IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016

Performance Analysis of Topologies using for RWA in Optical WDM Network

Radha Raman Chaurasiya[1], Jashwant Samar[2], Durgesh Wadbude[3]

Research Scholar, Computer Science Engineering, Mittal Institute of Technology, Bhopal (M.P), India[1]

Asst. Professor, Computer Science Engineering, Mittal Institute of Technology, Bhopal (M.P), India[2]

Head of Department, Computer Science Engineering, Mittal Institute of Technology, Bhopal (M.P), India[3]

Abstract: Fiber optic networks are known for their limitless capabilities and high bandwidth. To utilize this high capability network different multiplexing techniques are used. Wavelength division multiplexing (WDM) is one of the techniques which are most frequently used in WDM networks to utilize the available resources. In WDM network every link has its own bandwidth capacity. Whenever traffic is generated from source to destination the wavelength is assigned to each link to carry that traffic and out of the paths available between source and destination proper path is selected. So for routing and wavelength assignment problem different algorithms are used. In this thesis standard Routing and wavelength assignment algorithm is used. In this thesis analysis of different topologies in WDM network is done for different traffic patterns using routing and wavelength assignment algorithm (RWA). The MATPLAN WDM simulation tool based on MATLAB is used to simulate WDM topologies and to generate traffic patterns. Then behaviour of different topologies for distinct traffic patterns is analysed using the tool for different parameters. The parameters analysed in this thesis are message propagation delay which should be minimum, channel utilization which should be more, traffic carrying capacity of the network which should be high. It is found that mesh topology is better for high traffic but it is costly due to large number of links. So star topology is one topology which is better in all aspects.

Keywords: Wavelength division multiplexing (WDM), Routing and Wavelength assignment algorithm (RWA), MATPLAN.

INTRODUCTION

In this technologically advanced world where capabilities of the communicating devices and transmission media are increasing. Fiber optic cable has played an important role. It utilizes this, high capability media of transmission by performing multiplexing. Wavelength Division Multiplexing (WDM) is one such technology used in optical networks. Every single link in optical network has the capability to transmit gigabytes of data. Using WDM, data of multiple users is sent simultaneously through the same link by assigning distinct wavelengths. Such algorithm is referred as Routing and Wavelength Assignment Algorithm (RWA).

In this paper, all the optical network topologies are simulated using MATPLAN WDM tool based on MATPLAN. All such topologies are analysed for different dynamic traffic loads. Comparison between all the topologies is performed on the basis of some governing parameters like message propagation delay, channel utilization, traffic handling capacity and others. It is found that mesh topology is better for high traffic but it is costly due to large number of links so star topology is found better in all aspects.

WDM networks deals with two basic types of topologies:

a. Physical Topology: It specifies physical interconnection of nodes in the optical network. In optical network fibre cables are used to connect nodes. This topology can be Bus, Ring, Mesh and Star depending upon how the network is laid down.

b. Virtual Topology: It deals with the virtual light paths between the nodes of physical optical network which is used to transferring message between nodes without intermediate electronic processing of message.

VIRTUAL TOPOLOGY DESIGN

Virtual topology design problem can be considered to be composed of 4 sub problems and these are as follows:

a. Determining appropriate virtual topology that is which nodes within the physical network should be optically interconnected.
b. Routing of the light paths over the physical topology.
c. Wavelength assignment to the light path in an optimal way. Such that number of assigned wavelengths should be minimum.

d. Now routing the traffic on to the virtual topology rather than physical.

