Toward realization of smart manufacturing system

Design and implementation of monitoring/visualization system considering diversity of machine tools

Robot Revolution Initiative
WG for manufacturing business revolution through IoT
The Industrial Machinery Steering committee

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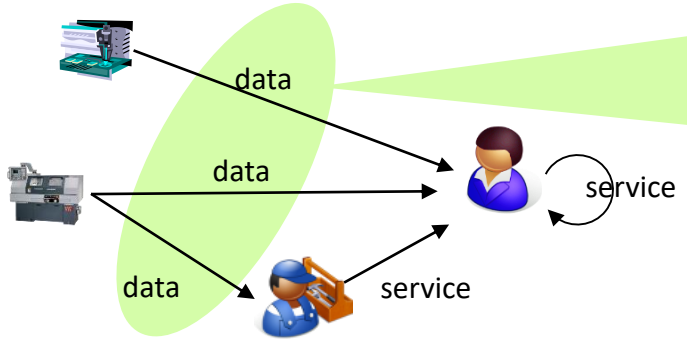
Supported by METI Ministry of Economy, Trade and Industry JMTBA

Who are we?

- The Industrial Machinery Steering committee
  - Started in 2015, as a sub-committee of Robot Revolution Initiative WG for manufacturing business revolution through IoT
- Objective
  - To design and implement a common interface of machine tools that eases design and implementation of IoT based services for the user of the machine tools, regardless of the types and suppliers of the tools.
    - Service needs:
      - Planning and scheduling of maintenance
      - Quality control and management
      - Monitoring of production conditions
      - Quality assurance with better traceability
      - Adaptable and resilient production
      - etc.



Identify common expression of data item associated with the context of their usage

- Activities
  - Conducted a study for realizing smart manufacturing and published a series of reports “Toward Realization of Smart Manufacturing System”
    - 2016 “Case: Improvement of the Machining Process Productivity Based on the Machine Tool Technology”
    - 2017 “Case: A cyber-physical manufacturing system enhanced with collective knowledge”
    - 2018 “Case: Collaborative design and implementation of monitoring/visualization system considering diversity of machine tools”
    - 2019 Coming soon

Overview

Objective

Design and validation of common expression of data obtained from machine tools in context of two cases, where decision makings require integration of the data of machine tools in a (even distributed) production line regardless of tools types and manufacturers

- Case 1: Planning and scheduling of maintenance of machine tools
- Case 2: Quality control and management with sufficient traceability

Design and implementation

Identification of data items for visualizing two types of information:

For case 1: When each machine tool should be maintained

19 data items are identified through detailed analysis of six activities for collecting necessary information for estimating the residual life of each component of a machine tool

For case 2: How manufacturing condition changes during a series of production

16 data items that are used for identifying the point of variation in machine shop tool conditions, work setting, and NC programs are identified.

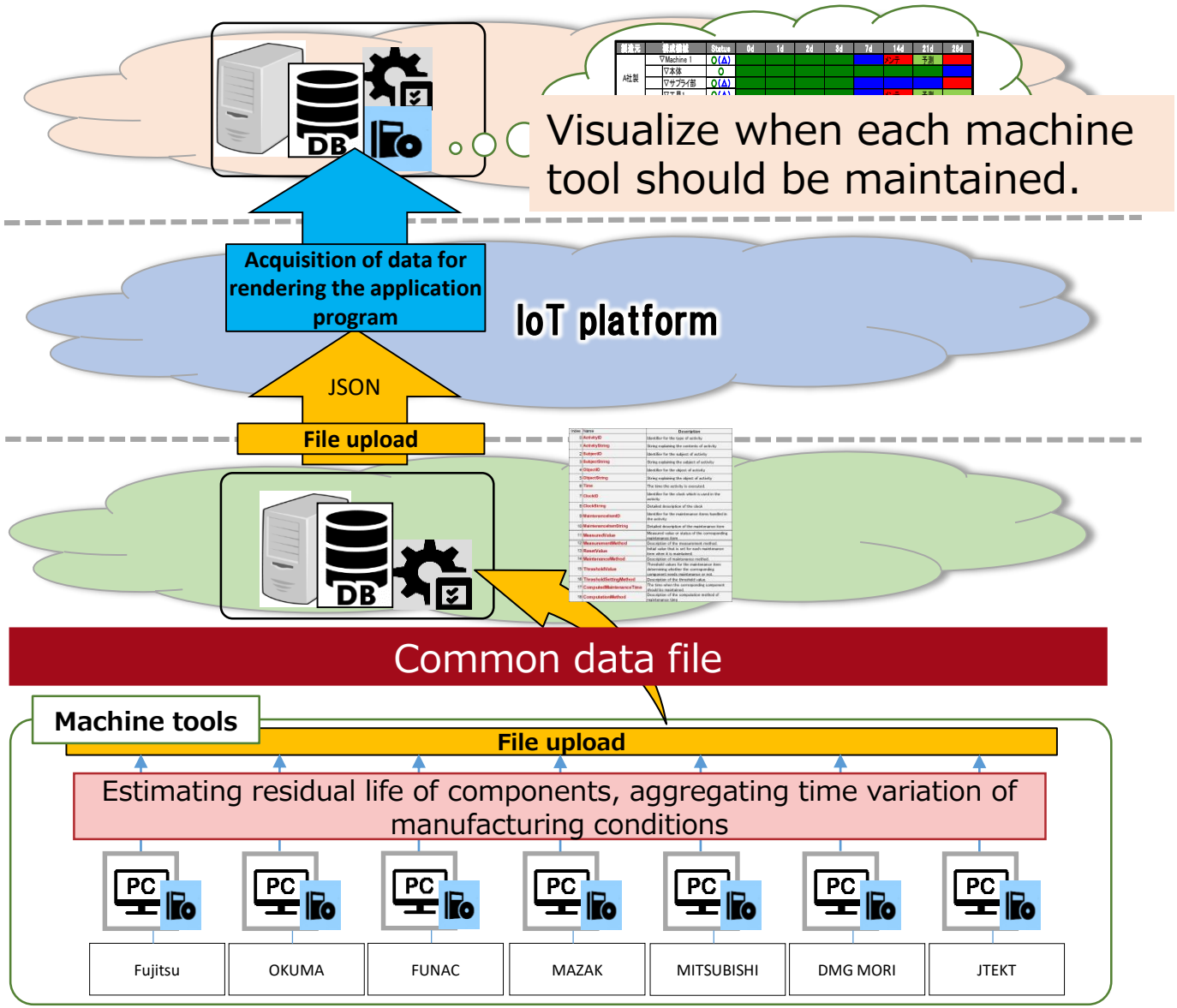
A prototype monitoring/visualization system is developed and demonstrated through an intensive collaboration among members of The Industrial Machinery Steering Committee.

