北京大学

PEKING UNIVERSITY

PENG CHENG LABORATORY

HUAWEI

nsdi'21

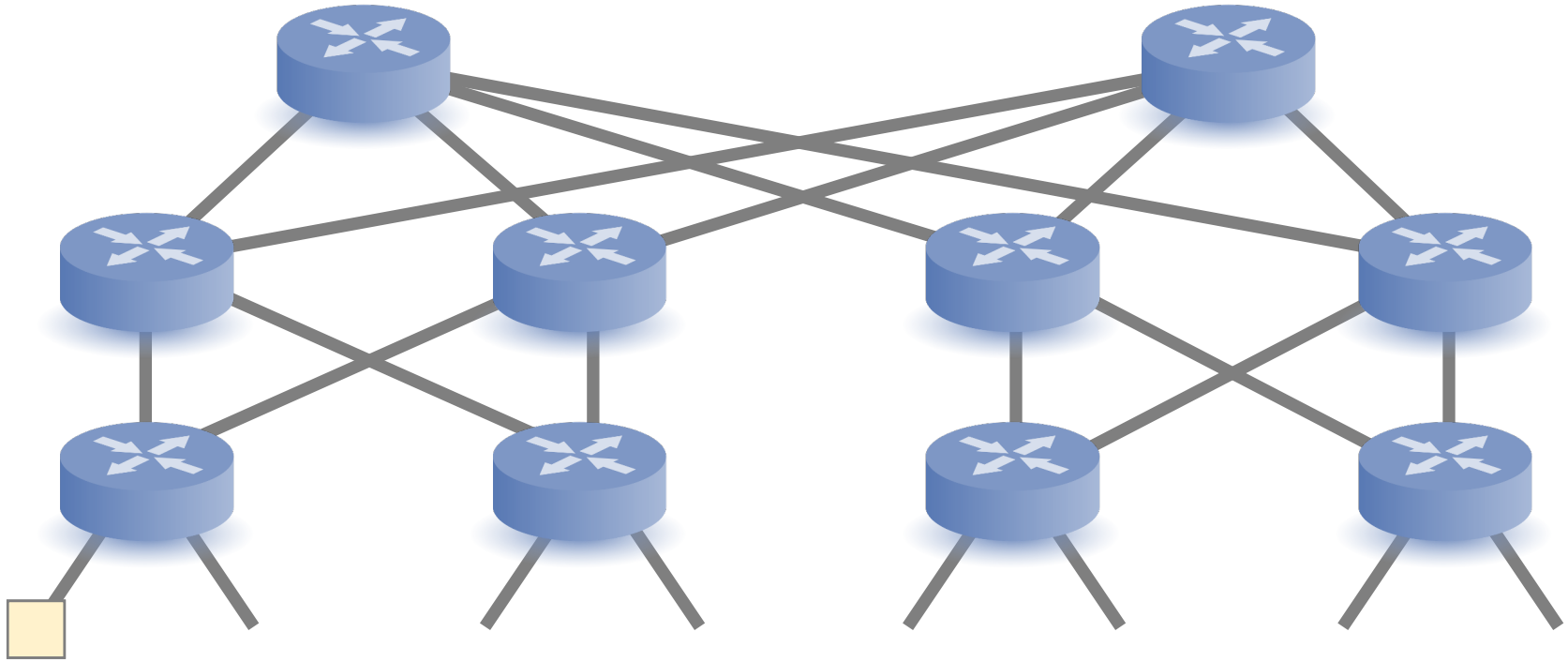
LightGuardian:

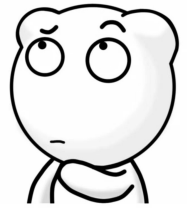
A Full-Visibility, Lightweight, In-band Telemetry System Using Sketchlets

Yikai Zhao, Kaicheng Yang, Zirui Liu, Tong Yang, Li Chen, Shiyi Liu, Naiqian Zheng, Ruixin Wang, Hanbo Wu, Yi Wang, Nicholas Zhang

Background

- measurement is central to successful network operations





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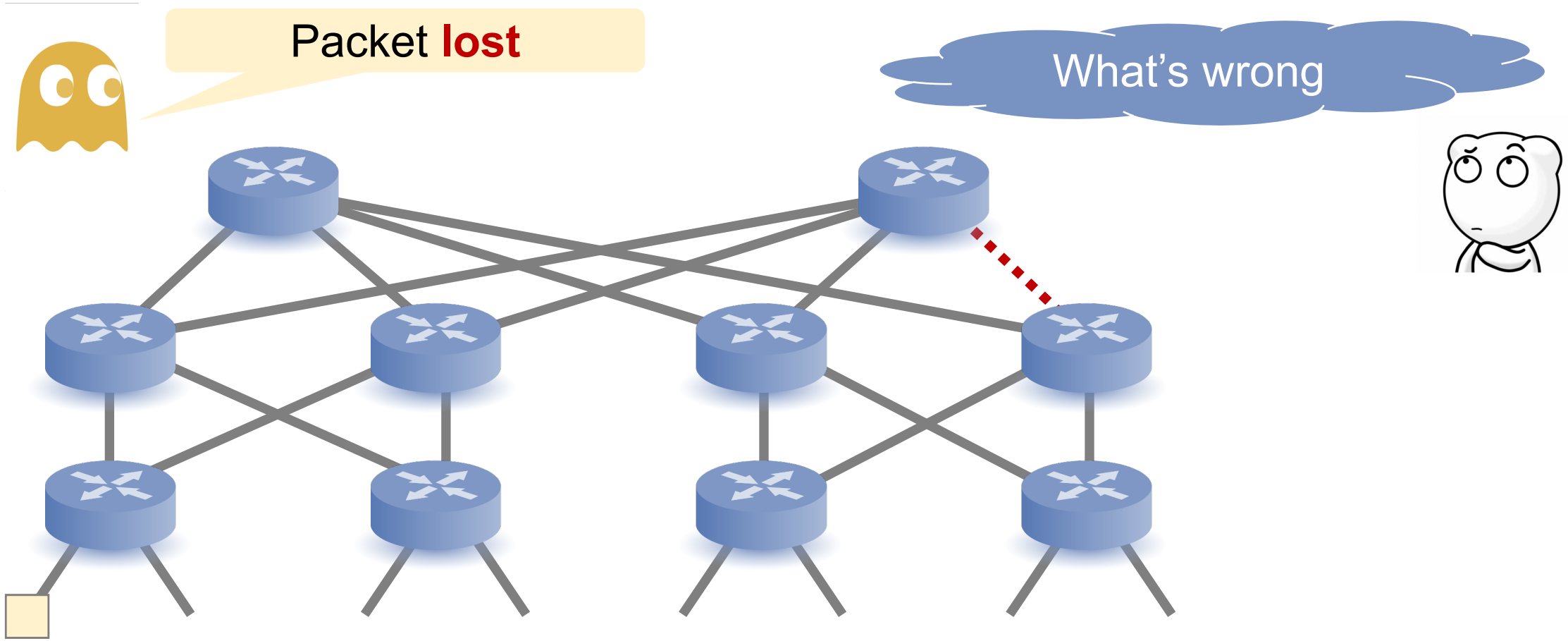

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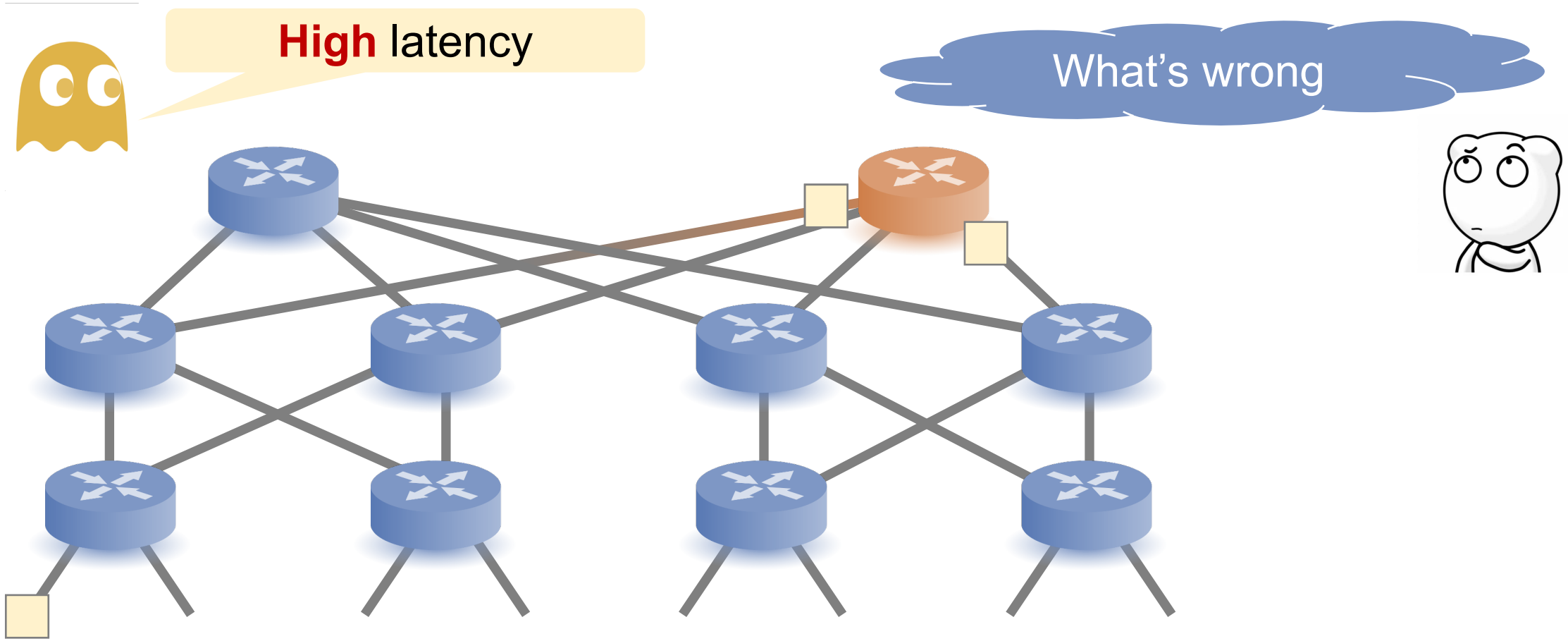
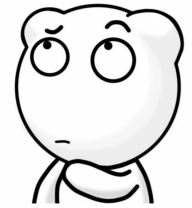


