Keynote Speech eKnow 2021 July, 2021

Agent Modeling, Internet of Things, and Multi-Dimensional Accounting for Managing Manufacturing Systems.

Gallery for
Evolutionary computation and
Artificial intelligence
Researches

IARIA

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Chiba University of Commerce

Outline

- AI/ML for Social System Implementation
- Roles of Agent Modeling in Knowledge Management
- Application of IoT & ABM in Manufacturing Management
  - Case1: Realtime Workers' Behavior Analysis and Agent Simulation
  - Case2: IoT Based Manufacturing Process Management
- How Accounting Concepts Work in a Firm
- Concluding Remarks

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Takao TERANO, Small Personal History

- 1978: Graduated Master Course Information Engineering, Tokyo Univeristy: OR & Num Analysis

- 1978～1989: Central Research Institute of Electric Power Industry (CRIEPI) , Information System R&D
  1980's in the 2-nd AI Era: Medmber of ICOT-WG, R&D for Expert Systems for Electric Power Industries

- 1990～2004: Grad. Sch. Sys. Mng. (GSSM), Tsukuba University, Japan; Assistant, Associate, & Full Professor
  Research and Education for Business People
  AI, Decision Making, Gaming Simulation, Social Simulation
  (1991: PhD, Tokyo Institute of Technology; 2009: Prof. Emeritus, Tsukuba Univ.)

- 2004～2018 Professor, Tokyo Institute of Technology, Japan
  Social Simulation, Service Sciences, Knowledge Systems, Evolutionary Computation
  (2018, Prof. Emeritus, Tokyo Institute of Technology)

- 2018～2018 Professor, Chiba University of Commerce, Japan
  AI & System Science, Social Systems; Technical Advisor, MIRAI Relations Co. LTD.

- Academic Societies: JSAI, JASMIN, JASI, JIPS, SICE, JSOR, PM, Evol. Econ., JASAG, TRAFST, PAAA

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ABSTRACT

Recent complex manufacturing systems including human, mechanical, and information resources require advanced knowledge management methodology. Agent modeling is a tool for understanding human and machine behaviors. Ubiquitous IoT devices can be equipped in various machines in a firm. In this talk, I would like to introduce the concepts of multi-dimensional accounting or multi-dimensional bookkeeping in order to manage such complex manufacturing systems, Although, bookkeeping is considered to be a traditional method to only record profits and losses of a firm, the integration of principles of both agent modeling and Internet of things gives new lights to multi-dimensional accounting systems. In this talk, based on our recent work with Professor Deguchi [3], [4] and our colleagues[1], [2], I will address novel ideas on knowledge management in manufacturing systems.

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Application of Artificial Intelligence and Machine Learning for Social System Implementation

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AI & Advanced ITs

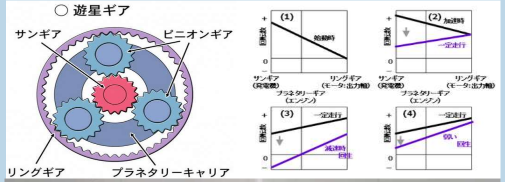
- Seemingly Intelligent Systems：
  - If Complete Information： Algorithm Design

    →Information Science
  - If Incomplete Information: Heuristics Implementation

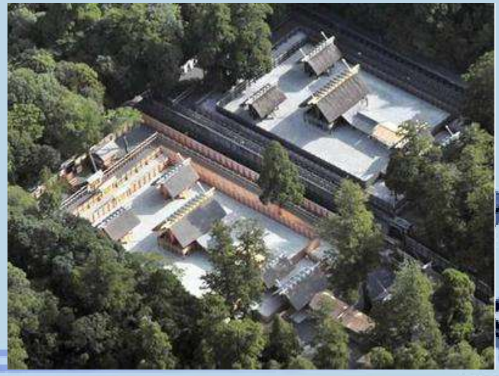
    →Artificial Intelligence

- Artificial Intelligence：
  - Strong AI
  - Weak AI

Algorithm Design



Expertise Transfer



How We Feel About AI & Big Data

- Intelligence：
  - When Information is Complete：
    - Algorithms -> Information Science
  - When Information is Incomplete:
    - Heuristics -> Artificial Intelligence
- AI：
  - Strong AI: to Understand Intelligence through Computing
  - Weak AI: To Develop Seemingly Intelligent Systems
- Big Data：
  - 3V: Volume; Variety；Velocity ⇐ Gartner Group
  - ＋2V: Value）; Veracity ⇐ IBM
- Agent-Based Modeling:
  - Scenario Analysis
  - Could-Be World …

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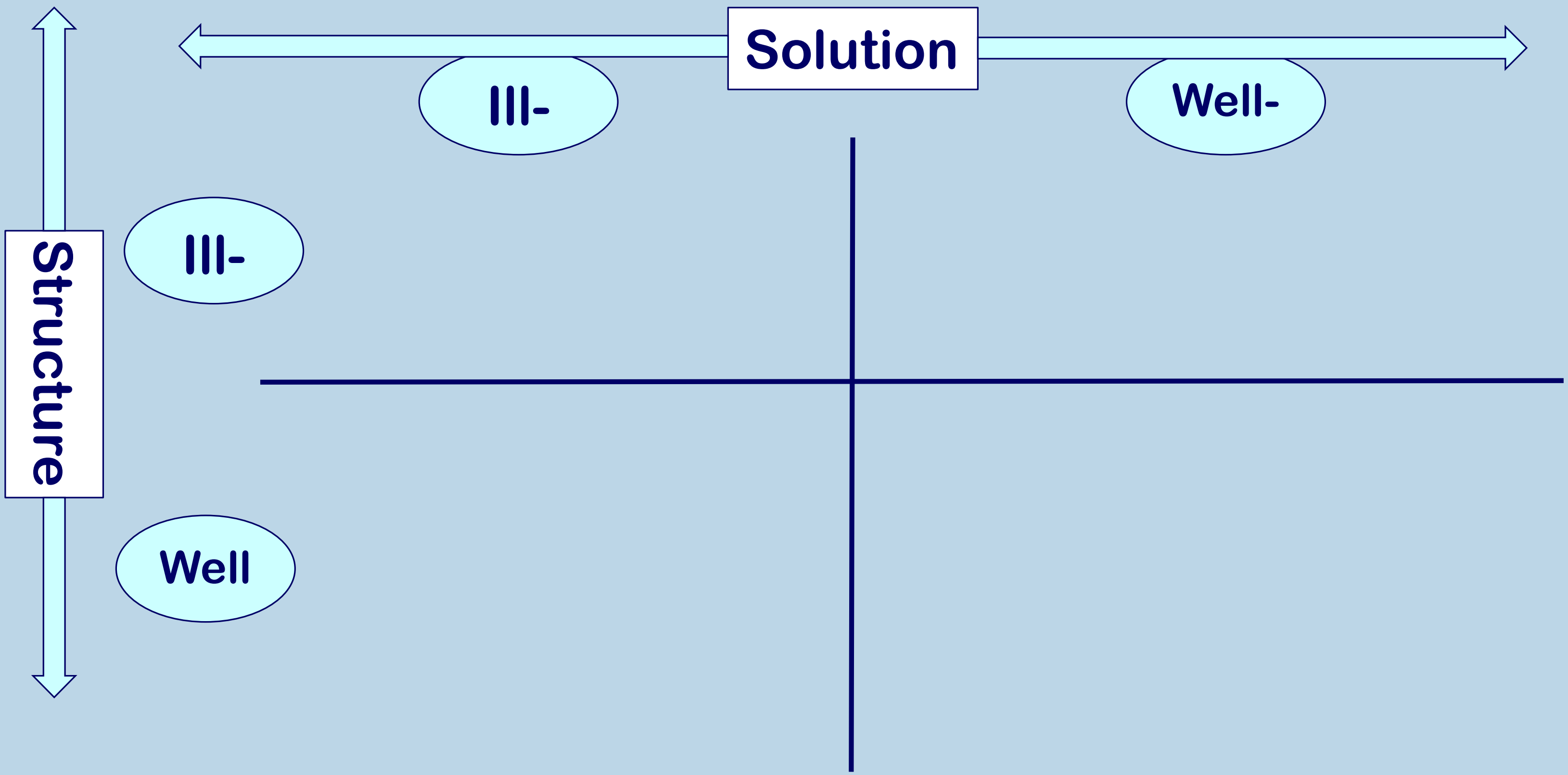
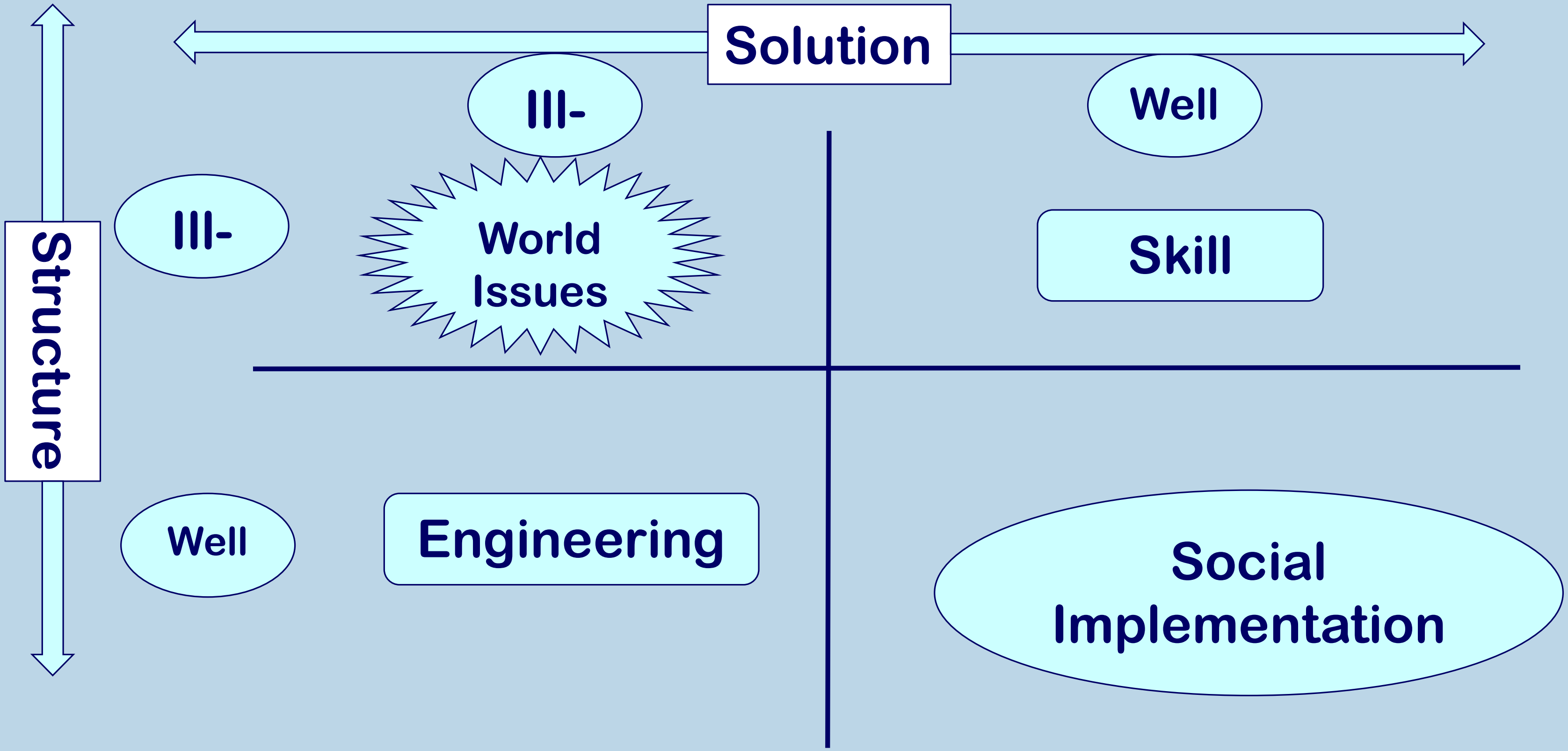
Solving Socio-Technical Problems



