Securing SDN-based monitoring

Obstacles and learned insights

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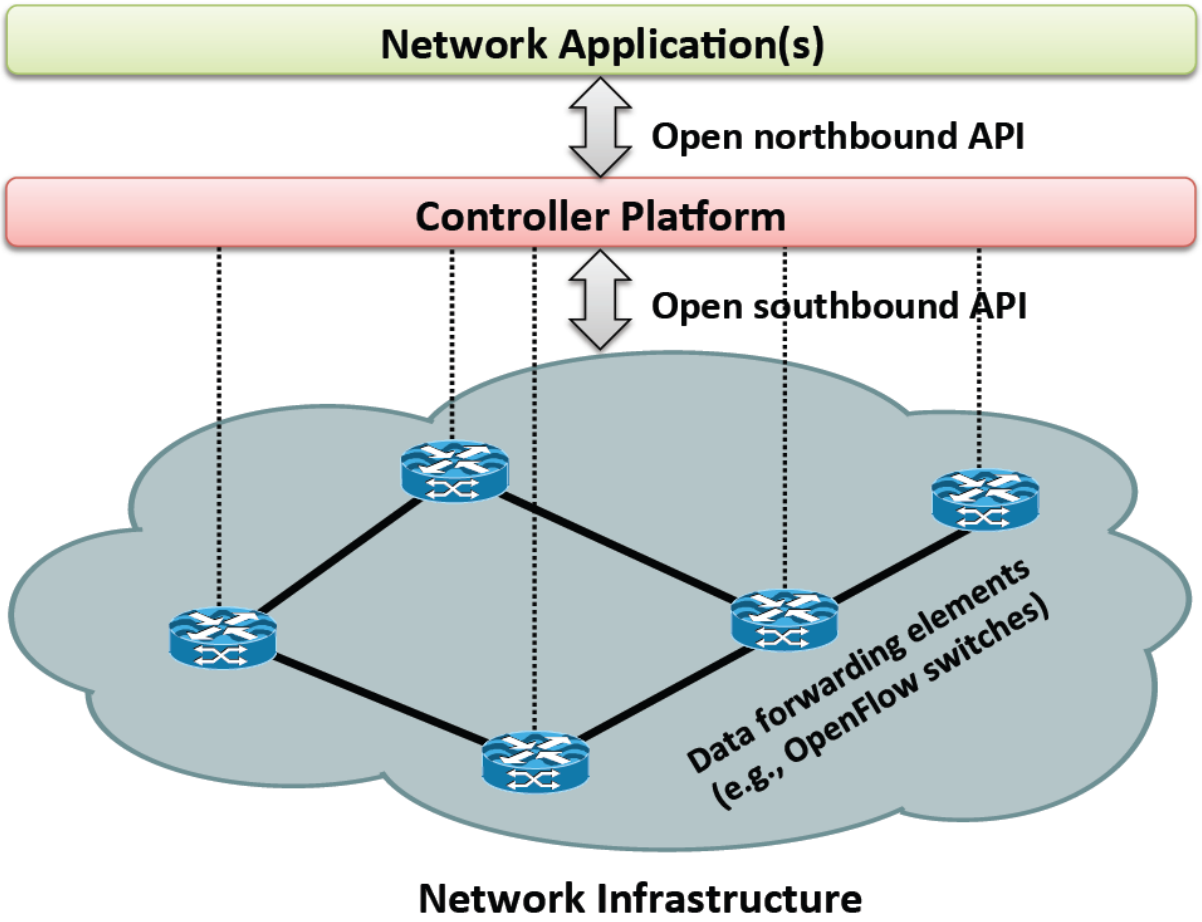
Introduction

An SDN network



Why network monitoring?

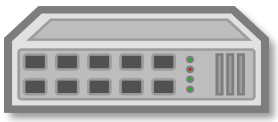
Collects and provides data about the current state of the network

- **Traffic engineering (**QoS-based routing)
- **Failure detection** (e.g., high loss rate)
- **Traffic shaping** (e.g., flow throttling)
- **Load balancing** (e.g., delay-based)

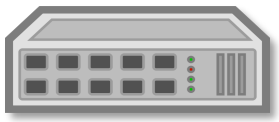
Traditional monitoring technique

Active flow discovery

Controller



Switch 1

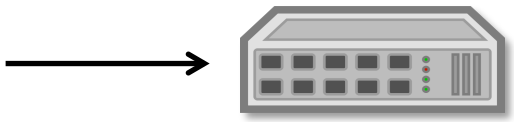


Switch 2

Traditional monitoring technique

Active flow discovery

Controller



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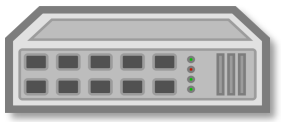
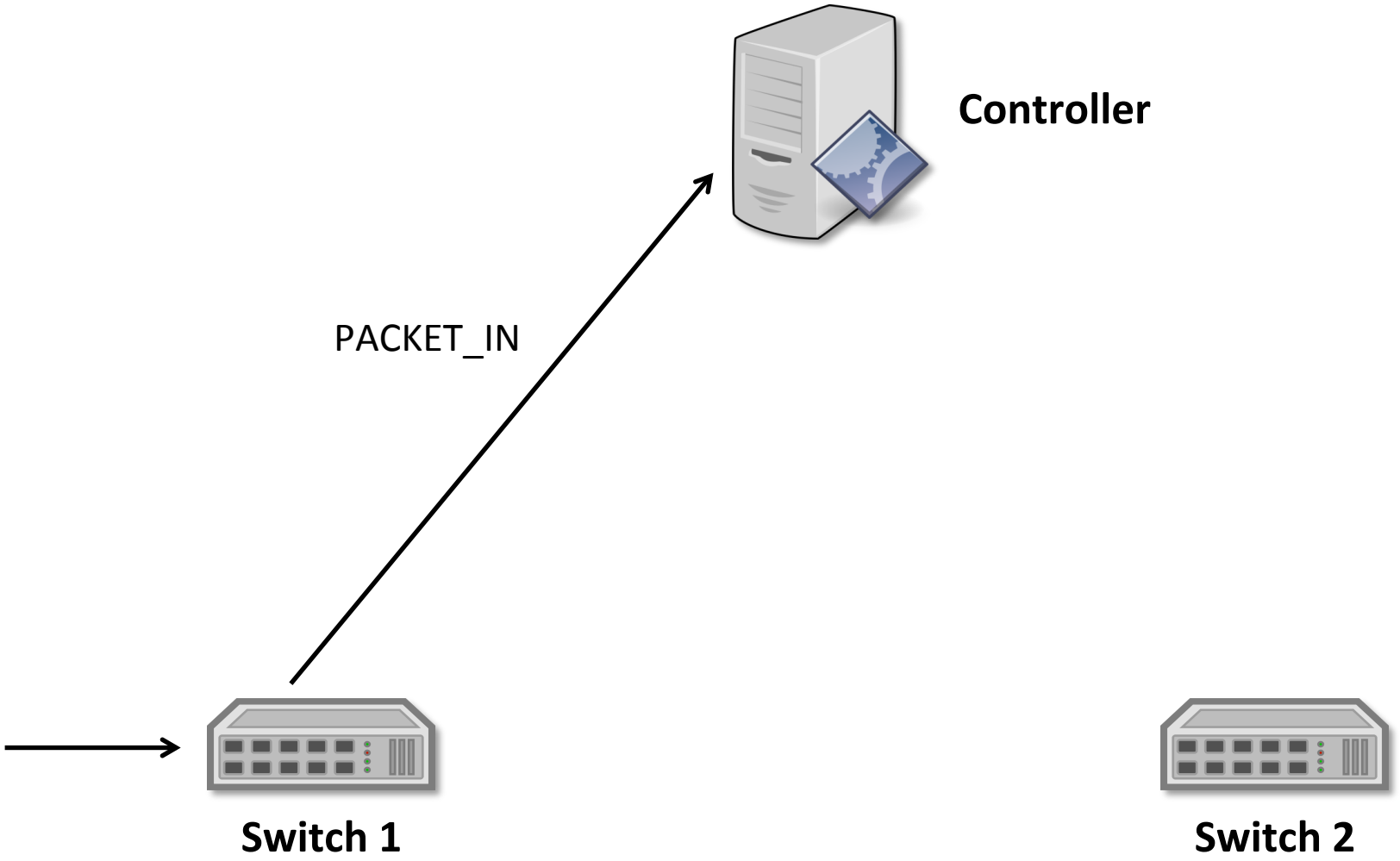


