



# Apply Neutrosophic AHP Analysis of the Internet of Things (IoT) and the Internet of Behavior (IoB) in Smart Education

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## Abstract

The concept of the "Internet of Things" (IoT) has emerged in recent years to describe our increasingly interconnected physical world. Even if there are now goods on the market that are connected to the Internet of Things, there are still obstacles to be addressed, such as security concerns and a general lack of trust in and familiarity with the technology. The purpose of this research is to examine what goes into making a good Internet of Things (IoT) system for smart education that deals with IoT. In this research, we use neutrosophic theory and the Analytic Hierarchy Process (AHP) to create a decision-support system based on rules for assessing the impactful elements of the Internet of Things in smart education. According to the results of this investigation, security, value, and connectivity are more crucial than intangible qualities (Telepresence and Intelligence). This research suggests that the internet of behavior (IoB) and a sustainable Internet of Things (IoT) ecosystem requires strong IoT security measures to be implemented once smart education has established a reliable IoT connection. Likewise, smart education needs to think about the benefits of IoT security and IoT ethics for the goods they use and the comfort of their staff.

**Keywords:** AHP; IoT; Smart System; Smart Education; Neutrosophic Sets; MCDM; IoB

## 1. Introduction

The proliferation of IoT-enabled applications across several sectors (e-commerce, e-health, connected cars, home automation, etc.) has resulted in an explosion in both the number of connected appliances and the volume of data they produce. Many businesses are already using IoT to raise their productivity, effectiveness, and competitiveness. Data from sensors and actuators in the Internet of Things is large, complex, and constantly evolving. Thus, the need for IoT data analytics arose. Analyzing data using statistical and machine learning techniques to draw conclusions and inform decision-making is what analytics is all about. This helps sectors like industry, education, etc. The process of text mining is an important part of data mining.[1]–[4] An overview of how the Internet of Things gadgets and Text Mining work is shown in Figure 1. Machines, in contrast to humans, have a more difficult time understanding text without the aid of context, background, and the interactions of many individuals. For many uses, text mining is essential. Using Text Mining methods, for instance, businesses may analyze user activity on social media sites (Facebook, Twitter) in order to better serve their consumers. Text may be clustered and classified to get a variety of information for use in the implementation analysis. Various Text Mining Techniques Can Be Put To Use.

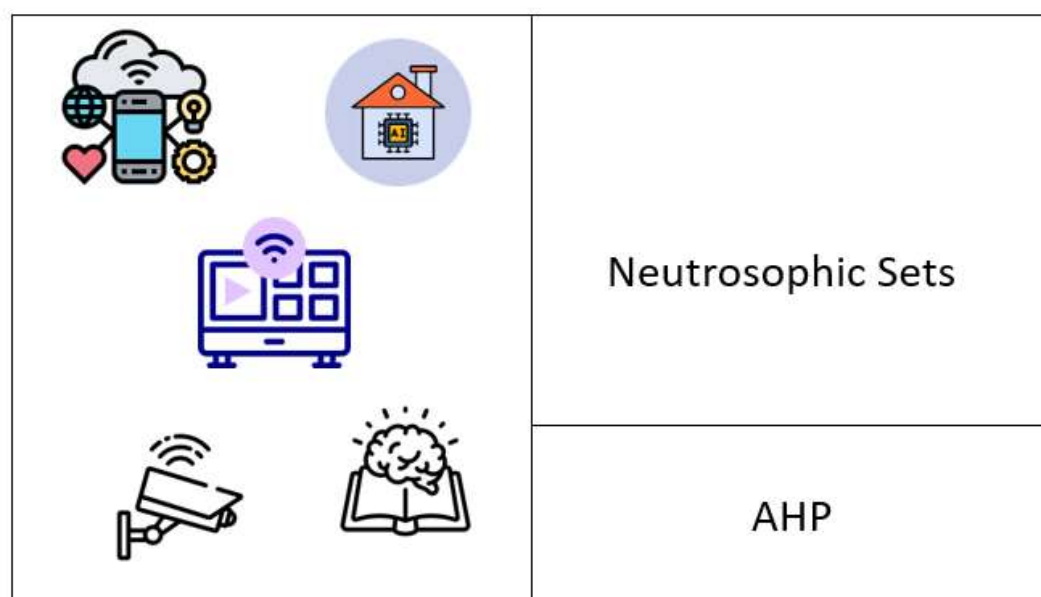


Figure 1: The neutrosophic sets, IoB and IoT.

