

On the impact
of variability on
buffer dynamics
in IP networks

Mechanism that create variability

- ❑ User behavior
 - Application level variability, e.g., Web
- ❑ Network characteristics
 - Different delays, round-trip time, cross traffic
- ❑ Feedback control
 - Reliability and adaptivity

Approach

- ❑ Study traces from simulations
 - Complete control over all aspects of network
Workload model, Network model, Protocol
- ❑ Real network traces used as benchmark
 - Simulation setup and trace analysis
- ❑ Simulation traces used for trace driven simulation
 - Study queuing dynamic
- ❑ Correlation of analysis results to simulation setup
 - Identify network features that cause divergence

Outline

- ❑ Simulation setup
 - Workload model
 - Network
 - Protocol
- ❑ Impact of variability at the application layer
 - Mice vs. elephants [V. Jacoson]

Workloads

❑ No variability:

- Infinite sources
 - 50 clients requesting big files

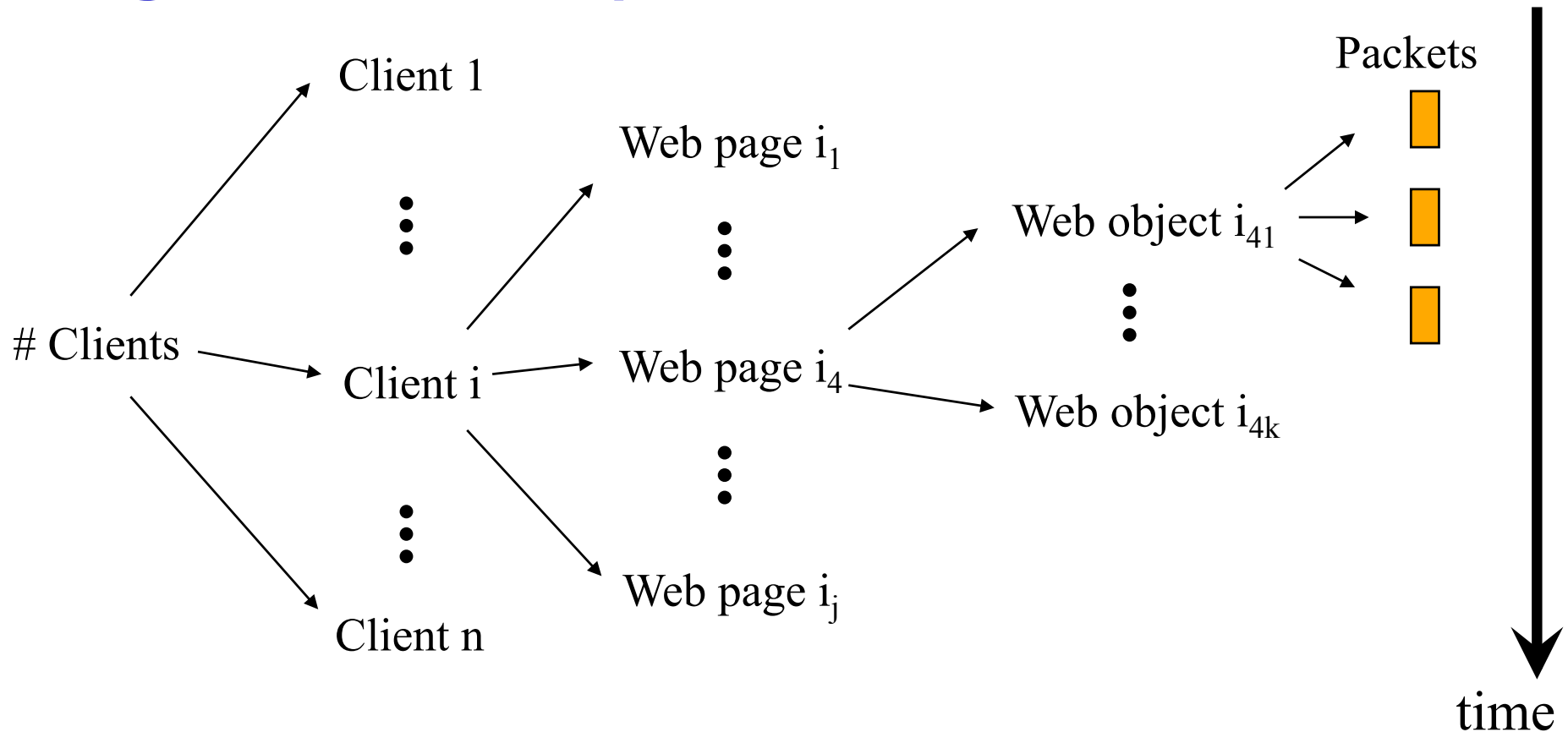
❑ High variability:

- Web sources
 - 350 clients down loading Web pages

❑ Simulation:

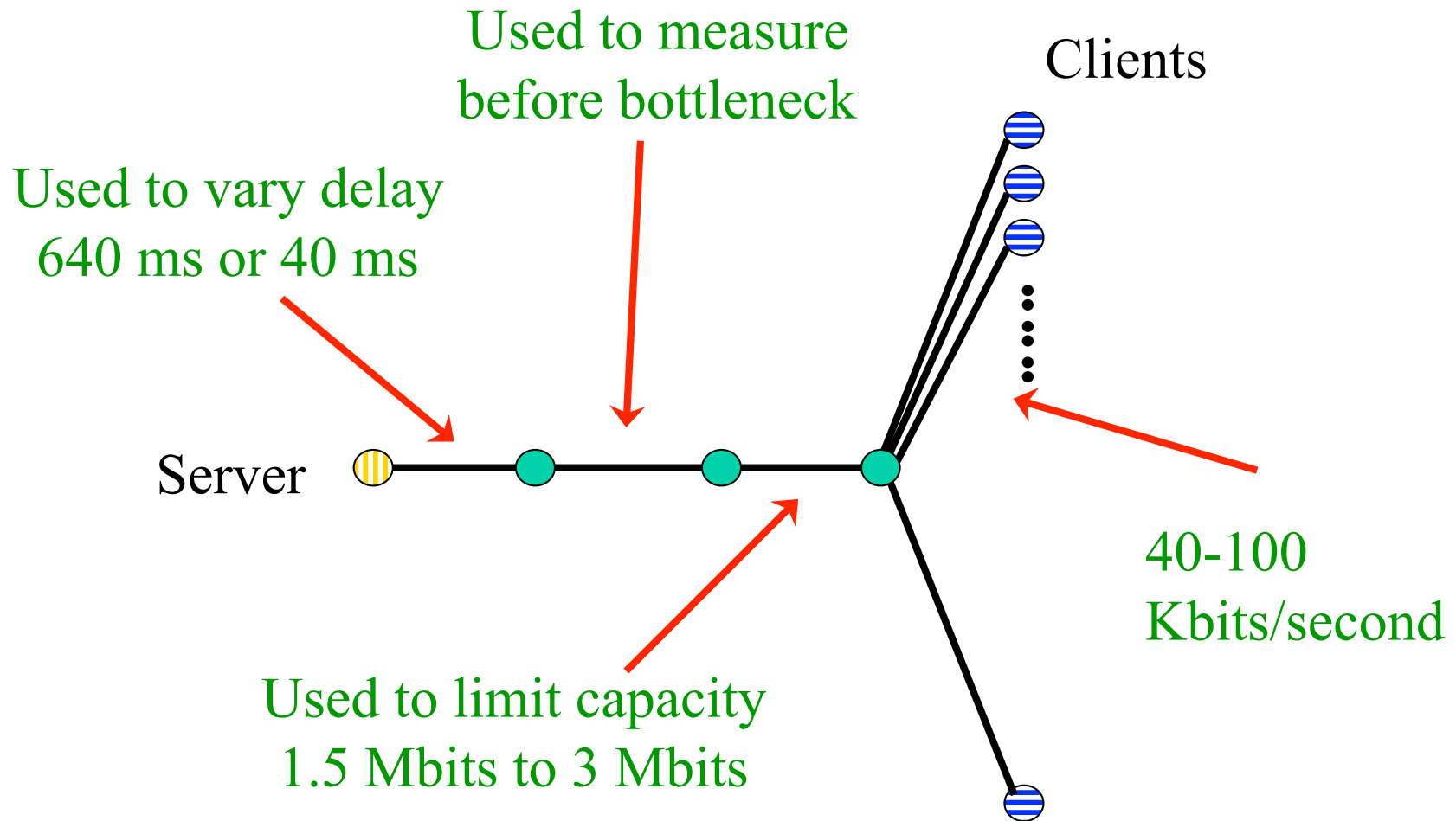
- Client startup: random time 0-600 seconds
- Duration: 4200 seconds
- Analysis: 900-4200 seconds

