Savitribai Phule Pune University Second Year of Computer Engineering (2015 Course) 210256: Advanced Data Structures Lab		
Lab Scheme: **PR: 04 Hours/Week**	**Credit** **02**	**Examination Scheme:** **TW: 25 Marks** **PR: 25 Marks**

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Course Objectives:-

- Hardware platforms and operating systems commonly used in IoT systems.
- Help the students in providing a good learning environment and also work with real time problems faced in day to day life.

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Course Outcomes:-

- Understand IOT Application Development using Raspberry Pi/ Beagle board/ Arduino board
- Develop and modify the code for various sensor based applications using wireless sensor modules and working with a variety of modules like environmental modules.
- Make use of Cloud platform to upload and analyze any sensor data

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Guidelines for Student Journal

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- Student should submit term work in the form of journal with write-ups based on specified list of assignments.
- Practical and Oral Examination will be based on all the assignments in the lab manual
- Candidate is expected to know the theory involved in the experiment.
- The practical examination should be conducted if and only if the journal of the candidate is complete in all respects.

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List of Experiments

Assignment No. 1

Aim : Study of Raspberry-Pi, Beagle board, Arduino and other micro controller (History & Elevation)

Objective:

1) To study various microcontrollers.

Theory:

Raspberry Pi :

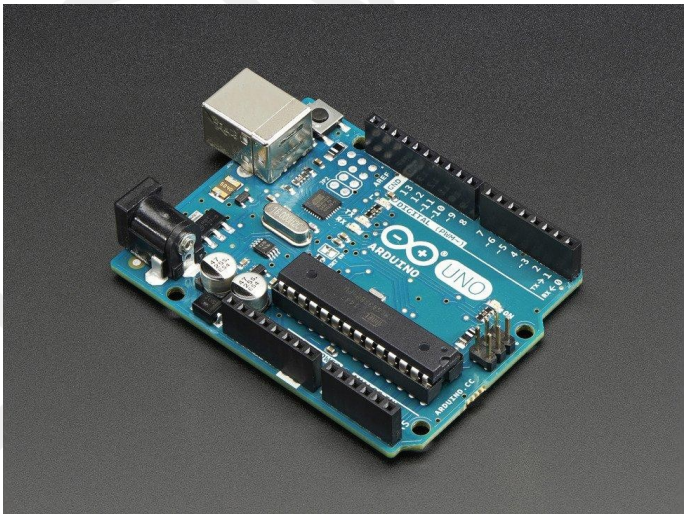
This is a big brother to Arduino and can be considered as a mini desktop computer tht can be purchased for around 35 USD. This has 4 USB slots, an ethernet port, HDMI port, Camera and LCD interfacing ports. This is pretty dumb on its own, but when you insert the SD card onto it, it receives its intelligence. The SD card has the powerful Linux OS and the memory.

Raspberry Pi has an excellent programming IDE with GUI. It can be connected to a laptop or PC and can be programmed. The disadvantage with Arduino is with its limited support for sensors and actuators as it has very limited interfacing mechanism with external sensors and actuators.

You can use Raspberry Pi for requirements that need high level of direct connectivity with the internet, like your standalone single sensor that needs to update certain readings over the internet to your data collection application.

Arduino

The Arduino board is the largest open-source platform in the world. Not only is it easy to understand, but its affordability makes it a viable choice to all skill levels. The size of the Arduino board paired with the great support that Arduino offers make it an easy pick for our top 4 open source boards list.Typically, an Arduino board consists of a Microcontroller ATmega328, operating voltage varies between models, a variety of Analog input pins, digital I/O pins, Flash memory, SRAM (varies/KB), EEPROM (varies/KB), Clock speed which changes depending on model.



Beagle bone black

This is pretty expensive at around 75 USD but includes the power of Raspberry Pi and the flexibility of Arduino. It comes embedded with Linux OS and a memory. It has a pretty fast processing cycle and comes with lots of input and output pins for connecting external sensors and actuators. Its biggest limitation is that of its single USB port.

BeagleBone can be used for situations where you want a Raspberry Pi but are ready to shell out a few more money! This is extensively used in industrial IOT where huge amount of data need to be read and transmitted at high speed.

