Performance Analysis of OADM Based Switched Multimegabit Data Service

Thesis submitted in partial fulfillment of the requirements for the award of degree of

Master of Engineering
in
Electronics and Communication Engineering

Submitted By
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CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, "***Performance Analysis of OADM Based Switched Multimegabit Data Service***", in partial fulfillment of the requirements for the award of degree of Master of Engineering in ***Electronics and Communication Engineering*** submitted in Electronics and Communication Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of ***Dr. R. S. Kaler (Sr. Professor)*** and refers other researcher's work which are duly listed in the reference section.

The matter presented in the thesis has not been submitted for award of any other degree of this or any other University.

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This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

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ABSTRACT

Optical fiber communication systems are being extensively used all over the world for telecommunication, video and data transmission purposes. The demand for transmission over the global telecommunication network will continue to grow at an exponential rate and only fiber optics will be able to meet the challenge. This is because the optical fiber capable of allowing the transmission of many signals over long distances. Switched Multimegabit Data Service (SMDS) is a telecommunications service that provides connectionless, high-performance, packet-switched data transport. Being neither a protocol nor a technology, it supports standard protocols and communications interfaces using current (and future) technology. SMDS allows users to transparently extend their data communications capabilities over a wider geographical area. Since it is a service offered by the telephone companies, SMDS permits this expansion using existing Customer-premises equipment (CPE) and protocols, with minimal investment in dedicated leased lines as the number of line terminations increases.

In this thesis, different LAN network and their performance for the success and the failure of the communication have been investigated. Industrial plants use conventional local area networks (LANs) to access a growing number of client/server (C/S) which have a direct impact on organization's productivity. SMDS has been defined by the IEEE 802.6 Metropolitan Area Network (MAN) standard, as implemented by Bellcore. It can use a variety of technologies, including Broadband ISDN (B-ISDN) and Distributed Queue Dual Bus (DQDB). Current North American implementations utilize DQDB with DS1 (1.5 Mbit/s) or DS3 (44.736 Mbit/s) lines. Other implementations utilize E1 lines at speeds in excess of 1.9 Mbit/s or E3 lines. Future SMDS networks will couple B-ISDN with SONET OC3 at 155.520 Mbit/s. The thesis analyzes the behavior of accepted and drop packets in the OADM (Optical Add/Drop Multiplexer) based SMDS network. OADM decides which packet is to accepted and which is to be dropped. Results analyze the behavior of accepted and drop packets at random time of packets generation in the real time.

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List of Abbreviations

LAN	Local Area Network
ISDN	Integrated Services Digital Networks
SMDS	Switched Multimegabit Data Services
OADM	Optical Add/Drop Multiplexer
WDM	Wavelength Division Multiplexer
GRIN	Gradient Index
CPE	Customer-Premises Equipment
FDDI	Fiber Distributed Data Interface
FLC	Ferroelectric Liquid Crystal
MAC	Media Access Control
B-ISDN	Broadband ISDN
FPS	Fast Packet Switching
ATM	Asynchronous Transfer Mode
DQDB	Dual Queued Data Bus
WAN	Wide Area Network
CPE	Customer Premises Equipment
SNI	Subscriber Network Interface
Bellcore	Bell Communications Research
SONET	Synchronous Optical Network
MAN	Metropolitan Area Network
SIP	SMDS Interface Protocol

ISSI	Inter-Switching System Interface
ICI	Inter-Carrier Interface
SDU	Service Data Units
PLCP	Physical Layer Convergency Protocol
PDU	Protocol Data Unit
GUI	Graphical User Interface

CHAPTER 1

INTRODUCTION

1.1 Introduction to Optical Communication

The progress of optical fibers has displaced copper wire as the transmission medium of choice for most commercial applications in telecommunications systems and computer networks worldwide. Optical fibers about the size of a human hair can carry several orders of magnitude more information than copper wires many times larger in diameter, and they are stronger, lighter, and cheaper. In addition, the signal-carrying load of already installed optical fiber cables can be readily increased as signal-processing technologies improve. Optical fiber communication systems have a long history and it was realized during the second half of the twentieth century that a greater transmission bandwidth could be achieved by employing optical waves as the carrier [1]. However, this possibility was not exploited until the invention of laser in the 1960s [2]. The main advantages of the optical fiber communications are the high speed, large capacity and high reliability by the use of the broadband of the optical fiber. The huge bandwidth of optical fiber communication system can be utilized to its maximum by using multiple access techniques.

LAN as the name suggests are local area networks which are limited in size and restrictive in distance. We have seen a whole plethora of techniques used to overcome these disadvantages ranging from the use of repeaters, the use of bridges and routers. Bridges enable like LANs to be linked but careful planning is needed to prevent information loops causing congestion. The multiprotocol router operates at layer 3 and thus enables different LAN technologies to be linked. There is a growing demand to link LANs. Up to 1994 this was predominantly undertaken by using private networks or ISDN. The service available was chosen based upon a combination of usage and tariffs. ISDN for example is cost effective up to about 4 hours against average Kilostream tariffs. It is becoming known as the four hour market. Higher speed (up to 2Mbit/s) point to point services can also be achieved over private circuits using

Frame Relay. The demand for LAN interconnect services over 2Mbit/s is growing and to meet this demand SMDS has been developed. Not all companies need speeds at greater than 2Mbit/s however and SMDS is offered at speeds ranging from 0.5Mbit/s to 25Mbit/s. In LAN network access is random and collisions occur are well suited to LAN's with low traffic demand [3].

Optical add–drop multiplexers (OADM) are indispensable elements in wavelength-division-multiplexed (WDM) networks. "Add" and "drop" here refer to the capability of the device to add one or more new wavelength channels to an existing multi-wavelength WDM signal, and/or to drop (remove) one or more channels, passing those signals to another network path. An OADM may be considered to be a specific type of optical cross-connect. Among various approaches to making optical add–drop multiplexers (OADMs), the one utilizing a thin film filter along with a pair of gradient index (GRIN) lenses has taken the lead due to its low cost, satisfactory performance, and high reliability. However, a recent improvement in ball-lens coating technology [4] has enabled ball lenses to offer competitive performance and obvious convenience in packaging, while presenting a distinct cost advantage over GRIN lenses. Switched Multimegabit Data Service (SMDS) is a datagram service intended for LAN interconnection which may be offered by Local Exchange and Interexchange Carriers [5,6]. SMDS allows users to transparently extend their data communications capabilities over a wider geographical area. Since it is a service offered by the telephone companies, SMDS permits this expansion using existing Customer-premises equipment (CPE) and protocols, with minimal investment in dedicated leased lines as the number of line terminations increases. SMDS is a connectionless public packet switched service which is currently defined to operate at 1.544 Mbps (DSl) or 44.736 Mbps (DS3). In addition, SMDS data units are large enough to encapsulate entire IEEE 802.3, IEEE 802.5, and Fiber Distributed Data Interface (FDDI) frames.

The use of OADM in SMDS can further increase the speed of the SMDS network as the collision rate decreases and OADM decides the wavelength which is to be accepted by the network. Different LAN networks can use OADM for further increase in the speed of the network.

1.2 Optical Add–Drop Multiplexer

OADM stands for optical add/drop multiplexer. This is a type of degree-2 optical node, which is generally used for the construction of a ring-based optical transport network. An OADM consists of three stages, namely, optical demultiplexer, optical switch or add/drop stage, and optical multiplexer. Optical demultiplexer functions to separate wavelengths in an inlet fiber onto individual fibers. These fibers are then either dropped, connected to 2x2 optical switches, or directly connected to optical multiplexer. The last stage is optical multiplexer which functions to multiplex all those wavelengths either added, directly from optical demultiplexer, or 2x2 optical switches, into an outlet fiber.

All the lightpaths that directly pass an OADM are termed cut-through lightpaths, while those lightpaths added/dropped at the OADM node termed added/dropped lightpaths. In addition, depending on whether 2x2 optical switches are deployed in the middle stage, OADM can be further classified into reconfigurable OADM if optical switches are deployed, or fixed OADM if everything is not reconfigurable. Physically, there are several ways to realize an OADM. One can use the traditional demultiplexer and multiplexer architecture to realize an OADM, or use a combination of fiber grating and optical circulators to realize an OADM. Although both have add/drop functionality, OADM is generally different from ADM. The former functions in the optical domain under WDM technique, while the latter is implicitly considered to functions in the traditional SDH/SONET networks.

The other critical issues in the design are insertion loss, cross-talk, and component count [7].The OADMs can be divided into two categories, namely, static (fixed) and dynamic (reconfigurable). The former type typically enables drop and/or add pre-determined channels while the latter type can provide much more flexibility, that is, channels can be added/dropped dynamically. The cost is a critical problem in designing and implementing of OADMs, especially the recent business downturn puts more significant pressure on substantial cost reduction while improving performance simultaneously. Various types of OADMs based on different optical devices have been proposed and developed. Riza proposed a reconfigurable OADM [8] where FBGs and ferroelectric liquid crystal (FLC) switch were cascaded in series and the FLC switches provided fast selection and switching of add/drop channels.

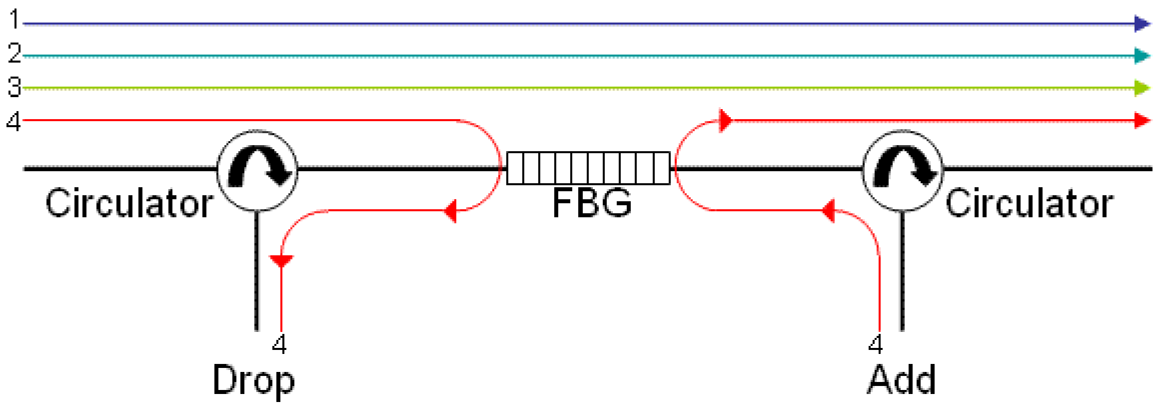

Figure 1.2: Optical add-drop multiplexer (**OADM**)

The figure above is an example of an OADM. It is clear from the figure that any number of wavelength can be added or dropped depending upon the requirement. This OADM also helps to increase the speed of the network by providing less congestion. It also helps to remove the collision and provide less congestion rate. In this case, the incoming red wavelength is dropped, while a different red wavelength is added. To some degree, OADMs are flexible. In other words, it is likely that this OADM could be configured to add and drop both red and green wavelengths, or it could be configured to pass all wavelengths through.

Metcalfe's Law states that the utility of a network grows proportionally to the square of the number of users (n^2) connected to it. [9] Unfortunately, as the number of users in a network increases, the complexity and expense of the network also increases. A mesh topology where each user is connected to every other user is not practical for networks of reasonable size. This leads to two competing goals of network design. One goal is, in general, to allow communication between all network users to maximize Metcalfe's Law. The other goal is that networks must be economical; otherwise no one would use them. Network switches were developed to meet these competing goals of wide open network communication and network economy.

