Versioned software defined networks

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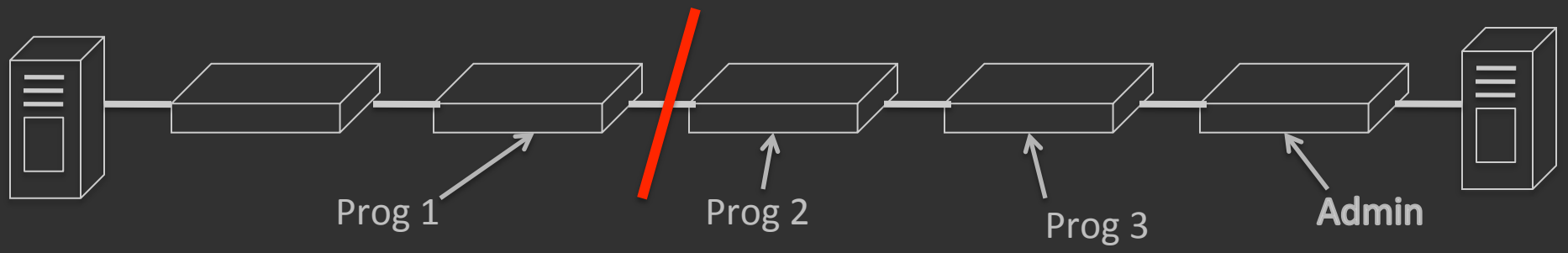
Debugging networks is difficult



- *Invisibility:* Automated protocols, programs, and services change how packets are forwarded
- *Non-proportionality:* Local changes can have global effects
- *Liveness:* System actively forwards packets while it is being debugged

Consequences

- VoIP outage
  - Hours-long outage
  - Dozens of emails
- Spanning tree protocol mismatch
  - 15-45 minute outages for isolated VLANs

Versioned networking

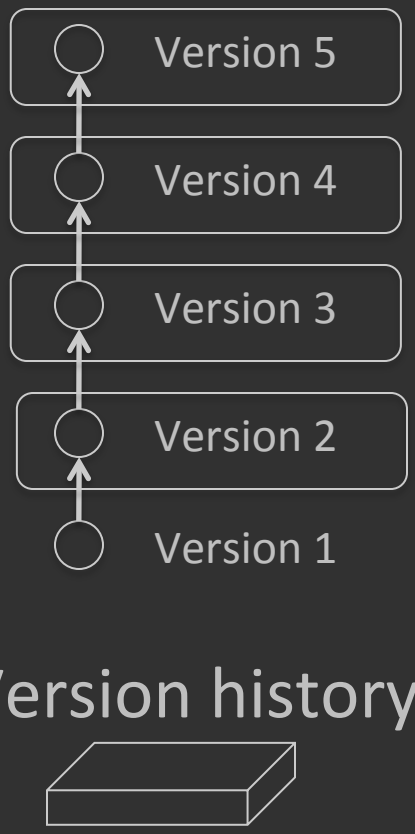
Versioned networks tries to make it easier to debug networks by helping a debugger to:

1. Quickly identify the cause of a problem and
2. Why that cause produces the problem

By allowing the debugger to ask four questions:

1. *What* did/does the network look like?
2. *When* did an operation take place?
3. *Why* did a program behave the way that it did?
4. *Who* executed that program?

