Systems Programming

Lecture 4 Introduction to RaspberryPi

Overview

Last Time

- Stat System Call
- Compiling, knowing Linux tools, etc

Today

- Introduction To RaspberryPi
- Final Task Using RaspberryPi

Readings

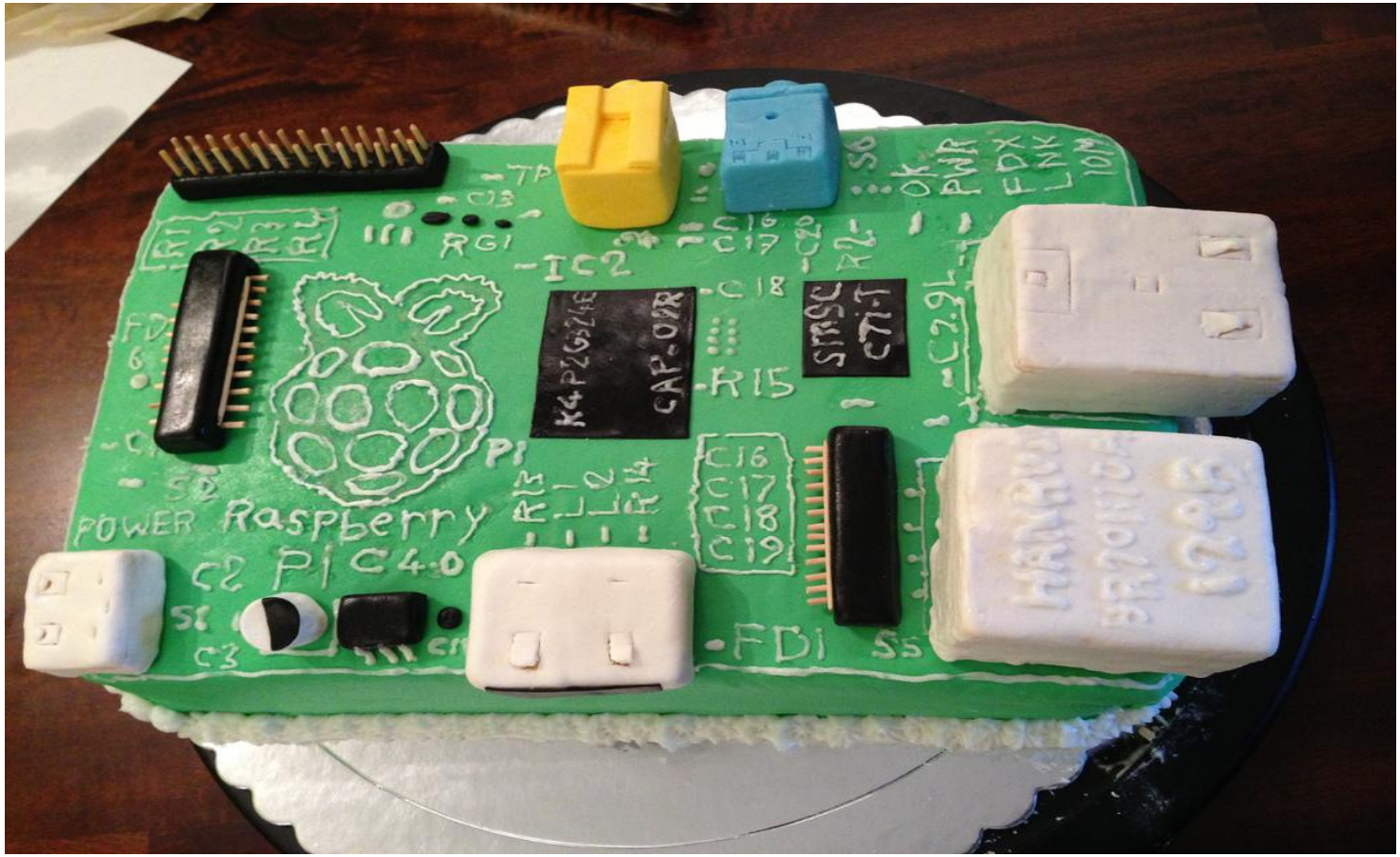
- Getting Started With RaspberryPi
- Raspberry Pi User Guide by Eben Upton
- RaspberryPi Online Resources

What We Will Covered Today :

- **Introduction to Raspberry Pi**
  - *Raspberry Pi is not about computing, but it's about how ideas can be implemented*
- **Emulating Raspberry Pi On QEMU For Sandboxing & Testing Purposes**

What is Raspberry Pi look like ?

