ISSN 2047-3338

The Switch Hierarchical Network Design Model (SHiNDiM): A Mechanism for Identifying and Determining the Correct Switch for the Appropriate Position in the Network Layer

Jameson Mbale

***Abstract*—Designing and developing a reliable and stable network required installing the right switches in the correct positions of the hierarchical network layers. The identification, acquisition and determination of the right switches required the expertise of highly skilled and qualified network Engineers. However, employing and maintaining such expertise in some of the ICT companies is very challenging. As a result, some companies had to employ less skilled employees in building such a network. Therefore it became a major challenge for less skilled Technicians to identify and determine the right switches for the correct positions within the network layers. It was in view of this challenge that the Switch Hierarchical Network Design Model (SHiNDiM) was fashioned to serve as a tool that automatically identified and indicated the positions of the various switches that were to be installed. The SHiNDiM architecture which used the SHiNDiM SEMINT Specific Parser (SSSP), was intelligently trained to retrieve the targeted switch features. Therefore this tool helped the Technicians who simply entered the variables to be processed and which produced indicators showing the respective positions of switches in the hierarchical network layers.**

***Index Terms*—Switch Features, Switch Hierarchical Network Design Model (SHiNDiM), Switch Position and SHiNDiM SEMINT Specific Parser (SSSP)**

I. Introduction

The Switch Hierarchical Network Design Model (SHiNDiM) was conceived as a tool to be used by Network Technicians who were finding it difficult to identify and determine the type of switches to be installed in the correct hierarchical network layer. This model used the SHiNDiM architecture that had the capability of manipulating and exploiting the switch features outlined in Table 1, to come up with the indicators showing the positions of the switches in the hierarchical network layers. The architecture of this model has several critical components such as: The Switch Features Repository (SFR), SHiNDiM SEMINT Specific Parser (SSSP), Merging Switch Features (MSF), Intersection Switch Features (intf), Switch Feature Sorter (SFS) and Layers that were discussed in detail in Section III. The complete flow mechanism of the SHiNDiM tool is demonstrated in Fig. 4.

J. Mbale is with the University of Namibia, Centre of Excellence in Telecommunications (CoE), Department of Computer Science, P/B 13301, Windhoek, Namibia. Mobile: +264813403635; fax: +264612063791; (e-mail: mbalej@yahoo.com).

A. *Statement of the Problem*

Building up a strong hierarchical network requires installing switches in the correct position in the network such as the access, distribution and core layers as shown in Fig. 1.

Large ICT companies that build such networks usually required highly skilled and experienced Network Engineers. In many cases, employing such personnel had been difficult due to shortages of people with the requisite high skill levels and usually ends up using lesser skilled manpower. In retrospect, it became very challenging for these less skilled personnel to purchase and determine the appropriate switches to be installed in the hierarchical network layer, due to very limited skills. It was in view of this that the SHiNDiM was developed to automatically identify and determine the right position of a particular switch in the hierarchical network layer. Using the SHiNDiM automated tool, the Engineer or Technician simply enters the switch features and the system runs through the whole process to determine the correct positions of the various switches. Armed with this tool, the company did not need highly skilled, expensive experts. Lesser skilled and paid Technicians were able to run the SHiNDiM which then identified and determined the right switches for the correct hierarchical network relieving the Technicians of the need for challenging and difficult analyses.

