FIT9137
Introduction to Computer Architecture and Networks

Week 9: Workshop on Network & Transport Layer

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Today: Week-8 Workshop

How long	What ?	Why ?
15 mins	Network Layer Routing & Resolution	Recap from pre-class activities and recorded videos
5 mins	Flux Q&A	Recap
45 mins	**Activity 1:** **(A.1)Static Routing** **(A.2)Examine Network Routing**	• Static Routing • Dynamic Routing • Examine Network Routing
5 mins	Take-home message	Conclusion
10 mins	Overview of Transport Layer and Flux Q&A	Recap on Transport Layer
30 mins	**Activity 2: Transport Layer**	▪ Apply your knowledge in Transport Layer ▪ Send and Receive Sequence numbers ▪ Segment size and segment numbers

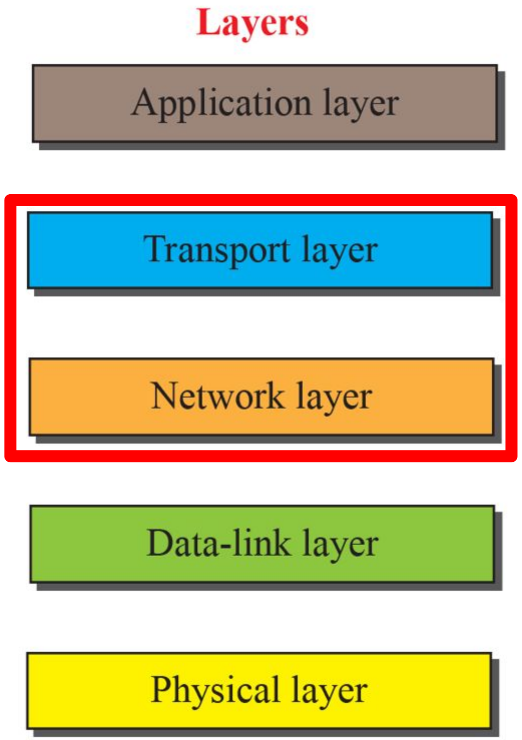
Network + Transport Layer

Network Layer:

- **addressing** and **routing** of packets
- connecting different networks

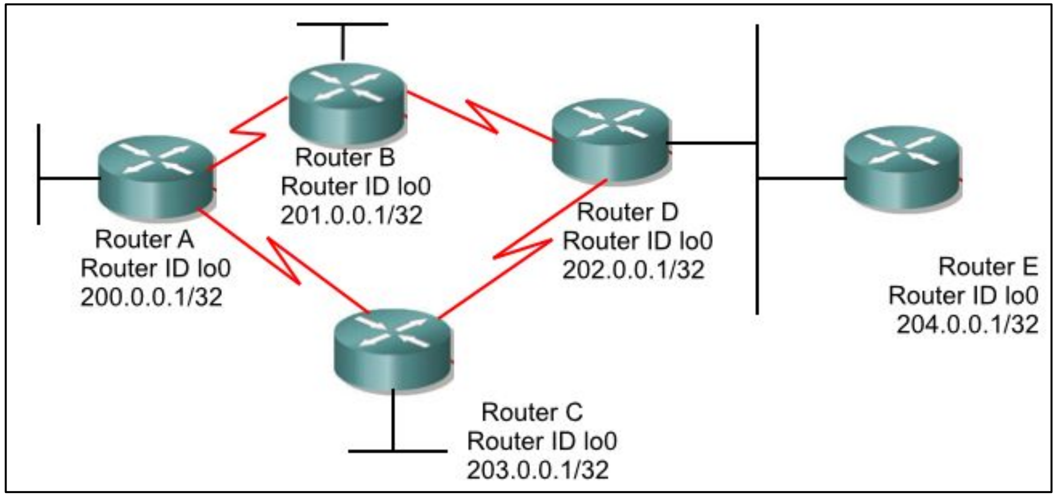
Transport Layer:

- establish **end-to-end channel**
- **reliable** communication (segmenting + ARQ)
- **addressing** of individual **applications**



