3GPP TSG-RAN WG2 Meeting #48bis
10th– 14th October 2005
Cannes, France

R2-052442

Single Layer versus Dual Layer (H)-ARQ

Agenda item: 6.3.4

Source: Nokia

Document for: Discussion

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Introduction

- This document presents Nokia's viewpoint on the discussion related to single-layer versus dual-layer (H)-ARQ.
- Our assumption is that we need to support two types of modes at radio link layer:
  - **Non-acknowledged mode (N-AM):** Target applications for this mode will primarily be error tolerant real-time services such as e.g. VoIP. The offered packet error rate (after L1 H-ARQ process) should be less than 10^{-2}. In this mode, applications do not experience any delay from L2 ARQ process.
  - **Acknowledged mode (AM):** A very low packet error rate within the E-UTRAN must be guaranteed. Our assumption is that a packet error rate down to 10^{-6} must be supported (according to TR 23.107). AM will only experience L2 retransmissions when L1 H-ARQ fails. L2 retransmissions will be much faster than RLC retransmission in 3GPP release 5/6!
- We will investigate how the error probabilities of the L1 control channel functionality (in both link directions – resource allocation, data reception and ACK/NACK reports) impact the overall performance of the radio link layer.
- In the following we consider both dual layer and single layer H-ARQ and discuss some essential advantages and disadvantages.

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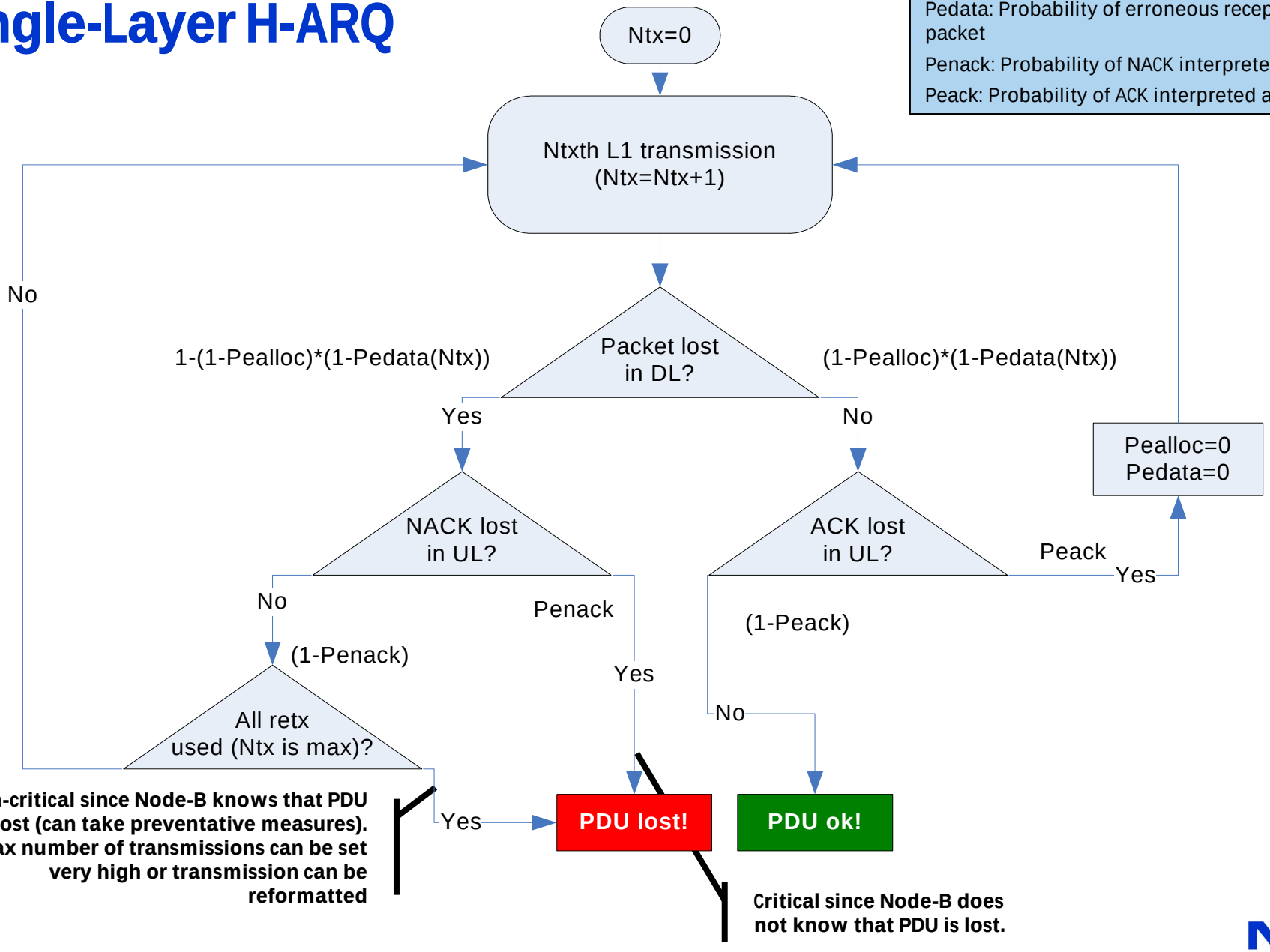
Single-Layer H-ARQ

