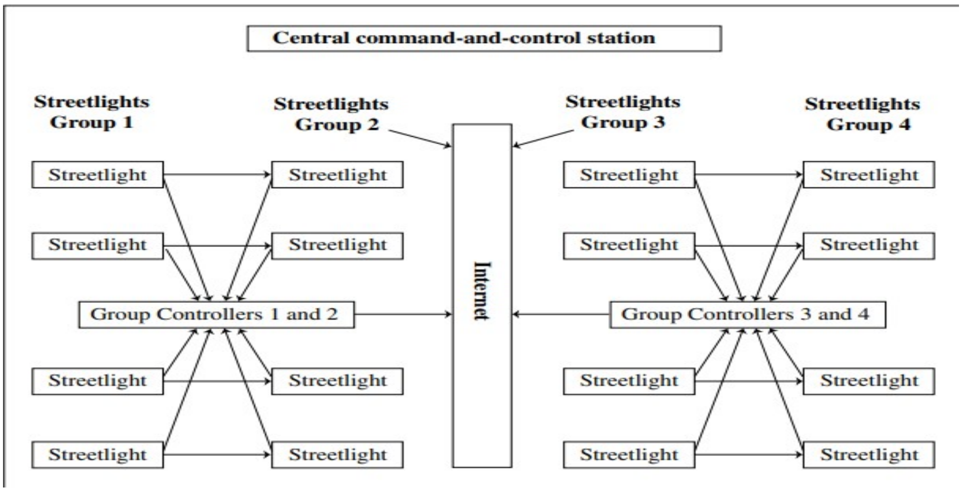
UNIT V: IoT Case Studies

IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.

5.0 CASE STUDY: SMART CITY STREETLIGHTS CONTROL AND MONITORING

Streetlights in a city can be made to function like living entities through sensing and computing using tiny embedded devices that communicate and interact with a central control-and-command station through the Internet. Assume that each light in a group of 32 streetlights comprises a sensing, computing and communication circuit. Each group connects to a group-controller (or coordinator) through Bluetooth or ZigBee. Each controller further connects to the central command-and-control station through the Internet. The station receives information about each streetlight in each group in the city at periodic intervals. The information received is related to the functioning of the 32 lights, the faulty lights, about the presence or absence of traffic in group vicinity, and about the ambient conditions, whether cloudy, dark or normal daylight. The station remotely programs the group controllers, which automatically take an appropriate action as per the conditions of traffic and light levels. It also directs remedial actions in case a fault develops in a light at a specific location.

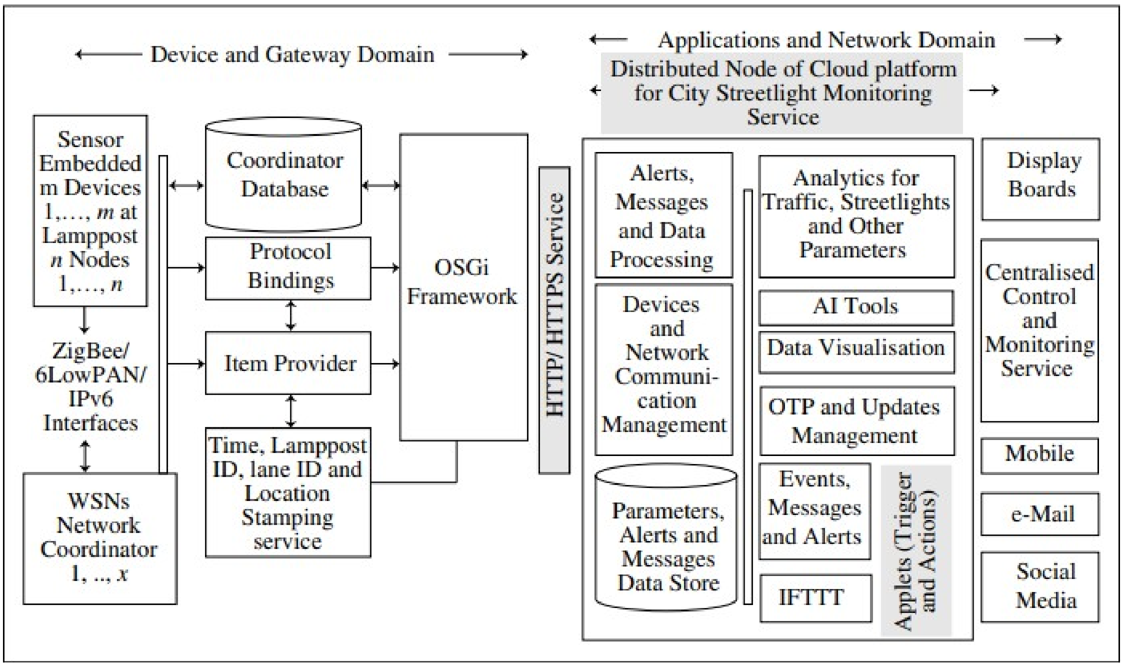


A lamppost hosts a streetlight, WSN actuator and sensors. The sensors enable messages for lamp functioning status, ambient light and traffic. The actuator enables switching the lights on and off. When ambient light is above threshold, then the lights are switched on. The WSN deploy sensors for detecting traffic presence and traffic density so that when traffic is not present, then lights are switched off. This results in saving of energy. The traffic density messages communicate to traffic-signal monitoring service. The WSN transceiver can also accept data from other services, such as Wi-Fi service, security service or traffic signalling service and retransmit onto the network of WSNs and then to access points. City services can deploy lampposts in street lighting systems as information networks. A lamppost can be an active node in the services network. Each transceiver at the lamppost can receive and retransmit in real time. Events, messages, alerts, triggers and notifications from a number of services can transmit for services such as smart parking, traffic signalling, waste management, air-quality index monitoring services, security services for home, banks and important public places, emergency services and hospitals. A control and monitoring service for city streetlights does the following tasks:

1. Measures and monitors the streetlights and measures traffic parameters in real time at preset intervals
2. Each WSN is uploaded by the program for configuring and communicating within the WSN network
3. The network connects a coordinator which deploys the data adaption, store, time, location, IDs stamping and gateway interfaces
4. Communicates the WSN network messages
5. Messages transmit at the preset intervals to the access point, which connects a coordinator.

6. Coordinator generates and communicates alerts, triggers, messages and data after aggregating, compacting and processing at data-adaptation layer.
7. Coordinator creates and updates in real time a database which transfers to the cloud for processing and for cloud data store.
8. Uses the OTP features and uploads the programs at the WSNs and gateways. An OTP module at the cloud node provides OTP management and uploads connectivity programs for gateways
9. Runs at the data-adaptation layer for faulty or inaccessible sensors at periodic intervals 10. Integrates data, and activates the alerts and triggers
11. Cloud node provides platform for processes, analyses and visualisation of the data and database information. The node provides analytics and AI for optimising monitoring and control functions.
12. Cloud platform can be CISCO IoT, IOX and Fog, Nimbits, my.openHAB, TCUO, AWS or Bluemix platform with Watson analytics.

Architecture Reference Model Two Domains:



Device and Gateway Domain Hardware and software components and modules are as follows: Hardware Hardware consists of m embedded-devices at a WSN. The n WSN node networks communicate between them using ZigBee/6LowPAN/IPv6 protocol. The city streetlight service deploys x coordinators.

A WSN measures the following parameters: (i) ambient light condition, whether above or below a preset threshold, (ii) presence or absence of traffic in vicinity, (iii) traffic density and (iv) lamppost status, whether non-functional or not Each lamppost need not measure traffic parameters. Each WSN configures the sensing devices so that a measurement activates or deactivates as per commands from the coordinator and central monitor service. Configuring the node enables each parameter measurement at different preset intervals

Software Open source IDE or Eclipse IoT stack which include OSGi can be used for software development at devices and gateway domain. Each WSN is assigned sensor-IDs, lamppost-ID, lane-ID, subgroup-ID (left and right sides traffic). A subgroup of wireless sensor nodes form a WSN network and an assigned network-ID. Each coordinator is assigned a coordinator-ID. Each coordinator has three modules: (i) protocol binding module, (ii) item provider module for communication of queried items, alerts, messages and data, and (iii) time, lamppost ID, lane ID and location stamping service

Applications and Network Domain Cloud platform for city streetlight monitoring service deploys a number of distributed nodes. Internet connectivity is using HTTP/HTTPS service. The IP protocol network routers connect each coordinator with a distributed node. The distributed node platform provides the:

(i) Alerts, messages and data processing module
(ii) Devices network and communication management module
(iii) Analytics tools for traffic, streetlights and other parameters
(iv) Data store for parameters, alerts and messages
(v) AI tools
(vi) Data visualisation tools
(vii) Coordinators, networks and nodes update management using OTP
(viii) Event messages, triggers and alerts for central control and monitoring services
(ix) IFTTT for communication to mobile, e-mail, social media and web services and applications.

