Industrial Edge 3rd Application Scenario
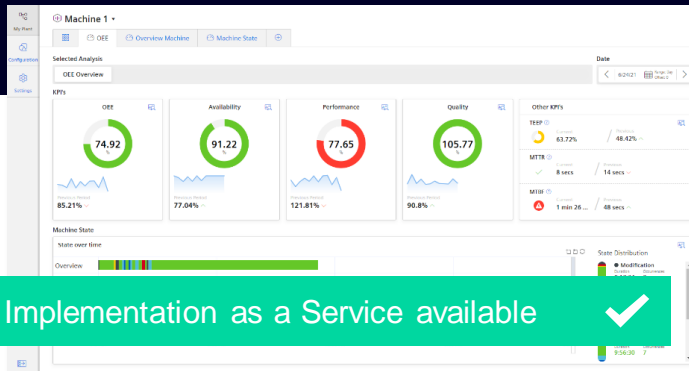
Example #1 - THT Close-Loop

SIEMENS

Industrial Edge Application Scenario Background
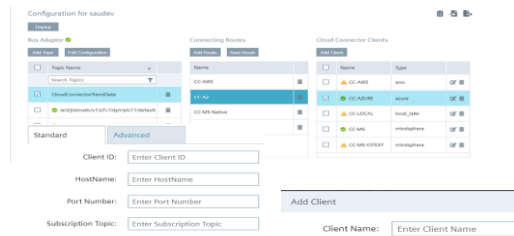Start your Industrial IOT journey

Performance Analytics
Detect and visualize root causes for efficiency losses in manufacturing

Implementation as a Service available ✔

Shopfloor to Cloud Connectivity
Integrate machine & production data securely into the company cloud

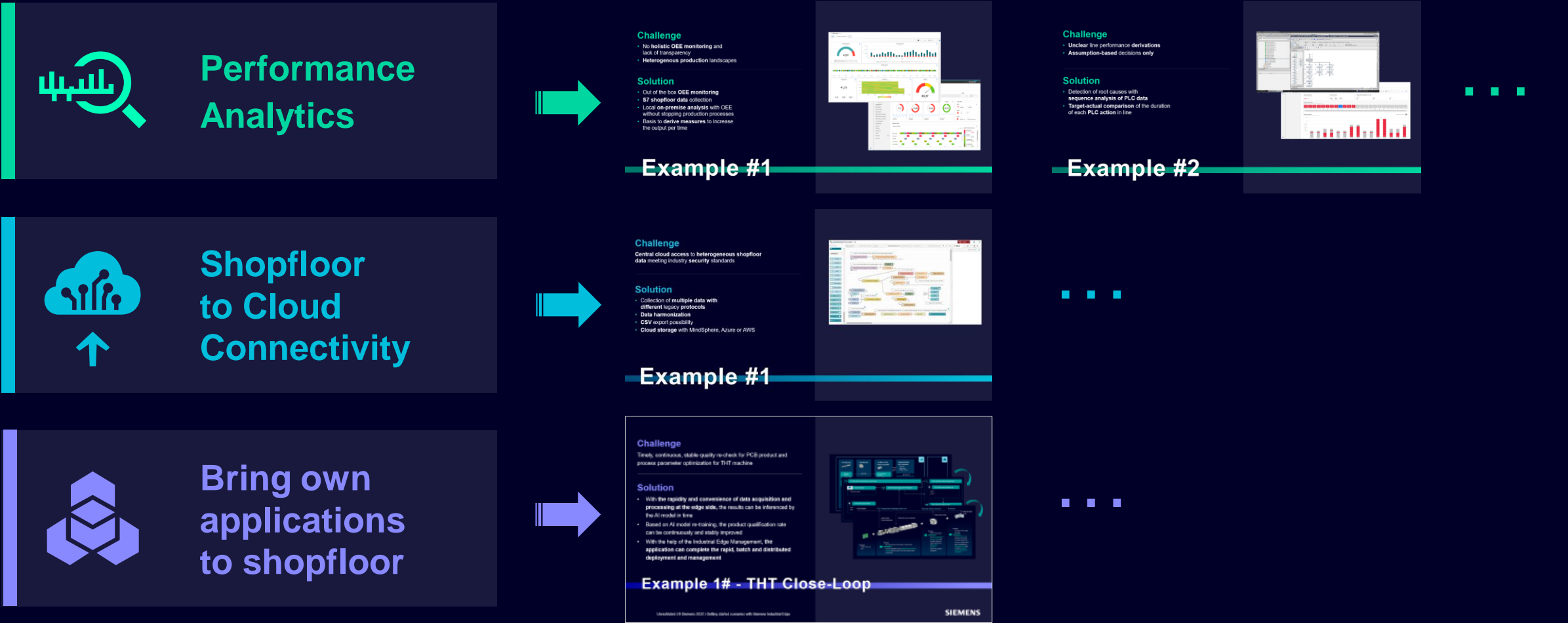Implementation as a Service available ✔

Bring own applications to shopfloor
Management and deployment of self-developed apps to the shopfloor

SIEMENS

Industrial Edge Application Scenario Background

Application Scenario structure

Performance Analytics

Challenge
- No **holistic OEE monitoring** and lack of transparency
- **Heterogeneous production** landscapes

Solution
- Out of the box **OEE monitoring**
- **S7 shopfloor data** collection
- Local **on-premise analysis** with OEE without stopping production processes
- Basis to **derive measures** to increase the output per time

Example #1

Challenge
- **Unclear** line performance **derivations**
- **Assumption-based decisions only**

Solution
- Detection of root causes with **sequence analysis of PLC data**
- **Target-actual comparison** of the duration of each **PLC action** in line

Example #2

. . .

