Open Systems Interconnection Model

Internetworking Models

In the late 1970s, the **Open Systems Interconnection (OSI) reference model** was created by the International Organization for Standardization to break the barrier of network communication.

The Layered Approach

A reference model is a conceptual blueprint of how communications should take place. It addresses all the processes required for effective communication and divides these processes into logical groupings called layers. When a communication system is designed in this manner, it's known as ***layered architecture***.

Advantages of Reference Models

The OSI model is hierarchical, and the same benefits and advantages can apply to any layered model. Advantages of using the OSI layered model include, but are not limited to, the following:

- Allows multiple-vendor development through standardization of network components
- Allows various types of network hardware and software to communicate
- Prevents changes in one layer from affecting other layers, so it does not hamper development

The OSI Reference Model

The OSI reference model was created in the late 1970's to help facilitate data transfer between network nodes.

The main reason the International Organization for Standardization (ISO) released the OSI model was so different vendor networks could work with each other.

The OSI has seven different layers, divided into two groups. The top three layers define how the applications within the end stations will communicate with each other and with users. The bottom four layers define how data is transmitted end-to-end.

The upper layers are responsible for applications communicating between hosts. Remember that none of the upper layers know anything about networking

The four bottom layers define how data is transferred through a physical wire or through networking devices. These bottom layers also determine how to rebuild a data stream from a transmitting host to a destination host's application.

The Upper Layers

Application	• Provides a user interface
Presentation	• Presents data • Handles processing such as encryption
Session	• Keeps different applications' data separate
Transport	
Network	
Data Link	
Physical	

The Lower Layers

Transport	• Provides reliable or unreliable delivery • Performs error correction before retransmit
Network	• Provides logical addressing, which routers use for path determination
Data Link	• Combines packets into bytes and bytes into frames • Provides access to media using MAC address • Performs error detection not correction
Physical	• Moves bits between devices • Specifies voltage, wire speed, and pin-out of cables

Network devices that operate at all seven layers of the OSI model include:

- Network management stations
- Web servers
- Gateways
- Network hosts

The OSI Layers

The OSI reference model has seven layers:

- Application layer
- Presentation layer
- Session Layer
- Transport layer
- Network layer
- Data link layer
- Physical layer

Layer functions

Application	• File, print, message, database, and application services
Presentation	• Data encryption, compression, and translation services
Session	• Dialog control
Transport	• End-to-end connection
Network	• Routing
Data Link	• Framing
Physical	• Physical topology

The Application Layer

The Application Layer of the OSI model marks the spot where users actually communicate to the computer. This layer is responsible for identifying and establishing the availability of the intended communication partner, and determining if sufficient resources for the intended communication exist.

Today, transactions and information exchanges between organizations are broadening to require internetworking applications like the following:

- World Wide Web (WWW)
- E-mail gateways
- Electronic Data Interchange (EDI)
- Special interest bulletin boards
- Internet navigation utilities
- Financial transaction services

The Presentation Layer

This layer presents data to the Application layer and is responsible for data translation and code formatting.

The OSI has protocol standards that defines how standard data should be formatted. Tasks like data compression, decompression, encryption, and decryption are associated with this layer. Some Presentation layer standards are involved in multimedia operations too. The following serve to direct graphic and visual image presentation:

- PICT
- TIFF
- JPEG

Other standards to guide movies and sound:

- MIDI
- MPEG
- QuickTime
- RTF

The Session Layer

The Session layer is responsible for setting up, managing, and then tearing down sessions between Presentation layer entities. This layer also provides dialogue control between devices, or nodes. It coordinates communication between systems, and serves to organize their communication by offering three different modes: simplex, half duplex, and full duplex.

Session layer protocols and interfaces

- Network File System (NFS)
- Structured Query Language (SQL)
- Remote Procedure Call (RPC)
- X Window
- AppleTalk Session Protocol (ASP)
- Digital Network Architecture Session Control Protocol (DNA SCP)

Transport Layer

The transport layer segments and reassembles data into a data stream. Services located in the transport layer both segment and reassemble data stream from the upper-layer applications and unite it onto the same data stream. They provide end-to-end data transport services and establish a logical connection between the sending host and destination host on an internetwork.

