MQTT connecting the Internet of Things

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Agenda

The Internet of Things

Why interoperability matters

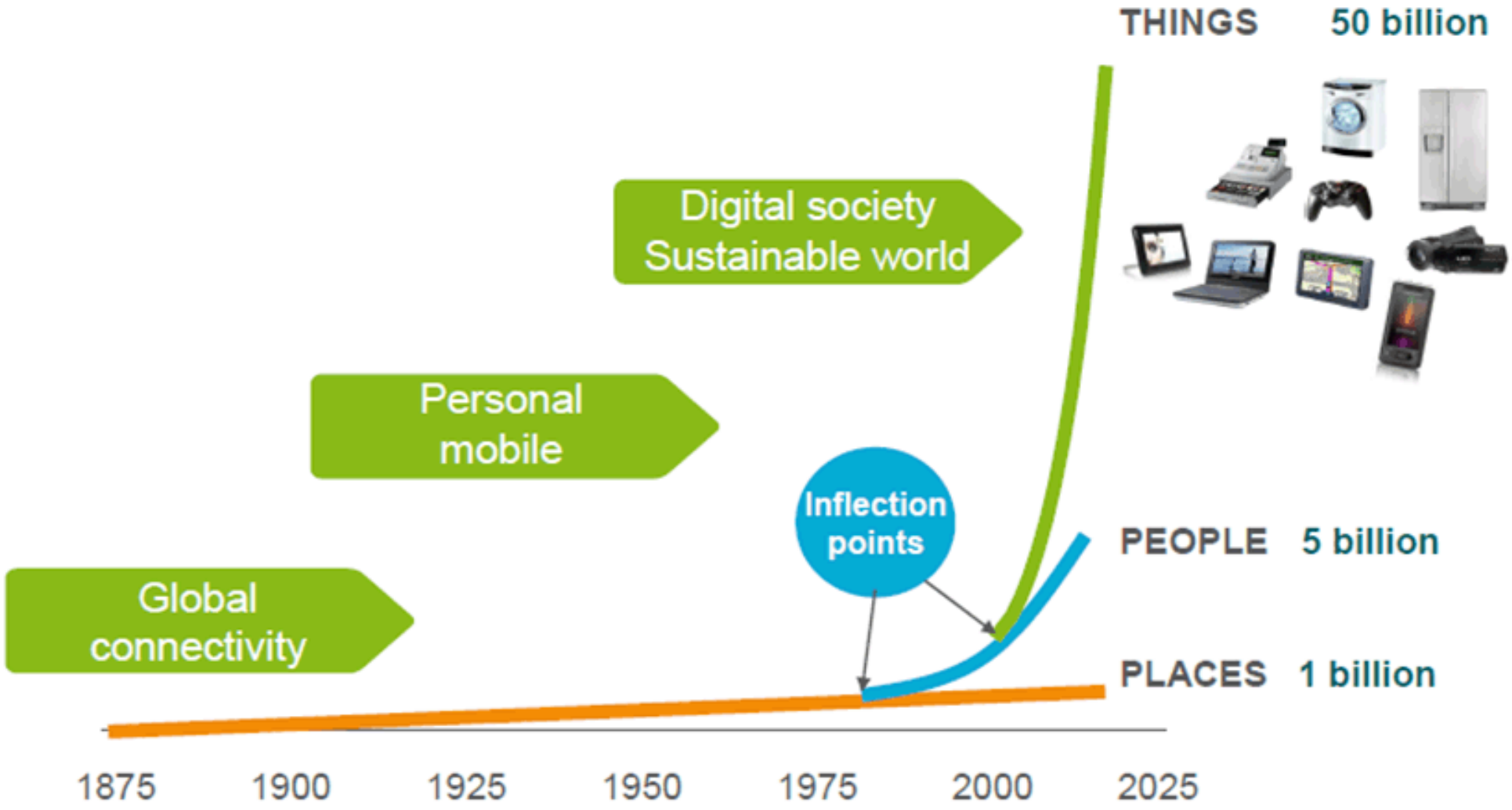
MQTT

- why, what, technologies

Demo

Real World Examples

Our world is filling with devices



Source: Ericsson AB, "Infrastructure Innovation - Can the Challenge be met?," Sept 2010

… but this isn't just about scale

5 years ago

- My phone only talked to other phones
- It sent data to others when I asked it to
- Mobile phone companies led the market

Today

- My phone can connect to almost anything
- It shares and receives information automatically
- Computer & content companies drive the market

Tomorrow?

- What will replace it?
- Who will it talk to?
- What companies will lead?

?

… and this isn't just about connecting people

We are building systems of systems

Latest generation car:

- 100 electronic controllers
- 10 million lines of code
- Its own IP address
- *Developed in 29 months*

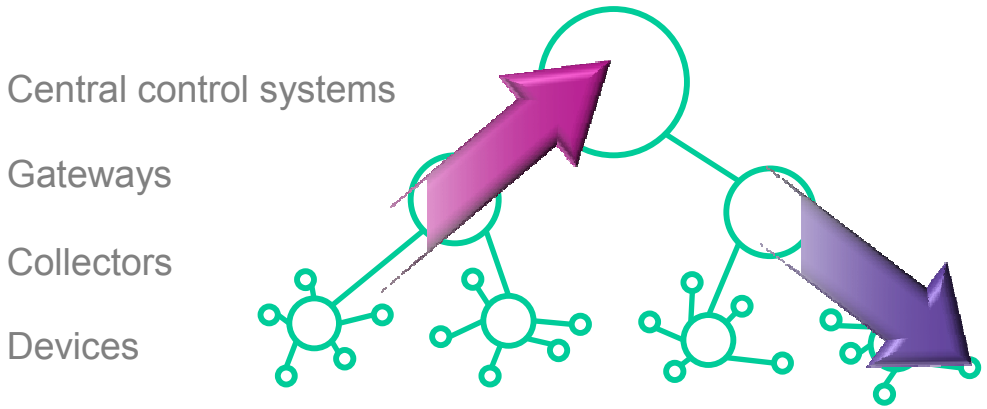
General Motors - 2011 Chevy Volt

http://ibm.co/btsi5C

… and this isn't just about instrumentation

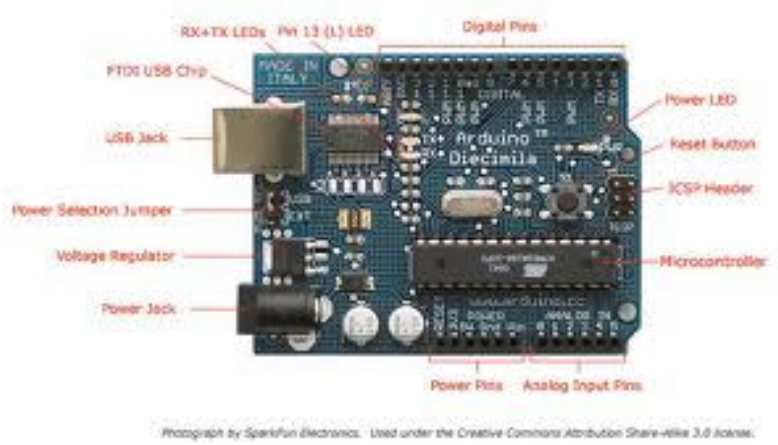
Most of today's edge connectivity follows a similar pattern

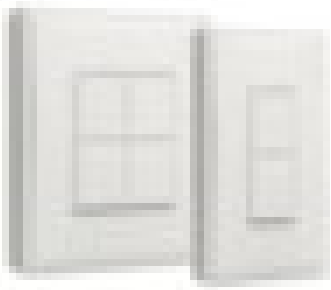
- Devices collect data for central processing
- Decisions are made centrally and pushed out to devices



What if we start adding intelligence throughout the network?

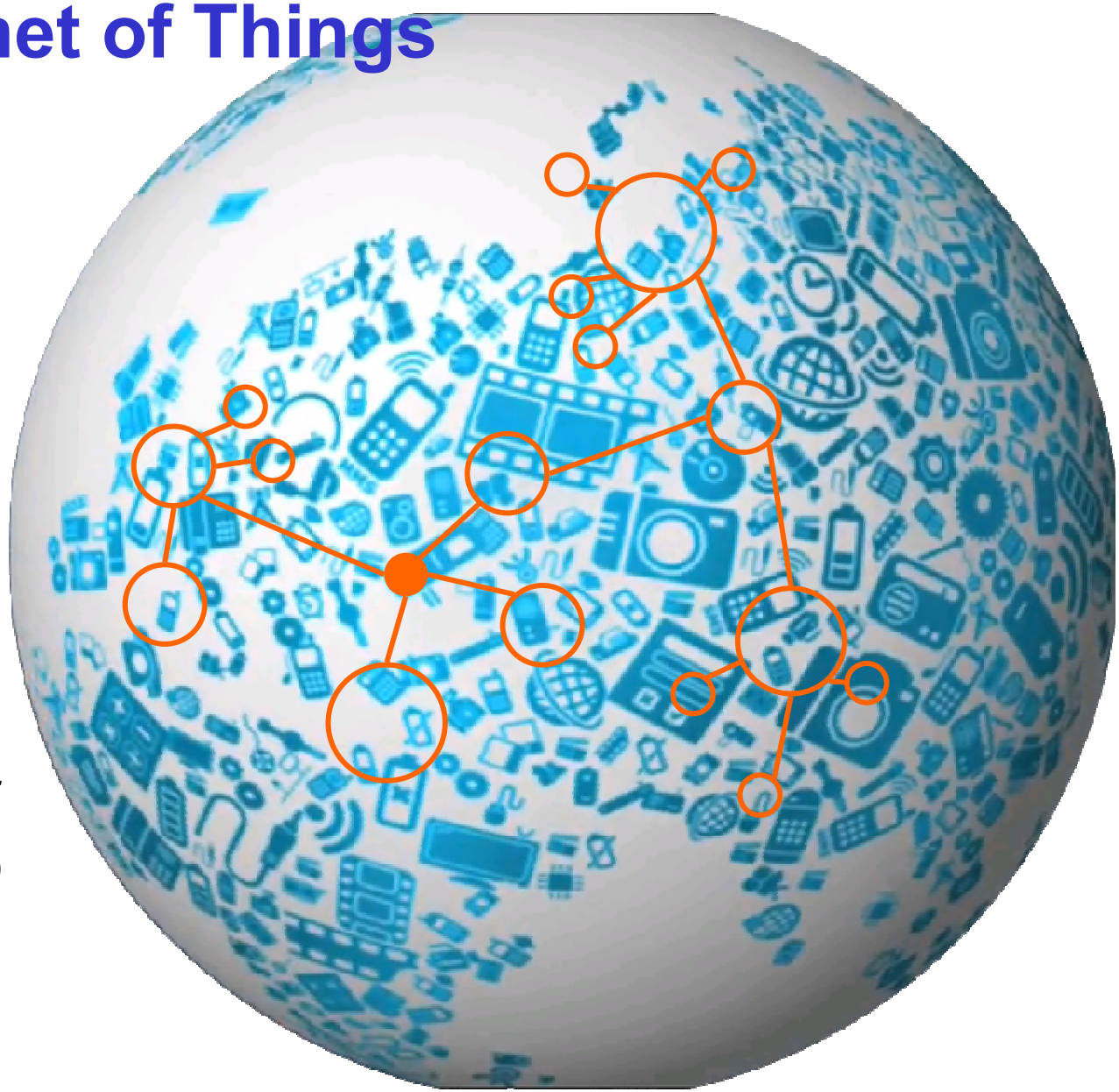
… price, power consumption, network, convenience