Shopfloor to Cloud Connectivity

Challenge

Central **cloud access** to **heterogeneous shopfloor data** meeting industry **security** standards

Solution
- Collection of **multiple data with different** legacy **protocols**
- **Data harmonization**
- **CSV** export possibility
- **Cloud storage** with MindSphere, Azure or AWS

Example #1
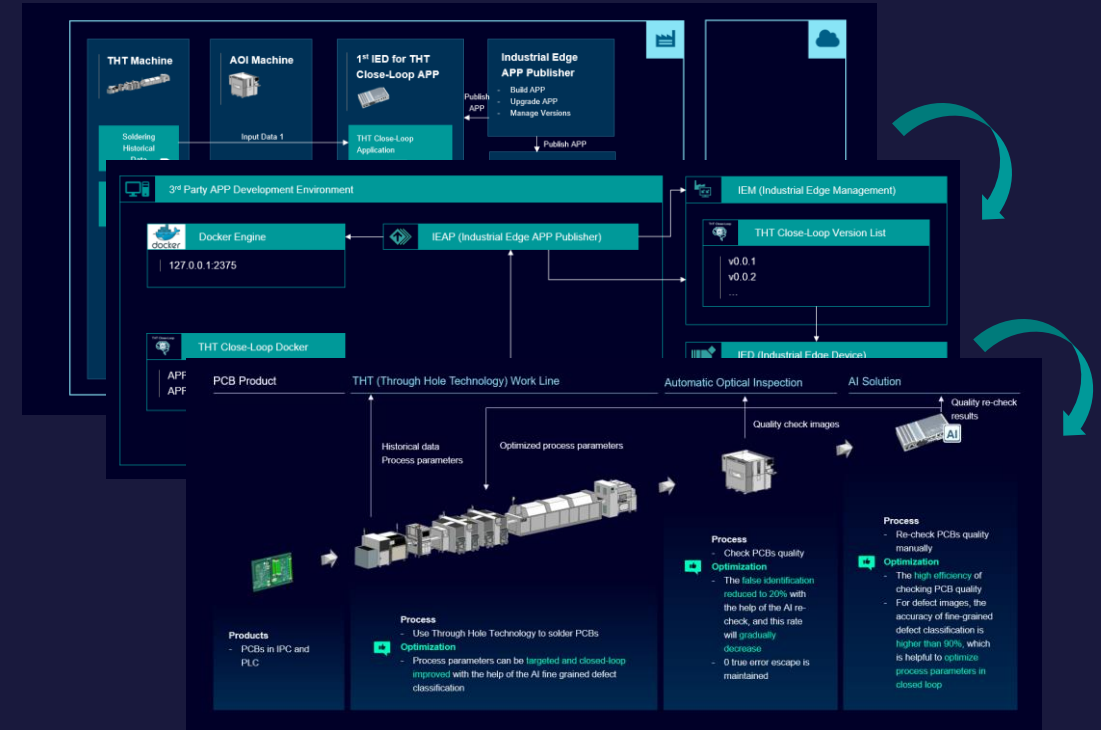
. . .

Bring own applications to shopfloor

Challenge

Timely, continuous, stable quality re-check for PCB product and process parameter optimization for THT machine
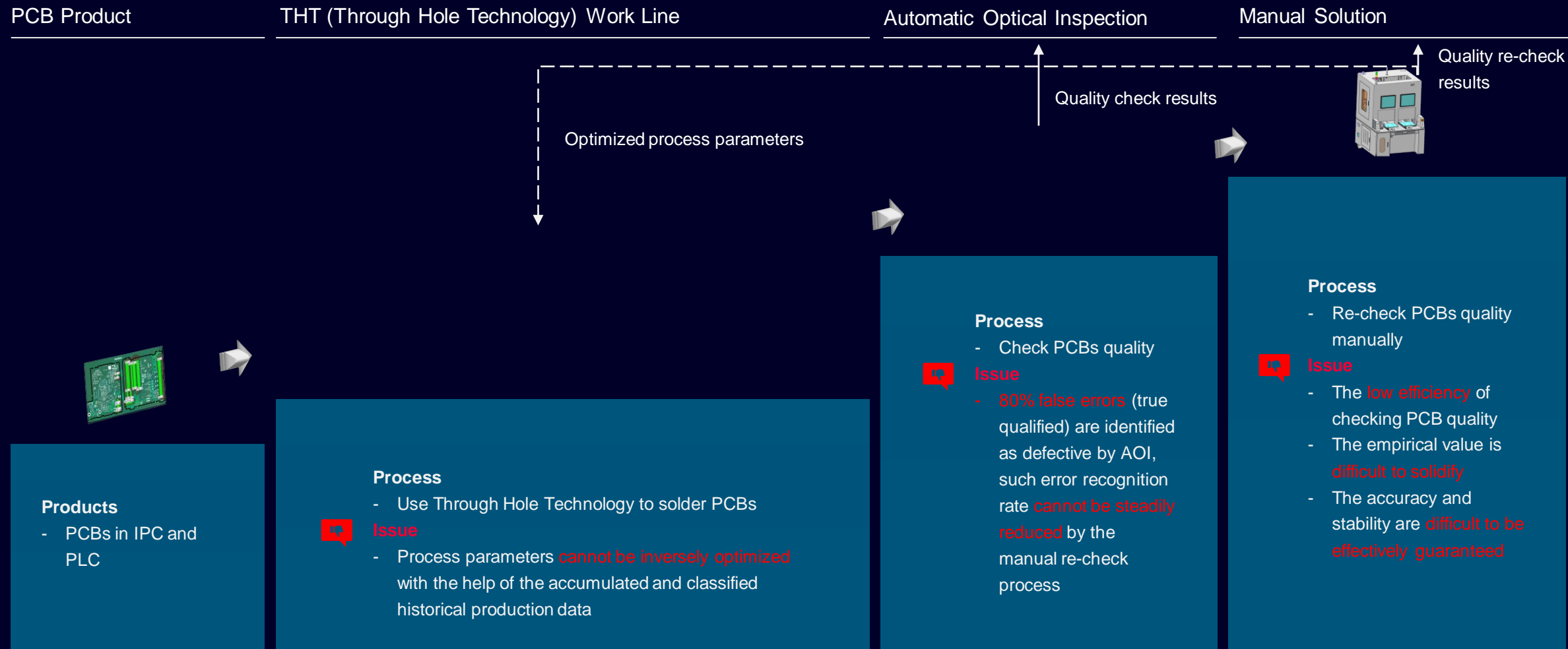
Solution
- With **the rapidity and convenience of data acquisition and processing at the edge side,** the results can be inferenced by the AI model in time
- Based on AI model re-training, the product qualification rate can be continuously and stably improved
- With the help of the Industrial Edge Management, the application can complete the rapid, batch and distributed deployment and management
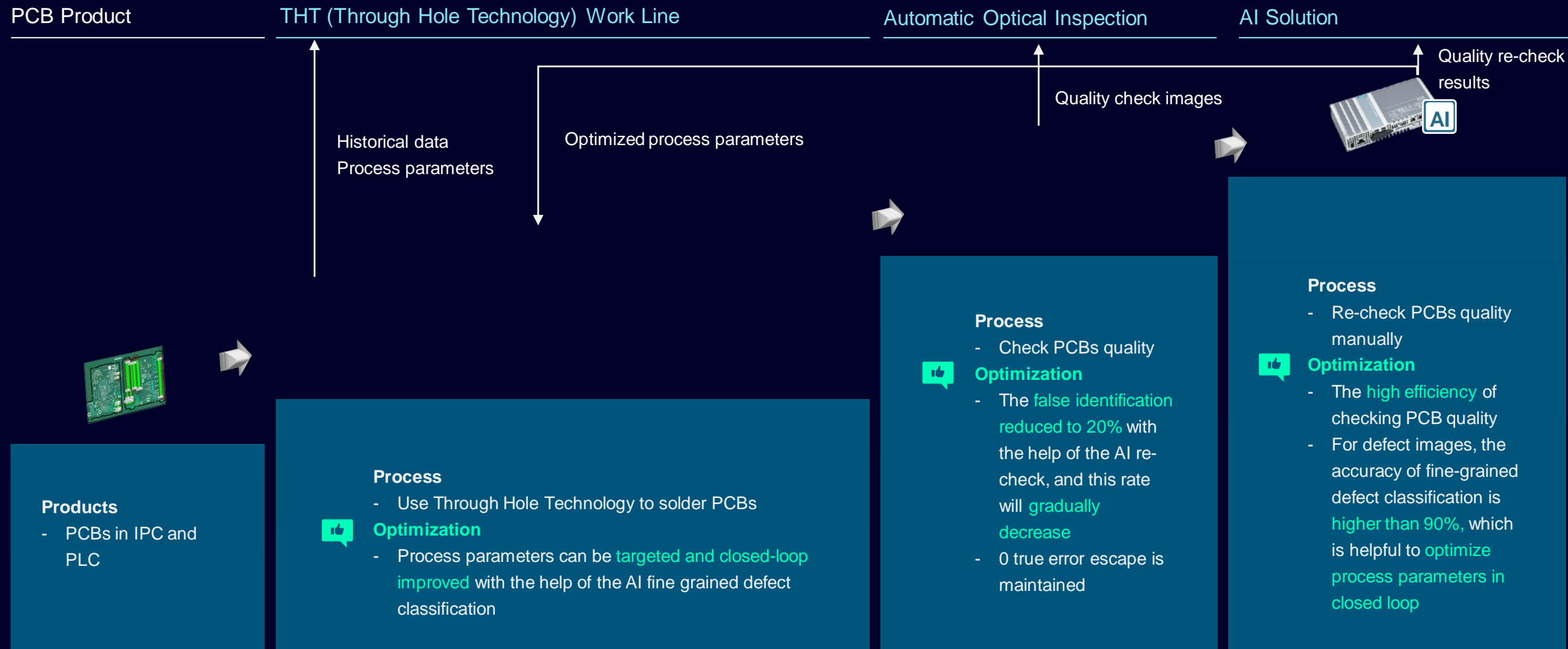
Example 1# - THT Close-Loop

