

# Computer Networks - Introduction

2017/18 Q2

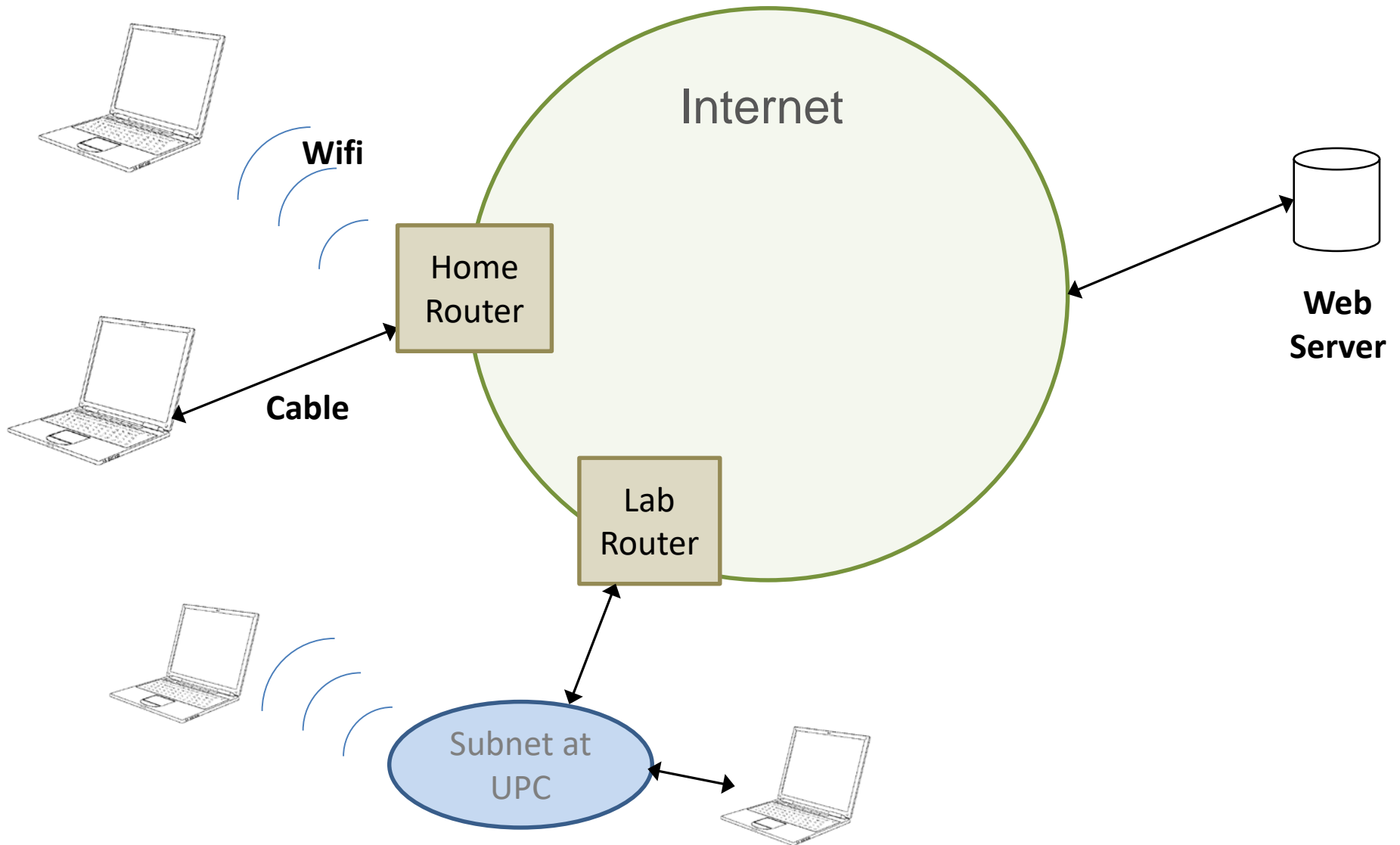
*Jaime Delgado*

DAC – UPC

# Contents

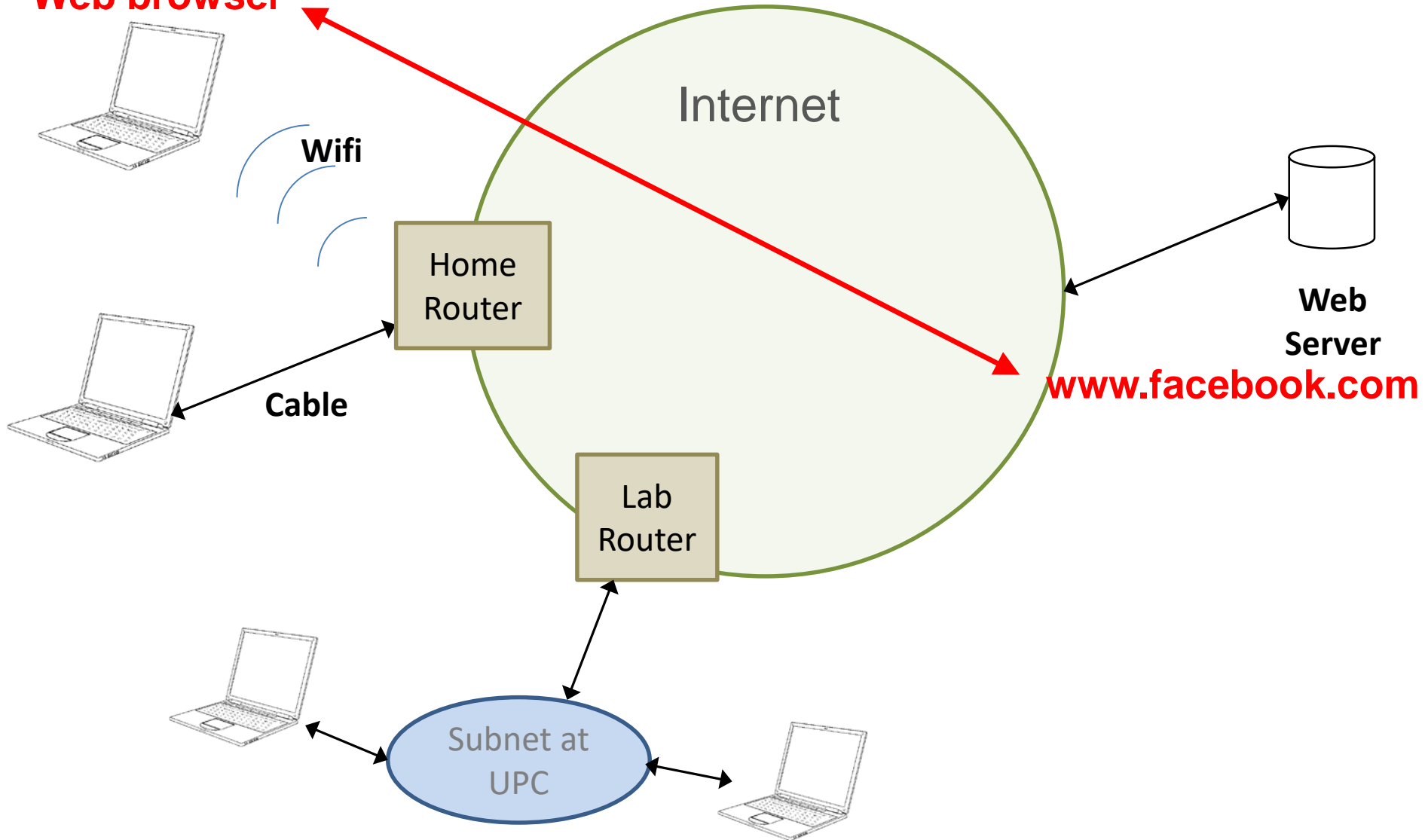
- From application to network.
- The Internet.
- Basic concepts.
- Communications reference models:
  - Internet.
  - OSI (Open Systems Interconnection).
- Information transmission.
- Standardization.

# From application to network



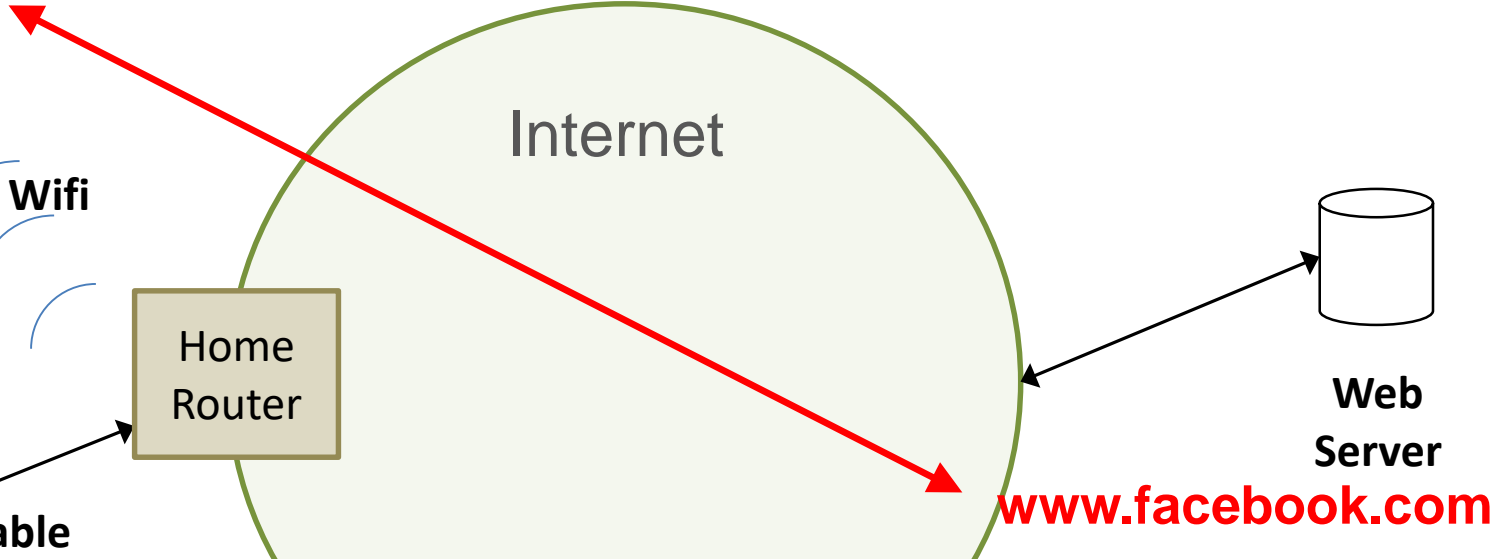
# From application to network

Web browser

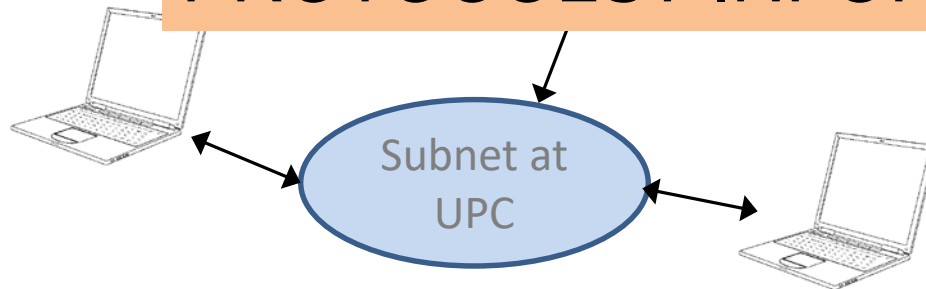


# From application to network

Web browser

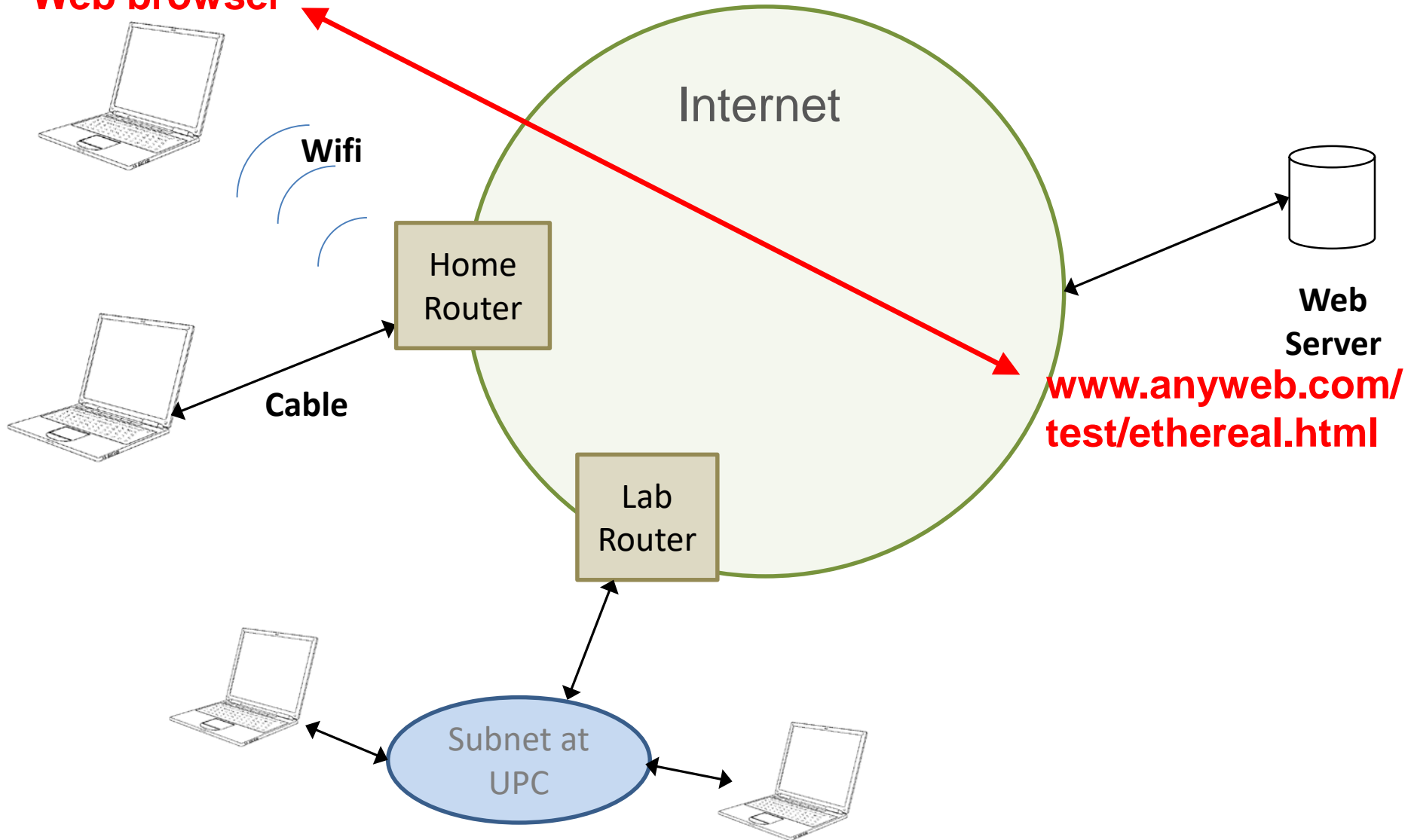


WHAT IS THE PROCESS?  
WHAT ARE THE STEPS?  
PROTOCOLS? INFORMATION?



