ISSN 2714-7533

Analysis on The Effect of Channel Bandwidth Occupying in LTE Frequency Band on Throughput

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ARTICLE INFO

Article history
Received November 17, 2022
Revised January 15, 2023
Accepted February 5, 2023

Keywords
Channel Bandwidth
LTE
Throughput

ABSTRACT

The maximum channel capacity of a 4G LTE network will be directly correlated to the channel bandwidth that occupies a certain radio frequency on that network. The number of Resource Blocks (RB), subcarriers, and Resource Elements (RE) as channel resources available to serve users concurrently will depend on the bandwidth channel sizes. Mobile service providers in Indonesia provide scalable channel bandwidth LTE 4G networks on a variety of frequency bands, including adjacent and non-adjacent bands. In this study, it was examined how channel bandwidth, which changes at 10MHz, 15MHz, and 20MHz, affects throughput to give user equipment the best possible performance (UE). This study makes use of actual measurement data from installed and active eNodeB or cells obtained via the drive test approach. According to the test, each channel's maximum throughput varies, however, there is no linear relationship found between channel bandwidth expansion and throughput. The 20MHz channel bandwidth, which is located in the 2300MHz frequency band, has a maximum throughput value of 64666.80 kbps.

1. Introduction

Availability of Coverage area with optimal quality and capacity is a major consideration in cellular network deployment. The three parameters will be interrelated in providing optimal service or user experience to cellular network users. The 4G LTE network is deployed on various bandwidth or carrier channels, namely 1.4MHz, 3MHz, 5MHz, 10MHz, 15MHz, and 20MHz. [1] The amount of channel bandwidth will affect the capacity of the cell which is directly related to the maximum data rate that can be handled by the cell. Channel bandwidth will affect the number of resource blocks, subcarriers, and resource elements as channel resources to serve User Equipment (UE)[2]. Given that each subcarrier in the 4G network has several subcarriers, the number of Resource blocks will also have an impact on the Reference Signal (RS) power for each subcarrier [3]. With non-adjacent frequency bands of 900MHz, 1800MHz, and 2100MHz and neighboring frequency bands of 2300MHz, Indonesian cellular operators build LTE 4G networks with channel bandwidths of 10MHz, 15MHz, and 20MHz [4]. The LTE network can be implemented across all frequency bands thanks to its scalable bandwidth channel. For operators, maintaining the highest level of service quality while operating under restrictive frequency licenses can be difficult. In this study, a channel bandwidth performance analysis was done on throughput that uses several frequency bands. Testing was done on eNodeB/cell LTE networks that utilize every available bandwidth channel. While Terms Discovery was being used for the analysis, the TEMS Pocket device was being used to gauge actual active cell performance. By confirming that the cell under test provides all bandwidth channels, the test employs the RAT lock and frequency lock techniques.

2. Literature Review

There have been numerous throughput analysis studies conducted in the past. The coverage area study using the FDD (Frequency Division Duplex) and TDD (Time Division Duplex) duplex methods is covered in the paper in [5]. For FDD mode and TDD mode, tests were run on channel bandwidths of 20 MHz in the 1800 MHz and 2300 MHz frequency bands, respectively. For FDD and TDD, the maximum range determined using the RSRP (Reference Signal Receive Power) setting is 789 m and 633 m, respectively.

The quality-of-service throughput parameter has been the subject of subsequent research [6]. This study examines the quality of service (QoS) for video streaming services used on the LTE network's FDD 1800MHz and TDD 2300MHz frequency bands. With a throughput rating of 891.16kbps and a latency of 48ms, TDD 2300 achieved a higher service integrity value. The throughput is 820.83kbps and the latency is 68ms on FDD 1800.

The research on how to use flexible bandwidth on LTE networks about improving network performance was done later [7]. The analysis was carried out through simulation, with a channel bandwidth increase from 5MHz to 8MHz producing an increase in mean throughput from 5,247 Mbps to 9,897 Mbps. The increase in channel bandwidth also affects the decrease in the SINR value.

