



Are Existing Performance Metrics Adequate?

Alan Clark
CEO, Telchemy



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Outline

- o IP Performance Metrics
- o Network Characteristics
- o Packet Loss Characteristics and Measurement
- o Jitter Characteristics and Measurement
- o Recommendations



Typical IP Performance Metrics

- Packet Loss
 - Equipment problems, misrouting, buffer overflow, transmission errors
- Jitter
 - Network congestion, contention and queuing delays
- Delay
 - Transmission delays, quasi-stable congestion levels



Core IP Network characteristics

- o Class "A" networks
 - High capacity optical fiber, high throughput routers
 - Very low jitter and packet loss, occasional link failures
- o Class "B" networks
 - T1/E1 trunk connections
 - Significant jitter and loss due to network congestion



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Corporate IP Networks

- Moving to 100BaseT Switched Ethernet but still some 10BaseT and Hubs
- Access links often T1/E1/PRI, sometimes fractional
- Mixture of digital leased line, frame relay and IP VPN
- Small offices and teleworkers may use low bandwidth links



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Teleworkers and Residential IP

- Low-mid bandwidth DSL and Cable Modem connections with little or no QoS control
- Often 10BaseT and IEEE802.11 LAN
- Can experience heavy usage of access links leading to high levels of jitter



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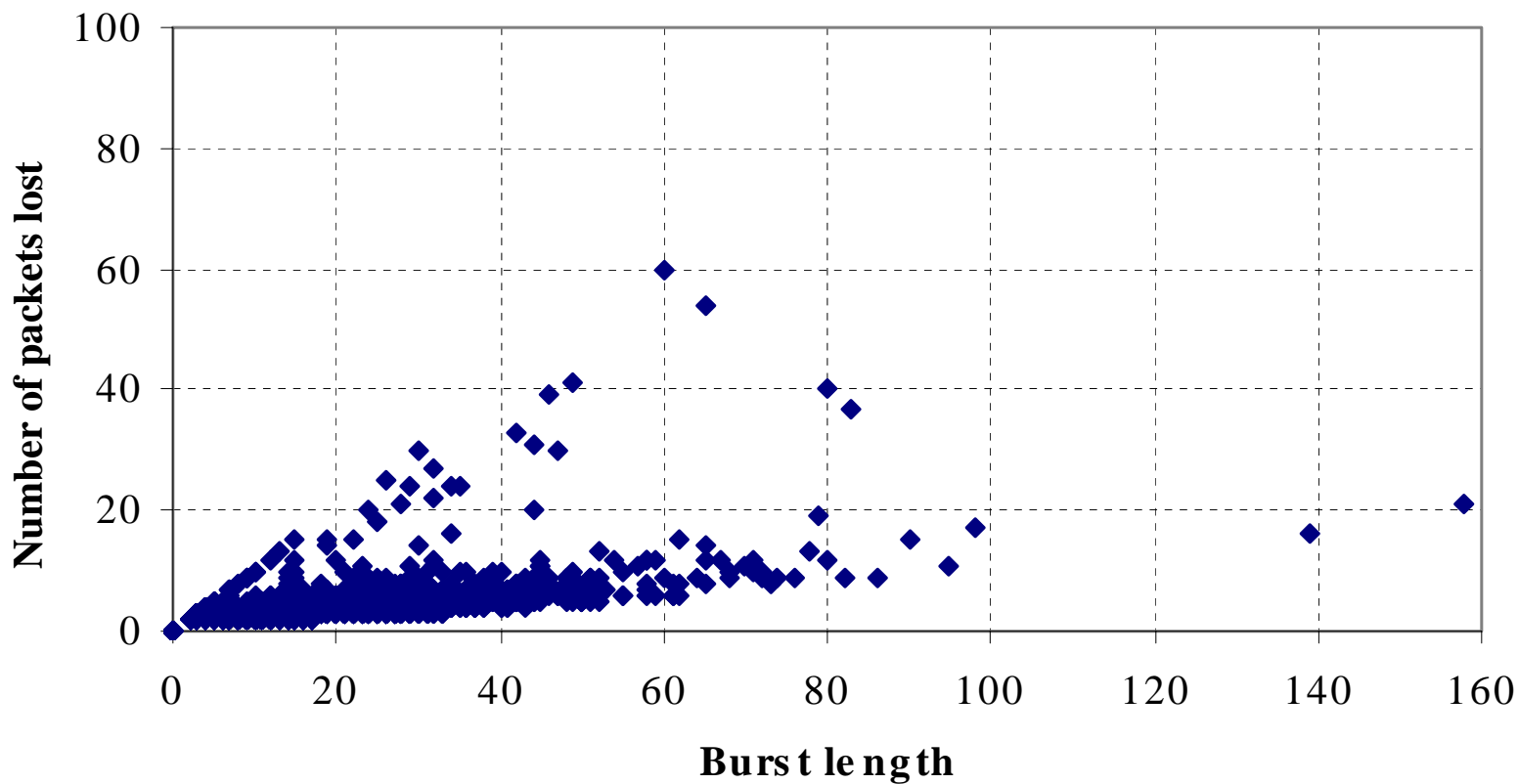
Packet Loss

