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A Survey on the applications of IoT: an investigation into existing environments, present challenges and future opportunities

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ABSTRACT

In today's digital environment, devices are able to interconnect and react to contextual data more than ever before: artificial intelligence is beginning to coordinate how data collected from sensors and de-vices within the network is analysed, and device ecosystems are replacing standalone devices to deliver solutions to the user. In this paper, the researcher explores current implementations of IoT that have led to positive outcomes for the user; but also, the challenges that remain in today's applications. Moreover, ex-ploring these current barriers may be able to infer future applications capable of being deployed on a global scale

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1. INTRODUCTION

Even over the past couple of years, the internet has seen major advancements in several areas. In contrast to the earliest form of internet-which consisted primarily of static text-based web pages-modern sites such as Facebook and YouTube include a rich variety of components that interact and summon data from other pages automatically. This marks what is referred to as the 'web 2.0' and combines the functionality of static information access and social capability together. However, building on this capacity to access information and act on this information with other online users: the next stage of advancement is predicted to move to socially enriched networks-to networks that consume and learn from data themselves. Under this model, the intelligence of networks extends beyond metaphorical locations of information and rich media; and extends to a network of data collected through physical devices. In this 'web 3.0' environ-ment, networks issue direct commands to physical machines and devices simultaneously: this enables networks to not only navigate user scenarios using real-time data collected through in-terconnected devices, but also deliver physical experiences to the user. Furthermore, in light of this potential, many large organisations and nation states have planned to switch to an IoT-based network in the near future: this includes major governments such as China, Russia, India and the United States. In this paper, the researcher provides a detailed overview of how government bodies and organisations are integrating IoT into sectors such as healthcare, trade, manufacture; and the creation of 'smart cities' that are more ecologically efficient. Moreover, this study highlights how the potential and planned future applications of IoT in such sectors; but also contrasts this against existing implementations and the barriers that will need to be overcome for major organisations to bridge this gap [1].

2. RESEARCH METHOD

Building on conceptual benefits of IoT that attract initial interest among major organisa-tions, this study will explore whether such benefits manifest in present-day IoT applications; how current applications are transmitted and classified; and the perceived challenges of organisations having experienced IoT applications in their present-day form. Furthermore, this examination of how organisations perceive existing implementations of IoT will not only seek to highlight the challenges that currently face IoT applications at the technology level; but also, the viability of their integration into social and economic scenarios. Moreover, future research may seek to further investigate the implications of IoT in the social and economic contexts that will be introduced in this paper.

2.1. IoT for manufacturing

With an expanding market and a push to integrate technologies that maintain competi-tiveness in meeting user demand: features that reduce cost, increase quality and improve lead time are increasingly attractive in the manufacturing sector. With the capacity to enhance these metrics and drastically improve efficiency of communication in routing, control and guidance; an IoT-based platform is perceived as an attractive 'transition environment' for organisations to move towards full IoT-based manufacturing [2].

2.1.1. Hardware for IoT manufacturing

In recent years, developments in artificial intelligence have been used to enhance lo-calised sensors as a means to increase the responsiveness of information transfer between lo-calised devices. Moreover, this has not only led to many specialist use-cases in scientific re-search, but has also led to applications outside of networks and communications. This integration and interconnection of embedded sensors forms the basis of the IoT concept, whereby a localised device is able to interpret its surrounding environment; and respond accordingly using thermal, photovoltaic or kinetic responses [3]. For the first function, (Tag) consists of two primary components: 1) the storage and pro-cessing unit, and 2) the receiving antenna. The information contained within the storage bin is transmitted via the antenna to the reader to the computer. On the other hand, the reader is divided into two components: 1) the processor, and 2) the memory unit. Under these components, the information is checked using the processor, which contains its own unique serial number. Furthermore, in in order to read the information encoded on a tag, a two-way transmitter-receiver called an interrogator or 'reader' used the antenna to emit a signal to the tag. In turn, the tag responds within the information contained in its memory blank, whereby the read results are then transmitted by the interrogator to a RFID computer program as shown in Figure 1 [4].

