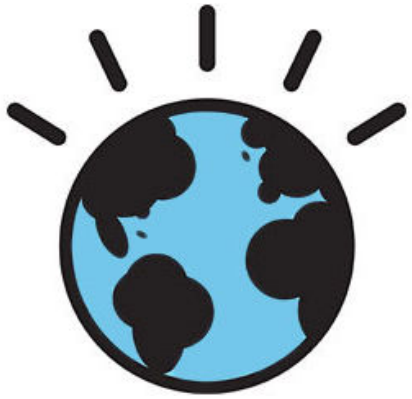
IBM Software Group

Connectivity for a Smarter Planet



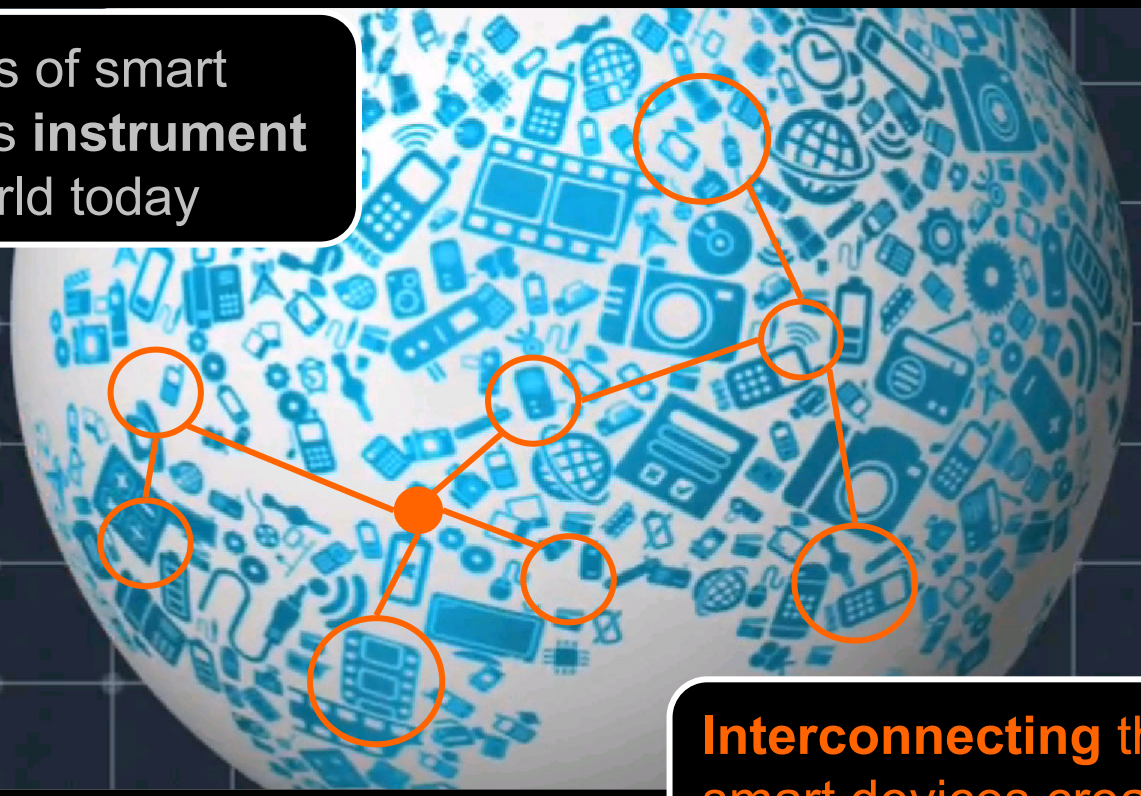
V1.4 22nd Feb 2010

Dave Locke
Pervasive Messaging and Advanced Technologies
IBM Hursley Lab

WebSphere. software

e business software

The Internet of Things

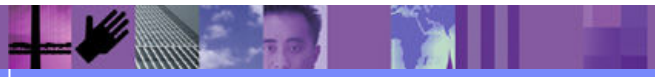


Trillions of smart devices **instrument** our world today

Interconnecting these smart devices creates a **Central Nervous System**

Agenda

- Background
- MQTT
- MQ Telemetry
- Real world examples



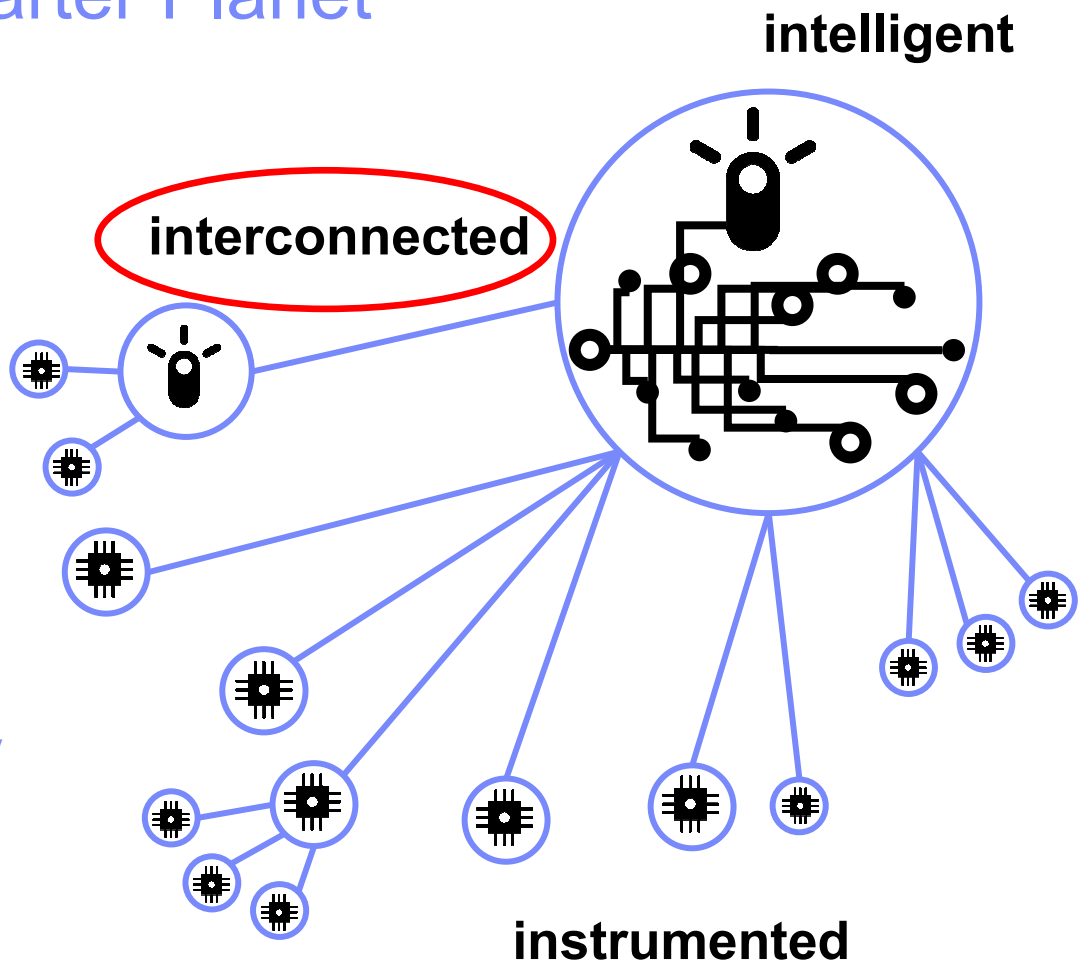
Connectivity for a Smarter Planet

Extend connectivity beyond enterprise boundaries to smart devices

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

Deliver **relevant data** to intelligent decision making assets

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



Blueprint for Edge Connectivity

Connectivity for Applications

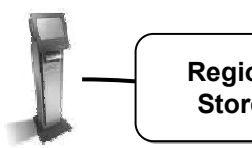
Transport	**WebSphere MQ** **REST/HTTP** **WS***

Intelligent

Head Offices, Data centres Cloud Computing

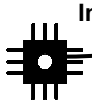
Mission-Critical Connectivity & Intelligence

Messages	**WebSphere MQ and MQ Telemetry**
Files	**WebSphere MQ File Transfer Edition**
Transform, Enrich, Mediate	**WebSphere Message Broker** **WebSphere ESB** **DataPower** **WebSphere Sensor Events**
Catalog	**WebSphere Service Registry & Repository**
Intelligence	**WebSphere Business Events** **Cognos. ILOG, SPSS** **InfoSphere Streams** **Other InfoSphere and Tivoli products**



Regional Offices Stores, Outlets

Interconnected



Instrumented

Connectivity for Smart Devices

Transport	**MQ Telemetry** **HTTP** **Multicast**

Remote Systems and Devices

Edge Gateways
Device hubs/controller that act as hubs/concentrators for connecting devices.

Embedded Controllers
Filtering of duplicate read events, Store-based HVAC & lighting controls, Industrial Network Gateways (SCADA)

Sensors
Power meters, weather data SCADA sensors, pressure, volume, RFID readers, Motion detectors…

Actuators
Tag printers, status lights, Load generation, HVAC and lighting, Valves, switches and pumps…

IBM's initial focus on pervasive messaging began with industrial automation and mobile computing

- **In the late '90s, IBM recognised market opportunities to:**
  - Help industrial customers break free of the “SCADA prison”
  - Enable mobile computing
- **Different system characteristics to cope with:**
  - constrained hardware

    mobile devices and PDAs

    embedded sensor hardware and controller boxes

    desktop PCs at a maximum
  - and are connected over networks that are often:

