An effective model for Selection of the best IoT platform: A critical review of challenges and solutions

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Abstract

The process of making an informed decision on which Internet of Things (IoT) platform to choose is an extremely important one in the modern world. The choice procedure is made more difficult as a result of (a) the vast number of IoT platforms that are offered on the market for IoT applications and (b) the wide diversity of functions and solutions that are provided by these platforms. In this article, the multi-criteria decision-making (MCDM) methodologies for selecting the specific Internet of Things platform are taken into consideration. The TOPSIS method is used in this paper to select the best IoT platform. TOPSIS method is a common MCDM method. TOPSIS method used the idea of the best and cost criteria to compute the distance from it.

During the IoT platform choice procedures, relevant aspects, such as the stability, consistency, protection, and privacy of IoT platforms, are regarded to be the most significant ones for making decisions.

Keywords: IoT; MCDM; TOPSIS; Decision Making; Internet of Things

1. Introduction

The majority of the time, selecting an Internet of Things platform for the creation of an Internet of Things system requires doing a comparative study of the characteristics offered by the various developers of Internet of Things platforms. In addition, Internet of Things developers frequently attach importance to well-known Internet of Things platforms, without taking into consideration requirements (variables) that could in the long term have an impact on the formation, preservation, modifying, efficiency, protection, and resizing of the Internet of Things systems that have been developed[1]–[3]. One of the ways to choose an Internet of Things platform is to first define a standard to reach the surface that incorporates the advantages and abilities of the many current Internet of Things platforms that are already in use. In a later step, a comparison study of the shortlisted platforms and the single reference platform is conducted, and the most effective Internet of Things platform is chosen[1], [4], [5].

Numerous MCDM approaches, like the analytic hierarchy process, the pair-comparison technique, and the Delphi technique, amongst others, have undergone extensive testing and are currently considered reliable.

The selection of an appropriate platform for the Internet of Things (IoT) while keeping in mind the factors that play a role in decision-making is an essential challenge[6]–[10]. The fact that it is so

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difficult to take into consideration all of the features, options, and application areas offered by IoT platforms is one of the primary reasons why it is essential to make use of the MCDM when selecting the appropriate specialized IoT platform. In addition, the selection of the wrong platform for the Internet of Things (IoT) might result in a decrease in the security and reliability of IoT devices.

Let's take a look at some of the most well-known specialist Internet of Things platforms, also known as cloud technologies, which may be used to develop a variety of IoT-based systems. There is not a single criterion that predominates in terms of the IoT platform. The majority of the time, Internet of Things systems that enable the greatest degree of security, for instance, do not enable the variety of datasets and visualization techniques, and vice versa. The Internet of Things platforms (solutions available) listed below is the ones that may be deemed most suitable for this type of description.

Every platform comes with its own set of benefits and drawbacks. An in-depth investigation of various Internet of Things platforms will be carried out to ascertain which one is the most ideally suited for customized IoT networks. Table 1 shows the list of criteria and alternatives.

Table 1: The description of criteria and alternatives

Name of criteria or alternatives	Description
Privacy and security	Compared to other types of products and services, the resources needed to run an IoT platform are substantially larger. If millions of units are going to be linked to the same IoT platform, then millions of security flaws need to be anticipated.
Operational Handling	Device setup, firmware (or program) upgrades, and problem detection and error management at the component level should all be taken care of by the IoT platform, which should also keep track of all smart sensors and their operating condition.
Operations Access	is another essential quality of an IoT system. For the IoT platform to function properly, some functions and information will need to be available, and this is what the API is for.
Process Management	The information gathered by IoT gadgets has a tangible impact on the world around us. Hence, the IoT platform must be capable of creating workflows, occasions, and other "intelligent actions" depending on particular different sensors.
Dataset management	This criteria is necessary to bring back some kind of order to the chaotic process of moving knowledge across, say, various computer systems and platforms.
Data Communication	utilized for exchanging information among the many nodes that make up an IoT system. Channels that are light on resources should be utilized to reduce power consumption and network traffic.
Presentation	allows people to see patterns and trends in data presented in visually appealing dashboards with graphs, charts, and simulations in two or three dimensions.
Data analysis	To get useful information from the data generated by sensors on an IoT platform, cognitive analysis is required. Analyses of IoT data may be broken down into4 categories: insights in real-time, batch, predictions, and user interaction
Alternatives	
IoT platform of Samsung	When it comes to defense, Samsung seeks to create a platform that handles everything, with offerings like their Artik Module, Cloud,

