A short introduction to the "Floor Population" Metrics

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- **Introduction**
- Objective
- Lucky Packets
- Metric Definitions
- Floor Window
- PDV Performance Limits
- Example Measurement
- Conclusion

Introduction

- What are the new metrics?
  - Floor Packet Count (FPC)
  - Floor Packet Percentage (FPP)
  - Floor Packet Rate (FPR)

- Where are they used? New ITU Recommendations
  - Defined in G.8260
  - Used in G.8261.1 as a network limit (1%)
  - Used in G.8263 as a slave tolerance limit (1% at slave spec'd min rate)

Packet Timing System

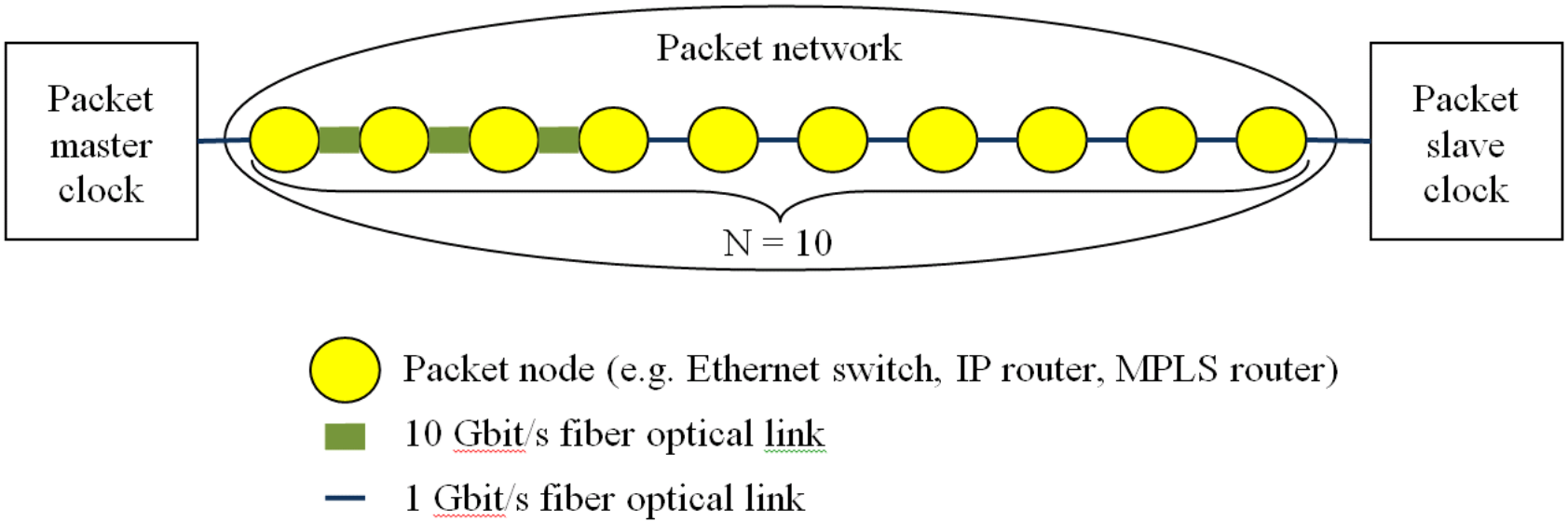
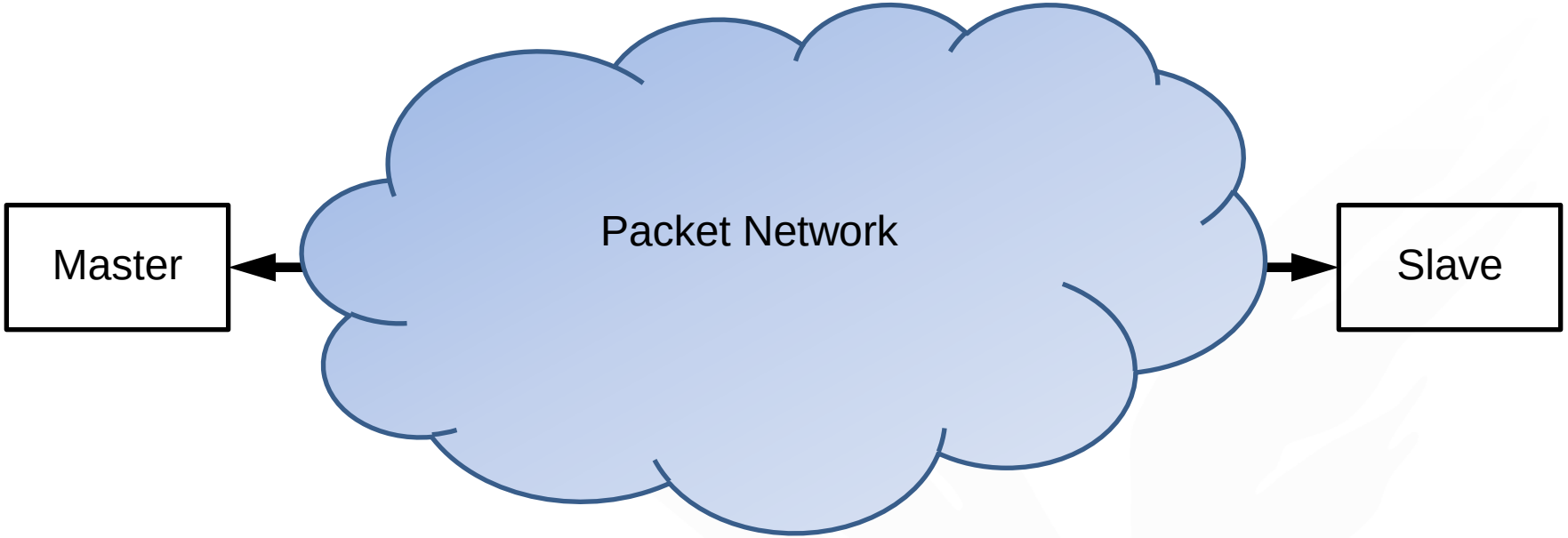


Figure 1/G.8261.1 - HRM-1 for Packet Delay Variation network limits

Packet Timing System



The Floor Population Metrics are a way to measure Packet Delay Variation (PDV) in this system

(NOTE: Other metrics, such as MAFE are also possible)

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Objective of the new metrics *(from G.8260)*

- To study the population of timing packets within a certain fixed cluster range starting at the observed floor delay
- To compare the population with acceptance or rejection thresholds
- To ensure that at least a minimum number of packets, or a minimum percentage of packets remains within the specified cluster range starting at the observed floor delay

Objective of the new metrics

To measure so-called “Lucky Packets”

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Quiz: Which of these shows Lucky Packets?

Lucky Packets

- Lucky packets are the packets that experience near minimum delay
  - They spend little or no time waiting in queues
  - They are fortunate to avoid congestion in the network
- Therefore lucky packets can be selected using a “cluster range”
  - Anchored at the minimum delay (observed or known)
  - Size of the cluster range affects the sensitivity of the measurement
- Cluster range is also called “Floor Window”
  - More on that in a minute

