

AIKO workshop 5

Data Contextualization for AI with OPC UA

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Agenda

1

Intro

2

OPC UA

3

Information
Modeling

4

AI with
OPC UA

Prosys OPC



- Founded in 1995
- Global expert in
 - OPC UA solutions and information modeling
 - IT/OT integration
 - Industrial Security
- An active member of the OPC Foundation and Open Industry 4.0 Alliance



- 50+ countries
- 1000+ customers

Jouni Aro, MScTech

- **Prosys OPC**
 - **CTO 1996->**
 - OPC Product Development 1999->
 - OPC Training 2003->
- **Finnish Society of Automation**
 - **OPC Committee 2003->**
 - OPC Committee, Chair 2013->
 - Speaker, Organizer, OPC Day Finland 2005->
 - Member of the Board 2025->
- **OPC Foundation**
 - **OPC UA Working Groups 2006->**
 - Technical Advisory Council, 2018->
 - Speaker, OPC Day Europe 2016 & 2017
 - Speaker, OPC North American Seminar Tour 2016 & 2017
 - Speaker, OPC Day International 2022, 2024, 2025, 2026
- IEC
 - IEC TC65/SC65E/WG8 (OPC UA), 2016->
- ISPE
 - Pharma 4.0, 2020->



CTO
Jouni Aro

Our Product Family

Developer Tools



OPC UA
SDK for Java



Sentrol
OPC UA & Classic
SDK for Delphi



QuickStart



**Solution
Development**



OPC UA
Forge



OPC UA
Monitor



Consulting



Workshops

Integration & Visualization

Simulation & Testing



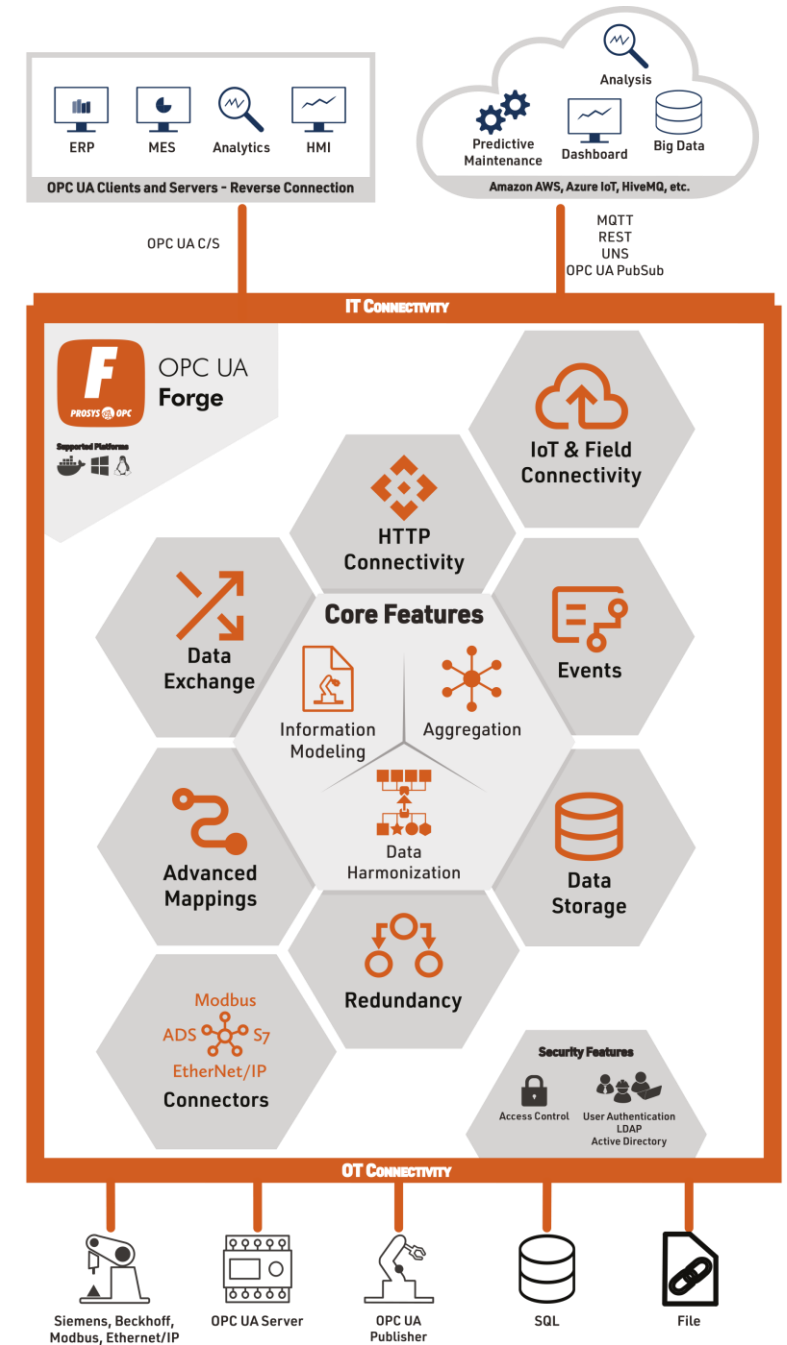
OPC UA
Simulation Server



OPC UA
Browser

Build with Prosys Forge

- Industrial DataOps & Edge Application
- OPC UA Server as the core
- Variety of south- and northbound connectivity
- Business logic tools
- Comprehensive security features
- Windows, Linux, Container
- Web configurator
- OpenAPI REST API