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	Protection, and ecosystem. Artik's quick and accessible platform is in charge of packaging.
IoT platform of Google	The Google Cloud service has several benefits, including the following: business acceleration; device acceleration; cost reduction through cloud service; and a community of partners.
IoT platform of IBM	IBM Watson's use of data science and machine learning opens up exciting new avenues for cyber security. IBM Watson provides its customers with several useful features, including remote access, highly secure, real-time data interchange, data sensors, and meteorological data service.
IoT platform of Bosch	The platform as a Service (PaaS), remote management, analytics, cost-effectiveness, and ready-to-use functionality are the primary characteristics of the Bosch IoT platform.
IoT platform of Microsoft	Device mirroring, a rules engine, identity registration, and information tracking are some of the primary capabilities offered by the Azure IoT platform.
IoT platform of AWS	The AWS Internet of Things platform has the following key characteristics: a registry for detecting equipment; a software development tool for devices; device shadowing; a secure network gate; and a rules system for evaluating incoming messages.
IoT platform of Kaa	The Kaa Internet of Things platform's primary capabilities includes the following: the ability to manage an unrestricted quantity of connected devices; the capability to carry out real-time technique can be implemented; the capability to carry out remote system procurement; the ability to collect and analyze sensor data; the capability to analyze user behavior and send appropriate alerts; and the capacity to build cloud storage for intelligent devices.

The goals of this study are (a) to establish the MCDM issue for choosing the IoT platform from a variety of options, and (b) to make a solution to the MCDM issue for improving the effectiveness of judgment procedures using a TOPSIS approach. Both of these objectives will be accomplished by the end of this study[11]–[16]. Table 2 shows the related work of the IoT methods.

Table 2: The previous IoT methods

Author	Main idea and advantages	Disadvantage	Validation
Qureshi, Kumar[17]	The use of third-party logistics (3PL) network operators is growing on a worldwide scale to help achieve strategic goals. In today's increasingly globalized market, logistics strategy formulation calls for a strategy that is both methodical and disciplined to keep an advantage over one's rivals. The transporters can only increase their market interests successfully by investing in logistics management that has benchmark efficiency. As a result, the use of benchmarking has developed into an essential component in improving efficiency to support logistics organizational strategies. To enable a general logistics task, they made use of a method known as the fuzzy analytic hierarchy process (FAHP). Key successful elements for logistics have been gleaned from the available research and ranked	Complication	Implementation

