Data Analytics and Artificial Intelligence

Vol: 3(5), 2023

REST Publisher; ISBN: 978-81-948459-4-2

Website: http://restpublisher.com/book-series/daai/

DOI: https://doi.org/10.46632/daai/3/5/1

Assessment of the Comprehensive Performance of 5G Base Station using the COPRAS

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Abstract. *As wireless internet expands quickly, so does people's anticipation for the effectiveness and efficiency of mobile communication. After 2020, the fifth generation (5G) of cell communication technologies will take over as the primary direction for wireless technology growth. Problems like bad customer experience and inadequate coverage area commonly arise when the size of 5G ground stations progressively grows. Therefore, it is essential to assess the overall performance of 5G access points to identify any issues that may have arisen during base station installation. The "COPRAS (Complex Proportional Assessment)" technique is employed in this research to assess the overall performance of 5G network sites. In this study, specific 5G base stations in an area are chosen for a thorough performance assessment. Factors such as "Signal coverage area (104 m2), Annual average business loadings (kW), Per capita input cost (rupee/person), Electric field intensity (V/m), and User experience degree" are taken into consideration to assess the overall performance of a 5G ground station. The rank of alternatives using the COPRAS method for Base Station 1 is second, Base Station 2 is fifth, Base Station 3 is fourth, Base Station 4 is third, and Base Station 5 is first. The result from the COPRAS analysis shows that the base station with a signal coverage area of 26.7104 m2, annual average business loadings of 22 kW, and electric field intensity of 1.32 V/m is optimized as the best among the 5G base stations considered.*

Keywords: *5G network, Signal coverage area, business loadings, Electric field intensity and MCDM.*

1. INTRODUCTION

The development of technology standards and the fostering of industry are crucial stages for the fifth-generation (5G) network. The majority of nations in the world view 5G as a high-priority area for development in their national digital agendas because it has the potential to improve the industrial structure and provide new competitive advantages. The "Enhanced Mobile Broadband (eMBB), massive Machine Type Communications (MTC), and Ultra-Reliable Low Latency Communication (URLLC)" are the main 5G applications that the "International Telecommunications Union (ITU)" identified [1]. The administration strategy for base stations is to build a broadcasting base station in an appropriate job so that the 5G network signal reaches the full planning area to satisfy user needs for 5G network packet forwarding in the proposed site. A very big community of users autonomously communicating with a correspondingly large population of clients and correspondence for a range of applications often generates connections utilising the 5G network [2,3]. To guarantee a certain Quality of Service (QoS) level, the bandwidth needed for each connection must be appropriate given the traffic requirement and network governance settings. The provision of adequate bandwidth to satisfy connections' QoS needs, as well as efficiently attaining that aim, are important considerations in the architecture of 5G networks. The network provider selects an ideal plan for the various users within the overall budget to satisfy connection requirements. Additionally, it is claimed that due to a shortage of resources, the danger of denying connection attempts is kept below a set threshold [4]. Additionally, a game theoretic method, such as and connections therein, could be used to think about the decision-making in terms of the mechanics of the cell screening process. The Internet service provider's pricing policies may have an impact on how the base stations are deployed. Their QoS-aware efficiency might be maximised by assigning network users in the best possible way to the most suitable cell [5]. To ensure fundamental communication needs are met and users' QoS requirements are satisfied, several existing projects used macro ground stations to cover broad areas, but they were unable to significantly lower deployment costs. High installation and maintenance expenses will be spent if the macro stations are installed widely and intensively to offer a positive user experience [6,7]. The transmission range and signal intensity will improve when more macro base stations are installed, but the aggregate cost of installing a station will rise as well. As a result, there is a trade-off between cost and transmission strength when establishing 5G macro and micro base units [8,9]. Only a wide operational spectrum, in the range of hundreds of MHz to several GHz, which is very challenging to produce below 24 GHz, can meet the high throughput statistics of 5G. Due to low power amplifiers efficiency (less than 20%), a smaller receiving functional aperture, and lower diffraction and scattering effects, mm-wave broadcasts have much worse RF link economies [10,11]. Massive antenna arrangements with hundreds of components are anticipated to be used in 5G systems to lessen these limitations. Currently, the use of a transceiver behind each antenna element results in excessive heat loss and high production costs. Due to this, hybrid beamforming techniques are now more appealing than digital beamforming [12]. In this study, a specific area's 5G base stations are chosen for thorough performance evaluation. To assess the overall performance of a 5G base station, factors such as "Signal coverage area (10^4 m^2), Annual average business loadings (kW), Per capita input cost (rupee/person), Electric field intensity (V/m), and User experience degree" are taken into consideration.