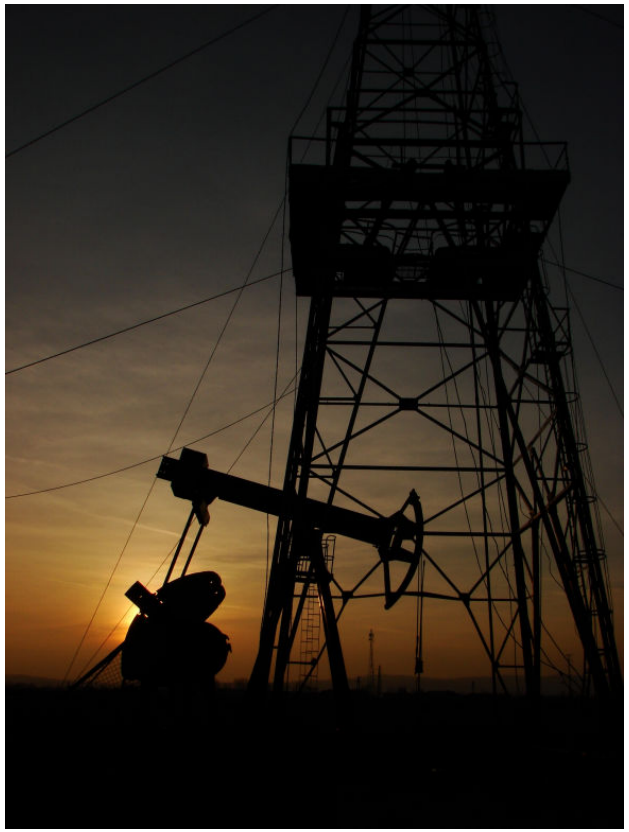
    expensive

    slow

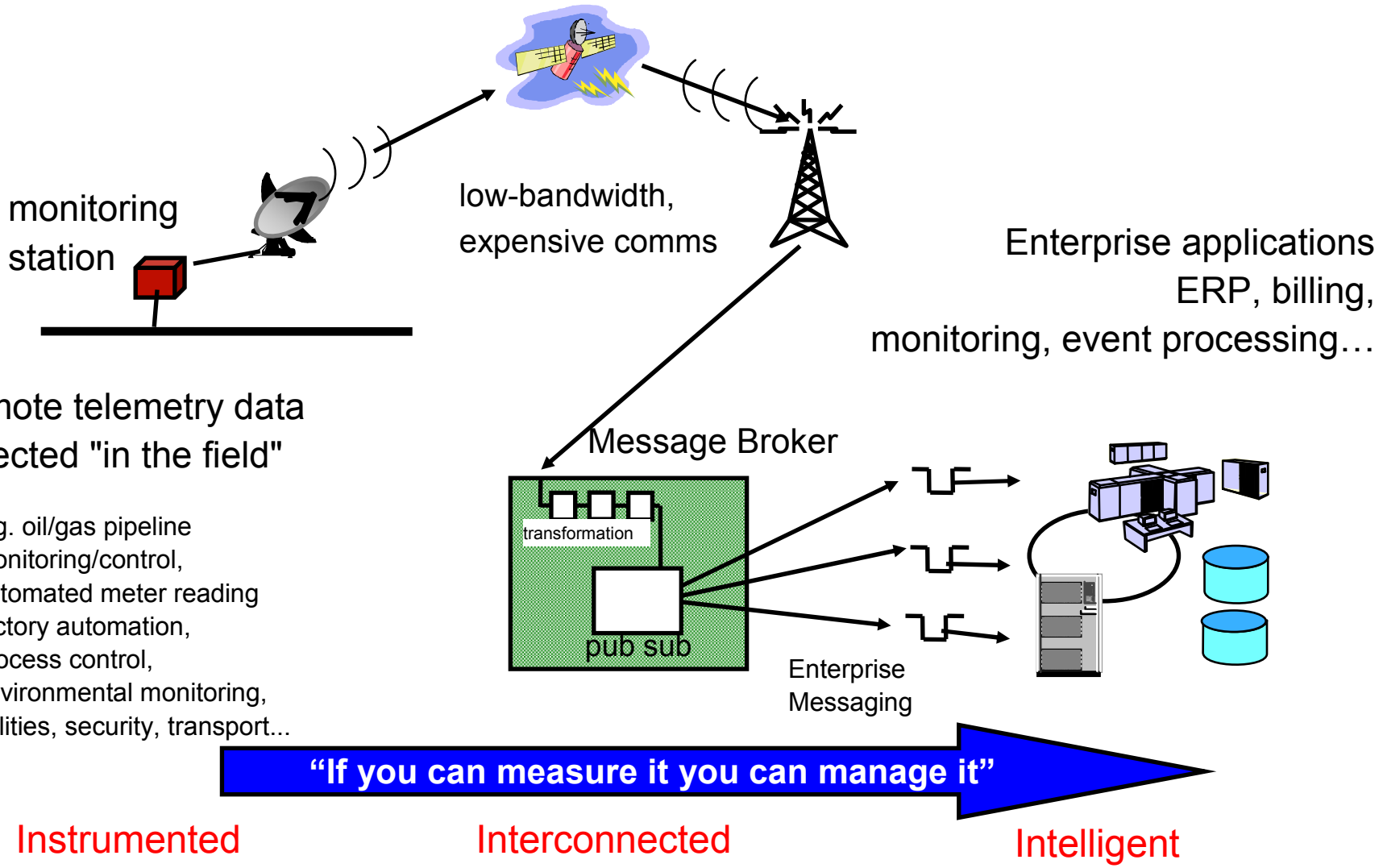
    fragile
  - and run in the field rather than within a data centre

    power stations, oil refineries, in vehicles
  - Existing solutions typically:

    Single vendor lock-in end-to-end – hard to mix sensor vendors.
    Lack of flexibility, expensive to change/extend core offerings
    Poor integration with back-end systems



Pervasive messaging is about end-to-end integration



The guiding principles of MQTT

- **MQTT was designed with the following primary intentions:**
  - Publish/subscribe messaging paradigm as required by the majority of SCADA and sensor applications.
  - Minimise the on-the-wire footprint.
  - Expect and cater for frequent network disruption.
  - Cope with slow, poor quality networks
  - Expect that client applications may have very limited processing resources available.
  - Provide traditional messaging qualities of service where the environment allows.
  - Publish the protocol for ease of adoption by device vendors and third-party client software.

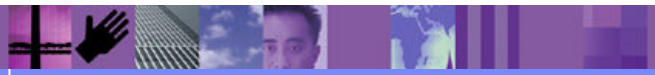
Key facts about MQTT

- **The MQTT specification is open**
- **Reduced complexity and footprint**
- **Simple / minimal pub/sub messaging semantics**
  - Asynchronous (“push”) delivery of messages to applications.
  - Simple set of verbs such as connect, publish, subscribe and disconnect.
- **Minimised on-the-wire format**
  - Protocol compressed into bit-wise headers and variable length fields.
  - Smallest possible packet size is 2 bytes.
  - Plain byte array message payload and no application message headers
- **Three qualities of service for both publishing *and subscribing*:**
  - 0 – message delivered at most once.
  - 1 – message will be delivered 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..

MQTT Products and Technologies

- **Enterprise MQTT servers**
  - *WebSphere MQ + MQ Telemetry feature*
  - *WebSphere Message Broker up to & including* v6

    Function migrated to MQ Telemetry
- **Mid size/premises servers**
  - *WebSphere Sensor Events*
- **Edge Servers**
  - *Lotus Expeditor Micro broker*
  - *WebSphere Telemetry Daemon for Devices (aka RSMB)*
- **Clients**
  - *Java (MIDP up)*
  - *C including a reference implementation*
- **Other**
  - *Third party and Opensource servers and clients*

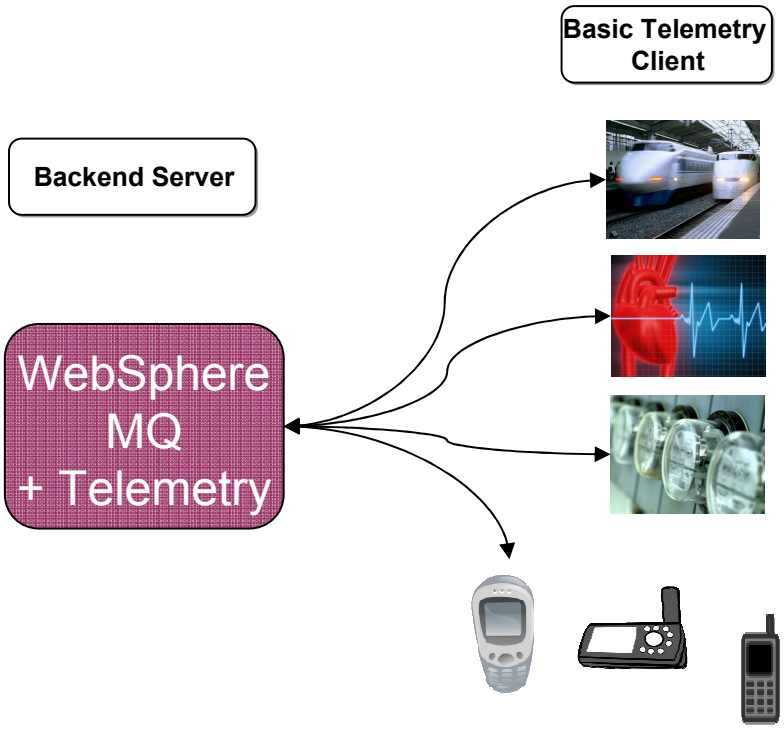


WebSphere MQ Telemetry

The WebSphere MQ Telemetry feature extends IBM's industrial strength enterprise message system to support:

- **The MQ Telemetry Transport (MQTT)**
  - Is Highly scalable
  - A single queue manager can handle 100,000+ concurrently connected MQTT enabled devices
- **Rich Security**
  - Network: SSL
  - Authentication: JAAS
  - Authorisation: OAM
- **Basic client:**
  - Direct connectivity from device
  - Java and C

  Very small footprint 30kb C, 100kb Java
- **Other clients available:**
  - Reference
  - Third party
  - Opensource
  - Roll your own



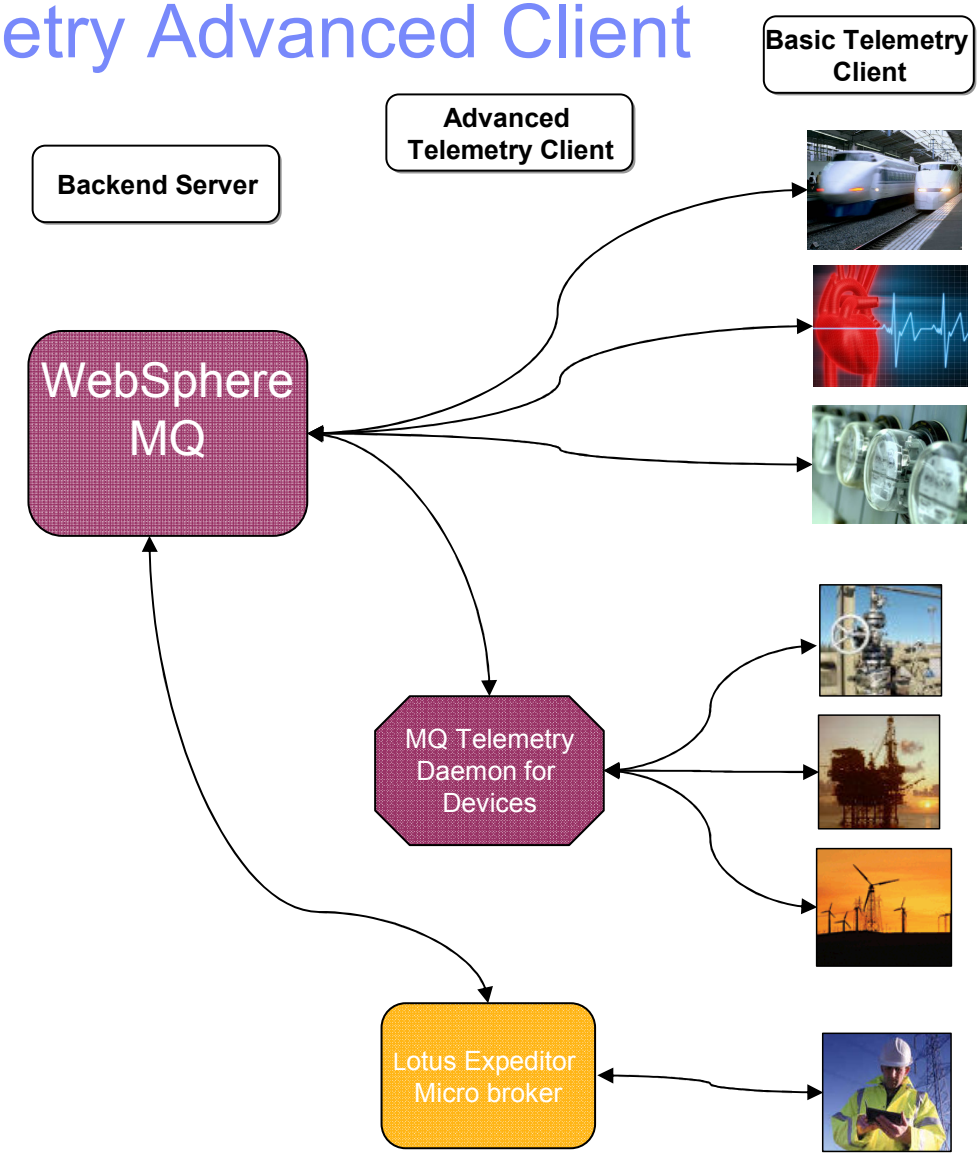
WebSphere MQ Telemetry Advanced Client

MQ Telemetry Advanced clients:

