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

QUESTION

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1 Comparative Study of IoT Development Boards

Features	Raspberry pi 4	Arduino Nano 33 IoT	Adrafruit feather 32u4 Bluefruit LE	ESP8266	Argon Particle	Banana Pi
Hardware	Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC	SAMD21 Cortex®-M0+ 32bit low power ARM MCU	ATmega32u	L106 32-bit RISC microprocessor core based	ARM Cortex M4F 32bit processor	ARM Cortex-A7 Dual-core (ARMv7-A) 1 GHz
Onboard Storage	NIL	256KB	32KB	512KB to 128MB	4MB	SD card and SATA 2.0
Power consumption	5.1V	3.3V	3.3V	3.6V	5.5V	5V
Operating systems	Raspbian, Ubuntu Core, non-Linux based Risc OS,Linutop	Windows, Macintosh OSX, and Linux operating	Mac OS X and Windows	Mongoose OS		Linux, Berryboot, FreeBSD
Communication protocol	I2C, SPI, CAN, Microwire, 1-Wire, and USB	I2C (TWI) and SPI communication, UART TTL (5V) serial communication	MQTT	CoAP, Mqtt and http	IEEE 802.11 b/g/n	I2C, SPI, CAN, Microwire, 1-Wire, and USB

GPIO pins	standard 40 pin GPIO header	14 digital I/O pins and 8 analog input pins	20 GPIO pins with 7 PWM pins and 10 Analog pins	17 GPIO pins	20 mixed signal GPIO (6 x Analog, 8 x PWM), UART, I2C, SPI	UART, I2C BUS, SPI BUS, WITH TWO CHIP SELECTS, CAN bus, ADC, PWM, +3.3V, +5V, GND
Cost	Rs 3000-5200	Under Rs2000	Around Rs 2200	Rs 445.05	Around Rs 2000	Rs 6000-10000
Supported Sensors	Motion Sensors, Navigation Modules, Bluetooth, Motors, Analogue Sensors, Current Supply, Displays	Gesture, light, proximity	Accel, Gyro, and Magnetometers, Barometric Pressure, Biometric, Cameras	temperature and humidity sensor, Pressure Sensors on Railway Tracks, Geolocation, Wireless Web Server, Air Pollution Meter	Analogue Sensors, Current Supply, Displays	Motion Sensors, Navigation Modules, Wireless, Infrared, Bluetooth
Limitations	Doesn't have internal Storage and Not able to run Windows Operating system	Lack of native connectivity		Doesn't have bluetooth connectivity		Absence of community

Table 1: Comparison of Selected IOT Boards

Summary

The IOT Boards are very useful in connecting different devices with each other. We have tried to compare these 6 different IOT boards in this paper on the basis of their cost, hardware, internal storage etc. We have tried to figure out which boards to use under different conditions

and which boards to avoid.

The Raspberry pi comes out to be a good IOT board as it has high RAM and an excellent processor. It should be considered over Banana pi as in Banana pi , there's absence of community which is a big drawback due to which it doesn't have community support for prototyping tools. Although, Banana pi has a better processor over Raspberry pi. Some problems with Raspberry pi is that it doesn't have its internal storage and also windows OS compatibility is still an issue. However, some versions of windows 10 may be operable in Raspberry pi 4. The Raspberry can be used as a full fledged desktop as it can connect to both LAN and Wi-Fi.

Now comes Arduino, which offers a wide range for open-source development kits, softwares and controls for building connected products. Arduino is very popular IOT board which is a big advantage over other boards. It has a large community support. The Arduino 101 is developed with Intel. It is greater retrieving sensor information and controlling actuators.

The simplest board to use in these boards is ESP8266 which is low cost Wi-Fi microchip. As more and more people tried using ESP8266, they explored the drawbacks of the chip and tried to improve it. For example, to develop ESP8266, people had to understand FreeRTOS and coded with the professional C language. But an Arduino IDE plug-in was then developed so that developers can use Arduino IDE to write ESP8266 command code to diminish the difficulty of development. It is clear that community support is a big advantage for any IOT device.

