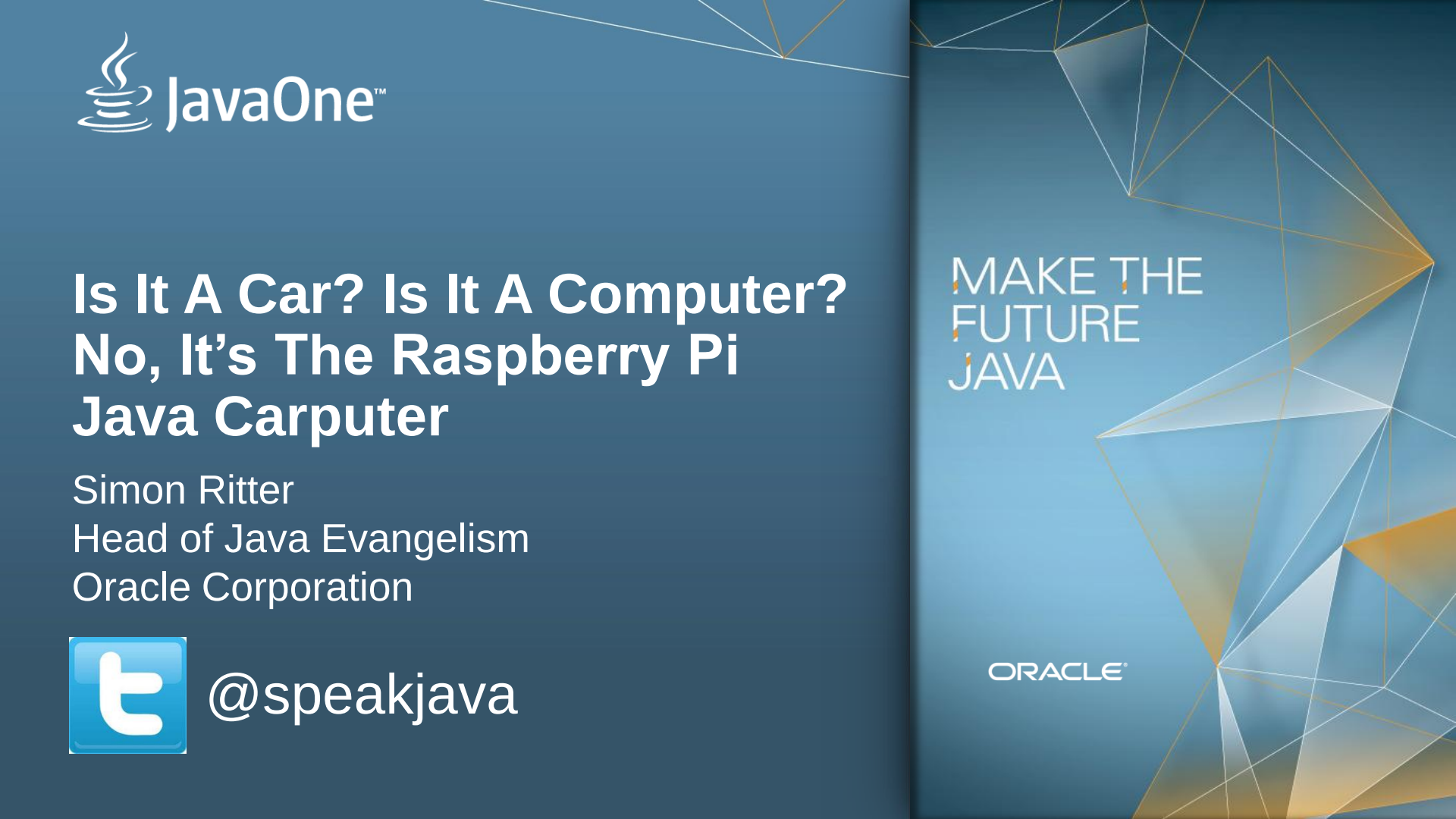

Java™



Is It A Car? Is It A Computer? No, It's The Raspberry Pi Java Carputer

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Head of Java Evangelism
Oracle Corporation

@speakjava

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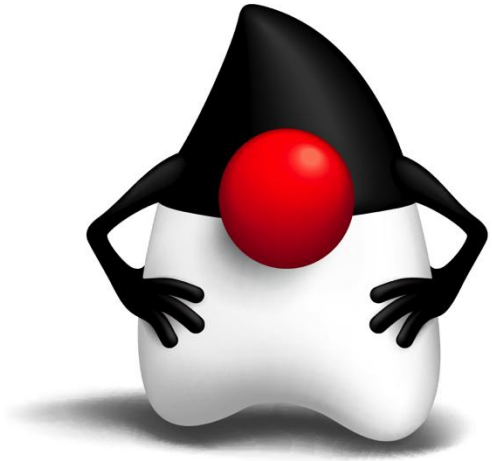
Program Agenda

- Cars and Computers
- The Raspberry Pi
- Embedded Java and JavaFX
- Building a Java Powered “Carputer”
- Demos

Cars And Computers



My First Car: 1981

1971 Mini Clubman 1000

- No electronics
  - Well, it had a radio
- Purely electromechanical
  - Points/Distributor
  - Carburettor/Manual choke
  - Drum brakes
  - Dynamo
  - Lights, horn, wipers, fan, ignition switch

