An Interval Valued Neutrosophic Sets Integrated with the AHP MCDM Methodology to Assess the Station of 5G Network

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Abstract

In latest days, 5G technology has undergone fast development and has since found widespread use in a variety of industries including medicine, travel, agriculture, and others. The 5G network's fundamental equipment, known as 5G ground stations, are responsible for achieving wireless signal transfer among wired communications systems and wireless endpoints. Additionally, 5G stations give communication range. Nevertheless, as the size of 5G ground stations continues to progressively develop, difficulties such as inadequate coverage area and subpar user experiences commonly arise. As a result, it is essential to conduct an all-encompassing performance evaluation of 5G ground stations in order to better understand the challenges that now exist in the development of ground stations. To begin, the components of the performance assessment index system, which include operating efficiency, economic condition, ecological effects, and social pressure, are assembled from their respective vantage points. In the next step, a unique hybrid multi-criteria decision-making (MCDM) approach that is built on the AHP methodology is used. In conclusion, ten 5G base stations are selected as samples for further investigation. The AHP is integrated with the Interval Valued Neutrosophic Sets (IVNSs). The IVNSs used to overcome incomplete and vague information. The AHP method used to compute the weights of criteria.

Keywords: Interval Valued Neutrosophic Sets; MCDM; 5G; AHP; Network

1. Introduction

The fourth generation of cellular mobile telecommunications, known as 4G, the third generation, known as 3G, and the second generation, known as 2G, have been superseded by the fifth generation, also known as 5G. Because of its high transfer rate, ultra-low latencies, energy conservation, increased system capacities, reduced costs, and pervasive connection, it is considered to be the next economic and technical wave of the global communications economy, following in the footsteps of the web and computers[1], [2].

In recent years, 5G technology has already been effectively used in a variety of industries, including traffic control, smart manufacturing, satellite technology, and unmanned aerial vehicle (UAV) operations [3]–[5]. Zhengfei Ren, the founder of Huawei, was quoted as saying that "5G is the future of innovation." The world's leading technology firms are scouring the vast expanse of the 5G industry for untapped commercial potential. However, depending just on oneself is not enough if they would like to carve out a space for themselves in the industry [6]–[8]. As a result, they should select a pioneering 5G business to collaborate with as soon as possible. Huawei, Nokia, Ericsson, ZTE, and Samsung are surely strong cooperating partners that should be weighted, and they are in the top echelon of 5G industry leaders [9]. As a result, we devised a method for selecting the most appropriate business with whom to collaborate in order to address the problem of dominating MCDM [10]–[12]. The Internet of Things, big data, and mobile cloud computing are a few examples of concerns that are being quickly developed and appropriately researched in relation to the 5G industry assessment.

1.1 Neutrosophic Sets

In 1965, Zadeh presented his key theory of fuzzy sets (FSs), which he had developed in order to cope with a variety of different sorts of uncertainty. Since that time, the idea has been effectively implemented in a variety of different domains [13], [14]. Nonetheless, there are circumstances in which it might be difficult to identify

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the grade of membership of an FS with a precise value. As a result, Turksen presented interval-valued FS, sometimes known as IVFSs, in the year 1986. After that, Atanassov came up with the idea of intuitionistic FS, which were intended to address the problem of a lack of information about non-membership levels. In addition, Gau and Buehrer developed ambiguous sets; per the Bustince, Atanassov's IFSs and these ambiguous sets are numerically identical objects [15], [16]. To this day, IFS has been used extensively in the process of finding solutions to MCDM issues in a variety of sectors, including but not limited to medical diagnostics, neural networks, color region separation, and market forecasting. After that, IFSs were expanded to become interval-valued IFS, which are abbreviated as IVIFSs, as well as intuitionistic interval FSs with triangular intuitionistic FS. Torra and Narukawa came up with the idea of hesitant FS as a solution to the problem of how to handle instances in which individuals are reluctant to declare their preference with respect to items throughout the process of making a choice. In fact, certain other expansions have been suggested, and approaches utilizing intuitionistic FS derived from the investigation of judgment conducted by some new organizations have been established [17], [18].

