

3GPP TSG RAN MEETING #84

RP-191406

NEWPORT BEACH, USA, JUNE 03 - 06, 2019

INTEL VIEWS ON RELEASE-17

SOURCE: INTEL CORPORATION

AGENDA ITEM: 8

DOCUMENT FOR: DISCUSSION

5G NR EVOLUTION

Release 15 NR

Basic features for eMBB and URLLC

- Flexible frame structure/numerology
- Forward compatible design
- Lower latency
- Advanced MIMO
- Advanced channel coding
- Network slicing
- Enhanced QoS
- Support various network architecture options inc. NSA and SA

Release 16 NR

More Use Cases

- URLLC enh.
- IIOT enh.
- V2X
- NR-unlicensed
- Positioning
- IAB

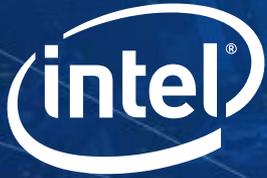
eMBB enh.

- MR-DC
- MIMO enh.
- Mobility enh.
- 2-step RACH
- UE power saving
- Cap. Sig. Optim.
- SON/MDT
- RIM/CLI
- etc.

Release 17 NR to study and develop features to support more use cases & deployment scenarios while further enhancing some of existing features

INTEL VIEWS ON REL-17 NR STUDY/WORK ITEMS/AREAS

Continuation / Further Enhancements	<p>Mobility enh. High speed scenario Aerial/Drone communication Mobility State Est. Leftovers from Rel-16 (mobility, power saving, NTN, etc.) (RP-191345)</p>	<p>Positioning enh. Sidelink based positioning Enhanced Uu based RAT dep. positioning (super-resolution) Extension of NR positioning in unlicensed spectrum Positioning in Idle/Inactive (RP-191158, 159)</p>	<p>MIMO enh. RS enh. for overhead reduction, perf. enh., coverage enh.; CSI enh.; UL MIMO enh.; Multi-TRP/panel; BM (Mechanism for MPE & sim Tx/Rx behavior if not covered in R16) (RP-191157)</p>	<p>V2X enh. Sidelink CA FR2 optimization UE-NW & UE-UE relaying Power saving in support of Pedestrian UEs</p>
	<p>IAB enh. Route aggregation using Network Coding Mobile relay (RP-191346)</p>	<p>Inactive Data Transfer To reduce latency and signaling in Inactive: Send data w/o Resume Request/RRCRelease; possibility via 2-step RACH; Maintaining UE resource config.; Preamble-less; Paging signal optimization (RP-191348)</p>	<p>Coverage Enhancements Evaluate NR MaxCL and identify the gap towards coverage requirements in TR38.913. Specify extreme coverage enhancement to target 164dB MaxCL at least to par with LTE</p>	<p>Others 1024QAM</p>
New Spectrum, Use Cases, Deployment Scenarios	<p>NR beyond 52.6GHz Up to 114.25GHz Study generic framework basis for diverse use cases & waveform selection Target Work Items in Rel-18 onwards (RP-191160, 161)</p>	<p>Multi-SIM Paging priority Paging collision Handling of connections when UE receives paging of USIM A, while the UE is actively communicating with USIM B (RP-191347)</p>	<p>NR based IOT Intermediate UE class, wearable, etc.</p>	<p>NR based MBMS Single or a limited number of cells only - not large area broadcast</p>
	<p>Non-Terrestrial Network Follow-up Rel-16 study</p>			



DETAILED VIEWS ON KEY AREAS

- NR Beyond 52.6Ghz
- NR Mobility enhancements
- NR Positioning enhancements
- Multi-SIM
- NR Inactive Data Transfer
- NR Coverage Enhancements
- NR MIMO enhancements
- NR V2X enhancements
- NR IAB & Network Coding



NR BEYOND 52.6 GHZ

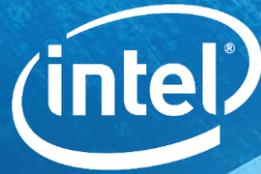
3GPP WORK PLAN FOR REL-17 AND BEYOND

Rel-17 NR beyond 52.6GHz SI (RAN1 led)