Traditional schooling has a number of obstacles that may be ameliorated by using Smart Education technologies, including location, accessibility, and the assessment of instructors and students. Smart Education has the potential to improve how students and teachers interact with one another in terms of the sharing and processing of information and ideas. Problems that would otherwise need specialized expertise to handle may often be tackled with the help of the right kind of information and some well-considered judgment calls on the part of the decision-maker. Text-based data that may be evaluated to create meaningful insights is growing in quantity as a result of new approaches to improving the present educational process. All interactions that take place in text format (email messages, discussion boards, or social shares) are used by text mining techniques, and their various facets are investigated by means of text mining methods suggested and examined in the literature. Sentiment analysis, opinion mining, and emotion analysis are all names for similar methods. Insights into improved decision-making and increased student engagement may be gained via the use of these methods. Opinion mining is one such use in smart learning, and it's used to gauge students' feelings about various lessons so that instructors may better cater to their individual requirements. However, the semantic variety of language makes it difficult to use sentiment in multimedia learning. IoT text mining has acquired a wider range of research prospects in a variety of industrial domains including healthcare, e-commerce, the internet of vehicles, and intelligent systems, as well as intelligent education. For instance, in Ittoo et al., the authors analyze various well-known state-of-the-art methodologies for text analytics by conducting a literature review. Nair et al. conduct a survey of text analytics algorithms and approaches, with an emphasis on their use in fields like electronic health records[5]–[9].

The IoT model's maturation into smart surroundings creation technology has drastically simplified human interaction. Issues of data security and privacy are important to regular corporate operations because of the inextricable link between this technology and actual world information. The goal of the IoT is to create a connected world where everything is intelligent and can help each other. This is achieved via the connection of sensors and devices, which makes it easier to make evaluations by analyzing previously collected user data. Using the Internet of Things (IoT), we may link computers and people so that they can exchange and receive data more efficiently. This is made possible via the use of sensors and networks that enable direct communication between all nodes[10]–[12].

An Internet of Things architecture has five distinct levels of design. While the network layer is in charge of data transfer, the physical layer is in charge of data collection and delivery to it[13]–[15].

The application layer addresses data administration and consumption. This means that an IoT device may adjust to any kind of smart surroundings. In the context of an IoT system or IoT sensor, each layer performs a different but equally important function. The functioning of each layer is outlined below[16]–[18].

#### A layer of Physical Substances

The Perception layer's hardware includes things like physical objects and sensors. Starting with data identification and ending with data collection and processing, this layer does it all. The network layer receives all this information and processes it further.

#### Data Link Layer

#### Physical Layer Network Layer

At the network layer, data collected by sensors and other Internet of Things devices are sent to a computer for processing. The results of the network layer are sent to the middleware, where analysis and decision-making take place.

#### System Software Layer

The Middleware layer is responsible for managing services between IoT devices. Information from the network level is gathered and stored for later use in analysis or decision-making.

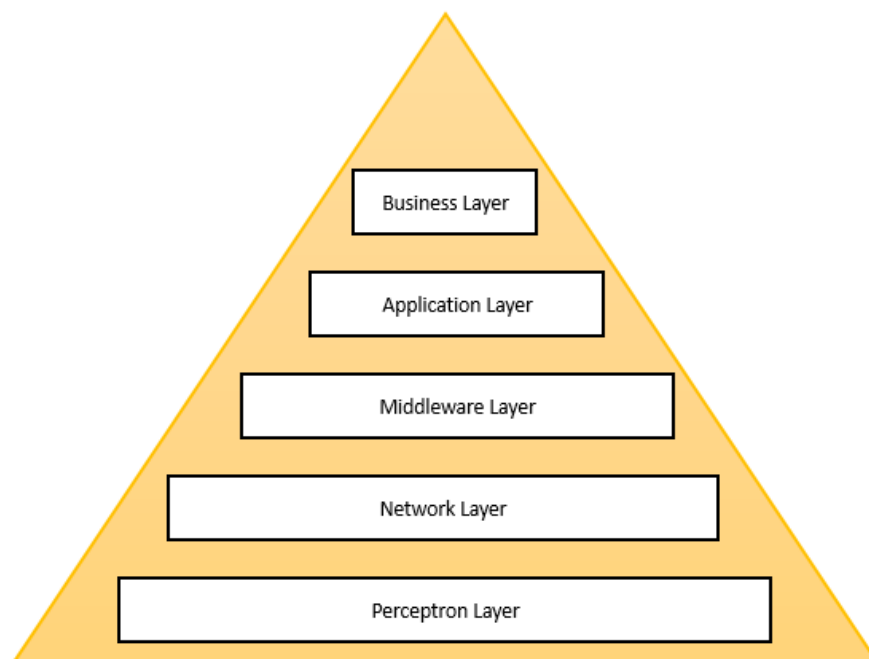
#### Layer of Applications

The Application layer is responsible for the worldwide administration of the various data deployed on IoT systems in smart enterprises, residences, clinics, schools, and healthcare.

