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OPTIMIZATION OF DISJOINTS FOR MINIMIZATION OF FAILURE IN WDM OPTICAL NETWORK

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Abstract

In an optical network, the fiber optic cable is used for communication between the nodes in a network by passing lights. The main problem in optical network is finding the link disjoints as well as optimal solution for the disjoints. To tolerate a single link failure in the network, the enhanced active path first algorithm is used which computes the re-routed back-up path. The multiple link failure in a network called fibre span disjoint path problem is solved using integer linear programming algorithm. The loop back recovery is used to provide pre-planned recovery of link or node failures in a network which allows dynamic choice of routes over pre-planned directions. Considering reliability in a mesh networks, the reliability algorithm helps to achieve the maximum reliability in two-path protection. It addresses the multiple disjoint failures that arise in a network and discusses the best solution between paths shared nodes or links. The unified algorithm is used to generate the optimal results with minimum cost for multiple link failures. The heuristic algorithm namely maximum arbitrary double-link protection algorithm helps to pre-compute the back-up path for double-link failures. In all the above approaches the shortest optimized path must be improved. To find the best shortest path, link-disjoint lightpath algorithm is designed to compute the disjoint occurred in a network and it also satisfies the wavelength continuity constraint in wavelength division multiplexing. A polynomial time algorithm Wavelength Division Multiplexing – Passive Optical Networking is used to compute the disjoint happen in the network. The overall time efficiency is analyzed and performance is evaluated through simulations.

Keywords:

Wavelength Division Multiplexing, Wavelength Continuity Constraint, Optical Networks, Loop Back Recovery, Double-Link Failure Recovery, Wavelength Division Multiplexing – Passive Optical Networking

1. INTRODUCTION

In an optical network, while communication from source to destination or from one node to another node there occur some problem [1]. The problems are: 1.Disjoint 2.Wavelength continuity constraint. These disjoints have to be rectified and it must satisfy the wavelength continuity constraint i.e. each node must support same wavelength. These problems can be overcome by using wavelength converter.

The optical networks are implemented using Wavelength Division Multiplexing (WDM) techniques for high speed wide area networks. In a WDM optical network the fiber link carries many wavelength and data packets transmitted along light paths. While transmitting packets from source to destination, the different wavelength range is used for communication between two nodes. But it is not supported by all the links, in that case the wavelength continuity constraint occurs. It is rectified by wavelength converters to support different range of wavelengths. Most common failures occurred in an optical network is cuts in the fibers, since optical links carry a high volume of data.

In the last few years there have been survivability issues in WDM networks [2]. Reid Anderson [3] proposed two techniques- protection and restoration to find disjoint in a WDM network. The protection helps to pre-provision the failure recovery. It supports only single link or node failures. The restoration is considered in more dynamic recovery. To tolerate any single link failure, the back-up path should not be shared with any fiber link with its corresponding active path. The Active Path First algorithm (APF) and Enhanced Active Path First algorithm (APFE) computes the best path when dislink happens by removing active dislink path and creating back-up path. The active and back-up path must maintain same wavelength throughout the entire path. Here, shared protection is more complicated than the dedicated.

Jian Qiang Hu [4] presented an algorithm to overcome the physical layer failure i.e. fiber cut failures. The single fiber span can cause multiple optical link failures. It embeds the optical link into physical layer to minimize the effect of physical layer failures on optical layer. The diverse routing problem is used to find two paths between a pair of nodes such that no single failure occurred in the network. The heuristic algorithm like integer linear programming algorithm is used to find the solution and it backtracks to find any disjoints in the network.

Muriel Medard [5] proposed an algorithm for pre-planned ultra fast restoration of service after the failure of a link or node. The WDM network expands the need and service restoration which is based upon the characteristics such as speed, transparency and flexibility. The generalized loop-back is done to achieve the loop-back recovery over the arbitrary two link redundant network and two node redundant networks. The primary and secondary digraphs provide the loop-backs to a set of wavelength in a fiber or set of fibers. The Operation Management Protocol Algorithm (OMPA) provides dynamic real time discovery of routings along pre-planned directions.