Unrestricted | © Siemens 2022 | Getting started scenarios with Siemens IndustrialEdge

SIEMENS

. . .

SIEMENS

Challenge

Timely, continuous, stable quality re-check for PCB product and process parameter optimization for THT machine

Solution

- With **the rapidity and convenience of data acquisition and processing at the edge side,** the results can be inferenced by the AI model in time

- Based on AI model re-training, the product qualification rate can be continuously and stably improved

- With the help of the Industrial Edge Management, **the application can complete the rapid, batch and distributed deployment and management**

Example 1# - THT Close-Loop

SIEMENS

Application Scenario Background

Original work process

PCB Product

THT (Through Hole Technology) Work Line

Automatic Optical Inspection

Manual Solution

Quality re-check results

Quality check results

Optimized process parameters

Products
- PCBs in IPC and PLC

Process
- Use Through Hole Technology to solder PCBs

Issue
- Process parameters cannot be inversely optimized with the help of the accumulated and classified historical production data

Process
- Check PCBs quality

Issue
- 80% false errors (true qualified) are identified as defective by AOI, such error recognition rate cannot be steadily reduced by the manual re-check process

Process
- Re-check PCBs quality manually

Issue
- The low efficiency of checking PCB quality
- The empirical value is difficult to solidify
- The accuracy and stability are difficult to be effectively guaranteed

SIEMENS

Application Scenario Background

Current work process

PCB Product | **THT (Through Hole Technology) Work Line** | **Automatic Optical Inspection** | **AI Solution**

Quality re-check results

Quality check images

Historical data
Process parameters

Optimized process parameters

Products
- PCBs in IPC and PLC

Process
- Use Through Hole Technology to solder PCBs

Optimization
- Process parameters can be targeted and closed-loop improved with the help of the AI fine grained defect classification

Process
- Check PCBs quality

Optimization
- The false identification reduced to 20% with the help of the AI re-check, and this rate will gradually decrease
- 0 true error escape is maintained

Process
- Re-check PCBs quality manually

Optimization
- The high efficiency of checking PCB quality
- For defect images, the accuracy of fine-grained defect classification is higher than 90%, which is helpful to optimize process parameters in closed loop

