The Internet of Things

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Who am I?

• Freelance developer
• Programming for 25+ years
• Apache Flex PMC, Incubator PMC, Apache member
• Run IoT meetup group in Sydney Australia
• Been tinkering with Arduino and open source hardware for 5+ years
Internet of Things?

• Small mostly dumb, low cost, low power computers
• Sense the environment around them
• Collate and push data up to somewhere to be analysed
• Enable something be controlled in some way
Rapid Growth

- Rapid growth over the last few years
- Estimated 9 billion connected things
- 25-100 billion connected things by 2020
- 1-20 trillion industry by 2020
What’s Changed

• Long tail of Moore’s Law
• Small cheap fast electronics
• Easy to program chips
• Rapid prototyping
• Low cost and low volume manufacture
Pebble
Clyde
Inside Clyde
Brad the Toaster
Problems

- Power
- Reliable bandwidth / communication
- Standards - everyone has their own
- Security
- Who owns the data?
- Licensing
A message you can Hug™
WeVibe

- remote control vibrator
- $3.75 million settlement for tracking users use
- matched data to users email addresses
Timer
Communicates with the motion sensor to detect when a stove is left on accidentally

What could go wrong?
Open Source Hardware

• Same as Open Source software right?
• Copyright and licensing
• Physical things require manufacture
• Costs to consider
• Distribution issues
• Some assembly required
Is it really Open Source?

- Where do you draw the line?
- Can it easily be made?
- Is all software available?
- Can you easily modify it?
OSHWA

- Open Source Hardware Association
  http://www.oshwa.org
- Came up with a definition of OSHW
- Checklist and guidelines
- Must be documented!
- Clarifies issue such as dual licensing (you can’t), royalties (no) + other issues
- Certification logo and process
Licensing
Licensing

• Software licenses generally deal with copyright as copyright gives instant protection

• Open source hardware consists of many pieces; bill of materials, pcb design, wire net, silk screen

• Copyright may not apply to all these things
Best (Educated) Guess

- Schematic layout - most likely
- Net list - no (it’s a fact)
- Component layout - automated may mean no copyright (what about creative/original layout?)
- Gerber files - quite likely
- PCB - aesthetic parts yes but layout and board probably not
- Source code - yes
- License may not be legal binding or enforceable
OSHW Licenses

- CERN and TAPR (copyleft style)
  http://www.ohwr.org/projects/cernohl/wiki
  http://www.tapr.org/ohl.html

- Solder Pad (Apache style)
  http://solderpad.org/licenses/

- Creative Commons
open hardware
OSHW Certification
varying scales

It Scales!
Arduino Platform

- Open source hardware and software platform
- Easy to program in a high level language
- Hardware is flexible, fast, consumes very little power and is cheap
- Easy to get up to speed with little programming or electronics knowledge
- Libraries to control or use LEDs, LCDs, GPS, ethernet and much more
Why Arduino?

- Mature platform
- Large community
- Low cost / low power
- Easy to program
- Easy to Prototype
- Open source hardware
- Many form factors
Arduino Board

- General purpose I/O pins
- Analogue Inputs
- USB for power and uploading software
- CPU (16Mhz but 16 MIPS!)
- Memory (only 32K)
- Great for prototyping
Arduino
Arduino Mini
Arduino 101
Industrino
ESP8266
Particle Electron
The Things Network

- The Things Network
  [https://www.thethingsnetwork.org](https://www.thethingsnetwork.org)
- Community based internet of things global network
- 100’s of communities all over the world
- Use LoRaWAN not WiFi or 3G - no ongoing costs
- Requires gateways, but a few gateways can cover a small city
Software

• Arduino - IDE and hardware
  http://arduino.cc/
• Fritzing - drop and drag circuit board designer
  http://fritzing.org/
• Commercial + OS Cloud platforms e.g. Open Sensors, Xively, etc
• Messaging platforms e.g. RabbitMQ or mosquitto
• More platforms Watson, AWS, Azure, ThingWorx, etc
void setup()
{
  pinMode(RED1, OUTPUT);
  pinMode(RED2, OUTPUT);
  pinMode(ORANGE1, OUTPUT);
  pinMode(ORANGE2, OUTPUT);
  pinMode(GREEN1, OUTPUT);
  pinMode(GREEN2, OUTPUT);
}

void loop()
{
DIY Protocols

- Firmata - lightweight extensible binary protocol
- HTTP - XML or REST familiar and easy to code
- Web Sockets - lightweight binary protocol
Firmarta

