CENTER FOR INTEGRATED ACCESS NETWORKS

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In This Issue

Director's Message

I would like to thank everyone who helped in the NSF site visit held on May 6 and 7, 2009. I am encouraged by the good news that NSF has recommended continuation of funding of CIAN for Year Two.

The NSF Panel expressed areas of improvement as indicated to us during their visit. Our Center is already taking steps to address those concerns by creating three working groups including cross-layer optimization with programmable optical layer (WGI), data centers (WGII), and testbed integration and access aggregation (WGIII).

The efforts of the working groups and the workshop will lead to the identification of the key trends, technical requirements, and challenges (bottlenecks), as well as matching the desirable outcomes with CIAN's present and future capabilities.

Accordingly, a strategy document that defines activities for CIAN that most closely match challenges and CIAN specific capabilities and resources will be formulated.

I look forward to seeing everyone and discussing the outputs of these groups at the CIAN retreat in the fall.

Dr Nasser Peyghambarian

Creating Transformative Optical Technologies to Enable an Affordable,Faster Internet for the Future

The Center for Integrated Access Networks (CIAN), an Engineering Research Center (ERC) headquartered at The University of Arizona, is focusing on removing one of the last bottlenecks in the Internet by developing optoelectronic technologies for high-bandwidth, low-cost, widespread access and aggregation networks.

The vision of CIAN is to create the "PC" equivalent for the optical access and aggregation network. It entails transforming the costly, discrete optoelectronic technologies of today's network into affordable, highly integrated optoelectronic subsystems that demonstrate novel optical network functionalities and infrastructure, enabling heterogeneous services.

CIAN's ultimate goal is 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 Gb per second and provision of the associated services to a broad population base, regardless of the "last-mile" technology. Attainment of this goal will enable affordable, flexible access to any type of service to anybody, anywhere, at any time.

Research Highlight

Ming-Chun Tien at UC Berkeley has been awarded 2009 Infinera Outstanding Student Recognition for his paper titled "Optofluidic Assembly of InGaAsP Microdisk Lasers on Si Photonic Circuits with Submicron Alignment Accuracy" presented at the 2009 Optical Fiber Communications (OFC) Conference.

A novel optofluidic assembly technique was demonstrated to integrate pre-fabricated III-V microdisk lasers on fully-processed CMOS wafers. This room-temperature optofluidic assembly process was realized using lateral-field optoelectronic tweezers.

Microdisk lasers were assembled on Si nanophotonic waveguides with sub-quarter-micron accuracy (determined by lithography). The on-chip lasers have potential applications in intra-chip and inter-chip optical interconnects. This technique can be used to assemble other heterogeneous nano-components. Silicon photonics offers a potential paradigm shift for photonic integrated circuits by leveraging on existing CMOS foundries and microelectronics infrastructures. Integration of on-chip laser sources has been difficult without requiring changes in the CMOS process, which will significantly increase the cost and partially offset the benefits of Si photonics. This optofluidic assembly process is like a "nanoscale pick-and-place" and does not require custom CMOS processing. The ultimate goal is to integrate electrically pumped microdisk lasers on CMOS Si photonics wafers. Optofluidic assembly is controlled by a digital light projector, which lends itself to parallel assembly. Wafer-scale assembly is another goal that this CIAN group is working towards.

CIAN Testbeds

Dr. Franko Kueppers, CIAN Testbed Lead and Associate Professor of Optical Sciences, The University of Arizona

CIAN's main testbed, located on the campus of UC San Diego, is a shared research facility where CIAN's research from the various thrusts is integrated, enabling collaborative research among CIAN participants and with the wider research and industrial community.

CIAN's Testbed Infrastructure, led by Franko Kueppers (pictured above) from The University of Arizona (UA), includes the testbed at UC San Diego for shared use, as well as satellite testbeds at Columbia University and the University of Southern California (USC). Professors Stojan Radic (pictured at bottom in the UCSD lab) and George Papen are co-leads on the UCSD facility, with Keren Bergman leading the satellite testbed at Columbia and Alan Willner at USC.

From left: UCSD's George Papen, Columbia University's Keren Bergman, and USC's Alan Willner

UCSD's Calit2 information technology facilities, including contiguous laboratory space and unique test capabilities, are at hand to assist in achieving CIAN's testbed vision, which is to:

- Provide a vertically integrative cross-thrust platform for testing CIAN technologies in a more system-driven environment than what individual academic laboratories offer.
- Enable measurement of key metrics for potential applications.
- Identify to CIAN researchers the key limitations and technology specifications that require improvement.
- Foster collaborations with industry and showcase CIAN technologies.
- Provide a unique educational environment for training graduate, undergraduate, and K-12 students.