Responsibility for services and worldwide administration of IoT devices falls under the Business layer. In addition to delivering the processed outcomes of operations, it also generates a marketing strategy, control charts, and network based on data from the protocol stack.

The ubiquitous and embedded properties that are so important to IoT applications set them apart from other IT-related strategies. Since the Internet of Things encompasses a wide range of technologies and application areas from sensors to interactive gadgets its underlying architecture might be classified as either vague or complex. Thanks to custom application programming interfaces and gateways, these interoperable technologies may exchange information and interact with one another and the outside world. These allow for systematically collecting and analyzing information from interconnected sensors and devices. The Internet of Things paradigm opens up exciting new avenues for utilizing the data produced by these networked mini-devices (sensors and actuators). However, leveraging such a massive data set presents additional difficulties in data analytics. The IoT architecture is shown in Figure 2 and consists of the many levels shown there.

The designs and technology behind them must be understood in order to assess, propose, and create infrastructure inside an institution, such as a university. For that purpose, we provide a summary of the system architecture, technology, and their application in smart schools and smart universities as shown in figure 2. The complexities of a layered architecture are determined by the number of levels used. From a safety and compatibility point of view, a five-layer design is tops.



Activate Wi

Figure 2: The IoT layer.

## 2. Smart Education in IoT and IoB

Despite several attempts, the majority of evaluations and publications to date have concentrated mostly on technical elements of the Internet of Things. In the sphere of education, in particular, there is no accessible evaluation of applications. For this reason, a comprehensive IoT study is necessary to learn about the nuances of this research field and the difficulties that arise during implementation. Security and privacy, accessibility, mobile-friendliness, dependability, performance, interchange, scaling, confidence, and administration are only a few of these issues[19]–[22]. Smart cities, smart power and grid, connected cars and maneuverability, smart homes, smart facilities and infrastructure, smart manufacturing and industrial production, smart health, food and water tracking and protection, and smart networks are just some of the IoT applications that have been formed in the requirements of potential users as shown in figure 3.

