Lab 06
Course: Networks System Design
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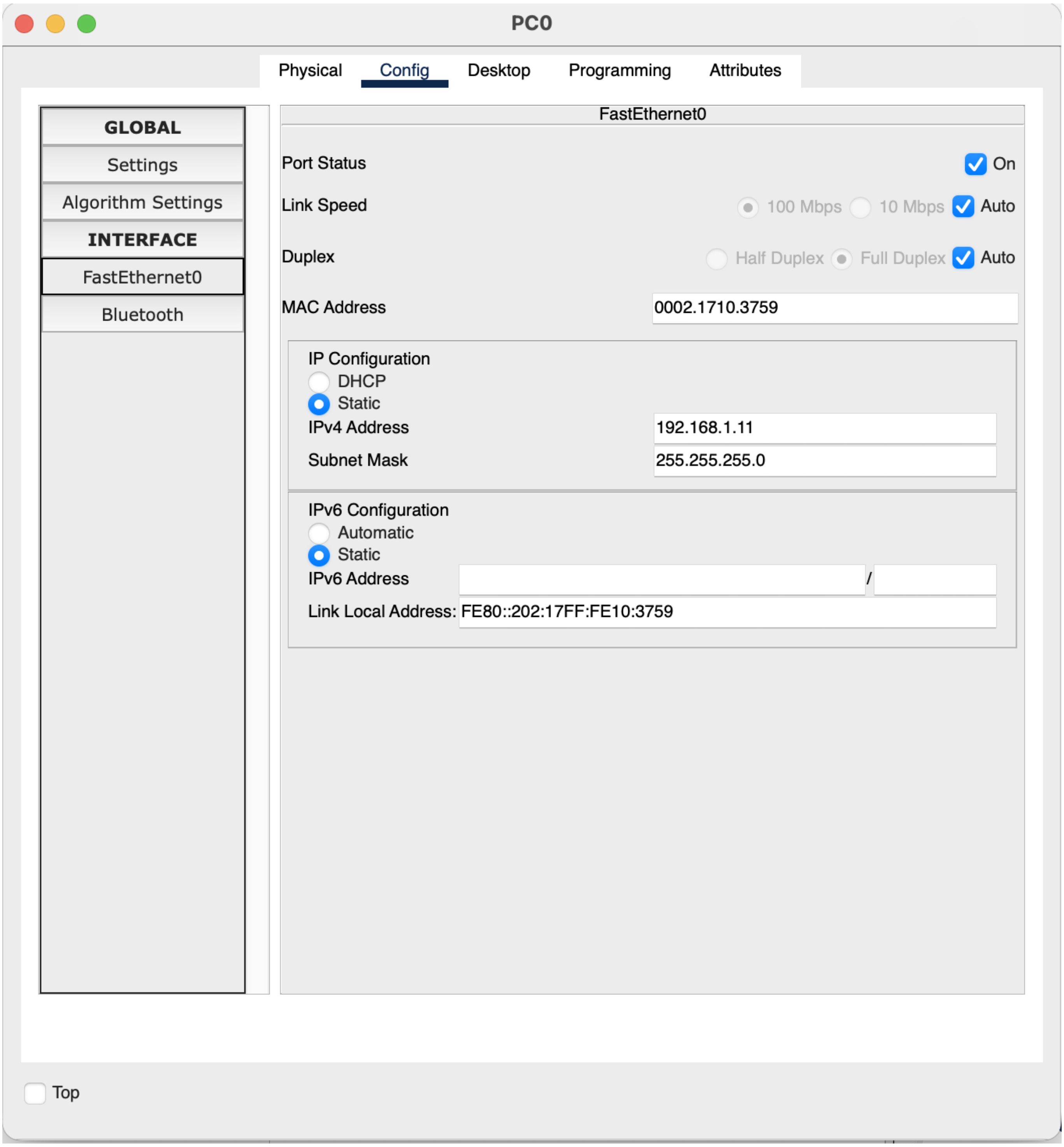
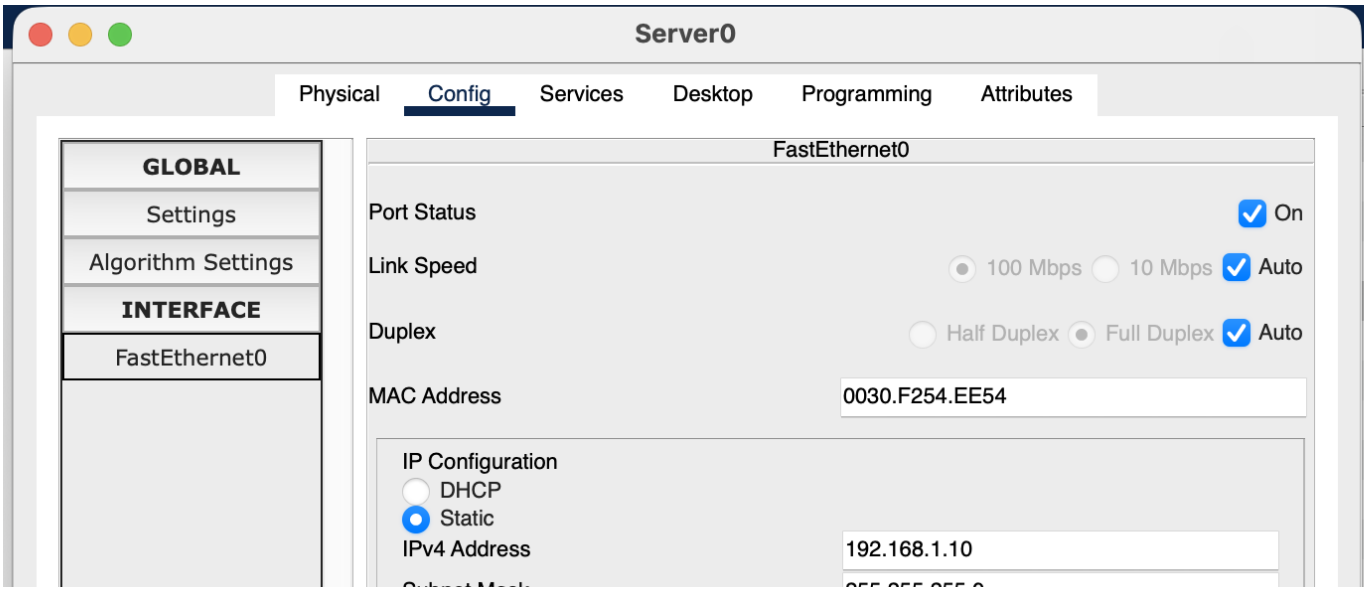
Instructor: Mr. Kuy Movsun
Due Date: Tuesday, 2 December 2025, 12:00 AM

