Understanding the impact of host networking elements on traffic bursts

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Burstiness has broad implications

Traffic Prediction

Design of Networks

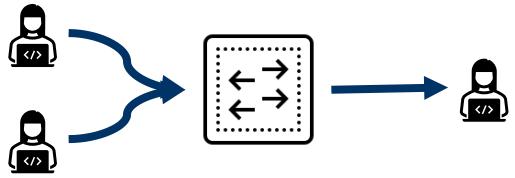
Network Performance

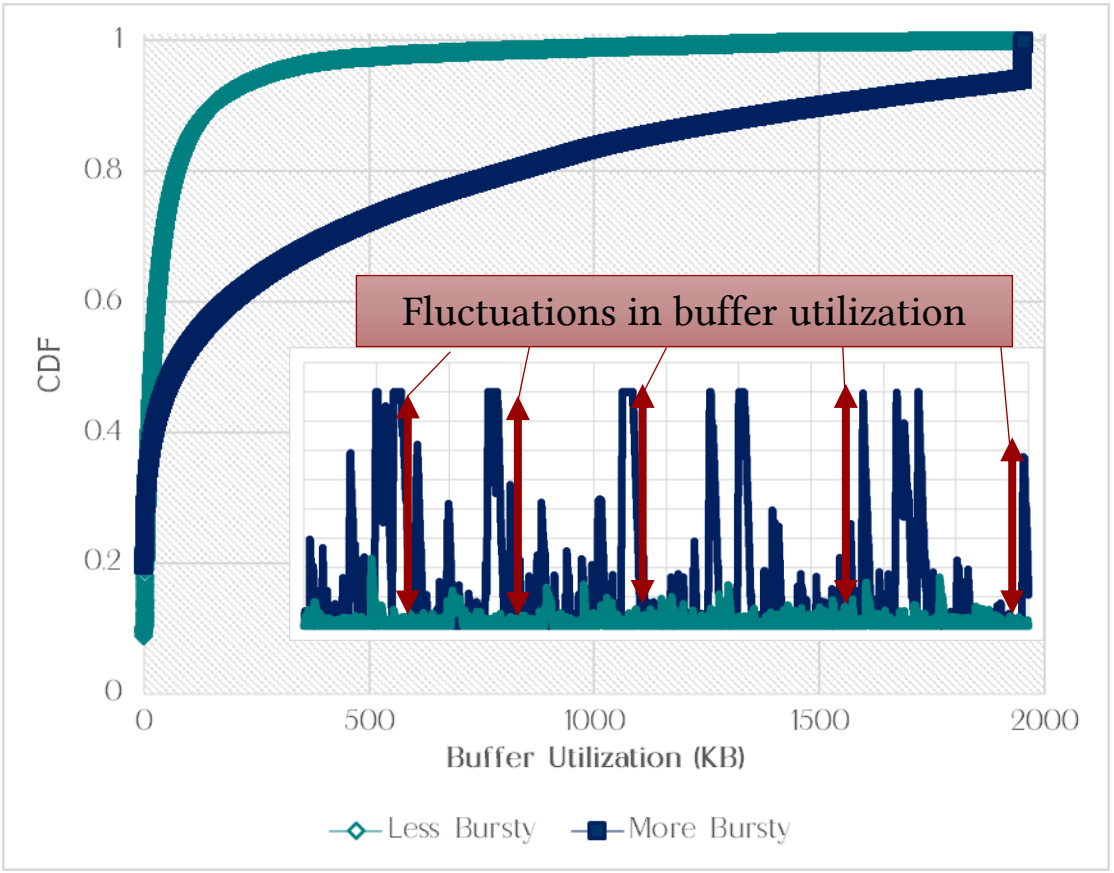
Burstiness degrades performance

Bursts are the major cause of **queue backlogs!**

A **4X** more bursty traffic results in **10X** longer buffer utilization tails!

10X longer p99 Round-Trip Times!!

