Congestion Reduced Routing in WDM Network

4th Semester Mini-project under guidance of Prof. Uma Bhattacharya

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The Team

Contents

Introduction

Optical Networks :

- Copper Fibres are replaced by the optical Fibres.
- Lightwave propagates through optical fibres by using total internal reflection.
- Low signal attenuation - As signal propagates through fibers, the signal strength goes down at a low rate (0.2 db/km). This means that the number of optical amplifiers needed is relatively low.
- Optical networks have found widespread use because the bandwidth of such networks using current technology is 50 terabits per second.

Constraint:

The optical connection between two corresponding nodes is taken to be limited by the number of channels in each fibre link.

Wavelength Division Multiplexing (WDM)

- The technology of using multiple optical signals on the same fiber is called Wavelength Division Multiplexing (WDM).
- Different Channels are multiplexed within the large bandwidth provided by the optical network.

Characteristics of WDM Network

Characteristics of WDM Optical Networking

Wavelength-division multiplexing (WDM) is a method of combining multiple signals on laser beams at various infrared (IR) wavelength for transmission along fiber optic media.

Some major characteristics of WDM Network :

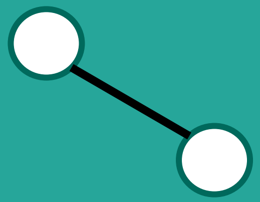
- Link Capacities
- Number of Transceivers
- Static or Dynamic Environments

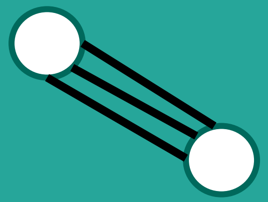
Link Capacity

It denotes the number of channels per link in a WDM Network.

For example if the link capacity is 3, then the number of channels per link in the network is fixed to 3.

So the link capacity is fixed in a WDM Network

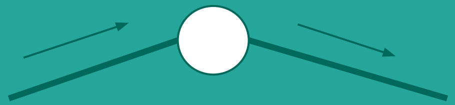




Number of transceivers

A combination of a transmitter and a receiver is called a transceiver
it converts an electrical signal to and from an optical signal.

The nodes in the network can be denoted as transceivers.
One node receives the signal and transmits it to the next node.
Thus, in a particular WDM Network, the number of transceivers is fixed.



Static - Dynamic Environment

Static Environment

In this case, the request set for source and destination is fixed and hence the set is static (does not change).

Dynamic Environment

The request set in this case is always dynamically changing as the algorithm is executed.

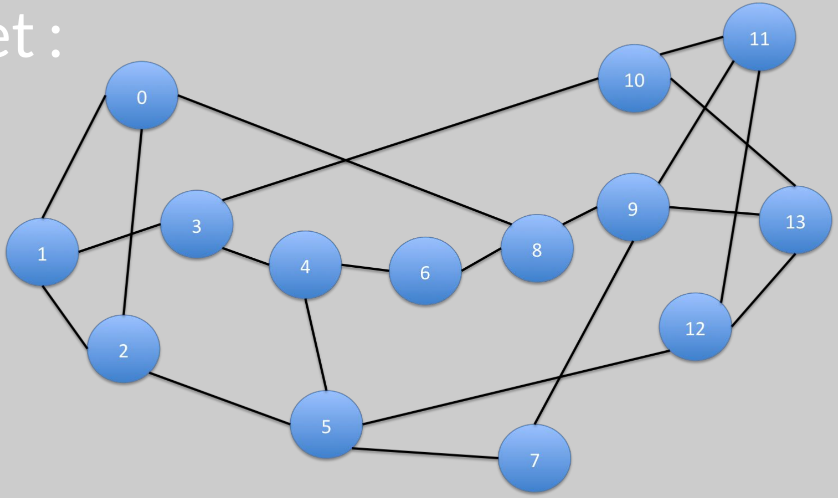
The Problem

Problem Definition

Given the NSF - 14 node network with edge weights, set of static requests and with certain link capacity,

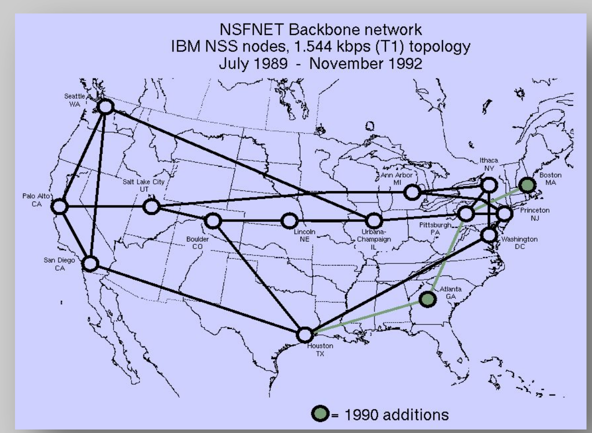
Find the congestion reduced routing maintaining the shortest path constraint as far as possible.

Physical Topology for NSF net :



- *The* ***National Science Foundation Network(NSFNET)*** *was a program of coordinated, evolving projects sponsored by the National Science Foundation (NSF) beginning in 1985 to promote advanced research and education networking*

- *NFS net is a 14 node network . With each node with a degree greater than 1.*
- *The graph has bidirectional links.*
- *Initially created to link researchers to the nation's NSF-funded supercomputing centers, FORMING the Internet backbone.*

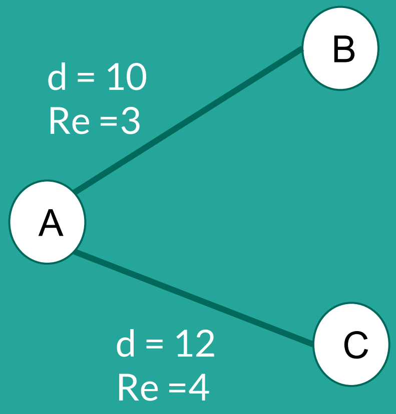


Functions Defined

We define two functions here to reduce congestion and also to consider the shortest path from a given source to destination node.

