Amer Diwan   Jeremy Siek   Bor-Yuh Evan Chang   Sriram Sankaranarayanan

Programming Languages Research at the University of Colorado, Boulder

PL research at CU has *breadth*!

How do we effectively express computation?
language design, type systems, logic

How do we make programs run efficiently?
performance analysis, compilation

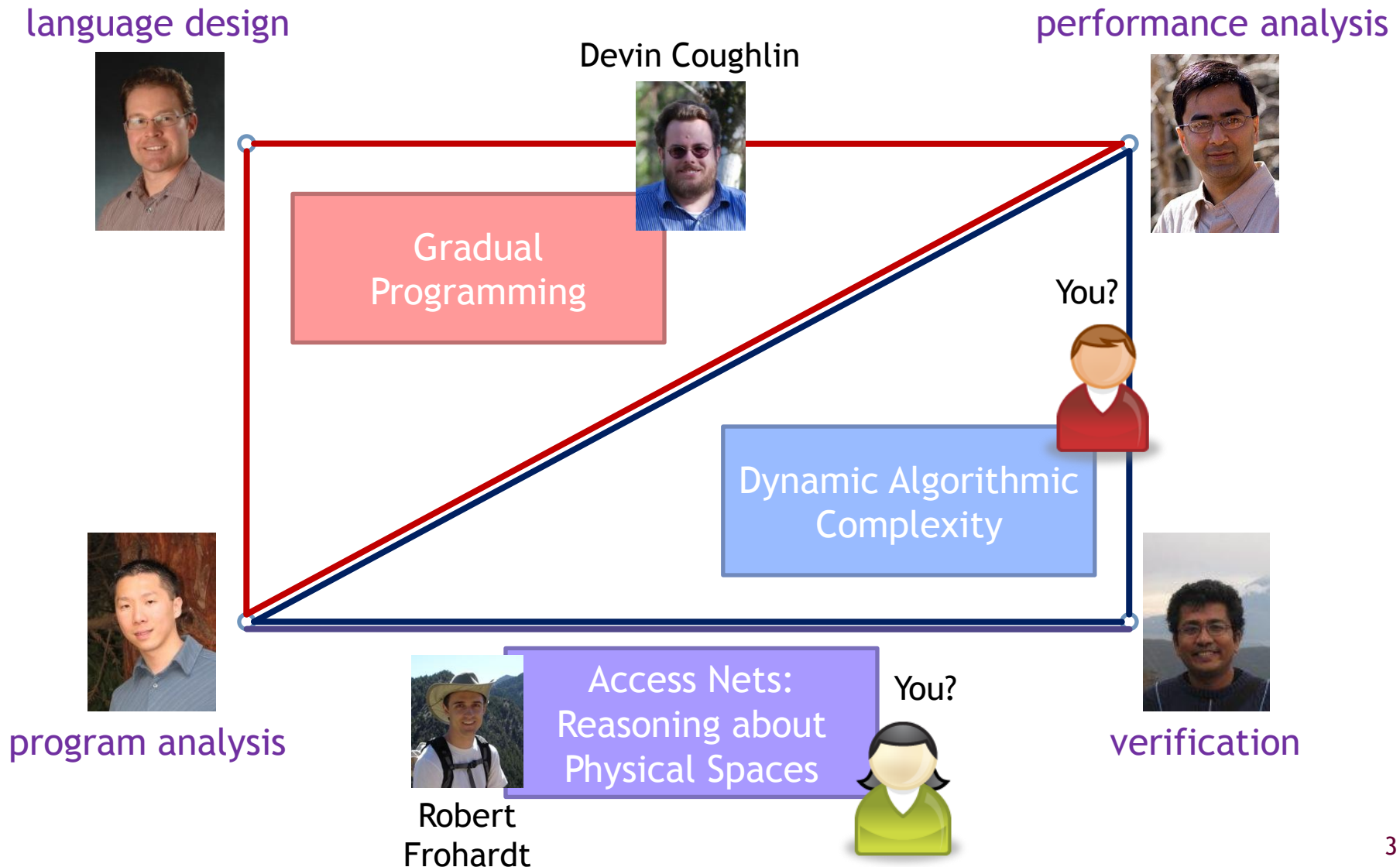How do we assist reasoning about programs?
program analysis, development tools

How do we get reliable, secure software?
verification, model checking

PL researchers at CU *collaborate*!

language design

performance analysis

Devin Coughlin

Gradual Programming

You?

program analysis

Dynamic Algorithmic Complexity

verification

Access Nets: Reasoning about Physical Spaces

You?

