Industrial Internet of Things

Chapter 1: Introduction to IIoT

Dr Abhishek Hazra

abhishek.h@iiits.in

Definition of IoT

"It's a global infrastructure for the information society, enabling advance services by interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies"

Characteristics of IoT

- Dynamic & Self-Adapting
- Self-Configuring
- Interoperable Communication Protocols
- Unique Identity
- Integrated into Information Network

Physical Design of IoT

- The "Things" in IoT usually refers to IoT devices which have unique identities and can perform remote sensing, actuating and monitoring capabilities.
- IoT devices can:
  - Exchange data with other connected devices and applications (directly or indirectly), or
  - Collect data from other devices and process the data locally or
  - Send the data to centralized servers or cloud-based application back-ends for processing the data, or
  - Perform some tasks locally and other tasks within the IoT infrastructure, based on temporal and space constraints

Case Study 1: Smart Home

Major Components:

- Connected radiator/heater
- Connected air conditioner
- Connected camera
- Connected door
- Connected window
- Connected microwave
- Connected refrigerator
- Connected water boiler

Illustration of smart home system.

Case Study 2: Smart Healthcare

Major Components:

- Connected medicine
- Body sensor network
- Healthcare robot
- Healthcare-specific smart home
- Home-hospital system
- User API
- Storage and processing
- Data Analytics

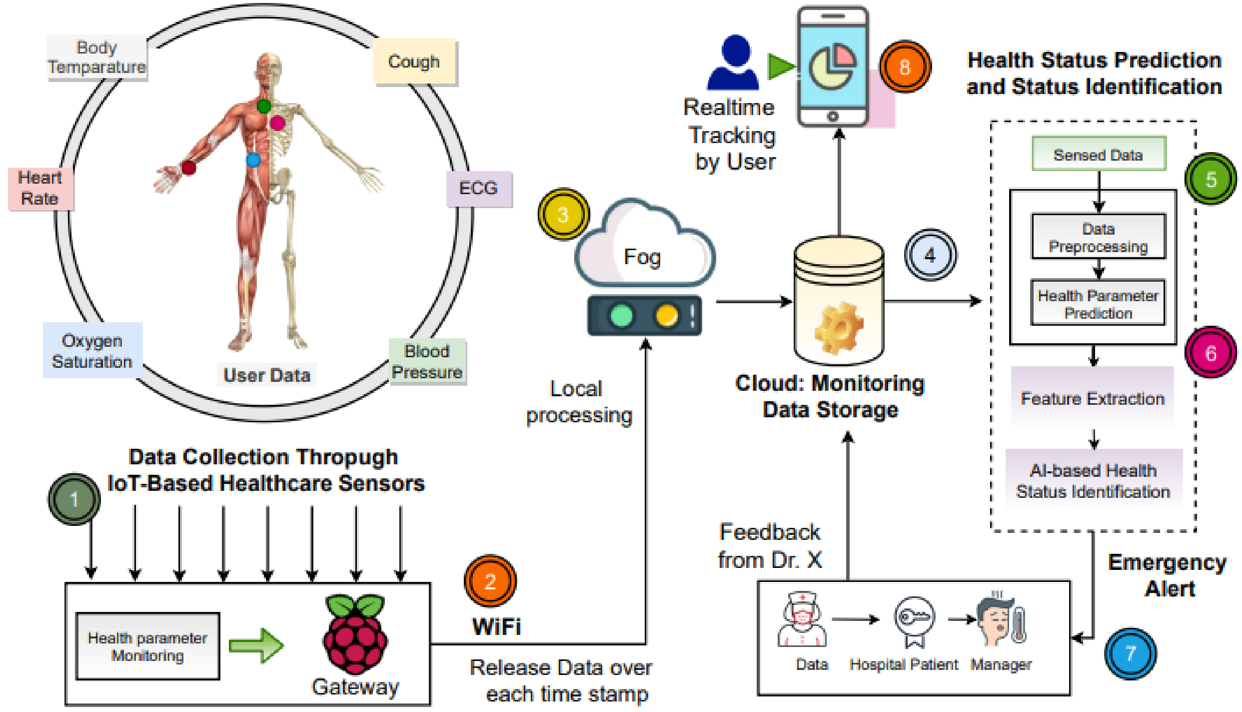


Illustration of smart healthcare system.

