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Multi-Criterion Decision Making for Wireless Communication Technologies Adoption in IoT

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ABSTRACT

There is an unprecedented growth of internet and internet-based technologies in the recent times. We are now switching to 5G as the most recent wireless communication technology. The internet of things has become a blessing for Industry 4.0 by challenging all the existing technologies in its utility for contributing to the industrial growth. There are a lot of wireless communication technologies for IoT, and it becomes difficult choice to select one suitable for an application. Authors have presented multi-criteria decision-making techniques which are very instrumental in making a confirmed decision on the choice of appropriate technology. This choice is done based on a number of deciding parameter which are used to differentiate between all the available options. The authors have identified 11 wireless communication technologies and seven parameters to evaluate the performance of the WCT's. All the seven parameters are considered in ranking and rank matrix is obtained. This technique can be very helpful for application designers so as to choose the right platform for their applications.

KEYWORDS

Absolute Rank, Hasse Average Rank, Internet of Things, Multi-Criterion Decision Making, Simple Additive Ranking, Wireless Communication Technologies

INTRODUCTION

In this era of technological advancement, we are facing massive disruption in all domains of our existing Industrial setup. Lampropoulos *et al.* (2019) explored that there is a lot of quest for the changes next industrial revolution, Industry 4.0 is going to have on our current state of practice. The most significant change that we have already started facing is role of internet and omnipresence of

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human reach due to it. Internet of Things (IoT) has started expanding its wings in all spheres of Human Technological progression. There has been a wide acceptance of IoT driven technology in the recent past, as instanced by Alam (2018), there will be 75.44 billion connected devices by the year 2021. The internet has expanded its wings and is now collaborating with data science and artificial intelligence to make our machines even smarter and talking to us all the time. It is a new era of thinking about smart machines and smarter technologies. The world is changing the dimensions of communication through use of IoT and smarter technologies. There are various wireless technologies available for communication in IoT and even newer technologies are evolving with changing needs of the market. Each of the technology has inherent advantages and limitations. There are various factors that impact the use of one technology over the other in terms of security, availability, applicability, reliability etc. It becomes a very complex task to take a decision on adoption of one technology over other as all technologies are competing with each other on their specific advantages to support the applications. In this paper the authors have presented a multi criterion decision making approach based on Hasse diagrams presented by Mao (2010) and Voigt *et al.* (2006), absolute reference discussed in research work of Keller *et al.* (1991), Hendriks *et al.* (1992) and average ranking techniques explored by Lewis *et al.* (1992) to select the best Wireless Communication Technology (WCT) from available options. This approach may be very instrumental for taking into account the impact of each of the contributing factors for choosing the right technology.

LITERATURE REVIEW

WCT has been the most widely used media for communication in the recent times replacing the old wired communication systems which suffered from the basic limitation to reach the remote areas. Gomez *et al*. (2010) explored various wireless various home automation protocols and architectures. Hussain *et al.* (2017) in their work identified the internet of things building blocks. Johari (2015) has discussed the various protocols for IoT communication. Garcia *et al*. (2018) concluded that popular Wireless options including WiFi, ZigBee, Bluetooth, WiMax, Z wave, NFC have grown as acceptable solutions to the IoT based communication requirements of current Smart City initiatives. Ramadan & Altamimi (2017) have used IoT wireless networks for a case study of disease production and the efficiency lies on how network forwards and interprets data. Waleed *et al.* (2016) discuss about the scope and opportunities of wireless 5G technologies in the Internet of Things and highlight the need of security in the Internet of Things as a major stakeholder to establish trust in adoption of wireless 5G networks. Pau *et al.* (2018) in their work summed up various available options for the wireless domain to cater to the needs of IoT. Authors summed up that every application domain needs specific requirements relating to the range, throughput, power consumption, and network topology. Besides, further considerations include the cost, ease of integration, and security. In Dhanda *et al.* (2019), the authors state that the outcome of a reliable communication broadly depends on the availability and reliability of the IoT application. The requirements pertaining to scalability and heterogeneity stage striking challenges to the research community. Mobility maintenance, packet delay and signal load are the primary attributes that inhibit reliable communication and affect the quality of service parameters in IoT. This paper presents the various types of wireless technologies available for the IoT and discusses the open challenges and research issues in IoT. Salman *et al.* (2017) in their research gave a brief overview of all the protocols available for IoT communication. A similar paper by Krejci *et al.* (2017) provides a comparative analysis to the developers, designers and the service felicitates with options for various layers of protocols specific for IOT and criteria's of how to choose between them. In Sabaei *et al.* (2015) the authors have made a comprehensive effort to identify the decision making in an environment where multiple attributes are required to be taken into consideration for decision making. Galli (2019) gave a system engineering approach to decision making using 17 evaluation criteria and gave some newer techniques to make a better decision in multiple parameters affecting the final outcome. Koksalan *et al.* (2011) presented a detailed analytical introduction to