- Act as a "concentrator/hub" for mini-networks of Telemetry devices
- Can connect to one or more backend servers
- Can buffer messages

- MQ Telemetry Daemon for Devices ships with MQ Telemetry
  Aimed at embedded / constrained systems
  Tiny footprint 100kb

- Micro broker ships with Lotus Expeditor
  Aimed at richer systems laptops
  100% Java
  Three versions:
    For devices (PDA…)
    For desktop
    For small servers



Early performance measurements for MQ Telemetry on Red Hat Linux - Multiple Publishers to single Subscriber

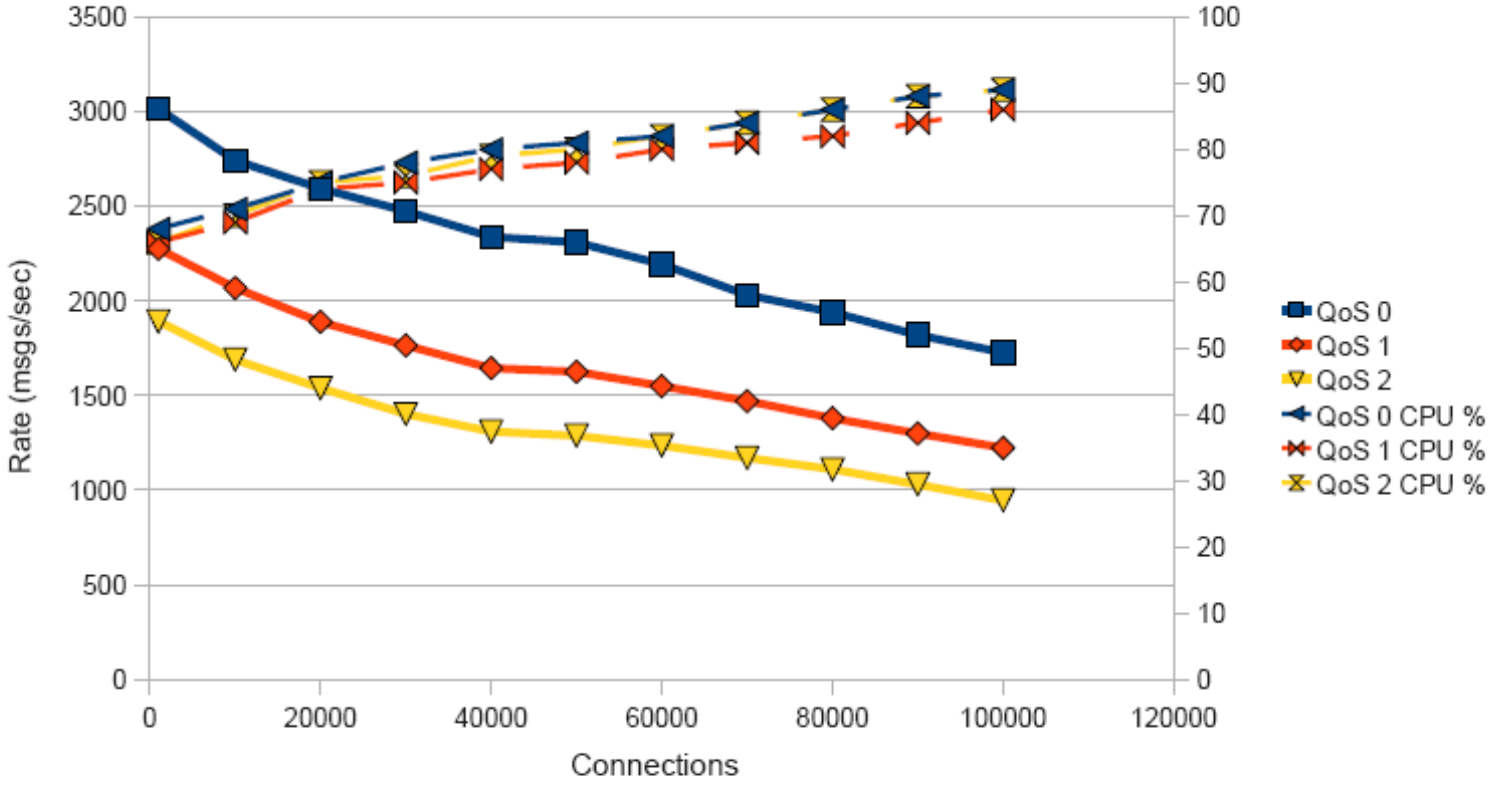
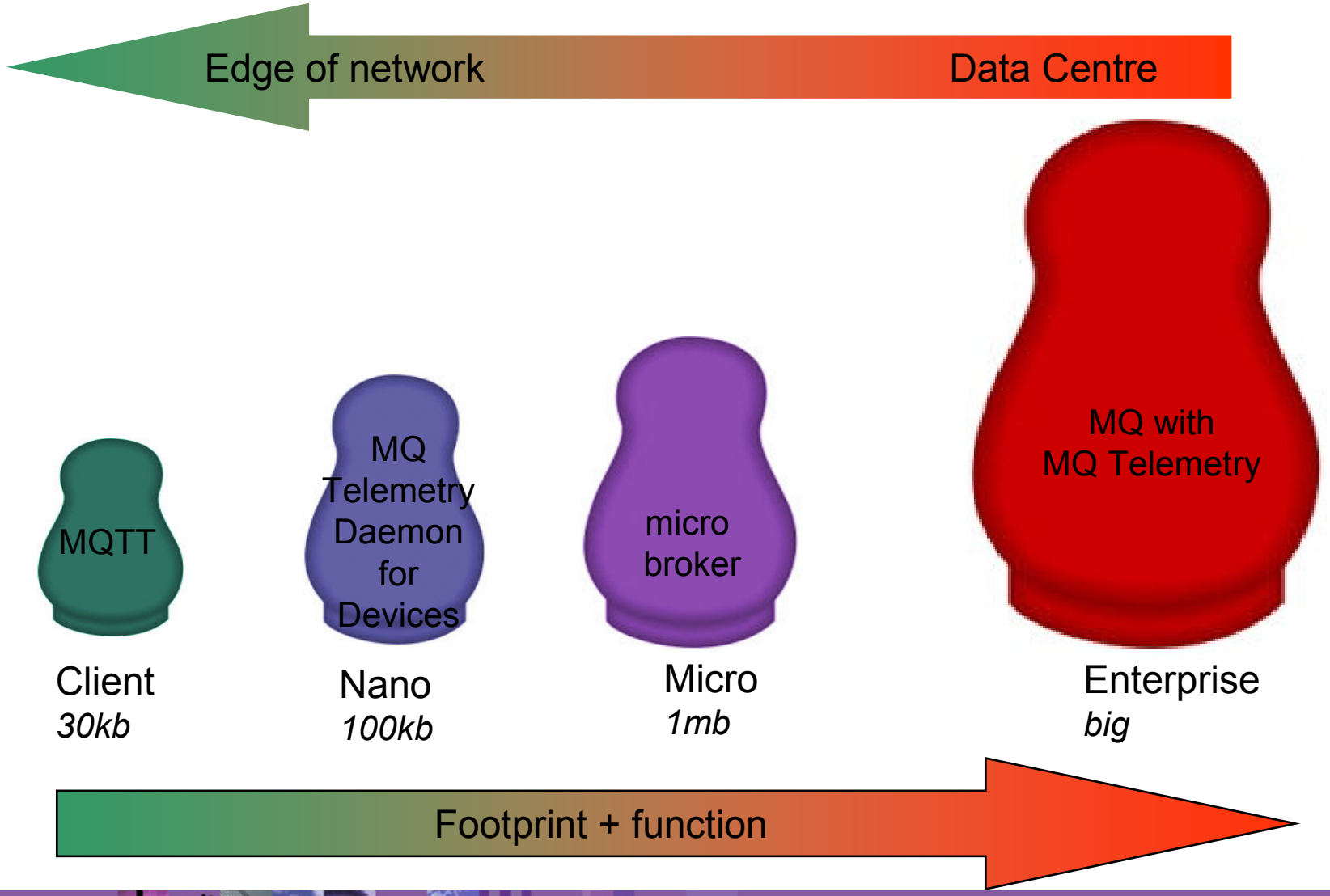
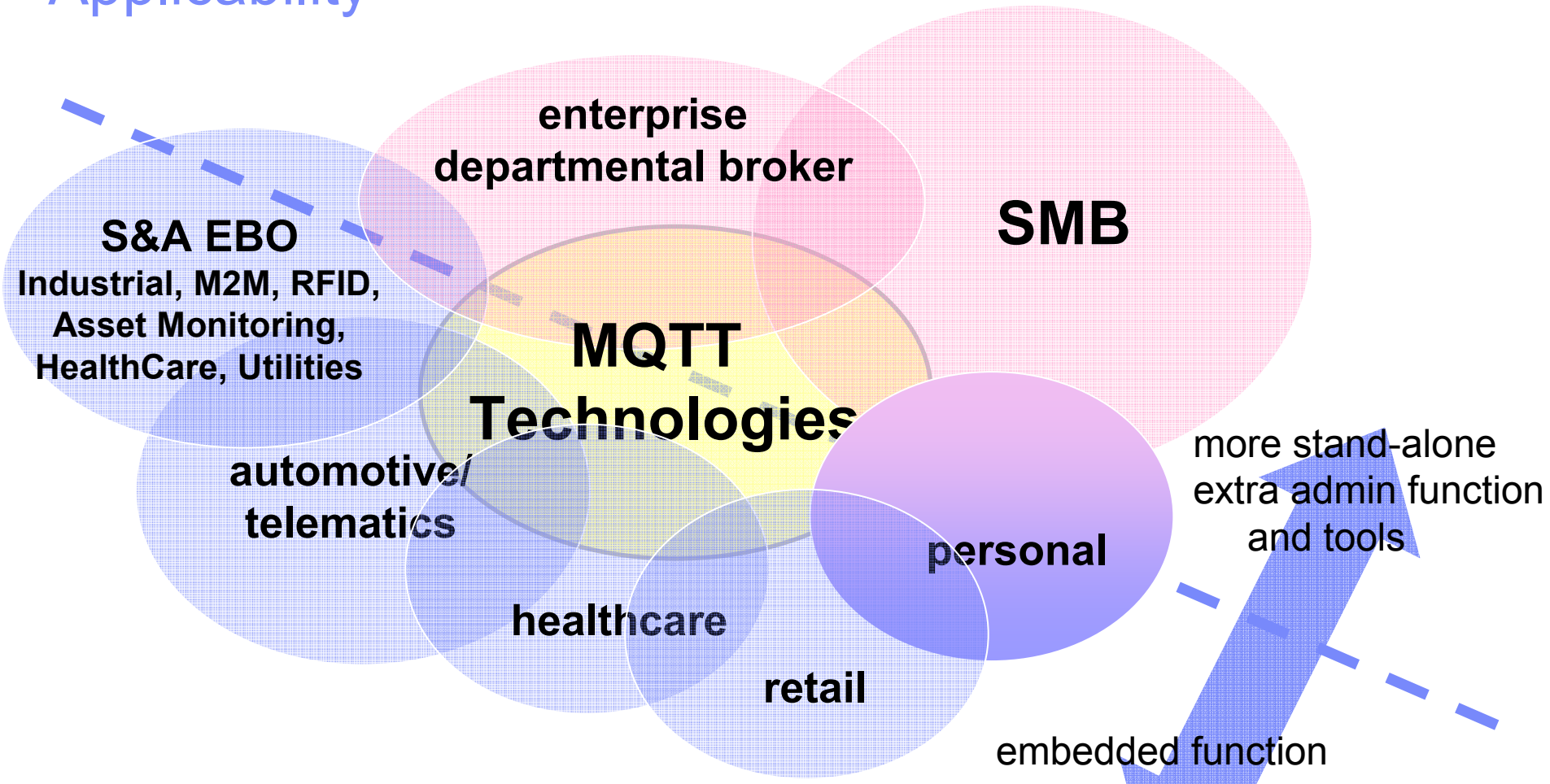


