3GPP TSG RAN#85
Newport Beach, USA, 16th – 20th, Sep 2019

RP-192069
Agenda item: 8.1.8

Rel-17 Power Saving Enhancements

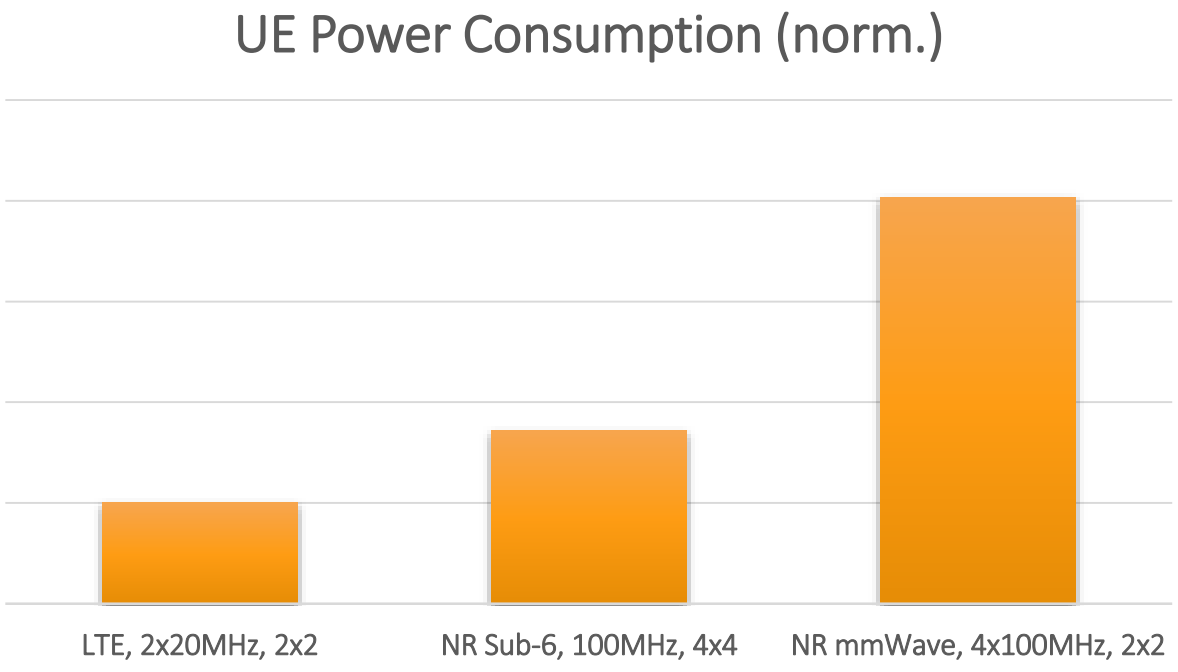
MediaTek Inc.

Motivation

User experience = key to 5G/NR success

- Mass transition to 5G will be slower if UE battery life expectations are not met
- Users expect better 5G device battery lifetime with 4G-like applications
- NR UE power saving features are essential enablers for the 5G ecosystem

User Experience	Design Aspect
Data Rate	Capacity
Battery Life	UE Power Saving



Power Saving Feature Migration Paths

Feature	Rel-15	Rel-16	Rel-17
cDRX	- Optimization for short Active Time	- Power saving signal/DCI for wake-up	- Enh. for at least multi-beam and CA operations - Enh. for power saving signal/DCI - reliability and functionality

L1-based adaptation	- DCI-based BWP switch framework:
	  - UE BW
	  - PDCCH monitoring period
		- BWP framework extension:
		  - Adaptation to maximum #MIMO layers
		  - Adaptation to SCell dormancy behavior
		  - Adaptation to cross-slot scheduling for an active BWP
			- Enh. for BWP framework to reduce system impact
			  - Reduced data interruption
			  - Reduced switch delay
			- Enh. for emerging 5G latency-sensitive services
			  - Cloud gaming, AR, XR, etc.
			  - New L1 dynamic scheme(s), e.g., PDCCH skipping

SCell adaptation	- MAC CE based SCell activation/deactivation		
Cross-slot scheduling	- K0/K1/K2 RRC Configuration		
Idle mode	- Priority search criterion	- RRM relaxation	- Enh. for idle-mode power saving - Subject to paging latency requirement for smartphones
Assistance info	- N/A	- UE suggestions for RRC state, cDRX setting, [#SCell and #MIMO layers]	- Enh. for assisting network and UE power saving

