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Low cost Parallel TCP optical Communication Between Data Centers

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Abstract:-**This presentation will discuss the relative merits of various monitoring schemes, and show that by providing faster turn-up time, minimizing dowii-time in case of ii fault and enabling performance optimization, optical domain performance monitoring provides cost savings to network operators. For applications applied in the Internet today, bit error requirements may be considerably alleviated as compared to those of synchronous digital hierarchy (SDH) systems without degrading the perceived quality of service for the end-user. A compact optical performance monitor for transparent dense wavelength division multiplex (DWDM) networks is demonstrated**

Keywords: **TCP/IP, DWDM, SDH, Optical performance, Data centers**

I. INTRODUCTION

The tremendous increase of data traffic in the worldwide Internet has driven the development of optical networks. They support dense wavelength division multiplex (DWDM) transmission, which is the enabling technology currently pushing the transmission bandwidths in optical core networks towards the multi-Tb/s regime [1-3].Transparent optical networks are a special kind of optical network as well as a transparent transmission domain within optical networks. The development of high speed computer networks and that of internet, in particular, has explored means of new business, scientific, entertainment, and social opportunities in the form of electronic publishing and advertising, real-time information delivery, product ordering, transaction processing, digital repositories and libraries, web newspapers and magazines, network video and audio, personal communication etc. The cost effectiveness of selling software, high quality art work in the form of digital images and video sequences by transmission over World Wide Web (www) is greatly enhanced as a consequence of technological improvement. The commercial exploitation of www is steadily being more appreciated. In WRON the optical wavelengths are used to simplify switching in the optical domain. A wavelength can be thought of as a transparent end-to-end connection passing through several switches without any processing between ingress and egress nodes. Alternatively, the wavelengths can be used in an OPS network to obtain a multiplexing gain. With OPS the payload is transparently routed through the optical network according to information contained inside its optical header. Some OPS schemes route individual data units (usually Internet Protocol packets) while other schemes aggregate packets destined for the same egress node inside the payload. OBS networks are characterized by a higher level of packet aggregation and the control information is sent ahead of the payload inside a control-packet

II. OPTICAL Q-METER

It uses an internal clock recovery that can be adjusted to various frequencies. Therefore, the OQM is not only independent of the binary data format, but also adjustable to given line rates. The principle of the OQM is shown schematically in Fig. 1.

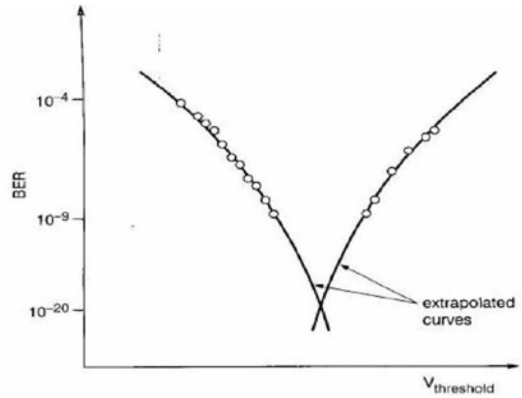

Fig.1 BER Estimation

An optical receiver detects the incoming optical signal. The electrical output of the optical receiver (data) is split into two signals and fed into a reference decision circuit (fixed reference voltage) and a variable decision circuit (voltage adjustable around reference voltage). In the reference decision circuit, the data signal is detected using the optimal threshold setting for the specific received signal. In contrast, the second decision circuit detects the data signal with a variable threshold, which is adjustable over the entire amplitude range between the ‘0’ and the ‘1’ level of the digital signal.

DC optical monitors generally consist of optical power monitor taps that estimate the average power. They are sometimes combined with the use of optical filters for wavelength selective power estimation or wavelength measurement. Low speed methods operate by adding a small analog signal to the optical signal of interest. The small analog signal can then be detected using inexpensive digital signal processing (DSP) methods. In undersea applications these functions are often combined with optical loopbacks [2]. High-speed methods fall into 2 categories: line error checking and amplitude histograms [3]. They both require high-speed electronics and are generally expensive, although they can measure all types of optical degradation

III. PARALLEL TCP THROUGHPUT

The expressions for end-to-end PLR are developed by considering the path of a packet being routed from its ingress node to its egress node in the network.