Multi Criteria decision (MCDM) making and its advantages. Jha *et al.* (2012) presents an overview and future directions for component selection in designing fault tolerant modular software systems . Dutta (2017) used a fuzzy approach for decision making in disease diagnosis. Naugle *et al.* (2019) presented a systems dynamics approach for rational decision making under the influence of various contributing parameters. Jha *et al.*(2014) gave framework on MCDM for optimal component selection based on cohesion and coupling for component based Software System.Kumar *et al.* (2016) explored the utility of multi criteria decision making (MCDM) for renewable energy. Shukla *et al.* (2019) have used a grey scale approach for efficient decision making in for sustainable development in marble industry. Different MCDM methods, their applications, strength and weaknesses have been discussed in the paper. The methods discussed include customized weighted sum method, a weighted product technique, analytical hierarchy process (AHP), elimination with choice translating reality, a Technique for creating preference of order by similarity of ideal solutions. There are many more such methods which define a solution for finding the best available solution to a decision making problem. Bali and Madan (2015) presented a study called TOPVEC Framework of critical success factors in COTS based software development Patil *et al.* (2004) presented the concept of partial ordered sets and linear extensions to make a decision of choice between multiple indicators. Voigt *et al.* (2006) evaluated multiple decision making indicators using Hasse Diagram Techniques (HDT) which originates from discrete mathematics. In Carlsen (2009), Tsonkova *et al.* (2015) and Carlsen (2015), the authors have presented how Hasse diagrams, partial order ranking techniques and the linear extensions can be given an equal opportunity to all the attributes making a decision be represented in an unbiased manner and allowing the decision in such an environment be made with consideration of all the present attributes. From the review of existing literature it may be enumerated that there is a wide range of wireless communication technologies available in today's scenario, these technologies may be applicable even to a single application in IoT, Carlson (2019),(2015) emphasized that we need to device a mechanism to choose between these existing technologies, linear extensions and total order ranking is very efficient technique to identify and rank these technologies for a particular application based on its requirements.

DIFFERENT IOT WIRELESS COMMUNICATION TECHNIQUES (WCT)

In the current era a number of wireless technologies at data link layer exist for the application designers and each of these technologies have their own specific attributes that make them suitable for use and attract the application designers. The major advantage of WCT includes no use of guiding cables, dependability, security, safety and many more. The various technologies adopted for Wireless Communication in IoT devices have been discussed by Salman *et al. (*2017), Alsharif *et al.* (2019), Kogias *et al.* (2019), Wang *et al.* (2018), Huynh *et al.* (2017) and Ghamari *et al.* (2015) in their respective research work. Authors have considered following 11 WCT's for selection of most suitable IoT communication based applications.

WiFi

Wireless Fidelity also called as Wifi is one of the widely used wireless technologies for connecting the electronic devices in wireless area networks (WAN). The Wifi technologies is based on IEEE 802.11standard that has an operational band in the range of 2.4 Ghz to 5 Ghz. This is an unlicensed band available worldwide for such usage, Anani *et al.* (2019). Due to the availability of high bandwidth, Wifi is capable of providing high data transfer rates in IoT Devices but it suffers from a limitation of higher power consumption compared to its competitor technologies.

