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Enabling IoT Condition Based Monitoring at Vattenfall Hydro

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Introduction to Vattenfall

The History of Vattenfall Hydropower

- First hydropower station was started in 1910
  - Trollhättan (Olidan) 1910
  - Älvkarleby and Porjus in 1915 (shown)
- They are still in operation!
- In total Vattenfall Hydro Nordic own and operate about 50 hydropower stations, with more than 130 large scale hydropower units.

Status of the Fleet

- Most of our units were constructed between 1950 to 1975
- The lifetime of a unit is normally 40 years or more.
  - Then a larger refurbishment takes place to provide another 40 years of operation.
- Most of our units has been renewed at least once.
- The long history and operational lifetime of a hydropower unit results in a large technical variation seen over our fleet of units.
  - This is of course also true for the control systems, which basically spans four decades of improvements and developments.

Keeping up With Development

- The long lifetime of a hydropower and the fast development within IT and Industry 4.0 creates a situation where only a minor part of our fleet is up to date in terms of digitalization.
- And due to our way of working we will always remain behind - seen over our entire fleet.
- Thus, there is a great need for a strategy and method for retrofit and digitally upgrade assets prior to our 40 years overhaul cycle.
- To address this dilemma a yearlong Proof of Concept (PoC) study called “IoT for Vattenfall Hydro” was started.

PoC IoT for Vattenfall Hydro

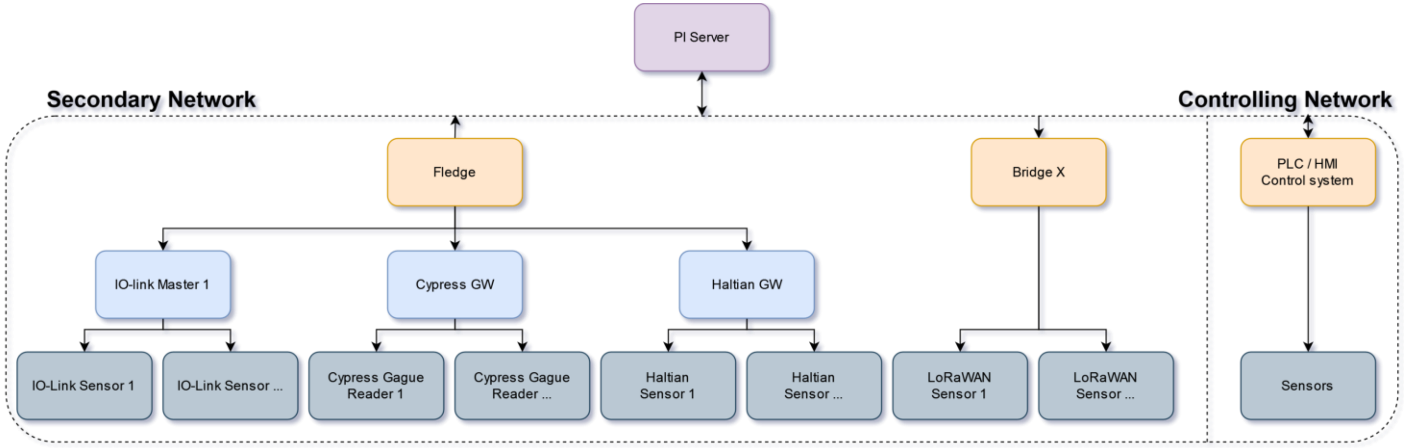
Goals defined for the PoC:

- Build a secondary network that enables testing of IoT* based sensors on site (which is separated from the controlling network).
- Test different types of IoT's on an older hydropower unit with few existing measuring points.
  - Prove that it is possible to retrofit and upgrade the level of digitalization on an older unit using IoT's.
  - Field test different types IoT sensors and gateways on site.
  - Bring data from sensor into our PI System.
  - Improve our existing method of working (speed of implementation and cost).
- Our test site, Laxede power station – 3 units of different age.

* IoT = Internet of Things. We have made the choice to use IoT as a collecting term for all our sensors tested in the secondary network, rather than categorize them into IoT/II0T/other type of sensors.

Scope of Work

- During the PoC we have tested several brands and concepts of IoT sensors.
- We have developed a system for transferring IoT data into our PI System in a secure and efficient way.
- Some IoT's were good some were not.
- There are several possible choices for data concentrator solutions, but no single commercial "of the shelf" solution at the start of the PoC.
- In this presentation we will focus:
  - How to automate and streamline the implementation of new sensors in our secondary network.
  - Show examples on how IO-link sensors can be used.
  - Present how FLEDGE can be used as a data concentrator.



What type of sensors were tested

- Sensor types:
  - IO-link based (via IoT port), industrial standard.
  - Haltian wireless mesh communicating sensors.
  - LoRa-Wan sensors
- What was measured:
  - Common process values, such as temperature, flow, level, pressure.
  - Vibrations monitoring on rotating machinery.
  - Environmental parameters, temperature and humidity.

