INTRODUCTION TO SINGLE BOARD COMPUTING

This is an introductory post which deals with single board computers, their need and examples. Two popular boards – Raspberry Pi and BeagleBone Black are also discussed in detail. In the end, the features of these two boards are also compared.

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Introduction

With the advent of technology in the consumer electronics domain, single board computers have become quite popular among both consumers and developers. These days everyone has virtually become so much "wired" that they cannot live without these so called – gadgets. Right from the mobile phone in your pockets to high end gaming consoles, including tablets, PCs, iPod, etc., everything is basically a single board computer.

Single Board Computers

What are they?

Yes, you guessed it right! It's a computer in a single board! ;) Now obviously you might raise the question "Are there Multiple Board Computers as well?" Well, as a matter of fact, yes! There is a difference between traditional computers and single board computers. You must be familiar that full-fledged computers (like PCs and Mac) have a motherboard. On the motherboard, you will essentially find a processor (like the Intel® Core™, AMD® Athlon™, etc.), and other circuitry associated with that. You will also find slots for other peripherals like RAM, ROM, Hard Disk, LAN Card, CPU Fan, Heat Sink, LCD monitor, etc. These peripherals need to be attached to the motherboard separately in order to make the PC/Mac fully functional.

Unlike PCs/Mac, single board computers consist of everything on a single board itself! On the board, we have a processor and all other necessary peripherals and circuitry as well. We have onboard RAM, ROM, flash storage, AV ports, Ethernet port, etc. This means that one board is sufficient to act as a full-fledged computer! Yes, even they can boot into an operating system (OS) like Linux, Android, etc. and operate like any other computer. Being lightweight and specific, they have found huge application in smartphones, tablets and other consumer products.

These days' semiconductor manufacturers are building ever powerful processors, which are no less than beasts, thanks to Moore's Law. These processors, based upon a unique architecture like ARM, Intel x86 or other custom architectures, give whopping performances like 1.2 GHz clock frequency, etc. When combined with 1GB DDR3 RAM, 2GB Flash storage, HDMI/AV port, USB ports, LAN ports, etc. on the same board, it becomes a single board computer! Simply power it up, connect to a display device and boom! You are all set to go… your computer has successfully booted into an OS like Linux, Android, etc.

These single board computers are not as powerful as the current day PCs, laptops or Mac, and hence do not dissipate much heat. In addition to that, the processors are designed in order to generate less heat and consume less power. That's why you can run your smartphone the entire day without charging the battery or cooling it down!

All the electronic gadgets that you see around – smartphones, tablets, etc. have one such single board computer inside them – their motherboard! Most of them will run Android and iOS (an OS just like Windows, Linux, Mac OSx, etc.). You can download and install apps just like you do on your PC.

Why do we need them?

There are several reasons one might opt to use a single board computer.**Portability** being one of the major features. You can carry around a small computer like your smartphone in your pocket everywhere you go! These devices are pretty **intuitive** to use as well. They consume **less power** and energy as compared to traditional computers. And the most important feature is being **cost effective**! Being low cost, these products can reach a much larger part of the community. And this makes them suitable for **developer** applications as well for development of new apps, testing, debugging, hardware development, **hacking**etc.

Examples

As an **end user** (or consumer), examples are all around you – electronic gadgets! Next time you look at any such gadget, Google out its specifications!

As a **developer**, apart from the gadgets, there are some notable single board computers available in the market for both, hardware and software development. Some of them include Raspberry Pi, The Beagles (BeagleBoard, BeagleBoard xM, BeagleBone, BeagleBone Black), PandaBoard, MK802, MK808, Cubieboard,MarsBoard, Hackberry, Udoo, etc. Recently, Intel® has also entered into the Open Source world with its Atom™ processor based MinnowBoard.

In this post, further we will discuss mostly about Raspberry Pi and The Beagles (mostly the new BeagleBone Black), since they are the two most cost effective and small sized single board computers.

Raspberry Pi

Raspberry Pi Model B (Image Courtesy: Wikipedia.org)

Raspberry Pi is a credit-card-sized single board computer developed by the UK based Raspberry Pi Foundation for the sole intention of teaching programming and basic computer science to school students. It runs Linux on a 700 MHz ARM processor, has two USB ports to connect the keyboard and mouse, supports video via HDMI and/or RCA, connects to the internet via the Ethernet port, storage handled by a SD card, and what will blow you away is its cost – merely $35!

