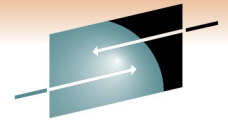# Connectivity for the Smarter Planet

Simon Gormley (sgormley@uk.ibm.com)
IBM Hursley Park

March 1st, 2011
Session 8910

1. **Context**

2. **Technology**
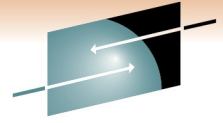
3. **Case studies**

Context

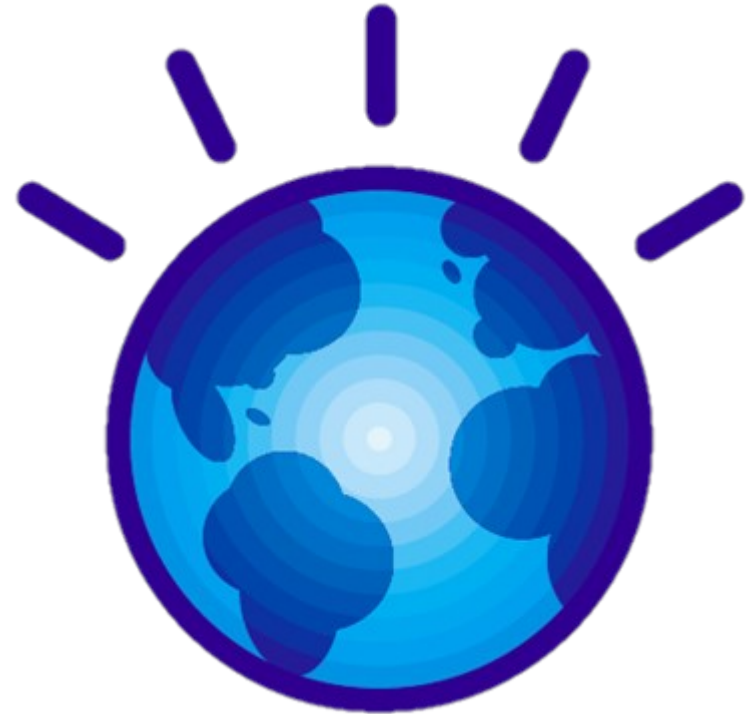# We are making progress on a Smarter Planet
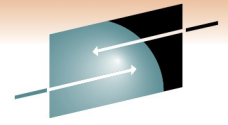
Smarter Traffic
$15 Million Average Savings

Smarter Energy
15% Average Peak Reduction

Smarter Supply Chains
30% Average Cost Reduction

Achieve agility and growth today…
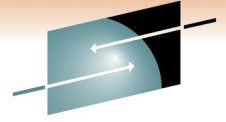
Discover Insights that enable innovation

Speed value and innovation with business-led discovery and change

Maximize the value of business interactions

Collaborate and connect with rich information in the right context

Optimize productivity and resources

Broadly flexibly and continuously improve and govern processes

The Internet of Things
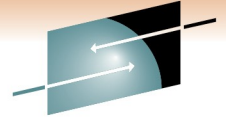
Trillions of smart devices **instrument** our world today
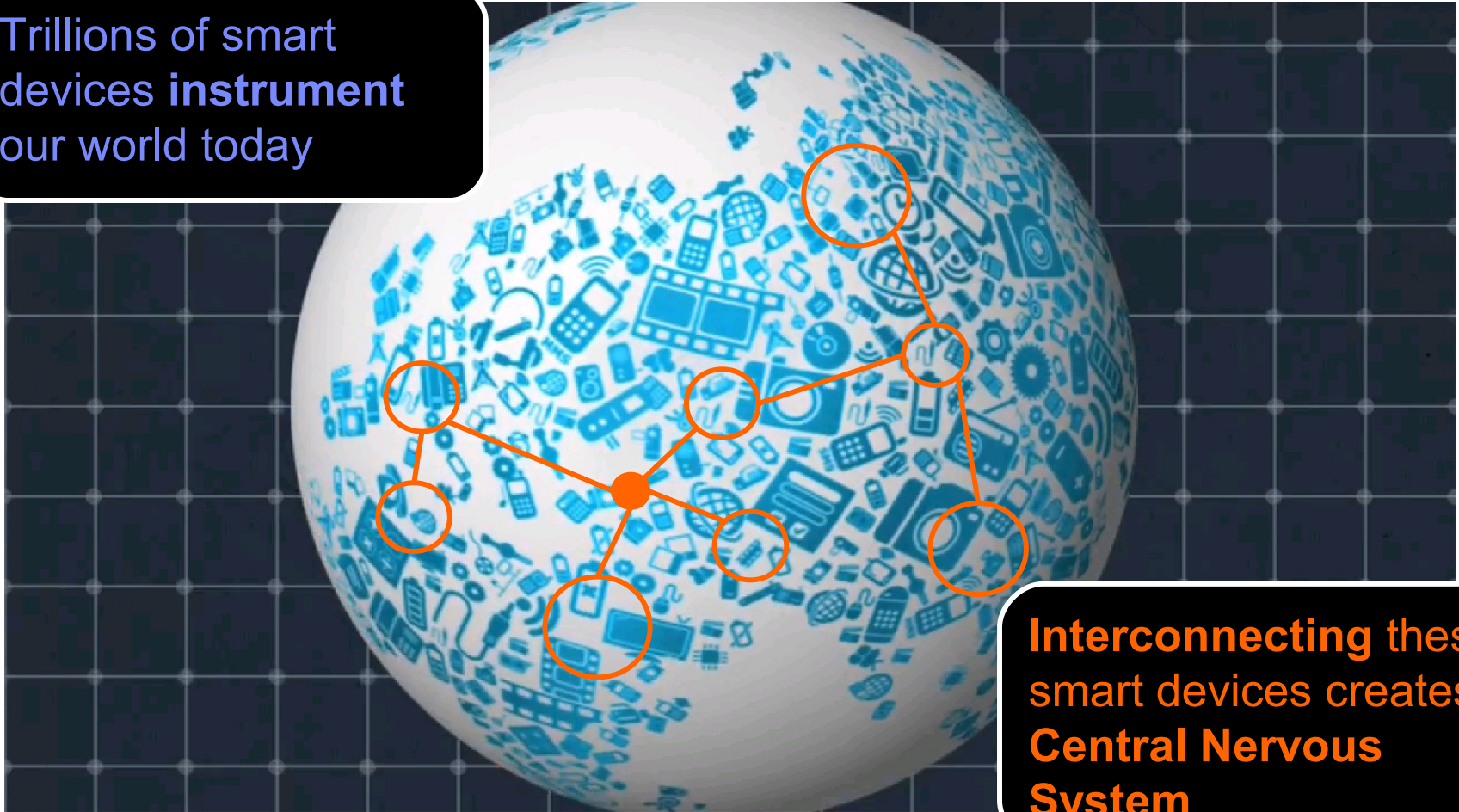
Interconnecting these smart devices creates a **Central Nervous System**