Solving Socio-Technical Problems



Solving Socio-Technical Problems

Solution

Structure

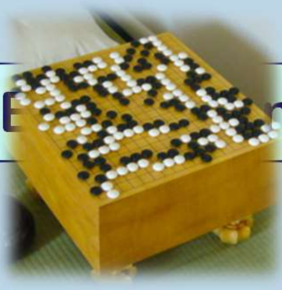
Ill-

Ill-

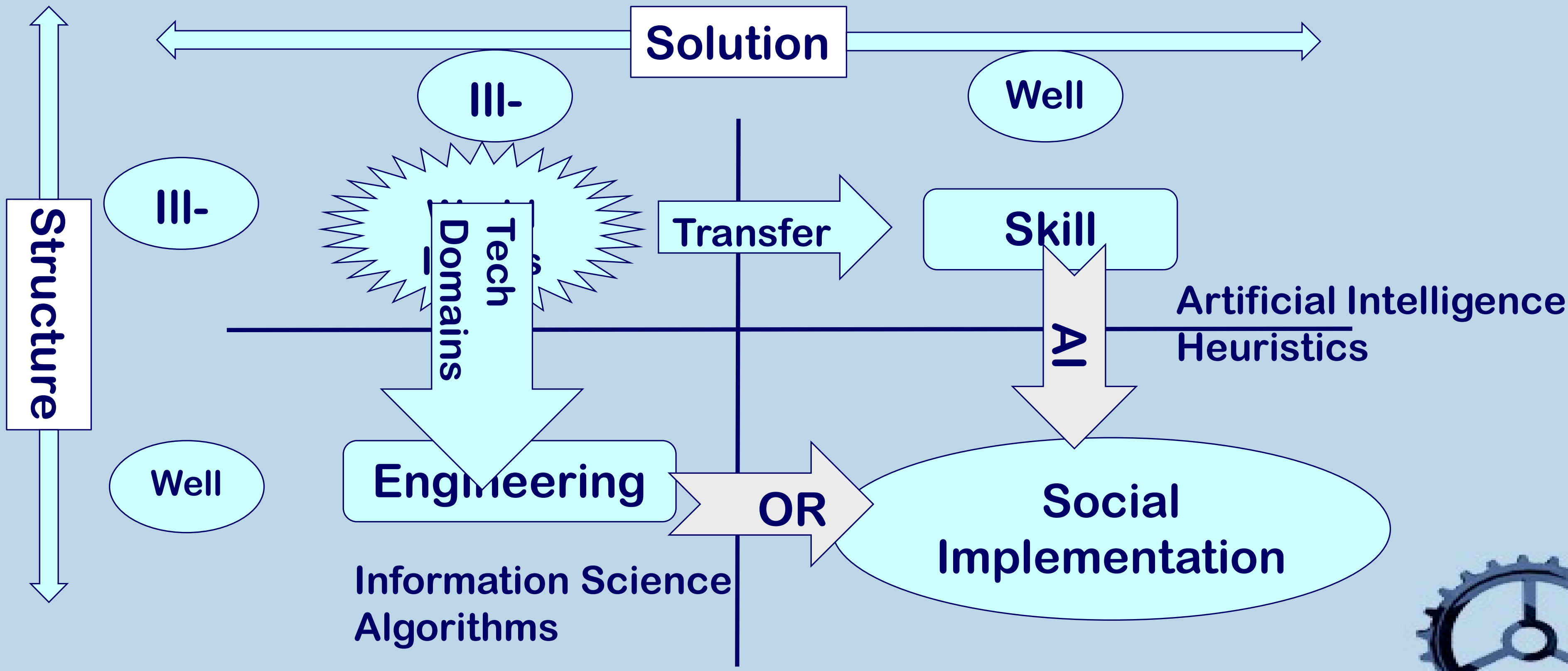
World Issues

Well

Well



Solving Socio-Technical Problems



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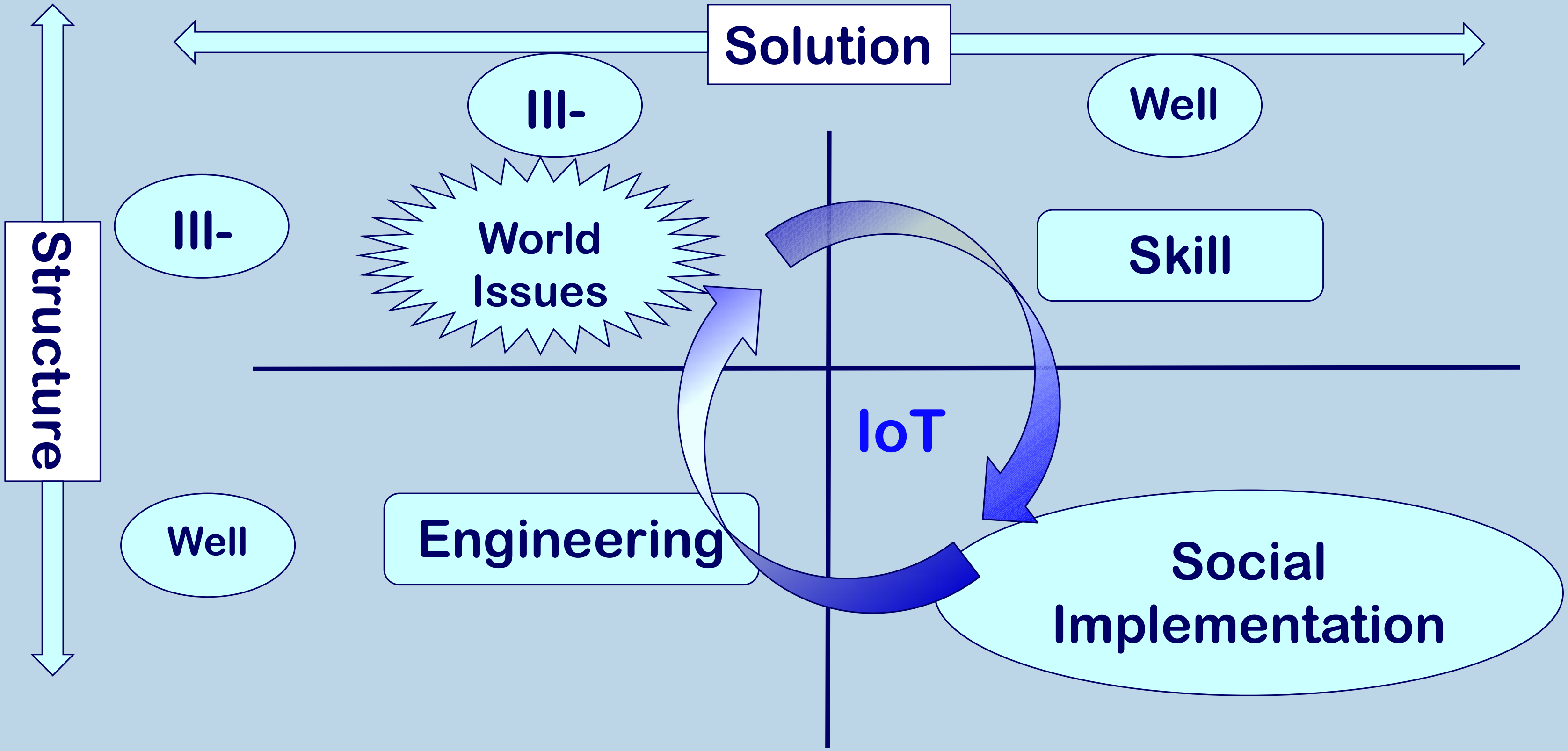
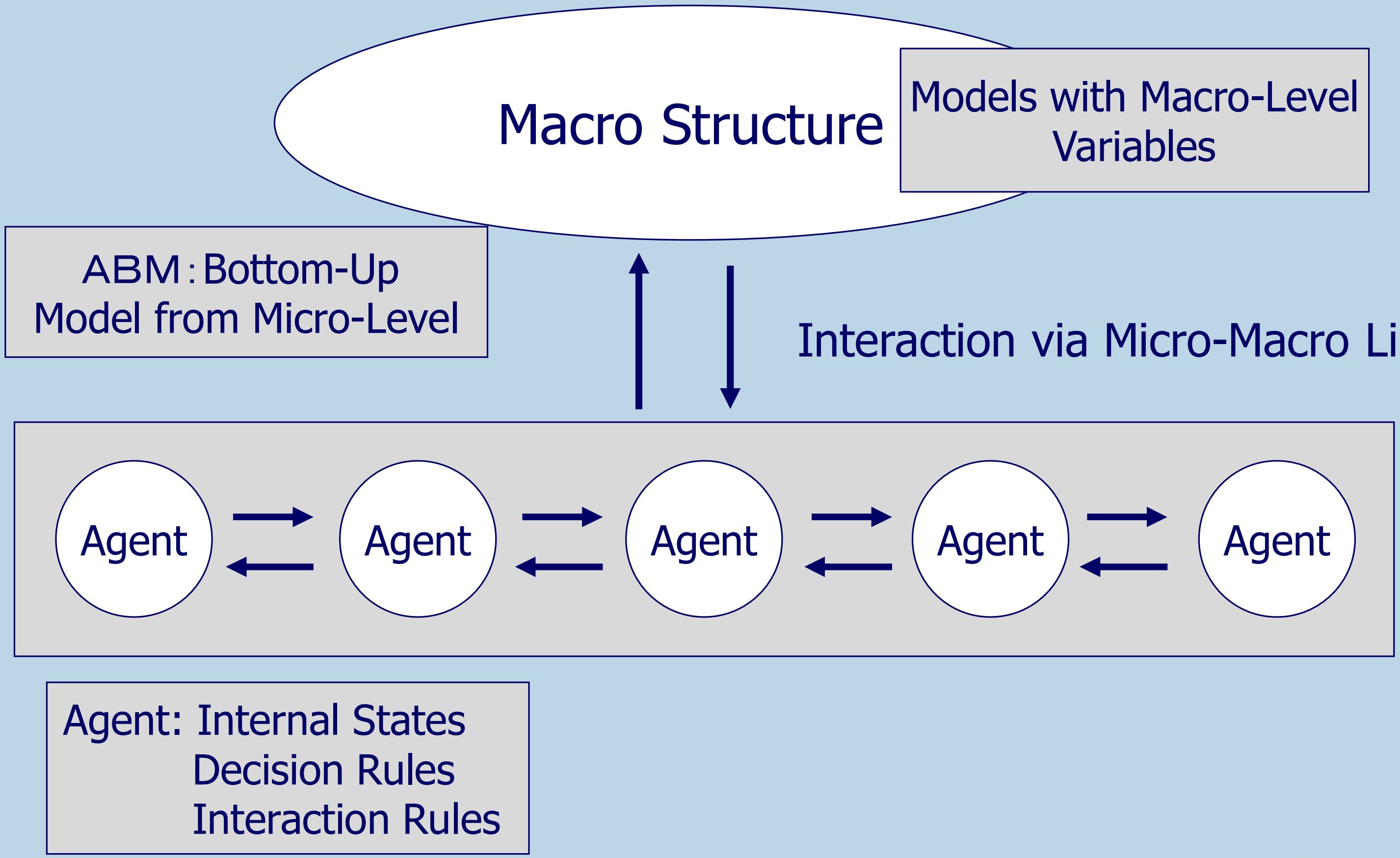
Solving Socio-Technical Problems



Roles of Agent-Based Modeling in Knowledge Management

Basic Mechanism for Agent-Based Modeling



Why Social Simulation is Difficult?

