

Ant colony optimization based multi-faults localization mechanism in elastic optical networks



Yanyan Xu^{a,*}, Guanggui Chen^a, Yeying Xu^b

^a School of Mathematics and Computer Engineering, Xihua University, No.999 Jin Zhou Rd. Jin niu District, Chengdu 610039, Sichuan Province, PR China

^b State Key Laboratory of Information Photonics and Optical Communications, Beijing University of Posts and Telecommunications, Beijing 100876, PR China

ARTICLE INFO

Article history:

Received 10 December 2013

Accepted 10 July 2014

Keywords:

Elastic optical networks

Network survivability

Multi-faults localization

Ant colony optimization

ABSTRACT

In order to withstand and recovery from multi-faults in elastic optical networks, we propose a novel multi-fault localization mechanism based on ant colony optimization and mixed line-rates. Multi-faults localization has been proved to be a NP-complete problem in wavelength switched optical networks, and all existing multi-faults localization algorithms require time that is super polynomial in the input size. Furthermore, multi-faults localization in elastic optical networks gets new features that the affected high-bit-rate services will play a greater role than the affected low-bit-rate services. In order to handle the mixed line-rates, we introduce the dependency metric which is used to describe dependency between alarms and likely causes. We establish the linear programming model for multi-faults localization and propose an objective function while considering the mixed line-rates. We implement the ant colony optimization based multi-faults localization mechanism on the stateful PCE-based multi-domain elastic optical networks test bed. The numerical results show that ant colony optimization based multi-faults localization mechanism has low flooding time and alarm packets, high success rate compared with the existing localization algorithms. We choose the best configuration of ant colony optimization based multi-faults localization by adjusting the parameters.

© 2014 Elsevier GmbH. All rights reserved.

1. 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 [1]. The spectrum-sliced elastic optical path network (SLICE) which was based on orthogonal frequency division multiplexing (OFDM) technology was proposed to enables sub-wavelength, super wavelength, and multiple-rate data traffics accommodation in a highly spectrum-efficient manner [2,3]. The center frequency and allocated bandwidth of an optical channel can be assigned arbitrarily in elastic 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 elastic optical networks [4].

Fault localization is a prerequisite for the protection and restoration mechanisms. Usually, centralized fault localization mechanisms provide a list of components whose faults explain the observed alarms. Such as [5], use pre-computation or sequential diagnosis to keep up with scalability. Distributed mechanisms rely on keep-alive or notification messages to locate the root of a fault. One of the most representative distributed-localization mechanisms is the link management protocol (LMP) [6], which is part of the GMPLS protocol suite. The LMP requires an always on supervisory channel (λ_0) to locate faults, which should not be in-fiber to avoid loss of the supervisory channel in the event of a link fault. Sichani and Mouftah presents a distributed fault localization protocol, called limited perimeter vector matching (LVM) protocol for localizing single link fault in all optical networks [7]. 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 [7]. To handle multi-link faults, it tries to separate each fault in a small perimeter area after identifying each perimeter area with its

* Corresponding author: School of Mathematics and Computer Engineering, Xihua University, No.999 Jin Zhou Rd. Jin niu District, Chengdu 610039, Sichuan Province, PR China.

E-mail address: xuyyts@163.com (Y. Xu).

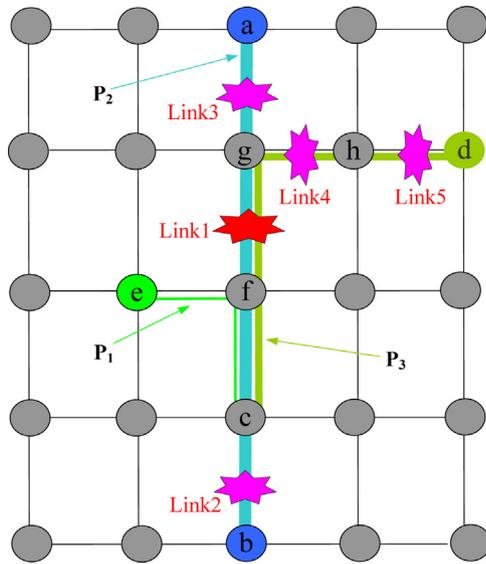


Fig. 1. Multi-faults and mixed line-rates in elastic optical networks.

corresponding fault and then localize the faults in parallel, respectively, in a distributed manner. In the paper [8], the author implement fuzzy fault set based multi-link faults localization mechanism in multi-domain large capacity optical networks. It has high scalability, speed and success rate compared with extended LVM protocol.

