International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Review of Hardware Platforms for Designing of Internet of Things (IoT) System

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Abstract
Microcontrollers are pivotal components in the realm of the Internet of Things (IoT), providing necessary computational power, memory, and connectivity for a wide range of applications. This review explores the key characteristics of microcontrollers that make suitable for IoT, considering their wide use and new emerging models. Study delves into the fundamental features required for IoT applications, such as low power consumption, compact form factors, diverse connectivity options, and flexible I/O (input-output) capabilities. The review covers a spectrum of microcontroller families from leading manufacturers, assessing their performance, energy efficiency, scalability, and ease of integration with various external devices for automation purpose.

Keywords: IoT, compact form factors, I/O

Introduction

IoT platform plays a crucial role for establishment and development of IoT system. IoT hardware platform is a amalgamation of embedded hardware, communication interface, and software development environment for complete IoT system. Collecting data is done through sensors and processing and sending data over the network is done by the microcontroller board and WiFi modules. As today idea is to make everything around us smart, for that more emphasis has to given on making the system smart by giving computational and communication capabilities to the sensors, as sensors are used for monitoring the external parameters.[4] According to the application of the system and the power requirement particular hardware platform are selected [1] [2] [3].
Brief description of various hardware platforms used till date is given below;

Arduino

Arduino is a company that offers open-source hardware as well as software to design the microprocessor and controller for the project and community-based service for manufacturing smart digital devices. Arduino offers various onboard features as in serial communication interfaces, Universal Serial Bus (USB), etc. C and C++ are the common languages used for programming the module. Some of the Arduino boards available in the market are Arduino Uno, Arduino Due, Arduino Mega, Arduino Leonardo, Arduino MKR Series IoT Boards.[5][6]

Arduino Uno

Arduino Uno board is based upon the ATmega328 microcontroller unit. It has a total of 14 input/output pins, out of which 6 of them are used as an analog input, another 6 are used by the PWM (Pulse Width Modulation) output. There is a reset button available on the board, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a power jack, a USB port, and an ICSP header is also available on the Arduino UNO board.[5][6]

Arduino Due

It is a microcontroller development board based on the AT91SAM3X8E SAM3X8E-32 BIT 32-bit ARM Cortex-M3 with a clock speed of 84MHz. This module has a total of 54 digital I/O pins, out of which 12 pins are used as PWM outputs, 16 analog inputs, 4 UARTs, 2 DAC (Digital to Analog Converter), 2 CAN, 2 TWI, SPI header, a JTAG header, a power jack, an USB OTG capable connection, and a reset button. This Arduino board is mostly used in powerful, large Arduino based projects.[5][6]

Arduino Leonardo

Arduino Leonardo is the first development board manufactured by the Arduino company, this board is very simple to use and cost effective [20]. It is based upon ATmega32u4, an 8-bit AVR microcontroller family member offering a clock speed of 16 MHz. Only one microcontroller is used in this board with the USB. On this development board, there are 20 digital I/O pins. Out of which 12 are used as analogue input pins and 7 pins as PWM outputs. It has SPI, a micro USB (CDC) port connection, a power jack, and a Reset switch interface.[5][6]

Raspberry Pi

The "Raspberry Pi" is the series of development boards manufactured by the "Raspberry Pi Foundation". A "United Kingdom" charity, focusing and aiming to educate people with embedded hardware and software programming for creating awareness and access to computer education.[5] The Raspberry Pi has commonly employed in small-scale IoT industries, educational projects, and robotics.[6] There are many types of models of Pi available in the market. They are as follows

- Pi 1 Model B (2012)
- Pi 1 Model A (2013)
- Pi 1 Model B+ (2014)
- Pi 1 Model A+ (2014)
- Pi 2 Model B (2015)
- Pi Zero (2015)
- Pi 3 Model B (2016)
- Pi Zero W (2017)
- Pi 3 Model B+ (2018)
- Pi 3 Model A+ (2019)
- Pi 4 Model A (2019)
- Pi 4 Model B (2020)
- Pi 400 (2021)

Particle Photon

Particle is an IoT hardware platform that offers embedded hardware, communication interfaces, cloud network services, and application builder tools for IoT services. The data can be accessed by IFTTT and use it for action and trigger purposes to send an email and receive commands through the user easily. It has an integrated development environment (IDE), software development tools, and various development modules for different IoT products. It has different types of communication modules such as Boron/Electron GSM with 2G/3G enabled. Particle is open source and can be integrated into other products. It has a powerful STM32F205RGY6 ARM Cortex M3 processor offering a clock speed of 120MHz with a Broadcom BCM43362 Wi-Fi chip. This module is called P-zero or PØ Wi-Fi module because of its tiny size.[5][6]

