Introduction to IoT and Its Industrial Applications (CS698T)
Indian Institute of Technology Kanpur
Assignment 1

QUESTION 1

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Comparative Study of IOT Boards

Parameters	Particle IO [1] (ARGON)	Espressif ESP8266 [1, 3]	Beaglebone Black [2, 4]	Arduino UNO [1, 3]	Raspberry Pi B+ [1, 3]	Discovery STMP-32MP157C [5, 7]
Processor	ARM Cortex-M4F 32-bit processor @ 64MHz	32-bit RISC	ARMv7-A Cortex-A8 64-bit Processor	ATMega 328P	Quad-core ARM Cortex A53	ARM® Cortex®-A7, Cortex®-M4
Operating Voltage	3.6VDC to 5.5VDC	3.0 to 3.6V	3.7V	5V	5V	5V/3A
Clock Speed	120MHz	26-52MHz	8MHz	16 MHz	1.2GHz	533 MHz
RAM	256KB	¡45kB	512MB	24KB	1GB	4-Gbit DDR3L
Flash Memory (Storage)	4MB	512KB-128MB	Off-chip	196KB	8GB-32GB	NA
Cost in Dollars	27	6	83.48	22.95	35	148.23
Communication Supported	IEEE 802.11 b/g/n support	IEEE 802.11 b/g/n	Bluetooth 4.1, BLE + IEEE 802.11 b/g/n + Ethernet	IEEE 802.11 b/g/n + IEEE 802.15.4 433RF + BLE 4.0 via Shield	IEEE 802.11 b/g/n + IEEE 802.15.4 433RF + BLE 4.0 Ethernet Serial	Wi-Fi® 802.11-b/g/n + Bluetooth® Low Energy 4.1

I/O Connectivity	20 mixed signal GPIO (6xAnalog, 8 x PWM) UART, 12C, SPI	SDIO 2.0, (H) SPI, UART, 12C, 12S, IRDA, PWM	2x46 GPIO pin headers	SPI I2C UART GPIO SERIAL PWM	SPI DSI UART SDIOCSI GPIO	Ethernet RJ454 × USB Host Type-AUSB Type-CTM DRPMIPI DSISM-HDMI® Stereo headset jack including analog microphone inputmicroSDTM card
Operating System	Device OS	Mongoose OS	Linux	Not Supported	Raspbian, OSMC, OpenELEC, Windows IoT Core, RISC	NA
Limitations	Incompatible with other popular operating systems like Linux	It is not capable of logic shifting 5V to 3V and requires an external logic level converter [9]	Only potential limitation here is its high cost	Doesn't support any OS	-	No proper community support like Particle IO or Raspberry Pi

Summary We've mentioned a few development boards here, but there are plenty of more possibilities that will best suit your product development needs. IoT development has a very bright future. It contributes to the solution of everyday difficulties by developing a variety of goods. It is evident from the above table that a Raspberry Pi is a clear winner in most of the situations. However, other boards offer a strong competition in different areas as specified below:

Raspberry Pi versus Arduino [2, 6] These two are the most popular boards among the researchers. The detailed analysis show that higher end development boards such as Raspberry Pi-4 B+ have higher performance in comparison with other boards like Arduino in terms of its storage and computing speeds but at the cost of higher price. The places where we need to perform a task repeatedly, we can use Arduino where we use Raspberry Pi where we need to perform multiple tasks together. Also Arduino is used for simple tasks as compared to Pi which is used for highly complex work. Pi in general can be thought of as a mini computer in itself. The key distinction between the two is that Arduino tends to have a strong I/O capability which drives external hardware directly. Whereas Raspberry Pi has a weak I/O which requires transistors to drive the hardware.

Espressif ESP8266 [3] The ESP8266 has exceptionally basic equipment foundational layout and is most superb utilized in customer applications, for example, information logging and control of actuators from online worker applications. Being a low cost device, it is a first choice for implementing sensor networks in an IoT scenario. However, due to limited storage and computing capabilities, and inability to support popular OS like Linux, it is used in a fewer areas as compared to other boards.

Particle IO - Argon [1] The Particle Argon is a significant IoT prototyping stage thinking about eliminated programming, straightforward code migration, and speedy progression of ventures. However, just like ESP8266, inability to support any other operating system is still a matter of concern here.