Switching in the electric domain is relatively straightforward. Network frames typically contain a header that contains the source and destination of the frame. As switching is usually done at level 2 of the OSI model, the address is usually a MAC address. The switch reads the destination address and forwards the frame to the appropriate port on the switch based upon internal address tables. Switching in the optical domain is not nearly as easy. The simplest approach is to use a series of conversions. Optical signals are generally switched by first converting the optical signal into an electric signal. The correct output address is determined by the frame header. A second conversion, this time electrical to optical is then applied to the signal before it is sent out on the correct port. This is expensive; the extra conversions and processing introduces delay and raise the cost of the switch. None-the-less, this is probably the most commonly used method of switching used today.

Another approach is to keep the signal in the optical domain as it is being switched. This topic has been widely researched for three decades, yet pure optical switches are still not widely used. In general, they are static and inflexible. The topic of optical switches is discussed in detail in [10].

A third approach (for WDM networks) is to use optical add-drop multiplexers (OADMs). An OADM takes a multi-wavelength signal arriving in an input fiber, drops one or more preselected wavelengths from the signal, and adds one or more pre-selected wavelengths into the multi-wavelength signal that exits in an output fiber. [11] Wavelengths carrying transit traffic pass straight through the OADM. Processing in an OADM is performed entirely in the optical domain to avoid the conversions between the electrical and optical domains. Thus, there is very little delay introduced in an OADM.

1.3 Introduction to SMDS

There is a growing interest in the development of broadband services and networks for commercial use in both local area and wide area networks. The initial stimulus some 10 years ago was the development of Asynchronous Transfer Mode (ATM) for use on broadband networks, under the banner of Broadband ISDN (B-ISDN). Recently there is a real pragmatic drive for broadband services, to meet the demand for increased bandwidth for remote sites inter-connection, and for image and high-speed data transfer. Broadband activity now has commercial services under a variety of titles, and most of these fall under the umbrella of Fast Packet Switching (FPS). This is a generic term that refers to the switching process being done at a layer which corresponds to layer 2 in the OS1 Reference Model. Some of these networking technologies use ATM techniques such as Switched Multimegabit Data Service (SMDS) [12] (can be offered using ATM) and Dual Queued Data Bus (DQDB) [13], and others not such as Frame Relay. Although it is possible to appreciate the differences between these technologies in terms of the network infra- structure, it is not very clear what each of them has to offer in terms of supporting applications. In particular, with the development of new applications, such as networked multimedia, desktop videoconferencing and entertainment services, the need for such broadband services is constantly growing. Also the interconnection of Local Area Networks (LANs) providing high-speed information transfer is becoming a strategic necessity for many enterprises to support their growing number of Workgroup-based and backbone-type LANS [14].

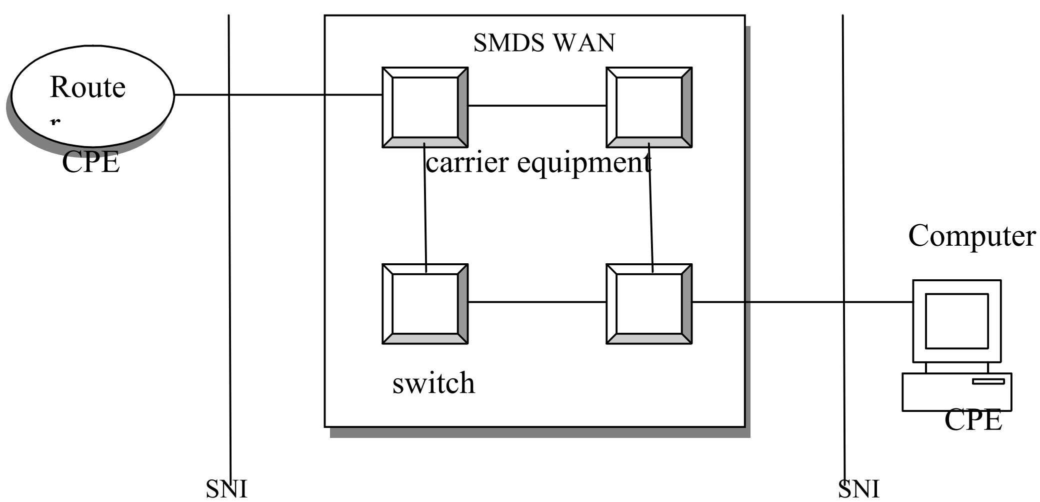

Figure 1.3: The SNI provides an interface between the CPE and the carrier equipment in SMDS.

SMDS networks consist of several underlying devices to provide high-speed data service. These include customer premises equipment (CPE), carrier equipment, and the subscriber network interface (SNI). CPE is terminal equipment typically owned and maintained by the customer. CPE includes end devices, such as terminals and personal computers, and intermediate nodes, such as routers, modems, and multiplexers. Intermediate nodes, however, sometimes are provided by the SMDS carrier. Carrier equipment generally consists of high-speed WAN switches that must conform to certain network equipment specifications, such as those outlined by Bell Communications Research (Bellcore). These specifications define network operations, the interface between a local carrier network and a long-distance carrier network, and the interface between two switches inside a single carrier network.

The SNI is the interface between CPE and carrier equipment. From this interface customer network ends and the carrier network begin. SNI makes the technology and operation of the carrier SMDS network transparent to the user.

SMDS is neither a protocol nor a technology, but more accurately it is considered as a standard. It is able to support standard protocols and communication interface using current and future technology. SMDS is a cell-based or considered as a cell relay which is for end-to-end application usage and also is a logical progression to ATM if the need arises. Cells are handled through SMDS switches, which are joined by high-speed DS-1, ISDN and SONET links. SMDS is very much like standard POTS whereby, once the user establishes the called party's telephone number, that SMDS number need only precede packets addressed to the called party. Therefore it makes it unnecessary to add remote ends in a private network, making it ideal for subscribers. SMDS primarily works with MANs and supports the ability to interconnect geographically dispersed multiple LANs operating at speeds up to 16Mbps and is considered an on-demand high bandwidth service, as well as a protocol-independent service that allows bandwidth to be dynamically allocated. It provides a large bandwidth at a bargain price, with the ease of a telephone, which makes it successful and ideally suited for users looking for a wide bandwidth digital connection. SMDS is said to be a cross between ATM and Frame Relay. It is noticed that current North America utilizes DQDB with DS1 (1.5Mbps) or DS3 (45Mbps) lines. Others utilize E1 lines at speeds in excess of 1.9Mbps or E3 lines.

1.3.1 History of SMDS

SMDS was first demonstrated in 1990 as a telecommunications-based system to link FDDI networks into a MAN. In 1991, it allowed transport of mixed data, voice and video on the same network. Basically SMDS is a broadband network technology developed by Bellcore. It is a subset of IEEE 802.6 DQDB MAN technology, which was developed to be a high-speed, connectionless, public, packet-switching service. The original Bellcore standard specified how Customer Premises Equipment (CPE) could access a SMDS switch located at a CO using twisted-pair wiring at the T-1 rate or optical fiber at the T-3 rate. The scope of SMDS has evolved since its original design to support WANs. It now includes higher rate definitions and in the future may operate at the OC-3 (155Mbps) SONET rate.

1.3.2 Topology

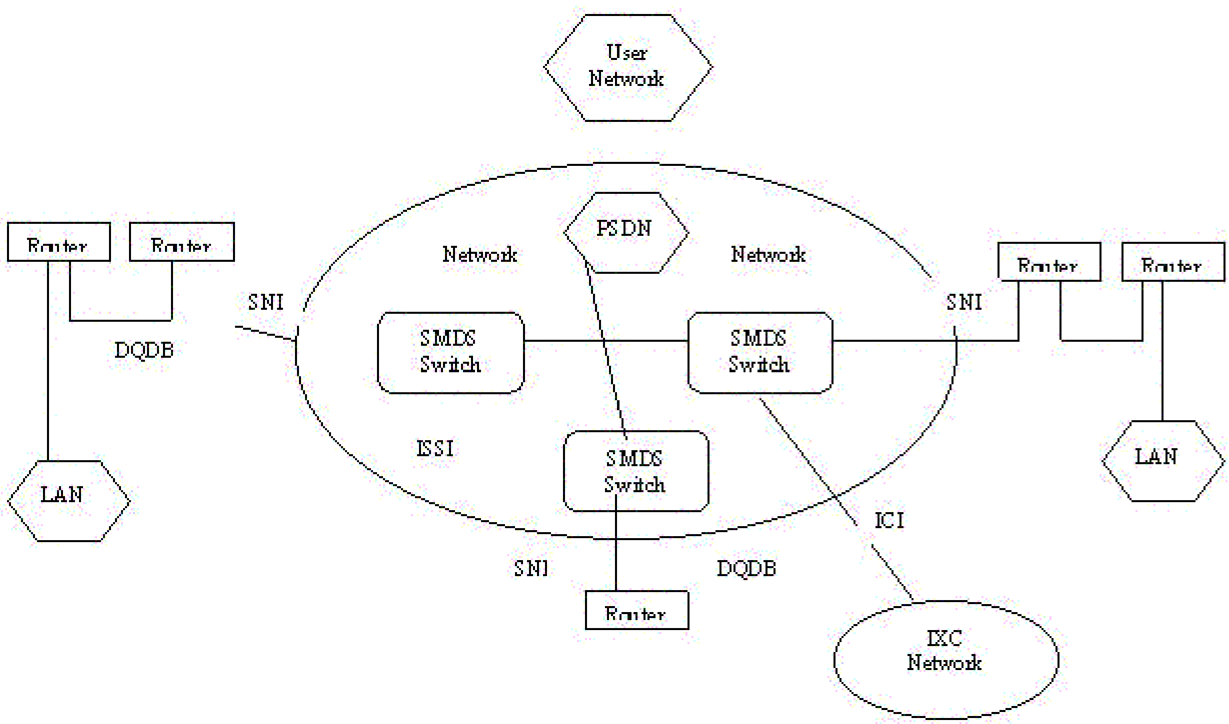

Figure 1.3.2: SMDS Topology

The figure 1.3.2 above shows a typical SMDS topology. SMDS uses the DQDB (Distributed Queue dual Bus) protocol at the SMDS SNI (Subscriber Network Interface). It defines the procedures for a user's CPE to interface with an SMDS network.

The SNI can also be referred to as the SMDS interface protocol (SIP) or an "access DQDB". The SNI operates between the CPE and the SMDS switching system. The SMDS switch is a high-speed packet switch that supports operations within a LATA. Multiple SMDS switches can be connected via an Inter-switching System Interface (ISSI). The Inter-carrier Interface (ICI) connects two LECs through an IXC. The ICI provides inter-LATA service and is also called Exchange Access SMDS.

1.3.3 Distributed Queue Dual Bus (DQDB)

The Distributed Queue Dual Bus (DQDB) is a data link layer communication protocol designed for use in metropolitan-area networks (MANs). DQDB specifies a network topology composed of two unidirectional logical buses that interconnect multiple systems. It is defined in the IEEE 802.6 DQDB standard. An access DQDB describes just the operation of the DQDB protocol (in SMDS, SIP) across a user-network interface (in SMDS, across the SNI). Such operation is distinguished from the operation of a DQDB protocol in any other environment (for example, between carrier equipment within the SMDS PDN). The access DQDB is composed of the basic SMDS network components:

- Carrier equipment: A switch in the SMDS network operates as one station on the bus.
- CPE: One or more CPE devices operate as stations on the bus.
- SNI: The SNI acts as the interface between the CPE and the carrier equipment.

The figure 1.3.3 below depicts a basic access DQDB, with two CPE devices and one switch (carrier equipment) attached to the dual bus.

