Energy Saving Transmission in OFDMA Based Multicarrier Base Stations by Green Communication

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ABSTRACT: In parallel with the amazing increase in mobile data traffic, an advanced cellular technologies progress, more than one component carrier (CC) can now be jointly utilized in a base station (BS). As a result, the energy consumption of the BS has become an important concern. The fast-growing requirement and development of the green communication technology have led to many energy-saving designs in mobile networks. In this project, a novel green rate-and-power control transmission scheme is therefore proposed for the BS transmission to address the problem of energy minimization at BS transceivers subject to certain quality-of-service and fairness requirements for all users. Communication activities in downlink transmissions of the BS with orthogonal frequency-division multiple access-based multi CCs are considered.

Keywords: Green Communication,Base station,LTEA,Carrier.

I.INTRODUCTION:

The fourth generation base station (BS) has been developed to have the promising feature of carrier aggregation (CA), jointly utilizing its multiple component carriers (CCs) based on respectively corresponding transceivers for transmissions, in order to achieve high total network capacity. The long-term evolution-advanced (LTEA) BS, which has been specified by the third generation partnership project (3GPP), is nowadays a typical representative. As a result, problems with energy consumption and the environment impacts on green house gases emissions like the carbon dioxide (CO_2) have become common critical concerns.Green communications is considered to be a new concept to minimize the total energy consumption in communication activities.

Keywords: Green Communication,Base station,LTEA,Carrier.

Basic Model of Communication System

- All communications systems consist of a transmitter (TX), a receiver (RX), and a transmission medium (Fig.1.1)

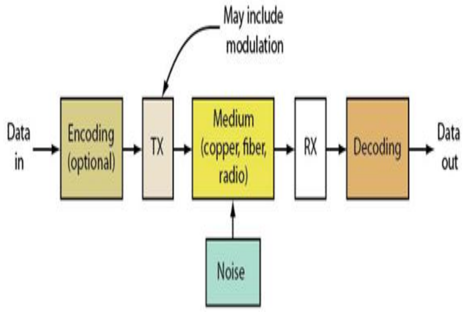
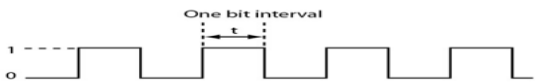


Fig.1.1: Simplified Model of Communication System

The TX and RX simply make the information signals to be transmitted compatible with the medium, which may involve modulation. Some systems use a form of coding to improve reliability. In this article, consider the information to be non-return-to-zero (NRZ) binary data. The medium could be copper cable like unshielded twisted pair (UTP) or coax, fiber-optic cable, or free space for wireless. In all cases, the signal is greatly attenuated by the medium and noise is superimposed. Noise rather than attenuation usually determines if the communications medium is reliable.

- **123 DATA RATE VERSUS BANDWIDTH**
- Digital communications send bits serially—one bit after another. However, you'll often find multiple serial paths being used, such as four-pair UTP CAT 5e/6 or parallel fiber-optic cables. Multiple-input multiple-output (MIMO) wireless also implements two or more parallel bit streams. In any case, the basic data speed (Fig.1.2)
- 

- **Fig.1.2: The bit time in this NRZ binary data**

signal determines data rate as 1/t

- Or capacity C is the reciprocal of the bit time (t):
  - $C = 1/t$ (1.1)
- C is the channel capacity or data rate in bits per sec.1ond and t is the time for one-bit interval. The symbol R for rate is also used to indicate data speed. A signal with a bit time of 100 ns has a data rate of:
- $C = 1/100 \times 10^{-9} = 10$ Mbits/s (1.2)

The big question is how much bandwidth (B) is needed to pass a binary signal of data rate C. As it turns out, it's the rise time (t_R) of the bit pulse that determines the bandwidth:

- $B = 0.35/t_R$ (1.3)

B is the 3-dB bandwidth in megahertz and t_R is in microseconds (µs). This formula factors in the effect of Fourier theory. For example, a rise time of 10 ns or 0.01 µs needs a bandwidth of: B = 0.35/0.01 = 35 MHz.A more precise measure is to use the Shannon-Hartley theorem. Hartley said that the least bandwidth needed for a given data rate in a noise-free channel is just half the data rate or:

