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Network Planning and Engineering for Fiber Optic Transport Systems

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ABSTRACT: In recent years, with the development of network technology and emergence of global Internet business, new Internet applications has a trend of explosive growth. Internet alone is introducing millions of individuals to a new world of information and technology. The demand for increasing bandwidth (voice, video, and data traffic) continues to drive the demand for fiber optical networks. Development of fiber optic transmission technology makes network transmission bandwidth be continuously increased. The methods to expand the backbone network capacity based on the optical fiber communication mainly include DWDM. The dense wavelength division multiplexing (DWDM) technology makes the telecom operators improve their network capacity by tens of times. In our project, An Efficient network planning and engineering for fiber optic transport system will be done using DWDM Technology

KEYWORDS: DWDM, network planning, Fiber optic transport system, Network capacity

I. INTRODUCTION

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber..The light forms an electromagnetic carrier wave that is modulated to carry information.

Over the last decade, fiber optic cables have been installed by carriers as the backbone of their interoffice networks, becoming the mainstay of the telecommunications infrastructure. The revolution in high bandwidth applications and the explosive growth of the Internet, however, have created capacity demands.

As a result, the once seemingly inexhaustible bandwidth promised by the deployment of optical fiber in the 1980s is being exhausted. To meet growing demands for bandwidth, a technology called Dense Wavelength Division Multiplexing (DWDM) has been developed that multiplies the capacity of a single fiber. DWDM systems being deployed today can increase a single fiber's capacity sixteen fold, to a throughput of 40 GB/s. This cutting edge technology-when combined with network management systems and add-drop multiplexers enables carriers to adopt optically-based transmission networks that will meet the next generation of bandwidth demand at a significantly lower cost than installing new fiber. The growth of the fiber optics industry over the past five years has been explosive. Analysts expect that this industry will continue to grow at a tremendous rate well into the next decade and beyond .In our project, By using DWDM technology network planning will be done for fiber optic transport systems.

II. RELATED WORK

With the development of network technology and emergence of global Internet business, new Internet applications has a trend of explosive growth. Internet alone is introducing millions of individuals to a new world of information and technology. The demand for increasing bandwidth (voice, video, and data traffic) continues to drive the demand for fiber optical networks. Development of fiber optic transmission technology makes network transmission bandwidth be continuously increased. DWDM can be used to expand the capacity of the fiber

In paper [1] Functions and applications of DWDM system components have been given. The operation of each component is discussed individually. DWDM terminology like Attenuation, dispersion, and optical signal to noise ratio (OSNR) are measures of optical signal quality and are the key factors involved in DWDM system design and operation. From transmitter to receiver, the quality of the optical signal and the path across which it travels

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determines if it is successfully detected and recovered at the receiving end. A description of each type of signal measure and its relationship to a DWDM system is given.

Paper [2] explained about the optimization method for the backbone WDM transmission network planning as well as survivability issues in the network Planning .The use of new technologies provides new subjects on network design and planning; Paper [3] has explained to overcome the bandwidth issue by using the wdm system.

DWDM, CWDM technologies are introduced to expand the capacity of the Fiber .DWDM is efficient compare to CWDM. Since Dwdm channel spacing is less than the CWDM Channel spacing Paper [4] explains Capacity expansion of the fiber optic network since the internet, cctv, television users are more now a days. High bandwidh is required. so to satisfy the user demand. Capacity of the fiber has to be expanded.

Paper [5] says about general characteristics of multihop systems are discussed, and various multihop approaches are reviewed. The construction of optimal structures based on minimizing the maximum link flow and optimizations based on minimization of the mean network packet delay are also reviewed Paper [6] includes Basics Of optical networking. copper has been replaced be the optical fiber because of Attenuation and interference Paper [7] Discusses the option of cost-effectiveness provided by the commercial second-generation optical amplifier system for network planners wanting more fiber-optic network capacity. How this service will be provided; Description of optical amplifier system. Amplifier and multiplexing technologies are required to expand the capacity.