Expansion for identifying further services with required data items

For case 1: Automating maintenance and recovery activities

For case 2: Quality stabilization in continuous production

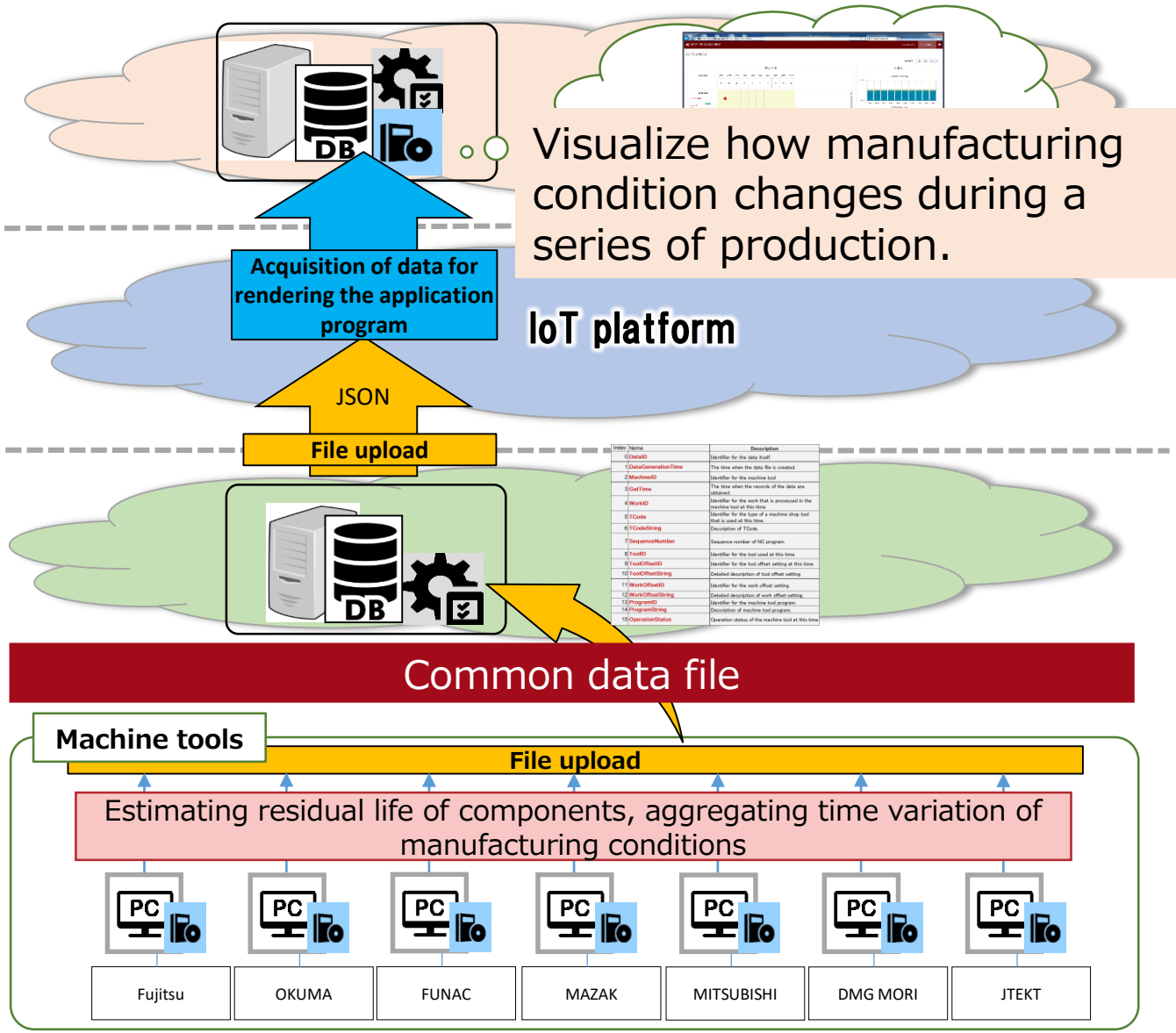
Common data items and the structure of a prototype system



19 Common data items used in case 1

Index	Name	Description
0	ActivityID	Identifier for the type of activity
1	ActivityString	String explaining the contents of activity
2	SubjectID	Identifier for the subject of activity
3	SubjectString	String explaining the subject of activity
4	ObjectID	Identifier for the object of activity
5	ObjectString	String explaining the object of activity
6	Time	The time the activity is executed.
7	ClockID	Identifier for the clock which is used in the activity
8	ClockString	Detailed description of the clock
9	MaintenanceItemID	Identifier for the maintenance items handled in the activity
10	MaintenanceItemString	Detailed description of the maintenance item
11	MeasuredValue	Measured value or status of the corresponding maintenance item
12	MeasurementMethod	Description of the measurement method.
13	ResetValue	Initial value that is set for each maintenance item when it is maintained.
14	MaintenanceMethod	Description of maintenance method.
15	ThresholdValue	Threshold values for the maintenance item determining whether the corresponding component needs maintenance or not.
16	ThresholdSettingMethod	Description of the threshold value.
17	ComputedMaintenanceTime	The time when the corresponding component should be maintained.
18	ComputationMethod	Description of the computation method of maintenance time

Common data items and the structure of a prototype system (cont.)