- Specifically, packets lost within the network or discarded before reaching the network API in the receiving system.

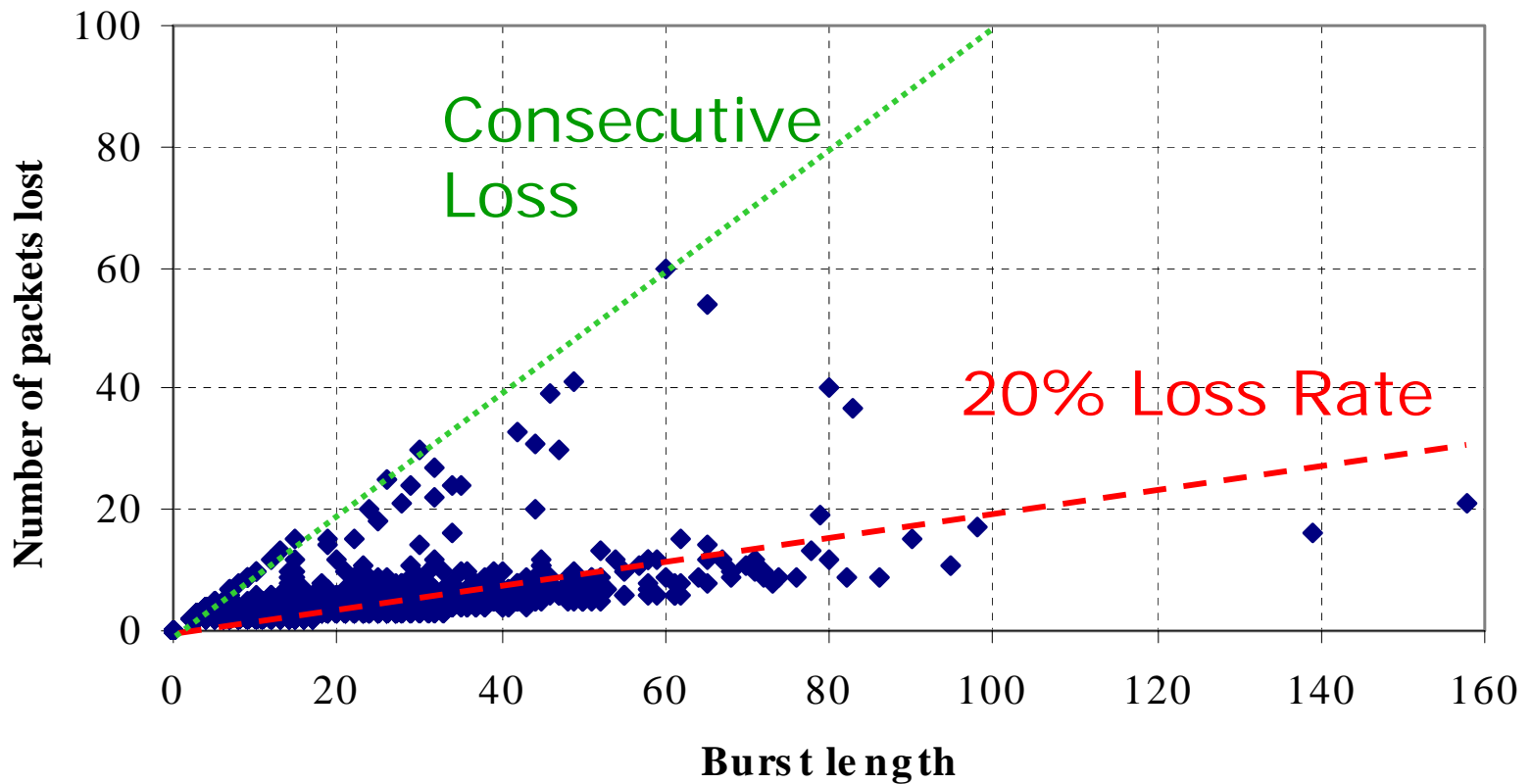


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Example packet loss distribution



