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Understanding of Internet of Things (IoT) and Experimental Approach using WICED Sense in Android Platform

Saminath.V, Jung Su

Abstract- Internet of Things (IoT) is extending your physical devices to internet lively connected with human. Controller based intelligent devices connected with low power wireless and sensor nodes, it accesses over the Internet. The power of internet makes intelligent interaction between human being and smart devices. Smart devices run autonomously self-decisive devices or externally monitored and controlled by human, anywhere in the universe. IoT brings ability to connect network automated devices and communicates remotely to manage multitudinous number of functioning over internet is viable solution. IOT device should have low power usages like Bluetooth Low Energy (BLE), sensor measures and control specific characteristic of the target device. The intelligence of IoT enables devices to perform their tasks and recognize and counteract threats. IoT brings you new shape on your business, Day-to-Day regular activity. This paper explains the details of BLE devices, IoT cloud connectivity, protocol communication and Android Platform Bridge for IoT communication. To Demonstrate IoT the development kit (WICED from Broadcom) integrated with Open source Cloud service architecture.

Index Terms- IoT: Internet of Things, BLE: Bluetooth Low Energy, SoC: System on Chip, URL: Unified Resource Locator, RFID: Radio Frequency, NFC: Near Field Communication.

I. INTRODUCTION

IoT enables you to manage and monitor all the devices in remote. There are various benefits of using Internet of Things, like offering new features on the products, Enhancing existing feature by add-on, allowing to make new business model. Devices are physically at remote place. We can employ following activities using IoT. If your devices become a faulty, we can run our diagnostic tool remotely, and we can suggest repairing the system based on the report. IoT allows you manage the physical device remotely, control, configure, and fix issues. It makes you close to your end clients, giving you a deeper and richer understanding of the working environment.

IoT establish bridge between the 'Digital world (Internet)' and the 'Real world (physical device)'. The devices objects are connected to the cloud and creates unique identification over the internet. IoT reference Design as explained in the Figure-1, is categorized into 6 major layers

1. Smart devices and Controllers
2. Connectivity and protocol Communication
3. Cloud Server and
4. Data Storage and Accumulation
5. Data analysis and Computing
6. User Application and Report Generation.

Devices can be connected to the Internet in two ways, either in an active mode or in a passive mode. In passive mode connection devices are not connected to internet directly, but it publishes device information to the internet. Each device has unique identification from RFID or Barcode like tags will be present. Ad-hoc device is connected in internet and publishes those information to cloud. In Active mode connection, device has capability of measuring various sensor information and record it. These information is directly broadcasted to clouds.

IoT has a lot of potential to enhance consumer's services and provides solutions to Health-care, Education, Transport, Energy, Security, Agriculture, Retail domains in all aspects of daily life. In the home security system, all smart devices are integrated and connected to cloud-based services and controlled by Smart Applications. The connected smart devices will enable a reduction in power utility costs and outages and it improves home security via remote monitoring.

IoT changes our life style in every aspects and surroundings becomes automated by connecting almost all devices over internet. Making Smart decision yields easy customization, avoiding human latency, optimizing utilization, lowering energy consumption, remote diagnosis, efficient operation, lower maintenance.

