Low-Power Optical Switching for Hurricane Resilient Communication

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Abstract This paper describes the prototyping effort of a low-power optical switching router which provides hurricane resilient communication. The proposed optical switching network can operate on backup powers during Hurricane power outage. FPGA hardware is built and the result is demonstrated in a network testbed with multi-party communication applications.

1. Introduction

Hurricanes usually cause damages to the transportation and power systems as well as expose regions to the threat of diseases. In order to handle emergency situations, a resilient and reliable telecommunication network would be very critical. However, during the hurricanes, the power systems are usually destroyed by the extreme weather, which blocks the regular communication channels. In this paper, a method that can keep low power consumption for optical switching and zero power for the default optical path is proposed based on the Reconfigurable Asymmetric Optical Burst Switching (RA-OBS) networks [1]. The proposed approach is implemented in the hardware tested.

2. Methodology

A dual-mode scheduling approach is proposed in this paper. In normal situations, a standard configuration is applied on the entire system, which means the optical signals can be switched in normal ways. In this mode, an integrated multi-mode scheduling approach is used as shown in Figure 1. The multi-mode channel selection and channel update unit can be shared among all three functions: burst scheduling in the optical burst switching (OBS) mode, connection setup/teardown in the optical circuit switching (OCS) mode, and channel reconfiguration in the electronic packet switching (EPS) mode. The proposed approach provides an integrated solution to the problem as well as enables dynamic wavelength sharing among different switching modes. In emergency situations such as main power down due to Hurricane, the scheduler changes the mode of the system to the low-power configuration, which means that backup batteries are used to drive the low power micro electro mechanical systems (MEMS) switches to implement optical signals switching. In the default path, the MEMS switches do not need any power to keep the default configuration, which will lead to zero energy consumption in passing optical signals in the core and low power consumption in the edge.

3. Simulation and Hardware Experimental Results

Both the traditional LAUC-VF scheduling [2] and the proposed integrated multi-mode scheduling are simulated for the optical signals using a 14-node,

21-link topology. Each optical link carries 8 data channels and 2 control channels at 1 GB/s in each direction. Every node sends traffic to all node and the bursts arrival follows a Poisson process with average burst size is 70 Kbytes. The result shows that although RA-OBS does not have full wavelength conversion capability, the proposed integrated scheduling delivers blocking performance close to full conversion LAUC-VF for relatively large number of electronic ports. This is because integrated scheduling can efficiently utilize the pool of E/O and O/E converters shared by multi-mode traffic. In addition to software simulation, the effectiveness of the proposed integrated multi-mode scheduling algorithm has been verified, and its speed and cost effectiveness in hardware implementation in a hardware testbed. The proposed algorithm is implemented in FPGA hardware using Hardware Description Language Verilog HDL. The FPGA hardware is used along with the optical switching node in the optical switching testbed. A large medical image transfer hardware experiment is demonstrated to test the reliability of the MEM switch. Figure 2 shows the system architecture and topology of the experiment. More specifically, three routers are in the same subnet while router 1 and router 2 are isolated by customer

VLAN tag from router 3. Server connected to 3Com switch streams two separate medical images traffics simultaneously each at the speed of 100 Mbps. The experiment swaps the SVLAN tag by routing the traffic to FWCDS1 and FW9500. At the egress port, clients get the traffic coming out from FWCDS2 and TVs display a portion of the high resolution medical images at both the client. On the server side, iPads dynamically setup and teardown the optical path by sending commands to DE3 FPGA board, which configures the optical switch upon receiving of correct command. By zooming or moving the miniature of medical images in the iPad application, server recalculates the position of current image and continuously streaming traffic to the clients depending on the availability of the optical path between server and clients.

