A Study of Various Hardware and Cloud Based Internet of Things Platforms

Ravi Payal and Amit Prakash Singh

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Ravi Payal , CDAC Noida, Research Scholar, USICT, IP University
Dr. Amit Prakash Singh, Professor, USICT, IP University

Abstract

This paper talk about various types of available Platforms related to Internet of things. For running various Internet of thing applications, there is a need of Hardware platforms and Software Platforms. Various types of Cloud based Internet of things (IoT) platforms are available. These IoT platforms are used for creating various types of research applications, scientific applications etc. Paper is divided into three main sections, first section discuss first about IoT , second section tells about various types of cloud based Internet of things (IoT) Platforms and third section talks about hardware platforms. Comparison between of Latest Cloud based IoT platforms is done.

Keyword

Internet of things, middleware, Raspberry pi, Arduino, IoT Platforms

1. INTRODUCTION: Internet of Things means that you can connect everything [1]. This can be achieved by using various controllers, sensors, embedded platforms, operating systems, cloud network etc. Internet of Things is a vision where each thing is connected to other thing via internet. It is a concept which is very popular now a days across all over the world. Here each object like living or non-living can be connected with each other via internet. Various types of applications are developed by using this concept. Researchers or Developers across all over the world are using this concept's for controlling, developing, monitoring etc for various applications. According to some big IT corporations and companies like Google, Amazon, Microsoft, IBM and some hardware platforms developers, there will be rapid growth and demand of IoT Products across all over the world in the coming years.
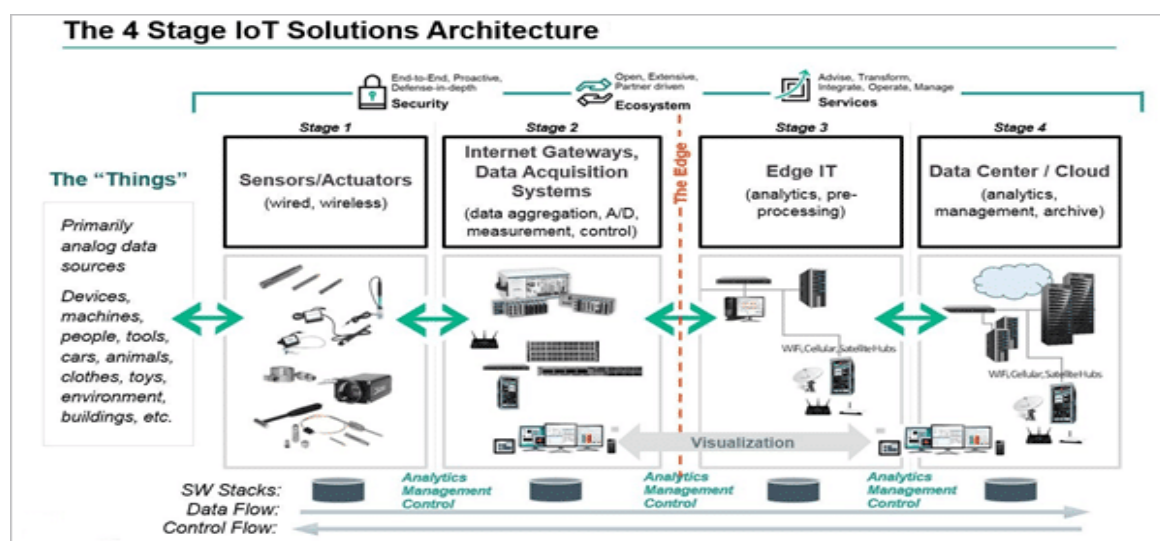
1.2 IoT Architecture

Figure 1. Stages of IoT Architecture (ref:https://www.softwaretestinghelp.com/best-iot-platforms/)

The diagram mentioned in Figure 1 shows the IoT Architecture. The IoT architecture consist of four stages. All the Stages have some defined work.

