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Analysis of Blocking Probability in OBS Networks

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Abstract- The quality of an optical signal degrades due to physical layer impairments as it propagates from source to destination. Due to this signal quality at the receiver or destination may be degraded, leading to increased call blocking. A performance indication of an All-Optical Network is the call blocking probability. The goal is to achieve a low overall blocking probability at an affordable cost and at the same time to make sure that other performance measures are within reasonable limits. This blocking probability can be affected by many factors such as network topology, traffic load, Routing and Wavelength Assignment(RWA) algorithm employed and whether wavelength conversion is available or not. In this paper, the performance of the some wavelength assignment algorithms is calculated in terms of blocking probability. Further, a new wavelength assignment algorithm "wavelength reservation" is proposed in this paper. The performance of this proposed wavelength reservation algorithm is compared with some other algorithms. The blocking probability is calculated to observe the effect of number of channels, number of nodes and load (in Erlangs) on each link in network.

Index Terms- Optical Burst Switching, Blocking Probability, Wavelength-Division Multiplexing, Wavelength Assignment, Wavelength Reservation

1. INTRODUCTION

In 1980s, a revolution in telecommunications networks began spawned by the use of relatively unassuming technology: fiber optical technology [1]. Optical networks are high capacity communications networks based on optical technologies and components that provide routing, grooming, and restoration at the wavelength level. An optical network is built by interconnecting various optical switches with wavelength-division multiplexing (WDM) fibers, i.e., fibers that can simultaneously transmit data over different wavelength.

In delivering IP traffic in optical WDM networks, there are three switching paradigm:

- Optical Circuit Switching (OCS)
- Optical Packet Switching (OPS)
- Optical Burst Switching (OBS)

1.1 Optical Circuit Switching: OCS a switching technique used in communication network because it is simple enough to carry analog signals. In this technique, the transmission medium is divided into channels using Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM) and Code division Multiplexing (CDM).In circuit switching the channel bandwidth is reserved for an information flow. Contention only occurs when allocating channels to circuit during circuit establishment. If there are not enough channels for the request, the call establishment may be delayed, blocked or even dropped. The performance of the circuit switched networks has been studied only with respect to Blocking Probabilities(BP).The BP have been derived using the reduced-load fixed point approximation based on solving Erlang's formula [2].In circuit switching, allocated resources are exclusively available to the end- to-end connection for its entire duration.

1.2 Optical Circuit Switching: OPS is the basis for Internet Protocol (IP).In packet switching, information flows are broken into variable-size packets (or fixed size cells as in the case of ATM).These packets are sent, one by one, to nearest router, which will look up the destination address, and the forward them to the corresponding next hop. This process is repeated until the packet reaches its destination.

1.3 Optical Burst Switching: OBS is one of the most efficient optical architecture of wideband optical communication. Initially, OBS was introduced for integrated transfer of voice and data over TDM links [3]. It exploits the terabit bandwidth of WDM transmission technology [4].In OBS, data is transported in various size units, called bursts. Each burst consists of control header and a burst payload. In OBS, the reserved resources at each switch and output link port are held only for the duration when they are needed for switching and transmission of individual bursts. The OBS network consists of core nodes and end devices interconnected by WDM fibers that transport data from various edge users. The users consists of an electronic router and an OBS interface, while the core OBS nodes require an optical switching matrix, a switch

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control unit and routing and signal processors.

Parameters	OCS	OPS	OBS
Bandwidth Utilization	Low	High	High
Optical Buffer	Not Required	Required	Not Required
Latency(set-up)	High	Low	Low
Proc./Sync. Overhead(per unit data)	Low	High	Low
Adaptivity (traffic & fault)	Low	High	High

Table1. Comparison between three Optical Switching Paradigms.

The OBS networks mainly consist of three components: ingress node, an egress node and a network of core nodes as shown in fig.1.At the ingress node, various types of client data from the access network are aggregated into data burst which is transmitted in the optical domain. To avoid buffering and processing of the optical data burst at the intermediate nodes called core nodes, a control packet also called Burst Header Packed (BHP), with the information about the length and arrival time of the data burst, is sent in advance. The BHPs are transmitted on a dedicated control wavelength, while the data burst are sent after some time on separate wavelength[5].The time lag between a BHP and the corresponding data burst is called Offset time which is set sufficient enough to enable the processing of BHP and to configure the switches at the core nodes.

