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Development Challenges Of The Internet Of Things In Yemen

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Abstract

The Internet of Things (IoT) promises to offer a revolutionary, fully connected "smart" world. Yet the challenges associated with IoT need to be considered and addressed for the benefit of individuals, society, and the economy to be realized.

This paper presents development challenges of the IoT in Yemen such as availability of internet at everywhere and at reasonable cost, shortage of IPv4 addresses and transition to IPv6, power supply for sensors, acceptability among the society, and finally security and privacy protection. Solutions to these challenges were devised.

The data for this study was collected through an online questionnaire that was focusing on the Yemeni specialists in the field of computer and information technology to determine their degree of agreement on challenges and solutions. The results showed that the degree of agreement was high. Based on our results the challenges and solutions were arranged according to the respondents' point of view.

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1.Introduction

IoT is a new step in technological progress, new stage for the development of the Internet [1], and provides great opportunities to be connected with the virtual world.

'IoT allows people and things to be connected anytime, anyplace with anything and anyone, ideally using any path/network and any service'. [2]

IoT enhances the collection, analysis, and distribution of data, which can be transformed into all kinds of receivers.

The main reasons behind this interest of IoT are the capabilities that it offers.

It promises to create the world around us where everything will be connected to each other via Internet and with minimum human intervention [1].

In recent time, an enormous amount of research, and development works are carried out in different parts of the world to make IoT feasible. The main application domains for the IoT are illustrated in Figure 1.

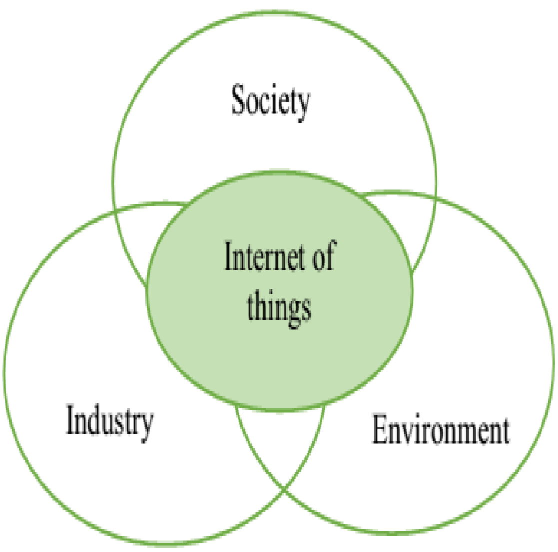

Fig1. Internet of things application domains

Cisco estimates that IoT will consist of 50 billion devices connected to the Internet by 2020 [3].

The aim of IoT is to make our daily life easier and smarter and to be applied in all areas of life; such as industry, environmental monitoring, healthcare, military, and management of cities. Imagine the world where billions of objects can communicate and share information. Data regularly collected, analyzed and used to initiate action, providing intelligence for planning, management, and decision-making. This is the world of the IoT, however, in Yemen, its scope develops slowly.

The development of IoT is a step-by-step process, IPv6 address space to make it possible to connect unlimited number of devices with Internet [2].

There are many difficulties in the field of IoT such as the problem of insufficient security, the less-protection of personal information, the complexity of communication, the variety of protocols, the lack of common standards, issues of power supply of connected devices, and the acceptability among the society [3], [4].

The broad scope of IoT challenges will not be unique to industrialized countries, but also developing regions will need to respond and realize the potential benefits of IoT.

In addition, the unique needs and challenges of the implementation in underdeveloped regions will need to be addressed, including infrastructure readiness, technical skill requirements, and policy resources.

This paper presents the most important challenges facing the IoT in Yemen currently; the main challenges of IoT in Yemen can be summarized as availability of internet at everywhere and at reasonable cost, shortage of IPv4 addresses and transition to IPv6, Power supply for sensors, acceptability among the society, security and privacy protection.

2. The Main Development Challenges of IoT in Yemen Currently

2.1. Availability of Internet at Everywhere and at Reasonable Cost

The success of the IoT depends on the availability of the Internet and its spread everywhere [5]. In addition, the Internet should be available with a reasonable cost; and this problem may not be very easy to be solved in Yemen.

