

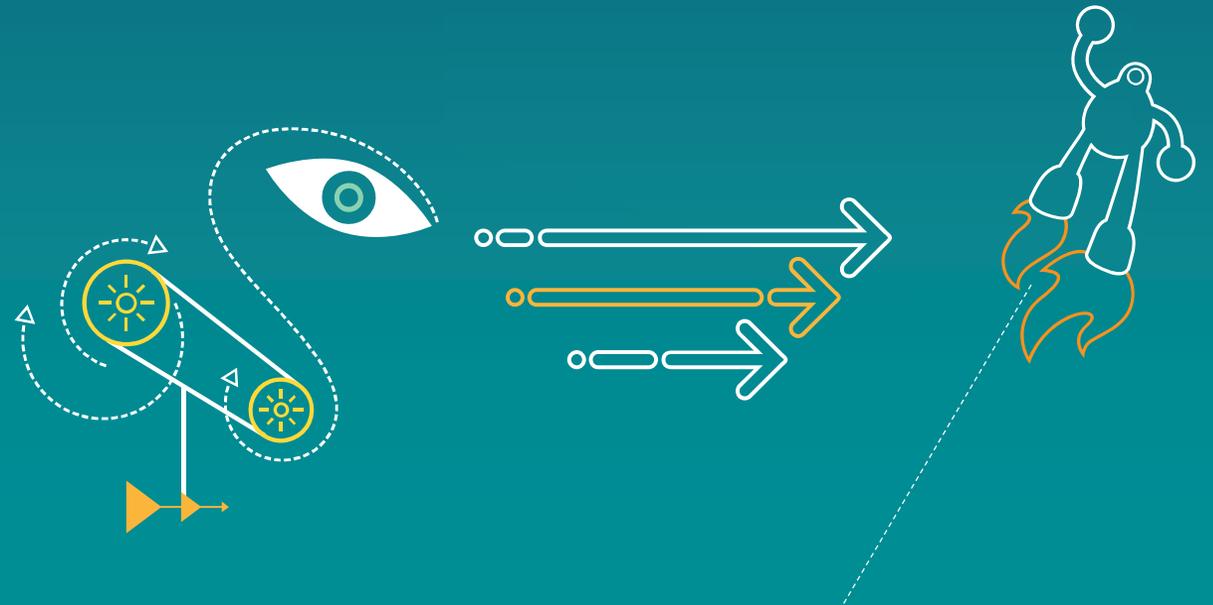
3GPP TSG-RAN WG4 #84bis

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Dubrovnik, HR

R4-1711560

Single vs. Dual Tx Performance Comparison



Background

- RAN plenary decided that NSA UE is allowed to declare the capability of only single Tx support by switching between NR and LTE carriers
- RAN1 has agreed on two NR-LTE power sharing modes
 - Semi-static TDM pattern for single-Tx switching between NR and LTE
 - Dynamic power sharing between NR and LTE for dual-Tx UE configuration
- This contribution evaluates the performance tradeoff of single versus dual Tx NSA support

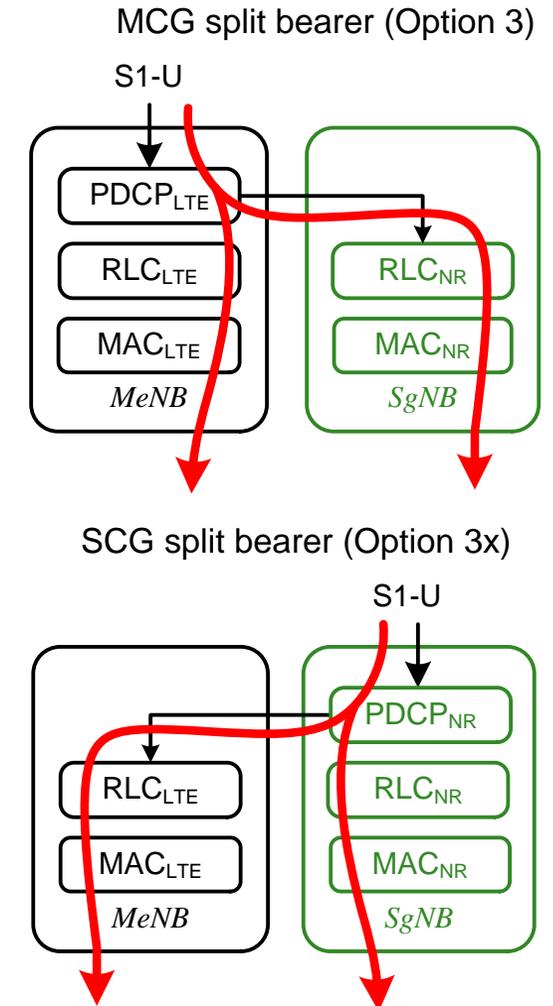
KPI's for Single/Dual Tx Comparison

- UL Capacity
- General NR impact
 - Frame structure
 - Latency impact
 - DL perceived throughput impact
 - MIMO impact
 - Dynamic TDD impact

