LINK AGGREGATION USING LACP AND PAgP

Report submitted to SASTRA Deemed to be University

as the requirement of the course

CSE 302: COMPUTER NETWORKS

Submitted by

SAM NISHANTH K

(Reg No.: 124004265, B.Tech` ***Electronics and Communication Engineering*****)**

DECEMBER 2022

SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

THANJAVUR, TAMILNADU, INDIA-613401

SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

THANJAVUR, TAMILNADU, INDIA-613401

Bonafide Certificate

This is to certify that the report titled "**LINK AGGREGATION USING LACP AND PAGP**" submitted as a requirement for the course, **CSE302: COMPUTER NETWORKS** for B.Tech. is a bonafide record of the work done by **Mr. SAM NISHANTH.K (Reg. No.124004265, B.Tech ELECTRONICS & COMMUNICATION ENGINEERING)** during the academic year 2021-22., in the School of Electrical and Electronics Engineering.

Project Based Work Viva voce held on 12th December,2022

Examiner 1 Examiner 2

ACKNOWLEDGEMENTS

First of all I express my gratitude to Prof. Dr S Vaidhyasubramaniam, Vice Chancellor, SASTRA Deemed to be University, who provided all facilities and constant encouragement during my study. I extend my sincere thanks to Prof. R Chandramouli, Registrar, SASTRA Deemed to be University for providing the opportunity to pursue this project.

I owe a debt of most profound gratitude to my mentor Dr. Rajesh.A (ECE/SEEE) for his valuable inputs, able guidance, encouragement, wholehearted cooperation and constructive criticism throughout my project on the topic “**LINK AGGREGATION USING LACP AND PAgP**”.

I take this opportunity to thank all my lecturers who have directly or indirectly helped my project.

LIST OF FIGURES

ABBREVIATIONS

LACP	-	Link Aggregation Control Protocol
PAgP	-	Port Aggregation Protocol
STP	-	Spanning Tree Protocol
Fa	-	Fast Ethernet
Gi	-	Gigabit Ethernet
IEEE	-	Institute of Electrical and Electronics Engineers
Mbps	-	Megabits per second
LAN	-	Local Area Network
VLAN	-	Virtual Local Area Network
BPDU	-	Bridge Protocol Data Unit
BID	-	Bridge ID
MAC	-	Media Access Control

ABSTRACT

A network loop occurs when a network has more than one active path carrying information from the same source to the same destination. The information loops and amplifies itself using the additional path instead of stopping when it reaches its destination. Network loops might cause a slow, irregular Internet connection or network failure.

Redundant links between switches is a good idea because they help prevent complete network failures in the event one link stops working. However, they often cause more problems because frames can be flooded down all redundant links simultaneously, this creates network loops. A looped topology is often desired to provide redundancy, but looped traffic is undesirable. The Spanning-Tree protocol was originally designed for bridges. Today, it is also applied to LAN switches and routers operating as a bridge. Spanning-Tree protocol ensures that all bridged segments are reachable but any points where loops occur will be blocked.

STP can help prevent bridge looping on LANs that include redundant links. Without STP, it would be difficult to implement that redundancy and still avoid network looping. STP monitors all network links, identifies redundant connections and disables the ports that can lead to looping.

One of the drawbacks of an STP is that in blocking redundant ports and paths, a spanning tree **reduces the aggregate available network bandwidth significantly**. Additionally, STP can result in circuitous and suboptimal communication paths through the network, adding latency and degrading application performance.

EtherChannel is a technology that was originally developed by **Cisco** as a LAN **switch-to-switch** technique of grouping several Fast or Gigabit Ethernet ports into one logical channel and redundancy without being blocked
by the Spanning Tree Protocol. EtherChannel configuration has one mode known as the
On mode. On mode forces the connection to bring all links up without using a protocol to negotiate connections. This mode can only connect to another device that is also set to on. When using this mode, the switch does not negotiate the link using either **PAgP** or **LACP**.

Configuration tasks can be done on the EtherChannel interface instead of on each individual port, ensuring configuration consistency throughout the links.
EtherChannel creates an aggregation that is seen as one logical link.
The loss of one physical link within the channel does not create a change in the topology; therefore a spanning tree recalculation is not required.
There is no need to upgrade the link to a faster and more expensive connection to have more bandwidth.

Table of Contents

CHAPTER 1

INTRODUCTION

Spanning Tree Protocol:

Spanning Tree Protocol (STP) is a Layer 2 network protocol used to prevent looping within a network topology. STP was created to avoid the problems that arise when computers exchange data on a local area network (LAN) that contains redundant paths. If the flow of traffic is not carefully monitored and controlled, the data can be caught in a loop that circles around network segments, affecting performance and bringing traffic to a near halt.

Networks are often configured with redundant paths when connecting network segments. Although redundancy can help protect against disaster, it can also lead to bridge or switch looping. Looping occurs when data travels from a source to a destination along redundant paths and the data begins to circle around the same paths, becoming amplified and resulting in a broadcast storm.

STP can help prevent bridge looping on LANs that include redundant links. Without STP, it would be difficult to implement that redundancy and still avoid network looping. STP monitors all network links, identifies redundant connections and disables the ports that can lead to looping.

Terms used in Spanning-Tree Protocol

BPDU Bridge Protocol Data Unit (BPDU) — All the switches exchange information to use in the selection of the root Switch

Bridge ID — The bridge ID is how STP keeps track of all the switches in the network. It is determined by a combination of the bridge priority (32,768 by default on all Cisco switches) and the base MAC address.

Root Bridge -The bridge with the lowest bridge ID becomes the root bridge in the network.

Nonroot bridge — These are all bridges that are not the root bridge.

Root port — The root port is always the link directly connected to the root bridge or the shortest path to the root bridge. If more than one link connects to the root bridge, then a port cost is determined by checking the bandwidth of each link.

Designated port — A designated port is one that has been determined as having the best (lowest) cost.
A designated port will be marked as a forwarding port.

Nondesignated Port — A nondesignated port is one with a higher cost than the designated port. Nondesignated ports are put in blocking mode.