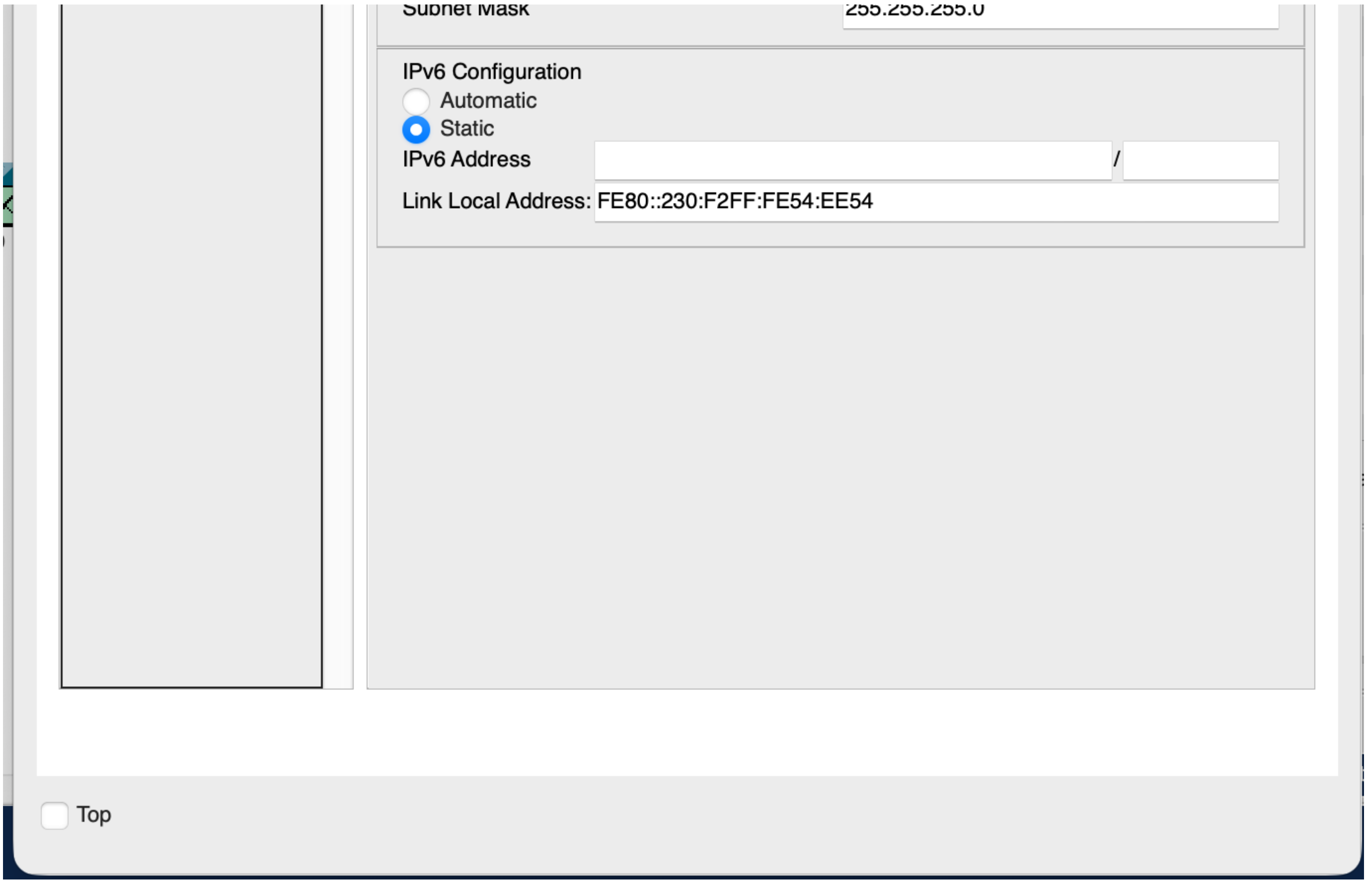
Link to my GitHub: https://github.com/Do-Davin/Network-Lab.git

