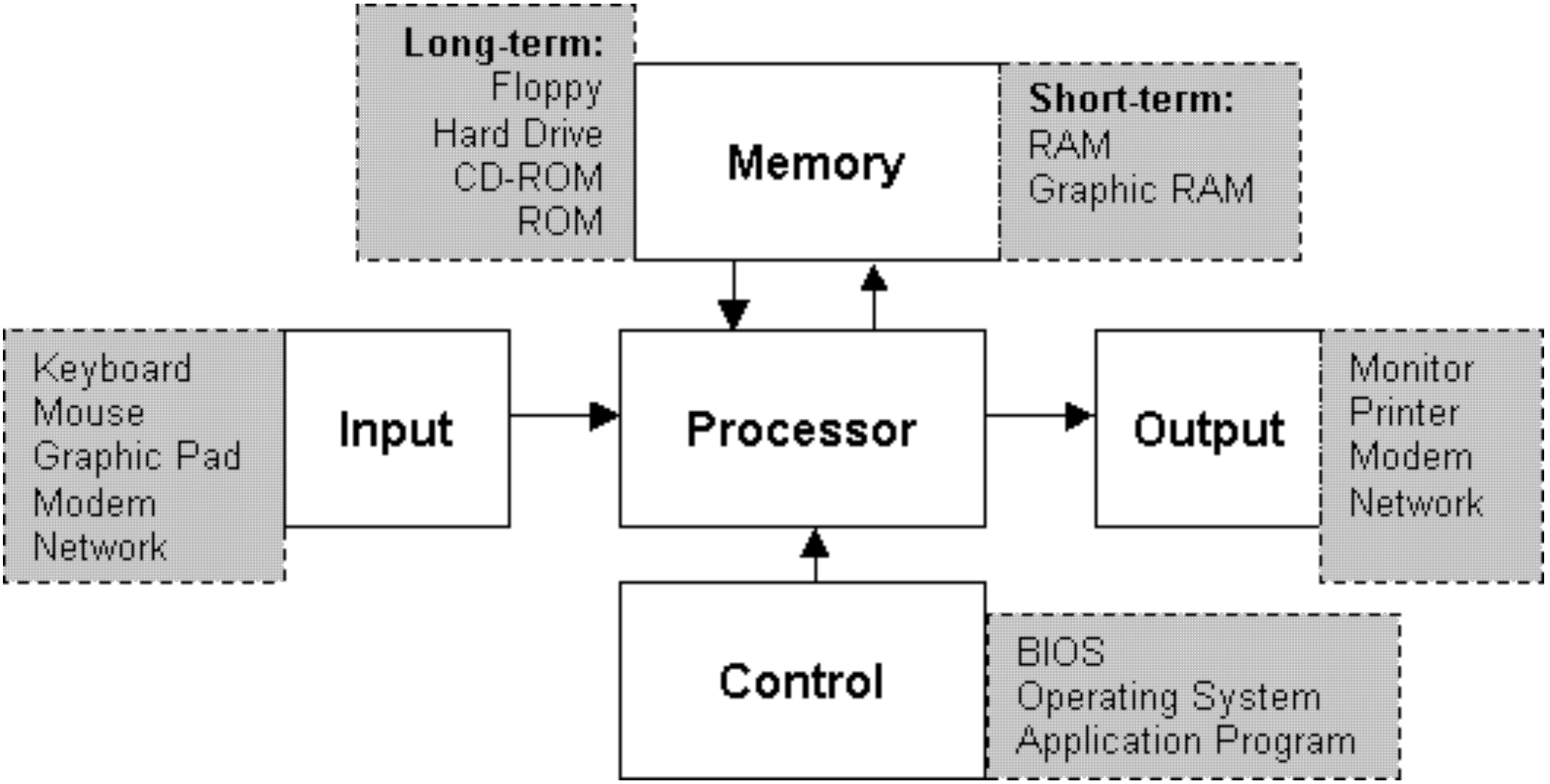
Microcontrollers vs. Microprocessors

Raspberry Pi, Linux, Alternatives

September 29, 2020


Arduino
Raspberry Pi

Flashback: Microcontrollers



What is in a computer?

