

# Lecture (03) Data Encapsulation and OSI model

By:

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## Agenda

- TCP/IP suite
  - Data Encapsulation
- OSI
  - History
  - OSI Layers
  - Layers function
  - OSI & TCP/IP & NetWare
  - Example protocols
  - OSI Layering Concepts and Benefits
  - OSI Terminologies
- Typical LAN Features for Physical layer
- Typical LAN Features for Data link layer

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## Data Encapsulation

What? And why?

The term encapsulation describes the process of putting headers and trailers around some data.

A computer that needs to send data encapsulates the data in headers of the correct format so that the receiving computer will know how to interpret the received data.

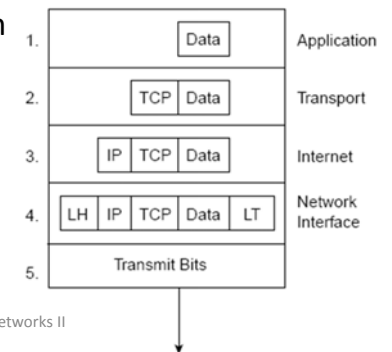
## Data Encapsulation (2)

**Steps:**

Regarding the previous Bob and Larry example, encapsulation process consists of 5 successive steps;

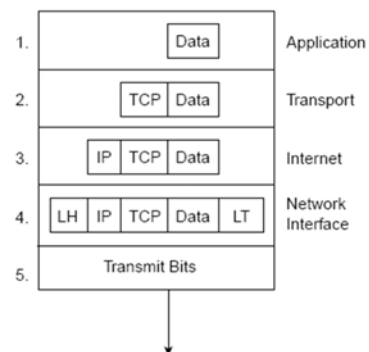
**Step 1:** Create the application data and headers—This simply means that the application has data to send.

**Step 2:** Package the data for transport—In other words, the transport layer (TCP or UDP) creates the transport header and places the data behind it.



## Data Encapsulation (3)

**Step 3:** Add the destination and source network layer addresses to the data— The network layer creates the network header, which includes the network layer addresses, and places the data behind it.

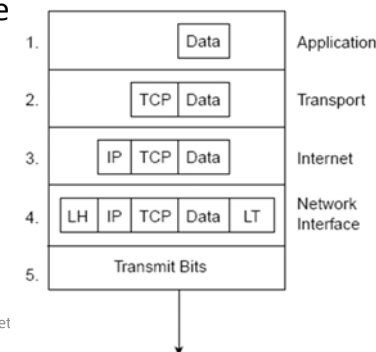


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## Data Encapsulation (4)

**Step 4:** Add the destination and source data link layer addresses to the data— The data link layer creates the data link header, places the data behind it, and places the data link trailer at the end.

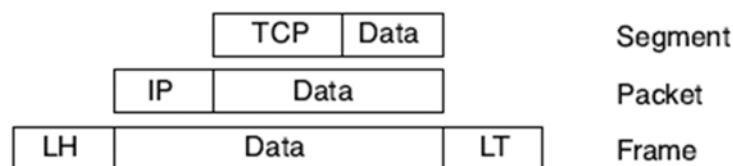
**Step 5:** Transmit the bits—The physical layer encodes a signal onto the medium to transmit the frame



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## Data Encapsulation (5)

Perspectives on Encapsulation and “Data”



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## OSI History

- OSI is the **Open System Interconnection** reference model for communications.
- Some participants in OSI’s creation and development wanted OSI to become *the networking* protocol used by all applications on all computers in the world.
- The U.S. government went so far as to require OSI support on every computer that it purchased, as of a certain date in the early 1990s, which certainly gave vendors some incentive to write OSI code.

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## OSI History (2)

- What is OSI today? OSI never succeeded in the marketplace.
- The U.S. government reversed its decision to require OSI support on computers that it bought, which was probably the final blow to the possibility of pervasive OSI implementations.
- But, the OSI model now is mainly used as a point of reference for discussing other protocol specifications

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## OSI Layers

- When OSI was in active development in the 1980s and 1990s,
- In some cases; the OSI committees created new protocols and specifications to implement the functions specified by each layer.
- In other cases, the OSI committees did not create new protocols or standards, but instead referenced other protocols that were already defined.
- For instance, the IEEE defines Ethernet standards, so the OSI committees did not waste time specifying a new type of Ethernet; it simply referred to the IEEE Ethernet standards.