Car Wiring: 1970s

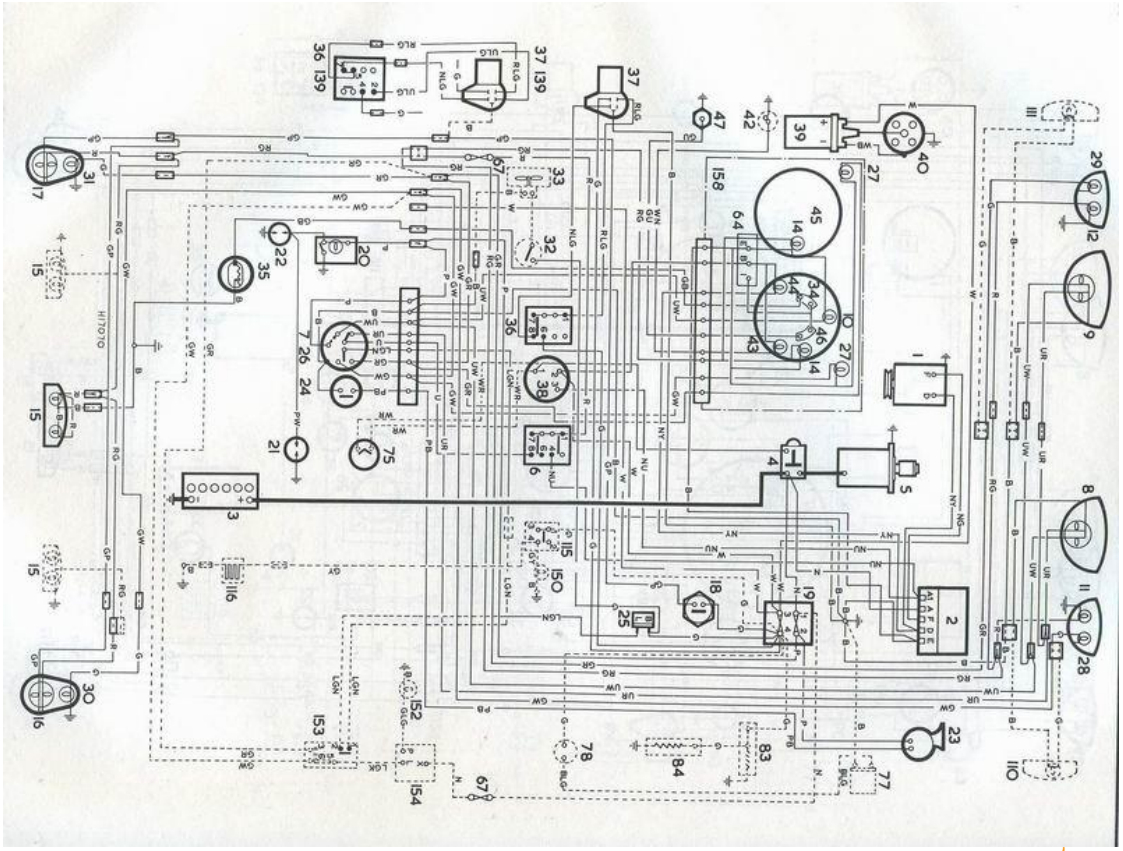


Image coutesy of Haynes manuals

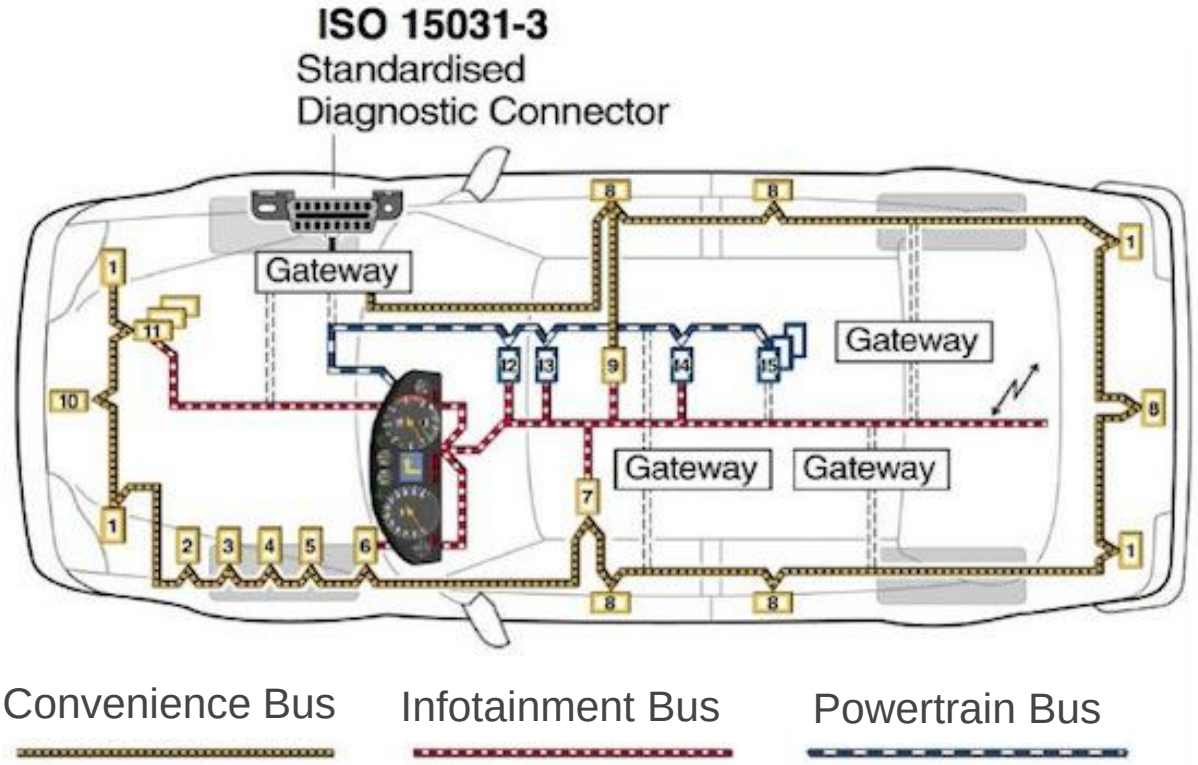
My Current Car

2011 Audi S3

- Lots of electronics
  - Engine Control Unit (ECU)
  - Fuel Injection/Electronic timing
  - “Fly-by-wire” throttle
  - Anti-lock Braking System (ABS)
  - Electronic Stability Program (ESP)
  - Magnetorheological Suspension
  - Satellite navigation
  - Auto-sensing wipers and lights

Car Wiring: 2011

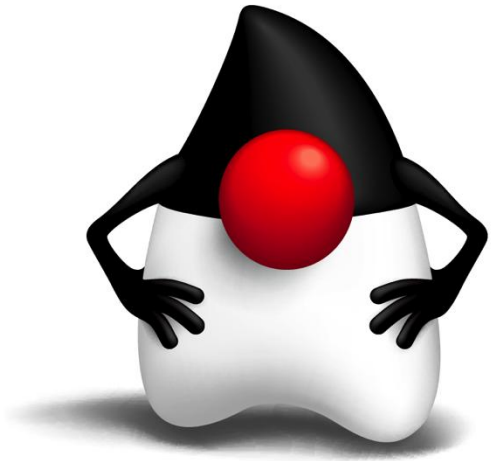
Bus architecture means substantially less wiring



Protocols For Car Bus Communication

- On Board Diagnostics (OBD-II)
  - Connector, SAE J1939 / ISO 15031-3
- OBD-II Protocols
  - SAE J1850 PWM or VPM
  - ISO 9141-2
  - ISO 14230
  - ISO 15765-4: Controller Area Network (CAN) Bus
    - 11 or 29 bit ID, 250 or 500 kbaud

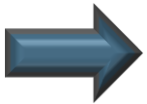
The Raspberry Pi



Raspberry Pi

History and Goals

- Project started in 2006
  - Goal was to devise a computer to inspire children
  - Inspiration from the BBC Micro project from 1981
  - Officially launched 29th Feb, 2012
  - Over 1 million boards shipped so far



JavaOne ORACLE

Raspberry Pi

Specification

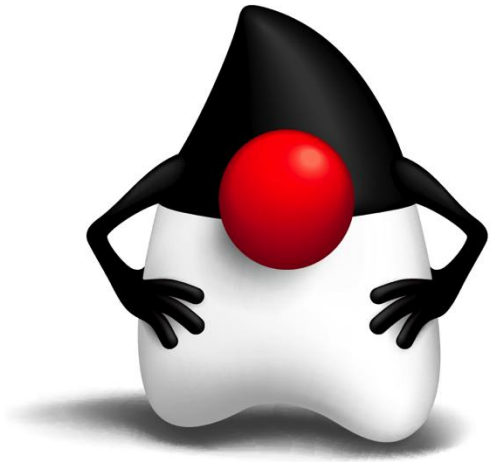
- CPU: ARM 11 (v6) core running at 700MHz
  - Broadcom SoC package
  - Can now be overclocked to 1GHz (without breaking the warranty!)
- Memory: 512Mb
- I/O:
  - HDMI and composite video
  - Audio out (3.5mm plug)
  - 2 x USB ports
  - Ethernet
  - Header pins for GPIO, UART, SPI and I2C

