Unleash the Potential of Industrial IoT
With Sparkplug

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About Me

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A comprehensive overview of the open-source IoT and Edge Computing platforms available at the Eclipse Foundation

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Agenda

➢ The Eclipse Foundation
➢ Interoperability in IIoT
➢ Sparkplug Overview
➢ Real-World Deployment
The Community for Open Innovation and Collaboration

Strategic Focus Areas

Cloud Native Java
We provide a collaborative environment for the world's leading Java ecosystem players to advance open source enterprise Java technologies for the cloud.

IoT & Edge
We enable industry leaders to collaborate on an end-to-end IoT architecture that is secure, flexible, and fully based on open source and open standards.

Automotive
We provide leading automotive OEMs, their suppliers, and partners with a sustainable, transparent, and vendor-neutral platform to collaborate on open technologies and standards.

Tools
The Eclipse IDE is the critical development environment for more than 6 million active users. Our community is innovating on the next generation of cloud native developer tools.
Open Source is Innovation at an Industrial Scale

**Commercial Adopters** focus resources on rapidly building differentiating features

**Technology Producers** jointly define roadmap and build core capabilities

**The Eclipse Foundation** provides an open, vendor-neutral environment to enable collaboration

$13+ billion of shared investment to date
Interoperability in IIoT
Software is eating the world
Openness creates ecosystems
Dream... and Reality

Enterprise Software

Looks Simple...

OT Data

Enterprise Software

It’s Difficult

OT Data

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Are We There Yet?

Traditional OT integration relies on polling/response

This wears your patience thin in the car...

...and wastes resources in the enterprise
Operational Technology **Data Challenges**

- Proprietary Protocols
- Multiple Data Formats
- No Contextual Information
- Designed for Operations
- Different Across Market Segments
- Poll / Response Data Retrieval
- Directly Coupled to Applications
- Isolated Networks
Information Technology Data Requirements

- Data Objects/Modeling
- Standard Data Formats
- Contextual Information
- Decoupled to Enterprise
- Publish / Subscribe Methodology
- Easy to Integrate
- Secure
IT vs OT

Information Technology

- Off-the-shelf
- Replaceable
- Frequent updates

Operational Technology

- Purpose-built
- Controls critical infrastructure
- Infrequent updates
The challenge is providing OT with the Tools and Technology to implement a solution that fulfill their requirements while fitting the architectures defined by IT.
What MQTT Offers

> Message Oriented Middleware
> Publish / subscribe infrastructure
> Invented for a real-time, mission critical SCADA solution

• Simple – Easy to implement on constrained devices
• Efficient – Use as little bandwidth and resources as possible
• Stateful – Method in which to save on bandwidth
• Secure* (leverages latest TCP/IP security technology)
• Open – No vendor lock-in
MQTT’s Interoperability Problem

The payload can be anything

The message can be anywhere

Are my devices actually online?
Sparkplug Overview
Interoperability for MQTT-based Industrial IoT solutions

- Standard Payloads
- Standard Topic Structures
- Session Management
Sparkplug Architecture

MQTT Server (broker)

SCADA / IIoT Host (Sparkplug)

MES (Sparkplug)

Historian (Sparkplug)

Analytics (Sparkplug)

MQTT EoN Node (Sparkplug)

Device

Sensor

Device

Device

4-20ma Input

Digital Output

Digital Input

Security

OT

IT
The Road to The Industrial Internet of Things

The "Internet of People" exploded due to two simple and open technologies:

**Hypertext Transfer Protocol (HTTP)**
An open protocol that defines "how" data can be transferred over the Internet.

**Hypertext Markup Language (HTML)**
An open specification that defines the structure of the data within HTTP messages.

For the "Industrial Internet of Things" to scale to its full potential the same type of open and simple technologies are needed:

**MQTT**
The dominant IoT messaging transport that is open and simple.

**Sparkplug**
An open specification that defines the structure and state of the data within MQTT messages.
Sparkplug Basic Principles

