# 5G RAN Optimizations through Radio Shared Data Layer (RSDL)


*Srinivas Kumar Tangudu*
*Product Manager, Nokia*
srinivas.kumar_tangudu@nokia.com

*Niraj Nanavaty*
*Product Manager, Nokia*
niraj.nanavaty@nokia.com

*Rajesh Banda*
*Product Manager, Nokia*
rajesh.banda@nokia.com

*Subramanya Chandrashekar*
*Senior Specialist, Nokia*
subramanya.chandrashekar@nokia.com

*Raghuram Krishnamurthy*
*Architect, Nokia*
raghuram.krishnamurthy@nokia.com

*Srinivas Bandi*
*Architect, Nokia*
srinivas.bandi@nokia.com



***Abstract*** *— This paper presents the challenges that are currently faced during X2/Xn handovers. Messages are exchanged between source and target eNBs over X2/Xn interface during handovers. This mechanism is quite inefficient due to messaging overheads, timers, retries and failures like message validation and resource unavailability. The paper proposes optimizations in the X2/Xn interface, thereby improving the handover success rate and reducing messaging overheads. The paper proposes moving the radio layer data from the individual nodes to a centralized database christened by us as "Radio Shared Data Layer" (RSDL) and demonstrates ensuing benefits. The paper also proposes an open interface from the radio shared data layer to 3rd party applications allowing them to be radio network context aware thus perform better and offer richer experience.*



***Keywords—5G, X2/Xn Handover, Radio Shared Data Layer***


## I. INTRODUCTION

Wireless mobile communication has come a long way starting from analog technologies such as AMPS (Advanced Mobile Phone System) and NAMPS (Narrow-band Advanced Mobile Phone System), evolving through digital voice-only 2G technologies like CDMA (Code Division Multiple Access) and GSM (Global System for Mobile communication) to data centric 3G technologies like UMTS (Universal Mobile Telecommunications Service) or WCDMA (Wide-band CDMA) and EV-DO (Evolution Data only or Evolution Data Optimized – a CDMA technology) to smart phone era 4G technology like LTE (Long Term Evolution) to new all-encompassing 5G technology. In all these technologies, mobility and optimal use of radio resources through load balancing are key features. 4G and earlier technologies used message exchange mechanism to carry out handovers and exchange data including neighbor lists and load information.

Such as mechanism is quite inefficient due to messaging overheads, timers, retries and failures such as message validation failure and resource unavailability. There is an urgent need to overhaul such a sub-optimal mechanism in 5G era to meet 5G performance requirements for ultra-reliable and low latency communication (URLLC).

## II. RADIO ACCESS NETWORK (RAN)

Wireless mobile communication system has two major parts – Radio access network (RAN) and Core. RAN consists of base transceiver station (BTS) or Base Station. BTS could be standalone or cloud based.

### *A. Standalone BTS*

Base stations are traditionally implemented as a standalone units or self-contained units on a specialized hardware equipment, with limited functionalities like remote radio heads separated from the system / baseband module units.

Standalone BTS is responsible for various functions like radio admission control, radio resource management (RRM), radio bearer control, mobility management, transport admission control, eNB/gNB measurement configuration, provisioning, CoMP, eMBMS and carrier aggregation.

### *B. Cloud BTS*

Cloud BTS introduced a completely new dimension to base station with software architecture split between centralized cloud and distributed baseband units. Base station software running on virtualized network functions (VNFs) in the cloud on a generic off-the-shelf hardware brings flexibility, scalability and reliability along with performance optimization. Non-real-time functions are implemented in the cloud bringing aggregation gains while real-time functions continue to be implemented on the distributed unit to meet performance demands.

### C. gNB

5G BTS is referred to as gNB. A gNB is a logical entity consisting of a Centralized Unit (CU) and one or more Distributed Units (DU). A gNB-CU consists of CU-Control Plane (CU-C) and CU-User Plane (CU-U).

