Internet of Things framework development using Fuzzy approach

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Abstract: Given the increasing usage of the Internet of Things (IoT) based services in all industries, integration and knowledge sharing between different scopes have valuable outputs and improve the competition in the ecosystem. So having a unique framework aids companies to increase their service value, decrease implementation cost, and as a result increase their earnings. Lack of integrated framework or best practices could yield to silo based activities that does not present the value of industrial IoT technology. This diversity may cause severe impact on both expected business value added services and platforms' security threats as well. So, in this study based on an in-depth review and the research results done in the IoT scope by international groups like OneM2M and IEEE P2413, four factors namely, knowledge creation, determination of service type, quality of services, and securing data transmission of users were identified and mapped to corresponding layers. These factors were adapted in Telecommunication industry that could increase the market share via IoT utilization. Then, using a hybrid quantitative approach, namely Fuzzy Decision Making and Trial Evaluation Laboratory (FDEMATEL) and Fuzzy Analytic Network Process (FANP) techniques, known as FDANP the importance and weight of each aforementioned factors in building the adapted framework was determined. The result of the analysis shows that the most important factor is "service type" and the most influential factor is "knowledge creation" whereas "quality of service" factor is the most permeable factors.

Keywords: Internet of Things (IoT), Telecommunication Companies, Information Technology (IT), Fuzzy theory, FDANP.

1. Introduction

In the ever- evolving environment of international business one of the most important technological trends is the Internet of Things (IoTs). IoTs, can be considered as a scenario in which all potential objects are equipped with unique identifiers that enable the ability to transfer data over a network without human-to-human or human-to-computer interaction (Valmohammadi, 2016). As 3G was developed from 2001, it has become relatively easy to have a machine or sensor communicate over data cellular network. Analysts put devices into two categories based on their traffic transmitted, data or voice. The first group also is called M2M or Machine to Machine. Deloitte Institute declared that IoT hardware and connectivity revenues are growing at about 10‐20 percent annually, while IoT applications and analytics services are growing even more rapidly at 40‐50 percent. Also 60 percent of all IoT devices are used by enterprises and industries, so over 90 percent of IoT services' revenue is generated by enterprise, not the end users. IoT, uses the concept of connectivity with simple and available technology. The real change is ability to engage the customers. Information about IoT devices are actually useful for manufacturing. This flow of information generated by each device, worth hundreds of dollars, and guide companies to adjust their products or services (Barker & Lee, 2015). IoT included various domain and services from smart homes, e-health, transportation, cloud computing and big data, smart cities, wearable sensors, and privacy and security concerns to social and industrial IoT (Logvinov, 2014).

Based on a Google trend report, we've had a paradigm shift in increasing interest to IoT based devices since 2014. Also Intel predicts to have more than 50 billion of connected devices in 2020. Ericson claims that 25 percent annual growth rate up to 2021 with the focusing on low latency LTE-based telecommunication network (Ericson Co., 2015). The rise of the Internet of Things, represents a massive opportunity for telecommunication companies. They are quickly advancing from a day in which there were two or three touch points in the home such as telephone or internet, to potentially dozens of devices. End users, government, industrial companies and SMB (small medium Business) need a unified management platform for the emerging smart devices, in order to be used at their full potential (Dhar, 2014).

In the present paper, different strategies are analyzed which telecommunication companies could choose in regards to quick growth of IoT services and markets. So at first, we take a look at the historical background of IoT solutions. In the next section, challenges of implementation of IoT services and benefits of union framework across multiple domains are discussed. And with analytical Fuzzy methods usage, the position of telecommunication companies in IoT union framework is introduced. The research findings are reviewed with the aid of 12 telecommunication experts in one of Iranian 4G Telecommunication Company.

2. Research background of IoT

In this section, the brief history of technology evolution for the Internet of Things is described. Many devices and sensors have been able to communicate with each other through wires such as SCADA industrial systems. An electromagnetic telegraph was invented by Baron Schilling in Russia, and in 1833 Carl Friedrich Gauss and Wilhelm Weber invented a code to rapport over a distance of 1200 m within Göttingen, Germany (Huurdeman, 2003). Samuel Morse sent the first Morse code public telegraph message in 1844 (Burns, 2004).

In 1926 Nikola Tesla in an interview with Colliers magazine announced that when wireless is soundly applied, the whole world will be changed into a huge brain, which indeed it means all things being particles of a real and rhythmic whole (Tesla, 1926). Also in 1950 Alan Turing argued that It can also be said that it is very good to provide a machine with the best sense organs and then through teaching to it provide the necessary basis for it to understand and speak English (Turing, 1950).