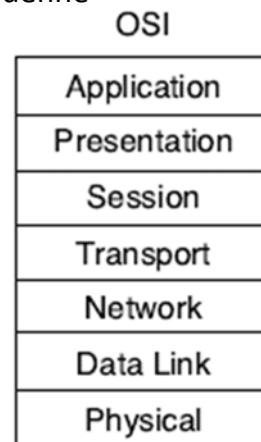
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## OSI Layers (2)

OSI consists of 7 different layers

- The upper layers of the OSI reference model (application, presentation, and session—Layers 7, 6, and 5) define functions focused on the application.
- The lower four layers (transport, network, data link, and physical—Layers 4, 3, 2, and 1) define functions focused on end-to-end delivery of the data.



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## Layers function

<b>7</b> application	<p><b>Layer 7</b></p> <p>defines the interface between the communications software and any applications that need to communicate outside the computer on which the application resides.</p> <p>For example, a web browser is an application on a computer. The browser needs to get the contents of a web page; <b>OSI Layer 7</b> defines the protocols used on behalf of the application to get the web page.</p>
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## Layers function (2)

6 Presentation	<ul style="list-style-type: none"><li>•Defines data formats, such as ASCII text, EBCDIC text, binary, BCD, and JPEG.</li><li>•Encryption also is defined by OSI as a presentation layer service.</li></ul> <p>For example, FTP enables you to choose binary or ASCII transfer. If binary is selected, the sender and receiver do not modify the contents of the file. If ASCII is chosen, the sender translates the text from the sender's character set to a standard ASCII and sends the data. The receiver translates back from the standard ASCII to the character set used on the receiving computer.</p>
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## Layers function (3)

5 Session	<p>defines how to start, control, and end conversations (called sessions).</p> <p>This includes the control and management of multiple bidirectional messages so that the application can be notified if only some of a series of messages are completed. This allows the presentation layer to have a seamless view of an incoming stream of data. The presentation layer can be presented with data if all flows occur in some cases.</p> <p>For example, an automated teller machine transaction in which you withdraw cash from your checking account should not debit your account and then fail before handing you the cash, recording the transaction even though you did not receive money. The session layer creates ways to imply which flows are part of the same session and which flows must complete before any are considered complete.</p>
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## Layers function (4)

4 Transport	<p>provide a large number of services, Although Layers 5 through 7 focus on issues related to the application, Layer 4 focuses on issues related to data delivery to the other computer— For instance,</p> <ul style="list-style-type: none"><li>• error recovery,</li><li>• segmentation of large application data blocks into smaller ones for transmission, and</li><li>• reassembly of those blocks of data on the receiving computer.</li></ul>
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## Layers function (5)

3 Network	<p>defines end-to-end delivery of packets.</p> <p>To accomplish this, the network layer defines logical addressing so that any endpoint can be identified. It also defines how routing works and how routes are learned so that the packets can be delivered.</p> <p>For example, IP running in a router is responsible for</p> <ul style="list-style-type: none"><li>•examining the destination IP address of a packet,</li><li>•comparing that address to the IP routing table,</li><li>•fragmenting the packet if the outgoing interface requires smaller packets,</li><li>•And queuing the packet to be sent out to the interface.</li></ul>
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## Layers function (7)

<b>2 Data link</b>	<p>Defines specifications of particular link or medium to deliver data across it. These protocols are necessarily concerned with the type of media in question;</p> <p>for example,</p> <ul style="list-style-type: none"> <li>•802.3 and 802.2 define Ethernet for the IEEE, which are referenced by OSI as valid data link layer (Layer 2) protocols.</li> <li>•Other protocols, such as High-Level Data Link Control (HDLC) for a point-to-point WAN link, deal with the different details of a WAN link.</li> </ul>
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## Layers function (8)

<b>1 physical</b>	<p>These physical layer (Layer 1) specifications, which are also typically standards from other organizations that are referred to by OSI, deal with the physical characteristics of the transmission medium.</p> <p>Connectors, pins, use of pins, electrical currents, encoding, and light modulation are all part of different physical layer specifications.</p> <p>Multiple specifications sometimes are used to complete all details of the physical layer.</p> <p>For example,</p> <ul style="list-style-type: none"> <li>•RJ-45 defines the shape of the connector and the number of wires or pins in the cable.</li> <li>•Ethernet and 802.3 define the use of wires or pins 1, 2, 3, and 6. So, to use a Category 5 cable with an RJ-45 connector for an Ethernet connection, Ethernet and RJ-45 physical layer specifications are used.</li> </ul>
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## Example protocols