Switch 2

Traditional monitoring technique

Active flow discovery



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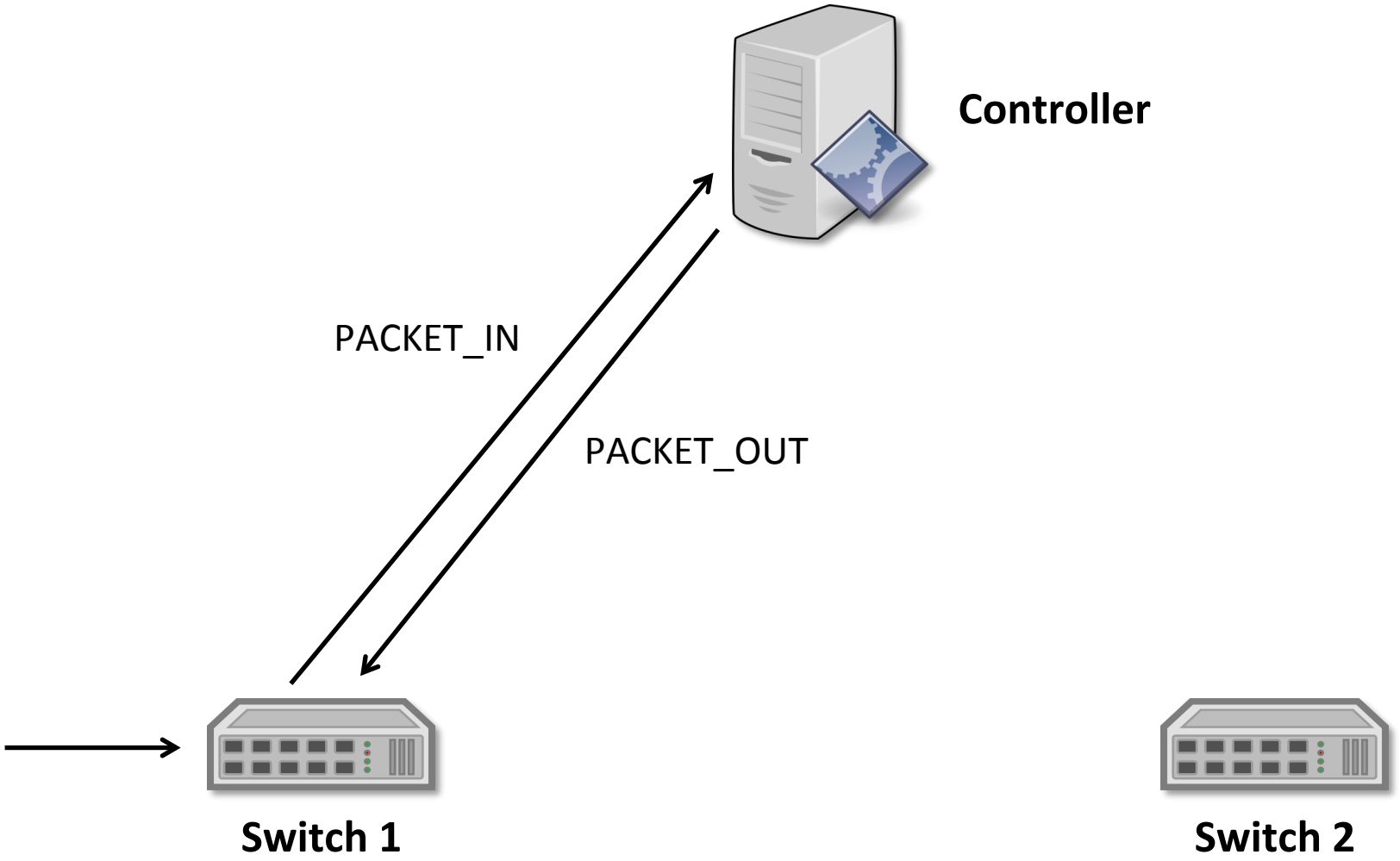
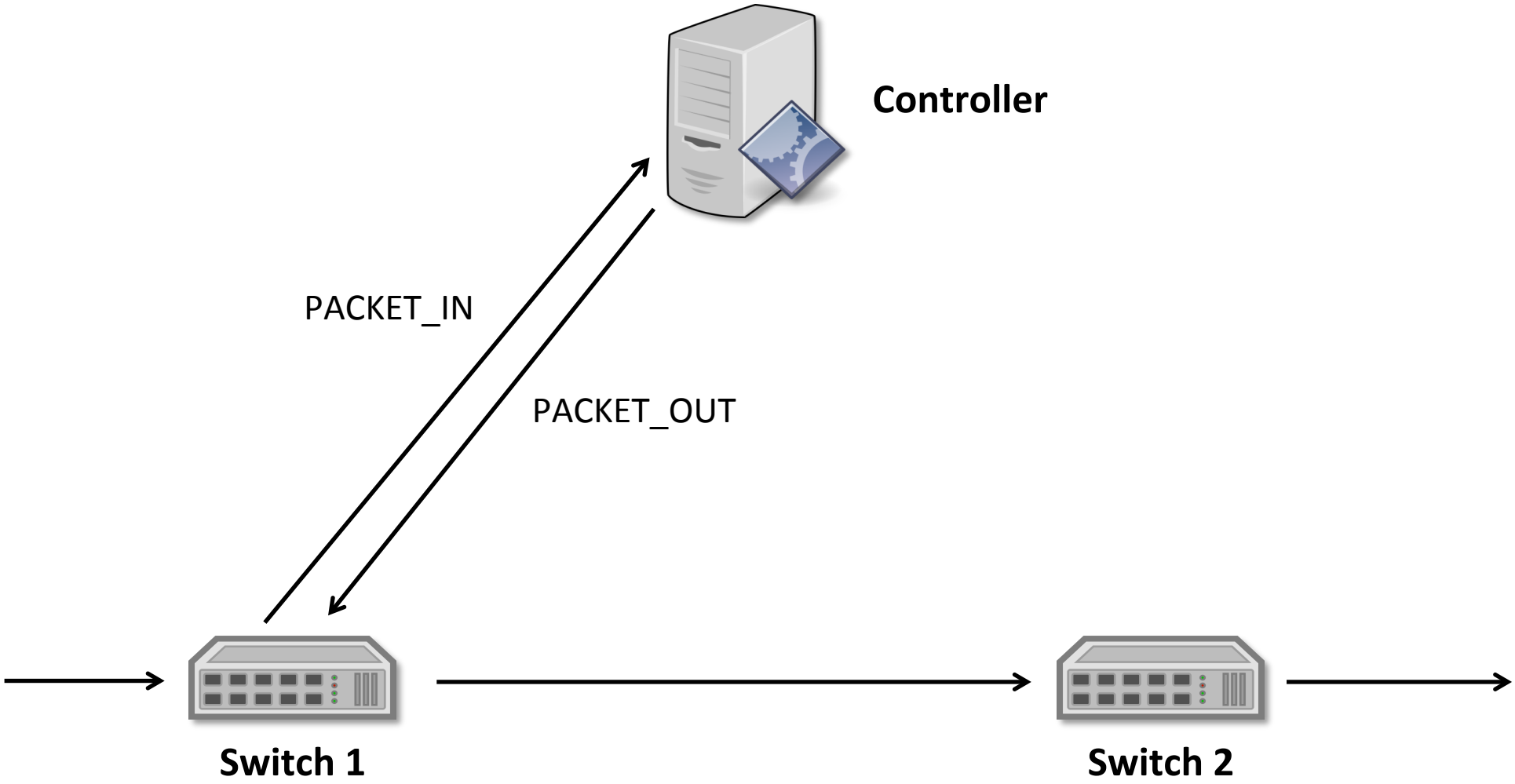
Active flow discovery



