Why-Pi

Why and how the Raspberry Pi came to be

Prepared for Jaycar Maker Hub (Sydney)
Raspberry Jam, 14th March 2020

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Raspberry Pi turns 8! + *gestation period of 4 years*

I had the pleasure of working alongside Jack Lang at large telco in the UK in the late 1990s - Jack is one of the founders and (retired) trustee of the Raspberry Pi foundation

I've also worked with the Raspberry Pi on various projects over the years including some, where I actually got paid!

I'm sharing some of Jack's story and will try and answer questions about the device, how the software works and maybe help you make it do whatever you want it to do

Come to the Jaycar Maker Hub (Central Park, Sydney)

This will be presented at the Raspberry Jam session at **2pm** on **14th March** - grab a free ticket on Eventbrite

RASPBERRY JAM

Raspberry Pi - what's that?

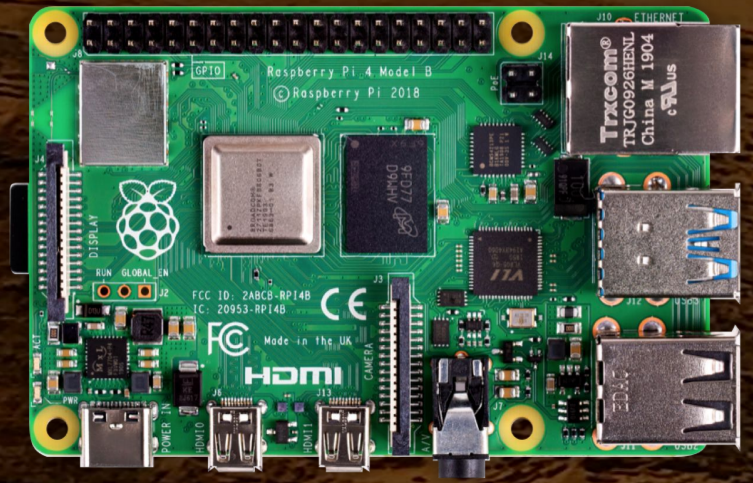
It's an affordable home computer ~ size of a credit card $35

More so, it's just the guts of a personal computer - with the intention you'll take that and go make it whatever you want

It's *real* purpose is **educational**

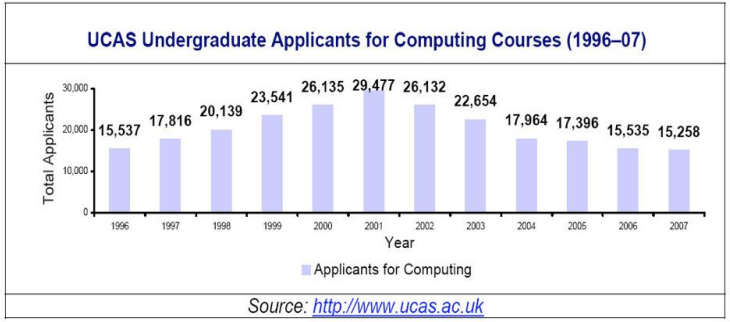
30 million have been sold worldwide since February 2012!

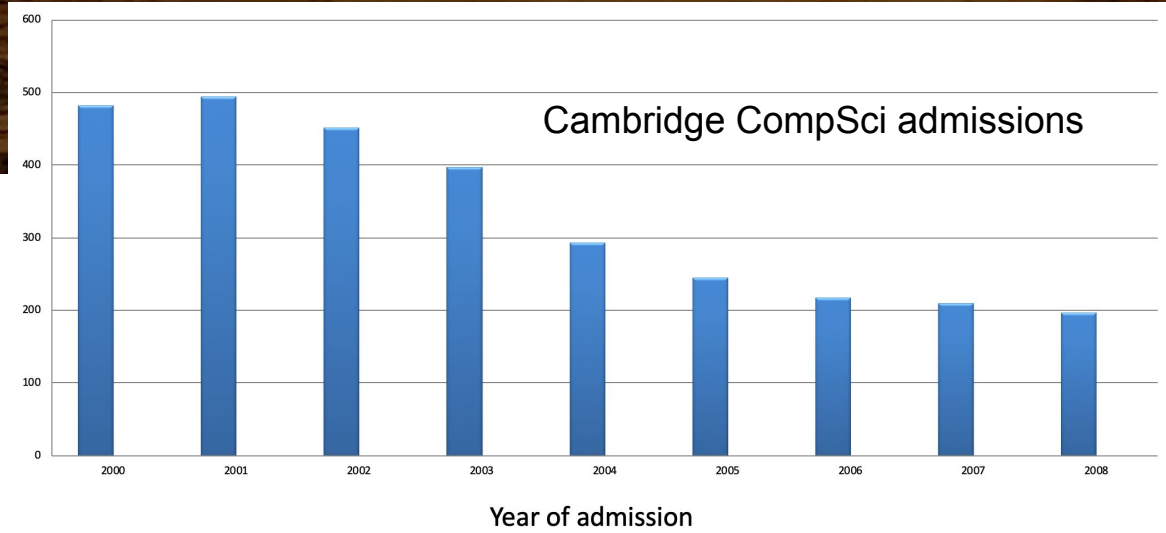
This is their story...



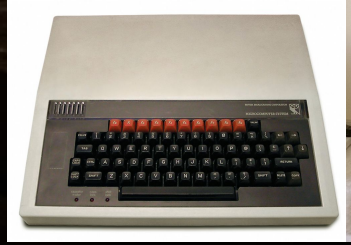
In the beginning...

The University of Cambridge department of Computer Science and Technology had a problem
The student numbers were dropping off and their initial general knowledge and experience was lower





What changed?



In part this was due to how computing was approached in the 80s/90s vs today - kids like me used to actually enjoy programming on the Sinclair ZX80/ZX Spectrum / Electron at home and the BBC Micro / Acorn Archimedes at school

```
  10 PRINT "© 2007 Pyrmont Brewe
ry"
  15 PRINT ""
  16 PRINT ""
  18 PRINT "Program:"
  20 PRINT "Half Way"
  30 PRINT "House"
  40 PRINT "Chocolate"
  50 PRINT "Stout"
  60> GO TO 10

RUN
```

R Tape loading error, 0:1

Who's to blame?

Not entirely fair to pick on individuals but basically *closed* devices like games consoles, phones and tablets come with significant obstacles and a steep learning curve to get to a point where you can actually be programming them

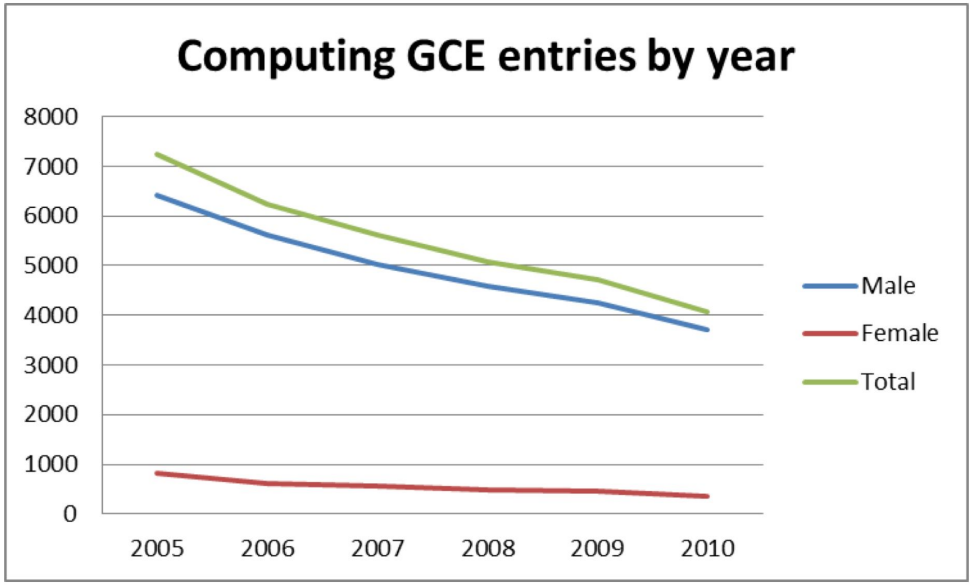
"To gain access to a command line, you have to download software, It has to ***occur to you*** *to do it."* [Mullins]

Why that's not so good...

