

# MQTT connecting the Internet of Things

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Dave Locke | WebSphere MQ Development | IBM

# Agenda

The Internet of Things

Why interoperability matters

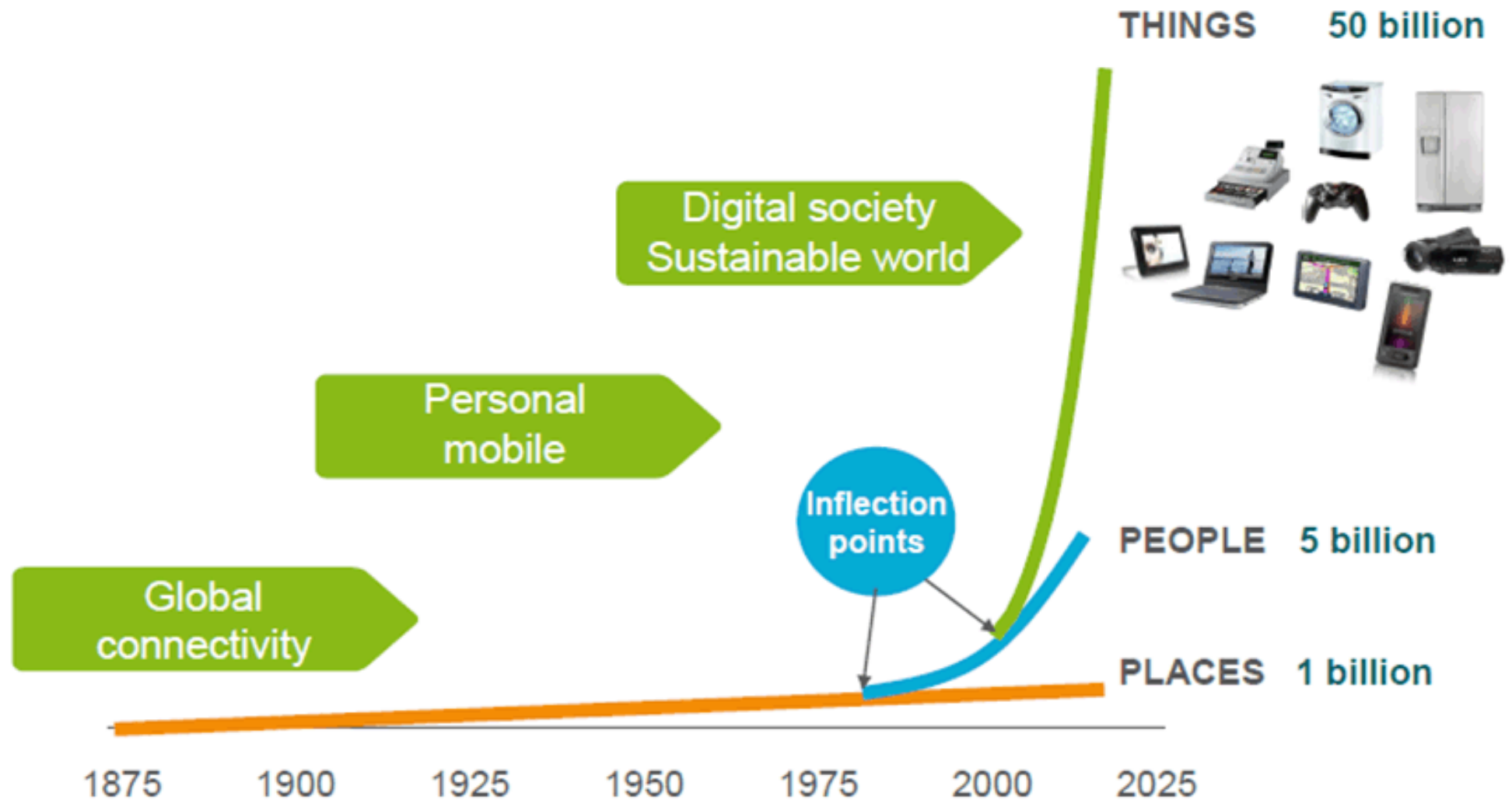
MQTT

- 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



- My phone only talked to other phones
- It sent data to others when I asked it to
- Mobile phone companies led the market
- My phone can connect to almost anything
- It shares and receives information automatically
- Computer & content companies drive the market
- What will replace it?
- Who will it talk to?
- What companies will lead?



MQTT, connectivity for the Internet of Things  
... 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

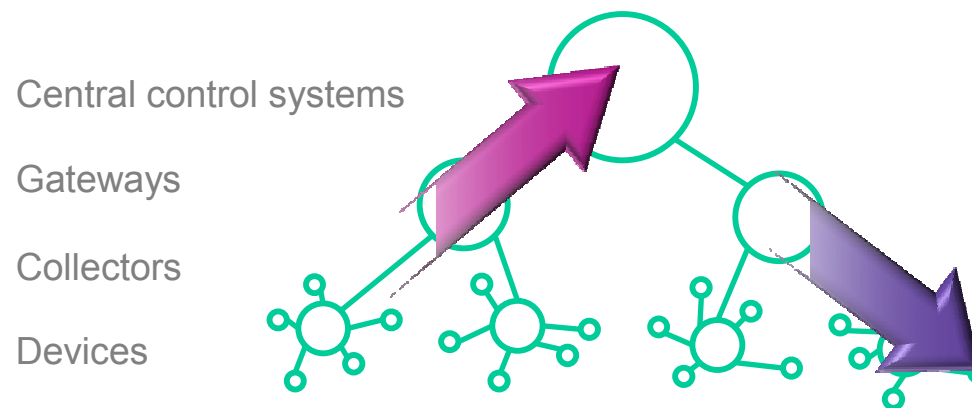
<http://ibm.co/btsi5C>

MQTT, connectivity for the Internet of Things  
... 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

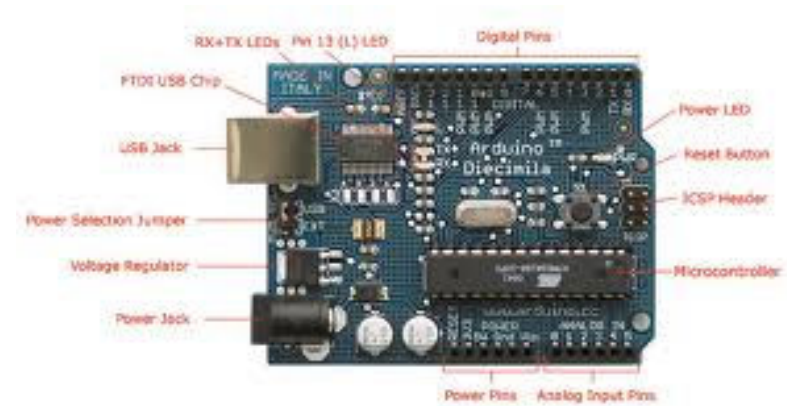


What if we start adding intelligence throughout the network?



# MQTT, connectivity for the Internet of Things

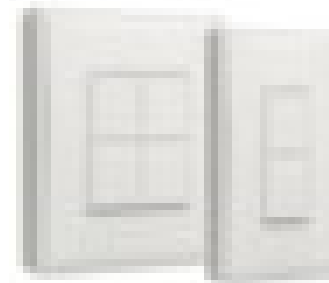
## ... price, power consumption, network, convenience



Photograph by SparkFun Electronics. Used under the Creative Commons Attribution Share-Alike 3.0 license.



- KORE**  
Inertial Motion Sensor
- CHROMA**  
Paint Matching
- THERMA**  
Surface Temperature
- CLIMA**  
Weather
- LUMA**  
Flashlight
- OXA**  
Gas Sensor



