Large Campus Network Using hierarchical Model

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Abstract

This paper presents a hierarchical model of localized company effective when is used in a university campus or site. To highlight the standard criteria for each layer of the model and to prove the positive aspects of this model is the best in use and make the Dell Network as case of study. Through the case of study it has been shown that the expansion of the on-site network does not affect services or bandwidth.

Keywords: Campus Network, Hierarchy Model, Case Study for Large Campus, Network Hierarchical Model.

شبكة موقعية كبيرة تستخدم إنموذج هرمي

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الخلاصة

يقدم هذا البحث نموذج هرمي لشبكة موقعية فعالة عند استخدامها في حرم جامعة او موقع. وابراز المعايير القياسية لكل طبقة من طبقات النموذج وجوانبها الايجابية للاستخدام الافضل وتقديم كدراسة لحالة شبكة شركة ديل. وتبين من خلال دراسة الحالة بان التوسع في الشبكة الموقعية لايؤثر على الخدمات أو على عرض النطاق الترددي.

الكلمات الدالة: شبكة موقعية ، النموذج الهرمي ، حالة دراسة لشبكة موقعية كبيرة، شبكة النموذج الهرمي.

Introduction

A campus network is a building or group of buildings all connected into one enterprise network that consists of many local-area networks (LANs). A campus is generally a portion of a company (or the whole company) that is constrained to a fixed geographic area, this can be presented in figure-1[1].
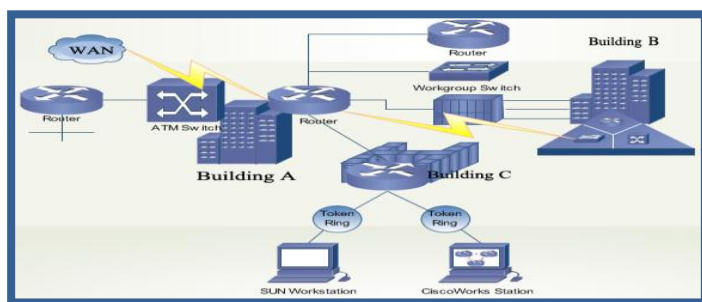

Figure1- Example of a Campus Network [1].

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Hierarchical Model

Hierarchical model is used to design a modular topology using scalable "building blocks" that allows the network to meet evolving business needs. The modular design makes the network easy to be scaled, understond, and troubleshooted by promoting deterministic traffic patterns.

Cisco introduced the hierarchical model in 1999, which uses a layered approach to network design, this is shown in figure-2.The building block components are the access layer, the distribution layer, and the core (backbone) layer. The principal advantages of hierarchical model are its hierarchical structure and its modularity [2].
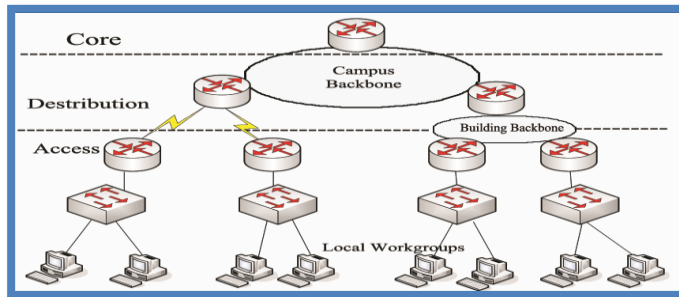

Figure 2- Hierarchical Model.

Typical enterprise hierarchical campus network design-The design of campus networks three layers

■ Access layer: Provides workgroup /user access to the network.

■ Distribution layer: Provides policy-based connectivity and controls the boundary between the access and core layers.

■ Core layer: Provides fast transport between distribution switches within the enterprise campus [3].

Large Campus Network

The large campus in the enterprise design consists of a centralized hub campus location that interconnects medium and small campuses of several sizes to provide end-to-end shared network access of resources and borderless services. The large campus typically consists of various sizes of building facilities and various organizational and departmental groups. The network scale in the large campus is higher than the medium and small campus networks and includes end users, IP-enabled endpoints, servers, security, and network edge devices. Multiple buildings of various sizes exist in one location [4].

