Burst contention resolving mechanisms for Optical Burst Switching

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Abstract: *Optical burst switching (OBS) technology is a promising solution for reducing the gap between transmission and switching speeds in future networks. This paper addresses the burst contention resolving mechanism and problem of routing optimization in optical burst switching (OBS) networks. Here, we will discuss the various contentions resolving techniques and focus on one main technique, known as wavelength conversion. For this, theoretical analysis of the performance of switches for wavelength converter in optical burst network is done.*

Keywords *-Optical burst switching, Contention resolution, Wavelength conversion.*

Introduction:

The telecommunication networks are experiencing a continuous increase in demand for transmission capacity. This trend is strictly related with the exponential growth of the Internet. The evolution of Internet technologies is accompanied by development of miscellaneous user and network applications, Peer-to-peer (P2P) data/multimedia file exchange, video broadcasting, grid services are among the most bandwidth- demanding applications [1]. Another consequence of the expansion of the Internet is the continuing paradigm shift from voice to data services.

Optical fibre offers enormous bandwidth in the telecommunications wavelength band around 1550nm, estimated at 25Tbits/sec. They are far more compact than copper cables, with many fibres able to fit in a single underground duct. They provide very low loss, allowing long repeater-less spans, which reduces maintenance costs. But due to dispersive effects and limitations in optical device technology single channel transmission is limited to only small fraction of fiber capacity [6]. To take the full advantage of potential of fiber, the use of Wavelength Division Multiplexing (WDM) technology has become the option of choice. With WDM, a number of distinct wavelengths are used to implement separate channels.

A burst switched network is a packet-like network where each switching node extracts control information from incoming packet header in advance in order to establish and maintain the appropriate switch connection for the duration of incoming burst of data packets. Optical burst switching (OBS) architectures were proposed in the late 1990s.

Optical Burst Switching is a photonic network technology which overcomes the Wavelength switching inefficiency by a proper exploitation of the statistical multiplexing in the optical layer. On the contrary to optical packet switching, OBS handles large data bursts aggregated from the client packets in order to reduce the processing and switching requirements. Moreover, a burst control packet is transmitted in a dedicated control channel and delivered with some offset time prior to the data burst.

In the optical burst switching the wavelength resources are shared between different connections, similar to OPS. At the edge of an OBS network, the packets coming from legacy networks (e.g., IP, ATM networks) are aggregated into large optical data bursts which are further transmitted and switched in the network.

Each burst has assigned a control packet. The burst control packet and its data payload are transmitted separately on dedicated wavelengths. The control packet is delivered to a core switching node with some offset time prior to the burst payload. In such a way an electronic controller of the core node has time both to process the control information and to setup the switching matrix for the incoming burst. The burst crosses the configured nodes remaining all the way in optical domain.

A transparent switching/routing of optical bursts from one fibre link to another is performed in an OBS core node.

Literature Survey:

Contention resolution

A burst contention occurs when more than one burst solicit for the same resources at the same moment. Resolution of the burst contention is a crucial problem in OBS networks. Two factors that complicate the contention resolution are unpredictable and low-regular burst statistics and the lack of optical memories. Loosing a burst that aggregates a number of packets may have worse effect than loosing a single packet. The burst contention can be resolved with the assistance of following mechanisms:

Wavelength Conversion (WC): Converts the frequency of a contending burst all-optically to other, available wavelength;

Deflection routing (DR): forwards a burst spatially, in the switching matrix, to another output port (fibre).

Fibre delay line (FDL) *buffering:* operates in time domain and resolves the contention by delaying the departure of one of bursts by a specific period of time.

Burst segmentation: each burst is divided into a few segments. If a burst contention occurs, instead of loosing the entire burst either the head or tail segments of one of the contending bursts are dropped.

The wavelength conversion technique in some details is described below:

Wavelength conversion:

The wavelength conversion is a natural way to resolve contentions in OBS net- works. A drawback of this mechanism, however, is high cost of WC devices, especially, in case of a full-wavelength conversion, which is performed in the wide frequency range. The benefits of conversion are largely dependent on the network load, the number of available wavelengths, and the connectivity of the networks [5]. To convert the wavelength we required wavelength converting switches. These switches route an incoming burst to an output. The input wavelength is converted to any available wavelength at the required output The switches are further used in the designing of OBS router.

According to their signal properties, WCs can be divided into three categories [4]:

1) Variable-input-fixed-output WCs, which can convert several input wavelengths into a certain output wavelength.