With High Network Reliability, Low Power Consumption, Low-Cost Hardware, Particle Argon Comes in the play. It is a great development kit with Wi-Fi and Bluetooth radios for connecting devices to make good connected products. Adafruit Feather 32u4 Bluefruit can be classified as 'all-in-one' Arduino-compatible plus Bluetooth Low Energy with built in USB and battery charging. We can say that Adafruit Feather 32u4 Bluefruit LE can be used while trying to make a gadget connect with a cell phone.

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2 Study on Popular IoT Simulators

IoT simulators allow us to design, create and test IoT apps and devices without actually using real IoT boards.Dinita (April 28, 2021)

IOTIFY

IoTify is a magnificent IoT simulator that helps you to create IoT frameworks in the cloud. It also facilitates you to set up your own virtual IoT lab. You can create traffic from large numbers of virtual endpoints that help to test systems, security, and quality of performance before the actual implementation of the IoT System. It can build up your system in JavaScript and a continuous beam of data is transferred through MQTT, HTTP, or CoAP. Manivannan and Radhakrishnan (November 2020)

BEVYWISE

Bevywise IoT Simulator is uncertain and easy to use. A client can interact with thousands of IoT gadgets using an amazing User Interface. It MQTT (virtual client) application in fog computing environment for users and function testing on the cloud. It can store all the simulation data in Flat records or My-SQL or SQL databases. Usually, it is used in large scale applications like smart city. Patel et al. (2019)

ANSYS

Ansys IoT simulation tools can helps you in creating and testing the IoT gadgets. Ansys is highly recommended for large scale applications in IoT industry. This IoT simulator mainly used in the assortment of fields, including wearable and clinical gadgets, drones, associated vehicles and mechanical hardware.Manivannan and Radhakrishnan (November 2020)

OMNET++

OMNeT++ is a non-profitable and C++ based simulator model. It can be used for free for educational or academic purposes. This instrument can transfer simulation information using SOAP API. OMNeT++ is fundamentally used for network applications of IoT. It supports 802.11, CSMA, TDMA, Hybrid protocol for MAC and routing.Patel et al. (2019)

COOJA

The Cooja is Java based simulator primarily developed for Contiki OS. It allows the developer to test their implementation long before deploying it to the target hardware. It supports all the protocols and APIs that can be used in Contiki OS. It is mainly used for general applications that focus on low power sensors. It is also able to emulate the execution of the exact

same firmware that may be uploaded to physical nodes, instead of simulating it..Dias et al. (2018)Chernyshev et al. (JUNE 2018)

NS-3

It belongs to the family of NS series simulators and the discreteevent simulator model. It used Rest API for exchanging simulation information. Most of the network protocols like FTP, TCP, UDP are supported by this. This is free software and publicly available for use. Users can create the application in C++ and Python and test it before final implementation.Patel et al. (2019)

Table of comparison of above IoT Simulators.

Features	IOTIFY	BEVYWISE	ANSYS	OMNET++	COOJA	NS-3
Scope	Hardware Connection	IoT Devise	IoT Industry	Network	Network	Network
IoT Architectural layer	Application Network	Network	network	Perceptual Network	Perceptual Network	Perceptual Network
License	GPL	Open	GPL	Academic	BSD	Open
Platform Support	Universal	Universal	Universal	Tiny-OS	Contiki OS	Universal
Type	Mobile App	Broker	Autonomous	Discrete event	Discrete event	Discrete event
Programming Language	Java, JavaScript	C, Python and Java	Fortran, C and C++	C, C++	Java	C++, Python
Scalability	Yes	Yes	Yes	Yes	Yes	Yes
Protocol optimization	Possible	Possible	Possible	Possible	Possible	Possible
Build in Iot Standards	Real Time	Real Time	Real Time	Manual Extension	All protocols supported by Contiki OS	802.15.4 LoRaWAN
Mobile Network Support	Yes	Yes	Yes	Yes	Yes	Yes
Dynamic Network Support	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic
API Integration	REST	REST	REST	SOAP	API supported by Contiki OS	REST
Service Domain	Smart City	Smart City	Industry	Generic	Generic with focus on low power sensors	Generic