After launching ARPANET and TCP/IP protocols and introducing World Wide Web in 1989, John Romkey created the first Internet ‘device’. A toaster that could be turned on or off over the Internet. In 1991, Mark Weiser's Scientific American article on ubiquitous computing called ‘The Computer for the 21st Century’ is written and described that "The most profound technologies are those that disappear. They weave themselves into the fabric of daily life until they are indistinguishable from it (Weiser, 1991). Quentin Stafford and Paul Jardetzky invented the Trojan Room Coffee Pot in the 'Trojan Room' within the Computer Laboratory of the University of Cambridge. It was used to monitor the pot levels and sent the result to the buildings server in 1993 (Stafford, 1995).

In 1998, InTouch project was developed by MIT, which applies to Synchronized Distributed Physical Objects for creating a tangible telephone for long distance communication (Brave et al., 1998). First, the Internet of Things term is announced by Kevin Ashton executive director of the Auto-ID Center in 1999. It linked the idea of RFID in P&G's supply chain to the then-red-hot topic on the Internet (Ashton, 2009). In 2005, The IoT hit another level when the International Telecommunications Union (ITU) published its first report on the IoT topic (ITU, 2005).

In 2008, a group of companies launched the IPSO Alliance to promote the use of Internet Protocol (IP) in networks of "smart objects". In 2011, with introducing IPV6 in public, IPV6 addresses could be assigned on every device. In other hand, many companies like Cisco, IBM, Ericson also telecommunication companies like AT&T and Telefonica produced educational and marketing initiatives on the IoT topic. In 2012, OneM2M is developed for finding technical specifications of IoT which addresses the need for a common M2M Service Layer that can be readily embedded within various hardware and software. OneM2M group has more than 200 members all over the world (OneM2M, 2015).IEEE P2413 working group defined a high level architectural framework for the Internet of Things (IoT) in 2014. Descriptions of various IoT domains and identification of commonalities between different IoT domains are focused by P2413 (Logvinov, 2014).As it could be found, union thinking of internet of things has been increased in recent years, so platform standardization is focused on the next sections of this paper.

3. IoT challenges and solutions

Delivering IoT based services encounter some obstacles that should be discovered and analyzed. The enormous number of connected devices and huge amount of data, creates challenges, particularly in the areas of security and data storage. Network service providers or tele-communication companies must determine what to do with the enormous amounts of data generated by IoT devices. The problem becomes clearer when telecommunication companies are the first point of contact with end users. This means they should offer support services. Indeed, it's not the "things" that matter, it’s the information that those things gather which leads to better and richer services (Dhar, 2014). Rogers, (2018) by literature argue that analyzing data gathered by IoT sensors and converting them to information will help organizations to improve quality of their products services.

Based on Telecom Italia, value chain of IoT consist of devices, connectivity, platforms, application and system integration that the last one or integration is the great part of business. IoT is Multiservice and multi-technology environment that because of immaturity, each zone planned and implemented its own platform. This differences increase the cost of information flow between various scopes and make IoT market vertical or complex so it reduced competitions (Scarrone, 2015). Also it is valuable to mention that, keeping the privacy and security of information gathered is one of the important challenges (Hawkes, 2014). To overcome challenges in newborn services in a variety of scopes, industries, devices, applications and infrastructures, making union framework and standardization will be the IoT roadmap. Based on our reviews, two academic and operational working group focused on the challenges. They try to introduce referenced framework and technical guidelines to increase the similarity of services. One of them which is named IEEE P2413, mostly focused on high level design of IoT services and the other or OneM2M group explained commonality of technical aspect of IoT implementation.

P2413 tries to introduce the integration market needs of IoT to have standard development framework. IoT architecture framework could lead to system benchmarking, safety, and security assessments. Development of networking and communication technologies is outside of the scope of P2413, but its approach to networking is focused on application and network channel aware communication and have hierarchical topologies in mind. It means in application view, it must be considered to have information flow, frequency, allowed latency, required safety and energy efficiency requirements. And in networking view, available transport options such as message confirmation, scheduled vs. real time delivery and path/media/channel selection are important. For ensuring human and environmental safety, interoperability between systems, alignment with regulatory and compliance checking with standard bodies are another key points in mentioned framework. Protection, Security, Privacy and Safety are the Quadruple Trust in P2413 that with the aid of threat assessment of IoT, security in depth could be achieved (Logvinov, 2014).