The three-tier campus for the large campus meets all key technical aspects to provide a well-structured and strong network foundation. The modularity and flexibility in a three-tier campus design model allows easier expansion and integration in the large campus network and keeps all network elements protected and available [4].

Case of study in large campus network (Large Campus Design with Dell Networking)

With Dell Networking in the campus network environment, the network will easily scale, providing for an easy yet feature rich deployment and faster more efficient on the ground running productivity. As depicted in figure-3, the Dell Networking 7000 series, 6200 series, and 5500 series all fit as access layer switches in a typical campus network [5].
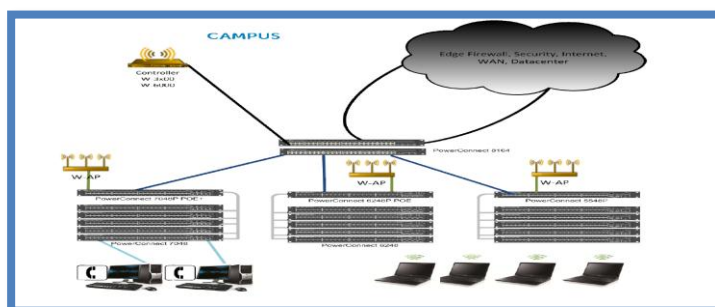

Figure 3-Campus Architecture Overview [5]

Large Campus (3000 Users)
    This section covers a basic generic configuration for the large campus with 3000 users or in this case 3000 ports accessible throughout 2 buildings. To show the port counts with a couple of different building types, the figure-4 displays a port count table for large campus with a 4 story and 3 story building.
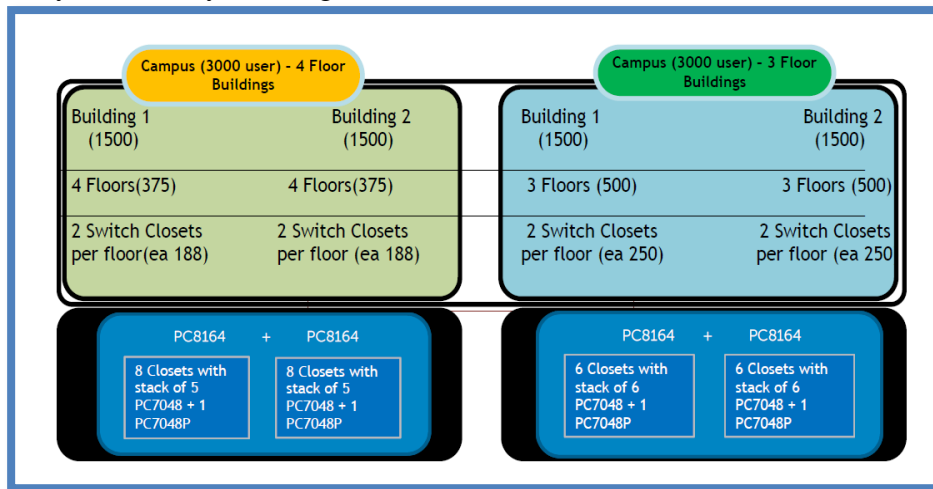

Figure 4- Port count table for large campus.

    With the understanding of how many ports are currently needed in an organization, many times a multiplier or estimated extra number is added for future growth considerations. As a best practice, 10% is added to the expected port count to account for this growth or unexpected additions. In this example, 10% was added to the port count to show how this should be done. Within the 4-floor building example, each closet needs the minimum of 188 ports to meet the 3000 port requirement; however, adding the 10% brings the number to 197.5 rounding up to 198. To account for 198 ports 5 Dell networking, 7048 switches are needed as shown in the switch numbers for each closet. As noted in the figure-4, each closet will have a stack of Dell Networking 7048's + 1 7048P (POE switch). The following examples are going to focus on the 4 floor building layout, which then in turn means that each closet will have a stack of 5 Dell Networking 7048 switches plus 1 Dell Networking 7048P. Simple math notes that this 240 GbE ports that will be used for wall or floor jack connections throughout each floor to enable the user's network access at desks, rooms, or other devices (printers, etc).
    Explaining this example in a different manner, from a networking switch perspective, there will be a total of 4 Dell Networking 8164F switches (2 per building), total of 40 Dell Networking 7048's, 8 Dell Networking 7048P (POE) switches,1 Dell Networking W-6000 or W3x00 wireless controller, and approximately 200 to 275 Dell Networking W-series Access Points [5].

