

## Network Architecture Models: Layered Communications

Encapsulation and De-encapsulation

(September 12, 2016 )

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### Learning objective

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- Understand the principles of layered communications

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### Hybrid TCP/IP-OSI Model

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Layers	Sample protocols for Web access
Application	HTTP
Transport	TCP
Internet	IP
Data Link	Ethernet, PPP
Physical	Ethernet, Modem standards, Telephone standards

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Layered Communications

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■ Application programs on different computers cannot communicate directly

– There is no direct connection between them!

– They need to use an indirect communication system

Browser

Trans

Int

DL

Phy

User PC

HTTP Request

→

⊘

Web App

Trans

Int

DL

Phy

Webserver

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Layer Cooperation on the User PC

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■ Application layer passes HTTP-request to Transport layer

Application

Transport

Internet

Data Link

User PC

HTTP Request

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Physical

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Layer Cooperation on the User PC

6

■ Transport layer creates a TCP segment

★ HTTP request is put in the data field

– A TCP header is added

■ So, Transport layer “encapsulates” HTTP request within a TCP segment

← TCP Segment →

HTTP Request

TCP-H

Data Field

TCP Header

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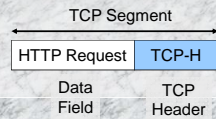
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## Encapsulation

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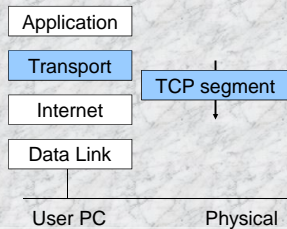
- **Encapsulation is:**
  - Embedding a received message in the data field of a new message
- **Example:** TCP encapsulates HTTP request in the data field of a new message called TCP Segment

[illegible]

## Layer Cooperation on the User PC

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- Transport layer passes the TCP segment down to the Internet layer



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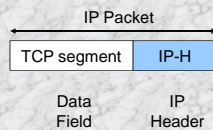
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### Layer Cooperation on the User PC

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- Internet Layer encapsulates TCP Segment within an IP packet

An IP packet to deliver a TCP segment has a TCP segment in its data field 



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Layer Cooperation on the User PC10

- The Internet layer passes the IP packet to the Data Link layer

Internet layer messages are called *packets* ★

Application

Transport

Internet

Data Link

IP packet

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User PC

Physical

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Layer Cooperation on the User PC11

- Data Link Layer encapsulates IP Packet within a *PPP Frame*

Data Link layer messages are called *frames* ★

- PPP frame has IP packet in data field ★
- PPP frame has a PPP Trailer and a PPP Header

PPP Frame Encapsulating an IP Packet

PPP-T

IP packet

PPP-H

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Layer Cooperation on the User PC12

- The Data Link layer passes the PPP frame to the Physical layer, which delivers it to the Physical layer on the first router, one bit at a time (*no message at the Physical layer*)

Application

Transport

Internet

Data Link

PPP frame

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To first router ★

User PC

Physical (10110 ...)

