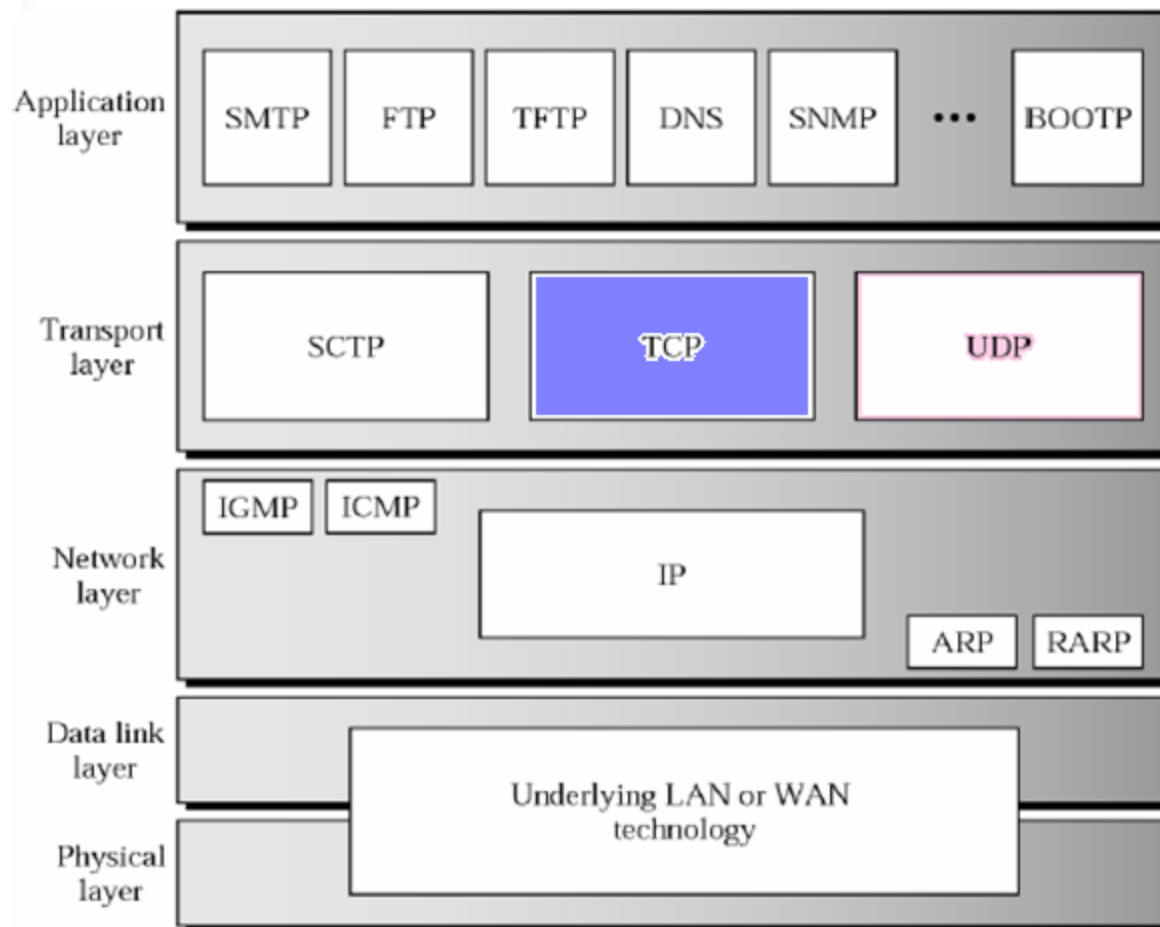


# Introduction to Computer Networks

Lecture 5: Transport Layer

Dr. Amal Elnahas

# Transport Control Protocol (TCP)

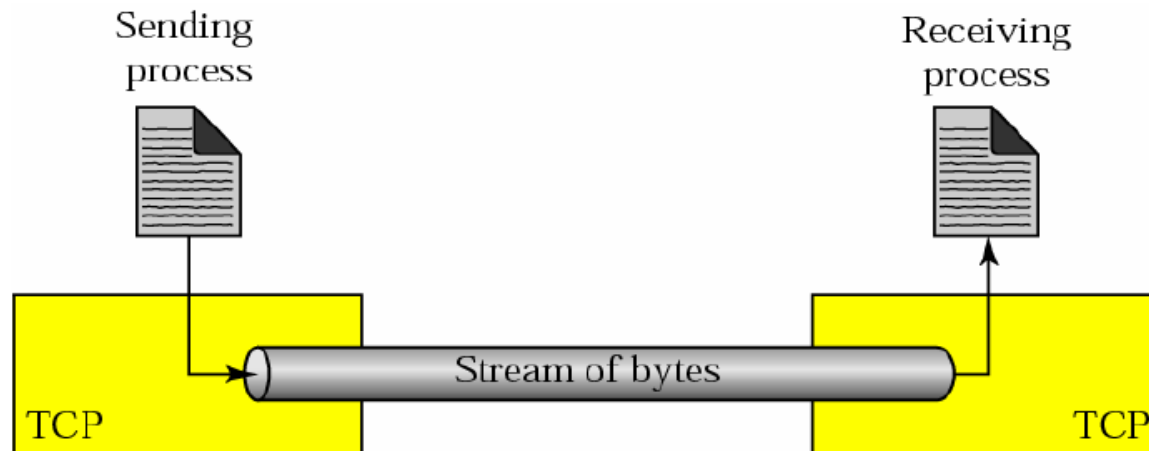


# TCP: Transport Control Protocol

- **Main Functions:**
  - Reliable and In-order delivery
    - Packets are all delivered and in the same order they were sent
  - Flow Control
    - Sending rate not to exceed receiving processing rate
  - Congestion Control
    - Sending rate not to exceed the slowest link on the path to destination

# TCP Properties

- Connection-based transmission:
  - Before transmission, TCP establishes a connection between source and destination
- Stream orientation:
  - TCP is a **byte** stream not message stream. Every byte has its own sequence number
- Full duplex connection
  - Concurrent transfer in both directions



## Important Note

- Each byte of data transferred is numbered by TCP. Numbering starts with a randomly generated number. This starting number is sent to the other party.
- How to select the starting number and inform the other party?

