Challenges in IoT: Design challenges,
Development challenges,
Security challenges, other challenges
Home automation,
Industry applications,
Surveillance applications,
Other IoT applications.

Unit IV

Challenges in IOT

The Internet of Things (IoT) has fast grown to be a large part of how human beings live, communicate and do business. All across the world, web-enabled devices are turning our global rights into a greater switched-on area to live in. There are many challenges facing the implementation of IoT. IoT security is not just device security, as all elements need to be considered, including the device, cloud, mobile application, network interfaces, software, use of encryption, use of the authentication and physical security.

IoT Data Analytics Challenges

As IoT has grown and evolved, it has become clear that traditional data analytics solutions were not always adequate. For example, traditional data analytics typically employs a standard RDBMS and corresponding tools, but the world of IoT is much more demanding. While relational databases are still used for certain data types and applications, they often struggle with the nature of IoT data. IoT data places two specific challenges on a relational database:

Scaling problems: Due to the large number of smart objects in most IoT networks that continually send data, relational databases can grow incredibly large very quickly. This can result in performance issues that can be costly to resolve, often requiring more hardware and architecture changes.

Volatility of data: With relational databases, it is critical that the schema be designed correctly from the beginning. Changing it later can slow or stop the database from operating. Due to the lack of flexibility, revisions to the schema must be kept at a minimum. IoT data, however, is volatile in the sense that the data model is likely to change and evolve over time. A dynamic schema is often required so that data model changes can be made daily or even hourly.

To deal with challenges like scaling and data volatility, a different type of database, known as NoSQL, is being used.

In addition to the relational database challenges that IoT imposes, with its high volume of smart object data that frequently changes, IoT also brings challenges with the live streaming nature of its data and with managing data at the network level. Streaming data, which is generated as smart objects transmit data, is challenging because it is usually of a very high volume, and it is valuable only if it is possible to analyze and respond to it in real-time. Real-time analysis of streaming data allows you to detect patterns or anomalies that could indicate a problem or a situation that needs some kind of immediate response. To have a chance of affecting the outcome of this problem, you naturally must be able to filter and analyze the data while it is occurring, as close to the edge as possible. The market for analyzing streaming data in real-time is growing fast. Major cloud analytics providers, such as Google, Microsoft, and IBM, have streaming analytics offerings, and various other applications can be used in house. (Edge streaming analytics is discussed in depth later in this chapter.)

Technological challenges of IOT

This part is covering all technologies needed to make IoT systems function smoothly as a standalone solution or part of existing systems and that’s not an easy mission, there are many technological challenges, Connectivity, Compatibility & Longevity, Standards and Intelligent Analysis & Actions [4].

Figure 1: Technological Challenges

Connectivity: Connecting so many devices will be one of the biggest challenges of the future of IoT, and it will defy the very structure of current communication models and the underlying technologies [2]. At present we rely on the centralized, server/client paradigm to authenticate, authorize and connect different nodes in a network.

This model is sufficient for current IoT ecosystems, where tens, hundreds or even thousands of devices are involved. But when networks grow to join billions and hundreds of billions of devices, centralized systems will turn into a bottleneck. Such systems will require huge investments and spending in maintaining cloud servers that can handle such large amounts of information exchange, and entire systems can go down if the server becomes unavailable.

The future of IoT will very much have to depend on decentralizing IoT networks. Part of it can become possible by moving some of the tasks to the edge, such as using fog computing models where smart devices such as IoT hubs take charge of mission-critical operations and cloud servers take on data gathering and analytical responsibilities [5].

Compatibility and Longevity: IoT is growing in many different directions, with many different technologies competing to become the standard. This will cause difficulties and require the deployment of extra hardware and software when connecting devices.

Other compatibility issues stem from non-unified cloud services, lack of standardized M2M protocols and diversities in firmware and operating systems among IoT devices.

Standards: Technology standards which include network protocols, communication protocols, and data-aggregation standards, are the sum of all activities of handling, processing and storing the data collected from the sensors [3]. This aggregation increases the value of data by increasing, the scale, scope, and frequency of data available for analysis.

Challenges facing the adoptions of standards within IoT

Standard for handling unstructured data: Structured data are stored in relational databases and queried through SQL for example. Unstructured data are stored in different types of NoSQL databases without a standard querying approach.

Technical skills to leverage newer aggregation tools: Companies that are keen on leveraging big-data tools often face a shortage of talent to plan, execute, and maintain systems.

Intelligent Analysis & Actions: The last stage in IoT implementation is extracting insights from data for analysis, where analysis is driven by cognitive technologies and the accompanying models that facilitate the use of cognitive technologies.

Factors driving adoption intelligent analytics within the IoT

Artificial intelligence models can be improved with large data sets that are more readily available than ever before, thanks to the lower storage

Security challenges in IoT :

1. **Lack of encryption –**

   Although encryption is a great way to prevent hackers from accessing data, it is also one of the leading IoT security challenges. These drives like the storage and processing capabilities that would be found on a traditional computer. The result is an increase in attacks where hackers can easily manipulate the algorithms that were designed for protection.
2. **Insufficient testing and updating** With the increase in the number of IoT(internet of things) devices, IoT manufacturers are more eager to produce and deliver their device as fast as they can without giving security too much of although.
   Most of these devices and IoT products do not get enough testing and updates and are prone to hackers and other security issues.

3. **Brute forcing and the risk of default passwords –** Weak credentials and login details leave nearly all IoT devices vulnerable to password hacking and brute force. Any company that uses factory default credentials on their devices is placing both their business and its assets and the customer and their valuable information at risk of being susceptible to a brute force attack.
4. **IoT Malware and ransomware –**Increases with increase in devices. Ransomware uses encryption to effectively lock out users from various devices and platforms and still use a user's valuable data and info. **Example –** A hacker can hijack a computer camera and take pictures. By using malware access points, the hackers can demand ransom to unlock the device and return the data.
5. **IoT botnet aiming at cryptocurrency –**IoT botnet workers can manipulate data privacy, which could be massive risks for an open Crypto market. The exact value and creation of cryptocurrencies code face danger from mal-intentioned hackers. The blockchain companies are trying to boost security. Blockchain technology itself is not particularly vulnerable, but the app development process is.