Once the burst reaches the egress node, it is disassembled into packets which are routed through the access network. Hence the ingress nodes are responsible for formation and transmission of the burst. So Characteristics of the traffic influenced by burst assembly, burst Disassembly and burst loss. The aggregation at the ingress node effects the distribution of packet size, arrival time between the burst and number of packet in burst. Similarly the distribution of input traffic at ingress node also influences the traffic in the core network. Today's the entire research in the OBS network's focuses on the techniques to minimizing the contention. Blocking probability, throughput, delay and loss performance is important measures of the performance of the networks.

Blocking Probability: In simple terms, it is the ratio of total number of call blocked to the total number of calls generated.

$$P_{Bavg} = \frac{Total\ Number\ of\ Call\ Blocked}{Total\ Number\ of\ Call\ Generated} \quad (1)$$

Throughput: In communication networks, throughput is the average rate of successful message delivery over a communication channel. The throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot.

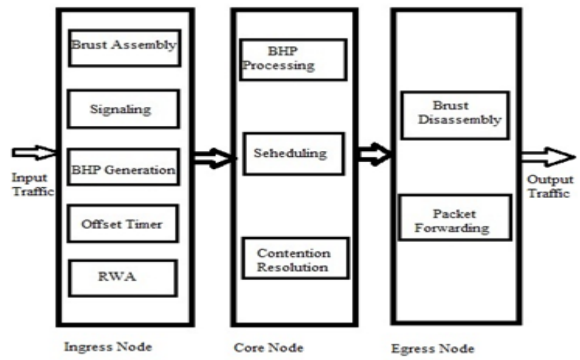

Figure 1. Nodes in OBS Networks

OBS networks lead to a higher efficiency than the OCS networks in utilizing the WDM bandwidth; under the identical network capacity and traffic demand, the OBS networks achieved 20% more throughput than the OCS networks [6].

In WDM, several wavelengths run on a fiber link that connects two optical switches. The multiple wavelengths can be exploited to minimize contentions as follows. If two bursts are destined to go out of the same output port at the same time. Both bursts can still be transmitted, but on two different wavelengths. This method may have some potential in minimizing burst contentions, particularly since the number of wavelengths that can be coupled together onto a single fiber continues to increase.

Wavelength assignment and wavelength conversion: Wavelength conversion is the process of converting the wavelength of an incoming channel to another wavelength at the outgoing channel. Wavelength converters are devices that convert an incoming signal's wavelength to a different outgoing wavelength, thereby increasing wavelength reuse, i.e., the same wavelength may be spatially reused to carry different connections in different fiber links in the network. In OBS with wavelength conversion, contention is reduced by utilizing additional capacity in the form of multiple wavelengths per link. A contending burst may be switched to any of the available wavelengths on the outgoing link. The following are the different categories of wavelength conversion:

(a) Full conversion: Any incoming wavelength can be shifted to any outgoing wavelength; thus there is no wavelength continuity constraint on the end-to-end connection requests.

(b) Limited conversion: Wavelength shifting is restricted so that not all incoming channels can be connected to all outgoing channels. The restriction on the wavelength shifting will reduce the cost of the switch at the expense of increased blocking.

(c) Fixed conversion: This is a restricted form of limited conversion, wherein each incoming channel may be connected to one or more pre-determined outgoing channels.

Wavelength assignment is the technique of assigning the wavelength to a particular route. Some of the types of wavelength assignment algorithms are listed as:

(*a*) ***Random Wavelength Assignment:*** In this one free wavelength is randomly selected from among the unused wavelengths available on the source-destination path.

(b) ***First-Fit (FF):*** In this scheme, all wavelengths are numbered. When searching for available wavelengths, a lower-numbered wavelength is considered before a higher-numbered wavelength. The first available wavelength is then selected. Compared to Random wavelength assignment, the computation cost of this scheme is lower because there is no need to search the entire wavelength space for each route. The idea behind this scheme is to pack all of the in-use wavelengths toward the lower end of the wavelength space so that continuous longer paths toward the higher end of the wavelength space will have a higher probability of being available. This scheme performs well in terms of blocking probability and fairness, and is preferred in practice because of its small computational overhead and low complexity.

