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Analysis of 3GPP LTE MAC Layer Procedure

(MAC Control Element: Buffer Status Reporting)

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***Abstract*— With the advent of telecommunications from the era of GSM to nowadays extensive LTE services multiple process have been metamorphosed to improve the efficiency of the services. Introduction of one such technique from 3GPP TS release version 10.0.0 to release 10.0.1 is Buffer Status Report and cancellation. To clarify the ambiguity about the quantity of data to be transferred and correspondingly allocation of bearer's network typically requires the buffer status reports from User Equipment's (UE) for scheduling of uplink resources. Extensive studies and research have established that the efficiency of scheduler will increase with the accuracy of the buffer status reports. Generally, in this paper, we propose and method for a UE to report accurate buffer status reports and also considering the circumstances to cancel the BSR in 3GPP Long Term Evolution.**

Keywords— LTE,LTE Protocol,MAC Layer,MAC Control Element.

I. INTRODUCTION (*SUMMARY*)

The main purpose of this document is to illustrate the need of Buffer Status Report (BSR) MAC CONTROL Element by the UE. Analyzing different conditions which triggers BSR MAC CE message for the eNodeB (provided in 3GPP release 10.1.0) for UL grant purpose[1]. The UE then sends the BSR MAC CE message on the provided UL grant PUSCH which contains all the details of the data available for transmission. Here, we also study a change request from the release version 10.0.0 to 10.1.0 which includes the scenario for the cancellation of BSR.

II. EASE OF USE

A. Project Scope (Hardware Implementation)

To describe and demonstrate the need of MAC layer Buffer Status Report*ing from UE to eNodeB* Scheduler, and the circumstances under which BSR's are cancelled by the UE as per 3GPP release 10.0.1 specification. The products will Support the BSR reporting from UE side (according to 3GPP defined TS Specifications at a bit rate less than 64 kbps). The product will support data rates of the order of 2 Mbps to 70 Mbps. It will be having Audio/Video interface with the peripherals like LCD screen. Currently simulating on Linux 14.04, final platform will be RTOS and ARM processor.

B. Why is BSR required?

When Scheduling Request for UL grant is sent to eNB, in the process to this

1. eNB would not know how much UL grant needs to be allocated for the UE and
2. Also, if the allocated grant was not sufficient, UE needs to keep sending SR's for UL grants till all the data is served, this results in increase in signaling overhead.

III. TYPES OF BSR'S (*DESCRIPTION*)

There are three BRS types according to the timing UE send BSR.

- Regular BSR – Regular BSR is sent when a New data arrives in UL buffer and the new data has higher priority than the one already waiting in the buffer.
- Periodic BSR – Periodic BSR is sent with the predefined periodicity. The periodicity is defined by Network and get informed to UE by RRC message.
- Padding BSR - Padding BSR is sent when the number of padding bits in a data message is larger than the size of BSR, so that the padding bit space can be used to send the BSR.

To make the process feasible certain classifications are made as listed below:

LCG (Logical Channel Group) - In 3GPP, LCG is defined as a group of Logical Channel whose buffer status is being reported. In LTE there are four LCGs being used and each of the group has its own ID labelled from 0 to 3.

A.Consequence of using Logical Channel Group (LCG): Suppose an UE is connected to more than one PDNs say IMS, VPN, VoIP, Internet, than it will have a number of radio bearers alongwith radio bearers for RRC signalling, thus updating eNb about a large number of radio bearers will require substantial signalling overhead. Introduction of the LCG mechanism has a positive impact on reducing this signalling overhead. The UE reports an aggregate buffer status for the combination of radio bearers in a logical channel group. The eNB knows the radio bearers contained in the group and their priorities, provided that the QoS requirements of the bearers in an LCG are similar it can schedule the UE in an appropriate technique.

Types of MAC BSR CE FORMAT [2]:

- **Short BSR MAC CE -** When only one LCG has data available for transmission short BSR MAC CE is used. Corresponding MAC CE LCID value is b'11101.

- **Long BSR MAC CE -** When more than one LCG has data available for transmission long BSR MAC CE is used. Corresponding MAC CE LCID value is b'11110.
- **Truncated BSR MAC CE -** When more than one LCG has data available for transmission but remaining UL allocation is not sufficient to send Long BSR then Truncated BSR MAC CE is used. Corresponding MAC CE LCID value is b'11100.

Fig 1. Short & Truncated BSR MAC PDU Structure

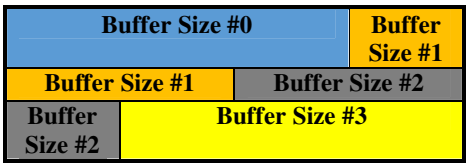


Fig 2. Long BSR MAC PDU Structure

Buffer Size #0 is BSR index for LCG 0,
Buffer Size #1 is BSR index for LCG 1,
Buffer Size #2 is BSR index for LCG 2,
Buffer Size #3 is BSR index for LCG 3.

A. Mapping of LCG Buffer Field Values with the BSR Buffer Size.

The buffer size field is 6-bit long for all formats of BSR MAC CE. Hence, 2^6 = 64 combinations (0 ~ 63 values). Generally, it would require too many bits to accomodate real data size in UL buffer, so data size has been broken into 64 different ranges and has been assigned an index to each of these ranges, i.e. in LTE there is a mapping between buffer size field value to the actual size of the buffers in bytes[2].