SIEMENS

Reference Architecture

📁 Share Folder

THT Machine

AOI Machine

1ˢᵗ IED for THT Close-Loop APP

Industrial Edge APP Publisher

- Build APP
- Upgrade APP
- Manage Versions

Publish APP

Soldering Historical Data 📁

Input Data 1

THT Close-Loop Application

Publish APP

2ⁿᵈ IED for DBs

Soldering Process Parameters 📁

Input Data 2

Output Data 2

2ⁿᵈ AI Model
Process Parameter Optimization

Re-train AI Models

1ˢᵗ Quality Detection Images 📁

Input Data 3

1ˢᵗ AI Model
Quality Re-check

Output Data 1

Quality Re-check Results

Microsoft SQL Server

MindSphere

or

aws

Synchronize AI Models

Industrial Edge Runtime

Device Firmware

AI Model Management

MINIO

Download AI Models

SIEMENS

Network Architecture

THT Machine

AOI Machine

1st IED for THT Close-Loop APP

2nd IED for DBs

SQL Server

Re-train AI Models

Windows Client for the machine data transmission

THT Close-Loop Application

ODBC

Port: 1433

MindSphere

or

aws

📁 **Share Folder**

1. Soldering Historical Data
2. Soldering Process Parameters
3. 1st Quality Detection Images

FTP

Port: 18000

AI Model Management

MINIO

Download AI Models

FTP

Port: 9000

e.g. IP - 192.168.0.200

e.g. IP - 192.168.0.131

e.g. IP - 192.168.0.132

SIEMENS

MinIO and SQL Server Features

Data storage and bidirectional transmission between app and cloud
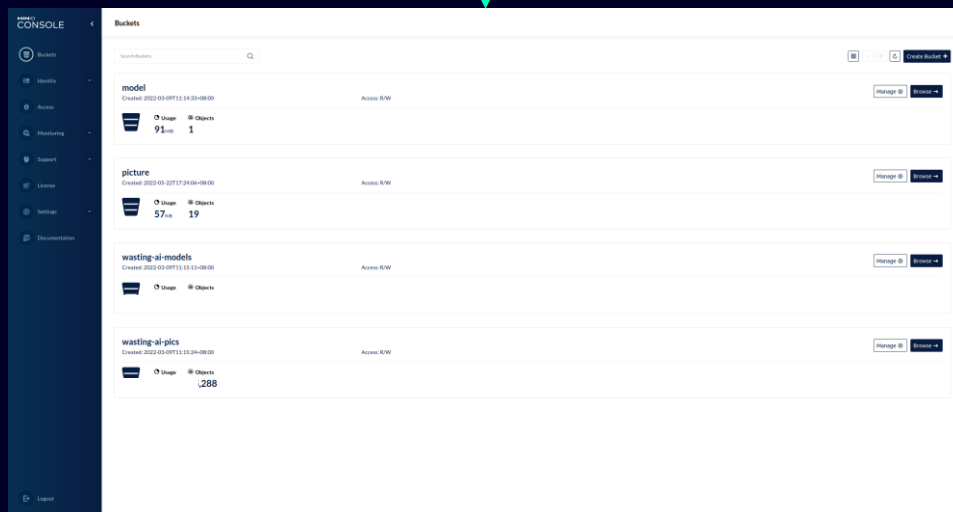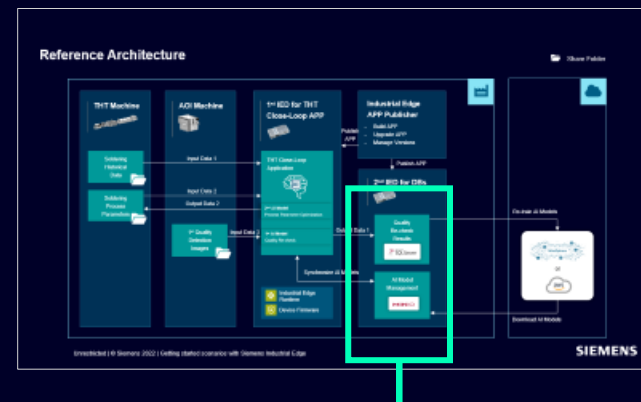
MinIO

- Download the AI models from the cloud and synchronize to the THT Close-Loop APP
- Collect the dataset from the THT Close-Loop APP and upload to the cloud for the AI models retraining
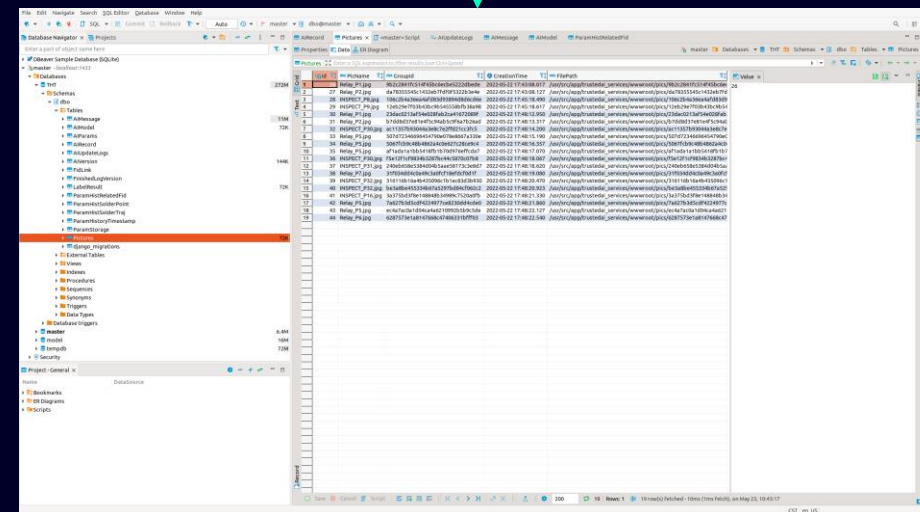
SQL Server

- Store all historical data and key results of the THT Close-Loop APP
- Provide data support for data interaction between MinIO and THT Close-Loop APP

SIEMENS

THT Close-Loop APP Feature - Quality Re-check
Quality re-check AI model

Input data

Unqualified results from AOI

Quality re-check model

Model content	Description
Name	ResNet (Residual Network) 50
Definition	The series of ResNet (ResNet50, ResNet101) are widely used in the fields of target classification, also regarded as a part of the backbone classical neural network for the computer vision tasks.
Layer amount	50
Parameter amount	$25.5*10^6$
Goal	Classify Quality re-check result into three types 1. OK 2. missing soldering 3. insufficient soldering

ResNet50 network structure

1. Convoluted the input
2. Enter the four residual blocks
3. Complete the full connection operation to facilitate the classification task

Table 1. Architectures for ImageNet. Building blocks are shown in brackets (see also Fig. 5), with the numbers of blocks stacked. Down-sampling is performed by conv3.1, conv4.1, and conv5.1 with a stride of 2.

