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PACKET LOSS CONSIDERATIONS FOR CPRI OVER ETHERNET

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Balázs Varga (A); balazs.a.varga@ericsson.com
János Farkas; janos.farkas@ericsson.com

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 PLR (Packet Loss Ratio)

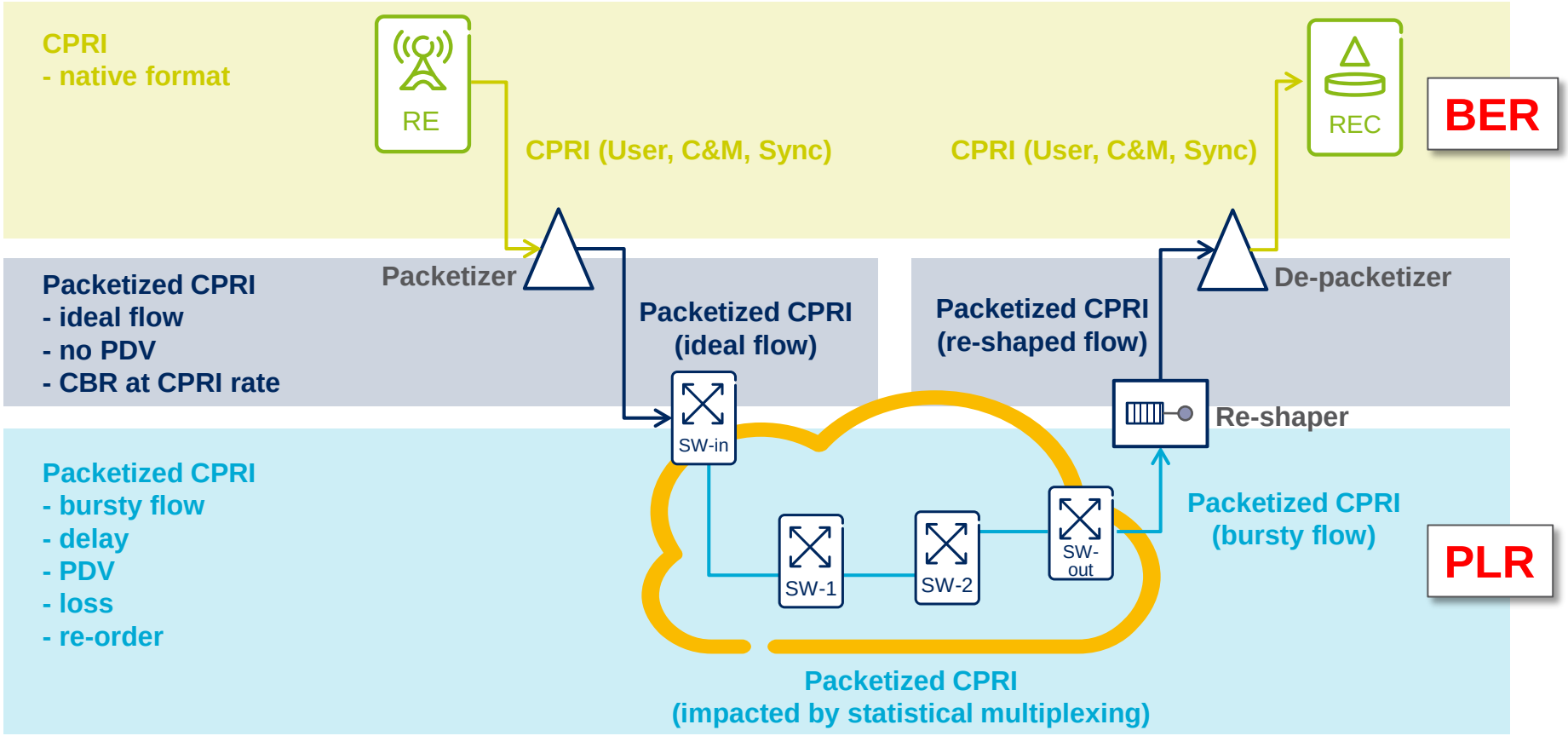
  Note: It would be FLR (Frame Loss Ratio) for Ethernet transport, however, CPRI also has a (TDM-)frame structure, therefore in this slides PLR is used for Ethernet transport in order to be unambiguous
- Optical transport (dark fiber or lambda):
  - Errors: bit errors
  - Characterized by BER
- Packetized transport
  - Errors:
    - loss of packets caused by congestion, failures, etc.
      note: late delivery also causes packet loss
    - 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 PLR

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 PLR/BER to be handled separately
  - If the service is not available, then the PLR/BER is 100% → not meaningful to characterize the service quality
  - PLR/BER is meaningful only when the service is available

BUILDING BLOCKS
FUNCTIONAL END2END (E.G. RE→REC)



PACKET LOSS CALCULATION
CONGESTION

- Packet loss caused by
  - Congestion
  - Transmission errors

Congestion related analysis

- Assumption
  - Well-designed TSN network for CPRI transport
    - CPRI packets (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 CPRI packets (with IQ samples) are expected to be never dropped due to congestion or late arrival.
  - Zero PLR due to congestion in a well-designed TSN network

PACKET LOSS CALCULATION
TRANSMISSION ERRORS

- Packet loss caused by
  - Congestion
  - Transmission errors

Transmission errors related analysis

- Packet 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 PLR 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 packet size (smaller packet size is prefferred)

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

Per hop values

BER_{Link}	Packet size	PLR_{Link}	BER_{CPRI}
10^{-12}	200 bytes	1.6×10^{-9}	1.6×10^{-9}
10^{-12}	1000 bytes	8×10^{-9}	8×10^{-9}

PACKET LOSS CALCULATION
TRANSMISSION ERRORS – CONT'D

- Packet loss caused by
  - Congestion
  - Transmission errors

Transmission errors related analysis

- Network failures:
  - These are somewhat more complicated.
  - Link or node failures cause packet loss.
  - Depending on the time period of the network failure, service might be assumed to be broken (non-available)
    - Such periods are excluded from PLR 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 PLR may not be meaningful again.
  - Note: Seamless redundancy functions and Pinned-down paths are envisioned to deal with impact of network failures.

SUMMARY
ACHIEVABLE PLR

- Packet 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
  - PLR should be defined for ”established and working” CPRI connections.
    Non-working time periods excluded from PLR measurement – they are part of availability considerations.
  - PLR can be calculated from BER and CPRI over Ethernet packet size in no seamless redundancy
  - Packet loss results in a burst of bit errors for the CPRI flow as lost samples are replaced by zeros

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