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Implementation of Ant Colony Optimization Algorithm for Survivable optical network

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ABSTRACT

In order to withstand and recovery from faults in WDM optical networks, we propose an efficient fault localization mechanism based on ant colony optimization and mixed line-rates. Faults localization has been proved to be a complete problem in wavelength switched optical networks, and all existing faults localization algorithms require too much time and success rate of these previous mechanisms have less tolerance. Faults localization in optical networks has new features give more preference to high bit-rate affected services than the low-bit-rate affected services. In order to detect the fault in mixed line-rates, we use ant colony optimization algorithm that detect the fault in various path in network. The numerical results show that ant colony optimization based fault localization mechanism has low flooding time, high success rate compared with the existing fault localization algorithms.

Keywords: WDM Networks, Ant Colony Optimization, Fault detection, Restoration.

INTRODUCTION

With the rapid growth of broadband services such as video sharing, high definition video-on demand and network computing, optical transport networks need to provide the ultra-high capacity to support the tremendous internet traffics. We are using optical networks[1-2] which are based on Orthogonal Frequency division Multiplexing (OFDM) technology, is used to enables sub-wavelength, super wavelength, and multiple data traffics accommodation in a highly spectrum-efficient manner. The center frequency and allocated bandwidth of an optical channel can be assigned arbitrarily in optical networks. It provides the flexibility and ultra-high capacity to support the emerging broad band services, but it also brings many new challenges for network planners while maintaining a high level of survivability. Network survivability has been a concern of utmost importance in large-capacity and high-speed optical networks. To make high survivability of optical network, we need to find out faults in the network and provide best solution by transferring link to alternative path using restoration mechanism. There are various mechanisms used to find out faults in the network but they are not efficient yet. So, we are using Ant Colony Optimization Algorithm to determine the faults present in optical network. This algorithm works on the basis of principle followed by ant in searching of food. They release a chemical substance behind called pheromone. This pheromone is used by next ant coming behind that helps them to find out the shortest path for food. After detection of faults, we restore the path and provide shortest alternative path.

The rest of paper is organized as: Section 2 consist of background of the proposed work and its related terminologies. In Section 3 a brief discussion of proposed work is made. Result analysis is done in section 4 and section 5 concludes the work.

2. Background

The important parameters concerning with the proposed work is discussed here:

2.1 Survivability:

Survivability is the ability of network to withstand and recover from failures. It is one of the most important requirements of networks. Its importance is magnified in fiber optic networks with throughputs on the order of gigabits and terabits per second.

2.2 Fault management scheme [3]:

Fault management has become critical in managing survivability of high speed networks. Impact of failure is aggravated with extremely high volume of traffic carried on WDM (Wavelength Division Multiplexing) networks.

In a WDM network, failure of a network element may cause failure of several optical channels leading to large data loss which can interrupt communication services. Fault management in optical network is done through reserving backup resources in advance called protection or restoration which can be further classified as Path protection or restoration and Link protection**.**

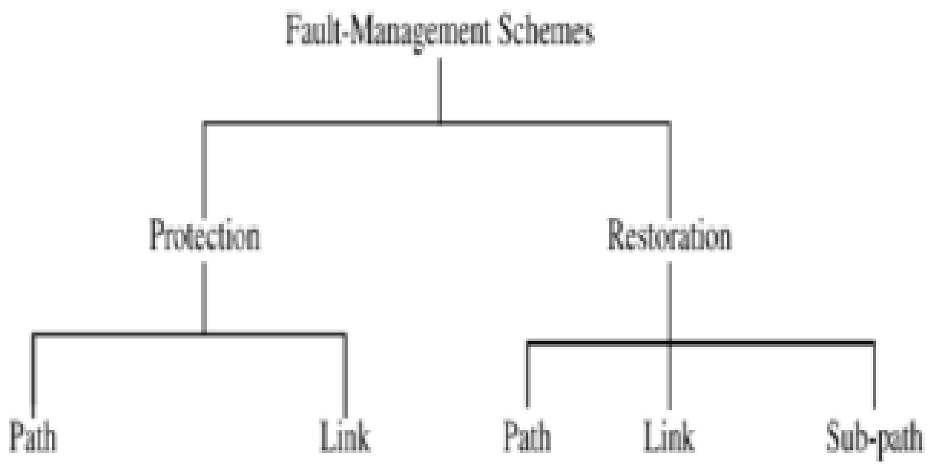

Fig 1: Fault management scheme. [3]