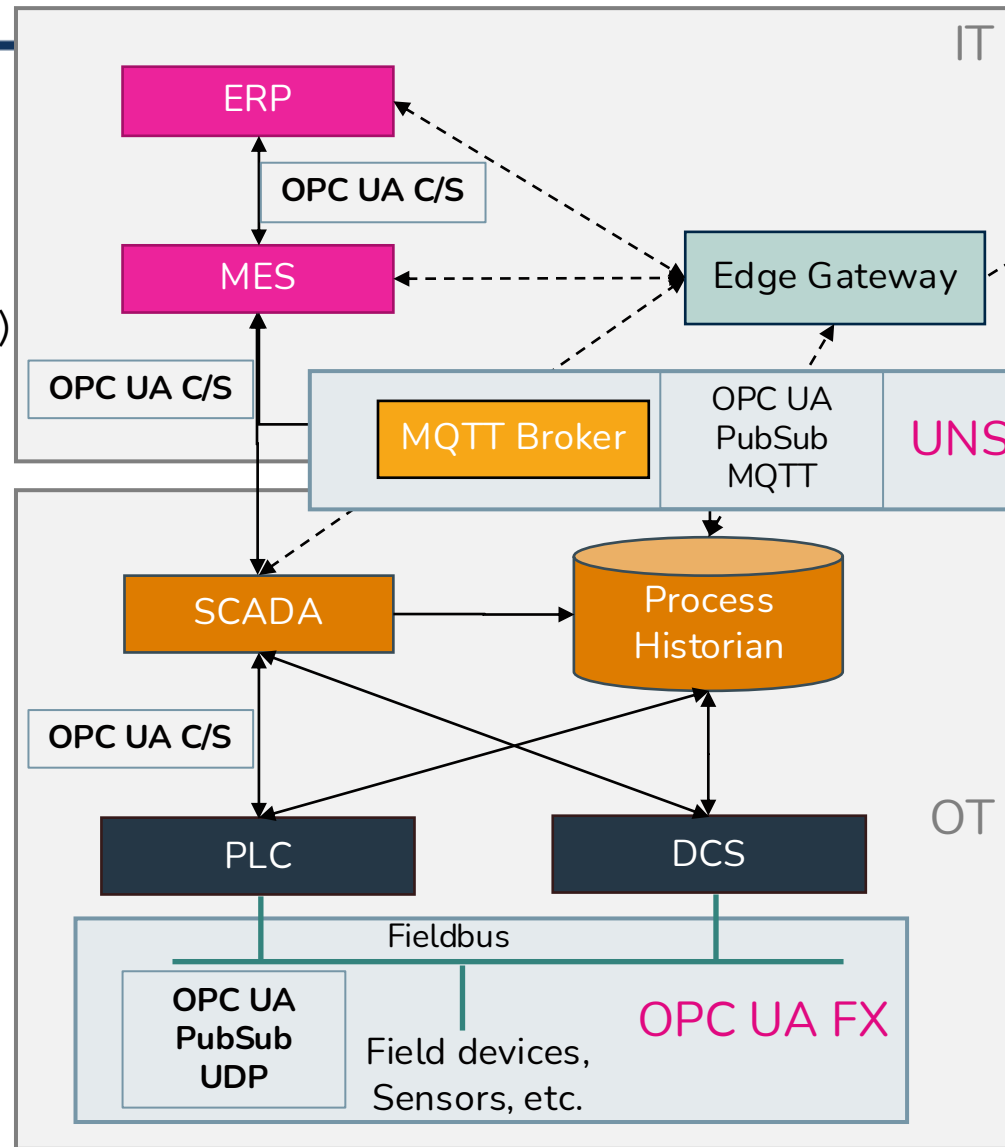




OPC UA

OPC UA Enabled Architecture

- OPC UA Client/Server (C/S)
 - Process Monitoring
 - Production Control (SCADA)
 - Production Orchestration (MES)
- OPC UA PubSub UDP
 - Field Level Communication
 - Field Exchange (OPC UA FX)
- OPC UA PubSub MQTT
 - Cloud Connectivity
 - Cloud Exchange (OPC UA CX)
 - Unified Namespace (UNS)



ERP = Enterprise Resource Planning
MES = Manufacturing Execution System
SCADA = Supervisory Control And Data Acquisition
PLC = Programmable Logic Controller
DCS = Distributed Control System

OPC Unified Architecture

- OPC UA is a global standard for Industrial Connectivity
 - OPC Foundation as a standardization body
 - Protocols available for Field Level, Industrial IT Level, and OT to Cloud Level communication
- OPC UA main benefits
 - Cross-vendor compatibility at the system level
 - Security built in
 - Large adoption among automation and industrial IT vendors
- Information modeling
 - Generic modeling language
 - Domain specific models via wide collaboration
 - Custom models

Information Modeling



Brownfield Device Control

- Process/Machine Control

- PLC
- SCADA
- DCS

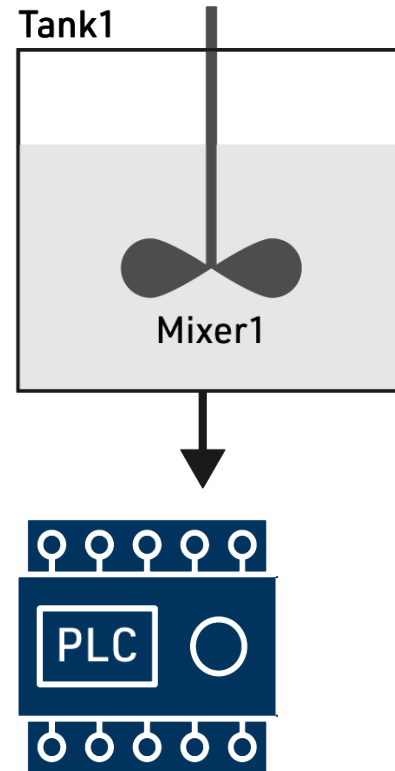
- Data Model

- Tags

- OPC UA Server

- Tags

- Is that it?