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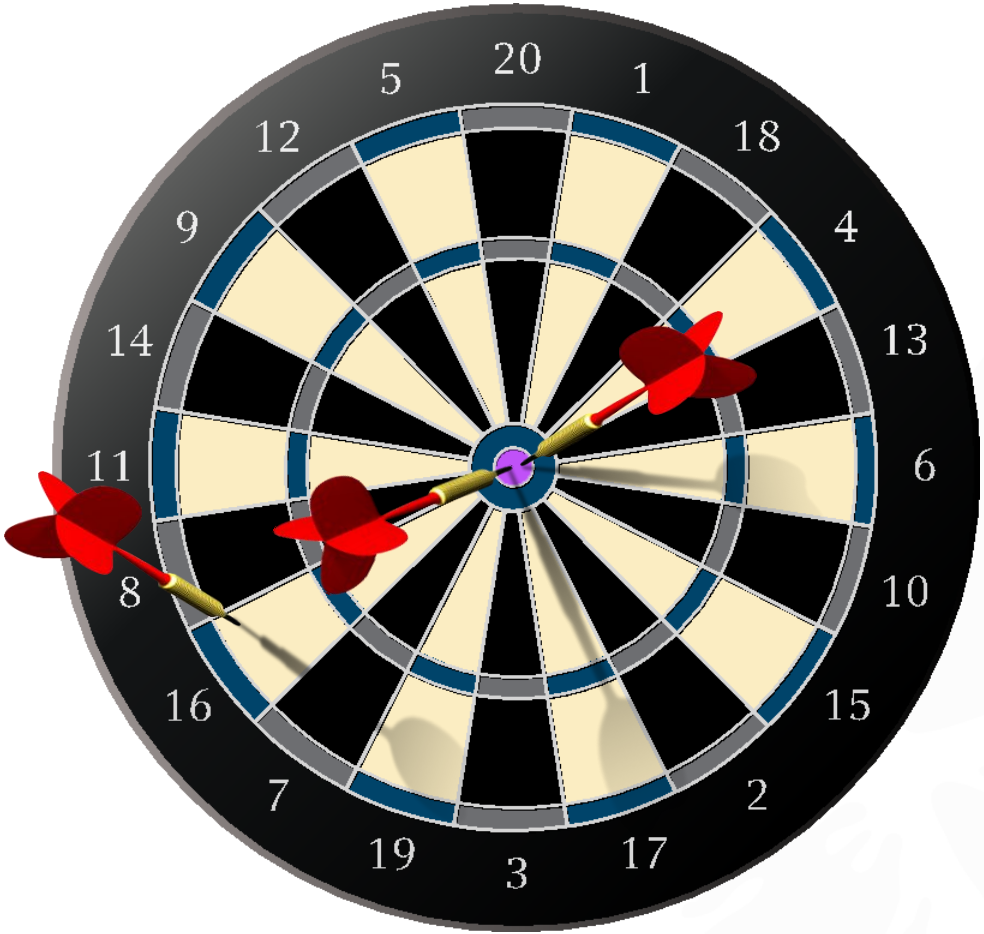
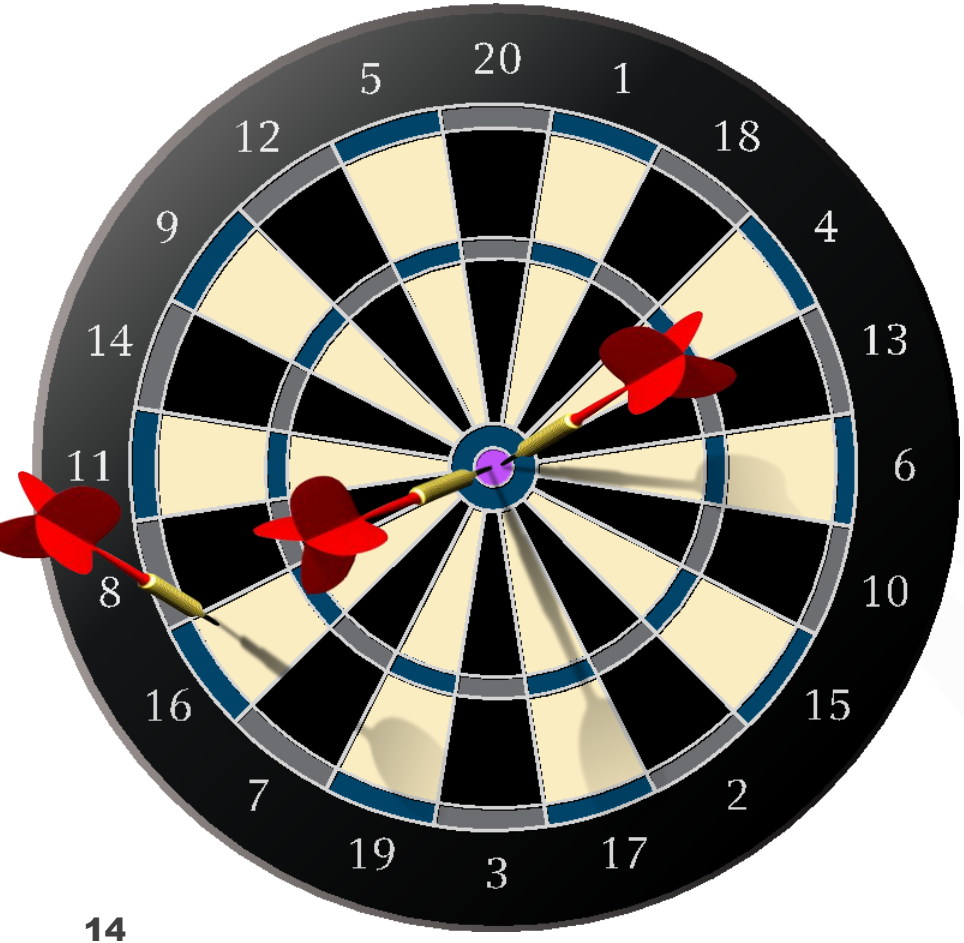
Analogy



Analogy



- Game lasted 1 minute
- Three darts thrown
- Two hit Bull's Eye
- 1 point for Bull's Eye

STATS

- Score=2
- Percent=67% (2/3)
- Rate=2/minute

Metric Definitions via Dart Board Analogy

- Floor Packet Count (FPC)
  - The number of times a dart landed in the Bull's Eye
- Floor Packet Percentage (FPP)
  - The percentage of times a dart landed in the Bull's Eye
- Floor Packet Rate (FPR)
  - The rate that darts land in the Bull's Eye (e.g. per minute or hour)
- To apply to packet timing systems:
  - Replace "dart" with "timing packets"
  - Replace "land" with "have delay" (or "are delivered")
  - Replace "Bull's Eye" with "Floor Window"
    - (size of Bull's Eye is analogous to the "cluster range"

Note: Full mathematical definitions are in backup slides

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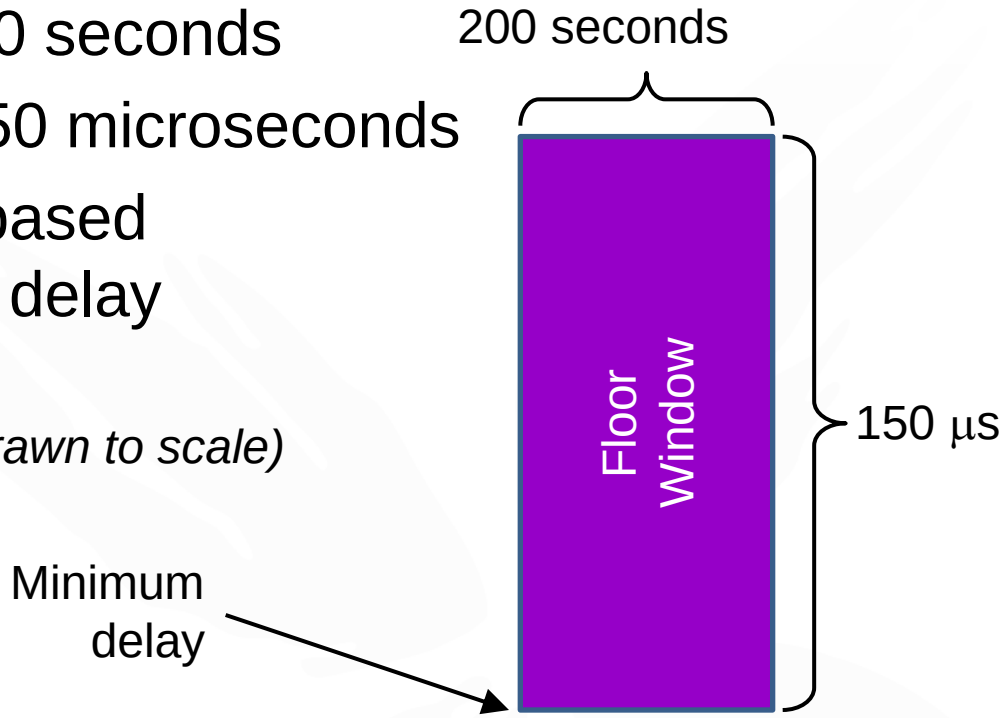
The Floor Window
(a.k.a. the Bull's Eye)

- Window has width, height and vertical position
  - Width is defined as 200 seconds
  - Height is defined as 150 microseconds
  - Position of window is based on minimum observed delay

(NOTE: Not drawn to scale)



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Network PDV Limit (G.8261.1)

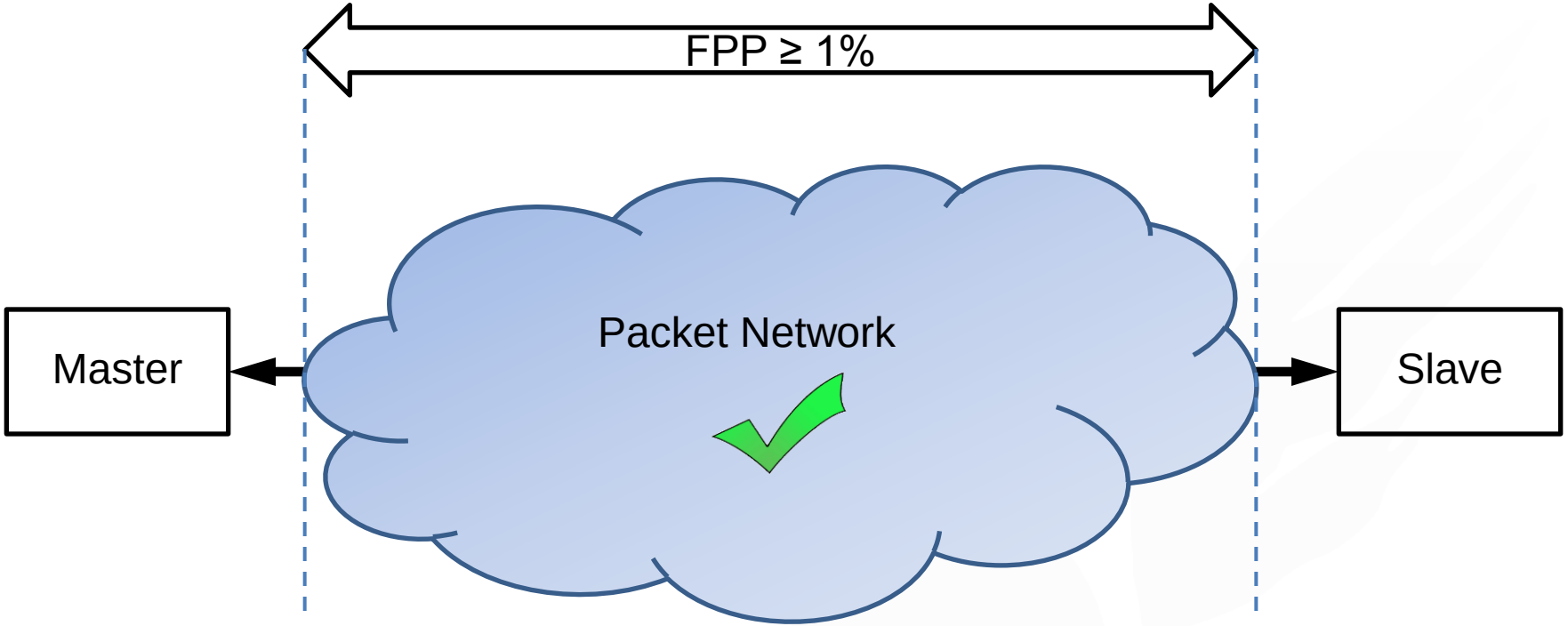
The Packet Delay Variation network limit at the point C of figure 3/G.8261.1 for the HRM-1 shown in figure 1/G.8261.1 is defined as follows:

With window interval $W = 200$s and fixed cluster range $\delta = 150\mu$s starting at the floor delay, the network transfer characteristic quantifying the proportion of delivered packets that meet the delay criterion should satisfy

$$\mathbf{FPP}\ (n, W, \delta) \geq 1\%$$

That is, the floor packet percentage must exceed 1%.

Network PDV Limit



NOTE: This is a relative measurement
and doesn't depend on timing packet rate

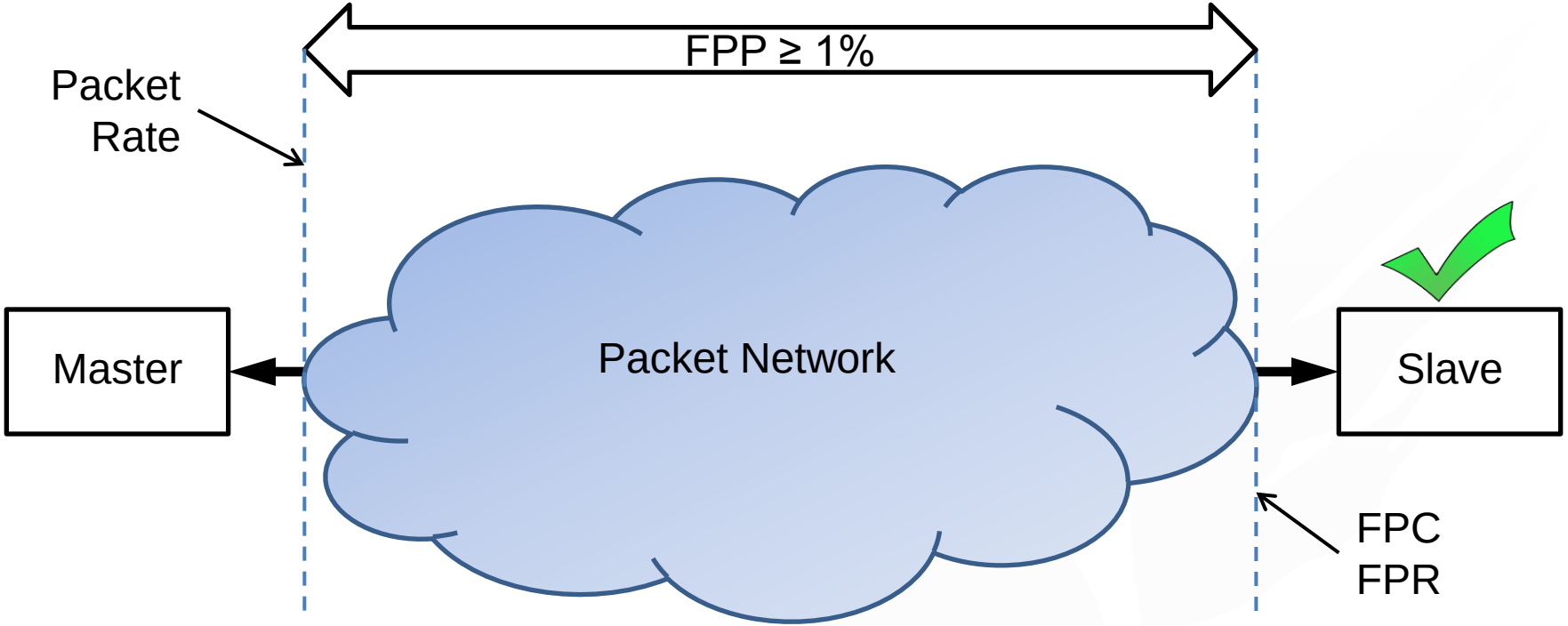
Slave PDV Tolerance (from G.8263)

The PEC-S-F must tolerate the noise at the limits specified in Recommendation G.8261.1, clause 8 (PDV network limits at point C).

[…]

Note: ***For the particular packet rate used by an actual PEC-S-F implementation***, within the range specified in Recommendation G.8265.1, the PEC-S-F clock must therefore tolerate the PDV generated by the network as specified in G.8261.1. More specifically, for the HRM-1 of G.8261.1, the PEC-S-F must meet the output performance specification for its particular packet rate when only 1% of the timing packets sent by the packet master remain in the 150µs fixed cluster range starting at the floor delay in every observation window of 200s.

Slave PDV Tolerance



NOTE: This is an absolute measurement
that depends on timing packet rate

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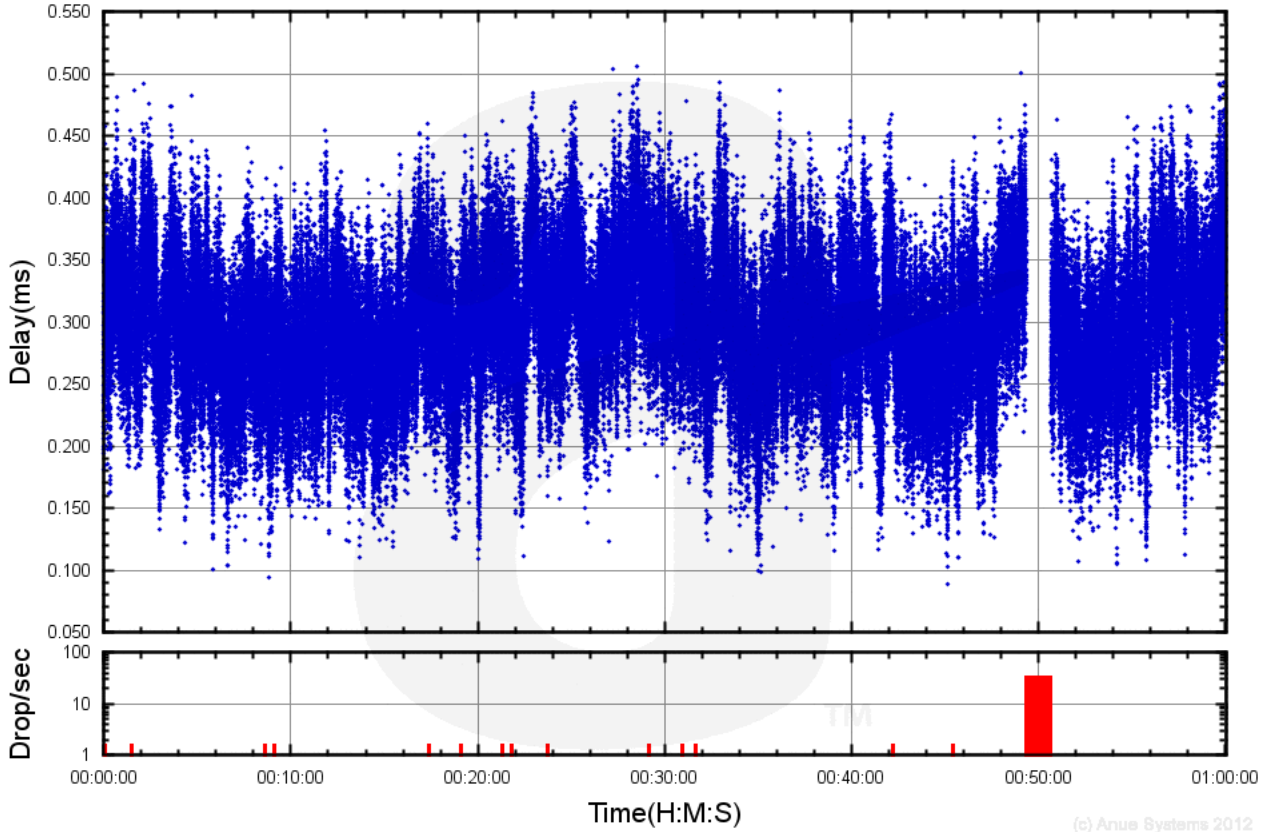
Example Measurement