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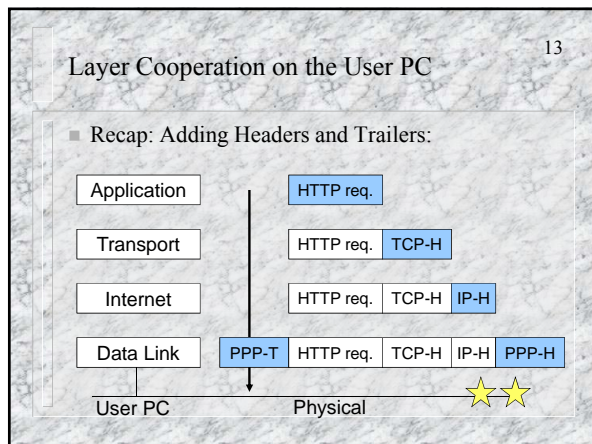
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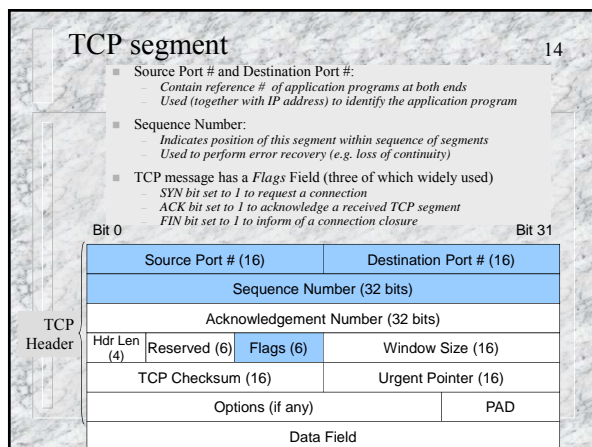
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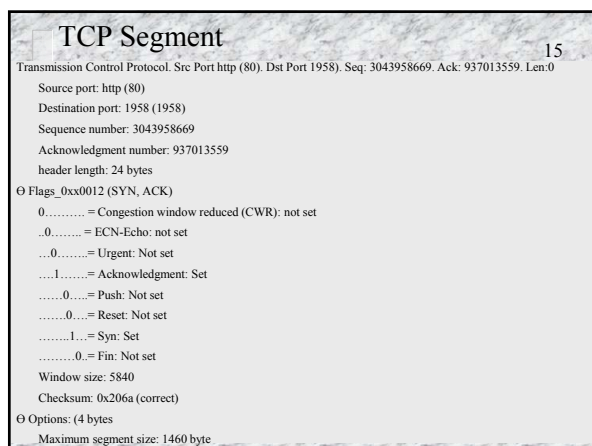
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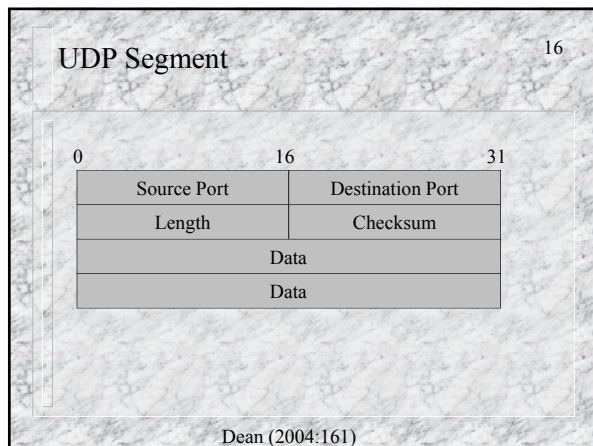
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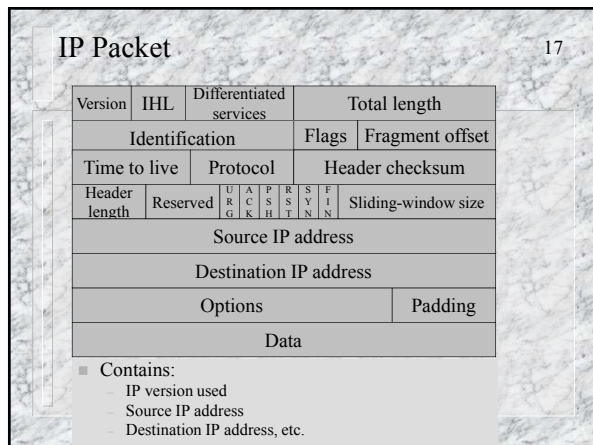
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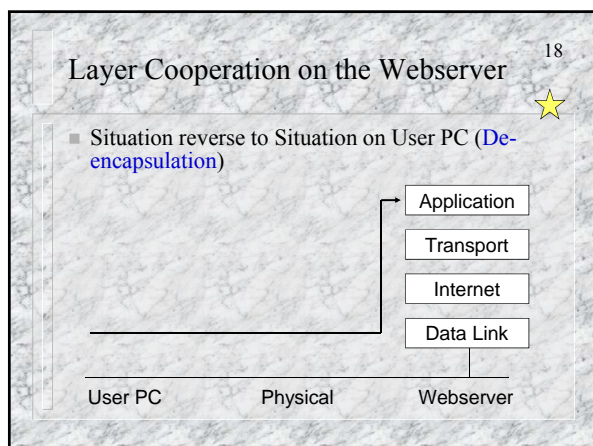
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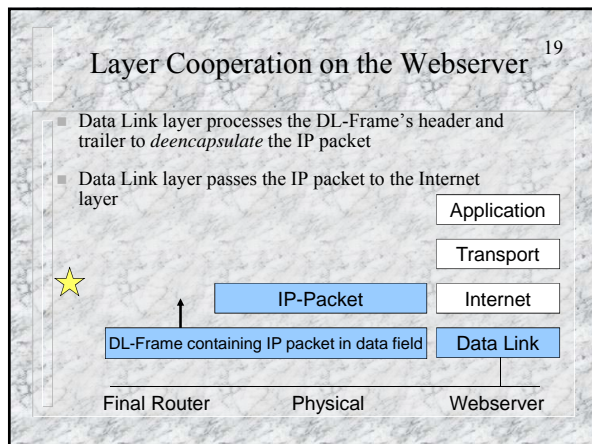
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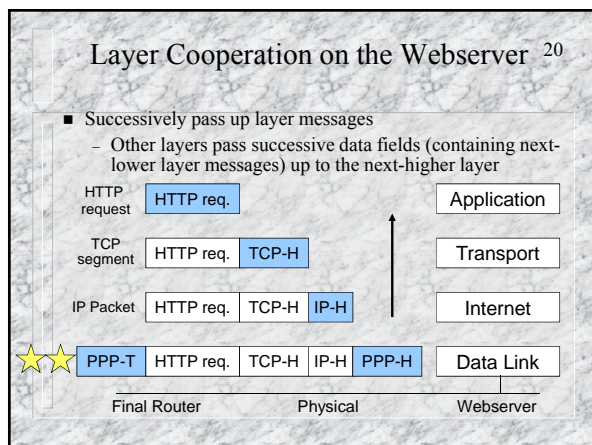
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### Hybrid TCP/IP and Windows Layering <sup>21</sup>