OPC UA Server

Objects

+ M10N: Byte

+ M1ERR: Byte

+ M1AV: INT16

+ M1SP: INT16

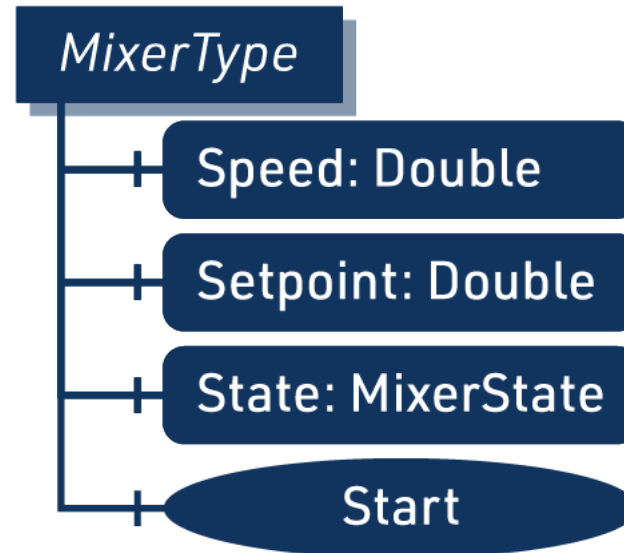
Better Semantics with OPC UA

- Variables
 - Standard DataTypes
 - Boolean, Int32, Double, etc.
 - Custom DataTypes
 - Structures
 - Enumerations
- Object
 - Device Structure
- ObjectType



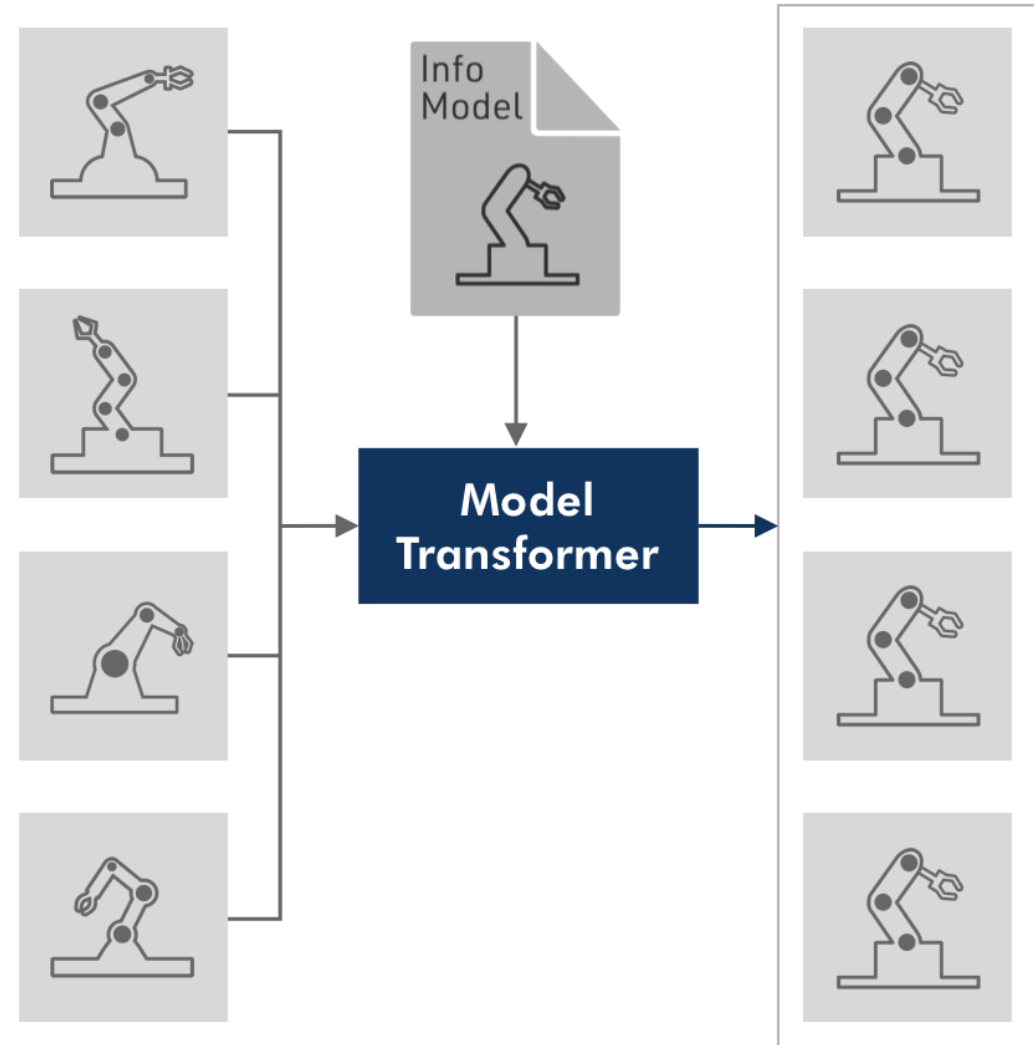
Additional Semantics with OPC UA

- Method Calls
- Events
- Alarms
- History
- State Machines



Information Models

- Domain specific models
 - Devices
 - Machinery
 - Robots
 - Process Automation (PA-DIM)
 - Etc.
- Custom models
 - Vendor specific
 - User specific



AI with OPC UA



AI as an Enabler

1. Information Model Exploration
 - Standard models enable better understanding
 - Model Context Protocol (MCP) enables AI chat interface
2. Time-Series Analysis
 - Forecasting
 - Anomaly Detection
3. Mapping Legacy Data to Standard Information
 - Laborious mappings made possible
 - Balance between automatic and manual verification

1. Information Model Exploration

- Target: Ask questions about production state and data
- Use Model Context Protocol on Prosys Forge
 - Enables mapping of the Forge Information Model to AI engines
 - Use Chatbots on top of Forge data

I'll search for a pH measurement node on the server.

