Downlink Resource Allocation in Long Term Evolution (LTE)

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Abstract

A scheduler is very imperative constituent in base station (BS) because it allocates the resource block (RB) to different consumers. The preeminent scheduler is a scheduler which can produce optimize throughput, low latency system and can produce best coverage gains. In order to improve a best scheduling, the scheduler must be conscious of the channel quality and also the scheduler should have acquaintance of the channel quality for each sub carrier and each user. This paper is more discussing on a model for downlink scheduling in long term evolution (LTE) system, which focus on both consumer situations and retransmissions with packet blending hybrid automatic repeat request (HARQ).

Keywords: *Downlink, HARQ, LTE, MCS, OFDMA, Resource Allocation, Scheduling.*

1. Introduction

Scheduling is one of important thing in wireless scheme. To produce high speed data services to mobile consumers, scheduling in wireless networks has hidden substantial contemplation [1]. An important representative in wireless configurations is that the channel quality fluctuates across the consumer citizens due to variances in path loss, as well as fading property. While scheduling choices are adopts, concern of every consumer's channel quality can be oppressed. One limit in LTE downlink scheduling is that all RBs fitting to a single consumer can be allocated to only one modulation and coding scheme (MCS) in each transmission time interval (TTI) or scheduling period.

One of important characteristic of mobile radio communication is the characteristically hasty and substantial differences in the immediate channel circumstances. There are numerous causes for these differences. Frequency selective fading will effect in hasty and random differences in the channel attenuation. The average received signal strength will be affect by shadow fading and distance-dependent path loss.

To attain as effective resource consumption as possible, channel-dependent scheduling in a mobile communication system contracts with how to portion between different terminals and the radio resource(s) existing in the system. Normally, this suggests reducing the quantity of resources desirable per consumer and hence permitting for as many consumers as possible in the system, while still substantial whatever quality-of-service requirements that may occur. Closely related to scheduling is link adaptation, which contracts with how to set the broadcast limits of a radio link to handle differences of the radio-link quality.

2. Related works

Scheduling in wireless networks has encountered extensive aid as a mean for allowing high speed data services to mobile users. An aim of any wireless scheduling scheme balances the users' QoS requirements. Jianwei et.al; proposed a model for downlink wireless scheduling, which takes into account both consumer channel situations and retransmissions with packet blending HARQ [2]. The goal of this project is to control a scheduling rule that reduces the average cost over time.

For the draining difficult, their exertion has recognized that the optimum strategy by no means interrupts the retransmission of a packet.

The technique of orthogonal frequency division multiplexing (OFDM) is the main physical layer design element for 3G-LTE downlink transmission scheme collective through either FDM or TDM as a multiple access method for the downlink shared data traffic channels. Youngnam et.al; proposed multiplexing technique collective through transmit antenna multiplicity for the downlink control channels in 3G-LTE [3]. Through computer simulation, the receiver performance of several candidate schemes are analysed under multi-path fading channel environments.

Adaptive modulation and coding (AMC) characteristics have been validated as an efficient and authentic transmission technique to maximize the spectral efficiency while fulfilling the bit error rate (BER) requirements. Juan et.al; proposed performance evaluation of LTE downlink physical layer according to the latest 3GPP specification [4]. The main characteristics at the LTE physical layer (like spatial multiplexing or AMC) are identified and studied.

Hybrid ARQ is ultimately a compounding of Forward Error Correction (FEC) with ARQ, in an optimal way. Hybrid ARQ schemes are ordinarily used to provide a reliable communication over noisy wireless channels. Kian et.al; proposed the evaluation of the performance of respective HARQ technique over the OFDMA downlink of the presently offered 3GPP LTE specification [5]. The schemes are associated in terms of Packet Error Rate (PER) and throughput in the setting their differing memory desires for implementation. Simulation results display that Type II Incremental Redundancy proposals the greatest throughput performance but at the cost of higher memory requirement.

A well-defined radio planning model including the coverage and capacity evaluations as well as frequency allocations attract great attention as it allows a macroscopic and valuable estimation for the entire network and can ease the decision making and network preparation for the operators. Liang proposed LTE system capacity and coverage had been investigated and the model has been suggested on the base of 3GPP LTE principles Release 8 [6]. This project also had studied about the frequency planning of LTE. The results of this project cover the intervention partial calculation of coverage, frequency of radio and the calculation of traffic capacity task. The application for the LTE Radio planning of this project was accomplished on the WRAP software platform.