Collapsed Aggregation/Core Layer Configuration
    The large campus with 3000 users is the focus. If there is existing infrastructure from another vendor that will need to work in conjunction with the Dell networking products, plan around how to insure these devices will interoperate with each other correctly. As an example VTP (VLAN Trunking Protocol) is a Cisco proprietary protocol and will need to be changed to GVRP (GARP VLAN Registration Protocol) in order to interoperate properly with the Dell Networking switches in some situations.

Configuration
    In the following sections, the example configuration for Dell network is captured and particular areas covered for their differences from a default switch configuration. Be aware that each building has this same configuration and that the two buildings will be joined together by an edge solution. This edge solution will consist of 2 – 8132F's working as Layer 3 switches to connect to the Internet, WAN, security and any other desired resources or services the customer may need [5].

VLAN implementation

For this example configuration of several VLAN's are used to provide for what a typical Large Campus architecture would potentially need. To see the full configuration of the Dell Networking 8164F which is used, which depicts in VLAN configuration on the Core/Aggregation switches (Dell Networking 8164F) steps.

VLAN configuration on the Core/Aggregation switches (Dell Networking 8164F) steps

```
vlan 10,100-107,200-207,300-307
exit
vlan 10
name "Mgmtvlan"
exit
vlan 100
name "account-finance"
exit
vlan 101
name "storage1"
exit
vlan 102
name "storage2"
exit
vlan 103
name "storage3"
exit
vlan 104
name "storage4"
exit
vlan 105
name "HR-database"
exit
vlan 106
name "exchange"
exit
vlan 107
name "lync"
exit
vlan 200
name "bldg1-1stfloor-Wwing-corpnet"
exit
vlan 201
name "bldg1-1stfloor-Ewing-corpnet"
exit
vlan 202
name "bldg1-2ndfloor-Wwing-corpnet"
exit
vlan 203
name "bldg1-2ndfloor-Ewing-corpnet"
exit
vlan 204
name "bldg1-3rdfloor-Wwing-corpnet"
exit
vlan 205
name "bldg1-3rdfloor-Ewing-corpnet"
exit
vlan 206
name "bldg1-4thfloor-Wwing-corpnet"
exit
vlan 207
name "bldg1-4thfloor-Ewing-corpnet"
exit
vlan 300
```

```
name "bldg2-1stfloor-Wwing-corpnet"
exit
vlan 301
name "bldg2-1stfloor-Ewing-corpnet"
exit
vlan 302
name "bldg2-2ndfloor-Wwing-corpnet"
exit
vlan 303
name "bldg2-2ndfloor-Ewing-corpnet"
exit
vlan 304
name "bldg2-3rdfloor-Wwing-corpnet"
exit
vlan 305
name "bldg2-3rdfloor-Ewing-corpnet"
exit
vlan 306
name "bldg2-4thfloor-Wwing-corpnet"
exit
vlan 307
name "bldg2-4thfloor-Ewing-corpnet"
exit
```

Multiple Spanning Tree (MST)

MST is set up on both Dell networking 8164F's with Root Bridge for certain VLAN's on each of the switches. The following configuration clip is the MST configuration for the first of the 2 switches (8164F) acting as Core/Aggregation switches.

Spanning-tree configuration for Core/Aggregation switches (Dell Networking 8164F)

```
spanning-tree mode mst
spanning-tree mst 200 priority 8192
spanning-tree mst configuration
instance 200 add vlan 200-207
exit
spanning-tree mst 300 priority 12288
spanning-tree mst configuration
instance 300 add vlan 300-307
exit
spanning-tree mst configuration
name "dell"
exit
spanning-tree mst configuration
revision 2
exit
```

Virtual Router Redundancy Protocol (VRRP)

VRRP is set up as master on the same switch that will have the root bridge for MST.