GetNodes >

Found the pH Sensor (node `i=5019`) under the LADS pH-Meter. Its `SensorValue` (node `i=6113`) is the measured pH — and it has `HasHistoricalConfiguration`, so history is recorded. Let me also grab the engineering units/range and then pull 10 seconds of history.

Read >

Confirmed — current pH = **4.19**, range 0-14 pH. Server clock is at 13:44:34 UTC. Let me pull the last 10 seconds of raw history.

HistoryReadRaw >

Got 10 samples, all reading exactly 4.19 pH (a stable acidic reading — makes sense for a sample that's settled on the sensor). Let me build a lab-themed chart artifact.

Created a file, read a file >

Found it — your pH measurement is the `SensorValue` of the pH Sensor inside the LADS pH-Meter:

Node

- Display name: `pH Sensor / SensorValue`
- NodeId: `nsu=.../pHMeter/;i=6113`
- Engineering unit: **pH** (potential of hydrogen), range **0-14**, history enabled
- Path: `pH-Meter → Functional Unit Set → pH-Meter Unit → FunctionSet → pH Sensor → SensorValue`

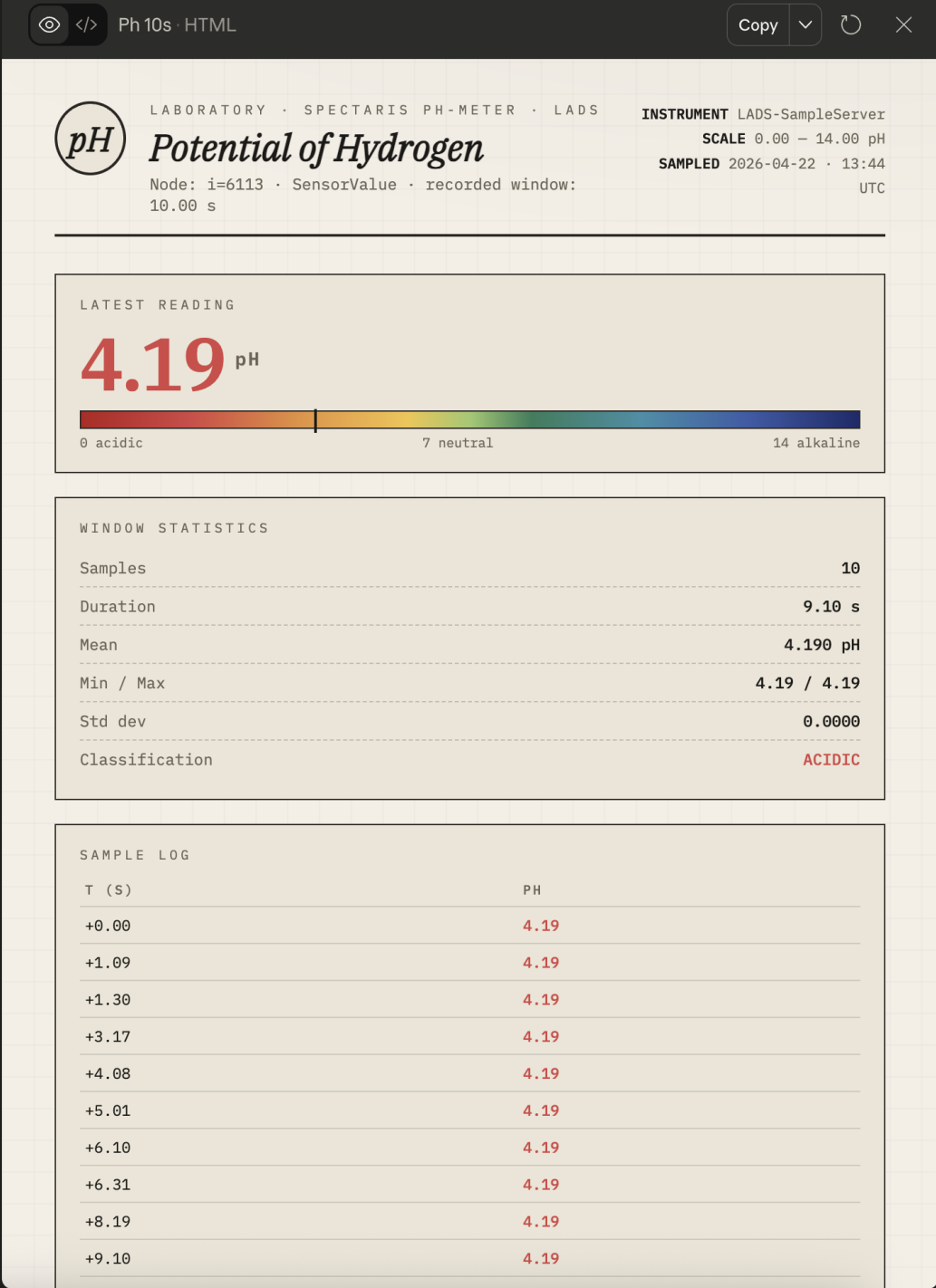
Readout for the last 10 seconds (13:44:24 → 13:44:34 UTC)

- 10 samples, all returning **pH 4.19** —  at line. The sensor is sitting on a stable, mildly acidic sample (think vinegar or tomato juice territory; well,

Reply...