2. MATERIALS AND METHODS

The selection of the proper substances for various elements is one of the most challenging tasks in the creation of products for diverse technical applications. Therefore, the architects must identify and select suitable materials with specific characteristics to produce the desired end with little cost involvement and specialized applicability [13]. Choosing the best resource when there are several, frequently at-odds criteria accessible is a common "multi-criteria decision-making (MCDM)" challenge. Therefore, the best alternative for a given input needs to be selected utilising a thorough and suitable process of material choosing [14]. The "COPRAS (COmplex PRoportional ASsessment) technique" is employed in this work to address several common material selection problems. "The complex proportional assessment (COPRAS)" created the "Zavadskas et al" technique, which uses a step-by-step ranking and evaluating procedure of the relevant options in terms of significance and usefulness level. This concept was used to handle a variety of construction, property preservation, economic, etc. challenges [15]. Despite a few minor flaws, "COPRAS MCDM" has many significant positive qualities that more than compensate for them. The main and most significant benefit of "COPRAS" is its ability to tackle positive and unfavourable aspects separately [16]. The relevance and usefulness level of the versions under consideration is determined by a set of criteria, according to COPRAS. These criteria appropriately specify the possibilities as well as the weights and amounts of each criterion. These guidelines [17] demonstrate that the COPRAS method is an important MCDM technique and a helpful decision-making tool. Options are rated by COPRAS using a single evaluation method that considers the influences of both the expense and benefit type criteria. It differs from other MCDM approaches in that COPRAS takes into account the "utility degree of options" which specifies a percentage and specifies the degree to which one remedy is superior to or poorer than the other various options utilised for evaluation [18]. Furthermore, COPRAS is much more durable than “WSM in the presence of data changes”, and judgments integrated with COPRAS are more precise and less biased than results with "TOPSIS and WSM" according to contemporary studies. COPRAS also has many advantages over other MCDM programs, such as "PROMETHEE, DEA, VIKOR, AHP, and ELECTRE" including a very simple and obvious MCDM approach that requires a lot less processing effort and a high possibility of graphical understanding [19,20].

Step 1: The decision matrix X, which displays how various options perform about certain criteria, is created.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & x\cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: Weights for the criteria are expressed as

$$w_j = [w_1 \ \cdots \ w_n], \quad (2)$$

$$\sum_{j=1}^{n}(w_1 \ \cdots \ w_n) = 1$$

the sum of the weight distributed among the evaluation parameters must be one.

Step 3: The matrix x_{ij}'s normalized values are computed as

$$n_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} \quad (3)$$

Step 4: Weighted normalized matrix N_{ij} is calculated by the following formula

$$N_{ij} = w_j \times n_{ij} \qquad (4)$$

Step 5: sum of benefit criteria and the sum of cost criteria are calculated by following equations 5 and 6 respectively.

$$B_i = \sum_{j=1}^{k} N_{ij} \qquad (5)$$

$$C_i = \sum_{j=k+1}^{m} N_{ij} \qquad (6)$$

Step 6: Relative significance Qi of each alternative is calculated using equations 5 and 6.

$$Q_i = B_i + \frac{min\,(C_i) \times \sum_{i=1}^{n} C_i}{C_i \times \sum_{i=1}^{n} (\frac{min\,(C_i)}{C_i})} \qquad (7)$$

Step 7: Next U_i is calculated.

$$U_i = \frac{Q_i}{max\,(Q_i)} \times 100\% \qquad (8)$$

In this study, a specific area's 5G base stations are chosen for thorough performance evaluation. To assess the overall performance of a 5G base station, factors such as "Signal coverage area (10^4 m^2), Annual average business loadings (kW), Per capita input cost (rupee/person), Electric field intensity (V/m), and User experience degree" are taken into consideration.

Signal coverage area (10^4 m^2): The network coverage of many ground stations is likely to intersect in real-world circumstances due to a lack of meticulous building design. The base network's signal transmission range cannot be determined using a straightforward circular area formula; instead, it must be adjusted to account for ground station overlap [21,22].

Annual average business loadings (kW): "Active antenna unit (AAU) and baseband unit (BBU)" are the essential components of the 5G base facility. Approximately 46% of the base channel's total energy use is accounted for by the energy expenditure of the two units, and the energy use of AAU equipment is mostly influenced by business workloads. To describe company loadings, the yearly average load indicator is chosen [23].

