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Single Valued Neutrosophic HyperSoft Set based on VIKOR Method for 5G Architecture Selection

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Abstract

This work introduces the framework for selecting architecture in 5G networks, considering various technological, performance, economic, and operational factors. With the emergence of 5G technology, the architecture selection process has become pivotal in meeting diverse requirements for ultra-high-speed connectivity, low latency, scalability, and diverse service demands. The evaluation comprehensively analyses different architecture options, including centralized, distributed, cloud-based, and virtualized architectures. Factors such as network performance, scalability, cost-effectiveness, security, and compatibility are considered within a multi-criteria decision-making framework. Findings reveal each architecture option's diverse strengths and limitations, emphasizing the importance of aligning architectural choices with specific use cases, deployment scenarios, and business objectives. We used the concept of multi-criteria decision-making (MCDM) methodology to control the various criteria. We used the single-valued neutrosophic set (SVNS) to deal with vague and inconsistent data. The SVNS is integrated with the hyperSoft set. The proposed methodology uses a single-valued neutrosophic hyperSoft set (SVNHSS) to select the best 5G architecture. We used the VIKOR method as an MCDM method to rank the alternatives. The proposed framework provides stakeholders with a structured methodology to evaluate and prioritize architecture options, facilitating informed decision-making in the complex landscape of 5G network deployments.

Keywords: HyperSoft Set; Single Valued Neutrosophic Set; VIKOR method; Multi-Criteria Decision Making; VIKOR Method.

1. Introduction

The fifth generation (5G) architecture represents a revolutionary leap in wireless communication technology, promising to transform how we connect, communicate, and interact with the digital world. Building upon the foundations of previous generations, 5G architecture introduces several vital advancements that enable faster data speeds, lower latency, higher capacity, and enhanced reliability. With its transformative potential, 5G is poised to fuel innovation and drive the development of new applications and services across various industries[1], [2].

At its core, 5G architecture is designed to meet the evolving demands of an increasingly connected society. It aims to support a massive increase in data traffic and accommodate the exponential growth of connected devices, ranging from smartphones and tablets to Internet of Things (IoT) devices, autonomous vehicles, and intelligent infrastructure. By providing an ultra-fast and robust network infrastructure, 5G architecture enables seamless connectivity and empowers many applications that rely on real-time data transfer and responsiveness[3], [4].

One of the defining features of 5G architecture is its utilization of advanced radio technologies. It incorporates new frequency bands, including traditional cellular frequencies and higher-frequency bands, such as millimetre waves

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(mmWave), to deliver unparalleled data rates. These higher frequencies offer wider bandwidths, enabling the transmission of large amounts of data at ultra-fast speeds. Additionally, 5G supports massive multiple-input multiple-output (MIMO) technology, which utilizes multiple antennas to enhance the capacity and efficiency of wireless communication[5], [6].

Another critical aspect of 5G architecture is its emphasis on network virtualization and software-defined networking (SDN). By virtualizing network functions and separating control and data planes, 5G enables greater flexibility, scalability, and agility in network management. This approach allows for dynamic allocation of network resources, efficient traffic routing, and on-demand service provisioning, leading to optimized network performance and improved user experience[7], [8].

Furthermore, 5G architecture introduces edge computing capabilities, bringing computing power closer to the network edge. 5G enables low-latency processing and real-time response for latency-sensitive applications such as autonomous vehicles, industrial automation, and augmented reality. By reducing the need for data to travel long distances to centralized data centres, edge computing enhances efficiency and responsiveness, supporting time-critical and bandwidth-intensive applications[9], [10].

Security and privacy are also integral aspects of 5G architecture. Robust security measures are crucial with the proliferation of connected devices and the increasing volume of sensitive data being transmitted. 5G incorporates advanced encryption, authentication protocols, and network-slicing techniques to ensure secure and private communication. Network slicing allows the creation of virtual networks dedicated to specific applications or user groups, providing customized security measures and isolation [11], [12].