The purpose and goal of OneM2M is to develop technical specifications of IoT. It addresses the need for a common M2M Service Layer that can be readily embedded within various hardware and software worldwide (OneM2M, 2014).In 1st release of OneM2M, it was described that beside differences in various domains of IoT, a similar architecture could be seen. It includes client side applications or application layer that should interact with middleware or service layer and it is based on next to communication networks or network layer. OneM2M tries to define a common service layer so access control, security, data processing and storage will be efficient. This type of commonality aids to have horizontal communication and covers a wider scope of markets (Blanz, 2015). The draft of 2nd version of OneM2M reports is published and it updates the technical specification of common reference model of IoT in detail.

4. IoT framework opportunity for telecommunication companies

According to the union oriented discussion in the previous sections of this paper, IoT could be segmented to three layers as application, service and network. Connecting devices in network layer is what generates data and leads to value creation. When the Internet had been emerged, most online services connected people, and there was a relatively high tolerance for low quality connections. People are good at coping with latency, errors or failure. Unlike people, even smart machines are poorly equipped to deal with these same communication issues (Wilson & Raynor, 2015).

Telecommunication companies as the main infrastructure service provider, are progressing towards the new age of IoT. This may be difficult for larger incumbents with entrenched business models, as they compete against new entrants which star their core network with an IoT model (Dhar, 2014). Telecommunication operators need to decide what role they want to play in IoT ecosystem. They have two broad choices. The first one is being a thing company or providing solution in vertical markets, so they need deep knowledge on the market. And the second choice is providing horizontal solution or presenting managed connectivity that focus on commonality of different industries (Rebbeck, 2015). Maximizing commonalities across sectors creates the necessary potential towards accomplishing both greater efficiencies as well as synergies across markets (Coffey, 2015).

Also its worth to mention that for network layer transmission and interworking between IoT Systems, 3GPP2 Underlying Network is introduced by OneM2Mand is based on 3GPP2 X. P0068 specifications (OneM2M, 2015). Therefore, it seems that the telecommunication operator has unique opportunity to involve and gain key role in the horizontal ecosystem of the IoT market by developing network infrastructure. Actually, because of low rate of traffic of each IoT devices, Telecommunication companies should focus on quality of their service or QoS parameter instead of amount of data. They should provide QoS support infra needed for IoT based applications and sensors. IoT devices need only very low-speed but high rate up-time service. Collecting and processing information which is transmitted in the network is another issue that they face (Wilson & Raynor, 2015). So, telecommunication operators have the opportunity to shape the IoT market.

With cooperation and integration in IoT ecosystem, telecommunication companies could offer services to horizontal market. Telecommunication operators' core business and strength is in providing communication network and offer services based on this valuable infrastructure, so telecommunication operators could use this position to grant network layer managed services to various horizontal industries. IoT has more revenue growth in service based strategy vs. hardware group, so telecommunication companies could offer value added services like knowledge creation to their customers based on processing data transmitted in their network (Nicoletti, 2015). Telecommunication operators could process IoT sensors data and use benefits of decision making mechanism like ANN to integrate sensors output and have correlation between them (Rodger, 2018).

The next issue is about offering trusted and secured connections that transmit private data about customers. Keeping and investing on secure channel for transmitting valuable data is another challenge that should be considered. Thinking about storing, analyzing, and offering value added knowledge-based services which creates value added is an important issue. The real time knowledge about the end-user and devices are actually being useful for industries and manufactures (Hawkes, 2014; Skinner, 2015).

Conducting cooperation through partnership or acquisition with other companies lead to better supporting IoT devices for various industries. So with having relationship with devices or application producers, telecommunication companies could maintain its key role in IoT ecosystem and also get rid of end users support complexity for sensors. Actually they will have the back office role and end-users face with device producer (Rebbeck, 2015).

Therefore, based on the analyses, the aim of this study is to verify the framework shown in *figure 1* towards considering and implementing IoT based services in Telecommunication companies. In other words, this means that the surveyed company should improve its infrastructure to establish secured and quality based network and create knowledge through processing the customers' data transmitted in its infrastructure. Also moving toward horizontal markets help them to be capable of offering services to various industries. And business cooperation with other companies that have strength in producing IoT application and devices, could lead at having vital role in ecosystem. Thus, telecommunication operators could benefit from IoT technology by referring to various factors of this framework. OneM2M refers to high level structure of the concepts and layers that should be focused on, and P2413 studies the factors that are important for developing IoT based platforms. So we want to map these two concepts to opportunity of telecommunication industry that is presented in figure 1. Due to position of Telecommunication Operators in market share, they could play vital role in all the 3 layers and also create value added IoT services by focusing on factors that increase the quality of services.

The factors illustrated shown in figure 1, i.e. knowledge creation, considering customer data security, quality of services, and service type and cooperation with other application or device producers which are customized from P2413 model are described more in details in the next section. They are mapped to oneM2M layered model that means in this layer Telecommunication Operator could gain the factors which are important for IoT platforms. You could consider that collecting sensor data and quality of services in network layer of Telecommunication companies, offering secured communication based on infrastructure developed in service layer and having cooperation with other producer in unified application layer for platform.