Output result

Classify unqualified results into three categories

Type 1 - Qualified
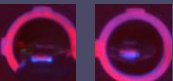
Type 2 – Unqualified in missing welding

Type 3 – Unqualified in insufficient welding

SIEMENS

THT Close-Loop APP Feature - Quality Re-check

Quality re-check AI model - inference

Description

- Based on the imported dataset and selected AI model, app can classify the quality issues and display the PCB quality re-check results in real time

Operation Step

1. Select a user-defined time range to view the PCB THT quality re-check results
2. Each line contains AOI check image, quality re-check result and other key information
3. AI model can classify the results into three categories: false failure (qualified), miss welding and insufficient welding. On the one hand, it can reduce the product waste caused by AOI misjudgment; on the other hand, it can provide help for the optimization of THT process parameters

SIEMENS

THT Close-Loop APP Feature - Quality Re-check

Quality re-check AI model – inference benefits

- Re-check the unqualified results from AOI and select qualified products, reduce product waste, and greatly reduce the false identification rate from 80% to 20%
- Classify the unqualified products into 2 types – missing welding and insufficient welding, provide direction for THT process parameter optimization

PCB quality check by AOI
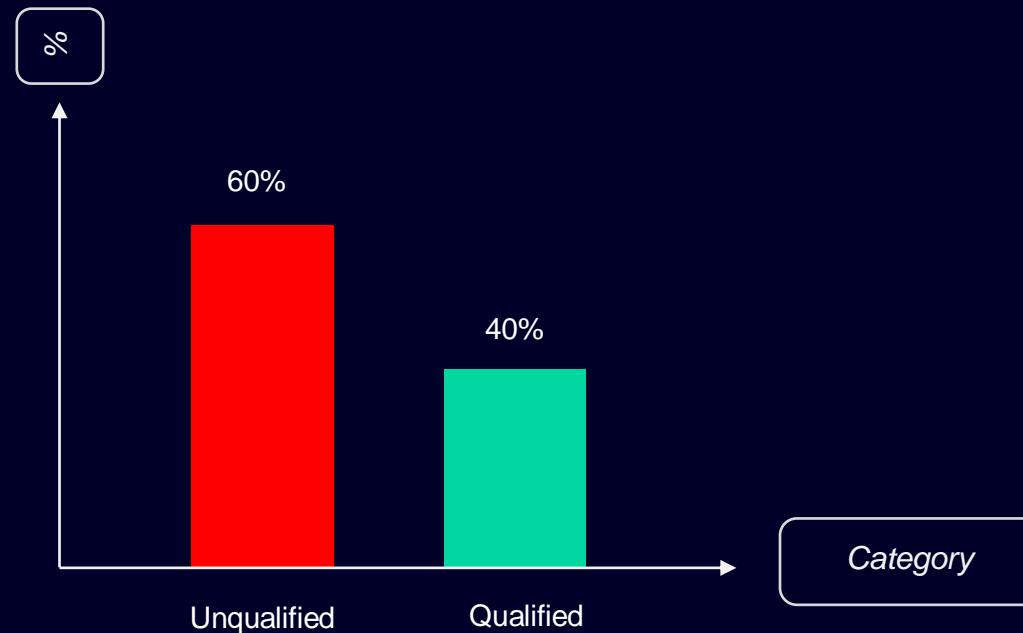
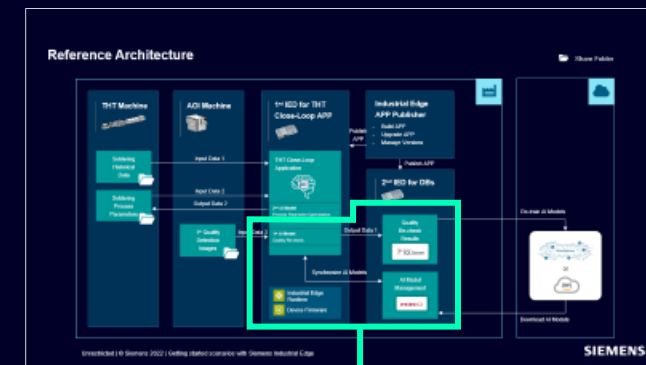**SIEMENS**

THT Close-Loop APP Feature - Quality Re-check

Quality re-check AI model – inference benefits

- Re-check the unqualified results from AOI and select qualified products, reduce product waste, and greatly reduce the false identification rate from 80% to 20%
- Classify the unqualified products into 2 types – missing welding and insufficient welding, provide direction for THT process parameter optimization

PCB quality re-check by AI model

SIEMENS
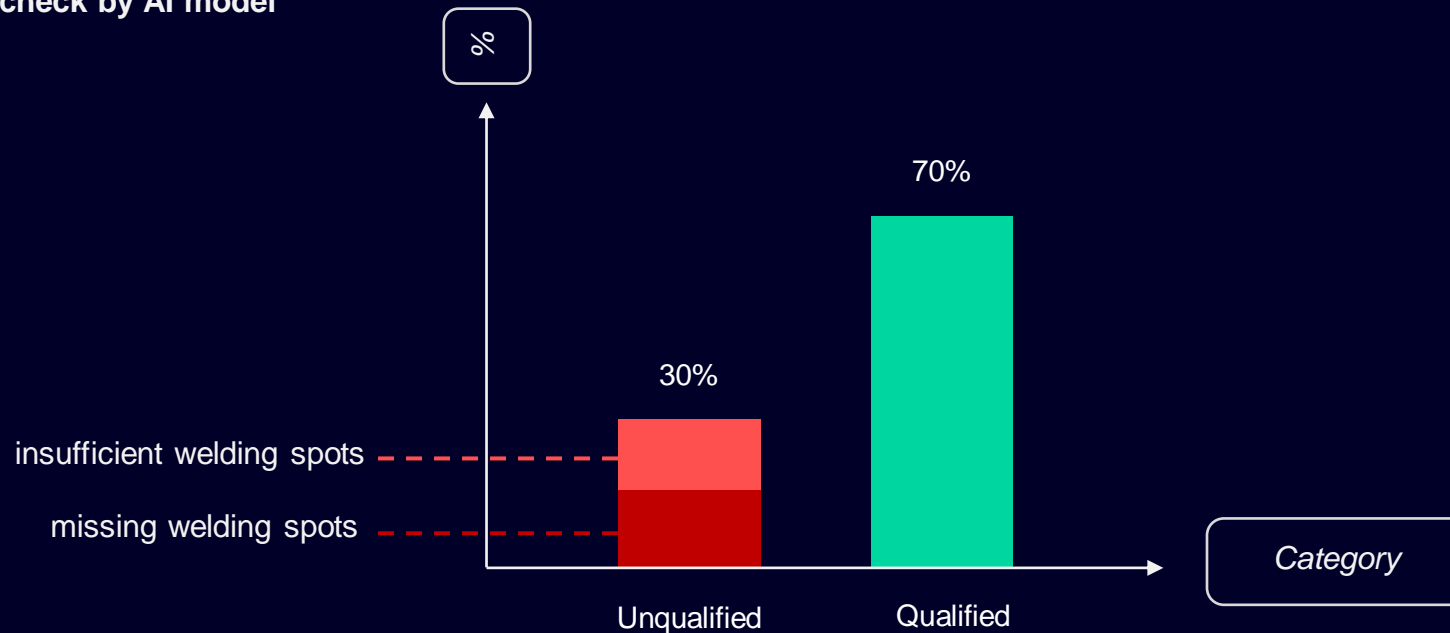
THT Close-Loop APP Feature - Quality Re-check
Quality re-check AI model - retraining

