Strategic implementation of smart manufacturing ecosystem by IVRA-Next framework

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Outline

1. Introduction to IVI
2. Scenarios of Smart manufacturing
3. Outline of the IVRA Next
4. Ecosystem of IVI platform
5. Inter-enterprise manufacturing integration
6. Connected industries open framework
IIoT/Smart Manufacturing Initiatives in Japan

Industrial Value Chain Initiative
Membership
(as April, 2018):

244 Members

Manufacturing member
91 Large enterprises
67 SMEs

Supporting member
31 Large enterprises
41 SMEs

Sponsor member
14 Organizations

SMEs are 47% of the total

IoT for all Industries and Society
IoT Acceleration Consortium
IoT Acceleration Lab

Robot revolution society
Robot Revolution Initiative (RRI)

Robot Innovation

Robot Usage Promotion

Smart Manufacturing

IoT-driven Transformation in Manufacturing

Interrelated

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Some Members of IVI

240+ companies, 600+ individuals

Mazak
Yazaki
HONDA
RICOH
MITSUBISHI HEAVY INDUSTRIES
MITSUBISHI HITACHI POWER SYSTEMS
Nakamura-Tome Precision Industry
Kajima
FUJITSU
Fuji Electric
OKUMA
TOSHIBA
KONICA MINOLTA
Mazda
YASKAWA
MITSUBISHI ELECTRIC
KOMATSU
SUMITOMO ELECTRIC
Kawasaki
Invented for life
BOSCH
TOYOTA
MiSUMi
DAIFUKU
Always an Edge Ahead
OMRON
HITACHI
DENSO
YKK
MES
JTEKT
NIKON
Panasonic
KOBELCO
NISSAN MOTOR CORPORATION
BECKHOFF
SONY
NEC
YOKOGAWA
NIKON
YAMAHA
Some Members of IVI

240+ companies, 600+ individuals
General structure of IVI organization

Manufacturer and SME who has a factory

Regular member

Academic member

Device model WG
Data model WG
Service Model WG
Use case WG
Common dictionary WG

Smart Scenario WG

Practical concerns in actual fields

Future testbed project

AS-IS scenario and TO-BE scenario are specified followed by experimental implementations

Support member

Individual member

Advanced study topics are investigated with respect to smart manufacturing

Implementation member

Sponsor member

IVRA Technical WG

TwG

Platform and implementation framework

Technologies and solution candidates

Advanced study group

ASG

Smart manufacturing Platformer
Component supplier
System integrator
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20 Smart Scenarios in 2015

- Cloud enabled monitoring platform for global distributed factories. [WG-101]
- Global B2B After-sales service for remote location with call center. [WG-402]
- One-stop portal and collaborative quotation management by connected SMEs. [WG-306]
- Cyber physical production and logistics systems with common interface. [WG-309]
- Risk management by connected production information in global SCM. [WG-310]
- Interoperable life cycle management for equipment and production line. [WG-105]
- Dynamic production optimization by simulation integrated CPPS. [WG-106-1]
- Real-time sensor data acquisition and analysis using multi-vendor network. [WG-106-2a]
- Maintenance operation and prediction by failure based data analytics. [WG-106-2b]
- Cloud based simple monitoring scalable for legacy production line. [WG-106-3]
- Knowledge of bill of production process for E-BOM to M-BOM traceability. [WG-208]
- Cyber dashboard for design and engineering of unexpected design change. [WG-108-3]
- Mass-customization for end users directory connected to factories. [WG-403]
- Agent based location free manufacturing in dynamic supply chain. [WG-207]
- Communication robot for autonomous MES connected among factories. [WG-108-2]
- Robotics line building for SMEs using cloud knowledge database. [WG-204]
- Proactive machine communicating with workers in IoT environment. [WG-108-1]
- Advanced quality assurance by connecting data - Toward 0 failure production. [WG-201]
- Standardization of working styles in "Man-Machine collaborative factories". [WG-211]
- Remote consulting service of production engineering by bill of process information.
67 Smart manufacturing scenarios on IVRA