The Internet of Things

- A central nervous system of smart devices
- Decentralized intelligence and control
- A huge distributed store of rapidly changing data
- Human and environment interactions driving webs of machine to machine (M2M) communications



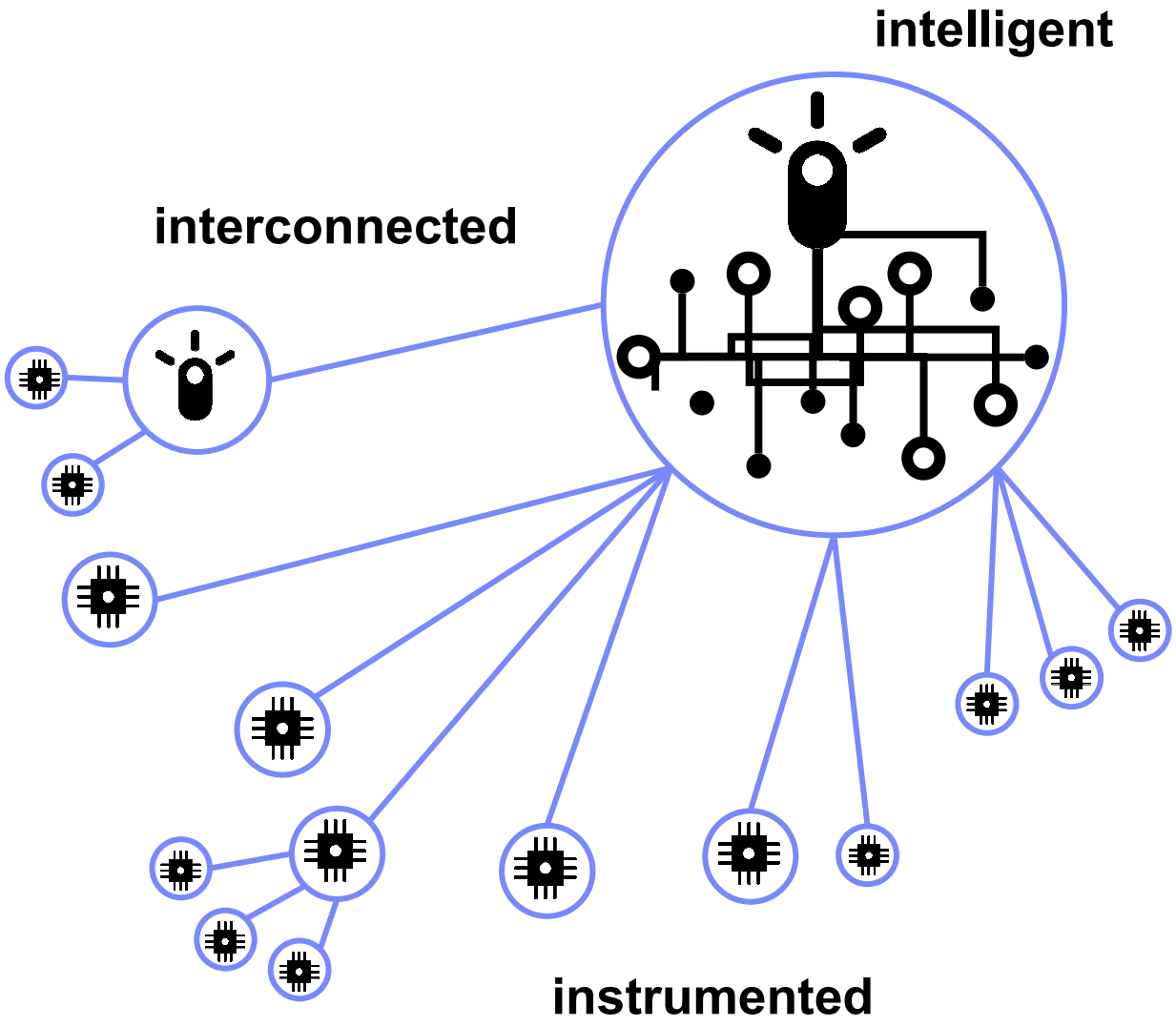
Connectivity and a Smarter Planet

Extend connectivity beyond enterprise boundaries to smart devices

Offer connectivity capabilities **optimized** for sensors and devices

Deliver **relevant data** to intelligent decision making assets to derive **business value**

Enable **massive scalability** of deployment and management of solutions



Why interoperability matters

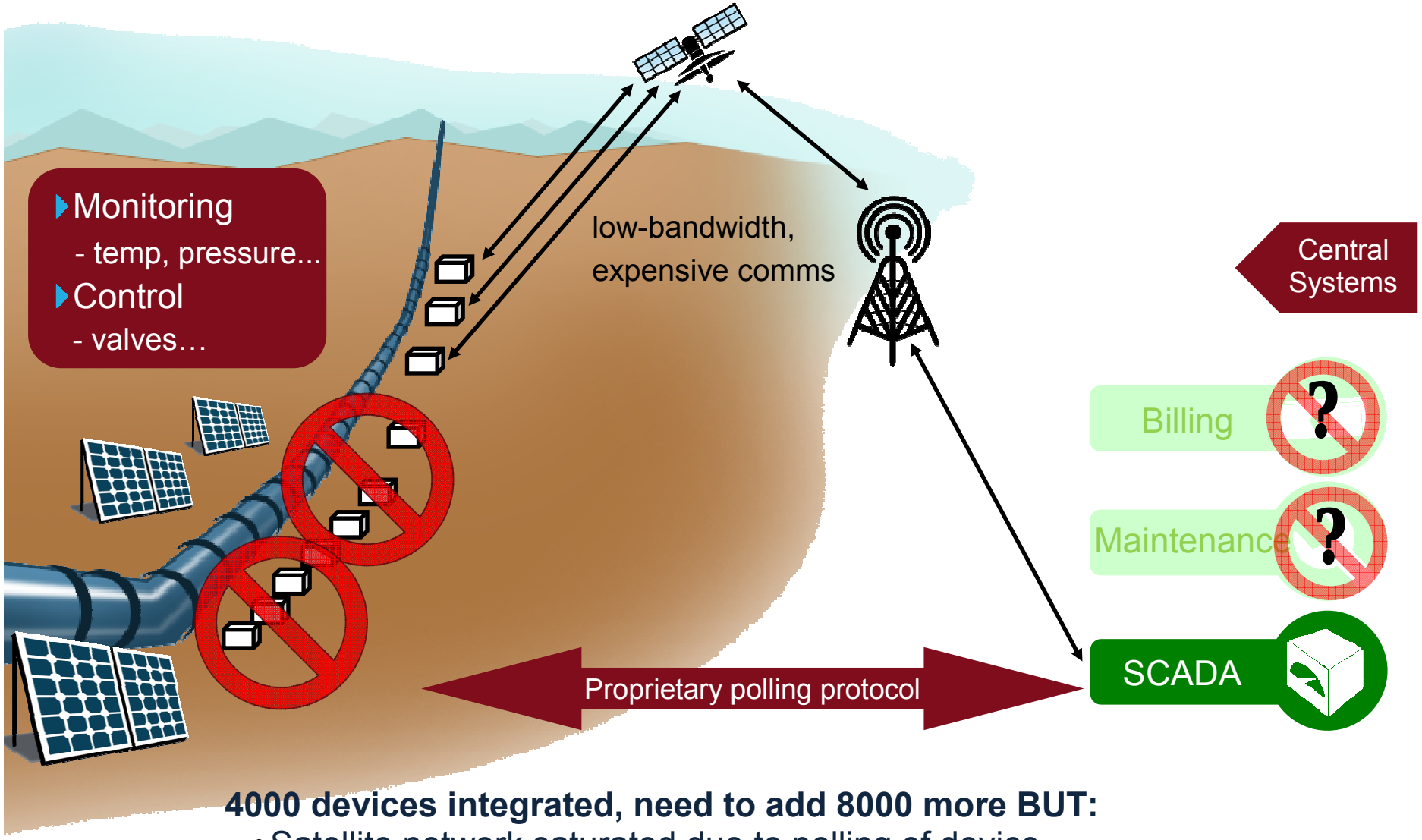
How did the Internet of computers form?

- Whether cause or effect, interoperability was key
  - Data transmission standards (Ethernet etc.)
  - Addressing standards (IP, DNS, URI etc.)
  - Discovery and routing standards (RIP etc.)
  - Transport standards (TCP, UDP etc.)
  - Data standards (**HTTP**, SMTP, POP etc.)

Why isn't HTTP enough?

