Application of FLEDGE at Neuman Aluminium: An Industrial Use Case

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Center for Digital Production - Research

1. Digital Engineering
   - Merge Design & Manuf.
   - Data Driven Design
   - Digital Twin Fidelity
   - „Wear-aware“ CAM

2. Adaptive Manufacturing & Smart Factories
   - Reconfigurability
   - Process Adaptability
   - Predictability
   - Shop Floor OS

3. Process-Based Manufacturing Orchestration
   - Orchestration & Data
   - Process based PLM
   - Deployability (HMI)
   - Data Contextualisation

4. Data Integration and Analytics for Digital Production
   - Interoperability
   - Advanced Analytics (AI)
   - PMV based Analytics
   - Knowledge Graphs

5. Sustainable Production Systems
   - Flexible Safety
   - Fail-safe Manufacturing
   - Circular Economy
   - Production as a Service
The Neuman Aluminium Group is your global partner for high-quality aluminium solutions.
Application Scenario

Scenario:

• Multiple Production Facilities in Europe
• Controlled by a Centralized MES
• MES Submits a Production Order to a Facility
• Machine Processes the Order and Notifies MES of Current Production Status
• MES Sends Data to a Subsequent Machine
• Once the Connection to the MES is Lost, Production will Continue as long new Input is Required

The centralized nature of the system creates a critical dependency on the network connection!
Architecture Variants
Roadmap for connected Production Systems (Neuman)

Open-source software stack to deliver device, core, application and supporting services for production equipment.

Self-healing, scalable, upgradable, flexible, platform independent and offline capable edge devices.

Knowledge or/and ML driven smart edge devices to semi-autonomously control machine, forward data and adjust production equipment.
Mapping Vision to Architecture

**Infrastructure Orchestration & Distribution**

- **Edge Device N**
  - **Edge Device 1**
  - **kubernetes**
  - **Rule Engine**
  - **ML Application**
  - **Low-Code Platform**
  - **System Monitoring**
  - **Transaction Manager**

**Plug-Ins:**
- REST
- S7
- OPC-UA
- MQTT

**Cloud**
- **Semantic Search**
- **Data Analysis**
- **ML Model Training**

**Plug-Ins:**
- **Data Streaming Service**
Fledge as Transaction Manager

Fledge...

... is open source.

... delivers data to different cloud services.

... collects data from any sensor.

... aggregates, combines and organizes data.

... transforms and filters data.

... buffers data & resends after connection is reestablished.

... is highly performant and resource efficient.
Current Project Status

EDGE Device

Grafana + Kibana

API + UI

Node-RED

Fledge stores the machine and production state.

Fledge forwards data to next machine or/and cloud services.

State Management

State

qty: [cnt1: 112, cnt2: 122]
state: (Hand, Automatik, Teilautomatik)
prematerialNr: 2345345
handlingUnit: 2343234
job: {ID: P43000, product: S5445, …}
quality: [{Part: 3222, state: ok}]

Machine UI triggers action to manipulate production state.

Actions

States

Machine UI triggers action to manipulate production state.

Fledge stores the machine and production state.

Fledge forwards data to next machine or/and cloud services.
New Fledge South S7 Plug-In
The plug-in is used to read data from a Siemens S7 PLC.

Features:
- Read Various PLC Data Types
- Arrays
- Objects/ Structs (UDTs)
- Array of Objects
- Optimized Reading of Data as Blocks

Output:
- JSON Object /
- Escaped String
- Flat Variable List

New Fledge North S7 Plug-In
The plug-in is used to write data to a Siemens S7 PLC

Features:
- Write Various PLC Data Types
- Verification: Write + Read
- Add Static Datapoint to Asset
- Limited Bool Support because of Snap7 -Python Library
Redux Data Flow

State Management

Redux Principles:

• Single Source of Truth: The state of your whole application is stored in an object tree within a single store.

• State is Read-only: The only way to change the state is to emit an action, an object describing what happened.

• Changes are made with pure functions: A reducer is a central place where state modification takes place. Reducer is a function which takes state and action as arguments, and returns a newly updated state.
New Fledge Rule Plug-In

The rule is used to detect if a data point is different from its previously received value within an asset.