Per capita input cost (rupee/ person): In contrast to functional efficiency, the base station also depends on financial achievement. The building costs of the base unit and the total population served can also be considered in the indication of "per capita input cost" [24].

Electric field intensity (V/m): There will be effects on the water and soil ecology, acoustic atmosphere, and electromagnetic nature during the building and maintenance of 5G base stations. The most crucial of these is the environment's electromagnetic radiation assessment. The "radiofrequency electromagnetic field and the power density (or electric field strength)" are the two detection parameters for the "electromagnetic radiation environment of 5G base stations", respectively [25].

User experience degree: Numerous elements frequently have an impact on user experience. Regarding signal quality and intensity, it is somewhat influenced by the psychological aspects of the user. Even though base unit electromagnetic radiation typically complies with national requirements, some customers continue to experience psychological issues. Industry leaders, researchers in the scientific community, and technical staff might be enlisted to educate the public about base stations to resolve disputes or misconceptions [26].

3. ANALYSIS AND DISSECTION

TABLE 1. Parameters of each base station

Base Station	Signal coverage area (104 m2)	Annual average business loadings (kW)	Electric field intensity(V/m)	User experience degree	Per capita input cost(rupee/ person)
BS1	24.28	14	4.09	6.8	4603.79
BS2	21.99	4	6.78	9.3	16113.15
BS3	21.87	8.9	5.62	8.1	7241.861
BS4	22.56	14.7	3.65	6.5	4384.539
BS5	26.7	22	1.32	5.1	2929.62

Table 1 shows the data set of the Main parameters of each base station. In this study, 5G base stations in a certain area are selected for comprehensive performance evaluation. "Signal coverage area (10^4 m^2), Annual average business loadings (kW), Per capita input cost (rupee/ person), Electric field intensity (V/m) and User experience degree" are used to evaluate the Comprehensive Performance of 5G Base Station.

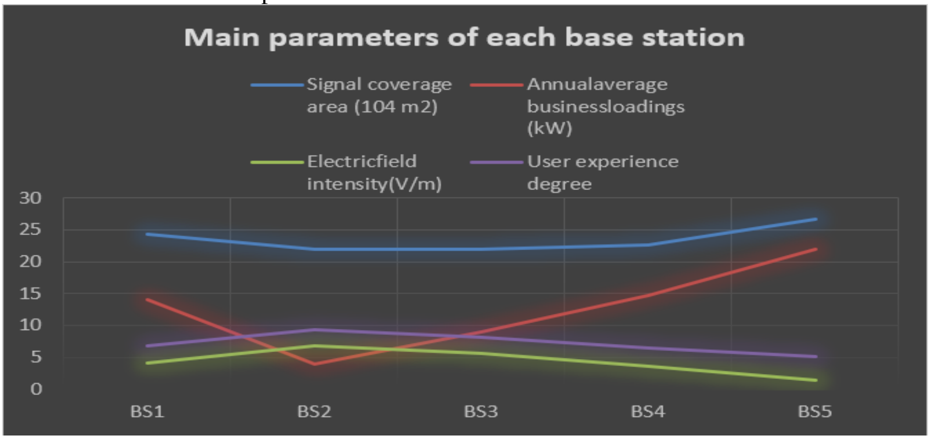

FIGURE 1. parameters of each base station

The figure illustrates the data set of the Main parameters of each base station. In this study, 5G base stations in a certain area are selected for comprehensive performance evaluation. "Signal coverage area (104 m2), Annual average business loadings (kW), Per capita input cost (rupee/ person), Electric field intensity (V/m) and User experience degree" are used to evaluate the Comprehensive Performance of 5G Base Station**.**

TABLE 2. Normalized matrix

0.2068	0.2201	0.1906	0.1899	0.1305
0.1873	0.0629	0.3159	0.2598	0.4568
0.1863	0.1399	0.2619	0.2263	0.2053
0.1922	0.2311	0.1701	0.1816	0.1243
0.2274	0.3459	0.0615	0.1425	0.0831

The normalized matrix of Performance Ratings of parameters of each base station is displayed in Table 2 above. Equation 3 was used to create this matrix.

TABLE 3. Weight Distribution

0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20

The preferred weight for the evaluation parameters is shown in Table 3. In this case, weight is equally distributed among evaluation criteria and the sum of weight distributed is one.