- In Problem Formulation:
  - Conflicts among Stakeholders' Concerns
  - Global and/or Inter-Cultural
  - Complex Adaptive and/or Learning Behaviors of Agents
  - Formation of Social Disciplines
  - Long Term Changes
  - Effects of Unpredictable Technology Changes
- In Technology and Systems
  - Methodologies on Design, Analysis, and Evaluation of the Target System
  - No Direct Control against Individuals and Firms
  - Cooperation of Technology and Systems

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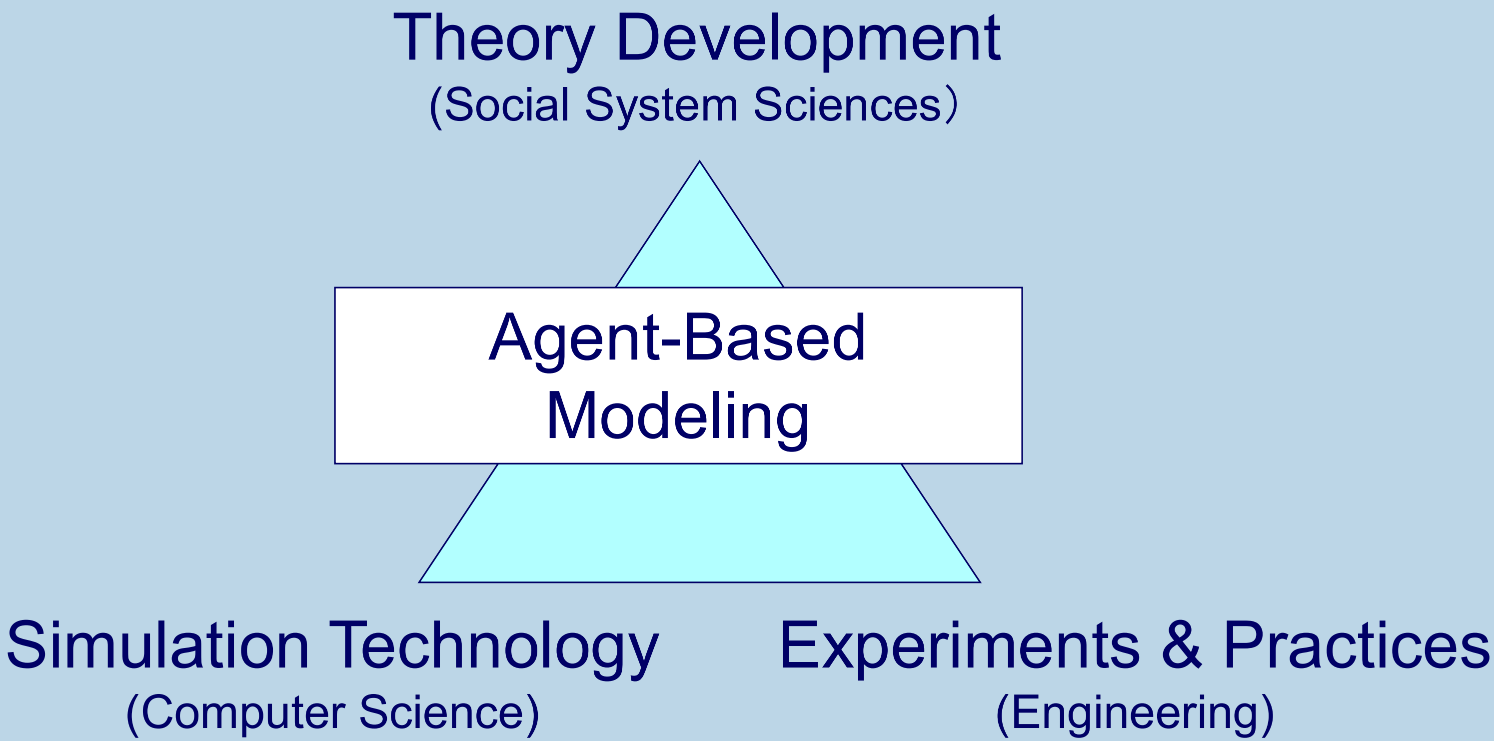
Research Strategy for ABM



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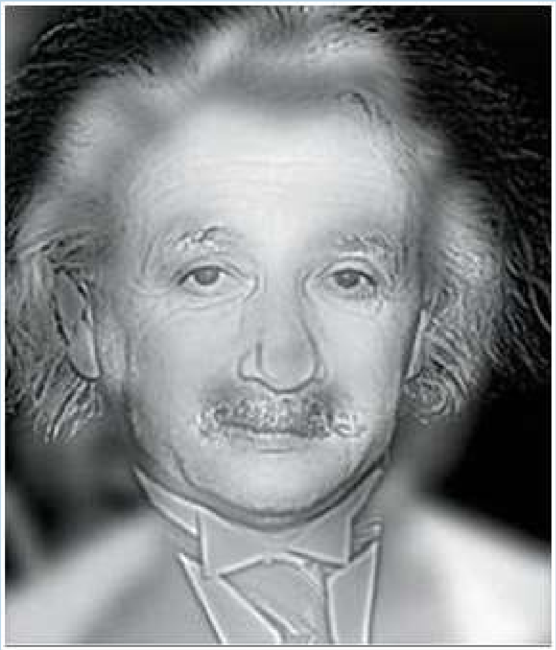
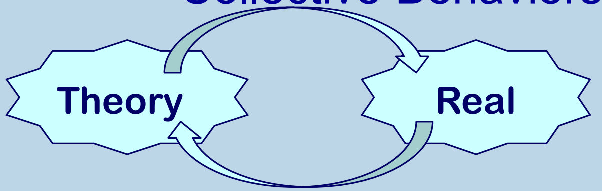
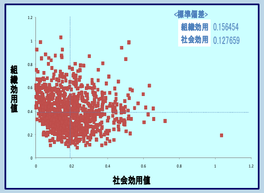
Two Faces of Research on ABM

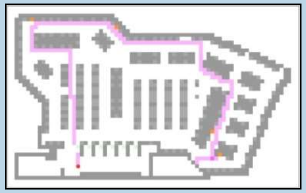


- Theoretical vs Real Issues
  - e.g., Game/Economics vs Collective Behaviors



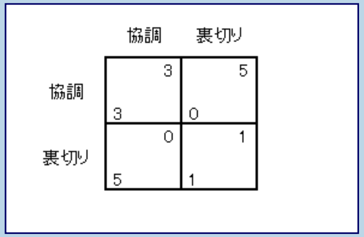
- Social vs Technical Time Scale
  - e.g., 1 Century vs 1 Decade
- Validation vs Accreditation

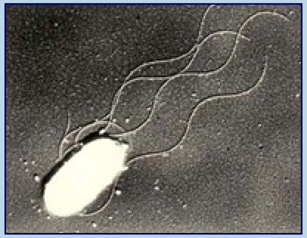




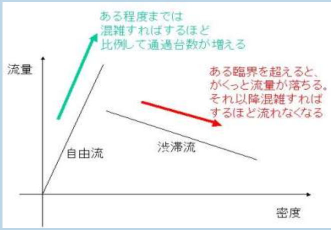
Three Levels of ABM

- Abstract Model

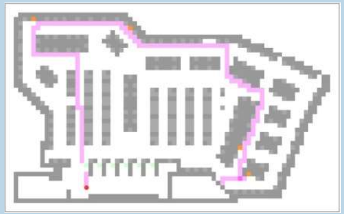




- Middle-Range Model



- Facsimile Model



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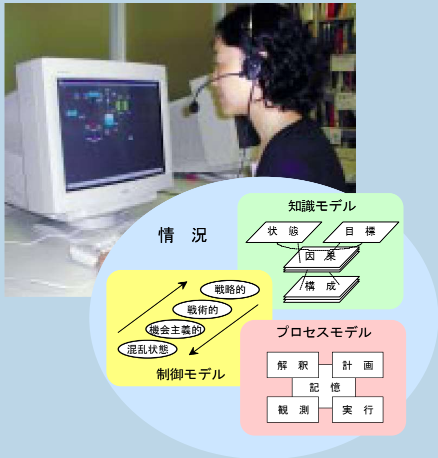
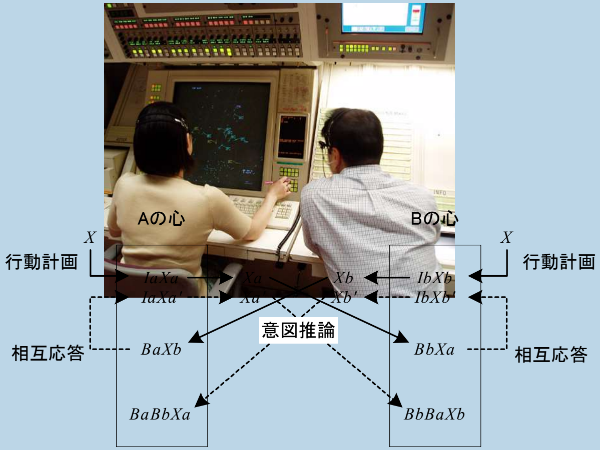
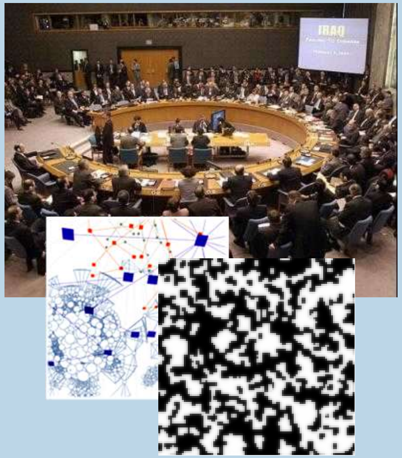
Scales of Models

Individuals	Groups/Frims	Societies







Micro	Meso	Macro
Cognitive M Cases	ABM	Physics
10**0	10**2 ~ 10**6	10**6 ~ 10**23

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Our Recent Topics At a Glance

- ABM at Financial Trading
- U-Mart Virtual Market Simulator
- Social Network Analysis
- Business Modeling
- History Simulation
- Chaos Control at Marketing Behaviors
- Doubly Complex Networks
- Mining on Enron Data
- Consumer Behaviors at a Supermarket
- Simulator on Organizational Adaptation
- Finding Trend Leaders with DM techniques
- Workers Behaviors and Agent Simulation in a Manufacturing Process

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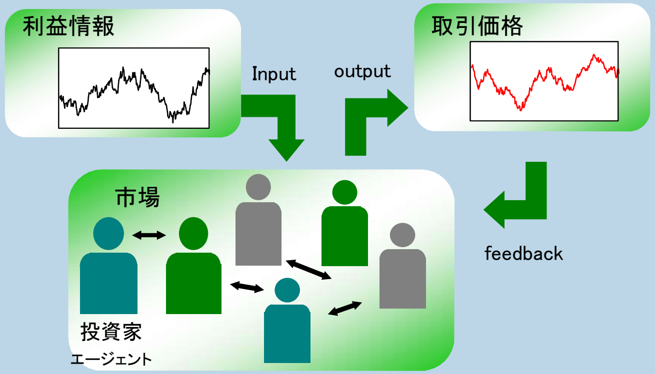
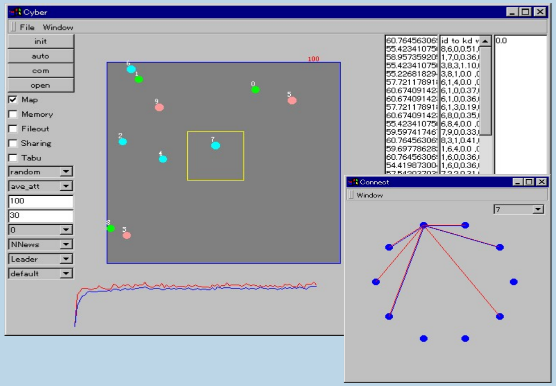
Research on ABM

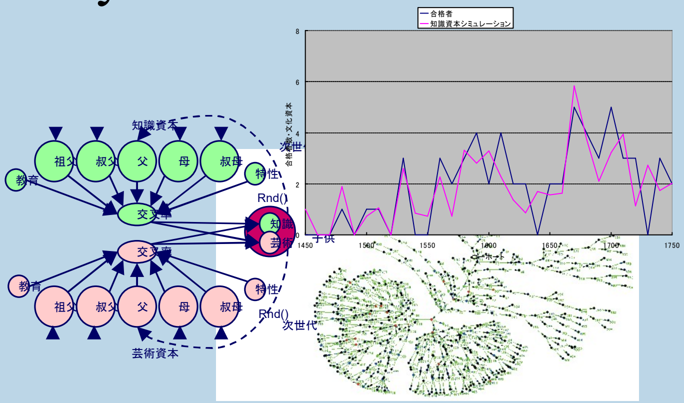
Financial Markets



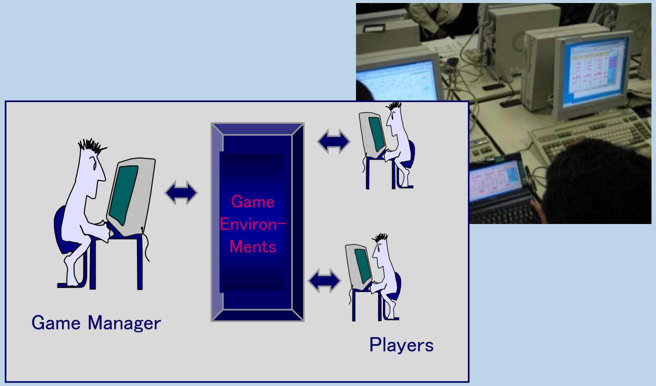
Social Interaction



History Simulation on China Exams.