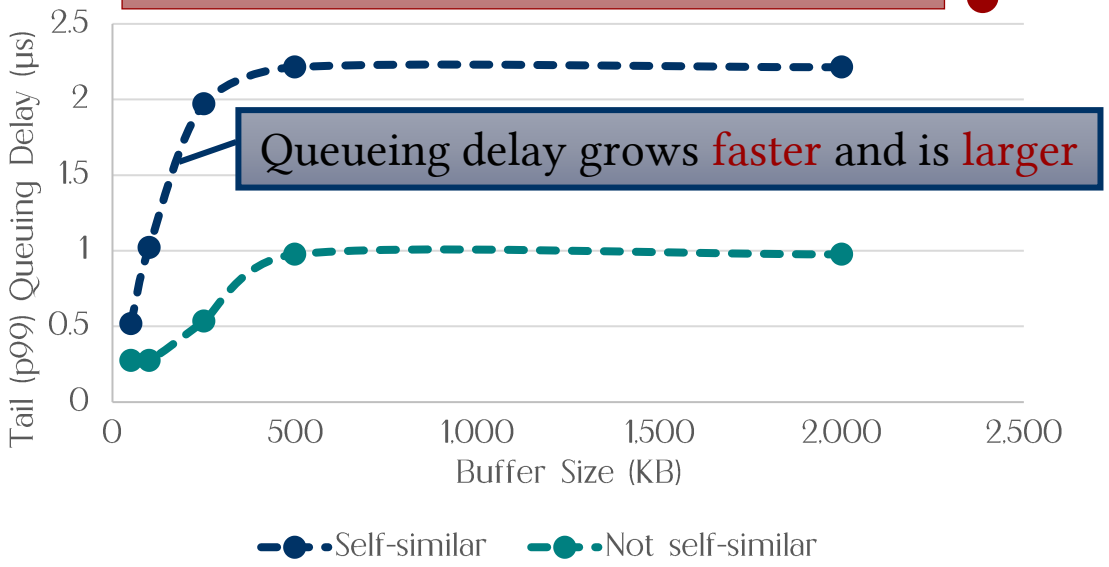


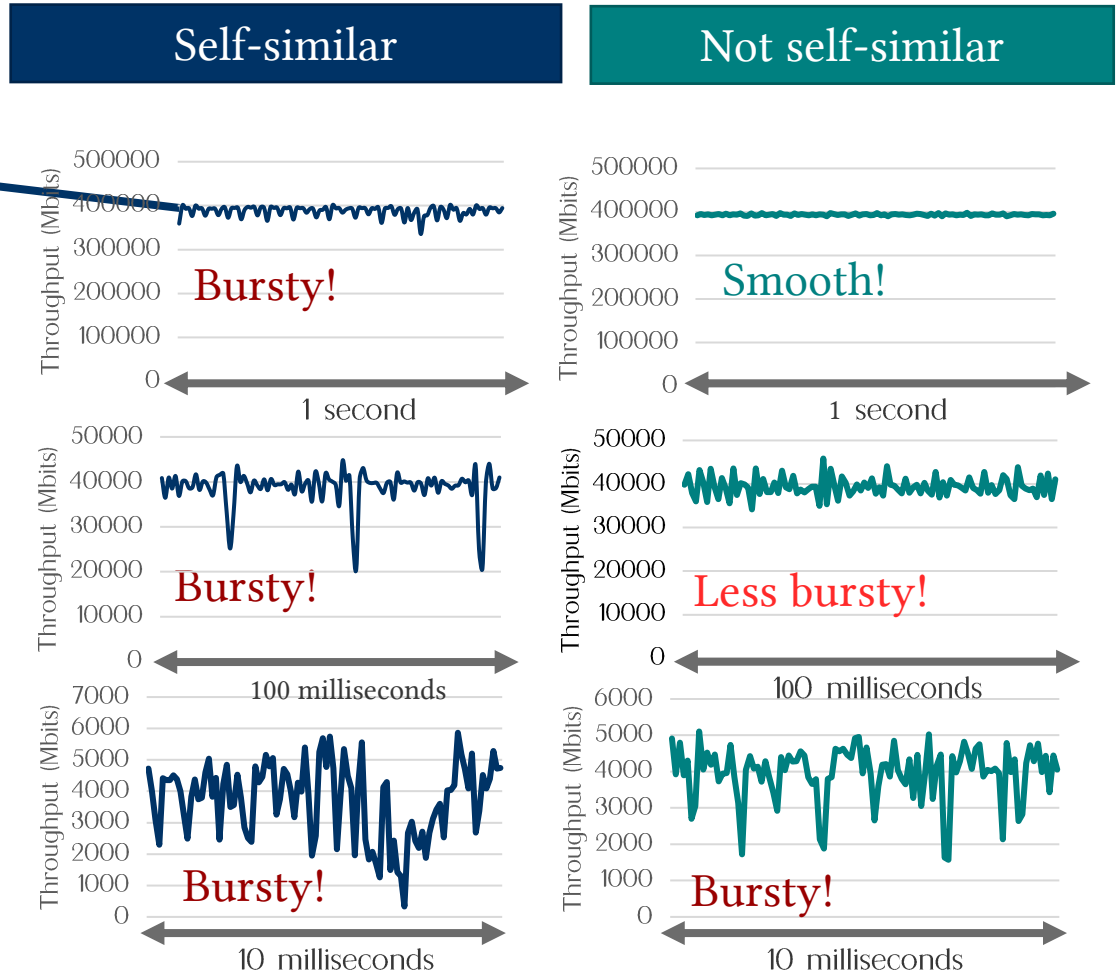


Buffer sizing depends on burst scales

Self-similarity: The traffic **remains bursty** at different timescales

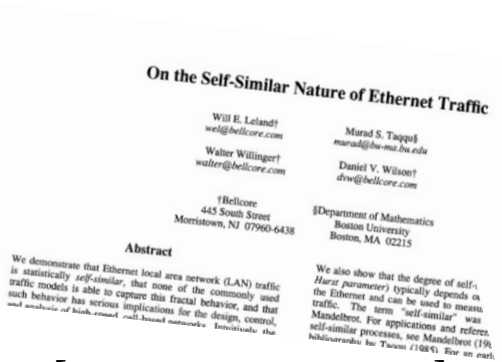
Smaller buffers are needed to control the **queueing delay**!



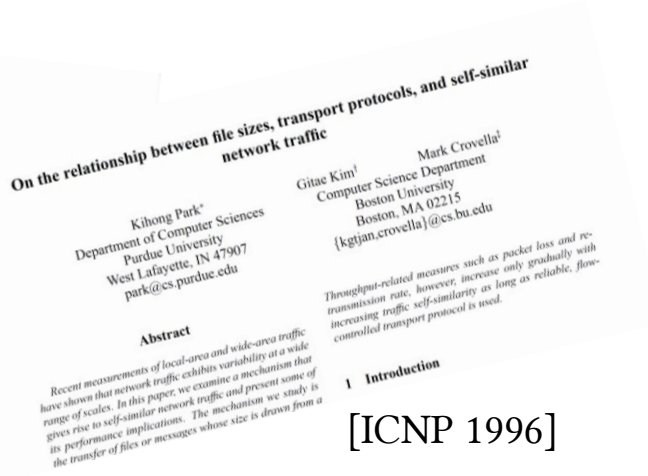


What causes the traffic to emerge in bursts **at different timescales**?

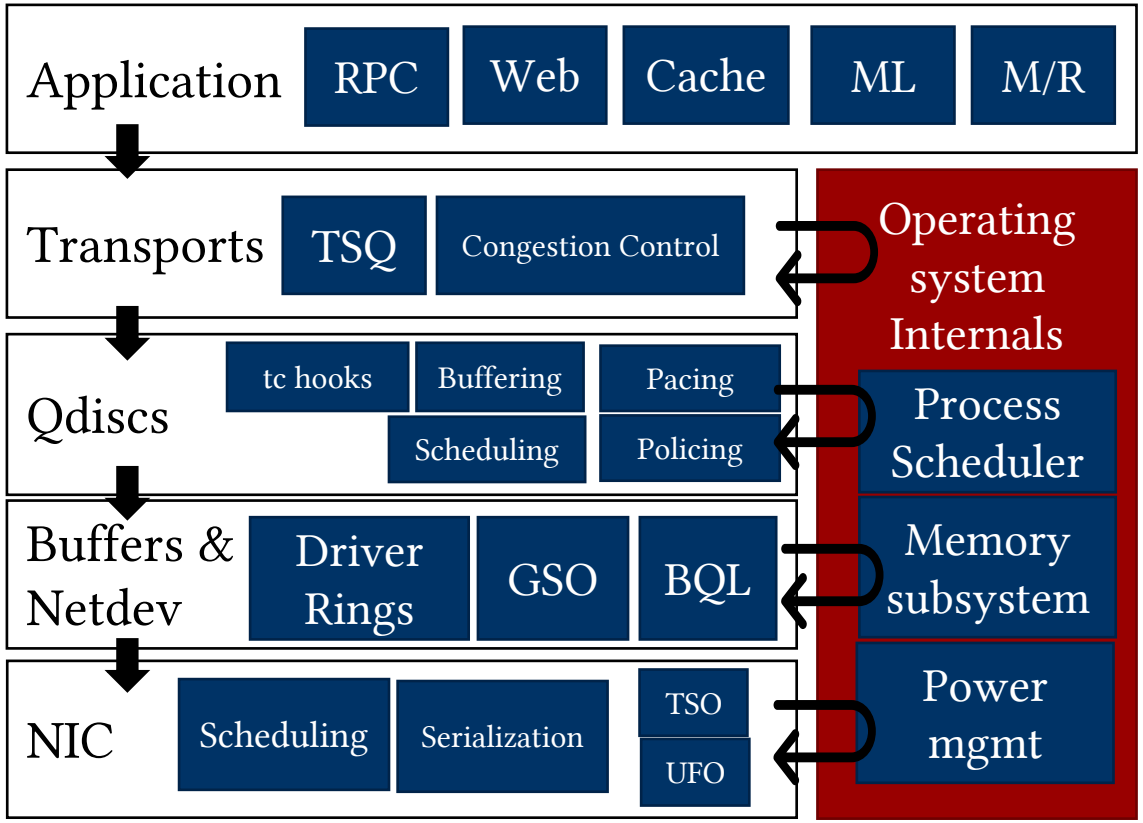
Valinor: A high-resolution traffic measurement framework



[IEEE/ACM ToN 1994]



[ICNP 1996]



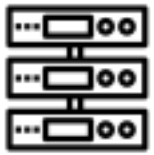
Our study uncovers:

Lower layers of the stack can undo **TCP pacing**	In Multi-queue NICs with Segmentation offload, enabling or disabling TCP pacing has no effect on burst lengths.
Congestion control variants result in significantly different self-similarity	TCP *cubic* results in a more self-similar traffic compared to *DCTCP* and *BBR.*
Process schedulers with coarse time-slicing result in heavy bursts	High self-similarity when running a network application under CPU contention with *Completely Fair Scheduler.*
Smaller **buffer sizes** in the hosts can significantly reduce burstiness	Driver buffer sizing enforced by *Byte Queue Limits* algorithm is a cause for longer bursts.

