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Intelligent Edge – the Path towards AI in Industrial Applications

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Edge Computing and AI for Industrial Applications – Outline

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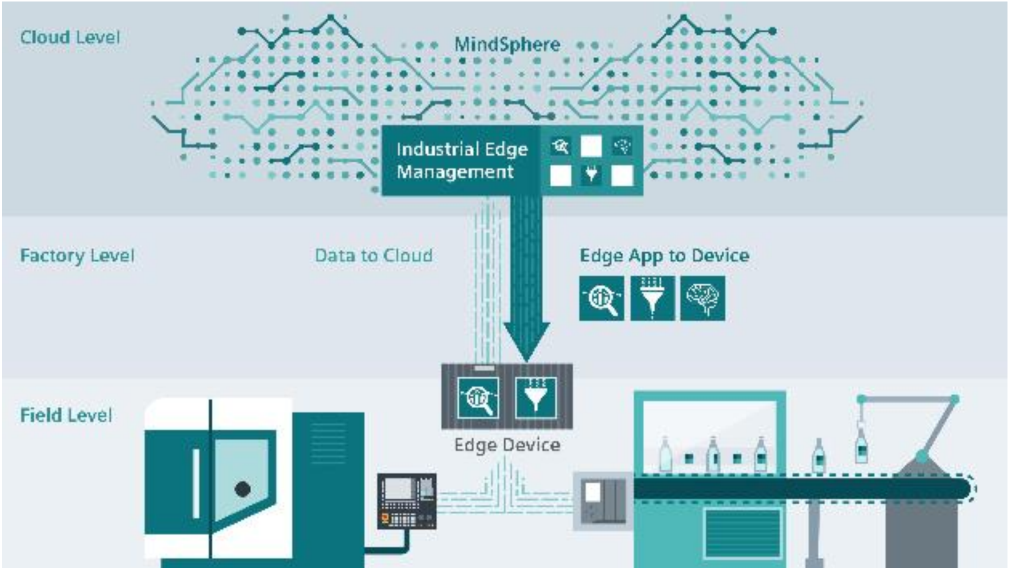
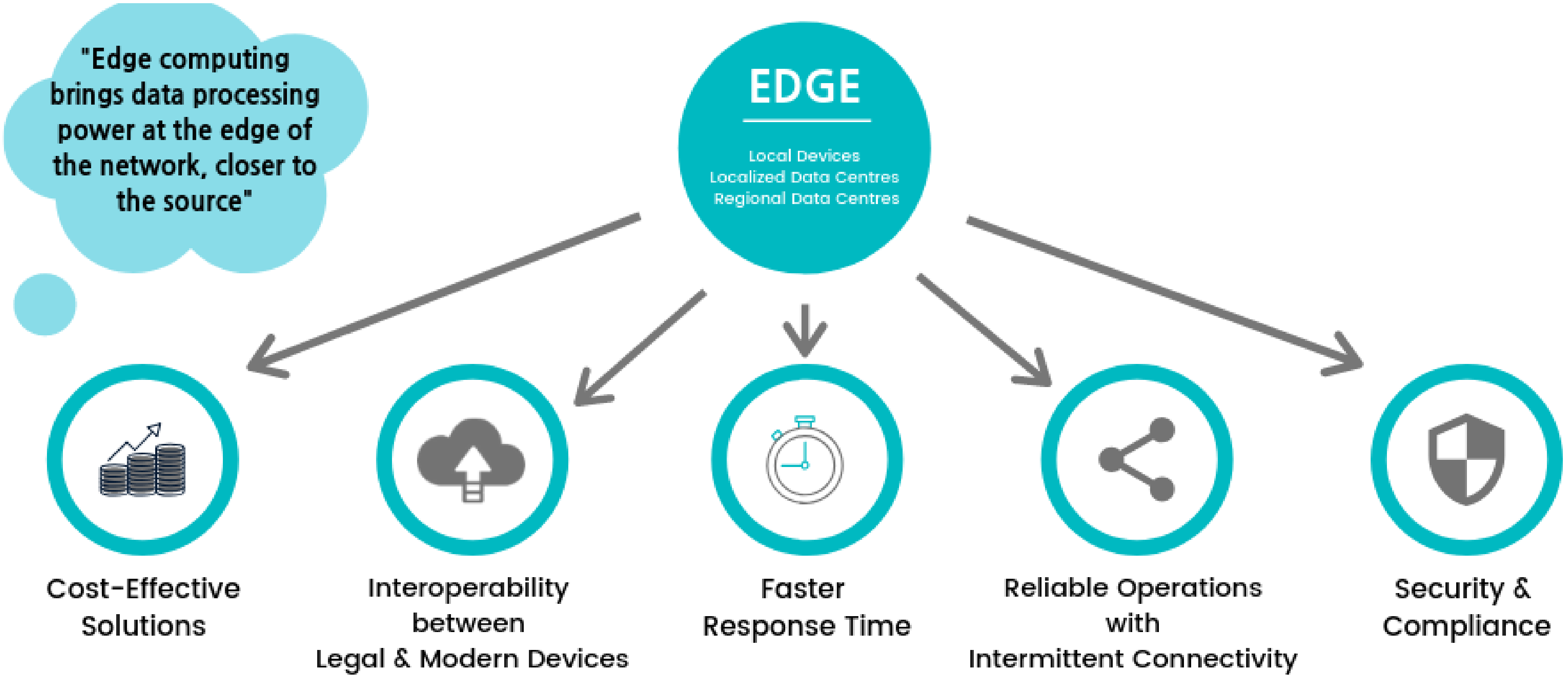
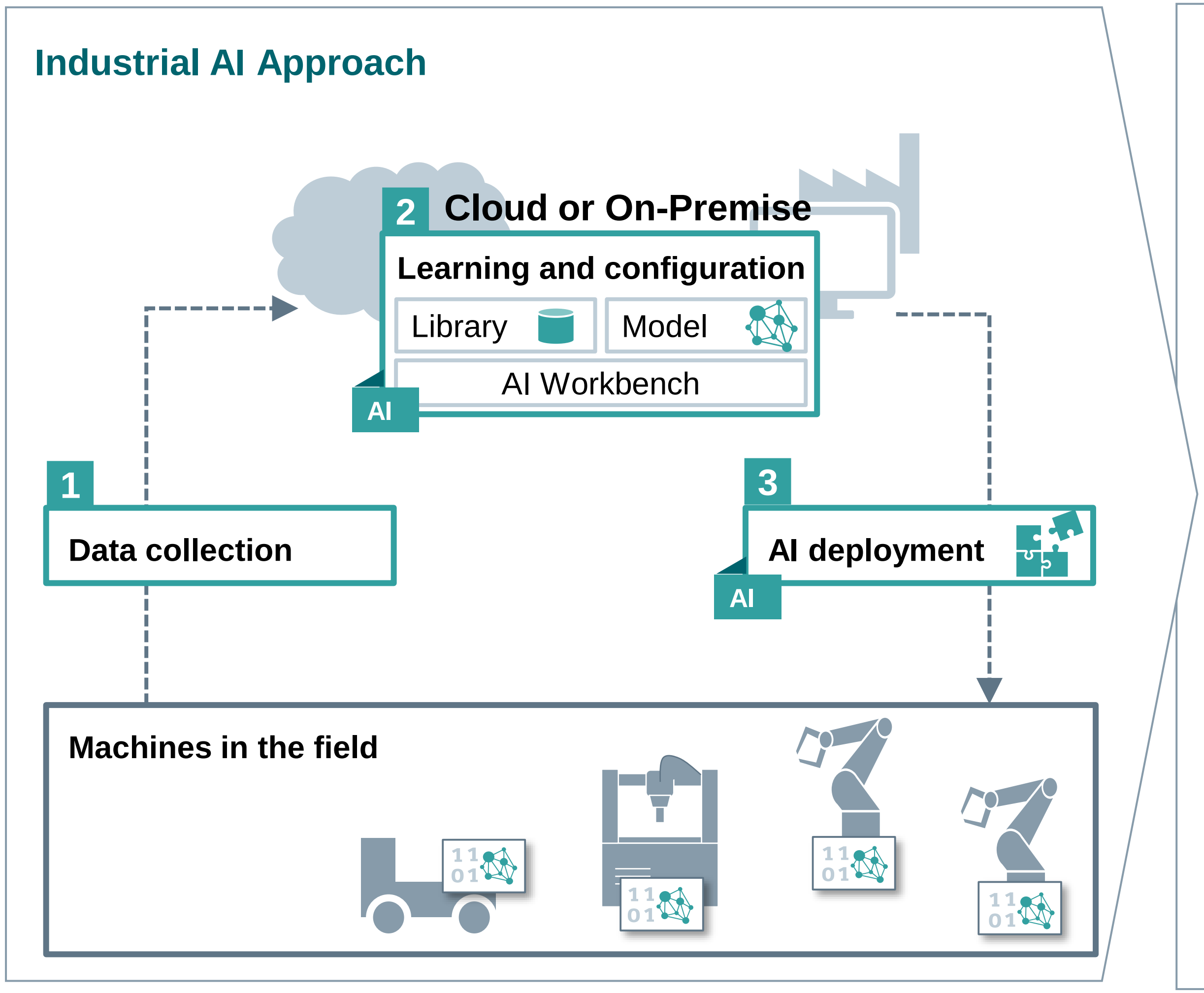
- What is Edge Computing?
- Managing AI Lifecycle
- Optimization of Models



5 Key Benefits of Edge Computing



Artificial Intelligence in Industry
Vision for Industrial AI Approach



→ **Requirements:**

1. **Data Collection:**
   Data directly from machines
   branch and process knowledge needed
   labeling of data
2. **Learning and configuration of AI Algorithm:**
   Algorithm and training knowledge needed
   Cloud or on-Premise
3. **Deployment of AI:**
   Industrial-suited Hardware required

