IoT Innovation Lab Setup

Fueling next generation of growth

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PAKUR POLYTECHNIC, PAKUR
&
SISAI TECHNOLOGIES PVT. LTD.

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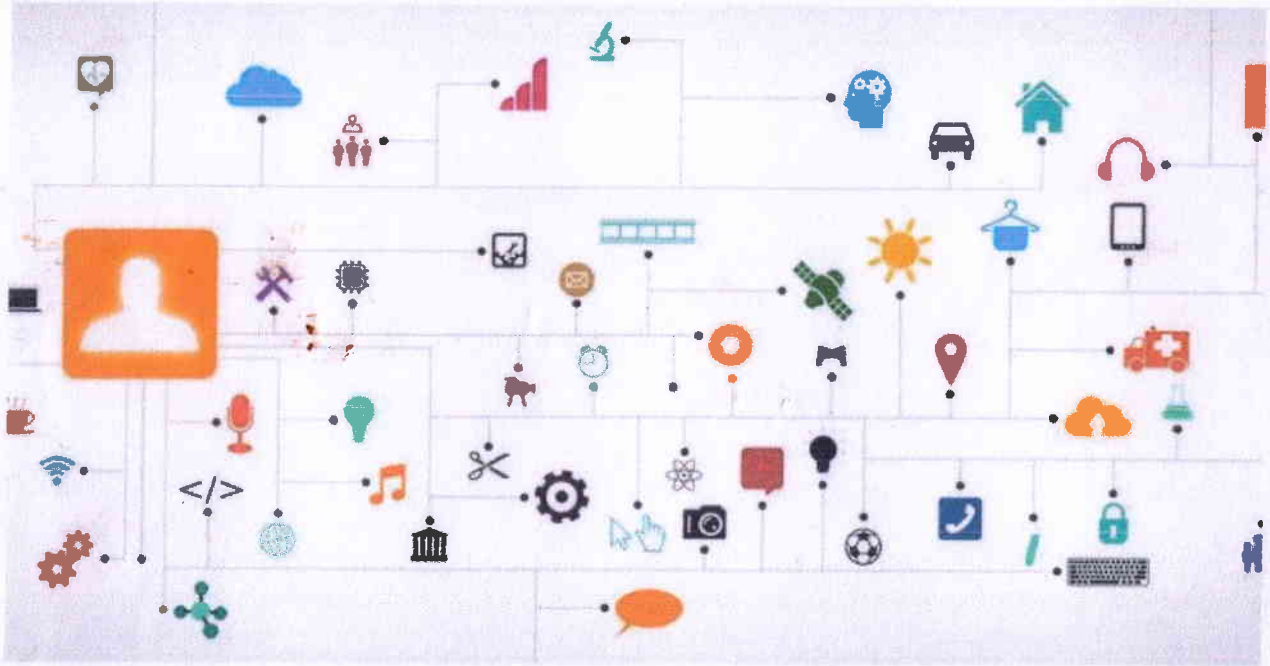


About Sisai Technologies

Sisai Technologies has been founded by Industry experts who have deep expertise in Hardware and Software design and development. Sisai Technologies delivers state-of-the-art technology solutions for Industry. At Sisai Technologies, our aim is to bring cutting edge and appropriate technology solutions to our customers. We try to achieve this with our years of industry experience and proficiency in technology.

Our vision is to provide simple technology solutions for complex business problems. Our expertise in Embedded System domain & Enterprise Software development bridge the gap between large multidisciplinary technology space like Cloud and IoT.

Our Services

- IoT /Embedded Applications Development
- Hardware Design and Development
- Industrial IoT Analytics
- SCADA/HMI
- IoT /Robotics/Tinkering Lab Setup

Credentials:

Rajesh K. Upadhyay

16 years of Industry experience in Solution Design & Architecture, Pre-sales, Product Management and Product Development. Experience in managing end-to-end execution of complex & high valued projects in a Global Delivery Model. Problem solver with a passion for technology. Worked with top Fortune-100 Technology firms like Symantec, BMC software and EDS in past. His last stint was with Cal soft Inc. where he worked with clients like IBM, Lenovo and Dell-EMC. He also had a stint at RRSSC, ISRO, Bangalore as a project trainee.AWS Certified Solution Architect Associate. Certificate on R Programming by Johns Hopkins University on Coursera

He did his Master's In Computer Application from Amravati University and Executive PGDBM from Symbiosis International University.