The sub problems b and c denotes RWA algorithm. Given the complexity of RWA, there are two general methodologies for solving the problem:

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016

ROUTING AND WAVELENGTH ASSIGNMENT (RWA)

To establish an optical path between source and destination pair is necessary to allocate a route and wavelength. This problem is known as the Routing and Wavelength Assigning (RWA) problem. RWA is a fundamental problem of all-optical networks, and arises in network designing applications, including traffic grooming, survivability network design, and traffic scheduling. Internet is formed by collection of network topologies. Different topologies show different performance parameters like packet loss, network congestion, delay and cost. Network congestion is an important parameter which must has to be reduced for optical. RWA problem can be static and dynamic. RWA of light paths in optical networks is usually done in two steps. First tries to find a route between the pair of nodes, and the then second assigns wavelengths for links of the route. The simulation suggests different solutions and handles these steps. Another approach is to combine these steps so that routing is tied to a particular wavelength. This approach is typically accomplished by starting with a particular wavelength and reducing the network topology to only those links on which this wavelength is available. RWA difficult problem can be divided into two separate sub-problems, the routing sub-problem and the wavelength assignment sub-problem and solve them individually.

```
{Routing assignment wavelength}
For connection request do (in parallel)
Select a path based on first-highest -probability-lookup
   Selection the first available wavelength on path
If (found)
     Setup a light-path
Else
  Select another path based on second highest probability
Select the first available wavelength on path
If (found)
    Setup a light-path
Else
     Consider a blocking case
        End if
    End if
End if
```

- The first method is solving the routing portion first, and then assigning a wavelength second. Three types of route selection are Fixed Path Routing, Fixed Alternate Routing, and Adaptive Routing.
- The second approach is to consider both route selection and wavelength assignment jointly.

A) Fixed path routing

Fixed path routing is the simplest approach to finding a light path. The same fixed route for a given source and destination pair is always used. Typically this path is computed ahead of time using a shortest path algorithm, such as [[Dijkstra's Algorithm]]. While this approach is very simple, the performance is usually not sufficient. If resources along the fixed path are in use, future connection requests will be blocked even though other paths may exist. The SP-1 (Shortest Path, 1 Probe) algorithm is an example of a Fixed Path Routing solution. This algorithm calculates the shortest path using the number of optical routers as the cost function. A single probe is used to establish the connection using the shortest path. The [[Analysis of algorithms| running time]] is the cost of Dijkstra's algorithm: $O (m+n\log n)$, where m is the number of edges and n is the number of routers. The running time is just a constant if a predetermined path is used

B) Fixed alternate routing

Fixed alternate routing is an extension of fixed path routing. Instead of having just one fixed route for a given source and destination pair, several routes are stored. The probes can be sent in a serial or parallel fashion. For each connection request, the source node attempts to find a connection on each of the paths. If all of the paths fail, then the connection is blocked. If multiple paths are available, only one of them would be utilized.

C) Adaptive Routing

The major issue with both fixed path routing and fixed alternate routing is that neither algorithm takes into account the current state of the network. If the predetermined paths are not available, the connection request will become blocked even though other paths may exist. Fixed Path Routing and Fixed Alternate Routing are both not quality aware. For these reasons, most of the research in RWA is currently taking place in Adaptive algorithms. Five examples of Adaptive Routing are LORA, PABR, IA-BF, IA-FF, and AQoS.
Adaptive algorithms fall into two categories: traditional and physically aware. Traditional adaptive algorithms do not consider signal quality, however, physically aware adaptive algorithms do.

WAVELENGTHASSIGNMENT

Wave length as sign ment methods are classified into many types for static and dynamic traffic.

Wavelength Assignment (WA) Problem -

A special case of the routing and wavelength assignment problem is that the paths are already given and we have to assign a wavelength while using the minimum number of wavelengths. This problem is called the wavelength assignment (WA) problem. To solve this problem, the following two constraints apply:

Wavelength continuity constraint: A light path must use the same wavelength on all the links along the path from network source to destination edge nodes.

Distinct wavelength constraint: All light paths using the same link must be allocated distinct wavelengths. OR two light paths must be assigned different wavelengths on any common link.

Three wavelength assignment algorithms are the following:

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016

• Random-fit algorithm: A set of wavelengths that can be used to set up the connection is determined then a wavelength is randomly selected from the set according to a uniform probability distribution.
• First-fit algorithm: In the first-fit, the wavelengths are numbered. The lowest numbered wavelength that can be used to set up a connection is used for the connection. The idea of the first-fit scheme is to group the usage of the wavelengths toward the lower end of the wavelengths so that high numbered wavelengths can contain longer continuous paths.
This scheme performs better than the random-fit scheme. Due to its simplicity and high performance, this scheme is preferred in practice.
• Most-used algorithm: The most-used scheme enhances the idea of the first-fit scheme of packing the usage of wavelengths. In this scheme, all the available wavelengths that can be used most to establish a connection are considered; the wavelength that has been used the most is selected for the connection. The most-used algorithm performs slightly better than the first-fit scheme.