→ Objective:
Automized Usage of AI Algorithms in an industrial environment

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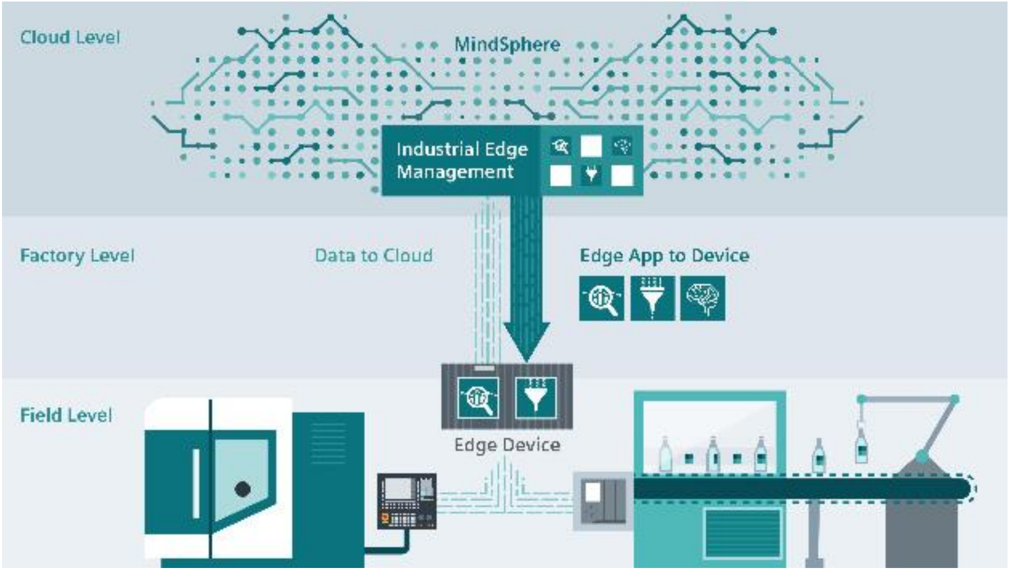


Low-Code platform

Build apps faster for cloud,
on-premise or hybrid infrastructure

IIoT as a service

Centralized compute & storage,
with solutions, apps & services

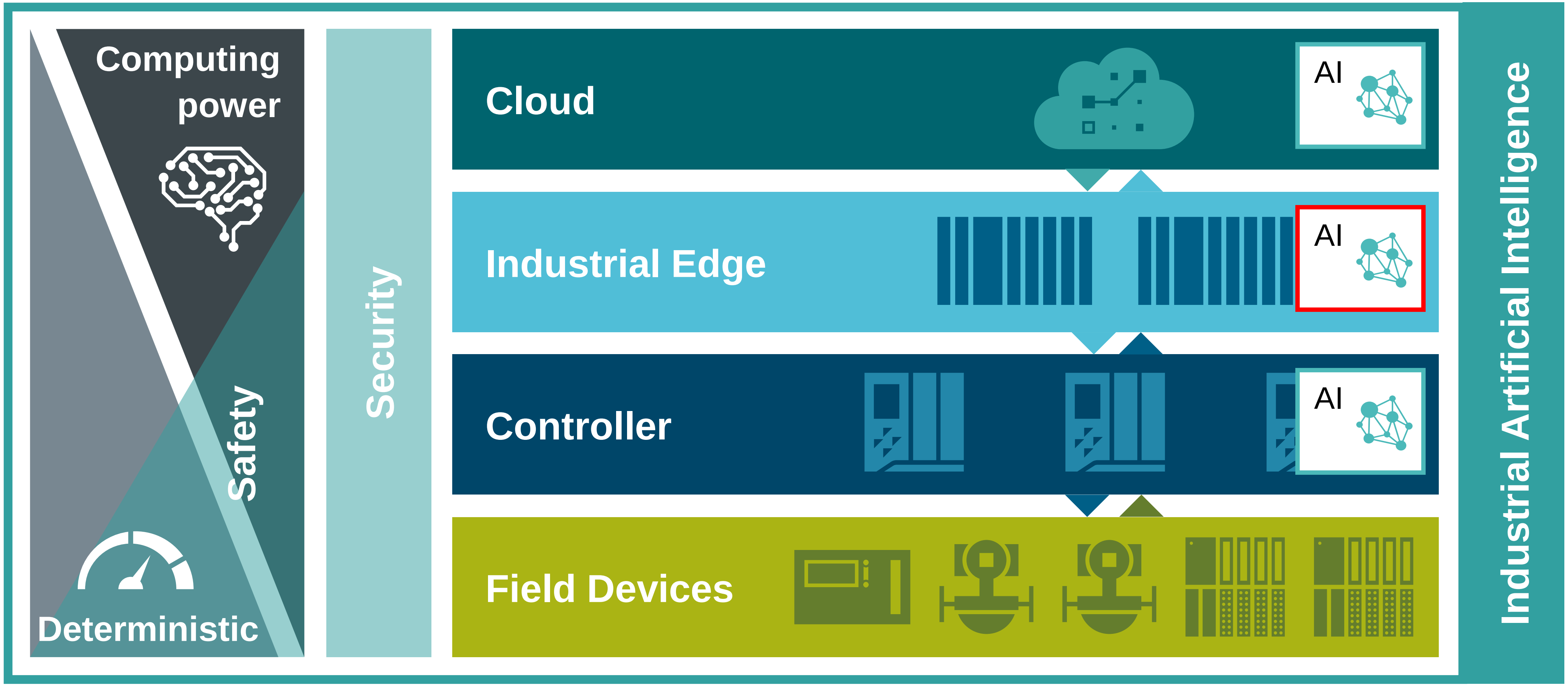
Edge Computing

Decentral compute & storage with
device runtime, apps & management

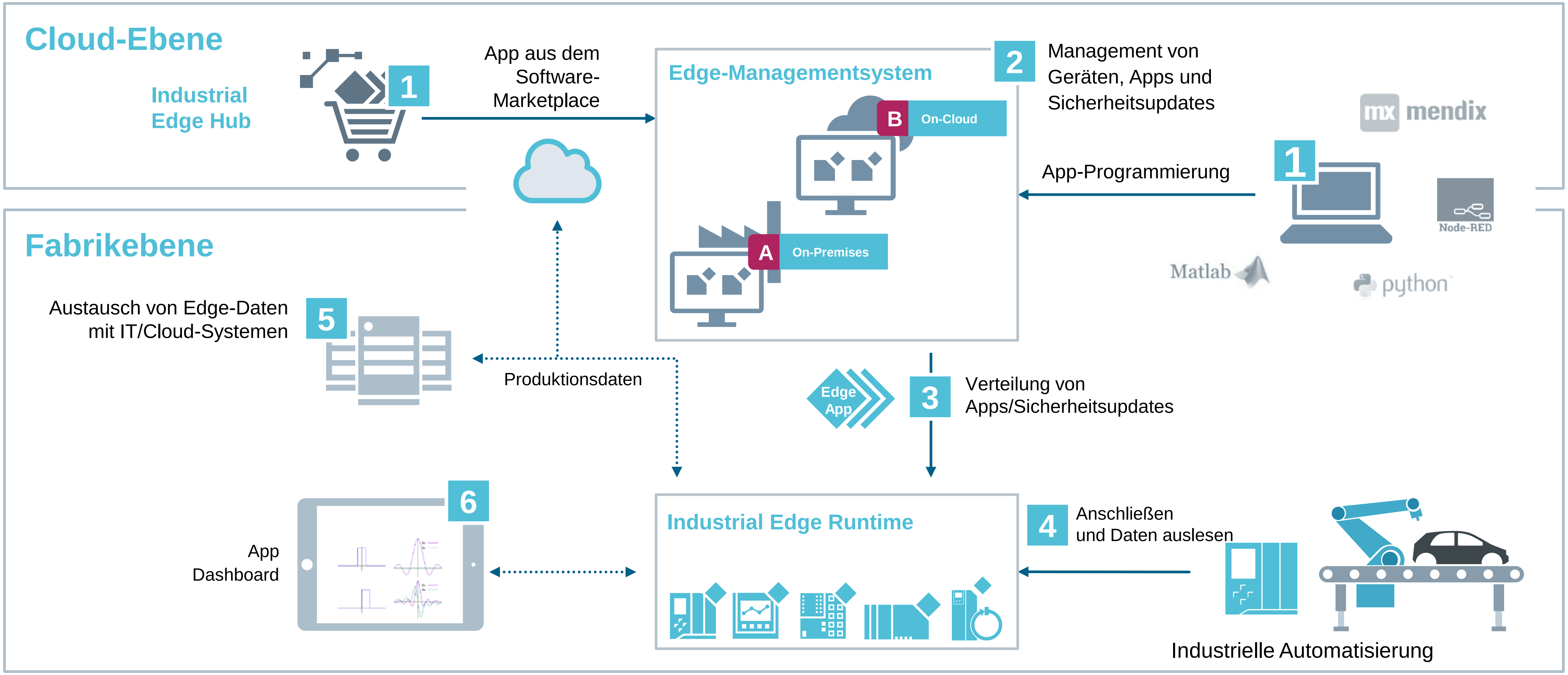
Field/Control

Automation runtime & engineering
connectivity

Artificial Intelligence in Industry
Platforms & Deployment



Siemens Industrial Edge Workflow



Additionally to devices by partners, Siemens provides a scalable industrial hardware to run Edge Applications

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- **1** S7-1500 TM MFP
- **2** IPC127E
- **3** IOT2050
- **4** RuggedCom APE
- **5** IPC227E
- **6** IPC427E
- **7** IPC6x7E

Available / Available mid-term

Potential future development

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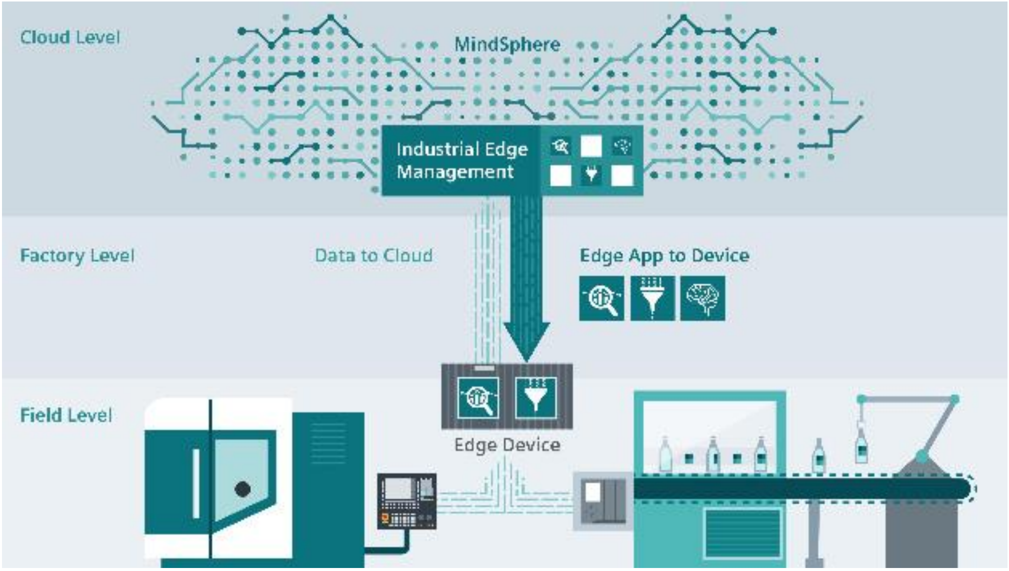