B. When to send Long/ Short BSR MAC CE?[3][4] -

To determine the pattern firstly, we need to categorize whether the BSR is Regular, Periodic or Padding BSR, and henceforth depending upon LCGs number BSR CE format are classified as Short BSR, Long BSR or Truncated BSR

- For Regular and Periodic BSR :

if(The number of LCG with allocated data > 1) --> Long BSR

else --> Short BSR

- For Padding BSR,

if(The number of padding bit >= the size of the Short BSR plus its sub-header && the number of padding bit <= the size of the Long BSR plus its sub-header)

{

if(The number of LCG with allocated data > 1) Truncated BSR

else

- Short BSR

}

else

{

Long BSR

}

C. Conditions Triggering BSR MAC CE:

To update the eNodeB scheduler, the UE sends Buffer Status Reports (BSRs) for the LCGs.

- New data arrives in previously empty buffers: Assuming that we are at the "beginning" of UL data transmission when all data buffers are empty, if data becomes available for transmission in the UE for any radio bearer a BSR is triggered. This type of BSR is known as Regular BSR.
- Higher Priority data arrives: If the UE has already sent a BSR and is waiting for an UL grant but then higher priority data becomes available for transmission, the eNB needs to know this and therefore a new BSR is triggered, even when the triggering RB is in the same LCG for which there is an outstanding BSR. This type of BSR is also known as Regular BSR.

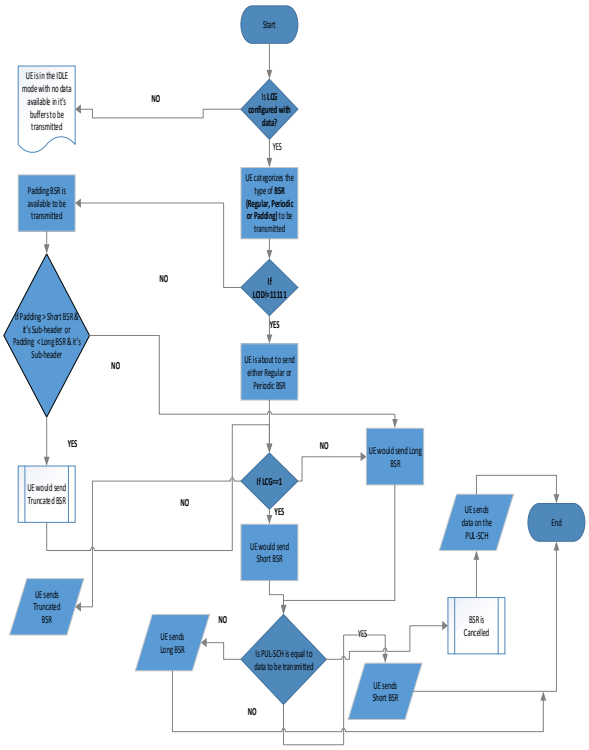
IV. WHEN ARE BSR'S CANCELLED :[5]

1. When the UL grant in this sub-frame is sufficient to accommodate all the available data in the UL buffers of UE for which the BSR is triggered but is in-sufficient to accommodate the MAC BSR CE, then the triggered BSR is cancelled.

2. When a BSR is included in a MAC PDU for transmission.

Interestingly, there is no direct relationship between the BSRs sent by the UE and how it is processed by eNB, in this context there is different functionality based on the UEs QoS and also resource grants are allocated to the UE to radio bearers on a logical channel priority basis. Membership in a particular LCG is not relevant. For example, let's say a UE requests resources for LCG 2 in order to send a HTTP request, in the meantime before the grant was allocated an RRC message becomes available to be sent, then the received RRC message gets priority and uses up as much of the resource as it needs[6]. The HTTP request will get the leftovers, if any.

The detailed Flow chart depicting BSR process measuring IE' and BSR CE cancellation:



Flow chart for the complete process

A. *Abbreations:*

BSR – Buffer Status Report

UE - User Equipment

eNb – Evolved-NodeB

UL – Uplink

DL – Downlink

QoS – Quality of Service

MAC – Medium Access Control Layer

SR – Scheduling Request

PUCCH – Physical Uplink Common Control Channel

PDN – Packet Data Network

IMS – IP Multimedia System

LCID – Logical Channel Identity

LCG – Logical Channel Group

SDU – Service Data Unit

PDU – Protocol Data Unit

RRC – Radio Resource Control Layer

V. CONCLUSION

In due course of implementation of the MAC protocol BSR procedure we have developed a Coding of the protocol using inter process communication technique of message queues and shared memory. In addition to this we have developed a hardware representation of UE – NEXP4 c5111 Chipset, in the ARM processor of which the software will be embedded. This product will support the BSR reporting from UE side (according to 3GPP defined TS Specifications at a bit rate less than 64 kbps)[6]. The product will support data rates of the order of 2 Mbps to 70 Mbps. It will be having Audio/Video interface with the peripherals like LCD screen. Currently simulating on Linux 14.04, final platform will be RTOS and ARM processor.

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