Physical Layer Investigation of an Optically Enhanced Chassis with 8-Servers

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Introduction

Background: Chassis are employed in different places such as data centers for internet search engine or at university campuses for scientific modeling and simulation. But as the speed of the multi-core processors are increasing; the communication between servers is becoming difficult due to large amount of data transfer between their processors over a copper wire connection. Therefore optical solutions seem to resolve this issue by offering higher bandwidth.

Objective: The purpose of this project is to determine the viability of an optically enhanced chassis with eight servers having both point-to-point and broadcast link between the (eight) servers. The chassis is proposed by Reflex Photonics.

Project Details: The project aims to present a chassis with 8-servers; providing 8x10Gbit/s bandwidth for communication between servers with better power consumption. This is made possible by bringing optic closer to the processor and by using an optical backplane. The optical chassis is shown in figure 1, and the details of a LightABLE™ Optical Engine is shown in figure 2.

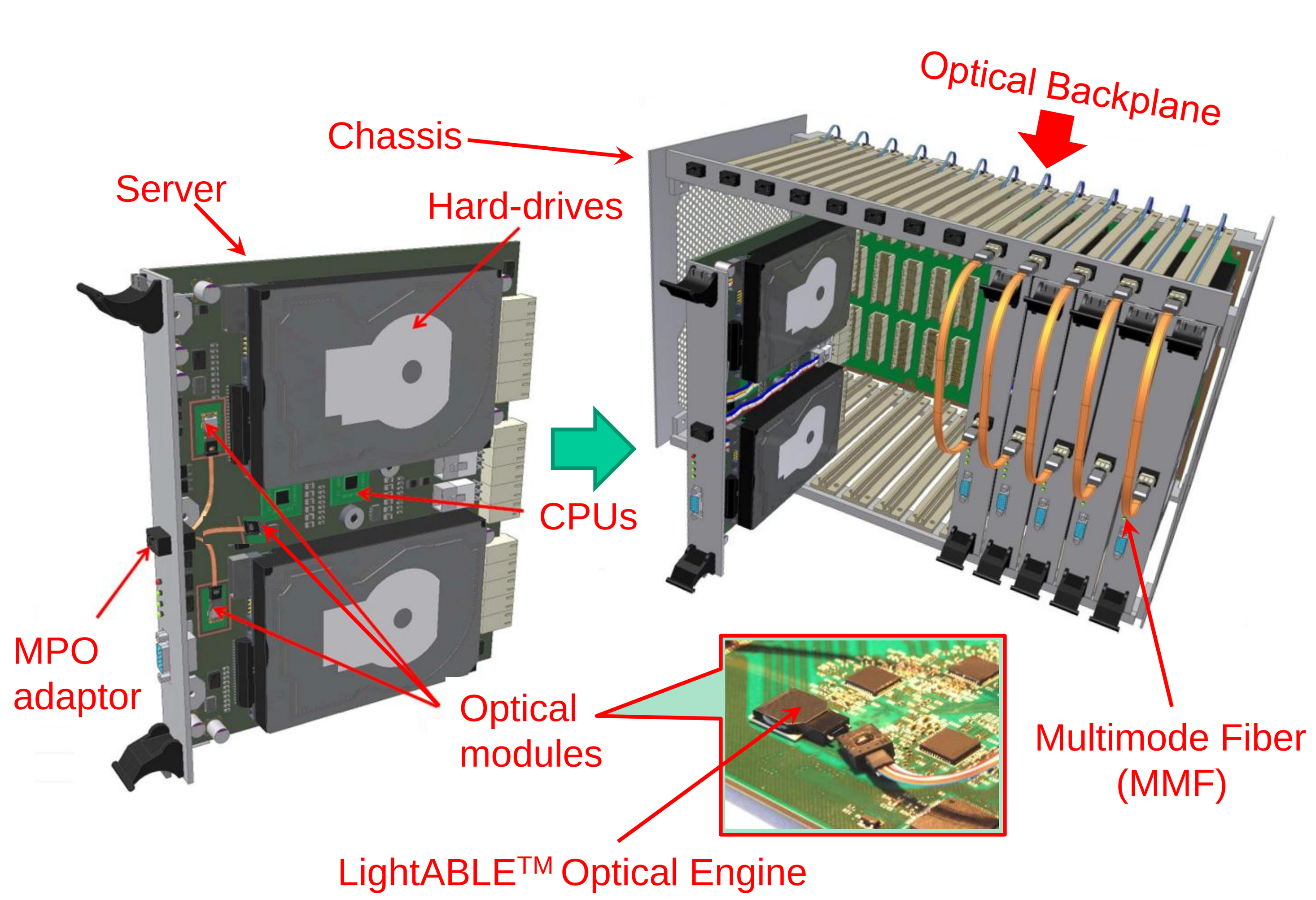

Fig. 1: An optically enhanced chassis. The chassis has an optical backplane with interconnections based on Mutlimode Fiber (MMF).And each server has three **LightABLE™ Optical Engines** (8-channels each) where one acts as a transmitter and the other two as receivers.