Figure 3: Linux multi-publisher, single-subscriber graph

A scalable family of Edge Messaging Technologies

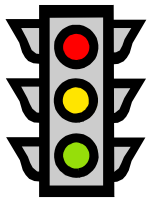


Applicability



Business Scenarios

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 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***

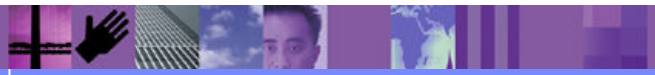
Prime Uses

- **Connecting Operations to IT**
  - Many existing systems have no connectivity or “proprietary” comms
  - “Adapt”

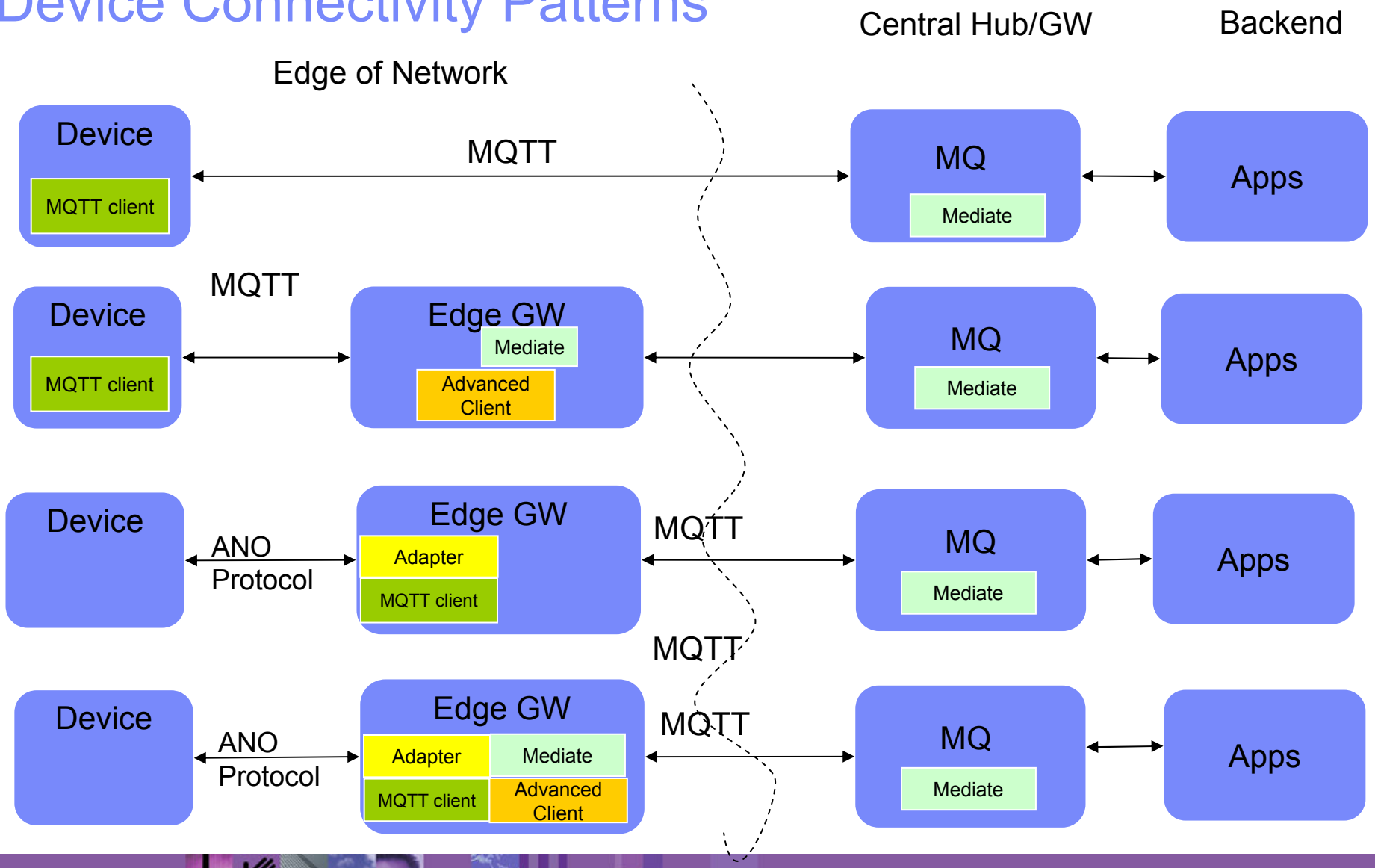
    Use adapters to connect to IT shop using MQTT
    For instance modbus to MQTT adapter
  - Provides

    An “open” system “breaking out of the SCADA prison”
    Data now accessible to many applications to use “intelligently”
    Highly scalable and secure
    Over fragile, expensive or low bandwidth networks
- **New Edge / Smarter Planet Solutions**
  - Connect devices at the edge of the network to the IT shop
  - Can be “embedded” from the start rather than “Adapting”
  - Enables new types of solution that require

    Highly scalable and secure
    On constrained devices
    Over fragile, expensive or low bandwidth networks

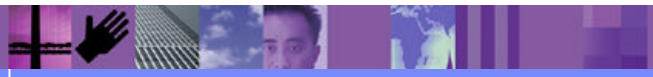


Device Connectivity Patterns

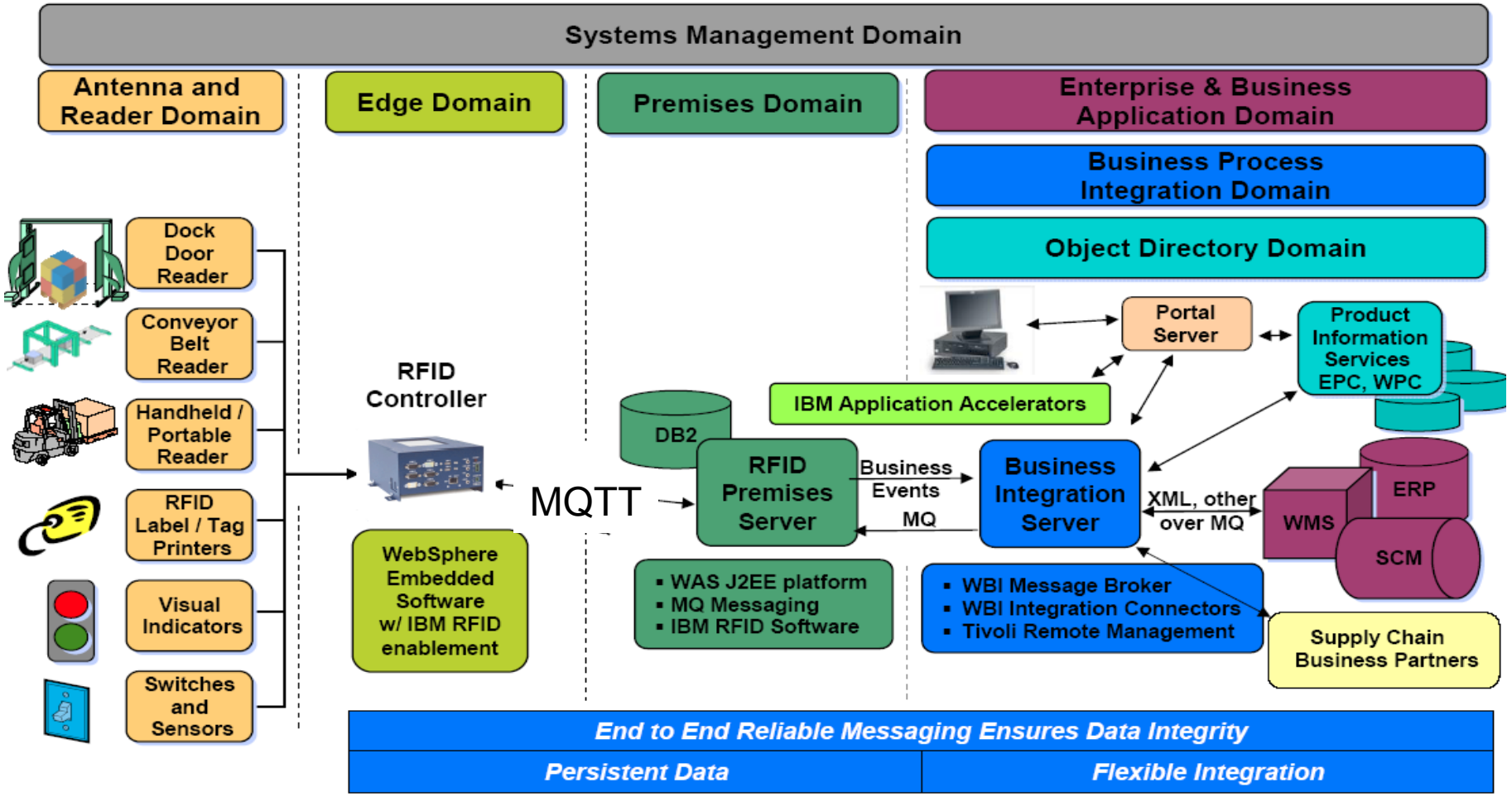


Examples

RFID

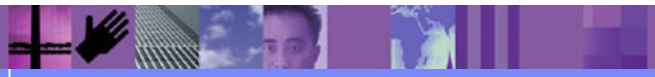


RFID: Solution architecture



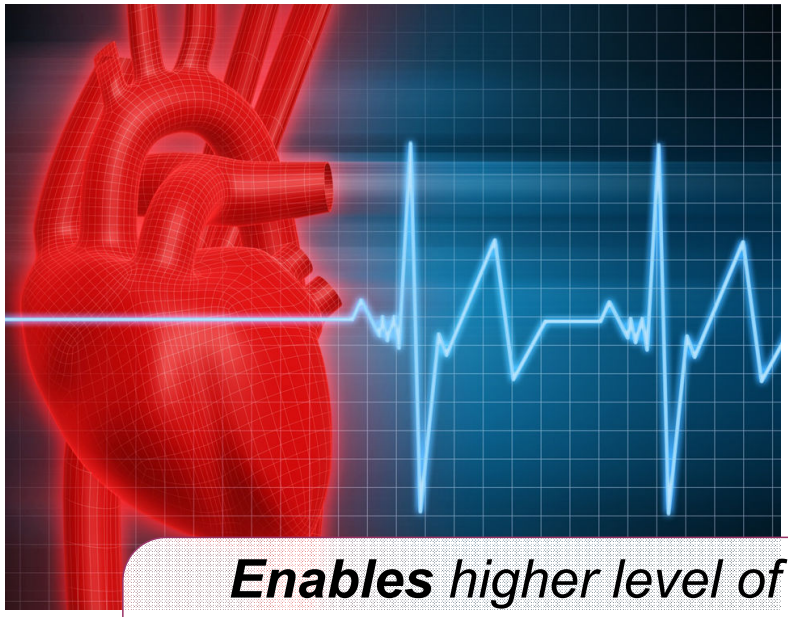
Examples

Health Care



Smarter Healthcare

Medical organization created a remote pace-maker monitoring solution to provide better patient care