Impact on UL Capacity

UL Capacity of NSA

- Traffic split could be directed to both NR and LTE carriers
- Separate eNB/gNB for LTE and NR carriers with independent scheduling
- Dynamic Tx power sharing algorithm at UE side



Dynamic Power Sharing at UE side for Dual tx Scenario

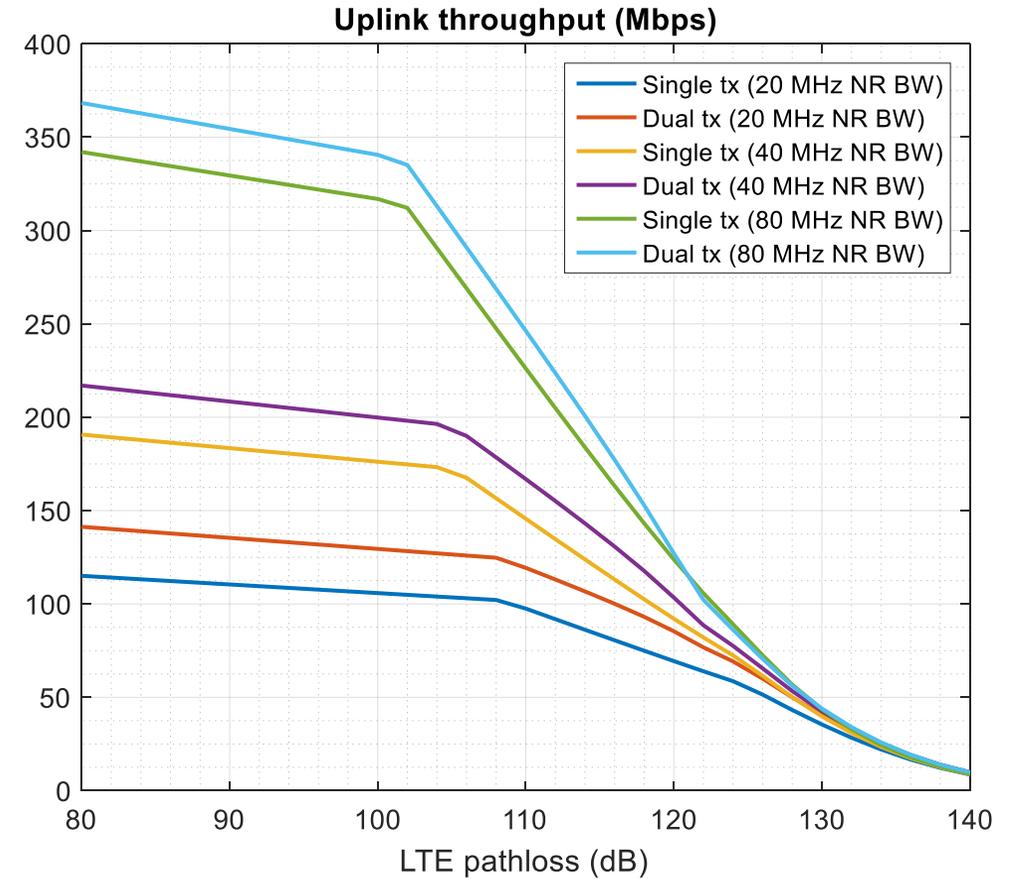
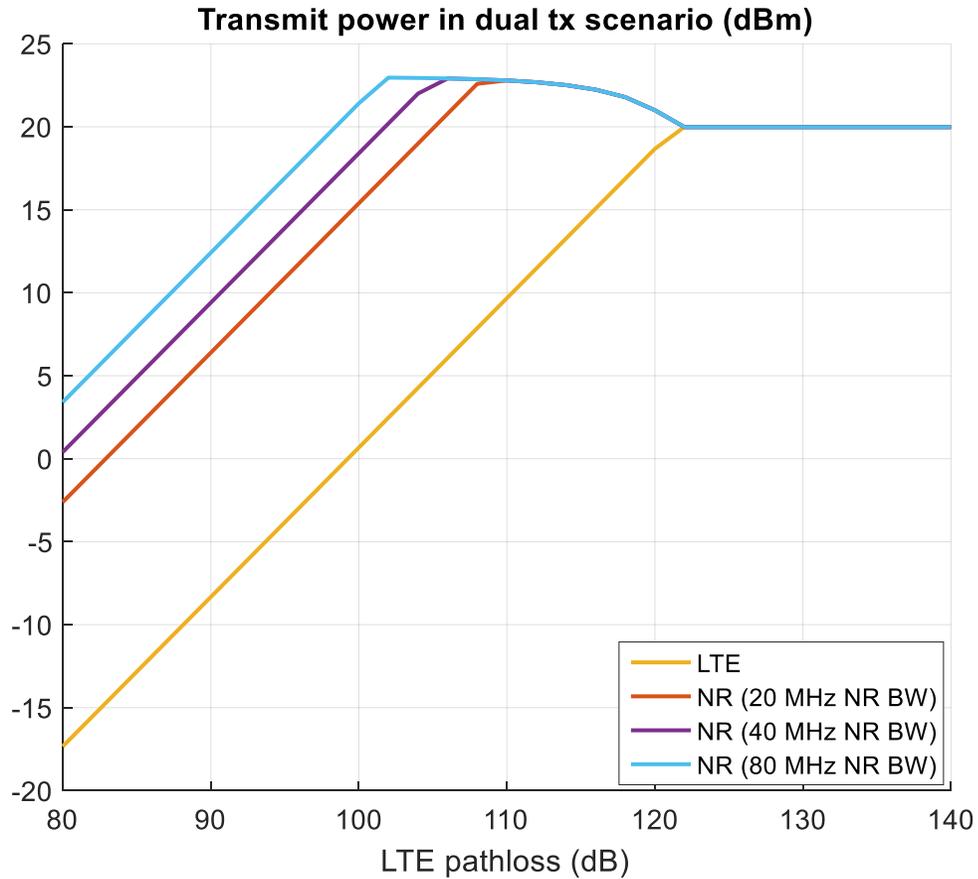
- The following has been agreed in RAN1:
 - At least for LTE-NR NSA operation
 - Maximum allowed power values for LTE (P_{LTE}) and NR (P_{NR}) are set separately
 - i.e., when UE is configured for NR, P_{LTE} can be configured up to P_{cmax} and P_{NR} can be configured up to P_{cmax} .
 - e.g. $P_{\text{LTE}} + P_{\text{NR}} > P_{\text{cmax}}$ or $P_{\text{LTE}} + P_{\text{NR}} = P_{\text{cmax}}$
 - All UEs are mandated to handle $P_{\text{LTE}} + P_{\text{NR}} = P_{\text{cmax}}$ while handling of $P_{\text{LTE}} + P_{\text{NR}} > P_{\text{cmax}}$ depends on UE capability
- A UE in dual transmission scenario may operate in a manner that after allocating the power required for LTE uplink it can use the remainder of its power for NR uplink
- With 23 dBm P_{cmax} , the dual tx scenario does not need to select a 20 dBm limit for LTE and NR, but can dynamically share the power
- This allows the optimization of the power allocation between LTE and NR in a UE-specific manner based on the pathloss

