Research and Development Activities at IETE Bangalore Center

Phase I. IETE Bangalore Centre established an IoT & Embedded Systems Lab in 2020 and has conducted many internship programs and short term courses. A brief description of the facility is given below:

1. Introduction

Recent advances in Mobile and Information technologies, IoT and embedded systems are paving the way for the next revolution in computing. Accordingly technology trends across the globe are pointing in the direction of Ubiquitous computing, Cloud Computing and wireless SCADA. In order to build up and mobilize skilled engineers to address the growing demand in this extremely fast moving this segment, IETE Bangalore centre proposed suite to setup state of the art laboratories for academic Institutions/Industries to enable research activities/Project work at the grass root level in these technology areas.

As research and education are complementary to each other, research and innovation developmental facilities are a necessity for engineering institutions. This brings sustainability to all teaching and learning processes and institutional developmental mechanism. Also various applications can be developed in these research areas resulting in patents.

IETE's IoT Lab is part of setting up technology infrastructure with modern teaching / learning aids and skilled human resources, for engineering students and professionals to acquire research skills sets.

2. Research possibilities:

A. With the advent of Internet of Things (IoT) applications are limitless and there is a huge scope for innovative projects of social value in this area.

B. Building Industrial automation can be done by using Zigbee to effectively deliver solutions for a variety of areas by the design of a multi-sensing, heating and air conditioning systems.

C. Using a wireless sensor network for security monitoring would allow quickly deployed large-scale intrusion detection. Whenever a sensor node detects motion or is moved from its original location, the node will generate an event, alerting the wireless network that something is wrong.

D. WSN/IoT has huge research possibilities for military and medical applications also in the field of Agriculture, Animal Husbandry and disaster management Cloud Lab Kit provides preconfigured platforms & Computing Environment for research.

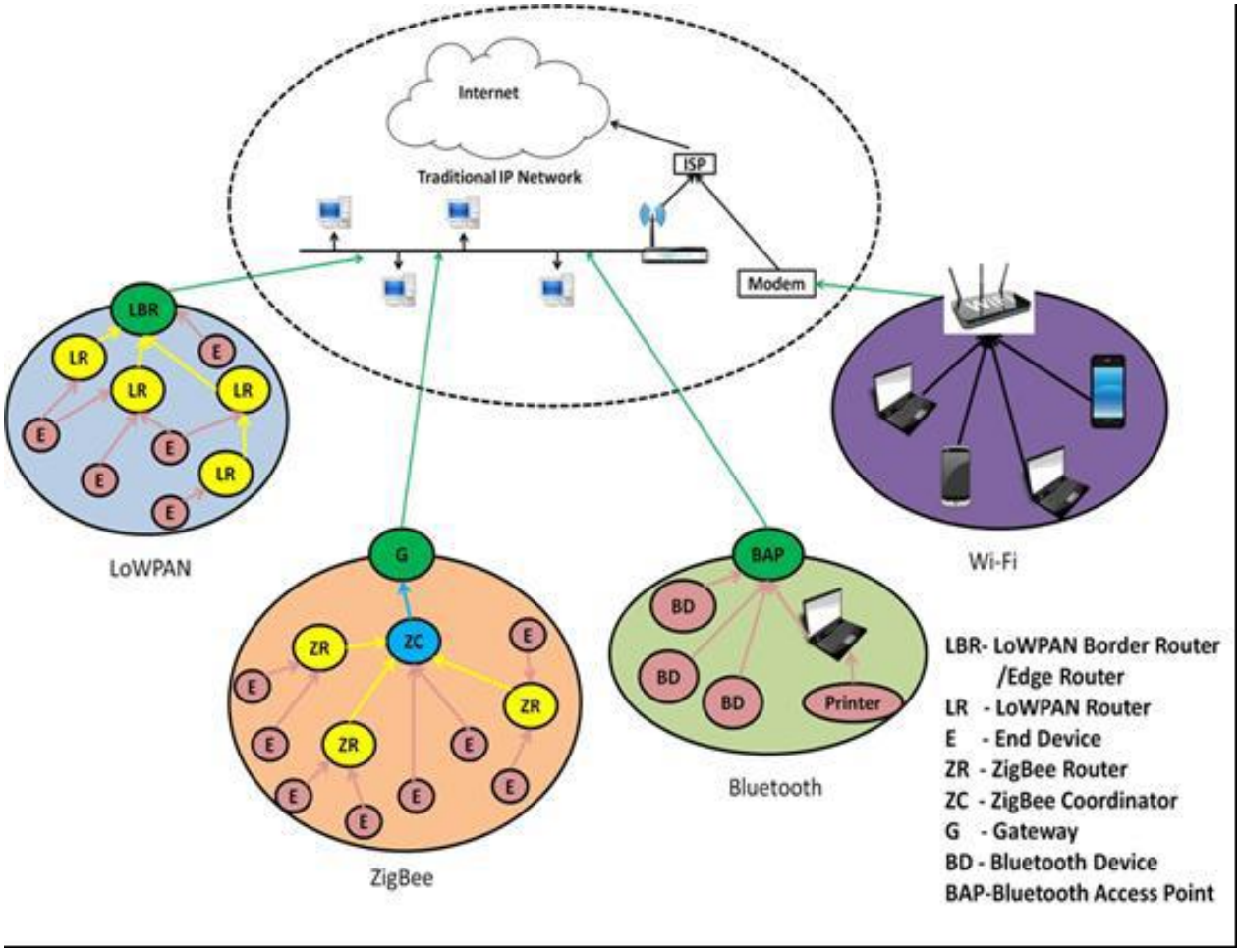
E. Programming environments – C, C++, Java