    a. **Stage 1**:- Stage 1 consist of Sensors/actuators. These are connected to the system through some wireless or wired medium. The main work is to collect the data for the environment and converted into useful form. The stage one sensors are connected directly to the real-world objects like device machines or people or tools or to some vehicle or environment etc. Sensors will collect the data mostly in analog form and these collected data converted to some other form.

    b. **Stage 2: -** Stage 2 consist of Internet Gateways, Data-Acquisition systems etc. Majorly On stage two the collected data is converted from analog form to digital forms. This stage consists of involvement of Analog to digital convertor, data aggregation's, router's etc.

    c. **Stage 3: -** Stage 3 consist of Edge IT System. Analysis of collected data occurred on this stage. Whatever the type of data is collected, various types of algorithms involved on this stage. Pre-processing of data takes place on this stage.

    d. **Stage 4: -** On stage four involvement of Cloud and Data centre comes in the picture. Here Data which requires more processing will be transferred to the cloud network or to data centre.

1.2 IoT Middleware

Middleware is a type of middle level agent between service provider and service consumer. It provides a large number of services to the applications from outside world and Applications will use only necessary set of service [13]. Middleware's acts as mediator between the different type of applications . IoT Middleware is a type of method which establishes the communication between different components of IoT System and provides the smooth flow of communication between all the devices available on the IoT System. IoT Middleware makes the life of IoT System easy and smooth.

2.Cloud Based Internet of things (IoT) Platforms

Currently various types of platforms are available for the implementation of applications in Market. All these platforms are available for implementing the tasks. Some of the popular platforms are discussed below. These platforms related to end to end connectivity, cloud storage, Data centre.

According to Kinsta[4] ,one of the cloud service provide" Worldwide spending on public cloud service and infrastructure is double over the next five year. It will be double from $229 billion run rate in 2019 to $500 billion by 2023" [4]. IoT cloud platform matters a lot for the application developers and researchers and developing a software for the IoT platform is a very challenging [5]. There are certain reasons and challenges for this.

1.**Correct Operating System**: - Most of the IoT devices have very small memory space and they are not so powerful. So choosing a right Operating system w.r.t application plays a very crucial role. This will help to achieve the desired functionality [5].

2. **Correct Gateway**: - Different IoT devices uses different IoT protocols in the implementations of applications [5]. These protocols differ according to the applications like WIFI, MQTT, CoAP, and Bluetooth. 6LowPAN, IPv4/IPv6 etc. So, we have to choose a correct gateway which will handle our application correctly.

3.**Security**: - Security is one of the major concern for IoT devices. Most of the IoT devices are not tested for penetration [5]. IoT Devices are complex in nature and they hold lot of Data [6]. Data protection is a major concern for the companies. Attackers get the access of One device on the network and after that they hack whole network. Security of IoT network is requires lot of modern technique's like PKI and digital certificates, API security, Network access control, multifactor authentication or biometrics , encryption technique's etc[7].

4. **Quality**: - Quality of software used in the application should be good. Testing and maintenance of software should be very hard and difficult [5]. Think about IoT devices in security system, a small mistake in planning of test conditions will cause a huge setback in the later stages. Choosing a right parameter on the Testing stage is very important.

5. **Cross-platform deployment**: -The application which should run on different platforms should be considered the acceptable applications. The various platforms uses various types of Operating system, protocols, architectures etc [5].

There are various type of IoT Platforms are available in the market. The Cloud based IoT platforms are mentioned below .