MAC, Routing Support and Standards	MQTT, HTTP, CoAP	MQTT	GIGE, MPI, TCP	802.11, CSMA, TDMA, Hybrid	IPv4, IPv6, 802.15.4	802.11, LTE, DCF, LRWPAN WiFi
Network Support	Custom Development	Multicast Network	Multicast Network	Multipath ring, Simple Tree routing, Bypass routing	Multicast Network	6Low, WPAN, DSR, OLSR
Security Measures	High	Medium	High	Medium	Medium	High
Cyber Resilience Simulation	Yes	No	Yes	Custom Extension	Custom Extension	No
Scale of Operation	Large Scale	Large Scale	Large Scale	Large Scale	Small Scale	Large Scale

Table 2: Comparison of Selected IOT Simulators

Comparison Summary

We have compared six simulators, namely Iotify, Bevywise, Ansys, OMNeT++, Cooja, and NS-3 based on parameters listed in table number 2. Every IoT simulator has some merits and demerits which makes them suitable for one application and not suitable for other applications.

IoTify
Pros: It is one of the best simulators present in the market. It has the ability to maintain a calculated distance from risk and death trolls. It is a more practical simulator than any other. Speed of simulation can be increased so conduct can be concentrated efficiently over a long period. You can control simulation through Web/API.It supports most popular protocols such as MQTT/HTTP/CoAP/AMQP/LWM2M by default.It can also help you to visualise through API.
Cons: It can be Costly to dig how one object is connected with other. To recreate anything, deep knowledge is required.

Bevywise
Pros: It is an genius simulator that has the ability to control thousand of MQTT client in a single box. It is known for the key factor of Industrial Automation. It has better predictive examination, Asset tracking system, Better Product Quality. It is highly used in Home security, Industrial automation and Power plant monitoring.
Cons: It requires more memory and sometime it takes more time for analysis than usual.

Ansys
Pros: It is famous for its 3D electromagnetic simulation programming for planing and recreating. Simulation is done with high speed. It supports RF and computerized gadgets.It also has easy to use graphical interface. It also support proactive error and workaround notification.
Cons: Cost of production is high. Now FEA programming has lower client base, so it requires

additional cost from the client base.

OMNeT++
Pros:It has better graphical user interface and it can be used free of cost for learning/ teaching purpose. It offers an Eclipse based IDE, a graphical runtime environment ans host of other useful tools.
Cons: Number of convection used by this simulation is less and it has some compatibility issues.

Cooja
Pros: It permits a client to interact with hubs from a few diverse deliberation levels. It empowers synchronous reproductions at the system and working framework.
Cons: It requires high memory and high configuration. Simulation level and loss rate are also high.

NS-3
Pros: It shows various scope of sensors performance of convection.it is free and open source and it is very suitable for networking research. It also support IP and non IP based protocols. It also has functionality of real time scheduling for interacting with real system.
Cons: This model does not support IPv6.

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3 Application Survey

With IOT devices, We can make infinite projects, such as smart home, or smart thermostat. The main issue when building project is which IOT board to use. In the last several years, many new IOT developmental boards have come in play which left us wondering how to utilise in the most efficient way. Below we have listed some IOT boards.

3.1 Raspberry pi 4

The Raspberry Pi 4 is a very useful IOT board due to the number of programming languages using which it can connect to the internet is Amazing. Some most used programming languages like Python, Java, and JavaScript are compatible with the RPi 4. It can be further used as standalone server for smart home automation. The GPIO pins of Raspberry pi 4 allows different sensors to be attached directly, which makes it very efficient in system deployment.

Raspberry pi 4 in Home Automation

Raspberry pi 4 can be considered over other IOT boards as it can be used as standalone server for smart home automation. The main advantage of Raspberry pi 4 is that it is easier to implement. Raspberry pi provides Hass.io which is a smart home OS that manages everything from the installation of home assistant to managing the Home Assistant user interface.. Has.io provides a loads of add-ons from encrypting Alexa and google assistant. Other than that, By using Mycroft Open-source assistant, we can make our own Raspberry Pi-based smart voice assistant. All we need is just Raspberry pi, speaker, audio mic, and Mycroft running on Raspberry pi.
So , raspberry pi seems most appropriate choice for Smart Home automation.