TABLE 4. Weighted normalized decision matrix

0.04136	0.04403	0.03812	0.03799	0.02610
0.03746	0.01258	0.06319	0.05196	0.09136
0.03726	0.02799	0.05238	0.04525	0.04106
0.03843	0.04623	0.03402	0.03631	0.02486
0.04549	0.06918	0.01230	0.02849	0.01661

The Performance Ratings of the parameters of each base station are shown in Table 4 as a normalized matrix. Equation 4 was used to calculate this matrix, which was produced by multiplying tables 2 and 3.

TABLE 5. the sum of benefit criteria and the sum of cost criterion

Base Station	Bi	Ci
BS1	0.16149	0.02610
BS2	0.16518	0.09136
BS3	0.16287	0.04106

BS4	0.15499	0.02486
BS5	0.15546	0.01661

Table 5 displays the total cost and total benefit criteria that were determined using equations 5 and 6. "Signal coverage area (104 m2), Annual average business loadings (kW), Per capita input cost (rupee/ person), Electric field intensity (V/m) and User experience degree" are used to evaluate the Comprehensive Performance of 5G Base Station**.**

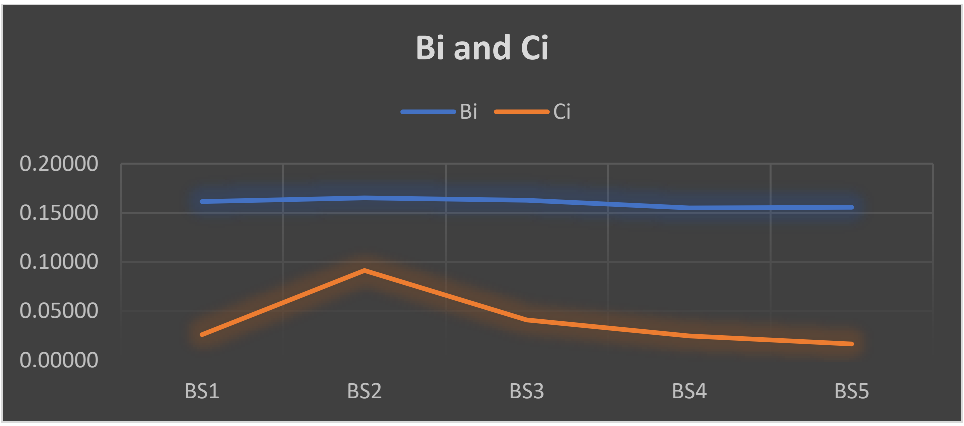

FIGURE 2. Bi and Ci

Equations 5 and 6 were used to calculate the total beneficial criteria and total cost criterion shown in Figure 2. "Signal coverage area (104 m2), Annual average business loadings (kW), Per capita input cost (rupee/ person), Electric field intensity (V/m) and User experience degree" are used to evaluate the Comprehensive Performance of 5G Base Station**.**

TABLE 6. Relative significance and Utility degree

Base Station	Qi	Ui
BS1	0.206	91.4862
BS2	0.178	79.1301
BS3	0.191	84.9608
BS4	0.201	89.5703
BS5	0.225	100.0000

Using equations 7 and 8, Table 6 displays the relative relevance and utility degree. Here utility degree value for Base Station 1 is 91.4862, Base Station 2 is 79.1301, Base Station 3 is 84.9608, Base Station 4 is 89.5703 and Base Station 5 is 100.

