



SCOPE OF REL-16 NB-IOT



INTRODUCTION

- › NB-IoT was during Release 13/14 designed as a lean and ultra-low complexity mMTC access technology.
- › Release 15 introduces support e.g. for TDD operation, early data transmission and a wake-up signal.
- › This contribution outlines our views on NB-IoT Release 16 which is based on the following observations and principles:
 - The number of connected devices will grow rapidly in the coming years.
 - This requires 3GPP to make the system more efficient and further improve the fundamental performance aspects; coverage, power consumption, system capacity.
 - Support new use cases when requested by the market.
 - Continue to follow the NB-IoT design principle of ultra-low complexity.



CONTENT



- › Our Release 16 proposal is divided into six areas covered in this presentation:
 - Enhanced network management tools
 - Further improved spectral efficiency
 - Improved coverage performance
 - Idle Mode mobility enhancement
 - Support of new use cases
 - Release 15 left overs

- › Items considered to be included in the ‘IoT/MTC Convenors’ preliminary Rel-16 recommendation is marked with **[INC.]**

ENHANCED NETWORK MANAGEMENT TOOLS

LOAD CONTROL [INC.]



› Congestion/load control in RRC connected mode [RAN2 lead]

- An mMTC network it is expected to manage high levels of connected devices.
 - › Besides the anticipated high load levels, this is a consequence of e.g. the long transmission times and long cDRX cycle.
- It is proposed that the Network control of UE behavior in RRC connected mode is extended to support the prevention of mobile originating signaling and/or data traffic.
 - › The most basic functionality is to enable access class barring in RRC Connected mode.
 - › A further enhancement is the support of SI acquisition in RRC Connected mode.

› Proactive load distribution [RAN2 lead]

- Introduce tool(s) for implicit load distribution over time to manage traffic spikes
 - › For mobile terminated access the paging cycle distribution across the DL frame structure provides load distribution over time. Similar functionality does not exist for the mobile originated (MO) access.
 - › Controlled spreading of MO access over time will improve the system capacity and quality. This can be facilitated with no additional/explicit signaling.
- Introduce a mechanism for preventing CE level ramping due to access overload
 - › A UE in good radio conditions should not be permitted to perform CE level ramping as this leads to reduced system capacity and increased interference levels.

ENHANCED NETWORK MANAGEMENT TOOLS

SON/ANR [INC.]



› SON/ANR [RAN2 lead, RAN3]

- LTE provides Self-Organizing Networks (SON) functionality to support network configuration, tuning and optimization. NB-IoT do however so far lack UE support for SON functionality.
- NB-IoT network configuration/tuning/optimization may therefor be unnecessarily time consuming, costly and inaccurate.
- It is proposed to specify the following SON enablers based on existing LTE features:
 - › Reporting of Cell Global Identity and strongest measured cell(s).
 - This is an enabler for Automatic Neighbor Relations (ANR) cell planning and important for avoiding and resolving PCI conflicts.
 - › Random access performance and radio link failure (RLF) reporting.
 - This will improve observability and control of random access performance and coverage.

FURTHER IMPROVED SPECTRAL EFFICIENCY



› DL channel quality feedback [RAN1 lead, RAN2, RAN4]

- Rel-14 supports early reporting of the anchor DL channel quality. Beyond this the eNB has limited information for performing efficient NPDCCH/NPDSCH link adaptation.
- It is proposed to introduced early non-anchor [INC.], periodic and event based DL channel quality feedback to support improved link adaptation.

› Closed loop UL power control [RAN1 lead, RAN2, RAN4]

- The inability to actively power control the NB-IoT UL leads to inefficient link adaptation and prolonged transmission times when using no repetitions. When using repetitions the use of max power may increase network interference levels.
- It is therefore proposed to introduce closed loop UL power control supported by periodic and event based PHR report.

› Cross-carrier scheduling [RAN1 lead, RAN2] [INC.]

- It is proposed to specify DCI support for cross-carrier scheduling.
- This will enhance the systems ability to efficiently share resources between NB-IoT and LTE, and later NB-IoT and NR.