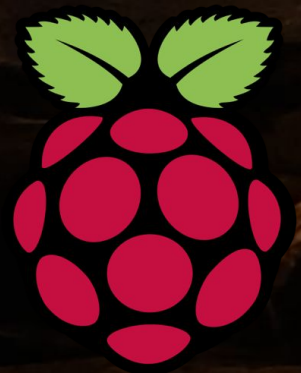
This all leads to *less enthusiasm* in the subject and some complacency that everything kind of seems ok in the industry

I myself was the only candidate to sit the (HSE equiv) exam in my school

I wasn't really taught programming/coding that was largely up to me



Raspberry Pi Foundation to the rescue!



“promote the study of computer science and related topics, especially at school level, and to put the fun back into learning computing”

UK registered charity (1129409)

Not for profit! *Income* ***£31.5M*** *- Spending* ***£27.9M***

(31 December 2018)

Raspberry Pi Foundation - who are they

Today ~ 135 people but in Feb 2008 **Jack Lang** wrote the π manifesto - *meanwhile* - **Eben Upton** had been experimenting with low cost designs *(with Broadcom)* and **David Braben** was thinking about educational software to increase the flow of games programmers *(he wrote Elite)*

The six trustees of the charity we really must thank are (Dr's):
Jack Lang, **Eben Upton CBE**, **David Braben OBE**,
Prof Alan Mycroft, **Rob Mullins** + **Pete Lomas FReng**

Raspberry Pi Foundation - who are they

PiPeople

Alan Mycroft
Eben Upton
Rob Mullins
Pete Lomas
Jack Lang
Dave Braben

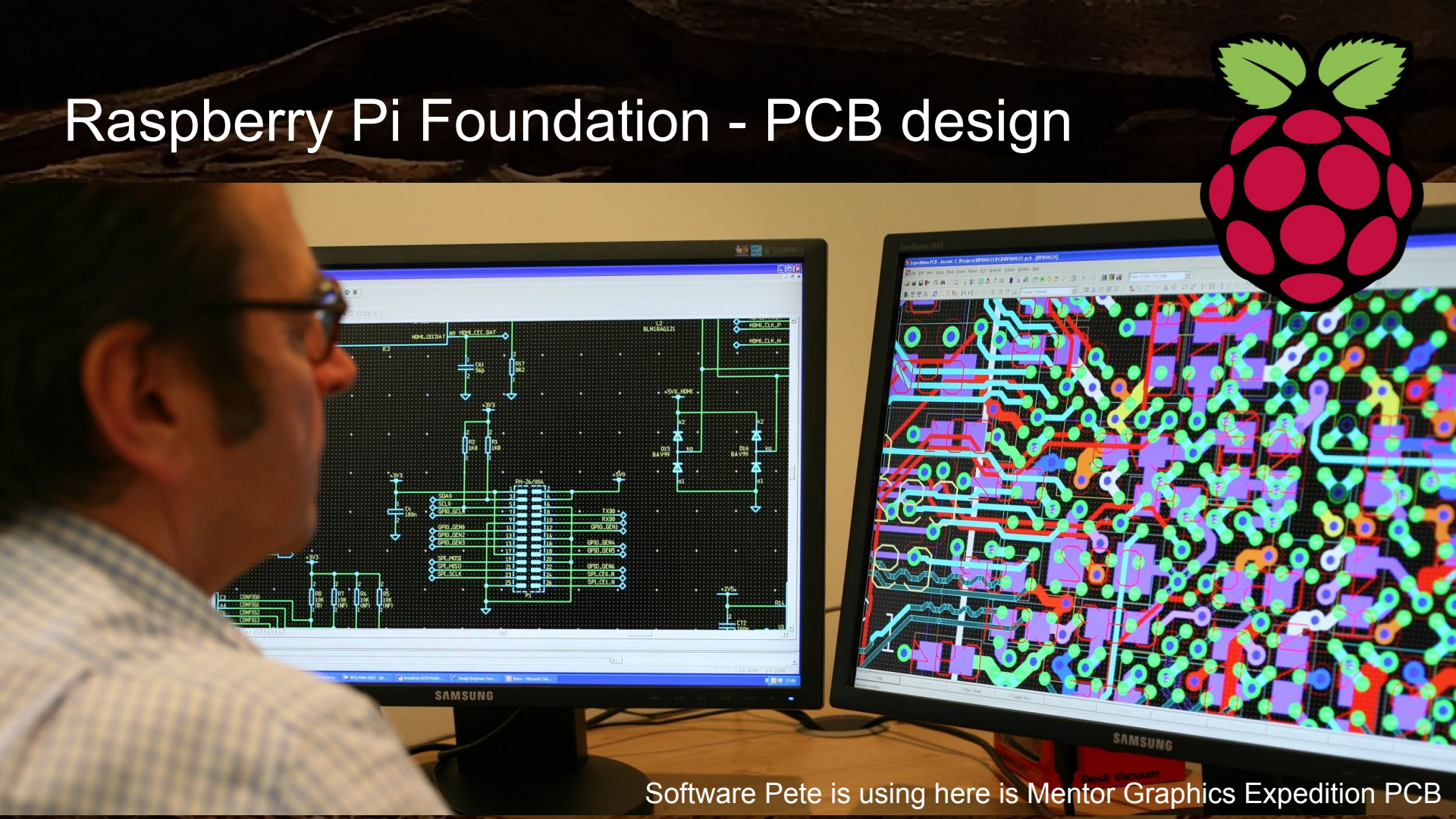
Raspberry Pi Foundation - Jack

I worked with Jack at ntl: (Virgin Media UK) he really is quite remarkable, witty and extremely knowledgeable