Following is the brief description of optical network Fault Management schemes:

2.2.1 Link Protection:

Backup paths and wavelengths are reserved around each link on the primary path during connection setup. When a link fails, all the connections traversing the failed link will be rerouted around that link and the source and destination nodes of the connections traversing the failed link would be unaffected by link failure.

2.2.2 Path Protection:

Source and destination nodes of each connection statically reserve a primary path and a backup path on an end-to-end basis during connection setup the. When a link fails, the source node and the destination node of each connection that traverses the failed link are informed about the failure and backup resources are utilized. Figure: 2 shows mechanisms for restoring connections.

2.3 Restoration Schemes:

2.3.1 Link Restoration:

In the event of a failure, the end nodes of the failed link participate in a distributed algorithm to dynamically discover a new route around the link, for each active wavelength that traverses the link. When a new route is discovered around the failed link for a wavelength channel, the end nodes of the failed link reconfigure their OXCs (Optical Interconnects) to reroute that channel onto the new route. Connection is dropped in case no new route and associated wavelength can be discovered for a broken connection.

2.3.2 Path Restoration

The source and the destination nodes of each connection independently discover a backup route on an end-to-end basis and such a backup path can be on a different wavelength channel. When a new route and wavelength channel is discovered for a connection, network elements are reconfigured appropriately, and the connection switches to the new path.

2.3.3 Sub-Path Restoration

When a link fails, the upstream node of the failed link detects the failure and discovers a backup route from itself to the corresponding destination node for each disrupted connection. Upon successful discovery of resources for the new backup route, intermediate OXCs are reconfigured appropriately and the connection switches to the new path. If sufficient resources are not available connection is dropped.

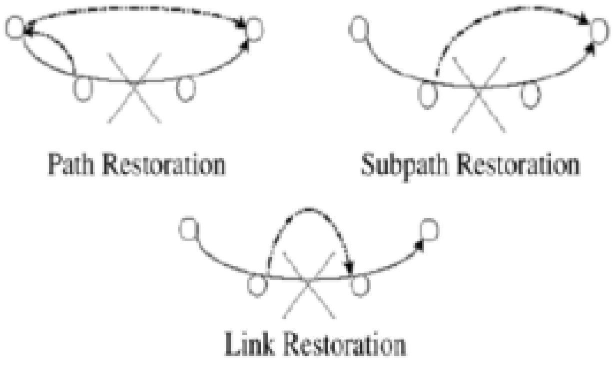

Fig2: Restoration [3]

2.4 Detection Technique [4]:

2.4.1 LMP (Link Management Protocol):

The LMP requires an always on supervisory channel to locate faults, which should not be in fiber to avoid loss of the supervisory channel in the event of a link fault.

2.4.2 LVM (Limited perimeter Vector Matching):

Limited perimeter vector matching (LVM) protocol for localizing single link fault in all optical networks. This protocol assumes that no power monitoring is available at each intermediate node and only destination node and gateway node are able to detect the power loss or quality degradation of an optical signal. Also parallel limited perimeter vector matching (P-LVM) protocol is proposed for localizing multi-link faults in all optical networks.

2.4.3 ACO (Ant Colony Optimization):

In order to withstand and recovery from multi-faults in optical networks, we propose a novel multi-fault localization mechanism based on ant colony optimization. Ant colony optimization based multi-faults localization mechanism has low flooding time and alarm packets, high success rate compared with the existing localization algorithms.

3. Proposed Work

The proposed work consist of two steps: (1) Fault localization by the help of ACO algorithm and (2) Restoration process which helps to reduce loss rate in the network.