25 Smart Scenarios in 2016

- Digitalization of process information and know-how on manufacturing [2A01]
- Connection of information on production preparation at design change [2A02]
- Utilization of robot program assets by CPS [2B01]
- Agile planning of production with real-time data on workers and things [2C01]
- Position control system for things at low cost [2C02]
- IoT to support workers in flexible manufacturing in kinds and volume [2D02]
- Traceability of quality data [2E01]
- Real-Time Management of Quality Data [2E02]
- Promotion of CPS in supply chain with standard interface [2F01]
- Promotion of CPS in supply chain with standard interface (shipping logistics) [2F02]
- Collaboration among companies through shared process information [2G01]
- Managing manufacturing progress and delivery time among plants [2G02]
- Sharing technical information for horizontal integration of SMEs [2H01]
- Horizontal integration of SMEs and visualization of process information [2H02]
- Service for SMEs to notice information on manufacturing progress [2H03]
- Manufacturing innovation for interactive growth between human and plant equipment [2J01]
- Predictive maintenance of presses and panel transportation devices [2K01]
- Inclusive PM / Predictive maintenance for ALL [2K02]
- Predictive maintenance system to detect signs of equipment abnormality at low cost [2K03]
- Smart maintenance with machine IoT data [2L01-1]
- Smart maintenance with digitalization of knowledge [2L01-2]
- Productivity improvement by visualization of equipment and workers [2L04]
- Mutual accommodation of facilities through shared production information [2L05]
- Managing Actual Operation Status of all Equipment in a Plant [2L06]
- Increasing added value of after-sales service [2M01]
22 Smart Scenarios in 2017

- Quality data connected with things [3A01]
- Data connection between design department and production department for realization of CPS [3A02]
- Connection of product design information and production technology information utilizing BOP via cloud [3A03]
- Realtime management of visual inspection process [3A04]
- Traceability of quality data (IoT utilizing Raspberry Pi and cloud) [3A05]
- Improvement of productivity and quality stability by visualization of operation result of equipment and human [3B01]
- Predictive maintenance and quality improvement in forging press line [3B02]
- Predictive maintenance and quality control for everybody [3B03-1]
- Predictive maintenance of equipment and real-time control of processing quality [3B03-2]
- Next-Generation IoT enabling predictive maintenance and real-time quality control [3B03-3]
- Improvement of overall equipment efficiency [3B04]
- Productivity improvement and automation of production lines by AI - Stage 1: inspection process - [3C01]
- Interactive growth of human and equipment in manufacturing [3C02]
- Manual for digitalization of skilled workers' technics - Don't let its digitalization be technics of skilled workers - [3C03]
- Improvement of robot facilities from launch through operation to maintenance by CPS [3C04]
- Improvement of production efficiency and ensuring delivery date by realtime process progress management and location management [3D01]
- Cyber-physical production by simulation for dynamic optimization [3D02]
- Visualization and reduction of short-time facility stops in SMEs by utilizing IoT [3D03]
- Production kaizen (improvement) by extended MES [3E01]
- Optimization of customers' operations by utilization of analyses on operation and material information [3E02]
- Comparison on Stage of Manufacturing Transformation Using IoT and Digitization [3E03]
- Connection of manufacturing and logistics [3E04]
3A03: Connection of product design information and production technology information utilizing BOP via cloud

Verification 1
Can BOM (parts) and BOP (manufacturing process) be associated with functions?

Verification 2
On what kind of functions do changes in assembly process and parts have effects?

Verification 3
In case of market complaints (malfunction), which part or process has the cause?

Results of experiments
① By connecting from demands through functions, parts to production process, visualized elements which are organically related.
② Solution of parts problems became more speedy by using the relation chart.
③ Solution of problems in product functions became more speedy by using the relation chart.
④ In experiments of two different types of products, the validity was verified.
3A04: Realtime management of visual inspection process

Simple collection of operation history using Raspberry Pi

Digitalize detailed history without changing inspection operation. Difference of time for inspection between workers can be analyzed from the collected data and utilized as standards for a training purpose.

- Low cost
- No need for changing operations
- Able to reduce variation between workers

Digitalization of visual inspection results with speech-recognition technology

Register instruction on visual inspection and the results in real time. Collected data is calculated, analyzed and used as an indicator of skills in order to help education of workers.

- Hands-free entry
- Operation management by voice (handover, discontinuation)
- Speeding up Kaizen cycle

Eye tracker’s support of visual inspectors

Eye tracker enables to take movies of visual inspection operation as well as data on eye gaze. It clarifies difference of visions and its duration between experts and new workers. Time needed for OJT can be shortened.