Well it's look like this delicious cake. Always make your *creative side* hungry

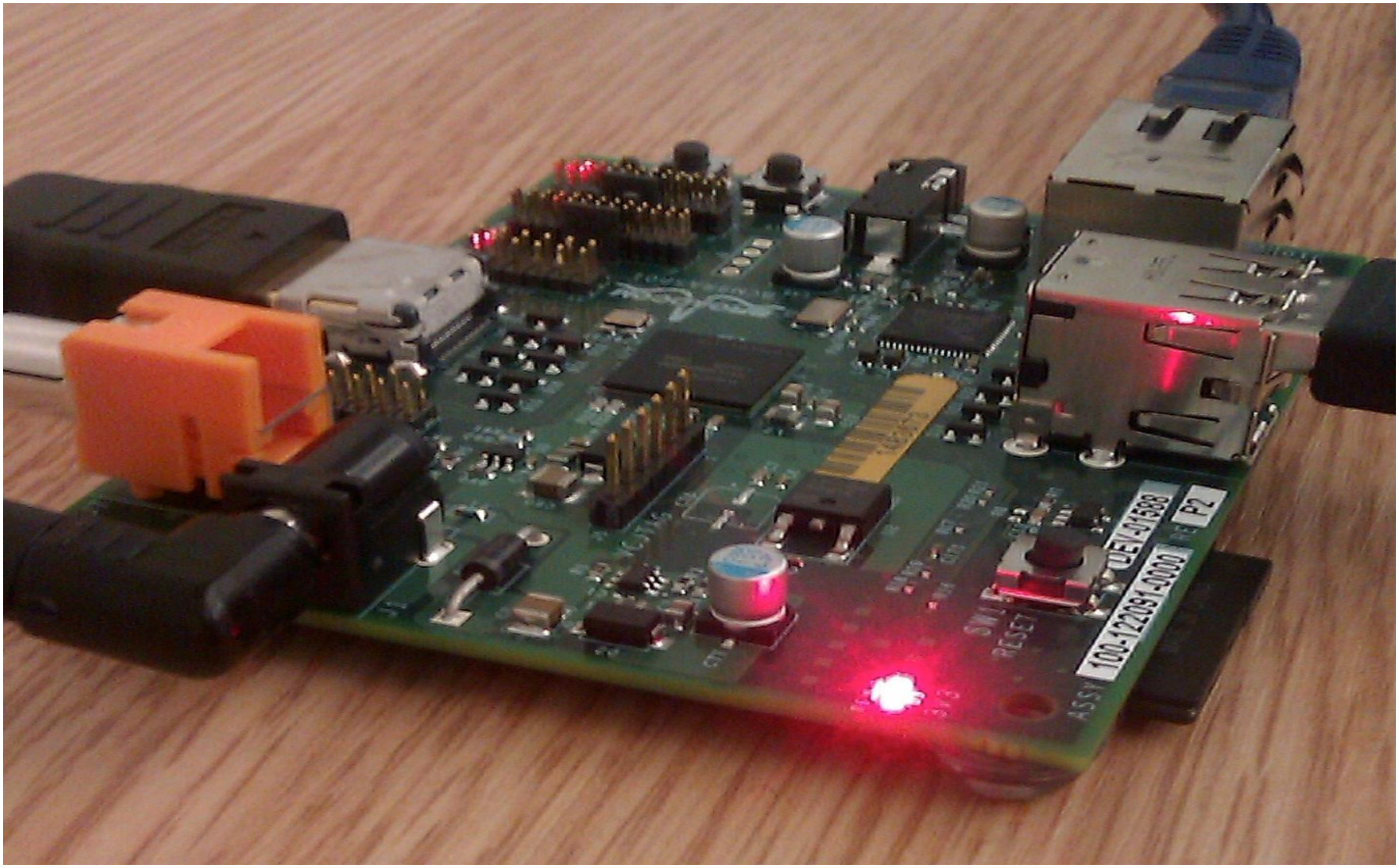


History of Raspberry Pi

Raspberry Pi is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation

- The prototype development was started back in 2006 by Eben Upton, PhD. He is a Technical Director of ASIC Chip Design at Broadcom and Visiting Researcher at Intel.
- It purpose was to encourage children to learn programming and Computer Science
- Nowadays, it becomes a toy for your creative mind and also implementation tool for creator
- It’s not about computing , but it teaches us how ideas can be implemented