# 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





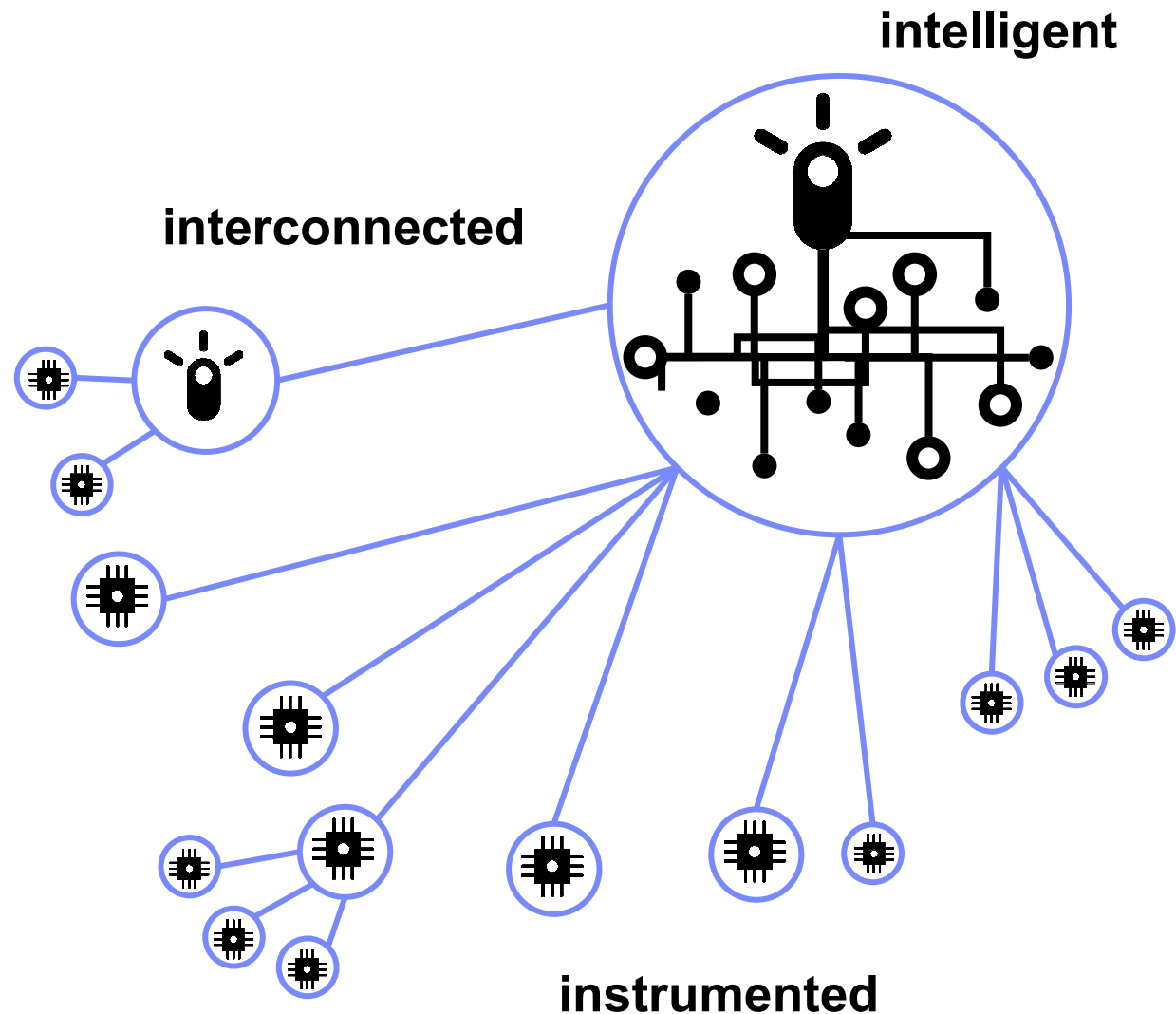
## Connectivity and a Smarter Planet

**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**

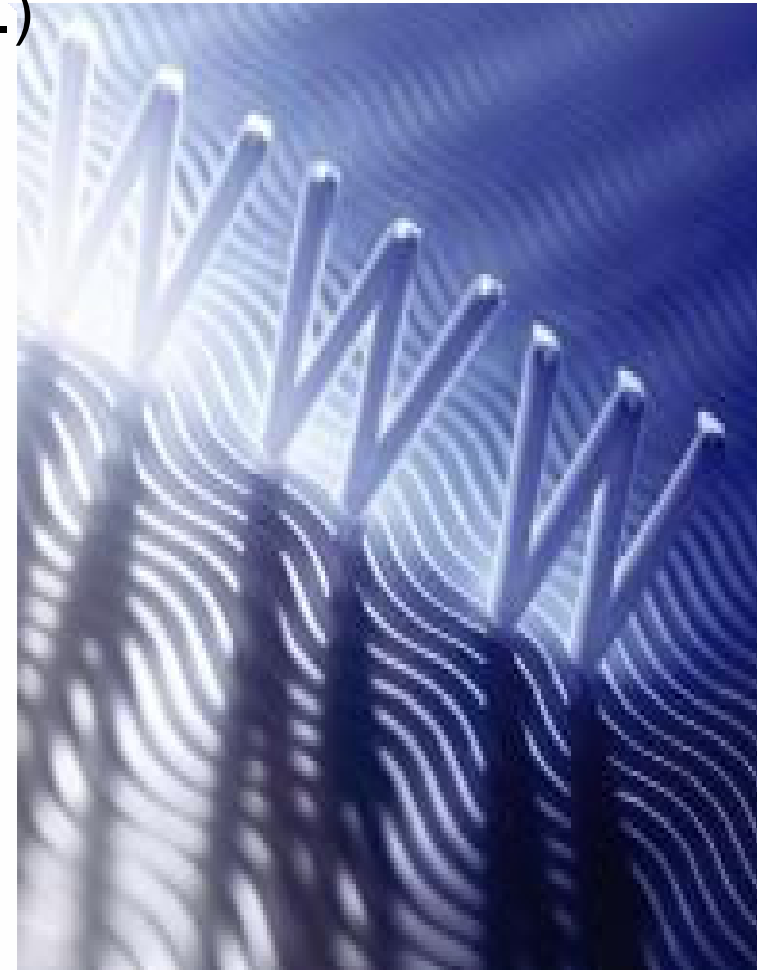
Enable **massive scalability** of deployment and management of solutions



## **Why interoperability matters**

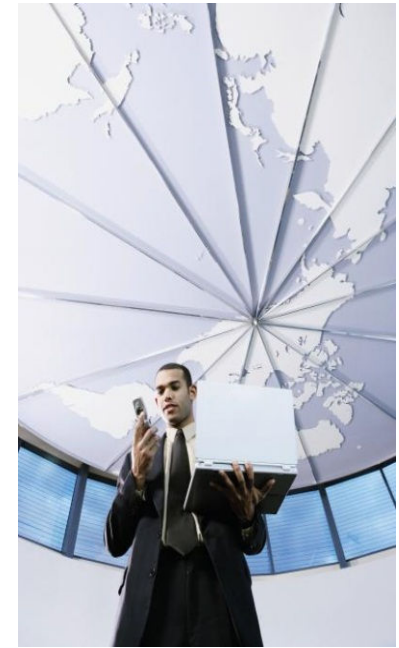
## How did the Internet of computers form?

- 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.)



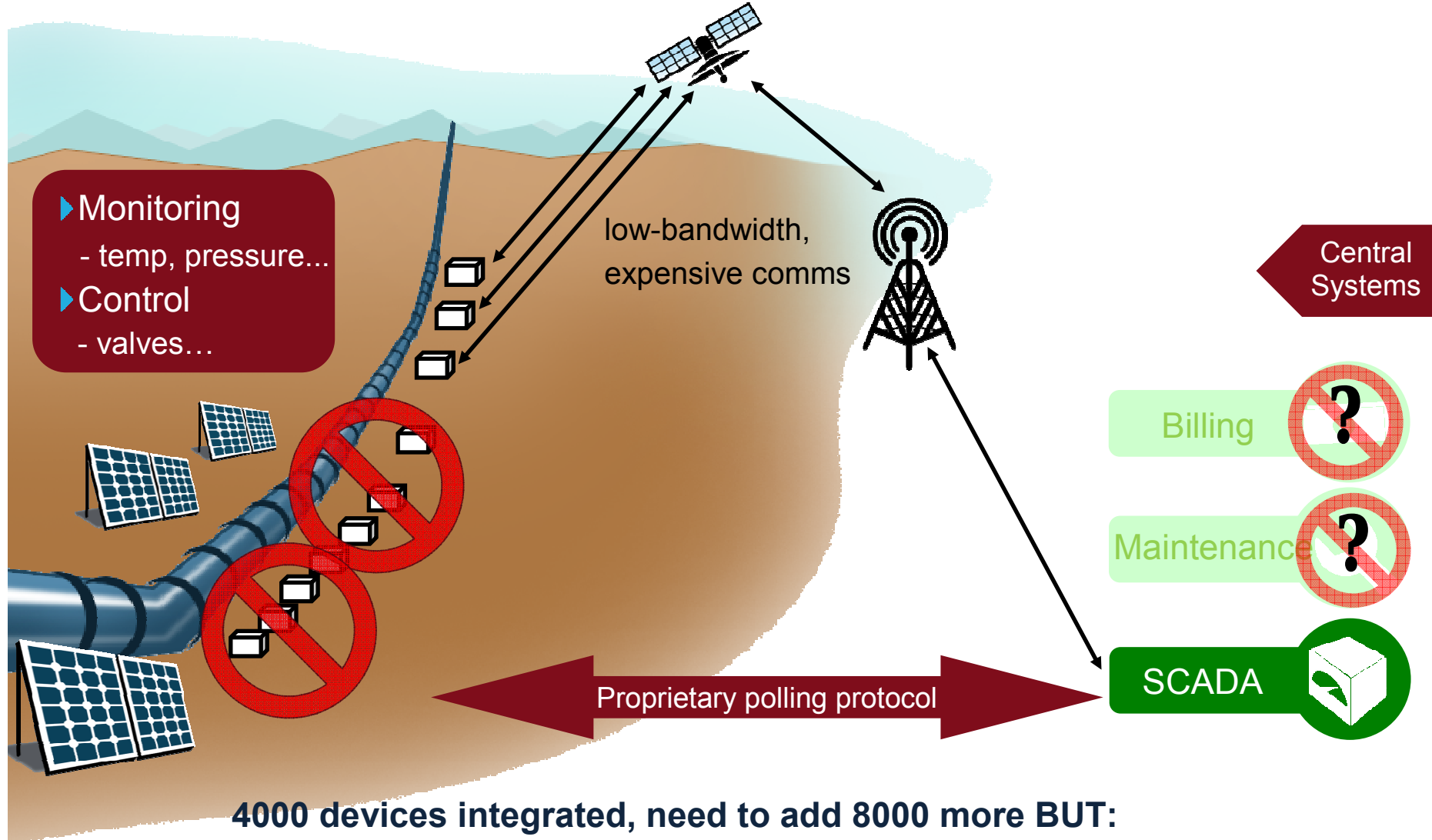
## Why isn't HTTP enough?