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	in order of importance. The test scenarios of LOGIN NET, a third-party logistics (3PL) services provider situated in the western portion of India, as well as those of four other providers, were benchmarked and used these crucial success variables.		
Wudhikarn, Chakpitak[18]	They devised a novel combined method for attempting to address the insufficiencies and shortfalls that are usually found in previous research findings on benchmarking, as well as for benchmarking intellectual capital (IC) in the poorly developed realm of shipping. This approach was created to address the inadequacies and shortfalls that are usually found in previous research on benchmarking. The suggested technique embedded the analytic network methodology and the notion of thoughts and non-thinking investments with the cliched benchmarking methodology to investigate the wide variety of components and indicators of IC that influence the sustainable growth of organizations. This was done to address the problem of not adequately considering the relationships that existed between previous benchmarking notions and the effects that their managerial factors had, as well as to investigate said connections. This innovative hybrid approach was put into action at four different commercial organizations that provide courier services. By taking into consideration the basic features of derivative instruments, the suggested technique ranked the various aspects to be considered in order of importance and determined the orders of magnitude of those aspects, including the components of the asset worth (IC). The findings that were collected show that management is focused on the IC of the company which is the top performer as well as other businesses. This benchmarked result indicated gaps and chances for growth in addition to prospects for sustainable growth for weaker logistics organizations. The upgraded framework has benchmarking procedures that are more methodical and particular, allowing for consideration of, access to, and comparison of more in-depth aspects of IC administration.	Complication	Implementation
Riaz, Qaisar[19]	They proposed an optimization problem linked to service quality cluster choice and utility maximization while taking into consideration power and workload limits for workloads that need extremely low latencies. In the realm of combinatorial optimization, the outer estimate approach is a tried and tested method that is also scalable concerning the number of vertices. This study aims to offer a networked identity algorithm that is based on the outside sufficient to control. This approach is effective for the issue that was posed. To verify the accuracy of the numerical findings, numerous simulations are used.	Negative load balancing	Simulation
Cuka, Elmazi[20]	Opportunistic Networks, also known as OppNets, are a sub-class of DTN that was developed as a particular kind of ad hoc network that may be used for things like responding to emergencies. OppNets are not like typical networks in that communication	Complication	Simulation

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	possibilities come and go at random. As a result, an end-to-end route among both the destination and the source may never be established. Connectivity is now available on a wide variety of devices thanks to the existence of networks, such as handheld devices, laptops, tablets, personal computers, and so on. The Internet of Items (IoT) will make it possible to link not just mobile smartphones and laptops but also structures, wearable gadgets, automobiles, and a wide variety of other things and objects in addition to traditional mobile phones and computers. The choice of the Internet of Things nodes that will carry out a job in OppNets is one of the challenges faced by these nets. They did this by putting in place two Fuzzy-Based Systems known as the Node Exclusion System (NES) and the Cluster Formation System (NSS) for the elimination and selection of IoT nodes in OppNets. We make use of the following three input variables for the NES algorithm: Node's Length to Event (NDE), Node's Battery Status (NBL), and Node's Free Cushion Space (NFBS). For the NSS algorithm, we make use of the following four input variables: Node's Amount of Past Interactions (NNPE), Node's Unique Confrontations (NUE), Base station Inter Initial Concentration (NICT), and Node Interaction Duration (NCD). IoT Cluster Formation Possibility is the variable that represents the outcome (NSP).		
Redhu and Hegde[21]	They came up with a mechanism for selecting online base stations that makes use of previous partial knowledge about apriori net coming into contact. The information on the net contact pattern is often gathered via the use of a variety of machine learning and forecasting approaches. The approach that is being presented chooses a routing protocol by jointly optimizing the performance of two network metrics, namely the data latency and the connection dependability. Using the knowledge about the a priori contact patterns, a heuristic formula is developed to simultaneously maximize the data latency as well as the connection dependability. At every moment in time, the best relay node is selected by finding a way to minimize the cost function. Modeling the network recommends changing Internet of Things devices using homogenous Poisson point processes is done during the performance assessment phase. The information on the length of time that each Internet of Things device has been in touch with its neighbours is updated regularly, and an online method is used to locate a relay node. When the information of apriori interaction patterns of Iot systems is applied, the outcomes of the simulation show that the suggested strategy results in a considerable improvement in both the data delay and the dependability of connections. The effectiveness of the packet transmission approach that has been suggested is evaluated with regard to radio range, mobility endurance, and connection characteristics of time-varying IoT nets. When compared to other	Energy consummation	Simulation

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	approaches, the suggested method demonstrates extra advantage in terms of cost savings associated with packet duplication.		

The remaining portions of this article are laid out in the following structure. The MCDM TOPSIS method is discussed in Section 2, which follows. Section 3 focuses on the findings, and Section 4 draws conclusions and looks forward to potential applications.

