Design and Simulation of Metro Ethernet using Optical System

Alireza Emamjomeh[1], Hossein Emami[2], Ali Hashemi[3]
1- Department of Electrical Engineering, Islamic Azad University, Majlesi Branch, Isfahan, Iran
Email: Alireza19838@yahoo.com
2- Department of Electrical Engineering , Islamic Azad University, Majlesi Branch, Isfahan, Iran
Email: h.emami@iaumajlesi.ac.ir
3- Department of Electrical Engineering, Islamic Azad University, Majlesi Branch, Isfahan, Iran
Email: a.hashemi@iaumajlesi.ac.ir

Accepted: July 2014 Revised: June 2014 Received: May 2014

ABSTRACT
Over the years, the discussion about achieving knowledge and discovering unknowns have attracted a lot of people and occasionally a news or text or short understanding of a new science absorbs scholars and people motivated to learn .looking in to the modern technology, we see new inventions and innovations which are unique .as an example, over the past years, new technology has been created in computer networks of which metro Ethernet has had a Noticeable advance in urban communication. Therefore the aim of this article is to provide and compile information regarding metro Ethernet technology. Utilizing Ethernet in urban networks needs the developing potential and strength that only exist in MPLS and IP levels. Layer two and three joint networks are solutions that join simplicity and economy of Ethernet at IP/MPLS scale. Different transfer technologies have been used in metro so metro services should be given on a mixture of optic and data switches, MPLS have been developed for this work and using generalized-MPLScontrol surface that support both data and optic switches performs it .In the beginning theories about using metro technology to produce urban networks are explained. Next a simulating called eNSP which is a suitable alternative for simulating metro Ethernet technology and at the end the result of the simulation will be presented.

KEYWORDS: Ethernet - MPLS – MAC – IP – VLAN – VPLS – VPN- IPTV.

1. INTRODUCTION

In the past decades ,Ethernet has been accounted of a built technology .Ethernet mediators enable you to have more band with low cost .these Ethernet parameters (high band width and low cost)and good performance ,simulates network Ethernet in using Ethernet as an access layer. Ethernet access has some good consequence for TDM network .as it is clear, Ethernet is known technology, simple but practical and wide usage .now Ethernet is used as superior technology widely in LAN and is practically a standard for the connection between the service providers and receivers. Today 98% of data traffic in networks all over the world is based on the Ethernet technology, it means that sending a parcel starts from one Ethernet networks and end in an Ethernet network, since the owners of local networks are interested in communicating beyond the company's borders, Ethernet was noticed as a cheap and simple solution. the same change can be observed in residential environments that is of course with the development of the different technology of access to wide spread networks such as DSL and coaxial cable , Ethernet has entered local networks slowly and its using in many cases providing high speed internet. In order to know metro networks it is necessary to define mesh networks that will be done in this project, and optic networks and switches are also explained .in order to define mesh networking in metro, it is needed to have an overview of current networks and next generation of the architecture of optic network.

2. RELATED RECORDS

As pattern ,Qom metro Ethernet networks has been designed in a way that provide up to 200 thousand high-speed lines to users and the systems and organizations that need more capacity communications with higher band with can connect to this networks using optic fiber. This network is designed in a way that all services that are practical on internet network can be done on it. It can also do advanced communication services like broadcasting TV channels with high quality with cooperation of TV stations. This is a new generation network that can provide all different services integratively on it and that is why this is digital convergent network that all functions can be done on it and it

has a central core and all the paths are netted and each of its paths can carry 10Giga bit per second and covers all telecommunication centers of the province.

3. PREVIOUS RESEARCH

Ali, Chiruvolu, andGe (2005) investigated the outlines novel algorithms for multipoint-TE in the metro Ethernet. They suggested a grouping scheme that extended the current label space in the provider domain and allowed fora large number of VLANs to be provisioned efficiently. They analyzed the issues of loadbalancing, multiple spanning trees, and interaction between grouping and bandwidthprovisioning, and suggested solutions. They explaineddifferentiated survivability in next-generation Ethernet and provided a novel schemebased on multiple spanning trees.

Padmaraj, Nair, Marchetti,Chiruvolu, Ali, andGe (2005) investigated traffic engineering which is one of the integralcomponents of QoS provisioning. They offered a scheme based onthe generation and management of multiple spanning trees fornear optimal traffic distribution.

Wang, Lynch,Ll, Klincewicz, Li, Doverspike, and Segal (2010) explained amethodology to enable the rapid introduction of metro Ethernetnetworks. They utilized a combination of numerous optimization algorithms and had been integrated into a pragmatic tool used by AT&T network planners. Case studies showed that the tool gave cost-effective solutions consistent with planner expectations and intuition.