Traditional monitoring technique

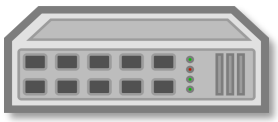
Active flow discovery



Traditional monitoring technique

Active probing

Controller



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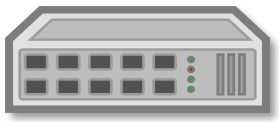
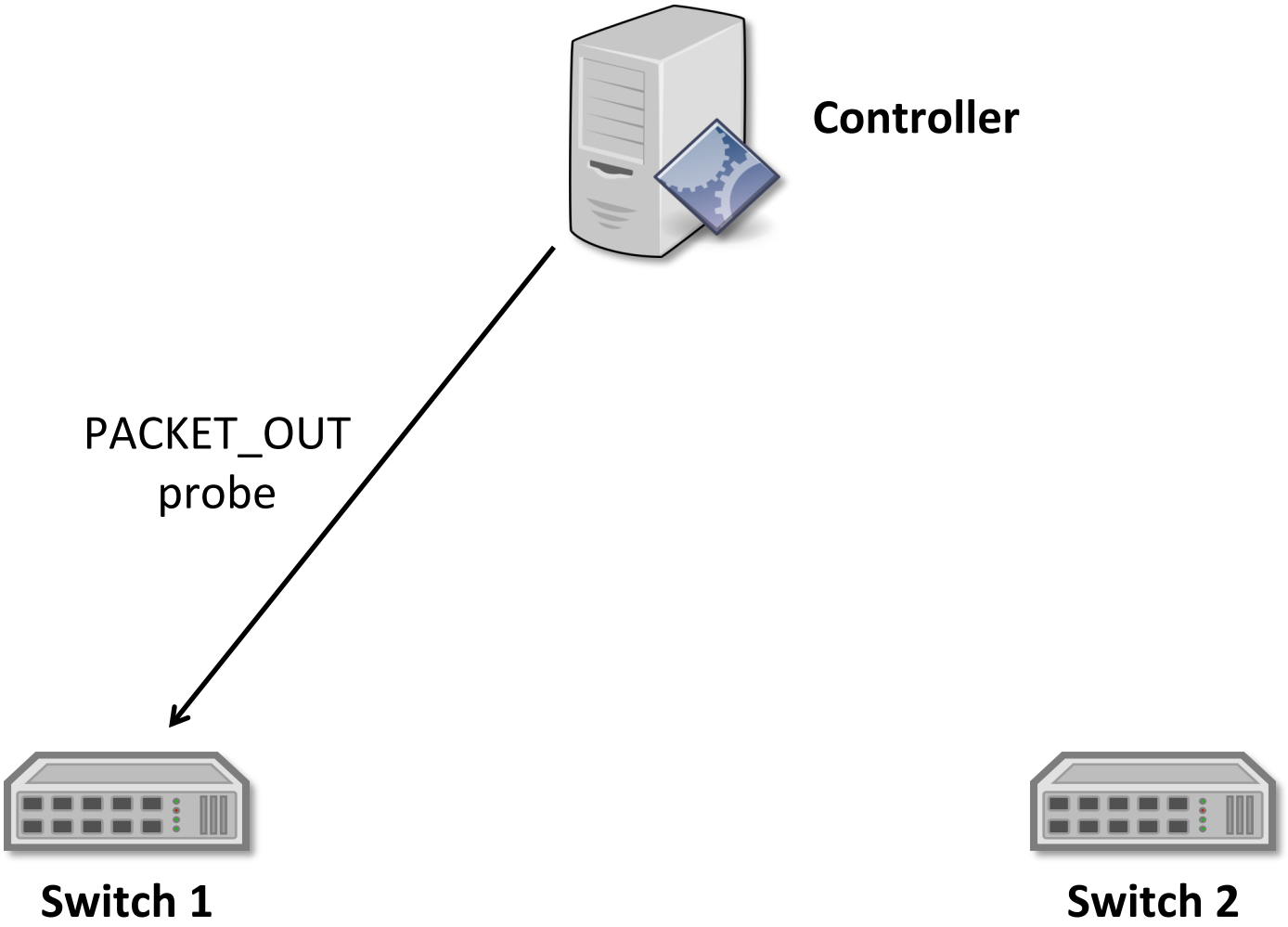


