Campus Network Design And Implementation Using Top Down Approach:
A Case Study Tarumanagara University

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Abstract **- Tarumanagara University already has a computer network infrastructure to support various activities both administrative and academic. Infrastructure that was built has been covering all areas of the building and the floor. With increasing range of services Tarumanagara University need to enhance local are network to accommodate their need. The new network infrastructure that is built must guarantee the quality of services, reliable, scalable and support future expansions.The network design is the most important and critical parts before developing a new network infrastructure.Analysis of user and network requirement has been done to design the network. For the analysis , the result design to implementing is hierarchical network design, high availability backbone,and users segmentation to all user with spreads on some building. The building block components hierarchical structure network are the core layer, the distribution layer and the access layer. Core layer is designed with redundant device using Layer 3 switch , Distribution layer at each building is design with using Layer 3 switch and Access layer is design with using layer 2 switch.**

Keywords: Hierarchical Network, High Availability Backbone, Top Down Approach.

I. INTRODUCTION

The increasing demand for high performance network (i.e. high throughput and low delays on an end-to-end basis, a degree of fairness in accessing available channel bandwidth among active users on the network, and a quality of service provisioning) has challenged network researchers to design network architectures capable of delivering a high quality of service to end users [3]. The network infrastructure design becomes critical part for some IT organization recent years. An important network design consideration for today's networks is creating the potential to support future expansions; reliable and scalable networks. This requires the designer to define the client's unique situation, particularly the current technology, application, and data architecture [4].

There are many types of campus network designs which provide high-availability, flexibility, scalability and manageability. The design of each option depends on functionality available in the network nodes and also it can be varied by the network designer or architect to achieve the optimal performance in a given network, or sometimes to reduce design costs. Top Down design is a discipline that grew out of the success of structure software programming and structured system analysis. The main goal of structured system analysis is to more accurately represent user need, which are unfortounaly often ignored or misrepresented. Another goal is to make the project manageable by dividing it into modules that can be more easly maintained and change [2]. It provides a modular topology of building block that allow the network to evolve easily[1]. Top Down Network Design advantages is begins with the focus on an organization's specific goals and requirements for network applications and services, while allowing potential future needs to be considered and account for [5] . In this paper we report on a case study of Tarumanagara University (UNTAR) considering to enhancement network design , implementation, and network performance improvement.

II. TOP DOWN APPROACH NETWORK DESIGN

Many network design tools and methodologies in use today resemble the connect-the-dots game that some of us played as children. These tools let you place internetworking devices on a palette and connect them with local-area network (LAN) or wide-area network (WAN) media. The problem with this methodology is that it skips the steps of analyzing a customer's requirements and selecting devices and media based on those requirements". [2]

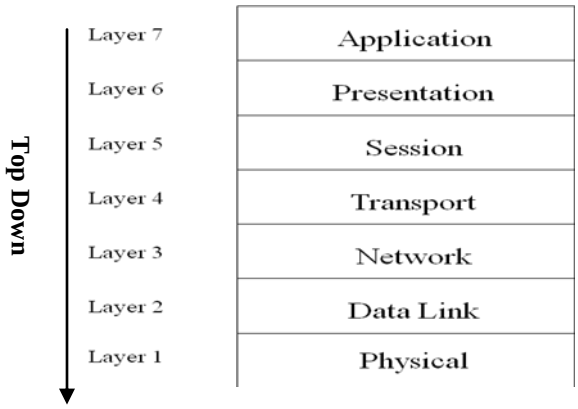


Figure 1. Top down approach network design

Good network design must recognize that a customer's requirements embody many business and technical goals including requirements for availability, scalability, affordability, security, and manageability. Many customers also want to specify a required level of network performance, often called a service level. To meet these needs, difficult network design choices and tradeoffs must be made when designing the logical network before any physical devices or media are selected. [2]. High-availability of the network has always been important in the internetworking world.