Hybrid TCP/IP-OSI Layering	Microsoft Windows Layering
Application	Clients and Services
Transport	Protocols
Internet	(TCP/IP, IPX/SPX, NetBEUI, etc.)
Data Link	Adapters
Physical	(Dial-up adapters, Network Interface Card, etc.)

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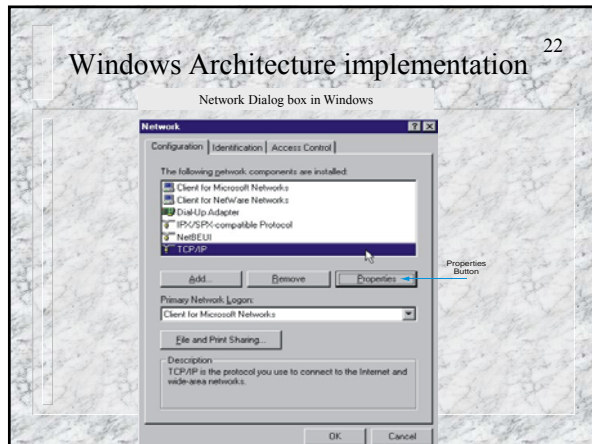
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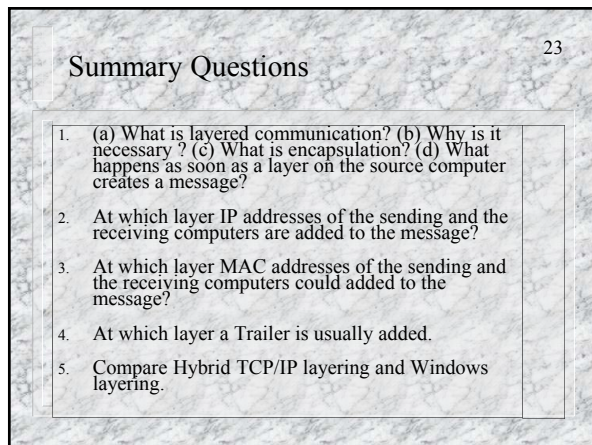
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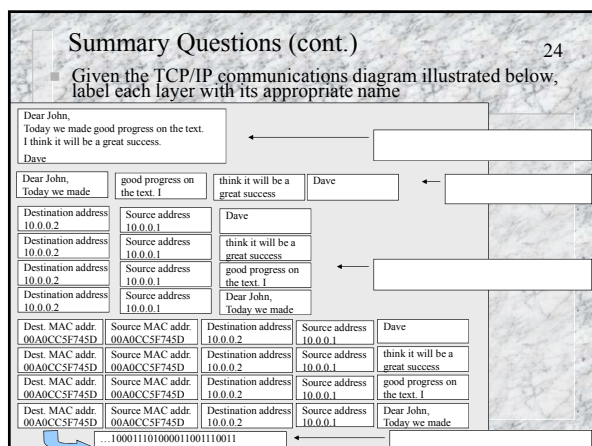
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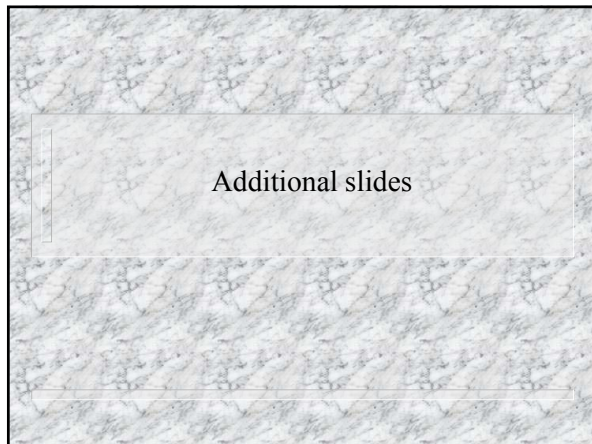
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### The First Router