Switch 2

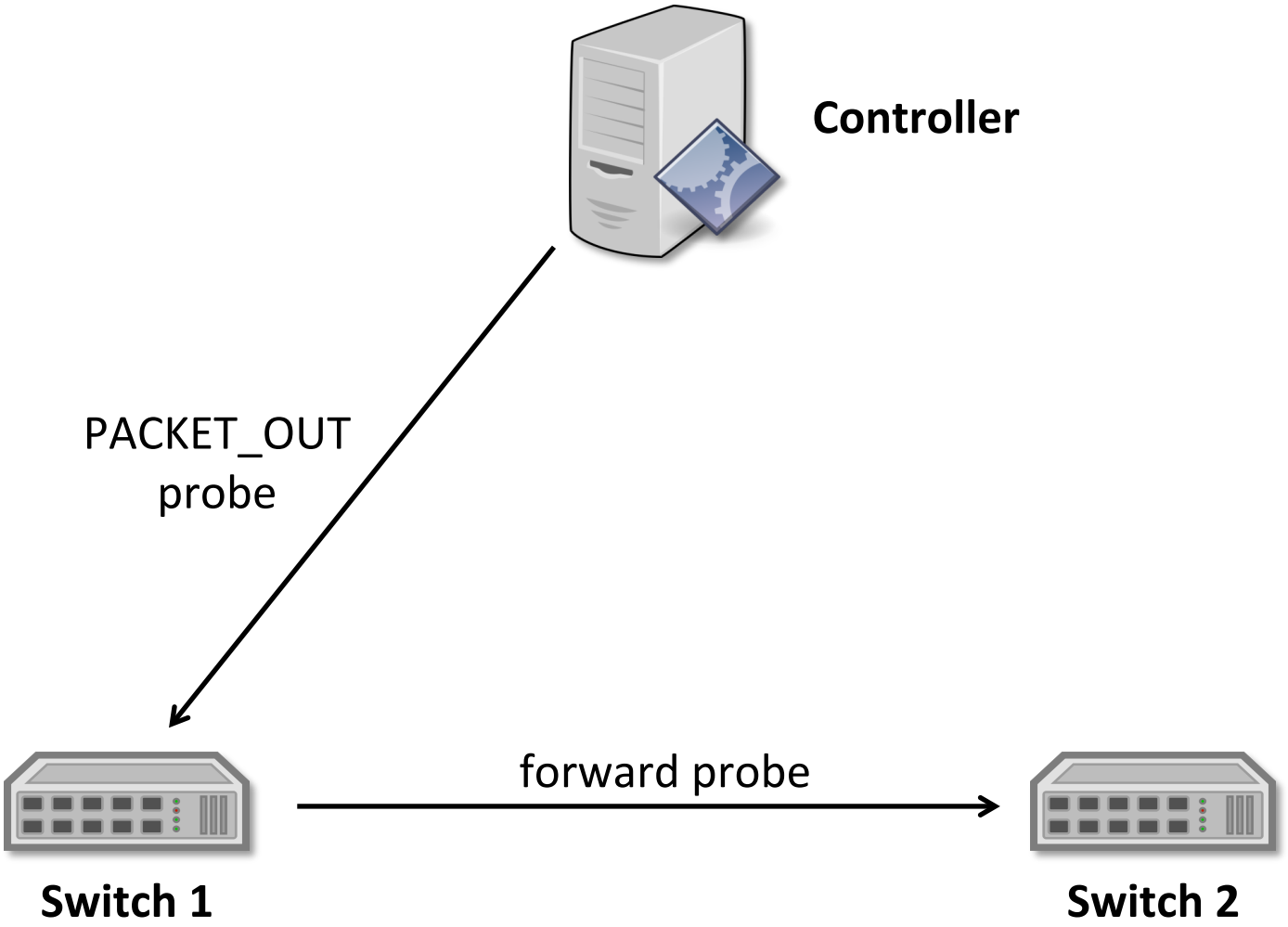
Traditional monitoring technique

Active probing



Traditional monitoring technique

Active probing



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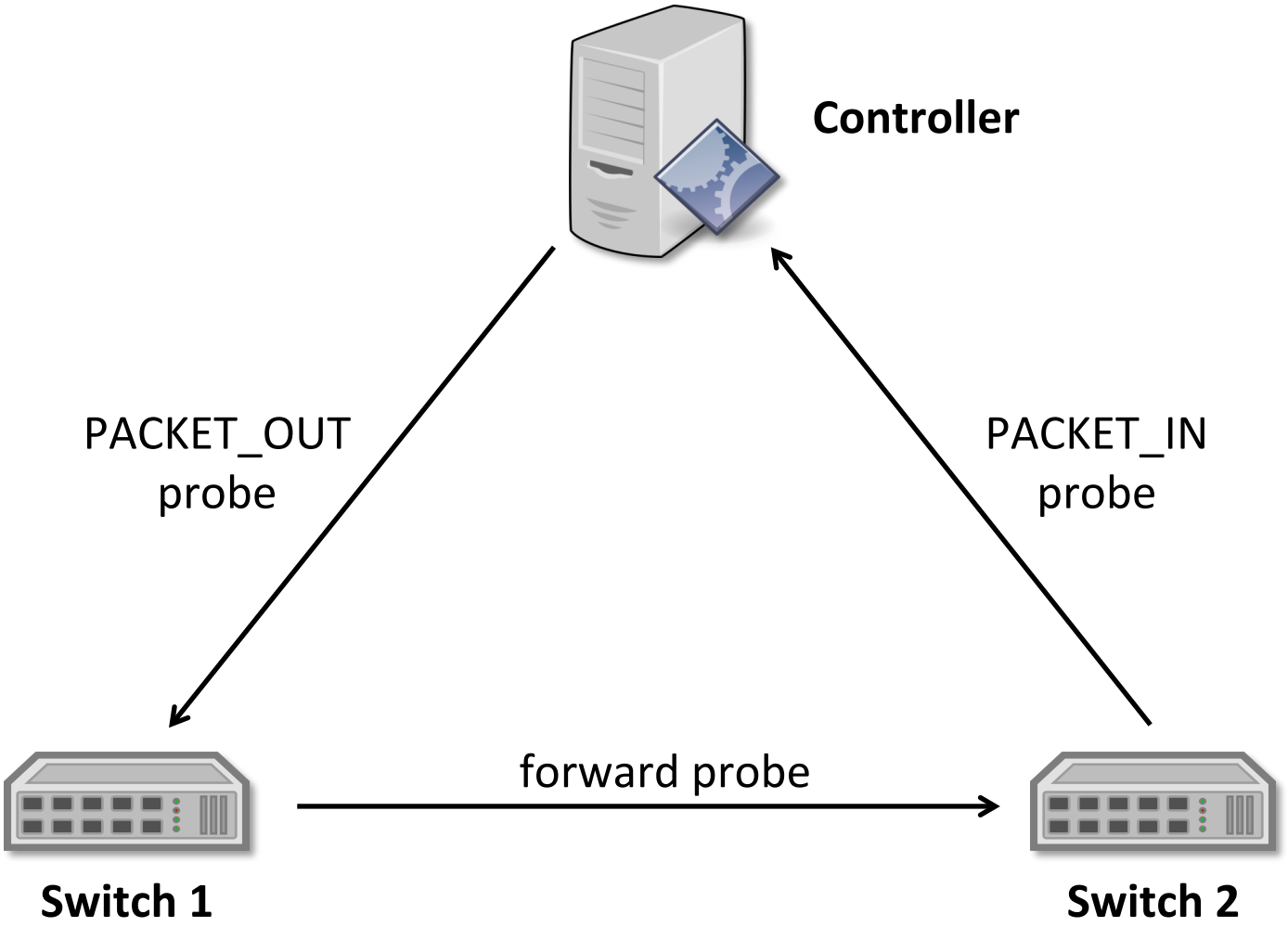
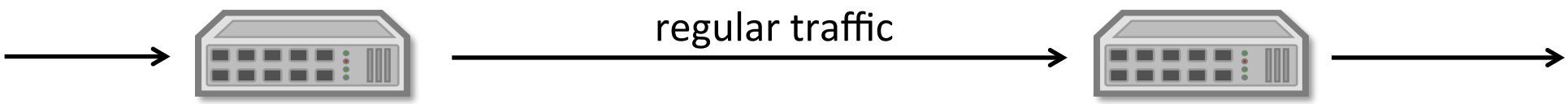


Traditional monitoring technique

Statistics request

Controller



Traditional monitoring technique

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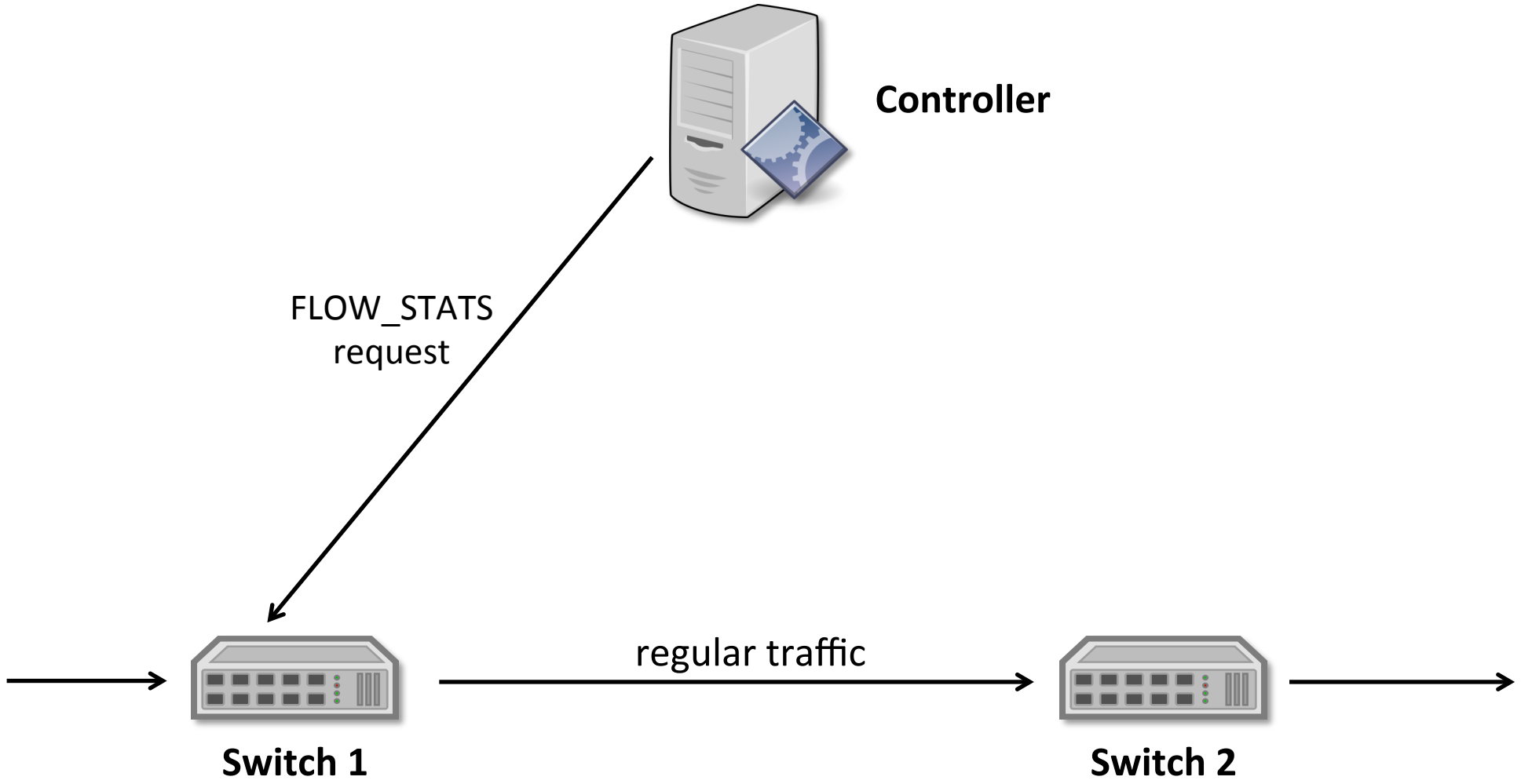