F. Parallel Environments- MPI, Map reduce

G. With the Arc Lib (Augmented Reality Lab Kit) many innovative and useful AR applications can be developed on Android platform that supports Camera capture, file I/O, image processing and graphics programming.

3. Internet of Things (IoT) & Embedded System- Development - Kits

Internet of things (IoT) provides IP connectivity to various ‘’Things’’ apart from general Desktops, Laptops and Mobile Devices. The term "things" means any physical parameter that could be sensed and connected to Internet. For example a device monitoring temperature and humidity at certain location and relaying the data will become a “thing’” in the IoT domain. Sensors are the building blocks of IoT which can collect parameters and low power wireless embedded systems transmit information to gateway devices. Gateway device will make the parameters available over internet so that parameters are globally accessible. Till now there is no dedicated network stack defined for IoT, as it is heterogeneous network of networks. The most popular protocols used for realization of IoT are Zigbee, 6lowPAN (IEEE 802.15.4), Bluetooth and Wi-Fi. Sample network architecture of IOT is depicted below for reference



In the existing Lab which was established by C DAC, Bangalore, we have the following:

a. Ubi-sense:

Ubi-Sense is a generic sensor board having the following listed sensors.

Sensors Temperature and Relative Humidity Light Intensity Barometric Pressure Proximity sensing Buzzer

All the sensors can be interfaced with microcontroller via I2C bus. It contains additional I2C connector for connecting external I2c compliant sensors to the communications modules. Ubi-Sense mates with all three Ubimote, BLE mote and Wi-Fi mote through their expansion connector and sensor interface libraries are available for all the communication modules. The platform could be used to educate students about MEMS based sensing, sensor interface and applications.

b. Ubimote:

Ubimote is a System on Chip based Low Power and Medium range RF communication module compliant toIEEE802.15.4 supporting a maximum transmitting power of +7 dBm. Ubimote supports application development Platforms like Contiki OS, Zigbee and custom stacks.