Background

- measurement is central to successful network operations
- **full-visibility**
  - per-hop flow-level information for all flows
- **lightweight**
  - computation, memory, bandwidth
- **robustness**
  - link failures, device failures



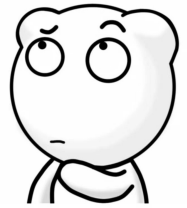
Background

- existing solution
  - sampling
  - probing
  - sketch-based

  } (currently) lack of **full-visibility**

  - in-band

  } (currently) lack of **lightweight**

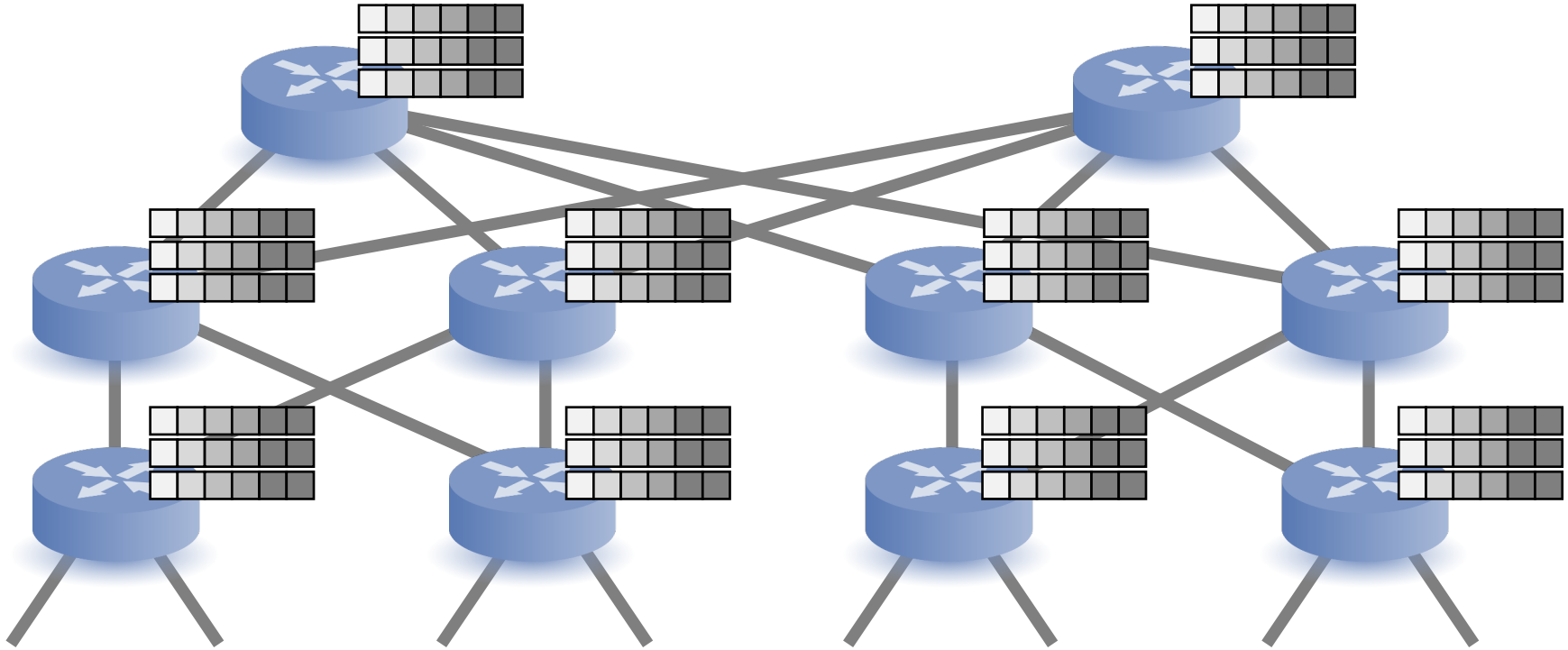


LightGuardian Overview

- Accurate & versatile device-local sketches
- In-band telemetry with sketchlets
- Incremental network-wide aggregation