3.2 Arduino Nano

When it comes about Portability, Arduino boards comes in play. Arduino boards are generally used to make electronic projects. While writing code for an embedded IOT device, programs written in the Arduino IDE will be compatible with many ESP and Arduino WiFi boards, whereas in other boards, it may be tough to port.

Wifi based Low-cost Monitoring of ECG and Temperature Parameters using Arduino

In remote areas and in any kind of natural disasters, the providence of medical aid during emergency is a very challenging task. It is very hard to provide costly medical equipments to

diagnose the patients. Here comes Arduino Nano, which can provide us a low-cost system which could be life saving in these kind of disastrous situations.
In this Case, we can collect information from a temperature sensor ,or a pulse rate sensor which can be further used to obtain the ECG of a patient and information about temperature of the patient. The information can be sent through WiFi to the server. The best thing about this board is that it is very cheap and easy to design. As in this kind of situation, we need information from many sensors, so, Arduino could play a lifesaving role in remote areas and critical situations.

3.3 Banana Pi

The Banana Pi comes with a very compact design and can be classified as mini computer. Through a single circuit board which is of size of a soap, we can get all important components of a full fledged desktop. It also provides basic interfaces like USB port which ensures that this board can be connected to additional devices like monitors, memory, cards, SSD's, HDD's etc.

Cloud server

We can use Banana pi as a cloud server if we want to store files centrally and want to access those files from different devices. For having privacy protection, we can remain independent from major cloud computing devices providers like drive, Microsoft onedrive and iCloud, for that having our own cloud server is a big plus point. For this purpose, we need a special software. By using Banana pi, there are ample amount of applications like ownCloud and Next-cloud. So, Banana Pi could be a great choice in this case.

3.4 Argon particle

The Argon is a very strong Wi-Fi enabled board that may work as a standalone Wi-Fi endpoint. It is based on the Nordic nRF52840. It has blessed with built-in battery charging circuitry which makes very simple to connect a Li-Po and deploy your local network in very short time. The Argon is a good board for connecting projects or as a gateway to connect an entire group of local endpoints.

PARTICLE - AIR QUALITY MONITORING KIT

Air quality monitoring is a very common IOT boards application. We can check dust levels in a workspace or industrial area or building, or we can measure overall air quality in public areas. This can be simply done using Particle Air Quality Monitoring Kit, a screen which can display readings, and particle device cloud to publish the collected data. That's it, this is all we need.

3.5 Adafruit Feather Bluefruit LE Board

Adafruit Feather 32u4 Bluefruit is all-in-one Arduino-compatible plus Bluetooth Low Energy. It is also equipped with built in USB and battery charging.

Adafruit in Bluetooth WFH Stress Monitor

In a COVID-present world, the line between personal life and professional life are blurrier than ever. In todays world , we need an external reminder which can reminder us to take a

deep breathe and relax whenever feeling stressed, anxious or may be overwhelming. That's where we need to have a system that can monitor our heart rate, our temperature, and noise in the workspace. We can make this project by adding external bluetooth sensors to our Adafruit board. Then we can further Notehub.io and Twilio's SMS service.

3.6 ESP8266

The ESP8266 is a system equipped with Wi-Fi microchip for IOT applications. It enables microcontrollers to connect 2.4GHz Wi-Fi , which uses 802.11 b/g/n.

ESP8266 - Geolocation Without GPS Module

By using this little ESP8266 IOT board, it is possible to get the location. It is the best choice for this particular application because of the following reasons: Other than ESP board, we don't require anything else , not even GPS module to get live coordinates. The other obvious reason is that ESP board is the cheapest among all other boards which gives it a big advantage. Now the question is that how is it possible. So, The answer is with the help of Google's Geolocation API.

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