Optimizing Spanning Tree Protocol using Port Channel For Greener Switching

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***Abstract*— Redundant design in layer 2 networks gives rise to problems such as mislearning of MAC addresses, broadcast storms and multiple frame copies. To prevent this IEEE 802.1d Spanning tree protocol is used. Spanning tree protocol removes the redundant links by disabling the ports to which the redundant links are connected. When the active link goes down the spanning tree protocol has to be executed again to place a redundant connection as active link. This causes convergence issues. Port Channels allows grouping of several Ethernet links to create one logical connection. In this paper we have used the redundant links between switches as port channels thereby making the switch to believe that there is only one connection instead of multiple physical connections to a switch thereby spanning tree protocol is never executed. Experimental analysis also showed that using port channels to eliminate layer 2 loops causes increase in bandwidth, enables load balancing and faster convergence between the links in the network. Power Consumed was also shown to be lesser in our experiments.**

***Keywords*— Redundant, Greener Switching, spanning tree protocol, convergence, Port Channel, switches, load balancing, Power.**

I. Introduction

Layer 2 redundancy commonly introduces layer 2 loops into a network design, which can create the following layer 2 problems [1].

- Multiple Frame Copies.
- Broadcast Storms.
- Mislearning Mac addresses.

Spanning tree protocol is used to remove layer 2 loops from the topology. Spanning tree protocol has a convergence time of 50-60 seconds per switch, so for a large network the convergence time would be huge. The spanning tree algorithm would need to be executed every time a new switch or a link comes up or goes down in the network. This creates performance issues on a layer 2 network. Such drawbacks have led to the development of certain protocols such as backbone fast, uplink fast and port fast. But these protocols still suffer from high convergence times. Our paper uses the concept of port channels to achieve faster convergence times and prevents the spanning tree algorithm to be executed every time a link goes up or comes down.

II. Port Channel

Port Channel is a layer 2 protocol. This is also called an Etherchannel or a Link Aggregation group depending on the documentation or the vendor being dealt with [2]. This port channel uses Link Aggregation and Control Protocol (LACP) to signal the establishment of the channel between two devices. Port Channel basically does two things

- Increases the available bandwidth between the two devices.
- Creates one logical path out of multiple physical paths.

Plain old port channels can be used between most Ethernet switches and many server NIC drivers support LACP as well for providing a port channel between a server and its upstream switch.

A. Link Aggregation and Control Protocol

LACP protocol belongs to the group of Dynamic Link Aggregation Protocols (IEEE 802.1AX-2008) [3]. Link Aggregation Control Protocol (LACP) allows the exchange of information with regard to the link aggregation between the two members of said aggregation. This information will be packetized in Link Aggregation Control Protocol Data Units (LACDUs). Each individual port can be configured as an active or passive LACP using the control protocol.

- Passive LACP: The port prefers not transmitting LACPDUs. The port will only transmit LACPDUs when its counterpart uses *active LACP* (preference not to speak unless spoken to).
- Active LACP: The port prefers to transmit LACPDUs and thereby to speak the protocol, regardless of whether its counterpart uses *passive LACP* or not (preference to speak regardless).

III. Spanning Tree Protocol

Switches use STP to remove layer 2 loops in the network. STP belongs to IEEE 802.1D and it is enabled by default on all layer2 devices. STP-enabled switches communicate to form a topology of the entire switching network, and then shutting down (or blocking) a port if a loop exists [4]. The blocked port can be reactivated if another link on the switching network goes down, thus preserving fault-tolerance. Once all switches agree on the topology database, the switches are considered converged. The STP process and the STP port states are explained as follows.

A. STP PROCESS

To maintain a loop free environment the STP performs the following actions [5] :

- A Root Switch is elected.
- The Root Port on all switches is identified except on the root switch.
- The Designated Port is identified on all switches on the network except on the root switch.
- If a loop exists, a port is placed in blocking state. If the loop is removed the blocked port is activated again.

Due to a large number of steps that STP undergoes to remove layer2 loops network convergence becomes an issue [6].

B. STP PORT STATES

Switch ports participating in STP process undergoes the following 5 states [7].

- Blocking
- Listening
- Learning
- Forwarding
- Disabled

During the entire length of the STP process, the switch ports will be in either blocking, listening or learning states. In these states the switch ports do not forward user traffic. The entire STP process will last for about 50 seconds during which all user traffic is dropped.

After the STP has been executed the switches decide upon which port to place in the disabled state. Once the switches in which there is more than one connection to the root switch place the ports in disabled state, the remaining ports are placed in the forwarding state and they start to forward user traffic.