- **Comprehensive study on waveform & system design framework**
 - Above 52.6 GHz up to 114.25 GHz
 - Focus on eMBB, IIOT, Uu, licensed spectrum, with some consideration for backhaul, sidelink, unlicensed bands, NTN
 - **Extremely circumspect in choosing waveform(s) taking into account various design requirements**, e.g., PA efficiency, performance, spectrum flexibility, complexity, compatibility with existing NR specs, market/implementation fragmentation (e.g., ideally a single waveform if technically feasible)
 - Study **generic framework basis** for diverse use cases
- **SI Scope (targeting work item(s) in Rel-18)**
 - Evaluation methodology, waveform(s) & applicable frequency ranges, channelization, physical channels/signals, frame structure, beam management, some aspects of operation in unlicensed spectrum, some NTN aspects, etc.

Rel-18 (and beyond) NR beyond 52.6GHz WI

- **WI scope: eMBB, IIOT, Uu, licensed & unlicensed**
- **Sidelink WI: Rel-18 or 19**
- **IAB WI: Rel-18 or 19**
- **NTN WI (?): Rel-19**



NR MOBILITY ENHANCEMENTS

OVERVIEW OF MOBILITY ENHANCEMENTS IN REL-16

In Rel-16, handover reliability and 0 ms handover interruption time are to be addressed

- 0ms interruption time:
 - Handover/SCG change with simultaneous connectivity with source cell and target cell
 - Make-before-break
 - RACH-less handover
- Reliability:
 - Conditional handover
 - Fast handover failure recovery

Scenarios considered in the WI:

- Inter and intra frequency handover/SCG change
- Inter-CU, intra-CU/inter-DU and intra-DU handover/SCG change
- Synchronous and asynchronous deployments as assumed in Rel-15 NR
- UE capability on the number of Tx/Rx chains
- Low and high velocity
- FR1 and FR2 frequencies

FURTHER MOBILITY ENHANCEMENTS IN REL-17

High speed scenario

- May suffer from more handover failures.
- HSDN (high speed dedicated network) is introduced in LTE, not supported in NR

Aerial/Drone communication

- LTE UAV SI observed in some scenario, mobility performance of Aerial UE is worse than a Terrestrial UE. In LTE, followings are specified
 - Subscription based identification of Aerial UE function, measurement triggering based on number of cells above a threshold, Height report triggering based on H1 and H2 events, Adding vertical speed to location info (and thus height report), Network polling of flight path plan

Enhancement of Mobility State Estimation (MSE)

- MSE is supported in LTE for both IDLE and CONNECTED mode. In NR, MSE is not supported for CONNECTED UE.
- The current cell based MSE is not accurate for NR since NR cell has different cell size and varies quite a lot;
- It is worthwhile to consider MSE in CONNECTED mode in order to set proper mobility parameters accordingly, and also more accurate MSE mechanism can be considered, e.g. based on sensors in the terminal, or different weight for different cell (HSDN), etc;

Leftovers from Rel-16 WI (mobility, power saving, NTN, etc)

- HO/SCG change in the context of E-UTRA/5GC and MR-DC (e.g. EN-DC) has been deprioritised.
- RAN4 concluded that handover with simultaneous tx/rx is not feasible in FR2.



NR POSITIONING ENHANCEMENTS

NR POSITIONING - REL-16 WI SCOPE OVERVIEW

NR Positioning Techniques

- Timing Based Solutions
 - DL-TDOA, UL-TDOA, multi-cell RTT (DL+UL)
- Angle Based Solutions
 - DL-AoD, UL-AoA
- E-CID (RSRP+ Serving cell RTT and UL AoA)

NR Positioning Applications Areas

- Regulatory use cases (e.g. E911)
- Commercial use cases (general)

NR Positioning based on RAT Dependent Solutions

- Focus on 2D horizontal positioning in FR1/FR2
 - < 3m accuracy indoor scenarios
 - <10m outdoor scenarios

Work Item Scope

- Design of DL positioning ref signals (PRS)
- Enh. of UL RS for NR positioning
 - UL SRS is a starting point
- Definition of UE and gNB Measurements
- Signalling and procedures inc. UE reporting
- Extension of LPP for RAT dependent solutions and GNSS SSR based on the “Compact SSR”
- Extension of NRPPa for RAT dependent solutions
- Study phase on UE-based DL only positioning
 - Location estimation at UE side

Spin-off Study Item (led by CMCC)