Valinor: A network traffic burst analyzer

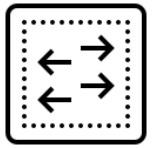
We need to capture **timestamps**!

We need to collect **metadata** and **statistics**!



1) Enables observing burstiness at upper layers of stack

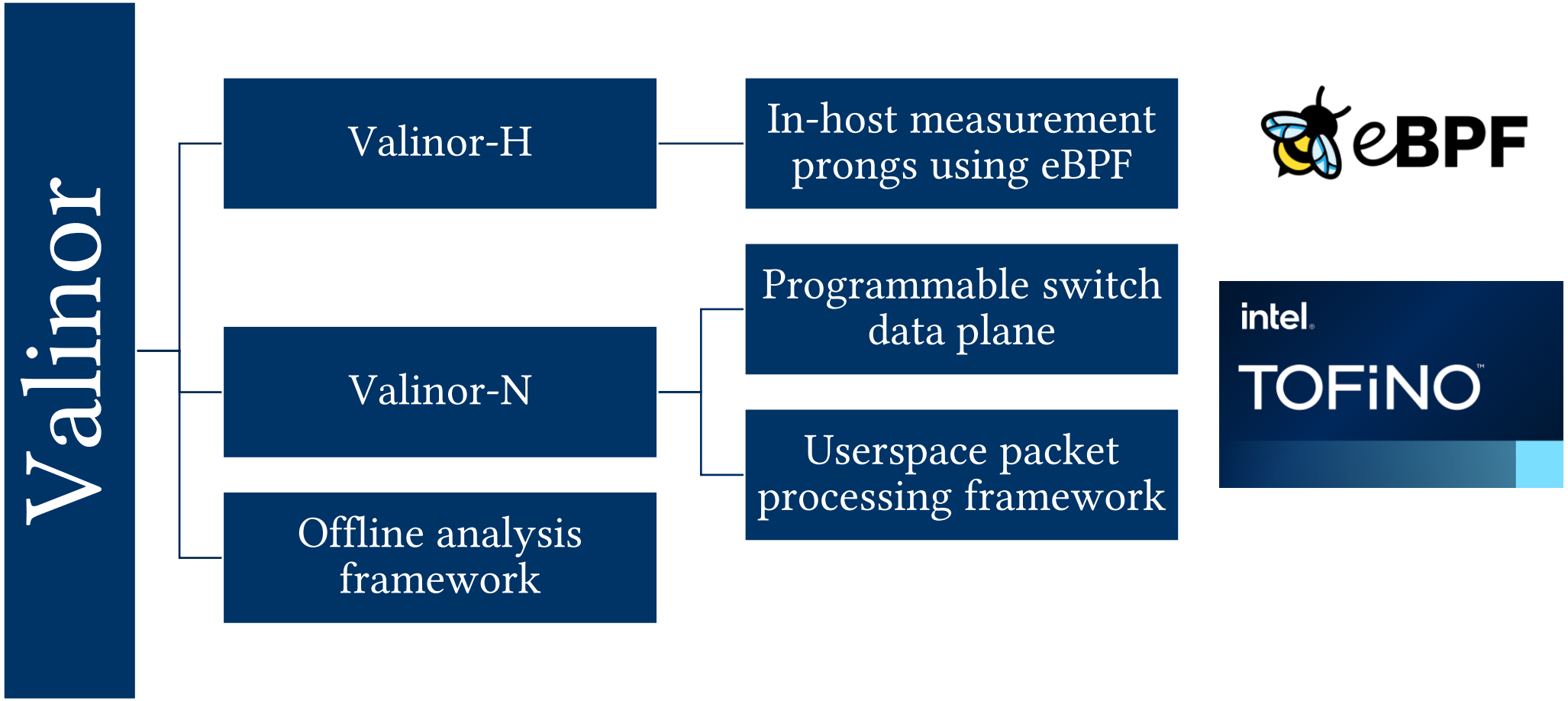