# Example (data at Web browser)

Web browser

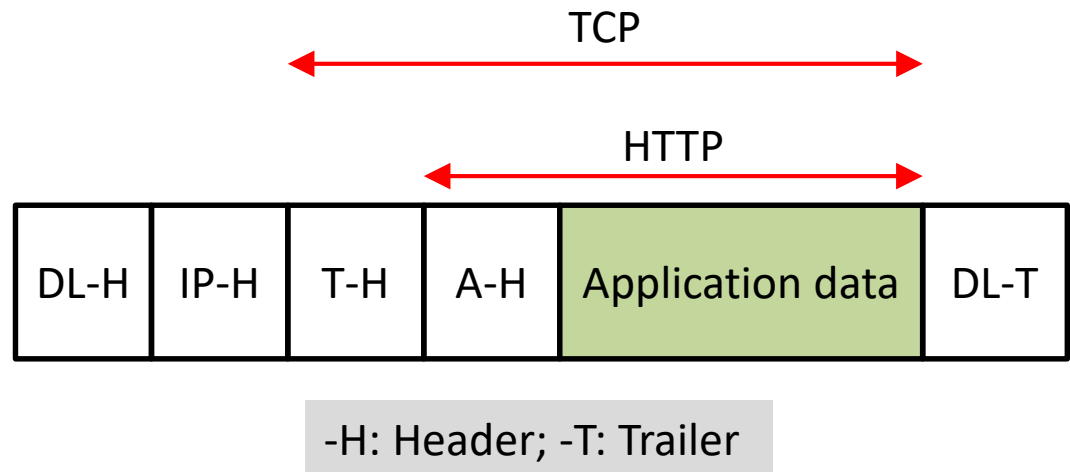
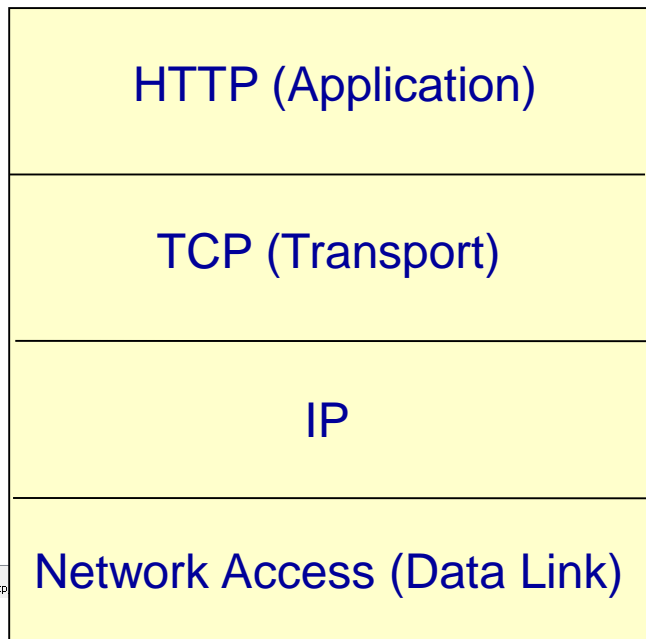


# Web protocol

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=2011387883
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
5	0.000330	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=1 Ack=446 Win=6432 Len=0 TSval=432614628 TSecr=2011387883
6	0.021452	192.168.69.1	192.168.69.2	HTTP	468	HTTP/1.1 200 OK (text/html)
7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

# Web protocol - HTTP

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=2011387883
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
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# TCP connection

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
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10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

> Frame 1: 74 bytes on wire (592 bits), 74 bytes captured (592 bits)

> Ethernet II, Src: Apple\_67:49:3c (00:0a:95:67:49:3c), Dst: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

> Internet Protocol Version 4, Src: 192.168.69.2, Dst: 192.168.69.1

> Transmission Control Protocol, Src Port: 34059, Dst Port: 80, Seq: 0, Len: 0

Source Port: 34059

Destination Port: 80

[Stream index: 0]

[TCP Segment Len: 0]

Sequence number: 0 (relative sequence number)

Acknowledgment number: 0

1010 .... = Header Length: 40 bytes (10)

> Flags: 0x002 (SYN)

Window size value: 5840

[Calculated window size: 5840]

Checksum: 0x9e89 [unverified]

[Checksum Status: Unverified]

Urgent pointer: 0

> Options: (20 bytes), Maximum segment size, SACK permitted, Timestamps, No-Operation (NOP), Window scale

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# TCP connection - IP

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
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3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
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> Frame 1: 74 bytes on wire (592 bits), 74 bytes captured (592 bits)

> Ethernet II, Src: Apple\_67:49:3c (00:0a:95:67:49:3c), Dst: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

> Internet Protocol Version 4, Src: 192.168.69.2, Dst: 192.168.69.1

- 0100 .... = Version: 4
- .... 0101 = Header Length: 20 bytes (5)
- > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
- Total Length: 60
- Identification: 0xf5d9 (62937)
- > Flags: 0x02 (Don't Fragment)
- Fragment offset: 0
- Time to live: 64
- Protocol: TCP (6)
- Header checksum: 0x398e [validation disabled]
- [Header checksum status: Unverified]
- Source: 192.168.69.2
- Destination: 192.168.69.1
- [Source GeoIP: Unknown]
- [Destination GeoIP: Unknown]

> Transmission Control Protocol, Src Port: 34059, Dst Port: 80, Seq: 0, Len: 0

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# TCP connection – Data link

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=...
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
5	0.000330	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=1 Ack=446 Win=6432 Len=0 TSval=432614628 TSecr=2011387883
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7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

▼ Frame 1: 74 bytes on wire (592 bits), 74 bytes captured (592 bits)

Encapsulation type: Ethernet (1)

Arrival Time: Oct 29, 2004 07:21:00.402416000 Hora de verano romance

[Time shift for this packet: 0.000000000 seconds]

Epoch Time: 1099027260.402416000 seconds

[Time delta from previous captured frame: 0.000000000 seconds]

[Time delta from previous displayed frame: 0.000000000 seconds]

[Time since reference or first frame: 0.000000000 seconds]

Frame Number: 1

Frame Length: 74 bytes (592 bits)

Capture Length: 74 bytes (592 bits)

[Frame is marked: False]

[Frame is ignored: False]

[Protocols in frame: eth:ethertype:ip:tcp]

[Coloring Rule Name: HTTP]

[Coloring Rule String: http || tcp.port == 80 || http2]

▼ Ethernet II, Src: Apple\_67:49:3c (00:0a:95:67:49:3c), Dst: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

- Destination: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)
- Source: Apple\_67:49:3c (00:0a:95:67:49:3c)
- Type: IPv4 (0x0800)

Internet Protocol Version 4, Src: 192.168.69.2, Dst: 192.168.69.1

Transmission Control Protocol, Src Port: 34059, Dst Port: 80, Seq: 0, Len: 0

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# HTTP Request

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=...
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
5	0.000330	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=1 Ack=446 Win=6432 Len=0 TSval=432614628 TSecr=2011387883
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7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

> Frame 4: 511 bytes on wire (4088 bits), 511 bytes captured (4088 bits)

> Ethernet II, Src: Apple\_67:49:3c (00:0a:95:67:49:3c), Dst: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

> Internet Protocol Version 4, Src: 192.168.69.2, Dst: 192.168.69.1

> Transmission Control Protocol, Src Port: 34059, Dst Port: 80, Seq: 1, Ack: 1, Len: 445

> Hypertext Transfer Protocol

> GET /test/ethereal.html HTTP/1.1\r\n

> [Expert Info (Chat/Sequence): GET /test/ethereal.html HTTP/1.1\r\n]

Request Method: GET

Request URI: /test/ethereal.html

Request Version: HTTP/1.1

Host: cerberus\r\n

User-Agent: Mozilla/5.0 (X11; U; Linux ppc; rv:1.7.3) Gecko/20041004 Firefox/0.10.1\r\n

Accept: text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.8,image/png,\*/\*;q=0.5\r\n

Accept-Language: en-us,en;q=0.5\r\n

Accept-Encoding: gzip,deflate\r\n

Accept-Charset: ISO-8859-1,utf-8;q=0.7,\*;q=0.7\r\n

Keep-Alive: 300\r\n

Connection: keep-alive\r\n

> Cookie: FGNCIIID=05c04axp1yaqynldtcdiwis0ag1\r\n\r\n

[Full request URI: <http://cerberus/test/ethereal.html>]

[HTTP request 1/1]

[Response in frame: 6]

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# HTTP Request - TCP

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=2011387883
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> Frame 4: 511 bytes on wire (4088 bits), 511 bytes captured (4088 bits)

> Ethernet II, Src: Apple\_67:49:3c (00:0a:95:67:49:3c), Dst: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

> Internet Protocol Version 4, Src: 192.168.69.2, Dst: 192.168.69.1

> Transmission Control Protocol, Src Port: 34059, Dst Port: 80, Seq: 1, Ack: 1, Len: 445

Source Port: 34059

Destination Port: 80

[Stream index: 0]

[TCP Segment Len: 445]

Sequence number: 1 (relative sequence number)

[Next sequence number: 446 (relative sequence number)]

Acknowledgment number: 1 (relative ack number)

1000 .... = Header Length: 32 bytes (8)

> Flags: 0x018 (PSH, ACK)

Window size value: 46

[Calculated window size: 5888]

[Window size scaling factor: 128]

Checksum: 0x16ca [unverified]

[Checksum Status: Unverified]

Urgent pointer: 0

> Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps

> [SEQ/ACK analysis]

TCP payload (445 bytes)

> Hypertext Transfer Protocol

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# HTTP Request - IP

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
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6	0.021452	192.168.69.1	192.168.69.2	HTTP	468	HTTP/1.1 200 OK (text/html)
7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

> Frame 4: 511 bytes on wire (4088 bits), 511 bytes captured (4088 bits)

> Ethernet II, Src: Apple\_67:49:3c (00:0a:95:67:49:3c), Dst: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

> Internet Protocol Version 4, Src: 192.168.69.2, Dst: 192.168.69.1

- 0100 .... = Version: 4
- .... 0101 = Header Length: 20 bytes (5)
- > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
- Total Length: 497
- Identification: 0xf5db (62939)
- > Flags: 0x02 (Don't Fragment)
- Fragment offset: 0
- Time to live: 64
- Protocol: TCP (6)
- Header checksum: 0x37d7 [validation disabled]
- [Header checksum status: Unverified]
- Source: 192.168.69.2
- Destination: 192.168.69.1
- [Source GeoIP: Unknown]
- [Destination GeoIP: Unknown]

> Transmission Control Protocol, Src Port: 34059, Dst Port: 80, Seq: 1, Ack: 1, Len: 445

> Hypertext Transfer Protocol

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# HTTP Request – Data Link

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=...
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
5	0.000330	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=1 Ack=446 Win=6432 Len=0 TSval=432614628 TSecr=2011387883
6	0.021452	192.168.69.1	192.168.69.2	HTTP	468	HTTP/1.1 200 OK (text/html)
7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

▼ Frame 4: 511 bytes on wire (4088 bits), 511 bytes captured (4088 bits)

Encapsulation type: Ethernet (1)

Arrival Time: Oct 29, 2004 07:21:00.402698000 Hora de verano romance

[Time shift for this packet: 0.000000000 seconds]

Epoch Time: 1099027260.402698000 seconds

[Time delta from previous captured frame: 0.000129000 seconds]

[Time delta from previous displayed frame: 0.000129000 seconds]

[Time since reference or first frame: 0.000282000 seconds]

Frame Number: 4

Frame Length: 511 bytes (4088 bits)

Capture Length: 511 bytes (4088 bits)

[Frame is marked: False]

[Frame is ignored: False]

[Protocols in frame: eth:ethertype:ip:tcp:http]

[Coloring Rule Name: HTTP]

[Coloring Rule String: http || tcp.port == 80 || http2]

▼ Ethernet II, Src: Apple\_67:49:3c (00:0a:95:67:49:3c), Dst: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

- Destination: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)
- Source: Apple\_67:49:3c (00:0a:95:67:49:3c)
- Type: IPv4 (0x0800)

► Internet Protocol Version 4, Src: 192.168.69.2, Dst: 192.168.69.1

► Transmission Control Protocol, Src Port: 34059, Dst Port: 80, Seq: 1, Ack: 1, Len: 445

► Hypertext Transfer Protocol

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# HTTP Response - HTML

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
6	0.021452	192.168.69.1	192.168.69.2	HTTP	468	HTTP/1.1 200 OK (text/html)
7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630