If you are interested in learning more about the capabilities of our testbeds or would like to affiliate your industrial research efforts with CIAN, please feel free to contact Dr. Franko Kueppers at franko.kueppers@optics.arizona.edu.

Prof. Stojan Radic in Calit2 Photonics Lab, home of the CIAN UCSD Testbed

SEEDing the Future

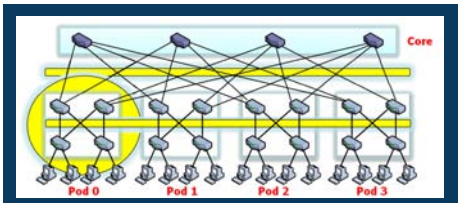
To protect their systems from network failures and to make sure that their data is delivered as fast as possible, popular services such as Google may replicate their data centers on multiple continents and at multiple sites based on their proximity to population centers. This presents two critical challenges for network systems researchers:

- Interconnecting multiple computers within a single data center; and
- Synchronizing individual data centers in wide-area replication.

CIAN's UC San Diego-led team of computer scientists and optical interconnection systems technologists is developing SEED, short for Scalable Energy Efficient Data Centers. 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, CIAN's Deputy Director and a professor of electrical and computer engineering in UCSD's Jacobs School of Engineering.

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



Scalability using identical network elements: fat tree built from 4-port switches, with 16 hosts organized into 4 pods, and full bisection bandwidth at each fat-tree level.

Current state-of-the-art optical communication technologies work well for very short communication distances (e.g., computer backplanes operating at distances of 100's m) or relatively long distances, such as the hundreds of kilometers over which metropolitan networks operate. The SEED concept could fill in the missing link.

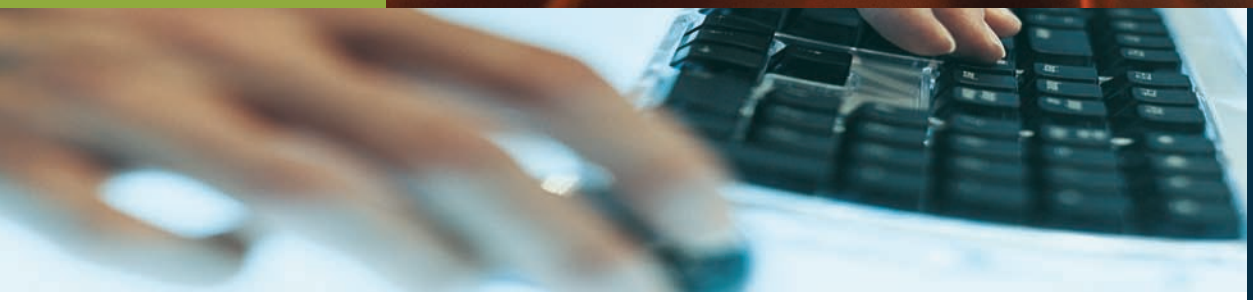
Interconnecting multiple computers within a single data center is straightforward as long as the number of machines remains small (in the tens or hundreds). But modern electronic interconnect technologies make it almost impossible to deliver large aggregate communication bandwidths between arbitrary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

Our current industrial interactions on future data center technologies include Sun Microsystems, IBM, HP and CISCO.



Working Groups

Working Groups have been designed to focus CIAN's systems vision on particular research projects. Input from industry, through CIAN's industrial membership base as well as GENI participants, is utilized for a high-level networking perspective on CIAN's research projects.

Currently technical jargon, such as "access aggregation" and "cross layer optimization", is inconsistently defined throughout the communications community. This ambiguity is a roadblock for academic/industrial collaborations and thus CIAN seeks to set a precedent of consistent terminology.

CIAN's three working groups are tasked to take a leading role in this clarification, and their analysis and conclusions will be distributed to the CIAN members and presented at the annual retreat. In particular, the three Working Groups established are:

- WGI on Cross-layer Optimization with Programmable Optical Layer
- WGII on Data Centers
- WGIII on Test-bed Integration and Access Aggregation

Education Update

CIAN's Education and Outreach programs include:

- Creating vertically integrated (from pre-college to post-graduate) curricula which are team-based, research-inspired, and industry-oriented;
- Promoting cross-disciplinary, diversity-oriented approaches to education for university researchers, college students, K-12 students, teachers, and the general public;
- Educating a skilled and diverse workforce to lead the next-generation communications industry;
- Integrating engineering, technology, and business education into the knowledge base of CIAN's students to stimulate technology transfer.