Even before it was launched in February 2012, it had gone viral among people! When I ordered it, it was backordered and took around 8-10 weeks for me to get it! But that isn't a problem now. It is manufactured and sold by element14/Farnell, RS Components and Egoman. The cost is low because there are no overhead charges, just the manufacturing cost; reason being Raspberry Pi Foundation is a non-profit organization aiming for charity, and want their product to be available and affordable to everyone! You can check out their website for several success stories of their charitable purpose.

However the low cost of Pi has led to several developers get their hands on it and work out several interesting projects and hacks using it! And the presence of GPIO (General Purpose Input/Output) pins on the board has lured many developers to use it for several physical computing projects which include hardware interfacing of electronics! Since it is **open source**, it has a huge community supporting it. Just check out its website, and you will get to know what people have done with it! You can also learn more about it at one of its distributors, Farnell element14.

Raspberry Pi Specifications

There are two models of Raspberry Pi – Model A and Model B. Let's have a look at some of its specifications:

R-Pi Features/Model	Model A	Model B
Target price:	US$25 Ext tax (GBP £16 Exc VAT)	US$35 Ext tax (GBP £22 Exc VAT)
System-on-a-chip (SoC):	Broadcom BCM2835 (CPU + GPU. SDRAM is a separate chip stacked on top)	
CPU:	700 MHz ARM11 ARM1176JZF-S core	
GPU:	Broadcom VideoCore IV,OpenGL ES 2.0,OpenVG 1080p30 H.264 high-profile encode/decode	
Memory (SDRAM)iB	256 MiB (planned with 128 MiB, upgraded to 256 MiB on 29 Feb 2012)	256 MiB (until 15 Oct 2012); 512 MiB (since 15 Oct 2012)
USB 2.0 ports:	1 (provided by the BCM2835)	2 (via integrated USB hub)
Video outputs:	Composite video | Composite RCA, HDMI (not at the same time)	
Audio outputs:	TRS connector | 3.5 mm jack, HDMI	
Audio inputs:	none, but a USB mic or sound-card could be added	
Onboard Storage:	Secure Digital|SD / MMC / SDIO card slot	
Onboard Network:	None	10/100 wired Ethernet RJ45
Low-level peripherals:	General Purpose Input/Output (GPIO) pins, Serial Peripheral Interface Bus (SPI), I²C, I²S[2], Universal asynchronous receiver/transmitter (UART)	
Real-time clock:	None	
Power ratings (provisional, from alpha board):	500 mA, (2.5 W)	700 mA, (3.5 W)
Power source:	5 V (DC) via Micro USB type B or GPIO header	
Size:	85.0 x 56.0 mm (two different boards, measured with callipers)	

