MAC Merge Functionality with 10BASE-T1L
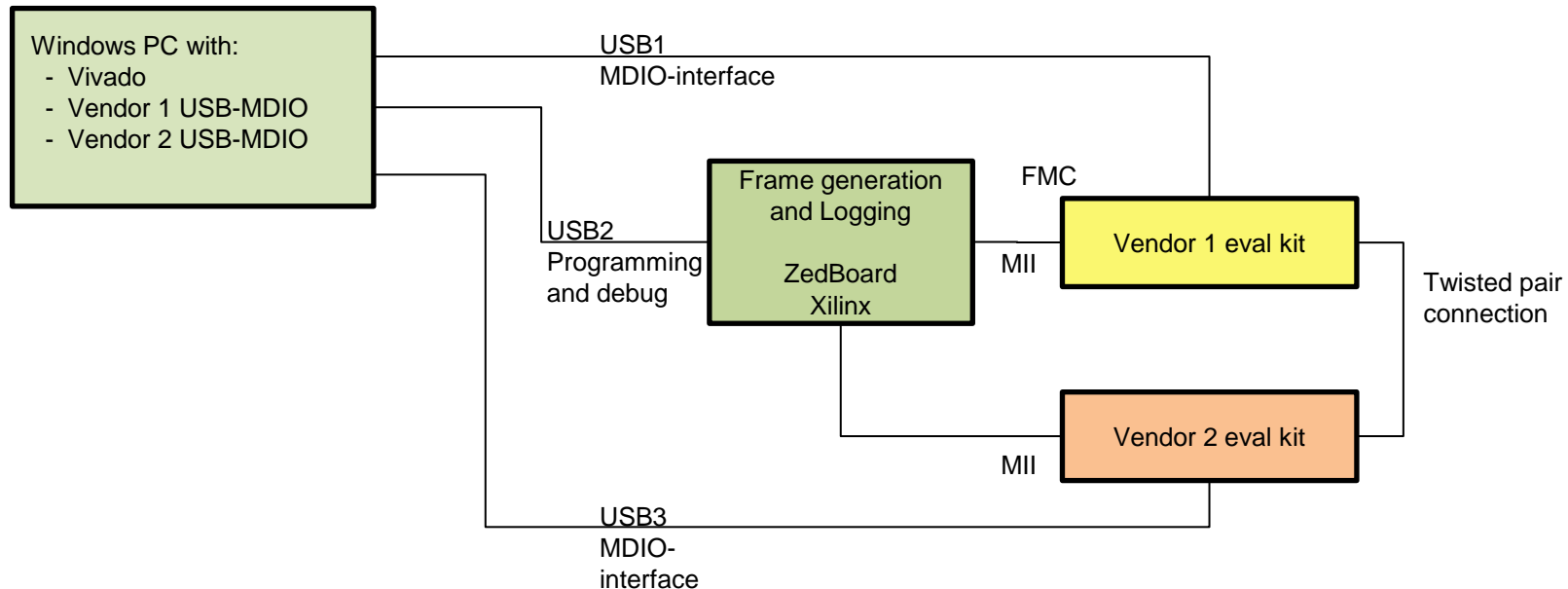
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Content

- **Investigation of available PHY hardware (finished)**

  - Shows that existing 10BASE-T1L PHYs accept Start mPacket Delimiters (SMDs) according to IEEE 802.3-2018 clause 99.3. Frames with different SMDs are accepted for transmit (TX) and receive (RX). A mixed vendor setup was used to perform and document tests with different combination of SMDs.

- **Feasibility Demonstration (reduced latency for high priority traffic - ongoing)**

  - The positive impact of implementing MAC Merge on a 10BASE-T1L link on high priority traffic latencies is demonstrated in a mixed-vendor setup with a fictive application.