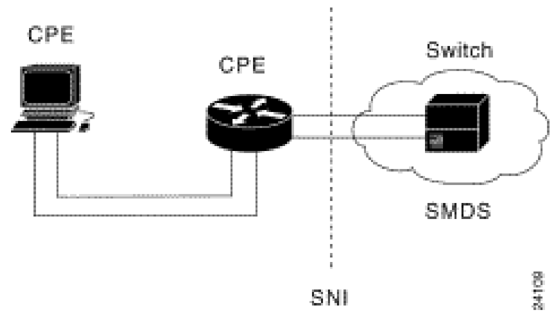

Figure 1.3.3: A Basic Access DQDB

A Basic Access DQDB May Consist of an End Node, a Router, and a Switch. An SMDS access DQDB typically is arranged in a single-CPE configuration or a multi-CPE configuration [15].

A single-CPE access DQDB configuration consists of one switch in the carrier SMDS network and one CPE station at the subscriber site. Single CPE DQDB configurations create a two-node DQDB sub-network. Communication occurs only between the switch and the one CPE device across the SNI. No contention is on the bus because no other CPE devices attempt to access it.

A multi-CPE configuration consists of one switch in the carrier SMDS network and a number of interconnected CPE devices at the subscriber site (all belonging to the same subscriber). In multi-CPE configurations, local communication between CPE devices is possible. Some local communication will be visible to the switch serving the SNI, and some will not.

Contention for the bus by multiple devices requires the use of the DQDB distributed queuing algorithm, which makes implementing a multi-CPE configuration more complicated than implementing a single-CPE configuration.

SMDS supports speeds of 1.544 Mbps over DS-1 transmission facilities, or 44.736 Mbps over DS-3 transmission facilities. Its speed can range up to 155Mbps over T-carrier facilities. It operates by accepting high-speed customer data in increments of up to 9,188 octets, and divides it into 53-octet cells for transmission through the service provider's network. These cells are reassembled, at the receiving end, into the customer data. SMDS speed is higher than Frame Relay and ISDN. SMDS is planned to increase the speed rates to 155.520 Mbps with OC-3c.

1.3.4 SMDS Interface Protocol

The SMDS Interface Protocol (SIP) is used for communications between CPE and SMDS carrier equipment. SIP provides connectionless service across the subscriber network interface (SNI), allowing the CPE to access the SMDS network. SIP is based on the IEEE 802.6 Distributed Queue Dual Bus (DQDB) standard for cell relay across metropolitan-area networks (MANs). In addition, DQDB was designed for compatibility with current carrier transmission standards, and it is aligned with emerging standards for Broadband ISDN (BISDN), which will allow it to interoperate with broadband video and voice services.

1.3.5 SIP Levels

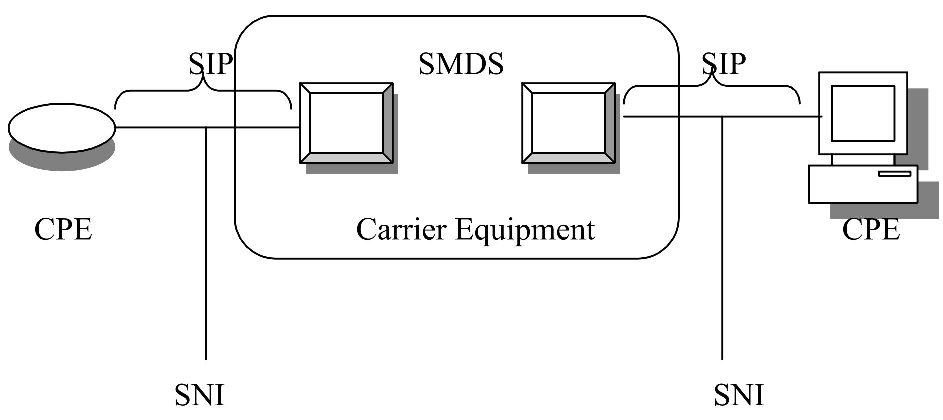

Figure 1.3.5 SIP provides connectionless service between the CPE and carrier equipment

SIP consists of three levels [16].

SIP Level 3 operates at the Media Access Control (MAC) sublayer of the data link layer of the OSI reference model.

SIP Level 2 operates at the MAC sublayer of the data link layer.

SIP Level 1 operates at the physical layer of the OSI reference model.

SIP Level 3 begins operation when user information is passed to SIP Level 3 in the form of SMDS service data units (SDUs). SMDS SDUs then are encapsulated in a SIP Level 3 header and trailer. The resulting frame is called a Level 3 protocol data unit (PDU). SIP Level 3 PDUs then are subsequently passed to SIP Level 2.

SIP Level 2, which operates at the Media Access Control (MAC) sublayer of the data Level layer, begins operating when it receives SIP Level 3 PDUs. The PDUs then are segmented into uniformly sized (53-octet) Level 2 PDUs, called cells. The cells are passed to SIP Level 1 for placement on the physical medium.

SIP Level 1 operates at the physical layer and provides the physical-link protocol that operates at DS-1 or DS-3 rates between CPE devices and the network. SIP Level 1 consists of the transmission system and Physical Layer Convergency Protocol (PLCP) sublayers. The *t*ransmission system sublayer defines the characteristics and method of attachment to a DS-1 or DS-3 transmission link. The PLCP specifies how SIP Level 2 cells are to be arranged relative to the DS-1 or DS-3 frame. PLCP also defines other management information.

1.3.6 Advantages of SMDS

SMDS is a high-speed, switched public data service that easily, flexibly and economically extends existing LAN capabilities over wide areas. Because it is transport independent, its service features can operate with technologies ranging from Frame Relay to ATM and dedicated private lines. Often called connectionless ATM, new users can be added or dropped without reconfiguring the network. The 56Kbps to 34Mbps service provides a fast, economical and reliable solution when organizations must transfer large, bursty files to remote locations, which frequently change. This revolutionary new service provides faster, money saving and effective means for networking and transporting large amounts of data.

SMDS advantages includes:

- Since SMDS cells are based on CCITT E.164 [17] addressing information, SMDS cells can be released into the public network delivery system--just like letters get dropped off at the post office. If you know someone's SMDS address, you can call up and begin sending and receiving data. Both locations must know the other's E.164 address to enable them to pre-configure the security screens.
- Many-to many mesh connectivity
- Multiple protocol support
- With SMDS, all of the information is transmitted at the port connection speed; users don't have to provision individual connections.
- SMDS also allows for the easy expansion of existing networks, since new sites can be quickly added to an SMDS net without totally reconfiguring the network. Additions to an SMDS network only require a simple update to a screening database on the SMDS switch.
- While SMDS is a public service, its addressing capabilities allow network managers to develop private, virtual networks using group addresses or address filtering techniques to create a common interest user group. With group addressing, organizations can provide customers with access to one group of files and suppliers with access to another group of files.
- In addition, SMDS offers a wide variety of options, such as faster service and addressing features.
- SMDS has multimedia capacities, having the ability to carry voice, video and data simultaneously with a high quality of service.
- Does not have to be located in the central office that is closest to the customer site.
- Call blocking, validation, and screening for security

Therefore, SMDS is an exciting new service that has many specialized features and important benefits. Subscribing to this service will be beneficial to in a multitude of ways.

1.4 Introduction to Artifex

Artifex is a simulation software for discrete-event systems and is targeted for the engineering of complex discrete-event systems, in a wide range of markets. Artifex is based on high level petri nets and it provides an excellent graphical user interface. This feature is unique and makes it easier for user to model any project required. Artifex being a general purpose simulation tool, can be used for a wide range of application design targeting top to bottom layers of the OSI model. Artifex is not only used to design network protocols but also applications like Communication networks, Various algorithms, Switching systems, Network topologies, etc.

1.4.1 What can we do with Artifex ?

With this simulation tool, you can design any required network model and make it work as required. the user can test various parameters of an existing model under test and can view their results while varying the environments in which it is run. This way, the user is able to judge the efficiency of the network under test under different conditions.

The environments/conditions may be:

- Traffic rate
- Routing path
- Packet/frame length
- Token arrival/departure rate
- Release and arrival delay
- Depending on certain fixed criteria
- Changing various parameters in each run of simulation. Etc.

Atrifex has a large support of libraries models. These are the models which are frequently used.

They are subdivided in various categories.

- Generators
- Measures
- Protocols

- Queues
- Switches, and many more.

Using these library models, the user can create some of the most widely used models at just one click. Artifex also allows the user to change/modify any parameter in the library model as per requirements thereby adding flexibility to the model.

1.4.2 Unique Features of Artifex

1.4.2.1 Time Function

One of the most important feature of Artifex is it's simulation time function. Artifex allows the user to simulate any model in real time simulating environment. Thus the user is able to obtain very accurate results when model under test is actually practically implemented. Apart from this, it also provides the simulation to be done in "virtual time". This feature is useful for testing of a model or to simulate at a faster rate. The simulation can be started or halted at any desired time period during the simulation. This is very helpful feature when the model under test is to be debugged. Artifex uses the Time Advance Mechanism resulting in efficient computational effort.

1.4.2.2 Time-Advance Mechanisms

In order to simulate elapsed time, a mechanism is necessary, which changes simulated time from one value to another. The mechanism that is most frequently used in common simulation software packages for discrete event simulation is next- event time advance. This approach sets the simulation clock to zero at the beginning of the simulation and the times of the occurrence of future events are determined. The clock is updated to the time the first event occurs and the system state is changed as a consequence of the event. The list of future events is updated as well, due to the effect the event had. This process is continued until some ending condition occurs. The advantage of this time advance mechanism is the efficient computational effort because all state changes happen at event times only and periods of inactivity are skipped by advancing the clock to the time of the next event.

1.4.2.3 Measurement Function

The biggest advantage of this tool is the graphical measurement function embedded in it. Using the measurement function of Artifex, the user can obtain a meaningful result. This software allows the user to either plot the graph with respect to time or to take a 2-D measurement with two unknown variables each on either of the axis. These measurements can be plotted using different representation formats available in Artifex as :

- Points
- Flats
- Linear interpolation

This type of measurement is unique to Artifex and thus is more advantageous than other similar tools available. Artifex also offers users to superimpose one graph over another to make comparisons between two or more graphs.

Preset default measurement functions are also embedded in the software.

Measurement for place tool are:

a) Queue length

b) Token arrival rate

c) Token departure rate

d) Token wait time etc.

Measurement for transition tool are:

a) Firings

b) Firing delay

c) Firing rate

d) Firing period etc.

Measurement for object toll are:

a) State

b) Color

c) Priority

1.4.2.4 Ease of Coding

The coding required to carry out the desired function in the project is based on c language. This language the most common and easy to understand, the user can design and learn the project very fast. This language also helps reduce the amount of coding required to be written to perform a similar task as compared with any other language. Artifex also provides it's user with a wide range of separate functions in the tool bar. This avoids any coding required to write subroutines in main programs there by reducing the coding and confusion of the user. The user simply has to write the required codes in the necessary field sections, this makes the project much more manageable for further analysis and future development.

1.4.2.5 Excellent graphical interface

Artifex has a very good functionality graphically. This user-friendly graphical interface is one of the strongest features of this tool. This reduces the time for user to get accustomed to the software. This excellent graphical interface helps the user to view the model at each of the stage of its build. The user can easily pin point the blocks required to change or modify in future. The graphical interface also provides facility to change the state and color of the objects under simulation. This feature is of great help when the model designed is very big and complex. The user can simply view the changes by simulating the top level design by keeping a note on the state and color of the object. This is a unique feature of Artifex.