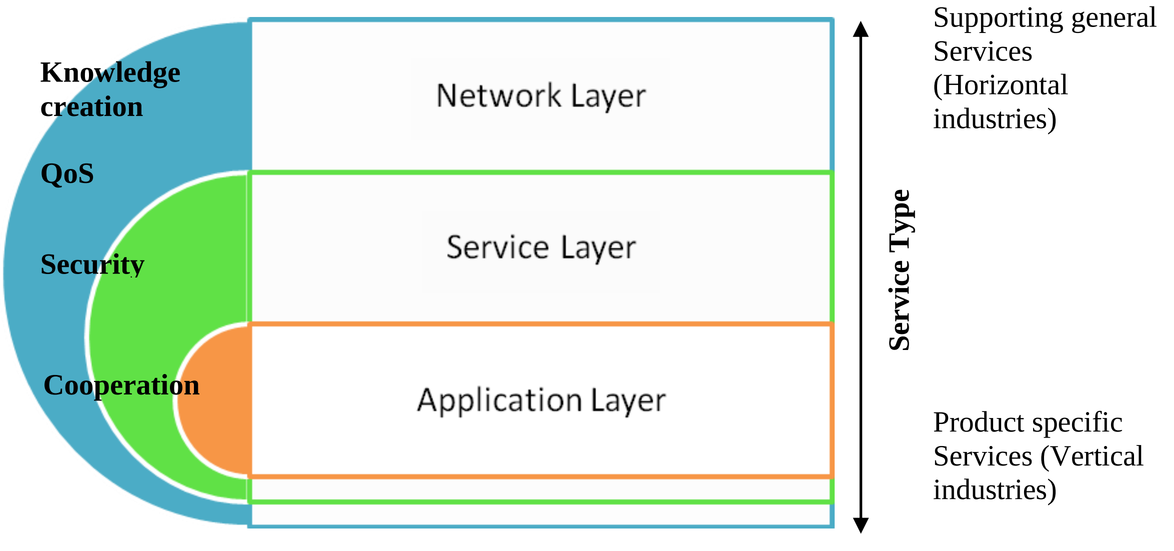

Figure 1. Key factors Telecommunication Company should consider in the IoT based environment framework, (adopted from OneM2M 3-layer model)

5. Research methodology

Case study method has been widely used in information systems studies (Gable, 1994). In our research, case study is suitable as it enables us to understand the paths leading to a certain outcome that could hardly be identified by testing the significance of a set of variables (Božic& Ozretic-Došen, 2015). Valmohammadi and Ghassemi (2016) by literature mention does not intend to extract facts from the sample to the population. And Kshetri (2007) argues that case study is suitable and necessary whereas theory exists but the researcher is in a different context or where there is no clear indication of cause and effect relations between the surveyed variables or involve time lags. As these factors exist in this study and according to the advice of Eisenhardt (1989) who argues that regarding case study considering best practices models is helpful, a leading Iranian telecommunication company which offers 4G services and is early stages of utilizing IoT technology was chosen for this case study.

6. Framework analysis

Based on historical review and analysis of operational and technical trend in the field of IoT in the above sections, we conclude 5 factors that must be considered by telecommunication companies. These factors include creating knowledge relating to sensors data that flow in their infrastructure, considering customer huge data security, changing their approach from traffic amount to quality of services, service type offering from vertical and specific industry to broad and horizontal ones. And, finally, the last one is cooperation with other application or device producers to have vital role in the ecosystem. Regarding the importance of knowledge creation, it should be mentioned that IoT devices could produce lots of data and network operators face a big storage of data. These data could be correlated and processed towards making information and knowledge. The obtained information and knowledge is a valuable resource to decision making of companies and managers.

For selecting the described factors, we used Fuzzy Delphi and to survey the inter-relationships among the factors and for prioritizing them we employed Fuzzy Decision Making and Trial Evaluation Laboratory (FDEMATEL) and Fuzzy Analytic Network Process (ANP) methods, respectively.

For the first time Zadeh (1965) introduced the fuzzy set theory to deal with the uncertainty due to imprecision or vagueness. Also Rodger mention that Fuzzy logic has many business applications, and it could be utilized in the shape of various methods. (Rodger, 2018) So, it was realized that application of fuzzy theory in the framework and different multi-criteria decision analysis(MCDA) such as fuzzy Delphi (FDM), FANP, and FDMATEL methods employed in this could help us to achieve the set objectives of this study much better.

