An Improved Approach of Sending BSR and SR Based on MAC Layer

in LTE System

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Abstract: **The Buffer Status Report (BSR) and Scheduling Request (SR) are important procedures based on Medium Access Control (MAC) layer in Long Term Evolution (LTE) system. First, we study the BSR, SR and Semi-Persistent Scheduling (SPS) separately, then illustrate the priority of BSR and other data when sending MAC PDUs. The issue about the priority has been definitely defined by 3GPP, but it doesn't explain the reason, the article made a detailed analysis of it. The UE will send BSR and SR for gaining radio resources, the resources may be wasted if they exist at the same time. Finally we proposed a solution of deciding whether triggering BSR and SR in SPS and a solution of conflicts between padding BSR and other kinds of BSR.**

Key Words: LTE; MAC; BSR; SR; SPS

I. INTRODUCTION

Responding to the Worldwide Interoperability for Microwave Access (WiMAX) market competition and maintaining advanced in the field of mobile communications, 3GPP launched the long term evolution (LTE) project of Universal Mobile Telecommunications System (UMTS) .In LTE system, the buffer status report (BSR) and the scheduling request (SR) are usually used in conjunction, the SR is used for requesting uplink shared channel resources, the BSR is used to provide the serving eNB information about the amount of resources are needed by the UE. The dynamic scheduling and the semi-persistent scheduling (SPS) are the most common scheduling mode in LTE system. Almost all applications and services are using the shared channel in LTE system, because the QoS requirements of various applications and services are different, so the scheduling will direct impact the QoS whether or not to meet requirements [1].

II. BSR PROCEDURE

When a logical channel is established, the UE allocates the logical channel to a logical channel group (LCG) in order to reduce the frequency of BSR reporting. The UE allocate resources to the higher priority logical channel in any unexpected conditions [2, 3].There are three kinds BSR: Regular BSR, Periodic BSR and Padding BSR. Regular BSR will be triggered in the following conditions: a. All buffers are empty, then new data arrives; b. A buffer is empty, and the corresponding logical channel priority lower than other buffers , then new data arrives; c. Any logical channel has data to transmit when retxBSR-Timer expires. Periodic BSR will be triggered when periodicBSR-Timer expires. Padding BSR will be triggered when number of padding bits is larger than or equal to the size of the Buffer Status Report MAC control element plus its subheader. For periodic and regular BSR, long BSR will be reported if more than one LCG has data available for transmission in the TTI where the BSR is transmitted, else report short BSR [4].

For Padding BSR, if the number of padding bits is smaller than the size of long BSR plus its subhead, but larger than or equal to the size of short BSR plus its subhead, and more than one LCG has data for transmission in the current TTI, reporter Truncated BSR, else report Short BSR. If the number of padding bits is larger than or equal to the size of Long BSR plus its subhead, then report Long BSR [5]. The BSR formats are described in Figure 1:
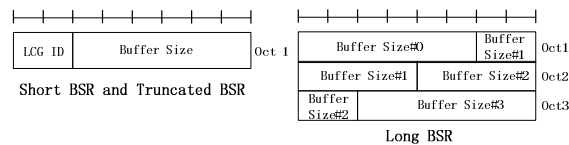

Figure 1 BSR format of control information unit

When a MAC PDU consists of a BSR, or the UL grant can accommodate all data for transmission, but the rest grant can not accommodate the BSR plus its subhead, the all triggered BSR will be cancelled.

III. SR PROCEDURE

If a BSR has been triggered and the UE has UL grant for transmission in the current TTI, then report a BSR. Otherwise, if the BSR has been triggered in the current TTI but there are no UL-SCH resources, then trigger an SR process.

The SR is used for requesting UL-SCH resources, when an SR is triggered, it would be in pending state until generate a BSR control element or the UL grant can accommodate all the data for transmission. The SR is sent on physical uplink control channel (PUCCH) in normal, if the SR can not be sent on PUCCH or there is no valid PUCCH resources then initiate a random access procedure.

Then to illustrate the relationship between SR and BSR based on downlink frame configuration 2[6] in TD-LTE, as described in Figure 2:
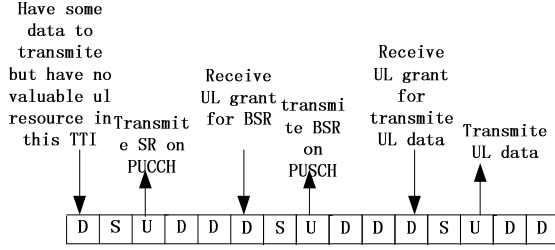
Figure 2 the relationship between SR and BSR

IV. SPS PROCEDURE

SPS is mainly used to allocate resource to periodic scheduling services, such as VoIP, Typically, the UE can skip two steps: the application of radio resource, eNB allocation resources to UE, then use pre-allocation resources to transmit data, so that can save time directly, otherwise change the transmission resources based on dynamic scheduling. Therefore, SPS is an effective additional to dynamic scheduling.