Flow Control

Data integrity is ensured at the transport layer by maintaining flow control and by allowing users to request reliable data transport between systems. Flow control prevents a sending host on one side of the connection from overflowing the buffers in the receiving host – an event that can result in lost data.

Reliable data transport employs a connection-oriented communication session between systems, and the protocols involve ensure that the following are achieved:

- Their segments delivered are acknowledged back to the sender upon their reception.
- Any segments not acknowledged are retransmitted.
- Segments are sequenced back into their proper order upon arrival at their destination.
- A manageable data flow is maintained in order to avoid congestion, overloading and data loss.

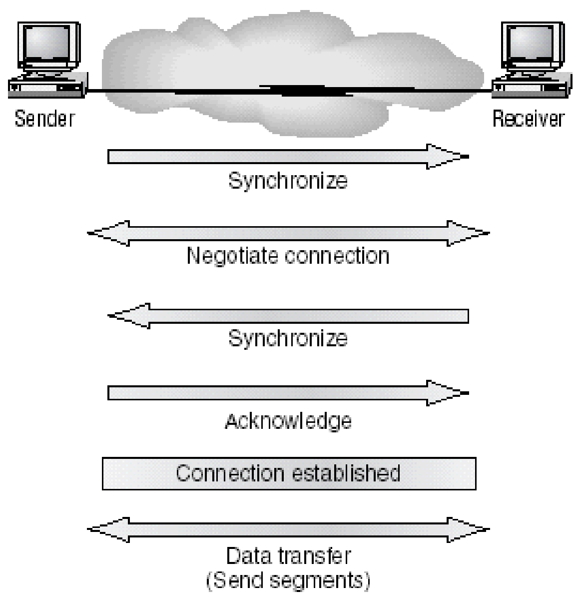
Connection-Oriented Communication

In reliable transport operation, one device first establishes a connection-oriented session with its peer system. Data is then transferred, and when finished, a call termination takes place to tear down the virtual circuit.

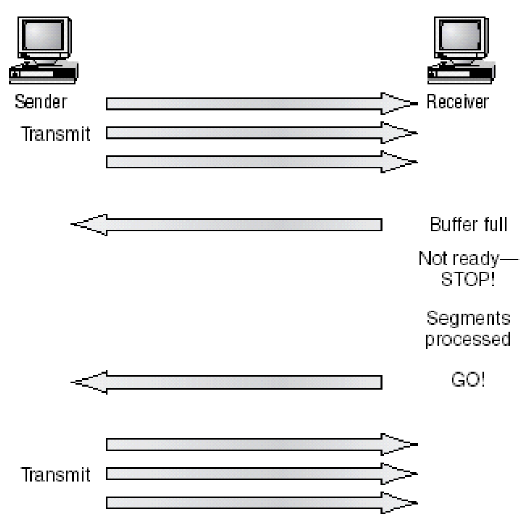
Steps in the connection-oriented session:

- The first "connection agreement" is a request for synchronization.
- The second and third segments acknowledge the request and establish connection parameters between hosts.
- The final segment is also an acknowledgement. It notifies the destination host that the connection agreement has been accepted and that the actual connection has been established. Data transfer starts.

Establishing a connection-oriented session



Transmitting segments with flow control

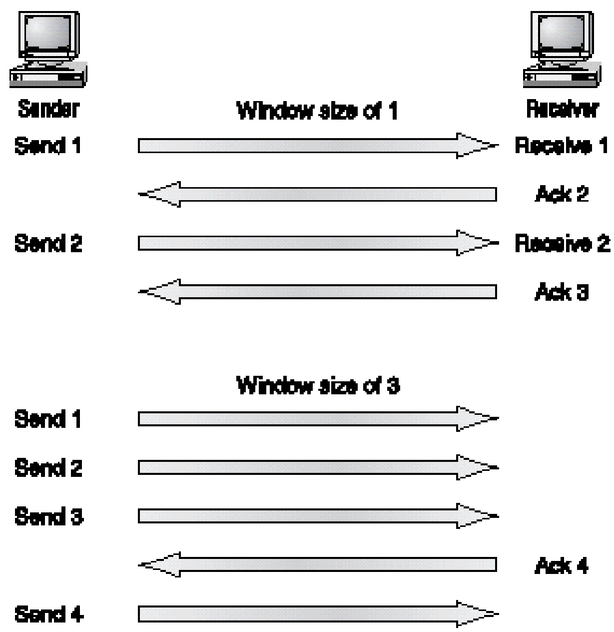


Windowing

The quantity of data segments the transmitting machine is allowed to send without receiving an acknowledgment for them is called a window.