5G architecture represents a significant leap forward in wireless communication technology, bringing unprecedented speed, capacity, and responsiveness to our interconnected world. By leveraging advanced radio technologies, virtualization, edge computing, and robust security measures, 5G architecture paves the way for transformative applications and services across industries such as healthcare, transportation, manufacturing, and entertainment. In addition, with the evolution of the beyond 5G (B5G) technologies, our digital world is expecting to encounter a great shift connectivity to reach degree that even exceed the level of capabilities posed by 5G networks. Though 5G is a noteworthy leap forward with its aforementioned services, the introduction of B5G has a great promise to revolutionize different phases of our daily lives in unimaginable manners. This advancement is likely to become the game-changer in sectors whereby data trust and responsibilities are paramount, including but not limited to finance, healthcare, and national security [13], [14].

This study used the MCDM method for ranking the 5G architecture. However, the evaluation data contains uncertainty, so the concept of the fuzzy set is introduced. The notion of an interval-valued fuzzy set, in which the degree of membership is an interval value in [0,1], was introduced due to the ambiguity around the membership degree. Later, Atanassov introduced the notion of the intuitionistic fuzzy set (IFS) in 1986, which includes the non-membership degree. IFS was used for a variety of purposes[15].

Nevertheless, ambiguous information often present in belief systems is impossible for IFS. The notion of a neutrosophic set was presented by Smarandache in 2000 as a solution to this insufficiency. In this set, membership (T), indeterminacy (I), and non-membership (F) degrees were quantified separately, meaning that T, I, and F $\in[0,1]$, and the sum T+I+F need not be contained in [0,1]. These mathematical methods have been extensively studied and effectively used to manage uncertainty; however, since they lack a parametrization tool and need all concepts to be precise, they often fall short when dealing with ambiguity in various real-world scenarios[16]–[18], [18].

As a result, Molodstsov proposed the soft set in 1999, a broad mathematical tool for handling uncertainty. A parameterized family of subsets of a discourse universe is what Molodstsov characterized as a soft set. Maji et al. first presented aggregation procedures on soft sets in 2003. Many applications have seen the effective use of soft sets and their hybrids[19], [20].

The characteristics must be further split into attribute values to improve decision-making in a range of real-world MCDM scenarios. In 2018, Smarandache created the notion of a hypersoft set[21], [22], a generalization of the soft set concept, therefore meeting this demand[23]–[25].

The main contributions of this study are:

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- Build the decision matrix between criteria and alternatives of 5G architecture to rank and select the best option.
- The VIKOR method is used as an MCDM method to evaluate and rank the alternatives.
- The proposed framework (SVNHSS) deals with uncertainty and vague data.
- HyperSoft is used to show the relation between criteria and attribute values.
- There are 18 criteria, and 49 attribute values are used in this study.

2. HyperSoft Set and VIKOR Method

The aim of this study, rank and select best 5G architecture based on various criteria and alternatives. These problem will have solved by using the single valued neutrosophic hypersoft set VIKOR method (SVNHSS). The VIKOR method is used to rank the alternatives, while the single valued neutrosophic is used to deal with vague data with the hypersoft set. The weight values are computed by the average method. The steps of the SVNHSS is introduced. The proposed method has the three steps includes, identify a set of criteria and alternatives, compute the weights of criteria by the average method, and rank the alternatives using the VIKOR method.

2.1 Identify a set of criteria and alternatives.

The experts and decision makers are defined a set of criteria based on a set of alternatives by the Questioners and literature review.

2.2 Compute the criteria weights.

We compute the criteria weights by the average method. We let the experts used the single valued neutrosophic scale to evaluate the criteria and alternatives, then compute the criteria weights. Table 1 shows the single valued neutrosophic numbers (SVNNs)

Table 1: The single valued neutrosophic numbers.