Raspberry Pi Alpha Board



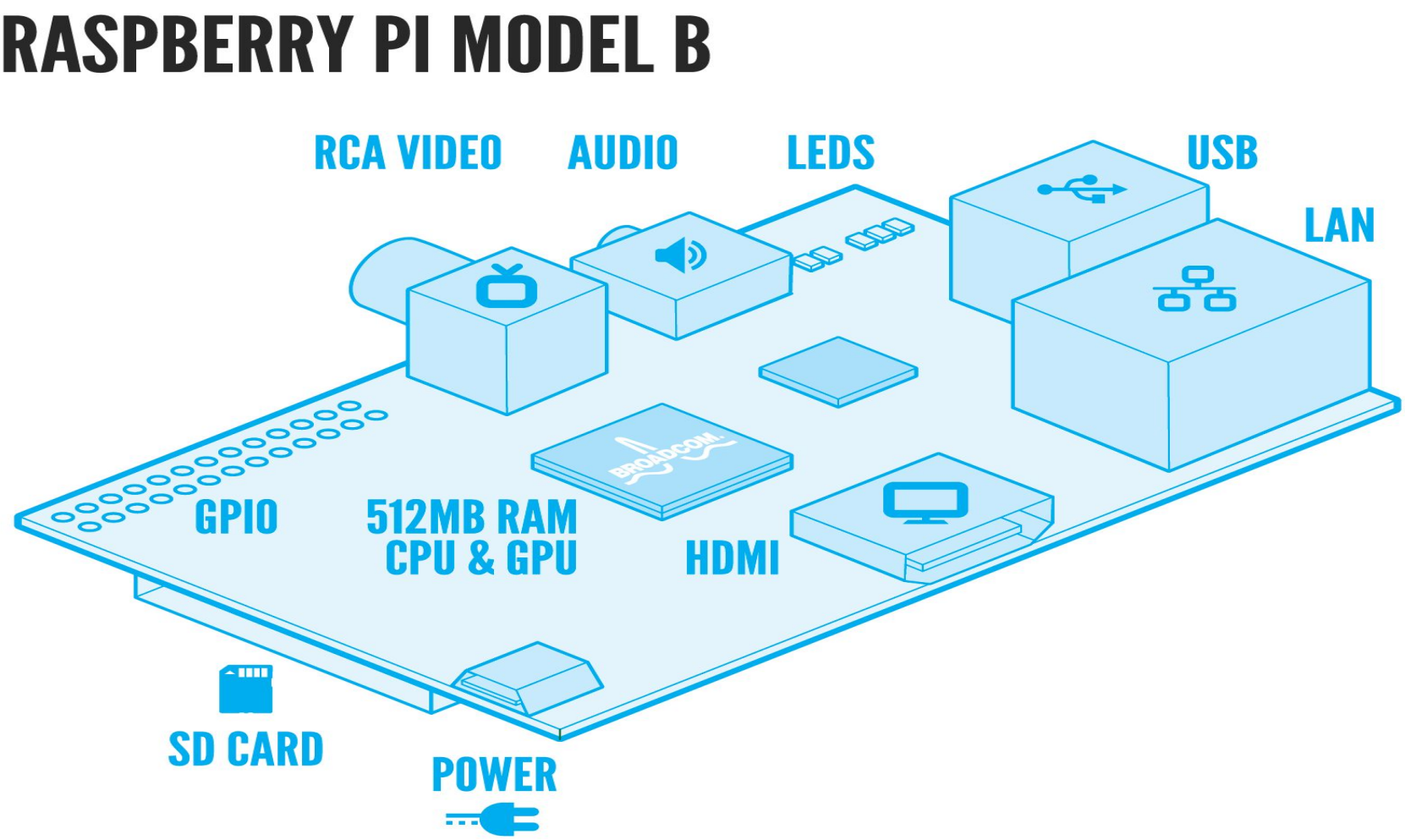
Raspberry Pi Specification

	Model A	Model B
Target price:[8]	US$ 25	US$ 35[75]
SoC:[8]	Broadcom BCM2835 (CPU, GPU, DSP, SDRAM, and single USB port)[3]	
CPU:	700 MHz ARM1176JZF-S core (ARM11 family, ARMv6 instruction set)[3]	
GPU:	Broadcom VideoCore IV @ 250 MHz[76][77] OpenGL ES 2.0 (24 GFLOPS) MPEG-2 and VC-1 (with license[73]), 1080p30 h.264/MPEG-4 AVC high-profile decoder and encoder[3]	
Memory (SDRAM):	256 MB (shared with GPU)	512 MB (shared with GPU) as of 15 October 2012
USB 2.0 ports:[15]	1 (direct from BCM2835 chip)	2 (via the built in integrated 3-port USB hub)[68]
Video input:	A CSI input connector allows for the connection of a RPF designed camera module[78]	
Video outputs:[8]	Composite RCA (PAL and NTSC), HDMI (rev 1.3 & 1.4),[79] raw LCD Panels via DSI[80][81] 14 HDMI resolutions from 640×350 to 1920×1200 plus various PAL and NTSC standards.[82]	
Audio outputs:[8]	3.5 mm jack, HDMI, and, as of revision 2 boards, I²S audio[83] (also potentially for audio input)	
Onboard storage:[15]	SD / MMC / SDIO card slot (3,3V card power support only)	
Onboard network:[8][15]	None	10/100 Ethernet (8P8C) USB adapter on the third port of the USB hub[68]
Low-level peripherals:	8 × GPIO,[84] UART, I²C bus, SPI bus with two chip selects, I²S audio[85] +3.3 V, +5 V, ground[76][86]	
Power ratings:	300 mA (1.5 W)[87]	700 mA (3.5 W)
Power source:[8]	5 volt via MicroUSB or GPIO header	
Size:	85.60 × 53.98 mm (3.370 × 2.125 in)[88]	
Weight:	45 g (1.6 oz)[89]	
Operating systems:	Arch Linux ARM,[2] Debian GNU/Linux, Fedora, FreeBSD, NetBSD, Plan 9, Raspbian OS, RISC OS,[32] Slackware Linux[90]	

Raspberry Pi Specification

Comparison chart :
https://www.element14.com/community/docs/DOC-82195/l/raspberry-pi-models-comparison-chart-poster-free-download