Traditional monitoring technique

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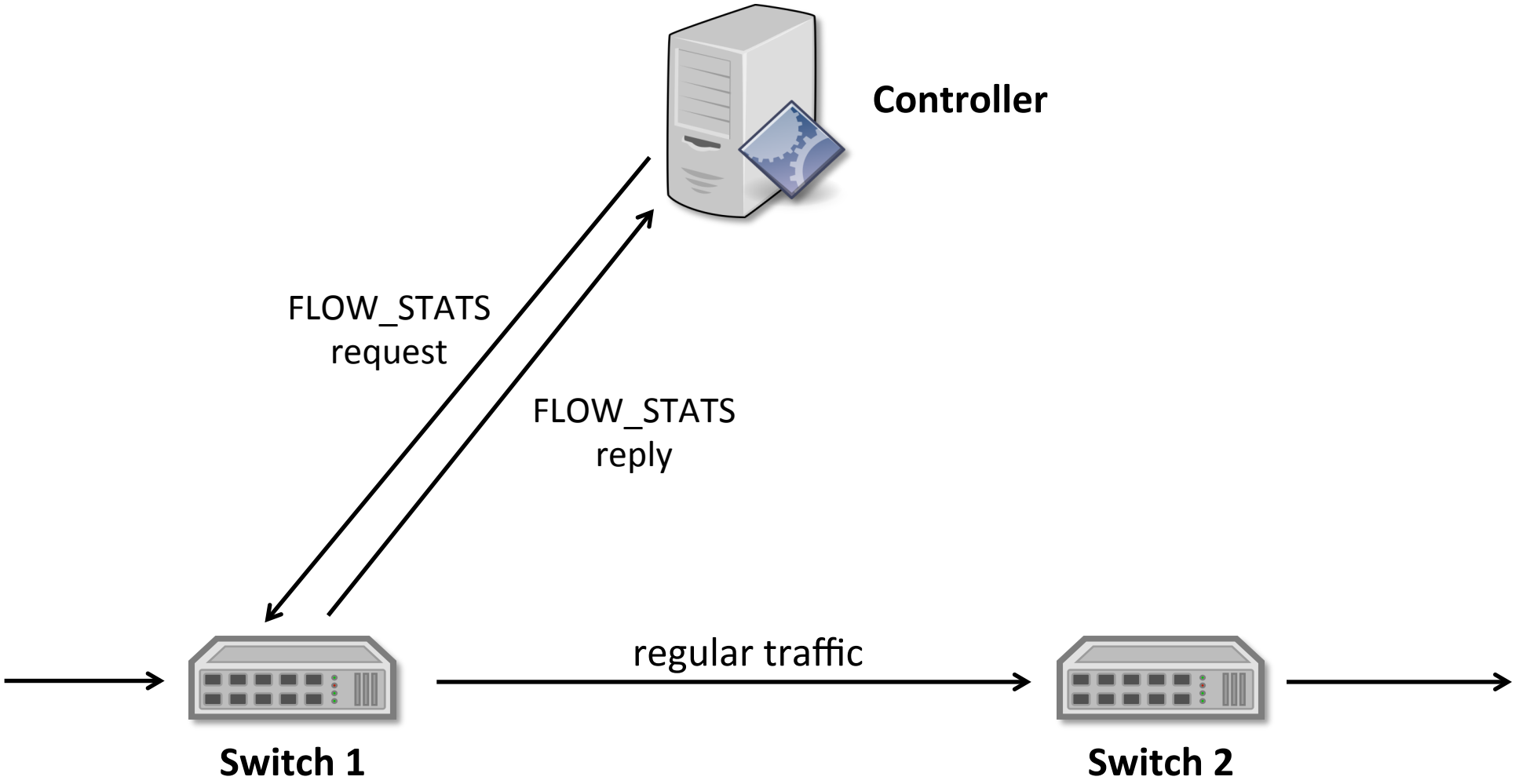
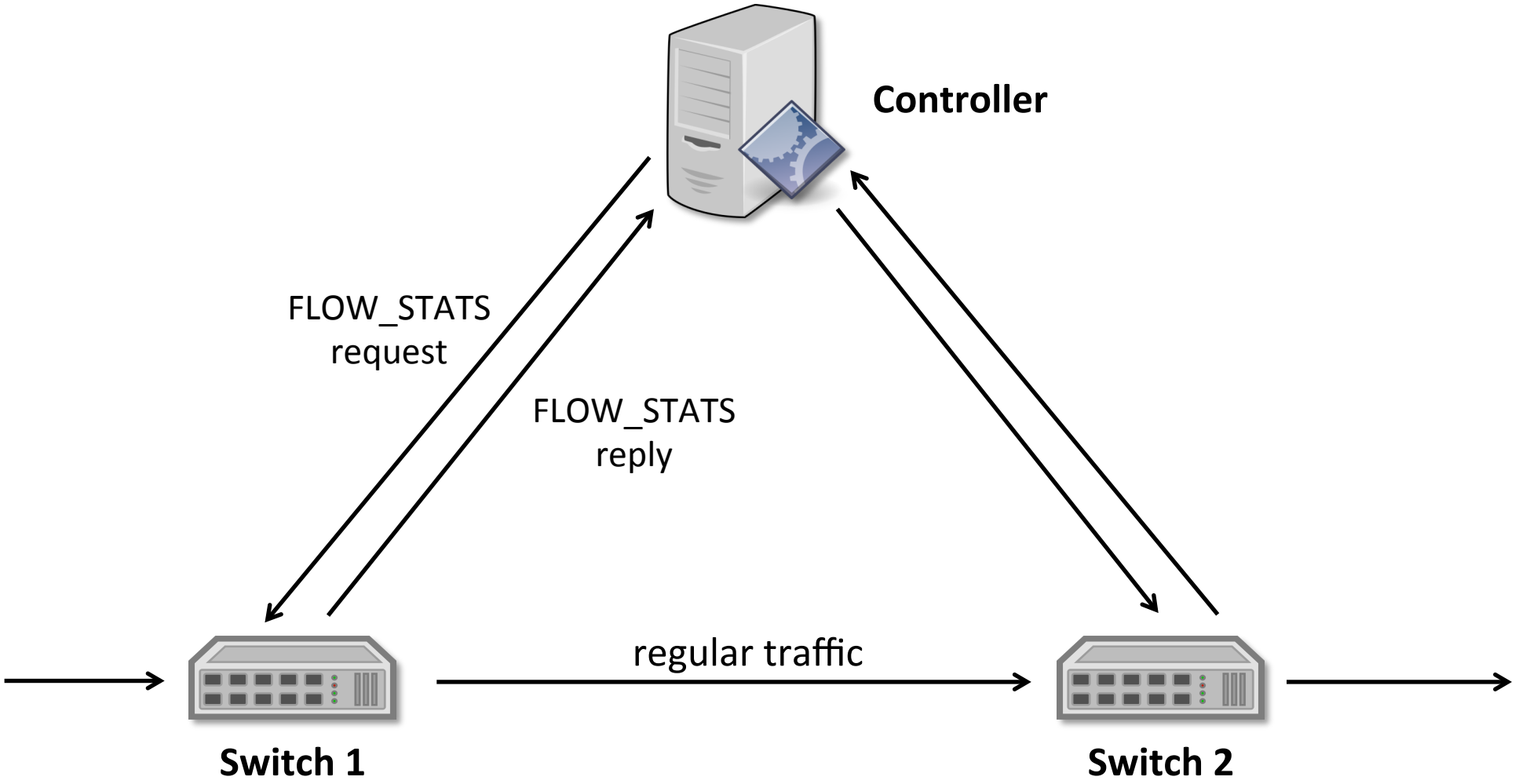