Lectures
Entrepreneurship
at Cambridge University

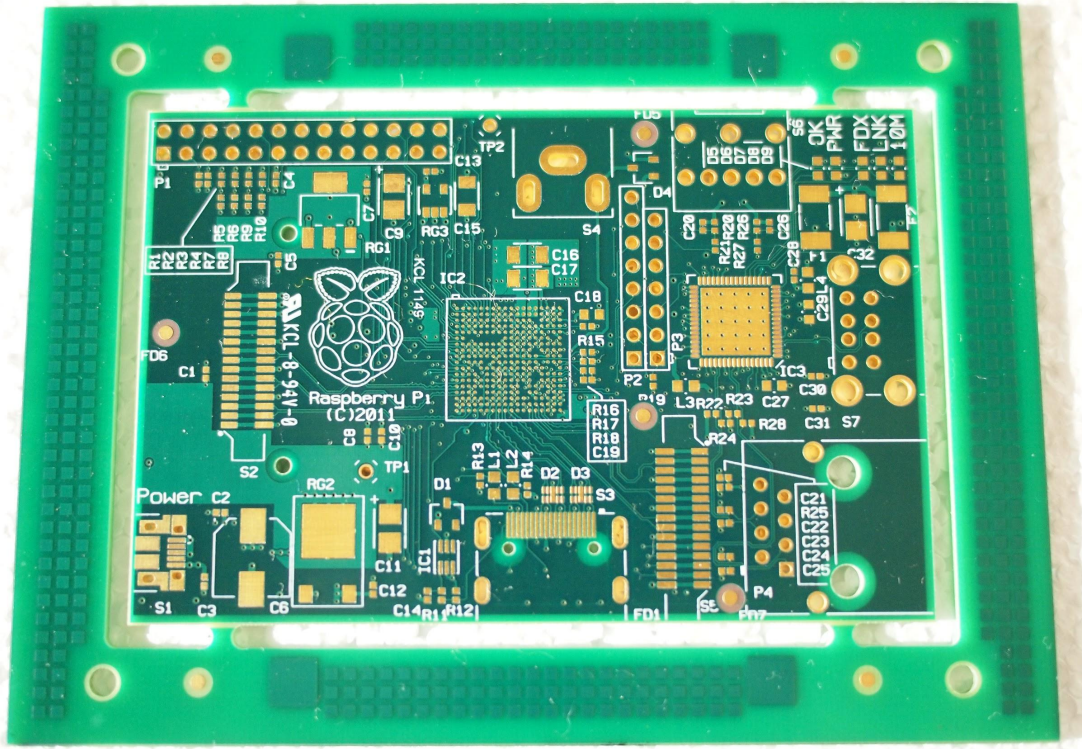
Knows bloody everyone
Has a fireworks license!
Taught me to network

Raspberry Pi Foundation - PCB design



Software Pete is using here is Mentor Graphics Expedition PCB

Raspberry Pi Foundation - first PCB born



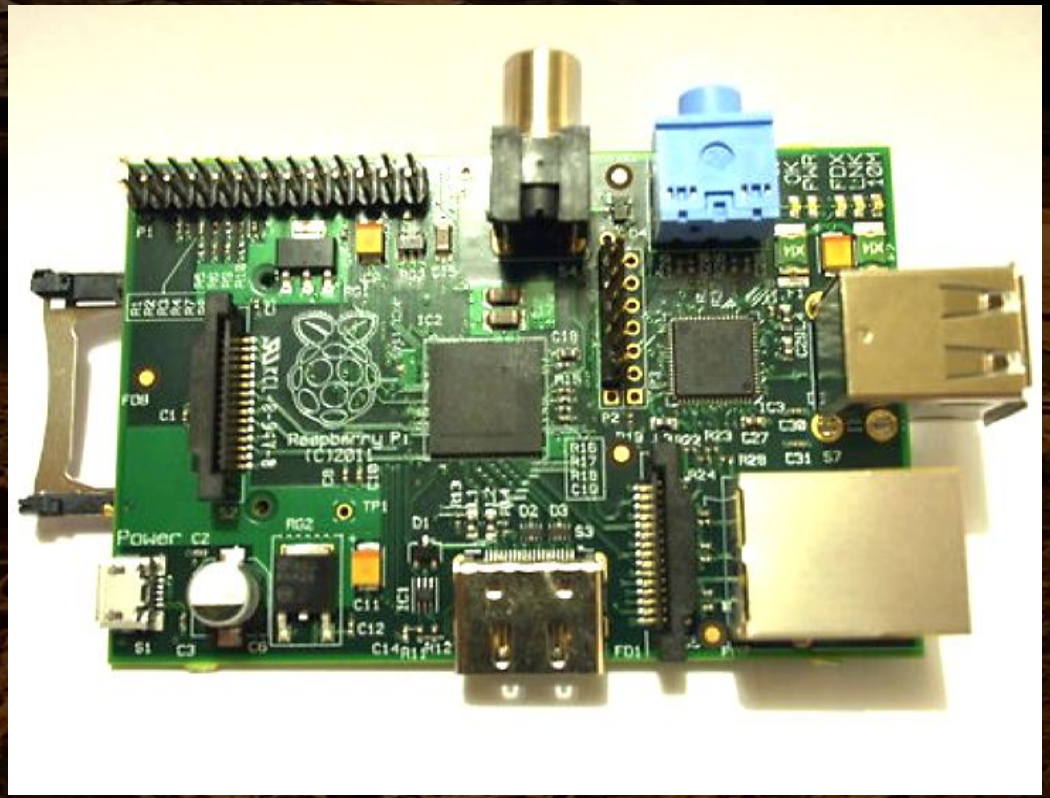
< A naked Pi

This photo is actually the **first ever** production Raspberry Pi board!

Manufactured in China (via Hong Kong distributor)

(thanks Pete Lomas for the photo)

Raspberry Pi Foundation - with clothes on



Raspberry Pi Foundation - first PCB

Pete checking it actually is the size of a credit card as was promised

Raspberry Pi Foundation - first 10,000 units

This is the initial 10,000 units that was going to be “about enough" (unpacking ceremony in Jack’s garage)

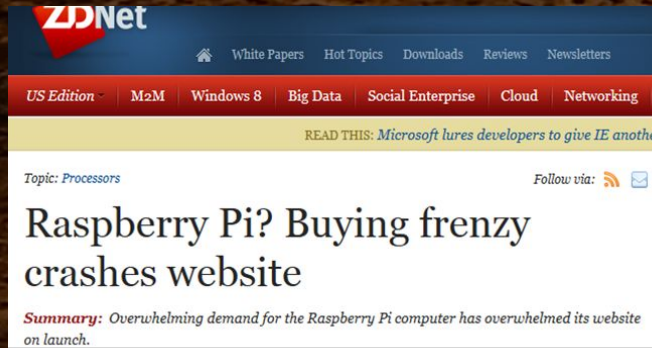
Raspberry Pi Foundation - eh oh!

"we accidently sold a million and it was all a bit embarrassing" *[Lang]*

With orders increasing quickly (> 350K) - the 6 part time trustees can't keep up - a separate company "Raspberry Pi Trading*" was set up 29th Feb 2012 to maintain the supply

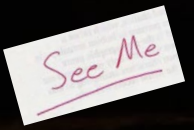
Fix, grant licenses RS and Premier Farnell (element14) to manufacture and distribute

** trading, fully owned by the foundation, Sony (Wales) 'made in UK'*

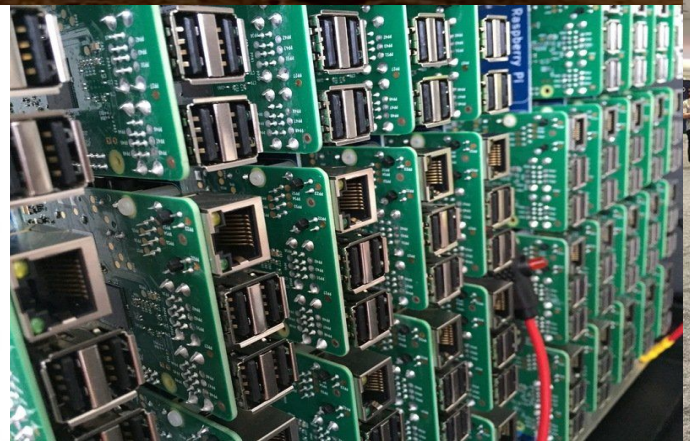


Raspberry Pi Foundation > 30 million units

Makes original estimate out by about 3000x :-)



So who's buying them? Hobbyists of course... but also can be used in larger clusters - which makes super computing affordable - all sorts of things requiring high CPU/GPU computation / modelling more achievable



Raspberry Pi Foundation - now also a shop!