IV. PORT CHANNEL IN STP

When more than one physical port on a switch is combined into a virtual port then the virtual port is called a port channel. During STP process switches which have more than one port connecting to the root switch, place the extra ports in disabled state. Thus even though there is bandwidth available it is not being used [8].

Thereby we combine all the switch ports which are connected to the root switch into a port channel, this makes the switch to see that there is only one port connecting to the root switch therefore the STP process of electing the root port on this switch will not be executed, but the bandwidth will be equal to the no of physical ports which uplink to the root switch [9]. Load Balancing can also be done on the physical ports in the port channel.

V. EXPERIMENTAL ANALYSIS

Experimental analysis of using Port channels to optimize the STP process was carried out using 3 Catalyst 2960 Cisco switches. We have used perl script to automate the process of placing physical ports in each redundancy in port channel. Our network topology is as shown in figure 1.

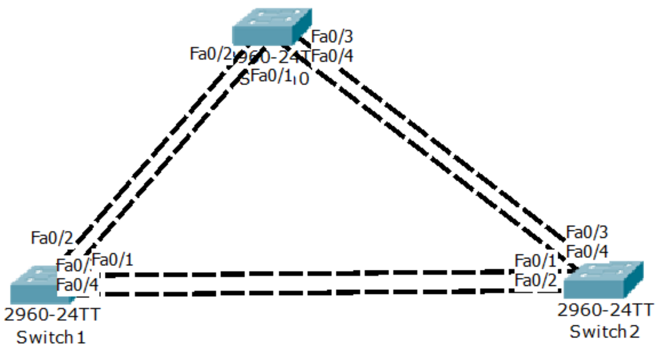

Fig. 1 Network Topology used in our experiment

A. NORMAL STP PROCESS

During the normal STP process the root switch elected was switch 0, the root ports on switches 1 and 2 were Fa0/1 and Fa 0/3 respectively. All other ports on switch 1 and switch 2 were in blocked state [10].

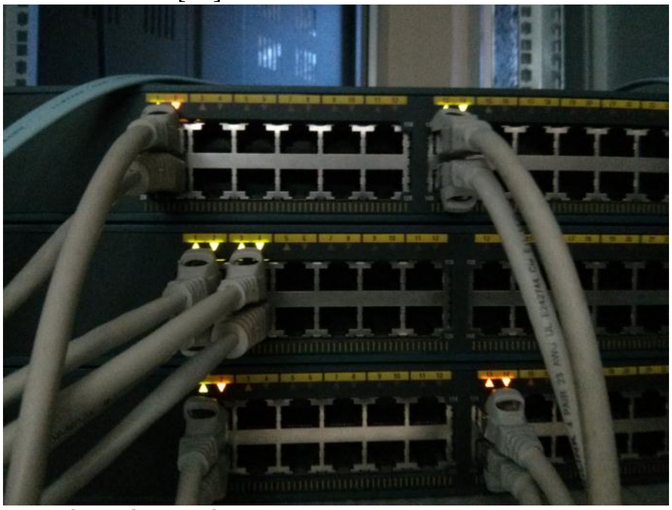

Fig. 2 The catalyst switches running STP.

The green colour link lights indicate that the packets are being forwarded out of these ports, whereas the orange coloured lights indicate that the port has been placed in disabled state by the Spanning Tree Algorithm.

B. *Port Channel in STP PROCESS*

We have placed the pair of redundant links to the root switch in a port channel.Fa0/1 and Fa0/2 of switch 1 are placed in port channel number 1 [11]. Fa0/4 and Fa0/3 are placed in port channel number 2.The respective ports to which these links uplink to in the root switch are also placed in the respective passive port channels .Also the redundant link between switch1 and switch 2 have been placed in port channel number 3. The effective topology now becomes

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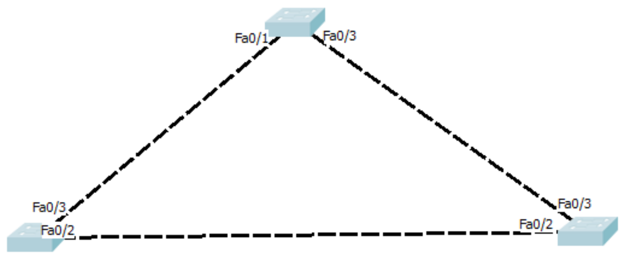


Fig. 3 The effective topology after using port channels.

The switches in the network now assume that the network is as shown in Figure 3 but physically the network has not changed from Figure 1.
Now in figure 3 also there is a layer 2 loop , the STP now has to run only for 6 links instead of the previous 12 links. The STP now blocks Fa0/2 of switch 1 to prevent a layer 2 loop.