CPU
Memory
I/O controllers
External storage

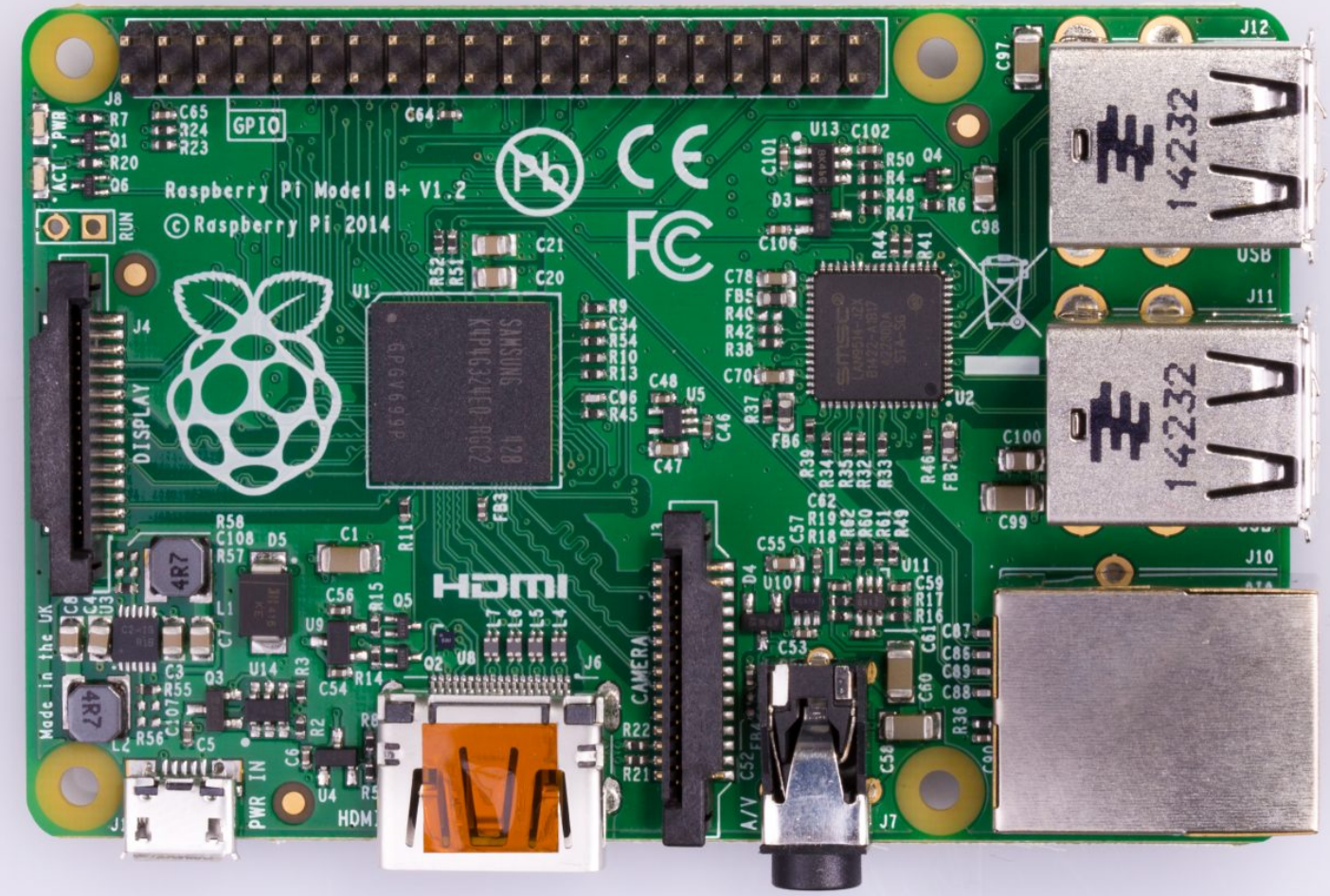


photo from WikiMedia, user Herbfargus

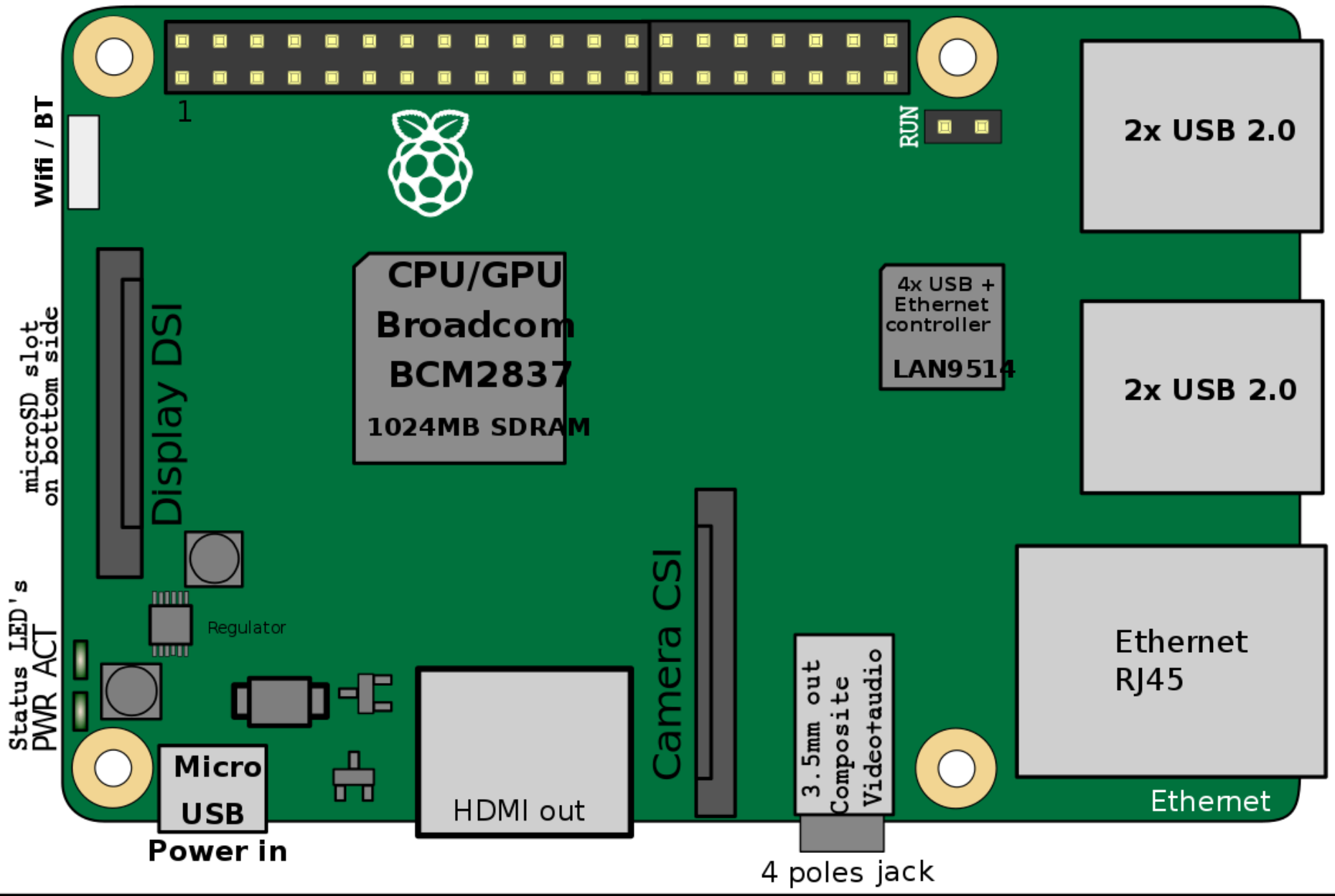


diagram from WikiMedia, user Era

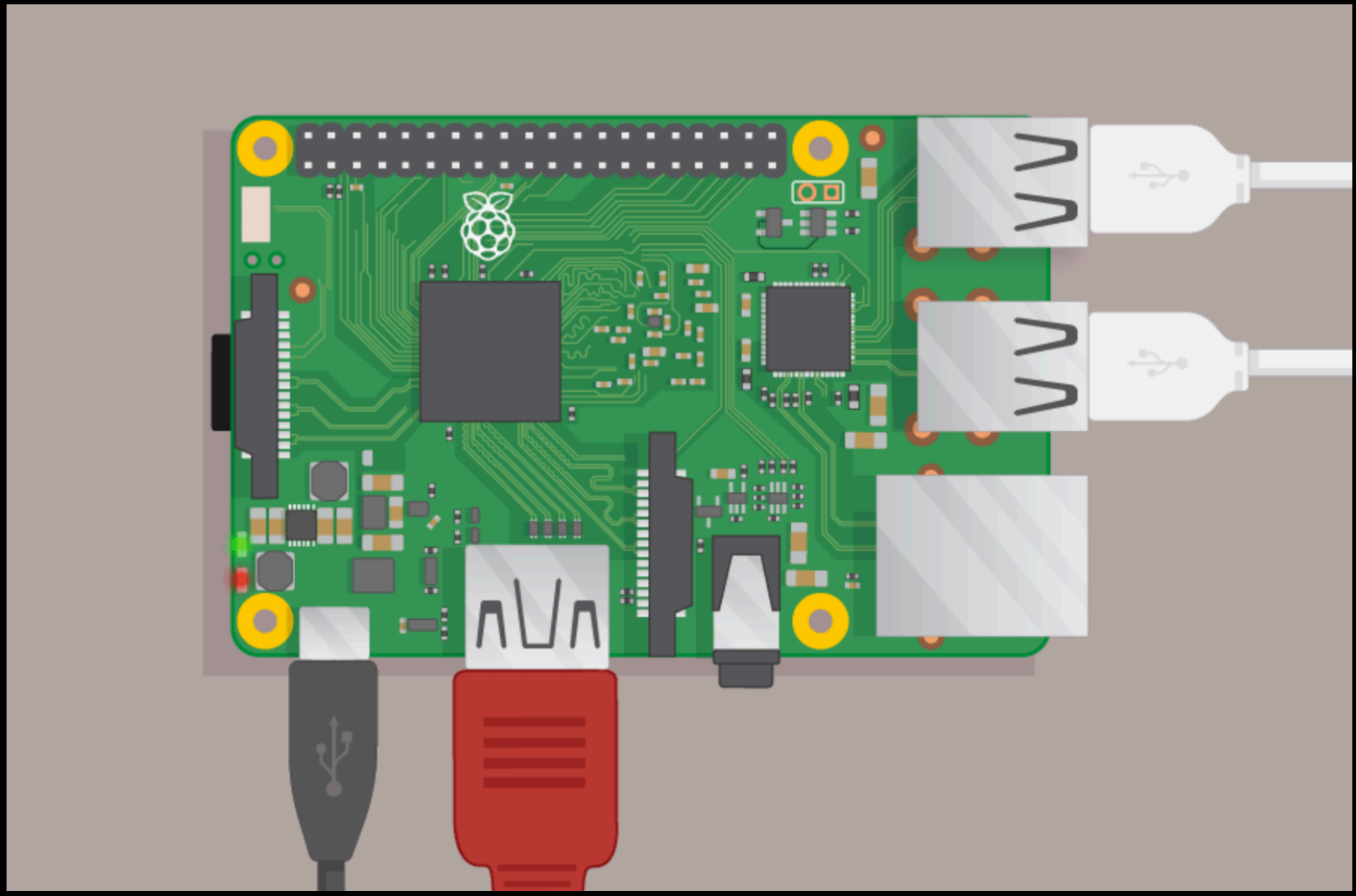
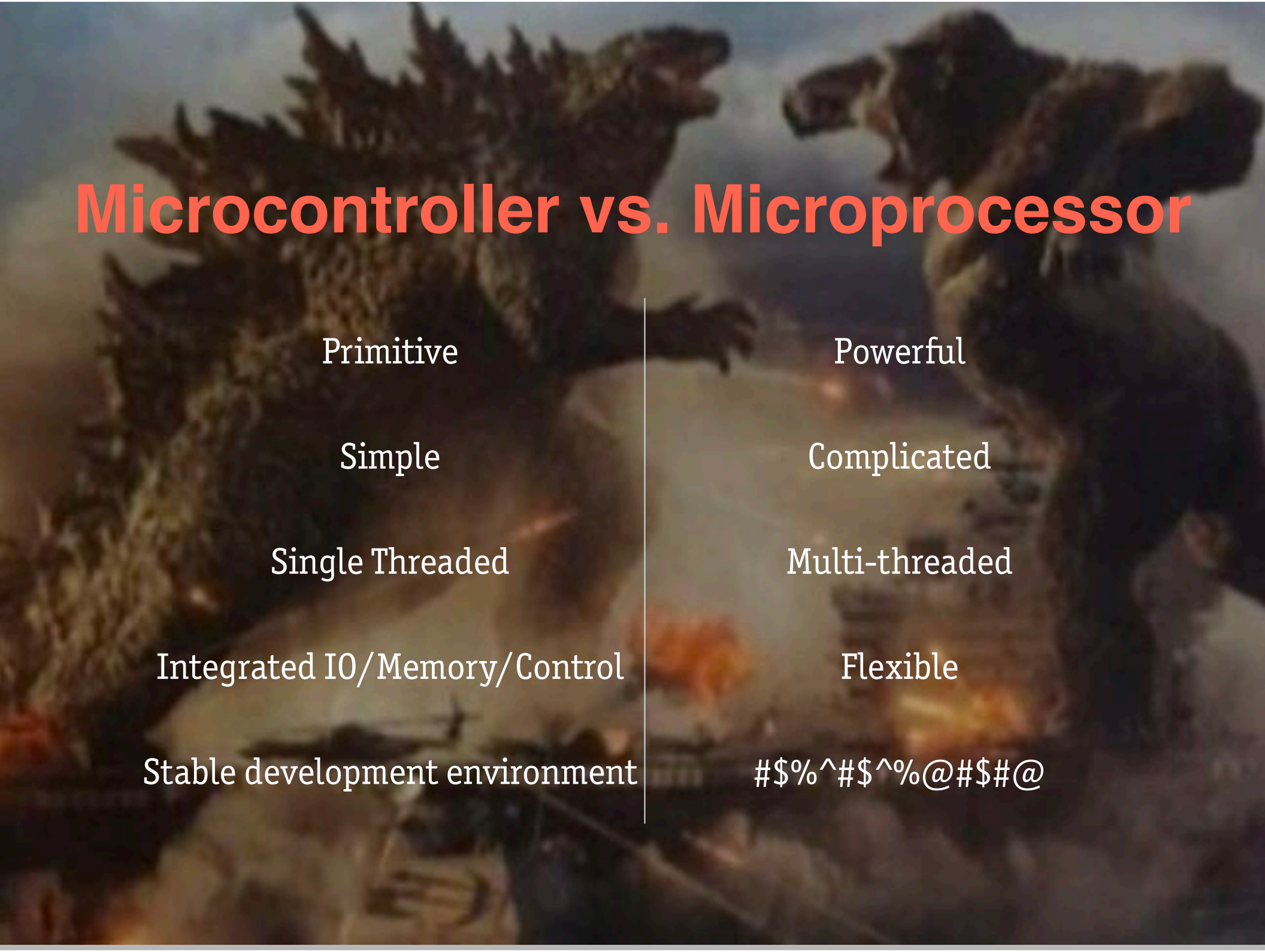


diagram from RaspberryPi.org



Microcontroller vs. Microprocessor

Primitive	Powerful
Simple	Complicated
Single Threaded	Multi-threaded
Integrated IO/Memory/Control	Flexible
Stable development environment	#$%^#$^%@#$#@

Operating Systems

Another key difference between microcontroller development and microprocessor development is the operating system.

An operating system (OS) is system software that manages computer hardware, software resources, and provides common services for computer programs.

Operating Systems

Arduino

- single-threaded, with some provision for hardware-driven timer and interrupt processes.
- Functions and commands are executed in a predescribed number of clock cycles.

RTOSes, or Real Time Operating Systems,

- multi-threaded for both microcontrollers and microprocessors
- RTOSes are designed to guarantee execution of external signalling and response in a deterministic amount of time
- for industrial equipment and devices where timing is critical

Operating Systems

Windows, MacOS and Linux are general purpose operating systems, and they are designed to manage the interaction with the user.

They handle multiple threads (internet packets, graphical display, user input, generation of sound) simultaneously, but the timing is non-deterministic.

