QoS aware Service Selection in IoT using ANP

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Article Info
Page Number: 283 – 299
Publication Issue:
Vol. 71 No. 3 (2022)

Article History
Article Received: *12 January 2022*
Revised: *25 February 2022*
Accepted: *20 April 2022*
Publication: *09 June 2022*

Abstract

The Internet of Things (IoT) raised the goal of the industrialization of human life through universal support for vast services and applications. However, the IoT environment is different from the cloud environment. An enumerable number of Similar services are available in the virtual world with various quality services. This causes service providers to be unable to present their services, and other side users cannot find suitable services of their preferences. QoS may solve their problem better and be more satisfied. This paper considered the IoT environment's layers such as; Things, communication, and Computing used to create a flexible IoT service selection framework. Further, demonstrate a case study of optimizing service selection based on QoS using ANP.

Keywords: QoS, IoT, ANP, IoT Services, Service Selection

1. Introduction

Process of communication found existed since the origin of the earth in one or the other way, but formal spoken communication started officially by human beings. Earlier, spoken communication used to happen among human beings, and gradually, started intercommunication between man and machines. But the current generation strives to build interaction among anything, like device-to-device

These devices are a small piece of physical world equipment, which has basic operations such as communication, sensing, actuation, data store, and processing capabilities [1]. Further, these devices establish networks for the information process using the internet. And these are termed the Internet of Things (IoT). The Internet of Everything (IoE) brings collectively people, processes, data, and things to connect with the network.

IoT is a new paradigm that considers ubiquitous things connected with wired and wireless, able to identify uniquely and interact with each other to reach a user's goal by making new applications/services [2]. It led to creating new capabilities and the growth of economic opportunities for businesses of individuals and countries in the form of service and applications such as Smart Energy & Grid, Smart Healthcare, Building & Home, Transport, Industry and Internet, City, Agriculture & Forming, Waste Management & Recycle, Social & Life Entertainment, Supply Chain & Retail Management, and Environment. It necessitates the IoE makes a significant percentage of physical objects to connect in the future [3].

An IoT environment structure designed with four-layered referential architecture, namely Physical layer, Network layer, Application support layer and Service layer [1]. Obtaining a specific service from the bottom-up approach is complex due to the interdependencies of layers. And this issue is addressed with the help of identifiers.

Identifiers are unique numbers in different levels used to recognize devices, services, and networks. A list of identified situations are as follows, Identifying things, Communicating between things, Connecting to networks a huge accommodation, Network technology independence of IoT devices, Association between Physical thing and virtual thing, Multiplicity, Permanent or limited lifetime, Identification of the IoT services [1]. There is a huge demand in society for IoT services, and it made the service providers tackle the issues of service selection optimization. Further, the service selection becomes challenging if the selection preference comes from the users' end.

Section 2 deals with service selection literature review and the internal structure of the IoT environment. Section 3 deals with the proposed architecture. Section 4 QoS metrics parameters related to the service discussed. Section 5 proposed an algorithm for service selection using ANP. And Section 7 demonstrated a framework using a Healthcare system case study and analyzed results outcome.

2. Related Work

This section is made of two subsections. Section 2.1 deals with service selection in the cloud and how it differs from the IoT environment. Section 2.2, the importance of Quality of Service (QoS) and the internal structure of the IoT environment related to service selection are discussed.

2.1. Service Selection

Service-Oriented Architectures (SOA) is an approach that addresses the requirements of loosely coupled, standards-based, and protocol independent distributed computing. It is an integration platform that utilizes Web services standards to support a wide variety of communications patterns over multiple transport protocols and deliver value-added capabilities for SOA applications [4].

In the paper [5] the author emphasized on design and implementation issues of a flexible network using Service Oriented Architecture methodology. It also highlighted a framework for Flexible Network Architecture.

The diversity, heterogeneity, and innovation in the network application domain prompted a new era of the Internet. In this paper, the authors' emphasized the development of improved Future Network using with broker's communication which works based on SOA while accounting and addressing the issues of CI failure factors [6].

The paper [7] focused on service selection made based on the user's choice, and deployed on the multi-cloud environment. The service performance matrices are measured with the help of reliability, cost, throughput, and availability attributes.

In [8], the author introduced TOPSIS and VIKOR as two decision-making models for IaaS cloud service selection. The criteria used for service selection are Storage, Bandwidth, and RAM. But this study was not focused on the IoT environment.