- **Publish/Subscribe approach**
  - Complete decoupling of devices and applications

- **Report by exception**
  - Reduces power and bandwidth requirements

- **Continuous session awareness**
  - Edge Nodes and Host applications advertise that they are now online or about to go offline

- **Birth and death certificates**
  - Relies on Last-will-and-testament feature of MQTT

- **Support for persistent and non-persistent connections**
Topic Structure

namespace/group_id/message_type/edge_node_id/[device_id]

Name to group nodes logically

spBv1.0
> "sp"
> [Payload encoding]
> [Encoding version]

> NBIRTH / NDEATH — Birth/death certificate for edge node. Birth: metric name, type, value for every metric. Death: all metrics marked as stale
> NDATA — Edge node data message. One or several metrics
> NCMD — Edge node command. Write metric on edge node.
> DBIRTH / DDEATH — Birth/death certificate for device.
> DDATA — Device data message. One or several metrics.
> DCMD — Device command. Write metric on device.
> STATE — Birth/death certificate of Host Application.
Payload Definition

> Payloads are always in binary

> Encoding: Google Protocol Buffers

> Encoding definition in .proto format

> JSON representation (right)

  - Metrics: Array of typed node or device metrics
  - Body: Arbitrary content (images, files)

```json
{
  "timestamp": 1641948773752,
  "metrics": [],
  "seq": 1,
  "uuid": "base64png",
  "body": "an array of bytes"
}
```
Metrics

> Defined as key/value/datatype

> Can add optional metadata and properties to them

> Sparkplug payloads can also contain DataSets and Templates.

  - DataSets: used to encode data matrices. You need to provide the number of columns, their names, and their types in addition to the data itself.

  - Templates: Allow you to define your custom data types

```json
{
    "name": "exterior_temperature",
    "alias": 130870,
    "timestamp": 1641950175801,
    "datatype": "Int8",
    "is_historical": false,
    "is_transient": false,
    "is_null": false,
    "metadata": {},
    "properties": {},
    "value": 23
}
```
DBIRTH and DDATA example

```json
{
    "timestamp": 1641940113424,
    "metrics": [
        {
            "name": "temp-value",
            "alias": 1,
            "timestamp": 1641940113424,
            "dataType": "Int8",
            "value": -24,
            "transient": false,
            "null": false,
            "historical": false
        }
    ],
    "seq": 1,
    "metricCount": 1
}
```

```json
{
    "timestamp": 1641940114576,
    "metrics": [
        {
            "name": "",
            "alias": 1,
            "timestamp": 1641940024394,
            "dataType": "Int8",
            "value": -25
        }
    ],
    "seq": 1
}
```

DBIRTH

DDATA
What Is an Eclipse Specification?

- Specification Document
- API
- TCK
- Compatible Implementation
- Compatible Implementation(s)

Combine

Specification
- Specification Document
- API
- TCK

Compatible Implementation(s)
Built in the Open

Sparkplug®
MQTT Topic & Payload Definition

Specification document
Technology Compatibility Kit (TCK)

https://github.com/eclipse/sparkplug

Open Source
Compatible Implementation

https://github.com/eclipse/tahu
Implement Sparkplug

Anyone can implement Sparkplug free of charge, no membership required.

Anyone can use the Sparkplug Technology Compatibility Kit (TCK) to validate conformance.

“Sparkplug”, “Sparkplug Compatible” and the logos are trademarks of the Eclipse Foundation.
Certify Your Products

1. Download, run and pass the TCK
2. Become a Foundation and Sparkplug Working Group member
3. Execute the Sparkplug Compatibility Trademark License Agreement
4. File a “Get Listed” request
5. Promote your product
Sparkplug Compatibility Program

Customer Confidence  Collaboration  Marketing Initiatives  Brand Development  Community Support
Real-World Deployment
Client: Waterford Township DPW

- **Serves 72,000 residents**
  - 360 miles (579 km) of water main and appurtenances
  - 355 (571 km) miles of sanitary sewer

- **System Consists of:**
  - 63 sewer lift stations
  - 19 production wells
  - 11 iron filtration pants
  - 2 elevated and 1 ground storage tanks
  - 1 high service pumping station
Legacy System

Legacy system issues
- Limited bandwidth
- Serial polling scheme
- Infrequent field activity

Problems needing a solution
- Data from each site only updated every 3-4 minutes, resulting in data loss and missed notifications
- Scaling up the system to more sites increased latency
Why Sparkplug?

