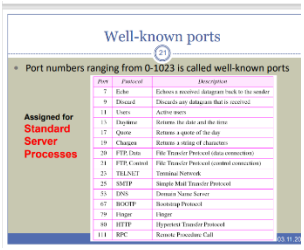
TCP

- Well known ports=Assigned for Standard Server Processes



- Registered ports

Ports ranging from 1024 - 49,151

Used for proprietary server processors or any client process

Normally not used

- Dynamic ports/ Ephemeral ports

From 49,152 to 65,535

Used by client processes temporarily

Source port address

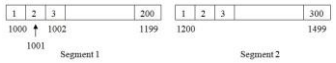
For client TCP header this is a dynamic port number

For server TCP header this is a well-known port number

Fields in the TCP Header That Ensure **Reliability**

Sequence Number (4 bytes)

Ensures **data is delivered in order** and detects **loss**.



Acknowledgment Number (4 bytes)

Enables **positive acknowledgment**, confirming which data has been received.

Checksum (2 bytes)

Detects **data corruption** during transmission.

Flags (6 bits within 2 bytes)

- **SYN:** Used to establish connections.
- **ACK:** Acknowledges received data.
- **FIN:** Used to terminate connections.
- **RST:** Resets (Destroy / Terminate) the connection.
- **PSH:** Pushes data to the application layer immediately.
- **URG:** Urgent pointer field is significant.

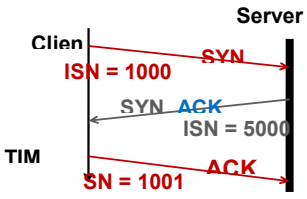
Header Length (HLEN)

Header length in bytes = HLEN x 4

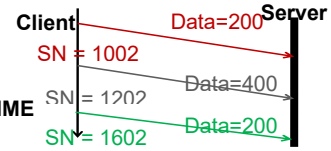
Sequence number

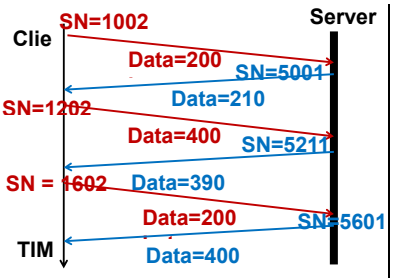
Sequence numbers of three-way handshake

SYN and ACK: 1 byte each

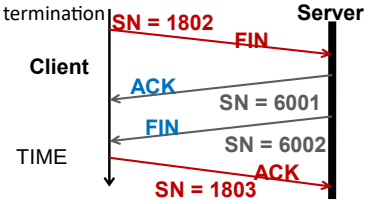


Sequence numbers of data segments

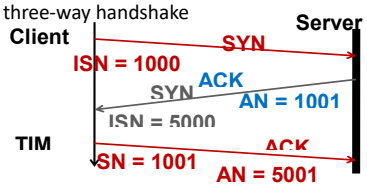


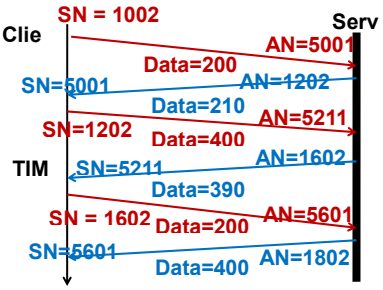


Sequence numbers of connection termination



Acknowledgement numbers of three-way handshake





Control (Fields)

RST – Reset

*Request for an unidentified port

Client or server has a problem

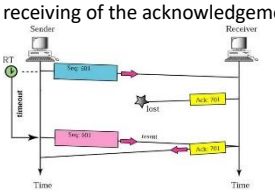
*The connection has been established

*The other side TCP is idle for a long time

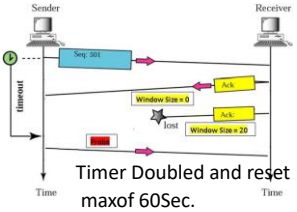
Timers

Retransmission-error control

Retransmission time =2 x Round Trip Time= the time between sending of the segment and receiving of the acknowledgement



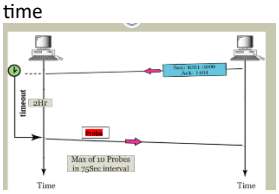
Persistence- To avoid problems of zero window size advertisement



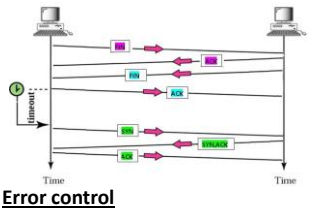
Timer Doubled and reset maxof 60Sec.