- Distance Ratio
- Availability Ratio

Distance Ratio

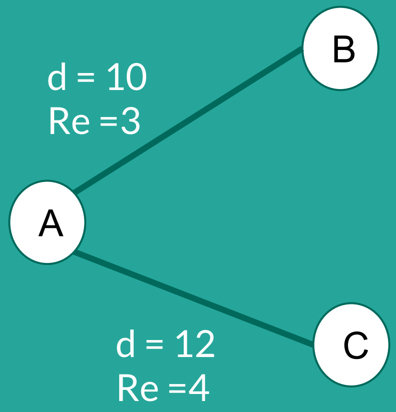


Maximum number of channels = 5
Number of requests through AB = 3
Number of requests through AC =4

Distance of link AB = d(AB) = 10
Distance of link AC = d(AC) = 12

d = distance of the link
Re =Number of Requests through that link

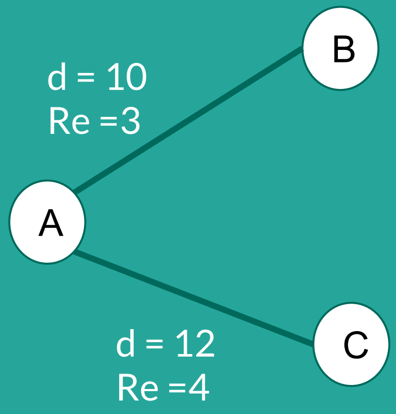
Distance ratio



For link AB:
Distance ratio = d(AB)/(d(AB) + d(AC)) = 10/(10+12) =10/22

For link AC:
Distance ratio = d(AC)/(d(AB) + d(AC)) = 12/(10+12) =12/22

Availability Ratio



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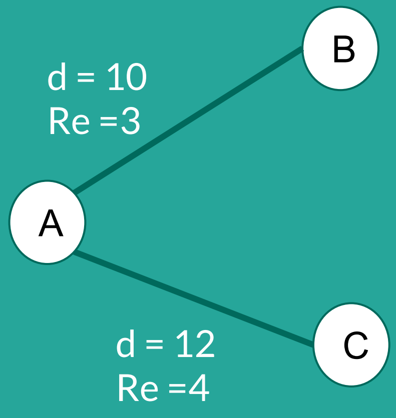


$$\text{Availability Ratio} = \frac{\text{Channel available}}{\text{number of channels}}$$

For link AB:
Channel available = (channel -Re) = (5-3)=2
Availability Ratio = (2/5)

For link AC:
Channel available = (channel -Re) = (5-4)=1
Availability Ratio = (1/5)

Shortest Path

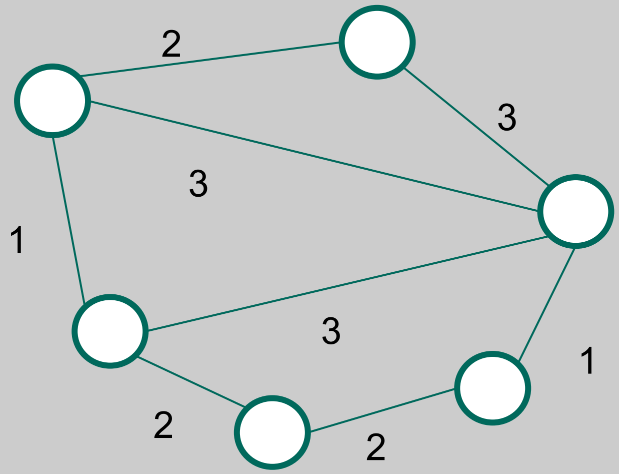
In this part we choose that path that is the shortest between a given source and destination, that is the path having minimum sum of weights

Congestion Reduced Routing

In this part, we choose the path that has the minimum congestion , that is the path having minimum no. of blockings

Shortest Path Routing

Shortest Path Routing

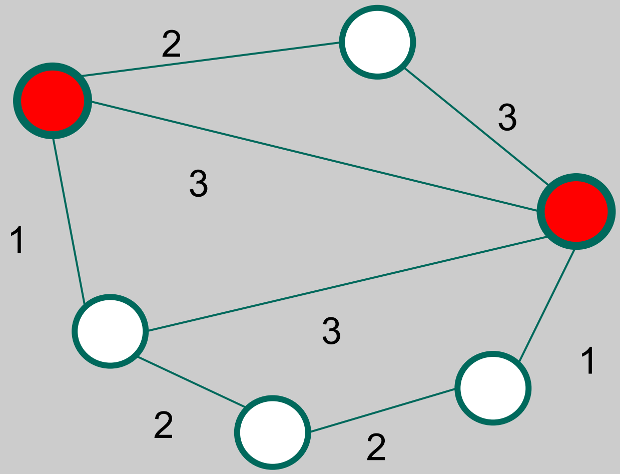


Goal :

To find the shortest path between two given nodes in a network.

Shortest Path Routing

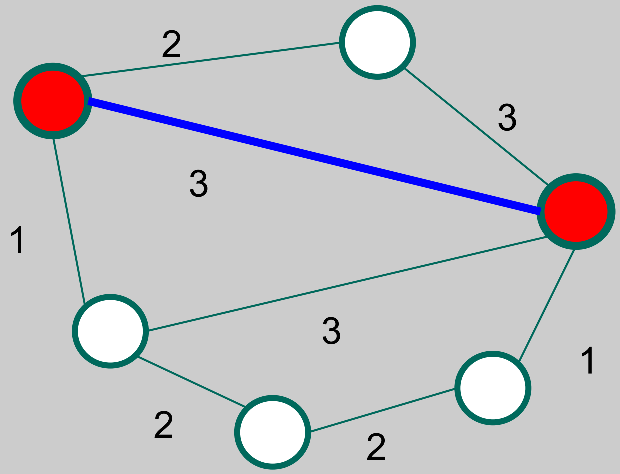
Source and destination marked red



Here we have a **source node** and a **destination node** and we send the data signal through the shortest path available between the two given nodes.