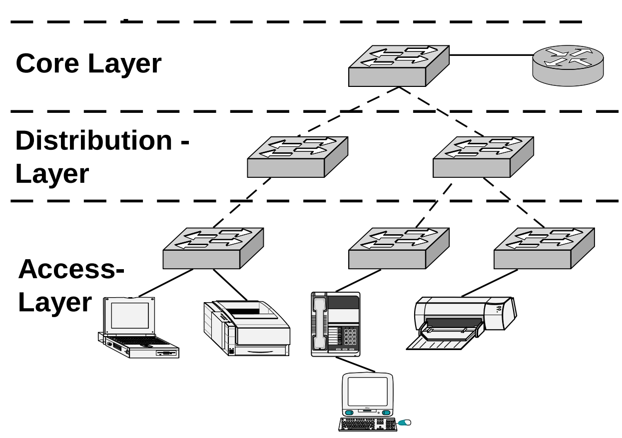

Fig. 1. Switch Hierarchical Network Layers

II. Related work

Determining the type of the switch to be installed in the hierarchical model layer in the network had been discussed by expert Engineers from various vendors. In [1] they emphasized that an Engineer should know which factors to consider when choosing a switch, and to be able to examine the required features at each layer in a hierarchical network. They also stated that an Engineer should be able to match the switch specification with its capability to function as either an access, distribution, or core layer switch. They also pointed out that Engineers should purchase the appropriate Cisco switch hardware to accommodate both current needs as well as future needs. They stated that when selecting a switch for the access, distribution, or core layers, Engineers should consider the capability of the switch to bear the port density, forwarding rates, and bandwidth aggregation requirements of your network. They discussed the function layers switch as: first was the access layer switches they facilitated the connection of end node devices to the network.

Second, was the distribution layer switches needed to support Quality of Service (QoS) to maintain the prioritization of traffic coming from the access layer switches that have implemented QoS. The priority policies ensure that audio and video communications would be guaranteed adequate bandwidth to maintain an acceptable quality of service.

Third, the core layer of a hierarchical topology was the high-speed backbone of the network and requires switches to handle very high forwarding rates. In [1] again they identified the current seven (7) switch products lines as: Express 500, Catalyst 2960, Catalyst 3560, Catalyst 3750, Catalyst 4500, Catalyst 490 and Catalyst 6500 time. In [2] the authors explained the switched layers. Accordingly, the core layer was a high-speed switching backbone which should be designed to switch packets as fast as possible. The distribution layer of the network provided boundary definition and was the place at which packet manipulation could take place. It included the following functions: address or area aggregation, Departmental or workgroup access, broadcast/multicast domain definition, VLAN routing, any media transitions that need to occur as well as required security considerations.

In [3] it was explained in detail the three typical hierarchical topologies: the core layer consisted of high-end routers and switches that are optimized for availability and performance. The core layer formed the high-speed backbone of the internetwork and it was critical for interconnectivity. The authors indicated that it should be designed with redundant components and should be highly reliable and able to adapt to changes quickly. The distribution layer had many roles, among which included controlling access to resources for security reasons, and controlling network traffic that traversed the core both of which enhance network performance and safety. The distribution layer often acted as the layer that delineated broadcast domains, and it implemented policies. An access layer was defined as that layer which connects users via lower-end switches and wireless access points. It provided users on local segments access to the internetwork. The access layer included routers, switches, bridges, shared-media hubs and wireless access points.

III. Appropriate Locations For Switches in the Hierarchical Model Layers

For the network to perform efficiently, it has to be properly designed in such away that, the right switches are installed at the correct positions or layers. The Engineer has to determine the position of a switch by using its features. Switches were manufactured according to different features depending on their functions. Thirteen switch features are illustrated in Table 1 as: port security, VLANs, faster Ethernet/gigabit Ethernet, power over Ethernet (PoE), link aggregation, quality of service, layer 3 support, high forwarding rate, gigabit Ethernet/10 gigabit Ethernet, redundant components, security policies/access control list and very high forwarding rate.

These features performed different functions. In [1] they further defined thirteen features as outlined as follows. The first feature, the port security allowed the switch to decide how many or what specific devices were allowed to connect to the switch. It was an important first line of defense for a network. Second, was the VLANs, that allowed a network to be logically divided into groups of network devices that acted as they were own independent network even if they shared a common infrastructure with other VLANs. They were also an important component of a converged network. Third were the fast Ethernet and Gigabit Ethernet. The Fast Ethernet allowed up to 100 Mbps of traffic per switch port. It was adequate for IP telephony and data traffic on most business networks, whereas, the Gigabit Ethernet allowed up to 1000 Mbps of traffic per switch port. Most modern devices, such as workstations, notebooks, and IP phones, supported Gigabit Ethernet. This feature allowed for much more efficient data transfers, enabling users to be more productive. Fourth was power over Ethernet (PoE), which was highly necessary when voice convergence was required or wireless access points were being implemented and power was difficult or expensive to run to the desired location. Fifth was link aggregation allowed the switch to operate multiple links simultaneously as a logically singular high bandwidth link. Sixth was quality of service that maintained the prioritization of traffic in a converged network support voice, video in preference to data network. Seventh was layer 3 support required because of the advanced security policies that could be applied to network traffic. Eighth was high forwarding rate required to handle high-speed backbone of network. Ninth was gigabit Ethernet allowed the corresponding distribution layer switches to deliver traffic as efficiently as possible to the core. Tenth was a redundant component which as the network grows, required the core layer switch that supports additional hardware redundancy features, such as redundant power supplies that can be swapped while the switch continues to operate. Eleventh was access control list that allowed the switch to prevent certain types of traffic and permit others.