ThreshHold – 60 Sec

Keep alive- To check whether client is alive if it is idle for a long time



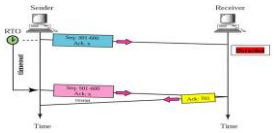
Time- waited- To avoid problems with delayed FIN segments



Error control

TCP uses the backward error control. If the receiver detects errors, it will discard that segment

- Errors in the received segment (corrupted segments)
- Segment is lost on the way before reaching the receiver (last segment)
- Duplicate received segments
- Out of order segments (the segment numbers are not received in order)
- Lost an acknowledgement on the way

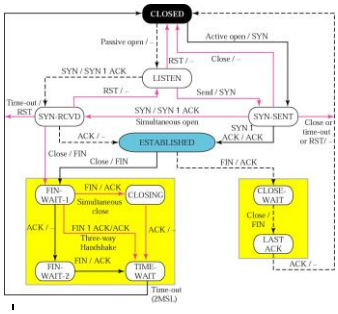


Window size

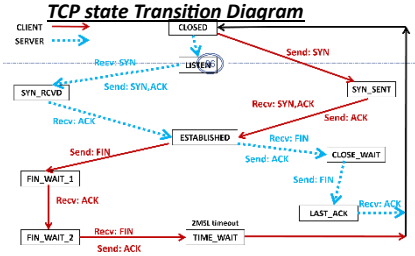
Receiver TCP buffer can be overflowed due to two reasons

- The receiver TCP buffer receives data very fast
- The receiver application consumes data very slowly

Receiver TCP should inform the sender TCP how much bytes of data it can accommodate



TCP state Transition Diagram

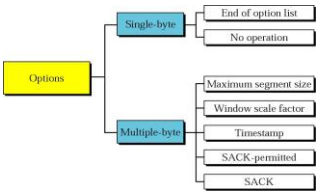


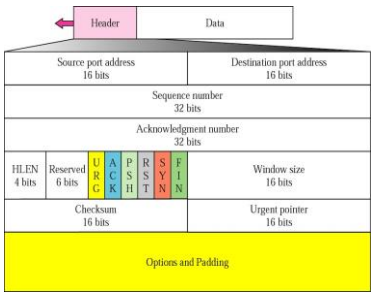
User Datagram Protocol (UDP)

*UDP does not have a connection establishment process UDP does not have a connection termination process UDP does not have error control, flow control and congestion control mechanisms UDP header has only 8 bytes (TCP 20 bytes)

*Since UDP does not get any feedback from the receiver, there is no guarantee of delivering data to the receiver by UDP Therefore UDP is an unreliable simple protocol Because of its simplicity it is used for specific applications especially the broadcast type applications

Port NO	Application
69	TFTP
53	DNS
161	SNMP
520	RIP





HeaderSize =HLEN x 4

OptionField = HeaderSize – Standard Header Size

Both URG & ACK flags are set.URG flag set means, this contains urgent data that should read 1st. ACK flag is set means reader get acknowledgement

Distance Vector Protocol &

Distance Vector Protocol	Link State Routing protocol
Routers share their entire routing table with neighbors periodically.	Routers share information about the status of their own links with all routers in the network.
Periodic	Event-driven
Slower	Faster
Less scalable	More scalable
Simple	Complex
Ex: RIP (Routing Information Protocol)	Ex: OSPF (Open Shortest Path First), IS-IS

Link State Routing protocol

TCP	UDP
Connection-oriented	Connectionless
Reliable (ensures delivery, retransmissions)	Unreliable (no retransmission)
Email, Web browsing	Video streaming

Redundant Links & Spanning Tree Protocol (STP)

Why Redundant Links Are Needed

To keep the network running if one link fails (fault tolerance).

helps prevent downtime in business-critical networks.

Problems with Redundant Links (Without STP)

 Loops cause broadcast storms (infinite frame circulation).
 Multiple **frame copies** can confuse devices.
 MAC **table instability**: Switches get wrong info about device locations.

What is STP?

Spanning Tree Protocol (STP) is used to prevent loops in Layer 2 (Ethernet) networks. It **blocks redundant paths** temporarily to create a **loop-free** topology.

How *STP Works (Spanning Tree Algorithm Steps)*

Elect a Root Bridge – the switch with the lowest Bridge ID. Assigned manually or by the manufacturer. Sometimes can be MAC addrs.

