BLOOM
CALM
PROGRAMMING THE CLOUD

Joe Hellerstein
Peter Alvaro

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

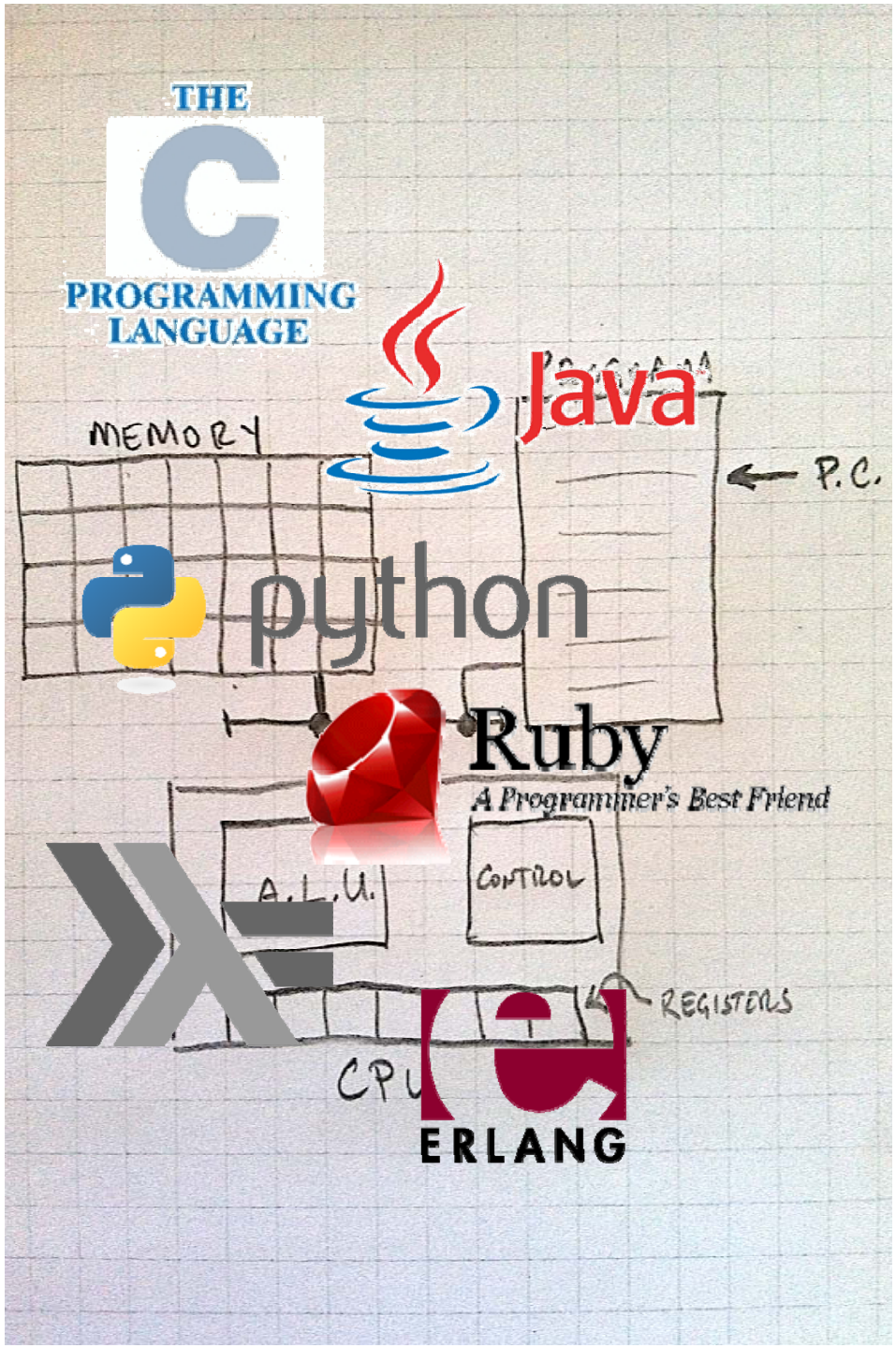
BOOM

In an era of cheap compute and ubiquitous data…

… **Productivity** is a key grand challenge in computing.