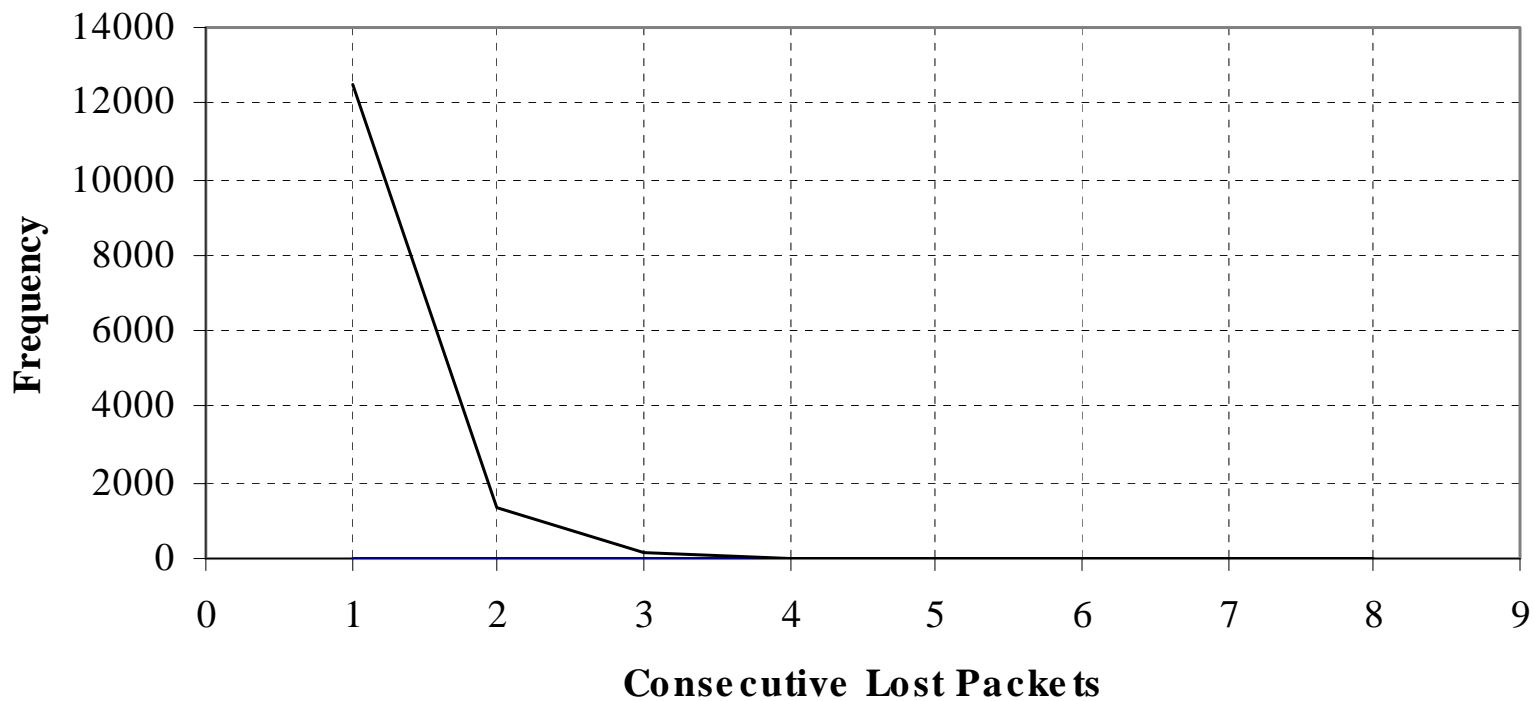
Example packet loss distribution





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Consecutive Loss Distribution



