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Challenges and Applications of Internet of Things (IoT) in Saudi Arabia

Mohammad Tabrez Quasim

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Challenges and Applications of Internet of Things (IoT) in Saudi Arabia

Mohammad Tabrez Quasim

College of Computing and Information Technology, University of Bisha, Bisha ,67714, Saudi Arabia

Abstract

Due to the development of communications technologies, the role of Internet has changed substantially. Now the internet connects thousands of people and physical devices around us. Space and computing infrastructure will become more common and accessible in the near future. Even in recent times, we are seeing the wired or wired sensors connecting people, machines, objects and platforms. In this paper, we present the context, state of the art, development, key players, technologies, challenges, and future opportunities in the field of the Internet of things (IoT) in view of such an internet situation with billions of connected devices. The IoT and machine-to-machine(M2M) industry of the Kingdom of Saudi Arabia (KSA) is estimated to grow from 4.88 billion dollars in 2014 to 16,01 billion dollars by 2020[26]. We also discuss general aspects and IoT problems and examine their involvement in the case of Saudi Arabia in a developing country.

Keywords—IoT, M2M, Sensors, Internet, Wireless, IOT applications

1 INTRODUCTION

The Internet of Things (IoT) is an ecosystem where various devices are connected to an internet infrastructure to interact and exchange data with each other in cyber-physical-space (CPS) [1,15,16]. Sometimes, IoT referred as connection to anything that means, human to human(H2H) connection, machine-to-machine(M2M) connection or thing-to-thing(T2T) connection or object to object to object(O2O) as shown in figure 1. With the advent of Internet of Things, a deluge of devices is being connected to the network and which is generating a large amount of data. There are approximately 8 billion peoples in this planet and there are already more than 35 billion IoT devices connected, so we can conclude that approximately 4-5 IoT devices per person are being used. So just imagine what happen if it increases up to 6-7 or may be 10 devices per person. In the urban city the use of internet is increasing and there would be more than 5-10 devices due to the tremendous growth in smart phone and connected devices. Overall, there are an estimated 127 new devices per second connecting to the internet. According to Gartner research, 75 billion "things" will be connected to the Internet by 2025[27]. In IoT, devices can exchange data, collaborate, and share experiences as humans do among themselves. The concept of IoT is not new, which has started with concept of "Web of Things" that was initiated in around the year 2000 [1,2,3]. In the last one decade, the concept has grown, it is taking a more visible and standard shape that would help in testing and developing usable IoT products with greater penetration into our daily life.

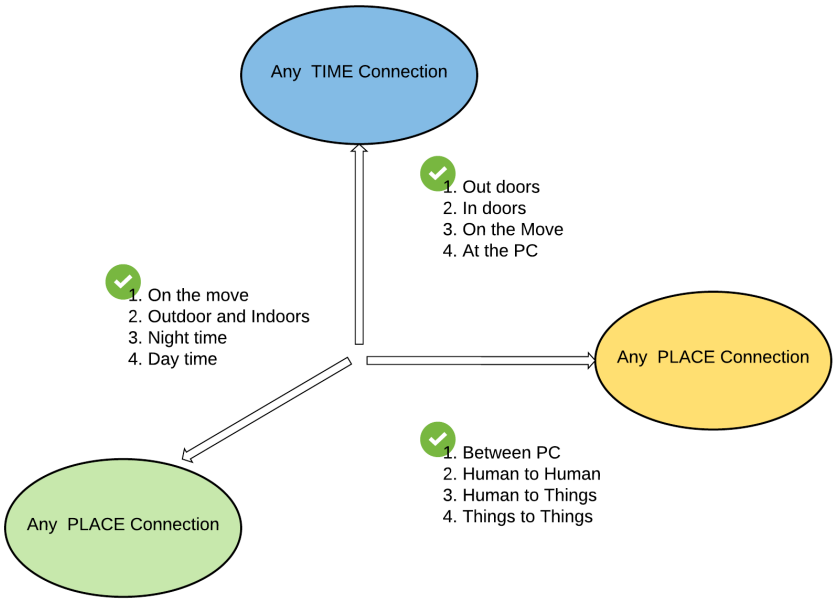

Figure 1. Connection dimension

Secondly, why the Internet is so popular? Why people talk so much about IoT? Why there is a huge demand for this? With one example we could understand from an organizational standpoint. A distribution company such as Almeria in Saudi Arabia could be either a pharmaceutical company or a FMCG company. A person goes to a shopkeeper at a terminal and uploads the information to the distributor and from the distributor points the information transfer to the carrying and forwarding agent in a real time way. The carrying and forwarding agent requires how many excuses and how much trucks will be necessary for delivery tomorrow, so that it can be planned correctly so that the goods are no longer stored in its warehouse by the distributor. The second example of Internet popularity is a better connection between human being. Utilizing sensors to help protect an ecosystem by monitoring air quality and wildlife atmospheric conditions. Therefore, introducing IoT is conceivable in every field to provide appropriate solutions for a wide range of applications such as smart health, medicine tracking, smart mosque, waste management, smart cities, traffic control, security, industrial control, emergency services, logistics and retail services. The technologies such as explainable artificial intelligence (XAI) and machine learning will result intelligent range of connected devices in the next decade.

The future of the IoT is beyond what we think today. We live in exponential times; the number of connected devices is growing exponentially as shown in figure 2. In near future our society will be completely connected that will be efficient and effective, with some fantastic application that have yet to be invented.