Raspberry Pi Carputer

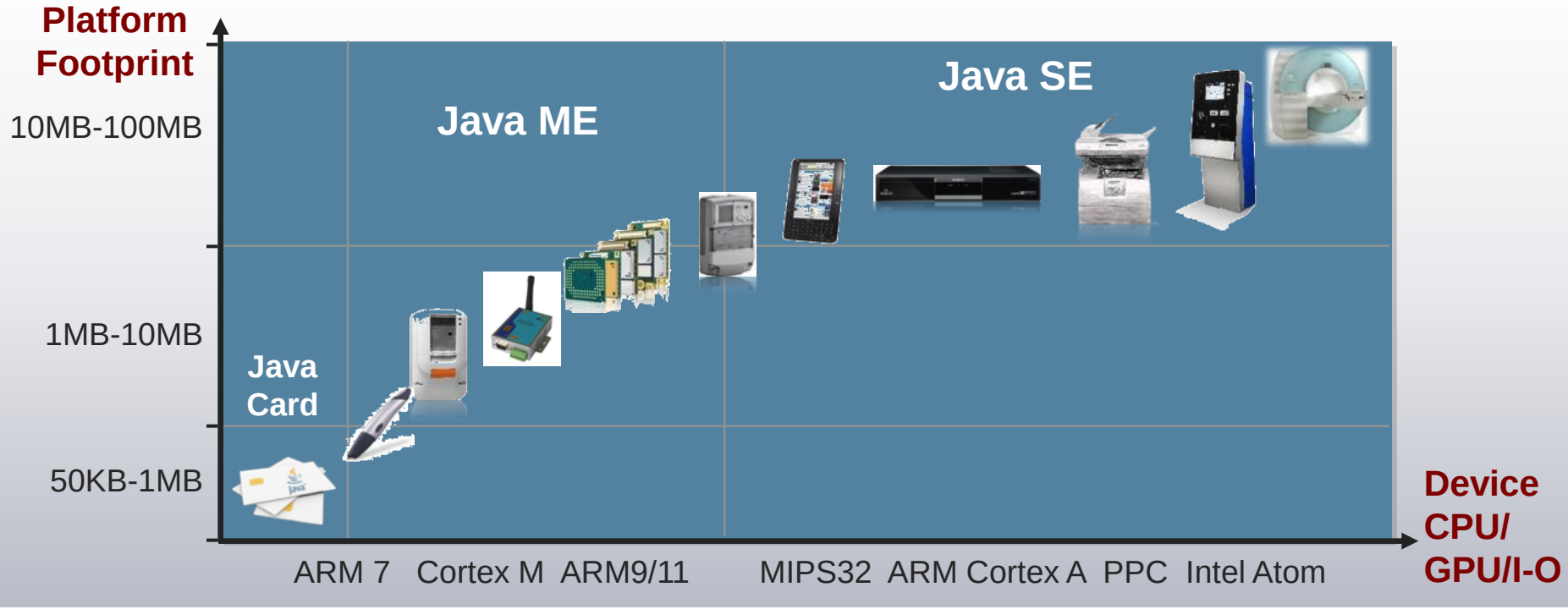
Advantages

- Plenty of computing power
  - With low electrical power consumption (< 1 Amp at 5V)
- Persistent storage provided by SD card
  - Disk drives not ideal in hot places with lots of vibration
- Supported device for embedded Java
  - Hardware floating point acceleration configured
  - Java SE Embedded and Java ME Embedded
  - JavaFX Prism graphics engine ported

Embedded Java and JavaFX



Java Technology for Embedded Devices



Java ME Embedded 3.3

Key Features

- Connected Limited Device Configuration 1.1
  - Reduced footprint JVM and core libraries
- Device Access API (new)
  - Standard library for access to
    - GPIO
    - UART
    - I2C/SPI
- Additional profiles used as required

Java SE 8 Embedded (Early Access)

Key Features

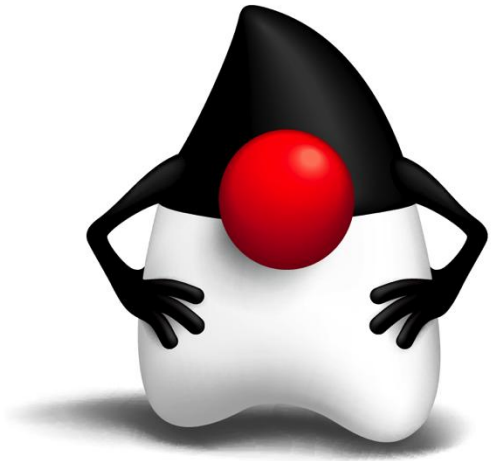
- Tuned for Raspberry Pi
  - ARM6 architecture does not require hardware FP
  - Raspberry Pi has one, so JVM needs specific compiler options
- Inlcudes JavaFX
- Includes compact profiles for reduced footprint
- Recently added to standard build platforms
  - EA updated as each new build comes out

JavaFX On Embedded Devices

Things To Consider

- JavaFX on embedded does not support the full feature set
  - No WebView component (not a problem for the carputer)
  - No direct media playback support
    - For video there is a work around (but, does the carputer need it?)
    - Sound would be nice, but not essential
- Remember resource constraints
  - Big scene graphs need memory and CPU cycles
  - Keep number of nodes small (ideally <50)

Building a Java Powered "Carputer"

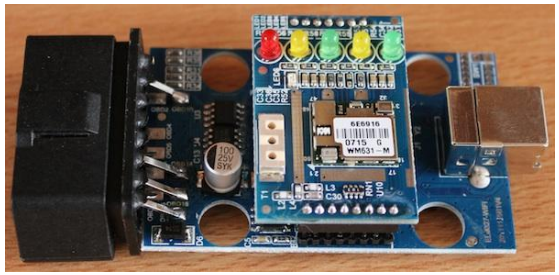


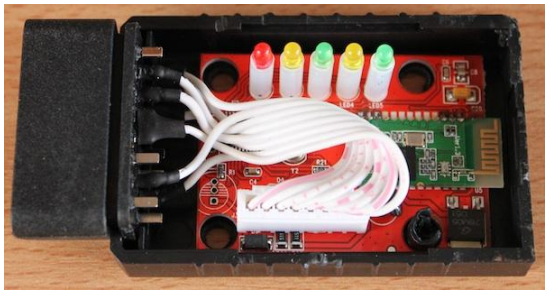
Carputer Design Objectives

- Display realtime data
  - Engine performance (Power, Torque, Load)
  - Driver data (Throttle position, steering angle, braking force, etc)
  - G-Forces on car
- Record data for later analysis
  - Produce graphs to display changes over time
  - Play at Formula 1
  - Improve driving style (!)

ELM327

Cheap way to hack your car





- WiFi or Bluetooth connection to OBD-II
- Fixed IP address, Ad-hoc networking
- Need to configure Raspberry Pi
  - **`/etc/network/interfaces`**
- AT style commands for control
- Non-AT commands are assumed to be OBD-II
  - Simple request-response interaction
  - Easy to write Java code to handle this

Touchscreen

Lots of things available on eBay

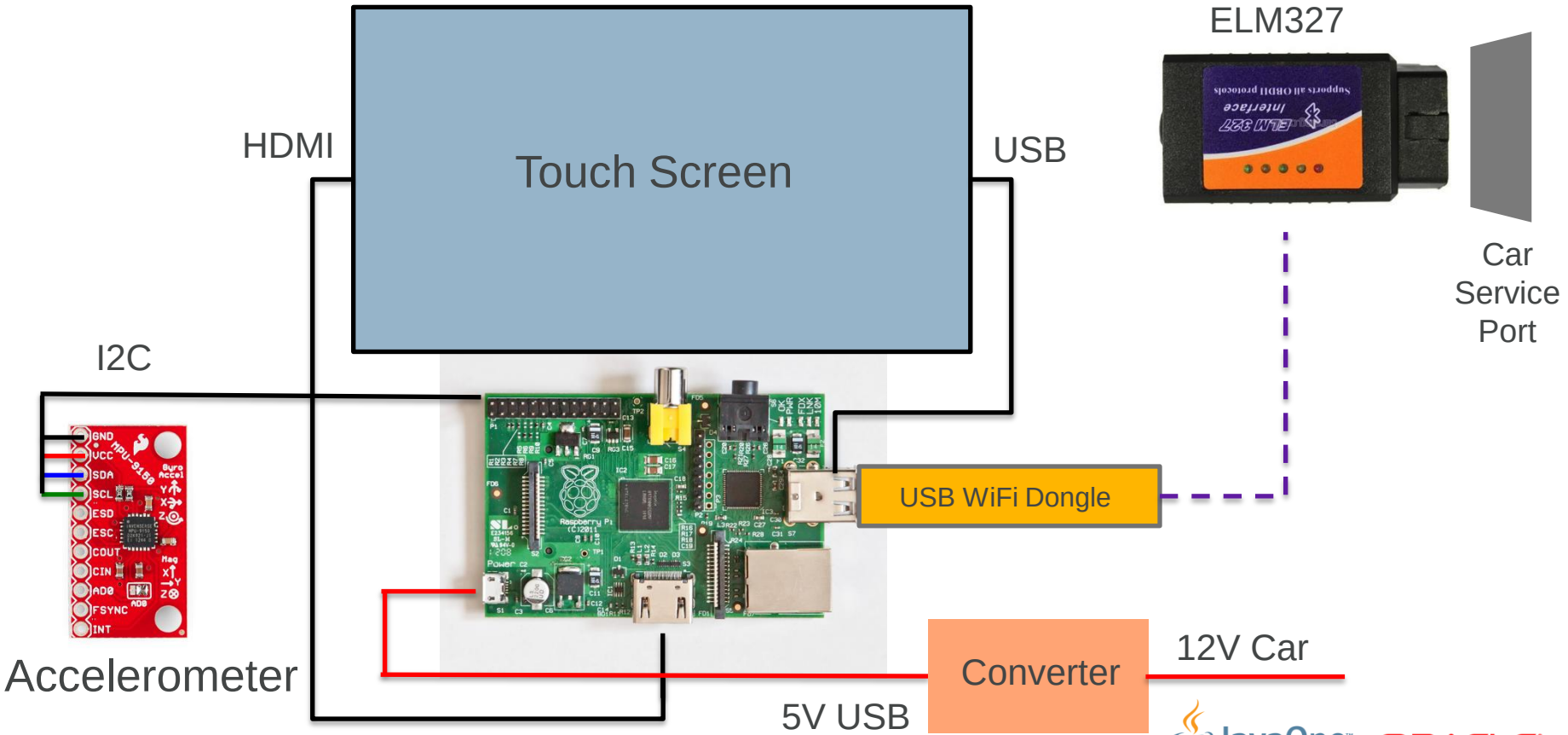
- 2 DIN fitting size
  - Ideal for centre console
- HDMI input
  - Specifically marketed for Raspberry Pi
- USB connection for touch screen