$B = C/2$ (1.4)

Or the maximum possible data rate for a given bandwidth is:

$C = 2B$ (1.5)

As an example, a 6-MHz bandwidth will allow a data rate up to 12 Mbits/s. Hartley also said that this figure holds for two-level or binary signals. If multiple levels are transmitted, then the data rate can be expressed as:

$C = (2B) \log_2 M$ (1.6)

M indicates the number of multiple voltage levels or symbols transmitted. Calculating the base 2 logarithm is a real pain, so use the conversion where:

- $\log 2N = (3.32) \log_{10} N$ (1.7)
- Here, $\log_{10} N$ is just the common log of a number N. Therefore:
  - $C = 2B(3.32)\log_{10} N$ (1.8)
- For binary or two-level transmission, the data rate for a bandwidth of 6 MHz is as given above:
- $C = 2(6)(3.32)\log_{10}2 = 12$ Mbits/s
- With four voltage levels, the theoretical maximum data rate in a 6-MHz channel is:
- $C = 2(6)(3.32)\log_{10}4 = 24$ Mbits/s
- To explain this, let's consider multilevel transmission schemes. Multiple voltage levels can be transmitted over a baseband path in which each level represents two or more bits. Assume we want to transmit the serial 8-bit byte (Fig: 1.3a).

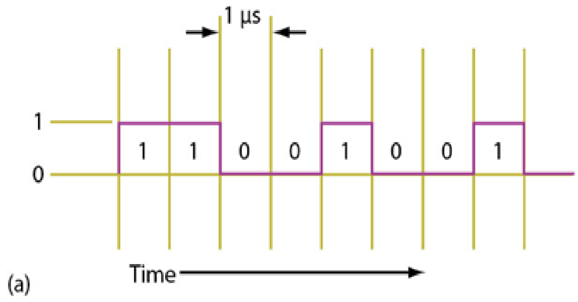


Fig.1.3: (a) Here, an 8-bit serial word in NRZ format is to be transmitted

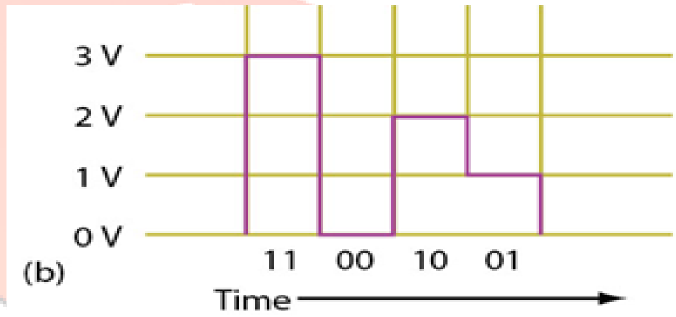


Fig.1.3: (b) The same bit streams, when transmitted in a four level PAM format, data rate

- Also assume a clock of 1 Mbit/s for a bit period of 1 µs. This will require a minimum bandwidth of:
- $B = C/2 = 1$ Mbit/s/2 = 500 kHz (1.9)
- With four levels, two bits per level can be transmitted (Fig.1.3b). Each level is called a symbol. In this example, the four levels (0, 1, 2, and 3 V) transmit the same byte 11001001. This technique is called pulse amplitude modulation (PAM). The time for each level or symbol is 1 µs, giving a symbol rate also called the baud rateof 1 MSymbol/s. Therefore, the baud rate is 1 Mbaud, but the actual bit rate is twice that, or 2 Mbits/s.

Note that it takes just half the time to transmit the same amount of data.

- What this means is that for a given clock rate, eight bits of data can be transmitted in 8 µs using binary data. With four-level PAM, twice the data, or 16 bits, can be transmitted in the same 8 µs. For a given bandwidth, that translates to the higher data rate equivalent to 4 Mbits/s. Shannon later modified this basic relationship to factor in the signal-to-noise ratio (S/N or SNR):
- $C = (B)\log_2(1 + S/N)$ (1.10)
- or:
- $C = B(3.32)\log_{10}(1 + S/N)$ (1.11)
- The S/N is a power ratio and is not measured in db. You will also hear S/N referred to as the carrier-to-noise ratio or C/N. C/N is usually defined as the S/N of a modulated or broadband signal. S/N is used at baseband or after demodulation.With a S/N of 20 dB or 100 to 1, the maximum data rate in a 6-MHz channel will be:
- $C = 6(3.32)\log_{10}(1 + 100) = 40$ Mbits/s
- With a S/N = 1 or 0 dB, the data rate drops to:
- $C = 6(3.32)\log_{10}(1 + 1) = 6$ Mbits/s
- This last example is why many engineers use the conservative rule of thumb that the data rate in a channel with noise is roughly equal to the bandwidth C = B.
- If the speed through a channel with a good S/N seems to defy physics, that's because the Shannon-Hartley formulas don't specifically say that multiple levels or symbols can be used. Consider that:
- $C = B(3.32)\log_{10}(1 + S/N) = 2B(3.32)\log_{10}M$ (1.12)
- Here, M is the number of levels or symbols. Solving for M:
  - $M = \sqrt{(1 + S/N)}$ (1.13)
- Take the case of a 40-Mbit/s data rate in a 6-MHz channel, if the S/N is 100. This will require multiple levels or symbols:
- $M = \sqrt{(1 + 100)} \sim 10$
- Theoretically, the 40-Mbit/s rate can be achieved with 10 levels.

OFDMA BASICS :OFDM is a multiplexing technique that subdivides the bandwidth into multiple frequency sub-carriers as shown in Fig. 4.1. In an OFDM system, the input data stream is divided into several parallel sub-streams of reduced data rate (thus increased symbol duration) and each sub-stream is modulated and transmitted on a separate orthogonal sub-carrier. The increased symbol duration improves the robustness of OFDM to delay spread. Furthermore, the introduction of the cyclic prefix (CP) can eliminate Inter-Symbol Interference (ISI) as long as the CP duration is longer than the

channel delay spread.

Parameters	Values	
System Channel Bandwidth (MHz)	5	10
Sampling Frequency (F_p in MHz)	5.6	11.2
FFT Size (N_{FFT})	512	1024
Number of Subchannels	8	16
Sub-Carrier Frequency Spacing	10.94 kHz	
Useful Symbol Time ($T_b = 1/f$)	91.4 µs	
Guard Time ($T_g = T_b/8$)	11.4 µs	
OFDMA Symbol Duration ($T_s = T_b + T_g$)	102.9 µs	
Number of OFDMA Symbols (5 ms Frame)	48 (including ~1.6 symbols for TTG/RTG)	

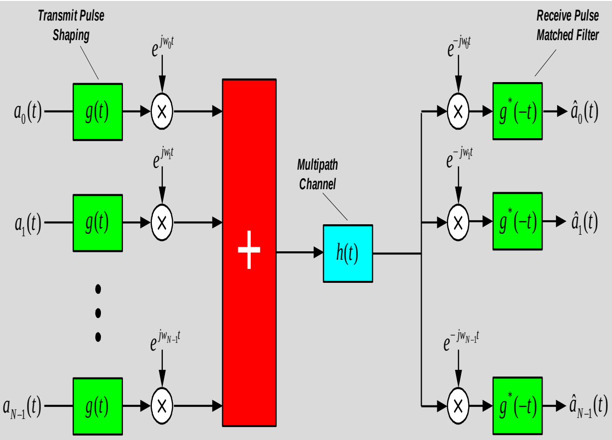


Fig.4.1: Basic Architecture of an OFDM System

SCALABLE OFDMA

IP-OFDMA mode is based upon the concept of

Scalable OFDMA. The scalability is supported by adjusting the FFT size while fixing the sub-carrier frequency spacing at 10.94 kHz. Since the resource unit sub-carrier bandwidth and symbol duration is fixed, the impact to higher layers is minimal when scaling the bandwidth. The IP-OFDMA parameters are listed in Table 4.1.

TABLE 4.1: OFDMA SCALABILITY PARAMETERS

8DEFINITION OF FAIRNESS ;Wireless networking domain, generally, fairness is attributed to resource sharing or allocation. The consequence of an unfair resource allocation among different individuals may lead to resource starvation, resource wastage or redundant allocation. Fairness has been mostly studied in resource allocation based on impartial and justified strategies. Fairness strategies allocate system resources reasonably to individuals of the system in a distributed or centralized fashion. In this paper, we use the term Individual (or Node)1 to refer to the autonomous constituent of a system.

4.8.1 FAIRNESS INDEX

In coherence with the model properties given above, Jain's fairness index is defined as,

$$f(\mathbf{X}) = \frac{\left[\sum_{i=1}^{n} x_i\right]^2}{n \sum_{i=1}^{n} x_i^2}, \qquad (4.1)$$

Where xi is the normalized throughput (in Kbps) of the i−th TCP flow and n is the number of connections. Example: A scheme gives 50, 30, 50 Mbps (throughput, ti) when the optimal is 50, 10, 10 Mbps (fair throughput, oi) Normalized Throughput: xi = ti/oi

= 50/50, 30/10, 50/10

=1, 3, 5

Fairness Index = (1+3+5)2 / 3(12+32+52) =92 / 3(1+9+25) = 0.77

4.8.2 FAIRNESS INDEX PROPERTIES

- **Scale independent**

  Standard deviation (Throughput) = 10 Mbps = 104 kbps

- **Bounded**

  Between 0 and 1 or 0 and 100% variance, standard deviation, and relative distance are not bounded.

- **Direct relationship**

Higher index means More Fair

Higher variance means less fair

- **Continuous**

  Min/max is not continuous. The index should be continuous. Any slight change in allocation should show up in the fairness index. In the above example, if the normalized throughput is 1, 4, and 5 respectively, the fairness should obviously be different, yet it is not reflected in the min-max ratio which remain at 1/5.

PROPOSED METHOD

The design of the radio resource management, the packet scheduling algorithm, and the power allocation to improve the system performance in individual aspects has been comprehensively studied in many papers, for example. From the practical perspective, an efficiently cross layer packet scheduling and resource management scheme was proposed in; a class of computationally efficient algorithms was presented for allocating subcarriers and power among users. In fast algorithms were proposed to compute the optimal resource allocation for maximizing the overall system utility.

However, these works did not consider the concern about the energy-saving issue. In other words, while they did have significant contributions in respective aspects, their designs were not capable of handling the increasingly critical energy consumption problem.

Recently, some research groups have paid attention to the energy-saving transmission related topics, for example, and References provided an overview and survey on the power consumption related issues in wired or/and wireless communication networks. Several energy-conserving network architectures were presented by the energy-saving management group in the 3GPP, an energy-saving algorithm was proposed for the dual cell high-speed downlink packet access system to exploit variations in network traffics. In, a computationally efficient power-saving scheme for downlink transmissions was proposed in orthogonal frequency-division multiple access (OFDMA)-based multi-CC systems, where the frame structure followed that of the LTE-A system, that is, the scheduling process was executed subframe by subframe. Nevertheless, the energy-saving transmission problem for next-generation BS transceivers still has not been fully investigated. Thus, how to minimize the energy consumption of the multiple transceivers in those BSs is still an open issue. While works concerned on such an issue, the fairness concept was not considered; thus, their energy-saving designs could not reflect the effectiveness of the overall system. Also, one can find in that the data rate could not be efficiently and adaptively adjusted according to network traffic loads.

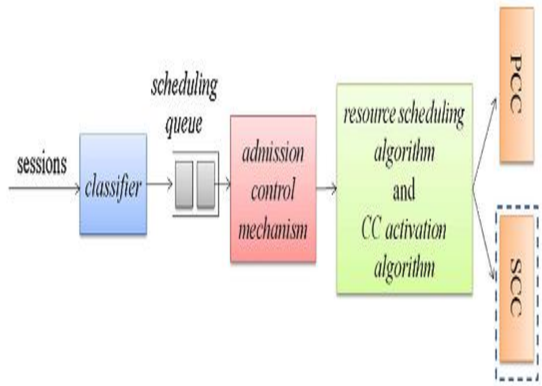


Fig 1:Power and Energy control mechanism

System model consisted of a classifier, a scheduling queue, an admission control mechanism, a set of algorithms, and 2 CCs with 2J RBs in each subframe on each CC for downlink transmissions. The dotted line for the SCC means that the SCC can be turn off based on the traffic load**.**

Moreover, in this model, let CRT and CNRT be the minimum required data rate for the RT and NRT sessions, respectively. For convenience, the PCC and the SCC are indexed as k = 1 and 2, respectively, and RT and NRT users are indexed as z = rt and nrt, respectively

The Fig.7.1 shows 4 levels of data rate, here the level 2 represents the lowest data rate and level 1 represents the highest data rate. It shows the EARCA condition of possibility. It changes the according to the users w.r.to time.

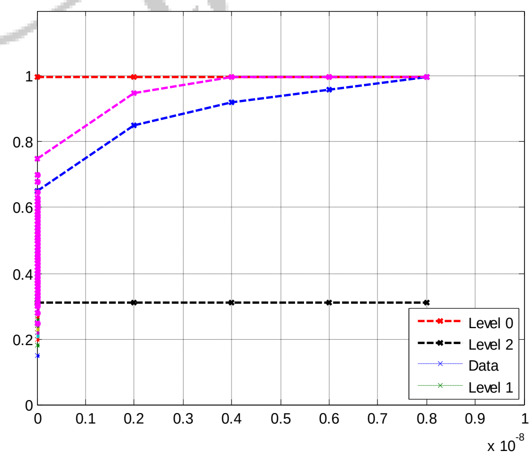


Fig.7.1. Illustration of the reduction ratio as a function of the channel gain being used to determine the allocating capacity for the NRT users

Fig.7.2. Slow time-varying traffic loads versus time

Fig. 7.3 shows energy consumption in non-real time user w.r.to EARCA. It compares the adaptive allocation algorithm between the proposed scheme.

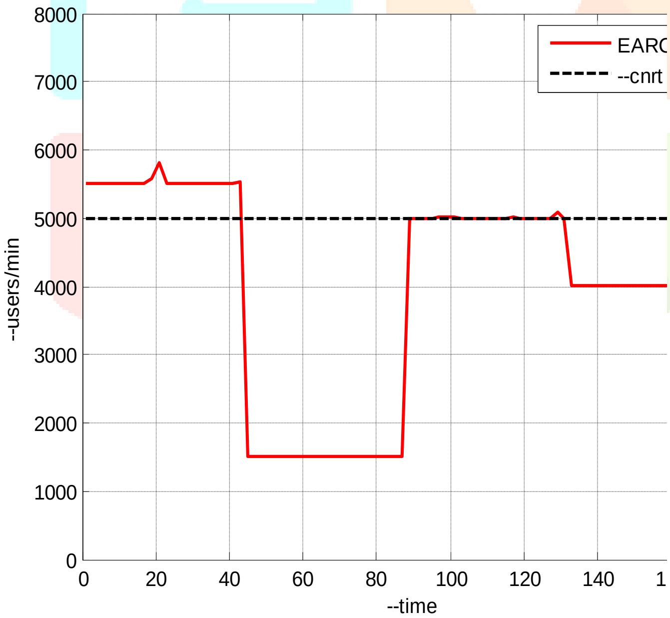


Fig.7.3: Comparison of the energy consumption between the proposed scheme with EARCA, Level 2, and the comparison scheme.

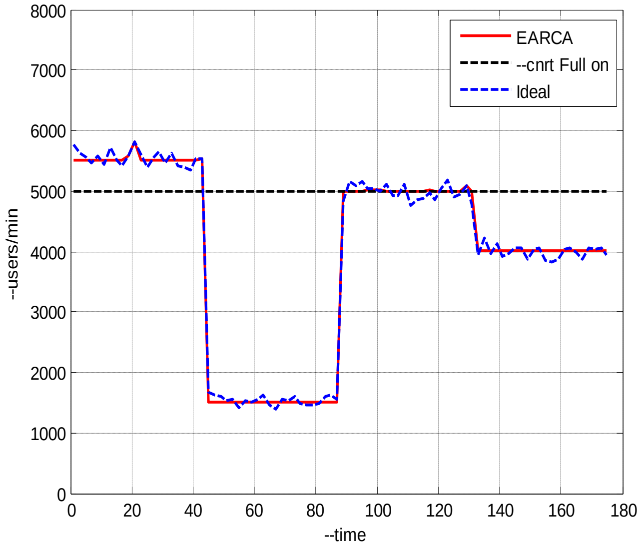


Fig.7.4: Comparison of the energy consumption between the proposed scheme with EARCA, Level 0, and the comparison scheme.

Fig.7.5 and 7.6 shows the average data rate and fairness index in adaptive allocation algorithm w.r.to EARCA.

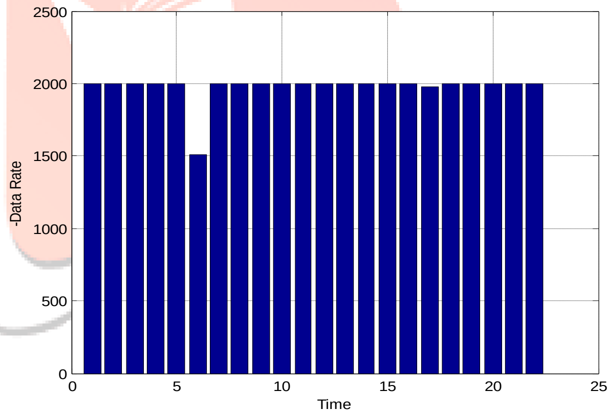


Fig. 7.5: NRT users' average data rate every10 minutes of the proposed scheme with EARCA.

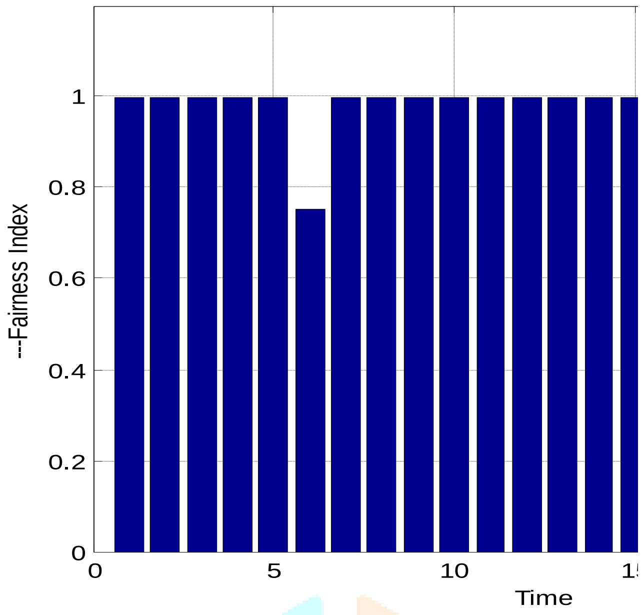


Fig.7.6: Fairness index of the proposed scheme.

7.2EXTENSION RESULTS

The Fig.7.7 shows the ideal users w.r.to EARCA.

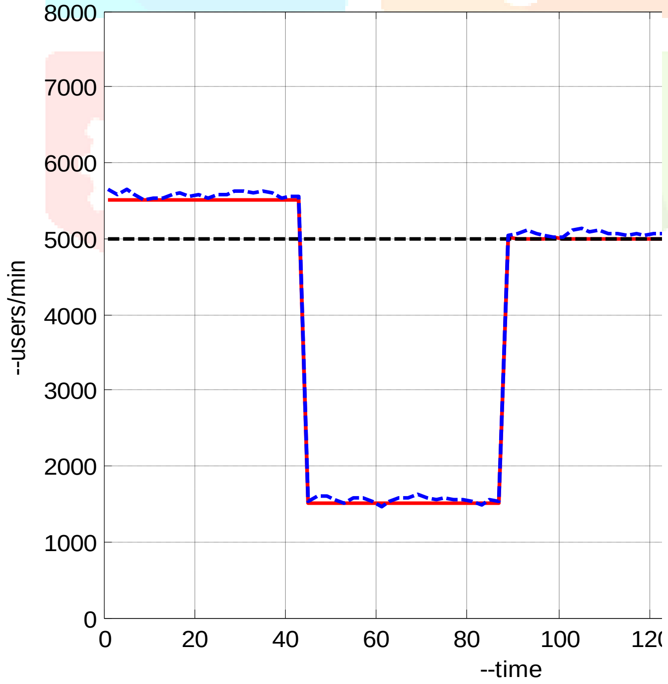


Fig.7.7: Comparison of EARCA, Ideal case and previous technique using SUI-3 channels

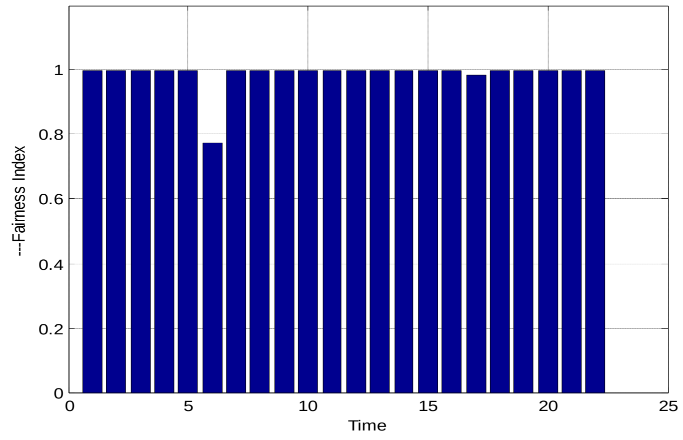


Fig.7.8: Fairness Index for SUI-3 channel

Fig.7.9 is the extension rate for SUI-3 model. It shows data rate for users in different time.

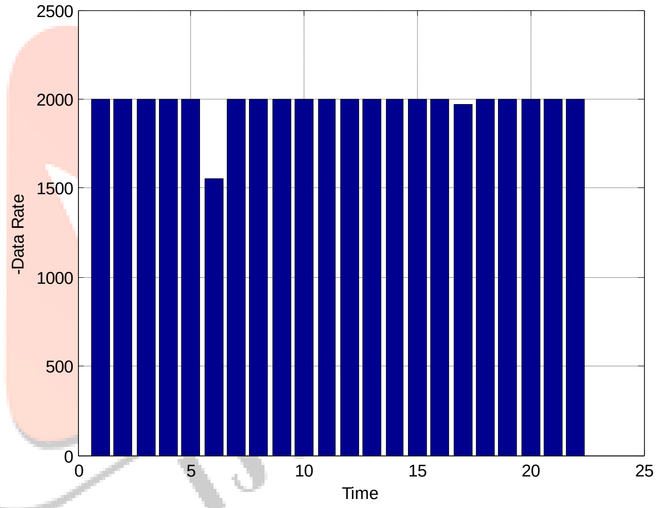


Fig.7.9: Data Rate for SUI-3 model

CONCLUSION AND FUTURE SCOPE

8.1 CONCLUSION

In this project, a novel energy-saving downlink transmission scheme in OFDMA-based multi-CC network systems was successfully proposed. The proposed scheme could allocate the radio resource with an adaptively rate-and-power control to users and support an acceptable level of the QoS and the fairness at the same time. Compared with the currently existing works, the proposed one had the great advantage of flexibility to activate/deactivate the SCC according to the dynamically fluctuating traffic load to effectively avoid unnecessary energy consumption. As a extension work we are going to use SUI-3 model as a channel which will give us the optimal results as compared to proposed work. Extension results will show that the EARCA algorithm proposed is very stable as compare to previous system models as well as it provides better QoS (Data rate) as well as Fairness Index. It was shown from simulation results in Section V that when the CC activation algorithm was employed, the energy consumption could significantly be reduced when the traffic load was relatively light. In addition, thanks to the assistance of the resource scheduling algorithm, the energy could be efficiently utilized. It was thus believed that the presented energy-saving scheme was an excellent approach to be employed in the future multi-CC cellular system at the BS side for transmissions to overcome the increasingly crucial problem of the rising energy cost and the CO2 emission concern.

8.2 FUTURE SCOPE

In proposed method, we are using adaptive resource algorithm. In that the users are not constant. According to the data rate the will vary. And the level that we are using only up to two levels.

In future, we can use more than two levels i.e., up to seven levels by using the next generation technology (5G). Due to this, the non-real time users may also get the speed of data same as real time users. For next generation we can use SUI-3 model with better QoS and fairness index.

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