Paper [8] describes an architecture and analyses the performance of dynamic provisioning of light paths in an optical network. Paper [9] Network traffic demands are forecast to increase for the foreseeable future, with the challenge being to meet the demand while maintaining or lowering network costs. Simply increasing capacity will not be sufficient; overall bandwidth utilization also needs to improve. A combination of improved transport capacity through increased spectral efficiency and bit rate along with better network utilization by integrating sub channel electrical grooming into the transmission system will be required. Smarter ways to utilize optical capacity are key since transmission costs have been decreasing slower than grooming and switching costs. Paper [10] Optical fiber communication from transmission to networking has been explained.. Over the last decade, fiber optic cables have been installed by carriers as the backbone of their interoffice networks, becom ing the mainstay of the telecommunications infrastructure. The revolution in high bandwidth applications and the explosive growth of the Internet, however, have created capacity demands.

III. THE CHALLENGES OF TODAY'S TELECOMMUNICATION NETWORK

Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Communication, which in the past was confined to narrowband voice signals, now demands a high quality visual, audio and data context. Every aspect of human interplay-from business, to entertainment, to government increasingly depends on rapid and reliable communication networks. Indeed, the advent of the Internet alone is introducing millions of individuals to a new world of information and technology. The demand for increasing bandwidth (voice, video, and data traffic) continues to drive the demand for fiber optical networks. The telecommunications industry, however, is struggling to keep pace with these changes. An enormous amount of bandwidth capacity is required to provide the services demanded by consumers.

IV. RESOLVING CAPACITY CRISIS

To reach the customer demand more capacity is needed, so carriers have three possible solutions: Install new fiber or Invest in new TDM technology to achieve faster bit rates. orDeploy Dense Wavelength Division Multiplexing. DWDM is the best choice which increases the capacity of the embedded fiber by combining and transmitting multiple signals simultaneously at different wavelengths on the same fiber. In effect, one fiber is transformed into multiple virtual fibers. So, to multiplex eight OC-48 signals into one fiber, you would increase the carrying capacity of that fiber from 2.5 GB/s to 20 GB/s. currently, because of DWDM, single fibers have been able to transmit data at speeds up to 400 GB/s.

A key advantage to DWDM is that it's protocol- and bit-rate-independent. DWDM-based networks can transmit data in IP, ATM,SONET /SDH, and Ethernet, and handle bit rates between 100 Mb/s and 2.5 Gb/s. Therefore, DWDM-based networks can carry different types of traffic at different speeds over an optical channel. So using the Wavelength Division Multiplexing Technology ,planning of network for the fiber optic transport system will be done.

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V. TECHNOLOGIES

i. *SONET/SDH*

SONET/SDH is standardized protocol that transfers multiple digital bit streams over optical fiber using lasers or Led. At low transmission rates data can also be transferred via an electrical interface. The method was developed to replace the Plesiochronous Digital Hierarchy (PDH) system for transporting large amounts of telephone calls and data traffic over the same fiber without synchronization problems. SONET-US and Canada (defined by ETSI Formalized as ITU), SDH-Rest of the world (Defined by Telecordia&ANSI)

This synchronization system allows entire inter-country networks to operate synchronously, greatly reducing the amount of buffering required between elements in the network. Both SONET and SDH can be used to encapsulate earlier digital transmission standards, such as the PDH standard, or they can be used to directly support either Asynchronous Transfer Mode (ATM) or so-called packet over SONET/SDH (POS) networking. Therefore, it is inaccurate to think of SDH or SONET as communications protocols in and of themselves; they are generic, all-purpose transport containers for moving both voice and data. The basic format of a SONET/SDH signal allows it to carry many different services in its virtual container (VC), because it is bandwidth-flexible

SONET/SDH advantages over PDH

- High transmission Data Rates
- International standards in digital format
- simplified add/drop function
- reliability(Back up circuit and repair mechanism)
- synchronous structure is flexible
- High availability and capacity.

SDH differs from Plesiochronous Digital Hierarchy (PDH) in that the exact rates that are used to transport the data on SONET/SDH are tightly synchronized across the entire network, using atomic clocks. SDH/SONET is completely synchronized .Hence it has developed to replace the PDH. PDH has not completely synchronized and also in PDH there is no international standard is present. SDH stands for synchronous digital hierarchy. SONET stands for synchronous optical networking. SDH differs from Plesiochronous Digital Hierarchy (PDH) in that the exact rates that are used to transport the data on SONET/SDH are tightly synchronized across the entire network, using atomic clocks. SDH/SONET is completely synchronized .Hence it has developed to replace the PDH. PDH has not completely synchronized and also in PDH there is no international standard is present. SDH stands for synchronous digital hierarchy. SONET stands for synchronous optical networking.