AI Lifecycle management

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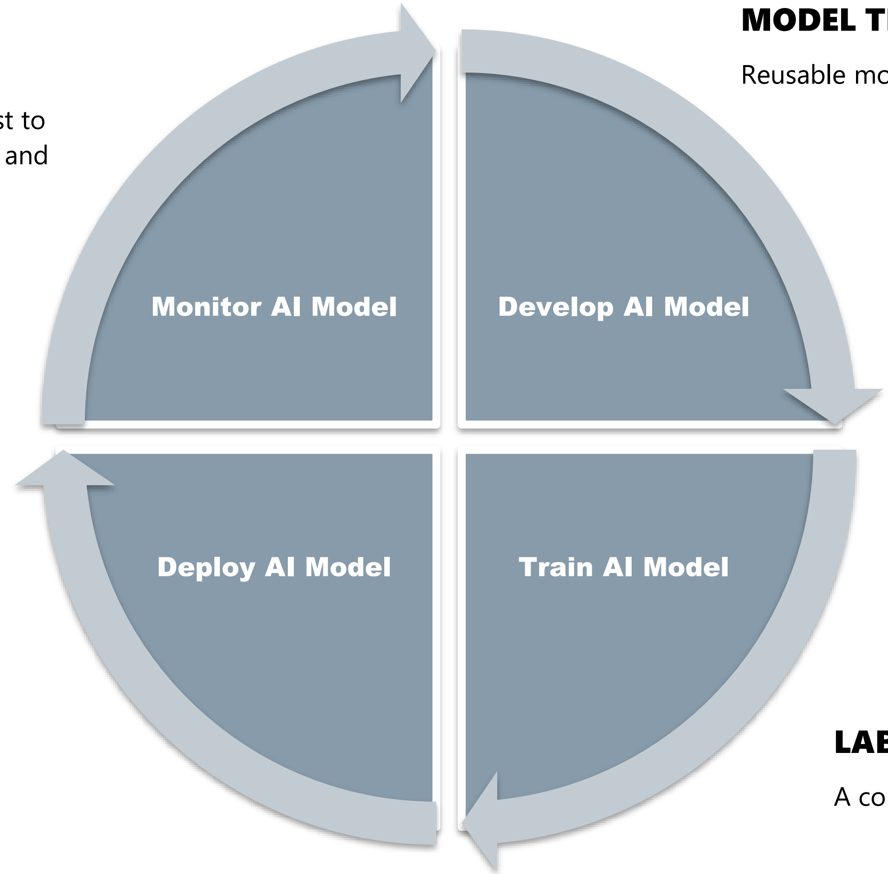
EXPERT VIEW

An interface that empowers a data scientist to quickly reason about system performance and failures

MODEL TEMPLATES

Reusable model artefacts



CONTINUOUS INTEGRATION

Testing and delivering new models and features through an automated pipeline

SYSTEM AGNOSTIC

Common runtime for cloud and edge

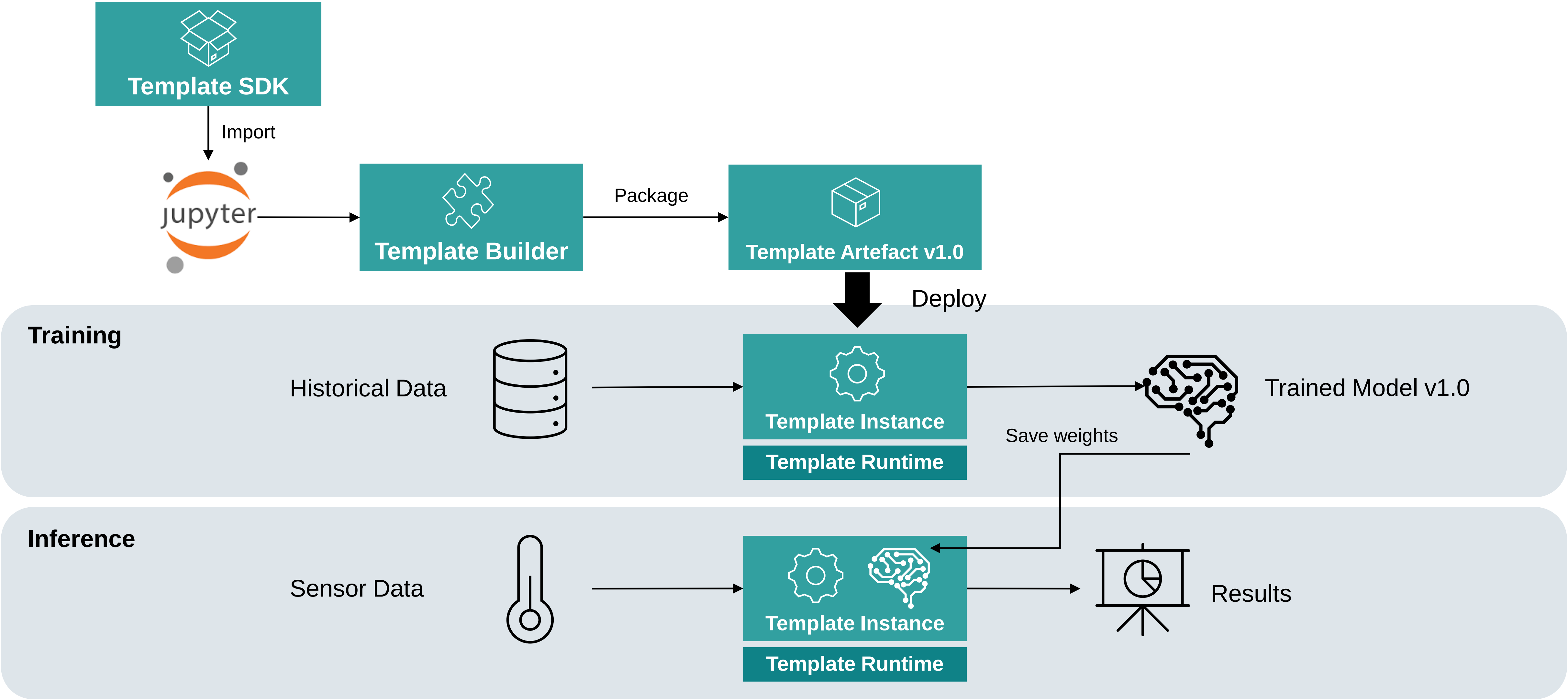
LABELLING UI

A convenient tool suite for labelling ML data

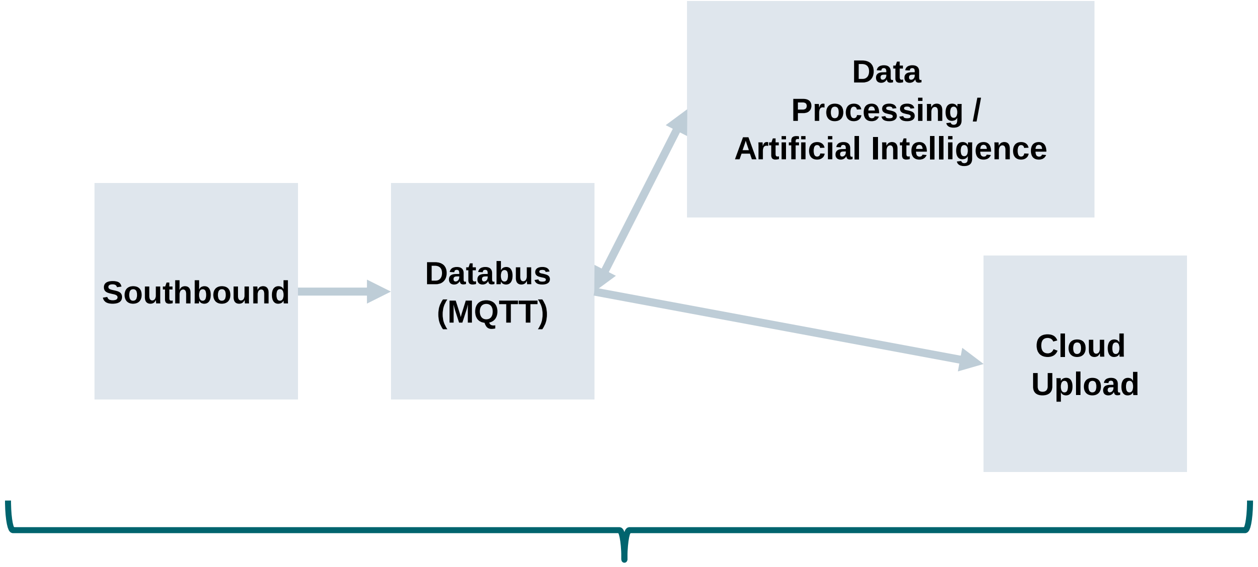
MODEL MANAGEMENT

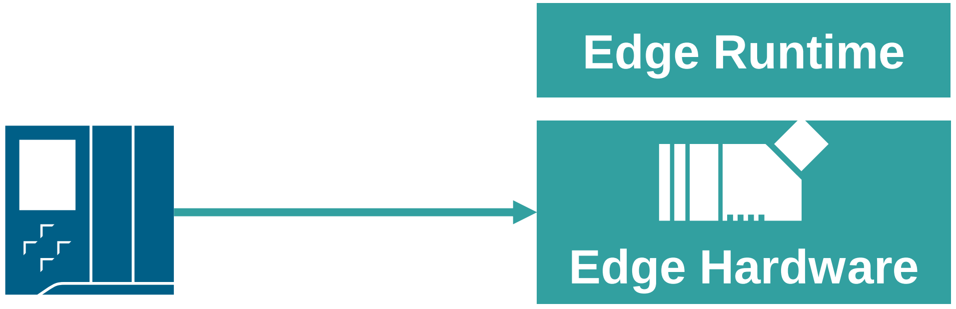
An integrated transparent system management interface