The Network Layer:
Routing

Routers



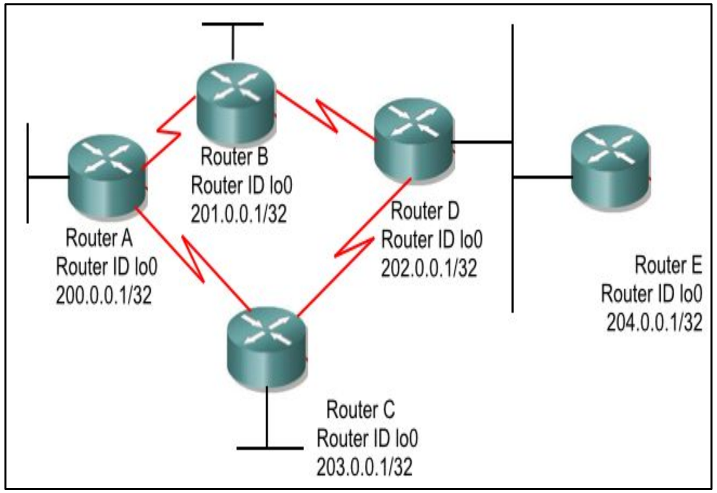
Routers connect networks

- Internet is a network of networks!
- Most important piece of Internet infrastructure

A router is a layer 3 device

- one IP address per **interface**, i.e. typically per subnet it is connected to
- Clients send packets to routers **if destination is outside their own subnet**
- Routers use IP address to determine over **where the packet is sent next**

Routing



For each incoming packet, the router

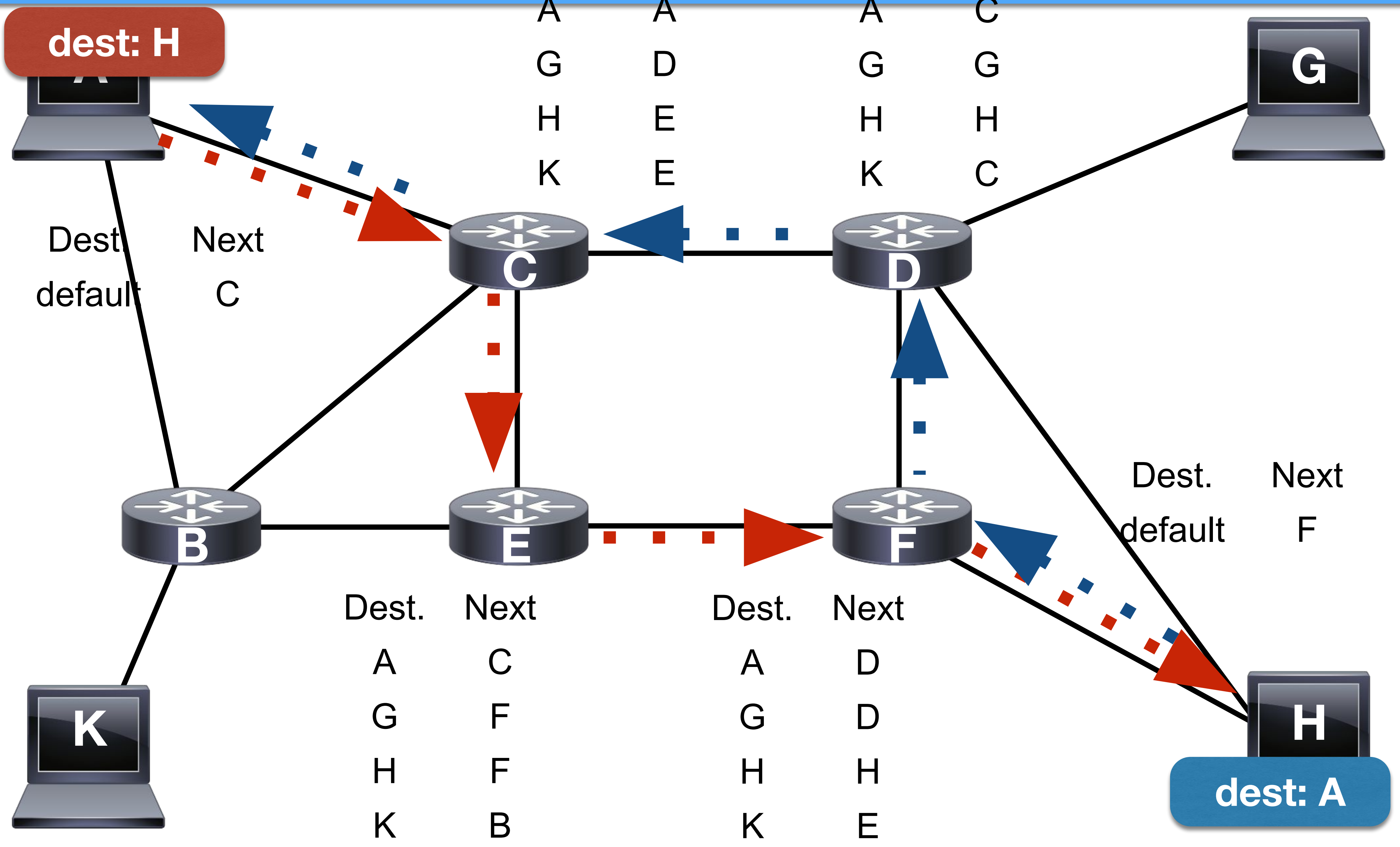
- looks at the packet's **destination IP address**