2.1 Microsoft Azure: -According to Microsoft, Internet of Things for your business starts with the things that are involved in your business and affect it the most [1].Globally, 90% of Fortune 500 companies are using Microsoft Azure to drive their business [8]. Enterprises across the globe now realizing the success of cloud for the business and azure plays a very global role on this. Azure supports the different type of programming languages, platforms, protocols, devises, databases, frameworks and tools [8]. User can deploy the applications using azure.
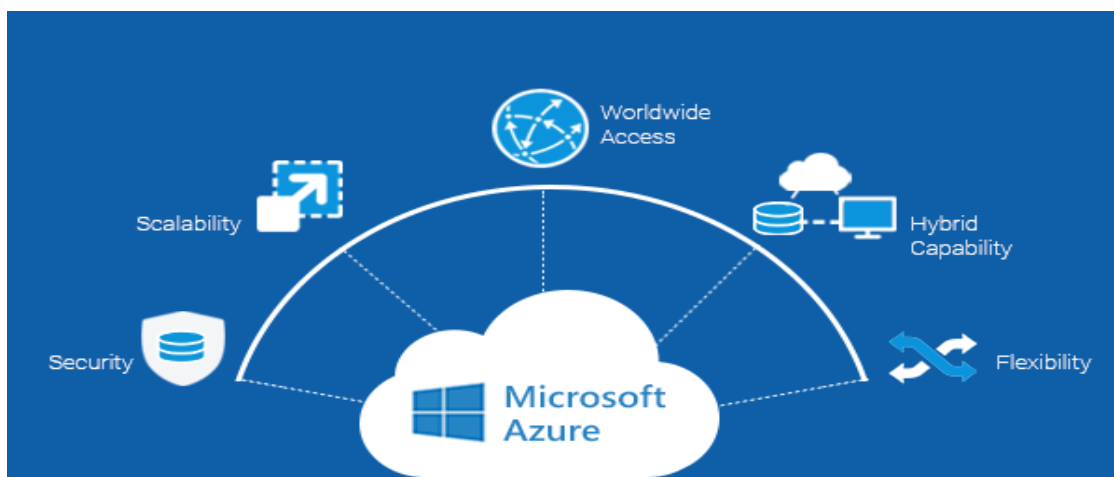

       Figure2. Microsoft Azure Platform

Microsoft azure intelligent system is a integrated platform and services that build a IoT systems and applications by gathering different data from integrated devices and processed the data. The core system consists of millions of devices and sensors. They will collect the data and run the applications. Power BI, office 365 and HD insight are the most powerful Microsoft assets.

Main Features of Azure

1.Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) capabilities
2. Secuirty offerings
3. Scalability and Ductility
4. Trusted support
5. Unmatched Hybrid Capabilities
6. Integrated capabilities
7. Analytics and Intelligence capability
8. Cost efficient platform
9. Interoperability
10. Easy Learning curve

2.2 Google Cloud Platform: This is another famous cloud platform used widely in the world. Platform provided by the google have four major services. They are Compute, Storage, Big data and Machine Learning. User can write the code, run, compile, test and deploy the applications. Majorly user will concentrate on the code and rest of the issues like infrastructure, computing power and storage will handle by GCP. GCP has a support of various available services of cloud like firebase, BigQuery, RiptideIO, Connecting Arduino and firebase etc [1].

Figure 3. Google Cloud Platform

Most of the components on this cloud are related to Google technologies and it supports few programming languages

Main Features of Google Cloud Platform

1. Cost effective
2. Highle Scalable
3. Customized to Machine type
4. Server less
5.Higher performance
6. Safe Cloud
7. Provide support if required

2.3Amazon Web Service or AWS: Amazon web service is the first company to launch its own cloud platform. Launched in 2004and slowly and slowly they added different applications on it. It is developed and owned by the Amazon only. It is a secure cloud platform which offers various services like storage, compute power, content delivery and many other functionality [9]. Basically AWS allows user to run web and application based servers in the cloud and to host them, stores all the data related to your application on the cloud and you can access it from anywhere, databases like MySQL, PostgreSQL, SQL are managed , through CDN (Content Delivery Network) it will delivery static and dynamic files anywhere , manage large emails.

Figure 4. **Amazon web serivces Platform**

Main Features of Amazon web services

1. Security
2. Data analytics and Storage
3. Pay-as you go model
4. Scalability
5. AR/VR tools
6. AI
7. Network and Content delivery