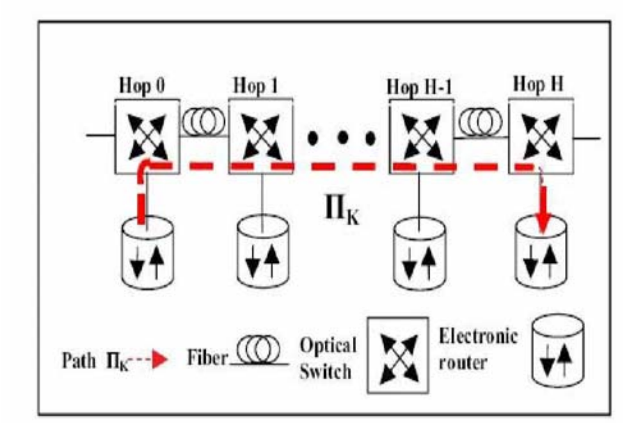

Fig.2 The optical packets burst in the path during HOPS

Fig. 2 represents an arbitrary end-to-end path πk in an optical network that traverses H+1 nodes from its source node to destination node, i.e. H hops. Since the path πk begins at the exit of the ingress router and ends at the entry of the egress router we only consider sources of packet loss in the optical path. Let the control-field contain C bits and let the payload consist of N IP packets of length mi, the index "i" ranging from 1 to N. M denotes the average packet-length, and the parameters related to the payload are linked by the following relation; P=∑mi = N·M bits. Total packet/burst length is L=C+P. Table I summarize the notations used in this article

Symbol	Symbol/parameter description
π_K	Optical path where PLR is computed
PLRT	Total packet loss rate (PLR) along π_K
PLRPHY	PLRPHY PLR due to physical impairments
H	Number of hops in path πK
mi	Length of IP-packet labeled "i"
M	Average length of IP-packets mi
P	Length of payload (fixed)
N	Average number of IP-packets inside the payload
C	Length of control-field
L	Total length of packet/burst. L =P+C
Rp	Number of regenerative points for payload along path π_K
Rc	Number of regenerative points for control-field along path π_K
BER	Bit error rate
Bp	BER for payload
Bc	BER for control-field
B	BER if BP=BC

Table I: List of parameters used

IV. PACKET LOSS AT THE NETWORK LAYER

The most commonly encountered effects for OPS/OBS are contention of packets/bursts at the output port [5] and failure to configure the switch before arrival of the payload [3] [4]. For some WRON networking schemes one may encounter the situation where a lightpath request is rejected [6], possibly resulting in massive packet loss. Table 2 lists the mentioned sources of packet loss and where they might be encountered.

Source of packet loss	WRON	OPS/OBS
PLR due to BER	YES	YES
PLR due to rejected light path request	YES	NO
PLR due to contention	NO	YES
PLR due to early arrival	NO	YES

TABLE II: PACKET LOSS IN WRON,OPS/OBS

When a packet/burst travels along its path π_k there is a possibility of encountering more than one effect at a time, e.g. a packet with one or more bit errors being blocked due to contention. By considering each effect as an independent phenomenon this possibility is ignored and the total packet loss would be overestimated. For most practical cases however, as will be shown, each individual source of packet loss will be limited by QoS considerations to values well below 10-3, a fact that effectively limits the chance of multiple faults. Using this approximation each source of packet loss can be treated independently

V. PROPOSED DWDM TEST BED

It consists of three sub-networks, a high channel capacity transmission line, a long haul transmission line and the metropolitan area network in Berlin (see Fig.3)