Our World is Filling with Devices

Pop Quiz

- **Grains grown each year**   1,000,000,000,000,000 (1 quadrillion)

Crawling the earth   100,000,000,000,000,000 (100 quadrillion)

Manufactured each year   10,000,000,000,000,000,000 (10 quintillion)

1 billion transistors for every one of us

Building a Smarter Planet

An opportunity to think and act in new ways—
economically, socially and technically.

Trends & Objectives
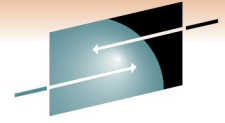
Business

IT

Discover insights that enable innovation

- Achieve savings with better decisions using real-time data
- Innovate with new business models
- Win loyalty through personalized incentives

Achieve increased IT flexibility

- Increased recognition of value of event-driven architecture
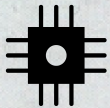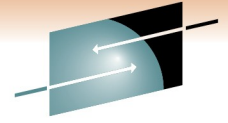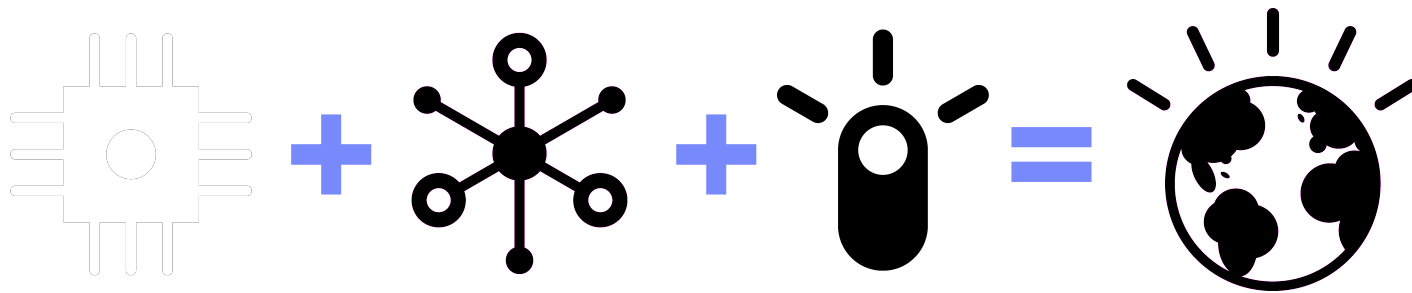- Increasing use of event-driven concepts e.g. pub/sub

Maximize value of business interactions

- Proactive response to current situations and predicted events
- Apply analytical techniques like systems thinking, scenario planning, game theory, value network analysis

Leverage connected smart devices

- Smarter devices enabling more intelligence at the edge
- Increased cross-over of technologies, tools and standards between enterprise and device worlds

Optimize productivity and resources

- Improve management of remote resources
- Maximize utilization of fleet or inventory
- Coordinate operations more efficiently by advanced planning

Encourage re-use

- More strategic approaches to IT architecture
- Focus on reducing time to value
- Service orientation enabling multi-channel re-use

Business Scenarios
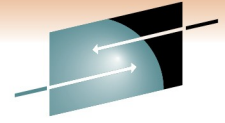
predict

alert

track

measure

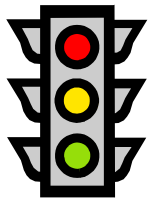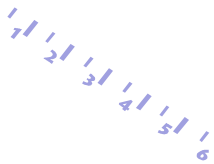| Scenario	Key Industries	Example
Automated Metering	Chemical & Petroleum Energy & Utilities	*Solution provider enables smart metering of home energy by using MQ Telemetry technology*
Distribution Supply Chain and Logistics	Retailers Distributors Consumer products Transportation	*Shipping company improves 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*