Robert Frohardt

Building Access Controls

Buildings are complex entities.

- Electronic Control of Buildings.

- Access is mediated by Software.

Roles

Professor   Admin   Student
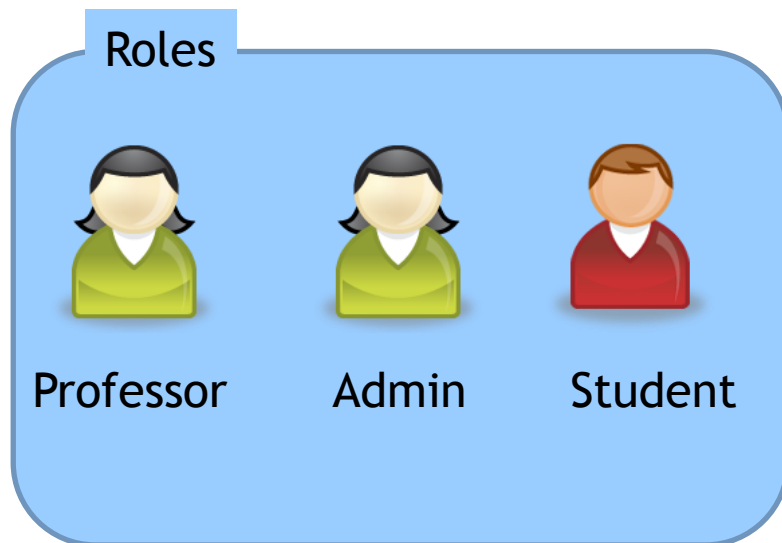
Software Defined Access Control

Access policies change with time.

Laboratory for Hot Research Topics.

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
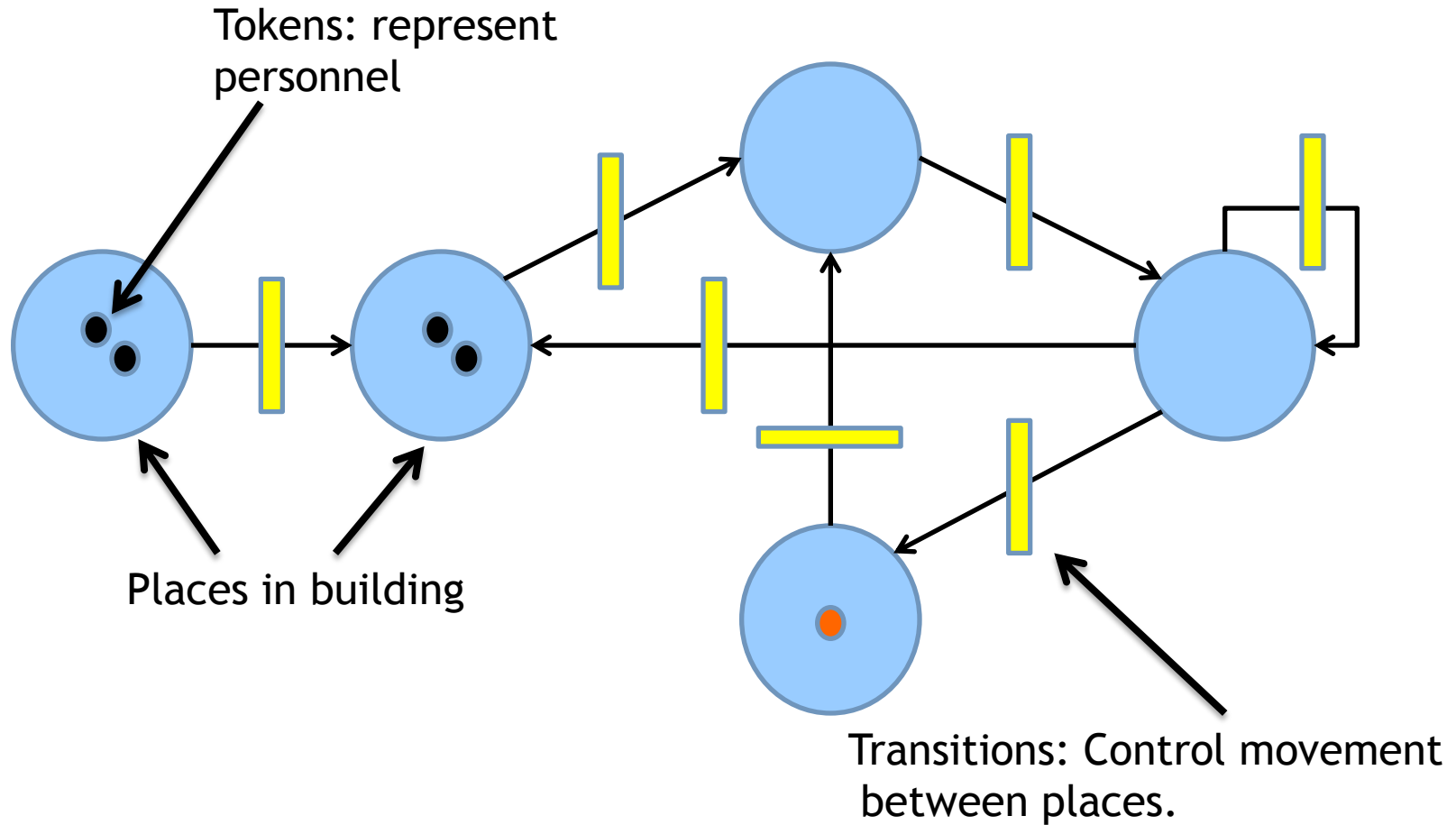
Changes for special events/emergencies