- Local LMF and LCS client in NG-RAN

REL-17 WORK ITEM SCOPE AND OBJECTIVES

Sidelink based positioning

- Define reference signals, measurements and signaling protocols to enable sidelink based ranging and positioning techniques
 - Relative and absolute positioning as well as proximity detection based techniques

Enhanced Uu based RAT dependent positioning technologies

- Enhanced measurements and reporting to facilitate more precise reliable positioning
 - Including support of super-resolution techniques for estimation of location parameters

Extension of NR positioning support in unlicensed spectrum

- Definition of gNB and UE behaviors for NR positioning support in unlicensed spectrum

Analysis and extension of NR positioning for non-terrestrial networks

Positioning support in RRC IDLE and Inactive



MULTI-SIM

BACKGROUND: MULTI-SIM ACTIVITY IN SA

SA1

- SA1 TR (S1-191255) and the SA1 WID (S1-191635).
- The SA1 study is estimated to be 95% complete.

SA2

- Rel-17 SA2 study item ([SP-190248](#)) has been approved with the following scope.
 - Delivering paging to USIM A while the UE is actively communicating with USIM B.
 - Suspension (or release) and resumption of an ongoing connection associated with USIM A to leave to the 3GPP system associated with USIM B
 - Paging collision
 - Emergency calls and sessions.
 - Handling of service prioritization

Scenarios

- Core Network
 - Both USIM in 5GS
 - Both USIMs in EPS
 - USIM A to 5GS and USIM B to EPS
 - Inter-MNO and intra-MNO
- RAN
 - LTE + LTE
 - LTE + NR
 - NR + NR
- UE capability
 - Single Rx / single Tx
 - Dual Rx / single Tx
 - Dual Rx/Dual Tx
 - Not within SA2 SI but it may be more practical if the UE supports CA or DC.

POTENTIAL RAN IMPACTS

Handling Paging priority

- Paging can be delivered to USIM A while the UE is actively communicating with USIM B.
 - Based on paging cause, the UE decide to keep connection with USIM B if paging cause of USIM A is lower priority. Otherwise, the UE decide to suspend/release the connection with USIM B.
- RAN impacts
 - Provide paging cause to the upper layer.
 - Reception of paging for single Rx: gap/interruption in connection with USIM B is needed.
 - No impact expected from paging cause prioritization and connection suspend/release as these should be specified in NAS

Paging collision

- Paging occasion can be colliding between USIM A and B because it is a problem for single Rx case.
 - NAS approach:
 - Change of 5G-S-TMSI upon UE request
- RAN impact
 - No impact to support the change of 5G-S-TMSI.
 - RAN level solution can be studied e.g. update of existing or new paging related parameter upon UE request.

Handling of connections when UE receives paging of USIM A, while the UE is actively communicating with USIM B

- **Approach 1:** maintain one connection only
 - If paging has lower priority, the UE delays paging response in USIM A. On the other hand, if paging has higher priority, the UE should prioritize response for paging.
 - The UE suspend(or release) connection with USIM B and initiate a new service request to the 3GPP system associated with USIM A.
 - The UE at NAS can initiate new service request to send the UE to connected mode in USIM B. After finishing connection in USIM A the UE at NAS can initiate service request to send the UE to connected mode in USIM B.
- **Approach 2:** operate both connections in parallel.
- **RAN impacts**
 - Approach1 might be transparent to AS layer.
 - Approach2 can be supportable by Rel-15 NR (xxxx) but further enhancements can be considered e.g. power control, TDM operation or UE capability coordination.



NR DATA TRANSMISSION FROM INACTIVE

DATA TRANSMISSION FROM INACTIVE

Background

- Rel-15 INACTIVE state
 - Provides much faster transition to connected
 - Fewer signalling compared to Idle to Connected
 - Possible to achieve about 30ms transition
- 2 step RACH (Rel-16)
 - Reduce delay of 4 step RACH
 - Msg A to be the same as msg 3
 - Resume request and Release to be used
 - No reduction in number of number of messages or signalling sequence expected
 - Overall concepts of INACTIVE re-used
 - UE transitions to CONNECTED, even if it is just for transmission of data

Objective:

- Further reduced latency and signalling for data transfer from INACTIVE

Possible areas for enhancement:

