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The Internet of Things- Introduction and Applications

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Abstract - *IoT (Internet of Things) is an advanced automation and analytics system which exploits networking, sensing, big data, and artificial intelligence technology to deliver complete systems for a product or service. These systems allow greater transparency, control, and performance when applied to any industry or system. IoT systems have applications across industries through their unique flexibility and ability to be suitable in any environment. They enhance data collection, automation, operations, and much more through smart devices and powerful enabling technology IoT systems allow users to achieve deeper automation, analysis, and integration within a system. They improve the reach of these areas and their accuracy. IoT utilizes existing and emerging technology for sensing, networking, and robotics. The IoT is a technological revolution that represents the future of computing and communications, and its development depends on dynamic technical innovation in a number of important fields, from wireless sensors to nanotechnology.*

Key Words: IoT, Innovation, Connectivity, Communication

1. INTRODUCTION

The Internet of Things represents a vision in which the Internet extends into the real world embracing everyday objects. Physical items are no longer disconnected from the virtual world, but can be controlled remotely and can act as physical access points to Internet services.

The phrase 'Internet of Things' well-known as IoT is coined from the two words i.e. 'Internet' and 'Things'. The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite (TCP/IP) to serve billions of users worldwide. While coming to the Things that can be any object or person which can be distinguishable by the real world. Internet of Things (IoT) promises a smart human being life, by allowing communication between objects, machines and everything together with peoples. IoT represents a system which consists things in the real world, and sensors attached to or combined with these things, connected to the Internet via wired and wireless network structure. The IoT sensors can use various types of connections such as RFID, Wi-Fi, Bluetooth, and ZigBee, in addition to allowing wide area connectivity using many technologies such as GSM, GPRS, 3G, and LTE.

Nowadays Internet of Things (IoT) gained a great attention from researchers since it becomes an important technology that promises a smart human being life, by allowing communications between objects, machines and everything together with peoples. IoT systems allow users to achieve deeper automation, analysis, and integration within a system. They improve the reach of these areas and their accuracy. IoT utilizes existing and emerging technology for sensing, networking, and robotics.

1.1 IoT- Key Features

The most important features of IoT include artificial intelligence, connectivity, sensors, active engagement, and small device use. A brief review of these features is given below:

AI – IoT essentially makes virtually anything "smart", meaning it enhances every aspect of life with the power of data collection, artificial intelligence algorithms, and networks. This can mean something as simple as enhancing your refrigerator and cabinets to detect when milk and your favorite cereal run low, and to then place an order with your preferred grocer.

Connectivity – New enabling technologies for networking and specifically IoT networking, mean networks are no longer exclusively tied to major providers. Networks can exist on a much smaller and cheaper scale while still being practical. IoT creates these small networks between its system devices.

Sensors – IoT loses its distinction without sensors. They act as defining instruments which transform IoT from a standard passive network of devices into an active system capable of real-world integration.

Active Engagement – Much of today's interaction with connected technology happens through passive engagement. IoT introduces a new paradigm for active content, product, or service engagement.

Small Devices – Devices, as predicted, have become smaller, cheaper, and more powerful over time. IoT exploits purpose-built small devices to deliver its precision, scalability, and versatility.

2. THE HARDWARE AND SOFTWARE PART

The hardware utilized in IoT systems includes devices for a remote dashboard, devices for control, servers, a routing or bridge device, and sensors. These devices manage key tasks and functions such as system activation, action specifications, security, communication, and detection to support specific goals and actions. The most important hardware in IoT might be its sensors. Today sensors are everywhere. We take it for granted, but there are sensors in our vehicles, in our smartphones, in factories controlling CO2 emissions, and even in the ground monitoring soil conditions in vineyards. While it seems that sensors have been around for a while, research on wireless sensor networks (WSNs) started back in the 1980s, and it is only since 2001 that WSNs generated an increased interest from industrial and research perspectives. This is due to the availability of inexpensive, low powered miniature components like processors, radios, and sensors that were often integrated on a single chip (system on a chip (SoC)). These devices consist of energy modules, power management modules, RF modules, and sensing modules. RF modules manage communications through their signal processing, WiFi, ZigBee, Bluetooth, radio transceiver, duplexer, and BAW.

Table -1

Accelerometers	Temperature Sensor
Magnetometers	Proximity Sensor
Gyroscope	Image Sensor
Acoustic Sensor	Light Sensor
Pressure Sensor	Gas RFID Sensor
Humidity Sensor	Micro Flow Sensor

IoT software addresses its key areas of networking and action through platforms, embedded systems, partner systems, and middleware. These individual and master applications are responsible for data collection, device integration, real-time analytics, and application and process extension within the IoT network. They exploit integration with critical business systems (e.g., ordering systems, robotics, scheduling, and more) in the execution of related tasks.