High variability workload: Web



- Parameters (similar to SURGE [BC98]):
 - Number of clients, pages, objects, packets per object
 - Time between Web pages, Web objects

A simple network topology

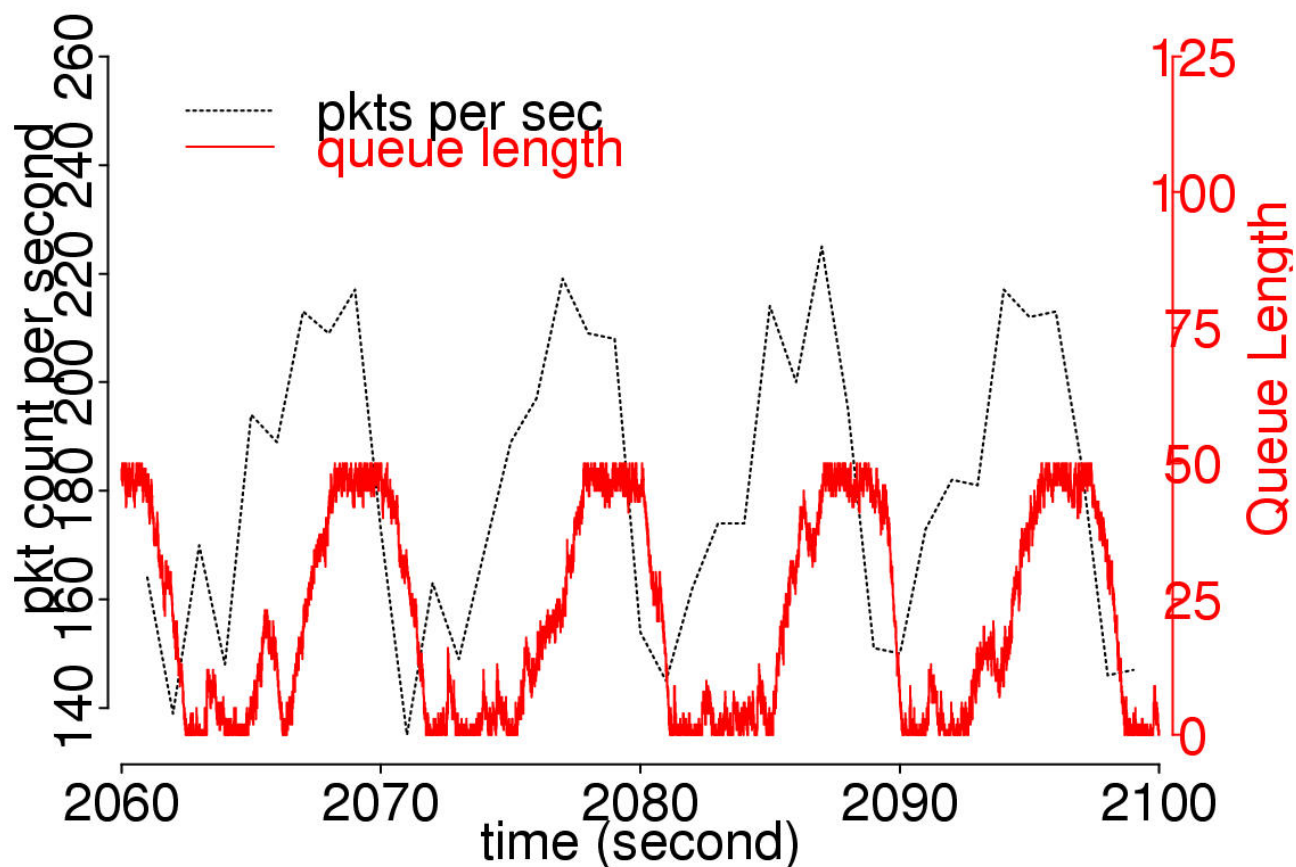


TCP: Reliable byte stream

- ❑ Data segmented into segments
- ❑ Segments are acked by receiver (cumulative)
- ❑ Timer for every segment
- ❑ Segments retransmitted
 - Timer goes off
 - Four duplicate Acks received
- ❑ Flow control
 - Sliding window protocol avoids losses at receiver
 - Bandwidth limits impose congestion window
 - Slow start increases cwnd exponentially
 - Congestion avoidance increases cwnd linearly
 - Packet losses triggers congestion window changes