Investigation of available PHY hardware - Setup
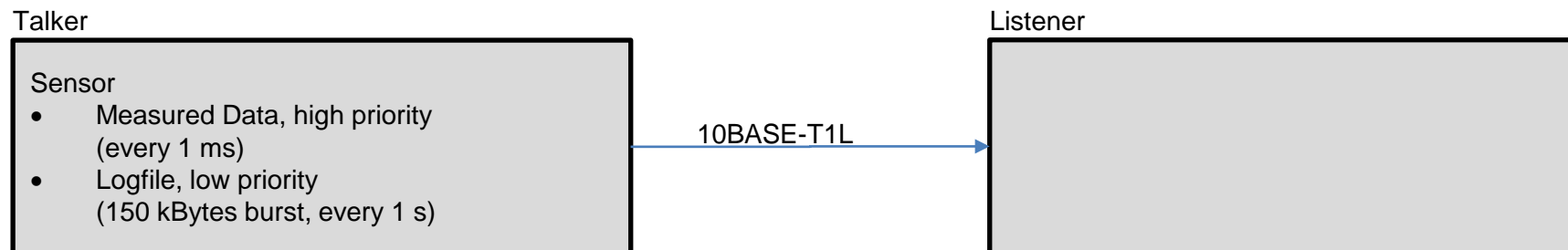
■ **Frame Generator transmits Ethernet Frames over the MIIs**

- SFD and all SMD values as defined in IEEE 802.3 clause 99 are inserted in the sent frames

- FDX operation (simultaneous send and receive)

Investigation of available PHY hardware - Results

■ **SFD and all SMD values successfully sent and received**

● The PHYs of both vendors that have been investigated support transmission of SFD and SMD values over the MII in both directions
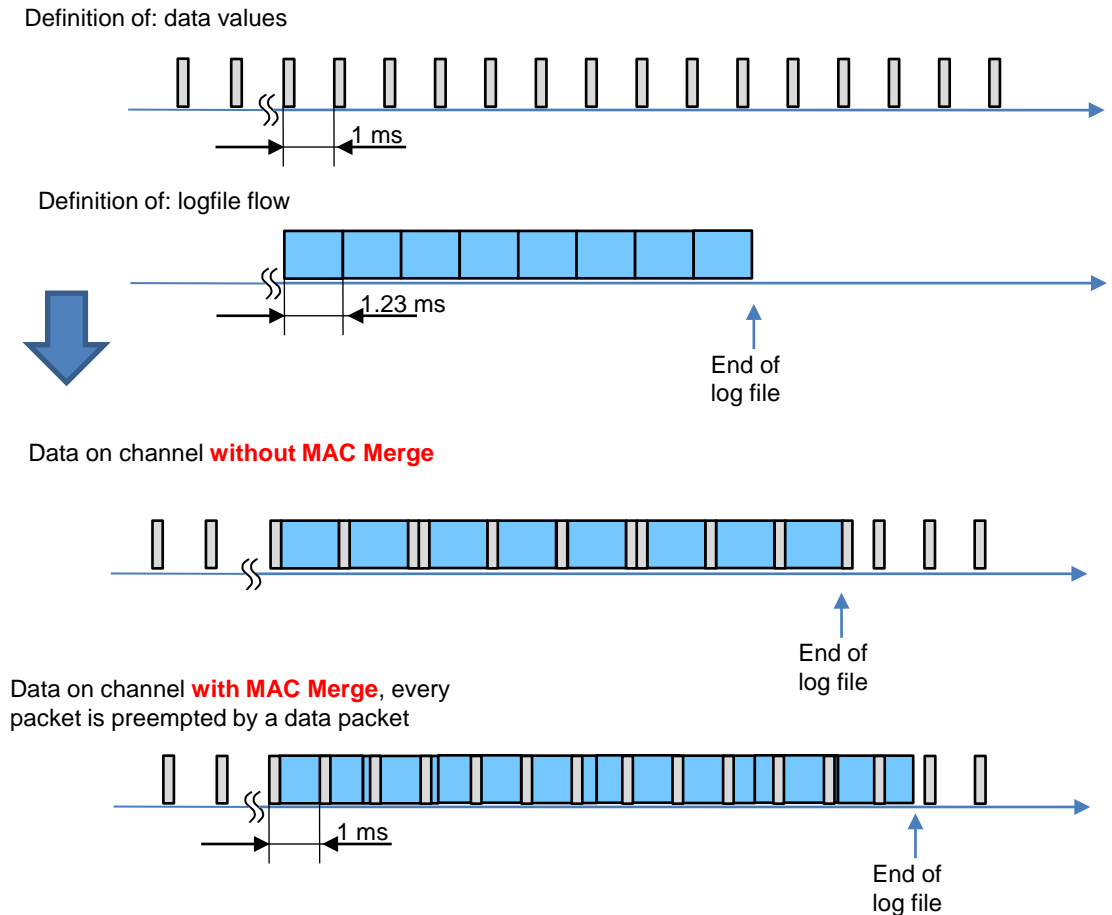
Feasibility Demonstration