HARQ schemes are basically used to provide a reliable communication over wireless multi-path fading channels. HARQ is able to compensate for errors and allows a better throughput performance. Zhongqui and Fei offered the downlink of LTE must be OFDMA established and might be employed AMC at the physical layer with combination of Hybrid ARQ at the data link layer [7]. Constellation Rearrangement (CR) method is applied in HARQ to raise M-QAM performance. Enhancement of system performance is perform by a developed mapping technique is used in full Incremental Redundancy (IR). An improved SNR approximation algorithm which condenses computational period is applied to get Channel Quality Indicator (CQI) and consistent MCS is selected to exploit throughput performance. Considerable spectral efficiency gain can be achieved from the joint design of AMC and HARQ.

3. Scheduling

3.1 Downlink Scheduling

In downlink, the process transmission of packet will be from BS to UE. In fact of dissimilar of requirements between the two directions and the tools at either end, the authentic application of the technology will be dissimilar among the downlink (from BS to UE) and the uplink (UE to the BS).

Nevertheless, OFDM was preferred as the signal carrier format since it is very irrepressible to interfering. In present years a considerable level of experience has been extended in its apply since the several methods of propagation that practise it along through WiMAX and Wi-Fi. OFDM is likewise a modulation format that is very appropriate for transmitting high data rates - one of the main requirements for LTE.

Orthogonal Frequency Division Multiple Access (OFDMA) is a multi-consumer version of OFDM. In a certain time, each consumer in an OFDMA system is commonly given convinced subcarriers to communicate. Synchronization of the uplink transmission is the one of the main difficulties with an OFDMA system. This is because each consumer has to transfer its frame so that they avoid to interfering the other consumers.

OFDM is a broadcast method that is developed by many independent carriers that communicates instantaneously. The key idea behind OFDM is that a signal with a stretched symbol period time is fewer sensitive to multipath fading, than a signal with a small symbol time. Therefore, an improvement in performance can be attained through conveyance some parallel symbols with a stretched symbol time than conveyance them in a series with a smaller symbol time.

For the LTE uplink, another scheme is used for the admittance is known as Single Carrier Frequency Division Multiple Access (SC-FDMA) which is a hybrid format [8]. This combines pliable subcarrier frequency allocation that OFDM offer and the low peak to average ratio accessible by single carrier systems through the multipath interfering flexibility.

4. System Structure

4.1 Scheduling Method

1. Scheduling ensures the apportionment of apportioned time frequency resource between consumers at every time instant
2. Scheduler is placed in the BS and conveying uplink and downlink resources
3. Scheduler controls which consumer the apportion resources (time and frequency) for every TTI would be apportioned for treatment of DL-SCH infection.

4.2 Proposed System Model

1. Classification
   a. Elementary unit of time, 0.5 millisecond: slot
   b. Resources are allocated at sub frame coarseness, unit of time, 1 millisecond: sub frame
   c. The BS, states to evolved Node B: eNB
   d. The mobile, states to user equipment: UE
   e. Physical resources in frequency and time applied to convey control information from eNB to UE, physical downlink control channel: PDCCH:
   f. Physical resources in frequency and time applied to convey data from eNB to UE, physical downlink shared channel: PDSCH:
   g. Extent of the signal to noise ratio (SINR) at the UE when eNB conveys at a reference power, fed back repetitively from the UE to the eNB, channel quality indicator: CQI:

2. LTE Downlink Scheduling

   LTE is an OFDM system where apparitional resources are shared in both frequency and time. A RB entails of 180 kHz of bandwidth for a time period of 1 millisecond. Consequently, apparitional resource allocation to diverse consumers on the downlink can be reformed every 1 millisecond (sub frame) at a coarseness of 180 kHz. LTE structures a Hybrid-ARQ apparatus founded on incremental redundancy. A transport block is encoded by a rate 1/3 Turbo encoder and, reliant on the CQI feedback, allocated RBs, and modulation, the encoded transport block is rate-matched applicably to competition the code rate reinforced by the indicated CQI. Retransmission in LTE is permits at an altered modulation pattern related to the first conduction.