- The HTTP standard revolutionized how *people* consume data
  - A single simple model: Send a request, read the response
  - Available via any tablet, laptop, phone, PC etc.
- The Internet of Things has fundamentally different challenges
  - HTTP remains ideal for requesting data from a known source
  - We also need an event-oriented paradigm:
    - Emitting information *one to many*
    - Listening for events *whenever they happen*
    - Distributing minimal packets of data in *huge volumes*
    - *Pushing* information over *unreliable networks*

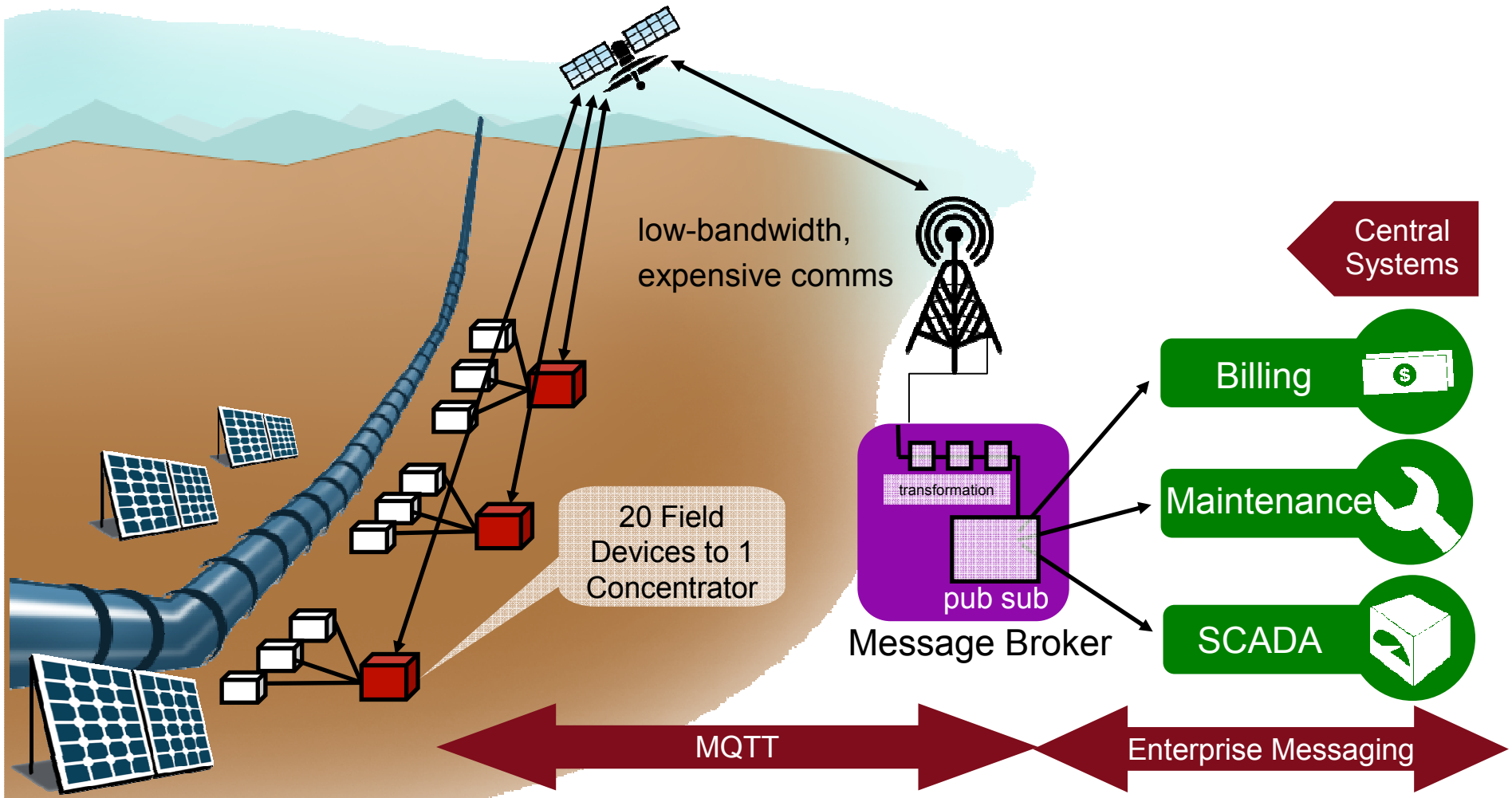
Pipeline – the need for scalable communications



4000 devices integrated, need to add 8000 more BUT:

- Satellite network saturated due to polling of device
- VALMET system CPU at 100%
- Other applications needed access to data ("SCADA prison")

Enter MQTT



Scalability for whole pipeline!
Network traffic much lower - events pushed to/from devices and report by exception
Network cost reduced
Lower CPU utilization
Broken out of the SCADA prison – data accessible to other applications

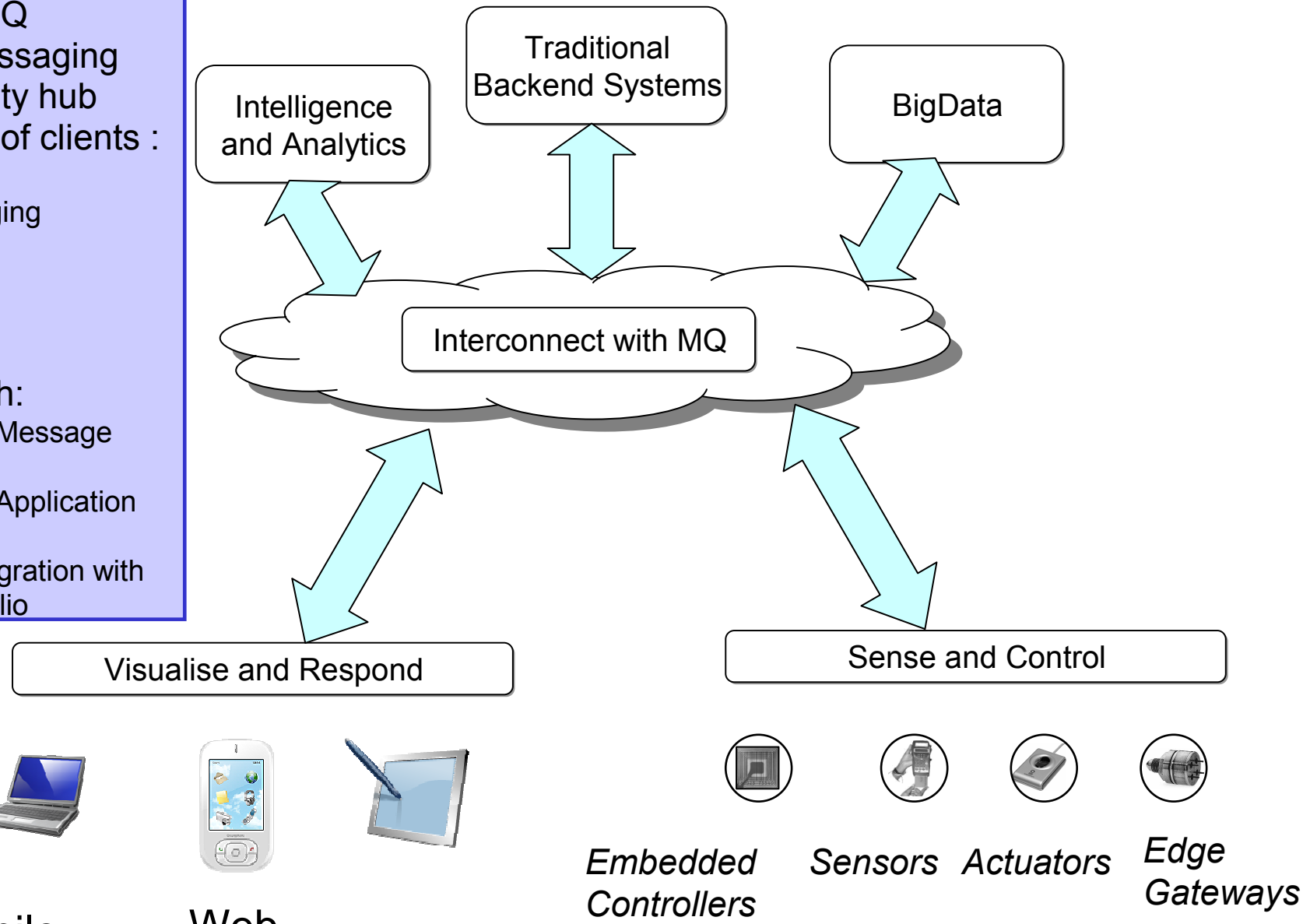
MQTT in a Nutshell

MQTT == MQ Telemetry Transport

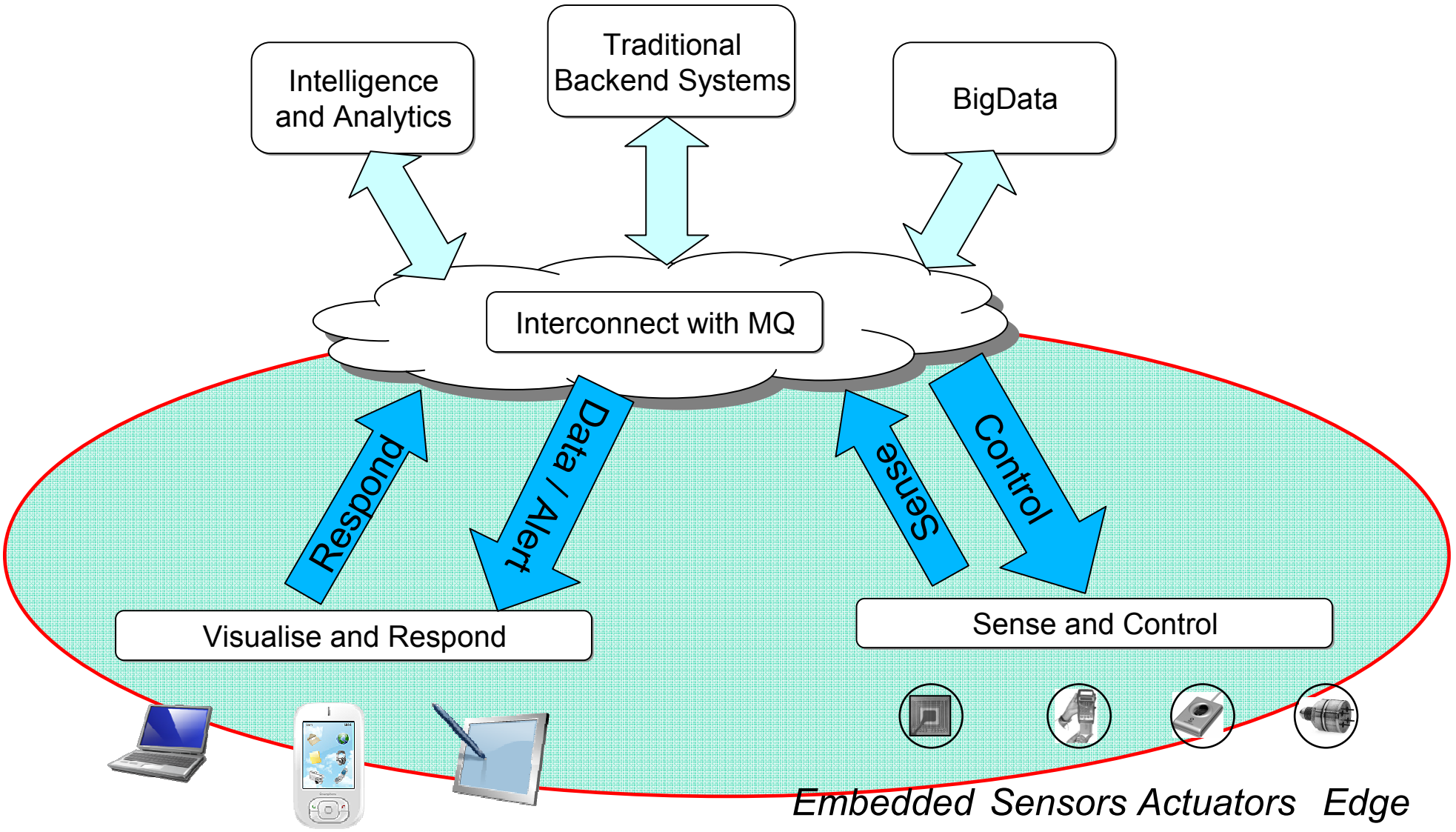
> "*An open royalty free light weight event and message oriented protocol allowing devices to asynchronously communicate in an efficient manner across constrained networks to remote systems*"