Traditional monitoring technique

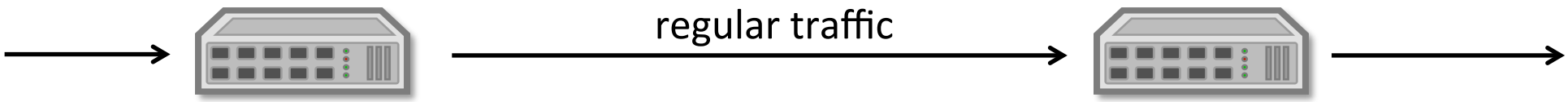
Statistics request



Traditional monitoring technique

Packet sampling

Controller

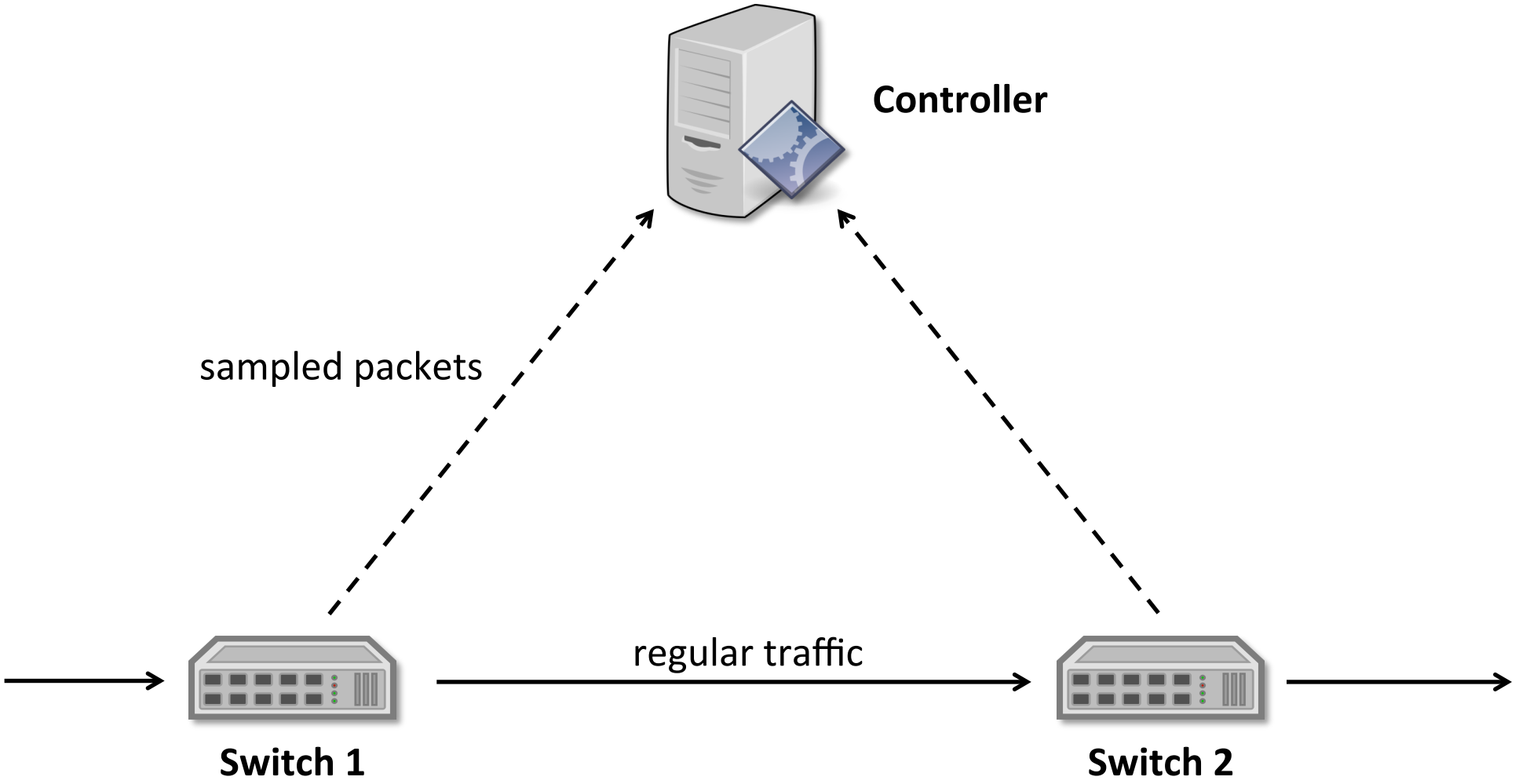


Switch 1

Switch 2

Traditional monitoring technique

Packet sampling



Traditional monitoring technique

Packet sampling

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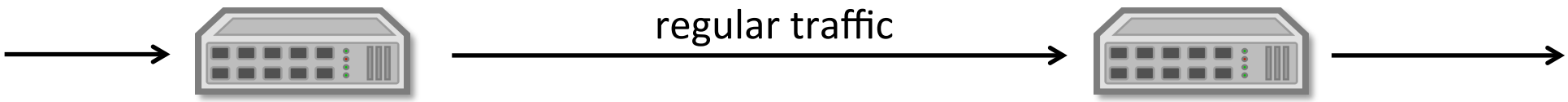


Switch 1

Switch 2

Common security pitfalls

- PACKET_IN-based flow discovery is vulnerable to DoS attacks due to slow control path
- Unprotected and detectable probes can be forged, replayed, delayed, etc.
- Switch counters are insufficient for asserting packet integrity

Iterative solution design

Iterative solution design

- Avoid the use of active probes
- Then how do we measure link delay?
  - Sample user packets during unpredictable times by sending them from source and target switches to the controller
- But the same packet must be sampled in both switches, how do we do this reliably?

Iterative solution design

- How do we assert packet integrity in a link?
  - Sample user traffic from source and target switches and compare the two samplings

- Again, the same portion of traffic must be sampled in both switches, how do we do this reliably?

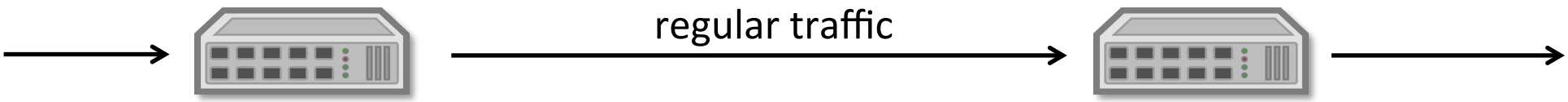
Solving the sampling problem in a link

- Most switches only support random sampling, which do not allow us to sample the same traffic at source and target switches

- We can add a tag to packets at the source switch, periodically modify its value, and sample a slice of traffic during the lifetime of a tag value