(c)***Wavelength Reservation:*** In Wavelength reservation, a given wavelength on a specified link is reserved for a traffic stream, usually a multi hop stream. This scheme reduces the blocking for multi hop traffic, while increasing the blocking for connections that traverse only one fiber link (single-hop traffic).There are two different wavelength reservation protocols: Forward reservation and backward reservation. In forward reservation, a 'resv' message (specifying path/wavelength) is sent from source to destination on specified path. The intermediate node executes the wavelength reservation operation when it receive 'resv' message. When the destination node receives 'resv' message then it sent a 'conf' message in upstream. In Backward Reservation, a 'prop' message (specifying path) is sent from source to destination. The message collects wavelength usage information on the relevant optical links as it propagates on specified path. When destination node received the 'prob' message it picks one free wavelength and a 'resv' message is sent upstream to finish the resource reservation.

2. HISTORICAL PERSPECTIVE AND RELATED WORK

Z. Rosberg *et.al.* [2], evaluated the packet delay distribution in an optical switched network. Two types of circuit allocation policies were integrated into their frame work. First, circuit holding times were fixed duration and allocated at the boundary of fixed time frames. Second, circuit holding times were adaptive to buffer size such that holding time was sufficient to empty a buffer. W. Liao *et.al.* [5], described the offset-time based Quality of Service (QoS) scheme when applied to an optical burst switched WDM networks with limited Fiber Delay Lines (FDLs).The QoS performance has been measured in terms of the burst loss probability and quereing delay as a function of maximum delay time of a FDL, the offset time difference, the number of maximum FDLs, the number of classes and the number of wavelengths. L. Pezoulas *et.al.* [7], proposed a distributed control algorithms called First-Available (FA) that can efficiently use to assign wavelength in networks with sparse wavelength conversion. The wavelength reservation protocol described is a backward reservation protocol. They compared the FA algorithm with other backward reservation algorithms such as first-fit and random, the performance of FA algorithm was better in case of sparse wavelength conversion. They analyzed that networks which have wavelength converters, the use of backward reservation algorithm such as First-Fit and Random do not offer any additional performance improvement. J. Y. Wei e*t. al.* [8], worked on just-in-time (JIT) signaling protocol for OBS. In JIT, there are two types of control packets corresponding to burst: setup packet and release packet. At each intermediate node, the desired bandwidth is reserved from the time at which the setup packet has been processed and relinquished after receiving the related release packet. The JIT-OBS paradigm is designed for ultra –low-latency unidirectional transport of data-bursts across an optical network. They examined the various scenarios that illustrate the operation of the JIT signaling protocol in connection establishment and teardown. The feature of JIT i.e. out-of-band control signal processing, that eliminates buffering of data –burst at intermediate nodes, while minimizing the setup time and maximizing the cross-connect bandwidth efficiency. In Just-In-Time (JET), bandwidth is reserved from the time at