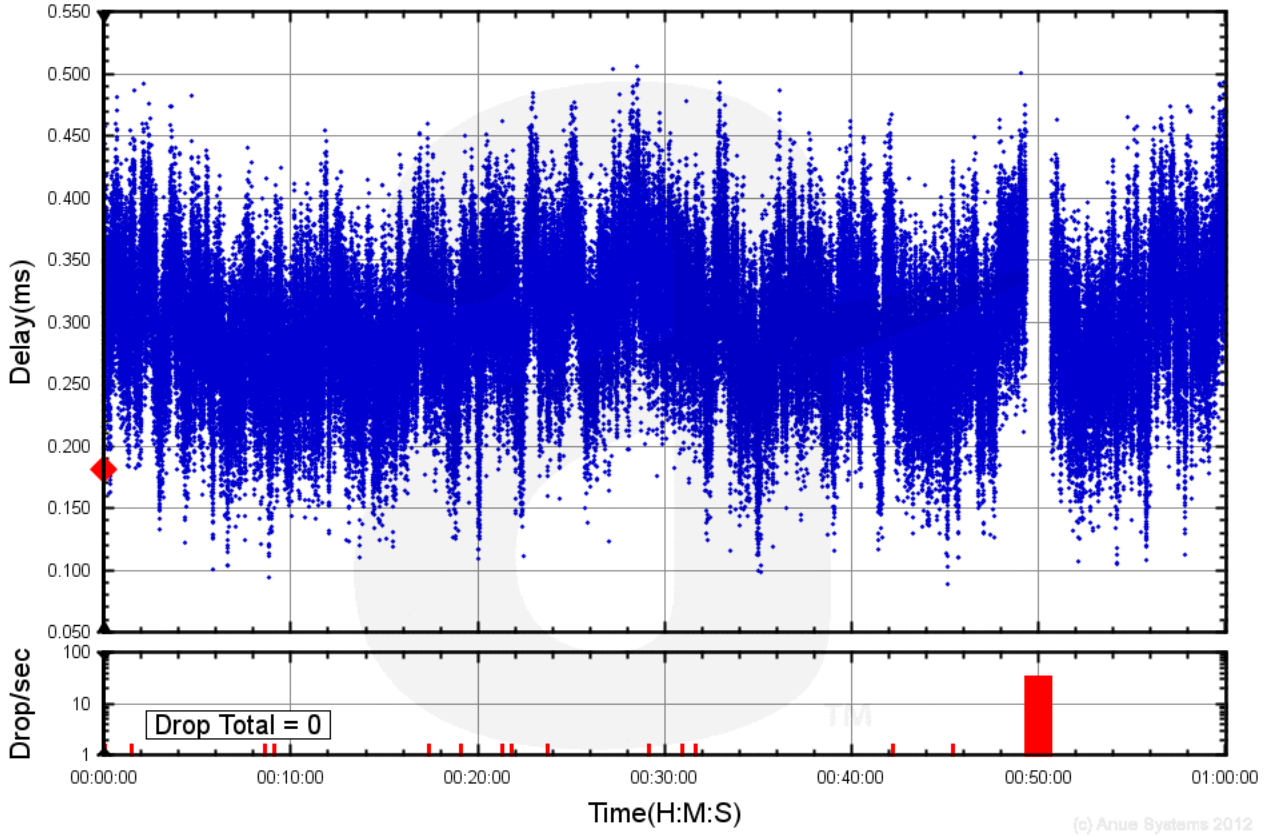
- Packet timing system operating at 32 packets per second
- Packet Delay Variation (PDV) based on flicker noise
- Low level of random packet loss (0.01%)
- Brief network outage (80 seconds)

- Steps for calculating FPC, FPP & FPR
  - Find minimum delay
  - Draw FPC graph, explain axes
  - Calculate with jumping window
  - Calculate with sliding window
  - Compare jumping and sliding

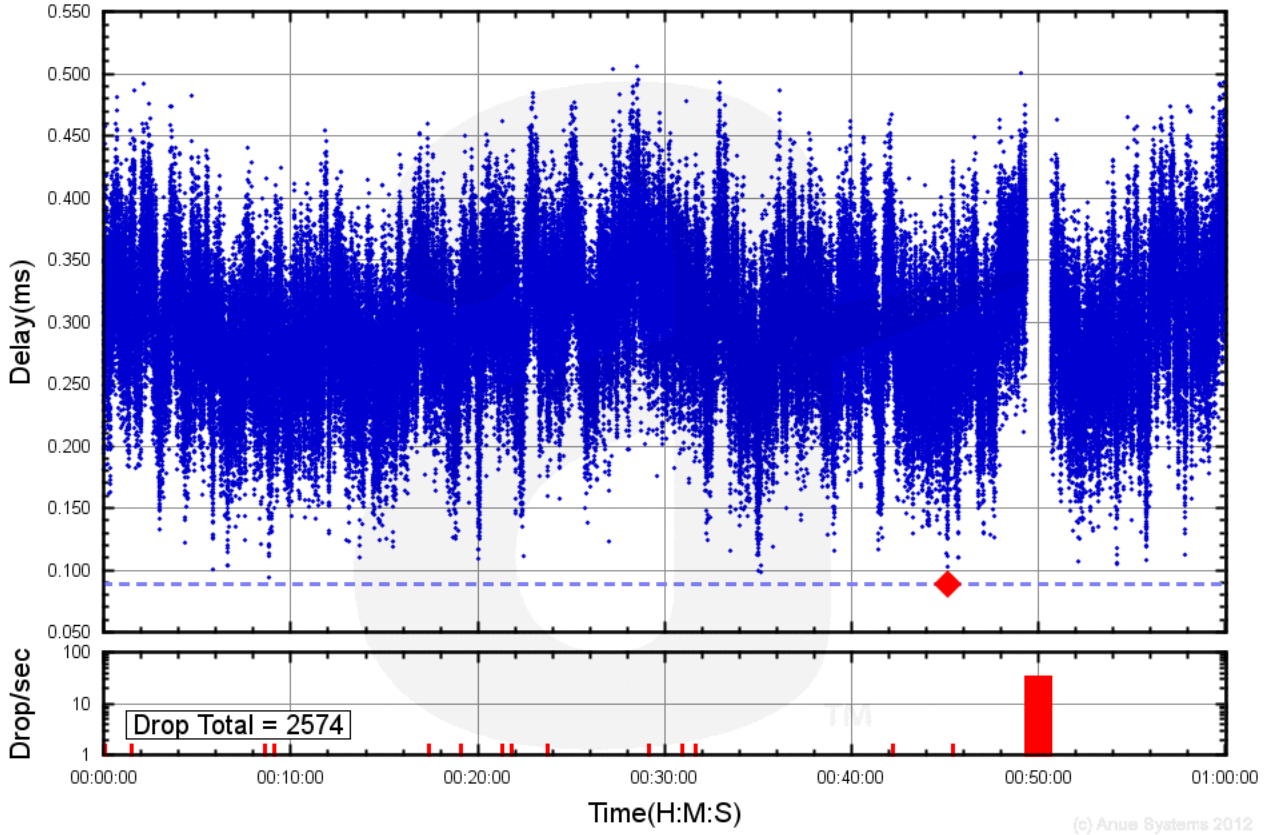
Example PDV with 0.01% Loss (@32 pkt/sec)



