PACKET/FRAME LOSS CONSIDERATIONS FOR CPRI OVER ETHERNET

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This presentation updates
http://www.ieee802.org/1/files/public/docs2015/cm-varga-CPRI-
packetloss-considerations-1215-v01.pdf
TRANSPORT ERRORS
PACKET NETWORKS

› CPRI flow is a TDM bit stream
  – Errors on the CPRI link are defined as Bit Error Ratio (BER)
  – Expected impact on systems connected via CPRI link as BER increase
    › (i) first there are no impacts on the systems  (BER tolerated)
    › (ii) there will be impact on UE throughput  (BER is disturbing)
    › (iii) the CPRI link resets  (BER severely impacts the systems)
      Note: UE (User Equipment)

› Several error parameters are defined in different SDOs
  – Focus in this contribution on BER (Bit Error Ratio) and FLR (Frame Loss Ratio)
    Note: It is FLR (Frame Loss Ratio) for a switched Ethernet transport network. Packet Loss Ratio (PLR) is a generic term for packet networks. CPRI also has a (TDM-)frame structure, which is referred to as “CPRI frame”.

› Optical transport (dark fiber or lambda):
  – Errors:    bit errors
  – Characterized by BER

› Switched Ethernet transport
  – Errors:
    › loss of frames    caused by congestion, failures, etc.
      note: late delivery also causes loss for CPRI
    › out-of-order delivery    caused by multiple paths, rerouting, etc.;
      note: can be also treated as loss if no re-ordering function at receiver
  – Characterized by FLR
TRANSPORT KPI
AVAILABILITY

› Availability
  – ITU-T Y.1563: "The Ethernet service availability definition is based on a model which uses two states corresponding to the ability or inability of the network to sustain the service in the available state."
  – For network services
    › Availability is the percentage of total scheduled service time that is categorized as available for the service
    › Availability is often defined by “nines”, e.g. five-nines (99.999%) etc.

› Availability and FLR/Ber to be handled separately
  – If the service is not available, then the FLR/Ber is 100% → not meaningful to characterize the service quality
  – FLR/Ber is meaningful only when the service is available
Building Blocks
Functional End2End (e.g. RE → REC)

CPRI
- native format

Packetized CPRI
- ideal flow
- no PDV
- CBR at CPRI rate

Packetizer

Packetized CPRI
- bursty flow
- delay
- PDV
- loss
- re-order

Packetized CPRI
- impacted by statistical multiplexing

Packetized CPRI (ideal flow)

Packetized CPRI (re-shaped flow)

Packetized CPRI (bursty flow)

BER

FLR

CPRI (User, C&M, Sync)

SW-1

SW-2

SW-in

SW-out

Re-shaper

De-packetizer

CPRI (User, C&M, Sync)
Frame loss caused by

- Congestion
- Transmission errors

Congestion related analysis

Assumption
- Well-designed TSN network for CPRI transport
  - Frames carrying CPRI data (with IQ samples) have
    - (i) high priority during transport and there is
    - (ii) no over-dimensioning used

Consequences
- CPRI traffic never face congestion during transport
- TSN tools are used for CPRI traffic to make their transport as fast as possible through the network so no late arrival should occur
- As a result frames carrying CPRI data (with IQ samples) are expected to be never dropped due to congestion or late arrival.
- Zero FLR due to congestion in a well-designed TSN network
› Frame loss caused by
  – Congestion
  – Transmission errors

Transmission errors related analysis
› Frame loss due to transmission errors may happen because of:
  – (i) bit errors
  – (ii) network failures

› Bit errors:
  – Ethernet frames are dropped if FCS fails.
  – How many Ethernet frames are affected for a given BER:
    › Theoretical FLR can be calculated from BER of a transport link.
    › For the CPRI bit-stream, Eth-frame drop will cause an increased bit error rate and bursty errors, which also depends on the frame size (smaller frame size is preferred)

Note: Seamless redundancy functions are envisioned to deal with impact of bit errors if needed.

<table>
<thead>
<tr>
<th>BER&lt;sub&gt;Link&lt;/sub&gt;</th>
<th>Frame size</th>
<th>FLR&lt;sub&gt;Link&lt;/sub&gt;</th>
<th>BER&lt;sub&gt;CPRI&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-12}$</td>
<td>200 bytes</td>
<td>$1.6 \times 10^{-9}$</td>
<td>$1.6 \times 10^{-9}$</td>
</tr>
<tr>
<td>$10^{-12}$</td>
<td>1000 bytes</td>
<td>$8 \times 10^{-9}$</td>
<td>$8 \times 10^{-9}$</td>
</tr>
</tbody>
</table>
Frame loss caused by
- Congestion
  - Transmission errors

Transmission errors related analysis

Network failures:
- These are somewhat more complicated.
- Link or node failures cause frame loss.
- Depending on the time period of the network failure, service might be assumed to be broken (non-available)
  - Such periods are excluded from FLR measurement.
- When the network is redundant and a new route can be found between the RE and the REC, then Ethernet frame delivery may not be ensured or out-of-order delivery might be expected during the rerouting.
  - Such a period may last for several 100s of msec in an Ethernet network (even in best case).
  - That would affect significantly the CPRI link (e.g. reset the CPRI communication).
  - So during the CPRI link reset scenario FLR may not be meaningful again.

- Note: Seamless redundancy functions and Pinned-down paths are envisioned to deal with impact of network failures.
Frame loss caused by
- Congestion: ZERO
- Transmission errors (bit error): Can be calculated from BER (if no seamless redundancy)
- Transmission errors (failure): N/A

Conclusion
- CPRI over Ethernet requires a well-designed TSN network
- FLR should be defined for "established and working" CPRI connections. Non-working time periods excluded from FLR measurement – they are part of availability considerations.
- FLR can be calculated from BER and CPRI over Ethernet frame size in no seamless redundancy
- Frame loss results in a burst of bit errors for the CPRI flow as lost samples are replaced by zeros