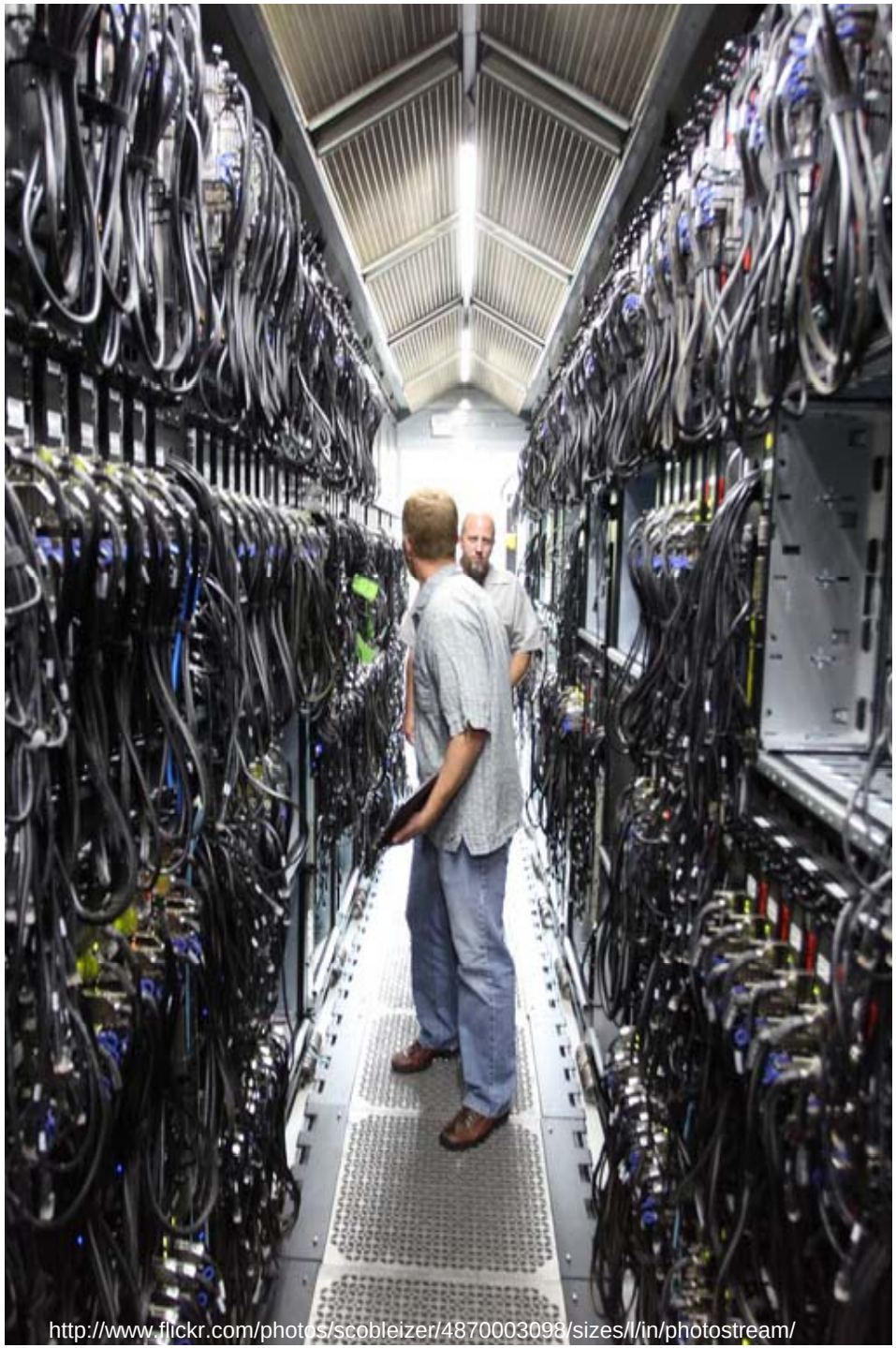
Berkeley **O**rders **O**f **M**agnitude project
OOM bigger systems, OOM less code.