- consults the **routing table:** *to which other router should I send a packet for this destination, or can I deliver it directly?*

- if destination not in table: send to **default gateway**

- if no default gateway configured: **packet can't be routed and is dropped**

Routing example



Dest.	Next
A	A
G	D
H	E
K	E

Dest.	Next
A	C
G	G
H	H
K	C

Dest.	Next
default	C

Dest.	Next
default	F

Dest.	Next
A	C
G	F
H	F
K	B

Dest.	Next
A	D
G	D
H	H
K	E

Types of decentralised routing

Static routing : Activity A

- Network manager prepares **fixed routing tables**
- Manually updated when the network changes
- Used in simple networks that don't change a lot

Dynamic routing : Activity A

- Routers **exchange information** to build routing tables **dynamically**
- Initial tables can be set up by network managers

Dynamic routing algorithms

Distance vector

Exchange information about **distance to destination**, choose **shortest route**

- **EIGRP** (Enhanced Interior Gateway Routing Protocol)
- **RIP** (Routing Information Protocol)
- **BGP** (Border Gateway Protocol)

Link state

Exchange information about **quality of links**, choose **fastest route**

- **OSPF** (Open Shortest Path First)

FLUX Question: WIFI

Your WiFi/ADSL modem at home is often called a **WiFi Router**. What kind of routing does it perform?

1. **Static routing**, all packets are routed to my ISP.
2. **BGP** routing, it connects my AS at home to the internet.
3. **Link-state routing**, to compensate for sometimes poor quality of ADSL connections.
4. **No routing**, the name is just used for marketing reasons.

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FLUX Question: Routing

A _____________________ routing table contains information entered manually.

A. static

B. dynamic

C. hierarchical

D. none of these options

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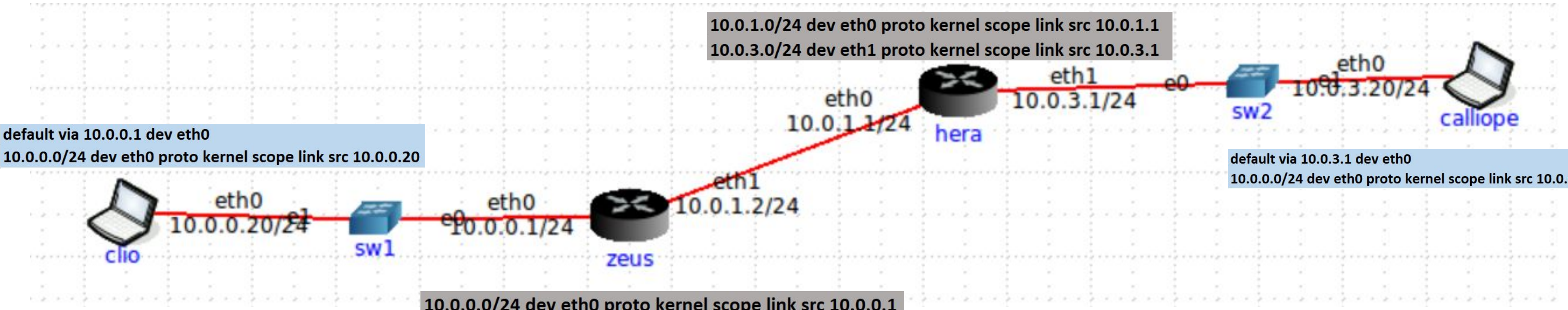
ACTIVITY A

