OSGi / Java in Industrial IoT

More than a Solid Trend - Essential to Scale into the World of Internet Connected Things

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Internet of Things
An attempt to understand it …

• With all the hype around it, it certainly must be something new?

• If it is something new, why do we see so much of the “old” just in new colors?

• With the promise of being disruptive – enabling digital transformation and new business models - does it not require new ways of thinking and doing things?
IIoT Enables Digital Transformation

Re-Thinking

• Products
• Value Add
• Business Model
• Business Processes
• Technological / Architectural Approach
What is different ....
 .... from “traditional” M2M / OT Solutions

IoT is ...

• no silos – any thing talking to any application
• about re-architecting the underlying OT infrastructure
• leveraging computational power at the edge where it makes sense
• agility (flexibility, scalability) at the edge – in hardware and software
• an ecosystem play – there is no one size fits all, no company that has / knows it all
• about scaling – not just up but out
What is different .... .... from “traditional” M2M / OT Solutions

In order to achieve this, we have to encapsulate the complexity of IoT

IoT Solutions ...

• have to be built on open and industry standards
• require strong ecosystems & communities
• have to be built from building blocks that integrate seamlessly
• require a highly modular approach in software
• needs hardware / OS functionality abstraction
open and industry standards
strong ecosystems & communities
building blocks that integrate
modular approach
hardware / OS abstraction
Aspects we Highly Appreciate .... ...
and we Associate Names With!

eclipse

iot
eclipse.org

OSGi Alliance

Java

Excellent foundation!
Anatomy of M2M / IIoT Solutions
The Key Elements from an OT / Eurotech Perspective

World of IT and Applications

IoT / M2M Integration Platform

IoT / M2M Communication

IoT / M2M Device (Hardware, IoT Middleware, Applications)
Anatomy of M2M / IIoT Solutions
Putting Things in Perspective (Industry 4.0 Customer View)

- Customer Relationship Management (CRM)
- Warehouse Management System (WMS)
- Enterprise Resource Planning (ERP)
- Manufacturing Execution System (MES)

Core IT Infrastructure:
- Application Integration
- Process Handling
- Data Management

Other Applications

IT Infrastructure Management & Services

IoT / M2M Integration Platform

Data Warehousing / Big Data
Anatomy of M2M / IIoT Solutions

Fundamental Elements

• **IT centric, cloud based M2M connectivity platforms** as building blocks for enterprise IT

• Implement “Enterprise Service Bus for Machines” like architectures to allow an easy integration of different device data systems and applications

• **Multi Service Gateway approach** to integrate and consolidate data streams and future proof investments

• **IT centric application development** to implement business logic in smart edge devices / service gateways

• **Off the shelf purpose built devices** (also customized & custom) designed to meet vertical market value propositions
Further Aspects We Will Touch … … All Java & OSGi Enabled

- Scaling with Multi-Service Gateways at the edge: Java / OSGi based **IoT device middleware / application framework**
- **Ecosystem** of ecosystems **example**: Red Hat, Eurotech & Open Source
- Extending the Solution “Southbound”: **Kura Wires**
- More flexibility “Northbound”: **Multiple Cloud Clients**
- Experience shared: **predictive maintenance use case** in industrial environments
Multi-Service Gateway Approach
Automation, Integration & Computation at the Edge

- **Multiple** business relevant tasks can be performed and are technically consolidated
- Data delivery using a **open protocol** effectively decoupling data providers and data consumers
- **IT centric device application development** using **software frameworks / IoT middleware** to implement business logic in smart edge devices / multi-service gateways
- More **efficient bandwidth utilization** – carrier cost optimization
- Scaling with **hardware options** - designed to meet vertical market value propositions
Multi-Service Gateway Approach

IoT Middleware Kura (ESF) – Java & OSGi Based

Eclipse Kura is a Java / OSGi-based Application Framework for IoT Multi-Service Gateways that simplifies the design, deployment and remote management of embedded applications. ESF is Eurotech’s commercial offering based on Kura.

- Standards based
- Device, interface, network abstraction
- Device management & application management
- Connectivity management
- Field data acquisition
- Data aggregation, computation and efficient communication
- Available for third-party HW and open hardware (Kura Project Eclipse Foundation)
Multi-Service Gateway Approach
IoT Middleware Kura (ESF) – Java & OSGi Based

- Platform independent
- Modular
- Services – reusable and discoverable
- Easier integration into complex systems
- Secure execution environment
- Resource management
## Kura & ESF Developer’s Experience

<table>
<thead>
<tr>
<th>Emulate on PC</th>
<th>Deploy on Target</th>
<th>Cloud Managed</th>
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</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Laptop Icon" /></td>
<td><img src="image2.png" alt="Gateway Icon" /></td>
<td><img src="image3.png" alt="Cloud Icon" /></td>
</tr>
</tbody>
</table>
| Start developing your IoT /M2M application in the comfort of your PC.  
- Full Eclipse Integration  
- Target Platform Definition  
- Emulated Services  
- Run/Debug from Eclipse  
- Support Mac/Linux Hosts | When you are ready, deploy your application on the gateway.  
- One-click Deployment  
- Eclipse Plugin  
- Remote Debugging | Provision and manage your applications in field devices from the Cloud.  
- Remote OSGi Management via MQTT  
- Web-based Console |
Edge Flexibility, TCO and Investment Protection