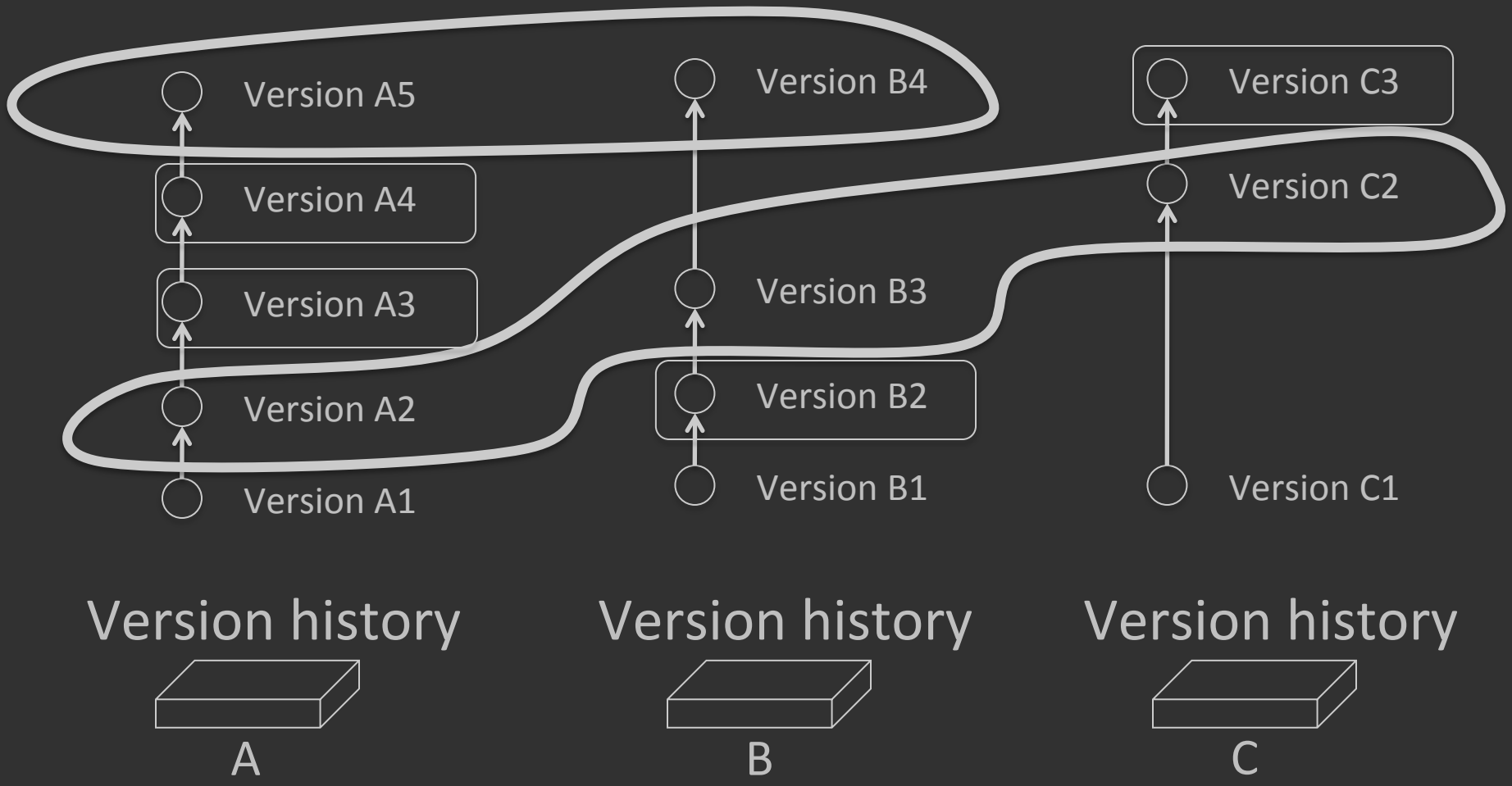
Versioned networks --- debugging with what, when, why, who



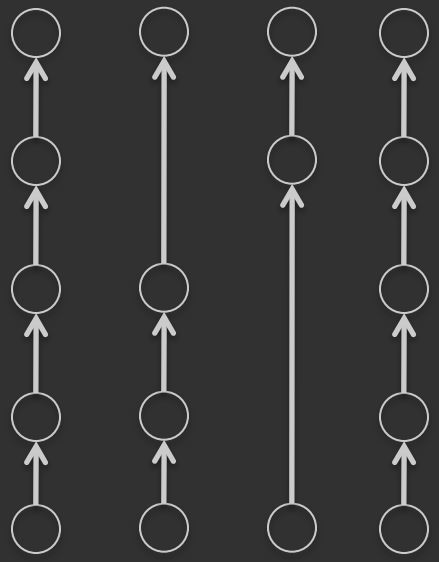
Version history

- Using what and when, construct a *version history*
- Automatically walk version history until find issue
- Using why and who, examine/undo operation associated version change that caused issue

Versioned network debugging: Multiple switches



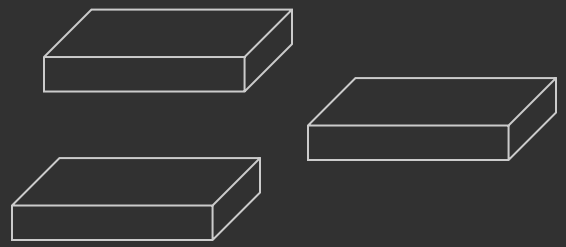
Goal: What, when, why, who



- *What* did/does the network look like?
- *When* did an operation take place (relative to other operations in the system)?
- *Why* did a program behave the way that it did?
- *Who* executed that program?