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Introduction to BnearIT

BnearIT

A consultancy agency from the northernmost part of Sweden

- Founded in 2002
- System developers, engineers and architects.
- Specialized in Service Oriented Architecture.
- Working in fields such as:
  - Aviation
  - Energy
  - Mining
  - Production
  - Telecom

Implementation of the IoT Solution

Prerequisites of the Implementation

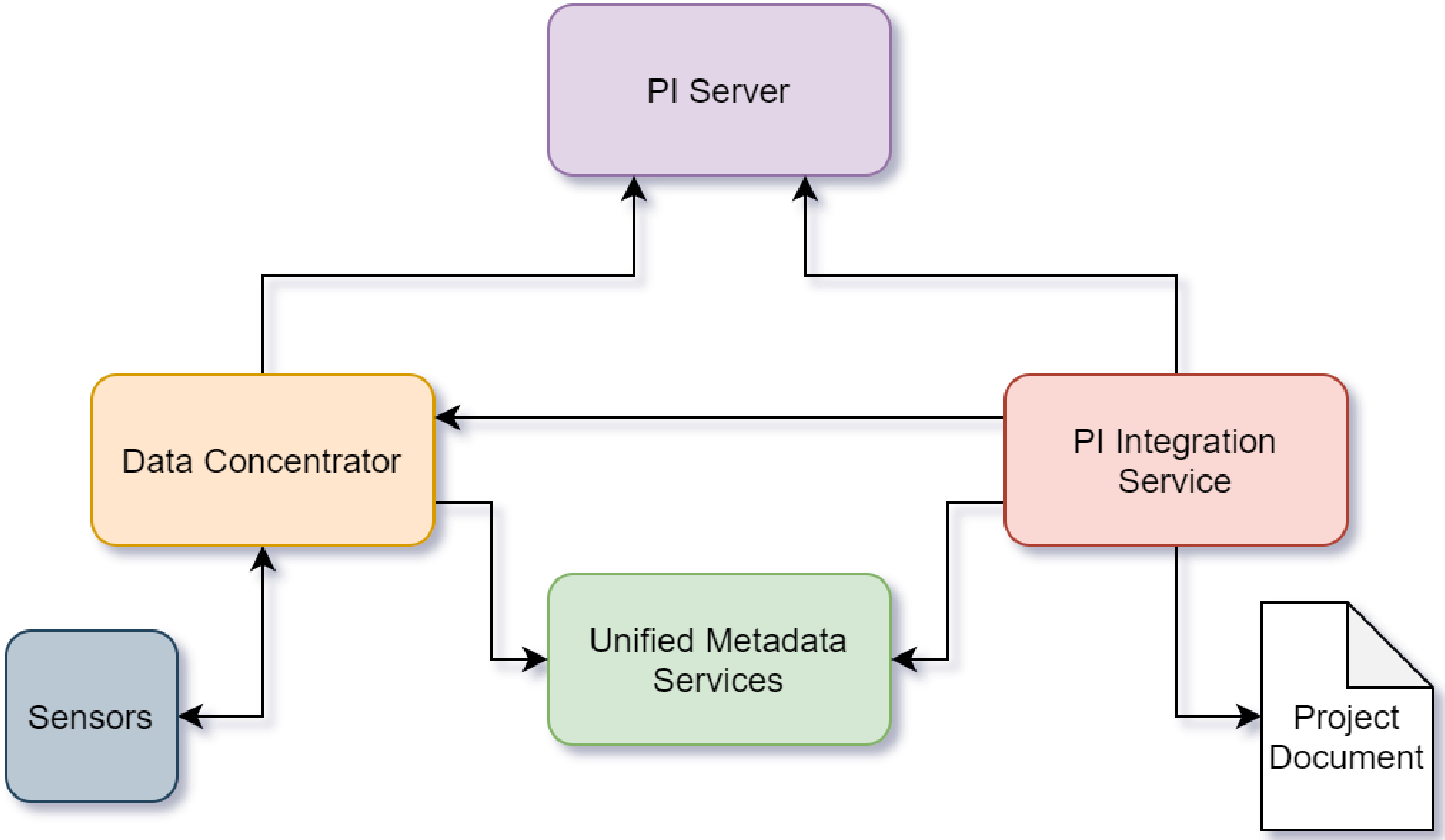
Requirements and limitations

- Data Archive PI Point naming should follow existing Vattenfall Hydro site standards.
- On-prem solutions using a secondary network.
- Ability to generate Asset framework (AF) structures.
- Ability to continiously push real-time data to the PI System.
- Leverage existing project documentation to speed up the integration process.