B. *DWDM*

Dense wavelength division multiplexing (DWDM) refers Originally to optical signals multiplexed within the 1550 nm band so as to leverage the capabilities (and cost) of erbium doped fiber amplifier (EDFAs), which are effective for wavelengths between approximately 1525–1565 nm (C band), or 1570–1610 nm (L band). Dense wavelength division multiplexing (DWDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e., colors) of laser light.

This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity.

Dense Wavelength Division Multiplexing (DWDM) is a technology that allows multiple information streams to be transmitted simultaneously over a single fiber at data rates as high as the fiber plant will allow (e.g. 2.4 Gb/s).

The DWDM approach multiplies the simple 2.4 Gb/s system by up to 16 times, giving an immense and immediate increase in capacity-using embedded fiber. A sixteen channel system (which is available today) supports 40 Gb/s in each direction over a fiber pair, while a 40 channel system under

Development will support 100 Gb/s, the equivalent of ten STM–64/OC–192 transmitters.

The benefits of DWDM over the first two options-adding fiber plant or deploying STM 64/OC-192 for increasing capacity are clear.

DWDM System components

- DWDM terminal multiplexer
- Intermediate line repeater
- optical add-drop multiplexer
- Optical Supervisory Channel (OSC)
- DWDM terminal demultiplexer

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- The terminal multiplexer multiplexes the all the signals (SONET/SDH, ATM etc) and It will be sent through optical fiber.

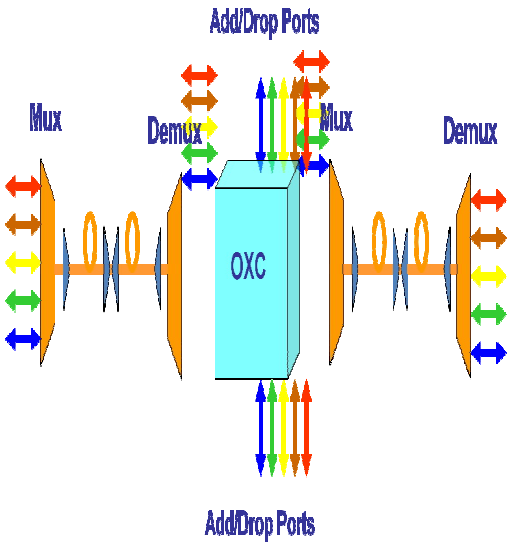

Fig 2.DWDM Structure

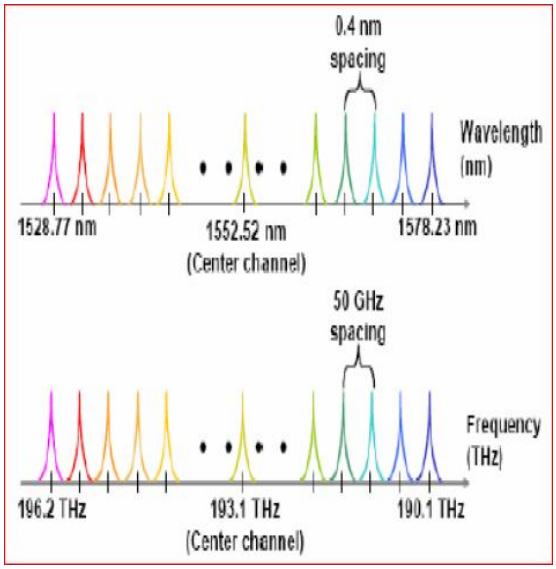

Fig 3.DWDM channel spacing

An intermediate line repeater is place approximately every 80-100 km to compensate for the loss of optical power as the signal travels along the fiber. Between multiplexing and demultiplexing points in a DWDM system, there is an area in which multiple wavelengths exist The OSC carries information about the multi-wavelength optical signal as well as remote conditions at the optical terminal. The terminal demultiplexer breaks the multi-wavelength signal back into individual signals and outputs them on separate fibres for client-layer systems (such as SONET/SDH) to detect