Forwarding Port — A forwarding port forwards frames.

Blocked Port — A blocked port is the port that will not forward frames, in order to prevent loops

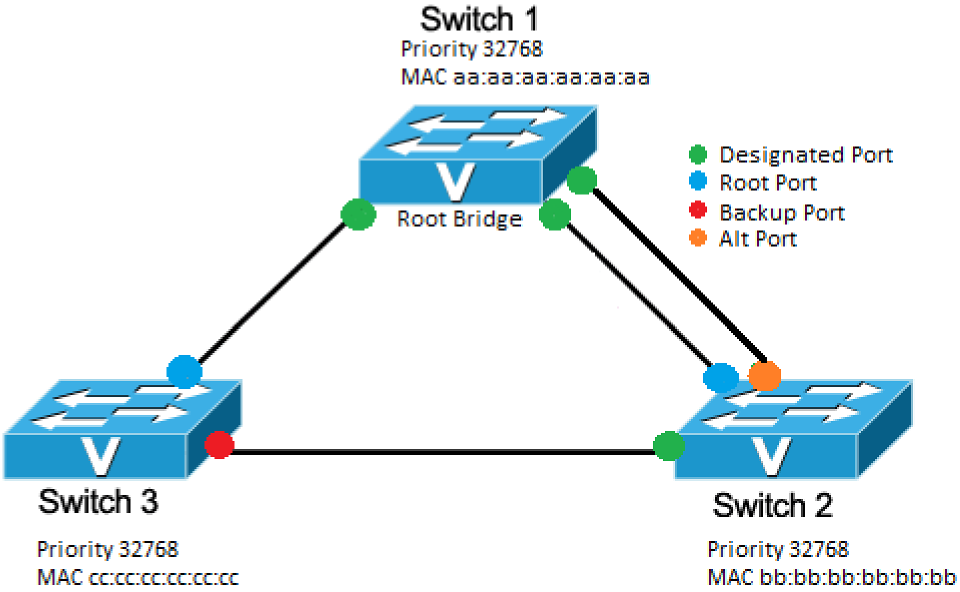

Fig. 1.1 STP Example

Electing Root Switch :

All switches in a LAN exchange Hello BPDU with each other. Firstly all switches consider themselves root switches but the root switch is selected based on the BID of a switch. A switch having a lower priority bit in BID is a selected root switch. If the priority bit gets tied, then the switch has a lower MAC address in Hello BPDU is the selected root switch. In the diagram shown below, SW1 becomes the Root switch after comparing BID from each switch in LAN.

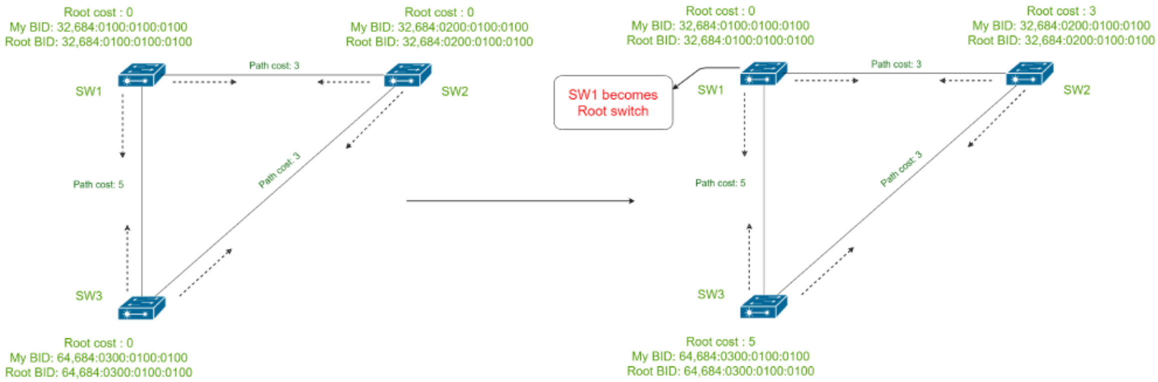

Fig. 1.2 Diagram of Root switch election

Choosing Root port on Non-root Switches :

The ports in each switch having minimum path cost to the root switch are chosen as the root port for that switch. In the diagram shown below, the Gi0/1 port of both SW2 and SW3 is chosen as the Root port (RP).

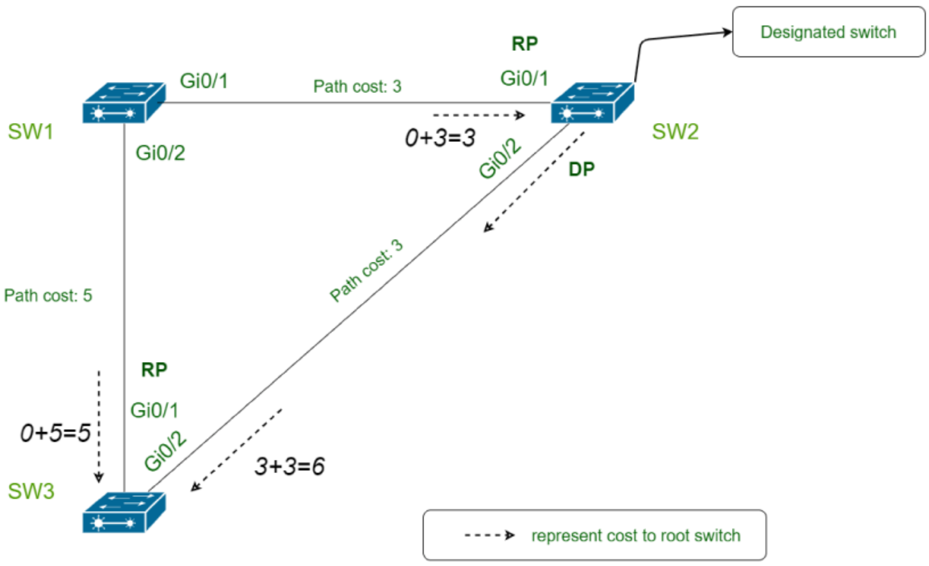

Fig. 1.3 Diagram of choosing Root-Port Non-Root port switches

Drawback of STP

One of the drawbacks of an STP is that in blocking redundant ports and paths, a spanning tree reduces the aggregate available network bandwidth significantly. Additionally, STP can result in circuitous and suboptimal communication paths through the network, adding latency and degrading application performance. A spanning tree cannot be easily segregated into smaller domains to provide better scalability, fault isolation, or multitenancy. Finally, the time taken to re compute the spanning tree and propagate the changes in the event of a failure can vary widely, and sometimes become quite large (seconds to minutes). This is highly disruptive for elastic applications and virtual machine migrations, and can lead to cascaded system level failures.