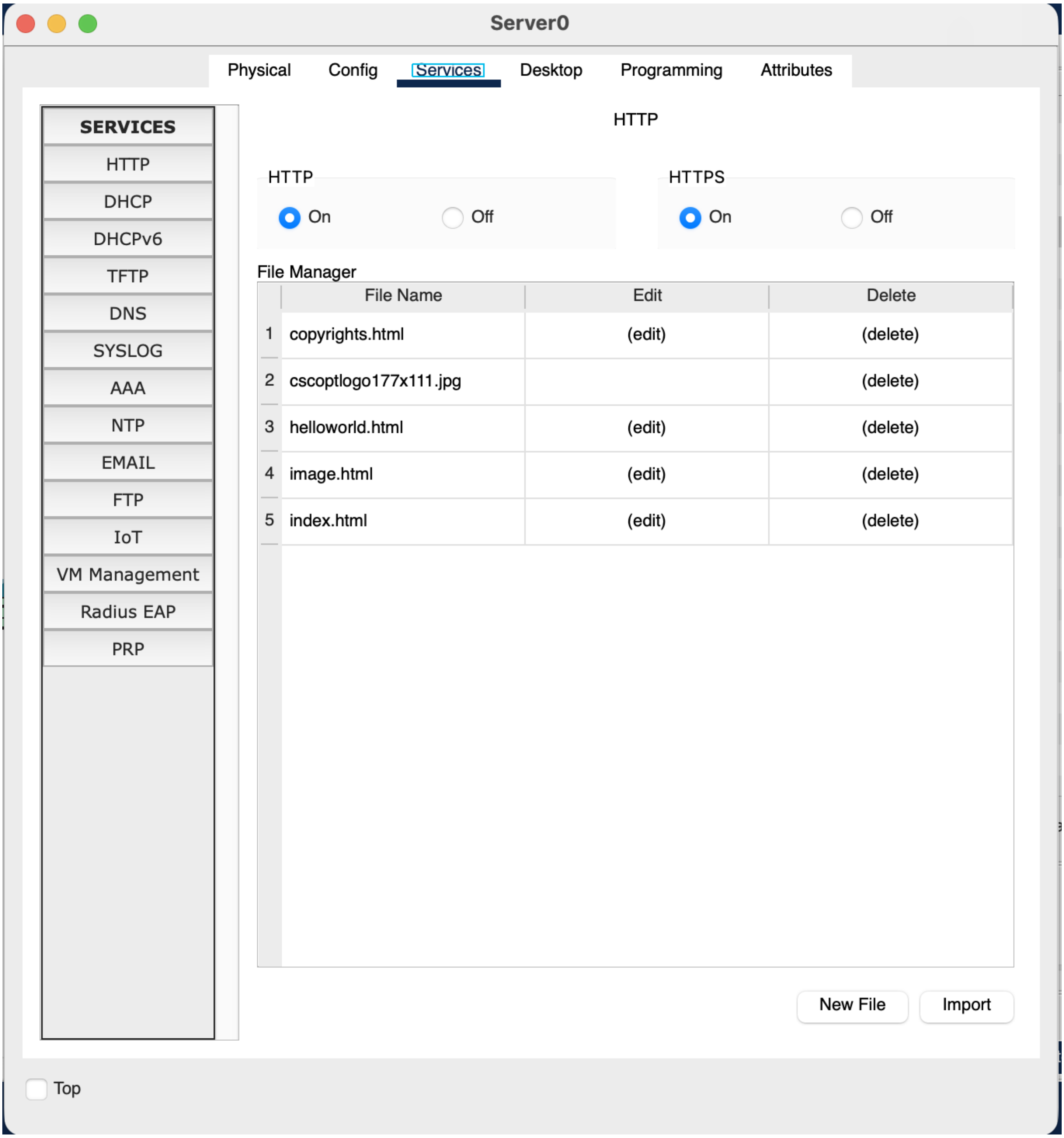
Part 1: Lab Setup

This section shows the basic network topology used in the simulation before starting all TCP experiments.

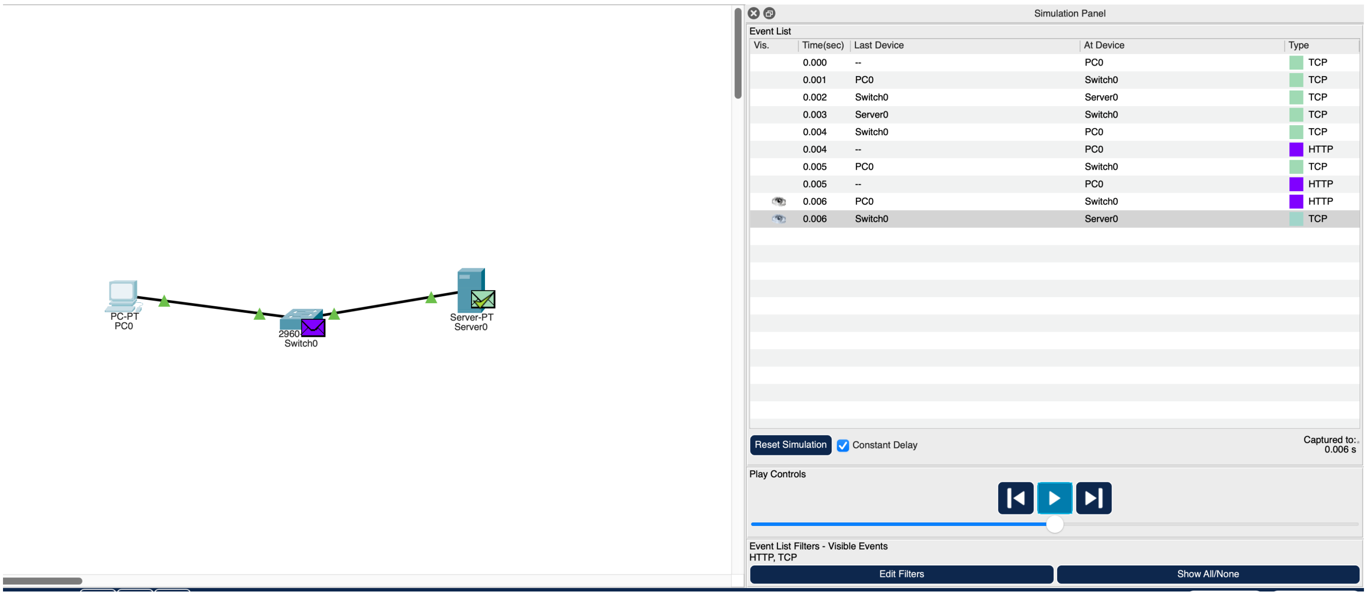

PC0
Physical
Config
Desktop
Programming
Attributes
GLOBAL
Settings
Algorithm Settings
INTERFACE
FastEthernet0
Bluetooth
FastEthernet0
Port Status
On
Link Speed
100 Mbps
10 Mbps
Auto
Duplex
Half Duplex
Full Duplex
Auto
MAC Address
0002.1710.3759
IP Configuration
DHCP
Static
IPv4 Address
192.168.1.11
Subnet Mask
255.255.255.0
IPv6 Configuration
Automatic
Static
IPv6 Address
/
Link Local Address:
FE80::202:17FF:FE10:3759
Top


Server0
Physical
Config
Services
Desktop
Programming
Attributes
GLOBAL
Settings
Algorithm Settings
INTERFACE
FastEthernet0
FastEthernet0
Port Status
On
Link Speed
100 Mbps
10 Mbps
Auto
Duplex
Half Duplex
Full Duplex
Auto
MAC Address
0030.F254.EE54
IP Configuration
DHCP
Static
IPv4 Address
192.168.1.10


Subnet Mask
255.255.255.0
IPv6 Configuration
Automatic
Static
IPv6 Address
/
Link Local Address: FE80::230:F2FF:FE54:EE54
Top



Part 2: The 3-Way Handshake



📝 Lab Analysis

Packet 1 (PC → Server):

Flag = SYN

This is the first step: PC initiates the connection.