Here is a comparison of the three

Name	Arduino Uno	Raspberry Pi	BeagleBone
Model Tested	R3	Model B	Rev A5
Price	$29.95	$35	$89
Size	2.95"x2.10"	3.37"x2.125"	3.4"x2.1"
Processor	ATMega 328	ARM11	ARM Cortex-A8
Clock Speed	16MHz	700MHz	700MHz
RAM	2KB	256MB	256MB
Flash	32KB	(SD Card)	4GB(microSD)
EEPROM	1KB		
Input Voltage	7-12v	5v	5v
Min Power	42mA (.3W)	700mA (3.5W)	170mA (.85W)
Digital GPIO	14	8	66
Analog Input	6 10-bit	N/A	7 12-bit
PWM	6		8
TWI/I2C	2	1	2
SPI	1	1	1
UART	1	1	5
Dev IDE	Arduino Tool	IDLE, Scratch, Squeak/Linux	Python, Scratch, Squeak, Cloud9/Linux
Ethernet	N/A	10/100	10/100
USB Master	N/A	2 USB 2.0	1 USB 2.0
Video Out	N/A	HDMI, Composite	N/A
Audio Output	N/A	HDMI, Analog	Analog

Conclusion: Thus we have studied Raspberry-Pi, Beagle board, Arduino and other micro controller.

Assignment No. 2

Aim: Study of different operating systems for Raspberry-Pi /Beagle board. Understanding the process of OS installation on Raspberry-Pi /Beagle board

Objective:

1) To study various embedded operating systems.
2) To learn OS installation steps for Raspberry-Pi/Beagle board

Theory:

Operating Systems for Raspberry-Pi

Windows

The process for Windows is a bit more straightforward. You will first need to download Win32 Disk Imager from SourceForge.Once Win32 Disk Imager is installed, run it as an administrator by right-clicking the program icon and selecting Run as administrator.Select the image file you extracted from the Raspbian ZIP file.Select the correct storage drive by choosing the drive letter in the dropdown menu below Device. Be completely certain you selected the correct drive before proceeding.Click Write.

Mac

Open Terminal by locating the app in Launchpad or by pressing command + spacebar and searching for the app in Spotlight.Change the directory you're working in to the location of the extracted image. For example, if you extracted the Raspbian image to your desktop, type cd Desktop/ and press enter.Identify the disk by typing diskutil list and pressing enter. Look for the name of the SD card you're using (it will appear the same in Terminal as it does on the desktop) and locate its identifier, which will look something like disk2 or disk3, depending on how many devices you have connected to your Mac.

A. OS installation Steps on Raspberry-Pi

1. Go to rasberry.org/download and download Raspberry-Pi desktop pc ISO image file

2. Extract image file

3. Format 4GB SD card using SD card Formatter

4. Using win32 Disk Manager Software write ISO image file to SD Card.

5. Put SD card on Raspberry-Pi

Operating Systems for Beaglebone Black

The embedded system from Texas Instruments comes preinstalled with the Ångström Linux operating system and has support for other popular distribution including Debian, Android, or Ubuntu. The Ångström Linux operating system

runs from the on-board eMMC memory, and in addition to the eMMC, you can boot directly from the MicroSD card.

Ångström Linux

It's the preferred operating system for Black and customized for embedded devices. It may be found in several versions, and depending on how long you purchased the BBB, you can check and install the latest version.

Debian

It's one of the most popular operating system for embedded systems with support for many architectures. The Debian OS can be found on Raspberry Pi and many more single board computers with a large usage in robotics. The best solution to use Debian on Black is to run the customized image for the BeagleBone boards.

Android

Android is a very popular operating system for mobile devices such as smartphones and tablets. Based on the Linux kernel, the Android is a good operating system compatible with embedded systems and able to support a wide range of applications. At this moment, you can run on Black the Android Jelly Bean version using a memory card with at least 4GB storage space.

Ubuntu

you can run on BeagleBone Black a custom version of Ubuntu, which is available in several versions with a wide range of improvements for more recent versions.