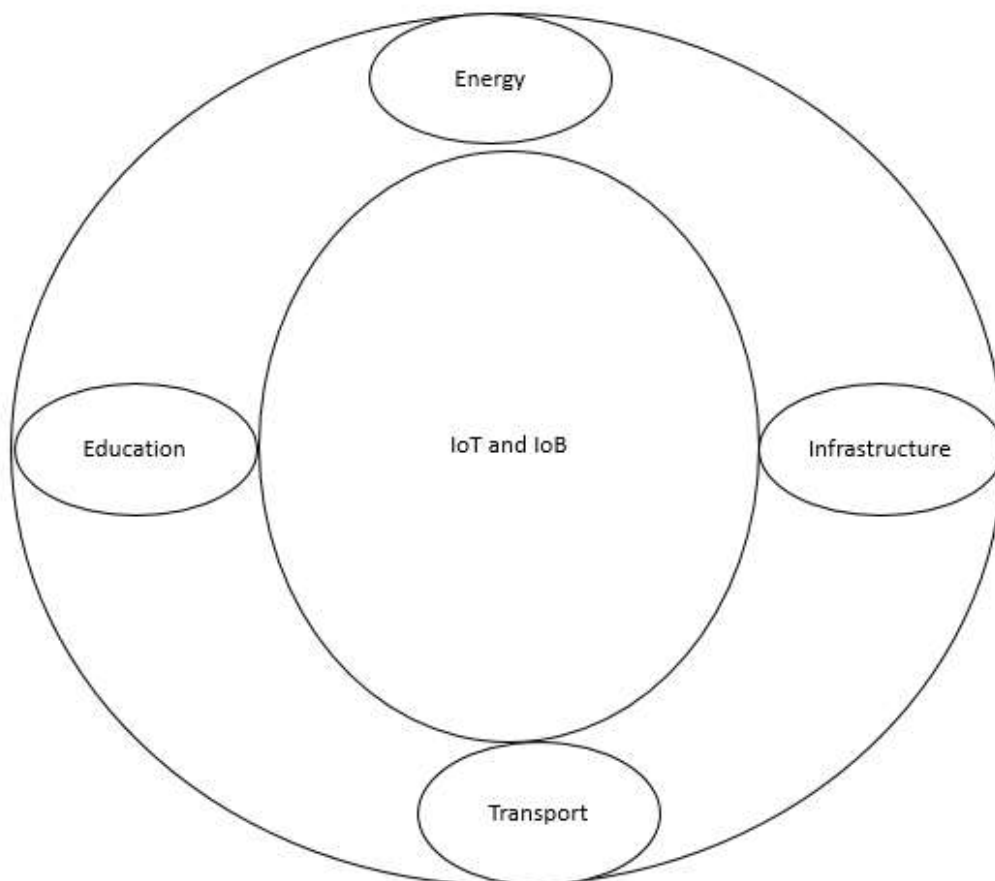


Figure 3: The application of the IoT.

In higher education, technologies have played a major role in bridging the gap between students, faculty, and administration. Because of its profound influence on the area of education, the idea of smart campuses has emerged to describe the resulting adjustments to the physical layout of educational institutions.

Here are a few examples of published research that explores how the Internet of Things (IoT) might be used to enhance and simplify the educational experience. Xu and Hela's research on how Cloud Hosting and IoT might be used to include the framework of instructional materials offers a paradigm for doing so. Research on the Internet of Things (IoT) right now is mostly technical in nature, as confirmed by the work of Whitmore, Agarwal, and Xu. Studies should be expanded to include administration, logistics, legal, finance, and society as the technique is further developed. In another paper, the authors examine the role of four technologies—the Internet of Things, Cloud Computing, data mining, and Triple-Play—in contemporary remote learning. Smart campuses and digital campuses are both defined and contrasted in the aforementioned study paper. Using an academic foundation, the authors of the study provide an integrated architectural approach for creating an IoT system.

An interesting paper is that of Cerdeira and Martins, in which the idea of a smart campus is broken down along four thematic axes: infrastructure, administration and management, operations, and learning. However, it is important to note that the infrastructure axis gives benefits for the other aspects, especially in the supply of information and connectivity, as well as the administration and governance of those institutions, despite the fact that some works recommend that this is the only defining feature of a smart campus.

The phrase "smart university" is become commonplace in academic writing. Universities that make effective use of technology to boost efficiency and raise the caliber of their graduates are aptly

called "smart universities". Regardless, there is always an opportunity for development, and educational institutions should strive to grow wiser. When it comes to creating a smarter college, the most effective technology solutions are those that foster teamwork and communication amongst students. The fields of "smart universities" and "smart education" are expanding rapidly in ways that reflect the assimilation of (1) intelligent sensors, (2) smart objects and environments, (3) government smart systems, agents, and educational software/hardware tools, and (4) creative teaching methods, instructional approaches, and the task are to implement grounded in cutting-edge technologies.

Based on the definition of a "smart university," the following are basic for a smart university:

- I. Education, both formal and informal, requires a unique intellectual setting to ensure that students and teachers alike are constantly developing their skills and knowledge.
- II. A sophisticated technological "structure" at the university level promotes the widespread use of intelligent technology and tools in the classroom.
- III. Instructional materials were developed in accordance with standardization guidelines for data and descriptions.
- IV. "Seamless" software compatibility across operating systems ensures that all students, teachers, and administrators may access course materials and communicate effectively from any device.
- V. A comprehensive suite of flexible learning tools that facilitates personalized instruction.
- VI. A robust online and mobile learning system built on Web 2.0 technologies gives students anywhere, anytime access to lessons from any part of the globe, no matter their schedules.
- VII. An advanced online school with a solid foundation.
- VIII. Integration of real-world practitioners into the course development and assessment process.

The Internet of Things (IoT) is a network of interconnected computing devices that collects, analyses, and acts on vast amounts of data about people's online activities in order to enhance their digital lives and the quality of their search results. The use of IoT devices for tracking behavioral data in the IoB workflow will make it simpler, quicker, and more effective as the quantity of such devices gathering vast quantities of data continues to grow. The goal of IoB is to apply psychological principles to data in order to generate new ideas, market existing ones, reimagine the value chain, boost profitability, or save expenses. Consequently, we will first employ linked devices to monitor user activity inside the IoB process. Machine learning and data analytics will be used to the gathered Internet of Things data. The information gained via analysis will be helpful, but it will need to be interpreted correctly using behavioral science principles. The collected data will be utilized to inform corporate decisions and shape customer actions, ultimately leading to the desired outcome. The IoB method is both proactive and descriptive. Users' actions are monitored and analyzed so that critical psychological factors may be identified and manipulated to meet the process goal. With these developments come a plethora of opportunities, but also a formidable set of difficulties.