Qingya She [6] proposed an algorithm for reliability between sources to destination if the link reliability is given. The WDM technology enables an optical fiber to carry multiple wavelengths simultaneously which allows higher capacity for optical links. The affected resources can be rerouted by back-up resources. The path protection scheme against a single link failure allocates the back-up path. The path protection achieves the higher resource efficiency and lower end to end propagation delay than the link protection. The Two steps Reliability Algorithm (TRA) improve end to end reliability and Maximum Reliability Algorithm (MRA) finds the shortest path with low computational complexity.

Currently finding the optimal disjoint paths between two nodes in a network with shortest path, S.Q.Zheng [7] proposed polynomial time algorithm to find two paths with minimum total cost. The MIN-MAX two path problem is NP-Complete. The generalized min-sum problem is used for finding the k-best paths in a network. The best path is transforming an arbitrary graph to a trellis graph. The shareability constraint is based on min-sum node or link and max-sum node or link. The unified algorithm is used to generate some algorithm for finding the best solution for link disjoints with minimum cost. The Min-Max Search and Min-Max Compute Algorithm find the shortest path from source to destination.

To protect the double link failures, Hongsik Choi [8] proposed an algorithm for two protection schemes such as link protection and path protection. The link protection is provided by back-up light path that is pre-computed with more protection capacity. The path protection is done by re-routing of all working light paths. It uses the rings in both clockwise and also in an anti-clockwise direction. It is also used for an availability of exactly one back-up path between any two nodes. The link failures are avoided by switching it to back-up path [9]. The Maximum Arbitrary Double-link Protection Algorithm (MADPA) helps to overcome the double link failures maintaining the back-up paths for disjoints.

Guoliang Xue proposed [10] an algorithm that computes the dislinks which can be achieved by isolating the failures using reduced 2-tree algorithm. It helps to separate the network tree link which has connected with two tree frame structure. To tolerate a link failure the path protection scheme establishes an active and back-up path that shares a common link on a common wavelength with SRLG. The Link Disjoint Light Path (LDLP) routing problem algorithm is used to find the link disjoint with optimistic shortest path [11]. These solutions are attractive and scalable to many networking problems.

2. DISJOINT PATH PAIRS WITH CONSTRAINT IN WAVELENGTH CONTINUITY

Reid Anderson [3] presented an algorithm to find the single link failure in a network while communicating the node from source to destination. It must satisfy the wavelength continuity constraint that is each node must supports the different range of wavelengths using wavelength converter. To tolerate a single link failure using active failure path this is replaced by the back-up rerouted path. It mainly concentrates on the link failures than establishing a new pair and helps to find a pair of disjoint paths using existing light paths. The active path first algorithm is used to compute the active failure path that is the path used by a channel get dislinks mean that it easily computes the reserved path [12]. The enhanced active path first algorithm computes the shortest back-up path with minimum cost even when the APF get fails. It tries to reduce the number of shared links in the pair of active-backup path iteratively.

2.1 ACTIVE PATH FIRST ALGORITHM

Input: Graph G, source s, destination t

Output: Active Path (AP) and Back-up Path (BP)

Steps

1. Find a source and destination lightpath
2. Find AP with minimum number of links
3. After removing the links in every active or reserved channel
4. Remove free channel using AP
5. Find BP using minimum number of links
6. Both AP and BP found means output the two paths

End.

2.2 ENHANCED ACTIVE PATH FIRST ALGORITHM

Input: Graph G, source s, destination t

Output: Active Path (AP), Back-up Path (BP), min_cost

Steps

1. Find a source and destination lightpath
2. Assign cost to each AP and BP
3. Find min_cost for BP
4. Compute link disjoint with min_cost

End.

2.3 SOLUTION USING ILP

$$(P): \min \sum_{|u,v| \in E} r(u,v) + r(v,u) + br(u,v) + b(v,u) \tag{1}$$

$$s.t \sum_{v \in V} r(x,v) - \sum_{u \in V} r(u,x) = \delta_{st}(x), \forall x \in V \tag{2}$$

$$s.t \sum_{v \in V} b(x,v) - \sum_{u \in V} b(u,x) = \delta_{st}(x), \forall x \in V \tag{3}$$

$$r(u,v) + r(v,u) \leq R(u,v) \forall (u,v) \in E \tag{4}$$

$$b(u,v) + b(v,u) \leq B(u,v) \forall (u,v) \in E \tag{5}$$

Notations

u, *v*- links that connecting a node to communicate

r - red link path

b - blue link path

δ_{st} - function with source and destination

V– nodes and links in a graph

The integer linear solution is used to compare the APF and APEF using Eq. (1), Eq. (2) and Eq. (3). The source s and destination *t* with formulation *P*, the (*u*,*v*) are the links that helps to communicating the two nodes with red path r and blue path *p* in a WDM optical network.