RWA ALGORITHM

Routing and wavelength assignment algorithm is applied for the given source and destination.
The source is the node which wants to transmit data and destination is the node to which data is to be transmitted.

The algorithm is as follows:

```
RWA(Source, destination)
{
Dijkstra(source, destination);
    Wavelength assignment(source, destination, V);
}
```

```
Dijkstra(Source, Destination, V)
{
Dist[Source] ← 0
For all v ϵ V – {S}
    Do dist[v] ← ∞
Source ← φ
Q ←V
While Q ≠ φ
Do u ← min(Q,dist)
  Source ← Source U {u}
  For all v ϵ neighbours[u]
    Do if dist[v] >dist[u] + W(u,v)
      Then d[v] ← d[u] + W(u,v)

Return dist.
}
```

ILLUSTRATING RWA

Consider a network having nodes A, B, C, D, E AND F. let's consider that A wants to send message to F and at the same time C wants to send message to E.

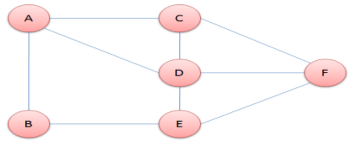


Fig 1: Hybrid network topology for illustrating RWA.

And let's consider routes selected by the Routing algorithm are as shown below.

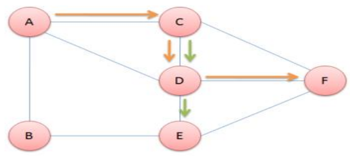


Fig 2: Data path from A to F in orange and C to E in green.

Now as one edge in this path is common that is C---D. This condition is called conflict. This conflict can be resolved using two approaches.

a. Alternate selection of Path using Routing algorithm: According to this approach different path can be selected between source and destination. So that conflict is not there.

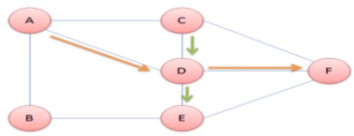


Fig 3: Alternate path for A to F to remove conflict.

Using different path will make both paths having no edge in common. So same wavelengths can be used for communication.

b. Distinct wavelength for all edges in common: If routing can't resolve common edge problem. Then only solution is to use distinct wavelengths for such edges.

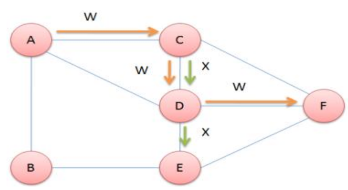


Fig 4 : Wavelength assignment for light paths from A to F and C to E.

This RWA problem is NP-Hard problem and thus many heuristic algorithms are also applied. But the objective of this paper is to analyse the topologies for different traffic

LITERATURE SURVEY

In [1] performance analysis of RWA algorithm is done for different topologies so that we can use topologies for specific application. Existing research demonstrated that Routing and Wavelength Assignment (RWA) algorithm

DOI 10.17148/IJARCCE.2016.5706

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016

and wavelength conversion are two primary parts for improving the blocking performance which are analysed in this paper.

In paper [2] it evaluates the performance of three wavelength allocation algorithms for allocating wavelength to optical WDM (Wavelength Division Multiplexing) networks and they are: first-fit algorithm, least-used algorithm and most-used algorithm. The objective of this experiment was to simulate the performance of wavelength allocation algorithms with different aspects: throughput and blocking probability.
In [3] problem of routing and wavelength assignment (RWA) in optical networks with wavelength division multiplexing (WDM). Two variations of the problem are also studied in this paper: static-RWA, whereby the network traffic requirements are recognized in advance, and dynamic-RWA in which network link connection requests arrive in some arbitrary fashion

S.Ramamurthy et. al. [4], proposed fixed-alternate routing and wavelength conversion**.** These two are improves the blocking performance and average link utilization of network. Alternate routing provides multiple possible paths between node pair's that's why it provides more benefits than wavelength conversion in denser network topologies at lower loads. The proposed methods use in future work is applied to a subroutine for use in iterative network design &optimization procedures. To make empirical observation as blocking performance of network topologies configurations and, to design alternate routing tables.