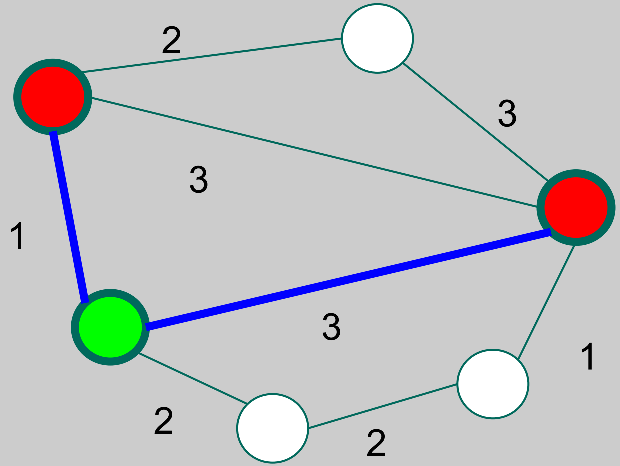
Allocate source node and destination node.

Shortest Path Routing



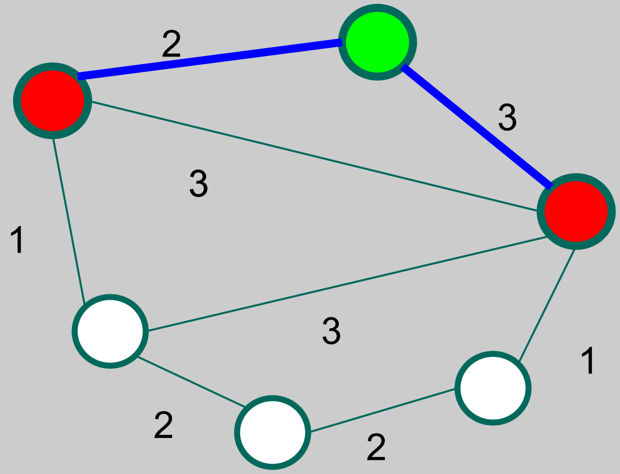
First Possible Path

Shortest Path Routing



Second Possible Path

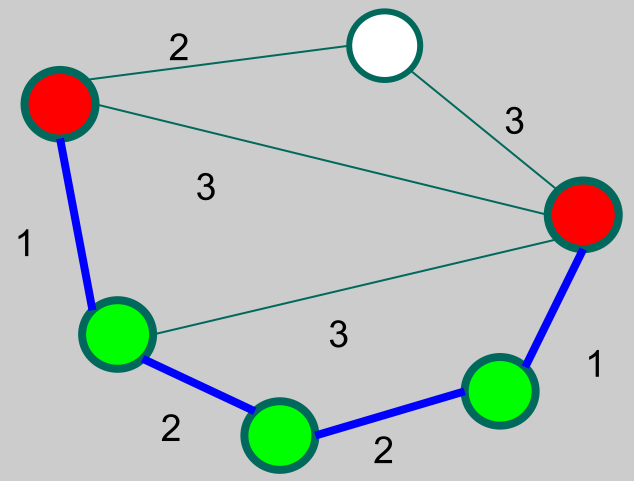
Shortest Path Routing



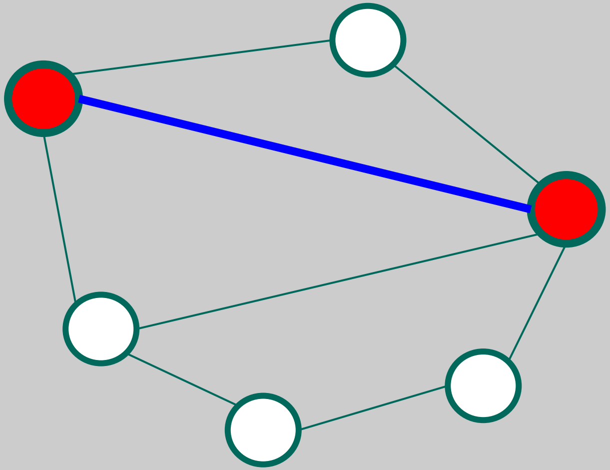
Third Possible Path

Shortest Path Routing

Fourth Possible Path



Shortest Path Routing



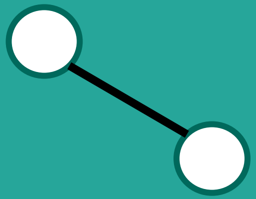
So we first check all possible paths from the given source and the given destination node

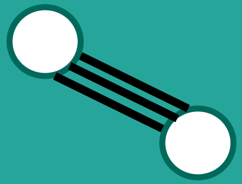
And then chose that path that has the minimum weight.

Choosing Path With Reduced Congestion

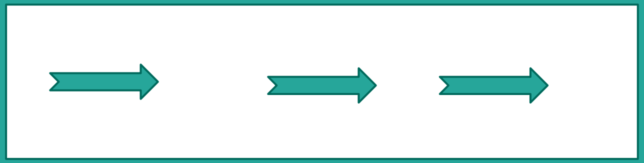
Each edge in the network has a constant link capacity (a fixed number of channels).