2) Does not need specialized HW/SW



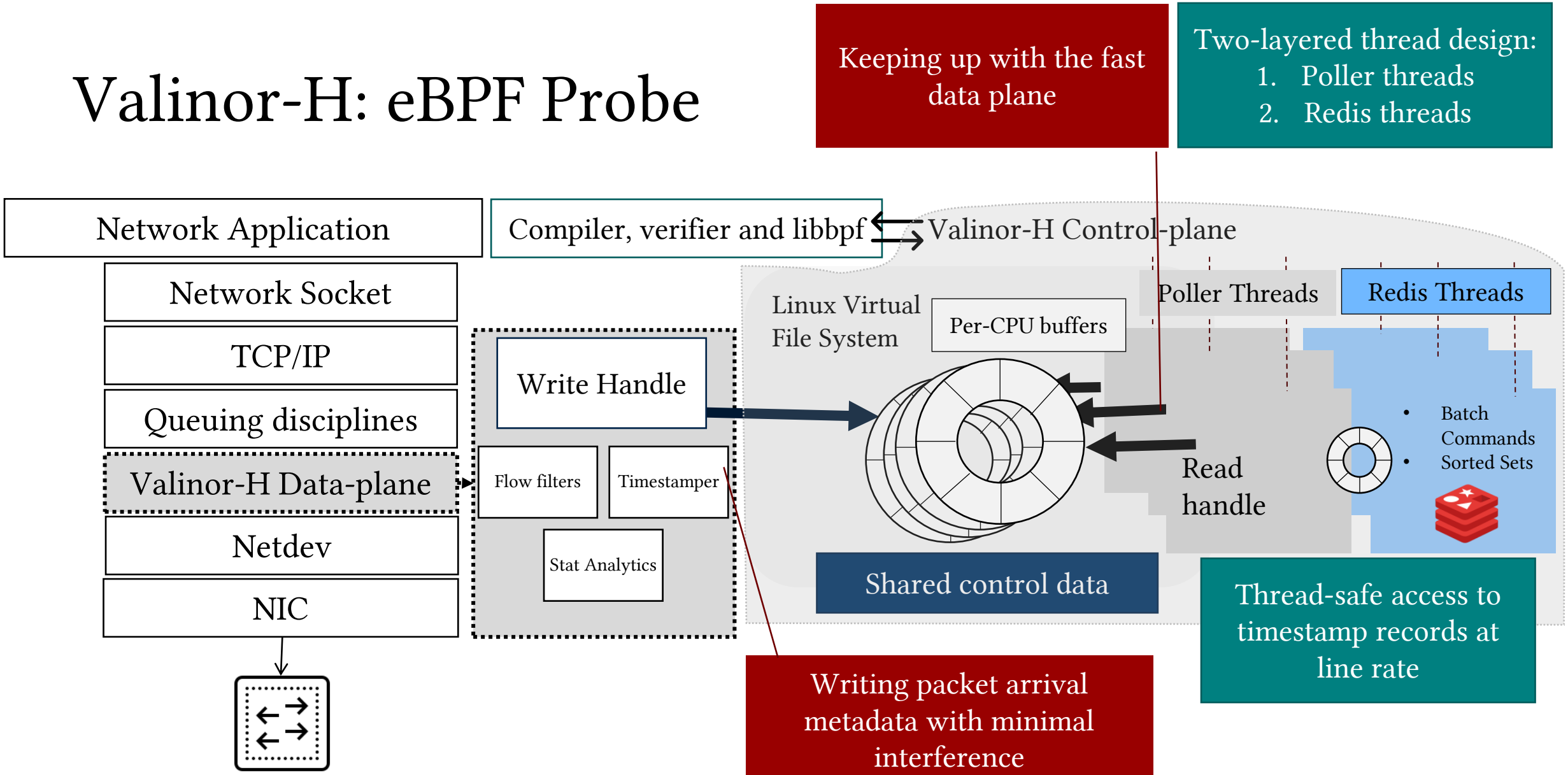
1) Enables observing bursts on the wire

2) Enables observing the aggregate behavior of bursts (queueing)

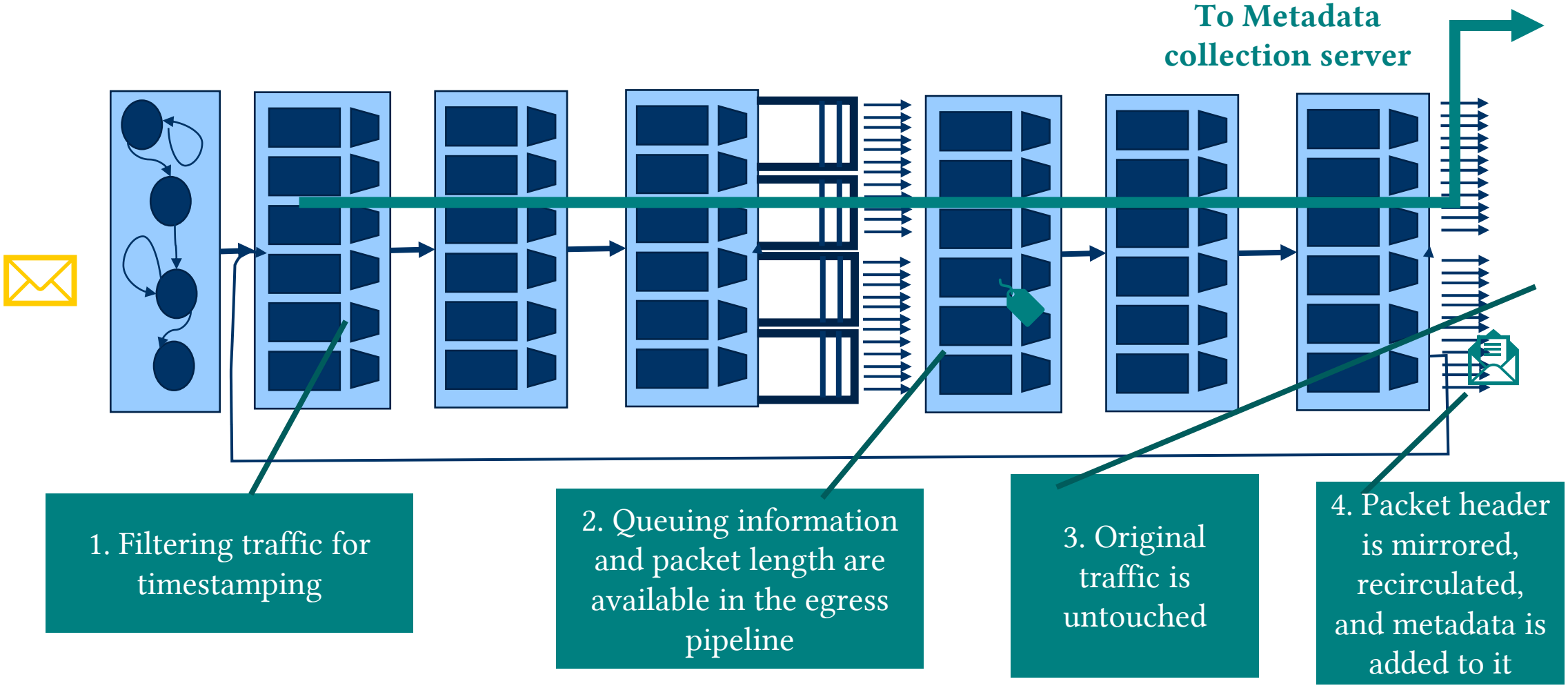
Valinor studies network traffic from two vantage points



