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Intuitive Based Defect Technique for Reducing Delay in Optical Networks

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Abstract: In Optical WDM networks, failures may occur in node or link which leads to a severe data loss in the network. So, Quick detection and isolation of faults is essential for the robustness and reliability of both the network and the services carried over it. In this paper, a fault management technique is proposed based on artificial neural networks which detect the failures and guarantee fast re-routing. To identify which network component is damaged and which node it belongs, each network component has a unique identification composed by a string. Here, the number of input set depends on the type of the node and its components. After these input sets are trained, the ANN generates desired output vector corresponding to the fault condition for a given input string. From the output vector, a notification is triggered with the node ID from where it is coming and the timestamp representing the failure time. By our simulation results we show that this technique is effective in detecting and locating the failures by reducing the end to end delay in the network.

Key words: Optical WDM Network · Fault management · Neural Networks and delay

INTRODUCTION

With the recent development in the high bit rate IP network applications the necessity for on demand provisioning of wavelength routed channels with service differentiated contributions within the transport layer is created. The diverse optical transport network architecture was provoked due to the fundamental developments in the wavelength division multiplexing (WDM) technologies. All the optical network services became feasible due to availability of ultra long reach transport [1].

Each light path carries a huge amount of traffic which causes failures in these networks. This may harm the end-user applications critically. With reference to their effect, the failures in optical networks are classified into two categories [2].

- The quality of transmission of every individual lightpath is affected by the wavelength level failure.
- All light paths are affected on an individual fiber in the fiber level failure.

Each lightpath is anticipated to operate at a rate of several gigabytes per second and so failure leads to relentless data loss.

A fault can be defined as an un-permitted deviation of at least one characteristic parameter or variable of a network element from acceptable/usual/standard values. Fault detection and localization are essential for providing continuous and reliable services in all-optical networks (AONs) with ever-increasing data rate as well as increased wavelength number and density in wavelength-division multiplexing (WDM).

The ability of the network to endure the failures is known as the Fault tolerance. The fiber which involves the failed link also fails since the failure occurs due to the node failure or link failure. Hence, fault management is essential for improving the reliability of a network.

Existing literatures uses a centralized fault management agent in which the agent communicates with all the network nodes through a reliable out-of-band control channel. There is a possibility of overhead for agent and agent failure in centralized management [3, 4]. In order to overcome the above drawbacks, we develop

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intelligent agents based on neural networks to predict the failures and to guarantee fast re-routing of these networks.

The rest of the paper has been organized as follows: Section 2 presents the related study of the work. Section 3 proposes the ANN based Fault management algorithm. Section 4 analyses the simulation and compares the performances. Section 5 concludes the paper.

Related Work: Mehdi Khani, Mohammed Ghasemzadeh, Fazlollah Adibnia and Mehdi Sarram [5] have introduced a method named Probabilistic Failure Location (PFL) to localize the faulty component in optical networks and especially useful in WDM networks due to their high bandwidth. This is very fast and robust to alarm errors. This method is based on establishing normalized fault vectors and construction of components matrix. It gives a prioritized list of component classes which are identified to be faulty and also it works well with multiple fault situations with a reasonable amount of false or lost alarms.

Hongqing Zeng, Alex Vukovic and Changcheng Huang [6] have developed a protocol where the source node of each light-path keeps sending hello packets to the destination node exactly following the path for data traffic. The destination node generates an alarm once a certain number of consecutive hello packets are missed within a given time period. Then the network management unit locates the faulty source based on the network topology by collecting all alarms. Also it sends fault notification messages through control plane to either the source node or all upstream nodes along the light-path.

Hongqing Zeng, Changcheng Huang and Alex Vukovic [7] have proposed an m-cycle construction for fault detection is formulated as a cycle cover problem with certain constraints. A heuristic spanning-tree based cycle construction algorithm is proposed and applied to different networks. Metrics including grade of fault localization, wavelength overhead and the number of cycles in a cover are introduced to evaluate the performance of the algorithm. Analyses indicate that the average node degree of a network plays an important role in the performance of m-cycle based fault detection and localization approaches.

G.Ramesh and S.SundaraVadivelu [8] have proposed a new fault localization algorithm for WDM networks which can identify the location of a failure on a failed light-path. Their algorithm detects the failed connection and then attempts to reroute data stream through an alternate path. They have assumed that a failure happens during the data transfer mode due to the short interval time of establishing a light-path. This implies that the destination node is aware of the source node and the setup route before an interruption of service occurs. The algorithm will be activated once a connection is disrupted. This happens when the destination does not receive expected data stream any longer. They also developed an algorithm to analyze the information of the alarms generated by the components of an optical network, in the presence of a fault [9].