Design challenge in IoT :

1. **Battery life is a limitation –**Issues in packaging and integration of small-sized chip with low weight and less power consumption. If you've been following the mobile space, you've likely see how every yr it looks like there's no restriction in terms of display screen size. Take the upward thrust of 'phablets', for instance, which can telephone nearly as huge as tablets. Although helpful, the bigger monitors aren't always only for convenience, rather, instead, display screen sizes are growing to accommodate larger batteries. Computers have getting slimmer, but battery energy stays the same.
2. **Increased cost and time to market –** Embedded systems are lightly constrained by cost. The need originates to drive better approaches when designing the IoT devices in order to handle the cost modelling or cost

optimally with digital electronic components. Designers also need to solve the design time problem and bring the embedded device at the right time to the market.

3. **Security of the system –** Systems have to be designed and implemented to be robust and reliable and have to be secure with cryptographic algorithms and security procedures. It involves different approaches to secure all the components of embedded systems from prototype to deployment.

Deployment challenges in IoT :

1. **Connectivity –** It is the foremost concern while connecting devices, applications and cloud platforms. Connected devices that provide useful front and information are extremely valuable. But poor connectivity becomes a challenge where IoT sensors are required to monitor process data and supply information.
2. **Cross platform capability –** IoT applications must be developed, keeping in mind the technological changes of the future. Its development requires a balance of hardware and software functions. It is a challenge for IoT application developers to ensure that the device and IoT platform drivers the best performance despite heavy device rates and fixings.
3. **Data collection and processing –** In IoT development, data plays an important role. What is more critical here is the processing or usefulness of stored data. Along with security and privacy, development teams need to ensure that they plan well for the way data is collected, stored or processed within an environment.
4. **Lack of skill set –** All of the development challenges above can only be handled if there is a proper skilled resource working on the IoT application development.

   The right talent will always get you past the major challenges and will be an important IoT application development asset.

APPLICATION OF IOT

Home Automation:

Home automation has received a lot of attention of late in the IoT/M2M context. Basic applications of the automated home include remote media control, heating control, lighting control (including low power landscape lighting control), and appliance control. Sensed homes, as examples of smart space, are seen as “next-step/nextgeneration” applications. Smart meters and energy efficiency (making use o potential of SG), discussed above, also fit this category. Telehealth (e.g., assisted living and in-home m-health services) also can be captured under this set of applications; security and emergency services also can be included here instrumentation of elements supporting daily living (e.g., appliances), comfort, health, security, and energy efficiency can improve the quality of life and the quality of experience. Home control applications include but are not limited to:

- _ Lighting control
- _ Thermostat/HVAC
- _ White goods/
- _ Appliance control
- _ In-home displays

Home security applications include but are not limited to:

- _ Door access phone
- _ Window locks
- _ Motion detector
- _ Smoke/fire alert
- _ Baby monitors
- _ Medical pendant