JavaFX And Touchscreen

Not completely straightforward

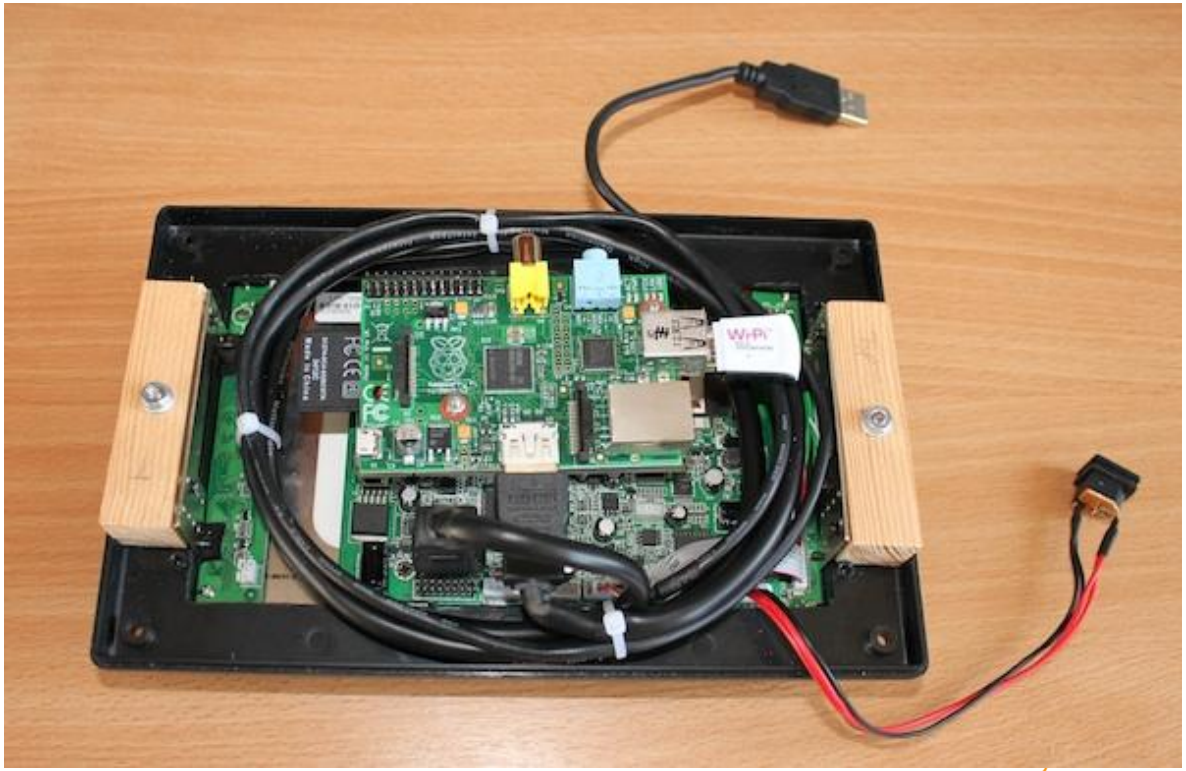
- Raspian Linux recognises device: eGalax Inc
- Creates two devices in **`/dev/input/event0`**, **`event1`**
- JavaFX sees devices and uses event0
  - No events generated
  - Need to use event1 (No idea why)
- Special build of JavaFX?
- Neccesity is the mother of invention
  - Delete event0 and **`mknod event0 c 13 65`** (same as event1)
  - Need script to repeat at boot time

Carputer Hardware Architecture



Touchscreen

Hardware Fitting Challenges



Accelerometer

- Sparkfun breakout board MPU 9150
  - 9 DoF sensor (accelerometer, gyroscope, compass)
- Communications via I2C
  - Configure Raspberry Pi **`/etc/modules`**
    - **`i2c-bcm2708`**, **`i2c-dev`**
    - **`i2c-detect -y 1`** to get address
  - Compass communication is a bit more complicated
    - Second I2C bus

Accelerometer Code

Using Pi4J Library on Java SE Embedded

```
I2CBus bus = I2CFactory.getInstance(I2CBus.BUS_1);
I2CDevice device = bus.getDevice(0x68);

/* Start sensing */
device.write(0x6B, (byte)0b00000000);
device.write(0x6C, (byte)0b00000000);

/* Set configuration */
device.write(0x1B, (byte)0b00011000); // Gyroscope
device.write(0x1C, (byte)0b00000100); // Accelerometer

device.read(0x3B, accelData, 0, ACCEL_PACKET_SIZE);
```

Compensating For Gravity In Acceleration

The Earth Sucks

- The accelerometer measures acceleration (obviously)
- Gravity is a constant acceleration
  - Consider it static acceleration
- What we want is dynamic acceleration
- Zero out gravitational effect
  - Assume no rotation of the sensor
  - Nearly correct, car will roll in corners and pitch under braking/acceleration
  - Good enough for the demo
  - Could integrate gyro and Kalman filter for higher accuracy

Calculating Power And Torque

Torque (Nm) = Mass x Wheel Radius x Acceleration (in G)

Torque (lb/ft) = Torque in Nm x 0.73756

Power (BHP) = Torque (lb/ft) x engine RPM / 5252

- Results will not have high accuracy
  - Values in red are not precise
- Dynamometer is the only way to get accurate figures
- Interesting to see values v. manufacturers figures

Carputer Software Architecture

Realtime Data

- Screens based
  - Splash screen
  - Basic and advanced car data
  - G forces on car
  - Graphed results of different parameters
- Simple UI
  - Can’t read numbers when driving
- Touchscreen to switch screens
  - Repurpose existing car controls to change screen?

UI Design Ideas

Take Inspiration From Others

Renault Megane Sport

UI Design Ideas

Take Inspiration From Others

Tesla

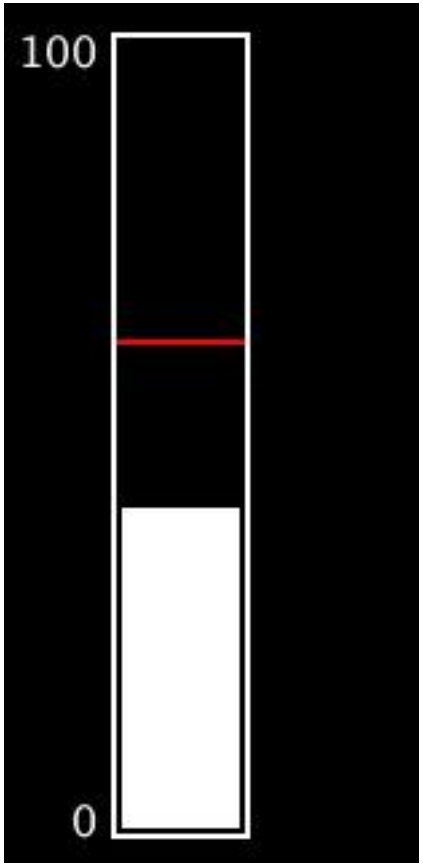
UI Design Ideas

Take Inspiration From Others

Lamborghini Reveton

Simple Data Display Control

- Only uses 3 nodes
  - Polygon
  - Rectangle
  - Line
  - Labels are optional
- Displays
  - Current value
  - Maximum value since start (resetable)
- Simple to understand from a glance