CASE STUDY

INDUSTRIAL IoT :

Industrial Internet of Things (IIoT) involves the use of IoT technology in manufacturing. IIoT involves the integration of complex physical machinery M2M communication with the networked sensors and use of software, analytics, machine learning and knowledge discovery. Example of the functions of IIoT are refining the operations for manufacturing or maintenance, or refining the business model of an industry.

IIoT applications are in the manufacturing, railways, mining, agriculture, oil and gas, utilities, transportation, logistics and healthcare services

Example1: How is IIoT technology used in optimising the bicycle manufacturing process?

The sensors at each manufacturing stage in a bicycle industry communicate information on completion at each stage for each bicycle. An IIoT application analyses that data on completion of each activity at each stage, including data of breakdowns, work stoppages and failures at the stages. The application enables the company to take steps and synchronises various actions to remove any bottlenecks due to the components supply or the manufacturing stage machinery or human failures. Bicycle manufacturing is thus optimised. Figure shows IIoT phases in the bicycle manufacturing process.

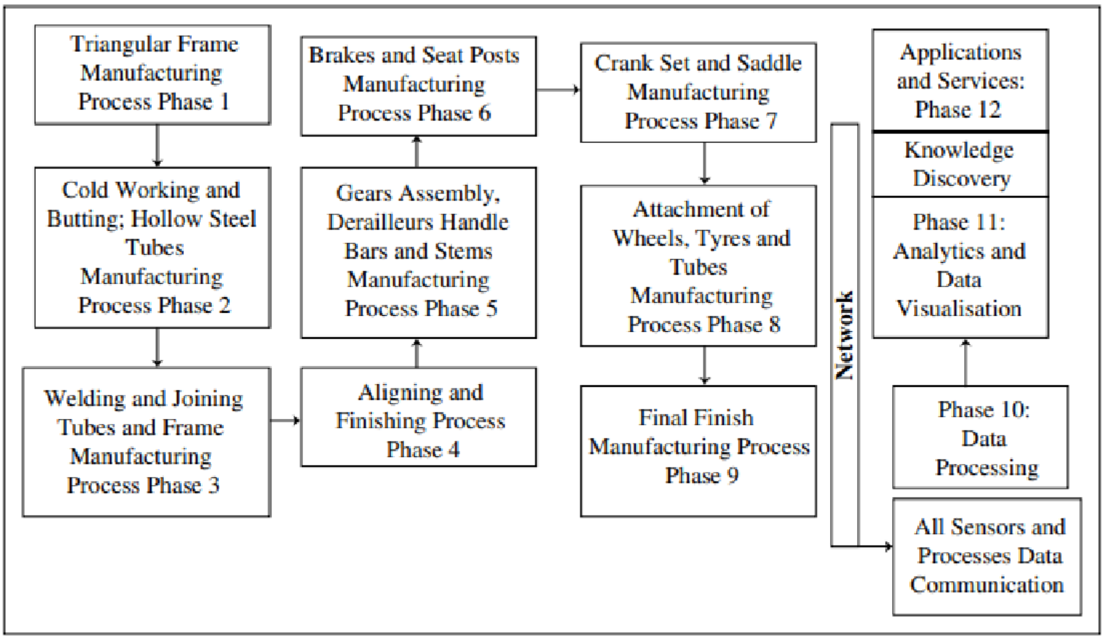


Figure IIoT phases in the bicycle manufacturing process

Example2. Problem How is IIoT technology useful in predictive maintenance of industrial processes? Solution Consider an application for predictive railroad service centre. Ultrasonic sensors, infrared temperature sensors and microphone sensors along railway tracks sense and communicate the captured data for each train passing through each segment track. The application predicts the failures. This enables undertaking of preventive maintenances.

Similarly, IIoT finds applications in predictive maintenance of aircraft parts, gas pipelines and machines used in production. Service-Oriented Cross-Layer Infrastructure for Smart Embedded Devices (SOCRADES) project developed an integration architecture which integrates shop floor industrial machines with enterprise systems. Three-level architecture has three levels—device management, service management and application interface for the systems.

Example 3. describes software for IIoT and M2M applications

How is IIoT technology useful in predictive maintenance of industrial processes? So

● GE Industrial Analytics Software Predix provides an IIoT platform. The platform provisions for sensorbased computing and predictive analytics.

● An advanced cloud-based service and software from Axeda Company manages connected products and machines. The software enables implementation of innovative M2M and IoT applications.

● OSI soft is software for real-time data management for sensor-driven computing. The sensors data is from the manufacturing processes and utilities companies such as electricity, phone and mining.

CASE STUDY TRANSPORTATION IoT :

IoT devices are deployed in a number of areas within the transportation sector, notably in traffic congestion systems, telematics systems within vehicles, tools and ticketing and security and surveillance to name but a few.

IoT for transportation is the networking of objects via embedded sensors, actuators and other devices that gather and transmit data about real-world activities. The use of IoT enabled technology is changing the way that the transportation sector operates. We wish to take a closer look at some of the areas within the transportation sector that are utilising IoT to transform how transportation systems gather and make use of data.

Benefits of IoT for Transportation

Some wider benefits that apply to the use of IoT technology within the transportation sector include:

1. Enhance Customer Experience

IoT technologies help to provide customers with more accurate, up-to-date, real-time data to better plan journeys and improve communication.

2. Improved Safety

The ability to track things such as train speeds, aircraft part conditions, roadway temperatures and the number of vehicles at an intersection using IoT enabled technology can all help to improve the safety of our transit systems worldwide.

3. Operational Performance

Transport Agencies adopting IoT technologies are already starting to see benefits in terms of operational performance. Cities can better monitor critical infrastructures and develop efficient processes to minimise operating costs and improve system capacity.

4. Environmental Improvements

By better monitoring congestion, IoT enabled systems can react quickly to evolving traffic patterns and return real-time data to help people to plan their journeys better. Reducing congestion and energy usage have a positive impact on the environment.

Five applications of IoT technology in transportation

These benefits of IoT technology in transportation can be applied through a number of applications within the sector. Here are five of the most common applications:

1.Traffic Management

Roading is by far the biggest segment within transportation when it comes to the adoption of IoT technologies and this is expected to grow as we head towards 2023. Within cities, data can be collected from CCTV feeds which transmit vehicle-related data to traffic management centres. Applications using IoT technology include:

- Smart parking

- Traffic lights
- Smart accident assistance

2. Toll and Ticketing

Conventional toll systems are becoming rapidly outdated. With the increase in vehicles on the roads, queues at toll booths have become a common sight, not to mention the manpower needed to operate toll booths on busy highways. Whilst automated tolls, using a RFID tag, have improved the flow of traffic, further improvements have been made possible by the use of IoT technology.

Many of today's modern vehicles are equipped with IoT connectivity. A vehicle can be detected up to a kilometre away from a tolling station, correctly identified and the barrier lifted for the vehicle to pass through. Alternatively, for older vehicles, a registered smartphone could serve the same purpose, taking automatic payment from the digital wallet linked on the phone.

3. Connected Cars

As mentioned above, cars today rely on connectivity and a key part of that is many new cars are now equipped with internet connectivity, sensors and actuators, all monitoring a wide range of applications from brakes and engine to the control of tyre pressure and exhaust gas composition.

In the future, connected cars will use the in-vehicles networks, radar and cameras to help detect and communicate with one other, prevent collisions and to help promote smooth traffic flow.