Business Modeling



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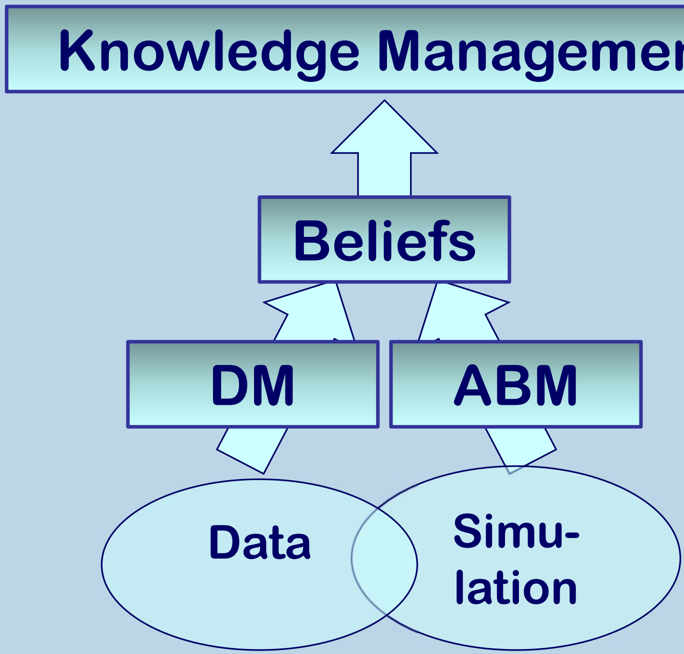
We must Establish …

- DM & ABM are communication tools for decision making & Knowledge Management



Application of IoT & ABM in Manufacturing Management

Case1: Realtime Workers' Behavior Analysis and Agent Simulation

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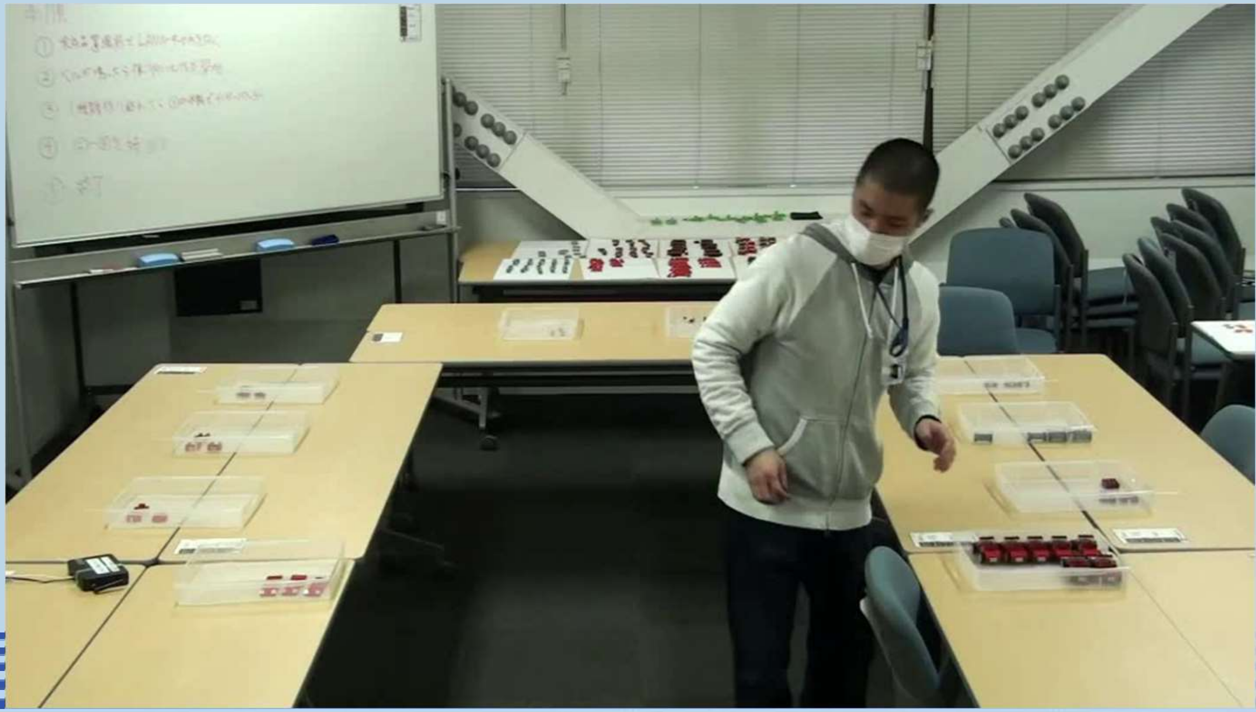
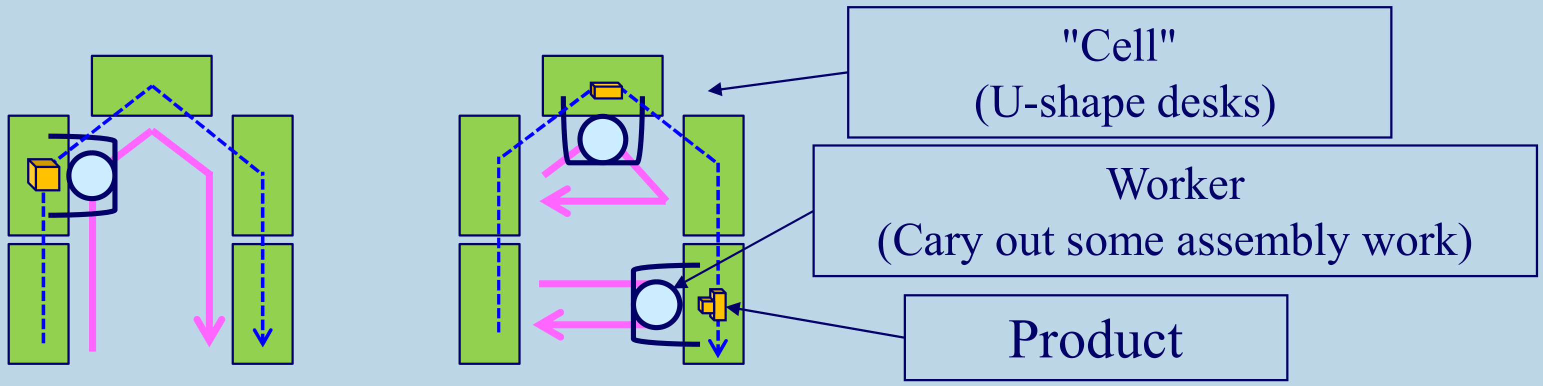
One Slide Summary

1. Develop a real time measurement system of workers' behavior using IoT based beacon devices and acceleration sensors.
2. ABS to simulate the production completion time in real time, and reduce the prediction error.



Background of the Research

- Cellular manufacturing system
  which are mainly processing by workers.



- The performance is often changed by workers' conditions at a factory.
  - ➢ Real-time measurement and simulation with the worker data is necessary.

- Development of the real time-measurement and -simulation system in the cellular manufacturing line by one worker.
  - ➢ Reduce the error of predicted production completion time.

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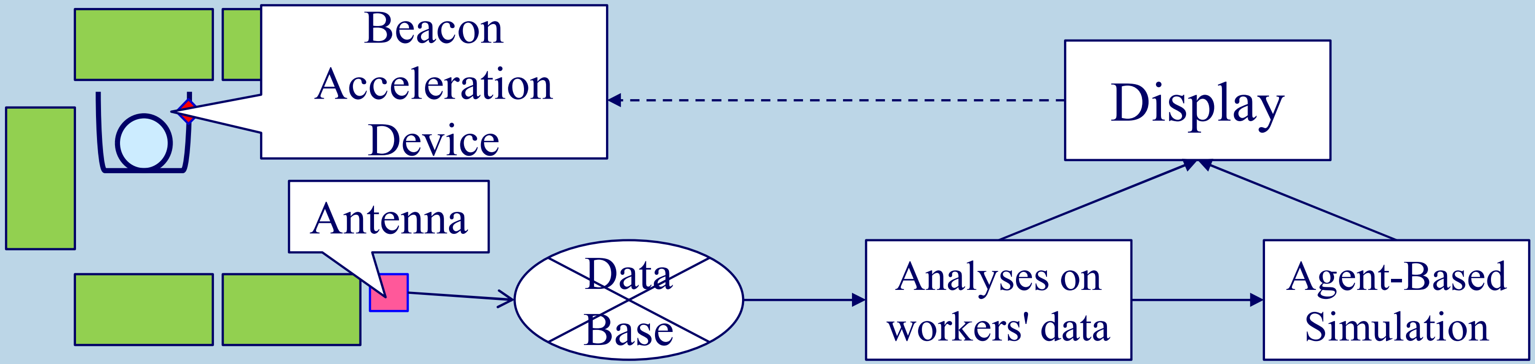
Proposed method - Configuration

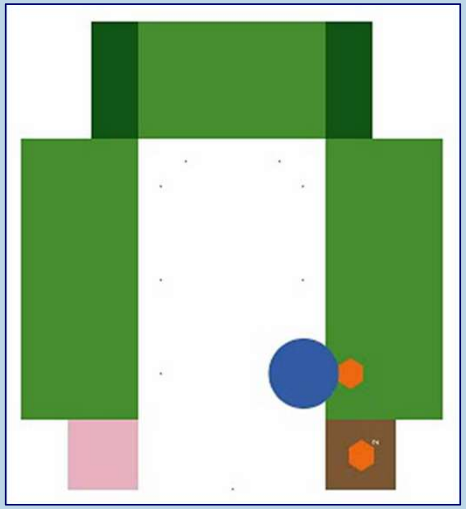
- System Configuration



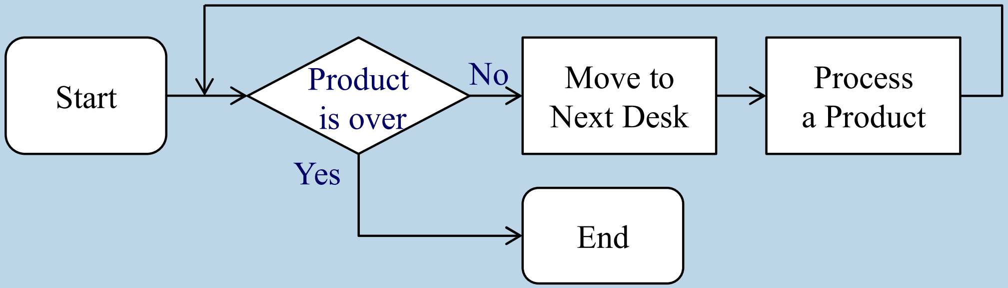
1. Field — Design an experimental cellular manufacturing line.
2. Measurement — Measure the workers' position and behavior by the beacon / acceleration device. Analyze actual production cycle time in real time.
3. Simulation — Develop agent-based simulator of the line, and predict a production completion time.

Agent-Based Simulator

- Developed an agent-based simulator



- Setup
  - Table layout and work order
  - Flow of worker agent



- Input　　Actual production cycle time.

  ↓ Data Assimilation of worker agent's assembly and moving speed with real workers' data

- Output　　Prediction of production completion time.

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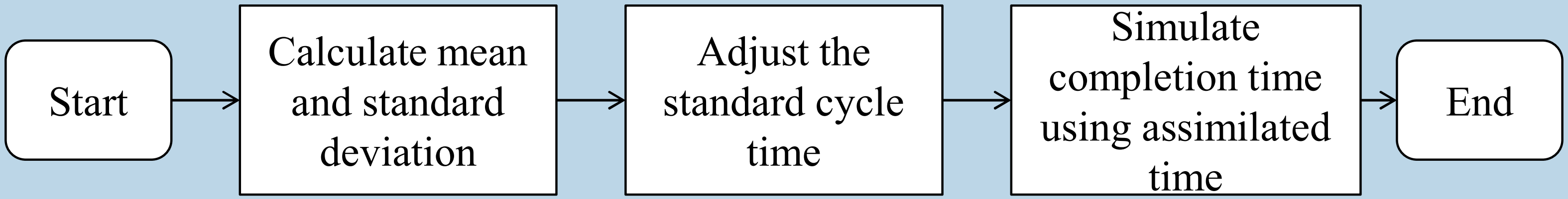
Simulation Design

- Workers' movement parameters are determined by Ready Work Factor (RWF) Method
- Basic predicted time is based on standard cycle time, which is often used in the product design.
- Each time to predict the production completion time; we assimilate the standard cycle time by actual cycle time.
- Simulate ten times, use average value.



Ready Work Factor Method

- ◆ RWF method is a technique for evaluating the work efficiency in Industrial Engineering.
- ◆ We can set the standard work time by resolving the work into the motion, evaluating the difficulty of motion, using the predetermined work time table.