According to the deployment of carrier aggregation employing frequency combinations or inter band frequencies, the paper in [8] executes LTE network planning. In the 850MHz range and the 1800MHz band, the channel bandwidth is 5MHz and 10MHz, respectively. Planning with LTE no CA and LTE CA techniques utilizing U-Net software. By using carrier aggregation, it is possible to raise the RSRP from -94.87 to -76.24dBm, the SINR from 3.77 to 5.6dB, and the throughput from 7.6 to 13Mbps. A wireless communication system must be able to maintain a consistent PRB (Physical Resource Block) utilization ratio to satisfy QoS requirements, particularly at the cell edge, according to research [9]. Throughput is affected by the PRB usage ratio. According to observations, when the ratio of PRB usage surpasses 70%, QoS may be impacted. Data speed is slowed down when the PRB utilization ratio rises. In [10] introduce an approach for resource allocation of elastic and inelastic adaptive real time traffic in fourth generation long term evolution (4G LTE) system. In [11] discusses optimizing the allocation of radio resource blocks for cellular communication systems with users running real-time, delay-tolerant applications, generating elastic and inelastic traffic on the network and modeled as logarithmic and sigmoidal utilities, respectively. In [12] The balance model investigation resource block allocation in the LTE downlink can be used to describe the process the allocation of resource blocks in the LTE downlink is tied to the user equipment requests priority. In [13] describes the behavior of LTE overseas and investigates the issue of block allocation of radio resources in the SINR restricted maritime channel by considering a network scenario with a different number of ships ferrying between two ports at a given time.

Paper in [14] investigate scheduling and power allocation for coordinated multi-point transmission in the downlink advanced long-term evolution system (LTE-A), where orthogonal sharing multiple access frequencies is used

Vol. 5, No. 1, April 2023, pp. 8-14

3. Method

The effect of channel bandwidth on throughput is analyzed based on real test results on active cells using the drive test method. Tests were carried out on cells that have channel bandwidths of 10MHz, 15MHz, and 20MHz which occupy frequency bands that are not adjacent, namely sequentially in the bands 900MHz, 2100MHz, 1800MHz, and 2300MHz. Regional planning and cell/eNodeB determination play an important role in achieving the objectives of this research. Regional planning is related to the existence of cells serving on all bandwidth channels and not using MIMO antennas. Measurements were made on eNodeB/cell with PCI number 328 in the city of Padang. Figures 1 and 2 show the location of the serving cell and the measurement route through the drive test.

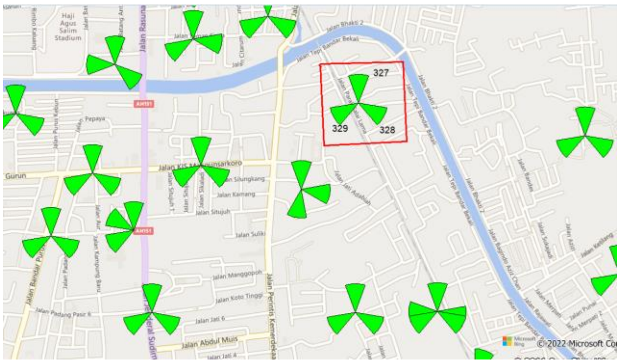

Figure 1. Serving Cell PCI 328

Figure 2. Drive test route

4. Results

4.1. Throughput testing based on channel bandwidth variations.

Tests were carried out on cells that have four channel bandwidth licenses that occupy different frequency bands as shown in Table 1.

Table 1. Cell Parameters (PCI 328)

Channel Bandwidth (MHz)	UL Frequency (MHz)	DL Frequency (MHz)	TxRx	50
10	885 - 895	930 - 940	SISO	75
15	1942.5 - 1957.5	2132.5 - 2147.5	SISO	75
20	1775 - 1795	1870 1890	SISO	100
20	2310 - 2330	2310 - 2330	SISO	100

The outcomes of throughput tests in the radio domain with varying channel bandwidth and other factors are displayed in Table 2. According to the test results, the maximum throughput values differ depending on the SINR values, modulation methods, and the number of PRBs on each bandwidth channel. The 20MHz band 2400 bandwidth channel of 64666.80kbps with 91 PDSCH Resource Block (PRB) numbers, modulation scheme 16QAM, and 18.8dB SINR conditions have the highest throughput values. While the throughput with the lowest SINR value and a channel bandwidth of 10MHz band 900 is 22137.20 kbps at 23PRB, QPSK modulation technique. The relationship between variations in channel bandwidth and maximum throughput values is nonlinear.