> **Single source-of-truth**
>  - Tags at edge are defined, and available throughout entire system

> **No re-entry of tags in SCADA**
>  - All edge tags automatically available to subscribing software applications

> **State management**
>  - Status of all edge devices known

> **Device originating**
>  - Outbound comms, no device ports opened

> **Bi-directional**
>  - Devices able to receive messages from SCADA

> **Store & forward**
>  - In event of comms failure, edge storage of process data stored, and forward upon comms restoration

> **Efficient payloads**
>  - Binary encapsulated messages save bandwidth
Sparkplug Infrastructure

- Replaced old RTU/radio combo with groov EPIC/cellular modem
- Deployed over a private Verizon cellular network
- Hosted an Ignition MQTT broker on AWS cloud instance
- Encrypted all communications for MQTT/SpB messages with TLS
- Closed all incoming ports on EPIC except to trusted IPs
Results of Implementation

> Sub-second latency across entire system
> Decreased bandwidth consumption
> Never miss a system action or an alarm notification
> Timely operations, edge status, and diagnostics data
> More processing power at the edge
> Better fault-tolerance and disaster recovery
Implementation Partner

PC-based I/O (1980s)

Co-developer & Founding Member (1996)

Ethernet I/O (1990s)

M2M (2000s)
PACs (2000s)

EPICs & RIOs (today)
Join Us!

Follow us!
sparkplug.eclipse.org

Implement Sparkplug

Join the Sparkplug Working Group
Making IIoT Open and Interoperable, Together
IoT Architecture

CONSTRAINED DEVICES
- Sensors
- Actuators
- Device Update Management
- Hardware Abstraction Layer
- Operating System
  - Real-Time Operating System

DEVELOPMENT TOOLS
- Protocols
- Connectivity
- Security
- Hardware

IOT / EDGE GATEWAYS
- Remote Device Management
- Field Connectivity

EDGE SERVERS
- Machine Learning
- Edge Analytics
- Edge Applications
- Edge Orchestration
- Operating System

IOT PLATFORM
- APPLICATIONS
  - EdgeOps
  - API Management
  - Application Runtime

INTEGRATION
- Device Management
- Device Connectivity
- Data Integration

DATA
- Data Management
- Analytics
- Machine Learning
Where Eclipse Projects Fit

CONSTRUED DEVICES
- Sensors
- Actuators
- Device Update Management
- Hardware Abstraction Layer
- Operating System
  - Real-Time Operating System

EDGE
- IOT / EDGE GATEWAYS
  - Kura
- Field Connectivity
- Edge Analytics
- Edge Orchestration
  - ioFog
  - keplere
  - VOLLTRON
  - TAHU
- Edge Runtimes
- Device Connectivity
  - diotino
  - Javascript

EDGE SERVERS
- Remote Device Management
- Machine Learning
- Data Management
- Analytics

IOT PLATFORM
- APPLICATIONS
  - EdgeOps
  - ioFog
  - keplere

INTEGRATION
- Device Management
- Device Connectivity
- Data Integration
  - Eclipse Dataspace Connector

DATA
- Storage
  - sql
  - NoSQL
  - Hadoop

DEVELOPMENT TOOLS
- Security
  - Hardware
- Eclipse Che
  - Theia
- Milo
  - Mita
  - MRAA
  - upm

CONNECTIVITY
- Protocols
  - LESHAN
  - milo
  - mosquitto
  - paho
  - TAHU
  - unice
  - w
  - Zenoh

SECURITY
- Hardware

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Thank You

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