▼ Hypertext Transfer Protocol

▼ HTTP/1.1 200 OK\r\n

- > [Expert Info (Chat/Sequence): HTTP/1.1 200 OK\r\n]
- Request Version: HTTP/1.1
- Status Code: 200
- [Status Code Description: OK]
- Response Phrase: OK
- Date: Fri, 29 Oct 2004 05:21:00 GMT\r\n
- Server: Apache/2.0.50 (Fedora)\r\n
- Last-Modified: Fri, 29 Oct 2004 05:20:21 GMT\r\n
- ETag: "126e1f-6d-371b2f40"\r\n
- Accept-Ranges: bytes\r\n
- Vary: Accept-Encoding\r\n
- Content-Encoding: gzip\r\n
- > Content-Length: 92\r\n
- Connection: close\r\n
- Content-Type: text/html; charset=UTF-8\r\n\r\n
- [HTTP response 1/1]
- [Time since request: 0.021170000 seconds]
- [\[Request in frame: 4\]](#)
- Content-encoded entity body (gzip): 92 bytes -> 109 bytes
- File Data: 109 bytes

▼ Line-based text data: text/html

```
<html>\n<head>\n\t<title>Ethereal Example Page</title>\n</head>\n<body>\n\t\tEthereal Example Page\n\t</body>
```



# HTTP Response - TCP

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=...
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
5	0.000330	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=1 Ack=446 Win=6432 Len=0 TSval=432614628 TSecr=2011387883
6	0.021452	192.168.69.1	192.168.69.2	HTTP	468	HTTP/1.1 200 OK (text/html)
7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

> Frame 6: 468 bytes on wire (3744 bits), 468 bytes captured (3744 bits)

> Ethernet II, Src: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3), Dst: Apple\_67:49:3c (00:0a:95:67:49:3c)

> Internet Protocol Version 4, Src: 192.168.69.1, Dst: 192.168.69.2

> Transmission Control Protocol, Src Port: 80, Dst Port: 34059, Seq: 1, Ack: 446, Len: 402

Source Port: 80

Destination Port: 34059

[Stream index: 0]

[TCP Segment Len: 402]

Sequence number: 1 (relative sequence number)

[Next sequence number: 403 (relative sequence number)]

Acknowledgment number: 446 (relative ack number)

1000 .... = Header Length: 32 bytes (8)

> Flags: 0x018 (PSH, ACK)

Window size value: 6432

[Calculated window size: 6432]

[Window size scaling factor: 1]

Checksum: 0x2eef [unverified]

[Checksum Status: Unverified]

Urgent pointer: 0

> Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps

> [SEQ/ACK analysis]

TCP payload (402 bytes)

> Hypertext Transfer Protocol

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# HTTP Response - IP

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=0
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
5	0.000330	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=1 Ack=446 Win=6432 Len=0 TSval=432614628 TSecr=2011387883
6	0.021452	192.168.69.1	192.168.69.2	HTTP	468	HTTP/1.1 200 OK (text/html)
7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

> Frame 6: 468 bytes on wire (3744 bits), 468 bytes captured (3744 bits)

> Ethernet II, Src: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3), Dst: Apple\_67:49:3c (00:0a:95:67:49:3c)

> Internet Protocol Version 4, Src: 192.168.69.1, Dst: 192.168.69.2

- 0100 .... = Version: 4
- .... 0101 = Header Length: 20 bytes (5)
- > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
- Total Length: 454
- Identification: 0xbfc4 (49092)
- > Flags: 0x02 (Don't Fragment)
- Fragment offset: 0
- Time to live: 64
- Protocol: TCP (6)
- Header checksum: 0x6e19 [validation disabled]
- [Header checksum status: Unverified]
- Source: 192.168.69.1
- Destination: 192.168.69.2
- [Source GeoIP: Unknown]
- [Destination GeoIP: Unknown]

> Transmission Control Protocol, Src Port: 80, Dst Port: 34059, Seq: 1, Ack: 446, Len: 402

> Hypertext Transfer Protocol

> Line-based text data: text/html

http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

Profile: Default

# HTTP Response – Data Link

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help



Apply a display filter ... <Ctrl-/> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.69.2	192.168.69.1	TCP	74	34059 → 80 [SYN] Seq=0 Win=5840 Len=0 MSS=1460 SACK_PERM=1 TSval=2011387883 TSecr=0 WS=128
2	0.000059	192.168.69.1	192.168.69.2	TCP	74	80 → 34059 [SYN, ACK] Seq=0 Ack=1 Win=5792 Len=0 MSS=1460 SACK_PERM=1 TSval=432614628 TSecr=...
3	0.000153	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=1 Ack=1 Win=5888 Len=0 TSval=2011387883 TSecr=432614628
4	0.000282	192.168.69.2	192.168.69.1	HTTP	511	GET /test/ethereal.html HTTP/1.1
5	0.000330	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=1 Ack=446 Win=6432 Len=0 TSval=432614628 TSecr=2011387883
6	0.021452	192.168.69.1	192.168.69.2	HTTP	468	HTTP/1.1 200 OK (text/html)
7	0.021629	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [ACK] Seq=446 Ack=403 Win=6912 Len=0 TSval=2011387905 TSecr=432614630
8	0.021755	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [FIN, ACK] Seq=403 Ack=446 Win=6432 Len=0 TSval=432614630 TSecr=2011387905
9	0.022677	192.168.69.2	192.168.69.1	TCP	66	34059 → 80 [FIN, ACK] Seq=446 Ack=404 Win=6912 Len=0 TSval=2011387906 TSecr=432614630
10	0.022715	192.168.69.1	192.168.69.2	TCP	66	80 → 34059 [ACK] Seq=404 Ack=447 Win=6432 Len=0 TSval=432614630 TSecr=2011387906

▼ Frame 6: 468 bytes on wire (3744 bits), 468 bytes captured (3744 bits)

Encapsulation type: Ethernet (1)

Arrival Time: Oct 29, 2004 07:21:00.423868000 Hora de verano romance

[Time shift for this packet: 0.000000000 seconds]

Epoch Time: 1099027260.423868000 seconds

[Time delta from previous captured frame: 0.021122000 seconds]

[Time delta from previous displayed frame: 0.021122000 seconds]

[Time since reference or first frame: 0.021452000 seconds]

Frame Number: 6

Frame Length: 468 bytes (3744 bits)

Capture Length: 468 bytes (3744 bits)

[Frame is marked: False]

[Frame is ignored: False]

[Protocols in frame: eth:ethertype:ip:tcp:http:data-text-lines]

[Coloring Rule Name: HTTP]

[Coloring Rule String: http || tcp.port == 80 || http2]

▼ Ethernet II, Src: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3), Dst: Apple\_67:49:3c (00:0a:95:67:49:3c)

► Destination: Apple\_67:49:3c (00:0a:95:67:49:3c)

► Source: Kingston\_2d:4a:a3 (00:c0:f0:2d:4a:a3)

Type: IPv4 (0x0800)

► Internet Protocol Version 4, Src: 192.168.69.1, Dst: 192.168.69.2

► Transmission Control Protocol, Src Port: 80, Dst Port: 34059, Seq: 1, Ack: 446, Len: 402