3.1 ACO Algorithm for Fault localization [5]

- The ACOMFL (Ants Colony Optimization Multi Fault Localization) algorithm is composed of two main parts. The first part is responsible for running the first stages of the algorithm such as the initialization of the parameters values including the desirability, pheromone table and fault set. In the second part, an ant starting from one alarm runs the ACOMFL process to select the caused fault and then the ant is routed to neither alarm according the pre-set traverse tables in the first part.
- At each selection, the ant runs the transition rule. The first step in this process is the computation of a random number which is used to decide if the ant is going to exploit previous pheromone deposits or try to look for new possible fault. If the ant finally traverse all the alarm, it means that searching the fault set has been successful, so that the global updating rule is started, using a positive feedback. The global updating rule is used by the feedback ants on the reverse path followed by the forward ant. The algorithm finishes when the feedback ant arrives the source alarm.

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3.2 RESTORATION [6]:

Restoration scheme has been proposed that decrease the loss rate.

The following is the detailed description of the proposed scheme:

In the proposed scheme, it is assumed that a link between nodes is bi-directional with a pair of unidirectional fibers on opposite directions. In normal operations, the search packet (Sp) containing messages are periodically transmitted to each nodes of link in every update interval to monitor the link state. In the proposed scheme only the forward direction link failure case has been considered i.e., from the upstream node (NU) to the downstream node (ND).When a link-failure happens, Sp message transmitted by NU is not delivered to ND. After FDT, ND goes into the link restoration state and transmits a recovery request message to the NU by the reverse paths, which is still working. NU confirms the recovery request by sending the restoration response message to ND. At the same time, it also notifies a link failure to the every source edge routers.

4. Result and Performance analysis:

The proposed work significantly reduces data loss rate along with optimal fault localization. The ACO algorithm and restoration scheme combine works better then other fault localization schemes. For analyzing the performance of proposed work, we consider a local mesh network resided in Indore, Madhya Pradesh, India.

4.1 Performance Parameters

4.1.1 Success rate: Success Rate is the fraction or percentage of success among a number of attempts.

Success Rate is expected to be high for Ant colony Optimization algorithm.

4.1.2 Flooding time: Flooding is a network routing algorithm in which every incoming packet is sent through every outgoing link expects the one is arrived on.

Flooding time is expected to be low for Ant Colony Optimization algorithm.

4.2 Result Analysis

4.2.1 Success rate: The ACO algorithm helps to find faulty paths more optimally then other similar algorithms. Table 1 shows a comprehensive analysis of success rate provided by ACO algorithm which is better then any other algorithms for fault tolerance.

Table 1. Analysis of Success rate of ACO algorithm

S.No.	Source	Destination	Success Vs Failure
1	IET(6)	IT PARK(2)	Success
2	RAJWADA(4)	MY(3)	Success
3	IT PARK(2)	RAJWADA(4)	Success
4	IT PARK(2)	RAJWADA(4)	Success
5	IT PARK(2)	RAJWADA(4)	Success
6	MY(3)	RAJWADA(4)	Success
7	MY(3)	MY(3)	Failure
8	IET(6)	IT PARK(2)	Success
9	RAJWADA(4)	RAJWADA(4)	Failure
10	RAJWADA(4)	IET(6)	Success

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Figure [4.1]-[4.11] shows how the rerouting is done in a network upon multiple failures by the help of ACO algorithm. From the Figures it is clear that out 10 attempts, we got 8 success in protecting a data loss.