2.4Thingworx: Thingworx is another popular platform designed by PTC and most of the industries are used it currently. It provides easy connectivity between the devices [1]. It focuses on reducing the time, cost and risk between M2M and other IoT applications. It uses for the development of various applications related to smart building, smart cities, smart agriculture, smart grid etc. Thingworx 8 IoT platform is very popular compare to previous versions [10].
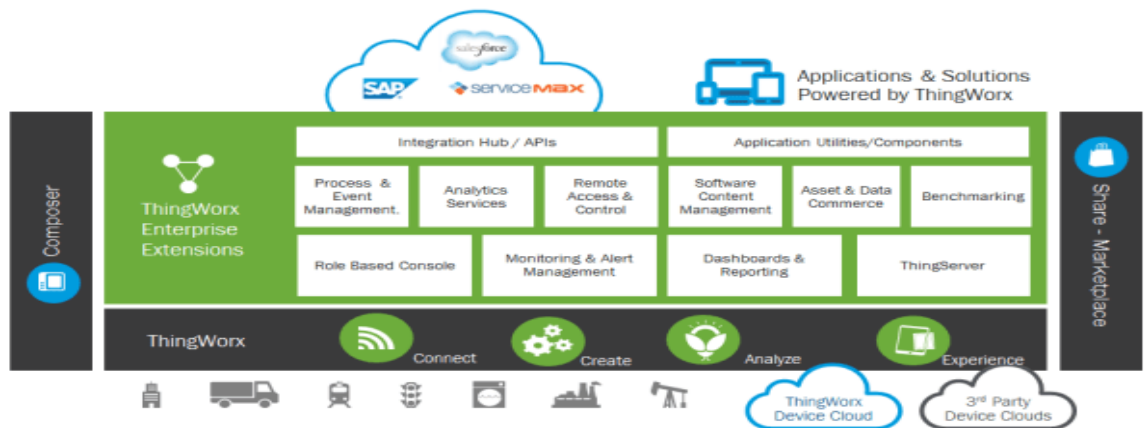
Figure 5. ThingWorx Platform

Thingworx IoT platform provides the millions of devices to connect together and it uses the protocol like MQTT, REST and sockets widely.

Main Features of Thingworx
1. Latest platform
2. Faster deployment time compare to other platform
3. Deployment feasibility
4. Flexible connectivity with devices
5. 3D storage engine
6. Search based intelligence

2.5 IBM Watson: This is a good platform for the IoT application development. The platform supports the programming languages like java, python, node js, php etc. IBM Watson backed by a IBM's the bluemix and hybrid cloud PAAS development platform. Due to its less complexity, this is good platform for the beginner level.

Figure 6.IBM Watson Platform

This platform can handle huge amount of data in real time and connections are also secure. The platform requires high maintenance cost, high switching cost and it takes time for integration. Main features of IBM Watson are

1. Device registration
2. Scalable connectivity
3. Powerful web dashboard
4. Secure communication
5. Storage of Data

2.6 Think Speak: ThinkSpeak is another IoT platform popular among the researchers and students. It is a Open source platform. This platform allows the user to collect the data from sensors and store data to cloud. This platform allows user to analyse data using MATLAB.
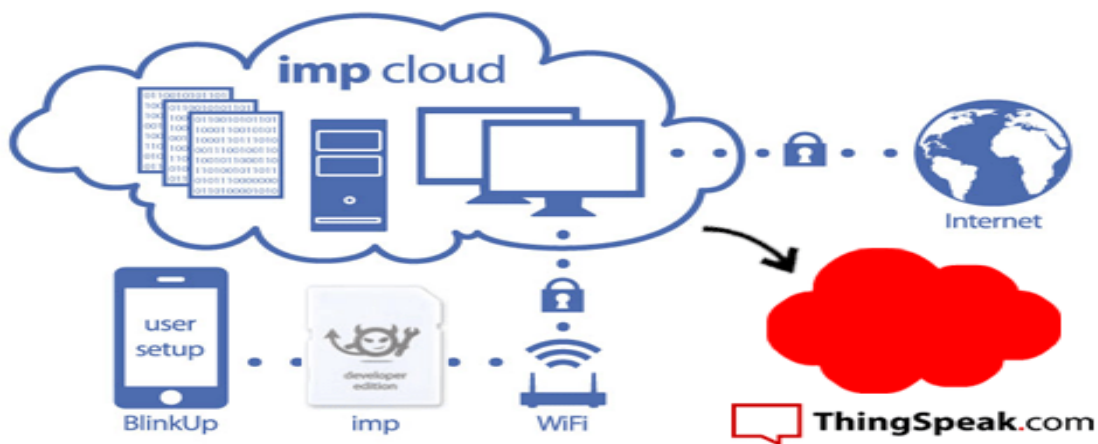