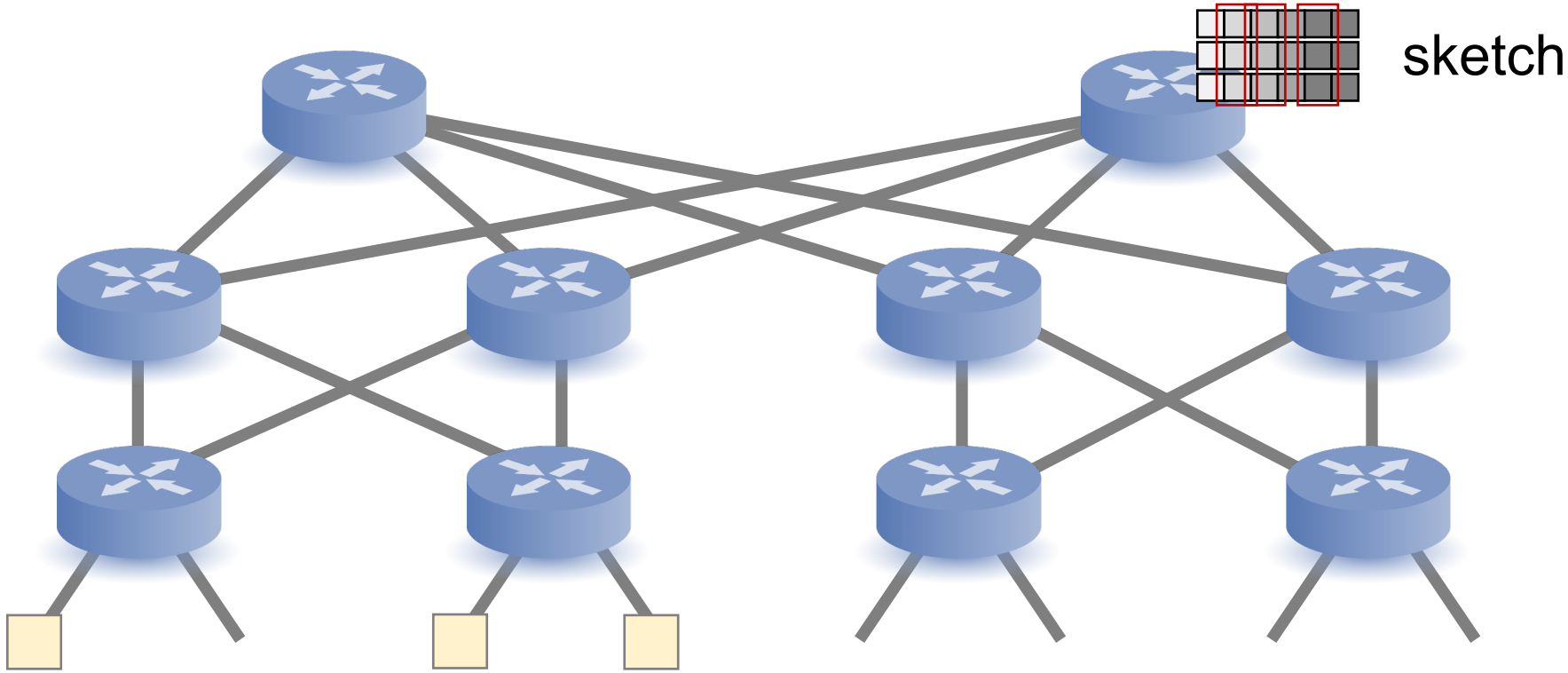
LightGuardian Overview

- Accurate & versatile device-local sketches



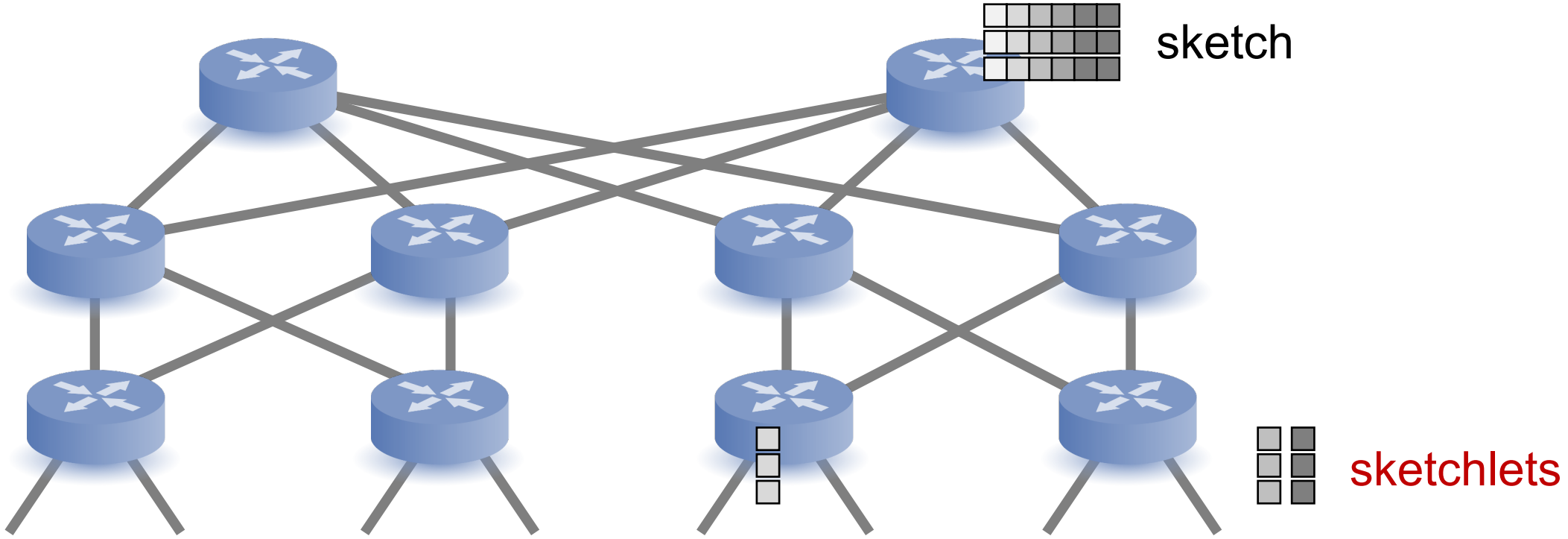
LightGuardian Overview

- In-band telemetry with sketchlets



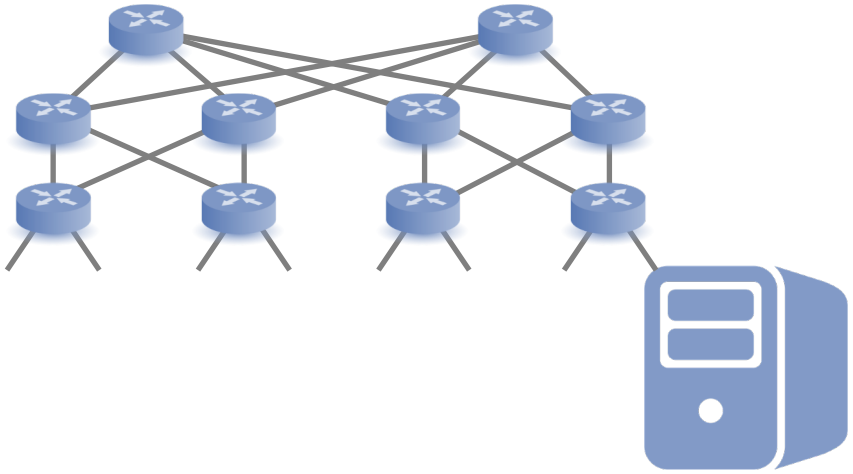
LightGuardian Overview

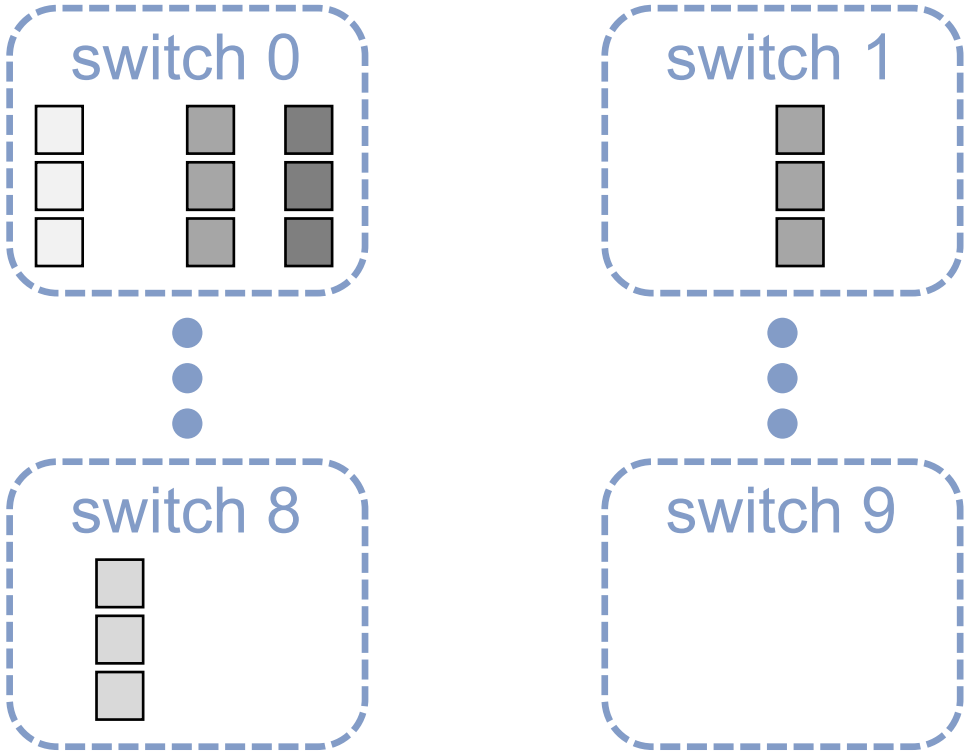
- In-band telemetry with sketchlets



LightGuardian Overview

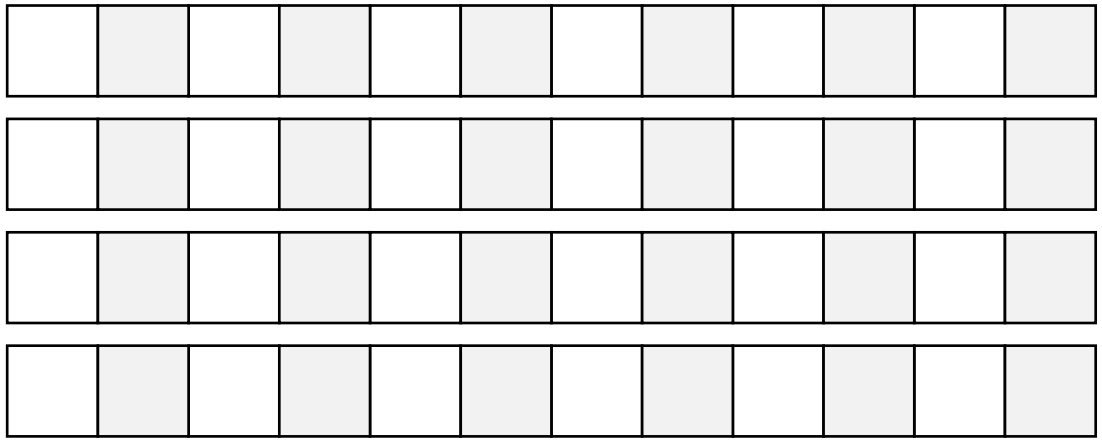
- Incremental network-wide aggregation





Device-local Sketch Design: SuMax

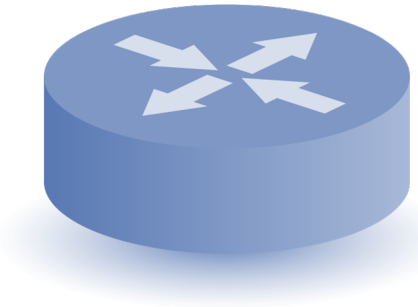
- record both of the **sum** value and the **maximum** value



SuMax Sketch

sum cell

max cell



Device-local Sketch Design: SuMax

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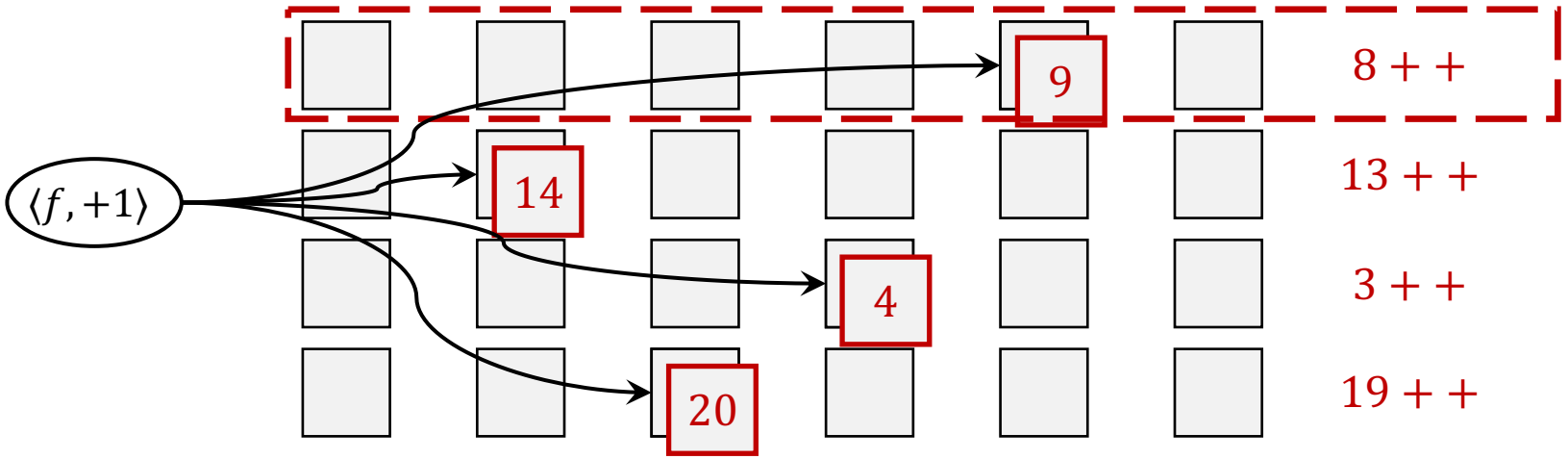
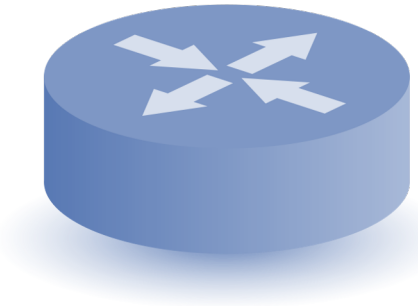
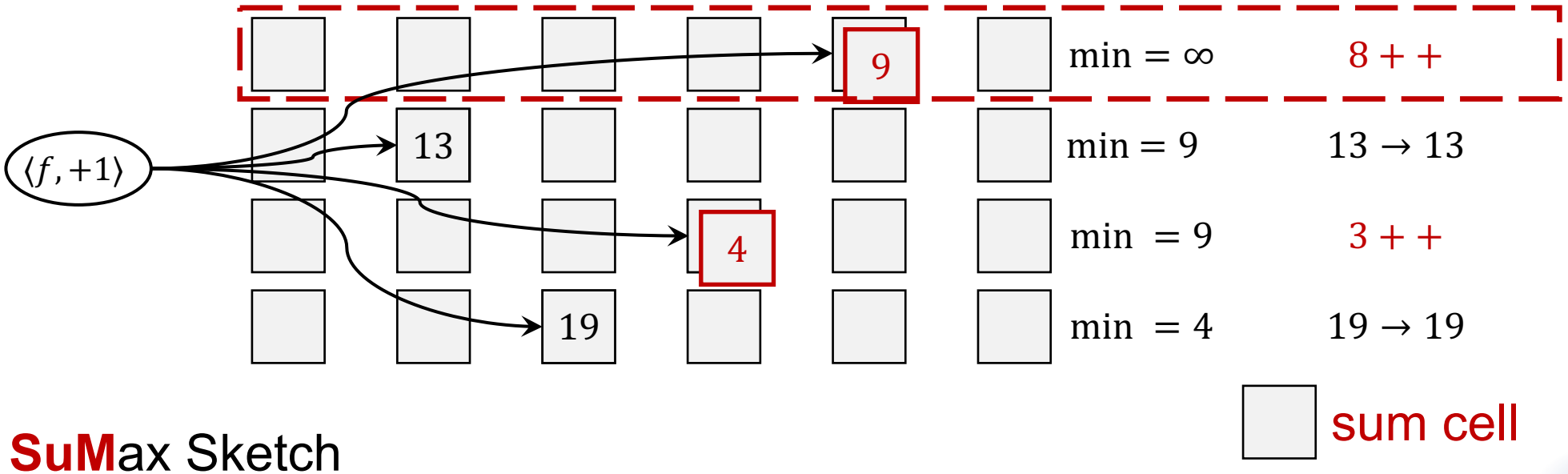