3. DIVERSE ROUTING IN OPTICAL NETWORK

Jian Qiang Hu [4] presented an algorithm to study the diverse that is different routing or different path problem in a network from source to destination by minimizing the physical layer failure called fiber cuts. The previous algorithm is concentrated on single link failure; here we concentrate on multiple routing problems. One single link failure will causes the multiple optical link failures. This is tolerated by using the exhaustive search algorithm that finds the solution among all the possible results and gives the best one [13]. It refers to the experienced based technique and helps to back track the back-up paths to recover the links. The ILP and MILP algorithm overcome the linear problem in previous stages that is infeasible. It is simply strengthened to get exact solutions in finding the disjoints in a network.

3.1 INTEGER LINEAR PROGRAMMING

Input: Graph G, vertex V, edge E

Output: Back-up path

Notations: Used to find the dislinks

c: cost of edge

u: source – destination column vector

A: the node edge incidence matrix

H: the risk edge incidence matrix

xi: column vector containing edge decision

zi: column vector containing failure decision

Step: Finding diverse path problem with minimum cost $\min c(X1+X2)$

$$Axi = u$$

$$Hxi <= |E|Zi$$

End.

4. GENERALIZED LOOP-BACK RECOVERY

Muriel Medard [5] proposed the loop back recovery for the link disjoint in an optical network. The loop back recovery provides the pre-planned recovery of a link or node failures in a network to perform generalized loop back recovery for link or node failures. It allows the dynamic choice or routes for the pre-planned directions from source to destination. The WDM based loop back recovery is used to back up other wavelength. The heuristic algorithm helps to compute the following two steps: Direction selection for recovery from link failures and direction selection for recovery from node failures [14]. The operation management protocol algorithm used to enable the distributed application for generalized loop backs. It uses the certain set of rules that helps to find the dislink between source to destination.

4.1 DIRECTION SELECTION FOR RECOVERY FROM LINK FAILURES

Input: Graph G, source s and destination t

Output: Recovery for link failures.

Steps

1. Set the condition *j*=1 // *j*-node at initial position
2. Choose any cycles in the graph
3. Assign value to the cycle
4. Find dislinks happened in the network
5. Condition satisfies means terminate
6. Otherwise increment the condition *j*
7. Choose the path for dislinks and update as a recovery

End.

4.2 DIRECTION SELECTION FOR RECOVERY FROM NODE FAILURES

Input: Graph G, source s and destination t

Output: Recovery for node failures.

Steps

1. Set the condition *j* =1 //*j*-node at initial position
2. Choose an arbitrary edge and assign value
3. Choose any cycles in the graph
4. Assign value to the cycle
5. Condition satisfies means terminate
6. Choose path in the graph having node failures
7. Order the new vertices by assigning the values
8. Choose alternate nodes and update as a recovery

End.

5. RELIABILITY IN TWO PATH PROTECTION

Xiaodong Huang [6] investigates the reliability of two link disjoint paths in an optical network. The previous studies are based on single link failures, multiple link failures and loop back recovery. Here, the author addresses the issues of reliability of two path protection and how to achieve the maximum reliability. The two step reliability algorithm improves the reliability by reducing the length of second path if the shortest path is given as one of the two paths and it will find the disjoints between source and destination. The maximum reliability algorithm calls the shortest path algorithm and achieves the low computational complexity [15]. It assigns the weight to each link and runs the algorithm with minimum total length to reconstruct the two disjoint paths.