1995 was the year when Smarandache introduced the concepts of neutrosophic logic and neutrosophic sets (NSs). The NS is an interval containing the values 0 to 1 plus, in which each component of the universe is assigned a level of truth, indeterminacy, and falsehood. This interval is called the nonstandard unit interval. This is obviously an addition to the conventional interval that was used in the IFS, which is [0, 1]. In addition, the uncertainty that is present in this scenario, also known as the indeterminacy factor, is not reliant on the truth or falsity values, but the uncertainty that is included is determined by the levels of acceptance and belonging and non-belongingness that are present in IFSs. In particular, with reference to the previously mentioned example of the expert statement, it is possible for NSs to represent it as x(0.5,0.2,0.6) [19], [20].

2. The AHP Method

The analytic hierarchy process, often known as the AHP, is a kind MCDM that is used for the purposes of solving and analyzing difficult situations. In the field of industrial engineering, the multi-criteria decision modelling (MCDM) subfield plays a significant role when it comes to the development of mathematical and computer tools for determining which option is preferable to others, given a set of specific requirements. The AHP is broken down into its component parts. The first thing that has to be done is to organize the issue into a hierarchy so that you can comprehend it better. The AHP has a purpose (objective) as the first level of its hierarchy, followed by evaluation criteria, sub-criteria, and eventually all of the accessible choices. Following the construction of the AHP hierarchy, policymakers will develop pair-wise comparative matrices in order to apply Saaty's scale to the weighing of criteria. In the end, the final weight of each option is computed, and then the options are ordered [21], [22].

After that, the AHP is capable of evaluating both the qualitative and quantitative aspects of the situation. As a result of this, it is one of the methods for making decisions based on several factors that is the most practically applicable [23], [24].

In practical contexts, requirements are often imprecise, convoluted, and inherently contradictory in their nature. In contrast, the use of crisp values in a similarity measure is not always correct because of the ambiguity and the ambiguous information that is accessible to those who make decisions. A growing number of scholars are beginning to use fuzzy set (FS). On the other hand, FS merely takes into account the truth degree. Atanassov is credited with developing the intuitionistic FS, which takes into account varying degrees of truth and falsity but does not take into account indeterminacy. Smarandache proposed neutrosophic sets as a solution to the problems that had been caused by fuzzy and intuitionistic FS. These sets take into account truth, indeterminacy, and falsity degrees simultaneously in order to accurately express ambiguous and inconsistent content. As a consequence, neutrosophic sets provide a more accurate portrayal of reality. For this reason, throughout the course of our study, we made use of the AHP when it was situated inside a neutrosophic atmosphere [25].

1. Build the hierarchy tree between criteria and alternatives.
2. Build the pairwise comparison matrix between criteria.
3. If there are many experts, aggregate it.
4. Convert the linguistic terms of experts by the Interval valued neutrosophic numbers (IVNNs) [26], [27].
5. Apply the score function to obtain one value [26], [27].
6. Normalize the pairwise comparison matrix
   To normalize the column entries, divide each one by the total value of the column and then average the results.
7. Compute the sum of the averages of each row.
8. Compute the weights of criteria

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9. Check the consistency ratio.
10. Build the decision matrix
11. Multiply the weights of criteria by the decision matrix
12. Rank the alternatives
    The alternatives are ranked according to the highest value of sum of each row in previous step.

3. Results

In order to conduct an accurate performance assessment of the 5G ground station, the comprehensive evaluation system is of the utmost significance. Variables that are transparent, all-encompassing, and particular need to be part of the assessment index system so that it may accurately represent the primary qualities and implications of the 5G ground station. In this research, the performance assessment of a 5G ground station is studied and assessed with the account of several viewpoints like operating, economic, ecological, and social performance.

The widespread availability of 5G broadband service has the potential to considerably enhance the capacities of social governance. It is much simpler to develop judgment processes that are scientific, well-refined, and smart if one permits the facts to "make recommendations."

As a result, the assessment of the effectiveness of 5G ground stations must pay close attention to the operating efficiency. It has been determined from the research that is currently available that the primary markers for determining an organization's overall level of operational efficiency are message coverage area and company loadings.

In contrast to the success of the ground station's operations, the economic results is also very important to the ground station. The number of individuals that are serviced may be taken into consideration with the cost of constructing the base station when calculating the cost of providing services on a per capita basis.

It is vital to take into consideration, in contrast to the efficiency of the ground station on its own, the influence that the ground station will have on the ecology outside of the ground station. In particular, ecological performance is primarily comprised of two factors: the first of these aspects is the influence on the surrounding system, and the second of these aspects is the effect on protection.

