1. With a neat block diagram, explain the basic building blocks of an IoT device.

ANS

7.1.1 Basic building blocks of an IoT Device

An IoT device can consist of a number of modules based on functional attributes, such as:

- Sensing: Sensors can be either on-board the IoT device or attached to the device. IoT device can collect various types of information from the on-board or attached sensors such as temperature, humidity, light intensity, etc. The sensed information can be communicated either to other devices or cloud-based servers/storage.
- Actuation: IoT devices can have various types of actuators attached that allow taking actions upon the physical entities in the vicinity of the device. For example, a relay switch connected to an IoT device can turn an appliance on/off based on the commands sent to the device.
- Communication: Communication modules are responsible for sending collected data to other devices or cloud-based servers/storage and receiving data from other devices and commands from remote applications.
- Analysis & Processing: Analysis and processing modules are responsible for making sense of the collected data.

The representative IoT device used for the examples in this book is the widely used single-board mini computer called Raspberry Pi (explained in later sections). The use of Raspberry Pi is intentional since these devices are widely accessible, inexpensive, and available from multiple vendors. Furthermore, extensive information is available on their programming and use both on the Internet and in other textbooks. The principles we teach in

this book are just as applicable to other (including proprietary) IoT endpoints, in addition to Raspberry Pi. Before we look at the specifics of Raspberry Pi, let us first look at the building blocks of a generic single-board computer (SBC) based IoT device.

Figure 7.1 shows a generic block diagram of a single-board computer (SBC) based IoT device that includes CPU, GPU, RAM, storage and various types of interfaces and peripherals.

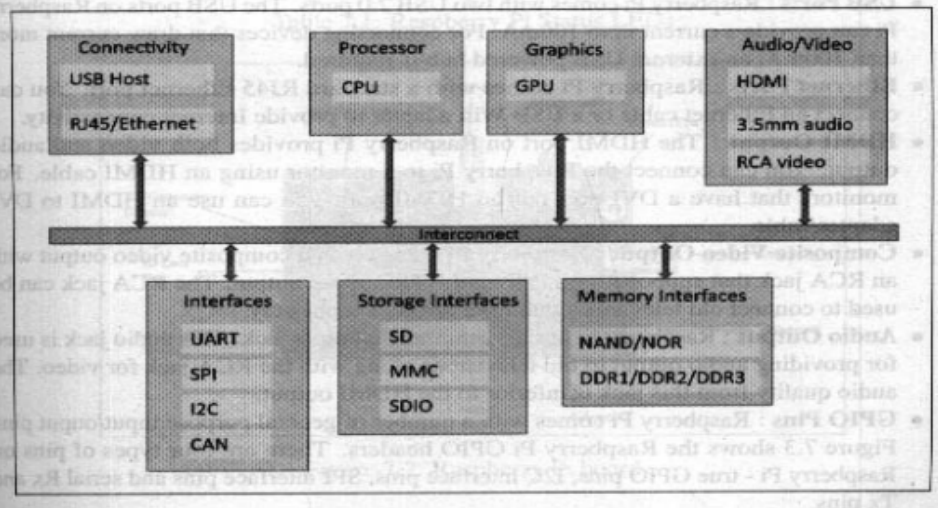


Figure 7.1: Block diagram of an IoT Device

2. Write a note on Linux on Raspberry Pi.

7.4 Linux on Raspberry Pi

Raspberry Pi supports various flavors of Linux including:

- **Raspbian** Raspbian Linux is a Debian Wheezy port optimized for Raspberry Pi. This is the recommended Linux for Raspberry Pi. Appendix-1 provides instructions on setting up Raspbian on Raspberry Pi.
- **Arch** : Arch is an Arch Linux port for AMD devices.
- **Pidora** : Pidora Linux is a Fedora Linux optimized for Raspberry Pi.
- **RaspBMC** : RaspBMC is an XBMC media-center distribution for Raspberry Pi.
- **OpenELEC** : OpenELEC is a fast and user-friendly XBMC media-center distribution.
- **RISC OS** : RISC OS is a very fast and compact operating system.

or disable SSH server and change boot behavior. It is recommended to expand the root file-system so that you can use the entire space on the SD card.

Though Raspberry Pi comes with an HDMI output, it is more convenient to access the device with a VNC connection or SSH. This does away with the need for a separate display for Raspberry Pi and you can use Raspberry Pi from your desktop or laptop computer. Appendix-A provides instructions on setting up VNC server on Raspberry Pi and the instructions to connect to Raspberry Pi with SSH. Table 7.2 lists the frequently used commands on Raspberry Pi.