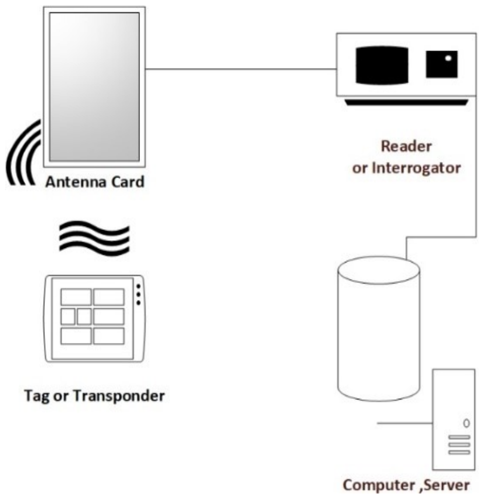

Figure 1. RFDI work

2.1.2. Software for IoT manufacturing

Building on the capacity of IoT sensors to enhance localised hardware and devices, IoT is also influencing the software used to coordinate the collective networks: in order for the sensors embedded across devices to interact efficiently as part of this collective network, this requires new approaches to manufacture software design. In order to further develop the fields of MIoT, TIoT, RIoT, HIoT and SIoT, the principles of IoT integration must inform future manufacture software at its design stage as shown in Figure 2. This implies that the first stage towards taking full advantage of the collective device networks is to ensure that future software packages for manufacture applications are designed to consider individual devices as part of an interconnected device network [5].

Furthermore, by designing software applications to coordinate a network of intercon-nected devices and sensors, this will enable future manufacturing processes to evaluate perfor-mance and administer solutions by collecting this real-time data. In addition, as well as security benefits of relying on a virtual storage space located in the cloud that is not defined by a physical location; the transition from localised to cloud-based storage systems also removes the burden of localised processing of complex directives and commands, thus reducing the overall processing footprint across the device network. Moreover, in addition to reducing the effective processing power required to action each issued command, the delegation of higher-processing to the cloud will also enable faster reaction times: this set of advantages is further highlighted in the below model illustrating the progress of MIoT in net energy consumption; but also indirect causes such as economic changes and overall enhancement to the user experience at each stage of the man-ufacture supply chain as shown in Figure 3 [6].

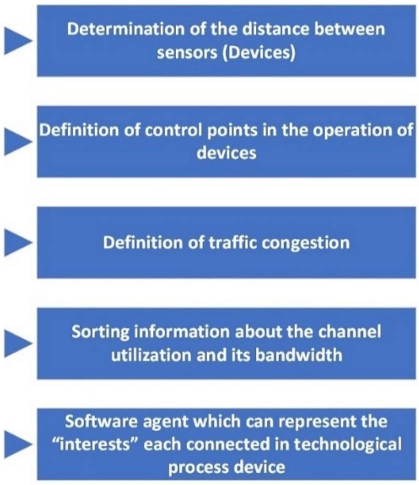

Figure 2. Stages of MIoT development

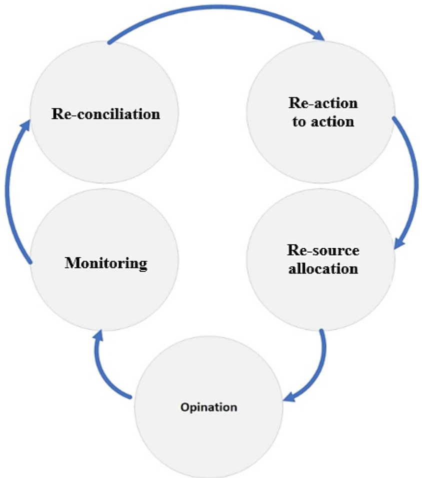

Figure 3. Life cycle of MIoT

2.1.3. The challenges of IoT manufacturing

The challenges facing IoT in manufacturing are numerous, including technical and social challenges. Despite the potential benefits of IoT on manufacture applications, there are numerous challenges to IoT: this encompasses technical limitations in achieving such conceptual benefits, but also socio-economic barriers that may limit the extent to which a full IoT-based supply chain could manifest [7].

a. Challenges

These include the capacity of present-day IoT systems to meet delivery times: despite advancements in the software and wireless technologies required to achieve IoT-based manufacture, difficulties in compatibility, integration and the realistic ability to achieve real-time transmission of data limit the ability of current applications to achieve the assumed delivery-time advantage over traditional alternatives.

b. Data storage and management

Similarly, despite the conceptual benefits of databases and cloud-based storage, the reliability of present-day cloud solutions is often inefficient in achieving all required outcomes in compliance and data security. However, there are increasing improvements in the immutability and cross-platform compatibility needed for cloud-based data management to be applied to manufacture applications and will be ex-plored further at the end of this paper.

c. Social challenges

In addition to current technical barriers facing IoT, the dimension of social expectations and biases towards traditional employment formats may also limit the speed at which fully IoT-based manufacture could manifest: as an IoT-based alternative would eliminate the need for many manual tasks at each stage of the supply chain, this may lead to large-scale displacement of employment. However, although the regulatory frameworks set by future governments may prioritise traditional labour over the benefits of increased supply chain efficiency; a mechanism will later be introduced in this study that preserves the same efficiency benefits of IoT, but without impacting the demand for traditional labour directly [8].