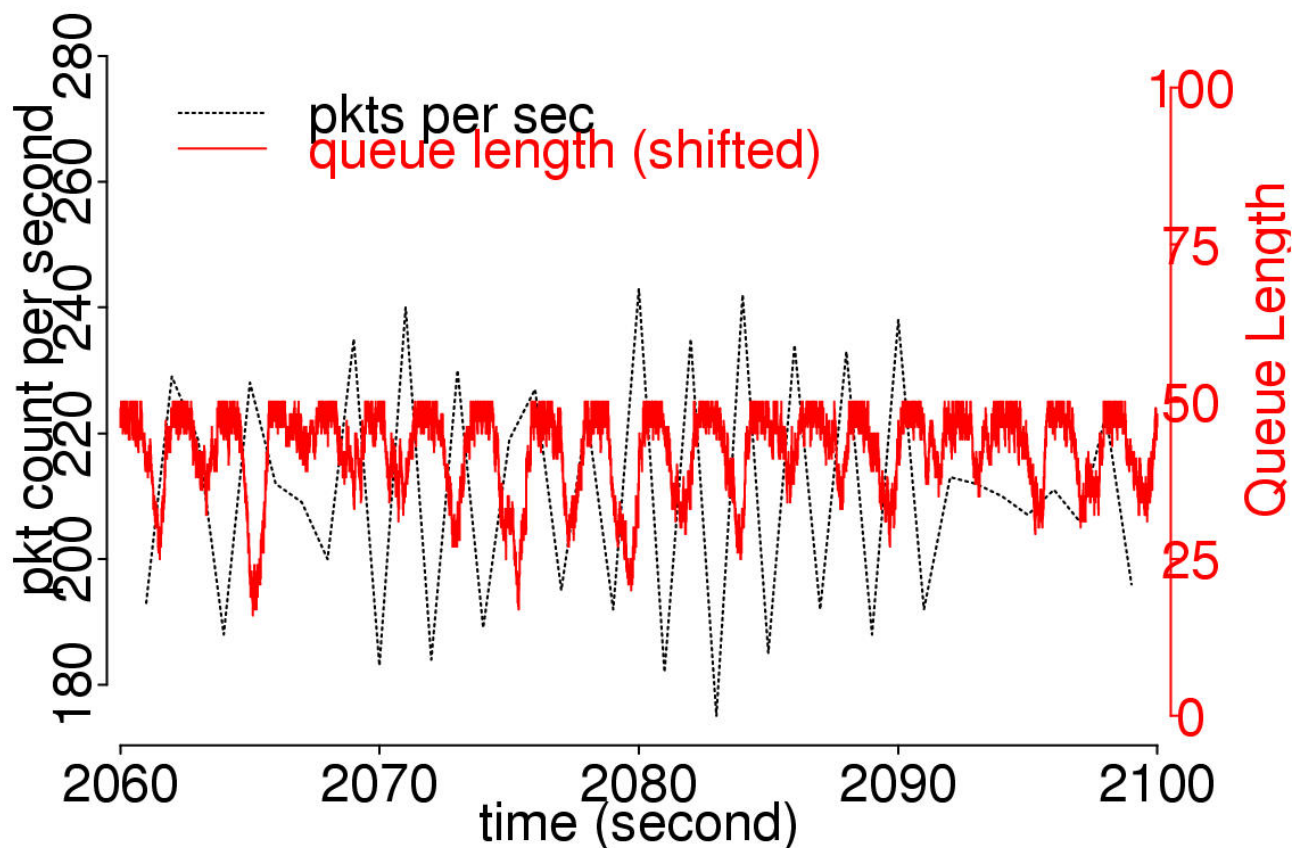
Elephants: Infinite sources

- Packet rate process and buffer occupancy process
 - Network round trip time 1.3 seconds