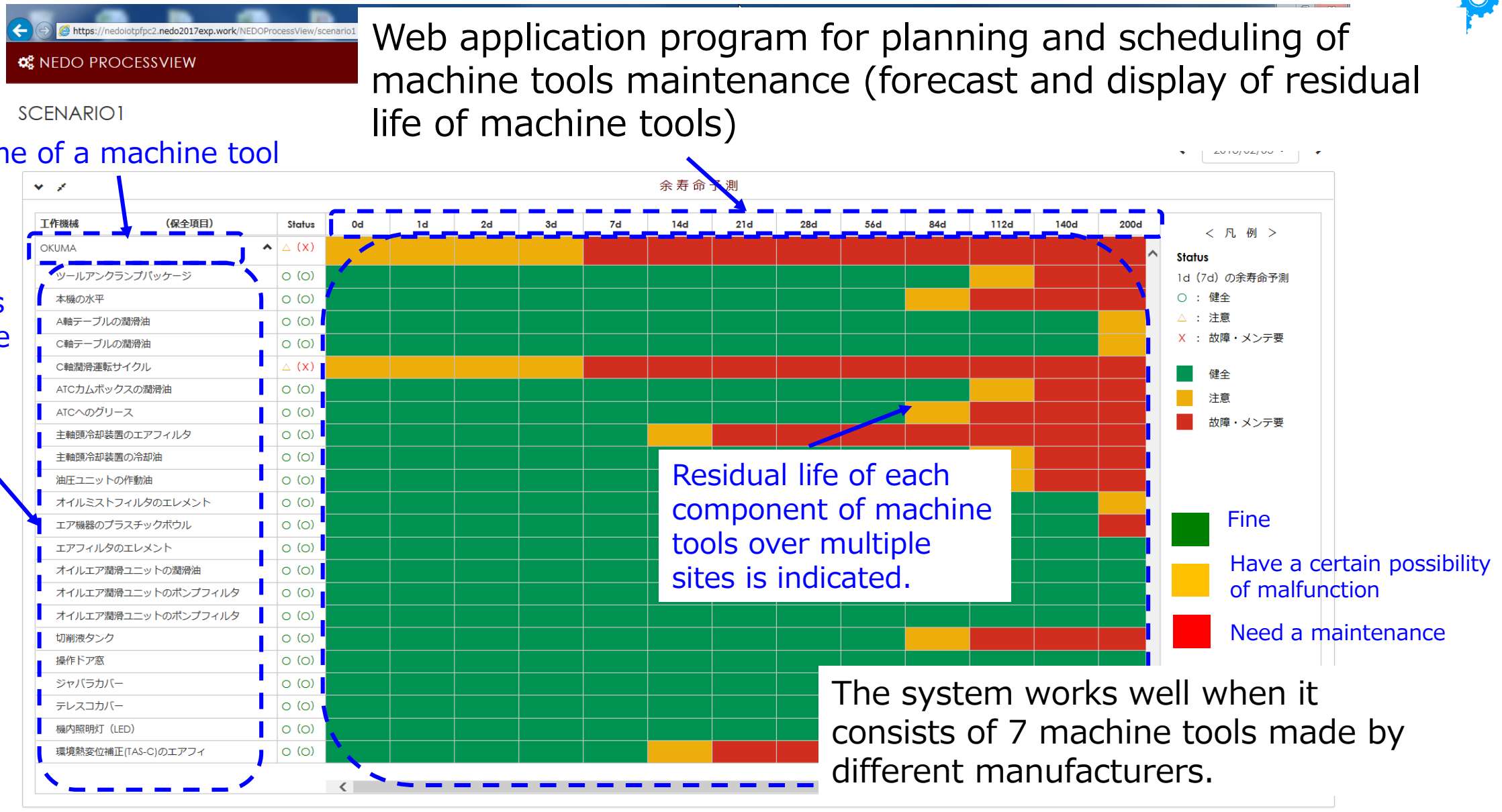


16 Common data items used in case 2

Index	Name	Description
0	DataID	Identifier for the data itself.
1	DataGenerationTime	The time when the data file is created.
2	MachineID	Identifier for the machine tool
3	GetTime	The time when the records of the data are obtained.
4	WorkID	Identifier for the work that is processed in the machine tool at this time.
5	TCode	Identifier for the type of a machine shop tool that is used at this time.
6	TCodeString	Description of TCode.
7	SequenceNumber	Sequence number of NC program.
8	ToolID	Identifier for the tool used at this time.
9	ToolOffsetID	Identifier for the tool offset setting at this time.
10	ToolOffsetString	Detailed description of tool offset setting.
11	WorkOffsetID	Identifier for the work offset setting.
12	WorkOffsetString	Detailed description of work offset setting.
13	ProgramID	Identifier for the machine tool program.
14	ProgramString	Description of machine tool program.
15	OperationStatus	Operation status of the machine tool at this time

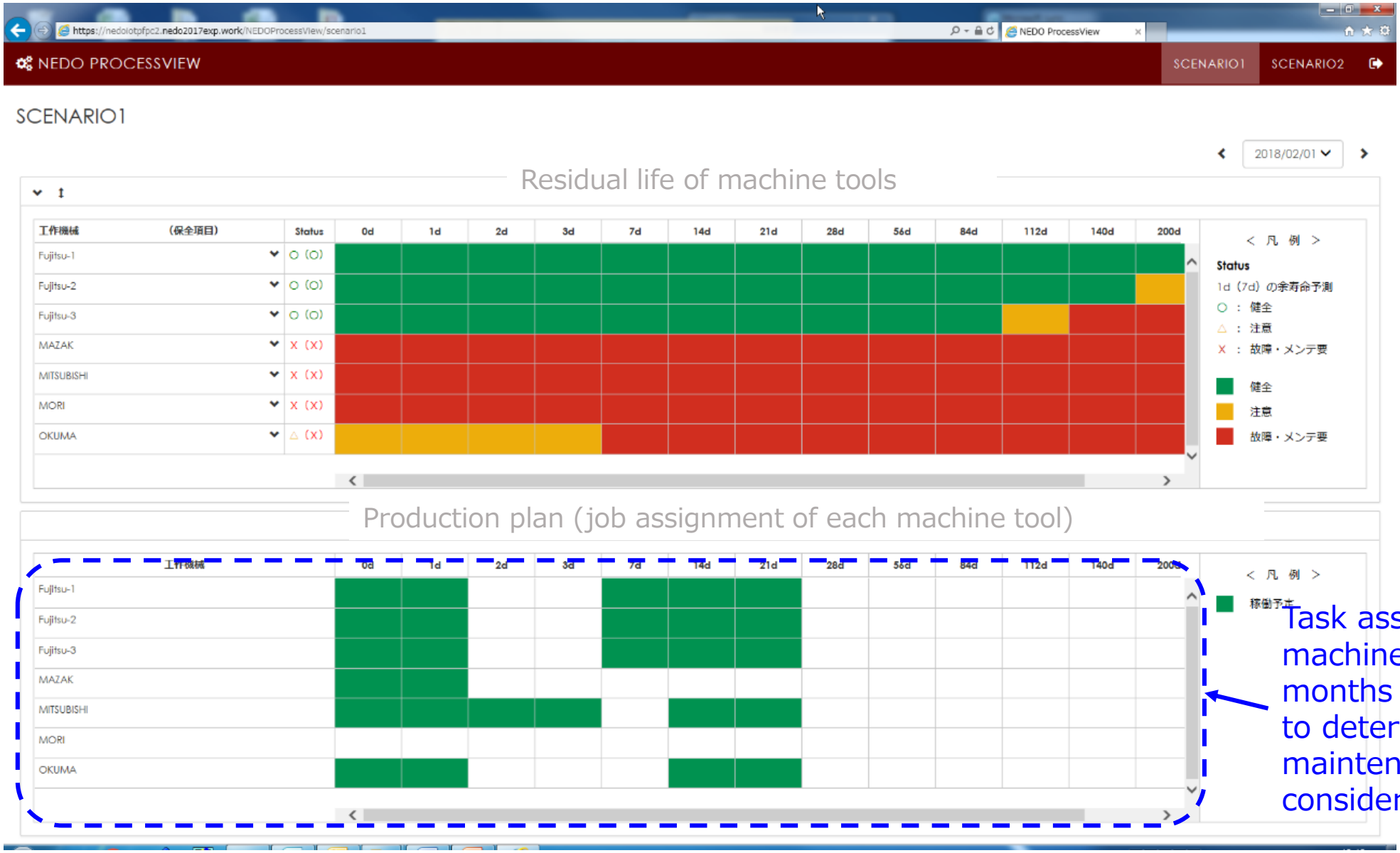
Hardcopy of the application program prepared for case 1

Web application program for planning and scheduling of machine tools maintenance (forecast and display of residual life of machine tools)



The system works well when it consists of 7 machine tools made by different manufacturers.