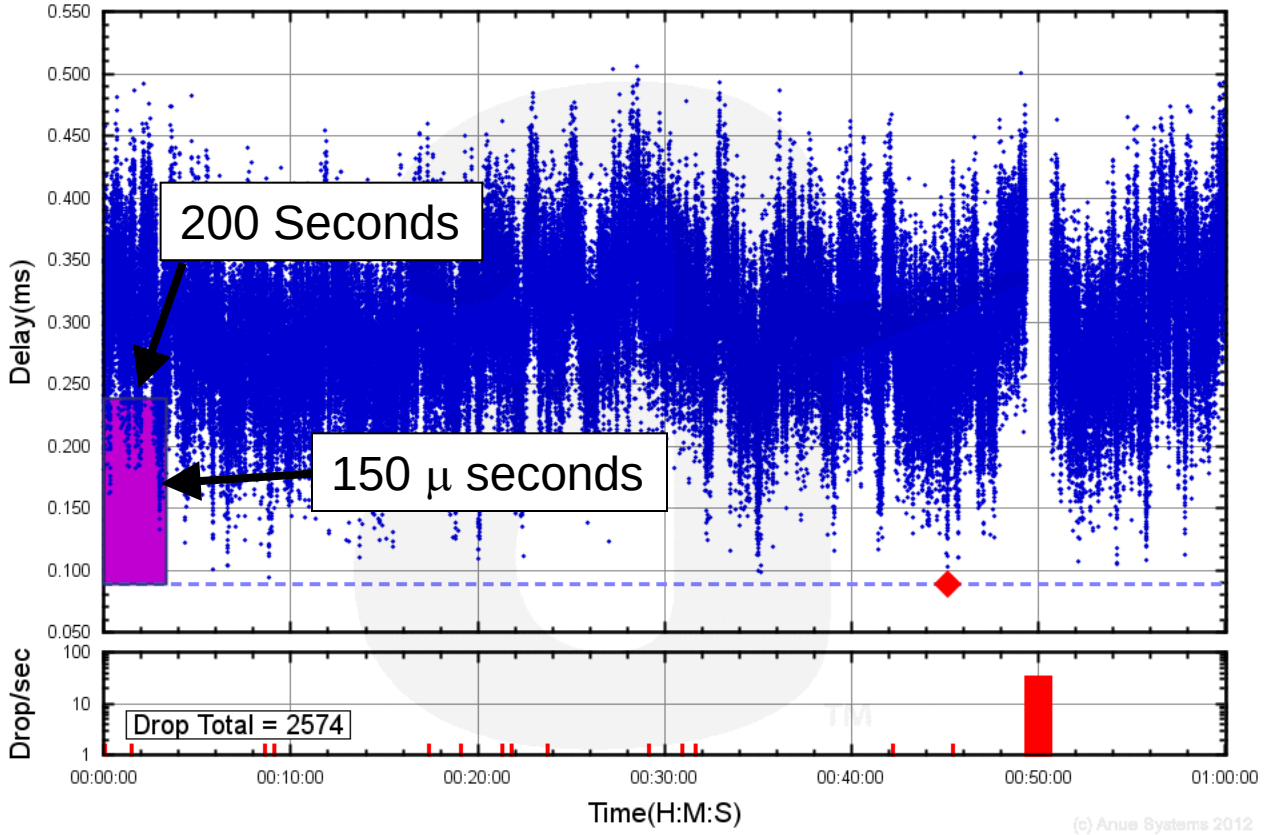
Search for minimum delay value



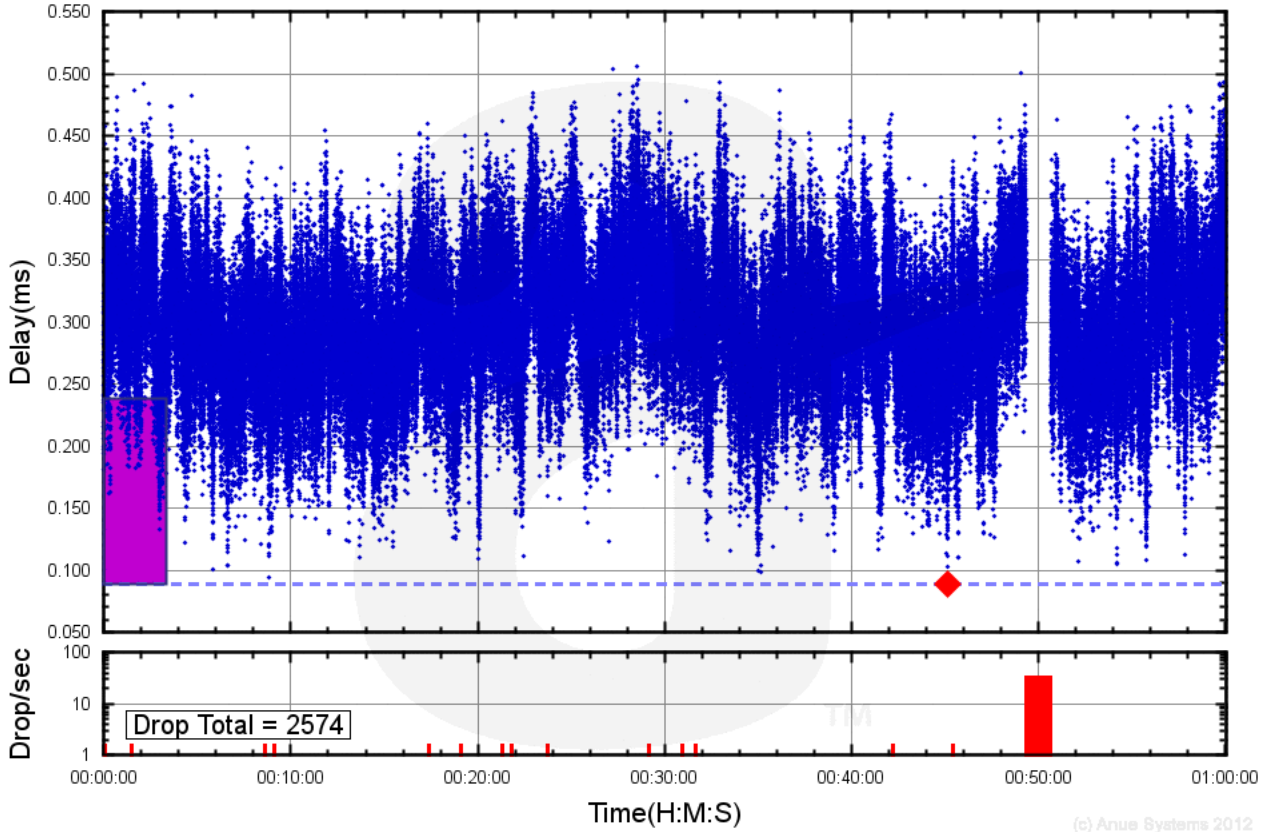
Draw horizontal line for minimum delay



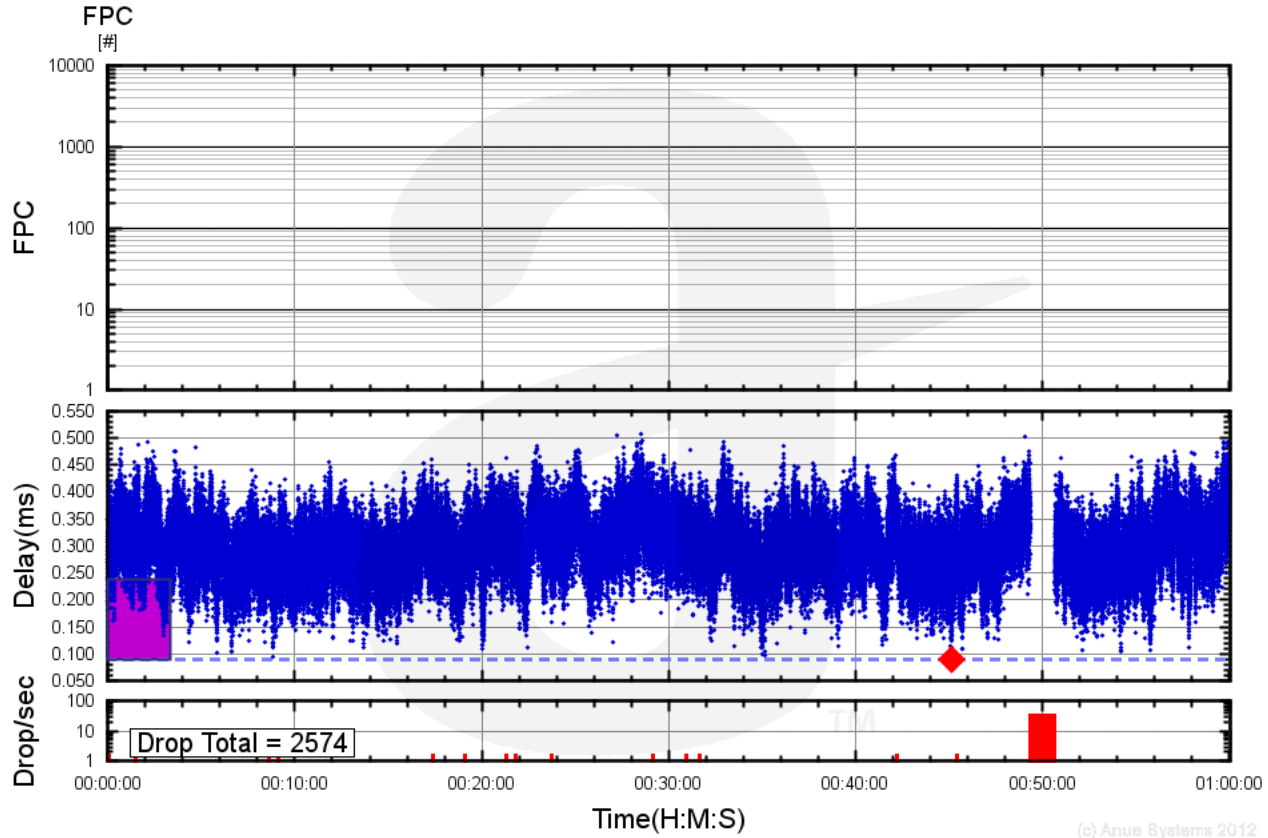
Draw the Floor Window



Add the FPC graph

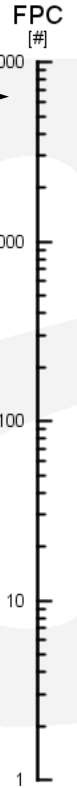


Look at just the FPC Axis



Look at just the FPC Axis

Largest possible value is 6400 pkt. *(32pkt/sec * 200 sec)*



Axis has logarithmic scale

Smallest countable value is one packet

Compare FPC to FPP

Largest possible value is 6400 pkt. *(32pkt/sec * 200 sec)*

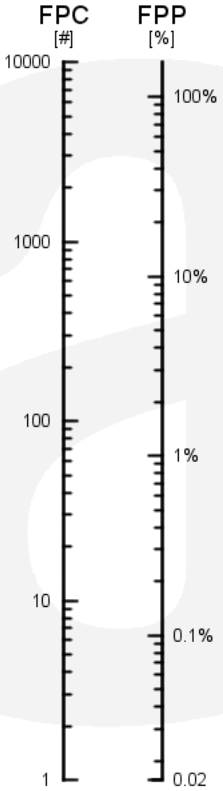
6400 pkt is 100%

64 pkt is 1%

Smallest countable value is one packet

Compare FPC and FPP to FPR

Largest possible value is 6400 pkt. *(32pkt/sec * 200 sec)*

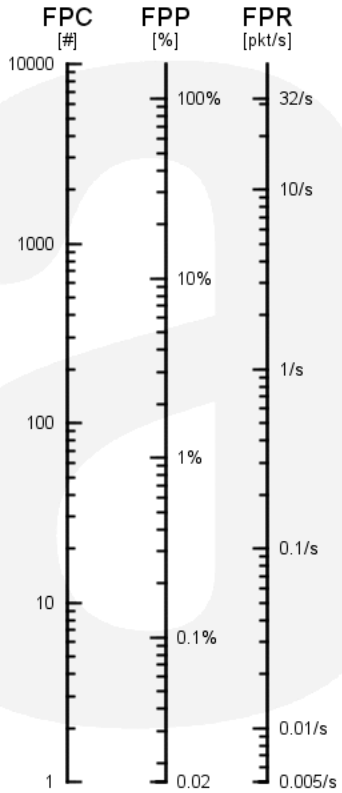


32 pkt/sec is max *(same as 100% FPP)*

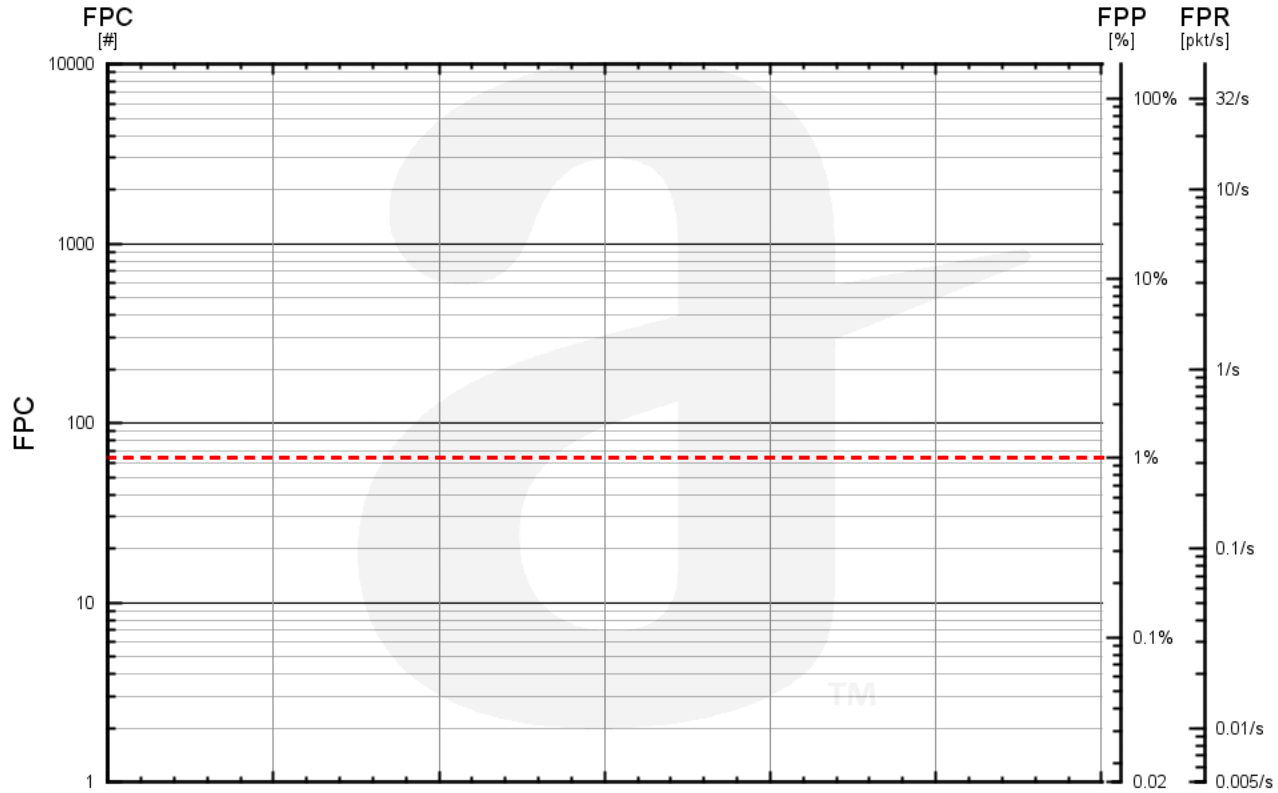
1% is 0.32pkt/sec and is 64 pkt

Smallest countable value is one packet

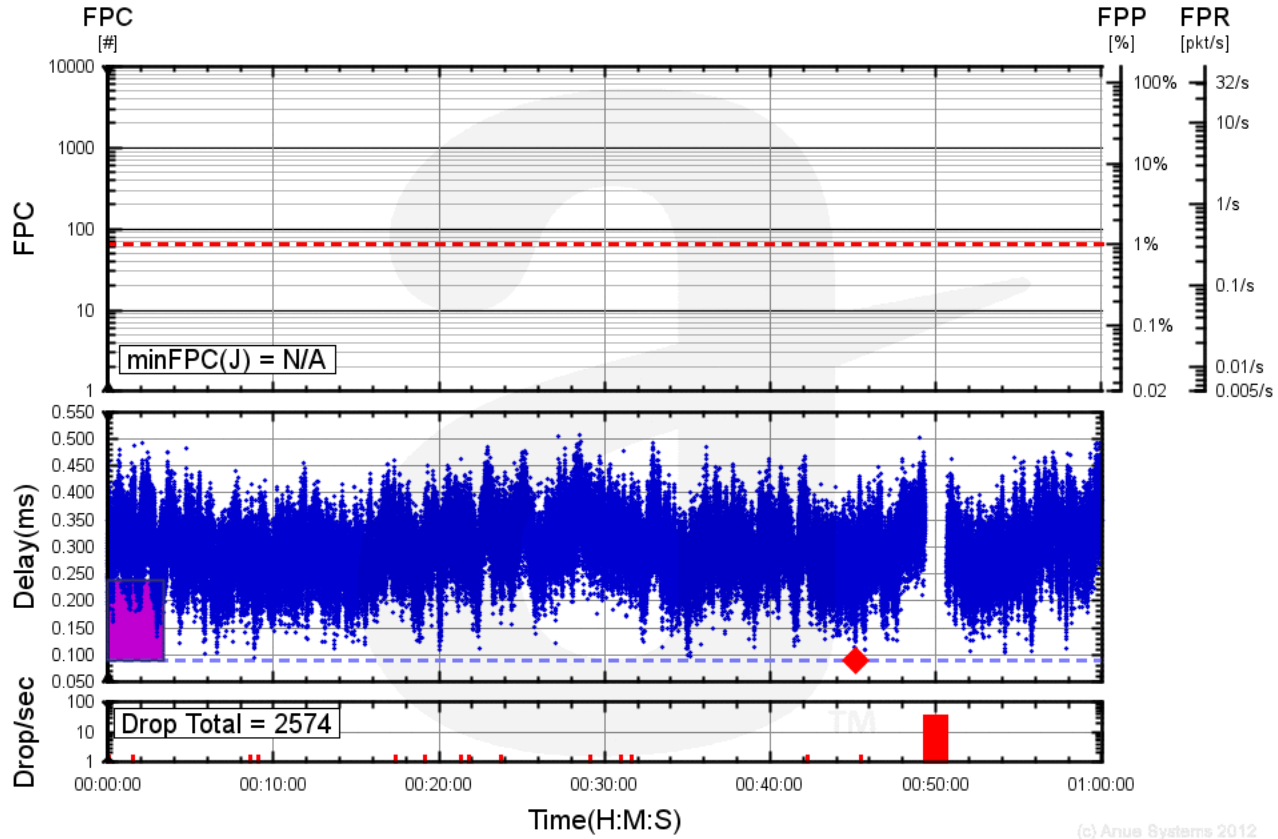