Architecture Overview

Data and assets: The two central parts of the architecture

- Service Oriented Architecture
- Data-centric design
- Containerized deployment



Unified Metadata Services

Finding and serving metadata to the system

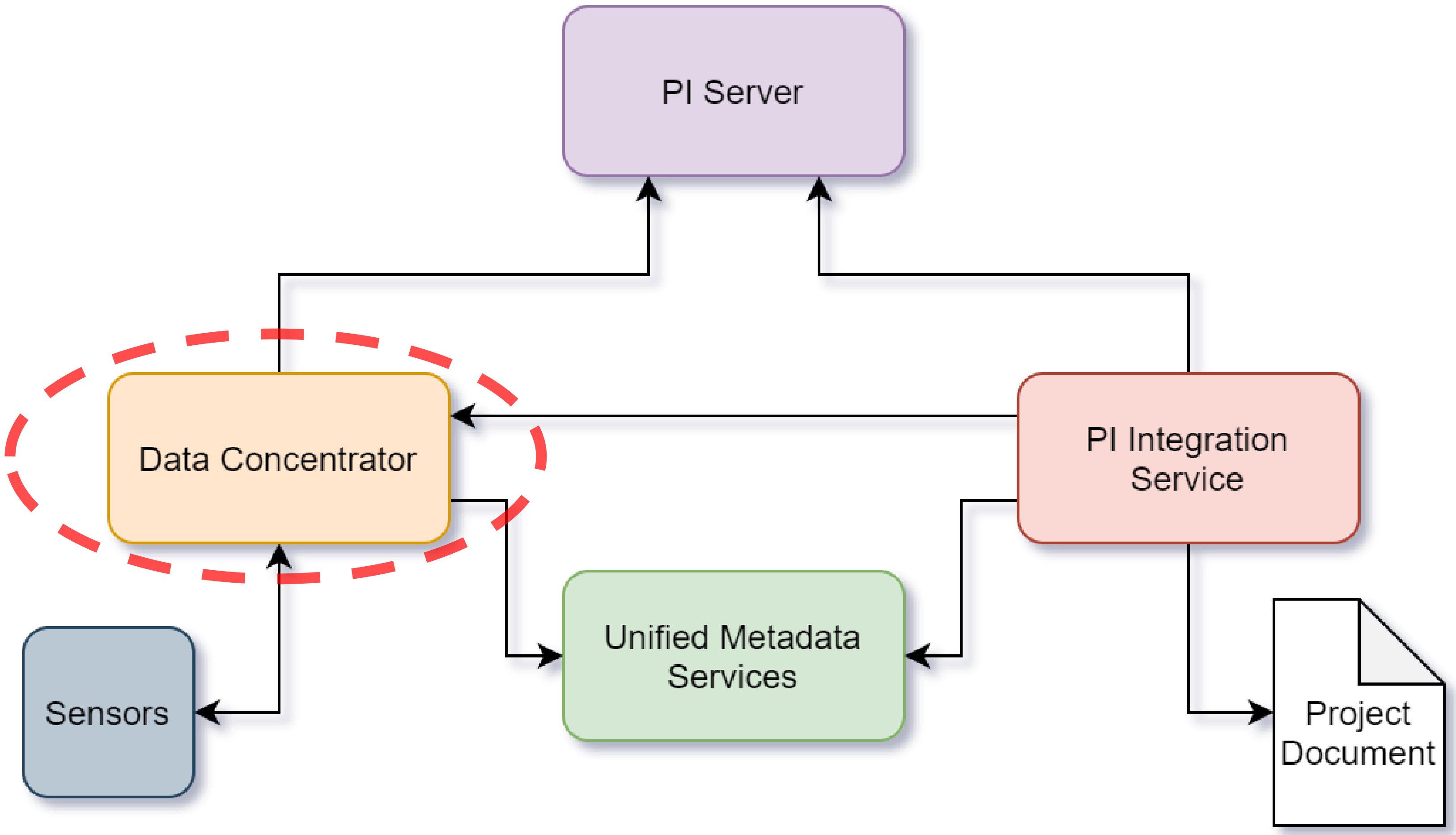
- Unified interface for fetching metadata for different sensor types.
  - IODD with IO-Link
  - Legacy file-structure parsing
  - Manual metadata entries

- Metadata required for each data point
  - Method for parsing raw sensor value
  - Units for the type of measurement
  - Format for which the value should be displayed