According to Internet Live Stats - Internet Usage & Social Media Statistics [6] the number of Internet users in Yemen is still limited with reference to the population as not to exceed 25% of the total population. Over 75% of the population in Yemen is still unable to use internet (Figure 2).

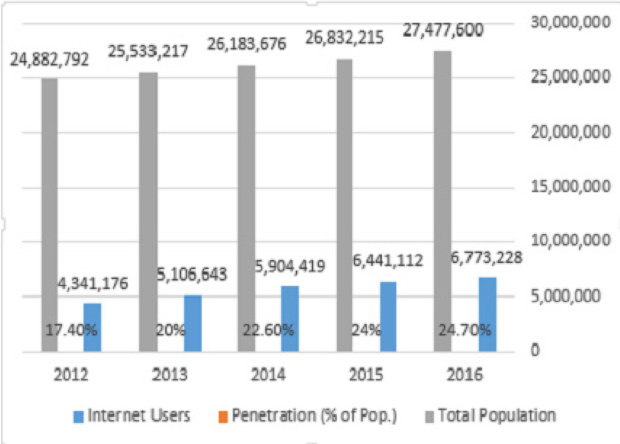

Fig2. Internet users and population statistics in Yemen

In order to make internet available, there is a need for huge investment in providing infrastructure and resources.

2.2. Shortage of IPv4 Addresses, and Transition to IPv6

Currently in Yemen, using the internet protocol (IPv4), IPv4 uses 32-bit (4-byte) addresses, IPv4 has only 4.3 billion (232) possible IP-addresses, IPv4 has been completely depleted by Feb 2011 [7]. Now in Yemen, the providers are using Network Address Translation (NAT) as a solution to IPv4 shortage.

Some hosts implement a level of security regarding how many connections should be accepted from another host and they do not respond if the defined number of requests has been reached. Hosts may decide that there is a load on them created by robots, and would take measures to protect from such actions like completely block the IP-address, or increase the intensity of the show captcha.

The quality of access to the Internet for users will be worse, and can break certain applications, or make these applications more difficult to run. [8]

The development of IoT requires many new sensors with new unique IP-addresses, NAT mechanisms limits the direct accessibility to IoT devices, so transition to the IPv6 is very necessary.

IPv6 uses 128-bit (16-byte) addresses, so the new address space supports approximately 340 undecillion (2128) addresses [9].

Currently, the Ministry of Communications and Information Technology is working for the transition to IPv6 [10]. IPv6 simplifies network management by using automatic configuration. Also, it provides new features enabling an easier configuration of devices, data streaming compliance, improved security, and effective peer-to-peer connections avoiding NAT barriers [7], [9].

IPv6 has been designed to provide secure communications for users and mobility for all devices.

In areas of network protocol security, IPv6 contains addressing and security control information, i.e., IPSec to route packets through the Internet. While in IPv4, IPSec is optional.

With IPv6, IPSec support is integrated into the protocol design and connections can be secured when communicating with other IPv6 devices.

IPSec provides data confidentiality, data integrity and data authentication at the network layer. It offers various security services at the IP layer and above.

IPv6 is the most suitable technology for the IoT, since it offers scalability, flexibility, tested, extended, ubiquitous, open, and end-to-end connectivity [7].

Most sensor networks use wireless communications networks such as IPv6 Low Power Wireless Personal Area Networks (6LoWPAN) [11], Bluetooth, Wi-Fi, WiMAX, 3G and 4G networks, and a satellite network (e.g., GPS).

Sensor networks in IoT use communication protocols based on IP (e.g., IPv6).

"IPv6-based solutions are key enablers for the success of the IoT interoperability, acceptance and integration" [7].

6LoWPAN is a key component in order to realize the IP-based integration of constrained devices.

It is used in a multitude of projects, exploring a wide range of use cases such as smart buildings, smart environments, smart cities, etc.

In all cases, constrained devices forming 6LoWPAN networks are used to collect information from the real world and this information is used to generate intelligence and make the world around us smarter [12].

6LoWPAN is a communication standard that allows the low-power devices to communicate and exchange data via IPv6 [13].

There are many benefits of using IP-based connectivity to form the sensor access network [13]:

-IP connects easily to other IP networks without the need for translation gateways or proxies.

-IP networks allow the use of existing network infrastructure.