Lianzhi (2010) examined reliability theory of computer communication network andsimulation experiment revealed that utilizing the system redundancy 2,link parallel redundancy, and interlaminar hybrid series-parallelredundancy, could better solve reliability of Metro Ethernet.

Torki, Mirjalily, andSaadat (2011) proposed an efficient fast algorithm to find the best spanning tree bymodeling and solving objective functions based on loadbalancing criterions. Utilizing this objective theycould balance thetraffic load on links and switches and showed the effectiveness of their approach.

4. HYPOTHESES

The existing network first was based on IP protocol .based on this, internet user connected to the internet using it. But due to the increase in demand for inter province connections and inefficiency of accessible network in the country for increasing number of these user and lack of economy in establishing these service in the accessible network because of the useless engagement of the bandwidth and other sources ,data company provider a service called intranet to the users , based on this subscribers with private Non-valid IP can just connect to IP network not the world web .they have global IP address pool and internet connections ,

.

1- Isolation of protocol which is run in an IP/MPLS common central base of the subscribers protocols.
2- The ability for subscribers to use MAC and IP address and their isolations from different IP/MPLS common central base.
3- Provision of connection security and isolation among different subscribers and common central base too.
4- Decreasing routing table volume and MAC table in common central base and limiting mentioned information in a common boundary between metro network and subscriber's network.
5- Traffic engineering between PE routers based on used bandwidth management or from pre-designing.
6- Provision of different telecommunication service from a high-speed single base to gain an optimal algorithm to increase the speed of electronic and telecommunication systems and decreasing the cost of purchase and maintenance.
7- Tunneling IPV6 traffic from IPV4 base using MPLS technology.

5. RESEARCH METHOD

The method faker to investigate the hypotheses was comparing old networks with IP/MPLS technology in order to show the weaknesses of the old network in comparison to this network.

5.1. The statement of the hypotheses

5.1.1. In the old networks in order to have a connection a many subscribers a connection between the subscribers protocols and carrier network was needed, but in metro network these protocol are completely isolated and the protocols of subscribers' sites are directly and only connected to each other.

5.1.2. In old networks the address of IP and MAC among all subscribers and carrier network had to be unique but in metro networks the possibility of reusing them in the area exists.

5.1.3. In old networks in order to separate the connection among different subscribers and between subscribers and carrier network needed a bulky configuration in security equipment but in metro network these connections are isolated without configuration

5.1.4. In old networks, in order to have a connection among the subscribers sites all the routers or network switches needed up to date routing table and subscribers switching, but in metro networks this volume of information is transferred to edge routers and switches.

5.15. In old networks in order to select the best, two way path between two routers, the only used way is routing protocols. The limitation of routing protocols in selecting the best way cause overutilization of the bandwidth and underutilization or no use of the other paths, so by traffic engineering tunnel, considering the management of bandwidth and guiding the intended traffic from a related tunnel, the mentioned problem is solved.

5.1.6. Using the technology MPLS tunneling enables different services such as IPTV interned and mobile back hall, E-commerce, E-learning and etc, on a high-speed common base.

5.1.7. In old networks in order to tunnel IPv6 traffic from IPV4 base implementation of GRE tunnels and ISATAPE and 6to4 is needed but in metro network using label switching itis possible implement 6PE and 6 VPE1 methods.

5.2. Scope of the research

With respect to the increasing technology and the development of the utilization of proposed facilities, there is a need for bandwidth and high speed and constant access to the telecommunication infrastructure all over the world. Due to the variety of the services and the number of users, the people's lives have been and will be dependent on this technology, in a way that a slight disturbance causes a big problem for people's daily activities. Therefore, in order to gain high speed, and economical and quick development and maintenance, the huge telecommunication networks need a shred network to transfer all services with different protocols on a shared infrastructure, and also implementing the method of packet switching rather than circuit switching. In this article, the MPLS network has been recommended as a solution and it is compared with the old networks. Moreover, the experimental sampleof this network has been implemented by HUAWEI technology.

5.3.Sample

In order to investigate the rate of the increase in telecommunication infrastructure and its penetration ratio in mobile operators and ISPs has been conducted.

6. THE RESULT OF HYPOTHESES TESTING:

6.1.Result of Testing H1 (This test is done over the VPLS (L2VPN) service.)

