Java™

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

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@speakjava

MAKE THE FUTURE JAVA

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Program Agenda

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

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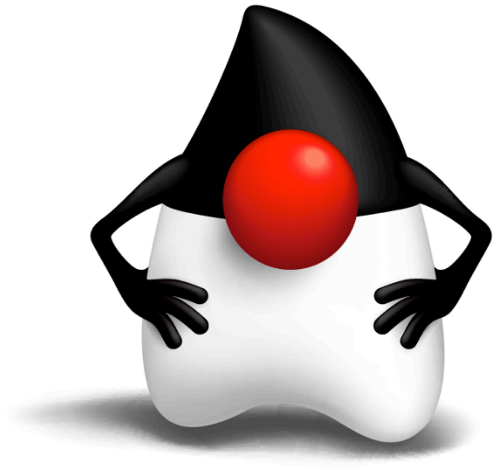
Cars And Computers



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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

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Car Wiring: 1970s

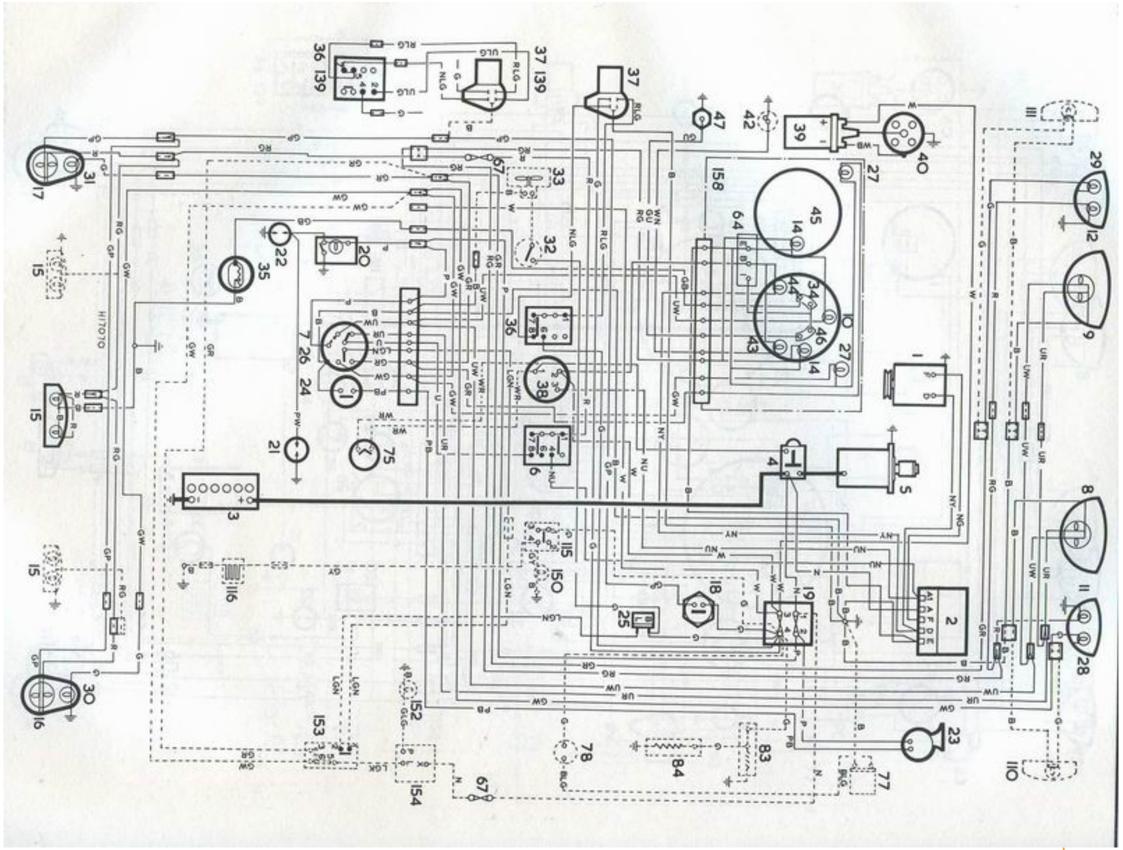

Image coutesy of Haynes manuals

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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

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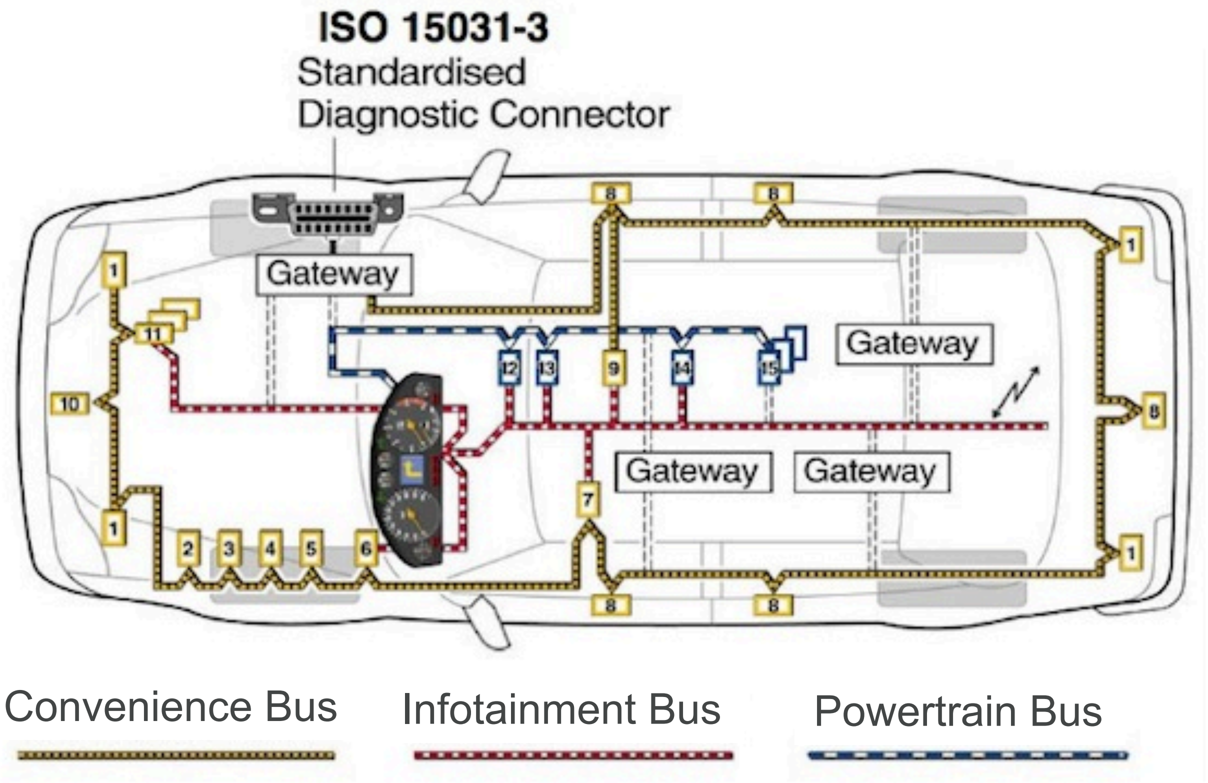
Car Wiring: 2011