### 3. Neutrosophic Sets

In this segment, we display a trapezoidal neutrosophic set based on the mixture of trapezoidal fuzzy values and a single-valued neutrosophic set and its score and accuracy functional areas. This extension is made possible by extending a trapezoidal intuitionistic fuzzy set, the practical preference, to a single-valued neutrosophic set[23]–[26].

We propose the following concept of a trapezoidal neutrosophic set as a generalization of a trapezoidal intuitionistic fuzzy set.

**Definition 1:**

Assuming  $X$  is a talkable universe, a trapezoidal neutrosophic set in  $X$  is characterized by the following formula.

$$\begin{aligned}
 N &\cong \{ \langle x, TN^{\sim}(x), IN^{\sim}(x), FN^{\sim}(x) \rangle \mid x \in X \}, \\
 \text{where } TN^{\sim}(x) &\subset [0,1], IN^{\sim}(x) \subset [0,1] \text{ and } FN^{\sim}(x) \\
 &\subset [0,1] \text{ are three trapezoidal fuzzy numbers } TN^{\sim}(x) \\
 &= (t1N^{\sim}(x), t2N^{\sim}(x), t3N^{\sim}(x), t4N^{\sim}(x)): \\
 X \rightarrow [0,1], IN^{\sim}(x) &= (i1N^{\sim}(x), i2N^{\sim}(x), i3N^{\sim}(x), i4N^{\sim}(x)): X \rightarrow [0,1] \text{ and } FN^{\sim}(x) \\
 &= (f1N^{\sim}(x), f2N^{\sim}(x), f3N^{\sim}(x), f4N^{\sim}(x)): X \\
 &\rightarrow [0,1] \text{ with the condition } 0 \leq t4N^{\sim}(x) + i4N^{\sim}(x) + f4N^{\sim}(x) \leq 3, x \\
 &\in X.
 \end{aligned}$$

These three trapezoidal fuzzy numbers may be written as  $TN(x)=(a,b,c,d)$ ,  $IN(x) = (e, f, g, h)$ , and  $FN(x) = (a, b, c, d) (l, m, n, p)$ . One fundamental component of the trapezoidal neutrosophic set is the number  $n = (a, b, c, d), (e, f, g, h), (l, m, n, p)$ .

The triangular neutrosophic number is a particular case of the trapezoidal neutrosophic number if the equivalence relations  $b = c, f = g$ , and  $m = n$ .

**Definition 2:**

A trapezoidal neutrosophic number, denoted as  $n = (a, b, c, d), (e, f, g, h), (l, m, n, p)$ , has a scoring function that can be written as

$$S(n) = \frac{1}{3} \left( 2 + \frac{a+b+c+d}{4} - \frac{e+f+g+h}{4} - \frac{l+m+n+p}{4} \right)$$

where the trapezoidal neutrosophic number  $n$  grows as  $S(n)$  grows. Equation simplifies to the following score function of the triangular neutrosophic number, in particular when  $b = c, f = g$ , and  $m = n$  hold in a trapezoidal neutrosophic number  $n$ .

$$S(n) = \frac{1}{3} \left( 2 + \frac{a+2b+d}{4} - \frac{e+2f+h}{4} - \frac{l+2m+p}{4} \right)$$

**Definition 3:**

One may define the accuracy function of a trapezoidal neutrosophic number, where  $n = (a, b, c, d), (e, f, g, h), (l, m, n, p)$ , as follows:

$$H(n) = \frac{a+b+c+d}{4} - \frac{l+m+n+p}{4}$$

**Definition 4:**

where the precision of the trapezoidal neutrosophic number  $n$  increases as  $H(n)$  becomes greater. Specifically, when the trapezoidal neutrosophic number  $n$  has the values  $b = c, f = g$ , and  $m = n$ .

$$H(n) = \frac{a+2b+d}{4} - \frac{l+2m+p}{4}$$

**Definition 5:**

Let

$n_1 = \langle (a_1, b_1, c_1, d_1), (e_1, f_1, g_1, h_1), (l_1, m_1, n_1, p_1) \rangle$  and  $n_2 = \langle (a_2, b_2, c_2, d_2), (e_2, f_2, g_2, h_2), (l_2, m_2, n_2, p_2) \rangle$  be two trapezoidal neutrosophic numbers. Then the order relation between two trapezoidal neutrosophic numbers is defined as follows:

$$S(n_1) > S(n_2), \text{ then } n_1 > n_2$$

$$S(n_1) = S(n_2), \text{ and}$$

$$H(n_1) = H(n_2), \text{ then } n_1 = n_2$$

$$H(n_1) > H(n_2), \text{ then } n_1 > n_2$$

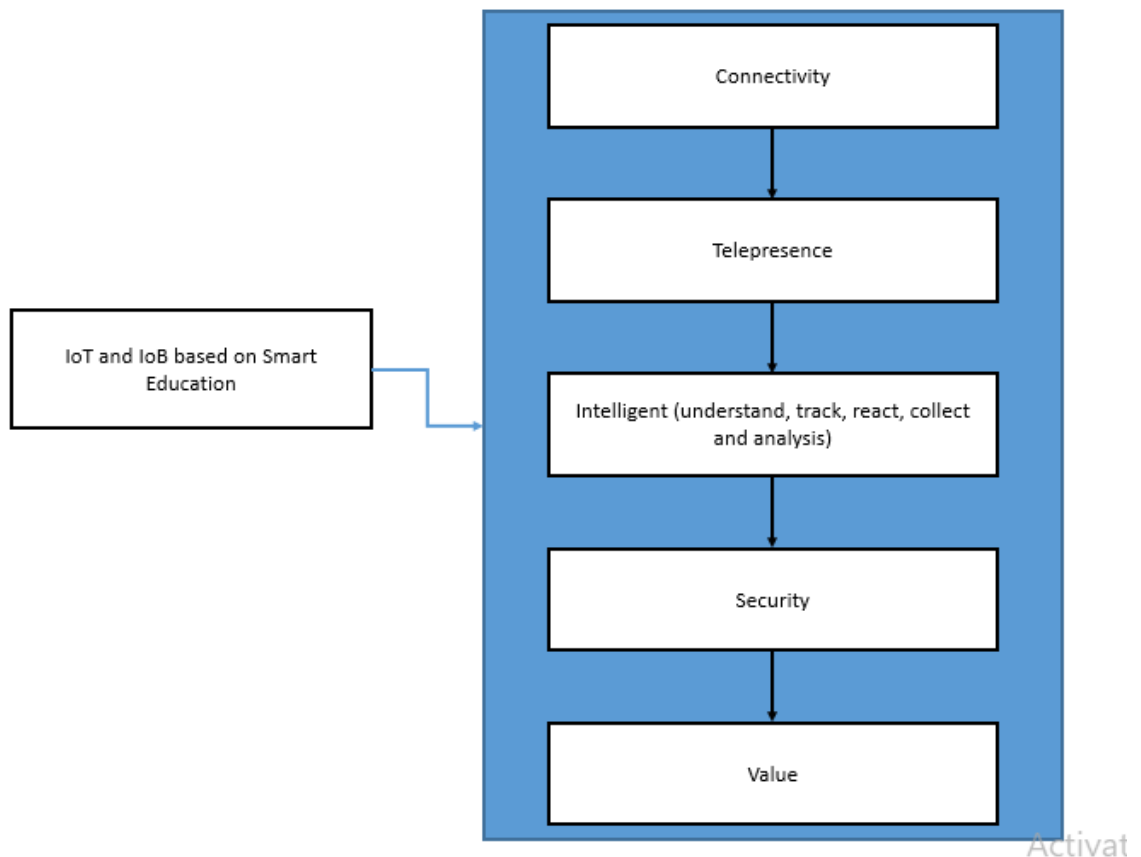


Figure 4: The AHP criteria.

In order to assess the important elements in IoT, this research builds a rule-based decision support structure using neutrosophic set theory and the approach of AHP. The Neutrosophic Analytic Hierarchy Process (AHP) is a synthetic expansion of the standard AHP approach that takes the uncertainty of the planners into account. Multiple criterion decision-making (MCDM) in neutrosophic settings may benefit greatly from the use of neutrosophic AHP. Determining the weights from the neutrosophic AHP pair-wise comparison matrices is a task best left to a scientific method when using neutrosophic AHP for many criterion decision-making. To estimate the MCDM and create comparisons for MCDM, AHP discovers weights, which may be thought of as values of "points." Nevertheless, neutrosophic AHP can expand these "points" to "lines" or even "surfaces," which is more useful. "a crisp point estimate approach such as the extension analysis or the neutrosophic preference processing (FPP) based nonlinear technique for neutrosophic AHP priority determination," as shown by Wang.

The AHP research framework is shown in Figure 4 and is based on a survey of the existing literature and conversations with subject matter experts.