Because of its cost and difficulties with termination the STP is very Rarely used in Ethernet networks

Bandwidth of a channel can be increased by

- Replacing the existing link with a higher speed link.
- Add more redundant paths.
- Implementation of ***ETHERCHANNEL*** for Link Aggregation

CHAPTER 2

ETHERCHANNEL

Wired methods of Networking are proven more effective than wireless. But while networking, it’s troublesome to manage many wires at once. To solve this problem, link aggregation plays a vital role. since it’s known to carry **multiple ports** collectively **as a single channel**. In other words, link aggregation combines multiple physical ports as one port, which makes it easy to carry out the task by the user. Also, it makes the process cost-effective

EtherChannel is a port link aggregation technology in which multiple physical port links are grouped into one logical link. It is used to provide high-speed links and redundancy. A maximum of 8 links can be aggregated to form a single logical link.

EtherChannel is a technology that was originally developed by **Cisco** as a LAN **switch-to-switch** technique of grouping several Fast or Gigabit Ethernet ports into one logical channel and redundancy without being blocked by the Spanning Tree Protocol. EtherChannel configuration has one mode known as the On mode.

On mode forces the connection to bring all links up without using a protocol to negotiate connections. This mode can only connect to another device that is also set to on. When using this mode, the switch does not negotiate the link using either PAgP or LACP.

Protocols for Link Aggregation

LACP:

LACP is an IEEE standard, which is a part of the IEEE 802.3 ad specification. LACP Ether Channel can be configured with a maximum of 16 Ethernet ports of the same kind. In that case, only up to eight links in the Link Aggregation Group will be activated, while the remaining eight links will be on standby mode. In the process, link aggregation takes place through two different modes, Active or Passive. Both are briefly explained below:

Active: To form an LACP connection, this interface keeps sending packets actively.

Passive: On the other hand, in the passive mode, the interface can give a response to LACP, but cannot initiate itself.

PAgP:

Port Aggregation Protocol (PAgP) provides the same negotiation benefits as LACP. PAgP is a Cisco proprietary protocol, and it will work only on Cisco devices. PAgP packets are exchanged between switches over EtherChannel capable ports. PAgP also has 2 modes Auto and Desirable.

• Auto mode sets the interface to respond to PAgP negotiation packets, but the interface will not start negotiations on its own.

• Desirable mode sets the interface to actively attempt to negotiate a PAgP connection.

CHAPTER 3

WORKING

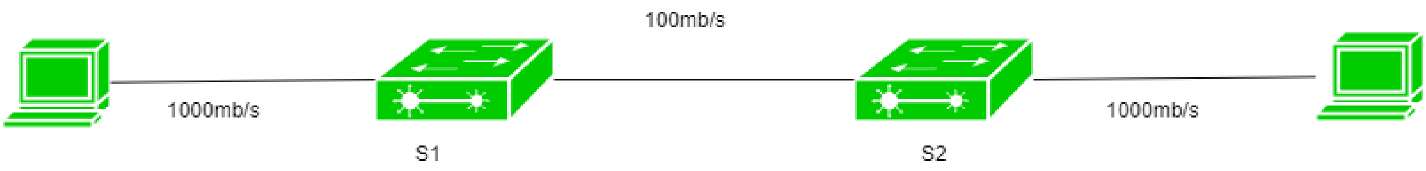

Fig 3.1 Switch Topology Example

Here is a topology in which two switches are connected with one PC each. The link between the switches and PC is 1000mb/s and the link between the switches is 100mb/s.

Now, suppose if you want to send traffic of more than 100mb/s then we have congestion as the link between the switches is of 100mb/s only and packets will start dropping. Now, to solve this problem, we should have a high-speed link between the switches. To achieve this, We can simply replace the current link with a high-speed link or we can bundle up more than one link of the same speed of 100mb/s. By forming an EtherChannel, you can bundle up more than one link into a single logical link. But, as you connect the switches with more than one link, STP (Spanning Tree Protocol) will block the least redundant link. As we have made an EtherChannel, all the links (that are grouped as one logical link k) will be treated as single logical links therefore no link will be blocked and also, it will provide us high-speed link and redundancy in our network.

Criteria – To form an EtherChannel, all ports should have:

1. Same duplex
2. Same speed

3. Same VLAN configuration (i.e., native VLAN and allowed VLAN should be same)
4. Switch port modes should be the same (access or trunk mode)

EtherChannel protocols – To form an EtherChannel, there are 2 protocols, port aggregation protocol (PAgP) and link aggregation control protocol (LACP).

1. **Port Aggregation Protocol (PAgP) –**
   The Cisco proprietary protocol Port Aggregation Protocol (PAgP) is an EtherChannel technology. It's a type of data/traffic load balancing that involves the logical aggregation of Cisco Ethernet switch ports.
   A PAgP EtherChannel can merge up to eight physical links into one virtual link. LACP, or Link Aggregation Control Protocol, is an IEEE open standard. These are namely:

1. **ON:** In this mode, the interface will be a part of EtherChannel but no negotiation takes place.
2. **Desirable:** In this mode, the interface will continuously attempt to convert the other side interface into an EtherChannel.
3. **Auto:** In this mode, the interface will become a part of EtherChannel if and only if it is requested by the opposite interface.
4. **Off:** No EtherChannel configured on the interface.

