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Optimum Regenerator Placement in WDM Optical Network

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Abstract:
Optical networks are used to transmit large amount of information with a high speed on a large area from source to destination. But during the transmission, physical impairments such as distortions, noise, negatively affect the quality of information during transmission in optical networks. The effect of physical impairments also affects the quality of optical signal. And the result of transmit limited and degraded information to a certain distance this paper reveals the performance on Regenerator Placement optical network. This paper also gives a comparison and calculation of blocking probability for better performance of signal from source to destination via use of regenerators. Different results are shown in the MATLAB simulation.

Index Terms: WDM, Blocking Probability, Regenerator, Impairments, Optical Networks

1. INTRODUCTION

WDM stands for wavelength division multiplexing, [1] which is a technology that multiplexes a large number of synchronous signals often known as carrier signals on a single main optical fiber with the help of different sinusoidal wave known as wavelengths the main advantage of this technique is that it enables the bidirectional communications over a single fiber or multiplications of the signals. WDM scheme is used in the optical networks. Optical networks are used to transmit large amount of information with a high speed on a large area from source to destination. But during the transmission, physical impairments such as distortions, noise, negatively affect the quality and failure of the signals, which failed the whole optical network. There are certain reasons for the failures of networks in which failure of link is most common. In this the two nodes in between of communication is distorted because of the failure of link between two nodes. The link that is failed is can be due to the noise or the slack connection between two nodes in the optical network, or the link loss could be due to the huge data loss as we already know that wdm consists of multiple channels as a result of high data and data loss [2]. Along with the failure of networks there is a fault management also which is too much important for the survivability of the particular network. We have to ensure that if the failure will occur though network should be work as in earlier means become unaffected with the failures. If we have to cover these kind of failure [3] then we have to set the two different kinds of light paths for the different requests in the optical network from source to the destination or we can say to the maximum optical reach. If there is two light path then there should be a primary light path and secondary light path which is consider as a second flight path which help us to ensure after the failure of the network. So we can say that both light path do not fail at the same time there must be a path which always be secure in the optical network and the main important thing is that both link have different path and not going to share the same path. This type of fault scheme [4] in which there is a dedicated path, it is called as dedicated path protection scheme. There are different approaches used for the solution of problem. In this paper there are different sections that include various problems are shown that are associated with the network.

A. Impairments:

We already know about the degradation of the signal when it propagates through the optical fiber from the source to the destination node, the quality of the signal is also degrades through the optical fiber. The main causes of these degradations are of the physical layer impairments [4]. Due to the increase of the distance the effects of physical layer impairments increases the effect of information or signal degradation is more in the optical network. Or we can say that the distance that the signal has to cover in the optical fiber is reduced or limited beyond the maximum distance it can travelled. That maximum distance is referred as the optical reach which is the final destination of the signal. The optical reach could be a limit that if the propagation is less beyond the optical signal then it will be degraded and not applicable for the optimum communication.

B. Regeneration:

To mitigate the problem of degradation there are special devices which are called regenerators. The main function of regenerators is to Re-shape, Re-Time and Re-Amplify [5] the signal. The process of this is called Regeneration or 3R Regeneration. In this the signal is the signal is restored to its maximum strength so that it could travel to the maximum optical reach or its destination. This process of regeneration is not a definite process and can be repeated. The main motto is used to regenerators is to maximize the strength of the signal which degraded in the earlier process. it consists of a node referred as regenerator node in the optical network.

C. Failures of Network:

There are certain reasons for the failures of networks in which failure of link is most common. In this the two nodes in between of communication is distorted because of the failure of link between two nodes. The link that is failed is can be due to the

noise or the slack connection between two nodes in the optical network, or the link loss could be due to the huge data loss as we already know that wdm consists of multiple channels as a result of high data and data loss. Along with the failure of networks there is a fault management also which is too much important for the survivability [6] of the particular network. We have to ensure that if the failure will occur though network should be work as in earlier means become unaffected with the failures. If we have to cover these kind of failure then we have to set the two different kinds of light paths for the different requests in the optical network from source to the destination or we can say to the maximum optical reach. If there is two light path then there should be a primary light path and secondary light path which is consider as a second flight path which help us to ensure after the failure of the network. So we can say that both light path do not fail at the same time there must be a path which always be secure in the optical network and the main important thing is that both link have different path and not going to share the same path. This type of fault scheme in which there is a dedicated path, it is called as dedicated path protection scheme.

2. BLOCKING PROBABILITY

Blocking Probability [7] is referred to regeneration of new occurring calls/signals while all the resources are busy. If the number of channels are zero that means there is 100% blocking probability. For considering the effect of blocking probability we analyze that as the number of channel increases the blocking probability decreases. The steps for placement of minimum number of Regenerators [8] in a optical network are: First we are taking two networks that is pre network and post network. For the blocking probability and number of calls relation we are taking this pre network. In second step check the blocking probability relation. Then design the post network and calculate the shortest path and then calculate the blocking probability from the post network compute the relation between the blocking probabilities. Then placed the regenerators in the post network and find the relation between number of calls and the blocking probability then compute the graph between them and make comparison.