4. Vehicle Tracking Systems

Vehicle tracking systems are typically used within the freight segment to help companies manage their fleets effectively. They also help to monitor driver behaviour and can collect data which informs on idling time and driving style. Examples of IoT-powered functionality include:

- Trip scheduling
- Fleet tracking
- Driving times and driver rest break scheduling
- Alerts for speeding, harsh cornering, acceleration or braking
- Monitoring of vehicle load
- Distance travelled and fuel consumption

5. Public Transport Management

One key area in which NEC has been operating is smart transportation, with a focus on the public transport segment. IoT technologies are already in wide use in this segment and our solutions, including integrated ticketing and automated fare collection, passenger information systems, passenger information display systems and advanced vehicle Logistics solutions, all utilizing IoT technology to help solve social and economic issues such as traffic congestion in public transport.

IoT technology for connected public transport systems provides the following benefits:

- **Real-time vehicle tracking** – this helps public transport agencies better communicate with customers and provide accurate arrival times through both mobile devices and passenger information displays at transit stops and stations
- **Data analysis and real-time management** – the technology allows transit agencies to monitor progress in real-time and make adjustments for unpredicted incidents such as accidents, roadworks, emergencies etc., helping to re-route and make journeys more efficient
- **Personalised travel information** – transit agencies can track and monitor commuter behaviour and travel patterns and deliver personalised information direct to their smart phone on key changes such as delays, station closures or re-routing

CASE STUDY

AUTOMOTIVE IoT :

Automotive IoT enables the connected cars, vehicles-to-infrastructure technology, predictive and preventive maintenances and autonomous cars.

Connected Cars Technology:

Automotive vehicles can drive through roads with little or no effort at all. A connected car with the combination of GPS tracking and an Internet connection enables applications such as:

1. Display for driver that enables driving through the shortest route, avoiding the congested route, etc.
2. Customisation of functioning of the vehicle to meet the driver's needs and preferences
3. Get notifications about traffic
4. Protecting cars against theft
5. Weather and enroute destinations
6. Keeping a tab on driver's health and behaviour.

Vehicle-to-Infrastructure Technology: Automotive IoT enables Vehicle-to-Infrastructure (V2I) technology. A vehicle communicates with other vehicles, the surrounding infrastructure and a Wi-Fi LAN. Examples of V2I applications are:

- Alerts and warnings for forward collision
- Information about blind spots
- Notification about a vacant parking space
- Information about traffic congestion on route to destination
- Stream live music and news

Predictive and Preventive Maintenances

How is an automotive IoT technology useful in predictive maintenance of an automobile by a service centre application?

Consider Internet of connected automotive components. A number of sensors for statuses and conditions of components are used. Examples are engine movements unit, axle, steering unit, brake linings, wipers, air conditioners, battery, tyre movements, coolant and shockers. The statuses and conditions data are needed for predictive maintenance.

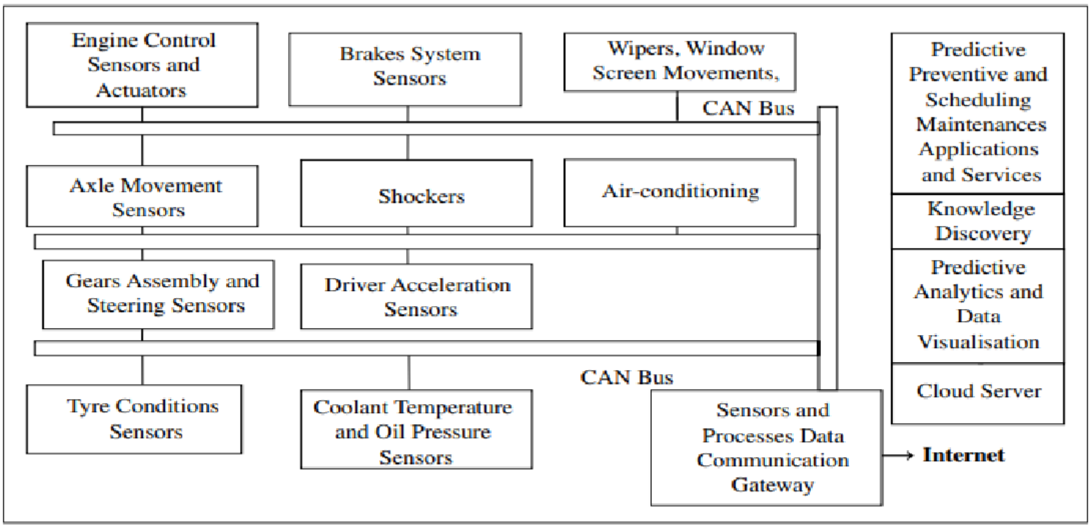


Figure Internet of connected car components for predictive and preventive maintenances of automobile by service centre

A component embeds computing hardware and for ultrasonic sensors, IR sensors, sound sensors, seat alignment sensors, height sensors, driver acceleration sensors at start, during running and driver braking characteristics and road friction, and microphone sensors. The sensors capture the data for noise, vibration and harsh driving and actions of the vehicle. The sense data communicates in real-time or stores and transmit when the automobile reaches a Wi-Fi node. The service centre application schedules maintenance alerts and predicts the failures and alerts for the actions. Figure shows Internet of connected car components for predictive and preventive maintenances of automobile by a service centre

CASE STUDY

APPLICATIONS AND SERVICES CONNECTED CAR :

Automotive Components Predictive Automotive Maintenance Service (ACPAMS) and Re-planning manufacturing process (RPMP) Two applications of the connected car are:

1. Automotive Components Predictive Automotive Maintenance Service (ACPAMS): Optimally-preparing and more effective maintenance, automatic detection of service requirements by direct transfer of service-relevant data to car maintenance and service centre, and driver/car user server and automatic reminder of servicing appointments shorten the service visits.

2. Re-planning manufacturing process (RPMP): The data are the customer ID and location and time stamped data as follows:

● In-car network data from ECUs Cluster of digital embedded devices/ car-health devices/sensors ● In-car climate control system

● Streaming audio video

● Maps, navigation, weather, mobile apps and user data

Identifying Requirements at Six Layers at ACPAMS and RPMP

Requirements at six layers for ACPAMS and RPMP applications and services are:

Layer 1 (Gather): The apps install at the mobile and wearable devices embed hardware and software for gathering the car location, weather, traffic, navigation and car-health data. ECUs cluster gathers the data using buses. The embedded sensors and device hardware and software gather the data and communicate that using the bus.