AI Templates - Workflow



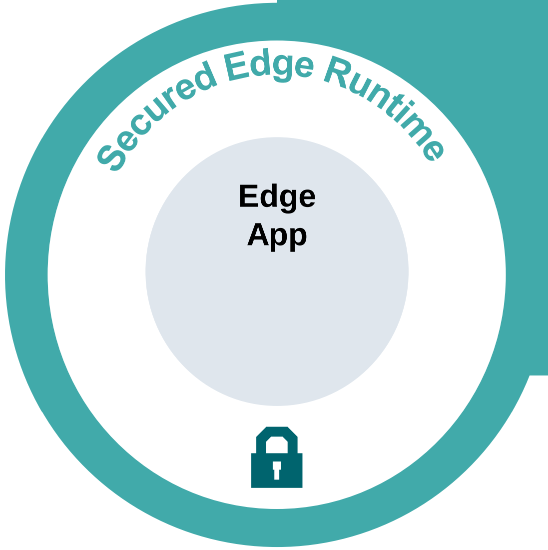
Industrial Edge
Example Edge AI App





Data Flow

- Ingest data using **Southbound** App
- Processing of machine data from **Databus**
- **Cloud Upload** computed data to local data lake or cloud services



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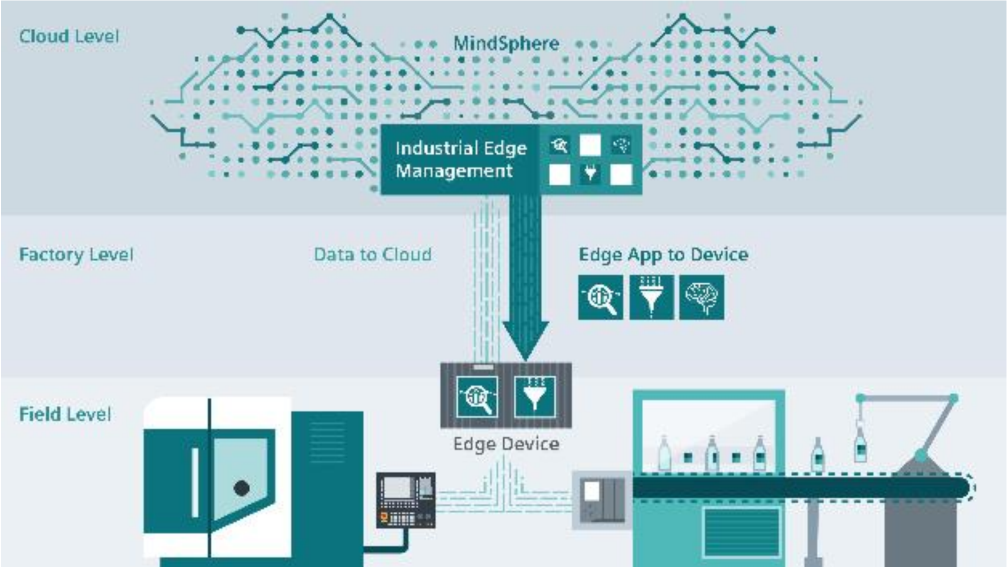
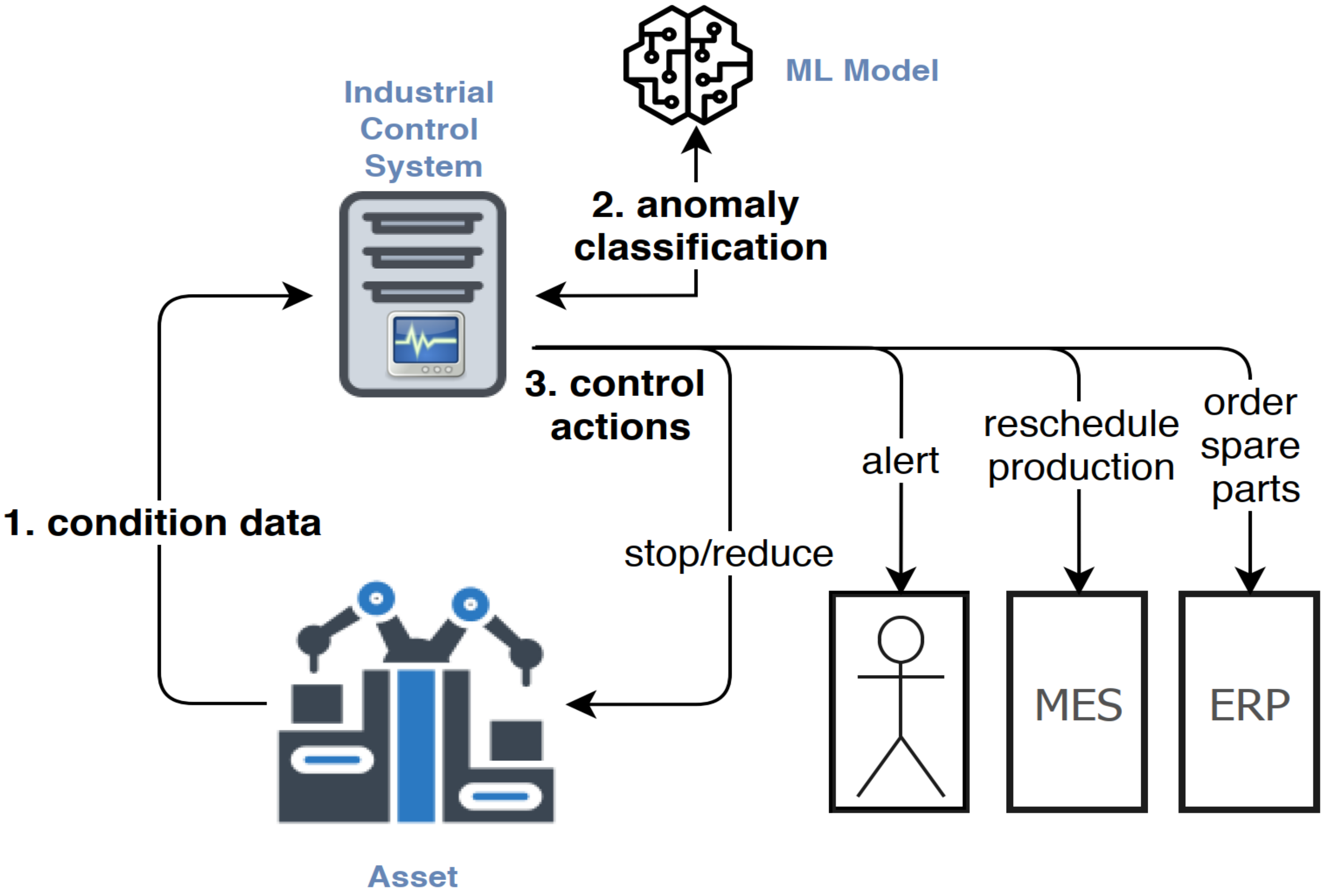


Motivation – Machine Learning Models in Industrial Environments

Example: Anomaly classification based on asset data:



Problem Statement

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- How can a machine learning model be improved with limited access to training data?

  (e.g., How can anomaly classification be improved if little to no anomalies occurred in the past?)

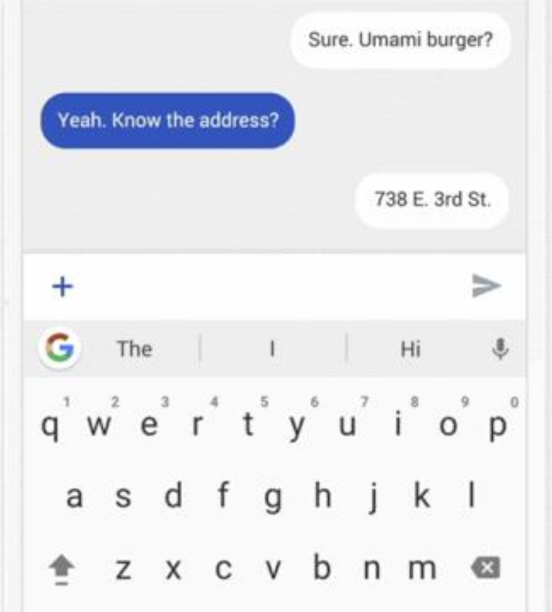
Possible Solution	Access data from other users/customers
Problem	Potentially sensitive data cannot be disclosed to third parties
Consequences	poor performance of ML model costly experiments to collect training data

Federated Learning

Federated Learning enables clients

- to **collaboratively learn a shared prediction model**
- while **keeping** all the **training data on device**,
- decoupling the ability to do machine learning from the need to store the data in the cloud [1].

Initial Use Case: Gboard on Android (2017, beta)



