Energy Efficient Optical Switching Networks for Hurricane-Resilient Communication

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Abstract This paper describes the design effort of an energy efficient optical switching network which provides hurricane-resilient communication. The proposed optical switching network can operate on backup powers during Hurricane power outage.

1. Introduction

Hurricanes usually cause damages to the transportation and power systems as well as expose the rural regions to the threat of diseases. In order to handle the emergency situations by providing the infrastructure for communication, a resilient and reliable telecommunication network would be very critical. However, during and after major hurricanes, the power systems are usually down for extended period of time due to the extreme weather, which blocks the regular communication channels. In this paper a method that can keep low power consumption for optical switching under the Software Defined Optical Network (SDON) [1] is proposed, which allows communications equipment operate on backup powers.

2. SDON

Figure 1 illustrates the structure of SDON. The software network controller and the physical hardware system are separated, which are connected by the common interface. The control system is highly centralized and physical hardware is flexible to support different network configurations and demands.

Optical Networking (SDON) the main functions of the physical layer in optical networks aretransmission and switching. There are two key hardware components in the physical layer – variable transponders and flexible switching nodes. Signal characteristics such as data rates, modulation formats and error-correction schemes for different DWDM channels can be dynamically changed by the variable transponder according to the link conditions and QoS requirements. There are several schemes to achieve these functions. The first scheme is the digital transmitter. In this scheme, the data are encoded with a suitable modulation format and then are modulated onto the in-phase optical signal. The second scheme is based on cascaded modulators and electrical-optical-electrical multilevel drive signal generators, which allow the network operator to select the encoding methods based on spectral efficiency. The third scheme is based on the multi-carrier signal to form high capacity super channels. At both the transmitting side and the receiving side, transmitters and receivers can support flexible optical channels with variable characteristics. In SDON, the network controller and physical hardware are separated from each other, which are connected by the common open interface. The SDON allows applications from different resources to program the flexible hardware equipment and implement the following specific functions in the network: impairment-aware routing, network defragmentation, optical grooming, resource allocation and protection. In addition to software applications, the SDON controller also has a network hypervisor, an operating system and a debugger and manager.

1. Self-Resilient Network Architecture

In self-resilient reconfigurable optical networks, each wavelength can be configured to a different switching mode based on link conditions and dynamic traffic loads, which is controlled by the optics defining software. Besides, selfresilient reconfigurable optical networks have the characteristic of asymmetry, which means the optics defining software canuse different switching modes for the two-way communication in a single application. The architecture of self-resilient reconfigurable optical networks is illustrated in Figure 2. The topology of the network consists of edge routers and core routers. Edge routers are connected with metro networks with different web services such as VPN, cloud computing and video streaming. Core routers connect edge routers/core routers with other edge routers/core routers. Three different types of traffic are supported simultaneously in the network: electronic packet switching (EPS) packets, optical circuit switching (OCS) connections and optical burst switching (OBS) containing control headers and data bursts. Different wavelengths can be independently configured or reconfigured into one of the three types of switching modes. The edge router aggregates and classifies traffic according to the dynamic traffic loads and link conditions. The scheduler in the core router switches traffic according to the traffic type. The EPS mode switches data based on electronic packets; OCS mode is operated according to the optical link reserved by the software application; OBS mode will first convert the control header into the electrical domain and then switch the burst data optically according to the information in the control header.

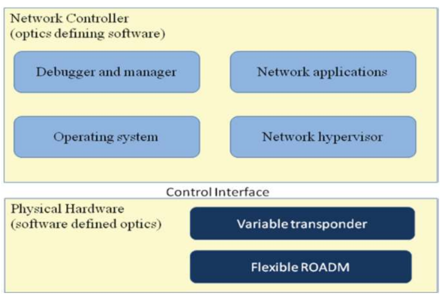

Figure 1 Structure of Software-Defined

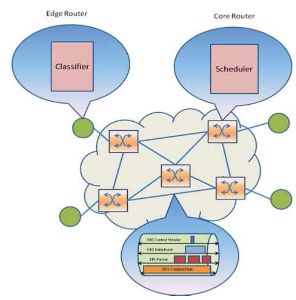

Figure 2 Self-resilient reconfigurable optical switching network

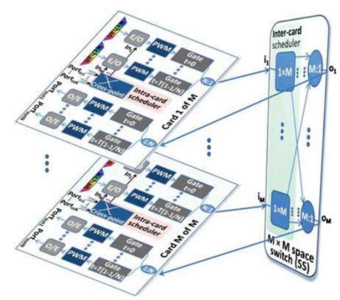

Figure 3 Space-time optical interconnection

2. Space-time Optical Interconnection Architecture

The space-time optical interconnection architecture has the potential to become a candidate for hurricane-resilient data center networks, because of its modularity, large scalability, and energy efficiency. The data center design can be carefully optimized by selecting the STIA size that leads to the most energy-efficient network. The STIA consists of M cards, each supporting N input ports and N output ports. The cards are interconnected through an M ×M SS. The STIA exploits the space domain to switch packets among cards, and the time domain to switch them among different ports of a card. The wavelength domain is exploited to achieve high throughput by encoding packets on multi-wavelengths. The wavelength domain is exploited to achieve high throughput by encoding packets on multiple wavelengths. These packets are optically generated from the serial electrical packets of duration T. The bits of the serial packets are used to simultaneously modulate a comb of N optical channels with a single broadband modulator. Then, a passive wavelength-striped mapping (PWM) element delays each modulated channel by T/N from each other and the delayed channels are gated in time to generate a WDM packet of duration T/N.

3. Acknowledgement

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4. References

[1] M. Channegowda, R. Nejabati and D. Simeonidou, "Software-Defined Optical Networks Technology and Infrastructure: Enabling Software- Defined Optical Network Operations," J. OPT. COMMUN. NETW, vol. 5, no. 10, pp. 274-282, 2013.