Lessons learned from analyzing real world traces

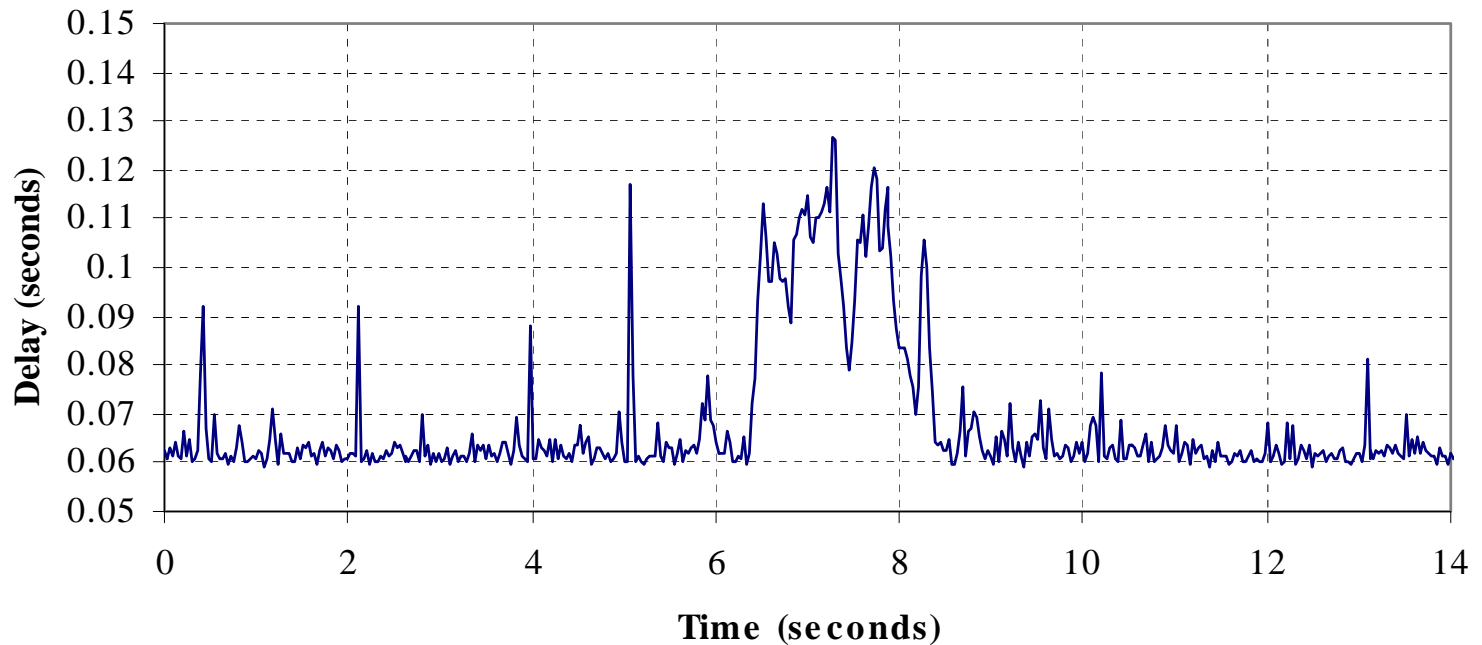
- Packets are usually lost singly - much less frequent to lose 2-3 consecutive packets
- Occasional very long consecutive loss periods due to link failure
- Much more common to see high loss periods - seconds in length - with loss densities of 30%
- Measurement of packet loss needs to be based around a burst model - e.g. Gilbert-Elliott, Markov Model with 3 or more states....



Jitter

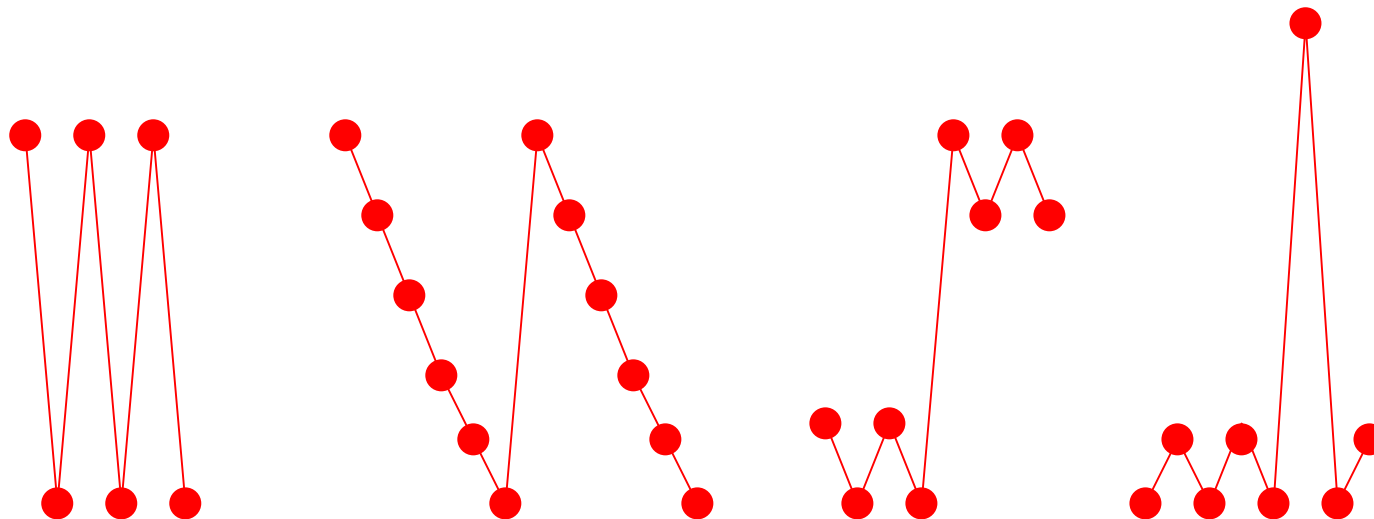
- Specifically - short term variations in transmission delay
- Real time systems often use a jitter buffer to remove jitter - but increases delay and packet loss
- The impact on performance is due to the combined effect of jitter and the jitter buffer