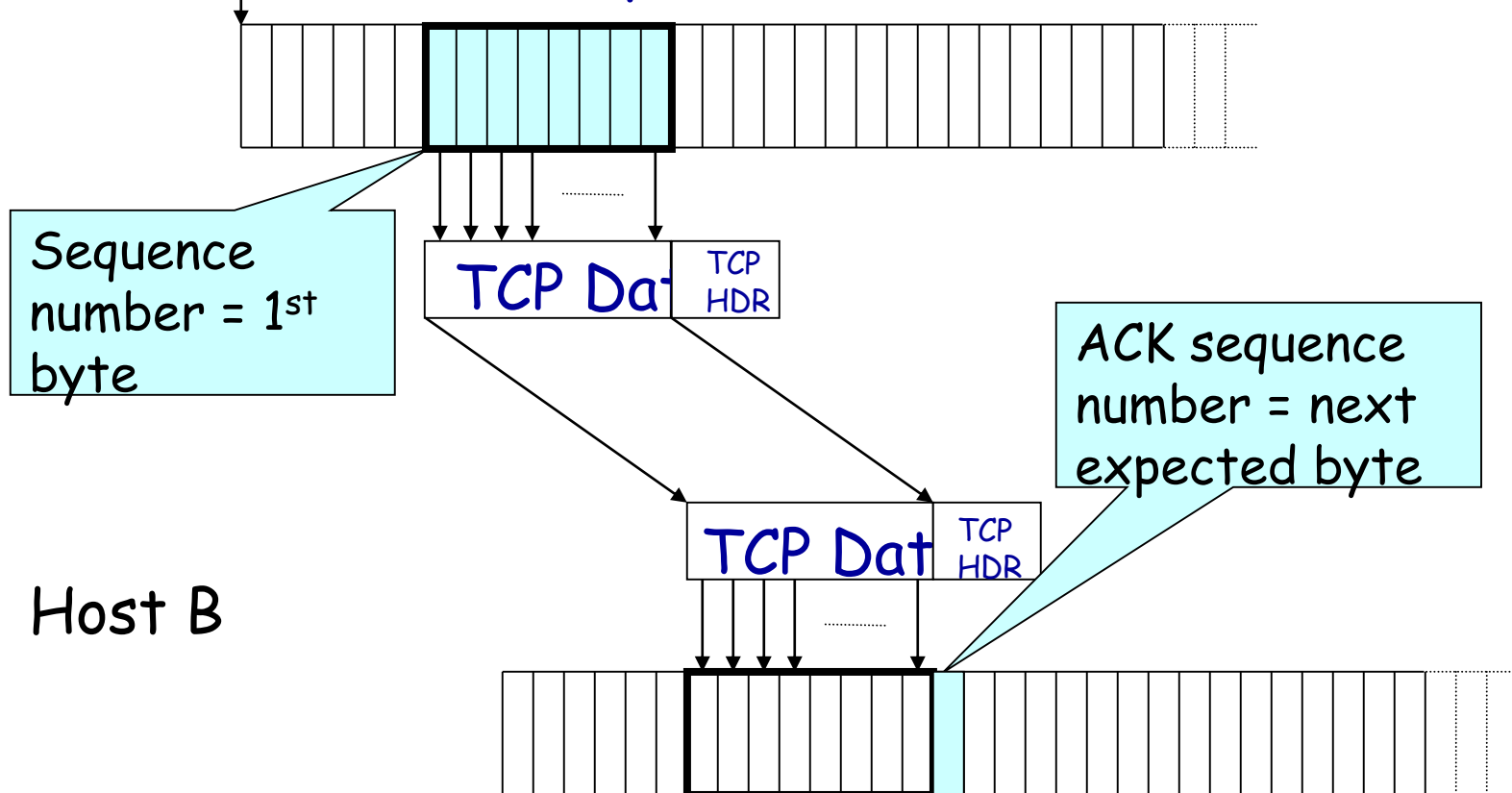


**3-way handshaking**

# Sequence Numbers

Host A

ISN (initial sequence number)



# TCP Header

Flags: SYN  
FIN  
RST  
PSH  
URG  
ACK

Source port		Destination port	
Sequence number			
Acknowledgment			
HdrLe	0	Flags	Advertised window
Checksum		Urgent pointer	
Options (variable)			
Data			

# Step 1: A's Initial SYN Packet

Flags: **SYN**

FIN

RST

PSH

URG

ACK

A's port		B's port	
A's Initial Sequence Number			
Acknowledgment			
20	0	Flags	Advertised window
Checksum		Urgent pointer	
Options (variable)			

A tells B it wants to open a connection...



## Step 2: B's SYN-ACK Packet

Flags: **SYN**  
FIN  
RST  
PSH  
URG  
**ACK**

B's port		A's port	
B's Initial Sequence Number			
A's ISN plus 1			
20	0	Flags	Advertised window
Checksum		Urgent pointer	
Options (variable)			

B tells A it accepts, and is ready to hear the next byte...