C. *ROADM*

It is form of an optical add drop multiplexer.It allows individual or multiple wavelengths carrying data channels added or dropped from transport fiber without converting signal on all the DWDM channels to electric signal &back again optical signals. In fiber optics, a reconfigurable optical add-drop multiplexer (ROADM) is a form of optical add-drop multiplexer that adds the ability to remotely switch traffic from a wavelength-division multiplexing (WDM) system at the wavelength layer. This is achieved through the use of a wavelength selective switching module. This allows individual or multiple wavelengths carrying data channels to be added and/or dropped from a transport fiber without the need to convert the signals on all of the WDM channels to electronic signals and back again to optical signals. The main advantages of the ROADM are: The planning of entire bandwidth assignment need not be carried out during initial deployment of a system. The configuration can be done as and when required without affecting traffic already passing the ROADM.ROADM allows for remote configuration and reconfiguration. In ROADM, as it is not clear beforehand where a signal can be potentially routed, there is a necessity of power balancing of these signals. ROADMs allow for automatic power balancing.

VI. NETWORK PLANNING

A . *Process Flow*

The below Flow Chart will give a general overview of the Process Involved during an individual project phase.

1. Gather All information required to start the Projec
2. Gather Site Survey and Fiber Characterization results (if any)
3. Create Rack Front View (RFV) using the Stencils and Diagram Templates using Microsoft Visio software
4. Create Signal Flow Diagrams (SFD) Using the Stencils and Diagram Templates using Microsoft Visio.
5. Gather IP and Commissioning related information Form the customer to complete

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6. .Commissioning and Provisioning information spreadsheet needs to be created.
7. Get the DND reviewed by a Senior Engineer before Releasing the project files. This completes network planning completely.

.B. *Gathering input files*

Equipment list (Sales Copy/ Bill of Materials BOM)

Every Project is identified by a six digit Project Number. The equipment list will consists of all the hardware required for each site being added in a Network.

1. Each Equipment list will consist to many sections
2. Type and configuration added at each site.
3. Auxiliary shelf equipment – Like Mounting Brackets, Power Harness, Cooling Unit, etc. .
4. Common Equipment- Consists of Filler Cards, Access Panel, Shelf Processors, Power Interface
5. Broadband Interfaces and photonic interface
6. Project related equipments-fibre management, ac rectifier

Photonic Configuration

Whenever the configuration of the Network being deployed is a Photonic Configuration, we require what is called the Modeler or the OPNET. The OPNET report gives details about the network connectivity, what Amplifiers is facing which direction, the wavelengths to be assigned, where attenuator pads should be used and the values to be used. All the photonic components will be a part of this input file

The excel file and either of the Visio or the PDF File should be available to start the DND Process for a Network with Photonic/DWDM Configuration.

C. *DETAILED NETWORK DESIGN:*

The various parts involved in Detailed Network Design are as below:

Rack Front View

Rack Front View is also referred as RFV. Rack Front View is a Visio file document which would indicate the installers the shelf and cards positions when they are on site installing the equipment. This file consists of a Rack Front view along with different components going into different slots. For all site

Signal Flow Diagram

Signal Flow Diagram is also referred as SFD. Signal Flow Diagram is an indication for the various inters connections that need to be done in a Site where the 6500 shelf is being added

Commissioning and Provisioning

Commissioning and Provisioning is an excel Spreadsheet document that is provided to the Field Engineering team to perform Commissioning and provisioning of the 6500 shelf at each site based on the configuration and the inputs received from the Customer. Each Type of Configuration that is configurable on a 6500 shelf is has different provisioning parameters. These parameters are to be taken into consideration for a particular type of configuration and the fields in the Provisioning tab of the spreadsheet.

5.3.4 Project Network Diagram

Project Network diagram also referred as PND is another Visio document which would give an overall view of the Network topology. PND is only done where ever applicable and necessary.

VII. RESULT

Network planning includes detailed network design (DND). As per the detailed network design procedure, for all sites Rack front view (RFV) created, Signal flow diagram (SFD) created for all sites. Similarly project network diagram (PND) developed which gives over all network topology and C&P has been developed. This completes the detailed network design (DND).Microsoft Visio software used to do network planning.