Layer Name	Examples
Application (Layer 7)	Telnet, HTTP, FTP, WWW browsers, NFS, SMTP gateways (Eudora, CC:mail), SNMP
Presentation (Layer 6)	JPEG, ASCII, EBCDIC, TIFF, GIF, PICT, encryption, MPEG, MIDI
Session (Layer 5)	RPC, SQL, NFS, NetBIOS names, AppleTalk ASP, DECnet SCP
Transport (Layer 4)	TCP, UDP, SPX
Network (Layer 3)	IP, IPX, AppleTalk DDP
Data link (Layer 2)	IEEE 802.3/802.2, HDLC, Frame Relay, PPP, FDDI, ATM, IEEE 802.5/802.2
Physical (Layer 1)	EIA/TIA-232, V.35, EIA/TIA-449, RJ-45, Ethernet, 802.3, 802.5, B8ZS

## OSI Layering Concepts and Benefits

- Many benefits can be gained from the process of breaking up the functions or tasks of networking into smaller chunks, called *layers*, and *defining standard interfaces between these layers*.
- **Easier to learn**—Humans can more easily discuss and learn about the many details of a protocol specification.
- **Easier to develop**—Reduced complexity allows easier program changes and faster product evolution.
- **Multivendor interoperability**—Creating products to meet the same networking standards means that computers and networking gear from multiple vendors can work in the same network.

# OSI Layering Concepts and Benefits (2)

- **Modular engineering**—One vendor can write software that implements higher layers— for example, a web browser—and another can write software that implements the lower layers—for example, Microsoft’s built-in TCP/IP software in its operating systems.

# OSI Terminologies

1. Some OSI layers are correlated to TCP/IP layers;

OSI	TCP/IP
Application	Application
Presentation	
Session	
Transport	Transport
Network	Internetwork
Data Link	Network Interface
Physical	

OSI transport layer correlate to TCP/IP transport layer (layer defines error recovery and segmentation)

OSI network layer correlate to TCP/IP internetwork layer (layer defines logical addressing and routing)

# OSI Terminologies (2)

Some OSI layers refers to a single layer in TCP/IP

OSI	TCP/IP
Application	Application
Presentation	
Session	
Transport	Transport
Network	Internetwork
Data Link	Network Interface
Physical	

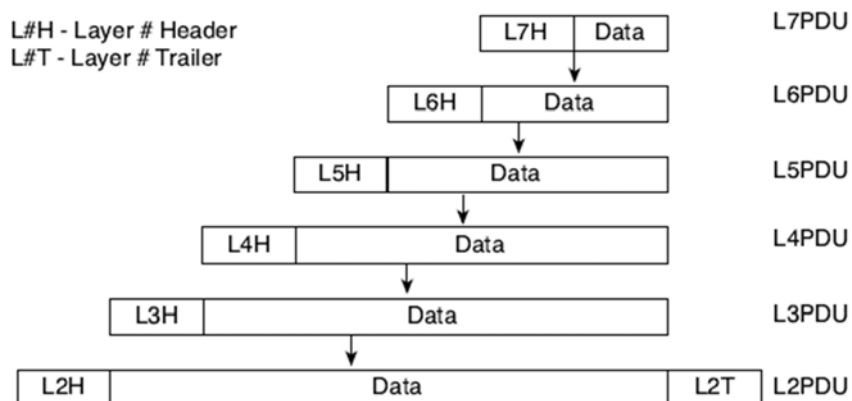
TCP/IP Application layer mapped to Layers 5,6,7 in OSI

Network layer in TCP/IP mapped to data link layer (Ethernet or HDLC) and physical layer (RJ45/Cat5)

# OSI Terminologies (3)

protocol data unit, or PDU represents the bits that include the headers and trailers for that layer, as well as the encapsulated data.

L#H - Layer # Header  
L#T - Layer # Trailer



# Foundation Topics

Ethernet is the undisputed king of LAN standards today.

Twenty five years ago, people wondered whether Ethernet or Token Ring would become win the battle of the LANs.

Eighteen years ago, it looked like Ethernet would win that battle, but it might lose to an upstart called Asynchronous Transfer Mode (ATM) in the LAN.

Today when you think of LANs, no one even questions what type—it's Ethernet.

# Foundation Topics (2)

From the original commercial specifications that transferred data

- 10 megabits per second (Mbps),
- 100 megabits per second (Mbps),
- 1 gigabits per second (Gbps),
- 10 gigabits per second (Gbps).

Ethernet defines both Layer 1 and Layer 2 functions of OSI model.