The Fuzzy Delphi Method is an analytical method based on the Delphi Method that draws on the ideas of the Fuzzy Theory. The Delphi Method is a type of collective decision-making method, with several rounds of anonymous written questionnaire surveys conducted to ask for experts' opinion. As a direct prediction method based on the expert judgment and expert meeting investigation method, it possesses the experts' anonymity, the main idea feedback, and statistical experts' options and make final convergence result properties (Linstone & Turoff, 2002).

ANP, also introduced by Saaty, is a generalization of the analytic hierarchy process (AHP). Whereas AHP represents a framework with a unidirectional hierarchical AHP relationship, ANP allows for complex interrelationships among decision levels and attributes. Not only does the importance of the criteria determine the importance of the alternatives, as in a hierarchy, but also the importance of the alternatives may impact on the importance of the criteria (Brauers&Zavadskas, 2008; Valmohammadi, 2010). The inability of ANP to deal with the impression and subjective in the pair wise comparison process has been improved in fuzzy ANP. Instead of a crisp value, fuzzy ANP applies a range of values to incorporate the decision maker's uncertainly (Turskis & Zavadskas, 2010). The DEMATEL originated from the Natural Sciences and Humanities Research Plan proposed by the Battelle Institute in 1971. During the initial stages of development, the DEMATEL was designed to identify intricate problems in the world such as racism, hunger, environmental protection, and energy conservation (Lee et al., 2010).

7. Survey process

In this study, we had 12 experts' idea in the field of telecommunication that answered the questionnaires. These experts work in one of the Iranian Telecommunication Company that offers 4G services to its subscribers. Telco Company known as Rightel started its activity in2010 aimed at rendering3G services and now offers 4G services as well. It aims to offer data related value added services to customers, based on Business-to- business (B2B) and business-to-customer (B2C) models. Given the importance of data usage within Rightel services, its valuable data strategy could be aligned with international Telecommunication operators around the world. Because, as it is obvious offering services based on 4G/5G data usage is very important, justifying the importance and contribution of this study towards achieving the objectives of this company.

For starting the survey, the designed questionnaires were distributed among the mentioned experts to answer the questions based on the usage and benefits of IoT for Telco Company, from their point of views to find out the importance of the 5 framework factors for Telco. As mentioned before, Fuzzy Delphi was employed to select the described factors, and hybrid FDANP technique to determine the interactions and interrelations among the factor (criteria) and identify the influential and permeable factors, and finally prioritizing these factors. In this study as Soleimani and Valmohammadi (2017) point out that fuzzy approach was utilized because this approach considers mental problems and uncertainty in decision making, and is suitable to perform the pair wise comparisons between the model factors.

Also, The Fuzzy Decision-Making Trial and Evaluation Laboratory (F. DEMATEL) technique was utilized to analyze data collected from the questionnaires and determine the interrelationships and impacts of factors. And the DEMATEL-based Fuzzy Analytical Network Process (F.ANP) was employed to prioritize the factors (Gharanfoli, Valmohammadi, 2019). The origin of DEMATEL is related to Battelle Memorial Institute of Geneva and for the first time DEMATEL was used on Science and Human Affairs program to solve complex and interrelated Problems (Valmohammadi and Sofiyabadi, 2015). Soleimani and Valmohammadi (2017) note that DEMATEL is used to calculate the direct and indirect relations among the criteria in order to find out the casual relationships, establishing the related structural model. Pai (2014) mentions that DEMATEL does not take into consideration the importance of the criteria, so ANP is further utilized to obtain the relative weights among the criteria. The ANP technique takes into account the dependence assumption among individual. Criteria that is more adapted with real world application (Zamani & Valmohammadi, 2018). Therefore, based on the method proposed by Hsu et al., (2012) i.e. application of a hybrid technique, namely DEMATEL and ANP it is possible to identify the critical decision-making factors with respect to the main objective of Rightel Telecommunication Services Company.

In Fuzzy Delphi method when the difference of experts' opinion on average is more than 0.2, having more than one iteration is necessary. As we encountered a scenario like this, the questionnaire was distributed for 3 times. The results of each round of the questionnaire distribution among the experts are shown in *tables* 1 to 3. In the 3rd round, we see that for the 5 factors, experts converged to 4 out of 5 factors and "cooperation with others" was eliminated. To cooperate with other application and device producers, we could have this consideration that all of the experts being in this survey have telecommunication skills and answer the questionnaire based on their expertise, so it is predicted that with changing and adding expert groups from all other suppliers and industries, we could generalize our results.