VRRP Configuration on Core/Aggregation switches (Dell Networking 8164F)

```
ip vrrp
interface vlan 200
vrrp 20
vrrp 20 mode
vrrp 20 description master
vrrp 20 ip 20.20.20.1
exit
interface vlan 201
vrrp 21
vrrp 21 mode
vrrp 21 description master
vrrp 21 ip 21.21.21.1
exit
interface vlan 300
vrrp 30
vrrp 30 mode
vrrp 30 description backup
vrrp 30 ip 30.30.30.1
exit
interface vlan 301
vrrp 31
vrrp 31 mode
vrrp 31 description backup
vrrp 31 ip 31.31.31.1
```

Quality of Service (QoS)

Configuration QoS is left as default. There are many different reasons to implement QoS on a campus network. QoS can be used to guarantee a type of traffic a certain amount of bandwidth. As an example, if is CSI storage is connected to this network ,it is highly advisable to implement QoS to give this storage a minimum guarantee of bandwidth to not impede its availability.

Access Layer Configuration

Large Campus configuration, the Dell Networking 7048 and 7048P are used as the Access Layer switches to be stacked in each closet (x2) on each floor of the two buildings. The Dell Networking 7048P has the distinct advantage of being a POE+ switch and delivering higher wattage for security cameras, wireless access points, and any other POE+ devices.

Stacking and the Power Connect 7000 series switch

The Dell Networking 7000 series switches that are used as Access or Edge connections have a consolidated management interface created by linking or stacking the switches. This type of deployment allows for greater scalability; in fact, those switches can be added and removed as necessary for maintenance or adding additional port count. The 7000 series switch is equipped with modular bays for two stacking modules positioned on the back side of the switch. Each stacking module has two ports, which provide for an aggregate bandwidth of 128 Gbps (4 ports, 16 GbpsTx and Rx each).

By connecting a cable from the last switch in a stack back to the first switch, the protection of redundant paths is created for control and data traffic, including support for LAGs configured across multiple switches. This means that any fault (a switch or a stack cable failure) does not affect the overall operation of the remaining stack elements.

The configuration file for stack configuration display a stacking configuration using a single dual-port stacking module with a single dual-port 10Gb SFP+ module for uplinks. can observe that the uplinks in this first configuration which is show in figure-5 come only from the Primary (management

switch) and Secondary (oper standby) members of the stack. This is only one of several methods that can be used. The Dell Networking 7000 series can have up to a total of 12 switches stacked [5].

Configuration file for stack configuration steps

```
slot 1/0 7     ! PowerConnect 7048
slot 1/1 11    ! SFP+ Card
slot 1/2 9     ! CX4 Card
…
…
slot 6/0 3     ! PowerConnect 7024P
slot 6/1 9     ! CX4 Card
slot 6/2 11    ! SFP+ Card
stack
member 1 7     ! PCT7048
member 2 3     ! PCT7048
member 3 3     ! PCT7048
member 4 3     ! PCT7048
member 5 3     ! PCT7048
member 6 3     ! PCT7048P
exit
```