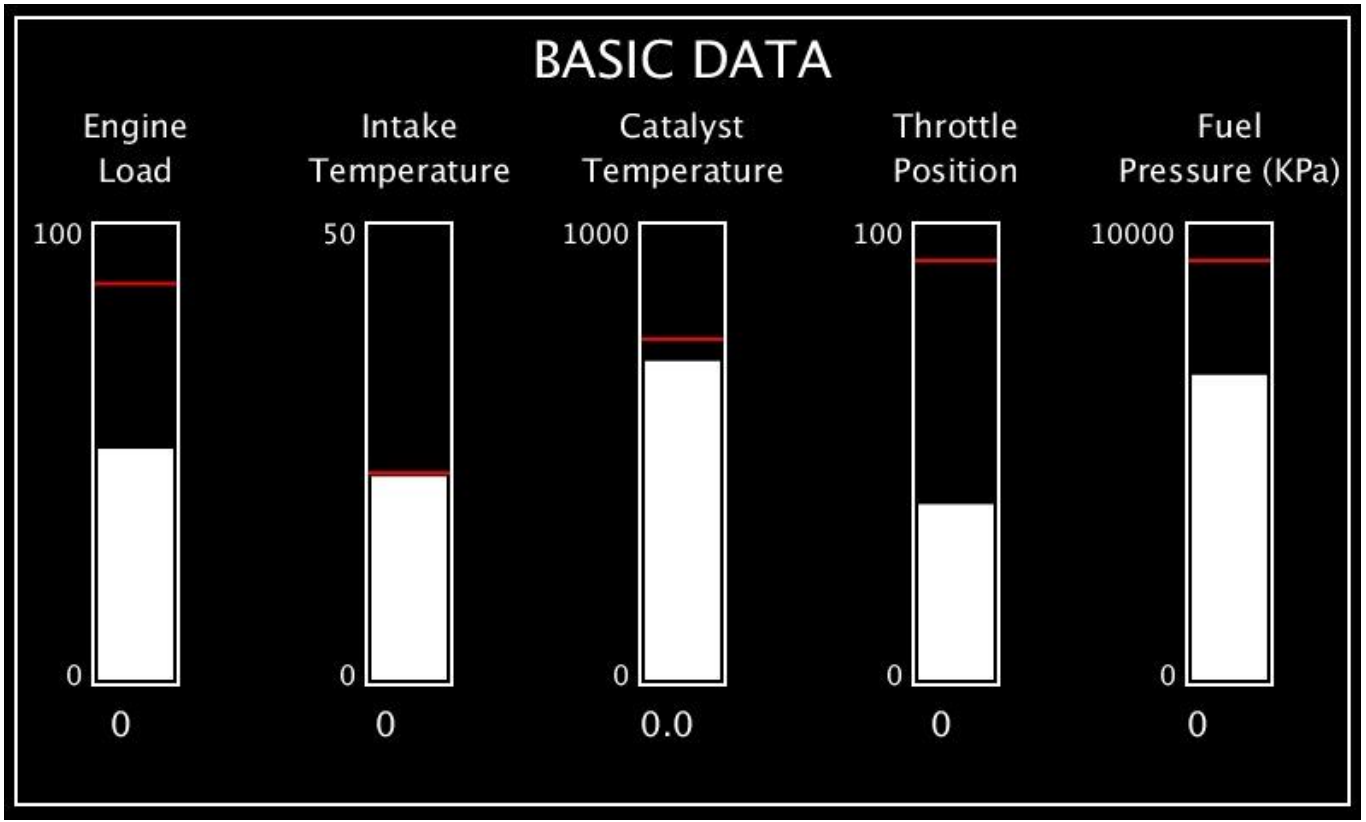
User Interaction

- Complex UIs are bad for driver distraction
  - Programming the SatNav while driving
- Make Carputer interaction as simple as possible
- Sequence of screens
  - Main menu? Too complex, too much reading
  - Cycle through screens (Keep number small)
  - Just touch screen to change to next display
    - Use `setMouseTransparent(true);`
  - Use steering wheel button