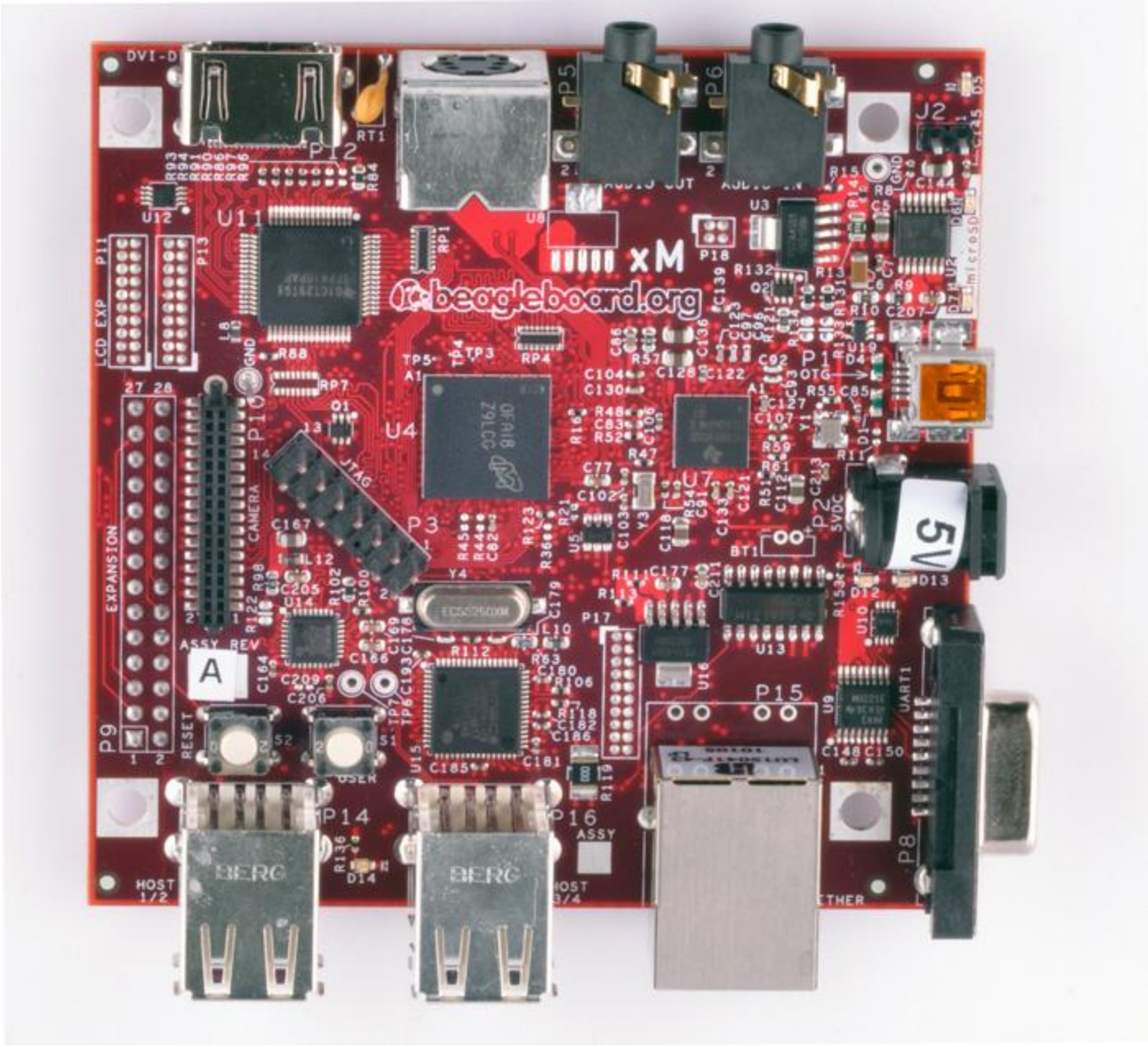
Source: http://elinux.org/RPi_Hardware

So you can see that Raspberry Pi is powerful enough to drive a 1080p monitor and serve as a full-on desktop computer! **In the upcoming posts on maxEmbedded, we will not only learn how to use Raspberry Pi as a desktop computer and a media center, but also for development and hacking purposes! So subscribe to stay tuned!**

The Beagles

Based upon ARM based processors from Texas Instruments, the Beagles are a bunch of single board computers aimed at open source computing. The Beagles consist of four siblings – BeagleBoard, BeagleBoard xM, BeagleBone and the all new BeagleBone Black.

BeagleBoard and BeagleBoard xM



BeagleBoard xM (Photo Courtesy: Texas Instruments)

BeagleBoard is $125 single board computer, which contains the OMAP3538 SoC by Texas Instruments (TI) based upon 720 MHz ARM Cortex-A8 processor. The cool thing about this board is that it has an on-board Digital Signal Processor (DSP) along with the ARM processor. The TMS32064xx DSP by TI is pretty powerful and is used for processing analog/digital signals (like audio, video, etc). It has a 512 MB SDRAM as well.

BeagleBoard xM is the successor of its elder sibling which costs $149, contains the AM37x SoC by TI based upon 1 GHz ARM Cortex-A8 processor. It has significant developments in the board design and specifications over the

traditional BeagleBoard. You can check out the differences here. This board is powerful enough to give laptop-like performance!
One of the best things about these boards is that they are open source and have good support from the developer community and has also developed an ecosystem by now.