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After designing the DND file or Document has to be sent to site /field engineers. They will configure as per the detailed network document and install. After completion of Installation finally network will be tested for 12hours or 24hours.our network has been tested for 24 hours. The result of the tested network has shown in below

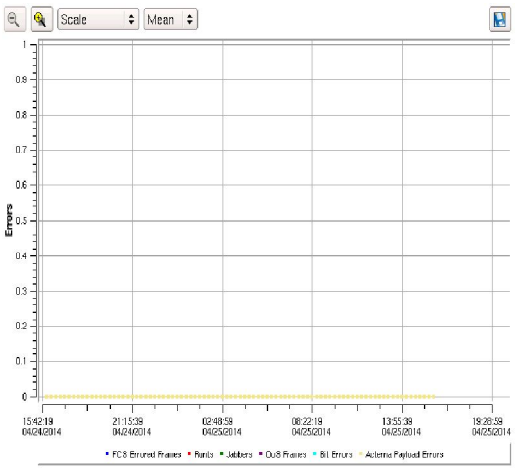

Fig.6. Errors in the network

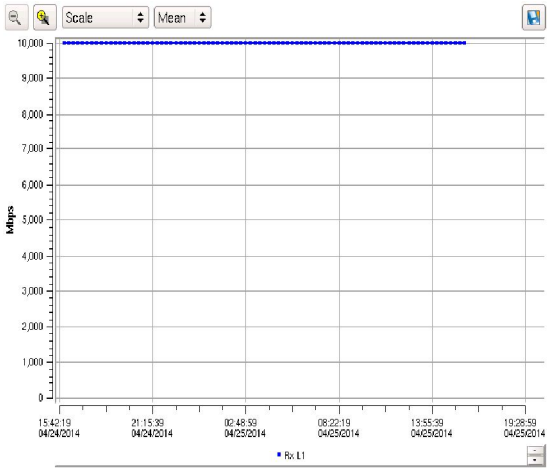

Fig.7 Throughput of the network

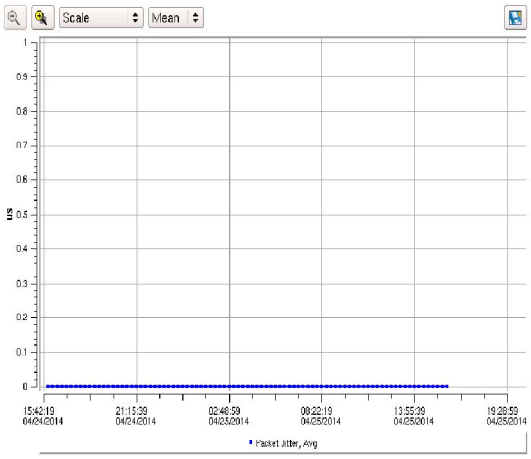

Fig.9 Packet Jitter in the network

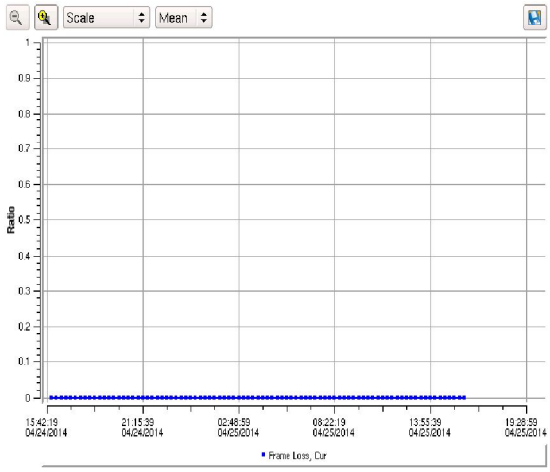

Fig 8 Frame Loss in the network

After network testing (Bit error rate testing) there is no Frame loss or packet jitter found in the network, from this we can conclude that network is error free.

VIII. CONCLUSION

In our project Network planning and engineering has been completed which includes detailed network design. After designing of the network, It has been tested for 24hours. Network test(Bit error testing) shown that our Network is completely error free. Finally we concluded that, after network planning/design and engineering for fiber optic transport system using DWDM system, the designed network is completely efficient.

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BIOGRAPHY

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