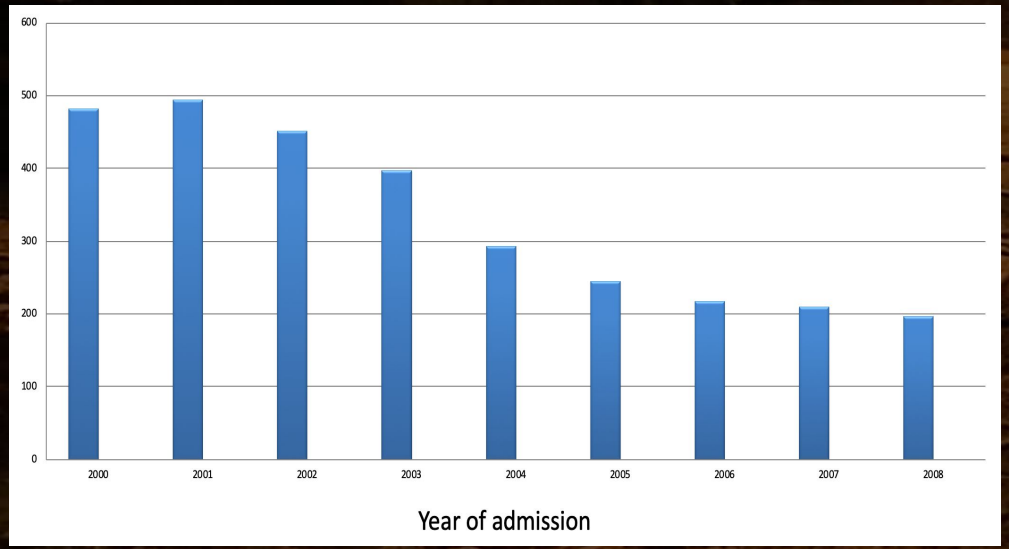
You'll find this today in downtown Cambridge (UK)

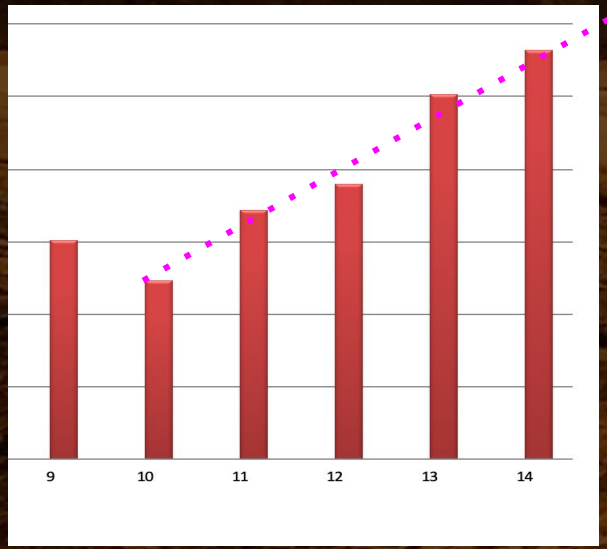
The Raspberry Pi Store - Grand Arcade Shopping Centre

Raspberry Pi Foundation - the best bit

What it's really about... CompSci students are back!

Cambridge had 1,307 applications in 2018 (vs only 197 in 2008)





Raspberry Pi Foundation - further kudos

Also Pi's are empowering many remote communities to be better educated in computer science and general

RachelPi are educational air drops in areas of poor connectivity runs as hotspot/web server hosting Wikipedia snapshot etc

Get going with a Raspberry Pi (headless setup)

Copy the Raspbian Linux distribution .iso file to an SD card

```
$ sudo dd if=/dev/rdisk1 bs=1m | wget https://downloads.raspberrypi.org/raspbian_full_latest
```

You don’t actually a need keyboard, mouse or a monitor ;-)

```
$ touch /Volumes/boot/ssh
$ vi /Volumes/boot/wpa_supplicant.conf
country=AU
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
network={
    ssid="YOUR_WIFI_NAME_BSSID"
    psk="YOUR_WIFI_PASSWORD"
}
$ sudo apt install realvnc-vnc-server realvnc-vnc-viewer
```

Set your expectations up realistically

The Raspberry Pi is *not* a PC, but is pretty powerful for its size

Cut down versions of Broadcom SoCs datasheets available
Broadcom BCM2711B0 quad-core A72 (v8-A) 64-bit 1.5GHz
4 Gigabyte LPDDR4 RAM

Wi-Fi (5G 802.11ac + 2G 802.11b/g/n)
Bluetooth 5.0 with BLE (low energy)

(make sure your USB PSU power supply is 2.5A or higher)

4K Video capabilities (VideoCore VI @ 500MHz)

Always been good - earliest model comparable to first Xbox - Roku boxes (e.g. Telstra TV) are part Raspberry Pi

XBMC also ruans, Netflix too! (at least until the DRM kicks in)
Frame buffer tech comes from latest Broadcom VideoCore V

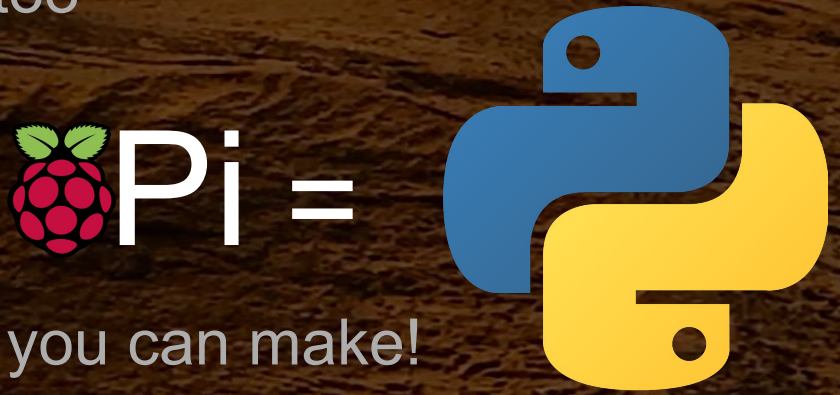
4K H.265 (HEVC) hardware decode * (60fps)
HD H.264 hardware decode * (1080p60fps)
OpenGL 3.0 3D Graphics (and GLES2)
Supports dual 4K HDMI displays!

* needs additional (low cost) license to unlock this feature

What can I do with my Raspberry Pi?

Sightly controversial comment - but - creating a website is kind of programming, but in traditional terms, really it's not

Yes of course do learn Flutter/React with JavaScript but also maybe also look at WebAssembly too
Challenge yourself to maybe see how you might do it in C or Rust
And everyone *must* learn Python
Why? Like lego, can bind anything you can make!



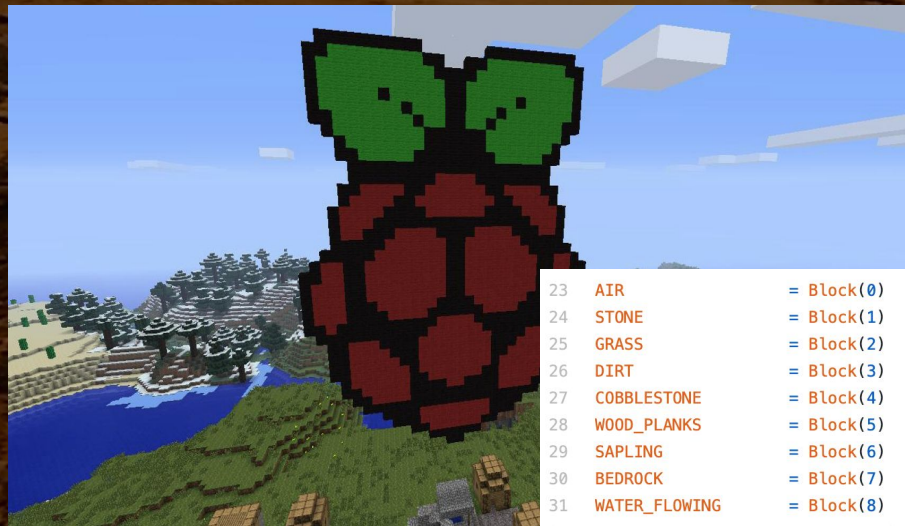
Maybe write a Minecraft (Python) mod

https://projects.raspberrypi.org/en/projects/getting-started-with-minecraft-pi

```
from mcpi.minecraft import Minecraft
mc = Minecraft.create()

x, y, z = mc.player.getPos()

DIAMOND = 57
mc.setBlock(x + 1, y, z, DIAMOND)
```



Not just software - Connect up to other hardware

By design the Raspberry Pi is easily connectable via USB, Wi-Fi, Bluetooth, Ethernet and...