For example, if the link capacity is 3 per edge, then we can describe it like below

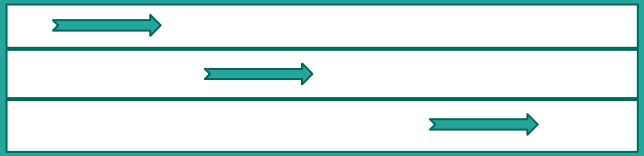




LINK



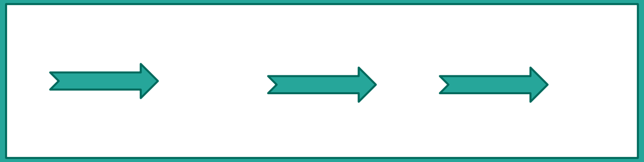
Channels within a link



Assuming Link Capacity = 3

BLOCKING OF LINKS

LINK



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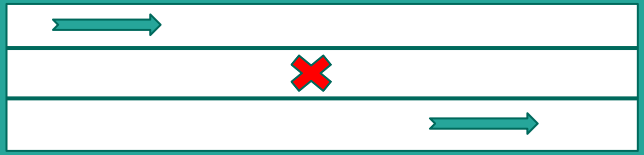
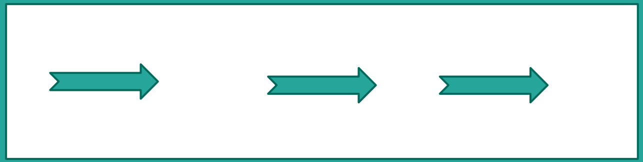


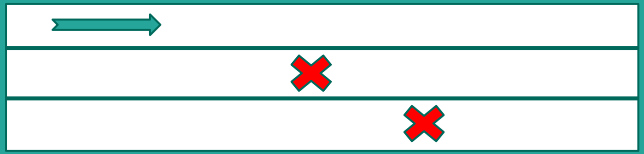
After passing of data packet through a particular channel, that channel can not be used again

BLOCKING OF LINKS

LINK



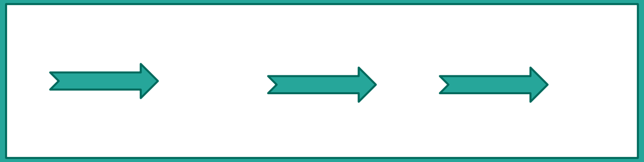
Channels within a link

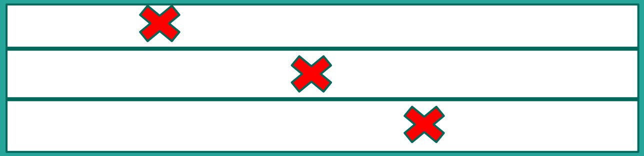


BLOCKING OF LINKS

LINK

Channels within a link





All the channels have been used up and hence the link gets blocked.
So no data packet can use this link for further data transfer.

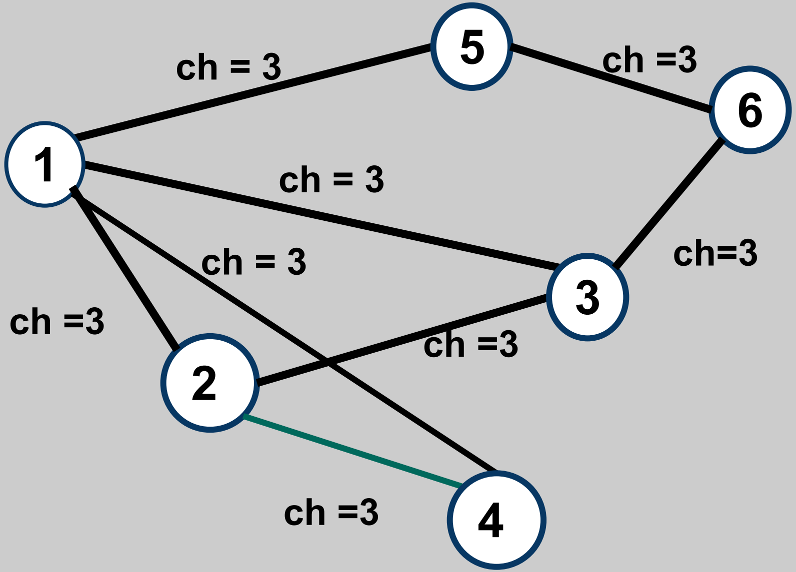
Congestion Reduced routing

Considering in each edge the number of channels is fixed.

In this graph , link capacity per edge equal to 3.

We are generating some requests here:

Source	Destination	Routing path	Channels link
1	3	1 - > 3	3
1	4	1 -> 4	3
2	3	2 -> 3	3
1	4	1->2-> 4	3, 3