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Connectivity for a Smarter Planet
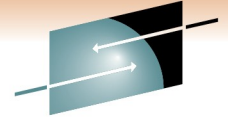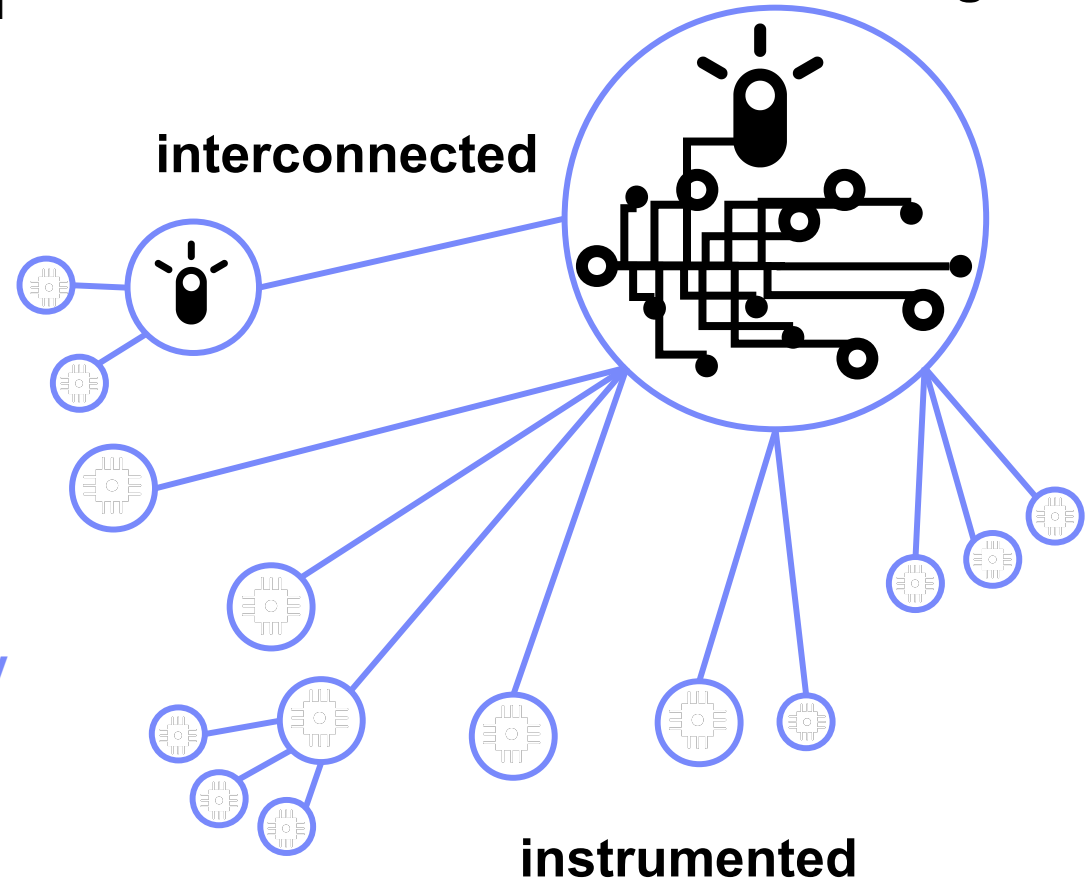
Extend connectivity beyond enterprise boundaries to smart devices

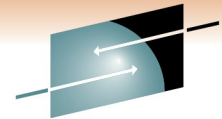Offer connectivity capabilities **optimized** for sensors and devices

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

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

Create **self-managing** device networks

intelligent

interconnected

instrumented

11
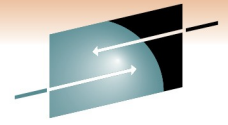
Blueprint for Edge Connectivity

Connectivity for Applications

Transport   WebSphere MQ
                REST/HTTP
                WS*

Intelligent

**Head Offices,
Data centres
Cloud Computing**

**Regional Offices
Stores, Outlets**

Interconnected

Mission-Critical Connectivity & Intelligence

Messages	WebSphere MQ
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

Instrumented

Connectivity for Smart Devices

Transport   MQ Telemetry
                HTTP
                Multicast

Remote Systems and 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…

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Technology

Introducing key technologies in the IBM messaging family

- MQTT
  - Specialist protocol for low powered devices and fragile networks
- WebSphere MQ Telemetry
  - High-scale connectivity from the edge into the enterprise
- WebSphere MQ
  - The world's leading enterprise messaging provider
- WebSphere Message Broker
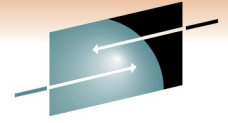 - Enterprise Service Bus providing any-to-any transformation and connectivity

Introducing MQTT

- The challenges of industrial control systems (supervisory control and data acquisition, or SCADA) well-suited to a messaging solution

  - Loose coupling, multi-protocol, separation of concerns...

- IBM developed a protocol for the MQSeries Integrator product designed for the constraints of the SCADA world.

  - MQ Integrator SCADA Device Protocol (MQisdp)

- Later renamed MQ Telemetry Transport – (MQTT) due to broader telemetry adoption

- Support has been available via SCADA nodes in WebSphere Message Broker from version 2.0 through version 6.1
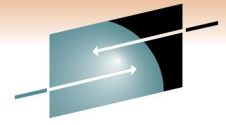
Design principles of MQTT

- 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 – built for *low bandwidth*, *high latency*, *unreliable*, *high cost* 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.
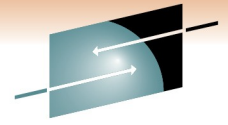
# Key facts about MQTT

- Reduced complexity and footprint

- Simple, minimal pub/sub messaging semantics
    - Asynchronous ("push") delivery of messages to applications
    - Simple set of verbs: connect, publish, subscribe, disconnect

- Minimised on-the-wire format
    - Plain byte array message payload
    - No application message headers
    - Protocol compressed into bit-wise headers and variable length fields
    - Smallest possible packet size is 2 bytes

- 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
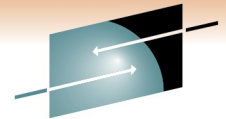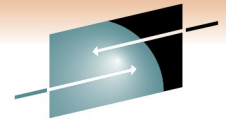
A 2 byte packet?!