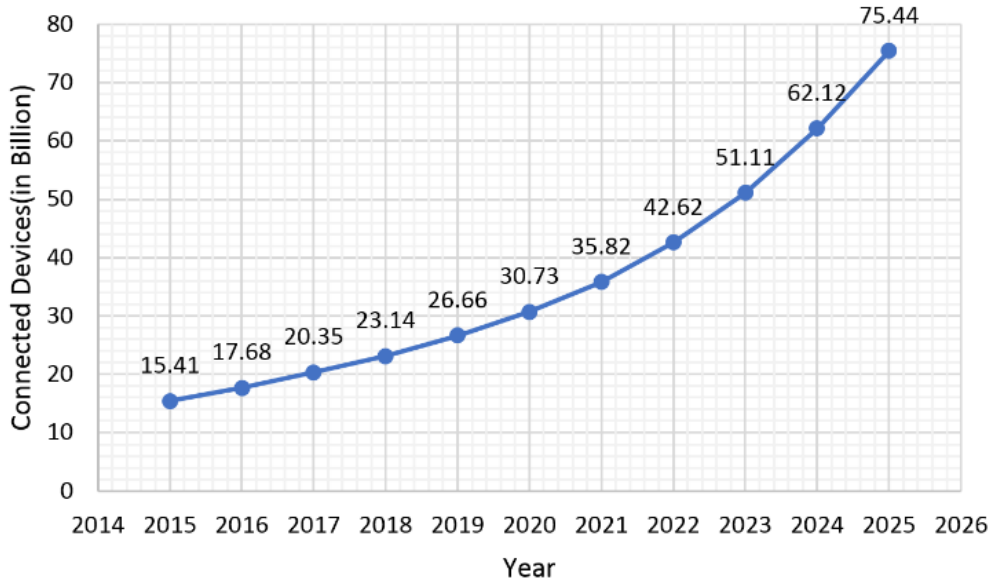

Figure 2. Growth of connected devices worldwide [28]

The Saudi Arabia is investing billions of dollars into the IoT technologies to complete the vision 2030[20,24,25,26]. Presently, the market is fragmented, with technology vendors, systems integrators, service providers, and telecom companies vying for a share of the market that provide opportunities for local, global services providers and technology vendors to form mutually beneficial partnerships [24].

In this paper, we explore growth of IoT Applications, prediction, complexity, and the challenges that this field would face. Some of the most recent technological innovations, changing role of the Internet, impact on economy and different IoT applications are the main motivations.

We have divided the discussions in the paper as follows: after the introduction in Section I, in Section II, we describe the state-of-the-art in IoT, prediction of IoT, IoT presence in Saudi Arabia economy, 5G Impact on IoT and key players in IoT. The Section III talks about future opportunities of the IoT in Saudi Arabia while as section IV talks about the real challenges for its implementation and growth. Finally, section V concludes the paper.

2 STATE-OF-THE-ART IN IOT

The IoT is bringing new opportunities and challenges for the Saudi Arabia to grow its economy. The new digital reforms include AI, blockchain, Smart Solutions and associated technologies. The Saudi Arabia is ready to welcome IoT as data-driven innovation in the area of energy, education, environmental management, security, traffic, healthcare, open data, has been well established. With the deployment of IoT, Saudi Arabia's economy will truly become self-reliant. In a survey it has been found that majority of medium-to-large organizations in Saudi Arabia (66%) believe that Industrial IoT (IIoT) technologies will become critical in the next five years [25,51 to 61].

The IoT will provide ultimate mean for diversification of the economy which will eventually lead to the creation of more jobs for the Saudi population. We can say that IoT technology will surely play important role in Saudi Arabia's drive for transformation as mentioned in vision 2030[20].

The global predictions about Internet of Things, worldwide for year 2019 is shown in the table I [21,22, 53].

Predictions	**Scope**
Overall growth across the board	The growth of IoT market will be in billion by 2025.
Deeper penetration in the manufacturing and healthcare industries	Number of connected devices in the manufacturing industry will be double by 2020. It's been said by 2019 that 87% of healthcare organizations worldwide will have adopted IoT technology.
Increased security at end Points	Manufacturing of devices with increased securtity at endpoints.
Smart common areas in cities around the world	Smart sensors around the neighborhood will record everything from walking routes, shared car use, building occupancy, sewage flow, and temperature choice, etc.
Connected smart cars	Now tons of vehicles have connected applications that shows up-to-date diagnostic information about the car. This is done with IoT technology, which is the heart of the connected vehicle.
More business organizations become smart	The future of IOT is bright, as customer not only the one who are using the IOT devices, business organizations are increasingly implement smart device in order to same money and time.
Artificial intelligence in IOT	Smart homes are the popular homes these days, when we allow AI based technology to record and collect customer data and record in the cloud. This help to understand the customer behavior and interest.
Routers become smarter and secure	IoT based devices reside in the homes and security software's most of the time not installed on the routers. However, IoT raised this issue and forces manufactures to think about the secure routers.

Table 1: Predictions of scope in Internet of things

A. 5G Impact on IoT

The Internet of things is a growing network of internet-connected physical devices processing to ability to collect and share massive volume of information/data. The 5G is the first generation of cellular network technology that has been designed by keeping requirements of IoT applications in roadmap. The earlier cellular technology was designed to be used by mobile phones with batteries that is charged once a day. Subsequently, we have seen that in each generation of cellular technology has consumed more power than the previous generation. The 5G has been optimized for devices sending small amounts of data, thus reducing the overhead of signaling and payload. Thus, 5G extends the life of devices and device can be left in the field for longer time without requiring costly maintenance. The 5G technology will bring in breakneck speeds, maximum connectivity, ultra-low latency, and universal coverage. These benefits would make IoT far more superior and more effective.

The existing applications, products and features would get enriched and enhanced. Another breakthrough advantage of using 5G would be the speed at which the data would get transferred. Considering the speed of transmitting data and resolve latency issues. Organizations are expected to start deploying more of these connected devices. currently, the number of connected devices is expected to exceed 30 billion. The implementation of 5G technology could prove to be a boon for many applications such as driverless cars. As driverless cars have cameras and sensors that are required to communicate with GPS and other sources in real time. The telecommunications industry would also get benefitted, as there will be a massive rise in wireless communications which are enabled by IoT. The IoT will account for one-quarter of the global 41million 5G connections in 2024[43-44].