Example time series plot of packet delay





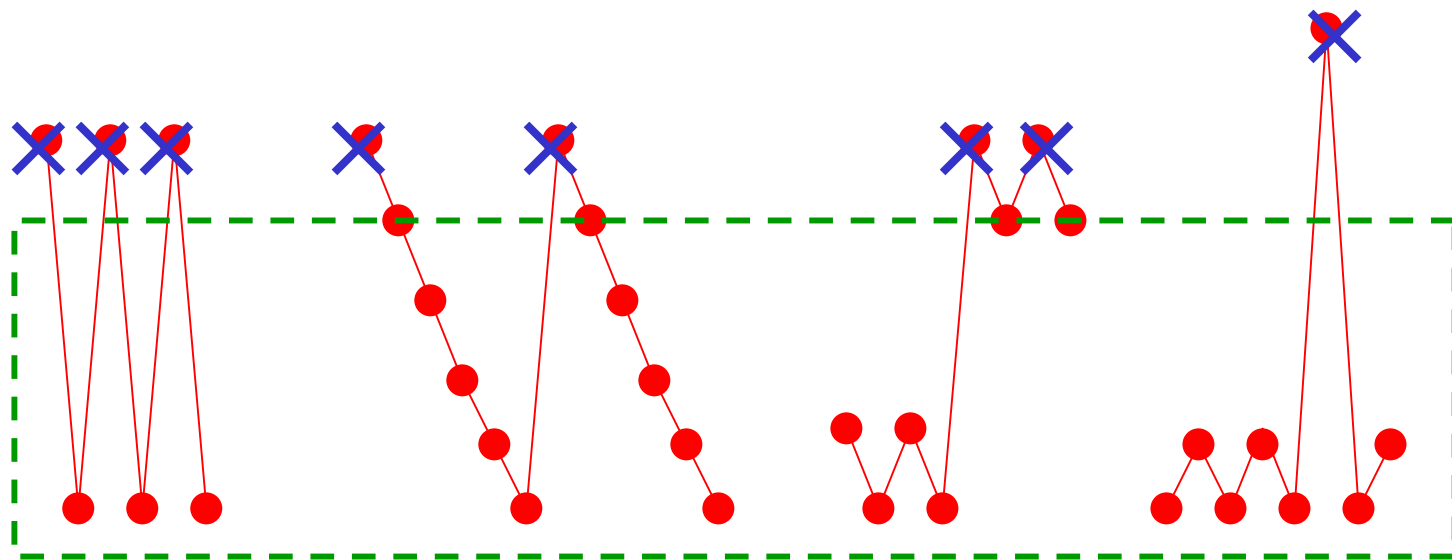
Jitter Characteristics



- What should we measure?
- Packet to packet delay?
 - Absolute delay?
 - Delay with respect to ?