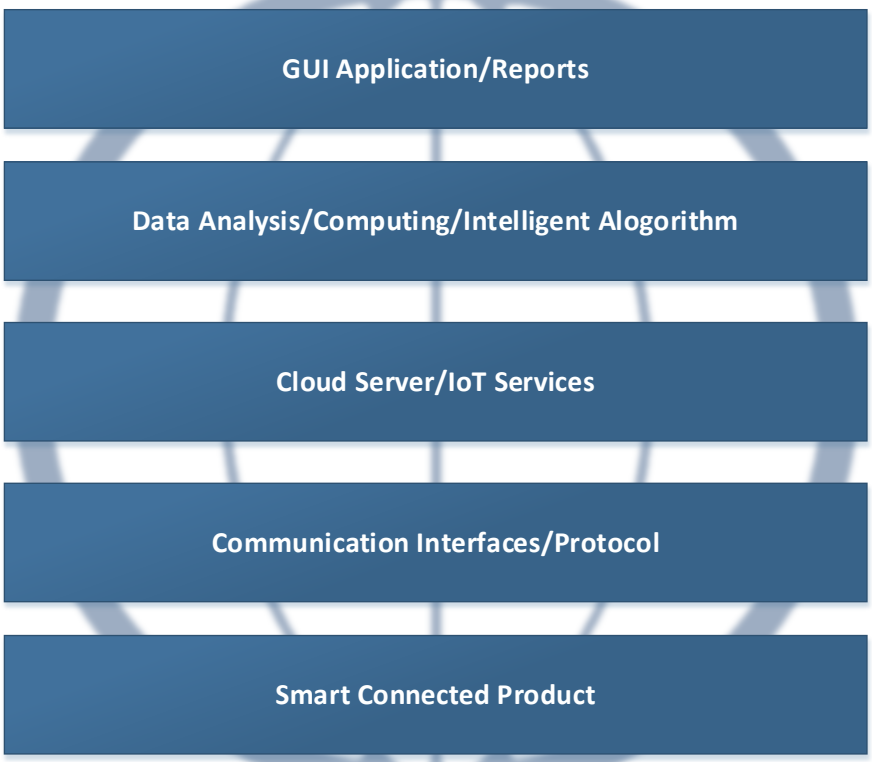

Figure-1: IoT Building Blocks

II. IoT Devices

IoT has plenty of constraints and restrictions to use smart device like, Size of the Messages, Distance between device communications, support of Wired/wireless technology, processing speed, data security. Based on the product solution, IoT components and technology used for design will vary. Table-1 describes plenty of embedded devices support for IoT product design and each has special characteristic to use the device. Application requirements can be changed as the number of sensor node needed, monitor only or monitor and control target nodes.

Table-1 IoT Device Characteristic

Technology	**NFC**	**RFID**	**BT**	**BLE**	**Wi-Fi**	**Zigbee**	**WPAN**	**WiMax**	**2G-3G**
Power	Low	Low	Low	Low	High	Low	Low	High	High
Speed (Kbps)	400	400	700	1000	100000	250	250	100000	5000
Distance covered in Meters	0.01	3	30	7	15	300	800	50000	Cellular Network depends
Cost to Build IoT	Less	Less	Less	Less	Average	Less	Less	High	High
IoT Target Application	Payment Application, Share Details in short Distance	Product Identification, Tracking Segments	Data Exchange in Medium distance, with medium scale of data	Fitness Tracking, Health Monitoring	Interface with Internet, IoT Server communication	Automotive product support, Sensor Interface, Home Automation	Automotive product support, Sensor Interface, Smart City Automation	Interface with Internet, IoT Server communication	Interface with Internet, IoT Server communication

IoT proficiency is defined by embedded processor used for real-time data processing. The microcontrollers are specially designed for IoT devices that sleep most of the time and wake up when needed for low power consumption. It simplifies and speed up the deployment of IoT products and makes launch into market on time.

Controller has features to maintain stack for cloud-based IoT management. Controller portfolio includes SoC, Development tools and software IP, secured interconnectivity of IoT, and provides the quickest and the most efficient path to deploy connected platforms and associated services, wearable extension.

As per the ARM IoT design statement, two classes of devices are used for Internet of Things (IoT). Devices have more complex capabilities with amply of local processing functionalities and similar complexity and those which are simpler local computation systems. The complex systems apply for Industrial controllers, ATM machines, Kiosks and Digital Signage. ARM Controller offers a wide range of solutions for these market products. These systems run with Smart Operating systems like Linux, Android or IOS and contain built in graphics cores to render UIs. Other one is relies on inexpensive, small sensors and the need to be power efficient, the ability to run on batteries for long time. The IoT is about the devices and services in end to end solutions. Internet of Things utilizes open source protocols like CoAP/HTTP, MQTT, TLS/TCP, DTLS/UDP and OMALWM2M for data communication and device management.

III. Bluetooth Low energy (BLE) devices

Bluetooth low energy technology is used to streams the connected devices information to Internet-based services and applications in limited power usage. Bluetooth low energy has significant features in IoT domain compared with other wireless technologie's seamless supports for smartphones and tablets. Bluetooth low energy (BLE) protocol allows a Bluetooth device to transfer small chunks of data in periodic interval. BLE device is connected with sensors, actuator and other measuring devices which require low power consumption during connectivity.

Bluetooth Smart BLE devices are optimized and operated with small coin battery, device consumes low cost and low power consumption, it is capable of sensor and attenuator information transfer. Bluetooth Smart Ready BLE devices are for low energy with support of Classic mode of bluetooth operations. Devices like mobile phones, tablets, and computers are used as gateway to pair with BLE devices. Bluetooth low energy uses a Client- Server model. The Client connects and accesses one or several Servers. Client devices operate as e Central role expect to get the sensor information, pass control information and the Server operate as Peripheral role which collects sensor information transit to central, has connected with sensor and attenuators. The gateway typically takes on the Client / Central role. There are four stages for data transactions.