Download the following file inside VM:

https://drive.google.com/file/d/1Xw9HPkPmfOoi19ARfSU2yASJP3_XCAxV/view

Activity 1: (A.1) - Static Routing



```
10.0.1.0/24 dev eth0 proto kernel scope link src 10.0.1.1
10.0.3.0/24 dev eth1 proto kernel scope link src 10.0.3.1
```

```
default via 10.0.0.1 dev eth0
10.0.0.0/24 dev eth0 proto kernel scope link src 10.0.0.20
```

```
default via 10.0.3.1 dev eth0
10.0.0.0/24 dev eth0 proto kernel scope link src 10.0.3.20
```

```
10.0.0.0/24 dev eth0 proto kernel scope link src 10.0.0.1
10.0.1.0/24 dev eth1 proto kernel scope link src 10.0.1.2
```

Activity 1: (A.2) - Examine Network Routing

Appendix

Codes: C connected, S static, R RIP

The network address 0.0.0.0/0 stands for the default gateway.

Canberra Router

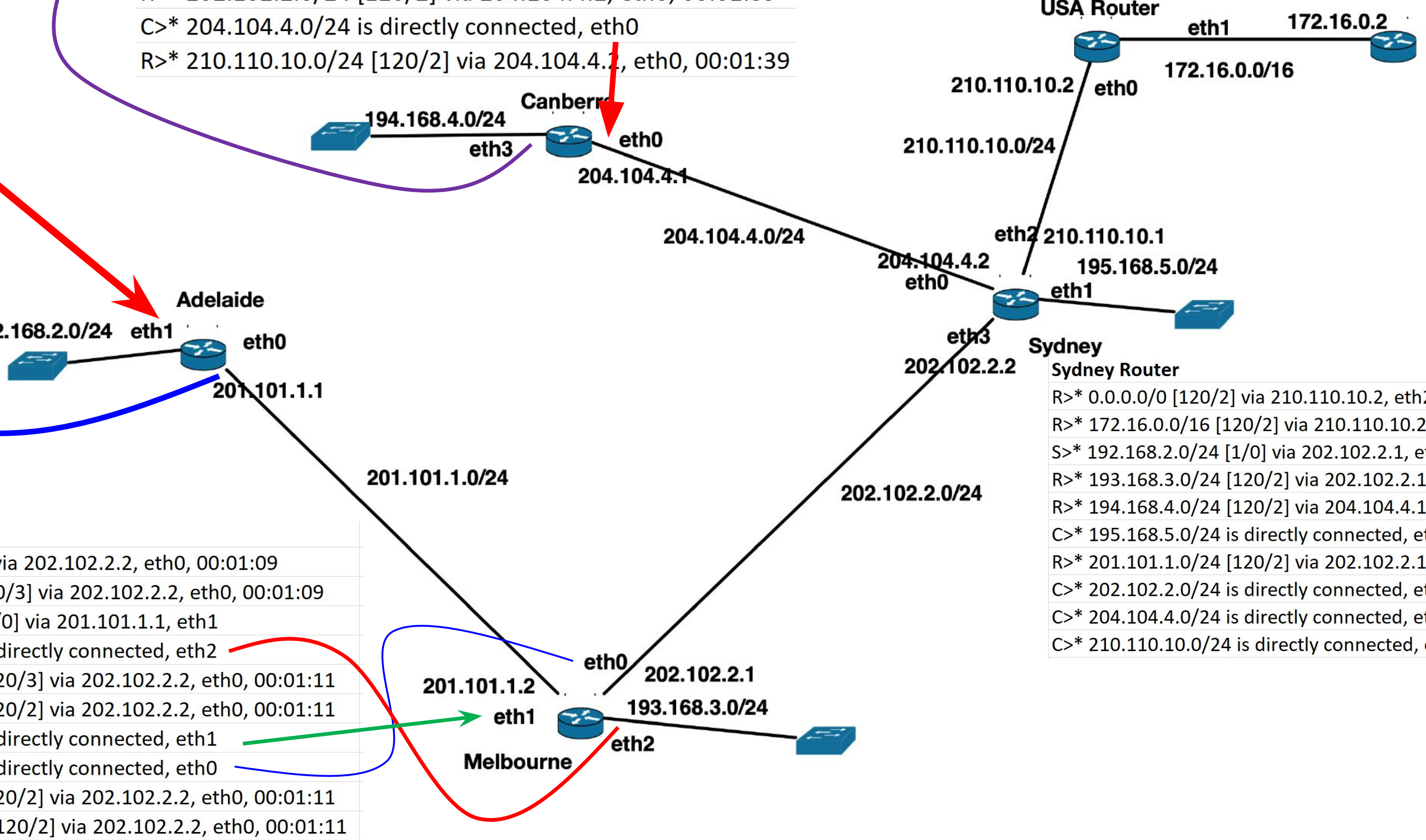
```
R>* 0.0.0.0/0 [120/3] via 204.104.4.2, eth0, 00:01:38
R>* 172.16.0.0/16 [120/3] via 204.104.4.2, eth0, 00:01:38
R>* 192.168.2.0/24 [120/2] via 204.104.4.2, eth0, 00:01:39
R>* 193.168.3.0/24 [120/3] via 204.104.4.2, eth0, 00:01:39
C>* 194.168.4.0/24 is directly connected, eth3
R>* 195.168.5.0/24 [120/2] via 204.104.4.2, eth0, 00:01:39
R>* 201.101.1.0/24 [120/3] via 204.104.4.2, eth0, 00:01:39
R>* 202.102.2.0/24 [120/2] via 204.104.4.2, eth0, 00:01:39
C>* 204.104.4.0/24 is directly connected, eth0
R>* 210.110.10.0/24 [120/2] via 204.104.4.2, eth0, 00:01:39
```