Command	Function	Example
cd	Change directory	cd /home/pi
cat	Show file contents	cat file.txt
ls	List files and folders	ls /home/pi
locate	Search for a file	locate file.txt
lsusb	List USB devices	lsusb
pwd	Print name of present working directory	pwd
mkdir	Make directory	mkdir /home/pi/new
mv	Move (rename) file	mv sourceFile.txt destinationFile.txt
rm	Remove file	rm file.txt
reboot	Reboot device	sudo reboot
shutdown	Shutdown device	sudo shutdown -h now
grep	Print lines matching a pattern	grep -r "pi" /home/
df	Report file system disk space usage	df -Th
ifconfig	Configure a network interface	ifconfig
netstat	Print network connections, routing tables, interface statistics	netstat -lntp
tar	Extract/create archive	tar -xzf foo.tar.gz

3.Explain the various Raspberry Pi interfaces

7.5 Raspberry Pi Interfaces

Raspberry Pi has serial, SPI and I2C interfaces for data transfer as shown in Figure 7.3.

7.5.1 Serial

The serial interface on Raspberry Pi has receive (Rx) and transmit (Tx) pins for communication with serial peripherals.

7.5.2 SPI

Serial Peripheral Interface (SPI) is a synchronous serial data protocol used for communicating with one or more peripheral devices. In an SPI connection, there is one master device and one or more peripheral devices. There are five pins on Raspberry Pi for SPI interface:

- **MISO (Master In Slave Out)** : Master line for sending data to the peripherals.
- **MOSI (Master Out Slave In)** : Slave line for sending data to the master.
- **SCK (Serial Clock)** : Clock generated by master to synchronize data transmission
- **CE0 (Chip Enable 0)** : To enable or disable devices.
- **CE0 (Chip Enable 1)** : To enable or disable devices.

7.5.3 I2C

The I2C interface pins on Raspberry Pi allow you to connect hardware modules. I2C interface allows synchronous data transfer with just two pins - SDA (data line) and SCL (clock line).

3. Develop a python code for blinking a LED with a Raspberry Pi.

Box 7.2: Python program for blinking LED

```
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
GPIO.setup(18, GPIO.OUT)

while True:
   GPIO.output(18, True)
   time.sleep(1)
   GPIO.output(18, False)
   time.sleep(1)
```

4. Develop a python code for controlling LED with a switch for Raspberry Pi.

Box 7.3: Python program for controlling an LED with a switch

```
from time import sleep
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
```

```
#Switch Pin
GPIO.setup(25, GPIO.IN)

#LED Pin
GPIO.setup(18, GPIO.OUT)

state=false

def toggleLED(pin):
   state = not state
   GPIO.output(pin, state)

while True:
   try:
      if (GPIO.input(25) == True):
         toggleLED(pin)
      sleep(.01)
   except KeyboardInterrupt:
      exit()
```

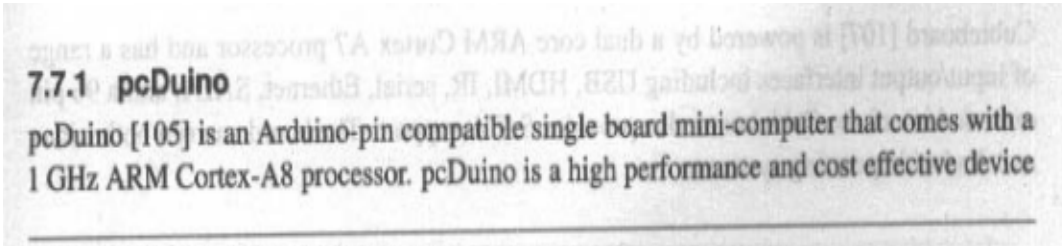
5. Explain the various features of Raspberry Pi board.

Figure 7.2 shows the Raspberry Pi board with the various components/peripherals labeled.