Solving the sampling problem in a link

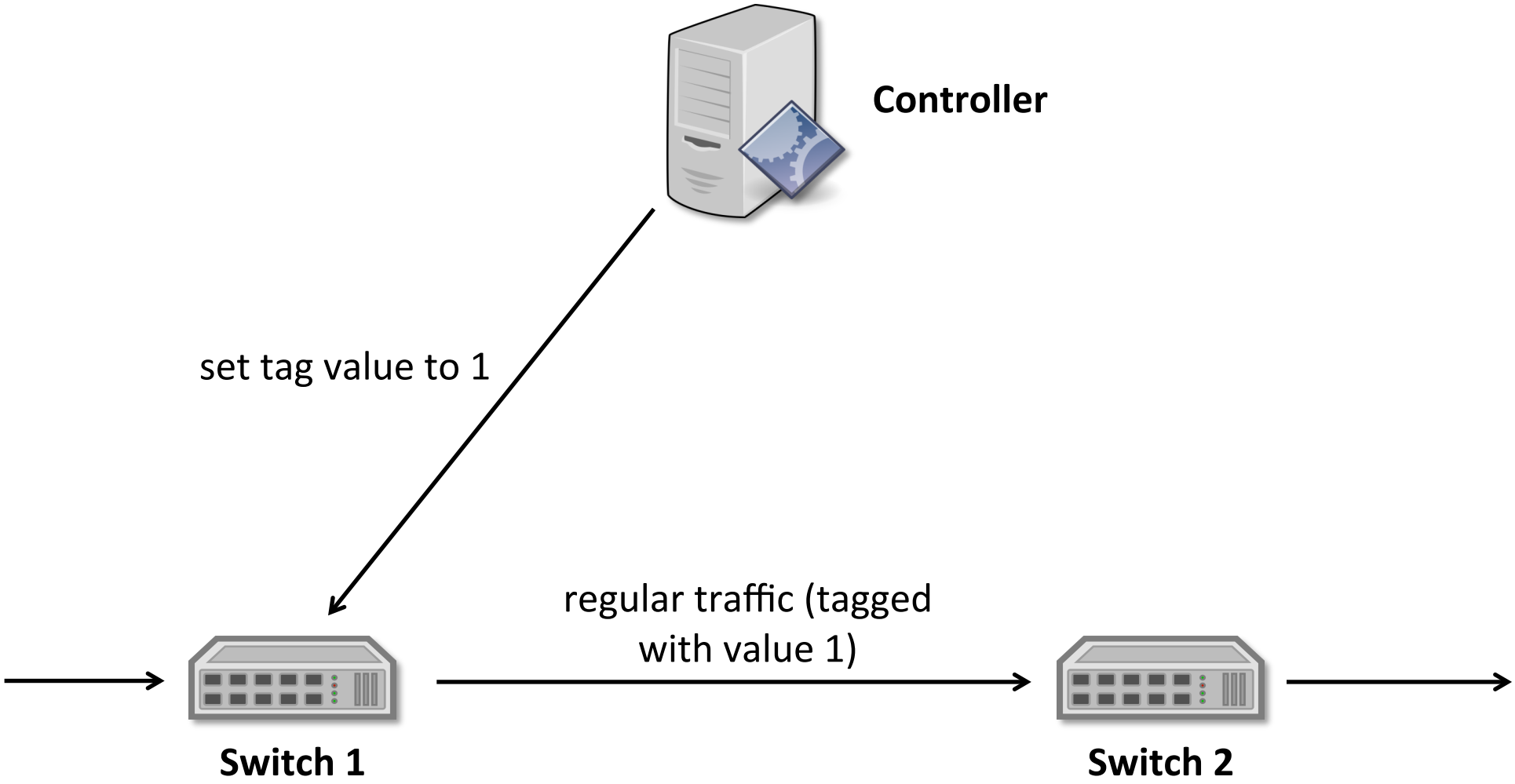
Controller



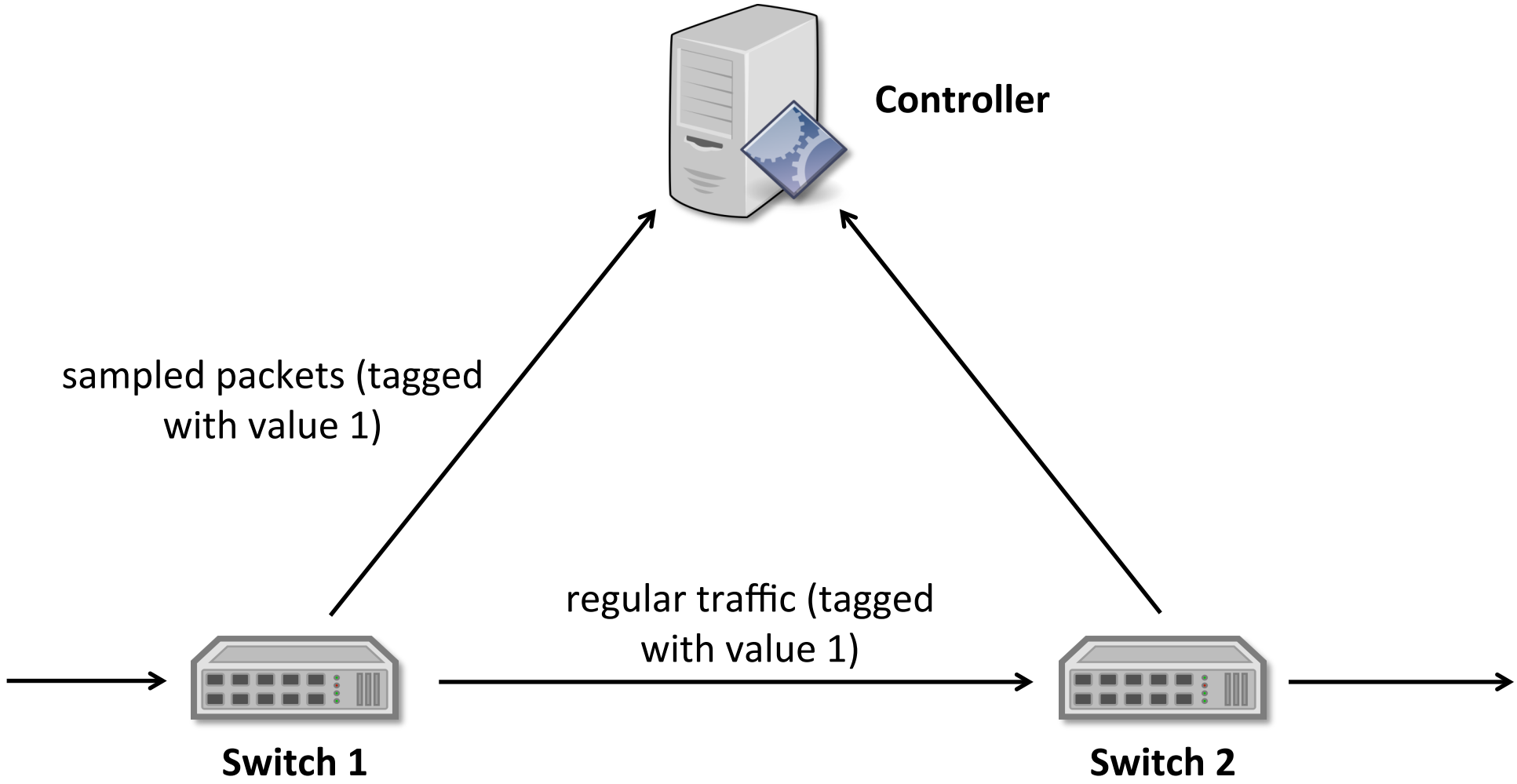
Switch 1

Switch 2

Solving the sampling problem in a link



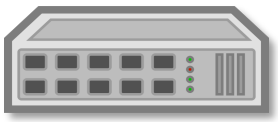
Solving the sampling problem in a link



Solving the sampling problem in a link

Controller

regular traffic (tagged with value 1)