Figure7. ThingSpeak Platform

The use can use Arduino, Raspberry Pi, and Beaglebone controllers to send sensor data on ThingSpeaK. This platform supports the programming languages like python, Node JS, Ruby etc. This platform supports small data, so this platform doesn't support applications where huge amount of data involved for storage.

2.7 Oracle IoT Platform: Oracle IoT cloud service is a Platform as a Service (PaaS) type cloud-based platform. This Oracle IoT platform provides the real time data analysis and endpoint management [10]. The Developer get real time information directly on the connected devices.
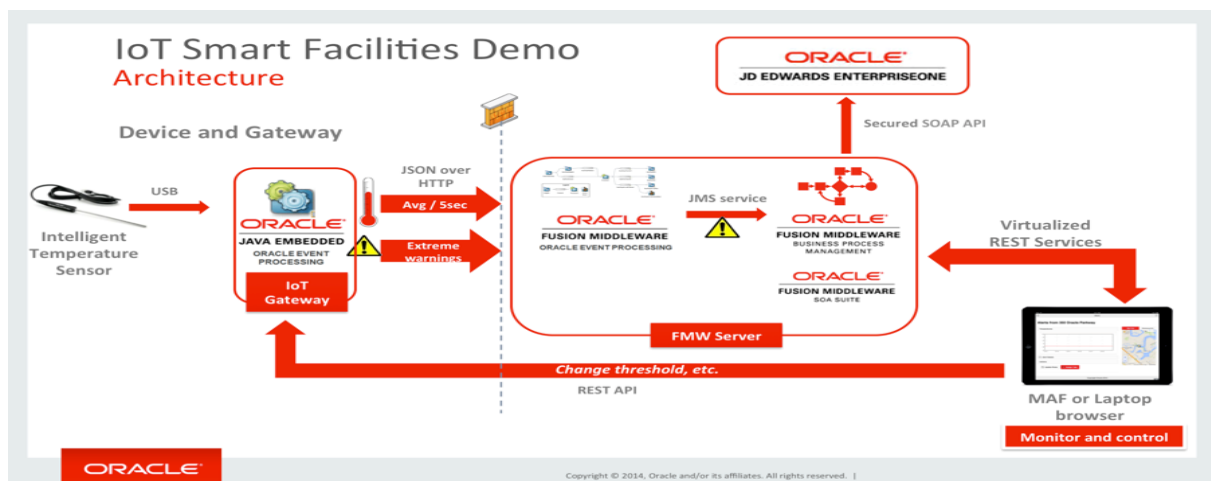
Figure 8. Oracle IoT Platform

The Main features of Oracle IoT Platform are
1. Secure and scalable
2. Real time Data
3. Integrated
4. Faster to Market
5. High Speed Messaging