Table 2. Througput$_{max}$ value on channel bandwidth variations and several radio domain parameters

PCI	Freq Band (MHz)	Channel Bandwidth (MHz)	Max Throughput (kbps)	SINR (dB)	PRB
328	900	10	22137.2	21.4	23
328	1800	20	24958.8	14.7	44
328	2100	15	48120.4	16.1	67
328	2300	20+10	64666.8	18.8	91

The results of monitoring the throughput and coverage characteristics while taking channel bandwidth variations are shown in Table 3. The maximum throughput numbers, as well as the Pathloss and RSRP parameters, varies for each bandwidth channel. Path loss on channel bandwidth fluctuations and changes in throughput with changes in RSRP is not linearly correlated. Changes in frequency bands that are connected to RSRP and throughput can be perceived as linearity.

Table 3. Througput$_{max}$ on variations of channel bandwidth and coverage parameters (RSRP, Pathloss)

PCI	Freq Band (MHz)	Max Throughput (kbps)	Channel Bandwidth (MHz)	Pathloss (dB)	RSRPmax (dBm)
328	900	22137.2	10	76.7	-60.9
328	1800	24958.8	20	85	-69.3
328	2100	48120.4	15	96	-80.7
328	2300	64666.8	20	97.4	-85.7

4.2. Correlation between Channel Bandwidth and Throughput

In the radio domain, theoretically Down Link (DL) data throughput is affected by the number of scheduled RB per subframe which is directly related to the amount of channel bandwidth, the Resort Element as calculated in Table 4.

Table 4. Max Throughput per scheduling block [2]

Parameter	Channel Bandwidth		
	10MHz	15MHz	20MHz
Resource Block (RB)	50	50	100
Resource Element (RE) per RB	84	84	84
RE Per Schedulling Block (2xRB): 1ms	168	168	168
Reference signal (RS) RE (per RB/RS (Per Scheduling)	8/16	8/16	8/16
RE per CRS (OFDM*12-4RS Tx): SISO	8	8	8
Total Number RE per Schedulling Block Available for PDSCH	144	144	144
Bits per Scheduling Block - QPSK (2 bits)	288	288	288
Bits per Scheduling Block - 16QAM (4 bits)	576	576	576
Bits per Scheduling Block - 64QAM (6 bits)	864	864	864
Max Theoretical L1 Througput (MBps)	43.2	64.8	86.4

The channel bandwidth determines the size of RB and RE. The modulation strategy has an impact on the number of bits in each symbol that are transferred to each RE. The maximum throughput increases as the channel bandwidth and bits per symbol increase. The throughput DL that the cell can handle at its maximum is calculated above. This is correlated with the results of the maximum PDSCH throughput test in Table 2.

On the LTE network, the efficiency domain factor also affects the PDSCH throughput, such as the RSRP and SINR parameters. SINR is determined by the UE position (RSRP, and interference between cells according to the following formula [2].

$$SINR = \frac{RSRP_{serv}}{\sum RSRP_{other}+1+N} \quad (1)$$

The effect of SINR and RSRP on throughput on different Channel Bandwidths can be seen based on the comparison of the test points on serving cell PCI 328 as shown in Figure 3 and Figure 4. It is taken into consideration that each bandwidth channel occupies a different frequency band and is not contiguous.