SuMax Sketch



Device-local Sketch Design: SuMax

- approximate conservative update strategy



SuMax Sketch

Device-local Sketch Design: SuMax

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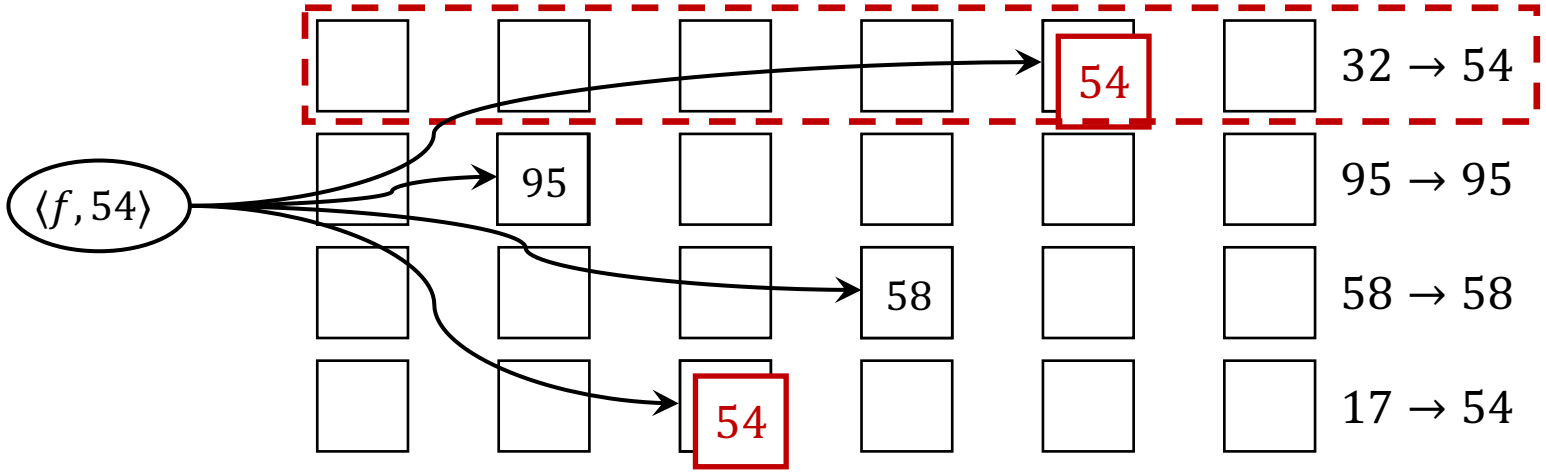
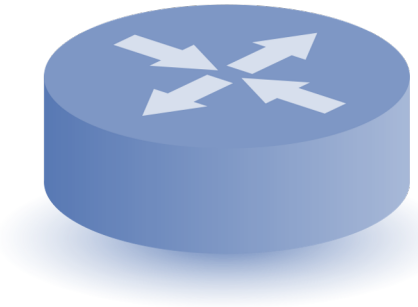
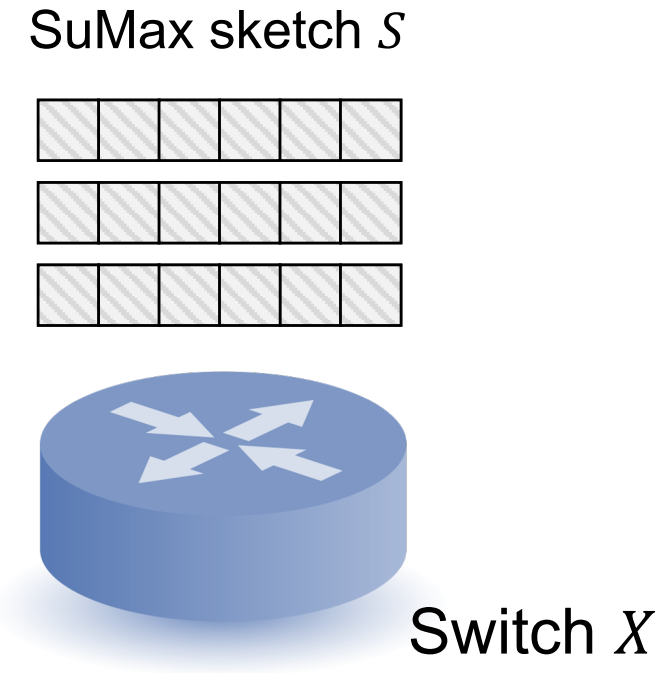


