Center for Experimental Research in Computer Systems

Georgia Institute of Technology
Ohio State University

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IUCRCERCS NSF Industry University Co-operative Research Center
Mission

Lead the innovation of systems, computing, and information technologies, to further the development of the interactive and distributed information services of the future, and to create the intellectual capital that can advance these technologies and fuel future discoveries.
Extended Mission

• Educational:
  – Seed new curricula and serve as a curricular resource for educational institutions worldwide
  
  – Business models for curricular and professional education delivery
  
  – Training of graduate students through the administration of an extensive internship program

• Outreach:
  – Work with our alumni to create new opportunities and build networks
  
  – Service to the broader community
CERCS Research Thrusts

- **Multicore Software Stack**
- **Energy Management**
- **Systems Infrastructure & Management**
- **End User Engagement**

### Scientific Computing
- **Programming models & Compilation** – IBM, Intel, Google, Logicblox
- **Execution models & run-time systems** – IBM, HP, NVIDIA
- **Heterogeneous Multicore Platforms** – IBM, Intel, HP, DOE Sandia, Keeneland
- **GreenCloud** – Intel, HP, IBM, OSIsoft
- **Configuration Management for Power Efficiency** – ATT
- **Power Efficient Global Memory Systems** – Intel
- **Platform Power Usage and Thermal Signatures**
- **CETI program** – OSU

### Enterprise Systems
- **High Performance I/O** – DOE
- **Entertainment Clouds** – Motorola
- **Privacy in Healthcare** – Childrens Hospital (joint with GTISC)
- **Cloud Computing Critical Enterprise and Data-Intensive Systems** – IBM, ICE, Yahoo, HP, Intel, Wipro

### Mobile Systems
- **Sample Research Projects**
Strategic Thrusts - Highlights

- **Scientific/Technical Computing – ’Big Data’: Scalable, Reliable Access:**
  - **GT: IHPCL Laboratory** (Intel and NVIDIA donations *Heterogeneous Virtualized Multicore (HVM) Platforms Lab – GPU, Tolopai, and newer asymmetric platforms*); Intel multicore education - cercs.gatech.edu/multicore;
  - **DOE: ORNL, Sandia:** *High Performance I/O initiative*; involvement with startups (RNet – Ohio); joint proposals, joint research/interns, joint papers, joint work with CMU.
  - **IBM/Intel** (IBM OCR grant: managed multicore systems, *Intel* - HVM; *LogicBlox* (Atlanta); interest from *ICE* (Atlanta)
  - **News:** Exascale dimensions explored in outstanding proposals; **NSF Track II** ‘Keeneland’ heterogeneous cluster machine, July 1 installation; New awards from DOE ORNL, Sandia; *Intel* educational efforts; joint proposals with Emory CCI – complex data sets
Strategic Thrusts - Highlights

- **Embedded Systems/Computer Architecture: Focus on Multicore:**
  - Boeing (testing – Mary Jean Harrold, also continued collaboration with TATA)
  - **IBM/Intel** (asymmetric multi-core platforms; ‘islands of cores’; NUCA and NUMA properties); **NVIDIA** GPU-based results (Kim, Yalamanchili)
  - **Motorola** (virtualizing mobile platforms; future home entertainment)
  - **Federal**: pervasive applications (transportation, robotics, sensor)
  - **Google** (data structure recognition and perf. characterization)
  - **Logicblox** (heterogeneous parallelism – data/threads and GPU acceleration)
  - Samsung (Star Center) center - separate efforts
  - **News**: GreenIT focus permits linkage with ‘Smarter Planet’ initiative (**IBM**); **Motorola** (joint with GVU and other research centers at Georgia Tech) with focus on EaaS (entertainment clouds): IP-TV head end used at GT; **NSF** award in privacy in mobile and pervasive systems (Ling Liu); **NSF** ‘Web on Demand’ (Ramachandran/Essa); **NSF** CRI simulation award (Yalamanchili et al.); **NSF** GPU autotuning award; **NVIDIA** and **Intel** equipment and student fellowship awards; Gavrilovska book on high performance communications; **NSA** funding on 3D die stacking (Lee)
Strategic Thrusts - Highlights

- **Enterprise Computing – Clean Information: Adaptive, Trusted, Sustainable:**
  - Cisco, (Netronome) (network and device virtualization)
  - IBM, Intel, OSIsoft, Yahoo (critical enterprise cloud computing (CECCS); autonomies in virtualized systems; SOA; I/O virtualization; trusted passages/reliable operation; coordinated power management; `GreenIT’ effort joint with ME; GreenIT FRP award to GT faculty group; new **GT TechWay** facility)
  - HP (automated deployment; scalable, `vManage’ open source data center management and monitoring; toward `monalytics’ exascale utility clouds, via OpenCirrus)
  - Travelport (runtime behavior/fault detection)
  - ICE (high performance financial codes; automated configuration management – also with ATT Labs)
  - VMWare (joint effort in cloud computing); numerous summer interns
  - Wipro (cloud computing) and Wipro – India; Infosys – India; GT India; `Service’ focus for Fall 2010 meeting
  - News: **GreenIT** effort receives large award: NSF CRI; OpenCirrus membership; NSF-funded projects on data privacy in mobile and in healthcare (Childrens Hospital); `health cloud’ collaboration with Center on Comprehensive Informatics (Emory); new NSF awards (e.g., debugging – Orso, spam detection - Pu); joint work with CMU, Intel Pgh; keynotes and invited talks by CERCS faculty; Yahoo student award
3000+ Cores (CERCS) in the Data Center Lab (ME)