Opus 4.7 ▾

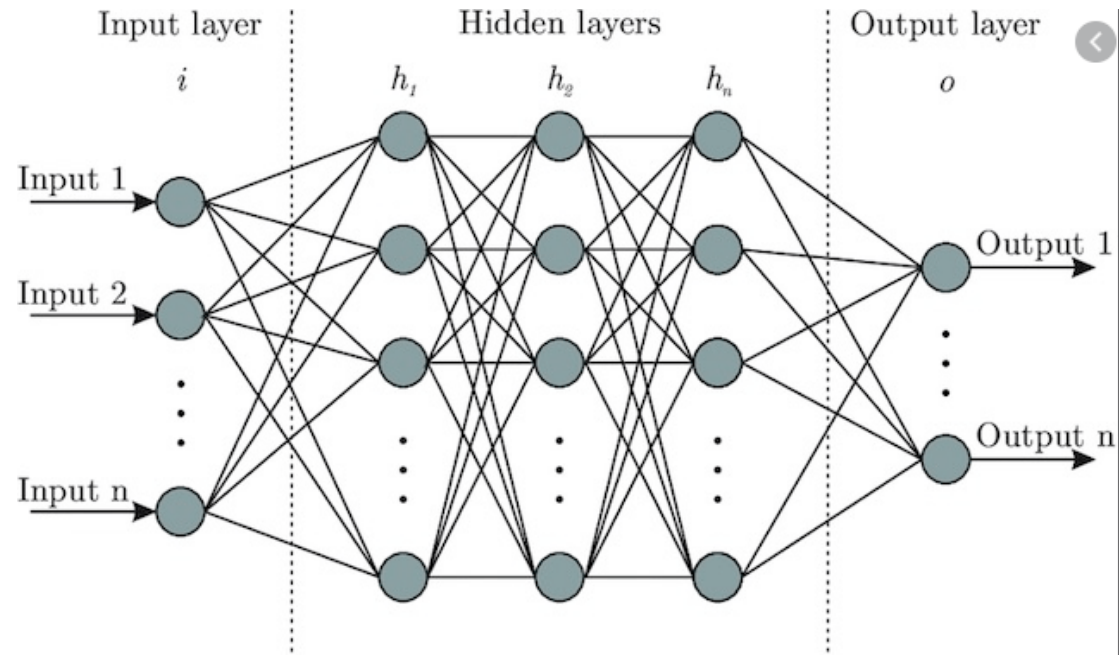


1. Information Model Exploration

- Asking to check out a variable and Claude
 1. Found the correct variable from the Forge address space
 2. Understood what the measurement is, based on the Laboratory and Analytical Device Standard (LADS) information model
 3. Found out that it has history available
 4. Generated a complete “industry grade” report for the measurement with a more complete analysis
- All this without specifically asking for it!

2. Deep Learning in Time Series Analysis

- Uses neural networks to learn time series patterns
- Improved performance compared to older methods
 - + More complex data
 - + Higher accuracy
 - Higher computational cost
 - Results difficult to interpret



I. Lam, "Visualizing neural networks." [Online]. Available: <https://medium.com/@irwinlam00/visualizing-neural-networks-2dd9ccb103ea>