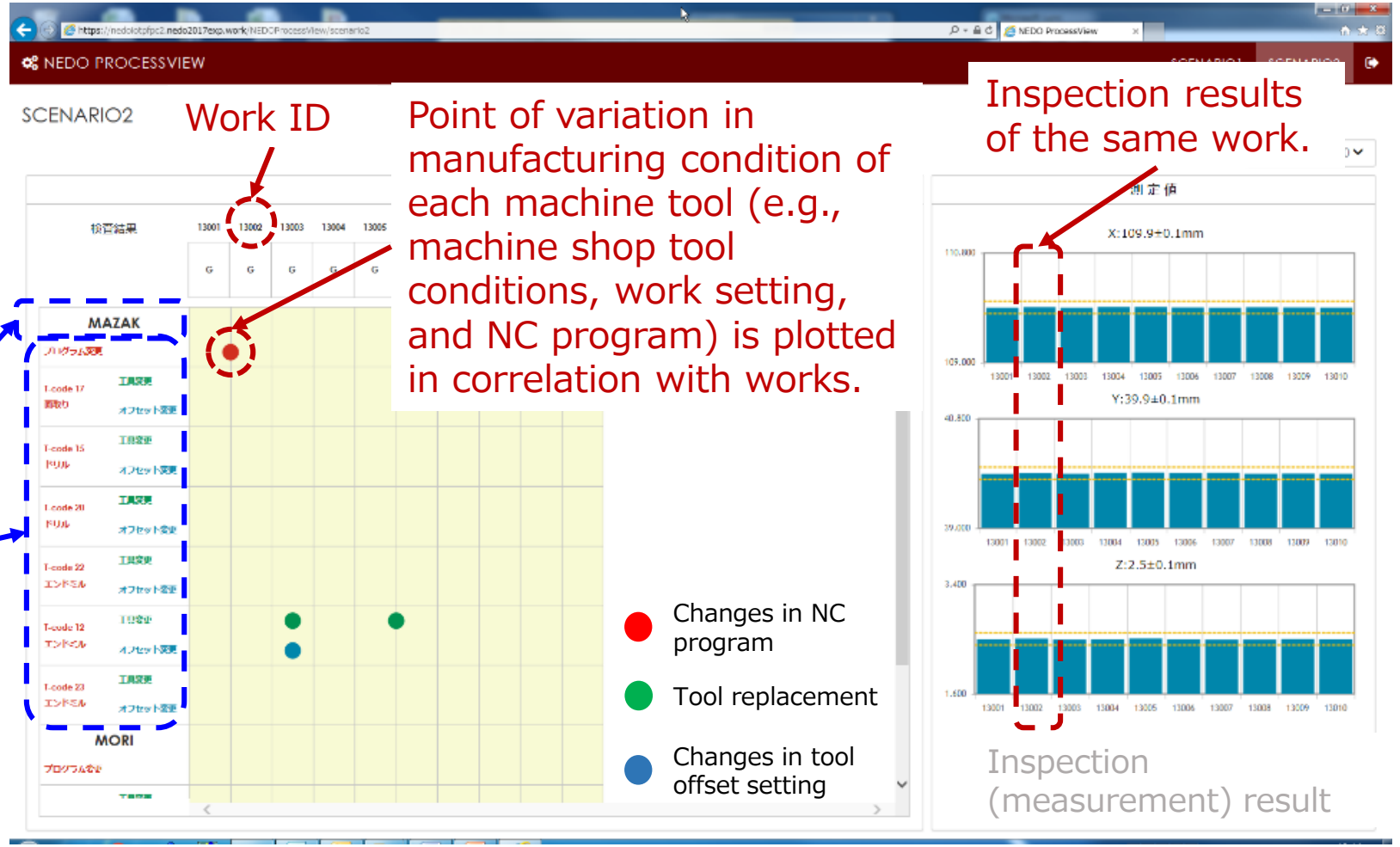
Hardcopy of the application program prepared for case 1 (cont.)



Task assignment of each machine tool for next six months is also indicated so as to determine optimal maintenance schedule considering their availability.

Hardcopy of the application program prepared for case 2

Web application program for quality control with sufficient traceability of production data