Samsung's Artik

Samsung's Artik is one of the platforms which is integrated for IoT and contributes the quickest way to impart assured connectivity, resourceful IoT devices and services. The Artik brings together all the hardware, software, cloud services, and security on a unique development board. It is always ready to interact with any device with the third-party application, devices or services.[2][5]

Intel IoT development boards

Intel is one of the corporations, which manufactures different types of development boards designed for sudden mock-up of computing smart devices to immediately produce Internet of Things and computing devices. Intel manufactures development mock up boards; these are individually designed for students, makers, researchers, and do it yourself (DIY) electronics addicts. Some of the popular IoT development boards manufactured by Intel are Intel Galileo Gen 2 development board, Intel Edison Breakout Board/kit, Intel Edison Board/Kit for Arduino, etc.[2][5]

Adafruit IoT development boards

Adafruit was founded in 2005 by MIT engineer, Limor "Ladyada" Fried. Adafruit is the smart electronics device/component which is manufactured by the Adafruit industry. With the help of these development modules, many problems can be solved, projects can be completed, and communication systems can be improved. The dimension and weight of the module is quite small and handy for the customers. Two types of Adafruit IoT development boards are discussed here named as Adafruit FONA and Adafruit FEATHER M0.[2][5]

NodeMCU

NodeMCU is open source platform, It's hardware is open for editing, modifying, building. NodeMCU development kit consists of ESP8266 wifi chip. The ESP8266 is a lost cost wifi chip developed by Espressif systems with TCP/IP protocol. The NodeMCU is available in various packages. Common to all the designs is the base ESP8266 core. ESP32 is a low-cost, low power system on ship (SoC) series with Wi-Fi and dual mode Bluetooth capabilities. The ESP32 family includes the ESP32-D0WDQ6, ESP32-D2WD, ESP32-S0WD, and the system in package ESP32-PICO-D4. It contains Tensilica Xtensa Lx6 microprocessor with a clock rate of up to 240 Mhz. ESP 32 is highly integrated with built in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters and power management modules. [8][9][10]

BeagleBone

Texas Instruments BeagleBone is the latest single board computer for computing and communication. It runs on the OS Linux, RISC OS, FreeBD, OpenBSD and additional distributions of Linux such as Ubuntu boards. The SoC uses the processor ARM cortex A15 core and DSP processor (TMS320C64x plus multimedia 4 GB eMMC) for graphics and video. The power required is 2 W. Memory on-board is 2 GB, plus in the memory support plus and micro-SD card.[7]

Comparison table for various hardware platforms used for IoT system design is given below:[1][2][3][7]

Parameter	Arduino UNO	Raspberry Pi	Particle Photon	Samsung Artik 05X	Intel Galileo	Adafruit FEATHER MO	NodeMCU	Beagle Bone
Processor	ATmega 328P	Quadcore ARM cortex A7/900 Mhz	STM32F205 RGY6 ARM M3	32bit ARM Cortex R4	Intel Quark SoC*1000	ATSAMD21G18 ARM Cor.M0	Tensilica LX6 Dual-Core	Dual core ARM A15/1.5 GHz
Operating voltage	7 - 12 V	5 V	3.3 V	5-12 V	7-15 V	3.3 V	3.3V operable with micro USB	7 – 12 V
RAM	2 KB	1 GB	128 KB	1280 KB	256 MB	32 KB	512 kB	512 MB
USB ports	1	5	1	1	4	2	1	3
General purpose input and output pins	20	40	18	68	20	----------	48	69 digital pins and 7 analog pins
Ethernet/Wi-Fi/GSM port	No port	1 ethernet, HDMI, camera port	----------	10/100 Ethernet connector port	100 Mbps ethernet port, N-2000 Wi-Fi adapter, no GSM port	----------	----------	2 ethernet port of 1 Gbps

Programming Language	C++	Python	C	C++	C++ uses Arduino IDE	Circuit Python	C++ used with Arduino IDE	C, C++, Java, Python
Application	Home automation, robotics, wearable technology	Desktop PC, robot controller, game servers	Prototyping of IoT projects	Production ready hardware, software tools integrated with IoT platform		Compatible with Arduino with integrated Wi-FI	Integrated Wi-Fi suitable for IoT projects	Robotics, IoT and automation

Conclusion

The literature review of microcontrollers used for IoT applications has highlighted several critical aspects that underlines their importance in the growing field of the IoT. Microcontrollers are backbone for IoT system, as computational power, memory, needed interface is provided from consumer electronics to highly automated industrial applications. Microcontrollers that offer low power consumption are particularly valuable for designing of IoT enabled system. The review has also identified the evolving nature of development tools, hardware and programming languages that support various microcontroller boards. This plays a crucial role in design, testing, and development of IoT devices. As technology continues to evolve, microcontrollers are expected to become even more energy-efficient, increased computational ability, extended memory so that system becomes more flexible and scalable.

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