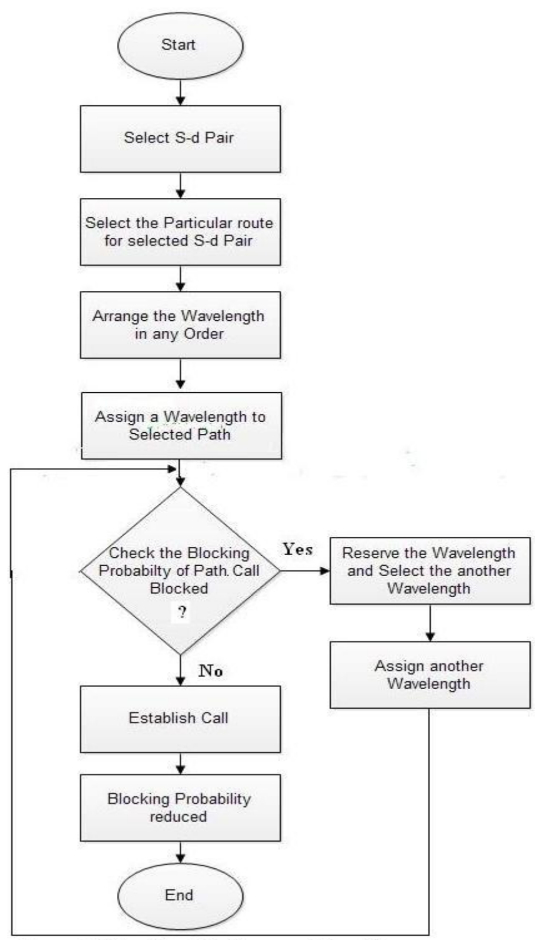

Figure A. Flow Chart For Proposed Algorithm

which the burst will arrive at the intermediate node and just allocated for the burst duration indicated in the control packet. C. F. Hsu *et.al.*[9], investigated the performance of deflection routing in prioritized JET based OBS networks with QoS support. Moreover, a model was proposed by them to approximate loss probability. Deflection routing provides an alternative to resolve contentions for the same output link. It may be implemented with or without output buffers. They observed that deflection routing improves performance of network but excessive deflection does not always bring gains. The offset time also affected the blocking performance. V.M.Vokkarane *et.al*. [10], packet losses were reduced by number of data channel scheduling algorithms that use burst segmentation and FDLs. The algorithm was based on the placement of the FDL buffers in the optical burst switched node. They also introduced two categories of scheduling algorithms base on FDL architecture: Delay-First (DF) and Segment-First (SF). DF algorithm was suitable for transmitting packets which have higher delay tolerance and strict loss constraints and SF algorithm suitable for data with higher loss tolerance and strict delay constraints.

3. ANALYTICAL MODEL

In this section, the frame work of the reservation algorithm is covered. If numbers of wavelengths are available in a network, then particular wavelength is selected for sending the data burst from source to destination nodes. The analysis aim is the checking of blocking probability for each wavelength assignment for particular route. The two constraints i.e. wavelength continuity constraint and Distinct wavelength constraint are kept in mind for making the algorithm. The name for proposed algorithm is Reservation algorithm. The algorithm for proposed technique is explained with the help of flow chart as shown in Fig.A.

4. SIMULATION RESULTS

In this paper, a new algorithm for wavelength assignment has been proposed and the performance of new wavelength assignment algorithm is evaluated in terms of blocking probability. The blocking probability of the proposed algorithm is compared with the some other algorithms i.e. First-Fit, Random and Best-Fit.

The simulation is carried out on simulation software MATLAB 7B of Mathworks. The blocking probability of the network; which is illustrated by eq. (1), compared depending upon the number of channel or wavelength, load and number of nodes.

We have fixed the value of the load as 3 Erlangs, number of nodes=20 and number of channels or wavelengths is varied. The Proposed algorithm is compared with first-fit, best-fit and random algorithm. The results are shown in fig 2-6.

The simulation shows that variation of blocking probability with the number of nodes. The blocking probability of random algorithms is found greater than the other algorithms. With the increase in number of channels or wavelengths the blocking probability of all the algorithms is decreases.

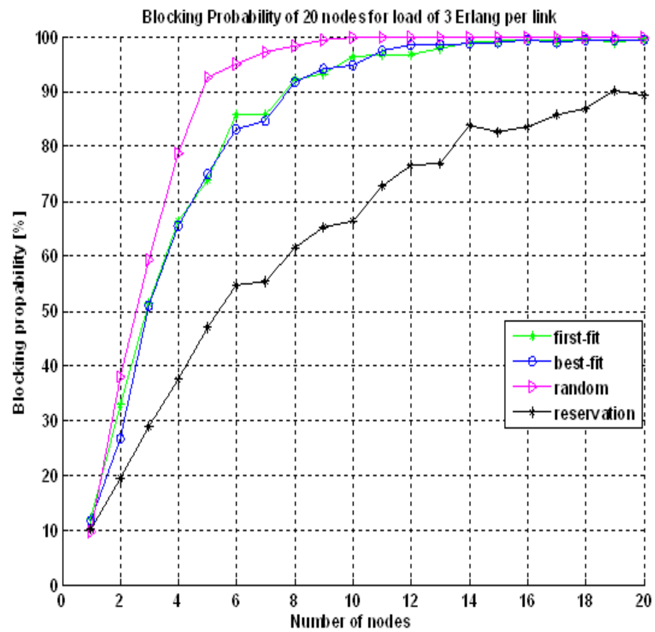

Figure 2. Blocking Probability of 20 Nodes for Number Wavelength is 5 when Load (in Erlang) per Link is 3