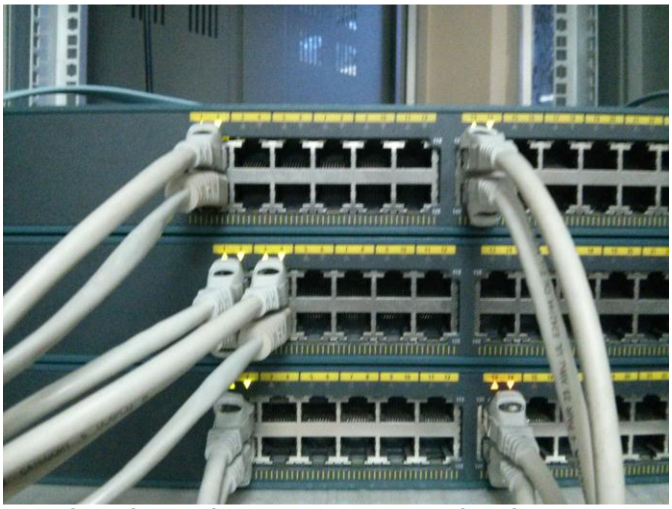


Fig. 4 The catalyst switches running STP using Port channels.

On comparing Fig.4 and Fig 2 we see that for the same layer 2 topology there are 4 switch ports which are in the disabled state when port channel is not being used, but when port channel is being used there are only 2 switch ports in the disabled state (only one switch port actually, since both the 2 disabled switch ports are of the same port channel) [12].

VI. RESULTS

On conducting the experiment we found the following results [13]:

- There was lesser CPU usage on the switches running STP using port channels when compared to the switches running only STP as shown in fig 5 and 6.
- Higher bandwidth between switches running STP using port channels when compared to the switches running only STP as shown in table1[14].
- Lesser instances of STP run on switches making use of STP on port channels as shown in fig 7 and 8
- Convergence time taken for the network running on STP using port channel is lesser when compared to the network running only on STP as shown in table 1.
- Power Consumed when network is running only STP is more than the power consumed when port channels are used to eliminate layer 2 loops as shown in table 1.