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

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.

<~ bloom

- 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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MIT Technology Review

10 BREAKTHROUGH TECHNOLOGIES

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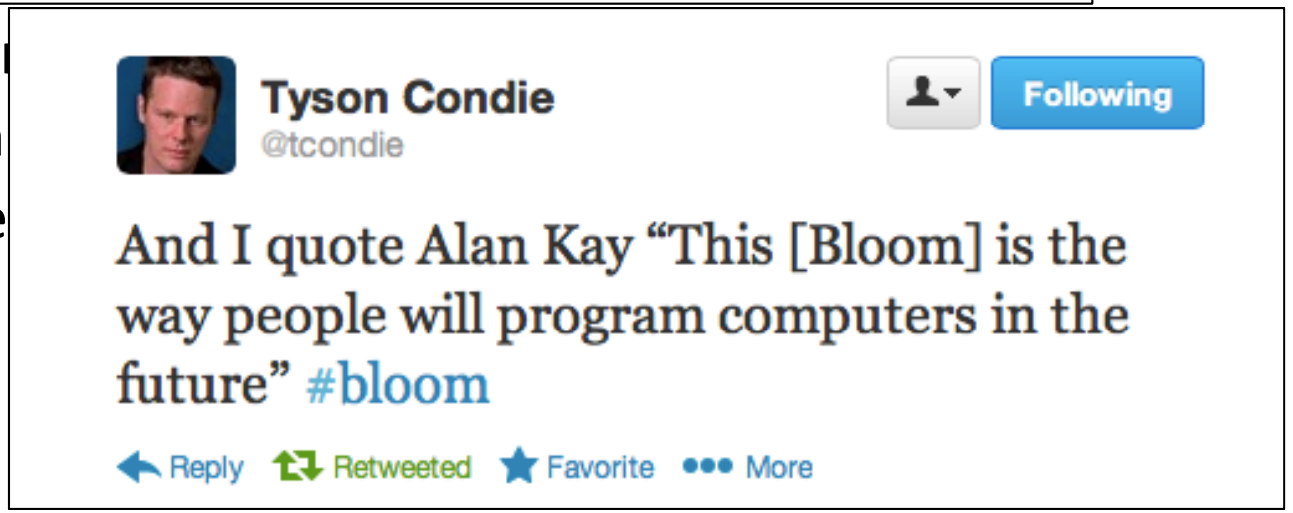