Assumptions

| | NR | LTE |
|----------------------------------|---|--------------------|
| BS Antennas | 64 TXRU, 256 elements | 4 TXRU, 8 elements |
| Carrier Frequency | 3.5 GHz* | 1.8 GHz |
| Bandwidth | {20, 40, 80} MHz | 10 MHz |
| DU configuration | DDDUU | FDD |
| Pathloss | NR pathloss 10 dB worse than LTE | |
| MIMO gain and processing backoff | 11 dB | 1 dB |
| Antenna Gain per element | BS: 8 dBi ; UE: 0 dBi | |
| BS Noise Figure | 5 dB | |
| UE Max Power | 23 dBm | |
| Penetration Loss | 20 dB | |
| Power control | P0 = 25 dB over thermal, $\alpha = 0.9$ | |

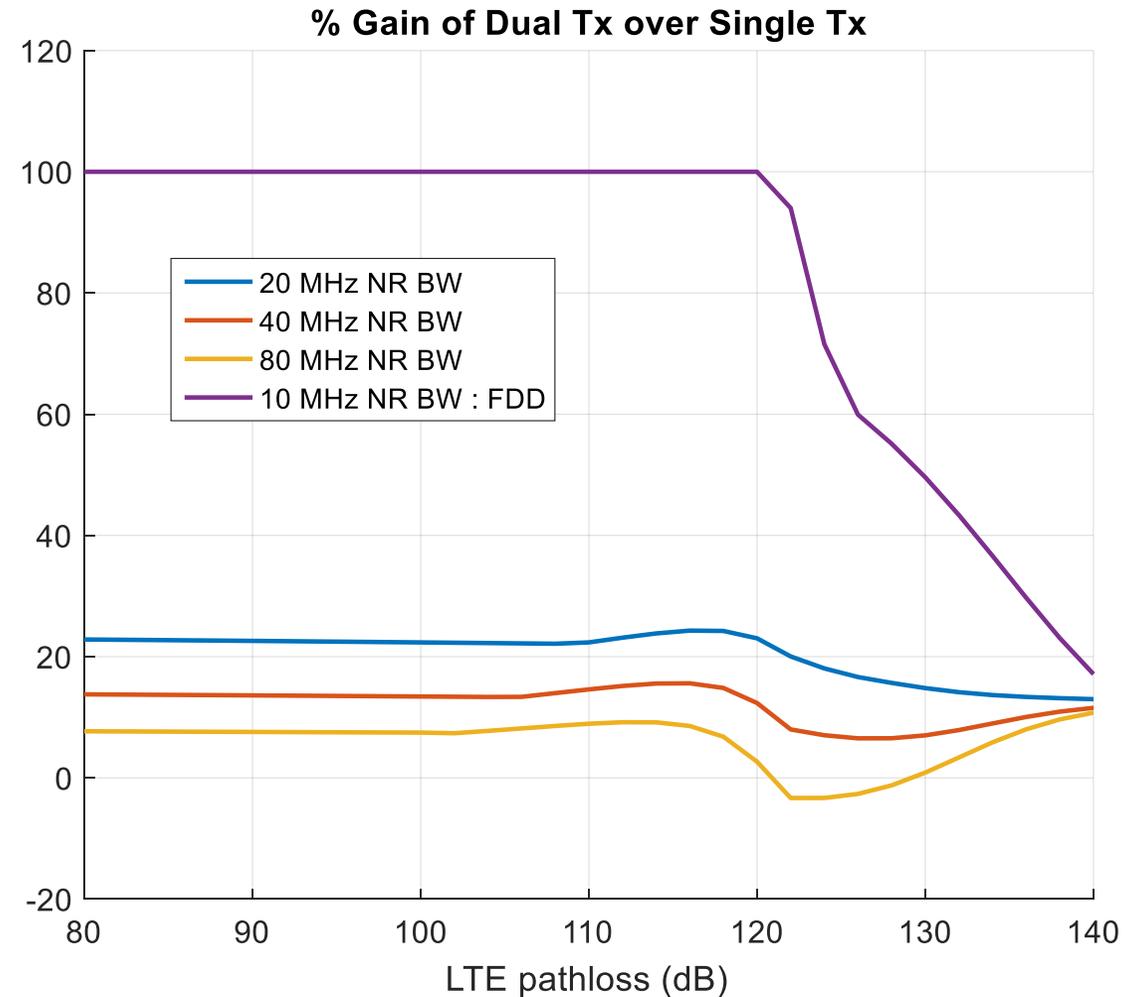
* NR 10 MHz FDD at 1.8 GHz was also studied

Transmit power and throughput (NR TDD + LTE FDD)



UL Capacity Study Observations

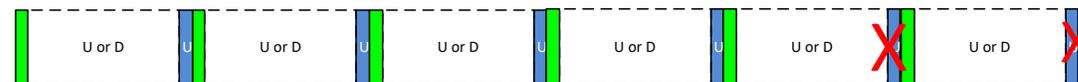
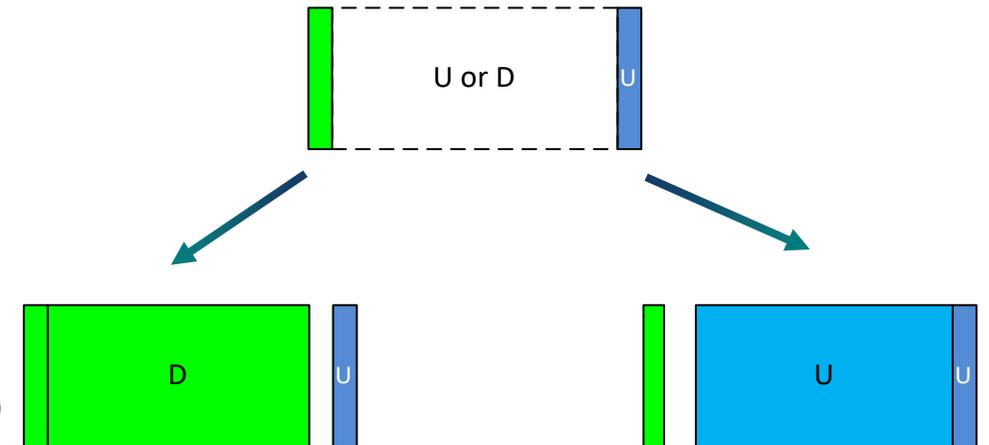
- NSA dual Tx solution is demonstrated to provide UL capacity gain over switched-Tx solution
 - In near cell condition
 - 8-22% gain for 20-80 MHz NR TDD + 10 MHz LTE
 - 100% gain for 10 MHz NR FDD + 10 MHz LTE
 - In far cell condition, up to 13% gain
- Fundamental advantage of dual Tx implementation
 - More optimal power sharing between LTE and NR



Impact on NR Frame Structure

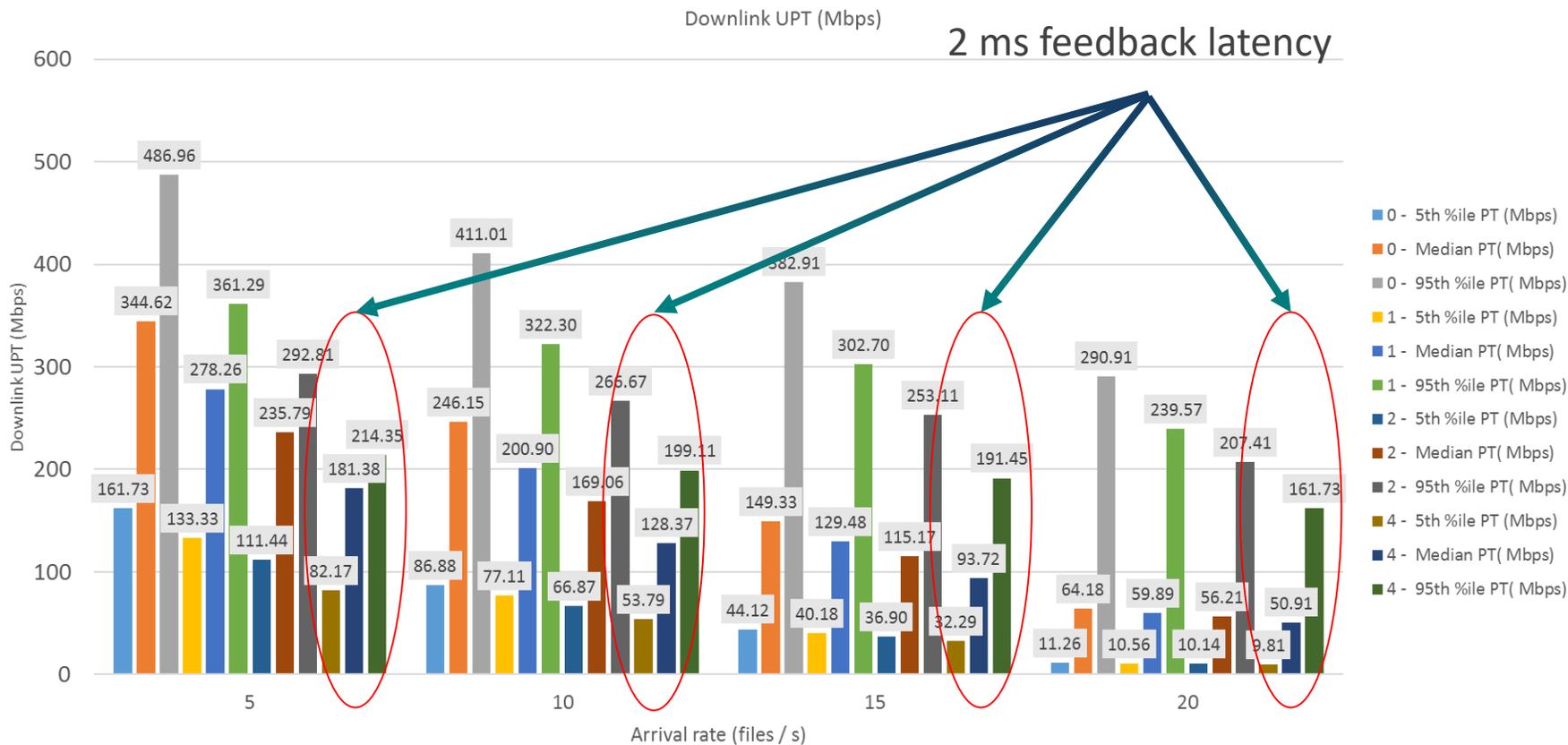
Single Tx switched architecture leads to severe restriction on NR frame structure

- Self-contained frame structure is a key feature of NR
 - Forward compatibility
 - Dynamic TDD
 - Low latency
 - Higher sounding frequency for massive MIMO
- Every single slot (0.5ms) has UE Tx (short UL control) regardless of TDD UL/DL traffic configuration
- Observation:
 - Single Tx switching disables some fundamental NR frame structure



DL UE Perceived Throughput Impact

Latency increase leads to loss in UE perceived throughput



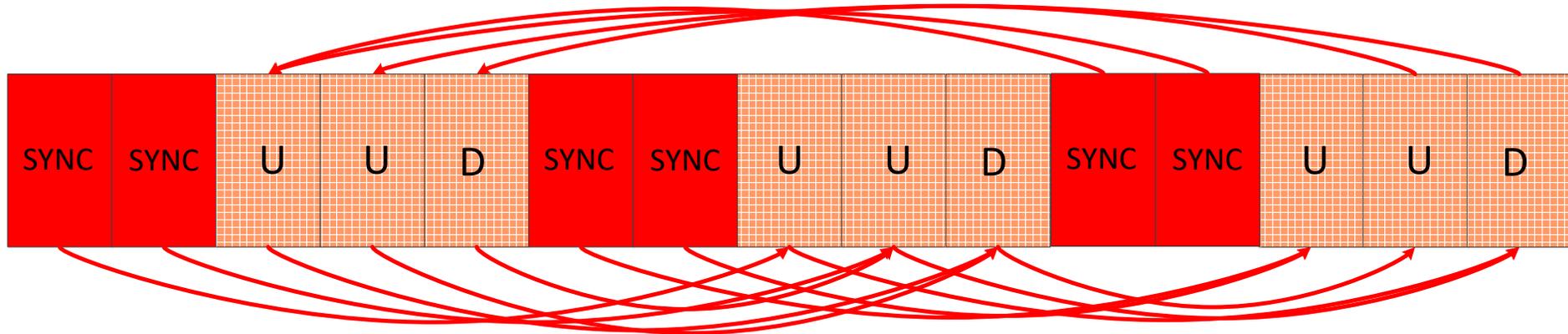
- As latency increases, the user perceived throughput shows noticeable degradation*
- Single Tx with LTE type of frame structure leads to large latency
 - DDDUU leads to average 2ms feedback latency
 - UE perceived Thrp loss

* Results shown for downlink FTP model 3 with 0.1 MB file size, 10 UEs/cell, for K1 = {0, 1, 2, 4}

Dual Tx Enables Forward Compatibility

Self-contained subframe removes subframe inter-dependency

4G LTE
TDD Or
NR Single Tx
switch

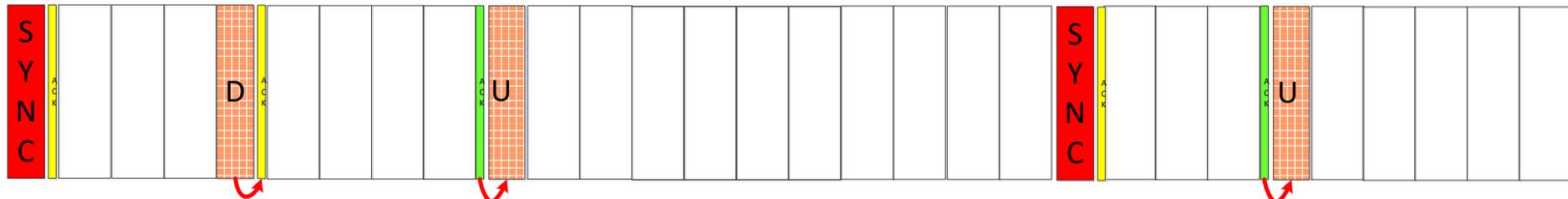


Not Forward Compatible

Constrained Forward Compatibility

↔ PDCCH ↔ UL data
UL data ↔ PHICH
PDSCH ↔ ACK
ACK ↔ ReTx

5G NR
TDD with
Dual Tx

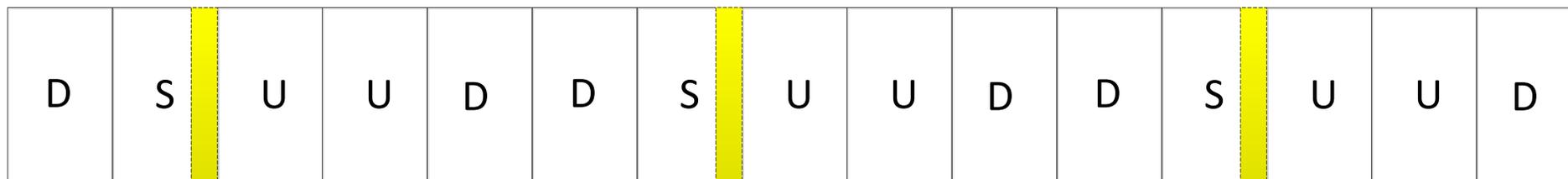


* Sub 6 GHz, macro cell numerology, 30 kHz tone spacing

Massive MIMO Optimized Sounding

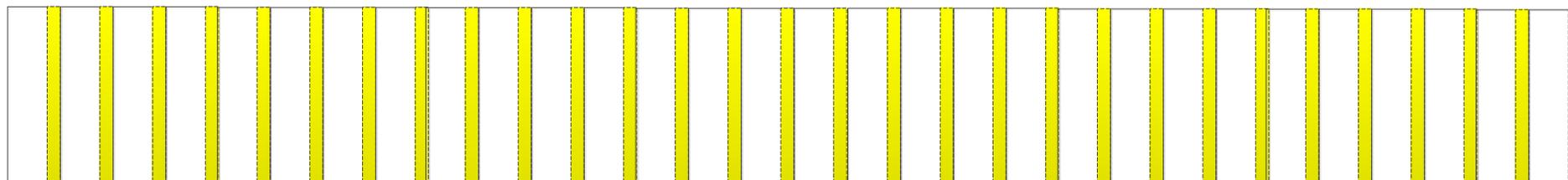
Channel sounding opportunity increases from ≤ 200 Hz to 2 kHz

4G LTE
TDD or
NR Single
Tx Switching



Sounding reference signal (SRS) opportunities

5G NR
TDD with
Dual Tx

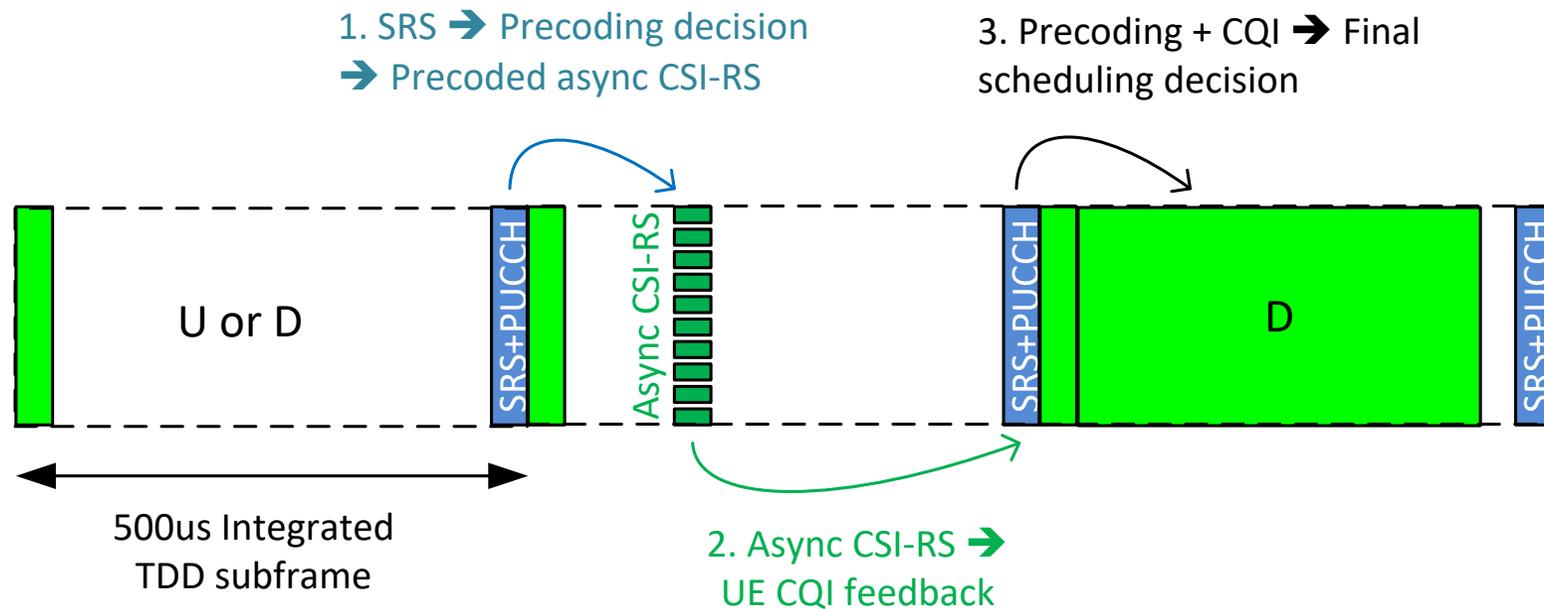


- Sub 6 GHz, macro cell numerology,
- 30 kHz tone spacing

Faster sounding enables wide area Massive MIMO coverage with mobility

Dual Tx with Self-contained SF Enables Massive MIMO Optimized TDD Reciprocity Procedures

Massive MIMO rate prediction latency reduction from > 10ms in LTE to 1ms



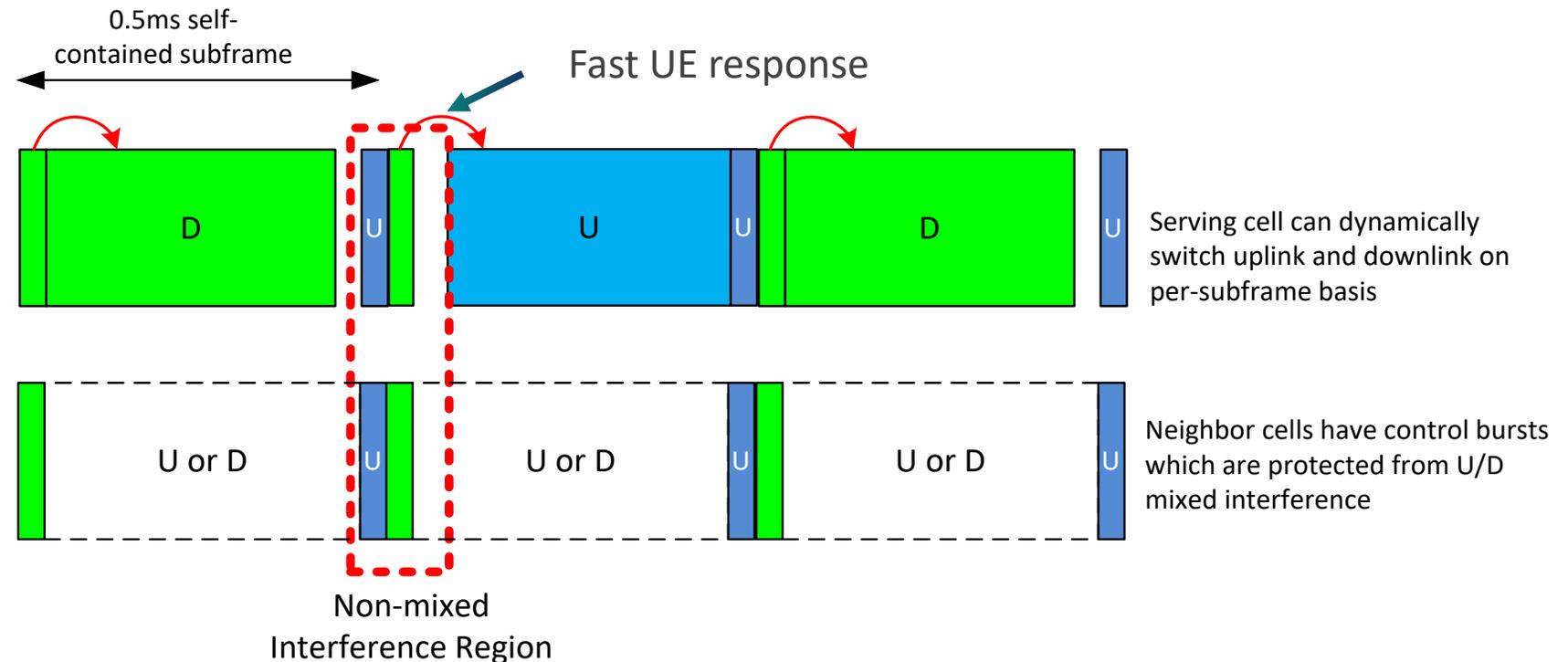
- Joint TDD reciprocity + feedback
- Enabler: Self contained SRS, async CSI-RS, CQI