- Ability to send data without Resume Request/RRCRelease (to INACTIVE) signalling
 - UE does not have to fully transition to CONNECTED
- Possibility to use 2 step RACH
- Maintaining UE resource configuration for data transfer in same cell or within an RNA
- Preamble-less access for UL synced UE
- Paging signal optimisation for DL data



NR COVERAGE ENHANCEMENTS

NR COVERAGE ENHANCEMENTS

TR38.913

- Target coverage is 164dB MaxCL for a data rate of 160bps
- For a basic eMBB extreme coverage
 - Stationary user:
 - 140dB for 2Mbps DL and 60kbps UL
 - 143dB for 1Mbps DL and 30kbps UL
 - Mobile user:
 - 140dB for 384kbps DL
- Evaluation methodology
 - link budget and/or link level analysis

Objectives

- Evaluate MaxCL for NR up to Rel-16 and identify the gap towards coverage requirements in TR38.913
 - FR1 is evaluated.
- Specify extreme coverage enhancements to target 164dB MaxCL at least to par with LTE
 - The requirement consideration of 164dB MaxCL is on FR1.
 - The same design can be applied to FR2 where the requirement 164dB MaxCL may not be fully satisfied for FR2.



NR MIMO ENHANCEMENTS

REL-17 NR MIMO: HIGH-LEVEL WORK DIRECTIONS

Similar to Rel-16, the work on MIMO enhancements in Rel-17 should focus on the following areas

- CSI enhancements
- Reference signal enhancements for MIMO operation
- Multi-TRP/panel enhancements
- Enhancements to beam management
- UL MIMO enhancements

REL-17 NR MIMO ENHANCEMENTS (1/3)

RS enhancements for MIMO operation

- Overhead reduction
 - TRS overhead reduction (e.g., cross-CC Type-A QCL, TRS-less CC, pure aperiodic TRS, etc.)
 - PT-RS design enhancement to support variable overhead for DFT-s-OFDM depending on MCS
- NR performance enhancements
 - PTRS enhancement for sub-OFDM symbol phase-noise compensation for CP-OFDM
 - Support of multiple ports for PUCCH Format 4 with $\pi/2$ BPSK
- Coverage enhancements for RS
 - Support of low PAPR for SRS to extend the coverage of SRS without relying on SRS repetitions
 - Coverage enhancements for CSI-RS, e.g., CSI-RS repetitions or low PAPR

Study on CSI enhancements

- The work on CSI enhancements in Rel-17 may focus on study of the scenarios where CSI enhancements are needed and associated performance gains, e.g., the need of supporting feedback of long-term channel statistics (e.g. channel covariance matrix), Doppler-domain compression, CSI feedback for partial reciprocity, etc.
- The outcome of the study phase can be Technical Report (TR) capturing Rel-17 study results

UL MIMO enhancements

- Support of frequency selective precoding for CP-OFDM
- Extension of DFT-s-OFDM support to more than 1 MIMO layer

REL-17 NR MIMO ENHANCEMENTS (2/3)

Multi-TRP/panel enhancements

- Rel-16 multi-TRP/panel enhancements in NR is likely to focus on FR1 operation due to limited time
- Rel-17 multi-TRP/panel enhancement may consider FR2-specific enhancements
 - Beam indication for multi-TRP / panel reception for PDCCH/PDSCH
 - Beam indication for multi-TRP / panel transmission for PUCCH/PUSCH
 - Enhanced multiplexing rules for physical channels and reference signals for DL and UL taking into account support of multiple panels at the gNB and UE (continuation of work from Rel-15 NR MIMO)
 - UL power control enhancements
 - Partial beam failure recovery to recover from beam failure for a link between one TRP and a UE panel

Other multi-TRP enhancement (pending Rel-16 progress on multi-TRP)

- CSI enhancements for NC-JT
- Support of more than two TRPs for NC-JT
- UCI multiplexing enhancements
- Support of repetitions of PDCCH, PUSCH for eURLLC

REL-17 NR MIMO ENHANCEMENTS (3/3)

Enhancements to beam management

- BM enhancements to address MPE issues due to safety emission limits in FR2 (RAN1/RAN4)
 - Introduce beam reporting to assist UL beam selection taking into account additional Tx power constraints due to safety emission limits
- Overhead and coverage enhancements for BM:
 - Support of Rx beam refinement with different granularities (sub-OFDM or multiple OFDM symbols) depending on propagation condition to the UE
- For higher carrier frequencies, accurate beam correspondence becomes more challenging due to more narrow beams (i.e. Tx/Rx beam pointing error becomes more pronounced).
 - Enhancements related to UL BM and UL beam failure procedure for the UE with partial BC