- Each bit in each byte is important!
- Still allows for a 256MB message
- API calls are likely to have additional data, such as message payload, topic information etc.

bit	7	6	5	4	3	2	1	0
byte 1	Message Type				DUP flag	QoS level		RETAIN
byte 2	Remaining Length							

Qualities of Service

Three qualities of service for both publishing *and subscribing*:

QoS 0: At most once delivery (non-persistent)
– No retry semantics are defined in the protocol.
– The message arrives either once or not at all.

QoS 1: At least once delivery (persistent, dups possible)
– Client sends message with Message ID in the message header
– Server acknowledges with a PUBACK control message
– Message resent with a DUP bit set If the PUBACK message is not seen
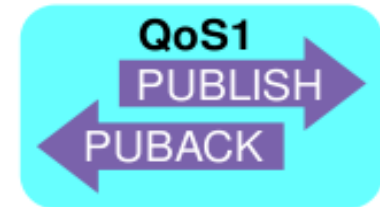
QoS 2: Exactly once delivery (persistent)
– Uses additional flows to ensure that message is not duplicated
– Server acknowledges with a PUBREC control message
– Client releases message with a PUBREL control message
– Server acknowledges completion with a PUBCOMP control message

QoS0
PUBLISH

QoS1
PUBLISH
PUBACK

QoS2
PUBLISH
PUBREC
PUBREL
PUBCOMP
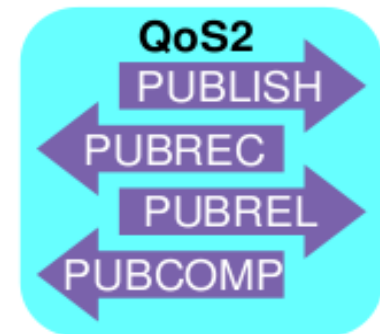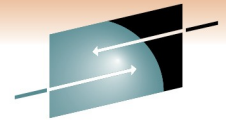
Example: connect and send an MQTT message

```
public void sendAMessage() throws MqttException {
    MqttProperties mqttProps = new MqttProperties();
    mqttProps.setCleanStart( true );
    MqttClient client = MqttClientFactory.INSTANCE.
        createMqttClient("testClient",
        "tcp://localhost:1883", mqttProps);
    client.registerCallback(this);
    client.connect();
    client.publish("abc/123",
        new MqttPayload(("Hello World!").getBytes(),0),
        (byte) 2, false);
    client.disconnect();
}

public void publishArrived(String topicName,
            MqttPayload payload,
            byte qos, boolean retained,
            int msgId) {
    System.out.println("Got it!");
}
```
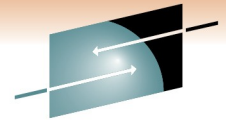
Create a connection using the connection factory, this time for a clean starting client

Register the class as a listener and connect to the broker
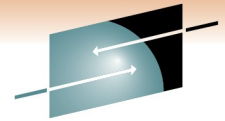
Publish a message to the given topic and disconnect

On receipt of a publication, simply spit out a message to the console to say we received it

WMQT Implementation

- New MQ service – MQXR ('eXtended Reach')
    - Separate purchasable extension
    - Available on Windows and UNIX
    - eGA 27 August 2010
- Fully integrated / interoperable with MQ
    - Publishers and subscribers can exchange messages
- Telemetry channels enable MQTT connections to Qmgr
- Supports MQTTv3 protocol (most common in use)
- Ships with reference Java (for MIDP upwards) and C clients
    - other APIs and implementations available via 3rd parties
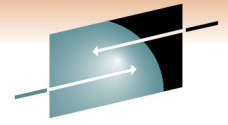
WebSphere MQ Explorer integration

Topology example: "simple" clients

WebSphere MQ Telemetry

WebSphere
MQ 7.0.1

MQXR

Sensors

Mobile
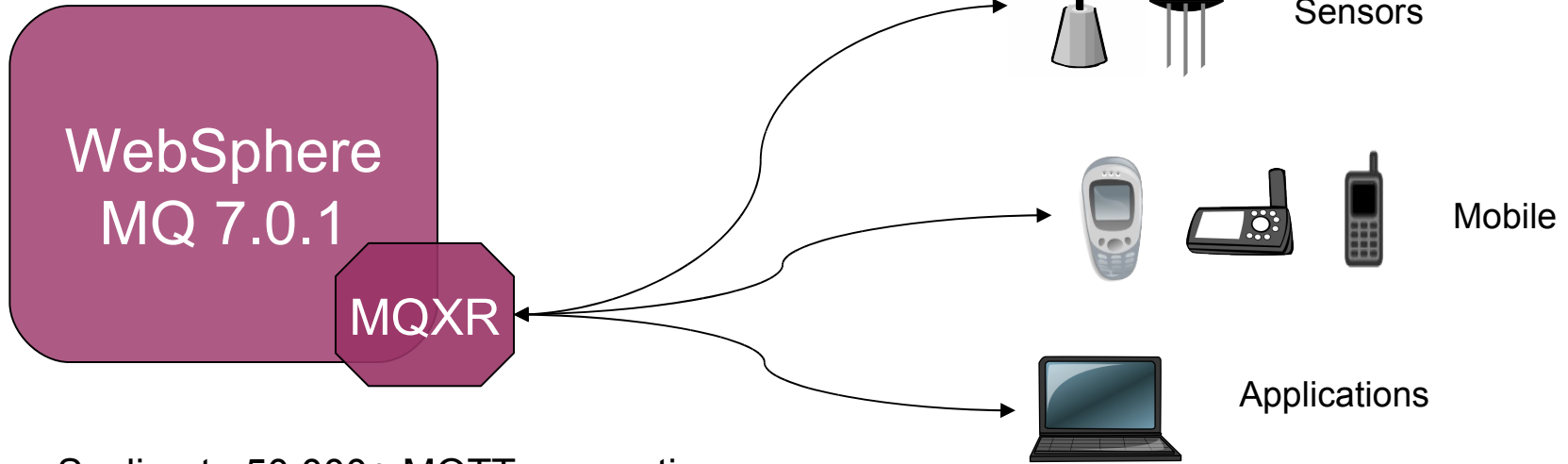
Applications

Scaling to 50,000+ MQTT connections
to a single queue manager*
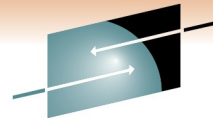
Topology example: "advanced" clients

