2011 International Conference on Computer Science and Information Technology (ICCSIT 2011)
IPCSIT vol. 51 (2012) © (2012) IACSIT Press, Singapore
DOI: 10.7763/IPCSIT.2012.V51.66

Research and Solution of Semi-persistent Scheduling Problem in LTE System

XiaoWen Li, ZiMing Yu[+] and Zhen Wei

ChongQing university of posts and teleconmunications, ChongQing, 400065, CHINA

Abstract. Schedule is the the pith and core technology of resource assignment by basic station to users in LTE(Long Term Evolution) system. With the emerge of the new service as VoIP(Voice on Internet Protocol), multimedia and so on, LTE system put forward a new schedule technique: semi-persistent scheduling(SPS). According to basic resource schedule technique and combining dynamic scheduling realization, this paper emphasize on semi-persistent scheduling(SPS) theory analysis and the problem of the resource collision during semi-persistent scheduling HARQ(Hybrid Automatic Repeat reQuest) process. a resolvent is given, which increasing the retransmission number and quality of service.

Keywords: semi-persistent, scheduling, HARQ

1. Introduction

Recently, LTE, as the evolution technology of 3G(the third generation) [1], has become the favor of many corporations in the world and the direction of development of mobile communication industry. LTE technology transmits the data on IP field instead of circuit field, such as VoIP service [2]. Comparing to 3G, LTE system has a huge improvement in system bandwidth, net delay and mobility. On the application side, LTE can support video telephone with high definition, game on line, video conferencing and so on.

Different than TD-SCDMA, LTE adopts SC-FDMA and OFDMA technology in uplink and downlink respectively [3]. Meanwhile, LTE system adopts the physical share channel to transmit data instead of physical dedicated channel,which maximize the efficient use of the radio resource shown as figure 1. The resource is allocated to every UE which detects the PDCCH addressed by a RNTI. The UE will use the resource that indicated by PDCCH to transmit or receive data. The LTE system supports two kind of scheduling programme: the dynamic schedule and the semi-persistent schedule [4]. The latter will presented in this article.

2. The semi-persistent scheduling introduction

LTE system schedules the resource by the way of shared, although to get the maximum use of resource, but this way increases the cost on control signal. Thus, decreasing the control information is the unavoidable problem need to resolve.

The semi-persistent parameter is configured by base station in setup of connection, then activated by PDCCH. Once the SPS is activated, UE will assume that the resource recurring in fixed subframe as shown in figure 1,which economize the control information efficiently.Moreover, LTE supports SPS and dynamic scheduling at the same time [5].

[+] Corresponding author. Tel.: 15215046689; fax: +0-000-000-0000 .
E-mail address: coolfishbone@126.com

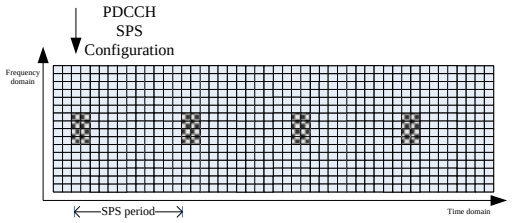

Fig1.SPS resource in time and frequnce

3. A semi-persistent scheduling transmission

The semi-persistent scheduling transmission has four steps:

- The configuration of semi-persistent parameter.
- the activation of semi-persistent scheduling.
- the transmission of semi-persistent scheduling on up and down link.
- the release of semi-persistent scheduling.

3.1. The configuration of semi-persistent parameter

The SPS parameter is configured to UE by RRC connectionsetup message, as follow [6]:

semiPersistSchedC-RNTI

semiPersistSchedIntervalUL
ENUMERATED{10ms,20ms,32ms,40ms,64ms,80ms,160ms,320ms,640ms}

impliciReleaseAfter ENUMERATED{e2,e3,e4,e8}

twoIntervalsConfig ENUMERATED{true}

semiPersistSchedIntervalDL
ENUMERATED{10ms,20ms,32ms,40ms,64ms,80ms,160ms,320ms,640ms}

numberOfConfSPS-Processes INTEGER(1…8)

3.2. The activation of semi-persistent scheduling

Once the SPS is activated by mistake, UE will use the recurred resource in a long time, which make a serious interference to normal data, thus, the activation of the SPS must be cautious to. As dynamic scheduling, semi-persistent scheme scheduled by PDCCH addressed by a RNTI, here, the SPS C-RNTI is used. In order to ensure the PDCCH addressed by SPS C-RNTI is not decoded to C-RNTI by mistake, LTE specify the PDCCH DCI format bit field [7]. A UE shall validate a semi-persistent scheduling assignment PDCCH only if all the bit fields is met. The validation is achieved if all the fields for the respective used DCI format are set according to Table 1 [8].