2.8.GE Predix IoT Platform: Predix is a platform launched by a GE. This is the world first platform for the Industrial applications. This platform is designed for the factories and it provides very simple ecosystem.
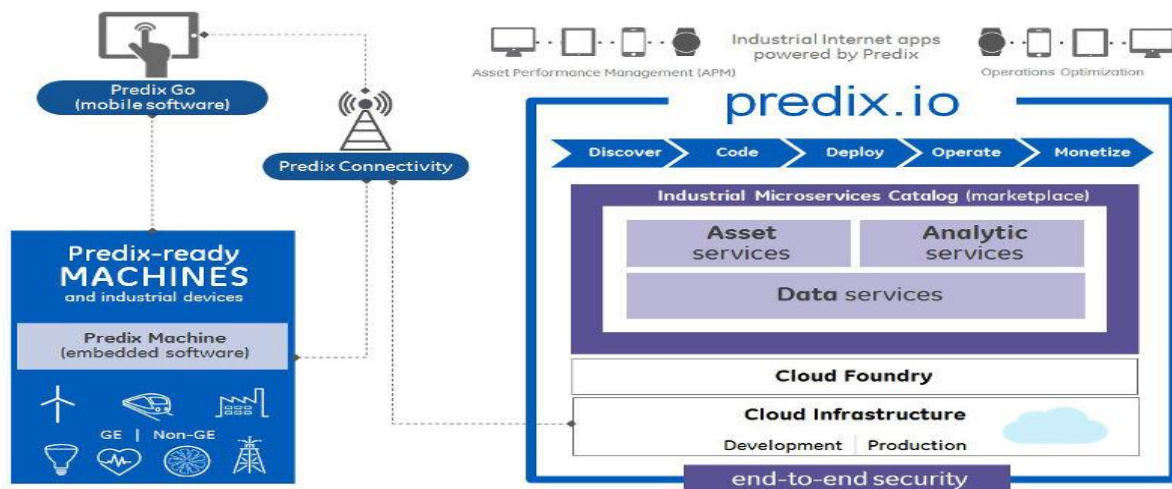

Figure 9. GE Predix Platform

The Main features of Predix IoT Platform are
1.It optimize assets and steps
2.Cuts unplanned downtime
3. Supports Industry applications
4.Real time data access

2.9 Salesforce: Sales force IoT cloud is powered by Thunder. This platform collects data from different devices, websites, applications and other sites. Collects real time data from any devices.
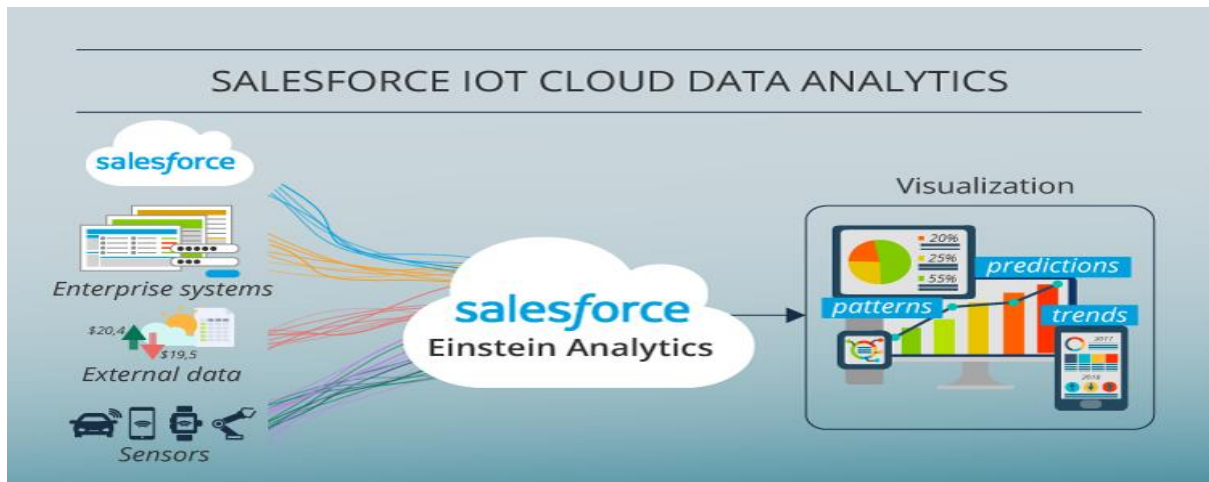
Figure 10. Salesforce Platform

The main features of Salesforce IoT Platform are
1.Real Time event processing
2. Technology optimization
3. We can test business data without programming
4. by using RESTFUL API, import data from anywhere.

2.10Kaa Iot Platform: Kaa is an open source and multipurpose IoT Platform. It facilitates data exchange among the attached devices, data analytics, visualization, and IoT cloud services [11].Kaa offers a large variety of IoT tools which are easy to use .Kaa SDK gets embedded into the targets device and then SDK collects data. SDK of Kaa requires 10KB RAM and 40KB ROM. NoSQL and MongoDB is used for the data storage in Kaa IoT Devices.