Features:

Highly integrated System on Chip with ARM Cortex M3 microcontroller with

- Up to 32-MHz Clock Speed
- Up to 32KB of RAM (16KB With Retention in All Power Modes)
- Two timers (16/32 bit)
- 512KB of In-System Programmable Flash
- Supports On-Chip Over-the-Air Upgrade (OTA)
- Battery Monitor and Temperature Sensor
- 12-Bit ADC With 2 Channels and Configurable Resolution
- USB 2.0 Full-Speed Device (12 Mbps)

External Flash Memory

- 8Mb Flash memory, Up to 75 MHz clock frequency
- SPI Interface , Write Protection, Deep Power Down Mode

RF subsystem

- ISM Band RF Transceiver with RF frequency range 2394-2507 MHz (2.4 GHz)
- IEEE 802.15.4 compliant DSSS baseband modem with 250 kbps data rate
- Low Power (RX -97dBm @ 20 mA, TX 0 dBm @ 24 mA)
- Ultra-low power down mode (<1.3μA)
- Good receiver sensitivity (-100 dBm), Adjacent channel rejection: 44 dB and Alternate channel rejection: 52 dB

Security sub system

- Future Proof AES-128/256, SHA2 Hardware Encryption Engine
- Optional – ECC-128/256, RSA Hardware Acceleration Engine for Secure Key Exchange
- Expansion headers for connecting Ubi-Sense, Ubi-DAC and external sensors
- Intelligent power system with rechargeable lithium polymer battery and solar energy harvesting

c. BLE mote

BLE mote is a system on chip based device for Bluetooth Low Energy based applications. This mote is compliant to the Bluetooth 4.0 standards with Low Energy Profile support.

Features:

- Highly integrated System on Chip with ARM Cortex M0 microcontroller with
- 256 kB embedded flash program memory, 32 kB RAM
- 1x32 bit Timer & 2x16 bit timers with counter mode
- 8/9/10 bit ADC with 8 configurable channels
- Low power comparator
- Supports various Serial Communication Interfaces like SPI,UART, I2C
    - CPU independent Programmable Peripheral Interconnect (PPI)
    - Real Timer Counter (RTC)
    - Watchdog Timer (WDT)
    - External Flash Memory
        - 8Mb Flash memory, Up to 75 MHz clock frequency
        - SPI Interface , Write Protection, Deep Power Down Mode
    - RF subsystem
        - 2.4 GHz (2.400 to 2.4835 GHz) ISM Band RF Transceiver compliant to Bluetooth 4.0 LE standards
        - 250 kbps, 1 Mbps, 2 Mbps supported data rates
        - GFSK Modulation
        - Programmable Transmit power of +4 dBm to -20 dBm (in 4 dB steps)
        - High Receiver Sensitivity (-93dBm in BLE)
        - Low Power (Peak Rx -93dBm @ 13 mA, Peak Tx 0dBm @ 10.5 mA)
        - Ultra-low power multiple down modes

Security sub system

- AES Hardware Encryption Engine (AES Electronic Codebook Mode Encryption, AES CCM Mode Encryption)
- Accelerated Address Resolver
- Random Number Generator

- Expansion headers for connecting Ubi-Sense, Ubi-DAC and External Sensors
- Intelligent power system with rechargeable lithium polymer battery

d. Wi-Fi mote

It is based on Wi-Fi Certified wireless MCU with built-in Wi-Fi protocol stack target for Internet of Things (IoT). The maximum RF transmitting power is up to +18dBm.For the application development Free-RTOS and TI-RTOS can be easily integrated.

Features:

High-performance ARM Cortex-M4 MCU with

- Wi-Fi Network Processor with 802.11 b/g/n Radio, Baseband, MAC, Wi-Fi driver
- Power-Management Subsystems with integrated DC-DC converters
- RAM of 256KB
- External Serial Flash Boot loader
- 2 General-Purpose Timers with 16-bit PWM mode
- 2 Channel 12-bit ADCs
- Clock sources with 40MHz and 32.768kHz

- Four Universal Serial Communication Interfaces (USCIs)- SPI, UART, I2C
- Provides an application throughput of maximum 16Mbps
- Supports Station, Access Point, and Wi-Fi Direct modes External Flash Memory
- 8Mb Flash memory, Up to 75 MHz clock frequency
- SPI Interface , Write Protection, Deep Power Down Mode