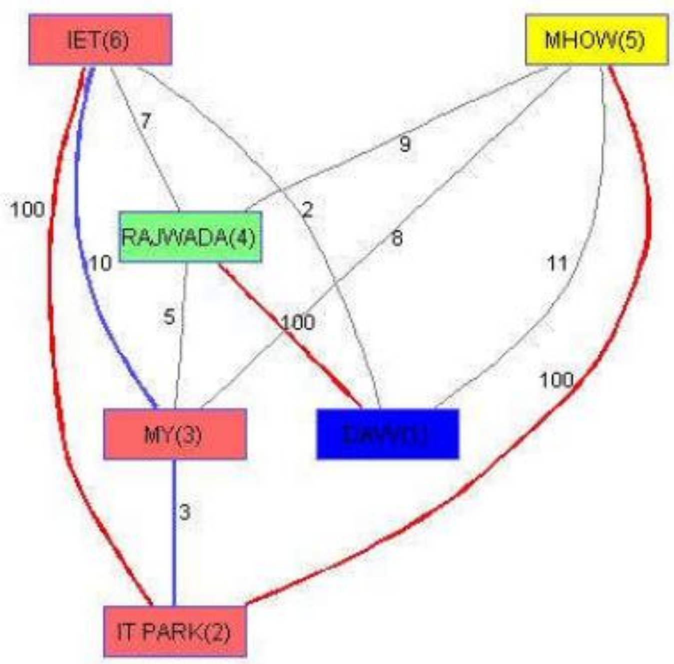

Fig 3: Source: IET(6), Destination: IT PARK(2)

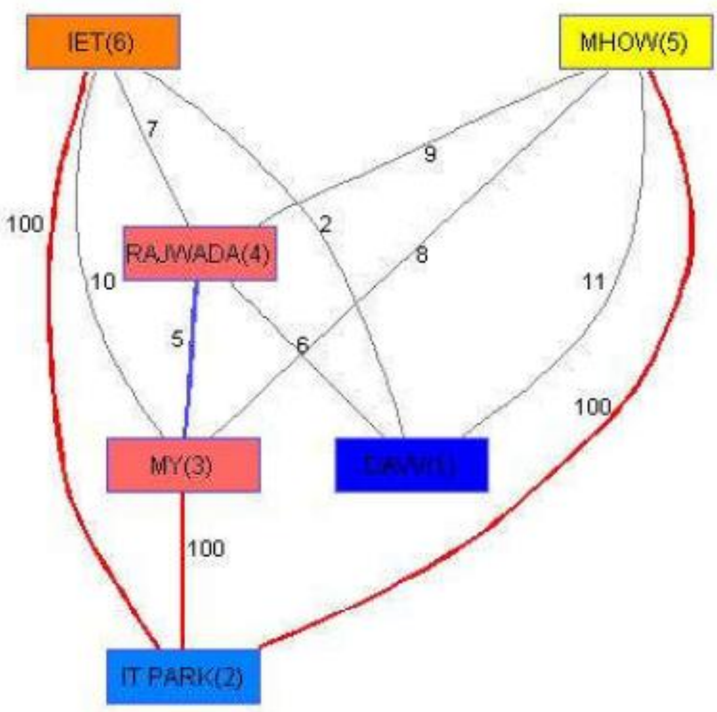

Fig 4: Source: RAJWADA(4), Destination: MY(3)

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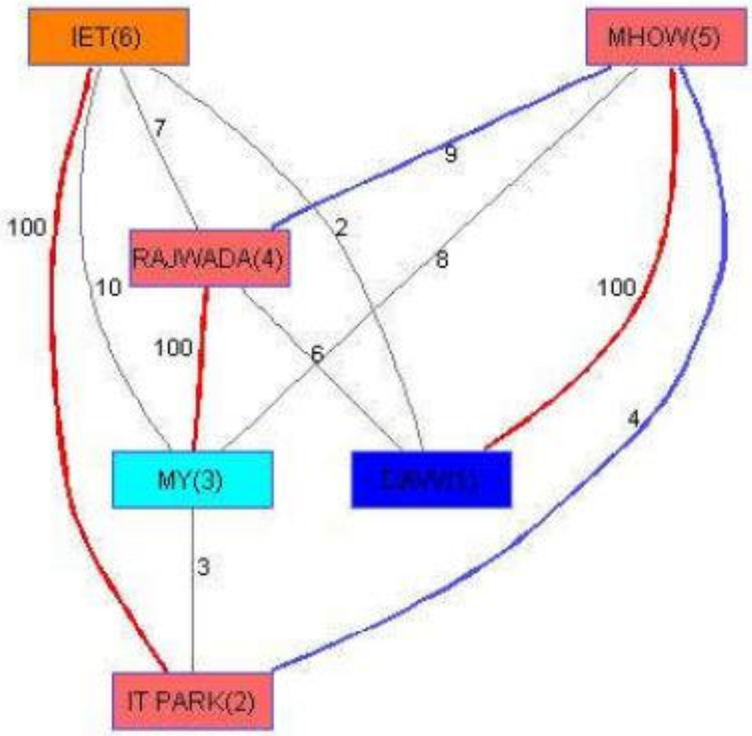