TABLE I
SWITCH FEATURES AGAINST THE LAYERS
KEY: SF_NO. = SWITCH FEATURE NUMBER; INTF = INTERSECTION FEATURES

SWITCH FEATURES	**Port Security**	**VLANs**	**Fast Ethernet/ Gigabit Ethernet**	**Power over Ethernet (PoE)**	**Link Aggregation**	**Quality of Service (QoS)**	**Layer 3 Support**	**High Forwarding Rate**	**Gigabit Ethernet/ 10 Gigabit Ethernet**	**Redundant Components**	**Security Policies/ Access Control List**	**Very High Forwarding Rate**
SF_No.	**1**	**2**	**3**	**4**	**Intf1**	**Intf2**	**5**	**6**	**7**	**8**	**9**	**10**
LAYERS												
Access	✓	✓	✓	✓	✓	✓						
Distribution					✓	✓	✓	✓	✓	✓	✓	
Core					✓	✓	✓		✓	✓		✓

ACLs also allowed you to control which network devices could communicate on the network. Using ACLs was processing intensive because the switch needed to inspect every packet to see if it matched one of the ACL rules defined on the switch. Twelfth was the security policies that define which communication protocols are deployed on your network and where they are permitted to go. Last the core layer of a hierarchical topology is the high-speed backbone of the network and requires switches that can handle very high forwarding rates.

From Table 1, it was illustrated that some switch features are common to all the three layers (eg, Link Aggregation and QoS). Such common features are the link aggregation and quality of service as indicated in Venn diagram format in Fig. 2. Also, Fig. 2 demonstrated some features that appeared in both layers and these were: redundant components, layer 3 support and gigabit / 10 gigabit.

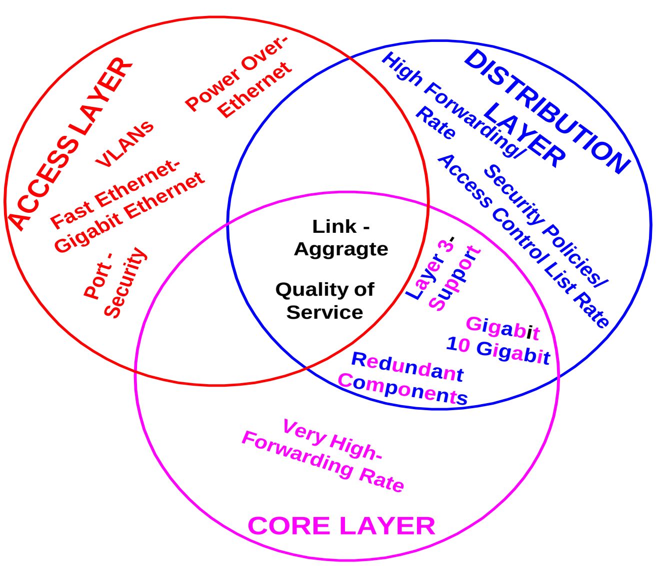

Fig. 2. Interrelation of Switch Features

IV. THE SHINDIM ARCHITECTURE

Much of the SHiNDiM architecture in Fig. 3 was designed to automatically identify the features of a particular switch and determine its position in the hierarchical network layer. The architecture was composed of the following components: the underlying Switch Features Repository (SFR), SHiNDiM SEMINT Specific Parser (SSSP), Merging Switch Features (MSF), Intersection Switch Features (intf), Switch Feature Sorter (SFS), and the three Layers.

