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Internet of Things (IOT) Tutorial

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Written By,

IIT Bombay Alumni Foundation's

Embedded Technosolutions

What is an Internet of Things (IOT)

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.

This tutorial aims to provide you with a thorough introduction to IoT. It introduces the key concepts of IoT, necessary in using and deploying IoT systems.

Chapter 1

IOT - Overview

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.

IoT exploits recent advances in software, falling hardware prices, and modern attitudes towards technology. Its new and advanced elements bring major changes in the delivery of products, goods, and services; and the social, economic, and political impact of those changes.

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.

IoT – Advantages

The advantages of IoT span across every area of lifestyle and business. Here is a list of some of the advantages that IoT has to offer –

- **Improved Customer Engagement** – Current analytics suffer from blind-spots and significant flaws in accuracy; and as noted, engagement remains passive. IoT

completely transforms this to achieve richer and more effective engagement with audiences.

- **Technology Optimization** − The same technologies and data which improve the customer experience also improve device use, and aid in more potent improvements to technology. IoT unlocks a world of critical functional and field data.
- **Reduced Waste** − IoT makes areas of improvement clear. Current analytics give us superficial insight, but IoT provides real-world information leading to more effective management of resources.
- **Enhanced Data Collection** − Modern data collection suffers from its limitations and its design for passive use. IoT breaks it out of those spaces, and places it exactly where humans really want to go to analyze our world. It allows an accurate picture of everything.

IoT – Disadvantages

Though IoT delivers an impressive set of benefits, it also presents a significant set of challenges. Here is a list of some its major issues −

- **Security** − IoT creates an ecosystem of constantly connected devices communicating over networks. The system offers little control despite any security measures. This leaves users exposed to various kinds of attackers.

- **Privacy** – The sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.
- **Complexity** – Some find IoT systems complicated in terms of design, deployment, and maintenance given their use of multiple technologies and a large set of new enabling technologies.
- **Flexibility** – Many are concerned about the flexibility of an IoT system to integrate easily with another. They worry about finding themselves with several conflicting or locked systems.
- **Compliance** – IoT, like any other technology in the realm of business, must comply with regulations. Its complexity makes the issue of compliance seem incredibly challenging when many consider standard software compliance a battle.

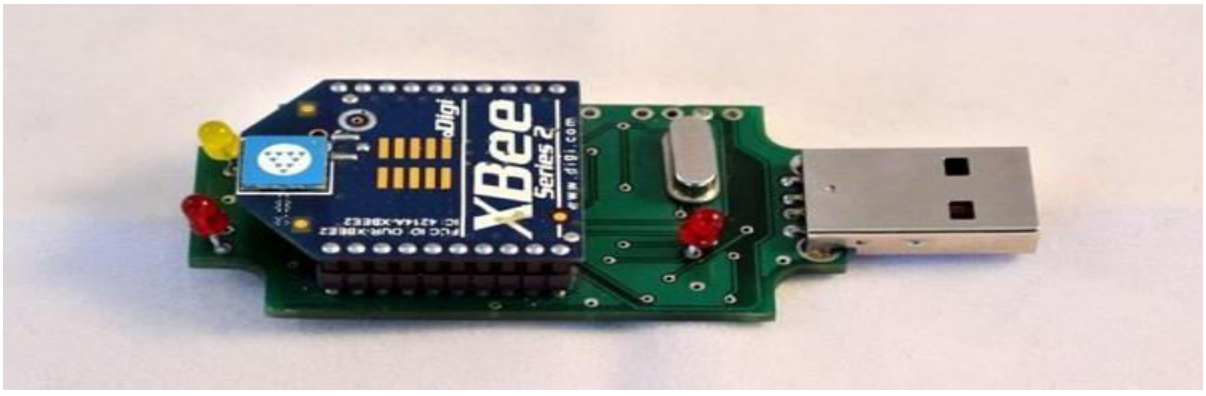
Chapter 2

IOT – Hardware

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.

IoT – Sensors

The most important hardware in IoT might be its sensors. 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.



The sensing module manages sensing through assorted active and passive measurement devices. Here is a list of some of the measurement devices used in IoT –

S.No	Devices	
1.	accelerometers	temperature sensors
2.	magnetometers	proximity sensors
3.	gyroscopes	image sensors
4.	acoustic sensors	light sensors
5.	pressure sensors	gas RFID sensors
6.	humidity sensors	micro flow sensors

Wearable Electronics

Wearable electronic devices are small devices worn on the head, neck, arms, torso, and feet.

