ENergy-efficient Light-wave Integrated Technology Enabling Networks that Enhance Datacenters (ENLITENED)

The projects of the ENergy-efficient Light-wave Integrated Technology Enabling Networks that Enhance Datacenters (ENLITENED) program seek to double datacenter energy efficiency by deploying new network designs enabled by integrated photonics technologies. Datacenters are a critical component of the modern internet, responsible for processing and storing the tremendous amount of data in the "cloud." These huge complexes also provide the computational power needed for handling "big data," a growing segment of the U.S. economy.

There are many approaches to improve energy efficiency in datacenters, but ultimately, the metal interconnects currently used to transmit information between the devices within a datacenter limit the efficiency gains possible. ENLITENED seeks to overcome the limitations of these interconnects and to prioritize overall datacenter energy efficiency. To achieve this, projects will use high-density, energy-efficient photonic interconnects and related switching/networking technologies, with the potential to double data center efficiency over the next decade. Photonic interconnects do not rely on electrons flowing through metal to transmit information. Instead, these devices send and receive information in the form of photons—light—enabling far greater speed and bandwidth at much lower energy and cost per bit of data.

PROJECT DESCRIPTIONS

Ayar Labs, Inc. – San Francisco, CA

LytBit: An In-Rack Optical Communications System – $2,000,000

The Ayar Labs, Inc. team will develop new datacenter architectures by using silicon-based photonic transceivers, devices that transmit and receive information. The Ayar Labs team will develop methods to co-package their optical transceiver with a processor chip, increasing system efficiency by reducing the amount of "hops" between components. Project partners will assist with providing hardware for the system.

Columbia University – New York, NY

Photonic Integrated Networked Energy-efficient (PINE) – $4,400,000

The Columbia University team will develop a transformative new network architecture to reduce datacenter energy consumption system-wide. The Columbia team will target three pillars of work: (1) improving resource allocation throughout the datacenter by untangling computing and memory resources and connecting them with a unified photonic interconnect; (2) introducing the concept of datacenter nodes based on multi-chip modules (MCMs) connected by integrated photonics with high bandwidth; and (3) developing a new generation of silicon-based photonic links.

IBM T.J. Watson Research Center 1 – Yorktown Heights, NY

Multi-wavelength Optical Transceivers Integrated on Node – $3,408,000

The IBM T.J. Watson Research Center team will develop a two-pronged approach to improve future datacenter efficiency. First, the team will greatly increase the power efficiency of network links by developing chip-scale optical modules that can be co-packaged with a switch or processor integrated circuit chip. By eliminating most of the traditional driver and receiver electronics that are part of today's board-mounted optical modules, these new modules will greatly reduce the cost of linking two points in a network. Secondly, the team will utilize the co-packaged optics to increase bandwidth of the system chips by at least two times, which will improve power efficiencies across the datacenter.

IBM T.J. Watson Research Center 2 – Yorktown Heights, NY

Optical Network using Rapid Amplified Multi-wavelength Photonic Switches (ONRAMPS) – $2,450,000

The IBM T.J. Watson Research Center team will develop network technology incorporating extremely low-power photonic switching devices that operate on the nanosecond scale. The IBM team will utilize semiconductor optical amplifiers to reduce complexity and cost while meeting space and power requirements in photonic interconnects. Both developments will enable significant gains in computational efficiency, exploiting these technologies to build entirely new datacenter architectures that reimagine the placement of computational and memory resources to drastically boost efficiency.

Massachusetts Institute of Technology – Cambridge, MA

Seamless Hybrid-Integrated interconnect NEtwork (SHINE) – $1,258,850

The Massachusetts Institute of Technology (MIT) team will pioneer a unified, light-based communication technology that can be scaled across chip-, board-, and rack-interconnect hierarchy levels for future energy-efficient datacenters. The MIT architecture uses an optical bridge to connect silicon semiconductors to flexible ribbons that carry light waves. The optical bridge will be engineered to use low energy per bit of information while remaining easily integrated into other photonic components.

University of California, Berkeley – Berkeley, CA

IceNet for FireBox – $2,000,000

The University of California Berkeley team will develop a new network topology, IceNet, for its FireBox warehouse-scale computer (WSC). The FireBox WSC leverages the energy efficiency and bandwidth density of integrated silicon photonic interconnects to enable a new low-latency network (IceNet) that will connect large amounts of high-speed memory, where data is stored, with thousands of compute nodes, where data is processed. IceNet will enable dramatic improvements in datacenter system efficiency, allowing for fine-grain power control of processors, links, and memory and storage components.

University of California, Santa Barbara – Santa Barbara, CA

Intelligent Reduction of Energy through Photonic Integration for Datacenters (INTREPID) – $4,400,000

The University of California, Santa Barbara team will develop and demonstrate a technology platform that integrates efficient photonic interfaces directly into chip "packages." By designing and packaging photonic components in tandem, the UCSB team hopes to create highly efficient interconnects that allow for flatter network hierarchies needing fewer energy-sapping layers thanks to significantly higher bandwidth.

University of California, San Diego – La Jolla, CA

Lightwave Energy Efficient Datacenter (LEED) – $3,800,000

The University of California, San Diego team will develop (1) a unique, scalable energy-efficient architecture that is based on the distributed control of light-based circuit-switches; (2) a large-port-count low-loss optical switch technology that routes information carried as light waves; (3) packaged, scalable, energy-efficient optical interconnect technology designed for the optical switch that does not require optical amplification. By combining these three technologies, the UC San Diego team hopes to create a highly scalable, easily controllable, energy-efficient network architecture for datacenters.

University of Southern California – Los Angeles, CA

System Testbed, Evaluation, and Architecture Metric (STEAM) – $1,000,000

The University of Southern California team will provide a framework and testbed for evaluating the potential of proposed photonic and optical-electronic technologies to reduce overall power consumption in datacenters. The STEAM project aims to offer an impartial assessment of emerging datacenter concepts and architectures through a unified virtual and physical testbed network based on the U.S. Government's DETER cybersecurity research platform, a system that allows researchers to run experiments on a "virtual internet."