This is good enough for interaction, however; the differences in execution time between a RTOS and a general purpose OS are too small for people to really notice.

Raspberry Pi

From the UK, specifically for education
15 million sold (as of July 2017) * Raspberry Pi Foundation,
3rd best-selling general purpose computer

Raspberry Pi B+

Microprocessor: ARM-based CPU, on-chip GPU
Storage: microSD card
Uses normal computer connectors, peripherals
  Audio, Video output: 3.5mm headphone, HDMI
  Peripheral IO: 4 USB
  Networking: 802.11n, Ethernet, Bluetooth
Target price: $35
Community

Raspberry Pi

Family	Model	Form Factor	Ethernet	Wireless	GPIO	Released	Discontinued
Raspberry Pi	B	Standard[a]	Yes	No	26-pin	2012	Yes
	A		No			2013	Yes
	B+		Yes		40-pin	2014	
	A+	Compact[b]	No			2014	
Raspberry Pi 2	B	Standard[a]	Yes	No		2015	
Raspberry Pi Zero	Zero	Zero[c]	No	No		2015	
	W/WH			Yes		2017	
Raspberry Pi 3	B	Standard[a]	Yes	Yes		2016	
	A+	Compact[b]	No			2018	
	B+	Standard[a]	Yes			2018	
Raspberry Pi 4	B (1 GiB)	Standard[a]	Yes	Yes		2019[31]	Yes[1]
	B (2 GiB)						
	B (4 GiB)						
	B (8 GiB)					2020	

Linux

- Based on UNIX command set
  - Began in 1991 as personal project of Finnish student Linus Torvalds to make a free OS kernel based on the x86
- Free
- Open source

image: December 2002 issue of Linux Magazine, retrieved from Wikipedia

Raspberry Pi vs. Laptop

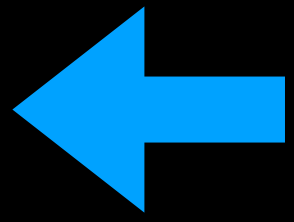
RPi has normal computer connectors, and you can hook it up to a monitor and keyboard.