Packet 2 (Server → PC):

Flags = SYN and ACK

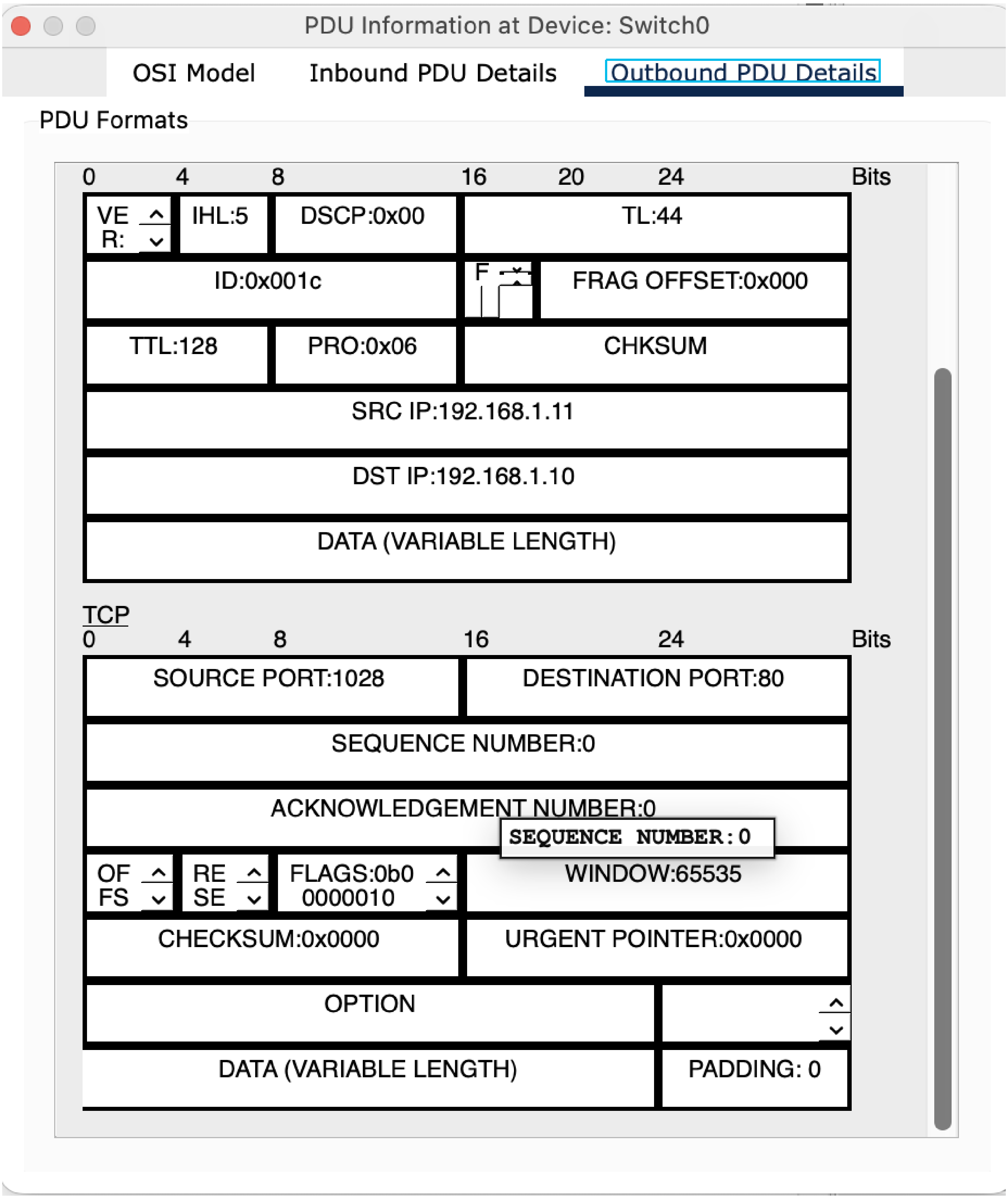
Server acknowledges the request and sends its own SYN.

Packet 3 (PC → Server):