Enhancements to beam management (cont'd)

- UE assistant beam management procedure P3
 - Support UE reports information to inform gNB on necessity of UE beam refinement



NR V2X ENHANCEMENTS

REL-16 V2X WI SCOPE OVERVIEW

NR V2X

- Main focus is on NR sidelink design primarily for FR1
- Enhancements on Uu link to control sidelink

NR V2X Use Case Groups

- Platooning
- Advanced driving
- Extended sensor sharing
- Remote driving

NR V2X KPIs

- Mission critical applications (URLLC-like sidelink)
- Support of periodic and aperiodic traffic models
- Unicast, groupcast and broadcast support at AS
- Range, latency, reliability, data rate are key KPIs

Work Item Scope

- Sidelink design for NR V2X use cases
 - Sidelink physical structure and procedures (HARQ/CSI/PC)
 - Sidelink synchronization signals and procedures
 - Sidelink resource allocation (Mode-1 and Mode-2)
- In-device coexistence solutions (TDM)
- QoS management and congestion control
- Cross-RAT PC5 scheduling and resource configuration
- Sidelink L2/L3 protocols and signalling
 - SL TX & RX in RRC, MAC, RLC, PDCP, and SDAP
 - AS level link management for unicast
- Network solutions to support NR sidelink
- RRM + UE TX/RX RF requirements

NR V2X IN REL-17 AND BEYOND

Candidate areas for Rel-17

- Sidelink enhancements (leftovers from R16)
 - Sidelink carrier aggregation (multiple sidelink CCs)
- Study and work on sidelink design for FR2
 - Sidelink physical structure
 - Sidelink physical layer procedures (including beam management considerations)
 - Sidelink synchronization
 - Sidelink resource allocation
- Support of UE-to-NW relaying
- Support of UE-UE relaying
- Power saving considerations in support of Pedestrian UEs
- Broadcast support on Uu link for V2X (?)

Rel 18

- NR V2X design for ITS spectrum above 52.6GHz, e.g., 63GHz



NR IAB ENH. & NETWORK CODING

POTENTIAL IAB ENHANCEMENTS FOR REL-17

Route Aggregation using Network Coding

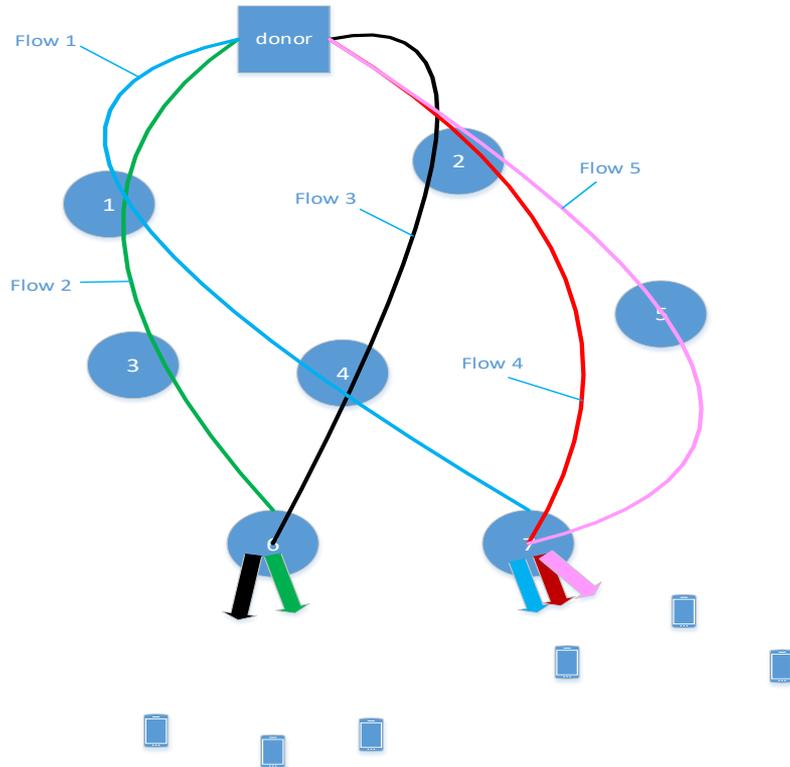
- Use of linear network coding to aggregate routes
- Leverages dual/multi connectivity
- Improves resilience to packet loss, temporary blockage, congestion