It has networking capability, you can put it on your home or office WiFi.

Raspberry Pi is smaller and cheaper, & easier for us to experiment and play with.

Replaceable: the microSD card that has the operating system and memory, or even the whole computer if you need to.

Dedicated: assign a computer per application

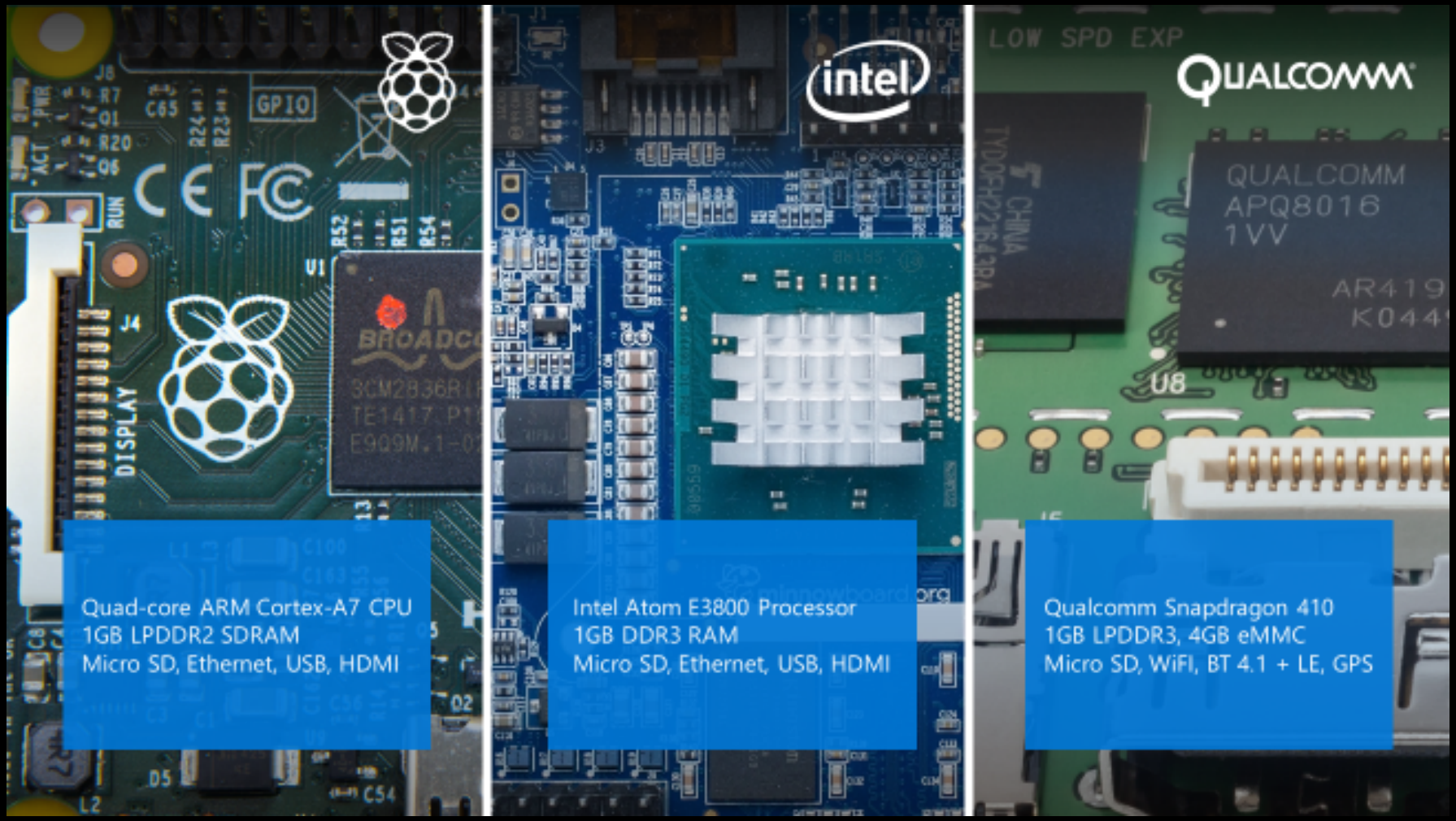


Android

"Linux makes up the core part of Android, but Google hasn't added all the typical software and libraries you'd find on a Linux distribution like Ubuntu. This makes all the difference."
Android allows central vetting of applications.

image: http://eliseinfotech.com/android-app-development/

Windows 10 IoT



https://blogs.windows.com/windowsexperience/2015/03/18/windows-10-iot-powering-the-internet-of-things/

Windows 10 IoT

Not open source
More peripherals likely to work
Allows you to program in Visual Studio and run code on Pi
Not a lot of community support

Pi Alternatives

BeagleBone Black wireless

Based on ARM Cortex A8
$75 MSRP
Less connectivity, more GPIO
Low power consumption
Intended to be integrated into products

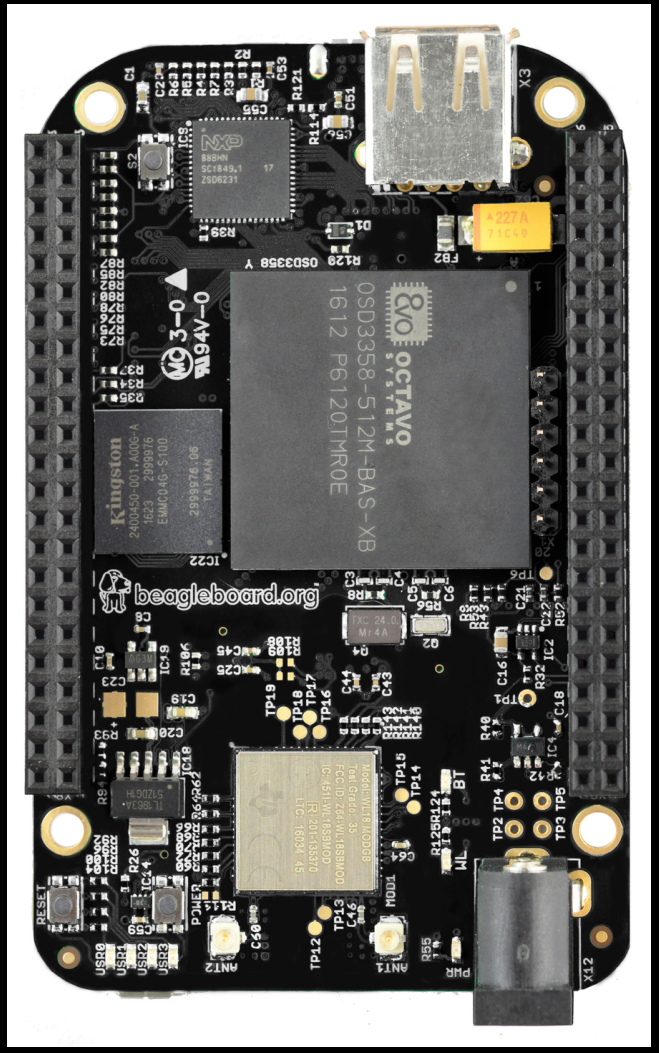


image: https://beagleboard.org/black-wireless

ODROID-XU4

Based on ARM Cortex
~$60 MSRP
More powerful than Pi
Open hardware
Less community support
Supports Linux, Android
2 USB, no Wifi or BT built in
Intended to promote Samsung, Android on IoT

