Large-Scale Integrated Photonics for Accelerated Communication and Computing

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ABSTRACT

The massive explosion in data acquisition, processing, and archiving, hindered by the end of Moore's Law, creates an opportunity for a complete redesign of the information technology stack, including hardware system architectures, devices, networks, and software to enable future computing systems with multi-exascale performance—and beyond. Key to success in this challenging endeavor will be the paradigm shift of moving from a processor-centric to a memory-centric approach. Architectural changes are necessary to overcome the limitations of the traditional compute-centric model, and will require new network layouts (e.g., Hyper-X) and new high-performance memory-addressing protocols (e.g., Gen-Z) that rely on a high-bandwidth and energy-efficient photonic interconnect. We will describe the state-of-the-art in datacom photonics and present the advances that will be necessary—and are already appearing in R&D laboratories—to enable memory-centric computing at scale.

Memory-centric computing would be an ideal heterogeneous platform for in-memory hardware accelerators that can be brought to bear on specific problems of scientific, engineering, or industrial interest. Ideally, a mature software ecosystem would simplify the design of a plug-and-play network interface that would allow users to compare the performance of the most advanced accelerators. We will describe such an accelerator—a coherent optical Ising machine--that targets NP-hard problems that scale exponentially as a function of system size and are common to applications such as traffic flow optimization, supply chain management, airline scheduling, and DNA sequencing. Optical Ising machines based on symmetry-breaking in pulsed optical parametric oscillators have already been shown to outperform a commercially-available quantum annealer, and there is good reason to believe that integrated photonic implementations of this approach can achieve similar results.

BIOGRAPHY

Ray Beausoleil is a Hewlett Packard Enterprise (HPE) Senior Fellow and a Senior Vice President, and an Adjunct Professor of Applied Physics at Stanford University. At HPE, he leads the Large-Scale Integrated Photonics research group, and is responsible for research on the applications of optics at the micro/nanoscale to high-performance classical and quantum information processing. His current projects include photonic interconnects for exascale computing, and low-power complex nanophotonic circuits. Ray received the Bachelor of Science with Honors in Physics from the California Institute of Technology in 1980, and his Ph.D. in Physics from Stanford in 1986 as a member of Ted Hänsch's research group. In 1996, Ray became a member of the technical staff at HP Laboratories. Among his early accomplishments at HP, he invented the optical paper-navigation algorithms incorporated into the HP/Agilent optical mouse, and now HP's large-format printers. He has published over 300 papers and conference proceedings and five book chapters. He has over 140 patents issued, and over three dozen pending. He is a Fellow of both the American Physical Society and the Optical Society of America, and the recipient of the 2016 APS Distinguished Lectureship on the Applications of Physics.