Outline

- Versioned networking goals
- **How do you build a versioned networking system?**
- Evaluation
- Discussion



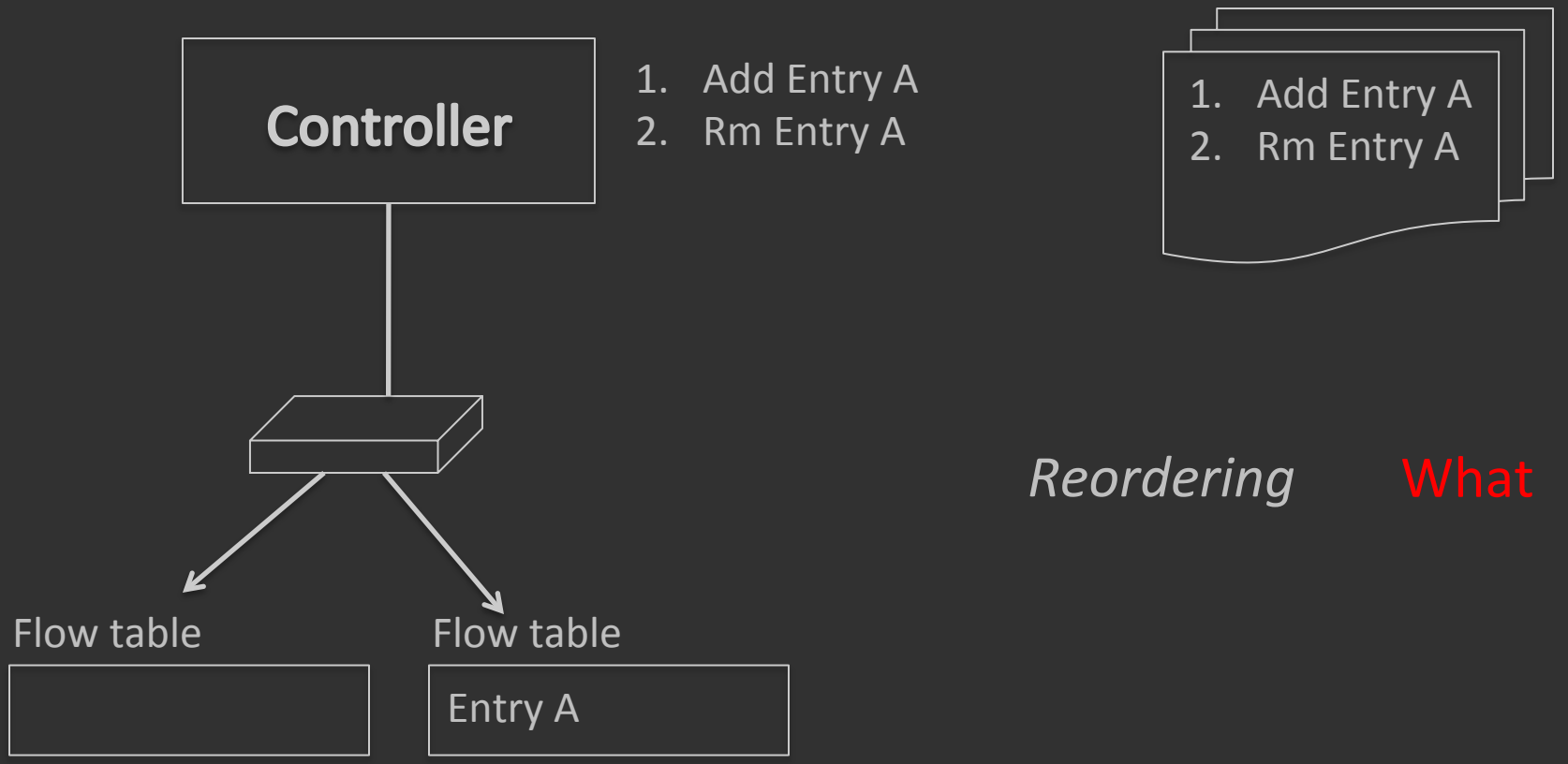
Who?
What?
When?
Why?