Valinor-H: eBPF Probe



Valinor-N: Enabling In-network measurements



Summary of Valinor findings

Lower layers of the stack can undo **TCP pacing**	In Multi-queue NICs with Segmentation offload, enabling or disabling TCP pacing has no effect on burst lengths.
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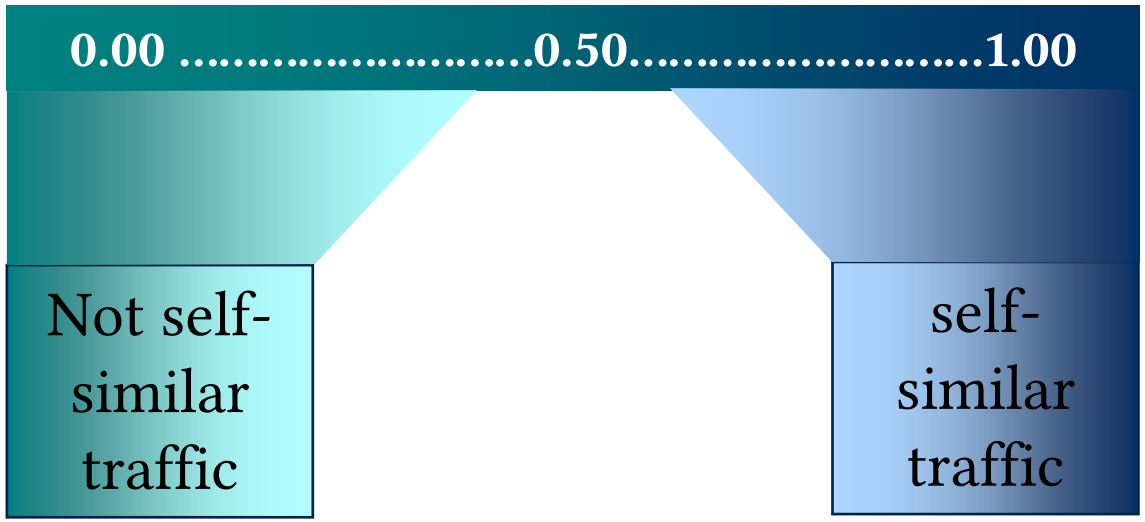
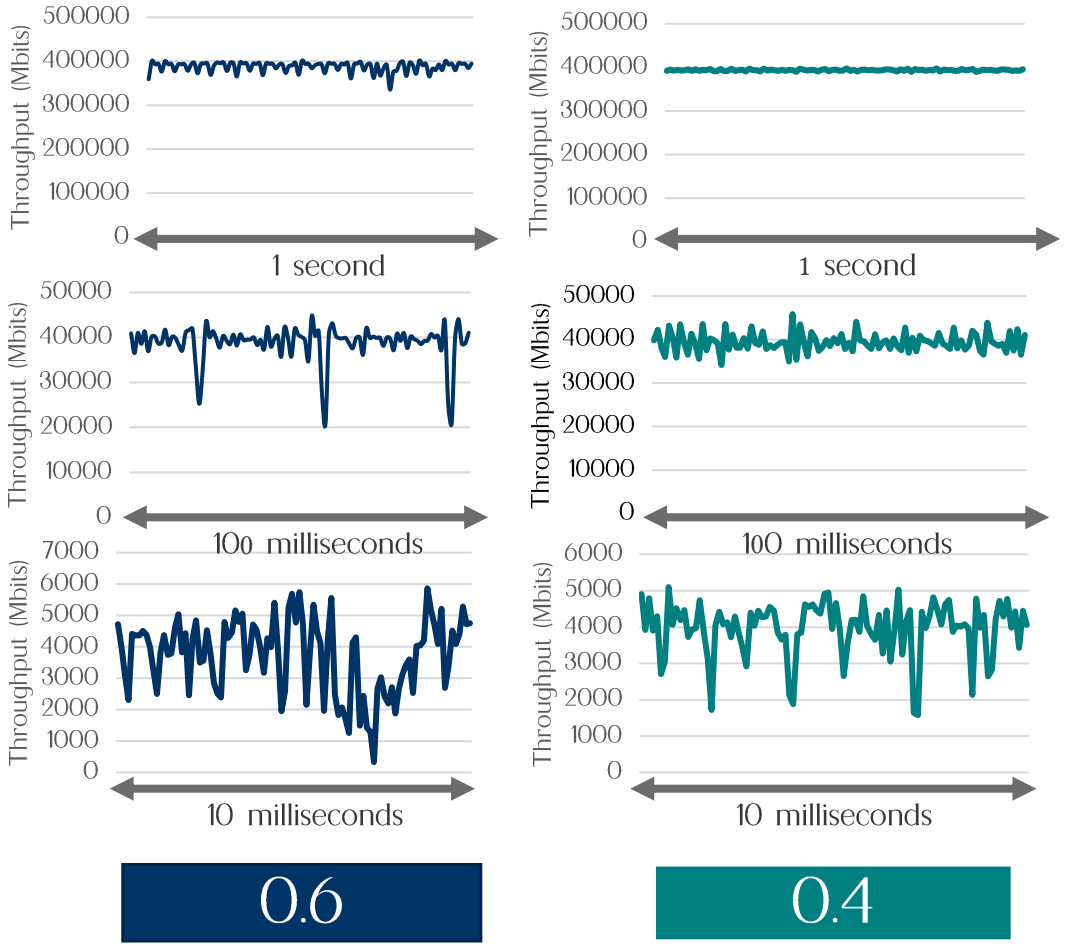
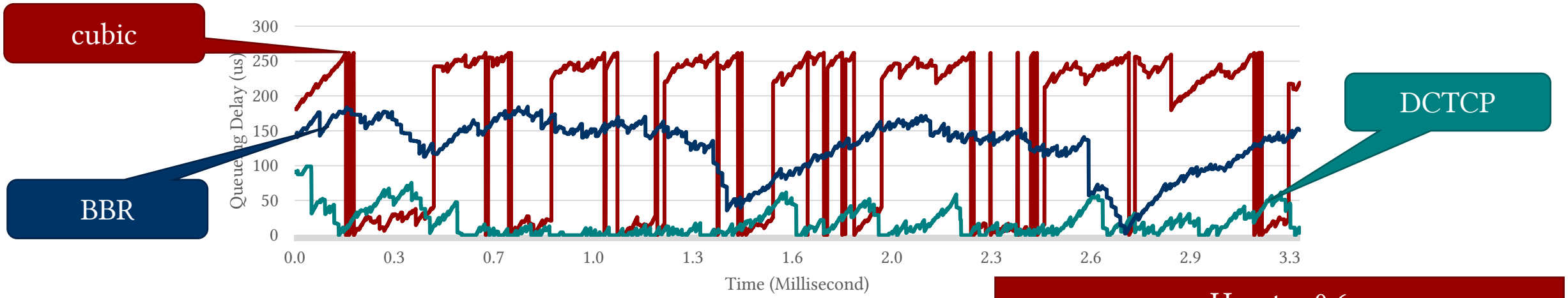
Hurst exponent: A measure of self-similarity

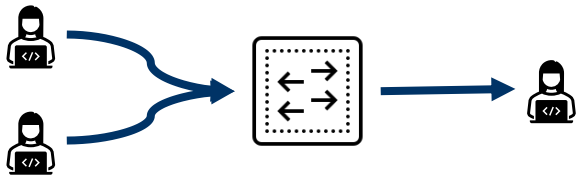
Measure of how bursts are preserved at scales