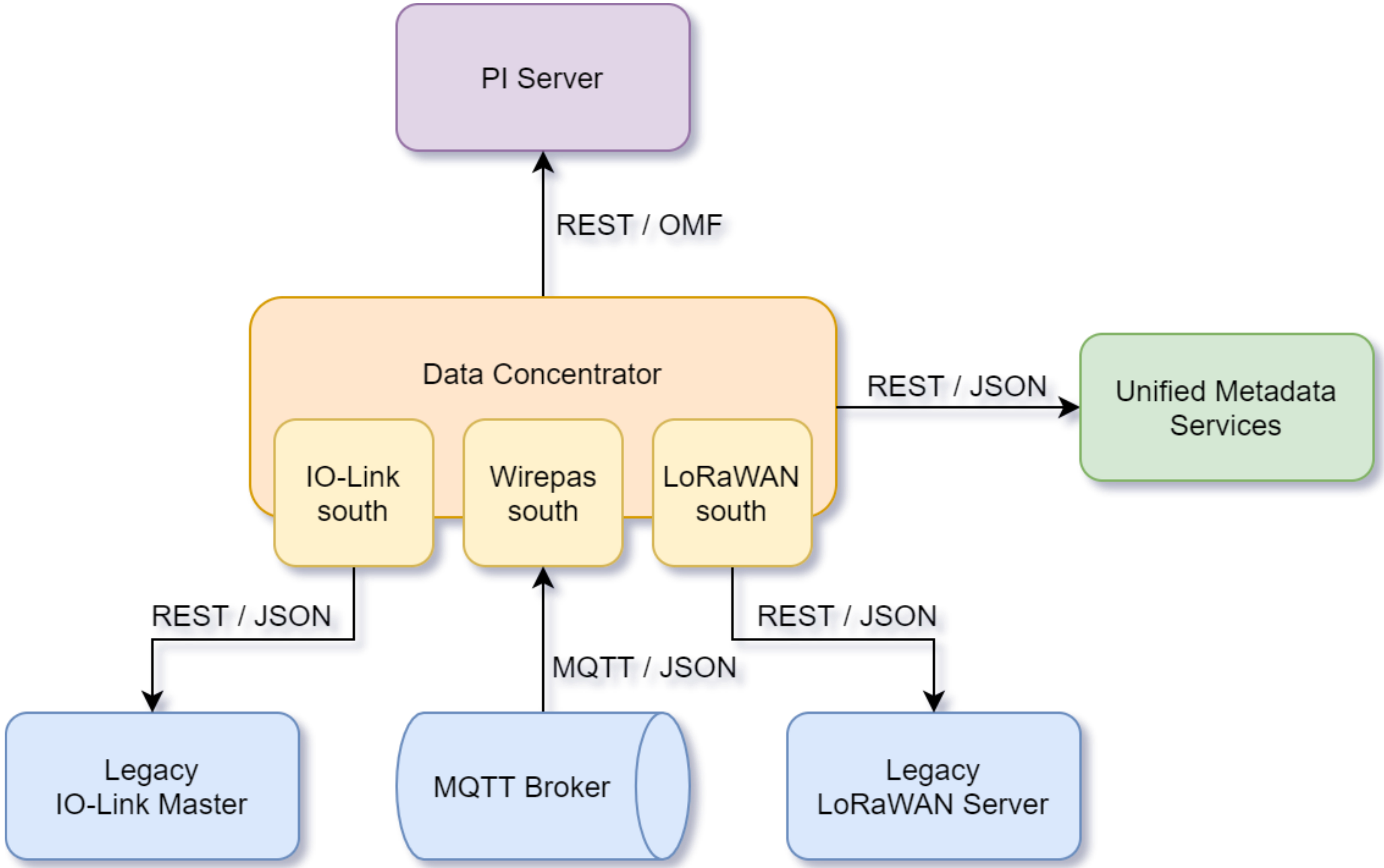
Data Concentrator

Data concentrator

Data transfer agent



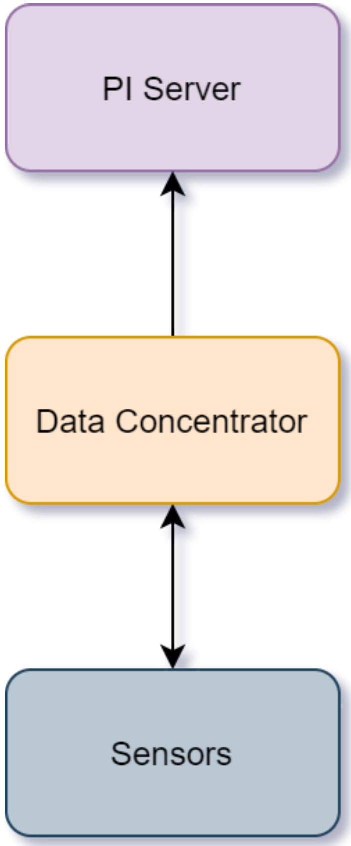
Data Flow Detailed Architecture



Data Concentrator

The choice of going with a product or a project

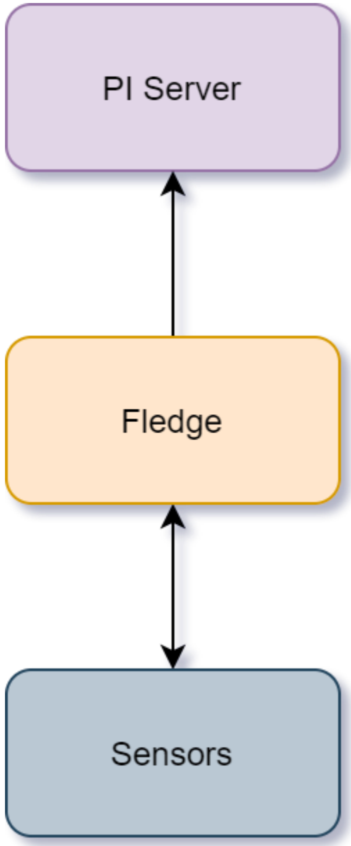
- Investigated two different products
- One excluded for not meeting project requirements
- The other had...
  - Issues with security
  - Plugins ran on a 20-year old Java VM
  - Problematic customization to fit the project requirements
  - Capacity issues, even when trasmitting low amounts of data



