MQTT & The Internet of Things

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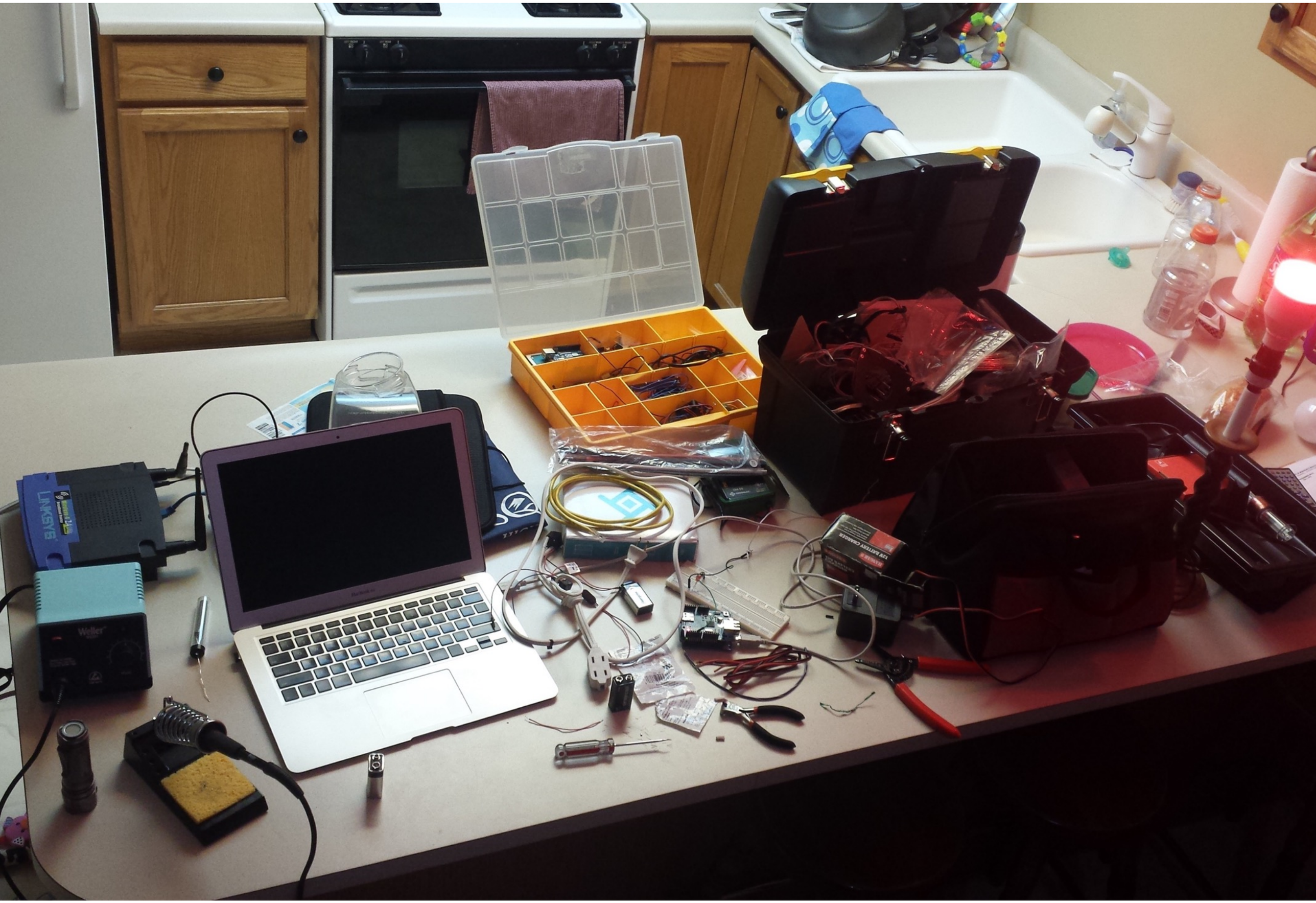
Cam Peterson

- Writing software pays my bills - Peterson Data
- Husband and father of two
- I like the outdoors (Kayaking, Fishing, Camping, Mountain Biking, Roadtrips)
- I love building stuff
- I like electronics (Soldering, Arduino, Raspberry Pi, Sensors)



Goal

I'm going to…

- Show you where MQTT fits in the Internet of Things
- Show you some code
- Live demo