(Note: please see next slides and RP-191346 for more details on Network Coding)

Mobile relay

- BS type mobile relay
- UE type mobile relay – study with sidelink (not in IAB scope)

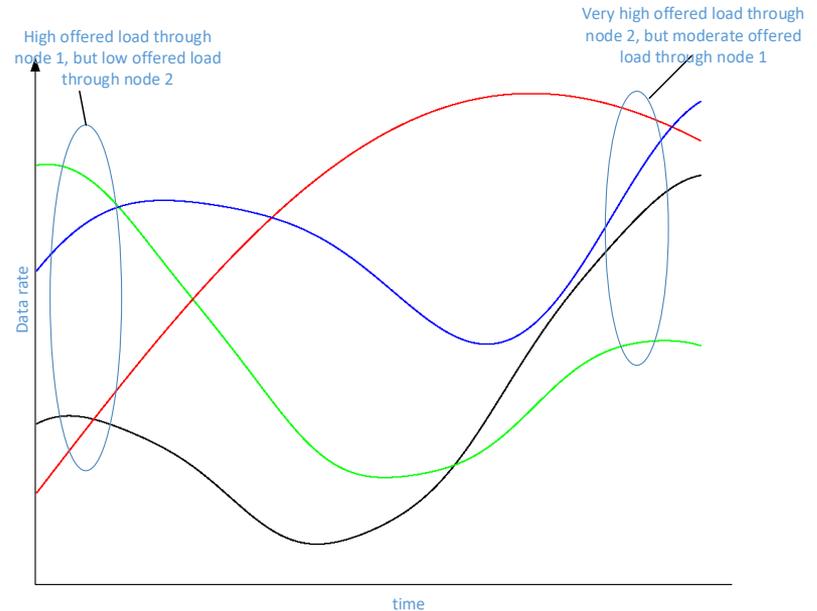
KEY SHORTCOMINGS IN REL 16 IAB



Rudimentary handling of multiple routes

- Each UE bearer mapped to single route
- Insufficient capability to load balance across routes

Data rate variations on different routes can result in **congestion** on some routes even when other available routes to same destinations have capacity



Data rates on routes over time; data rates vary due to UE application demands, number of UEs etc