Configuration –

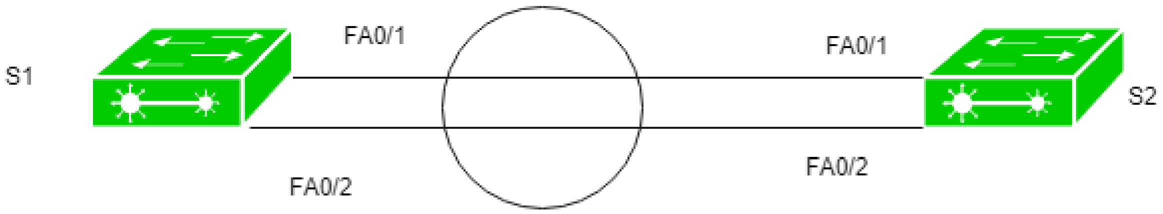

Fig 3.2 Link Aggregation

There is a small topology in which 2 switches S1 and S2 are connected with each other and we have to bundle these two links into a single logical link.

```
S1(config)# interface fa0/1
S1(config-if)# channel-group 1 mode desirable
S1(config)# interface fa0/2
```

```
S1(config-if)# channel-group 1 mode desirable

S1(config)# interface port-channel 1
S1(config-if)# switchport trunk encapsulation dot1q
S1(config-if)# switchport mode trunk
```

Here, the user has used the mode desirable and switch-port mode trunk. The modes should be the same on both switches therefore the user will configure this on the other switch also.

Now, configuring on switch S2:

```
S2(config)# interface fa0/1
S2(config-if)# channel-group 1 mode desirable
S2(config)# interface fa0/2
S2(config-if)# channel-group 1 mode desirable
S2(config)# interface port-channel 1
S2(config-if)# switchport trunk encapsulation dot1q
S2(config-if)# switchport mode trunk
```

2. Link Aggregation Control Protocol (LACP) –

Link Aggregation Control Protocol is an IEEE protocol, originally defined in 802.3ad, used to form an EtherChannel. This protocol is almost similar to Cisco PAgP. There are different modes in which you can configure your interface. These are namely:

1. **ON:** In this mode, the interface will be a part of EtherChannel but no negotiation takes place
2. **Active:** In this mode, the interface will continuously attempt to convert the other side interface into an EtherChannel.
3. **Passive:** In this mode, the interface will become a part of EtherChannel if and only if it is requested by the opposite interface.
4. **Off:** No EtherChannel configured on the interface.

Configuration –

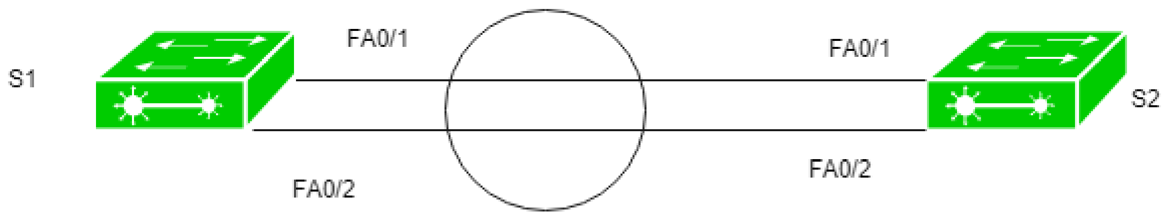

Fig 3.1 Link Aggregation

Taking the same topology, you will now configure LACP on both switches.

First, configuring for S1:

```
S1(config)# interface fa0/1
S1(config-if)# channel-group mode active
S1(config)# interface fa0/2
S1(config-if)# channel-group mode active

S1(config)# interface port-channel 1
S1(config-if)# switchport trunk encapsulation dot1q
S1(config-if)# switchport mode trunk
```

Now, configuring for S2:

```
S2(config)# interface fa0/1
S2(config-if)# channel-group mode active
S2(config)# interface fa0/2
S2(config-if)# channel-group mode active

S2(config)# interface port-channel 1
S2(config-if)# switchport trunk encapsulation dot1q
S2(config-if)# switchport mode trunk
```

CHAPTER 4

MERITS

MERITS OF LAC and PAg PROTOCOL:

- Increased **Bandwidth**: Use EtherChannel and combine two or four links into one logical link. It will double or quadruple your bandwidth. For example, four 100Mb Fast Ethernet connections bonded into one could provide you up to 800Mb/second, full duplex.

- Provides **Redundancy**: Since there are many Ethernet links combined into one logical channel, it automatically allows more available links in case one or more links go down.

- Most configuration tasks can be done on the EtherChannel interface instead of on each individual port, ensuring configuration consistency throughout the links.

- EtherChannel relies on existing switch ports. There is no need to upgrade the link to a faster and more expensive connection to have more bandwidth.

❖ **Load balancing** takes place between links that are part of the same EtherChannel. Depending on the hardware platform, one or more load-balancing methods can be implemented. These methods include source MAC to destination MAC load balancing, or source IP to destination IP load balancing, across the physical links.

❖ EtherChannel creates an aggregation that is seen as one logical link. When several EtherChannel bundles exist between two switches, STP may block one of the bundles to prevent switching loops. When STP blocks one of the redundant links, it blocks the entire EtherChannel. This blocks all the ports belonging to that EtherChannel link. Where there is only one EtherChannel link, all physical links in the EtherChannel are active because STP sees only one (logical) link.

❖ EtherChannel provides redundancy because the overall link is seen as one logical connection. Additionally, the loss of one physical link within the channel does not create a change in the topology; therefore a spanning tree recalculation is not required. Assuming at least one physical link is present; the EtherChannel remains functional, even if its overall throughput decreases because of a lost link within the EtherChannel.

CHAPTER 5

Configuration

In this project, we have 3 switches to be configured.