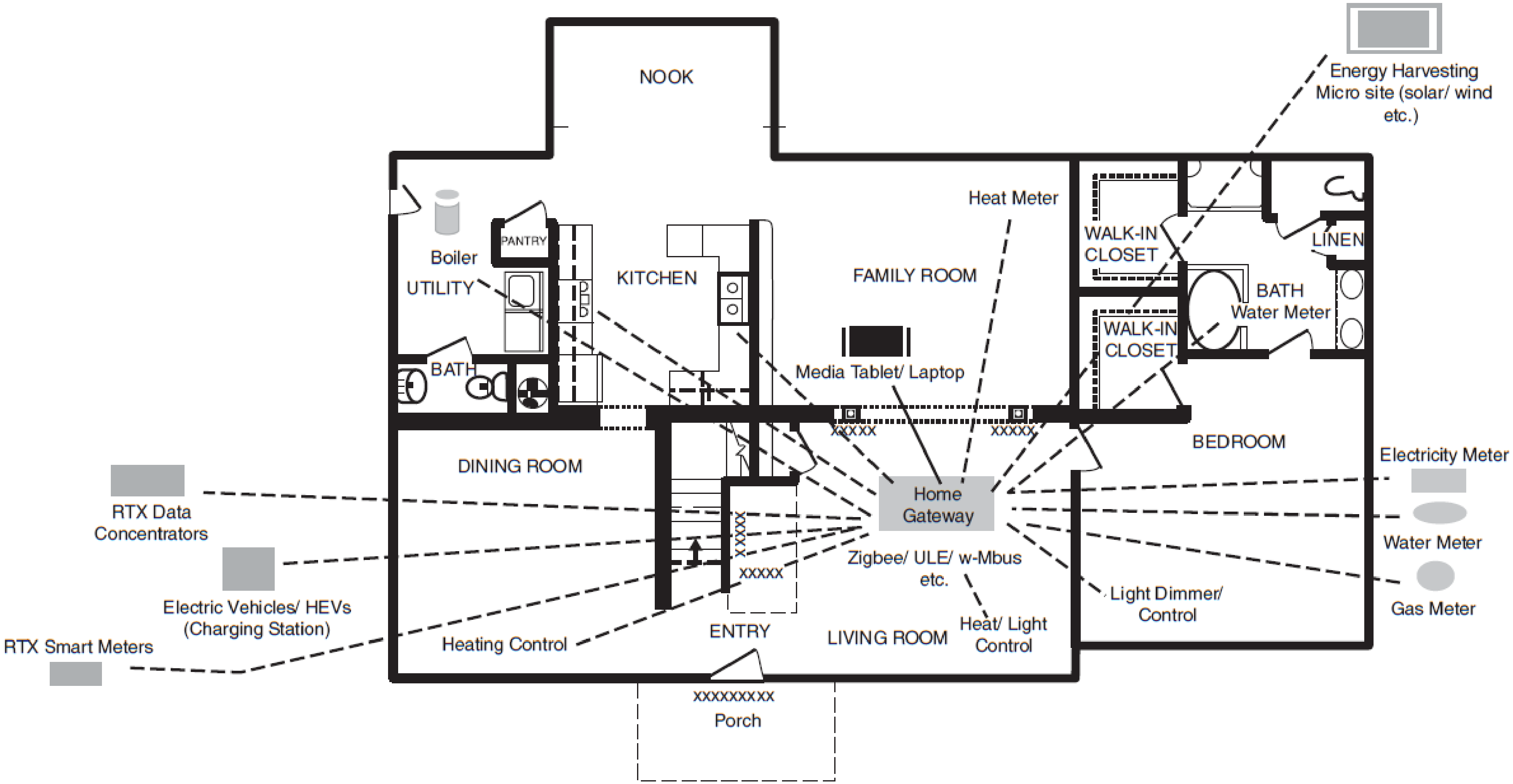


FIGURE 3.7 Home automation example.

See Figure 3.7 for an illustrative example.

Energy efficiency at home is a key application of interest because of the possibility of monetary saving for the consumer. Occupancy sensors can be used to establish whether there is somebody in a room or not and when the room becomes unoccupied the lights are automatically switched off; other types of sensors can be used to control te energy consumption from different equipments (e.g., temperature, TVs, and so on). The sensors and actuators can be autonomous (as in the case of light sensors), or can be connected to anM2Mgateway control node (wirelessly or using wires, e.g., via PLC). By integrating the data from a plethora of sensors (e.g., outside temperature, multizone heating status), the gateway can dispatch the appropriate commands to the relevant actuators (e.g., to switch off the heater in a room or zone, or in the entire house). The M2M system allows reducing energy consumption by automatically adapting the use of the house equipment to various short-term situations (people moving in and out of rooms, people going to work and retuning later) or long-term situations (people taking vacations or long weekends or managing a second/vacation home)

Smart Cities:

Cities around the world are getting “smarter” everyday through the implementation of Internet of Things (IoT) devices. “What exactly does it mean for a city to get smarter?” you ask. According to Kate Meis of Green Biz, “Smart cities are communities that are building infrastructure to continuously improve the collection, aggregation and use of data to improve the lives of their residents by harnessing the growing data revolution, low-cost sensors and research collaborations, and doing so securely to protect public safety and individual privacy."

A more efficient water supply

The Internet of Things has the potential to transform the way cities consume water. Smart meters can improve leak detection and data integrity; prevent lost revenue due to inefficiency, and boost productivity by reducing the amount of time spent entering and analyzing data. Also, these meters can be designed to feature customer-facing portals, providing residents with real-time access to information about their consumption and water supply.

An innovative solution to traffic congestion

As more and more people move to cities, traffic congestion – which is already a massive problem – is only going to get worse. Fortunately, the Internet of Things is well positioned to make improvements in this area that can benefit residents immediately. For example, smart traffic signals can adjust their timing to accommodate commutes and holiday traffic and keep cars moving. City officials can collect and aggregate data from traffic cameras, mobile phones, vehicles, and road sensors to monitor traffic incidents in real-time. Drivers can be alerted of accidents and directed to routes that are less congested. The possibilities are endless and the impact will be substantial.

More reliable public transportation

Public transportation is disrupted whenever there are road closures, bad weather, or equipment breakdowns. IoT can give transit authorities the real-time insights they need to implement contingency plans, ensuring that residents always have access to safe, reliable, and efficient public transportation. This might be done using insights from cameras or connected devices at bus shelters or other public areas.

Energy-efficient buildings

IoT technology is making it easier for buildings with legacy infrastructure to save energy and improve their sustainability. Smart building energy management systems, for instance, use IoT devices to connect disparate, nonstandard heating, cooling, lighting, and fire-safety systems to a central management application. The energy management application then highlights areas of high use and energy drifts so staff can correct them.

Research shows that commercial buildings waste up to 30 percent of the energy they use, so savings with a smart building energy management system can be significant. As more smart city buildings use energy management systems, the city will become more sustainable as a whole.

Improved public safety

Smart cities and their CSP partners often implement video monitoring systems to tackle the safety concerns that come up in every growing city. Some cities now have hundreds of cameras monitoring traffic for accidents and public streets for safety concerns. Video analytics softwarehelps process the thousands of hours of video footage each camera produces, whittling it down to only important events. Systems using IoT technology turn every camera attached to the system into a sensor, with edge computing and analytics starting right from the source. Artificial intelligence technology like machine learning will then complete the analysis and send video footage to humans who can react quickly to solve problems and keep residents safe.

Cities are also improving public safety with smart lighting initiatives that replace traditional streelights with connected LED infrastructure. Not only do the LED lights last longer and conserve energy, they also provide information on outages in real time. City workers can use that information to ensure important areas are well lit to deter crimes and make the public feel safer.

Energy:

The general goal is to monitor and control the consumption of utilities-supplied consumable assets, such as electricity, gas, and water. Utility companies deploy intelligent metering services by incorporating M2M communication modules into metering devices ("the thing"); these intelligent meters are able to send information automatically (or on demand) to a server application that can directly bill or control the metered resource. The ultimate objective is to improve energy distribution performance and efficiency by utilizing accurate real-time information on endpoint consumption. A variation of this application for metering of gas, electricity, and water is a pre-payment arrangement: here a consumer can purchase a specific volume of gas, electricity, water, and so on by pre-payment; the information about the purchased volume is securely transmitted to the metering device and then securely stored on the M2M modules. During use, the actual information about the consumed volume is transmitted to theM2Mmodule, and when the purchased volume has been consumed, the supply can be stopped (via a secure actuation capability) (5, 37). See Figure 3.2 for an example of a smart flowmeter for a water utility application; similar concepts apply to natural gas or electric power.