First let decision makers to evaluate the criteria to build the pairwise comparison matrix. The three decision makers build the three decision matrices as shown in Tables 1-3. Aggregate the pairwise comparison matrices into one matrix as shown in Table 4.

Table 1: The first pairwise comparison matrix.

	Net$_{C1}$	Net$_{C2}$	Net$_{C3}$	Net$_{C4}$
Net$_{C1}$	1	0.25	0.12	0.96
Net$_{C2}$	4	1	0.67	0.333
Net$_{C3}$	8.333333	1.492537	1	0.76
Net$_{C4}$	1.041667	3.003003	1.315789	1

Table 2: The second pairwise comparison matrix

	Net$_{C1}$	Net$_{C2}$	Net$_{C3}$	Net$_{C4}$
Net$_{C1}$	1	0.33	0.33	0.12
Net$_{C2}$	3.030303	1	0.76	0.333
Net$_{C3}$	3.030303	1.315789	1	0.12
Net$_{C4}$	8.333333	3.003003	8.333333	1

Table 3: The third pairwise comparison matrix

	Net$_{C1}$	Net$_{C2}$	Net$_{C3}$	Net$_{C4}$
Net$_{C1}$	1	0.33	0.33	0.12
Net$_{C2}$	3.030303	1	0.76	0.333
Net$_{C3}$	3.030303	1.315789	1	0.12
Net$_{C4}$	8.333333	3.003003	8.333333	1

Table 4: The combined pairwise comparison matrix

	Net$_{C1}$	Net$_{C2}$	Net$_{C3}$	Net$_{C4}$
Net$_{C1}$	1	0.513333	0.26	0.613333

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Net_{C2}	2.690657	1	0.586667	0.542
Net_{C3}	4.79798	1.94621	1	0.546667
Net_{C4}	3.563596	2.349224	3.654971	1

Then normalize the pairwise comparison matrix by sum of each column and divide each value by it. Then compute the weights of criteria. Figure 1 shows the weights of criteria. Then check the consistency ratio. The consistency ratio is less than 0.1, so the opinions of experts are valid. The move to the next step.

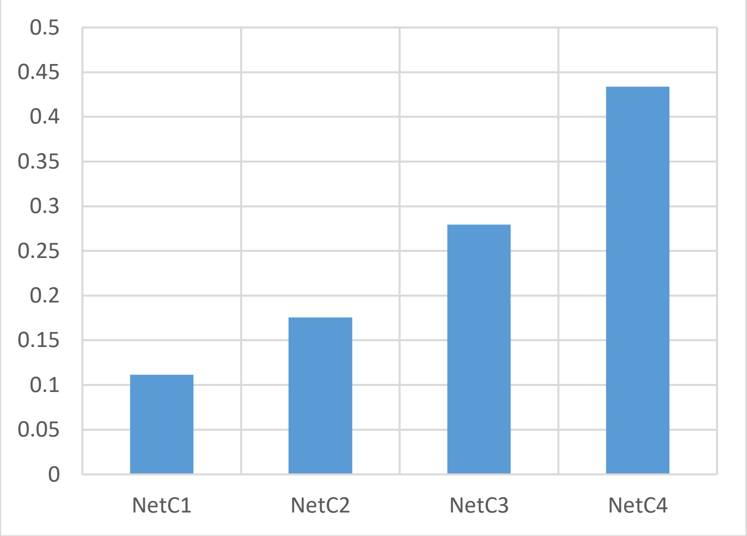

Figure 1: The weights of criteria.

Then let three experts to evaluate the criteria and alternatives to build the decision matrix. Then aggregate the decision matrices into one matrix as shown in Table A.1-A.3 in appendix A. Then multiply the weights of criteria by the aggregated decision matrix. Then compute the sum of each row. Then rank the alternatives according to the highest value of in the sum score. Figure 2 shows the rank of 10 stations.