- There is no “one-size fits-all” but an open software architecture that allow flexible options according to the customer specific application needs:
  - Wide range of HW options: performance, I/O and features
  - Across different chip architectures: from Intel to ARM
  - Any form & shape: from open hardware CPU-Board to SBC to certified device
  - Any Phase of IoT Implementation
    - Re-fitting existing devices / assets
    - New “IoT embedded” solutions – of the shelf and custom designs
  - Any level of complexity
    - From telemetry like applications to powerful software defined IoT Gateways and smart edge devices
Ecosystem: Red Hat & Eurotech & Open Source

Enterprise IT Experience & Products

Open Source & Open Standards

OT Experience & Products

IoT Solutions
Eurotech Commercial IoT / M2M Stack
Set of Integrated OT HW & SW Building Blocks

World of IT

IoT Integration Platform

MQTT
TCP/IP

Client

IoT Device Middleware
Device HW

IT Application Integration
Real-Time Data
Historical Data
Device Management
Embedded App Management
Connectivity Management
Security
Administration

Connectivity & Delivery
Administration
Embedded Application
Security
Network
Configuration
Field
Protocols
Basic
Services
OT Hardware Integration / Device Abstraction
Java / OSGi
Yocto, WR Linux,
Certified Modems
M2M / IoT
Gateways & Devices

TCP/IP

Eurotech Commercial IoT / M2M Stack
Set of Integrated OT HW & SW Building Blocks

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TCP/IP
Eurotech & Red Hat IoT / M2M Stack
Complete Set of Integrated OT HW & SW Building Blocks

World of IT

iot Integration Platform

MQTT

TCP/IP

Client

IoT Device Middleware

Device HW

JBoss Fuse

A-MQ

BRMS

IT Application Integration

Real-Time Data

Historical Data

Device Management

Embedded App Management

Connectivity Management

Security

Administration

Embedded Applications

Security

Administration

Connectivity & Delivery

Network Configuration

Field Protocols

Basic Services

OT Hardware Integration / Device Abstraction

Java / OSGi

Red Hat Enterprise Linux

Certified Modems

M2M / IoT Gateways & Devices

Hitachi High-Tech
Open Source IoT / M2M Stack
Complete Set of Integrated OT HW & SW Building Blocks
Constantly Evolving and Improving

- Extending the Solution “Southbound”: **Kura Wires**
- More flexibility “Northbound”: **Multiple Cloud Clients**

- Connectivity & Delivery
- Administration
- Embedded Applications
- Field Protocols
- Basic Services
- IoT Hardware Integration / Device Abstraction

**Kura Wires**

- TCP/IP
- MQTT
- Device HW
- IoT Device Middleware

**Kapua**

- Cloud Client
- Cloud Client
- Administration
- Network Configuration
- Field Protocols

**ESF**

- Java / OSGi
- Yocto, WR Linux

**Certified Modems**

- M2M / IoT Gateways & Devices
Extending “Southbound”: Kura Wires

- **Dataflow programming** – application logic is expressed as a directed graph
- **Application logic is simplified** to node connections
- **Modular**, extensible & flexible
- **Simplifies development tasks** – especially, but not only: sensor, actuator & other field technology integration. **Preliminary support** includes:

Logical connections between the Wire Components are known as **Wires**.
Flexibility “Northbound”: Multiple Cloud Clients

World of IT

- IoT Integration Platform
- MQTT
- TCP/IP

Client

- IoT Device Middleware
- Device HW

Cloud / Data Center

- Everyware Cloud

Extended device and embedded application management

- Connectivity & Delivery
- Administration
- Embedded Applications

- Security
- Network Configuration
- Field Protocols
- Basic Services

OT Hardware Integration / Device Abstraction

Java / OSGi

Yocto, WR Linux

Certified Modems

M2M / IoT Gateways & Devices

World of IT

TCP/IP

MQTT

Client

IoT Device Middleware

Device HW

Cloud Client

Cloud Client

Everyware Cloud

Connected Cloud

Cloud Client

Cloud Client

Administration

Embedded Applications

Network Configuration

Field Protocols

Basic Services

OT Hardware Integration / Device Abstraction

Java / OSGi

Yocto, WR Linux

Certified Modems

M2M / IoT Gateways & Devices

Everyware Cloud

Extended device and embedded application management

Cloud Client

Cloud Client

Administration

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Basic Services

OT Hardware Integration / Device Abstraction

Java / OSGi

Yocto, WR Linux

Certified Modems

M2M / IoT Gateways & Devices

Everyware Cloud

Extended device and embedded application management
Simple Analytics Integration

Connect Devices to Cloud

Data & Device Management

Multi-Service Gateways

Design your Reports and Dashboards

Generate the Aggregated Data

Analytics & BI Tools

IoT Integration Platform

PCN

PLC
Simple Analytics Integration

Generate from Everyware Cloud Console the OLAP cubes for BI tools like Pentaho

Depending on application scenario, different implementation scenarios need to be supported
Analytics / Pentaho Integration (Scenario 2)
Many Use Cases
Use Case: Industrial Predictive Maintenance
Predictive Maintenance Solutions
Selection of Use Cases