Beaglebone Black [8] It is apparent that Beaglebone is simply more versatile and compatible with makers and developers' use. It is pretty well documented which allows users to have enough support and tutorials for projects and learning. One of the major drawbacks is, it is costlier than Pi, which a offers somewhat more features and is more commonly used. If you're looking for affordable, casual use and versatility, Raspberry Pi would be more suitable for you. But if you're more into IoT applications and stability for industrial usage, this is the one.

Discovery STMP32MP157C [5, 7] These highly secure boards are specifically designed to accelerate 3D graphics in applications such as graphical user interfaces (GUI), menu displays or animations.There is a dedicated 3D graphics processing unit (GPU) and MIPI-DSI display interface and a CAN FD interface. The only drawback is its 148 whopping dollars price, which might not be justified over a much cheaper Raspberry Pi available in the market.

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QUESTION 2

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Simulators: Simulators are devices or systems which enables the experimenter to reproduce the similar conditions which Iot devices will experience in real life but without any fatal risk or uncertain danger from the actual Iot device.

Following are a few popular simulators that are widely used for simulation of IoT devices and applications:

Simulator	**CupCarbon**	**IoTIFY**	**TOSSIM**	**BEVY-WISE**	**Mob-IoTSim**
Scope	Network	Hardware Connection	Tiny OS	IoT Device	IoT Networks
Type	Agent-based discreteevent	Mobile App	Sensor Observation Service	Broker	Research Based
Programming Language	Java Custom scripting	Java Python	C Python	Python Java	C++ C Sharp
Architecture Layers	Perceptual Network	Application Network	Communication Network	Network	Application Network
Scale of Operation	Small scale	Large Scale	Small Scale	Large scale	Large scale
Built-In Standards	802.15.4 LoRaWAN	Real time	Injecting Packets	Real Time	Devices Profile for Web Services (DPWS)
API Integration	UDX	Rest	Real Time	Real Time	REST
Cyber Resilience Simulation	NO	YES	Yes	No	No
Service Domain	Smart City	Smart City	Generic	Smart City	Generic
Security measures	High	High	High	Medium	Medium

Table 2: Comparison Table for few Popular IoT simulators [2]

Summary

1 **CupCarbon Simulator** [1]
CupCarbon is a multi-agent and discrete event wireless sensor network simulator which is based on geolocation.It helps to simulate and models the actual working of wireless sensors network in real life on graphical interface of *OpenstreetMap*. CupCarbon is composed of three main components: a multi-agent simulation environment, mobile simulation, and the WSN simulator (WiSen).
It also supports Physical layer Protocols such as Zigbee,WiFi and LoRaWAN.

2 **IoTIFY** [2, 6]
IoTIFY is a test system that uses device virtualisation and intelligent device simulator.It lets you quickly create virtual devices on cloud. It can create traffic from a large number of virtual endpoints and test your foundation for scale, security and quality so as to recognise and fix issues before actual implementation. Protocols supported are MQTT, HTTP, CoAP, LWM2M , UDP and TCP.It use in-memory databases, focus on read and write latencies, use messaging protocols such as NATS to speed things up, and heavily use replication and load balancing.

3 **TOSSIM** [5]

TOSSIM is a smart wireless sensor network simulator and is used to simulate TinyOS (action based OS) smart devices.Good thing about Tossim is its versatility and support for large number of sensors and system configuration. Some benefits of this simulator are precise nodes evaluation, simpler architecture and captures hidden terminal problems. It captures TinyOS behavior at a low level. It simulates the network at a bit level and interrupts every system.

4 **BEVYWISE-IOT** [4]
Bevywise allows you to simulate a huge number of IoT devices based on MQTT protocol in a matter of moments with its impressive GUI. It can send real time dynamic messages within a range or from a random set or values based on time and client in two different formats text and JSON.It can can store simulation information in FLAT records or MySQL and SQLite databases. It has Behaviour response engine which will respond to the subscriber based on the received messages topics. When the simulation request is received, the virtual connected devices start publishing the data to the endpoint. REST API provides methods to update and query device data in the DB.