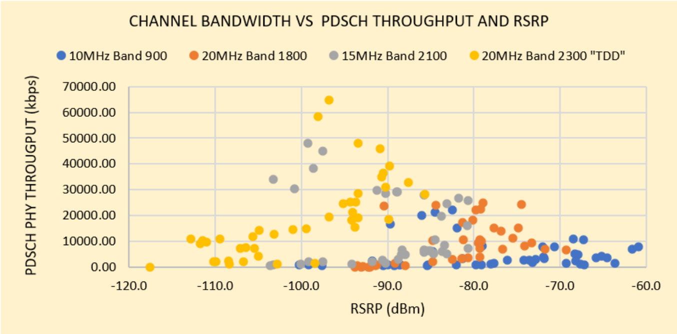

Figure 3. RSRP and throughput correlation on channel bandwidth variations

Figure 3 shows that the dominating throughput value will rise the better the RSRP value on each bandwidth channel. There is no linear change in the RSRP value of throughput when compared to changes in channel bandwidth, however, the frequency band that the channel bandwidth occupies has a greater impact on throughput growth. The maximum RSRP and throughput increase with the frequency band that the channel bandwidth occupies. Conversely, the maximum RSRP and maximum throughput lower the frequency band occupied by the channel bandwidth (figure 4).

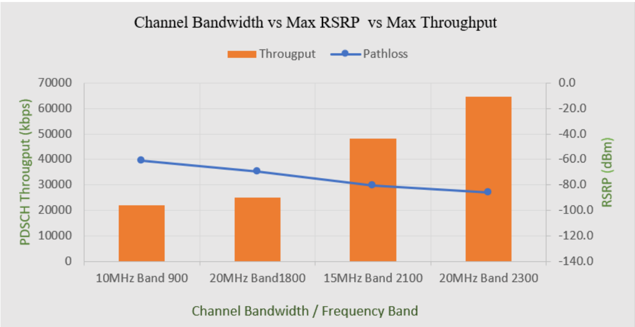

Figure 4. Graph of channel bandwidth to coverage and throughput parameters

Based on SINR parameters, channel bandwidth performance against throughput can also be examined. Shannon states that SINR, bandwidth, and channel capacity all influence channel capacity (C) in bps. The channel capacity can be mathematically stated using the following formula. [10].

$$C = 3.32\, B\, log_{10}\,(1+\frac{S}{N}) \quad (2)$$

Where C = channel capacity (bps)

B = occupied bandwidth in (Hz)

$\frac{S}{N}$ = Signal to Noise Ratio (dB)

According to formula 2, the channel capacity will be at its highest under favorable SNR circumstances. If this relationship holds for the test findings depicted in Figure 5, then throughput increases when SINR on each channel's bandwidth increases. Changes in SINR and throughput are not linearly affected by changes in channel bandwidth.

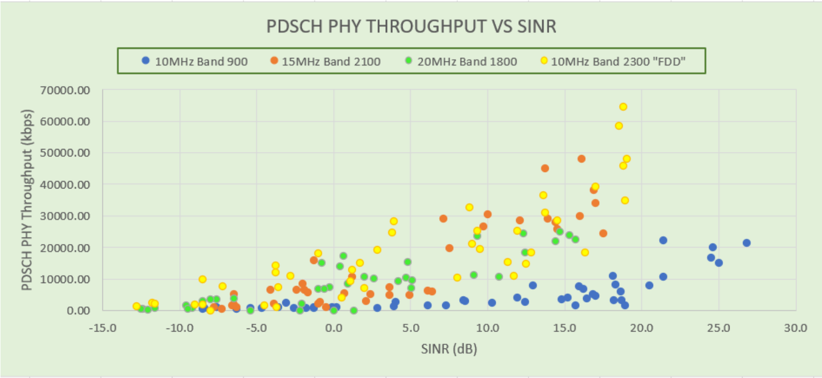

Figure 5. SINR and throughput on channel bandwidth variations

5. Conclusions

The maximum capacity of a cell is affected by channel bandwidth. The maximum user throughput may be affected by the channel bandwidth. The amount of PRBs, bits per scheduling block, has an impact on channel bandwidth performance. The maximum throughput does not increase linearly with increased channel bandwidth. The 20MHz channel bandwidth in the 2300 band, 15MHz in the 2100 band, 20MHz in the 1800 band, and 10MHz in the 900 bands have the best throughput from highest to lowest. The maximum throughput and the frequency band that the channel bandwidth uses have a linear correlation.