Health Monitoring and Failure Prediction of Gas Turbines (for Power Production)

Health Monitoring and Failure Prediction of Industrial Machines

Health Monitoring and Failure Prediction of Construction Machinery

Health Monitoring and Failure Prediction of Trains

Health Monitoring and Failure Prediction for Medical Equipment

Health Monitoring and Failure Prediction of Industrial Motors
<table>
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<th>Statement</th>
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<tr>
<td>Data Ownership</td>
<td>- Production companies consider their data as their know-how.</td>
<td>- Design for Edge-Cloud solution (On premise or on private cloud).</td>
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<tr>
<td>Inter Operability</td>
<td>- Production companies only like to share pre-processed and aggregated data outside</td>
<td>- Local preprocessing and integration to other application using secure pub/subscribe messaging (e.g. MQTT technologies)</td>
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<tr>
<td>Data Quality</td>
<td>- Existing data quality is rarely available at the beginning of a project</td>
<td>- Implement flexible data capture and fine tune it on the spot</td>
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<tr>
<td>Learning by doing</td>
<td>- Data Analytics is a «Iterative Process»</td>
<td>- Design for flexible local update of pre-processing required</td>
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<tr>
<td></td>
<td></td>
<td>- Start and learn. If you wait for perfect understanding, you will never start</td>
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## Key Learnings at HHT (2)

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<td><strong>Value Chain of Data</strong></td>
<td>-  Data and data analytics are only on part of the business value</td>
<td>-  Design open IoT module</td>
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<tr>
<td></td>
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<td>-  Design for «actionable results»</td>
</tr>
<tr>
<td><strong>Standards</strong></td>
<td>-  There are many standards, non of them is winner at the moment. Many will co-exist for quite some time</td>
<td>-  Go for practical approach. Learn and Adapt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-  Use, what best helps you</td>
</tr>
<tr>
<td><strong>Business Model</strong></td>
<td>-  Predictive Analytics creates core value, but may take long development time.</td>
<td>-  Plan for complementary values ( e.g. health monitoring)</td>
</tr>
<tr>
<td></td>
<td>-  «Real time» data capture is required for «Proof the Concept»</td>
<td>-  Plan for fast initial revenue streams</td>
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Lumada Platform

Digital Business Solutions

- Smart City
- Smart Industry
- Smart Healthcare
- Smart Business

Lumada - IoT Core Platform

- Advanced Analytics & Tools
- Stream & Batch Data Processing
- Core Components
- Application Integration
- Edge Integration
- Foundation

IT, OT & IoT Infrastructure

As-a-Service Models
Use Case – Industrial Motors

Machine health monitoring - Capturing in-use vibration of factory equipment allows monitoring and predictive maintenance...

Real-time alerts and historical analysis - Using the HHT Analytic tool provides characterization metrics between machines and operating environments, through the equipment life-cycle.
Use Case - using Java, OSGi & MQTT

Control Panel:
- Boundary variable
- Critical value
- Missing value treatment option
- Number of consecutive alarms
- Email notification address

Local data processing:
- FFT
- Data Analytics

IoT Gateway

Everyware Cloud

ERP

Alarms

Web Portal

Vibration Data
Use Case - OSGi Bundle

OSGi Bundles

Motor Monitor

Motor Monitor Configuration
- *port:*
- *port_mode:*
- *use_lct:*
- *window_size:*
- *ud_k:*
- *ld_k:*
- *alarm_threshold:*
- *publish_data:*

Motor Monitoring Service

Motor Monitor

Motor Monitor Configuration
- *port:*
- *port_mode:*
- *use_lct:*
- *window_size:*
- *ud_k:*
- *ld_k:*
- *alarm_threshold:*
- *publish_data:*

Motor Monitoring Service
Software Defined Machines

Source adapted from “Software gibt den Takt vor”, C. Kühnl in Mechatronic & Fertigung”, 2010
Conclusions, Summary

• The concept of a **Software-defined Gateway** or Multi-Service Gateway is very powerful. The ability to program smart edge devices (including gateways), leveraging a **Java/OSGi IoT Middleware like Kura** on abstracted hardware, offers substantial benefits to companies that need their value proposition extended to the IoT edge.

• The Software-defined Gateway does **require a dynamic changing of device software**, offering an effective application life cycle management. Remote **device** and embedded application **management is a significant part of the TCO** of IoT solutions. The use of **M2M / IoT Integration Platform** capabilities is improving overall cost and time-to-market significantly.

• IoT is an ecosystem play and we are part of a **powerful & productive ecosystem**
Conclusions, Summary

Eclipse IoT: Most complete Open Source Stack of Java / OSGi IoT Building Blocks

- Software-defined Gateway or Multi-Service Gateway
- M2M / IoT Integration Platform