Huizang et. al. [5], study focuses on the RWA problem in wavelength routed optical networks. In this paper they are proposed Adaptive routing and Distributed Relative Capacity Loss (DRCL) which work well in distributed controlled network. Here routing decisions play a significant role in determining the blocking performance of a network. They propose ongoing research include comparison of Relative Capacity Loss (RCL) and (DRCL) on several other aspects like bandwidth requirement of control messages and computation overhead.

G Shen et. al. [6], this paper presents heuristic algorithms that may be used for light path routing and wavelength assignment in optical WDM networks under dynamically varying traffic conditions. here two methods are done greedy algorithm was taken under wavelength conversion WDM,and exhaustive algorithm taken under non-wavelength conversion WDM.Greedy and least loaded algorithms are better compare to others in non-wavelength comparison environment, this provides less blocking probability. Here compromise no conversion approach of wavelength conversion and full conversion requirement of non-wavelength conversion areas are future research topics.

Jun Zhou et. al. [7], addressed in large networks maintaining precise global network state information is almost impossible. Many factors affected such as non-negligible propagation delay, infrequent state up-dates due to overhead concern and hierarchical topology aggregation. Here they proposed Dynamic Routing and Wavelength Assignment (DRWA) under single and multi-fiber systems with three wavelength assignment heuristics First-Fit**,** Random-fit, Most- used. here first-fit and most used perform poorly in the presence of imprecise global network state information, then conclude that the new RWA algorithm that can tolerate imprecise global network state information may need to be developed for the dynamic connection management in the future WDM networks.

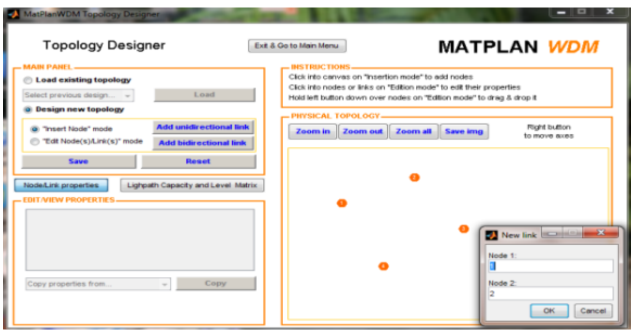
Bo Li and Xiaowen Chu et. Al. [8], described that blocking is the main performance index in the design of an all optical networks, here they have to take both RWA algorithms are consider with wavelength conversion. here two methods are proposed 1.Weighted Least Congestion Routing and First-Fit wavelength assignment (WLCR-FF)algorithm outperforms all existing RWA algorithms(Static, fixed-alternate &least-loaded routing)in sparse or full wavelength conversion.2.Weight Maximum Segment Length(WMSL)algorithm for Dynamic RWA algorithm can outperform all existing wavelength converter placement algorithm in terms of call blocking performance by a large margin.

EXPERIMENTAL SETUP

The simulation tool used in this dissertation is MATPLAN WDM 0.61. This tool runs using MATLAB. MATPLAN WDM is used for analysis of optical network for different traffic and topologies. It takes physical topology and traffic pattern data for various network topologies. We have taken all four topologies like bus, star, ring and mesh with different number of nodes and network traffic file.
MATPLAN home page consists of following tabs:
- Design Virtual Topology & Flow Routing.
- What if Analysis.
- Multi Hour Analysis.
- Dynamic Analysis.
- Topology Designer.

TOPOLOGY DESIGNER

In topology designer we have to select insert node mode and we can just put node in physical topology area in right hand side of interface. Links can be bidirectional and unidirectional which can be added as shown below.