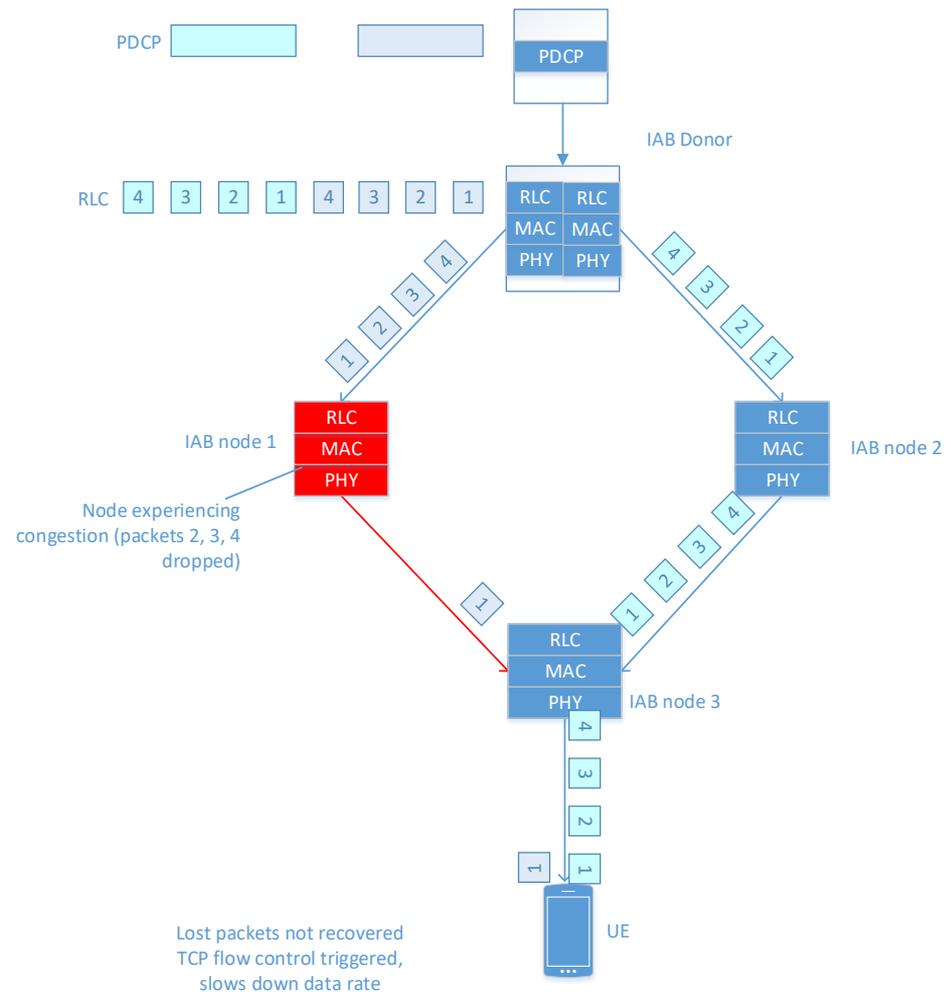
EFFECTS OF CONGESTION IN IAB

Congestion scenario:

- IAB node 1 experiencing congestion, drops RLC packets
- Dropped packets on first route cannot be recovered
- ✓ TCP flow control triggered and data rate reduced even though second route has capacity

