Method for Power conservation for VoNR devices

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***Abstract*— With the introduction of 5G New Radio (NR), telecom operators are planning to integrate network elements of NR in different configurations for a phased and overlaid deployment and coexistence with 4G. Third Generation Partnership Project (3GPP) standardizes the deployment operation mode of the next generation network, viz. working in Stand Alone (SA) NR scenarios and Non Stand Alone (NSA) NR mode scenarios. Specifically as defined in the specification, Option 7 is where UE is connected to 5G Core Network (5GCN) via either 4G enhanced Node B (eNB) cell or 5G next generation NodeB (gNB) cell. Voice services available in 5GCN is referred to as Voice over NR (VoNR), and the power consumption for a User Equipment (UE) is dependent, on the physical resource allocation strategy in the serving cell. Available procedures of system selection defined in 3GPP are based on measurement of reference signal power levels, and priority criteria as defined in the System Information of the 5G/4G network. In this paper for the first time, we have discussed novel protocol and algorithm through which the UE maintains a history of availability of features like Semi-Persistent Scheduling (SPS), Connected Mode Discontinuous Reception (CDRX) and VoNR in the serving area of a cell, and uses this information later, during system reselection evaluation due to mobility. Through our proposed changes, a UE a) gets VoNR service more often and b) conserve more energy when the VoNR service is activated by the user. We present an analytical model and through simulation show that during VoNR service, power is conserved due to SPS and CDRX on the selected cell.**

Keywords—5G, NR, VoLTE, VoNR, CDRX, SPS

I. INTRODUCTION

With the introduction of 5G New Radio (NR) standards by Third Generation Partnership Project (3GPP), telecom operators are migrating their services to NR in a phased manner. Though voice services will be made available initially via Voice over LTE (VoLTE) service on 4G network, eventually voice services in 5G, referred as Voice over NR (VoNR), is expected to be next revenue stream for the operator, Thus it is important to offer the service with reduced power consumption when compared to other Over the Top (OTT) Voice calling applications.

During connected mode, the physical channel allocation strategy adopted by the scheduler in the 4G or 5G network, allocates enough idle period referred to as Connected Mode Discontinuous Reception (CDRX) which has been introduced to reduce User Equipment (UE) power consumption during a call. Specifically, CDRX allows the UE to remain in connection with gNB while periodically powering down or entering into a sleep mode based on data traffic conditions in order to reduce power consumption.

Another technique called a Semi Persistent Scheduling (SPS) has been introduced to reduce traffic over control signalling due to a transmission time interval (TTI) based grant allocation, and reducing UE power consumption. A gNB configures a UE with SPS only once in order to receive uplink/downlink (UL/DL) resources at a specific interval. Further, SPS reduces power consumption of the UE, as the UE is not required to decode all Packet Downlink Control Channel (PDCCH) packets.

Currently, if a UE is in coverage region of more than one gNB or cell, and when UE is in an idle mode, the UE will be unaware whether the serving cell supports SPS and/or CDRX. Further, even after moving to a connected mode, e.g., for a VoNR call, if a serving cells signal condition is good and the serving cell does not support either of SPS or CDRX, the UE still remains camped on the particular cell. Thus, the UE is unable to conserve power because of lack of information on whether a serving cell supports SPS or CDRX. Thus, a need exists for an effective method for power efficient system selection for a VoNR enabled device.

In this paper, to the best of our knowledge for the first time we introduce novel protocol and algorithm through which the UE maintains a history of availability of features like SPS, CDRX and VoNR in the serving area of a cell, and uses this information later, during system reselection evaluation due to mobility.

Through our proposed changes, a UE

a) gets VoNR service more often and

b) conserve more energy when the VoNR service is activated by the user

We present an analytical model and through simulation show that during VoNR service, power is conserved due to SPS and CDRX on the selected cell.

The rest of the paper is organized as follows, Section II describes the required background on 5G Network architecture and gives the changes as compared to 4G LTE Network architecture. Section III discusses the proposed solution and Section IV presents the improvement expected from the proposal. Section V gives the conclusions of our work.

II. 5G BACKGROUND

Fifth Generation (5G) network is designed for supporting features like enhanced Mobile Broadband (eMBB), massive Machine Type Communication (mMTC) and Ultra Reliable Low Latency (URLLC) communication. Architecturally, Third Generation Partnership Project (3GPP) has built 5G

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New Radio (NR) as an extension over Long Term Evolution (LTE) 4G architecture with some major advancements to enable new concepts of Network Slicing. Basic difference between NR and LTE architectures are

1) Control plane (CP) and User plane (UP) functionality are separated in network nodes, as shown in Fig.1 and Fig. 2:
   a. In LTE, MME was responsible for Signaling and GW for User plane, however some of the session related signaling is carried by S/P-GW, using S5 interface;
   b. In 5G, both UP and CP are handled by different nodes. Where, SMF takes care of CP and UPF is responsible for UP processing;
2) 5G has introduced few new functionalities:
   a. In Control plane, under g-NB & AMF, Support of Network Slicing.
   b. New architecture, as explained in step-1, divided based on CP & UP.
   c. New architecture, for UP, includes Quality of service (QOS) based bearer mapping to exchange User plane data instead of end to end bearers as in LTE.