Smart watches not only help us stay connected, but as a part of an IoT system, they allow access needed for improved productivity.

Current smart wearable devices include

- **Head** – Helmets, glasses
- **Neck** – Jewelry, collars
- **Arm** – Watches, wristbands, rings
- **Torso** – Clothing, backpacks
- **Feet** – Socks, shoes

Smart glasses help us enjoy more of the media and services we value, and when part of an IoT system, they allow a new approach to productivity.

Standard Devices

The desktop, tablet, and cellphone remain integral parts of IoT as the command center and remotes.

- The **desktop** provides the user with the highest level of control over the system and its settings.
- The **tablet** provides access to the key features of the system in a way resembling the desktop, and also acts as a remote.
- The **cellphone** allows some essential settings modification and also provides remote functionality.

Other key connected devices include standard network devices like **routers** and **switches**

Chapter 3

IOT – Software

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.

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.

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.

Real-Time Analytics

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.

Chapter 4

IOT – Technology & Protocol

IoT primarily exploits standard protocols and networking technologies. However, the major enabling technologies and protocols of IoT are RFID, NFC, low-energy Bluetooth, low-energy wireless, low-energy radio protocols, LTE-A, and WiFi-Direct. These technologies support the specific networking functionality needed in an IoT system in contrast to a standard uniform network of common systems.

NFC and RFID

RFID (radio-frequency identification) and NFC (near-field communication) provide simple, low energy, and versatile options for identity and access tokens, connection bootstrapping, and payments.

- RFID technology employs 2-way radio transmitter-receivers to identify and track tags associated with objects.
- NFC consists of communication protocols for electronic devices, typically a mobile device and a standard device.

Low-Energy Bluetooth

This technology supports the low-power, long-use need of IoT function while exploiting a standard technology with native support across systems.

Low-Energy Wireless

This technology replaces the most power hungry aspect of an IoT system. Though sensors and other elements can power down over long periods, communication links (i.e., wireless) must remain in listening mode. Low-energy wireless not only reduces consumption, but also extends the life of the device through less use.

Radio Protocols

ZigBee, Z-Wave, and Thread are radio protocols for creating low-rate private area networks. These technologies are low-power, but offer high throughput unlike many similar options. This increases the power of small local device networks without the typical costs.

LTE-A

LTE-A, or LTE Advanced, delivers an important upgrade to LTE technology by increasing not only its coverage, but also reducing its latency and raising its throughput. It gives IoT a tremendous power through expanding its range, with its most significant applications being vehicle, UAV, and similar communication.

WiFi-Direct

WiFi-Direct eliminates the need for an access point. It allows P2P (peer-to-peer) connections with the speed of WiFi, but with lower latency. WiFi-Direct eliminates an element of a network that often bogs it down, and it does not compromise on speed or throughput.

Chapter 5

IOT – Common Uses

IoT has applications across all industries and markets. It spans user groups from those who want to reduce energy use in their home to large organizations who want to streamline their operations. 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.

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

Joan runs 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.

Government and Safety

IoT applied to government and safety allows improved law enforcement, defense, city planning, and economic management. The technology fills in the current gaps, corrects many current flaws, and expands the reach of these efforts. For example, IoT can help city planners have a clearer view of the impact of their design, and governments have a better idea of the local economy.

Example

Joan lives in a small city. She's heard about a recent spike in crime in her area, and worries about coming home late at night.

Local law enforcement has been alerted about the new "hot" zone through system flags, and they've increases their presence. Area monitoring devices have detected suspicious behavior, and law enforcement has investigated these leads to prevent crimes.

Home and Office

In our daily lives, IoT provides a personalized experience from the home to the office to the organizations we frequently do business with. This improves our overall satisfaction, enhances

productivity, and improves our health and safety. For example, IoT can help us customize our office space to optimize our work.

Example

Joan works in advertising. She enters her office, and it recognizes her face. It adjusts the lighting and temperature to her preference. It turns on her devices and opens applications to her last working points.

Her office door detected and recognized a colleague visiting her office multiple times before she arrived. Joan's system opens this visitor's messages automatically.