V. BSR METHOD USED IN CONJUNCTION WITH SR

A. The priority dealing of BSR and PHR

When the Long BSR and the Power Headroom Reporting (PHR) are triggered at the same time, the PHR requires 2 bytes to be sent and the Long BSR requires 4 bytes. If the physical layer receives an UL grant in this TTI, and remaining 4 bytes are not used. There are two programs: generate a Short BSR and a PHR or generate a Long BSR. If generate a Short BSR and a PHR, because there are multiple LCGs have data for transmission, and a Short BSR can only provide information of one LCG, so that the eNB can not know how much data available for transmission UL until the UE send next BSR[7]. This program will lead to a waste of resources and delay data transmission uplink, so this program is not used. Therefore, the rest 4 bytes are used to generate a Long BSR, that is, when assemble a MAC PDU the BSR has a higher priority than the PHR.

B. The priority processing of the BSR and the data of
each logical channel

The BSR procedure can be only used in RRC_CONNECTED, RRC will send a RRC connection request message on the CCCH when trigger an RRC_IDLE to RRC_CONNECTED transition, because the message is sent in RRC_IDLE, so the BSR procedure does not be triggered [3, 8].
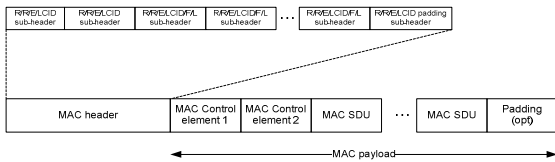

Figure 3 Example of MAC PDU

RRC will send an connection reestablish request message on the CCCH during handover, and the SR and BSR procedure will be triggered .Figure 3 shows that MAC control elements are always placed before MAC SDUs. The BSR unit is generated as the format of MAC control element information, so the priority of sending SR to gain an UL grant is higher than sending BSR through the SR priority for sending BSR, the remaining resources are allocated for transmission the MAC SDU associated with RRC connection reestablishment message. In this case, the transmission of RRC connection reestablishment request message will be delayed, the likelihood of connected success will be decreased. In addition, the messages sent on the CCCH via a TM RLC entity without any modification[9].There is a possible the size of RRC connection reestablishment request message is larger than the UL grant, if the MAC SDU associated with RRC connection reestablishment message is placed after the BSR control element, it will increase the likelihood of insufficient resources [10,11].If the resource is not enough, RRC connection reestablishment message can not be sent until have new resources, so that the time delayed will be longer. So that the BSR has a higher priority than RRC connection reestablishment message, Figure 4 illustrates assemble a MAC PDU according to the priority of the data from logical channel and the BSR element.
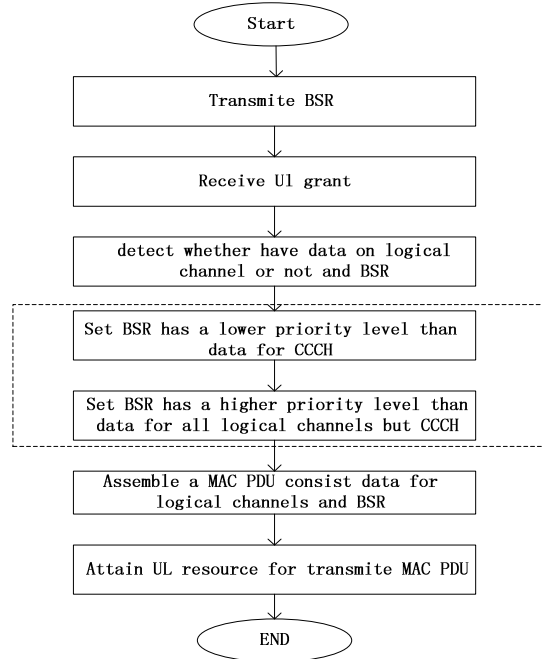

Figure 4 The priority of BSR and data from logical channels

C. A solution scheme of whether to trigger the SR and
BSR under SPS

The SPS is an optimization for the SR, the eNB allocate resources by the PDCCH control information one-off in SPS, and the UE periodically gains radio resources by pre-setting. If RRC activated SPS, the radio resources are gained by BSR and SR procedure may be overlapped with pre-allocation resources, so that it is

necessary to establish a mechanism to coordinate the SR and SPS procedure.

After SPS procedure is activated, if BSR triggered conditions are met in some TTI, the UE does not trigger the SR procedure immediately. In this case, all pending BSR may be canceled; BSR may be sent after gain UL resources by a PDCCH order; BSR may be sent on the resources gained by SPS procedure. But it is not clear that which scheme should be used in LTE technical specification.