Introducing Ion and IoE

Internet of Things (IoT) is a network of physical devices called "Things". It includes Industrial Machines, vehicles, buildings, wearables and other items. These things are embedded with electronics, sensors and actuators. Network connectivity enables these "Things" to collect and exchange data with each other.

Global Standards Initiative on Internet of Things (IoT-GSI) defines IoT as "The infrastructure of the information society"

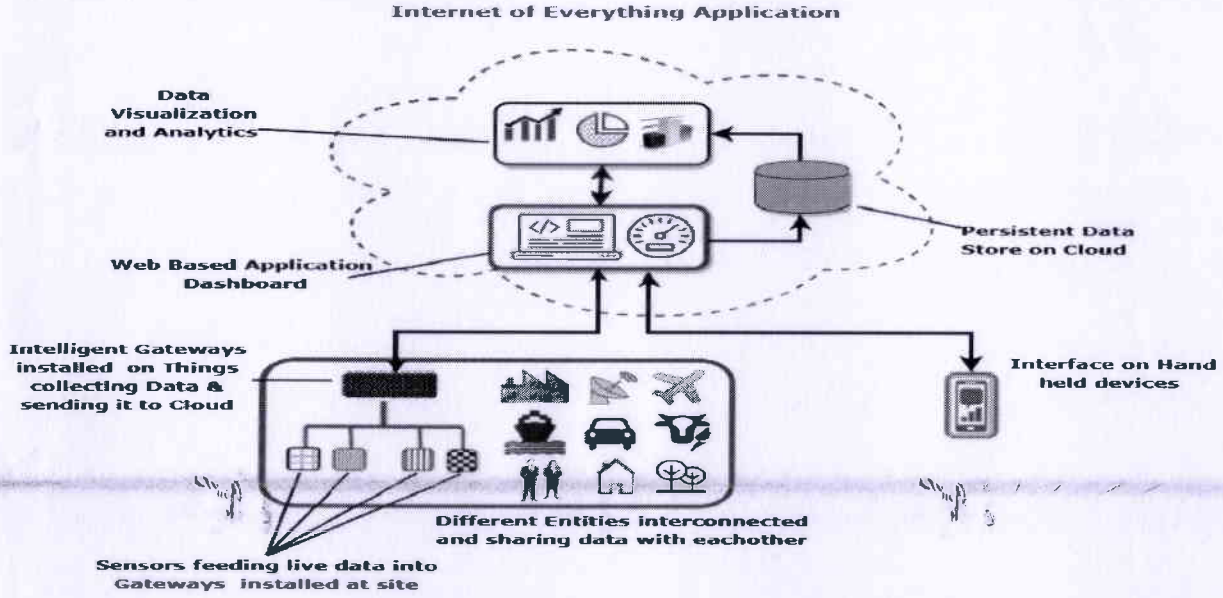
The Internet of Everything (IoE) is the next stage of IoT where we bring people and processes to IoT infrastructure. The Internet of Everything is the intelligent connection of people, process, data, and things. The Internet of Everything (IoE) includes:

- **People**: Connecting people in more relevant, valuable ways.
- **Data**: Sensor data collected from environment.
- **Process**: Analysing the collected data and interpreting it to deliver the right services.
- **Things**: Physical devices and objects connected to the Internet.

The Internet of Everything (IoE) describes a world where billions of interconnected ubiquitous objects have intelligence to detect about their environment and exchange information with each other.

IoT and IoE Infographics

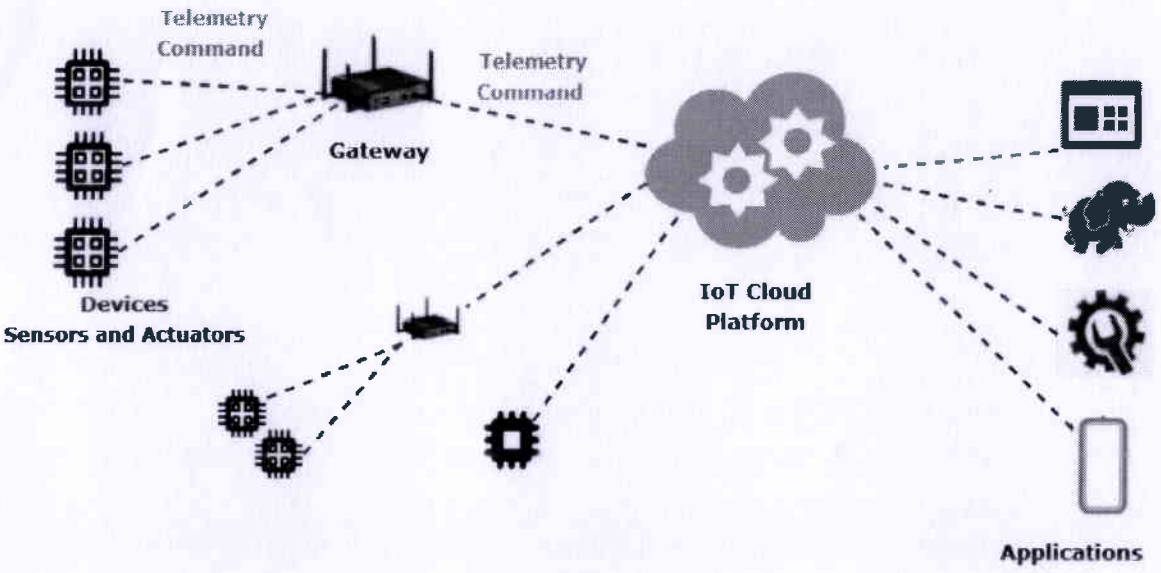
A typical IoT/IoE application will look like this