Top-down network design is a methodology for designing networks that begins at the upper layers of the OSI reference model before moving to the lower layers. It focuses on applications, sessions, and data transport before the selection of routers, switches, and media that operate at the lower layers. The top-down network design process includes exploring divisional and group structures to find the people for whom the network will provide services and from whom you should get valuable information to make the design succeed. Top-down network design recognizes that the logical model and the physical design may change as more information is gathered [2] . Top Down and Bottom Up Approach network design Comparison as follows:

A. Top Down Approach

Advantages

- Begins with a focus on an organization's specific goals and requirements for network applications and services, while allowing potential future needs to be considered and accounted for.[5]
- Incorporates organization requirement [6]
- Give the big picture to organization and designer.[6]

Disadvatages

- Requires thorough initial needs analysis in order to determine specific requirements, and ensure that all possible applications and services have been considered.[5]
- Incrporates organization requirement.[6]

B. Bottom Up Approach

Advantages:

- Allow quick response to design request [6]
- Facilitates design base on previous experience [6]
- Generally a faster approach based on past projects and implementations that works within an existing environment.[5]

Disadvantages:

- Implements little or notion of actual organization requirement.[6]
- May result in inappropriate network design.[6]
- The approach may not take all necessary applications and services into consideration, leading to a design that ultimately may not meet the needs of an organization, and may need to be redesigned in the future.[5]

III. BACKROUND

Tarumanagara University consist of several buildings located separately. Each building is connected to each other through Local Area Network**.** Application that run comprised a mini computer and internet acces available. The applicatilon is used to support various operations such as academic, administrative and library. Currenly Tarumanagara University has provide variety of new application to meet the needs of users, for examples electronic mail, file transfer, database access, web application , terminal emulation.

Tarumanagara University (UNTAR) is plan to enhancing Local Area Network to accommodate their needs. Existing network is show figure 2.

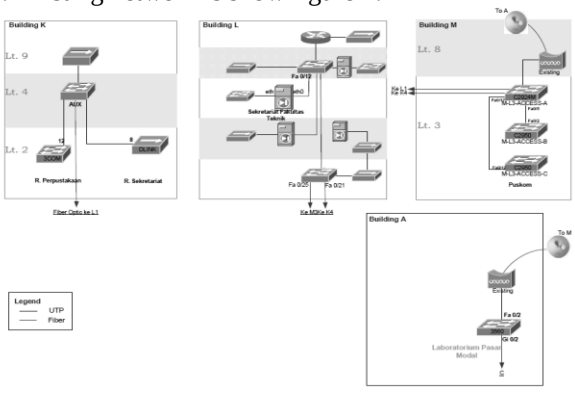


Figure 2. Existing Physical Network

Figure 2. shows existing physical network design. From the figures, it can be concluded as no hierarchical network design (existing switches are put

in cascade), Reduce the network performance ,no high availability , only one device and link is used , point of failure , when a switch or link is down, users and/or the other switch will have no connectivity.

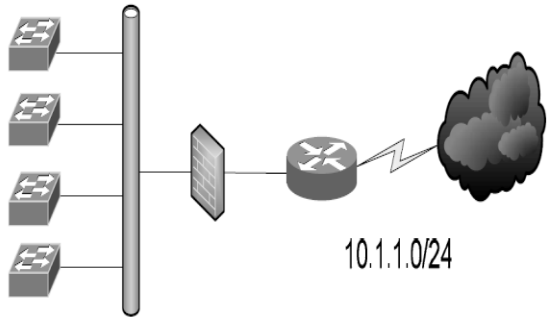


Figure 3. Existing logical network design

Figure 3. shows existing logical network design. From the figures, it can be concluded as no segmentation , users at all buildings use the same segment (flat addressing10.1.1.0/24), and the drawback by using flat addressing is broadcast domain cannot be limited into one building. To Enhancement Local Area Network the idea is to build hierarchical network design, users segmentation to all UNTAR's users which spreads on some buildings, high availability backbone and provide centralized management and monitoring system for network devices.

