Modeling and Simulation of Functional Extension to Network Switches in Network Simulator (ns-2)

Dayanand D. Ambawade, *Member, IEEE* and Prachi U. Gharpure, *Member, IEEE*

***Abstract*-- This paper describes a methodology to create models for network devices in particular network switches, to be simulated in ns-2. After describing the features and services of network switch like port trunking, MAC addresses filtering; a corresponding representation of a switch with those features is shown. The paper then presents simulation results of such a switch. The basic dumbbell model of ns-2 has been used for extending the featured switch. The simulation results show the predicted behavior of the featured switch.**

***Index Terms*-- Ethernet Switch, LAN, Network Design Network modeling, Simulation, Port Trunking, STP, MAC address, VLAN.**

I. Introduction

MODELING is an effective method to represent real systems for simulation environments. Simulation of communication networks and its components allows investigation and reasoning about the qualities of a new or proposed system without the high cost and risk of disrupting the real system.

The proposed system is to design, develop, implement and simulate the features and services provided by switching technologies. It enables to understand better ways a designing a network, network capacity planning, network integration and reconfiguration. Simulation has been used primarily to verify the extended functionality, evaluate the performance and guide the design of switches as well as a complete network.

II. Network Simulation

It is possible to simulate Network Switch by using general purpose programming languages or software packages such as SIM [2] and Network Simulator (ns-2). For the purpose of simulating the switch model ns-2 has been used.

A. Network Simulator (ns-2)

NS (version 2) is an object-oriented, discrete event driven network simulator developed at UC Berkeley written in C++ and OTcl. It implements network protocols such as TCP and UDP, traffic source behavior such as FTP, Telnet, Web, CBR and VBR, router queue management mechanism such as Drop Tail , RED and CBQ, routing algorithms such as Dijkstra, and more. NS-2 also implements multicasting and some of the MAC layer protocols for LAN simulations [1]. NS-2 provides well-documented trace format for interpreting simulation results.

But network switches are not directly supported by ns-2. To some extent switch model in router node switch is viewed as a "transparent tunnel", incoming packets are cut through the tunnel without buffering and /or switching. An extension to ns-module library is needed to support a network switch..

B. Related Work

A recent experiment [4] has designed and implemented a Network Switch with basic features in ns-2. Developed switch presented in [4] is derived from a parent class in ns-2 and designed and implemented as a standard component module for ns library.

C. General Purpose Switch Model

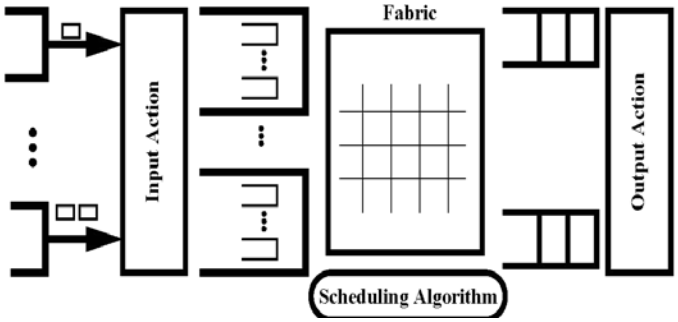


Fig. 1. Switch Architecture [2]

A Switch is a complex system which includes different mechanisms and technologies [8] and [9]. The switching architecture can be decomposed in three main functional components:

- The queuing models refer to the buffering and the congestion mechanisms implemented in the switch.

Dayanand Ambawade is a Asst. Professor in the Sardar Patel Institute of Technology at University of Mumbai (e-mail:dd_ambawade@rediffmail.com).

Dr. Prachi Gharpure, is a Professor and HOD of Computer Engineering Dept, Sardar Patel Institute of Technology at University of Mumbai. (e-mail:{Prachi.gharpure} @gmail.com)

- The switching algorithm implementation refers to the decision making process within the switch (how and where a switching decision is made).
- The switching fabric is the path that data take to move from one port to another.