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- First router receives an IP packet (encapsulated in a frame) in one *port (interface)*
- Must make a *router forwarding decision*: select the port to use to send it back out

```
graph LR; Packet[Packet] --> RouterA[Router A]; RouterA -- "B?" --> B[B]; RouterA -- "C?" --> C[C]; RouterA -- "D?" --> D[D];
```

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### Layer Cooperation on the First Router

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- So far, we have only looked at User PC & Webserver
  - But deencapsulation and encapsulation also occur on *EACH* router
- Frame arrives at a port on the first router
  - Port's Data Link layer receives the PPP frame containing an IP packet

```
graph LR; Internet[Internet] --- Router[First Router]; Router --> DataLink[Data Link]; DataLink --> PPPFrame[PPP Frame];
```

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Layer Cooperation on the First Router

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- Incoming Data Link on the Router
  - Deencapsulates the IP packet from the PPP frame
  - Passes the IP packet to the router's Internet layer

The diagram illustrates the initial step of packet reception. An 'IP Packet' (blue box) is shown being received at the 'Incoming Port on First Router'. It moves through the 'Data Link' layer (white box) and is then passed to the 'Internet' layer (white box) within the 'First Router'.

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Layer Cooperation on the First Router

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- Routers only have Physical, Data Link, and Internet layer
  - So Internet layer is the highest layer on a router for router forwarding
  - Internet layer decides where to send the packet next: another router or the destination Webserver

The diagram shows the 'Internet' layer (blue box) as the highest layer on the 'First Router'. Below it are two 'Data Link' layers (white boxes), which are connected to the 'Incoming Port on First Router'.

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Layer Cooperation on the First Router

30

- Internet layer passes IP packet to Data Link layer on the selected output port that will carry the IP packet to the next router or the destination Webserver

The diagram shows the final step of packet forwarding. An 'IP Packet' (blue box) is passed from the 'Internet' layer (white box) down through the 'Data Link' layer (white box) to the 'Selected Output Port on First Router'.

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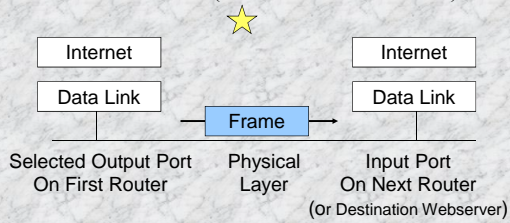
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## Layer Cooperation on the First Router

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- The Data Link and Physical layer on the selected port sends the frame encapsulating the IP packet onto the next router (or destination Webserver)



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