### D. X2/Xn functions & procedures

Operators configure an eNB (LTE BTS) or a gNB (5G BTS) manually or through automated negotiated way with the information about peer eNBs or gNBs. These peer eNBs or gNBs exchange messages regularly or on a need basis over X2/Xn interface. These messages include eNB/gNB configuration update and handover request messages. These messages are large containing significant chunk of information including vital information on load and resource availability. This information needs some further intelligent processing. During failures, multiple such messages need to be sent back and forth leading to increased delay. These message exchanges warrant for indirect functions like message validations, retry timers, message version comparisons, comprehensive error management of returning different error codes.

Figure 1 shows some of the messages and information elements exchanged among the eNBs/gNBs and data storage on the eNBs/gNBs.

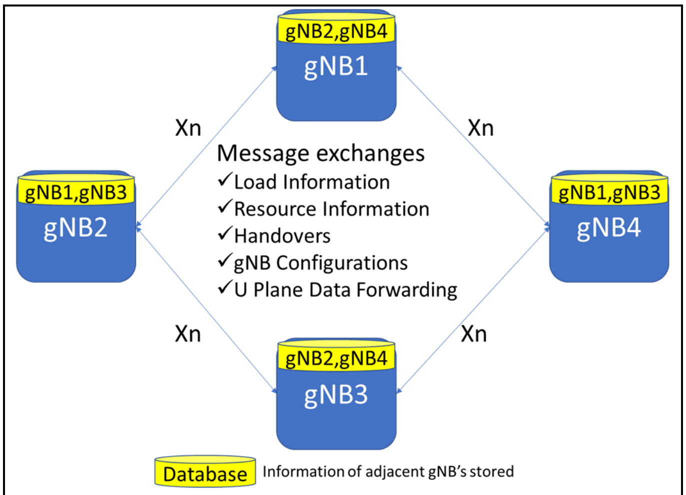


*Figure 1 Depiction of data storage in each gNB*

### E. Mobility management

Mobility management function allows handover of a user equipment (UE) from a source eNB/gNB to a target eNB/gNB. Source eNB/gNB (denoted as 'S-gNB') configures the UE with measurement reporting criteria. On meeting these criteria, the UE sends measurement reports to the S-gNB. Based on the measurements reported by the UE, the S-gNB identifies possible target eNB/gNB (denoted as 'T-gNB') using certain algorithm.

The S-gNB initiates a handover preparation by sending X2AP:*RESOURCE STATUS REQUEST* message to determine the load on the T-gNB. On receipt of successful X2AP:RESOURCE STATUS RESPONSE message from the T-gNB, the S-gNB proceeds with the handover.

The S-gNB sends X2AP:HANDOVER REQUEST to the T-gNB along with the necessary information (UE context including security context, RB context (along with E-RAB – RB mapping) and target cell info.

The T-gNB checks for resource availability. If resources are available, it reserves needed resources and sends back the X2AP:HANDOVER REQUEST ACKNOWLEDGE message containing new C-RNTI, T-eNB security algorithm, dedicated RACH preamble and some other information elements.

During handover, the S-gNB sends SN status message which includes the uplink/downlink PDCP SN and HFN status to the T-gNB. The S-gNB receives downlink data from the Serving Gateway (SGW) and forwards the same to the T-gNB.

### F. Messages related to other functions

There are some additional messages that are exchanged between two X2/Xn nodes. Some of them are periodic while the others are exchanged on a need basis. These messages consist of large data of information. These messages need to be sent to multiple of eNBs/gNBs.

Following are few of these messages:

- RESOURCE STATUS REQUEST
- RESOURCE STATUS RESPONSE
- LOAD INFORMATION
- ENB CONFIGURATION UPDATE
- ENB CONFIGURATION ACKNOWLDGE
- MOBILITY CHANGE REQUEST
- MOBILITY CHANGE ACKNOWLEDGE

### G. Optimizations needs

With 5G technology, number of cells is set to increase exponentially so would number of gNBs proportionately. Especially, with cm wave and mm wave, cell coverage will be less and number of gNBs will increase in case of dense deployments. Such network densification will lead to signaling storm in 5G RAN due to increased number of handovers, CoMP negotiations, load information sharing and so on.

With cell sizes becoming smaller and stricter demand on handover latencies being set for 5G, there is a need to reduce the signaling storm by devising an efficient handover mechanism.