A Connectivity Hub

- WebSphere MQ provides a messaging and connectivity hub with a rich set of clients :
  - MQTT
  - Web Messaging
  - MQI
  - JMS
  - XMS
  - multicast
- Integrating with:
  - WebSphere Message Broker
  - WebSphere Application Server
  - Allowing integration with a wide portfolio



The Realm of MQTT



MQTT, connectivity for the Internet of Things

MQTT: a messaging protocol suited for constrained devices and networks

Open

- Open royalty free spec designed for the world of “devices”
- Wide variety of clients and servers
  - Hobbyist to enterprise
  - Open source to commercial

Lean

- Minimized on-the-wire format
  - Smallest possible packet size is 2 bytes
  - No application message headers
- Reduced complexity/footprint
  - Clients: C=30Kb; Java=100Kb

Reliable

- Three qualities of service:
  - 0 – at most once delivery
  - 1 – assured delivery but may be duplicated
  - 2 – once and once only delivery
- In-built constructs to support loss of contact between client and server.
  - “Last will and testament” to publish a message if the client goes offline.
- Stateful “roll-forward” semantics and “durable” subscriptions.

Simple

- Simple / minimal pub/sub messaging semantics
  - Asynchronous (“push”) delivery
  - Simple set of verbs -- connect, publish, subscribe and disconnect.

MQTT Products and Technologies

Enterprise MQTT servers

- *WebSphere MQ*
- *IBM Messaging Appliance**

Mid size/premises servers

- *WebSphere Sensor Events*

Edge Servers

- *WebSphere MQ Telemetry Daemon for Devices (aka RSMB)* – *ships with WebSphere MQ*

Clients

- *Java (MIDP up)*
- *C including a reference implementation*

Other

- *Third party and Opensource servers and clients*
  - *16+ MQTT severs*
  - *40+ MQTT clients*

MQTT Enterprise Server Support

- 1999 till 2010: enterprise server support for MQTT available in MQSI and WMB
  - WMB 6.1 (SCADA node) is the last release to support MQTT
  - WMB 7 utilises the new support in MQ to handle MQTT
- 2010: MQ Telemetry Feature for MQ 7.0.1 released.
  - Supports MQTTv3 protocol
  - MQTT messages translated to standard WMQ messages
  - Administration included as part of WebSphere MQ Explorer
  - Separate CD and install
  - Priced per MQTT connection
  - Also known as MQXR (eXtended Reach)
- 2011: MQ Telemetry Feature integrated into MQ 7.1
  - Standard MQ Installer – optional feature
  - MQSC support
- 2012: MQ 7.5 Telemetry feature:
  - New pricing model
    - Price per connection ***removed*** for MQTT clients (not Advanced clients)
  - Additional platform support
    - Now supports Windows, Linux, ZLinux, AIX
  - *Open source MQTT Clients*
- 2013: IBM Messaging Appliance
  - Statement of direction in Oct 2012

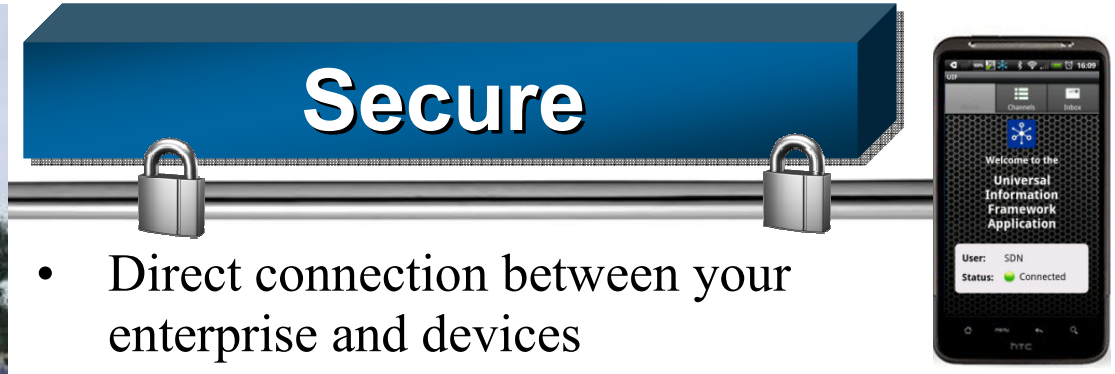
Emerging threats: Industrial espionage

WebSphere MQ an Enterprise class MQTT server

Scalable

- 240,000 concurrently connected devices tested with <5% CPU on a single IBM WebSphere MQ queue manager
- Tiny client libraries (30kb) for use on devices, mobiles…
- Inter-operate with other applications/WMB….
- Create, config, run, send message in < 5 mins

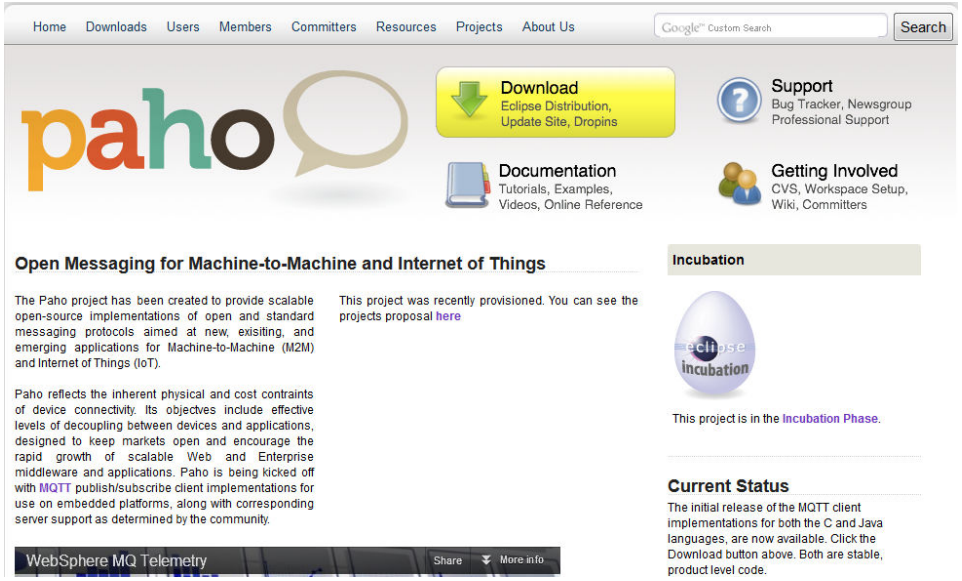
Secure



- Direct connection between your enterprise and devices
- Network: TLS/SSL
- Pluggable Authentication: JAAS
- Authorization: OAM

It is Open and on the way to being a Standard

- Open Source
  - Eclipse.org Paho project
  - IBM Contributed MQTT clients



- Standard
  - MQTT is being standardised at OASIS

OASIS
Advancing open standards for the information society

- Third party and Opensource servers and clients
  - 16+ MQTT severs
  - 40+ MQTT clients

MQTT, connectivity for the Internet of Things

MQTT clients for many *mobile* platforms and application styles

- Available from new IBM Messaging Community on DeveloperWorks

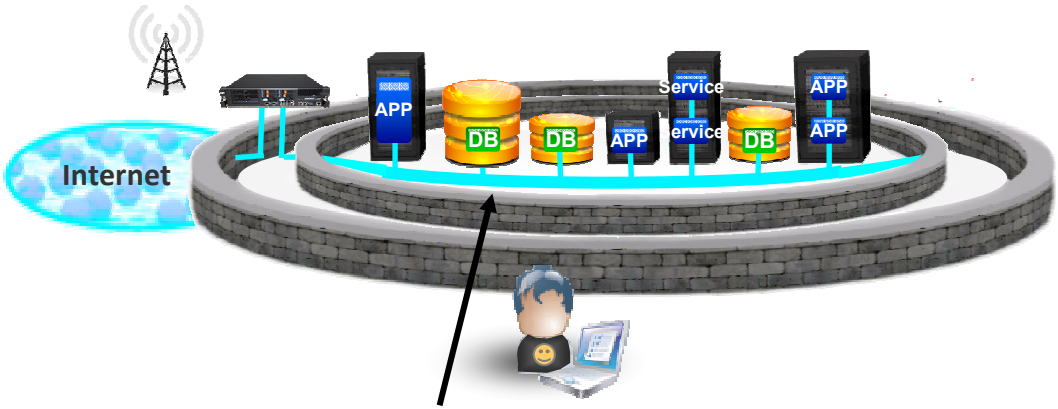
Worklight developers
Developer experience augmented with mobile messaging

Apple iOS
Messaging for native iOS apps

Android
Messaging for native Android apps

JavaScript
Messaging for **Hybrid apps**

JavaScript*
Messaging for Web **apps**



MQTT

- Reliable messaging protocol
- Access to enterprise
- Reliable delivery
- Conserve device power
- Reduce network traffic

WebSphere MQ

- Universal Enterprise Messaging
- Provide access to enterprise apps and data already connected by MQ
- Pub/sub model to enable dynamic distribution of notifications

