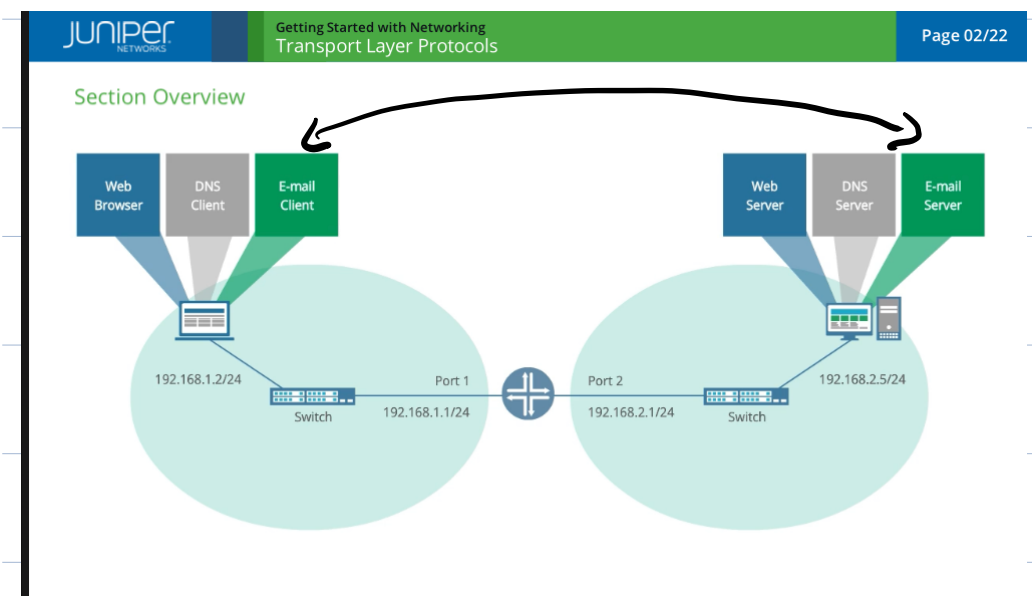
Transport Layer Protocols

- How does data get from one host application program, sending computer, to a suitable application on the receiving computer



Introduction

Reminder:

Sending an email, your computer send the data using the Internet Protocol

- Routers use destination IP address & routing tables to route the packet through network to correct host
  - Encapsulation in a frame including layer 2 address
    - Switch use this to direct to correct computer

⇒ But once the data arrived, how does it know which application to use?

⇒ How does the sending computer

know that it has arrived succesfully

Transport Layer 4

- Allow true end to end communication (application → to → application)
  - use UDP or TCP can route data to the correct application (use software ports)

[Destination Port]

The destination port number is analogous to the name in a letter's address

- Provides a way of getting the data to the correct Application layer

protocol and ultimately to the correct application program.

Source port

Log: like the name on the sending side (who send the letter)

* Note

Each Application Layer protocol receives a unique numerical identifier or Software port, which is different than a physical or hardware port

[HTTP: port 80, DNS, SMTP] ...

Software Ports, Hardware Ports, IP

Interfaces

- Software Ports: specific to the layer & are used to route data to the correct applications

- Hardware Ports: NIC's (Layer 1)

- IP Interfaces: Layer 3

* Software Port Numbers

- Port 0
- Port 1-1,023

} common TCP/IP applications.