Bluetooth

This is based on the IEEE 802.15.1 standard. It is employed for short range communication between static as well as mobile devices in a personal area network (PAN). It employs a low cost transceiver microchip and utilizes the band of 2.4 Ghz. The Bluetooth technology also shares the common free license zone with other technologies, Dhanda (2019). Bluetooth 5 delivers four variants of data rates in order to cater to a variety of transmission ranges: 2 Mbps, 1 Mbps, 500 kbps, and 125 kbps in Bluetooth version 5.0.

Bluetooth Low Energy (BLE)

It is also called Bluetooth smart and was introduced in Bluetooth version 4.0. This technology is targeted towards the applications relying on lower power consumption, BLE provides a lower data throughput of 1Mbps utilizing GFSK modulation scheme. Occasionally BLE's max data throughput of 1Mbps may not be suit the products which need a continuous streaming of data like wireless headphones, while other IoT applications only need to send small bits of data periodically.

Z Wave

This wireless technology generally finds its application in home automation. Z-wave technology enables devices "mesh" together with each other by sending signals over low-energy radio waves on a dedicated frequency for transmission. Every Z-wave device possesses a small built-in signal repeater that sends and receives network information. Z wave offers better signal transfer and reception compared to its competing technologies due to repeaters present in each device in the network and making the network even stronger.

Near Field Communication (NFC)

This is a very short range (less than 10 cm) communication protocol. Generally used in applications like contactless payments including credit cards, smart cards, e ticketing etc, Sethi (2017). This distance limit ensures much safer communication among devices while it needs more time as the devices are needed to be moved physically in close proximity to make a communication or transaction possible.

Zigbee

This is a low power, low data rate transmission technique usually finds in applications where we need to have interoperability between devices which are from different manufacturers. Zigbee is an open source protocol and all the manufacturers may use it in their applications, Sethi (2017). Zigbee is based on IEEE 802.15.4 standard. It uses three unlicensed bands for communication.

ANT

It is an ultra- low power transmission protocol. The device using this technology can run on a coin cell for years of operation. This is a self adaptive technology which is capable of making quick meshes. It required a low cost design and operates with a single chip.

DASH7

This is recent wireless communication protocol that is primarily used in active RFID devices, generally functions in globally accessible industrial scientific medical band. Ayoub *et al.* (2018) stated that it has been specifically targeted for scalable and long-range outdoor implementation having much better data rates than the popular ZigBee. This is an affordable protocol that enforces encryption and implements IPv6 addressing. It targets bursty, light weighted, asynchronous and on the move traffic and hence typically suits IoT applications.

Home Plug

Home plug greenphy was developed by home plug powerline alliance and generally employed in home automation. This WCT has been primarily focussed on reducing the power consumption and affordability of HomePlug-AV additionally providing its reliability, availability, coverage and interoperability. It supports a power-save operational profile that permits the nodes to sleep by synchronizing their respective sleep time and waking them up whenever needed.

EnOcean

EnOcean is a wireless communication technology with prime focus on energy conservation, it is very often implemented in automation based applications, yet has potential to be utilized for other IoT applications. The fundamental approach is to harvest motion or any other type of environmental energy efficiently and then convert it to any form of usable energy by employing specific transducers. EnOcean protocol provides small packet size and is employed purposes including cooling, ventilation, and heat based IoT applications.

LoRaWAN

LoRaWAN is a recently introduced long-range protocol for application in wide-area networks. This particular WCT has been purposely designed to support IoT applications enabling power economy, affordability, dynamics, reliability, and duplex communication requirements. It is designed for wireless networks that can be scaled to a capacity of millions of devices, Poursafar (2017). It enables redundant operation, power optimization, affordable, mobile, and energy procuring systems to shape the upcoming requirements of IoT along with supporting the mobility and easy to use features.

Table 1 shows the technical specifications of the various wireless communication technologies used in the modern day Internet of Things (IoT) applications.