-IP is open and free, with standards, process and documents available to anyone.

6LoWPAN works on the IPv6 protocol suite based on IEEE 802.15.4 standard. Hence, it has the characteristics of low-cost, low-rate and low-power deployment.

2.3. Power Supply for Sensors

Power consumption has the greatest challenge for sensors.

Today, sensors need to be able to sustain longer battery lifespan, especially in cases such as outdoor deployments, to shorten hardware maintenance and to prevent breakdown of communication.

The most important factors for IoT power sources are [14]:

•Wireless, and smart self-charring capability.

•Environment friendly and cost-effective materials.

•Flexible shape and small size.

•Enhancement in energy and power density.

•Longer lifetime.

Sensors must operate fully autonomously, as well as continuously in order to fulfill the highly benefit of IoT potentials. Batteries use to supply the necessary energy required for sensor signal processing and communication.

There is a need to use new types of rechargeable batteries which are environment friendly.

The rechargeable batteries will need to be charged from different renewable energy sources; wind and solar energy.

The choice of wind energy may not be limited for sensor nodes due to its initial investment and availability of wind.

The development of new, efficient, and compact batteries, as well as new energy generation devices or energy harvesting will be the main power source for IoT devices [15].

"Energy harvesting technologies [16] use power generating elements such as solar cells, piezoelectric elements, and thermoelectric elements to convert light, vibration, and heat energy into electricity, then use that electricity efficiently." These technologies will help in the growth of the IoT.

2.4. Acceptability among the Society

Through interviews conducted by the researchers, it turned out most consumers are not ready to use the IoT technology because they do not have enough knowledge about it.

Most companies in Yemen consider that the technology is not mature, the infrastructure of companies is not adequate, and IoT implementation may be expensive.

There are also many concerns related to security and privacy [17], some applications handle sensitive information about people, such as their location and movements, or their health and purchasing preferences.

The researchers believe that trust in and acceptance of IoT will depend on the protection it provides to people's privacy, and the levels of security it guarantees to systems and processes.

2.5. Security and Privacy Protection

IoT raises important questions and introduces new challenges for the security of systems, processes and the privacy of individuals.

Privacy should be protected at the device, in storage during communication and in the processing which helps to protect the sensitive information.

To assure data confidentiality during the transmission of data, the most common approach is encryption.

To secure the information exchange in the IoT, existing encryption technology needs to be carefully reviewed [18]. The encryption algorithms need to be faster and less energy consuming.

Security at both the device and network is critical to the operation of IoT.

This does not require the search for a solution that does not yet exist or proposing a revolutionary approach to security, but rather an evolution of measures that have proven successful in IT networks, adapted to the challenges of IoT and to the constraints of connected devices.

For privacy the situation is more serious, the heterogeneity and mobility of 'things' in the IoT will add complexity to the situation.

Moreover, privacy-preserving technology is still in early stages.

In the future, new standards and technologies should address security and privacy features for users, network, data and applications.

3. Methodology

The data for this study was collected through an Online questionnaire that was focusing on the Yemeni specialists in the field of computer and information technology.

The questionnaire was grouped thematically into different subsections: personal data, development challenges of the IoT in Yemen, and proposed solutions to overcome the challenges successfully.

3 point Likert scale is used to measure the respondent's degree of agreement or disagreement with each statement.

The used scale is (Agree digitally represented by 3, Neutral digitally represented by 2, and Disagree digitally represented by 1).

The survey was conducted in Arabic language, but the questionnaire was translated for the analysis into English.

Our respondents were specialists in the field of computer and information technology.

57 respondents participated in the survey; more than (60 %) of the respondents were master and PhD holders. The analyzed sample consisted of 57 respondents.

3.1 Research Goals

The research aims are:

1.Determine the main development challenges of the IoT in Yemen currently.

2.Identify the solutions to overcome these challenges successfully.

3. Ordering the challenges and solutions according to the respondents' point of view.

4. Results and analysis

The data were collected via a questionnaire. It was quantitatively analyzed using the Statistical Package for the Social Sciences (SPSS) software.

The data preparation process ensured that the data set have no missing values and they didn't distort significantly by the different opinions of specific groups.

Outline and statistical results of the questionnaire have been identified as interesting by:

1.determining if the scale is reliable.