► Hypertext Transfer Protocol

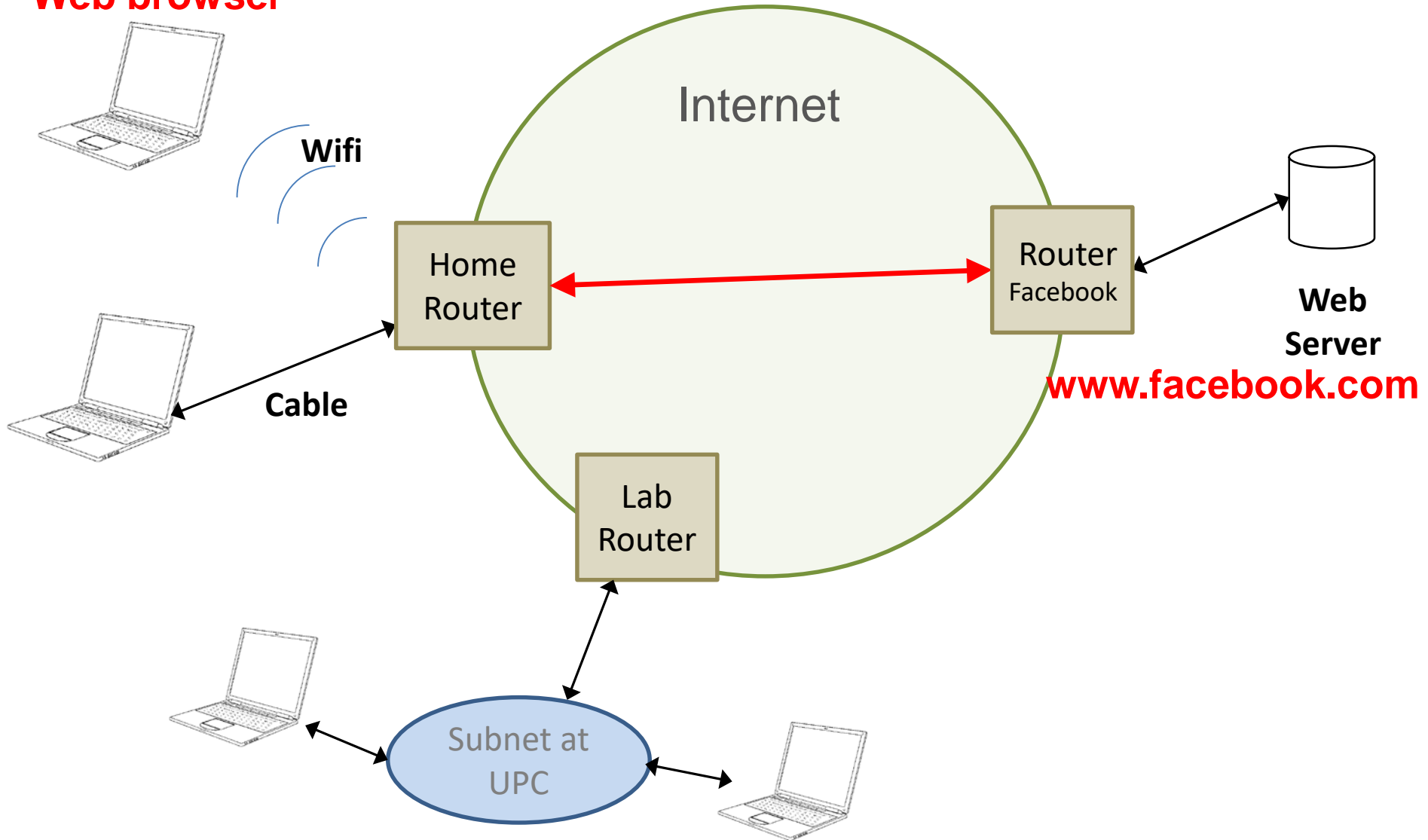
http\_gzip

Packets: 10 · Displayed: 10 (100.0%) · Load time: 0:0.1

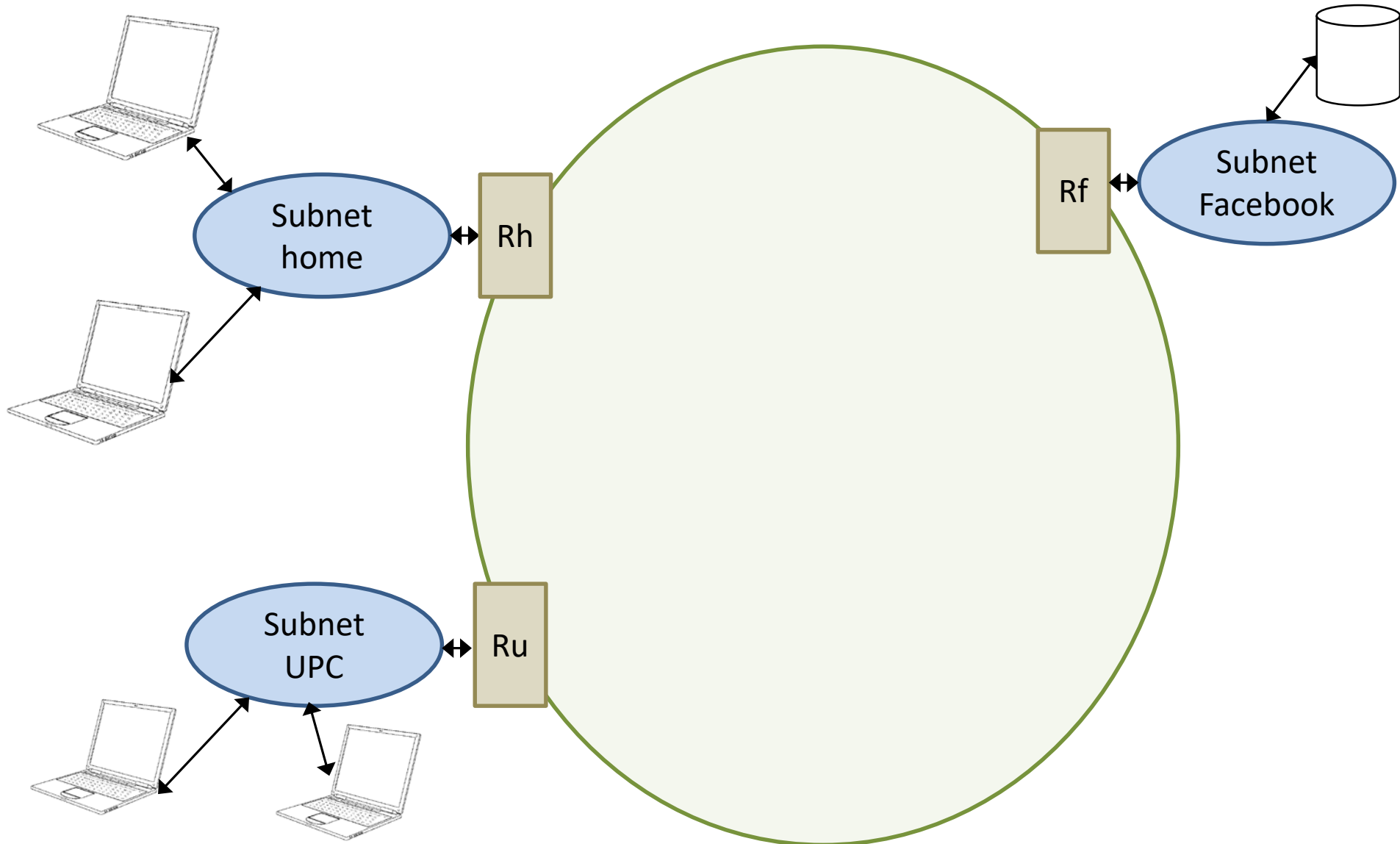
Profile: Default

# From application to network

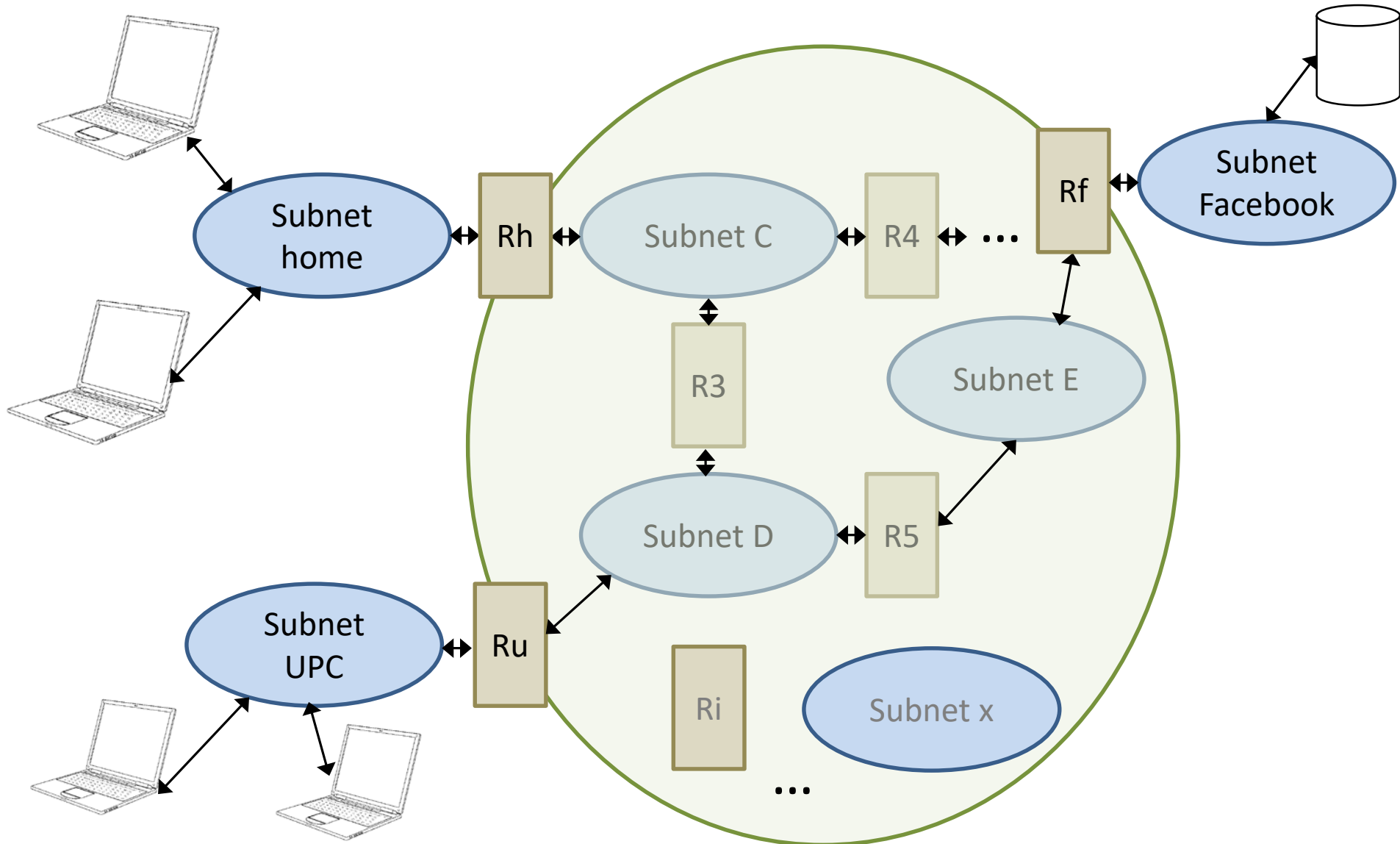
Web browser



# The network

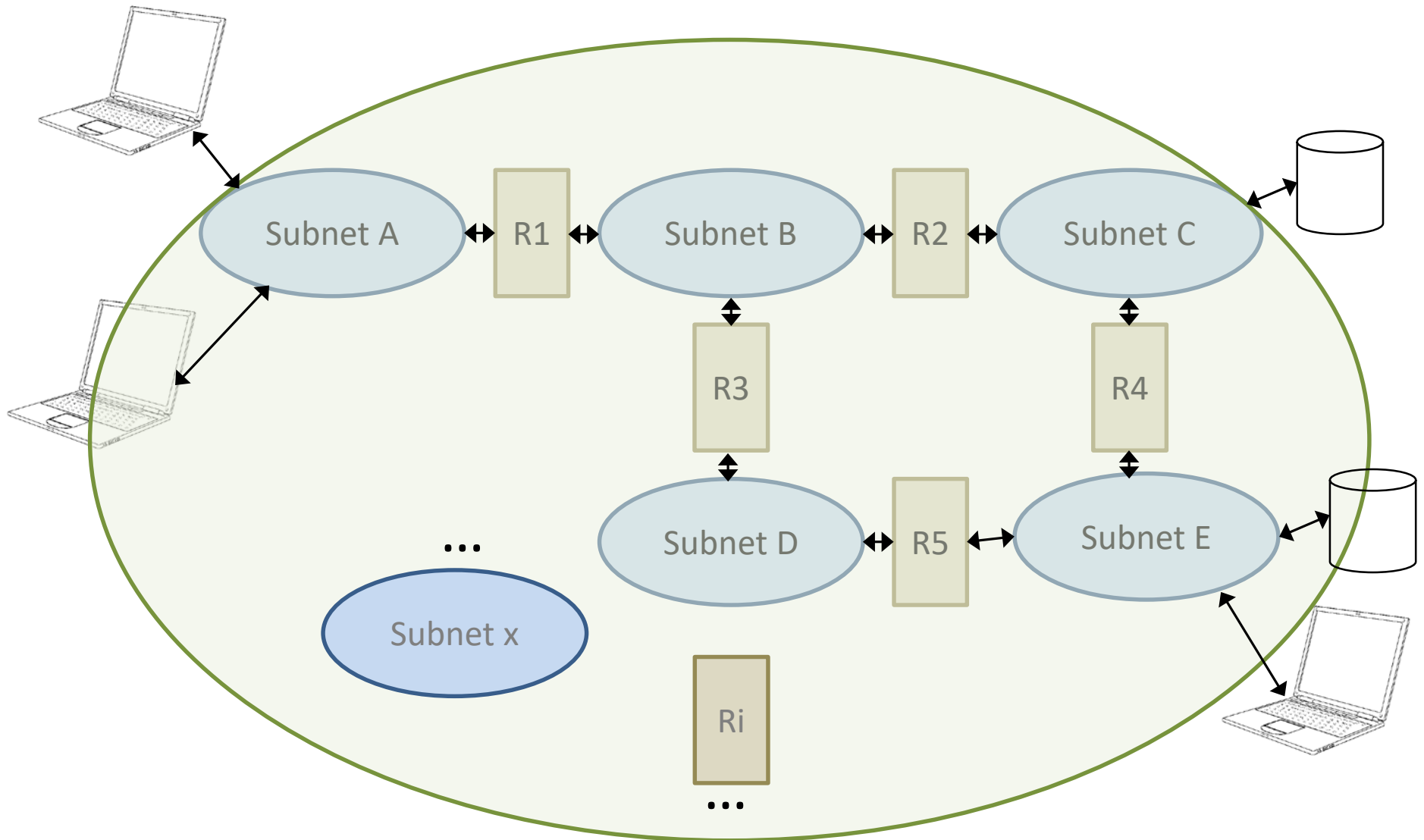


# The network



# The Internet

Ri: Router



# Basic concepts

- Host: Computer, Server, ...
- Network equipment: Routers, ...
- The Internet: Network of (sub)networks.
- How to approach the complexity:
  - Model/Structure with Layers/Levels.



# Reference models

- Model/Structure with Layers/Levels  
→ Layer independence.
- Models:
  - “Formal”: OSI (Open Systems Interconnection), from ISO.
  - “Informal” model: Internet.
- Service & Protocol:
  - Service: from one layer to the above one.
  - Protocol: between the same layer entities from two remote systems.

# OSI model



“Application”  
layer

# OSI model



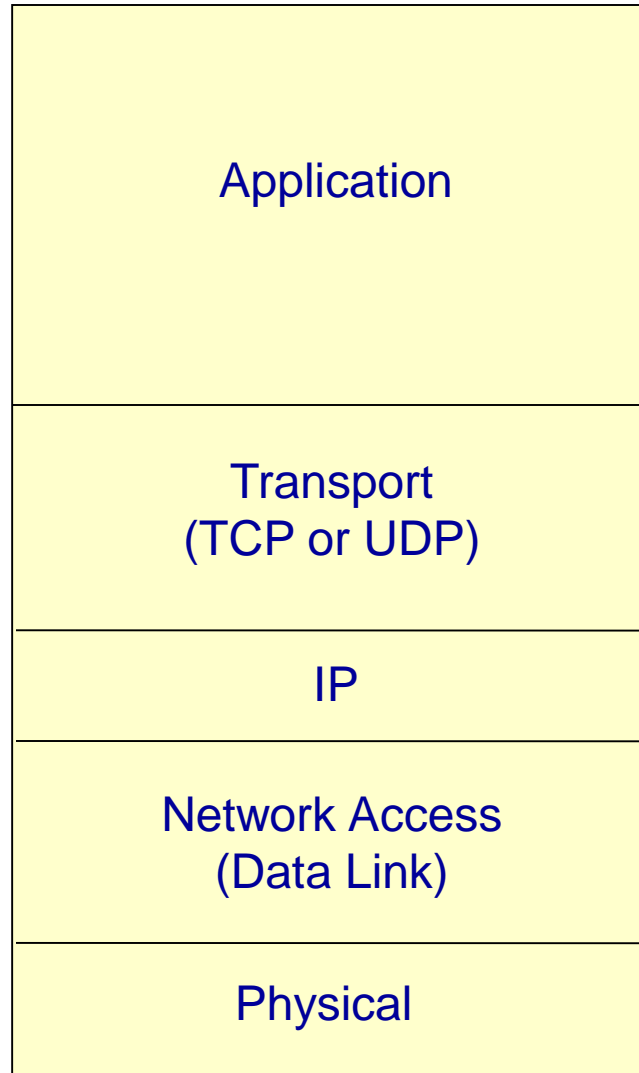
Only in the  
Computer  
("Host")

# OSI model



The  
Network

# Internet model



# Models comparison

Application	Application
	Presentation
	Session
Transport (TCP or UDP)	Transport
IP	Network
Network Access (Data Link)	(Data)Link
Physical	Physical

# Models comparison

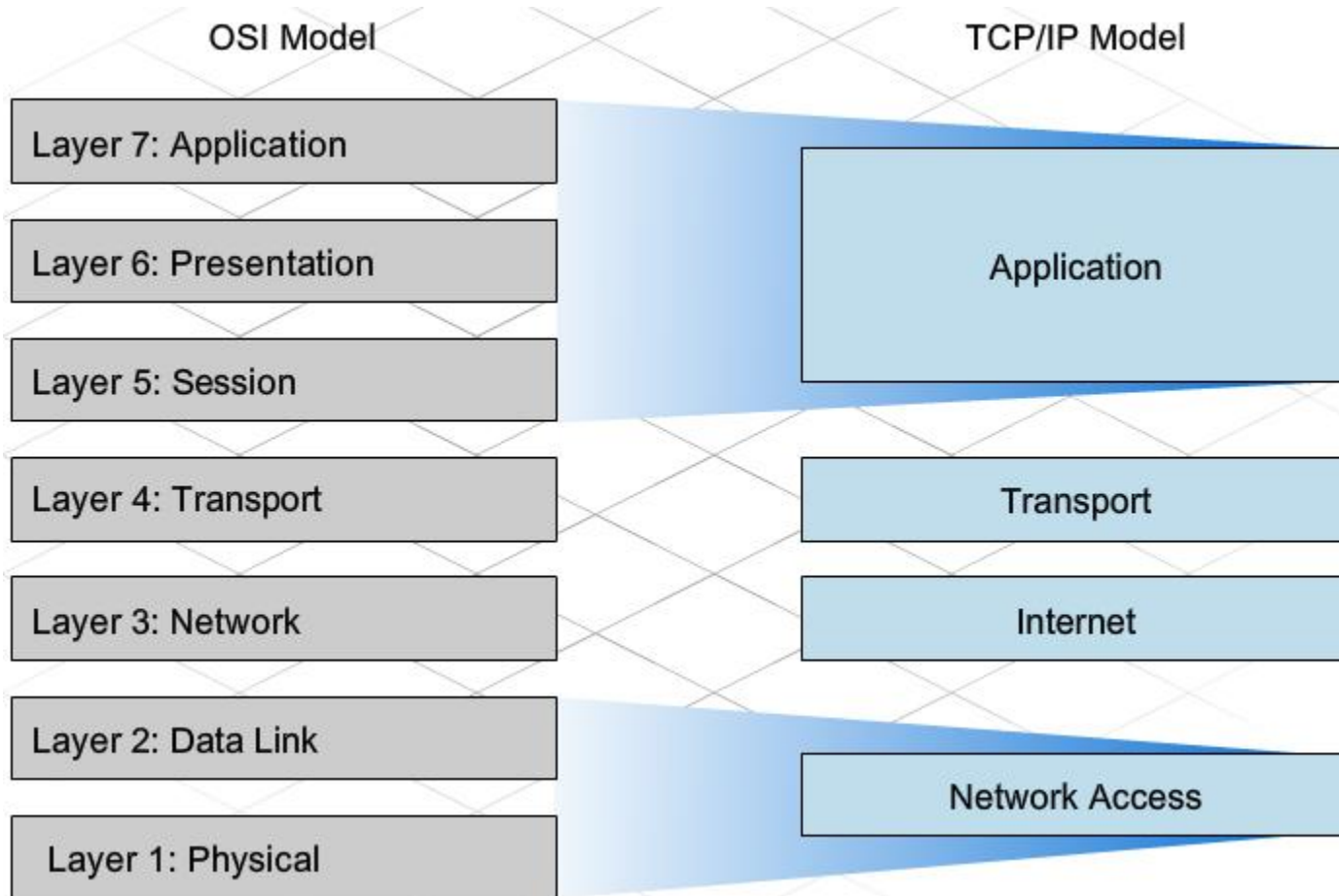
OSI Model

7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

TCP/IP Model

5	Application
4	Transport Control Protocol (TCP) User Datagram Protocol (UDP)
3	Internet Protocol (IP)
2	Data Link
1	Physical