2.2. IoT for transportation

In addition to increasing the efficiency– and in some cases, safety-of the manufactur-ing process; IoT also presents an opportunity to increase the safety of passengers in transport scenarios. Furthermore, the integration of interconnected sensors into roads and devices would enable IoT networks to forecast congestion, identify breakages; and in-turn administer real-time actions across all connected vehicles in order to preserve travel speed and passenger safety. Moreover, a detected fault could enable a vehicle to be reirected through a shorter passage to-wards the same destination, assuring passenger safety whilst maintaining the requirement whilst avoiding congestion: with 5G connectivity enabling the reaction-time that would be required by high-speed transport scenarios, internet terminals and cloud-based artificial intelligence could be combined to coordinate this real-time flow of data that would be required for an IoT transportation system [9].

2.2.1. Hardware for IoT transportation

a. The vehicle-to-vehicle (V2V) solution

The national highway traffic safety administration (NHTSA) is exploring the use of vehicle-to-vehicle (V2V) communications in order to reduce traffic accidents and improve overall safety. Current implementations of V2V technology are designed to reduce unexpected proximity between vehicles, notify drivers of unexpected changes in surrounding vehicles; and thus, reduce unexpected accidents. Furthermore, an additional application of V2V includes a left turn assist that warns the driver not to turn left depending on the flow of the oncoming traffic; and also, an intersection move assist warns the driver when not to enter the intersection when the probability of collision with other vehicles is high. Collectively, this combination of V2V assist functions currently prevent up to 592,000 collisions per year [10].

b. Real-time vehicle location information and data sharing

By connecting to a network of in-terconnected devices with access to real-time location data, a mobile application is able to warn passengers of unexpected waiting; predict accurate travel times based on this real-time data; and delivery these notifications wirelessly as the location of the user is changed by a moving vehicle. Furthermore, in addition to real-time user scenarios, this data aggregated IoT devices also enables transit officials to diagnose inefficiencies within the transport net-work, and apply modifications to the structure of the transit network [11].

2.2.2. Software for IoT transportation

Software used for IoT transportation applications follow six principles of implementation: the ability to interface with technology used for radio frequency identification; the processing of data collected from the surrounding environment using sensors; the active or planned integration with nanotechnology; a compatibility with intelligent embedded technology; and the incorporation of other technologies such as cloud computing and IPv6.

a. Nanotechnology

Once a device is constructed at the scale of nanometres, components begin to exhibit unique physical properties not found in equivalent devices constructed at traditional scales. For example, an object built using iron diamond alloy at a scale of 20-30 nm exhibits a mag-netic force that is 1,000 times higher than the same alloy used for larger traditional com-ponents. Building on these advances, the unique benefits of nanotechnology have been applied to IoT systems: just as electronic tags can be used to track larger objects, electronic tags developed at the nano scale now enable IoT systems to monitor changes occurring at the molecular level, and trigger changes in response to this collected data. This represents a newfound opportunity to apply the conceptual benefits of IoT information processing to bi-ological systems and other complex environments that would be out of reach for traditional sensors and devices [10].

b. Cloud computing

Cloud computing refers to a combination of internet technologies that enable data storage and processing capabilities that are dynamic, easily scalable and independent of one phys-ical location. This set of information processing and storage functions is often referred to metaphorically as the ‘cloud’; although this term originally referred to the telecommunica-tions network, this has since evolved to encompass the interconnected technologies that enable virtualised storage locations. Since its inception, modern cloud platforms are able to complete 10 trillion operations per second for the user, with the processing capacity to simulate nuclear explosions; model weather patterns and predict climate change; and project trends in the consumer market. Moreover, this cloud network is accesses and sustained by a range of mobile and computing devices, each enabling the user to access the system according to his or her requirements.

c. Embedded technology

Embedded technology involves embedding a computer as a component for information pro-cessing and as part of an application system: this embedded set-up can function with a minimal amount of code; and yet automate numerous activities with fast reaction times. Em-bedded technologies. As embedded technologies have become more widespread through-out the 21st century, common household appliances such as refrigerators and washing machines have become capable of interacting with a wider network of interconnected de-vices. Moreover, as embedded technologies are centred around software applications, future updates to this governing software will enable manufacturers to enhance functionality and response times without modifying the original hardware: future applications will be able to control devices according to precise function, required priority level as part of the device network, and required level of power consumption. To illustrate this relationship, the below model highlights how advancements in IoT have in turn enhanced energy efficiency and distribution; economic mobility and perceived quality of life [12].

2.2.3. The challenges of IoT transportation

a. Security vulnerability

With the number of devices and sensors connected to the network growing exponentially, measures must be taken to protect networks from vulnerabilities and protect sensitive data. Although registering for an enterprise mobility management (EMM) solution and ensuring compliance of all IoT devices to an organisation's security policies may mitigate this chal-lenge to an IoT transportation network, a long-term strategy for combatting security vulner-ability include data transfer encryption, control of user access and other measures such as mandatory device authentication.

b. Extending the network infrastructure

As IoT devices proliferate existing networks, one challenge will be capacity of organisations to sufficiently extend their network infrastructure as the number of IP addresses and vol-ume of data increases over time, and to maintain compliance with increasing workload of information technology (IT) teams.