WebSphere MQ Telemetry

WebSphere MQ 7.0.1

MQXR

Sensors

Mobile, smart meters

Applications

MQTT

WebSphere MQ Telemetry Daemon for Devices
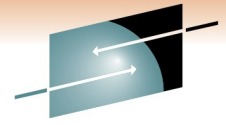
Rich clients requiring buffering, remote management capabilities, or advanced data handling

Microbroker (Lotus Expeditor, WebSphere Sensor Events)
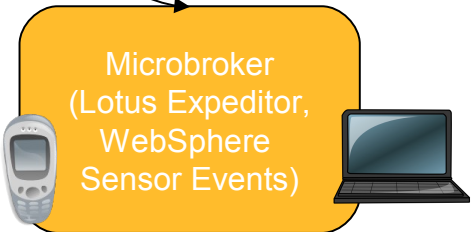
WebSphere software

Lotus software

Security options

- Securing mobile / remote clients can be vital!
- WMQ Telemetry supports two key technologies:
- SSL – encryption and authentication
- JAAS – authorization

Configurable:
- Use clientId
- Use userid/pw on API
- Static username on channel (useful for grouping clients)

Telemetry channel may also use SSL

WebSphere MQ

MQXR

JAAS

→ userid/pw
← "OK / no way!"
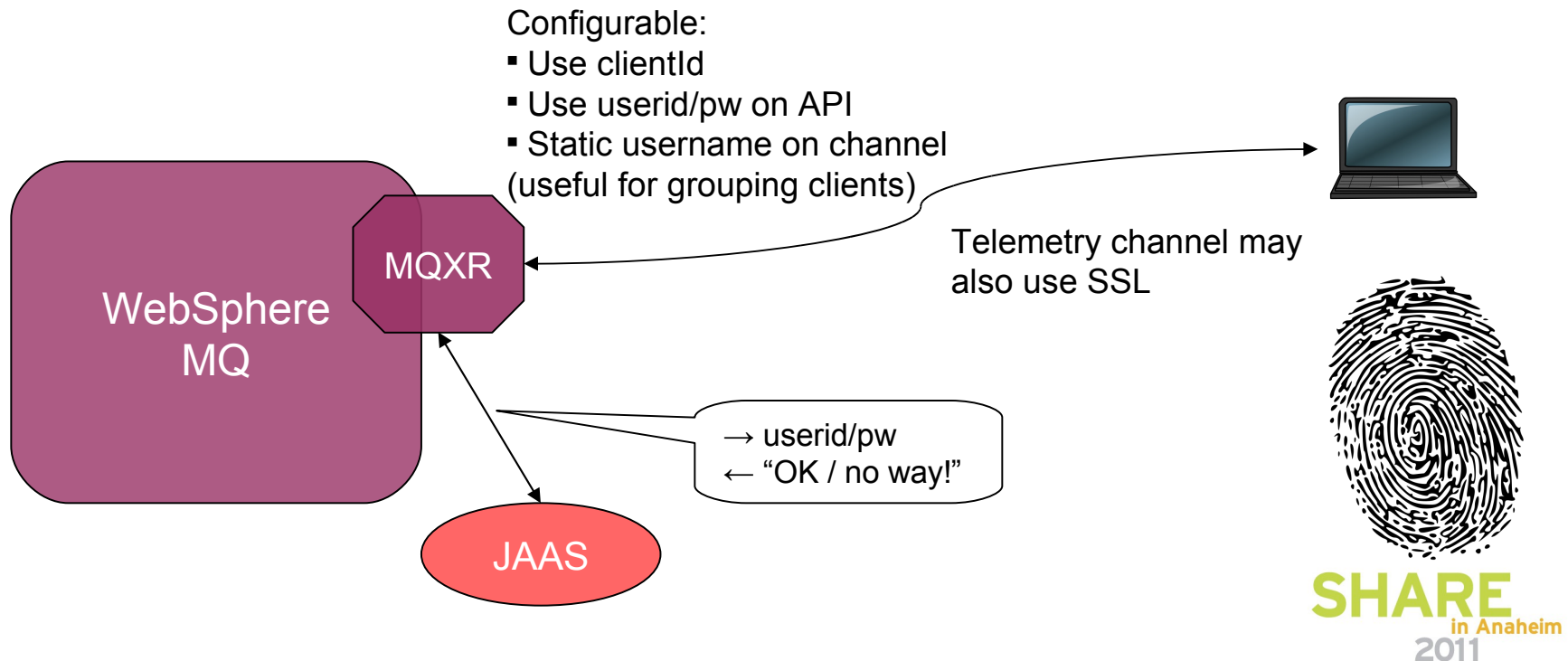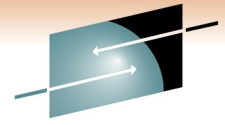
Topology example: enterprise gateway
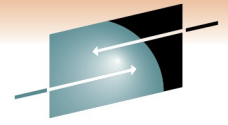
Multiplex devices at edge of enterprise
Integrate "any-to-any" via WMB