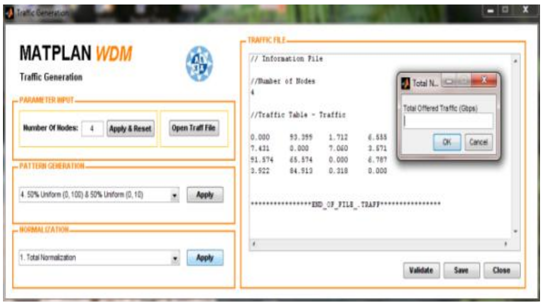


Traffic Generation

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016



Traffic pattern can be generated using above interface. Just input the number of nodes in topology and pattern generation and normalization technique from the drop down menus. At last in the popup appeared we have to give the total traffic we want to offer.

MESH TOPOLOGY

Table 1: 9-Node Mesh topology

Number of nodes	9
Total links	18
Lightpath Capacity	60 gbps
No of Wavelengths	40
Number of traffic level	1
Type of connection	Bidirectional

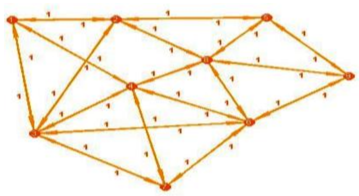


Fig 5.4: - 9-Node Mesh Topology

For topology simulation we have used MatPlanWDM0.61 as the simulation tool. It takes physical topology and traffic pattern data for various network topologies. We have taken all four topologies like bus, star, ring and mesh with 9-node network traffic file. We have to give topologies in .xml & traffic file in .traff format. The algorithm we used here is a testing algorithm. After that we have selected sweep parameters with lower & upper limits and number of sweep points to start simulation.

COMPARATIVE ANALYSIS AND RESULTS

What –If Analysis -

In what if analysis we have analysed our topologies in interns of following parameters:

- Carried / offered traffic Vs. Traffic demand.
- Message propagation delay vs. traffic demand %.
- No. of used wavelength channels vs. traffic demand %.
- No. of used wavelength channels Vs. Wavelength channel capacity.
- No. of light paths per fiber links Vs. No. of wavelengths per fiber.

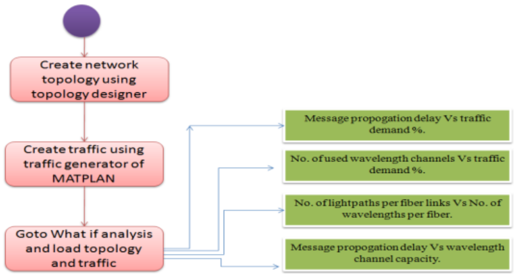


Fig 5: Figure showing flow chart of WDM topology analysis.

Analysis of optical WDM topologies in terms of above parameters :

Carried / offered traffic Vs Traffic demand

This analysis is done in order to check the traffic handling capacity of the network topologies. For a given network topology with fixed bandwidth and available wavelengths as the traffic demand increases packets are dropped and some data loss occurs. So this analysis is important to check for a given bandwidth how different network topologies behave for different traffic demand. So higher the curve of the topology the better it handles the network traffic. From the graph shown below it is clear that Mesh topology handles the traffic better than other topologies.

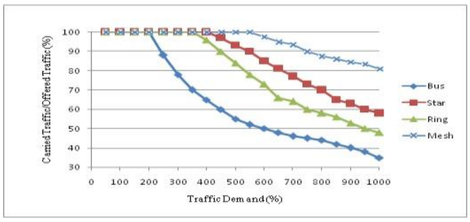


Fig6: Carried / offered traffic Vs. Traffic demand

Message propagation delay vs. traffic demand %

This analysis is done to check some of the problems that come with the merits of topologies. Like in start topology initialization and scalability are merits but whole network traffic passes through the central connecting device. So it creates a bottleneck and results are poor for star topology. While for mesh they are good as whole traffic is through a multiple cable which efficiently takes advantages of multiplexing and optical fibre cable capacity.