CS194-17 at Berkeley: Programming the Cloud

- 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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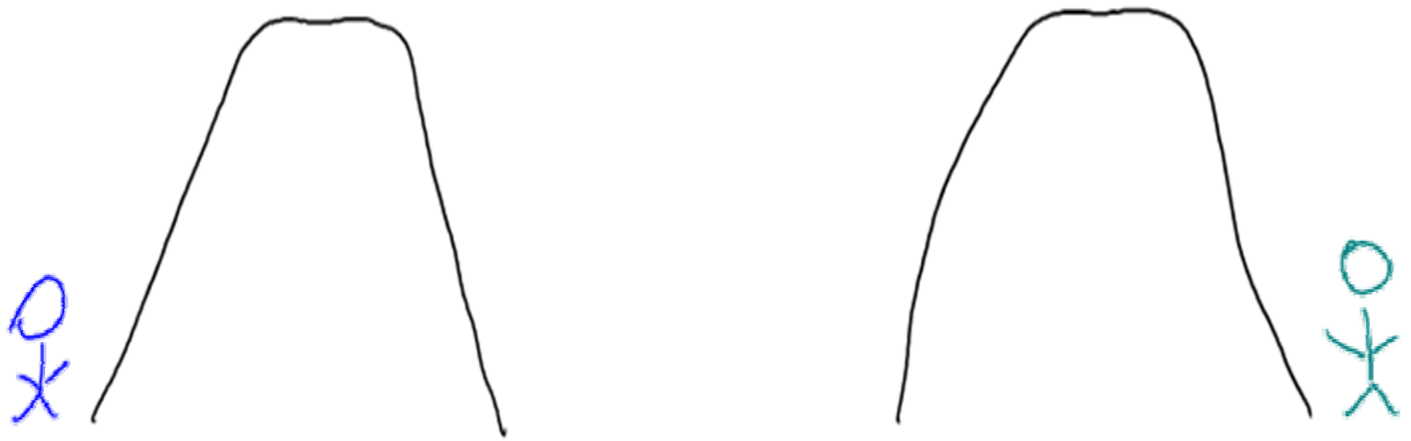
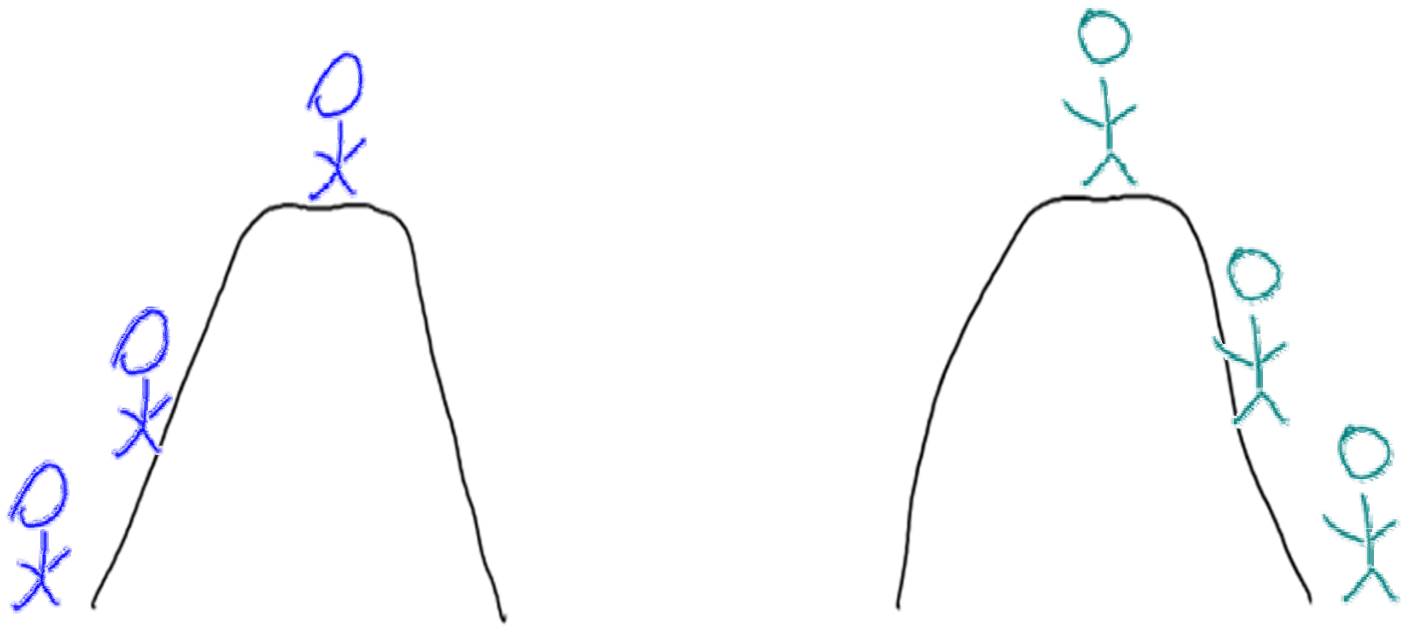
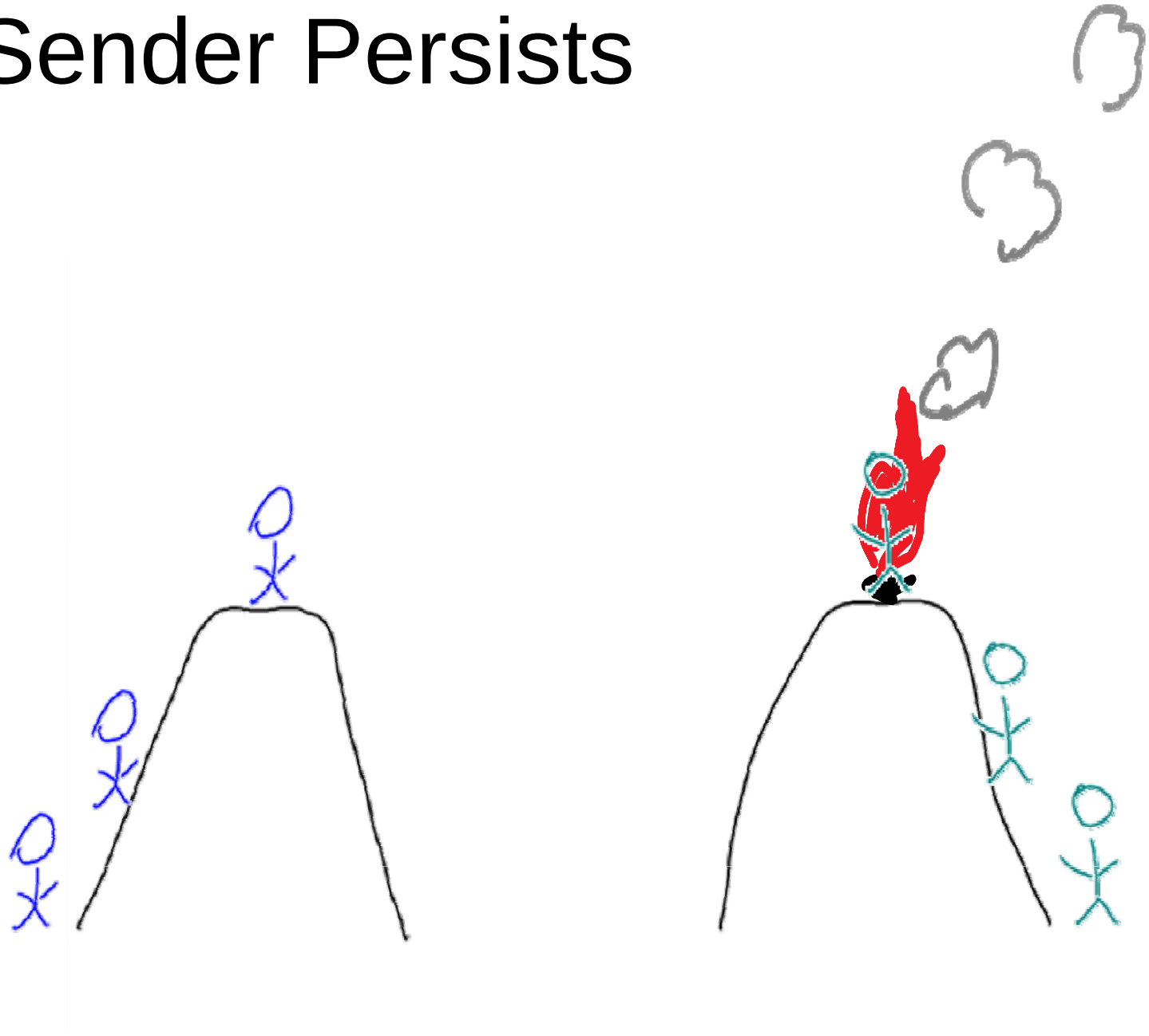
The Land of Two Mountains