The service selection process depends on several attributes, usually called Quality of Service (QoS) [9]. One of the significant challenges in the IoT service selection mechanism is flexibility in selection. An enormous number of similar services are available with different quality levels. As a service provider, it could be hard to present the distinct feature of the service into a virtual world, and also for the user, it could be hard to select a suitable service as per requirement.

2.2. Internal structure of IoT based on QoS

In [10, 11], introduced the three-layer architecture to guarantee the QoS in IoT. The layers were made based on Service, Network and Sensing of devices. In paper [10], focused on resource cost and optimization of IoT network performances.In paper [11], focused on solving traditional network issues, such as availability, real-time data delivery, latency, and scalability.

In [12], IoT applications are developed with four main segments: Communication, Information transfer, Interface, and Service Manager.

Currently, most of the researchers focus on layer architecture. In paper [13],the author introduced an IoT layer system created with three main components: Things, Communication, and Computing. To define any application or service in an IoT environment, Communication, Things, and Computing are the main components. And it is significant to understand QoS matrices in every layer of the IoT services.

In [14], an author introduced a Physical Service Selection in an IoT environment and extended work in [15] for device selection.The performance matrices are created based on reliability, reputation, cost and processing time, time, availability, and service area. But in this paper, the flexibility of IoT service is limited to devise selection only.

In [16], the author designed MCDM for IoT service selection and proposed a Fuzzy technique for order preference by similarity to ideal solution (FTOPSIS) based on FAHP and Fuzzy technique

3. Proposed Architecture

The layered architecture representation of service selection in IoT framework looks as shown in Figure 1. A user interacts with a framework using the application layer. The layer may consist of Web applications, API’s, or any specific interfaces. This application layer makes interaction with IoT devices through the Internet layer. The resource manager is responsible for allocating/deallocatingIoT-related resources. The device in the Things layer interacts with other devices and generates real-time data using sensors. The Communication layer establishes connectivity with Edge nodes and provides Security & Privacy at the device level. This layer is a part of the IoT system. The Computing layer contains computational elements, which help in processing real-time data and are accomplished based on Cloud instructions.

Researchers and experts contributed a lot in designing well-defined IoT models, which can provide several services at a time. This not only popped up a service selection issue for the existing system but also thinks to provide a better QoS.

QoS is used to measure the capability of the system and resources needed for IoT service. It allows the service provider and user to get a rich perception of the delivery and usability of the services.

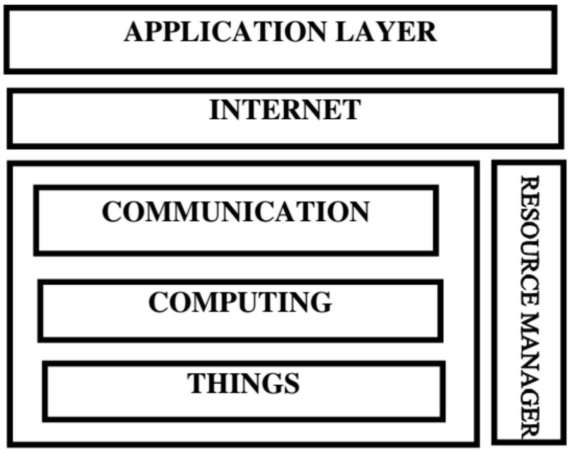

Fig.1. Layer Architecture of IoT System

4. QoS Metrics related to IoT

The IoT service composition changes dynamically from application to application. A suitable IoT service selection based on QoS metrics is to be needed. The dynamic change could handle flexibility in selecting QoS metrics. In our case, the identified three main components Things, Communication, and Computing.

4.1 QoS Metrics related to Things

An enormous variety of sensors are available in the market. And these sensors are selected based on the type of applications and user's requirements. The author has identified 21 different QoS parameters in this regard [17, 18, 19, 20, 21, 22, 23, 13, 24], and the list made as shown in Table 1.

4.2 QoS Metrics related to Communication

Communication is the spine of IoT service. Poor network service selection could cause a bad experience, and sometimes it might not work appropriately. The author has identified 15 different QoS parameters in this regard which can make the communication service better [25, 21, 26, 13, 27, 28, 29, 30, 31], and the list made as shown in Table 1

4.3 QoS Metrics related to Computing

The large volume of data received from various IoT devices is needed to store for computing purposes. A Cloud provides unlimited storage and scalable options to a user. Computing helps the management of devices or things. The author has identified 12 different QoS parameters in this regard that can make the computing service better [32, 13, 19, 21, 33], and is as shown in Table 1.