USA Router

```
S>* 0.0.0.0/0 [1/0] via 172.16.0.2, eth1
C>* 172.16.0.0/16 is directly connected, eth1
R>* 192.168.2.0/24 [120/2] via 210.110.10.1, eth0, 00:00:15
R>* 193.168.3.0/24 [120/3] via 210.110.10.1, eth0, 00:00:14
R>* 194.168.4.0/24 [120/3] via 210.110.10.1, eth0, 00:00:15
R>* 195.168.5.0/24 [120/2] via 210.110.10.1, eth0, 00:00:15
R>* 201.101.1.0/24 [120/3] via 210.110.10.1, eth0, 00:00:14
R>* 202.102.2.0/24 [120/2] via 210.110.10.1, eth0, 00:00:15
R>* 204.104.4.0/24 [120/2] via 210.110.10.1, eth0, 00:00:15
C>* 210.110.10.0/24 is directly connected, eth0
```

Adelaide Router

```
S>* 0.0.0.0/0 [1/0] via 201.101.1.2, eth0
C>* 192.168.2.0/24 is directly connected, eth1
S>* 193.168.3.0/24 [1/0] via 201.101.1.2, eth0
S>* 194.168.4.0/24 [1/0] via 201.101.1.2, eth0
S>* 195.168.5.0/24 [1/0] via 201.101.1.2, eth0
C>* 201.101.1.0/24 is directly connected, eth0
```



Sydney Router

```
R>* 0.0.0.0/0 [120/2] via 210.110.10.2, eth2, 00:02:02
R>* 172.16.0.0/16 [120/2] via 210.110.10.2, eth2, 00:02:02
S>* 192.168.2.0/24 [1/0] via 202.102.2.1, eth3
R>* 193.168.3.0/24 [120/2] via 202.102.2.1, eth3, 00:02:02
R>* 194.168.4.0/24 [120/2] via 204.104.4.1, eth0, 00:02:03
C>* 195.168.5.0/24 is directly connected, eth1
R>* 201.101.1.0/24 [120/2] via 202.102.2.1, eth3, 00:02:02
C>* 202.102.2.0/24 is directly connected, eth3
C>* 204.104.4.0/24 is directly connected, eth0
C>* 210.110.10.0/24 is directly connected, eth2
```