B. Industry Key Players in Saudi Arabia

The IoT and M2M market is expected to grow from $4.88 billion in 2014 to $16.01 billion by 2019, at a Compound Annual Growth Rate (CAGR) of 26.8% [24, 21]. In Saudi Arabia, the major market of IoT and M2M communication is primarily due to automotive and control system. The IoT has become integral part of the Future Internet that will have network infrastructure with self-configuring capabilities. Also, this kind of network will be interoperable and thus standard communication protocols need to be adhered. In simple terms, IoT is like layer of digital information that covers the physical world. Industries around the world are realizing up-to 50% of savings on energy, and operational expenditure that increase up-to 25% revenues by the adaption of IoT. So, Arab World has started investing at the right to reap the benefits of IoT.

The Kingdom is investing billions of dollars into IoT and aims to implement smart and technology advanced solutions to lead the country in IoT technologies to achieve vision 2030. Saudi IoT aims to bring into the limelight the enormous potential of the internet revolution and the Internet concepts. Saudi IoT coincides with the objective of the 2030 vision, where internet technology is a necessity and compliments the huge investments to simplify businesses in a smarter way which is an added value [46]. In a survey by Micro Market Monitor, the competitive players such as Alcatel-Lucent, AT&T, ZTE, IBM, and Huawei Technologies have large stake in IoT market worldwide [24]. In the table II, we have presented the technology key player in Saudi Arabia.

STC	STC is laying down through its connectivity layer a potential enablement capabilities for KSA enterprise and government agencies. They are developing IoT Application Enablement Platform (AEP), M2M Connectivity platform and LPWAN Technologies
Huawei	The Ministry of Communications and Information Technology (MCIT) partnered with Huawei to launch of the Kingdom's first Internet of Things (IoT). [23]
Zain	Developing 5G and IoT ecosystem, NB-IoT Smart City.
Cisco Saudi Arabia	Cisco has been working with the Saudi government organization has implemented several digital initiatives, namely education,healthcare,broadband ,WiFi, and in future it will implemented on smart Hajj,energy transportation,cloud storage.
Siemens KSA	MindSphere is an open software platform developed by Siemens for the IoT Business. MAC Saudi Arabia is the first facility in the Kingdom to

	offer a living laboratory for R&D and demonstrations of new smart technologies and services
AEC	Smart Mosque, Medicine Tracking using Blockchain, Smart Health
Machinestalk	First fully developed Saudi IoT platform company
Mobily	M2M Energy Management solutions

Table 2: Role of Key players of IoT in Saudi Arabia

The region wise role of the IoT in Saudi Arabia's manufacturing market is shown in the figure 3[45].

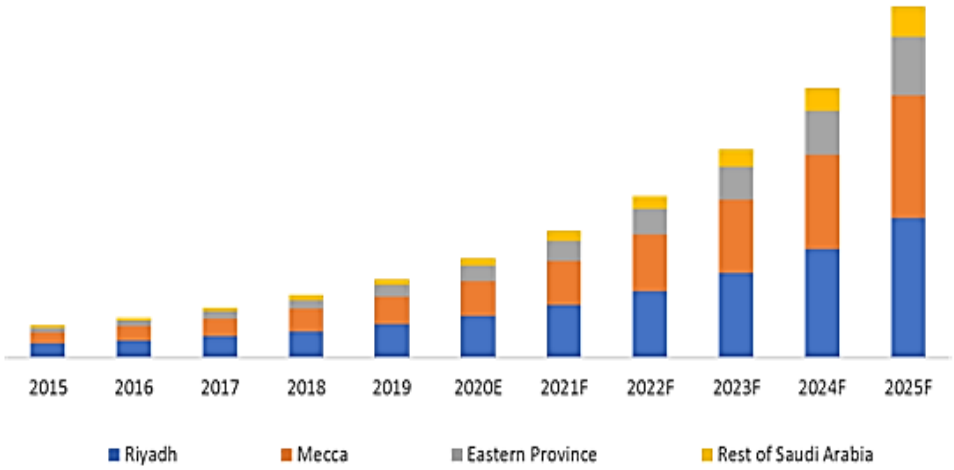

Figure 3: Saudi Arabia IoT in manufacturing market[45]

C. Academic Research in IoT

The academic institutions have great role to play in awareness, innovations and adaptability of any technology. Based on the Web of Science (WoS) database, if we search the publications using "Internet of Things and Saudi Arabia" as keywords for last five years since 2015 to 2019 then we get below graph as shown in figure 4. The figure clearly shows that there is a continuous growth of research in academic community. Although, the number paper is relatively less as compared to any other developed country.