Health and Medicine

IoT pushes us towards our imagined future of medicine which exploits a highly integrated network of sophisticated medical devices. Today, IoT can dramatically enhance medical research, devices, care, and emergency care. The integration of all elements provides more accuracy, more attention to detail, faster reactions to events, and constant improvement while reducing the typical overhead of medical research and organizations.

Example

Joan is a nurse in an emergency room. A call has come in for a man wounded in an altercation. The system recognized the patient and pulls his records. On the scene, paramedic equipment captures critical information automatically sent to the receiving parties at the hospital. The

system analyzes the new data and current records to deliver a guiding solution. The status of the patient is updated every second in the system during his transport. The system prompts Joan to approve system actions for medicine distribution and medical equipment preparation.

Chapter 6

IOT – Education Application

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.

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 lowcost, low-power small devices, which still offer high performance. This technology aids in managing costs, improving the quality of education, professional development, and facility management improvement through rich examinations of key areas −

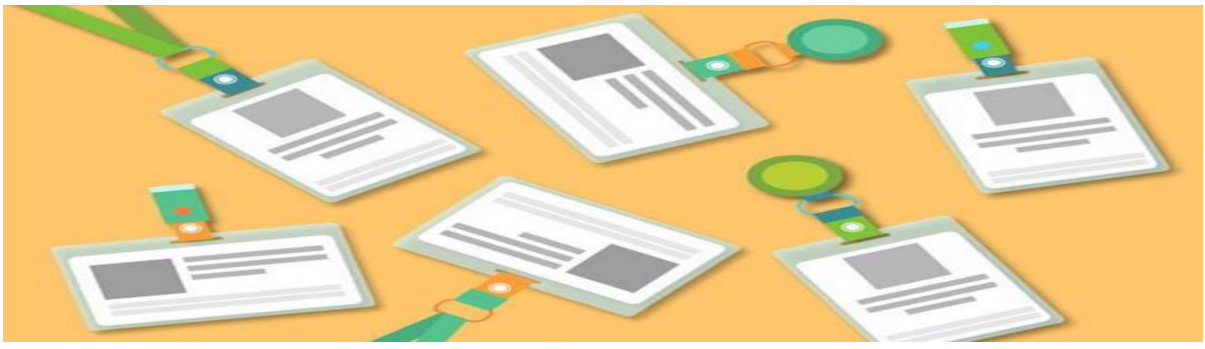
- Student response, performance, and behavior
- Instructor response, performance, and behavior

- Facility monitoring and maintenance
- Data from other facilities

Data informs them about ineffective strategies and actions, whether educational efforts or facility qualities. Removing these roadblocks makes them more effective.

Educators

Information provided by IoT empowers educators to deliver improved education. They have a window into the success of their strategies, their students' perspective, and other aspects of their performance. 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.



A school in Richmond, California, embeds RFID chips in ID cards to track the presence of students. Even if students are not present for check-in, the system will track and log their presence on campus.

IoT provides instructors with easy access to powerful educational tools. Educators can use IoT to perform as a one-on-one instructor providing specific instructional designs for each pupil; for example, using data to determine the most effective supplements for each student, and autogenerating content from lesson materials on-demand for any student.

The application of technology improves the professional development of educators because they truly see what works, and learn to devise better strategies, rather than simply repeating old or ineffective methods.

IoT also enhances the knowledge base used to devise education standards and practices. Education research suffers from accuracy issues and a general lack of data. IoT introduces large high quality, real-world datasets into the foundation of educational design. This comes from IoT's unique ability to collect enormous amounts of varied data anywhere.

Personalized Education

IoT facilitates the customization of education to give every student access to what they need. Each student can control their experience and participate in instructional design, and much of this happens passively. The student simply utilizes the system, and performance data primarily shapes their design. This combined with organizational and educator optimization delivers highly effective education while reducing costs.

Chapter 7

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.

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.

Smart trashcans in New York tell garbage collectors when they need to be emptied. They optimize trash service by ensuring drivers only make necessary stops, and drivers modify their route to reduce fuel consumption.

In the area of management, IoT supports cities through its implementation in major services and infrastructure such as transportation and healthcare. It also aids in other key areas like water control, waste management, and emergency management. Its real-time and detailed information facilitate more prompt decisions in contrast to the traditional process plagued by information lag, which can be critical in emergency management.

Standard state services are also improved by IoT, which can automate otherwise slow processes and trim unnecessary state expenses; for example, it can automate motor vehicle services for testing, permits, and licensing.