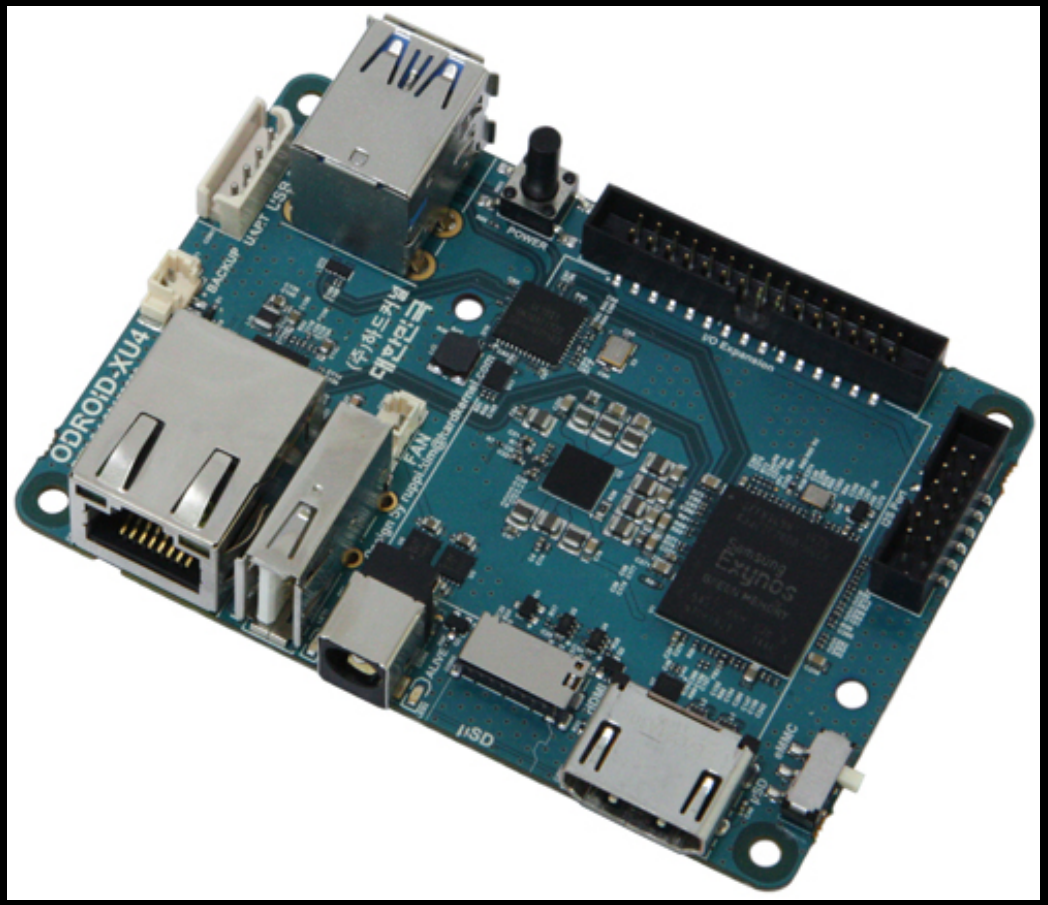


image: http://www.hardkernel.com/main

LattePanda

Runs Windows 10, Linux
~$89 MSRP
Has an Arudino integrated
Normal PC peripheral drivers will work
Intended to promote Windows Infrastructure