2.3. IoT for retail

There is no doubt that the development of networks, communication, sensors and their emergence into artificially-intelligent IoT platforms will transform how future products are trans-ported and manufactured; but this will also cause the retail sector underpinning this supply chain to adapt to this same IoT-driven intelligence. With large volumes of consumer and activity data collected at each stage of the purchase cycle, this will enable organisations to cease modelling sales scenarios using past client data; and develop models using the most up-to-date indicators from across the IoT network. In turn, this enhanced accuracy enabled through real-time data will empower consumers to make more calculated decisions: this advantage of product data coupled with the enhanced functionality for cashless payments may accelerate consumer competition by increasing the number of displayed options a consumer can consider and purchase within the same allocated time in a retail environment [13].

2.3.1. Hardware for IoT retail

One application of IoT in retail hardware is the microcontroller, Arduino; which is used for building digital devices and interactive objects that are able to sense and control objects in the physical world: it has 14 digital input/output pins (of which 6 can be used as PWM outputs); 6 analogue inputs; a 16 MHz quartz crystal; a USB connection; a power jack; an ICSP header; and a reset button. In addition, the microcontroller is provided with everything needed to inte-grate the microcontroller with other hardware; is able to connect seamlessly to a computer using a USB cable; and can be powered using a standard AC-to-DC adapter or battery. In addition, one further example of IoT-compatible retail hardware is the ESP8266 Wi-Fi Module: this is a self-contained and integrated TCP/IP protocol stack that provides the microcontroller access to the user's Wi-Fi network and the ESP8266 can either host an application or offload all Wi-Fi networking functions from another application processor. Furthermore, each ESP8266 module comes pre-programmed with an AT command set firmware: this enables the user to seamlessly connect the module to his or her Arduino device and access the maximum signal strength available from the Wi-Fi Shield. Additionally, as well as being an 'out of the box' solution and practical to install, the ESP8266 module is highly cost-effective compared to other solutions, and has subsequently attracted a large user base. In addition to this example of IoT hardware used for retail functions, the cell Load Cell A also makes use of IoT-based functionality: this device is described as a measuring device capable of measuring item weight 'at the finest figure" due to its high accuracy [14].

2.3.2. Software for IoT retail

As illustrated in Figure 4, under this software design, these two inputs are provided by HX711 and the RFID reader to the Arduino processor: this functions by producing an analogue cell from the load cell to the HX711; converting this into a digital signal; using the RFID tag to transmit information about the product to the RFID reader, and then sending this information back to the Arduino processor. In addition, all information produced by the Arduino processor is processed using a Wi-Fi Module stores in the cloud: all sored information in the cloud can be accessed through an Android App and Server in order to produce a certain result. Furthermore, each RFID tag is used to store different product information: this makes it paramount to assign the correct RFID tag to the right product, and for the correct information interpreted by the RFID reader to be sent to the Arduino for processing [15].

In its application to retail scenarios, a mobile device is used to control a mobile appli-cation: this facilitates simple customer-facing functions such as viewing a list of available items for purchase, viewing a map of the product, searching for further products, checking the nutrient contents of a product or checking its expiry date. In turn, this enables the customer to create his or her own list of products, and also to build custom lists according to visible discount rates and advantageous combinations. Conversely, for the administrator, the login portal enables a different set of functions such as adding or removing visible items, evaluating the client-facing product list, and tracking purchase patterns. In addition, the mobile application is able to use the IoT network to detect stock in product inventory; subsequently provide a warning message to the administrator if an order request exceeds that of available stock inventory; and lastly trigger the administrator to make an order using the web server. This web server interface provides the advantage of display-ing the most up-to-date information and metrics on an organisation's available products as shown in Figure 4 [16, 17].