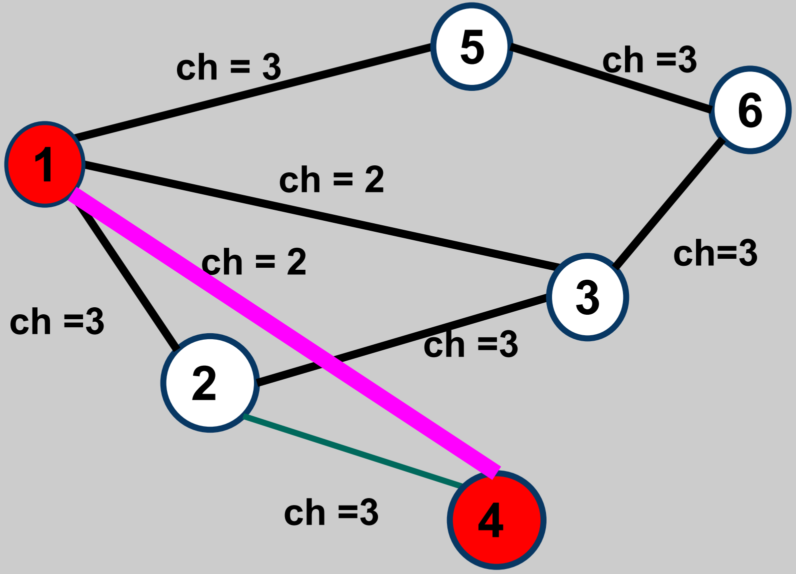


link capacity = number of channels per edge

Congestion Reduced routing

SECOND REQUEST

Source	*Destination*	*Path*	*Channel Remaining per link*
1	*4*	*1->4*	*2*

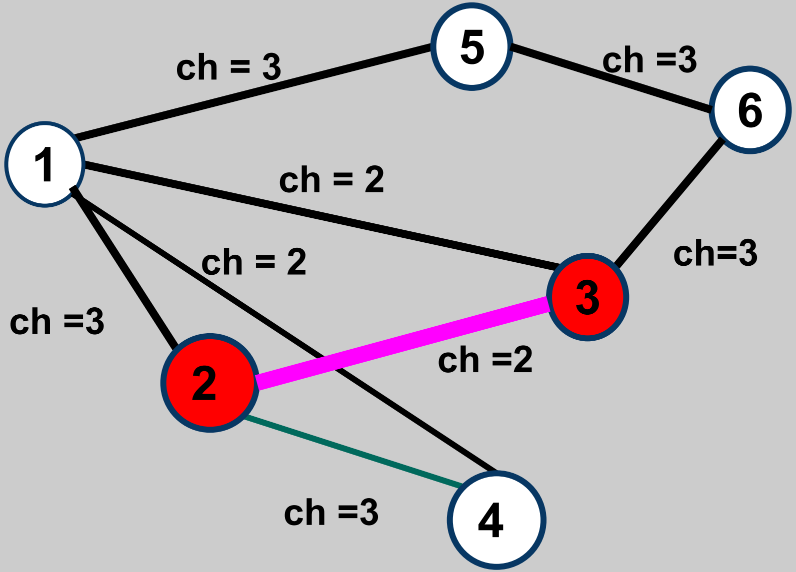


ch = channels remaining

Congestion Reduced routing

THIRD REQUEST

Source	Destination	Path	Channel Remaining per link
2	3	2->3	2

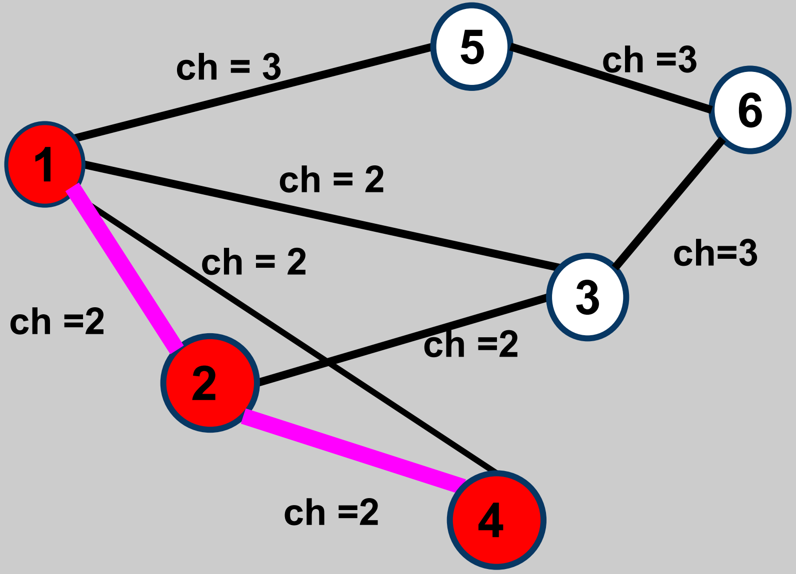


ch = channels remaining

Congestion Reduced routing

FOURTH REQUEST

Source	*Destination*	*Path*	*Channel Remaining per link*
1	*4*	*1->2->4*	*2,2*



ch = channels remaining

The Algorithm

Probability of choosing a path

The probability of choosing an optimum path depends on both the least congestion and minimum weight(shortest path).

So , probability of choosing a path can be given by,

$$P = (\text{availability ratio})^{a} * (1 - \text{distance ratio})^{b}$$

a ,b are some constants

Hence, we chose that path in which our probability turns out to be maximum.

Optimal path

In our case, we first find all possible paths between source and destination node and calculate the probability for each path.

Probability for each path is calculated by summing up the availability ratio and distance ratio for each edge in the path and then applying the given formula.

We then chose the path whose probability comes out to be maximum.

For blocking

We check in each edge of a path between source and destination for blocking.

If any edge in the path has all its channels exhausted, the whole path gets blocked.

Results

Results

There are 3 cases to be noted here.

- $a>b$
- $a = b$
- $a < b$

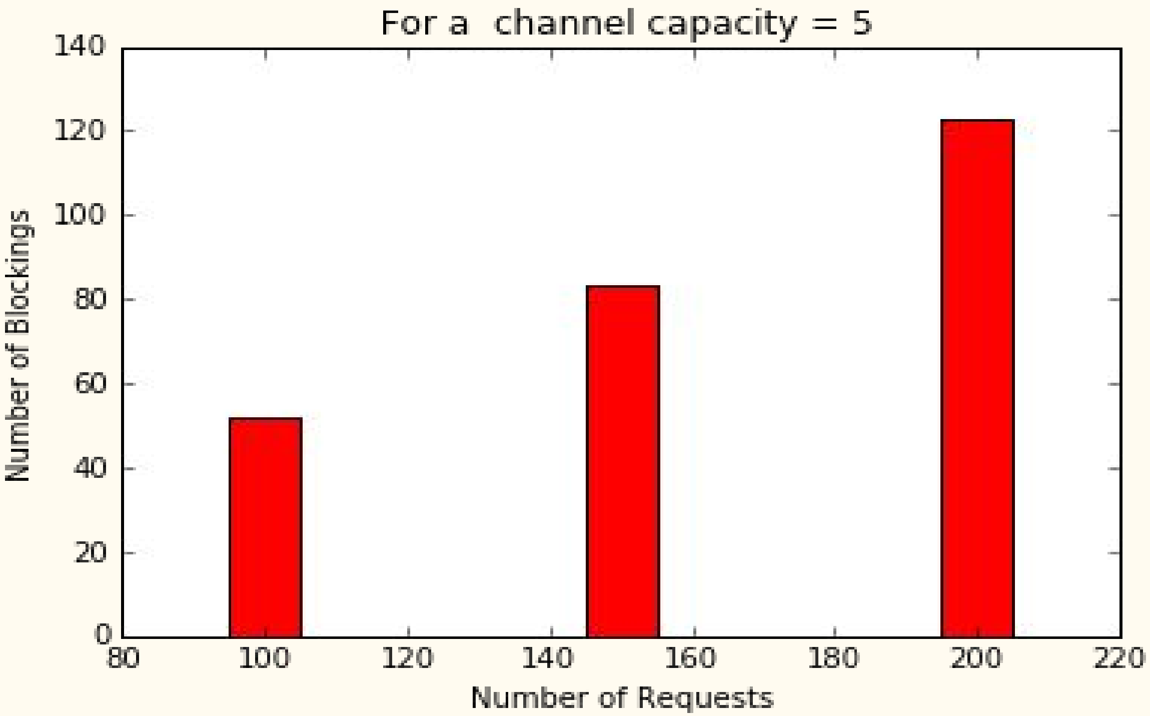
$a>b$ - indicates Higher Priority is given to congestion.