Ready Work-Factor (RWF) Time Table

距離または重量の表示：ーまで、+超　時間値はすべて RWF 単位(RU)で示す　1RU=0.001 分　ATAC 吉田良耿

[移動]	ワークファクター数				
	0	1	2	3	4
	重量限界Kg				
指、手	-0.5	-1.0	-1.5	-2.5	+2.5
腕	-1.0	-2	-3	-5	+5
足	-1.5	-4	+4		
脚	-2.5	-8	+8		
胴	-3.5	-16	+16		
移動距離 cm					
-10 A	2	3	4	5	6
-25 B	4	5	6	7	8
-50 C	5	7	9	11	13
-75 D	7	9	11	13	15
-100 E	9	11	13	15	17

(注１)　胴の動作は移動距離を２倍する
(注２)　圧力をかける、及び前腕旋回はクラスA

[取り上る] (移動と掴む)	つかみのワークファクター				
	0	1	2	3	4
	時間値（RU）				
移動距離 cm -10 A	8	9	10	12	15
-25 B	12	13	14	16	19
-50 C	17	18	19	21	24
-75 D	21	22	23	25	28
-100 E	25	26	27	29	32
移動距離 cm	重量に対する追加時間				
-25		1	2	3	4
+25		2	4	6	8
	その他の追加時間				
非可視			1		
両手同時			2		

(注５)「取り上げる」時間値は可視性つかみを基礎に「伸ばす」「つかむ」「運ぶ」を合せた時間値
(注 6)両手同時動作の場合は非可視の値を加える

Table Reference： 吉田良秋, "RWF法(Ready Work-Factor)とは", 大阪科学技術センター, http://www.atac.ne.jp/others/rwf_1.pdf (accessed 25th February 2016) (in Japanese)

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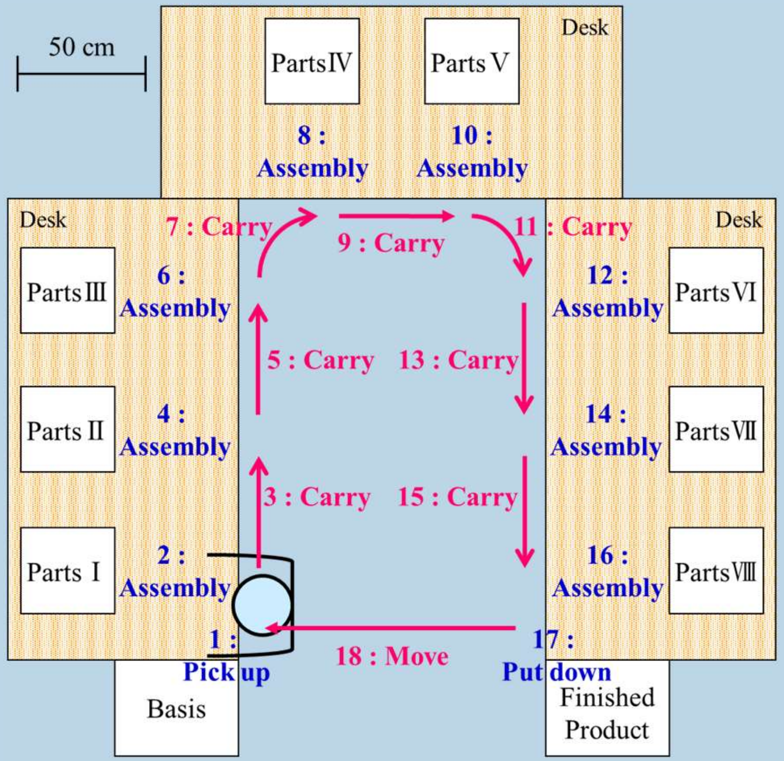
Toy Assembly Line for the Experiment

1. Field Design



2. Product Design

Car

Penguin

House

Work No.	Standard Work Contents	Standard Work Time [s]		
		Car	Penguin	House
1	Basis Pick up	1.14	1.14	1.14
2	Parts I Assembly	9.84	7.38	2.46
3	Carry	1.20	1.20	1.20
4	Parts II Assembly	7.38	7.38	14.76
⋮	⋮	⋮	⋮	⋮
16	Parts VIII Assembly	5.16	2.70	9.84
17	Product Put down	0.78	0.78	0.78
18	Move	1.68	1.68	1.68
Total (Standard Cycle Time [s])		64.14	46.80	78.42

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IoT Based Measurement Devices

- Beacon device with acceleration sensor

  We collect the data,
  Time, ID, Signal strength, Temperature, Acceleration(3-axis).

Device

Antenna

Bluetooth Low Energy Beacon

- Bluetooth Low Energy Beacon
  - A wireless communication technology using a calling device and a receiving antenna.
  - When the device and the antenna to communicate, it is able to store the ID, the received time, and a received signal strength indicator (RSSI).
  - we can estimate the distance between the device and the antenna by the RSSI

- The device has become smaller with the BLE beacon or other sensors.
  - ➢ Use these devices easily and inexpensively.

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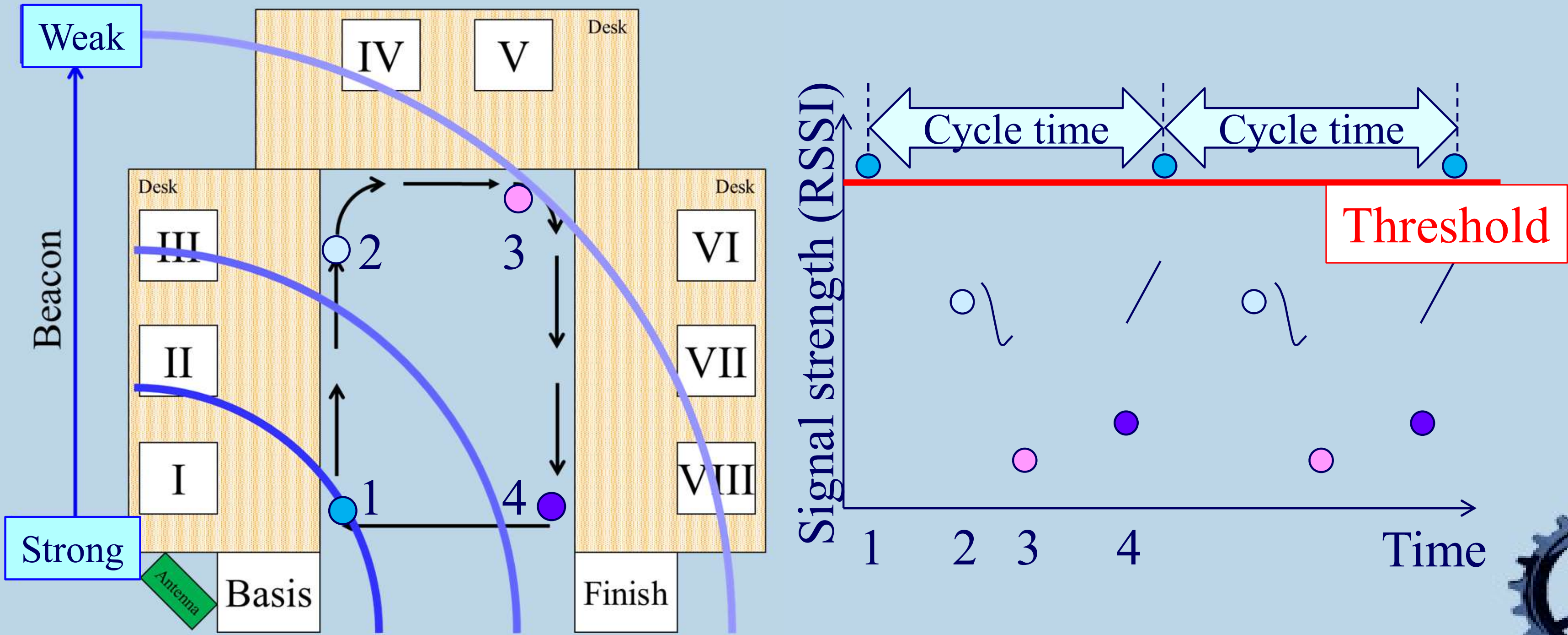
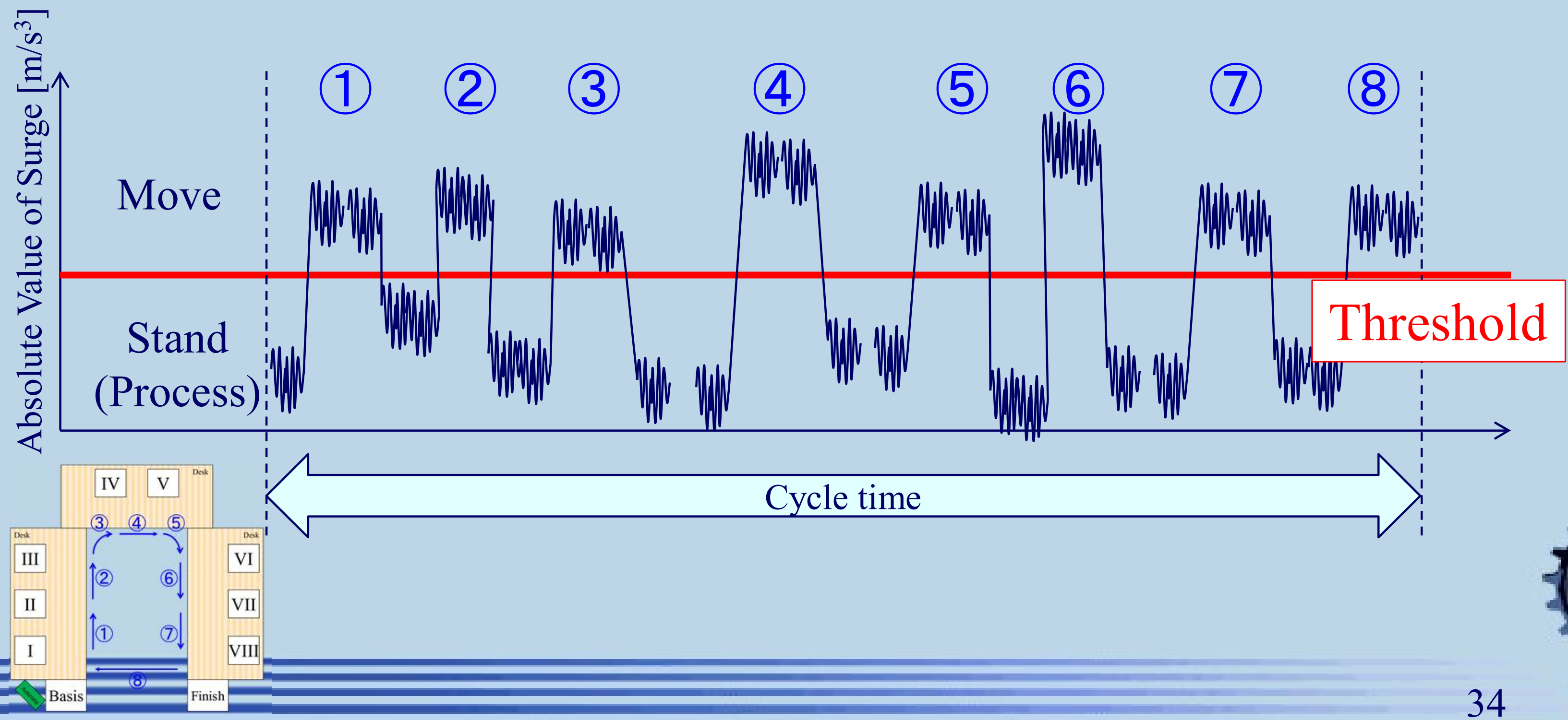
Measurement and Analysis Method

- Analyze the actual production cycle time using the received signal strength indicator (RSSI) of the beacon.



Cycle Time Assessment

- Using the differential values of acceleration (Surge [m/s^3]), count the number of movement in one cycle time.
  - If the number is too much / less, exclude the cycle time.



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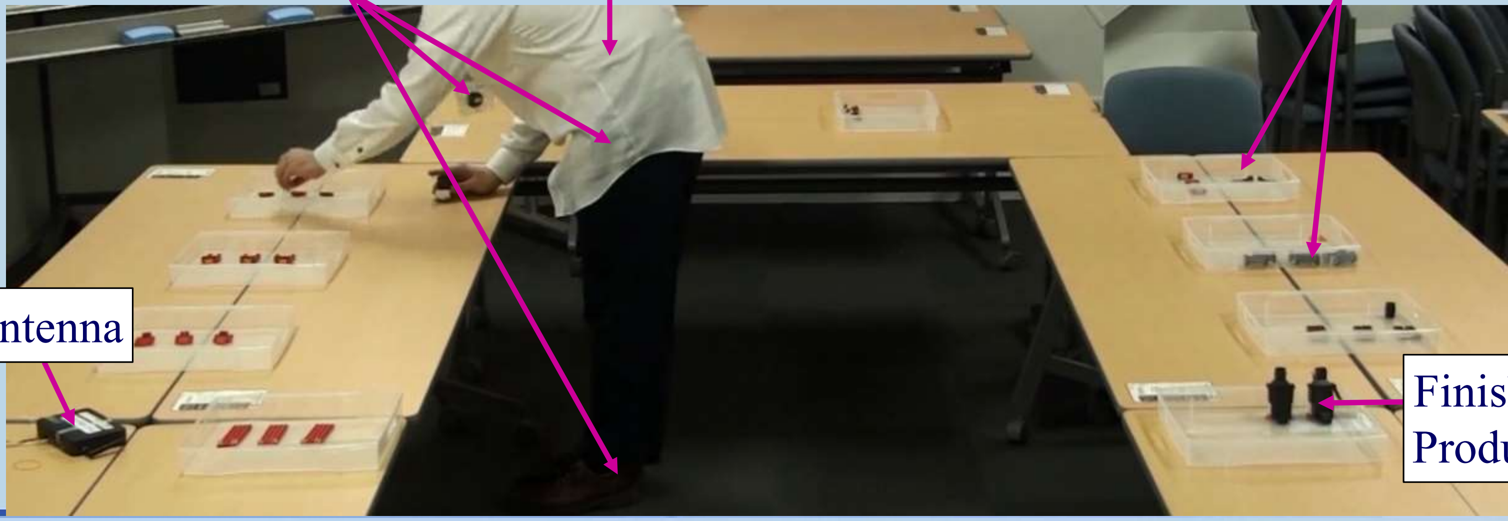
Experiment

- Five worker subjects are assigned.
- They wear the IoT devices to the chest, hip and ankle.
- They are required to assemble 30 pieces in total in order of 10 pieces of Car, Penguin, and House.



