Technical Paper

Comba

Open RAN and the Machines - NB-IoT

NB-IoT was first introduced by 3GPP in 2016. It is one of the low power wide area (LPWA) networks defined by 3GPP for Internet of Things (IoT) applications. NB-IoT is the foundation for applications like remote metering, environmental monitoring and other sensor networks which rely on battery powered IoT devices. The standard enables the much-needed energy-saving and extended coverage features that match the application scenarios. This technology has since been deployed by many operators in many countries and serves millions of subscribers (IoT devices). According to GSMA, as of Feb. 2022, there are 110 NB-IoT networks around the globe.

For Open RAN to be deployed in brownfield networks, NB-IoT is a mandatory feature to reach service parity. To maximise the depth and breadth of the NB-IoT coverage, an MNO usually deploys it in a low-frequency FDD band like 800MHz.

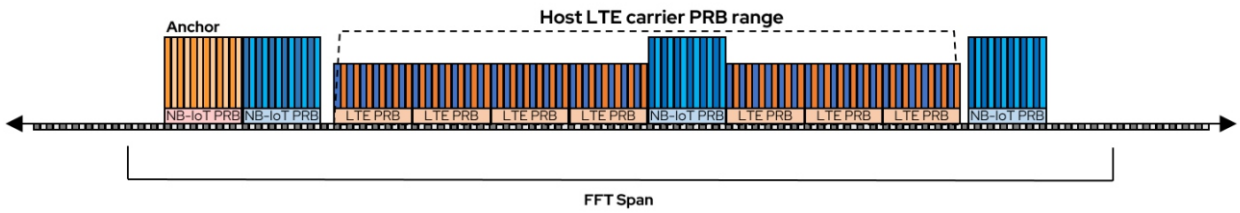
Although it is a very important feature for Open RAN networks, the O-RAN officially approved the full NB-IoT specification. The solution we present is a pre-standard solution which is agreed upon with a close DU software partner, that aligns with where we believe the standard is heading.

NB-IoT can be deployed in guard-band and in-band modes, so the solution should be able to handle both scenarios.

Downlink User Plane

In the DL user plane, there are mainly two solution alternatives, one is using a separate endpoint, while another is using a common endpoint for both NB-IoT and LTE carriers. Since from the RU perspective, NB-IoT is similar to LTE carriers, Comba is using the common endpoint in our solution to handle guard band NB-IoT carrier and use an extended PRB space approach that can be used to indicate the guard band NB-IoT carrier. As the below diagram depicts, the NB-IoT carrier will have a higher power density than the LTE carrier. The O-RU will allow a maximum of 6dB higher power for the NB-IoT carrier.

Guard-band and In-band NB-IoT carriers with host LTE carrier



Note: The subcarrier spacing depicted represents the downlink 15kHz SCS used for both LTE and NB-IoT, while NB-IoT would use either 15KHz or 3.75KHz in the uplink.

Uplink User Plane and RACH

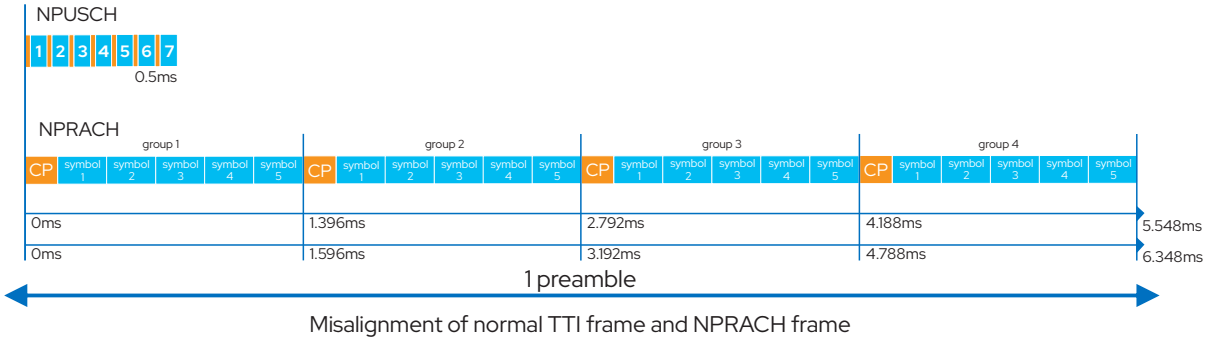
In the uplink, there are NPUSCH and NPRACH functions. O-DU has to distinguish the NB-IoT RACH from the LTE carriers RACH, because NB-IoT RACH has multiple repetitions, to enhance the coverage area. To handle this different, separated endpoint is inevitable. Therefore, the solution uses different eAxC IDs for the NPRACH and PRACH.