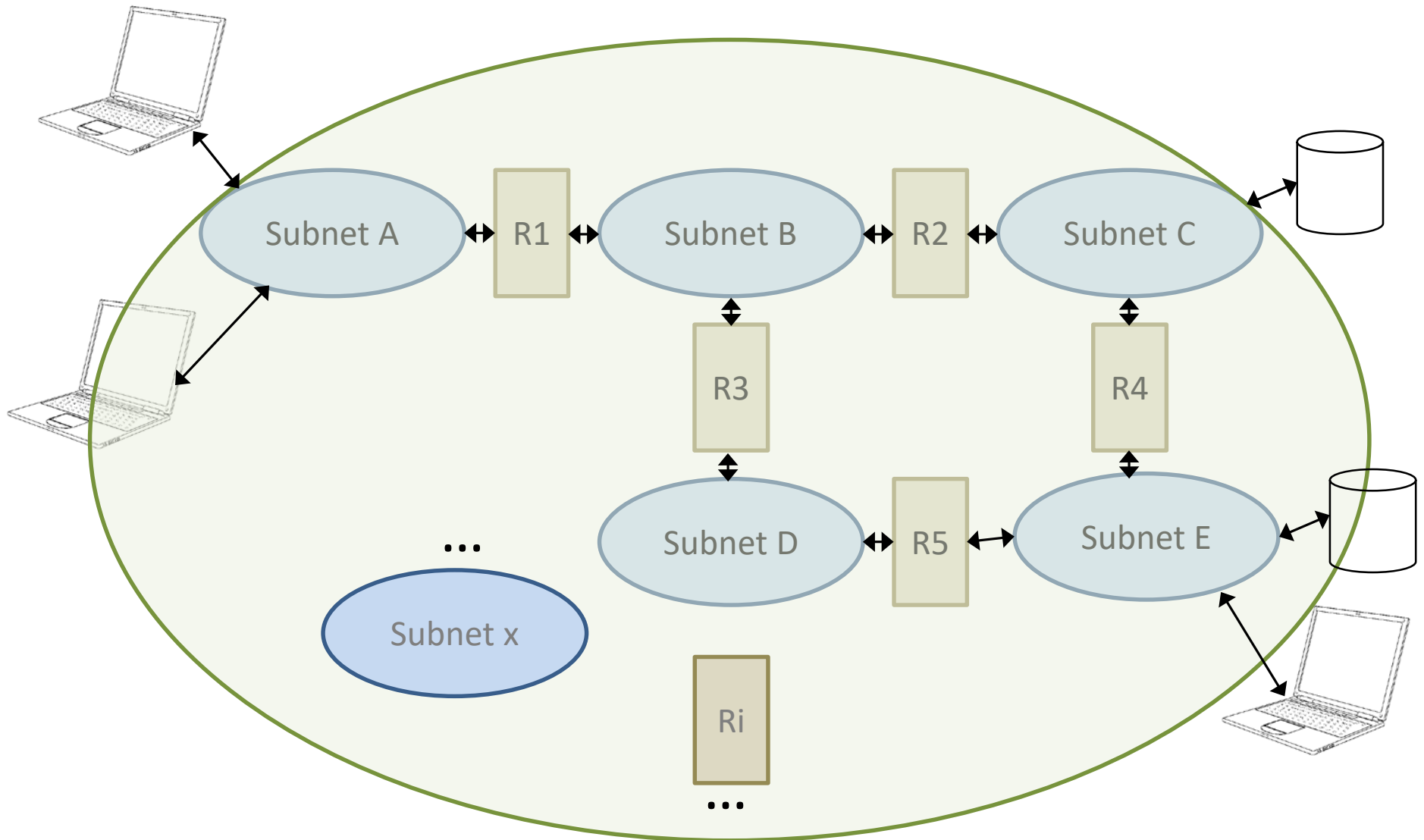
# Yet another view





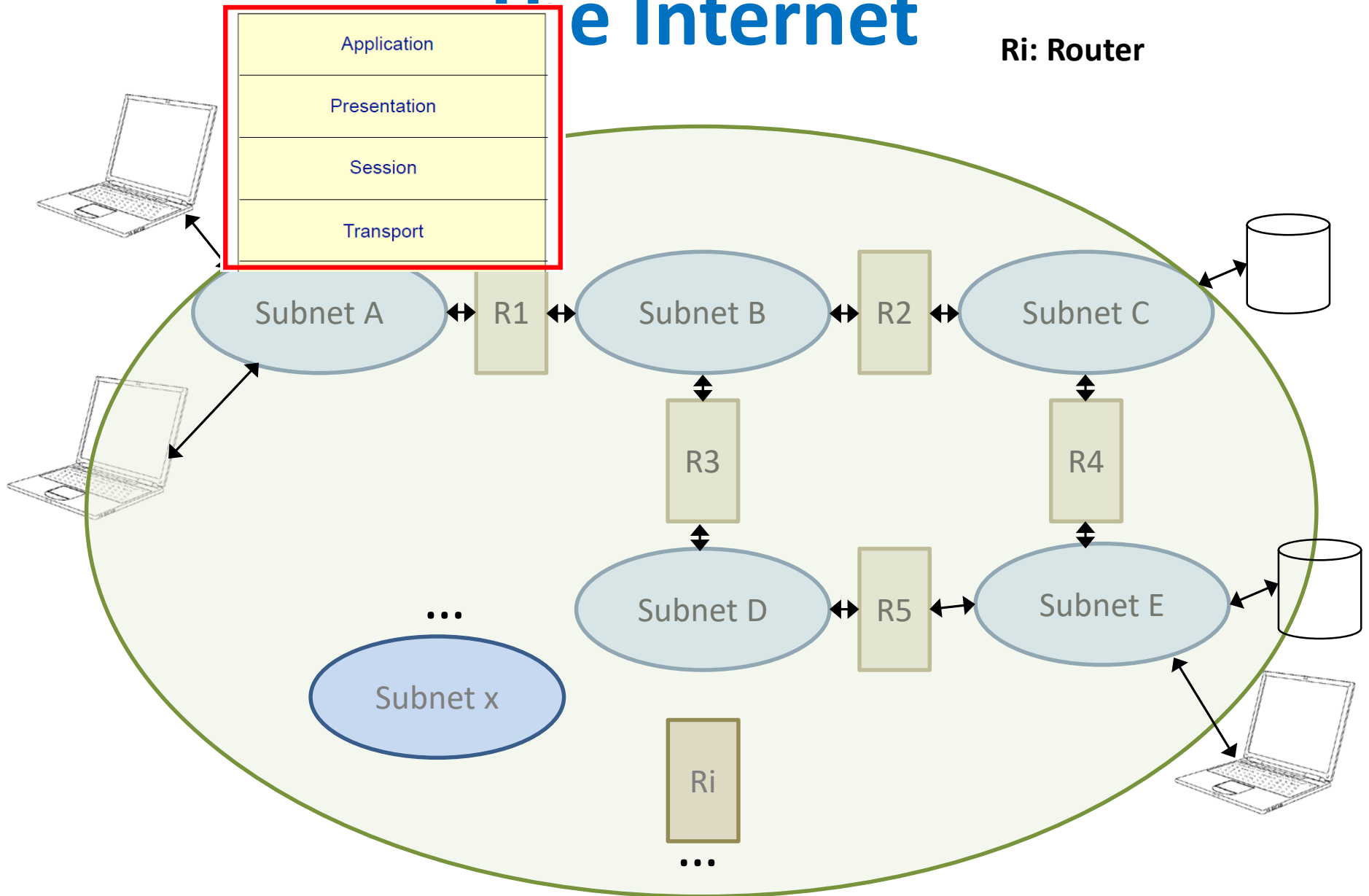
# The Internet

Ri: Router

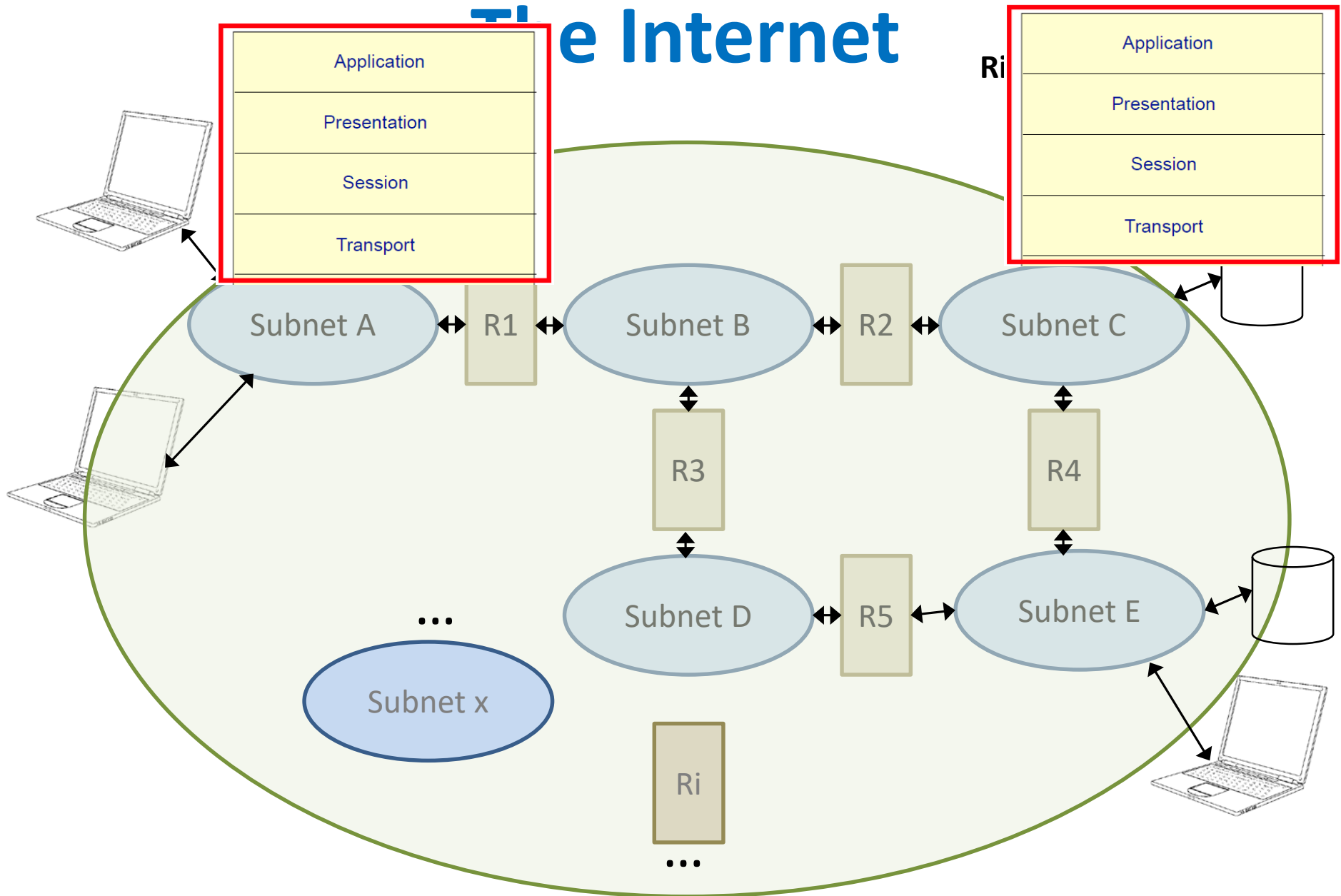


# The Internet

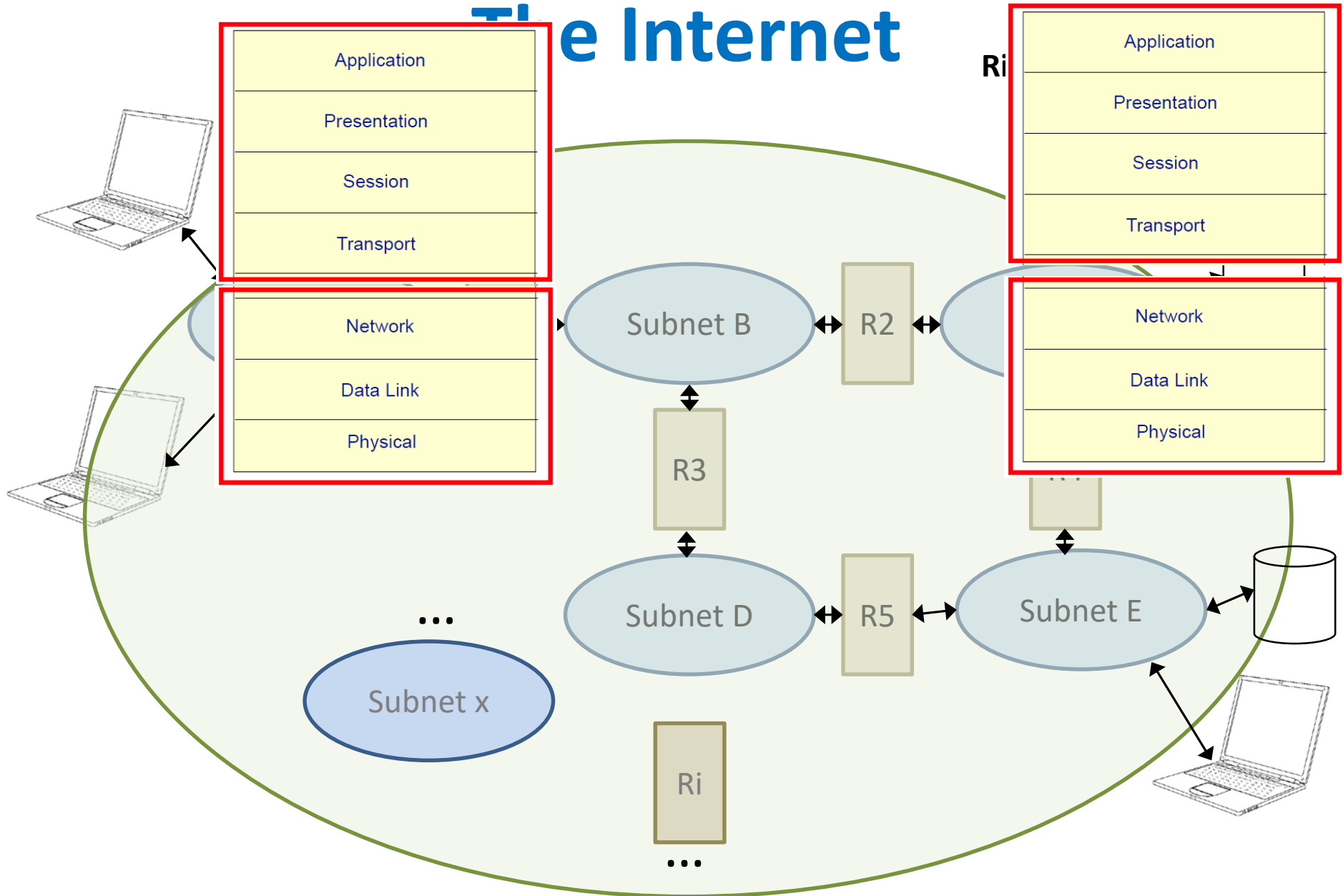
Ri: Router



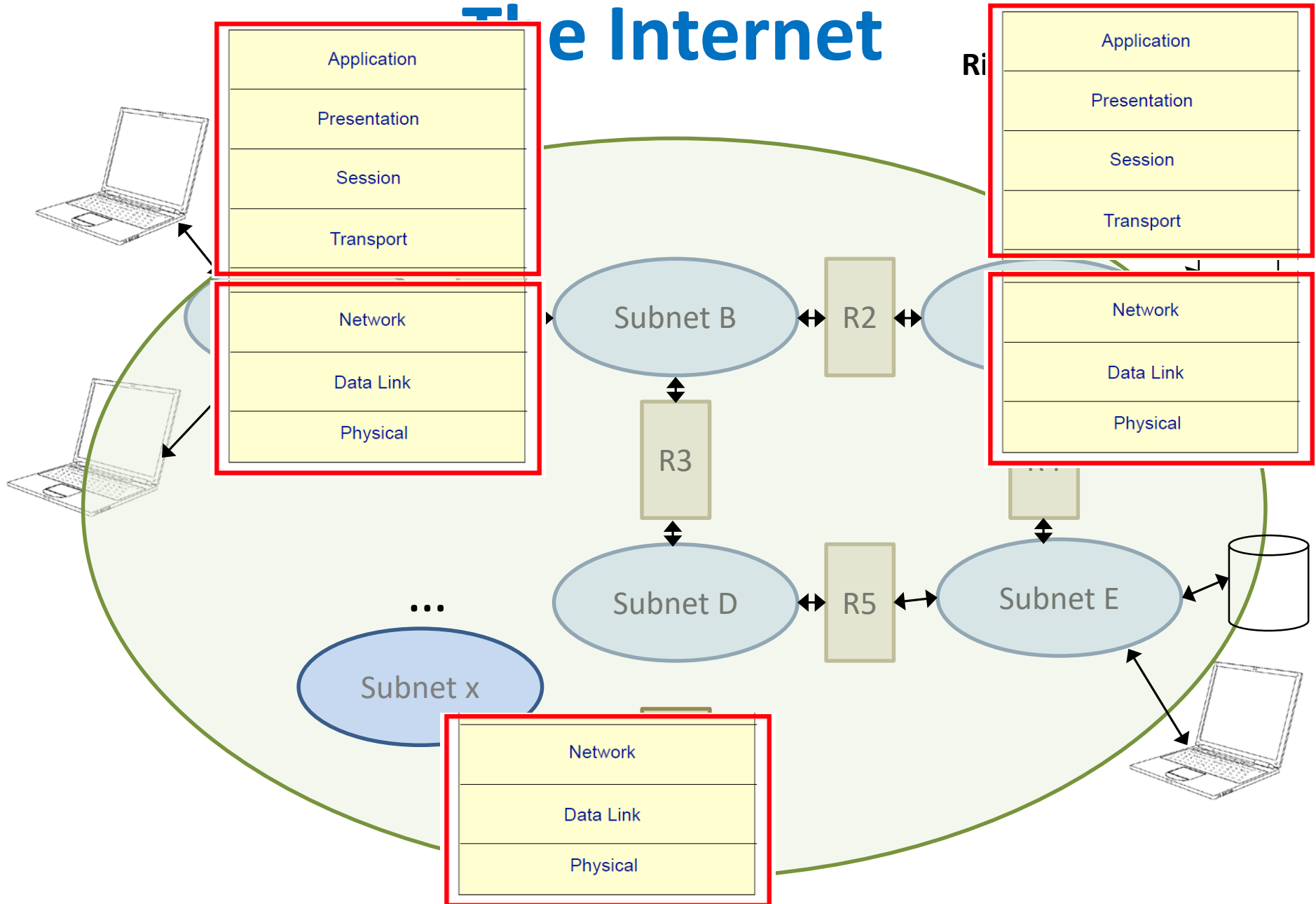
# The Internet



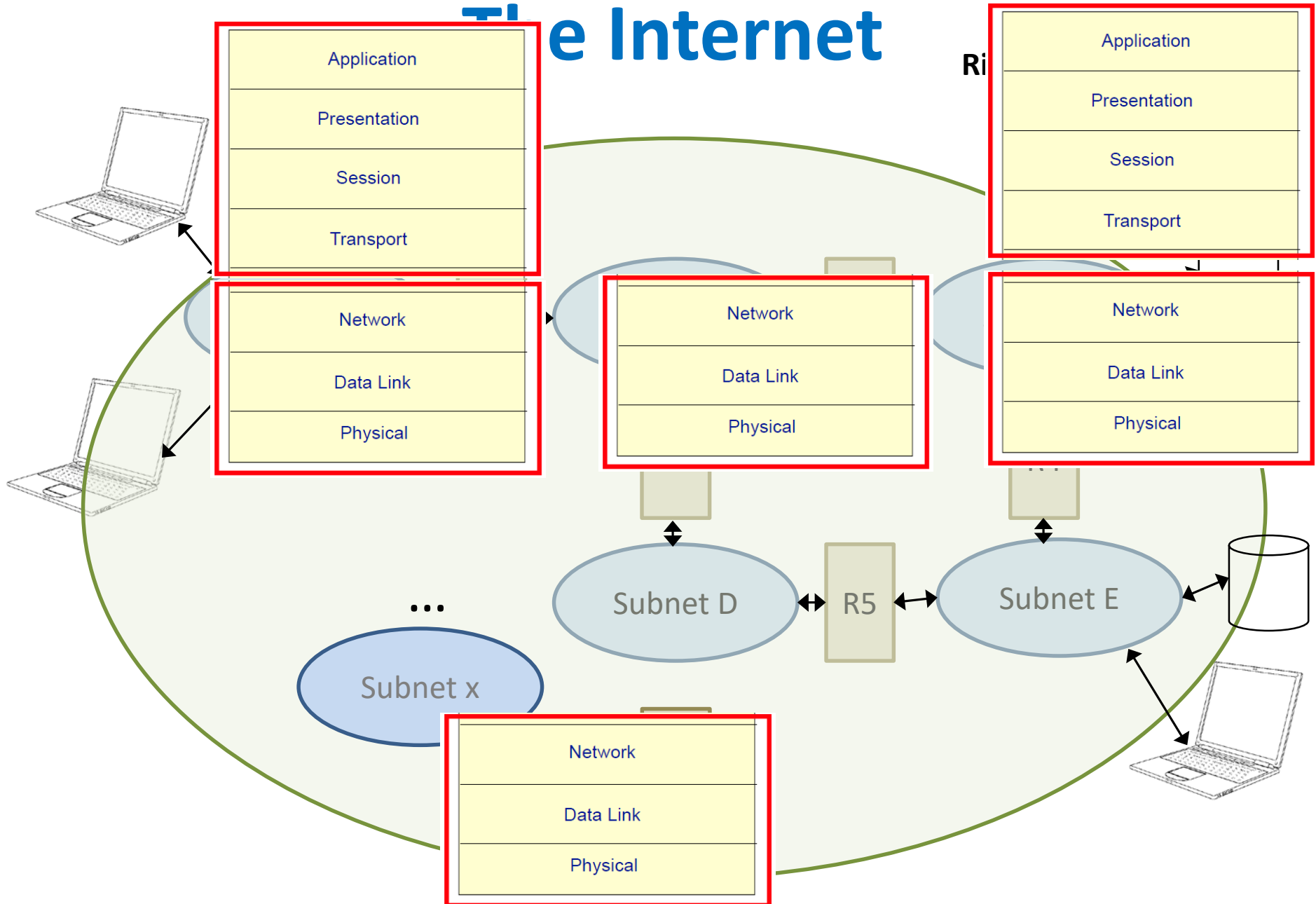
# The Internet



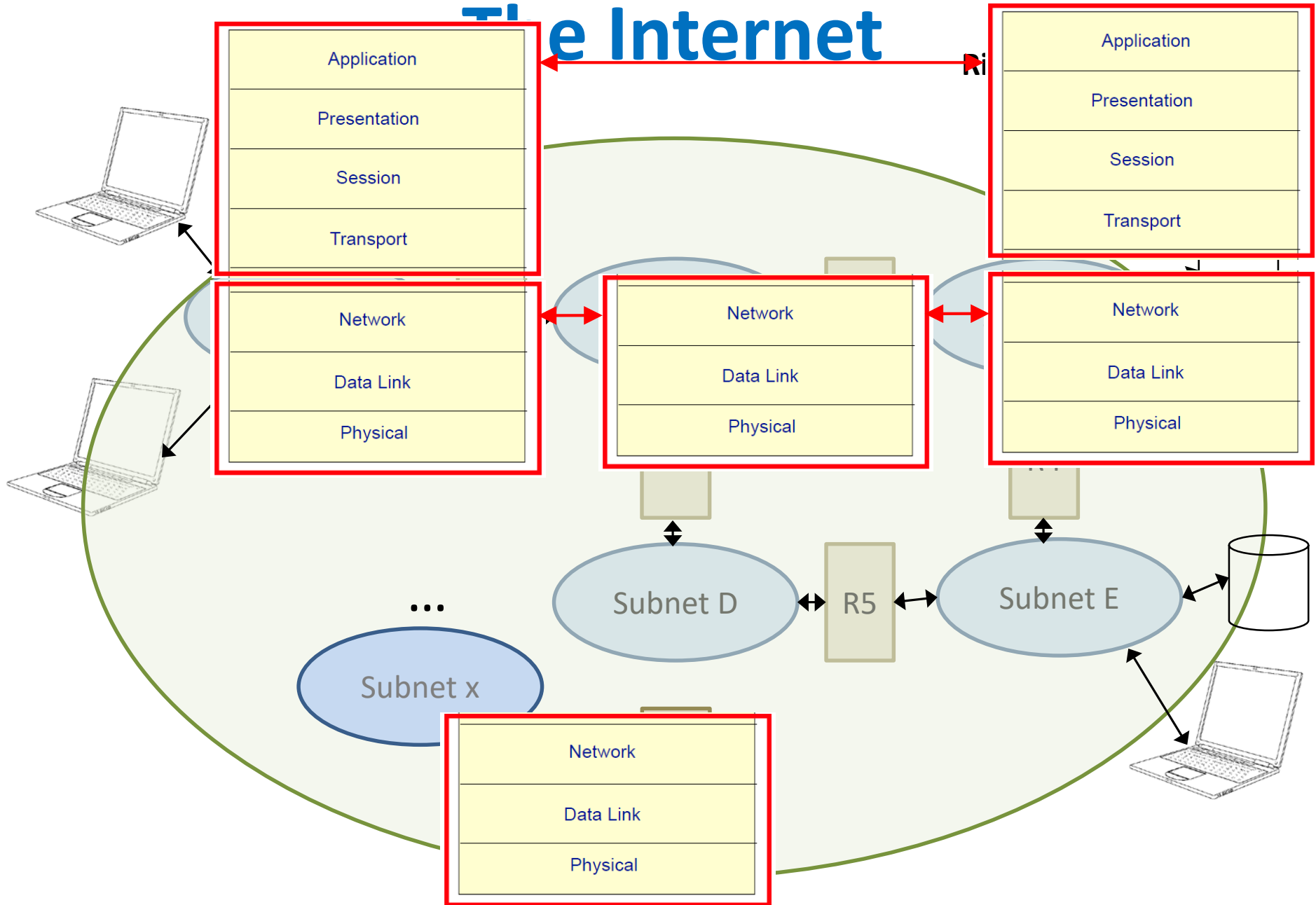
# The Internet



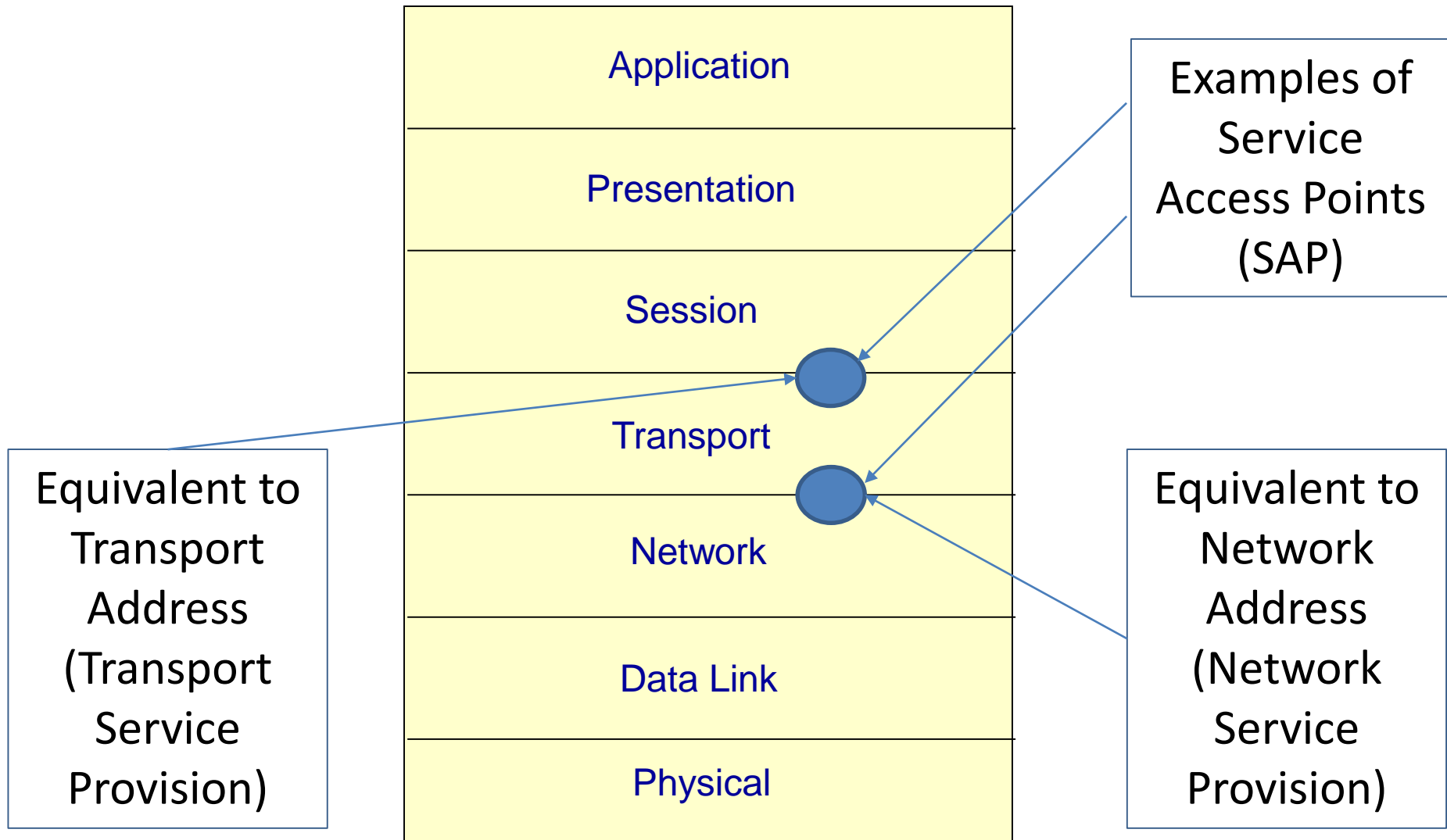
# The Internet



# The Internet

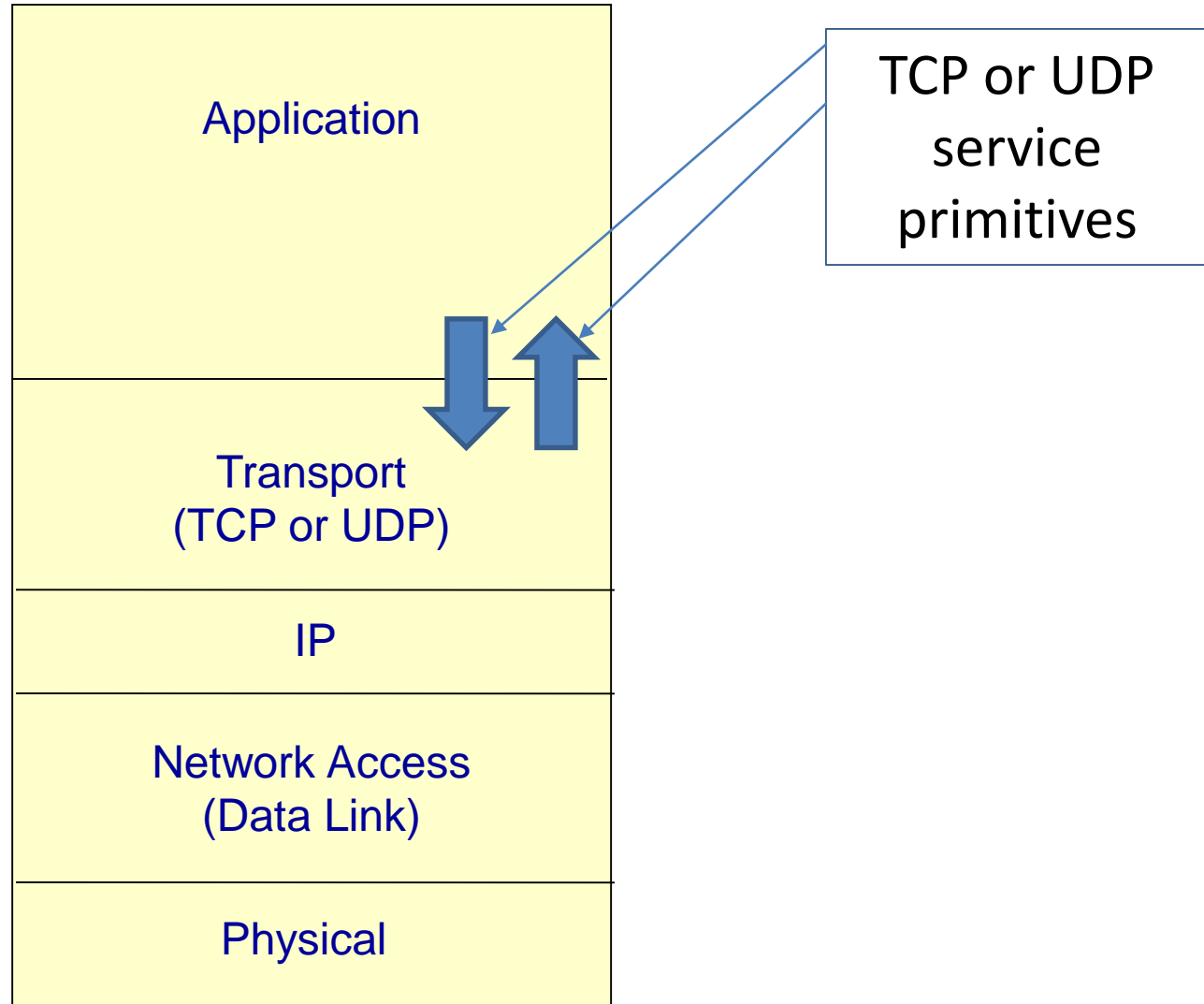