[1] https://ai.googleblog.com/2017/04/federated-learning-collaborative.html

Motivating Federated Learning (FL) Scenario: Vibration-sensing Dataflow

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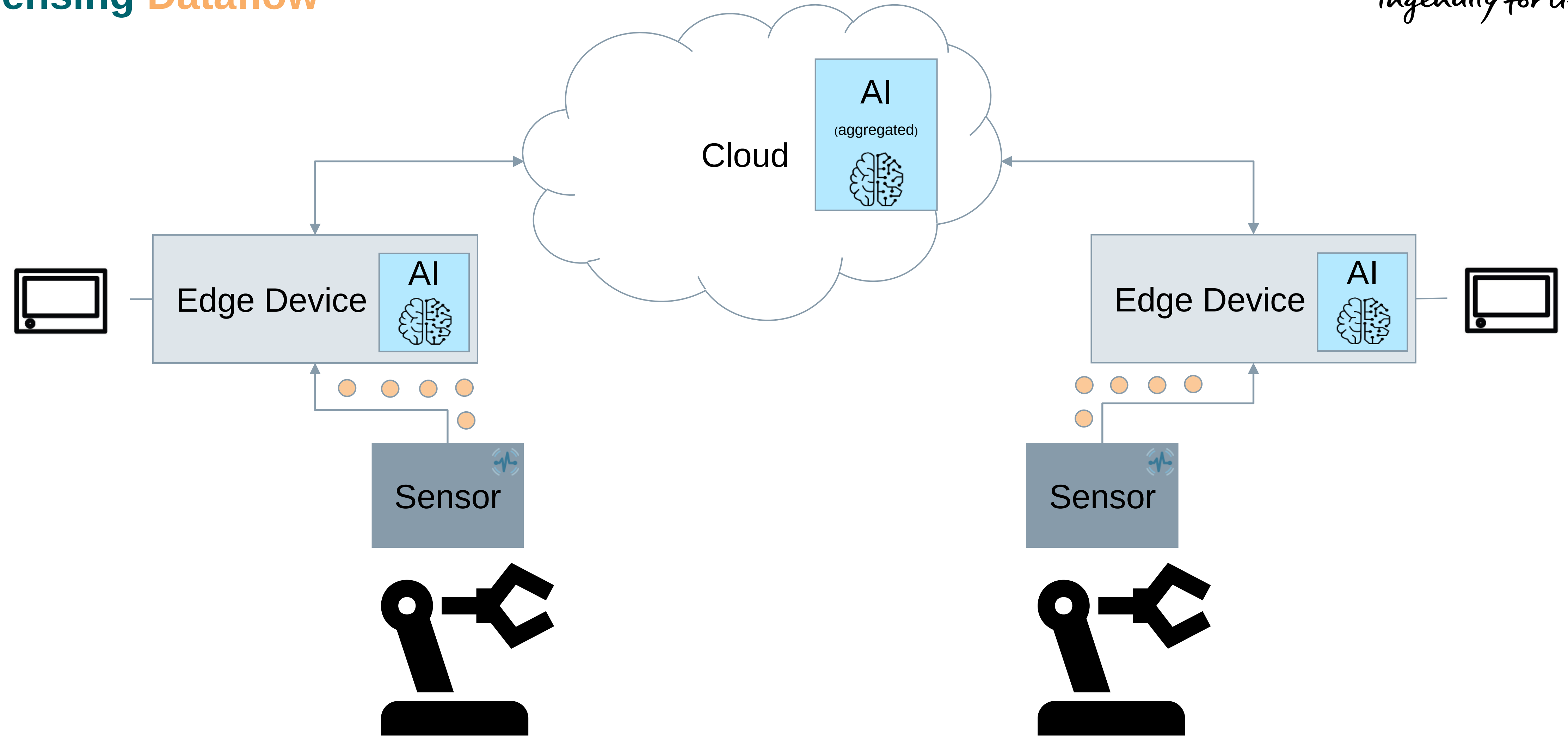

Motivating Federated Learning (FL) Scenario: Vibration-sensing Training & Inference

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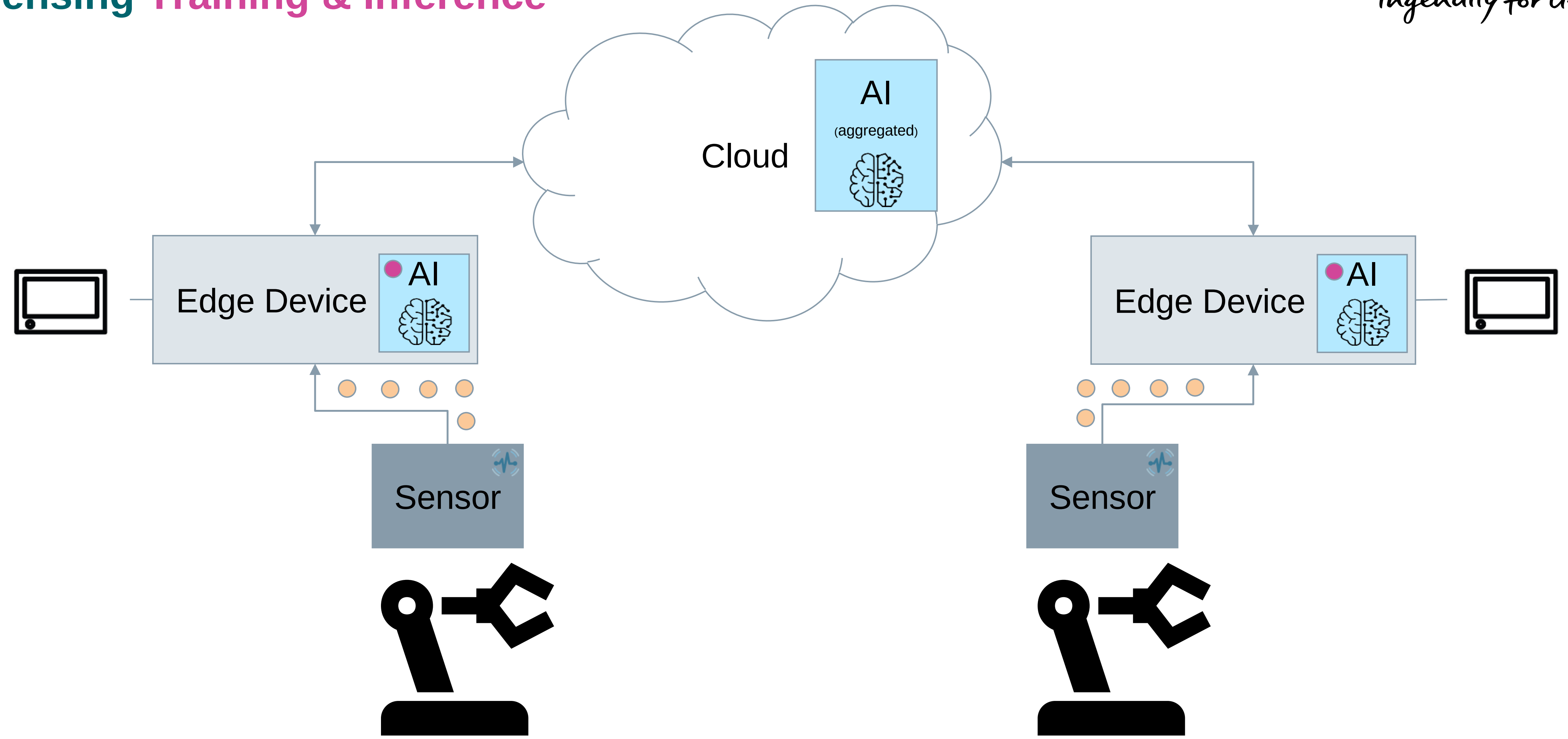

Motivating Federated Learning (FL) Scenario: Vibration-sensing Knowledge Exchange

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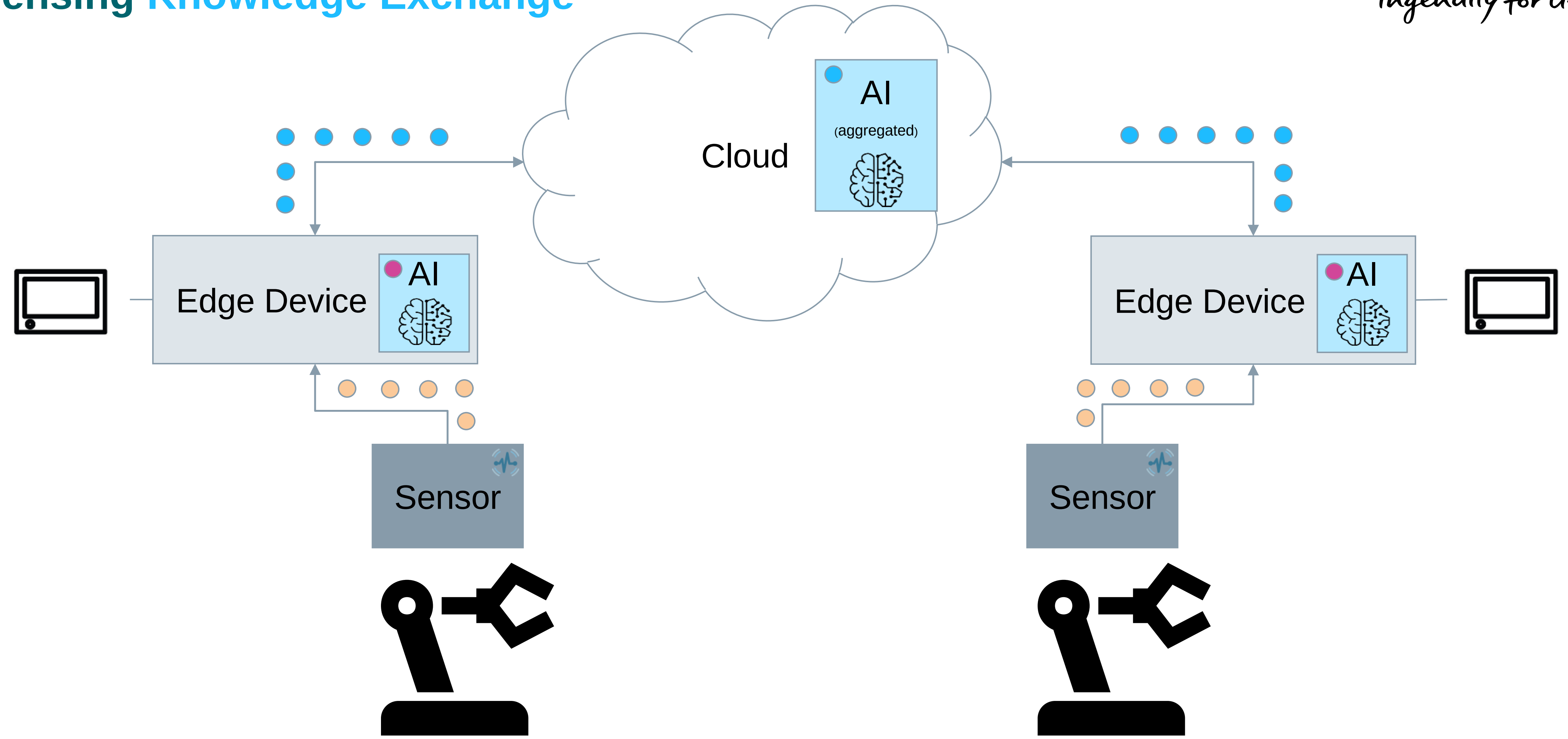