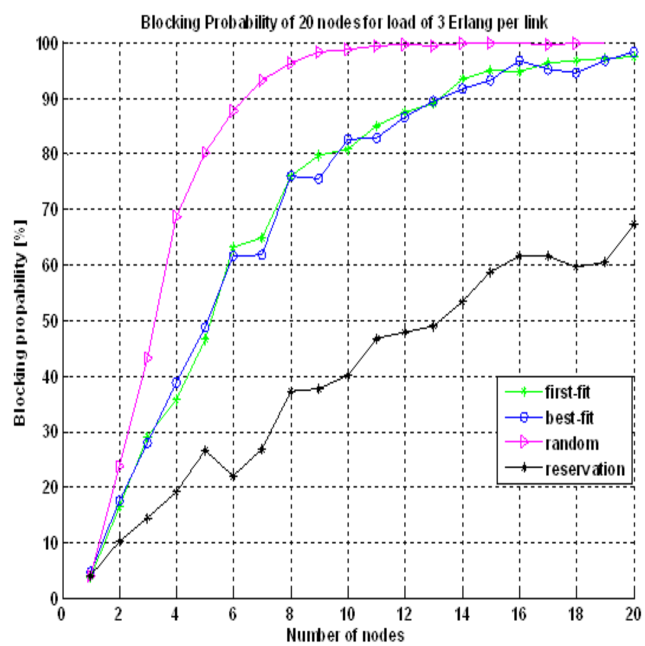

Figure 3. Blocking Probability of 20 Nodes for Number Wavelength is 6 when Load (in Erlang) per Link is 3

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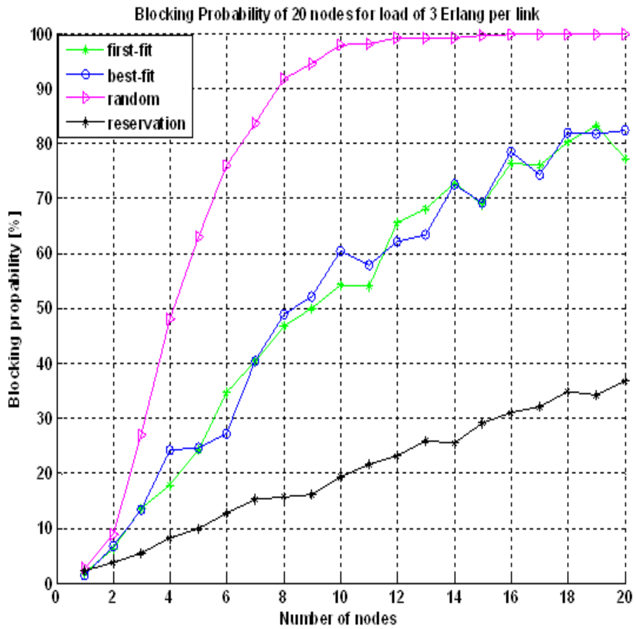

Figure 4. Blocking Probability of 20 Nodes for Number Wavelength is 7 when Load (in Erlang) per Link is 3

