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# Embedded Programming: A backbone of Internet of Things (IOT)

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*Abstract:*

*Internet is global platform. Billions of people worldwide are using Internet for various purposes like browsing, sending and receiving emails, online shopping, playing games, social networking applications, etc. Due to Industry 4.0 there is a boom of information technology, in which IOT is considered as major transformation in computer field. For exchanging and sensing information different physical object are connected with Internet just due to IOT. IOT can easily identify, locate, track, monitor and manage all connected physical objects with internet. Embedded programing plays a significant role in controlling working of IOT based devices. This paper provides detail information about how Embedded programming enables creation of smart and connected devices that can interact with the physical world and exchange data with other connected devices.*

*Keywords:* IOT, Internet, Embedded, Programming, Arduino UNO

**Introduction:**

Embedded programming plays a very vital role in the development of Internet of Things (IoT) systems. It allows the software to run directly on the microcontroller of IoT devices, enabling these devices to interact with the physical world and exchange data with other connected devices. Embedded Programming integrates computing and networking capabilities in day today used devices. IOT devices are dependent on embedded systems which are integrated with circuits which can be program to perform different tasks. Due to embedded system IOT device can connect with other devices, interact with the devices, shares, transmit, analyze, retrieve required amount of data to and from cloud based systems. IoT devices require low power consumption and compact size. By

using specialized programming languages, algorithms, and tools, developers can optimize the code for embedded systems, resulting in smaller, more efficient, and low-power consuming devices

**What is IOT?**

The Internet of Things (IoT) refers to the interconnected network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, and connectivity which enables these objects to connect and exchange data. The IoT allows for the collection and transfer of data over the internet. The IoT has grown rapidly in recent years, with an increasing number of devices being connected to the internet, from smart home appliances to wearable technology and industrial machines. This growth made advancement in technology as well as it has reduced the cost of these components also. IOT collect large amount of data in real time from various devices connected with the Internet. This collected data then used for processing, analyzing, disseminating, improving efficiency, making better decisions, for predictions. As example Smart AC through temperature sensor sense environmental and room's current temperature and based on this sensed data it will adjust room temperature on its own. Another important benefit of the IoT is the ability to remotely monitor and control devices.

**Embedded Programming:**

Embedded programming is the process of writing software for small, single-purpose devices that are part of a larger system. It involves programming microcontrollers, sensors, and other specialized devices to perform specific tasks within a larger system. The software is integrated into the device's hardware and is designed to perform specific tasks, such as controlling motors, reading sensors, or displaying information on a screen. The programming languages like C, C++ are used to write software functionalities.

**How Embedded Programming used to control IOT devices:**

Embedded programming is used to develop IoT devices which can communicate and exchange data over the internet. IoT devices are small, low-power devices that are connected to the internet and can collect and exchange data. Embedded programming is used to create the software that runs on these devices, allowing them to function as part of the IoT network. To control IOT devices Arduino UNO board is used. Arduino UNO is a microcontroller board. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, and a power jack. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board is programmed using the Arduino Integrated Development Environment (IDE).
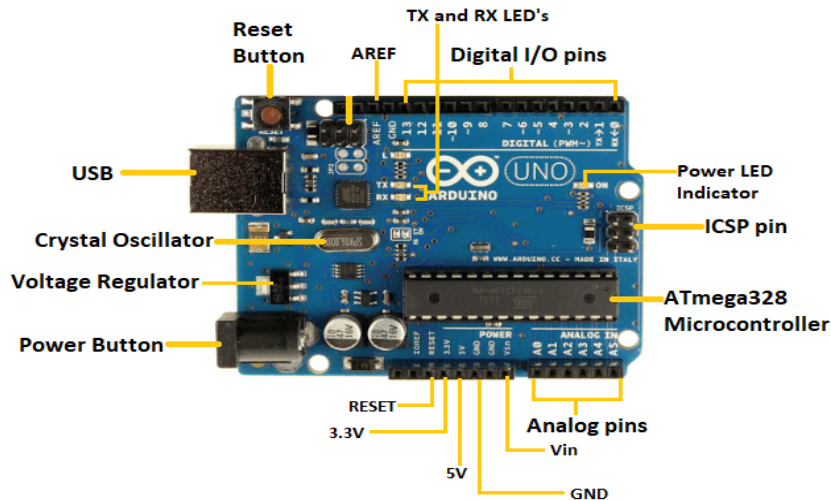
Arduino Integrated Development Environment (IDE) is a free, open-source software that supports multiple platforms such as Windows, macOS, and Linux. It allows users to write, upload, and debug code for Arduino boards and provides a simple and intuitive interface for developing embedded systems. Arduino boards are programmed in "C. Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

