Intro to Raspberry Pi

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Raspberry Pi Models and Alternatives

- Raspberry Pi 1A, 1A+, 1B, 1B+
- Raspberry Pi 2B
- Raspberry Pi 3A+, 3B, 3B+
- Raspberry Pi 4B
- Raspberry Pi Zero, ZeroW
- RockPi
- OrangePi
- Le Potato
- Asus Tinkerboard
- Udoo Bolt
- Odroid N2+

Computer Architecture

- Processor (CPU)
- Memory (RAM)
- Persistent Storage
- Network
- Peripherals

Processor (Arm)

- What is a processor?
- What is a core?
- x86, x64, Arm32, Arm64 (Advanced RISC Machine (ARM))
- Arm reduced instruction set allows for simpler processor design and lower power usage
- What is clock speed?

Volatile Memory (RAM)

- Think sticks of memory
- Clock speed independent of processor
- Don’t forget about processor cache, e.g., L1, L2, L3 etc (speed/size tradeoff)
- “Swap Space” (MS ‘page file’)
- ECC’s + SEU’s

Persistent Storage

- AKA “the disk” (not the “disc” which is a cd)
- Can be many types of media, tapes, cd’s, various “hard drives”, SD cards, might even be over a network
- Typically considered the primary bottleneck of compute
- Classical HDD’s (spinny disks, magnetic memory)
  - A file can be at many different locations which the OS keeps track of, the head needs to locate all the parts of the file to read and write
- SSD (solid state device) + M.3 SSD’s
- Project Silica
- “RPi” → microSD
- Speed measured in Reads and Writes per second or bytes read or written per second
- Can also be constrained through cableing or interfacing to the motherboard
- Compression is typically used here due to cpu usage in compressing and decompressing data

Network

- NIC – Network interface card
- Bits or Bytes i/o per second (your isp will often measure bits) (1 byte is 8 bits)
- Often fixed to the board from the factory
- Special NIC's used in network bonding combine multiple sources – might be through adapter connection to the board

Peripherals

- GPIO
- UART
- Graphics – HDMI out
- USB
- Audio
- Bluetooth

Practical: Let’s Get Started

- Demo – Let’s use Official Raspberry Pi Imager to flash a micro-SD card
- Balena Etcher is a common tool but best to stick with official software as much as possible

Power Considerations

- Arm Power requirements allow us to be portable
- Easy to connect a battery
- Requires 5V through microUSB (might be USB-C)
- Buck converter
- Voltage regulating transistor

Cooling Options

- Newer models often overheat
- Overheating can permanently damage processor and other board components
- Three modes of heat transfer: “Convection, conduction and radiation”
- Heat sinks, fans, water cooling

Operating System Options - What's are the differences?

- Raspbian / RPi OS (a pi specific flavor of debian) – with and without GUI
- Ubuntu + Ubuntu Server
- Windows IoT Core
- Build-a-Pi - not an OS but an automated toolset suited for Ham Radio
- Fedora
- Kali – security related
- Gentoo + Arch
- FreeBSD
- RadioPi

Processor Constructs in the OS

- Kernel – part of the OS that interacts with the hardware
- Process
  - Allocated dedicated memory, some in “user land” some in “kernel land”
  - Scheduling algorithm
    - Could be purely parallel
    - Could be first come, first serve
    - Could be Round Robin
    - Could be Shortest Remaining Time (shortest average wait time per process)
    - Many others
- Context Switch
- Threads
  - Exist within a process
  - Have their own memory
  - Also context switch
- Concept of RTOS
- Services + Daemons

Raspberry Pi OS Setup By Example

Demo Ubuntu Server

Intro to Linux

- Concept of Users
- Concept of directories and structure
- Concept of files - everything in Linux is a file
- File permissions
- What are the directories and what do they do?
- Interacting with peripherals
- Resource usage
- Managing and enabling peripherals
- Installing and managing software for the Pi
- Running 'headless'
- VNC (RDP)

Linux - Users

- Think User account
- User name + password
- Set of assigned resources
- Visibility
- Resource Permissions
- “Superuser”
- Standard User
- System User
- Service account – automation
- “logname” + “whoami”
- “su <name” to change user
- “sudo passwd <username” to change users password

Linux File System - Directories

- Imagine a tree structure
- Imagine branches and leaves
- “Root Directory”
- A directory contains files and other directories
- The “Desktop” for example, exists in a certain directory location

How do we navigate the file system?