Federated Learning – Enabling Concepts

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- **Federated Averaging**

  Algorithm averaging models retrieved from local clients

- **Secure Aggregation**

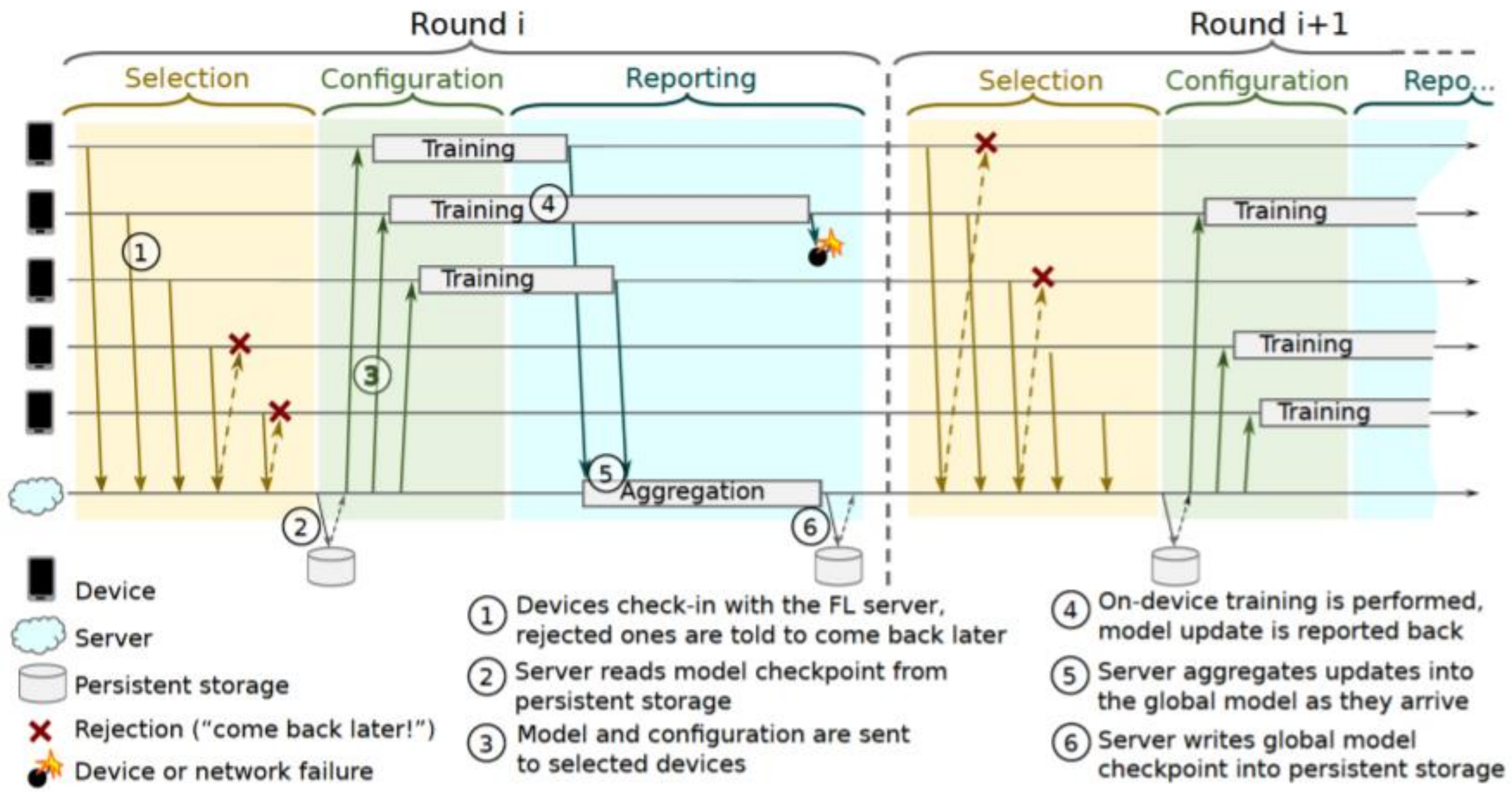
  Protocol ensuring that a server can only decrypt the average update if a large number of users have participated.

Algorithm 1 `FederatedAveraging`. The K clients are indexed by k; B is the local minibatch size, E is the number of local epochs, and η is the learning rate.

Server executes:
  initialize w_0
  for each round $t = 1, 2, \dots$ **do**
    $m \leftarrow \max(C \cdot K, 1)$
    $S_t \leftarrow$ (random set of m clients)
    for each client $k \in S_t$ **in parallel do**
      $w_{t+1}^k \leftarrow \text{ClientUpdate}(k, w_t)$
    $w_{t+1} \leftarrow \sum_{k=1}^{K} \frac{n_k}{n} w_{t+1}^k$

ClientUpdate(k, w)**:** // *Run on client* k
  $\mathcal{B} \leftarrow$ (split $\mathcal{P}_k$ into batches of size B)
  for each local epoch i from 1 to E **do**
    for batch $b \in \mathcal{B}$ **do**
      $w \leftarrow w - \eta \nabla \ell(w; b)$
  return w to server

Federated Learning Protocol



Towards Federated Learning at Scale: System Design:

https://arxiv.org/pdf/1902.01046.pdf

Proof of Concept – MNIST Image Data

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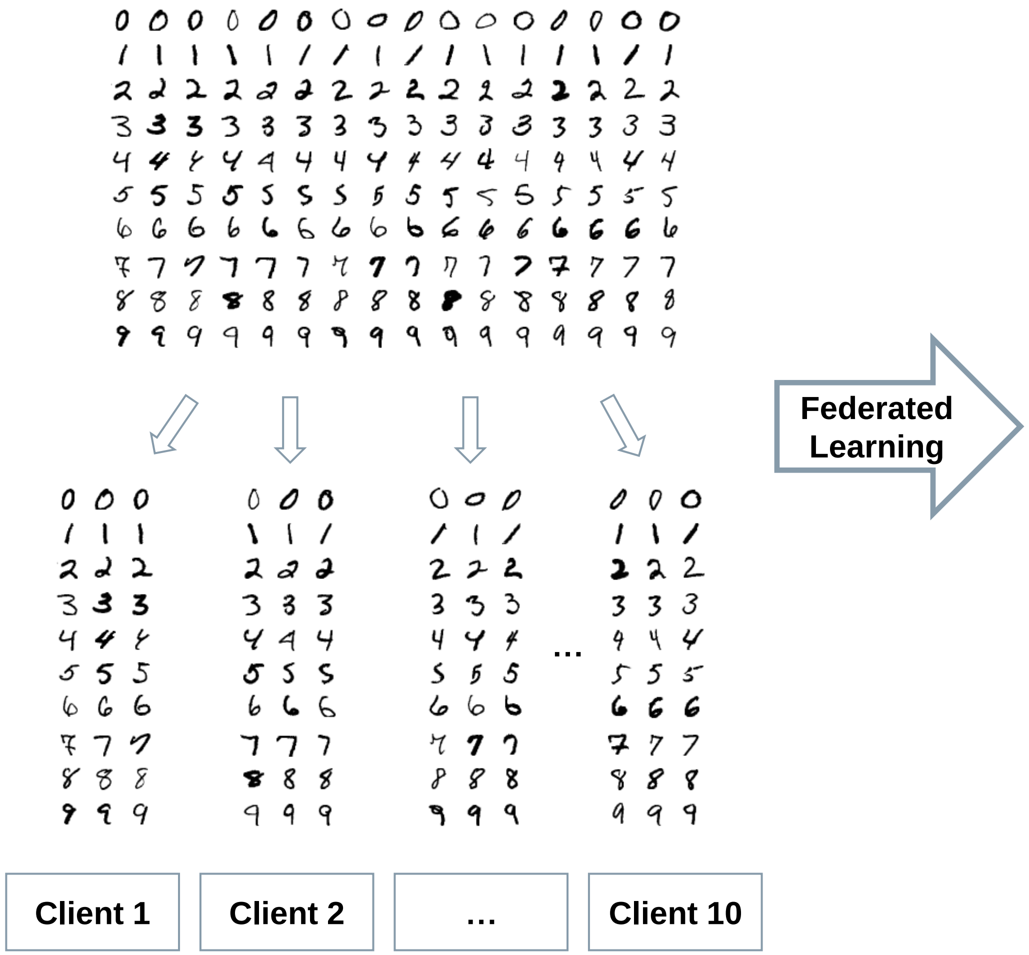

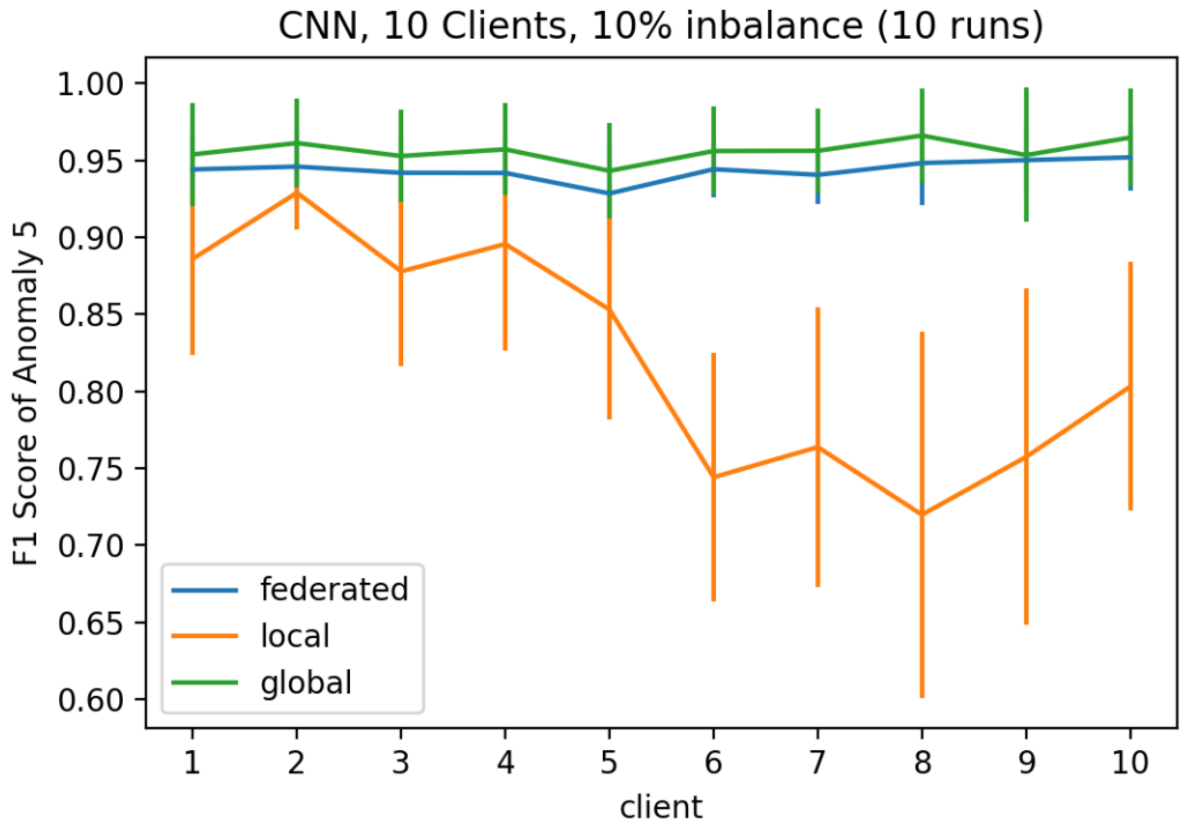

Federated Learning with 10 Clients on MNIST Dataset
(Source: Markus Kittel, Denis Krompass (CT RDA BAM MIC-DE))