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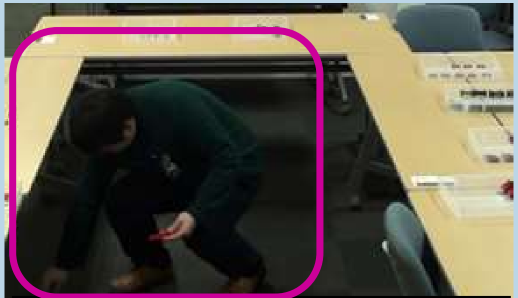
Result - Real time measurement

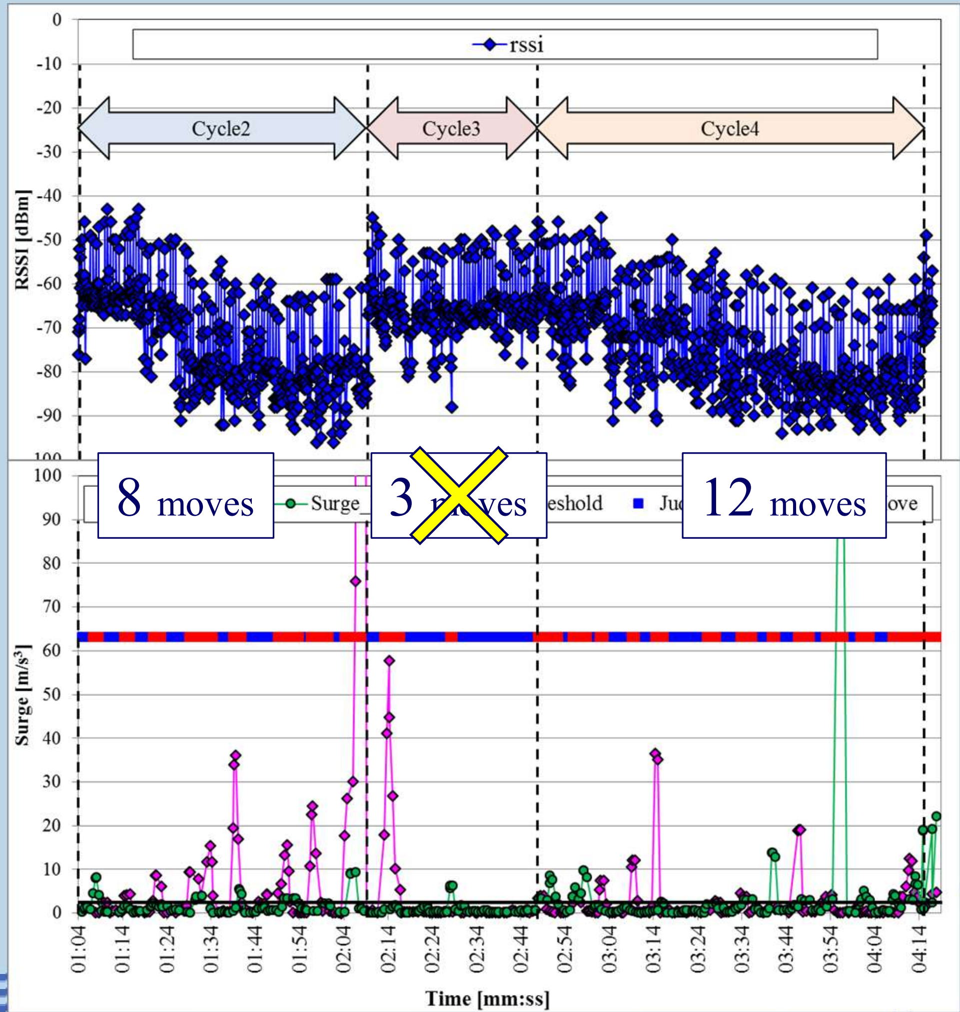
- Graph of
  RSSI and Surge

The Cycle 3 is excluded

In cycle 3



Pick up the dropped parts



Results of Real time measurement from Movies and IoT Devices

- Result of all subjects.
  - Collective Rate of the actual production cycle time

    148 data / 150 products 98.7 %
  - Accuracy Rate of whether including non-standard move.

    135 data / 148 products 91.2 %
  - Compare the collected cycle time from the proposed method with the time from a conventional video analysis.

    Relative error rate 3.2 %

➢ In real time, we are able to collect the actual cycle time, which error rate is close to conventional video analysis.

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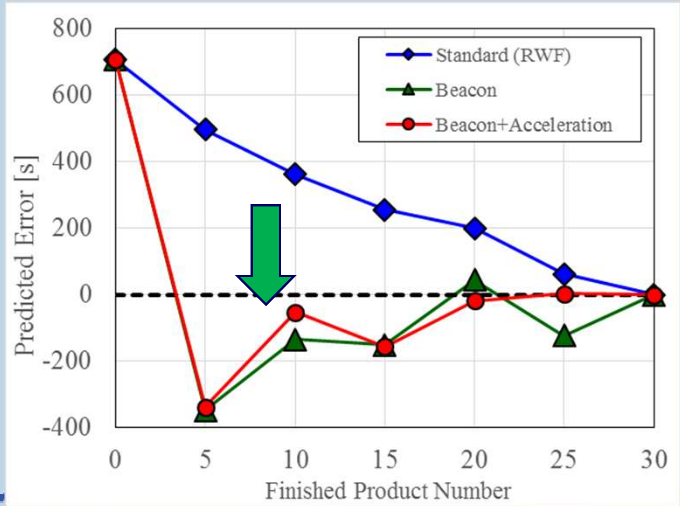
Results of Real time Agent Simulation

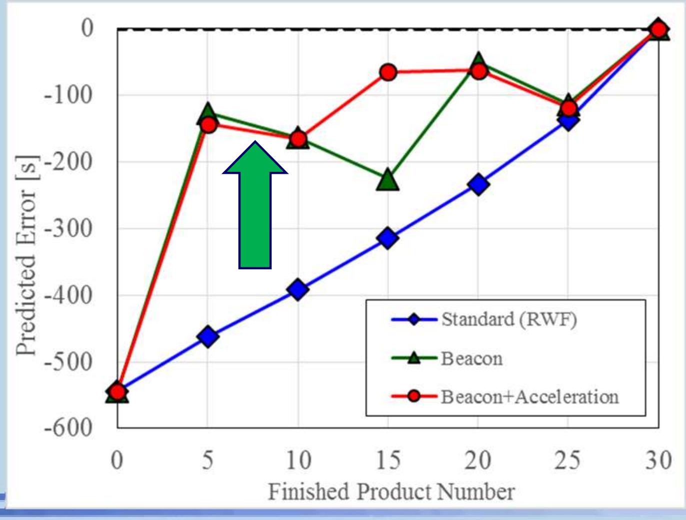
- Result of Root Mean Square Error of predicted [s] in all subjects
  - Reduce the error of predicted production completion time.

The Method	***Finished Product Number***					
	5	*10*	*15*	*20*	*25*	*All*
Standard (RWF)	348	279	222	175	82	239
Beacon + Acceleration	251	157	150	111	75	160

Result of First Worker

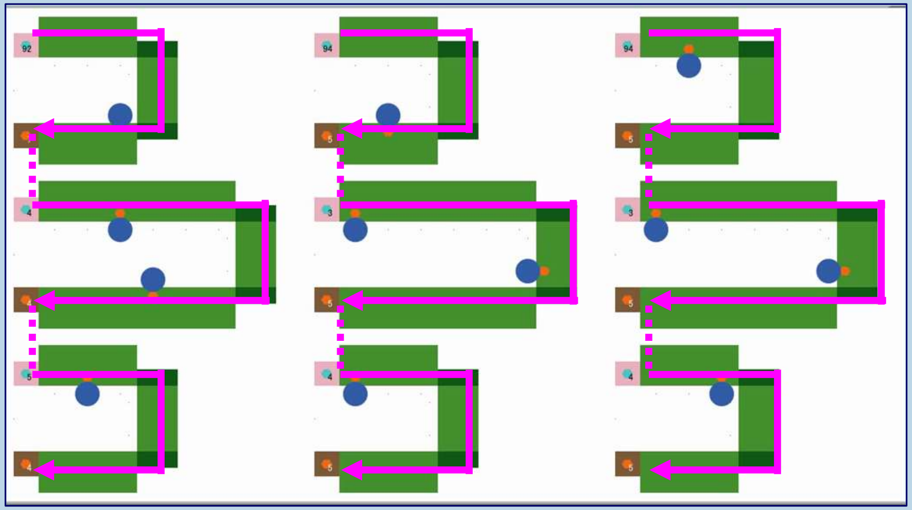


Result of Third Worker



Summary of Workers' Behavior Analysis and Agent Simulation

- In the cellular manufacturing line:
  - Real time measurement system of workers' behavior.
  - Agent simulation using the workers' data.
- We can carry out a new manufacturing management
  - Collected the actual cycle time in real time.
    - with IoT devices, prediction of the completion time



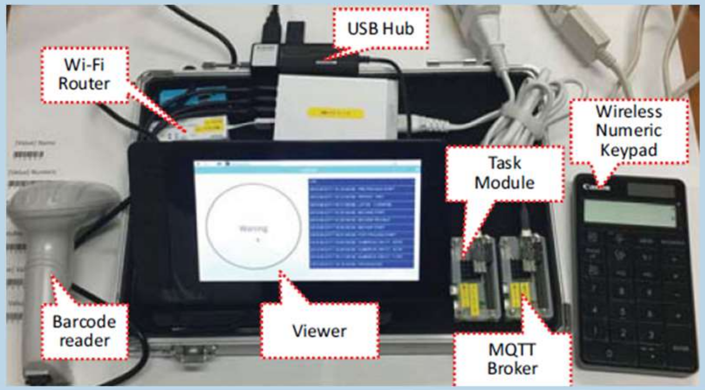
Application of IoT & ABM in Manufacturing Management

Case2: IoT Based Manufacturing Process Management

Sample of a Manufacturing Factory

Machining Center

IoT Devices



Human
Operator

Products
(Machinery
Parts)