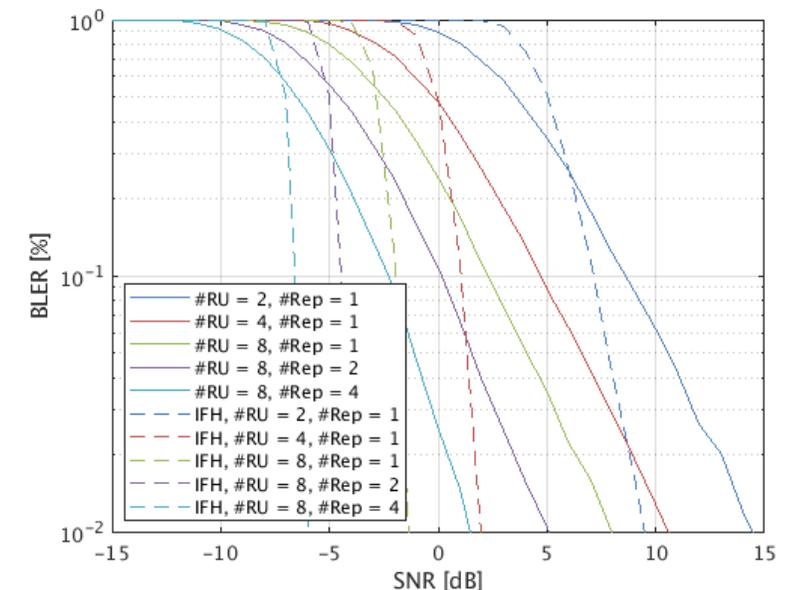
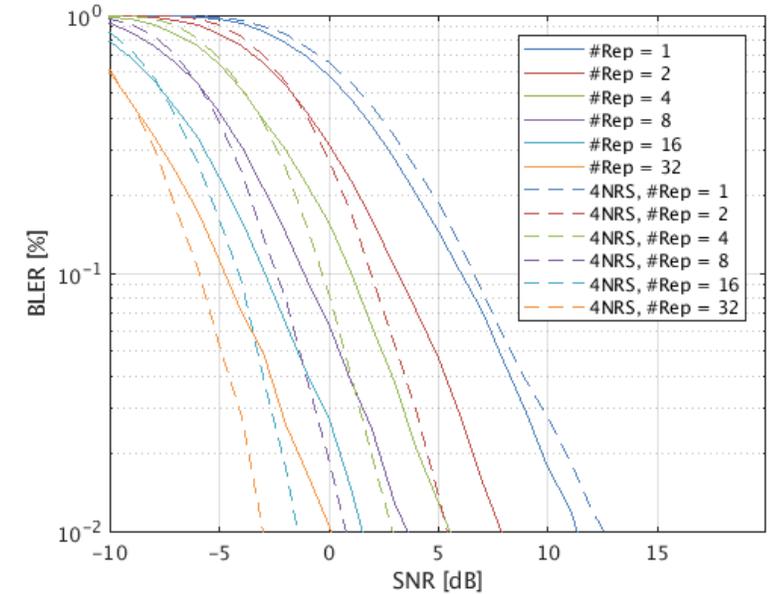
IMPROVED COVERAGE PERFORMANCE

› Four NRS antenna ports [RAN1 lead, RAN2, RAN4]

- The BS support for 4 physical antenna ports is increasing. This improves UL performance.
- To also support enhanced NPDCCH/NPDSCH performance in RRC Connected it is proposed to specify TM2 with support for 4 NRS ports, i.e. SFBC combined with antenna port switching.
- The added space diversity brings significant gains in the low SINR domain, as exemplified to the right for the NPDCCH.
 - › The performance degradation for the no repetition case is due to the added NRS overhead. Since the feature is intended for UEs in poor radio conditions, this is not an issue.

› Frequency Hopping [RAN1 lead, RAN2, RAN4]

- FH is a well proven method for improving performance in narrowband systems.
- It is applicable to both NPDSCH and NPUSCH, regardless of the BS antenna configuration.
- The added frequency diversity brings significant gains in the low SINR domain, as exemplified to the right for the NPUSCH F1 single subcarrier allocation using TBS 256 bits.



IDLE MODE MOBILITY ENHANCEMENT [INC.]



› Idle-mode inter-RAT mobility [RAN2 lead]

- There is a growing eco system for NB-IoT chipset and modules.
- In many cases these support multiple RATs.
- To enhance the devices ability to camp on the most suitable RAT it is proposed to specify the most basic level of support for idle-mode inter-RAT mobility.

SUPPORT OF NEW USE CASES



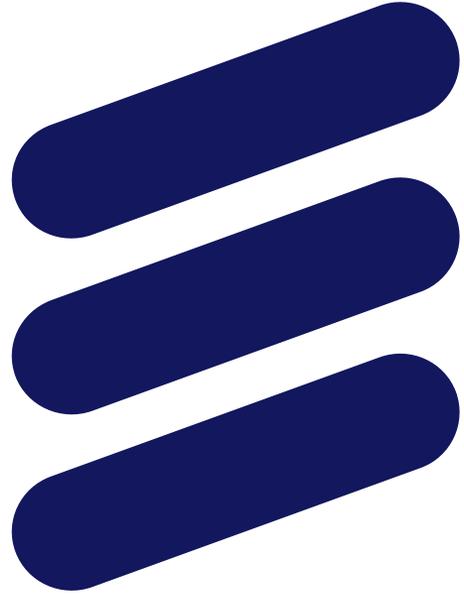
› Public warning system [RAN2 lead]

- NB-IoT is with its long range and robust performance suitable as a warning and alert system. Examples of commercial activities using NB-IoT as a warning system is already available.
- To support this it is proposed that NB-IoT from Rel-16 supports:
 - › Earthquake and Tsunami Warning System (ETWS) features
 - › Commercial Mobile Alert System (CMAS) features

RELEASE 15 LEFT OVERS



- › In Release 15 time did not permit specification of the following features which should be prioritized in Release 16:
 - Mobile terminated Early Data Transmission [INC.]
 - › This to support User Plane and Control Plane data transmission in Msg4.
 - Small cell UL power control enhancement
 - › Typically the permitted UL power level (P_{max}) is limiting the UE output power in a small cell scenario. For a small cell UE in deep indoor coverage this may lead to wasteful use of high PUSCH repetition levels.
 - › Support for CE based UE power limitation is proposed as a mechanism to improve the small cell UE battery life and spectral efficiency.



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