Above diagram shows different objects like House, industrial units, aeroplanes, ships, farms etc are interconnected and exchanging information. This seamless exchange of information is made possible by robust and ubiquitous Backend Infrastructure comprising sensors, gateways and private, public and hybrid cloud.

Backend of Iot/IoE application.

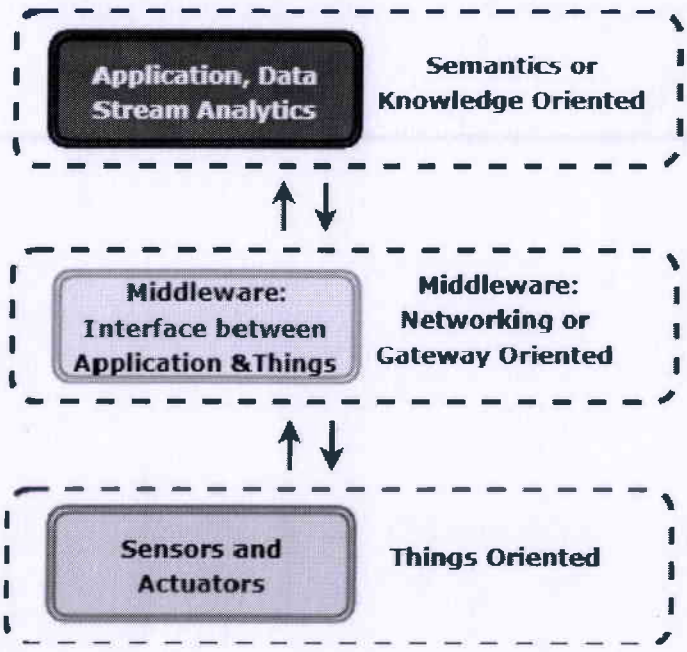
Below diagram shows the components working in the background of an IoT/IoE application



It has Sensors and Actuators at one end. Then it has various software application and tools at other end. These components are interconnected via various communication protocols. Different protocol is used at different stage. The data from Sensors and Actuators is collectected at gateway devices, then it is sent to applications running on Cloud.

IoT Technology Stack

In a simplified form, IoT/IoE technology stack will have three layers as shown below.



IoT/IoE as a technology is amalgamation of three broad technology paradigms:

Semantics: Knowledge oriented applications processing data from sensors. Semantic Execution Environments, Smart Semantic Middleware. Wide range of software and various tools to analyze the collected data, applications which makes use of the analyzed data. Software and tools can run, chips, On-Premise Data-Center or Public/Private Cloud.

Internet or Middleware: Connectivity to enable objects to exchange data with other connected devices Middleware interconnecting Devices and Software Stack. IPSO (IP for smart objects), Internet 0, Web of Things, Wireless Internet Service Provider (WISP), ZigBee, Sub-Ghz

Sensors and Actuators: "Things" embedded with Microcontrollers, Microprocessors, sensors and Actuators. Micro-Electro-Mechanical systems (MEMS) devices interacting with physical world. Smart Things: Smart Devices, RFID, NFC, Wireless Sensors and Actuators (WSANs), Everyday Objects

Challenges and Opportunity

IoT/IoE technology is being used in many sectors now. With growth and widespread adoption, it also poses many challenges and opportunities. Challenges for IoT can be broadly categorized in these three areas.