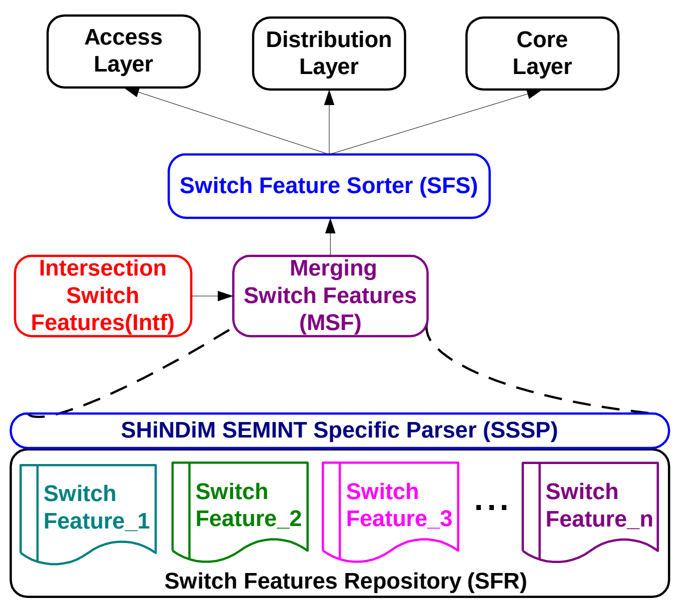

Fig. 4. SHiNDiM Switch Features Architecture

The underlying Switch Features Repository component consisted of a collection of heterogeneous features ranging from Switch Feature_1 to Switch Feature_n as demonstrated in Fig. 3. These features were also introduced in Table 1.

This work employed the framework of [4,5] the SEMINT Specific Parser, which was defined as a tool that automatically extracted schema information and constraints from the database catalogues and statistics on the data contents using queries over data.

V. The Model Overview

In this work, the SEMINT Specific Parser was improved to intelligently and skillfully extract the Switch Features of that particular switch being dealt with and it was referred to as SHiNDiM SEMINT Specific Parser. When the SSSP was activated, it intelligently extracted the Switch Features of the switch being assessed to determine in which hierarchical level it fitted. The extracted features were passed to the MSF component.

Once the MSF component received the input from the SSSP, then Intf automatically sends the intersection features to the MSF. These two inputs were merged into a complete feature of the switch and were sent into the SFS component. Then the SFS directed that switch's features to the right layer. This marked the accomplishment of determining the right position of the switch in the hierarchical network layer.

VI. The Detailed Information Flow Within SHiNDiM

The logic flow that determines the identification of the right switch in a hierarchical network layer is demonstrated in Fig. 5.

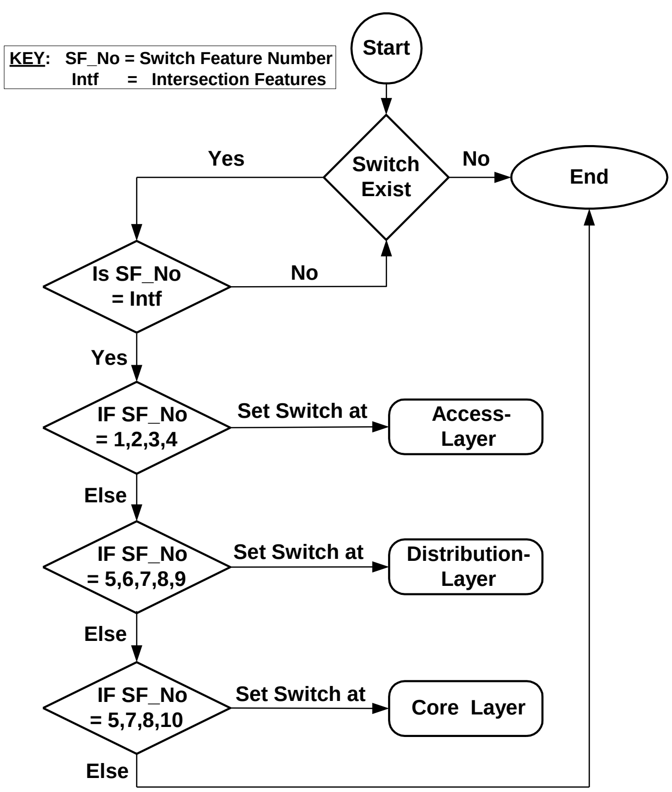

Fig. 5. The Flow Chart Mechanism

The variables used in the flow chart were drawn from Table 1 in the Switch Feature (SF_No.) row. From that row, the corresponding SF_No. and Switch Features were labeled by numbering them. These numbers were the variables used in the flow chart mechanism model.