- 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*



# MQTT, connectivity for the Internet of Things

## Pipeline – the need for scalable communications

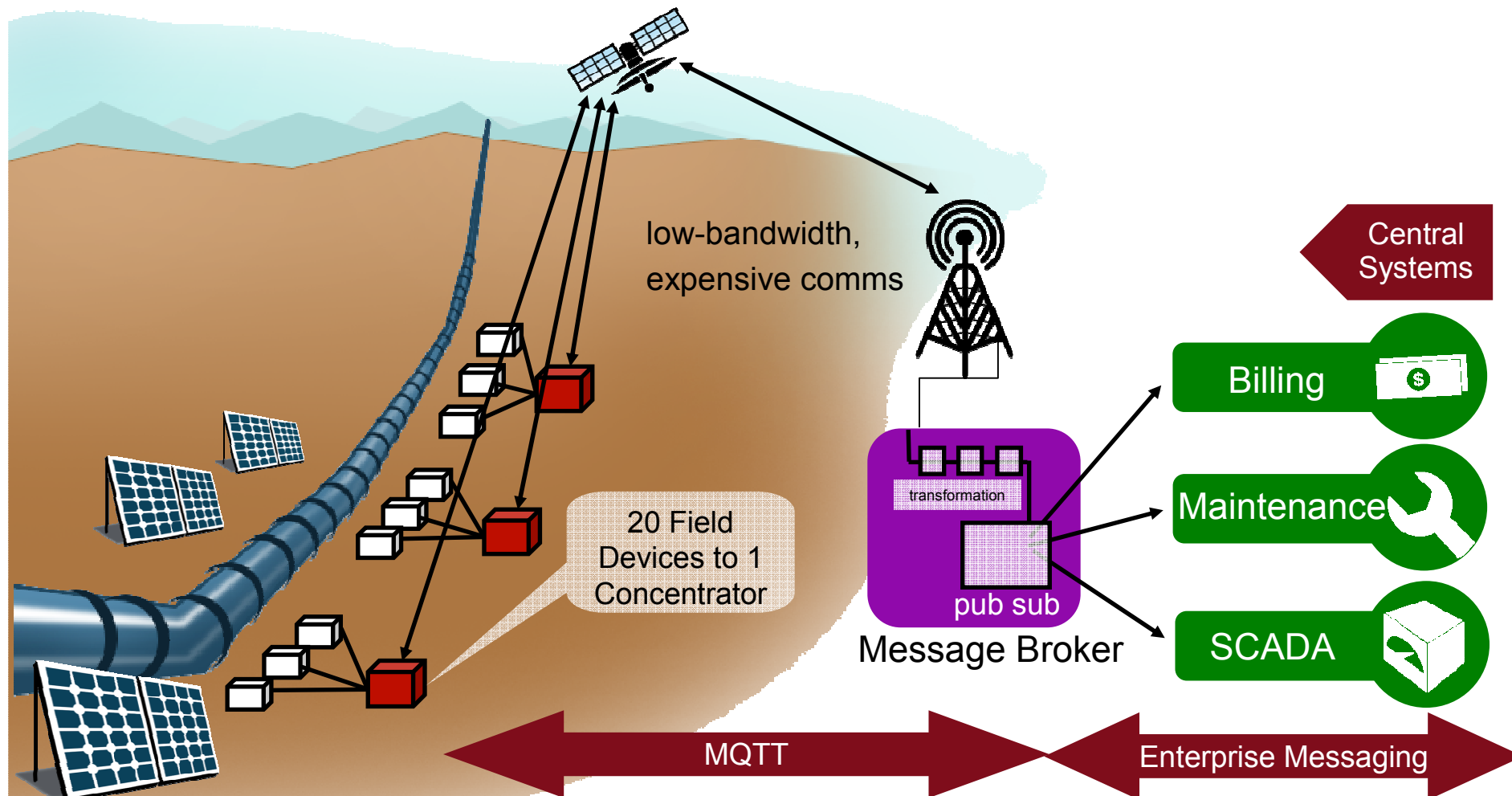


**4000 devices integrated, need to add 8000 more BUT:**

- 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

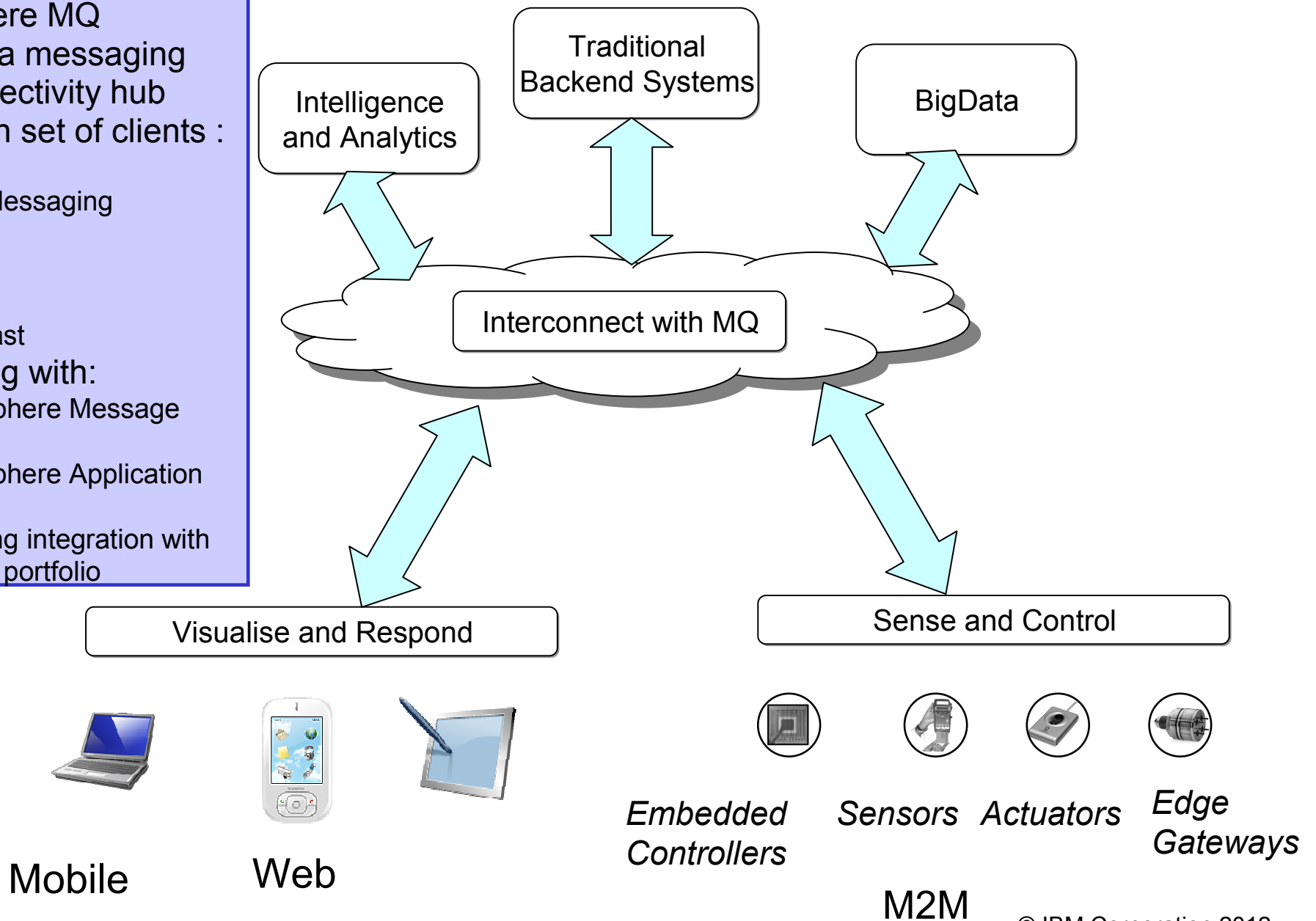
MQTT == MQ Telemetry Transport

*“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”*

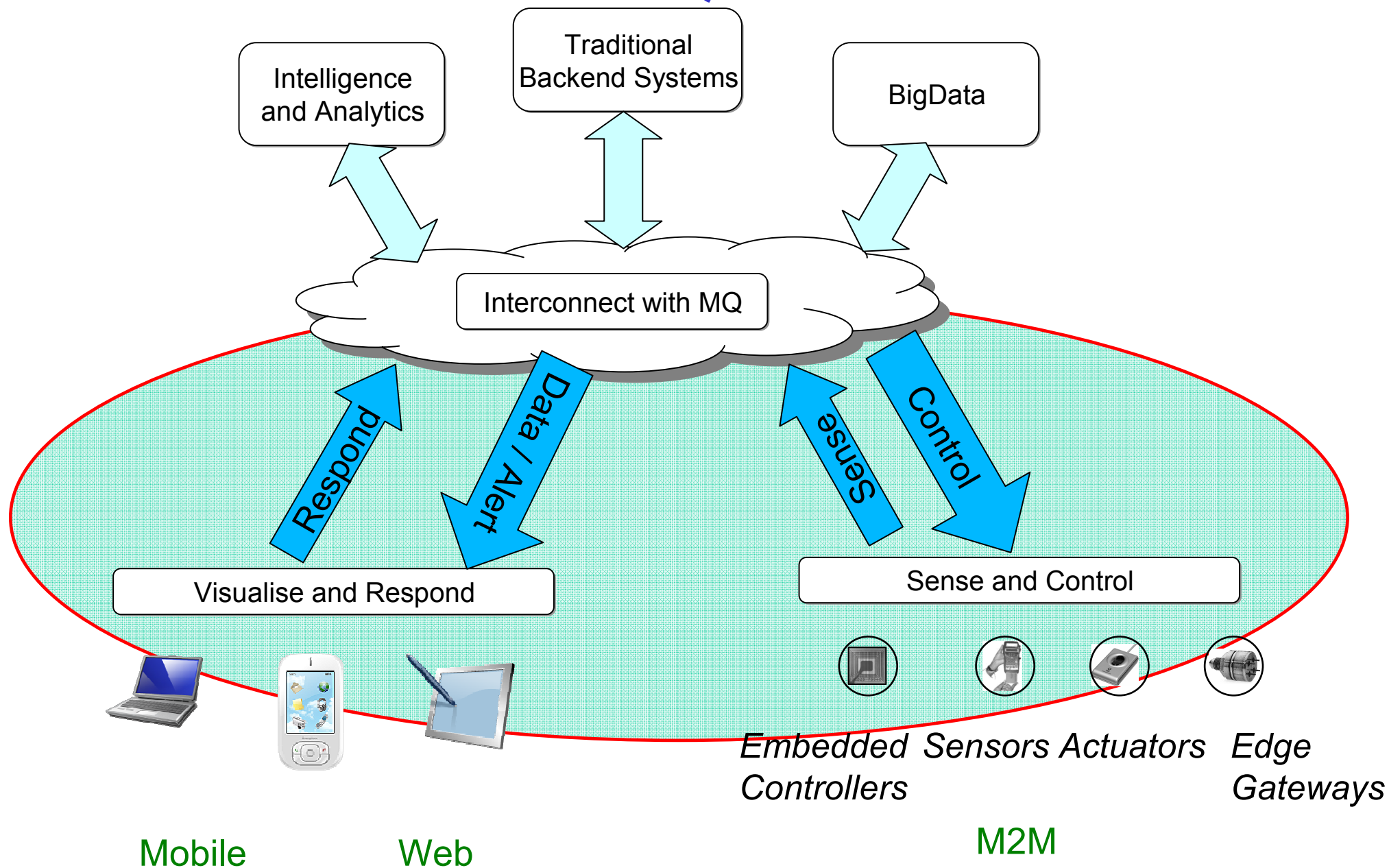