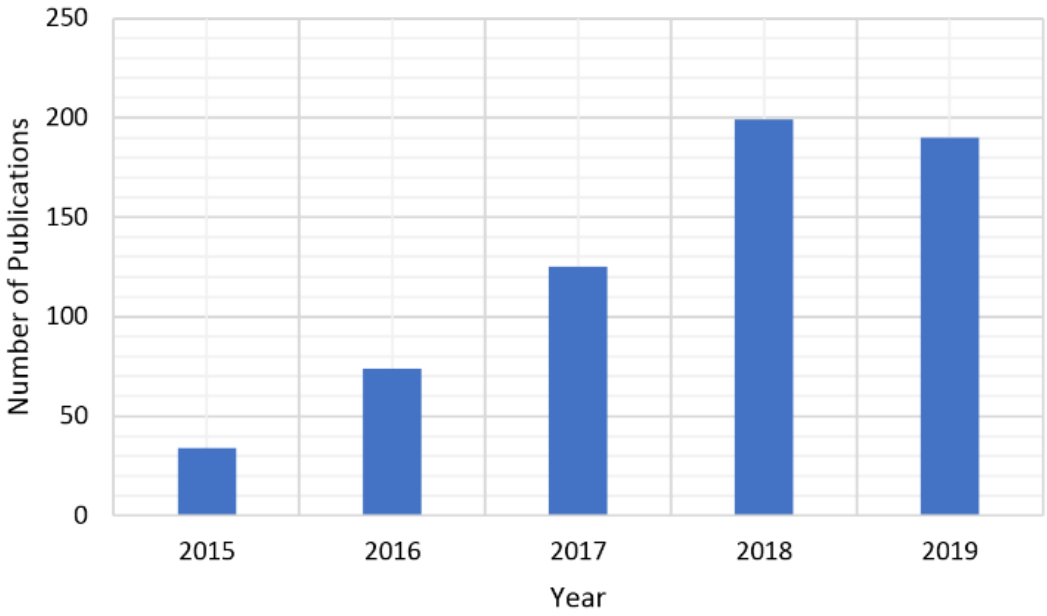

Figure 4.: Number of Publications of Saudi Arabia in IoT

D. Health Infrastructure using IoT.

Healthcare is one of the main focus areas in KSA for vision 2030. This is a big concern where experts are seeking to identify the most suitable solutions to improving the quality of life for patients worldwide. Technology plays an important role for upgrading the Saudi Health Sector day by day. And, there are many applications is used in IoT in the health care system such as patient monitoring system, fitness application, and senior citizen care etc [29]. There are also many challenges like security, safety, integrity mobility etc when applied the new concept [30,31].

3 GENERIC ARCHITECTURE OF IOT

A general approach to understand the IoT reference architecture is based on seven layers as below [13]. Authors have presented seven layers based on reference architecture for IoT [13] as shown in figure 5.

A. Layer 1

This layer includes sensors, gadgets, and controllers. Generally, gadgets are the genuine endpoint for IoT. Depending on the application requirements, different kinds of sensors can be deployed for various purposes. The sensors have the ability to take estimations and readings; for instance, air pressure, quality of air, temperature, humidity, magnetism, etc.

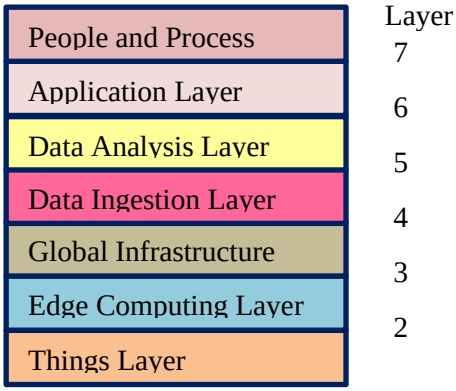

Figure 5: IoT Seven-Layer architecture

B. Layer 2

This layer is responsible for communication conventions and edge outlining. The IoT information is handled on the edge of the network [12]. Primarily, this layer is responsible for flow control, reliability issues, Quality of Service (QoS), and energy optimization. Also, it is responsible for cross-layer communications as when required.

C. Layer 3

This layer is the worldwide foundation layer and provide a common interface framework for cloud like Aamazon, Google [15,16]. An extensive arrangement of coordinated administrations in this layer plays out the accompanying capacities; Gateway, Routing and Addressing, Network Capabilities, Transport Capabilities, Error location, and Correction. Also, this layer is responsible for message steering, distribution and buying. This layer deals with numerous systems and access conventions that are expected to be interoperable in a heterogeneous design. These heterogeneous systems can be private, public that should be able to provide communication necessities for transmission and security [12, 13].

D. Layer 4

This layer incorporates Big data, purging, spilling and information processing tasks. It deals with QoS management, device management, Business Process Modeling (BPM), Business Process Execution (BPE), Authorization, Key Exchange and Management, Identity Management, Trust and Reputation [13, 19]

E. Layer 5

This layer is responsible for data analysis and mining of the information. Many machine learning approaches may be deployed for analysis and learning purposes in this layer. This layer provides business intelligence and thus increase Return on Investments (ROI) in IoT to support business sustainability [19].

F. Layer 6

This layer includes custom applications that make use of the things' information for business growth [19]. The end-user will interact with this layer. The applications range in this layer could be from various industries, for example, manufacturing industries, oil and natural gases, hospitals, security, transportation, retail, conditioning, human services, and so on. This is also interesting to note that with wide use of auto-capturing technologies like RFID [14] and NFC are nowadays advancing in their capability.

G. Layer 7

This layer involves individuals, organizations, joint effort and basic leadership which depends on the data obtained from IoT environment. In this layer, the items to be identified differs from physical moving articles; this layer includes people, vehicles and ecological factors etc.

4 APPLICATIONS, CHALLENGES AND OPPORTUNITIES

In this section we investigate broad areas of applications for IoT that directly impact our lives.

A. Smart Home appliances

Though this area is not new but with the advent of IoT it has geared up. The home automation with active assistance is already a known concept [10]. This system will monitor home appliances, entertainment system, lighting, climate etc. and takes appropriate decision based on the predefined parameters. They make our life easier by following all of the instructions accordingly. There are many products for smart home from the companies like Nest, Ecobee, Ring and August, to name a few, will become household brands and are planning to deliver a never seen before experience. A smart home is a home where all energy-consuming devices in the home can communicate with each other[33]. Smart home is important because if the device in the home can converse and share data, then that system will work in a way that makes the home as effective as it could be. As the home becomes more efficient, then less electricity is needed for the homes to provide energy and energy can either. It is thus in a manner that saves energy and saves money to control and monitor the machine. In fact, IoT has an important role to play in assisting the senior citizens and the disabled people [32]. It allows them to control domestic appliances such as air conditioning, television, and tubes by automation effectively. The intelligent house sends and receive sensor information using the MQTT (Message Queue Telemetry Transport) [34]. The Raspberry pi gateway accesses the sensor information used for temperature and humidity monitoring in the rooms. The smart device is based on MQTT and raspberry pi and can be monitored globally [32].