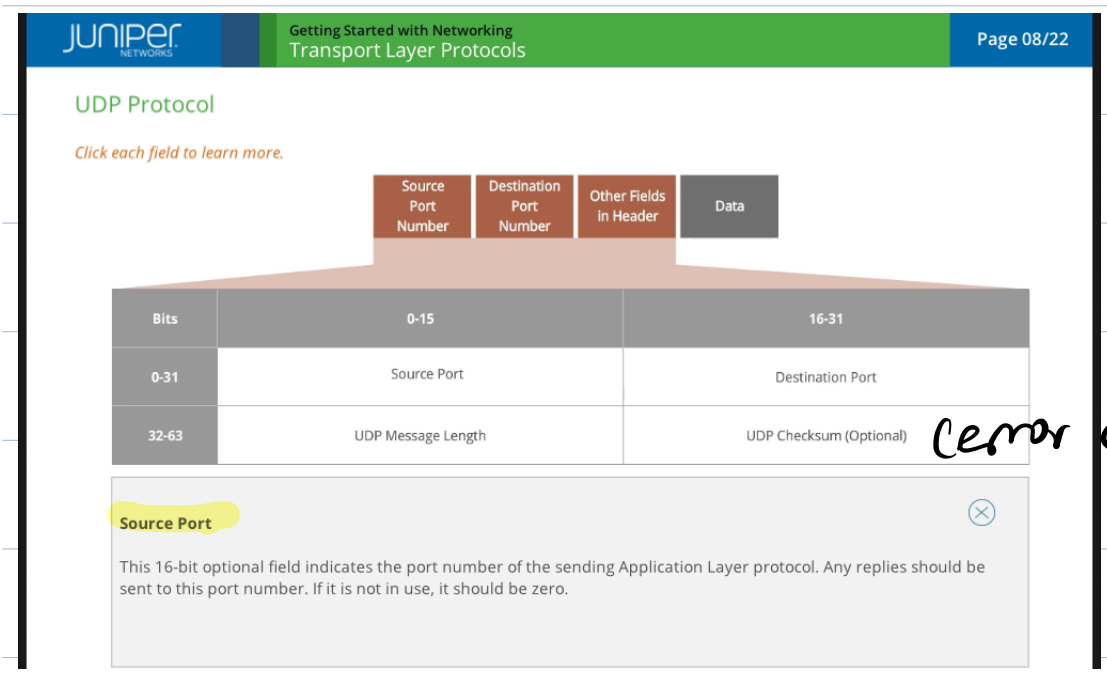
- Port 1204, 49,151 } Register ports

- Port 49,152-65,535 } Dynamic or Private ports

* Not managed by IANA

* Data Multiplexing

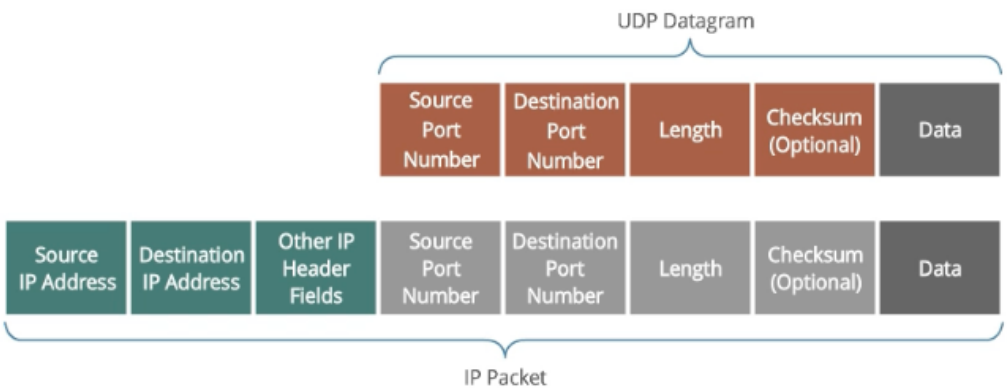
UDP Protocol



(error checking)

Features:

- Limited error-checking capabilities
- No recovery mechanisms (unreliable)
- Checksum is optional
- Application using UDP interact almost directly with IP in the Network Layer



Examples of UDP Applications

Applications for which speed is more important than reliability use UDP. The following are examples:

- Domain Name System (DNS)
- Trivial File Transfer Protocol (TFTP)
- Simple Network Management Protocol (SNMP)
- Streaming video and audio applications.

If an application needs more reliability than UDP offers, it uses TCP instead.

Overview: TCP

"Requesting return receipt from post office"

∴

↳ TCP uses a sophisticated system of sequence numbers, acknowledgements, flags, and timers, which UDP does not use, ∴ TCP is more complex

TCP provides a reliable service using:

- Sequence numbers
- Acknowledgements
- Flags
- Timers.

Overview of TCP

UDP	TCP
Multiplexes data using ports	Multiplexes data using ports
Connectionless	Connection-oriented
Unreliable	Reliable
Unordered data; duplicates possible	Ordered data; duplicate detection
Datagrams	Segments
No flow control	Flow control

TCP provides a windowing system to regulate the flow of data between computers.

TCP Protocol

Click each field in the TCP header to learn more about its functions.