- Inter-Networking to connect Sensors, Middleware and Cloud applications
- Compliance & Security
- Interoperability & Standards

Sensors in IoT will be generating huge amount of data stream. The number of connected devices runs into billions. The network should support this huge flow of data. Cloud based analytics tools will be processing these data continuously. Vital information provided by these sensors will be available on cloud. There is a big security risk for these vital information. But, at the same time, it also offers newer opportunities to companies offering security services.

IoT technology should not be constrained with Hardware dependency. Diverse set of devices will be connected and ready to sense and generate the data. We need an interoperable platform where sensors and Actuators can be connected in plug-n-play manner. Devices must be produced conforming to a common standard. This will allow interoperability among various IoT products and solutions.

IoT is growing up very fast. IoT is no longer just a subject of Computer Science journals or IEEE research papers. Commercial products based on IoT framework is hitting the market. More and more companies are adopting IoT to develop commercial products and solutions. In order to make IoT/IoE a mainstream technical solution, researchers and developer have to address these concerns. To fulfill the need of IoT, IEEE has separate division (IEEE IoT) for IoT.

Use Cases

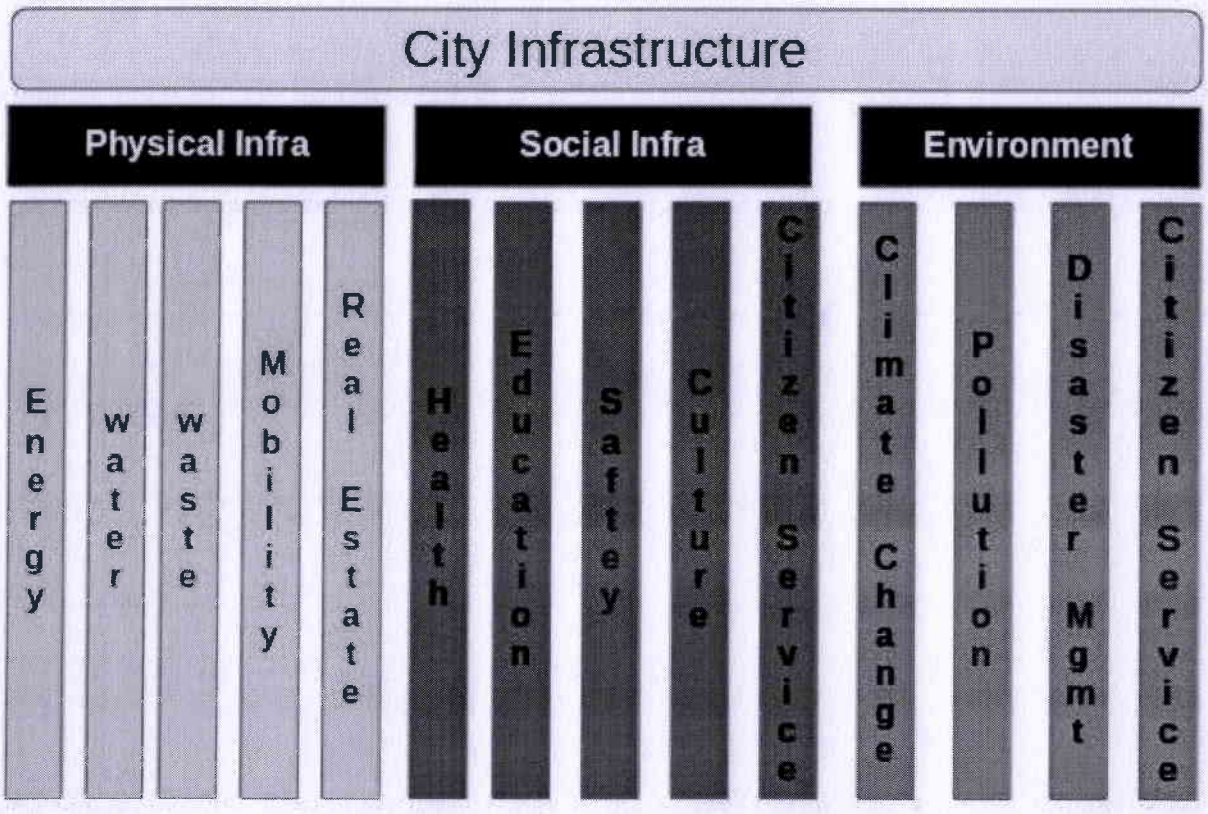
There are several sectors where IoT/IoE solutions can be used. Some of the relevant sector for Jharkhand state will be

Smart City

Ministry of Urban Development, Nodal agency for Smart city project of GOI, has categorized common issues of city into three sectors:

- Physical Infrastructure
- Social Infrastructure
- Environment

Basic physical infrastructures of the cities are being developed to cater the need of the growing population of cities. But, there is a limit, beyond it's not easy to grow infrastructure due to various constraints. Even if, there is sufficient availability of resources, problem comes in distribution and optimal use of resources. For example, how to utilize fleet of bus for city transports service.