5.1 TWO STEP RELIABILITY ALGORITHM

1. Assigns the weight for each link $0<q<1$
2. Run the shortest path algorithm
3. Obtain the first shortest path
4. Delete all links on first shortest path
5. Run the shortest path algorithm again
6. Obtain the shortest path disjoint with first path

5.2 MAXIMUM RELIABILITY ALGORITHM

1. Assigns the weight for each link $0<q<1$
2. Run Suurbella's algorithm to find link disjoint path with min_length
3. Reconstruct the node disjoints
4. Choose the shortest path as recovered path

6. MINIMUM COST MULTIPLE PATHS IN A NETWORK

Jianping Wang [7] proposed an algorithm for two fundamental issues: The criteria for finding the best solution path by sharing nodes and links are achieved by how it finds the best solution. It includes the cost parameter that helps to overcome the disjoint in an optical network with optimized solution. It is also used to rectify the multiple disjoints with minimum cost. The unified algorithm helps to generate the polynomial time algorithm for finding the best solution for link disjoints using min-max search and min-max compute. The min-max search is used to compute the dislinks that occurred in the network [16]. The min-max search modified algorithm helps to find the solution using possible outcomes to find the optimized solution.

6.1 MIN-MAX SEARCH ALGORITHM

Input: Graph G, flag, link shareability *k* and *k*'

Output: Compute nearest path

Steps

1. Compute the min-max link shareability *k*
   a. Split the nodes with graph G
   b. Set flag=0
   c. Assign capacity to all links
2. Find the maximum flow
3. Find the minimum cost k-flow
4. Construct the set of paths to be nearest

End.

6.2 MIN-MAX COMPUTE ALGORITHM

Input: Graph G, link shareability *k*

Output: Compute nearest path

Steps

1. Compute the min-max link shareability *k*
2. Find the maximum flow with iteration
3. Find the minimum cost k-flow
4. Compute the shortest path

End.

7. DOUBLE-LINK FAILURE RECOVERY IN OPTICAL NETWORK

Hongsik Choi [8] proposed an algorithm for double link recovery in WDM optical network while communicating from source to destination. The heuristic algorithm pre-computes the back-up path for links. The maximum arbitrary double link protection problem helps to compute the double link failures by following three phases: Pre-processing, contraction and expansion. The double recovery cover method is used to overcome the double link failures and computes the back-up path with link identification [17]. The performance of these algorithms is based on protection capacity and restorability. The protection capacity reserved the capacity for protection of all links. The restorability tolerates the double link failure.

7.1 MAXIMUM DOUBLE LINK PROTECTION

1. Pre-processing the edges and vertex
2. Contract the graphs using following rules
   a. Merge the nodes with same links
   b. Merge the nodes with same degrees
   c. Merge the adjacent nodes to each other and degrees>3
3. Expanding the graph.

8. COMPUTING DISJOINT LIGHTPATH PAIRS

Guoliang Xue [10] proposed an algorithm to find the link disjoints that occurred in a WDM network while communication from source to destination. It gives the solution for two issues: Finding the link disjoint in a network and computing the best path. To tolerate the single link failure in a network it creates a back-up path for the active failure path [18]. The reduced 2-tree algorithm is used for isolating the failure links based on two or more than two links connecting the node which is separated and find the link failures. The running time of the algorithm is O (nW2). After finding the link failures, the dislinks get computed and back-up path is created with optimal shortest path [19]. The LDLP algorithm easily computes the dislinks in a network and gives the shortest path to communicate between the nodes. The LDLP is divided into three phases: Contraction operations to compute the reduced 2-tree, to convert the reduced 2-tree into a triangle using contraction operations and compute the shortest path pairs [20]. It eliminates the wavelength continuity constraint which supports all type of wavelength while communication between two nodes in a network.

8.1 REDUCED 2-TREE ALGORITHM

Input: Get the two nodes source s and destination t with their intermediate links

Output: Reduced 2-Tree

Steps

1. After getting the links use queue to store the nodes
2. Separate the nodes which has more than degree-2
3. Update the degrees of two nodes which form a triangle
4. Insert it into the queue if degree is 1

End.

8.2 LINK DISJOINT LIGHT PATH ALGORITHM

Input: A WDM optical network with source s and destination t.

Choose wavelengths $\lambda 1$ and $\lambda 2$.

