The OSI Model and the TCP/IP Protocol Suite

Outline:
1. Protocol Layers
2. OSI Model
3. TCP/IP Model
4. Addressing
OBJECTIVES

- To discuss the OSI model and its layer architecture and to show the interface between the layers.
- To briefly discuss the functions of each layer in the OSI model.
- To introduce the TCP/IP protocol suite and compare its layers with the ones in the OSI model.
- To show the functionality of each layer in the TCP/IP protocol with some examples.
- To discuss the addressing mechanism used in some layers of the TCP/IP protocol suite for the delivery of a message from the source to the destination.
Computer Network Components

Components of a computer network:

- Computer with NIC (PCs, laptops, handhelds)
- Routers & switches (IP router, Ethernet switch)
- Links” Transmission media” (wired, wireless)
- Protocols (IP, TCP, CSMA/CD, CSMA/CA)
- Applications (network services)
  i.e. Network Operating System (NOS)
- Humans and service agents
we discussed that a protocol is required when two entities need to communicate.

When communication is not simple, we may divide the complex task of communication into several layers.

The sending computer must:

◦ Recognize the data.
◦ Divide the data into manageable chunks.
◦ Add information to each chunk of data to determine the location of the data and to identify the receiver.
◦ Add timing and error-checking information.
◦ Put the data on the network and send it on its way.

In this case, we may need several protocols, one for each layer.
Let us use a scenario in communication in which the role of protocol layering may be better understood.

We use two examples. In the first example, communication is so simple that it can occur in only one layer.
• Assume Maria and Ann are neighbors with a lot of common ideas. However, Maria speaks only Spanish, and Ann speaks only English.

• Since both have learned the sign language in their childhood, they enjoy meeting in a cafe a couple of days per week and exchange their ideas using signs.

• Occasionally, they also use a bilingual dictionary. Communication is face to face and happens in one layer as shown in Figure.
• Now assume that Ann has to move to another town because of her job. Before she moves, the two meet for the last time in the same cafe.
• Although both are sad, Maria surprises Ann when she opens a packet that contains two small machines.
  • The first machine can scan and transform a letter in English to a secret code or vice versa.
  • The other machine can scan and translate a letter in Spanish to the same secret code or vice versa.
• Ann takes the first machine; Maria keeps the second one.
• The two friends can still communicate using the secret code, as shown in Figure.
Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards.

Almost three-fourths of countries in the world are represented in the ISO.

An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model.

It was first introduced in the late 1970s.
Topics Discussed in the Section

- Layered Architecture
- Layer-to-layer Communication
- Encapsulation
- Layers in the OSI Model
ISO is the organization; OSI is the model.
OSI Model and Nora

Application 7th floor  Nora gets secret message from Number One

Presentation 6th floor  Message is translated, encrypted and miniaturized

Session 5th floor  Security checks message, adds checkpoints to ensure the embassy receives whole message

Transport 4th floor  Message is analysed, combined if necessary and broken into smaller pieces

Network 3rd floor  Personnel check the message, determine the address, indicate fastest route to Embassy

Data Link 2nd floor  Message placed in special packet contains message, sender and destination ID

Physical 1st floor  Prepared for a trip to the KSA Embassy
An exchange using the OSI model (Encapsulation)
The physical layer is responsible for moving individual bits from one (node) to the next.
Summary of OSI Layers

- **Application**: To allow access to network resources
- **Presentation**: To translate, encrypt, and compress data
- **Session**: To establish, manage, and terminate sessions
- **Transport**: To provide reliable process-to-process message delivery and error recovery
- **Network**: To move packets from source to destination; to provide internetworking
- **Data link**: To organize bits into frames; to provide hop-to-hop delivery
- **Physical**: To transmit bits over a medium; to provide mechanical and electrical specifications
The TCP/IP protocol suite was developed prior to the OSI model.

Therefore, the layers in the TCP/IP protocol suite do not match exactly with those in the OSI model.
Comparison between OSI and TCP/IP
A private internet
In this section we briefly describe the functions of each layer in the OSI model.
Physical layer

- defines the procedures and functions that physical devices and interfaces have to perform for transmission to occur.

- The physical layer is concerned with the following:
  - Physical characteristics of interfaces and media:
  - Representation of the bits
  - Data rate, the number of bits sent each second.
  - Line configuration, Point to point or multipoint configuration.
  - Physical topology
  - Transmission Mode : Simplex, half duplex or full duplex
Communication at the physical layer

Legend

- Source
- Destination

A

R1

R3

R4

B

Physical layer

Link 1

Link 3

Link 5

Link 6

Physical layer

Source

Destination

011 ... 101

011 ... 101

011 ... 101

011 ... 101
The unit of communication at the physical layer is a bit.
Data Link Layer

- The data link layer transforms the physical layer, a raw transmission facility, to a reliable link and is responsible for node-to-node delivery.