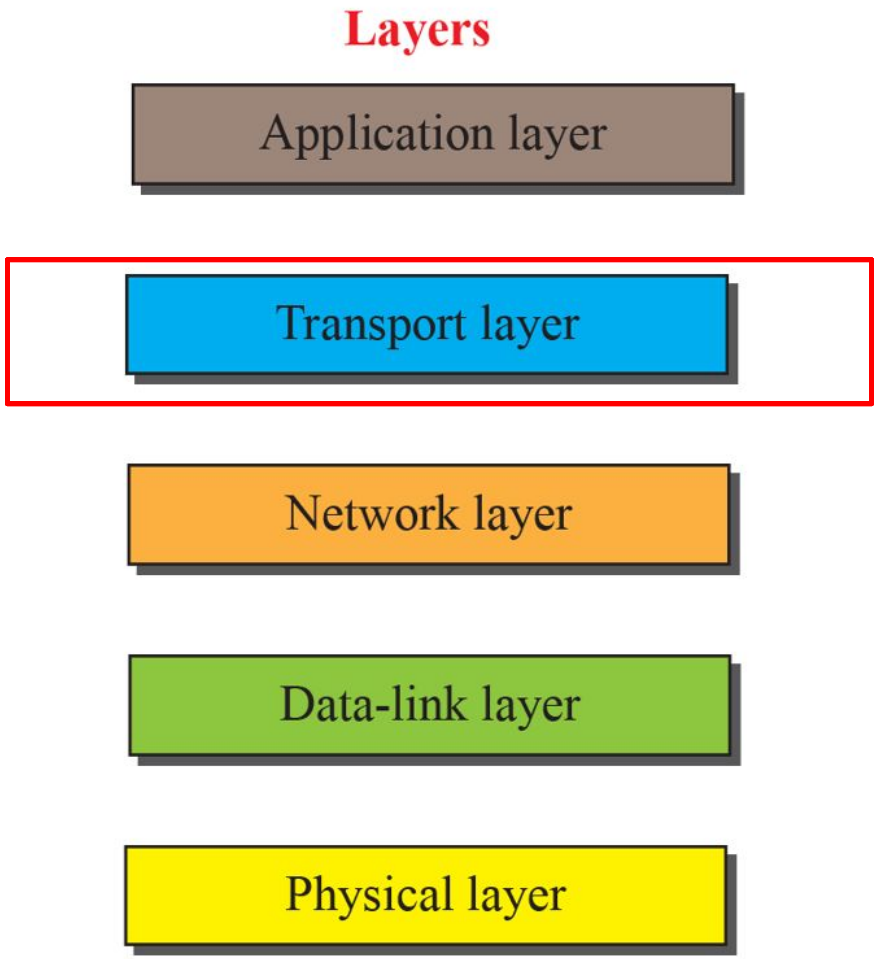
Melbourne Router

```
R>* 0.0.0.0/0 [120/3] via 202.102.2.2, eth0, 00:01:09
R>* 172.16.0.0/16 [120/3] via 202.102.2.2, eth0, 00:01:09
S>* 192.168.2.0/24 [1/0] via 201.101.1.1, eth1
C>* 193.168.3.0/24 is directly connected, eth2
R>* 194.168.4.0/24 [120/3] via 202.102.2.2, eth0, 00:01:11
R>* 195.168.5.0/24 [120/2] via 202.102.2.2, eth0, 00:01:11
C>* 201.101.1.0/24 is directly connected, eth1
C>* 202.102.2.0/24 is directly connected, eth0
R>* 204.104.4.0/24 [120/2] via 202.102.2.2, eth0, 00:01:11
R>* 210.110.10.0/24 [120/2] via 202.102.2.2, eth0, 00:01:11
```

The Transport Layer:

TCP / UDP

TCP: A reliable end-to-end channel



Transmission Control Protocol (TCP)

Connection-oriented

- A **virtual circuit** is established between two devices
- To the application it always looks like a **point-to-point full duplex** connection
- Messages split into **segments** for transmission

Reliable

- Errors are **detected** and **corrected**
- Segments are re-assembled in the correct **correct order**

Used by e.g., HTTP, SMTP, IMAP, SSH…..