$a = b$ - indicates same priority given to both congestion and distance

$a < b$ - indicates higher priority is given to shortest distance.

Graph Characteristics for a>b

Plotting between blockings and number of request sets for a given channel capacity



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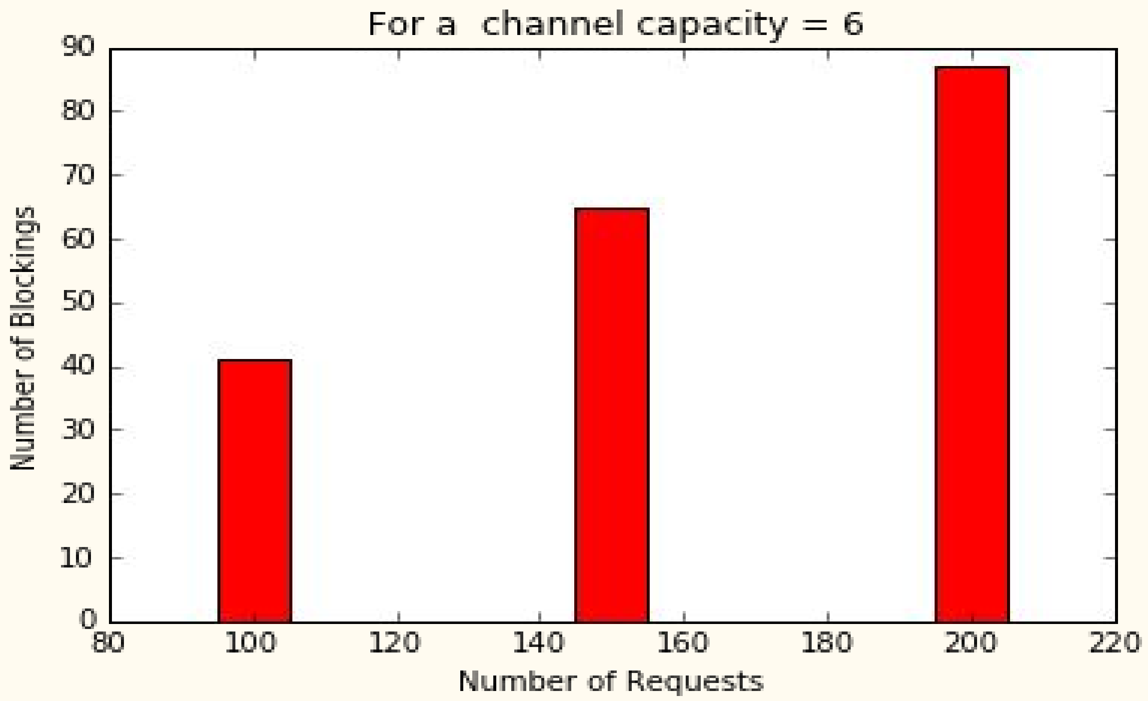