B. Internet of Smart Agriculture (IoSA)

The smart agriculture is crucial and less addressed area. The continuous increase in population demands for food supply[36]. The Governments agencies are helping farmers to use advanced techniques and research to increase food production. The Smart Agriculture is one of the fastest growing field in IoT that will provide effective production of food. As we understand that farming operations is usually remote and the large number of livestock that farmers work on, all of this can be monitored by the Internet of Things. The IoT can revolutionize the way farmers operate day to day to make it easier. But, as mentioned earlier, this area is unaddressed and idea is yet to reach a large-scale attention. Therefore, smart farming has a lot of potential to become an important application field, specifically in the agricultural-product exporting countries. Various technologies are being applied in smart agriculture such as Internet of things, big data, cloud computing, internet with 5G technology are a few to name. It helps the world food problem that is the world food production needs to increase by 70% by 2050 to feed the growing population of the world. In fact, it is not about feeding people we need to give them good food, nutritious food and we need to increase this food production without harming the environment. The amount of

land is not increasing the water level is going down, the soils is not getting any richer so how to get this increase food production in a responsible way. Most of the land for agriculture in rural areas but now the rural areas are converted into the urban areas in a speed way and the agriculture land is using for residential complex, industrialization. We need to increase our production in smart way using IoT in agriculture also called as precision agriculture [35,36]. The precision agriculture as a technique has been shown to improve yield that is take care of plants better and it has been shown to reduce cost because it uses less water, pesticide, nutrients to protect the environment.

C. Internet of Smart Health (IoSH)

This is another important application area of IoT that has variety of applications in healthcare [17, 18]. This area helps in remote monitoring tools to advance and smart sensors to equipments integration in medical health [17]. It has the potential to improve how medical practitioner deliver care and also keep patients safe and healthy. IoT enabled healthcare can permit patients to spend more time interacting with their doctors, which can enhance patient engagement and satisfaction. From personal fitness sensors to surgical robots, IoT in healthcare brings new tools updated with the trendy technology in the ecosystem that helps in creating better healthcare [11,18]. IoT helps to revolutionize healthcare and provide pocket-friendly solutions for both the patient and healthcare professional. Value-based care is emerging as a new global paradigm to address how patient and overall healthcare are delivered and paid. The value-based care is a relationship between a patient outcome, clinical performance and the associated cost shown in figure 6. The shift to value-based care promises to drive down costs and improve patient outcomes [61 to 70]. It will incentivize care providers to better engage patients and more consistently adopt evidence-based medicine in diagnosis and treatment decisions. But, measuring value across the care continuum will be a challenging task. It will require a much more data driven approach to care delivery. Adoption of advance data management analysis capabilities will be critical to the success of this transformation. A major driving force behind this transformation is the emergence of Internet of Smart Health (IoSH) or more specifically connectivity between patients, clinicians, machines and care environments. This connectivity will ultimately result in exponentially increase in the amount and dimensionality of data. The data available for operational efficiencies and clinical decision making. The intelligent analytics will be an imperative, not an option, enabling faster and more precise diagnoses and more scientific determination of the most appropriate and effective treatment plan. The shift to value-based care is occurring, and IoT will play a vital role. The result, Improved outcomes, reduced costs and ultimately, easy access to high quality care for more people across the globe.

Figure 6: Value-based healthcare

There are many benefits in healthcare using IoT discussed in the table 3. In smart health care system sensors are using to sense the hospital surroundings conditions like humidity, temperature etc. the nurses and medical staffs are responsible for following the ward condition time to time. Using RFID (Radio Frequency Identification) reader sensor verified the genuineness and integrity. Patient health condition is monitored by nurses and she will be updated the condition (like temperature heart beat) time to time and based on this condition it will be showing in graphical chart. Details of the patient sent to a doctor. The doctor will be generating the graphical chart and prescription based on history of the patient [37].

Features	**Benefits**
Improved Disease Management	The patient is monitored on a continuous basis. And, Real time health data is available thus disease is treated before they get out of hand.
Remote Monitoring	Remote Monitoring of patients, health statistics and diagnosis with Internet of Things (Telemedicine) diagnosis and medication requirement.
Better Treatment	Connected health-care solutions and virtual infrastructure makes treatment precise and better.
Improved Emergency Medical Treatment	IoT's advanced automation and analytics allows more efficient emergency response service.
Talking Medical Devices	Medical devices remind patients to take medicine as prescribed and other necessary action to improve

	health.
Accurate collection of health-care data	It minimizes errors and makes precise medication
Ingestible	Pill-size ingestible sensor that measures if patients are taking medications as prescribed by doctors.
Predicting the arrival of patient	Using Machine learning and IoT Medical devices reminds for predicting the arrival of predicting the arrival of patient.

Table 3: Benefits of smart healthcare

D. Internet of Smart Cities (IoSC)

In the smart cities, there are eight centers of gravity for internet of thing application starting a manifest. These are the eight most popular use case with IoT (Internet of Things) for smart cities such as follows:

1. Assisted Vehicles (Example Autonomous Vehicles)
2. Traffic and Parking
3. Transportation Solution
4. Energy and utilities Solution
5. Waste Management Solution
6. Public Safety
7. Citizen Connection
8. Environment Solution

The projection is there in the coming decades overs two third population will live in cities. The Urban and rural areas moving to changes in technologies are representing new opportunities to improve connectivity, public safety and the overall experience residence and visitors. To create a safe and secure city requires preparing for wide variety of challenges from protecting critical infrastructure to medicating the risk for criminal activity and cyber-attacks. The 24x 7 crime prevention and public safety strategy is essential to actively maintain the safety and also relying in emergency preparation to respond quickly in a crisis situation. There are various services provided in the smart city showing in Figure 7.