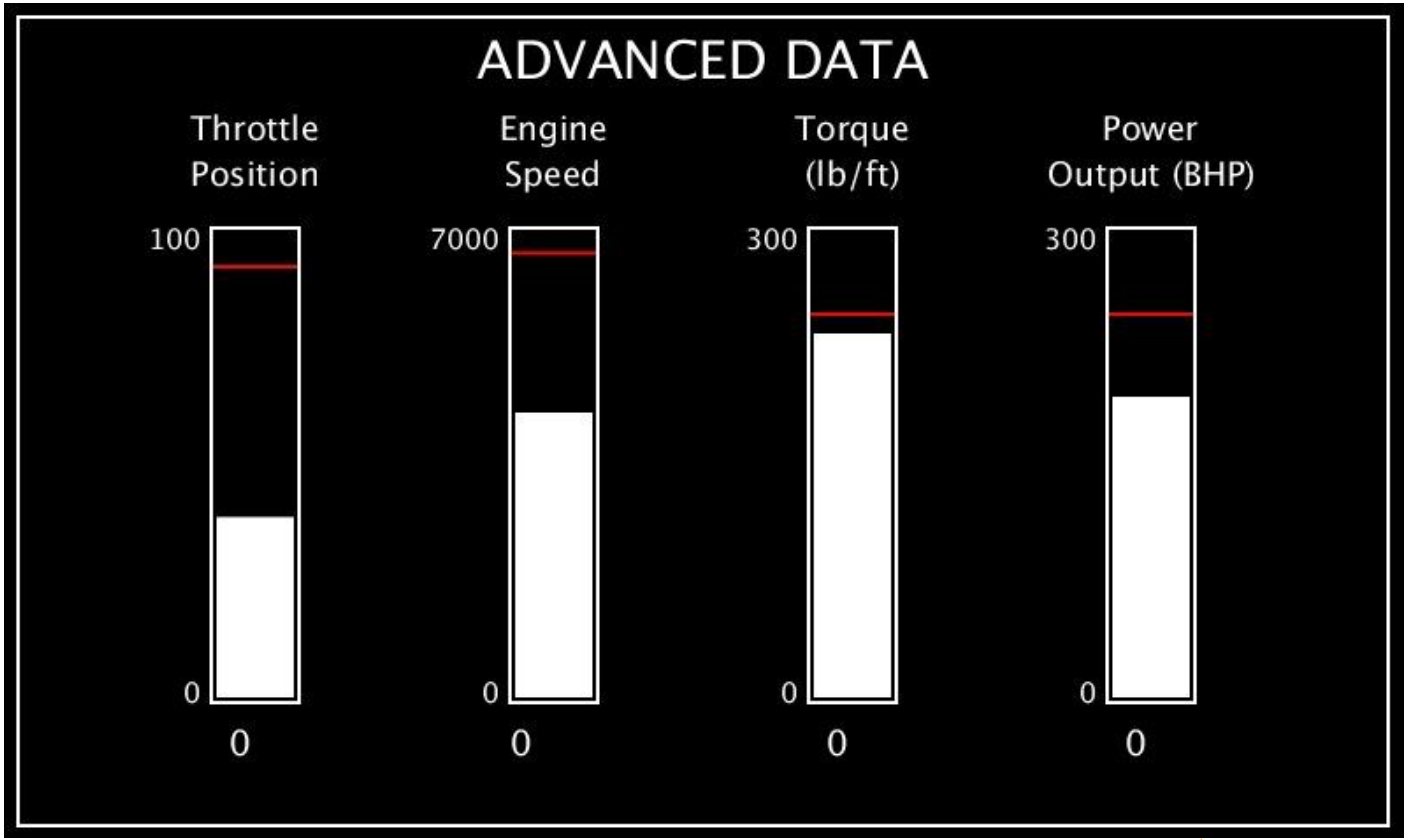
UI Screens

Splash Screen

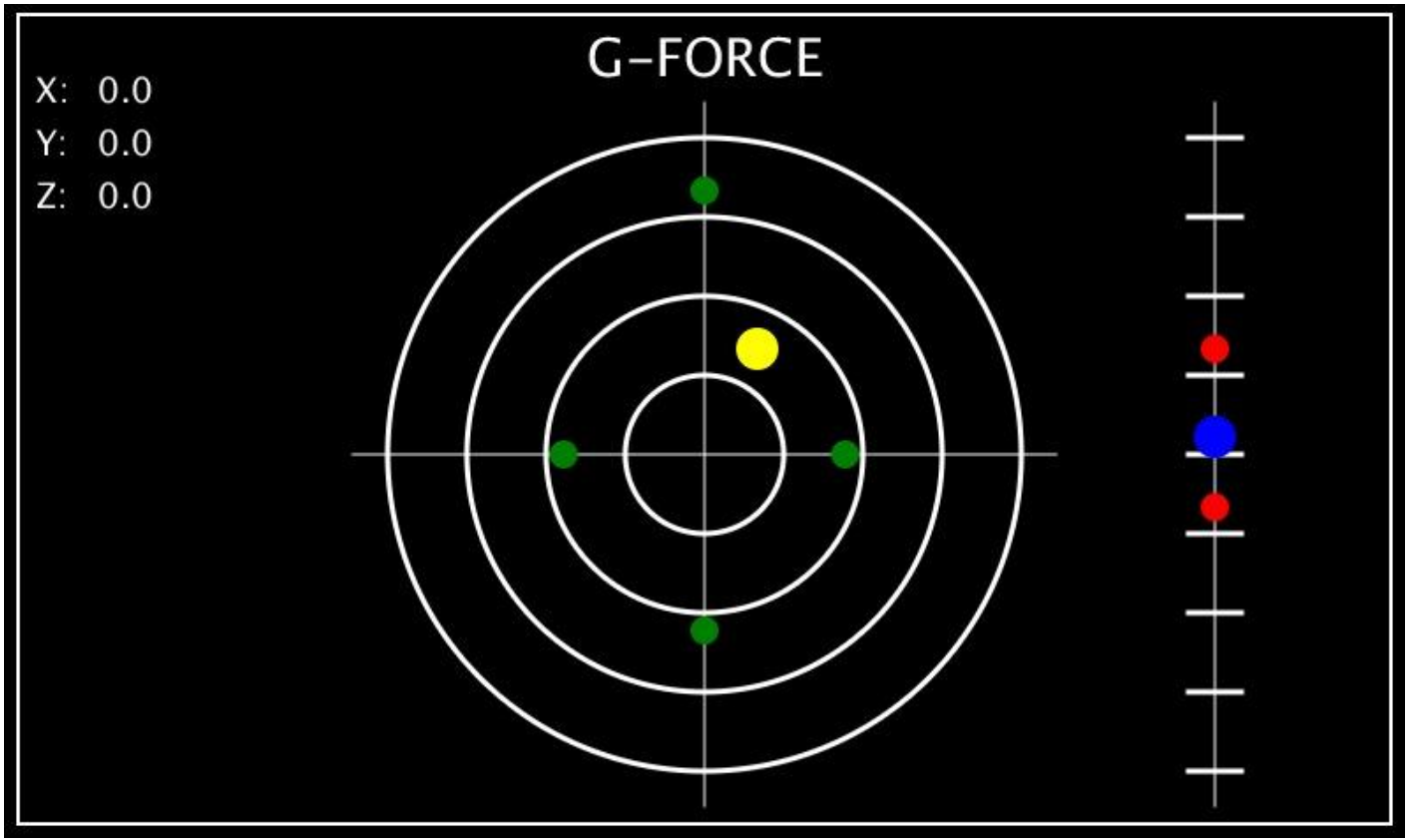
UI Screens



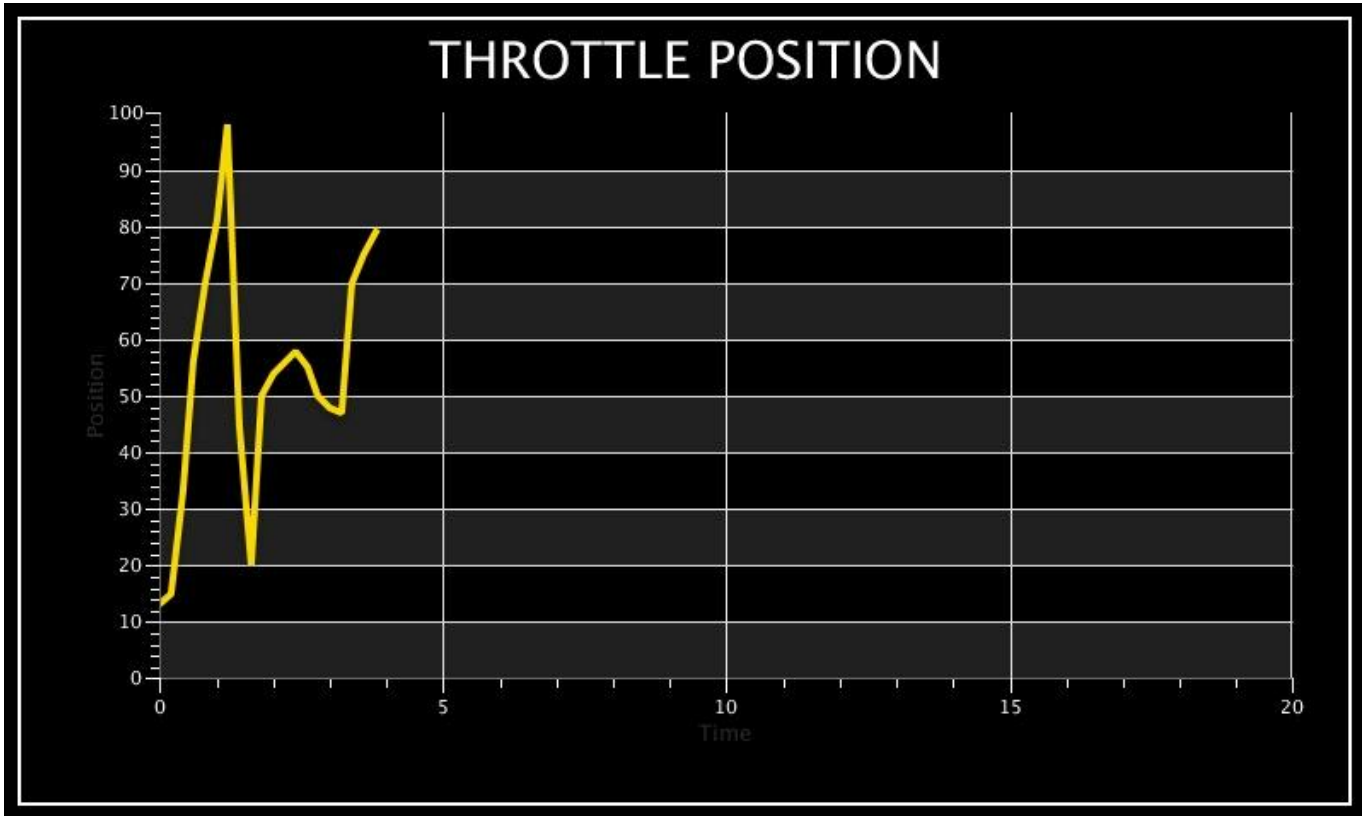
UI Screens



UI Screens



Graph Plots Of Throttle Position And Power

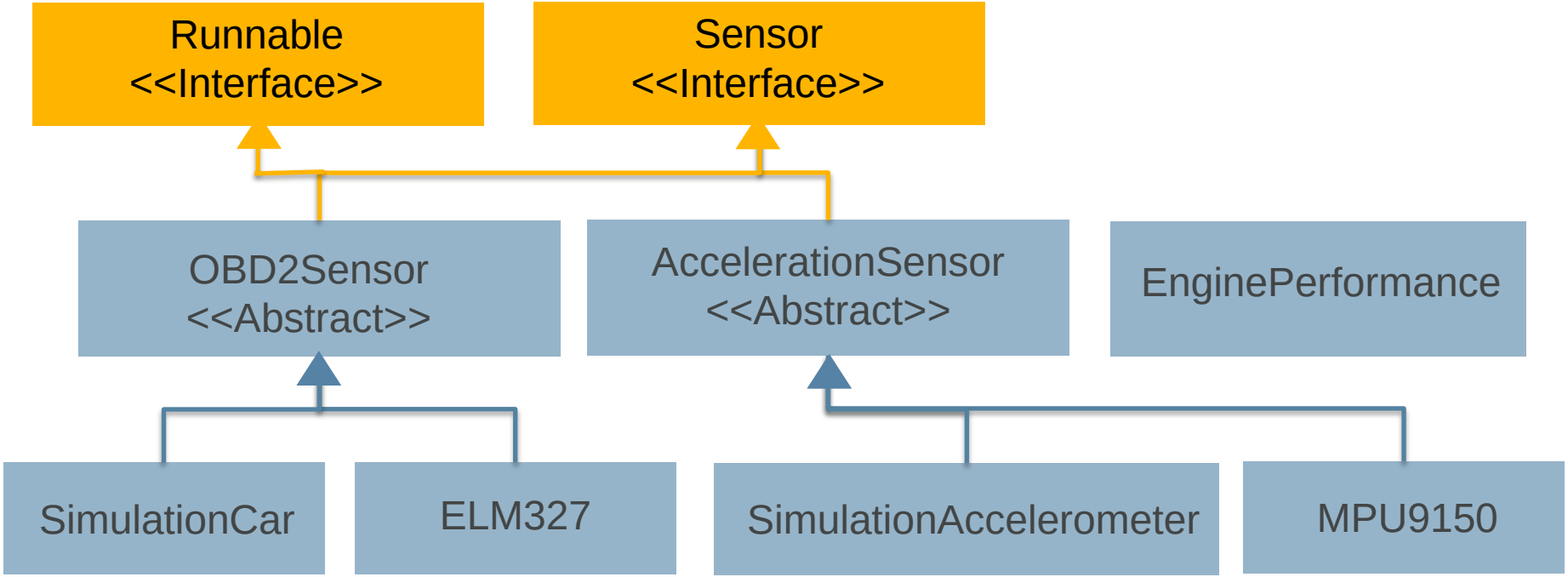


JavaFX Charts And Colours

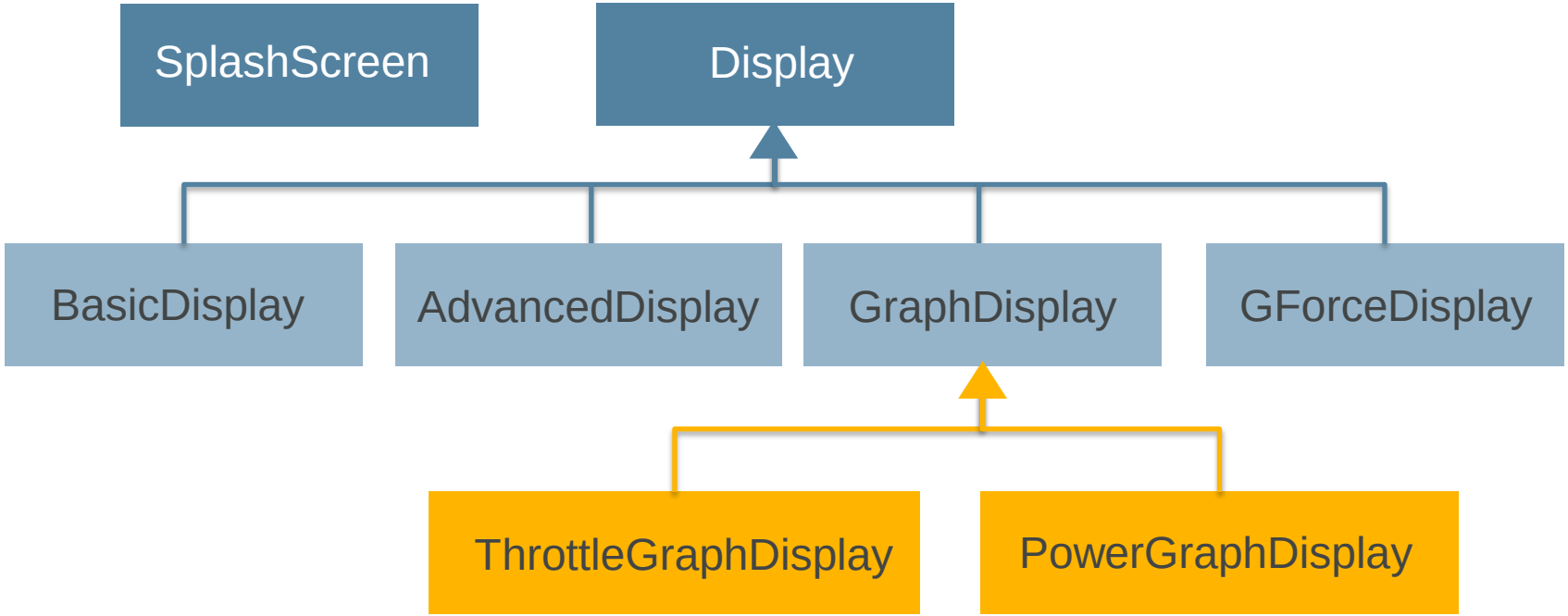
Can Only Be Changed Using CSS

```
.axis { -fx-tick-label: #FFFFFF; }

.axis-tick-mark { -fx-stroke: #FFFFFF; }

.axis-minor-tick-mark { -fx-stroke: #000000; }

.chart-plot-background { -fx-background-color: #000000; }

.chart-alternative-row-fill { -fx-fill: #000000; }

.default-color0.chart-series-line { -fx-stroke: #FFFF33; }
```