# OSI model: details

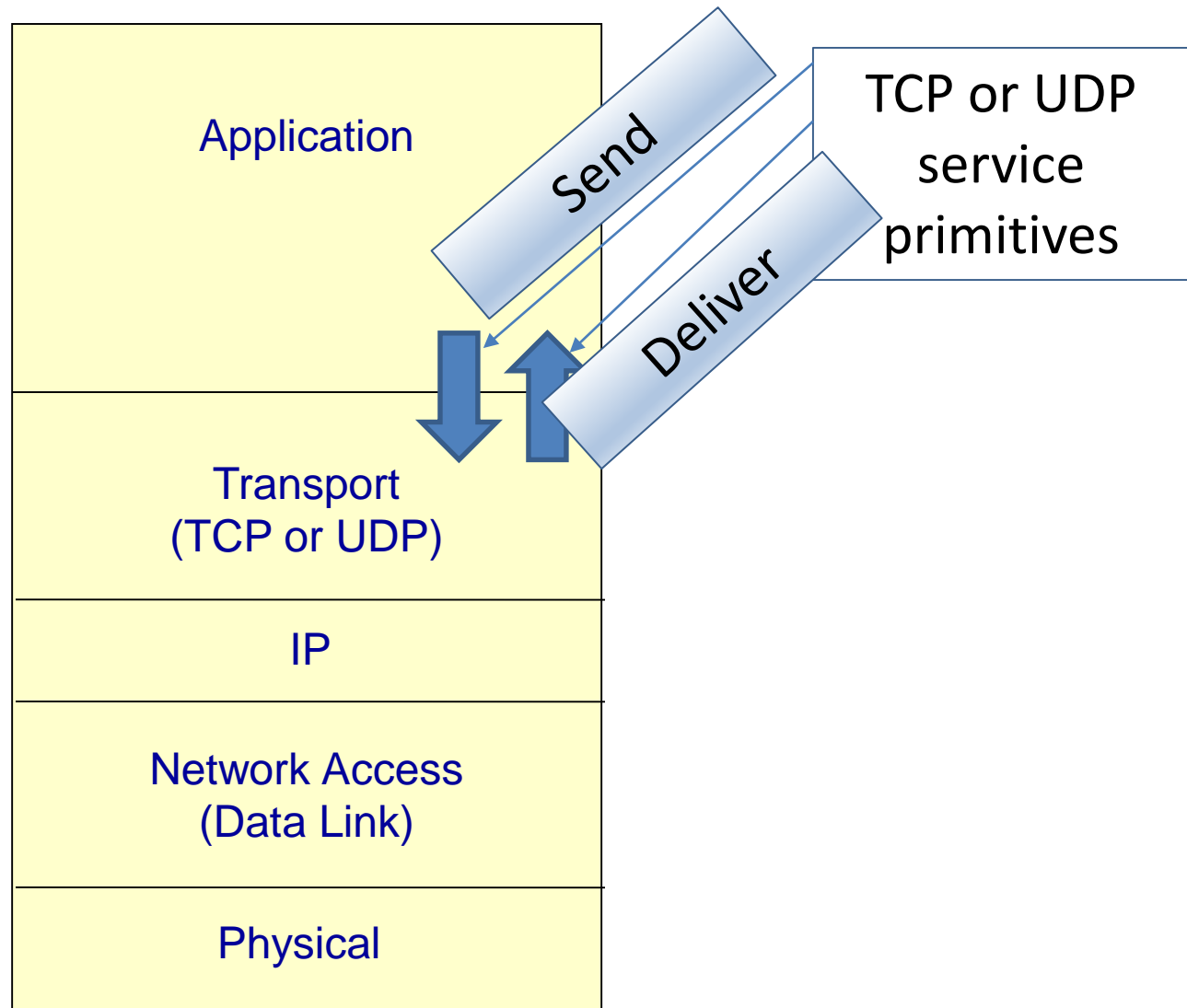




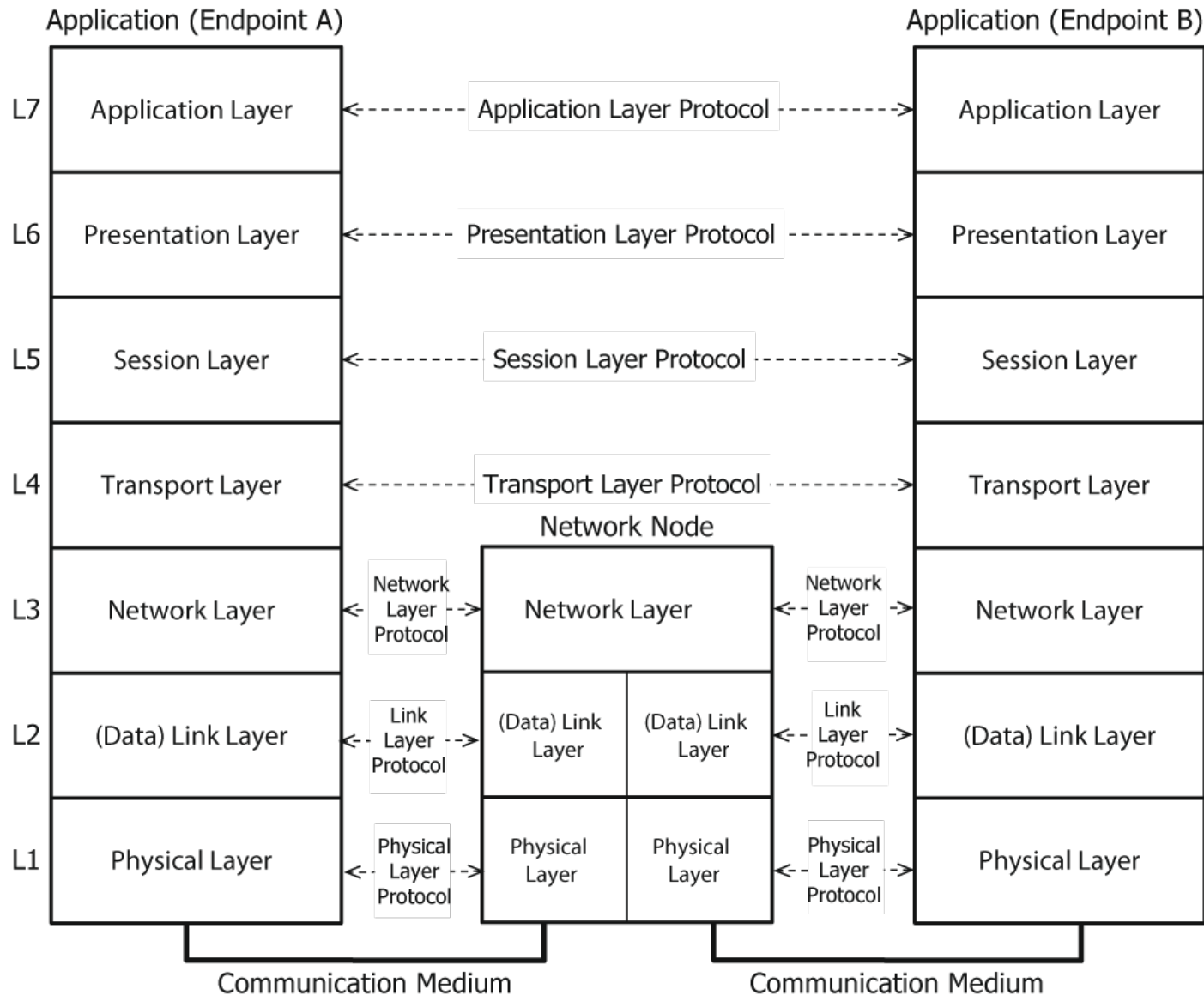
# Internet model: details



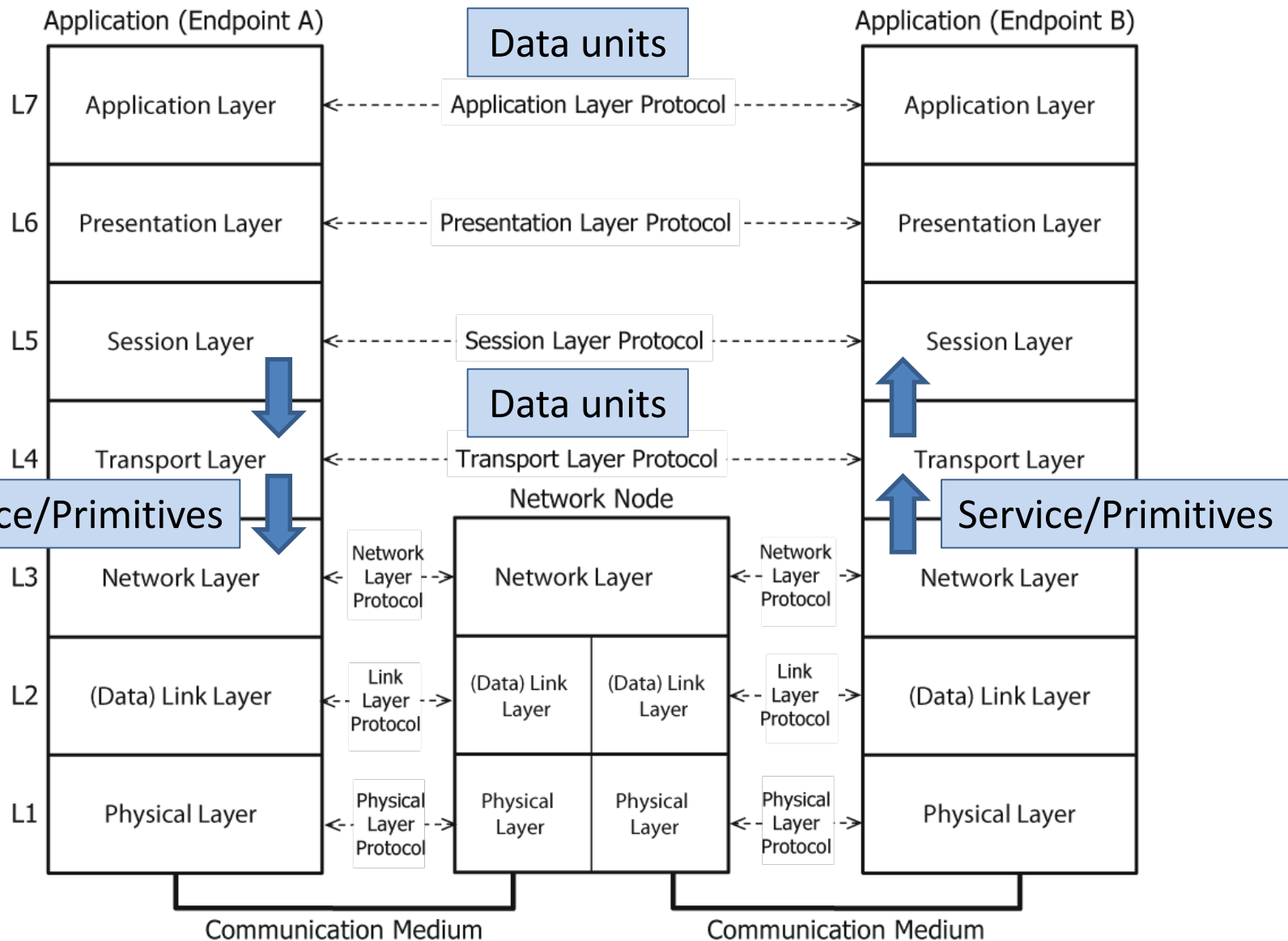
# Internet model: details



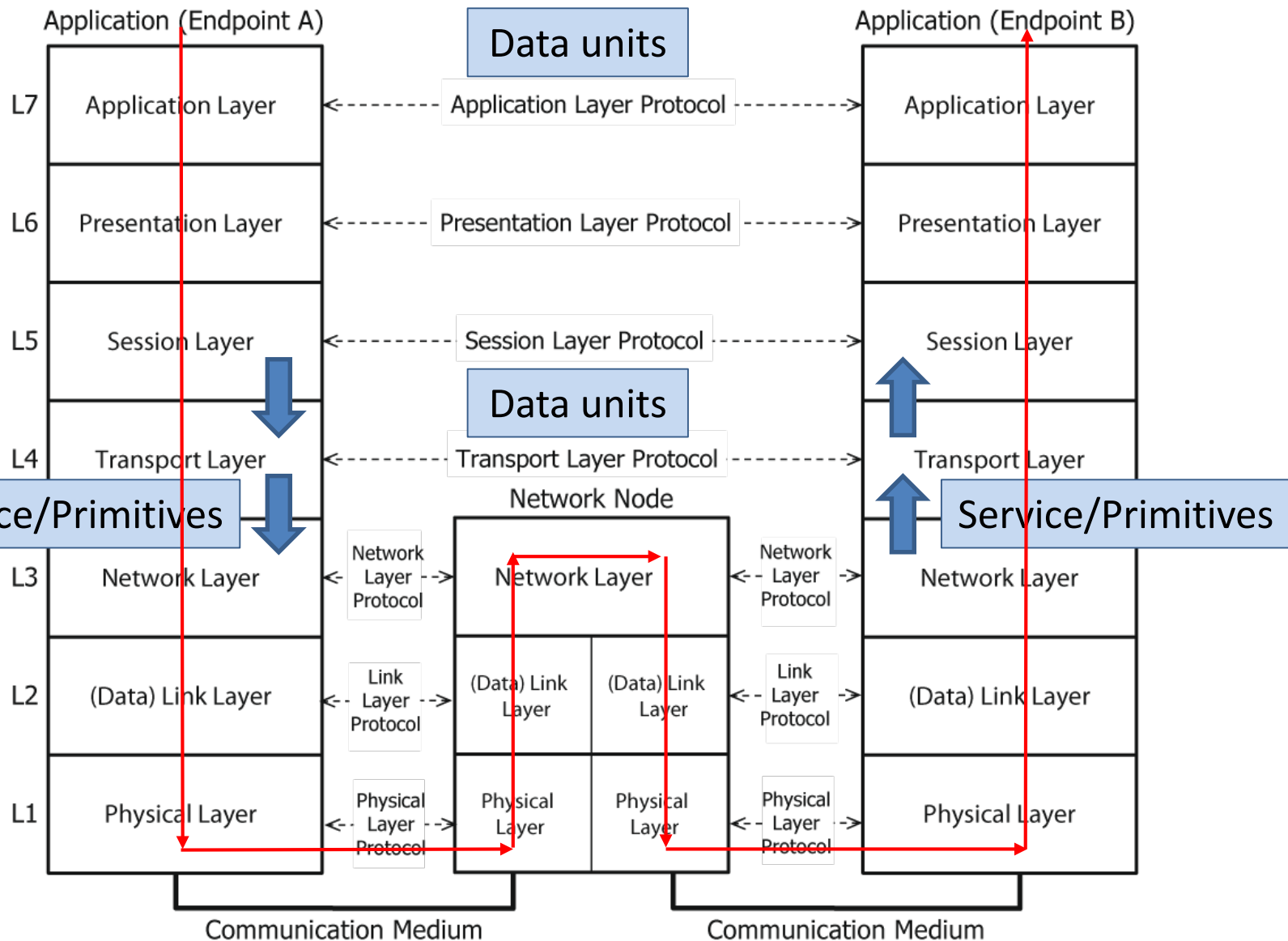
# Communication



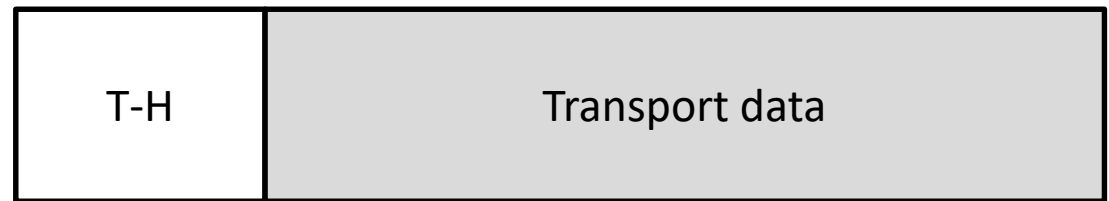
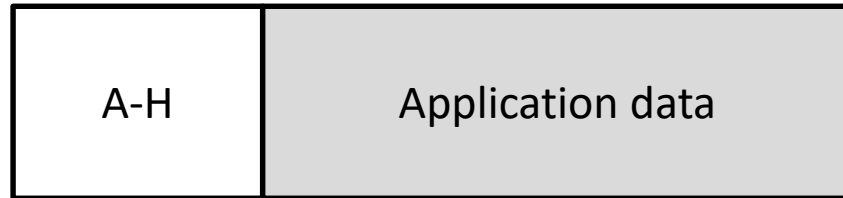
# Communication



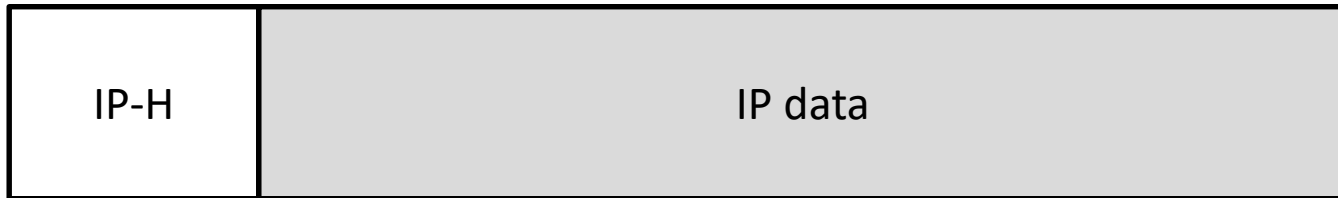
# Communication



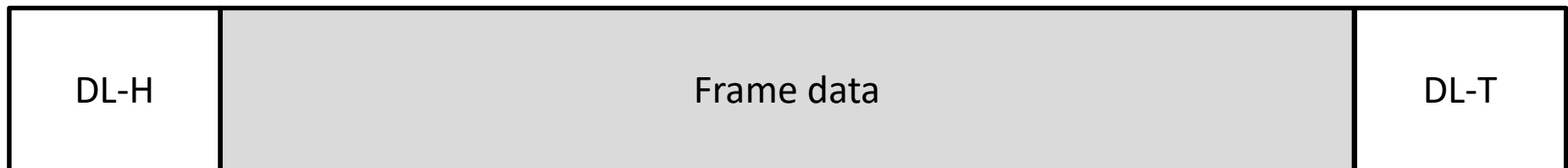
# Protocol data units



Transport segment

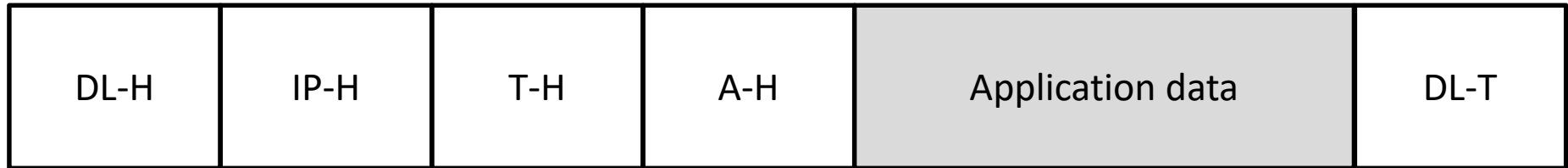


IP datagram



Data link frame

