Comparison of Raspbian to Windows 10 IoT Core operating systems and development tools

By Clarke Bowers
ABOUT THE PRESENTER

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- Clarke Bowers Consulting, LLC
- http://www.cbsoftwareengineering.com/
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- 35 years of industry experience
- He has architected and developed embedded systems, desktop applications, enterprise data warehouses, web sites and web services; cloud bases and locally hosted solutions
- He holds six patents

You can find this presentation and all the examples at: https://1drv.ms/f/s!Ar3pO7_GhJY9hOtmaUYC20lCv4T1-g
AGENDA

Talk

- Raspberry Pi hardware overview
- Raspbian Linux
- Windows 10 Core
- Others operating systems
- Installation, boot and shutdown
- Demonstration
  - Bobble head Santa
  - 3D Compass

Lab 1

- Eclipse IDE Python & C++
- I²C Libraries
- Code examples of
  - Barometer
  - Magnetometer

Lab 2

- Visual Studio C# & .NET framework
- GPIO & Interrupts
- Cross platform development
- Code examples of
  - Magnetometer
  - Accelerometer
March 21
Raspberry Pi 3 B+

- 2018
- Broadcom BCM2837B0, ARMv8 1.4GHz, 4-core 64-bit
- No GPU
- 1GB of RAM
- Micro SD slot (no storage included)
- No display
- 4 x USB 2.0
- Full-size HDMI
- Gigabit Ethernet, 802.11.b/g/n/ac Wi-Fi, Bluetooth 4.2
- 40 pin GPIO
- Not included: power supply, batteries, power switch, keyboard, mouse, heat sinks, case
- $35

Panasonic CF-C1 Laptop

- 2010
- Intel Core i5 M520 2.4GHz, 2-core 64-bit
- Integrated 500 MHz GPU
- 2GB of RAM
- 250GB hard drive
- 12.1-inch 1280x800-pixel multi-touch-capable display
- 3 x USB 2.0
- DB15 VGA
- Gigabit Ethernet, 802.11n Wi-Fi, Bluetooth 2.1
- RJ11 Dialup Modem
- Included: power supply, batteries, power switch, keyboard, trackpad, fan
- $2,000
IOT APPLICATION #1: TIDAL PROBE

- Mount Raspberry Pi, GPS, sensors and batteries on buoy
- Measure location, linear acceleration, angular acceleration, temperature and barometric pressure
- Transmit to cloud via G5 cellular

Application for harbor pilots. It tracks the cargo ships location and pulls latest buoy data from cloud for nearby buoys. Displays on map the microclimate marine conditions.
MEMS

- Micro-Electro-Mechanical Systems, or MEMS, is miniaturized mechanical and electro-mechanical elements that are made using the techniques of microfabrication.

- The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters.

- The types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics.

- At least some elements having some sort of mechanical functionality whether or not these elements can move.
MIXED SIGNAL

- Mixed-signal integrated circuit is any integrated circuit that has both analog circuits and digital circuits on a single semiconductor die.

- Many new or improved applications are possible because firmware running on DSPs (Digital Signal Processing) or micros with analog or mixed-signal silicon analog front ends.

- Many traditionally analog systems now have a firmware component.

- Our sensors
  - I2C Bus is digital
  - Sensor is analog
  - ADC (Analog to Digital Converter) bridges from one to the other

Figure 9. Magnetometer block diagram
WHEATSTONE BRIDGE

- Developed by Charles Wheatstone
- Used to measure very low values of resistances down in the milli-Ohms range.
- Two series-parallel arrangements of resistances connected between a voltage supply terminal and ground producing zero voltage difference between the two parallel branches when balanced.
- Two input terminals and two output terminals consisting of four resistors configured in a diamond-like arrangement as shown.

All our sensors are some type of wheatstone bridge. With three fixed resistors and one resistor which varies linearly with the property of interest.
<table>
<thead>
<tr>
<th>Magnetometer</th>
<th>Temperature</th>
<th>Gyroscope</th>
<th>Acceleration</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetoresistance material</td>
<td>Thermal resistance material</td>
<td>MEMS metal fragment</td>
<td>MEMS metal fragment</td>
<td>MEMS metal bar</td>
</tr>
<tr>
<td>Magnetic moment</td>
<td>Heat</td>
<td>Angular rate</td>
<td>Linear moment</td>
<td>Barometric Pressure</td>
</tr>
<tr>
<td>microGauss</td>
<td>degrees centigrade</td>
<td>Degrees per second</td>
<td>Micro-g (gravities)</td>
<td>hectopascals</td>
</tr>
</tbody>
</table>
The Wheatstone Bridge creates a linear response to the measured property. Slope is the unit of measure per bit, for example, 0.2 degrees centigrade per bit. Intercept is the offset from zero, and can be affected by environmental factors, MEMS design, and calibration. Calibration can remove the offset.
**Sources of Error**