Table 1: QoS Metrics Parameters

Things	Communication	Computing
Accuracy, Availability, Drift, Flexibility, Interoperability, Long-Term Stability, Memory Resources, Mobility Support, Noise, Operating environment, OTA Update, Power Consumption, Precision of the sensors, Price, Range, Reliability, Resolution, Response Time, Security, Sensitivity, and Weight.	Availability, Bandwidth, Delay, Interoperability, Jitter, Loss rate, Mobility Speed, Monitoring, Network Connection Time, Pricing, Range, Reliability, Security and Privacy, Service-Level Agreement, and Throughput.	Accuracy, Availability, Capacity, Customer Support Facility, Interoperability, Pricing, Reliability, Reputation, Response Time, Scalability, User Feedback, Security and Privacy

5. IoT Service Selection: Proposed framework

AHP is one of the MCDM methods that make the decision problem into the hierarchical structure, reducing the complexity of the decision problem [34]. AHP executes the pairwise comparison with criteria and of the alternatives, which gives great help to the decision-makers. Its main goal is to succeed the problem of unidirectional hierarchical relationships among decision levels. The workflow diagram of the proposed framework using ANP is as shown in Figure 2.

In the proposed framework the selection of the best service is made based on different criteria. In our case, it tried to examine three components Things, Communication, and Computing. These are the criteria of service selection (i.e.,Concrete Service). The sub-criteria depends on the selected QoS parameters (Quantitative and Qualitative) asdecided by the User / Customer. Mathematically it is expressed as in equation (4). Similarly suitable Abstract service (AS_i) needed to be identified, which defines in equation (2). This constructs hierarchy network as shown in Figure 3.

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The service selection has contacted many dependencies among the components (i.e., goal, clusters, criteria, sub-criteria, and alternatives). And the proposed service solution in selecting the best services based on ANP in IoT is as shown in Algorithm 1.

The pairwise comparison matrix for components needs internal judgement. The comparison matrix relative values are ordered in Fundamental Scale [34], which ranges from 1 to 9. Actually, these are the priorities suggested for ANP [34], and it represents QoS attributes with one another. The comparison matrix size n x n, defines ”n” number of QoS parameters. The comparison of row r^thQoS attribute with column c^thQoS attribute will yield QoSrc, it represents the relative influence of parameter of row ”r” with respect to the parameter of column ”c”. When 〖QoS〗_rc=k and 〖QoS〗_cr=1/k, where k is Relative Quality Matrix [34]. The comparison matrix representation is as shown in Equation 1.