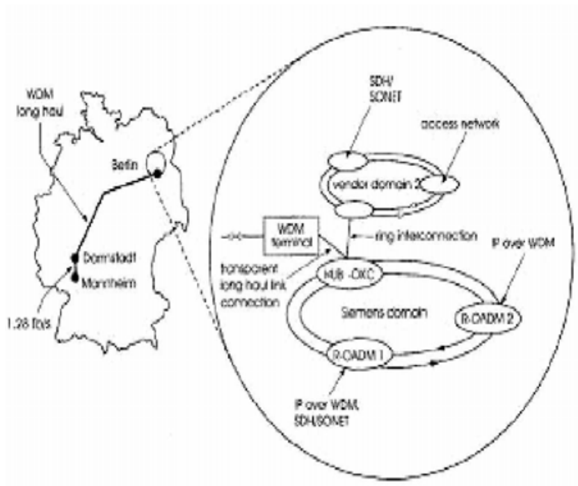

Fig.3 Architecture of Kom Net DWDM

The high capacity link is a 110 km long bidirectional transmission system for a final capacity of 1.28 Tb/s, which is deployed between the cities of Mannheim and Darmstadt (near Frankfurt). The 750 km transmission, which cannot be simulated under laboratory conditions. The system is designed to transport 16 x 10 Gb/s over the 750 km distance using only seven optical amplifiers but no inline o-e-o regeneration. The DWDM KomNet field trial consists of a bidirectional two fibre ring capable of transmitting up to 80 x 10 Gb/s. We can achieve this high capacity transmission in the ring network by using 50GHz interleaver technology [2]. The ring has a circumference of 60 km (spans: 11.7,23 and 25 km) with one optical cross connect (HUB-OXC) node and two remotely configurable optical adddrop multiplexers (OADM) at different locations (see enlargement in Fig. 3). The architecture of the configurable OADMs is depicted schematically in Fig. 4. Addingldropping of individual wavelength channels as well as 1 + 1channel path protection are performed exclusively in the optical network layer. Therefore, the OADM has three system stages with different functionalities: (i). a wavelength or optical frequency switching stage;(ii) a space switching stage; (iii) a protection switching stage.

The core of the OADM consists of a combination of fibre Bragg gratings (FBG) and optical circulators as wavelength or optical frequency switches (OADM-R units between the two optical line interface (OLI) cards

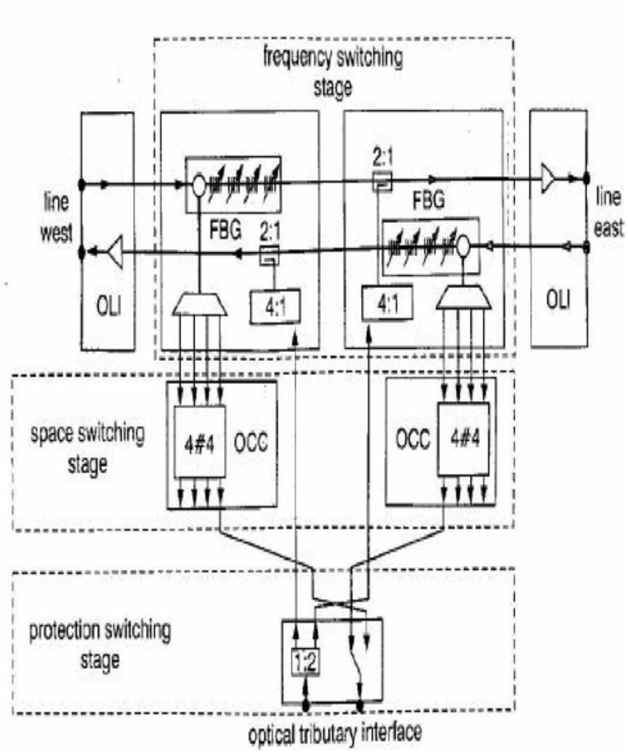

Fig .4 Architecture of add/drop multiplexers in DWDM Network

VI .RESULTS

In Figure 5 we plot packet loss rate due to bit errors, named PLRPHY, as function of BER with total packet/burst length L and number of hops H as parameters. The plots are derived from (4) which assume that the whole packet/burst will be discarded in presence of one or more bit-errors. Compared to the effects BER and packet/burst length we observe a limited sensitivity regarding number of hops