Description

- Not all re-check results are accurate, especially in the early stage of model deployment, which requires repeated training of the model through human intervention to make the model deduction results more accurate

Operation Step

1. Select a user-defined time range to view the PCB THT quality re-check results
2. Using the field experience to correct some of the AI re-check results, then save and upload the correction results to the cloud, so that the model can be further trained and optimized based on these corrected results
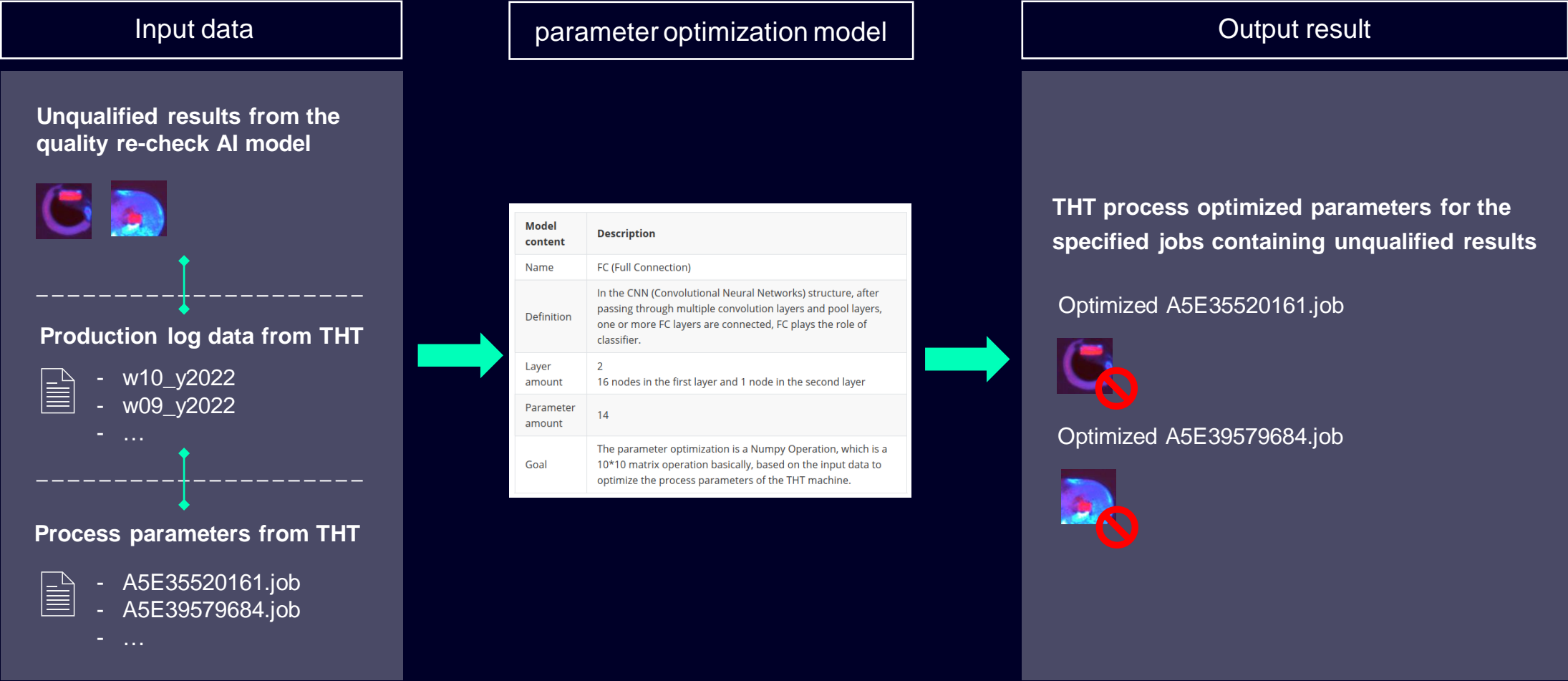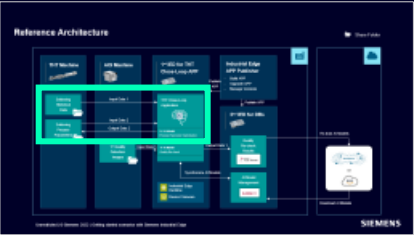
SIEMENS

THT Close-Loop APP Feature - Process Parameter Optimization
Process parameter optimization AI model

	Input data		parameter optimization model		Output result

Unqualified results from the quality re-check AI model

- -

Production log data from THT

- w10_y2022
- w09_y2022
- …

- -

Process parameters from THT

- A5E35520161.job
- A5E39579684.job
- …

Model content	Description
Name	FC (Full Connection)
Definition	In the CNN (Convolutional Neural Networks) structure, after passing through multiple convolution layers and pool layers, one or more FC layers are connected, FC plays the role of classifier.
Layer amount	2 16 nodes in the first layer and 1 node in the second layer
Parameter amount	14
Goal	The parameter optimization is a Numpy Operation, which is a 10*10 matrix operation basically, based on the input data to optimize the process parameters of the THT machine.