Linguistic Variables	SVNNs
Absolutely High	(0.9,0.1,0.2)
Very High	(0.8,0.2,0.3)
High	(0.7,0.3,0.4)
Moderate High Equal	(0.6,0.4,0.5)
Equal	(0.5,0.5,0.5)
Moderate Low Equal	(0.4,0.5,0.6)
Low	(0.3,0.6,0.7)
Very Low	(0.2,0.7,0.8)
Absolutely Low	(0.1,0.8,0.9)

2.3 Rank the alternatives by the SVNHSS-VIKOR method.

The soft set can be defined as:

Let μ be a universe of discourse, $p(\mu)$ the power set of μ, and A a set of attributes. Then, the pair $(F,\mu), F: A \rightarrow P(\mu)$ is called a Soft Set over μ

The HyperSoft can be defined as[21], [26]–[33]:

Let μ be a universe of discourse, $p(\mu)$ the power set of μ. $Let\ a_1, a_2, \dots a_n\ for\ n \geq 1$, be n distinct attributes, whose corresponding attributes are respectively the set $A_1, A_2, \dots A_n\ with\ A_i \cap A_j = \emptyset, for\ i \neq j, and\ i,j \in \{1,2,\dots n\}$. Then the pair $\left(F: A_1 \times A_2 \times \dots A_n \rightarrow p(\mu)\right)$ is called a HyperSoft over μ.

Step 1. Build the decision matrix

The decision matrix is built based on a set of criteria $A5GA_1, A5GA_2, \dots A5GA_n$ and a set of alternatives $5GAL_1, 5GAL_2, \dots 5GAL_m$. The set of criteria are evaluated based on a their values $A5GF_1, A5GF_2$

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$$X = \begin{matrix} & A5GA_1 & \cdots & A5GA_n \\ 5GAL_1 & A5GF_1 & \cdots & A5GF_n \\ \vdots & \\ 5GAL_m \end{matrix} \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Where $i = 1,2, \ldots m; j = 1,2, \ldots . n$

Step 2. Applied the HSS to choose the ordered tuple

The HSS is applied to choose the best attribute value for all criteria based on alternatives.

Step 3. Apply the score function

The score function is applied to show the crisp values for all SVNNs.

$$S(x_{ij}) = \frac{2 + T - I - F}{3} \quad (2)$$

Where T, I, F refer to the truth, indeterminacy and falsity memberships degree for the SVNNs.

Step 4. Compute the benefit and cots values.

$$b_i = \max[x_{ij}] \quad (3)$$

$$c_i = \min[x_{ij}] \quad (4)$$

Step 5. Compute the utility measure value and regret measure value [34-35].

$$u_i = \frac{w_j[b_i - x_{ij}]}{b_i - c_i} \quad (5)$$

$$u_i = \frac{w_j[x_{ij} - b_i]}{b_i - c_i} \quad (6)$$

$$R_i = \max of \left\{ \frac{w_j[b_j - x_{ij}]}{b_j - c_j} \right\} \quad (7)$$

Step 6. Compute the VIKOR index.

$$V_i = \varphi \left[\frac{u_i - u_i^-}{u_i^+ - u_i^-} \right] + (1 - \varphi) \left[\frac{R_i - R_i^-}{R_i^+ - R_i^-} \right] \quad (8)$$

Where $u_i^+ = \max u_i$, $u_i^- = \min u_i$, $R_i^+ = \max R_i$ *and* $R_i^- = \min R_i$. The value φ between 0 and 1, we used it in this paper as 0.5.

3. Results and Discussion

This section introduces the results of the SVNHSS-VIKOR method for selecting best 5G architecture.

3.1 Identify a set of criteria and alternatives.

We identified 18 criteria and 5 alternatives in this study based on opinions of experts and decision makers. Then we used 49 attributes values for all criteria.

The criteria of the 5G selection Architecture and their values are:

$A5GA_1$= Throughput

$A5GA_2$=Latency

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$A5GA_3$=Reliability

$A5GA_4$=Coverage

$A5GA_5$=Mobility Support

$A5GA_6$=Capacity

$A5GA_7$=Flexibility

$A5GA_8$=Expandability

$A5GA_9$=Initial Investment (INV)

$A5GA_{10}$=Total Cost of Ownership (TCO)

$A5GA_{11}$=Security Measures

$A5GA_{12}$=Redundancy and Failover

$A5GA_{13}$=Quality of Service (QoS):

$A5GA_{14}$=Interoperability (INT)

$A5GA_{15}$=Standards Compliance (STN)

$A5GA_{16}$=Power Consumption (PCN)

$A5GA_{17}$=Ease of Deployment

$A5GA_{18}$=Network Management (NM)

The attributes values are:

$A5GF_1$= $\{\text{Throughput} < 1\ Gbps, \text{Throughput} > 10\ Gbps\}$

$A5GF_2$= $\{\text{Latency} < 1ms, \text{Latency} = 10ms\}$

$A5GF_3$= $\{high, medium, low\}$

$A5GF_4$= $\{urban, suburban, rural\}$

$A5GF_5$= $\{Low\ speed, medium\ speed,\ \ high\ speed\}$

$A5GF_6$= $\{Capacity < 1000\ devices\ per\ km^2, capacity\ > 10{,}000\ devices\ per\ km^2\}$

$A5GF_7$= $\{low\ flexible, moderate\ flexible, high\ flexible\}$

$A5GF_8$= $\{limited, moderate, or\ extensive\}$.

$A5GF_9$= $\{low\ \text{INV}, moderate\ \text{INV}, high\ \text{INV}\}$.

$A5GF_{10}$= $\{low\ \text{TCO}, moderate\ \text{TCO}, high\ \text{TCO}\}$

$A5GF_{11}$= $\{basic\ security, standard\ security,\ \ advanced\ security\}$

$A5GF_{12}$= $\{basic\ Redundancy, moderate\ Redundancy, comprehensive\ Redundancy\}$

$A5GF_{13}$= $\{basic\ QoS, acceptable\ QoS, superior\ QoS\ \}$

$A5GF_{14}$= $\{compatible\ INT, partially\ compatible\ INT, incompatible\ INT\}$

$A5GF_{15}$= $\{fully\ compliant\ STN, partially\ STN\ Compliance, non\ compliant\ STN\}$

$A5GF_{16}$= $\{low\ \text{PCN}, high\ \text{PCN}\}$

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A5GF$_{17}$= $\{complex\ development, easy\ development\}$

A5GF$_{18}$= $\{manual\ NMS, semi\ automated\ NM, fully\ automated\ NM\ \}$

3.2 Compute the criteria weights. The criteria weighted are computed based on the average method as shown in Figure 1. The latency and reliability, and coverage has the highest weight but the ease of development has the lowest weight.

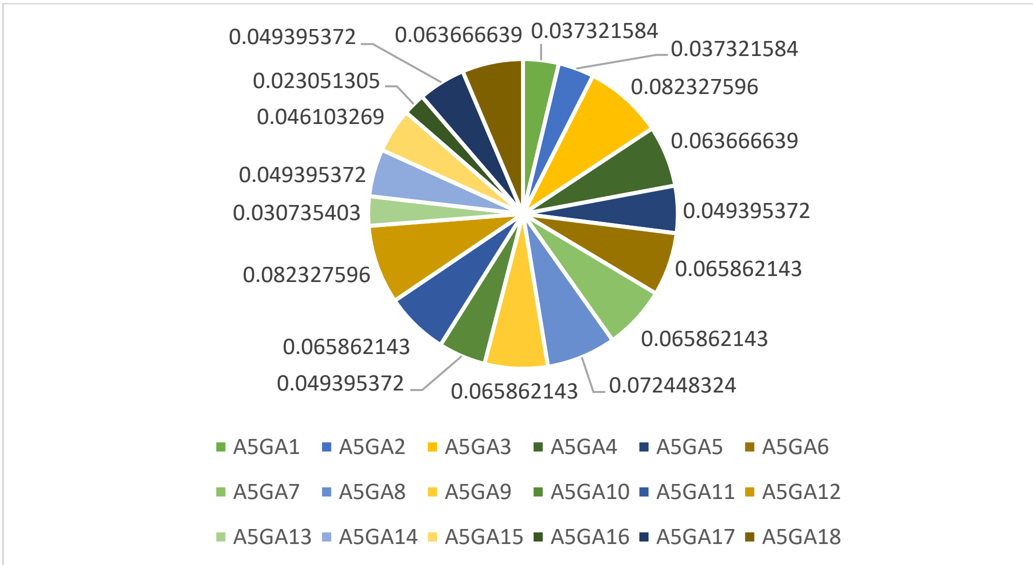

Figure 1: The criteria of 5G architecture weights.