1) Scanning
2) Advertising
3) Initiating
4) connecting

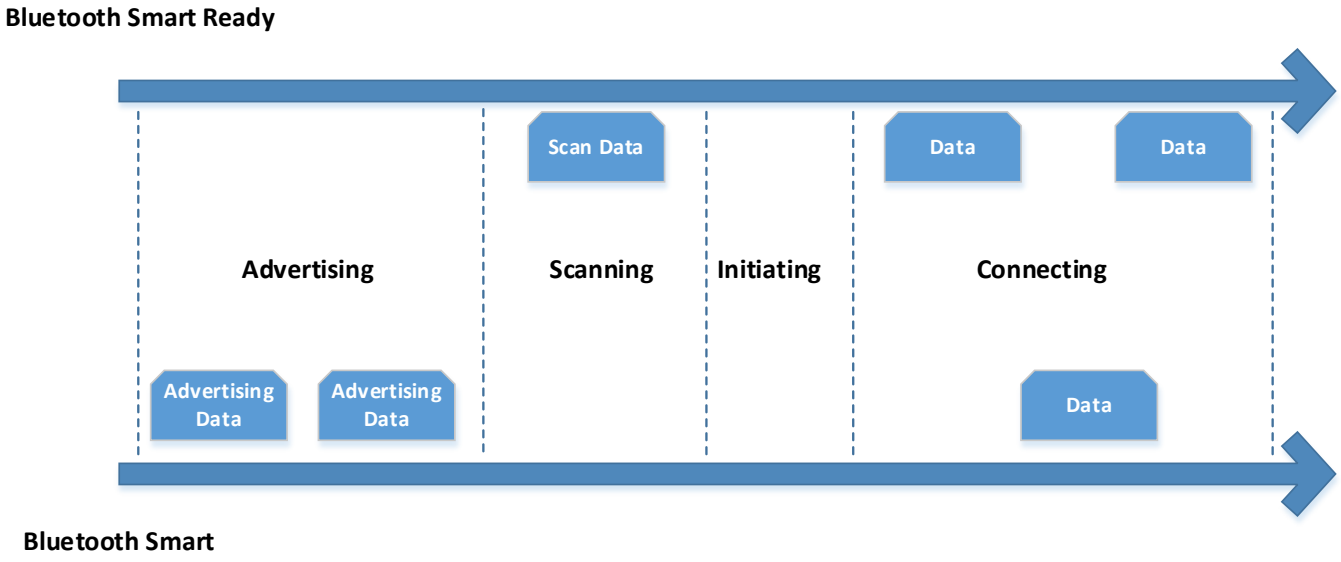

Figure-2: BLE Connectivity Sequence

Bluetooth smart device transmit non-connectable advertising packets periodically over the air medium, anyone willing to receive them. Bluetooth Smart Ready Repeatedly scans the preset frequencies to receive any non-connectable advertising packets currently being broadcasted. The WICED sense device is "advertising" when he wants to connect. The Smart Device is scanning for new devices, When the Observer finds a new device it wants to connect to it. Then it initiates a connection and pair it. The advertisement may contain broadcasted data.

IV. Experimental Setup

Figure-3 explains the experimental set-up for IoT development. WICED sense kit is built by Broadcom BCM20737 SoC, supports Bluetooth low energy with wireless charging and integrated five sensors: gyroscope, accelerometer, eCompass, pressure and humidity/temperature. WICED sense device pair with smart device and transmit real time data to paired device. Android/IoS based Smart phone has wireless supports like Wi-Fi, Bluetooth, NFC and Develop Application for communicate with WICED sense. Smart devices has Bluetooth capability to pair with WICED sense kit, sends sequence bytes of sensor data. The paring sequence is explained in figure-2, after starting scan operating device paired each other. Smart device send initialize configuration and sensor on/off to wiced sense kit. Then Smart device start to receive encoded byte of information from WICED device.

Smart phone Connect to the IoT Foundation Cloud using Client application which passes URL, Port number and Client ID. The server is identified by client host name, port number and register itself. Once connection is established with IoT server register with the callback function, notification messages intimates data processing. Sensor messages packetized and published to IoT server. Message payload are encapsulated with various attributes. Payloads uploaded to IoT server continuously with fixed interval of time. During message transaction disconnect information receives via callback notification.

After receiving the payload information, the IoT server decode information and display in messages with time information. Messages are different types of event, connection oriented message, published sensor message. Decoded payload data are stored into database for final report generation or, UI application development for end-customer.

Typical architectural approach can be used for design with wearable devices that communicates with the cloud. Wearables devices have many features like tracking, reporting on individual activities communicate with a smartphone or tablet.