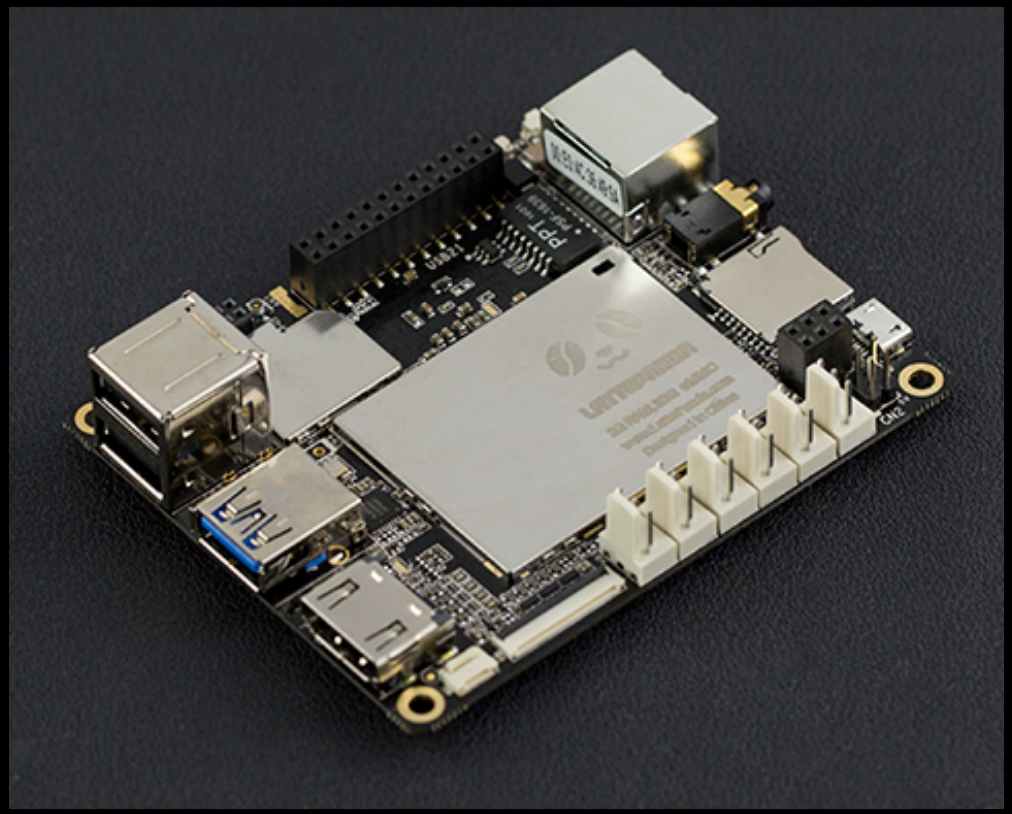


image: https://www.lattepanda.com

Jetson Nano

Runs Ubuntu Linux
~$99 MSRP
Quad-core ARM A57

Intended to promote NVIDIA as deep-learning platform

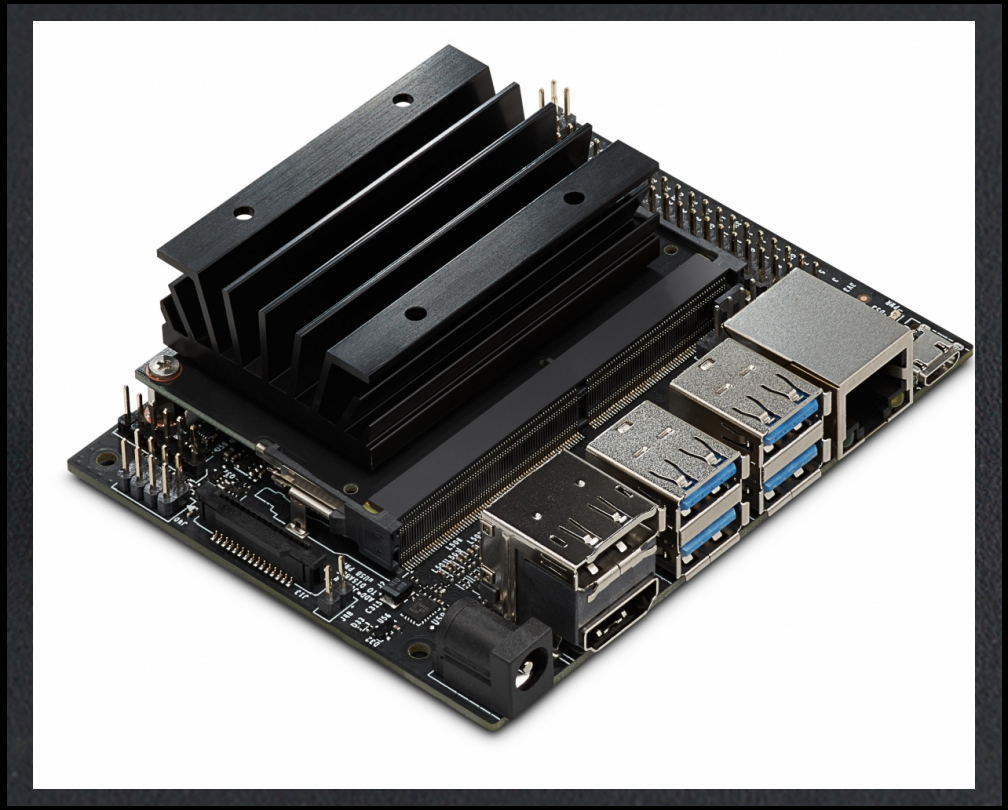


image: https://www.lattepanda.com

Raspberry Pi (RPi) Zero W

Smaller
MicroSD card slot
MiniHDMI
2 micro USB ports
Wifi
$10

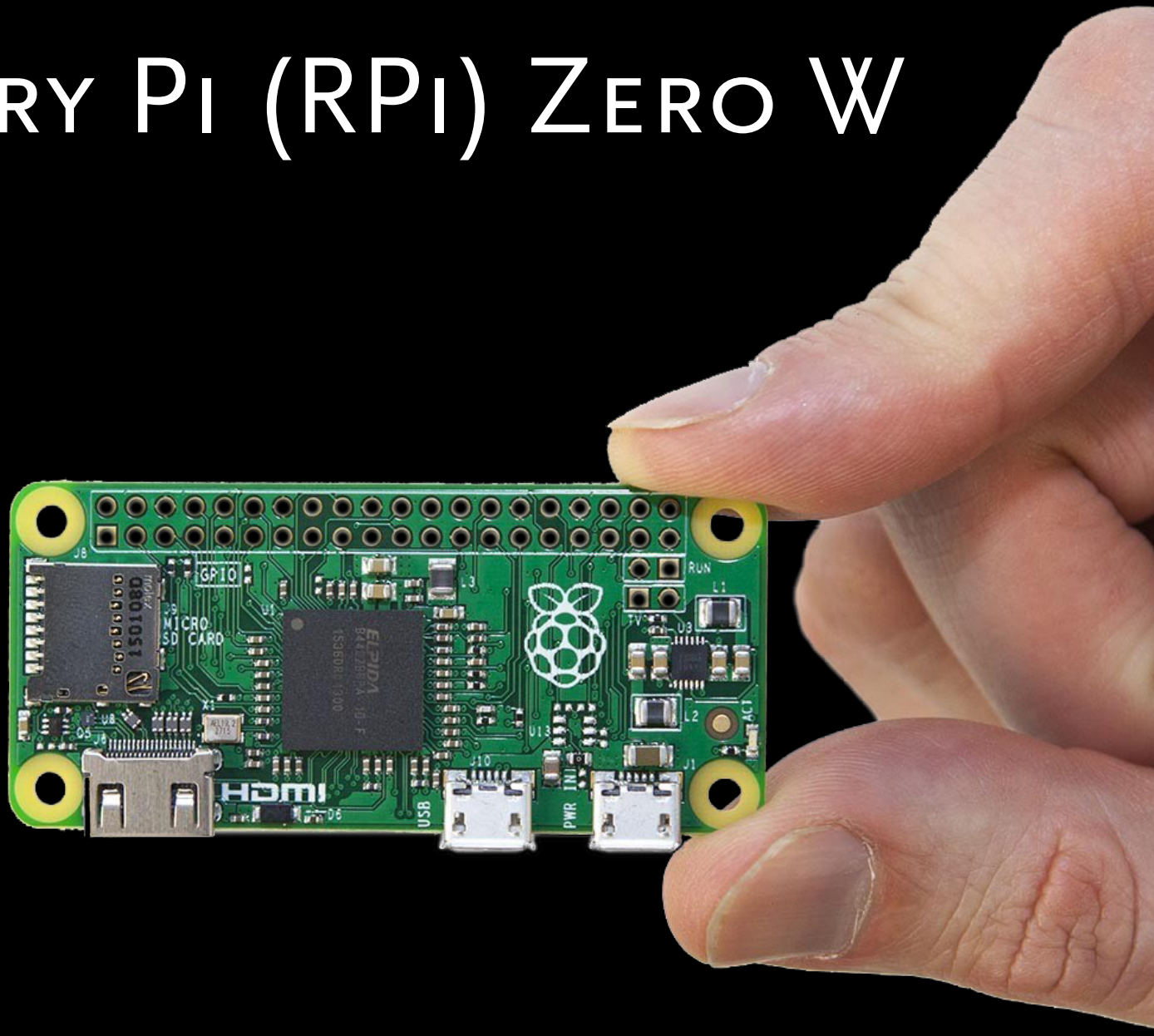


image: Pi Supply

Raspberry PI alternatives

Products > High-Tech

Last update 2018 Aug 2 02:25:54

Favorite 2

Compare boards which could replace a Raspberry Pi

Compatible Raspberry PI HAT (Hardware Attached on Top): Have the same GPIO layout

You might also be interested by: http://socialcompare.com/en/comparison/arm-boards or http://socialcompare.com/en/comparison/raspberrypi-models-comparison

	Raspberry Pi 3 B+	Raspberry Pi Zero	CHIP	Banana Pi	BeagleBONE BLACK	BeagleBone	A20-OLinuXino-LIME
Image							
HAT compatible	✓	✓					
Height	3.37 in (85.6 mm)	1.18 in (30 mm)	1.57 in (40 mm)	2.36 in (60 mm)	2.15 in	2.15 in	84 mn
Width	2.22 in (56.5 mm)	2.55 in (65 mm)	2.36 in (60 mm)	3.62 in (92 mm)	3.4 in	3.4 in	60 mn
Weight	1.58 oz (45 g)	0.31746 oz (9 g)		1.69 oz (48 g)	1.4 oz	1.4 oz	
Price	US$35.00	US$5.00	US$9.00		US$45.00	US$89.00 (Digikey)	€33.00
Technical details							
CPU	1.4GHz 64-bit quad-core ARMv8	1 GHz Low Power ARM1176JZ-F	1 GHz Allwinner A13 Compatible SoC	1 GHz ARM Cortex-A7 dual-core			Allwinner A20 dual core Cortex-A7 processor (1 GHz)
GPU	VideoCore IV	Dual Core VideoCore IV® Multimedia Co-Processor	ARM Mali-400	ARM Mali-400 MP2 GPU dual-core			dual-core Mali 400 GPU
RAM	1 GB	512 MB	512 MB (DDR3)	1 GB	512 MB	256 MB	512 MB (DDR3)
4K compatible	✗	✗	✗	✗			
Onboard storage			4 GB EMMC				
Flash storage types							
Ethernet (LAN, RJ45)	✓ 10/100/1000	⊖ via USB	✗	✓ 10/100/1000			✓
USB	✓ 4x USB2.0	✓ micro + micro OTG	✓ 1x USB2.0 + micro OTG	✓ 2x USB2.0 + micro OTG			✓ 2 USB (High-speed host with power control and current limiter)
SATA Ports	✗	✗	✗	✓	✗	✗	✓ SATA connector with 5V SATA power jack
HDMI port	✓ 1	✓ mini	⊖ via adapter	✓	✓ micro	✓ DVI-D	✓ + LCD connector compatible with with 4.3", 7.0", 10.1" LCD modules from Olimex
Wi-Fi	✓ 2.4GHz and 5GHz 802.11 b/g/n/ac	✗	✓ 802.11 b/g/n	✗	✗	✗	✗
Bluetooth®	✓ 4.2, BLE	✗	✓ 4.0	✗	✗	✗	✗