Fig 5: Source: IT PARK(2), Destination: RAJWADA(4)

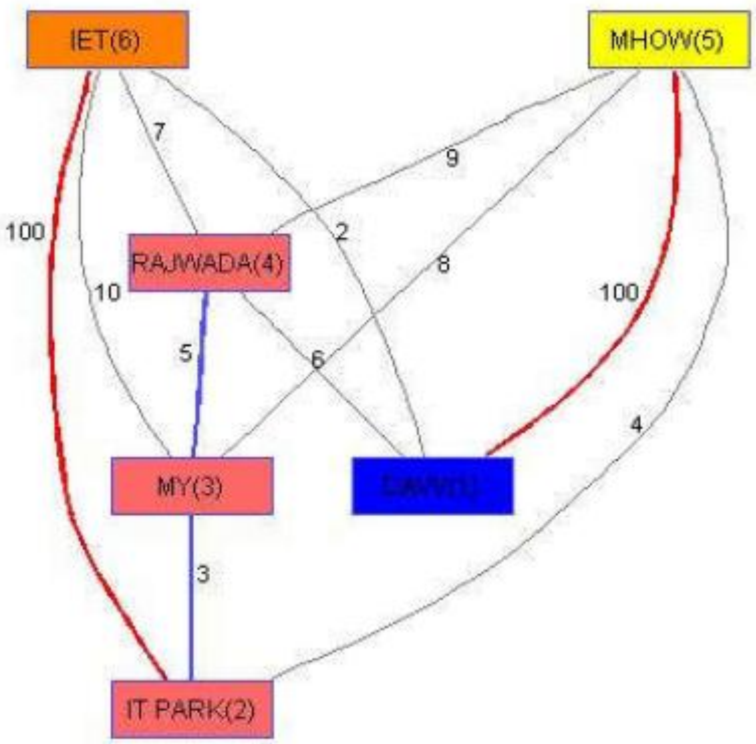

Fig 6: Source: IT PARK(2), Destination: RAJWADA(4)

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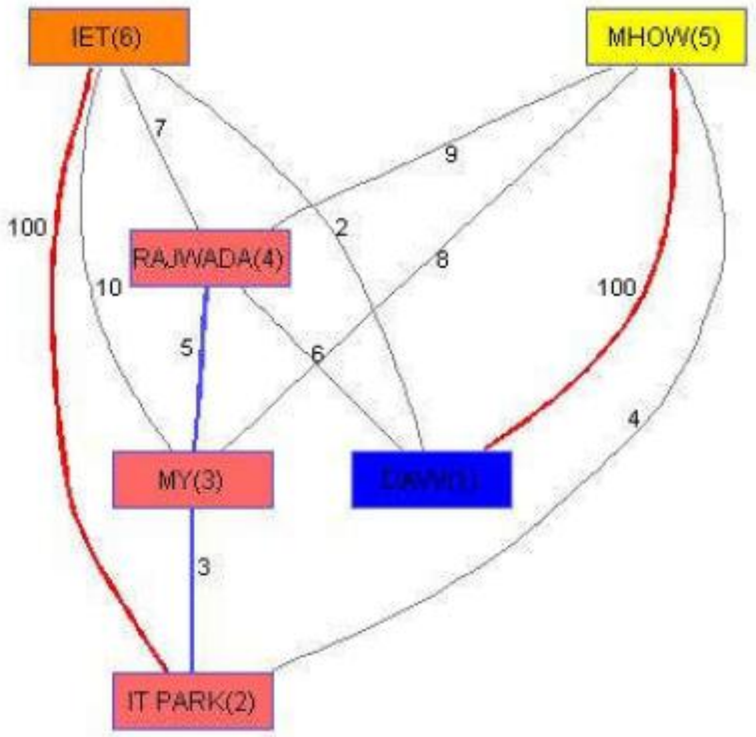