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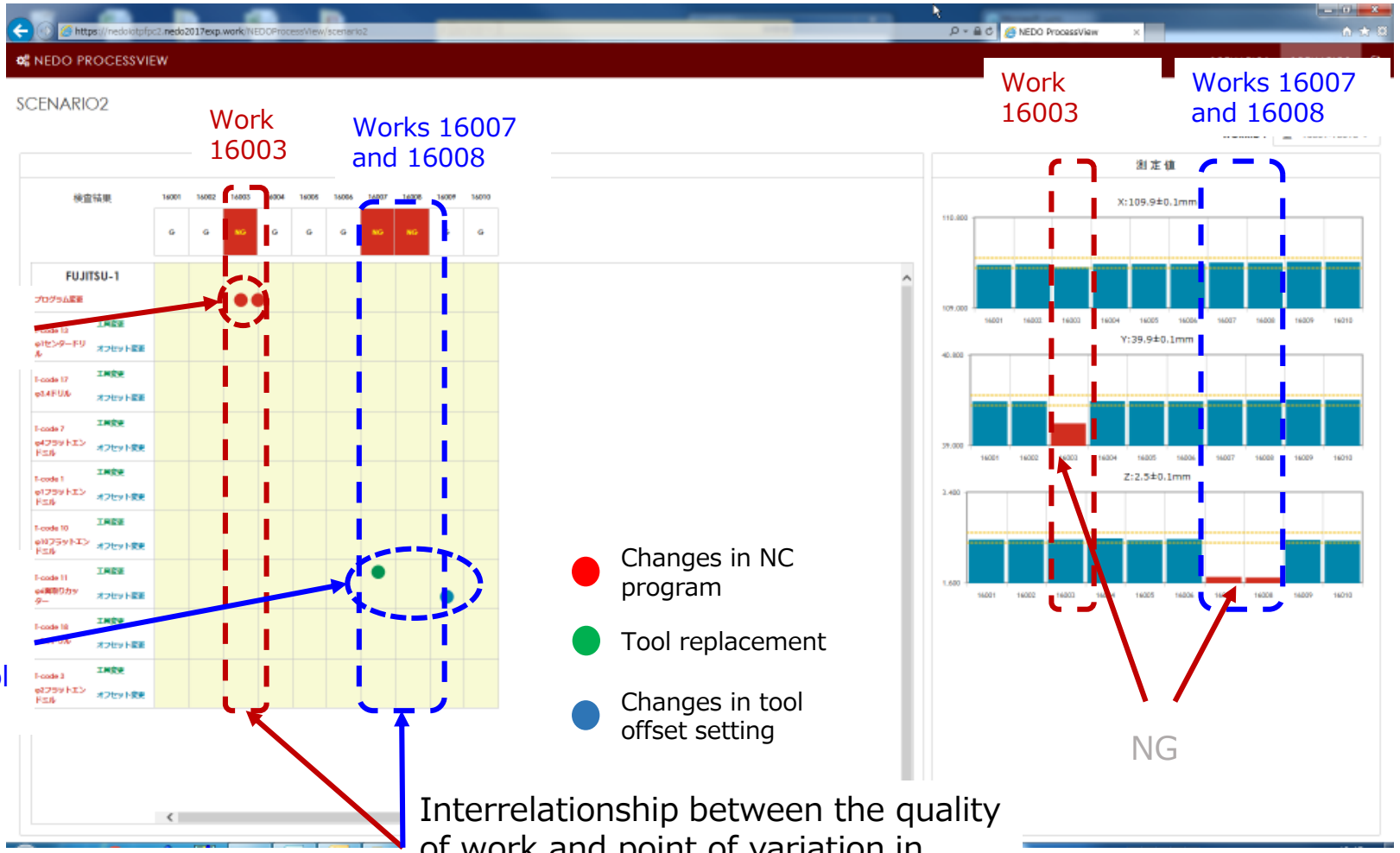

Interrelationship between the quality of work and point of variation in production condition can be found.

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Identification of data items for visualizing two types of information:

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Expansion for identifying further services with required data items

For case 1: Automating maintenance and recovery activities

For case 2: Quality stabilization in continuous production

Expansion of case 1: Automation of maintenance and recovery activities: Business View

Background

- An Example of Application Scenario Value-Based Services

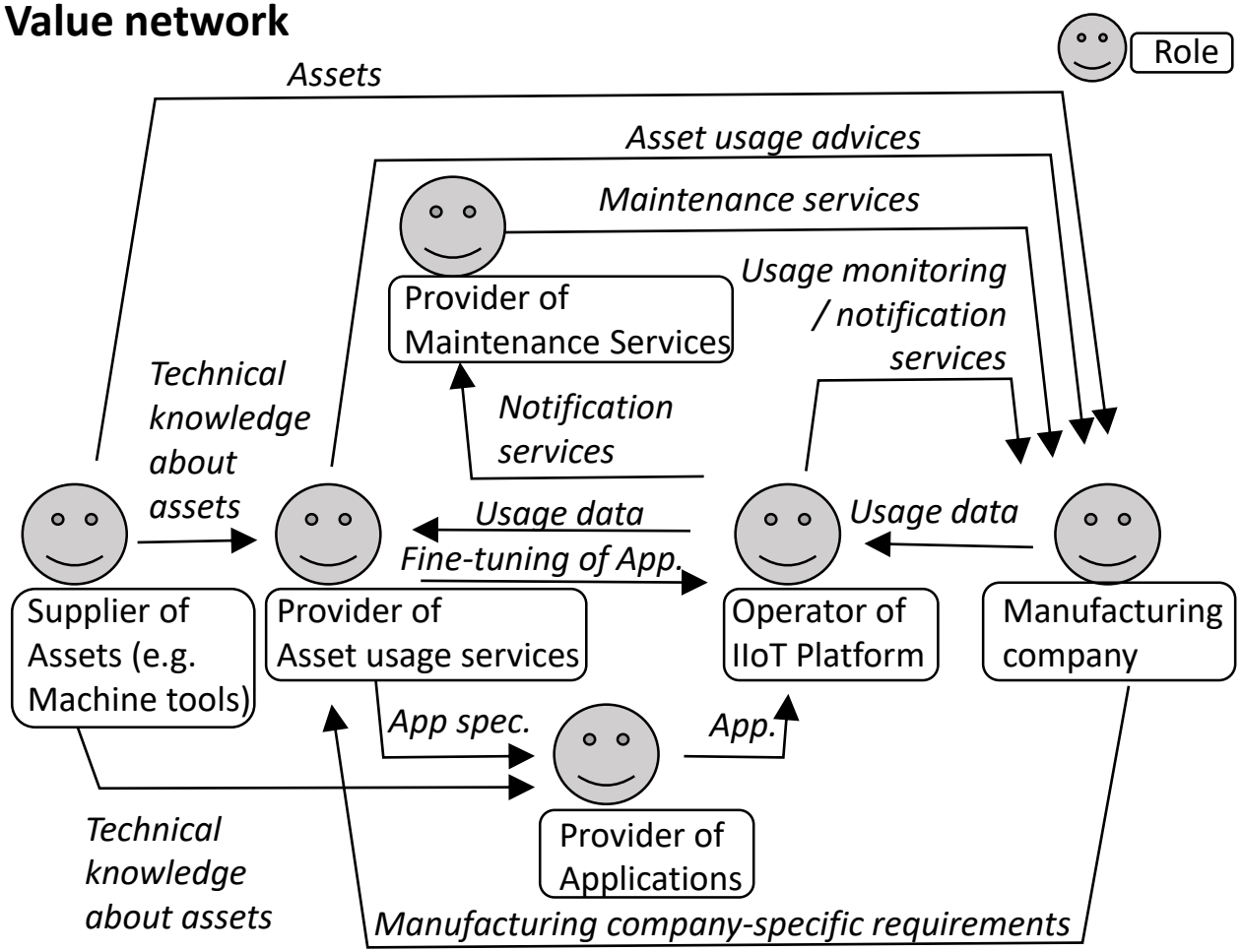
Value proposition

- Usage data collected and analyzed by applications on IIoT platform specifies conditions on executing (partially automated) services.
- The applications are fine-tuned with technical knowledge about assets and manufacturing company-specific requirements.
- The services can be integrated with production planning and execution.