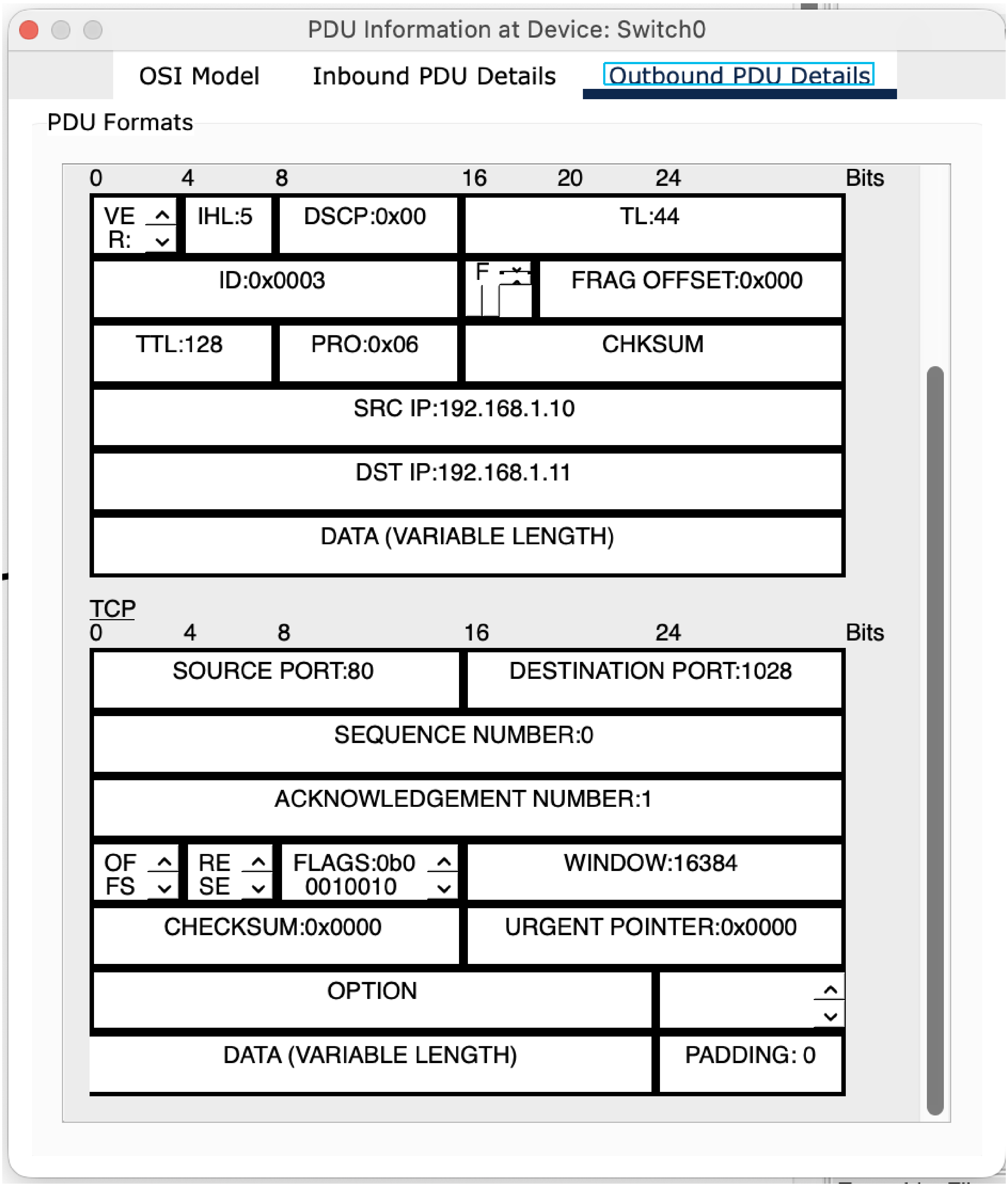
Flag = ACK

PC confirms the connection is established.

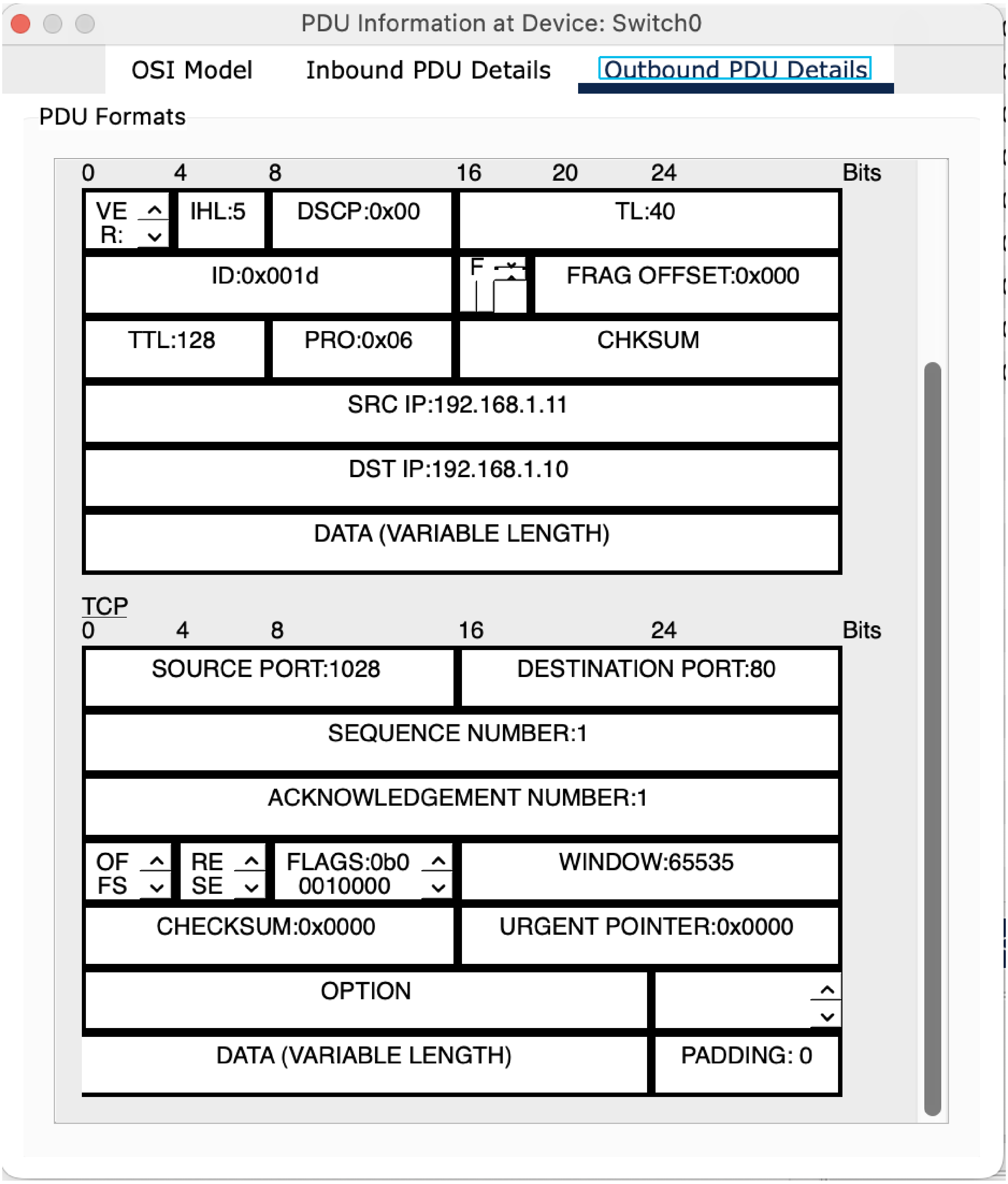
Packet 1:


PDU Information at Device: Switch0
OSI Model
Inbound PDU Details
Outbound PDU Details
PDU Formats
0 4 8 16 20 24 Bits
VER:
IHL:5
DSCP:0x00
TL:44
ID:0x001c
F
FRAG OFFSET:0x000
TTL:128
PRO:0x06
CHKSUM
SRC IP:192.168.1.11
DST IP:192.168.1.10
DATA (VARIABLE LENGTH)
TCP
0 4 8 16 24 Bits
SOURCE PORT:1028
DESTINATION PORT:80
SEQUENCE NUMBER:0
ACKNOWLEDGEMENT NUMBER:0
SEQUENCE NUMBER: 0
OFFS
RESE
FLAGS:0b00000010
WINDOW:65535
CHECKSUM:0x0000
URGENT POINTER:0x0000
OPTION
DATA (VARIABLE LENGTH)
PADDING: 0

Packet 2:


PDU Information at Device: Switch0
OSI Model
Inbound PDU Details
Outbound PDU Details
PDU Formats
0 4 8 16 20 24 Bits
VER:
IHL:5
DSCP:0x00
TL:44
ID:0x0003
F
FRAG OFFSET:0x000
TTL:128
PRO:0x06
CHKSUM
SRC IP:192.168.1.10
DST IP:192.168.1.11
DATA (VARIABLE LENGTH)
TCP
0 4 8 16 24 Bits
SOURCE PORT:80
DESTINATION PORT:1028
SEQUENCE NUMBER:0
ACKNOWLEDGEMENT NUMBER:1
OFFS
RESE
FLAGS:0b0 0010010
WINDOW:16384
CHECKSUM:0x0000
URGENT POINTER:0x0000
OPTION
DATA (VARIABLE LENGTH)
PADDING: 0

Packet 3:



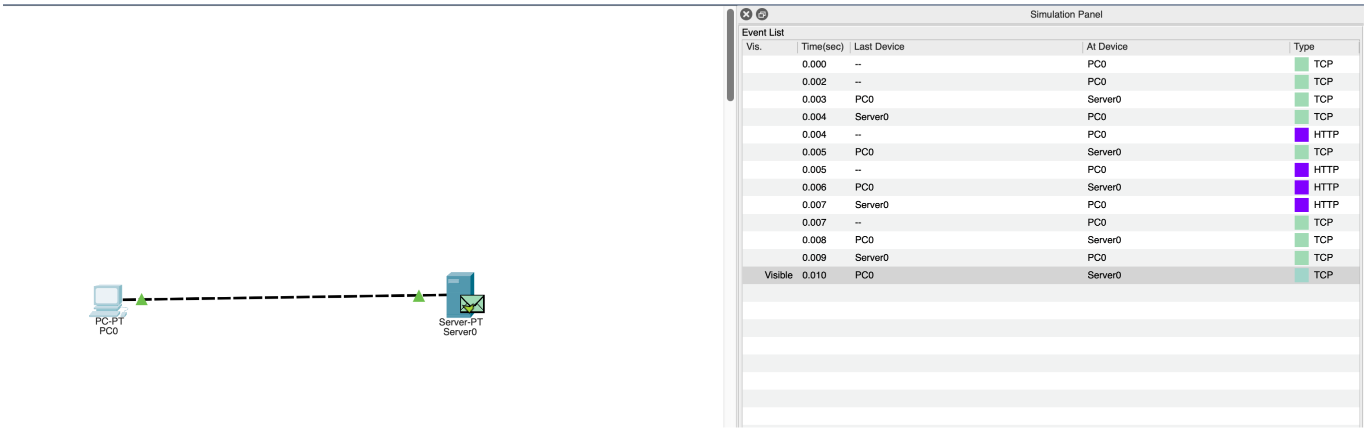
Draw It: Sketch the 3 arrows on paper and label them (SYN, SYN-ACK, ACK).

```
PC → Server : SYN
Server → PC : SYN–ACK
PC → Server : ACK
```

Analysis

- The TCP 3-Way Handshake establishes a reliable connection before any data is exchanged.
- Once the handshake is complete, the HTTP request–response process can start.

Part 3: The Sequence Number Detective



Task

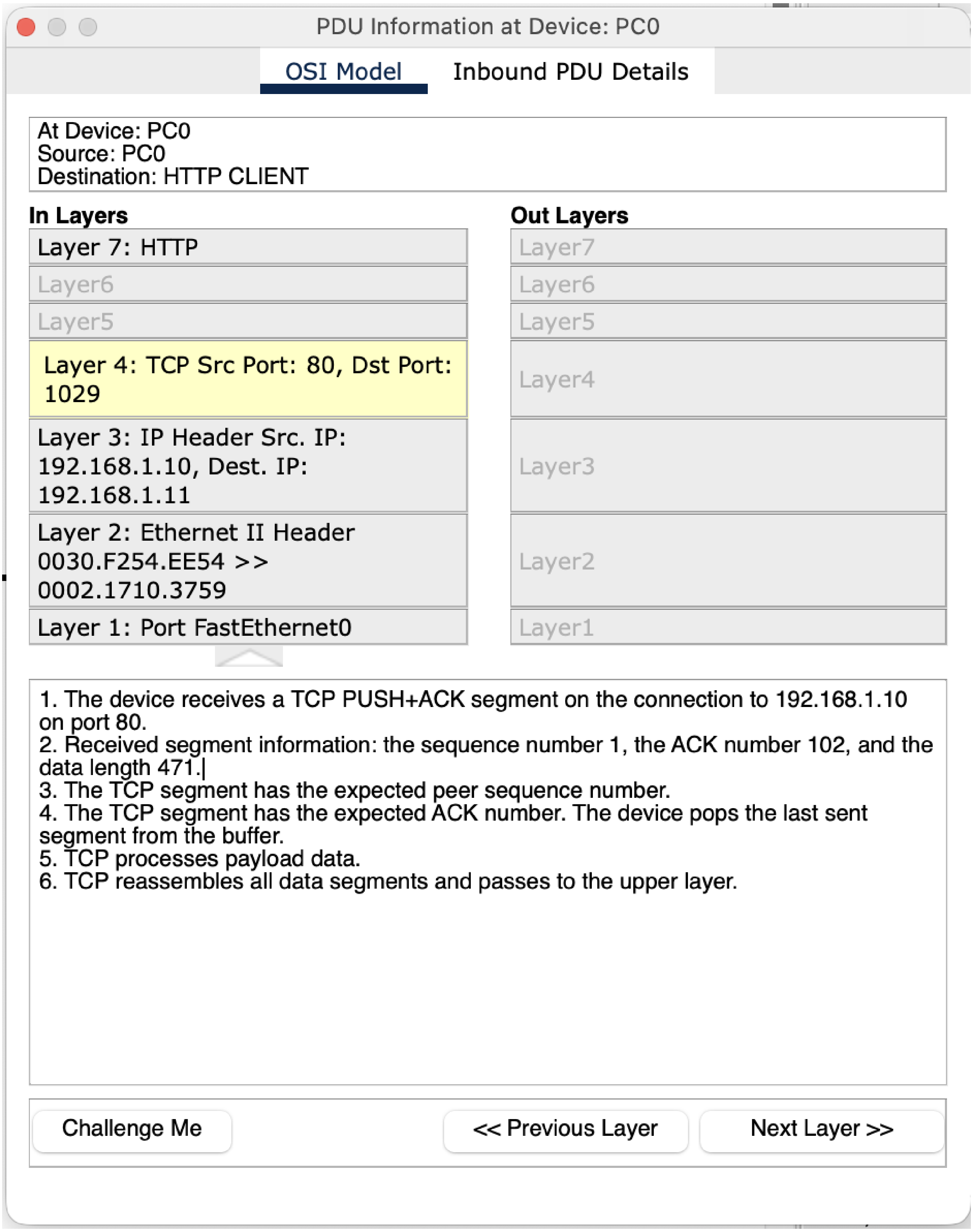
- Continue simulation after the TCP handshake.
- Capture the HTTP response packet from Server0 to PC1.
- Inspect the TCP Header for:
  - Sequence Number (Seq)
  - Data Length (Len)