2.ordering the challenges and proposed solutions according to their means (showing the top results)

3.determining whether the sample mean is statistically different from a midpoint.

4.conducting significance tests at 95% confidence level.

4.1 Reliability

Cronbach's alpha is the most common measure of internal consistency ("reliability").

It is most commonly used when using multiple Likert questions in a survey/questionnaire that form a scale and in order to determine if the scale is reliable [19].

Cronbach alpha values must meet the minimum accepted criteria i.e above 0.6 in order to confirm the consistency and reliability.

The Reliability Statistics table that provides the actual value for Cronbach's alpha is shown in the table below:

Cronbach's Alpha	Cronbach's Alpha Based on Standardized items	N of Items
.621	.641	12

Table 1. Reliability Statistics

The value of the Cronbach's alpha is 0.62, which indicates acceptable level of internal consistency for scale.

4.2 Descriptive statistics

The statistics of development challenges of the IoT in Yemen currently are shown in table 2.

	N	Mean		Std Deviation
	Statistics	Statistics	Std Error	Statistics
Availability of internet Everywhere and at Reasonable Cost	57	2.877	.0564	.4255
Power Supply for sensor	57	2.649	.0729	.5507
Acceptability among the Society	57	2.526	.0906	.6841
Shortage of IPV4 addresses	57	2.474	.0906	..6841
Transition from IPV4 to IPV6	57	2.404	.0997	.7526
Security and Privacy	57	2.386	.1055	.7963
Valid N(listwise)	57			

Table 2. The statistics of development challenges of the IoT in Yemen currently

The challenges were ordered according to their mean as illustrated in figure 3.

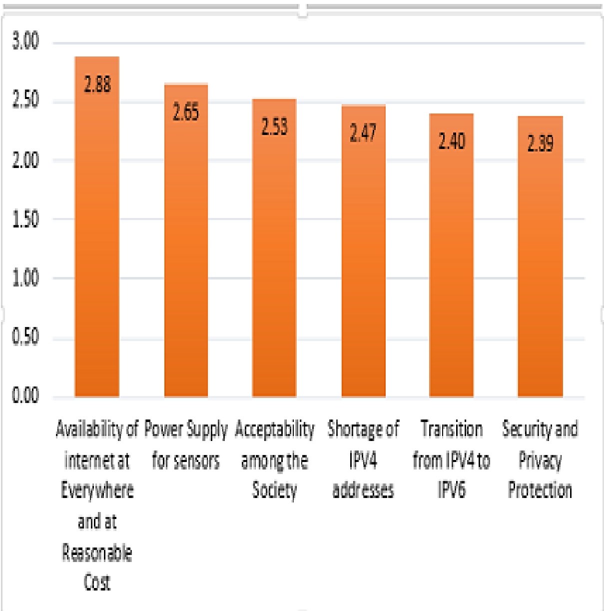

Fig 3. Ordering the challenges according to their mean

The statistics of proposed solutions to overcome the challenges successfully are shown in table 3.

	N	Mean		Std Deviation
	Statistics	Statistics	Std Error	Statistics
Investment and providing the necessary resources to improve the telecommunications infrastructure and opening the area of competition	57	2.992	.0175	.1325
Awareness of the field of information security in society	57	2.912	.0378	.2854
Using new types of rechargeable batteries friendly to environment	57	2.860	.0527	.3981
increase the level of technical skills in society	57	2.860	.0464	.3504
Transition from IPV4 to IPV6	57	2.807	.0527	.3981
Awareness of the importance and benefits of the IoT	57	2.754	.0675	.5099
Valid N(listwise)	57			

Table3. The statistics of proposed solutions to overcome the challenges successfully

The solutions were ordered according to their mean as illustrated in figure 4.