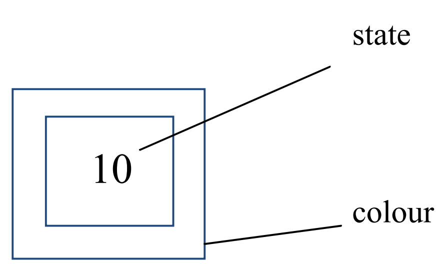

Figure 1.4.2.5 Object tool

1.4.2.6 User Defined Measurement

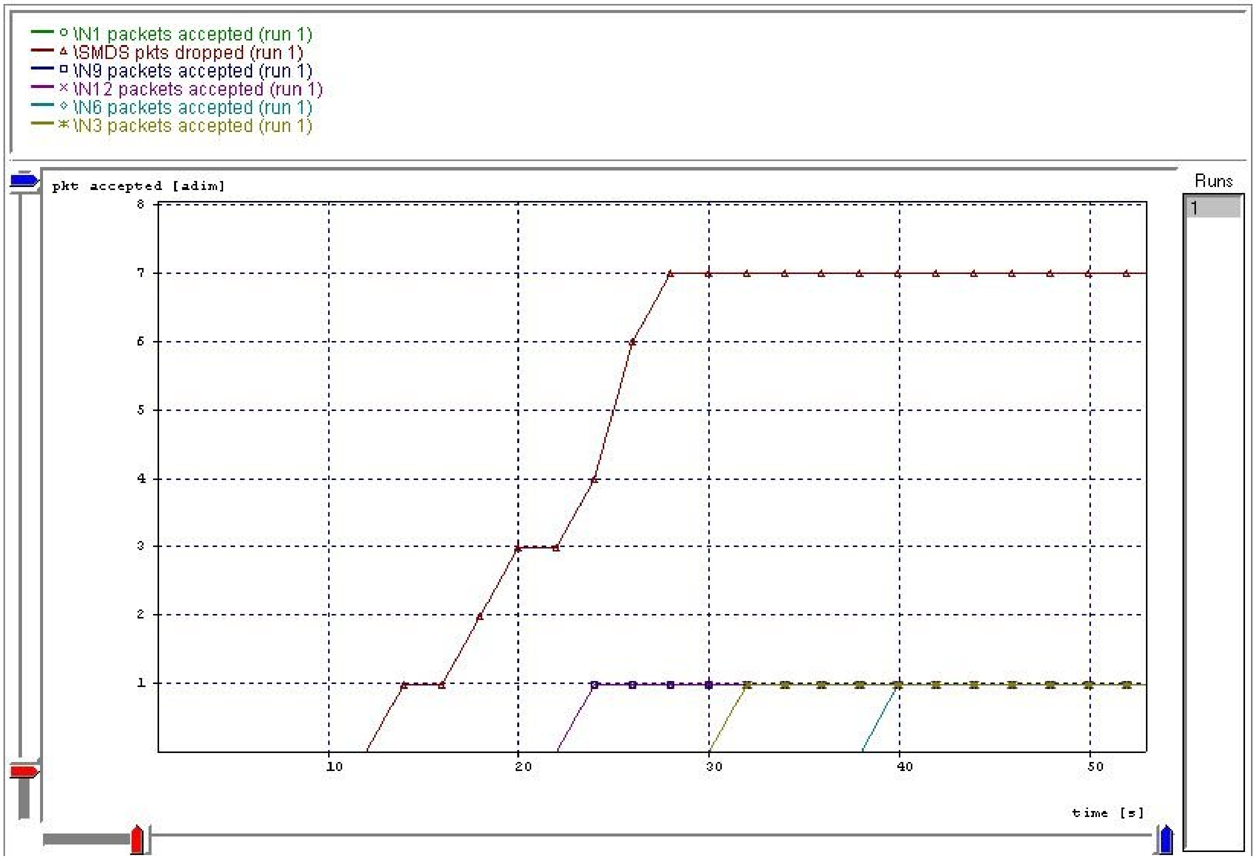

Figure 1.4.2.6 Accepted and dropped packets in the network.

• Proven scalability to very high degrees of complexity and Iterative model development.

• Real-time and Virtual-time simulation with full user control of model's execution.

• Visual Dynamics representation during model's execution and Simulation data analysis with representation.

• Windows-standard and consistent GUI improves usability and reduces learning time.

• Generates complete documentation (Report) about models in standard formats (LaTeX, PostScript, HTML).

• The same development environment is available on Unix and Windows NT platforms.

• Easily integrates existing code and C/C++ integrated environments.

• Models are automatically targeted for all major platforms (Unix, Windows NT, VMS, most Real-time kernels).

These features makes ARTIFEX the most versatile and most popular simulation tool as compared with other simulators in market. Artifex is not only useful to design protocols and communication networks, but can also be used extensively in field like :

- DEFENCE
- TRANSPORTS
- TELECOM
- FINANCE
- WORKFLOWand
- AUTOMATION industries.

This makes Artifex a General purpose and versatile simulation tool. No other counterpart tool is capable of this wide applications.

CHAPTER 2

LITERATURE SURVEY

2.1 Literature survey

Daniel Martinez [18] proposed an ATM-based architectural approach, as implemented in At&T's Broadband Networking System 2000 (BNS-2000), to provide Frame Relay as well as SMDS services on the same platform. The BNS-2000 represents a grow able and modular architecture that has been built to comply with international standards such as ANSI, CCITT and ETSI to support the emerging needs of the market.

Vijay Varadharajan et al. [19] considered the issues that needed to be addressed in the design of security services for such high-speed networks. First the relevant characteristics of broadband network interfaces are discussed, some of the existing security protocols for TCP/IP and OSI networks [20] are reviewed, and their suitability for providing security in broadband networks assessed. Then the developed arguments are applied to design security services for the connectionless LAN and SMDS networks and connection-oriented Frame Relay networks.

Michael A. Gallo et al. [21] has explained the full networking structure of SMDS. All the parts and data flow mechanism is explained. SMDS is based on IEEE 802.6, a data link layer protocol for MAN networks. W. D. Zhong et al. [22] proposed that MEMS technology makes the coupling and assembly of the switch, filter and circulator easy, precise, and reliable due to the fiber grooves. Various data formats can be added and/or dropped by the proposed OADM because it is bit-rate independent.

Yu-Lung Lo et al. [23] proposed a new dynamically selective optical add/drop multiplexer (OADM) and optical cross-connect (OXC) configuration for dense wavelength division multiplexed (DWDM) networks in which fiber collimators in coupling are analyzed in order to characterize the insertion loss and output power equalization in OADM and OXC. Thus the reliability of optical switch operation, therefore, can be enhanced. Ming Li et al. [24] showed that by increasing the separation between the two waveguides of the symmetric coupler, the resultant similarity of the square distributions of the two eigen modes ensures that the two self-coupling coefficients can reach zero simultaneously with the cross-coupling coefficient being near maximum. Therefore, the design has low cross-talk and low back-reflection at the input and add ports.

Toshihiko Sugie et al. [25] describe various wavelength-division multiplexing (WDM) technologies and typical WDM networks, including system configurations and field trials for access and metropolitan area networks. WDM schemes and related devices are also described, and methods of standardization and future trends. A configurable optical add-drop multiplexer (OADM) based on fiber Bragg gratings is reported by P S Andre et al. [26] in which dynamical selection of the add-drop or pass-through functionality is realized according to the control of an optical switch. James D McCabe [27] discussed the trial of scientific user applications over the Switched Multimegabit Data Service (SMDS). An interLATA (Local Access Transport Area) testbed was built between NAS and Rockwell International, using AT&T, GTE, and PacBell SMDS. The interactive and throughput characteristics of SMDS were tested using interactive and file transfer applications.

Hongyue Zhu et al. [28] proposed an optical add/drop multiplexers (OADMs) which can significantly reduce the cost of metro optical wavelength-division multiplexing (WDM) ring networks by allowing traffic to bypass intermediate nodes without expensive opto-electro-opto (O-E-O) conversion. Some traditional OADMs, called fixed OADMs (FOADMs), can only add/drop traffic on a specific wavelength. Reconfigurable OADMs (ROADMs) are emerging, which can add/drop traffic onto/from different wavelengths at different time. ROADMs provide desirable flexibility. In order to be cost effective, some ROADMs employ architectures that tune the ROADM continuously from one wavelength to another, crossing through all the wavelengths in between, which may cause interference to the connections, if any, on those wavelengths being crossed.

Diptish Dey et al. [29] demonstrated the concept for building a packet switched MAN with support for multicasting in the optical domain has been presented. This enables optical packet-switching at intermediate nodes on a ring. The nodes are capable of transmitting and receiving at all wavelengths. Slavisa Aleksic et al. [30] discussed that future metropolitan area networks (MANs) must be capable of providing high bandwidth, supporting multiple protocols, fast provisioning of different granularities of bandwidth, as well as good scalability and protection. All-optical packet switching, while combining high throughput with a large flexibility, might be a good candidate for next-generation MANs. Biswanath Mukherjee et al. [31] demonstrated some of the architectural challenges involved in the design of all-optical packet switched networks, and it is shown that how future networks could be integrated with other network segments, to provide users end-to-end connectivity with performance and simplicity.

R.S. Kaler et al. [32] demonstrated the quality-of-service offered by the metropolitan area network which is based on optical cross connect (OXC) and arrayed waveguide grating (AWG) demultiplexer operating at 10 Gb/s with 0.1 nm channel spacing for NRZ signal transmission. The OXC and AWG demultiplexers in the proposed architecture allow incremental expansion in terms of the number of wavelength channels to be transmitted. Dispersion and crosstalk are the main signal-degrading factors arising from the operation of the OXC and the effectiveness of each factor is individually investigated. Hiroaki Harai, *et. al.* [33], treated a performance optimization problem in all-optical networks. They studied blocking performance of the optical network and proposed a heuristic algorithm to minimize an overall blocking probability by properly allocating a limited number of nodes with wavelength conversion capability.

Jennifer M. Yates *et. al.* [34], examined the blocking performance of networks in which connections may be blocked due to either insufficient capacity or due to limitations in the transmission network. Analytical expressions and network simulations were used to examine blocking in networks, in which the quality of the received signal may be so poor that the connection is effectively blocked.

Brett Schein *et. al.* [35], developed a system model to approximate the blocking probability for both the fixed and reconfigurable systems. They also characterized the gain in traffic capacity that is configurable wavelength division multiplexed network offering over a fixed topology network where lightpath connections are fixed and cannot be changed.

Hai Le Vu *et. al.* [36], computed and derived the scalable approximations for blocking probability. They have also provided new loss models for Hybrid Optical Switch (HOS) combining optical circuit switching and optical burst switching. Exact blocking probabilities were computed when no priority was given to either circuits or bursts. The sensitivity of the analytical results to burst length and circuit holding-time distributions was quantified by simulation. It was demonstrated that how the proposed approximations can be used for multiplexing-gain evaluation of a hybrid switch.

Several wavelength OADM's have been proposed based on arrayed wave-guide gratings (AWG) [37]. P. S. Andre et al. [38] proposed a configurable optical add-drop multiplexer (OADM) based on fibre Bragg gratings. Dynamically selection of the add-drop or pass-through functionality is realised according to the control of an optical switch. Hattori et al. [39] proposed a novel switch configuration for an optical add/drop multiplexer. By utilizing a certain Mach-Zehnder interferometer both as a component of a double-gate switch and as a level equalizer, reduced the number of Mach-Zehnder interferometers from five in a conventional switch configuration to three.