I'm <u>not</u> going to…

- Cover all the features in detail
- Try to convince you that MQTT is the only way to go

You can play along at home…

- PC: mosquitto on your computer
- MyMQTT (Android) - MQTTClient (iOS - $0.99)
- Wifi: MQTT (OPEN)
- IP Address: 192.168.1.104
- Topic: openwest/lights/color-LIFX
- Message: red, blue, white, yellow, green, purple

IoT

https://vimeo.com/80887929

INTERNET OF THINGS LANDSCAPE

Platforms & Enablement (Horizontals)

Connectivity: IFTTT, Sympl.io, ioBridge, ARRAYENT, electric imp, haystack, ThingWorx, sensinode, NODE, EVRYTHNG, bugswarm

Open Source Platforms: sense, spark, Nimbits, ThingSpeak

Software Platforms: sense, SmartThings, Withings, NINJABLOCKS, xively, TWINE, OSITO, zonoff

Sensor Networks: MESHSYSTEMS, SAFECAST

Enabling Networks: FreedomPop, Open Garden, SocialSign.in, SIGFOX

Corporates: IBM, GE, LG, cisco, Honeywell

Applications (Verticals)

Quantified Self

Wearable Computing: GLASS, Pebble

Fitness: FUEL, amiigo, Withings, fitbit, JAWBONE

Health: BASIS, LUMOback, HAPIfork, wahoo FITNESS, Msignal, NuMetrex

Family: REST, Live!y, Good Night Lamp, EVADO FILIP, Withings

Lifestyle

Leisure: blossom, ICA kitchen, Thimble, iGrill, remee, HEXBRIGHT, sobi

Pets: gibi, FITBARK

Toys: sifteo, MakieLab, KAROTZ, greenGOOSE

Music: gtar

Gardening: BITPONICS, plantlink, Koubachi

Home Improv.: Radiator Labs, netatmo

Connected Home

Home Automation: SmartThings, stick N FIND, NINJABLOCKS, revolv, Ubi, NODE, electric imp, lapka, Wovyn

Energy Efficiency: knut, nest, wemo, tado°, LIFX, ecobee, belkin echo, micasaverde

Security: Kwikset, ALARM.COM, BOSCH, CANARY, Lockitron, HomeMonitor, iSmartAlarm

New Interfaces: NeuroSky, sphero, EQUISO, emotivo, gestigon, PrimeSense, InteraXon, LEAP

Industries

Retail: Nomi, euclid, placemeter

Healthcare: ViSi MOBILE, AdhereTech, AliveCor, TELCARE, intelligentM

Automotive: mojio, Dashlabs, SYNC, OpenXC, entune

Smart Buildings: APOGEE, Johnson Controls, Schneider Electric

Industrial Internet

Robotics: KIVA Systems, ROMOTIVE, Double Robotics, Airware, iquus robotics, ROBOTEX, 3D Robotics, MOMENTUM

Greentech: BigBelly SOLAR, Axeda, enlighted, GRIDMOBILITY

3D Printing: 3DSYSTEMS, MezzoMill, Stratasys, formlabs, shapeways, MakerBot INDUSTRIES, RepRap

Building Blocks

Connection Protocols: neul, ZigBee, macheen, RFID, NFC, Wi Fi, Bluetooth, M-Bus, MQTT, 2G 3G 4G

Telecom: at&t, verizon, T-Mobile, Virgin mobile, boost mobile

M2M: CROSSBRIDGE, gemalto, Jasper wireless, Numerex, Telit ERICSSON

Software: amazon web services, hadoop

Mobile: iOS, Parse

Hardware: opengate, ARDUINO, beagleboard.org, spark

Parts / Kits: MAKEY MAKEY, TinkerForge, littleBits, readymate, MOSORO

Services: ICH International, DRAGON innovation, makexyz, TINKERCAD, adafruit, CIRCUIT LAB

Incubators: BOLT, HAXLR8R, LEMNOS Labs, springboard();

Funding: KICKSTARTER, indiegogo

Distribution: GRAND ST., Anvil

Categorizing IoT

Information and analysis

1 Tracking behavior

Monitoring the behavior of persons, things, or data through space and time.

Examples:
Presence-based advertising and payments based on locations of consumers

Inventory and supply chain monitoring and management

2 Enhanced situational awareness

Achieving real-time awareness of physical environment.