Fire emergency access policies

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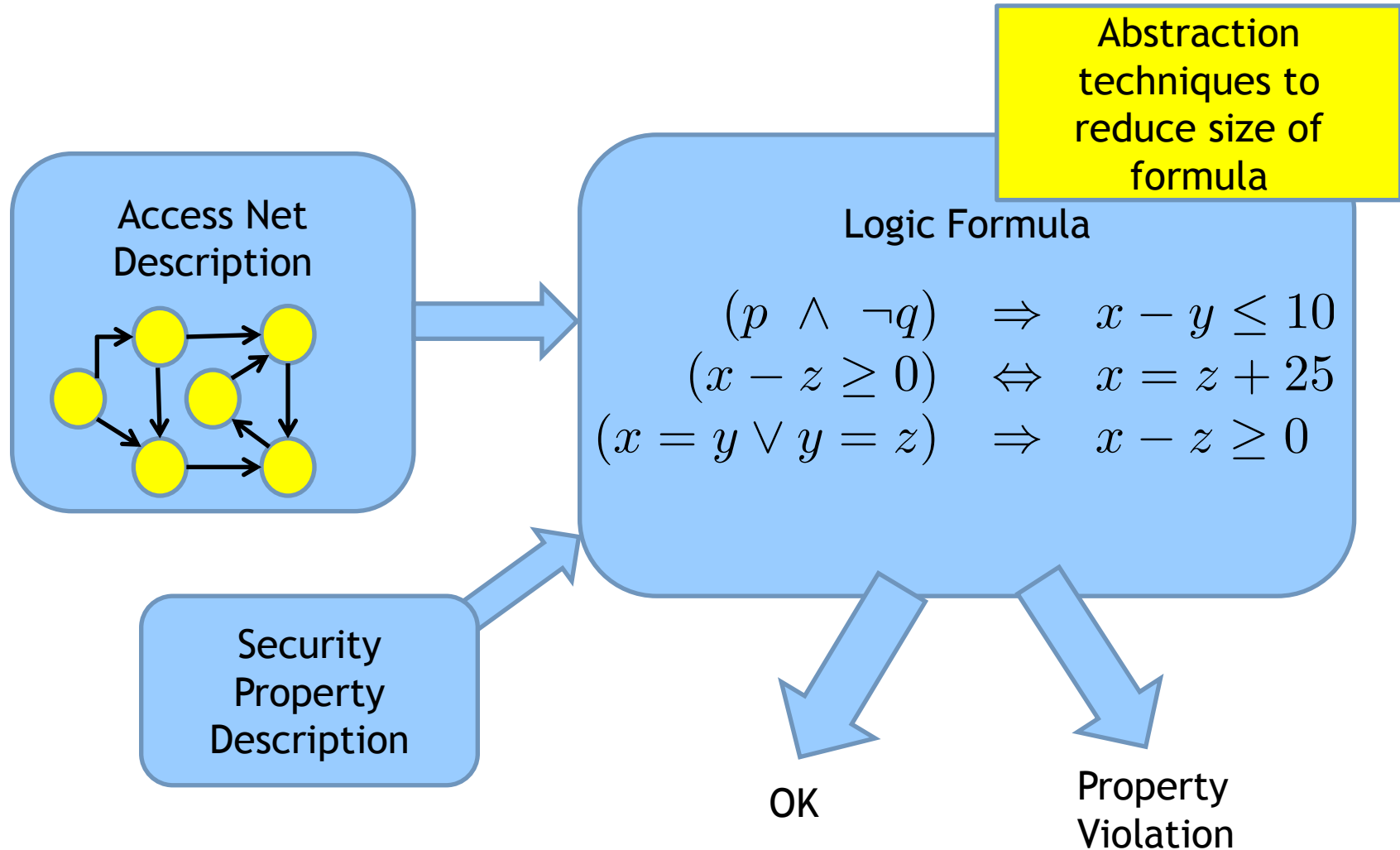Door 3: Emergency personnel only.
Elevator 1: ….