2. Deep Learning Architectures

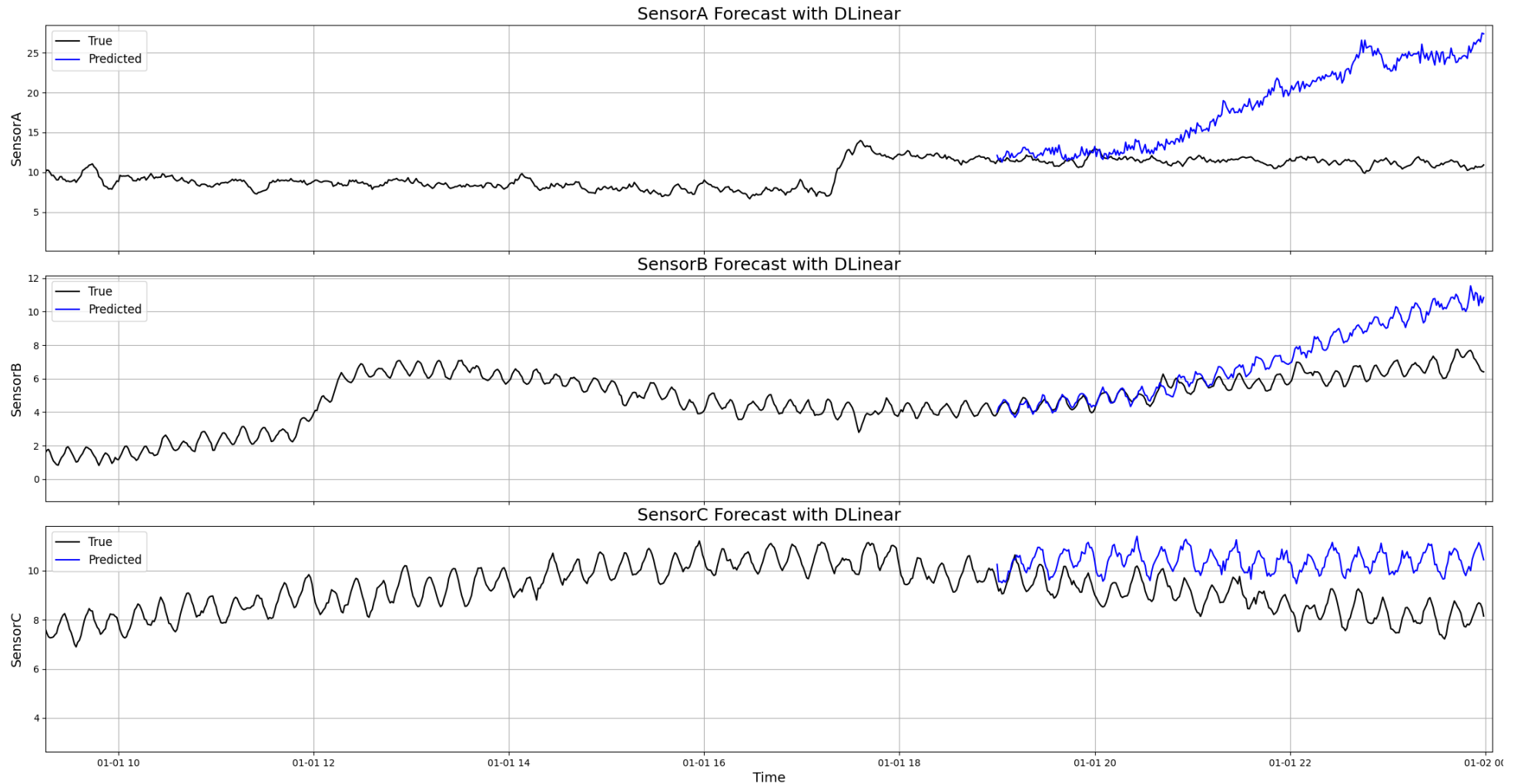
A) Forecasting

- Recurrent Neural Networks (RNN)
- Convolutional Neural Networks (CNN)
- Transformers
- Multi-Layer Perceptrons (MLP)
- (Foundation Models)