Case Study 3: Smart Agriculture

Major Components:

- Connected plants
- Connected animals
- Connected barn
- Connected agricultural equipment
- Connected packing and shipping
- Weather forecast
- Prediction (Artificial Intelligence)
- Cloud data analytics

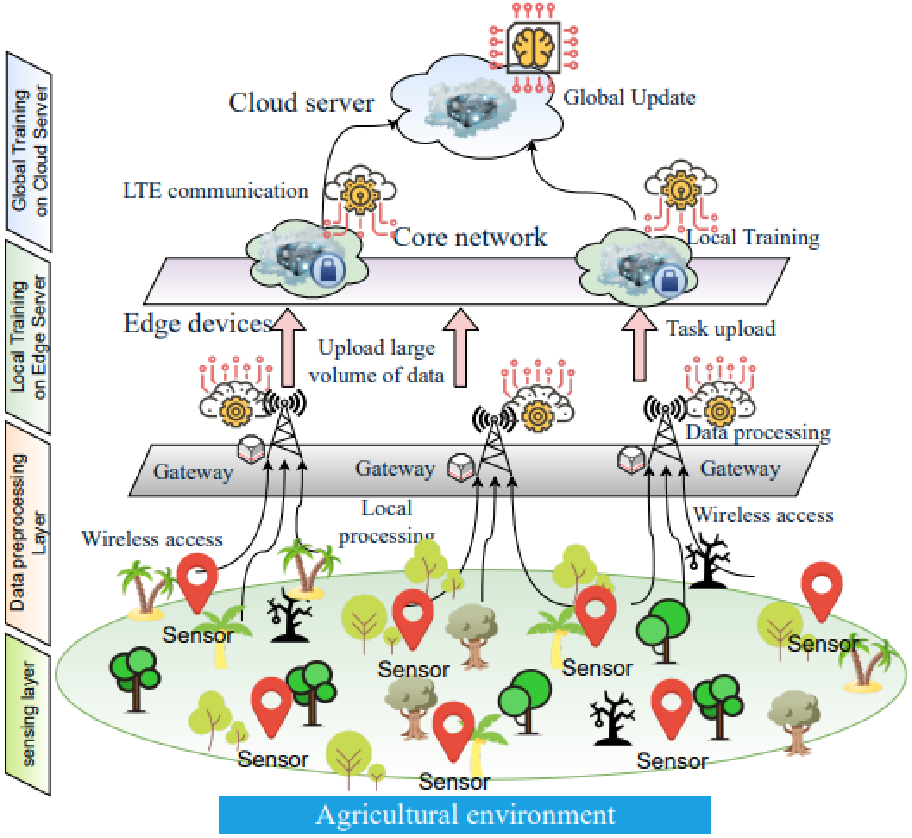


Illustration of smart agriculture system.

Case Study 4: Smart Transportation

Major Components:

- Smart connected vehicle
- Connected base station
- Connected roadside Unit
- Connected fog-cloud computation
- Connected traffic information
- Safety, security, and environment