- Fictitious application with cyclic traffic and concurrent best effort file transfer

- Show reduction of worst case latency from ~1.3 ms to < 0.2ms

- Focus on 10Base-T1L itself (no traffic shaping and other TSN elements)

Talker

Sensor
- Measured Data, high priority
  (every 1 ms)
- Logfile, low priority
  (150 kBytes burst, every 1 s)
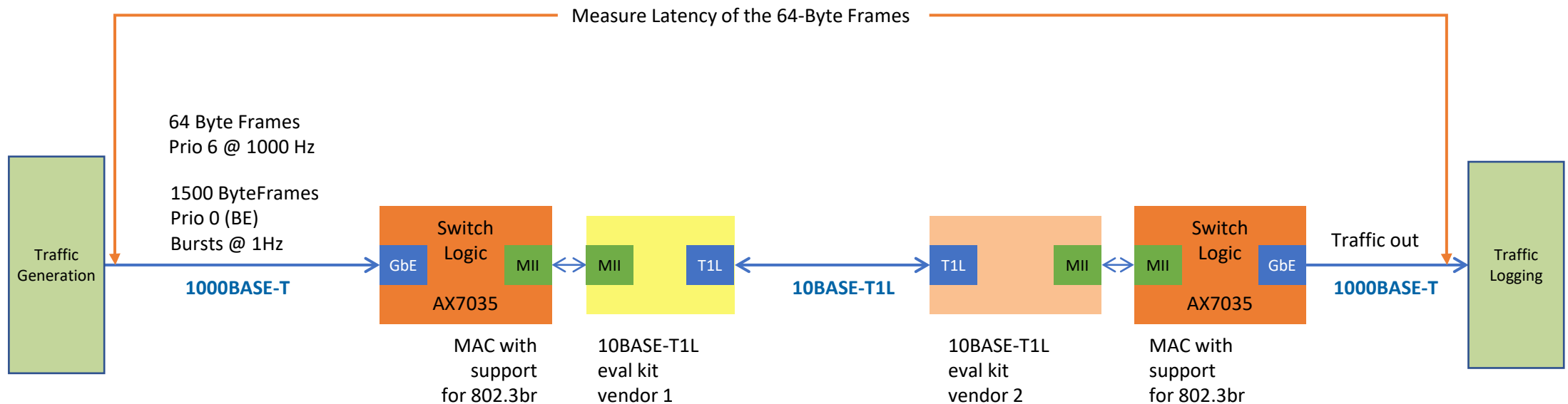
10BASE-T1L →

Listener

Feasibility Demonstration – expected results

- Short frames (RT traffic, prioritized)

- Background traffic, 120ms burst every second (12% of observation time in average)

- The short periodic frames are delayed up to 1.23 ms with disabled MAC Merge (1500 Bytes payload)

- Worst case delay will be reduced to the transmission time of the minimum size fragment (123 Bytes payload)