The Center is developing new programs of outreach, creating internship/mentoring programs, and developing assessment and tracking processes.

Optics Summer Camp

During the week of June 8-12, nineteen local Tucson high school students spent their afternoons at UA's College of Optical Sciences. The lighthearted curriculum included a variety of lectures, experiments, and demonstrations to teach an introduction to optics. The student's measured the speed of light by microwaving a plate of marshmallows and identifying the "hot spots." The optical property known as index of refraction was visualized by a Schlieren imaging system, after careful optical alignment helium could be seen rising from a balloon and loud screams created detectable pressure waves.

Student Leadership Council Retreat

CIAN's Student Leadership Council conducted its inaugural retreat May 7-8, 2009, led and organized by CIAN student Julian Sweet. A variety of activities were conducted to promote greater interaction and understanding between CIAN students representing the different institutions.

CIAN RET Program at UC San Diego

The Research Experiences for Teachers (RET) program is one way CIAN accomplishes its educational outreach goals. At UC San Diego three science teachers from Sweetwater High School , Preuss School and High Tech High participated in the 6-week summer program from June 29 to Aug 7, 2009. The teachers utilized resources that were available to them to develop lesson plans that excite and revitalize student interest in STEM careers. As a group, the teachers have been actively involved in an educational research project on remote access to the high-end Photonics Lab, and they worked on ways to present newly-possible and sophisticated experiments to high school, and even middle school students.

EYE ON IT
Industrial Collaboration Program

CIAN's Industrial Collaboration and Technology Transfer Program is involved in all aspects of the center's strategic planning, supervision of and collaboration in research projects, operation of testbeds, mentoring of students and postdoctoral fellows, and education. The goals of this program are to provide an industry voice in CIAN; industry guidance in the selection and emphasis of research projects; an avenue for tech transfer from CIAN to industry; and a path for industrial support of and participation in educational programs.

Industrial Member Benefits Include:

- Access to the CIAN test bed for prototype testing.
- Access to faculty expertise for problem solving, consultation and research collaboration.
- Access to students from the partner universities.
- Access to state-of-the-art facilities at each partner university.
- Invitation to the annual IAB Meeting that includes presentations by CIAN researchers and member companies; and opportunities to interview prospective employees.
- Participate in guiding CIAN's strategic project selection process.
- Enter into sponsored research projects with CIAN faculty.
- Graduate student and postdoctorate internship and mentoring opportunities.
- Opportunities for industrial researchers to work at partner university labs.
- Access to CIAN related intellectual property for the purpose of CIAN research within Members own facilities and for the duration of the ERC