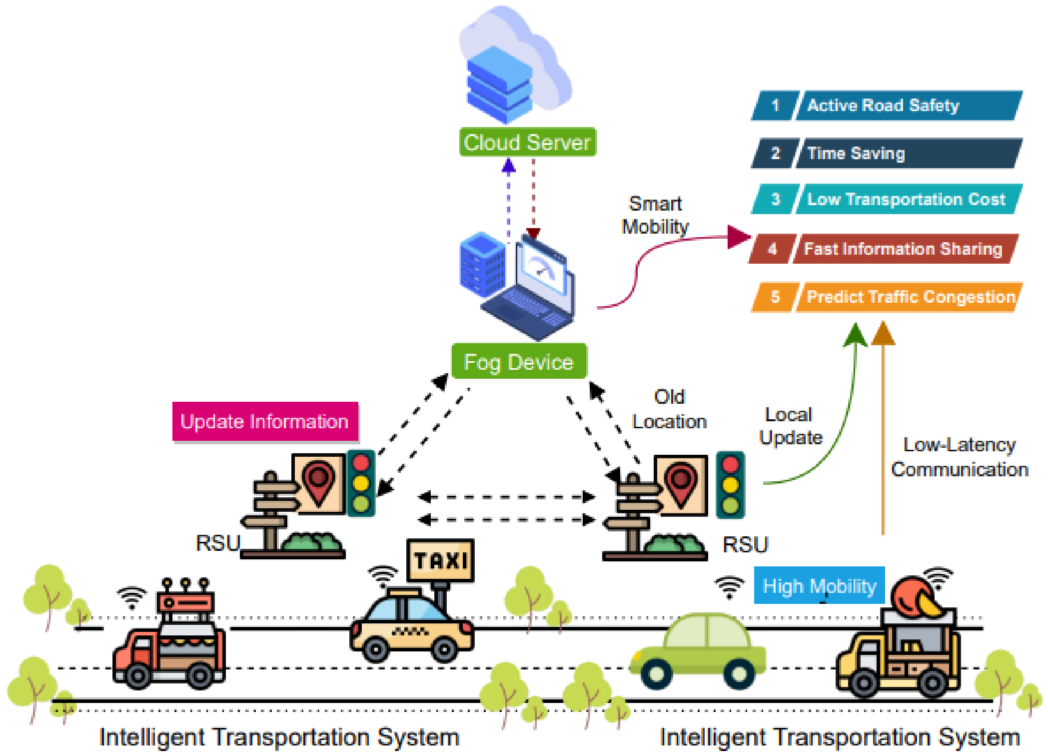
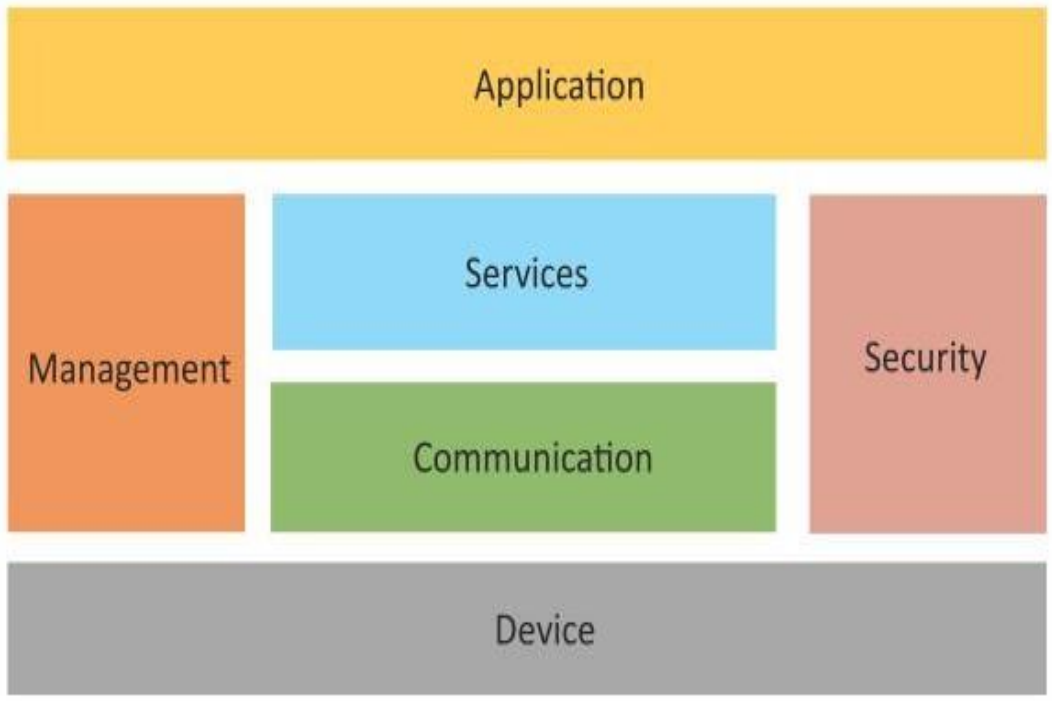


Illustration of smart transportation system.

Logical Design of IoT

- Logical design of an IoT system refers to an abstract representation of the entities and processes without going into the low-level specifics of the implementation.

- An IoT system comprises of a number of functional blocks that provide the system the capabilities for identification, sensing, actuation, communication, and management.