Example:
Sniper detection using direction of sound to locate shooters

3 Sensor-driven decision analytics

Assisting human decision making through deep analysis and data visualization

Examples:
Oil field site planning with 3D visualization and simulation

Continuous monitoring of chronic diseases to help doctors determine best treatments

Automation and control

1 Process optimization

Automated control of closed (self-contained) systems

Examples:
Maximization of lime kiln throughput via wireless sensors

Continuous, precise adjustments in manufacturing lines

2 Optimized resource consumption

Control of consumption to optimize resource use across network

Examples:
Smart meters and energy grids that match loads and generation capacity in order to lower costs

Data-center management to optimize energy, storage, and processor utilization

3 Complex autonomous systems

Automated control in open environments with great uncertainty

Examples:
Collision avoidance systems to sense objects and automatically apply brake

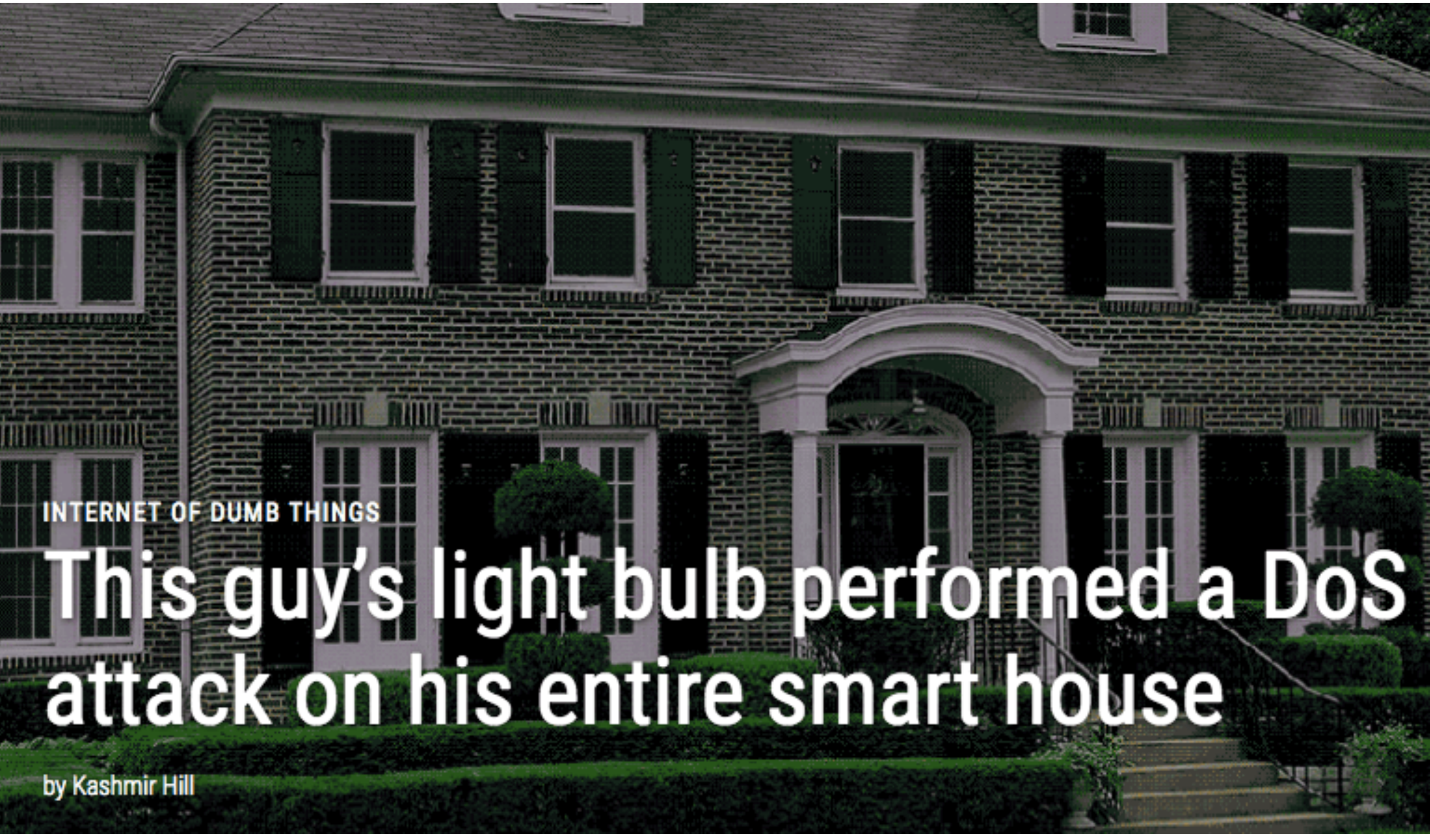
Clean up of hazardous materials through the use of swarms of robots