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

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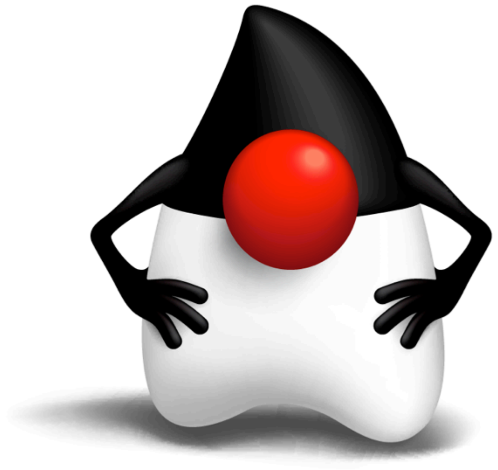
The Raspberry Pi



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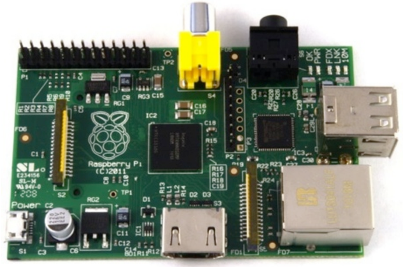
Raspberry Pi

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



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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

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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

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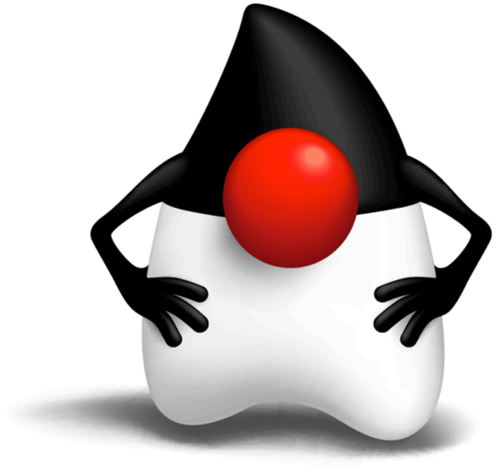
Embedded Java and JavaFX



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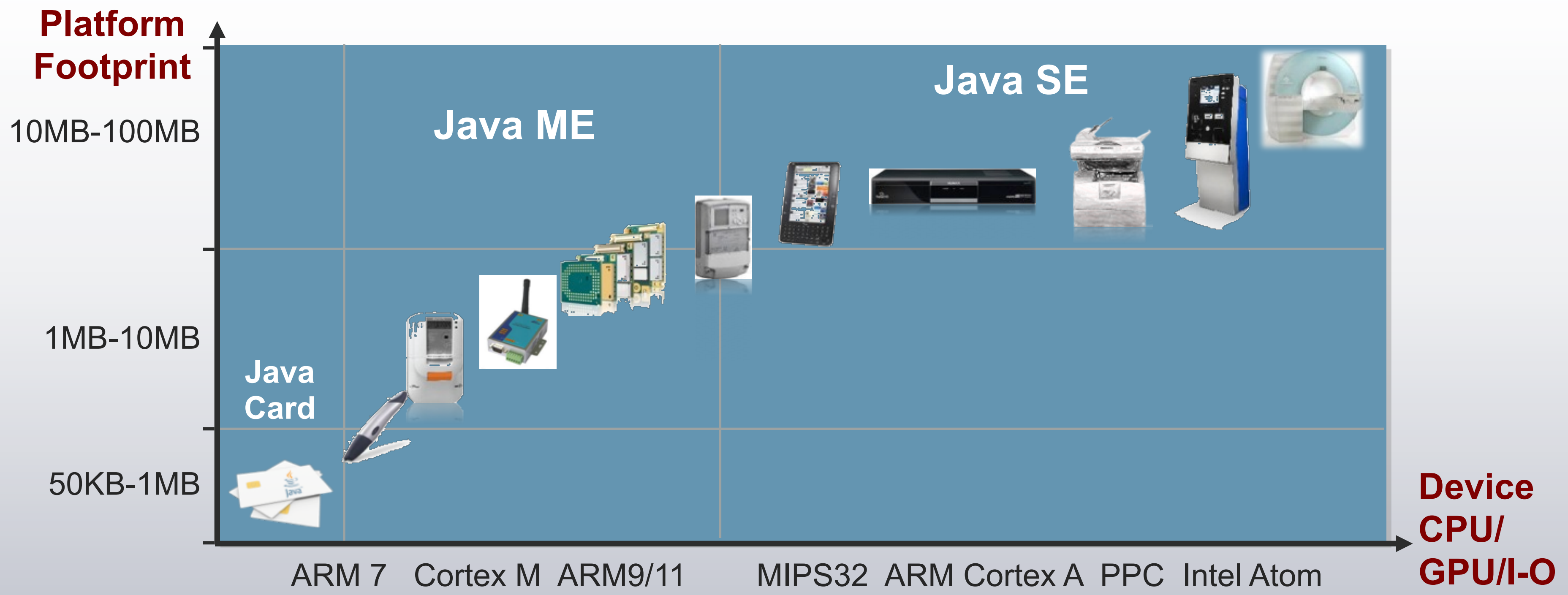
Java Technology for Embedded Devices



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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

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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

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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)

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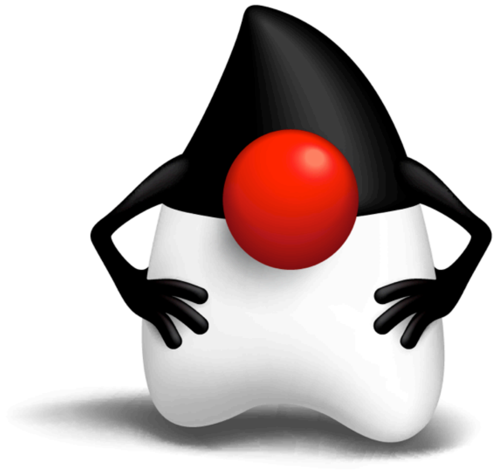
Building a Java Powered "Carputer"



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 (!)