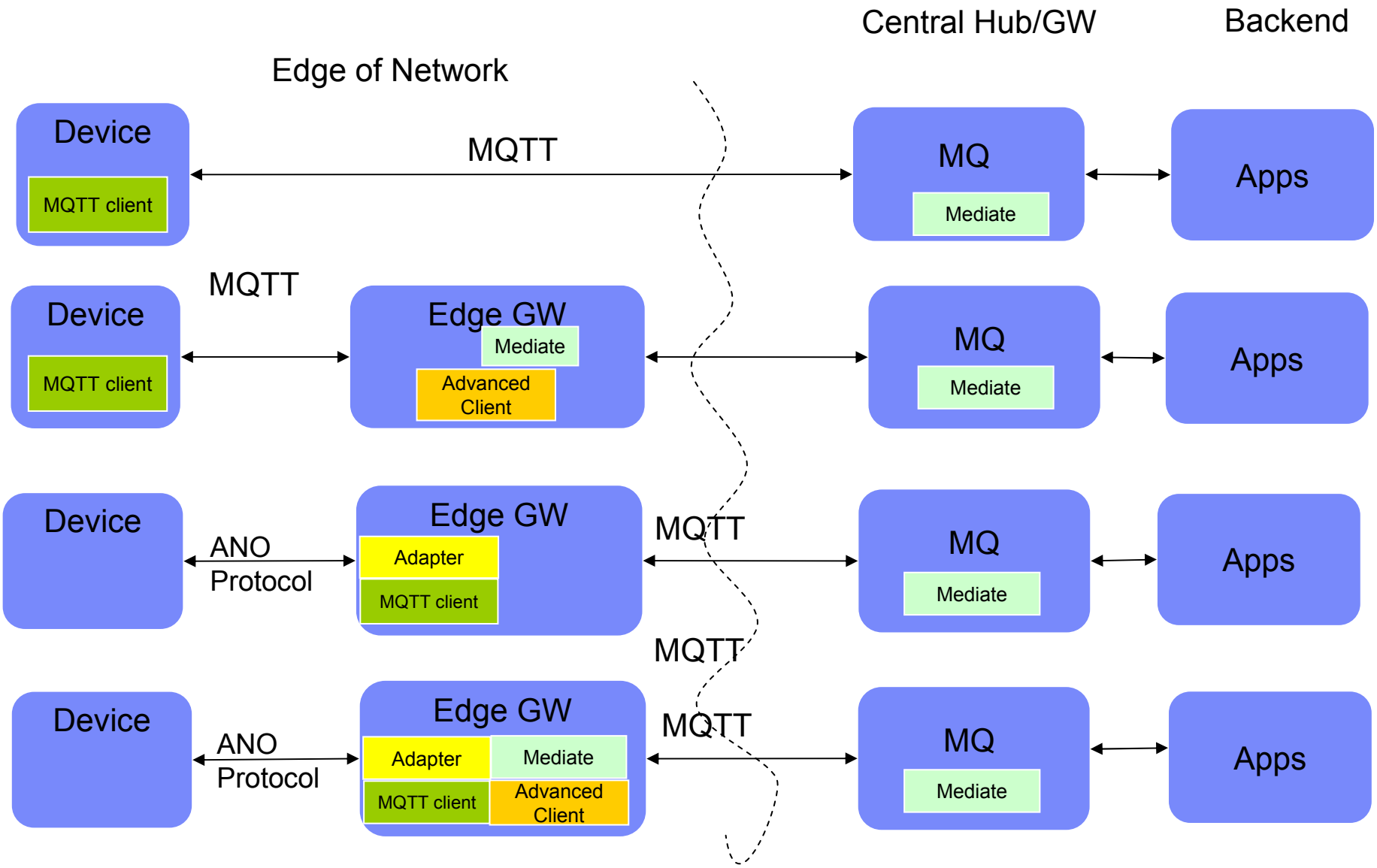
Benefits of MQTT verses HTTP

- Push delivery of messages / data / events
  - MQTT – low latency push delivery of messages from client to server and **server to client**
  - HTTP – push from client to server but poll from server to client
- Efficient use of network
  - For an M2M project the number of bytes with MQTT was **137130 bytes per device per month** with HTTP the number of bytes was **801000 bytes per device per month**
- Reliable delivery over fragile network
  - MQTT will deliver message to QOS even **across connection breaks**
- Decoupling and publish subscribe – **one to many delivery**

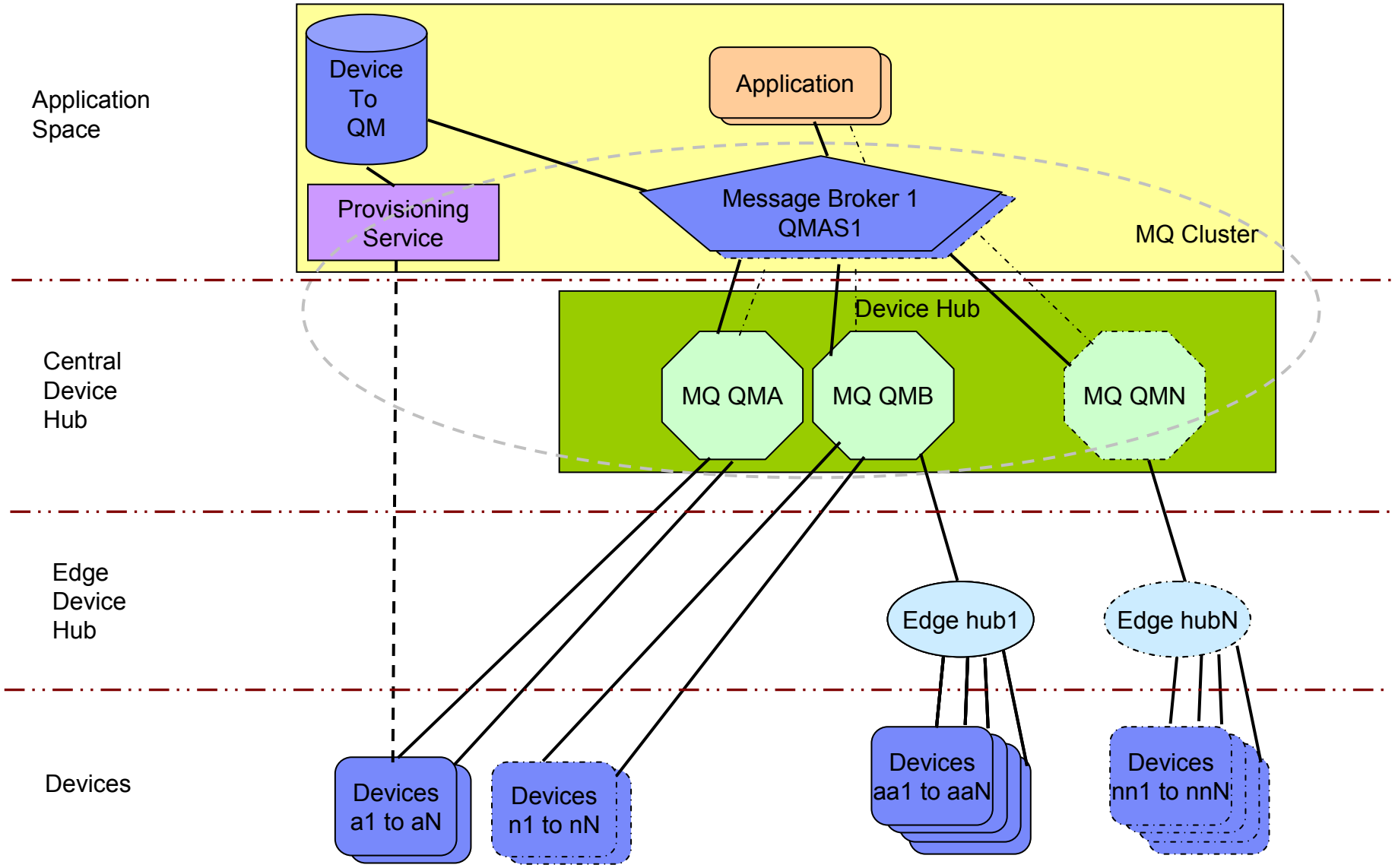
		3G		Wifi	
		HTTPS	MQTT	HTTPS	MQTT
receive	messages / hour	1,708	160,278	3,628	263,314
	% battery / msg	0.01709	0.00010	0.00095	0.00002
	msgs (note losses)	240 / 1024	1024 / 1024	524 / 1024	1024 / 1024
send	msg / hour	1,926	21,685	5,229	23,184
	% battery / msg	0.00975	0.00082	0.00104	0.00016