Wi-Fi network processor subsystem

- Dedicated ARM MCU completely offload the host MCU
- Robust 802.11 b/g/n radio, baseband, and MAC
- Powerful crypto engine for a fast, secure WLAN and Internet connections with 256-bit encryption.
- Supports WPA2 personal & enterprise security and WPS 2.0.
- Embedded IPv4 TCP/IP stack

Security sub system

- Hardware Crypto Engine for Advanced Fast Security including AES, DES, and 3DES, SHA2 and MD5, CRC and Checksum
- Expansion headers for connecting UbiSense and any other external sensors
- Intelligent power system with rechargeable lithium polymer battery

e. WINGZ Multiprotocol Gateway

WINGZ Gatewayis a low power, microprocessor based embedded platform for interfacing various communication interfaces. It communicates with the End Point Nodes through IEEE-802.15.4 RF interface and functions as the Data Terminal Unit and network controller. The collected data is stored on the Gateway's SD Card. The stored data may be offloaded to alternate devices or web-servers through the wireless interfaces like WiFi, GSM/GPRS and 3G or can also be downloaded manually, using wired interfaces like RS-232 and USB. The Gateway provides an Operator Interface for intended users to interact and configure.

Features:

Processor

- ARM Cortex-A9 application Processor(Single/dual/quad)
- CPU clock speed up to 1GHz
- 2D and 3D graphics co-processors

Power Management

- Advanced power management system with module wise power control
- Flexible power input with dynamic source switching
- Integrated Li-Ion battery management with solar energy harvesting capability
- Dynamic Voltage and Frequency Scaling

Memory

- 1 GB/2 GB DDR3 SDRAM
- 4GB/8GB onboard eMMC flash memory
- External Micro-SD card support (up to 32GB)
- 4Mbytes Serial Flash

Connectivity

- Onboard Gigabit Ethernet (RJ45) ports
- Two USB 2.0 host type A ports
- One USB-OTG Port
- One High speed CAN (DB-9) port
- Supports various Serial Communication protocols like SPI, I2C, UART

Display

- Onboard 7" LCD with capacitive touch panel
- High Definition Video Output through HDMI Port

Camera

- Supports CMOS Camera (Optional 5MP Raspberry Pi camera)
- Supports various USB based web cameras

Audio

- High quality Stereo audio codec
- Mobile phone compatible 3.5mm audio port for Audio In/Out Wireless Connectivity

- High Range IEEE802.15.4 (Zig Bee/6LoWPAN) Transceiver (up to 22dBm Tx power)
- Dual Mode Bluetooth4.0 Connectivity (with BLE profile)
- IEEE802.11b/g/n compliant WLAN (Wi-Fi) Modem
- 3G Cellular Network Connectivity (GSM/GPRS/EDGE/HSPA+)
  GPS/NGSS Positioning system

Onboard Sensors

- Temperature and Relative Humidity Sensor
- Digital Ambient Light Sensor
- 3-Axis Digital Accelerometer

Debug Interface

- JTAG connector (20-pin) for Main Processor
- SWD connector for BLE SoC

OS Support

- Linux
- Android
- Windows*

Application

- Gateway device between the WPAN and IP network
- Coordinator device for the WPAN networks
- Indoor/Outdoor deployment of Internet of Things solutions
- Single board computer
- Unified control and monitoring console for various wireless networks

4. Possible list of experiments on IoT& Embedded Lab

a. Embedded Programming

1.1. Toggling LEDs
1.2. Transmitting a string through UART
1.3. Controlling LEDs blinking pattern through UART
1.4. Echo each character typed on serial terminal.
1.5. Digital IO configuration.
1.6. Timer based LED Toggle.