Client Pains

Physicians needed better monitoring of cardiac patients

Improve efficiency of checkups

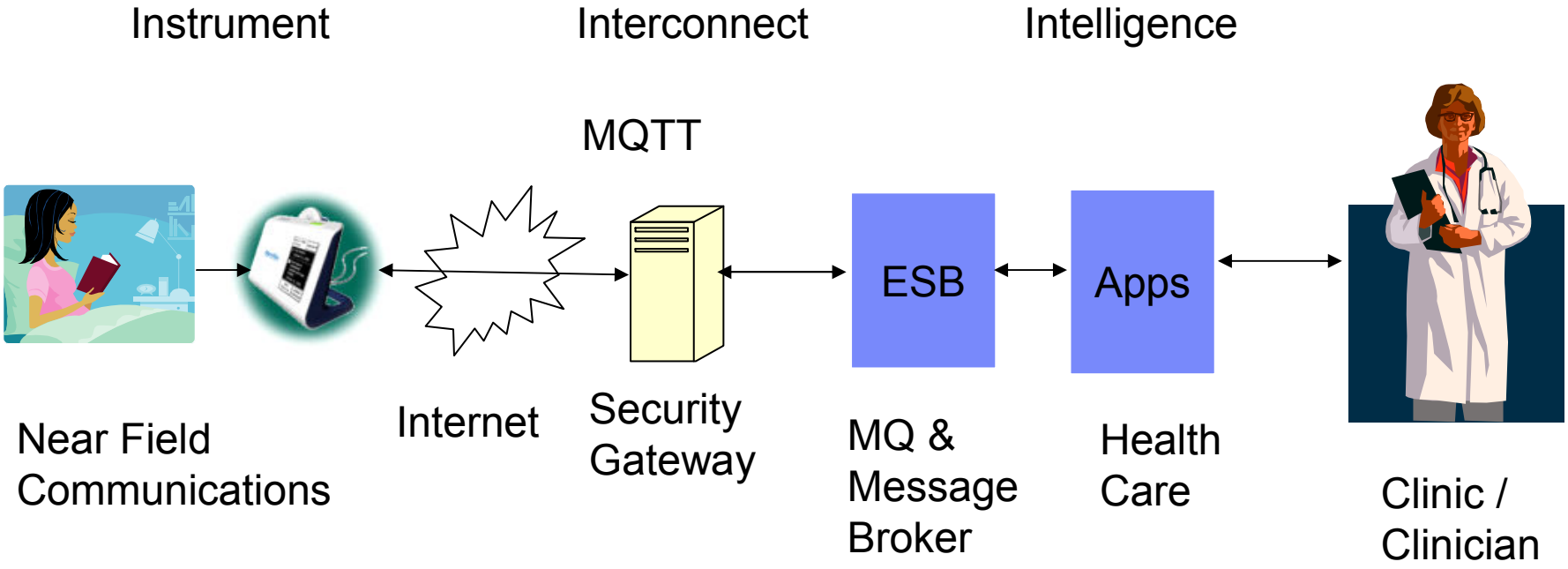
Meet healthcare data capture standards

Enables *higher level of patient care and peace of mind*

Improves *administrative efficiency and maintenance*

Helps *conform to standards and ease integration of data*

Home Pace Maker Monitoring Solution



Monitor large numbers of patient's pace makers in their home
- Collect diagnostics and periodically dial health care provider
- Immediately dial if abnormality detected
- Often over "old" – very slow, fragile dial up connections
- Remove need for patient to visit to clinic on fixed interval
- Clinician only sees patients with problems

Examples

Energy and Utilities

Improving Energy Usage

Utility company developing an Intelligent Utility Network offering for optimizing load on electricity grids

Business Partner

Needs robust middleware technology to connect to remote smart homes/meters

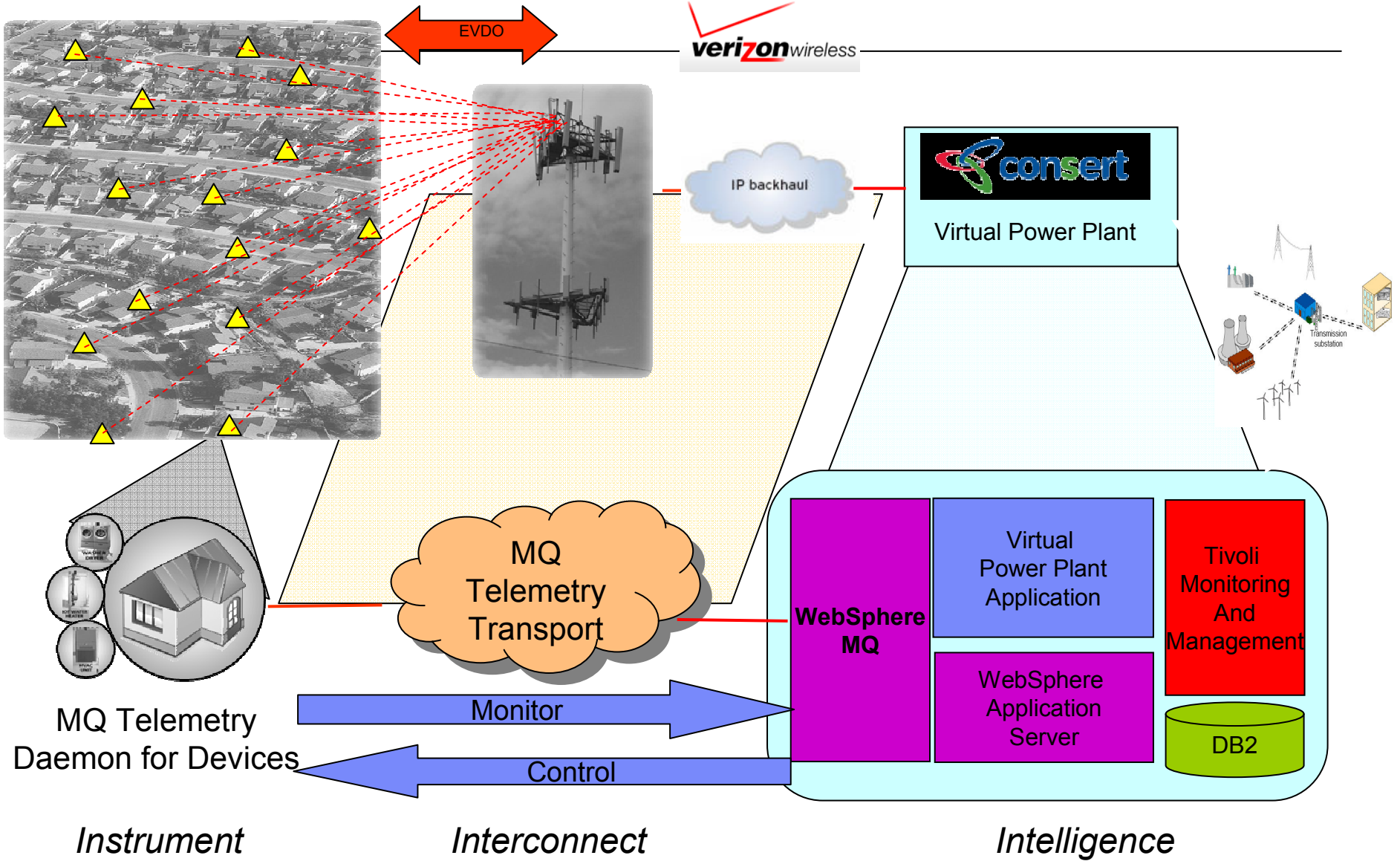
Needs to be able to rapidly scale solution

Able to offer *daily energy savings of 15-20%*

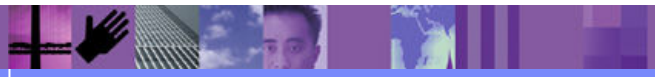
Enables *utilities to reduce peaks and avoid punitive charges*

Helps save electricity *through better peak load management*

Consert create a Virtual Power Plant with MQ Telemetry

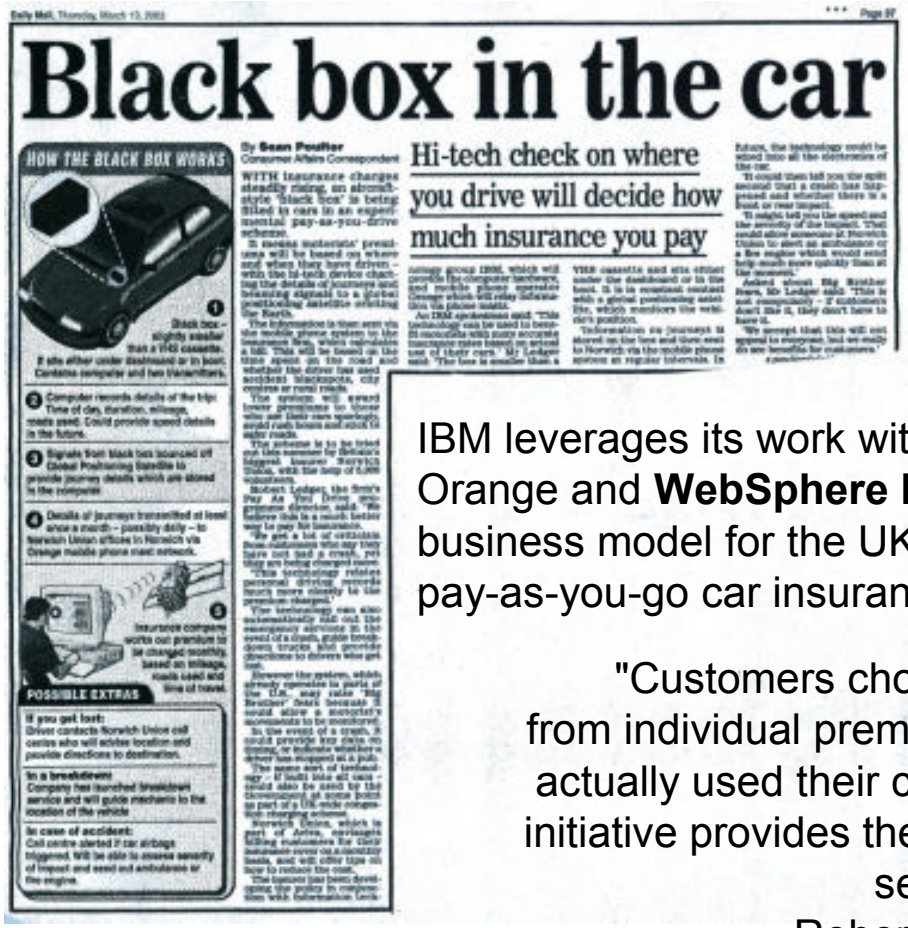


Examples
Telematics



Vehicle Telematics – Press Articles

Norwich Union Insurance drives new business model with WebSphere MQ Everyplace



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.