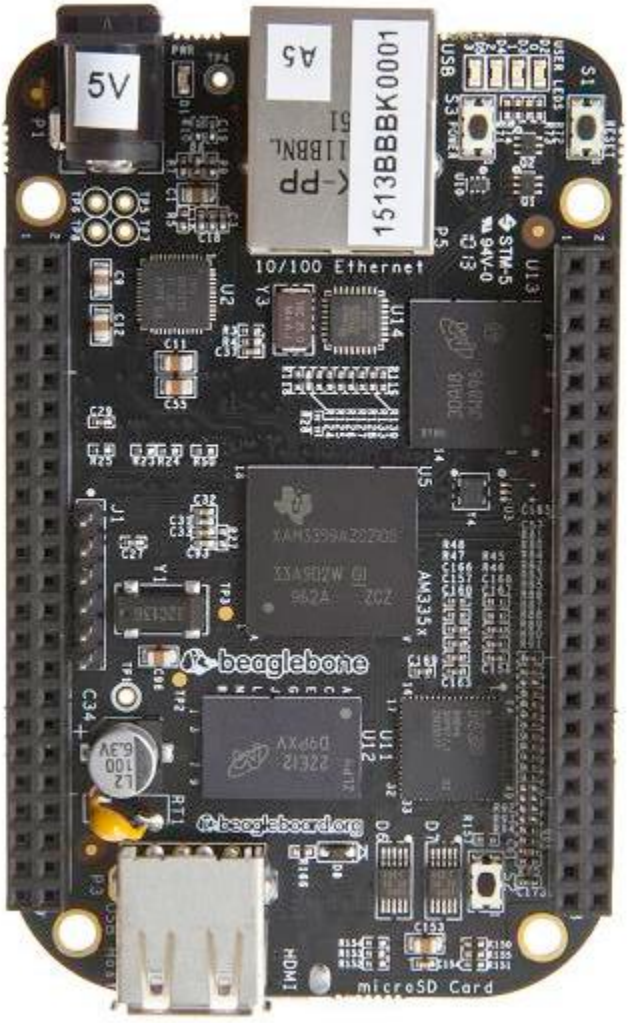
BeagleBone

BeagleBone

This is a smaller version of the BeagleBoard(s). It has an AM335x 720 MHz ARM Cortex-A8 processor from TI and costs $89. But unlike the BeagleBoard(s), this doesn't have a DSP at all. It has 32 KB of EEPROM and 256 MB DDR2 RAM. What made it more popular among developers is its greater scope for hardware interfacing with more number of GPIO pins and more supported interfaces (like UART, Timers, PWM, ADC, SPI, etc).

So till now we have discussed about Raspberry Pi, BeagleBoard, BeagleBoard xM and BeagleBone. You can refer to this site for a comparison of specifications between them all. But more than all of them, we are interested in discussing about the all new revolutionary BeagleBone Black released this April (2013).