WCT SELECTION CRITERIA

There are a number of criteria's which need to be taken into account for selecting a particular wireless communication technology for a specific application. The various technologies have been compared on their key performance attributes by Lee *et al.* (2007). Kondratenko *et al.* (2018) has proposed several parameters to select a particular technology over other for WCT's. Elfouly et al. (2017) have insisted that for an efficient WSN energy consumption is one of the most important parameter along with other parameters. Several technologies may appear to suit a particular application but we need to analyze each of these technologies on some specific attributes and then come on a decision of selecting a particular WCT. The various specific attributes to be taken into consideration are:

Table 1. Various popular IOT Wireless Technologies in use

WCT Technology	Range	Data Rate	Frequency
WiFi	100 Mts	54 Mbps	2.4 Ghz and 5 Ghz
Bluetooth	10 Mts	24 Mbps	2.4 Ghz
Bluetooth Low Energy	8-10 Mts	1 Mbps	2.4 Ghz
Z Wave	30 Mts	100 Kbps	900 Mhz
Near Field Communication	Upto 10 cm	424 Kbps	13.56 Mhz
Zigbee	100-1500 Mts	250 Kbps	868 Mhz, 915 Mhz, 2.4 Ghz
ANT	30 Mts	60 Kbps	2.4 Ghz
DASH7	1-2 Kms	200 Kbps	868 Mhz, 915 Mhz
Home Plug	200 Mts	200 Mbps	4.5-21 Mhz
EnOcean	300 Mts	125 Kbps	315 MHz, 868 Mhz, 900 Mhz
LoRaWAN	< 30 Kms	.3-50 Kbps	868 Mhz, 900 Mhz

1. **Reliability:** Reliable data transfer has a direct impact on the user transfer and the battery life of the device. If there is a situation of undeliverable packet to the destination due to reasons including interference from adjacent channels, deliberate frequency jamming etc. then the transmitter keeps on trying to deliver the packet till it it delivered on the expense of battery.
2. **Security:** WEP and WPA2 are the standards being in force to ensure the security of data on wireless networks. Some of the hardware equipments find it difficult to adopt WPA2 without firmware updation.
3. **Range:** Higher transmission power enables better range due to high signal to power ratio of transmission. Regulatory bodies control the maximum power output in the license free 2.4 GHz ISM band.D
4. **Data Rate:** IoT sensor devices generally transfer periodic data to the central controller. This minimizes the power consumption. Bandwidth requirement are typically modest here.
5. **Signal Latency:** Latency related to the time lapsed between transmission of signal and the reception of signal. Though this lies in the range of milliseconds but becomes very crucial in some of the IoT applications.
6. **Power Transfer:** Various technologies differ from each other in terms of distance to which power can be propagated by them.
7. **Topology:** In the current scenario the existing WCTs broadly support four different types of topologies to serve different applications which include peer to peer, broadcast, star and scanning.

SELECTION OF THE MOST SUITABLE IOT WCT

We have a number of WCTs available and need to give due weightage to a number of evaluation parameters while analyzing the suitable WCT for any application. In our work we have used a noble multi criteria decision making technique for finding out the most suitable WCT. This method demonstrated Juneja *et al.* (2019) takes into account the significance of all the contributing attributes in the selection of a WCT. We have used Simple Additive ranking, Hasse Diagrams presented by Mao (2010) and Voigt *et al.* (2006), Carlsen (2009) and Carlsen (2015) and Absolute reference mentioned by Keller *et al.* (1991) and Hendriks *et al.* (1992) for ranking the WCTs for suitability of a particular application.

Simple Additive Ranking (SAR)

SAR technique provides ranking to the objects taking into account each criterion separately and subsequently ranks the succeeding aggregation of the weighted ranks using the arithmetic mean. Ranking r_{ij} of *i*-th element corresponding to the *j*-th parameter is calculated, the corresponding index value is generated by Equation 1:

$$s_i = \frac{\sum_{j=1}^{P} w_j \cdot r_{ij}}{n} \tag{1}$$

Then this value is normalized using Equation 2:

$$S_i' = \frac{S_i - 1/n}{1 - 1/n} \tag{2}$$

Hasse Diagram

Hasse diagrams visualize the order of relation between the partial order sets (poset). Two objects a and b of a poset are ordered if all attributes of a are less than or greater than that of b. Hasse diagrams consists of a directed graph which consists of a set E of objects drawn as circles, circles at the top of the graph are the best objects to suit a ranking criteria and the ones at the bottom are least suited. These objects have no predecessors and are called as maximal points. A line between two objects in the Hasse diagram represents that two objects under consideration are related.