Model B Configuration Example

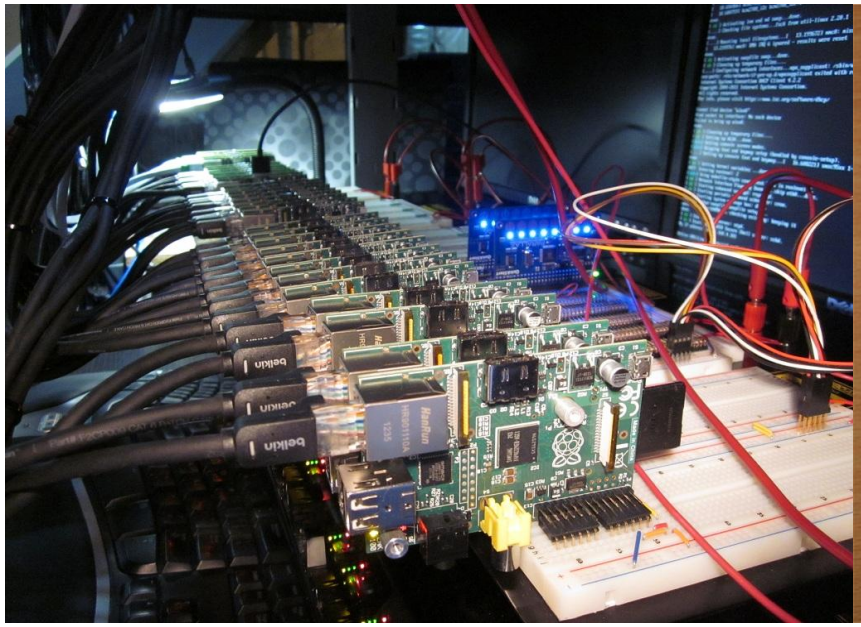


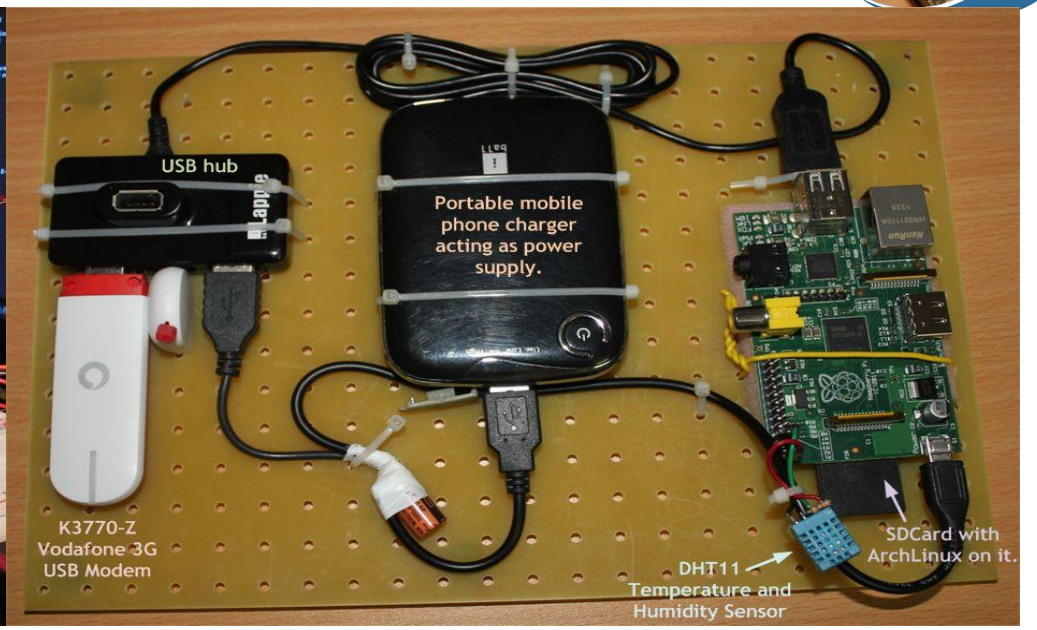
Ideas with Raspberry Pi

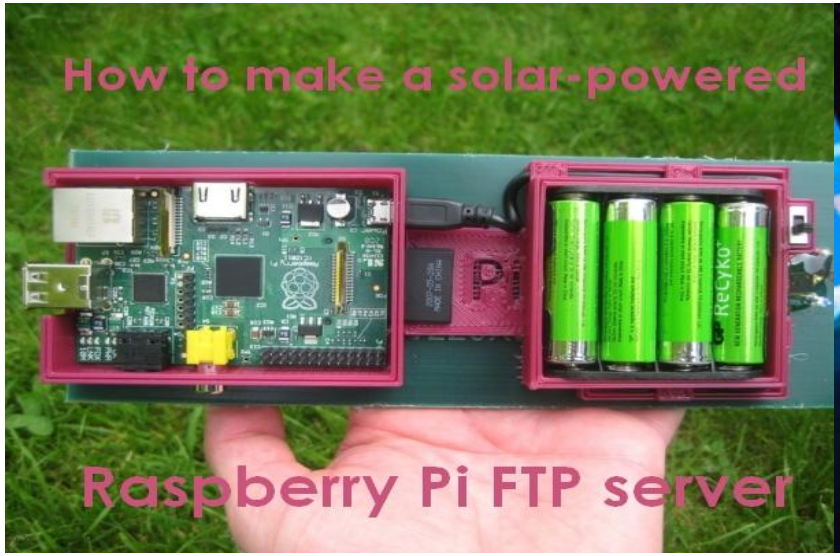
You can turn Raspberry Pi into :

1. Home Media Center
2. Home Security Center
3. FM Radio Transmitter
4. Robot Control Board
5. Home Automation & Smart Home
6. Cloud Computing Nodes
7. High Altitude Weather Monitoring Balloon
8. And many many more…

Ideas with Raspberry Pi







Raspberry Pi Resources

1. http://elinux.org/RPi_Hub

   Varieties of Documentation including kernel compilation, add on hardware

2. http://www.raspberrypi.org/

   Raspberry Pi Foundation Official Sites

3. http://raspi.tv/

   Raspberry Pi Tutorial on Videos

4. http://www.themagpi.com/

   Raspberry Pi Monthly Magazine

Raspberry Pi Resources

1. http://makezine.com/2013/04/14/47-raspberry-pi-projects-to-inspire-your-next-build/
    a. Inspiring Ideas