Ant colony optimization (ACO) has been applied to many combinatorial optimization problems. It can run continuously and adapt better to changes in real time [9]. We apply Ant colony optimization into multi-faults localization aiming at search the optimal fault set. The rest of the paper is organized as follows. Section 2 introduces the existing fault localization algorithms and analyses the used optimization strategies. Section 3 gives the detailed analysis of multi-faults localization in elastic optical networks. Section 4 applies ACO into multi-faults localization and gives the detailed description of the ant colony optimization based multi-faults localization algorithm (ACOMFL). Section 5 evaluates the performance of ACOMFL algorithm through numerical results. Finally, we conclude this paper in Section 4.

2. Multi-faults localization in elastic optical networks

In this paper, we focus on the fault model where multiple links fail in a random and concurrent order. We only consider the multi-domain elastic optical networks without signal monitoring at each intra-domain nodes and only gateway nodes, destination nodes are equipped with monitoring devices. Once such a link fails, a set of destination nodes connected to light-paths with mixed line-rates detect signal loss or high signal-to-noise ratio.

As presented in Fig. 1, the established light-paths with mixed line-rates in the network are $P_1: c \rightarrow f \rightarrow e$ (two subcarriers), $P_2: b \rightarrow c \rightarrow f \rightarrow g \rightarrow a$ (eight subcarriers), $P_3: b \rightarrow c \rightarrow f \rightarrow g \rightarrow h \rightarrow d$ (four subcarriers). Then the destination nodes a, d detect the signal loss but the destination node e does not detect any abnormal. So the occurred faults affect the light-paths: P_2, P_3 . In the case of single link fault, we could diagnose $Link_1$ is the failed link without a doubt. But under multi-link faults, we cannot determine which link has a fault because there are several link combinations which can cause observed alarms, such as: $Link_3 \cup Link_4$, $Link_2 \cup Link_3$, $Link_3 \cup Link_4 \cup Link_5$, etc. Moreover, links located in light-path P_2 will be the most preferred option because P_2 is the light-path with largest line-rate. The affected light-path P_2 with high line-rate will be more likely to indicate the location of likely causes

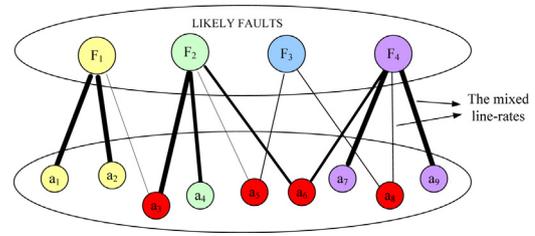


Fig. 2. The dependency between alarms and likely faults.

than other affected light-paths with low line-rate. In other words, we must consider the line-rate of each established light-path when we search the optimal fault set from all likely causes.

3. Key principle of multi-faults localization and Lp model

We use a bipartite graph to represent the dependency between possible observable symptoms (e.g., alarms) and corresponding likely causes (e.g., link fault) [10]. The bottom partition consists of all the received alarms and the top partition consists of the likely causes. An edge exists between an alarm and a likely cause if that alarm can be observed given the likely cause. The edge exists between an alarm and a likely cause in elastic optical networks has a dependency metric which reflects the line-rate of affected light-path. We use the notation $Bip.G$ to represent the bipartite graph. Notation F represents the likely fault set and notation A represents the received alarm set. Notation a represents one received alarm, $Fault(a)$ represents all the likely causes whose failures can cause the alarm a . Notation F_d^i represents the i th fault in $Fault(a)$ and the $line-rate(a, F_d^i)$ represents the line-rate of the affected light-path which passes through the fault F_d^i and also causes the alarm a . Notation NLP represents the set of the normal light-paths and n represents one normal light-path in the NLP . $Normal(n)$ represents the total normal elements in normal light-path n . The steps of proposed algorithm are given as follows.

Algorithm 1 Bip.G

Require: Bip.G to be set up

1: $F \leftarrow \Phi$

2: for $a \in A$ do

3: Find all likely fault: $Fault(a)$ and record the dependency

4: $F = F \cup Fault(a)$

5: endfor

6: for $n \in NLP$ do

7: Find all normal element $Normal(n)$

8: $F = F / Normal(n)$

9: endfor

10: for $a \in A$ do

11: Calculate the weight for each dependency based the line-rate

12: $weight(a, F_d^i) = line-rate(a, F_d^i) / \max(line-rate)$

13: endfor

15: Return A, F and the dependency metric

As presented in Fig. 2, the bipartite graph is composed by alarms, corresponding likely faults and the dependency metrics. The weight for dependency metric is calculated based on the line-rate of all affected light-paths. Considering the dependency metric on the edge between an alarm and a likely fault in elastic optical networks, the linear programming model of multi-faults localization in elastic optical network is as follows. The likely cause set is described by the faults set F , indexed by i . The observable alarm set is described by the alarms set A , indexed by j . The edge exists between an alarm and a likely cause is described by e_{ij} , and w_{ij} represents the weight on this edge. The largest weight on edges incident to likely fault F_i is described by w_i . $A(t)$ represents total received alarms at the network management center in the t period of time. $A(F_i)$ represents

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات