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Resource Allocation & Energy Consumption Reduction for 5G (NR-New Radio) Wireless Communication †

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Abstract: Abstract: Resource Allocation is one of the most challenging issues in LTE & 5G communication in the modern era. In wireless communication, the proper method of assigning resources to subscribers has received considerable attention. So, in this thesis, we are introducing an approach based on visualizing resource allocation. It will help the users allocate their resources correctly and effectively and divide the subscriber's situation into three parts (Good, Mid, Cell edge) by checking the R.F. condition. If the subscriber is in a cell edge situation, we won't count it to reduce computational complexity. Those users to whom we have allocated the resource will save a lot of time and energy if they are stable. We've used Adobe X.D. (UI/UX) software interface to design the layout of the resource allocation scenario. The layout shows our prototype on a live server. And we have also delivered some logic by using the IF-THEN statement through membership function in fuzzy logic. Using those logics, eNodeB will get the user's information, so it would be easy for eNodeB to decide how the machine will work.

Keywords: resource allocation; resource block; CQI; UI/UX; Fuzzy logic Interface; 5G-NR; LTE

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1. Introduction

Resource allocation is the bandwidth, power, modulation level, and how to allocate them based on the different scenarios of the users. If we consider a cell, someone will be in cell edge position someone will be in mid cell position, someone will be in good or excellent RF condition. So, depending on the users if we provide the bandwidth, if we talked about the power level, if we assign the modulation level then this all-allocation process is called resource allocation.

We have a lot of methodology regarding resource allocation, but there are very few effective methods. But they have still some limitations. In generally the operators allocate resources based on approximate assumption. That's why they can't optimize resource perfectly, which is one of the major problems for resource utilization. There are two different types of mobile users, one is dynamic(movable) and other is stationary(non-movable). In researched scenarios we have figured out that, Dynamic users are not getting enough blocks to use. On the contrary, Stationary users are getting more than enough blocks and they are not even using it. In this research we analyze the CQI value for each (Dynamic & Stationary) user to allocate proper resources for their communication.

The feedback of the channel quality indicator (CQI) in a long-term evolution (LTE) system is critical for expressing the instantaneous channel status information in the system [1]. The precision of the channel estimate procedure is crucial to the accuracy of the CQI calculations, which are used to assign the proper modulation and coding scheme. The Evolved Node B (eNodeB) must identify the channel quality indicator (CQI) to make correct scheduling decisions and to perform proper link adaptation (L.A.) to assign modulation and coding scheme to the channel (MCS). The channel quality index (CQI) translates the channel state to an index form, which is reported by the user equipment (U.E.) to the eNodeB [2,3]. Good SINR value provide better CQI which help to provide better MCS in eNodeB and eNodeB calculating resource block depending upon the time and gives resource block where needed.

We used two different sorts of simulations in this thesis. We provide a well-designed system that will use a UI/UX interface to determine the fixed value and work through interfacing. It is an online and mobile applications user experience (UX) design tool based on vectors. It creates every interface of the application to show the visual of the whole process. Visualizations, layouts, and U.I. designs mixed with the user experience in real-time, allowing the user to replicate the flow. That is, we are demonstrating the method on a live server. eNodeB additionally has the Fuzzy Interface Logic (FLC) technique implemented. The FL (fuzzy logic) concept has been chiefly used in nonlinear systems to describe their performances. To handle complicated issues effectively, F.L. is employed, rather than true or false, to express their outcomes in the form of a range. It is possible to combine items into a fuzzy set, and each component of this set is described by a fuzzy membership function, which has an upper and lower bound of 0 to 1 [4]. Because of their fuzzy nature, fuzzy-based rules help handle and represent nonlinear systems [5,6]. eNodeB will acquire information about the user conditions using the FLC IF-Then statement, making it simple for eNodeB to deliver suitable Resource allocation for the respective user while maintaining QoS [7,8].

2. Measurement of CQI SINR & Modulation and Coding Scheme (MCS)

The CQI measurement model in the simulator is based on four fundamental phases: measuring SINR, injecting measurement error into SINR, transforming SINR values to discrete CQI steps, and lastly, CQI reporting according to a specified scheme [8–10].

$$\mathrm{SINR_{(dB)}(m)} = 10 * \log_{10}[\mathrm{SINR_{lin}(m)}] + \mathrm{Error_{(dB)}} \quad (1)$$

$\mathrm{Error_{(dB)}}$ represent Gaussian distributed error with a zero mean and defined variance incorporated into the measured ideal SINR.

$$\mathrm{CQI_{(dB)}} = \mathrm{StepQ_{(dB)}} * \mathrm{ground}\left(\frac{\mathrm{SINR_{(dB)}}}{\mathrm{StepQ_{(dB)}}} + 0.5\right) \quad (2)$$

In CRS resource elements, signal power (S) is divided by the total interference and noise (I+N), expressed as SINR. SINR is a measure of signal strength.

$$\mathrm{SINR_{(dB)}} = \frac{\mathrm{S}}{\mathrm{N} + 1} \quad (3)$$

Modulation specifies the maximum number of bits that may be conveyed by a single RE, regardless of whether they are useable or parity bit

$$2^n = modulation\ Oreder \quad (4)$$

3. Proposed System Model

In this research, we represent the resource allocation technique based on the CQI index. When any user sends a request for attending a call, we will figure out the channel condition of the call through SINR. Then we will check the CQI condition of the demanding call by SINR. And the conditions of the call will the estimate through mapping its discrete value, which we consider as the CQI INDEX. After that, we check the state of the call based on the CQI Index. Like- is the user either in stationary condition or in dynamic condition? If the user is in a stationary condition, then check if previous resources are available or not. If the resources are available, then assign the User as MCS. After that, we will review the R.F. condition of the user. For figuring out the condition of the call, either

Good or Middle or cell edge. If the call maintained Good or Middle condition, then allocated the resources and forwarded it to the next step through eNodeB.

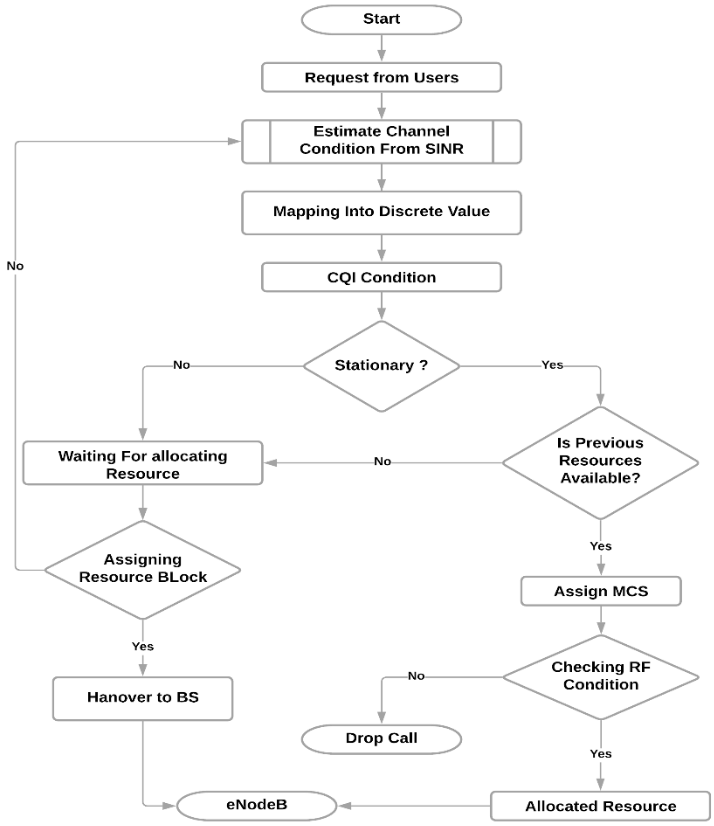

Figure 1. Flowchart of Proposed System Model.

Otherwise, if the user is not in Stationary condition, then will wait until the allocation of the resources block. If the resource block remains empty, then we will assign it to the user. After that, the proposed system will be sent to the eNodeB in the next step. If the resource block is not empty, we will send it back to the user to check the SINR value.

Proposed System Model Illustrate by UI/UX Interface

UI/UX has two types of the working process

1. Design
2. Making Prototype

In design, we have to design frame-by-frame. Each frame shows the numbers and activities of the user animatedly. The frames are processed as singular blocks. And, this process we can control in the prototype level, which aims at interconnect every frame. The animation of the Apps depends on how we have designed them in these two levels

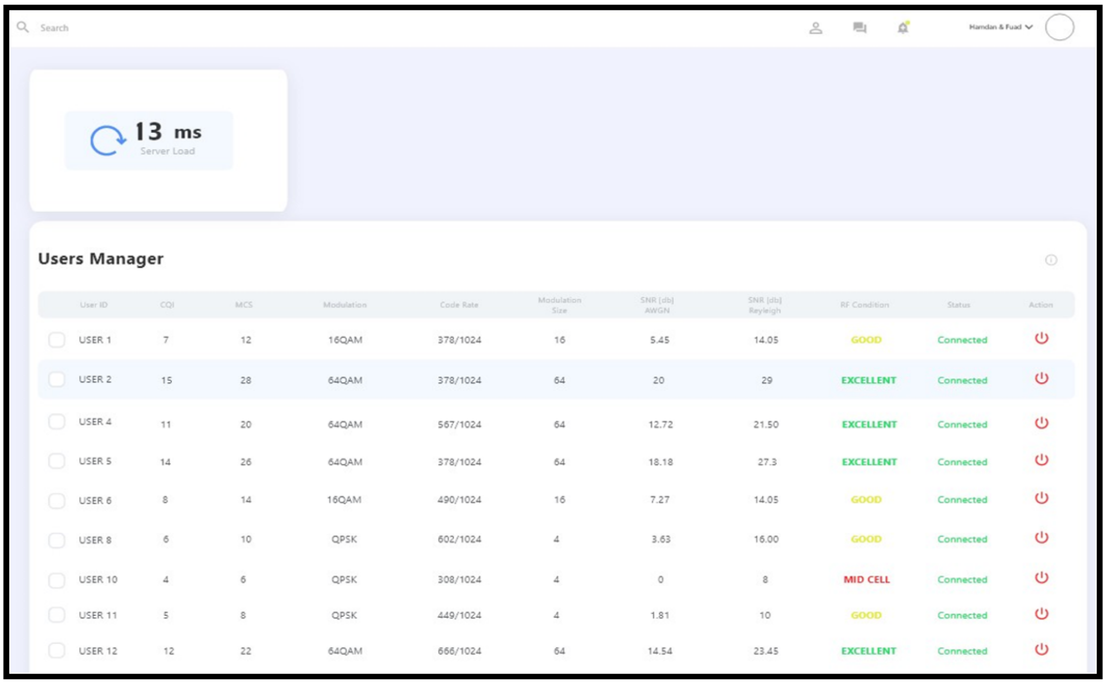

Figure 2. Assigning All users based on CQI, and Eliminating Cell Edge Condition Users.

Table 1. Characteristics of the Different Transmission Modes and SNR Thresholds for Different Channel Conditions with SISO [9].

CQI	MCS	Modulation	Code Rate	Modulation Size	SINR [dB] AWGN	SINR [dB] Rayleigh	CQI	MCS	Modulation
1	0	QPSK	78/1024	4	−5.45	1.95	1	0	QPSK
2	2	QPSK	120/1024	4	−3.63	4	2	2	QPSK
3	4	QPSK	193/1024	4	−1.81	6	3	4	QPSK
4	6	QPSK	308/1024	4	0	8	4	6	QPSK
5	8	QPSK	449/1024	4	1.81	10	5	8	QPSK
6	10	QPSK	602/1024	4	3.63	11.95	6	10	QPSK
7	12	16QAM	378/1024	16	5.45	14.05	7	12	16QAM
8	14	16QAM	490/1024	16	7.27	16.00	8	14	16QAM
9	16	16QAM	616/1024	16	9.09	17.90	9	16	16QAM
10	18	64QAM	466/1024	64	10.90	19.90	10	18	64QAM
11	20	64QAM	567/1024	64	12.72	21.50	11	20	64QAM
12	22	64QAM	666/1024	64	14.54	23.45	12	22	64QAM
13	24	64QAM	772/1024	64	16.36	25	13	24	64QAM
14	26	64QAM	873/1024	64	18.18	27.3	14	26	64QAM
15	28	64QAM	948/1024	64	20	29	15	28	64QAM

4. Proposed Fuzzy Logic Controller Simulation Model

The overall system is controlled using an FLC Mamdani modification. FLC simulation model is designed to carry out the specific input-output ranges [43]. The fuzzy logic controller using the Mamdani modification model associated with the inputs and outputs membership functions. Four parameters are set as input functions with three outputs variables. The FLC takes four inputs as User condition, RSRP level, SINR level, Noise level. It also takes three outputs as CQI, MCS, and code rate.

In input-1 (User Condition), input-2 (RSRP Level), input-3 (SINR Level) input-4 (Noise Level) have fourteen membership functions. In output-1 (CQI Index), output-2 (MCS) and output-3 (Code Rate) have ten membership functions.

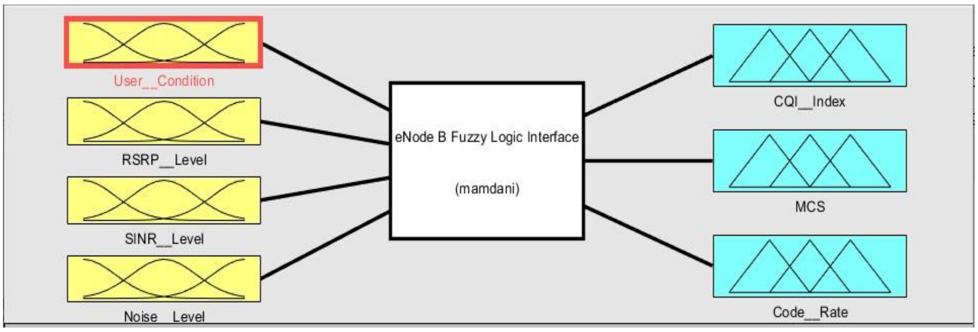

Figure 4. FLC Interface Model using Mamdani Modification.

We utilized four inputs in this simulation, which have different membership functions. Based on those input variables, we create 5*3*3*3 = 135 fuzzy interface rules to generates outputs using IF and THEN statements. And, following F.L. interface rules were implemented for simulating the result.

- ✓ If User Condition is Middle and RSRP Level is Very Low, SINR Level is Low, and Noise Level is Low. CQI Index is Cell Edge, MCS is Level_1, Code Rate is Low
- ✓ If User Condition is Slow and RSRP Level is Very Low, SINR Level is Low, and Noise Level is Low, then CQI Index is Cell Edge, MCS is Level_1, and Code Rate is Low.
- ✓ If User Condition is Slow and RSRP level is Very High, SINR Level is High, and Noise Level is Low, then CQI Index is Good, MCS is Level_3, Code Rate is High.
- ✓ If User Condition is Middle and RSRP Level is Medium and SINR Level is Medium, and Noise Level is Medium, then CQI Index is Mid Cell, MCS is Level_2, Code Rate is Medium
- ✓ If User Condition is Fast and RSRP Level is Low, SINR Level is Low, and Noise Level is Low, then CQI index is Cell Edge, MCS is Level_1, Code Rate is Low.
- ✓ If User Condition is Fast and RSRP level is Very High, SINR Level is High, and Noise Level is High, then CQI Index is Good, MCS is Level_3, Code Rate is Medium.

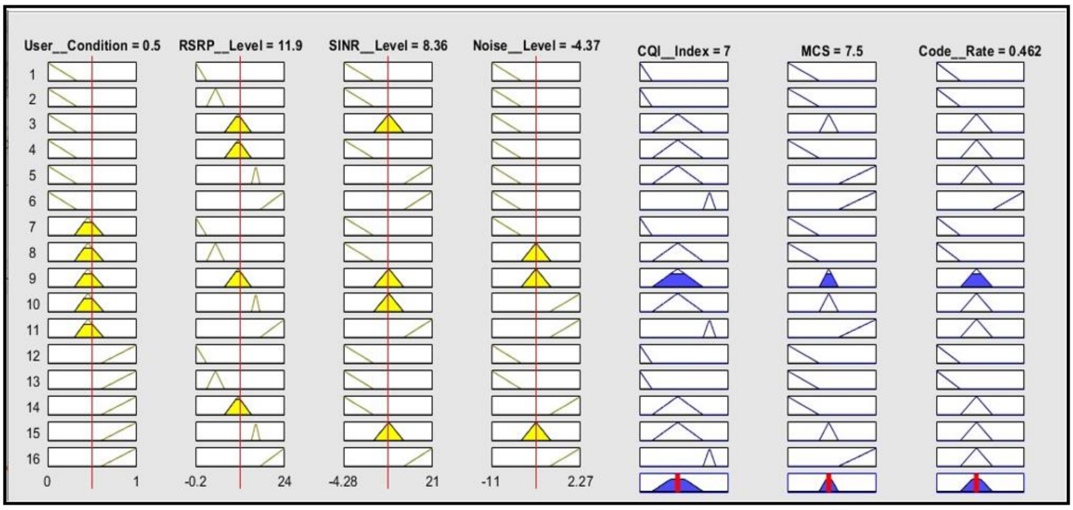

Figure 5. Fuzzy Logic Interface Rule View Plot.

5. Simulation Result

From the simulation part, we investigated that our proposed system worked correctly. When we provide rules in the Mamdani modification interface, it works dynamically to identify the user CQI, what MSC is used for the user and the code rate of the user. From the rule view graph Figure 5, we have shown that when the user condition is middle and RSRP level, SINR Level and Noise level are in medium, then our design model dynamically calculates the user information as CQI condition is middle, MCS level-2 that means user used 16QAM modulation technique and code rate also the medium. From this output, data B.S. can allocate proper resources for the user. The simulation result of four input membership functions is User condition = 0.5; RSRP level = 11.9; SINR level = 8.36; Noise Level = −4.78 as shown is Figure 5.

6. Conclusions

As we know, we have already introduced ourselves to a lot of resource allocation techniques. We are applying the CQI method, which is considered to be the best among them. The user who provides the best CQI gets the top priority and will allocate resources to that particular user. As there are many cells in 5G technology, the CQI method will play a decisive role in resource allocation. It will consume time and, along with that, will show less complexity. In this thesis, we have worked with two types of simulation. We introduce a well-designed system that will calculate the fixed value with UI/UX interface and work through interfacing. That means we are presenting the mechanism through the live server. And we have also implemented the Fuzzy Interface Logic (FLC) method at eNodeB. Using the FLC IF-Then statement, eNodeB will get the information of the user conditions, which is easy for eNodeB to provide proper Resource allocation for the respective user with maintaining the QoS.

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