- Chip manufacture
  - The traces on the IC are never perfect
  - Laser trim (removes error)
  - PROM (stores correction)
  - Just specified (live with it)

- Temperature error source
  - Fixed resistors in the bridge will vary some
  - Variable resistor may drift with temperature

- Temperature error correction
  - On die temperature sensor automatically corrects
  - On die temperature provides value & your code corrects
  - Spec tells error & you must measure

- Nonlinearity
  - Some material are not perfect straight lines over the range for the part
  - Better manufactures specify the guaranteed non-linearity. In other word worst case for it.
FILTERING

- Low Pass (LPF)
  - Remove high frequency noise and signals

- High Pass (HPF)
  - Remove low frequency noise and signals

- Band Pass (BPF)
  - Remove high and low frequencies
  - Infinite Impulse Response (IIR) filter
  - Finite Impulse Response (FIR) filters
    - narrow transition bands

![Diagram of normalized output power versus increasing frequency for a low pass filter with 3 dB point labeled as cutoff frequency (f)].
 Unix -> Linux -> Debian -> Ubuntu -> Raspbian
  Release 9.4 (stretch)
  Open source, https://www.raspbian.org/

  NOOBS, New Out Of the Box Software
  Easy operating system installer contains Raspbian and LibreELEC.
  Alternative operating systems links: Ubuntu Mate, Snappy Ubuntu Core, Libreelec, Pinet, OsMc, Risc Os
    which are then downloaded from the internet and installed.
  Windows 10 Iot Core is shown as an option on NOOBS, but will not install!

  SD Card Formatter: https://www.sdcard.org/downloads/formatter_4/
  Use Win32DiskImager to make a bootable SD card https://sourceforge.net/projects/win32diskimager/
  Default user login: pi, password: raspberry

 Beware Raspbian from Raspberrypi.org now includes cripple-ware
DEBIAN TOOLS INSTALL

- sudo apt-get install packageName
  - X-man is a manual
  - X-dev are developer tools
  - libxxx are static link libraries
- sudo apt update & upgrade
- Raspbian requires ARM EABI armhf from the raspberrypi.org repositories. Do not load from Debian

<table>
<thead>
<tr>
<th>Package Name</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>gpiod, libgpiod-dev</td>
<td>GPIO</td>
</tr>
<tr>
<td>python-all</td>
<td>Python</td>
</tr>
<tr>
<td>i2c-tools, libi2c-dev</td>
<td>I2C tools &amp; libs</td>
</tr>
<tr>
<td>eclipse, eclipse-cdt</td>
<td>IDE, C++</td>
</tr>
<tr>
<td>python-smbus</td>
<td>I2C Python</td>
</tr>
<tr>
<td>node, nodejs</td>
<td>Node</td>
</tr>
</tbody>
</table>
# Booting & Shutdown

## Windows 10 Core
- Green light blinks a couple times during boot and forever after shutdown
- Boots in more than a minute

## Raspbian
- Green light blinks when accessing SD card
- Boots in ten seconds
- Quick power off – Alt-SysRq-I (system request kill all processes) then Alt-SysRq-O (system request power-Off)

Boots on power connection. There is no power switch or reset button. Do not plug a transform into The ⅛” coaxial connector (that is audio & video out). Plug USB power adapter into micro-USB (not the standard USB-A connectors)
COMPOSITE VIDEO & AUDIO

- Do not plug a transform into the ⅛” coaxial connector (that is audio & video out)
- 3.5mm jack is **FOUR** pole audio and composite video (not a 3 pole for ear buds). Ring 2 must be ground!
- Raspberry Pi Display Resolution if monitor is disconnected
- The Raspberry Pi may not maintain Display Resolution if monitor is disconnected. The EDID of the monitor is used to set the resolution of the system when one is connected. When disconnected, the Raspberry Pi firmware defaults to what is in the config.txt in the root of the SD card.

```
tvservice -s
```

- [https://www.raspberrypi-spy.co.uk/2014/07/raspberry-pi-model-b-3-5mm-audiovideo-jack/](https://www.raspberrypi-spy.co.uk/2014/07/raspberry-pi-model-b-3-5mm-audiovideo-jack/)
- [https://bhavyanshu.me/tutorials/force-raspberry-pi-output-to-composite-video-instead-of-hdmi/03/03/2014/](https://bhavyanshu.me/tutorials/force-raspberry-pi-output-to-composite-video-instead-of-hdmi/03/03/2014/)
Windows IoT Core is a version of Windows 10 that is optimized for smaller devices with or without a display that run on both ARM and x86/x64 devices. The Windows IoT Core documentation provides information on connecting, managing, updating, and securing your devices, and more.