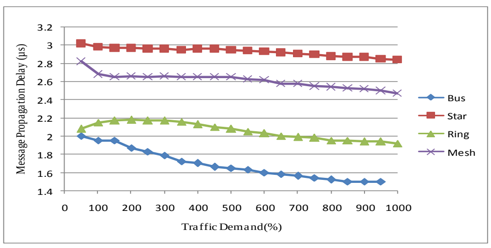


Fig 7: Message propagation delay vs. traffic demand

No. of used wavelength channels vs. traffic demand %

From this analysis it is concluded that variable nature is shown by every topology which depends on the traffic demand. No. of used wavelength channels should be less according to RWA. So mesh topology is the one in which

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016

this is minimum of all. Because in mesh topology common links are less as compared to other topology. On an average in bus topology number of used wavelength channels is more.

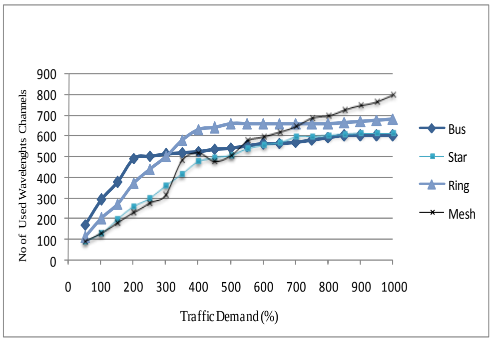


Fig: 8 No. of used wavelength channels vs. traffic demand

No. of used wavelength channels Vs Wavelength channel capacity

As the wavelength channel capacity increases no. of used wavelength channels will decrease as more bandwidth will be available. But in bus topology it will be more. Which is similar to what is concluded from previous graph? Mesh topology is better in this scenario.

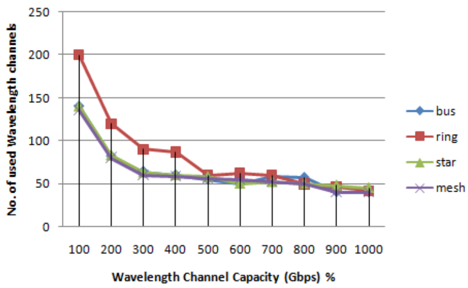


Fig 9:No. of used wavelength channels Vs. Wavelength channel capacity.

No. of light paths per fiber links Vs No. of wavelengths per fiber

It is clear from the analysis that for all topologies no. of light paths per fibre link are independent of no. of wavelengths per fibre. But it is maximum for bus topology as single cable is shared among all the nodes.

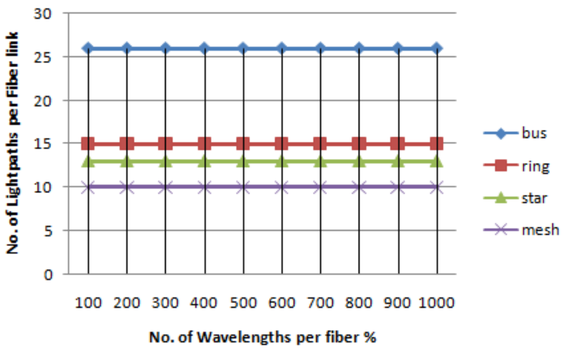


Fig 10:No. of light paths per fiber links Vs. No. of wavelengths per fiber.

SUMMARIZATION OF RESULTS

Analysis	Bus	Ring	Star	Mesh	Final Comment
Carried / offered traffic Vs Traffic demand	4	3	2	1	Mesh topology has the best traffic handling capacity in comparison of all.
Message propagation delay Vs. traffic demand %.	4	3	1	2	Bus topology has the minimum propagation delay as single backbone network is there. No routing overhead.
No. of used wavelength channels Vs. traffic demand %.	4	2	3	1	No. of wavelength channels used should be less which is minimum in star topology.
No. of used wavelength channels Vs. Wavelength channel capacity.	3	4	2	1	Same as previous
No. of light paths per fiber links Vs No. of wavelengths per fiber	3	4	2	1	Same as previous.

CONCLUSION

In this paper different WDM topologies are studied using MATPLAN WDM tool. These network topologies are studied for different network traffics. It is found that mesh topology is better than other topologies for heavy traffic and if traffic is low or moderate then ring topology is better. Mesh topology outperforms all other topology

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 7, July 2016

except mesh topology mesh topology is cost efficient than ring topology.