Citizens are at the center of the smart city. The focus is on improving infrastructure services like water supply, sanitation, solid waste management, transportation, affordable

housing and power supply. Smart City is all about making city livable, solve citizen's problem, enable citizen participation and provide good governance.

These are some of the problems, city administrators have to face on day-today basis. Public services need to be customized as per needs of citizens. Citizens need accurate and relevant information about services and facilities whenever they need.

As per **Smart City technology framework prepared by NASSCOM**, Smart City will provide a 'single point of contact' or City Dashboard for citizens that deliver services and information to citizens. The wide use of mobile phones and Wi-Fi networks allows local governments to deliver services to its citizens on mobile. IoT/IoE can play a big role in this providing solution to problems faced by city administrators as well as Citizens.

Industry

Jharkhand state has industries of all shape and size. Some of the largest industries of India are situated in Jharkhand. These industries are automating their manual processes. Industries today are adopting **Industry 4.0 standards** to increase productivity and quality of product. These industries are one of the biggest users of IoT/IoE tools and techniques. They need trained resources who can handle such automated machinery conforming to Industry 4.0 standards. Trained students can find ready placement in these industries.

Mining Industry

Jharkhand state is home to many Mines extracting critical natural resources. One of the critical aspect of Mining industry is safety and enhanced productivity. To achieve this two targets, dangerous activities involved in mining processes are being automated. IoT and IoE comes handy in automating the existing processes.

Agriculture

Agriculture is one area where technology is used to increase the food production. Government is helping and encouraging farmers to use advanced techniques and research to increase food production. Smart farming is one of the fastest growing field in IoT.

Customized IoT/IoE solution can be developed to solve the local problems of farmers. Data can be collected from fields such as soil type, soil moisture, nutrients etc. This data

can be analyzed to provide meaningful suggestion on quantity of fertilizers. It can be used to control the water usage for plant growth.

Forest Management

Jharkhand state is full of natural resources. One of them is forest. Many animals live in this forest. Forests have been dwelling of local population since ages. Forests are source for livelihood for many. It produces Lac and Tendu patta which are raw material for other products. Forests are great source of tourism. IoT/IoE can be used to manage this precious resource. Using this technology, we can devise mechanism to optimize the usage and regulate the illegal and unauthorized use.

Importance of Iot and IoE Lab at Educational Institutes

As per various market research, Internet of Things Market to reach **267 Billion USD By 2020.** IOT Technologies growth are not a single technology growth. This is combination of different branches of technologies, such as electronics, mechanical, wired communication, Wireless communication, computer science, IT branches, and others.

New economic analysis by Cisco reveals that the Internet of Everything is a $4.6 trillion opportunity for global public-sector organizations over the next decade, as a result of cost savings, increased productivity, new revenues and enhanced citizen experiences.

Are Academia ready for this opportunity?

Academia and Industry today are working and operating at different levels. There is gap between between expectations of Industry from Academia and what institutions are teaching to their students. Rapid change in technologies and vast opportunities in IoT/IoE technologies require to come together to address and solve real world challenges.

Course Curriculum of educational institutions are heavy on theory side with less focus on experimentation and product development. Study of theoretical knowledge alone is not sufficient for students to match expectation from Industries. Industries today want a attitude to innovate, strong analytical skills, collaborative approach to deconstruct any problem and ability to develop a working solution. Development of IoT/IoE lab will

substantiate the theory being taught at institutes. Fully functional IoT/IoE lab will fill the gap between needs of industry and educational institutions.
Students can get benefited with such facility within their institutes. Institutes can become inhouse research lab which can cater to the needs of local society and business needs.
Some of the benefits of IoT/IoE lab in Jharkhand:

- Agriculture sector
- Forest resource management
- Social Security
- Smart City

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One of the biggest use of IoT/IoE is in Smart City project. There are many areas in Cities where issues can be solved using IoT/IoE.