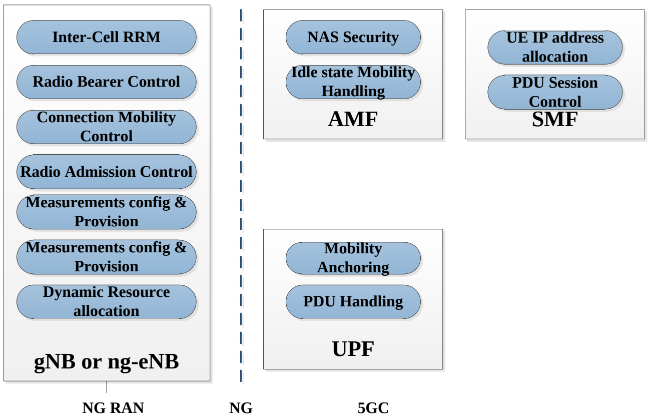

Fig. 1. Functional Split in 5G

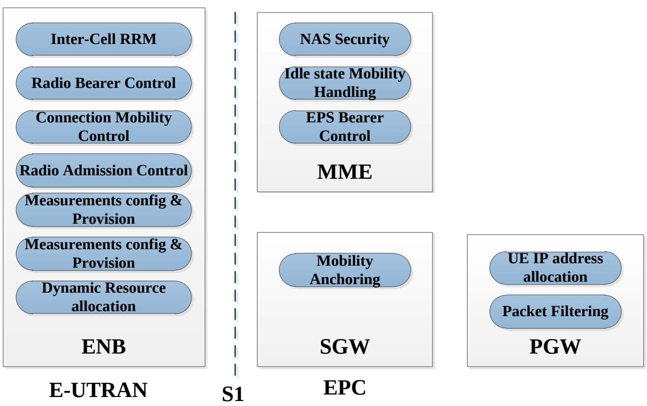

Fig 2. Functional Split in LTE

There are changes in the bearer architecture in 5G as compared to LTE and the same is described in Fig. 3 and Fig.4. As explained the introduction of QoS flows enable 5GC to enforce the quality of service level control and not necessarily a per user approach as present in LTE network architecture.

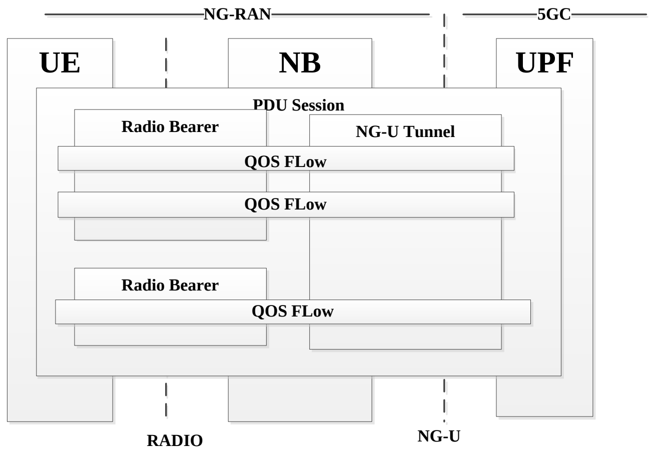

Fig. 3. Bearer in 5G

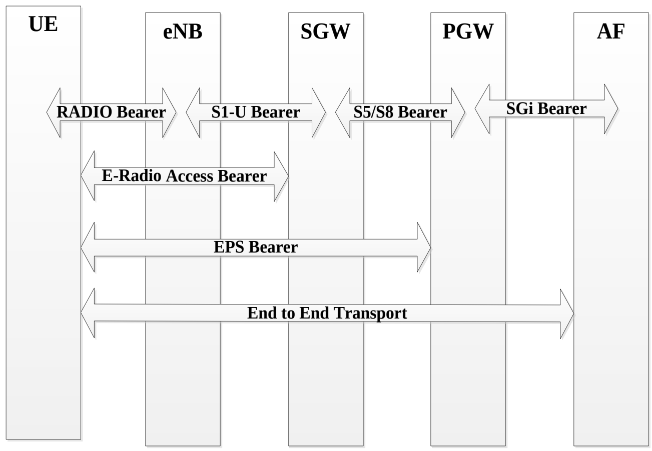

Fig. 4. Bearer in LTE

While 3GPP is defining both a new 5G core network (5GC) as well as a new radio access technology called 5G "New Radio" (NR), It is possible to integrate elements of different generations in different configuration with 5G: Stand Alone (SA) and Non Stand Alone (NSA). As captured in Fig.5. SA scenario uses only one Radio Access Technology (RAT) (5G NR or the evolved LTE (Long Term Evolution) radio cells) and the core networks are operated alone.