- https://github.com/firmata/protocol
- Midi message format
- Wide range of supported languages
- Arduino standard library
- Good for host computer to arduino
HTTP

- Arduino standard libraries
- Web server (20 lines of code) compiles to about 12K
- HTTP header hack
- Return JSON, XML, CSV or whatever
- Requires ethernet or WiFi shield
Problems with HTTP

- Large requests - huge amount of unwanted header information
- Expensive to setup/shutdown requests
- No data push
WebSockets

• Bidirectional real time communication over a single TCP/IP socket
• Fast protocol has low overhead and connections kept open (500:1 vs HTTP)
• Binary and text support
• Multiple versions of the protocol
• Nice simple Javascript API
Browser Support

• Limited support for older browsers
• Internet Explorer 9 support via a plugin
• Work on mobile iOS Safari (6+) and Android (4.4)
• Latest version IE10+, Chrome 14+, Firefox 11+, Safari 6+
• “Standards” are such wonderful things
Standards / Protocols

• CAN Bus (Controller Area Network)
  Lightweight vehicle bus protocol no host

• CoAP (Constrained Application Protocol)
  HTTP Lite - multicast, low overhead, simple

• MQTT (Message Queue Telemetry Transport)
  Lightweight pub/sub, many to many, topic matching, QoS, payload can be anything

• XMPP (Extensible Messaging and Presence Protocol)
  Jabber - decentralised text protocol
CAN Bus

- Been about since 1980s, specification 1991, ISO standard 1993
- Robust
- Automotive industry but has other industrial applications (fieldbus)
- Atmel AVR processors
- Arduino support through hardware
MQTT

- OASIS specification
- Publish / Subscribe requires a broker
- Advanced features include quality of service, last will and testament, bridging
- Payload are blobs
- Arduino and OS software support (mosquitto)
- Run on a wide range of devices / platforms
Yet more standards!

- 6LoWPAN (IP6 over Wireless Personal Networks)
- AMQP (Advanced Message Queueing Protocol)
- STOMP (Simple Text Oriented Messaging Protocol)
- OMA LWM2M (Open Mobile Alliance Lightweight Machine to Machine)
Rapid Prototyping

- Manufacture prototypes cheaply
- Can iterate designs quickly
- Easy to use software
- Tools are cheaper than you think or can access via hacker spaces
Prototype
Fritzing

- Very easy to use
- Large library of parts
- Easy export of files
- Auto route not very useful
- Breadboard view not compact
Breadboard View
PCB View
Check Your Design
PCB ordering services

- Hackvana
  http://www.hackvana.com
- OSH Park
  https://oshpark.com
- Seeed Studio Fusion PCB
  http://www.seeedstudio.com
Boards
It works!
I can’t wait 2-3 weeks!

- Can pay more to quicker turn around
- Can use chemicals to etch boards and use surface mount or drill holes by hand (several hours)
- Can use CNC machine to cut and drill (several hours)
CNC Machines

- Opposite of a 3D printer
- Smaller, cheaper, better software
- Can cut metal, wood, plastic, wax + more
- Can do 3D as well as 2D
- Othermill and Otherplan software (free)
What can Apache Do?

• Implement and support standard protocols (eg CoAP, MQTT)
• Look to see how existing projects can be used in this space. Already happening with Apache Cassandra, Apache Storm, Apache Spark, Apache Apex, Apache Kafka, Apache Hadoop and others.
• Look at OSWH licensing and see if it’s comparable with ASF licensing
• Encourage hardware vendors to release code under more permissive licenses. Mynewt has done good work here.
• New protocols?
Apache Mynewt (incubating)

- Real time operating system
- Linux for embedded devices that can’t run Linux
- BLE support
- Targets multiple devices
- Simple build and package management
- Simulator
- Should be out of incubation soon
Apache Edgent (incubating)

- Edge device operating system
- Run on Java devices and Android (currently)
- Provides real time analytics on streaming data
- Filter and collates data
- Connects into Apache Kafka, Apache Spark and Apache Storm
- Name changed from Quarks
Questions?

Ask now, see me after the session, follow me on twitter @justinmclean or email me at justin@classsoftware.com.