Partial Order Sets (POSET)

The partial order creates a ranking relation between several elements simultaneously considering multiple parameters of the elements. Two elements are said to be comparable if all attributes of one element (a1) are less than or equal to or more than the corresponding attributes of the other (a2). If the element a1 has 3 attributes (4, 6, 8) and element a2 has three similar attributes with values (1, 2, 3). Figure 1 shows attributes A1, A2 and A3 of two elements a1 and a2. It is very clear from Figure 1 that a1>a2 as all attributes of a1 are greater than that of a2.

Figure 2 shows that element a1 is bigger than element a2 with the help of a Hasse Diagram. But if for the elements a3 (3, 5, 4) and a4 (2, 4, 7), we try to create an order then these two elements become incomparable due to their incomparable attribute combinations. So in order to sequence these elements a1, a2, a3 and a4, we create a partial order also called a poset. The most crucial factor in sequencing a poset is the number of comparisons which may be actuated. It is expected to gather as much comparisons as feasible as each present incomparability of the poset represents one corresponding indetermination. The comparison that may be realized is dependent on number of attributes which are needed to be taken into consideration for the purpose of creating order. On addition of new attributes to the poset, there will be a decrease in the comparisons this leads to increase in the degree of indetermination. In poset having a considerably huge number of elements

Figure 1. Attributes A1, A2 and A3

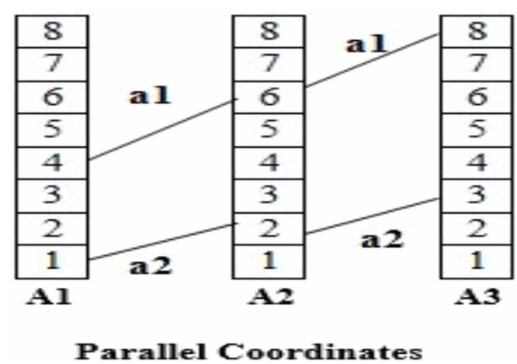
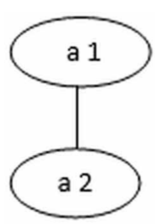


Figure 2. Hasse diagram for element a1and a2



and uncorrelated attributes, the quantum of comparisons shrink to half whenever an attribute is added as stated by Lebanon *et al.* (2002), Peter *et al*. (2003) and Restrepo *et al.* (2006), they have used the same concept in ranking posets in their respective research.

Average Rank and Total Order

Average rank determination can be realized through the use of the local partial order. Average Ranking is done through an empirical relation relying on linear extensions of partial order. Linear extension is typically prediction of partial order spawning a total order that conforms for all relations present in partial order. Therefore, from a partial order ranking it is feasible to estimate linear extensions, and correspondingly evaluate an average ranking of each element based on its ranking frequencies for all linear extensions. Consequently, the averaged rank of the element x can be valued by using the following formula presented by Bruggemann *et al*. (2004) and Bruggemann *et a*l. (2011):

$$Rk_{(av)} = (S+1)*(N+1)/(N+1-U) \quad (3)$$

where S is the aggregate number of descendants of the element x, N is the number of elements (of the residual quotient set), and U is the range of elements incomparable with x.

Absolute Reference

The absolute reference presented in their work by Keller *et al.* (1991) and Hendriks *et al.* (1992) measures the displacement between each element into consideration and corresponding element of reference, which represents overall optimum of all the criteria taken into consideration. In absolute reference, we need the characterisation of the values and conditions of optimum, i.e. for each criterion it is necessary to unambiguously establish not only whether the best condition is fulfilled with a minimum value or a maximum value of the criterion, moreover the specific optimum values. Each criterion first prerequisites to be normalized and weighed to account for its significance. After opting the distance measure, the method calculates the overall N distances among elements under consideration and the reference element. Here Euclidean distance is used, distance of i-th element from the reference element (i*) is defined with Equation 4:

$$d_{ii}* = \sqrt{\sum_{r=1}^{R} \left(y_{if} - y_{i*r}\right)^2 \cdot W_r} \quad (4)$$

Corresponding to every element a representation of its similarity compared to the set reference element is worked out with the help of the Euclidean distance incorporating the following expression:

$$S_i = 1 - d_{ii}* \text{ where } 0 \leq S_i \leq 1 \quad (5)$$

This degree of similarity is used for ranking of the elements. It ranges from 0 (if there is no similarity between the considered element and the reference element) and 1 (if there occurs thorough resemblance amongst the considered element and the reference element).