Functioning of IoT/IoE Lab at Institution

IoT and IoE are multidisciplinary subject. It includes knowledge of Computer Science, Information Technology, Electronics & Embedded, Electrical and Networking technology. Institutions should develop a fully functional IoT/IoE lab where students can learn the techniques of IoT/IoE. The students will be encouraged to think and experiment with the gadgets. The focus will be on how to use these components to create useful IoT/IoE devices. The inspiration for devices should come from the environment where students live.

The teaching staff of the institutions can be trained and empowered to become innovators. They can participate in various local activities where such expertise is needed. They can contribute to local industry requirements. The Lab can be used by local industry for various experimentation. This will trigger business growth in the region where these institutions are situated.

The training will imbibe necessary and important skills to students. They can be absorbed by the industry. Most important aspect is, they will have all the right skills for entrepreneurship. Students can start their own venture providing innovative solutions to problems.

Course Content

1. Introduction - Concepts and Definitions behind IoT/IoE:

Develop an understanding of underlying technology of IoT/IoE. Understanding of Building blocks of IoT/IoE. IoT Enabling Technologies. Different Levels of IoT Systems. Introduction to IoT Platforms. Basic Architecture and Components. IoT Design Methodology. IoT Applications Design.

Learning Objective

- Understand how to develop and implement IoT technologies
- Identify issues and design challenges in IoT applications
- Ability to select appropriate hardware and software components for IoT applications

2. IoT Device Design - Sensors, Actuators, Analog and Digital Signal Processing:

Understand working on Sensors and Actuators. Understanding of Sensing technology. Classification & selection criteria based on nature, frequency and amplitude of signal. Understand working of Actuators. Learn interface between "Things". Relationship between physical devices. Learn how "Things" communicate and exchange the data with each other. Collecting and Communicating the data from connected devices;

Learning Objective

- Knowing about various types of Sensors: Analog and Digital
- Connecting Sensors and Actuators with Gateways or Concentrators
- Controlling Actuators through application
- Signal processing and Image processing techniques

3. IoT Communication and Networking Protocols:

Understand Networking concepts and Protocols used in IoT/IoE. Knowledge of various Communication Protocols: RS232, RS422, RS485, USART, Ethernet, Bluetooth, Zigbee, WiFi, HTTP, Websockets, MQTT, Industrial and Automotive Networks. Understanding network types and networking models.

Learn how to establish communication between devices set up across different geographic locations.

Learning Objective

- Learn to select appropriate communication and networking technologies for IoT application.
- Using Communication Protocols for exchange of data between "Things".
- Security issues in IoT/IoE communications.
- Network Security. How to protect the device and data from hacking.

4. Building Blocks of IoT/IoE Application - Hardware, IoT Platforms, Cloud computing:

Learn about building blocks of IoT/IoE. Learn about different components used in IoT/IoE. Know about various IoT/IoE Platforms. Understand working on Microcontrollers and Microprocessors. Understand about components - On-board buses, I/O interfaces, Cache, Memory Management etc. How to select appropriate devices and components. Design & build IoT hardware.

Concept & Architecture of Cloud, Role of Cloud Computing in IoT, Tools, API and Platform for integration of IoT devices with Cloud.

Learning Objective

- IoT/IoE Operating system
- Setup on IoT/IoE programming and runtime environment on Development boards
- Connecting various sensors and Actuators to Development boards
- Connecting Communication Modules on Devices.
- Interface with Cloud.
- IoT/IoE device management.

5. Data Management in IoT:

Data Acquisition, storage, management, visualization and analytics. Data storage and processing on embedded devices. Storing IoT/IoE sensor data on Cloud storage. Understanding different data models and formats. Understand batch data, streaming data, multimedia data. Manage big data. Various data acquisition tools used in IoT/IoT. Filtering and Processing of raw data. Analytics to derive meaningful information from semi-processed and processed data. Issues with data handling.

Learning Objective

- Ability to collect various Sensor Data
- Storing and managing sensor data in various formats.
- Data Visualization tools and techniques
- Manage Big Data in IoT systems
- Various data filter and analytics techniques

6. Developing full stack IoT/IoE Application - Programming tools and APIs:

Understand various tools and technologies for development of IoT/IoE applications. Design and Architecture of IoT/IoE. Learn how to use software tools and technologies for IoT. Ability to apply all the concept learnt earlier into building application. Problem analysis and Debugging skills. Mobile interface of IoT/IoE application. Server Management.

Learning Objective

- Learning various Programming Languages and tools
  - Embedded C
  - Python
  - Android
  - Java
  - NodeRed
- Troubleshooting techniques

7. IoT/IoE Project

Build an IoT/IoE project which solves a real time problem. The idea for project should be taken from your real time problem students see in their environment. This will test the knowledge acquired during the training program.