Elect Root Ports – The port with the least cost path to the root is root port.

Elect Designated Bridges-designated bridge is the bridge with least cost to root.

Elect Designated Port-designated port is the bridge with least cost to LAN segment.

Advantages of STP

Prevents Infinite Loops. Ensure there is only **one logical path** between any two switches

Prevents Infinite Loops. STP keeps the network **stable** and **usable**, even with redundancy.

Disadvantages of STP

Wasted Redundant Links:

*Some backup links are **active but blocked**, so they **don't carry any data**.***Suboptimal Paths**: STP may **block shorter paths** and use **longer ones**, making the network **less efficient**.

BPDU – Bridge Protocol Data Unit

Special message used by STP to share information about Bridge IDs & root path cost between switches (Bridge ID, cost, etc.).

STP Port States

 Blocking – no data forwarded; prevents loops.
 Listening – processes BPDUs, no MAC learning.
 Learning – learns MAC addresses, no data forwarding.
 Forwarding – sends and receives data.
 Disabled – admin or failure shuts down the port.

STP Path Cost vs Bandwidth

Higher **bandwidth = lower path cost**

ACL

Tell what types of data access or deny based on source address, destination address, protocol, upper layer port no.

Things ACL can do

 Prevent unwanted traffic

Prevent hackers from penetrating the network

 Prevent employees from using systems in unauthorized manner
 Filter routing updates Match packets for prioritization
 Match packets for VPN tunneling
 Match packets for implementing quality of service features

How ACL works?

*ACL have many statements
*They operate in sequential, logical order
*If statement 1 is matched, router has to carry out the action defined in that statement
*Continue looping until a statement is matched
+Wildcard Mask = 1 means need not to check
+Wildcard Mask = 0 means need to check
Ex: 172.30.16.29 0.0.0.0 checks all the address bits.
(Host(172.30.16.29))
Accept any address: 198.10.0.1 255.255.255.255.
Abbreviate using the keyword **any**.

Standard ACL

Router (config) # access-list access-list-number {permit | deny} {Source address} {wildcard

ACL No= 1-99
*Checks source address
****Standard ACLs*** should be placed as close to the ***destination*** as possible

Permit my network only

access-list 1 permit 172.16.0.0 0.0.255.255
access-list 1 deny 0.0.0.0 255.255.255.255) / access-list 1 deny any

Extended ACL

ACL No= 100-199
*Checks destination address
****Extended ACLs*** should be placed as close to the ***Source*** as possible

Router (config) # access-list access-list-number {permit | deny} {protocol} {Source address} {wildcard mask} {destination address} {wildcard mask} {eq | lt | gt} {port number}

*Needs to restrict Internet access of 192.168.10.0 to allow only website browsing
192.168.10.0 0.0.255 any eq 80
80 OR http
R1 (Config) # access-list 103 permit tcp

Apply ACL to an interface

Router (config-if) # {protocol} access-group access-list-number {in | out}
Ex: R1 (config) # interface s0/0/0
R1 (config) # ip access-group 103 out

RAM - running configuration file
ROM-bootable IOS image & bootstrap program
NVRAM - startup configuration file - Retains content when router is powered down
Flash memory - fully functional IOS image.Is a type of electronically erasable, programmable ROM (EEPROM)

Router# copy startup-config running-config
Router#show startup-config

Classful Addressing - Subnet Mask
Net ID part: All 1's
Host ID part : All 0's
Default Gateway IP Address
120.0.0.0 - 120.0.0.50
Loopback address
Any address start with 127.
Public IP Addresses
Is any valid address that can be accessed over the Internet.
Private IP Addresses

Class	Private Network Address	# Net
A	10.0.0.0	1
B	172.16.0.0 to 172.31.0.0	16
C	192.168.0.0 to 192.168.255.0	256

This host on this network
Net Id 0's
Host Id 0's
Specific host on this network
Net Id 0's
Host Id Specific
Limited Broadcast Address
Net Id 1's
Host Id 1's
No: of Sub Net= 2^n
(n= Extra bits get from host part)
No of total address= $2^{\text{no: of host bits}}$
Remaining host bits
Usable IP addresses = $2^{\text{no: of host bits}}-2$

Dual Stack – IPv4 and IPv6 to coexist on the same network.