Jitter Characteristics

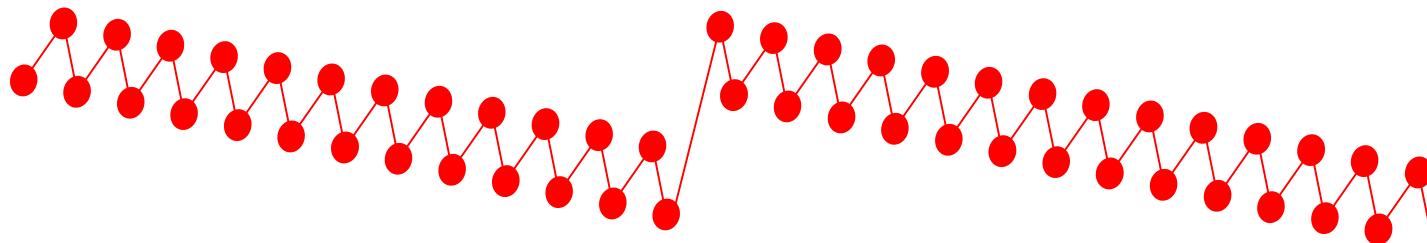


What really counts is what the end system would do as a result of delay variations
Lesson: estimate (or count) which packets would be discarded due to jitter



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Timing Drift



Can occur between end systems and between end and measuring system.

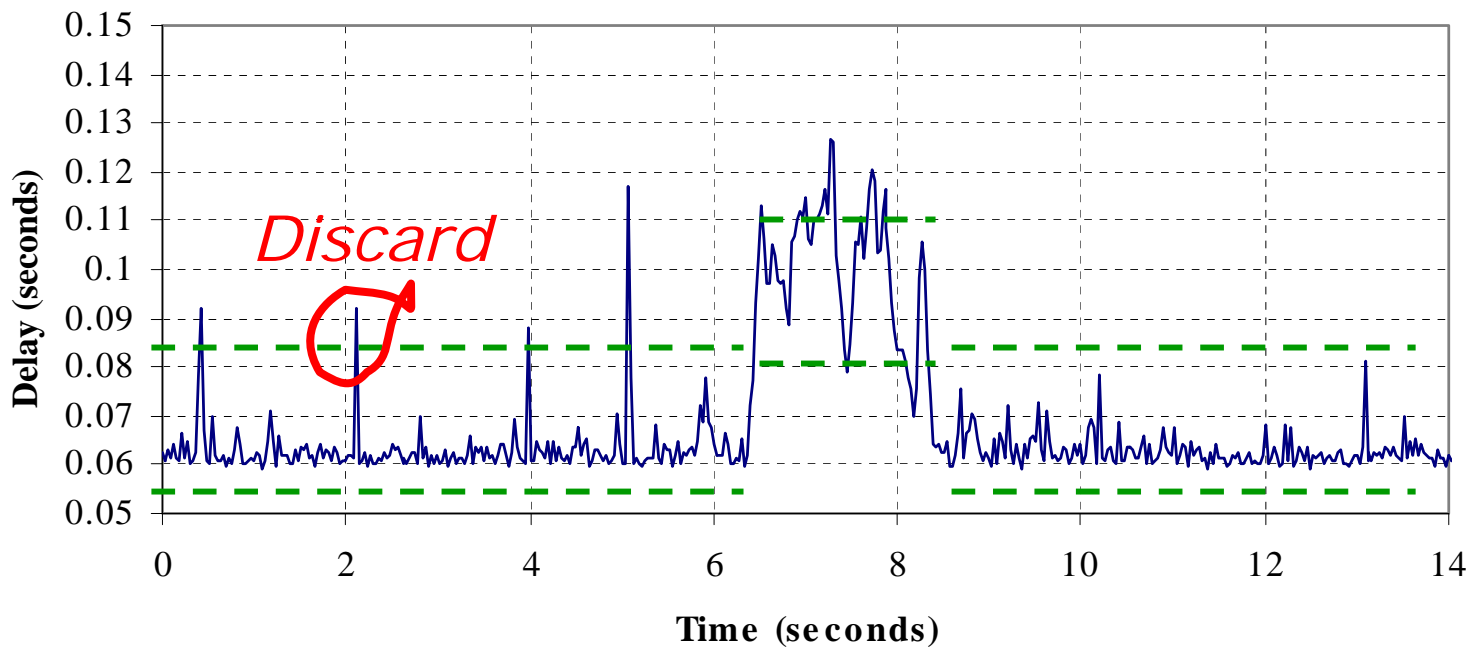
Effect on VoIP is usually small however can cause significant measurement errors for delay and jitter



