Failure Disposal by Interaction of the Cross-layer Artificial Intelligence on ONOS-based SDON Platform

Bing Zhang(1) , Yongli Zhao(1)*, Boyuan Yan(1), Longchuan Yan(3, 4), Ying Wang(2), and Jie Zhang(1)

(1) State Key Laboratory of Information Photonics and Optical Communications, Beijing University of Posts and Telecommunications, Beijing, 100876, China

(2) State Grid Information & Telecommunication Company, Beijing, 100761, China

(3) Institute of Information Engineering, Chinese Academy of Sciences, Beijing 100093, China

(4) School of Cyber Security, University of Chinese Academy of Sciences, Beijing 100049, China

yonglizhao@bupt.edu.cn

Abstract: We propose a new architecture introducing AI to span the control layer and the data layer in SDON. This demonstration shows the cooperation of the AI engines in two layers in dealing with failure disposal.

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1. Introduction

Software Defined Networking (SDN) is changing the traditional management and control of networking devices. Software Defined Optical Network (SDON) emerged for flexible control of the optical networking, achieving significant improvements in scalability, flexibility, and openness. As the number of heterogeneous devices and the service types in the network is increasing, there will be some new challenges in the future optical networks, such as massive data analysis, complex status control and emergency management [1]. The rapid development of artificial intelligence makes it possible to solve these problems [2].

Intelligent optical network technology has evolved from Automatically Switched Optical Network (ASON) to SDON. As artificial intelligence (AI) technology becomes more and more mature, some new concepts about the combination of artificial intelligence and optical networks are proposed. For example, AI engines can be embedded in each transport equipment in an on-board fashion [3]. In this way, on-board AI can extract features from original data to AI in control plane and solve equipment-level issues and make local optimization. But in some cases, on-board AI engine can only execute operation in the equipment layer scope and can't cooperate with central AI engine in control plane. For example, based on on-board AI only the raw data of a single device can be processed locally, while interaction among multiple devices cannot be performed.

In the context of SDON, AI in optical networks plays an important role in building a fully automated network, as there are plenty of jobs that rely heavily on experts. To fully utilize the ability of AI for building network automation, this work proposes the concept of cross-layer AI for optical networks. The main idea of the cross-layer AI is that AI engines in data plane and control plane could coordinate to support cross-layer optimization through data interaction. AI in data plane can not only use the AI engines to process massive data that is too huge for an individual controller to deal with and provide equipment layer information for the control layer AI, but also accept the instructions of the AI in control plane and use the deep learning model to optimize the equipment layer.

2. Architecture of Cross-layer AI and Applications

This demo shows the concept of cross-layer AI in optical networks to enable AI engines in control plane and data plane to coordinate to solve cross-layer issues. Based on the architecture of on-board AI, we introduce some different AI engines into the architecture. With the added AI engines, we can implement deep optimization in both device level and network level of optical transport networks.