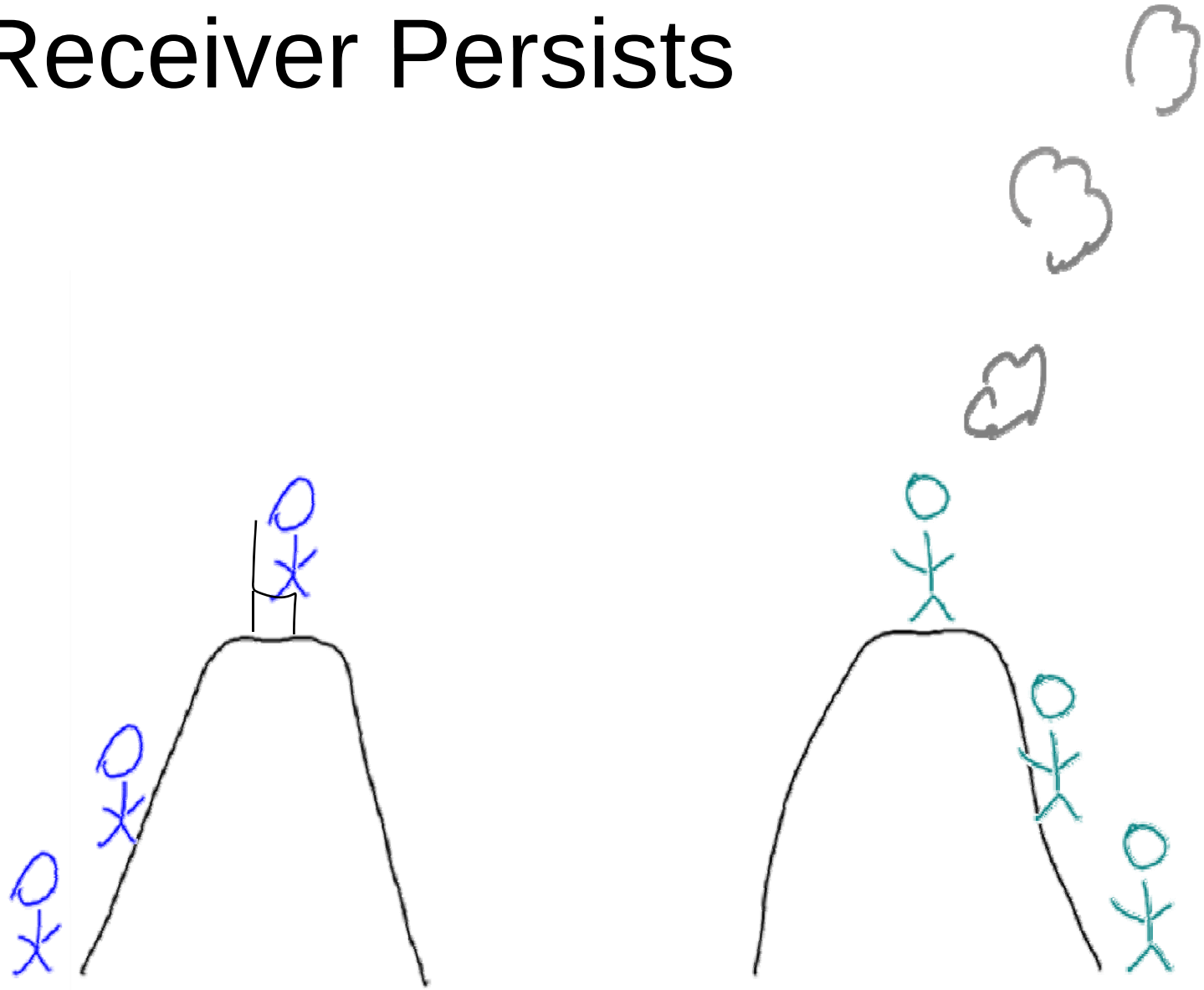
Rendezvous by Luck (Smoke Signals)