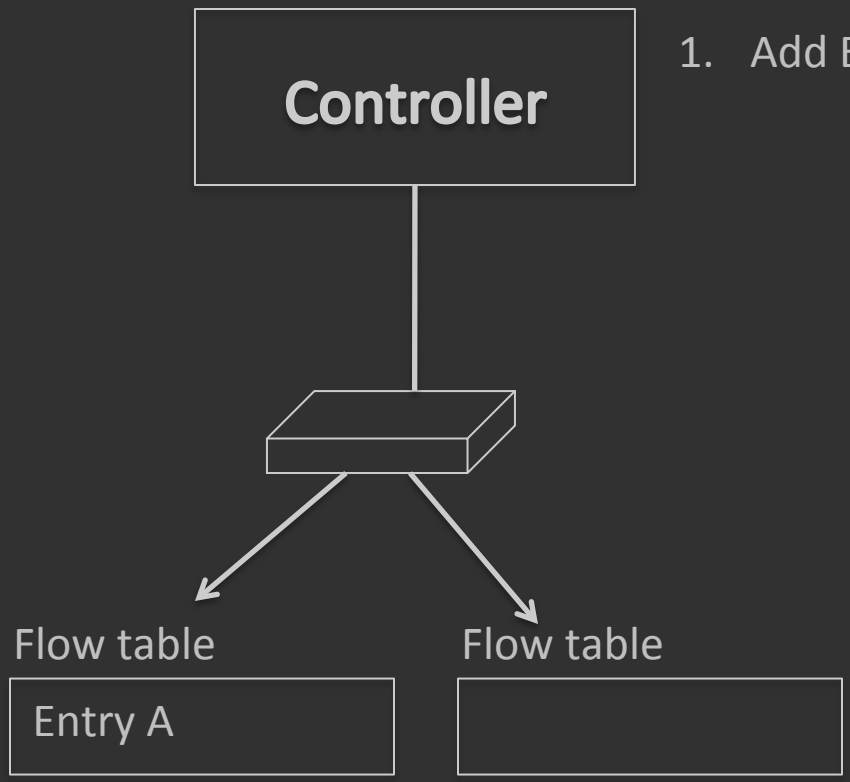
Four challenges

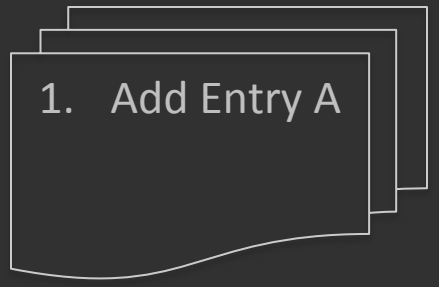
- Switches can *reorder* flow mods
- Switches can *reject* flow mods
- Switches *never send a positive ack* for flow mods
- Distributed system

Two techniques

- Automatic barrier insertion
- Transactions


Controller
1. Add Entry A
2. Rm Entry A
1. Add Entry A
2. Rm Entry A
Reordering
What
Flow table
Flow table
Entry A





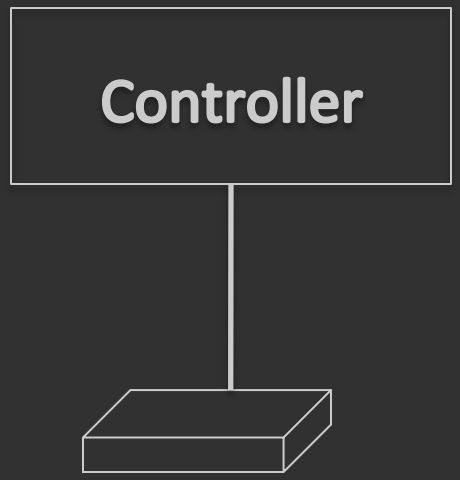
Reordering What

Reject What
No ack When

Technique 1: Barrier insertion

- Barriers
  - Switch returns barrier response after all previous commands processed
- Automatically insert barriers after operations