Web Services

HTTP

WebSphere
Message Broker

WebSphere MQ
Telemetry

WebSphere
MQ 7.0.1

MQXR

DB

Files

CICS, IMS

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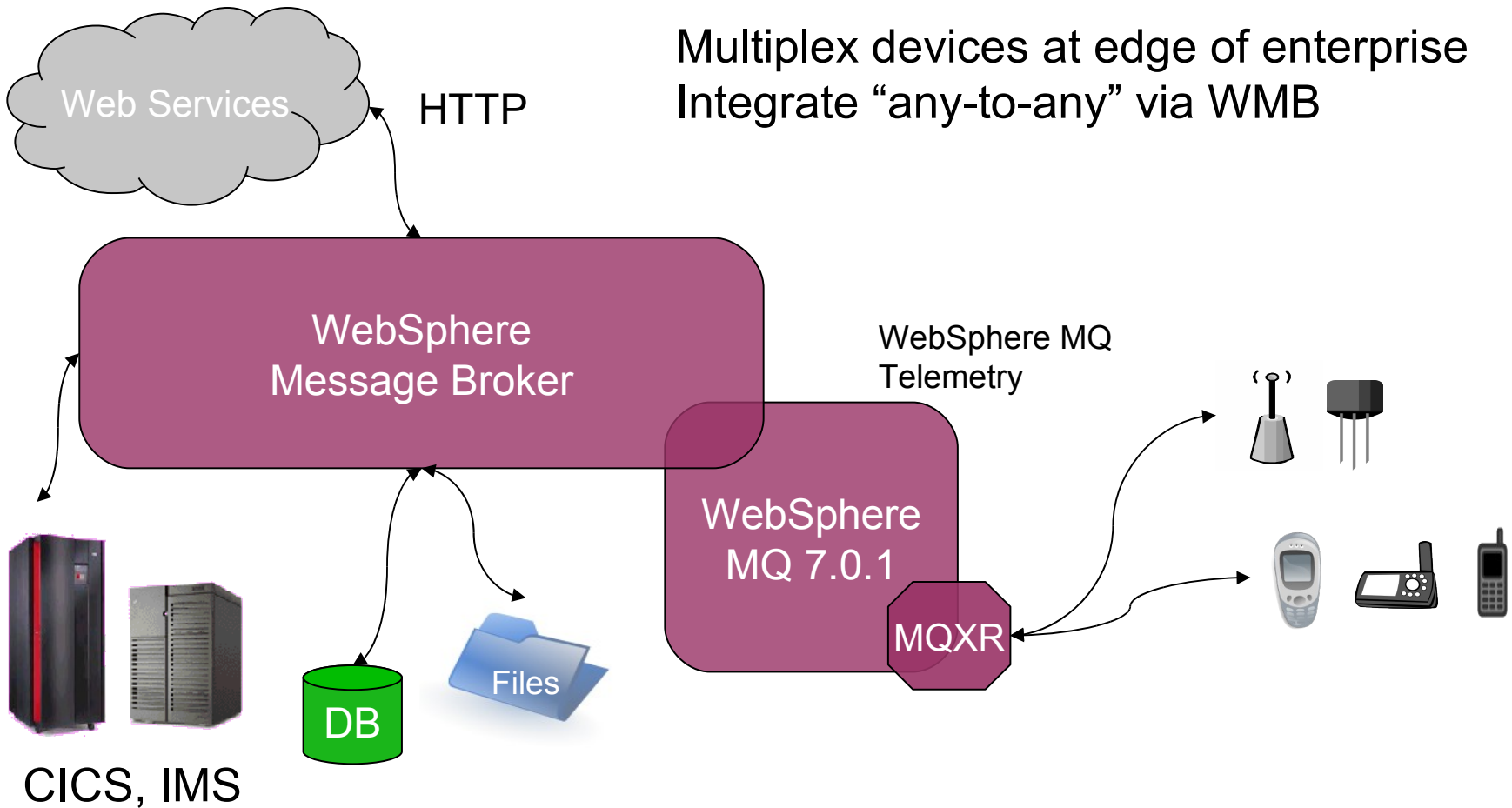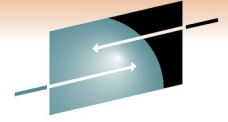
Migration from WMB SCADA nodes

- High-level steps:
- Upgrade to WMQ v7
- Upgrade to WMB v7
- Install WMQ Telemetry feature
- Ensure MQTT v3 protocol used by client apps
- Modify message flows to use JMSInput or MQInput nodes in place of SCADA nodes

Case studies

Transforming Railway Operations

National railway infrastructure company *created solution for real-time rail monitoring*

Client Pains

Difficulty integrating and sharing information

Lack of real-time data

Home-grown solution expensive to build and maintain

Improved reliability and timeliness of train services

Able to allocate railway resources more efficiently

Instant access to real-time data across organization
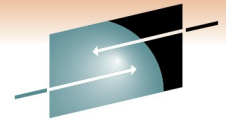
Smarter Healthcare

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
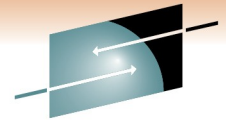
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Improving Energy Usage

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 meters

Needs to be able to rapidly scale solution nation

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*

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IBM   **City Command Center**   Smarter Cities

Home | Applications | More...   smartcity | Edit My Profile | Log

City Central | **Water Management** | **Distribution** | **Waste** | **Transport Management** | **Bus** | **Roads** | **Utilities Management**

Water Management Scorecard +

Sectors	Target %	Actual %	Status
Water Quality Management			
North	97	98	🟢
South	95	96	🟢
Central	95	94	🟠
East	97	97	🟢
West	95	95	🟢
Water Distribution Management			
North	97	97	🟢
South	97	97	🟢
Central	95	97	🟢
East	97	98	🟢
West	95	96	🟢
Water Waste Management			
North	97	97	🟢
South	97	97	🟢
Central	97	95	🟠
East	97	98	🟢
West	95	97	🟢
Water Treatment Management			
North	97	97	🟢
South	97	97	🟢
Central	95	95	🟢
East	97	97	🟢
West	95	95	🟢