IoT enabling technologies

- Wireless connectivity
- Sensors and Actuators
- Cloud Computing
- Edge Computing
- Data Analytics and Machine Learning
- Blockchain

Wireless connectivity

- **Wi-Fi:** Commonly used for high-speed connections, suitable for applications in homes, offices, and urban areas.
- **Bluetooth:** Ideal for short-range connections between devices, often used for wearable devices and smart home applications.
- **Zigbee:** Designed for low-power, low-data-rate communication, suitable for applications requiring energy efficiency, like home automation.
- **LoRaWAN:** Provides long-range, low-power connectivity, making it suitable for applications in agriculture, smart cities, and Industrial IoT.
- **Cellular Networks (5G, LTE-M, NB-IoT):** Cellular technologies offer wide coverage and support for various IoT use cases, from connected vehicles to remote monitoring.

Sensors and Actuators

- **Temperature Sensors:** Measure ambient temperature and help control heating, cooling, and climate systems.
- **Motion Sensors:** Detect movement, enabling applications like security systems, smart lighting, and activity tracking.
- **Humidity Sensors:** Measure moisture levels in the air, important for HVAC systems, agriculture, and storage environments.
- **Proximity Sensors:** Detect the presence of objects or people, used in touchless interfaces, parking assistance, and industrial automation.
- **Actuators (e.g., Servos, Motors):** Convert electrical signals into mechanical motion, enabling devices to perform physical actions like opening doors, moving robotic arms, etc.

Cloud Computing

- **Scalability:** Cloud platforms can scale resources up or down according to demand, ensuring optimal performance and cost-efficiency.
- **Storage:** Cloud storage provides a centralized and accessible repository for storing and managing IoT-generated data.
- **Data Processing:** Cloud platforms offer powerful processing capabilities to analyze and extract insights from massive datasets.
- **Remote Access:** IoT devices can be monitored and managed remotely through cloud-based dashboards and applications.
- **Integration:** Cloud services enable seamless integration of data and functionality across diverse IoT devices and applications.

Edge Computing

- **Low Latency:** Edge computing reduces data processing time by processing data closer to where it's generated, improving real-time responsiveness.
- **Bandwidth Optimization:** Only relevant data is sent to the cloud, reducing the amount of data transferred and conserving network bandwidth.
- **Privacy:** Processing data locally reduces the need to send sensitive information to the cloud, enhancing privacy and security.
- **Offline Operation:** Edge devices can continue functioning even when disconnected from the cloud, ensuring uninterrupted operations.
- **Real-time Analytics:** Immediate data analysis at the edge allows for quick decision-making without waiting for data to travel to the cloud.

Data Analytics and Machine Learning

- **Predictive Maintenance:** ML algorithms can predict equipment failures before they happen, minimizing downtime and maintenance costs.
- **Anomaly Detection:** ML models identify unusual patterns in data, helping to detect security breaches, fraud, and abnormal behaviors.
- **Pattern Recognition:** ML can recognize complex patterns in data, assisting in image and speech recognition, as well as predictive analysis.
- **Personalization:** ML algorithms can analyze user behavior to provide personalized recommendations and experiences.
- **Optimization:** ML can optimize processes by analyzing data to identify inefficiencies and suggest improvements, such as supply chain optimization.

Blockchain

- **Decentralization:** Blockchain operates on a decentralized network, enhancing security and reducing the risk of single points of failure.
- **Immutability:** Once data is added to a blockchain, it cannot be altered or deleted, ensuring data integrity and auditability.
- **Security:** Transactions on a blockchain are encrypted and validated by a consensus mechanism, making it highly secure against unauthorized access and tampering.
- **Transparency:** All participants in a blockchain network have access to the same data, fostering transparency and trust.
- **Smart Contracts:** Blockchain supports self-executing smart contracts, which automatically execute predefined actions when specific conditions are met.

Predecessors of IIoT

The Industrial Internet of Things (IIoT) has evolved from earlier technologies and concepts in the industrial and manufacturing sectors. Here are some key predecessors that laid the groundwork for the development of IIoT:

- SCADA (Supervisory Control and Data Acquisition)
- PLC (Programmable Logic Controller)
- M2M (Machine-to-Machine) Communication
- Embedded Systems
- Enterprise Resource Planning (ERP) Systems
- Wireless Sensor Networks (WSN)

Thank You!