References

[1] Dahlman, arkvall, Skold.. "4G, LTE-Advanced Pro and The Road to 5G "Third Edition, Elsivier, 2016

[2] Jar.M., , and Fettweis.G, Throughput Maximization for LTE Uplink via Resource Allocation, 2012, International Symposium on Wireless Communication Systems (ISWCS)

[3] X. Zhang, "LTE Optimization engineering handbook ", first edition, IEEE Pres, Willey, 2018

[4] Republik Indonesia "Peraturan menteri Komunikasi dan Informatika Republik Indonesia no 27 Tahun 2015 Tentang Persyaratan Teknis Alat Dan/Atau Perangkat-Perangkat Telekomunikasi Berbasis Standar Teknologi Long Term Evolution "Kementrian Komunikasi dan Informatika, Jakarta, P.5, 2015

[5] Chandra, D., Yusnita, Bahari, "The Analysis of Service Integrity on Video Streaming Services Using Time Division Duplex and Frequency Division Duplex Technology on LTE Networks", International Journal of Advanced Science Computing and Engineering ISSN 2714-7533 Vol. 3, No. 2, August 2021

[6] Chandra, D., Bahari, "LTE Network Area Coverage on FDD and TDD Technology", International Journal of Advanced Science Computing and Engineering ISSN 2714-7533 Vol. 2, No. 1, April 2020, pp. 21-33

[7] Adityo , Usman, Cahyono, "Analisis Penerapan Flexible Bandwidth Untuk Meningkatkan Performansi Jaringan Lte", Seminar Nasional Inovasi Dan Aplikasi Teknologi Di Industri 2018

[8] Mubarok, Putri, Analisis, "Dampak Inter-Band Carrier Aggregation pada Perencanaan Jaringan LTE-Advanced", 2019 ELKOMIKA

[9] Hwang, Park, “On the Effects of Resource Usage Ratio on Data Rate in LTE Systems”, ICACT 2017 February 19 ~ 22, 201

[10] Hadi.A.A., Clancy.C., "A utility proportional fairness approach for resource allocation in 4G-LTE," in IEEE International Conference on Computing, Networking and Communications: Computing, Networking and Communications Symposium (ICNC'14 - CNC), 2014

[11] Ghorbanzadeh .M., Abdelhadi.A., Clancy .C., A Utility Proportional Fairness Radio Resourc Block Allocation in Cellular Networks, Hume Center for National Security and Technology Virginia Tech, Arlington, VA, 22203, USA

[12] Al Dulaimi, A.M., Al-Azzawi.E.M., Al-Anssari.A.I., Balancing model of resource blocks allocation in LTE downlink, 2016, International Conference on Electronics and Information Technology (EIT)

[13] Kachroo.A., Ozdemir.M.K., Mogulkoc .H.t., Optimization of LTE radio resource block allocation for maritime channels, 2016 IEEE 37th Sarnoff Symposium

[14] Jar.M., , and Fettweis.G, Throughput Maximization for LTE Uplink via Resource Allocation, 2012, International Symposium on Wireless Communication Systems (ISWCS)

[15] Yu.I. and Yin.C., Block-Level Resource Allocation with Limited Feedback in Multicell Cellular Networks, Journal of Communications and Networks, Vol. 18, No. 3, June 2016

[16] Cox.. “An Introduction To LTE, LTE-Advanced, Sae, Volte And 4G Mobile Communication” Second Edition, Wiley, 2014

[17] Arthur, Forgor, Effah, Analysing the Effect of MIMO Configuration on The Throughput of LTE Network in Multipath Environtments, 2019, International Conference on Communications, Signal Processing and Networks (ICCSPN)

[18] Vijeth J. Kotagi, Rahul Thakur, Sudeepta Mishra, and Chebiyyam Siva Ram MurthyAssigning Downlink Transmit Power and Resource Blocks to LTE Enabled IoT Networks, IEEE Communications Letters (Volume: 20, Issue: 8, August 2016)

[19] Haider.F., Hepsaydir.E., Binucci.N., Performance analysis of LTE-advanced networks in different spectrum bands, 2011, Wireless Advanced

[20] Liu,.J., Shen.G.,, Performance of Multi-Carrier LBT Mechanism for LTE-LA, 2016, IEEE 83rd Vehicular Technology Conference (VTC Spring)