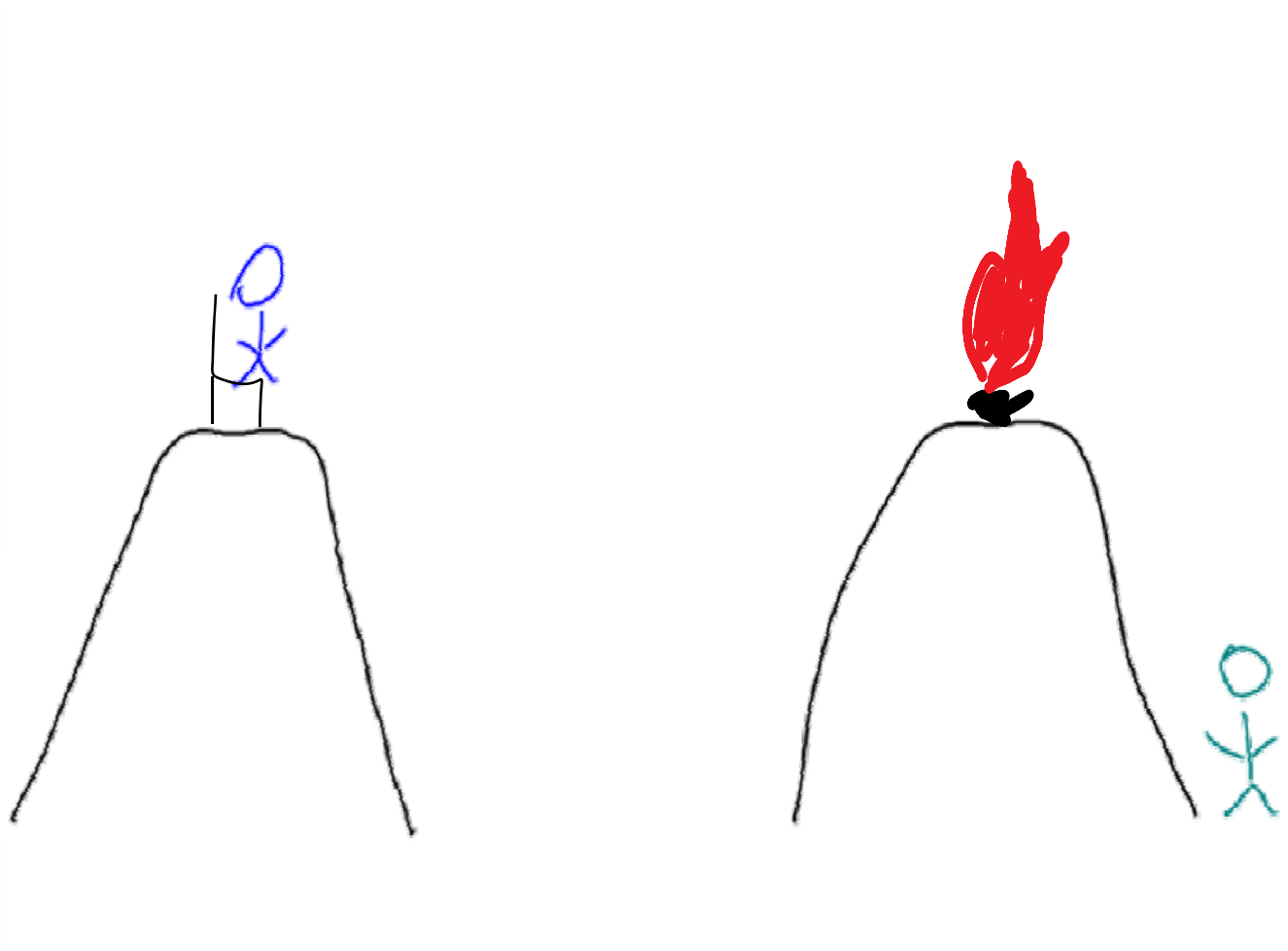
Sender Persists



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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emily andrews

andy hutchinson

Key Results 1

- **BOOM Analytics** [Alvaro, et al. Eurosys '10]
  - HDFS rebuilt in Overlog, the predecessor to Bloom, with HA and scale-out
  - Hadoop scheduler as well
- **Bloom^L:** 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^L 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