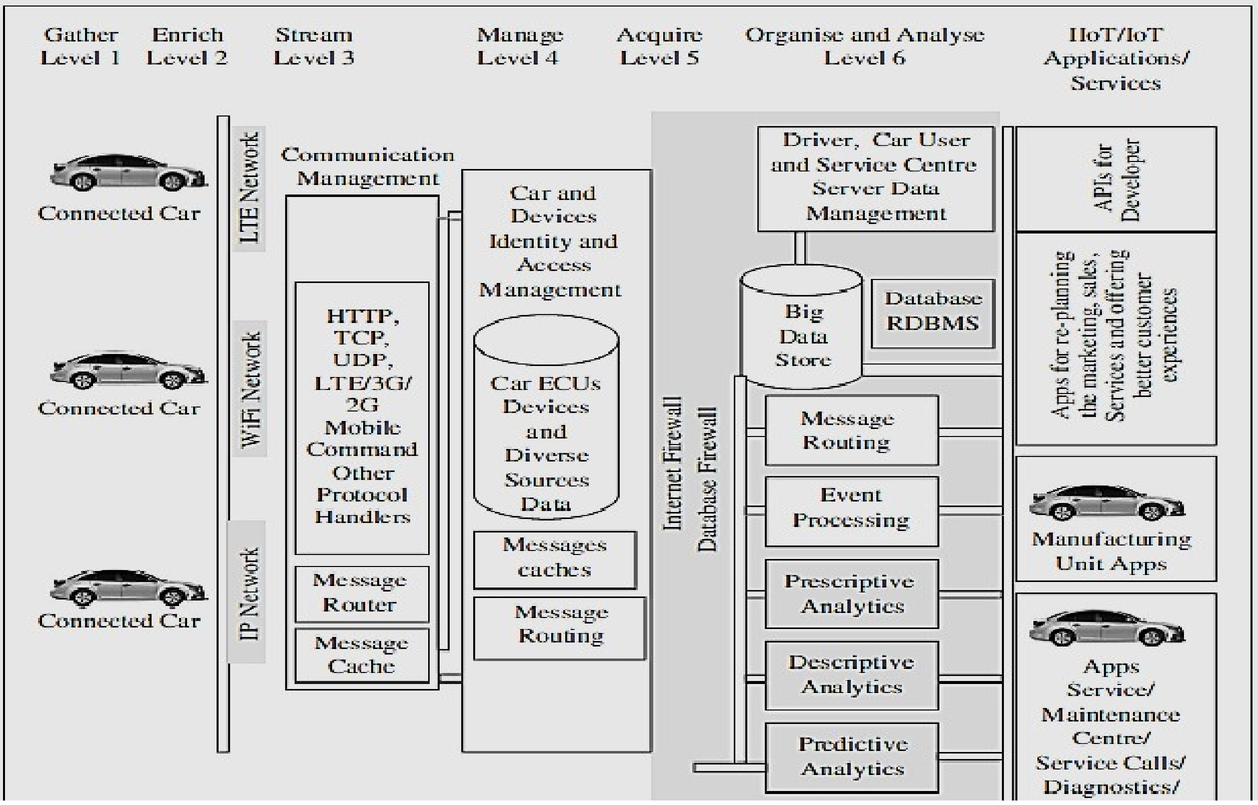


Fig Data flow diagram of connected cars

Layer 2 (Enrich and Stream): Software at car central computer access the data of layer 1. The data collects using CAN, MOST, Ethernet and Miracast Wi-Fi devices and display board. Software enriches the data by generating time series and location-stamped data and adapts the data for sending it to the network. The central-computer has smart gateway for ECUs cluster and provides cryptographic authentication, integrity and confidentiality functions for car cluster security.

Layer 3 (Manage): TCUP or a cloud server PaaS consists of communication management functions for the accesses, and ECU cluster, infotainment and other systems management, data and messages routing and caching. Layer 4 (Acquire and Organise): The platform acquires the ACPAMS and RPMP data, events and data of devices and diverse sources.

Layer 5 (Analyse and Intelligence): The platform organises data as big data store and database RDBMS. Data is analysed using the event processing, message routing, analytics and AI. Layer 6 (Enterprise Integration, Complex Applications Integration and SoA): Services and applications run on the processors for the service, production and manufacture, data visualisation, re-planning, re-scheduling or innovating the production and better customer experiences using ACPAMS, RPMP and services data.

CASE STUDY

:*HOME AUTOMATION:-*

Smart Home Sensors and actuators manage a smart home with an Internet connection. Wired and wireless sensors are incorporated into the security sensors, cameras, thermostats, smart plugs, lights and entertainment systems. Do-it-Yourself (DIY) sensors and actuators, include smart plug, motion detector, door/window detector, smoke detector, energy meter interface (electric, gas, water), remote control (built-in authentication), smart relay, surveillance camera, Wireless Hi-Fi speakers, HUE LED lights, electric utility meter etc.24 A connected home has the following applications deployed in a smart home:

- Mobile, tablets, IP-TV, VOIP telephony, video-conferencing, video-on-demand, videosurveillance, Wi-Fi and internet
- Home security: Access control and security alerts
- Lighting control
- Home healthcare
- Fire detection or Leak detection
- Energy efficiency
- Solar panel monitoring and control
- Temperature monitoring and HVAC control
- Refrigerator network with maintenance and service centres
- Automated meter reading

Domain Architectural Reference Model Below Figure shows the data-flow diagram and domain architecture reference model for home automation lighting, appliances and intrusion monitoring services.

appliances and intrusion monitoring services.

Figure shows that open-HAB has an event bus. The bus is asynchronous. The event bus refers to a communication bus for all protocol bindings. The bindings link to the hardware. The event bus is the base service of open-HAB. Example of the event is command, which triggers an action or a state change of some item or device. Another example of event is status update which informs about a status change of some item or device. For example, in response to a command.

The open-HAB service is integration-hub between such devices and bindings between different protocols used for networking the home devices, OSGi and HTTP service. Usually just one instance of open-HAB runs on a central coordinator (computer) at home. Event Administration Service of OSGi service is used for remote services. Several distributed open-HAB instances can connect and deploy the event bus.

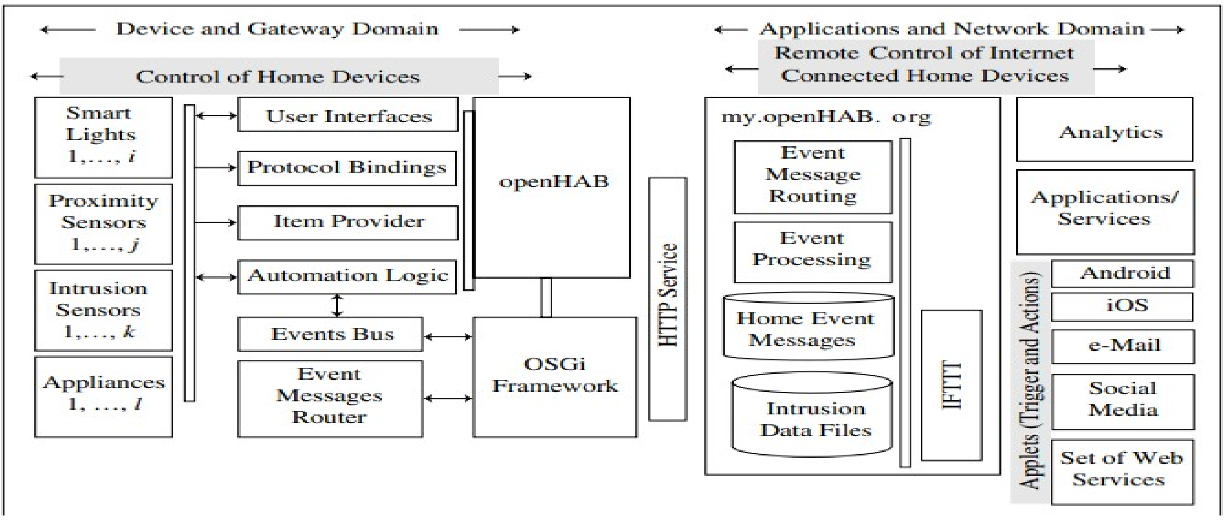


Figure:-Data-flow diagram and domain architecture reference model for home automation lighting,

Design Implementation of Device and Gateway Domain Hardware and Software

An implementation of home premise intrusion circuits and embedded sensor devices software needs high computing power for intrusion detection. Described Raspberry Pi 2 model B+ (RPi 2) which can be deployed due to high computing power. An implementation of home premise lighting and appliances embedded sensor devices software needs computing power for lighting automation and Arduino or RPi boards can be deployed. The open-HAB can be used for end-to-end solutions for smart home applications and services.