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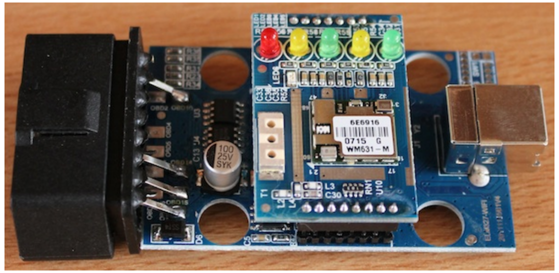
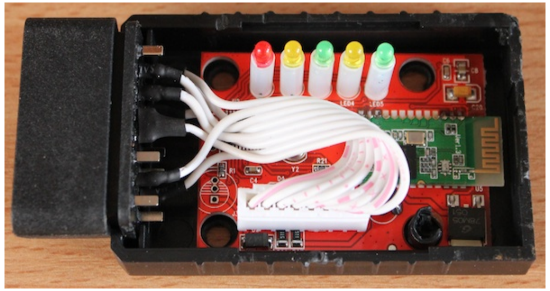
ELM327

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





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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

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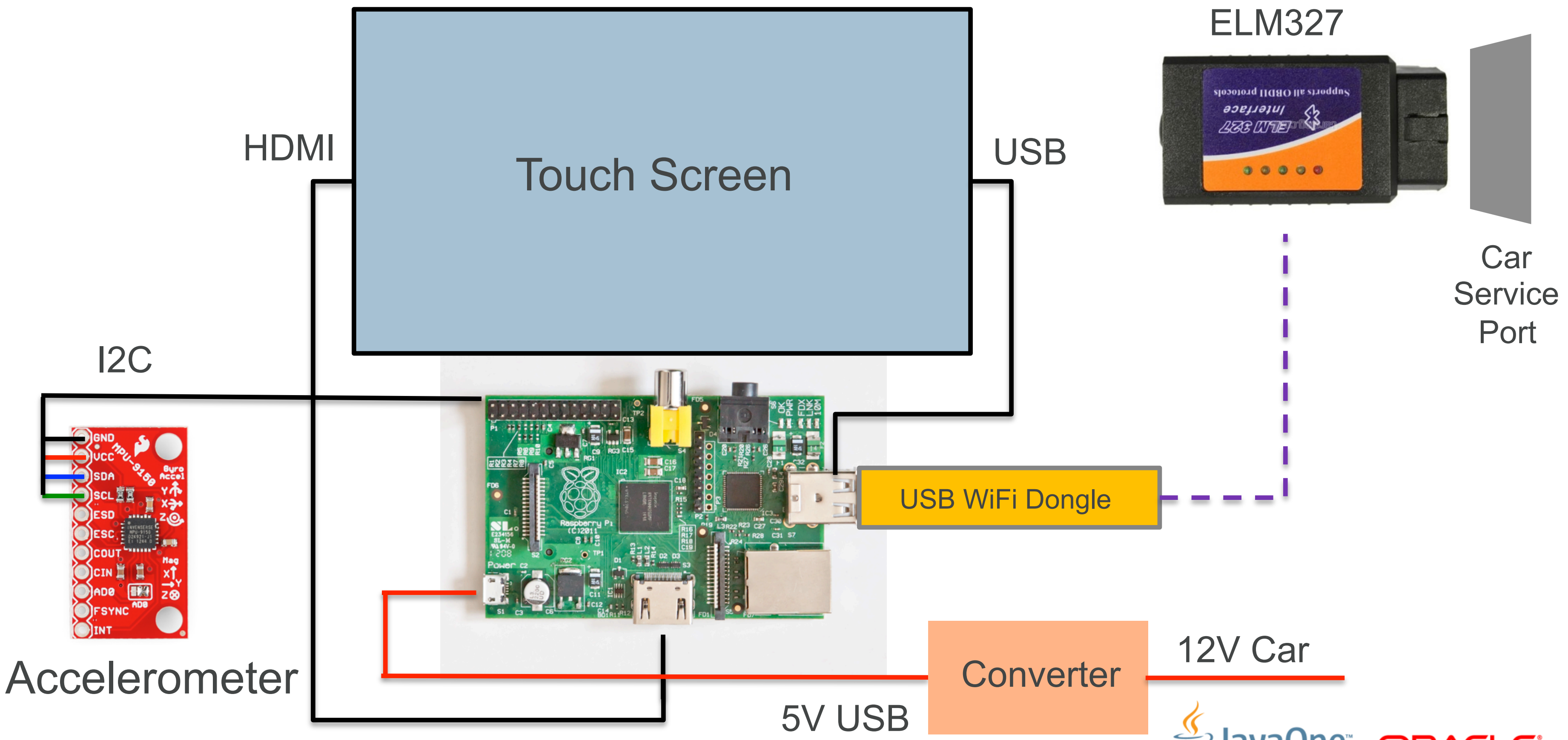
Carputer Hardware Architecture



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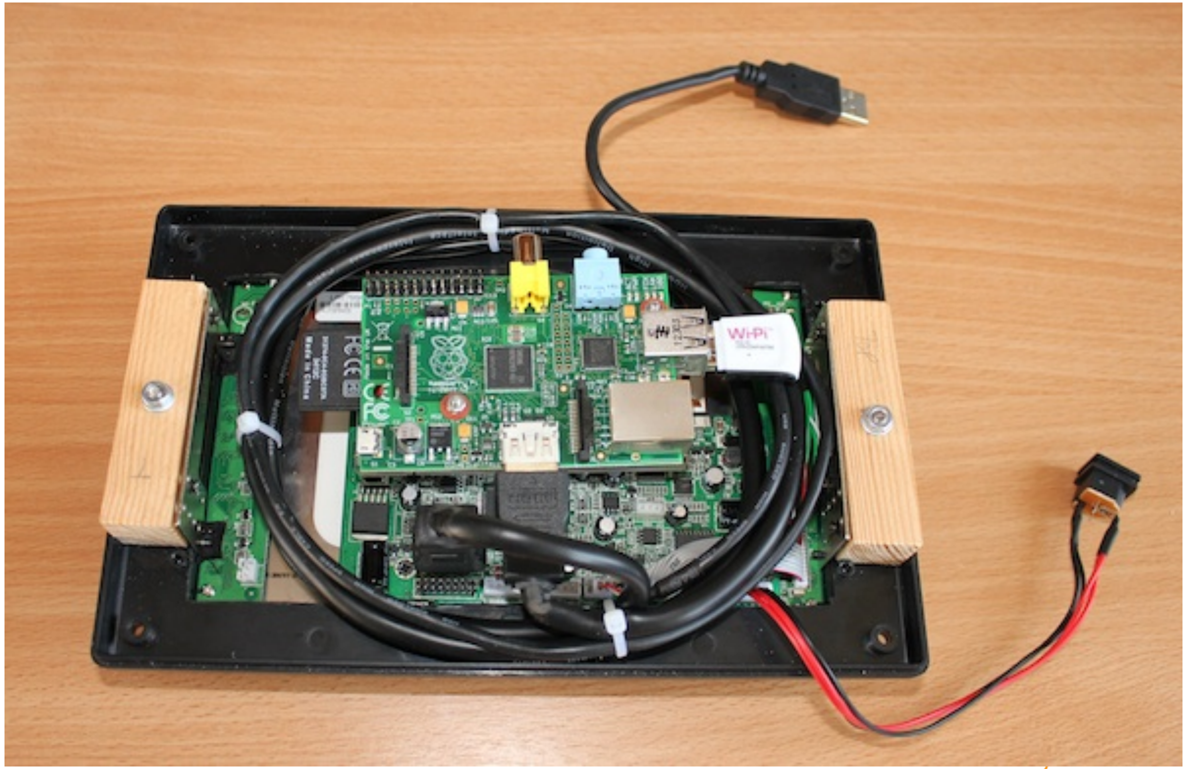
Touchscreen