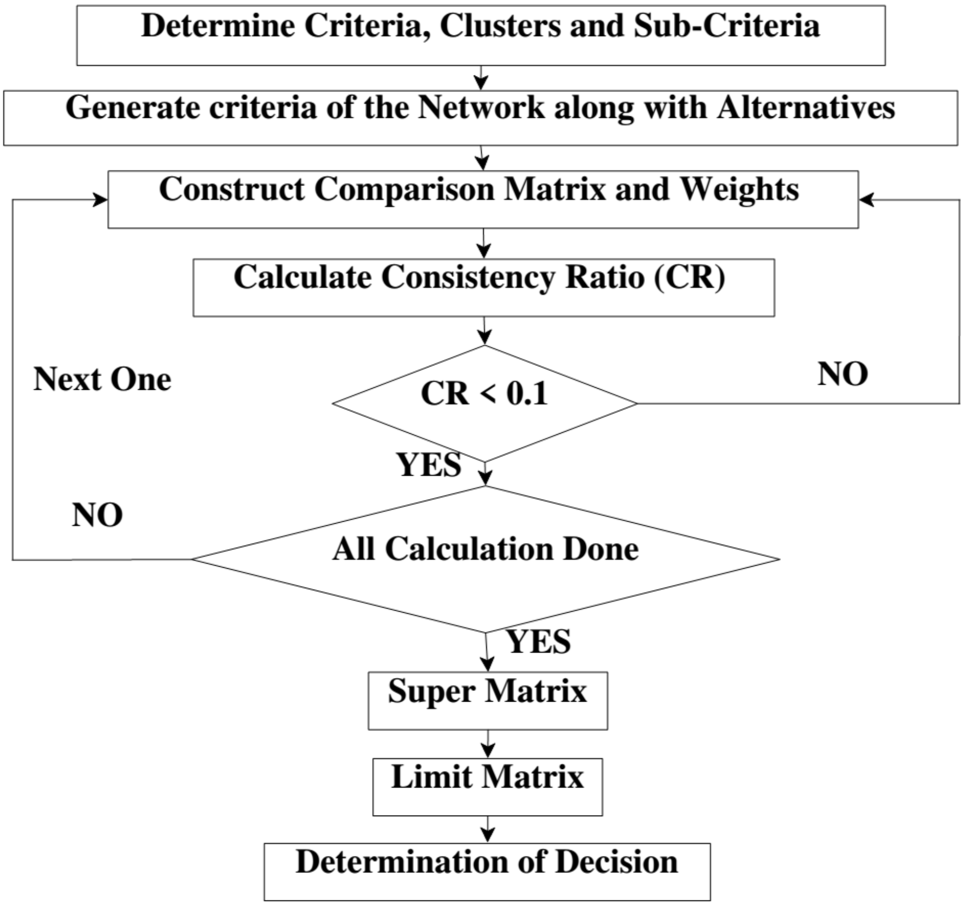

Fig.2. Flow chart of service selection mechanism

<u>Algorithm 1: Proposed Algorithm</u>:

Step 1: Determine Criteria, Clusters and Sub-Criteria
Step 2: Generate criteria of the Network along with Alternatives
Step 3: Construct Comparison Matrix and Weights
3.1 Construct Comparison Matrix
3.2 Calculate Criteria Weight
Step 4: Calculate Consistency Ratio (CR)
Step 5: Check Consistency Ratio
Step 6: Repeat Steps 3 to 5 and calculate criteria weight until Calculation done
Step 7: Super Matrix

7.1 Unweight Super Matrix
7.2 Weighted Super Matrix
Step 8: Limited Matrix

$$QoS = (QoS_{rc})_{nxn} = \begin{matrix} QoS_{11} & \dots & QoS_{1n} \\ \vdots & \vdots & \vdots \\ QoS_{n1} & \dots & QoS_{nn} \end{matrix} where QoS_{rc} = k and QoS_{cr} = \frac{1}{k} \quad \dots.$$
(1)

$$k is Realtive Qualitiy Matrices (Table 1)$$

The comparison matrix of each entry needs to be normalized, and an average of each row gives a priority vector, defined as relative criteria weight. The evaluation of Consistency Ratio (CR) depends on Random Index (RI) [34] and Consistency Index (CI). The values of RI is pre-defined.

$$CR = \frac{CI}{RI} and CI = \frac{\lambda_{max} - n}{n-1}$$

Where λ_max is defined as maximum Eigen values of comparison matrix

If the calculated value of CR is less than 0.1, then it is considered as consistency in pair comparison judgment. Otherwise, the process has to repeat and recalculated for the following points.

- Comparison Criteria (or Cluster or sub Criteria) with respect to Goal.
- Comparison Alternative with respect to Criteria.
- Comparison Criteria with respect to Alternative.

After the evaluation of relative weights (local) from each matrix, construct the super matrix for m Criteria and n alternatives. Then the super matrix size will become S × S, where S = m + n + 1. The filled relative weights entry must match with pair component indexes. To compute the Weighted Super matrix, the Super matrix is transformed to column stochastic. If needed the columns are again normalized to keep summing to 1. Weighted Super matrix should be limited by raising it to a sufficiently large power until it converges into a stable limit matrix. Limited Matrix give priorities of alternatives. The priorities helps to rank best suitable service based on user QoS parameters.

5.1 Applying Workflow of ANP into Proposed Framework

The process of service selection in IoT done at two levels, Abstract service and Atomic or Concrete services.The ”Abstract Service (AS_i)”, is the main service function of IoT.

AS_i = {CS_{i1}, CS_{i2}, CS_{i3},… CS_{im}} $and i \epsilon [1, n]$, $j \epsilon [1, m]$ ….. (2)

And it is made up of collection of ”Concrete Services (⟦CS⟧_ij)” which are of homogeneous functional and different QoS levels in nature. The second service is the Concrete service, also called ”Atomic Service”. It is provided by the active IoT devices.

CS_{ij} = {$QoS(CS_{i1}), Action\ (CS_{ij})$} …..(3)

Where $QoS(CS_{ij})$, is QoS of CS_{ij} and $Action(CS_{ij})$ is functionality of CS_{ij}.