SuMax Sketch

max cell



Transmission of Sketchlets



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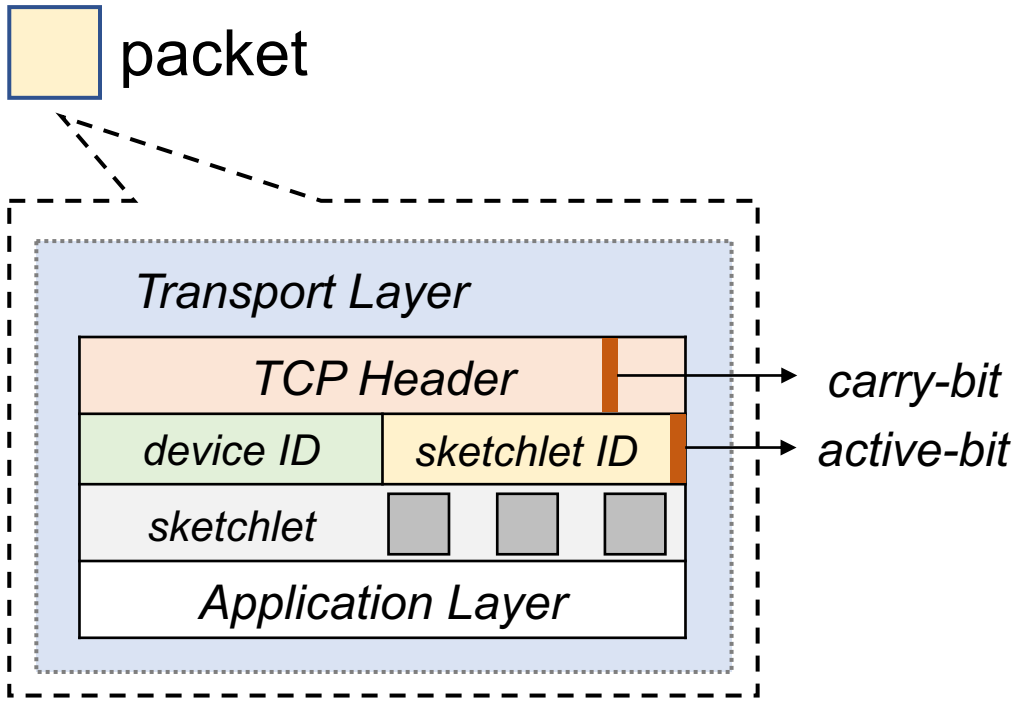
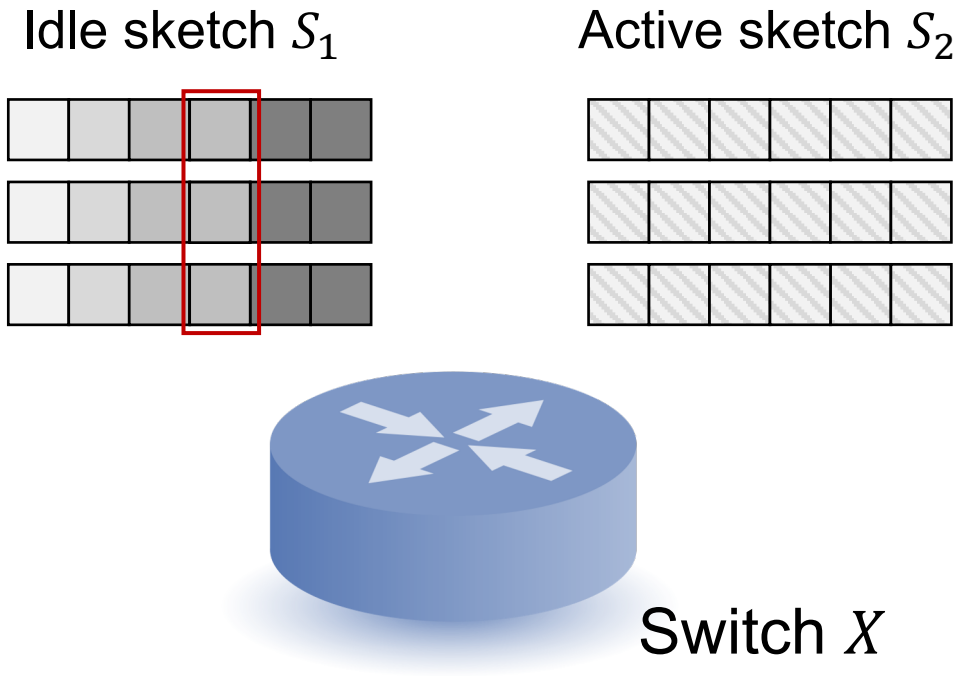
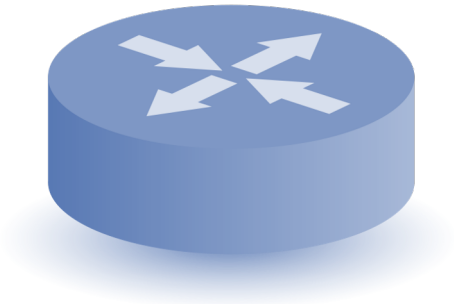
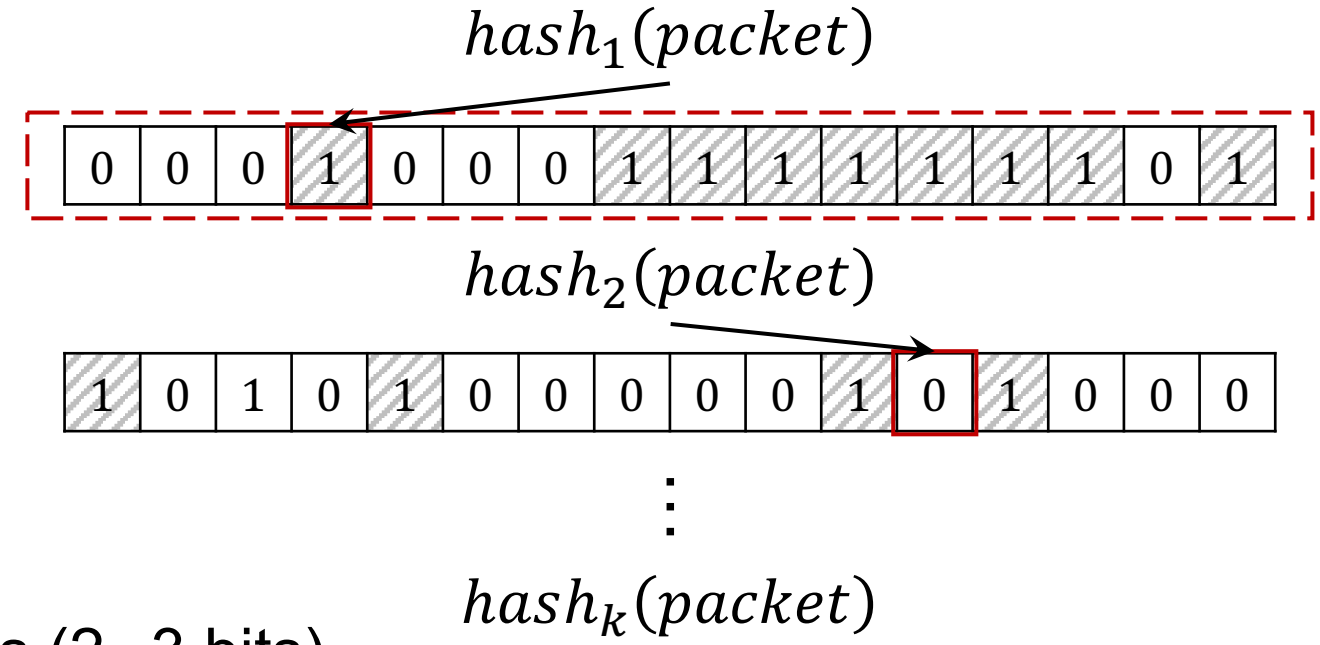




Transmission of Sketchlets

- Sketchlets Selection: *K+chance Selection*

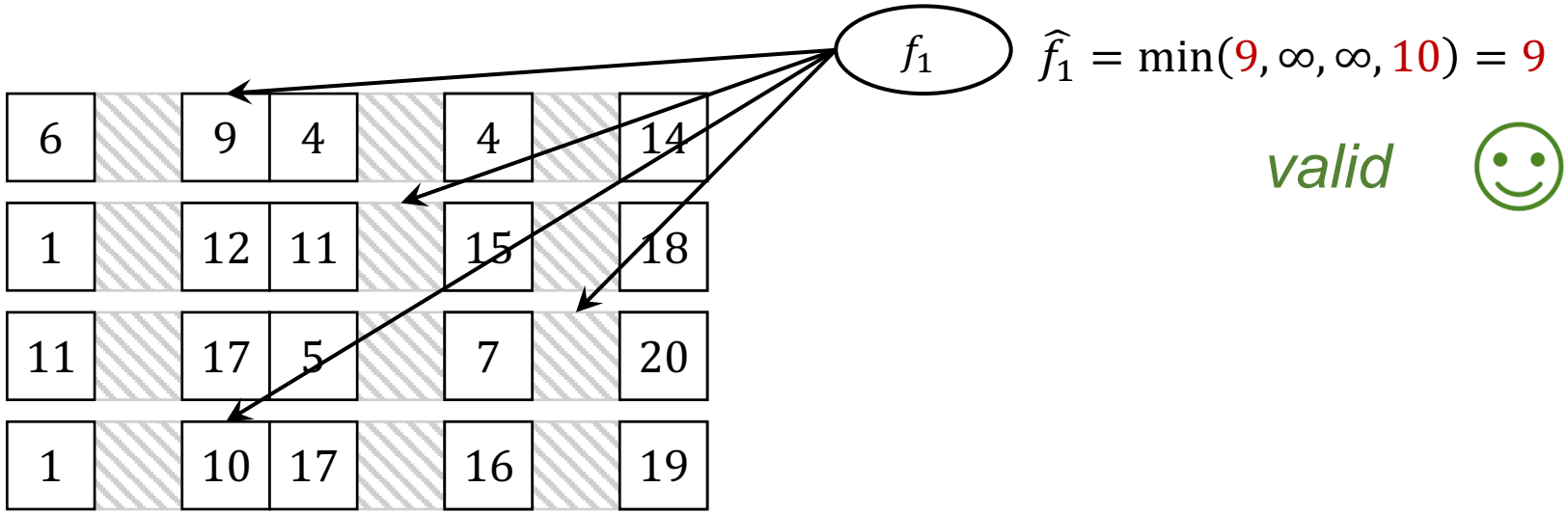




- just takes $\lceil \log(k+1) \rceil$ bits (2~3 bits)