Table 1. FuzzyDelphi output-1st iteration

Item	**factors**	**Very high**	**High**	**medium**	**Low**	**Very low**	**Max**	**mod**	**min**	**Expert non fuzzy mean**
		9	**7**	**5**	**3**	**1**				
		(10,9,7)	**(9,7,5)**	**(7,5,3)**	**(5,3,1)**	**(3,1,0)**				
1	Knowledge creation	9	2	1	0	0	9.58	8.33	6.33	8.21
2	Security	6	5	1	0	0	9.33	7.83	5.83	7.75
3	QoS	8	4	0	0	0	9.67	8.33	6.33	8.22
4	Cooperation with others	6	5	0	1	0	9.17	7.67	5.67	7.58
5	Service type	7	5	0	0	0	9.58	8.17	6.17	8.07

Table 2. Fuzzy Delphi output-2nd iteration

Item	factors	Very high	high	medium	low	Very low	max	Mod	min	Expert non fuzzy mean	Difference between 1st and 2nd results
		9	7	5	3	1					
		(10,9,7)	(9,7,5)	(7,5,3)	(5,3,1)	(3,1,0)					
1	Knowledge creation	9	2	1	0	0	9.58	8.33	6.33	8.21	0.00
2	Security	8	3	1	0	0	9.50	8.17	6.17	8.06	0.31
3	QoS	8	4	0	0	0	9.67	8.33	6.33	8.22	0.00
4	Cooperation with others	6	3	3	0	0	9.00	7.50	5.50	7.42	0.17
5	Service type	7	5	0	0	0	9.58	8.17	6.17	8.07	0.00

Table 3. Fuzzy Delphi output-3rd iteration

Item	factor	Very high	high	Medium	low	Very low	max	mod	min	Expert non fuzzy mean	Difference between 2nd and 3rd results
		9	7	5	3	1					
		(10,9,7)	(9,7,5)	(7,5,3)	(5,3,1)	(3,1,0)					
1	Knowledge creation	9	2	1	0	0	9.58	8.33	6.33	8.21	0.00
2	Security	8	4	0	0	0	9.67	8.33	6.33	8.22	0.17
3	QoS	8	4	0	0	0	9.67	8.33	6.33	8.22	0.00
4	Cooperation with others	6	5	1	0	0	9.33	7.83	5.83	7.75	0.33
5	Service type	7	5	0	0	0	9.58	8.17	6.17	8.07	0.00

After selecting 4 factors as security, QoS, service type and creating knowledge, FDEMATEL is utilized to determine the interactions of the factors. *Table* 4 shows direct Fuzzy interrelation matrix for paired comparison of the factors' impacts on each other.

Table 4. Direct Fuzzy interrelation matrix

	C_1			C_2			C_3			C_4		
	I	M	L	I	M	L	I	M	L	I	M	L
C_1	0	0	0	0.625	0.875	1	0.75	1	1	0.5	0.75	1
C_2	0	0.125	0.375	0	0	0	0.5	0.75	1	0.375	0.625	0.875
C_3	0	0	0.25	0	0.125	0.375	0	0	0	0.75	1	1
C_4	0.125	0.375	0.625	0.625	0.875	1	0.375	0.625	0.875	0	0	0

In *table* 5 the results of the calculation towards determining the importance (R+D) and influence and permeability (R-D) of the main factors are shown. The $\tilde{r}_i$ index denotes the sum of the rows i and the index $\tilde{d}_j$ represents the sum of column j from the matrix $\tilde{\boldsymbol{T}}_C$ with respect to the corresponding factor. Similarly, we calculate the $\tilde{R}_i$ and $\tilde{D}_j$ indices. The index $\tilde{R}_i$ represents the sum of the rows i and the index $\tilde{D}_j$ represents the sum of the j column of the $\tilde{\boldsymbol{T}}_{\mathbf{D}}$ matrix. It should be mentioned that the matrices of total relationship and full relationship of the main indicators, respectively.

The obtained results show that the most important factor is "service type" with the weight of 4.788 and the most influential factor is "knowledge creation" (1.885) whereas "quality of service" factor is the most permeable factor (-1.06). It means that changing service type to broad horizon in the market could influence other factors and has more positive impact. On the other hand, QoS is the factor that is influential and working on other factors could increase its quality and results.

Table 5. The influential and permeable factors

	$\tilde{R}$	$\tilde{D}$	$\tilde{R}+\tilde{D}$	$\tilde{R}-\tilde{D}$
Knowledge Creation	2.787	0.902	3.69	1.885
Security	1.803	2.101	3.904	-0.3
QoS	1.48	2.542	4.022	-1.06
Service type	2.132	2.656	4.788	-0.52

For structural relation within the factors based on the experts' opinions, the value equal to Geometric mean or threshold of 0.409 is considered and relation with lower importance below threshold is omitted (see table 6).