In our case, the QoS attributes of CS_{ij} is made up of collection of QoS attribute of three components of IoT, such as Things (T), Communication (N) and Compute (C). And it is represented as follows.

An enormous variety of sensors are available in the market. And these sensors are selected based on the type of applications and user's requirements. The author has identified 21 different QoS parameters in this regard [17, 18, 19, 20, 21, 22, 23, 13, 24], and the list made as shown in Table 1.

$QoS(CS_{ij}) = \{qosT^{ij}, qosN^{ij}, qosC^{ij}\}$ …. (4)

Where,

$qosT^{ij} = \{qosT_1^{ij}, qosT_2^{ij}, qosT_3^{ij}, \ldots, qosT_k^{ij}\}\ and k\epsilon[1, a]$

$qosN^{ij} = \{qosN_1^{ij}, qosN_2^{ij}, qosN_3^{ij}, \ldots, qosN_l^{ij}\}\ and l\epsilon[1, b]$

$qosC^{ij} = \{qosC_1^{ij}, qosC_2^{ij}, qosC_3^{ij}, \ldots, qosC_o^{ij}\}\ and o\epsilon[1, c]$

6. Service Selection model

SLet $'S'$ be the set of services supported by user' choice and it is represented as

$s\epsilon\{CS_1, CS_2, \ldots, CS_x\}$ …. (5)

Different QoS attributes carried out by services are broadly classified into two categories; Positive attribute (A) & Negative attribute (N). In general a service can be viewed as

$A = \sum_{i=1}^{y} A_i + \coprod_{j=0}^{z} N_j$ …. (6)

Where $A\epsilon\{a_1, a_2, \ldots, a_y\} and N\epsilon\{n_1, n_2, \ldots, n_z\}$

$if E(X-S)^2 = 0$ …. (7)

Then, X = 'S' with probability 1 or X converges to 'S' with probability 1. User wants to get done an application 'S' to a tolerance limit of ∈. Let σx^2 is variability of measurement, according to Chebyshev inequality it is given as,

$P\{X - S| \leq 1 - \frac{\sigma_x^2}{\epsilon^2}$ …. (8)

If $\sigma x$is very much smaller than ∈then observed variable X is between $(S - \in)$ and $(S + \in)$ which is almost certain and one measurement of X is sufficient, otherwise insufficient. To improve the accuracy of the estimate, `$S$` need to take 'n'measurements corresponding to 'n' random variables $\{X_i, = 1, \ldots, n\}$ with mean 'S'and noise random variable W_i given by

$X_i = S + W_i i = 1, \ldots., n$ …. (9)

Average of 'n' random variables represented as

$X^\wedge = \frac{X_1 + X_2 \ldots X_n}{n}$ …. (10)

Where, mean of $X^\wedge$is 'S and variance is n σx^2 and corresponding Chebyshev inequality is given by

$P\{X - S| \leq 1 - \frac{\sigma_x^2}{n\epsilon^2}$ …. (11)

Discrete sequence of random variables represented as $\{X_1, X_2 \ldots, X_M, \ldots\}$ converges to a limiting random variable X, iff, for any $\in > 0$, however for smaller, find a number n0 such that

$|X_N(\xi) - X(\xi)| < \epsilon$ …. (12)

For every $n > n_0$ and every ξ if it is right for variables. A sequence of random variables represented as $\{X_n\}$ converges almost surely to the random variable X, if for every ξ point in the same space M satisfies the following criterion;

$\lim_{x \to \infty} |X_N(\xi) - X(\xi)| < \epsilon \to 0$ …. (13)

With probability 1. This can also be written as

$P(X_n \to X) asn \to \infty$ …. (14)

7. Case Study

The use of IoT devices in the healthcare domain is becoming prominent due to its efficient impact on its usage and results [35]. Nowadays, different types of wearable healthcare devices are available in the market to a suite for the real-time patient health monitoring. In this paper the the author tried to demonstrate the QoS aware flexible service selection in IoT devices using ANP algorithm, especially for ECG monitoring system as a case study purpose. The ECG sensor devices get signals and send them to the cloud through the Internet for continuous monitoring and also for medical assistance in case of emergencies [35]. To show the ability of the proposed framework, the author used online available first-hand data.