IoT also aids in urban improvement by skipping tests or poor research, and providing functional data for how the city can be optimized. This leads to faster and more meaningful changes.

Creating Jobs

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

National Defense

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.

IoT automates the protection tasks typically spread across several departments and countless individuals. It achieves this while improving accuracy and speed.

Chapter 8

IOT – Environmental Application

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.

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.

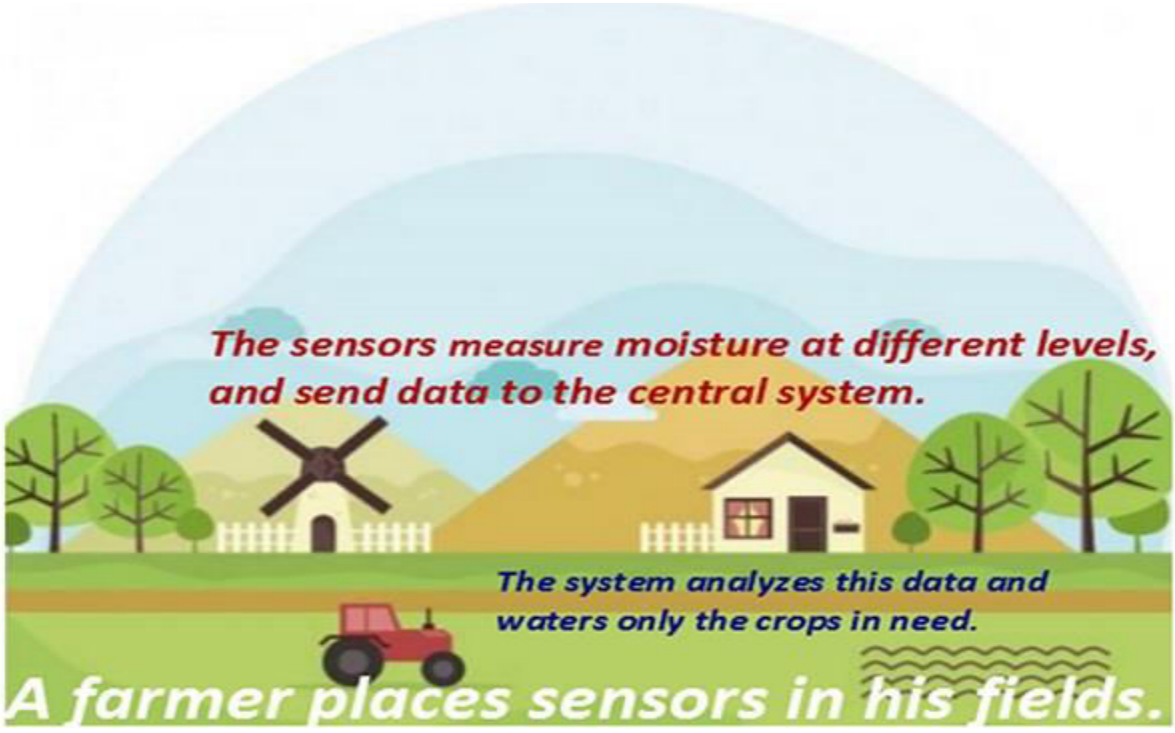
Extreme Weather

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.

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.



Much of commercial farming, like weather monitoring, suffers from a lack of precision and requires human labor in the area of monitoring. Its automation also remains limited.

IoT allows operations to remove much of the human intervention in system function, farming analysis, and monitoring. Systems detect changes to crops, soil, environment, and more. They optimize standard processes through analysis of large, rich data collections. They also prevent health hazards (e.g., e. coli) from happening and allow better control.

Chapter 9

IOT – Manufacturing Applications

Manufacturing technology currently in use exploits standard technology along with modern distribution and analytics. IoT introduces deeper integration and more powerful analytics. This opens the world of manufacturing in a way never seen before, as organizations become fully developed for product delivery rather than a global network of suppliers, makers, and distributors loosely tied together.

Intelligent Product Enhancements

Much like IoT in content delivery, IoT in manufacturing allows richer insight in real-time. This dramatically reduces the time and resources devoted to this one area, which traditionally requires heavy market research before, during, and well after the products hit the market.