Revenue mechanism

- Manufacturing company pays for asset usage monitoring services supporting operational decision makings on asset utilization.
- Manufacturing company pays for asset usage advices supporting tactical decision makings (evaluation of asset usage policy).
- Manufacturing company or provider of maintenance services in contract pays subscription services for optimal maintenance and recovery of assets.

Value network



- Single stakeholder can assume multiple roles and multiple stakeholders can perform the same role.
- Assignment of the roles to stakeholders is business specific.

Expansion of case 1: Automation of maintenance and recovery activities : Usage View

Major Activities

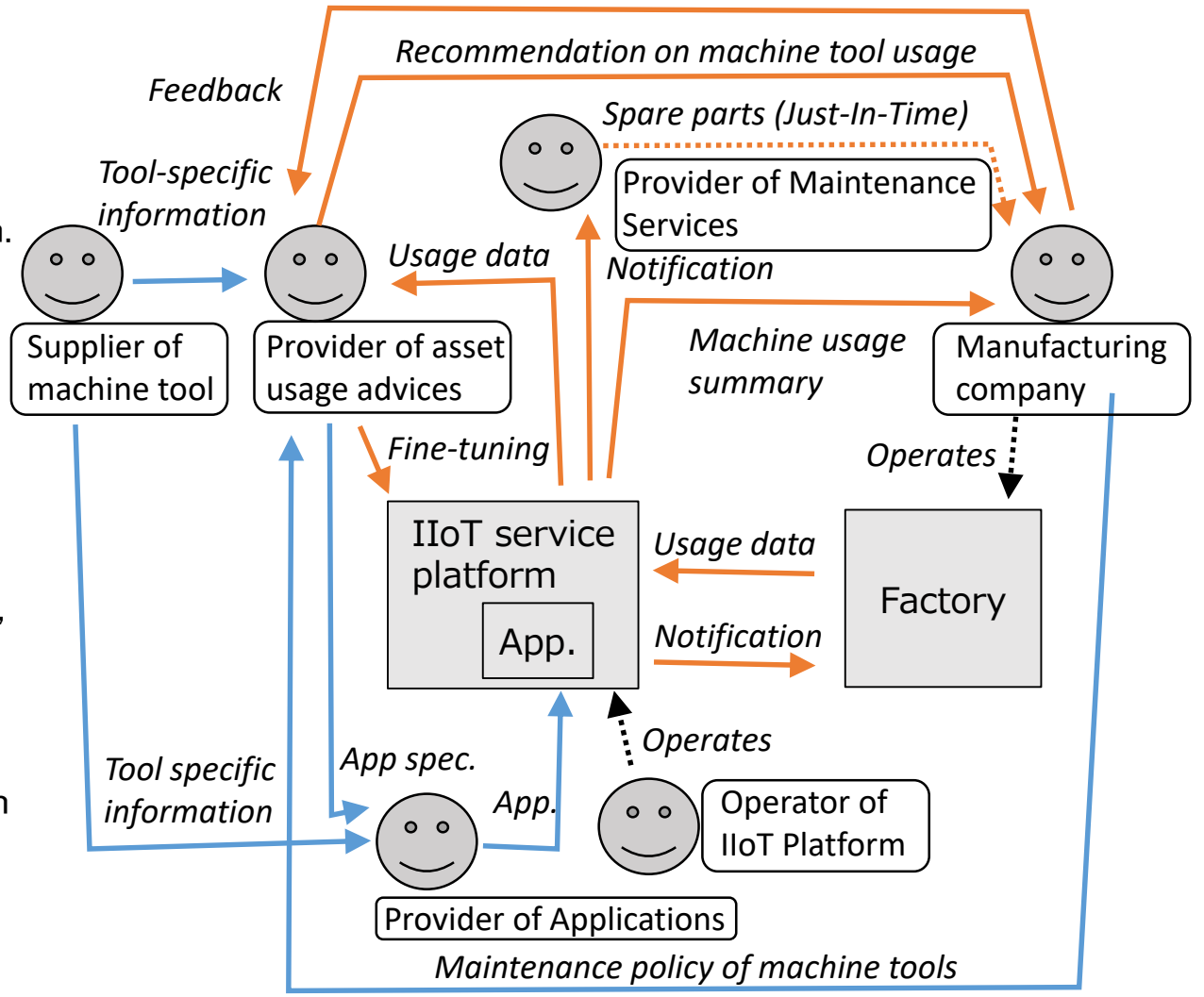
Set-up stage

- Manufacturing company (MC) defines maintenance policy for machine tools.
- Provider of asset usage advices formulates the specifications on the monitoring and notification application.
- Provider of applications implements the application and installs on the IoT service platform.
- Supplier of machine tools offers machine tool-specific information useful for development and fine-tuning of the application.

Operation and maintenance stage

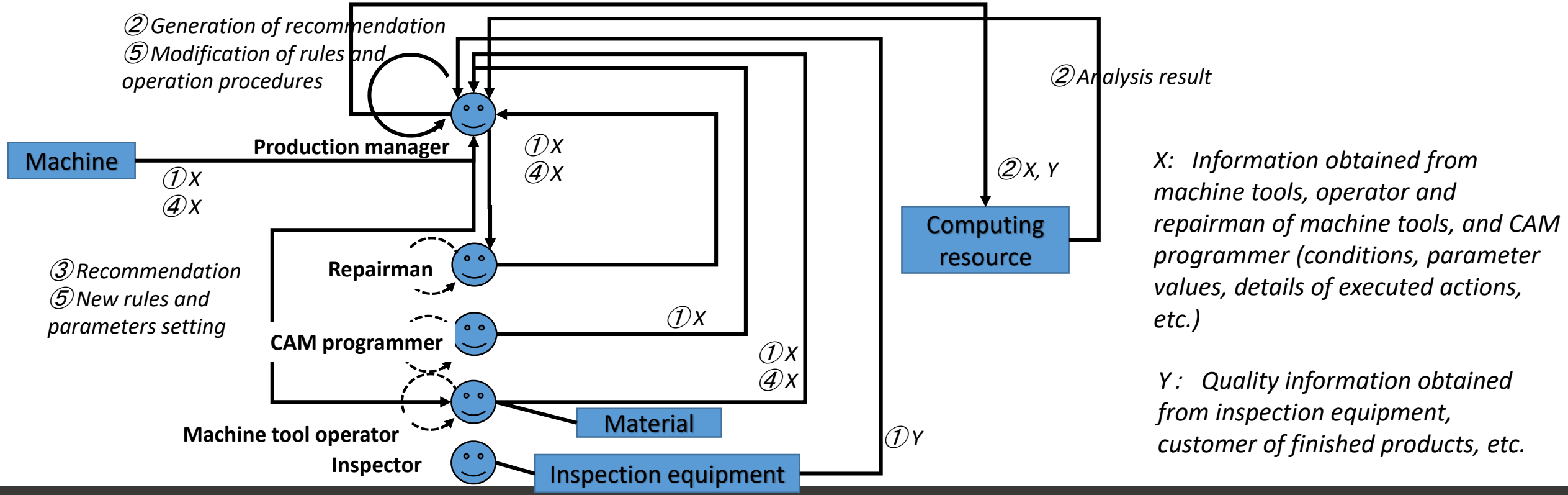
- MC (automatically) updates the state of machine tools (e.g., process parameters) when notified by the application.
- MC monitors machine tool usage with the application and performs maintenance (e.g., repair or replacement of parts).
- Provider of maintenance services delivers spare parts when notified by the application (just-in-time).
- Provider of asset usage advices gives recommendations about machine tool usage to MC and fine-tunes the application following the feedback from MC.

