Class-Based Aggregation in Optical Packet Switched WDM Networks

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Optical packet switching, packet classification, packet aggregation, packet scheduling

Abstract
A novel architecture for class-based aggregation in optical packet switched network is proposed. A hardware implementation of the proposed architecture is also described. Furthermore the performance of the architecture with self similar traffic is investigated.

Introduction
Optical packet switching is a promising technology for realising IP over WDM networks. Optical packet switched (OPS) WDM networks introduce switching functionality at two levels of granularity, fast switching at the optical packet level and slow switching at the wavelength level. All optical networks with these features will be able to fit in a realistic network scenario where the circuit switched and the packet switched traffic will be transported through the same infrastructure [1-4]. In such networks an OPS edge router provides the interface between the optical network and the traditional electronic packet domain. The edge router also provides an aggregation mechanism for the OPS network. The aggregator accepts labelled packets (IP/MPLS) from a number of sources and maps them directly to the OTN in the form of optical packets. The edge router then maps the optical packets on to appropriate wavelengths.
In todays networks with heterogeneous traffic it is essential to provide quality of service (QoS) for a number of clients. To provide QoS in the packet switched networks, routers must categorise packets in to predefined classes and ensure for each class of traffic required resources from the network are guaranteed. In the OPS network a packet must be classified to a predefined class of service relevant to the optical domain.

Packet classification in the OPS network
Packet classification is a function which determines the flow that a packet belongs to based on the fields in the packet header. In the OPS network, introduction of MPLS/MPλS control protocol means that assignment of a specific class in to packets is done while the packets enter at the edge node of the network [5].

Traffic aggregation
In order to reduce the number of entities that must be processed per unit time in the core of the OPS network as well as to increase bandwidth efficiency, single or multiple packets with the same destination and QoS may be grouped together at the edge of the network forming an optical packet.

Functional architecture
The Class-based aggregation unit is an important part of the edge OPS router and in the proposed approach it is located at the output section of the edge router. Figure1 shows a functional model of the edge router as ingress node:

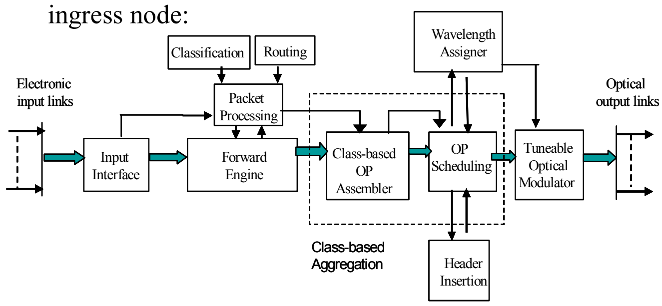

Figure 1. Functional model of the edge router as ingress node in the OPS network

In this model both a class-based optical packet assembler (aggregator) and an optical packet scheduler construct a class-based aggregation unit. In the proposed class-based aggregation architecture, other parts of the edge router are left aside and it is assumed the aggregation hardware receives required control signals and messages from the other parts of the edge router. An aggregation buffer is assigned to set of packets with the same destination address and the same class of service. To provide flexibility, the aggregation unit for each port comprises a set of unassigned buffers. They are assigned dynamically to a specific destination and specific class or classes based on the request from the control plane. These buffers aggregate incoming IP packets and construct the optical packets. Each aggregation buffer has two trigger parameters for transmission of an aggregated optical packet. These two parameters are the maximum holding time in the buffer and the maximum number of bytes per optical packet, which are defined based on the class of service.

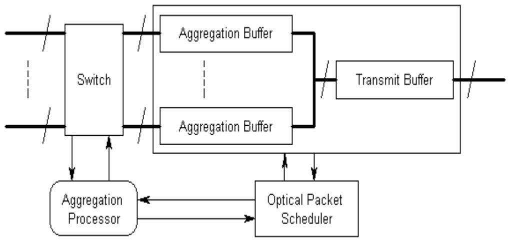

Figure 2. Functional architecture of the class-based aggregation unit

Triggered optical packets are scheduled to transmit based on their priority and class of service by the optical packet scheduler. This unit also generates appropriate control messages for the wavelength assigner and the header insertion sections.

Hardware implementation and prototyping

High speed packet processing and reconfigurability are two important requirements for next generation edge routers. Such routers must be able to upgrade in terms of new routing tasks, network functionality and speed (OC-768, 40 Gbps) [6].

Reconfigurable hardware like FPGA is being developed for high speed proposes. New FPGAs with multiple embedded processors provide a suitable hardware platform for implementing network processor functionality.

In order to examine our design approach and confirm suitability of that for the OPS network an FPGA platform with an embedded processor was chosen for prototyping the proposed class-based aggregation architecture. Because of the limited number of high-speed (Giga bits) I/O in the prototype platform (Virtex-II Pro from Xilinx), the proposed architecture has been implemented for three number of classes and one destination with 10 Gbps data rate. The class-based assembler comprises three FIFO buffers and the optical packet scheduler comprises one transmission FIFO buffer. A real time optical packet scheduling algorithm with the help of a hardware-software co-design tool (Handel-C) was implemented. This algorithm controls transmission of optical packets. The optical packets are of variable length which is integral multiple of a unit length.

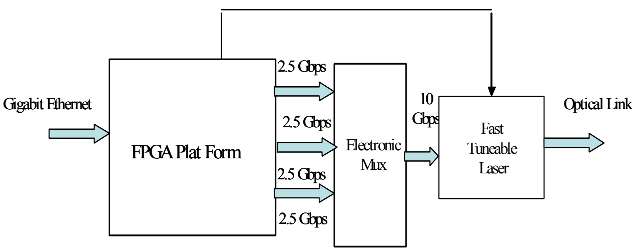

Figure 3. Functional block diagram of the prototype platform

A computer based simulation method was used to evaluate the propose architecture with real traffic. To model incoming packet streams from an IP router, multifracal wavelet model (MWM) for packet inter-arrival time was used [7]. Also by using internet traffic measurement results [8] and the fact of predominance small packet in IP traffic, a suitable model for packet length distribution has been derived. The proposed novel class-based aggregation method with representative traffic source model is now under simulation to investigate the effect of the aggregation on traffic shape, burstiness and packet loss rate. The simulation results will be presented at the time of conference.

Conclusion

Optical packet switching is an attractive alternative for efficiently realising optical packet switched WDM networks integrated with the traditional electronic packet switched network. This article represented a method for efficient traffic aggregation based on the class of service at the edge optical router to provide finer service granularity and more flexible architecture in comparison to the current wavelength switching technology thereby improving OTN utilization.

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Vitae

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