Data Concentrator

Fledge: The open source alternative

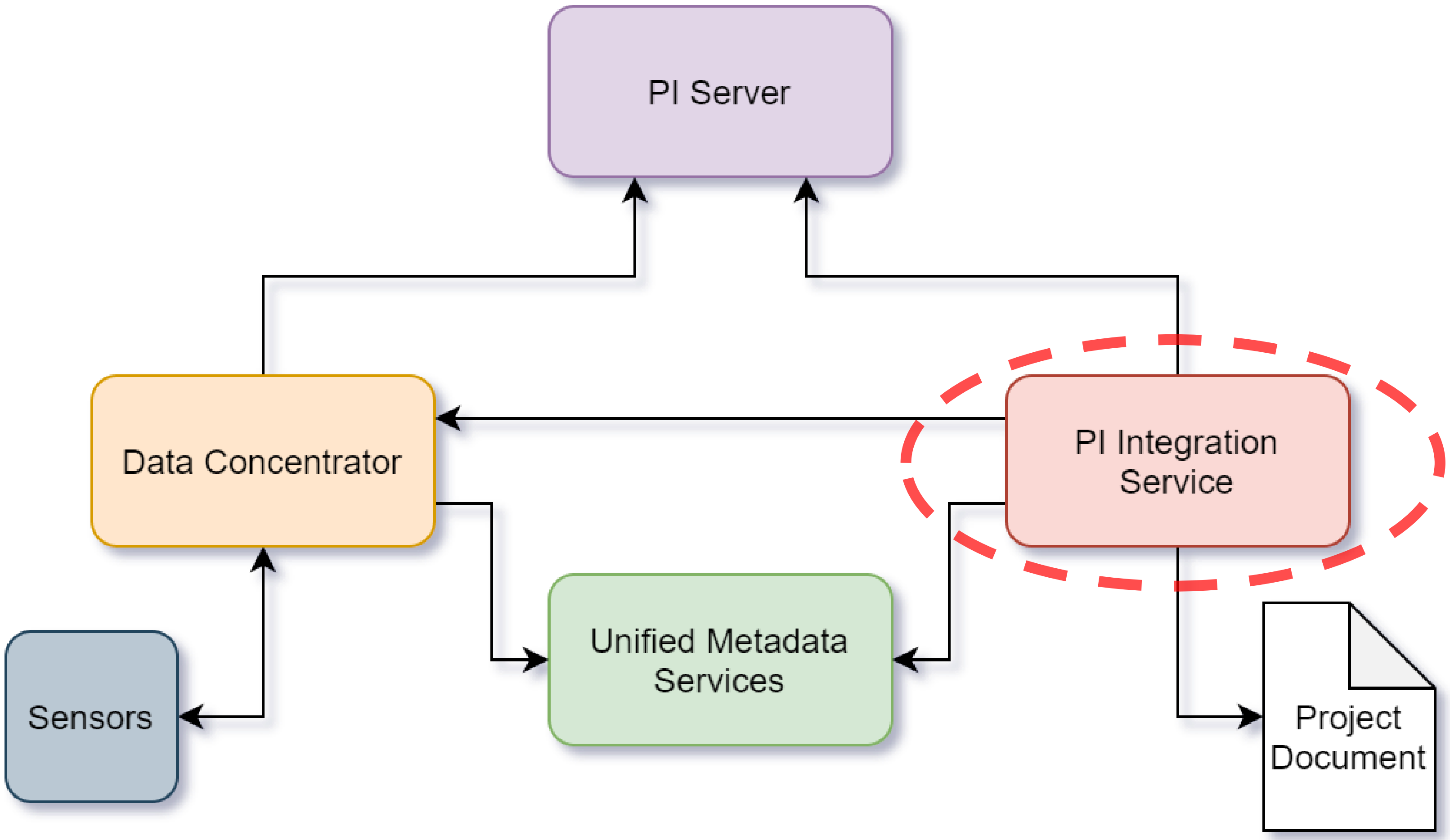
- Fully open source project
- Managed by the Linux Foundation
- Functional plugin framework
  - North plugins for data transmission
  - South plugins for data collection
- Capacity to transmit real-time data 1000-folds what was previously tested
- Constantly improved and developed



PI System Integration Service

PI System Integration Service

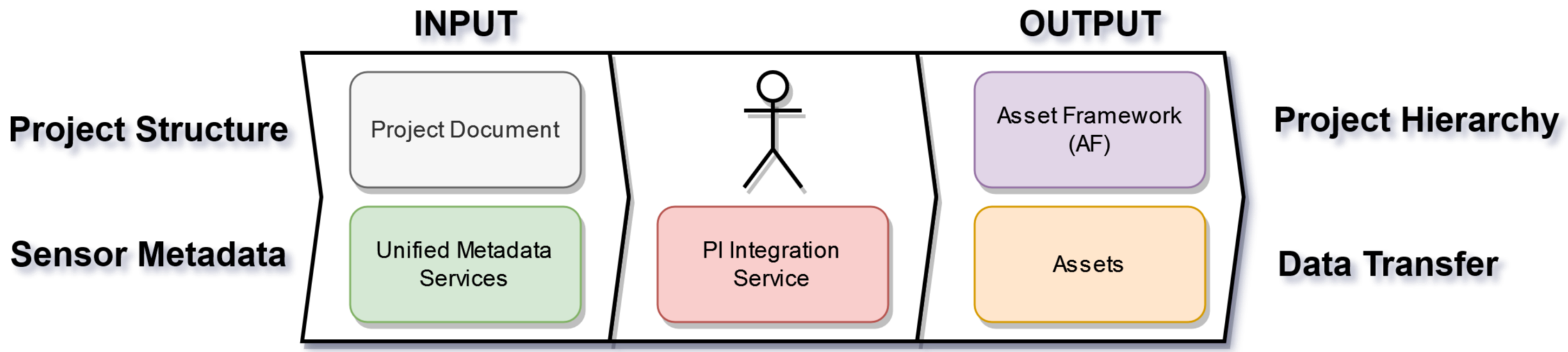
The common denominator



PI System Integration Service

Creating context to domain- and hardware-specific information.