7.1 Application of proposed framework and result analysis

As there are several quality metrics available in the current system. It is not viable to collect all for demonstration purposes. Hence, the evaluation of services is on a limited number of quality metrics. Here, it is limited to three and kept these three healthcare services anonymous. In this paper, the three different ECG healthcare services define as CS1, CS2, and CS3, as in Table 2.

Table 2: QoS Parameters

QoSPrameters	Things			Communication			Compute		
	Resolution (μV)	Operating temperature range (ºC)	Accuracy (%)	Jitter (ms)	Delay (ms)	Through put (Mbps)	Price per Month	Response Time (ms)	Availability
CS1	0.3	-45 to +85	±5	20	30	50	127	12.71	99.47
CS2	0.25	-25 to +75	±8	25	35	30	161	11.13	99.84
CS3	0.3	-23 to +60	±8	30	50	60	277	11.19	99.94

Corresponding to these services identified nine QoS attributes: Resolution, Operating temperature range, Accuracy, Jitter, Delay, Throughput, Pricing, Response time, and Availability. And these are represented as C1, C2, C3, C4, C5, C6, C7, C8, and C9 respectively. Based on relative importance the corresponding weights are assigned and is as shown in Table 3.

Table 4: Pairwise Comparison of Criteria of weight

C1	C2	C3	C4	C5	C6	C7	C8	C9

C1	½	1	1/5	½	1/3	3	2	1/3	1/4
C2	1	2	¼	½	1/3	½	1/3	1/4	1/5
C3	4	5	1	2	2	3	3	2	1
C4	3	3	½	1	1	2	3	1	¼
C5	2	2	½	1	1	1	2	1/2	1/3
C6	2	1/3	1/3	1	1/2	1	½	1/2	¼
C7	5	4	1	3	4	4	5	3	1
C8	3	½	1/3	½	1/3	2	1	1/2	1/5
C9	4	3	½	2	1	2	2	1	1/3

Also, the first three criteria (C1, C2, & C3) is related to the Thing component, later three criteria (C4, C5, & C6) is related to the Communication component, and the last three (C7, C8, & C9) is related to Computing.

Table 4: Linguistic Variables for the Ratings

Notation	Value
Very Poor (VP)	1
Poor (P)	2
Medium Poor (MP)	3
Fair (F)	5
Medium Good (MG)	7
Good (G)	9
Very Good (VG)	>9.5

To express ratings for all criteria uses linguistic rating variables as given in Table 4. The arbitrary IoT user specifies the comparative importance of the criteria to each criterion. And correspondingly the Service priorities made are shown as in Table 5.

Table 5: Pairwise Comparison of Criteria of weight

	C1	C2	C3	C4	C5	C6	C7	C8	C9
CS1	VG	G	MP	G	G	MP	F	MP	P
CS2	F	MP	P	F	MP	MP	G	MG	VG
CS3	F	G	MP	P	MP	VG	G	P	MP

Later, the weight of every pair of criteria is measured using a pairwise comparison matrix. The user gave most important relative value to accuracy of the sensing devices because of the healthcare application. And for computing criteria the availability and response time are preferred. The next importance has given to the parameter addressed by the user is a delay of network. Price is a moderately criterion according to the user, while the remaining attributes are the least significant. After the evaluation of these nine attributes, C1, C2, C3, C6, and C9 are found to be the positive parameters while the remaining C4, C5, C7, and C8 are the negative parameters.

Table 6: Weight obtain with respect to Goal and Criteria

Criteria	Relative Weight	CR
C1	0.04400	0.06032
C2	0.06129	
C3	0.19883	
C4	0.08585	
C5	0.11266	
C6	0.05441	
C7	0.06106	
C8	0.12199	
C9	0.25991	

Table 7: Weight Alternative wrt CS1

Criteria	Relative weight	CR
C1	0.17234	0.08203
C2	0.21483	
C3	0.03676	
C4	0.16495	
C5	0.26096	
C6	0.03056	
C7	0.03263	
C8	0.01546	
C9	0.0715	

Table 8: Weight Alternative wrt CS2

Criteria	Relative weight	CR
C1	0.0347	0.04076
C2	0.06126	
C3	0.01985	
C4	0.04481	
C5	0.06503	
C6	0.04481	
C7	0.15352	
C8	0.35436	
C9	0.22166	

Table 9: Weight Alternative wrt CS3

Criteria	Relative weight	CR
C1	0.18701	0.03034
C2	0.08397	

C3	0.04636
C4	0.04858
C5	0.02496
C6	0.33881
C7	0.02496
C8	0.05561
C9	0.18974

The author has used Superdecition version 3.2 tool for evaluating the data and found criteria weight (CR) as 0.06032 as in Table 6. As the CR value is less than 0.1 so it is a consistent pair and can be used further IoT Service Selection processes. The pairwise comparison matrix calculated using criteria with respect to CS1, CS2 and CS3, are 0.04663, 0.04076 and 0.03034 respectively, and which is as shown in Table 7, 8 and 9.