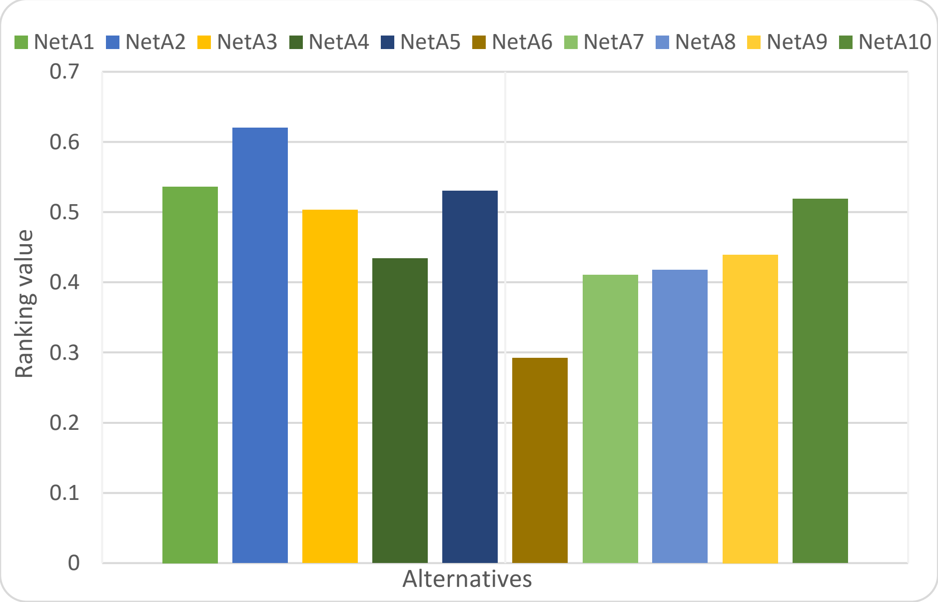

Figure 2: The best and worst options.

4 Conclusions

As a result of the ongoing advancement of 5G networks, an increasing number of 5G ground stations are being built to accommodate the requirements of people's everyday lives. As a result, the performance assessment may not only determine whether or not the ground station has satisfied the predicted criteria, but it can also be used as a basis for the following planning of the facility location for a 5G ground station.

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INSs, a new subfield of NSs, have the potential to be used in the solving of issues that include information that is unclear, inaccurate, partial, or irregular and may be found in real-world applications in science and technology. In this study, a strategy for addressing MCDM issues employing INSs. However, it has been discovered that the value of each criteria cannot be determined in specific cases due to the nature of the conditions. As a consequence of this, an outranking procedure based on the AHP was developed for the purpose of addressing MCDM issues involving INSs.

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Appendix A

Table A.1. The first decision matrix.

	Net_{C1}	Net_{C2}	Net_{C3}	Net_{C4}
Net_{A1}	0.12	0.76	0.96	0.33
Net_{A2}	0.33	0.76	0.12	0.96
Net_{A3}	0.96	0.76	0.25	0.33
Net_{A4}	0.67	0.96	0.25	0.25
Net_{A5}	0.76	0.96	0.67	0.25
Net_{A6}	0.33	0.33	0.76	0.12
Net_{A7}	0.12	0.33	0.96	0.33
Net_{A8}	0.96	0.12	0.12	0.76
Net_{A9}	0.25	0.25	0.12	0.76
Net_{A10}	0.25	0.96	0.96	0.67

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Table A.2. The second decision matrix.

	Net_{C1}	Net_{C2}	Net_{C3}	Net_{C4}
Net_{A1}	0.25	0.25	0.25	0.96
Net_{A2}	0.33	0.76	0.12	0.96
Net_{A3}	0.96	0.76	0.12	0.33
Net_{A4}	0.25	0.96	0.96	0.25
Net_{A5}	0.76	0.96	0.67	0.12
Net_{A6}	0.33	0.25	0.25	0.12
Net_{A7}	0.25	0.33	0.25	0.33
Net_{A8}	0.96	0.12	0.12	0.25
Net_{A9}	0.25	0.25	0.12	0.76
Net_{A10}	0.12	0.96	0.25	0.25

Table 3. The third decision matrix.

	Net_{C1}	Net_{C2}	Net_{C3}	Net_{C4}
Net_{A1}	0.12	0.33	0.33	0.76
Net_{A2}	0.33	0.76	0.12	0.96
Net_{A3}	0.76	0.76	0.33	0.76
Net_{A4}	0.33	0.33	0.25	0.33
Net_{A5}	0.76	0.96	0.67	0.25
Net_{A6}	0.33	0.76	0.33	0.12
Net_{A7}	0.33	0.33	0.76	0.33
Net_{A8}	0.96	0.12	0.12	0.76
Net_{A9}	0.25	0.33	0.12	0.76
Net_{A10}	0.33	0.96	0.33	0.33

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