Rajneesh Randhawa et al. [40] investigated all-optical WDM networks based on a slotted multichannel ring topology. The topology provides one logical channel to be associated with each destination node. Each channel is shared in statistical time division by all nodes transmitting to a given destination. The paper also discussed how the Artifex is used for the simulation of the model. The C/C++ coading is used to simulate the result graphically. R.S. Kaler et al. [41] proposed the dedicated protection of six node ring network by taking normal fiber link and the protection fiber link. The restoration has been shown by switching of the traffic from the normal link to the protection link when an outage is occurred in the normal link. The normal link is again repaired and the traffic is switched back to the normal link.

June-Koo Rhee et al. [42] proposed a metro-area optical-ring network based on a novel optical add-drop multiplexer (OADM) architecture using a wavelength blocker. The performance of the OADM and capability of optical channel dedicated protection in a two-fiber ring network with 24×10 Gb/s dense wavelength division multiplexing traffic capacity is being demonstrated. The bit-error rate performance of the network is studied for the normal operation and for the transition to the protection state from a failure. The network protection for all channels is provided within 5 ms on a cable-cut failure. Importance of transient-gain control during protection switching to reduce the network transients is also discussed.

2.2 Motivation

In fibre optic communication, there is degradation in transmission signal or the collision in the transmitted packet as the number of nodes increases. With the increase in number of nodes or the increase in the demand of the same channel or the destination node there always occurs collision. In optical communication the packets are converted into electrical signals and when this multiple signals collide they get degraded and network failure occurs. So here OADM is proposed to switch between various MAN networks to support the SMDS network. When there is large congestion then there is always collision so OADM is used which generates the loss signal to effectively communicate between the nodes. If there is large congestion then the OADM loss some of the signals which can further are taken when there is less congestion. By using this network failure can be avoided to some large extent and the proper communication between the source and the destination can be maintained for longer period of time. In this thesis, the behavior of the network is demonstrated and the drop and accepted packets through OADM is analyzed.

2.3 Objectives of Thesis

The objectives of the thesis consisted of several main stages. Initially the SMDS network is proposed with a switch which can carry out the communication. The literature review was beneficial in understanding the operation of SMDS network. When OADM has been selected, the switch has been replaced by the OADM which can effectively add/drop packets or signals. Thus the speed and the performance of the network have been increased. So the main objectives of the thesis are:

- To analyze the behavior of SMDS network as how the packets are generated, accepted, path travelled, collision, etc.
- To analyze the behavior of accepted and drop packets in the OADM to increase the network performance.
- To increase the speed of the communication without the collision of any packet.

2.4 Outline of Thesis

The thesis is divided into six chapters:

First Chapter presents a brief introduction of SMDS network, its architecture. OADM is also discussed which is used in SMDS network. The introduction to Artifex which simulate the network is also discussed.

Second Chapter includes the literature survey of the SMDS network and its related theory. Different OADM related literatures which increase the network performance are studied.

Third Chapter includes the Simulation of Switched Multimegabit Data Service with Different Interconnected LANs which demonstrate the performance of the network.

Fourth Chapter includes the Performance Analysis of OADM Based Switched Multimegabit Data Service in which the performance of OADM is demonstrated to increase the speed of the SMDS network.

Finally Fifth Chapter includes conclusion and future scope of the work done.

CHAPTER 3

SIMULATION OF SWITCHED MULTIMEGABIT DATA SERVICE WITH DIFFERENT INTERCONNECTED LANS

3.1 Abstract

The switched multi-megabit data service (SMDS) is a high-performance, public, packet-switched data service. Offered as public network equivalent of a MAC-level service, the datagram transport offered by SMDS is easily integrated into networking protocol architectures using local area network (LAN) or metropolitan area network (MAN) technologies such as Ethernet and fiber distributed data interface (FDDI). SMDS and the accompanying OADM service were successfully demonstrated. The signals travelled and how they reach to the destination node in low traffic network is being demonstrated. OADM allows WDM through which there is less chance of collision and mixing of the signal and the communication takes place effectively.

3.2 Introduction

There is a growing interest in the development of broadband services and networks for commercial use in both local area and wide area networks. Switched Multimegabit Data Service (SMDS) is a telecommunications service that provides connectionless, high-performance, data transport. Switched Multimegabit Data Service (SMDS) is a datagram service intended for LAN interconnection which may be offered by Local Exchange and Interexchange Carriers [5,6]. SMDS allows users to transparently extend their data communications capabilities over a wider geographical area. SMDS permits this expansion using existing Customer-premises equipment (CPE) and protocols, with minimal investment in dedicated leased lines as the number of line terminations increases. SMDS is currently defined to operate at 1.544 Mbps (DSl) or 44.736 Mbps (DS3). Other implementations utilize E1 lines at speeds in excess of 1.9 Mbps or E3 lines. Future SMDS networks will couple B-ISDN with SONET OC3 at 155 Mbps. In addition, SMDS data units are large enough to encapsulate entire IEEE 802.3, IEEE 802.5, and Fiber Distributed Data Interface (FDDI) frames. To size the link sets, network planners/administrators must know

(i) the end-to-end traffic requirements and

(ii) the routing strategy.

The end-to-end traffic requirements can possibly be obtained from billing records. Another alternative is to estimate the end-to-end traffic requirements from aggregate link flows by using the Moore-Penrose pseudo-inverse. The routing algorithm for SMDS networks is specified in [43]. Also the interconnection of Local Area Networks (LANs) providing high-speed information transfer is becoming a strategic necessity for many enterprises to support their growing number of Workgroup-based and backbone-type LANs [44].

There is also a significant change in the nature of network traffic. It is more and more of the form of burst traffic characterized by an unpredictable demand for bandwidth of several megabytes. The new generation of networking technologies enables interconnection at high-speeds in the range of Mbit/s or even Gbit/s over very wide areas, which effectively moves the bottleneck from networks to end systems. Furthermore, the user is able to access bandwidth on demand and the user is only charged for the bandwidth actually used. So OADM [20] is implemented in between the SMDS network to meet the requirement of the bandwidth. One may even argue that the success of a high-speed technology in the future will be determined not only by its cost effectiveness but also by the level of trust that can be placed on its performance, security and availability. As the treatment of SMDS in an enterprise TCP/IP network is straightforward and existing solutions may be applied directly. SMDS, however, is intended to be a national and even global service, and affords new opportunities for communication. The same set of problems must be resolved in this environment as in enterprise networking: packet delimiting, protocol multiplexing, address resolution, and routing. Packet delimiting and protocol multiplexing are not affected by scale and the same approaches may be used. The solutions for address resolution and routing, however, are affected by scale. The overhead of existing solutions will not be tolerable, and new mechanisms must be found to resolve addresses and route in a very large network [45].

3.3 Simulation Setup

In this model, there are 3 different LAN networks in which the packets are generated which demands for another node in another or same network. In this network there are different interconnected LANs which are operated on SMDS network. So this network fulfills the demand of different nodes in the network. If node N1 and N5 demands for the same node N4, then there is collision in the LAN_1. If node N1 and N7 demands for N12 then the packets goes through SMDS switch but the collision occurs at LAN_3. This type of collision should be also taken to account for the proper communication. When there is large no. of LANs then there is always collision which results bad communication and with low speed.

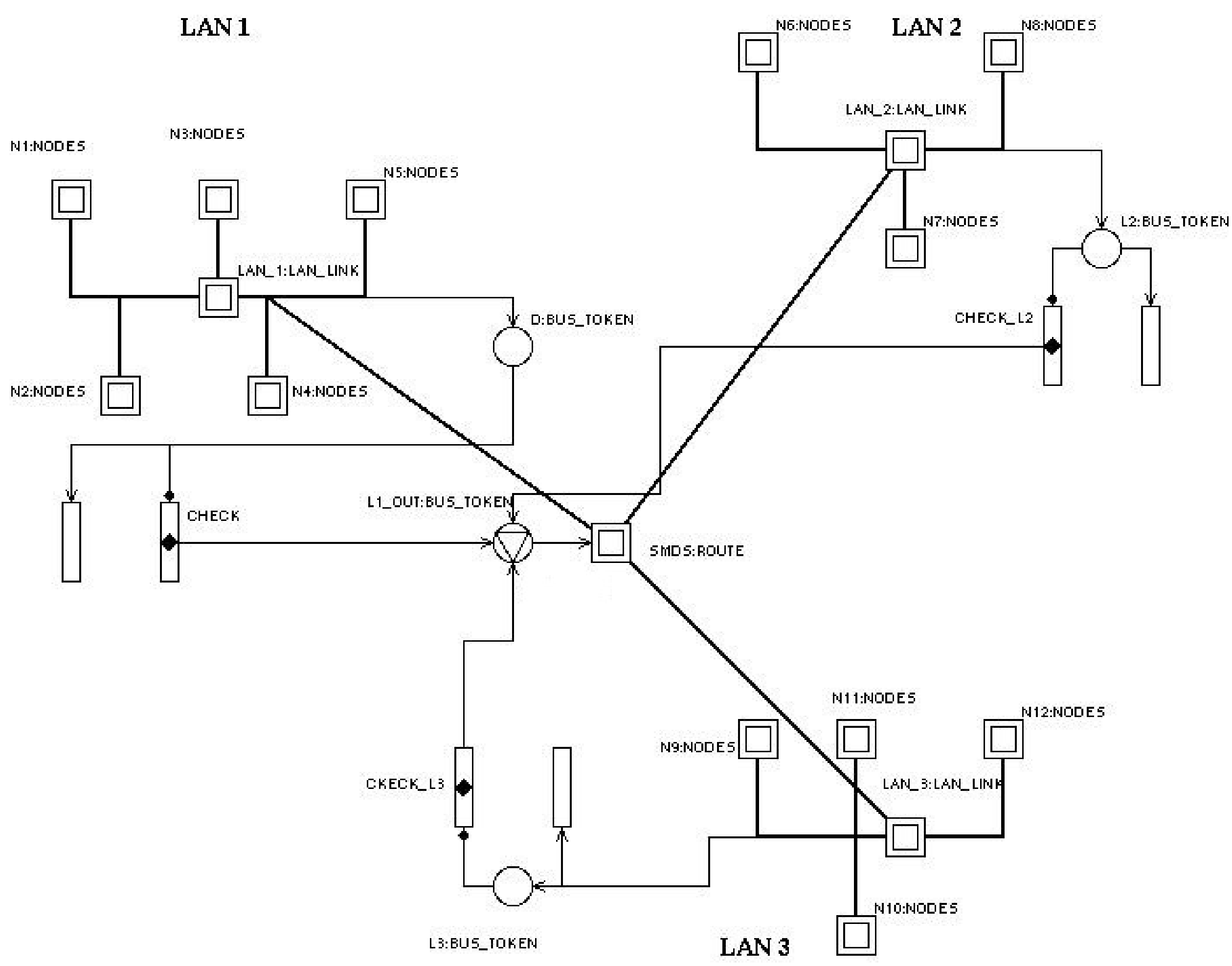

Figure 3.3 (a) SMDS network architecture

The architecture of node is given in Figure 3.3 (b). In this packets are generated in INITIATE, which goes to the REQUEST in which there is C++ coding which decides the destination node in the network. The following C++ coding results the packet to generate at the node.

```
int dummy;
XX->temp = XX->my_id;
printf("sender id is: %d\n",XX->temp);
printf("send to node: ");
scanf("%d",&dummy);
HOLD->id=dummy;
HOLD->self_id = XX->my_id;
xx_setcolor(3);
xx_setstate(xx_getstate() +1);
```

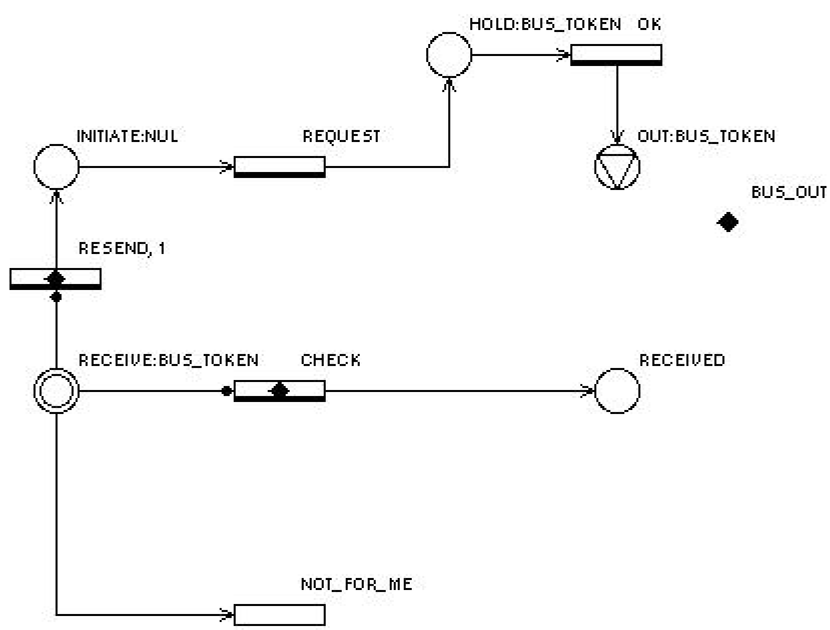

Figure 3.3 (b) Node architecture

When there is collision between the packets then there is retransmission of the packet. Because of this retransmission the delay increases. When there is no collision then at the receiver side the packet is received at RECEIVE and then this packet is checked for that particular node and is received at that node.