Downlink scheduling choices can be prepared on the beginning of the ensuing figures for each consumer.

i. In the LTE construction downlink data movements from a Packet Gateway to eNB and then to the UE. An IP link and the eNB to UE is across the wireless link is PDN GW to eNB. Once the logical link from the carrier to the UE is group, a QoS Class Identifier (QCI) is specified: QoS Class Identifier (QCI).
ii. CQI rumours are formed by the UE and fed back to the eNB in quantised form sporadically, but with an assured delay. These reports comprise the rate of the signal-to-noise and -interference ratio (SINR) evaluated by the consumer. The LTE system permits some reporting choices for both wideband (over the system bandwidth) and sub band (slimmer than the system bandwidth) CQI, with the second permitting manipulation of frequency selective fading: CQI.
iii. The buffer state concerns to the state of the consumers' buffers, demonstrating the data presented for scheduling: Buffer State.
iv. At time t, ACK/NACK for all broadcasts arranged in sub frame $(t - 8)$ are acknowledged to the scheduler: Phy ACK/NACK.
v. Scheduling choices can also be created on scheduling choices in the past. Let's say, if a consumer was assigned various RBs over the previous limited sub frames, then its urgency at the present sub frame may be abridged. A generally applied method is to sustain the average rate, $x_i(t)$ at which a consumer is obliged: Resource Allocation History.

Intended for every sub frame t, the scheduler first allocates RBs and power to retransmissions for packets which were not decrypted effectively at time $(t - 8)$; the modulation and coding scheme for a retransmission is reserved the matching as for the prior broadcast. The outstanding apparitional resources and power are scattered between the outstanding consumers for broadcasts of novel packets. Precisely, every obligation involves of the following:

i. character of the consumer for which the obligation is prepared,
ii. quantity of RBs allocated,
iii. broadcast power for every RB,
iv. MCS for packet broadcast.

4.3 Generic LTE Frame Structure

OFDM has various benefits containing its hardiness to interference and multipath fading. Although, it might perform to be a principally complex method of modulation, it offers this one to digital signal processing methods. In opinion of its benefits, the application of ODFM and the related admission technologies, OFDMA and SC-FDMA are best varieties for the different LTE mobile standard.

The benefit with OFDM systems is the ability to completely remove ISI (Inter Symbol Interference) between OFDM symbols [9]. The ISI is usually removed by adding a cyclic prefix to the OFDM symbol before transmitting it. A disadvantage with an OFDM system is that usually the subcarriers will not be orthogonal when received at the receiver due to Doppler shift and different frequencies in the local oscillators at the transmitter the receiver. Hence, this frequency offset has to be estimated.

Since the ISI can be removed; each subcarrier will experience only a flat fading channel. This statement would also hold for a Frequency division multiplexing (FDM) system, but in FDM there are guard bands between each bearer.

Nevertheless, even though it's various benefits, OFDMA has some weaknesses such as high peak to average power ratio (PAPR) and high sensitivity to frequency offset. PAPR occurs justify to casual dynamic adding of subcarriers and effects in spectral spreading of the signal significant to attached channel interfering. It is a difficult that can be swamped through high density amplifier linearization and point power amplifiers techniques. UE becomes costly while these approaches can be applied on the BS. Therefore, LTE uses SC-FDMA with cyclic prefix on the uplink which decreases PAPR by way of there is only a single carrier as disparate to N bearers.

Diverse time intervals within LTE in the time domain are explicit as multiples of a basic time unit Ts=3.255 x 10-8. Every frame is separated into ten as a sized sub frame of 1ms in distance with the radio frame has a distance of 10ms. Scheduling is complete on a sub frame foundation for both the downlink and uplink. Each sub frame contains of two correspondingly slots sized which is 0.5ms in length. Every slot in routine contains of an amount of OFDM symbols which can be either seven for normal cyclic prefix or six for extended cyclic prefix [10]. Figure 1 presentments the frame structure in FDD mode (Frame Structure Type 1).

The useful symbol time is 66.7μs. The first symbol has CP length is 5.2μs for the normal mode. The outstanding of six symbols have a CP of length 4.7μs. The purpose for varied CP size of the first symbol is to attain the overall slot size in associations of period units dividable by 15360. The CP is 16.7μs for the extended mode. The CP is longer than the individual delay spread of a few microseconds normally faced in recurrence as shown in Figure 2. The normal CP is applied in high data rate and urban cells applications while the extended CP is applied in special cases.