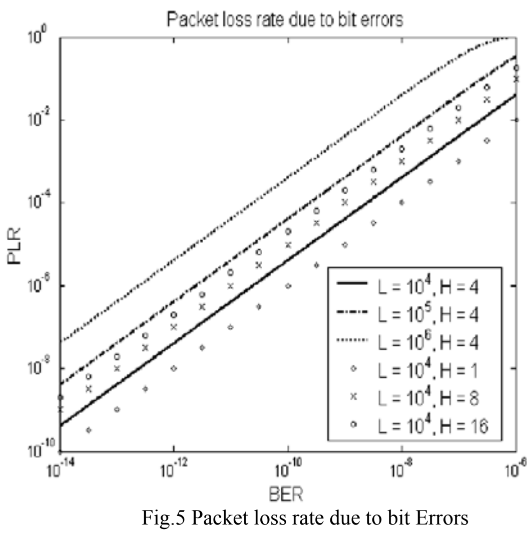

Fig.5 Packet loss rate due to bit Errors

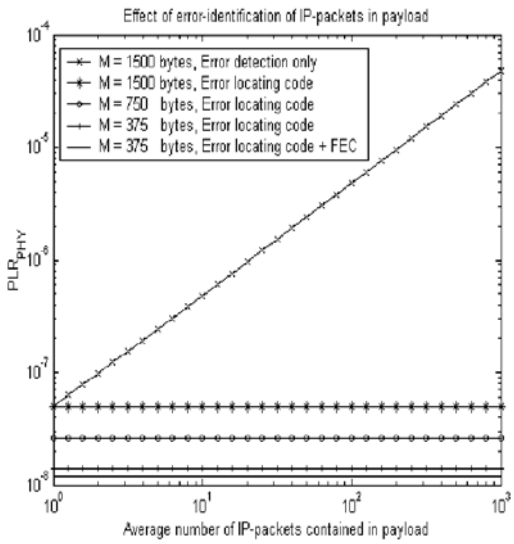

Fig.6 Comparison of PLR performance for OBS schemes

The upper curve illustrates that for a given average IP packet length the system without error locating code is less effective than a system with error locating code. That is the price paid for reduced complexity.

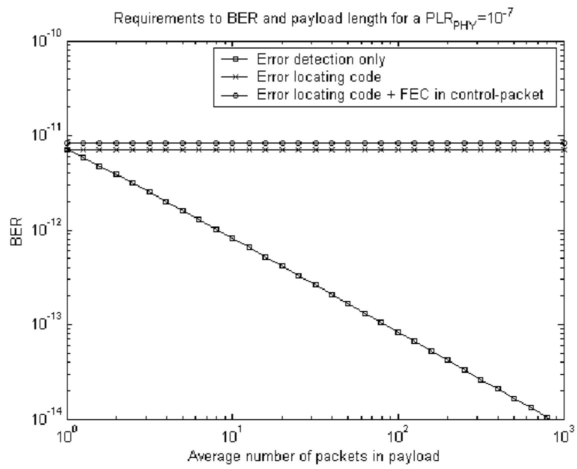

Fig. 7 Targeted PLRPHY =10-7, the curves illustrate required BER an-maximum number of packets

The three middle plots use error locating code in the control-field, each curve assumes a packet length distribution with mean M for the packets contained inside the payload. There is a clear performance difference with respect to average IP-packet length. This should not be surprising; a payload containing N long IP-packets will contain more bits than a payload with N smaller packets, hence higher PLR for the system carrying longer packets. M is significantly larger than C in the example above, thereby limiting the penalty involved when bit errors occur in the control-field. However, for OPS systems carrying IP packets of lengths that are similar to the control field length, the packet loss rate will significantly increase.

It should be remembered that the results were obtained assuming a relatively short control-field thereby yielding an important gain using error locating code. For OBS schemes with large bursts it is not necessarily trivial to achieve high gain, and efficient implementation of error locating code is required.

VII. CONCLUSION

This paper addressed the questions of effectiveness, fairness, and efficiency when applications use parallel TCP connections to increase throughput. We have presented a compact and low-cost device for optical performance monitoring. It works independently of data format and line rates, and is therefore very well suited for the rapid characterisation and in-service monitoring of transparent optical channel connections in alloptical, transparent and configurable networks. With the Q-factor method, providers of dark-fibre or leased wavelength services can infer the BER offered to their customers without knowing the actual data service running over the optical channel. This is particularly important in metropolitan networks with their large variety of different transport protocols. Assuming realistic network parameters we found that packet loss due to bit errors may be the dominant source of packet loss on the network layer. The TCP congestion avoidance algorithm is a simple control system that is designed to ensure effective, fair, and efficient allocation of network bandwidth between competing TCP flows. Future work on congestion avoidance should take into account the existence of systemic packet loss to ensure that the goals of effective, fair, and efficient allocation of bandwidth are realized.

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