Reporting Metrics: 
Different Points of View
(revisions and discussion)

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“Our plans miscarry because they have no aim. When a man does not know what harbor he is making for, no wind is the right wind.”

Seneca
Different Points of View (POV): 2 key ones

- When designing measurements and reporting results, MUST know the Audience to be relevant
- Key question: “How will the results be used?”

**Network Characterization:**
- Monitoring (QA)
- Trouble-shooting
- Modeling
- SLA (or verification)

**Application Performance Estimation:**
- Metrics Facilitate process
- Transfer-dependent aspects
- Modify App Design

How can I _______ my network?

What happened to my stream?
Summary from IETF-66:

- Set a LONG Loss threshold
  - Distinguish between Long Finite Delay and Loss
  - Avoid truncated distributions
- Delay of Lost Packets is UNDEFINED
  - Maintain orthogonality – avoid double-counting defects
  - Use conditional distributions and compute statistics
- Report BOTH Loss and Delay
- Report BOTH the Sample Mean and Median.
  - Comparison of the Mean and Median is informative
  - Means may be combined over time and space (when applicable)
  - Means come with a weighting function for each sample if needed, the sample Size, and Loss simply reduces the sample size
  - Means are more Robust to a single wonky measurement when the sample size is Large
- Move the Industry Away from “Average Jitter”
  - Use the 99.9%-ile minus minimum PDV
  - Portray this as a Delay Variation “Pseudo-Range”
What’s Next?

- Proposal:
  - Make this draft the basis for non-short-term reporting
  - Complement to current draft, without the restrictions
Matt, you can delete whatever I don’t use, these are all from the IETF-66 presentation.
Revisions and new material in 01

- Discussion on Loss Threshold (sec 3.1)
  - Referred to IPv6 Hop Limit along side TTL
- Expanded discussion on overlap between Loss and Delay metrics when Loss = $\infty$ Delay (sec 4.1.2)
  - Also added a Figure with CDF showing mass at $\infty$
- Additional comparison of Mean and Median (sec 4.2)
  - Under Preferred Statistics
- New section on Sample Size (sec 5.2)
  - What does it mean to be “Large”? A distribution-free discussion
- Expanded Reporting Section (sec 6)
- Reference to OWAMP in the Security Section
Background on this Discussion/Draft

- Talk at IETF-65, comparing different ways to implement RFC 3393 on Delay Variation, ending with
  - “How do you want to use the DV Results?”
  - Two primary ways to measure within the options of 3393
  - Choices have profound implications, made clear in slides
  - Topic for a future draft…

- draft-shalunov-ippm-reporting
  - Real-time display of short-term network state, using only “on-the-fly” calculations
  - Stream and Metric parameters chosen for Loss, Delay, Delay Variation, Duplication, and Reordering
  - I would have made different choices for many parameters when reporting performance under other circumstances…

- Stas’ comments on the Composition Framework

- Side point: Metric Parameters/Options make the IPPM Registry less-effective…
Outline

2. Purpose and Scope
   Delineate the 2 POV, and their effect on metric and stream params and the desirable statistics for reports.

3. Effect of POV on the Loss Metric
   3.1. Loss Threshold
   3.2. Errored Packet Designation
   3.3. Causes of Lost Packets

4. Effect of POV on the Delay Metric
   4.1. Treatment of Lost Packets
       4.1.1. Application Performance
       4.1.2. Network Characterization
       4.1.3. Delay Variation
       4.1.4. Reordering
   4.2. Preferred Statistics
   4.3. Summary for Delay

5. Sampling: Test Stream Characteristics

6. Reporting Results
Effect of POV on the Loss Metric

- Loss Threshold – waiting time for each packet
  - Network Char – distinguish Loss and Long (Finite) Delay
  - RFC 2680 declines to recommend a value
  - “good engineering, including an understanding of packet lifetimes, will be needed in practice.”
  - The methodology says to use “a reasonable value.”
  - Routing Loops can cause long delays
  - Packet lifetime is still limited by hops traversed (TTL)
    - (100ms Link + 100ms Queue) x 255 hops = 51 seconds
  - Deliberate Packet Storage is a Replay Attack
  - Application Perf - long thresh. can be revised downward

- Errored Packet Designation
  - “If the packet arrives, but is corrupted, then it is counted as lost.”

- Causes of Lost Packets (discard, corruption, failures)
Comparison of Parameter Classifications

IPPM RFCs

Packet Arrival in <= Thresh?