IV. CAMPUS NETWORK DESIGN

First focus is to provide a high avalability backbone in the network, redundant link and a fast link failure detection and failover inside the routing protocol is required four buildings need to be interconnected. Building I,J,K,L,M and R are located at the same area, whereas Building A is located at different area.

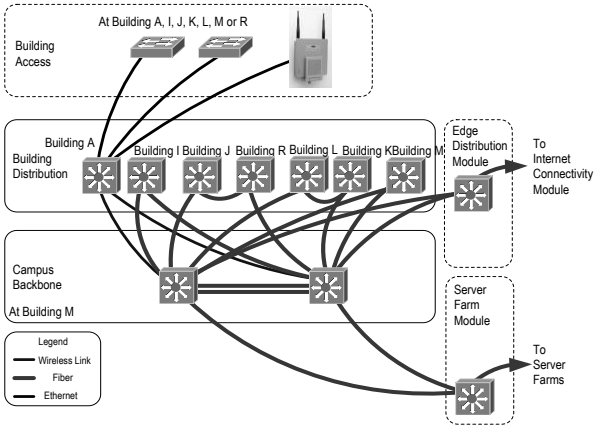


Figure 4. High availibility backbone network.

Campus Network design topologies should meet customer's goal for availability and performance by featuring small bandwith domains, small broadcast domains, redundancy, mirrored server and multiple ways for workstations to reach a router for off-net communication [2]. Tarumanagara University network design enhancement covers Hierarchical Network Design based on industry's best practice and well-known three hierarchical layers (Core, Distribution and Access Layer), A Hierarchical design avoids the the need for a fully meshed network in which all network nodes are interconnected. [1] The building blocks components are the access layer, the distribution layer, and the core layer as show in figure 5.The core serves as a backbone for the network. The core devices are high capacity routers and expected to be very resilient. The distribution layer aggregates nodes from the access layer , protecting the core from high desity peering.. Catalyst 3750 will be used as Core Switches. Connectivity between Core Switches (Core) is using ether-channel (2 ports). Catalyst 3560 will be used as Building Distribution (Distribution). Distribution will connect to Core by redundant links. Core Switch as layer 3 device, providing routing inter-distribution switch. To ensure high availability at core layer, two links will be deployed. Distribution Switch as layer 2 and 3 device. As layer 2 device: trunk connection to access switch , As layer 2/3 device: routing inter-VLAN and route it to core when the destination is out of there. Segmentation to group users into 4 segment at each building and High Availability at chassis and link levels.

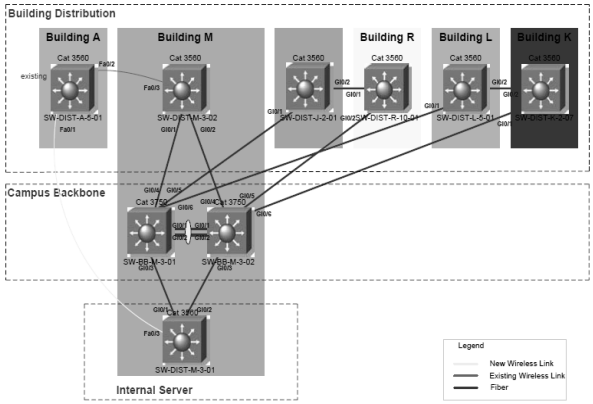


Figure 5. Physical network design

Figure 5. shows physical network design. From the figures, it can be concluded as high availability (redundant core switch, redundant wireless link and redundant link at interbuilding connectivity), and hierarchical network design layering the network into core, distribution and access.