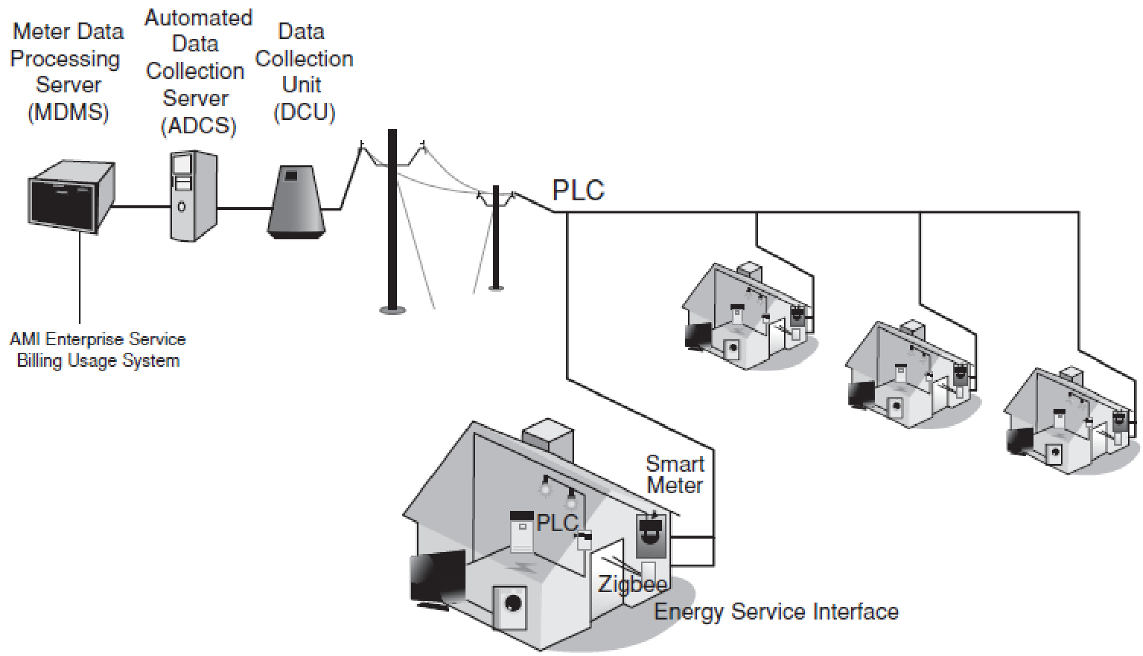
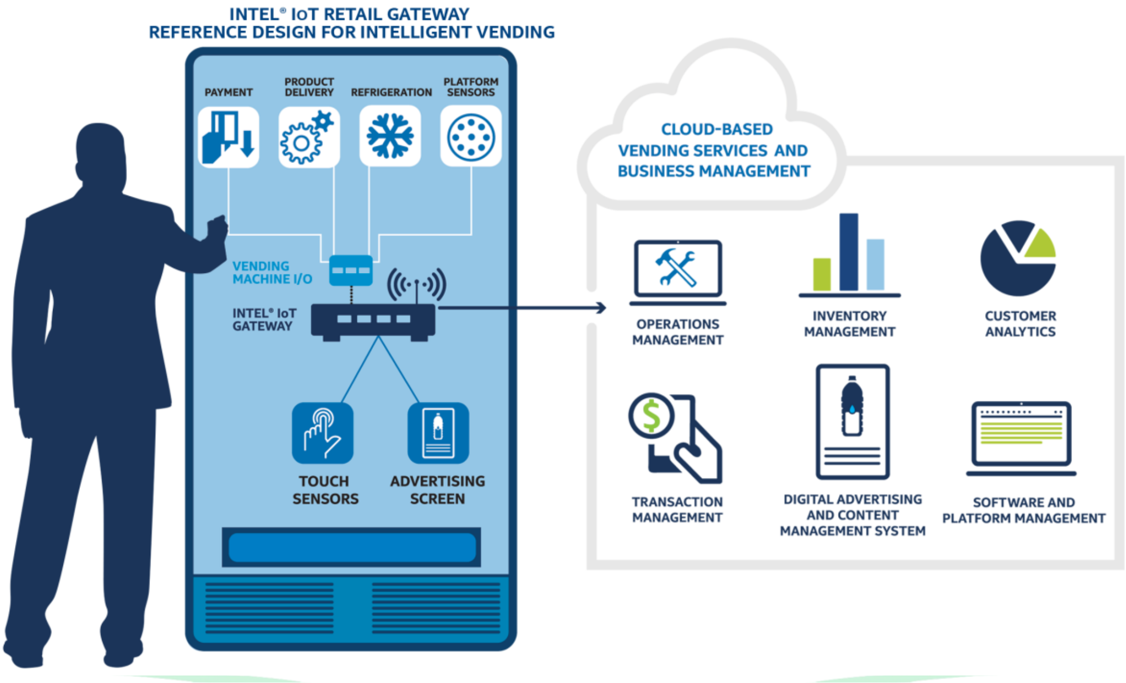


FIGURE 3.3 Advanced Metering Infrastructure.

The advanced metering infrastructure (AMI) is the electric information service infrastructure that is put in place between the end-user (or end device) and the power utility. AMI is a system for implementing the SG, and it is the principal means for realizing DR. According to press time market forecasts, shipments of smart meter units were expected to continue to grow at a 15% annual rate, with a total of about half-a-billion meters shipped by 2015. Proponents expect that the use of smart appliances and energy management systems will allow consumers to manage and reduce their energy bills and overall consumption. The combination of the AMI meter and an appropriate home area network (HAN) enables consumers to become aware of electricity consumption costs on a near real-time basis; to be able to monitor their energy usage; and to manage their usage based on their financial metrics. To assist consumers in managing their energy use, manufacturers are designing products that contain built-in communication systems that communicate with the HAN (and the AMI meter).

AMI can utilize a number of methods and communication standards to connect the end device to the applications of the utility company. To communicate between physical service layers, some combinations and/or refinements of existing communication protocols are required. See Figure 3.3, loosely modeled after reference (37). While a number of power line carrier (PLC)-based communication approaches are technically feasible, at the current time none of these technologies and protocols have reached the level of technical maturity and cost competitiveness to enable one to institutionalize a viable solution. However, there is work underway by several industry and/or standards organizations to develop standards for devices supporting these applications.