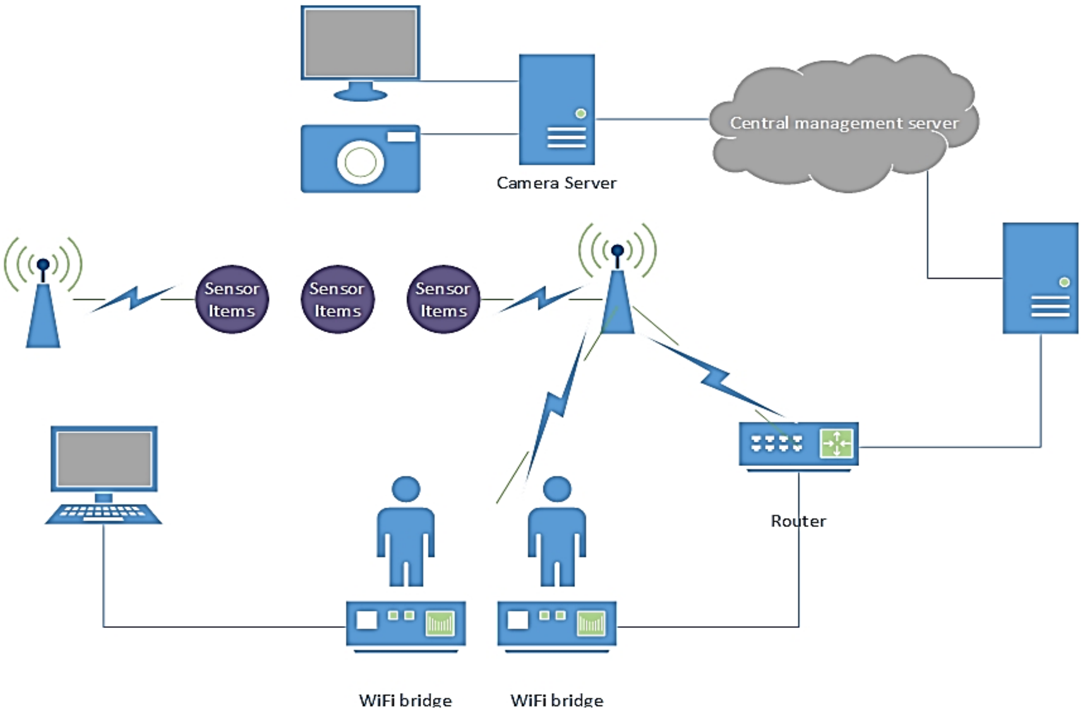

Figure 4. Structure design for IoT retail as example

2.3.3. The challenges to IoT retail

On the one hand, there is no doubt that IoT technology represents a major opportunity to enhance retail operations and experiences by improving operating efficiency. However, despite the conceptual benefits of IoT in the retail sector, the majority of current IoT implementations are considered undermined by several factors. On the one hand, the potential ease of use and flex-ibility of IoT technology is limited by its lack of uniform standards: this directly undermines the conceptual benefit of combining a wide variety of sensors, computers and other devices under large interconnected networks. However, in addition to a low maturity of the industry, the factor of cost also undermines the conceptual advantage an IoT system would eventually acquire through economies of scale: key components such as RFIDs are still out of reach of most projects and or-ganisations; and presents a secondary issue whereby larger organisations capable of negotiating a lower cost-per-unit may acquire a monopolistic competitive advantage through unrivalled data processing and market scanning capabilities [13].

2.4. IoT for healthcare

On the one hand, the rise of Internet of Things (IoT) technologies characterises some of the most significant advances of the 21st century, and has subsequently been associated to futuristic projects in next-generation manufacture, automated warehousing and environmentally-sensitive smart cities. However, although IoT does present the opportunity to redesign traditional industries into an ecosystem of interconnected devices, this metaphor of the 'intelligent organ-isms' may also able to enhance the biological systems from which IoT was inspired: with billions of data points and a rate of change that has always been out of reach of traditional platforms, an IoT-based understanding of medical and biological environments provide more accurate and responsive solutions to complex medical conditions. However, beginning with the medical sector, IoT technologies already represent an improvement to patient care at the organisational level: the costs incurred by institutions through inefficient waiting times could be mitigated by applying IoT to shift and task-flow management [18].

2.4.1. Hardware for IoT healthcare

In order to combat this risk of unexpected hardware failure, the new e-Alert IoT driver solution by Philips is designed addresses this dilemma by detecting pending malfunctions of medical hardware in real time, and then deploying solutions such as staff alerts in-time before a vital system fails. In addition, one further example of an IoT-based solution to healthcare scenarios is the use of a real-time location system to facilitate live asset tracking within the hospital building: although this process of tracking devices, visitors and personnel may appear as a manual process in smaller organisations, maintaining this oversight at the same standard for large organisations with multiple campuses and thousands of staff is not sustainable without turning to automated alternatives that replicate this same contextual aware-ness. One IoT platform built in recognition of this dilemma is iBeacon developed by technology Co. Ltd and incorporates the Bluetooth gateway G1 in order to achieve the multi-node tracking a real-time asset tracking system requires. On the other hand, one further case of IoT within a healthcare setting may represent one of the most advanced developments in healthcare to date, and even IoT technology as a whole: one application of IoT is revolutionising the process of drug prescription, with microsensors embedded into the pill capsules; this ability to track signals emitted from each embedded sensor enables a more precise control over drug dosage, enabling doctors to be notified in the event or overdose, or when the dose appears insufficient according to the reported absorption within the patient's body. Moreover, this configuration is further combined with the functionality of an external patch for continual tracking, and a smartphone app that displays contextual suggestions inferred through using this data [18].