- Hands-free entry
- Able to store information as images and voice
- Speeding up Kaizen cycle

- Hands-free operation using a headset
- Possible to enter without looking at the monitor by instruction and answer by voice

Visual inspector
Eye tracker
Data storage, transfer
3B01: Improvement of productivity and quality stability by visualizing operation results of equipment and human

Optimized way of collaboration between equipment and workers are visualized to improve productivity with IoT.

Place a camera above the workplace and record operations

Set operation spaces on axes of movies to track movement of workers (shown in red) → Acquire data on when and where the worker is

Techniques of exerts’ efficient production is visualized analyzing a set of data on equipment operation and human motion.
3B02: Predictive maintenance and quality improvement in forging press line

【Predictive maintenance for equipment failure: breakage of balancer rods】

◆ Analyze time series variation of press load

◆ Detected signs of abnormalities about one month before

Place: Mazda Motor, forging plant
Target facility: 6,000 t forging press line
Parts produced: Crankshafts

Detect signs of failures from disturbance in waveform of the load

【Determine the causality between crankshaft underfill and equipment data】

There was a new finding on correlation between a process and quality data.

As instant analyses based on statistics have became possible, operators can use the results for quality improvement.
3B03-1: Predictive maintenance and quality control for everybody

Target facility: Carburizing furnace

Ultraprecise parts (tip diameter 0.17 mm)

Gain new insights from sensor and visual data

Analysis combining various data

Target facility: Former Bearing Inner/outer rings

Quantitative management of quality and equipment

Analysis on equipment operation results and quality data

Comparative analysis of waveform

Digital conversion

Amplitude FFT

After maintenance: Camera AE data
Using IVI platform component, developed a system in which data is collected and analyzed to provide advices, and furthermore types of advices can be added.

Converted technics of experts into explicit knowledge that can be accumulated and utilized in logics.
Concern in the shipping field

- There are many know-hows in loading operations, so productivity is dependent on individual skills. It is difficult to hand down such know-hows.
- It was not possible to prove the results of shipping, although there was data on inspection before shipping.

Experiment result

- Product collection, inspection, loading

Loading simulation & support by AR

Experiment result

- 51sec./box
- ▲6sec./box

Loading proof data

- 57sec./box

Analysis on human motion

Digitalize and record workers’ motion in order to use it for training, quality assessment when there is unstandardized motion, and investigation of defect causes.

Through quantitative evaluation of workers’ motion data taken with optical sensors, it is verified that the method can be utilized for training and consideration on operation standards.
Segment of concerns on system exploration

4A : Quality Assurance
4B : Plant Maintenance
4C : Optimization and Improvement
4D : Vertical integration
4E : Horizontal integration

Industrial Needs from manufacturer’s side

Needs from solution and methodology side

4F : data collection and analysis
4G : visualization and notification
4H : Acquisition and standardization
4J : Real-time monitoring and control
4K : security related technologies
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IVRA-Next: Strategic implementation framework

Strategic implementation framework of industrial value chain for connected industries

IVRA Next

Download at http://iv-i.org/en/
General views of smart manufacturing

Business Layer

Activity Layer

Specification Layer

Type (generalized side)

Product axis (thing)

(Service axis (occurrence)

Instance (actual object side)

Knowledge axis

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Smart manufacturing unit and cycles

Activity View (Plan Do Check Act)
Asset View (Personnel, Plant, Product, Process)
Management View (Quality, Cost, Delivery, Environment)

Smart Manufacturing Unit (SMU)
Cyber world and physical world

Business Layer

Activity Layer

Specification Layer

Cyber world

Physical world

Digitalized one can go to the cyber world

Service can be executed by the corresponding trigger

IoT device is included so this can go up

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Cyclic Process for self-improvement

Stage 1: Problem concerned
- Exploration
- System
- Actual System
- Stage 4

Stage 2: System Realization
- System Orchestration
- System Recognition
- AS-IS model
- TO-BE model

Stage 3: System Orchestration
- System Realization
- System Recognition
- System Orchestration

Stage 4: Problem concerned
- Exploration
- System
- Actual System
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Platform on the Cyber World and the Physical World

<table>
<thead>
<tr>
<th>Management layer</th>
<th>Activity layer</th>
<th>Specification layer</th>
</tr>
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<tbody>
<tr>
<td>Cyber world</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical world</td>
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</tr>
</tbody>
</table>

Smart Manufacturing Unit (SMU)

Platform

Cyber world

Data

Logic

Process

IoT

Actor

Operation

Activity

Info.