Retail Management:



Retailers are adopting IoT solutions across a number of applications that are improving store operations, reducing theft, increasing purchases through cross selling, enabling precise inventory management, and most importantly enhancing the consumer's shopping experience. The IoT is enabling physical retailers to compete more strongly against the online challengers, to regain lost market share and continually attract consumers into the store, thus making it easier for them to buy more while saving money.

Kaa is a leading enterprise IoT platform that can enable these benefits for retail companies and serve as an IoT backbone for numerous smart retail services and solutions. It allows you to quickly implement necessary applications for tracking goods with RFID tags, ensure items on-shelf availability, utilize Bluetooth beacons to provide customers with personalized mobile shopping experience, and set up digital signage in the store to attract visitors and help them navigate through your products, discounts, and loyalty programs. IoT retail solutions powered by Kaa can help you ensure that your customers have thorough information on everything they might like in your store, and thus bring them closer to a buying decision.

Featuring enterprise-grade security mechanisms, Kaa is also a safe choice for mobile payment solutions, mobile POS systems, and smart vending machines. Mobile payment applications built with Kaa can be used with all modern mobile devices and easily integrated with a retail management system in place to enable automated items inventory processing.

Logistics:

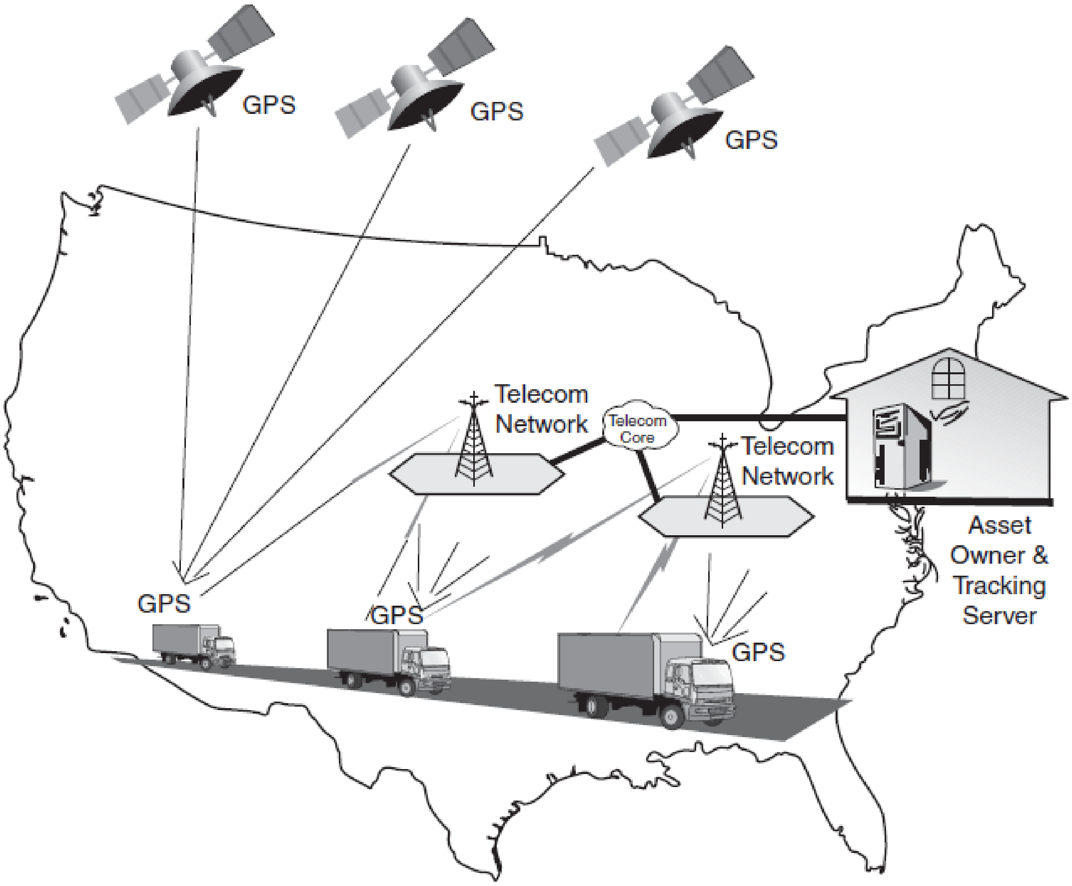


FIGURE 3.5 Vehicular asset tracking.

IoT/M2M automotive and transportation applications focus on safety, security, connected navigation, and other vehicle services such as, but not limited to, insurance or road pricing, emergency assistance, fleet management, electric car charging management, and traffic optimization. These applications typically entail IoT/M2M communication modules that are embedded into the car or the transportation equipment. Some of the technical challenges relate to mobility management and environmental hardware considerations. A brief description of applications follows from Reference 13 (on which the next few paragraphs are based). *tolen vehicle tracking (SVT):* A basic application for automotive M2M communications is tracking of mobile assets—either for purposes of managing a fleet of vehicles or to determine the location of stolen property. The goal of a SVT system is to facilitate the recovery of a vehicle in case of theft. The SVT service provider periodically requests location data from the Telematics Control Unit (TCU) in the vehicle and interacts with the police. The TCU may also be capable of sending out automatic theft alerts based on vehicle intrusion or illegal movement. The TCU may also be linked to the Engine Management System (EMS) to enable immobilization or speed degradation by remote command. Vehicles contain embedded M2M devices that can interface with location-determination technology and can communicate via a mobile cellular network to an entity (server) in the M2M core.