Figure 11. Kaa Platform

This platform is Not able to deploy the applications on the PaaS model
The Main feature of Kaa IoT Platform are

1.Low development time
2.Open source and free
3.easy and direct device implementation
4.Fast market time
5. Large number of devices and sensors are integrated at a time.
6. Simple to use

3. Hardware Platform

Like Software platforms, hardware platforms also play a very important role for developing IoT applications [2]. Various types of boards are available in the market and researchers /developers are using these available hardware boards for developing the applications. For developing various applications developers are integrating different types of sensors and using various types of features like Wi-Fi/Ethernet/I2C, IO pins etc [2]. There are some famous hardware boards used for developing applications

3.1 Beaglebone Black

The Beagle Board is a low-power, lowcost board, open **source and community-supported development platform** produced by Texas Instruments in the year 2008. It is based on ARM processor. The board consist of all basic networking tools. Board consist of Ethernet connection Developer can use Services like FTP, Telnet, and SSH. Board can access remotely and coding can be updated. ON the Beagle board we can write our code in C, C++, Python, Perl, Ruby, Java or in any shell scripting language. This board support the Linux. Board Boot Linux in 10-12 seconds and get started on development in less than 5 minutes with just a single USB cable.
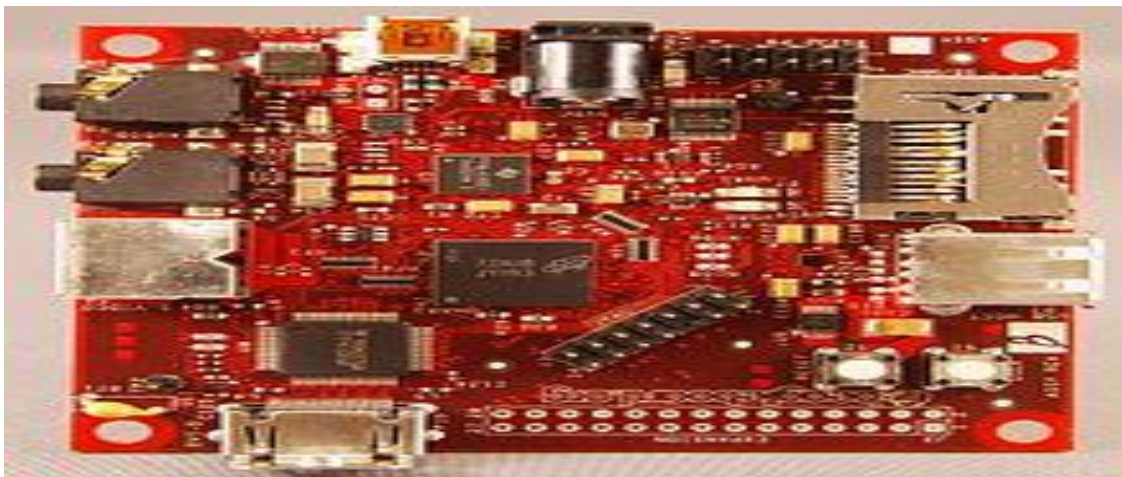

Figure 12. BeagleBoard

3.**2 Raspberry pi Board**: Raspberry pi is used widely in the education and industry. This Hardware platform is used in the various applications related to Embedded and IoT. From last three to four years it is widely used all over the world. The cumulative sales of Raspberry pi reached to 19 million In March 2018 and it became one of the best-selling general-purpose computers worldwide.