1.7. On-chip Temperature measurement through ADC.

b. RF experiments

2.1. Point to point communication of two Ubimotes over the radio frequency.

2.2. Multi-point to single point communication of Ubimotes over the radio frequency.

c. Experiments on interfacing with UbiSense

3.1. I2C protocol study

3.2. Reading Temperature and Relative Humidity value from the sensor.

3.3. Reading Light intensity value from light sensor.

3.4. Reading of atmospheric pressure value from pressure sensor.

3.5. Proximity detection with IR LED.

3.6. Generation of alarm through Buzzer.

3.7. Transmitting the measured physical value from the UbiSense over the Air.

d. WSN Applications

4.1. Demonstration of a peer to peer network topology using coordinator and end device network device types.

4.2. Demonstration of peer to peer communication between coordinator and end device through Router.

4.3. Establishing Many to one Communication (Star Network Topology)

4.4. Establishing Tree Network Topology

4.5. Establishing Cluster Tree Network

5. IoT applications

5.1. Porting 6lowPAN stack on Ubimote for enabling it with IPv6

5.2. 6lowpAN network formation with motes and PC

5.3. IP based lighting control

5.4. IP based sensor monitoring through Ubi-Sens.

Apart from the above listed experiments on Bluetooth, WI-Fi and heterogeneous network setup for IOT and interoperability achievement among various protocols can be tried on IOT research

Phase II. The Centre now proposes to have an**Augmented Reality (AR)&Virtual Reality (VR) Lab**, integrated with the above mentionedIoT& Embedded Lab. Brief details are as follows:

Introduction:

INDUSTRY 4.0 is here! Augmented Reality (AR) and the Industrial internet opportunities, along with Industries 4.0 are dramatically reshaping manufacturing industry. Digital Thread – Unleashing a seamless flow of data across the value chain that will link every phase of the product lifecycle: from design, sourcing, testing and production to distribution & point of sale.Digital Twin – Digital Models that Virtually represent their physical product and process counterparts. Digital Thread and Digital Twin are the two major aspects of Digital Transformation and Industry 4.0. Institutions that produce the Engineers of tomorrow will need multidisciplinary skills to embrace this rapid change in their employing organizations. AR is one of the fastest growing segments of the technology market and provides some of the most exciting and game-changing possibilities in software today. As a result, the market projections for AR are astounding.

In view of the above, IETE Bangalore is shortly purchasing a software license from PTC India, a leading MNC in the field of IoT& AR.

PTC's ThingWorx provides complete Industrial Internet of Things (IIoT) Platform and AR capabilities, allowing users to source, contextualize, synthesize, orchestrate, and engage with data from their connected products, operations, and software.

AR and IoT –

Augmented Reality provides the ability for users to experience digital information in the context of a physical product: in the field, on the shop floor, in the showroom floor, or on the cab of a machine. It can also bring the machine or the shop floor to the user wherever they might be. AR brings incremental value to the enterprise across multiple domains. AR also presents the next generation of interface to the end customer. Just as smart phones, the Internet, and mobile devices have disrupted the way we search for information and conduct commerce today, AR presents itself as the next window to the customer. Whoever controls the AR experience will dictate what customers and service technicians see, and by default the services or products they buy.

By incorporating AR into their IoT strategy, enterprises across the globe are bringing clarity and efficiency to a variety of initiatives across diverse industries. Furthermore, with nearly 50 billion connected devices expected by the year 2020 and more coming online every day, the market has begun to see an explosion of purpose-built applications. Managing the development, deployment, and maintenance of such a vast array of independent, purpose-built apps will overwhelm even the most effective content creators.

Key Capabilities of AR

- Visualize
  - IoT data
  - Digital models
  - Third-party data Business systems information
- Instruct/Guide ○ Real-time transfer of knowledge and expertise
  - Digital step-by-step instructions to guide user
- Interact
  - Expand and customize control of product functions
  - Modify digital designs
  - Enhance physical products with digital experiences

PTC's Vuforia is a powerful, cross-platform Augmented Reality solution, delivering high-value results for industrial manufacturing, service, sales and marketing, and training organizations. Our field-proven technologies and innovative solutions help bring to life the revolution of smart connected products and smart connected operations. Vuforia empowers businesses to lower costs, improve overall quality of their products and workforce, and increase the performance of their most important asset – their people. Vuforia provides:

Seamless integrationwith industrial product design, lifecycle management, equipment and products - The PTC heritage of CAD, PLM, and IIoT has infused AR offerings with a keen awareness of industrial operations and business drivers. The Vuforia platform directly integrates ThingWorx real-time data and proactive insights of asset performance directly into AR experiences.