Hardware Fitting Challenges



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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

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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);
```

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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

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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

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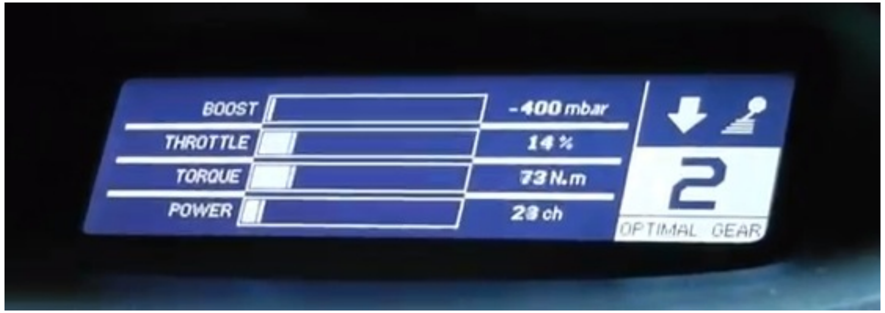
Carputer Software Architecture

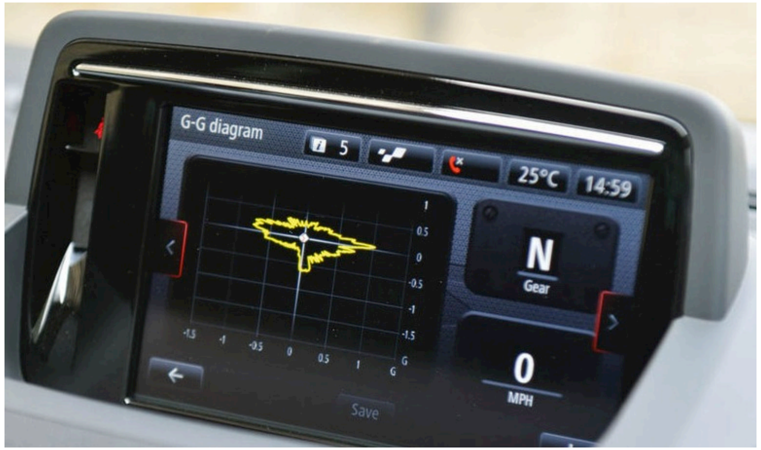
Realtime Data

- 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

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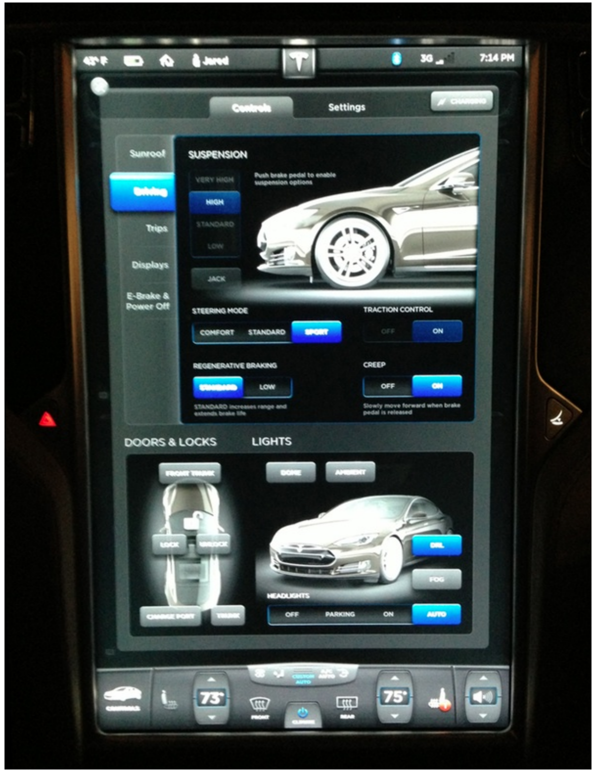
UI Design Ideas

Take Inspiration From Others



Tesla

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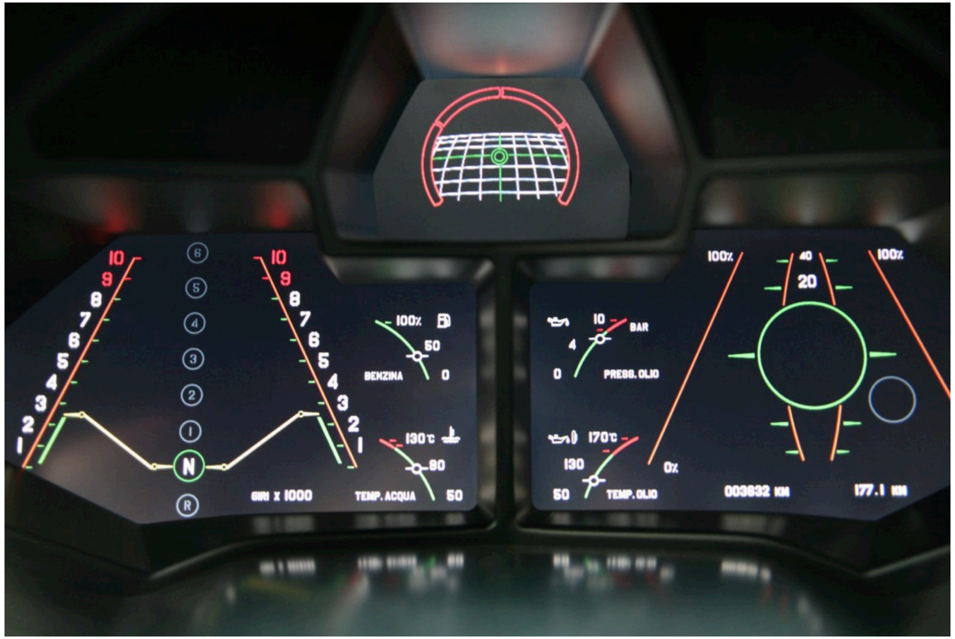
UI Design Ideas

Take Inspiration From Others



Lamborghini Reveton

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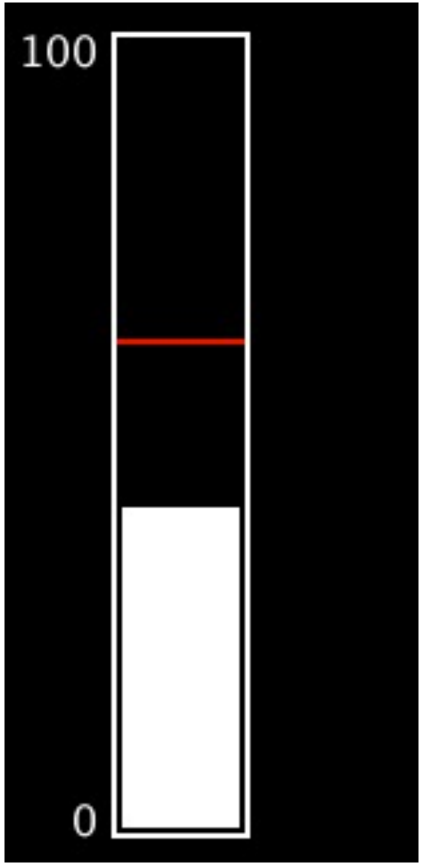
Simple Data Display Control