Windows are used to control the amount in outstanding, unacknowledged data segments.

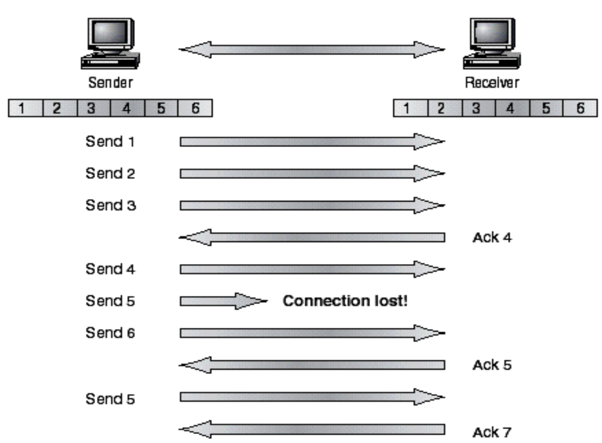
Windowing



Acknowledgments

Reliable data delivery ensures the integrity of a stream of data sent from one machine to the other through a fully functional link. It guarantees that data won't be duplicated or lost. This is achieved through ***positive acknowledgment with retransmission.***

Transport layer reliable delivery



Network Layer

The network layer manages device addressing, tracks the location of devices on the network and the best way to move the data.

Routers (layer-3 devices) are specified at the network layer and provide the routing services within an internetwork.

Two types of packets used at the network layer:

Data packets – used to transport user data through the internetwork. Protocols used to support data traffic are called ***routed protocols***.

Route update packets – used to update neighboring routers about the networks connected to all routers within the internetwork. Protocols that send route update packets are called ***routing protocols***.

Information on a routing table includes:

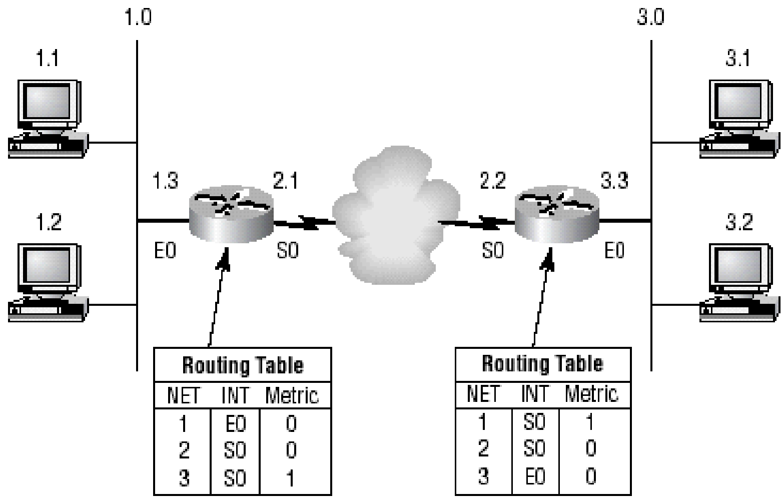
- Network addresses
- Interface
- Metric

Important points on a router

- Routers, by default, will not forward any broadcast or multicast packets.
- Routers use the logical address in a network layer header to determine the next hop router to forward the packet to.
- Routers can use access lists, created by an administrator, to control security on the types of packets that are allowed to enter and exit an interface.
- Routers can provide quality of service (QoS) for specific types of network traffic.