Features:

- Configurable to Monitor Multiple Assets
- Can be Configured to Rename Data Points

New Fledge Notification Plug-In

The notification is used to create a new asset based on data previously received from the rule plugin and the assets already collected by Fledge.

Features:

- Configurable Asset Name to Create
- Can be Configured to Choose which Assets and Data Points Should be Used to Create the New Asset.
- Can be Configured to Rename Data Points
- Can be Configured to Authenticate against the FLEDGE REST API.
Developed and Relevant Fledge Plug-Ins

Developed by ACDP

• Transaction Manager
  • **fledge-south-s7-python** https://github.com/kropatschek/fledge-south-s7-python.git
  • **fledge-north-s7-python** https://github.com/kropatschek/fledge-north-s7-python
  • **fledge-north-opcuaclient** https://github.com/kropatschek/fledge-north-opcuaclient

• State Management
  • **fledge-rule-delta** https://github.com/kropatschek/fledge-rule-delta.git
  • **fledge-notify-customasset** https://github.com/kropatschek/fledge-notify-customasset.git

Provided Plug-Ins by FLEDGE

South
  • **fledge-south-http** https://github.com/fledge-iot/fledge-south-http.git
  • **fledge-south-opcua** https://github.com/fledge-iot/fledge-south-opcua.git
  • **fledge-south-modbustcp** https://github.com/fledge-iot/fledge-south-modbustcp.git
  • **fledge-south-mqtt** https://github.com/fledge-iot/fledge-south-mqtt.git

North
  • **fledge-north-kafka** https://github.com/fledge-iot/fledge-north-kafka.git
  • **fledge-north-opcua** https://github.com/fledge-iot/fledge-north-opcua.git
  • **fledge-north-http** https://github.com/fledge-iot/fledge-north-http.git

Notification
  • **fledge-notify-asset** https://github.com/fledge-iot/fledge-notify-asset.git
  • **fledge-rule-delta** https://github.com/kropatschek/fledge-rule-delta.git
  • **fledge-notify-customasset** https://github.com/kropatschek/fledge-notify-customasset.git

Filter
  • **fledge-filter-asset** https://github.com/fledge-iot/fledge-filter-asset
  • **fledge-filter-delta** https://github.com/kropatschek/fledge-filter-delta.git
  • **fledge-filter-expression** https://github.com/fledge-iot/fledge-filter-expression.git
  • **fledge-filter-change** https://github.com/fledge-iot/fledge-filter-change.git
Demo
Learnings

Performance
- We tested FLEDGE with sampling rates of 50 ms.
- FLEDGE is very resource efficient, runs on a Raspberry Pi.

Flexibility
- The current approach supports a variety of architecture concepts.
- The services and plug-ins of FLEDGE can be combined to cover a big variety of use cases.
- Supports multiple protocols south and north.

Extendability
- Plug-Ins can relatively easy be developed after an initial training period.
- Other plug-ins can be used as templates.

Usability
- Documentation provides great support for users.
- Community is helpful and open to new contributors.

Open Challenges
- Better open-source tool support for monitoring and orchestration of edge devices.
- Improvement of FLEDGE Documentation for Developers.
Trust open-source and start to adapt and improve FLEDGE!!!
Feedback Develop and Debug FLEDGE Plug-Ins

- Documentation for developers should be extended.
- Logger cannot be stopped manually from the GUI to look at specific error messages. All Plug-Ins must be stopped sometimes to catch the error message.
- Only single log pages can be viewed and the search only works page wise.
- For debugging North Services Node-RED is a useful tool.
- Debugging North Services can be tricky since sometimes after reconfiguring North Services the Service runs into unpredictable states.
- Cannot set debug level via GUI for python plug-ins.
- There is no option available to clean the log if it is full.
- Importing other fledge configurations is not supported and exporting only the configuration is not supported.
- Increase community for testing FLEDGE or develop more unit tests.
- Provide more sample code for plug-ins.
- It is difficult to overview what classes can be used and how to achieve a certain goal.