Pealloc: Probability of UE missing a resource allocation

Pedata: Probability of erroneous reception of a data packet

Penack: Probability of NACK interpreted as ACK

Peack: Probability of ACK interpreted as NACK



Non-critical since Node-B knows that PDU is lost (can take preventative measures). Max number of transmissions can be set very high or transmission can be reformatted

Critical since Node-B does not know that PDU is lost.

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Single-Layer H-ARQ

- From Rel5/Rel6 HSDPA it has proven very difficult to guarantee a NACK->ACK error less than 10^{-3} although 10^{-4} was the original target.
- Assuming a NACK->ACK error probability of 10^{-3} and a required residual BLER of less than 10^{-6}, we can derive the following:
  - The 1st transmission BLER needs to be significantly less than $10^{-6}/10^{-3}$; e.g. 10^{-3}.
  - A requirement of 10^{-3} only covers the direct path towards a lost PDU!
- The 1st transmission BLER consists of two components which must both be true:
  - The physical channel allocation needs be correctly decoded at UE (error probability, Pealloc).
  - The data vector needs be correctly decoded at UE (error probability, Pedata).
  - E.g. (1-Pealloc)*(1-Pedata) > (1-10^{-3}).
- Operating the allocation control signaling as well as the data channel below 10^{-3} has a significant cost at the physical layer.

