BLOOM
CALM
PROGRAMMING THE CLOUD

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AGENDA

• Brief research background from the BOOM project
  • http://boom.cs.berkeley.edu

• A taste of CS194-17, “Programming the Cloud” and the bloom language

• Some related work
BOOM

In an era of cheap compute and ubiquitous data...
... Productivity is a key grand challenge in computing.

Berkeley Orders Of Magnitude project
OOM bigger systems, OOM less code.

Significantly improve productivity for developers of distributed systems.
THE von NEUMANN MACHINE

- ORDER
  - LIST of Instructions
  - ARRAY of Memory

- THE STATE
  - Mutation in time
DISTRIBUTED COMPUTING IS THE NEW NORMAL

- ORDER IS TOO COSTLY
  - Coordination

- THE STATE IS HEARSAY
  - Delay
  - Failure

http://www.flickr.com/photos/scobleizer/4870005698/sizes/l/in/photostream/
KEEP CALM AND QUERY ON

DISORDERLY PROGRAMMING
STATE
- Order-insensitive objects

LOGIC
- Order-insensitive merge rules

IMPLICATION: KEEP CALM
- Asynchrony is irrelevant
- Replication is easy
- Coordination is unnecessary

Not always possible! But often.
- Disorder by default
- Order is the exception.

The CALM Theorem says when.
• A disorderly distributed language as above
  • [Hellerstein, et al. CIDR11]
  • http://bloom-lang.org
  • Ruby prototype: Bud
    % gem install bud

• Theoretical grounding: Dedalus
  • A logic for data, space and time
  • Model-theoretic (fully declarative) semantics
  • [Alvaro, et al. Datalog2.0-11, Datalog2.0-12]
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  • [Alvaro, et al. Datalog2.0-11, Datalog2.0-12]
• A disorder
  • [Hellerstein, et al. CIDR11]
  • [Alvaro, et al. Datalog2.0-11, Datalog2.0-12]

• Theoretical
  • A logic for data, space and time
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• Ruby prototype:
  • `gem install bud`

• Theoretical
  • A logic for data, space and time
  • Model-theoretic (fully declarative) semantics
  • [Alvaro, et al. Datalog2.0-11, Datalog2.0-12]
• A distributed data structure
  • [Hellerstein, et al.]
  • http://bloom-lang.org
  • Ruby prototype: Bud
  • Theoretical grounding:
  • A logic for data, space and time
  • Model-theoretic
  • [Alvaro, et al. Datalog2.0]
CS194-17 at Berkeley: Programming the Cloud

• Joe Hellerstein & Peter Alvaro
  • Now in its second offering.

• Tuesdays: Big Picture
  • lectures on distributed systems fundamentals

• Thursdays: Hands On
  • live-coding in Bloom

• We’ll do a bit of a blend today…
Lessons for Today

1. Communication as Rendezvous in Space & Time
2. The Duality of Communication and Storage
3. Assessing the need for Coordination protocols
   • CALM program analysis
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The Land of Two Mountains
Rendezvous by Luck
(Smoke Signals)
Sender Persists
Receiver Persists
Both Persist
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Directions for Thought

• Thm (CALM): Consistency As Logical Monotonicity
  • <=: *Distributed code that’s monotonic will be “eventually consistent” without coordination.*
    • Corollary: *It is sufficient to use coordination only to “guard” the non-monotonic statements in a program.*
  • =>: *Any eventually consistent program is in some fundamental way monotonic.*

• Said differently:
  • “Thank you for all the Paxos, Dr. Lamport. Do I need it?”
  • Or perhaps better: “What is time for? Must I spend it?”

• [Hellerstein, SIGMODRecord 3/10; Ameloot PODS11, ICDT12, Marczak Datalog 2.0-12]

• **Realized in practice via Bloom/Budplot.**
More Results

- http://boom.cs.berkeley.edu
- http://bloom-lang.org

Materials for this talk:

- https://github.com/programthecloud/ptcrepo/tree/gh-pages/demo
BOOM TEAM

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Joshua rosen  Emily Andrews  Andy Hutchinson
Key Results 1

• **BOOM Analytics** [Alvaro, et al. Eurosyst ‘10]
  - HDFS rebuilt in Overlog, the predecessor to Bloom, with HA and scale-out
  - Hadoop scheduler as well
• **Bloom**: Beyond sets/tables [Conway, et al. SoCC ‘12]
  - Extensions for natural monotone data types like counters, vector clocks, KVS with commutative merges
  - Safe mappings between these types
• **Blazes**: Coordination analysis of streaming services [Alvaro, et al. In process]
  - Grey-box: bring CALM analysis to popular streaming systems like Storm
  - White-box: more fully automated stream analysis in the Bloom context
• **Correct, Composable Concurrent Editing** [Conway, et al. In process]
  - Google-Doc style concurrent editing remains a black art
    - Operational Transforms
  - Lattices underlie a lot of the intuition
  - Bloom provides a rich language for composing lattices and traditional data
  - Automated analysis of correctness
Key Results 2

- **Consistency and Causality in the Wild (Bailis et al.)**
  - Probabilistically Bounded Staleness [VLDB ‘12]
  - Dangers of Causal Consistency and a Solution [SoCC ‘12]
  - HAT, not CAP: Towards Highly Available Transactions [HotOS ‘13]
  - Bolt-On Causal Consistency [SIGMOD ‘13]
Summing Up

• Distributed? Disorderly by default.
  • Logic and Lattices in Space and Time

• The Duality of Communication and Storage
  • Unifying the two linguistically makes for nice code

• Assessing the need for Coordination protocols
  • CALM leads to straightforward program checks in Bloom
  • Points to games we can play in other languages/systems
  • Many interesting questions remain