... upon receiving this packet, A can start sending data

## Step 3: A's ACK of the SYN-ACK

Flags: SYN  
FIN  
RST  
PSH  
URG  
**ACK**

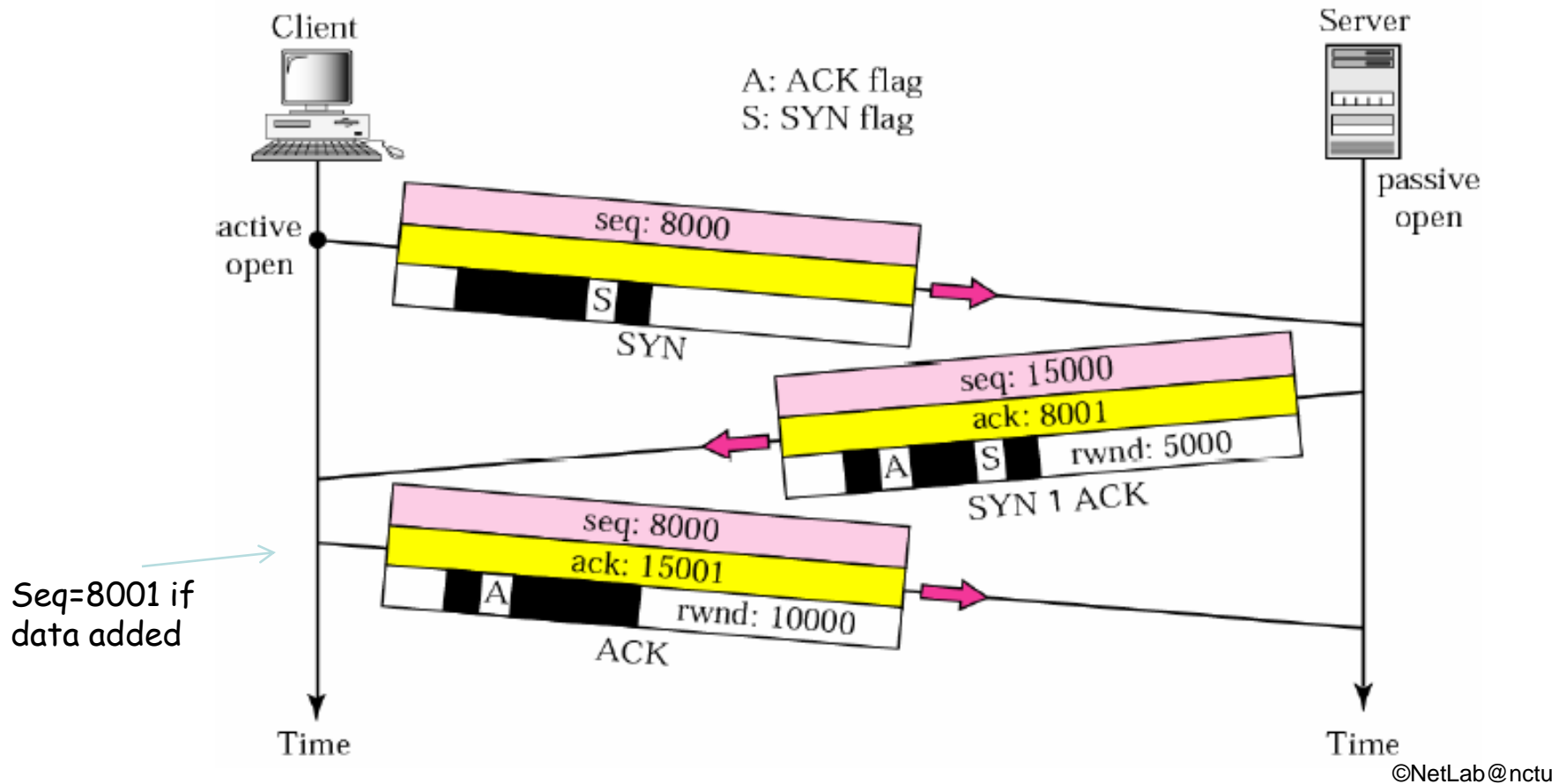
A's port		B's port	
Sequence number			
B's ISN plus 1			
20	0	Flags	Advertised window
Checksum		Urgent pointer	
Options (variable)			