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2.1 Data Collection

This software manages sensing, measurements, light data filtering, light data security, and aggregation of data. It uses certain protocols to aid sensors in connecting with real-time, machine-to-machine networks. Then it collects data from multiple devices and distributes it in accordance with settings. It also works in reverse by distributing data over devices. The system eventually transmits all collected data to a central server.

2.2 Device Integration

Software supporting integration binds (dependent relationships) all system devices to create the body of the IoT system. It ensures the necessary cooperation and stable networking between devices. These applications are the defining software technology of the IoT network because, without them, it is not an IoT system. They manage the various applications, protocols, and limitations of each device to allow communication.

2.3 Real-Time Analysis

These applications take data or input from various devices and convert it into viable actions or clear patterns for human analysis. They analyze information based on various settings and designs in order to perform automation-related tasks or provide the data required by industry. Application and Process Extension These applications extend the reach of existing systems and software to allow a wider, more effective system. They integrate predefined devices for specific purposes such as allowing certain mobile devices or engineering instruments access. It supports improved productivity and more accurate data collection.

3. COMMUNICATION MODEL

3.1 Device-to-Device Communication

The device-to-device communication model represents two or more devices that directly connect and communicate between one another, rather than through an intermediary application server. These devices communicate over many types of networks, including IP networks or the Internet. Such devices use protocols like Bluetooth, Z-Wave, or ZigBee to establish direct device-to-device communications.

These device-to-device networks allow devices that adhere to a particular communication protocol to communicate and exchange messages to achieve their function. This communication model is commonly used in applications like home automation systems, which typically use small data packets of information to communicate between devices with relatively low data rate requirements. Residential IoT devices like light bulbs, light switches, thermostats, and door locks normally send small amounts of information to each other (e.g. a door lock status message or turn on light command) in a home automation scenario.

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Fig 1

3.2 Device-to-Cloud Communication

In a device-to-cloud communication model, the IoT device connects directly to an Internet cloud service like an application service provider to exchange data and control message traffic. This approach frequently takes advantage of existing communications mechanisms like traditional wired Ethernet or Wi-Fi connections to establish a connection between the device and the IP network, which ultimately connects to the cloud service.

Like in the Smart TVs, the television uses an Internet connection to transmit user viewing information to the manufacturing company for analysis and to enable the interactive voice recognition features of the TV. In these cases, the device-to-cloud model adds value to the end user by extending the capabilities of the device beyond its native features.

Fig 2

3.3 Device-to-Gateway Communication

In the device-to-gateway model, or more typically, the device-to-application-layer gateway (ALG) model, the IoT device connects through an ALG service as a conduit to reach a cloud service. In simpler terms, this means that there is application software operating on a local gateway device, which acts as an intermediary between the device and the cloud service and provides security and other functionality such as data or protocol translation.

This communications model is frequently used to integrate new smart devices into a legacy system with devices that are not natively interoperable with them. A downside of this approach is that the necessary development of the application-layer gateway software and system adds complexity and cost to the overall system.

3.4 Device-to-Device Communication

The back-end data-sharing model refers to a communication architecture that enables users to export and analyze smart object data from a cloud service in combination with data from other sources.

This architecture supports "the user's desire for granting access to the uploaded sensor data to third parties". This approach is an extension of the single device-to-cloud communication model, which can lead to data silos where "IoT devices upload data only to a single application service provider". A back-end sharing architecture allows the data collected from single IoT device data streams to be aggregated and analyzed.
For example, a corporate user in charge of an office complex would be interested in consolidating and analyzing the energy consumption and utility data produced by all the IoT sensors and Internet-enabled utility systems on the premises. Often in the single device-to-cloud model, the data each IoT sensor or system produces sits in a stand-alone data silo. An effective back-end data sharing architecture would allow the company to easily access and analyze the data in the cloud produced by the whole spectrum of devices in the building. Also, this kind of architecture facilitates data portability needs. Effective back-end data sharing architectures allow users to move their data when they switch between IoT services, breaking down traditional data silo barriers.

4. CHALLENGES

Five key IoT issue areas are examined to explore some of the most pressing challenges and questions related to the technology. These include security; privacy; interoperability and standards; legal, regulatory, and rights; and emerging economies and development.