## A Connectivity Hub

- 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, connectivity for the Internet of Things

## 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 servers*
- *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

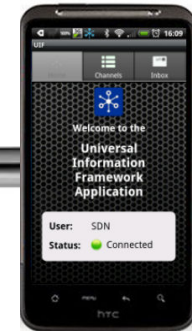
## Scalable

- 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



- Third party and Opensource servers and clients

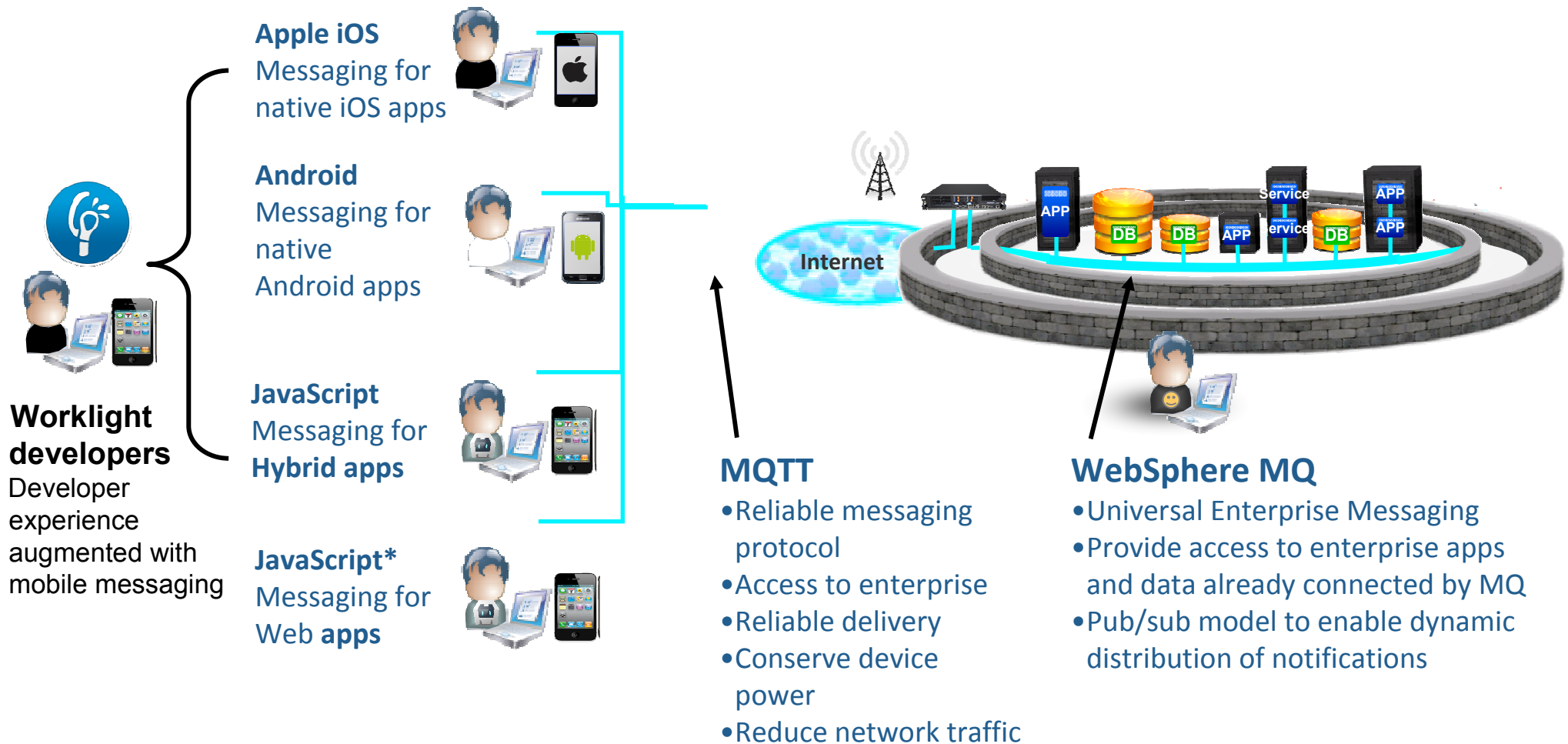
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- 40+ MQTT clients