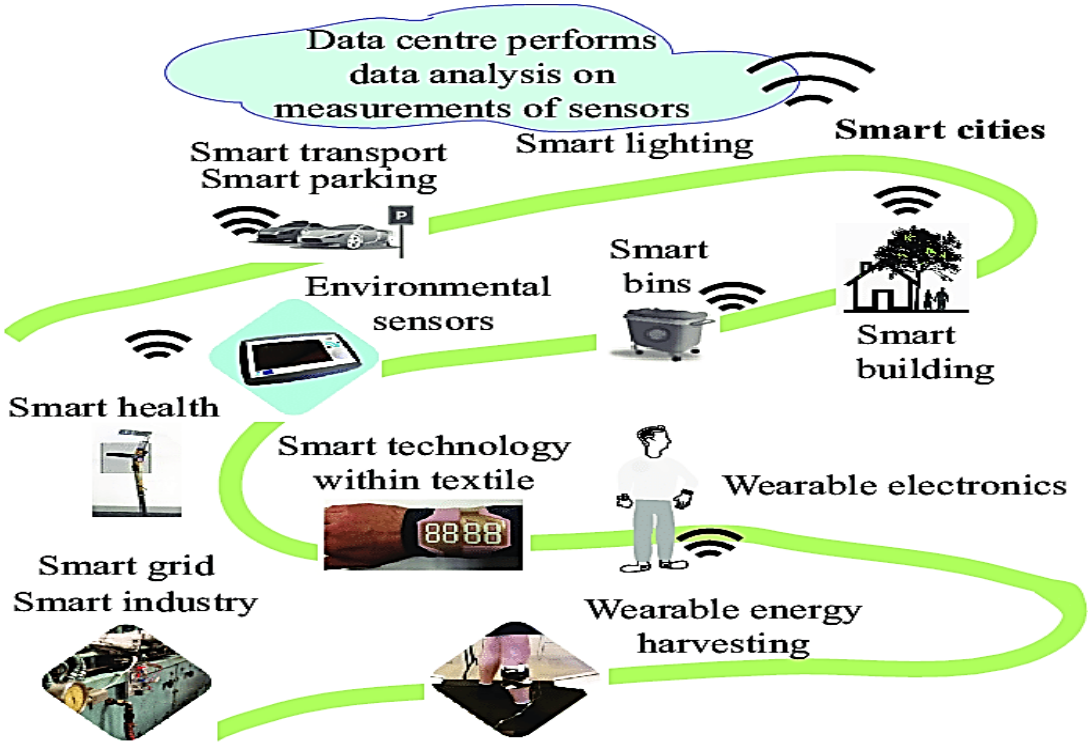

Figure 7: Application areas of smart cities

The Smart city is another powerful application of IoT producing interest among world's population. Smart surveillance [6], automated transportation, children tracking [5], smarter energy management systems [7, 8], water distribution, urban security and environmental monitoring, smart garbage/waste management using CrAN (Crowd Associated Network) [4], Green and clean environment, all are examples of Internet of Things applications for smart cities. IoT will resolve fundamental issues faced by the people living in cities like pollution, traffic congestion and shortage of energy supplies etc. Products like cellular communication enabled Smart Belly trash will send alerts to municipal services when a bin needs to be emptied [9,38]. With the help of GPS, information from drivers' cell phones (or street surface sensors inserted in the ground on parking spaces), smart stopping arrangements can decide if the parking areas are available or reachable and make an ongoing stopping map. At the point when the nearest parking space turns out to be free, drivers get a notice and apply the guide on their smartphone to find out a parking space faster and simpler rather than aimlessly driving around. Moreover, IoT has number of applications such technology allows us to have strong communication between different stakeholders [51-51] such as relationship between hospitals, patient, families, police stations, shopping malls as shown in figure 13.

E. Internet of Smart Industry (IoSI)

One way to think of the Industrial Internet is by looking at connected machines and devices in industries such as electricity generation, oil, gas, and healthcare. It also makes use of conditions

where unplanned downtime and system failures can result in life-threatening situations. A device embedded with the IoT tends to encompass gadgets such as fitness bands for heart monitoring or smart home appliances. These systems are functional and can provide ease of use but are not reliable due to the fact they do not typically create emergency situations if a downtime was to occur.

Figure 13: General IoT applications

F. Internet of Smart Retail

The Internet of Things is also changing the world of retail. IoT is important for retail success, if retailers can avoid its security issues[40]. Most of the internet of things especially in retail organization is going to heavily rely on wireless communication using various different RFID technologies whether it is new field communication ZigBee, Zwave, Bluetooth all connecting to enterprise business solutions [39]. According to Euromonitor International's report at the end of last year, the retail industry in Saudi Arabia is worth $106 billion and is forecast to steadily rise to $119 billion by 2023[50]. Vendor are using IoT technology to enhance their customer experience, cut costs, fuel growth and increase overall efficiency. There are several ways the retail industry

should take advantage of IoT innovation. Sensors are currently being used to monitor customer service, to provide visibility into the supply chain, and to monitor food safety

a) Monitor customer service

Retailers use IoT to improve customer satisfaction. IoT sensors associated to a dashboard or collection of color-coded buttons allow stores to gather customer feedback quickly after the shopping experience. This data offers insights into customer satisfaction in real time which can improve customer service in the store.

b) To provide visibility into the supply chain

Retailers also use the IoT sensors to monitor goods across the entire supply chain. Tracking systems disclose useful data such as position, temperature, moisture, shock and tilt, providing insights into quality control and traceability. Tracking solutions help decide whether products are secure, delivered on time and conveyed under ideal conditions. All information that can help retailers increase the quality of their transport logistics, reduce product harm and prevent loss.

c) Monitoring food health

Companies in the food and beverage industry use IoT technology to control storage space temperature to help them ensure that food does not spoil. Prepared food spoilage and depletion in the retail grocery industry leads to a major loss in productivity, with groceries losing an average in $70 million per annum to spoil themselves. IoT applications can help to decrease spoilage losses and ensure that food safety protocols are enforced by efficient control of the food storage facilities temperature. It is achieved with a simple computer mounted in the storage unit and linked to an online dashboard which is programmed to submit alerts in case of high temperature rates. Real-time IoT sensor data can help retailers protect perishable goods, provide full freshness and reduce waste.

d) Controlling assets

Vendors are monitoring missing shopping carts and baskets using IoT technology. Tracking these items will help the stores cut back on the cost of replacing them. By installing sensors on assets such as shopping carts, retailers can monitor them at their exact position and provide status notification and warnings if they are harmed. Such sensors will allow retailers to enhance their customer service by ensuring that there are always enough shopping bags and carts available for shoppers.