CASE STUDY OF MULTI CRITERIA SELECTION OF WCT

The wireless communication technologies identified in the Section 3 above are among the most commonly employed media for communication in the IoT based devices. We have taken the criteria mentioned in Section 4 above as the key attributes for any of the wireless communication technology for IoT to create a rank matrix. The process adopted by us in our research work has been represented by Figure 3.

We have used partial order, average ranking and linear extensions for ranking the WCT. Here we have considered the identified attributes to make a decision. The attributes are represented by literal P as Reliability(P1), Security(P2), Range(P3), Data Rate(P4), Signal Latency(P5), Power Tranfer(P6), Topology(P7) have been evaluated as a case study for all the prevalent IoT WCT's which are represented by the literal Q as Wifi(Q1), Bluetooth(Q2), Bluetooth Low Energy(Q3),Z wave(Q4), Near Field Communication(Q5), Zigbee(Q6), ANT(Q7), DASH7(Q8), Home Plug(Q9), EnOcean(Q10), LoRaWAN(Q11). We have rated these 7 attributes on a scale of 0 to 9 for an IoT application for all the available WCT's as shown in Table 2. As similar type of approach was followed by considered by Kondratenko *et al*. (2018) in their work on selecting the ranking parameters.

RESULTS

The above-mentioned ranking criteria's namely Simple Average Ranking (SAR), Hasse Average Ranking (HAR) and Absolute Reference (AR) have been applied on all the available techniques in Table 2 based on the seven evaluation parameters. The ranking of these models for the three ranking methods is given in Table 3. The models have been ranked based on absolute ranking in this table. It is evident from the ranking table that all the three methods are giving different ranking to different WCTs due to their inherent evaluation technique. Here Simple additive ranking provides a basic ranking focused on weighing each criterion, Hasse average ranking uses posets and average ranking to find the ranking and is able to identify the three levels of ranks that may be assigned to different WCT's.

Figure 3. Process of Identifying the most suitable WCT for IoT Application

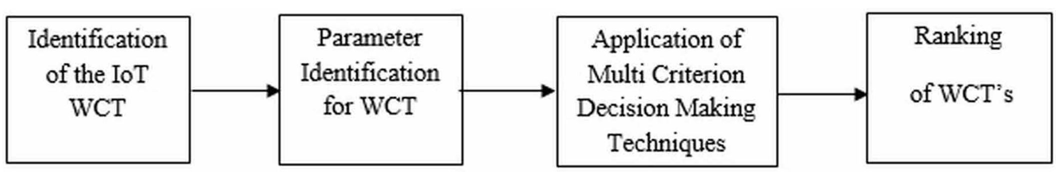


Table 2. WCT's and attribute weights

WCT/Att.	P1	P2	P3	P4	P5	P6	P7
Q1	7	9	4	3	5	6	5
Q2	4	4	7	9	4	8	6
Q3	5	4	2	4	8	8	4
Q4	8	9	7	8	6	7	5
Q5	3	4	8	7	9	5	6
Q6	1	5	6	6	6	4	3
Q7	7	3	8	7	7	8	4
Q8	9	2	9	3	2	5	8
Q9	5	6	8	3	4	4	1
Q10	7	8	4	8	2	5	6
Q11	4	4	8	4	6	3	7

Table 3. Ranking of WCT's with multiple ranking techniques sorted by absolute reference