Definition of: data values

1 ms

Definition of: logfile flow

1.23 ms

End of
log file

Data on channel **without MAC Merge**

End of
log file

Data on channel **with MAC Merge**, every
packet is preempted by a data packet

1 ms

End of
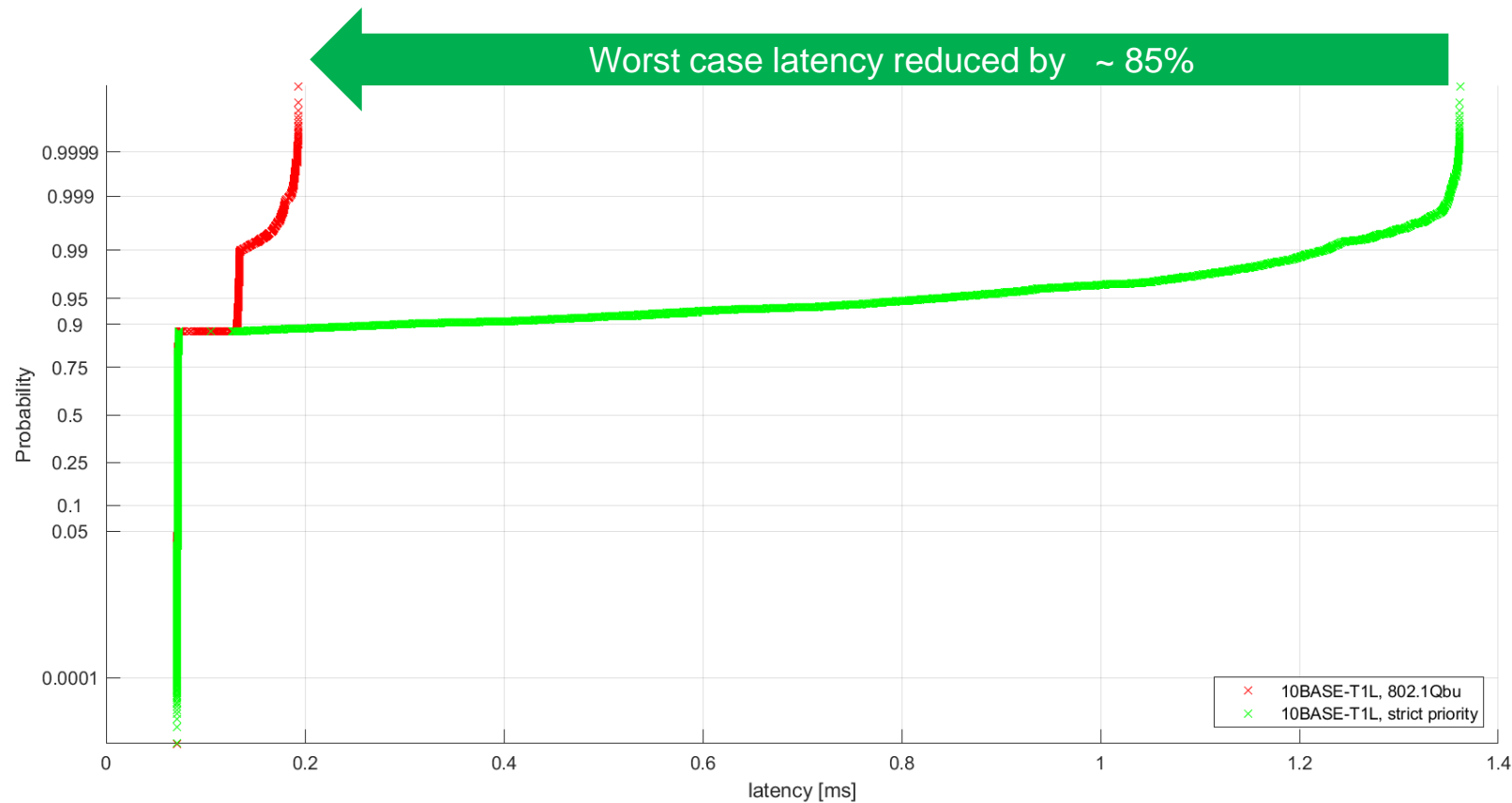log file

Feasibility Demonstration - Setup

- IEEE 802.1AS based time stamping at traffic generation and logging nodes

- Link delays on the 1000BASE-T links and PHYs are neglectable compared to latency on the 10BASE-T1L link for the purpose of this demonstration

Measure Latency of the 64-Byte Frames

64 Byte Frames
Prio 6 @ 1000 Hz

1500 ByteFrames
Prio 0 (BE)
Bursts @ 1Hz

Traffic Generation

1000BASE-T

Switch Logic — GbE — MII
AX7035
MAC with support for 802.3br

MII — T1L
10BASE-T1L eval kit vendor 1

10BASE-T1L

T1L — MII
10BASE-T1L eval kit vendor 2

MII — Switch Logic — GbE
AX7035
MAC with support for 802.3br

Traffic out
1000BASE-T

Traffic Logging

Feasibility Demonstration – First Results (vendor 1)