- Command line application
- Portable.
- Configurable and modular.
- One set of inputs may generate multiple sets of output.



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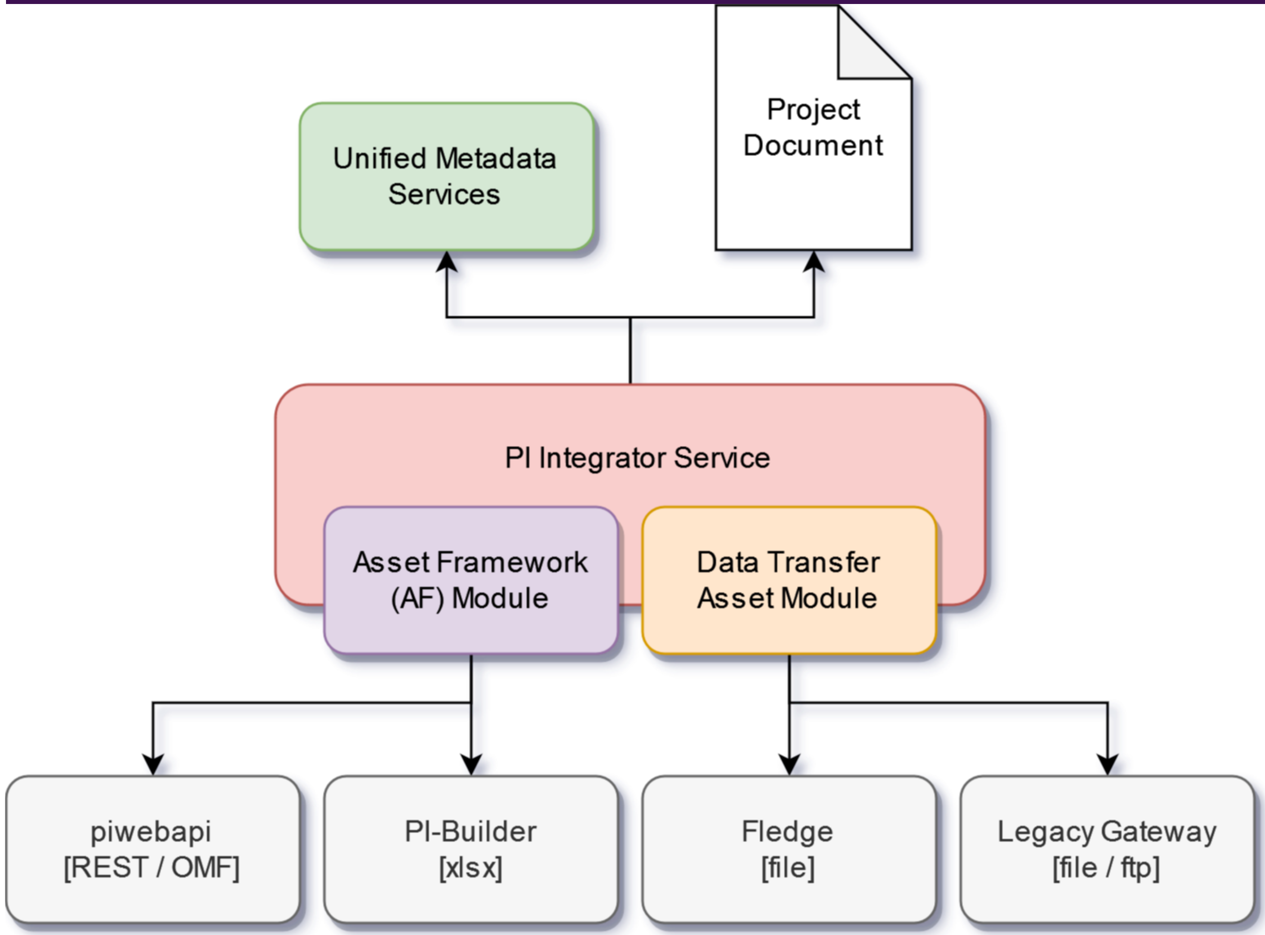
PI System Integration Service

