ICMP), the Address Resolution Protocol (ARP0, and the Reverse Address Resolution Protocol(RARP). These are described in the table. All traffic, whether incoming or outgoing, must pass through the IP.

The Internet Layer

- The addressing scheme of IP accomplishes the primary purpose of the network layer, which is to route packets between different hosts. In the continuous improvement of the TCP/IP protocol suite the IP is evolving to encompass a lager number of addresses and enhanced routing capabilities. Thus in the literature there are literature there are numerous articles dealing with migration from IPv4 (version 4) to IPv6 (version 6).
  - IP is a connectionless protocols so that it does not guarantee delivery of packet to adjacent layers. If connection-oriented service is desired, high-level protocol in either the transport or application layer must take care or application layer must take care of it.
  - In addition to handling the routing of packet between station connected to different network, the internet layer also deals with congestion control. When congestion occurs, the routers that interconnect the intermediate network my discard packets. The transport layer then is responsible for recovery from these losses.

Addressing

Figure 2.17 *Addresses in TCPIIP*

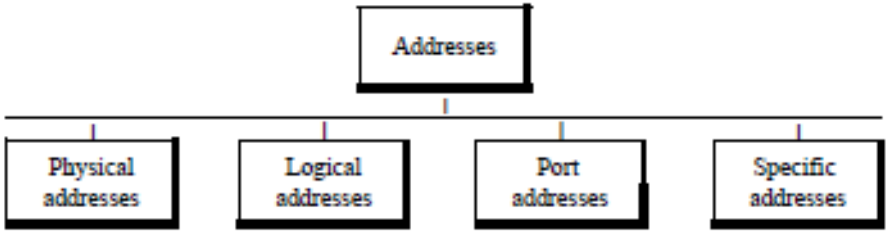
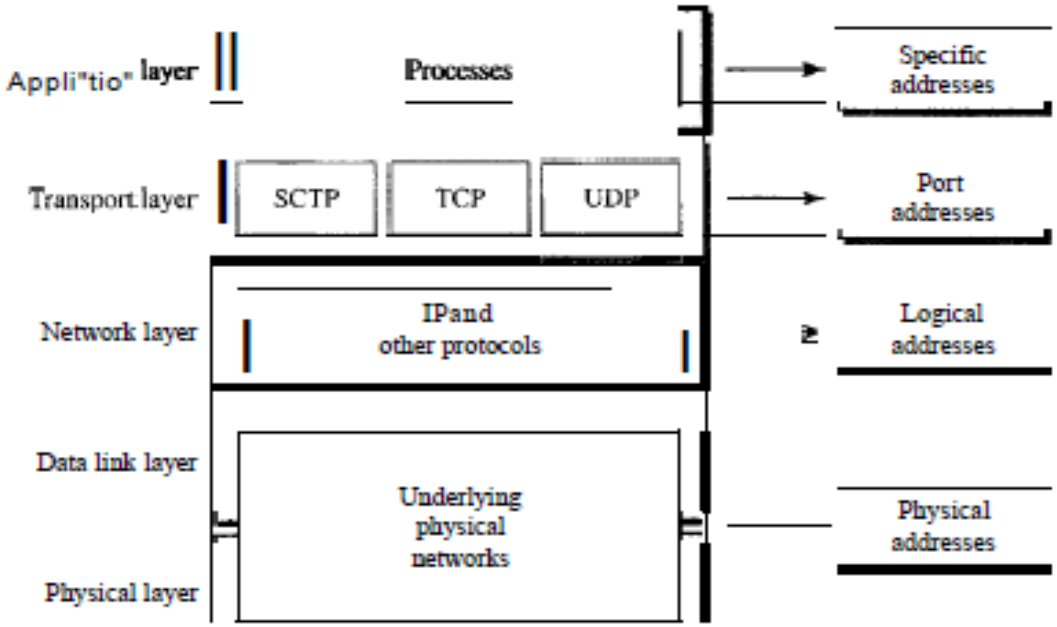


Figure 2.18 *Relationship of layers and addresses in TCPIIP*



Addressing

07:01:02:01 :2C:4B
A 6-byte (12 hexadecimal digits) physical address

- Physical address : 07: 01:02:2C:4B (a 6-byte (12 hexadecimal digits) physical address.
- Logical address : 192.168.4.7
- Port address : 753 (a 16-bit port address represented as one single number)
- Specific address :
  - e-mail address , for example, rahmalia@darmajaya.ac.id.
  - and the Universal Resource Locator (URL), for example: darmajaya.ac.id.

End