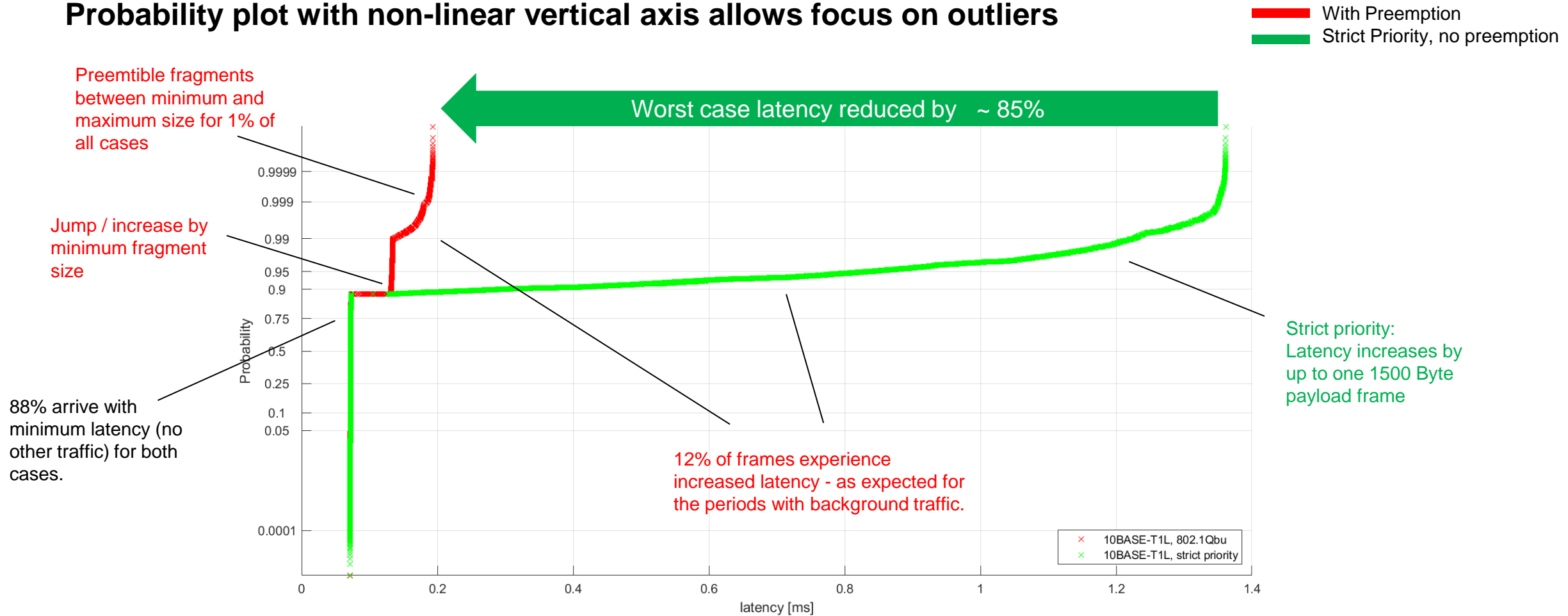**Probability plot with non-linear vertical axis allows focus on outliers**

Results are for vendor 1 only. Mixed-vendor measurements will follow.

Feasibility Demonstration – First Results with comments

Probability plot with non-linear vertical axis allows focus on outliers

Preemtible fragments between minimum and maximum size for 1% of all cases

Jump / increase by minimum fragment size

88% arrive with minimum latency (no other traffic) for both cases.

Worst case latency reduced by ~ 85%

Strict priority: Latency increases by up to one 1500 Byte payload frame

12% of frames experience increased latency - as expected for the periods with background traffic.

With Preemption
Strict Priority, no preemption

× 10BASE-T1L, 802.1Qbu
× 10BASE-T1L, strict priority

Results are for vendor 1 only. Mixed-vendor measurements will follow.