Technique 1: Barrier insertion



1. Send set of operations that commute
2. Send barrier
3. Receive barrier response
4. Send another set of operations that commute
5. Send barrier
6. Receive barrier response

What Because operations between barriers commute, reordering safe

When Because wait on barrier response before issuing new commands, know *when* operations have completed

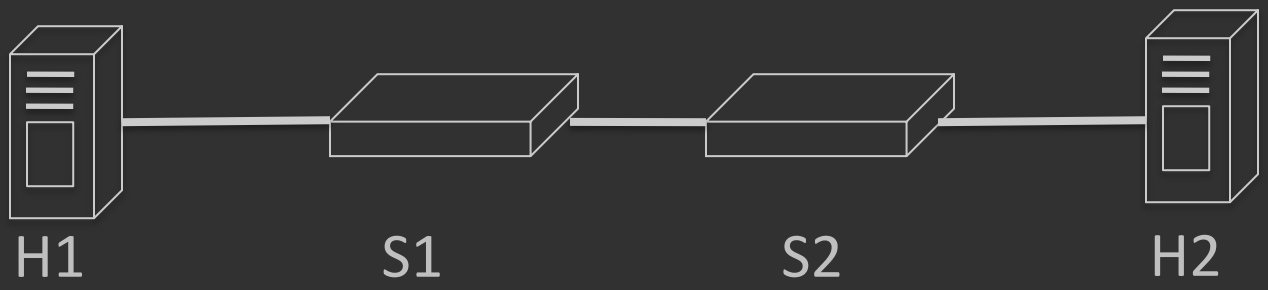
Technique 2: Transactions

- *Why* did running the VoIP SDN program insert bad flow mods?
- Insight: Leverage determinism
  - Absent races, re-excuting a program with identical arguments and internal state produces the same output

Technique 2: Transactions

- When each program begins, log its arguments
- Take locks on internal state program touches
- Log changes to all internal state

Transactions + Barriers



1. Log H1, H2
2. Take locks on internal objects program touches
3. After execution logic has completed:
    1. Issue flowmods to S1 and S2
    2. Issue barriers to S1 and S2
4. On barrier success reply
    1. Log changes to internal objects
    2. Release locks

Guarantees

- Preserves causality in logs
- Allows offline replay
- Supports what, when, why, who queries

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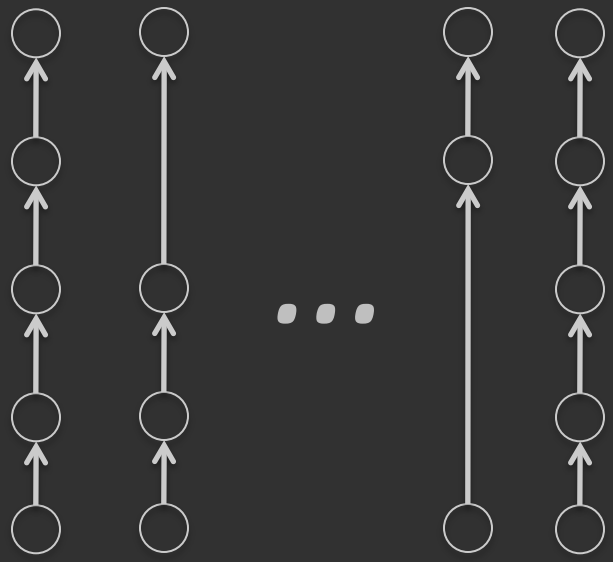
Criteria