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 Polices

Access Net Description

Security Property Description

Logic Formula

$$\begin{aligned}
(p \ \wedge \ \neg q) &\implies x - y \leq 10 \\
(x - z \geq 0) &\iff x = z + 25 \\
(x = y \vee y = z) &\implies x - z \geq 0
\end{aligned}$$

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

Mytkowicz, Diwan, Hauswirth, Sweeney. *Evaluating the Accuracy of Java Profilers*.

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*.

Siek, Wadler. *Threesomes, With and Without Blame*.

< 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

Sankaranarayanan. *Automatic Abstraction of Continuous Systems using Change of Bases Transformations.*

ESOP 2010   Cyprus

Laviron, Chang, Rival. *Separating Shape Graphs.*

< 23% acceptance rate   < 27% acceptance rate

PL research at CU is *successful*!

HSCC 2010 (2)   Stockholm, Sweden

Sankaranarayanan. *Automatic Invariant Generation for Continuous Systems using Ideal Fixed Points.*

Truong, Sankaranarayanan, Fainekos, Pappas, Ivancic. *Monte-Carlo Methods for Falsification of Temporal properties.*

VMCAI 2011   Austin, Texas

Frohardt, Chang, Sankaranarayanan. *Access Nets: Modeling Access to Physical Spaces.*

< 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.*
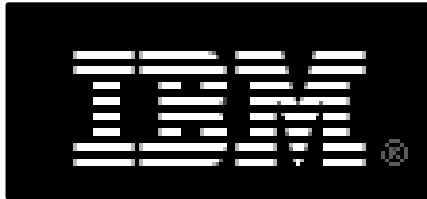
and more ...

Papers $\Rightarrow$ Travel + PhD

PL research at CU has *world-wide collaborations*!

MSR – WA

Google - CA

Apple - CA

IBM – NY

NEC– NJ

U. Edinburgh

ENS - Paris

U. Lugano

Collaborators ⇒ Internships and Jobs

PL students have *interned* at ...

After *graduation*,
PL students have gone to …

faculty

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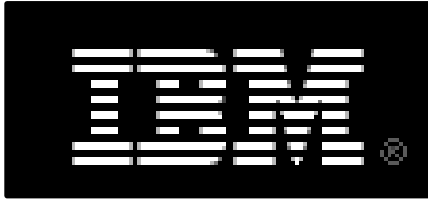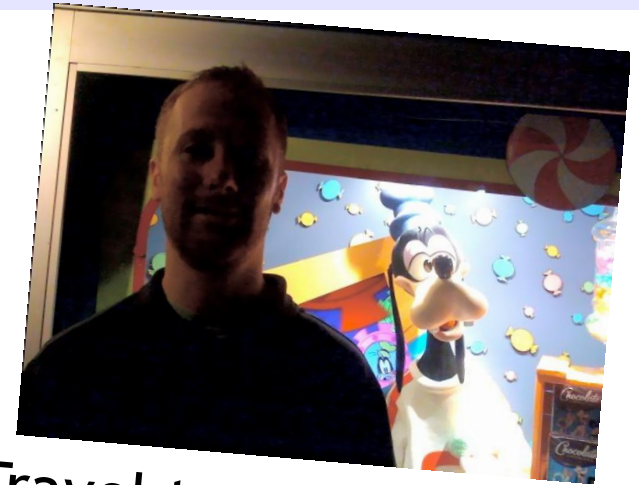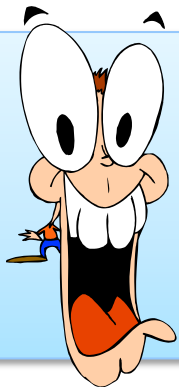
The PL group has *fun* together!

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

Devin

Weiyu

Aditya

Huck

MS

PhD

Sam

Jonathan

Aleks

Hadjar

You?

You?

Amer

Jeremy

Faculty

Evan

Sriram

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!**