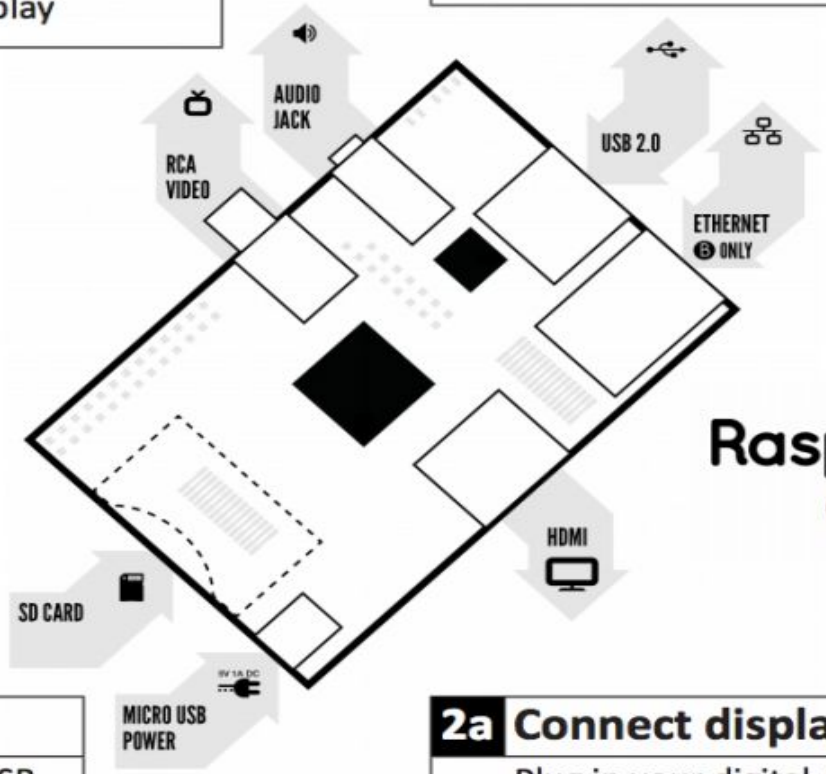
Raspberry Pi Resources

2b Connect display

If *not* using HDMI, plug in your analogue TV or display

3 Connect input

Plug in a USB keyboard and mouse



4 Connect network

Connect to your wired network [optional]

Raspberry Pi
Quick start

1 Insert SD card

See page 3 for how to prepare the SD card

5 Power up

Plug in the micro USB power supply

2a Connect display

Plug in your digital TV or monitor

Raspbian GNU/Linux

- Raspbian GNU/Linux is a free Operating System for Raspberry Pi.
- It is a port from Debian GNU/Linux targeted specially on Raspberry Pi ARM Architecture
- It comes with over 35,000 packages, pre-compiled software bundled in a nice format (using Debian Packages) for easy installation on your Raspberry Pi.
- Latest Raspbian is built using Debian Stretch 9.0

Obtaining Raspbian

You can obtain Raspbian Disk Images from Raspbian Mirror Site :

- http://downloads.raspberrypi.org/raspbian_latest
- https://projects.ui.ac.id/attachments/7322/2013-09-25-wheezy-raspbian.zip
- http://kambing.ui.ac.id/tonny/sysprog_2017/rpi/2017-08-16-raspbian-stretch.zip

Emulating Raspberry Pi

For Development Purposes , we can try to emulate Raspberry Pi using Virtual Machine.

Raspberry Pi is using ARM Architecture Processor, so we can not run its OS on Virtual Box.

You will need a Virtual Machine which can emulated ARM Instruction Set on top of x86 Processor : *QEMU* .

But you still can not emulated Raspberry Pi GPIO !

Obtaining QEMU

For GNU/Linux on Debian and Ubuntu derivatives, you can do this to install QEMU :

- On Debian : $sudo apt-get install qemu qemu-system qemu-utils
- On Ubuntu : $sudo apt-get install qemu qemu-system qemu-utils qemu-kvm-extras

For M$ Windows :

- Obtain QEMU Binaries and install it
- https://projects.ui.ac.id/attachments/7366/qemu-w32-setup-20131101.exe

Virtual Raspbian using Qemu

Note : this guides use raspbian wheezy (2013)

1. Download Raspbian Image http://kambing.ui.ac.id/rpiimages/raspbian/2013-09-25-wheezy-raspbian.zip
2. Download linux kernel for qemu
3. Qemu Installation

$ sudo apt-get install qemu-system

4. Qemu directory for raspberry pi

$ mkdir ~/qemu_vms/

5. Download/copy Raspbian Wheezy to ~/qemu_vms/
6. Download kernel-qemu to ~/qemu_vms/

Virtual Raspbian using Qemu

7. File Information

$ file ~/qemu_vms/2013-09-25-wheezy-raspbian.img

2013-09-25-wheezy-raspbian.img: x86 boot sector; partition 1: ID=0xc, starthead 130, startsector 8192, 114688 sectors; partition 2: ID=0x83, starthead 165, startsector 122880, 5662720 sectors, code offset 0xb8

8. Mounting the image into /mnt

$ sudo mount ~/qemu_vms/2013-02-09-wheezy-raspbian.img -o offset=62914560 /mnt

9. Edit the ld.so.preload file

$ sudo nano /mnt/etc/ld.so.preload

Comment out the line in the file (use a # as the first character of the line) and save the file (CTRL+X, then "Y" for yes).

