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DESIGN AND IMPLEMENTATION OF RECOVERY MANAGEMENT IN ALL OPTICAL NETWORKS

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Abstract

Abstract: All-Optical Networks exhibit varied advantages like performance efficiency, throughput etc but their efficiency depends on their survivability as they are attack prone. These attacks can be categorised as active or passive because they try to access information within the network or alter the information in the network. The attack once detected has to be recovered by formulating back-up or alternative paths. The proposed heuristic uses Honey-Bee algorithm, inspired by Bee-hives. The bees in bee-hives exhibit unique behaviour while searching for nectars from flowers and this phenomenon is being utilised in the proposed heuristic.

Index Terms*: All-optical network (AON), Swarm Intelligence, Honey Bee Algorithm*

1. INTRODUCTION

A network is defined as survivable if it is capable of attack recovery in the event of attack occurrence. The degree of survivability is determined by the network's ability to survive single or multiple attacks. Fast and reliable recovery methods are essential to efficiently protect the network against any such attacks. The main objective of recovery management technique is to employ accurately, rapidly and without incurring additional cost for rerouting the traffic.

In the first half of the 1990s most of the attack recovery techniques in optical networks employed point-to-point systems and Self-Healing Rings(SHRs), as natural extensions of the SONET recovery techniques. Protection methodologies used in SONET were widely accepted as simple and reliable. It was only in the second half of the 1990s and beyond that recovery techniques included Tellium implementation of commercial equipment, Shared Backup Path Protection (SBPP). Different recovery methods have their advantages and disadvantages. For example, one recovery method can be very fast but can use excessive redundant capacity while the other can be slower but can use redundant capacity very efficiently. Depending upon the customers' needs and how critical their services are, the recovery methods can be selected for implementation.

Recovery methods can be classified depending upon the survivability definitions presented below:

- Protection signifies techniques with which the back-up or alternative paths are pre-computed before the occurrence of an attack. It may be noted that such back-up routes have been pre-computed but not pre-configured prior to attack occurrence. This holds true for the recovery techniques used in point-to-point and Self-Healing Ring (SHR) architecture of WDM or SONET.

- Restoration denotes recovery techniques where the back-up or alternative paths are nor pre-computed prior to attack occurrence but calculated in real time after an attack has been actually detected. Switching equipments and spare capacity in conjunction with rerouting schemes are then used to reroute the traffic. Recovery in such situations is accomplished by employing intelligence that resides at a centralised network manager or controller or at individual switching nodes.

Thus in this study we focus on the protection techniques which could be pre-computed prior to an attack but can only be configured after its occurrence. The proposed design and implementation of recovery management is based on Swarm

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Intelligence. Swarm Intelligence has become an active area of research over the past years due to design adaptive, decentralized, flexible and robust artificial systems, capable of solving problems through solutions inspired by the behaviour of social insects. Research in this field has largely been focused on working principles of ant colonies and how to use them in the design of novel algorithms for efficiently solving combinatorial optimization problems. Nobel laureate Karl von Frisch deciphered and structures these into a language, in his book 'The Dance Language and Orientation of Bees'. The research paper presented comprises of underlining theory of the proposed heuristic, data structure in section 2 followed by algorithm. Section 3 shows the results and concludes the research work.

2. PROPOSED HEURISTIC BASED ON HONEY BEE ALGORITHM

Nobel laureate Karl von Frisch in his book, explained the very unique and peculiar behaviour of bees, their foraging activities as a social and communicative effort, indicating both the direction, distance and quality of food sources to their fellow foragers through a "dance" inside the bee hive (on the "dance floor"). The bees come out of their bee- hives in order to collect nectars from flowers at different sites or places. Their hunt for best flowers for nectars often terms them as foragers. Upon their return from a foraging trip, bees communicate the distance, direction, and quality of a flower site to their fellow foragers by making waggle dances on a dance floor inside the hive. By dancing zealously for a good foraging site they recruit foragers for the site. In this way a good flower site is exploited, and the number of foragers at this site is reinforced. In this research study, bee agents are modelled in packet switching networks, for the purpose of finding suitable paths between sites, by extensively borrowing from the principles behind the bee communication. Honey bees evaluate the quality of each discovered food site and only perform waggle dance for it on the dance floor if the quality is above a certain threshold. Not each discovered site receives reinforcement. As a result, quality flower sites are exploited quite extensively. After waggle dancing inside the hive, the dancer bee often called the scout bee goes back to the flower patch with follower bees that were waiting inside the hive. More follower bees are sent to explore the promising patches. The majority of foragers exploit the food sources in the closer vicinity of their hive while a minority among them visit food sites far away from their hive. The nectars which hold above or at par the threshold quality are selected by the bees.