This study uses an updated version of a well-known MCDA technique (i.e., AHP) to examine this question within the context of a neutrosophic decision-making framework characterized by uncertainty. NST and AHP are brought together in the proposed N-AHP method, with a first-of-its-kind application of single-valued trapezoidal neutrosophic values (SVTNNs) to AHP computations. To accommodate the neutrosophic rating system in the AHP computations, the SVTNNs' subtraction, multiplication, and inverse operators are likewise changed and altered. To rephrase, the proposed N-AHP uses SVTNNs in place of crisp values, which is the main difference between the regular AHP and the N-AHP. Because of this, the AHP technique would be even more effective in encapsulating the experts' subjective doubts.

Using the following guidelines, the suggested N-AHP technique evaluates the identified blockchain hurdles and ranks them.

First, we'll break the issue down into subproblems:

Using the AHP technique, it is necessary to create a hierarchy consisting of the aim, the criteria, and the options in order to simplify the issue. One tier of obstructions was included in the decision-making hierarchy for this analysis.

Second, we'll create a comparison matrix by matching up pairs:

Using the Saaty significance scale, experts assess the importance of different factors (criteria) based on their respective weights ( $C_i$  vs  $C_j$ ) (Saaty, 1980). In the questionnaire, specialists are asked to provide a relative relevance to each component by selecting a linguistic term. When this is done, the numerical equivalent of the sentence replaces the figurative one (i.e., 1 to 9).

Given a set of elements denoted by  $C_1, C_2, \dots, C_n$ , and an assessment of a pair of elements,  $C_i$  and  $C_j$ , by the  $k$ th decider ( $k=1, 2, \dots, p$ ),  $a_{ijk}$ . This generates a comparison matrix based on the strength of the relationships between the pairs.

When determining the CR:

To determine whether or not the ratings are consistent with one another, Saaty (1980) advised doing a consistency test. The randomized index (RI) is dependent on the number of items being evaluated ( $n$ ), and  $\max$  is the largest value of the eigenvector, which allows us to test for cardinal and outcome stability in pairwise comparisons. Expert reevaluation is necessary if Cronbach's alpha value is less than 0.1.

Substituting SVTNNs for the language data:

Matrix elements used for pairwise comparisons are swapped out for their corresponding SVTNNs.

By compiling the SVTNNs' professional opinions:

The views of the numerous experts are aggregated and their weighting is determined using the trapezoidal neutrosophic weighted arithmetic averaging (TNWAA) operator. Every expert's experience and expertise in their respective sector is used to provide weight to their opinion.

The synthesized neutrosophic values are calculated as follows.

Every element's artificial neutron value

Finding the ultimate weights of significance:

$W$  in SVTNNs represents the final importance weights that are determined. The score function should be used to convert the weights to discrete numbers for easier comparison.

#### 4. The Application

There are five criteria that need to be weighed using the N-AHP are shown in figure 4. There is just one tier in the decision tree for this issue. The final consistency is computed and the results show that the opinions of experts are valid.

This research utilizes an AHP questionnaire in combination with in-person interviews to rank all of the variables and sub-factors influencing the Internet of Things. IoT executives and marketing executives of organizations will have a clear road map thanks to this rating, which illustrates the relative significance of the success elements compared to each other. The results line up with the associations predicted by the literature. The ranks and weights shown above make it easy to understand the key findings of this research. Security ( $w = 0.45$ ), Quality ( $w = 0.16$ ), Connection ( $w = 0.15$ ), Videoconferencing ( $w = 0.13$ ), and Intellect ( $w = 0.09$ ) are the primary elements in order of importance. This AHP analysis shows that safety, value, and connection are more important than videoconferencing and intelligence. This study's findings show that, among specialists, security, usefulness, and connection rank higher than more abstract considerations (Telepresence and Intelligence). If a business is going to implement an IoT system, there are a few concrete considerations that must be made first and foremost: internet security; market demand; market fragmentation; partnering, and policy decisions; and third, constant communication between IoT objects as well as facilities via IoT technology. To create the IoT platform seem more present, genuine, and intelligent, businesses must deploy the technology of intangible elements once the tangible components have been fully established. Figure 5 shows the weights of the criteria. Table 1 shows the pairwise comparison matrix. Table 2 shows the normalized pairwise comparison matrix.