Output: A shortest path with link disjoint back-up path

Steps

1. Compute the reduced 2-tree
   a. Find the dislinks by isolation
   b. Separate the degree 2 nodes
2. Convert reduced 2-tree into a triangle
   a. Check reduced 2-tree is a triangle
   b. 2-tree separator that forms the triangle with successor of nodes
3. Compute the shortest pair of link disjoints
4. Stop when pair does not exist
5. Extract the link disjoints

End.

9. COMPARISON TABLE

Table.1. Comparison of parameters for various algorithms

TITLE	Disjoint path pairs with wavelength continuity constraint[13]	Diverse routing in optical network[19]	Generalized loop-back recovery[25]	Reliable in two path protection[31]	Minimum cost multiple paths in a network[40]	Double-link failure recovery[46]	Computing disjoint lightpath pairs[50]
PROTECTION	Considered	Considered	Not considered	Considered	Considered	Not considered	Not considered
COST	Considered	Considered	Considered	Not considered	Considered	Not considered	Considered
RELIABLE	Not considered	Not considered	Not considered	Considered	Considered	Considered	Considered
SPECIFICATION	Wavelength continuity constraint	Different routes in mesh network	Multiple path with loop back recovery	Protection	Min cost	Recovery-double link	Isolating the failures
ALGORITHM	Active path first, Enhanced active path first	Exhaustive search algorithm, Mixed integer linear programming	Heuristic algorithm, Operation management protocol algorithm	Two step reliability algorithm, Max. reliability algorithm	Unified algorithm, Heuristic algorithm	Maximum arbitrary double-link protection algorithm	Reduced 2-tree algorithm, Link Disjoint Light Path algorithm
PERFORMANCE EVALUATION	99.8% -Finding the disjoints and alternate path	90.1% -Path detection	91% - Heuristic algorithm	99.9% -MAX-REL with protection	92.8% - Minimum cost for disjoint paths	98.8% - finding double link failure	75%-Quality of finding the disjoints
ADVANTAGE	Easier to solve. Use different wavelengths	Reduced running time.	Bandwidth utilization and restoration capability	Max reliability	More efficient at time	Easy to find double link failures	Eliminates wavelength continuity constraint.
DISADVANTAGE	Min number of different wavelengths	Bandwidth & cost is mentioned	Based on preplanned information	Theoretical based	Confusion-more no. of networks	Planar double recovery cover method	Disjoint size may not be optimal. Insecure - need protection

10. PROPOSED WORK

To address the challenges like insecure data delivery, less bandwidth capacity, less accuracy in shortest path over LDLP, Wavelength Division Multiplexing – Passive Optical Networking (WDM-PON) algorithm is proposed. A WDM-PON design is used to separate Optical-Network Units (ONUs) into several virtual point-to-point connections over the same physical infrastructure. The Arrayed Waveguide Grating (AWG) filter used in WDM-PON is used to avoid traffic occurred in the network. It separates the wavelength for individual delivery and increases the bandwidth capacity for communication. Thus, it provides flexible access to the networks. For optimal shortest path, Ant Colony Optimization (ACO) algorithm is used to solve the computational problems. The algorithm searches for an optimal path in a graph which is based on the behaviour of ants seeking a path between their colony and a source of food. Ant colony optimization algorithms have been applied to many combinatorial optimization problems.

10.1 WAVELENGTH DIVISION MULTIPLEXING – PASSIVE OPTICAL NETWORKING (WDM-PON)

WDM-PON is a passive optical networking approach currently developed by several companies, which adequately address the challenges over fiber-based networks. It offers lower latency than TDM-based approaches in networking. A notable advantage of this approach is the combination of high capacity per user, high security, and longer optical reach. WDM-PON is highly suitable for applications such as mobile backhaul or business Ethernet service provision.

10.1.1 WDM-PON Algorithm:

Input: A graph G, source S, destination T with wavelengths $\lambda1$ and $\lambda2$.

Output: A shortest back-up path for link disjoint

Steps

1. Compute the optical network units

2. Allow step-wise channel upgrades
3. Improves the performances using AWG filter
4. Stop when path does not found
5. Extract the solutions

End.