Industrial Federated Learning (IFL)

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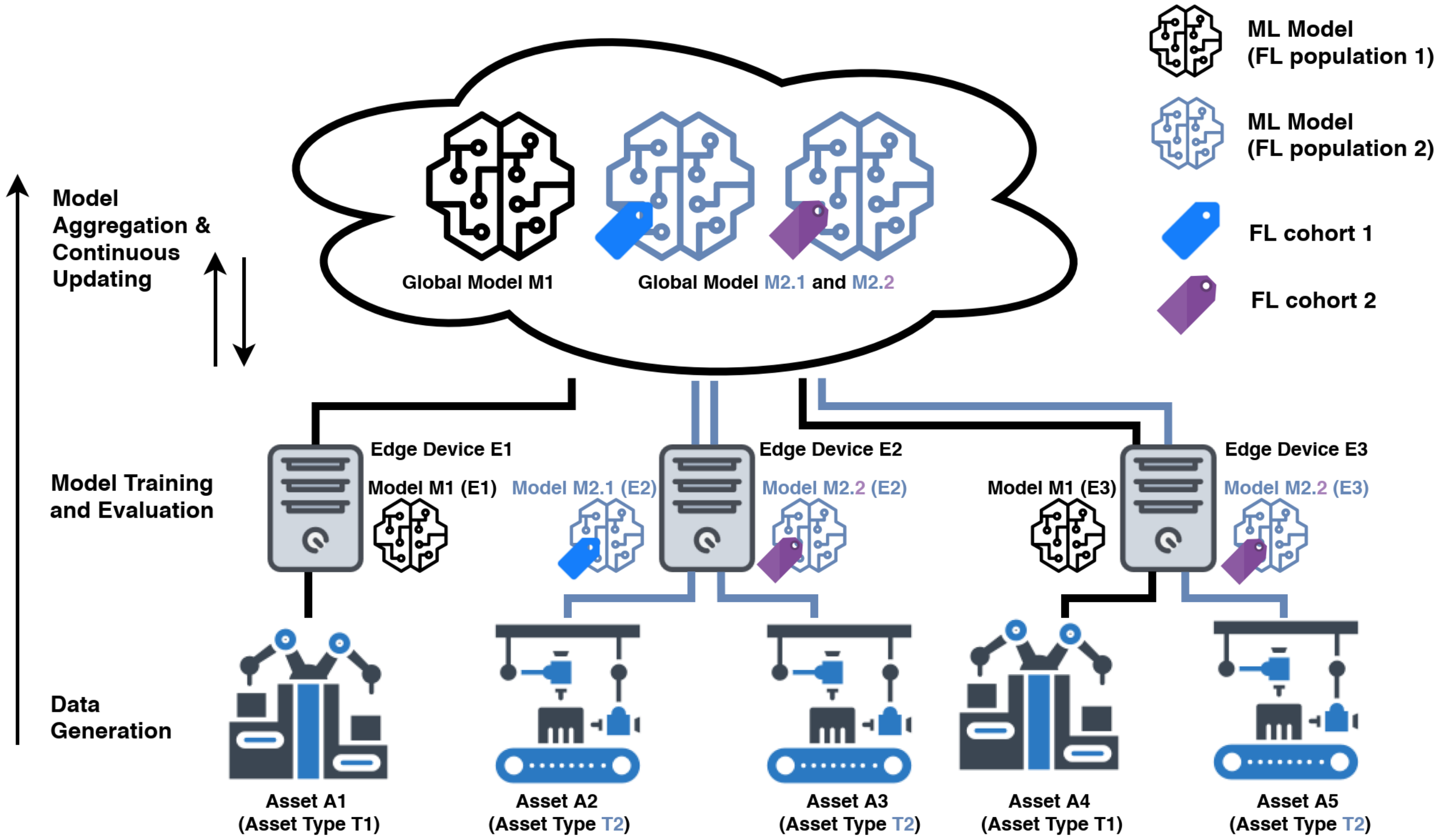
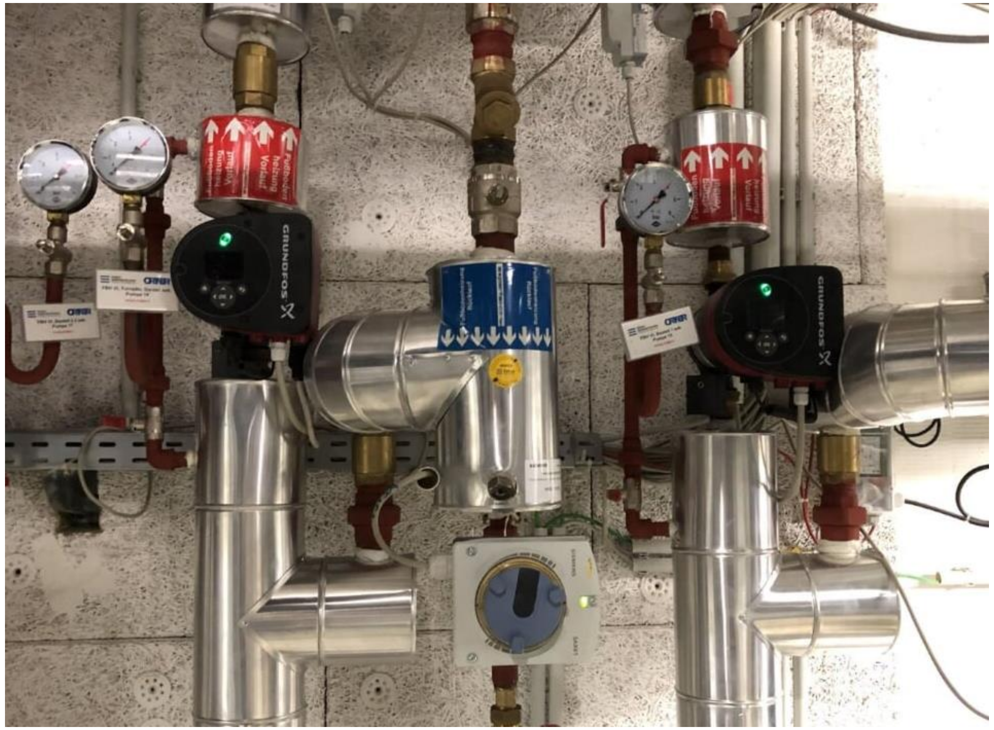
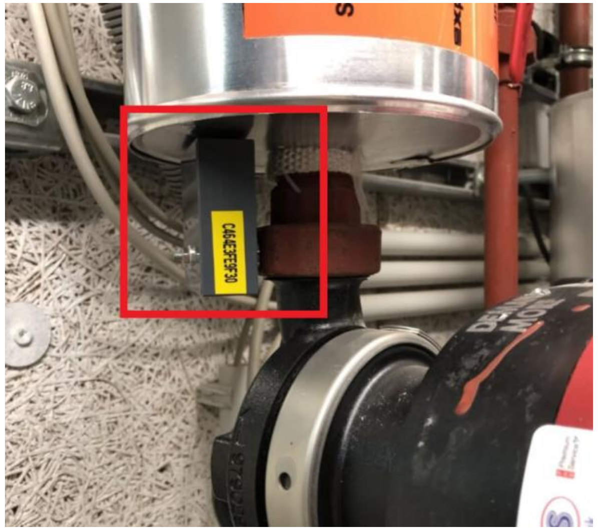


Hiessl, Thomas & Schall, Daniel & Kemnitz, Jana & Schulte, Stefan. (2020). Industrial Federated Learning – Requirements and System Design. 10.1007/978-3-030-51999-5_4.

Use Case - Building Technologies: Circulation pump models - Aspern Smart City Research (ASCR)

- Vibration Data → Model building (e.g., for condition monitoring) → Federated Learning