2.4.2. Software for IoT healthcare

In considering the IoT software used for medical applications, current platforms are cho-sen and to contribute to one of the following three categories:

a. Reducing the waiting time of patients within the emergency waiting room. Not only is ex-tended time in the waiting room unproductive for both patents and staff members; but also incurs a wide range or expenses throughout a medical organisation. However, as demon-strated (also mentioned in the above section) by the Sinai Medical Centre in New York City, IoT-based software applications are not only able to innovate the delivery of complex med-ical procedures; but also regulate and update the systems of management that coordinate vital human resources.
b. Health monitoring from remote locations one further example of how IoT may enhance the ability of patients to monitor vitals and apply appropriate solutions is the use of telemedicine: visually, this likely appears the quintessential combination of a medical service and internet technologies; but also offers a broader benefit by reducing the number of patients enquiring at the waiting room level only to discover that a remote from of treatment would have been more efficient as shown in Figure 5 [19].

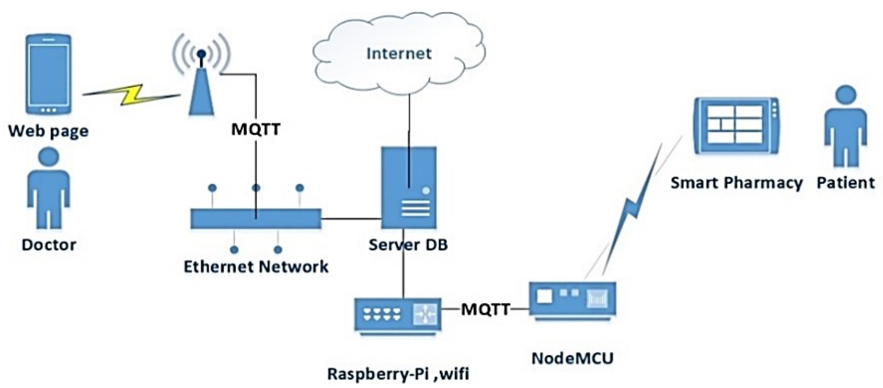

Figure 5. Structure design for IoT healthcare as example

2.4.3. The challenges of IoT healthcare

Despite its positive benefits, there are challenges that remain in IoT-based healthcare ap-plications, some of which extend beyond the delivery of medical care itself. The first example is the perceived threat to privacy and data security: this primarily involves the potential misuse of personal medical records, or the unintended distribution of sensitive medical data to organisations with more commercial incentives. On the one hand, in both intent and design, an IoT configura-tion inherently requires large volumes of data to be shared with the cloud, and to be interpreted according to the inferred patterns they represent: this may primarily involve quantitative environ-mental data when applied to a dilemma such as congestion or waiting times; but may also apply to qualitative and behavioural data if given access to transcripts and patient recordings [19].

3. IOT TECNOLOGIES FOR COMMUNICATION

Within a standard IoT configuration, all items are connected to the internet through de-vices, each capable of modelling part of their surrounding environment: when connected together using short-range radio frequency identification (RFID) as a collective network, this is intended to create a combined entity that 'intelligently interprets and manages' connected devices within the local environment [20]. Whether the concept of the global neural network or the concept of 'nation intelligence' when interacting with a country such as China: this inherent interconnection of devices as part of a combines intelligent entity forms the cornerstone of the IoT model. Fur-thermore, one key step towards the realisation of this IoT concept was M2M technology, short for 'machine-to-machine' and implying communication as the exchanged activity. Moreover, this concept marked a precursor to the modern IoT concept, where by machines and humans would communicate interchangeably towards a collective outcome: this would in-turn also imply ubiquity and an independence from location in today's context due to the availability of mobile devices. Today, M2M refers to the integration of a wireless communication and information technology for two-way communication, and is primarily designated towards a wide range of applications and long-distance wireless technologies such as GSM/GPRS/UMTS; or radio-based signals such as Wi-Fi, Bluetooth, Zigbee, RFID, and UWB [21]. In addition, this configuration can be combined with XML and Corba as well as a location service technology based on GPS, wireless terminals and networks.