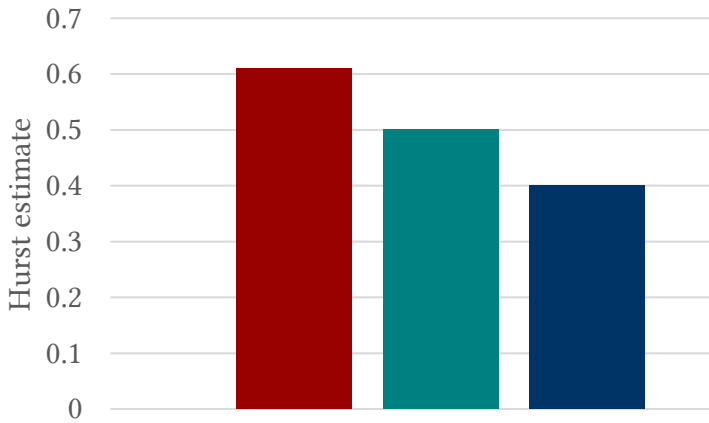


Observing TCP congestion control variants





- 2-1 Incast
- Map-Reduce flow size distribution
- 40Gbps offered load

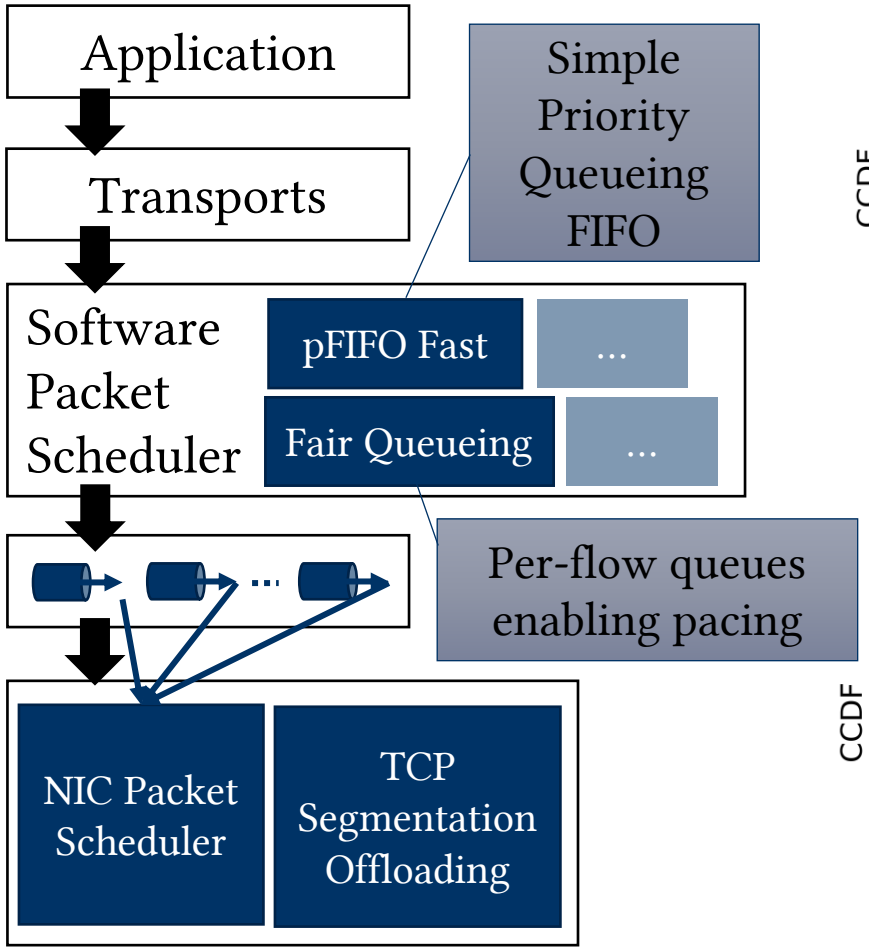


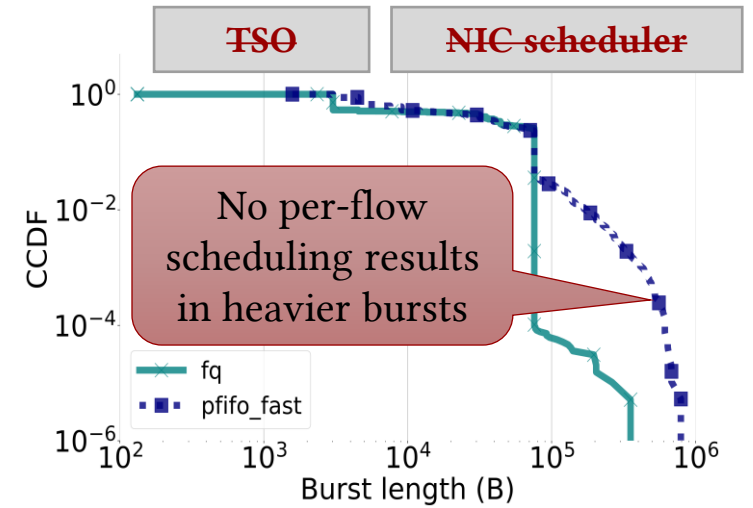
Hurst = 0.6
cubic traffic is self-similar

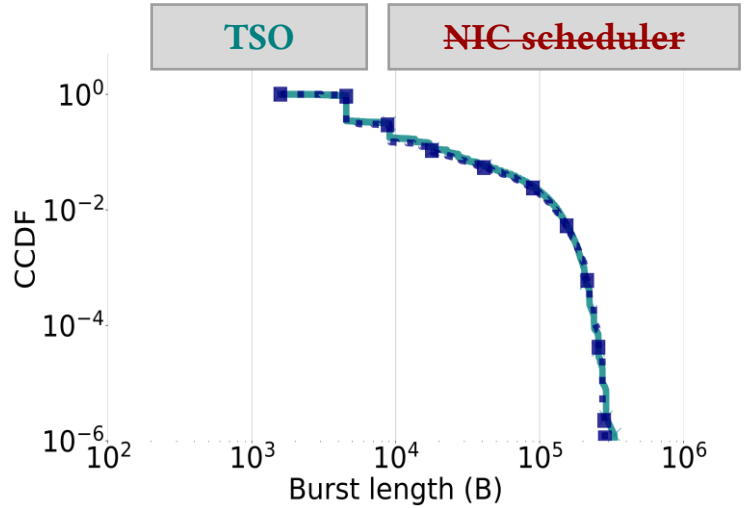
Hurst ≤ 0.5
BBR and DCTCP traffic are not self-similar

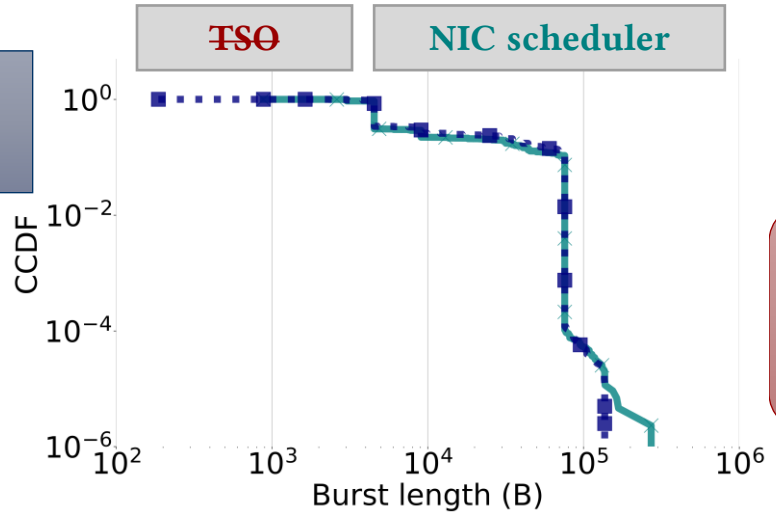
Buffer sizes can be tuned based on self-similarity of congestion control variants

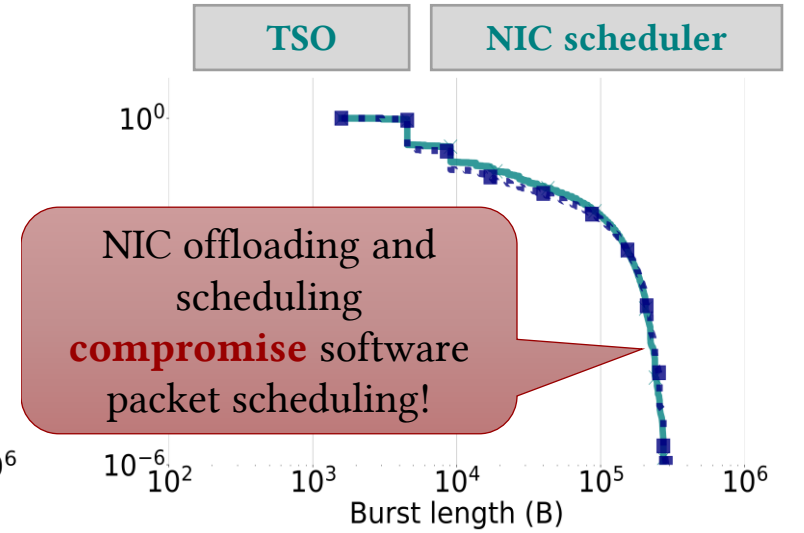
Is software effective in shaping the traffic?