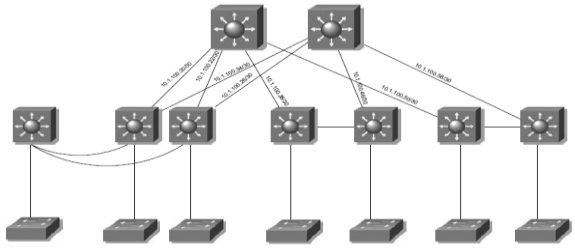


Figure 6. Logical network design

A. Naming Convention

As in every organization, UNTAR will have its own naming convention for all the network devices. The naming convention in UNTAR will follow: {Device}-{Layer}-{Building}-{Floor}-Number}.
Device is type of the device, it can be Switch, Wireless Bridge, Router, Server (SW|WB|RO|SVR). Layer is in what hierarchy layer the device will act as (ACC | DIST | BB | NMS | BRD). Building is to describe where the device will be located (A|M|J|R|L|K). Floor is describe the floor of Building. Number is describe how many device with the same attribute.

Example: SW-BB-M-3-01 means: UNTAR's Backbone Switch located at 3rd floor Building M, WB-BRD-A-5-01 means: UNTAR's Wireless Bridge (new) located at 5th floor Building A.

B. Layer 2 Design

Layer 2 design covers Per-VLAN Rapid Spanning Tree Protocol Design, Trunking Protocol Design, VLAN Design in each Distribution Switch, VLAN Trunking Protocol, and Interface Attachment configuration. To provide faster convergence based on IEEE 802.1w, Per-VLAN Rapid Spanning Tree Protocol or PVRST+ for short will be deployed in the new Layer 2 backbone. UNTAR's new distribution switches act as layer 2 backbone to access switches that support both Spanning Tree Protocol (STP) and Per-VLAN Rapid STP (PVRST+). By assuming that existing access switch supports PVRST+, PVRST+ can be used as STP type. But if access switch cannot support PVRST+ so the STP type is automatically changed to STP.

Links between distribution switch and access switch is deployed using layer 2 protocol. Since there are needs of communication among different VLANs at each building, trunking protocol must be configured in order for those VLANs to communicate. IEEE 802.1Q standard widely used as trunking protocol is implemented.

The VLAN Assignment in UNTAR will be differed based on the person's title for each building:

TABLE 2. VLAN DESIGN

Building	M	A	J	R	L	K
Direction	2	6	10	14	18	22
Lectures	3	7	11	15	19	23
Student	4	8	12	16	20	24
Staff	5	9	13	17	21	25
Management	26	26	26	26	26	26

The reason to use different VLAN at different building is to simplify the administrator to distinguish VLAN per building. Guest VLAN is included in Student VLAN.

VTP here is used to make consistent VLAN configuration of entire network. VTP is Layer 2 trunk protocol to manage the addition, deletion, and renaming of VLAN (happen at the VTP server mode). The VTP client mode just receives the update from VTP server. VTP will synchronize VLAN information within a VTP domain. This reduces the need to configure the same VLAN on each switch. All switches with the same management domain share their VLAN information. A switch can participate in only one VTP management domain. Switches in different domains do not share VTP information. Each switch share their management domain, VLAN and the parameter, configuration revision number. Every distribution switch will act as VTP server for the connected access switches.

C. Layer 3 Design

Layer 3 design will cover IP Address Assignment, DHCP configuration, Routing Protocol and SNMP configuration. The IP Addresses in UNTAR will be divided based on Building as follows:

TABLE 4. IP ADDRESS ASSIGNMENT

No.	Building	Users IP Address	Servers IP Address
1.	Building A	10.1.2.0/24 – 10.1.9.0/24	10.1.1.0/24
2.	Building M	10.1.10.0/24 – 10.1.17.0/24	10.1.18.0/24-10.1.19.0/24
3.	Building J	10.1.20.0/24 – 10.1.29.0/24	
4.	Building R	10.1.30.0/24 – 10.1.39.0/24	
5.	Building L	10.1.40.0/24 – 10.1.49.0/24	
6.	Building K	10.1.50.0/24 – 10.1.59.0/24	
7.	Inter-switch	10.1.100.0/24	
8.	Loopback	10.1.200.0/24	

Once users was assigned to a specific VLAN (related to its MAC address), the next step is to acquire the IP Address through DHCP configuration. Every distribution switch will be DHCP server to users at its

building. IP for servers will be manually configured. The routing confguration in UNTAR will use EIGRP dynamic routing protocol.

