

3GPP TSG RAN Meeting #72
Busan, Korea, June 13 - 16, 2016

Document for: Discussion
Agenda Item:

RP-160996



Motivation for new WI on Enhancement of NB-IoT

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Justification

- Rel-13 introduces NB-IoT with 180kHz/200kHz UE RF bandwidth which can be deployed in 3 scenarios
 - In-band
 - Guard-band
 - Standalone
- It is important to further enhance NB-IoT in R14
 - Further enhance NB-IoT in R14 without significantly increasing device cost
 - Support of higher peak data rate and voice by introducing a new high-end UE category

NB-IoT+ narrow band positioning (1)

- IoT positioning is different from the MBB positioning
 - Different applications from smart phones
 - Locate lost children/old people, animals/pet tracking. Both outdoor and indoor positioning are required. Precision of 50m is required and of 20m is desired for outdoor scenario. Low power consumption is necessary to avoid frequent re-charging
 - Logistics such as asset tracking, such as bicycle, electrical bicycle tracking, valuable goods and vehicles tracking. Both outdoor and indoor positioning are required. Precision of 50m is desired for outdoor scenario. Low power consumption is necessary to avoid frequent re-charging
 - Traffic report with location to improve the operation efficiency, i.e., fast repair. Applications include smart street lighting, smart water pipe leakage monitoring, smart trash bin, microgeneration (monitoring status of generation equipment (solar, wind, thermal) with sensors, smart grid (energy infrastructure monitoring), fire hydrant network monitoring, environmental monitoring. Generally outdoor and precision of 50m is desired.
 - Different constraints from smart phones
 - Most of devices are stationary or nomadic, i.e. not continuously moving
 - Narrower UE transmission and receive bandwidth
 - Needs low cost and low power consumption
 - Accuracy of no less than 50m at least for outdoor applications

NB-IoT+ narrow band positioning (2)

- Design principle
 - UTDOA is preferred
 - It has small impact on device cost. OTDOA may increase the device complexity
 - Some tracking applications are less sensitive to power consumption because 10 year's battery life is not required for tracking applications such as animal tracking, people tracking
 - No impact to the power consumption if the device is stationary and equipped with battery because positioning only occurs once or few times.
 - Can be based on single tone hopping or dedicated reference signal
 - Accumulate energy in time to achieve better accuracy
 - Improved E-CID positioning [RAN4 lead]
 - RSRP/RSRQ based
 - UE Rx-Tx based on existing signal
 - eNB AoA

NB-IoT+ multi-cast downlink transmission(1)

- Motivation
 - Software/firmware update is an essential service for IoT in future, to allow deployed devices to receive patches and software upgrades without in-field device replacement.
 - To improve the spectrum efficiency for software/firmware upgrade
- Design principle
 - Extend Rel-13 SC-PtM to support narrowband operation and coverage enhancement
 - Could include uplink feedback
 - The solution should not significantly increase the device cost and power consumption
 - Can be TDM with unicast or a dedicated PRB

NB-IoT+ multi-cast downlink transmission(2)

- Design principle
 - Group RNTI can be introduced to allow multiple users to receive the same traffic
 - Techniques to improve the multi-cast efficiency need to be considered
 - Handover may not be needed
 - Needs to consider dedicated resources or dynamic resources

NB-IoT+ non-anchor PRB improvements

- **Motivation**

- To further improve the system efficiency for multi-carrier scenarios

- **Design principle**

- Cross PRB dynamic scheduling for unicast transmissions [RAN1 lead, RAN2]
- SI transmissions on non-anchor carrier(s) [RAN1 lead, RAN2]
- Multiple configured NB-IoT carriers for NB-PRACH transmission [RAN1 lead, RAN2]
- Standalone PRB as the anchor and in-band PRB as the non-anchor PRB

NB-IoT+ Mobility enhancement

- Motivation:
 - In Rel13, idle mobility and load balance is provided mainly for low mobility UEs. Load balance for inter-frequency (anchor) carriers is available only for cell selection.
 - High mobility is an important scenario e.g. logistics tracking. Service continuity and the mobility performance needs to be enhanced to better serve the above applications.
- Design principle:
 - Techniques in cell reselection can be applied to enhance the inter-frequency load balance.
 - Measurement and/or reporting in connected mode can be applied to improve the mobility.
 - Data forwarding techniques can be used to improve the service continuity

NB-IoT+ contention based uplink access (1)

- Motivation
 - Signaling (e.g., scheduling, uplink synchronization) consumes a significant part of over-the-air transmissions, and therefore a large proportion of the communication delay and device power consumption
 - Emergency reports are very high priority when they do need to be sent with shorter latency by reducing signaling, e.g. fire alarm, lost person, etc.
- Design principle
 - Less signaling before uplink data transmission to reduce the transmission delay
 - Allocate dedicated time-frequency resources for contention based uplink access

NB-IoT+ contention based uplink access (2)

- Design principle
 - No uplink TA; longer CP can be used to enable asynchronous uplink transmission
 - Coarse levels of MCS can be supported to improve the capacity. Downlink measurements can be a reference for uplink MCS.
 - Single tone transmission may be enough for small traffic applications
 - No uplink TA. Uplink transmission is based on the downlink synchronization
 - ACK/NACK of NPUSCH may be helpful for better quality of services
 - Open loop power control to mitigate the interference
 - Space diversity can be applied to mitigate the interference
 - Contention resolution techniques needs to be considered
 - Support both MO and MT services
 - Can happen in idle mode and connected mode

Higher capability NB-IoT UEs

- Motivation
 - Support of voice
 - To better support the children/old people tracking application
 - To have one NB-IoT deployment that supports low rate and higher rate M2M services, with UEs deployed according to need
- Design principle
 - 16-QAM support
 - More than 1 HARQ process
 - Faster decoding times compared to Rel-13
- For voice support:
 - Necessary mobility enhancements
 - Larger TBS size and support for full buffer traffic
 - Semi-persistent scheduling

Support inter-RAT mobility SI/WI in SA2

- Motivation
 - One candidate application scenario is embedding the NB-IoT chipset into smart phone. When the smart phone is out of coverage or almost out of power, the NB-IoT chipset can be turned on and the MBB modem can be turned off to extend the battery life.
 - When the smart phone is lost, the owner can be able to turn off the smart phone completely while the NB-IoT equipped with its own small battery still works. So the owner is able to protect the security of the smart phones and the location information provided by NB-IoT is helpful for the owner to find the smart phone.
 - In the early phase, the dual mode of NB-IoT and GPRS may be helpful to guarantee the coverage.
- Only necessary support in RAN according to TSG SA work