THT process optimized parameters for the specified jobs containing unqualified results

Optimized A5E35520161.job

Optimized A5E39579684.job

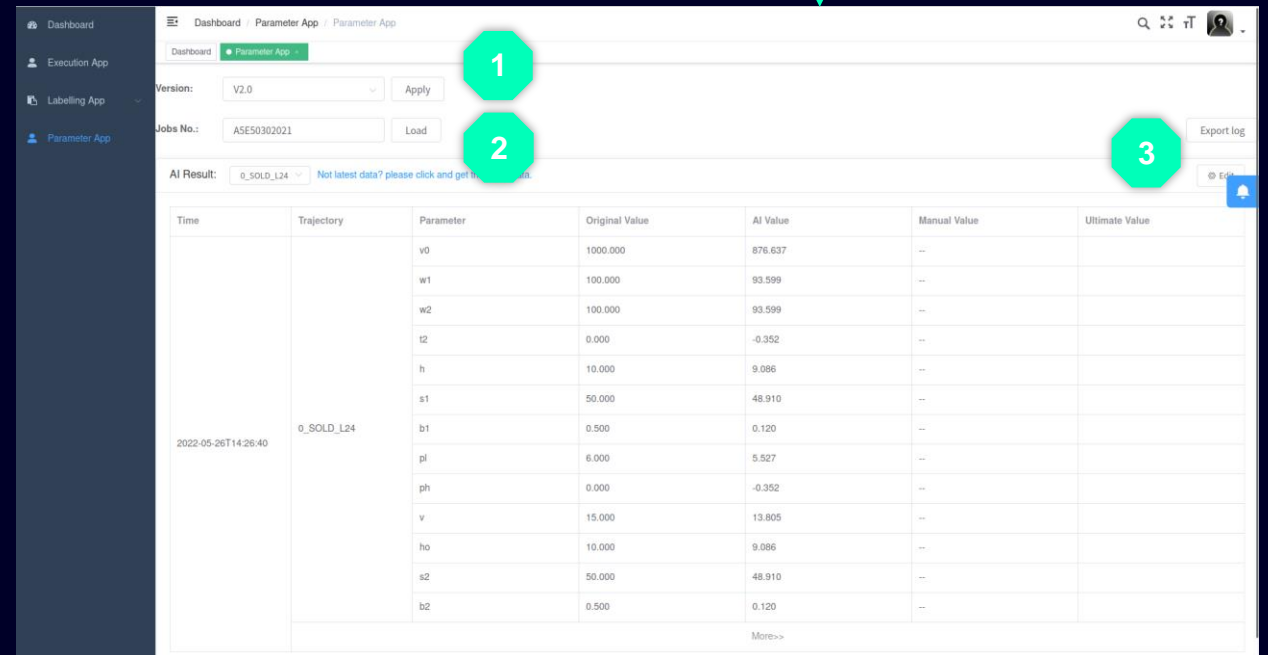**SIEMENS**

THT Close-Loop APP Feature - Process Parameter Optimization
Process parameter optimization AI model - inference

Description

- When the data imported to the process parameter optimization AI model, the app can inference and display the optimized parameters for the corresponding jobs and product, so that user can view the optimized results in real time

Operation Step

1. Select and apply a specified version of the AI model for the inferencing
2. The app can display the latest optimized parameters for the specified product
3. User can intervene the optimized parameters based on the operator experience so that the THT process can use the most accurate and correct parameters to solder the PCBs in the next batch
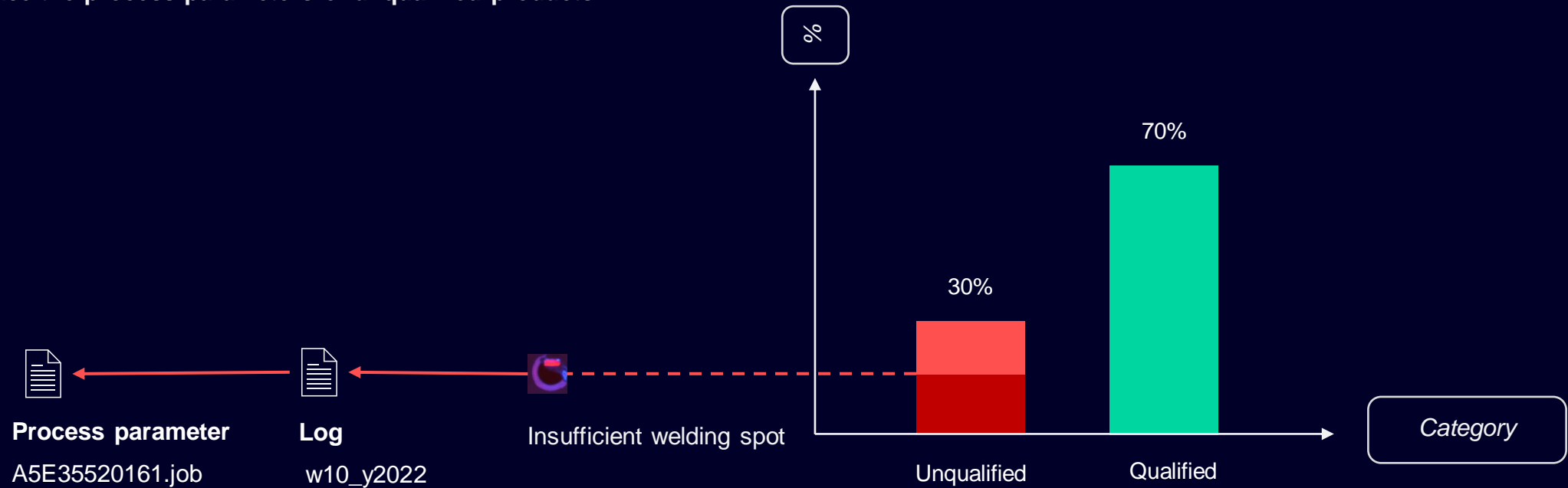
SIEMENS

THT Close-Loop APP Feature - Process Parameter Optimization

Process parameter optimization AI model - inference benefits

- Trace and optimize the process parameters of unqualified products, solve the problem of unqualified products from the root, and further reduce the unqualified rate of products