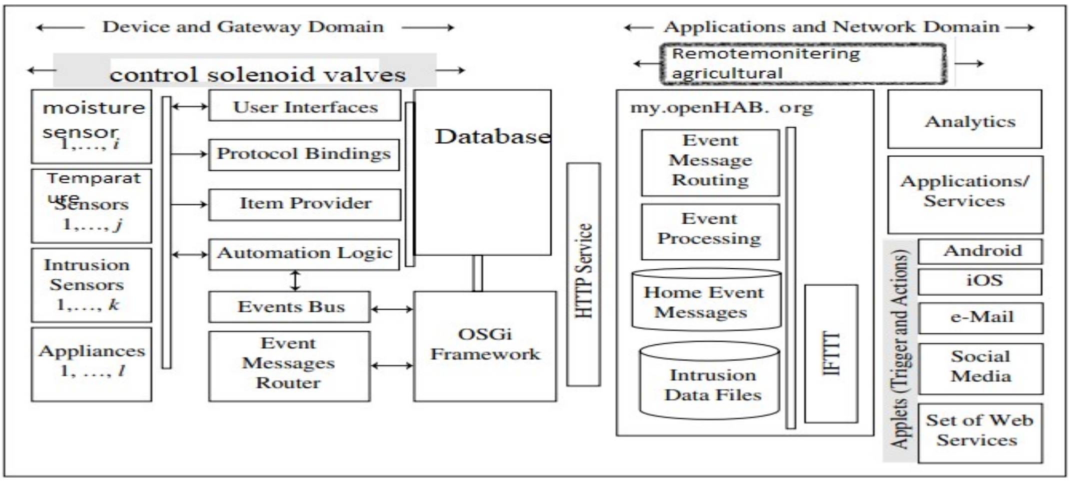
CASE STUDY

5.6 :SMART AGRICULTURE:

Smart Irrigation Smart irrigation deploys sensors for moisture. A smart irrigation monitoring service does the following tasks:

1. Sensors for moisture and actuators for watering channels are used in smart irrigation.
2. Uses soil moisture sensors with a sensor circuitry board with each one installed at certain depth in the fields.
3. Uses an array of actuators (solenoid valves) which are placed along the water channels and that control deficiencies in moisture levels above thresholds during a given crop period.
4. Uses sensors placed at three depths for monitoring of moisture in fruit plants such as grapes or mango, and monitors evapotranspiration (evaporation and transpiration)
5. Measures and monitors actual absorption and irrigation water needs
6. Each sensor board is in a waterproof cover and communicates to an access point using ZigBee protocol. An array of sensor circuits forms a WSN.
7. Access point receives the data and transfers it to an associated gateway. Data adapts at the gateway and then communicates to a cloud platform using LPWAN.
8. The cloud platform may be deployed such as Nimbits, my.openHAB, AWS or Bluemix.
9. Analytics at the platform analyses the moisture data and communicates to the actuators of water irrigation channels as per the water needs and past historical data
10. Measurements at the sensors are at preset intervals and actuators activate at analysed required values of the intervals.
11. The platform uploads the programs to sensors and actuators circuitry and sets preset measurement intervals of T1 (say, 24 hour) each and the preset actuation interval of t2 (say, on 120 hour)
12. Sensed moisture sensor values when exceed preset thresholds then trigger the alarm
13. An algorithm uploads and updates the programs for the gateways and nodes.
14. Runs at the data-adaptation layer and finds the faulty or inaccessible moisture sensors at periodic intervals

15. Open source SDK and IDE are used for prototyping the monitoring system



Smart Farming is a hi-tech and effective system of doing agriculture and growing food in a sustainable way. It is an application of implementing connected devices and innovative technologies together into agriculture. Smart Farming majorly depends on IoT thus eliminating the need of physical work of farmers and growers and thus increasing the productivity in every possible manner.

With the recent agriculture trends dependent on agriculture, Internet of Things has brought huge benefits like efficient use of water, optimization of inputs and many more. What made difference were the huge benefits and which has become a revolutionized agriculture in the recent days.

IoT based Smart Farming improves the entire Agriculture system by monitoring the field in real-time. With the help of sensors and interconnectivity, the Internet of Things in Agriculture has not only saved the time of the farmers but has also reduced the extravagant use of resources such as Water and Electricity. It keeps various factors like humidity, temperature, soil etc. under check and gives a crystal clear real-time observation.

The following are the benefits of adopting new technology - Internet of Things in Agriculture:

1. Climate Conditions:

Climate plays a very critical role for farming. And having improper knowledge about climate heavily deteriorates the quantity and quality of the crop production. But IoT solutions enable you to know the real-time weather conditions. Sensors are placed inside and outside of the agriculture fields. They collect data from the environment which is used to choose the right crops which can grow and sustain in the particular climatic conditions.

2. Precision Farming:

Precision Agriculture/Precision Farming is one of the most famous applications of IoT in Agriculture. It makes the farming practice more precise and controlled by realizing smart farming applications such as livestock monitoring, vehicle tracking, field observation, and inventory monitoring. The goal of precision farming is to analyze the data, generated via sensors, to react accordingly.

3. Smart Greenhouse:

To make our greenhouses smart, IoT has enabled weather stations to automatically adjust the climate conditions according to a particular set of instructions. Adoption of IoT in Greenhouses has eliminated the human intervention, thus making entire process cost-effective and increasing accuracy at the same time. For example, using solar-powered IoT sensors builds modern and inexpensive greenhouses. These sensors collect and transmit the real-time data which helps in monitoring the greenhouse state very precisely in real-time.

4. Data Analytics:

The conventional database system does not have enough storage for the data collected from the IoT sensors. Cloud based data storage and an end-to-end IoT Platform plays an important role in the smart agriculture system. These systems are estimated to play an important role such that better activities can be performed. In the IoT world, sensors are the primary source of collecting data on a large scale. The data is analyzed and transformed to meaningful information using analytics tools. The data analytics helps in the analysis of weather conditions, livestock conditions, and crop conditions.

CASE STUDY

:IOT HEALTH CARE SYSTEM

Apart from monitoring patients' health, there are many other areas where IoT devices are very useful in hospitals. IoT devices tagged with sensors are used for tracking real time location of medical equipment like wheelchairs, defibrillators, nebulizers, oxygen pumps and other monitoring equipment. Deployment of medical staff at different locations can also be analyzed real time.

The spread of infections is a major concern for patients in hospitals. IoT-enabled hygiene monitoring devices help in preventing patients from getting infected. IoT devices also help in asset management like pharmacy inventory control, and environmental monitoring, for instance, checking refrigerator temperature, and humidity and temperature control.

The healthcare-specific IoT products opens up immense opportunities. And the huge amount of data generated by these connected devices hold the potential to transform healthcare.

IoT has a four-step architecture that are basically stages in a process (See Figure 1). All four stages are connected in a manner that data is captured or processed at one stage and yields the value to the next stage. Integrated values in the process brings intuitions and deliver dynamic business prospects.

Step 1: First step consists of deployment of interconnected devices that includes sensors, actuators, monitors, detectors, camera systems etc. These devices collect the data.

Step 2: Usually, data received from sensors and other devices are in analog form, which need to be aggregated and converted to the digital form for further data processing.

Step 3: Once the data is digitized and aggregated, this is pre-processed, standardized and moved to the data center or Cloud.

Step 4: Final data is managed and analyzed at the required level. Advanced Analytics, applied to this data, brings actionable business insights for effective decision-making.

IoT is redefining healthcare by ensuring better care, improved treatment outcomes and reduced costs for patients, and better processes and workflows, improved performance and patient experience for healthcare providers.

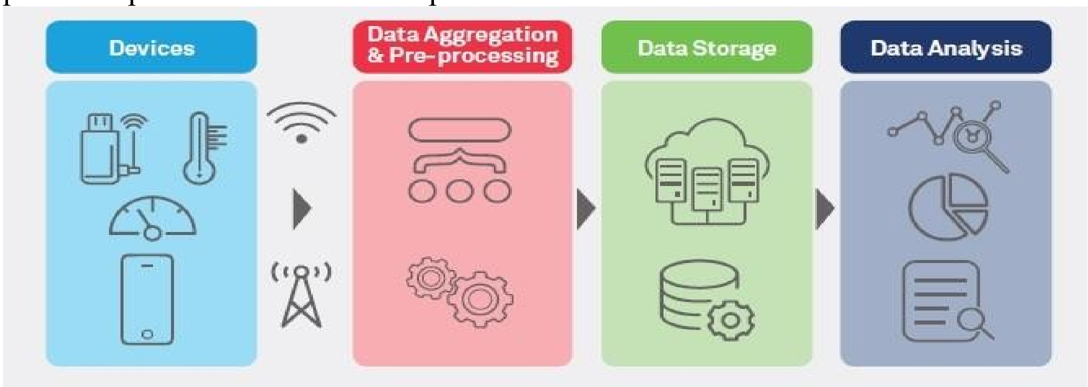


Figure : The four stages of IoT solutions

The major advantages of IoT in healthcare include:

- **Cost Reduction**: IoT enables patient monitoring in real time, thus significantly cutting down unnecessary visits to doctors, hospital stays and re-admissions
- **Improved Treatment:** It enables physicians to make evidence-based informed decisions and brings absolute transparency
- **Faster Disease Diagnosis:** Continuous patient monitoring and real time data helps in diagnosing diseases at an early stage or even before the disease develops based on symptoms
- **Proactive Treatment**: Continuous health monitoring opens the doors for providing proactive medical treatment
- **Drugs and Equipment Management:** Management of drugs and medical equipment is a major challenge in a healthcare industry. Through connected devices, these are managed and utilized efficiently with reduced costs
- **Error Reduction:** Data generated through IoT devices not only help in effective decision making but also ensure smooth healthcare operations with reduced errors, waste and system costs

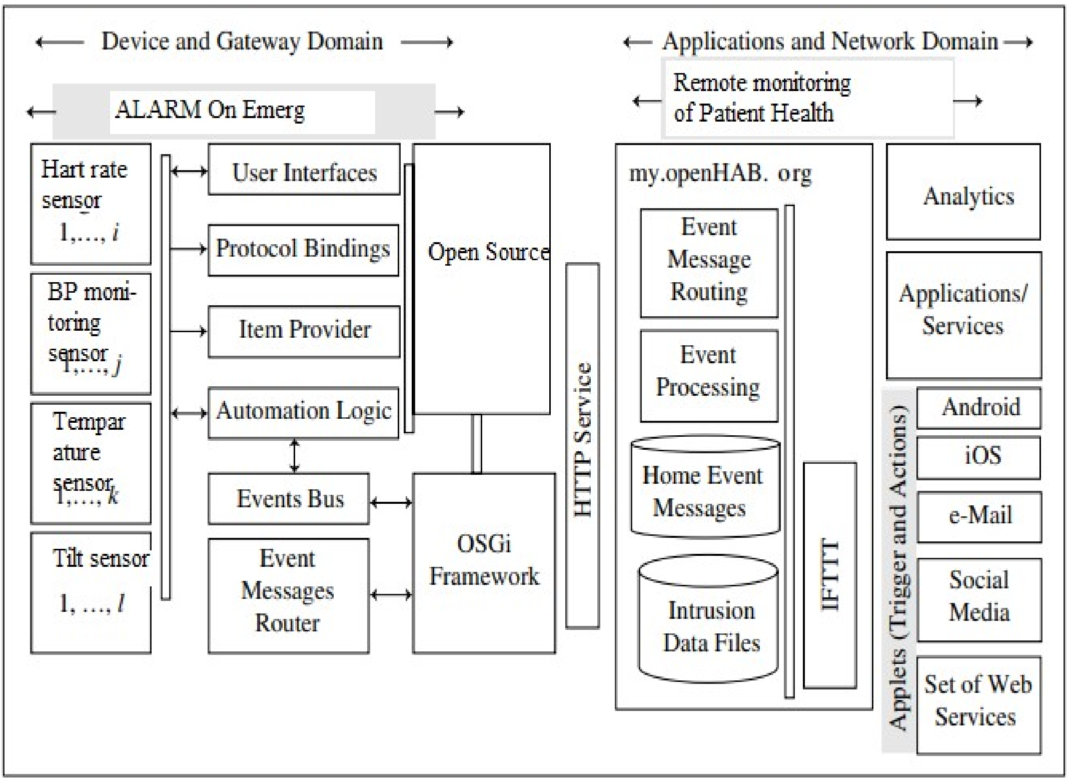


Fig:IoT Data flow diagram in Heath care System

Healthcare IoT is not without challenges. IoT-enabled connected devices capture huge amounts of data, including sensitive information, giving rise to concerns about data security. Implementing apt security measures is crucial. IoT explores new dimensions of patient care through real-time health monitoring and access to patients' health data. This data is a goldmine for healthcare stakeholders to improve patient's health and experiences while making revenue opportunities and improving healthcare operations. Being prepared to harness this digital power would prove to be the differentiator in the increasingly connected world.

8HOME AUTOMATION MINI PROJECTS

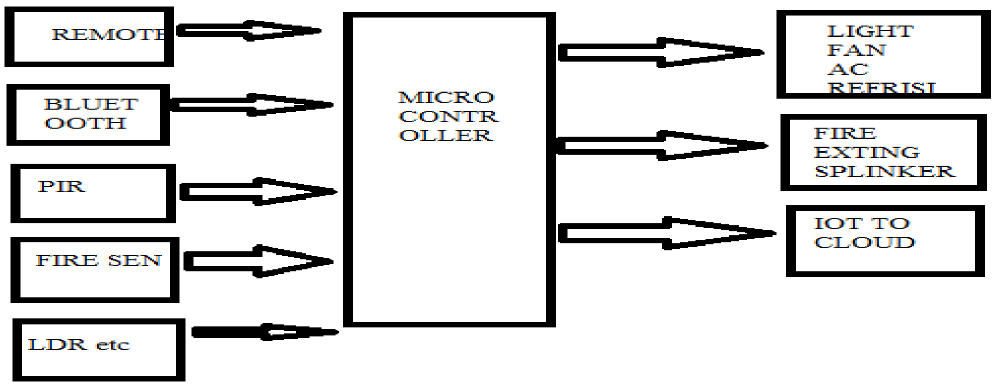
Smart Lighting

Smart lighting for homes helps in saving energy by adapting the lighting to the ambient conditions and switching on/off or dimming the lights when needed. Key enabling technologies for smart lighting include solid state lighting (such as LED lights) and IP-enabled lights. For solid state lighting solutions both spectral and temporal characteristics can be configured to adapt illumination to various needs. Smart lighting solutions for home achieve energy savings by sensing the human movements and their environments and controlling the lights accordingly. Wireless-enabled and Internet connected lights can be controlled remotely from loT applications such as a mobile or web application. Smart lights with sensors for occupancy, temperature. lux level, etc., can be configured to adapt the lighting (by changing the light intensity, color, etc.) based on the ambient conditions sensed, in order to provide a good ambiance.

Smart Appliances

TVs allows users to search and stream videos and movies from the Internet on a local storage drive, search TV channel schedules and fetch news, weather updates and other content from the Internet. Open Remote is an open source automation platform for homes and buildings. Open Remote is platform agnostic and works with standard hardware. With Open Remote, users can control various appliances using mobile or web applications. Open Remote comprises of three components - a Controller that manages scheduling and runtime integration between devices, a *Designer* that allows you to create both configurations for the controller and create user interface designs and Control Panels that allow you to interact with devices and control them.