Info.
Tools and repositories for smart manufacturing

Collaboration Chart

Logic Chart

Allocation Chart

124 Scenarios (292 scenes) in 2017

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Actor</td>
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<td>Thing</td>
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<td>Information</td>
<td>829</td>
</tr>
<tr>
<td>Data</td>
<td>619</td>
</tr>
</tbody>
</table>
Annual cycle using dictionary and repository
Ecosystem Management by Loosely Defined Standards

Platform WGs

- Platform Common Architecture
- Platform Reference Model

Manufacturing personnel

- Collaboration scenario
- Business scenario working groups

chooses appropriate platform

needs

refers

Component providers

- Component Profile
- Platformers

proposes/ provides

creates profiles

Scope / Terms
Functional model / Things model / Information model / Data model / Test scenarios

Manufacturing reality FIRST!
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Relationship of Hierarchies and Cyber & Physical

Activity layer

Actor (human/machine)

Thing (human/machine)

Info.

Activity

Concern

Logic

Process

Data

Operation

Trigger

Condition

Event

Property

Physical world

Cyber world

Specification layer

Component

Platform

Platform ecosystem

Data connection within a platform

Data connection between platforms

Platform

Service

Service

Data

Attribute

Operation

Trigger

Condition

Event

Platform

Service
IVRA for Connected Industries

- Smart Manufacturing Unit (SMU)
- Supplier
- Hyper Connection Terminal (HCT)
- Distribution center (SMU)
- Customer’s factory
- Actor/Thing Info./Data
- Portable Loading Unit (PLU)
- Supplier’s supplier factory (SMU)
- Hyper Connection Server (HCS)
- Connection manager
- PLU

- ✓ Outside data can be obtained correctly?
- ✓ Data is absolutely true without tampering?
- ✓ Right things can be identified by data?
- ✓ Heterogeneous semantics are acceptable?
- ✓ Data sovereignty and IPR are controlled?

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Cyber Physical and Financial integration
Payment is possible only after registration.

The container does not open without registration.

Make payment according to a transaction.

Certifying registered data:

(1) Request certification
(2) Hash calculation of data
(3) Compare with the hash value registered with the certificate number
(4) Receive the certification result

Message body (form of file)
Hash code

PLU-P ID

Company A
Company C
Company E
Company F
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Data Interoperability among platforms

(1) HCT shows data profile that any components on the platform X can provide.

(2) App that has a service of the profile requests data through HCT and HCS.

(3) The machine data is provided to the App on the different platform by solving the gap of semantics.

Different platforms cannot be connected directly.
Data transfer with message profile

Profiles are created in off-line bases collaborating and negotiating value exchange between parties, whereas data transfer is fully available in the cyber world.

Inter enterprise data exchange needs commitment of data usage and warranty. CIOF allows the data receiver to use it only for the service described in the profile.
Connection using a common dictionary

(FANUC) Data provider's side
Connection terminal
Connection server
CP → HCT → HCS
Data connection server
Transaction history server
Common dictionary server
Public key server

(Data receiver's side)
Connection server
Connection terminal
CP → HCT → HCS
Hyper Connection Server (HCS)
Data connection server
Transaction history server
Common dictionary server
Public key server

Service at sender side
Local dictionary of the sender

Service at receiver side
Local dictionary of the receiver

Manufacturing PF (Data provider's side)
Manufacturing PF (Data receiver's side)
Profile for System Integration

- Platform Reference Model
  - Common Data Model
  - Proprietary model of platform
  - Implementation Data Model
  - Existing Data Model

- Domain Data Model
  - Common dictionary
  - Local dictionary

- X Platform Model
- Y Platform Model

- Software
  - Cloud
  - API
  - Component

- Site A
- Site B

Actual data in each fields

AS-IS

TO-BE

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Life cycle management of common dictionaries

1. **Stage 1**
   - Maintenance of the common dictionary
   - Utilize the common dictionary according to actual circumstances of individual sites

2. **Stage 2**
   - Application on local dictionaries
   - Investigate a dictionary actually used and contents defined

3. **Stage 3**
   - Survey on dictionary usage
   - Consider adding terms frequently used to the common dictionary by consolidating

4. **Stage 4**
   - Construction of a new dictionary
   - Update the dictionary periodically in consideration of compatibility with the past cases

**Format**
- Competitive (Closed)
- Operative (Disclosed)
- Cooperative (Open)

**Index**
- Content
Thank you!
Danke schön.

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