**Writing Sketches:**

**Sketches** are the programs written using Arduino Software (IDE). Using Text editor sketches are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.
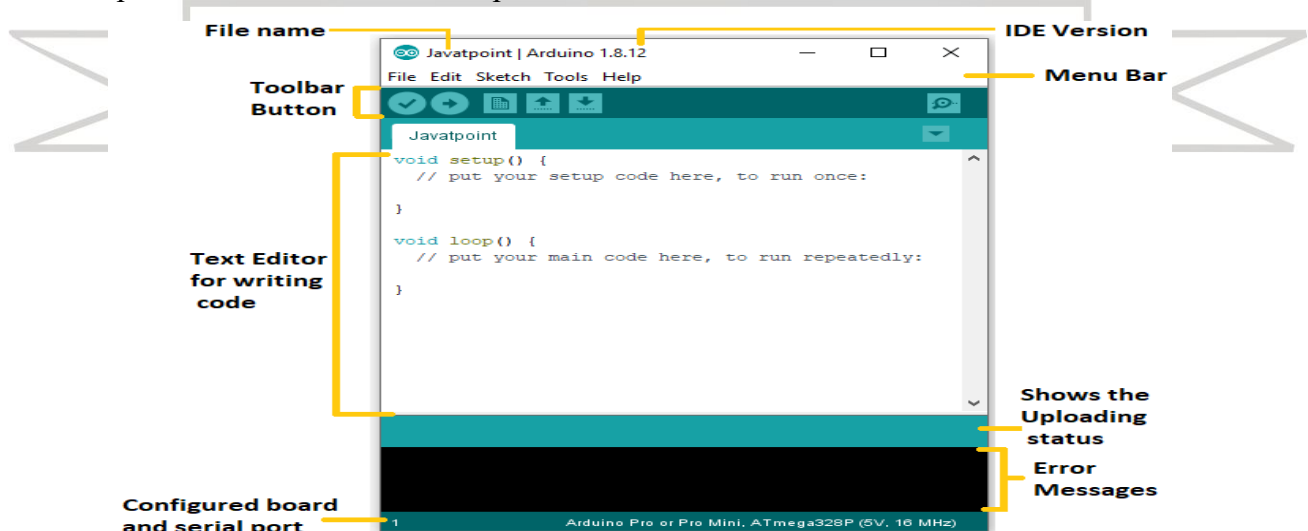
**The structure of Sketches:**

A blank Arduino sketch contains following two functions **Setup()** and **loop().** When Arduino sketch starts executing by default the setup() function is called first. Setup() function gets executed only once. It is mainly used to initialize variables, to set pin Modes, for making settings for hardware components and to use different libraries. Where the loop() is executed repetitively. So using this micro controllers execute their firmware code by repeating their it for an infinite number of times while they remain powered on. The setup() and loop() functions have void return types.

**Example:**

**A simple LED blinking program using Arduino UNO board:**

Arduino Board and external LED connected with it:
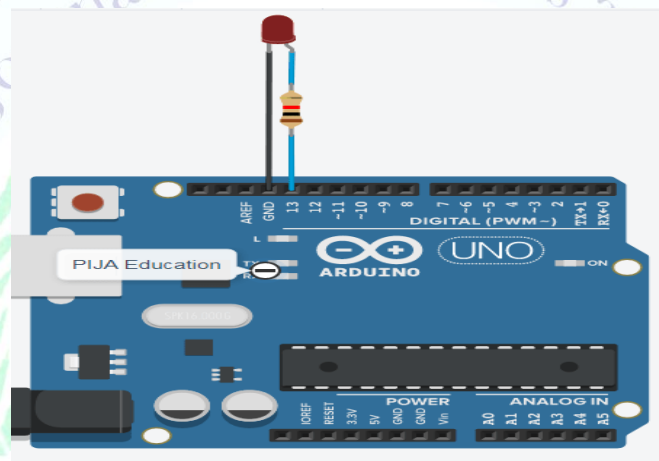


**Sketch (Embedded Program code):**

```
void setup() {
  pinMode(13, OUTPUT);  // set the LED pin as output
}

void loop() {
  digitalWrite(13, HIGH);  // turn the LED on
  delay(1000);             // wait for 1 second
  digitalWrite(13, LOW);   // turn the LED off
  delay(1000);             // wait for 1 second
}
```

In above program, setup() and loop() are the two functions. When Aurdino board starts then setup() function gets called once. The loop() function gets called repetitively. The pin Mode function to set pin 13 as an output where LED has connected, and the digital Write function to turn the LED on and off. The delay function is used to wait for a specified number of milliseconds. The code file is called as sketch.

**Conclusion:**

Embedded programming provides the necessary computing and networking capabilities to connect and control devices in the IoT environment. It provides real-time processing and energy-efficient operation and enables the integration of smart devices. As Arduino IDE uses Embedded C and C++ like languages to create sketch so it becomes easy to handle functionality code for any IOT based device through Embedded programming. Hence embedded programming is a backbone for IoT devices to work more effectively and efficiently.

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