The M2M devices will communicate directly with the telecommunication network; the M2M devices will interface with location-determination technology such as standalone GPS, or network-based mechanisms such as assisted GPS, Cell-ID, and so on. For theft tracking applications, the M2M device is typically embedded in an inaccessible or inconspicuous place so that it may not be easily disabled by a thief. The tracking server is an entity located in the M2M core and owned or operated by the asset owner or service provider to receive, process, and render location and velocity information provided by the deployed assets. The tracking server may trigger a particular M2M device to provide a location/velocity update, or the M2M devices may be configured to autonomously provide updates on a schedule or upon an event-based trigger.

_ ***Remote diagnostics***: Remote diagnostic services can broadly be grouped into the following categories:

Maintenance minder—when the vehicle reaches a certain mileage (e.g., 90% of the manufacturer's recommended service interval since the previous service), the TCU sends a message to the owner or the owner's named dealership, advising the owner (or the dealership) that the vehicle is due for service.

Health check—Either on a periodic basis or triggered by a request from the owner, the TCU compiles the vehicle's general status using inbuilt diagnostic reporting functions and transmits a diagnostic report to the owner, the owner's preferred dealership, or to the vehicle manufacturer.

Fault triggered—When a fault (a diagnostic trouble code [DTC]) is detected with one of the vehicle systems, this triggers the TCU to send the DTC code and any related information to the owner's preferred dealer, or to the vehicle manufacturer.

Enhanced bCall—When a manual breakdown call is initiated by the owner, the TCU sends both position data and DTC status information to the roadside assistance service or to the vehicle manufacturer.

Fleet management: The fleet owner wishes to track the vehicles—that is, to know, over time, the location and velocity of each vehicle—in order to plan and optimize business operations. A fleet management application assumes that a fleet of vehicles have been deployed with M2M devices installed that are able to:
_ Interface with sensors on the vehicle that measure velocity
_ Interface with devices that can detect position
_ Establish a link with a mobile telecommunication network using appropriate network access credentials, such as a USIM (universal subscriber identity module)
_ *Vehicle-to-infrastructure communications.* A European Intelligent Transport Systems Directive3 seeks the implementation of eSafety applications in vehicles. Some vehicle manufacturers have begun to deploy vehicle-to-vehicle communication, for example, in the context of wireless access in vehicular environments (WAVE). On the other hand, vehicle to roadside applications are less well developed;

in this case, vehicles have embedded M2M devices that can interface with location-determination technology and can communicate via a mobile

telecommunication network to an entity (server). This application assumes that vehicles have been deployed with M2M devices installed that are able to:
_ Interface with sensors on the vehicle that measure velocity, external impacts
_ Interface with devices that can detect position
_ Establish a link with a mobile telecommunication network using appropriate network access credentials, such as a USIM
_ Upload or download traffic and safety information to a traffic information serve.

Agriculture:

The Internet of Things (IoT) has the capability to transform the world we live in; more-efficient industries, connected cars, and smarter cities are all components of the IoT equation. However, the application of technology like IoT in agriculture could have the greatest impact.

The global population is set to touch 9.6 billion by 2050. So, to feed this much population, the farming industry must embrace IoT. Against the challenges such as extreme weather conditions and rising climate change, and environmental impact resulting from intensive farming practices, the demand for more food has to be met.
Smart farming based on IoT technologies will enable growers and farmers to reduce waste and enhance productivity ranging from the quantity of fertilizer utilized to the number of journeys the farm vehicles have made.

<u>Applications of IoT in Agriculture</u>

Precision Farming

Also known as precision agriculture, precision farming can be thought of as anything that makes the farming practice more controlled and accurate when it comes to raising livestock and growing of crops. In this approach of farm management, a key component is the use of IT and various items like sensors, control systems, robotics, autonomous vehicles, automated hardware, variable rate technology, and so on.

The adoption of access to high-speed internet, mobile devices, and reliable, low-cost satellites (for imagery and positioning) by the manufacturer are few key technologies characterizing the precision agriculture trend.

Precision agriculture is one of the most famous applications of IoT in the agricultural sector and numerous organizations are leveraging this technique around the world. CropMetrics is a precision agriculture organization focused on ultra-modern agronomic solutions while specializing in the management of precision irrigation.

The products and services of CropMetrics include VRI optimization, soil moisture probes, virtual optimizer PRO, and so on. VRI (Variable Rate Irrigation) optimization maximizes profitability on irrigated crop fields with topography or soil variability, improve yields, and increases water use efficiency.

The soil moisture probe technology provides complete in-season local agronomy support, and recommendations to optimize water use efficiency. The virtual optimizer PRO combines various technologies for water management into one central, cloud based, and powerful location designed for consultants and growers to take advantage of the benefits in precision irrigation via a simplified interface.

Agricultural Drones

Technology has changed over time and agricultural drones are a very good example of this. Today, agriculture is one of the major industries to incorporate drones. Drones are being used in agriculture in order to enhance various agricultural practices. The ways ground-based and aerial based drones are being used in agriculture are crop health assessment, irrigation, crop monitoring, crop spraying, planting, and soil and field analysis.

The major benefits of using drones include crop health imaging, integrated GIS mapping, ease of use, saves time, and the potential to increase yields. With strategy and planning based on real-time data collection and processing, the drone technology will give a high-tech makeover to the agriculture industry.

PrecisionHawk is an organization that uses drones for gathering valuable data via a series of sensors that are used for imaging, mapping, and surveying of agricultural land. These drones perform in-flight monitoring and observations. The farmers enter the details of what field to survey, and select an altitude or ground resolution.

From the drone data, we can draw insights regarding plant health indices, plant counting and yield prediction, plant height measurement, canopy cover mapping, field water ponsing mapping, scouting reports, stockpile measuring, chlorophyll measurement, nitrogen content in wheat, drainage mapping, weed pressure mapping, and so on.

The drone collects multispectral, thermal, and visual imagery during the flight and then lands in the same location it took off.

Livestock Monitoring

Large farm owners can utilize wireless IoT applications to collect data regarding the location, well-being, and health of their cattle. This information helps them in identifying animals that are sick so they can be separated from the herd, thereby preventing the spread of disease. It also lowers labor costs as ranchers can locate their cattle with the help of IoT based sensors.