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Dual-Layer H-ARQ

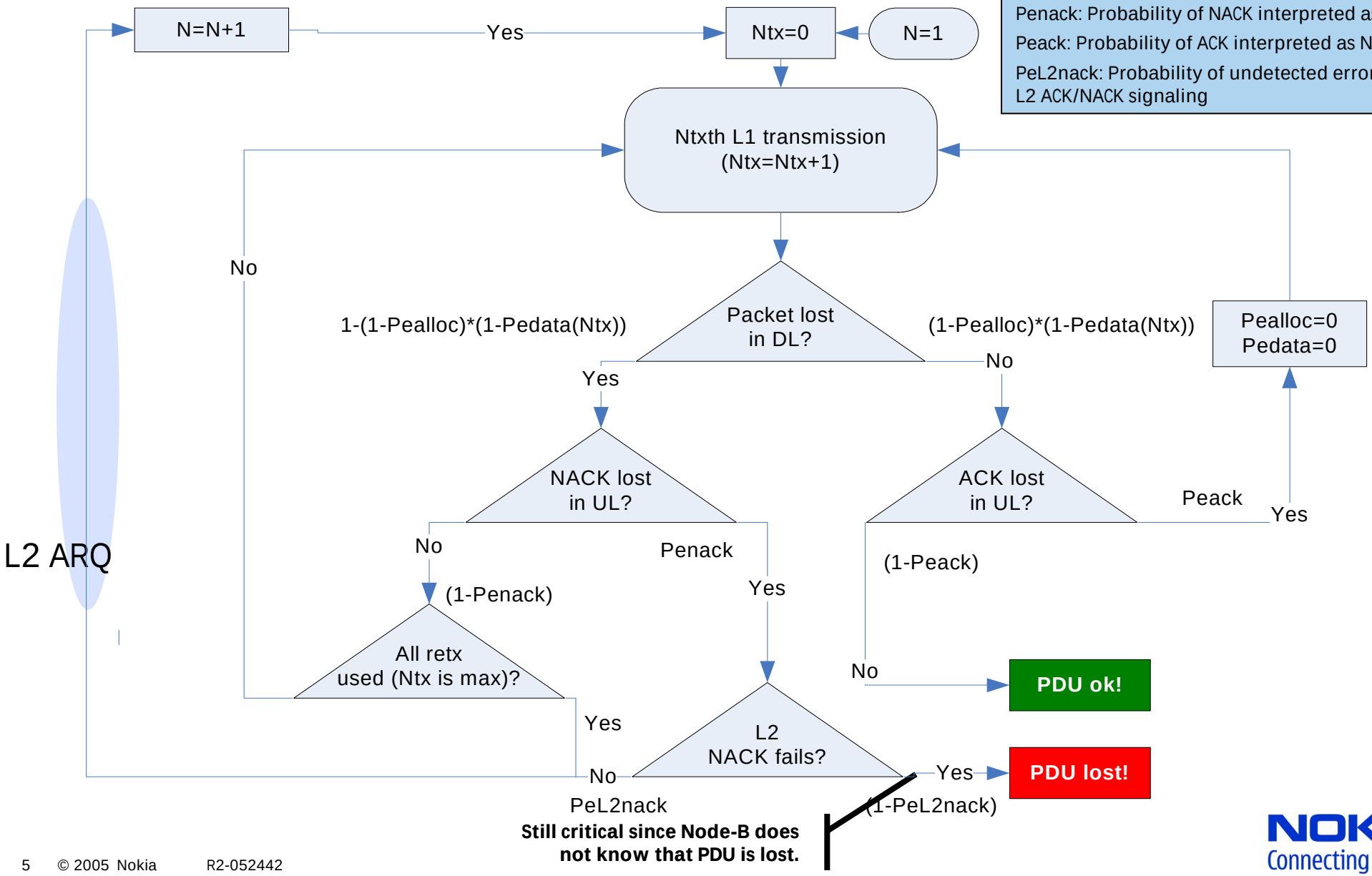
Pealloc: Probability of UE missing a resource allocation

Pedata: Probability of erroneous reception of a data packet

Penack: Probability of NACK interpreted as ACK

Peack: Probability of ACK interpreted as NACK

PeL2nack: Probability of undetected error on the L2 ACK/NACK signaling



Still critical since Node-B does not know that PDU is lost.

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Dual-Layer H-ARQ

- With a dual layer H-ARQ, a L2 PDU is only lost if (1) the NACK is lost and (2) the L2 ACK/NACK functionality fails.
- The L2 ARQ functionality can be designed for almost an arbitrary ACK->NACK error probability (matter of windowing, polling strategies, windows, CRC, etc.).
- Using L2 retransmissions, we get more uncorrelated retransmission attempts (e.g. L1 can now freely reformat the data, provide more robust transmission, etc.).
  - This can be an advantage when the radio channel quality estimate for the UE is somehow corrupted or rapidly deteriorates.
- L2 retransmissions can be made with very high performance:
  - Fast L2 retransmissions are controlled by Node B
  - By multiplexing the L2 ACK/NACK with user or control data, the resulting overhead for error detection and protection (CRC) becomes smaller.

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Conclusions

- Based on the previous discussions we believe that E-UTRAN should support a dual-layer (H)-ARQ as the default solution.
- **Main advantages of dual-layer mode:**
  - We can achieve very low residual error rate at radio link layer without spending excessive resources at L1.
  - We can keep the L1 functionality the same for both radio link layer acknowledged and non-acknowledged mode and thus reduce the complexity of the L1 H-ARQ processes.
  - Dual-layer is the current standard in 3GPP: L2 ARQ corresponds to RLC ARQ in Rel5/6. Depending on E-UTRAN architecture, if the radio link layer can be terminated in Node B, the delay can be much reduced

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