Guide to Internet of Things Solution Development

Renuka Prasad[1*], K N Subramanya[2]

[1]*Department of MCA, RV College of Engineering, Bengaluru*
[2]*Principal, RV College of Engineering, Bengaluru*

Abstract

Internet of Things is fast emerging as a technology solution for a variety of complex problems. Implementation of IoT demands upskilling on the existing technologies and research on the futuristic technologies. In this paper, details of various stages of development of an introductory laboratory based on IoT are presented. The technology domains in IoT and their implementation at different levels of complexity are presented. Project based learning approach is adopted for imparting IoT skills for applications in areas such as agriculture, healthcare and manufacturing.

1.0 Introduction

Internet of Things (IoT) is a rapidly evolving technological driving force of the IT industry. The demand of Industry level skills in IoT as well as IoT enabled solutions is rapidly increasing. Consequently, demand for IoT connectivity sensors, wireless devices and hands-free connectivity is witnessing new heights. Industry 5.0 covers IoT sensor enabled devices, vehicles, equipment and machinery connected to one another. The basic requirement of Industry 5.0 is IoT contributing to the development of the infrastructure [1-3].

IoT was initially used in business and manufacturing and was known as machine–machine communication. Presently, the technology is expanding to homes and workplaces with smart devices, transforming the places to smart places. Earlier IoT was known as internet connected devices to perform ubiquitous, invisible and pervasive computing. Today the technology is known as Internet of Things to connecting things than people in the World. Internet of Things is a way of programming the physical world. Programming physical world involves monitoring or controlling things, essentially sensors or actuators. It is done to monitor or control a physical phenomena like temperature, humidity, force, position, flow light radiation, velocity, occupancy and others [4-5]. The main objective of this paper was to identify the major domains of IoT, components of IT solutions, up skilling requirements and typical IoT solutions for applications such as weather monitoring, acquaponics, Blue tooth communications and Home automation which are developed and demonstrated as part of the up skilling modules.

* Mail address: e-mail: renukaprasadb@rvce.edu.in

2.0 Multidisciplinary domains of IoT

IoT is multidisciplinary in nature and it encompasses domains such as embedded systems, communication protocols, cloud computing, wireless sensor networks, application development and data analytics. It draws expertise from different engineering disciplines for sensor development, driver development for different architectures, network laboratory to handle secured computing and communication, application development to integrate sensors / actuators and development boards with online hosted services or local services on a local cloud infrastructure and IoT Data Visualization and Analytics laboratory for monitoring the data and generating analytics to for decision making.

2.1 Components of a typical IoT solution

Processing, storing and computing the sensor data are the key tasks associated with IoT Solutions.

The components of a typical IoT solution (Fig. 1) are [6]:

- Things (Devices - sensors / actuators)
- Development Boards based on microcontroller or microprocessors
- Networking Infrastructure
- Computing server cluster for Alert, Storage and processing services at local or remote location
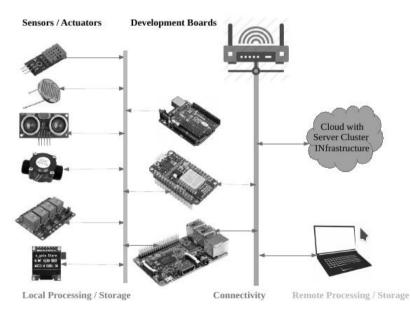- Development, testing and deployment infrastructure

Fig 1. Components of a typical IoT solution

Automating the process of programming the physical world to monitor or control a physical quantity using IoT needs upskilling in the following areas [7-8]:

- Basic knowledge of the physical phenomena and their properties in the physical world
- Fundamentals of current, voltage, resistor, transistor, capacitor
- Fundamentals of programming using high level programing languages

As per the predictions of the industries and markets, enormous amount of data is generated through the exponential increase of sensors across industries and technology users. Collecting, visualizing, and analyzing data decision making based on the data analysis is a key business across all verticals and domains [9-10] which demands skilled human resource.

2.3 IoT Startup and Industry Expectations

Present market needs demand that the human resource be conversant with appropriate skillset. Table 1 shows a comprehensive list of the expected skillset.