4.1 Security

While security considerations are not new in the context of information technology, the attributes of many IoT implementations present new and unique security challenges. Addressing these challenges and ensuring security in IoT products and services must be a fundamental priority. Users need to trust that IoT devices and related data services are secure from vulnerabilities, especially as this technology becomes more pervasive and integrated into our daily lives. Poorly secured IoT devices and services can serve as potential entry points for cyber attack and expose user data to theft by leaving data streams inadequately protected. The interconnected nature of IoT devices means that every poorly secured device that is connected online potentially affects the security and resilience of the Internet globally. This challenge is amplified by other considerations like the mass-scale deployment of homogenous IoT devices, the ability of some devices to automatically connect to other devices, and the likelihood of fielding these devices in insecure environments. As a matter of principle, developers and users of IoT devices and systems have a collective obligation to ensure they do not expose users and the Internet itself to potential harm. Accordingly, a collaborative approach to security will be needed to develop effective and appropriate solutions to IoT security challenges that are well suited to the scale and complexity of the issues.

Beyond costs, other security issues are:

a. Unpredictable Behaviour – The sheer volume of deployed devices and their long list of enabling technologies means their behavior in the field can be unpredictable. A specific system may be well designed and within administration control, but there are no guarantees about how it will interact with others.

b. Device Similarity – IoT devices are fairly uniform. They utilize the same connection technology and components. If one system or device suffers from a vulnerability, much more have the same issue.

c. Problematic Deployment – One of the main goals of IoT remains to place advanced networks and analytics where they previously could not go. Unfortunately, this creates the problem of physically securing the devices in these strange or easily accessed places.

d. Long Device Life and Expired Support – One of the benefits of IoT devices is longevity, however, that long life also means they may outlive their device support. Compare this to traditional systems which typically have support and upgrades long after many have stopped using them. Orphaned devices lack the same security hardening of other systems due to the evolution of technology over time.

e. No Upgrade Support – Many IoT devices, like many mobile and small devices, are not designed to allow upgrades or any modifications. Others offer inconvenient upgrades, which many owners ignore, or fail to notice.

f. Poor or No Transparency – Many IoT devices fail to provide transparency with regard to their functionality. Users cannot observe or access their processes and are left to assume how devices behave. They have no control over unwanted functions or data collection; furthermore, when a manufacturer updates the device, it may bring more unwanted functions.

4.2 Privacy

The full potential of the Internet of Things depends on strategies that respect individual privacy choices across a broad spectrum of expectations. The data streams and user specificity afforded by IoT devices can unlock incredible and unique value to IoT users, but concerns about privacy and potential harms might hold back full adoption of the Internet of Things. This means that privacy rights and respect for user privacy expectations are integral to ensuring user trust and confidence in the Internet, connected devices, and related services. Indeed, the Internet of Things is redefining the debate about privacy issues, as many implementations can dramatically change the ways personal data is collected, analyzed, used, and protected. For example, IoT amplifies concerns about the potential for increased surveillance and tracking, difficulty in being able to opt out of certain data collection, and the strength of aggregating IoT data streams to paint detailed digital portraits of users. While these are important challenges, they are not insurmountable. In order to realize the opportunities, strategies will need to be developed to respect individual privacy choices across a broad spectrum of expectations, while still fostering innovation in new technology and services.

4.3 Interoperability/ Standards

A fragmented environment of proprietary IoT technical implementations will inhibit value for users and industry. While full interoperability across products and services is not always feasible or necessary, purchasers may be hesitant to buy IoT products and services if there is integration inflexibility, high ownership complexity, and concern over vendor lock-in.
In addition, poorly designed and configured IoT devices may have negative consequences for the networking resources they connect to and the broader Internet. Appropriate standards, reference models, and best practices also will help curb the proliferation of devices that may act in disrupted ways to the Internet.

4.4 Legal Regulatory and Rights

The use of IoT devices raises many new regulatory and legal questions as well as amplifies existing legal issues around the Internet. The questions are wide in scope, and the rapid rate of change in IoT technology frequently outpaces the ability of the associated policy, legal, and regulatory structures to adapt. One set of issues surrounds cross border data flows, which occur when IoT devices collect data about people in one jurisdiction and transmit it to another jurisdiction with different data protection laws for processing. Further, data collected by IoT devices is sometimes susceptible to misuse, potentially causing discriminatory outcomes for some users. Other legal issues with IoT devices include the conflict between law enforcement surveillance and civil rights; data retention and destruction policies; and legal liability for unintended uses, security breaches or privacy lapses. While the legal and regulatory challenges are broad and complex in scope, adopting the guiding Internet Society principles of promoting a user's ability to connect, speak, innovate, share, choose, and trust are core considerations for evolving IoT laws and regulations that enable user rights.