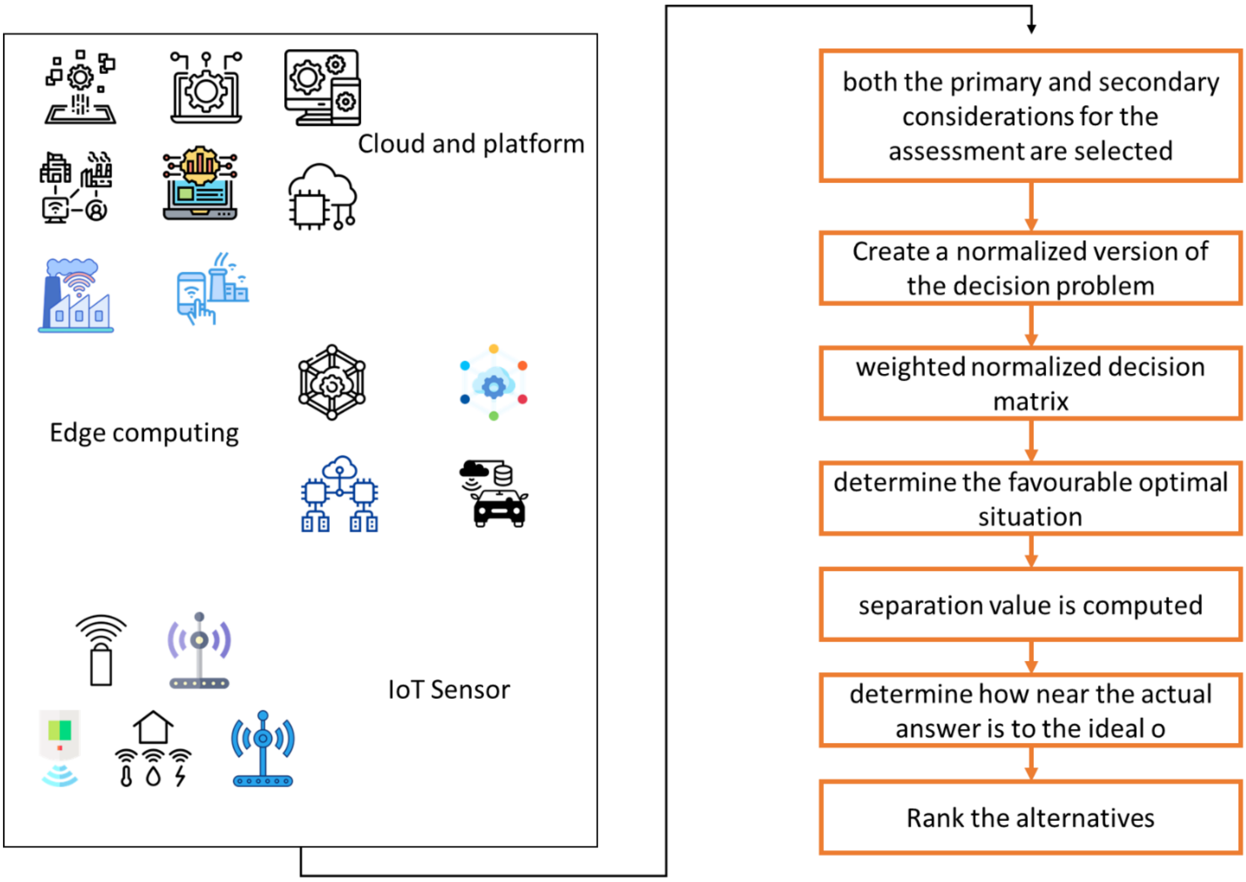

Figure 1: The proposed model for selecting the best IoT platform

2. MCDM TOPSIS Methodology

The TOPSIS technique is a component of MCDM approaches that may be used to find a solution to a particular kind of decision-making challenges. This approach is predicated on the assumption that the option that is selected has to have the smallest possible Euclidean separation from the best solution, while also having the greatest possible distance from the bad perfect solution. Figure 1 shows the proposed framework.

The following are the stages that are included in the TOPSIS methodology:

In the first step, both the primary and secondary considerations for the assessment are selected.