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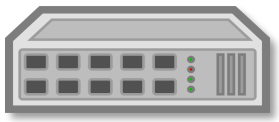
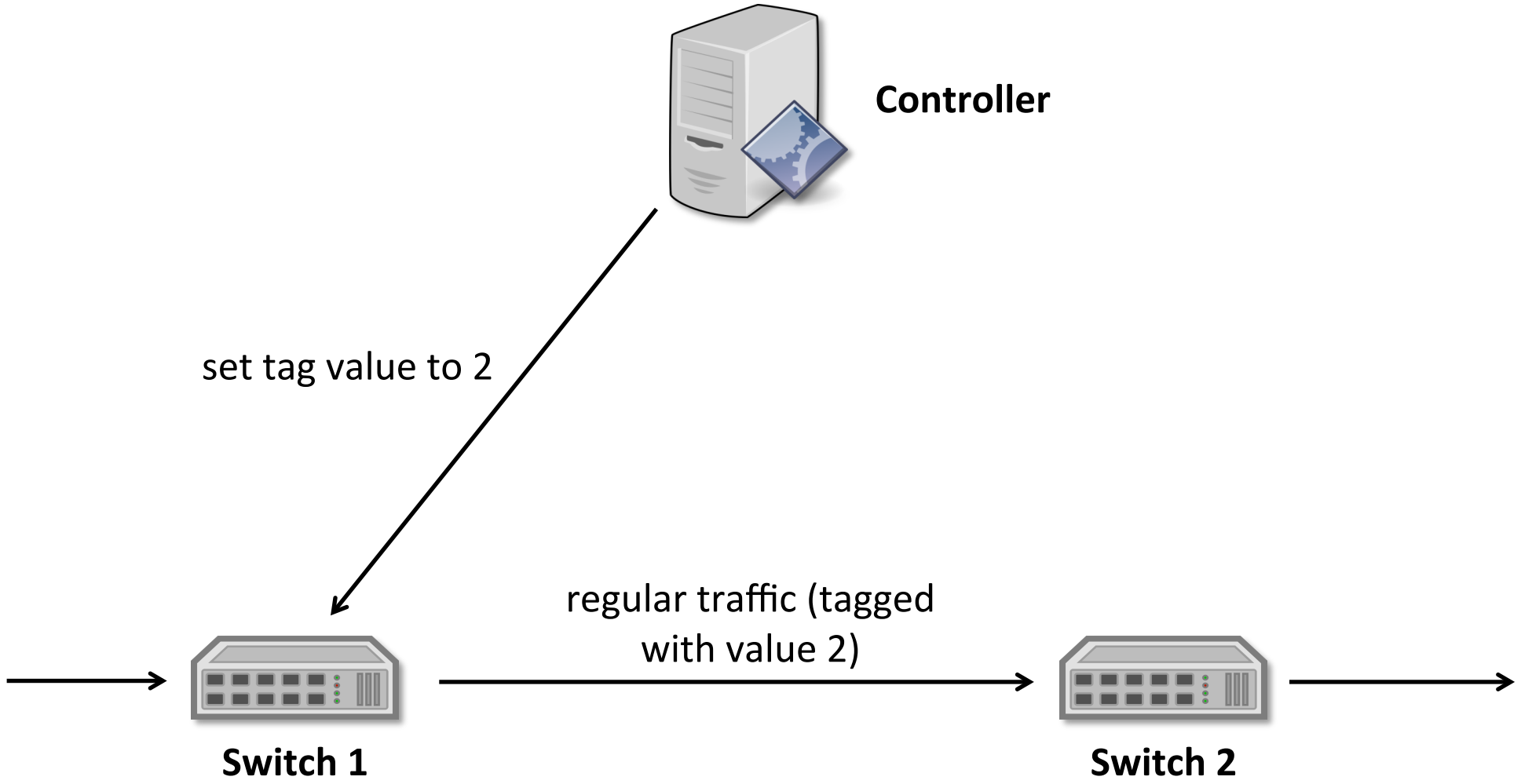


Switch 2

Solving the sampling problem in a link



Solving the sampling problem in a link

- Experiments with physical switches show that getting a slice of traffic via the control channel overloads the switches !!!

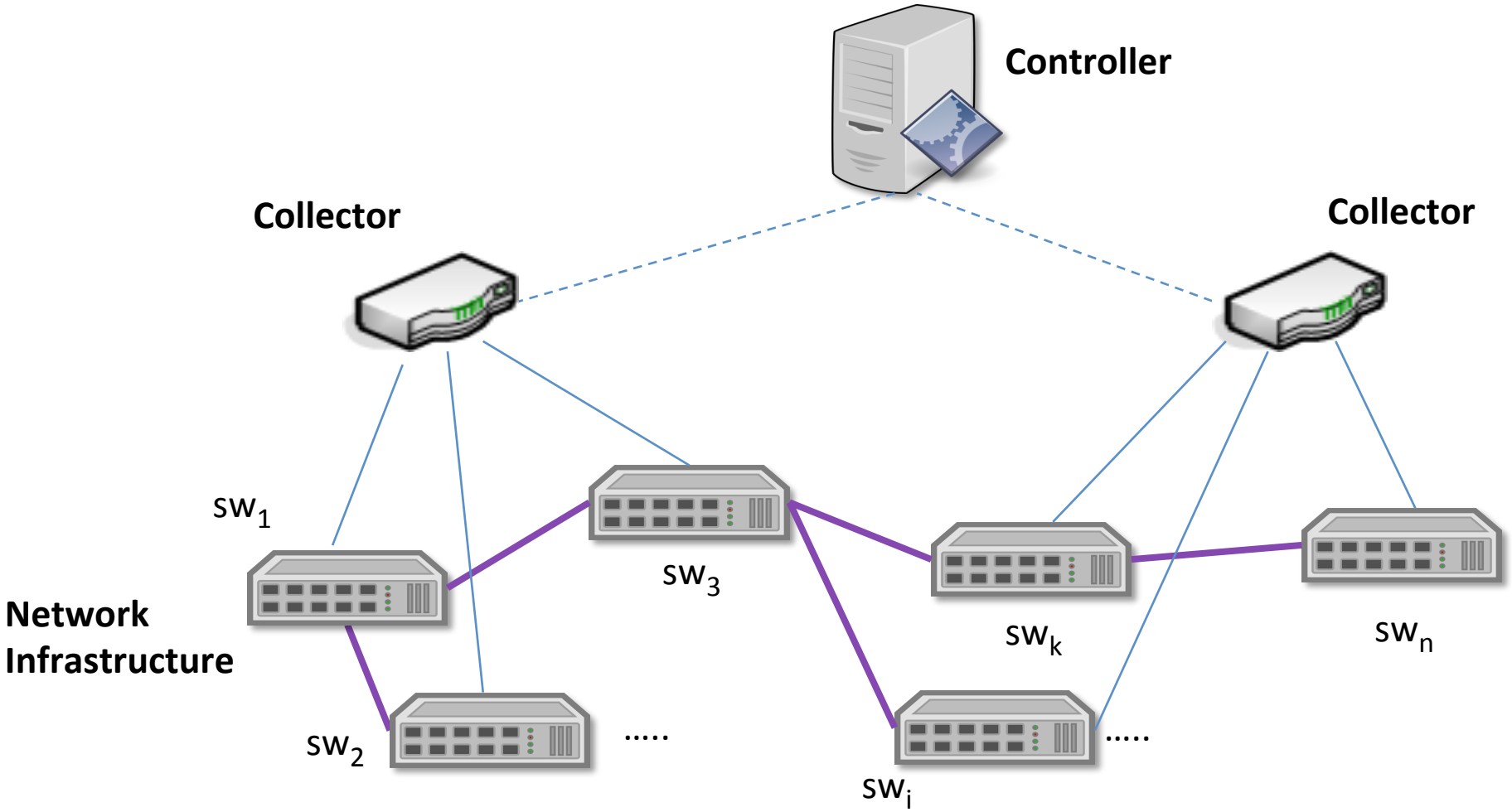
- The control channel is very slow, so we need an alternative channel to sample packets from switches to the controller

Current solution

- Send packets from the switches to local collector machines via traffic mirroring, which works fine at line rate

- The collectors send time-stamped packet hashes to the controller
  - We still need to resolve the clock synchronization problem

Current solution



Current solution

- Packet delay is measured by getting the difference between the timestamps of the same hash

- Enhanced loss rate is measured by finding the proportion of source traffic that is missing from the target traffic
  - This grants us the assertion of packet integrity

Future optimizations

- Use trajectory sampling at the collectors to reduce the amount of traffic sent to the controller

- Complement sampled probing with active probes, protected with keyed cryptographic hashes

Thank you!