Upcoming Events

- **Nov 10, 2009**

  IAB Meeting
  Los Angeles , CA

- **Nov 11-12, 2009**

  CIAN Retreat
  Los Angeles , CA

- **April 1, 2010**

  SAB Meeting
  New York , NY

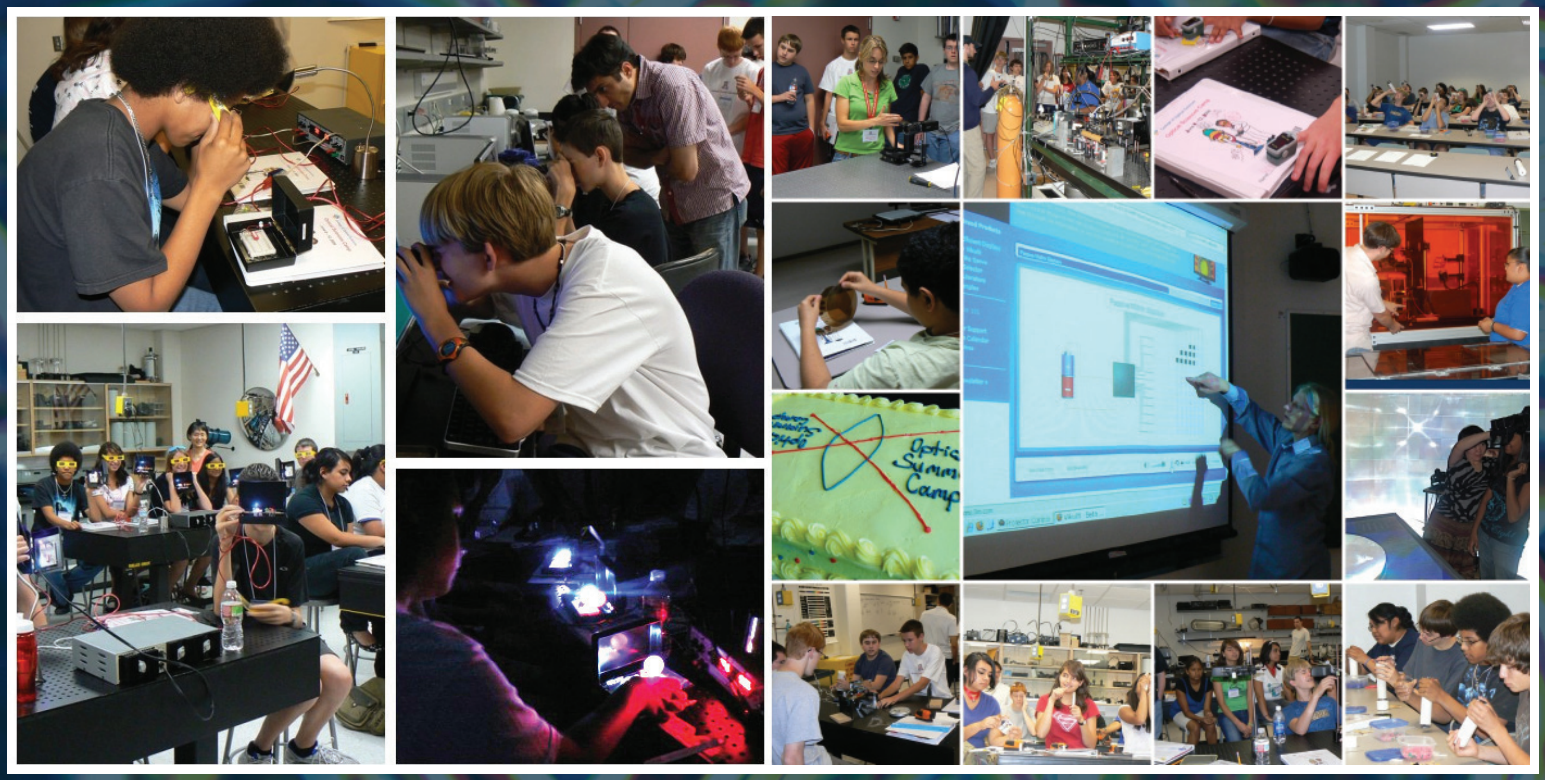
CIAN Leadership

Have a question about CIAN? Want to make contact about industry collaborations, research thrusts or educational opportunities? CIAN's leadership invites inquiries and they stand ready to respond. They include:

Director	Dr. Nasser Peyghambarian *nnp@u.arizona.edu*
Deputy Director	Dr. Yeshaiahu Fainman *fainman@ece.ucsd.edu*
Administrative Director	Dr. Eugene Cochran *ecochran@optics.arizona.edu*
Education Director	Dr. Meredith Kupinski *mwhitaker@optics.arizona.edu*
Industry Director	Dr. Robert Norwood *rnorwood@optics.arizona.edu*
Thrust 1 Lead	Dr. Alan Willner *willner@usc.edu*
Thrust 1 Co-Lead	Dr. Keren Bergman *bergman@ee.columbia.edu*
Thrust 2 Lead	Dr. Axel Scherer *etcher@caltech.edu*
Thrust 2 Co-Lead	Dr. Ming Wu *mingwu@berkeley.edu*
Thrust 3 Lead	Dr. Connie Chang-Hasnain *cch@eecs.berkeley.edu*
Thurst 3 Co-Lead	Dr. Hyatt Gibbs *gibbs@optics.arizona.edu*
Testbed Lead	Dr. Franko Kueppers *franko.kueppers@optics.arizona.edu*
Testbed Co-Lead	Dr. George Papen *gpapen@ece.ucsd.edu*
Testbed Co-Lead	Dr. Stojan Radic *radic@ece.ucsd.edu*

UA's Meredith Kupinski directs CIAN's educational activities, while the university's Robert Norwood oversees CIAN's industry collaboration and innovation focus.

Optics Summer Camp & SLC Retreat



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