- Let's take a look at some commands and what they do
- "ls"
- "cd"
  - "cd .." takes us closer to root by one directory
- "pwd"
- "~"
- "history"
- "clear"
- "mkdir"
- The "man" pages
- <command> --help

Linux File System - Files

- Everything in Linux is a file
- Most files do one of three things
- Read, Write, and Execute
- Files also have permissions assigned to them
- They can be used as 'pipes' between processes

Linux File System – How do we interact with files?

- “less”
- “cat”
- “cp”
- “mv”
- “rm”, “rm -r”
- “touch”
- Nano + Vi
- “grep”
- “find”
- “|” pipes
- What is a ‘regex’?

File Permissions

- read (easy to multi-read at the same time)
- write (difficult to multi-write at the same time)
- and execute (./ command)
- “chmod”
- “chown
- “lsattr -l”

What are the primary directories and what do they do?

- '/' Root
- /etc/ → editable text configuration
- /bin/ → contains binaries + executables necessary to the OS
- /usr/ → binaries relevant to specific users (compile manually location) mapped to PATH
- /home/ (~) → files and software for specific users
- /tmp/ → temporary files that go away on reboot
- /var/ → Logs and cache and other volatile files
  - What are system logs and how can we use them?
- /opt/ → optional or add-on software
- /boot/ → files needed to boot the system
- /dev/ → device files, (e.g., sda and sda1 are your disks)
- /lib/ → common software libraries
- /media/ → tries to auto attach devices for you
- /mnt/ → e.g., plugin a usb and it gets mounted to media
- /proc/ → created by kernel to keep track of running processes
- /run/ → used for system startup
- /sys/ → provides an interface to the kernel
- /srv/ → website specific information when hosting a webserver
- /sbin/ → system binaries only executed by root user
- symlinks

Interacting with Peripherals

- "lsusb"
- "lsusb -t"
- "ls /dev/*USB*"
- "ls /dev/ttyUSB0"
- "dmesg | grep "tty""

Managing System Resources
The Processor

- “top”
- “ps”, “ps -ef”, “ps -aux”
- “ps -ef | grep …”
- “ps -p”
- “top -H”
- “lscpu”
- “cat /proc/type_PID_here/status”
- “htop”
- “kill”, “kill -9”

Managing System Resources
Memory

- “free”
- “htop”
- “cat /proc/meminfo”

Managing System Resources
Disk usage

- “du -sh”
- “df -H”

Managing System Resources
Processor Temperature

- “cat /proc/cpuinfo”
- “vcgencmd measure_temp”

Managing System Resources
Network

- May require installing “net-tools”
- “ifconfig”
- “enthool”
- “netstat”
- “ping”
- “telnet”
- “mtr”
- “traceroute”
- “nslookup”, “dig”, “host”
- “tcpdump”
- “Arp” (Address Resolution Protocol)
- “ss” – network statistics
- “iftop”

Useful Commands

- “tee”
- “tail”
- “ctrl-c”
- “ctrl-z”
- “sudo”
- “printenv”
- “tar” + “zip” + “unzip”
- “which”
- “whatis <command>”
- “sudo !!”
- “wget” + “curl”
- “diff” (compare 2 files)
- “sort” (cat filename | sort)

Managing and enabling peripherals

- “sudo raspi-config”
- Enabling SSH
- Enabling RDP
- Enabling overclocking
- Enabling camera
- Enabling SPI
- Enabling I2C
- Enabling 1-Wire
- Enabling Remote GPIO

Installing and managing software for the Pi

- “cat /etc/os-release”
- “apt”, “apt-get”, “apt-get upgrade”, “apt-get update”
- sudo apt-get install <package>
- sudo rpi update
- sudo shutdown -r now, sudo reboot
- Why do we do this? What is the SDLC?