- The Data Link layer is concerned with the following:
  - Framing.
  - Physical addressing, each node has its unique address.
  - Flow Control.
  - Access Control.
  - Error control, normally achieved through a trailer to the end of the frame.
Communication at the data link layer

Legend
- Source
- Destination
- Data
- H Header

Data link
Physical

A

Link 1

B

Data link
Physical

Link 1

A

R1

R3

R4

B

Link 3

Link 5

Link 6

Legend
- Source
- Destination
- Data
- H Header

Frame

D2
H2

Frame

D2
H2

Frame

D2
H2

Frame

D2
H2
The unit of communication at the data link layer is a frame.
Network Layer

• Is responsible for the source-to-destination delivery of a packet possible across multiple networks.

• Functions:
  • Logical addressing.
  • Routing, It determines which path the data should take based on network conditions, priority of service, and other factors.
The unit of communication at the network layer is a datagram (Packet).
Transport Layer

- The transport layer is responsible for process-to-process delivery of the entire message.

- Makes sure that the data arrives without errors, in the proper sequence and in a reliable condition.

- Functions:
  - Port addressing, 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, each having a sequence number.
  - Connection control: The transport layer can be either connectionless or connection-oriented.
  - Flow control
  - Error control
Communication at transport layer

Legend

- Source
- Destination
- D Data
- H Header

Transport
Network
Data link
Physical

A

R1

R3

R4

B

Transport
Network
Data link
Physical

Link 1

A

D4 H4
Segment

Link 2

Link 3

Link 4

Link 5

Link 6

B

D4 H4
Segment
The unit of communication at the transport layer is a segment, user datagram, or a packet, depending on the specific protocol used in this layer.
Session Layer

- the session layer, allows two applications on different computers to open, use, and close a connection called a session.
  - (A session is a highly structured dialog between two workstations.)

- Functions:
  - **Dialog control**
    - It also makes sure the session is orderly, establishing which node transmits first, how long it can transmit, and what to do in case of an error.
    - It performs name-recognition and other functions, such as security, that are needed to allow two applications to communicate over the network.
  - **Synchronization**
    - The session layer synchronizes user tasks by placing checkpoints in the data stream.
    - The checkpoints break the data into smaller groups for error detection. It allows information of different streams, perhaps originating from different sources, to be properly combined or synchronized.
      - An example application is web conferencing, in which the streams of audio and video must be synchronous to avoid so-called lip synch problems. It ensures that the person displayed on screen is the current speaker.
presentation layer

• The presentation layer is responsible for translation, compression, and encryption.
• **Deals with the actual formatting of the data.**
  ◦ For example, data might be converted from EBCDIC to ASCII formatting so that the receiving node can understand it.
Application Layer

- This layer relates to the services that directly provide user interfaces support user applications or services, such as software for file transfers, database access, and e-mail.
- In other words, it serves as a window through which application processes can access network services.
- The application layer enables the user to access the network.
- This would be the layer that a programmer uses to allow his application to access a network service, such as linking into a database.
Communication at application layer

TCP/IP Protocol Suite
The unit of communication at the application layer is a message.
Four levels of addresses are used in an internet employing the TCP/IP protocols:

- physical address
- logical address
- port address
- application-specific address.
Each address is related to a one layer in the TCP/IP architecture, as shown in Figure.
Example 1: physical addresses

Sender

10

87 10 Data

LAN

28

packet discarded

53

packet discarded

87

Receiver

87 10 Data

1

2

3

4

Data87 10

packet accepted
As we will see later, most local area networks represent the physical address in two ways:

- **IPv4**
  - use a 32-bit (4-byte) physical address written as decimal digits; every byte (2 hexadecimal digits) is separated by a dot, as shown below:
    
    128.7.0.0

    A 4-byte (a byte represent 8 bits called octet) physical address

- **IPv6 (new version)**
  - use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:
    
    07:01:02:01:2C:4B

    A 6-byte (12 hexadecimal digits) physical address
Example 2: logical addresses

Sender
A/10

LAN 1

To another network

F/20

Router 1

T/99

Physical addresses changed

Data

Physical addresses changed

Data

LAN 2

LAN 3

Receiver
P/95

Router 2

Z/66

To another network

N/33

40 TCP/IP Protocol Suite
The physical addresses will change from hop to hop, but the logical addresses remain the same.
• the purpose of ports is to uniquely identify different applications or processes running on a single computer and thereby enable them to share a single physical connection to a packet-switched network like the Internet.
Example 3: port numbers

Internet

A Sender

H2

AP

AJ

Data

j

P

AP

AJ

Data

H2

AP

AJ

Data

--- Application programs ---
The physical addresses change from hop to hop, but the logical and port addresses usually remain the same.
Example 3

A port address is a 16-bit address represented by one decimal number as shown.

753

A 16-bit port address represented as one single number
References

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