This observation has been utilised for recovery management in optical networks, after an attack has been detected in an optical node. The bees' behaviour has been transformed into an agent model that has two types of agents: short distance bee agents and long distance bee agents. Short distance bee agents collect and disseminate routing information in the neighbourhood (upto a specific number of hops) of their source node while long distance bee agents collect and disseminate routing information to all nodes of a network. In both the situations, the bee agents create alternative or back-up paths from a specific source node to a destination node. The source node is that optical node which wishes to send some data packets to a specific node. This specific node is the destination node, which receives data packets from the source node. If an attack has been detected at a node in between these two source and destination nodes then an alternative path has to be formulated so that the data packets could be send successfully between these two nodes. The task of the short distance bee agents are to explore those alternative paths with minimum distances, whereas the task of the long distance bee agents are to search for those alternative paths with distances more than the minimum distances. The idea behind the exploration of such back-up paths is to enumerate all the back-up paths as far as possible so that one or any of them could be used for data transmission after an attack. If an attack has been detected at an optical node covering many of the neighbouring nodes then back-up paths with larger distances could be availed. Alternatively, if an attack has been detected at an optical node without hampering the other neighbouring nodes then back-up paths with shorter distances could be used. The back-up paths with shorter distances can be designated as Local paths whereas with larger distances as Global paths.

2.1. Data Structure

The data structures that are adapted for this algorithm are listed below:
Assumptions: Consider an All-Optical-Network (Fig. 3) with A, B, C, D, E, F, G and H as its optical nodes. At any time, t, data packets are sent to an optical node say, E from node D. Then the node D becomes the source node and E becomes the destination node. The algorithm formulates the local, short distance paths with maximum 3 hops whereas the global, long distance paths with more than 3 hops. According to this analogy, there can be several paths. The path with minimum distance (3 hops) can be considered as the Local path or Primary path. The path with more than three hops can be considered as the Global paths.

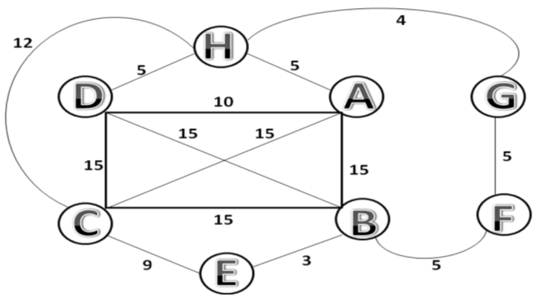

Fig.1. Mesh topology network

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Volume-3, Issue-2, 53-57

Following are the several alternative paths from node, D to node, E:

i. D → B →E ----Local Path(distance = 18 kms) less than 3 hops.

ii. D→ C→E ----Local Path(distance = 24 kms)

iii. D→H→C→E ---Local Path(distance = 27 kms) equal to 3 hops

iv. D→H→G→F→B→E --- Global Path(distance = 22 kms) more than 3 hops

v.D→A→H→G→F→B→E---Global Path(distance = 32 kms)

vi. D→H→A→C→E --- Global Path(distance = 34 kms)

If any of the optical nodes encounters an attack in one of these paths, thereby affecting the data transmission then the alternative, back-up paths can be used for recovery management. For example, if data transmission took place using the Local path (D→B→E) with shortest distance and suddenly an attack was recognized at node B. Then, the recovery management based on Honey-Bee algorithm would immediately forward the alternative, back-up paths from the routing table. The recovery method would forward only those back-up paths which do not have node B as their intermediate node. Here, in this situation the local path with nodes, D, C and E would be selected or else the local path with nodes, D, H, C, and E would be selected. Alternatively, the global path with nodes, D, H, A, C, and E may also be selected.