4.5 Emerging Economy and Development Issues

The Internet of Things holds significant promise for delivering social and economic benefits to emerging and developing economies. This includes areas such as sustainable agriculture, water quality and use, healthcare, industrialization, and environmental management, among others. As such, IoT holds promise as a tool in achieving the United Nations Sustainable Development Goals. The broad scope of IoT challenges will not be unique to industrialized countries. Developing regions also will need to respond to realize the potential benefits of IoT. In addition, the unique needs and challenges of implementation in less-developed regions will need to be addressed, including infrastructure readiness, market and investment incentives, technical skill requirements, and policy resources.

5. BROAD APPLICATIONS

IoT has applications across all industries and markets. It proves not just useful, but nearly critical in many industries as technology advances and we move towards the advanced automation imagined in the distant future.

5.1 Engineering, Industry and Infrastructure

Applications of IoT in these areas include improving production, marketing, service delivery, and safety. IoT provides a strong means of monitoring various processes, and real transparency creates greater visibility for improvement opportunities. The deep level of control afforded by IoT allows rapid and more action on those opportunities, which include events like obvious customer needs, nonconforming product, malfunctions in equipment, problems in the distribution network, and more.

Example; A manufacturing facility that makes shields for manufacturing equipment. When regulations change for the composition and function of the shields, the new appropriate requirements are automatically programmed in production robotics, and engineers are alerted about their approval of the changes.

5.2 Marketing and Content Delivery

Current advertising suffers from excess and poor targeting. Even with today's analytics, modern advertising fails. IoT promises different and personalized advertising rather than one-size-fits all strategies. It transforms advertising from noise to a practical part of life because consumers interact with advertising through IoT rather than simply receiving it. This makes advertising more functional and useful to people searching the marketplace for solutions or wondering if those solutions exist. IoT functions in a similar and deeper way to current technology, analytics, and big data. Existing technology collects specific data to produce related metrics and patterns over time, however, that data often lacks depth and accuracy.

5.3 Environmental Monitoring

The applications of IoT in environmental monitoring are broad: environmental protection, extreme weather monitoring, water safety, endangered species protection, commercial farming, and more. In these applications, sensors detect and measure every type of environmental change.

a. Air and Water Pollution

Current monitoring technology for air and water safety primarily uses manual labor along with advanced instruments, and lab processing. IoT improves on this technology by reducing the need for human labor, allowing frequent sampling, increasing the range of sampling and monitoring, allowing sophisticated testing on-site, and binding response efforts to detection systems. This allows us to prevent substantial contamination and related disasters.

b. Extreme Weather

Though powerful, advanced systems currently in use allow deep monitoring, they suffer from using broad instruments, such as radar and satellites, rather than more granular solutions. Their instruments for smaller details lack the same accurate targeting of stronger technology. New IoT advances promise more fine-grained data, better accuracy, and flexibility. Effective forecasting requires high detail and flexibility in range, instrument type, and deployment. This allows early detection and early responses to prevent loss of life and property.

c. Commercial Farming

Today's sophisticated commercial farms have exploited advanced technology and biotechnology for quite some time, however, IoT introduces more access to deeper automation and analysis.

5.4 Transportation Applications

At every layer of transportation, IoT provides improved communication, control, and data distribution. These applications include personal vehicles, commercial vehicles, trains, UAVs, and other equipment. It extends throughout the entire system of all transportation elements such as traffic control, parking, fuel consumption, and more.

a. Rails and Mass Transit

Current systems deliver sophisticated integration and performance; however, they employ older technology and approaches to MRT. The improvements brought by IoT deliver a complete control and monitoring. This results in better management of overall performance, maintenance issues, maintenance, and improvements. Mass transit options beyond standard MRT suffer from a lack of the integration necessary to transform them from an option to a dedicated service. IoT provides an inexpensive and advanced way to optimize performance and bring qualities of MRT to other transportation options like buses. This improves services and service delivery in the areas of scheduling, optimizing transport times, reliability, managing equipment issues, and responding to customer needs.

b. Road

The primary concerns of traffic are managing congestion, reducing accidents, and parking. IoT allows us to better observe and analyze the flow of traffic through devices at all traffic observation points. It aids in parking by making storage flow transparent when current methods offer little if any data.

c. Automobile

Many in the automotive industry envision a future for cars in which IoT technology makes cars "smart," attractive options equal to MRT. IoT offers few significant improvements to personal vehicles. Most benefits come from better control over related infrastructure and the inherent flaws in automobile transport; however, IoT does improve personal vehicles as personal spaces. IoT brings the same improvements and customization to a vehicle as those in the home.

d. Commercial Transportation

Transportation benefits extend to business and manufacturing by optimizing the transport arm of organizations. It reduces and eliminates problems related to poor fleet management through better analytics and control such as monitoring idling, fuel consumption, travel conditions, and travel time between points. This results in product transportation operating more like an aligned service and less like a collection of contracted services.