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



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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

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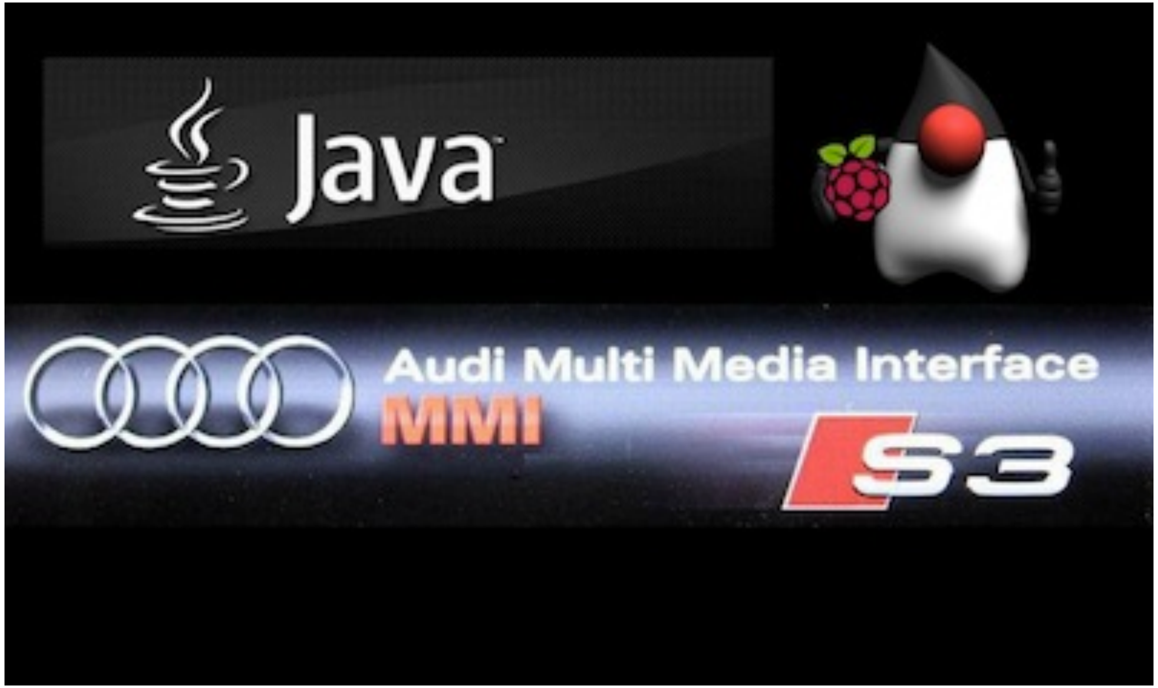
UI Screens

Splash Screen



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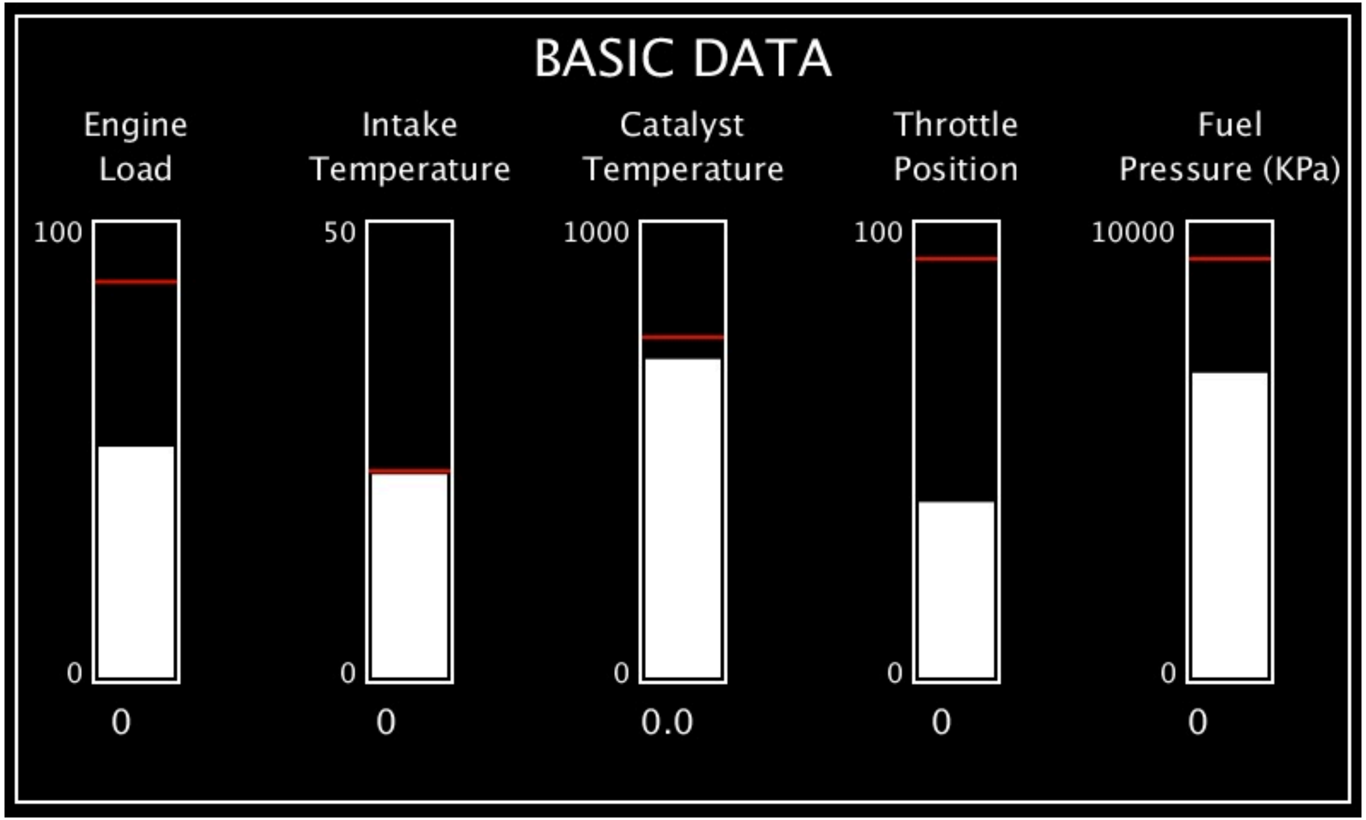
UI Screens



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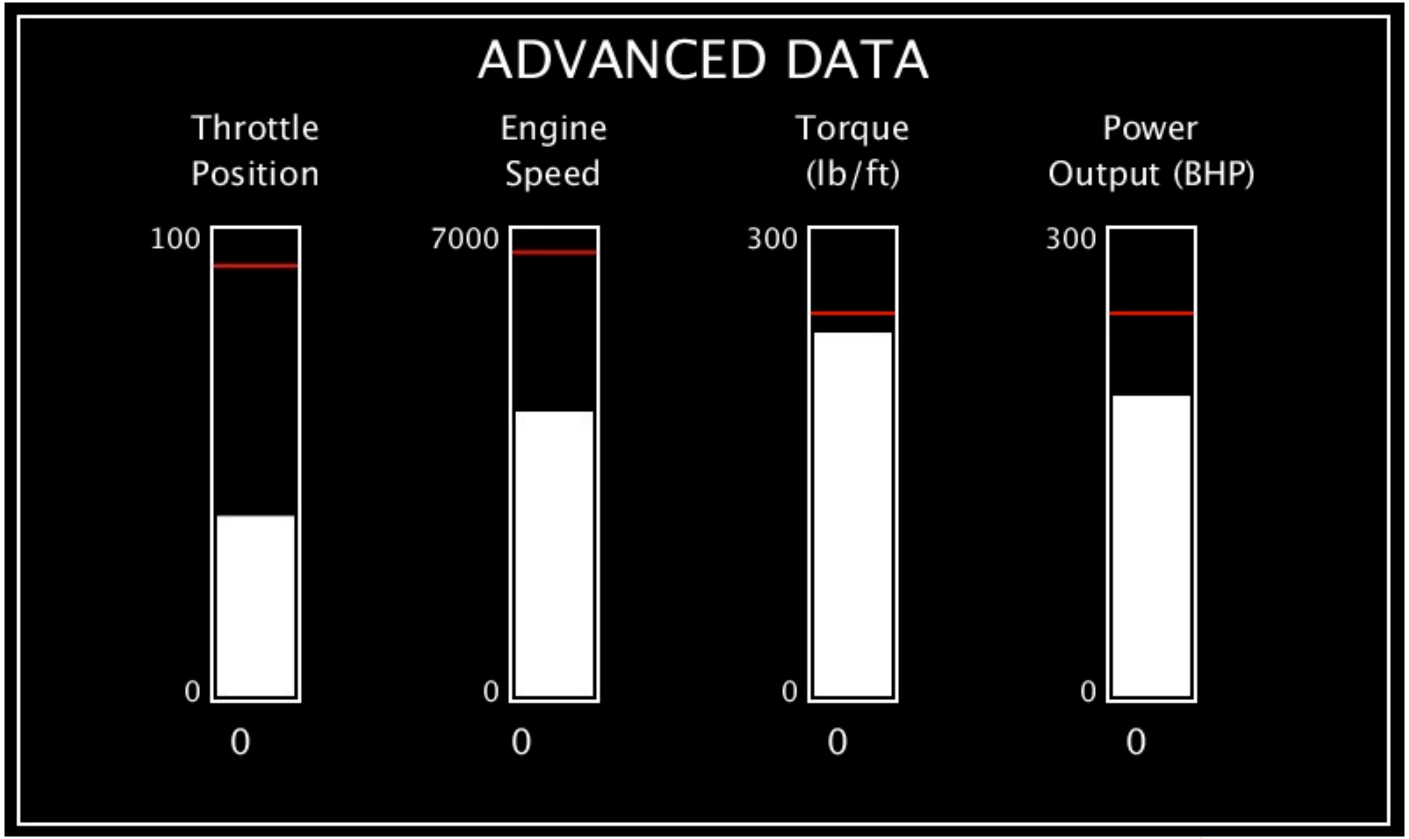
UI Screens



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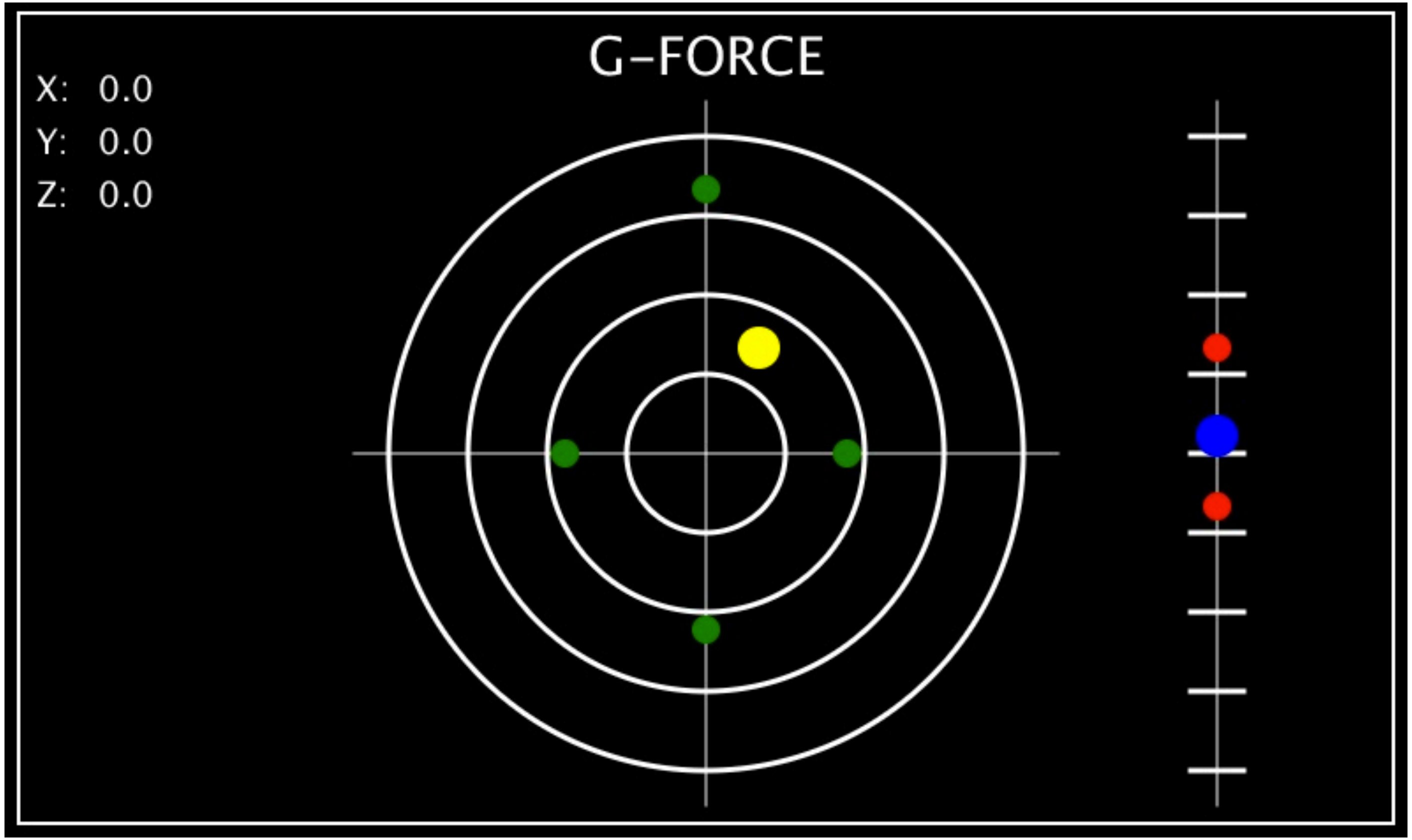