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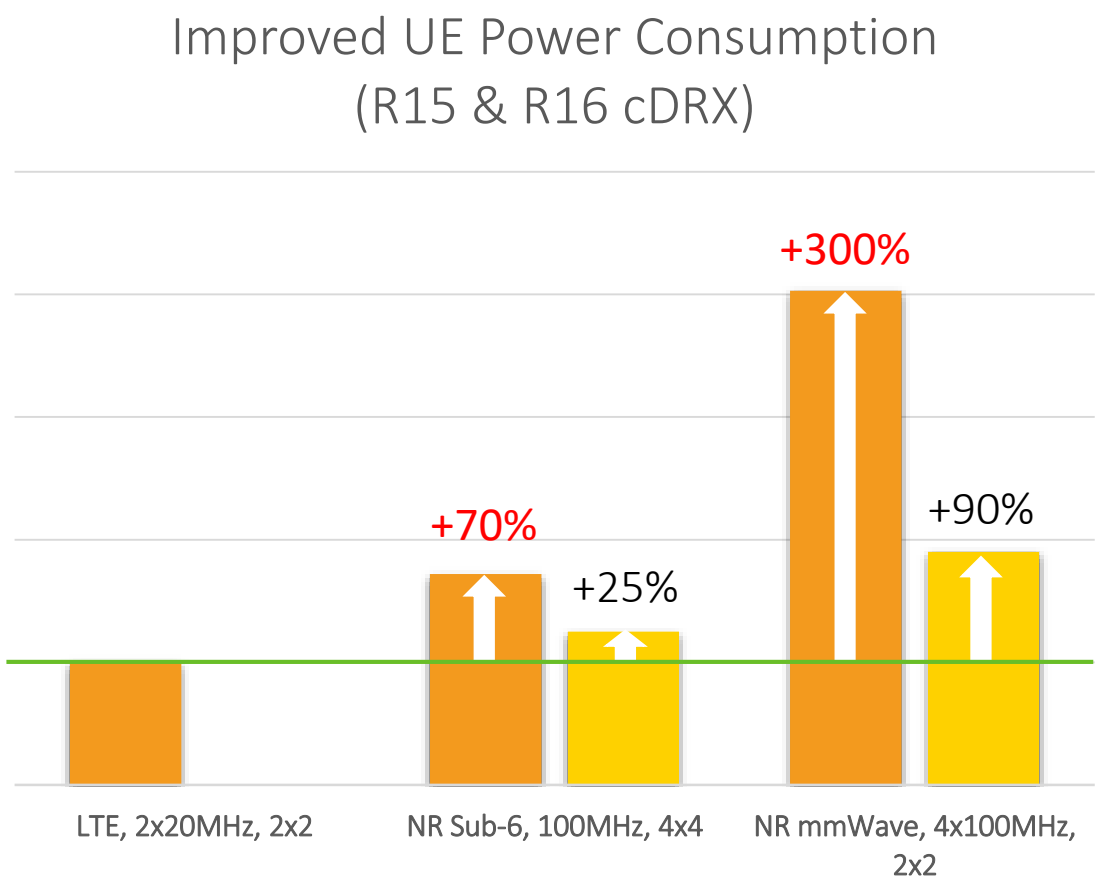
Connected-Mode DRX

- **R15:** Config. Optimization for reduced Active Time
- **R16:** Power saving signal for wake-up
  - FR1: From +70% to +25% vs LTE baseline
  - FR2: From +300% to +90% vs LTE baseline