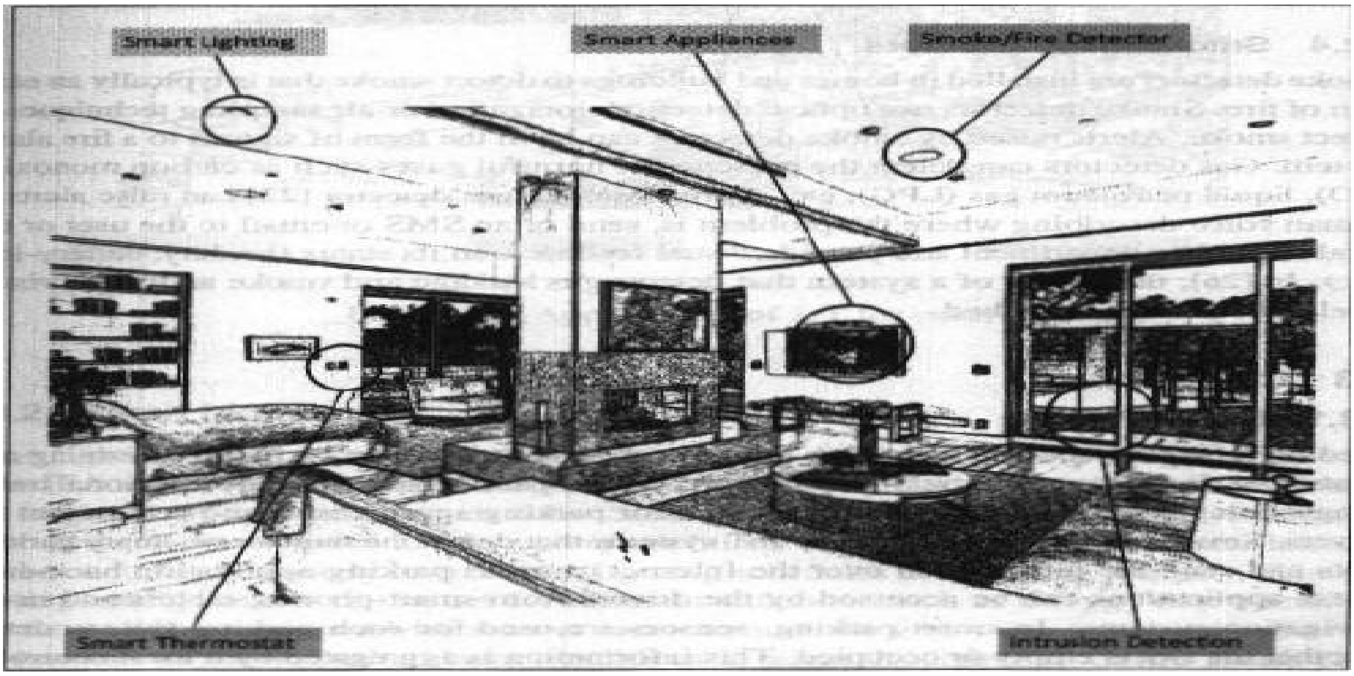
Intrusion Detection



Home intrusion detection systems use security cameras and sensors (such as PIR sensors and door sensors) to detect intrusions and raise alerts. Alerts can be in the form of an SMS or an email sent to the user. Advanced systems can even send detailed alerts such as an image grab or a short video clip sent as an email attachment. A cloud controlled intrusion detection system is described in that uses location-aware services, where the geo-location of each node of a home automation system is independently detected and stored in the cloud. In the event of intrusions, the cloud services alert the accurate neighbors (who are using the home automation system) or local police.

Smoke/Gas Detectors

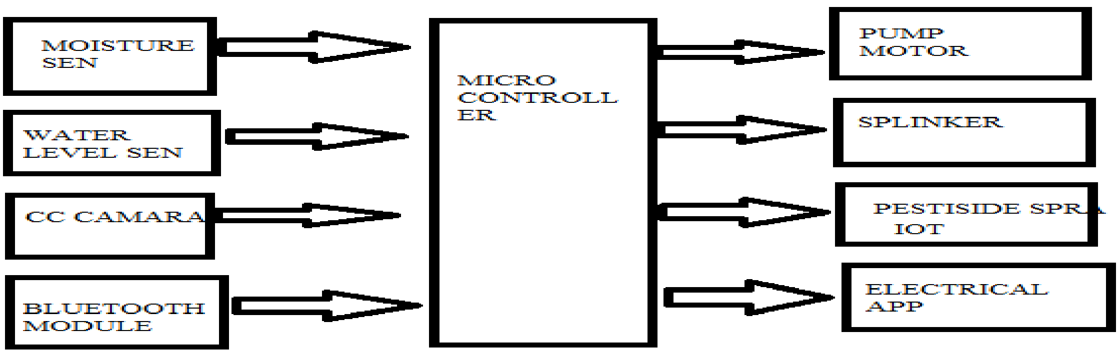
Smoke detectors are installed in homes and buildings to detect smoke that is typically an early sign of fire. Smoke detectors use optical detection, ionization or air sampling techniques to detect smoke. Alerts raised by smoke detectors can be in the form of signals to a fire alarm system. Gas detectors can detect the presence of harmful gases such as carbon monoxide (CO), liquid petroleum gas (LPG), etc.

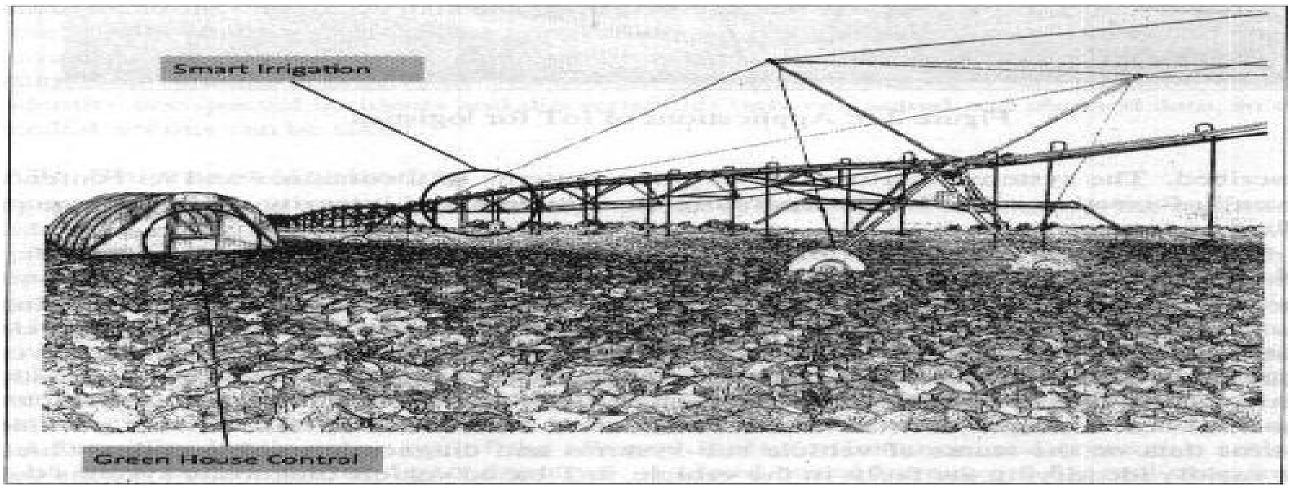


AGRICULTURE MINI PROJECTS

Smart Irrigation

Smart irrigation systems can improve crop yields while saving water. Smart irrigation systems use loT devices with soil moisture sensors to determine the amount of moisture in the soil and release the now of water through the irrigation pipes only when the moisture levels go below a predefined threshold. Smart irrigation systems also collect moisture level measurements on a server or in the cloud where the collected data can be analyzed to plan watering schedules. Cultivar's Rain Cloud is a *device* for smart irrigation that uses water valves, soil sensors and a WiFi enabled programmable computer.





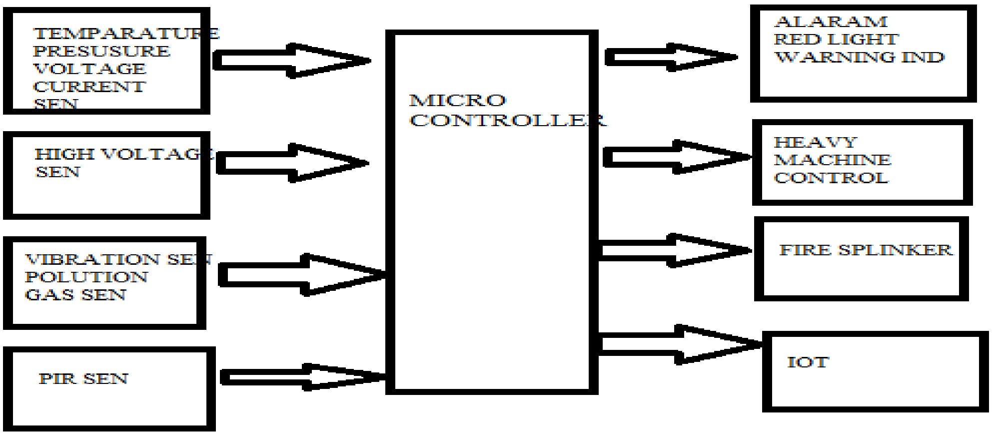
Green House Control

Green houses are strictures with glass or plastic roofs that provide conducive environment for growth of plants. The climatological conditions inside a green house can be monitored and controlled to provide the best conditions for growth of plants. The temperature, humidity, soil moisture, light and carbon dioxide testis are monitored using sensors and the climatological conditions arc controlled automatically using actuation devices (such as valves for releasing water and switches for controlling fans). loT systems play an important role in green house control and help in improving productivity. The data collected from various sensors is stored on centralized servers or in the cloud where analysis is performed to optimize the control strategies and also correlate the productivity with different control strategies. In the design of a wireless sensing and control system for precision green house management is described. The **system uses wireless sensor** network to monitor and control the agricultural parameters like temperature and humidity in real time for better management and maintenance of agricultural production.