The potential of IoT in the retail sector is enormous. IoT provides an opportunity to retailers to connect with the customers to enhance the in-store experience. Smartphones will be the way for retailers to remain connected with their consumers even out of store. Interacting through smartphones and using beacon technology can help retailers serve their consumers better. They can also track consumers path through a store and improve store layout and place premium products in high traffic areas.

G. Internet of Smart Learning

Technology has changed the way we live, learn and work[41]. The plethora of data available on education and the development of new technologies has made us reconsider how students are taught and educational institutions are run. The way IoT in learning environments support

educators can influence how we as a society collaborate, communicate and operate. The IoT is changing the landscape of education.

a) Safety issues

Parents are constantly worried about safety of their child with traveling of school bus and inside the school, but with the IOT they can know about real time location, pick and drop alert and route deviation alert which makes more aware and when the child reaches school premises with the help of indoor sensors they can update all the time. The students can take following benefits from IOT.

1) Auto Attendance Monitoring- When the students come inside the school premises the attendance can monitor automatically using IoT devices.
2) Constantly monitoring for safety - Students monitor constantly with smart sensors and they can call help using IOT devices if there any emergency.
3) Interactive display Board - Using smart board the students can take a knowledge and also there is option for virtual learning or remote learning, if any students has missed the class or he wants to listen the lecture again then there is option for recorded lecture.

Figure 8. IoT Benefits for education actors

In this era, various resources for learning purposes to make things simpler, stronger and smarter. With the help of IoT education as a means of teaching, monitoring and research that facilitates and smarts education life[42].

The Open University, UK, launched a new IoT-based approach courses called “My Digital Life” for undergraduate students in the department of computer science contains the IoT definition on the base on its importance as a dynamic subject. This subject helps students to use ICT as a resource and to prepare for understanding the function of IoT to the real world. It is used to teach the students to develop the fundamental principle of programming language IoT [48]. According to [49], as an IoT teaching tool, English terminology is taught using trained IoT-based models that use voice and visual sensors for English learners and also learn the pronunciation

H. G. Internet of Smart Grid

The smart grid can be defined as a combination of electrical power grid and IT.

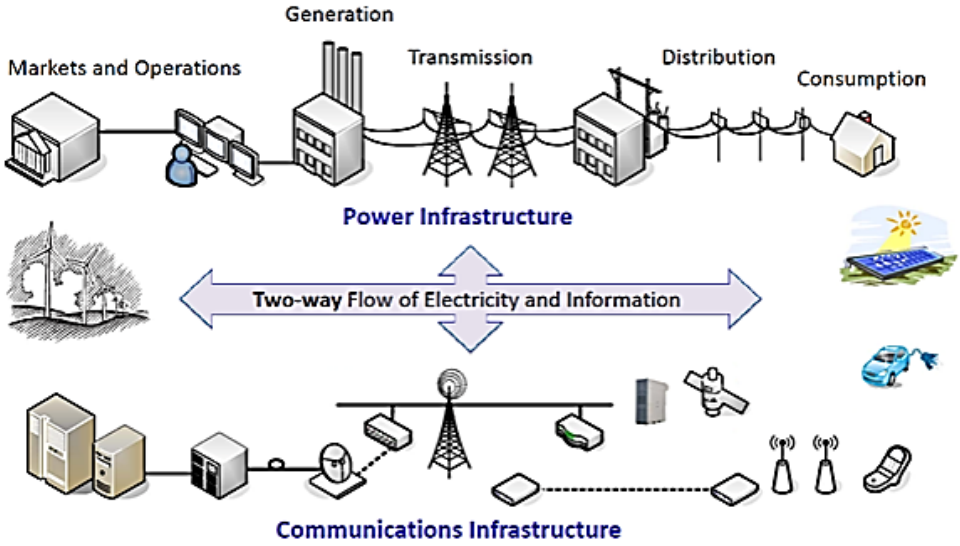

Figure 9. Future smart grid

In future smart grid, we can use different kinds of renewable energy sources like wind and solar panel. In Figure 9, the sensors are retrieving data from power panels. Transmitting the data in real time and also showing the electricity and information in two-way communication.

1) Smart Meter

A smart power meter is a modern type of smart gas and power meter that can relay meter reading for more error-free energy bills remotely easily to the electric supplier as shown in Figure 10. The system used in smart meters is a secure national communication network, which automatically and wirelessly transfers the real energy consumption to the supplier.

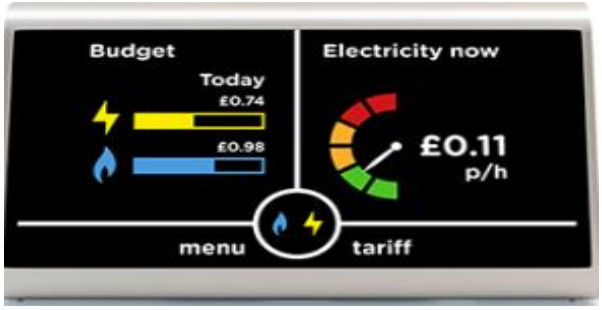

Figure 10: Smart Meter

Saudi Electricity Company (SEC) has signed 9.5 billion SAR contracts for the ambitious project with a target to build 10 million smart meters by the end of March 2021[47]. IoT is a vital part of smart grid as it facilitates an uploading of various parameters and downloading of commands from utilities. Consumer can monitor their real time energy statistics and control the time of the day usage based on unit prices. IoT is also playing an important role in smart grid home automation. Various communication protocol such as ZigBee, Cellular technologies, Wireless HART, Bluetooth, WiMAX etc. can be used for communication between network devices.

2) Smart Generation

When electric supplier starts to generate production of electricity so they are using different types of renewable resources like solar panel, wind, hydro station. So, they are transmitting this energy

using of automation component like SCADA, PLC and we are distributing this energy as per the demand and supply. Commercial purpose needs more power, so they will identify usage and demand from the market automatically they will distribute this energy in smarter way.