Table 10: Alternatives with respect to Criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9
CS1	0.35294	0.405844	0.27778	0.40541	0.406977	0.35714	0.44498	0.30508	0.3324
CS2	0.29412	0.324675	0.44444	0.32432	0.348837	0.21429	0.35101	0.34839	0.33363
CS3	0.35294	0.269481	0.27778	0.27027	0.244186	0.42857	0.20402	0.34652	0.33397

As CR values are less than 0.1, so it indicates that all weights are consistent. The Weight of alternative with respect to Criteria is shown in Table 10. This table represents services and its corresponding criteria weights.

The Figure 4 (a) represent CS1, CS2, and CS3 services comparative graph with respect to IoT Component Things. From graph it is observed that service CS1 is best suitable for Operating temperature range, and that of service CS2 is for Accuracy, and that of service CS3 best suitable for Resolution services.

Table 11: Weighted Super Matrix

		Thing			Communication			Compute			Alternatives		
	Goal	C1	C2	C3	C4	C5	C6	C7	C8	C9	CS1	CS2	CS3
Goal		0	0	0	0	0	0	0	0	0	0	0	0
C1	0.044	0	0	0	0	0	0	0	0	0	0.17234	0.0347	0.18701
C2	0.06129	0	0	0	0	0	0	0	0	0	0.21483	0.06126	0.08397
C3	0.19883	0	0	0	0	0	0	0	0	0	0.03676	0.01985	0.04636
C4	0.08585	0	0	0	0	0	0	0	0	0	0.16495	0.04481	0.04858

C5	0.11266	0	0	0	0	0	0	0	0	0	0.26096	0.06503	0.02496
C6	0.05441	0	0	0	0	0	0	0	0	0	0.03056	0.04481	0.33881
C7	0.06106	0	0	0	0	0	0	0	0	0	0.03263	0.15352	0.02496
C8	0.12199	0	0	0	0	0	0	0	0	0	0.01546	0.35436	0.05561
C9	0.25991	0	0	0	0	0	0	0	0	0	0.0715	0.22166	0.18974
CS1	0	0.35294	0.40584	0.27778	0.40541	0.40698	0.35714	0.44498	0.30508	0.3324	0	0	0
CS2	0	0.29412	0.32468	0.44444	0.32432	0.34884	0.21429	0.35101	0.34839	0.33363	0	0	0
CS3	0	0.35294	0.26948	0.27778	0.27027	0.24419	0.42857	0.20402	0.34652	0.33397	0	0	0

Figure 4 (b) represents comparative graph with respect to IoT component Communication. The service CS1 is best suitable for Delay, and service CS2 comes with moderate Delay, and service CS3 is best for through put services.

Table 12: Limit Matrix

	All Column*
Goal	
C1	0.0665
C2	0.0623
C3	0.0172
C4	0.0450
C5	0.0620
C6	0.0661
C7	0.0344
C8	0.0682
C9	0.0784
CS1	0.1828
CS2	0.1598
CS3	0.1575

From Figure 5(a) it is observed that service CS1 is best suitable for Price, and service

CS2 is suitable for moderate Price, and similarly service CS3 is best suitable for Response time. And also it is observed that all three services (CS1, CS2, & CS3) has got almost equal weight for Availability. From Figure 5(b) it is come to known that service CS1 is best for Price, service CS2 is best for Accuracy, service CS3 is best for Through put. Comparatively price of CS1 is very low with other service and CS1 Accuracy equals with that of service CS2.