http://www.mckinsey.com/insights/high_tech_telecoms_internet/the_internet_of_things

http://www.intel.com/content/dam/www/public/us/en/images/iot/guide-to-iot-infographic.png

http://d3uifzcxlzuvqz.cloudfront.net/images/stories/content/infographic/IoT-Infographic/postscapes-harbor-iot-infographics.jpg

http://www.zeronaut.be/wp-content/uploads/2013/08/internetofthings2.jpg



INTERNET OF DUMB THINGS

This guy's light bulb performed a DoS attack on his entire smart house

by Kashmir Hill

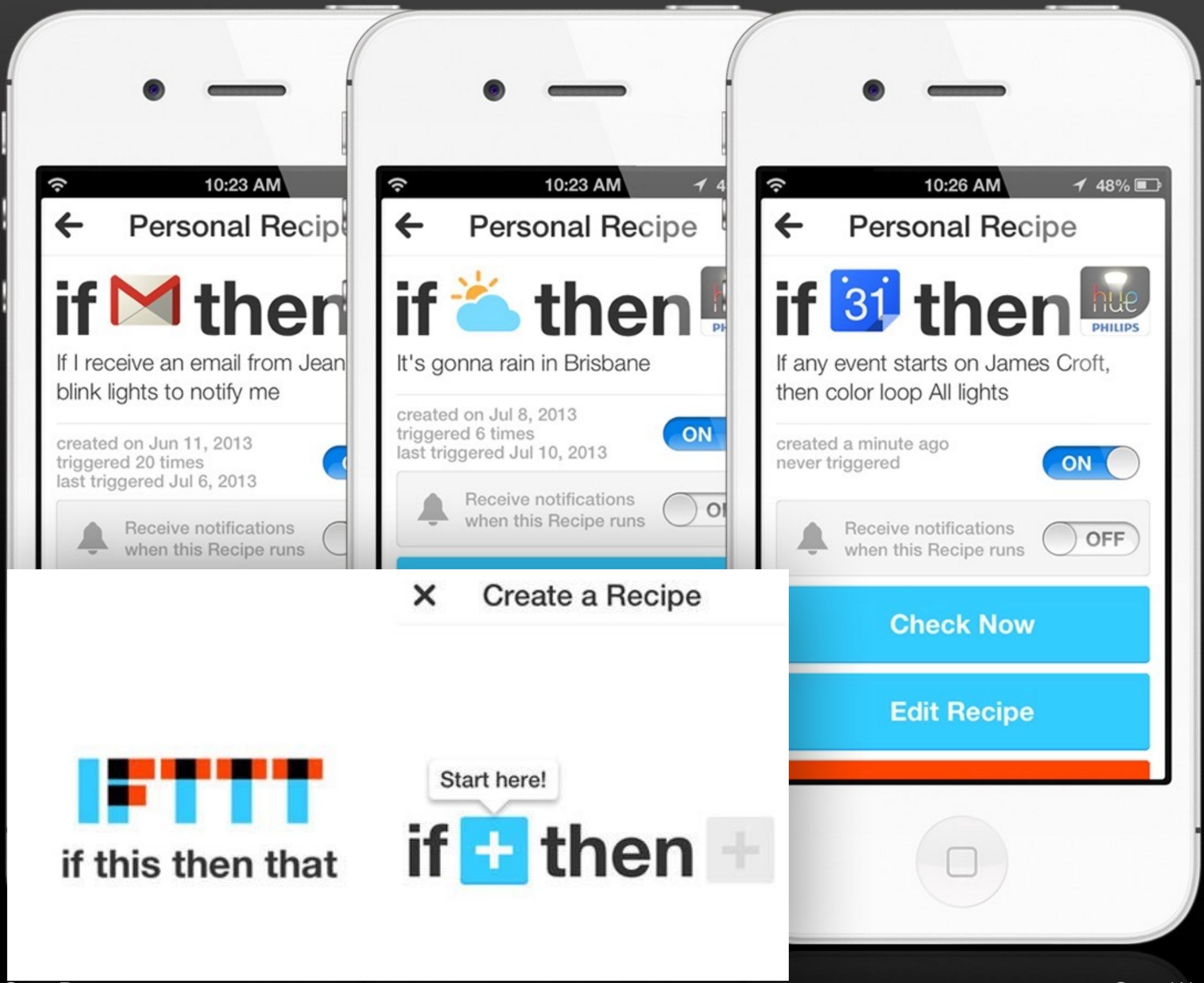
“it's not just about putting a sensor in everything”