3.3 Rank the alternatives by the SVNHSS-VIKOR method.

Step 1. Build the decision matrix between 18 criteria, 49 attributes values and 5 alternatives in this study as shown in Table 2 by Eq. (1).

Table 2: The values of criteria, attributes values and alternatives for decision matrix.

		5GAL$_1$	**5GAL$_2$**	**5GAL$_3$**	**5GAL$_4$**	**5GAL$_5$**
A5GA$_1$	A5GF$_1$	(0.9,0.1,0.2)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.9,0.1,0.2)
	A5GF$_2$	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GA$_2$	A5GF$_3$	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.9,0.1,0.2)
	A5GF$_4$	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GA$_3$	A5GF$_5$	(0.9,0.1,0.2)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
	A5GF$_6$	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
	A5GF$_7$	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.2,0.7,0.8)	(0.1,0.8,0.9)
A5GA$_4$	A5GF$_8$	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
	A5GF$_9$	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.9,0.1,0.2)
	A5GF$_{10}$	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.6,0.4,0.5)
A5GA$_5$	A5GF$_{11}$	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)
	A5GF$_{12}$	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
	A5GF$_{13}$	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.7,0.3,0.4)	(0.6,0.4,0.5)

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A5GA6	A5GF14	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF15	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA7	A5GF16	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF17	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF18	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA8	A5GF19	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
	A5GF20	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF21	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA9	A5GF22	(0.9,0.1,0.2)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF23	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF24	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GA10	A5GF25	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF26	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
	A5GF27	(0.8,0.2,0.3)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)
A5GA11	A5GF28	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF29	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF30	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA12	A5GF31	(0.9,0.1,0.2)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
	A5GF32	(0.3,0.6,0.7)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)
	A5GF33	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GA13	A5GF34	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)
	A5GF35	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF36	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA14	A5GF37	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.6,0.4,0.5)	(0.9,0.1,0.2)
	A5GF38	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.2,0.7,0.8)	(0.1,0.8,0.9)
	A5GF39	(0.9,0.1,0.2)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA15	A5GF40	(0.3,0.6,0.7)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)
	A5GF41	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.2,0.7,0.8)	(0.1,0.8,0.9)
	A5GF42	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA16	A5GF43	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.9,0.1,0.2)
	A5GF44	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA17	A5GF45	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF46	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GA18	A5GF47	(0.3,0.6,0.7)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.2,0.7,0.8)	(0.1,0.8,0.9)
	A5GF48	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
	A5GF49	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)

Step 2. Applied the HSS to choose the ordered tuple.

Let $C = A5GA_1 \times A5GA_2 \times A5GA_3 \times A5GA_4 \times A5GA_5 \times A5GA_6 \times A5GA_7 \times A5GA_8 \times A5GA_9 \times A5GA_{10} \times A5GA_{11} \times A5GA_{12} \times A5GA_{13} \times A5GA_{14} \times A5GA_{15} \times A5GA_{16} \times A5GA_{17} \times A5GA_{18}$ and the attribute values are $(A5GF_1, A5GF_2, \dots A5GF_{49}) \in$. We choose the 18 attributes values as $A5GF_2 \times A5GF_4 \times A5GF_5 \times A5GF_{10} \times A5GF_{13} \times A5GF_{15} \times A5GF_{18} \times A5GF_{20} \times A5GF_{23} \times A5GF_{25} \times A5GF_{30} \times A5GF_{31} \times A5GF_{36} \times A5GF_{37} \times A5GF_{40} \times A5GF_{44} \times A5GF_{46} \times A5GF_{48}$. The decision matrix of chosen ordered tuple is shown in Table 3.

Table 3: The ordered tuple of attributes values based on alternatives.

	5GAL1	**5GAL2**	**5GAL3**	**5GAL4**	**5GAL5**
A5GF2	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GF4	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GF5	(0.9,0.1,0.2)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GF10	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.6,0.4,0.5)
A5GF13	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GF15	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)

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A5GF18	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF20	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF23	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF25	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF30	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF31	(0.9,0.1,0.2)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A5GF36	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF37	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.6,0.4,0.5)	(0.9,0.1,0.2)
A5GF40	(0.3,0.6,0.7)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)
A5GF44	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF46	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.5,0.5,0.5)	(0.4,0.5,0.6)
A5GF48	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.4,0.5,0.6)	(0.9,0.1,0.2)

Step 3. Apply the score function by Eq. (2) to compute the crisp values.
Step 4. Compute the benefit and cots values by Eqs. (3 and 4). All criteria are benefit except initial investment and total cost are cost criteria.
Step 5. Compute the utility measure value and regret measure value by Eqs. (5-6) a shown in Table 4.