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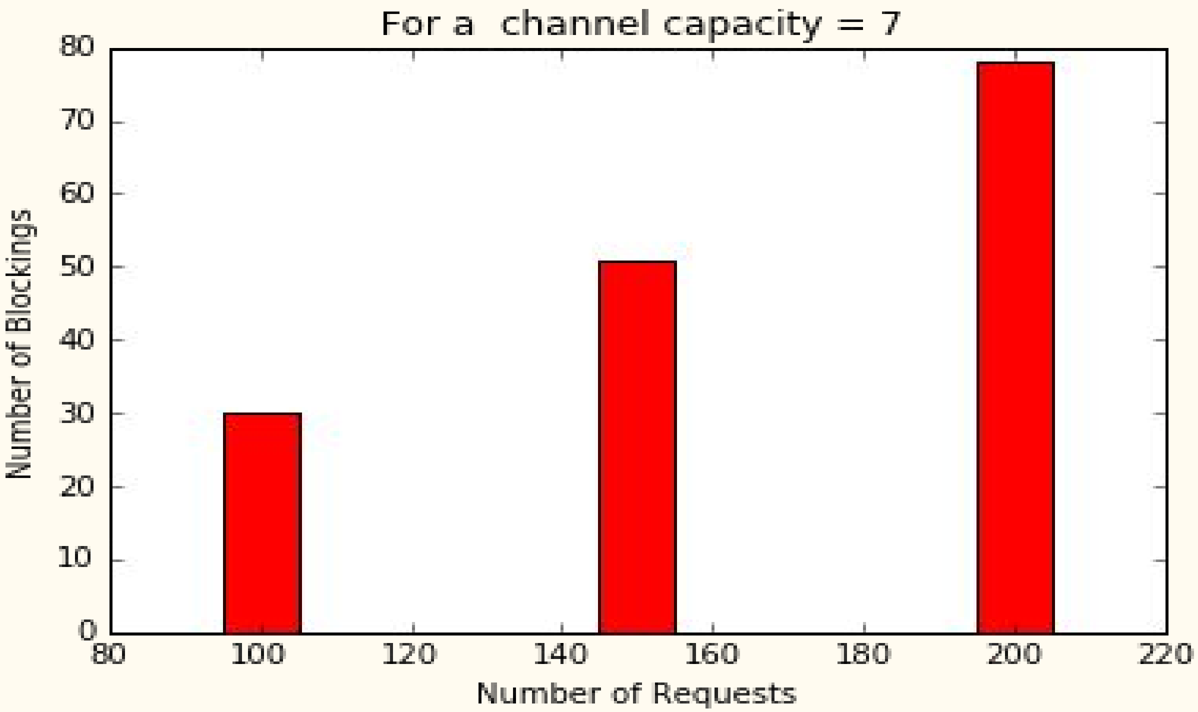
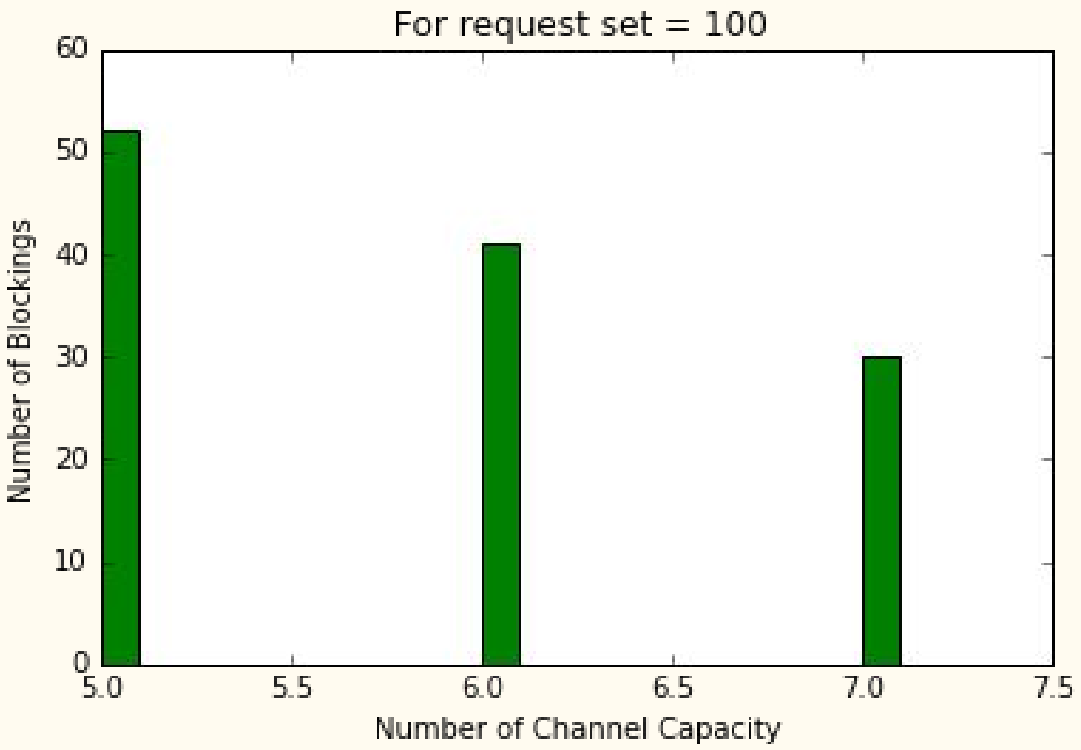


Plotting between blockings and channel capacity for given number of request set



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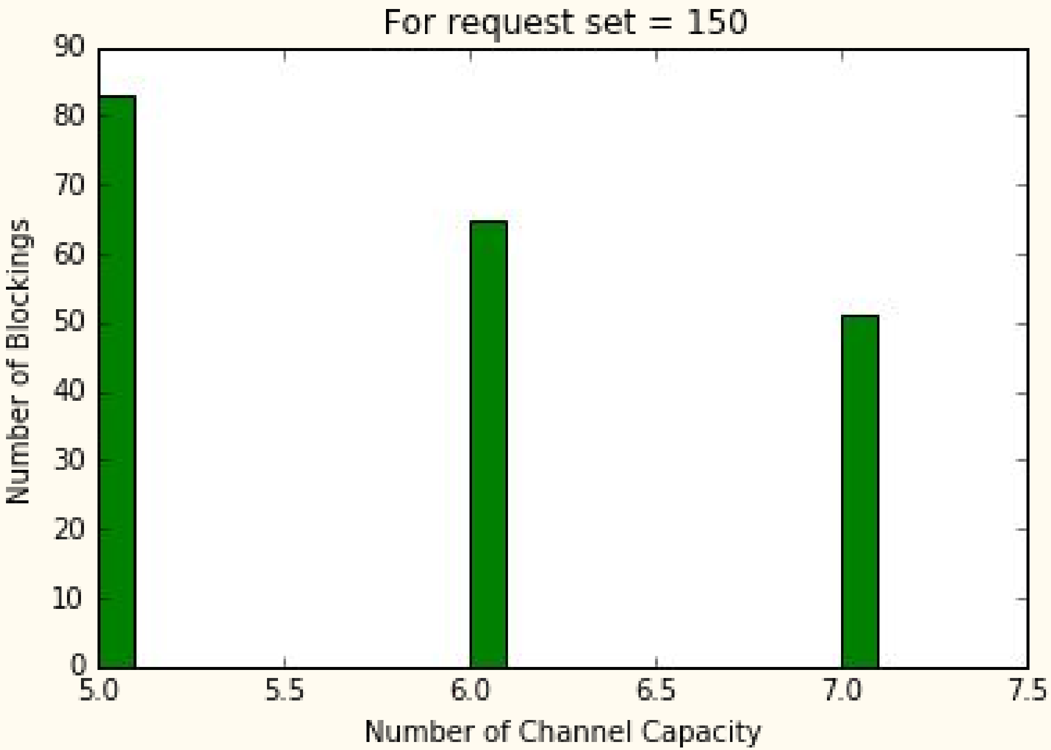