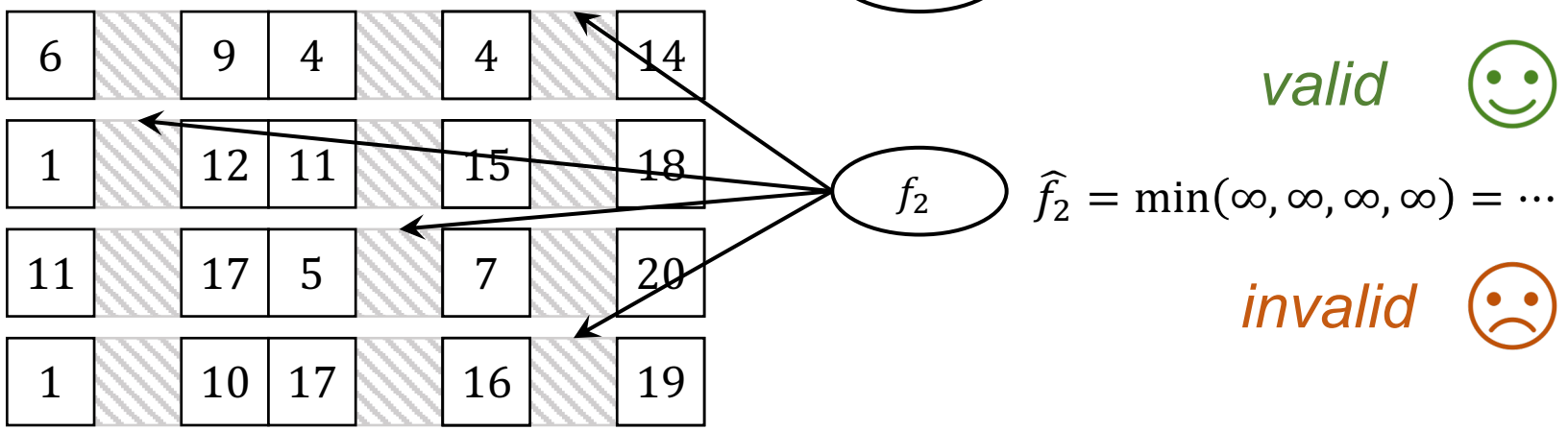
Reconstruction and Analysis

- Incremental reconstruction



Reconstruction and Analysis

- Incremental reconstruction

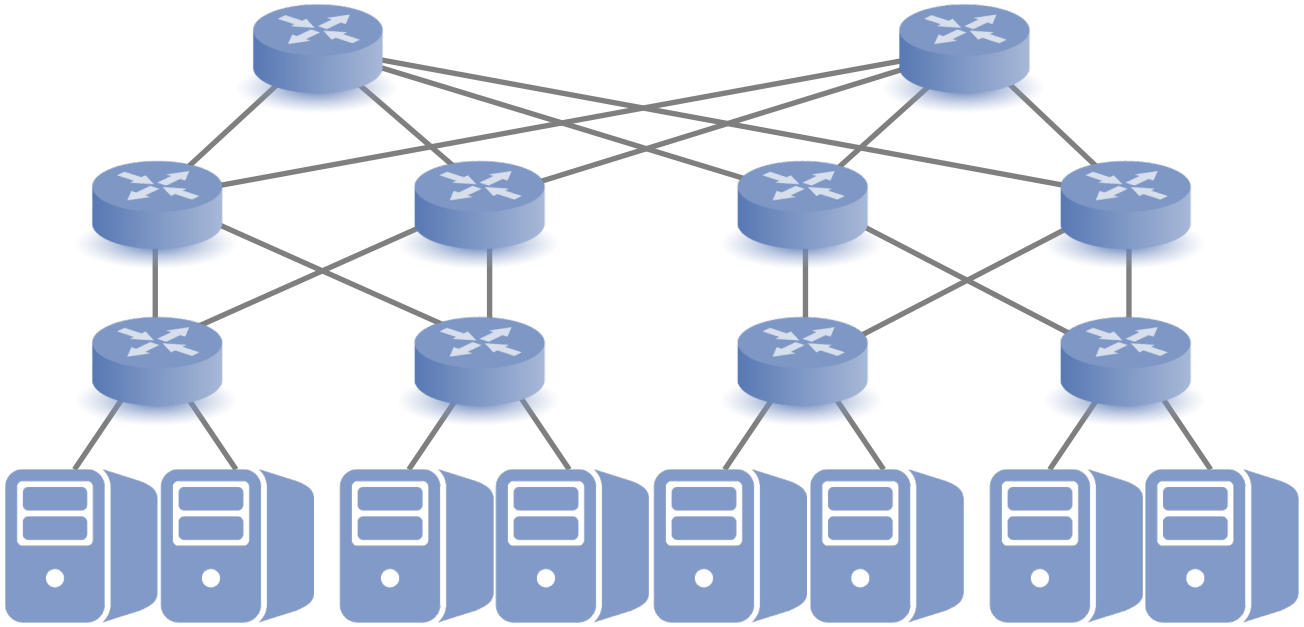


Reconstruction and Analysis

- Locating Inflated Latency
- Locating Packet Drops
  - Blackhole
  - Loop
  - Random packet drops
- Locating Abnormal Jitters
- Finding Abnormal Forwarding Path

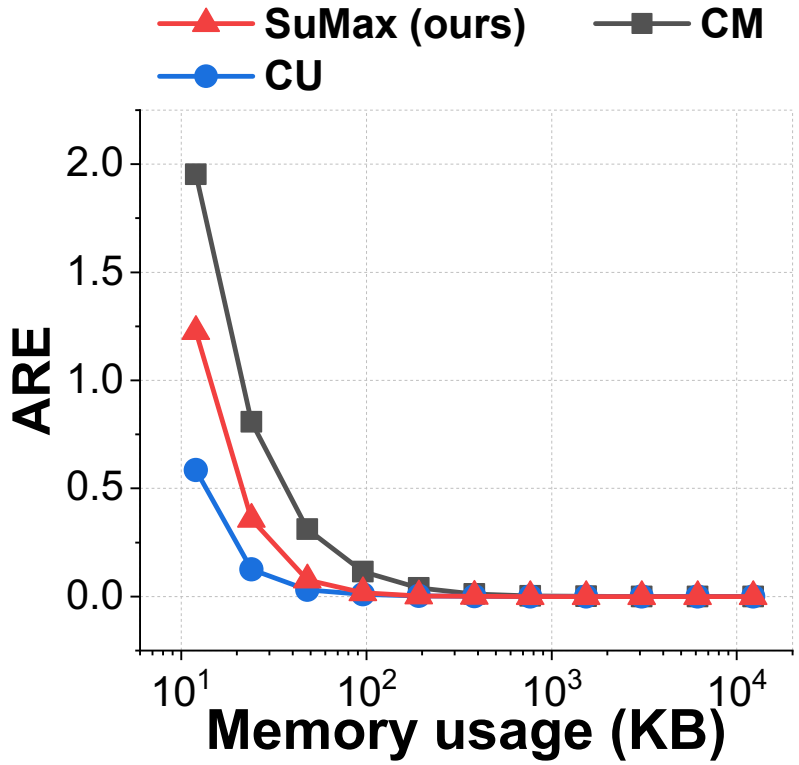
Experimental Results

- Testbed
  - Tofino-40GbE



Experimental Results

- How accurate can our SuMax sketch measure per-flow statistics?
- Flow size estimation



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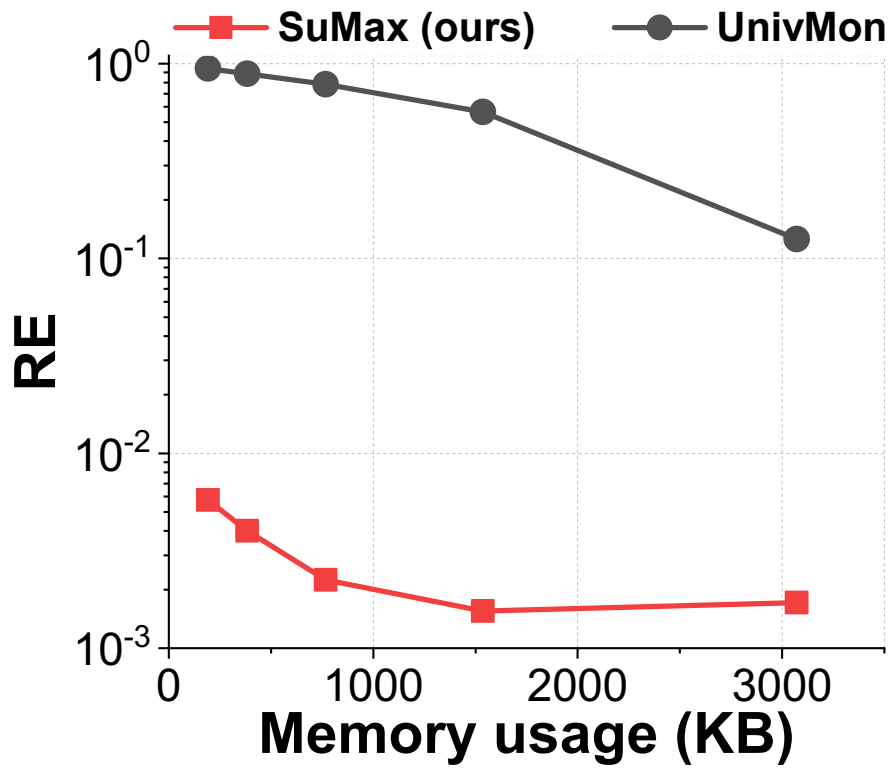
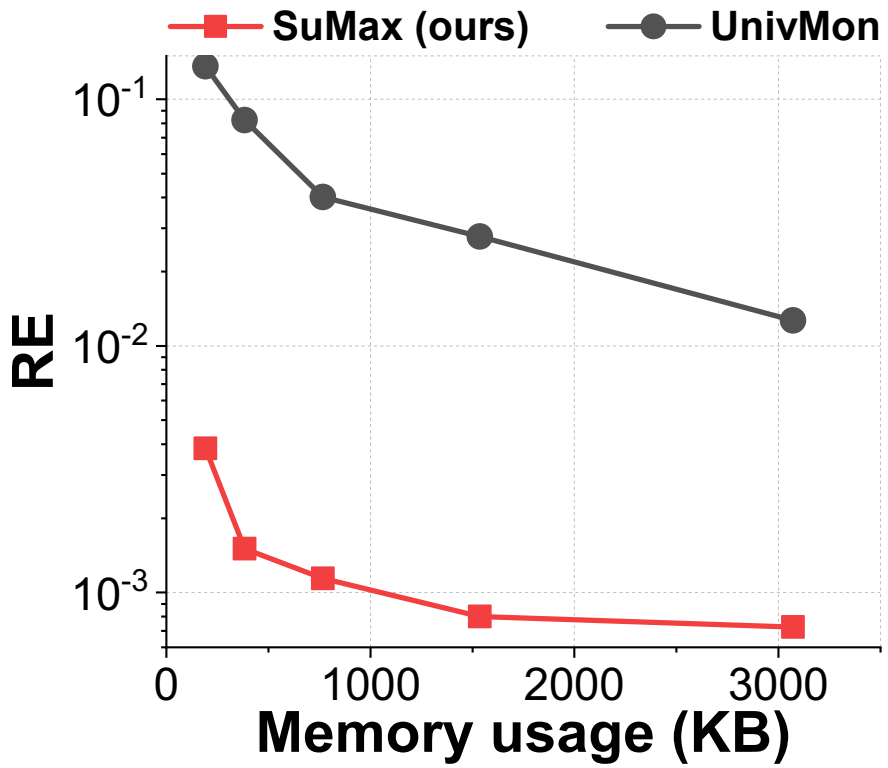


Experimental Results

- How accurate can our SuMax sketch measure per-flow statistics?
- Flow size estimation
- Cardinality estimation
- Entropy estimation