“it's about the system, the experience”

–Tim O’Reilly

http://venturebeat.com/2015/03/04/tim-oreilly-silicon-valley-is-massively-underestimating-the-impact-of-iot-interview/

http://bits.blogs.nytimes.com/2015/02/04/tim-oreilly-explains-the-internet-of-things/



More on IoT

- http://radar.oreilly.com/iot
- http://postscapes.com/companies/
- https://info.tempoiq.com/metronome-the-weekly-newsletter-from-tempoiq

Why not use HTTP?

MQTT

"MQ for Telemetry Transport (MQTT) is an efficient, lightweight M2M/IoT protocol designed for publish/subscribe message oriented middleware data transport systems. It is ideal for connecting with remote locations where a small protocol footprint is needed and network bandwidth is at a premium."

http://www.mqtt.com/

History

- MQTT was invented by Dr Andy Stanford-Clark of IBM, and Arlen Nipper of Arcom (now Eurotech), in 1999.

- “MQTT stands for MQ Telemetry Transport. It is a publish/subscribe, extremely simple and **lightweight** messaging protocol, designed for **constrained devices** and **low-bandwidth**, high-latency or **unreliable networks**. The design principles are to **minimize network bandwidth** and device resource requirements whilst also attempting to ensure reliability and some degree of assurance of delivery. These principles also turn out to make the protocol ideal of the emerging “machine-to-machine” (M2M) or “Internet of Things” world of connected devices, and for mobile applications where bandwidth and battery power are at a premium.”

http://mqtt.org/faq

http://en.wikipedia.org/wiki/MQTT

Why MQTT?

- one to one communication
- one to many communication
- Constrained networks
- Lossy connections
- Simple & easy
- TCP - simple firewall and security implementations

Google Trends

Google searches for mqtt up 41% in past week

Worldwide - Friday, February 27, 2015 - Friday, March 6, 2015

The number 100 represents the peak search interest. Learn more

MQTT is a Protocol

http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html

Eclipse Paho

- “The Paho project provides open-source client implementations of open and standard messaging protocols aimed at new, existing, and emerging applications for Machine-to-Machine (M2M) and Internet of Things (IoT).”

- http://eclipse.org/paho/
- http://git.eclipse.org/c/paho/

How it works

http://forkbomb-blog.de/2015/all-you-need-to-know-about-mqtt

MQTT Architecture (man mosquitto)

- Broker
- Clients
- Topics
- QoS
- Will

Broker

- Clients (things) connect to a broker and subscribe to different topics

- The Broker is responsible for ensuring delivery of messages

Clients

- C
- Javascript
- PHP
- Python
- Java
- C#
- Mosquitto
- more…

https://github.com/mqtt/mqtt.github.io/wiki/libraries

https://github.com/mqtt/mqtt.github.io/wiki/tools

Demo 1
Simple Publish

https://github.com/bluerhinos/phpMQTT

Topics

- Topics are a hierarchy
- The slash (/) is a separator.
- Wildcards (+, #)
  - + - single level of hierarchy. Get messages of the resource that follows
    - openwest/+/status
    - Both: openwest/demo1/status & openwest/demo2/status
  - # can be used as a wildcard for all remaining levels of hierarchy
    - openwest/#
    - All: openwest/demo1/status, openwest/popcorn, openwest/light/not/used

Demo 2
Subscribe to many Topics

https://github.com/bluerhinos/phpMQTT

Demo 3
Subscribe to many Topics

https://github.com/mqttjs/MQTT.js

Demo 5
Control (in Clojure)

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QoS (Quality of Service)

- 0 - “At most once” - you don’t get any messages you missed while disconnected

- 1 - “At least once” - missed messages are saved and delivered at least once

- 2 - “Exactly once”