When the Engineer initiated the process, the system first checked if there existed a switch. If there was no switch then the whole process ended. If the switch or switches were available, then the system checked if the SF_No for Intf1 and intf2 were both available. If not available, then the process was re-started to check whether switch/switches existed. If the SF_No for Intf1 and intf2 were both available then the system went to the next process to test for variables 1,2,3,4. If these variables were satisfied, that particular switch was identified to be suitable and installed in the access layer. If not satisfied, the system went to the next process to test for variables 5,6,7,8,9. If these variables were satisfied, then that particular switch was approved as appropriate for installation at distribution layer. In the case where the variables were not satisfied, the system went to the next process to test for variables 5,7,8,10. If these satisfied the test, then the involved switch was identified to be the correct type for installation at the core layer. However, when the test failed, then the process terminated.

VII. Discussion

As discussed earlier, the Network Engineers (NEs) had challenges in identifying and determining the correct switch to be installed in the correct hierarchical network layer. In many situations, the NEs were responsible for the selection and purchase of network hardware such as switches, etc. In other cases, some NEs proved lacking in experience with regard to the knowledge of recommending the correct switch for the right hierarchical network layer. In those situations they often ended up acquiring wrong switches for the particular layers. As a consequence, installing incorrect switches in the hierarchical layers resulted in poor network performance. For instance, installing the lower-end switches meant for the access layer into the core layer which required switches for high-speed backbone of the internetwork, caused the whole system fail to function. In that case, the wrongly installed switches in the core layer would fail to cope up with heavy flow of traffic which required switches that could accommodate the high-speed network backbone. It was in view of that, SHiNDiM was envisaged as system which could be used to identify and determine the correct switch for the right hierarchical network layer. Whether the NEs were competent or not, using such a system they simply applied the variables shown in Table 1 into SHiNDiM. Then the SHiNDiM tested all the features of the switch and determined for its right position of the hierarchical network layer. Such a model assisted the NEs to install and the correct switches in the network and that improved the performance of the system.

VIII. Conclusion

To build a very strong, stable and reliable network, it requires the installation of the right switches in the following correct hierarchical network layers: core, distribution and access. As discussed earlier, companies responsible of building such networks had challenges of using less competent Technicians or Engineers who were not conversant in identifying the correct switches to install in the right layers. This work introduced the SHiNDiM tool which was used to identify and determine the suitable switches to be set in the appropriate layers. The tool has the SHiNDiM architecture that used the switch features to identify the right switches. The architecture had very useful functional components such as: Switch Features Repository (SFR), SHiNDiM SEMINT Specific Parser (SSSP), Merging Switch Features (MSF), Intersection Switch Features (intf), Switch Feature Sorter (SFS), and the three Layers. This model used the SHiNDiM SEMINT Specific Parser (SSSP), a component that was intelligently trained to retrieve the targeted switch features. The retrieved switch features were processed by the entire system to come up with the indicators that determined the position where the switches were going to be installed in the hierarchical network layers.

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Jameson Mbale became a Senior Lecturer and Head of Department of Computer Science at the University of Namibia (UNAM) in 2008. He was the founder and appointed the coordinator of Centre of Excellence for Telecommunications (CoE) at UNAM in 2011. He obtained a Ph.D. Degree in Computer Science and Applications at Harbin Institute of Technology (HIT), China in 2003. He received M.Sc. Degree in Computer Science from Shanghai University, China, in 1996. He got B.A. Degree in Mathematics and Computer Science at the University of Zambia, in Zambia in 1993. His research interest is in telecommunications, Wireless Network and Network Security.