10. Unmount the /mnt

$ sudo umount ~/qemu_vms/2013-02-09-wheezy-raspbian.img /mnt

11. $ cd ~/qemu_vms/

Virtual Raspbian using Qemu

10. Execute the qemu

$ qemu-system-arm -kernel kernel-qemu -cpu arm1176 -m 256 -M versatilepb -no-reboot -serial stdio -append "root=/dev/sda2 panic=1" -hda ~/qemu_vms/2013-02-09-wheezy-raspbian.img -redir tcp:5022::22

11. Qemu gives you a root shell, run:

$ fsck /dev/sda2

12. Restart the qemu

$ shutdown -r now

13. Login into The System

Login as pi

Password raspberry

Running Raspbian on QEMU

Make a work directory and download all necessaries image

- $mkdir emulator
- $wget \ https://projects.ui.ac.id/attachments/7322/2013-09-25-wheezy-raspbian.zip
- $wget https://projects.ui.ac.id/attachments/7367/kernel-qemu

The last item in download list is optimized ARM kernel image for QEMU from (initially) XecDesign. Now : https://github.com/dhruvvyas90/qemu-rpi-kernel

Running Raspbian on QEMU

First Setup ON QEMU, we need to modify several things such as unload unnecessary library and adjusting block device path.

- **First Boot on GNU/Linux**
  - $qemu-system-arm -kernel kernel-qemu -cpu arm1176 -m 256 -M versatilepb -no-reboot -serial stdio -append "root=/dev/sda2 panic=1 rootfstype=ext4 rw init=/bin/bash" -hda 2013-09-25-wheezy-raspbian.img
- **First Boot on M$ Windows**
  - C:\>qemu-system-armw.exe -kernel kernel-qemu -cpu arm1176 -m 256 -M versatilepb -no-reboot -serial stdio -append "root=/dev/sda2 panic=1 rootfstype=ext4 rw init=/bin/bash" -hda 2013-09-25-wheezy-raspbian.img
- **See the github wiki : command for recent raspbian**

Running Raspbian on QEMU

- **Unload unnecessary libraries :**
  - $sudo nano **/etc/ld.preload**
  - Put a # in front of the first line so that it looks like this:
  - #/usr/lib/arm-linux-gnueabihf/libcofi_rpi.so

- **Adjusting block device path so it will consistent with the real Raspberry Pi**
  - $sudo nano **/etc/udev/rules.d/90-qemu.rules**
  - Put these lines as its content
  - KERNEL=="sda", SYMLINK+="mmcblk0"
  - KERNEL=="sda?", SYMLINK+="mmcblk0p%n",

Some notes on Raspbian (on QEMU)

- ALSA function for sound card is still problematic
- expand_rootfs will not work on QEMU. You will get at about 890 MB of free spaces on emulated disk.
- If you need more space, you can increase disk image size using qemu-img .
  - $qemu-img resize 2013-09-25-wheezy-raspbian.img +1G
- After that you can resize the partition size after you start up qemu again using fdisk and resize2fs

Raspbian First Boot

On its first boot, Raspbian will start raspi-config tool for initial configuration.