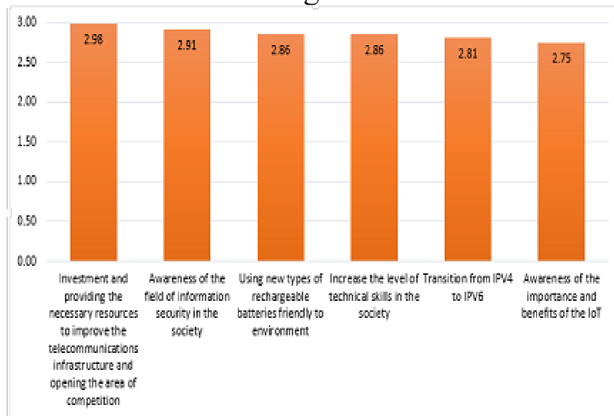

Fig4. Ordering the solutions according to their mean

4.3 One sample T test

The one sample T test is used to test the statistical difference between "the mean of the challenges and solutions", and "the midpoint" (the midpoint = 2).

The null hypothesis (H0) and alternative hypothesis (H1) of the one sample T test can be expressed as:

H0: $\mu = x$ (the mean of the challenges and solutions is equal to the midpoint).

H1: $\mu \neq x$ (the mean of the challenges and solutions is not equal to the midpoint).

Where μ is the midpoint, and x is mean of the challenges and solutions.

The data should include one continuous, numeric variable (represented in a column) that will be used in the analysis.

The variable 'means_of_C_S' used which a continuous variable representing means of the challenges and proposed solutions.

The 'means_of_C_S' exhibit a range of values from 2.39 to 2.98.

The result of the one-sample statistics and one-sample test is shown in table 4 and table 5.

	N	Mean	Std.Deviation	Std. Error Mean
means_of_C_S	12	2.7076	.21124	.06098

Table 4. One-sample statistics

	TestValue=2					
	t	of	Sig(2-tailed	Mean Difference	95% Confidence internal of Difference	
					Lower	Upper
means_of_C_S	11.604	11	.000	.70758	.5734	.8418

Table 5. One-sample test

Since $p < 0.001$, we rejected the null hypothesis i.e the mean of the challenges and solutions is equal to the midpoint and conclude that the mean of the challenges and solutions is significantly different from the midpoint.

The mean of the challenges and solutions is about 0.71 greater than the midpoint.

5. Discussion

It is clear from the results of this work that the degree of agreement is great; both for the development challenges of the IoT in Yemen, and for the proposed solutions to overcome them. The challenges and proposed solutions to overcome them can be summarized in the following table (table 6).

Challenge	Overcome by
Availability of internet at everywhere and at reasonable cost.	Investment and providing the necessary resources to improve the telecommunications infrastructure and opening the area of competition.
Transition from IPV4 to IPV6	
Power supply for sensors	Using new types of rechargeable batteries which are environment friendly.
Shortage of IPV4 addresses	Transition from IPV4 to IPV6
Security and privacy protection.	Awareness of the field of information security in the society
Acceptability among the society - -	-Awareness of the importance and benefits of the IoT. -Awareness of the field of information security in the society. -Increase the level of technical skills in the society.

Table 6. The challenges and the proposed solutions

Challenge Overcome by Availability of internet at everywhere and at reasonable cost.Investment and providing the necessary resources to improve the telecommunications infrastructure and opening the area of competition.

Transition from IPV4 to IPV6

Power supply for sensors Using new types of rechargeable batteries which are environment friendly.

Shortage of IPV4 addresses Transition from IPV4 to IPV6

Security and privacy protection. Awareness of the field of information security in the society

Acceptability among the society -

Awareness of the importance and benefits of the IoT.

-Awareness of the field of information security in the society.

-Increase the level of technical skills in the society.

The following challenges: power supply for sensors, and security and privacy protection are common for all countries.

The acceptability among the society for the IoT depends on the security and privacy protection.

6. Conclusion

This paper presented, the IoT as a technology that will change the world to make it smarter. The main aim of research is to identify the development challenges of the IoT in Yemen currently, and propose solutions to overcome them successfully. The empirical study aims to assess the degree of agreement of Yemeni specialists in the field of computer and information technology about these challenges and proposed solutions, and to consider whether there are other challenges and solutions from their point of view. The results showed that the degree of agreement was great, it is about 90%. The degree of agreement mean of the challenges and solutions is about 0.71 greater than the midpoint.

Challenges and solutions were arranged according to the respondents' point of view. The statistical analysis confirmed that the assessment instrument was reliable.

The transition from IPv4 to IPv6 is very important step for development the IoT in Yemen now. Security and privacy protection are very important topics for research in the field of IoT.

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