REFRENCES

[1] Santhosh Kumar C, Piruthiviraj.P , Dr.PreetaSharan, "Performance Analysis for All- Optical Networks Using Wavelength Routing Methods in Different Topologies", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Issue 5, May 2014.

[2] Chunyong Yang, Shaoping Chen, "Performance analysis of topologies for optical wavelength convertible networks", College of Electronics Information Engineering, South-Central University for Nationalities, Wuhan 430074, China.

[3] Hyo–Sik Yang and Martin Reisslein, Martin Herzog, Martin Maier, and Adam Wolisz, "Metro WDM Networks: Comparison of Ring and Star Topologies".

[4] Ali Norouzi ,A.HalimZaim†, Berk BurakUstundag, "An integrated survey in Optical Networks: Concepts, Components and Problems", IJCSNS International Journal of Computer Science and Network Security, Vol.11 No.1, January 2011.

[5] Santhosh Kumar C, Piruthiviraj.P , Dr.PreetaSharan, "Performance Analysis for All- Optical Networks Using Wavelength Routing Methods", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Issue 5, May 2014.

[6] Rajalakshmi P, Ashok Jhunjhunwala, "Routing Wavelength and Timeslot Reassignment Algorithms for TDM based Optical WDM Networks - Multi rate traffic demands", Networks, ICON '06. 14th IEEE International Conference, 2006.

[7] Satinder Kaur1, Dr. Kamal Sharma, Er. Gurinder Singh, "Design & Implementation of Optical Routing with Effect on Performance Parameters", International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 1, Issue 2, Sept 2014, pp. 31-36.

[8] P. Pavon-Marino, R. Aparicio-Pardo, G. Moreno-Munoz, J. Garcia-Haro, and J. Veiga-Gontan, "MatPlanWDM: An Educational Tool for Network Planning in Wavelength-Routing Networks", in Lecture Notes in Computer Science, vol. 4534, Proceedings of the 11th International Conference on Optical Networking Design and Modelling, ONDM 2007, Athens, Greece, pp. 58-67., May 2007.

[9] S.C. Tan,F.M. Abbou "The effect of Stimulated Raman Scattering (SRS) in Routing and Wavelength Assignment (RWA) in WDM mesh and ring topologies" in Optik 123 (2012) 1934– 1937.

[10] T.K Ramesh,Sandeep Kumar Konda, Dr. P.R Vaya "Survivable Traffic Grooming RWA Protocol for WDM Networks" in International Conference on Communication Technology and System Design 2011.

[11] Aminbrahimzadeh,AkbarGhaffarpourRahbar,BehroozAlizadeh "Request differentiation in dynamic light-path establishment for WDM routed all optical networks of data centers" in Optical Fiber Technology 21 (2015) 73–80.

[12] JulianadeSanti,AndréC.Drummond,NelsonL.S.daFonseca "Holding-time-aware dynamic traffic grooming algorithms based on multipath routing for WDM optical networks" in Optical SwitchingandNetworking16 (2015)21–35.

[13] Jashwantsamar "Analysis of dynamic traffic patterns on wdm optical networks for different topologies using rwa algorithm" Vol. 4, Issue 12, December 2015.

[14] Der-RongDin "Genetic algorithm for virtual topology design on MLR WDM networks" in Optical SwitchingandNetworking18(2015)20–34.

[15] Ravi TejaKoganti, DeepinderSidhu "Analysis of Routing and Wavelength Assignment in Large WDM Networks" in Procedia Computer Science 34 (2014) 71 – 78.

BIOGRAPHY

I am Research Scholar, Computer science Engineering, Mittal institute of technology, Bhopal (M.P), India. I am **Radha Raman Chaurasiya** I have completed my thesis under the guides of prof. jashwantsamar and research topic is "Performance Analysis of topologies using for RWA in optical WDM network Research Scholar, Computer science Engineering, Mittal institute of technology, Bhopal (M.P), India.