OS installation Steps on Beagle board

1. Go to http://beagleboard.org/latest-images/ and download latest Debian image files

2. Extract image file

3. Format 4GB SD card using SD card Formatter

4. Using win32 Disk Manager Software write ISO image file to SD Card.

5. Put SD card on Beagle board

Conclusion: Thus we have studied different operating systems for Raspberry-Pi /Beagle board and understanding the process of OS installation on Raspberry-Pi /Beagle board.

Assignment No. 3

Aim : Write an application to read temperature from the environment. If temperature crosses threshold value then it notifies with buzzer

Objective:

The system sends an SMS alert and sounds a buzzer if the temperature crosses certain static thresholds or increases/decreases suddenly

Theory:

Problem statement

Today, every business in existence has a server room. A server room is a part of a data center and is used to store, power and operate computer servers and associated equipment. These computer servers operate continuously and generate a lot of heat in the process. If a server room gets overheated, the electronic components may get permanently weakened, the servers may fail and even server room fires can be caused leading to machine damage and loss of a significant amount of data. On the other hand, the cooling systems installed in the server rooms if run at full blast, may consume a lot of energy, lead to high electricity bills and even harm the environment.

Proposed solution

In order to prevent such scenarios, a temperature monitoring and alerting system would come in handy. The system created here monitors its surrounding temperature and if the temperature crosses certain thresholds, it sends an SMS alert to each of the registered phone numbers while simultaneously initiating an audible alert signal at the location of the server room so that the concerned personnel on-site can take care of the situation immediately.

Here, both static and dynamic thresholds are defined for the sensed temperature to ensure enhanced protection of the servers from damage. The optimal static thresholds can vary for different server rooms but the general temperature range for proper functioning of server rooms is 18°C - 27°C as stated by ASHRAE. The dynamic thresholds are calculated for anomaly detection using Z – score analysis wherein if the temperature increases or decreases suddenly, SMS and buzzer alerts are sent

Follow the steps below to set up your hardware:

Step 1: Connecting The Temperature Sensor

Place the LM35 temperature sensor on the breadboard and connect its three leads via jumper wires to the respective pins of the Bolt module. Keeping the flat side of the sensor towards yourself:

a. Connect the leftmost lead which is the supply terminal to the 5V pin of the Bolt module.

b. Connect the middle lead which is the analog output terminal to the Analog Input pin (A0) of the Bolt module.

c. Connect the rightmost lead which is the ground terminal to the GND pin of the Bolt module.

Step 2: Connecting The Buzzer

Place the buzzer on the breadboard and connect its leads via jumper wires to the respective pins of the Bolt module. Remove the seal covering the buzzer opening after the connections are done.

a. Connect the longer lead which is the positive terminal (indicated by a '+' sign on the seal in the image) to GPIO pin 0 of the Bolt module.

b. Connect the shorter lead which is the negative terminal to the GND pin of the Bolt module.

CONFIGURING THE SOFTWARE

Now, we move on to the software configurations. The code is written using Python 3 on Ubuntu which uses Linux kernel. Follow the steps below to complete the software setup:

Step 1: Installing Ubuntu VPS (Optional)

Step 2: Creating a Twilio Account

Step 3: Locating The API Key And Device ID

Step 4: Defining Static Thresholds

Step 5: Defining Constant Parameters For Anomaly Detection

Step 6: Creating a Configuration File

DEPLOYING THE SYSTEM

Step 1: Powering ON The Bolt Module

Step 2: Executing The Main Code

Conclusion

The 'Temperature Monitoring And Two Way Alerting System' that we have created can, thus, be used to protect server room machines from damage and

prevent data loss due to overheating. A large number of such systems need to be installed in a server room in order to continuously track the temperature of all the areas of the room.

Assignment No. 4

Aim : write a program using arduino to control LED(one or more ON/OFF)or blinking.

Objective: The LED which is connected to the Arduino's GPIO blinking with a certain frequency.