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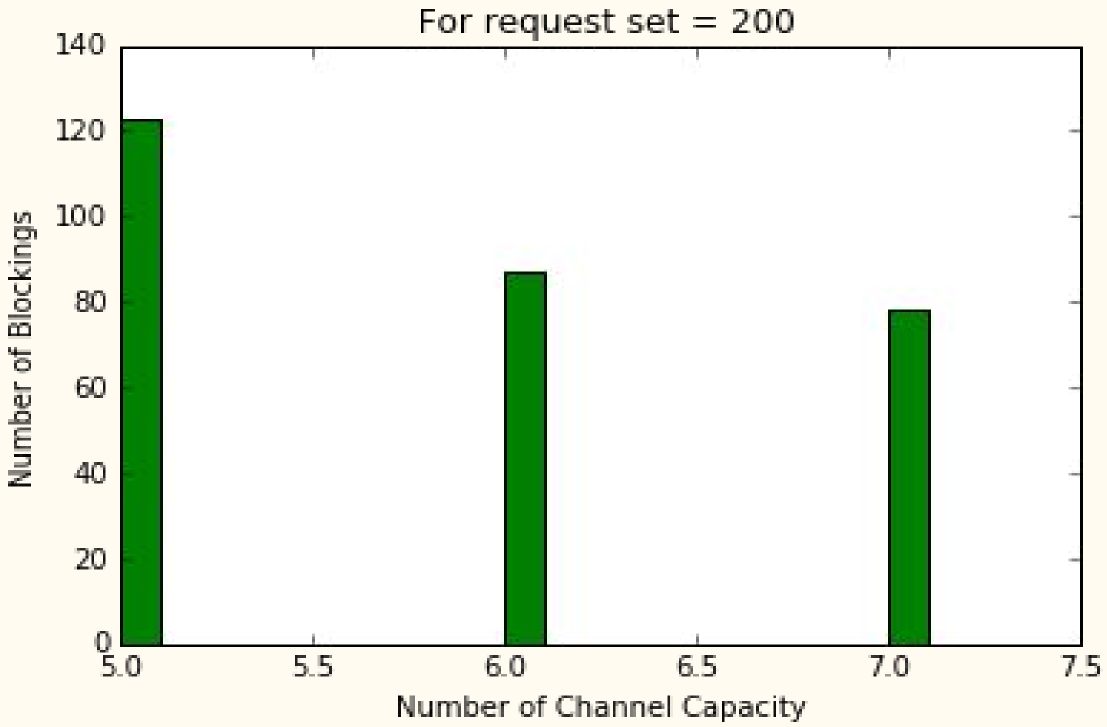


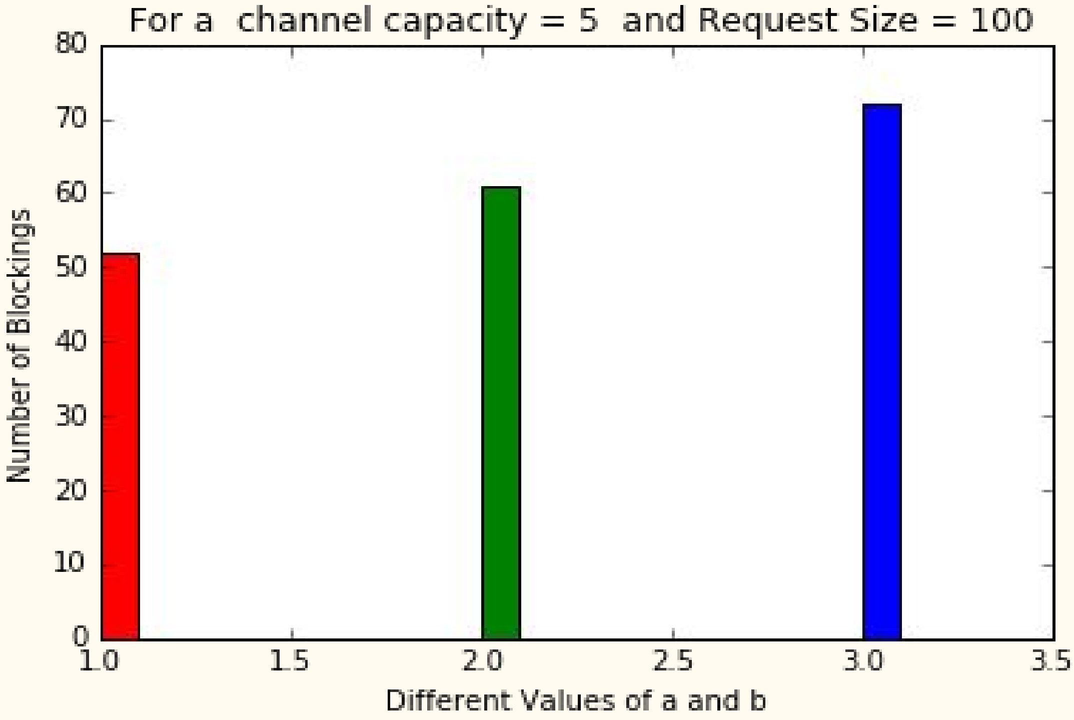
We get the same characteristics for both $a = b$ and $a < b$.

Checking for blocking under different values of a and b for a given request set and channel capacity

Red : (a > b)

Green : (a = b)

Blue : (a < b)



Result Table

Capacity	Number of Requests	a > b	a = b	a < b
5	100	52	61	72
5	150	83	95	117
5	200	123	136	155
6	100	41	48	56
6	150	65	78	84
6	200	87	105	123
7	100	30	36	39
7	150	51	59	71
7	200	78	98	112

Observations

- So as the link capacity increases, the no. of blockings decreases.
- As the number of requests increases, the no. of blockings increases.
- The congestion is minimum in case of ($a > b$) and increases gradually and becomes maximum in case of ($a < b$).

Hence, as we increase ‘a’ , that is giving priority to congestion, then the number of blocking reduces.

Conclusion

- We observe that the number of blockings get reduced to a great extent when we use congestion reduced routing.

- Thus we can conclude that Congestion reduced routing in WDM Network reduces blocking and hence can be preferred more for data transfer operations.

Thank You