Aug,30, 2022

Understanding Complex Social-Technical Systems through Agent and Gaming Simulation

Takao TERANO

Professor, Chiba University of Commerce, Japan

Professor Emeritus, Tokyo Institute technology,

Professor Emeritus, Tsukuba University,

terano@cuc.ac.jp

https://teranolab.sakura.ne.jp

CUC Chiba University of Commerce 千葉商科大学

Gallery for Evolutionary computation and Artificial intelligence Researches

GEAR

ABSTRACT

Agent-Simulation is a tool to know about a could-be-world. Also, Gaming-Simulation is a language to communicate the future. In this talk, I will discuss a new approach to understand complex socio-technical systems through both concepts. We start basic features on complex and/or complicated socio-technical systems, which address both technical and social issues with human decision- making processes. Then, we explain the importance of new ways of system thinking with human-in-the-loop manners. For the purpose, we propose a methodology to amalgamate agent- and gaming-simulation.

GEAR

Outline

- Introduction
- Difficulties of Socio-Technical Problems
- What is Agent-Simulation
- What is Gaming-Simulation
- Applying AI/ML for Social System Implementation
- Our Challenge to Socio-Technical Problems
- Concluding Remarks

GEAR

Takao TERANO, Small Personal History

- 1978: Graduated Master Course Information Engineering, Tokyo University: OR & Numerical Analysis

- 1978～1989: Central Research Institute of Electric Power Industry (CRIEPI) , Information System R&D
  1980's in the 2-nd AI Era: Member 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)

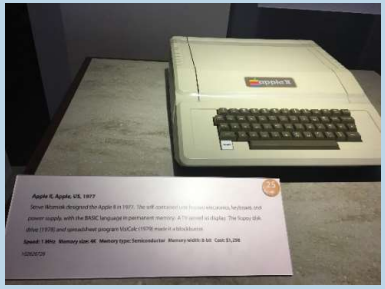
- 2018～2018 Professor, Chiba University of Commerce, Japan
  AI & System Science, Social Systems; Technical Advisor, MIRAI Relations Co. LTD.

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

GEAR

Recent Development of Computers

- In 1977: Deployment of Apple II and Boeing 747
  - Apple II
    - 4 k Byte RAM
    - 1 m Hz CPU Speed
    - JPN 350, 000
  - B747:
    - 300 t Loading Capacity
    - 1,000 km/h Speed
    - JPN 10,000 M(～ Price of a Super Computer at the day)



- In 2018:
  - Apples iMAC Pro
    - 128 G byte RAM
    - 18 Core Xeon Processors; 3.2GHz CPU Speed / One Processor
    - JPN 1.50 M
  - If the Performance of B747 would show the same advancement…
    - 30,000 M t Loading Capacity
    - 60 M km/h Speed (~ Much faster then the Speed of Light!)
    - JPN 40,000 M