# MQTT, connectivity for the Internet of Things

## MQTT clients for many *mobile* platforms and application styles

- Available from new IBM Messaging Community on DeveloperWorks



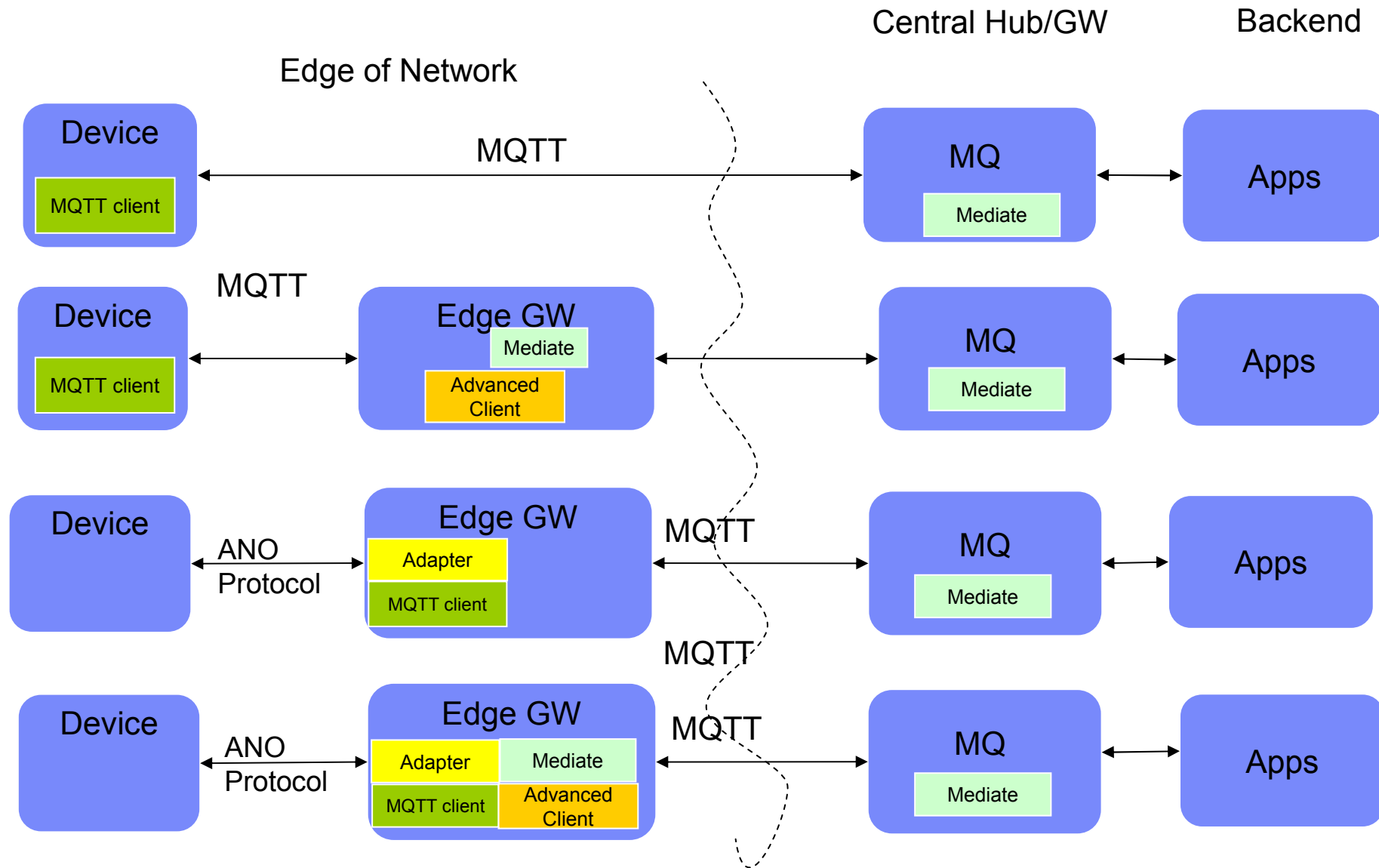
## Benefits of MQTT verses HTTP

- 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**

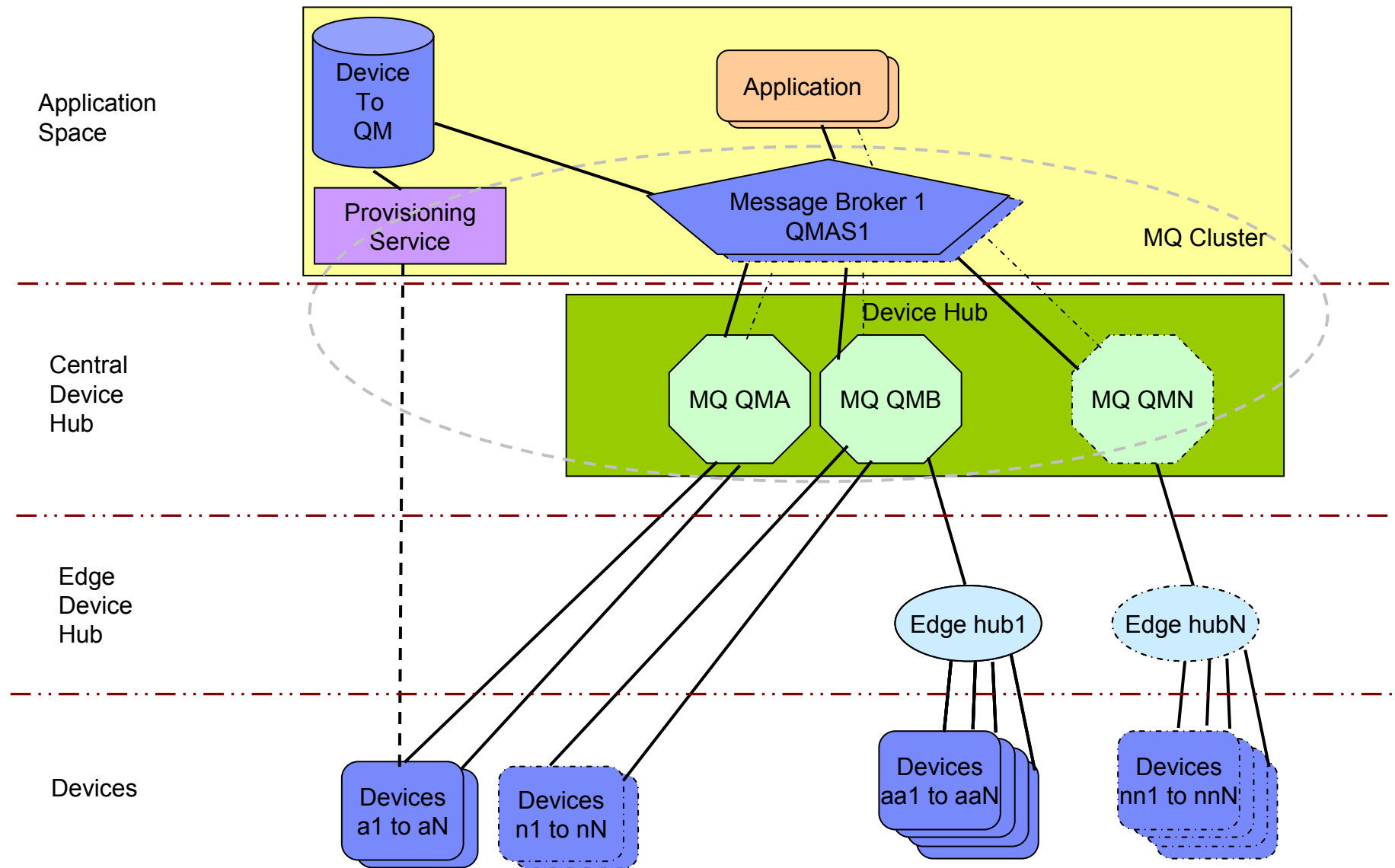
		3G		Wifi	
		HTTPS	MQTT	HTTPS	MQTT
receive	messages / hour	1,708	160,278	3,628	263,314
	% battery / msg	0.01709	0.00010	0.00095	0.00002
	msgs (note losses)	240 / 1024	1024 / 1024	524 / 1024	1024 / 1024
send	msg / hour	1,926	21,685	5,229	23,184
	% battery / msg	0.00975	0.00082	0.00104	0.00016