Use Case – Digilab
Image-based Anomaly Detection

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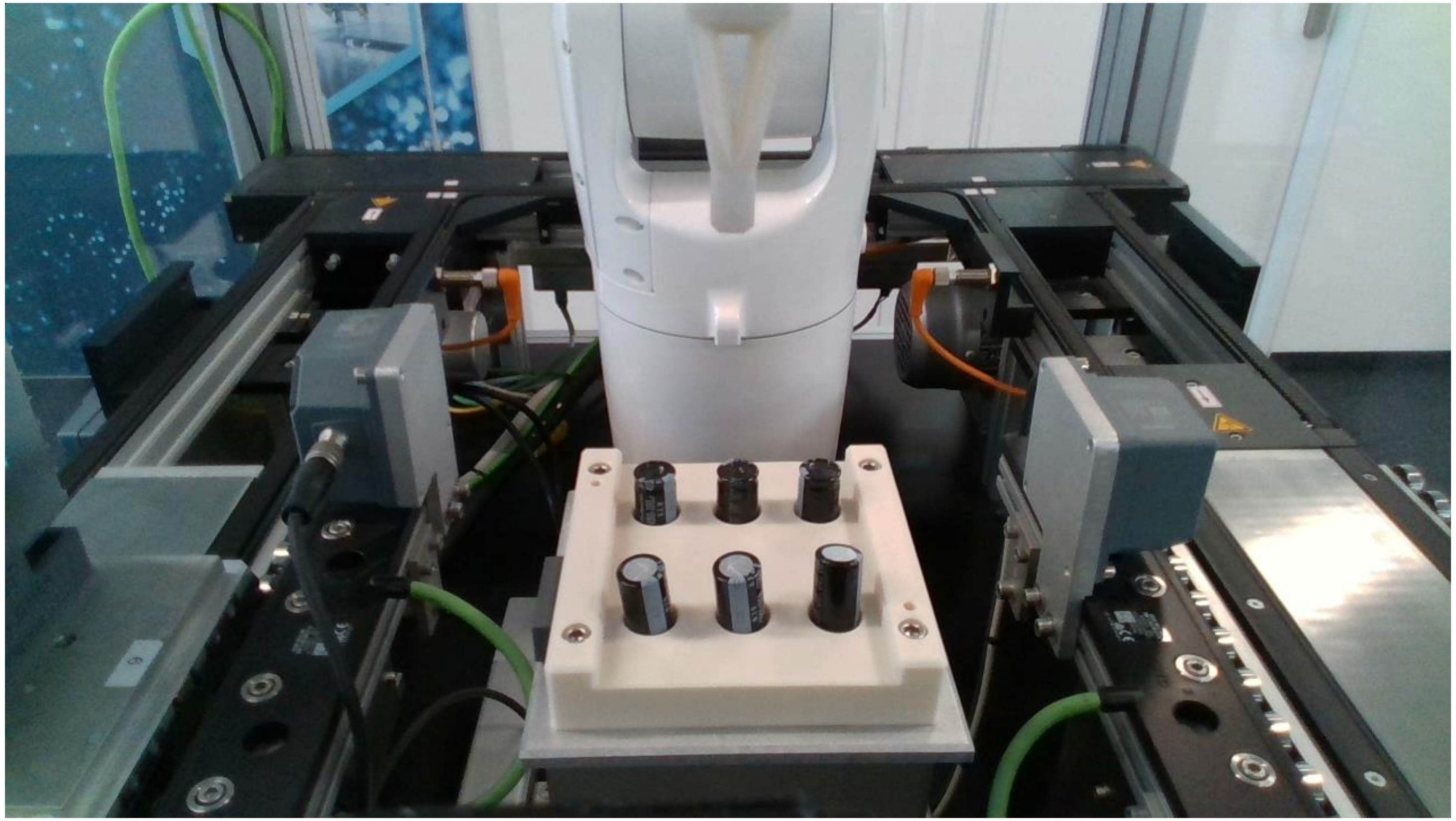
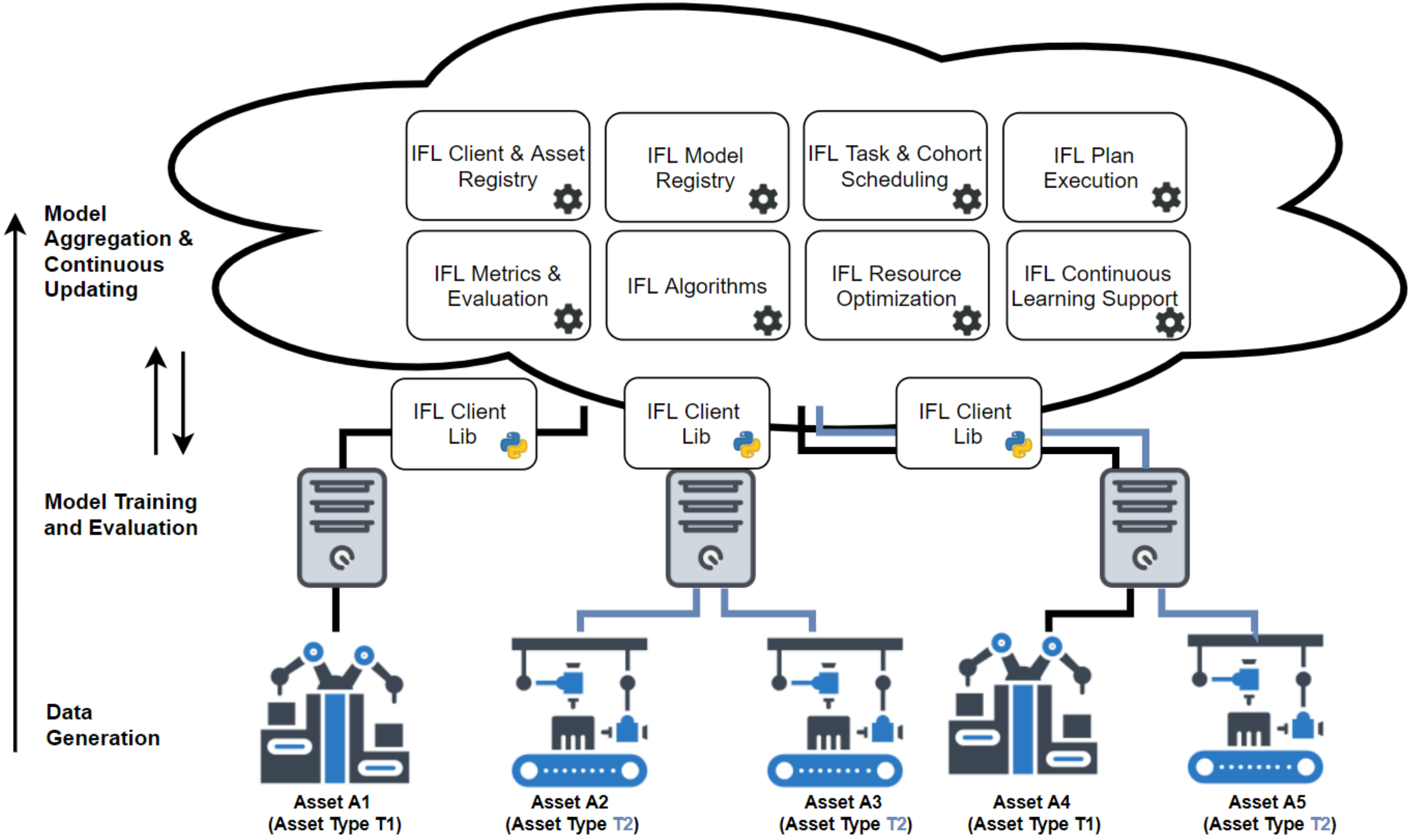
- Images of capacitors → Anomaly detection models → Federation



IFL System – Building Blocks



Artificial Intelligence in Industry
Recap and challenges for configuration technologies

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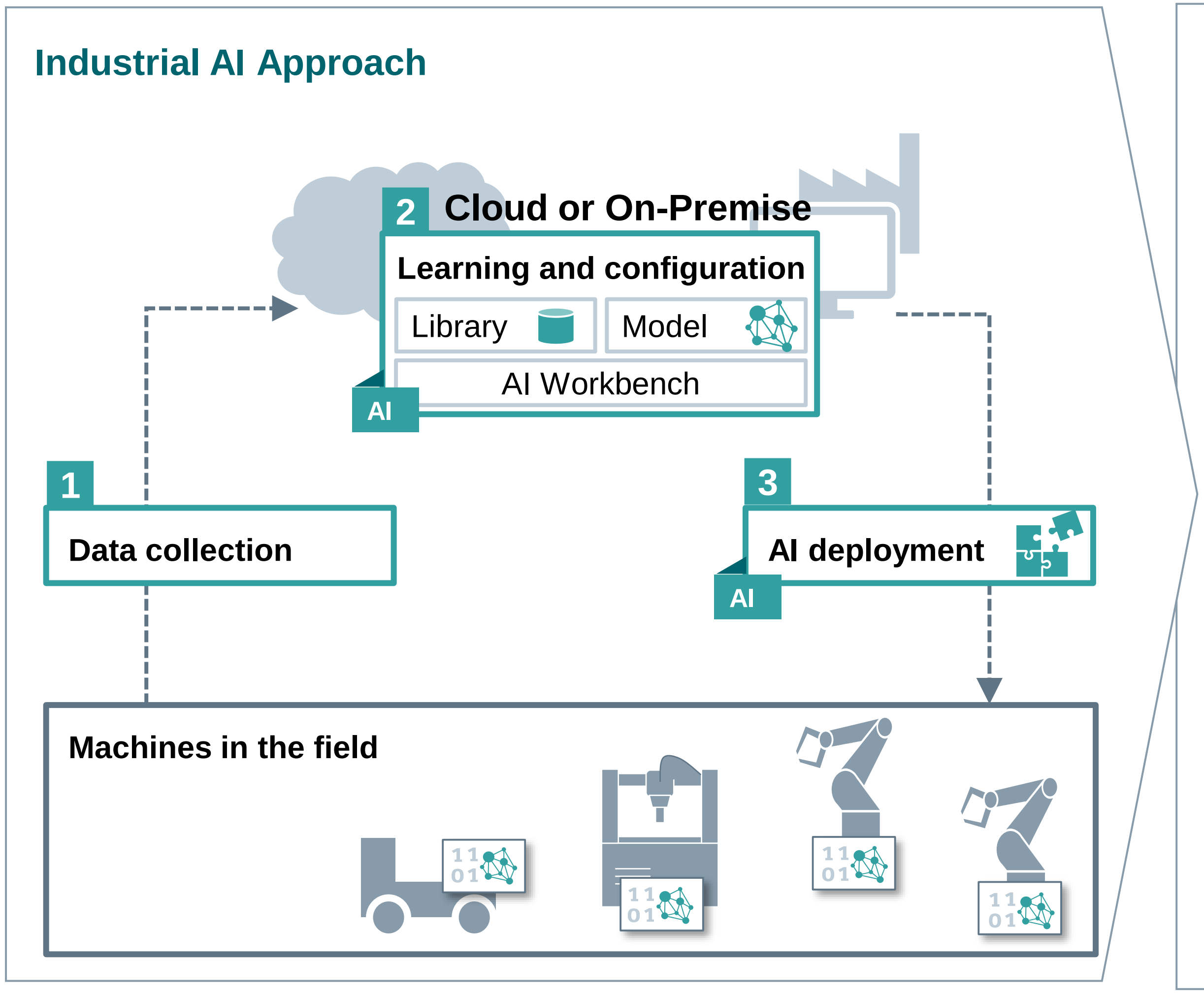

→ **Challenges:**

1. **Data Collection:**
   Configuring different data sources
   Semantic understanding of data points
2. **Learning and configuration of AI Algorithm:**
   Configuration and optimization of AI models
   Configuration of AI pipeline
3. **Deployment of AI:**
   HW selection
   Automatic deployment

Thank you!

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