SEEDING the Future

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To protect their systems from network failures and to make sure that their data is delivered as fast as possible, popular services such as Google may replicate their data centers on multiple continents and at multiple sites based on their proximity to population centers. This presents two critical challenges for network systems researchers: interconnecting multiple computers within a single data center; and synchronizing individual data centers in wide-area replication.

Calit2 researcher Nikola Alic at work in the Photonics Lab, CIAN's shared-use testbed on the UC San Diego campus.

A University of California, San Diego-led team of computer scientists and optical interconnection systems technologists in the Center for Integrated Access Networks (CIAN) is developing Scalable Energy Efficient Data Centers (SEED, for short). It consists of novel optical interconnection technologies for a multi-stage network topology. The goal is to build SEED as an integrated solution encompassing physical layer hardware, protocols and topologies - while offering tomorrow's data centers greater scalability, bisectional bandwidth, fault tolerance and energy efficiency.

"This integrated solution would accommodate the growing size and performance required of future data centers, while minimizing the cost and energy per switched bit," says Shaya Fainman, a professor of electrical and computer engineering in UC San Diego's Jacobs School of Engineering, and Deputy Director of CIAN.

Currently working on the project with Fainman: fellow UC San Diego electrical engineering professor George Papen; UCSD Center for Networked Systems director Amin Vahdat; Columbia University professor Keren Bergman, who runs the CIAN satellite testbed at Columbia; Caltech professor Axel Scherer; and professor Ming Wu from UC Berkeley.

Shaya Fainman, Deputy Director of CIAN

Current state-of-the-art optical communication technologies work well for very short communication distances (e.g., computer backplanes operating at distances of hundreds of meters) or relatively long distances, such as the hundreds of kilometers over which metropolitan networks operate. The SEED concept could fill in the missing link.

Interconnecting multiple computers within a single data center is straightforward as long as the number of machines remains small (in the tens or hundreds). But modern electronic interconnect technologies make it almost impossible to deliver large, aggregate communication bandwidths between arbitrary nodes in a single data center.

CIAN researchers are developing novel integrated optical interconnection technologies for tomorrow's data centers. However, most of these technologies use somewhat discrete components and could not be integrated into large system arrays that can scale at low cost. Now that is changing, thanks to recent advances in nanophotonics using a silicon CMOS-compatible manufacturing process. Chip-scale, highly integrated optoelectronic solutions can now be realized at low cost, while still meeting the needs of future data centers.

The UCSD team, based in the Photonics Lab of the California Institute for Telecommunications and Information Technology (Calit2), is developing the SEED instrument to create the technology base for an order-of-magnitude improvement in both the cost and energy per switched bit. "It can also act as a platform for training the next generation of network engineers who must be equally versed in optical and electrical networks," adds Fainman. "This CIAN research has important ramifications for everyone. After all, technologies that enable larger and more energy-efficient information processing in data centers will affect almost every aspect of life in the digital age."

CIAN is an NSF Engineering Research Center (ERC) headquartered at The University of Arizona. CIAN aims to provide the technological foundation for an advanced optical network that simultaneously achieves efficient high data rate aggregation, amortizing the cost for end users, while providing the necessary flexibility to support diverse end-user requirements. The development of these technologies is essential for delivery of single-user data rates approaching 10 Gigabits per second and provision of the associated services to a broad population base, regardless of "last-mile" technology.

CIAN's Testbed Infrastructure, led by UA professor Franko Kueppers, includes the main, shared research testbed at UC San Diego (co-led by professors Stojan Radic and George Papen), as well as satellite testbeds at Columbia University (with Keren Bergmann as lead) and the University of Southern California (led by Alan Willner).

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