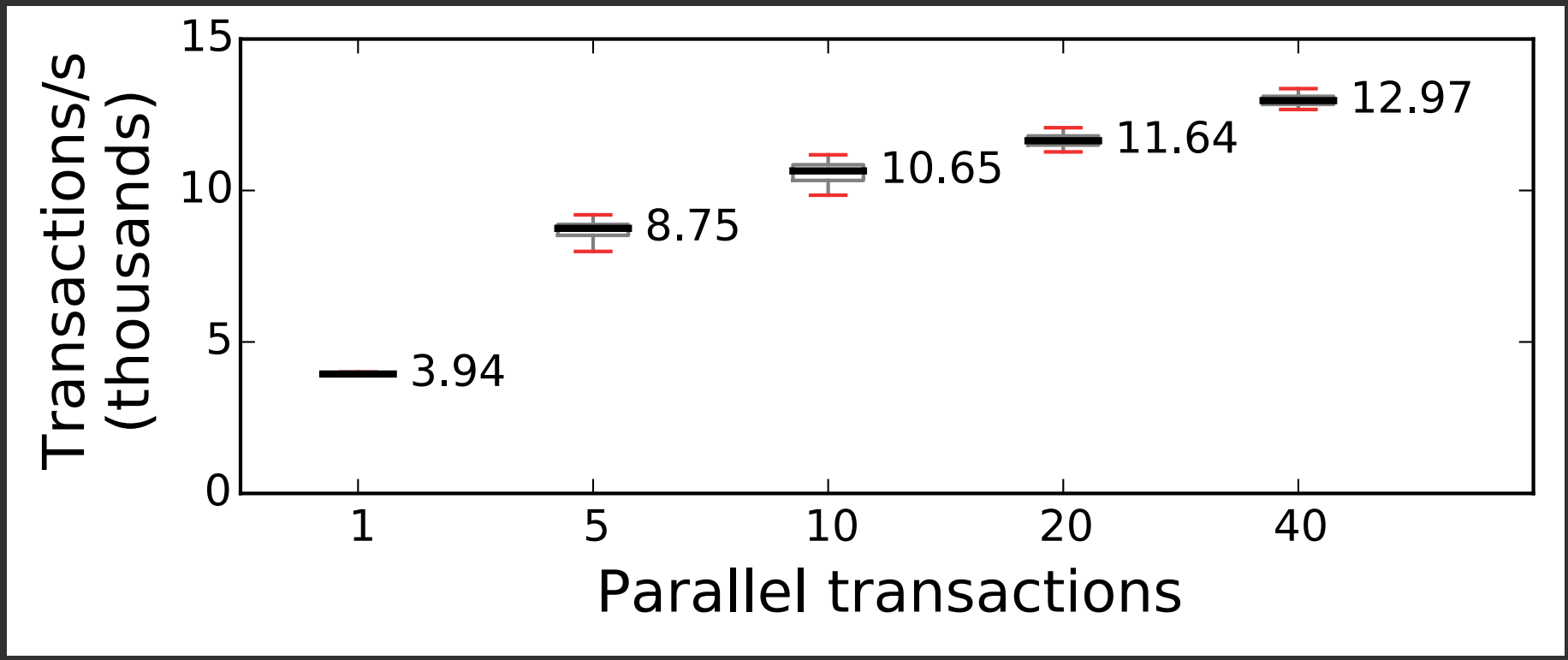
- Ease of use
- Performance
- Correctness

Ease of use



100 version histories
100k operations across them
<20 seconds to replay operations

Performance



Correctness

- Forcing reordering between barriers, over 100k operations, switch state agrees with version history
- Over 100k operations with 1% and 5% errors, switch state agrees with version history

Outline

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- **Discussion**

SDN

- *Visibility:* Have access to switching and forwarding state in way that never did before
- *Manipulability:* Multiple layers and vendors provide a uniform API to program the network

Versioned software defined networking

- Retrospective visibility and manipulability
  - What
  - When
  - Why
  - Who

Soap box

- Many existing tools and frameworks do not provide visibility for you. You can't even answer questions such as, approximately, what did my network look like?
- Eventual consistency is bullshit. Networks that sometimes go down for 30-45 minutes is bullshit.
- It's time to build, monitor, and debug networks in intelligent ways

Technique 1: Barrier insertion

- I think that ONOS may be starting to add these as well, but I know of no other system that either exposes them or automatically adds them.
- In these systems, it requires:
  - Bug free code
  - Heroic effort
  - Polling

Barrier insertion batching

- If a program makes changes over a series of switches, should we do each serially? Or should we batch them?

Versioned networking

- *What* did/does the network look like?
- *When* did an operation take place (relative to other operations in the system)?
- *Why* did a program behave the way that it did?
- *Who* executed that program?

- Offline, can modify and replay
- Rollback and roll forward
- Over series of controller, not just one