2017 Winter Review
2017 Winter Review: Lab Overview and Update

John Ousterhout
Faculty Director
Thank You, Sponsors!
Special Thanks To...
Platform Lab Vision

- **New platforms enable new applications:**
  - Relational databases → Enterprise applications
  - HTTP + HTML + JavaScript → Internet commerce
  - GFS + MapReduce → Big Data (large-scale analytics)
  - Smart phones + GPS → Google Maps, Uber, …

- **Mission:**
  - Define the next generation of platforms
  - Stimulate new classes of applications
  - One or two flagship projects at any given time

- **Current focus: platforms for large-scale control**
  - Big Control Platform
  - Granular Computing Platform
What is a Platform?

- General-purpose hardware or software substrate

- Simplifies construction of a class of applications (or higher-level platforms)
  - Solves common problems
  - Usually introduces (simplifying) restrictions

- Example: MapReduce
  - Applications: large-scale analytics
  - Problems solved: hides latency, handles slow/crashed servers
  - Simplifying restrictions: two-phase decomposition, large sequential accesses
Platform Lab Faculty

Peter Bailis
Bill Dally
Sachin Katti
Christos Kozyrakis
Phil Levis
Nick McKeown
John Ousterhout (Fac. Director)
Guru Parulkar (Exec. Director)
Balaji Prabhakar
Mendel Rosenblum
Keith Winston
Matei Zaharia
Platform Lab News

● **Additional faculty:**
  - Peter Bailis (Big Data, databases)
  - Balaji Prabhakar (Networking)
  - Matei Zaharia (Big Data, systems, Spark creator)

● **NSF Expedition proposal on Big Control**
  - Promoted to second round

● **Definition of granular computing platform**

● **Promotions and awards:**
  - Sachin Katti: tenure
  - Christos Kozyrakis: ACM Fellow
  - Dinesh Bharadia: MIT TR35, Marconi Young Scholar
  - Best paper awards: ISCA, MOBICOM, Sensys (runner-up)
## Recent/Soon-To-Be Graduates

<table>
<thead>
<tr>
<th>Name</th>
<th>Research Area</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankita Kejriwal</td>
<td>Secondary indexes for RAMCloud</td>
<td>Google</td>
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<tr>
<td>Camilo Moreno</td>
<td>Communication in many-core chips</td>
<td>Intel Labs</td>
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<td>Kanthi Nagaraj</td>
<td>Programmable network fabrics</td>
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<td>Hang Qu</td>
<td>Task scheduling for cloud analytics</td>
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Big Control

- **Enormous swarms of devices:**
  - Collaborative
  - Centrally controlled

- **The morning commute**
  - 1M+ self-driving cars

- **Large distribution center**
  - 10,000+ indoor drones

- **Disaster recovery**
  - 1000+ drones, automated ground-based vehicles
  - Coordinated mapping and search
  - Data integration
  - Mobilized response
Big Control, cont’d

- **Interesting properties:**
  - Scale
  - Collaboration
  - Latency

- **Control will become more centralized:**
  - Easier application development
  - More powerful features (e.g., integrate back-end datasets)
  - More robust!

- **Lab goal:** define and enable the Big Control paradigm

- **Create two new platforms:**
  - Big Control Platform (BCP)
  - Granular Computing Platform
Multi-Level Control Loops

- Datacenter
- DC Network
- Wired Network
- Wireless Network
- Edge Cloud
- Attitude Stabilization: 1000 Hz
--directed Mapping: 1 Hz
- Formation Flying: 10 Hz

Devices
System Overview

Big Control Platform (BCP)

- Directed Info Gathering
- Deep Reinforcement Learning
- Adaptive Optimal Sched.
- Stable Trajectory Planning
- Data Ingestion, Fusion, Inference
- Declarative Planning
- Geometric Data Structures, Distributed State Management