Table 4. The measure and utility degree.

	5GAL1	**5GAL2**	**5GAL3**	**5GAL4**	**5GAL5**
A5GF2	0.031429	0.037322	0	0.005893	0.011786
A5GF4	0.031429	0.037322	0	0.005893	0.011786
A5GF5	0	0	0.027443	0.054885	0.082328
A5GF10	0	0.044073	0.053868	0.063667	0.044073
A5GF13	0.021166	0.035278	0.049395	0	0.021166
A5GF15	0	0.019756	0.039513	0.052685	0.065862
A5GF18	0	0.019756	0.039513	0.052685	0.065862
A5GF20	0	0.016717	0.050152	0.061298	0.072448
A5GF23	0	0.019756	0.039513	0.052685	0.065862
A5GF25	0	0.024692	0.049395	0.024692	0.049395
A5GF30	0	0.019756	0.039513	0.052685	0.065862
A5GF31	0	0	0.027443	0.054885	0.082328
A5GF36	0.023643	0.030735	0	0.004729	0.00946
A5GF37	0.034194	0.041793	0.049395	0.034194	0
A5GF40	0.046103	0.025933	0.031696	0.037462	0
A5GF44	0.010478	0.016765	0.023051	0	0.004193
A5GF46	0	0.024692	0.049395	0.024692	0.049395
A5GF48	0	0.044073	0.053868	0.063667	0

Step 6. Compute the VIKOR index by Eq. (8) as shown in Figure 2. We show alternative 1 is the best and alternative 5 is the worst.

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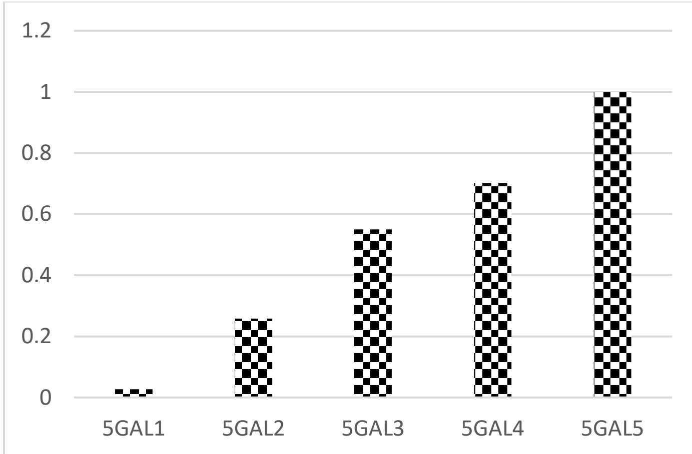

Figure 2: The values of VIKOR index.

4. Conclusions

The selection of architecture for 5G networks is a critical decision that necessitates a holistic evaluation encompassing diverse factors. The assessment of architectural options revealed a spectrum of strengths and trade-offs. Centralized architectures offer streamlined management but may encounter scalability challenges. Distributed architectures provide enhanced reliability but may face complexities in synchronization. Cloud-based architectures offer flexibility but pose concerns regarding latency and data privacy. Virtualized architectures showcase agility but demand robust hardware resources. The selection process highlighted the importance of aligning architectural choices with specific use cases and operational requirements. Moreover, ensuring interoperability, security, and compliance with 5G standards emerged as crucial considerations. The proposed MCDM framework under SVNHSS is a valuable tool for stakeholders to navigate the complexities and trade-offs associated with selecting the optimal architecture for 5G networks. Collaboration among industry stakeholders, policymakers, and technology providers will be essential in adapting architectures to meet evolving demands and ensuring the successful deployment of 5G networks. We used 18 criteria and 49 attributes values based on 5 alternatives. We used the VIKOR method to rank the alternatives. In future work, deep learning

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