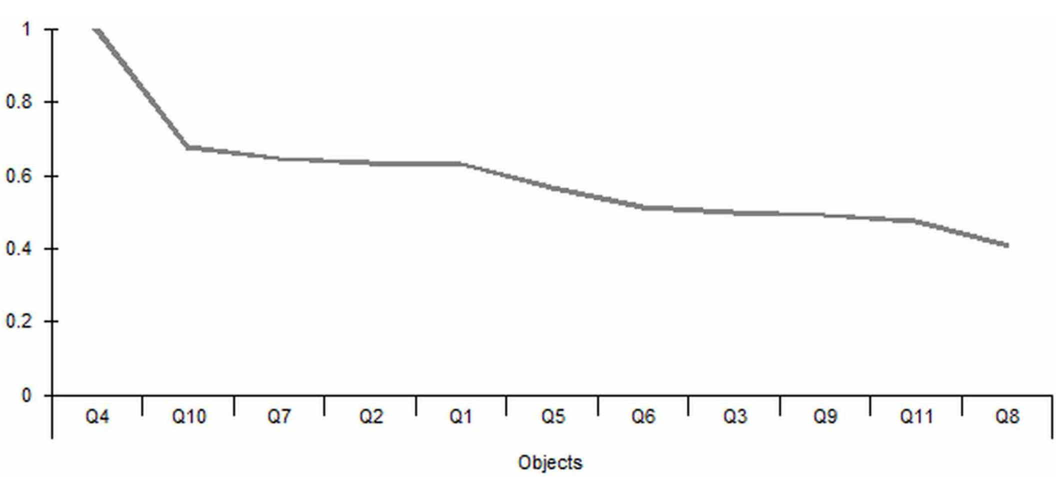
Rank	WCT	SAR	HAR	Absolute Reference
1	Q4	0.700	0.800	1.000
2	Q10	0.528	0.500	0.678
3	Q7	0.585	0.500	0.646
4	Q2	0.542	0.500	0.635
5	Q1	0.485	0.300	0.631
6	Q5	0.557	0.500	0.567
7	Q6	0.314	0.300	0.512
8	Q3	0.485	0.500	0.500
9	Q9	0.328	0.500	0.492
10	Q11	0.471	0.500	0.473
11	Q8	0.499	0.500	0.407

While the absolute reference calculates the final ranking based on the euclidean distance from the mean value for different decision parameters. The final ranking of various wireless communication technologies based on Absolute rankings represented by Figure 4. The WCT Q4 i.e. Z wave ranks the best WCT's as per the weightage given to its various attributes.

CONCLUSION

We have evaluated the available wireless techniques for random application environments and used 7 parameters to decide on the choice of a particular WCT among options for implementation of a particular Internet of Things (IoT) application. This approach may be applied to make an informed decision on the selection of an appropriate technology based on various attributes which are inherent requirement for the implementation of any application. Various attributes which are required for any wireless communication technology to be implemented have some of the matching parameters as

Figure 4. Absolute ranking of various technologies based on 7 attributes



shown in Table 1, in such situation the methodology proposed in this research would be helpful for finding out the actual ranking of the various technologies in terms of the user need set for a particular IoT application. Three multi criteria decision making techniques have been explored here. All the techniques consider the participation of some quantum of the deciding parameters in their ranking of the Wireless Communication Technologies. The Hasse Average ranking technique used here typically is a discrete mathematics approach to rank using graphical structures and give equal weightage to each participating object in the comparisons and draw a relation of hierarchy among various objects under comparison having multiple attributes to compare at the same time. These techniques can be very instrumental in making a resolution on evolution of WCT's for the selection of the applications of Internet of Things. As IoT is an emerging field and there is a lot of effort being made to come out with a standard set of protocol to leverage the technology, in such scenario this methodology may provide more trust to the application designers while making a choice on the WCT. The methods explored in this research work may be used in drawing inferences for making other such crucial decisions where multiple criteria decision making is required and it is very critical to ignore any of the attribute parameters.

Through this work the authors have proposed a methodology which can be used for WCT adoption in IoT still there may be some limitations which can influence these decisions. The priorities assigned by experts to different parameters for different WCT's may be biased due to various technological, financial and personal factors. This may finally lead to selection of inappropriate WCT for the wireless applications. So we need a rational allocation of priorities to various attributes for this. There is a need for standardization of rating for various comparison parameters. One more improvisation that can be added as a future dimensional extension in the current proposed methodology is ranking by weights. We can assign weights to various criteria and allocate them priority while ranking which will make the selection of WCT even more rational. Higher weights may be assigned to those parameters which have major role in the performance measurement and feasibility of the IoT application and lower to those whose role is limited compared to the others.

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