The All New BeagleBone Black

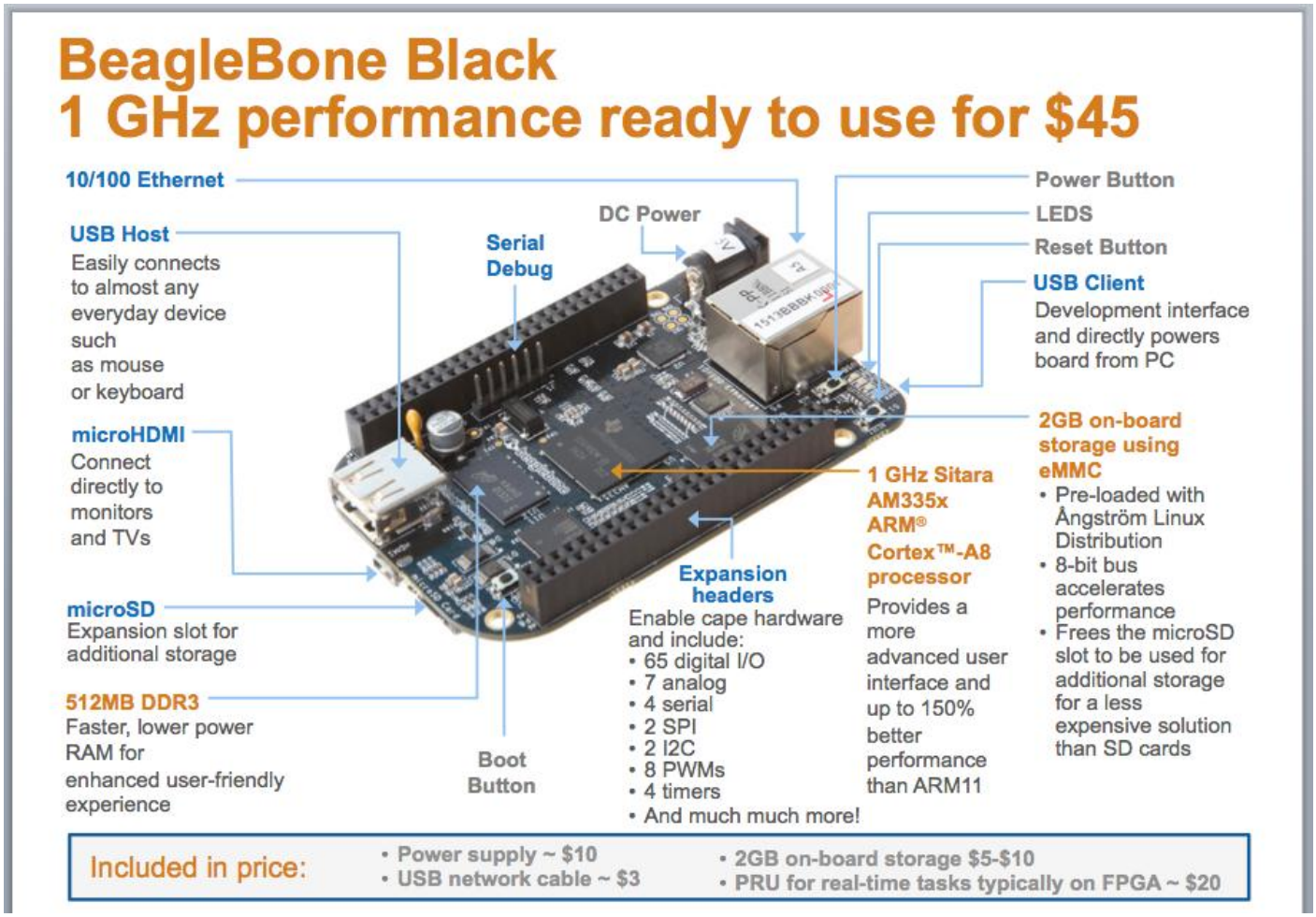


BeagleBone Black (Image Courtesy: Texas Instruments)

The BeagleBone Black is a $45 mini-PC and is the most recent version of the Beagles and contains a TI Sitara AM335x ARM Cortex A8 processor running at 1 GHz clock speed. It has the same pin layout as that of its previous white version BeagleBone. It has 512 MB DDR3 RAM and 2 GB on-board flash storage which is used to boot an OS. By default, it comes with the Linux Angstrom pre-loaded OS and can support different flavors of Linux and Android.

Similar to the Raspberry Pi, it comes with one USB port, one microUSB port, a micro HDMI port, a micro SD card slot and a 10/100 Ethernet jack. Now unlike the 8 digital pins of Raspberry Pi, BeagleBone Black has 65 digital I/O pins, analog pins, SPI, I2C, PWM, timers, and much more! We will discuss more features in the next section where

we compare BeagleBone Black and Raspberry Pi. Again, you can learn more about the BeagleBone Black at its distributor, Farnell element14.



BeagleBone Black Specs (Courtesy codeduino.com)

Raspberry Pi vs BeagleBone Black

As you would have read above, currently the two most trending single board computers are Raspberry Pi (R-Pi) and the BeagleBone Black (BBB). Lets compare them feature-wise.