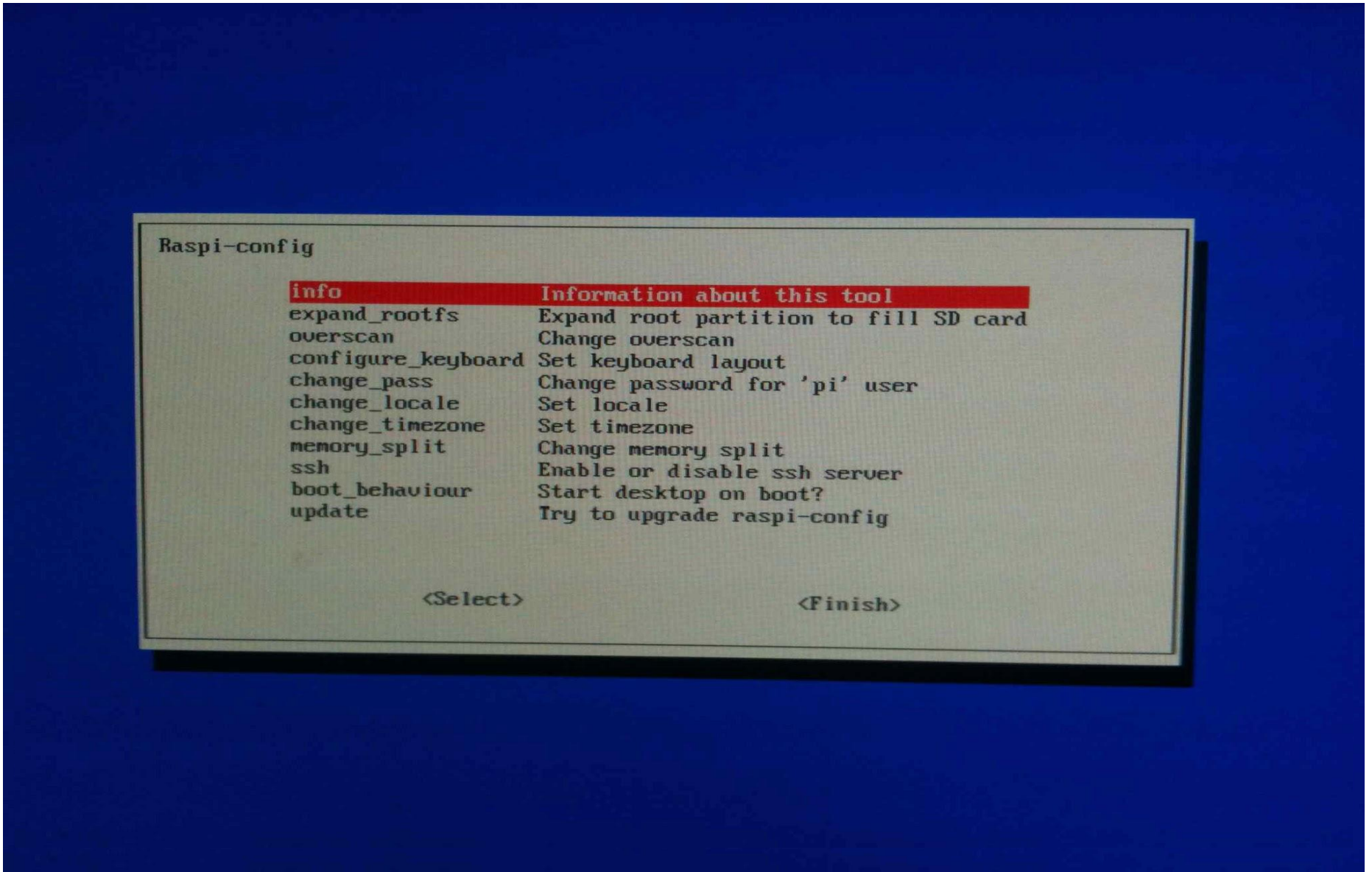
Here are some important configurations you can do with raspi-config :

- **expand_rootfs**
  - expanding Raspbian root partition to use entire SDCARD
- **configure_keyboard**
  - Raspbian default keyboard layout is Great Britain. You can change it into International Keyboard
- **change_locale**
  - Set system wide locales and language

Raspbian First Boot

- **overclock**
  - boost your Raspberry Pi into maximal 1 Ghz clock
  - WARNING : Use with caution
- **configure_timezone**
  - set Raspberry Pi timezone
  - Raspberry Pi does not have Real Time Clock (RTC) chip, so you must use Network Time Server (eg ntp.ui.ac.id) in order to get reliable time source
- **memory_split**
  - set CPU/GPU memory split
- **ssh**
  - enable or disable SSH server on boot

Your First Initial Setup : raspi-config



Repository Setup

```
$sudo nano /etc/apt/sources.list
```

……..

deb http://kambing.ui.ac.id/raspbian/raspbian wheezy main contrib non-free

deb-src http://kambing.ui.ac.id/raspbian/raspbian wheezy main contrib non-free

…….

$sudo apt-get update && apt-get upgrade

Example of Packages Instalation

Install and Using vim as your editor

- $sudo apt-get install vim
- $sudo update-alternatives --config editor

Using ntpdate to obtain time information from network time server

- $sudo apt-get install ntpdate
- $sudo ntpdate ntp.ui.ac.id

Some Important Files To Remember

1. /etc/network/interfaces
   Network Configuration
1. /etc/apt/sources.list
   Repository Configuration
1. /boot/cmdline.txt
   Kernel Boot Parameter
1. /boot/config.txt
   Firmware Boot Parameter

QA