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Future HPC systems with Scalable, Modular, and Flexible All-to-All Optical Interconnects

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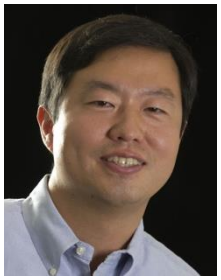
Abstract – We discuss a new computing paradigm enabled by embedded attojoule nanophotonics in both von Neumann and non von Neumann computing. The combined system expects to perform energy-efficiently with high-throughput for most workloads. For von Neumann computing, we will embed attojoule nanophotonics integrated with nanoelectronics in CPUs and memories to provide ultra-high throughput, minimal access latency, and low power dissipation that remains independent of capacity and distance. The computing systems exploit modular integration of energy-efficient 3D-electronic-photonic-ICs (3D EPICs) and their interconnections through all-to-all, contention-less, and arbitration-free wavelength routing in cyclic Arrayed-Waveguide-Grating-Routers (AWGRs). For non von Neumann computing, we are investigating attojoule nanophotonic neurons in photonic neural networks to enable extremely energy-efficient neuromorphic computing. In one estimate, 100x improvements in energy-efficiency compared to IBM's TrueNorth neuromorphic processors can be possible. Integration and scaling of the combined computing system, and efforts behind simulations and benchmarking will also be discussed.



Bio – S. J. Ben Yoo is a Distinguished Professor at the University of California at Davis (UC Davis). His research at UC Davis includes 2D/3D photonic integration for future computing, cognitive networks, communication, imaging, and navigation systems, micro/nano systems integration, and the future Internet. Prior to joining UC Davis in 1999, he was a Senior Research Scientist at Bellcore, leading technical efforts in integrated photonics, optical networking, and systems integration. His research activities at Bellcore included the next-generation Internet, reconfigurable multiwavelength optical networks (MONET), wavelength interchanging cross connects, wavelength converters, vertical-cavity lasers, and high-speed modulators. He led the MONET testbed experimentation efforts, and participated in ATD/MONET systems integration and a number of standardization activities. Prior to joining Bellcore in 1991, he conducted research on nonlinear optical processes in quantum wells, a four-wave-mixing study of relaxation mechanisms in dye molecules, and ultrafast diffusion-driven photodetectors at Stanford University (BS'84, MS'86, PhD'91, Stanford University). Prof. Yoo is Fellow of IEEE, OSA, NIAC and a recipient of the DARPA Award for Sustained Excellence (1997), the Bellcore CEO Award (1998), the Mid-Career Research Faculty Award (2004 UC Davis), and the Senior Research Faculty Award (2011 UC Davis).