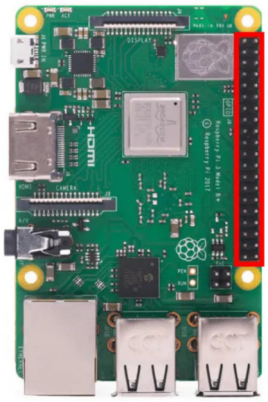
Running 'headless'

- SSH
  - What does it do?
  - SSH from a windows machine
    - using powershell
    - using PuTTY
- VNC
  - 'Remote desktop'

What are some other things that I can do?

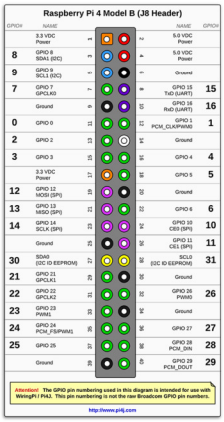
- Bourne and Bash shell scripting for automation
- Cron introduction for scheduled tasks
  - https://www.freeformatter.com/cron-expression-generator-quartz.html
- Let’s ask ChatGPT (www.chat.openai.com/chat)

Introduction to the GPIO interface



Raspberry Pi 3 B+ GPIO Header

Pin#	NAME		NAME	Pin#
01	3.3v DC Power		DC Power 5v	02
03	GPIO2 (SDA1 , I²C)		DC Power 5v	04
05	GPIO3 (SCL1 , I²C)		Ground	06
07	GPIO4 (GPIO_GCLK)		(TXD0) GPIO14	08
09	Ground		(RXD0) GPIO15	10
11	GPIO17 (GPIO_GEN0)		(GPIO_GEN1) GPIO18	12
13	GPIO27 (GPIO_GEN2)		Ground	14
15	GPIO22 (GPIO_GEN3)		(GPIO_GEN4) GPIO23	16
17	3.3v DC Power		(GPIO_GEN5) GPIO24	18
19	GPIO10 (SPI_MOSI)		Ground	20
21	GPIO9 (SPI_MISO)		(GPIO_GEN6) GPIO25	22
23	GPIO11 (SPI_CLK)		(SPI_CE0_N) GPIO8	24
25	Ground		(SPI_CE1_N) GPIO7	26
27	ID_SD (I²C ID EEPROM)		(I²C ID EEPROM) ID_SC	28
29	GPIO5		Ground	30
31	GPIO6		GPIO12	32
33	GPIO13		Ground	34
35	GPIO19		GPIO16	36
37	GPIO26		GPIO20	38
39	Ground		GPIO21	40



Over the wire protocols

- UART
- SPI
- I2C
  - https://www.circuitbasics.com/basics-of-the-i2c-communication-protocol/
  - What are some common things that use i2c?
  - How can we wire up i2c with the gpio pins of the pi?
- RS-232
- TTL

GPIO Interaction

- How can we manually trigger hi's and low's with CLI?
- “raspi-gpio” get prints the state of all GPIO pins
- “raspi-gpio get X” prints the state of GPIO pin X
- “raspi-gpio set X op” sets GPIO pin X as an output
- “raspi-gpio set X dh” sets GPIO pin X to drive high
- “raspi-gpio set X dl” sets GPIO pin X to drive low
- How can we trigger hi’s and low’s programmatically?
  - Let’s ask ChatGPT to give us an example
  - Does it work?

Ham Radio Related Programs

- Direwolf
- AX.25 + Linpac
- Winlink
- Hamlib
- FLRig
- YAAC + Xastir (APRS)
- LinBPQ
- WSPR
- WSJT-X + JTDX + JS8Call
- Wireshark
- D-Rats
- Telnet
- zyGrib
- QSSTV
- GQRX
- VOACAP
- Chirp
- QTel
- Gpredict
- wxtoimg
- Acfax + hamfax
- fbb
- Linpsk
- multimon

Demo: Let's install Direwolf as an example...

- What is a software TNC vs hardware TNC, what are the differences?
- What is the KISS and AGWPE protocol and how does it differ from AX.25?
- Now that we have Direwolf installed and configured, let's install Pat Winlink
- Let's hookup our signalink tnc device and our radio
  - interoperability of signalink usb device
  - mobilinkd tnc
  - Soundmodem
  - Dale's device
- Let’s try and connect to Gary's gateway with everything wired up and send an email

Demo Part 2

- Let's schedule some automation with cron