Parameters	**Expressions**	**Outputs**
Total Symbol Length, T_s	T_s=1/(15000 x 2048)	3.255 x 10^{-8} s
Frame size, T_{frame}	T_{frame} = 307200 x T_s	10 ms
Sub Frame size, $T_{subframe}$	$T_{subframe}$ = 30720 x T_s	1 ms
Slot size, T_{slot}	T_{slot} = 15360 x T_s	0.5 ms
Useful Symbol Time, T_u	T_u = 2048 x T_s	66.7 μs
Normal Cyclic Prefix, T_{cp} (first symbol)	T_{cp}= 160 x T_s	5.2 μs
Normal Cyclic Prefix, T_{cp} (following symbols)	T_{cp} = 144 x T_s	4.7 μs
Extended Cyclic Prefix, T_{cp-e}	T_{cp-e} = 512 x T_s	16.7 μs
Subcarrier spacing, Δf	Δf = 1/ T_u	15 kHz
Sampling rate, f_s	f_s = Δf x N	15000N

Table 1: Downlink LTE Parameters

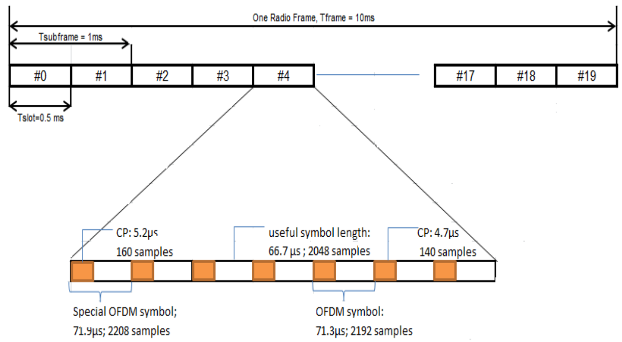

Figure 1: Frame Structure Type 1

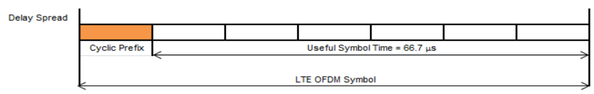

Figure 2: Symbol Structure

The figure of sub bearers N series from 128 to 2048 in the frequency domain, subject on channel bandwidth with 512 and 1024 for 5 and 10 MHz, correspondingly, existence most usually apply in rehearse. The subcarrier spacing is $\Delta f = 1/T_u = 15$ kHz. The sampling rate is $f_s = \Delta f \times N = 15000 N$. This effect in a sampling rate that's multiple or sub multiple of the WCDMA chip rate is 3.84 Mcps: LTE strictures have been preferred such that sampling rates and FFT lengths are simply attained for all process approaches whereas at the equivalent period assuring the easy employment of dual method procedures with a collective clock reference.

The broadcast can be organized by RBs each of which contains of 180 kHz or 12 consecutive sub carriers, for the period of 0.5ms per one slot. This coarseness is chosen to bind signalling overhead. A Resource Element (RE) is the slightest delimited unit which contains of one OFDM sub carrier throughout one OFDM symbol interval. Every RB contains of 12X7 = 84 RE for normal cyclic prefix while for extended CP, it contains of 72. Figure 3 shows the structure of RB.

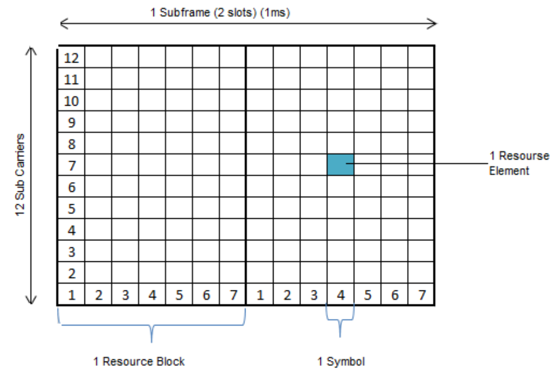

Figure 3: RB and RE

4. Conclusions

The LTE system applied incremental redundancy (IR) established hybrid ARQ with chase combining as a special case of IR. In attentiveness to judgment and adaptively, asynchronous adaptive (AA) hybrid ARQ is applied in the downlink while synchronous adaptive hybrid ARQ is supported in the uplink. Both channel-dependent scheduling and link adaptation try to exploit the channel differences through suitable handling former to broadcast of the data. Nevertheless, due to the random nature of the differences in the radio-link quality, perfect adaptation to the instantaneous radio-link quality is never possible.

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