Last Will

- A client may inform the broker of a message that it should send, should the client become disconnected unexpectedly (Topic, QoS, just like other message)

MQTT vs. HTTP

- Both based on TCP
- HTTP is “1-to-1”, MQTT can be "1-to-1" and “1-to-many"
- MQTT is more focused on the messages than documents
- MQTT is simple
- MQTT has 3 QoS, HTTP has 1
- MQTT has small message

MQTT at Facebook

- "*we use MQTT to update notifications, messages, and bookmarks*" - c. 2012

- "One of the problems we experienced was long latency when sending a message. The method we were using to send was reliable but slow, and there were limitations on how much we could improve it. With just a few weeks until launch, we ended up building a new mechanism that maintains a persistent connection to our servers. To do this without killing battery life, we used a protocol called MQTT that we had experimented with in Beluga. MQTT is specifically designed for applications like sending telemetry data to and from space probes, so it is designed to use bandwidth and batteries sparingly. **By maintaining an MQTT connection and routing messages through our chat pipeline, we were able to often achieve phone-to-phone delivery in the hundreds of milliseconds, rather than multiple seconds**."

- https://www.facebook.com/notes/facebook-engineering/building-facebook-messenger/10150259350998920

- https://www.facebook.com/notes/facebook-engineering/under-the-hood-rebuilding-facebook-for-ios/10151036091753920

Performance

- Benchmark 0.6.1-alpha on a ubuntu/14.04 server with 8 cores, 32G memory from QingCloud

- 200K+ Connections, 200K+ Topics, 20K+ In/Out Messages/sec, 20Mbps+ In/Out with 8G Memory, 50%CPU/core

- https://github.com/emqtt/emqttd

MQTT Service Providers

- ThingFabric (by 2lemetry - acquired by Amazon)
- CloudMQTT

- HiveMQ

- OpenSensors.io
- Meshblu (by Octoblu - acquired by Salesforce)

- ThingMQ

https://github.com/mqtt/mqtt.github.io/wiki/servers

Other IoT Protocols

- CoAP http://coap.technology/
  - “The Constrained Application Protocol”
- **WAMP http://wamp.ws/** (check this one out)
  - “The Web Application Messaging Protocol”
- STOMP http://stomp.github.io/
  - “The Simple Text Oriented Messaging Protocol”

Technology	PubSub	RPC	Routed RPC	Web native	Cross Language	Open Standard
WAMP	✔	✔	✔	✔	✔	✔
AJAX		✔		✔	✔	
AMQP	✔	(✔)			✔	✔
Apache Thrift		✔			✔	
Capn'n'Proto		✔			✔	
Comet				✔	✔	
OMG DDS	✔				✔	✔
D-Bus					✔	
CORBA	✔	✔			✔	✔
DCOM	✔	✔			✔	
Java JMS	✔					✔
Java RMI		✔				✔
JSON-RPC		✔		✔	✔	✔
MBWS			?			
MQTT	✔				✔	✔
REST		✔		✔	✔	
SOAP		✔		✔	✔	✔
socket.io	✔			✔		
SockJS				✔	✔	
STOMP	✔			✔	✔	✔

http://wamp.ws/compared/

IoT & Messaging Services/Providers

- https://xively.com/

- http://www.pubnub.com/

- http://www.rabbitmq.com/

- http://www.amqp.org/

- https://temboo.com/

Demo 6

Composable Systems (Clojure, Arduino, Ruby)

You can play along at home…

- PC: mosquitto on your computer
- MyMQTT (Android) - MQTTClient (iOS - $0.99)
- Wifi: MQTT (OPEN)
- IP Address: 192.168.1.104
- Topic: openwest/instruments/1
- Message: any number between 30 & 90

In closing

- Internet of Things (IoT) is about the experiences we can create with connected systems.
- MQTT is a protocol for connecting devices, sensors and applications
- MQTT does not solve every problem
- When designing your system, start with the problem and work backward

Requirements (since TCP, network connection required)

Questions?

- Juggling Data Connectivity Protocols for Industrial IoT
  - http://www.eetimes.com/author.asp?section_id=36&doc_id=1326169
- An Enterprise Developer's Journey to Internet-of-Things (IoT)
  - http://burrsutter.blogspot.com/2015/04/an-enterprise-developers-journey-to.html