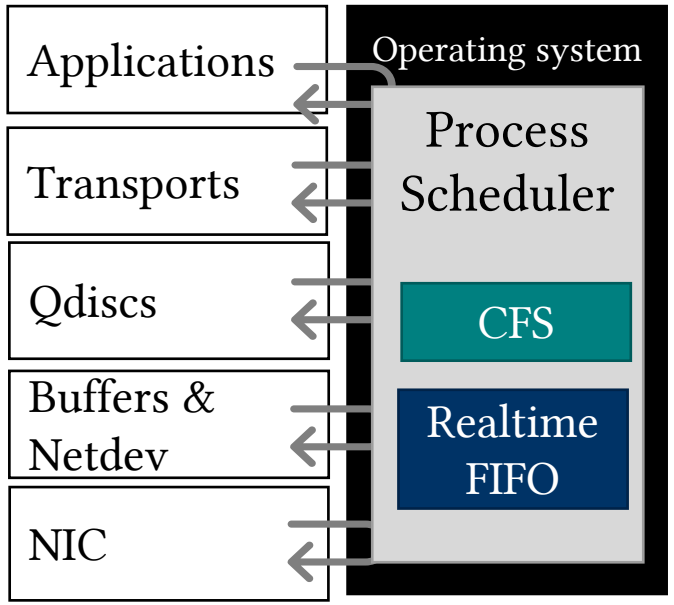








Even process scheduling matters!

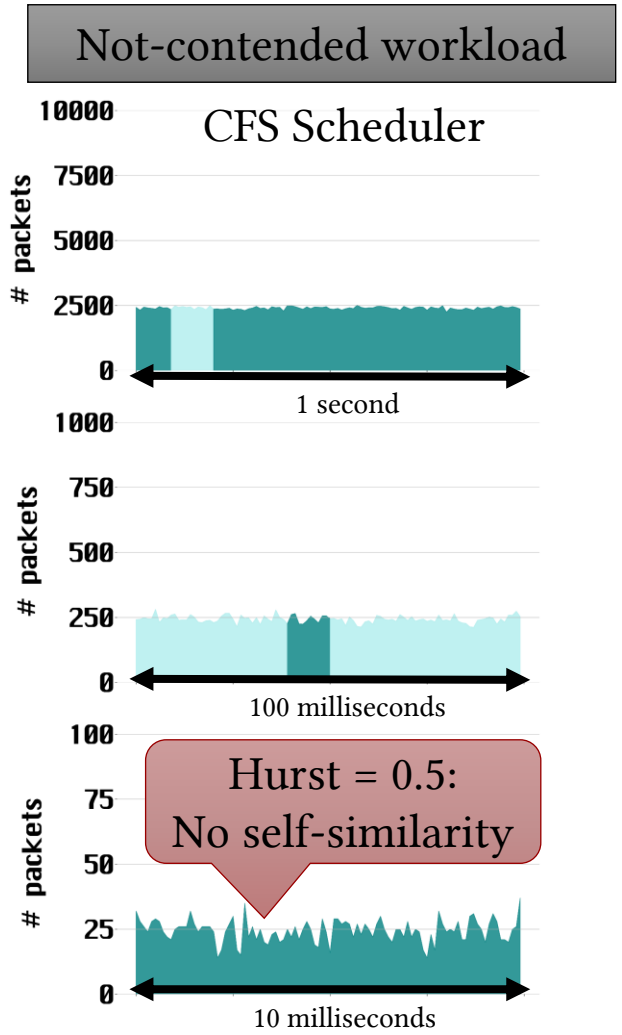


CFS

- Coarse-grained timeslicing
- Fairness

Realtime FIFO

- Strict prioritization



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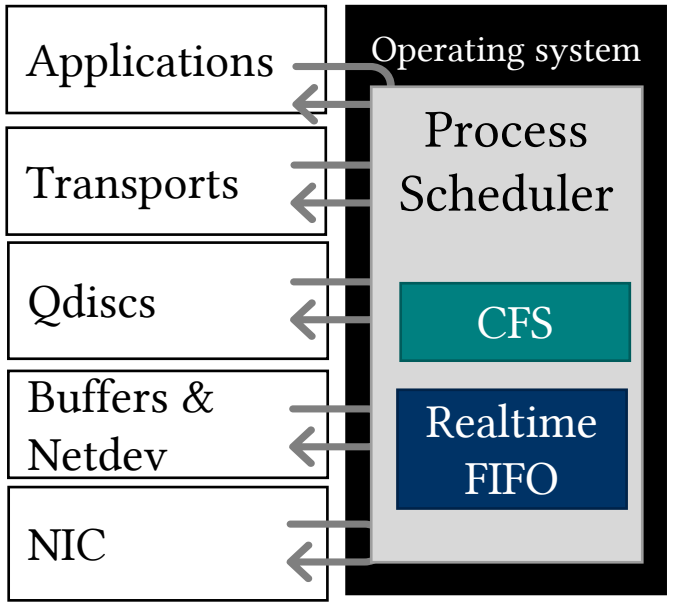

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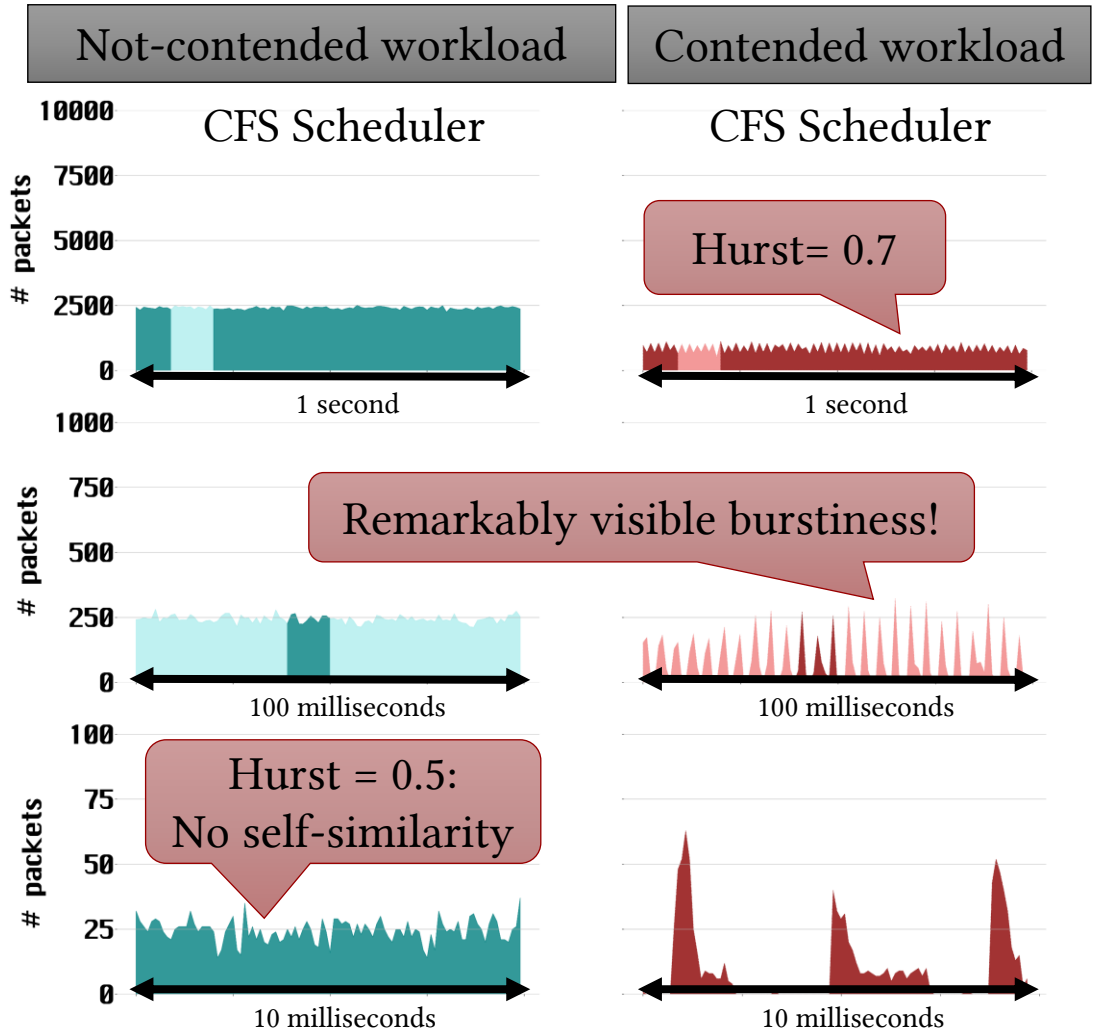