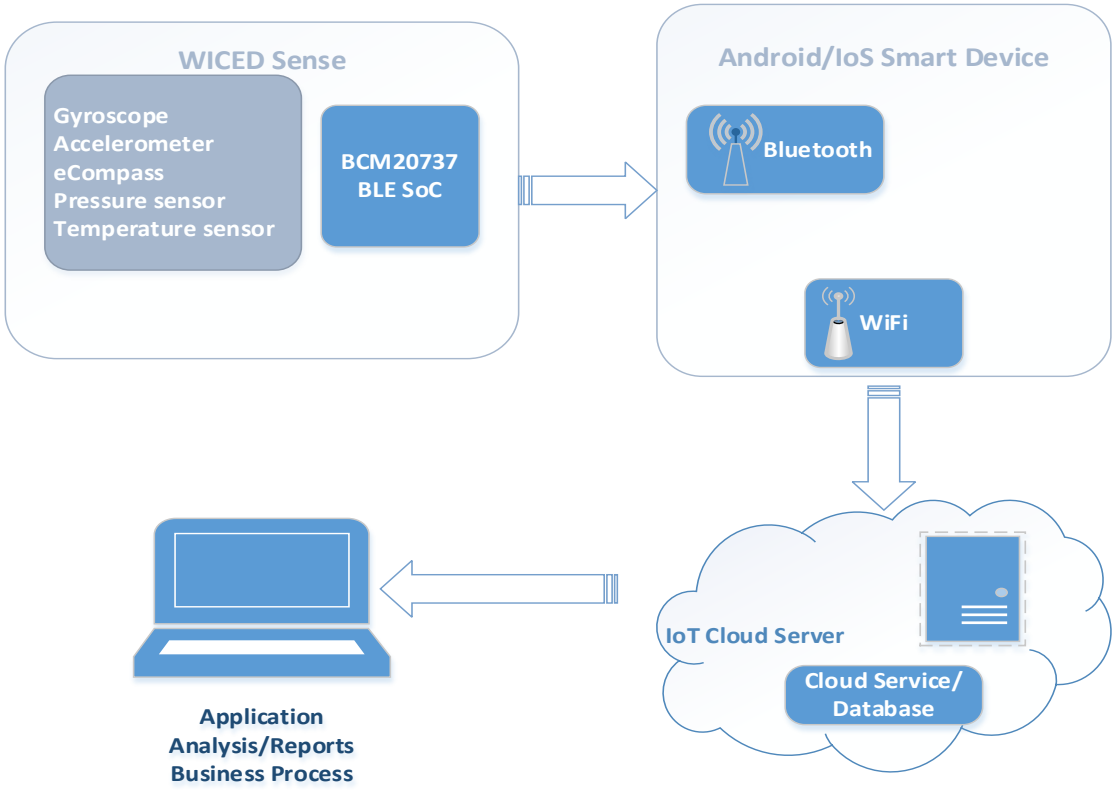

Figure-3: Experimental set-up for IoT

V. RESULTS

The WICED kit consists of a Bluetooth Low Energy (BLE) SoC with five sensors and is powered by coin cell battery. The appearance of the kit is small form factor, cheaper cost and easy choice for experimentation of IoT. Android Phone (supports SDK 4.4) is used for development of IoT Hybrid applications. WICED sense kit transmit Sensor information's via BLE to paired devices. Android phone has two major applications (Interfacing with BLE, Protocol communication with IoT foundation Server) developed in Cordova Java script. The WICED sense firmware by default stream data, Android phone scan and pair with the sensed device. Application receives stream of encoded bytes. Application has algorithm to extract the sensor byte streams and displays on phone in figure-4. It displays the current value of gyroscope, accelerometer and movement of WICED sense. It displays the Connectivity information with WICED sense and IoT foundation server.