Table1.SPS activation PDCCH DCI format

Bit field	DCI format 0	DCI format 1/1A	DCI format 2/2A/2B
TPC command for scheduled PUSCH	set to ‘00’	N/A	N/A
Cyclic shift DM RS	set to ‘000’	N/A	N/A
Modulation and coding scheme and redundancy version	MSB is set to ‘0’	N/A	N/A
HARQ process number	N/A	FDD: set to ‘000’ TDD: set to ‘0000’	FDD: set to ‘000’ TDD: set to ‘0000’
Modulation and coding scheme	N/A	MSB is set to ‘0’	For the enabled transport block: MSB is set to ‘0’
Redundancy version	N/A	set to ‘00’	For the enabled transport block: set to ‘00’

3.3. The transmission and HARQ of semi-persistent scheduling on uplink

After the semi-persistent scheduling uplink grant is configured , the UE shall consider that the grant recurs in each subframe for which [9]:

$$(10 * SFN + \text{s}ubframe) = [(10 * SFN_{start\ time} + subframe_{start\ time}) + N * semiPersistSchedIntervalUL] \bmod 10240 \quad (1)$$

Where SFNstart time and subframestart time are the SFN and subframe, respectively, at the time the configured uplink grant were (re-)initialised.

For transmiting data in uplink, the UE shall upon detection of a PDCCH with DCI format 0. New transmissions are performed on the resource and with the MCS(Modulation and Coding Scheme) indicated on PDCCH or Random Access Response. LTE adopts synchronous adaptive HARQ or synchronous non-adaptive HARQ. Adaptive retransmissions are performed on the resource and, if provided, with the MCS indicated on PDCCH. Non-adaptive retransmission is performed on the same resource and with the same MCS as was used for the last made transmission attempt. For SPS, the Non-adaptive retransmission is performed, which may result in a resource collision between retransmission and new transmission. Taking the TDD as an example briefly and give a solution to the collision as fellow.

Assuming TDD uplink-downlink configuration 2, the semiPersistSchedIntervalUL configured as 20ms. Shown as figure 2: the SPS is activated by PDCCH addressed to SPS C-RNTI at subframe 3, then, UE will transmit or receive data periodically every 20ms start at subframe 7. For TDD uplink-downlink configuration 2, the uplink retransmission interval is 10ms, which cause the process 0 collide with process 1 at the second retransmission.

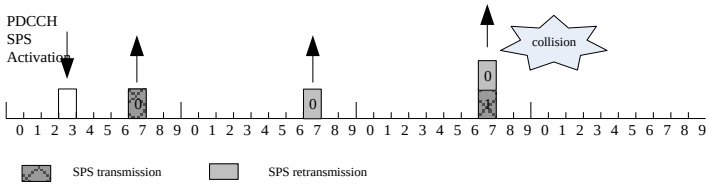

Fig2.SPS scheduling in UL with single period

As the figure 2 shown, the collision result in the serious decreasing of transmission performance. LTE also put forward a solution to this, which the twoIntervalsConfig is configured. Illustrated in figure 3 as follow:

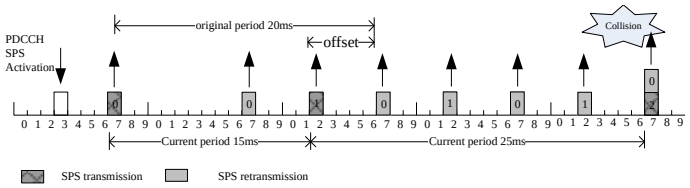

Fig3.SPS scheduling in UL with two period

If the twoIntervalsConfig is enabled, the double semi-persist period is configured. According to the TDD uplink-downlink configuration, the Offset is set. In this condition, the UE shall consider that the grant recurs in each subframe for which:

$$10 * SFN + subframe = [(10 * SFN_{start\ time} + subframe_{start\ time}) + N * semiPersisSchedIntervalUL + Offset * (N \bmod 2)] \bmod 10240 \quad (2)$$

For all N>0;

The scheduling period is changed to: PersistSchedIntervalUL - Offset and semiPersistSchedIntervalUL + Offset. In the instance above, the semi-persistent period is changed from the fixed 20ms to 15ms and 25ms. Although the process 0 collide with process 2 at the forth retransmission, comparing to single period configuration, the process 0 has double the number of retransmission after the double period is enabled, which absolute meet the QoS of service as VoIP. Need to point is, if under a fast-varying channel, only to increase the semi-persistent period, the QoS also can be met

3.4. The transmission and HARQ of semi-persistent scheduling in downlink

Unlike the uplink transmission, LTE downlink retransmission adopts asynchronous adaptive HARQ. Because of this, downlink retransmission dose not exist resource collision. The double period is not configured. UE shall consider that the grant recurs in each subframe for which:

$$10 * SFN + subframe = [(10 * SFN_{start\ time} + subframe_{start\ time}) + N * semiPersistSchedIntervalDL] \bmod 10240 \quad (3)$$

For all N>0;

Where SFNstart time and subframestart time are the SFN and subframe, respectively, at the time the configured downlink assignment were (re-)initialised.

For downlink, LTE reserve numberOf ConfigSPS_Process number of configured HARQ processes for Semi-Persistent Scheduling, which counted from 0 to numberOfConfigSPS_Process - 1. In order to save downlink process number, LTE support the mixed scheduling scheme with semi-persistent and dynamic. LTE allow a dynamic process use the process ID which belongs to a semi-persistent process that already succeed temporarily. Taking TDD as an example to analyse the downlink scheduling process.