Source: http://stephendnicholas.com/archives/1217

Device Connectivity Patterns



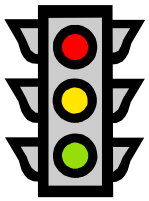
Patterns – topology example



Making it Real
Some Real World Examples

Business Scenarios – where might it be used

predict



alert

track

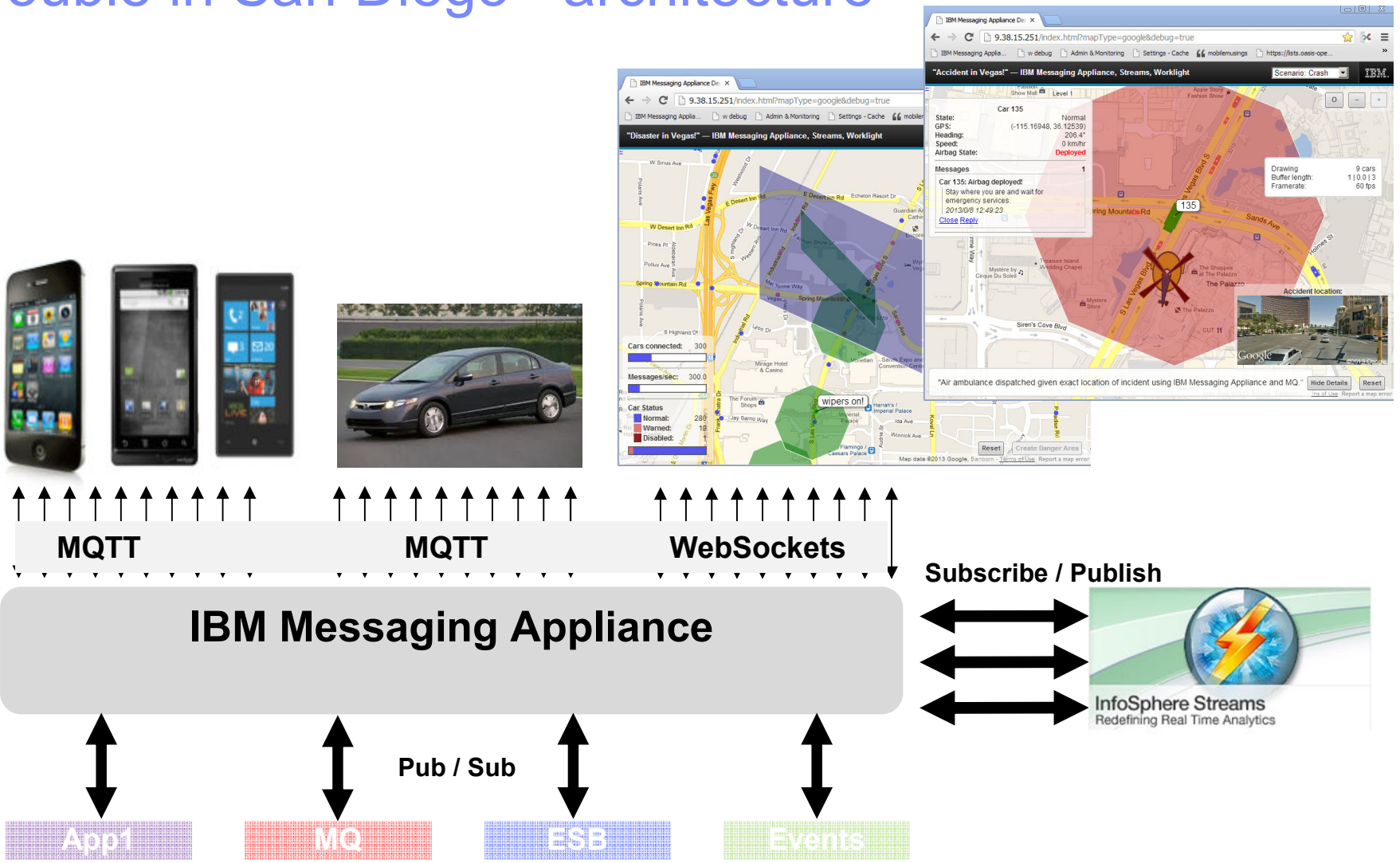
measure

Scenario	Key Industries	Example
Automated Metering	Chemical & Petroleum Energy & Utilities	*Solution provider enables smart metering of home energy by using MQ Telemetry technology*
Distribution Supply Chain and Logistics	Retailers Distributors Consumer products Transportation	*Shipping company improves customer loyalty by providing up-to-the-moment detailed tracking information for cargo* *Transportation company improves customer safety and satisfaction with improved tracking of fleet*
Industrial Tracking & Visibility	Automotive Industrial manufacturing Aerospace Defense	*Manufacturing company automates inventory checking to improve management of stock and optimize production rates*
Healthcare Personal & Resource Tracking	Pharmaceutical companies Health trials Hospitals Nursing Homes	*Medical organization uses MQ Telemetry to track health of at-risk patients to increase safety and quality of patient care* *Hospital uses MQ Telemetry to track expensive surgery equipment to maximize utilization and reduce waiting lists*
Location Awareness and Safety	Chemical & Petroleum Energy & Utilities Homeland Defense	*Gas company uses MQ Telemetry to monitor and control gas pipeline operations* *Government monitors dams and flood-risk areas to increase early-warning detection and prediction capabilities*
Executive Alerting	Insurance Banking	*Bank alerts Personal Account Managers when new clients open accounts >= $2M improving customer satisfaction*

Demo

Video: Trouble in San Diego

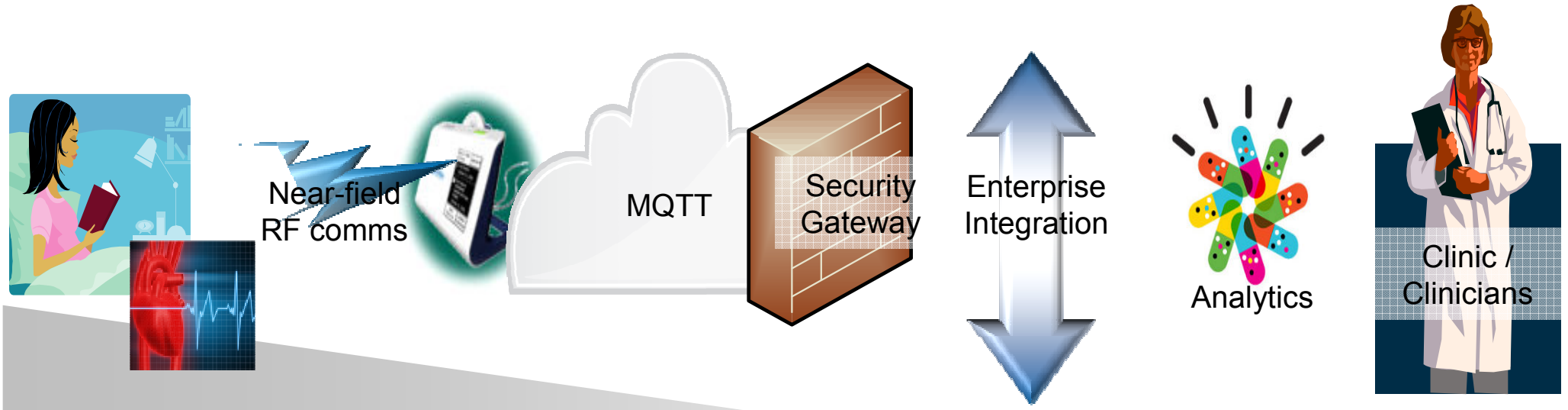
Trouble in San Diego - architecture



(fyi – **everything** in demo is via pub/sub and topics)

A real world Healthcare example

- Smart, connected, pacemakers eliminate the need for regular clinic visits
- Problems are detected early, preventing potentially life threatening incidents



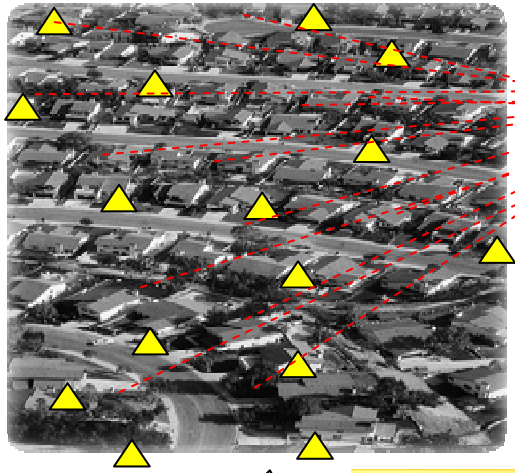
Smart pacemaker records data

Bedside appliance extracts information

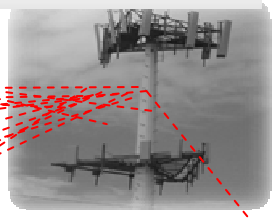
Analytics build patient knowledge and extract insight