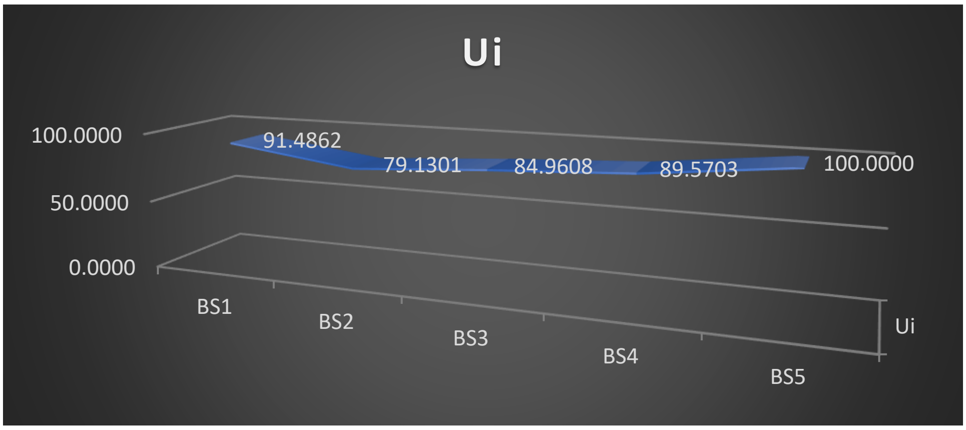

FIGURE 3. Utility Degree

Figure 3 shows the illustration of the Relative significance and Utility degree calculated by using equations 7 and 8. Here utility degree value for Base Station 1 is 91.4862, Base Station 2 is 79.1301, Base Station 3 is 84.9608, Base Station 4 is 89.5703 and Base Station 5 is 100.

TABLE 7. Rank

Base Station	Rank
BS1	2
BS2	5
BS3	4
BS4	3
BS5	1

Table 7 shows the rank of alternatives BS1, BS2, BS3, BS4 and BS5 using utility degree values in table 6. Here rank of alternatives using the COPRAS method for Base Station 1 is second, Base Station 2 is fifth, Base Station 3 is fourth, Base Station 4 is third and Base Station 5 is first.

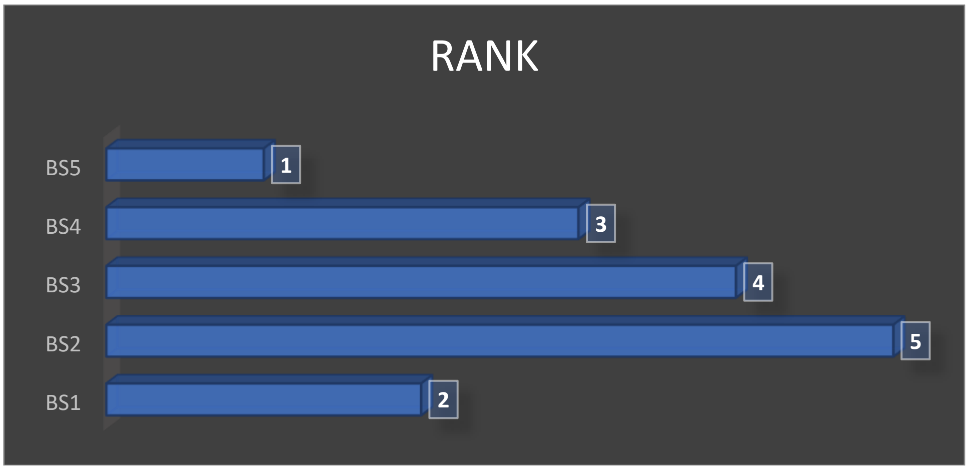

FIGURE 4. Rank

Figure 4 illustrates the ranking of Ui from Table 6. Here rank of alternatives using the COPRAS method for Base Station 1 is second, Base Station 2 is fifth, Base Station 3 is fourth, Base Station 4 is third and Base Station 5 is first. The result from COPRAS analysis shows that the base station with a Signal coverage area of 26.710^4 m^2, Annual average business loadings of 22 kW, and Electric field intensity of 1.32 V/m is optimized as the best among the 5G base stations taken.

4. CONCLUSION

As the mobile network expands quickly, so do people's expectations for the effectiveness and efficiency of mobile connectivity. The fifth-generation (5G) mobile connectivity technology will be the future of wireless technologies advancement after 2020 as a new generation of mobile transmission technology. With its high speed, low delay, and vast connection capabilities, fifth-generation mobile communication technology may offer users quicker and more effective services. The development and commercialization of 5G have simultaneously enabled communication to transcend the prior fixed mode and heralded the dawn of the age of co-connection across people and everything. Ever more 5G base units are being built to suit people's choices, and daily needs as 5G technology continues to advance. Thus, the overall effect can be used as a guide for future 5G base station location selection strategies in addition to determining whether the access point has satisfied the expected requirements. In this study, the "COPRAS (COmplex PRoportional ASsessment) technique" is used to evaluate the comprehensive performance of 5G base stations. The rank of alternatives using the COPRAS method for Base Station 1 is second, Base Station 2 is fifth, Base Station 3 is fourth, Base Station 4 is third and Base Station 5 is first. The result from COPRAS analysis shows that the base station with a Signal coverage area of 26.710^4 m^2, Annual average business loadings of 22 kW, and Electric field intensity of 1.32 V/m is optimized as the best among the 5G base stations taken.

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