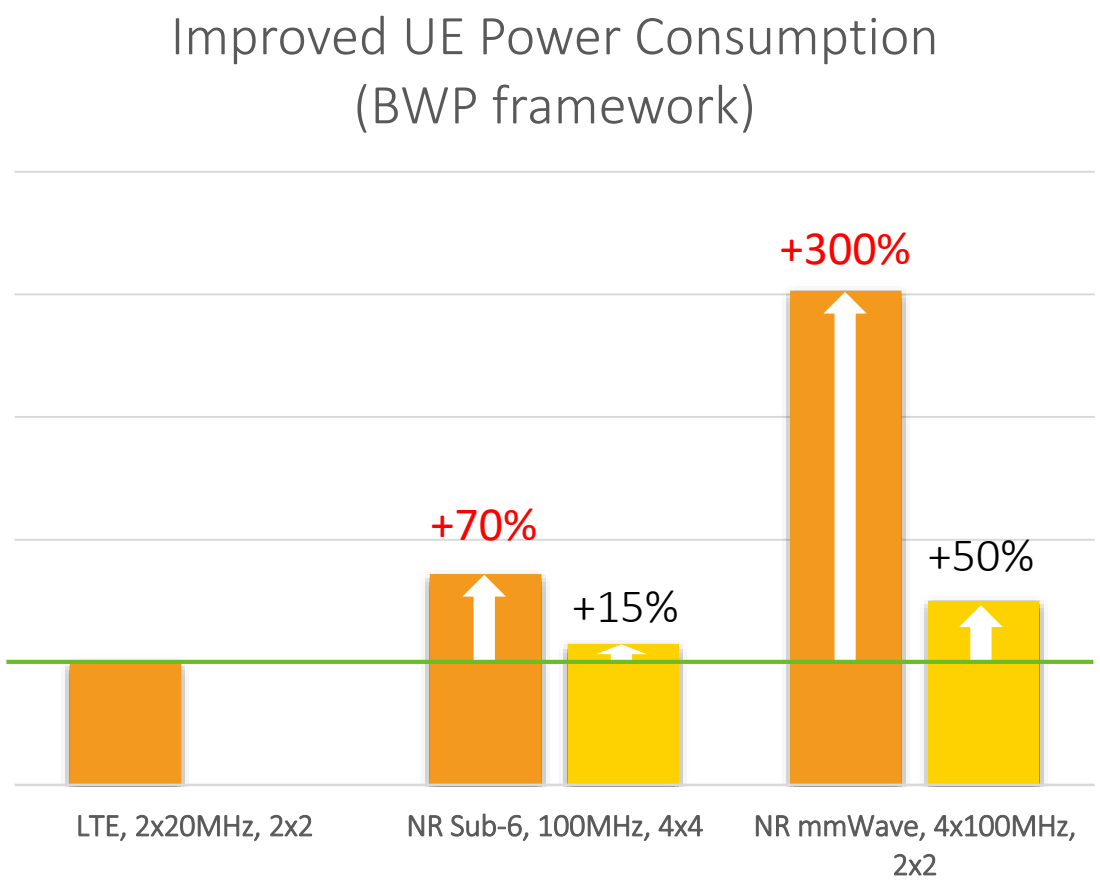
- **R17 Recommendations:**
  - Enhancements for at least **multi-beam** and **CA** operations
  - Enhancement or **power saving signal: Reliability & functionality**



BWP-Based Power Saving

- **BWP framework** (+ R15 cDRX)
  - BW Scaling
  - PDCCH monitoring adaptation
  - SCell dormancy behavior
- FR1: From +70% to +15% vs LTE baseline
- FR2: From +300% to +50% vs LTE baseline
- Better power saving; but data interruption during BWP switch
  - FR2: 18 slots w/o data scheduling

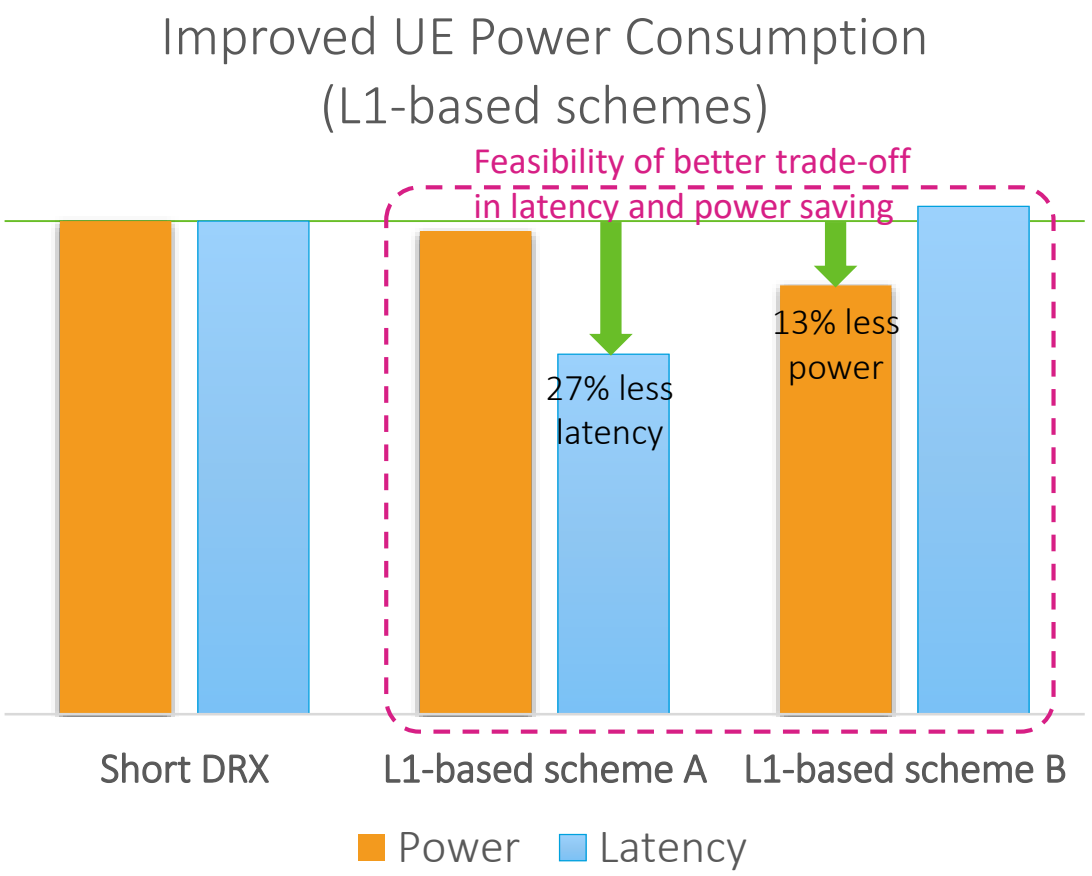
- R17 Recommendations:
  - Reduced switch delay
  - Reduced data interruption