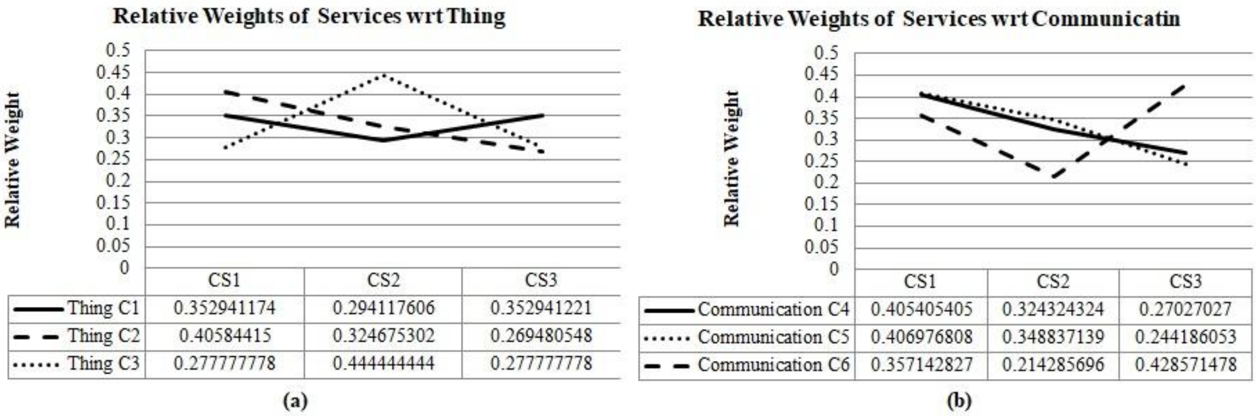

Fig.4. Relative Weight of Service with respect to (a) Things and (b) Communication

Weighted super matrix which represent collection of individual relative weights, comparable with each other as shown in Table 11.Weighted super matrix powered with arbitrary k + 1, to construct a limit matrix as shown in Table 12. From the limit matrix for service CS1, CS2 and CS3 the final weights are measured as 0.182754, 0.159777 and 0.157469 respectively.

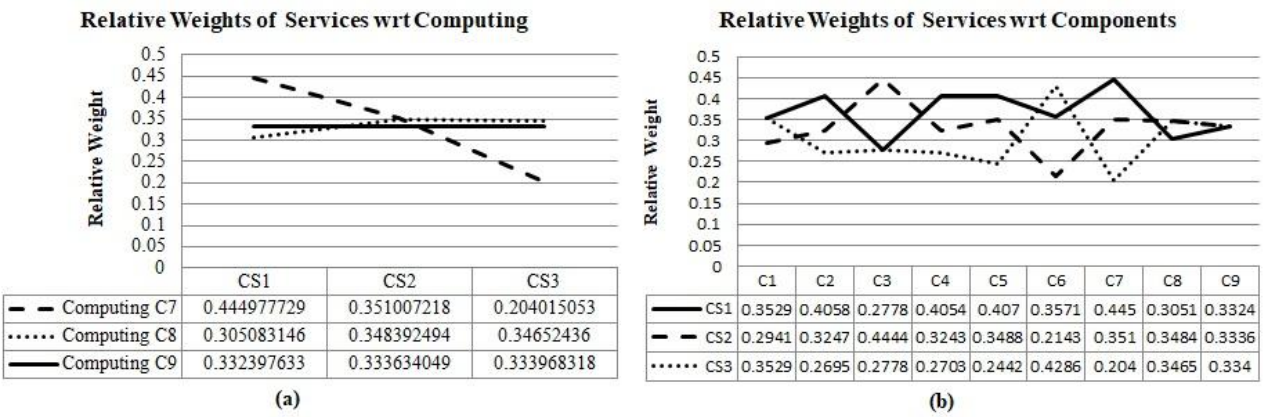

Fig.5. Relative Weight of Service with respect to (a) Computing and (b) Component

As per AHP algorithm the service CS2 is ranked first, but in case of ANP, the service CS1 ranked first even though it has only one best value C7 out of top three Goal criteria i.e.,C9, C3 and C7 even CS1 has comparatively high weights with other services. Based on weight the ranking of services are made as shown in Table 13. In this way a best suitable service can be made available to user.

Table 13: Ranking Matrix

Service	Weight	Rank
CS1	0.182754	1
CS2	0.159777	2
CS3	0.157469	3

8. Conclusion

IoT services are in high demand, making it a route for a Businessman to present multiple Services for users to seduce as their clients. In our observation, making flexible services per user's preferences is more complex, but this can be solved with the help of QoS. The author designed a flexible service selection framework based on IoT basic architecture and defined essential components are Things, Communication, and Computing. Identified 48 QoSattributes considering these components. Also demonstrated how a framework selects services considering QoS using ANP.

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