Switch 1 CLI:

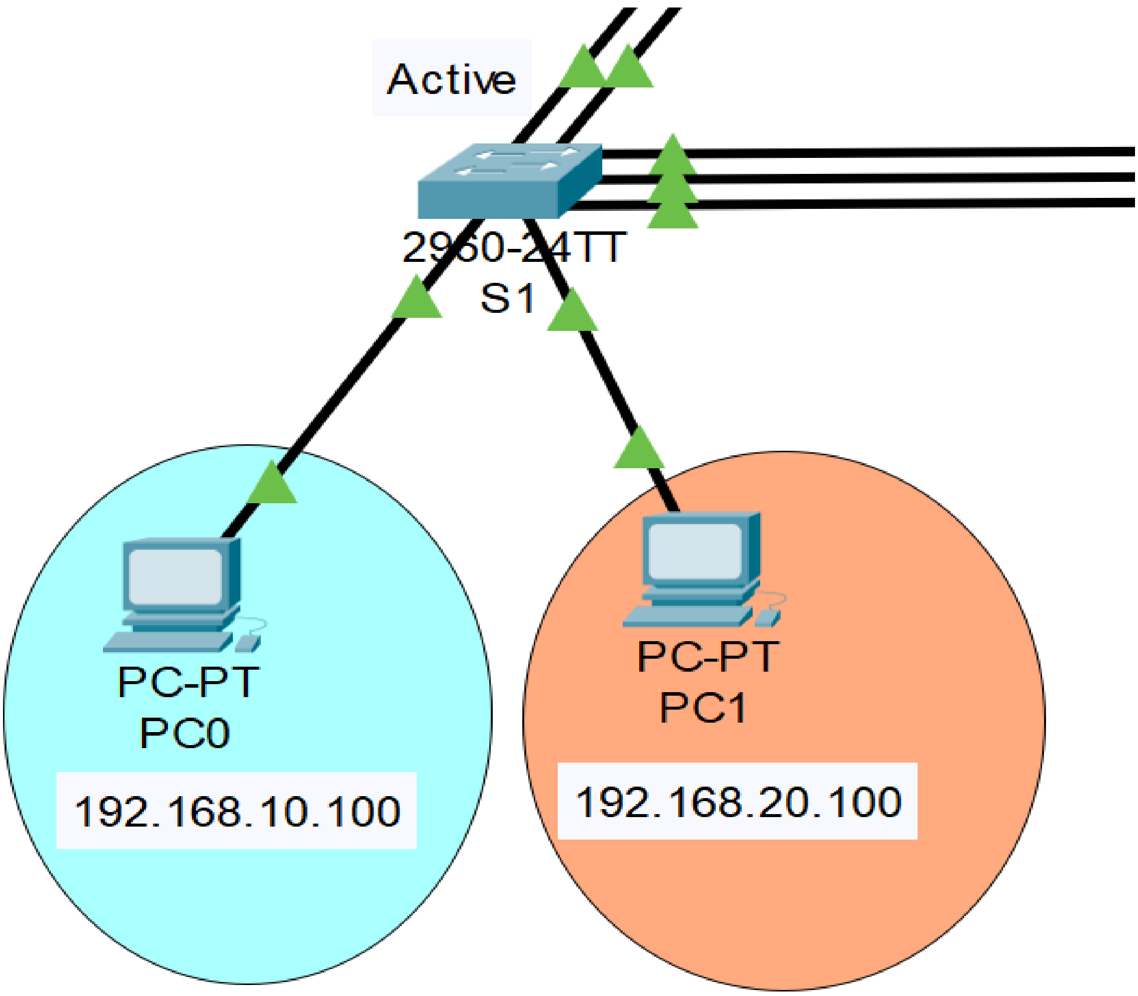

Fig 5.1 Switch 1 Links

Command Line Interface:

CHANNEL GROUP 3(Static)

```
S1>enable
S1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
S1(config)#interface range fastethernet 0/17-19
S1(config-if-range)#channel-group 3 mode on
```

CHANNEL GROUP 1(LACP)

```
S1(config-if-range)#exit
S1(config)#interface range gigabitethernet 0/1-2
S1(config-if-range)#channel-group 1 mode active
```

Switch 2 CLI:

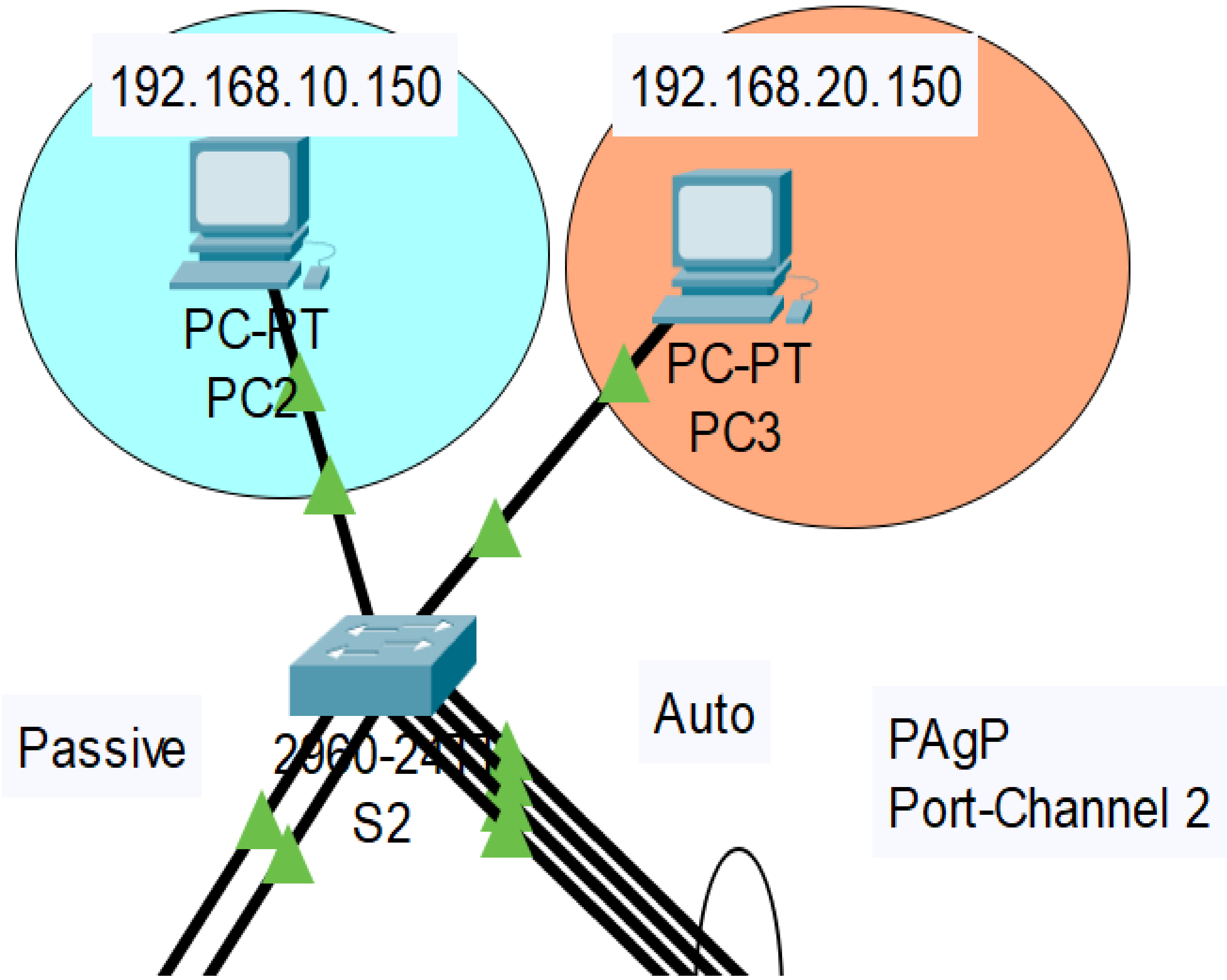

Figure 5.2 Switch 2 Links

Command Line Interface:

CHANNEL GROUP 1(LACP)

```
S2>enable
S2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
S2(config)#interface range gigabitethernet 0/1-2
S2(config-if-range)#channel-group 1 mode passive
```

CHANNEL GROUP 2(PAgP)

```
S2(config)#interface range fastethernet 0/21-24
S2(config-if-range)#channel-group 3 mode auto
```

Switch 3 CLI:

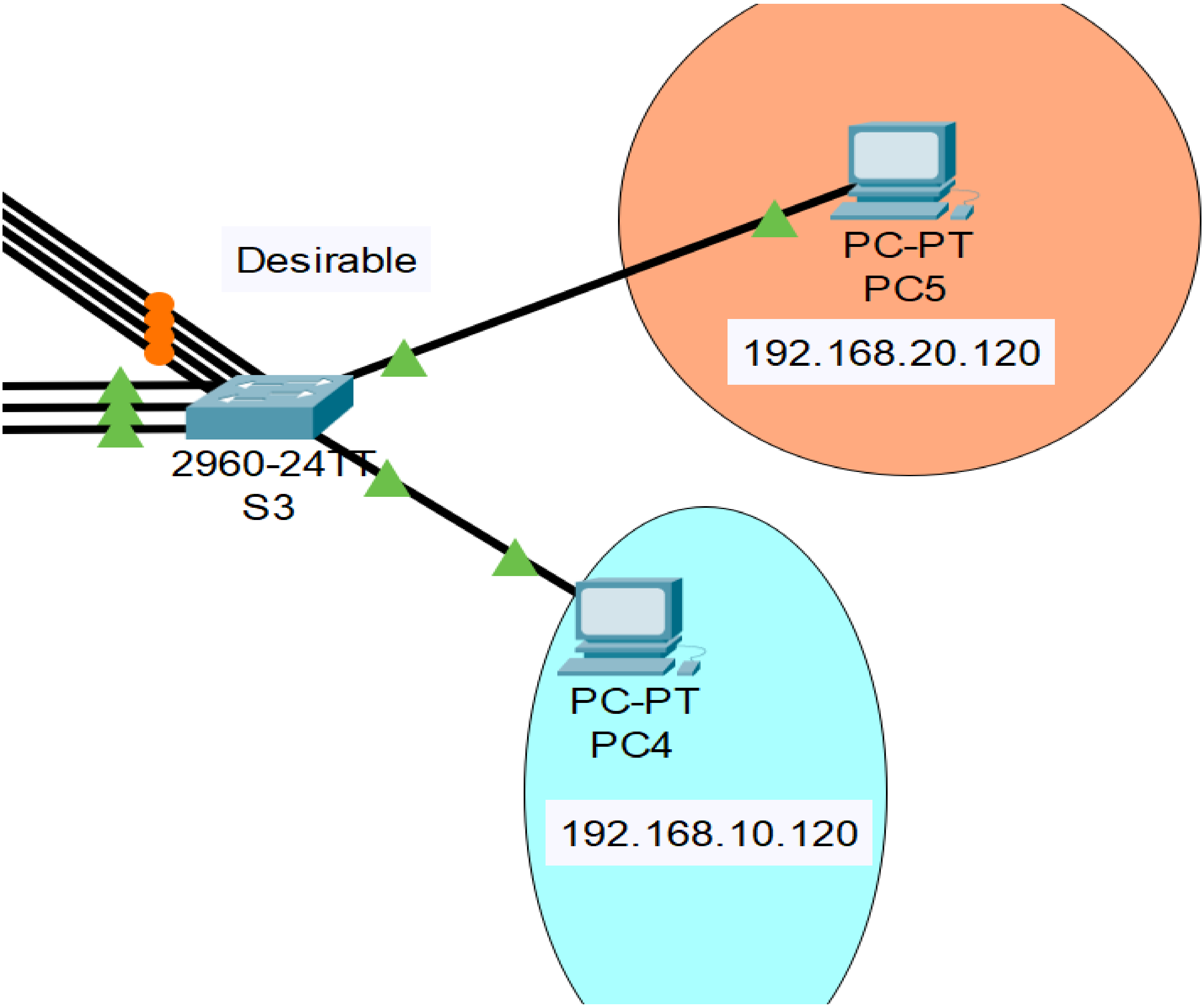

Fig 5.3 Switch 3 links

Command Line Interface:

CHANNEL GROUP 2(PAgP)

```
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#interface range fastethernet 0/21-24
Switch(config-if-range)#channel-group 2 mode desirable
```

CHANNEL GROUP 3(Static)

```
Switch(config)#interface range fastethernet 0/17-19
Switch(config-if-range)#channel-group 3 mode on
```