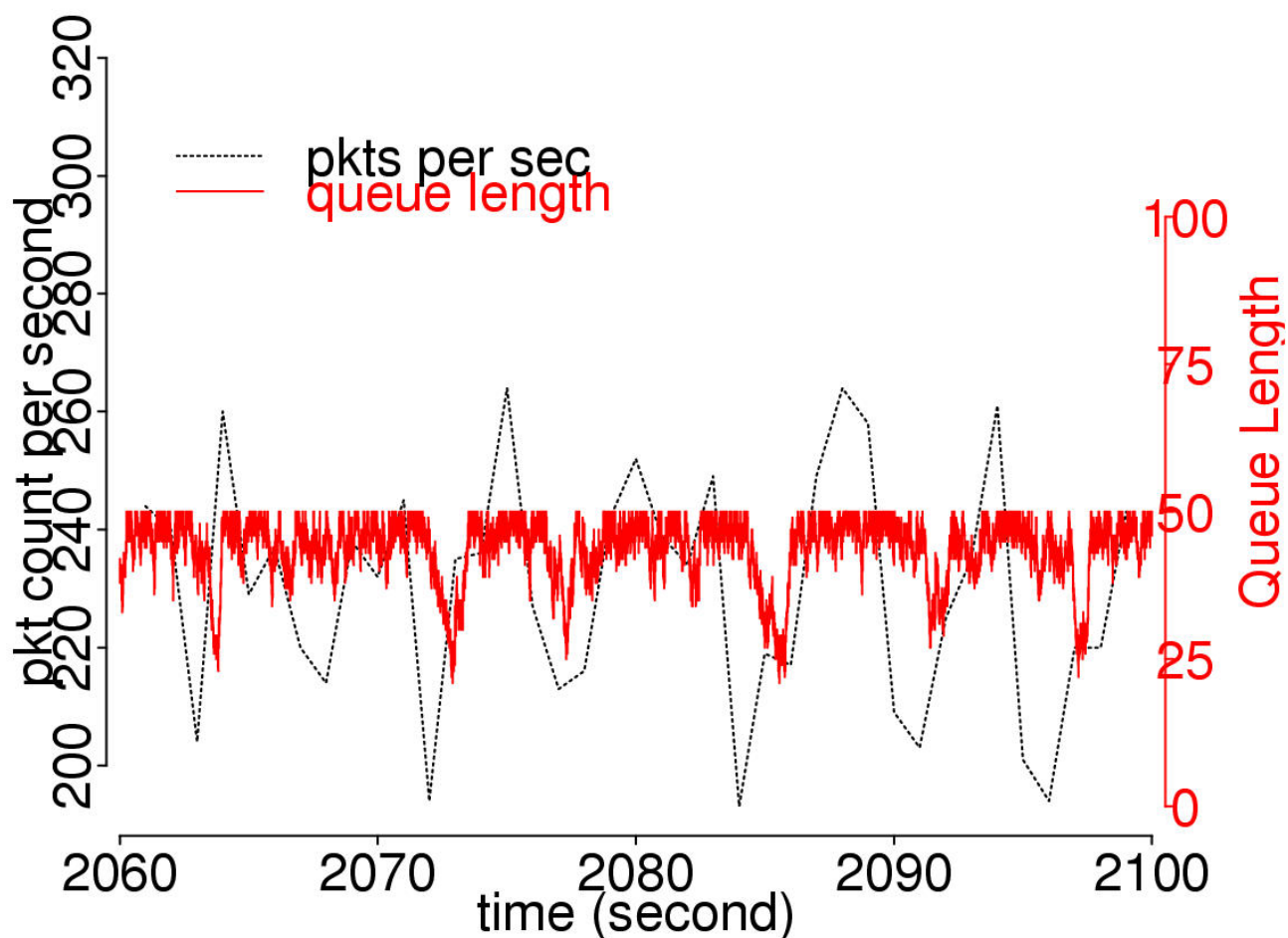
Elephants (cont.)

- ❑ Packet rate process and buffer occupancy process
 - Network round trip time 0.14 seconds