In L2VPN service, we are able to connect the devices over MPLS core like they are connected over a LAN switch inside the same VLAN; to build up this service, a remote LDP session is established among PE devices and a pesudowire is made among them over the MPLS core connecting each PE attached circuit to that pseudowire; as this connected among CE sites, is established over these pseudowires, there is no possibility of CE connection to the MPLS core or to CEs of different customers; to show this feature, we brought up VPLS service among R2 and R3 and established ISIS neighborship directly among R4 and R5 over the MPLS core; then from customer we made ping test toward MPLS core to show that it fails.

if you check the CE router routing-table, you recognize there is no route for MPLS core and they are completely isolated to each other also there is no negotiation of any protocol among MPLS core and customer network; customer sites negotiate their own rotocols! as you can see, then ping toward any IP address in core is not successful

6.2. Result of Testing H2,H3

Refer to VPLS service simulated before; the customer connections are established over pseudowires which are isolated from each other per customer and core; so the IP addresses and MAC addresses are isolated per customer and from core; inside the MPLS core, each VPNv4/VPNv6 route is advertised by RD:subnet/mask format; the addition of ROUTE DISTINGUISHER (RD) parameter to VPNv4/v6 route, makes it possible to also have IP address duplication per customer; on PE side, there is one routing-table instance per customer and one another for MPLS core so the forwarding information base per customer and MPLS core is different.

6.3. Result of Testing H4

We simulated a VPNv4 VRF service to test this one; as you will see, there is no route for the customer in the MPLS core; the BGP VPNv4 sessions are established toward R1 as RR to reduce the number of needed BGP sessions

.

6.4. Result of Testing H5

To convey all customer services (L2/L3VPNs) among R2-R3 as PE routers, the best path is R2-R3 direct link; this causes the over untilization of this link but under-utilization of R2-R1-R3 path; this causes congestion on the first link; by using TE technology which works on top of RSVP protocol, we can implement call admission control; in this simulation, we implemented bidirectional TE tunnels among R2-R3 to convey the customer services among R2-R3 over the longer path.

1- R1/R2/R3 configuration:

R1:

```
mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

ospf 1 router-id 1.1.1.1
 opaque-capability enable
 enable traffic-adjustment
 advertise mpls-lsr-id
 area 0.0.0.0
  network 0.0.0.0 255.255.255.255
  mpls-te enable
#

interface GigabitEthernet0/0/0
 undo shutdown
 ip address 10.1.2.1 255.255.255.0
 mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

interface GigabitEthernet0/0/1
 undo shutdown
 ip address 10.1.3.1 255.255.255.0
 mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

R2:

mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

ospf 1 router-id 2.2.2.2
 opaque-capability enable
 enable traffic-adjustment
 advertise mpls-lsr-id
 area 0.0.0.0
  network 0.0.0.0 255.255.255.255
  mpls-te enable
#

interface GigabitEthernet0/0/0
 undo shutdown
 ip address 10.1.2.2 255.255.255.0
 mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

interface GigabitEthernet0/0/2
 undo shutdown
 ip address 10.2.3.2 255.255.255.0
 mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

explicit-path 23
 next hop 10.1.2.1
 next hop 10.1.3.3
#

interface Tunnel0/0/2
 ip address unnumbered interface LoopBack0
 tunnel-protocol mpls te
 destination 3.3.3.3
 mpls te tunnel-id 2
 mpls te path explicit-path 23
 mpls te igp shortcut ospf
 mpls te igp metric absolute 1
 mpls te commit
#

R3:

mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

ospf 1 router-id 3.3.3.3
 opaque-capability enable
 enable traffic-adjustment
 advertise mpls-lsr-id
 area 0.0.0.0
  network 0.0.0.0 255.255.255.255
  mpls-te enable
#

interface GigabitEthernet0/0/0
 undo shutdown
 ip address 10.1.3.3 255.255.255.0
 mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

interface GigabitEthernet0/0/2
 undo shutdown
```

```
 ip address 10.2.3.3 255.255.255.0
 ospf cost 10
 mpls
 mpls te
 mpls rsvp-te
 mpls ldp
#

explicit-path 32
 next hop 10.1.3.1
 next hop 10.1.2.2
#

interface Tunnel0/0/3
 ip address unnumbered interface LoopBack0
 tunnel-protocol mpls te
 destination 2.2.2.2
 mpls te tunnel-id 3
 mpls te path explicit-path 32
 mpls te igp shortcut ospf
 mpls te igp metric absolute 1
 mpls te commit
#
```

2- Traffic toward the remote PE loopback0 (used as LSR-ID and BGP next-hop) is routed into the configured TE tunnel; that TE tunnel is established over the explicit-path configured by our pre-determination.

6.5. Result of Testing H6

To show this ability of the MPLS core network; we have implemented the following concurrent services in the simulator as the following:

1- VPLS
2- L3VPN (VPNv4)
3- 6VPE
4- IPTV over VPLS

To share the interface and MPLS core we implemented those services per PE-CE sub-interface; also a TE tunnel has been configured for traffic engineering among R2-R3.