Shavings from
Cutting Process

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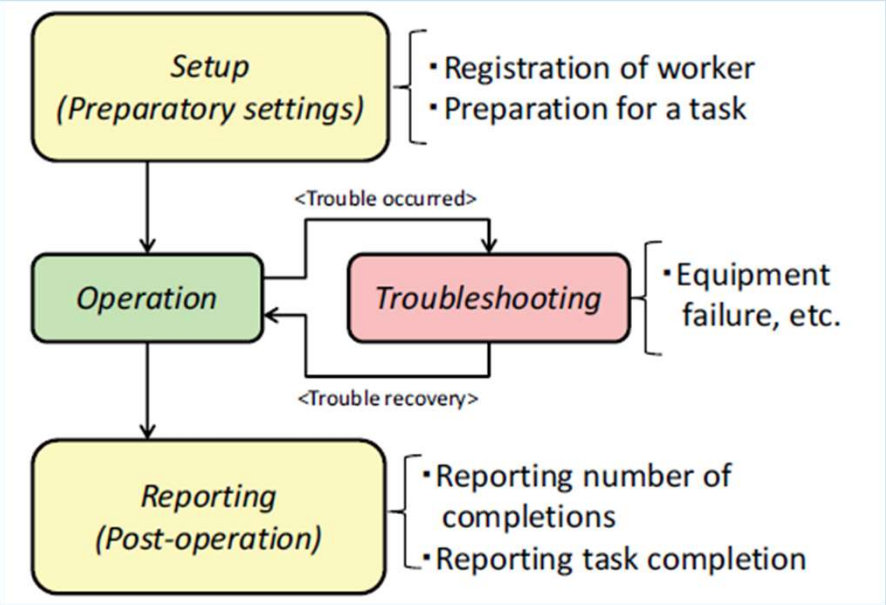
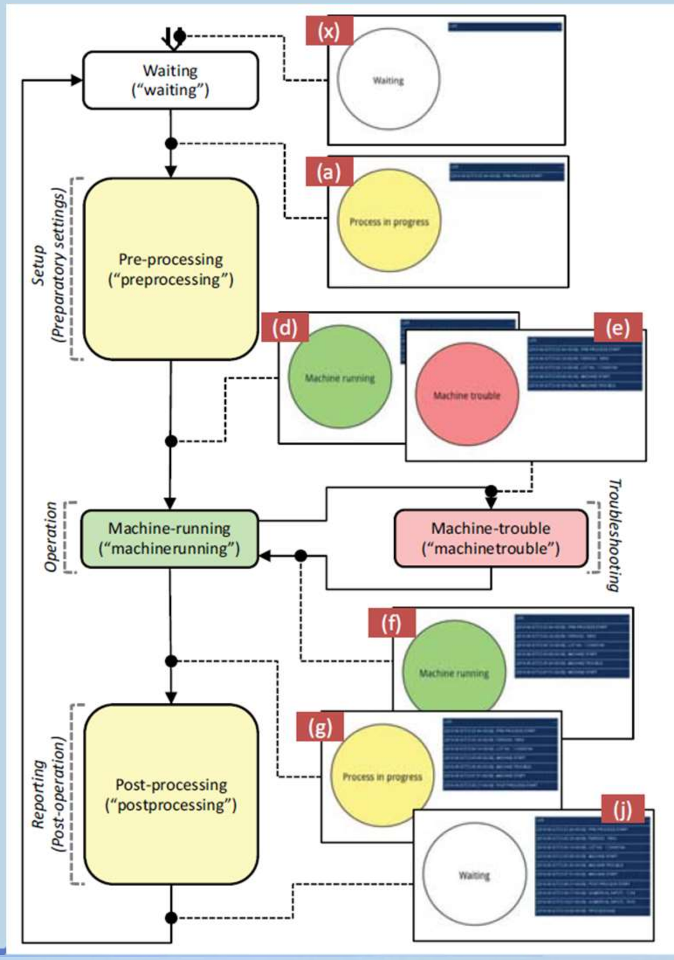
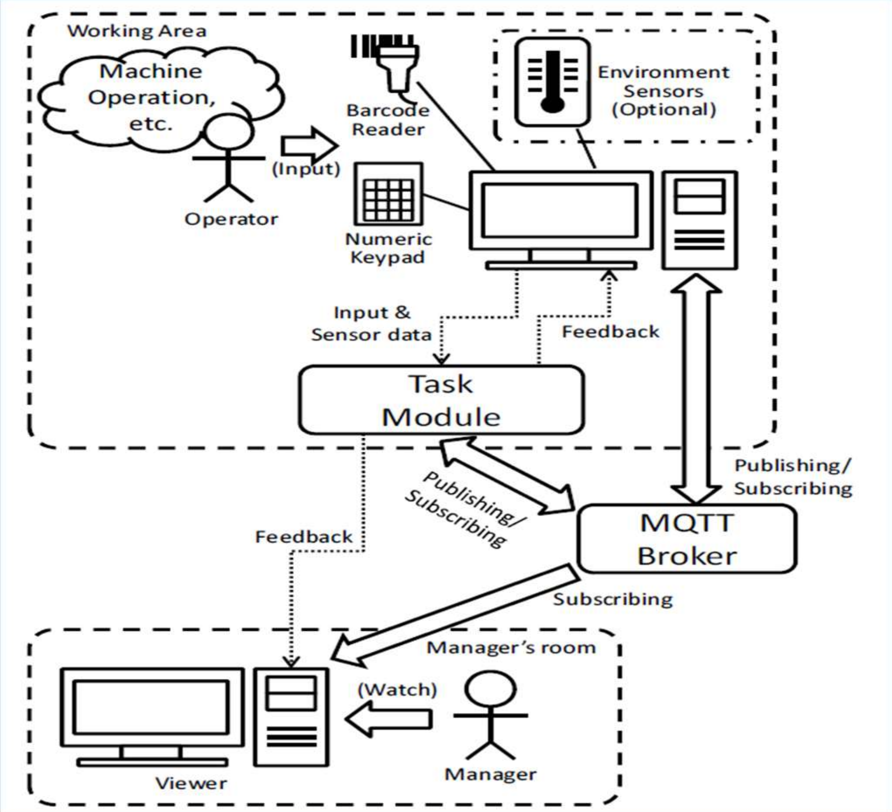
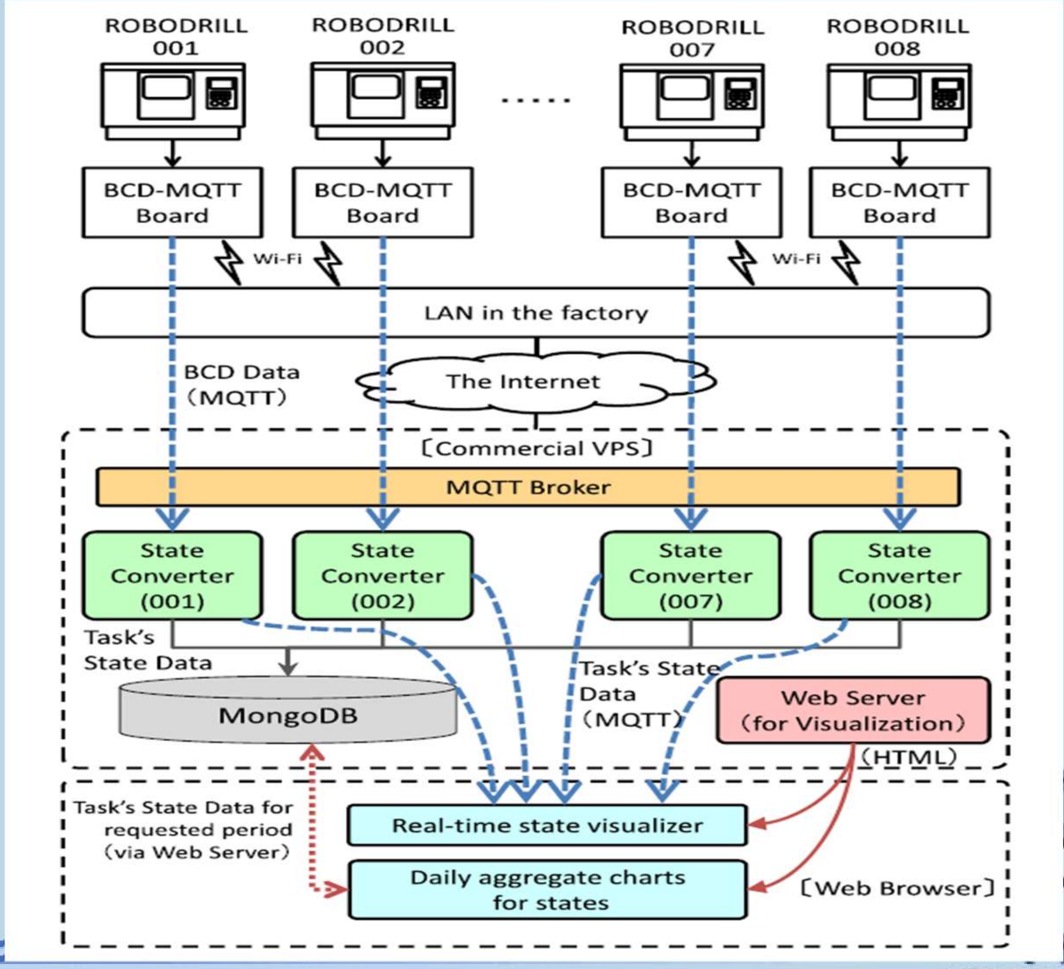
Manufacturing System and IoTs





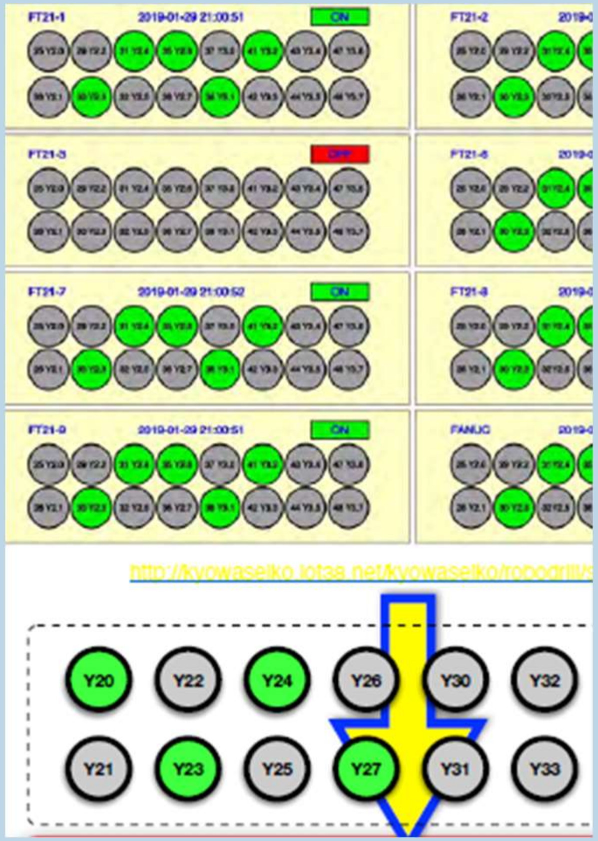
System Architecture of CPS & IoT Systems

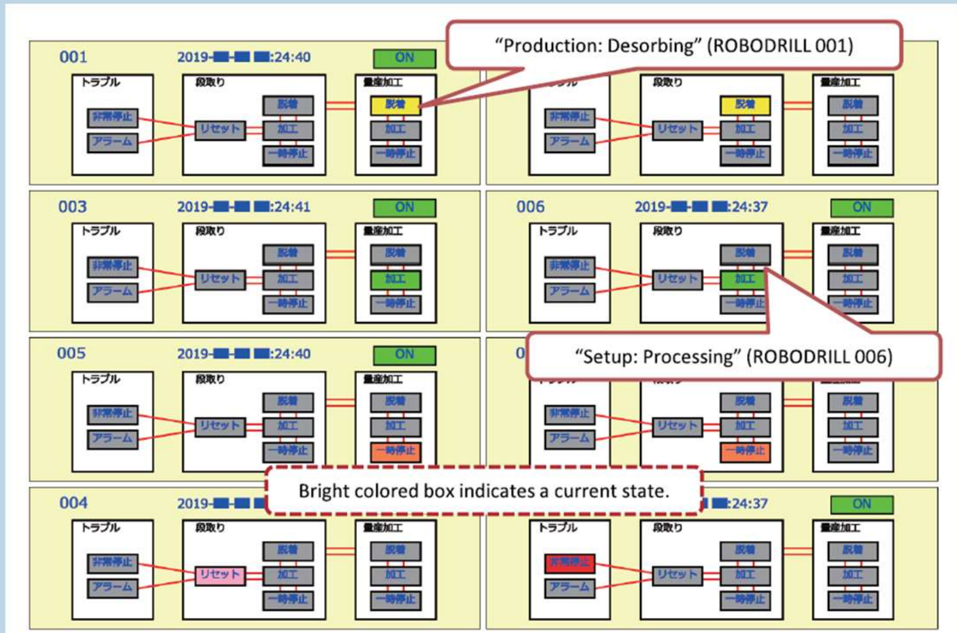




Task Module: Management Software
MQTT: http like protocol

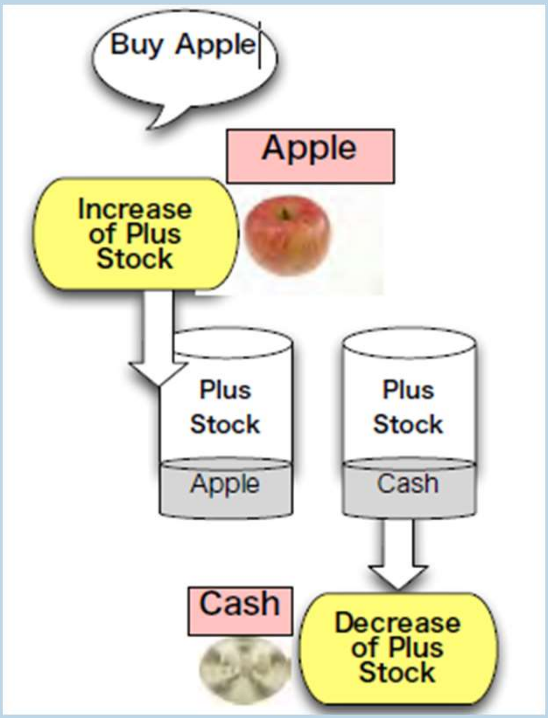
Examples of the Production System Management