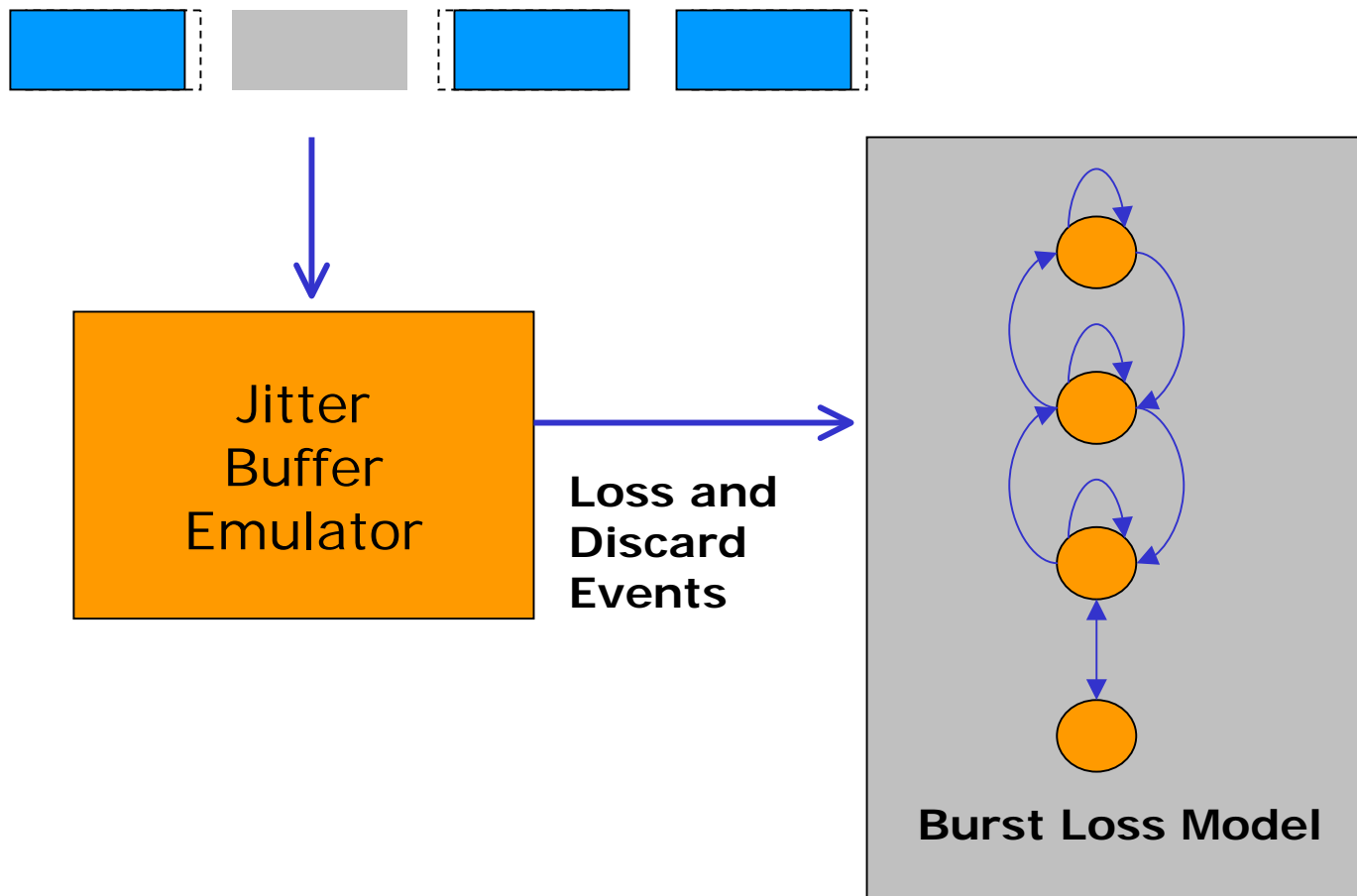
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Estimating the *effects* of jitter