INDUSTRY MINI PROJECTS

Machine Diagnosis & Prognosis

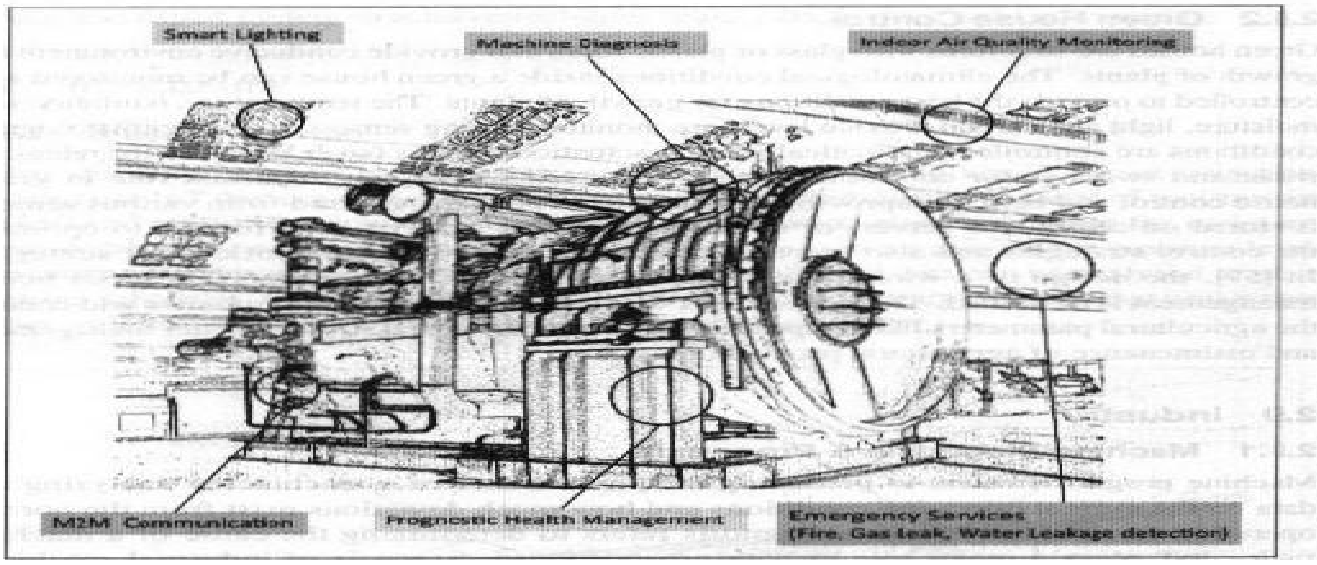
Machine prognosis refers to predicting the performance of a machine by analyzing the data on the current operating conditions and how much deviations exist from the normal operating conditions. Machine diagnosis refers to determining the cause of a machine fault. fa plays a major role in both prognosis and diagnosis of industrial machines. Industrial machines have a large number of components that must function correctly for the machine to perform its operations. Sensors in machines can monitor ihe operating conditions such as (temperature and vibration levels). The sensor data measurements are done on tinescales of few milliseconds to few seconds, which leads to generation of massive amount of data. IoT based systems integrated with cloud-based storage and analytics back-ends can help in storage, collection and analysis of such massive scale machine sensor data.



A number of methods have been proposed for reliability analysis and fault prediction in machines. Case-based reasoning (CBR) is a commonly used method that finds solutions to new problems based on past experience. This past experience is organized and represented as cases in a case-base. CBR is an effective technique for problem solving in the fields in which it is hard to establish a quantitative mathematical model, such as machine diagnosis and prognosis. Since for each machine, data from a very large number of sensors is collected, using such high dimensional data for creation of case library reduces the case retrieval efficiency. Therefore, data reduction and feature extraction methods are used to find the representative set of features which have the same classification ability as the complete of

Indoor Air Quality Monitoring

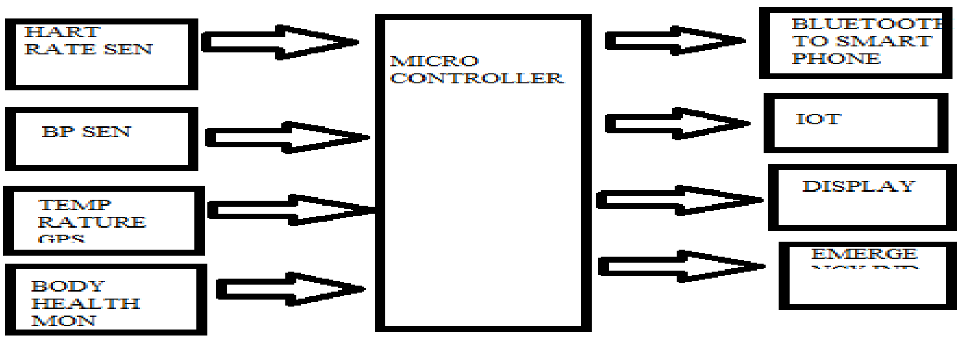
Monitoring indoor air quality in factories is important for health and safety of the workers. Harmful and toxic gases such as carbon monoxide *(CO),* nitrogen monoxide *(NO),* Nitrogen Dioxide *(NO2),* etc., can cause serious health problems. loT based gas monitoring systems ' can help in monitoring the indoor air quality using various gas sensors. The indoor air quality can vary for different locations. Wireless sensor networks based loT devices *can identify the* hazardous zones, so that corrective measures can be taken to ensure proper ventilation. In a hybrid sensor system for indoor air quality monitoring is presented, which contains both stationary sensors (for accurate readings and calibration) and mobile sensors (for coverage). In a wireless solution for indoor air quality monitoring is described that measures the environmental parameters like temperature, humidity, gaseous pollutants. aerosol and particulate matter to determine the indoor air quality.



HEALTH & LIFESTYLE MINI PROJECTS

Health & Fitness Monitoring

Wearable loT devices that allow non-invasive and continuous monitoring of physiological
parameters can help in continuous health and fitness monitoring. These wearable devices may can be in various forms such as belts and wrist-bands. The wearable devices form a type of wireless sensor networks called body area networks in which the measurements from a number of wearable devices are continuous sent to a master node (such as a smart-phone) which then sends the data to a server or a cloud-based back-end for analysis and archiving. Health-care providers can analyze the collected health-care data to determine any health conditions or anomalies. Commonly uses body season include: body temperature, heart rate, pulse oximeter oxygen saturation (SPo2), blood pressure, electrocardiogram (ECG), movement (with accelerometers), and electroencephalogram (EEG). An ubiquitous mobility approach for body sensor networks in health-care is proposed in [72]. In [73], It wearable ubiquitous health-care monitoring system is presented that uses integrated electrocardiogram (ECG). accelerometer and oxygen saturation (Sp02) sensors. Fitbit wristband [74] is a wearable device that tracks steps, distance, and calories burned during the day and sleep quality at night.



Wearable Electronics

Wearable electronics such as wearable gadgets (smart watches, smart glasses, wristbands, etc.) and fashion electronics (with electronics integrated in clothing and accessories. (e.g., Google Glass or Moto 360 smart watch) provide various functions and features to assist us in our daily activities and making us lead healthy lifestyles. Smart watches that run mobile operating systems (such as Android) provide enhanced functionality beyond just timekeeping. With smart watches, the users can search the Internet, play audio/video files, make calls (with or without paired mobile phones), play games and use various kinds of mobile applications [681. Smart glasses allows users to take photos and record videos, get map directions, check flight status, and search the Internet by using voice commands [69]. Smart shoes monitor the walking or running speeds and jumps with the help of embedded sensors and be paired with smart-phones to visualize the data PO]. Smart wristbands can track the daily exercise and calories burnt [71].

Fig: Applications of IoT for health