3-D files can easily be transformed into step-by-step procedural instructions in Vuforia AR experiences. Vuforia platform solutions can work on premise or provide secure cloud hosting depending on your data requirements.

Strong partnerships with an ecosystem which brings to life innovative optics, performance and devices best suited for industrial use -Vuforia works closely with all major handheld and head-worn devices, operating systems and chip manufacturers, calibrating the highest potential device-specific AR performance. This allows optimized, cross-platform AR experiences without extensive testing by the content creator.

IoT Integration-ThingWorx:
Platform Vuforia Studio is fully integrated with PTC's ThingWorx Platform – the industry-leading IoT platform – allowing users to leverage their connected asset data in real-time AR experiences. ThingWorx is the industry leading, award-winning Industrial Innovation Platform from PTC that includes technologies and tools that enable users to rapidly develop, deploy, and extend IoT applications and Augmented Reality (AR) experiences. ThingWorx contains a broad set of features, including a variety of connectivity options, application development tools, analytics, and AR technology all built around a single, real-time view of a physical object in the digital world - the ThingModel. The platform eliminates complex connectivity, programming, and deployment tasks for developers while providing powerful end-user solutions that deliver high levels of return on investment. Using the ThingWorx Platform, organizations can quickly take their business to a new level by building smart, connected products, operations, and software.

Overview of PTC Vuforia:
Augmented reality is an exciting industry that is gaining a ton of traction in various markets from retail to manufacturing. In this course, you will get a high-level overview of this market (strategy, use cases, development practices) and then you will build out two apps, one for a consumer use case and another for an industrial use case. In this project-based experience you will setup AR projects, create AR experiences with 2D and 3D assets, setup custom logic and events, and integrate data from smart, connected products. The intent is that you will walk away with a strong understanding of AR development strategies and be able to make your own AR experiences using Vuforia Studio. Experiences can be viewed with supported device using Vuforia view app.

Course Objectives: After completing this course one will be able to:
- Understand the concepts of Augmented Reality
- Know about PTC's solutions for AR segment
- Learn about the role of Vuforia Studio for developing AR experiences
- Learn how to use Vuforia Studio and Vuforia View App for developing experiences
- Create your own AR experiences using Vuforia Studio

Course Structure:
1. IoT Fundamentals
2. Fundamentals of IoT Development with ThingWorx
3. AR Basics
4. Fundamentals of AR Development with Vuforia Studio
5. AR Development with Vuforia Studio
6. Develop your own AR experience
7. Assessment

IoT Overview: - Introduction and fundamentals:

In this course, you will have an overview of Internet of Things and smart, connected products. You will also understand the importance of IoT platform for developing IoT applications. You will learn how to use ThingWorx to model applications that communicate with smart, connected things. You will model your solution using things, thing shapes, and thing templates. Then, you will combine those elements into mashups (Web pages). You will add functionality to your things using properties, services, to automate tasks and communicate with external data sources. You will store information in data tables as well as gain experience using data shapes.

Course Objectives

Understand the concepts of IoT and smart, connected products

- Know about PTC's solutions for IoT segment
- Learn about the role of IoT platform for developing IoT applications
- Learn how to use ThingWorx to model applications that communicate with smart, connected products
- Create your own IoT application by utilizing ThingWorx platform

Curriculum Topics:

- Module 1 Internet of Things Overview
- Module 2 About PTC &ThingWorx
- Module 3 ThingWorx Platform Overview
- Module 4 Introduction to ThingWorx
- Module 5 Create your own IoT application

Under the terms of purchase,PTC will give 25 licenses with which up to 250 students a year can be trained. The course length is 100 hours and batch size limited to max 25, average 20 to ensure proper education delivery to the students. They will provide Kits to 75 trainees in a year.