Granular Computing Platform

- Real-Time Sensing
- Real-Time Actuation

Wired and Wireless Networks

Devices

Data Repositories

Cluster Scheduling
- Low-Latency RPC
- Scalable Notifications
- Thread/App Mgmt
- Hardware Accelerators
- Low-Latency Storage
Big Control Platform

- **What is MapReduce for control?**
  - Solve common problems
  - Simple framework
- **Example: declarative planning**
  - Specify plans in high-level language (~ SQL)
  - Generate device-specific commands automatically (~ query optimizer)
Granular Computing

- **Big Data**: process data in large sequential chunks
- **Big Control**: process data in very small chunks
  - Example: 10,000 devices, updates all-to-all every second
  - Each device notification triggers internal events for fusion, inference
- **Granular computing**:
  - Support tasks lasting 10ms → 1µs
  - Efficient instantiation, communication
  - Short duration => large numbers
  - Highly elastic
  - Must coexist with traditional large tasks
- **Related trends**: micro-services, lambdas
Granular Computing Examples

- Remote task with durable results: 20 µs
- Local task with volatile results: 500 ns
- Fanout to 100+ threads, interactive results:
  - Real-time event-driven inference
  - Exploratory data analysis
  - Instant video encoding
Networking Platform

- Rearchitect the network for control applications:
  - Ultra-reliable
  - Ultra-low and predictable latency
  - Secure, robust

- Slicing architecture:
  - Decouple control and data planes
  - Virtualize network substrate (multiple control/data planes)
  - New algorithms for allocating resources among competing slices
Project Plan

- **Phase 1 (Years 1-2): exploration, infrastructure**
  - Simple control applications for learning
  - Prototypes of BCP subsystems, Granular Computing Platform
  - **Milestone: ready to design BCP**

- **Phase 2 (Years 3-4): BCP version 1**
  - Integrated version of BCP
  - Revisions to Granular Computing Platform
  - Port a few applications
  - **Milestone: BCP runs a few simple applications**

- **Phase 3 (Year 5): capstone demonstration**
  - Disaster recovery demo, possibly others
  - Continued evolution of BCP, Granular Computing Platform
  - **Milestone: capstone demo**
Next Steps: More Students!

- Long lead-time (new PhD admits commit early)
- Planning for heavy recruiting this spring
- Students rotate in 2017-2018, align in Spring 2018
- Big Control seminar in Fall 2017
- Also: funding always a challenge; hoping to win Expedition competition
Agenda

9:15 — 10:30am  Big Control Platform (BCP) Abstractions and Services
  ● Directed Information Gathering — Riccardo Spica
  ● Deep Reinforcement Learning for Device Control — Blake Wulfe
  ● Distributed Geometric Data Structures — Philip Levis

10:30am — 11:00am  Break

11:00 — 12:15pm  Self Driving Programmable Networks
  ● Data Driven Networking — Sachin Katti
  ● Self Driving Networks — Balaji Prabhakar
  ● Weld: Fast Data Analytics on Modern Hardware — Shoumik Palkar

12:15 — 12:45pm  Lightning Talks by Students

12:45 — 2:00pm  Lunch and Poster Session
Agenda, Cont’d

2:00 — 2:45pm  Invited Sponsor Talks
- Network Management beyond SDN — Jeff Mogul, Google
- Potential Big Control Use Cases — Ayush Sharma, Huawei

2:45 — 3:45 pm  Panel on Granular Computing
Keith Winstein, Christos Kozyrakis, Philip Levis, John Ousterhout

3:45 - 4:15pm  Break

4:15pm — 5:30pm  Granular Computing Platform
- NanoLog: A Nanosecond Scale Logger — Stephen Yang
- RAIL: Predictable, Low Tail Latency for Flash-based SSDs — Heiner Litz
- TETRIS: Scalable and Efficient Neural Network Acceleration with 3D Memory — Mingyu Gao

5:30 — 5:45 pm  Wrap up

5:45 — 7:00pm  Reception
Conclusion

- Platform Lab program now fully formed
- Time to execute

How can we collaborate with industry for this research agenda?
Questions/Discussion