TCP

TCP implements segmentation

- large application layer messages are split into segments

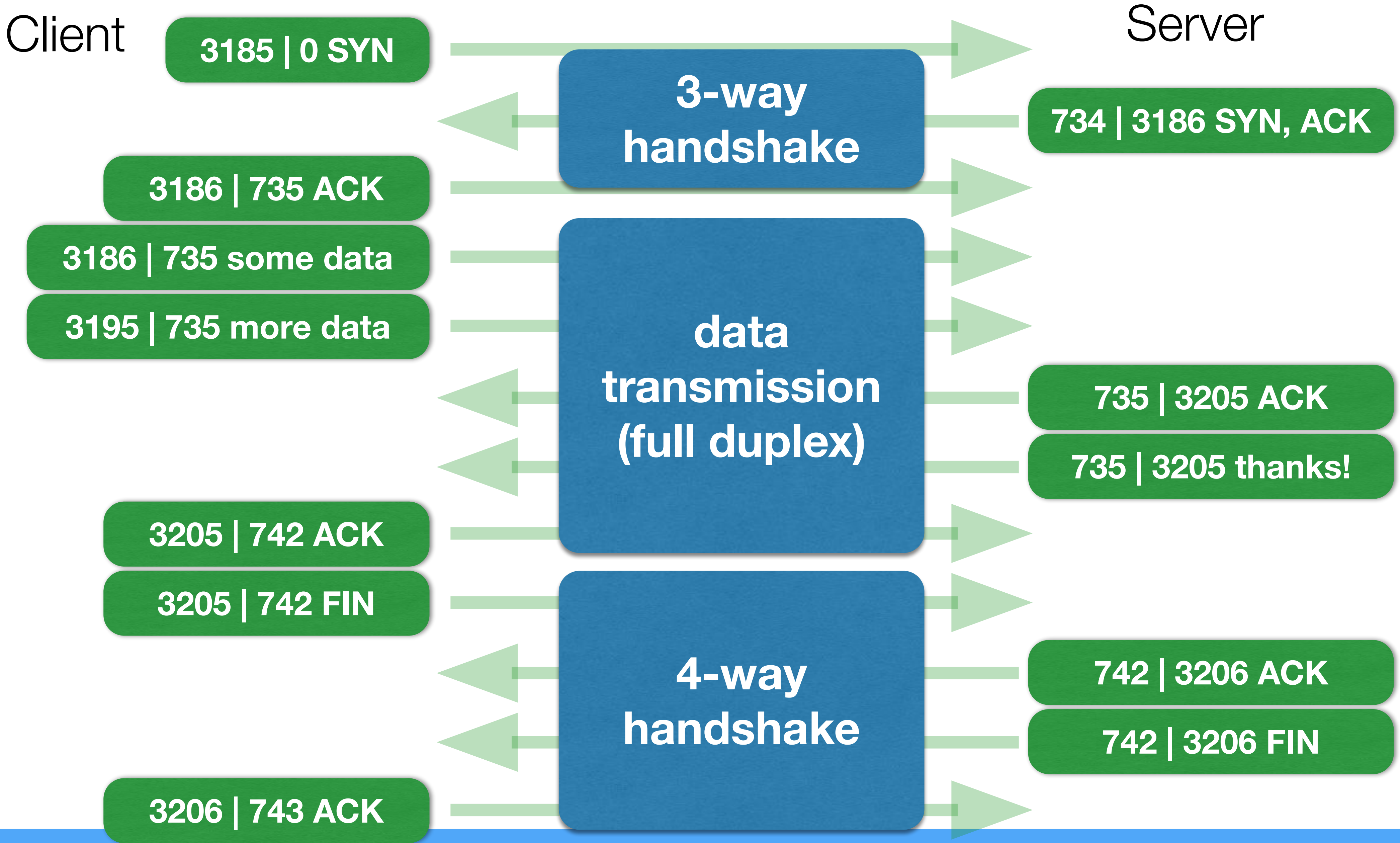
How fast to send segments?

- Sending too many at once may overload receiver or intermediate path with lower bandwidth

How to decide the segment size?

- Sending too large segments requires IP to **fragment**
- Large segments also increase errors

TCP session Management



FLUX Question:

Which of the following are **NOT** the characteristics of UDP?

A. UDP is connection oriented.

B. UDP is unreliable.

C. UDP is at the transport layer.

D. UDP uses no acknowledgements.

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ACTIVITY B

Next week: Application Layer

- Architectures: client-server, multi-tier, peer-to-peer
- World Wide Web: HTTP and HTML
- Email: SMTP, POP, IMAP