The architecture of LAN_1 is given in Figure 3.3 (c). The packet which is generated by node is received from input IN and it goes to output OUT after satisfying the particular condition. When the collision occurs then these packets returns to its source node and the retransmission takes place. Here the no of packets which can pass easily through the network can be increased by changing the predicate in the LINK.

When the collision occurs there is jam in the network which results in the network congestion.

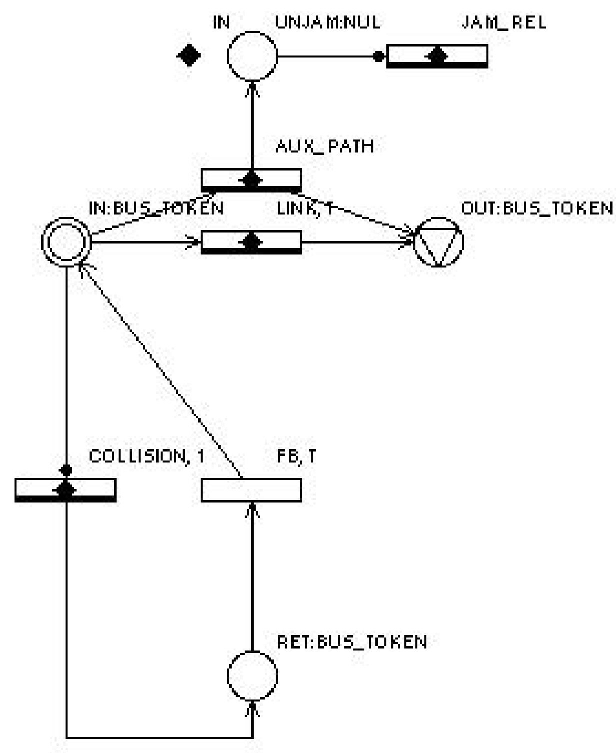

Figure 3.3 (c) LAN_1 architecture

3.4 Results and Discussion

When the simulation starts a token is put in the INITIATE of source node which demands for any node in the SMDS network which is shown in Figure 3.4 (a), the packet goes through LAN_1 or through which that particular LAN belongs. Then it moves to the SMDS switch which makes the packet to go through the destination LAN. After the packet is received through the destination LAN then it checks for the destination node and sends to it. If the collision occurs then the packet is retransmitted through the source node.

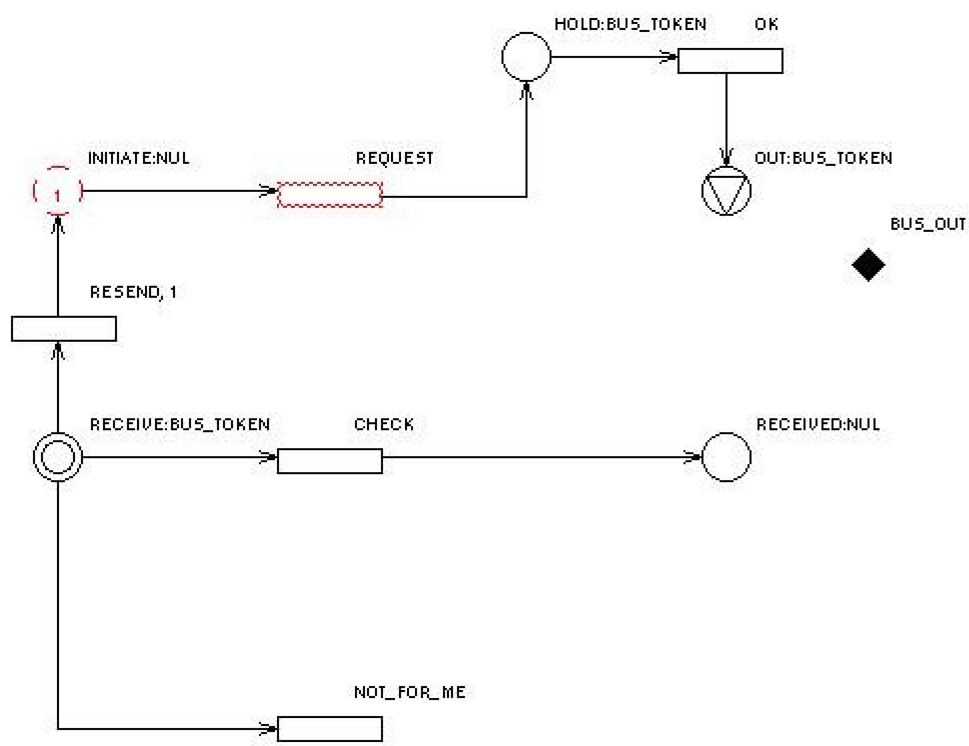

Figure 3.4 (a) Packet is being put in INITIATE

After putting the packet the condition is checked in the REQUEST and the destination node is decided. And at the receiver side the packet is received and it checks the condition that whether the packet is for that node or not.

In Figure 3.4 (b), consider that node N1, N5, N6 demands for different nodes on different LAN. If N1 demands for N9, N5 demands for N12 and N6 demands for N2 then result after simulation is shown in the following figure.

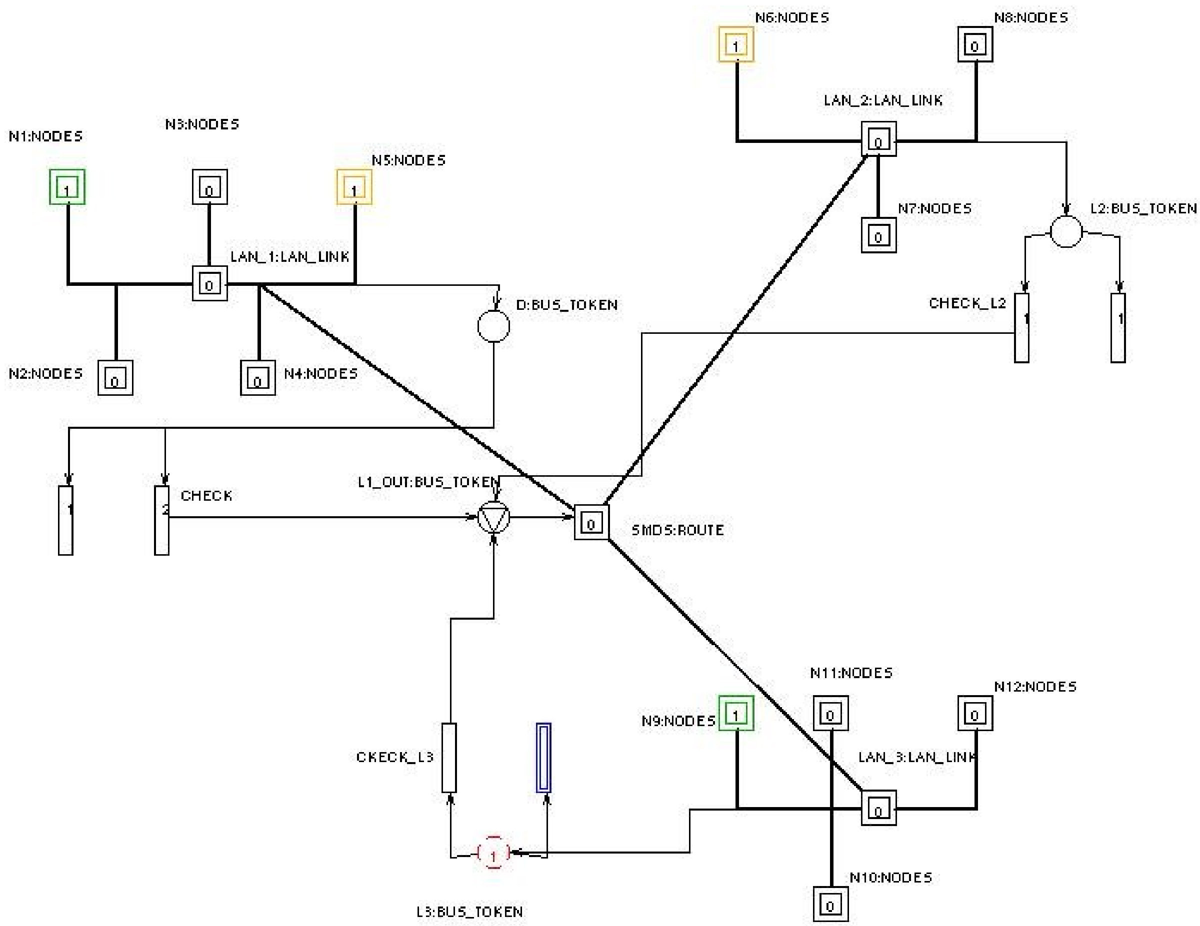

Figure 3.4 (b) SMDS network after simulation

Figure 3.4 (c) shows how the packets are transferred to the destination node. As the collision occurs so sender node N5 and N6 retransmit the data and delay is introduced between the sending of these packets. The delay introduced results in the proper communication but the speed of the network is reduced. If any sender request for node which is not in the network then this delay is further introduced, and this packet cannot be dropped from the network. The SMDS network is suitable for small network.