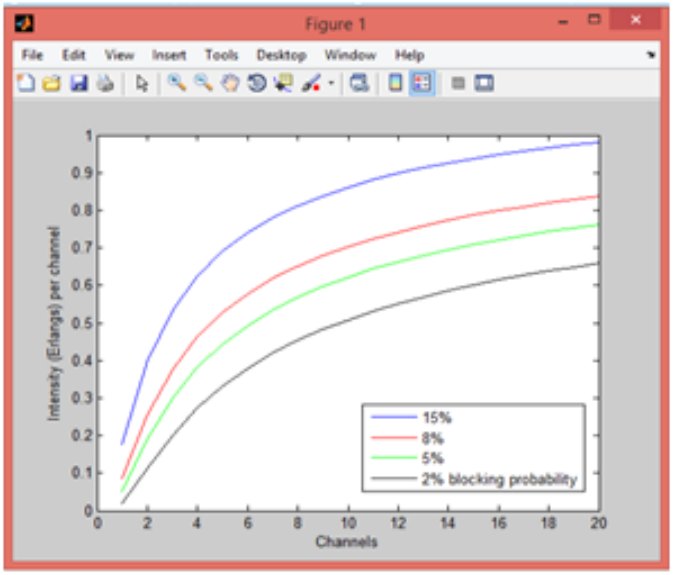

Figure.1. Graph showing Blocking Probability vs Calls

As from the figure 2 its clear the relation between the blocking probability and number of calls that when the number of calls or channels are increased then the blocking probability is decreased. In the graph the blue curve shows when N=1, red shows N=2 and so on. The calculation of this blocking probability is done with the Erlang B formula, which isused for the calculation of blocking probability.

$P_{b=}$ B(E,m)=$\frac{E^{m}}{m!}$ / $\sum_{i=0}^{m} Ei/i!$

where:

- $P_b$is the probability of blocking
- m is the number of identical parallel resources such as servers, telephone lines, etc.
- $E = \lambda h$ is the normalised ingress load (offered traffic stated in erlang).

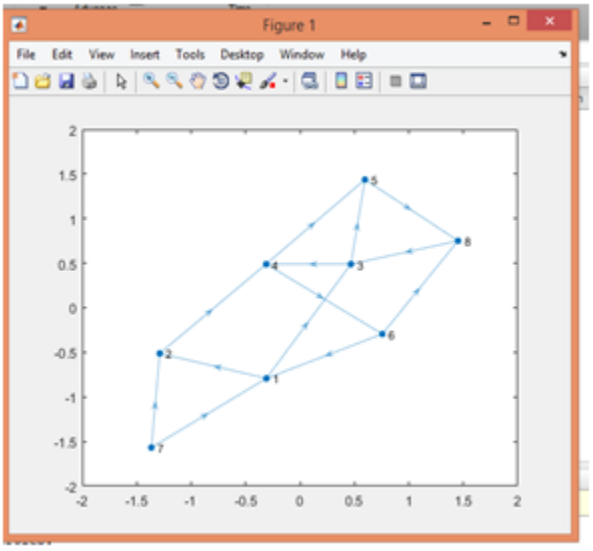

Figure.3. Pre network graph without regenerators

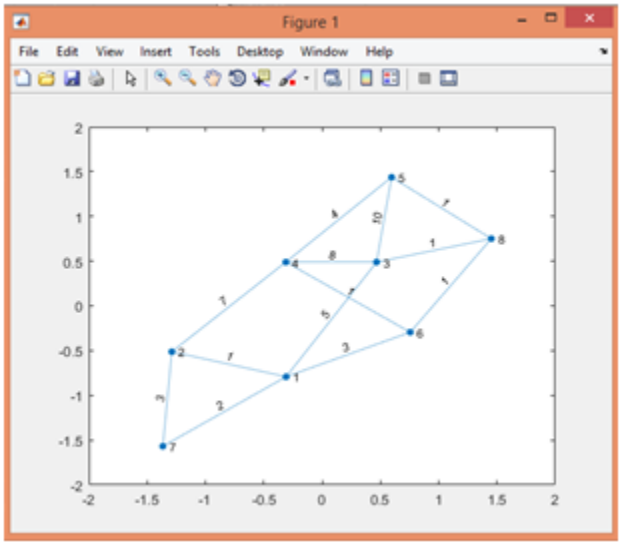

Figure.4. Pre network graph with weights

Figure 3 shows the optical network having eight nodes without the placement of regenerators. The weight or load is assigned in the pre network is shown in figure 4.