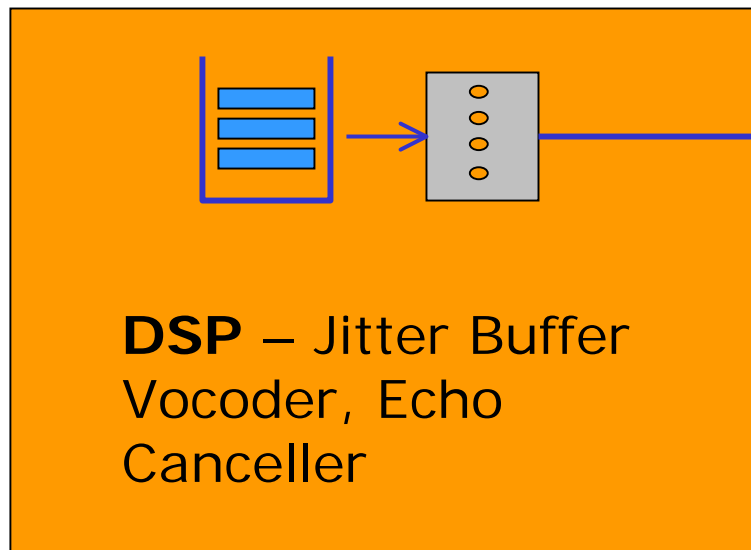
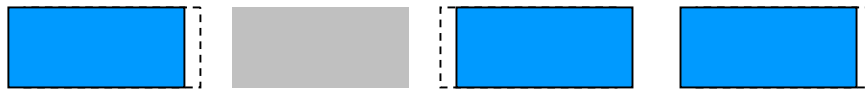
Jitter Buffer *Emulator*



Measuring the combined effects of jitter and loss - midpoint



Measuring the combined effects of jitter and loss - endpoint



Burst Metrics API

- percent lost
- percent discarded
- gap length/density
- burst length/density

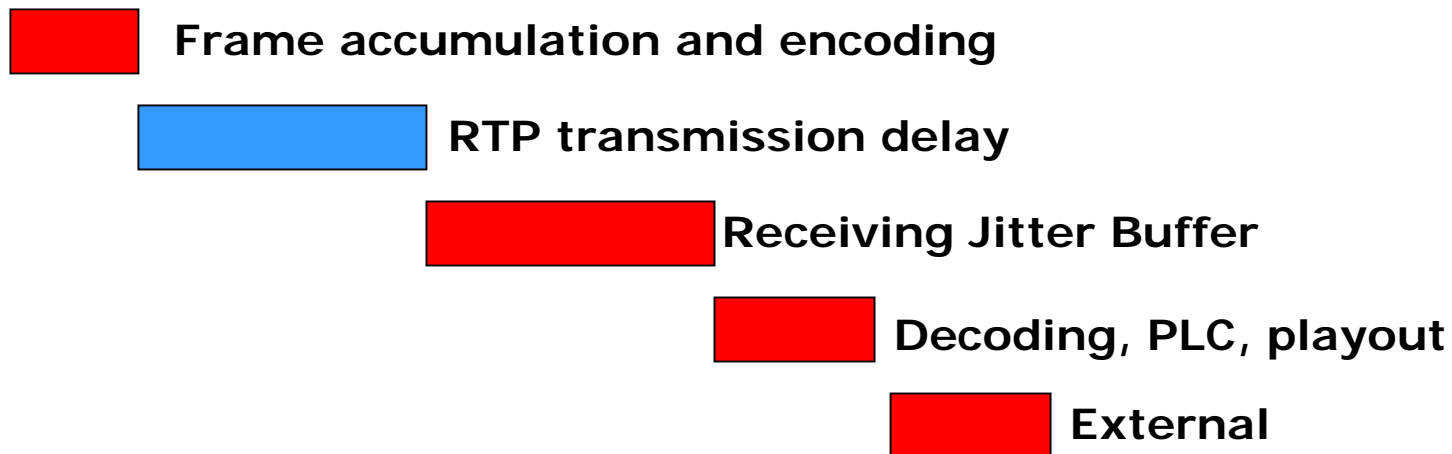


Delay

- Mid-stream systems often rely on RTCP to estimate round trip delay
 - RTCP is often not implemented by end systems
 - RTCP delay is only the VoIP packet path delay and does not include external circuit switched path delays



Sources of delay



End System Delays can be more substantial than transmission delay, particularly with high jitter levels and adaptive jitter buffers



RTCP XR VoIP metrics

- o RTCP XR reports:-
 - Proportion of packets discarded
 - Proportion of packets lost
 - Length and density of bursts (periods of high loss/discard density)
 - Length and density of gaps
 - End system delay
 - Packet path delay
 - and more.....



Recommendations

- Understand that packet path properties are time varying
- Don't measure jitter but do:-
 - Measure packet discards resulting from jitter
 - Count discards as lost packets
- Use a "proper" model for packet loss distribution (e.g. Markov model with 3+ states, Gilbert-Elliott model...)
- Incorporate end system delays - if known
- Use RTCP XR!!!! (*as this implements the above*)