10.2 OPTIMAL SHORTEST PATH

For optimal shortest path, Ant Colony Optimization (ACO) algorithm is used. This Ant system was aimed to solve the travelling salesman problem, in which the goal is to find the shortest round-trip to link a series of nodes. The general algorithm is relatively simple and based on a set of ants, each making one of the possible round-trips along the nodes in the network. At each stage, the ant chooses to move from one node to another according to some rules:

10.2.1 ACO Algorithm:

Input: A graph G, source S, destination T

Output: Optimized shortest path

Steps

1. It must visit each node exactly once
2. A distant node has less chance of being chosen $dij = [(xi - xj)2 + (yi - yj)2]1/2$ //dij - distance between two nodes x and y.
3. Update the trail path.
4. Deposit all the path links.
5. After each iteration, trails of nodes path are updated.

   $\tau ij(t+n) = p \times \tau ij(t) + \Delta \tau ij$

   where, $\Delta \tau ij$ – deposited path

   p – rate of path travelled decay per time interval

   $\tau ij(t)$ - intensity of path t- time n- count

End.

10.2.2 Example:

In Fig.1, it gives the shortest path by calculating the count of high bandwidth rate during transmission of packets. In an optical network the possible paths are chosen based on shortest distance without any dislink path and high bandwidth range.

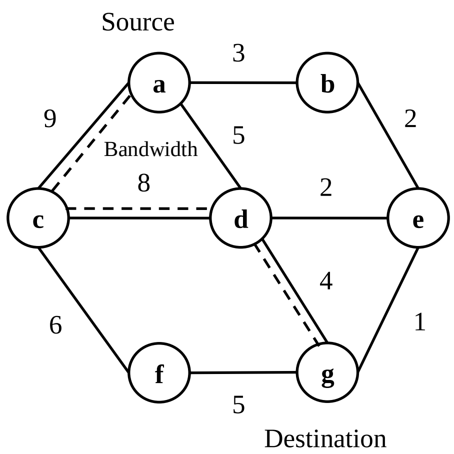

Fig.1. Network Model

Table.2. Shortest Path Calculation

Sl. No.	Possible Path	Bandwidth Range
1	a c d g	9+8+4 = 21
2	a c f g	9+6+5 = 20

In the above sample data, the shortest path is 21 depending upon the high bandwidth rate calculation it reaches the destination faster than the other path with bandwidth range 20. Hence, the ACO algorithm helps to find the best optimized for the active dislink path with reduced cost and it takes less time consumption for re-routing the back-up path. The accuracy of the algorithm is high than the other shortest path methods.

11. PERFORMANCE EVALUATION

To validate WDM-PON with existing LDLP algorithm it considers following parameters such as longer optical reach due to less disjoints and optimized shortest path with less time consumption in delivering the packets. The WDM-PON improves the performance by

- Longer optical reach
- Optimized shortest path

The AWG filter avoids the traffic in the network and thus it increases the bandwidth capacity. Obviously, it leads to longer optical reach with reduced disjoint. From Fig.2, it is observed that there is a deviation in the disjoint reduction using WDM-PON than the LDLP algorithm and other previous existing methods.

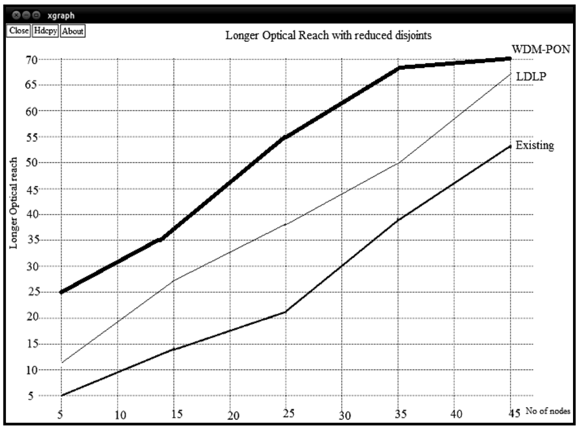

Fig.2. Optical reach

From Fig 2 it is observed that there is a drastic deviation in run time when applying ACO algorithm to find shortest path in WDM optical network. But LDLP algorithm consumes more time because it traverses all the nodes in the network to find shortest path.