Information Flows on System under Consideration



Expansion of case 2: Quality stabilization

- Target: quality control and management in continuous production
  - The quality of finished workpiece inevitably vary even though they are processed by the same machines with the same setups.
  - Support a production manager to stabilize quality of finished workpiece
    - Collect every usual/unusual actions (and parameter values) executed by asset operators and repairmen as well as time series conditions of assets and environment.
    - Analyze correlation between quality and collected information
    - Generate recommendation action based on the analysis result



X: Information obtained from machine tools, operator and repairman of machine tools, and CAM programmer (conditions, parameter values, details of executed actions, etc.)

Y : Quality information obtained from inspection equipment, customer of finished products, etc.

Expansion of case 2: Quality stabilization (Business view)

Background

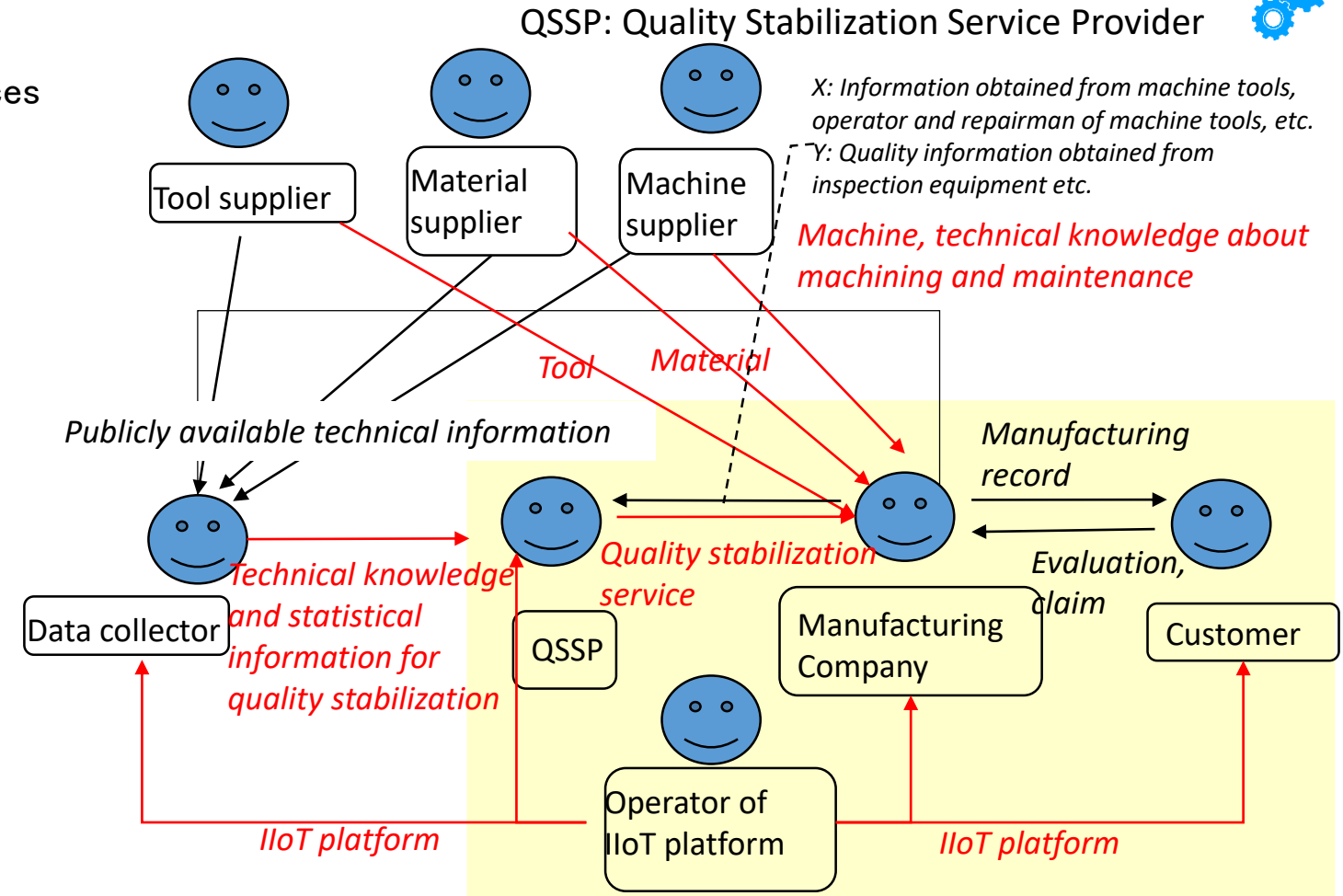
- An Example of Application Scenario Value-Based Services

Value proposition

- Publicly available information collected, analyzed and interpreted by data collector is used for Quality Stabilization Service Provider (QSSP)
- Operation and maintenance data collected and correlated with quality inspection results (incl. claim) on IIoT platform generates operation and maintenance recommendation for manufacturing company, by using technical knowledge and statistical information provided by data collector.

Revenue mechanism

- Manufacturing company pays for quality stabilization services supporting operational decision makings on quality control and management.
- QSSP pays for technical knowledge and statistical information provided by data collector.



Data collector, who collects public information from a number of parties and provides summary and analysis results via service platform, plays a central role.
IIoT platform used by a quality stabilization service provider can be different from that used by data collectors and other parties.