Table 6. The factors relation matrix

Threshold = 0.409		**C_1**	**C_2**	**C_3**	**C_4**
Knowledge creation	**C_1**	0.186	0.729	0.867	0.849
Security	**C_2**	0.175	0.291	0.586	0.585
QoS	**C_3**	0.131	0.317	0.289	0.603
Service type	**C_4**	0.265	0.618	0.637	0.468

Then, F.ANP was employed to weigh and prioritize the factors. So, the experts were asked to determine the relations of the factors. Figure 2 shows the network map of relations (NMR). This figure demonstrates the interactions among the factors. The network map is illustrated with R+D horizontally and R-D vertically. The main factors with positive values of $(\tilde{D}-\tilde{R})$ are certainly influential and those with negative values of $(\tilde{D}-\tilde{R})$ show the definite permeability by the other factors. Eventually, positive values of $(\tilde{D}-\tilde{R})$ indicate causal factors, and negative values of $(\tilde{D}-\tilde{R})$ show effect factors. The relations between cause and effect factors are shown by drawing points of coordinate. And the degree of causality of the factors on each other are drawn in a Cartesian coordinate system, which is based on the T matrix (Gharanfoli and Valmohammadi, 2019).

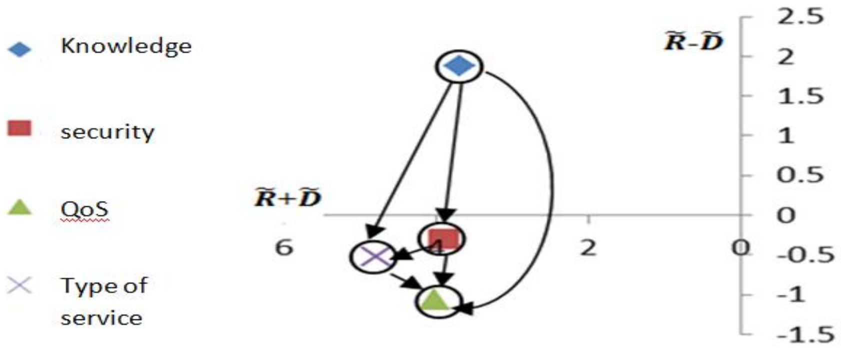

Figure 2. The network map of relations

Compatibility ration for the validity of comparison is done by Geometric mean method and for fuzzy numbers, Logarithmic squares method is used. Pair wise comparison matrix for main factors is shown in *table* 7. Also, interrelations of the main factors with their relevant indicators are shown in *tables* 8 to 10.

Table 7. The Pairwise comparison matrix for the main **factors**

	C_1			C_2			C_3			C_4			w_1		
C_1	1	1	1	0.33	2.27	7	0.25	1.15	5	0.25	1.97	7	0.32	0.35	0.28
C_2	0.14	0.44	3	1	1	1	0.13	0.51	5	0.14	0.94	4	0.19	0.16	0.19
C_3	0.2	0.87	4	0.2	1.95	8	1	1	1	0.25	1.28	8	0.26	0.28	0.28
C_4	0.14	0.51	4	0.25	1.06	7	0.13	0.78	4	1	1	1	0.21	0.19	0.23
CR= 0.0058															

Table 8. Interrelation of the main **criteria** for security

	C_1			C_4			W		
C_1	1	1	1	0.167	1.292	7	0.519	0.572	0.519
C_4	0.143	0.726	6	1	1	1	0.481	0.428	0.481
CR=00									

Table 9. Interrelation of the main **criteria** for QoS

	C_1			C_2			C_4			W		
C_1	1	1	1	0.33	2.22	7	1	1.94	4	0.483	0.508	0.445
C_2	0.14	0.45	3	1	1	1	0.2	0.74	3	0.213	0.216	0.305
C_4	0.25	0.51	1	0.33	1.35	5	1	1	1	0.304	0.276	0.25
IR= 0.0031												

Table 10. Interrelation of the main **criteria** for service type

	C_1			C_2			C_3			W		
C_1	1	1	1	1	3.36	7	0.33	1.51	4	0.438	0.507	0.439
C_2	0.14	0.3	1	1	1	1	0.13	0.41	1	0.165	0.146	0.144
C_3	0.25	0.66	3	1	2.46	8	1	1	1	0.398	0.347	0.417
IR= 0.0012												

$$
\begin{array}{c|ccc|ccc|ccc|ccc|}
 & & C_1 & & & C_2 & & & C_3 & & & C_4 & \\
C_1 & 1 & 1 & 1 & 0.519 & 0.572 & 0.519 & 0.483 & 0.508 & 0.445 & 0.438 & 0.507 & 0.439 \\
C_2 & 0 & 0 & 0 & 1 & 1 & 1 & 0.213 & 0.216 & 0.305 & 0.165 & 0.146 & 0.144 \\
C_3 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0.398 & 0.347 & 0.417 \\
C_4 & 0 & 0 & 0 & 0.481 & 0.428 & 0.481 & 0.304 & 0.276 & 0.25 & 1 & 1 & 1
\end{array}
$$