5 **MobIoTSim** [3]
MobIoTSim is a mobile-based simulator for IoT devices.It helps researchers and cloud application developers to learn IoT device handling without buying real sensors, and to test and demonstrate IoT applications utilizing multiple devices.It can substitute real devices by mimicking their behaviour by using IoT protocols such as MQTT,HTTP,etc and uses different formats like JSON,etc. Advantages of this mobile approach are that mobile devices can act as micro-gateways to capture IoT data from sensors representing a semi-simulated environment, and outdoor IoT deployments can also be designed and evaluated in a more realistic way (e.g. using wireless mobile data communication instead of WiFi).

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Following are the applications of various boards as discussed in the first question:

1 Arduino UNO [5]

1.1 Arduino Satellite (ArduSat)

ArduSat is an open source satellite completely based on Arduino to create a stage for space discoveries. Built by Spire previously known as NanoSatisfi, ArduSat collects various types of information's from the space environment, with the help of numerous sensors that includes temperature sensors, pressure sensors, cameras, GPS, spectrometer, and magnetometer etc with its programmable Arduino processors. This platform also allows common public to experiment their projects in space. ArduSat can be used for photography from space, making a spectrograph of the sun, detecting high energy radiation, compiling temperature readings and observing meteors etc. .

1.2 ArduPilot (ArduPilotMega - APM)

ArduPilot is an unmanned aerial vehicle (UAV) based on the open source platform and built using Aruino Mega which is able to control independent multicopters, fixed-wing aircraft, traditional helicopters and ground rovers. It was created by the DIY Drones community in 2007 and was also an award winning platform of 2012.

2 ParticleIO (ARGON) [6]

2.1 Reduction in traffic noise

This board can be easily used to collect data using sensors which will then be transferred over Particle cloud, and could be accessed easily from anywhere. One of the main issues with such an application could be a source for a power supply, as the setup needs to be deployed somewhere. The Argon takes care of this for you with its included charging circuitry, which makes it easier to connect a Li-Po battery.

3 Espressif ESP8266[7]

3.1 Implementation of Esp8266 in Home automation:

Due to its compact size, wide availability, and low cost, this can be easily used in building simple to complex home automation projects. Its WiFi module is widely used in several autonomous

as well as non-autonomous systems.

3.2 Wearabale device

The ESP8266 board used was NodeMCU 1.0 (ESP-12E Module) with CPU Frequency: 80MHz and Flash Size: 4M (3M SPIFFS). the development of prototype that enables monitoring of heart rate and inter beat interval for several subjects

4 Beaglebone Black[8]

4.1 Efficient and self-controlled surveillance drone

Due to its networking capabilities(it is capable for providing all sorts of networking services like FTP, TELNET, SSH an), remote control, multitasking capabilities(uses Linux), time management(has NTP) and growing worldwide support, this board is an ideal choice for building such a drone.

5 Raspberry Pi[1]

5.1 Contactless Thermal Scanning

Amidst CoVid-19, It has become necessary for public shops to install thermal scanner but popular Handheld scanners poses health risk on the shops staff. with Raspberry Pi quadcore processor and network capabilities, contactless thermal scanners can be built for different areas i.e Airports, hospitals, stations, etc. for independent temperature scanning.

5.2 Agriculture sector

Agriculture and animal farming are one of the largest contributing sectors to the global economy, yet highly undermined for technological revolutions. With affordable technologies like IoT and Raspberry Pi, farmers are now achieving better yields, maintaining assets, and making better farming decisions.

6 Discovery STMP32MP157C[2]

6.1 Asset Tracking[3]

Industries of nearly every kind benefit from asset tracking not only because it prevents theft, loss, and damage, but because assets comprise such a large percentage of a company's holdings that asset management is essential for meeting compliance and industry standard regulations. Asset tracking that delivers real-time data contributes to a healthy bottom line, and IoT devices and systems make asset tracking more accurate and reliable than ever before.

6.2 Packaging industry[4]

In the logistics sector, it's fatal when a machine runs out of labels. To prevent this situation, service technicians or operators need to be notified well in advance before this happens. The sensor's data counter triggers an alarm on their smartwatch or other wearables, allowing the operator to take immediate action to prevent stagnation. In some industries, an alarm notification can be life saving.

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