CHAPTER 6

SNAPSHOTS

ETHERCHANNEL GROUPS ARE CREATED ON EACH SWITCH WITH THEIR RESPECTIVE PROTOCOLS USED FOR CONFIGURING

Switch 1

```
Device Name: S1
Custom Device Model: 2960 IOS15
Hostname: S1

Port                 Link   VLAN   IP Address         MAC Address
Port-channel1        Up     --     <not set>          0000.0CA3.893E
Port-channel3        Up     --     <not set>          0001.96EE.4880
FastEthernet0/1      Up     10     --                 000C.CF19.CA01
FastEthernet0/2      Down   1      --                 000C.CF19.CA02
FastEthernet0/3      Down   1      --                 000C.CF19.CA03
FastEthernet0/4      Down   1      --                 000C.CF19.CA04
FastEthernet0/5      Down   1      --                 000C.CF19.CA05
FastEthernet0/6      Down   1      --                 000C.CF19.CA06
FastEthernet0/7      Down   1      --                 000C.CF19.CA07
FastEthernet0/8      Down   1      --                 000C.CF19.CA08
FastEthernet0/9      Down   1      --                 000C.CF19.CA09
FastEthernet0/10     Up     20     --                 000C.CF19.CA0A
FastEthernet0/11     Down   1      --                 000C.CF19.CA0B
FastEthernet0/12     Down   1      --                 000C.CF19.CA0C
FastEthernet0/13     Down   1      --                 000C.CF19.CA0D
FastEthernet0/14     Down   1      --                 000C.CF19.CA0E
FastEthernet0/15     Down   1      --                 000C.CF19.CA0F
FastEthernet0/16     Down   1      --                 000C.CF19.CA10
FastEthernet0/17     Up     --     --                 000C.CF19.CA11
FastEthernet0/18     Up     --     --                 000C.CF19.CA12
FastEthernet0/19     Up     --     --                 000C.CF19.CA13
FastEthernet0/20     Down   1      --                 000C.CF19.CA14
FastEthernet0/21     Down   1      --                 000C.CF19.CA15
FastEthernet0/22     Down   1      --                 000C.CF19.CA16
FastEthernet0/23     Down   1      --                 000C.CF19.CA17
FastEthernet0/24     Down   1      --                 000C.CF19.CA18
GigabitEthernet0/1   Up     --     --                 000C.CF19.CA19
GigabitEthernet0/2   Up     --     --                 000C.CF19.CA1A
Vlan1                Down   1      <not set>          00E0.F76B.9002
```

Fig 6.1 Switch 1 Interfaces

Spanning tree Switch 1

```
S1>enable
S1#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     0001.9682.51AE
             Cost        3
             Port        27(Port-channel1)
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     00E0.F76B.9002
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- ---------------------------
Gi0/2            Desg FWD 4         128.26   P2p
Gi0/1            Desg FWD 4         128.25   P2p
Po1              Root FWD 3         128.27   Shr
Po3              Desg FWD 8         128.28   Shr

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    32778
             Address     0001.9682.51AE
             Cost        3
             Port        27(Port-channel1)
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
 --More--
```

Fig 6.2 Switch 1 STP

```
S1>enable
S1#show etherchannel summary
Flags:  D - down        P - in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 2
Number of aggregators:           2

Group  Port-channel  Protocol    Ports
------+-------------+-----------
+----------------------------------------------

1      Po1(SU)           LACP   Gig0/1(P) Gig0/2(P)
3      Po3(SU)           -      Fa0/17(P) Fa0/18(P) Fa0/19(P)
```

Fig 6.3 Switch 1 Etherchannels

Hence etherchannel 1 and 3 are created in Switch 1

Switch 2

```
Device Name: S2
Custom Device Model: 2960 IOS15
Hostname: S2

Port                 Link   VLAN   IP Address         MAC Address
Port-channel1        Up     --     <not set>          00D0.58D3.D858
Port-channel2        Up     --     <not set>          0001.4221.0566
FastEthernet0/1      Up     10     --                 0001.63A7.8501
FastEthernet0/2      Down   1      --                 0001.63A7.8502
FastEthernet0/3      Down   1      --                 0001.63A7.8503
FastEthernet0/4      Down   1      --                 0001.63A7.8504
FastEthernet0/5      Down   1      --                 0001.63A7.8505
FastEthernet0/6      Down   1      --                 0001.63A7.8506
FastEthernet0/7      Down   1      --                 0001.63A7.8507
FastEthernet0/8      Down   1      --                 0001.63A7.8508
FastEthernet0/9      Down   1      --                 0001.63A7.8509
FastEthernet0/10     Up     20     --                 0001.63A7.850A
FastEthernet0/11     Down   1      --                 0001.63A7.850B
FastEthernet0/12     Down   1      --                 0001.63A7.850C
FastEthernet0/13     Down   1      --                 0001.63A7.850D
FastEthernet0/14     Down   1      --                 0001.63A7.850E
FastEthernet0/15     Down   1      --                 0001.63A7.850F
FastEthernet0/16     Down   1      --                 0001.63A7.8510
FastEthernet0/17     Down   1      --                 0001.63A7.8511
FastEthernet0/18     Down   1      --                 0001.63A7.8512
FastEthernet0/19     Down   1      --                 0001.63A7.8513
FastEthernet0/20     Down   1      --                 0001.63A7.8514
FastEthernet0/21     Up     --     --                 0001.63A7.8515
FastEthernet0/22     Up     --     --                 0001.63A7.8516
FastEthernet0/23     Up     --     --                 0001.63A7.8517
FastEthernet0/24     Up     --     --                 0001.63A7.8518
GigabitEthernet0/1   Up     --     --                 0001.63A7.8519
GigabitEthernet0/2   Up     --     --                 0001.63A7.851A
Vlan1                Down   1      <not set>          0001.9682.51AE
```