IoT also reduces the risks associated with launching new or modified products because it provides more reliable and detailed information. The information comes directly from market use and buyers rather than assorted sources of varied credibility.

Dynamic Response to Market Demands

Supplying the market requires maintaining a certain balance impacted by a number of factors such as economy state, sales performance, season, supplier status, manufacturing facility

status, distribution status, and more. The expenses associated with supply present unique challenges given today's global partners. The associated potential or real losses can dramatically impact business and future decisions.

IoT manages these areas through ensuring fine details are managed more at the system level rather than through human evaluations and decisions. An IoT system can better assess and control the supply chain (with most products), whether demands are high or low.

Lower Costs, Optimized Resource Use, and Waste Reduction

IoT offers a replacement for traditional labor and tools in a production facility and in the overall chain which cuts many previously unavoidable costs; for example, maintenance checks or tests traditionally requiring human labor can be performed remotely with instruments and sensors of an IoT system.

IoT also enhances operation analytics to optimize resource use and labor, and eliminate various types of waste, e.g., energy and materials. It analyzes the entire process from the source point to its end, not just the process at one point in a particular facility, which allows improvement to have a more substantial impact. It essentially reduces waste throughout the network, and returns those savings throughout.

This XRS relay box connects all truck devices (e.g., diagnostics and driver cell) to the XRS fleet management supporting software, which allows data collection.

Improved Facility Safety

A typical facility suffers from a number of health and safety hazards due to risks posed by processes, equipment, and product handling. IoT aids in better control and visibility. Its monitoring extends throughout the network of devices for not only performance, but for dangerous malfunctions and usage. It aids (or performs) analysis and repair, or correction, of critical flaws.

Product Safety

Even the most sophisticated system cannot avoid malfunctions, nonconforming product, and other hazards finding their way to market. Sometimes these incidents have nothing to do with the manufacturing process, and result from unknown conflicts.

In manufacturing, IoT helps in avoiding recalls and controlling nonconforming or dangerous product distribution. Its high level of visibility, control, and integration can better contain any issues that appear.

Chapter 10

IOT – Healthcare Applications

IoT systems applied to healthcare enhance existing technology, and the general practice of medicine. They expand the reach of professionals within a facility and far beyond it. They increase both the accuracy and size of medical data through diverse data collection from large sets of real-world cases. They also improve the precision of medical care delivery through more sophisticated integration of the healthcare system.

Research

Much of current medical research relies on resources lacking critical real-world information. It uses controlled environments, volunteers, and essentially leftovers for medical examination. IoT opens the door to a wealth of valuable information through real-time field data, analysis, and testing.

IoT can deliver relevant data superior to standard analytics through integrated instruments capable of performing viable research. It also integrates into actual practice to provide more key information. This aids in healthcare by providing more reliable and practical data, and better leads; which yields better solutions and discovery of previously unknown issues.

It also allows researchers to avoid risks by gathering data without manufactured scenarios and human testing.

Devices

Current devices are rapidly improving in precision, power, and availability; however, they still offer less of these qualities than an IoT system integrating the right system effectively. IoT unlocks the potential of existing technology, and leads us toward new and better medical device solutions.

IoT closes gaps between equipment and the way we deliver healthcare by creating a logical system rather than a collection of tools. It then reveals patterns and missing elements in healthcare such as obvious necessary improvements or huge flaws.

The ClearProbe portable connected ultrasound device can use any computer anywhere as a supporting machine. The device sends all imaging records to the master system.

Care

Perhaps the greatest improvement IoT brings to healthcare is in the actual practice of medicine because it empowers healthcare professionals to better use their training and knowledge to solve problems. They utilize far better data and equipment, which gives them a window into blind spots and supports more swift, precise actions. Their decision-making is no longer limited by the disconnects of current systems, and bad data.

IoT also improves their professional development because they actually exercise their talent rather than spending too much time on administrative or manual tasks. Their organizational decisions also improve because technology provides a better vantage point.

Medical Information Distribution

One of the challenges of medical care is the distribution of accurate and current information to patients. Healthcare also struggles with guidance given the complexity of following guidance. IoT devices not only improve facilities and professional practice, but also health in the daily lives of individuals.

IoT devices give direct, 24/7 access to the patient in a less intrusive way than other options. They take healthcare out of facilities and into the home, office, or social space. They empower

individuals in attending to their own health, and allow providers to deliver better and more granular care to patients. This results in fewer accidents from miscommunication, improved patient satisfaction, and better preventive care.