HOW THE BLACK BOX WORKS

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 launched breakdown service and will guide mechanic to the location of the vehicle

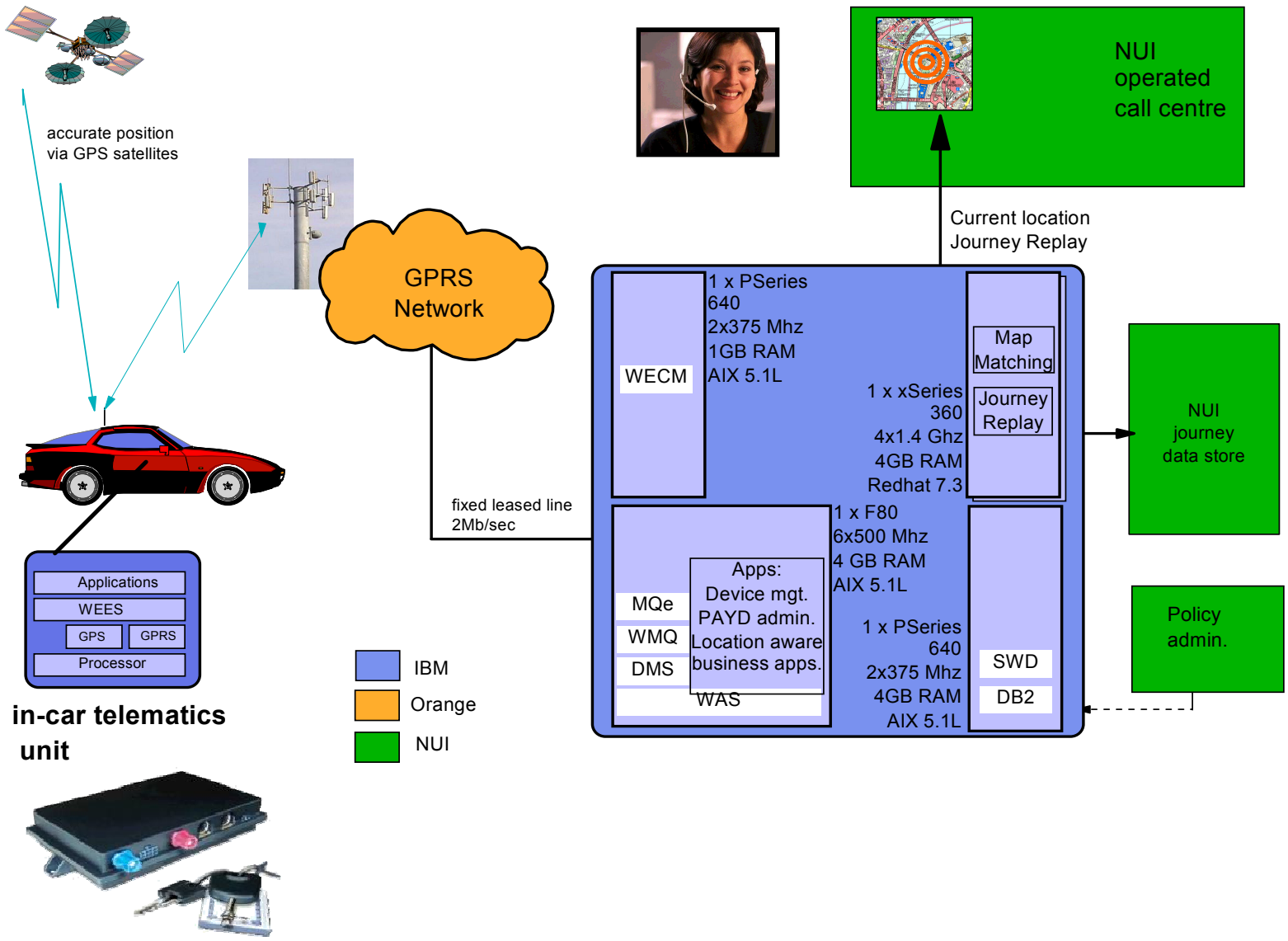
In case of accident:
Call centre alerted if car airbags triggered. Will be able to assess severity of impact and send out ambulance or fire engine.

NORWICH UNION

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 Everyplace** 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

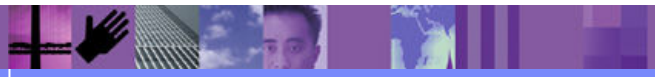


Others telematics

U.S. Army (TACOM)

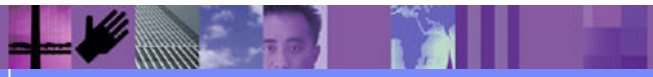
The military enhances personnel safety and cuts repair time and costs by implementing a wireless end-to-end remote diagnostic system designed and installed by IBM

- **IBM transformed TACOM's disjointed repair procedures and technologies into one seamless, end-to-end diagnostic system, where they can diagnose problems and perform fixes remotely.**
- **Benefits: New Set of Diagnostic Capabilities, Prognostic Detection, Reduction in Personnel, Streamlines Supply Chain Management, Reduced Repair Time**



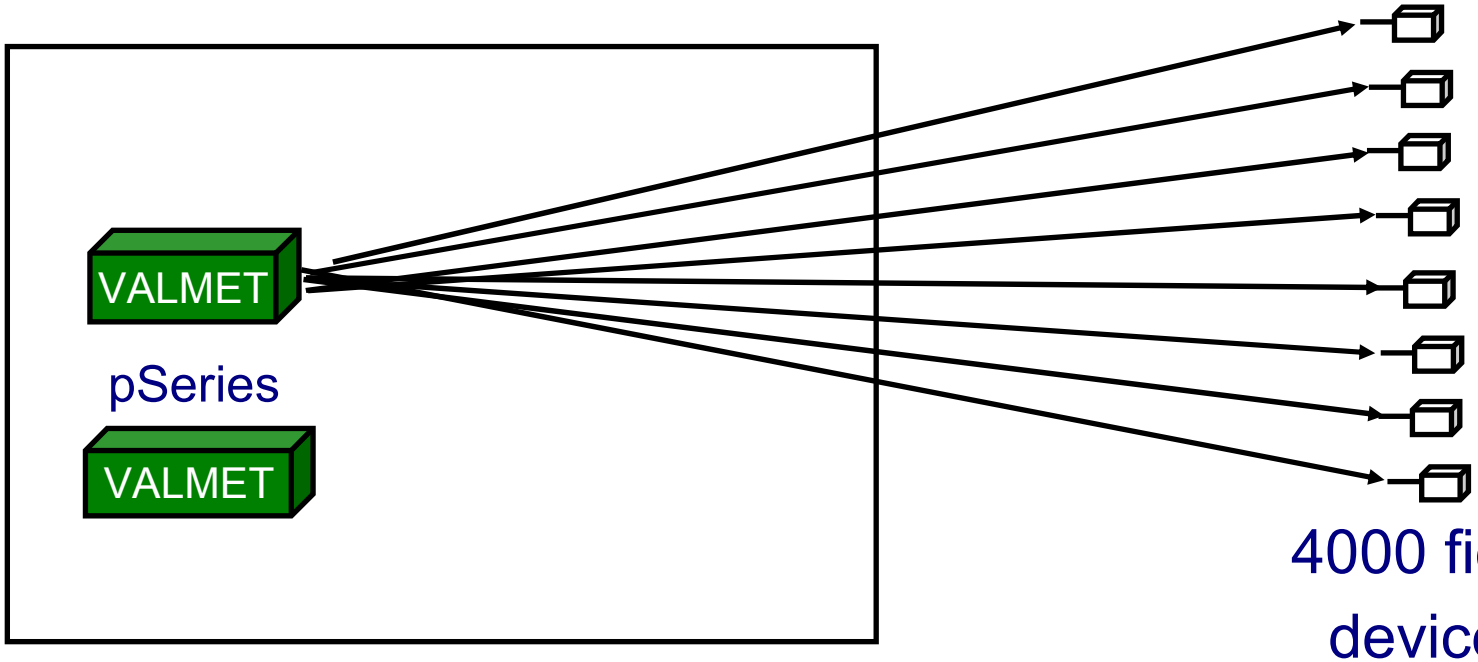
Examples

Scada



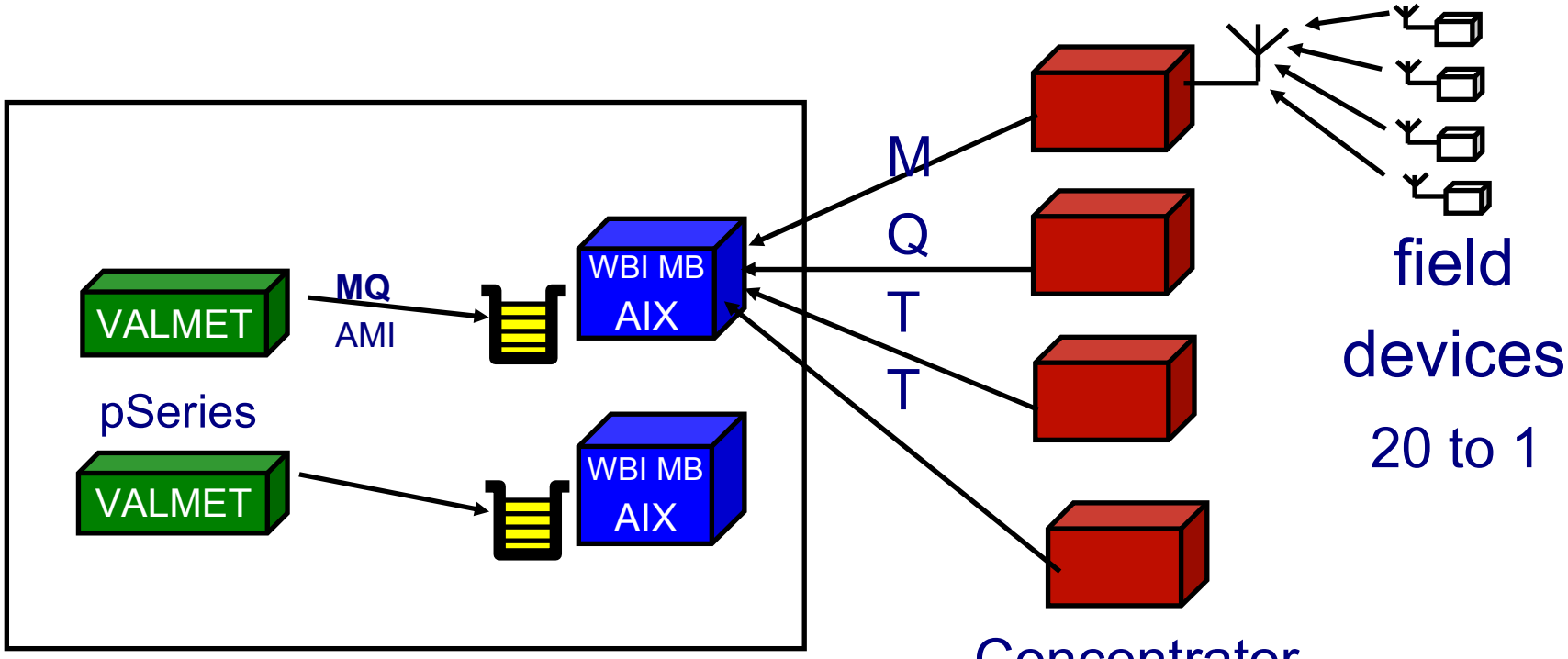
Remote monitoring station

Pipeline Project - original system



- network saturated with poll traffic
- VALMET system CPU at 100%
- 8000 more devices to integrate
- other applications needed data ("SCADA prison")

Pipeline Project - now in production

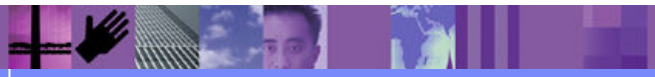


- network traffic much lower (RBE)
- host CPU much lower (MQ AMI client)
- scalability for whole pipeline
- other apps can subscribe to get data