JMB North America is an organization that offers cow monitoring solutions to cattle producers. One of the solutions helps the cattle owners observe cows that are pregnant and about to give birth. From the heifer, a sensor powered by battery is expelled when its water breaks. This sends an information to the herd manager or the rancher. In the time that is spent with heifers that are giving birth, the sensor enables farmers to be more focused.

Smart Greenhouses

Greenhouse farming is a methodology that helps in enhancing the yield of vegetables, fruits, crops etc. Greenhouses control the environmental parameters through manual intervention or a proportional control mechanism. As manual intervention results in production loss, energy loss, and labor cost, these methods are less effective. A smart greenhouse can be designed with the help of IoT; this design intelligently monitors as well as controls the climate, eliminating the need for manual intervention.

For controlling the environment in a smart greenhouse, different sensors that measure the environmental parameters according to the plant requirement are used. We can create a cloud server for remotely accessing the system when it is connected using IoT.

Health and Lifestyle:

e-Health applications include health and fitness. Advocates envisage an environment where mobile health monitoring systems interoperate seamlessly and cohesively to reduce the lag time between the onset of medical symptoms in an individual and the diagnosis of the underlying condition. These applications make use of one or more biosensors placed on, or in, the human body, enabling the collection of a specified set of body's parameters to be transmitted and then monitored remotely. These sensors free patients from the set of wires that would otherwise tie the patients to a specific site at home or to a hospital bed; the on-body sensors are generally light and the links are wireless in nature, allowing the patient to enjoy a high degree of mobility (7). Sensors may consist of several wearable body sensor units, each containing a biosensor, a radio, an antenna, and some on-board control and computation. When multiple sensors are used by a patient, they are typically homed to a central unit also on the body. These on-body sensor systems—the sensors and the connectivity—are called wireless body area networks (WBANs), or alternatively, medical body area networks (MBANs), or alternatively medical body area network system (MBANS), although in the latter case the term does not necessarily mean a wireless system.

Figure 3.4 provides a pictorial view of a WBAN.

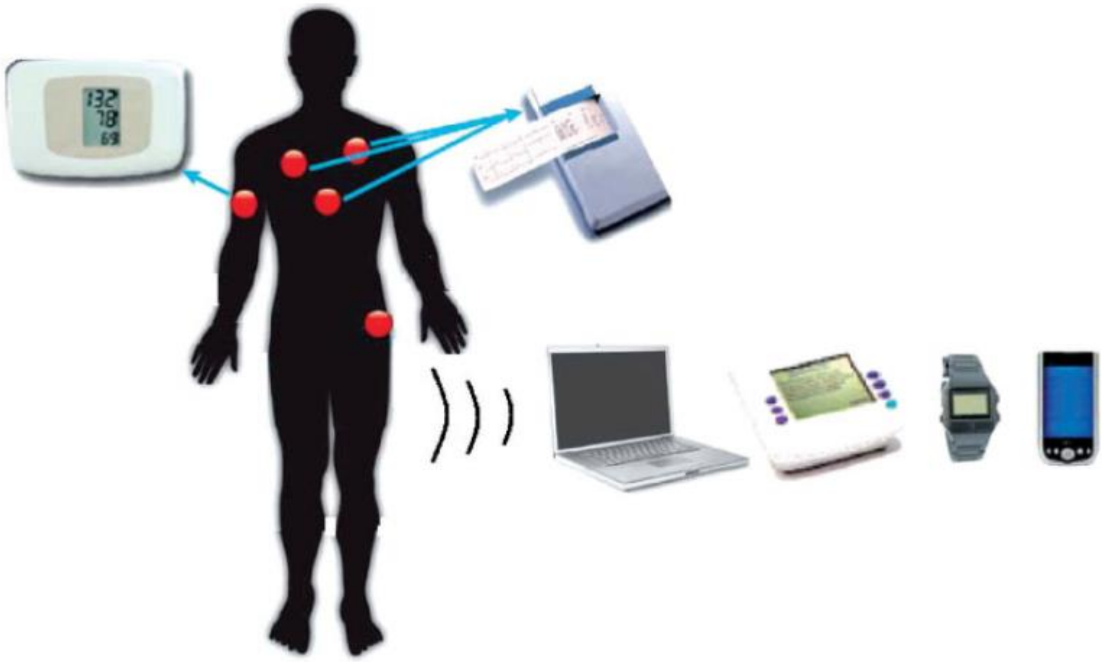


FIGURE 3.4 Wireless body area network/Medical body area network.

MBAN technology consists of small, low powered sensors on the body that capture clinical information, such as temperature and respiratory function. Sensors are used for monitoring and trending for disease detection, progression, remission, and fitness. As patients recover, MBANs allow them to move about the healthcare facility, while still being monitored for any health issues that might develop. MBANs consist of two paired devices—one that is worn on the body (sensor) and another that is located either on the body or in close proximity to it (hub) (9). Some of these devices are disposable and are similar to a band-aid in size and shape; the disposable sensors include a low power radio transmitter. Sensors typically register patient's temperature, pulse, blood glucose level, blood pressure (BP), and respiratory health; the benefits include increased mobility, better care, and lower costs. Examples of healthcare related sensors include, but are not limited to:

_ **Glucose meter:** A device that measures the approximate concentration of glucose in the blood; it is used by chronic disease (e.g., diabetes) management applications.

_ **Pulse oximeter:** A device that indirectly measures the amount of oxygen in a patient's blood (oxygen saturation (SpO2)).
_ **Electrocardiograph (ECG):** A device that records and measures the electrical activity of the heart over time.
_ **Social alarm devices:** Devices that allow individuals to raise an alarm and communicate with a caretaker when an emergency situation occurs; the caretaker may be a monitoring center, a medical care team, or a family member; these include devices fall detector and panic pendant/wrist transmitters.

Industrial internet of things (IIoT)

The industrial internet of things, or IIoT, is the use of internet of things technologies to enhance manufacturing and industrial processes.