Draw the 1% FPP Limit Line



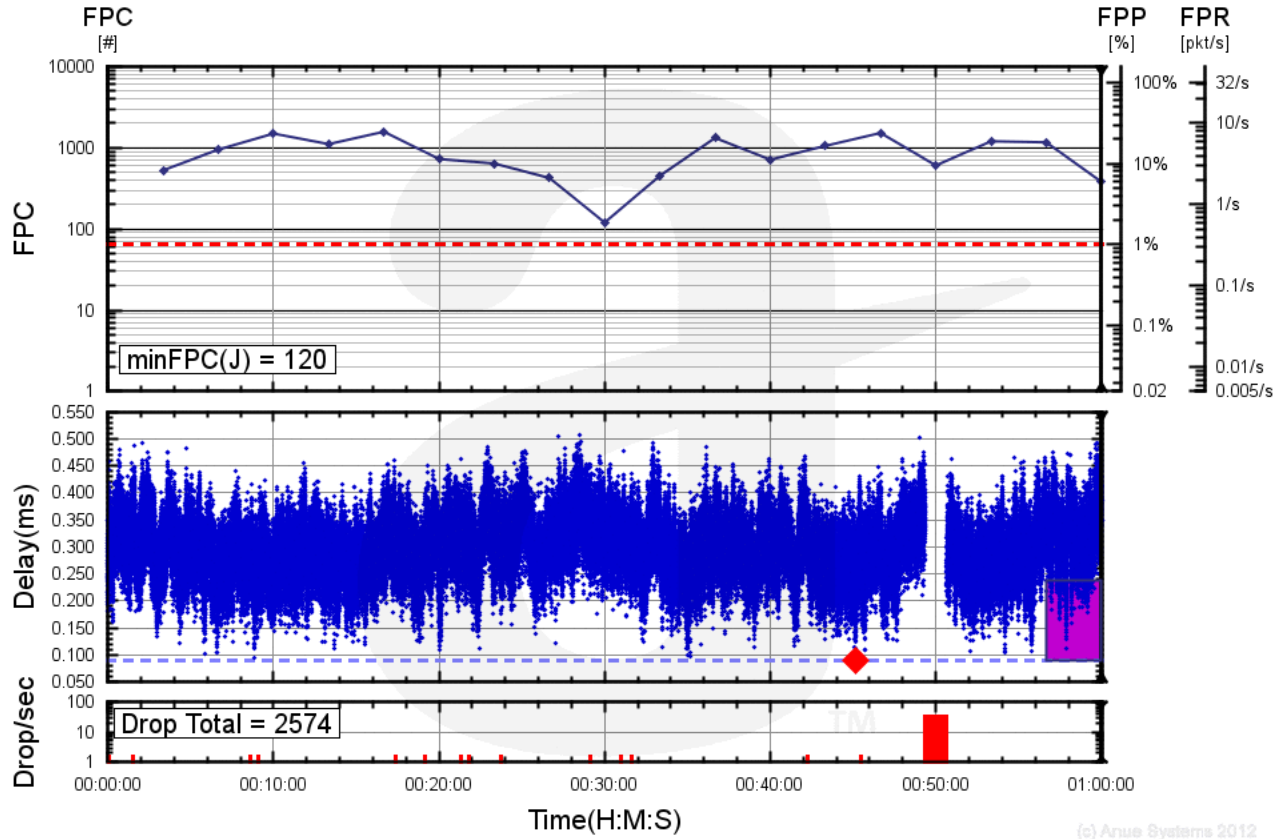
Draw the 1% FPP Limit Line



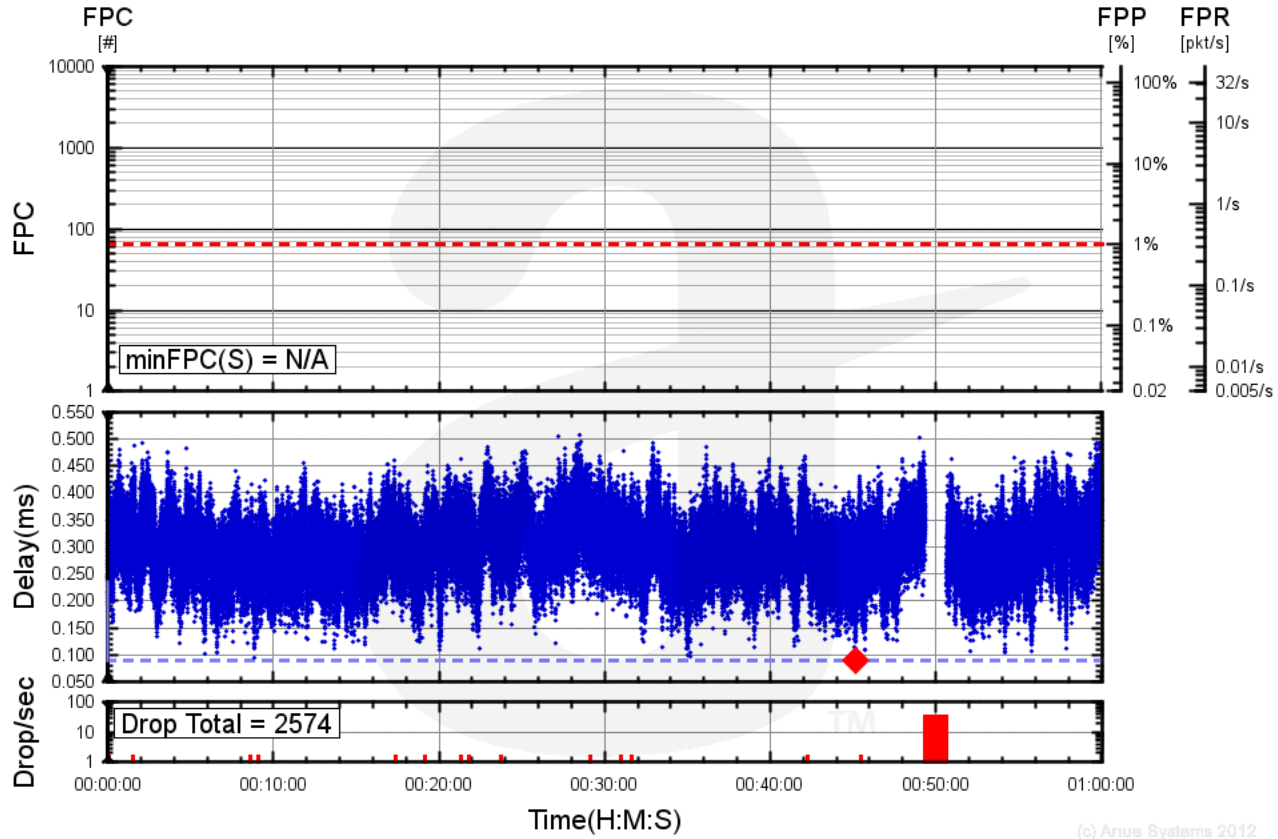
Calculate with Jumping Window



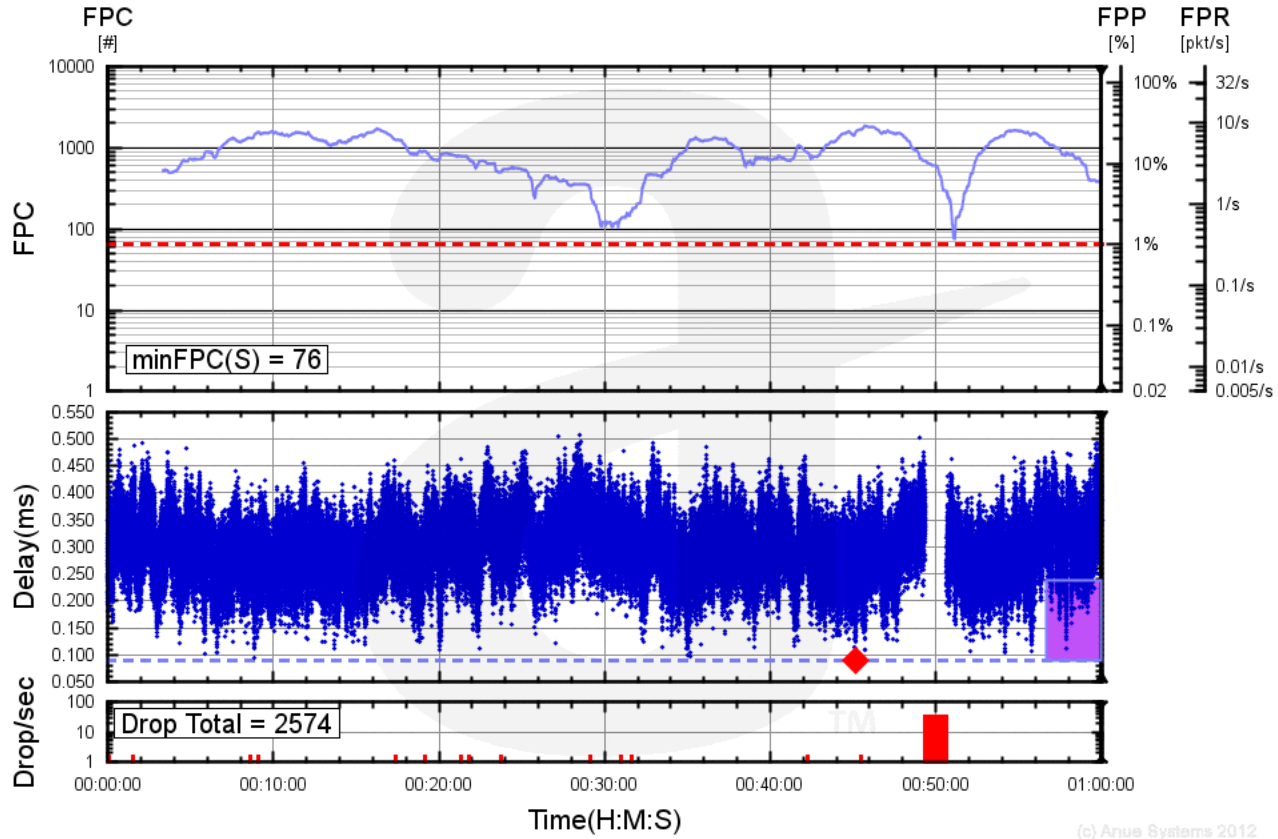
Calculate with Jumping Window



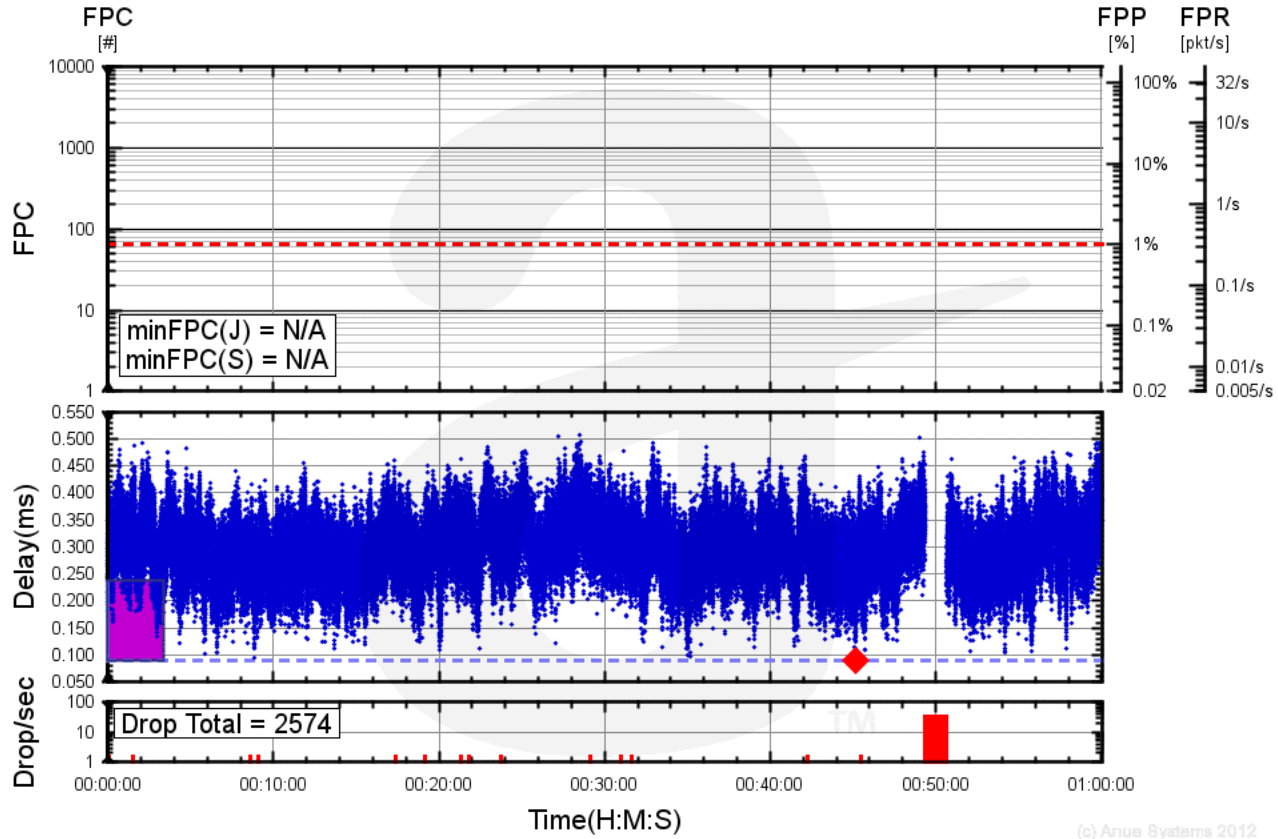
Calculate with Sliding Window



Calculate with Sliding Window



Compare: Jumping/Sliding



Conclusion

- Three new related metrics for “Lucky Packets”
  - FPC (Floor Packet Count) *[How many]*
  - FPP (Floor Packet Percent) *[What percent]*
  - FPR (Floor Packet Rate) *[How often]*

- PDV Limit is FPP ≥ 1%
  - Window width is 200 sec.
  - Window height is 150us

- Two ways to calculate (depending on amount of window overlap)
  - *Jumping windows*
  - *Sliding windows*

Thank You! Questions?

Backup Slides

Formal Mathematical Definition

- $x[i]$ is the measured latency of timing packet i,
  - $0 \le i < N$. (i.e. there are N packets in the data set