There are different ways to build up the switch architecture with each of these components. Its modeling is shown as figure-1.

III. EXTENDED SWITCH MODELING

Features of proposed network switch model are as follows:

A. Port Trunking

When bandwidth of a single port (100 Mbps or 1000 Mbps) is not enough, port trunking is able to provide more bandwidth between switches. By combining the bandwidth of multiple ports together, traffic bottleneck between highly utilized switches can be eliminated. It is the IEEE 802.3ad link aggregation protocol. Refer to figure-2

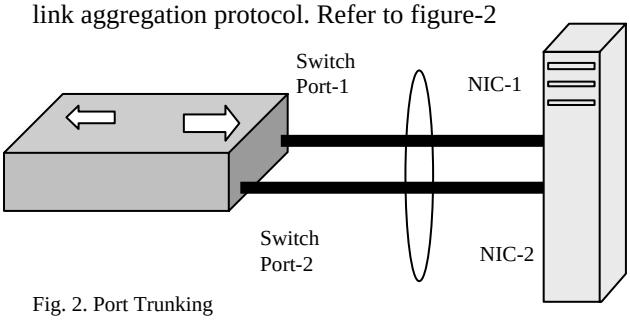
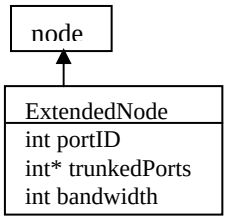


Fig. 2. Port Trunking

Node class from ns-2 is used as base class for the extended switch to provide port trunking feature. Refer figure-3



Pseudo code for the constructor of ExtendedNode class

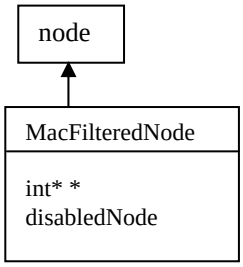
```
Parameters:
PortID[] to be trunked
noOfPortsTrunketed

Start
assign portID
for I = 1 to noOfPortsTrunked
   { trunkedPortsI]= portID[i]
     bandwidth
     = speed* noOfPortsTrunketed
   }
end
```

Fig. 3. Class with Port Trunking

B. MAC address filtering

Switch allows the network administrator to enter a list of MAC (Media Access Control) addresses that are allowed to communicate on the network. This is a strategy for controlling host network access using MAC address filtering. There are a number of uses for MAC filtering. The most common use for MAC filtering is reactive. One of the better use for MAC filtering is to proactively control which nodes can access the network by implementing MAC-based filtering on Layer 3 interfaces and Layer 2 switch and bridge ports. Figure–4 shows the extended class with MAC addresses filtering features.



Pseudo code for the constructor of MacFilteredNode class

```
Parameters:
PortID[I ] [I-1 ] to be blocked
I – number of ports to be blocked
Default: all ports are enabled
Start
For j=1 to I
For k= 1 to I-1
If j<>k{
DisabledNode[j][k] = 0 ;
// blockes the port from j to k
}
end
```

Fig. 4. Class with MAC address filtering

IV. EXTENDED SWITCH SIMULATION

A. Simulation Setup

The experiments were conducting using ns-2. The network model that we examined is using familiar dumbbell topology that is frequently used in network research studies.

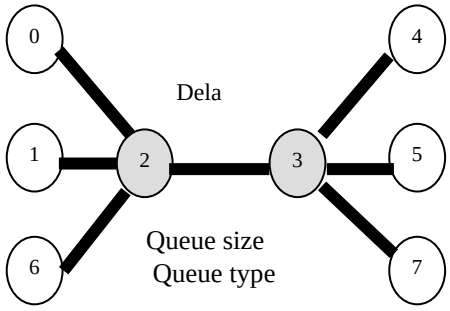


Fig. 5. Dumbbell Model for Switch with Network Traffic

The objective of this simulation is to test featured switch model and to analyse the behaviour of the two features: Port Trunking and MAC addresses filtering. We have defined a scenario, which collects three-source traffic (nodes 0, 1 & 6) and two receivers (nodes 4 & 5). In order to simulate the model (see the figure-5), node 0 & 6 have been truncated for bandwidth enhancement.

