Optics in Computing for "More than Moore" performance and "Beyond von Neumann" architectures

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How should someone exploit photonics in computing? Simply replacing the electrical with optical wires and increasing the datarate is the first and obvious answer, but the idiosyncrasy of photons can lead to improved architectures that can offer additional functionality in Datacom and computercom environments. This talk will concentrate on how photonics can bring significant functional benefits in computing architectures, extending along the past and the present of optical interconnect technologies up to the emerging area of photonics for Deep Learning and Neural Network processing machines.

We will cover the important progress made in the field of optical interconnects and related technologies during the last 10 years, discussing the main performance and energy challenges currently faced by the computing industry [1]. The current research efforts for releasing disaggregated DataCenter architectures will be outlined, addressing the employment of high-performance and high-functionality photonics that can ensure the high-bandwidth and low-latency communication metrics required at all hierarchy levels, spanning from rack-to-rack down to chip-to-chip interconnects [1]. We will demonstrate high-port count optical switch layouts based on the Hipoλaos Optical Packet Switch architecture with up to 1024x1024 input/output ports that allow for low-latency values well below the 1μsec target of disaggregated DCs [2]. We will also demonstrate how silicon photonics and electro-optic PCBs can be utilized towards realizing on-board resource disaggregation for multi-socket compute node applications, holding the credentials to replace the dominant QPI interconnect by offering >60% improvement in energy consumption with a single-hop flat interconnect topology for >8-socket connectivity [1].

Finally, we will demonstrate how optics can be incorporated in the emerging paradigm of neuromorphic computing towards offering high-performance at a significantly lower power envelope compared to electronic neuromorphic machines, introducing a new paradigm for the next decade of research in the non-von-Neumann computing landscape. We will present the main principles of neuromorphic photonic architectures together with the first experimental cornerstones along feed-forward, convolutional and recurrent neuromorphic architectures where optical hardware will be demonstrated to perform intelligent tasks in image and bit pattern recognition applications [3].

ACKNOWLEDGMENT: This work has been carried out within the frame of the European H2020 projects ICT-STREAMS, L3MATRIX and MASSTART.

REFERENCES

[1] T. Alexoudi et al., J. Lightw. Technol. 37, 363 (2019).
[2] M. Moralis-Pegios et al., J. Lightw. Technol. 37, 1415 (2019).
[3] G. Mourgias-Alexandris, et al., Opt. Express 27, 9620 (2019).