2) Fixed-input-variable-output WCs, which can change a certain input wavelength into more than one output wavelengths that are often closely neighboring to the input Wavelength.

3) Variable-input-variable-output WCs, which are capable of converting a band of wavelengths into another waveband.

Lot of research had been already done in it. Jeyashankher Ramamirtham, Jonathan Turner [3] designs two switches using tunable lasers to implement wavelength conversion. One is a strictly non-blocking design, which also requires optical crossbars and passive multiplexers and demultiplexers. The second design replaces the optical crossbars of the first design with passive Wavelength Grating Routers (also known as Arrayed Waveguide Grating Multiplexers or AWGMs). This option is very attractive because WGRs are relatively simple to fabricate, are inexpensive and consume no power. The second substitutes Wavelength Grating Routers (WGR) for the optical crossbars, reducing cost, but introducing some potential for blocking.

Switch Based on Optical Crossbars

The crossbars implement a combination of switching and multiplexing, since there may be several signals on a given input fiber that are propagated to the same output fiber. Input section has an optical demultiplexer that separates the different wavelength channels from each other before propagating through Tunable Wavelength Converters that quickly tune to any of the output wavelengths. The wavelength converters are followed by Crossbars. Outputs of each crossbar are then connected to distinct passive multiplexers, which constitute the output section of the switch. The crossbars can be followed by additional passive multiplexers, reducing the required size of individual crossbar components.

To route an incoming burst to an output, the input wavelength is converted to any available wavelength at the required output, and the crossbar is configured to propagate the signal to the required output. The switching and multiplexing capability of the crossbar ensures that there is no blocking, so long as there is an available wavelength on the selected output. Because burst arrival is unpredictable, there will be times in an OBS router when no output wavelength is available for an arriving burst. In routers with no internal buffering, such bursts are discarded.

Switch Based on Wavelength Grating Routers

Tunable wavelength converters are the only active components. Since the wavelength routers have *f* inputs and *g* outputs, *f/g* fibers connect each input section with each output section. In this design, the tunable wavelength converters are used to switch signals to distinct output wavelengths, to avoid wavelength conflicts on the output links and in combination with the Wavelength Grating Routers, they provide the required space switching. By tuning the laser to one wavelength in the appropriate set of *f/g* wavelengths for the desired output, we can "steer" the signal to the desired output port. Jeyashankher Ramamirtham, Jonathan Turner Concluded that for a typical switch configuration, the WGR-based design can deliver more than 87% of the throughput of a fully non-blocking switch.

Tunable wavelength converters (TWC s): TWCs belong to variable-input-variable –output WCs, which are capable of converting a band of wavelengths into another waveband .TWC is further divided into two subgroups according to its wavelength-conversion range: full-range WCs (FRWCs) are capable of changing any input wavelength into any output wavelength used in a fiber link, whereas limited-range WCs (LRWCs) can only convert a part of the used wavelengths to a limited number of output wavelengths.

Sparse wavelength conversion: The costs of all optical networks that deploy wavelength converters can be reduced by deploying wavelength converters only at a few well-selected network nodes rather than equipping each node with its own wavelength converter. This type of conversion is called *sparse wavelength conversion*. Analysis [5] indicates that, in most cases, either a relatively small fraction of the nodes has to be equipped with wavelength conversion capability for good performance. Important conclusion of their study is that the usefulness of wavelength converters depends on the connectivity of the network in a manner that cannot be predicted by intuition. When the connectivity is low (i.e. in the ring) converters are not very useful because of the high load correlation. This high correlation implies that the expected number of links shared by any two sessions is large; conversion just permutes the wavelengths used by the sessions without greatly increasing the ability to accommodate a new session. When the connectivity is high (i.e. in the hypercube or a densely connected random topology) converters are not very beneficial because of small hop-lengths, despite **low** load correlation and significant traffic mixing.

Conclusion:

Optical burst switching is a viable solution for efficient optical networks. In general, wavelength converters are more effective when the number of wavelengths is larger and when the load is lower. Blocking probability is not only one performance measure parameter, other parameter such as throughput and delay in a packet-switched network could be considered to study the usefulness of wavelength conversion. The high blocking probability is considered a serious challenging issue of OBS. Therefore, there is a strong requirement for contention resolution mechanisms (wavelength conversion, FDL buffers, and deflection routing, opto-electronic solutions), also with QoS support, applied in hardware or as an accurately operating control algorithm.

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