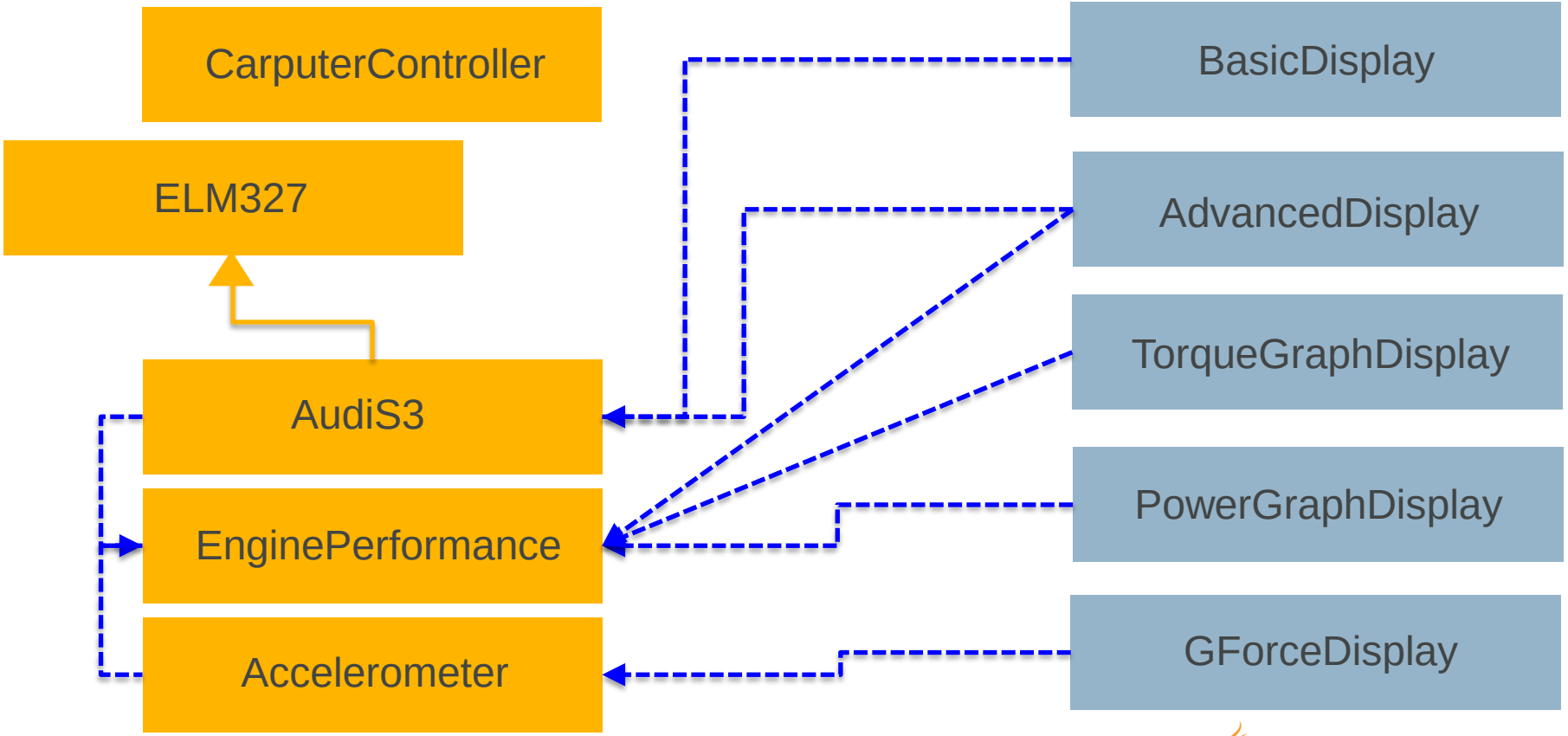
Design: Model



Design: View



Design: Controller

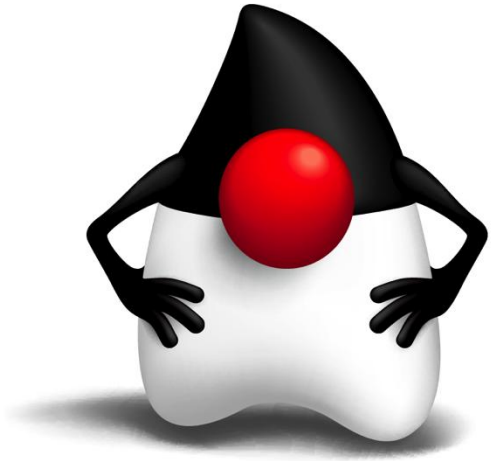


Using Car Control Buttons

Monitoring CAN Bus Data

- Not simple
  - Car manufacturers don’t share the CAN bus IDs and message formats
  - Even things like Audi forums can’t supply this
  - Need to reverse engineer
- ELM327 has **`AT MA`** command
  - Monitor all CAN Bus traffic
  - Need to pick the relevant message from a LOT of data
  - Once the ID is know use **`AT MT xx`** to monitor transmit messages

Future Ideas, Conclusions and Resources

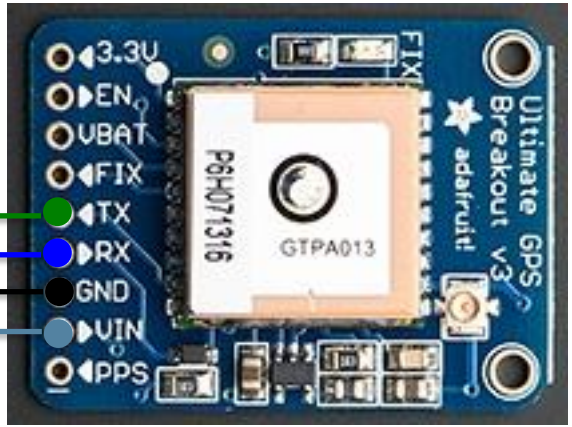


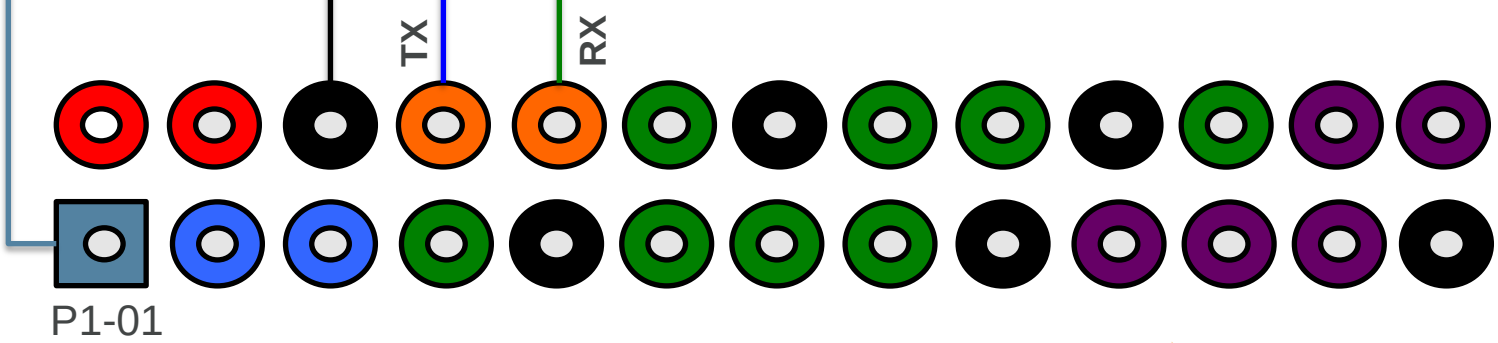
What Next

- Integrate heart rate monitor to add biometric data
- Heads Up Display (HUD)
  - Microprojector and half-silvered perspex
- Further investigation of CAN Bus signals
  - Brake pressure, steering position
  - Use other switches
  - Send commands (this is rather scary)

Adafruit Ultimate GPS Breakout

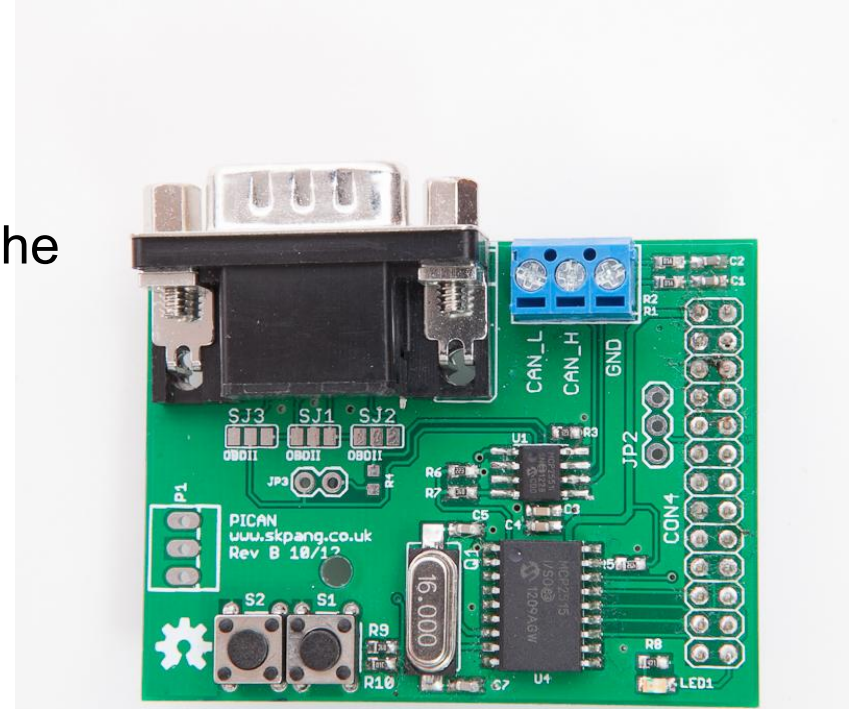
NOTE: RX ⟷ TX
TX ⟷ RX





The Pi Can Interface

- Can’t read CAN bus and OBDII at the same time via ELM327
- Use connector for entertainment system
- Need to check that I2C for accelerometer will still work
- Reasonable cost, $50

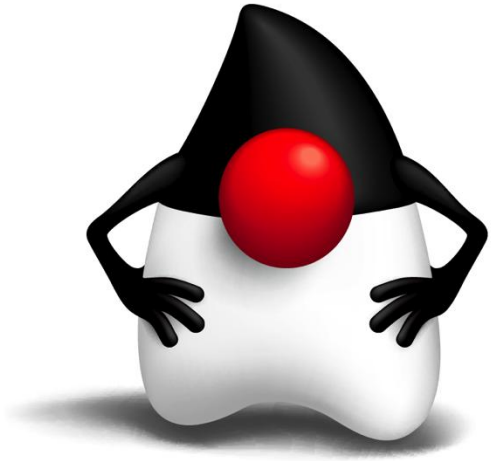


Resources

- www.audi.com
- www.raspberrypi.org
- javafx.oracle.com

- blogs.oracle.com/speakjava

Demos



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