Router

Routing table used in a router



Data Link Layer

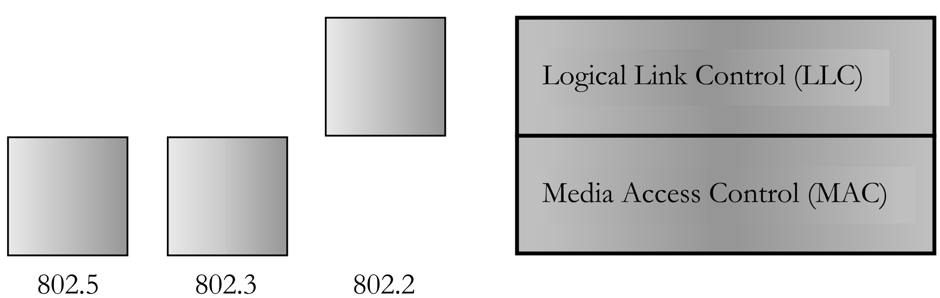
The data link layer provides the physical transmission of the data and handles error notification, network topology and flow control.

The data link layer formats the messages into pieces, called a ***data frame*** and adds a customized header containing the hardware destination and source address.

The IEEE Ethernet data link layer has two sublayers:

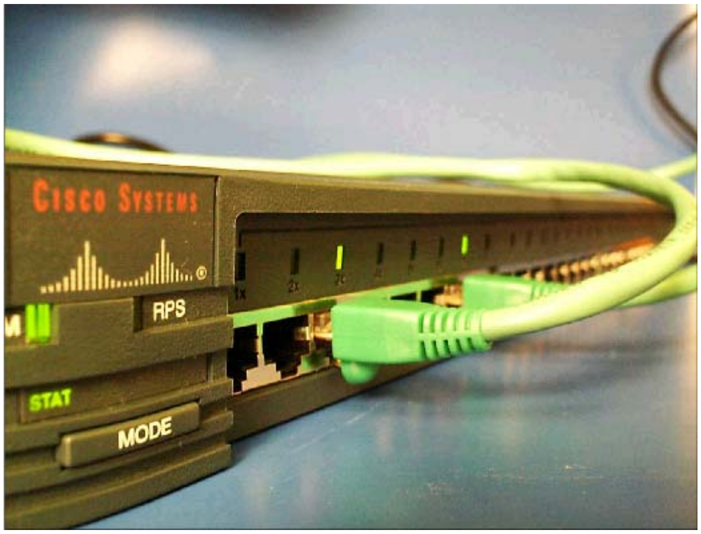
Media Access Control (MAC) 802.3 – defines how packets are placed on the media. Physical addressing and logical topologies are defined here. Line discipline, error notification and ordered delivery of frames can be used at this sublayer.

Logical Link Control (LLC) 802.2 – This sublayer is responsible for identifying Network layer protocols and then encapsulating them. An LLC header tells the data link layer what to do with a packet once a frame is received. The LLC can also provide flow control and sequencing of control bits.



Switches and bridges at the data link layer

Switches and bridges filter the network using MAC addresses. Bridges and switches read each frame as it passes through the network. These devices puts the source hardware address in a filter table and keeps track of which port the frame was received on.



Switch

Physical Layer

The physical layer specifies the electrical, mechanical, procedural, and functional requirements for activating, maintaining and deactivating a physical link between end systems.

The physical layer's connectors and different physical topologies are defined by OSI as standards, allowing disparate systems to communicate.

Hubs at the Physical Layer

A hub is really a multiple-port repeater. Hubs don't examine any of the traffic as it enters and is then transmitted out to the other parts of the physical media.

Data Encapsulation

When a host transmits data across a network to another device, the data goes through encapsulation.

Each layer communicates only with its peer layer on the receiving device. To communicate and exchange information, each layer uses Protocol Data Units (PDU). These hold the control information attached to the data at each layer of the model.

PDUs for the OSI Layers:

Layer 5 – 7: Data stream
Layer 4: Segment
Layer 3: Packets
Layer 2: Frames
Layer 1: Bits

At a transmitting device, the data encapsulation method works like this:

1. User information is converted to data for transmission on the medium.
2. Data is converted to segments and a reliable connection is set up between the transmitting and receiving hosts.
3. Segments are converted to packets, and a logical address is placed on the header so each packet can be routed through an internetwork.
4. Packets are converted to frames for transmission on the local network. Hardware addresses are used to uniquely identify hosts on a local network segment.
5. Frames are converted to bits, and a digital encoding and clocking scheme is used.