Mice and elephants: Web sources

- Significant portion of connections are short

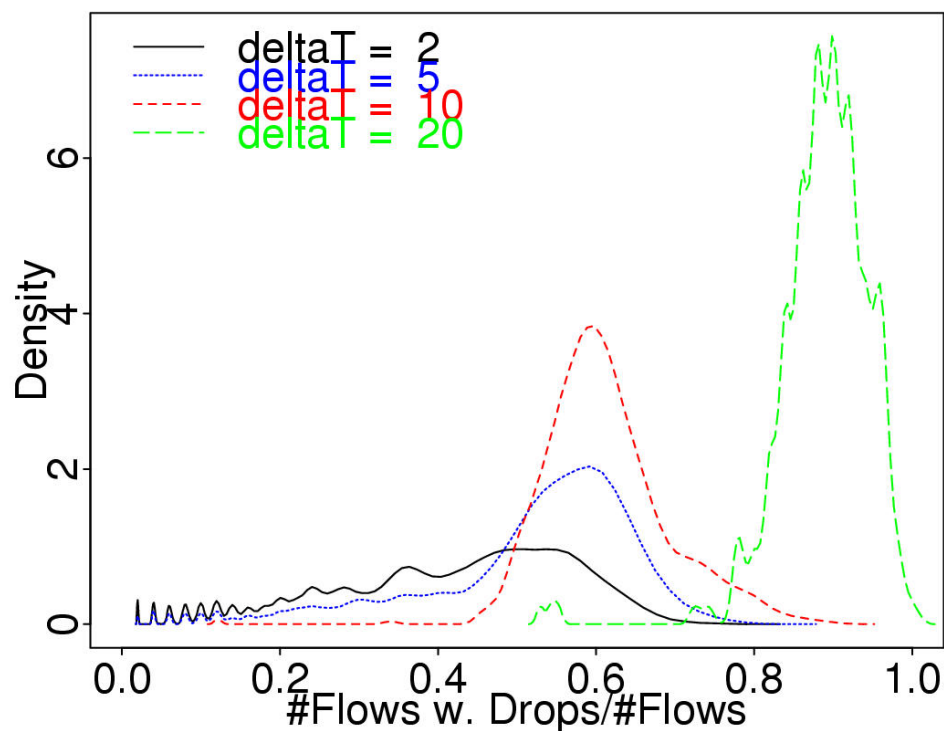


Elephants vs. Mice

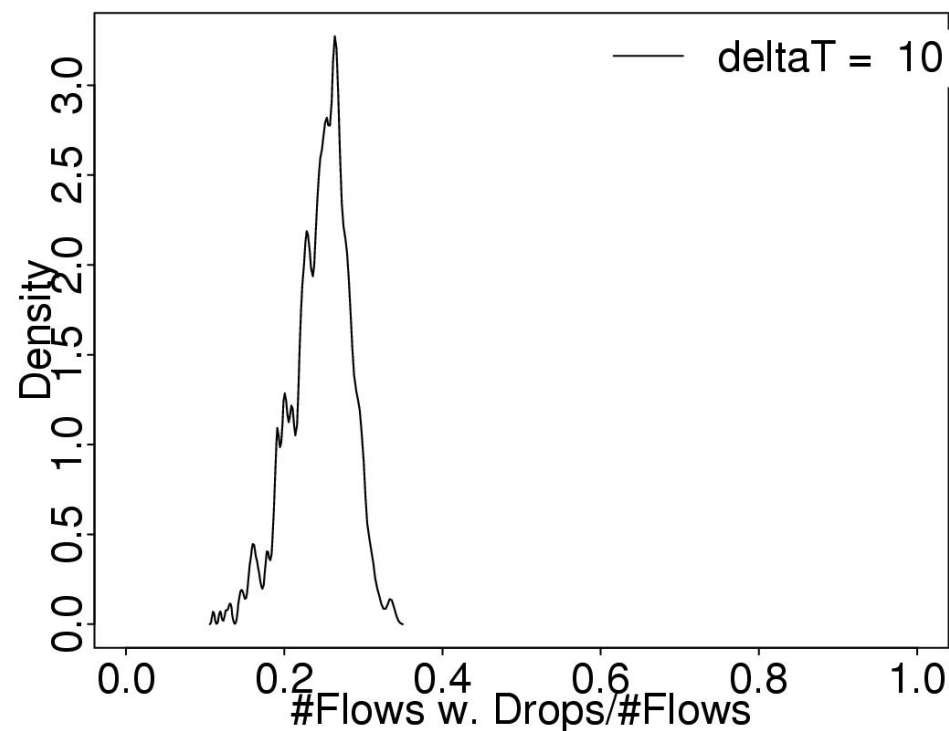
- ❑ No variability in workload and network
 - synchronization of packet rate process
 - synchronization of buffer occupancy process
- ❑ Mice stop synchronization
 - no apparent synchronization
 - higher packet arrival process
 - higher utilization