UI Screens



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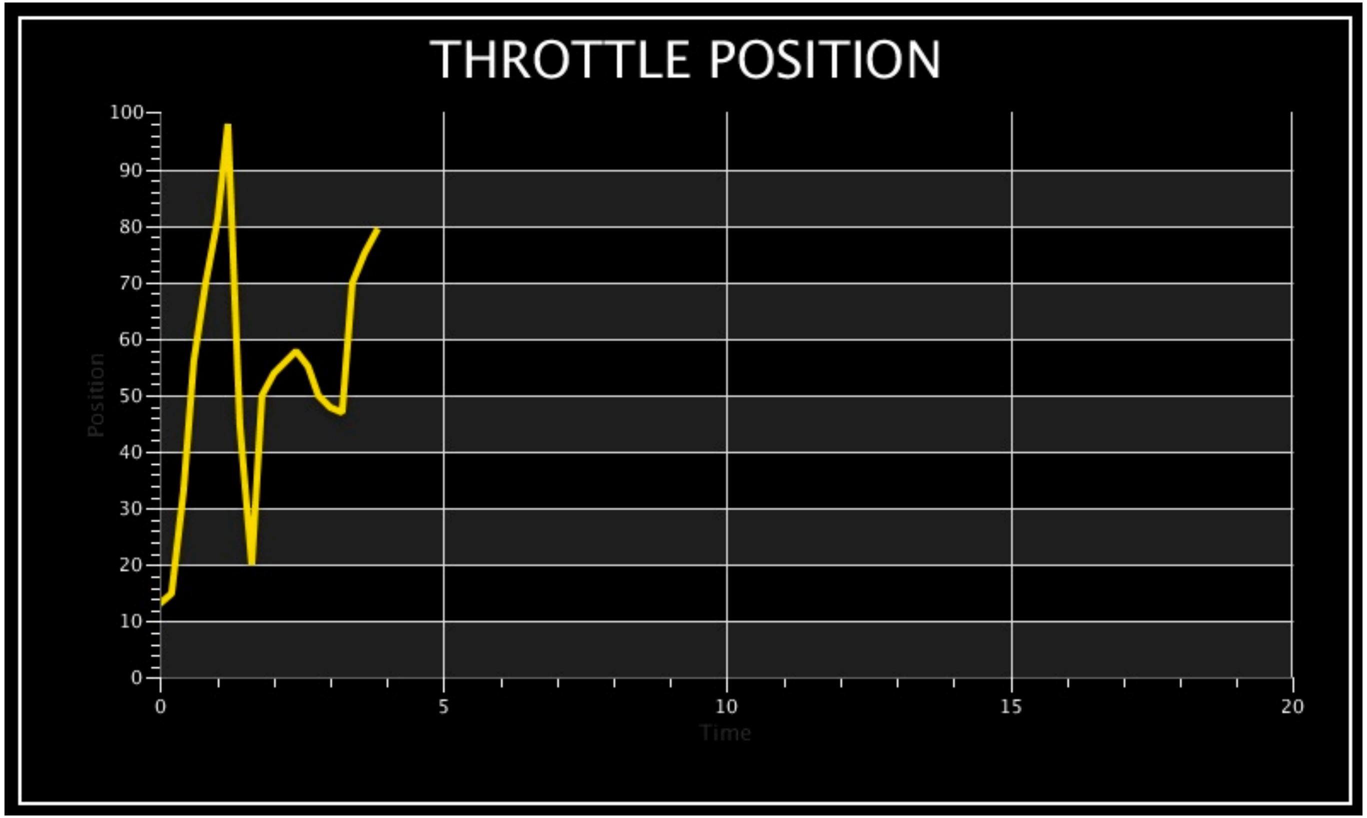
Graph Plots Of Throttle Position And Power



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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

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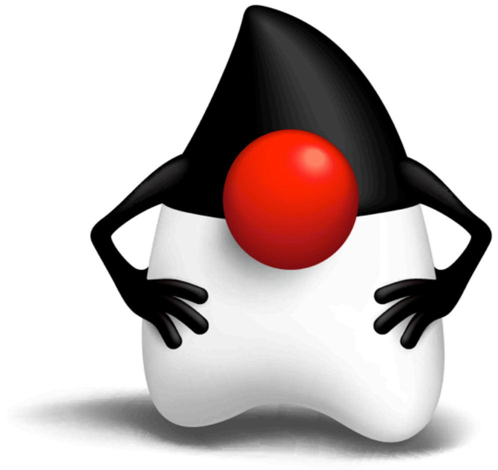
Future Ideas, Conclusions and Resources



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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)

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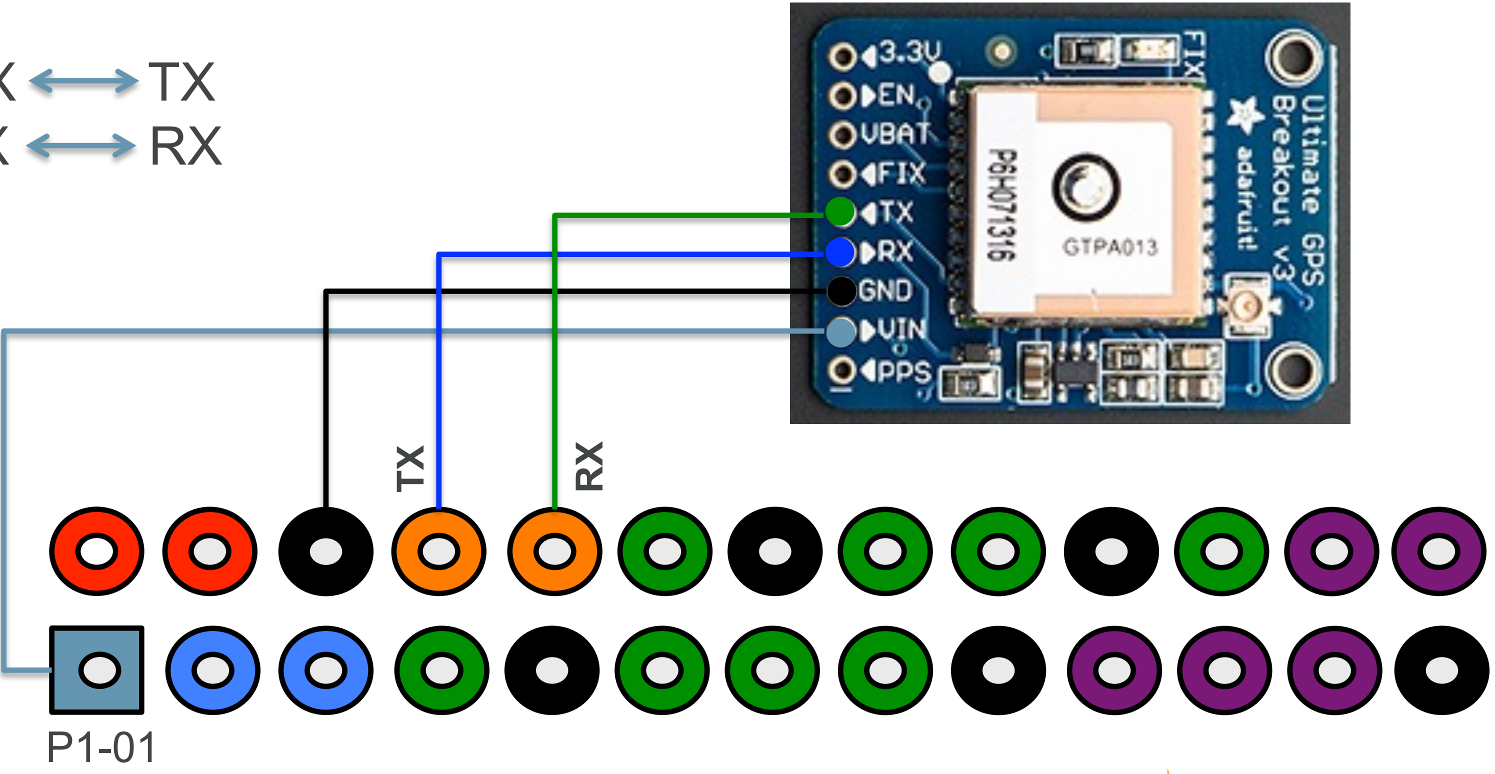