- 1200 Sq. foot floor space
- 79,200 CFM of air supply
- 6 CRAC units, 4 Downflow and 2 Upflow
- 4 rows with 7 racks per row
- 3 feet under floor plenum
- Perforated tiles with variable area dampers

415 W/ft²
Power density
18kW average rack power density
Can be split to two 600 sq. ft. partitions.
Various air flow distribution modes

Yogendra Joshi: International Workshop on *Thermal Design and Management in Electronics*, January 8th 2010, Mumbai, India
Strategic Thrusts - Highlights

End user engagement – CETI@OSU (Ramanathan, Ramnath)


- Modeling and Analysis Frameworks for Adaptive Complex Enterprises (ACE)
  - Enterprise modeling and analysis for architecture evaluation, operational improvements
  - Outputs: Reference Enterprise Architectures, Governance methods, Roadmaps, Portfolios

- Collaborative Enterprise Systems (KI) – The ‘Mirror’
  - For enabling collaboration, service composition, intelligence mining, location-based services
  - Outputs: Reference system architectures, Design of intelligent services, component models, integration architectures.

- Integrated Development Environments (IDE)
  - For developing, managing and monitoring the ACE
  - Outputs: Tools, cognitive models

- Software Engineering Research and Education (SE)
  - Agile and structured SDLC, ITIL, Technology Strategy and Management, Enterprise System Architecture Design and Evaluation
  - Outputs: Case studies, methodologies, education models, curriculum
## High Quality Engagement

### Nationwide Insurance 2005-2010

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<thead>
<tr>
<th>Current Research</th>
<th>Classroom and Peer-Based Learning</th>
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<tr>
<td>• Data center power conservation</td>
<td>• 11 EA Forums</td>
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<td>• Document management reference architecture</td>
<td>• Enterprise Java workshop</td>
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<td>• Business Intelligence Reference Architecture</td>
<td>• Innovation and leadership workshop</td>
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<td>• CETI Colloquia</td>
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<td>• Curriculum influence of MEL program</td>
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<th>Collaboration metrics to-date:</th>
<th>Next Steps:</th>
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<td>• 8 research projects</td>
<td>• Placement: graduate interns and hires</td>
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<td>• Interactions with 30+ local companies and CERCS at Georgia Tech.</td>
<td>• Involvement in Capstone projects</td>
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<td>• 35 Nationwide personnel</td>
<td>• Professional development programs</td>
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<td>• 40 students</td>
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<td>• 5 internships (one current), 1 hire</td>
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...for broader impact/reach: Agrawal, Arora, Srinivasan, Stev...
CERCS Personnel

• Faculty

• Associated Faculty/Researchers
  – Tucker Balch (GT-Robotics), Patrick Bridges (UNM), Ron Brightwell (Sandia), Irfan Essa, Byron Jeff (Clayton State), Yogendra Joshi (ME), Scott Klasky (ORNL), Tahsin Kurc (Emory), Kang Li, Sung Kyu Lim, Arthur Maccabe (ORNL), Vernard Martin (Emory), Vincent Mooney, Jeff Nichols (ORNL), Ron Oldfield (Sandia), Kalyan Perumalla (ORNL), Joel Saltz (Emory), Jeff Vetter (ORNL), Patrick Widener (Emory)
Industrial Relations

• IUCR CERCS Center
  – Contributors (GT): Boeing, Cisco, Delta, DOE, Fujitsu, HP, IBM, ICE, Intel, LogicBlox, Motorola, Netronome, NVIDIA, OSIsoft, TCS, Travelport (Worldspan), VMWare, Wipro, more in Ohio
  – Industry Workshops and Industrial Advisory Board

• Joint initiatives - e.g., Ohio State (joint curriculum/facility efforts), joint work with Emory’s CCI, OpenCirrus participation, CMU collaboration

• Internship Program
  – Amazon, ATT, CISCO, Dell, Delta, (DoCoMo), DOE (ORNL, Sandia), Google, HP, IBM, ICE, Intel, Microsoft, Motorola, NEC, NetApp, QualComm, (Radisys), TCS, TravelPort (Worldspan), VMWare, Wipro, Yahoo

• Evolving relationships:
  – Amazon, ATT, DoCoMo, Microsoft, NEC, NetApp, NVIDIA, QualComm, Raytheon, RNet, VMWare, Yahoo, Xilinx