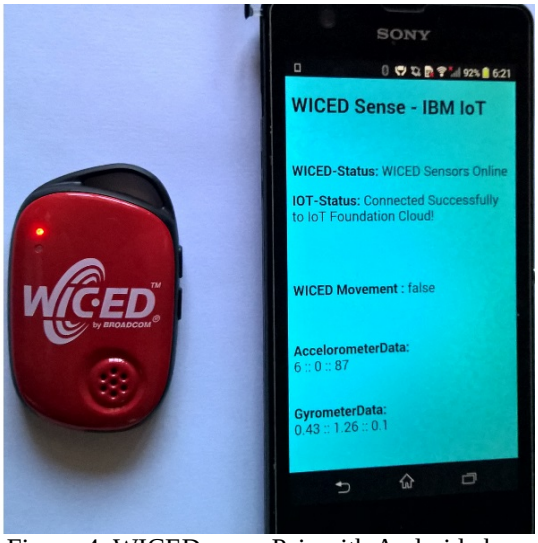

Figure-4: WICED sense Pair with Android phone

Android application connects to IoT Foundation server, MQTT library provides MQTT services, Message Queue, Telemetry Transport, light weight messaging protocol. MQTT client is open source libraries support for different platforms, like C, C++, Java, JavaScript, and Ruby. Android application do IoT service configuration and registration as MQTT device as explained in Reference [2]. The payload message is encoded in JSON format and published to IoT server in fixed interval of time. Figure-5 display the WICED sense data on IoT foundation server. Two event types of information display in server, Device Status and Message are published. Device Status interested on device is connected or disconnected with time information. Message status display the complete payload message sent by the WICED sense device. Devices tab has device type information, Last Synced details, Message reporting interval and owner of the module.

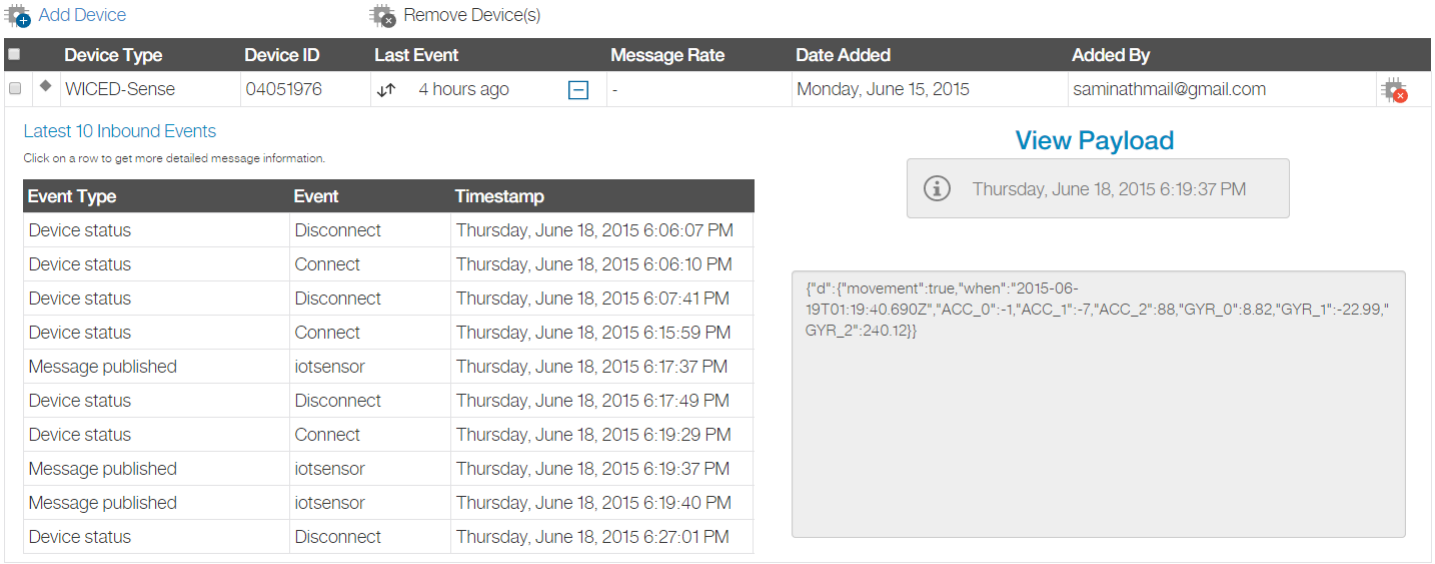

Figure-5: IoT Foundation server with WICED Data

VI. CONCLUSION

IoT lets RFID, BLE, Wi-Fi and other sensor networks empower computers to perceive the world for themselves. IoT captures real-time data and provides services remotely to targeted mobility devices with efficient and effective manner, dramatically reducing wasting of time and improving productivity. The Internet of Things promises to deliver a step change in individuals' quality of life and enterprises productivity. IoT touches every aspect of our lives, make easier our lives and decides how things will ACT. Explains the end-to-end system which enables your devices to connect to the IoT Foundation server. This experimental set-up explains the solution of MQTT open source library, Android Application development and internal of WICED sense development, simple and interesting way to build Internet of Things (IoT). Further development initiates supplementary action for each message data, send an SMS alert, write data to big database, or Display the movement of Sense data.

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AUTHORS

First Author – Saminath, M.E Drives and Embedded Controls, Accenture and s.x.veerapandian@accenture.com.
Second Author – Jung Su Jin, Master's degree in Electronics, jungsu.jin@accenture.com.