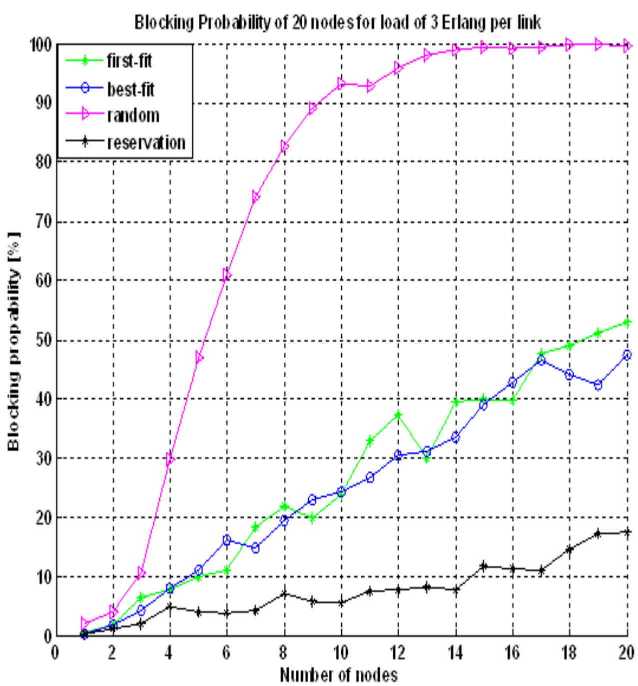

Figure 5. Blocking Probability of 20 Nodes for Number Wavelength is 8 when Load (in Erlang) per Link is 3

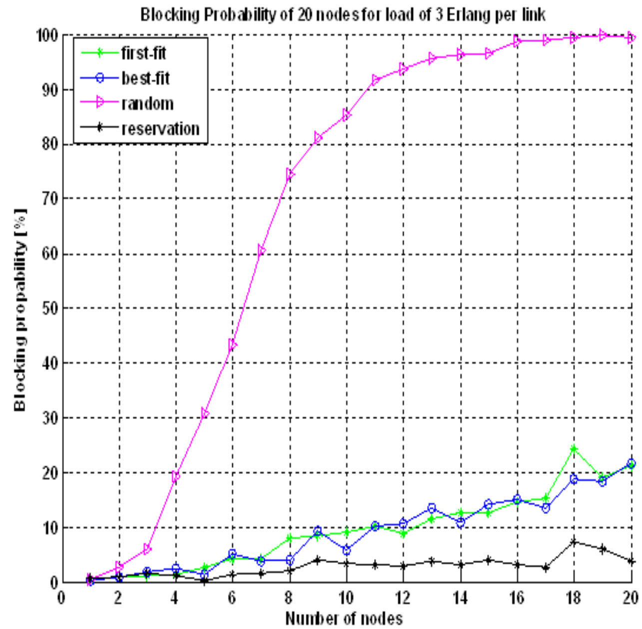

Figure 6. Blocking Probability of 20 Nodes for Number Wavelength is 9 when Load (in Erlang) per Link is 3

As shown in fig.2 for 10 number of node when load at each link is 3 Erlangs the blocking probability of random algorithm is 100%, it is in range of 90% to 94 % for first-fit and best-fit algorithms, but for proposed algorithms it is near to 67 %. With the increase in number of nodes the blocking probability increases for each algorithm but every time the blocking probability of proposed algorithm is found lesser. As shown in fig 2-6,with the increase in number of node the blocking probability in every algorithm become stable and reaches 100% whereas at the same instant the blocking in case of proposed algorithm in nearly 89 % for 20 number of nodes. When we increase the number of channels the blocking probability is decreased. For proposed algorithm the blocking probability is 89% at 20 number of node as we discussed above, it is 4 % with a 9 number of channel for same number of nodes as shown in fig.6.

Now, we double the value of load on each link i.e. fixed the value of the load is equal to 6(in Erlangs), network having number of nodes is 20 and number of channels or wavelengths is varied. Again the Proposed algorithm is compared with first-fit, best-fit and random algorithm. The results are shown in fig 7-11.With these results it has been proved that the blocking probability is minimum in the proposed algorithm than other algorithm.