Experimental Results

- How accurate can our SuMax sketch measure per-flow statistics?
- Flow size estimation
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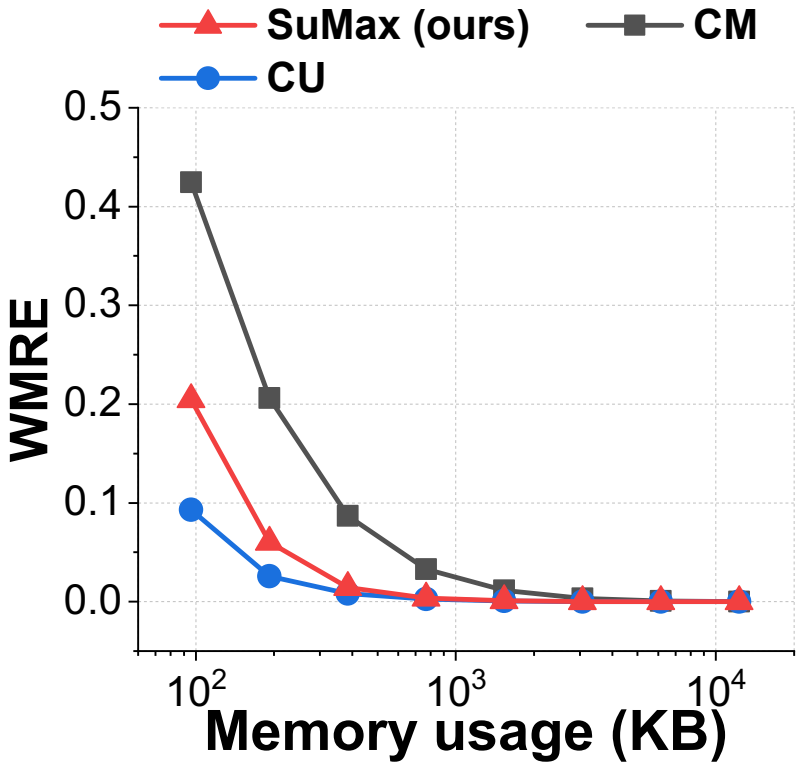
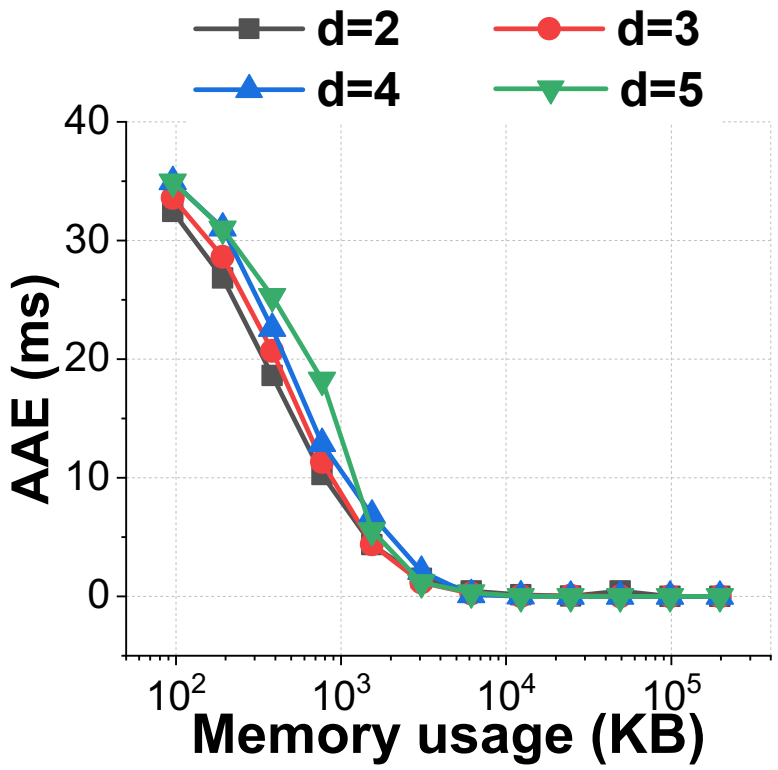
- Entropy estimation
- Delay distribution



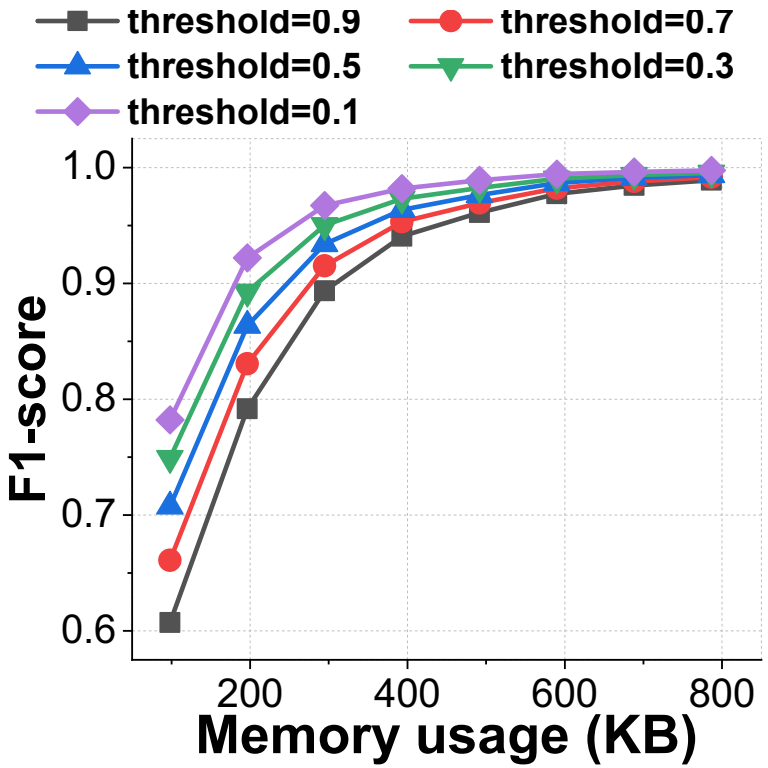
Experimental Results

- How accurate can our SuMax sketch measure per-flow statistics?
- Flow size estimation
- Cardinality estimation
- Entropy estimation
- Delay distribution
- Maximum inter-arrival time



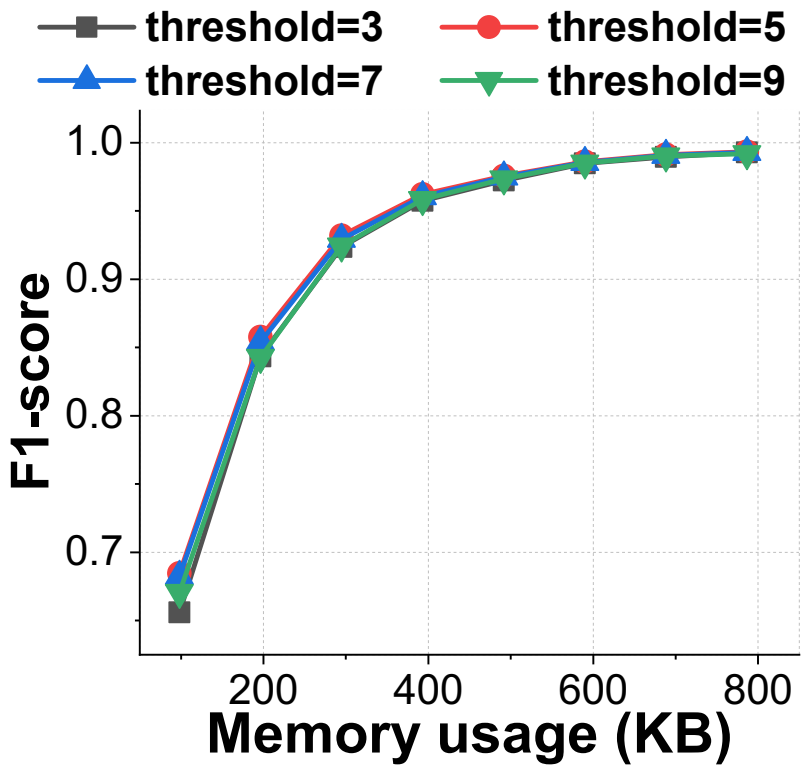
Experimental Results

- How accurate can LightGuardian detect network anomalies?
- Locating blackholes



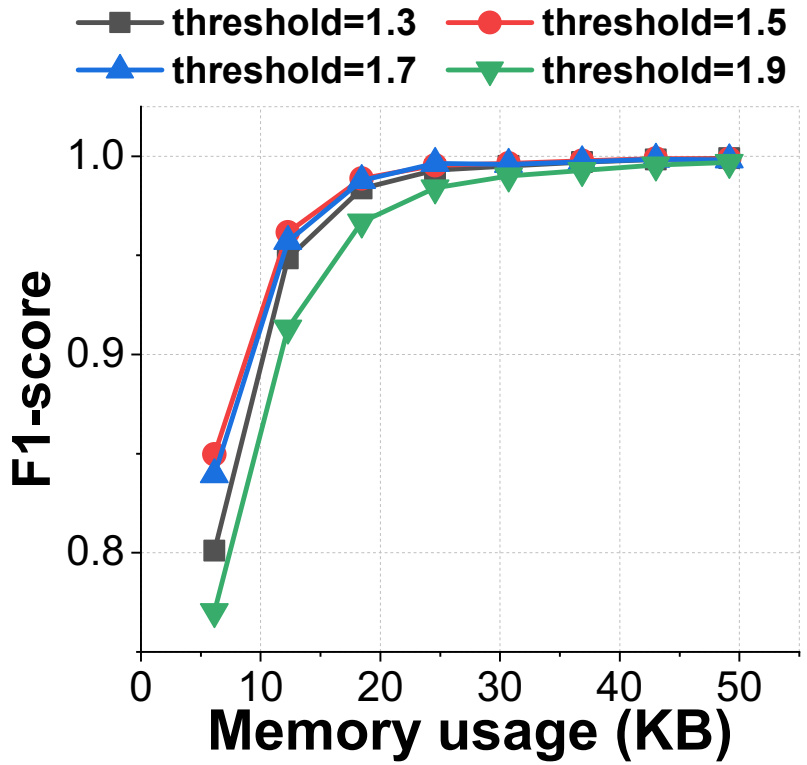
Experimental Results

- How accurate can LightGuardian detect network anomalies?
- Locating blackholes
- Locating loops