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

## Device Connectivity Patterns



## Patterns – topology example

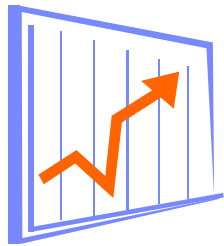


# Making it Real

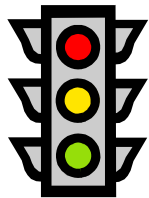
## Some Real World Examples



## Business Scenarios – where might it be used



predict



alert



track



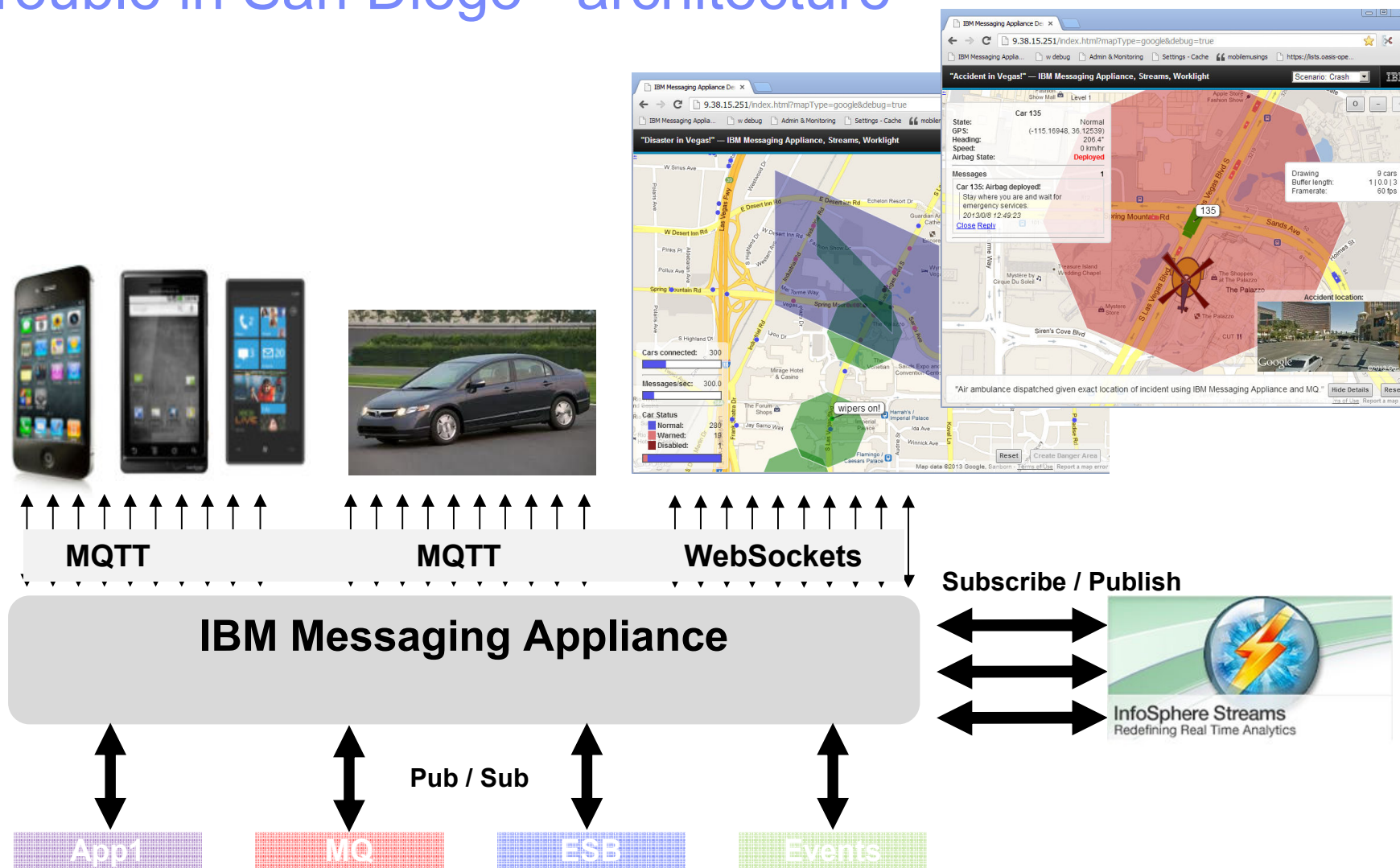
measure

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

## Demo

## Video: Trouble in San Diego

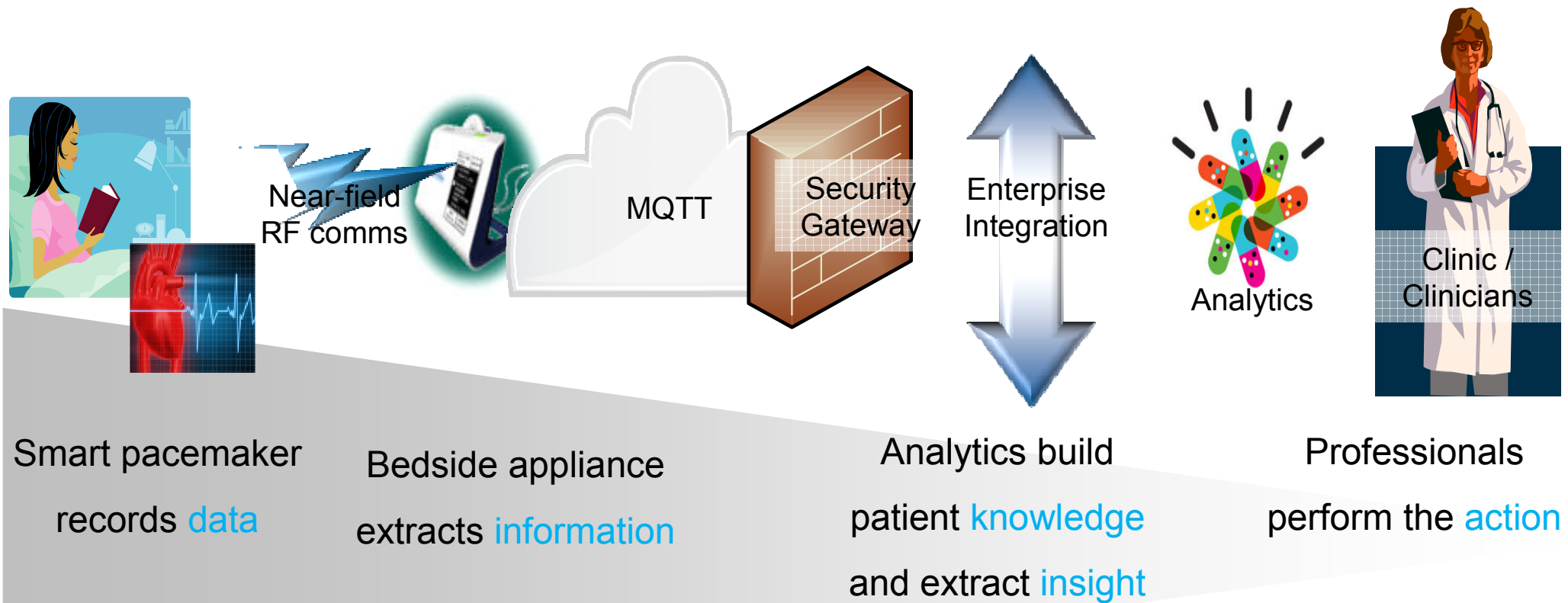
## Trouble in San Diego - architecture



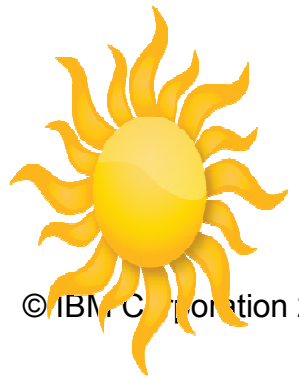
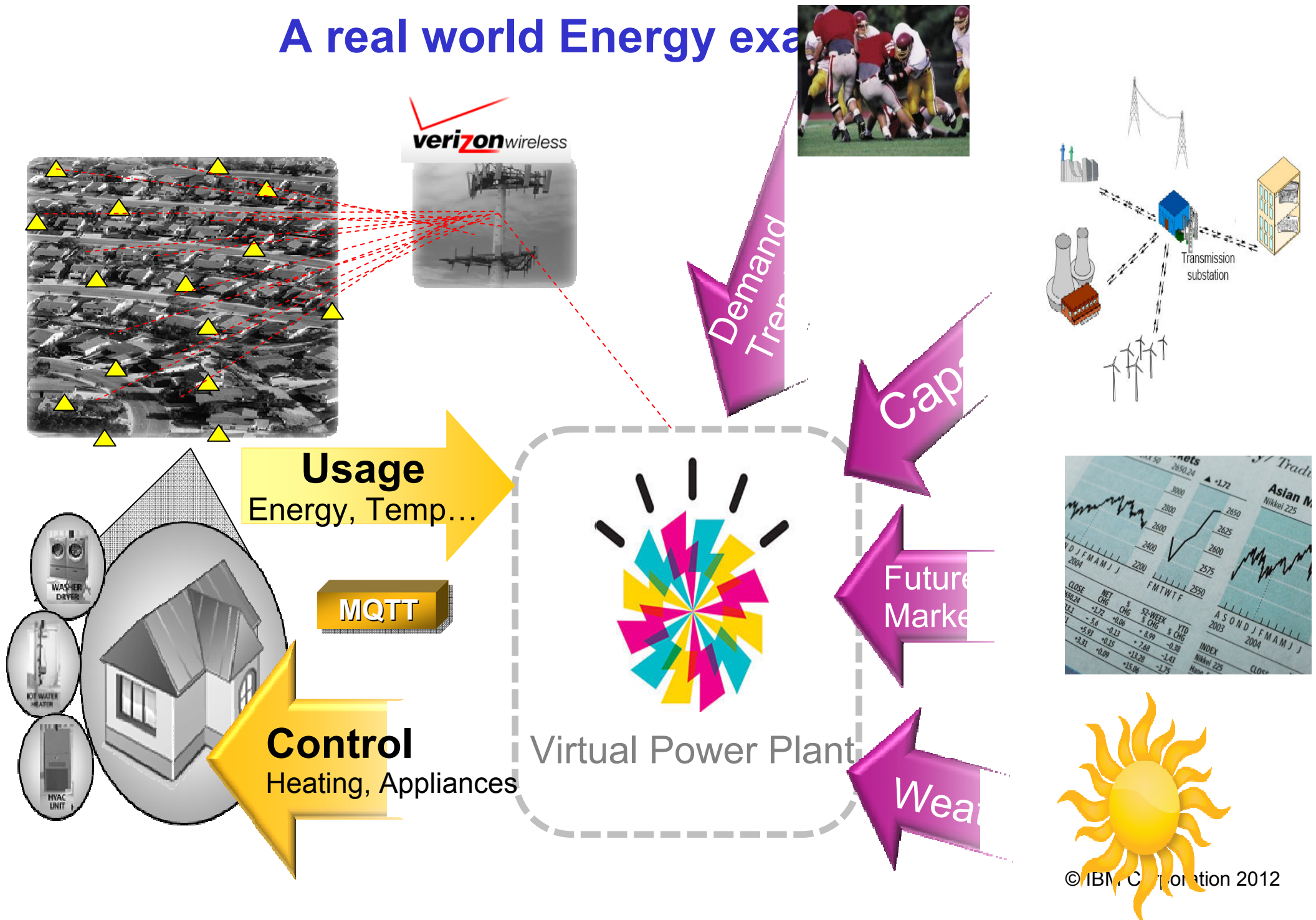
(fyi – everything in demo is via pub/sub and topics)

## A real world Healthcare example

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



## A real world Energy example





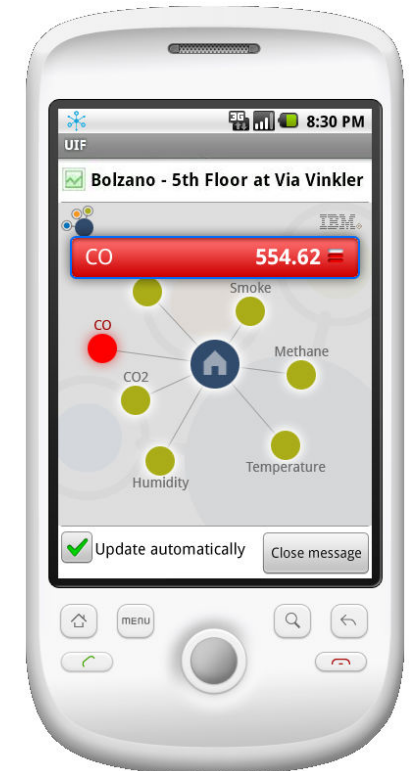
## A Mobile Dashboard

- 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

Daily Mail, Thursday, March 13, 2008

# Black box in the car

By Sean Poulter  
Consumer Affairs Correspondent

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

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

A Norwich Union-style premium will be based on where and when they have driven - with the hi-tech device changing the details of journeys and sending signals to a global positioning satellite orbiting the Earth.

The information is then sent via the mobile phone system to the insurer. The hi-tech device is a box, this will be based on the time spent on the road and whether the driver has used accident blackspots, city centres or rural roads.

The system will award lower premiums to those who are seen to be driving safely, and could also be used to reward those who are seen to be driving dangerously.