Step 2 involves representing all of the information that is now accessible about the output responses in the structure of evaluation criteria.

Step 3: Create a normalized version of the decision problem, called Z_{ij}, by utilizing the equation.

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$$Z_{ij} = \frac{u_{ij}}{\sqrt{u_{ij}^2}} \quad (1)$$

Step 4: In the fourth step, you will build the weighted normalized decision matrix by multiplication the normalized decision matrix by the ratings that are connected with it. The formula for calculating the weighted normalized value Vij is as follows:

$$WZ_{ij} = w_{ij} \times Z_{ij} \quad (2)$$

Step 5: In the fifth step, we determine the favorable optimal situation as well as the bad ideal alternative.

These results are arrived at by

$$I^{+} = \begin{Bmatrix} (\max WZ_{ij} \,|j\varepsilon J), negative\ criteria \\ (\min WZ_{ij} \,|j\varepsilon J\ positive\ criteria) \end{Bmatrix} \quad (3)$$

$$I^{-} = \begin{Bmatrix} (\min WZ_{ij} \,|j\varepsilon J), negative\ criteria \\ (\max WZ_{ij} \,|j\varepsilon J\ positive\ criteria) \end{Bmatrix} \quad (4)$$

Step 6: The separation value is computed in Step 6, the last step.

The following characteristics differentiate each possibility from the one that represents the positive ideal:

$$Q_i^{*} = \sqrt{\left(\sum (I_{ij} - I_j^{+})^2\right)} \quad (5)$$

$$Q_i^{-} = \sqrt{\left(\sum (I_{ij} - I^{-}{}_{j})^2\right)} \quad (6)$$

Step 7 involves doing a calculation to determine how near the actual answer is to the ideal one.

The following is a definition of what constitutes relative proximity:

$$T_i^{*} = \frac{Q_i^{-}}{Q_i^{-} + Q_i^{*}} \quad (7)$$

The effectiveness of the options is shown to be superior the greater the T_i^{*} the value that is shown.

Step 8. Place the relative proximity value in the order of importance.

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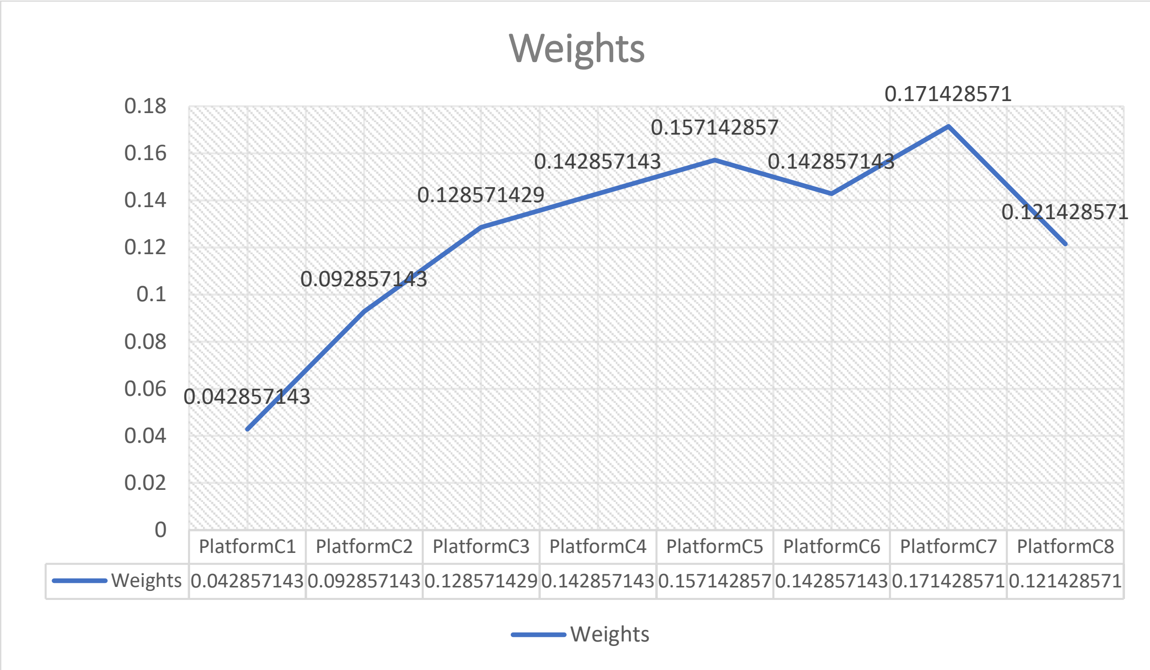