Emergency Care

The advanced automation and analytics of IoT allows more powerful emergency support services, which typically suffer from their limited resources and disconnect with the base facility. It provides a way to analyze an emergency in a more complete way from miles away. It also gives more providers access to the patient prior to their arrival. IoT gives providers critical information for delivering essential care on arrival. It also raises the level of care available to a patient received by emergency professionals. This reduces the associated losses, and improves emergency healthcare.

Chapter 11

IOT – Security

Every connected device creates opportunities for attackers. These vulnerabilities are broad, even for a single small device. The risks posed include data transfer, device access, malfunctioning devices, and always-on/always-connected devices.

The main challenges in security remain the security limitations associated with producing lowcost devices, and the growing number of devices which creates more opportunities for attacks.

Security Spectrum

The definition of a secured device spans from the most simple measures to sophisticated designs. Security should be thought of as a spectrum of vulnerability which changes over time as threats evolve.

Security must be assessed based on user needs and implementation. Users must recognize the impact of security measures because poorly designed security creates more problems than it solves.

Example

A German report revealed hackers compromised the security system of a steel mill. They disrupted the control systems, which prevented a blast furnace from being shut down properly, resulting in massive damage. Therefore, users must understand the impact of an attack before deciding on appropriate protection.

Challenges

Beyond costs and the ubiquity of devices, other security issues plague IoT −

- **Unpredictable Behavior** − 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.

- **Device Similarity** – IoT devices are fairly uniform. They utilize the same connection technology and components. If one system or device suffers from a vulnerability, many more have the same issue.
- **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.
- **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 and abandonware lack the same security hardening of other systems due to the evolution of technology over time.
- **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.
- **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.

- **No Alerts** – Another goal of IoT remains to provide its incredible functionality without being obtrusive. This introduces the problem of user awareness. Users do not monitor the devices or know when something goes wrong. Security breaches can persist over long periods without detection.

Chapter 12

IOT – Identity Protection

IOT devices collect data about their environment, which includes people. These benefits introduce heavy risk. The data itself does not present the danger, however, its depth does. The highly detailed data collection paints a very clear picture of an individual, giving criminals all the information they need to take advantage of someone.

People may also not be aware of the level of privacy; for example, entertainment devices may gather A/V data, or “watch” a consumer, and share intimate information. The demand and price for this data exacerbates the issue considering the number and diversity of parties interested in sensitive data.

Problems specific to IoT technology lead to many of its privacy issues, which primarily stem from the user's inability to establish and control privacy −

Consent

The traditional model for “notice and consent” within connected systems generally enforces existing privacy protections. It allows users to interact with privacy mechanisms, and set preferences typically through accepting an agreement or limiting actions. Many IoT devices

have no such accommodations. Users not only have no control, but they are also not afforded any transparency regarding device activities.

The Right to be Left Alone

Users have normal expectations for privacy in certain situations. This comes from the commonly accepted idea of public and private spaces; for example, individuals are not surprised by surveillance cameras in commercial spaces, however, they do not expect them in their personal vehicle. IoT devices challenge these norms people recognize as the "right to be left alone." Even in public spaces, IoT creeps beyond the limits of expected privacy due to its power.

Indistinguishable Data

IoT deploys in a wide variety of ways. Much of IoT implementation remains group targeted rather than personal. Even if users give IoT devices consent for each action, not every system can reasonably process every set of preferences; for example, small devices in a complex assembly cannot honor the requests of tens of thousands of users they encounter for mere seconds.

Granularity

Modern big data poses a substantial threat to privacy, but IoT compounds the issue with its scale and intimacy. It goes not only where passive systems cannot, but it collects data

everywhere. This supports creation of highly detailed profiles which facilitate discrimination and expose individuals to physical, financial, and reputation harm.

Comfort

The growth of IoT normalizes it. Users become comfortable with what they perceive as safe technology. IoT also lacks the transparency that warns users in traditional connected systems; consequently, many act without any consideration for the potential consequences.

Conclusion

IOT is a recent technology which helps to connect the world very quickly & at low cost.It also have improved the performance of data exchange , for eg. Before IOT we were using SMS to convey the text messages but now Whats App is available to convey the Text,Images,Audio & Video messages at low cost & higher speed,this is beauty of an Internet of Things (IOT).