- **Processor & RAM** : Raspberry Pi is based on an ARM processor. The latest version of Raspberry Pi (Model B, Revision 2) comes with 700 MHz Low Power ARM1176JZ-F processor and 512 MB SDRAM.
- **USB Ports** : Raspberry Pi comes with two USB 2.0 ports. The USB ports on Raspberry Pi can provide a current upto 100mA. For connecting devices that draw current more than 100mA, an external USB powered hub is required.
- **Ethernet Ports** : Raspberry Pi comes with a standard RJ45 Ethernet port. You can connect an Ethernet cable or a USB Wifi adapter to provide Internet connectivity.
- **HDMI Output** : The HDMI port on Raspberry Pi provides both video and audio output. You can connect the Raspberry Pi to a monitor using an HDMI cable. For monitors that have a DVI port but no HDMI port, you can use an HDMI to DVI adapter/cable.
- **Composite Video Output** : Raspberry Pi comes with a composite video output with an RCA jack that supports both PAL and NTSC video output. The RCA jack can be used to connect old televisions that have an RCA input only.
- **Audio Output** : Raspberry Pi has a 3.5mm audio output jack. This audio jack is used for providing audio output to old televisions along with the RCA jack for video. The audio quality from this jack is inferior to the HDMI output.
- **GPIO Pins** : Raspberry Pi comes with a number of general purpose input/ouput pins. Figure 7.3 shows the Raspberry Pi GPIO headers. There are four types of pins on Raspberry Pi - true GPIO pins, I2C interface pins, SPI interface pins and serial Rx and Tx pins.
- **Display Serial Interface (DSI)** : The DSI interface can be used to connect an LCD panel to Raspberry Pi.
- **Camera Serial Interface (CSI)** : The CSI interface can be used to connect a camera module to Raspberry Pi.
- **Status LEDs** : Raspberry Pi has five status LEDs. Table 7.1 lists Raspberry Pi status LEDs and their functions.
- **SD Card Slot** : Raspberry Pi does not have a built in operating system and storage. You can plug-in an SD card loaded with a Linux image to the SD card slot. Appendix-A provides instructions on setting up New Out-of-the-Box Software (NOOBS) on Raspberry Pi. You will require atleast an 8GB SD card for setting up NOOBS.
- **Power Input** : Raspberry Pi has a micro-USB connector for power input.

6. Write a note on the following:

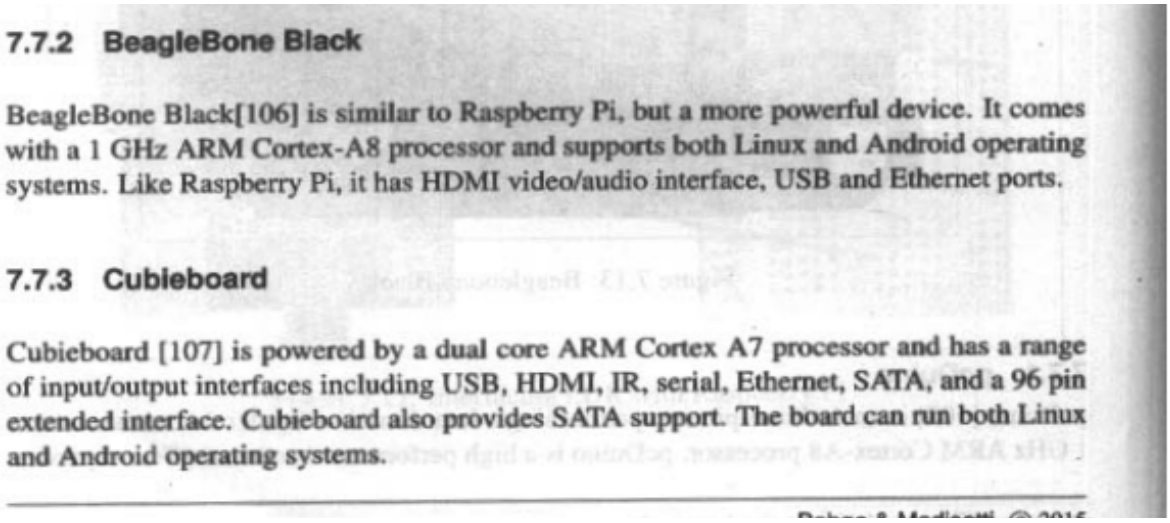
   i. pcDuino



7.7.1 pcDuino

pcDuino [105] is an Arduino-pin compatible single board mini-computer that comes with a 1 GHz ARM Cortex-A8 processor. pcDuino is a high performance and cost effective device that runs PC like OS such as Ubuntu and Android ICS. Like, Raspberry Pi, it has an HDMI video/audio interface. pcDuino supports various programming languages including C, C++ (with GNU tool chain), Java (with standard Android SDK) and Python.

   ii. BeagleBone Black iii> Cubieboard



7.7.2 BeagleBone Black

BeagleBone Black[106] is similar to Raspberry Pi, but a more powerful device. It comes with a 1 GHz ARM Cortex-A8 processor and supports both Linux and Android operating systems. Like Raspberry Pi, it has HDMI video/audio interface, USB and Ethernet ports.

7.7.3 Cubieboard

Cubieboard [107] is powered by a dual core ARM Cortex A7 processor and has a range of input/output interfaces including USB, HDMI, IR, serial, Ethernet, SATA, and a 96 pin extended interface. Cubieboard also provides SATA support. The board can run both Linux and Android operating systems.