... has 28x user GPIO supporting various interface options

Up to 6x UART (serial port signalling, which includes USB too)
Up to 6x I^2C (Inter-Integrated Circuit serial bus)
Up to 5x SPI (Serial Peripheral Interface bus)
1x SDIO interface (SD card)
1x DPI (Parallel RGB Display) 24-bit RGB24 (8 bits for red, green and blue) or RGB666 (6 bits per colour) or RGB565 (5 bits red, 6 green, and 5 blue)
1x PCM (pulse code signal modulator - sample analog signals in digital form)
Up to 2x PWM channels (pulse width modulated signals)
Up to 3x GPCLK outputs (General Purpose Clock pins - output a fixed frequency)

Connect up to other hardware devices - GPIO

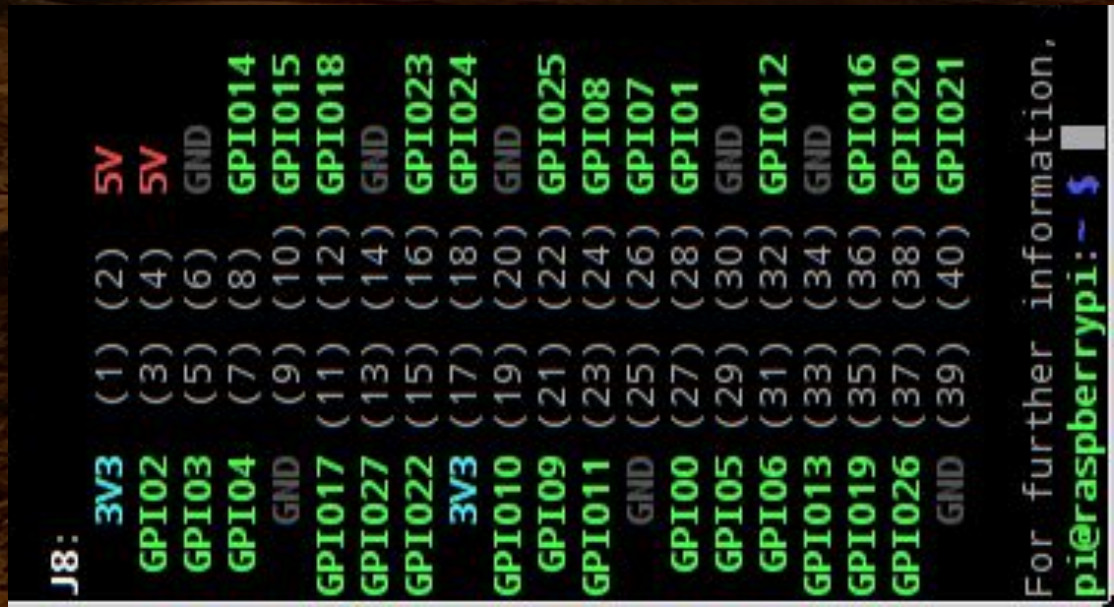
General Purpose In/Out pins - 40 pin header at the top of the board
(can use regular IDC ribbon cable etc to attach to breadboard etc or make a 'hat' board)

3.3V high

0V low

GPIO2/3 fixed pull-up resistors
others are software configurable

```
import pigpio
pi = pigpio.pi()
pi.write(19, int('True'))
pi.stop()
```



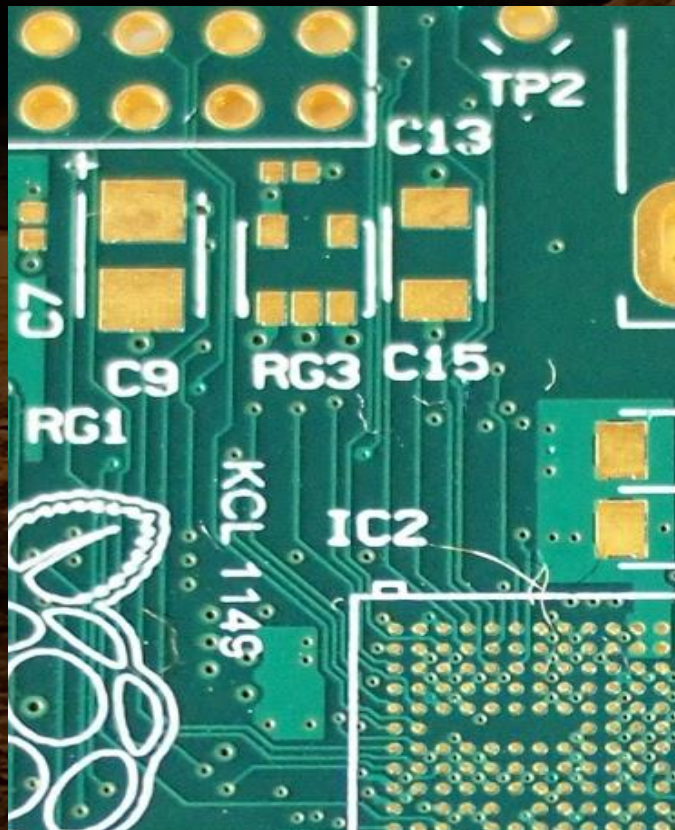
Connect up to other hardware devices - SPI bus

I2C + SPI serial buses (warning 3.3V not 5V)
SPI allows for up to five attached devices
I2C allows up to six addressable devices

Pin19 = SPI MOSI (SDO) Pin21 = SPI MISO (SDI)
Pin23 = SPI SCK (clock) Pin24+26 = SPI CE0/CE1 = SS (shift select)

Software is off by default, run raspi-config to enable the devices
/dev/spidev0.0 and /dev/spidev0.1

```
import spidev
spi.open(0 bus, 1 device)
spi.xfer2([0x1234 some message])
```



Connect up to other hardware devices - I²C

Inter-Integrated Circuit - 2 wire addressable serial bus
Up to 6 buses - any number of addressable devices (also HDMI)