Effect of synchronization

- Percentage of connections with losses during ΔT



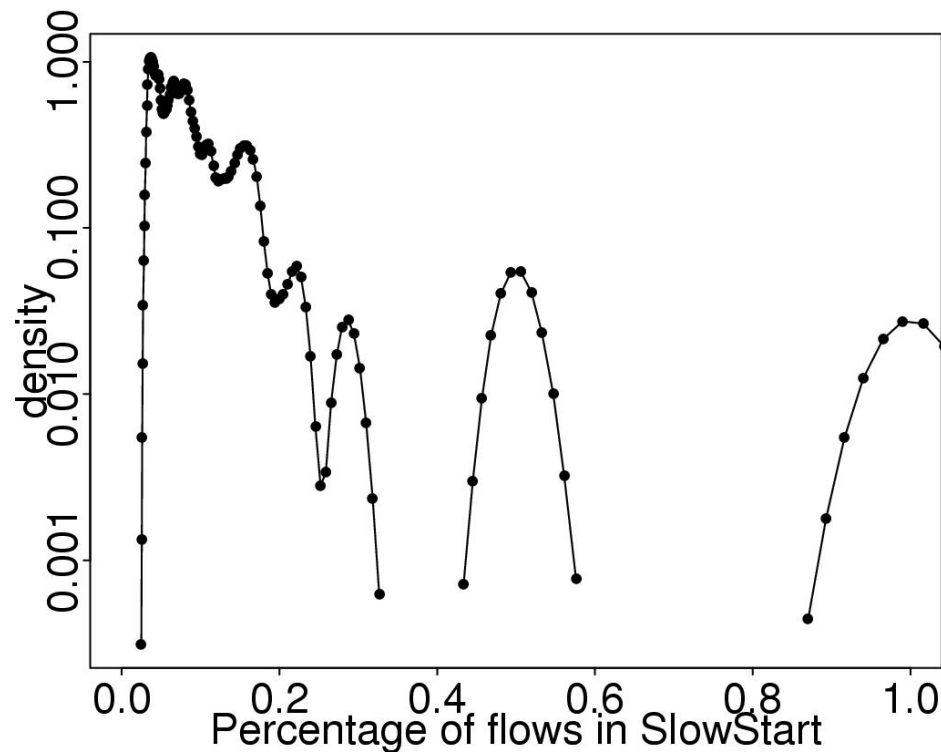
Infinite sources



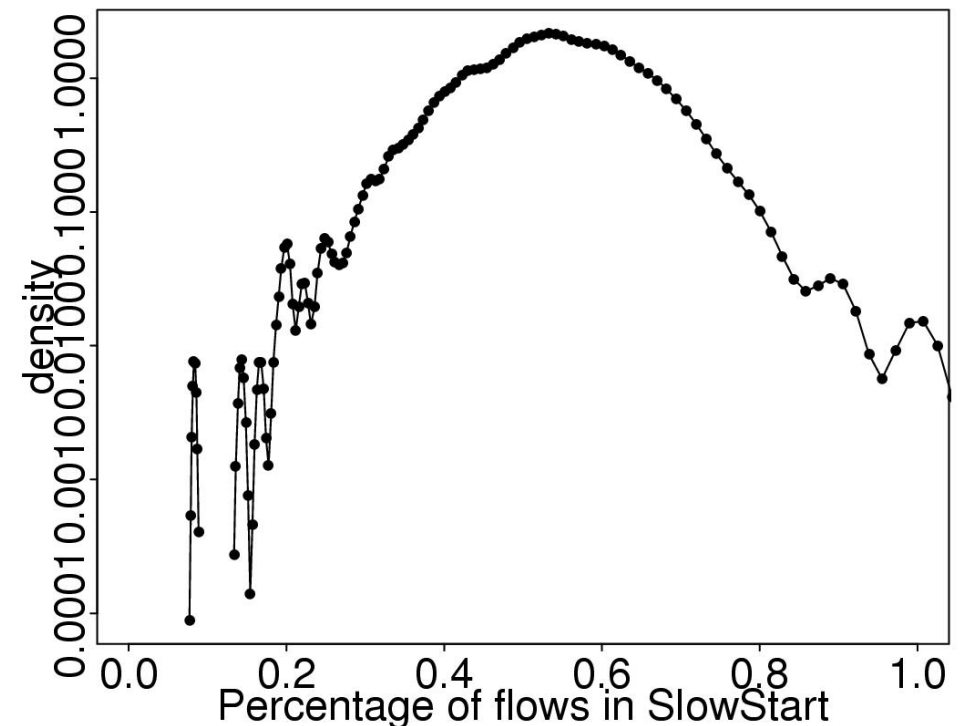
Web sources

Effect of synchronization (cont.)