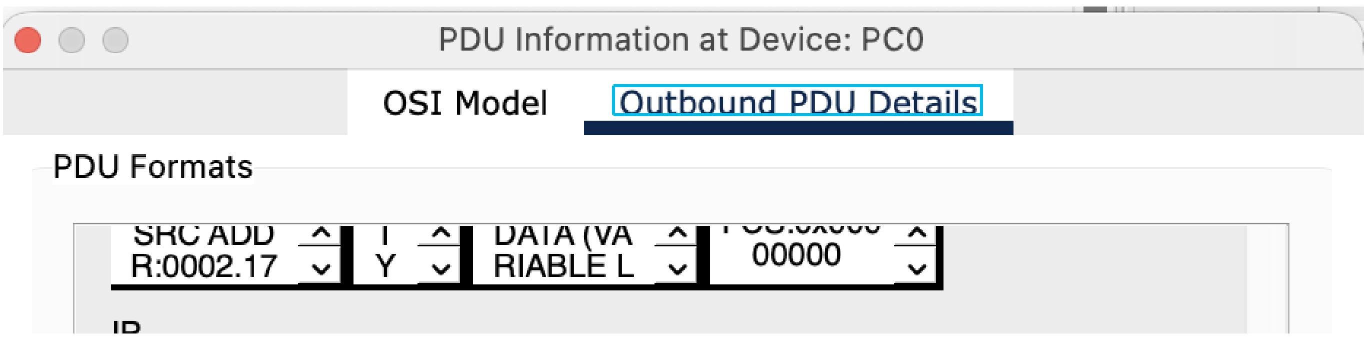
Steps

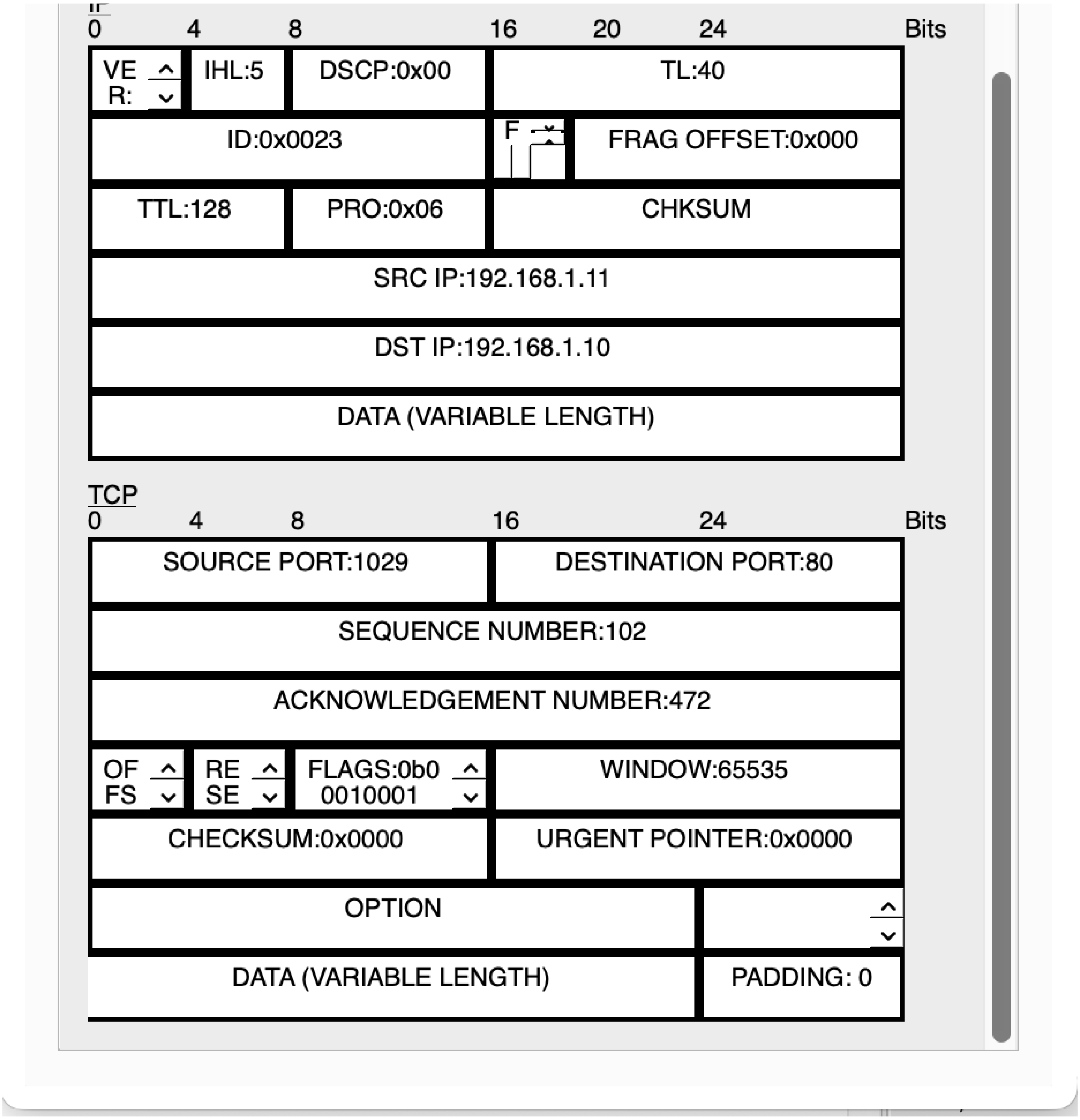
1. Click Capture/Forward until the HTTP packet appears from Server0 → PC1.
2. Open the packet details and record:
   - Sequence Number (Seq): 1
   - Data Length (Len): 369
3. Predict the Acknowledgement Number:
   - Formula:

```
Expected ACK = Seq + Len
```