Table 1 IoT Enabling Technologies, activities and expected skillset

IoT Enabling Technology	IoT activities and associated skillset expected
Sensor Development and Embedded Systems	Product (sensor) Design and Development, Sensing mechanism, Sensor Data Conversion techniques, Driver development for different architectures
Networking and Communication technologies IT Infrastructure	Building a Secured Communication Network for sensors/actuators and development boards to communicate with others similar boards or computing nodes. Setting up secured computing and storage environment Local processing and storage or remote processing and storage Setting up web, file, networking services to generate alerts in various forms and cloud services Device to device communication Mesh Networking with Custom Firewall Communication via Bluetooth, Wi-Fi, UWB, LoRa, LAN, WAN,..
Application Development with Visualization and Analytics	Sensor Data Logging Application, Sensor Data Visualizing Application, Mobile Application to view and monitor devise activities, Data Visualization and Analytical tool Gateway Application to integrate third party services Web Framework like django, cakephp, django Mobile Application Development on Android or PWA
Cloud Computing	Local or Remote Processing, storage, computing services and integration of other third party services
Communication Protocols / Models and Standards	Http, ssh, ftp, MQTT, COAP, RS485, i2c,spi Request-Response, Publish-Subscribe, Pull-Push and REST Api

3.0 Typical IoT Modules developed

IoT solutions were developed for several applications. IoT enabled Aquaponics, weather monitoring, home automation and Bluetooth communication are presented in Fig. 2.

IoT enabled weather monitoring system (Fig 2a) includes connecting of several components such as electronic gadgets, sensors and automotive electronics. The system deals with monitoring and controlling the environmental conditions like temperature, relative humidity, light intensity and CO level with sensors and sends the information to the web page and then plot the sensor data as graphical statistics. The data updated from the implemented system can be accessible in the internet from anywhere in the world. IoT based Aquaponics (Fig. 2b) is a food production method which combines traditional hydroponics with aquaculture in a symbiotic relationship. It facilitates a sustainable system with necessary input as water and nutrients to grow terrestrial plants and aquatic life. IoT enabled Bluetooth communication (Fig. 2c) entails two main system; an acquisition system and a central server, under the Client-Server paradigm and the IoT technologies. The system has modules such as measurement (Bluetooth beacons), data aggregation and transmission, storage, web-interface and cloud services for data, and results visualization. Home automation combined with IoT (Fig. 2d) aims to control home electrical appliances resulting in affordable lighting solutions and optimum utilisation of energy. It is meant to control all the devices of a smart home through internet protocols or cloud based computing.
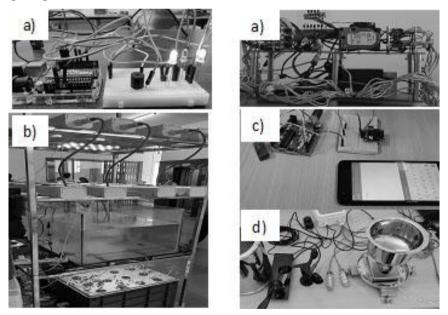

Fig. 2. a) Weather monitoring, **b)** Acquaponics, **c)** Blue tooth communications and **d)** Home automation

The technologies, framework and hardware required for developing IoT applications are presented in Fig. 3.
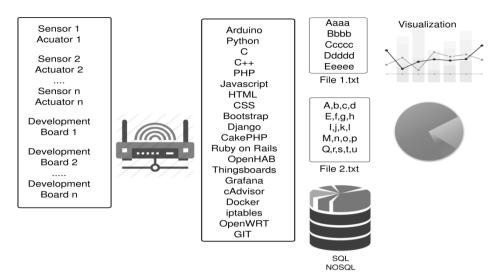

Fig. 3. Technologies, Framework and Hardware needed for while developing IoT Application

4.0 Conclusions

The multidisciplinary domains of Internet of Things, the major components involved in IoT application development, the IoT enabling technologies, activities in IoT design and expected skillset by the industries are highlighted. Technologies, framework and hardware required for developing IoT are identified. Typical IoT applications are presented.

This paper was based on the experiences gained as part of the activities of CISCO-RVCE-Centre of Excellence in Internet of Technologies. The Centre provides guidance on IoT prototype solutions by collaborating with industries. The participants of the upskilling programmes undergo experiential learning in IoT application development enabling conceptualization of the protocols and algorithms along with the knowledge and skills for identifying the IoT components and the interconnectivity.

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