Examples

Facilities Management:–

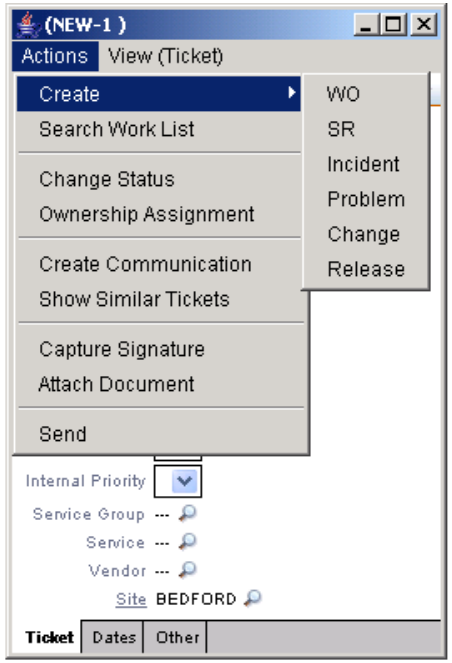
Scheduling
Commissioning
Maintenance
Testing



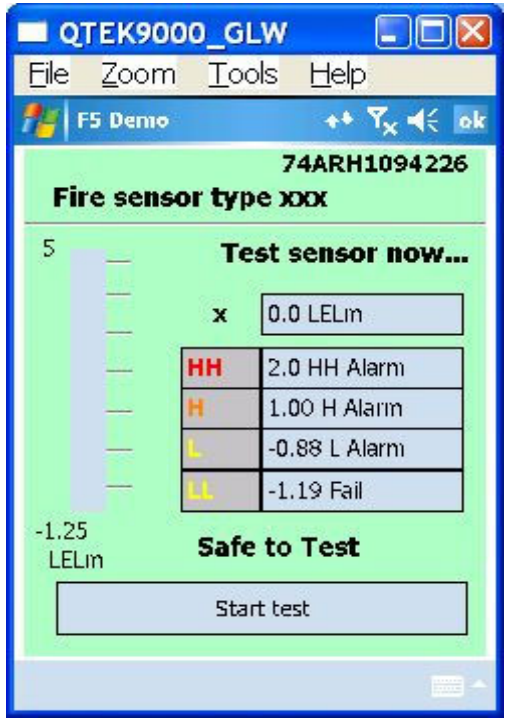
Field Engineer – Commison, Maintain, Test

- **Enable mobile work force**
  - Increase accuracy
  - Increase productivity
- **Obtain work order details / Check lists**
  - Work order management
  - Provide ”guided” procedures or check lists
- **Provide location guideance**
  - Display map of installation and location of relevant equipment
- **Require necessary technical information**
  - Historian
  - Manuals, data sheets and certificates
  - Near real time
- **Update back office maintenance system and commissioning system**

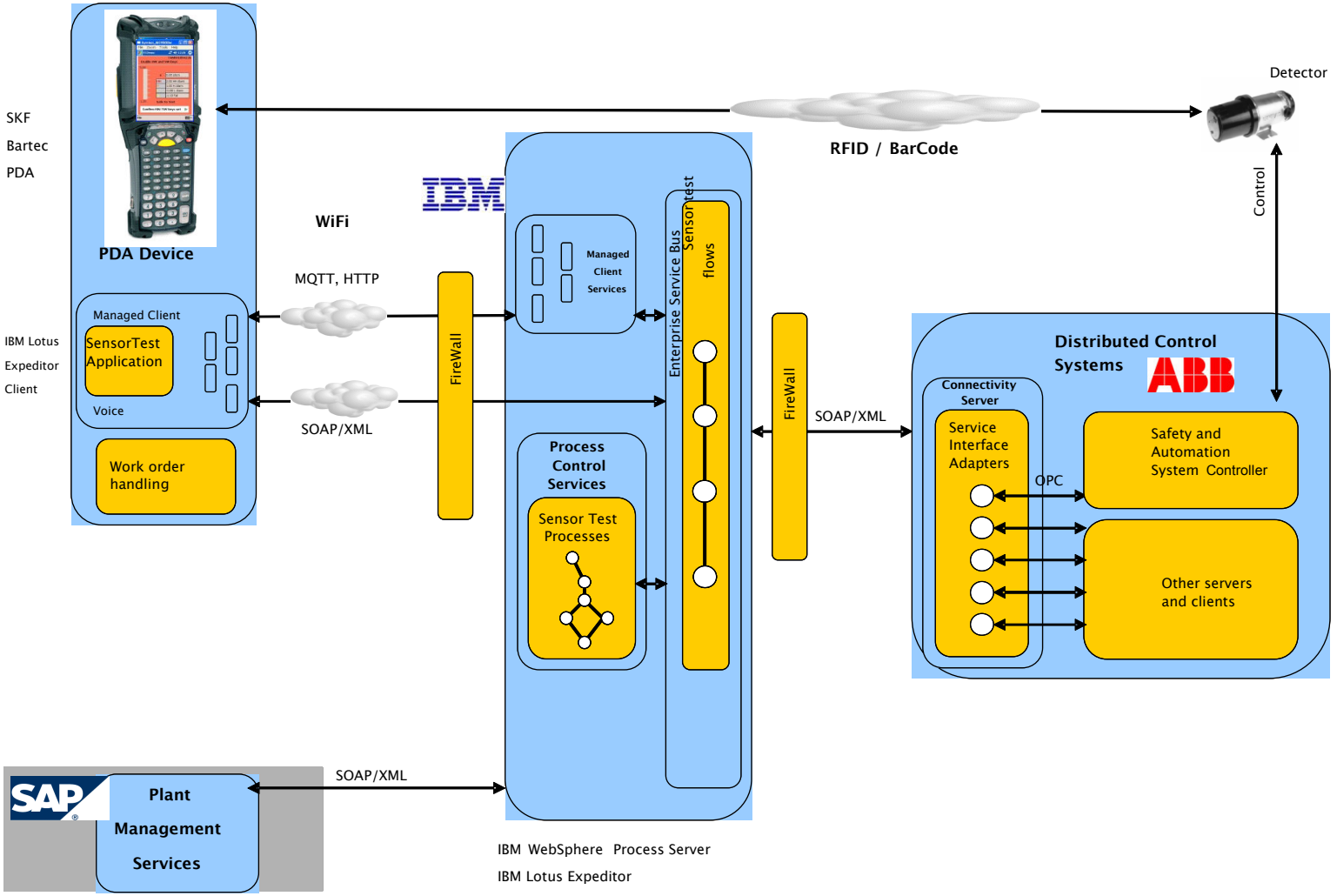
Work Order/check lists



Real time data

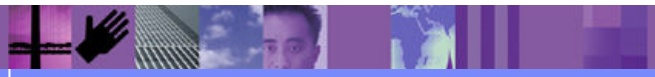


Architecture: Device to PDA



Examples
Retail

Lotus Expeditor Integrator



Use case scenario from retail industry - “Price update”

Retail industry is a typical business that deals with data for remote locations - retail stores.

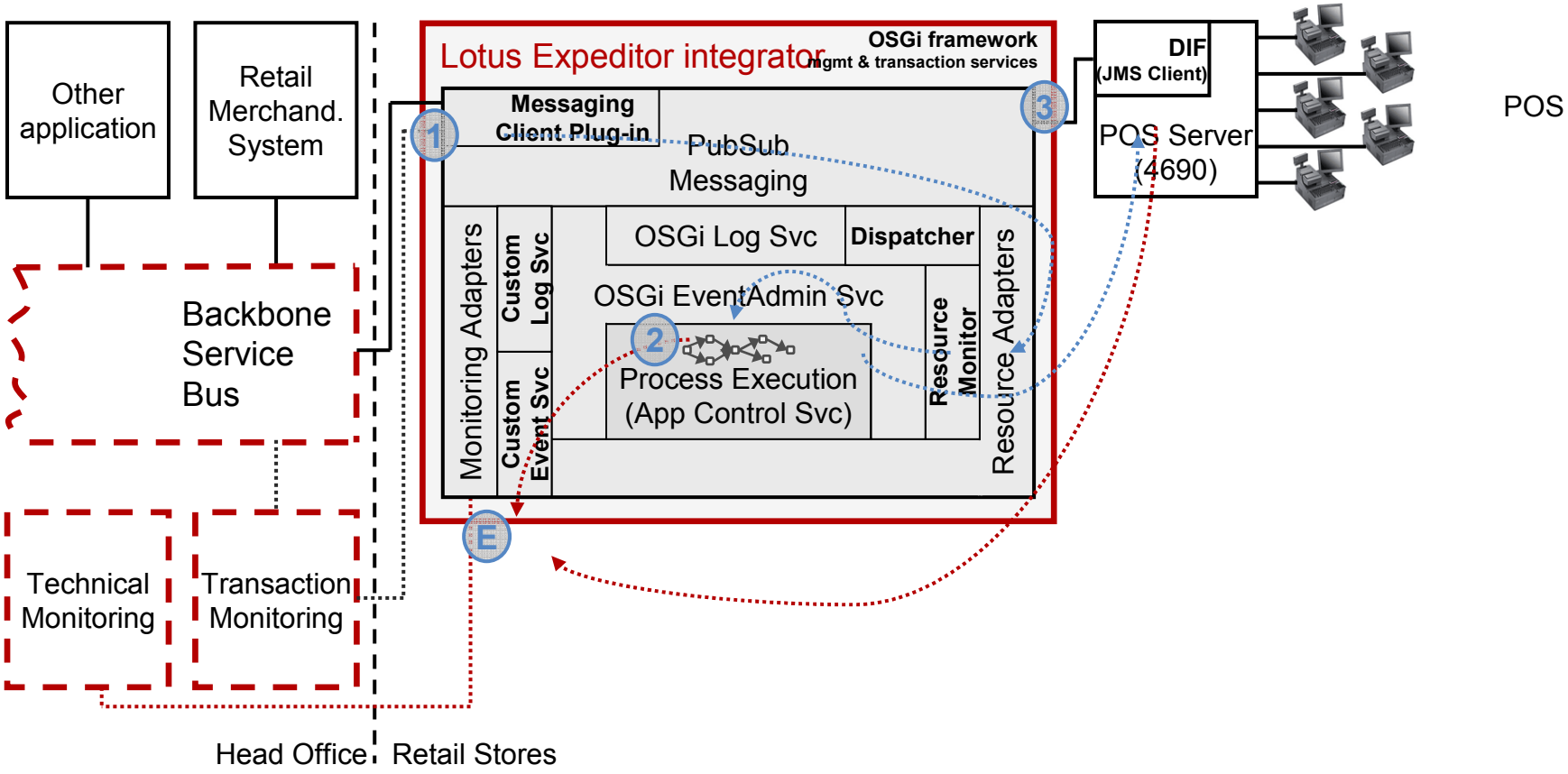
- Imagine a typical retail use case. Price update for advertised sales deals.

- What’s the situation?
  - Retail Merchandising System sends out the packaged data for updating stores till Monday morning.
  - POS systems need to be up to date when store opens and customers want to buy on Monday the items being advertised.

- Questions you might ask ..
  - Did the data for new prices really arrived?
  - Are these data correct (e.g. matching with merchandising flyers from weekend)?