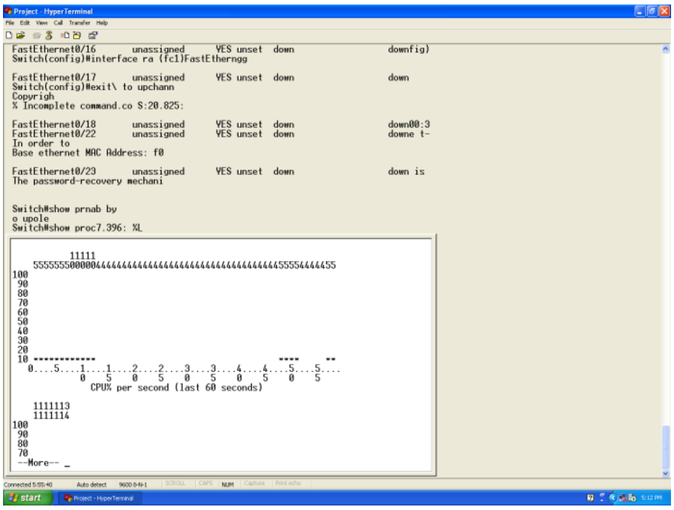


Fig.5 CPU usage when STP runs on port channel

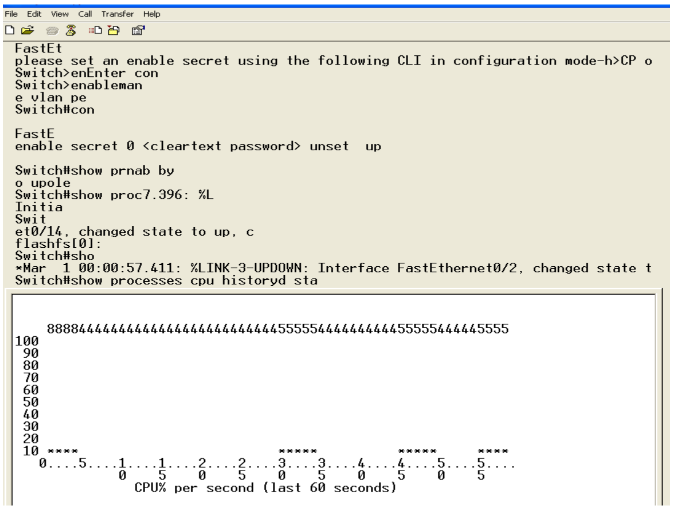
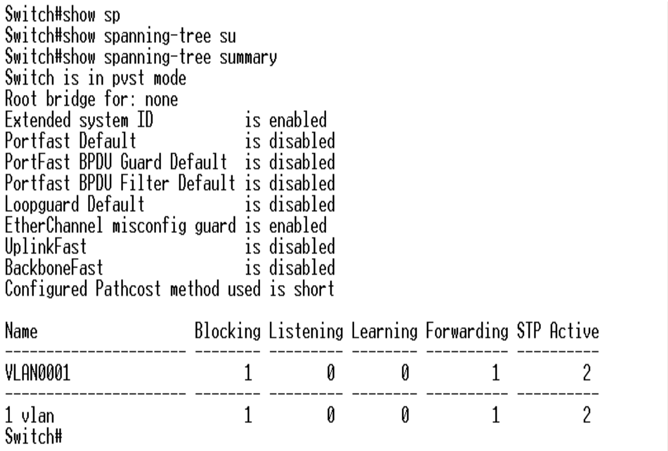


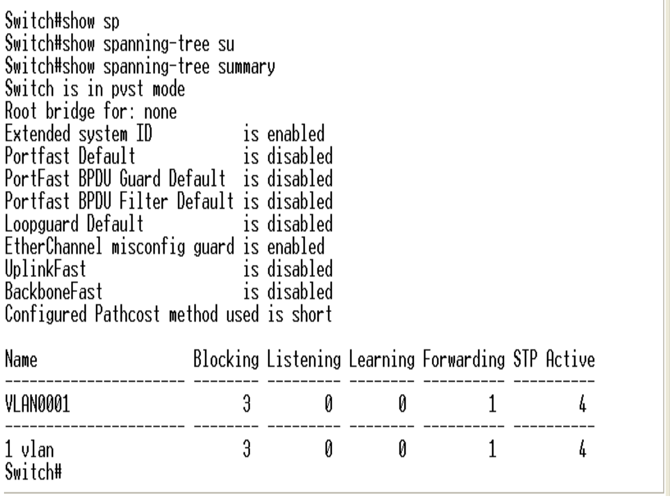
Fig.6 CPU usage when STP does not use port channel



```
Switch#show sp
Switch#show spanning-tree su
Switch#show spanning-tree summary
Switch is in pvst mode
Root bridge for: none
Extended system ID           is enabled
Portfast Default             is disabled
PortFast BPDU Guard Default  is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default            is disabled
EtherChannel misconfig guard is enabled
UplinkFast                   is disabled
BackboneFast                 is disabled
Configured Pathcost method used is short

Name                   Blocking Listening Learning Forwarding STP Active
---------------------- -------- --------- -------- ---------- ----------
VLAN0001                      1         0        0          1          2
---------------------- -------- --------- -------- ---------- ----------
1 vlan                        1         0        0          1          2
Switch#
```

Fig.7 Hyperterminal screenshot showing no of STP instances running when STP process makes use of port channels



```
Switch#show sp
Switch#show spanning-tree su
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Root bridge for: none
Extended system ID           is enabled
Portfast Default             is disabled
PortFast BPDU Guard Default  is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default            is disabled
EtherChannel misconfig guard is enabled
UplinkFast                   is disabled
BackboneFast                 is disabled
Configured Pathcost method used is short

Name                   Blocking Listening Learning Forwarding STP Active
---------------------- -------- --------- -------- ---------- ----------
VLAN0001                      3         0        0          1          4
---------------------- -------- --------- -------- ---------- ----------
1 vlan                        3         0        0          1          4
Switch#
```

Fig 8: Hyperterminal screenshot showing number of STP instances running when STP process does not use port channel

Table 1 showing time to taken to achieve certain network parameters

Properties	STP with Port channel	STP without Port channel
Bandwidth b/w 2 switches	100 Mbps	200 Mbps
Initial Convergence time	5 seconds	56 seconds
Link Failure convergence time	NIL	34 seconds
Power consumed per physically connected Ethernet port	10 Watts	22 Watts
Power consumed by layer 2 devices in the network	210 W (avg for 36 hours)	254W(avg for 36 hours)

VII. Conclusions

From the experiment we can conclude that using Port channels for the STP process not only results in faster convergence times and increased bandwidth between the 2 switches but also results in lesser CPU cycles on the switches in the network, this causes lesser power to be consumed in the network giving rise to a greener layer 2 network. The cost per unit data in the switching network also goes down.

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