Proposed Fault Management Technique: In Artificial Neural networks, there are three layers namely the input layer, output layer and the hidden layer in neural networks. The number of neurons is equal to the number of variables in the input layer. The desired number of quantities is calculated from the input and the perception response is made available in the output layer [10].

The components that can send alerts for the administrator during the occurrence of some abnormal condition of functioning have microprocessor and they are called alerting components. The components that can able to send alert can be divided in the following groups:

Active Components: The network components that can send alert to the administrator when they are not working properly.

Passive Components: The network components that can send alerts when some external event occurs, that is, they send alerts for the manager informing an abnormal condition in some point of the channel, even when they are not responsible for the problem.

When a fault occurs, in order to identify which network component is damaged and

which node it belongs; each network component has a unique identification. In the network model used here, this identification is composed by a string of four fields (C_1, C_2, C_3, C_4) having the following meaning for a local node:

C_1: It indicates the category and it can assume the following values:

0 – Non-alerting components; 1 – Active; 2 – Passive; 3 –Masking.

C_2: It indicates the node id.
C_3: It is always 0 for a local node.
C_4: It identifies the position of the component inside the node.

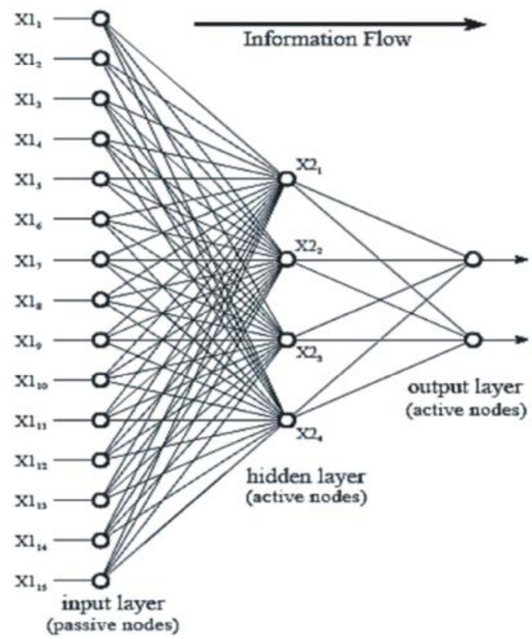

Fig. 1: Layers of Artificial Neural Network

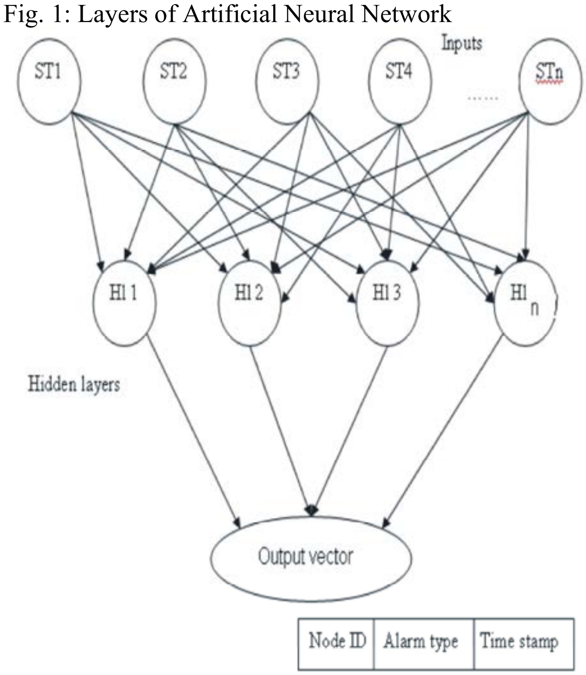

Fig. 3: ANN Model for Detection

Table 1: Examples of the Components and their Identification

Add/Drop Filter	(1,X,0,1), (1,X,0,2)
Receiver	(2,X,0,1), (2,X,0,2)
Protection switch	(2,X,0,3)
Re-generator/Re-shaper/	
Re-timing amplifier	(2,X,0,4), (2,X,0,5)
Transmitter	(3,X,0,5), (3,X,0,6)
Local Access Port	(0,X,0,0)

The values of C_4 vary according to the component:

Local Access Port = 0;
Add/Drop Filter = 1 or 2;
Receiver = 1 or 2;
Re-generator/Re-shaper/Re-timing amplifier = 4 or 5;
Transmitter = 5 or 6;
Protection switches = 3.

Table 1 shows the example of the components and their identification inside the node X. In order to realize the location of the damaged components, the algorithm needs only the identification of the elements that are sending alerts to the management room.