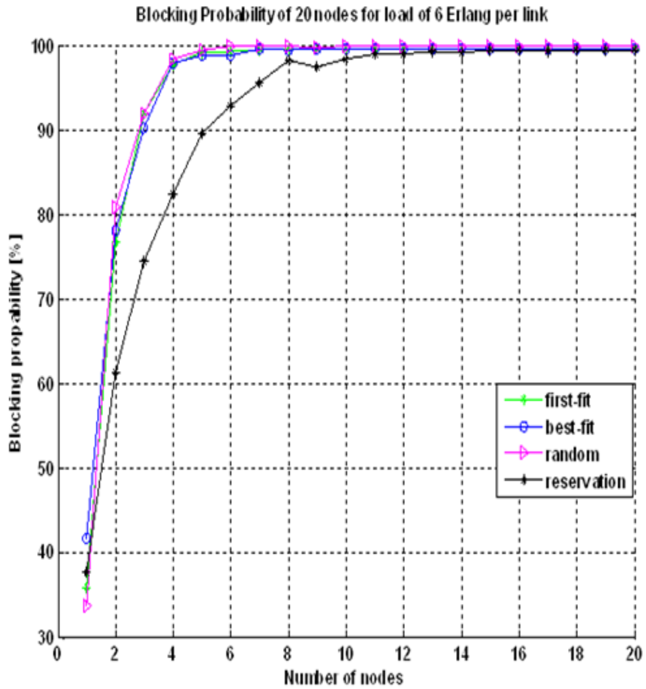

Figure 7. Blocking Probability of 20 Nodes for Number Wavelength is 5 when Load (in Erlang) per Link is 6

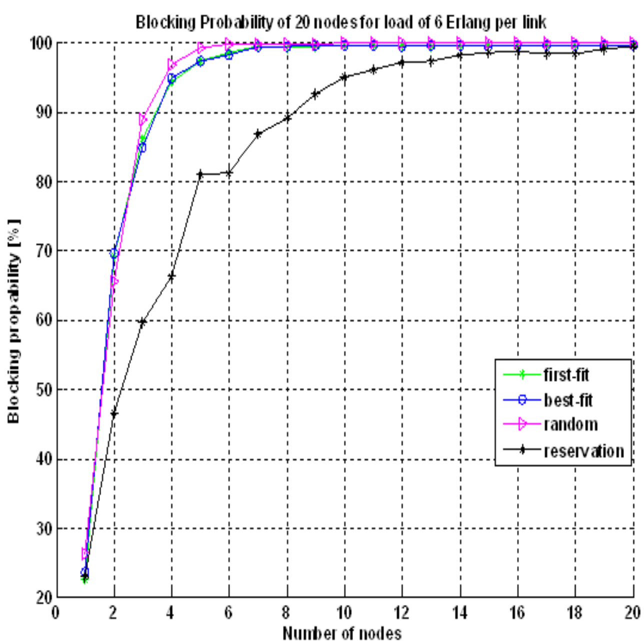

Figure 8. Blocking Probability of 20 Nodes for Number Wavelength is 6 when Load (in Erlang) per Link is 6

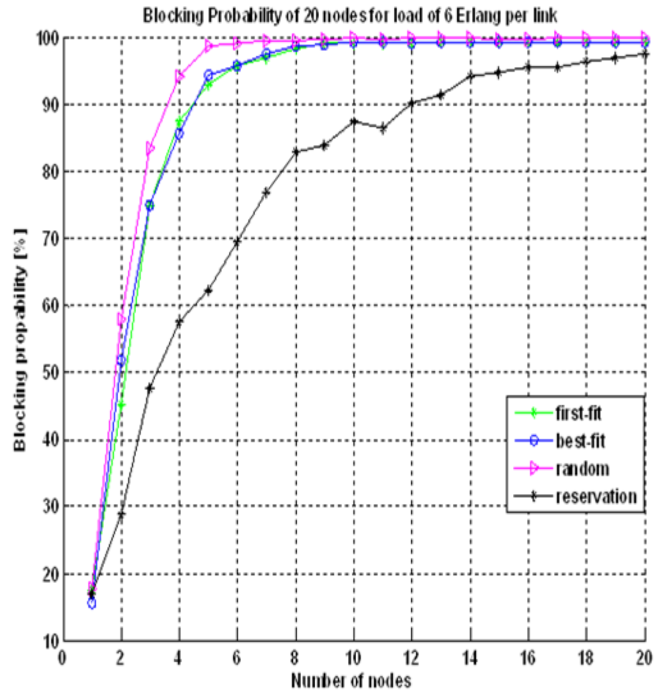

Figure 9. Blocking Probability of 20 Nodes for Number Wavelength is 7 when Load (in Erlang) per Link is 6