3) Smart consumption

Smart consumption will make the response to demand and lies at the interface between distribution management and infrastructure automation.

H. Challenges and opportunities of IoT

1) Challenges

There are so many challenges when we are going to implement IoT as shown in Figure 11. Some of the challenges are discuss as follows:

a. Security/Personal safety - It is very important and high rated challenges. The most of the devices are used in the IoT infrastructure and who is monitor our devices our data. This is the big challenge. User Data Cloud be vulnerable for theft. People personal safety is a concern and challenge. Too Many devices are in the loop, one device is getting attacked, rest of the devices could also be attacked. Poor security features can let the attackers damage the whole network.

b. Privacy - There are no privacy we could say because we are continuously monitored. we could be tracked/monitored by anyone, as you can connected 24x7 in the internet. We could be tracked without our permission in place.

c. Data Extraction from complex/dynamic changing environments - Suppose a very temperature sensitive material is being transported so how to sense the data (Temperature/humidity etc) during transport from a transport vehicle. Suppose drugs are getting transport one place to another and drugs are to be maintained a particular temperature. we have to make sure the drugs are maintained a particular temperature if we miss one degree centigrade it will spoil.

d. Connectivity - Connectivity is very important because without connectivity nothing to be happen where there is no connectivity or low connectivity the IOT is failure. Many countries have got many different ranges per licenses where the most prominent free license 2.5GHZ Band is everywhere.

e. Power Requirement - Most of the IoT devices are powered by battery. Thanks to long lasting batteries, however, demand for power is ever on the rise and usage of green power sources like solar/wind is to motivated

f. Storage - There is one more challenge we are facing where we can store our data. Are we storing our data in the cloud or in the local server?

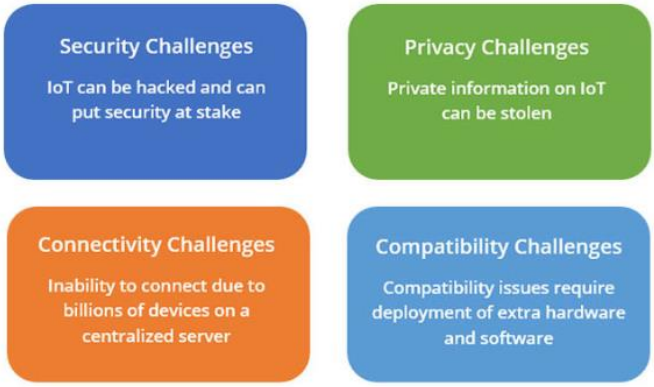

Figure 11: Challenges in Internet of things

While the future of IoT seems to be promising but there are several weaknesses inherent in the idea itself. There are real concerns about the devices from various organizations who may not be interested in connecting their devices with each other because it may open up a new channel for stealing or sabotaging information. Some doubt surely would play in this scenario. If the people cannot be integrated with the system in a smooth way, potentially IoT cannot make any significant difference in our daily life or for the companies to satisfy their customers or buyers. The compatibility between different kind of hardware involved would be a real challenge. The second, is associated with the substantial Investment. This should include funding the thorough pioneering research works which may increase significantly in the coming days. The third issue is the security, connecting devices across the globe is the major concern that may be compromised by a group of hackers. Ongoing activities of hackers attempting to pick up control over smart fridges or smart TVs are not doing any good to the reputation of IoT. Security like many other settings, would be a real concern for IoT. The data challenges, different formats and capacity is another concern in this series. The last issue is the lack of standardization among IoT protocols.

2) Future Opportunities

The opportunities for IoT are indeed many. There is no shortage of interest from the industries and common people. Recent initiatives such as “Open Interconnect Consortium”, “The AllSeen Alliance” and the proposal from IBM (Adept) for the use of modified Bitcoin blockchains in IoT. A blockchain is a distributed public database that maintains a continuously growing list of data transactions, protected against tampering and revision. It grows linearly and chronologically as new completed blocks are added to it. Blockchains hold promises in helping to resolve most of the above problems and in alleviating integration challenges. Bitcoin blockchains take a lot of computing power to generate. IBM proposes to increase speed and scalability by partially replacing the “proof of work” part of the block by a “proof of stake”, which require far less computations. As we know that every threat comes with some opportunity. Therefore, let us briefly summarize the strength, weakness, opportunities and threats (SWOT) as shown in Figure 12.

Strengths	**Opportunities**
Behavior Tracking	Medical Applications
User Friendliness	Wearable Devices
Cost Minimization	Smart home Innovation
Sensor-Driven	Standardization

Weaknesses	Threats
Compatibility	Hacking
Substantial Investment	Development Cost
Security	Lack of Interest
Data challenges	User's expectaton

Figure 12: SWOT Analysis of IoT

In future we will review the eco-structure of IoT. In eco-structure, the billions of devices can communicate simultaneously, autonomously and securely. The system made up three levels. First layer is intelligent Blockchain, this is how ensure system in technically and scalability. The second layer is Open Economic Framework that allows IoT devices interact with each other and negotiate contract terms. Third layer is Autonomous Economic Agents that represents IoT devices. Artificial Agents provides them mobility to search, negotiate and trade knowledge prediction value using digital currency. The Agents gather imprecise information from different sources, creating knowledge which delivers valuable insights that will be meaningful impact of our life.

5 CONCLUSION

Technology is necessary to achieve the ubiquitous network society that we expect for the future. With the tremendous advancements of electronics and IT, we have already entered some type of mature stage. Based on the current platform, the IoT is growing at a rapid pace. With the promise of easing daily life, governance of people, sharing information the Internet of Things has attracted many sectors and people in the globe. In this paper we have discussed many aspects like market size, Key players in IoT, prediction about market, academic aspects, general architecture, opportunities and challenges. The willingness of the people to welcome new technologies and the vision of a digitally capable society are the positive points for successful IoT-based settings in Saudi Arabia

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