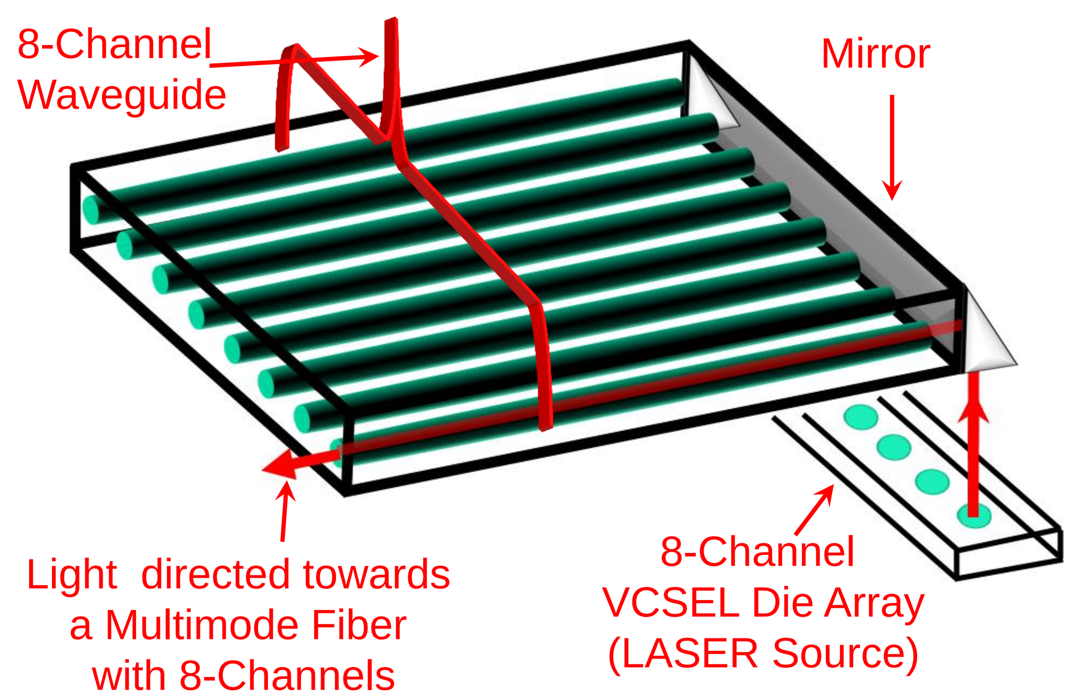

Fig. 2: Inside view of an **LightABLE™ Optical Engine** as a **Transmitter**. The VCSEL – converts electrical current into optical power and transmits a beam of light towards a Multimode Fiber; after the mirror deflecting the beam into the waveguide.
The optical engine as a **Receiver** would have a Photodetector Array instead of a VCSEL Array. The beam of light would then travel in the opposite direction and get deflected onto a photodetector – converts optical power into electrical current.

Methodology

The circuit in figure 3 shows the optical interconnection between **Server A** and the **Optical Backplane**. The interconnection between the remaining servers and the optical backplane is done in a similar fashion.

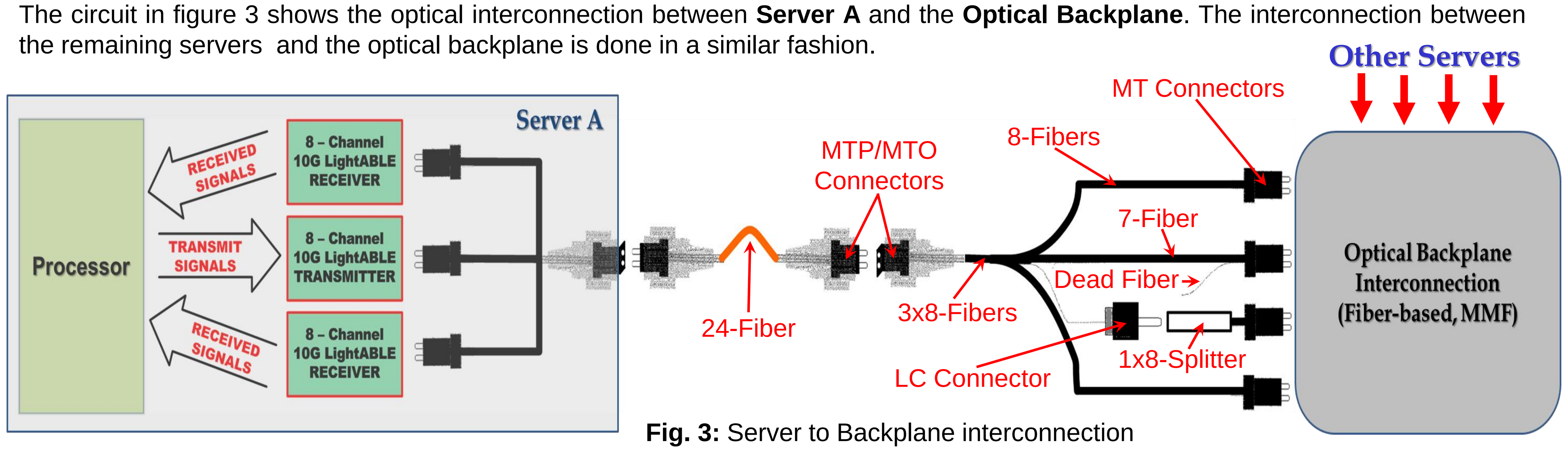

Fig. 3: Server to Backplane interconnection

Methodology (continued)

Since the components on all the servers are the same therefore a simulation can be done between two servers in order to determine the system performance. The simplified circuit in figure 4 is simulated in OptiSystem.