Currently all over the world more than 20 million users are using the raspberry pi board for the learning, research applications and projects. From last few years researchers are also using this board for IoT and Machine learning applications. There are three generations of Raspberry Pi board: Pi1,Pi2 and Pi3. ON these generations There are two types of boards. Model-A and Model-B. Normally. Model-A is cheap variant and it have reduced RAM and ports.
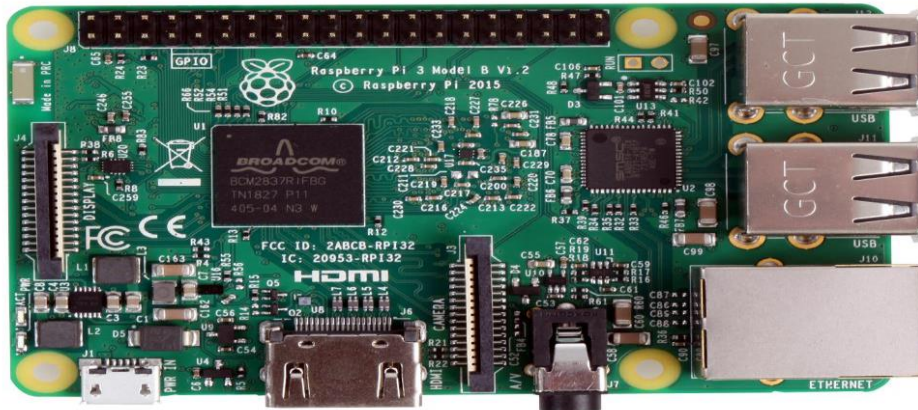

Figure13.Raspberry Board

3.3Arduino Board:Arduino is another board used for hardware applications related to Embedded and IoT. This board is also used for education and research. Although both Raspberry pi and Arduino are used for the practical applications purpose. There are certain differences between both the boards. This board have the capability to connect by ethernet and WIFI. Board is based on ATmega2560 AVR microcontroller. It has 70 digital input/output pins (of which 14 can be used as PWM outputs and 16 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button

3.4 ESP8266: The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and 32-bitmicrocontroller. It was manufactured by Espressif Systems in the year 2014. It has 16 GPIO pins. The GPIO pins allows SPI, I2C, PWM, A/D convertor etc. Board is popular for making IoT Project. This board is available from different vendors but these boards will vary in terms of pins, flash memory,data and built on chip antenna. Some of the Most common variants are ESP-01, ESP-03, Olimex ESP8266 Eval Board.

Figure14. ESP8266

4.0 Comparison of Boards

From the Above discussion it is very much clear that Raspberry pi and Arduino Board are two most popular boards among researchers. There is certain comparison between above discussed boards.

Parameters	Beaglebone Black	Raspberry Pi Model B	Arduino Mega 2560	ESP8266 (ESP-12E NodeMCU)
SOC	Sitara AM3358	Broadcom BCM2837B0	ATmega2560	Xtensa Single-core 32-bit L106
Frequency	1 GHz	1.4 GHz	16 MHz	80MHz
Processor	ARMv7-A Cortex-A8 64-bit Processor	ARMv8-A Cortex-A57 64-bit processor	AVR 8-bit	Tensilica Xtensa 32-bit
Flash	Off-chip	4GB on-board(Off-chip)	256KB (on-chip)	64KB (on-chip)
RAM	512MB	2GB	8KB	32KB
MicroSD Slot	Yes	Yes	No	No
Wi-Fi	Yes	Yes	No	Yes
HDMI	Yes	Yes	No	No
USB Ports	Yes	Yes	No	No
Bluetooth	Bluetooth 4.1, BLE	Bluetooth 4.1, BLE	No	No

Table1. Comparison table between Different Hardware boards

Conclusion

From the content of this paper it can be concluded that for developing IoT Application's or for IoT research both Hardware and software platforms plays a very important role. Although all the cloud-based platforms play a good role and have its own advantages but Microsoft Azure, Google cloud platform and Amazon web service are the three most popular cloud based IoT Platforms all over the world. Thing Worx is also very popular for education-based projects. Talk about Hardware based platforms for the IoT solutions. Comparison table 1 between all the fours hardware boards is defined. The Raspberry pi and Arduino Board are the two most popular boards for developing the applications. Although both the hardware boards are useful for the different applications. It all depends on the type of applications you want to run. If application is such type where we are repeating same task again and again then on that case Arduino is used but applications which involve multiple tasks together prefer Raspberry Pi. Arduino is used for performing simple applications where as Raspberry pi is used for Complex applications

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