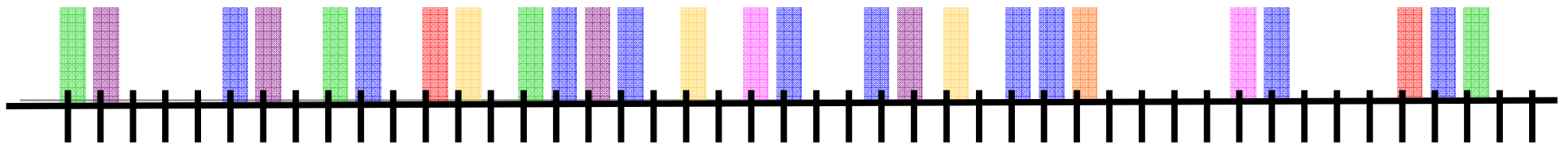


# New Network Layer Metrics for Packet Loss, Delay, Delay Variation



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Note: there may be intellectual  
property associated with some of this  
material.

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# Motivations

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## Applications: Service level agreements (SLAs)

- Accurate and robust SLA compliance monitoring is important for service providers and their customers
- Increasing interest in detailed performance metrics
  - Quantiles, not just means
  - Burst performance patterns, not just long term-averages

## Scope of this talk

- Some limitations of Poisson probing
- Network layer performance metrics: packet loss, delay, delay variation
- Reachability also important for SLAs, but don't consider here (but see RFC 2678)

# Leverage recent research advances?

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Much recent research work on active performance measurement, including:

- Identifying limitations of some metrics
- New probing methods
- New network characteristics of interest
- New statistical metrics
  - New statistics of current sample metrics
  - New statistics of new sample metrics

# Metrics under consideration here

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## Packet loss

- New active probing methods for packet loss
- New mean packet loss rate metric
- New metrics for loss episode statistics

## Delay

- New metric for average packet delay
- New metrics for delay percentiles

## Delay variation

- New statistical metric

# Limitations of Poisson Probing of Loss

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## Sometimes statistically suboptimal

- Doesn't always minimize variance of loss rate estimators
- Other probing strategies also yield unbiased loss rate estimators

## New Probing Methods

- Time between probes to follow Erlang distribution
  - Compare: exponential distribution for Poisson probes

## Published work:

- F. Baccelli, S. Machiraju, D. Veitch, J. Bolot. The Role of PASTA in Network Measurement. ACM SIGCOMM, 2006.
- F. Baccelli, S. Machiraju, D. Veitch, J. Bolot. On Optimal Probing for Delay and Loss Measurement. ACM IMC, 2007.
- Improved estimation accuracy vs. Poisson probes seen in simulation evaluation in some cases

# New Probing Methods for Loss and Loss Episodes

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## Poisson probing limitation:

- Does not support accurate estimation of temporal loss patterns

## New probing method

- use probe set of n packets: n follows geometric distribution
- probes sets separated by exponentially distributed time

## New metrics

- **frequency** and **mean duration** of loss episodes
  - Related to VoIP burst loss metrics of RFC 3611

## Published work:

- J. Sommers, P. Barford, N. Duffield, A. Ron. A Geometric Method for Improving Packet Loss Measurement. IEEE/ACM Trans Networking, 2008.
- J. Sommers, P. Barford, N. Duffield, and A. Ron. [Accurate and Efficient SLA Compliance Monitoring](#). Proceedings of ACM SIGCOMM, 2007

## Evaluation in a controlled laboratory setting

- Good estimation accuracy of congestion episode characteristics
- Significantly improved accuracy of packet loss vs. existing methods

## Tool

- Embodied in Badabing tool available at <http://wail.cs.wisc.edu/>

# One-way delay: mean delay

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Building a more accurate average delay statistic

Method

- use Simpson's method of numerical integration
  - non-uniform weighting of packet delays

Published Work

- J. Sommers, P. Barford, N. Duffield, and A. Ron. [Accurate and Efficient SLA Compliance Monitoring](#). Proceedings of ACM SIGCOMM, August 2007.

Evaluation

- some improvement in accuracy over existing methodology

# One-way delay variation: delay quantiles

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Two proposals for measuring delay quantiles

1. B.Y. Choi, S. Moon, R. Cruz, Z.-L. Zhang, C. Diot. Practical delay monitoring for ISPs. ACM CoNext, 2005.
  - Use quantiles of measured probe delay to **estimate** quantiles of underlying distribution
  - Find number of probes needed for given confidence bound
  - Some parameter estimation from measurement required
2. J. Sommers, P. Barford, N. Duffield, and A. Ron. [Accurate and Efficient SLA Compliance Monitoring](#). Proceedings of ACM SIGCOMM, August 2007.
  - Use quantiles of measured probe delay to **bound** quantiles of underlying distribution
  - Lightweight: works directly from delay samples alone.



# One-way delay: delay variation

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## Published Work:

- J. Sommers, P. Barford, N. Duffield, and A. Ron. [Accurate and Efficient SLA Compliance Monitoring](#). Proceedings of ACM SIGCOMM, August 2007.

Samples are the same as in RFC 3393

## New Delay Variation statistic

- Closest in spirit to Type-P-One-way-ipdv-jitter statistic in RFC 3393
- Similar to RTP jitter metric (RFC 3550)

## Evaluation in controlled lab setting:

- Mix of long and short lived TCP session, UDP
- New statistic more robust than Type-P-One-way-ipdv-jitter
- more accurately tracks turbulent conditions

# Summary

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Increasing need for SLA compliance monitoring has driven new measurement methodologies

Recent advances in performance metrics research

- New sampling methods and new statistics
- Network-layer performance metrics
  - Delay: estimates of mean delay and delay percentiles
  - Loss rate: estimates of congestion episode characteristics, and loss average statistic
  - Delay variation: new qualitative statistic

Timely opportunity to revisit and expand IPPM recommendations?