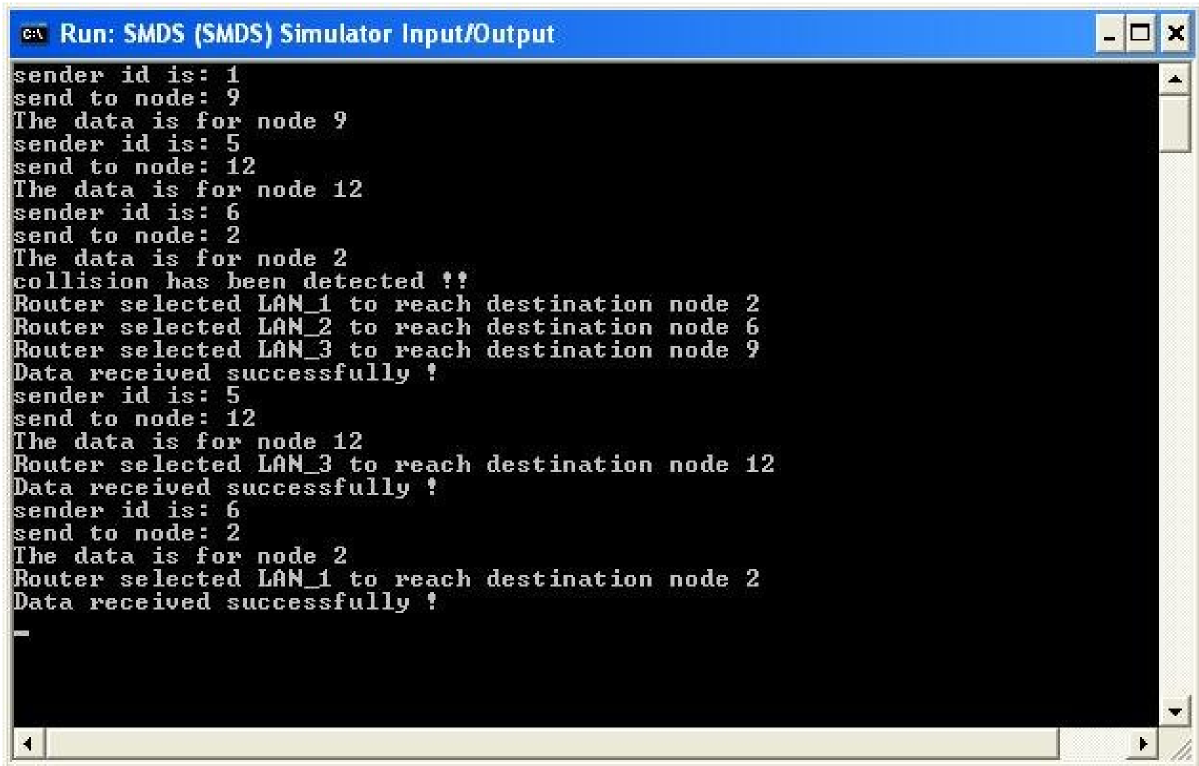

Figure 3.4 (c) Result of transmitted packets in the command prompt

3.5 Conclusion

SMDS provides proper communication in the network between different interconnected LANs so that communication between the sender and the receiver takes place effectively. This work has progressed rapidly and is sufficient to allow equipment from different vendors to interoperate in support of LAN interconnection across SMDS. SMDS provides any-to-any data communications, at very high speeds, to and from sites throughout the UK. Data is segmented into 53-byte cells, which are then transmitted into the SMDS network mesh and routed independently from switch to switch to their destination, requiring no call set-up or dose process. SMDS is therefore more flexible and faster than connection-oriented communications. SMDS provides users with the cost effectiveness of a public switched network, the benefits of fully meshed, wide-area interconnection and the privacy and control of dedicated private networks. SMDS will enable customers to achieve mesh connectivity with fewer access lines and less network equipment at lower costs than with point-to-point leased lines.

CHAPTER 4
Performance Analysis of OADM Based Switched Multimegabit Data Service

4.1 Abstract

An early MAN service is the Switched Multimegabit Data Service (SMDS) which has been specified to provide efficient high-speed data transport in the E1 to 34 Mbps range with future extensions to incorporate isochronous transport for the addition of constant-bit rate services such as voice and video services. This chapter proposes an implementation of a SMDS-based high-speed data service using OADM and MAN interconnection. A routing strategy which matches the security requirements for addressing in metropolitan network environments is presented. The OADM approach using WDM increases both network capacity and resilience in a cost-limiting and cost-incremental fashion. So when OADM is used in different interconnected LAN networks then the performance of the SMDS network increases and congestion is reduced to maximum extent.

4.2 Introduction

An optical add-drop multiplexer (OADM) is a device used in wavelength-division multiplexing systems for multiplexing and routing different channels of light into or out of a single mode fiber (SMF). This is a type of optical node, which is generally used for the construction of optical telecommunications networks or in different interconnected LAN network. "Add" and "drop" here refer to the capability of the device to add one or more new wavelength channels to an existing multi-wavelength WDM signal, and/or to drop (remove) one or more channels, passing those signals to another network path. An OADM may be considered to be a specific type of optical cross-connect. All the light paths that directly pass an OADM are termed cut-through lightpaths, while those that are added or dropped at the OADM node are termed added/dropped lightpaths. An OADM with remotely reconfigurable optical switches (for example 1×2) in the middle stage is called a reconfigurable OADM (ROADM). Ones without this feature are known as fixed OADMs. While the term OADM applies to both types, it is often used interchangeably with ROADM. Figure 4.2 shows the general OADM architecture.

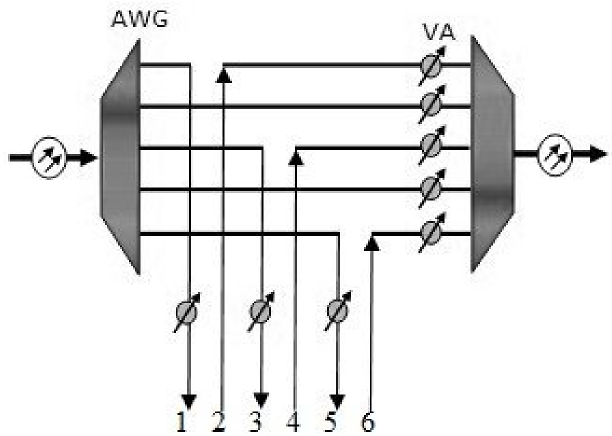

Figure 4.2 OADM Architecture

In this OADM architecture wavelength 1,3,5 are dropped while wavelength 2,4,6 are added. So the performance of the network can be increased. An OADM consists of three stages, namely, optical demultiplexer, optical switch or add/drop stage, and optical multiplexer. Optical demultiplexer functions to separate wavelengths in an inlet fiber onto individual fibers. These fibers are then either dropped, connected to 2x2 optical switches, or directly connected to optical multiplexer. The last stage is optical multiplexer which functions to multiplex all those wavelengths either added, directly from optical demultiplexer, or 2x2 optical switches, into an outlet fiber. Physically, there are several ways to realize an OADM. One can use the traditional demultiplexer and multiplexer architecture to realize an OADM, or use a combination of fiber grating and optical circulators to realize an OADM.

OADM implementation in different interconnected LANs increases the speed of the network. The OADM add/drops packets which are of not use or which can create more congestion. OADM is used as a switch in the network which provides the proper and high speed communication in the network.

4.3 Simulation Setup

The simulation is done with the help of Artifex tool. In SMDS network we studied that the different LANs network are connected through OADM. In our simulation model we designed four different LANs which are connected through OADM which decides the path of the traffic. The nodes generate the random traffic and when the traffic exceeds the bandwidth the packets drops giving rise to proper communication without congestion in the channel. The OADM connected LAN networks are shown in Figure 4.3 (a).

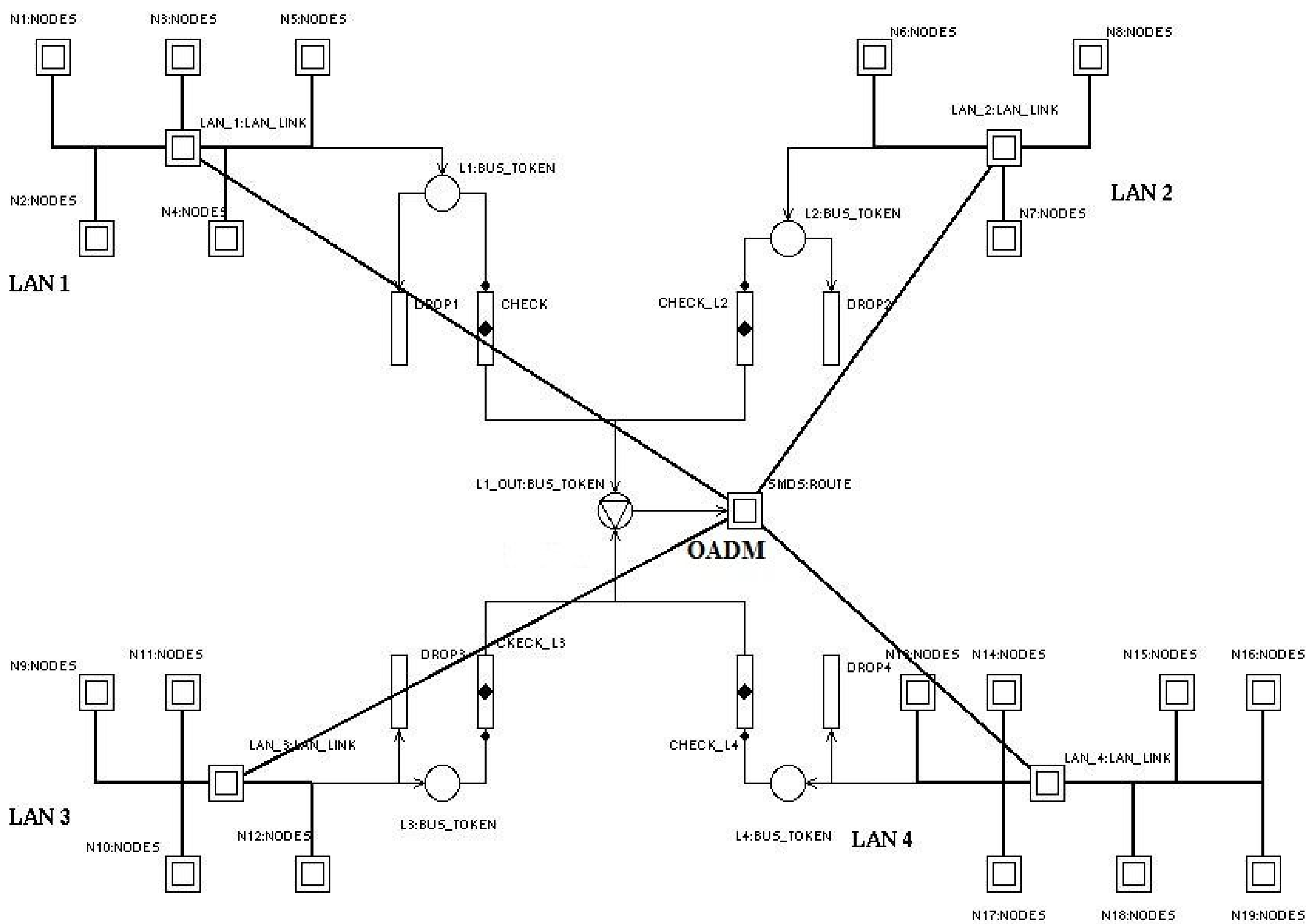

Fig 4.3 (a) SMDS Network

In this network it is considered that the packets in the nodes are generated at random. Some nodes demand for that node which is not in the network so these particular packets are dropped by the OADM while the other packets are successively received by the destination nodes. The two IDs are given to the packets which are its source ID and other is destination ID. The node and the OADM architecture are shown in Figure 4.3 (b), (c) respectively.