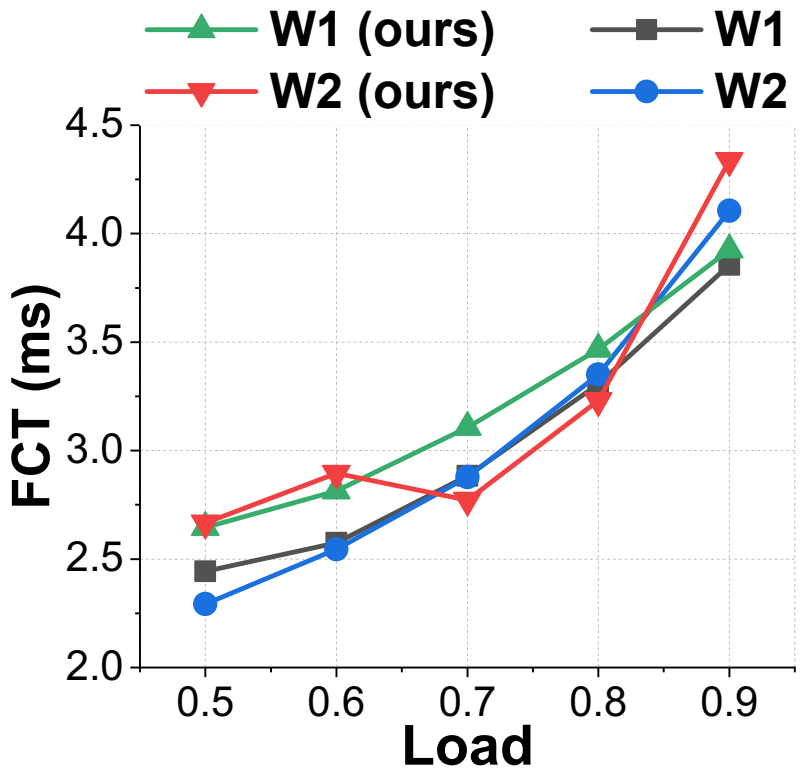
Experimental Results

- How accurate can LightGuardian detect network anomalies?
- Locating blackholes
- Locating loops
- Locating abnormal jitters



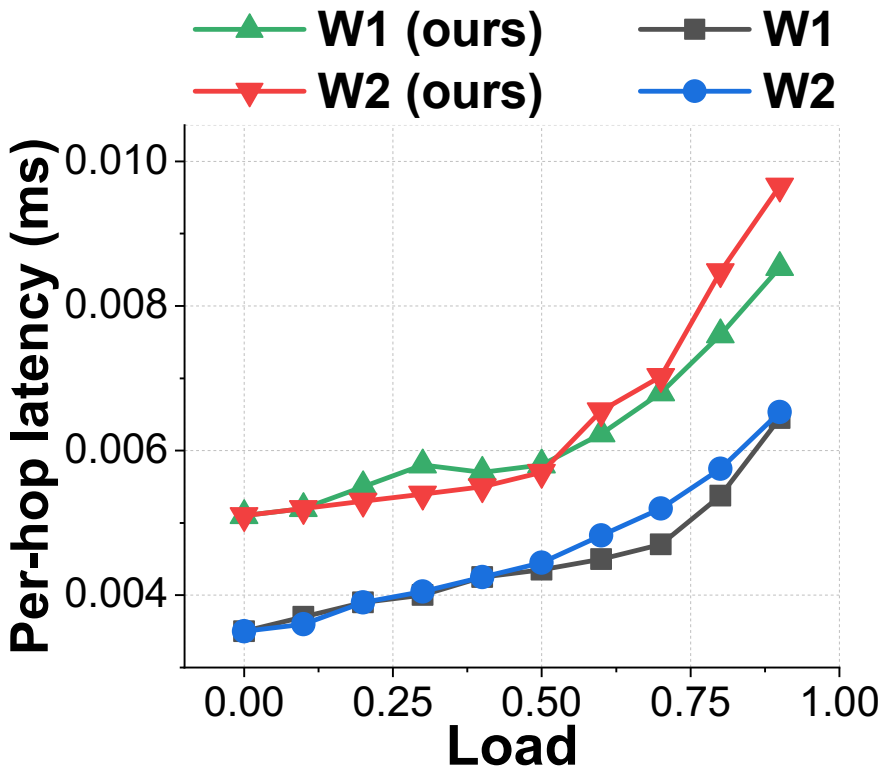
Experimental Results

- How much is the overhead of sending and aggregating sketchlets?
- FCT



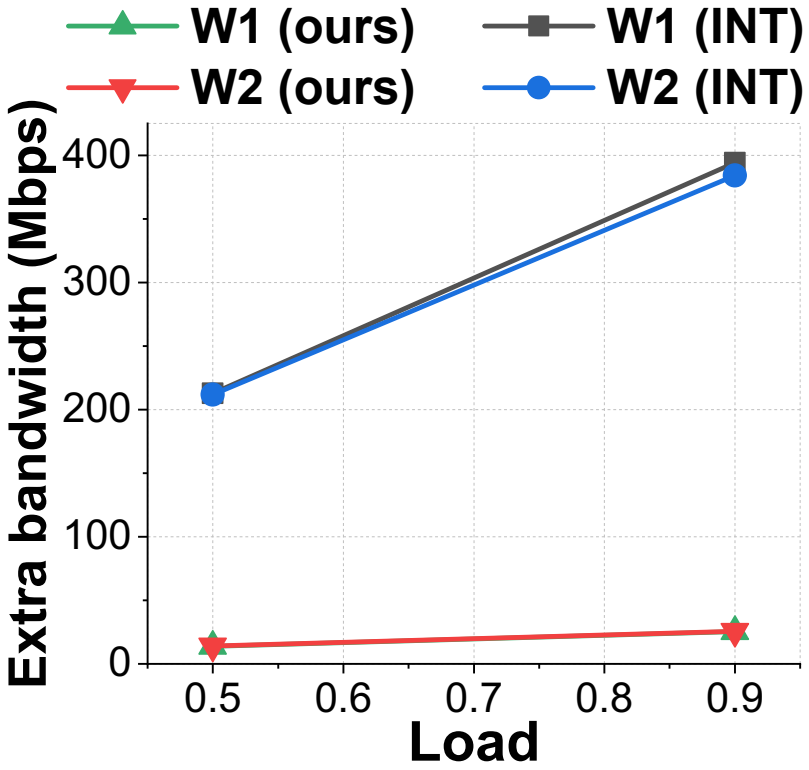
Experimental Results

- How much is the overhead of sending and aggregating sketchlets?
- FCT
- Per-hop latency



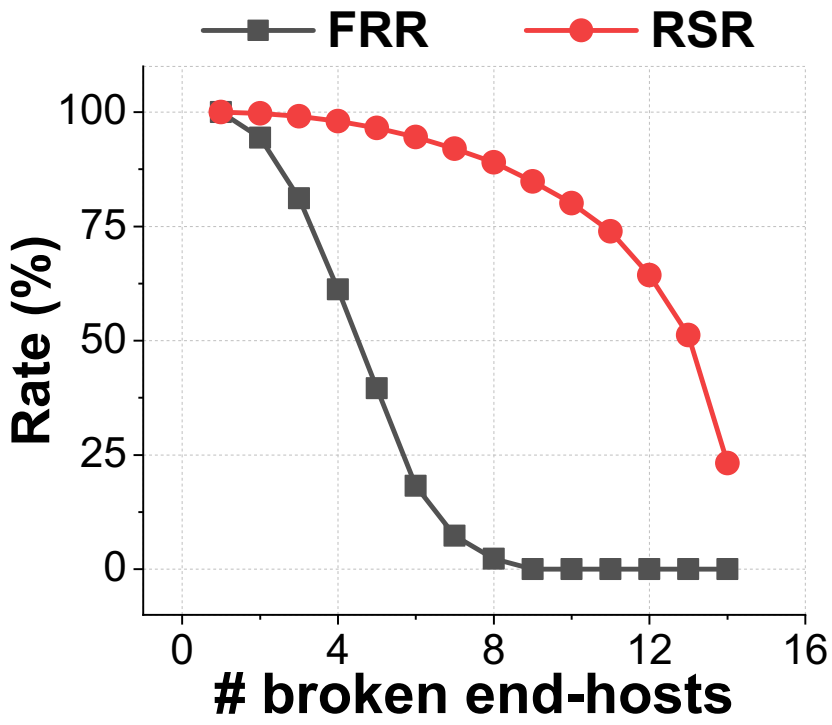
Experimental Results

- How much is the overhead of sending and aggregating sketchlets?
- FCT
- Per-hop latency
- Bandwidth overhead



Experimental Results

- Is LightGuardian resilient to network failures?
- Full-Recovery Rate (FRR):
  - the probability of recovering all sketches
- Recovering-Sketch Rate (RSR):
  - the ratio of the number of recovered sketches to the number of all sketches



LightGuardian

- **full-visibility:** deploy SuMax sketch, monitor various per-flow per-hop information for all flows
- **Lightweight:** use only 0.07% total bandwidth capacity
- **Robustness:** incremental reconstruction

Thank you!

- Our code is open-source!
- https://github.com/Light-Guardian/LightGuardian

- zyk@pku.edu.cn