- Fractions of connections with losses in slow-start



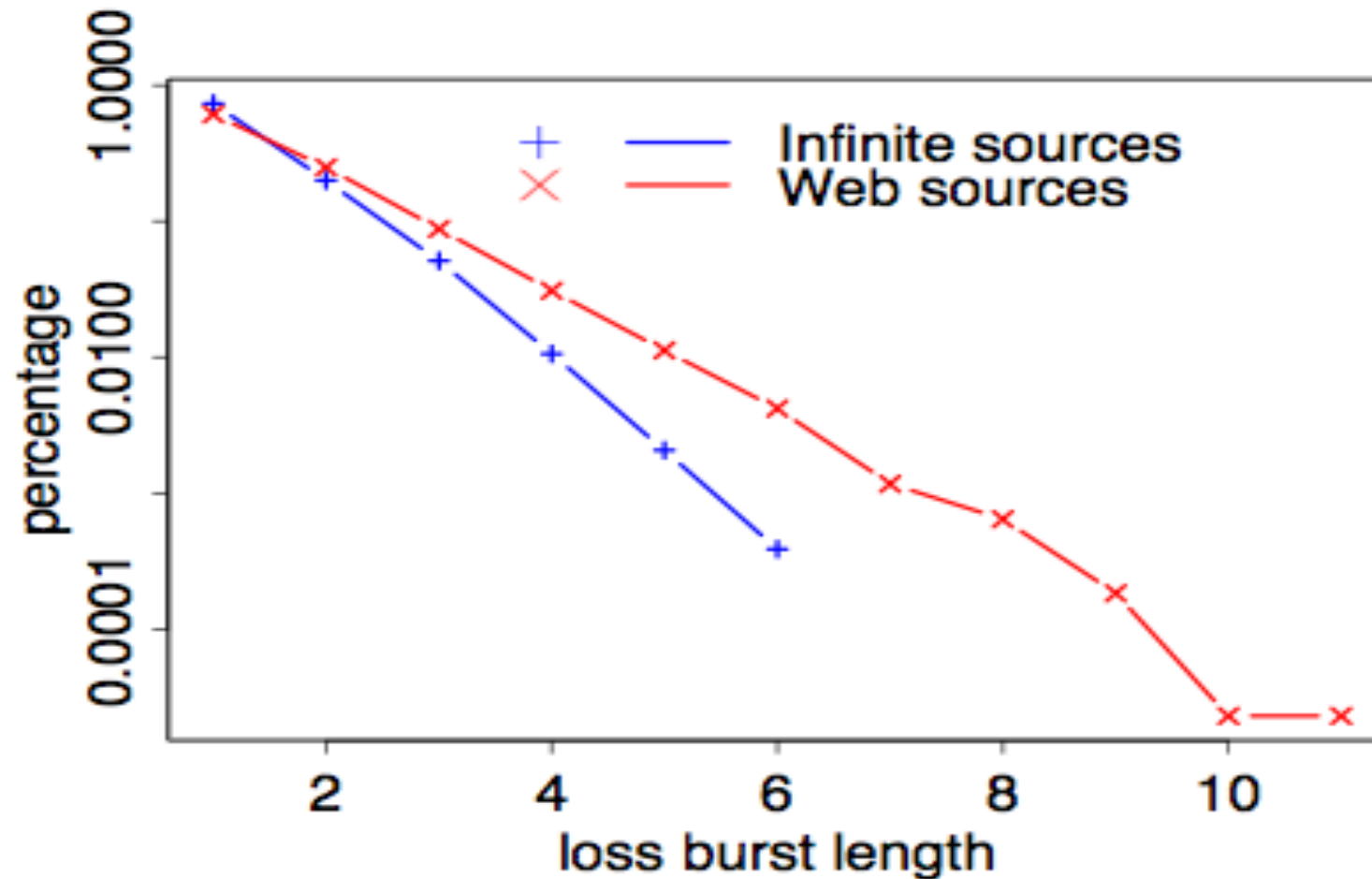
Infinite sources



Web sources

Effect of synchronization (cont.)

- Distribution of number of consecutive packet drops



Why mice eliminate synchronization

□ Mice

- Too short for feedback
- TCP states non-synchronized
- Arrival highly bursty
- Large fraction in slow-start

□ Elephant

- Within two cycles losses for almost all connections
- TCP states synchronized
- Small percentage in slow start

□ Consequence

- # of burst losses larger for Web than Infinite srcs

Conclusion

- ❑ Infinite source models and queue analysis provide necessary simplifications for
 - Analysis
 - Simulations

- ❑ Challenge
 - Address variability at
 - User level
 - Network level