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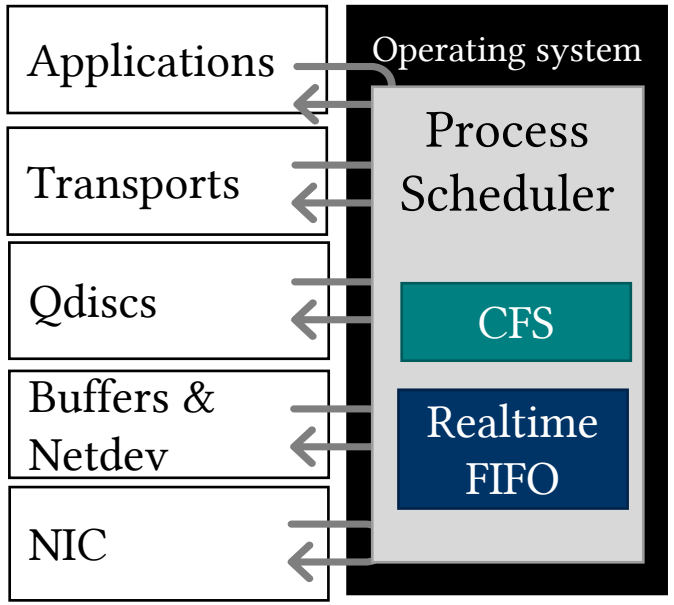

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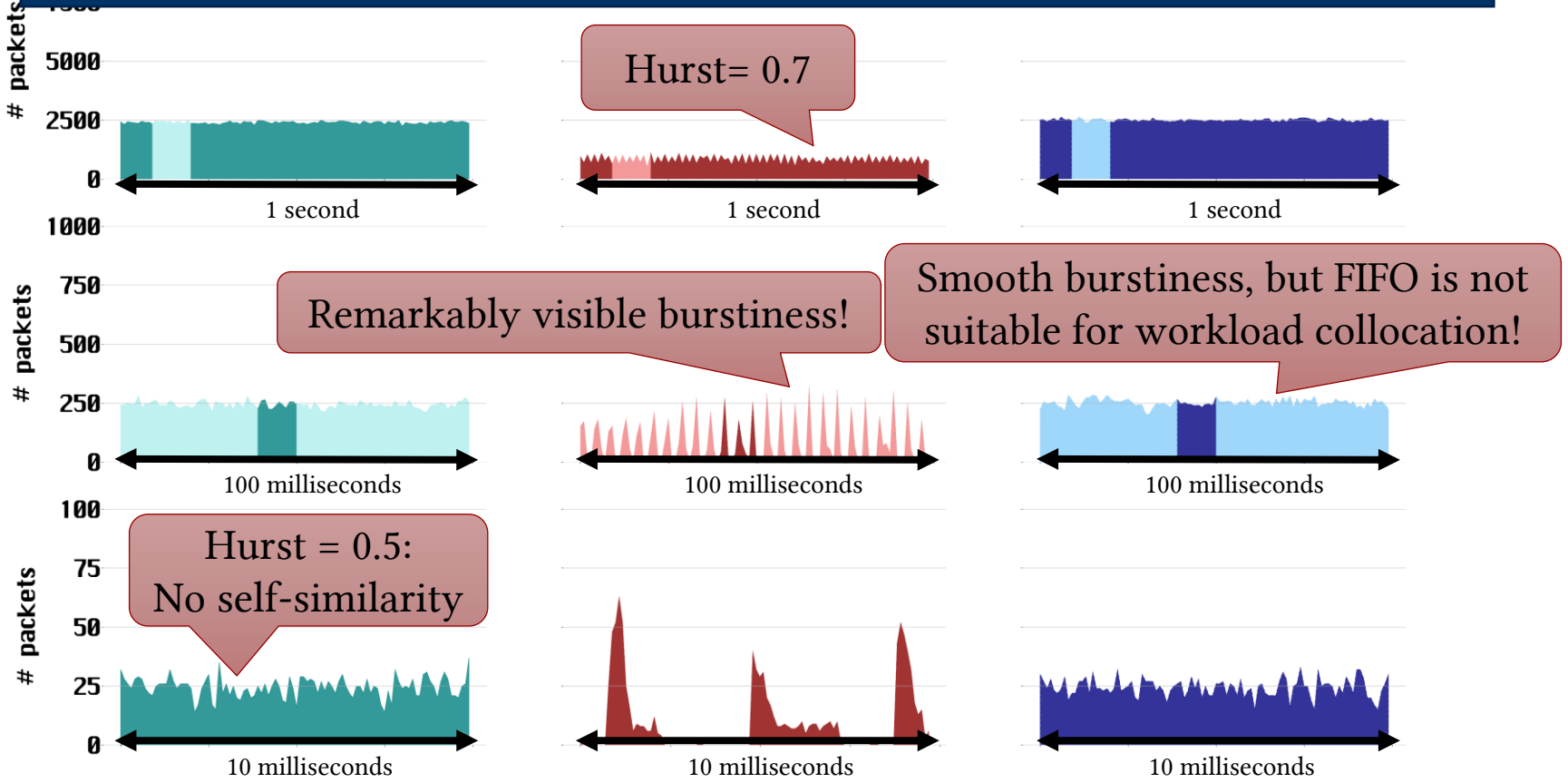
Designing **burst-aware process schedulers**: A tradeoff between **latency**, support for **collocation**, and **burstiness**!



Implications for network design

- Valinor measures the burstiness of individual network stack components.
- Lower layers of the stack **compromise** software shaping.
- Existing burst countermeasures in the software **are not effective!**
- Pacing and shaping must be **pushed down** the stack.
- Network stack layers must be **co-designed** with **burstiness** in mind.
- Visit https://hopnets.github.io/valinor for Valinor artifacts.