Expansion of case 2: Quality stabilization (usage view)

Major activities for supporting SDCA

Do/Act

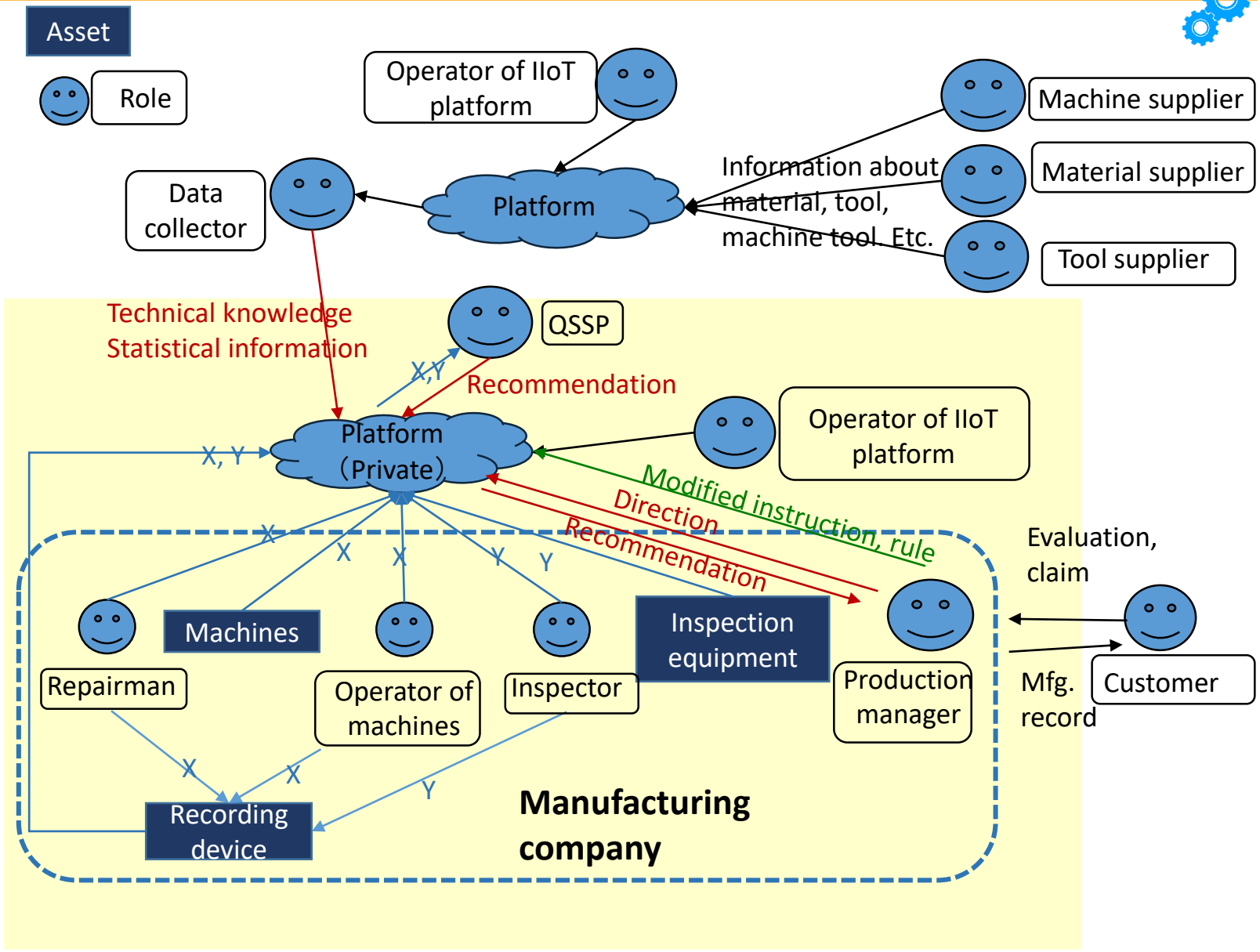
- Operator of machines and repairmen execute their operation based on pre-defined instruction (or direction from production manager)
- Machines, inspection equipment, and recording device record every actions of operators and repairmen as well as state, conditions and parameter values of machines (X).

Check

- Production manager analyzes time series variation in quality (Y) to find out sign of degradation.
- Quality Stabilization Service Provider (QSSP) analyze relationship between X and Y and generate operation recommendation.
- Production manager determines quality recovering actions and sends directions.

Standardize (Generalize)

- Production manager evaluates the efficiency and effectiveness of the actions and determine/modify operation instruction. He/she also modifies data items to be recorded.



Summary

Design and validation of common expression of data obtained from machine tools in context of two cases

- Case 1: Planning and scheduling of maintenance of machine tools
- Case 2: Quality control with sufficient traceability of production data

Identification of data items for visualization of two types of information:

- For case 1: When each machine tool should be maintained
  - 19 data items are identified through detailed analysis of six activities for collecting necessary information for estimating the residual life of each component of a machine tool
- For case 2: How manufacturing condition changes during a series of production
  - 16 data items that are used for identifying the point of variation in machine shop tool conditions, work setting, and NC programs are identified.

A prototype monitoring/visualization system is developed and the feasibility and the validity of the system is confirmed through demonstration using multiple types of machine tools (made by different manufacturers) distributed in seven different sites.

Further services and required data items are identified by expanding the scope of the cases above.

- For case 1:Automation of maintenance and recovery activities
- For case 2: Quality stabilization in continuous production

A part of this work is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

Robot Revolution & Industrial IoT Initiative

Activities

● Forum Industrie 4.0 (meets RRI) *@ Hall 8*

- Monday, 1 April, 12:30-13:00,
  "IoT Design Approach by Adapting Framework", Mr. Hiroshi YAMAMOTO, Toshiba Corp., Corporation Digitaization CTO
- Monday, 1 April, 14:00-14:30,
  "Connected Industries Open Framework for Industrial Value Chain Transformation", Dr. Yasuyuki NISHIOKA, Industrial Value Chain Initiative, President
- Tuesday, 2 April, 16:00-16:30,
  "Navigation Scheme of Smart Manufacturing System Development for Each Maturity Level Enterprise",
  Dr. Youichi NONAKA, Hitachi, Ltd., Senior Chief Researcher
- Wednesday, 3 April, 10:00-10:30,
  "German-Japan Collaboration for Standardization in Smart Manufacturing", Dr. Fumihiko KIMURA, The University of Tokyo, Professor Emeritus
- Wednesday, 3 April, 11:00-11:30
  "Toward Realization of Smart Manufacturing Systems",
  Dr. Shinsuke KONDOH, National Institute of Advanced Industrial Science and Technology, Group leader

● 13th German – Japanese Economic Forum *@ Hall 27*

Wednesday, 3 April, 13:45–14:30

- "IIoT Security: The role of trustworthiness in international value chains", Ms. Masue SHIBA, Toshiba Corp.
- "Standardization Activities in Germany-Japan Cooperation for Smart Manufacturing", Dr. Youichi NONAKA, Hitachi. Ltd.

● Japan Pavilion for Connected Industries *@ Hall 8 F19*