Also known as the *industrial internet* or *Industrie 4.0*, IIoT incorporates machine learning and big data technologies to harness the sensor data, machine-to-machine (M2M) communication and automation technologies that have existed in industrial settings for years.

The driving philosophy behind IIoT is that smart machines are better than humans at accurately and consistently capturing and communicating real-time data. This data enables companies to pick up on inefficiencies and problems sooner, saving time and money and supporting business intelligence (BI) efforts.

In manufacturing specifically, IIoT holds great potential for quality control, sustainable and green practices, supply chain traceability and overall supply chain efficiency.

In an industrial setting, IIoT is key to processes such as predictive maintenance (PdM), enhanced field service, energy management and asset tracking.

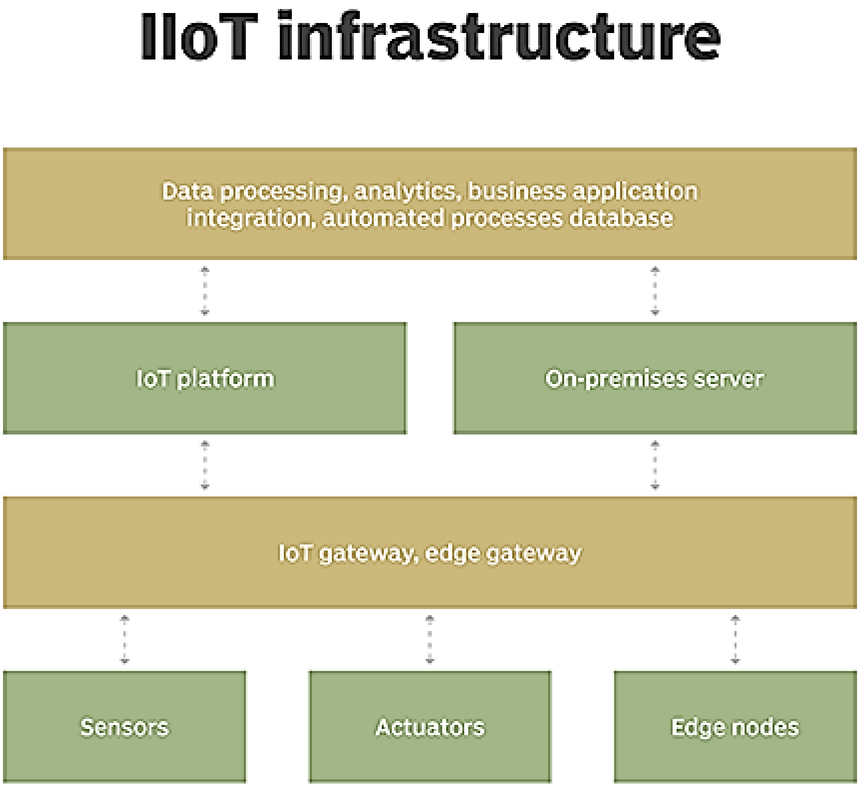
How IIoT works

IIoT is a network of devices connected via communications technologies to form systems that monitor, collect, exchange and analyze data, delivering valuable insights that enable industrial companies to make smarter business decisions faster.

An industrial IoT system consists of:

- intelligent assets -- i.e., applications, controllers, sensors and security components -- that can sense, communicate and store information about themselves;
- data communications infrastructure, e.g., the cloud;
- analytics and applications that generate business information from raw data; and
- people.

Edge devices and intelligent assets transmit information directly to the data communications infrastructure, where it is converted into actionable information on how a certain piece of machinery is operating, for instance. This information can then be used for predictive maintenance, as well as to optimize business processes.



Benefits of IIoT

One of the top touted benefits the industrial internet of things affords businesses is predictive maintenance. This involves organizations using real-time data generated from IIoT systems to predict defects in machinery, for example, before they occur, enabling companies to take action to address those issues before a part fails or a machine goes down.

Another common benefit is improved field service. IIoT technologies help field service technicians identify potential issues in customer equipment before they become major issues, enabling techs to fix the problems before they inconvenience customers.

Asset tracking is another IIoT perk. Suppliers, manufacturers and customers can use asset management systems to track the location, status and condition of products throughout the supply chain. The system will send instant alerts to stakeholders if the goods are damaged or at risk of being damaged, giving them the chance to take immediate or preventive action to remedy the situation.

IIoT applications and examples

In a real-world IIoT deployment of smart robotics, ABB, a power and robotics firm, is using connected sensors to monitor the maintenance needs of its robots to prompt repairs before parts break.

Likewise, commercial jetliner maker Airbus has launched what it calls "factory of the future," a digital manufacturing initiative to streamline operations and boost production. Airbus has integrated sensors into machines and tools on the shop floor and outfitted employees with wearable tech, e.g., industrial smart glasses, aimed at cutting down on errors and enhancing workplace safety.

IoT for Environmental Protection:

Environmental monitoring is a broad application for the Internet of Things. It involves everything from monitoring levels of ozone in a meat packing facility to monitoring national forests for smoke. Using IoT environment sensors for these various applications can take an otherwise highly labor-intensive process and make it simple and efficient.

Below, we've outlined eight of the most common IoT environmental monitoring use cases, a few considerations when selecting an IoT network, and why a low power, wide-area network (LPWAN) may be your best solution.

8 IoT Environment Monitoring Use Cases

1. **Monitoring air** for quality, carbon dioxide and smog-like gasses, carbon monoxide in confined areas, and indoor ozone levels.
2. **Monitoring water** for quality, pollutants, thermal contaminants, chemical leakages, the presence of lead, and flood water levels.
3. **Monitoring soil** for moisture and vibration levels in order to detect and prevent landslides.
4. **Monitoring forests** and protected land for forest fires.
5. **Monitoring for natural disasters** like earthquake and tsunami warnings.
6. **Monitoring fisheries** for both animal health and poaching.
7. **Monitoring snowfall levels** at ski resorts and in national forests for weather tracking and avalanche prevention.
8. **Monitoring data centers** for air temperature and humidity.