B) Anomaly Detection

- Forecasting-based
- Reconstruction-based

2.A Time-Series Forecasting



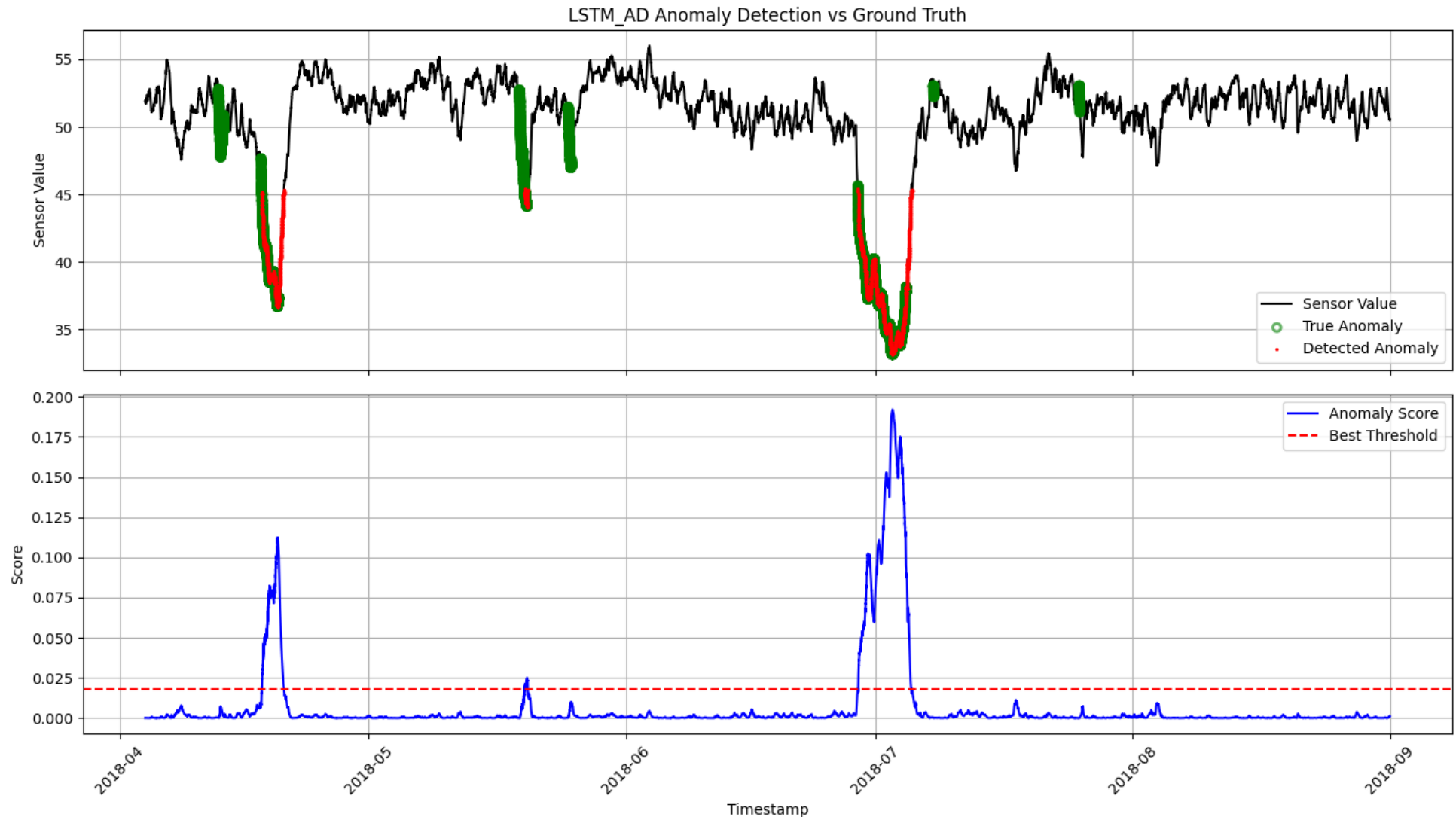
2.A Forecasting Results

- MLP-based models greatly outperformed other architectures
 - Higher prediction accuracy
 - Faster computation times
- CNN-based models were slow
- RNN-based models were inaccurate
- Transformer-based models struggled with accuracy
- NHITS was the most accurate model
- Foundation models showed promise but had limitations

Model	Model Type	Avg. Rank All	Avg. Time (s)
NHITS	MLP	8.770	1.069
NBEATS	MLP	9.523	0.759
NLinear	MLP	10.971	0.516
DLinear	MLP	11.144	0.529
MLPMultivariate	MLP	11.226	0.501
MLP	MLP	11.256	0.577
PatchTST	Transformer	11.431	12.289
TiDE	MLP	12.401	2.519
TimeMixer	MLP	12.853	2.256
TSMixerx	MLP	13.270	0.800
KAN	MLP	13.541	1.287
BiTCN	CNN	13.920	121.549
TimesNet	Transformer	14.437	73.113
TCN	CNN	14.619	50.117
RMoK	MLP	15.106	0.790
TSMixer	MLP	15.306	0.710
SOFTS	MLP	15.844	0.827
DeepNPTS	Transformer	16.667	3.354
LSTM	RNN	17.193	7.249
GRU	RNN	17.317	11.557
RNN	RNN	17.400	5.203
DilatedRNN	RNN	17.453	13.113
TimeXer	Transformer	18.604	2.059
iTransformer	Transformer	18.777	0.807

Average rank of forecasting models across all datasets and horizons

2.B Time-Series Anomaly Detection



2.B Anomaly Detection Results

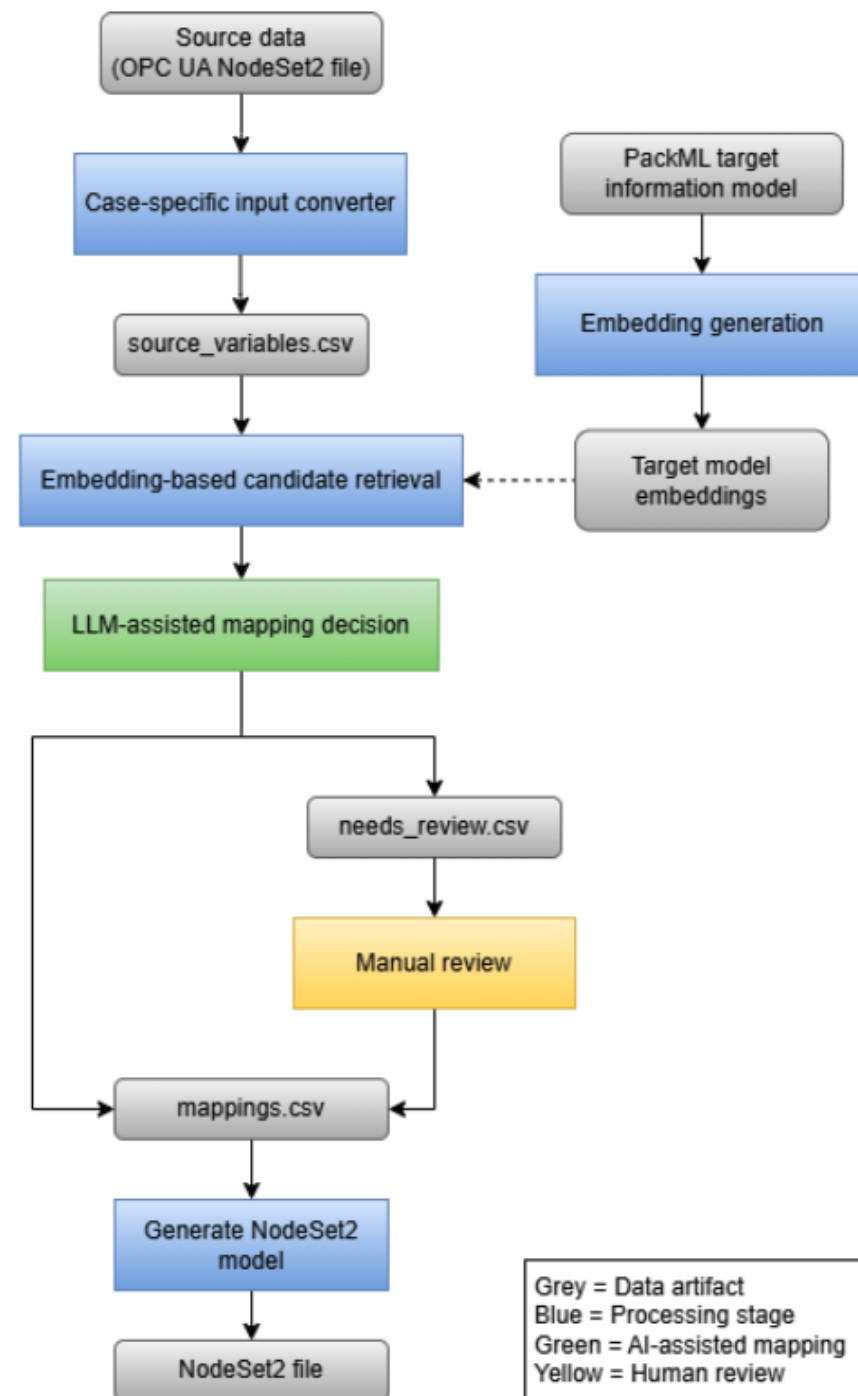
- MAD-GAN, LSTM-AD and VAE performed the best
- Pre-trained MOMENT-model performed the worst
- Challenges:
 - Change in data behaviour
 - Selecting anomaly threshold
 - Choosing the window size