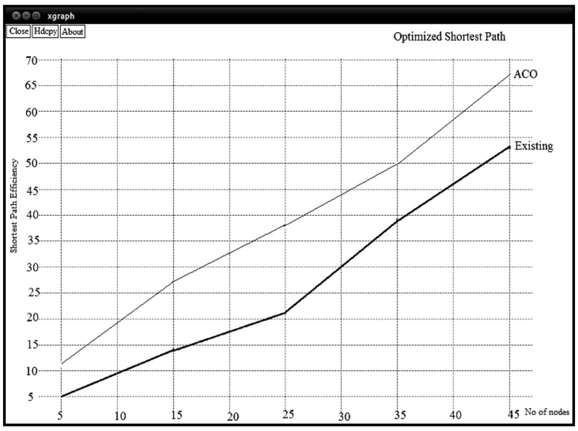

Fig.3. Shortest Path

12. RESULTS AND DISCUSSIONS

From the session 2, the optimal solutions are determined in finding the disjoint and alternate path up to 99.8% using no more than 6ms for complete execution of a network. But it is not suitable for diverse routing in a network. There by overcoming the above issue the ILP and MILP algorithm reduces the running time in path detection by 90.1%. Later, a new concept generalized loop back recovery is introduced to improve the running time by finding backup path using heuristic algorithm upto 91%. The main drawback is that it works based on pre-planned information. The upper bound is theoretical based one, and not proved practically. Since, reliability is not concentrated in existing works a newly introduced MAXimum RELiability (MAX-REL) algorithm is implemented which provides 99.9% protection in single link failure. Followed by existing MAX-REL algorithm, the Min-Max search algorithm finds the dislink paths in a network with minimum cost. To computing the disjoint occurred in the network the LDLP algorithm improves the quality upto 75% with shortest back-up path. But the disjoint size may not be optimal because they doesn't mentioned how long the isolation to be takes place, when there is communication between a large network with many number of nodes. There will be chance of hacking or misusing the paths by altering it which cannot reach the destination so in secure one; we have to concentrate on protection. But still there are some issues in the existing work such as reducing disjoints, bandwidth capacity etc. To address the mentioned issues a polynomial time algorithm WDM-PON is proposed to find the dislinks in the network with high bandwidth capacity and reducing the count of disjoints. The best optimal solution for dislinks with shortest back-up path using ACO algorithm. The WDM-PON supports different range of wavelength between the nodes in a network. It efficiently finds the dislinks between the node in a network while transmission of packets from source to destination.

13. CONCLUSION

The previous issues related to link failure in a network is completely addressed using polynomial time algorithm. The algorithm is used for computing the pair of dislinks in a WDM optical network with a minimum isolation pairs. The algorithm is easily modified to compute the pair of link or node disjoint that occurred in the network. With a lot of attention, it can easily tolerate the link failures happened during transmission of packets from source to destination. An active path first and an enhanced active path first heuristic algorithm gives the best computational results and optimal solutions in all cases. Since the more complicated problem of finding back-up path with dedicated protection is NP-Complete. It can currently investigate the shared path protection. It gives solution to the diverse routing problem and provides the guaranteed loop recovery to the link or node disjoints. The performance of TRA is more time-efficient heuristic algorithm compared to previous studies. MRA can improve the reliability at the cost with higher hop distance. The link and node shareability with a minimum cost for multiple paths is achieved by min-max search and compute algorithm. Even though, the above discussed algorithms gives better result to link failures in a network it couldn't overcome the issues such as reducing the count of disjoints, longer optical reach by increasing the bandwidth, optimized shortest path for active dislink path and so on.

To overcome the mentioned issues in the above existing algorithms, a new algorithm Wavelength Division Multiplexing – Passive Optical Networking (WDM-PON) is proposed. A polynomial time algorithm WDM-PON computes the link-disjoint lightpaths in an optical network and receives a lot of attention with high performance, longer optical reach. It avoids the disjoint occurred in the network upto 70% than the previous methods and LDLP algorithm. The ACO algorithm solves the computational problem in finding the path and gives result with optimized shortest path.

14. FUTURE WORK

For additional protection we can extend the algorithm with hiding the major links between the nodes in a network, And have to concentrate on capacity planning and overall path cost of a network. The trade-off between restorability and back-up capacity must be noticed. The existing optical networks disjoint size may not be optimal with reduced 2-tree and LDLP algorithm.

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