Look at the design; each loopback on CE represents a service please refer to the following picture;

To check the concurrency of the services you can use the ping test and use the multicast ability of the simulator!

For the multicast service output; the multicast routing and PIM neighborship is established among R4-R5 over the VPLS L2VPN network along with IGP neighborship; for future optimization of IPTV service over VPLS it is recommended to implement IGMP snooping on L2VPN service to avoid extra not needed broadcasts!

Now the multicast routes are being checked on R4 and R5! Keep in mind that this service is implemented over the VPLS service so on MPLS core there is no multicast routing but just multicast switching! To make that multicast routes to be established, we must play a movie in simulator; now the multicast routes are established as the following.

6.6. Result of Testing H7

Refer to the design, no IPv6 address is configured in the MPLS core; just CE and PE-CE links are configured with IPv6; by using MPLS and MPBGP, it is possible to tunnel the IPv6 traffic over the IPv4 core by label switching; two approaches exist to implement this service; one is 6PE and the other one is 6VPE; the first method is implemented over the global IPv6 routing table and for the second method, it is implemented in VRF and the corresponding routes are advertised among just PE routers using BGP VPNv6 address-family; we selected this service to get benefit of IP address re-use.

Here R1 is configured as route-reflector; we get benefit of this feature to reduce the number of established BGP sessions of an address-family among N routers, from N*(N-1)/2 to N sessions; R1 doesn't have the VRF routes and shouldn't participate in routing path of the VRF traffic; it just reflects the BGP address-family updates.

Total number of routes from all PE: 4

Route Distinguisher: 22:33 //this parameter is added to any route of VPNv4/VPNv6 address-family to make that route unique inside the MPLS core network; so a VPNv4/v6 route is determined by RD:subnet/mask; this feature makes it possible to get benefit of any customer IP address duplication as long as RD of each VRF is different from the other one and that should be!

take a look at the BGP VPNv6 family routing-table of the PE router; the IPv6 subnet of the customer is found just in routing-table of the PE;the P routers just label switch is labeled packet to just convey it toward the remote PE. Look at the 2002:4:4:4::30/128 route which is R4 IPv6 loopback as a VRF customer; the next-hop is 2.2.2.2 so that means such traffic should be tunneled toward R2 as the remote PE;

- Remember we have routed traffic toward that remote PE over the tunnel 0/0/2 which is a TE tunnel with a pre-determined path; so we achieved to tunnel IPv6 traffic over IPv4 MPLS core and implemented CAC to avoid under-untilization of R2-R1-R3 path for all services among R2-R3.

The updates are received by BGP routing-table and then are installed into the VRF routing-table; all packet routing are done by routing-table

7. CONCLUSION

MPLS (multi protocol label switching) technology is a new method to get a shared quick communication infrastructure to provide a variety of services based on the clients' needs. In this network a sample of VPLS (virtual private LANs witching) and ATOM (any transport over MPLS) has been introduced and simulated that give the ability of CAC(call admission control), it also give clients the access to service provider infrastructure so giving urban services like e-commerce and e-learning by service provider to clients with data center is possible. Moreover, providing internet service on this infrastructure concurrently is possible. Also, MPLS network guarantees the security of each client by isolating their connections with the clients without the need for configuration and installing security equipment among the clients. Utilizing this network and having high-speed connections (10Gbps, 40Gbps, 100Gbps) in MPLS core, it is possible to meet all clients' needs on a shared infrastructure.

REFERENCES

[1] A, Frank John, and M., Ruediger Arndt. **"Method of configuring a valid IP address and detecting duplicate IP addresses in a local area network."** *U.S. Patent No*. 5,724,510. 3 Mar. 1998.

[2] A. , Loa, , T., Madsen. **"Provider provisioned virtual private network (VPN) terminology".** *RFC* 4026, March, 2005.

[3] Mannie, E, "**Generalized multi-protocol label switching (GMPLS) architecture"**. *Interface*, *501*, 19, 2004..

[4] N, Fabio, J., Pareta Xavier Masip Bruin, and S., Sánchez Lopez**. "Optical Network Design and Modeling."** 2007.

[5] Nestle, Elliot, , Robert F. Schunneman. **"TIME DIVISION MULTIPLEXING."** *U.S. Patent No*. 3,599,160. 10 Aug. 1971

[6] Sh , Laxman, , Sh., Ambe. **"Fastpath implementation for transparent local area network (LAN) services over multiprotocol label switching (MPLS)."** *U.S. Patent No*. 20,030,174,706. 18 Sep. 2003

[7] Tappan, Daniel C., et al. **"IPv6 over MPLS IPv4 core."** *U.S. Patent No*. 7,246,175. 17 Jul. 2007.