Programming Languages Research at the University of Colorado, Boulder

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PL research at CU has **breadth**!

**How do we effectively express computation?**
- Language design, type systems, logic

**How do we assist reasoning about programs?**
- Program analysis, development tools

**How do we make programs run efficiently?**
- Performance analysis, compilation

**How do we get reliable, secure software?**
- Verification, model checking
PL researchers at CU collaborate!

language design

Gradual Programming

Devin Coughlin

You?

Dynamic Algorithmic Complexity

program analysis

Access Nets: Reasoning about Physical Spaces

Robert Frohardt

You?

verification
Building Access Controls

Buildings are complex entities.

- Electronic Control of Buildings.
- Access is mediated by Software.

Roles

Professor  Admin  Student
Software Defined Access Control

Access policies change with time.

Student: Access from 9 a.m. to 5 p.m. weekdays.
   : No access weekends and holidays.

Professor: Access from 9 a.m. to 5 p.m. weekdays.
   : Access from 9 a.m. to 2 p.m. weekends/holidays

Changes for special events/emergencies

Door 1: Open.
Door 2: Closed.
Door 3: Emergency personnel only.
Elevator 1: ....

Laboratory for Hot Research Topics.

Fire emergency access policies
Policy Hazards

• Inconsistent policies: does not secure key parts of building.

• So secure that no one can get in.

• Can personnel exit the building in all situations?
  - Especially important for emergencies.
Access Nets: Modeling Access Control Policies

Tokens: represent personnel

Places in building

Transitions: Control movement between places.
Verifying Access Policies

Access Net Description

Security Property Description

Logic Formula

\[(p \land \neg q) \implies x - y \leq 10\]
\[(x - z \geq 0) \iff x = z + 25\]
\[(x = y \lor y = z) \implies x - z \geq 0\]

Abstraction techniques to reduce size of formula

OK

Property Violation
Experiment: CU Engineering Center

• This building!!
Office Building

• Plans for a multi-tenant office building obtained.
  - Four floors
  - 250 places
  - 24 access control roles.

• Verified many different security properties.
  - Use of “abstraction” to reduce problem size considerably.
Future Directions

• Building evacuation simulations.
  - Access control vs. safe evacuations.

• Challenge: Specify policies for Denver International Airport?
  - Many thousands of people using the airport.
  - Really complex and involved policies.
  - Electronic access control.
  - Having consistent set of policies is critical.
PL research at CU is **successful**!

**POPL 2011** (2)  Austin, Texas
Rival, Chang. *Calling Context Abstraction with Shapes.*
Ahmed, Findler, Siek, Wadler. *Blame for All.*

**PLDI 2010** (2)  Toronto, Canada
Khoo, Chang, Foster. *Mixing Type Checking and Symbolic Evaluation.*

**POPL 2010** (2)  Madrid, Spain
Harris, Sankaranarayanan, Ivancic, Gupta. *Program Analysis via Satisfiability Modulo Path Programs.*

< 23% acceptance rate  < 27% acceptance rate
PL research at CU is **successful**!

**ESOP 2011**  
Saarbrücken, Germany  
Colon, Sankaranarayanan. Generalizing the Template Polyhedral Domain.

**HSCC 2011**  
Chicago, Illinois  

**ESOP 2010**  
Cyprus  
Laviron, Chang, Rival. Separating Shape Graphs.

< 23% acceptance rate  
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**HSCC 2010** (2)  
Stockholm, Sweden


**VMCAI 2011**  
Austin, Texas


< 23% acceptance rate  
< 27% acceptance rate
PL research at CU is successful!

CGO 2010
Toronto, Canada
Gottschlich, Vachharajani, Siek. An efficient software transactional memory using commit-time invalidation.

and more ...

Papers ⇒ Travel + PhD
PL research at CU has world-wide collaborations!

Collaborators ⇒
Internships and Jobs
PL students have interned at ...
After *graduation*, PL students have gone to ...
The PL group has fun together!

Group meetings at the Boulder Tea House once/twice a month

Travel to conferences (Todd at OOPSLA’09)

Our mentoring: Guide you to research that excites you!
Our group

PhD

Sam

Jonathan

You?

Aditya

Huck

Aleks

You?

Amer

Jeremy

Evan

Sriram

Faculty
Some of our other research projects

- Understanding performance
- Program metamorphosis
- Lightweight data collection
- Blind optimization
- Algorithmic optimizations
- Validating architectural simulators
- Using non-linear dynamics to understand computer systems
- Programming languages for kids
- Cooperative program analysis
- Post-mortem analysis and error reporting
- Security policies for power-grids
- Analysis of web languages

- Modeling and validating building security policies
- Explanation-generating analysis
- Generic programming
- Meta-programming
- Gradual type checking
- Software transactional memory
- High-level optimizations for memory efficiency
- Finding bugs in parallel programs
- Cyber-physical systems verification

- And soon projects created by you!