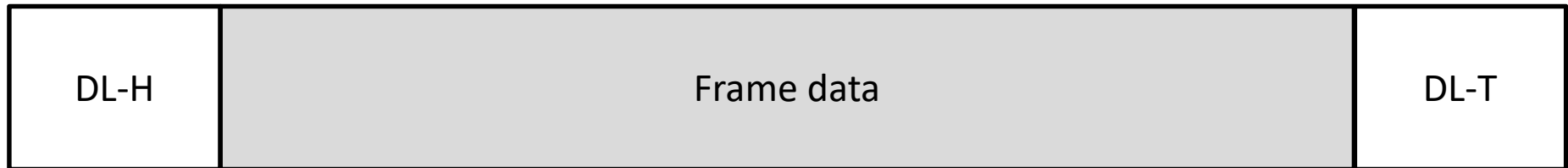
# Protocol data units



Transport segment



IP datagram



Data link frame

# More basic concepts

- Service (Operations, Primitives)
- Protocol (“Dialogue”, Interaction)
- Information (“Message”)
- Format (Data Units: header and “user” data)
- Specific data units:
  - Transport (TCP): Segment.
  - Transport (UDP): Datagram.
  - IP: Datagram.
  - Data link: Frame.
- **Protocol vs. Format**



# More basic concepts

## Internet model:

- Based on the IP (Internet Protocol)
- Data unit → Datagram
- IP is connection-less!
- TCP is connection-oriented!!
- Connection-less: No pre-defined path.
- Connection-oriented:
  - 3 phases (connection, data transfer, release)
- “Best effort” vs. Reliable.

# Standardization

- Common specifications for interoperability
- Open vs. Closed development
- Forum-like: industry, users, service providers, regulators, administration, ...
- “Formal” standardization organizations:
  - *(States-based)*  
ISO, IEC, ISO/IEC, ITU, ITU-T, CEN, ...
  - *(Organizations/Individuals-based)*  
IEEE, IETF, W3C, ...
- **SDO: Standards Development Organization**