Assuming TDD uplink-downlink configuration 1, semiPersistSchedIntervalDL=10ms, numberOfConfigSPS_Process = 2. Illustrated as figure 4, the SPS is activated by PDCCH in subframe 0. Then UE transmit a ACK for process 0 in subframe 7 after decode the data of process 0 successfully. Then the process ID 0 can be allocated to dynamic process temporary. If this be done, the base station allocates the dynamic transmission in subframe 9. Assuming the dynamic process succeeds after twice transmission, then eNB need to expect a ACK in subframe 3 at the third frame. Whereas, in subframe 0 of the third frame, the process ID 0 will be given back to semi-persistent process. Thus, in subframe 7 of the third frame, eNB will be confused by receiving a ACK and a NACK for process ID 0 at one time.

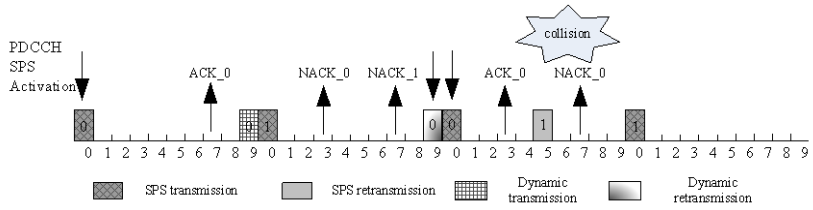

Fig4. SPS scheduling in DL

Can be deduced is that, although LTE do not specify the maximal transmission number, the dynamic retransmission time can not exceeded the time of number Of ConfigSPS_Process multipy semiPersistSchedIntervalDL.

However, need to point is, adjusting the parameter numberOfConfigSPS_Process and semiPersistSchedInterval DL with channel quality, the retransmission number of dynamic can be increased to a certain extent and met the QoS.

3.5. Semi-persistent scheduling release

As SPS activation, the SPS release is also need to indicated by PDCCH. UE validate the PDCCH addressed to SPS C-RNTI. The validation is achieved only if all the fields for the respective used DCI format are set according to table 2.

Table 2.SPS release validation PDCCH DCI format

Bit field	DCI format 0	DCI format 1A
TPC command for scheduled PUSCH	set to ‘00’	N/A
Cyclic shift DM RS	set to ‘000’	N/A
Modulation and coding scheme and redundancy version	set to ‘11111’	N/A

Resource block assignment and hopping resource allocation	Set to all ‘1’s	N/A
HARQ process number	N/A	FDD: set to ‘000’ TDD: set to ‘0000’
Modulation and coding scheme	N/A	set to ‘11111’
Redundancy version	N/A	set to ‘00’
Resource block assignment	N/A	Set to all ‘1’s

Added, to ensure the semi-persistent scheduling resource to be released, the UE shall clear the configured uplink grant immediately after implicitReleaseAfter number of consecutive new MAC PDUs each containing zero MAC SDUs have been provided by the Multiplexing and Assembly entity, on the semi-persistent scheduling resource.

4. Epilogue

Scheduling is the key factor to evaluate a system is good or not. Semi-persistent schduling is the optative scheduling scheme for IP services which becomes the mainstream in the mobile communication. This article conducte a detailed study to semi-persistent schduling. For the collision happened during transmission, the improvement is given. Through the instance, the QoS is met after the improvement scheme is executed.

5. Acknowledgements

This work is supported by Major Project of National Science and Technology in Development of TD-LTE Wireless Integrated Test Instrument, and under Grant no.2009ZX03002-009.

6. References

[1] XiaoWen Li, GuiYong Li, XianLiang Chen. TD-SCDMA third generation mobile telecommunication system\ signalling and realization [M], BeiJing: POSTS&TELECOM PRESS, 2003.

[2] KePing ZHang. LTE-B3G/4G Wireless Mobile Communication System [M]. BeiJing: PUBLISHING HOUSE OF ELECTRONICS INDUSTRY, 2008.

[3] 3GPP TS 36.211 V9.0.1. Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulations[S].2009.

[4] Sara.S Quazi.R Priority-coupling-a semi-persistent MAC scheduling scheme for VoIP traffic on 3G LTE.10th international conferance ,telecomunications,2009.

[5] Stefania Sesia, Issam Toufik, Matthew Baker. LTE – The UMTS Long Term Evolution : From Theory to Practice[M]. A John Wiley and Sons, Ltd, Publication, 2009.

[6] 3GPP.TS36.331 V9.0.0 Evolved Universal Terrestrial Radio Access (E-UTRA)Radio Resource Control (RRC)[S/OL], 2009.

[7] 3GPP TS 36.212 V9.0.1. Evolved Universal Terrestrial Radio Access (E-UTRA); multiplexing and channel coding[S].2009.

[8] 3GPP TS 36.213 V9.0.1. Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures[S], 2009.

[9] 3GPP TS 36.321 V9.1.0. Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification[S].2009.