Fig 7: Source: IT PARK(2), Destination: RAJWADA(4)

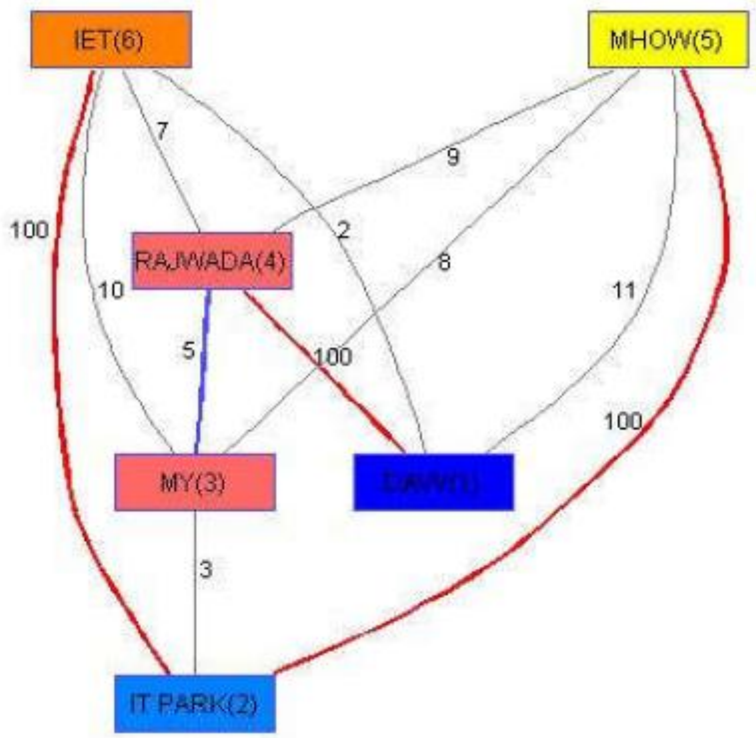

Fig 8: Source: MY(3), Destination: RAJWADA(4)

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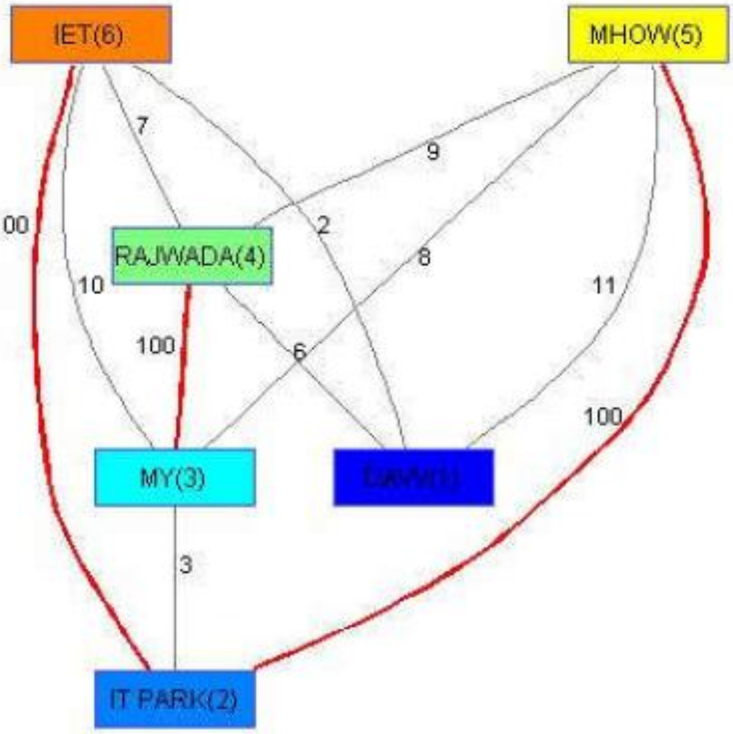