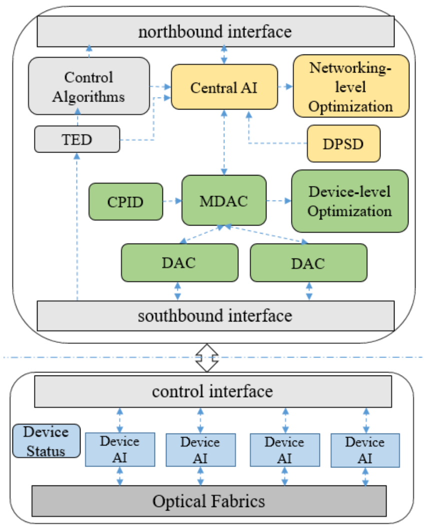

Figure 1 Proposed cross-layer AI architecture

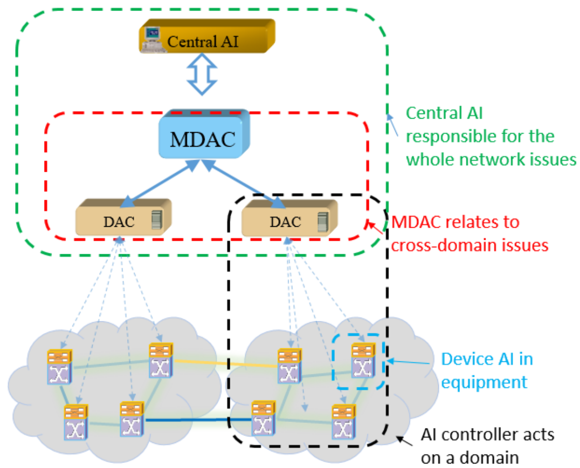

Figure 2 Action scopes of different AI engines

Fig. 1 illustrates the architecture of transport equipment and controller with cross-layer AI for optical networks. Different Device AI Controllers (DAC) are deployed for different domain that contains several devices with AI engine like on-board AI in data plane. Multi-domain AI coordinator (MDAC) orchestrates all AI controllers according to the distribution of devices in a network. Traffic Engineering Database (TED) is related to network traffic management. With the corresponding to data plane status database (DPSD), we introduce control plane information database (CPID) into data plane to store the data from AI engines for control plane. With all the AI engines, the central AI engine can make cross-layer network optimizations by considering network status in both equipment-level and network-level. All the controllers are developed based on ONOS. Action scopes of different AI engines are differ from each other and there can be some interaction between AI engines as shown in Fig. 2 .Based on the above cross-layer AI SDN platform, several valuable experiments can be conducted and demonstrated. For example, Tidal traffic prediction, network performance can be evaluated on different scalabilities, such as node, link, and services, anomaly action detection and routing and wavelength assignment [4-5].

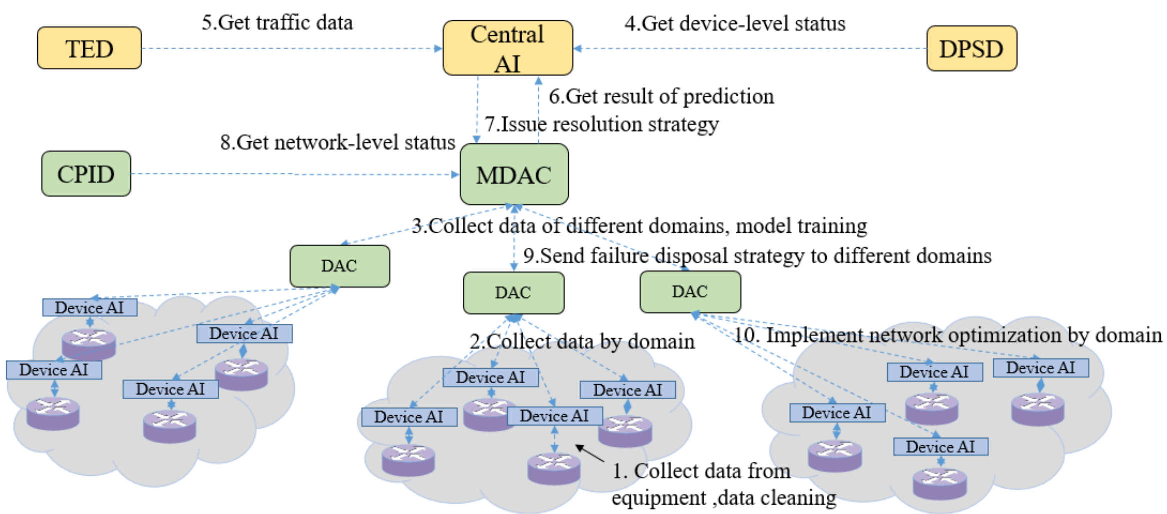

Figure 2 Workflow for disposal of specific failure

In the real networks, there are many different application scenarios based on this architecture. Figure 3 shows the general workflow of AI application for disposal of specific failure. Cross-layer AI applications for optical networking can be implemented in the way as follows:

1）Device AI in an on-board fashion makes data purification and extract features from original data, such as running temperature, transmitting power, receiving power, CPU utilization, and etc. 2）DACs collect data from all the device AI engines in different domains. 3）MDAC collects data from different domains and selects the appropriate method for model training. 4) Central AI gets device-level status. 5）Central AI receives traffic data from TED. 6）Central AI gets predicted results from MDAC. 7）Central AI integrates all the network and device information and sends issue resolution strategy. 8）MDAC gets network-level status from CPID. 9）MDAC sends failure disposal strategy to different domains and orchestrates all DACs to disposal failures, such as schedule the service in the network and other subsequent operation. 10) DACs implement network optimization by domain following the strategy.

Based on the above solution, an application of failure disposal including data compression, failure prediction, traffic prediction and service adjustment through cross-layer AI interaction will be demonstrated. As shown in Fig. 4, for *failure prediction*, data collection, compression and purification are performed in *step1*. Failure prediction within the domain is performed by DAC after model training in *step2* and cross-domain failure prediction must be coordinated by MDAC in *step3*. For *service adjustment*, Central AI collect the whole network topology and resource data through MDAC（*step4*）and send routing and wavelength assignment strategy to MDAC(*step5)*. At last, DACs manage to complete service adjustment in *step6*.

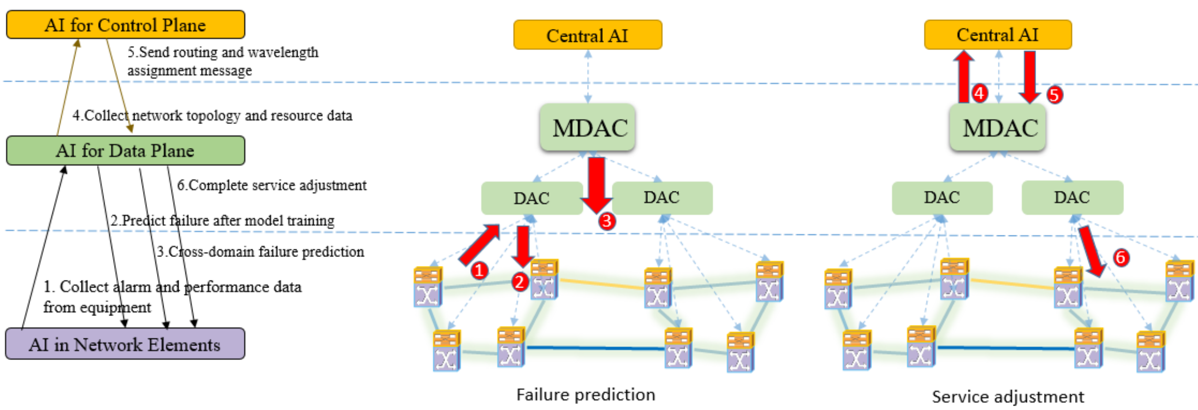

Figure 4 Failure disposal by cross-layer AI interaction

3. Innovation

Several innovations are presented in this demonstration. Compared to on-board AI which only sends data one way to control plane, AI engines in different planes can mutual collaboration in the architecture of cross-layer AI. Through introducing new AI engines we can not only improve the efficiency of information processing, but also complete the cross-layer optimization strategy, which can realize more effective network optimization measures.

4. Relevance

This work, to the best of our knowledge, would be the first public demonstration involving cross-layer AI on SDON. By attending this demo, the participants will gain knowledge on operating mechanism of cross-layer AI, as well as scenarios like failure disposal based on existing network equipment. Previous demonstrations and implementations have all been focused around the control plane in SDN. In this sense, this demonstration extends beyond previous work to bring together advancements in cross-layer interaction of SDN, automatic data analysis and failure disposal. Cross-layer AI enables several unique and significant possibilities for optical networks.

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