Power Saving for Emerging 5G Services

- Emerging 5G services:
  - Cloud gaming, Mobile AR/VR
  - Very short data arrival interval
- UE keeps busy even with DRX
- Latency ~cycle/2 if DRX ON timing not matched to data arrival
- L1 dynamic scheme(s) can improve

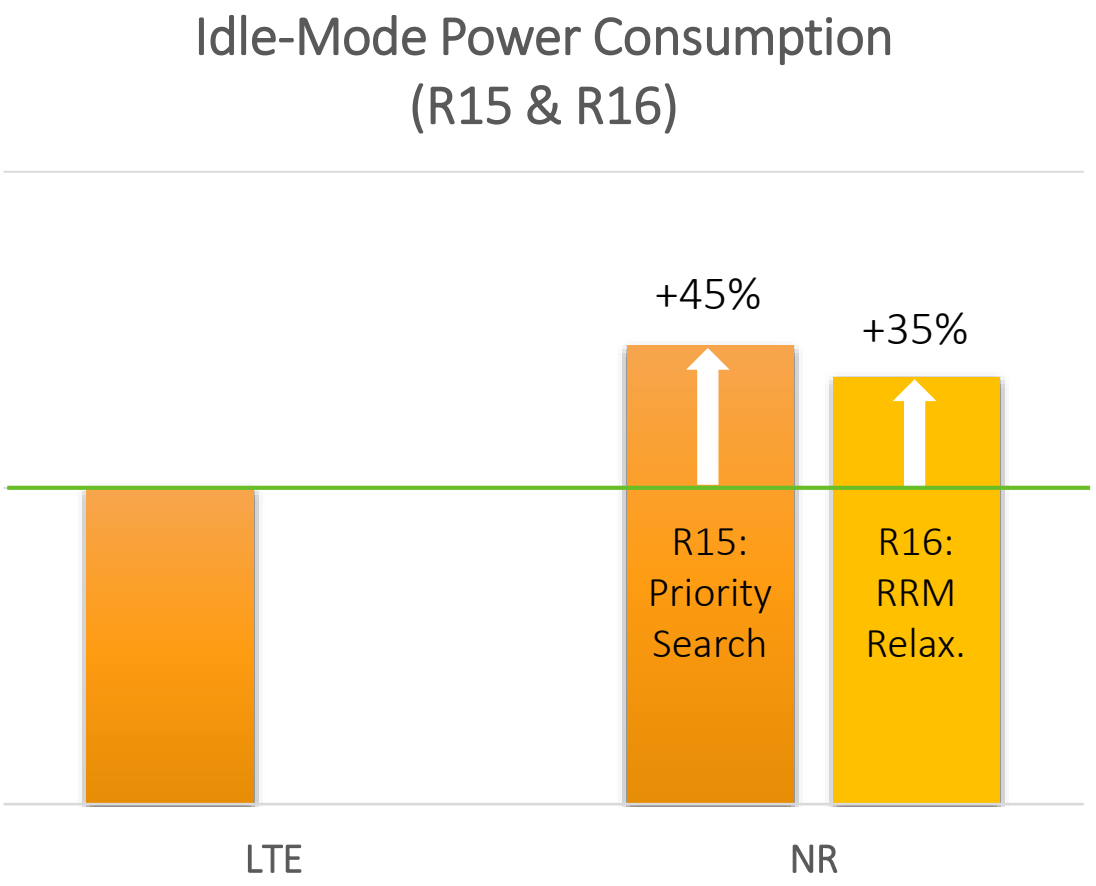
- **R17 Recommendation:**
  - New L1 dynamic scheme(s) for improved latency and power-saving trade-off (with short DRX or no DRX)