A20-OLinuXino-LIME - HAT compatible

el.com/main

Other considerations

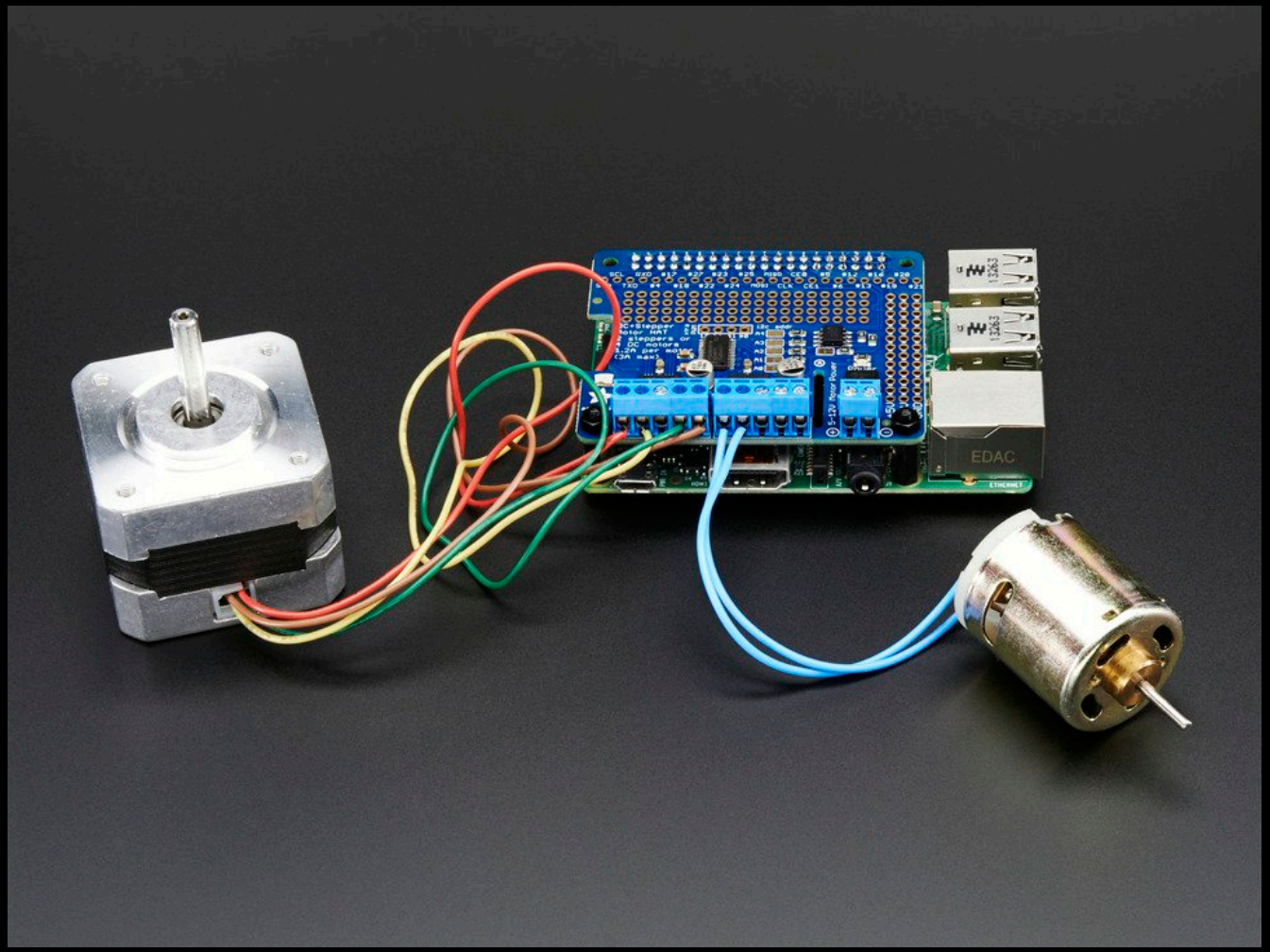
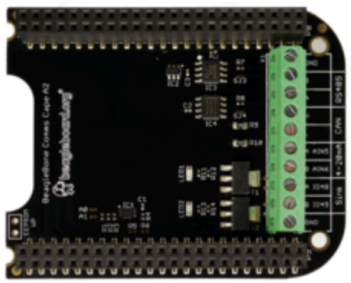


image: Pi Supply

Other considerations

BeagleBoard.org® Capes



BeagleBoard.org Comms Cape

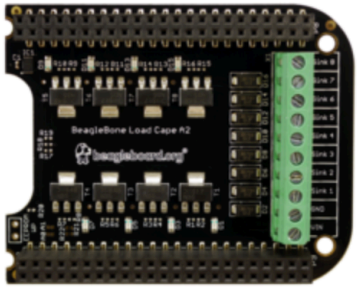
For industrial communication applications. Provides an array of communication protocols including one RS485, one CAN, two analog 4–20 mA current loops, and two 3A 50V interfaces allowing the control of high current loads.

Additional details

- RS485
- CAN
- 2x 4-20ma current loop inputs
- 2x 3A 50V sinks for high-current loads
- I^2C EEPROM

Purchase

Select a distributor to buy



BeagleBoard.org Load Cape

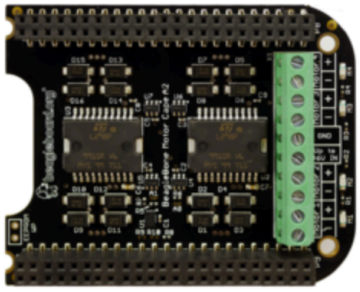
Drive high-current loads like relays, motors, solenoids, and high current LEDs.

- 8x 3A 50V sinks for high-current loads
- I^2C EEPROM

Additional details

Purchase

Select a distributor to buy



BeagleBoard.org Motor Cape

Drive DC motors with direction and PWM control.