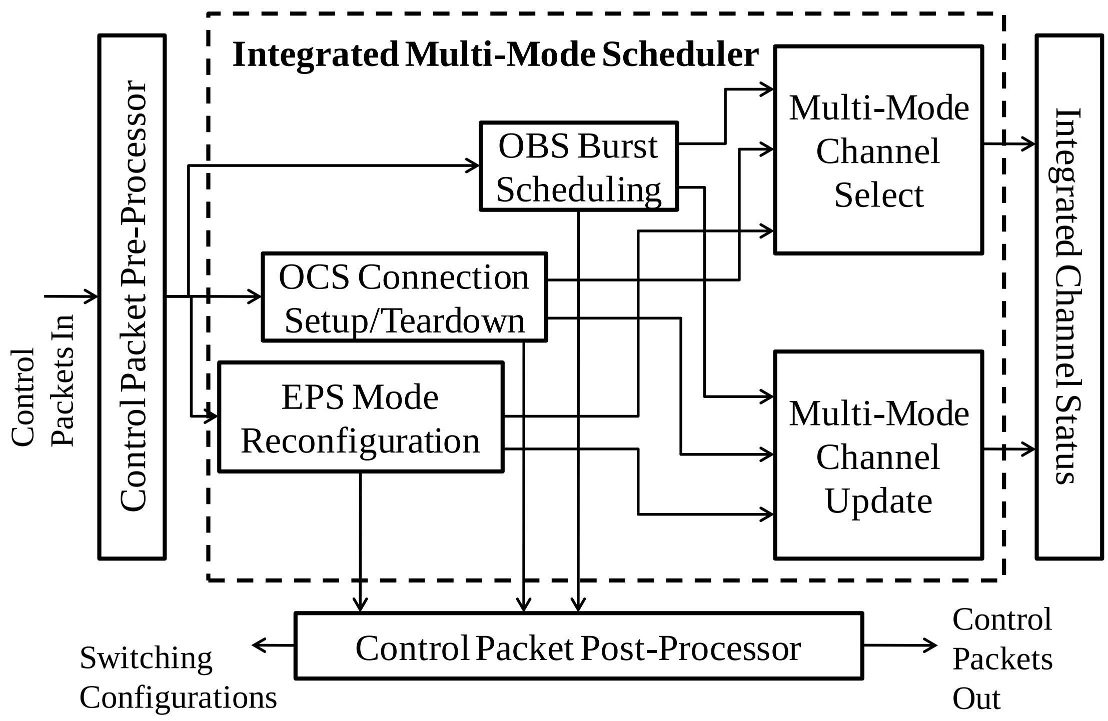

Figure 1: Integrated Multi-Mode Scheduler

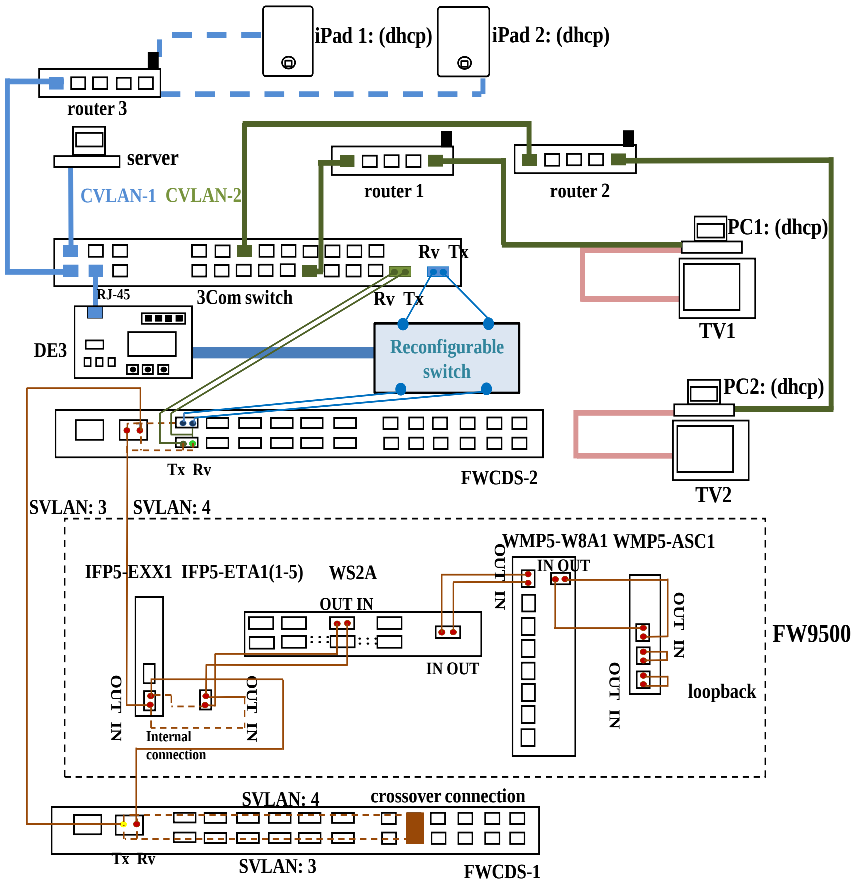

Figure 2: System architecture of medical image transfer experiment

4. Conclusion

In this paper, a dual-mode scheduling scheme for the optical burst switching network is proposed. The scheme can provide burst scheduling in the OBS mode, connection setup/teardown in the OCS mode, as well as channel reconfiguration in the EPS mode in an integrated fashion in both normal and emergency situations. The performance of the proposed integrated scheduler has been verified using OBS-ns2 simulator as well as in a hardware testbed. More specifically, the algorithm is implemented on FPGA hardware in an optical switching testbed. The result demonstrated in real hardware shows that the proposed algorithm can make adjustment according to environmental factors and switch between the normal mode and the emergency mode. All these results are based on low power passive optical switches and couplers that can be used in hurricanes and other extreme weathers.

5. Acknowledgement

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6. References

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