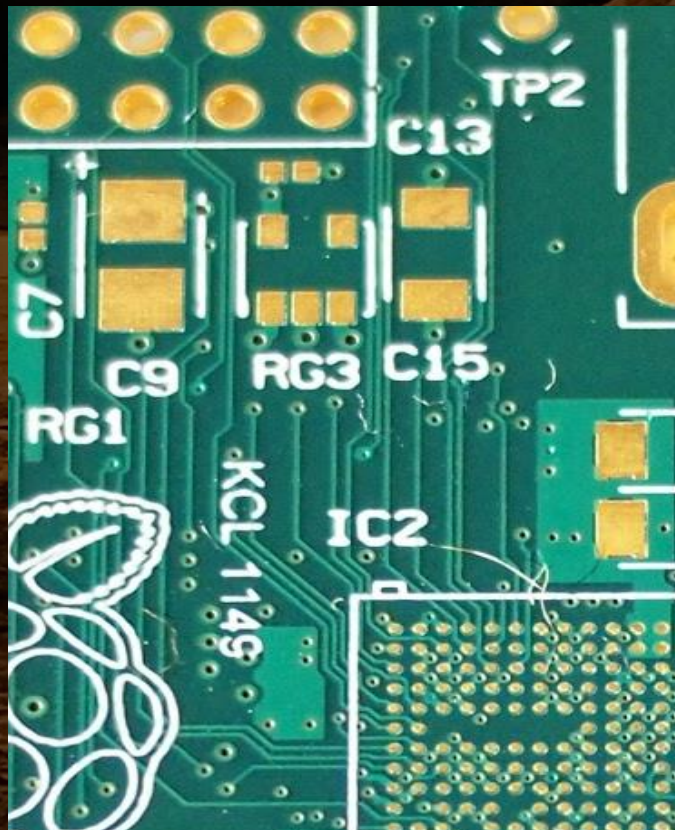
Pin3+27 = I²C SDA 0/1 (serial data)
Pin4+28 = I²C SCL 0/1 (serial clock line)

```
import smbus

channel = 1    # 1 is connected to the GPIO pins
addr = 0x60 # for your device

# Register addresses
reg_write = 0x40

bus = smbus.SMBus(channel)  # initialize
bus.write_i2c_block_data(addr, reg_write, msg)
```



Connect up to other hardware devices - USB2/3

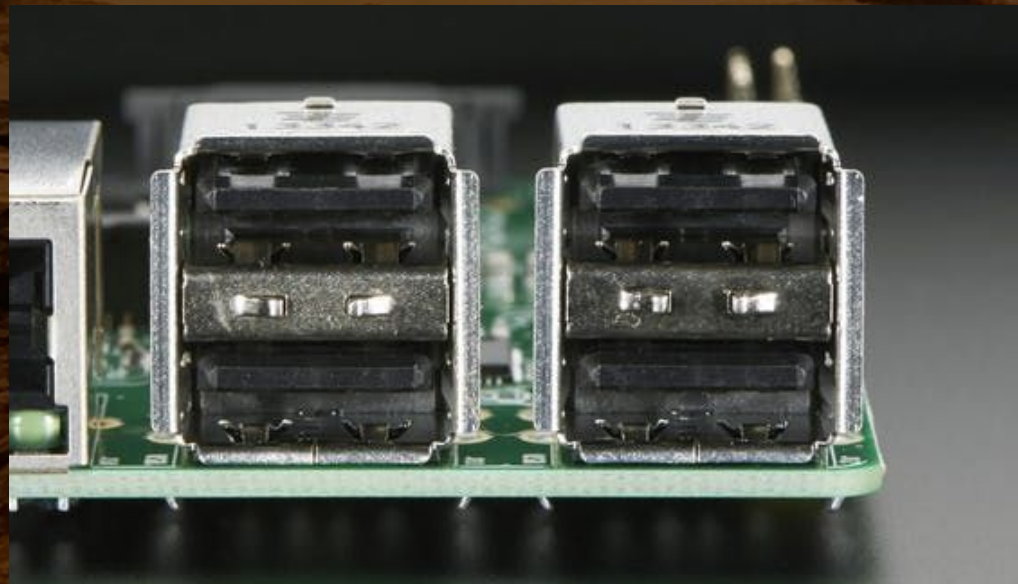
Universal Serial Bus - many USB devices out there with standard drivers, Pi4 has 2 x USB2 and 2 x USB3

Four transfer types: bulk (HDD), interrupt (mice/keyboard HID), isochronous and control endpoints

```
import usb

args["idVendor"] = 0x16c0 # uDMX
args["idProduct"] = 0x5dc # uDMX
device = usb.core.find(**args)

device.ctrl_transfer(type, req)
device.write(1, 'DMX_CH1=RGB')
```



Perhaps give this a go!

This was Vivid Sydney - July 2019

4 x 6m towers (at the Garden bar)

USB uDMX controller which could be controlled with a Pi

Actually was just USB - but easily SDI can control addressable LED light strips etc using a Pi

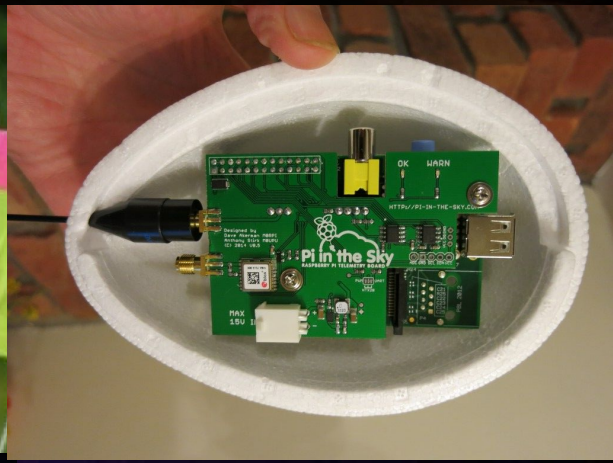
Could come in useful

BrewPi

A modern brewery controller

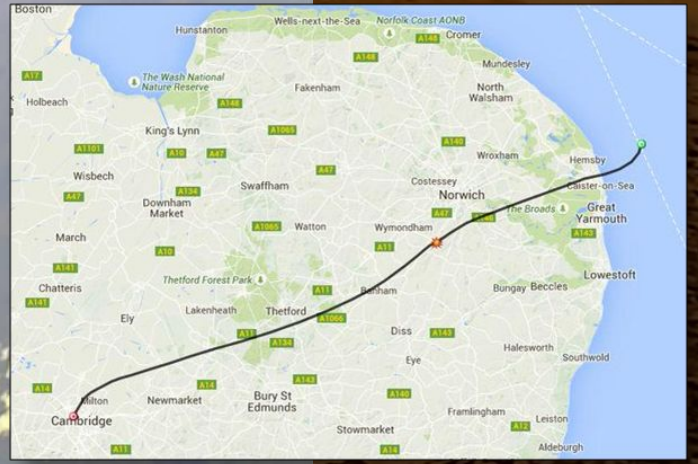
The BrewPi Spark 3 is a temperature controller that can control your beer or wine fermentation with 0.1°C precision. It sends data to a Raspberry Pi to show a control panel with graphs in your browser.