Fig 9: System failure

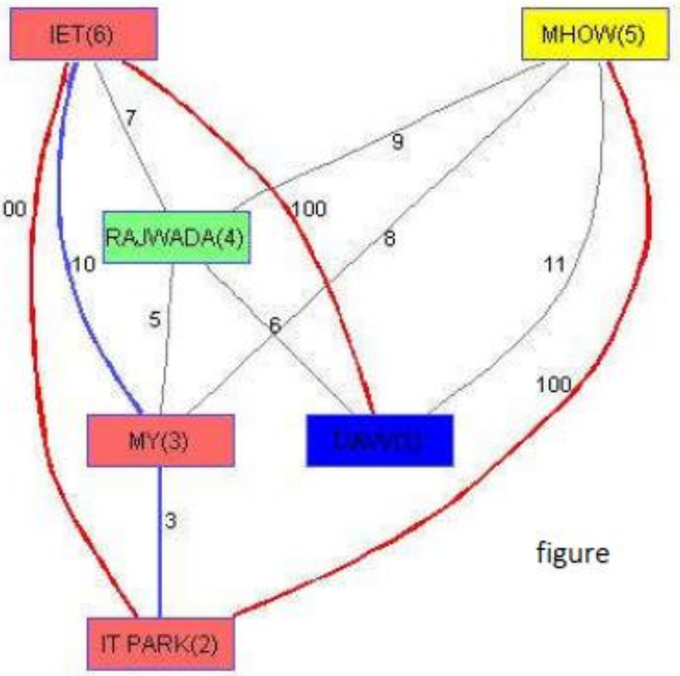

Fig 10: Source: IET(6), Destination: IT PARK(2)

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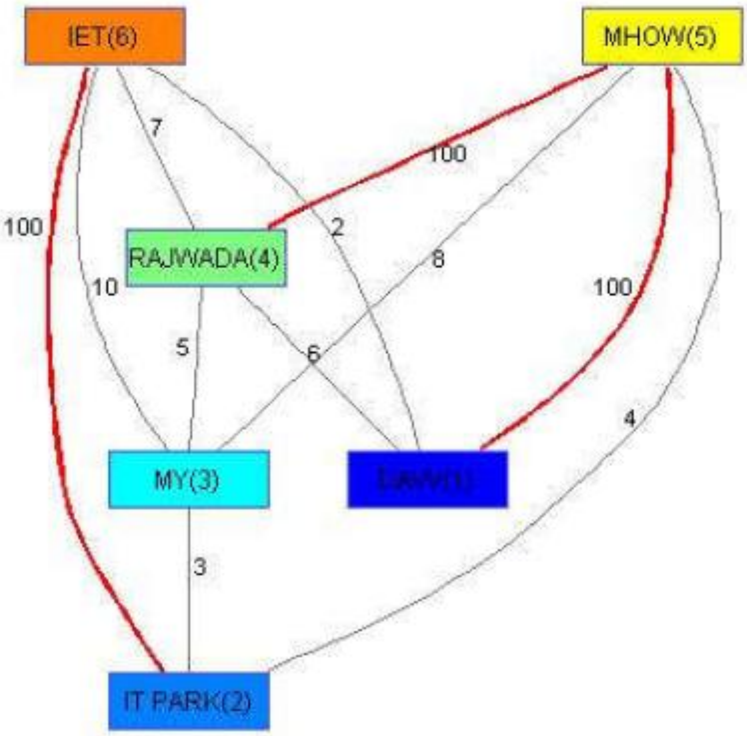