How Accounting Concepts Work in a Firm

What is Multi-dimensional Accounting System



Tabular Style Bookkeeping

Debit Side	Credit Side
3.00 Apple Euro	3.00 Cash Euro

If we use only currency unit for every account title such as “Yen”, then it is called standard description of book keeping system.
x=30^<cash,Yen>+30<apple,Yen> Buy Apple by Cash

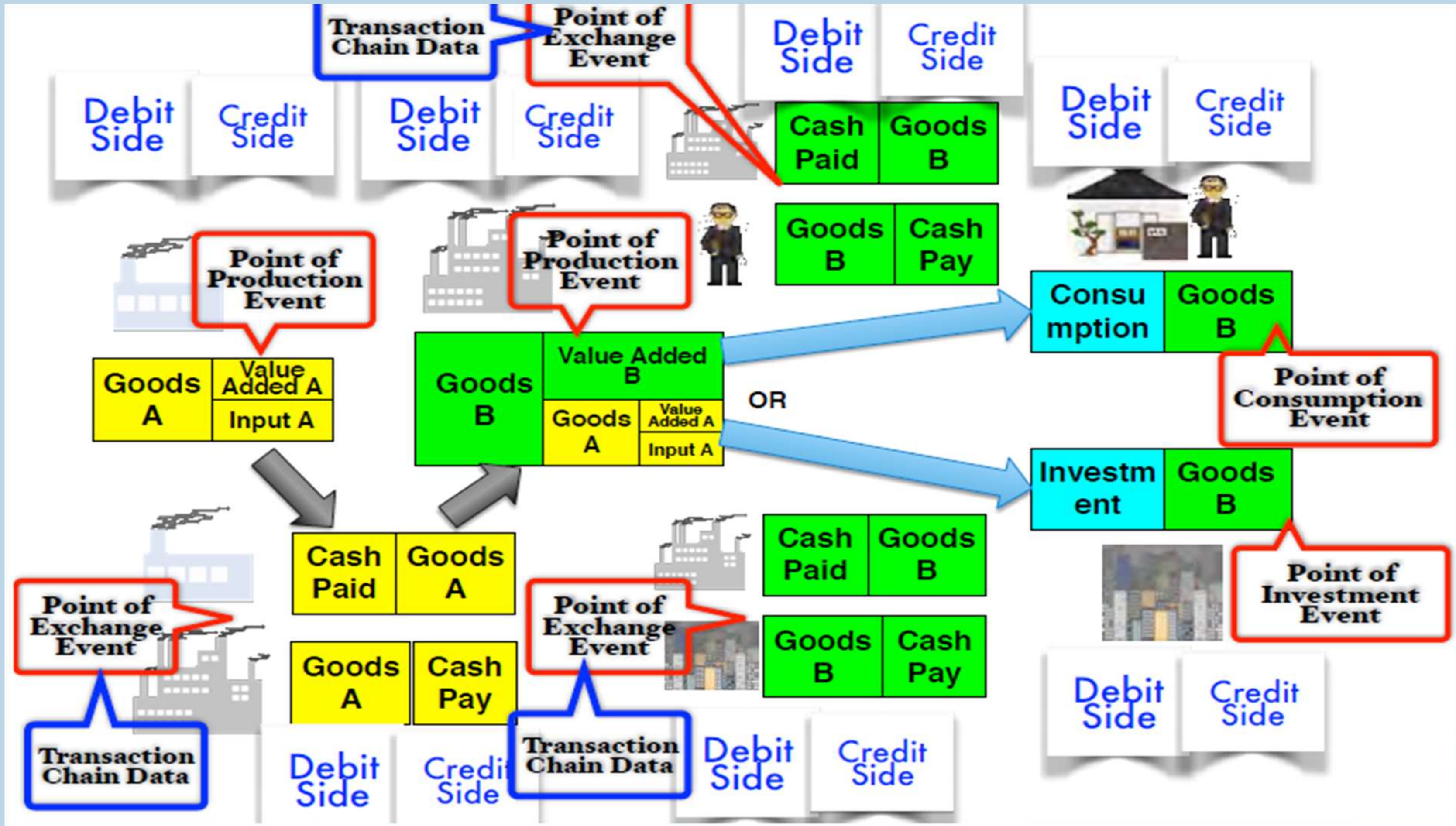
Debit Side	Debit Side
1 Apple Kg	3.00 Cash Euro

If we use suitable unit for each account title, such as “Kg” for “Apple” and “Yen” for “Cash”, then It is called In Multi Dimensional Description of book keeping system.
x=30^<cash,Yen>+1<apple,Kg>
Buy Apple by Cash

Description of Real Stuff and Money

MDAS: Multi-dimensional Accounting System

Value Added Production and Supply Chain Systems



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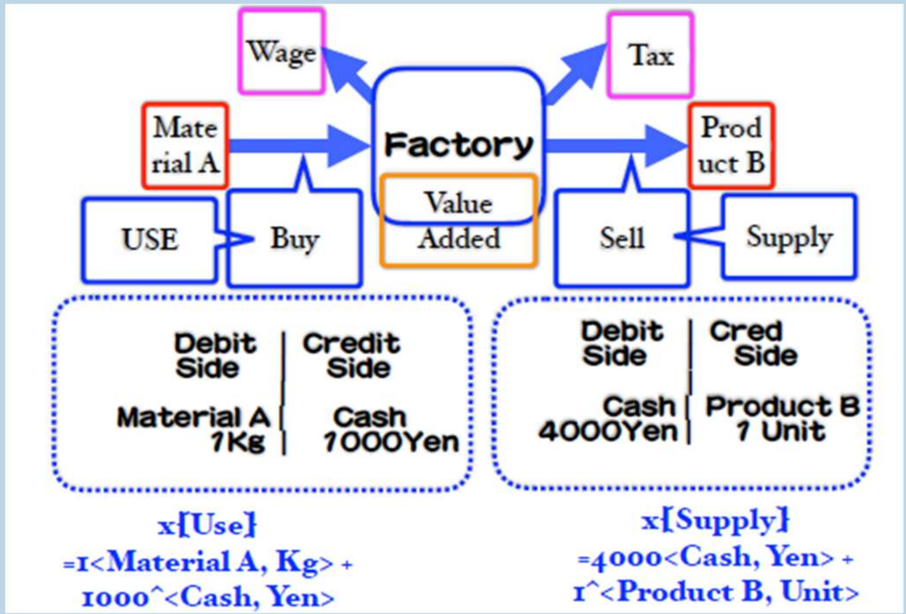
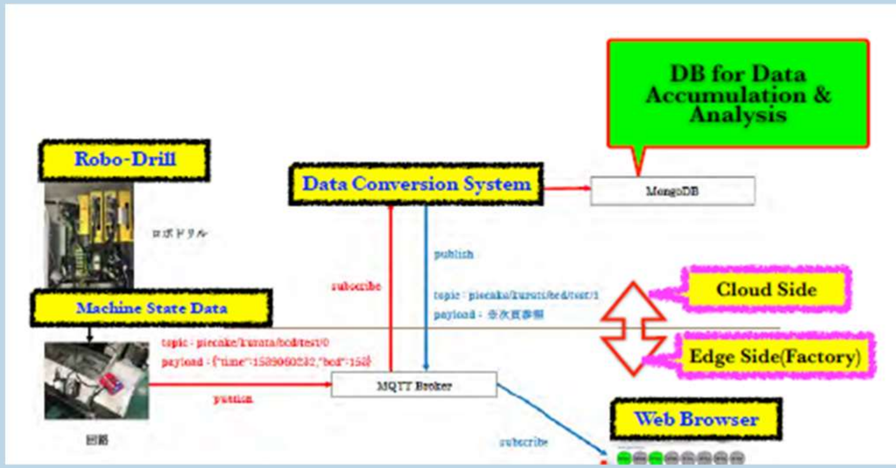
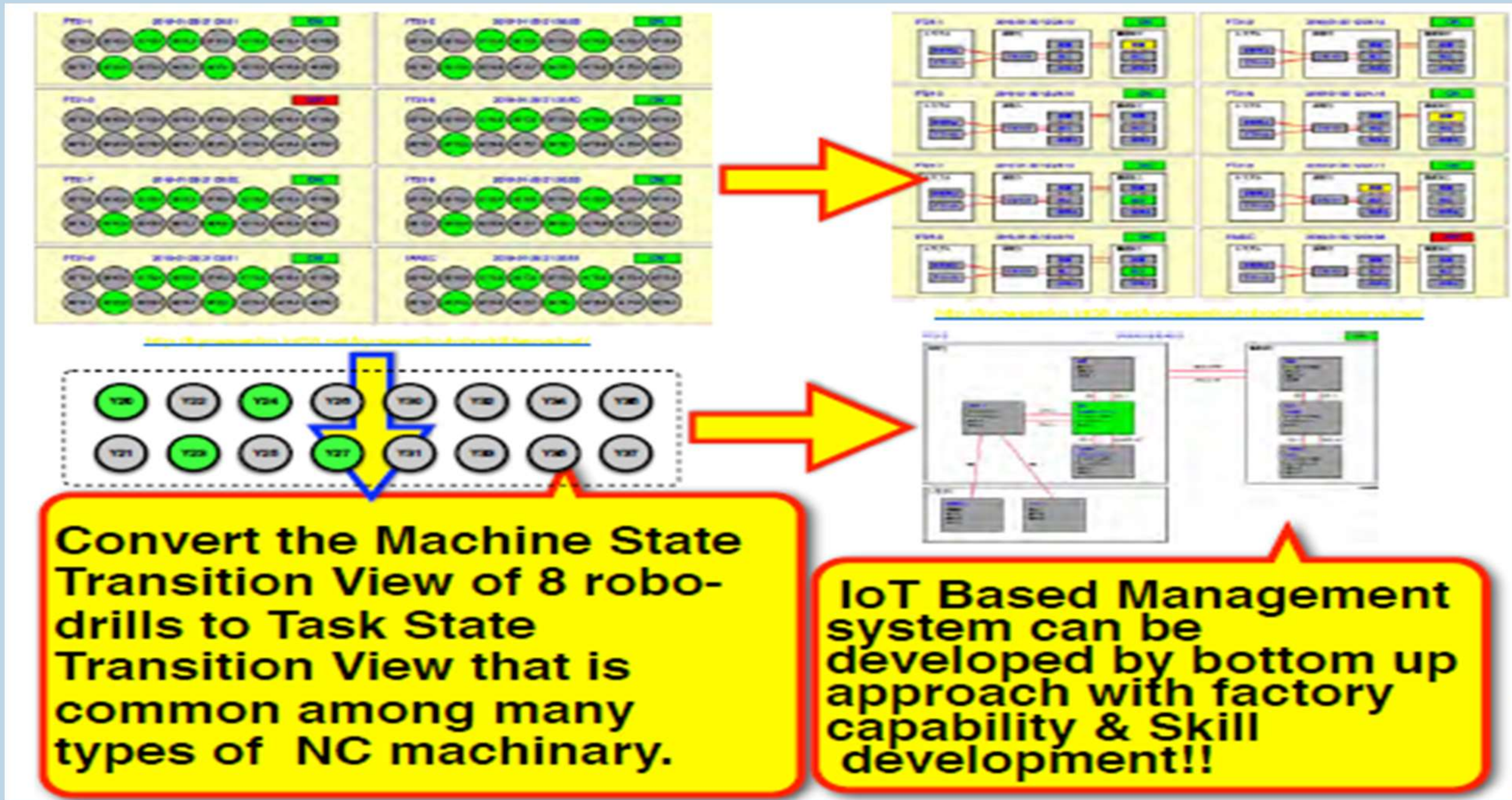
Cost Accounting through MDAS





MDAS and a Manufacturing System



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Concluding Remarks

- Social System Implementation with AI/ML Technology is Immature
- Roles of Agent Modeling is Essential in Knowledge Management
- Application of IoT & ABM in Manufacturing Management
  - Case1: Realtime Workers' Behavior Analysis and Agent Simulation
  - Case2: IoT Based Manufacturing Process Management
- Multidimensional Accounting System will Work

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Home Bring Messages

"Art is a lie that helps us see reality"

by Pablo Picasso

-> Agent Simulation and IoT are a lie that helps us see reality

"Everything is Obvious Once You Know the Answer"

by Duncan J. Watts

-> Something may be Obvious Once You Know Multi-Dimensional Accounting Systems

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