- NO: Designate Packet as Lost
  Designate Delay as Undefined (or Infinite)

- YES: Packet in error?
  - NO: Calc. Delay according to Wire times
  - YES: Process Packet for Delay

ITU-T Y.1540

Packet Arrival in <= Tmax?

- NO: Designate Packet as Lost (possibly Misdirected)

- YES: Process Packet for:
  - Delay and DV
  - Error
  - Spurious
  - (Reordering)
  - (Duplicate)
Effect of POV on the Delay Metric

One-way Delay RFC 2679

3.4. Definition:

For a real number \(dT\), \(\text{Type-P-One-way-Delay}\) from Src to Dst at \(T\) is \(dT\) means that Src sent the first bit of a Type-P packet to Dst at wire-time \(T\) and that Dst received the last bit of that packet at wire-time \(T+dT\).

\(\text{Type-P-One-way-Delay}\) from Src to Dst at \(T\) is undefined (informally, infinite) means that Src sent the first bit of a Type-P packet to Dst at wire-time \(T\) and that Dst did not receive that packet.

- How do these two different treatments align with the needs of the 2 main audiences for measurements?
- How have lost packets been treated in more recent metric definitions, such as delay variation and reordering?
Effect of POV on the Delay Metric (2)

- **Application Performance**
  - Receiver processing “forks” on arrival or time-out
  - Arrive within the time tolerance:
    - Check for errors
    - Remove headers
    - Restore order
    - Smooth delivery timing (de-jitter buffer)
  - Time-outs spawn other processes (recovery):
    - Re-transmission
    - Loss concealment
    - Forward Error Correction

- Therefore: Maintain a distinction between packets that actually arrive within tolerance, and those that do not.
- Measure Delay as a conditional distribution (conditioned on arrival within tolerance)
Network Characterization

- Assume both Loss and Delay will be reported (at least)
- Packets that do not arrive within the Loss Threshold are reported as Lost, AND
- When they are assigned UNDEFINED delay, then the network’s ability to deliver is captured only by the Loss metric
- If we were to assign Infinite Delay to the Lost Packets, then:
  - Delay results are influenced by packets that arrive, and those that do not.
  - The delay and loss singletons do not appear orthogonal
  - The network is penalized in both Loss and Delay metrics
**Effect of POV on the Delay Metric (4)**

- **Orthogonal?**
  - Loss: Undefined, 0 not possible
  - CDF: Conditional CDF
  - Delay, s: 0, 1, 51, +∞

- **Non-Orthogonal?**
  - Loss: 0%
  - CDF: Equal to fraction lost
  - Delay, s: 0, 1, 51, +∞
**Effect of POV on the Delay Metric (5)**

- **Delay Variation**
  - RFC 3393 excludes lost packets from samples (sec 4.1)
  - Reduces the event space by conditioning on arrival
  - Considers Conditional Statistics
  - Allowing packets with Infinite delay to be considered would influence the results in a non-useful way

- **Reordering**
  - The draft excludes lost packets based on a loss threshold, so maintains orthogonality to Loss
  - If we fail to distinguish between loss and delay, and assign lost packets some long delay value (e.g., infinity),
  - then the sequence numbers of packets assigned a long delay will surely be less than “Next Expected” value (if or when they arrive)
  - and they could be designated reordered.
Status of IPPM Active Work in this area

- New effort chartered on Metric Composition and Aggregation:
  - Framework Draft – common concepts and terminology
  - Temporal Aggregation – short-term meas. in long-term
  - Spatial Aggregation – summarize many paths across net
  - Spatial Composition – combine perf. of many sub-paths
    - Defined a “Finite Delay” Metric, enabling computation of the mean delay, and simple aggregation.
    - Avoids the informal assignment of “infinite” delay when a packet is lost – simply leave delay UNDEFINED.
    - This is consistent with the One-way Delay RFC 2679

- Future of this work will be influenced by the conclusions of this discussion
Preferred Statistics on Delay

● Sample Mean is Ubiquitous in Reporting (almost)
  ➔ Usually based on a conditional distribution
  ➔ Has some robustness to single errors in large sample
    ✩ Vast crowds consider it useful (not harmful)
    ✩ Robustness is both a strength and a weakness
    ✩ Yes, you can run with scissors

● Median has different properties

● It can be informative to report BOTH Mean and Median
  ➔ When they differ, there’s information ...

● Delay Variation – See IETF-65 slides on Jitter Metric Comparison