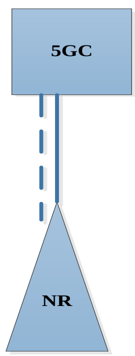

Fig. 5. SA, Option 2, 3GPP NR [6]

NSA scenario, as shown in Fig. 6, combines NR radio cells and LTE radio cells using dual-connectivity to provide radio access and the core network may be either EPC (Evolved Packet Core) or 5GC.

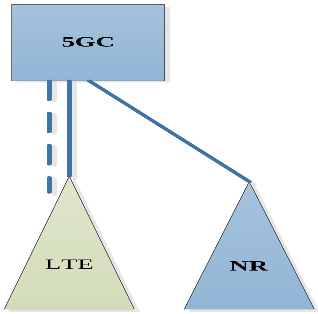

Fig. 6. NSA, Option7, 3GPP NR [6]

III. PROPOSED SYSTEM SELECTION

Based on our proposal, the UE reads the system information of current serving cell and neighbouring cell. If a UE is currently in a cell not supporting SPS or CDRX in SA scenarios, UE shall analyse the stored information, it received from system information from network and prior camping history and if SPS or/and CDRX available in neighbouring cell, whose reference signal power is also above a threshold, UE shall reselect to neighbouring cell.

The method also discuss about NSA scenarios, specifically option 7, If UE is connected to a cell, with eNB which in turn is connected to 5GC and this cell does not support VoNR. If UE call preference is VoNR, when UE initiates an NR call, instead of handling the call as volte, UE shall check the available information about prior camped cells and find the neighbouring cell supporting VoNR with frequency above a threshold and UE can initiate a fast cell reselection procedure to neighbouring cell.

A. Detailed Approach

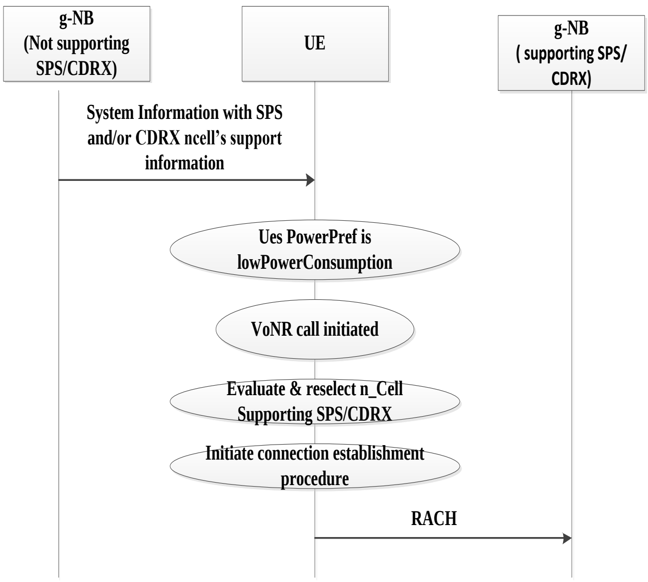

Fig. 7. Approach for SA

As captured in Fig. 7, the following procedure is carried out by the UE.

a. UE is camped on cell, which does not support SPS and/or CDRX.
b. UE neighboring cell had support for SPS and/or CDRX.
c. UE reads system information from network and identify, based on received SI and prior camping history, if a neighbor cell supports SPS and/or CDRX.
d. UE evaluates the information and evaluate current frequency of the new identified target cell is greater than Threshold x during a time interval for T_{time} reselection, "Threshold can be broadcasted by the network or implementation specific offset," UE shall initiate cell reselection to neighboring cell.
e. T (non-serving Cell) is the neighboring cell supporting SPS and/or CDRX.
f. S (serving Cell) is the current camped cell not supporting SPS and/or CDRX.
g. Thresh specifies the threshold used by the UE, when reselecting towards the higher priority frequency X than current serving frequency.
h. T_{time}, is the time interval for which the target should satisfy the reselection criteria for reselection to initiate from source to target cell.