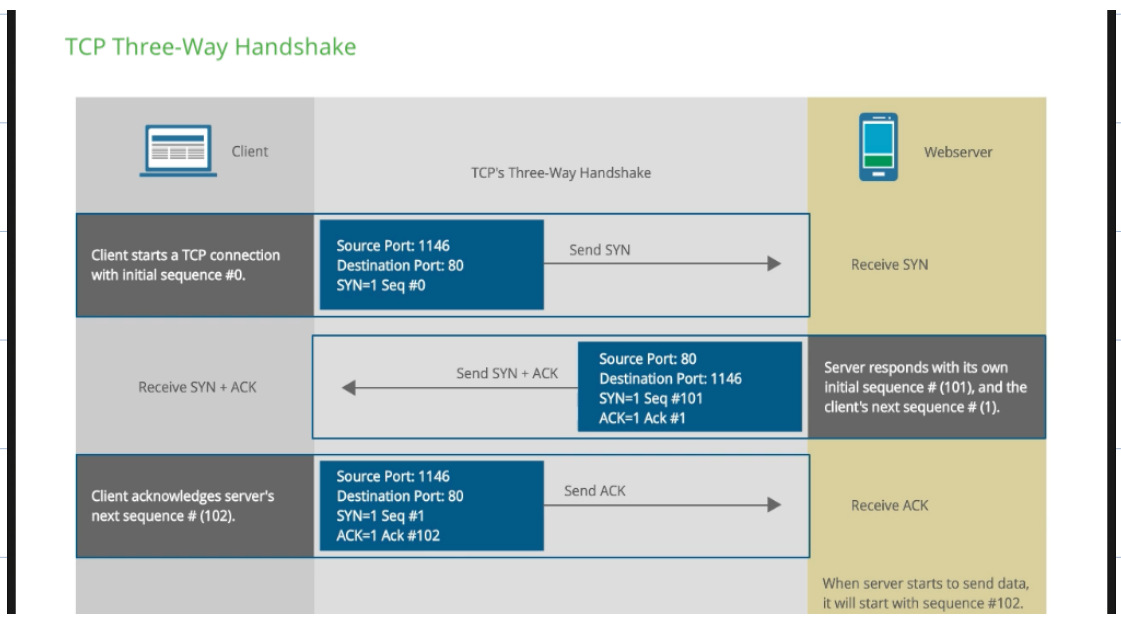
	Bits 0-3	4-7	8-15	16-31
0	Source Port			Destination Port
32	Sequence Number			
64	Acknowledgement Number			
96	Data Offset	Reserved	CWR ECE URG ACK PSH RST SYN FIN	Window
128	Checksum			Urgent Pointer
160	Options (Optional)			

The 8 flag or control bits, are as follows:

- CWR and ECE: The Congestion Window Reduced, or CWR flag, and the Explicit Congestion Notification Echo, or ECE flag, are used to negotiate congestion notification capabilities.