Figure 2: The weights of criteria.

3. Results and discussion

In this section, the steps of the TOPSIS method are applied to rank and select the best IoT platform.

In the first step, three experts collected criteria and alternatives from the previous studies as shown in table 1. Then let experts evaluate the criteria and alternatives to compute the weights of criteria and rank the alternatives. Experts evaluated the criteria on a scale from 1 to 9. Then apply the average method to compute the average score of three experts. Then compute the weights of the criteria. Figure 2. Shows the weights of the criteria.

Step 2 involves representing all of the information that is now accessible about the output responses in the structure of evaluation criteria. Let experts evaluate the criteria and decision-making to build the decision matrix. Then aggregate the decision matrix into one matrix as shown in table 3.

Step 3: Use Eq. (1) to compute the normalization decision matrix as shown in table 4.

Step 4: In the fourth step, the weights of criteria are multiplied by the normalization matrix to compute the weighted normalized decision matrix by using Eq. (3) as shown in table 5.

Step 5: In the fifth step, all criteria are positive. The positive and negative ideal solutions are computed by using Eqs. (3,4).

Step 6: The separation value is computed by using Eqs. (5,6)

Step 7 involves doing a calculation to determine how near the actual answer is to the ideal one by using Eq. (7)

Step 8. Rank the alternative according to the highest value of T as shown in figure 3.

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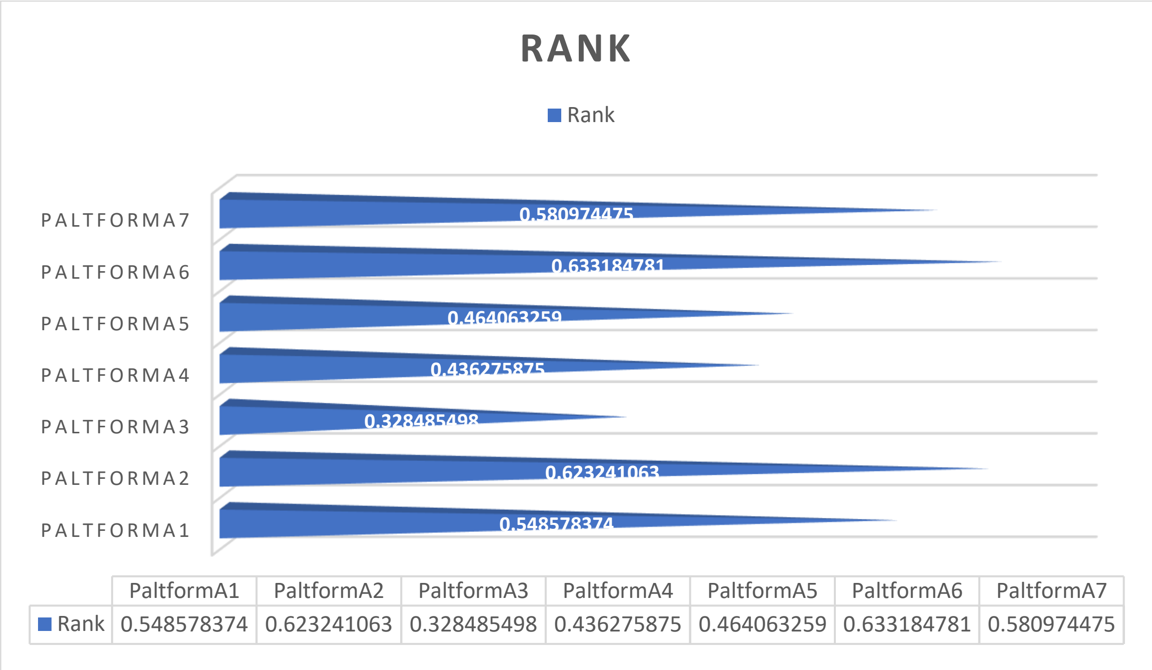

Figure 3: The rank of alternatives.