D. Network Management

Network management is a important component in a campus network design. Network management will be enabled at every network devices so that can be monitoring logging , troubleshooting, security and other common management function.

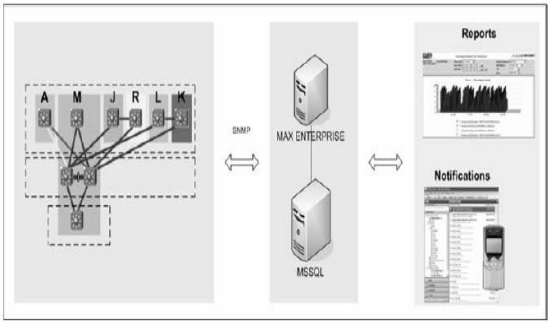
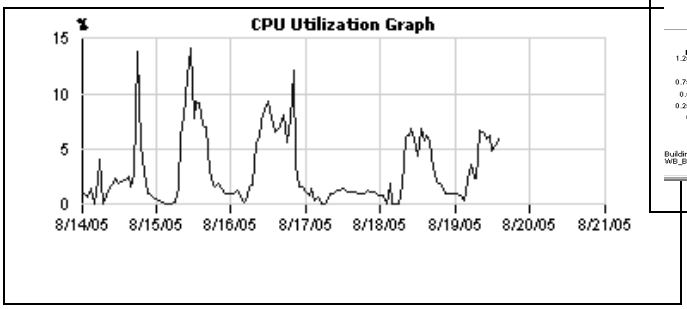


Figure 7. Network management design

E. Performance

1. Router/Switch Report
   a. System Health

      Node Reports will provides the following :
      - Overall performance summary of the router in terms of the hardware performance. This allows user to forecast instances when a router overloads not only by traffic volume but also because of other issues that directly impact router performance (e.g., CPU Utilization, buffer overrun, outage).
      - Trending and summarized analysis such as load, errors, outages, availability, traffic distribution in each router interface.



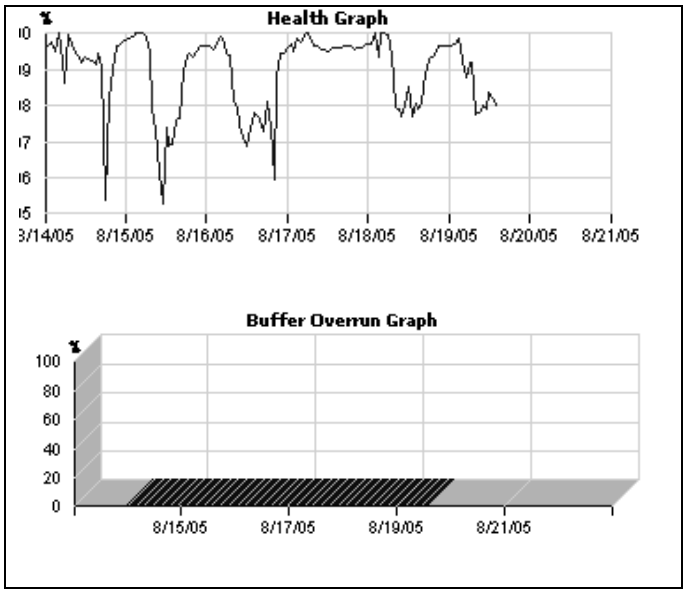


Figure 8. Switch/router system health

b. Traffic Distribution

Router (Traffic Distribution) Reports provide users with the distribution graphs of all traffic passing through the interfaces of the routers..