Use case execution for “Price update”

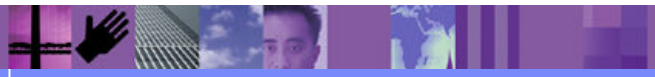
A message with price update data is being sent to store and must be delivered to POS Server



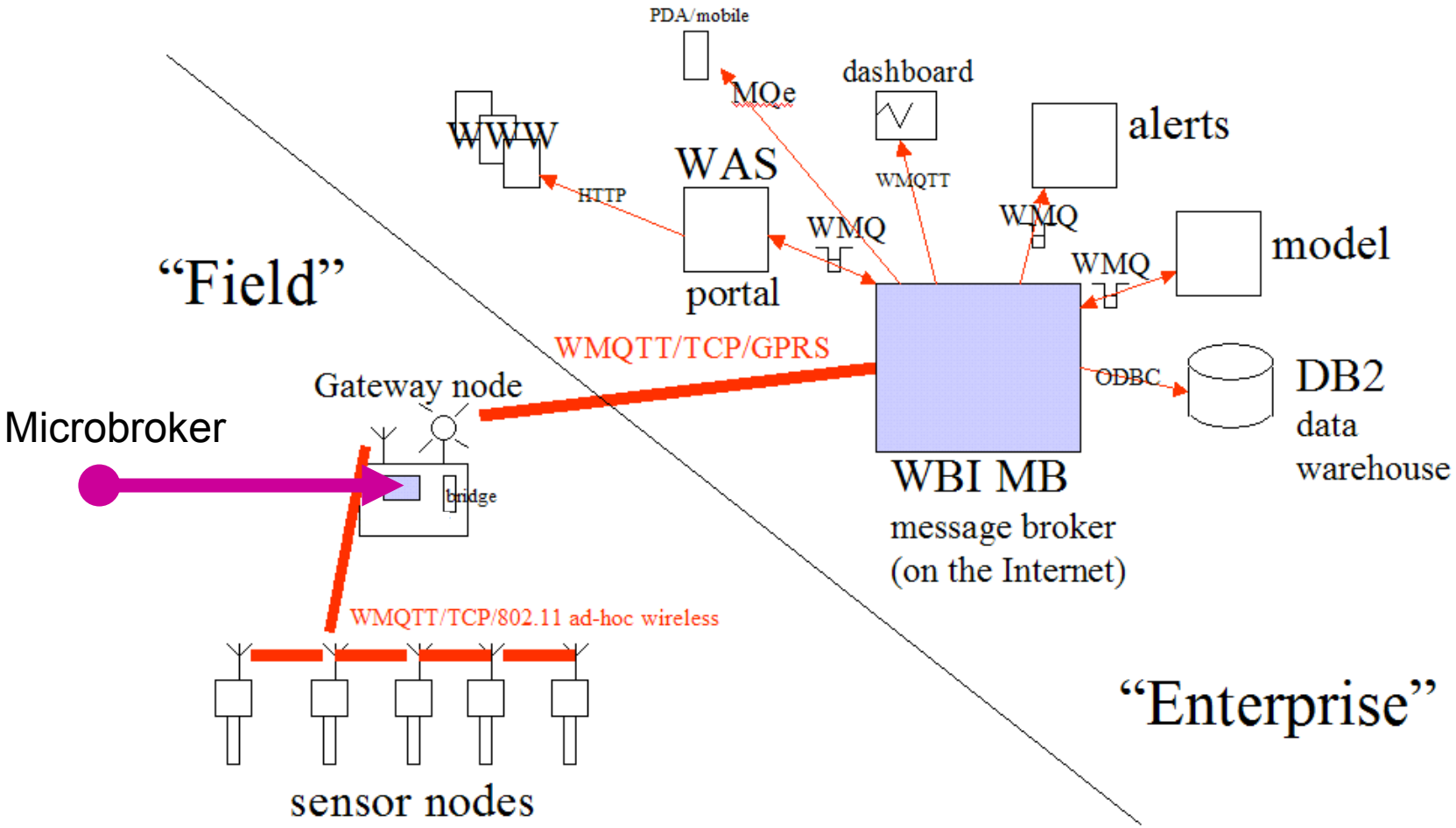
1. When a message with price update payload occurs an event will be generated on a pre-defined trigger topic.
2. Use case related flow within Process Execution Service is being initiated by this event on the pre-defined trigger topic.
3. Flow reads the message payload data from PubSub Messaging and writes them to 4690 DIF through outgoing message queue.
E. Business Events will be generated at start and end of the transaction within Process Execution Service.

Examples

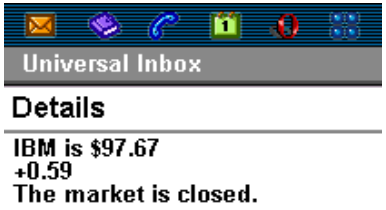
Others

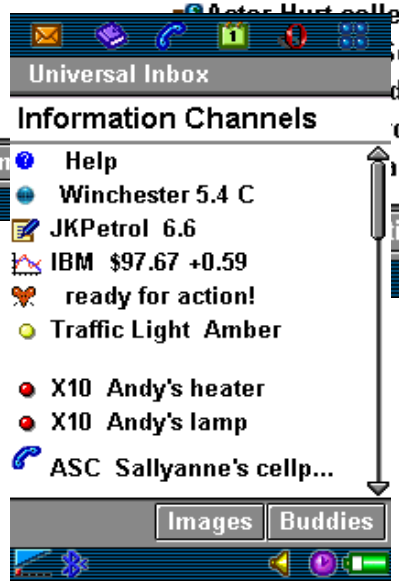


Typical deployment – FloodNet project



“UIB” - Universal InBox

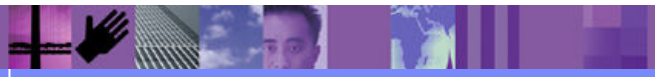




- Live dashboard display
- SMS/IM-style messaging
- Alerts and notifications
- Action buttons to activate/respond
- Image and sound delivery

Useful Links

- MQTT
  - http://mqtt.org
- WebSphere MQ and MQ Telemetry
  - http://www-01.ibm.com/software/integration/wmq/
- MQTT: the Smarter Planet Protocol
  - http://andypiper.co.uk/2010/08/05/mqtt-the-smarter-planet-protocol/
- Lotus Expeditor (micro broker)
  - http://www.ibm.com/software/lotus/products/expeditor/
- Sensor Solutions
  - http://www-01.ibm.com/software/solutions/sensors/



Some areas that telemetry has been used…

HVAC Control

Chemical Detection

Trickle Feed

POS

Stock Checks

Field Force Automation

- Sales Force Automation
- Field Service Engineers
- Service Delivery

Asset Management And Monitoring

RFID

Parking Tickets

Fire Sensors

Pipeline Monitoring and Control

Flood Defence Warning

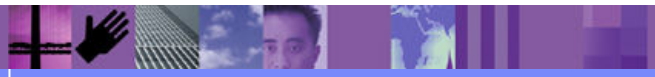
Kiosks

Vehicle Telematics

- Cars / Military – Diagnostics and Prognostics
- Pay As You Drive Insurance

Home Automation

Publish Subsribe with MQTT



Basic PubSub app

User Fred is interested in receiving notification when the alarm system state on his home changes

Subscribers

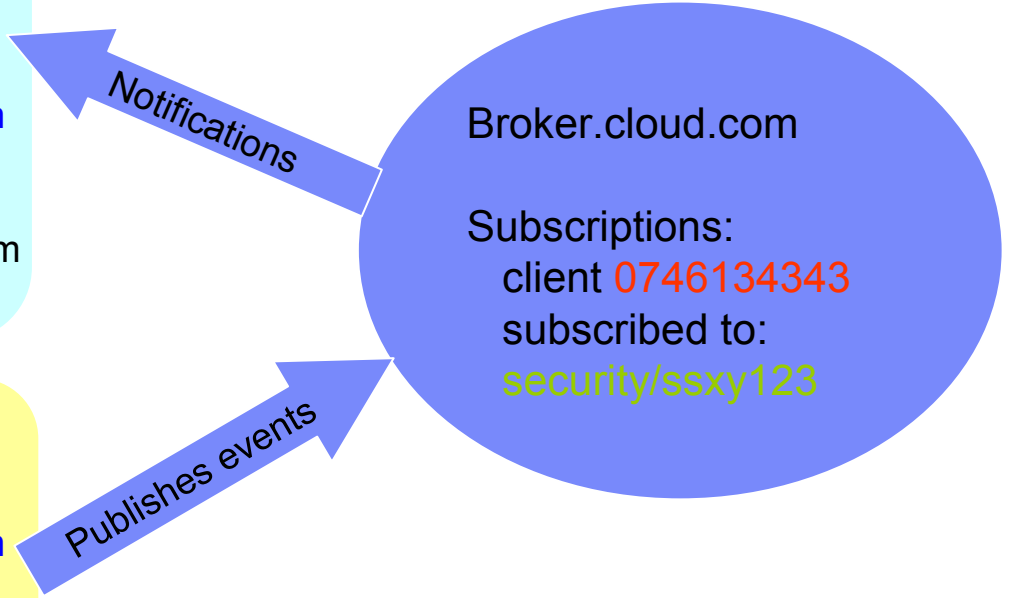
Device: subscribes for security events for Fred's house)

1. MQTT connect to broker at broker.cloud.com with ID 0746134343 (e.g. phone no)
2. MQTT subscribe security/ssxy123/#
3. Message listener called when security system events received.

Publisher(s)

Home: publishes security system state changes

1. MQTT connect to broker at broker.cloud.com with ID ssxy123
   Can stay connected all the time or connect when there is a message to send
2. MQTT publish security/ssxy123 <state change>



Notes:

- The MQTT Client ID must be unique in the context of the broker it connects to
- A subscription can be durable, here a broker stores messages when the client is not connected or non-durable, here the subscription is forgotten when the client disconnects.

Basic PubSub app – multiple subscribers

User Fred and monitoring service is interested in receiving notification when the alarm system state on his home changes

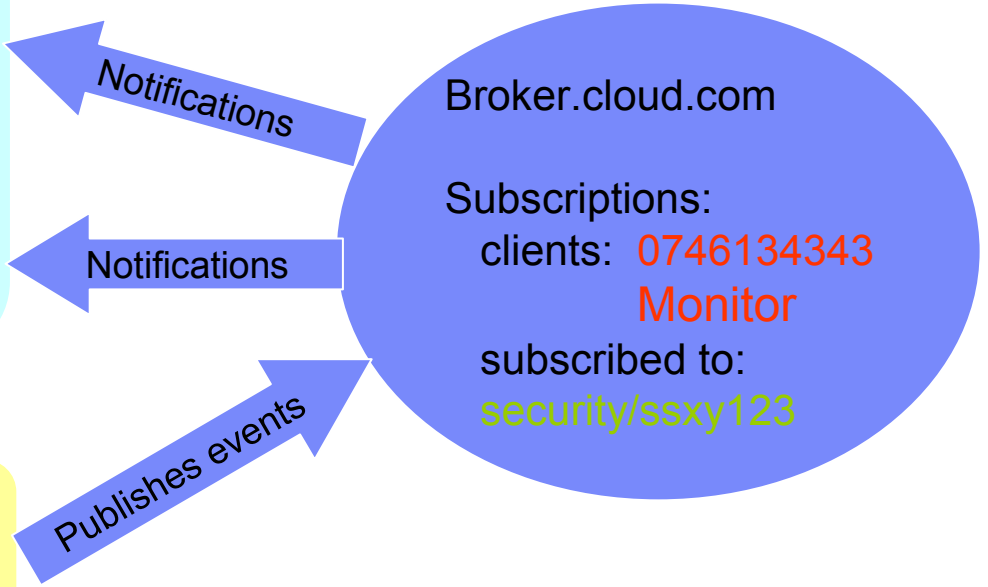
Subscribers

Fred's Device: subscribes for security events for Fred's house
- 0746134343 subscribes security/ssxy123/#

Monitoring Service: subscribes for security events for Fred's house)
- Monitor subscribes security/ssxy123/#

Publisher(s)

Home: publishes security system state changes
- MQTT publish security/ssxy123 <state change>



Notes:
- The MQTT Client ID must be unique in the context of the broker it connects to
- A subscription can be durable, here a broker stores messages when the client is not connected or non-durable, here the subscription is forgotten when the client disconnects.