Fig 11: System Failure

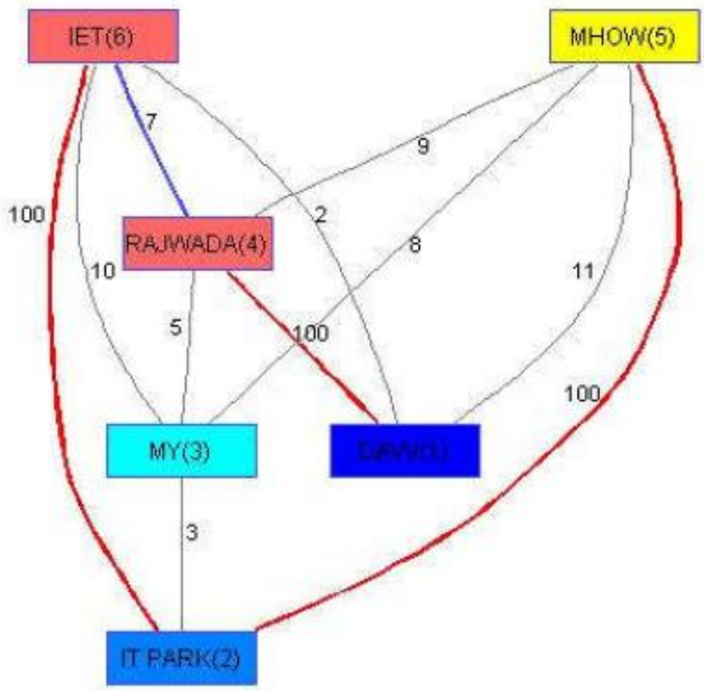

Fig 12: Source: RAJWAD(4), Destination; IET(6)

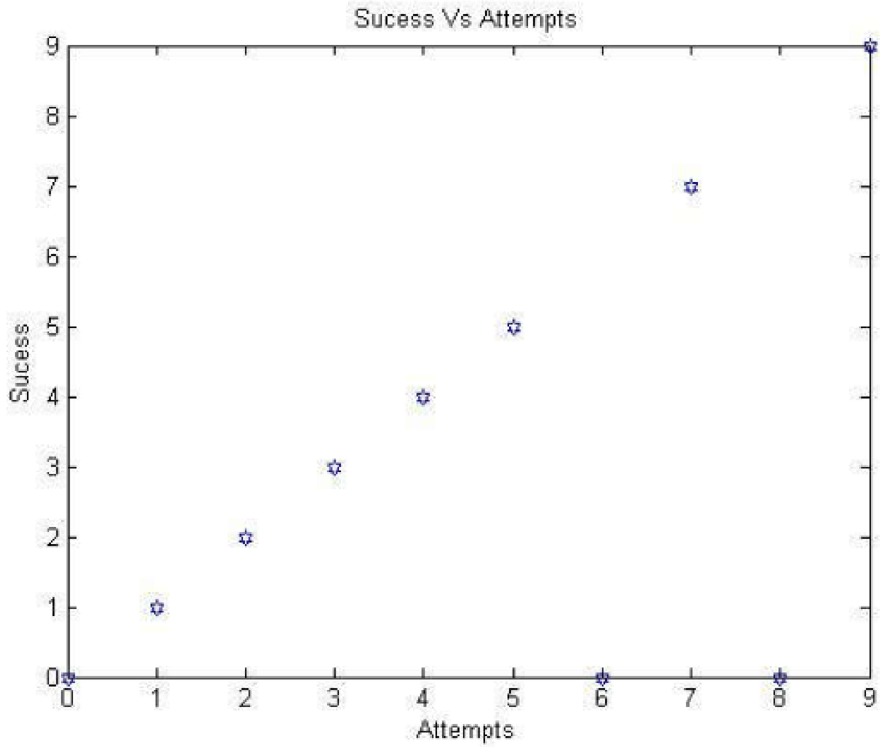

Fig 13: Success vs Attempt

4.2.2 Number of Iteration v/s Time

When we analyze the code corresponding to the ACO algorithm, we find that as we increase the load in the network in terms of number of iterations, then it also increases restoration in the network which is shown in Table 2, but at the same time success rate is also good.

Table 2. Evaluation of Restoration Time with increased number of failures

S.No.	Number of Iterations	Time (in secs)
1	5	6.88
2	6	15.32
3	7	18.28
4	8	21.20
5	9	24.41

5. CONCLUSION:

We concluded from the above results, Out of 10 attempts we get 8 success and 2 failures. Therefore our success rate is 80%. The current available techniques such as LVM and LMP have success rate less than 80%, so we can say that this algorithm performs better than others. Still it is typical to implement this algorithm in real physical optical networks because in real life the network is very huge and have large number of nodes. Fault detection and restoration plays crucial role in optical network because it helps in detecting the fault and finding alternate path, which is useful to eliminate any important data loss.

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