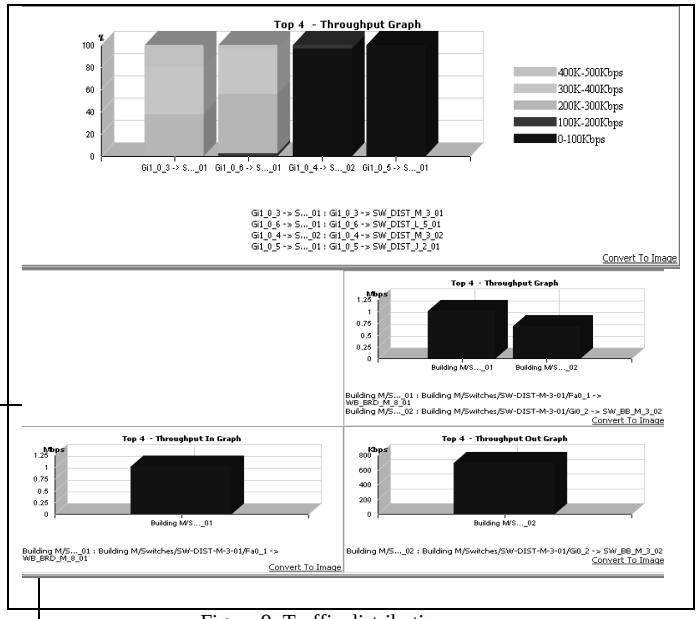


Figure 9. Traffic distribution

c. Interface Utilization

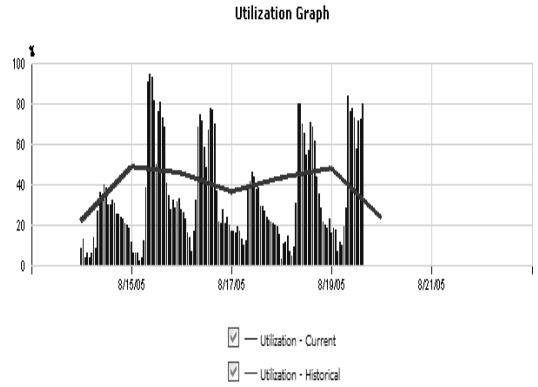


Figure 10. Interface Utilization Current Vs History

2. Server Report.

Server Summary Reports provide the summary and trend analysis of top CPU utilized and top memory utilized servers.

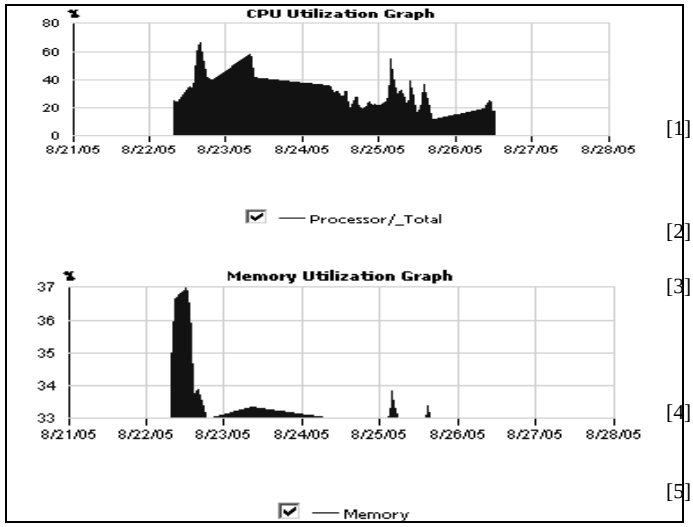


Figure 11. Server Trend

V. CONCLUSION

Tarumanagara University enhancing Local Area Network to accommodate their needs. Using The top-down network design process to find the people for whom the network will provide services and from whom you should get valuable information to make the design succeed. First focus is to provide a high avalability backbone in the network, redundant link and a fast link failure detection and failover inside the routing protocol is required four buildings need to be interconnected. The building block components hierarchical structure network are the core layer, the distribution layer and the access layer. Core layer is designed with redundant device using Layer 3 switch , Distribution layer at each building is design with using Layer 3 switch and Access layer is design with using layer 2 switch. Implement Network Management Systems need for Fault Management and Performance Management, enhanced functionality for data analysis, reporting, notification and escalation. Furthermore, the Intrusion Detection System implementation is discussed to address network security concerns.

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