4. IMPLICATIONS FOR FUTURE RESEARCH

In considering the weaknesses in current IoT networks identified in this paper, there ap-pears to be five distinct areas of research that may be able to enhance the functionality, reliability and market viability of future IoT systems; and ultimately enable a wider range or future organisa-tions and cases to incorporate IoT into their core operations and business model :

a. The capacity to coordinate physical assets

Within the paradigm of embedded systems, small embedded computing devices are treated as 'assets' (or deeply embedded systems) that send and receive information on the wider network: this can include devices such as smart sensors at home or industrial sites. Further, embedded system design can also be understood as a design quality that seeks to minimise net power consumption through the added efficiency provides through the network and economies of scale: example functions that indicate this intentional design are to enter sleep mode following a period of inactivity. Furthermore, when running in their low performance state, the current architecture of em-bedded processors effectively renders power consumption negligible when idle. Moreover, this design quality may also manifest as an eventual reduction in the prices of core network components: as the price of 32-bit MCUs falls and Linux is unable to support MCUs without MMUs; this would make RTOS is preferred choice for IoT-based OSs running on MCUs as RTOS-based designs run more flexibly on such systems, with extensive software choices.

b. Ubiquitous Internet function

Qualities such as 'location independence' and wireless data transfer may also be used to further advances in fully ubiquitous systems where the inter-action between cloud networks and physical devices is not required [22].

5. DISCUSSION

In response to the continuous growth and advancement of IoT technologies, this has led many government bodies to allocate funds to support this transition. According to the most recent data from the World Statistics revealed at Figure 6: As of 2018, the expenditure rate amounted to 646 billion dollars (USD); and is expected to reach an expenditure rate of 1000 billion dollars by 2022 [23]. In addition to this trend, another factor driving the significance of IoT is its dramatic in-crease in the number of devices that are connected online. Moreover, this rapid increase in inter-net capability among devices will in-turn require updated standards, and a re-designed technology infrastructure., this required advancement of technology ecosystem is promoted through IoT platforms. Furthermore, although this has already in-part led to a total 15.41 billion devices connected to the Internet; by 2025, this number of devices is expected to reach 75 billion.

According to our survey, which sought to investigate examples of present-day applica-tions: a large number of organisations across different countries already specialise in applications that-collectively-would facilitate full IoT platforms. As highlighted in Table 1, this comprises of 22 companies, among which 43% provide applications focused on medical applications; 30% for manufacturing applications; 20% for the 'smart city' concept; 4% for retail scenarios; and % for enhancing transportation.as shown in Figure 7. In addition, we have designed a model for the Internet of things platform in general, ex-plaining the relationship of the following classes: (buildings; economy; education; energy; environment; healthcare; infrastructure; mobility; research, technology and innovation; social inclusion) as shown in Table 2. The platforms generally focus on some basic features such as device management, application development and application continuity. In this paper, we have shown the most important Platforms that focus on MIoT, TIoT, RIoT, HIoT and SIoT. as shown in Table 1.

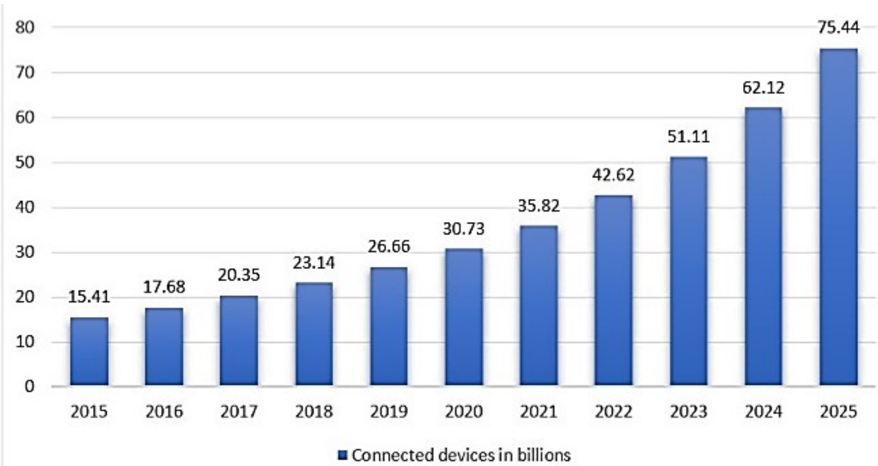

Figure 6. Connected devices in the world 2015-2025 [23]

Table 1. IoT's Platforms specifications

IoT's Platforms	Easy connectivity	Low complexity	Machine Learning for complex Big-Data Analysis	Free/Paid
Amazon Web Services (AWS) [24]	Yes			Free
Ayla Network [25]	Yes			Paid
Artik [26]	Yes	Yes		
Bright Wolf Strandz Enterprise [27]	Yes	Yes		Free/Paid
Bosch IoT Suite [28]	Yes	Yes		Free/Paid
Cisco Cloud Connect [29]	Yes	Yes		Paid
Carriots [30]	Yes	Yes		Free
C3 [31]	Yes			Paid
Datav by Bsquare [32]	Yes	Yes		Free
Device Pilot Service [33]	Yes	Yes		paid
General Electric's Predix [34]	Yes	Yes		Paid
Google Cloud Platform [35]	Yes	Yes		Free
IBM Watson [36]	Yes	Yes		Free
Kaa [37]	Yes	Yes		Free
Mocana [38]	Yes	Yes		Free
MBED IoT's Device [39]	Yes	Yes		Free/Paid
Mindsphere by Siemens [40]	Yes	Yes	Yes	Paid
Microsoft IoT [41]	Yes	Yes	Yes	Paid
Oracle Integrated Cloud [42]	Yes	Yes		Free
Salesforce IoT's Cloud [43]	Yes	Yes		Paid
Thing Speak [44]	Yes	Yes	Yes	Paid

