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Optical Burst Switching and Wireless communications - are they similar?

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Abstract

Optical Burst Switching (OBS) was an area of networks under intense research in the early years of this century. At some point, the interest in the area faded, but not without leaving a large and meaningful corpus of science, some of which can be of interest to other areas of the networking research world. The goal of this summary paper is to contribute to bring some of the research done in OBS that may be interesting in areas such as wireless communications.

1. Introduction

Optical Burst Switching (OBS) had its bright years in the first decade or so of this century. It was a promising technology that aimed to solve the problem of the inexistence of all-optical routers, in the sense that, between an ingress and an egress node in a network connected by optical fibers, the data units (packets if one wishes to call it so), have to be converted from electronic to optical form, transmitted to the next node, at this node, received in optical form, converted from optical to electronic form, interpreted, switched (or routed) to the appropriate exit port, and there, again, converted from electronic to optical form, and so on until the packet arrives at its destination. This was known as the O-E-O conversion, for Optical-Electronic-Optical. Differently, an all-optical router would do all the operation in an optical manner, as the packet would be received, processed, and switched by optical logic, but the technology as not evolved yet as to fill in this promise. This is known as Optical Packet Switching (OPS).

A network where the intermediate nodes have their switching matrix configured in a manner that packets entering the router in a given channel are always forwarded to another predefined channel, allow the creation of a circuit switching network, i.e., the network is configured as a set of predefined circuits, and the edge nodes act as add and drop points where the packets are received from the ingress interfaces and dropped at the egress interfaces. This is knows as Optical Circuit Switching (OCS). Yet, this is not efficient as it does not allow for the optimum use of the different channels that a single fiber may support.

So between the unfeasible all-optical packet switching (OPS) and the inefficient optical circuit switching (OCS), OBS proposed a compromise. The first notable feature of the OBS paradigm was the use of an off-band signaling scheme. In OBS, a Control Packet (CP) send in a dedicated control channel would allow the optical router to configure its optical switching matrix to allow the incoming burst to be forwarded without the O-E-O conversion. Many different algorithms and architectures have been proposed to maximize the throughput and minimize the collisions in OBS, but for the vast majority, the key is to send the control packet (that is electronically interpreted at each node) just the enough amount of time as to allow all the switches in the path to configure and reserve its resources to allow the successful passing of the data burst.

Because sending one control packet to configure the network optical routers for each of the packets that needed to traverse the networks was just as inefficient as performing Optical Packet Switching, the packets received from tributary networks would be assembled into bursts. The data bursts contain the packets that are destined to the same egress node, in a manner that aimed to maximize the size of the burst while minimizing the delay of packets.

In a nutshell, this is the Optical Burst Switching paradigm, and there were a couple of companies (not very successful from a commercial perspective) that sold OBS routers and solutions.

Stepping back to the beginning, the problem that OBS tried to solve was this: in optical networks, all egress nodes are hidden one from the other, i.e., an egress node has no way to know if a given resource at an intermediate router is going to be available for its data transmission. When two resources contend for a resource, say a switching matrix position or a given channel (in the case of Optical Networks, this could be described as a wavelength), there is a collision and one of the bursts is dropped.

And, to some extent, this is similar to the problem of the hidden node in wireless data transmission, a problem that is mitigated by the use of a series of mechanisms, including the IEEE 802.11 CSMA/CA (Carrier Sense Multiple Access / Collision Avoidance). In Wi-Fi the problem exists only between the Wi-Fi client (in the role of tributary network) and the Access Point (in the role of ingress node).

This paper tries to bring back some of the strategies that were researched in the context of OBS and raise the question of “are these useful for Wi-Fi”?

Regarding the title of the paper, it is quite clear that OBS is not similar to Wi-Fi.

2. Control Channel and control packet

In a similar manner, OBS and Wi-Fi can use several channels as transmission media. OBS can use different wavelength bands in a fiber, and Wi-Fi also uses wavelength bands, over space. In a similar manner to OBS, it probably makes sense to consider a specific channel to convey control and signaling messages. But also in a similar manner, this could make sense if the messages in the data channels are somehow composed of aggregated frames, as to form a burst of data (we'll discuss this later). The problem here is that for OBS, the control channel is a dedicated wavelength that undergoes O-E-O conversion and is not subject to collisions as it is a point-to-point dedicated channel. Yet, given the size of the potential control messages for Wi-Fi, this channel could possibly be used in a time multiplexed manner.

3. Data aggregation

In OBS, the packets are assembled into bursts at the ingress node, according to several criteria, the first and most relevant, its egress address in the network. Other criteria may be parameters regarding Quality of Service, packets flaged as urgent or from prioritary addresses. There is a large corpus of science produced in this area, but the advantages of burst aggregation seem evident, and not only for OBS but also for regular networks. It all comes down to the issue that both the ingress and egress nodes need to know how to perform the packet assembly and disassembly.

In a regular network data transmission, because of the very low Maximum Transmission Unit size (MTU) imposed by Ethernet (1500 Bytes), it is extremely common that a tributary machine forms a stream of packets. Also, transmitting data as bursts is not a new feature for Wi-Fi.

The problem of the separation of packets in the transmission needs to be further researched, arguing that with current data transmission speeds, the packets could possibly be sent back-to-back with little or no silence in between.

4. Additional points of research

OBS has a clear advantage regarding Wi-Fi when it comes to the number of channels that it has available. While for optical communications methods like Wavelength Division Multiplexing (WDM) and Dense WDM or ultra Dense WDM (DWDM, uDWDM) the number of channels is very large (from the tens to the hundreds), for Wi-Fi the number of available channels is quite limited, making it a hard choice to reserve a channel exclusively for signaling.

Another point of possible similarity of OBS with Wi-Fi is the self-signaling of the frames, as in fact, the transmitting node knows in advance what are its transmission requirements. The initial frame of the transmission could contain its own signaling data, allowing the Access Point to act accordingly, for example, by reserving just the additional time in the channel for that transmission.

6. Conclusions

Every time a new architecture or network paradigm arises, a set of very specific problems is discovered and calls out for attention. Yet, there may be similarities between the new field and previous research.

This paper has tried to raise questions rather than tried to answer them. OBS was eventually a branch in the evolutionary tree of optical networks, but that does not mean that this is a dry branch, nor does it mean that its fruits cannot be reused.

The issues of OBS data aggregation and signaling are among those that may still prove to be of interest.

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