Configuration file for stack configuration steps displays the running configuration files stacking section. Using the typical CLI command "show running-configuration" displays this information. By reviewing this information, you can determine if all modules on each switch in the stack are operating and are configured as expected.
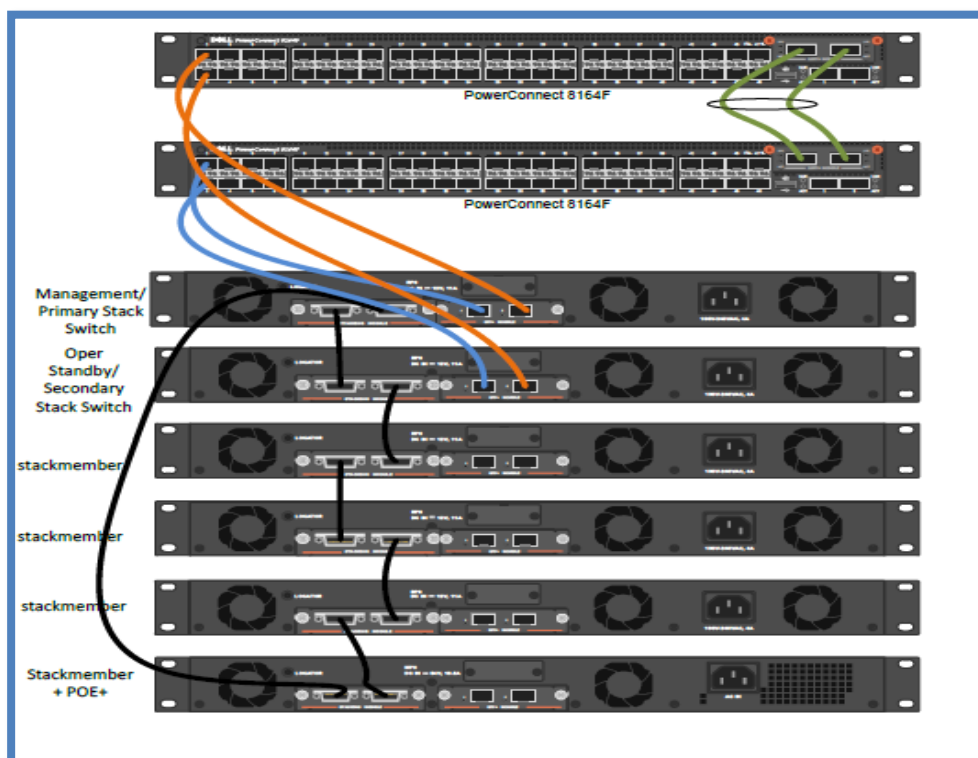

Figure 5- Method(1)

Method(1) Basic ring topology stacking with primary (management switch) and secondary (operation standby) connections to the core/aggregation (representative of a single closet stack of Dell Networking 7048's aggregating into the building Dell Networking 8164's).With proper planning and configuration, the switches can be configured to match the configuration for location purposes, but typically if the automatic configuration takes place many of the decisions for location are based on which switch has the lowest MAC address. With this manual or automatic configuration, make sure to understand which switches are the Management (Primary) and Operational Standby (Secondary)

switches in the stack. Failover planning should be done to understand what happens if a particular switch in the stack fails.

Using the show switch command the switches and their roles can easily be determined as long as the switches are physically placed in a way that matches the switch configuration [5].

Show switch command for stack information

```
console#show switch
     Management Standby   Preconfig     Plugged-in     Switch       Code
SW   Status    Status     Model ID      Model ID       Status       Version
---  --------- ---------  ------------  -------------  ------------ -----------
1    Mgmt Sw               PCT7048        PCT7048         OK          5.0.1.3
2    Stack Mbr Oper Stby  PCT7048        PCT7048        OK           5.0.1.3
3    Stack Mbr            PCT7024        PCT7024        OK           5.0.1.3
4    Stack Mbr            PCT7024        PCT7024        OK           5.0.1.3
5    Stack Mbr            PCT7024        PCT7024        OK           5.0.1.3
6    Stack Mbr            PCT7024        PCT7024        OK           5.0.1.3
7    Stack Mbr            PCT7024P       PCT7024P       OK           5.0.1.3
```

Figure-6 shows second method for uplink configuration may be preferred in many situations to change the potential hop count and mux path choice. This configuration may not provide for much in the way of additional gains with regular use but each infrastructure is unique. This configuration is offered as a valid second option.