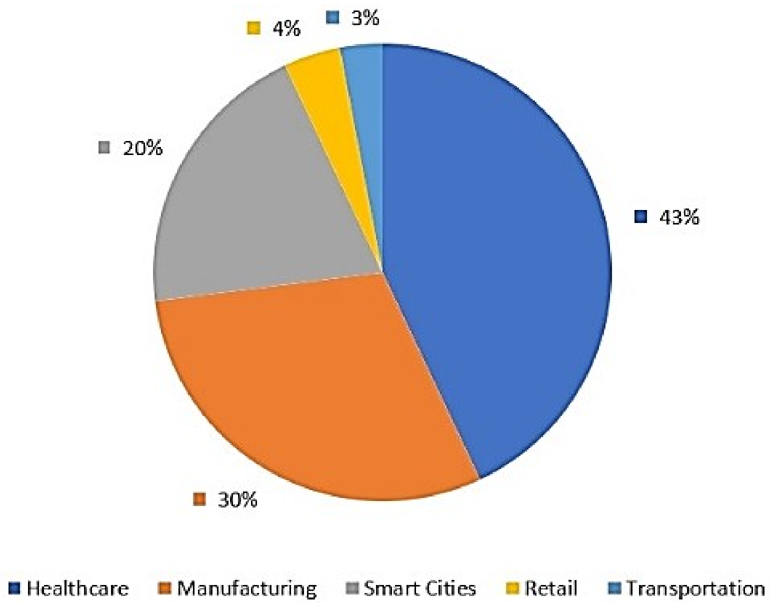

Figure 7. Targeted applications for IoT in the study

Table 2. Model of IoT platform

Classes	Resources	Innovations	Quality of living
Buildings	Energy consumption of existing buildings for space Heating; Cooling; Water Heating Cost optimisation.		
Economy		Purchasing power Quantity of headquarters of international companies; Quantity of new enterprises; Direct investment flows; Technology-intensive products sales.	
Education		Quantity of whole-day; integrated schools; Quantity of high-quality childcare offerings; Educational level.	
Energy	The total final energy consumption; Primary energy input; Renewable sources of energy.		
Environment			Share of green spaces; Savings achieved by municipal; waste management.
infrastructure	Openness of government; Quantity of pilot projects with ICT enterprises in their ability to serve as showcases for the city and its economy; Public space; Wi-Fi coverage		
Healthcare			Affordability of healthcare services; Quantity and quality of their leisure time.
Research, Technology		The attractiveness of the research and innovation hub; The quantity of research units at international corporations; the Quantity of international leading researchers; the quantity of international students.	
Social inclusion		Safety of living ; Attractiveness of housing environment; the Absence of gender superiority.	

As we have shown some platforms that deal with IoT, it has been shown that most of these platforms are easy connectivity, but not all of these platforms are available as free, on the other hand, there is some complexity in the Artik [26] platform and C3 [31] platform , but in general all platforms need to develop, testing for years in order to We categorically guarantee that it is secure, available, easy to use and necessary [22].

6. CONCLUSION

Overall, there is no doubt that the internet of things (IoT) phenomenon has matured into a set of credible applications and utilities and is beginning to define the operating model for future manufacture, transport and retail activity. However, despite what may appear to be the next step along a trajectory towards increasing automation and a higher-leverage role of the human worker, the conceptual and longer-term benefits of an IoT platform are still undermined by barriers that may limit the speed at which this transition can occur: despite proven enhancements to commer-cial scenarios and user experience, scenarios such as medical care that are built around different incentives may prioritise stability and compliance over technical advancement; and established supply chain networks that are otherwise eager to enhance efficiency and speed of delivery may favour a gradual transition so long as IoT platforms remain in their testing stage.

However, despite these present barriers, the impact of IoT platforms still holds the po-tential to not only redesign existing mechanisms of delivery and organisational management; but also, to reshape the priorities, dynamics and interconnectivity of entire established industries at the foundation of our everyday experience. Moreover, this rebirth of the ‘intranet’ in a format that intelligently coordinates nearby devices may not only transform the functionality and synergy be-tween both physical and software environments; but may also extend to the most fundamental ecosystems of biology and medical treatment.

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