Hardware:

- Arduino nano
- USB Type-B cable (for connecting the Arduino nano to our Laptop or Compute)
- Red LED 5mm (we can also use a different color LED)
- 1K (kilo-ohm) resistor for limiting the current.
- A computer or Laptop with Latest Arduino IDE software and drivers

Theory:

What is the LED?

The LED is the abbreviation of light emitting diode. It is usually made of gallium arsenide, gallium phosphide

semiconductor materials. The LED has two electrodes: a positive electrode and a negative one. It lights up only when a forward current passes, and it can flash red, blue, green, yellow, etc. The colour of the light depends on the material it is made.

In general, the drive current for LED is 5-20mA. Therefore, in reality it usually needs an extra resistor for current limitation so as to protect the LED.

Procedure

Now we'll discuss about how we are going to make this happen.

First and foremost step is to grab the components. The components needed are: LED(1), Arduino UNO(1), Resistor 221 0hm(1) [you can use your choice], Jumper wires(1), Bread board(1). We aren't mentioning about any required power supply here. Because, 5 V power supply can be get through USB connected to your computer, for the purpose of dumping the code to micro controller. It is also possible to use a battery to provide the power instead of depending on USB.

Plug the short leg of LED into the GND (ground) header. Also connect the positive leg to digital pin '8' as per the code we use now. You can use any of the other digital pins, and change the '8' in your code to match. Don't forget to add a resistor in between positive leg of LED and digital output pin of Arduino, to prevent the burning of LED due to high voltage. Remember, a resistor can connect in either way around. Use a bread board and a pair of jumper wires to make all the above mentioned connection.

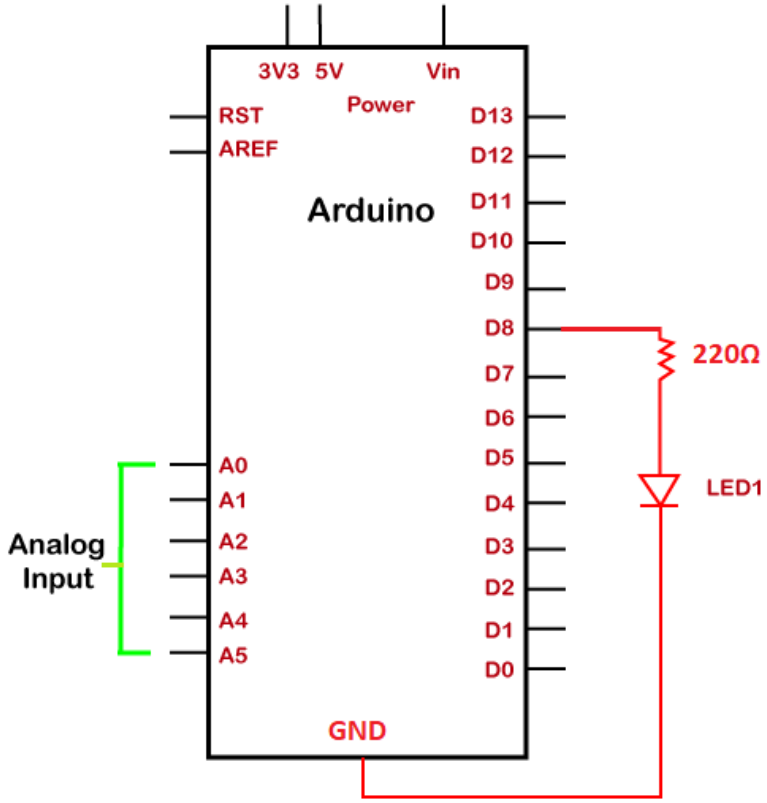
Or you can consider of blinking an in-built LED in the Arduino board itself and thus avoid the whole external circuit procedure discussed above. You have to change pin number to '13' or 'BUILT_IN', in the code using (the BUILT_IN led and pin 13 connected internally)

Get the code, then connect the Arduino to the computer through USB port. Choose the board type and COM port number in the software. Then first verify and next go for upload. Then observe the magic happens on your LED.

Structure of the project

The structure clearly shows the pinout of the UNO board. It also displays the LED and resistance connected to the board.

It is shown below:



Conclusion: Thus we have studied how to how to connect LED to arduino.