2. data link layer
1. physical layer

# Typical LAN Features for Physical layer

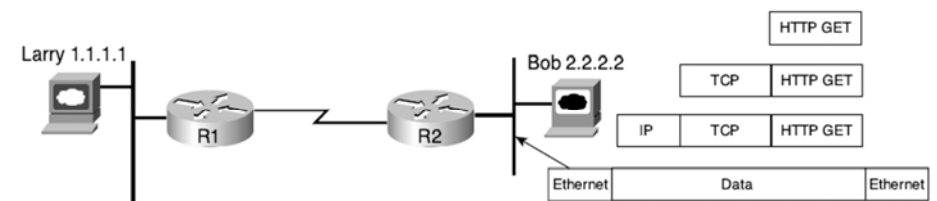
## Definition

- The OSI physical layer defines the standards used to send and receive bits across a physical network.
- The OSI physical layer and its equivalent protocols in TCP/IP define all the details that allow the transmission of the bits from one device to the next.

# Typical LAN Features for Physical layer

Consider the example of the web browser requesting a web page from the web server.

Following figure reminds you of the point at which Bob has built the HTTP, TCP, IP, and Ethernet headers, and is ready to send the data to R2.



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physical layer defines the details of cabling—

- the maximum length allowed for each type of cable (CAT5, 6,...),
- the number of wires inside the cable,
- The shape of the connector (RJ-45 connector) on the end of the cable,
- the purpose of each pin, or wire of cable.

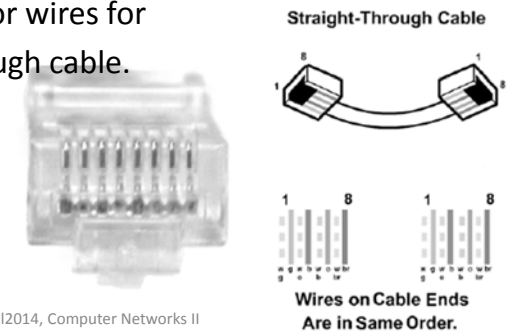
For instance, on a standard Category 5 (CAT5) unshielded twisted-pair (UTP) Ethernet cable, pins 1 and 2 are used for transmitting pins 3 and 6 are used for receiving data.

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### A straight-through cable

- connects pin 1 on one end of the cable with pin 1 on the other end, pin 2 on one end to pin 2 on the other, and so on.
- If you hold the cable so that you compare both connectors side by side, with the same orientation for each connector, you should see the same color wires for each pin with a straight-through cable.



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### twisted pair cable

By twisting the wires, the electromagnetic interference caused by the electrical current is greatly reduced.

So, most LAN cabling uses two twisted pairs—one pair for transmitting and one for receiving.

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### Physical layer specs

Function	Description
Cabling	Defines the number of wires and the type of shielding used (or not used).
Connectors	Defines the shape of the connectors and the number of pins.
Pins	Defines the purpose of the pins. For instance, one pin might be used to signal to the other device whether it is allowed to send.
Voltage and current	Defines the electrical characteristics of the endpoint devices that use a cable.
Encoding	Defines how a device signals a binary 0 or 1 onto the transmit pin(s). For instance, +5V might mean 1, and -5V might mean 0. (Many encoding schemes)

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# Typical LAN Features for data link layer

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## Definition

OSI Layer 2, the data link layer, defines the standards and protocols used to control the transmission of data across a physical network.

If you think of Layer 1 as “sending bits,”

you can think of Layer 2 as

1. knowing when to send the bits,
2. noticing when errors occurred when sending bits,
3. and identifying the computer that needs to get the bits.”

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## Functions

- **Arbitration**—Determines when it is appropriate to use the physical medium
- **Addressing**—Ensures that the correct recipient(s) receives and processes the data that is sent
- **Error detection**—Determines whether the data made the trip across the physical medium successfully
- **Identification of the encapsulated data**—Determines the type of header that follows the data link header

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## Data Link Function 1: Arbitration

### Real life example

Imagine trying to get through an intersection in your car when all the traffic signals are out— you all want to use the intersection, but you had better use it one at a time.

You finally get through the intersection based on a lot of variables—

- how tentative you are,
- how big the other cars are,
- how new or old your car is, and
- how much you value your own life!



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Regardless, you cannot allow cars from every direction to enter the intersection at the same time without having some potentially serious collisions.



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## What about the LAN?

- With some types of physical networks, data frames can collide if devices can send any time they want.
- Then the data in each frame is corrupted and the LAN is unusable.
- The specifications for these data-link protocols define how to arbitrate the use of the physical medium to avoid collisions, or at least to recover from the collisions when they occur.
- Ethernet uses the *carrier sense multiple access with collision detection (CSMA/CD) algorithm* for arbitration.