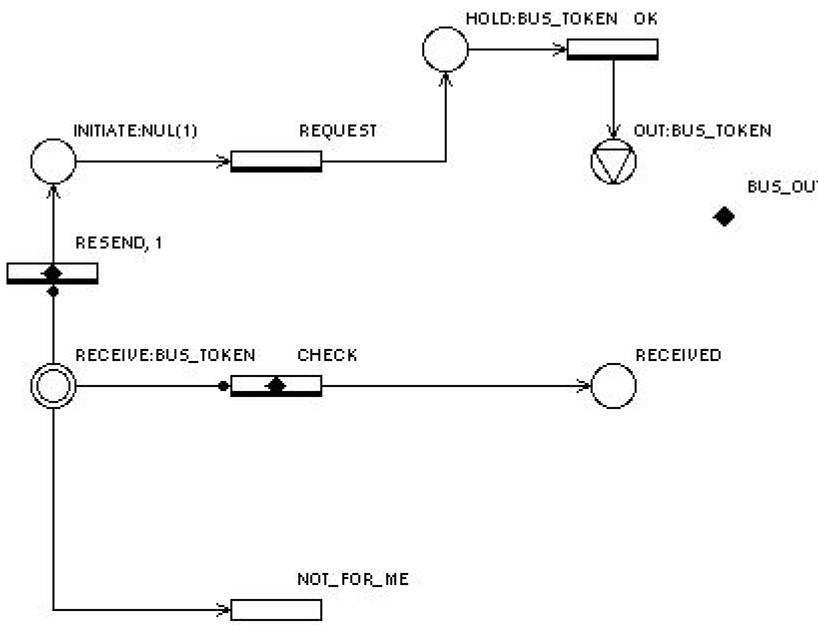

Fig 4.3 (b) Node Architecture

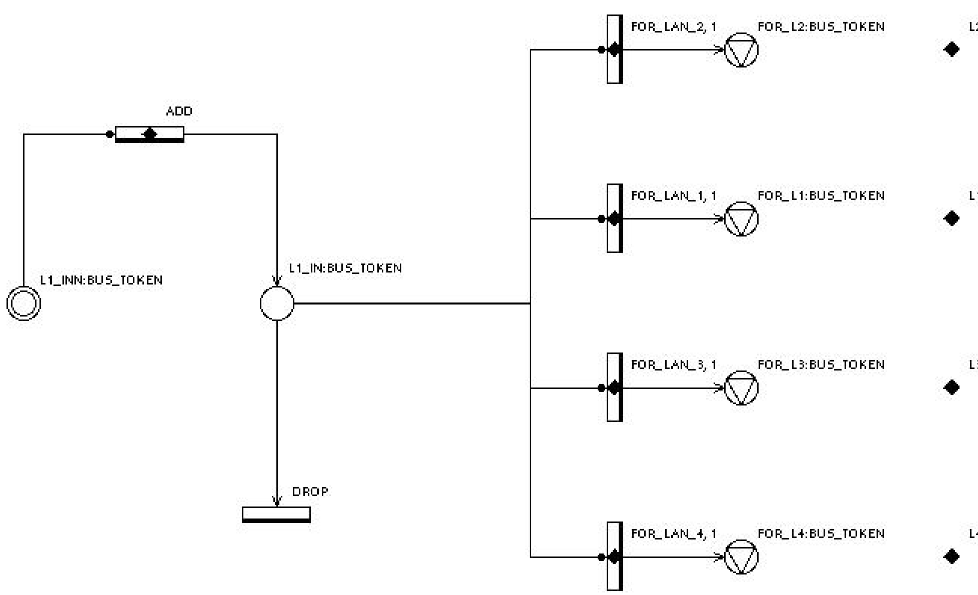

Fig 4.3(c) OADM Architecture

In the OADM architecture the incoming packet arrives in L1_IN and these packets follows their respective path to which they are meant for. By checking the condition of the incoming packets the FOR_LAN sends these packets to the particular port. If the packet demands for the node which is not in the network then these are rejected.

When the traffic originates randomly from any node and demands for different network, then the OADM checks whether the particular node exists in the existing connected LANs or not. If OADM finds the node connected in it then it makes the path to follow that particular node, and if OADM fails to find the node then it discard the packet. In this model we pre-decided the destination node of the randomly generated packets to analyse the performance behaviour of the accepted and dropped packets through the OADM. The OADM can be reconfigured by giving some different condition in its architecture.

4.4 Results and Discussion

The result of accepted packets is shown in the Figure 4.4 (a). These accepted packets are those which are in the network as we have already decided which packet is to accept and which is to reject to analyse the performance of the network. In this graph N1, N3, N6, N9 are the accepted packets.

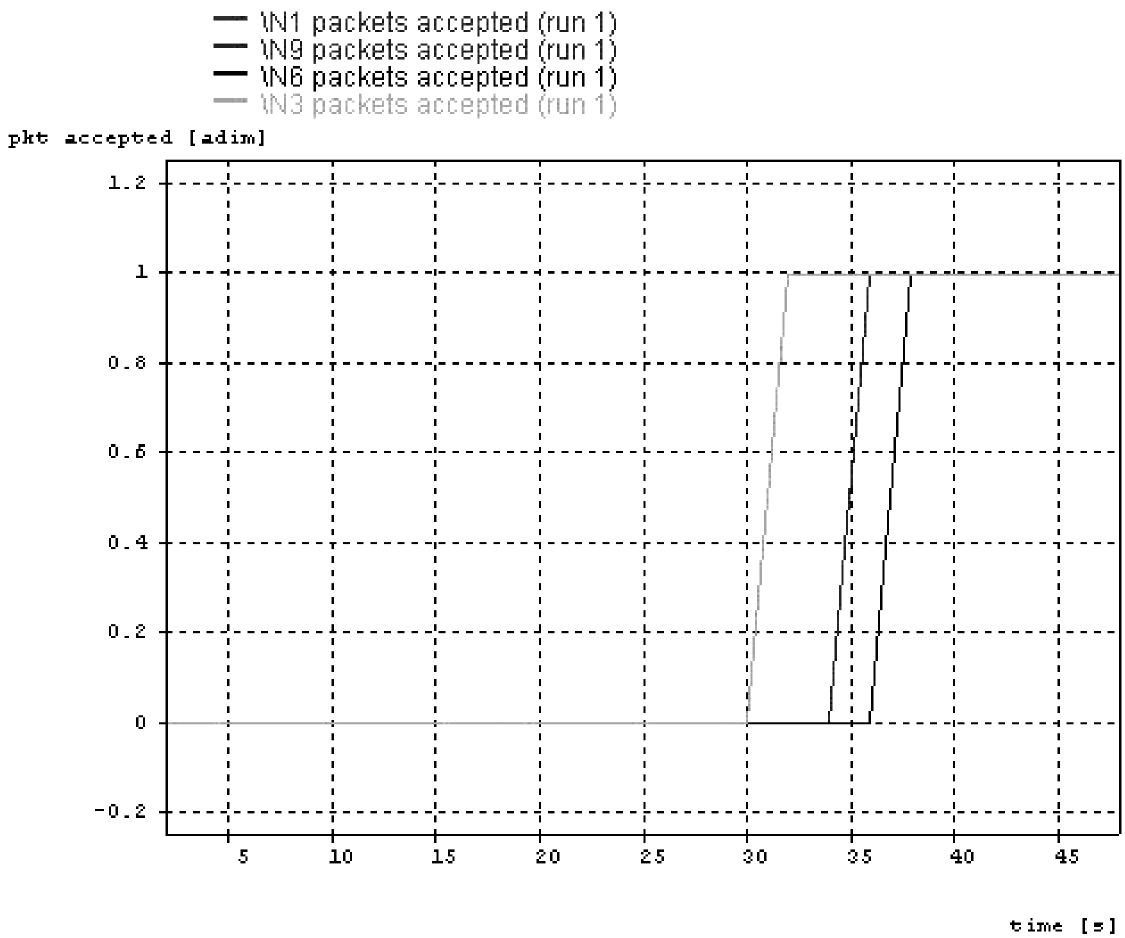

Figure 4.4 (a) Accepted Packets

As these packets are accepted which means they are successfully reached to their destination. The destination ID of that particular packet of the node is in the network and OADM accept that packet for the proper communication in the SMDS network.

Figure 4.4 (b) shows how the packets are dropped from the network through OADM. The packets which are not in the network or the packets which creates unnecessary congestion in the network are dropped by the OADM. In the previous chapter SMDS switch is replaced by OADM by which the speed and the performance of the communication increase. From the following graph the packets which are dropped are not considered in the network.

Figure 4.4 (b) Dropped Packets

4.5 Conclusion

The simulation model shows that OADM drops all the packets which have no meaning in the network. OADM allows large unit of capacity to be routed cheaply around networks with the possibility of flexible provision of add and drop provision and the bandwidth of network increases. On a purely capital cost basis an estimated 50% reduction could be accomplished using the optical layer when core traffic exceeds 20X current levels. Optical networking components will have element managers associated with the individual optical systems (OADM's, WADM's and OLA's) integrated into the Network Control Layer, representing a straightforward addition to its functionality.

OADM drops the packets which are not necessary in the SMDS. By this the reliability of the network increases. Simulations have shown that the addition of OADMs to SMDS has a significant impact upon network performance. In some simulations, converting the network from switches to OADMs led to an 84% drop in overall network delay. OADM placement in the network can also have a large impact on the performance. In one simulation of an entirely switched network (where one switch was replaced with an OADM), a bad addition led only to a 3.09% delay reduction while the optimal addition led to a 10.71% delay reduction. If a single OADM can have such a significant impact, optimal placement of several OADMs can have a large impact.

CHAPTER 5

Conclusion and Future Work

5.1 Conclusion

In this thesis the simulating technique for performance analysis of SMDS network through OADM is being analyzed. The congestion, accepted and the dropped packets can be analyzed through this model. The measured trial connection and found an end-to-end delay well within the guaranteed maximum of 140 ms at TI offering. The connection delivers a throughput very near the T1 rate for large packets and is limited by the switch processing only for very small packets. When the endpoints are widely separated geographically, propagation delays become increasingly important. SMDS is intended primarily for inter-LAN connection and data applications. It should function well for this purpose since file transfer applications are not delay-sensitive and usually comprise large packets. Further, applications that produce small packets often produce packets infrequently and do not require large bandwidth. The results show that the network delay increases linearly with the packet size and end-to-end distance. The measuring throughput correlates with the SMDS Interface Protocol (SIP) limitation well.

The speed and the performance of the SMDS are increased by the use of OADM by reducing crosstalk or congestion in the network. Since SMDS is a public service, any SMDS customer can exchange data with any other customer. The SMDS Interest Group, an association of service providers, equipment manufacturers, and users, develops technical specifications, promotes awareness of SMDS, stimulates new applications, and ensures worldwide service interoperability, working with its international affiliates. SMDS is considered to be an intermediate between the packet-switched services offered today and the ATM service of the future. The current implementation of SMDS in North America has Customer Network Management (CNM) capabilities. OADM has reduced the network congestion and makes the communication at the faster rate. This implementation allows the customer to maintain control over the network functions, including: Performance management, Fault management, Accounting management, Configuration management, Security management.

The CNM implementation currently in place for SMDS is the Simple Network Management Protocol (SNMP). This is a LAN network management supported by many vendors and used on many non-TCP/IP networks. In some simulations, converting the network from switches to OADMs led to an 84% drop in overall network delay.

5.2 Future Scope

There are a couple of areas where future work is needed. Studies could be conducted on networks larger than 13 nodes. Also, the addition of OADM modules to commercial tools like Opnet could be a valuable tool for network designers.

We can connect multiple OADM or OXC units in series; thus, the number of dynamical DWDM channels will rise. As the number of signals increase, OADMs and OXCs may find more important applications in a cascade formation and are of better use in DWDM systems and networks. Cascading will expand DWDM scalability and reduce the required constitutive elements. Also, the reliability in operating optical switches for the proposed new OADM and OXC could be enhanced owing to a fewer number of single-sided mirrors. Another important factor in OADM evaluation may be the degree to which demand levels can be estimated ahead of time, with greater predictability reducing the level of connectivity required at each OADM.

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