Figure 3. The interdependency matrix for the main **factors** (W2)

The interdependency matrix was calculated which is shown in *figure* 3. Finally, as is shown in figure 4 through multiplying W2 by W1, the priorities of the main factors are determined (see *figure* 4).

$$
W_{factors} = w_2 \times w_1 \quad \begin{vmatrix} 0.484 & 0.526 & 0.449 \\ 0.142 & 0.126 & 0.16 \\ 0.178 & 0.178 & 0.191 \\ 0.196 & 0.17 & 0.2 \end{vmatrix}
$$

Figure 4. Prioritizing of the main factors

At the final stage, using Center of gravity (COG) method the number are defuzzied which the results are shown in *table* 11.

Table 11. De-fuzzification of the priorities

Priority	Weight	factors
1	0.486	Knowledge creation
4	0.143	Security
3	0.182	QoS
2	0.189	Service Type

8. Conclusion, further research, and limitation

Internet of Things or IoT is the effective new revolution that will impact the explosion of connected devices. Actually this will add billions of new connected data sources globally and it will require a suitable infrastructure that maintains and transmits large amounts of data, and telecom industry has this opportunity to avail of it. IoT has been one of the greatest opportunities that telecommunication sector has had in the last years. Telecom business needs to understand the new ecosystem and how they could offer services based on their strength and influence this environment. Actually, they shall not forget or confuse their business model, with respect to its core business model but they should focus on their capabilities which are their network and infra. In this paper we analyzed the various vision and models that different industries use for offering IoT services. Because of IoT immaturity, doing more research towards having a unique framework is vital. With the aid of this unique framework, all industries could transmit different data generated from IoT devices and reach to valuable knowledge. Telecommunication companies have this opportunity to offer and implement network required to transmit IoT devices data in horizontal industries securely. Also they could have business value added service for other companies and enterprises for instance offering knowledge created through processing of the produced data. But, as mentioned in the IoT framework opportunity for telecommunication companies section of this paper, telecommunication companies should consider QoS based changes in their infra. They previously focused on the amount of data transmitted but now they should offer quality for stable services. Also, having cooperation with the other IoT application and device companies could help them to have their main and vital role in the ecosystem. And offering infra services to companies, will release them from facing with increased demands of end users.

In this paper, with Fuzzy methods, we identified and prioritized 4 factors based on the view of the experts for offering IoT services by Iranian Telecommunication Company. As described in previous sections, Rightel case study could be considered a valuable sample for studying Telco’s IoT strategy and could be generalized for other Telco Companies that focus on 4G/5G data usage. Which is the main contribution of this study. To the best knowledge of the authors this study is among the first of its kind which attempts to develop an IoT framework consisting of the main factors which could help the policy makers and top managers of the of the surveyed company to utilize the capabilities of IoT towards competing effectively and efficiently with their rivals in the Iranian telecom market.

Knowledge creation was ranked the first with the weight of 0.486, and service type ranked the second with the weight of 0.189, followed by QoS and security factors, third and fourth with the weights of 0.182 and 0.143, respectively. Therefore, it could be concluded that focusing on knowledge creation for horizontal industries is the most important criterion. And as we discussed in the last sections of this paper, moving towards IoT services instead of producing hardware or software leads to more revenue. So our analytical result is aligned with IoT trend in world. Thus, the Telecommunication companies should focus on processing data transmitted on their network and create value added knowledge for other different industries.

Based on Fuzzy methods which were used in this study, knowledge creation is the influential factors and security, QoS and service type are the permeable factors. So this result also confirms the importance of investing on knowledge creation in IoT industry for Telecommunication companies. As mentioned in the analysis section, the measure "cooperation with others", was not verified by the experts and eliminated form this study. This could be due to the focus of this research on telecommunication companies.

Finally, one of the main limitations of this study is the generalization of the findings, which may be limited by the single case study method used which stems from the nature of this kind of research method. So it's suggested with the inclusion of the experts of other industries, such as applications producer companies, IoT sensor producers, network and telecommunication companies, in future studies efforts be made towards developing a comprehensive IoT framework, which might be applicable to all industries.

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