Decide for yourself if the Earth is flat or round



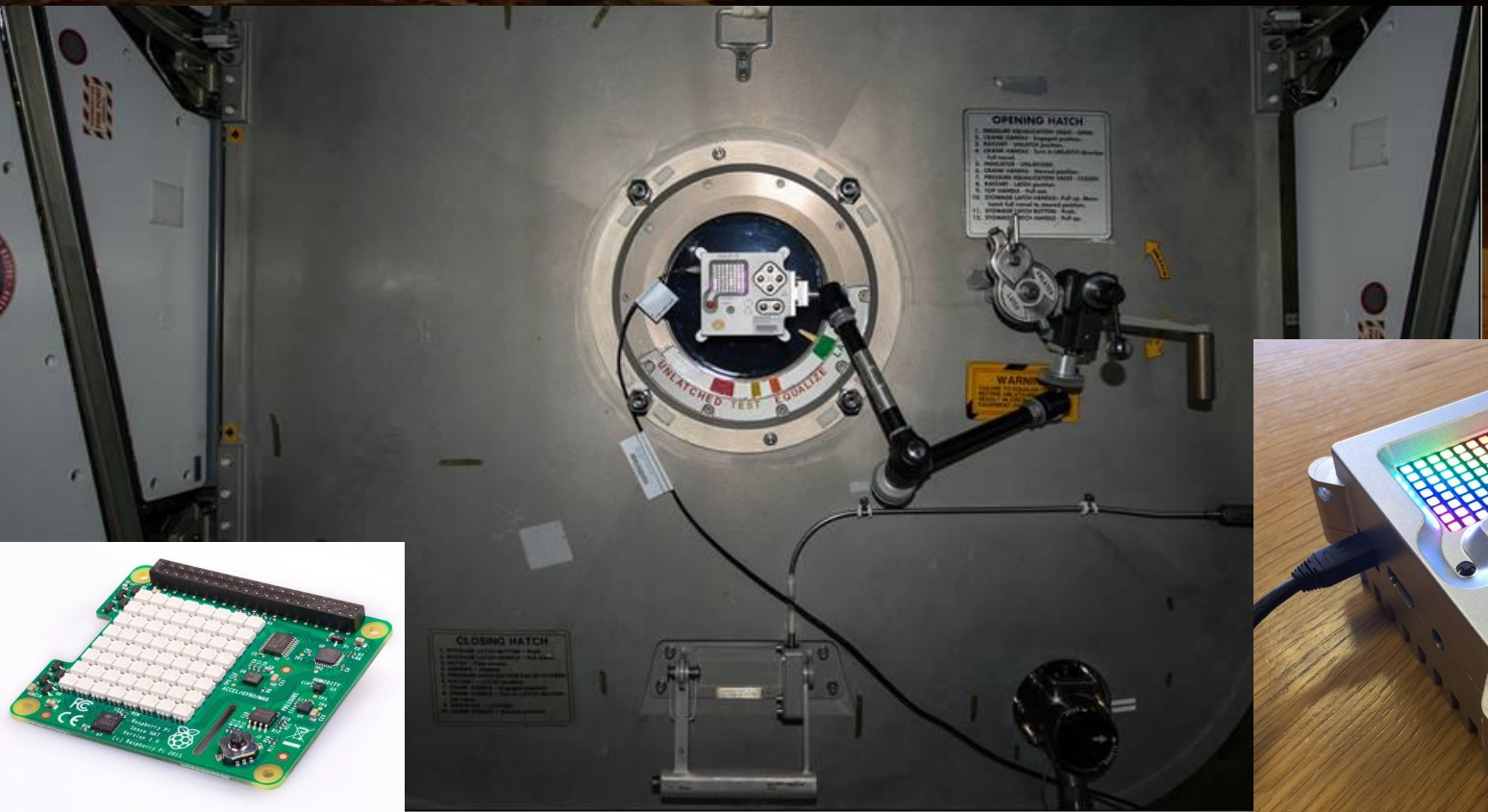
Decide for yourself if the Earth is flat or round

(Pi in the Sky - photo credit Dave Akerman)



Or run your code up here (AstroPi with Tim Peake on ISS)

Or run your code up here (RasPi + SenseHAT - photo credit ESA)



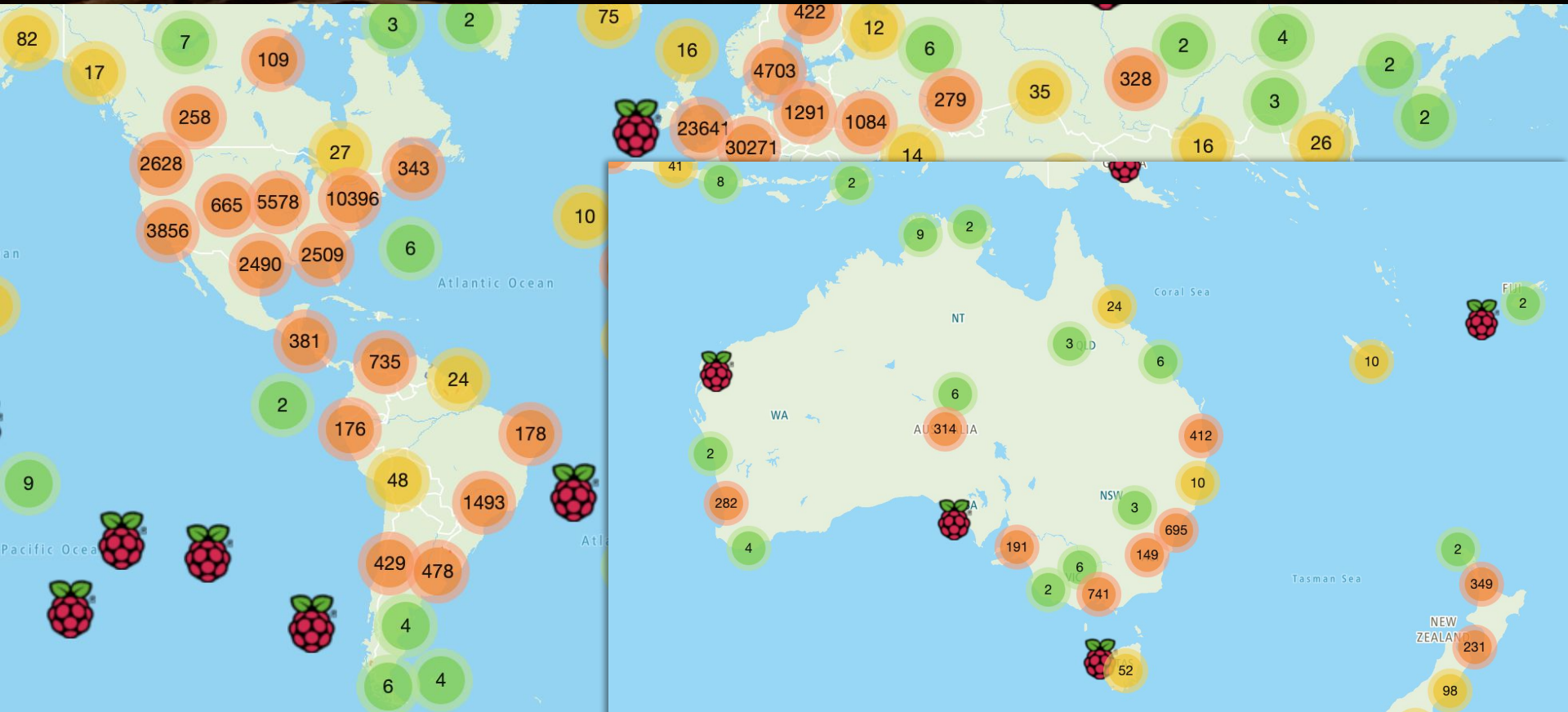
Two AstroPi's on the ISS

Ed - visible camera
Izzy - Infrared

But, please don't go and do this...

Bitcoin mining - a pretty disgraceful and blatant misuse of the Earth's fragile resources - just a selfish waste - no, no, no

Who ya gonna call? (rastrack.co.uk map of registered Pi's - help is out there!)