Model	Avg. F1 Score	Avg. Time (s)
MAD-GAN	0.773	7.5
LSTM-AD	0.772	12.5
VAE	0.748	7.0
AE	0.714	161.5
TranAD	0.564	13.5
USAD	0.463	6.5
MOMENT	0.051	62.0

3. AI-Assisted Mapping

- Enable model transformations
 - Large models
 - Acceptable work time
- Confidence-based evaluation:
 - Automatic mapping
 - Manual verification
 - Rejected without review

(Tuomas Kauppinen: AI-Assisted Variable Mapping to OPC UA Information Models, MSc Thesis, Tampere University, 2026)



3. AI Assisted Mapping

- Case Study
 - OPC UA PackML model
 - Administrative Information
 - Control-related Information
 - Status and performance related information
 - Legacy data
 - Project-specific variable naming conventions without a unified semantic policy
 - Plus hierarchy information
 - A lot of ambiguity, making automated mapping a non-trivial task.

3. AI-Assisted Mapping

- Methods

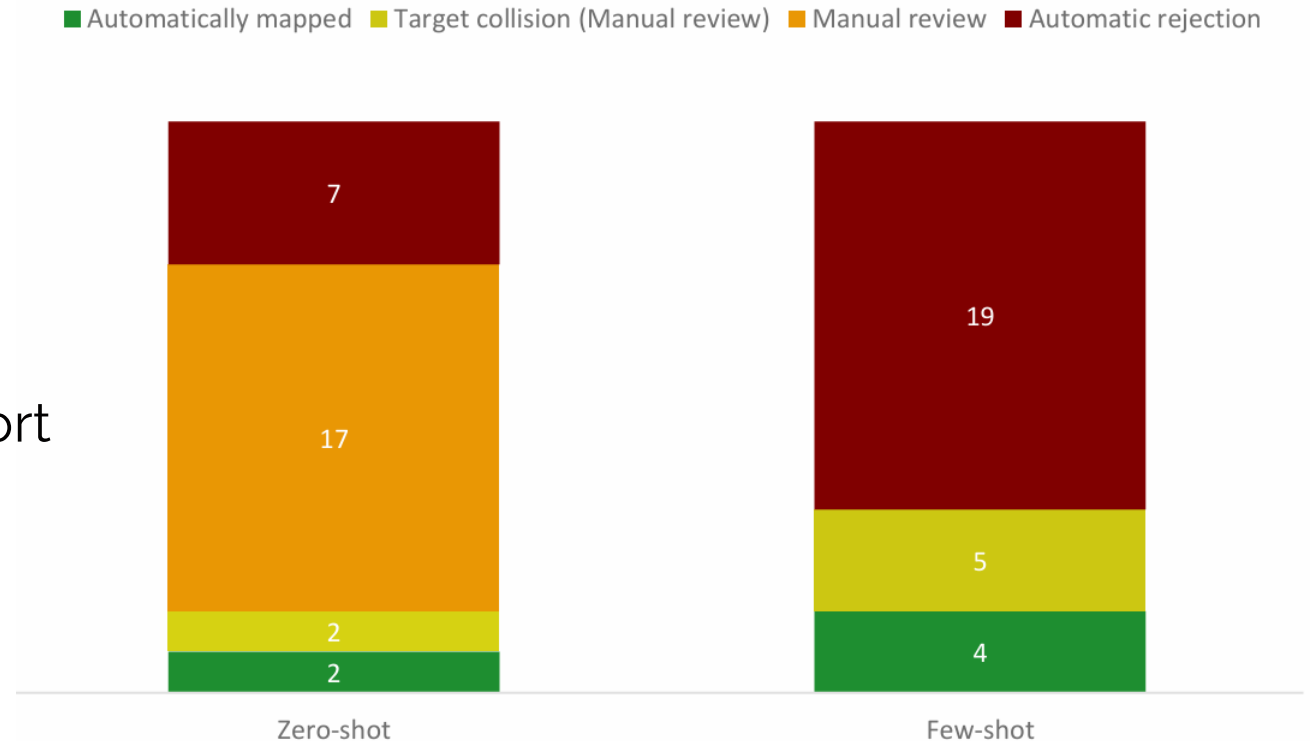
- Zero-shot

- LLM does not receive any examples of the actual mappings

- Few-shot

- LLM receives a couple of example mappings to support its decision making

- Results





Conclusion

Data Contextualization for AI with OPC UA

- OPC UA Enables
 - Data Aggregation from different sources
 - Data Contextualization to information models
- AI Enables
 - Chat-based queries
 - Time-series analysis
 - Legacy data mapping
- AI with OPC UA Enables
 - Higher level information
 - More understanding

Thank You!

Please contact us for more
information.



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OPC UA
Forge



OPC UA
Simulation Server



OPC UA
Forge Plugin



OPC UA
Browser