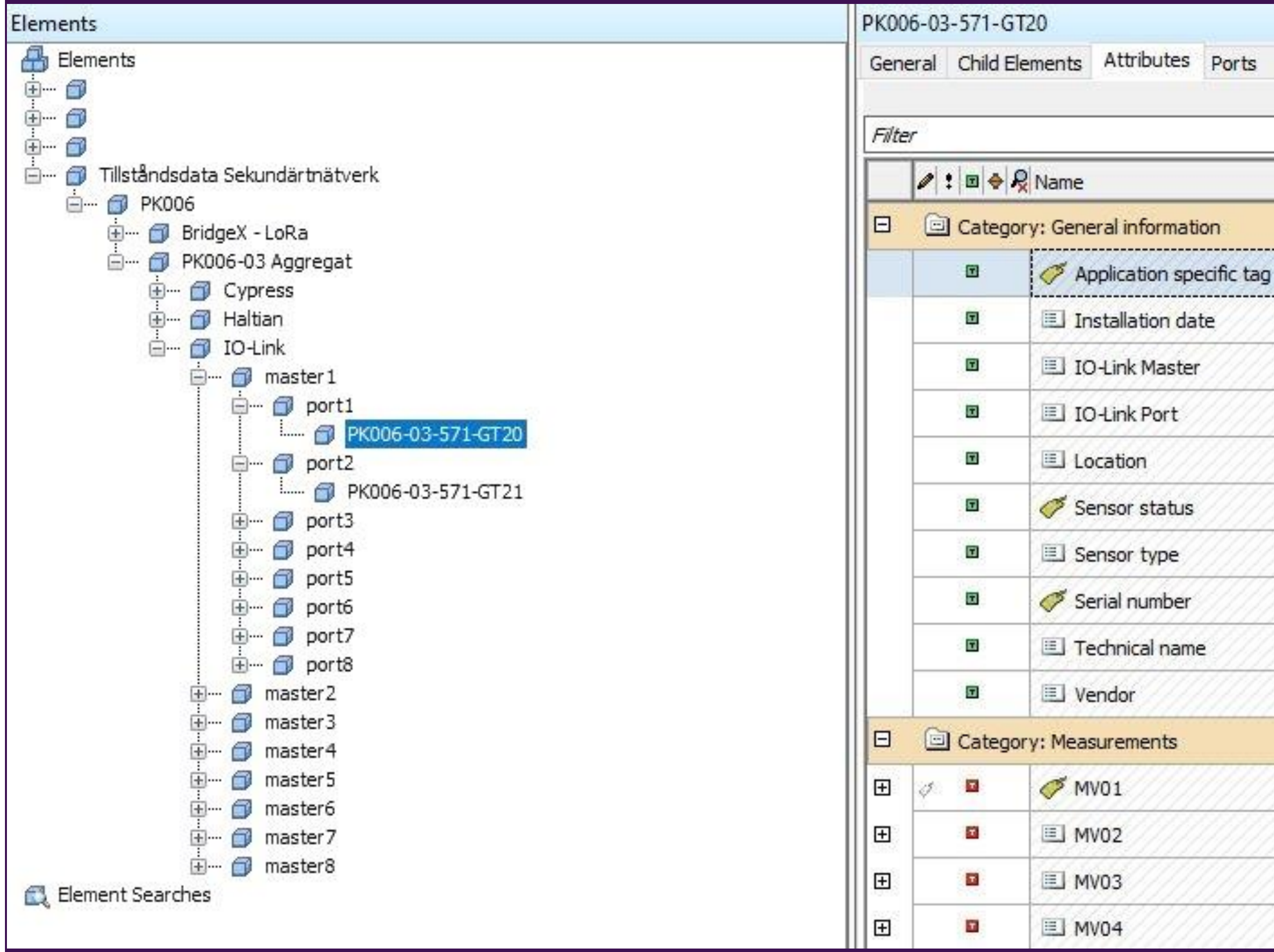
- Project document
  - **Domain specific information**. [names, locations, traits, descriptions, connections]
- Unified metadata services
  - **Sensor specific information**. [units, scaling, offsets, intervals, special handling]
- Asset framework (AF) Hierarchy.
  - Metadata enriched hierarchies, references PI-points.
  - Different hierarchies, ordering and structure depending on configuration.
  - Output formats: Excel PI-Builder, Piwebapi
- Data transfer assets.
  - Generates device specific asset files, specifies how to transfer data.
  - Output formats: Files, REST calls.



