3GPP TSG RAN WG1 #94bis
Chengdu, China, October 8 - 12, 2018
Agenda item 7.1.4

R1-1811239

Revision of R1-1809431

Maintenance for NR-LTE co-existence

Qualcomm

Background

- RAN1 has considered two UE types
  – UE capable of dynamic power sharing, a.k.a. Type 1
  – UE not capable of dynamic power sharing, a.k.a. Type 2
- In the EN-DC power control procedure, RAN1 has considered that 'NR' in the Type 1 UE modem knows about 'LTE' but not the other way around
  – This is because the different time-lines between LTE and NR
    - This resulted in the decision of not changing LTE power by RAN1 power control definition for Type 1 UEs
    - This resulted in the decision of not supporting sTTI in EN-DC

Background

- The 4ms LTE timeline has always been assumed for LTE
  - E.g. no look-ahead in LTE CA or LTE DC

- **R1-143517,** WF on “look-ahead” aspect in asynchronous dual connectivity, Ericsson, NTT DoCoMo, Softbank, Nokia Networks, Nokia Corporation, Alcatel-Lucent Shanghai Bell, Alcatel-Lucent
- Agreements:
  - At least for PUCCH and PUSCH, for asynchronous dual-connectivity,
    - All remaining power is first made available to CG associate with earlier transmission
  - No-Look-ahead (for the case that transmission timing difference is larger than around 33 micro sec) is specified as the UE behavior
  - Definition of synchronous and asynchronous dual-connectivity is according to RAN4
    - Timing relationship in any TA groups should be clarified in RAN4
  - FFS: For asynchronous dual connectivity with the case that transmission timing difference is very small (e.g., around 33 micro sec)

Background

- The same assumption (no LTE look-ahead) has been made for EN-DC
- **R1-1715185,** Way forward on power sharing for LTE-NR NSA operation, Ericsson, CATT, Samsung, Mediatek, Nokia, NSB
- Agreements:
- 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_LTE + P_NR > P_cmax or P_LTE + P_NR = P_cmax
  - Signaling details for P_LTE, P_NR are left to RAN2, RAN4.
  - Note: 'P_cmax' is a limit that is similar to 'The configured maximum UE output power' that was specified for LTE.
  - Note: The network will still have flexibility to prioritize or reserve certain NR transmission power depending on network implementation
  - All UEs are mandated to handle P_LTE + P_NR = P_cmax while handling of P_LTE + P_NR > P_cmax depends on UE capability
  - At least, when DL/UL LTE sTTI/reduced UE processing time based operation is not configured for the UE, if total transmit power exceeds P_cmax when there is simultaneous NR and LTE UL tx,
    - For NR, UE scales down/drops NR transmission and NR power scaling details are left to UE implementation (note: it is not intended to have RAN4 test from RAN1 perspective)
  - If there are two or more UL carriers, the power scaling or tx dropping can be performed for each of the UL carriers separately or jointly up to UE implementation
    - For LTE, no change in power control procedure
  - FFS the case when DL/UL LTE sTTI/reduced UE processing time based operation is configured for the UE
  - The following is FFS
    - The case when P_NR is configured such that P_NR < P_cmax, and UE can use power up to P_cmax in NR when it knows that there will be no UL transmission in LTE by semi-static configuration (e.g., measurement gap, DL/UL configuration)

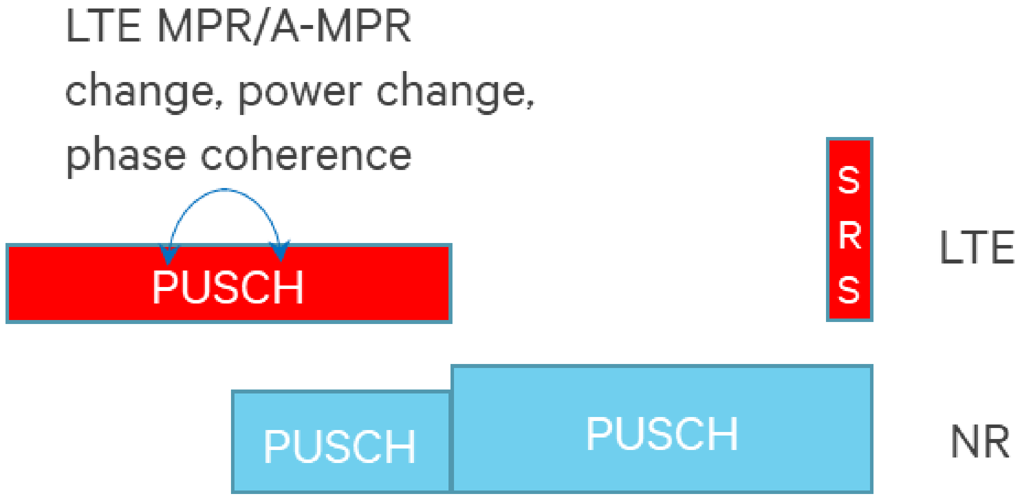
Background

- RAN4 has defined MPR/A-MPR definitions [R1-1807805, “LS on RAN4 agreement on intraband EN-DC A-MPR”], which made different set of assumptions
  - ‘LTE side knows about NR side’, even if NR UL grant arrives much later than LTE grant
  - LTE PHR has a dependency on NR grant, even if NR UL grant arrives much later than LTE grant

- The RAN4 decisions require substantial changes in the LTE processing time requirements, even though the NR Work Item was aimed to minimize impact resulting from NSA to LTE physical layer

Background

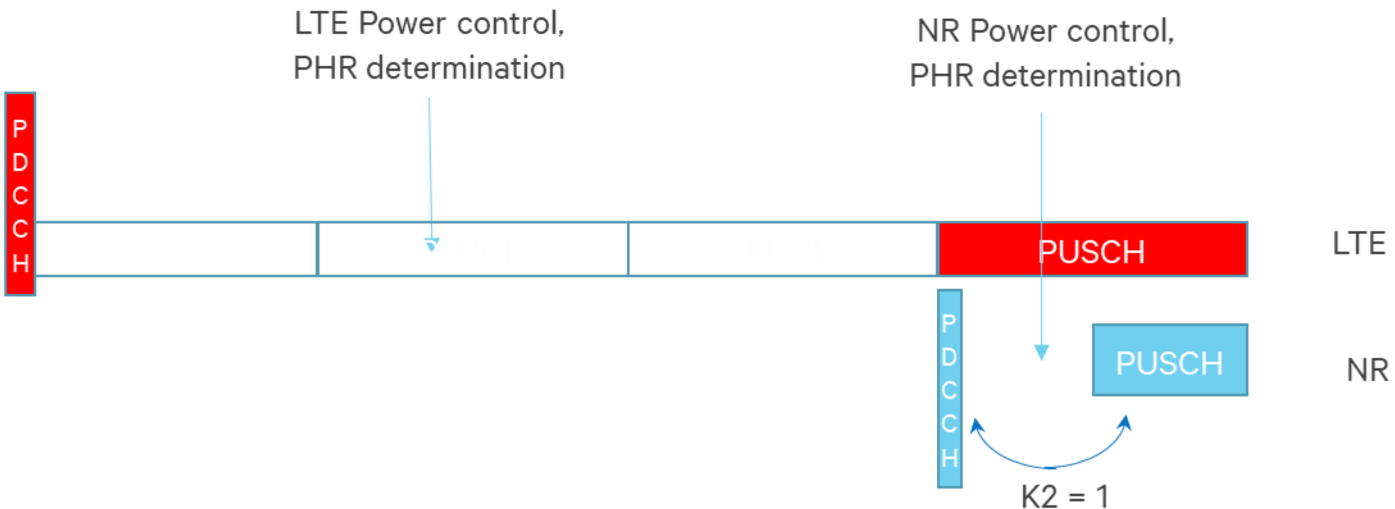
- Consider that LTE and NR use different slot formats, numerologies, the situations depicted below will occur for Type 1 UEs



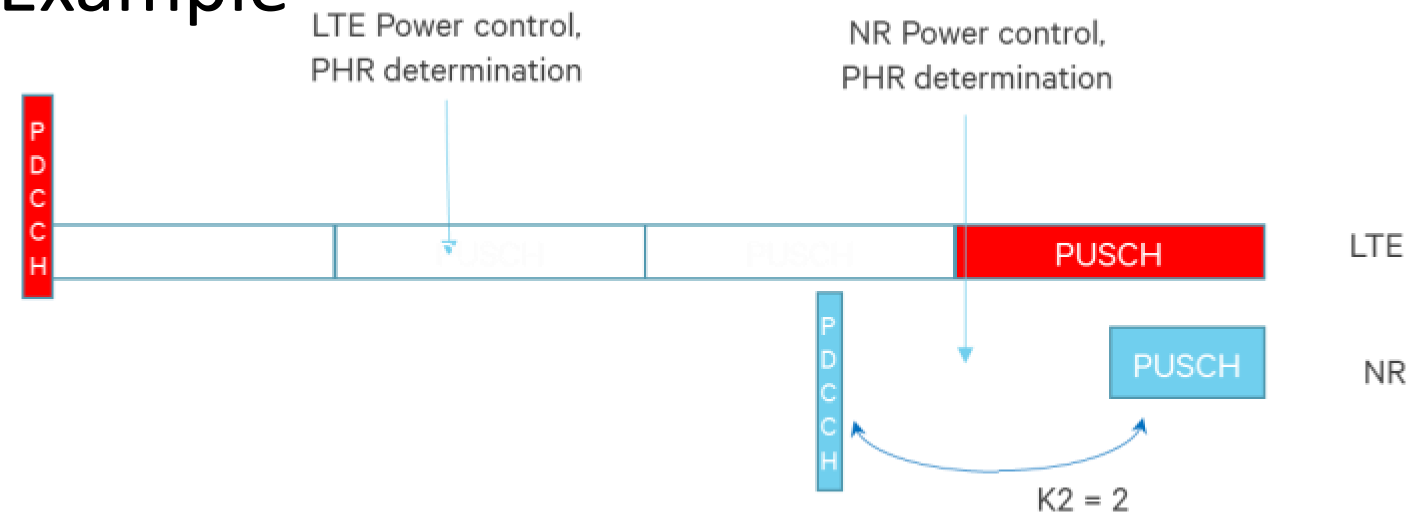
- The RAN4 decision results in LTE power changes within the LTE subframe, which is not supported in the LTE air-interface

Background

- FDD Example



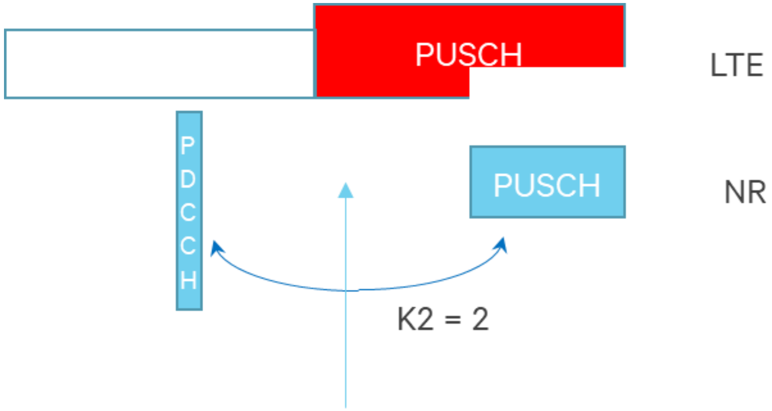
- TDD Example



Background

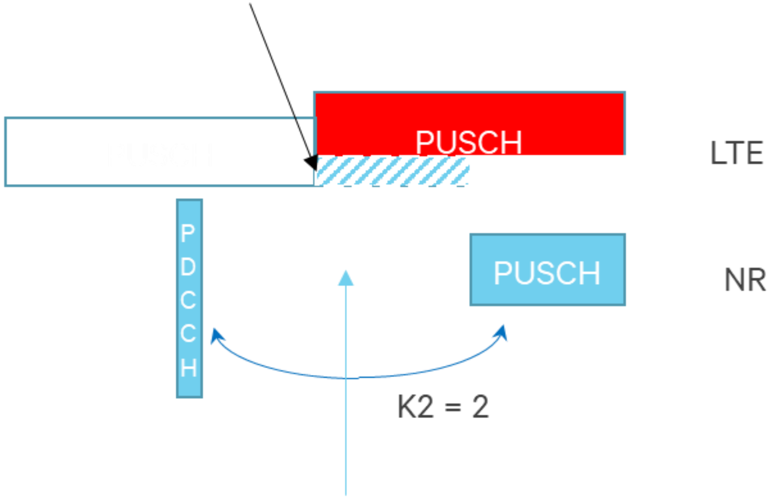
- Example

MPR/A-MPR change



NR Power control,
PHR determination

UE would be allowed to apply to same MPR/AMPR in first slotas in second slot but even NR timeline is not met



NR Power control,
PHR determination

Proposal 1

- Adopt Alt.1 with the following modification
  - UE is allowed to drop NR if the NR power scaling (related to MPR and power cap) is more than XdB or if the LTE-NR PSD difference is more than YdB
  - X is [0, 2, 4, 6]dB
  - Y is up to RAN4
- Potentially adopt Alt.2 if FFS can be resolved
  - New signaling for
    - '1-bit' to configure Alt.2 mode
    - '1-bit' for Alt.2 UE capability
- No new signaling for LTE processing time capability

Background to Proposal 1

- Alt.1. MPR/A-MPR applies to combined power
  - LTE power is determined independent of NR (i.e. with assuming no NR transmission)
  - LTE power is not changed if a later NR grant is received
    - UE is expected to adjust NR power to take advantage of relaxation provided by MPR

Note: Alt.1 requires no RAN1 specification changes

Note: Alt.1. depends on adoption by RAN4

Note: Alt.1 does not depend on timeline constraints

Note: Whether Alt.1 needs new MPR/A-MPR values is up to RAN4

Background to Proposal 1

- Alt.2. Delayed NR
  - LTE power is determined with taking into account NR scheduling information received ‘in time’
  - FFS handling of NR scheduling information received not in time
  - FFS Optional/Mandatory
  - FFS if Delayed NR method is configurable

Note: NR scheduling information includes DCI scheduling UL, DCI scheduling DL for which HARQ-ACK is sent, power control, etc.

Note: Alt.2. depends on adoption by RAN4

Proposal 2 (PHR)

- Adopt one of the following alternatives
  - Alt.1
    - The PHR reported in LTE is not dependent on NR allocation, i.e. the LTE PHR in EN-DC is always calculated with the assumption of no NR transmission
  - Alt.2
    - The PHR reported in LTE depends only on NR scheduling information received simultaneously or earlier than LTE scheduling information
      - Scheduling information includes for example PDCCH scheduling UL or PDCCH scheduling DL for which HARQ is sent in the UL, PDCCH including TPC, etc.

Note: Current RAN1 LTE specification implies Alt.1

Note: If RAN4 adopts EN-DC MPR/A-MPR framework where LTE maximum power depends only on LTE information then Alt.1 would be adopted

Proposal 3 (TDM)

- Clarify in the RAN1 EN-DC procedures that a UE indicating single Tx capability is not expected to be configured with simultaneous transmission in the MCG and SCG (both for TDM Case 1 and Case 2)

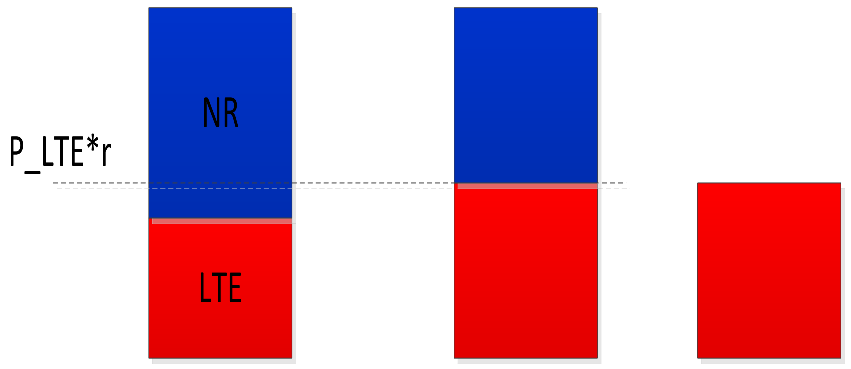
Proposal 4 (NE-DC)

- The dynamic power sharing mechanism may negatively impact NR scheduling latency. To ensure LTE connectivity with un-coordinated NBs, certain power can be reserved for LTE. Since fast processing capability is expected for NR, LTE transmit power should be determined first and then NR transmit power. It's therefore sensible to limit LTE transmit power if there is any potential of collision with NR and allow NR to take all the remaining power. The details of such a power control mechanism are described in the following proposal.

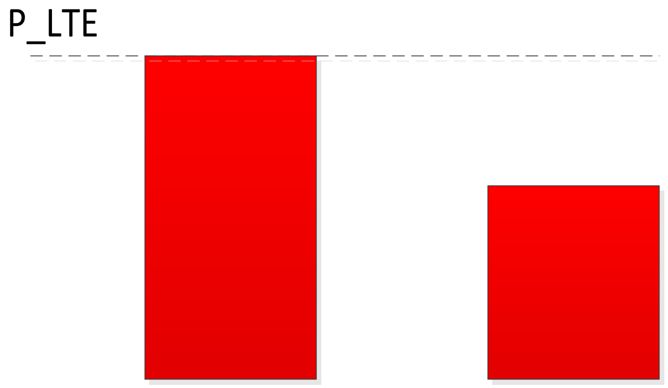
- **Proposal 4: For NE-DC, support the following dynamic power control:**
  - **UE is configured with p_LTE for LTE, r(<=1), and with p_NR for NR**
  - **For an LTE subframe that overlaps with any possible NR UL symbol(s), set LTE power limit Pcmax=p_LTE*r; otherwise, set power LTE limit Pcmax=p_LTE.**
    - **A possible NR UL symbol is identified as an NR symbol configured as flexible or UL based on cell-specific or UE-specific (if configured) tdd_UL_DL_Configuration_Common/dedicated.**
      - **FFS dynamic SFI based on DCI format 2_0**
  - **The remaining power up to p_NR is allocated to NR by setting NR power limit as Pcmax= min(p_NR, p_total-p_lte_actual) where p_lte_actual is the power allocated to LTE.**

Background to Proposal 4 (NE-DC)

- LTE power setting with and without potential collision with NR is depicted in the following figure.



subframes overlapped with NR UL symbol(s)



Subframes not overlapped with NR UL symbol(s)