The UE detects whether SPS has been activated when BSR triggered conditions are met in some TTI, handled by the normal process if SPS is not activated: If the BSR is Regular BSR, the SR procedure will be triggered; If the BSR is Periodic BSR, the BSR will not be sent until gain UL resources next periodic. If SPS has been activated the following judgment is required: a. the duration between the TTI which BSR are triggered in and the TTI which the next UL resources are gained pre-configured by SPS whether within a certain range; b. the UE's buffer size is larger than the uplink resources size. Drawn an effective mechanism to decide whether to trigger the BSR and SR based on the above two conditions[12].
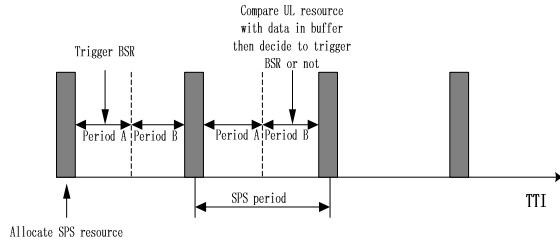

Figure 5 How to trigger the BSR in SPS condition

As shown in Figure 5, the UE periodically gains resources in SPS procedure; the SPS periodic is divided into period A and period B. If the BSR is triggered in period A, the BSR will be sent in normal regardless of the impact of SPS, this is because there is a long time from period A to next UL resources allocation in SPS, the overlapping is small and will not cause a great waste of resources. If the BSR is triggered in period B, the duration between period B to next UL resources allocation in SPS is small, if we send the BSR and SR blindly, it is likely to gain too much radio resources then cause much waste of resources, so that it is necessary to determine the relationship between the data size in UE's buffer and the allocated resource size by the SPS: If the UL resources are allocated by the SPS are not accommodate all data in UE's buffer, trigger a BSR procedure in normal; if the UL resources can accommodate all the data, the BSR procedure shall be cancelled. There is a special case: The BSR is triggered and the SPS allocates resources at the same TTI, the BSR will be sent on the resources are allocated in the SPS procedure.

D. A solution scheme of the conflict between padding BSR and Regular(Periodic) BSR

A MAC PDU contains at most one BSR control element even through multiple BSRs are triggered. If the UE gains too more resources, the remaining resources can accommodate a padding BSR element after assemble a MAC PDU consists of a Regular or Periodic BSR ,MAC SDUs and other control element, do not process padding block usually because of the Regular BSR and the Periodic BSR has a higher priority than padding BSR. As described in figure 6 (a), there are 2 bytes are remaining after assemble a MAC PDU contains a Short BSR, the usual practice is to ignore the remaining 2 bytes, although this can meet the priority requirement, but do not make full use of all resources[13]. In figure 6 (b), if only one LCG has available data and meet the Regular BSR trigger conditions, then an SR is triggered to gain UL resources, several TTIs has passed when received an UL grant, there may be that more than one LCG have data to send at this time. The Short BSR will be placed before any MAC SDU, there are 2 bytes remaining after assemble a MAC PDU contains control elements and MAC SDUs, we can not assemble a Truncated BSR because a MAC PDU only can contain one BSR element, In order to make full use of all resources, all MAC SDUs should be put back 2 bytes, then assemble a Long BSR. This approach not only meets the standard, but also reduces the redundant bits, and also can report several LCGs' information. This is an effective approach to short transmission delay.
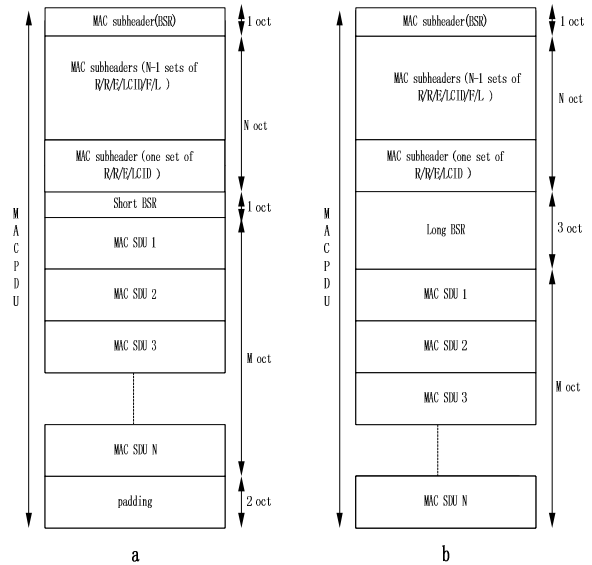

Figure 6 BSR filling

VI. CONCLUSION

Currently, TD-LTE system has been used in commercial trial in China, LTE technology is becoming mature. In UMTS system the scheduling function is implemented on the RNC [14], but in LTE system MAC layer is responsible for scheduling function. The BSR and SR procedure is defined to achieve scheduling function, at last proposed a solution of deciding whether triggering BSR and SR in SPS and a solution of conflicts between

padding BSR and other kinds of BSR, it can be better scheduling resources.

VII. ACKNOWLEDGMENT

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