- Sub 6 GHz, macro cell numerology,
- 30 kHz tone spacing

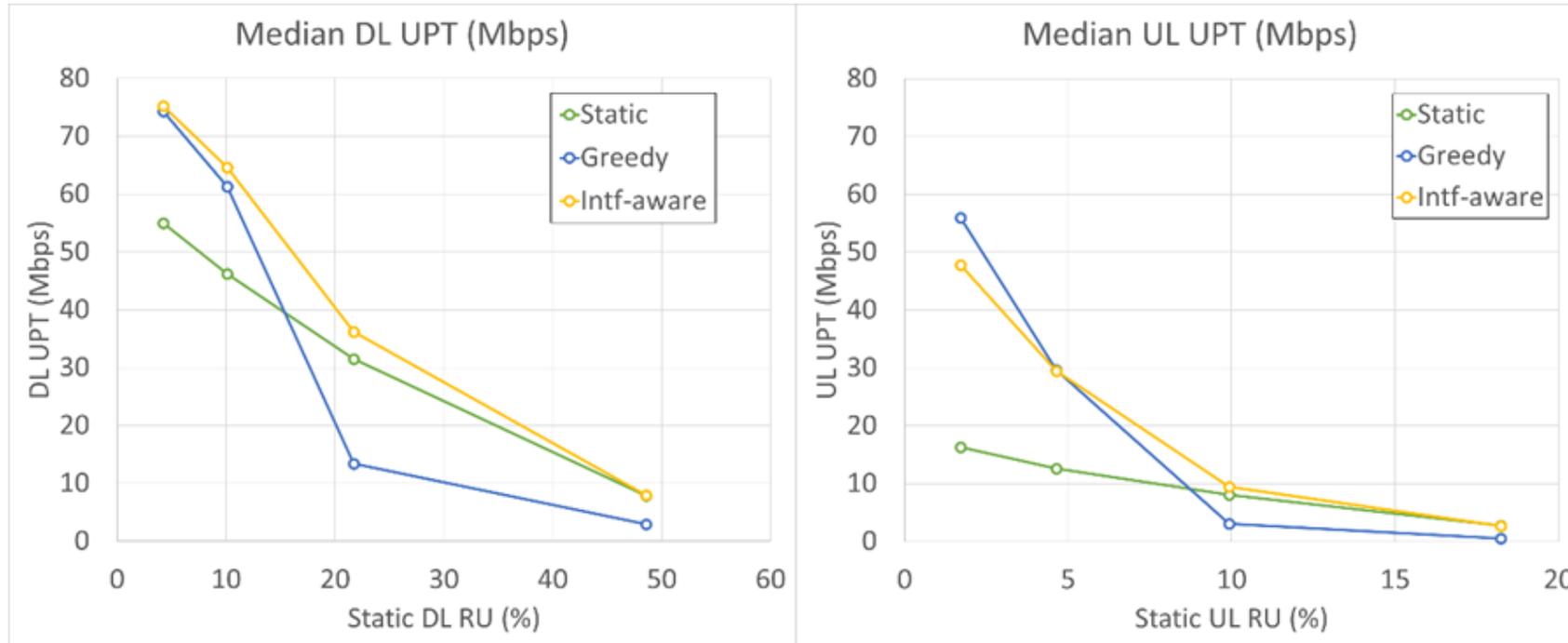
Dual Tx Enables NR Dynamic TDD

Self-containable subframes allow dynamic TDD traffic with protected control bursts

- NR provides robust control in non-mixed interference region while allowing data to be dynamically switched between DL and UL
- Fast UE response allows the control to switch traffic direction dynamically



Dynamic TDD gains



- Dynamic TDD capability allows a cell to dynamically select the slot format (DL vs UL) depending on traffic conditions
- Results* show significant gains in user experience for dynamic TDD over static TDD
- Dual transmit capability enables dynamic TDD operation

* Results are shown for two dynamic TDD scheduling algorithms (greedy and interference aware), in comparison with static TDD operation

Conclusions

Significant Gain Due to Dual Tx Observed

- NSA dual Tx solution is demonstrated to provide UL capacity gain over switched-Tx solution
 - In near cell condition
 - 8-22% gain for 20-80 MHz NR TDD + 10 MHz LTE
 - 100% gain for 10 MHz NR FDD + 10 MHz LTE
 - In far cell condition, up to 13% gain
- NSA dual Tx enables fundamental NR self-contained frame structure
 - Dynamic TDD capacity increase
 - More robust /efficient massive MIMO operation
 - Low latency and higher UE perceived throughput
 - Forward compatibility