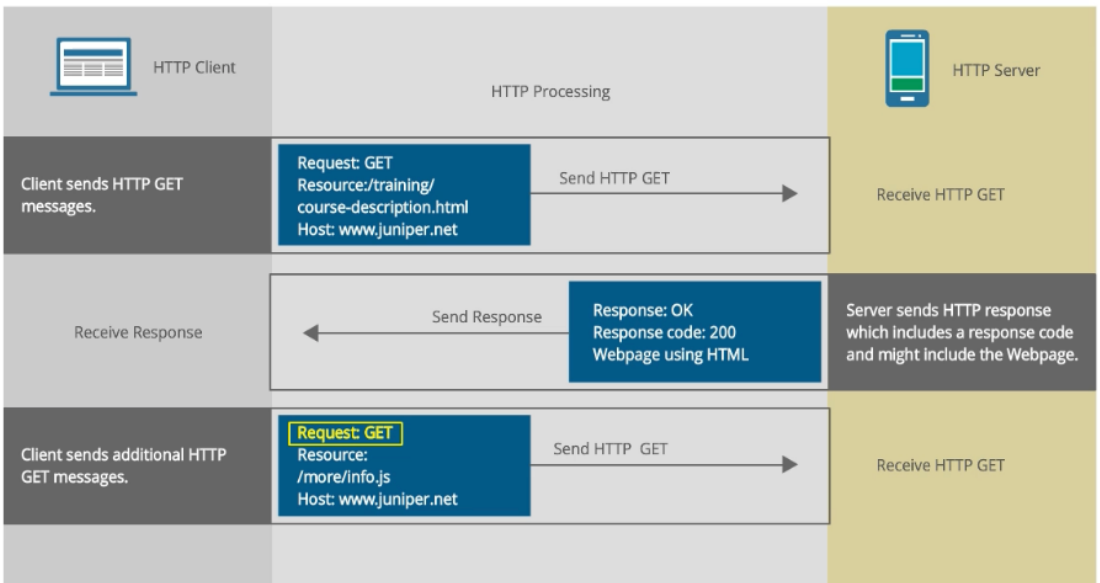
Application Layer Protocol using TCP

- HTTP
- SMTP
- FTP



Local now then we HTTP web service to send & receive data

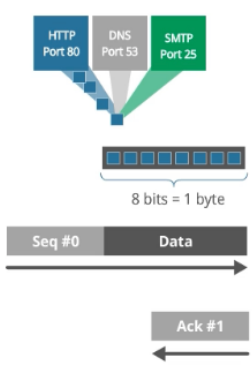
HTTP

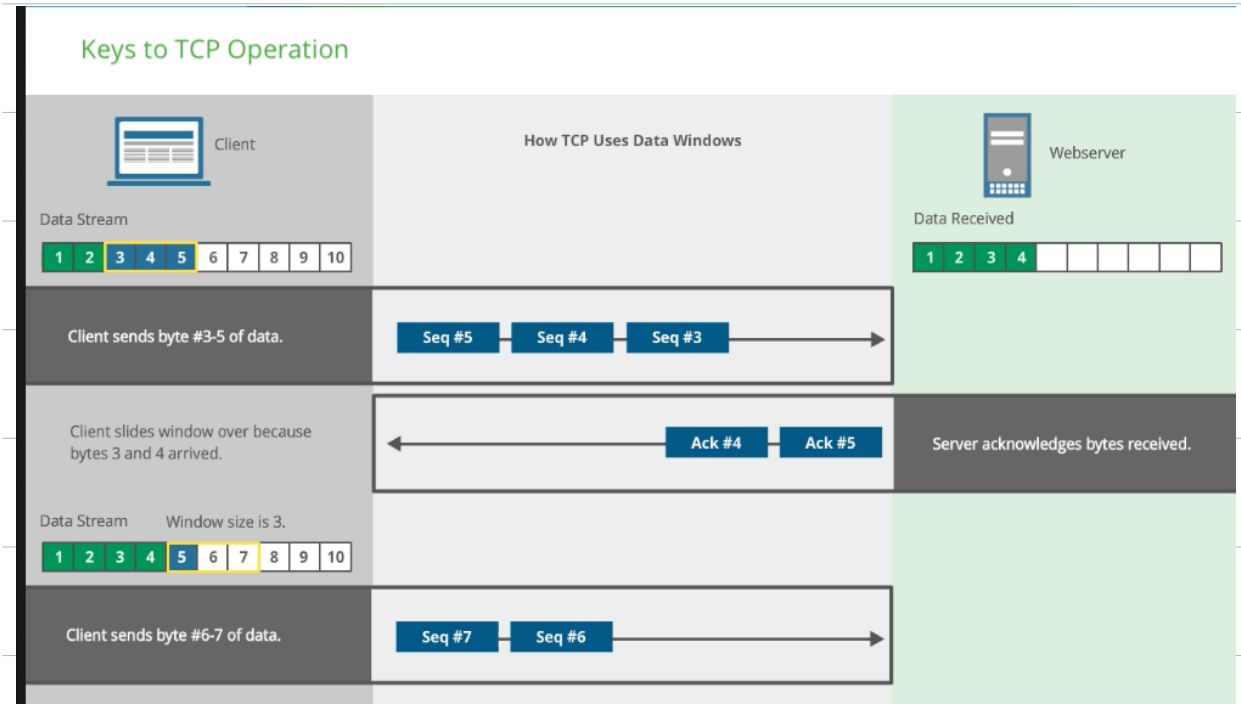


Keys to TCP Operation

Keys to TCP Operation

- Application Layer protocols send data to TCP as a continuous stream of bits
- TCP groups bits into bytes, and bytes into manageable chunks or segments that can be one byte or many bytes in length
- Each byte of data sent over a TCP connection has a sequence number
- Each byte is acknowledged
- Sequence numbers are used to:
  - Acknowledge which data has been received
  - Determine if data has been lost or damaged
  - Put data into the correct order




Keys to TCP Operation
Client
How TCP Uses Data Windows
Webserver
Data Stream
1 2 3 4 5 6 7 8 9 10
Data Received
1 2 3 4
Client sends byte #3-5 of data.
Seq #5
Seq #4
Seq #3
Client slides window over because bytes 3 and 4 arrived.
Ack #4
Ack #5
Server acknowledges bytes received.
Data Stream
Window size is 3.
1 2 3 4 5 6 7 8 9 10
Client sends byte #6-7 of data.
Seq #7
Seq #6