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## Data Link Function 2: Addressing

### A real life example

- When I sit and have lunch with my friend "X", and just "X", he knows I am talking to him.
- I don't need to start every sentence by saying "Hey, "X" ..."
- Now imagine that a few other people join us for lunch—I might need to say something like "Hey, "X" ..." before saying something so that "X" knows I'm talking to him.

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## What about the LAN?

- Many physical networks allow more than two devices attached to the same physical network (shared medium).
- So, data-link protocols define addresses to make sure that the correct device listens and receives the data that is sent.
- By putting the correct address in the data-link header, the sender of the frame can be relatively sure that the correct receiver will get the data.
- It's just like sitting at the lunch table and having to say "Hey "X" ..." before talking to "X" so that he knows you are talking to him and not someone else.

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## Addressing techniques

- Ethernet uses Media Access Control (MAC) addresses, which are 6 bytes long and are represented as a 12-digit hexadecimal number.
- Frame Relay typically uses a 10-bit-long address called a data-link connection identifier (DLCI)—notice that the name even includes the phrase *data link*.

### Data Link Function 3: Error Detection

- Error detection discovers whether bit errors occurred during the transmission of the frame.
- To do this, most data-link protocols include a *frame check sequence (FCS)* or *cyclical redundancy check (CRC)* field in the data-link trailer.
- This field contains a value that is the result of a mathematical formula applied to the data in the frame.

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- Error detection does not imply recovery;
- most data links, including
  - IEEE 802.5 Token Ring and
  - 802.3 Ethernet,
- do not provide error recovery.
- The FCS allows the receiving device to notice that errors occurred and then discard the data frame.
- Error recovery, which includes the resending of the data, is the responsibility of another protocol.

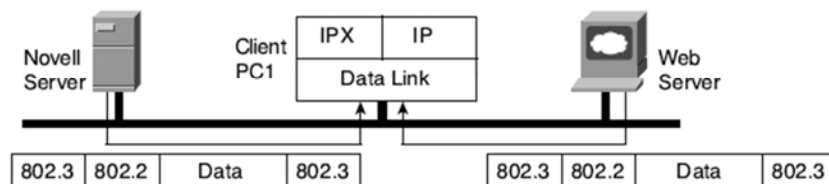
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### Data Link Function 4: Identifying the Encapsulated Data

- Finally, the fourth part of a data link identifies the contents of the Data field in the frame.
- The following figure shows a PC that uses both TCP/IP to talk to a web server and Novell IPX to talk to a Novell NetWare server or apple talk server.

*Multiplexing Using Data-Link Type and Protocol Fields*

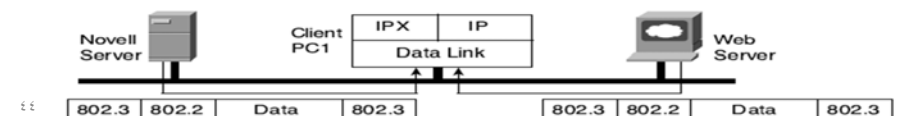


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- When PC1 receives data, should it give the data to the TCP/IP software or the NetWare client software?
- Of course, that depends on what is inside the Data field. If the data came from the Novell server, PC1 hands off the data to the NetWare client code.
- If the data come from apple device, PC1 hands off the data to apple talk client code.
- If the data comes from the web server, PC1 hands it off to the TCP/IP code. But how does PC1 make this decision?

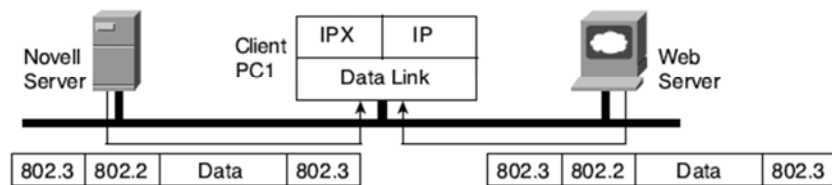
*Multiplexing Using Data-Link Type and Protocol Fields*



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- Well, IEEE Ethernet 802.2 Logical Link Control (LLC) uses a field in its header to identify the type of data in the Data field.
- PC1 examines that field in the received frame to decide whether the packet is an IP packet or an IPX packet, apple talk packet.

Multiplexing Using Data-Link Type and Protocol Fields



- Each data-link header has a field, generically with a name that has the word *Type in it*, to identify the type of protocol that sits inside the frame's data field.
- In each case, the Type field has a code that means IP, IPX, apple talk or some other designation, defining the type of protocol header that follows.

Multiplexing Using Data-Link Type and Protocol Fields

