Performance Investigation of Scheduling Algorithms for LTE Networks

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ABSTRACT: *LTE is a mobile communication standard, which was introduced by 3GPP. LTE is fastest and latest technology with revolutionary data rate, high spectral efficiency, high user fairness, useful bandwidth, high throughput, less delay and low packet loss ratio etc. LTE support many applications. LTE in its services is facing many problems like improper scheduling, allocation of improper resources and unequal fairness to the user end devices. Goal of this paper is investigating downlink scheduling algorithms, to check the best one in multiple scenarios specifically for real time applications like video and VoIP in already existing algorithms. The best one algorithm will be more optimal with fairness, throughput, packet loss ratio, high spectral efficiency and proper allocation of resources to the user end devices. This paper also provides better understanding about fairness in detail.*

Keywords: LTE (Long Term Evolution), 3GPP (3rd Generation Partnership Project), VoIP (Voice Over IP), QoS (Quality of Serves)

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1. Introduction

1.1 Fairness Index

In wireless networking domain, generally, fairness is characteristic for beneficial aid distributing or assigning of resources. Where, unfair useful resource assign effect, amongst distinct human beings also can bring about beneficial aid starvation, useful resource loss or unnecessary resource allocation. However fairness in most cases, researched in resource Assigning [1]. Next question that comes in our mind obviously is when unfairness happens than which are the techniques we should perform?

This isn't researched in detail. Typically, researchers centered on measuring the fairness in resource allocations. Devising strategies to mitigate unfairness is also a critical element of fairness. Unfairness occurs Once, then there are sorts of techniques that should be perform at the same time [2, 3]:

- Balancing entities which are dealt with unfairly in the prior resource assignment turn period. By using some way entities damages are focused within modern-day spherical for assignments.
- To attain the fairness again, regulate the assignment of resources, in favor of the people handled unfairly with no any settlement.

1.2 Fairness Types

If we focus on targeted fairness, it strives to get fair distribution of resources on the other hand resultant fairness proclaims for fair use.

Short- period fairness concentrates on just resource allocation for an awful short period of time. In other way, calculation of the fairness is happened at some specified instants. Quite the reverse, long-period fairness finds the assigning of resource designed for an extended duration of time (otherwise till end of time duration). But it is very hard to guarantee the short-period fairness with rare resources, when various individuals are striving for long-term measurements.

If we talk in sense of the system and individual, then Fairness is assumed on both stages. The system fairness focuses on the whole fairness surrounded by every user in the system. On the other hand, individual fairness specifies that either any individual user is acted equally by the system or not? [4]

1.3 Utility

Sign of utility might denote performance or efficiency in major circumstances and situations. For example, this is frequently merely classified as throughput, latency and additional performance factors. In this paper, the word "utility" denotes the metric that could point out either the resource assigning assure an entity or not? From performance index Utility was generally transformed, not including the fairness [5].

Following 3 terms utility, fairness and resource assigning are dissimilar to each other:

This is proved that; in resource allocation utility is a basic rule. Guarantee the reasonable fairness is an additional necessary rule for allocation. Thus, resource allocation is the achievement though fairness and utility. Limiting the allocation is done by these two rules (utility and fairness) [6].

1.4 Fairness Index Measures: Jain's Fairness Index

Expression for Fairness Index measure, is given below [1]

$$\frac{(\sum_{i=1}^n x_i)^2}{n \sum_{i=1}^n x_i^2} \quad (1)$$

Here x_i is the stabilized (normalize) good put (or throughput; which is maximum number of useful bits per second in Kbps) for the i -th TCP (Transmission Control Protocol) scheme and n is the number of links.

1.5 Scheduling

Main goal of a Scheduler is to get the optimize allocation of the resources in the units like time, frequency and power etc for the UEs, with satisfying level of QoS. "Scheduling means if you have number of resources and you have to decide that how to distribute them in different active users for their QoS requirements". Scheduler exists in the Base Station. It controls the assigning of RBs among Users with the defending of intra-cell interference. For different networks there are different schedulers [11, 12, 13]. List of schedulers is provided in figure 3. Packet scheduler's job is the use of different sources of information to allocate resources and coordinate activities, so that interference can be avoided. It also has the freedom of controlling the allocation of resources in time, frequency and power domains.

Figure 1. Scheduling Strategies of LTE

2. Performance Investigation

Parameter	Value
No. of Cells	1
Radius of Cell	1 KM
No. of Macro Users	10-50
Traffic	VOIP, VIDEO
Schedulers Type	PF, MLWDF, EXPPF, FLS, OPTEXP, OPTLOG
Frame Structure	Frequency Division Duplex (FDD)
Speed	3 KM/hr, 30 KM/hr
Max Delay	0.1 ms
Video Bit Rate	242 kb/s
Cell Transmit Power	43 dBm
Bandwidth	5MHz
Homogeneity	Macro only
Mobility Model	Random

Table 1. Simulation Parameters

2.1 Methodology

We have performed simulations on a simulator known as LTE-Simulator; which is an open source frame work. We run simulations for major six existing schedulers to check throughput, spectral efficiency, PLR and fairness. Here we checked the best scheduler for each environment.