Asset Framework (AF) Output

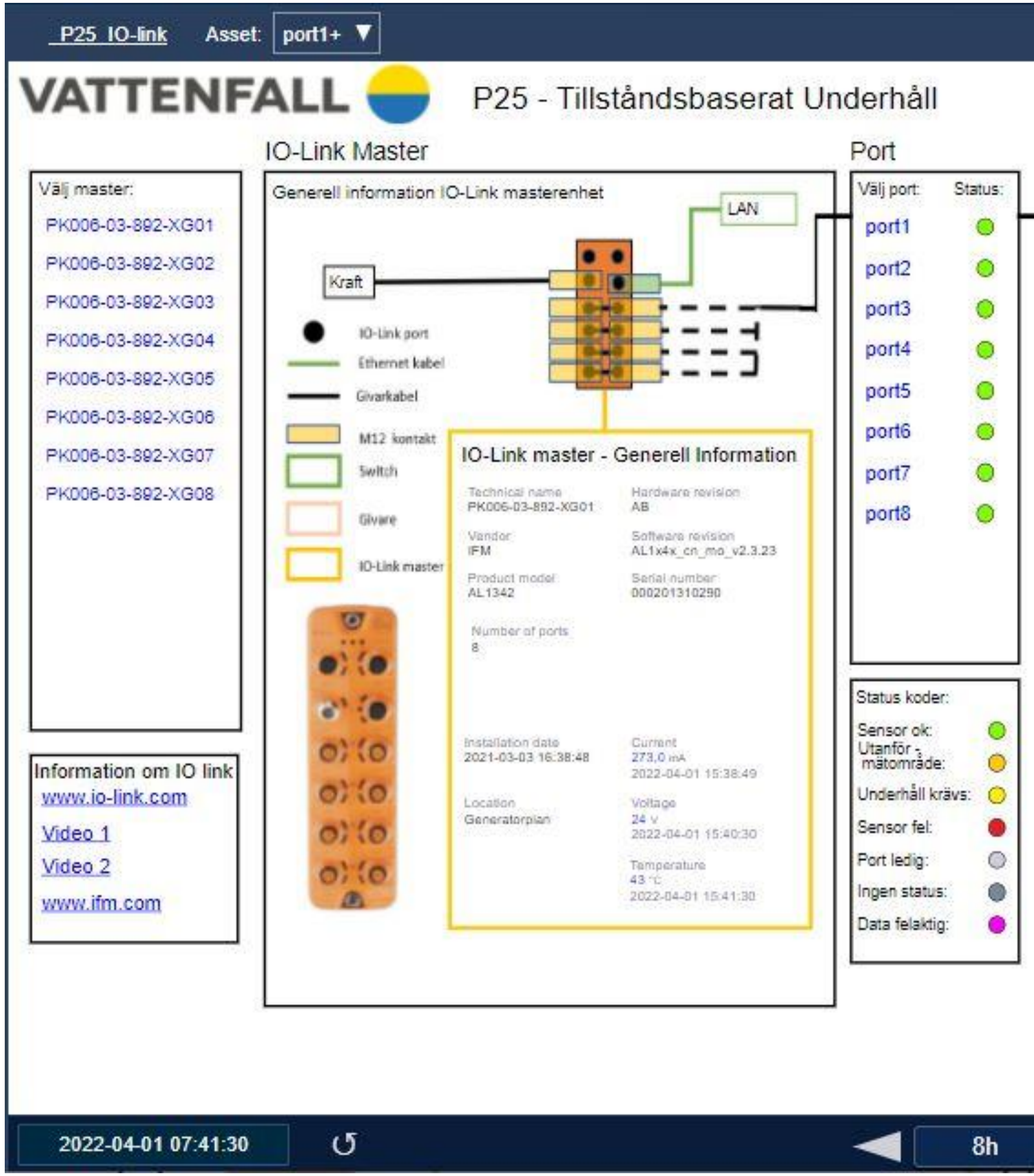
Example Hierarchy

- Sensor type hierarchy example.
- Static- and dynamic elements.
- Vattenfall naming standards
- Domain-information attributes
- Sensor specific attributes
- Sensor- and gateway status attributes.



PI Vision Display for IO-Link

- IoT's visualized in PI Vision
- IO-link based example
- Measurements, sensor- and gateway status data.
- Template approach



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Summary

Impact of the Project

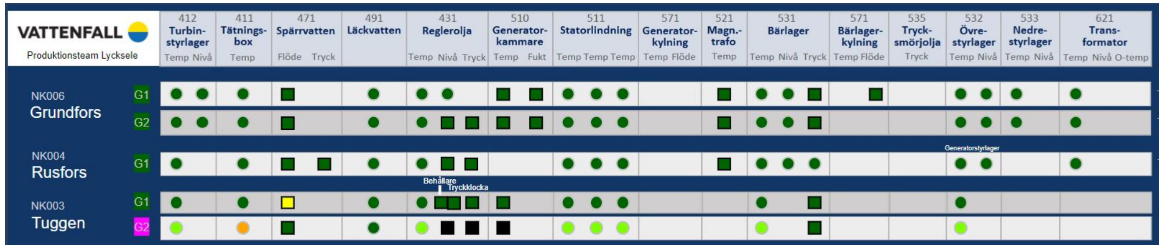
- Secondary network
  - Increases time savings.
  - Lowers the need for IT-personel, security configuarations and software adjustments.
  - Reduces the amount of stakeholders, project complexity and dependencies on external actors.
- Electrical installation
  - Plug-n-play sensors with quick-connectors allows for fast installations, simple documentations and schematics.
- PI-integration
  - Uses already established project documents to semi-automatically generate Asset Framework (AF) hierarchies and data transfer assets.

Conclusions

- At the end of the PoC period the findings and results were evaluated:
  - We managed to meet all our project goals, in full or in part.
  - We are especially satisfied with the performance of the IO-link system.
  - The Fledge gateway impressed on us, both in performance and in simplicity of use and implementation.
  - The cost of implementation per measuring point is significantly lower compared to our existing method.
- Vattenfall Hydro now plan for a larger roll out.
  - The goal is to close the gap between our current state with too few measuring points and the desired state. The goal is to reach a level where efficient digital Condition Based Maintenance is possible for all our hydro power plants.
  - Further improvements of the working process will be made.
  - Although good results will we probably not use Fledge as our main type of gateway.

Number of PI-points in Laxede

	Laxede G1	Laxede G2	Laxede G3
Before PoC	321	385	166
After PoC	321	385	**251**



Enabling IoT Condition Based Monitoring at Vattenfall Hydro

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Challenge

The long history and lifetime of hydropower units create a situation with a large technical and digital variation seen over Vattenfall's entire fleet.

An efficient condition monitoring requires sensor data, and preferably all units should be on similar level. Today there is a large gap.

Solution

Use a secondary network in order to allow IoT based sensors to retrofit and complement missing CBM measuring points on an existing hydropower unit.

We utilized existing AVEVA PI System tools and open-source software, Fledge, to connect and transferer real time data into our PI System.

Benefits

We show how to overcome the gap in measuring points on existing units without the requirement of a large refurbishment.

The PoC shows that this way of working is significantly cheaper and more efficient compared to Vattenfall's traditional methods.

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