2.2. Description

The proposed recovery management using the Bee-Hive algorithm could be summarized as follows:

i. The network is organized into fixed partitions called foraging regions. A partition results from particularities of the different IP-address classes.
ii. Each node also has a node specific foraging zone which consists of all other nodes.
iii. The idea is that each bee agent while travelling, collects and carries path information, and that it leaves, at each node visited, the trip time estimate for reaching its destination node from source node over the incoming link. Bee agents use priority queues for quick dissemination of routing information.
iv. Thus each node maintains current routing information for reaching nodes within its foraging zone and for reaching the representative nodes of foraging regions. This mechanism enables a node to route a data packet (whose destination is beyond the foraging zone of the given node) along a path toward the representative node of the foraging region containing the destination node.
v. The next hop for a data packet is selected in a probabilistic manner according to the quality measure of the neighbours; as a result, not all packets follow the best paths. This will help in maximizing the system performance though a data packet may not follow the best path, a concept directly borrowed from a principle of bee behaviour.
vi. Each node periodically sends a short distance bee agent, by broadcasting replicas of it to each neighbour site.
vii. When a replica of a particular bee agent arrives at a site it updates routing information there, and the replica will be flooded again, however, it will not be sent to the neighbour from where it arrived. This process continues until the life time of the agent has expired, or if a replica of this bee agent had been received already at a site, the new replica will be killed there.
viii. Each node also launches long distance bee agents that would be received by the neighbours and propagated as in vii. However, their life time (number of hops) is limited by the long distance limit.

Both the short distance as well as long distance bee agents evaluates the back-up or alternative paths so that they could be used for attack recovery management.

2.3. Algorithm

Step1: Accept the source node and the destination node.

Step 2: Accept the IP-address of the source node and check its validity using the following classification. The classes are identified as the foraging regions.

<u>IP address classes</u>

Class Start address Finish address

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Volume-3, Issue-2, 53-57

A	0.0.0.0	126.255.255.255
B	128.0.0.0	191.255.255.255
C	192.0.0.0	223.255.255.255
D	224.0.0.0	239.255.255.255
E	240.0.0.0	255.255.255.255

Step 3: If the source node is found to be valid then continue to Step 4. Else stop and discontinue the network between source and destination nodes.

Step 4: Form the distance matrix for the given network.

Step 5: Search the nearest node from the source node with minimum distance.

Step 5: Accept the neighbouring node with the minimum distance and search for the next node as above.

Step 6: Repeat step 3 and step 4 until the destination node is not reached.

Step 7: In this way find all the paths from source node to destination node.

Step 8: Find the number of nodes in each path.

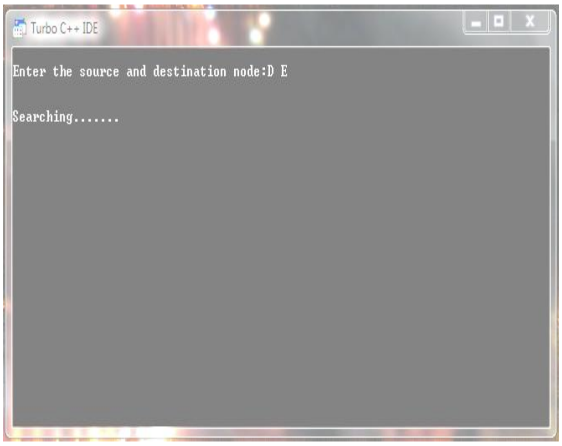
Step 9: If number of nodes is less than equal to 3 then consider it as Local path.

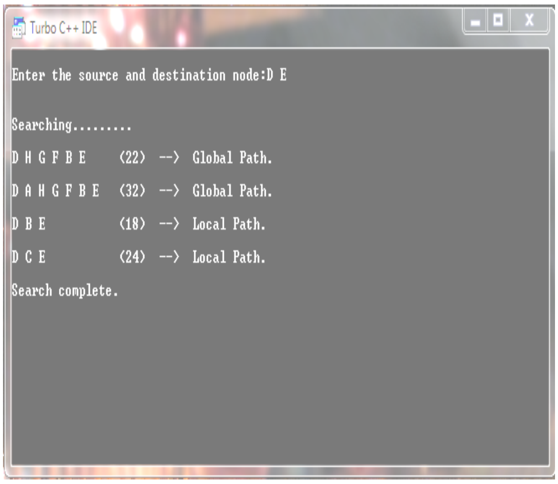
Else mark it as Global path.

Step 10: Stop.

3. RESULTS AND CONCLUSIONS

The results show that the proper determination of alternative, back-up paths between a source and destination node. The usage of local path occurs when there occurs no attack in the AON whereas the usage of global paths is due when there occurs attack on the network. Thus the proposed heuristic not only determines the primary path but also calculates their back-up paths. Figures represent the depiction of both local and global paths in the network.





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