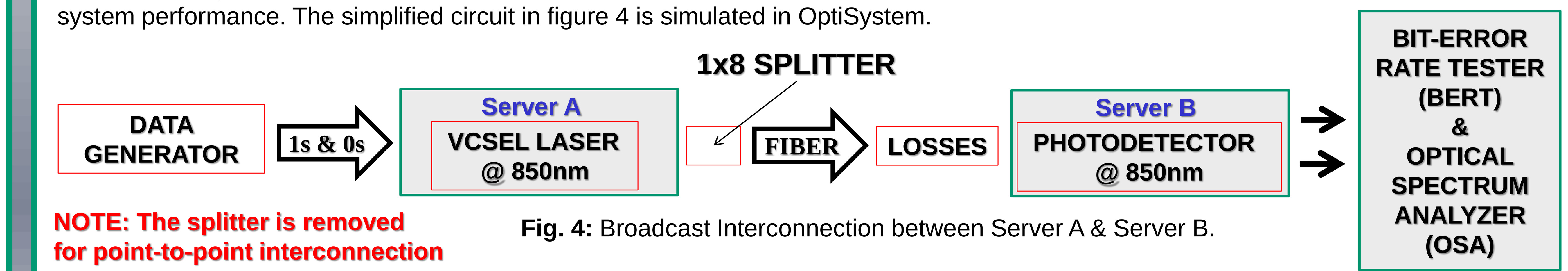

Fig. 4: Broadcast Interconnection between Server A & Server B.

The bits from the Data Generator are modulated by the LASER of **Server A** and transmitted as optical pulses to the Photodetector of **Server B** via a multimode fiber. These optical pulses are split into eight equal signals for broadcast, but not in the case of point-to-point communication.

Also, there are five connectors for broadcast (four connectors for point-to-point) transmission between each server and the optical backplane where each connector has an insertion loss of 0.5dB. Therefore between Server A and Server B the total insertion loss due to all the connectors is 5dB for broadcast (4dB for point-to-point) transmission.

The output signal is analyzed using a BERT – calculates the bit errors per total number of bits transmitted and an OSA – calculates the optical power of a signal.

Results and Discussion

The simulation results are summarized in the following table:

INTERCONNECTION BETWEEN SERVERS A & B	OPTICAL INPUT POWER (dBm)	INSERTION LOSSES (dB)	OPTICAL OUTPUT POWER (dBm)	CHANGE IN POWER (dB)	BIT-ERROR RATE (bits/second)
Point-to-point	6	4	2	4	0
Broadcast	6	5	-8	14	0

Table 1: Results for the interconnection between Server A & Server B.

The results seem to indicate a very good optical communication system since a **bit-error rate of 10^{-12}** is considered a benchmark. In order to reach this marginal level the system would have to experience more losses, therefore the losses were increased incrementally and the results are summarized in table 2.

INTERCONNECTION BETWEEN SERVERS A & B	OPTICAL INPUT POWER (dBm)	TOTAL LOSSES (dB)	OPTICAL OUTPUT POWER (dBm)	CHANGE IN POWER (dB)	BIT-ERROR RATE (bits/second)
Point-to-point	6	23	-18	24	10^{-12}
Broadcast	6	15.5	-18	24	10^{-12}

Table 2: Results for the interconnection between Server A & Server B if experiencing higher losses.

The results in table 2 shows the flexibility with respect to the total losses that this system could endure while meeting the bit-error rate standard of 10^{-12}. As a final point these simulations were done using a commercial VCSEL (LASER Source) and its physical parameters were generated with a component (available in OptiSystem) when some information from the VCSEL datasheet was provided. Therefore an improvement to this simulation can be done if the physical parameters are available.

Conclusion

It can be concluded from the simulation results that the system can endure losses as high as 15.5dB (23dB) for broadcast (point-to-point) transmission while maintaining the standard bit-error rate 10^{-12}.

Also the simulation could be improved if the physical parameters of the VCSEL are available. One possible way is to conduct a few experiments on a commercial VCSEL in the lab and then try finding its physical parameters.

Reference

[1] M.N. Sakib, M. Sowailem, M.S. Hai, H. Abbas, G. Azmy, R. Varano, D. Rolston, and O. Liboiron-Ladouceur, "Development of Optically Enhanced Interconnectivity for Computing Platforms, CIPI Annual General Meeting, May 2011.