In the Artificial neural networks the input set represents a string which has four components C_1, C_2, C_3 and C_4 (explained in section 4). In Figure 3, we take n number of strings ST_1, ST_2, ST_3, ST_4, … ST_n as input layer to the ANN. Several possibilities can occur by the combination of these inputs. For each node, atmost 10 strings can be generated. We consider a NSF network of 14 nodes. So totally 10 x 14=140 input sets are used in the input layers and trained. The input sets are given to the hidden layers Hl_1, Hl_2, Hl_3, Hl_n. The nodes in the hidden layer vary for every input pattern and the performance of the network in determining the optimum hidden nodes was carried out. The output layer contains 1 set which represents a vector containing 3 fields: Node ID, Alarm Type and Time stamp.

From the output vector, the alarm type is first checked whether it is a true alarm or false alarm. If the alarm is true, the node ID from where it is coming and the timestamp representing the failure time, are noted from the vector. If the alarm is false it is ignored. Then it is finally intimated to the administrator to announce the fault location and time, upon which the administrator invokes the recovery techniques [11].

RESULTS AND DISCUSSION

The simulation is carried out on ns-2 network simulator with an extensive simulation study to examine the performance of our ANN based distributed fault detection algorithm.We use the Optical WDM network simulator (OWns) patch in ns2, to simulate a NSF network (Figure.4) of 14 nodes [12].

The ANN code is written and compiled as a separate C++ module and the predicted output of faulty nodes are integrated with ns2. Initially the input file is trained with the Artificial Neural Network with number of faults is set

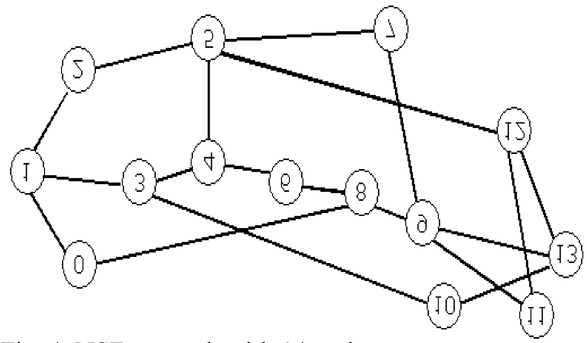

Fig. 4: NSF network with 14 nodes

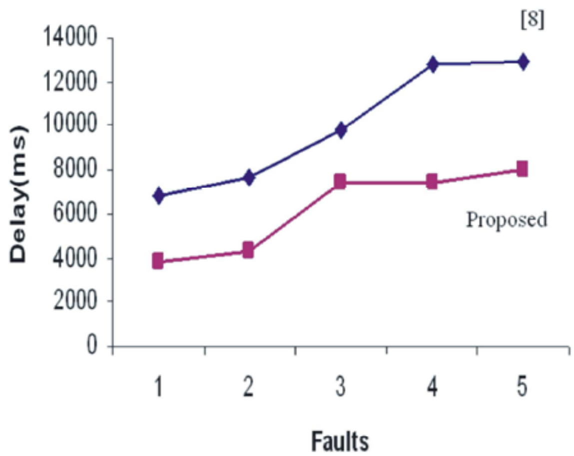

Fig. 5: No of faults Vs delay [8]

as 1 to 5 in simulation settings. The corresponding test data file is read and the ANN agent in NS2 invokes the ANN module as an external procedure where the ANN module compares the test data with the trained data and returns the predicted list of faulty nodes to the ANN agents in NS2.The ANN agent notifies the faulty nodes information to the source node using the routing protocol. After notification process, the source node invokes the fault recovery algorithm to rectify the fault [13].

The variation of delay with number of faults for the proposed ANN based fault localization and detection technique with reference to the existing FLAC scheme is given in Figure 5. For a number of faults as 5, it is observed that the average end to end delay for the ANN technique is only 7967ms and it is 12901ms for FLAC technique [14]. This reduction in delay is due to the recovery time involved in the ANN technique. As soon as the alert is generated, the recovery mechanism is triggered immediately which results in less delay. Since the fault recovery time is less in ANN, our proposed technique achieves minimum delay results in fast detection and localization of faults.

CONCLUSION

In this paper, we have proposed a ANN based fault management technique to detect the failures and to guarantee fast re-routing of these networks. When a fault occurs, each network component has a unique identification composed by a string of four fields in order to identify which network component is damaged and which node it belongs. The string contains the node id, type of component and position of the component inside the node. In ANN, the input set was represented by this string and provided to the input layer for training. The number of input set depends on the type of the node and its components. After these input sets are trained, for a given input string, the ANN generated desired output vector corresponding to the fault condition. From the output vector, the alarm type is first checked whether it is a true alarm or false alarm. If the alarm is true, the node ID from where it is coming and the timestamp representing the failure time, are noted from the vector. Then it intimates the administrator the fault location and the time. By our simulation results we showed that this technique is effective in detecting and locating the failures by achieving minimum delay [15-17].

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