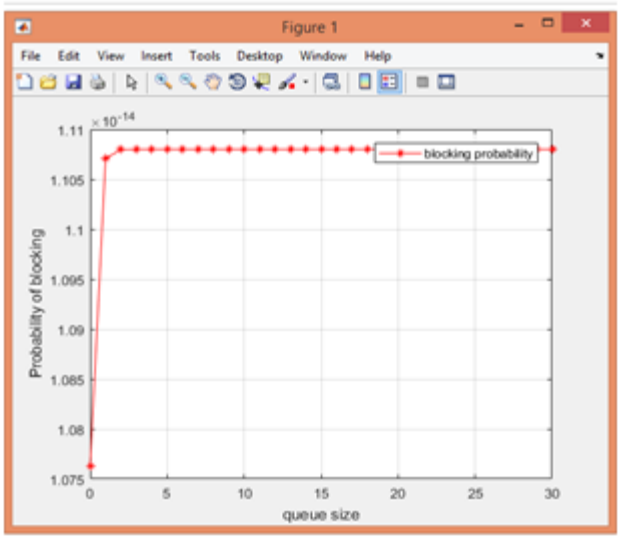

Figure.5. Blocking Probability of Pre network

From above pre network, blocking is calculated according to the Erlang B formula with suitable predefined weights. Next step is to place regenerators at the suitable nodes. The mathematical formulation steps are given below.

- **Mathematical Formulation:**

Steps for the optimum regenerator placement[9] in the network

- Calculate the all possible paths from each node in the network
- Calculate the distance between each nodes that selected for the analysis in the network
- Calculate blocking probability in each node
- Find the shortest node in the network
- Check the intermediate node in which the number of calls reach maximum to optical reach.
- Place regenerator on the intermediate nodes.
- Compute the blocking probability
- Compare the blocking probability in both cases.

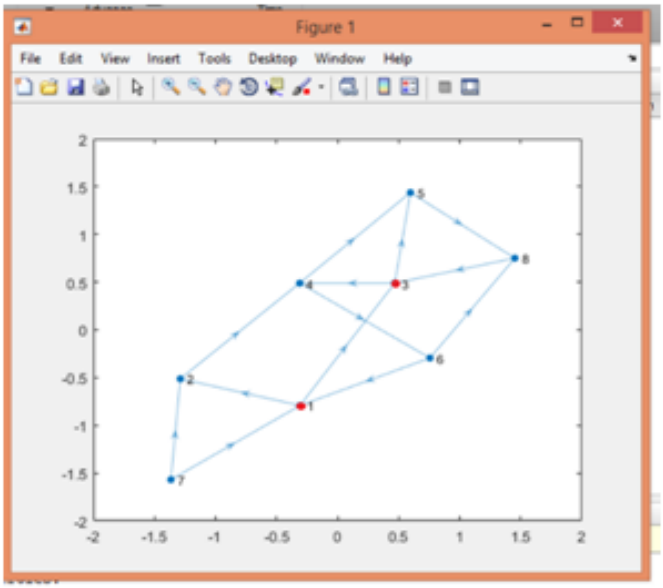

Figure.6. Post network graph with regenerators

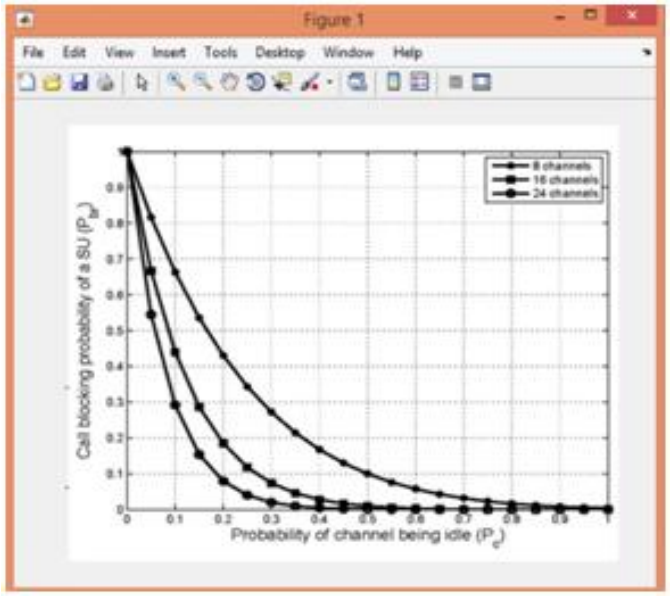

Figure.7. Blocking probability with regenerators

In the figure 6 the regenerators are placed at node 1 and 3 in a red mark. These regenerators are placed according to the heuristic algorithm and the graph between the calls and the probability is shown in figure 4 where in additional 8 nodes or channels we also shown for 16 and 24 channels. So from the above results it is proved that blocking probability is inversely proportional with the number of channels.

3. CONCLUSION

This paper deals with different simulation results of blocking probability and number of calls and finally a optimum regenerators are placed at a particular nodes. A heuristic approached is also discussed for the placement of regenerator at correct place when disjoint occurs.

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