Router nodes (2 & 3) are of 1.5 Mb, 10 ms & queue size 100 and rest all nodes are of 5Mb, 10 ms.

B. Simulation results

We check the influence of port trunking on throughput between nodes 0 (trunked port) to 4 and 1 to 5. Throughputs are measured for the same port with and without port trunking feature and compared with other port as shown in figures 6 and 7 respectively. The results clearly show that in spite of channel congestion and noise there is an improvement in the throughput of the traffic.

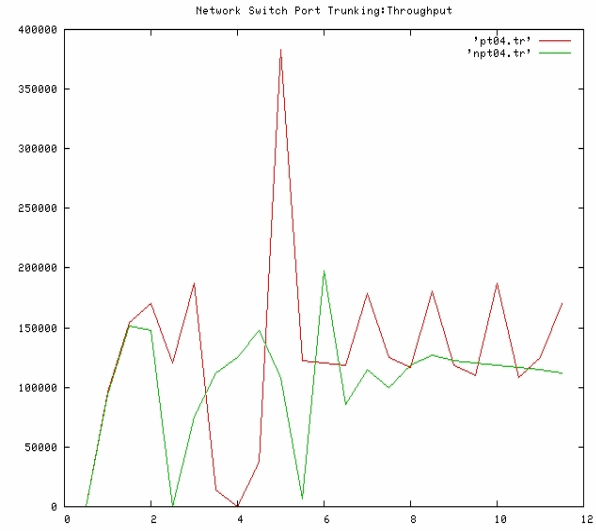


Fig. 6. Simulation Graph with Port Trunking Feature of Switch

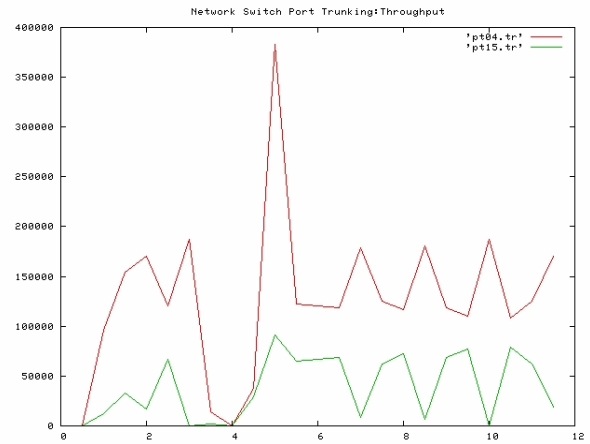


Fig. 7. Comparison Simulation Graph with Port Trunking Feature of Switch

V. CONCLUSION

In this paper modeling and simulation of an extended network switch in ns-2 is presented. The extended functionality of network switch facilitates the network designers in understanding the role of switch and evaluating switch network performance. Simulations based on various scenarios with extended features such as port trunking and MAC addresses filtering have been performed. The simulation results show the predicted behavior of the featured switch. The other features like STP, Port Mirroring and VLAN can be simulated with further extension of the proposed extended switch model.

VI. REFERENCES

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VII. BIOGRAPHIES

Dayanand Ambawade is a Asst. Professor in the Sardar Patel Institute of Technology at University of Mumbai. His research interests include networking, network security, mobile computing & open source softwares (Linux/Unix). He received a M.Tech from Indian Institute of Technology, Bombay in Communication Engineering. He is a member of the IEEE.Contact him at {dd_ambawade} @rediffmail.com

Dr. Prachi Gharpure, is a Professor and HOD of Computer Engineering Dept, Sardar Patel Institute of Technology at University of Mumbai. Her research interests include networking, object oriented analysis and design, education technology etc. She received her Ph.D. (Tech) in Computer Technology from SNDT Women’s University, Mumbai . She is a member of the IEEE. Contact her at {Prachi.gharpure} @gmail.com