Step 1 – Trace the process parameters of unqualified products

Process parameter
A5E35520161.job

Log
w10_y2022

Insufficient welding spot

%

70%

30%

Unqualified
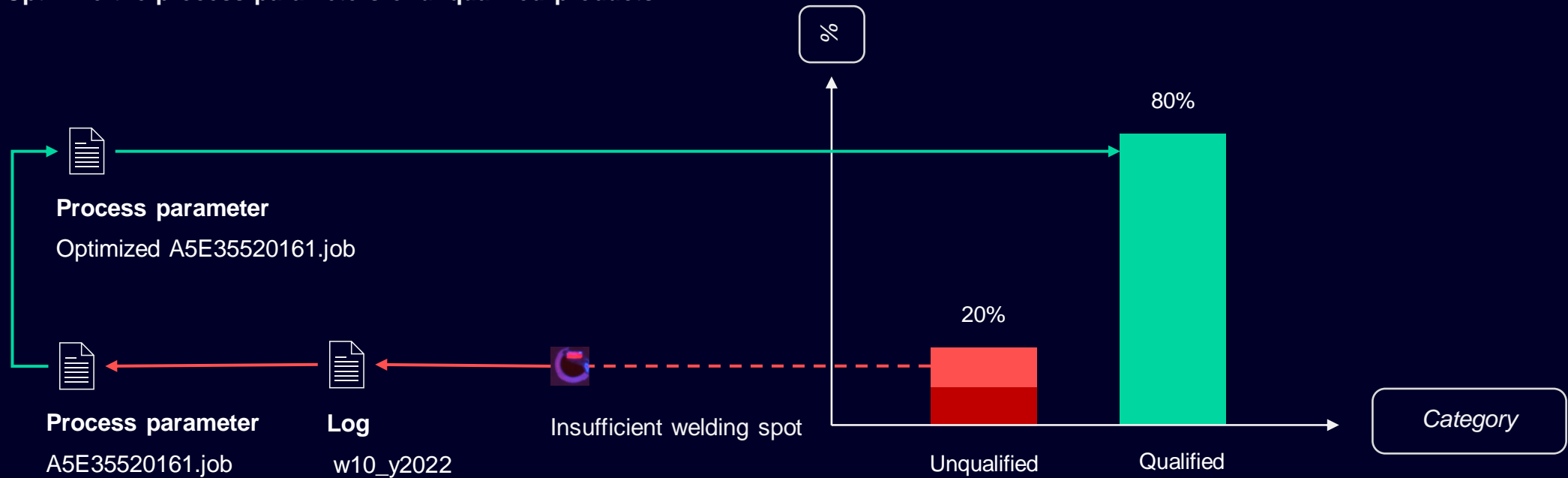
Qualified

Category

SIEMENS

THT Close-Loop APP Feature - Process Parameter Optimization

Process parameter optimization AI model - inference benefits

- Trace and optimize the process parameters of unqualified products, solve the problem of unqualified products from the root, and further reduce the unqualified rate of products

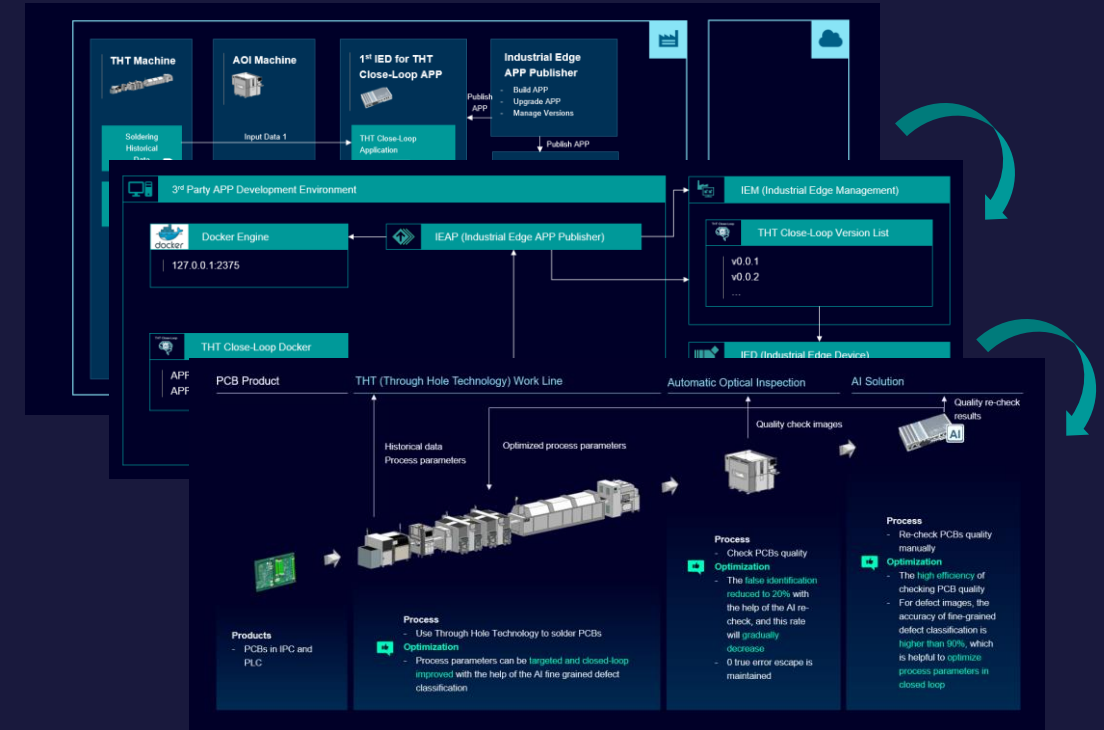**Step 2 – Optimize the process parameters of unqualified products**

Process parameter
Optimized A5E35520161.job

Process parameter
A5E35520161.job

Log
w10_y2022

Insufficient welding spot

80%

20%

Unqualified

Qualified

Category

%

SIEMENS

Challenge

Timely, continuous, stable quality re-check for PCB product and process parameter optimization for THT machine

Solution

- With **the rapidity and convenience of data acquisition and processing at the edge side,** the results can be inferenced by the AI model in time

- Based on AI model re-training, the product qualification rate can be continuously and stably improved

- With the help of the Industrial Edge Management, **the application can complete the rapid, batch and distributed deployment and management**

Example 1# - THT Close-Loop

SIEMENS

Thank you !

SIEMENS