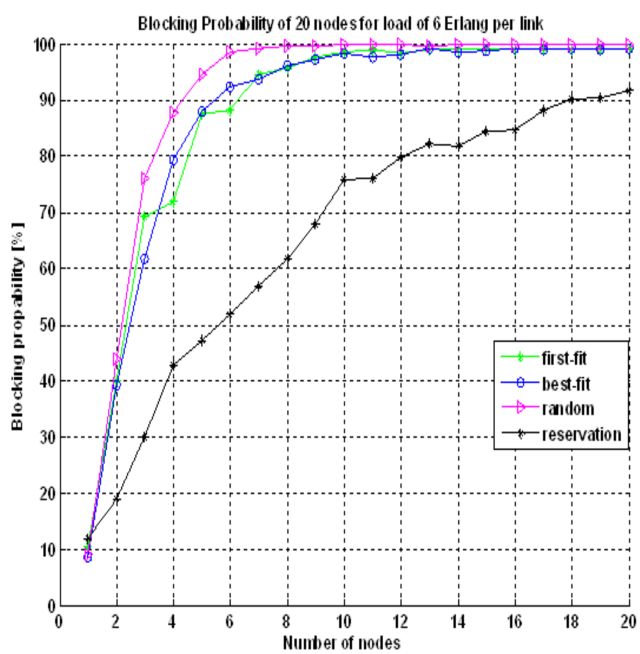

Figure 10. Blocking Probability of 20 Nodes for Number Wavelength is 8 when Load (in Erlang) per Link is 6

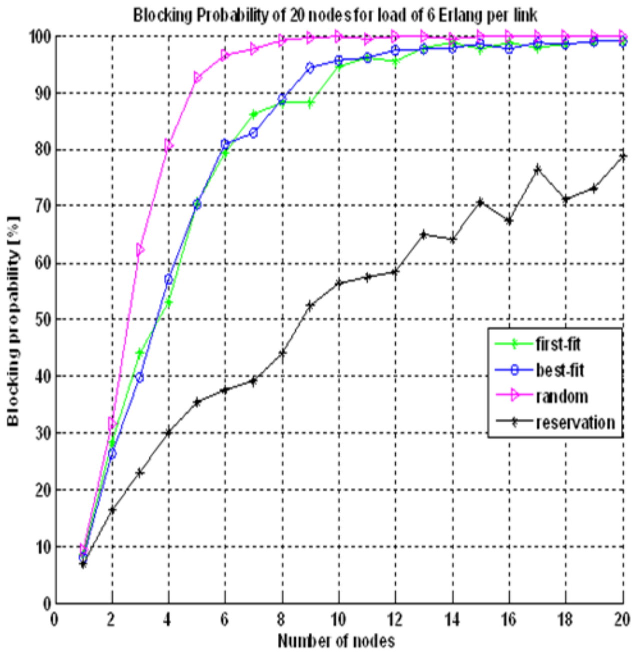

Figure 11. Blocking Probability of 20 Nodes for Number Wavelength is 9 when Load (in Erlang) per Link is 6

Second, with the increase in value of load (in Erlangs) on each link of the network the blocking probability is also increased. This effect is more cleared when we compared the fig. 2 and fig.7.

- From fig.2, when load is equal to 3(in Erlangs) and number of channel is 5, the blocking probability for proposed algorithm is 84 % at the instant when number of nodes is equal to 14.
- As shown in fig. 7, blocking probability was 98% for same number of channel and nodes, when load on each link is 6(in Erlangs).

The increase in load value also affects the performance of other algorithms. Blocking probability is increased with the increase of load on links.

5. CONCLUSION

This is analyzed that Random algorithm offers the most blocking probability and the proposed algorithm "Reservation Algorithm" offers the least blocking probability. The blocking performance of WDM network has been analyzed for the network having 20 nodes and varying number of channels or wavelengths. As the number of wavelengths increases the blocking probability decreases. Moreover, the load on the links also affects the performance of the networks. For fixed number of wavelength, as the load per link (in Erlangs) increases the blocking probability also increases. The results show that performance of first-fit is near to best-fit but it is better than the random algorithm whereas the proposed algorithm offers the least blocking.

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