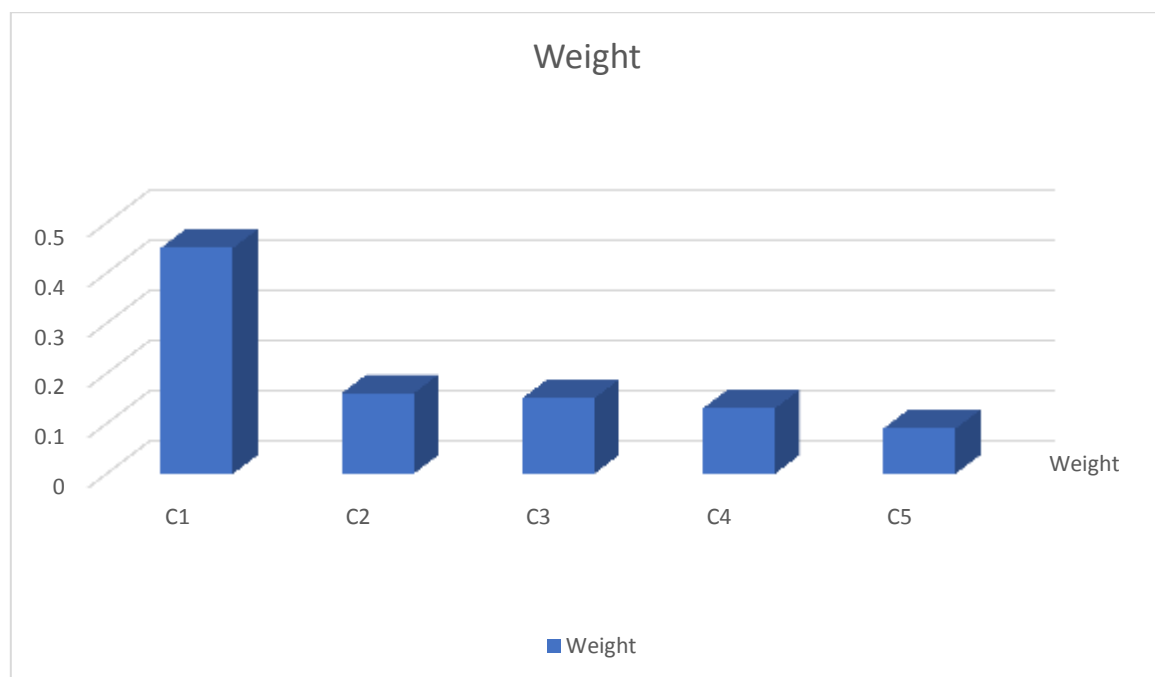


Figure 5: The weights of criteria.

Table 1: The comparison matrix.

	C1	C2	C3	C4	C5
C1	1	0.2	0.6	0.8	0.9
C2	5	1	0.7	0.6	0.2
C3	1.666667	1.428571	1	0.4	0.1
C4	1.25	1.666667	2.5	1	0.3
C5	1.111111	5	10	3.333333	1

Table 2: The normalized comparison matrix.

	C1	C2	C3	C4	C5

C1	0.099723	0.021516	0.040541	0.130435	0.099723
C2	0.498615	0.107582	0.047297	0.097826	0.498615
C3	0.166205	0.153689	0.067568	0.065217	0.166205
C4	0.124654	0.179303	0.168919	0.163043	0.124654
C5	0.110803	0.53791	0.675676	0.543478	0.110803

## 6. Conclusion

Since the commercial value of IoT is so substantial, from digitizing internal processes and consumer experiences to releasing disruptive new digital goods and business models, the present design and creation of IoT may radically alter the whole industrial landscape.

McKinsey predicted in their 2015 study that by 2025, the Internet of Things could produce an annual \$11.1 trillion in economic value. Forrester, in contrast, found in 2016 that IoT has two primary chances to provide value for businesses. Both goods and corporate operations may benefit from the Internet of Things. Business organizations may utilize IoT to enhance their internal systems with more accurate and timely information thanks to the connectivity it provides across their product lines and their customers' experiences. Smart applications including home automation, smart cities, the healthcare sector, safety & security, precision farming, etc. are now receiving the majority of attention in the research and development of IoT. Despite the fact that enterprise IoT advancement is still a fairly recent phenomenon and layout, most businesses are concentrating their IoT development efforts on strategic road maps, the enhancement, and accessibility of service organizations, and the introduction of new business models and product or service offerings. All of these enhancements and advancements need to be founded on a more precise understanding of the physical and intangible aspects that affect IoT applications. This research divides the efficacy of the internet of things into its concrete and intangible components. Security, value, and connectivity all fall under the "tangible" category, whereas "telepresence" and "intelligence" belong to the "intangible" category. The AHP findings show that the physical evidence is more crucial than the intangible component since the intangible dimension can only be established after the physical dimension has been put in place.

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