The scheme is to be tried on a limited basis by Norwich Union's largest business customer, the City of London Corporation, with the aim of saving them money on their insurance.

Robert Ledger, the firm's programme director, said: "We believe this is a much better way to pay for insurance. It gets a lot of credit from motorists who say they have not had a crash, yet they are being charged more."

"This technology relates personal driving records much more closely to the premium charged."

The technology can also automatically call out the emergency services in the event of a crash, give breakdown tracks, and provide directions to drivers who get lost.

However, the system, which already operates in parts of the U.K., may raise "Big Brother" data issues. It could allow a motorist's movements to be monitored. In the event of a crash, it could provide key data on speed, or indicate whether a driver has stopped at a junction.

The same sort of technology - it built into all cars - may be used to help to reduce the cost of insurance at some point as part of a U.K. wide congestion charging scheme.

Norwich Union, which is part of Aviva, is looking to drive a new business model for its customers. The firm's insurance cover is based on a fixed premium, and will offer a pay-as-you-go model to reduce the cost.

The firm has been developing the policy in conjunction with information technology group IBM, which will provide the computer hardware, and mobile phone operator Orange which will relay information via phone masts.

An IBM spokesman said: "This technology can be used to help insurers to make more accurate insurance rates based on actual use of their cars. My Ledger said: "The time is overdue than a future, the technology could be used to tell all the electronics of the car."

"It could then tell you the split second that a crash has happened and whether there is a head or rear impact."

"It might tell you the speed and the severity of the impact. That could allow someone at Norwich Union to send an ambulance or a fire engine which would help much more quickly than at the moment."

Asked about Big Brother issues, Mr Ledger said: "This is not compulsory - if customers don't like it, they don't have to have it."

"We accept that this will not appeal to everyone, but we really do see benefits for customers."

**HOW THE BLACK BOX WORKS**

1. Black box - slightly smaller than a VHS cassette. It sits either under the dashboard or in boot. Contains computer and two transmitters.

2. Computer records details of the trip. Time of day, duration, mileage, route used. Could provide speed details in the future.

3. Signals from black box transmitted off Coast Protection's satellite to provide journey details which are stored in the computer.

4. Details of journeys transmitted at least once a month - possibly daily - to Norwich Union offices in Norwich via Orange mobile phone mast network.

5. Insurance company works out premium to be charged monthly, based on mileage, route used and time of travel.

**POSSIBLE EXTRAS**

If you get lost: Driver contacts Norwich Union call centre who will advise location and provide directions to destination.

In a breakdown: Company has 24-hour breakdown service and will guide mechanics to the location of the vehicle.

In case of accident: Call centre alerted if car airbags triggered. Will be able to assess severity of impact and send out ambulance or fire engine.



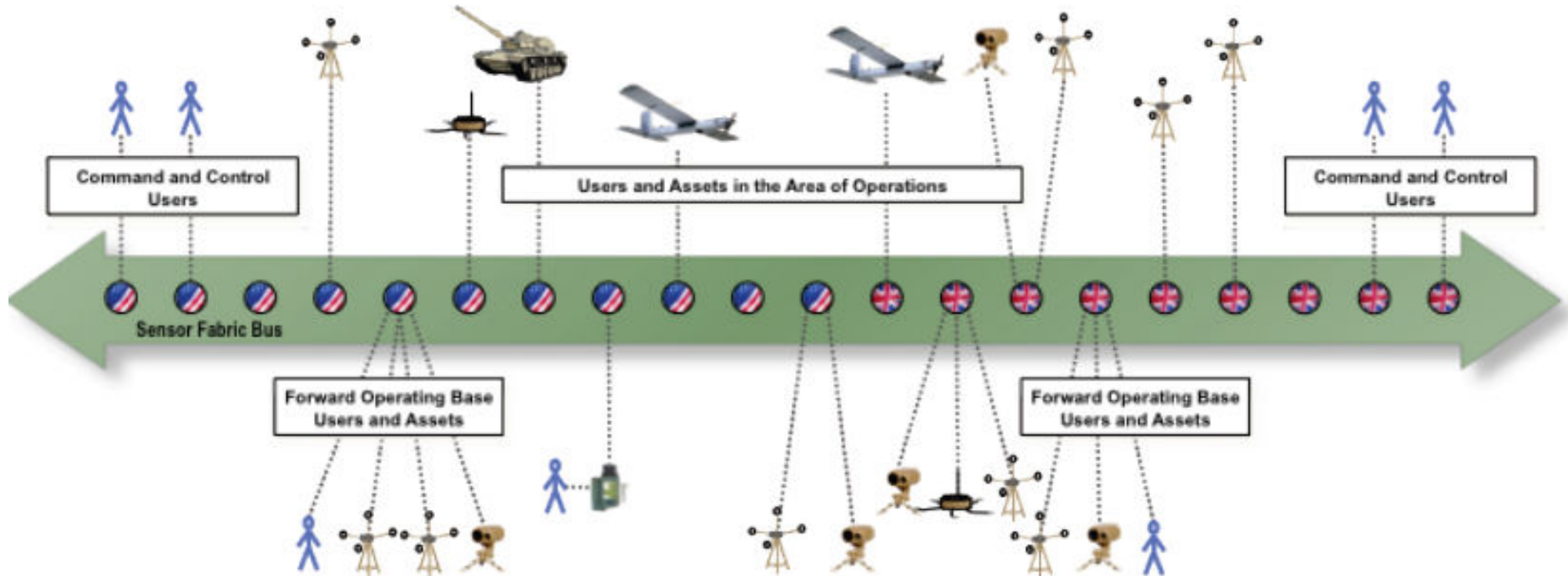
Norwich Union are the UK's largest insurance group, backed by Aviva plc with over £200 billion of assets under management and 25 million customers worldwide, a market share of around 16 per cent and is more than 1.5 times the size of its nearest rival. It is also the largest personal lines insurer.

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







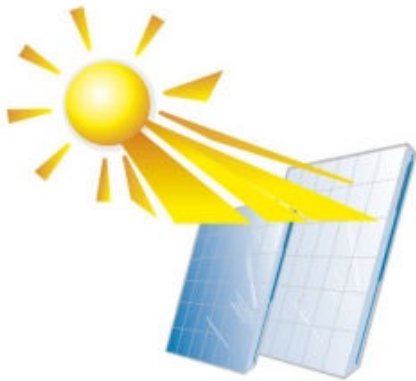
Lucy Zhang, a software engineer at Facebook, has written about their new [Facebook Messenger](#) app:

*“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.**”*

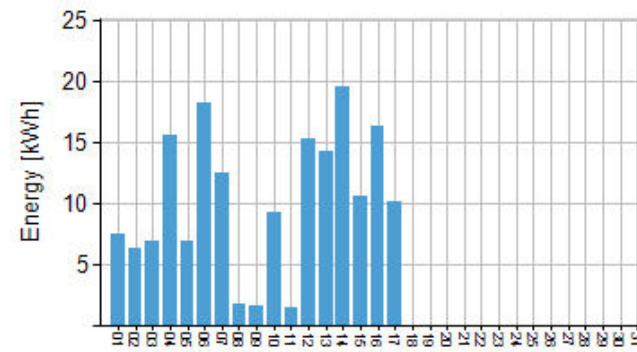
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## ▼ Overview

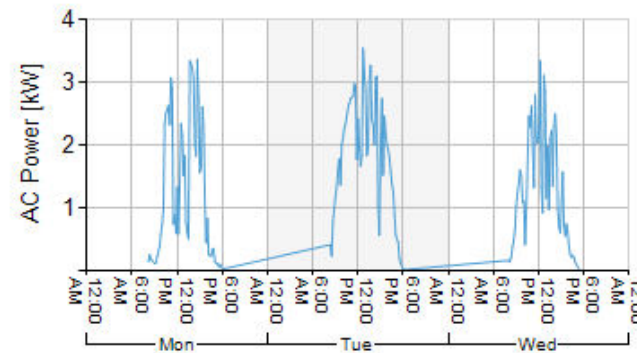
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Module: ()  
Generator Power: 4000 Wp  
Angle: 0 °  
Status: Online 21:48:54 (IP: 86.150.98.95)  
Generator Power actual: 0 W  
**Inverters:**  
1 x Fronius IG TL 4.0  
  