Tunneling- transporting IPv6 over an IPv4 network. The IPv6 packet is encapsulated inside an IPv4 packet

Translating- NAT64 can transfer IPV6 to IPV4

Rule 1 (Omitting Leading 0s)

Rule 2 (Omitting All 0 Segments)

× Unicast: One device send one device
× Multicast: 1 device sent many device
× Any cast: One device sent the nearest device and that nearest device sent another device

IPv6 Unicast Addresses

*Global unicast -Global unicast can be configured statically or assigned dynamically.
*Link-local-communicate with other device in same local link
*Unique local-Similar to private address in IPV4

Adaptive Routing

• Each router maintains a routing table • Routing table modifies itself according to the network changes

Advantages - Network traffic is minimized - Low latency - The best route will be selected most

Disadvantages - Router memory need to keep a routing table

Host Specific Routing

Each router keeps one record/entry for each • Table entry has Host IP and the Interface

Disadvantages • Large number of records •Table updating is difficult and complex **Network Specific Routing**

One record for one network) • Table entry has Network address and Interface

Advantages • Number of records are limited (Table updates are not for each host but for a network) •Update is easy

Static routing

Router (config) #ip route <destination network><desti. Network subnet mask><next hop address | exit interface | Both>

Default routing

B (config) #
B (config) #ip route 0.0.0.0 0.0.0.0 172.16.2.2

RIP

Router (config) #router rip Router (config-router) #network<net address>

RIP V2

Router (config) #router rip
Router (config) #version 2
No auto-summary
Router (config-router) #network <net-address> (Directly connected)

EIGRP

Router (config) #router Eigrp AS
Router (config-router) #network<net-address>

Switch

Based on physical factor
1. Fixed config (Can't modify phy.)
2. Modular config (Ports can add or remove)
3. Stackable config (Sw connected. Kept one on other, Daisy wheel cableling stru.)

Business Considerations On Selecting switches • Cost • Speed and #of Interfaces
• Port Density • Power • Power access points, • 24/7 Continues access • Port Speed • Ethernet, Fast Ethernet, Gigabit Ethernet • Scalability • Network growth

Switch Functions

•Address learning (MAC address table)
• Forward/filter decisions(only forwarded out the specified destination port)
• Loop avoidance((STP is used to stop network)

Configuring Basic Switch Management Access with IPv4

S1#configure terminal
S1 (config) # interface vlan 99
S1 (config-if) # ip address 172.17.99.11 255.255.255.0
S1 (config-if) # no shutdown
S1 (config-if) # exit
S1 (config) # ip default-gateway 172.17.99.1
S1 (config) # end
S1# copy running-config startup-config

•Dynamic MAC addresses –MAC Add. Added dynamically
• Sticky MAC addresses –Learned dynamically & can save permanently
•Permanent MAC addresses –Manually assign specific port that unchanged

Permanent MAC addresses

Port Security-Limits #of valid MAC Addr.on a switch port (More Secure)
Restrict port 0/1 so that only 3 MAC addresses can be learned on port 0/1

Switch (config) #interface Ethernet 0/1
Switch (config-if) # switchport port-security maximum 3(default 1)

Port Security do in 2 modes

***Access Mode- End device Connection**

Switch# interface E0/4
Switch (config-if) #switchport mode access
Switch (config-if) #switchport port-security
Switch (config-if) #switchport port-security mac-address 0200.1111.1111

*Disable Unused Ports using **shutdown**
*Use show **port-security interface** to verify max # MAC addresses

VLAN

***Trunk Mode- Connect Switch**

S1# Configuration terminal
S1 (config) # interface FastEthernet0/1
S1 (config-if) # switchport mode trunk
S1 (config-if) # switchport trunk allowed vlan 10,20,30,99
S1 (config-if) # end

No switchport allowed vlan<vlan list> (**Disable**)
No switchport allowed native vlan (Default)

Inter-VLAN Routing Using Routers

Configure Router-on-a Stick: Switch

S1 (config) # vlan 10
S1 (config-vlan) # vlan 30
S1 (config-vlan) # interface f0/5
S1 (config-if) # switchport mode trunk
S1 (config-if) # end

Configure Router-on-a Stick: Router

R1 (config) # interface g0/0.10(subintrfce)
R1 (config-subif) # encapsulation dot1q 10
R1 (config-subif) # ip address 172.17.10.1 255.255.255.0
R1 (config-subif) #exit

Creating VLAN

S1 (config) # interfaceg0/0
S1 (config) # no shutdown
S1# config t
S1 config) # vlan 10
S1 (config-vlan) # name student
S1 (config-vlan) # end

Assigning ports

S1 (config) # interface f0/18
S1 (config-if) # switchport mode access
S1 (config-if) # switchport access vlan 20
S1 (config-if) # end