Shallow dive into Linux device drivers userland

You can totally develop code on a Pi but typically how we do things is cross compile from a more capable machine

Cross compiling for ARM - kernel flags - firmware repo armv7 vs aarch64 - arm-linux-gnueabihf-ld

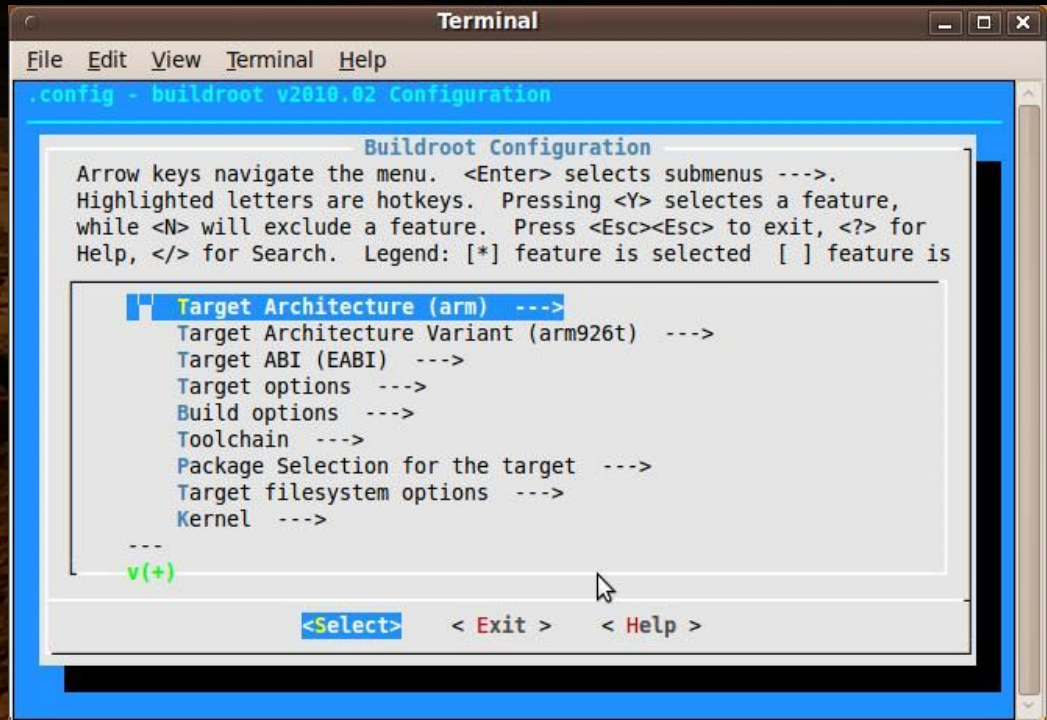
```
KERNEL=kernel7 && make bcm2709_defconfig
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabihf- menuconfig  #hard float
```

User space abstractions to framebuffer / DirectFB / Wayland
Using OpenMAX - Open GLES
Audio too - SDL2 / Alsa

BuildRoot (rolling your own distro from scratch)

Kernel - bcm2709_defconfig
BusyBox
µClibc

Raspberry Pi isn't so resource constrained to really need to do this glibc works fine



Google ChromeOS aarch64 (arm64-generic)

Make your own Chromebox!

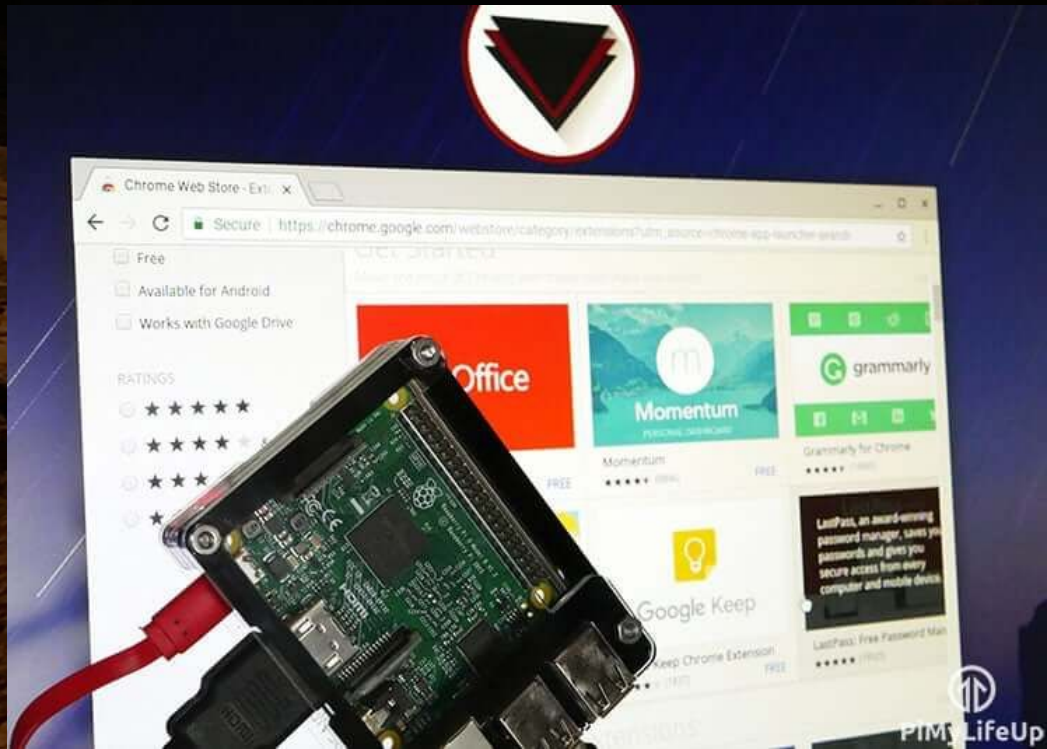
Chromium OS on a Pi

```
cros_sdk -- ./build_packages
    --board=rpi3

cros_sdk -- ./build_image --board=rpi3

cros flash usb:// rpi3/latest
```

Check out FydeOS



Microsoft Window 10 (IoT edition)

Quick bring up

Working with WinCE nostalgia

Number of ARM compiled apps remains fairly limited

But nothing stopping you compiling your own!

Remembering RiscOS

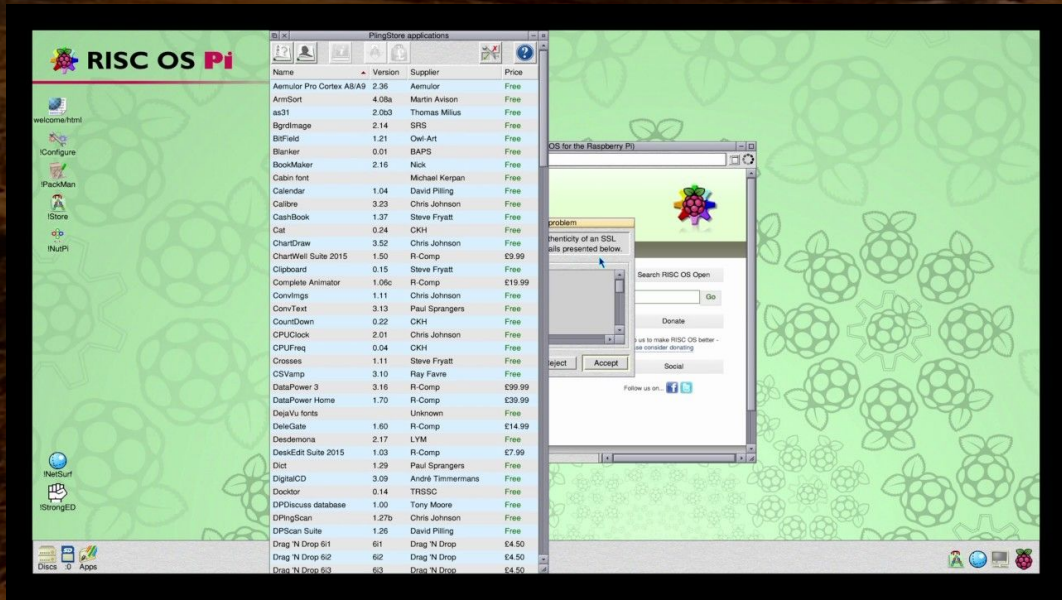
Many UK kids will have used RiscOS (possibly unknowingly)

Quick bring up of RiscOS

I had my school buy the full documentation set!

(and yes I read them ;-)

Happy days



Thanks!

You may have noticed I’m still working on these slides

but the final set will be here:

http://bit.ly/2vr4Hws