A tells B it wants is okay to start sending

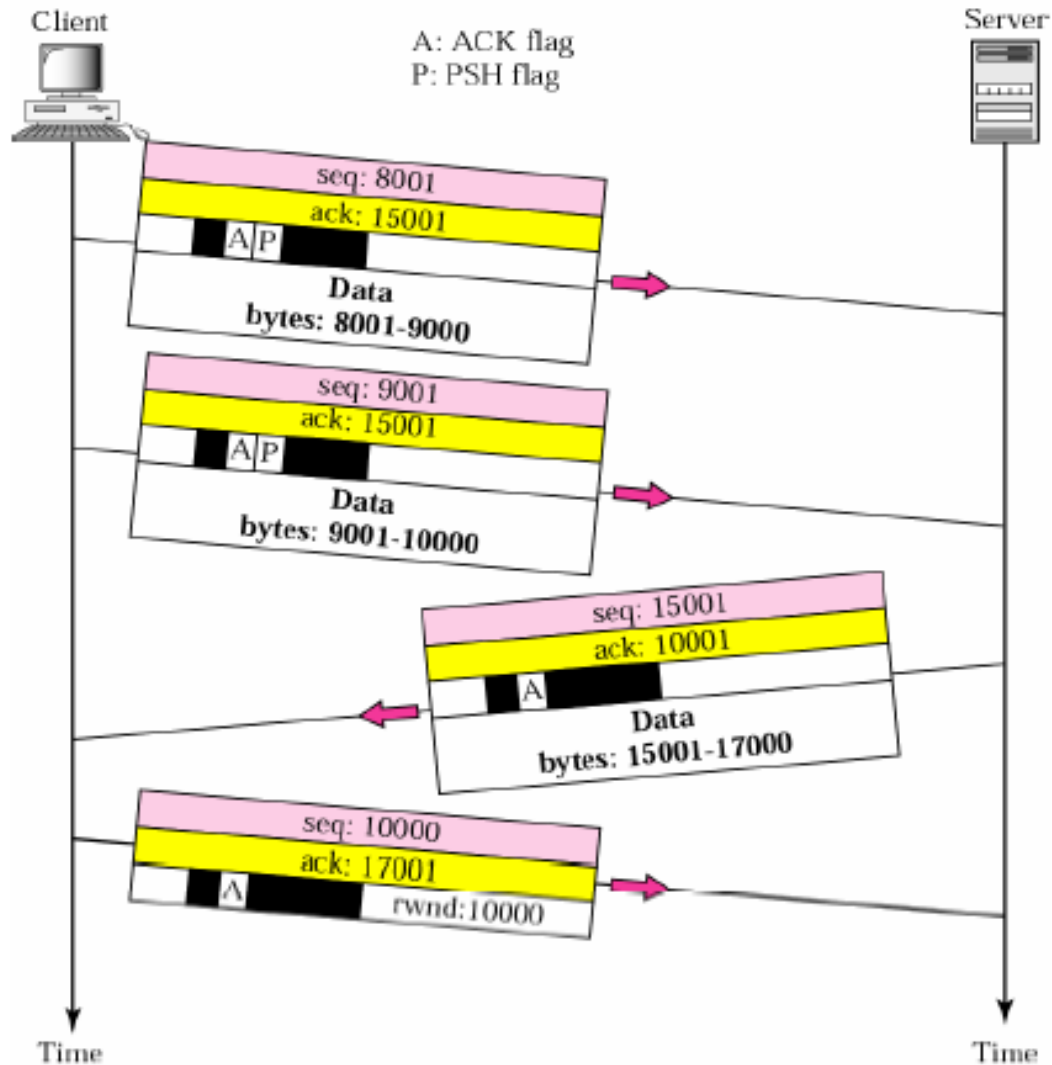
... upon receiving this packet, B can start sending data

# TCP Connection Management

- 3-way handshaking



# Data Transfer



# Important Notes

- SYN segment can not carry data, but consumes 1 seq number
- SYN+ACK segment can not carry data, but consumes 1 seq number
- ACK segment, if carrying no data, consumes 0 seq number

# TCP Connection Tear Down

Modified 3-way handshake