- 4x 3A motor outputs up to 46V
- I^2C EEPROM

Additional details

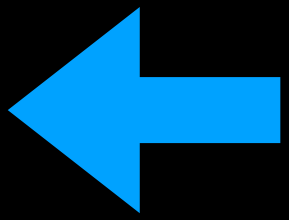
Purchase

Select a distributor to buy

[Beagleboard Capes]

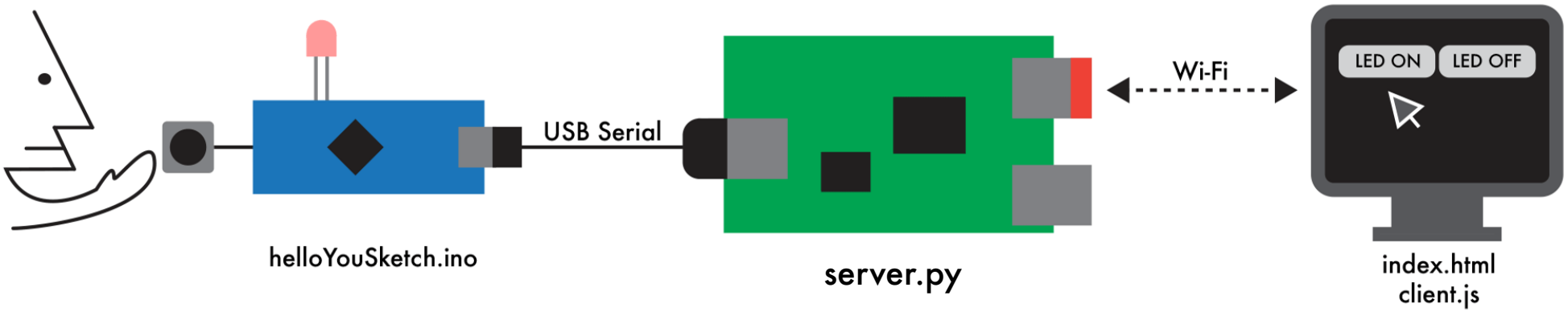
Criteria for selecting SBCs

Price
Power consumption
Availability
Product roadmap
Community support
Software support
Operating System



Interaction Engine

Microcontroller+Microproccesor!!!



The Interaction Engine is a framework for prototyping web-connected hardware.

We use a set of widely supported tools to create a system to help interaction designers quickly realize new, multimodal interactive experiences.

Interaction Engine

Microcontroller+Microproccesor!!!

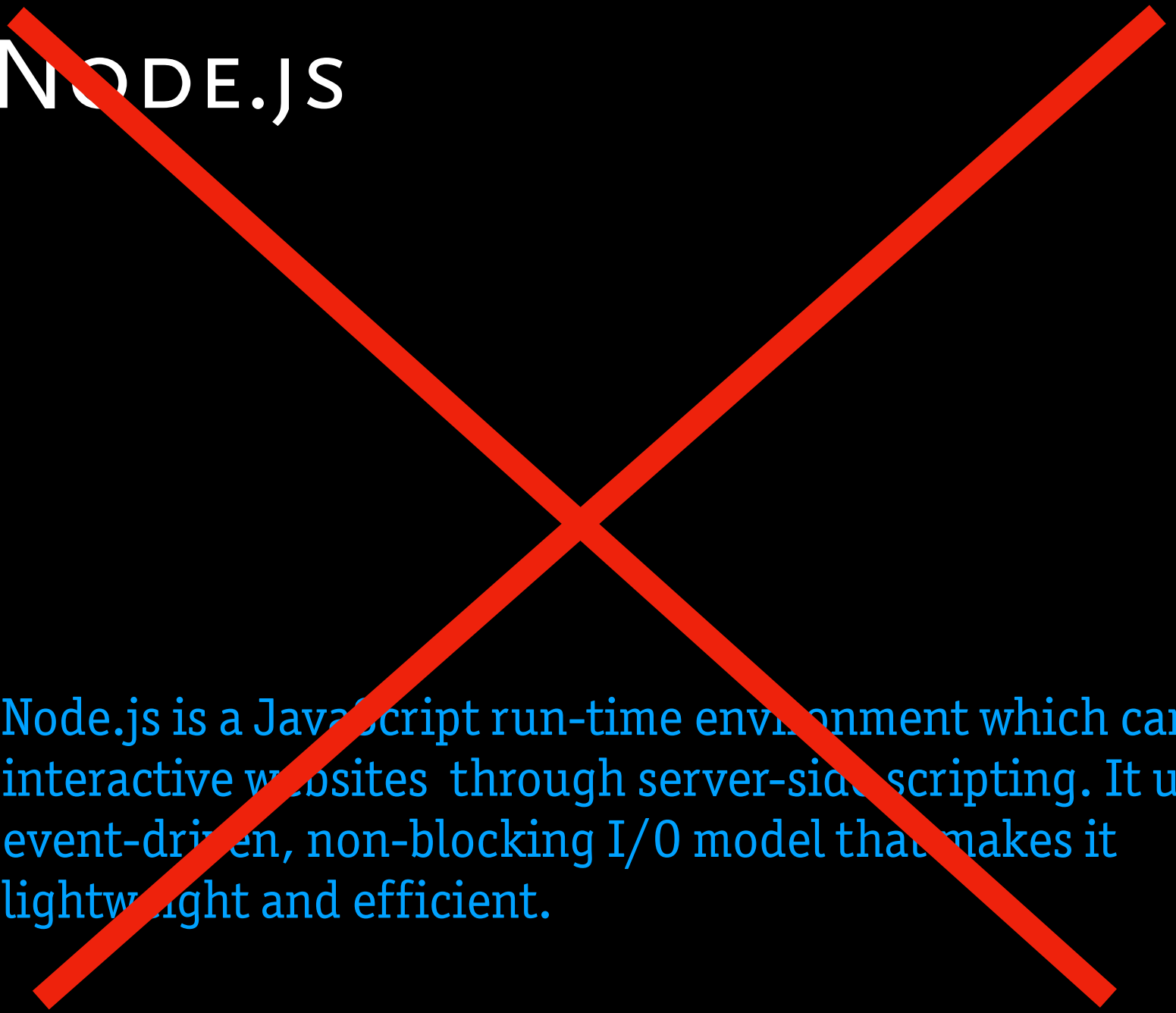
Pros:

- GPIO on Pi is not easily usable
- Libraries more plentiful for the Arduino than Pi GPIO
- Enables modular development
- Upgrade computation, not IO
- Firewalls power and electronics issues from Pi

Cons:

- A bit expensive
- Revision control complicated
- (Now is the moment that we need Git)

NODE.JS



Node.js is a JavaScript run-time environment which can make interactive websites through server-side scripting. It uses an event-driven, non-blocking I/O model that makes it lightweight and efficient.

NPM

Packages people 'npm install'

browserify
browser-side require() the node way
16.1.0 published 3 weeks ago by goto-bus-stop

gulp
The streaming build system
3.9.1 published 2 years ago by

npm
a package manager for JavaScript
5.7.1 published a week ago by zkat

grunt-cli
The grunt command line interface
1.2.0 published 2 years ago by vladikoff

grunt
The JavaScript Task Runner
1.0.2 published 4 weeks ago by vladikoff

cordova
Cordova command line interface tool
8.0.0 published 2 months ago by stevegill

bower
The browser package manager
1.8.2 published 6 months ago by sheerun

express

express
Fast, unopinionated, minimalist web framework
4.16.2 published 5 months ago by dougwilson

forever
A simple CLI tool for ensuring that a given node script runs continuously (i.e. forever)
0.15.3 published a year ago by indexzero

Node.js' package ecosystem, npm, is the largest ecosystem of open source libraries in the world. (https://www.npmjs.com)

We're moving to python

Cons:

- Now you need C++ (for Arduino), Python (for the Pi) and Javascript+HTML (for the webpages)

Pros:

- There are lots of cool libraries
- They actually work
- They get updated when they don't work
- Now we can do a lot of ML

Software Best Practices

Start early
- bugs are best resolved with time rather than intensity
- time enables collaboration

Make a plan, keep the plan updated
- a plan will help you when you get lost
- a plan will help you remember what you did
- a plan helps others see where you went wrong

Software Best Practices

Don't code alone
- do not beat your head on problem for more than 1 hour
- see if anyone else has had your problem
- use Discord to get help

Documentation
- write down your sources
- when you hit an error and resolve it, write it down YOU WILL SEE IT AGAIN

Commit & Push often