Also, keep in mind that every infrastructure has its unique qualities that may lend to creating more uplinks or less uplink based on how well the network handles oversubscription. With this type of configuration, more uplinks can be added between the Access Layer stack (Dell Networking 7048's) and the Core/Aggregation Layer (Dell Networking 8164F's).
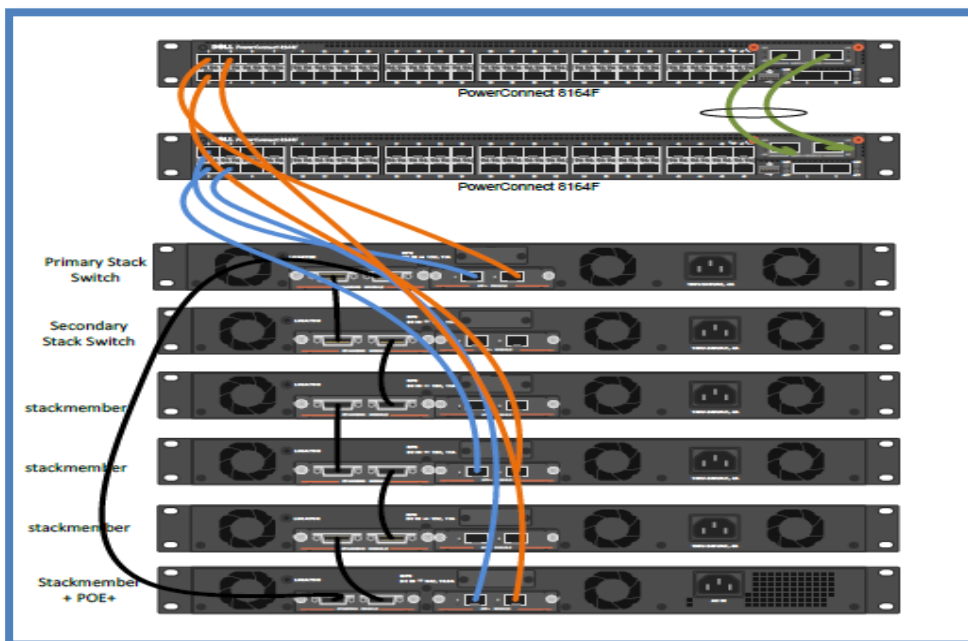

Figure 6-Method (2)

Multiple Spanning Tree Configurations at the Access Layer

The Dell Networking 7048's stacked have the following configuration establishing which MST instances they are participating in. Notice that these the MST instances match up with the corresponding instances on the core/aggregation layer switches, but the instances on this access layer stack have the default priority. With the default priority set and the core/aggregation switch set to a lower priority, the root bridge is always established at the specific core/aggregation switch for that particular set of VLAN's.

Access Layer MST configuration

```
spanning-tree mode mst
spanning-tree mst configuration
instance 200 add vlan 200-207
exit
spanning-tree mst configuration
instance 300 add vlan 300-307
exit
spanning-tree mst configuration
name "dell"
exit
spanning-tree mst configuration
revision 2
exit
```

Conclusions
- To measure the port for future growth. As a best practice, 10% is added to the expected port count to account for this growth or unexpected additions.
- Any fault (a switch or a stack cable failure) does not affect the overall operation of the remaining stack elements. Through connecting a cable from the last switch in a stack back to the first switch, the protection of redundant paths is created for control and data traffic, including support for LAGs configured across multiple switches.

References
1. Thomas M. Thomas, Atif Kahn.**1999**.*"CCIE Fundamentals:Network Design and Case Studies*".2nd Edition. Cisco Press. Part of the CCIE Professional Developmentseries.
2. San Jose.**2008**."Campus Network for High Availability Design Guide",Cisco*Validated Design,*15734(1), pp: 95134-1706.
3. Bob Vachon and Rick Graziani .**2014**. *"Connecting Networks Companion Guide*". 1st Edition. Cisco Press.
4. Rahul Kachalia.**2011**.*"Borderless Campus 1.0 Design Guide",* 2nd Edition.Cisco-Cisco Validated Design.
5. Robert Hartman, Ashish Malpani, Manjesh Siddamurthy, Tracy Alonzo, Colin King and Kevin Locklear. **2013**."Campus Networking Solutions Reference Architecture 1.0 (Large Campus*)". Dell*, 1.0(1).