Report : Scorecard   **Location :** All
Period : Tuesday 08/12

Water Event Management +

Type	ID	Source	Description	Time/Date	Status
Water Overflow	ABC234E	Water Waste	Predicted precipitation 24HRS - ETA 11:00 09/12 Ongoing maintenance/ potential sewerage overflow.	11:00 08/12	🟠
Water Quality	QCD234A	Water	PH Level below LCL	10:53 08/12	🟠

Report : Water Events - Status
Date : 08/12/2009 Tuesday   New Event   Enlarge

Collaboration Space *

Water + Transport Region Experts

John Meegan
Senior Waste Water Manager

Thomas Freund
Senior Water Manager

Michael Cosgrove
Senior Waste Water Engineer

- 88 **Water + Transport Agency (2/4)**
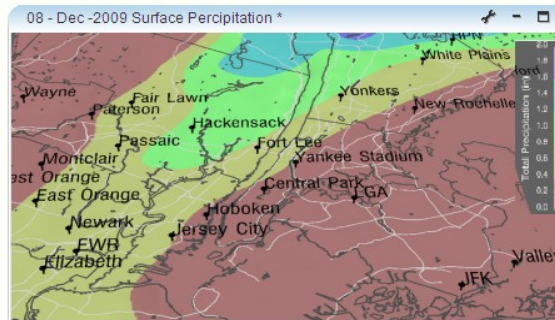 - 88 **Bus Transport Agency (1/1)**
    - Michael Kehoe
  - 88 **Metro Transport Agency (0/1)**
    - E. Michael Huestis
  - 88 **Water Distribution Agency (1/2)**
    - michael_cosgrove@ie.ibm.com - Mich
    - Thomas J. Freund

📶 Feeds
📅 Day-At-A-Glance
⊘ Activities
⭐ Primary Contacts

Flood Prediction *

Attribute	Alert	Min	Max	Actual
Wind Speed	🟢🟡🔴	0	60	35 knots
Wind Direction	🟢🟢🔴	90	270	80 deg
Temperature	🟢🟢🟢	-10	50	21 m
Cloud Cover (High)	🟢🟡🟢	0	100	99 %
Cloud Cover (Low)	🟢🟡🔴	0	100	82 %
Rainfall	🟢🟡🟢	0	10	5 mm

< Fri 05 Jun 2000 12:00 >

EcoRhythms

08 - Dec -2009 Surface Percipitation *

White Plains, Wayne, Fair Lawn, Paterson, Yonkers, New Rochelle, Hackensack, Passaic, Fort Lee, Montclair, Yankee Stadium, Orange, East Orange, Central Park, GA, Newark, Hoboken, Jersey City, EWR, Elizabeth, Valley, JFK

Alarm Management

Serviceability   Date: 10.2009

Site	Status	Actual	Actual %
PH	🟢🟢🔴	3	30
Pipe Breackage	🟢🟢🔴	0	0
Sewer Overflow	🟢🟢🔴	0	0
Turbidity	🟢🟠🟢	6	60
Pumping Rate	🟢🟢🟢	4	40

<<MORE>>

File: City Water Managemen 09/1   Enlarge

Home | Applications | More...

smartcity | Edit My Profile | Log O

City Central | Water Management | Distribution | Waste ▾ | Transport Management | Bus | Roads | Utilities Management

Waste Management +

Tabular Detail | System Map | Layers | Central Region ▾

Layers
- [X] Pipe
- [ ] Pump
- [ ] Sewers
- [X] Hold Tanks
- [ ] Weirs
- [ ] Weather

New York

Water Waste Event Management +

Source	Destination	Ack	Description	Time/Date	Focal Point
Water Waste	Water Waste	✓	Maintenance deployed. Open Status.	11:45 08/12	
Water Management	City Central	✓	Overflow alert. Potential Sewage overflow	11:41 08/12	
Water Management	Water Distribution	✓	Overflow alert. Potential Sewage overflow	11:40 08/12	

Type	Sev	ID
Water Overflow	2	ABC234E

More >>

Update | Back

Collaboration Space *

Water + Transport Region Experts

John Meegan
Senior Waste Water Manager

Thomas Freund
Senior Water Manager

Michael Cosgrove
Senior Waste Water Engineer

- 88 Water + Transport Agency (2/4)
  - 88 Bus Transport Agency (1/1)
    - Michael Kehoe
  - 88 Metro Transport Agency (0/1)
    - E. Michael Huestis
  - 88 Water Distribution Agency (1/2)
    - michael_cosgrove@ie.ibm.com - Mich
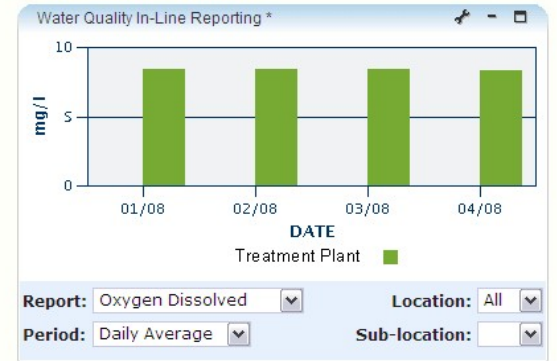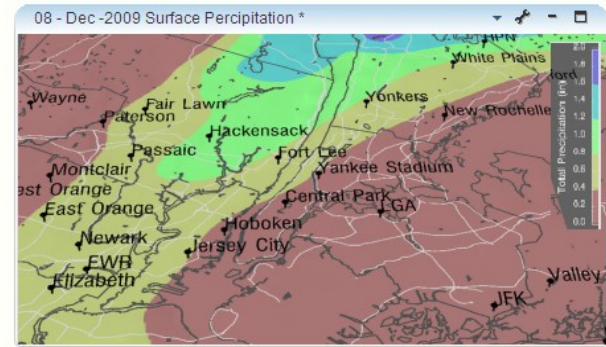   - Thomas J. Freund