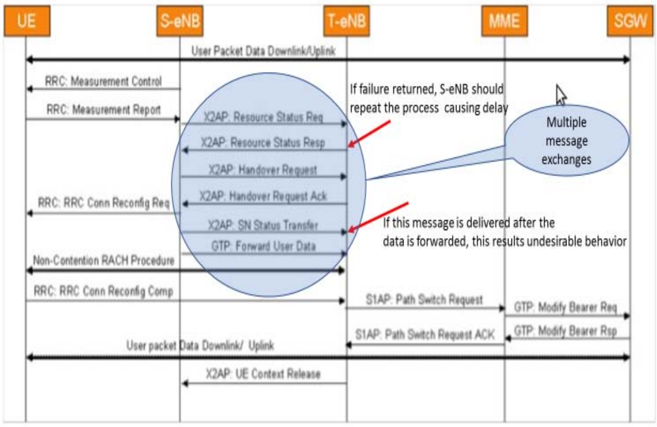


*Figure 2 Signaling during X2/Xn handover*

Further, features like dual-connectivity/multi-connectivity, CoMP, carrier aggregation among multiple macro and micro sites need optimized inter-gNB co-ordination.

## III. PROPOSED RSDL AND CRSDLF

To optimize inter-gNB coordination, we propose a new architectural element – centralized radio shared data layer (RSDL) that stores data that are usually exchanged between two gNBs to carry out various functions. However, just a data storage function is not sufficient for optimization. Therefore, we propose a centralized RSDL function (CRSDLF) – an intelligence layer operating on RSDL, that aides in taking the most optimal handover decision and orchestrating procedures such as CoMP, multi-connectivity optimally.

CRSDLF is placed along with a set of gNBs and eNBs, hosted in the same data center to store and access information instead of exchanging it among multiple gNBs/eNBs over external interfaces through messages.

CRSDLF works on the latest centralized data thus makes the most informed decision and avoiding many error scenarios thus optimizing various procedures involving multiple gNBs/eNBs.

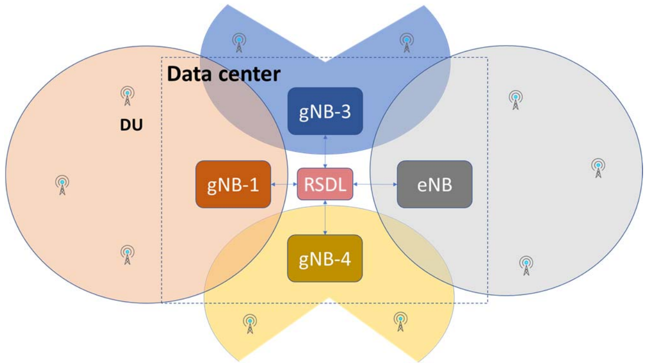


*Figure 3 Cloud RAN with CRSDLF*

Further, RSDL being a common repository accessed by multiple gNBs/eNBs allows common data to be updated and accessed by multiple gNBs/eNBs avoiding costly message exchanges thus reducing latencies associated with message formation, message transmission and message processing.

### A. *Data splitting*

Radio data pertaining to a gNB is shared among the gNBs which have X2/Xn connection with it. As per the new proposal, the radio data is stored in the RSDL and the CRSDLF processes the data and takes necessary actions.

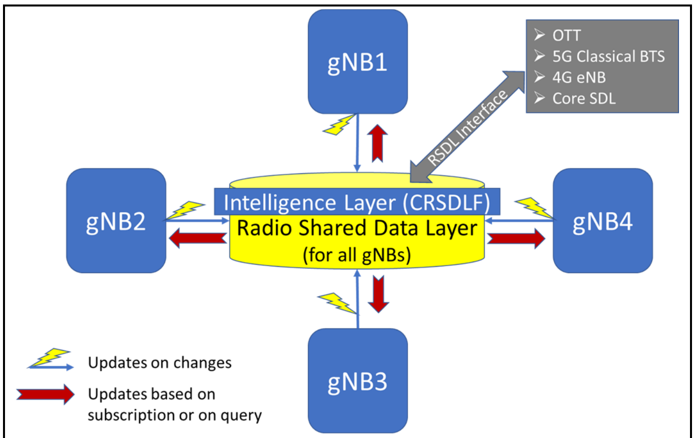


*Figure 4 Depiction of data storage in CRSDLF*

RSDL and CRSDLF should be placed in such a way that the end-to-end access latency and security requirements are met. CRSDLF monitors changes of the parameters related to the messages given in Figure 4 and triggers appropriate actions.