Any given unit of data is committed to a single route

Even with multiple routes, the weakest link significantly impacts performance



NETWORK CODING FOR IAB

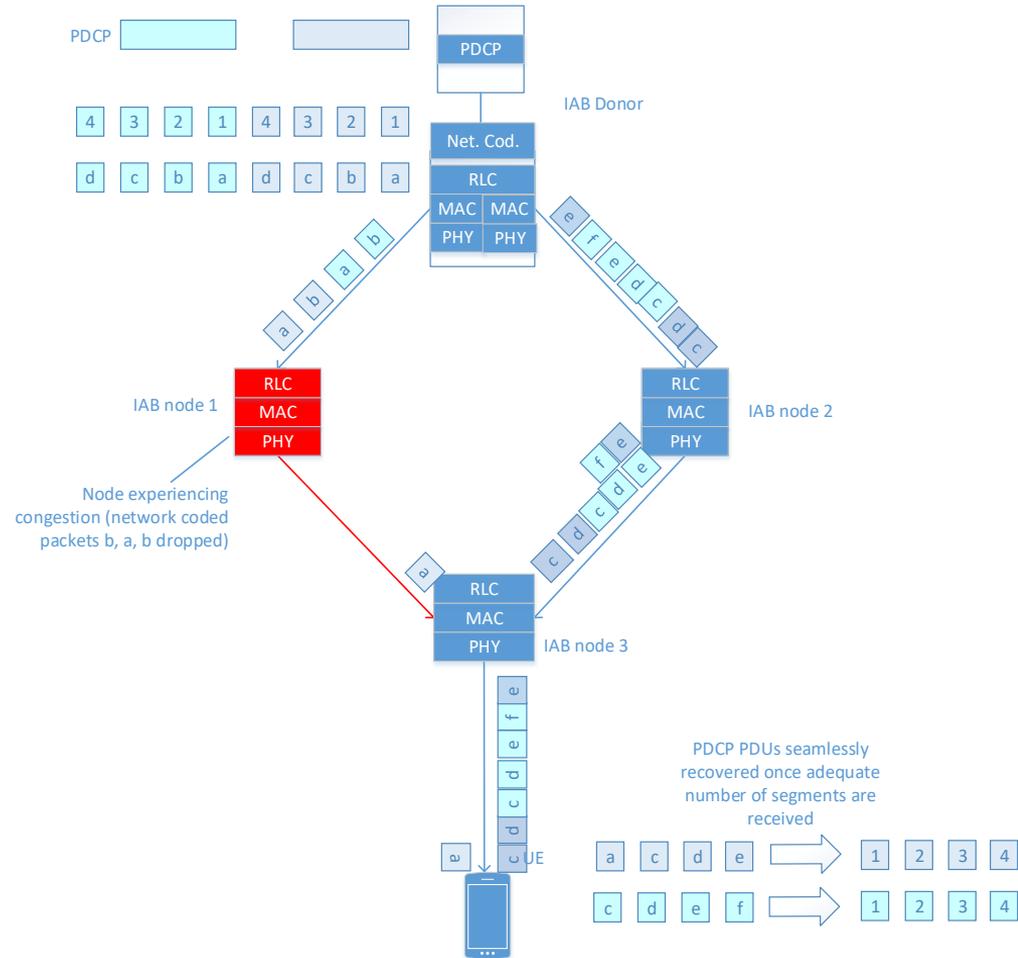
Network coding of segments of PDCP PDU

If a segment is lost, not necessary to know which specific segment is lost

PDCP PDUs seamlessly recovered by UE

- UE indicates number of segments received/needed
- Donor generates additional network coded segments and transmits over second route
- No loss of data and no impact to TCP
- Natural load balancing between the two routes
- Resilient to packet dropping (until all routes experience overload)

Effectively combines multiple routes into one “pipe”



NETWORK CODING FOR IAB – SUMMARY OF KEY ASPECTS

Split one PDCP PDU into segments and perform (linear) network coding

- can maintain sequence no relationship between PDCP PDU and RLC-NC segments
- Network coded segments are linear combinations of original segments (with different network coded segments being linearly independent)

Padding to evenly divide a PDCP PDU into N segments

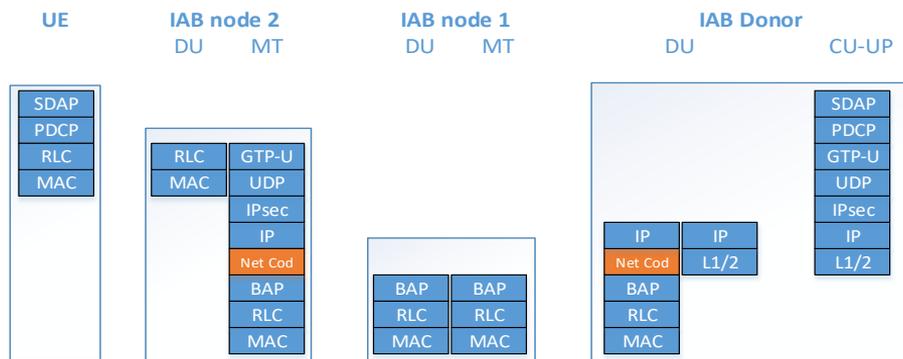
Feedback: number of additional segments needed (after N have been transmitted)

Transmitting end generates NC segments; intermediate nodes just forward NC segments

- RLC-UM may be sufficient (RLC-AM may not be needed)

Segmentation for NC is independent of RLC segmentation

PROTOCOL OPTIONS FOR NETWORK CODING IN IAB

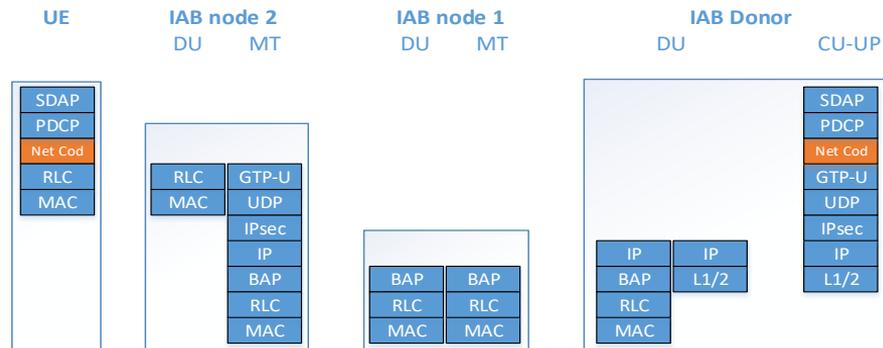


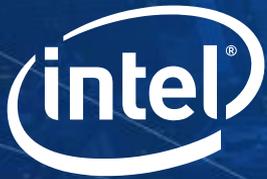
Network coding above BAP in donor DU and MT

- Transparent to UE
- Can leverage multiple routes between donor DU and access IAB node

Network coding below PDCP in CU-UP and UE

- Can leverage multi-connectivity support at UE (in addition to multiple routes to access IAB node)
- Transparent to IAB nodes





THANK YOU!