Feature	Raspberry Pi (Model B) (R-Pi)	BeagleBone Black (BBB)	Remarks
Cost	$35 + Tax	$45 + Tax	BBB costs $10 more than R-Pi, but it's justified. Read ahead to know why!
Processor	700 MHz Broadcom BCM2835 ARM11 (Overclocked till 1 GHz)	1 GHz TI Sitara AM3358 ARM Cortex A8	Even though both operate at the same frequency (after overclocking the R-Pi), ARM Cortex-A8 processor provides up to 150% better performance than ARM11.
RAM	512 MB SDRAM	512 MB DDR3 RAM	DDR3 RAM is faster than SDRAM and consumes lesser power. So bonus for BBB.
GPU	VideoCore IV with 1080p video encoder/decoder for H.264, MPEG2 and VC1	PowerVR SGX530 and no video encoder/decoder	R-Pi can play 1080p Full HD videos smoothly, but BBB can't. BBB should be able to play 480p/720p videos decently.
Storage	SD card slot	2 GB onboard eMMC Flash storage and a micro SD card slot	BBB can run OS from its onboard Flash and its micro SD card can be used for additional storage (optional). For R-Pi, it needs an external SD card to boot up.
Ethernet	10/100 M	10/100 M	Both offer similar performance.
USB	2 host ports	1 client / 1 host port(s)	2 host ports in R-Pi ensure that a USB keyboard and a USB mouse can be connected directly,

			which is not possible in BBB. For BBB, an external USB hub might be necessary.
Video	HDMI (1080p), Composite	Micro HDMI (1280×1024 max)	R-Pi has standard HDMI along with Composite RCA (AV) output supporting Full HD, whereas BBB has a micro HDMI port with limited resolution and lacks AV port.
Audio	Via HDMI, 3.5mm audio jack	Via HDMI only	A major limitation in BBB, extra hardware may be required for BBB to output audio without HDMI.
Power	Micro USB 5v or GPIO header; 322 mA when idle. Rated at 700 mA	Micro USB 5v, GPIO header or DC jack as well, 210-460 mA when idle	BBB has an option to be powered up via a DC adaptor along with the choice for USB. If more load is connected to the boards (like USB keyboard and mouse), it is suggested to go for higher current rated power sources (like 1A or so).
Peripherals	8 GPIO pins, PWM, SPI, I2C, USART, CSI (Camera Serial Interface), DSI (Digital Serial Interface)	65 GPIO pins, SPI, I2C, USART, CAN, Timers, Analog, LCD, PWM	No match for BBB here! Unless you want to connect a camera module through the CSI port, BBB offers a lot more opportunities to hack.
OS Support	Linux (supporting ARMv6)	Linux, Android	Ubuntu cannot run on R-Pi since it supports hardware with ARMv7 or higher. BBB is universal in this regard and has a lot of options.

So it is clear that BeagleBone Black has much more to offer than the Raspberry Pi, and that too for $45 only! To summarize, BeagleBone Black has a better and faster processor and RAM, internal flash storage, an Ethernet port, a DC power jack, an excellent OS support with nearly all flavors of Linux and Android running on it and lots of possibilities for **hardware hacking**. On the flip side, it loses to Raspberry Pi as a **teaching/learning resource** and a **media center** with limited video resolution and missing AV output and single USB port. And as far as the online resource and community is concerned, both are satisfactory. You will never be lost with any of these devices, you can always get help online! Slowly, maxEmbedded will also turn into one of the resources for them!
So to end this comparison, I would like to state that both the devices are meant for different purposes. Raspberry Pi is primarily aimed at **education**, whereas BeagleBone Black is meant for **developers**. If you want to make an application involving a media center or GUI, Raspberry Pi is the best. If you want to make a good embedded systems or robotics based project, BeagleBone Black would suit your needs, and prove even more powerful than the Arduino! Hey wait, now what's Arduino? A new term, or rather a new device! We'll see it in the next post!

Summary

Now this is more than enough for one single post! Let's summarize what we discussed in this post:

- We discussed about the basics of single board computing along with their practical implementations and examples.
- Then we discussed about Raspberry Pi, which is a single board computer, and its features.
- Then we checked out the Beagles – a family of four single board computers – BeagleBoard, BeagleBoard xM, BeagleBone and BeagleBone Black.
- Then we saw BeagleBone Black in detail.
- Finally we ended with a comparison between Raspberry Pi and the BeagleBone Black.

Source: http://maxembedded.wordpress.com/2013/07/02/introduction-to-single-board-computing/