Fig 6.4 Switch 2 Interfaces

Spanning tree Switch 2

```
S2>enable
S2#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     0001.9682.51AE
             This bridge is the root
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0001.9682.51AE
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/21           Desg FWD 19        128.21   P2p
Fa0/22           Desg FWD 19        128.22   P2p
Fa0/23           Desg FWD 19        128.23   P2p
Fa0/24           Desg FWD 19        128.24   P2p
Gi0/1            Desg FWD 4         128.25   P2p
Gi0/2            Desg FWD 4         128.26   P2p
Po1              Desg FWD 3         128.27   Shr
Po2              Desg FWD 7         128.28   Shr

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    32778
             Address     0001.9682.51AE
             This bridge is the root
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
             Address     0001.9682.51AE
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  20
```

Fig 6.5 Switch 2 STP

```
S2>enable
S2#show etherchannel summary
Flags:  D - down        P - in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 2
Number of aggregators:           2

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------

1      Po1(SU)           LACP   Gig0/1(P) Gig0/2(P)
2      Po2(SU)           PAgP   Fa0/21(P) Fa0/22(P) Fa0/23(P) Fa0/24(P)
```

Fig 6.6 Switch 2 Etherchannels

Hence etherchannel 1 and 2 are created in Switch 2

Switch 3

```
Device Name: S3
Custom Device Model: 2960 IOS15
Hostname: Switch

Port                 Link   VLAN   IP Address         MAC Address
Port-channel2        Up     --     <not set>          000D.BD35.CB56
Port-channel3        Up     --     <not set>          0060.7099.197D
FastEthernet0/1      Up     10     --                 0060.3E81.3701
FastEthernet0/2      Down   1      --                 0060.3E81.3702
FastEthernet0/3      Down   1      --                 0060.3E81.3703
FastEthernet0/4      Down   1      --                 0060.3E81.3704
FastEthernet0/5      Down   1      --                 0060.3E81.3705
FastEthernet0/6      Down   1      --                 0060.3E81.3706
FastEthernet0/7      Down   1      --                 0060.3E81.3707
FastEthernet0/8      Down   1      --                 0060.3E81.3708
FastEthernet0/9      Down   1      --                 0060.3E81.3709
FastEthernet0/10     Up     20     --                 0060.3E81.370A
FastEthernet0/11     Down   1      --                 0060.3E81.370B
FastEthernet0/12     Down   1      --                 0060.3E81.370C
FastEthernet0/13     Down   1      --                 0060.3E81.370D
FastEthernet0/14     Down   1      --                 0060.3E81.370E
FastEthernet0/15     Down   1      --                 0060.3E81.370F
FastEthernet0/16     Down   1      --                 0060.3E81.3710
FastEthernet0/17     Up     --     --                 0060.3E81.3711
FastEthernet0/18     Up     --     --                 0060.3E81.3712
FastEthernet0/19     Up     --     --                 0060.3E81.3713
FastEthernet0/20     Down   1      --                 0060.3E81.3714
FastEthernet0/21     Up     --     --                 0060.3E81.3715
FastEthernet0/22     Up     --     --                 0060.3E81.3716
FastEthernet0/23     Up     --     --                 0060.3E81.3717
FastEthernet0/24     Up     --     --                 0060.3E81.3718
GigabitEthernet0/1   Down   1      --                 0060.3E81.3719
GigabitEthernet0/2   Down   1      --                 0060.3E81.371A
Vlan1                Down   1      <not set>          000A.F313.AB19
```

Fig 6.7 Switch 3 Interfaces

Spanning tree Switch 2

```
Switch>enable
Switch#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     0001.9682.51AE
             Cost        7
             Port        27(Port-channel2)
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     000A.F313.AB19
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/22           Desg FWD 19        128.22   P2p
Fa0/21           Desg FWD 19        128.21   P2p
Fa0/24           Desg FWD 19        128.24   P2p
Fa0/23           Desg FWD 19        128.23   P2p
Po2              Root FWD 7         128.27   Shr
Po3              Altn BLK 8         128.28   Shr

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    32778
             Address     0001.9682.51AE
             Cost        7
             Port        27(Port-channel2)
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
 --More--
```

Fig 6.8 Switch 3 STP

```
Switch>enable
Switch#show etherchannel summary
Flags:  D - down        P - in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 2
Number of aggregators:           2

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-------------------------------------------

2      Po2(SU)           PAgP   Fa0/21(P) Fa0/22(P) Fa0/23(P) Fa0/24(P)
3      Po3(SU)           -      Fa0/17(P) Fa0/18(P) Fa0/19(P)
```

Fig 6.9 Switch 3 Etherchannels

Hence etherchannel 2 and 3 are created in Switch 3

CHAPTER 7

Conclusion

Why Do We Need EtherChannel?

Increased Bandwidth

In our network planning, we always take into account the cost. For example, our company needs more than 100 Mbps bandwidth, but our hardware only supports Fast Ethernet (100 Mbps). In this case, we can opt not to upgrade the hardware by implementing EtherChannel.

Also, we might think that if we have two or more links between two switches, like in our figure above, then we can utilize the full bandwidth of these links. But, in a traditional network setup, Spanning Tree Protocol (STP) blocks one redundant link to avoid Layer 2 loops. Our solution to this problem? EtherChannel.

EtherChannel aggregates or combines traffic across all available active links, which makes it look like one logical cable. So in our example, if we have 8 active links with 100 Mbps each, that will be a total of 800 Mbps. If any of the physical links inside the EtherChannel go down, STP will not see this and will not recalculate.

Redundancy

Since more than one physical connection is combined into one logical connection, EtherChannel enables more available links in instances where one or more links go down.

Load Balancing

With load balancing, we are able to balance the traffic load across the links and improves the efficient use of bandwidth.

CHAPTER 8

References

- https://www.geeksforgeeks.org/etherchannel-in-computer-network/

- https://en.wikipedia.org/wiki/EtherChannel

- https://www.cisco.com/c/en/us/tech/lan-switching/etherchannel/index.html

- https://study-ccna.com/what-is-etherchannel/

- https://www.youtube.com/watch?v=j6-kadxwIFQ

- https://www.geeksforgeeks.org/link-aggregation-control-protocol/

- https://en.wikipedia.org/wiki/Port_Aggregation_Protocol