- τ_P is the nominal time between timing packets
- δ is the cluster range (vertical window height)
- W represent the window interval (horizontal window width)
  - It can also be expressed as K samples, $K = W/\tau_P$.

Note: It is assumed that the packet rate of the timing flow is nominally constant. The case for a variable rate of packet transmission is for further study.

Mathematical Definition of the Metrics

- Step 1: Find the minimum delay packet

$$d_{\min} = \min_{0 \le i < N} x[i]$$

- Step 2: Calculate the indicator function

$$\phi_F(i,\delta) = \begin{cases} 1; & \text{if } x[i] \le d_{\min} + \delta \\ 0; & \text{otherwise} \end{cases} \qquad \text{for } 0 \le i < N$$

Mathematical Definition of the Metrics (cont.)

- Step 3: Count the packets in the window (FPC)

$$FPC(n,W,\delta) = \sum_{j=n-(K-1)}^{n} \phi_F(j,\delta)$$

- Step 4: Express this result as a packet rate (FPR)

$$FPR(n,W,\delta) = \frac{FPC(n,W,\delta)}{W}$$

- Step 5: Also express as a percentage (FPP):

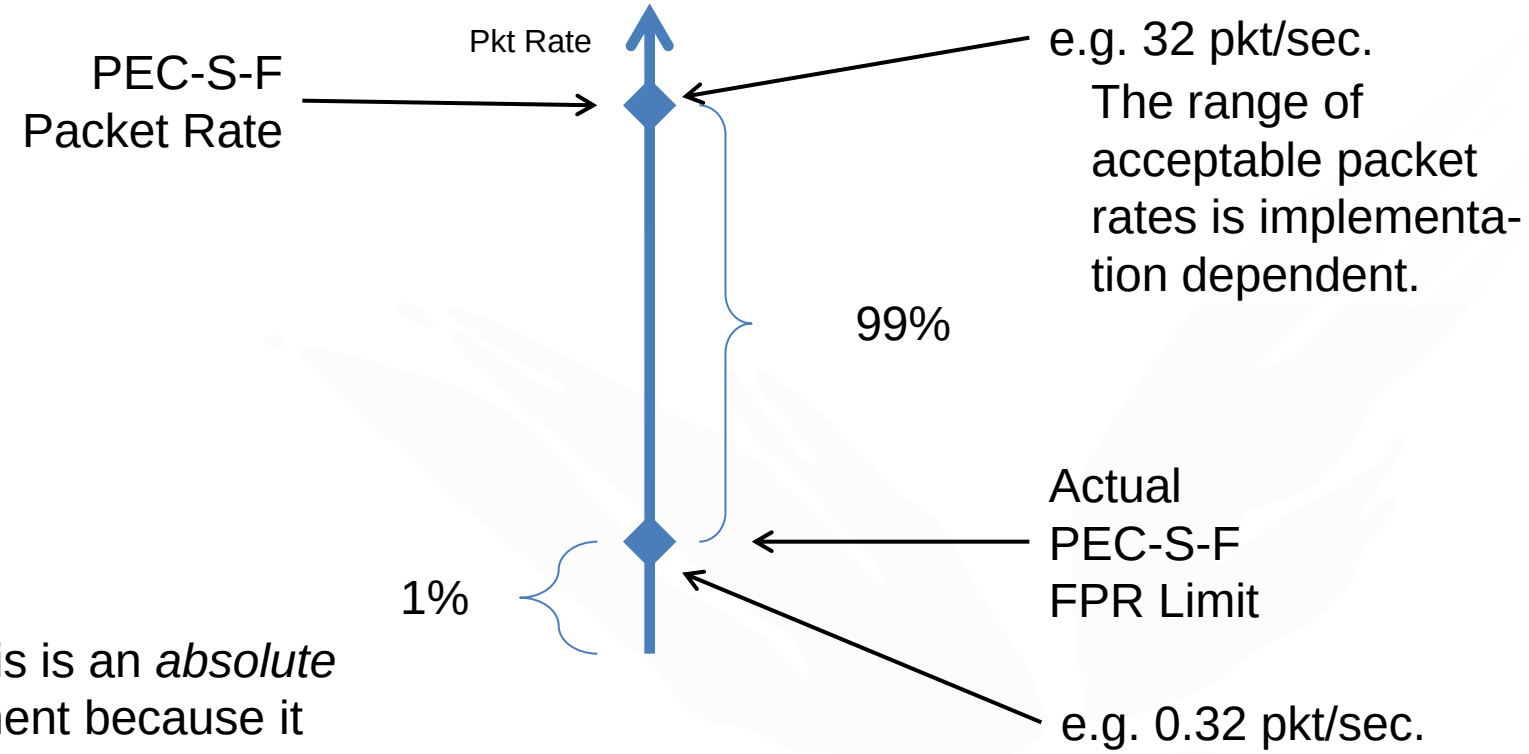
$$FPP(n,W,\delta) = \left(\frac{\tau_P}{W}\right) \times FPC(n,W,\delta) \times 100\,\%$$

Absolute and Relative Metrics

- FPP is a relative metric
  - Calculation does not depend on packet rate
  - Relative means that the metric tells us what has changed between reference planes.
- FPC and FPR are absolute metrics
  - Calculation depends on the rate at which timing packets are sent

- Network performance is best measured as a relative limit
  - FPP compares the network output relative to its input
  - Since the network doesn't create the packets, can't be absolute
- Slave performance is best measured with an absolute limit
  - FPC or FPR
  - But G.8263 refers to G.8261.1 limit at a given packet rate (still absolute)

Slave PDV Tolerance Limit is absolute



NOTE: This is an *absolute* measurement because it depends on timing packet rate.

NOTE: But it allows different PEC-S-F implementations to have different limits.