The above approach can be extended to NSA Scenarios as below, as captured in Fig. 8.

a. UE is supposed to be camped on LTE cell connected to 5GC.
b. UE neighboring cell is associated with NR-enB and can support VoNR calls.
c. Specifically, Cell-S is current eNB associated cell and cell-T is non-serving neighboring cell with NR. If UE initiates a VONR call and Cell-T supports VONR while current cell Cell-S does not.
d. UE shall evaluate the Prior camping history and identify a neighboring cell supporting VoNR.
e. UE shall also evaluate received SI and prioritize a cell with SPS and/or CDRX
f. UE evaluates the information and evaluate current frequency of the new identified target cell is greater than Threshold x during a time interval for T_{time} reselection, "Threshold can be broadcasted by the network or implementation specific offset," UE shall initiate cell reselection to neighboring cell.
g. T (non-serving Cell) is the neighboring cell supporting SPS and/or CDRX.
h. S (serving Cell) is the current camped cell not supporting SPS and/or CDRX.
i. Thresh specifies the threshold used by the UE, when reselecting towards the higher priority frequency X than current serving frequency.
j. T_{time}, is the time interval for which the target should satisfy the reselection criteria for reselection to initiate from source to target cell.

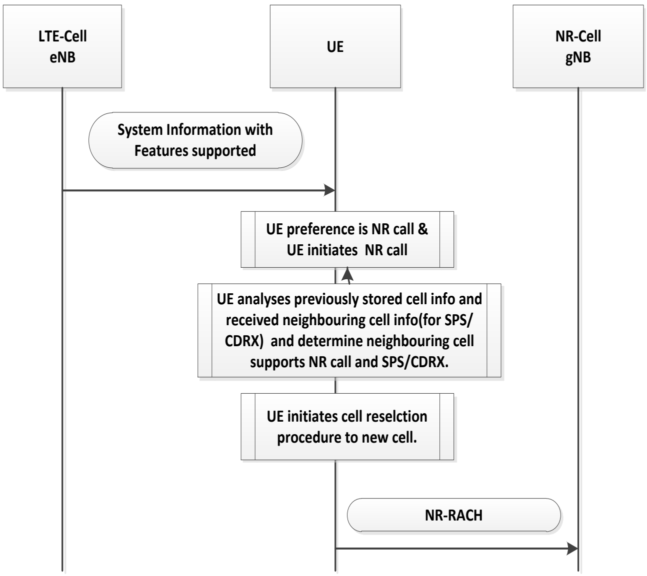

Fig. 8. Extended Approach for NSA

B. Overload in Network and the Solution thereof:

Based on the proposal, if all UEs reselect based on SPS/CDRX support, then it is possible that it can cause high idle mode camping traffic on the cells supporting these features (crowded paging) and very low camping traffic on cells that do not support these features. Further, if all the traffic is concentrated only on cells supporting SPS/CDRX, then it can cause high-connected mode traffic on the cells supporting these features (crowded RACH) and very low traffic on cells that do not support these features. In order to solve this problem we propose that only those UEs which supports SPS and which are 'Voice centric' will be applying this scheme.

Also, in case of Air interface Overload detection by gNB, it can redirect or handover the UE to another cell (based on measurement reports from the UE.

IV. ANALYTICAL RESULTS

Based on [7], as shown in Fig. 9, it can be seen that SPS has good performance from Power saving perspective both in cell edge and cell centre for a LTE Network for VoLTE Service. We can assume a very similar gain in NR, and VoNR service, thus we believe that a system selection based on CDRX and SPS will have immense advantages from a power saving perspective, as compared to Dynamic Scheduling (DS).

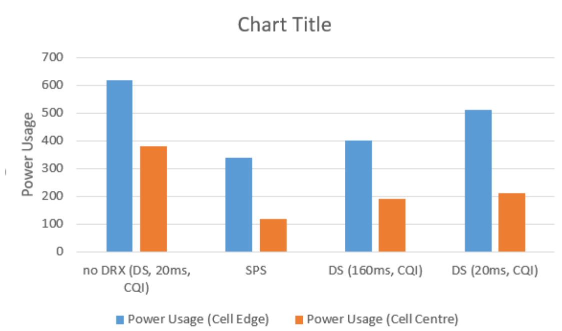

Fig. 9. Average power usage for VoLTE over LTE [7]

V. CONCLUSION

For VoNR kind of applications on 5G UE the traffic pattern necessitates use of SPS/CDRX as there is good amount of power saving for the UE. SPS brings down the power consumption per TTI by almost 50% compared to dynamic scheduling, and further 10-15% if we use Connected DRX in the deployment. SPS and CDRX are gNB scheduler implementation, and also depends on UE support (capability information). In our proposed solution, we discuss a method to assist UE in early detection of SPS/CDRX in the gNB scheduler through an internal database in UE. Through our proposed changes, the 5G UEs can get VoNR service more often and also conserve more energy when the VoNR service is activated by the user

VI. REFERNCES:

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