5.5 IoT- Educational Applications

IoT in the classroom combines the benefits of IoT in content delivery, business, and healthcare. It customizes and enhances education by allowing optimization of all content and forms of delivery. It enables educators to give focus to individuals and their method. It also reduces costs and labor of education through automation of common tasks outside of the actual education process.

a. Education Organizations

Education organizations typically suffer from limited funding, labor issues, and poor attention to actual education. They, unlike other organizations, commonly lack or avoid analytics due to their funding issues and the belief that analytics do not apply to their industry. IoT not only provides valuable insight, but it also democratizes that information through low cost, low-power small devices, which still offer high performance.

b. Educators

Information provided by IoT empowers educators to deliver improved education. IoT relieves them of administrative and management duties, so they can focus on their mission. It automates manual and clerical labor and facilitates supervising through features like system flags or controls to ensure students remain engaged.

c. Personalized Education

Each student can control their experience and participate in the instructional design, and much of this happens passively. The student simply utilizes the system, and performance data primarily shape their design. This combined with organizational and educator optimization delivers highly effective education while reducing costs.

5.6 IoT- Government Applications

IoT supports the development of smart nations and smart cities. This includes enhancement of infrastructure previously discussed (e.g., healthcare, energy, transportation, etc.), defense, and also the engineering and maintenance of communities.

a. City Planning and Management

Governing bodies and engineers can use IoT to analyze the often complex aspects of city planning and management. IoT simplifies examining various factors such as population growth, zoning, mapping, water supply, transportation patterns, food supply, social services, and land use. It gathers detailed data in these areas and produces more valuable and accurate information than current analytics given its ability to actually "live" with people in a city.

In the area of management, it also aids in other key areas like water control, waste management, and emergency management. It's real-time and detailed information facilitate more prompt decisions.

b. Creating Jobs

IoT offers thorough economic analysis. It makes previous blind spots visible and supports better economic monitoring and modeling. It analyzes the industry and the marketplace to spot opportunities for growth and barriers.

c. National Defence

National threats prove diverse and complicated. IoT augments armed forces systems and services and offers the sophistication necessary to manage the landscape of national defense. It supports better protection of borders through inexpensive, high-performance devices for rich control and observation.

5.7 IoT- Law Enforcement Applications

IoT enhances law enforcement organizations and practice and improves the justice system. The technology boosts transparency, distributes critical data, and removes human intervention where it proves unnecessary.

a. Policing

IoT systems save costs by reducing human labor in certain areas such as certain traffic violations. IoT aids in creating better solutions to problems by using technology in the place of force; for example, light in-person investigations of suspicious activities can be replaced with remote observation, logged footage of violations, and electronic ticketing. It also reduces corruption by removing human control and opinion for some violations.

b. Court System

Current court systems utilize traditional technology and resources. They generally do not exploit modern analytics or automation outside of minor legal tasks. IoT brings superior analytics, better evidence, and optimized processes to court systems which accelerate processes, eliminate excessive procedures, manage corruption, reduce costs, and improve satisfaction.

This reduces costs and accelerates many processes which often require months of traversing legal procedures and bureaucracy.

6. IoT- Advantages

a. Data

The more the information, the easier it is to make the right decision. Knowing what to get from the grocery while you are out, without having to check on your own, not only saves time but is convenient as well.

b. Tracking

The computers keep a track both on the quality and the viability of things at home. Knowing the expiration date of products before one consumes them improves safety and quality of life. Also, you will never run out of anything when you need it at the last moment.

c. Time and Money:

The amount of time saved in monitoring and the number of trips done otherwise would be tremendous. The financial aspect is the best advantage. This technology could replace humans who are in charge of monitoring and maintaining supplies.

7. CONCLUSION

While the concept of combining computers, sensors, and networks to monitor and control devices has been around for decades, the recent confluence of key technologies and market trends is ushering in a new reality for the "Internet of Things''. IoT promises to usher in a revolutionary, fully interconnected "smart" world, with relationships between objects and their environment and objects and people becoming more tightly intertwined. The prospect of the Internet of Things as a ubiquitous array of devices bound to the Internet might fundamentally change how people think about what it means to be "online". The Internet of Things is happening now, and there is a need to address its challenges and maximize its benefits while reducing its risks.

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