- Feeds
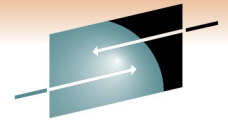- Day-At-A-Glance
- Activities
- Primary Contacts

Bulletin Board

Potential CSO reported to Transport Departme...
wpsadmin - All

Manage | Add

08 - Dec -2009 Surface Percipitation *

Water Quality In-Line Reporting *

mg/l

10

5

0

01/08 | 02/08 | 03/08 | 04/08

DATE

Treatment Plant

Report: Oxygen Dissolved   **Location:** All

Period: Daily Average   **Sub-location:**

Some areas that MQTT has been used…

HVAC Control

Chemical Detection

Trickle Feed

POS

Stock Checks

Field Force Automation

Asset Management And Monitoring

• Sales Force Automation
• Field Service Engineers
• Service Delivery

RFID

Fire Sensors

Pipeline Monitoring and Control

Parking Tickets

Flood Defence Warning

Kiosks

Vehicle Telematics

Home Automation

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

MQTT Demo
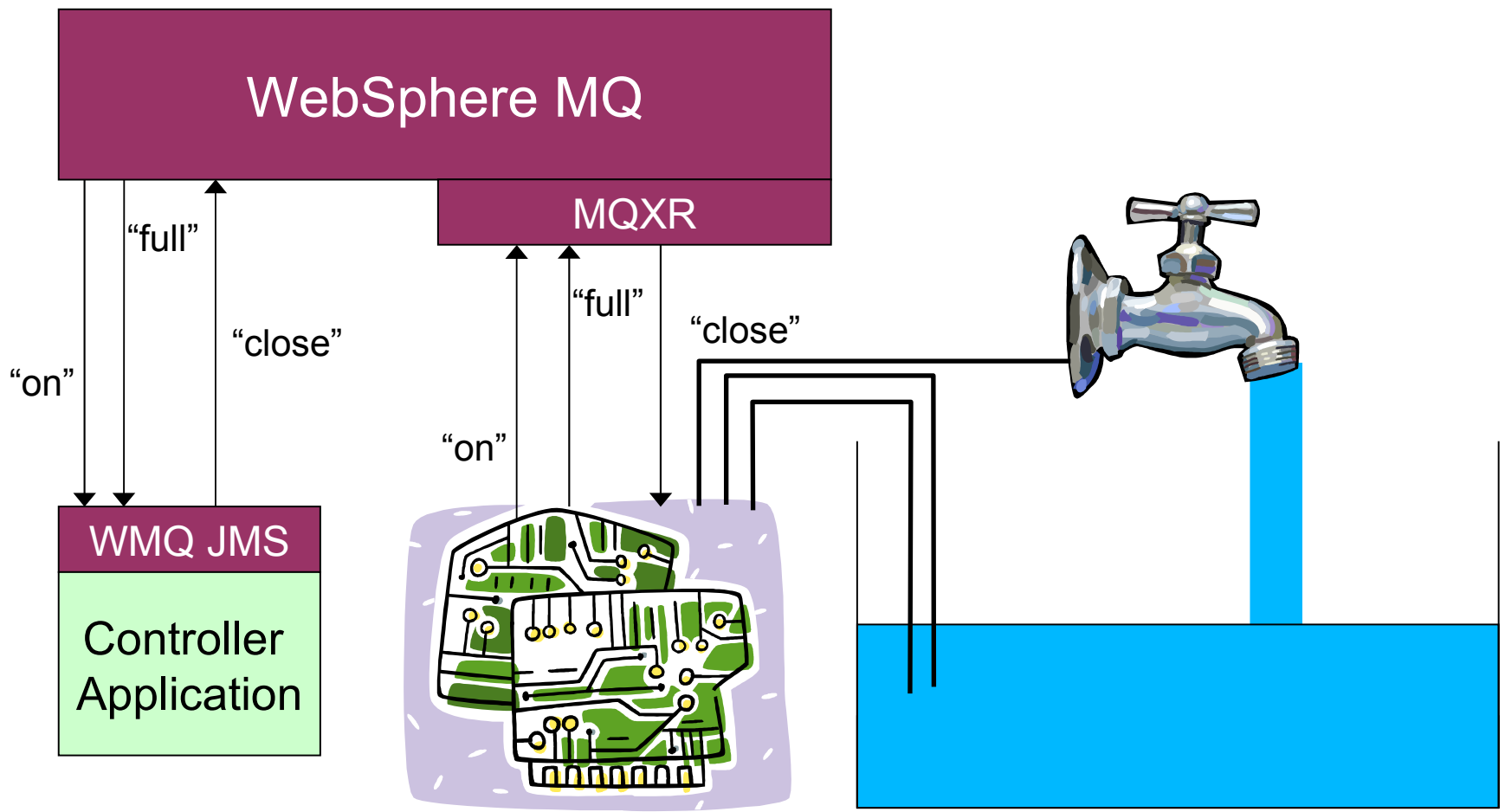
Thank you!

Contact: Simon Gormley sgormley@uk.ibm.com

http://www.ibm.com/smarterplanet

Please fill out your EVALUATION FORMS
This was Session 8910