Table 3: The decision matrix

	Paltform C1	*Paltform C2*	*Paltform C3*	*Paltform C4*	*Paltform C5*	*Paltform C6*	*Paltform C7*	*Paltform C8*
Paltform A1	4.333333	7.666667	4	7	8	9	5	5.333333
Paltform A2	4.666667	8	9	6	3	8	6.666667	3
Paltform A3	5	2	3	4	4	6	2.666667	2
Paltform A4	3	1	7	4.666667	6	9	4.666667	4
Paltform A5	2	9	2	5	6	7	9	9
Paltform A6	4	6.333333	5.666667	8.666667	7	8	6	8
Paltform A7	5	4	7	8.333333	6.333333	8	3.666667	6.333333

Table 4: The normalized decision matrix

	Paltform C1	*Paltform C2*	*Paltform C3*	*Paltform C4*	*Paltform C5*	*Paltform C6*	*Paltform C7*	*Paltform C8*
Paltform A1	0.396312	0.471058	0.258139	0.40941	0.505852	0.429547	0.33057	0.342447
Paltform A2	0.426798	0.491539	0.580813	0.350923	0.189695	0.381819	0.44076	0.192626
Paltform A3	0.457283	0.122885	0.193604	0.233949	0.252926	0.286364	0.176304	0.128418
Paltform A4	0.27437	0.061442	0.451743	0.27294	0.379389	0.429547	0.308532	0.256835
Paltform A5	0.182913	0.552982	0.12907	0.292436	0.379389	0.334092	0.595026	0.577879
Paltform A6	0.365826	0.389135	0.365697	0.506889	0.442621	0.381819	0.396684	0.51367

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Paltform A7	0.457283	0.24577	0.451743	0.487393	0.400466	0.381819	0.242418	0.406656

Table 5: The weighted normalized decision matrix

	Paltform C1	*Paltform C2*	*Paltform C3*	*Paltform C4*	*Paltform C5*	*Paltform C6*	*Paltform C7*	*Paltform C8*
Paltform A1	0.066893	0.033004	0.03535	0.056066	0.069273	0.010944	0.045269	0.008725
Paltform A2	0.072039	0.034439	0.079538	0.048056	0.025977	0.009728	0.060359	0.004908
Paltform A3	0.077185	0.00861	0.026513	0.032038	0.034636	0.007296	0.024144	0.003272
Paltform A4	0.046311	0.004305	0.061863	0.037377	0.051955	0.010944	0.042251	0.006544
Paltform A5	0.030874	0.038744	0.017675	0.040047	0.051955	0.008512	0.081484	0.014723
Paltform A6	0.061748	0.027264	0.05008	0.069415	0.060614	0.009728	0.054323	0.013087
Paltform A7	0.077185	0.01722	0.061863	0.066745	0.054841	0.009728	0.033197	0.010361

4. Conclusion

Because it is difficult to take into consideration all of the features, possibilities, and services offered by IoT platform developers, it is necessary to use the MCDM techniques when selecting a specialized IoT platform. This is one of the reasons why employing these methods is necessary. In addition, if the platform is not chosen carefully, the reliability and security of the IoT systems may be compromised. The authors demonstrate how to solve the MCDM issue by using the linear convolution technique with a straightforward ranking approach to the formation of weight coefficients for criterion. Because of this, DM is possible to analyze the results of the ranking of the IoT platforms, taking into account the circumstances and needs of IoT systems. The TOPSIS method is used in this paper to rank and select the best alternatives.

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