2.2 Results

Graphs for 3kmph

Here in this scenario; PF has least fairness and OPTEXP has highest fairness. As the number of user increases; fairness decreases.

Here MLWDF has maximum fairness average till and decreases as users increase. EXPPF has highest fairness peaks. As the number of user increases, fairness decreases for all schedulers and also fluctuates. For OPTEXP maximum fairness is 48.75% (or 0.4875 fairness Index).

Here in this case; PF has maximum PLR. OPTEXP has highest performance, because it has least PLR. As the number of user increases PLR also increases.

In this case; PF has minimum PLR. MLWDF has highest PLR average. As the number of user increases; PLR decreases.

Here in this scenario; PF has minimum throughput. And throughput fluctuates as users increase. OPTEXP has highest throughput average.

Here PF has maximum throughput. And throughput increases as users increase. MLWDF has highest throughput average.

2.3 Graphs for 30kmph

Here PF has least fairness and OPTEXP has highest fairness. As the number of user increases; fairness decreases for all schedulers.

Here MLWDF has maximum fairness till 50 users. MLWDF has highest fairness average. As the number of users increases, fairness fluctuates for all schedulers.

Here in this case; PF has maximum PLR. OPTEXP has highest performance, because it has least PLR. As the number of user increases PLR also increases.

In this case; PF has minimum PLR. OPTEXP has highest PLR average, because it has maximum PLR. As the number of user increases; PLR decreases.

Here PF has minimum throughput of 10 users till 50 users. And throughput fluctuates as users increase. OPTEXP has highest throughput average.

Here in this scenario; PF has maximum throughput from 10 users till 50 users. And throughput increases as users increase. OPTEXP has maximum throughput of 0.45 Mbps for 50 users.

2.4 Summary of Results

1. Fairness for Speed 3KM/hr

Video Traffic		VoIP Traffic	
PF	7.7%	PF	29.9%
MLWDF	13.7%	MLWDF	30.2%
EXPPF	12.8%	EXPPF	30%
<u>FLS</u>	<u>24.2%</u>	FLS	29.2%
OPTEXP	19.6%	OPTEXP	28.9%
OPTLOG	13.3%	<u>OPTLOG</u>	<u>31.5%</u>

2. Throughput (bits/s) for Speed 3KM/hr

Video Traffic		VoIP Traffic	
PF	645848.4	PF	422273.6
MLWDF	2115186	<u>MLWDF</u>	<u>445124.8</u>
EXPPF	1874926.8	EXPPF	420201.2
<u>FLS</u>	<u>5246970.8</u>	FLS	400695.4
OPTEXP	3256251.2	OPTEXP	418514.4
OPTLOG	2043779.6	OPTLOG	436600

3. PLR for Speed 3KM/hr

Video Traffic		VoIP Traffic	
PF	0.92	PF	0.0007
MLWDF	0.737	MLWDF	0.005
EXPPF	0.764	EXPPF	0.002
<u>FLS</u>	<u>0.468</u>	<u>FLS</u>	<u>0.001</u>
OPTEXP	0.623	OPTEXP	0.0009
OPTLOG	0.745	OPTLOG	0.002

4. Fairness for Speed 30KM/hr

Video Traffic		VoIP Traffic	
PF	10%	PF	28.5%
MLWDF	26.6%	MLWDF	29.1%
EXPPF	25.9%	EXPPF	30.30%
<u>FLS</u>	<u>32.7%</u>	FLS	30.8%
OPTEXP	28.7%	<u>OPTEXP</u>	<u>31.4%</u>
OPTLOG	25.7%	OPTLOG	30.34%

5. Throughput (bits/s) for Speed 30KM/hr

Video Traffic		VoIP Traffic	
PF	887056	PF	427720
MLWDF	2154261.2	MLWDF	438509.2
EXPPF	2075976	EXPPF	407799.2
<u>FLS</u>	<u>5139667.8</u>	<u>FLS</u>	<u>439678.4</u>
OPTEXP	3044184.8	OPTEXP	426092
OPTLOG	2165614.4	OPTLOG	421104.4

6. PLR for Speed 30KM/hr

Video Traffic		VoIP Traffic	
PF	0.814	PF	0.0006
MLWDF	0.689	MLWDF	0.001
EXPPF	0.706	EXPPF	0.0018
<u>FLS</u>	<u>0.19</u>	<u>FLS</u>	<u>0.00081</u>
OPTEXP	0.544	OPTEXP	0.0008
OPTLOG	0.689	OPTLOG	0.00208

Note: Best Results are underlined and bolded.

3. Summary

The 3GPP LTE goals intend to get highest data speed, spectral elasticity with faultless mobility and improved QoS above a whole IP system. In this project, we have performed some scheduling algorithms for LTE Advanced networks. By scheduling algorithms we distribute radio resources. Between UEs in well-organized method to improve the fairness of system. Finally we investigate the performance of different scheduling algorithms for macro environment. We also summarized the results for different environments.

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