The release for the Raspberry Pi 3B+ (the downloadable ISO can be found here) is a technical preview and there is currently no timeline for a release version. For a better evaluation experience and for any commercial products, please use the Raspberry Pi 3B or other devices with supported Intel, Qualcomm or NXP SoCs. From https://docs.microsoft.com/en-us/windows/iot-core/release-notes/currentcommercial

- Cost $0.00
# Raspbian Hardware

<table>
<thead>
<tr>
<th>Name</th>
<th>Processor</th>
<th>Cost</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>APC</td>
<td>VIA ARM Cortex-A9</td>
<td>$49 to $59</td>
<td>APC is a fundamental redesign of the PC based on the Neo-ITX form factor</td>
</tr>
<tr>
<td>Raspberry Pi 2 &amp; 3</td>
<td>Broadcom ARM</td>
<td>$35</td>
<td>All versions are supported including the 3 B+ (the only version currently for sale). The Broadcom Wi-Fi chip is supported.</td>
</tr>
<tr>
<td>Raspberry Pi Zero</td>
<td>Broadcom ARM</td>
<td>$5 - $10</td>
<td>Supported both Wi-Fi and Bluetooth versions</td>
</tr>
</tbody>
</table>
## W10 IOT Core Hardware

<table>
<thead>
<tr>
<th>Name</th>
<th>Processor</th>
<th>Cost</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UP</strong></td>
<td>Intel Pentium, Atom, Celeron &amp; Apollo</td>
<td>$150 to $400</td>
<td></td>
</tr>
<tr>
<td><strong>DragonBoard 410c</strong></td>
<td>Qualcomm Snapdragon 400</td>
<td>$75</td>
<td>Product of Arrow Electronics</td>
</tr>
<tr>
<td><strong>MinnowBoard Turbot</strong></td>
<td>Intel Atom</td>
<td>$150 to $200</td>
<td>Open source hardware</td>
</tr>
<tr>
<td><strong>Raspberry Pi 2 &amp; 3</strong></td>
<td>Broadcom ARM</td>
<td>$35</td>
<td>3 B+ is only preview without Wi-Fi chip support. Windows 10 prefers a TPM chip &amp; GPU. Pi has neither. Pi 2 is discontinued.</td>
</tr>
<tr>
<td><strong>Raspberry Pi Zero</strong></td>
<td>Broadcom ARM</td>
<td>$5–$10</td>
<td>Not supported by Windows 10</td>
</tr>
</tbody>
</table>
Remote administration and development for Windows 10 IoT Core

- Ip4 address port 8080
- List installed applications
- Start, Stop or set to auto-start application
When the credentials dialog opens, make sure you use yourrpi3machinename\Administrator for the user name. The default password is p@ssw0rd. You need to connect with the computer name in front of the username. The zero can easily be mistaken as an 'O' so calling that part out.

- VS2017 Community Edition
- Install Windows IoT Core Project Templates for VS 2017 (VS Extensions & Updates)
- Install latest Windows development SDK (MSDN downloads)
- Windows 10 IoT Dashboard
GENERAL PURPOSE I/O

- All services based on Broadcom SoC capabilities
- J8 40 pin connector 0.1” centers on Raspberry Pi ([http://pi4j.com/pins/model-3b-plus-rev1.html](http://pi4j.com/pins/model-3b-plus-rev1.html))
- 3.3 & 5.0 VDC and ground

I²C (Inter-Integrated Circuit) Bus
- Single master
- 126 slave devices
- kHz speeds

Other: UART (RS232), Pulse-Code Modulation (a.k.a. I²S, Inter-IC Sound)

SPI (Serial Peripheral Interface) Bus
- Multiple masters
- Multiple slaves (independent or cooperative slaves)
- Limited by TTL signal levels
- DMA (Direct Memory Access)
- MHz speeds

GPIO (27 pins)
- Write (set) high or low
- Read signal level (high or low)
- Interrupt on transition (either way)

Beware, hardware is not transactional. You cannot roll it back. Do not leave new code running unattended!

- Inertial measurement unit (IMU), STµLSM9DS1, 3D digital linear acceleration sensor, a 3D digital angular rate sensor, and a 3D digital magnetic sensor


- I2C bus
  - 400 KHz, fast mode operation

- 6-pin connector for top of PI J8

- Side four pin jumper to PI J8

- All five interrupt pins available on bottom