4. Forward the next packet (PC1 → Server0).
5. Confirm the Acknowledgement Number matches your prediction.


PDU Information at Device: PC0
OSI Model
Inbound PDU Details
At Device: PC0
Source: PC0
Destination: HTTP CLIENT
In Layers
Layer 7: HTTP
Layer6
Layer5
Layer 4: TCP Src Port: 80, Dst Port: 1029
Layer 3: IP Header Src. IP: 192.168.1.10, Dest. IP: 192.168.1.11
Layer 2: Ethernet II Header 0030.F254.EE54 >> 0002.1710.3759
Layer 1: Port FastEthernet0
Out Layers
Layer7
Layer6
Layer5
Layer4
Layer3
Layer2
Layer1
1. The device receives a TCP PUSH+ACK segment on the connection to 192.168.1.10 on port 80.
2. Received segment information: the sequence number 1, the ACK number 102, and the data length 471.
3. The TCP segment has the expected peer sequence number.
4. The TCP segment has the expected ACK number. The device pops the last sent segment from the buffer.
5. TCP processes payload data.
6. TCP reassembles all data segments and passes to the upper layer.
Challenge Me
<< Previous Layer
Next Layer >>


PDU Information at Device: PC0
OSI Model
Outbound PDU Details
PDU Formats
SRC ADD R:0002.17
Y
DATA (VA RIABLE L
00000



Analysis

- TCP uses sequence numbers to track byte order and ensure reliable delivery.
- The client acknowledges the last byte received + 1.
- This confirms successful receipt and readiness for the next segment.

Part 4: Breaking the Network (TCP Retransmission)

Task

- Observe how TCP handles packet loss by forcing a failure in the network.

Steps

1. Reset Simulation completely.
2. Set filters to allow TCP packets.
3. On PC1, open the browser and request the website again (Server0).
4. Wait until the 3-Way Handshake is complete.
5. Before the HTTP packet returns, use the Delete Tool (X) to cut the cable between Server0 and Switch0.
6. Continue clicking Capture/Forward to observe events.

Observations

- PC1 waits for the HTTP response but does not receive it.
- After a timeout, TCP automatically retransmits the packet.
- This shows TCP's reliability mechanism: it detects loss and resends data.

Analysis

- TCP Retransmission ensures reliable delivery by resending lost packets.
- If this were UDP (e.g., live video stream):
  - The packet would not be resent.
  - UDP is connectionless and does not guarantee delivery.
  - Lost packets simply result in missing frames or data.

Key Takeaway

- TCP sacrifices speed for reliability (resends lost data).
- UDP sacrifices reliability for speed (no retransmission).

Part 5: The Pipeline Race

Scenario

- Link speed: **1 Gbps**
- Packet Transmission Time: **0.008 ms**
- Round Trip Time (RTT): **30 ms**
- Formula for Utilization:

```
U = (N × Transmission Time) / (RTT + Transmission Time)
```

Questions & Calculations

Q2 (Stop-and-Wait, N=1):

U = (1 × 0.008) / (30 + 0.008) ≈ 0.000266 (or 0.0266%)

Q3 (Pipelining, N=3):

U = (3 × 0.008) / (30 + 0.008) ≈ 0.000799 (or 0.0799%)

Q4 (Improvement Factor):

Factor = U(N=3) / U(N=1) = 0.000799 / 0.000266 ≈ 3.0

📊 Results Table

Scenario	N	Utilization (U)	Percentage
Stop-and-Wait	1	0.000266	0.0266%
Pipelining	3	0.000799	0.0799%
Improvement Factor	-	~3×	3 times better

Analysis

- **Stop-and-Wait** uses the link inefficiently because the sender must wait for every ACK before transmitting the next packet.
- **Pipelining** sends several packets at once, which boosts link utilization.
- With even 3 packets in the pipeline, the utilization becomes roughly three times higher.

Part 6: Flow Control & Teardown

Steps Performed

1. Reconnect cables between **Server0** and **Switch0**.
2. Load the webpage successfully from **PC1**.
3. Opened the **last TCP packet** received by PC1.
4. Found the **Window Size** field in the TCP header.
5. Close the browser.
6. Observe the **FIN packets** exchanged during connection termination.

Key Findings

1. Flow Control (Window Size)

- **The Window Size** tells the server how many bytes the PC is currently able to receive.

- Example:

    - If the window size is 4096, PC1 is saying:

      "My buffer has room for 4096 more bytes, send only this much before waiting."

- This prevents the sender from overwhelming the receiver.

2. Connection Teardown (4-Step TCP Closing) TCP closes connections gracefully using a four-step FIN handshake:
3. PC1 → Server0: FIN

4. Server0 → PC1: ACK
5. Server0 → PC1: FIN
6. PC1 → Server0: ACK

This ensures both directions of communication are properly closed.

Analysis

- **Flow Control:** protects the receiver from buffer overflow by regulating how much data can be sent.
- **Teardown:** ensures both sides finish communicating cleanly, preventing data loss.
- Unlike UDP (no formal closing), TCP guarantees an orderly shutdown.