Students can make project in groups or alone depending upon complexity of the problem.

8. Hands on Sessions:

- Sensors – Classification & selection criteria based on nature, frequency and amplitude of signal
- Interfacing sensors data to Microcontroller / Microprocessor
- Signal acquisition and signal processing using ADC and Microcontroller.
- Output analog signal interface using DAC
- Interfacing peripherals & Programming GPIOs – Input/output peripherals, Sensor modules
- Schematic and PCB Layout design training to make own device

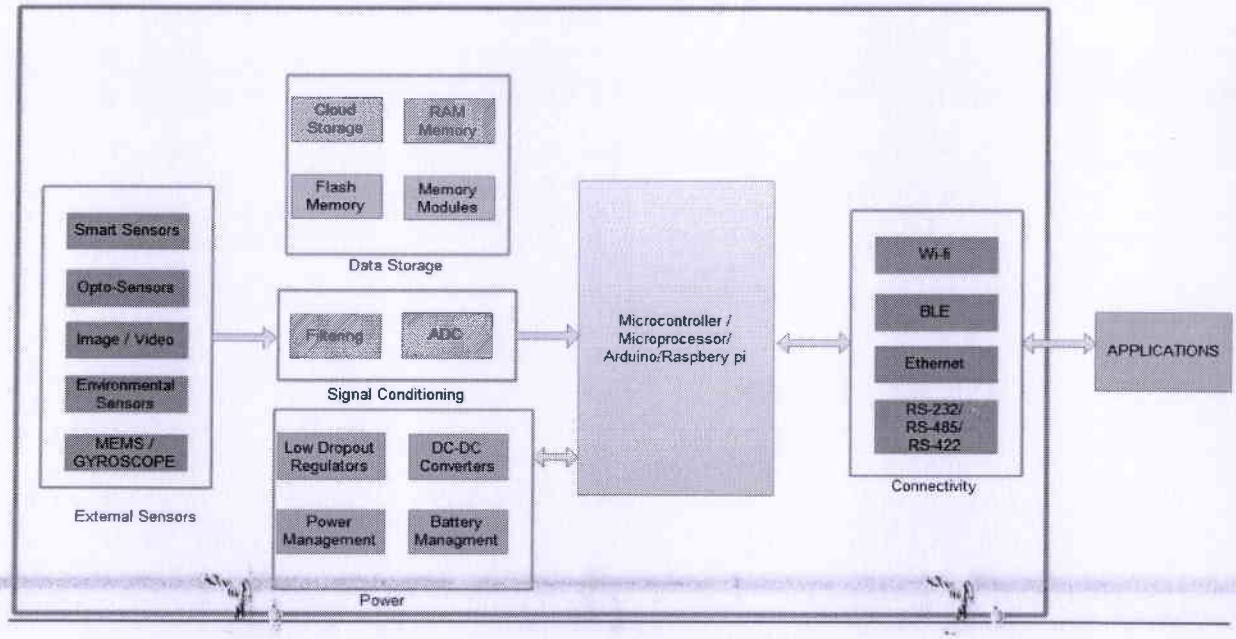

Fig: Block Diagram for Hardware Interface Module

- Develop an understanding and use of typical processors and peripherals relevant to IOT and design & build IOT hardware
- Identify processor architecture relevant to IoT applications
- Selection Criteria of Low power processor and microcontrollers
- Memory architecture - Cache,Memory Management and Memory protection
- Speed vs Power optimizations; On-board / On-chip buses and I/O interfaces
- Timing Management , resource utilization for applications.
- ADC, DAC Interface
- Implementation of RS-422, RS-485 and RS-232 protocols
- LASER/ APD/ Infrared sensor interface and control
- Build IoT hardware using components - processors, memory and peripherals
- Measure and optimize performance of IoT hardware
- Interfacing switches and LEDs with MCUs
- Developing advanced user interfaces using Android and Java.
- Interfacing sensors and other peripherals using SPI and I2C communication protocols
- Setting up wireless (bluetooth) link between systems
- Configuring bluetooth module
- Configuring and uploading data on cloud using WiFi ESP8266 module(For Arduino) using AT commands
- Programming ESP8266 module (For Arduino) using embedded-C/python to access/upload data on cloud
- Programming Raspberry Pi using Python
- Programming Arduino Uno using Embedded C
- Setting up HTTP server and testing HTTP methods on local host and with cloud
- Setting up MQTT server and testing publish & subscribe methods
- Implementation and testing of Ethernet protocols. Understanding TCP/IP protocol and pushing and pulling data from cloud using Get/Post methods.