For the NPUSCH U plane packets, in of 15kHz SCS, it is similar to the normal LTE. However, for 3.75kHz SCS, we must use a separate endpoint.

THE CONTROL PLANE

While the user plane is simple, the control plane is more complicated. One of the main functions of the control plane is to manage how the O-RU processes the signal, for example, one can instruct the O-RU when to remove and when to add the Cyclic prefix (CP) packets.

According to the O-RAN standard, a control plane packet should be provided for every TTI or subframe, however, as mentioned above, NPRACH has multiple reptitions, and the NPUSCH subframe duration is not aligned with the NPRACH groups.



Misalignment of normal TTI frame and NPRACH frame

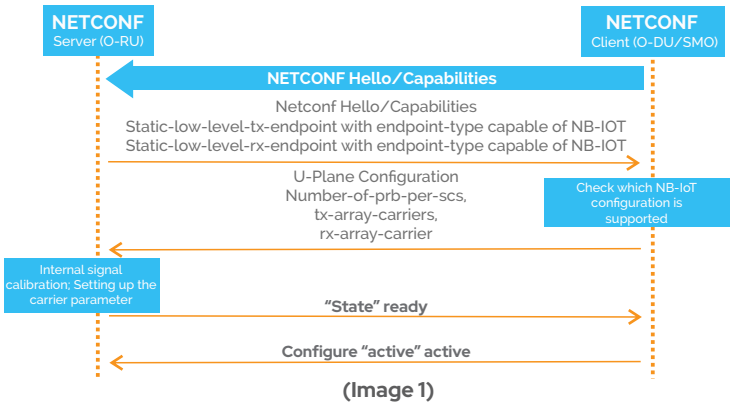
Given the above, Comba and our DU partner defined a method to align the timing of NPRACH by customized control plane packet which ensures that the O-RU can timely know how to group the symbols and how many repetitions there are in the NPRACH that the DU has configured.

THE MANAGEMENT PLANE

The management plane covers both in-band and guard-band operation of multiple NB-IoT carriers with the host carrier. It follows the sample user plane configuration procedure as LTE or NR.

As per the endpoint capability (Image 1), a new entry in the Yang model is also required. To keep the minimal modification in our solution before the O-RAN specification is finalized, only the endpoint type "NB-IoT" is introduced to represent O-RU support NB-IoT.

The extended PRB value will be presented to indicated guard-band NB-IoT (Image 2).



(Image 1)

LTE Channel Bandwidth	Start PRB num	Stop PRB num
10 MHz	0	51
20 MHz	0	105

(Image 2)

RADIO UNIT

As mentioned in the DL User plane, both in-band and guard-band NB-IoT carriers will transmit at a higher power level than the LTE carrier, and the O-RU will allow +6dB power for the NB-IOT carrier. To unify the implementation, it is expected that the DU sends a higher power scale of the input IQ symbol to the O-RU.

The O-RU can then use a common gain control for both LTE and NB-IoT carriers.

Another important feature in the O-RU is the shaper digital filter design which allows extra PRB at the edge of the LTE channel bandwidth for the guard band NB-IoT deployment.

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