Access to the data stored in RSDL is available to all the gNBs on request or according to a subscription mechanism managed by CRSDLF.

CRSDLF provides an interface for OTT players. This interface allows applications/services to gain valuable insights into a radio network and helps optimize their performance. It could also facilitate new features and capabilities into these applications/services. For example, insight on the radio bandwidth availability to the users enabled the video application/service to adapt the end user video quality.

This interface can be extended towards the 4G eNB, Core Shared Data Layer (SDL) and 5G Standalone BTS.

This approach is in line with architectural requirement of stateless virtual RAN functions and brings in high availability to RAN functions. It also allows to eliminate the need for local storage.

### B. *Mobility management with CRSDLF*

Let us revisit the handover scenario orchestrated by CRSDLF leveraging RSDL.

In case of handover preparation, the S-gNB receives measurement reports from the UE once measurement reporting criteria that were previously configured by the S-gNB are met. The measurement is transparently stored in RSDL by the S-gNB. CRSDLF analyzes this update made into RSDL and initiates a method to identify most suitable T-gNB without any need to exchange messages like RESOURCE STATUS REQUEST. With this approach, handover failures are avoided and messaging is reduced.

CRSDL function indicates T-gNB of its selection. The T-gNB allocates resources and obtains the information (UE context including security context, RB context (along with E-RAB – RB mapping and target cell info) of the user already present in the RSDL. The T-gNB updates the information like new C-RNTI, T-gNB security algorithm, dedicated RACH preamble and other parameters in the RSDL.

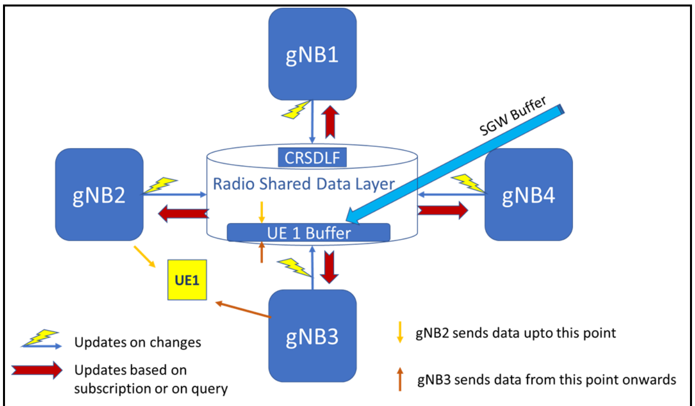


*Figure 5 Buffer management during handover*

The CRSDLF allocates a buffer in the RSDL for storing incoming data from the SGW. It also maintains latest pointer information pointing to the next data chunk to be sent over to the UE, in the RSDL. The CRSDLF also allocates space for the S-gNB to store the hand over data and SN Status. After successful handover completion, the T-gNB simply reads the latest pointer information and starts sending data from that point onwards thus avoiding the need to forward data over X2/Xn interface. Especially, in eMBB use case, the downlink data is huge in size. Such a mechanism will reduce the forwarding overhead during handover.

As depicted in Figure 5, during handover, the S-gNB receives data from the SGW and stores them in the RSDL. Further, storing data in RSDL optimizes multicast or broadcast services as the gNBs serving participating UEs that have subscribed to multicast or broadcast services would pick up the data from the RSDL and send to the UEs avoiding the need for storing data on each of the gNBs.

## IV. Conclusion

As the RAN functions are being virtualized and centralized, splitting the radio data from different virtualized RAN functions to a centralized data storage function i.e. RSDL and combining it with an intelligent orchestration function i.e. CRSDLF will optimize procedures like handover, CoMP, multi-connectivity and carrier aggregation. Further, the RSDL optimizes the resource utilization for packet processing for eMBMS and handover.

As next steps, we plan to simulate proposed solution and carry out a comparative study of existing solution and proposed solution considering latency and error probability as metrics of interest.

## References


[1] 36.423 TS Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 Application Protocol (X2AP)