Idle-Mode Power Consumption

- +45% more idle-mode power consumption than LTE
  - Distributive SSB resources
  - More wake-ups and corresponding energy overhead
- R17 enhancement needed for smooth migration to SA

- R17 Recommendations
  - Paging enhancement(s) for reduce UE wake-up frequency
  - Assistant information and/or resource for reduced UE wake-up time in idle-mode



Suggestions for R17 Power Saving Enhancement

- Enhancements for NR UE Power Saving Features
  - Connected mode DRX
  - BWP framework
  - Aiming for better power saving and less system performance impact (incl. latency, data interruption)
- Enhancements for emerging NR use cases
  - 5G differentiating services, including cloud gaming, mobile AR, XR etc.
  - NSA to SA, by improving idle-mode power consumption
- Study network power saving to improve overall NR energy efficiency

THANK YOU!

- For more details of the technical evaluations, please refer to R1-1909740
- Please refer to the following pages for more specific items suggested for R17 power saving enhancements (as in RP-192070)

Suggested Initial WID Scope for Email Discussion

Suggestion Initial WID Scope for Email Discussion (1/4)

1. Specify enhancement(s) for connected-mode DRX operations [RAN2, RAN1, RAN4]
   a) Specify enhancement(s) for reducing PDCCH monitoring power consumption, regarding multi-beam, carrier-aggregation, multi-TRP and dual-connectivity operations [RAN2, RAN1]
   b) Specify measurement relaxation, especially for short DRX cycle [RAN2, RAN4]
   c) Specify RS assistance to UE warm-up (e.g., time/frequency/beam tracking) for DRX on-duration and/or WUS occasion [RAN1, RAN2]

Suggestion Initial WID Scope for Email Discussion (2/4)

2. Specify enhancement(s) for L1-based power saving schemes [RAN1, RAN2, RAN4]
   a) Specify enhancement(s) for power saving signal reliability, considering miss-detection due to beam and/or LBT failure and false-alarm [RAN1, RAN2]
   b) Specify enhancement(s) for triggering power saving adaptations using power saving signal, including triggering BWP switch on specific parameter(s), SCell dormancy behaviour switch and A-CSI report without PDCCH monitoring [RAN1, RAN2]
   c) Specify enhancements for BWP switch with difference only in power saving related parameter(s), including PDCCH monitoring setting, CSI setting, TDRA table, and/or maximum number of MIMO layers:
      i. Allow UE to indicate reduced BWP switch delay and interruption time [RAN4]
      ii. Reduce RRC signalling overhead for BWP configuration [RAN2]
   d) Study/specify DCI-based scheme to trigger aperiodic short-term PDCCH monitoring skipping for latency-sensitive services, based on short DRX or no DRX [RAN1, RAN2]

Suggestion Initial WID Scope for Email Discussion (3/4)

3. Specify enhancements to reduce UE idle-mode power consumption [RAN1, RAN2, RAN4]
   a) Specify broadcasting assistance information to idle mode UEs, including the information of potentially cell-wise available RS and/or code rate limit on paging data [RAN1, RAN2]
   b) Specify enhancement(s) for paging indication, time-frequency synchronization, and RRM measurement to reduce UE wake-up time, including enhancement(s) for PDCCH-based paging indication and/or additional RS/sequence [RAN1, RAN4]
      - Note: No impact to legacy idle-mode UEs
   c) Specify paging procedure enhancement for reduced UE wake-up frequency, including reduction in paging false alarm rate [RAN2]

Suggestion Initial WID Scope for Email Discussion (4/4)

4. Study/specify techniques for network power saving, including [RAN1, RAN2, RAN4]
   a) Study/specify gNB antenna adaptation and network cells ON/OFF and the corresponding requirement(s) on UE [RAN1, RAN4]
   b) Study/specify UE assistance information to assist network power saving [RAN1, RAN2]

5. Extend UE power consumption model to cover more use cases [RAN1]
   a) Include traffic model for services of lower latency requirement, e.g., cloud gaming, XR, etc.
   b) Extend simulation assumptions, including DC and CA with SCell dormancy behaviour, NR-U power scaling regarding LBT, FR2 BW scaling, UE behaviour for beam-management, UE behaviour for paging monitoring regarding measurements, etc.