Last Import: 10/17/2012  
Feed-in tariff: 0.433 Pound



## Totalview - October 2012



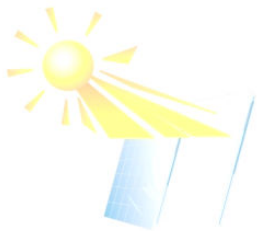
## Dayview - 10/15/2012 - 10/17/2012



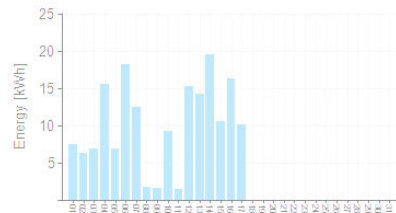
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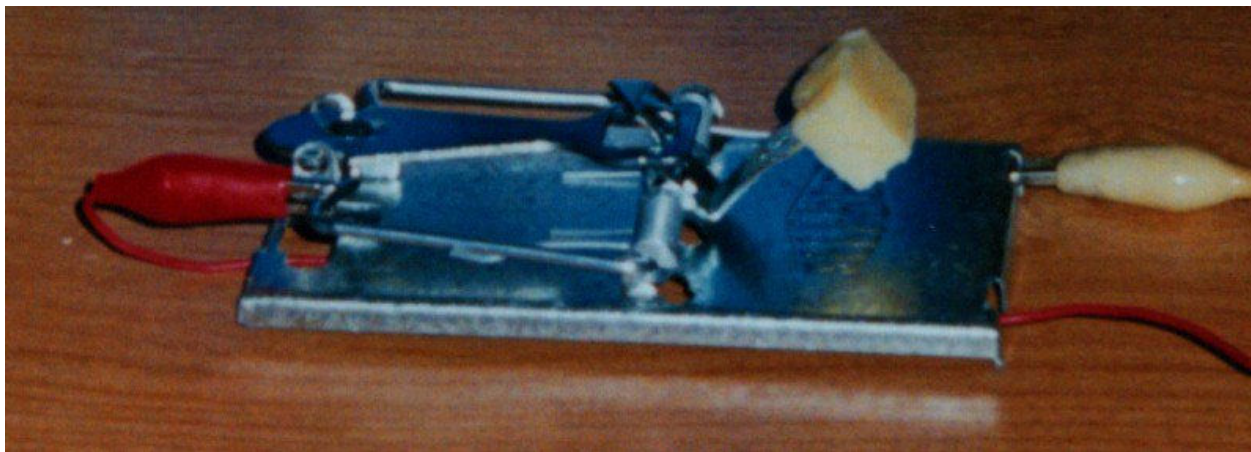
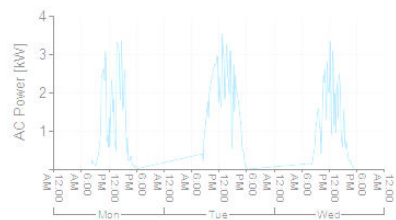
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## Totalview - October 2012



## Dayview - 10-15-2012 - 10-17-2012



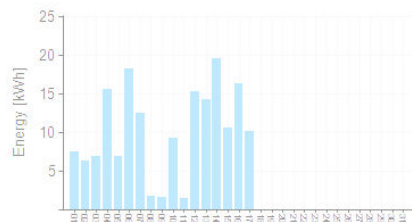


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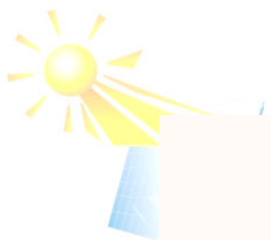
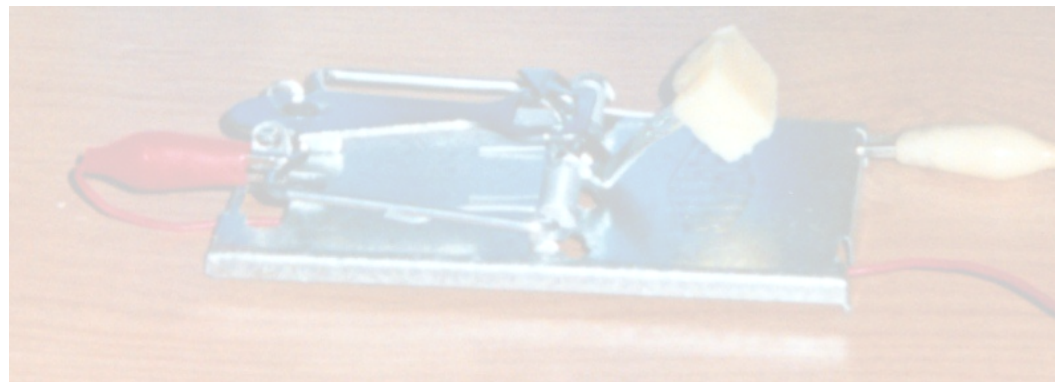
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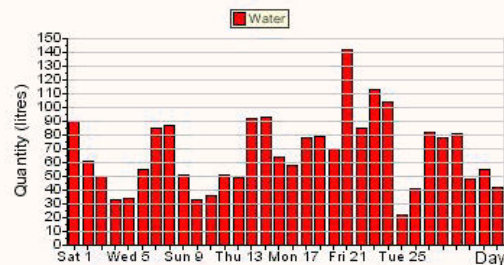
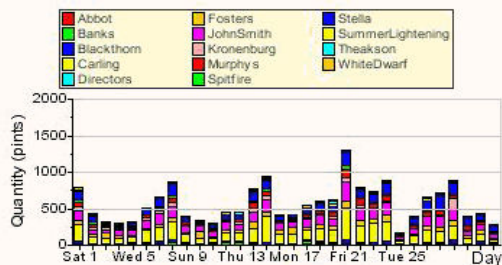
## Totalview - October 2012



## Dayview - 10-15-2012 - 10-17-2012



## Monthly Dispense Throughputs

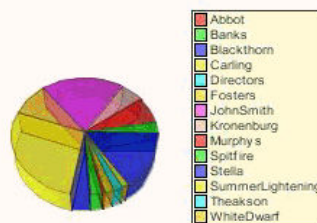
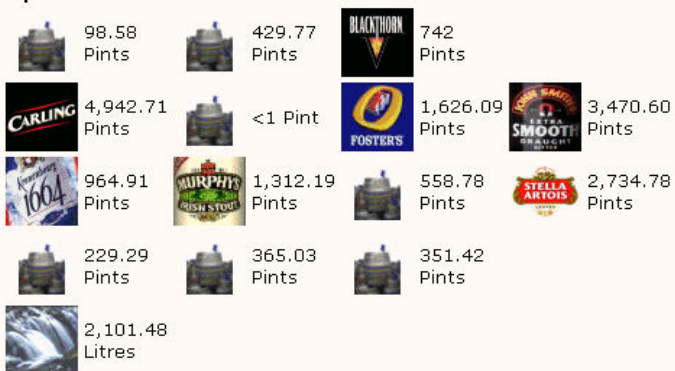


## Total Monthly Dispense

All Beers 17,826.17 Pints

All Soft Drinks 2,101.48 Litres

### By Brands



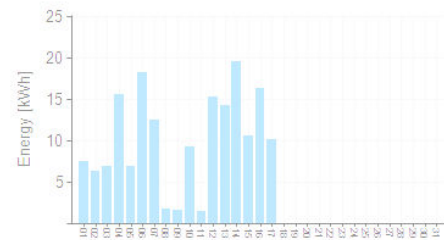
# MQTT, connectivity for the Internet of Things

Overview

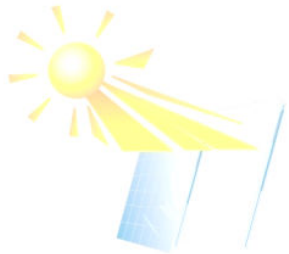
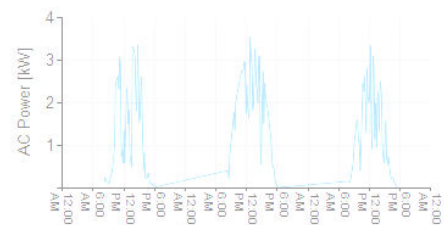
Datalogger ID: 240.13081  
Module: ()  
Generator Power: 4000 Wp  
Angle: 0°  
Status: Online 21:48:54 (IP: 86.150.98.95)  
Generator Power actual: 0 W  
Inverters:  
1 x Fronius IG TL 4.0

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

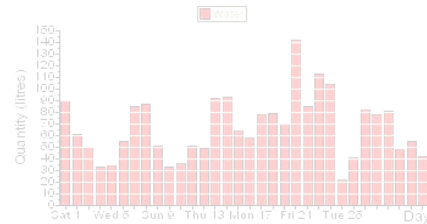
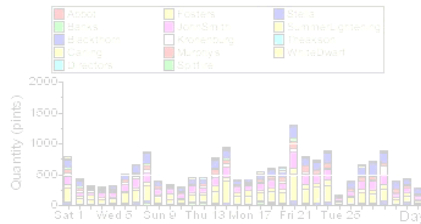
TotalView - October 2012



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



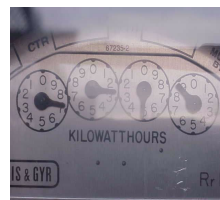
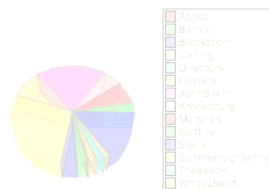
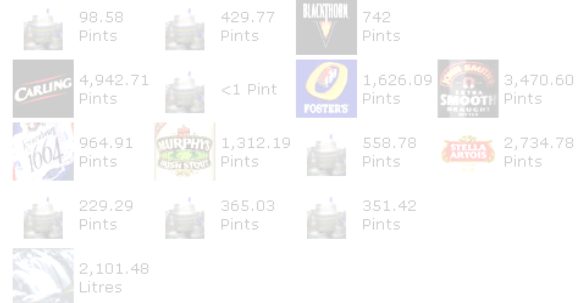
Monthly Dispense Throughputs



Total Monthly Dispense

All Beers 17,826.17 Pints  
All Soft Drinks 2,101.48 Litres

By Brands



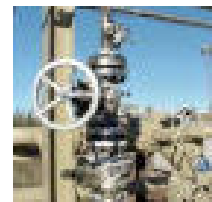
power meter



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

# MQTT, connectivity for the Internet of Things

## 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



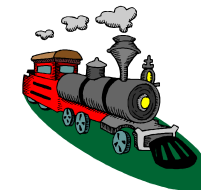
Medical



Field Force  
Automation



Home  
Automation



Railway

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