Professionals perform the action

A real world Energy exa

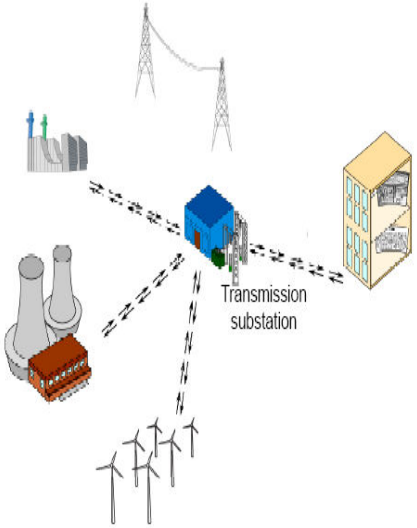


verizon wireless



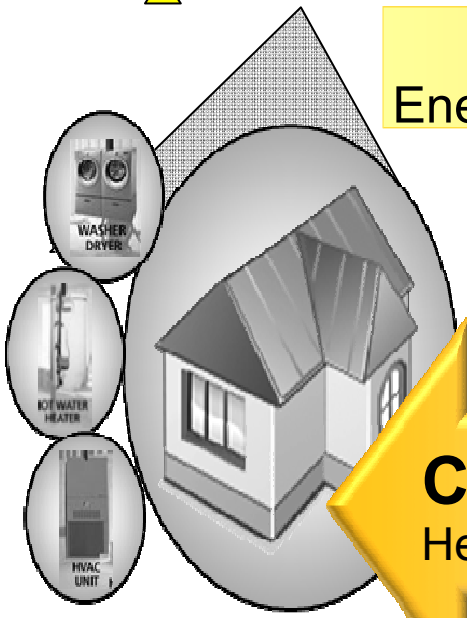
Demand
Tre

Cap



Usage
Energy, Temp…

MQTT

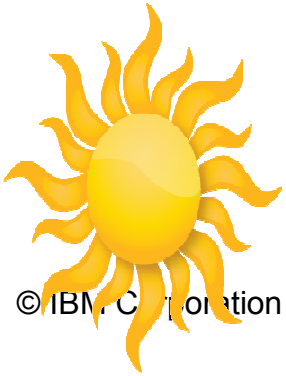


Control
Heating, Appliances

Virtual Power Plant

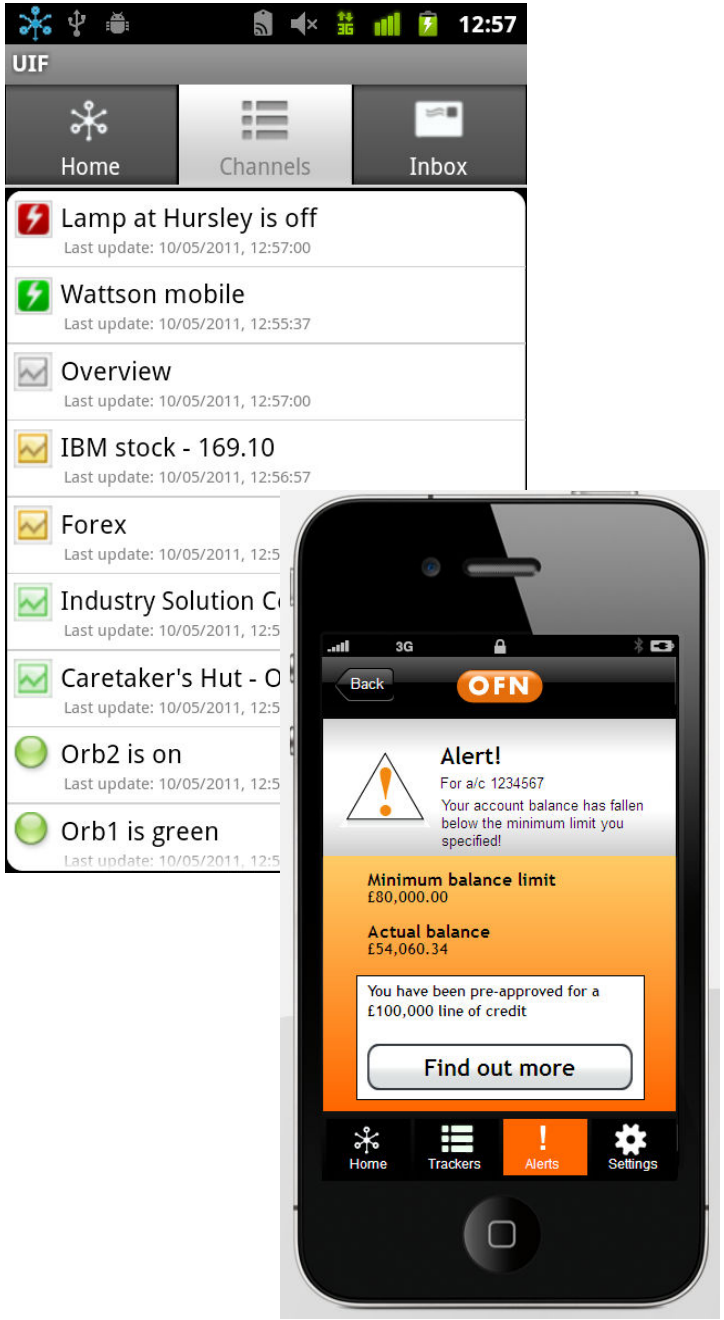
Future
Marke

Wea



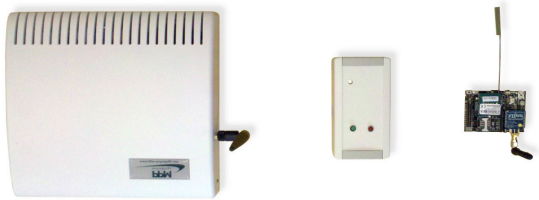
A Mobile Dashboard

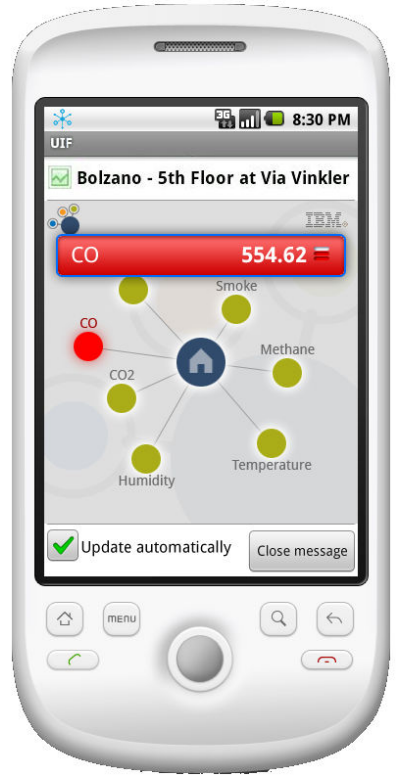
- Alerts from enterprise systems
- Business process (workflow) interactions
- Person-to-person communications (peer to peer)
- Live information monitoring (status channels)
- Location based awareness / alerting
  - Retail offers
  - Traffic infrastructure (alerts about incidents on your route home)
- Remote monitoring and control
  - Communicate with sensors and physical devices



The Living Safe Project

- Partnership with Italian Government
- Coping with an ageing population
- Instrumenting homes
- Mobile wardens
- UIF used to monitor status and receive alerts & instructions





Telematics

Norwich Union Insurance drives new business model with WebSphere MQ

Black box in the car

Hi-tech check on where you drive will decide how much insurance you pay

By Sean Poulter
Consumer Affairs Correspondent

WITH insurance charges steadily rising, an aircraft-style 'black box' is being fitted to cars in an experimental pay-as-you-drive scheme.

It means motorists' premiums will be based on where and when they have driven – with the hi-tech device charting the details of journeys and beaming signals to a global positioning satellite orbiting the Earth.

An IBM spokesman said: "This technology can be used to benefit motorists who make accurate insurance claims based on actual use of their cars." Mr Ledger said: "The box is smaller than a

HOW THE BLACK BOX WORKS

POSSIBLE EXTRAS

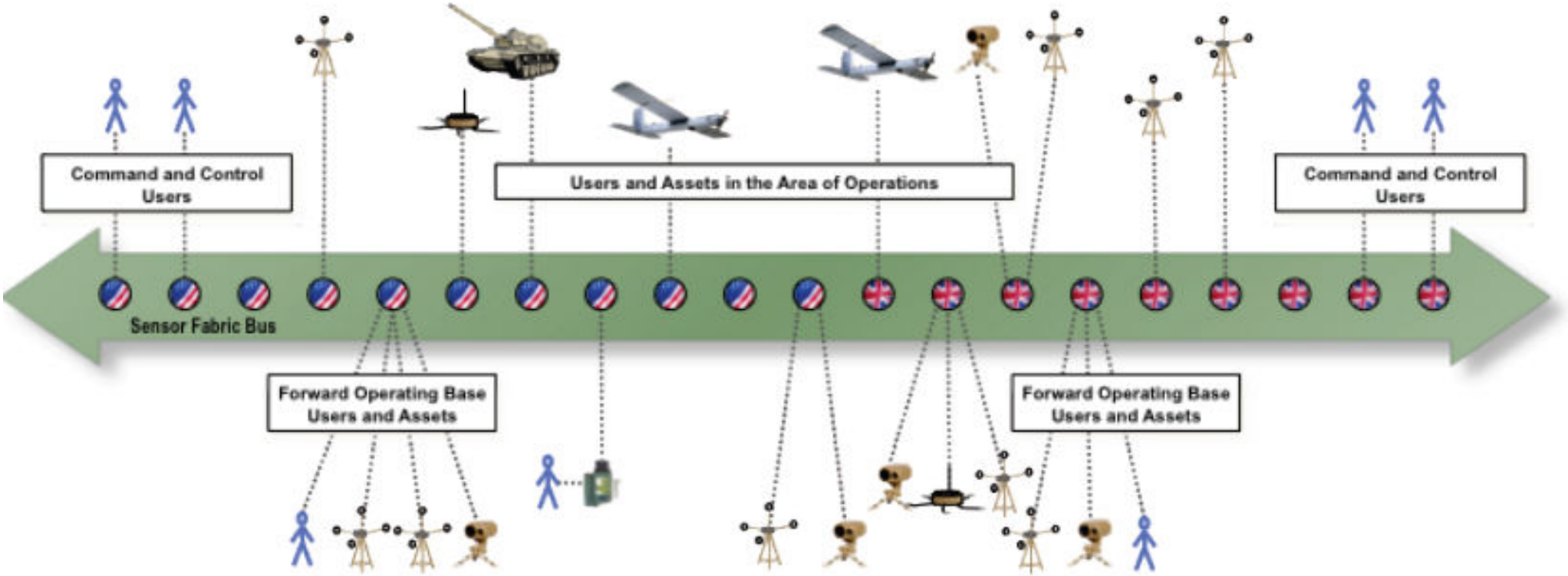
NORWICH UNION

Norwich Union are the UK's largest insurance group, backed by Aviva plc with over £200 billion of assets under management and 25 million customers worldwide, a market share of around 16 per cent and is more than 1.5 times the size of its nearest rival. It is also the largest personal lines insurer.

IBM leverages its work with Progressive Insurance, its partnership with Orange and WebSphere MQ to drive an innovative new business model for the UK's largest insurer, Norwich Union Insurance – pay-as-you-go car insurance

"Customers choosing Pay As You Drive™ insurance will benefit from individual premiums based on how often, when and where they actually used their cars. Motorists would receive a fairer deal as this initiative provides them with the opportunity to really be in the driving seat when it comes to controlling their premiums."
Robert Ledger, programme director for Norwich Union

Information / Sensor Fabric



Lucy Zhang, a software engineer at Facebook, has written about their new Facebook Messenger app:

*"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**."*

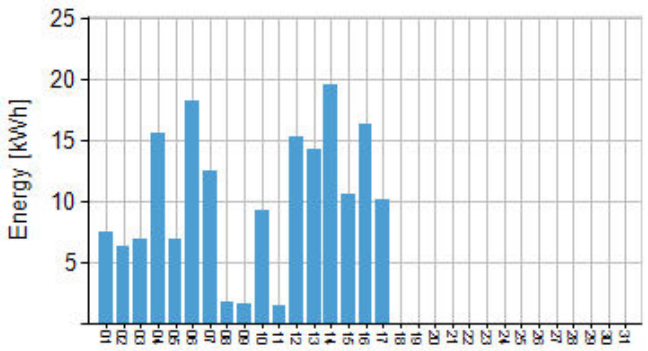
MQTT, connectivity for the Internet of Things

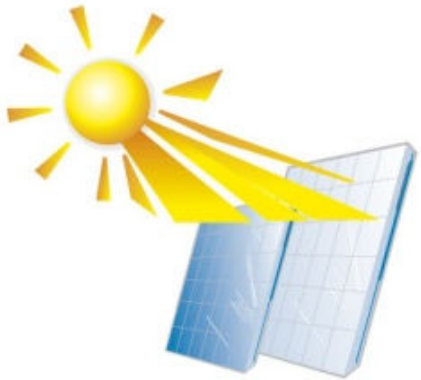
Overview

Datalogger ID: 240.13081
Module: ()
Generator Power: 4000 Wp
Angle: 0 °
Status: Online 21:48:54 (IP: 86.150.98.95)
Generator Power actual: 0 W
Inverters:
1 x Fronius IG TL 4.0

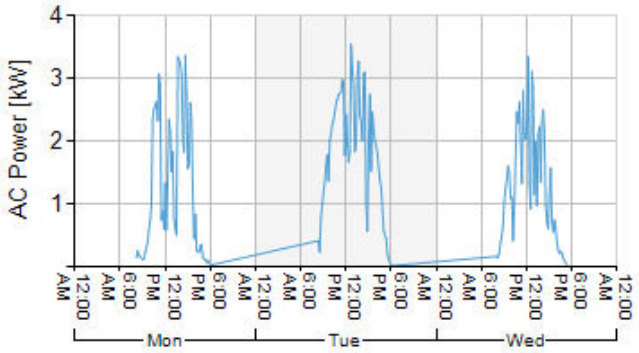
Last Import: 10/17/2012
Feed-in tariff: 0.433 Pound