Adafruit Ultimate GPS Breakout

NOTE: RX ⟷ TX
TX ⟷ RX



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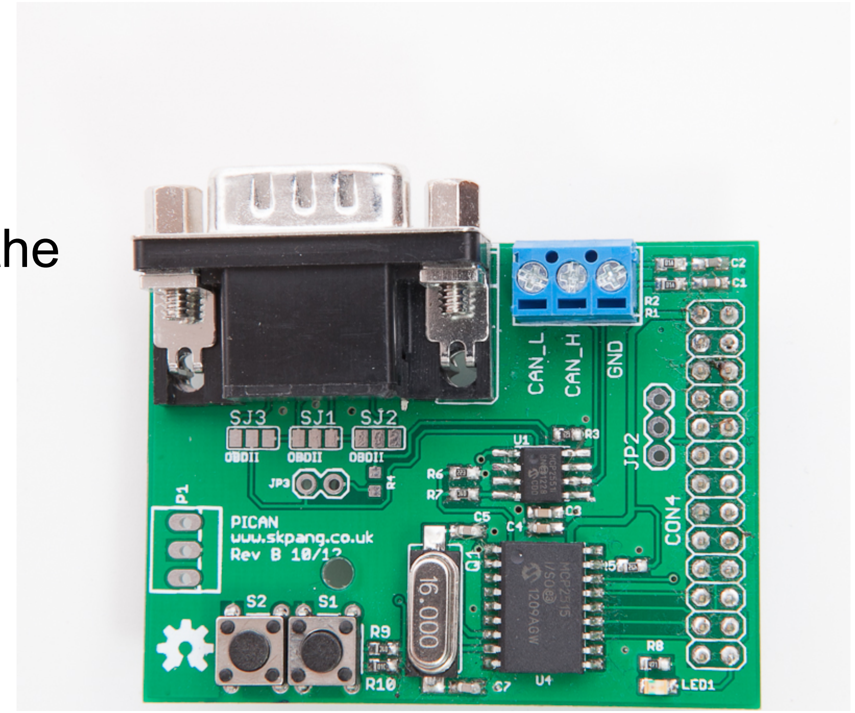
The Pi Can Interface

- 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



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Resources

- www.audi.com
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- blogs.oracle.com/speakjava

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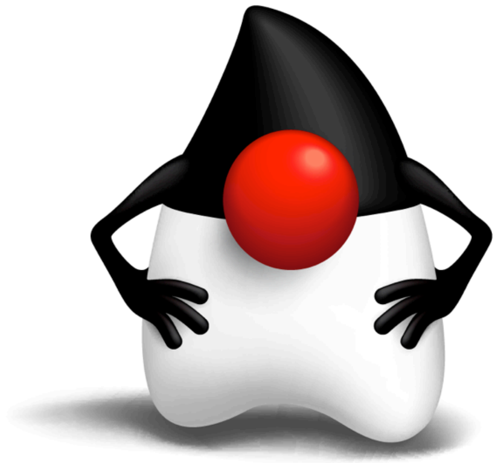
Demos



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