Note: Above course content and list of Lab session is for reference only. Implementation of such program depends on various factors.

Required Components for Lab Setup

Hardware Component

Sr. No	Component Name
1.	Buzzer 5V
2.	DIP Switch - 8 Position
3.	9V Battery snap Connector
4.	12V,10AH battery and connectors
5.	4 Pin DIP PCB Momentary Push Button Switch 1
6.	Coin Cell Batteries
7.	Zinc Carbon (6F22) 9V Battery
8.	4 Pin RMC Female Connector with Wire (2.54 mm pitch)
9.	7 Pin RMC Female Connector with Wire (2.54 mm pitch)
10.	Wired USB Mouse
11.	Wired USB Mini Keyboard
12.	L293D IC based stepper motor driver
13.	USB Pen Drives
14.	Airplane 9g Mini Servo – SG-90
15.	Raspberry pi NoIR Camera (Black)
16.	DC Geared Motors (100 and 45 RPM)
17.	DHT11 Temperature And Humidity Sensor

18.	DRV8825 Stepper Motor Driver Module with Heatsink
19.	Piezo Ceramic based Ultrasonic Sensor
20.	Wi-Fi Module
21.	VEEROBOT Smoke, Gas, LPG, Butane, Hydrogen, Gas Sensor Detector Module (MQ-2)
22.	AD8232 Single Lead Heart Rate Monitor with ecg leads and disposable surface electrodes
23.	xcluma Hc Sr501 Hc-Sr501 Adjust Infrared Ir Pir Motion Sensor
24.	MCP3008 IC – 10 bit Analog to digital converter IC
25.	+12 VDC operated BLDC Motor Driver
26.	Low power BLDC Motor
27.	Three axis ADXL335 accelerometer
28.	GY521 is a 3 axis gyroscope plus accelerometer module based on MEMS IC MPU6050
29.	Texas instruments MSP432 Launchpad - MSPEXP432P401R LaunchPad board with accessories, Micro-USB cable
30.	NFC/RFID Transceiver booster pack for TI launchpad: DLP-7970ABP Board,Type 2 NFC Tag
31.	ESP32 Development Board : SX1278 ESP32 LoRa with 0.96 Inch Blue OLED Display, Bluetooth, WIFI Lora Kit
32.	CC3120BOOST - Daughter Board, Wi-Fi® CC3120 Wireless Network Processor Booster Pack Plug-In Module: CC3120 BoosterPack board, Micro USB cable
33.	Stepper motor: NEMA-17, Model - 42HT47 Two Phase Four wire,
34.	Asus Tinker board: ASUS Tinker Board (Quad Core / 2GB / Giga LAN / WiFi / BT4.0), Passive heatsink and accessories, 5V 2.5 A Micro USB power adapter, Plastic case for Asus tinker
35.	Arduino Uno Board with Accessories
36.	GrovePi Starter Kit (Raspberry Pi 3 + set of Sensors)

37.	Drone - QuadCopter Kit
38.	REES52 KT-1008 Electronic Fun Kit Bundle
39.	Lab Tools - Soldering Kit, Helping 3rd Hand with Magnifying Glass, Set of Tweezers, IPA(IsoPropyle Alcohol) Solution, Brush, Wire Cutter, Glue gun, ScrewDrivers, Connector Wires etc

Note: Above list is for reference. Hardware (electronics & embedded components, devices, equipments etc) required for an IoT/IoE Lab depends on type, size and nature of Lab. The exact list of Hardware can be be finalized after discussion with stakeholders.

Programming Language & Software

Category	Description
Programming Language	Embedded C, Android, Java
Scripting Language	Python
RDBMS Database	MySQL, PostGreSQL
NoSQL Database	MongoDB
Data Visualization	Kibana ES
Machine Learning	TensorFLow
Data Analytics	Spark
Big Data	Hadoop

Note: Software names given above are just for reference. There are multiple options available for each category. It may change depending upon types of application being developed.

Tools and Platform

Category	Description
Cloud Platform	Public Cloud platforms AWS & Azure
Networking	WLAN(Wi-Fi Local Area Network)
PCB Design Tool	Fritzing
Development Tool	NodeRed (Development tool for wiring together hardware devices)
IDE	Arduino Editor
OS	Linux(Ubuntu or Fedora), Raspbian
Compiler	gcc