Totalview - October 2012

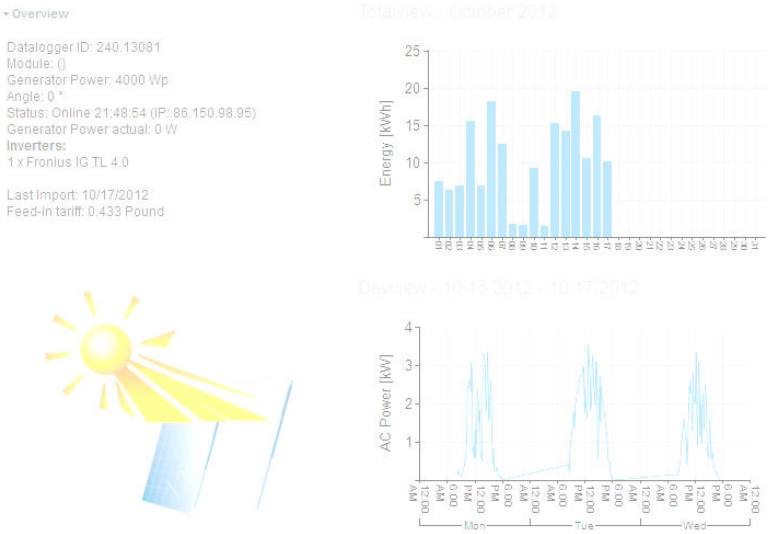


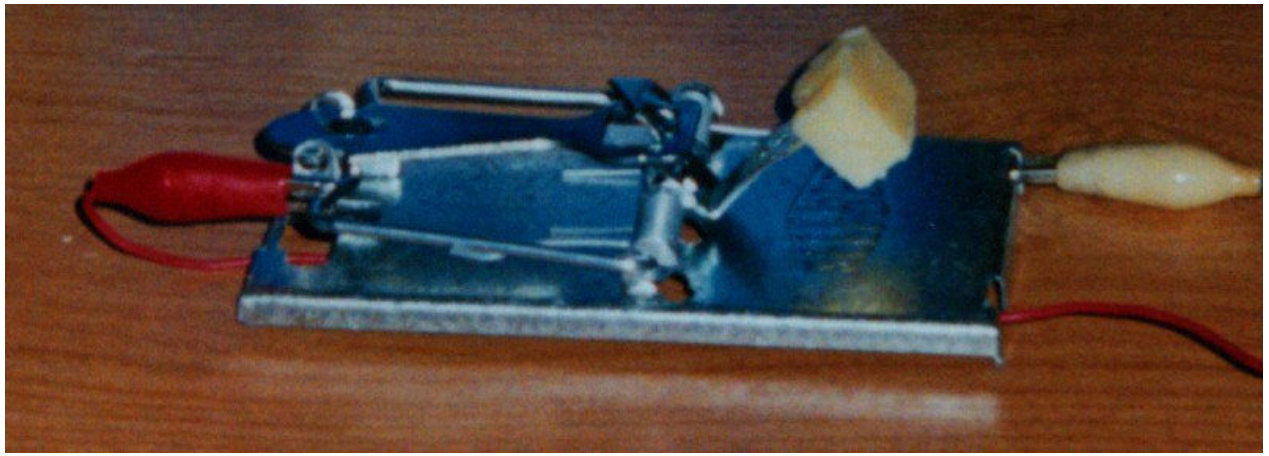


Dayview - 10/15/2012 - 10/17/2012

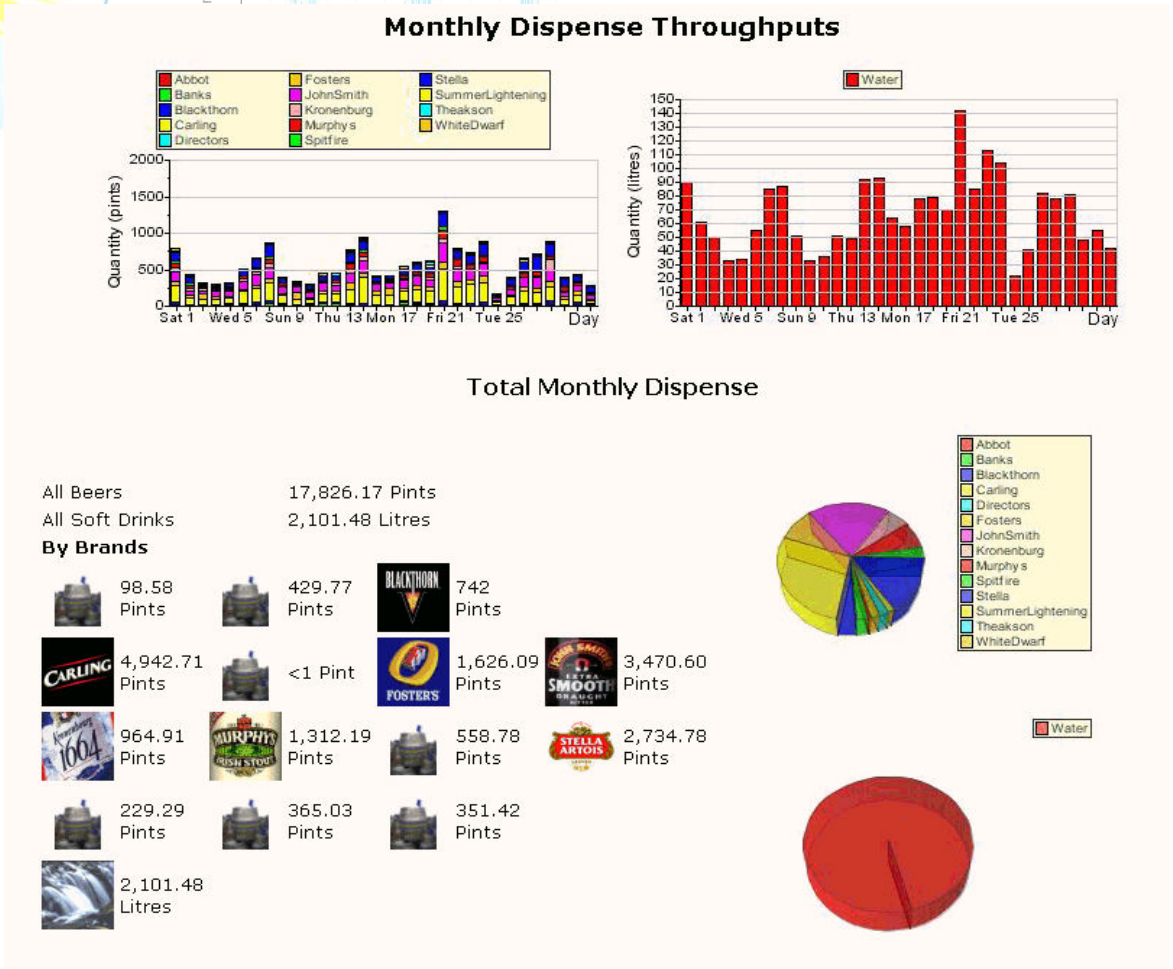


MQTT, connectivity for the Internet of Things

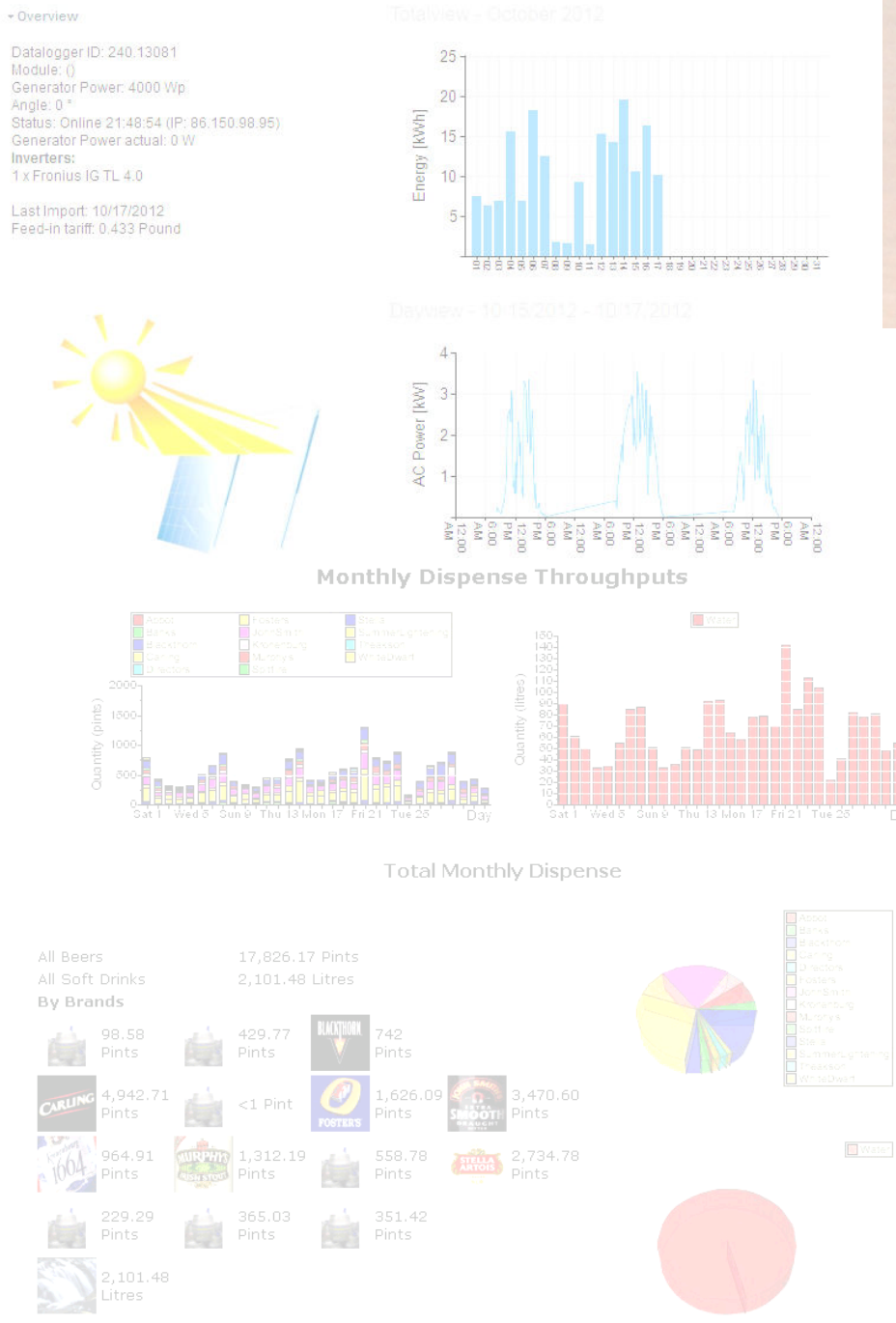


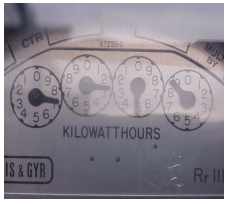


MQTT, connectivity for the Internet of Things



MQTT, connectivity for the Internet of Things



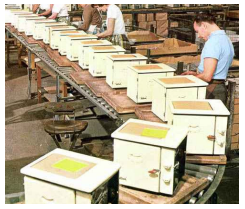


power meter

flowmeter

current clamp

valve position



proximity sensor

machine tool status

Summary for Extending WebSphere MQ to Mobile

So with IBM WebSphere MQ

providing your Enterprise Messaging backbone

and its MQTT capabilities

providing reliable messaging to both mobile devices and sensor & telemetry solutions

your business applications can be accessed on the move

Ensuring you don't lose any data, and keep your transactions flowing

and your customers can have a more dynamic and rewarding interaction with you

Without draining their batteries or chewing through their data contract

Keeping them informed wherever they are

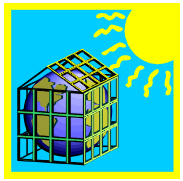
Some areas where MQTT has been used

POS

Kiosks

Slot Machines

Automotive/
Telematics



Environment &
Traffic Monitoring

Fire & Gas
Testing

Chemical
Detection

Asset tracking /
management

SCADA

Medical

Field Force
Automation

Home
Automation

Railway

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