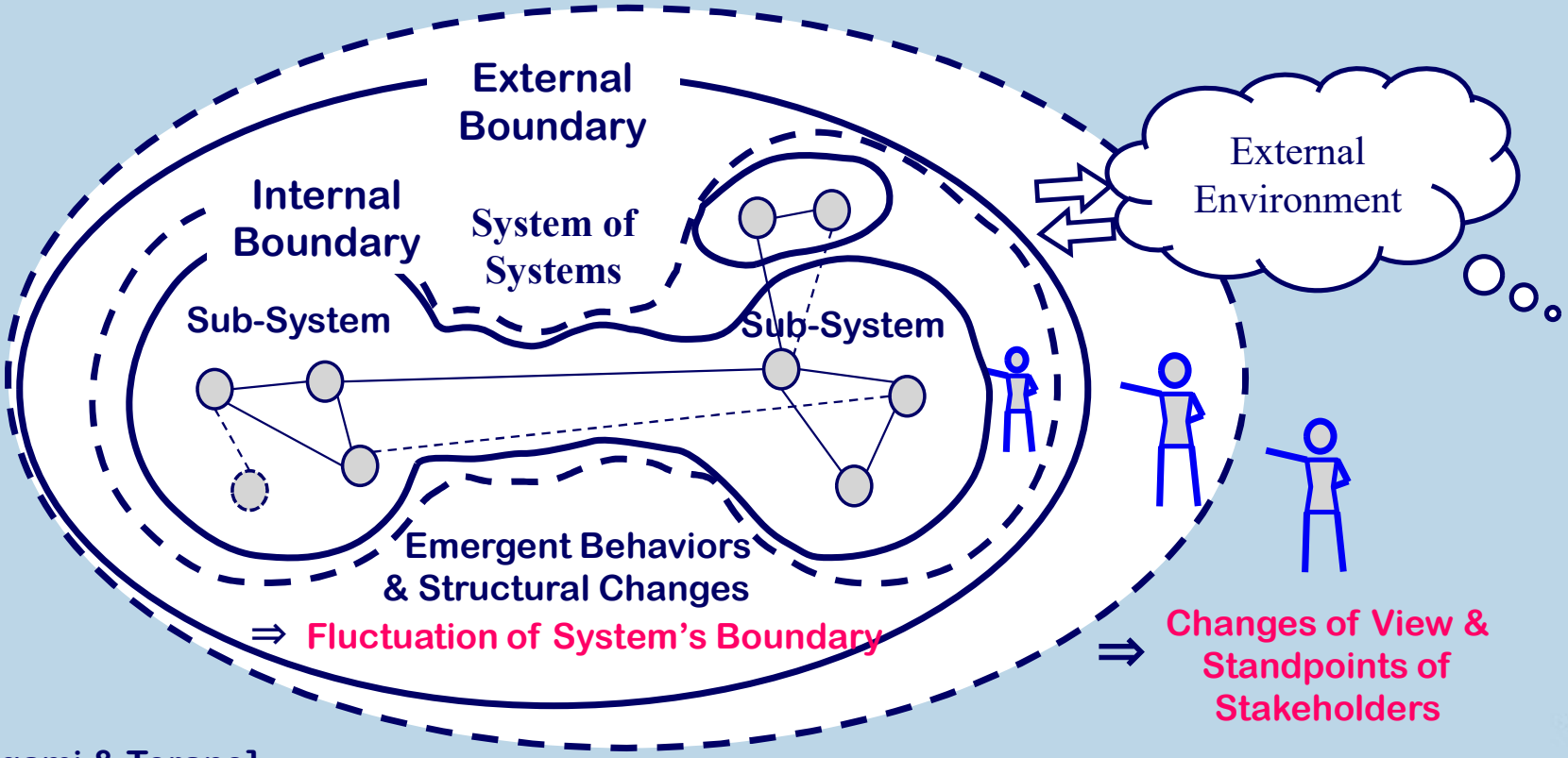
GEAR

Why Socio-Technical System 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

GEAR

Fluctuation of Boundary and Stake-Holders of Socio-Technical Problems

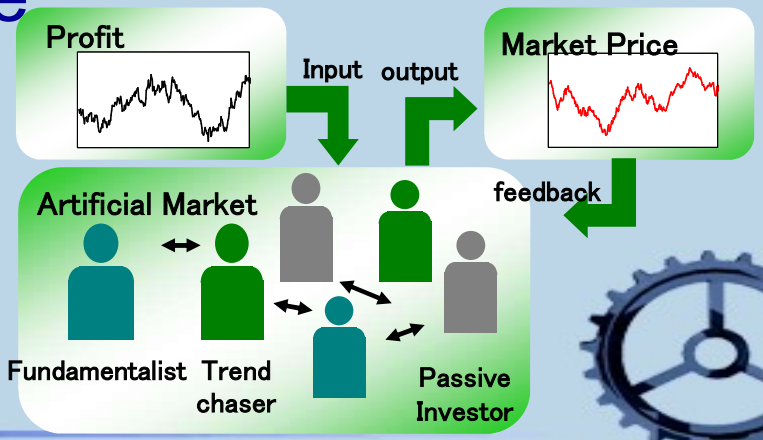


[Kunigami & Terano]

GEAR

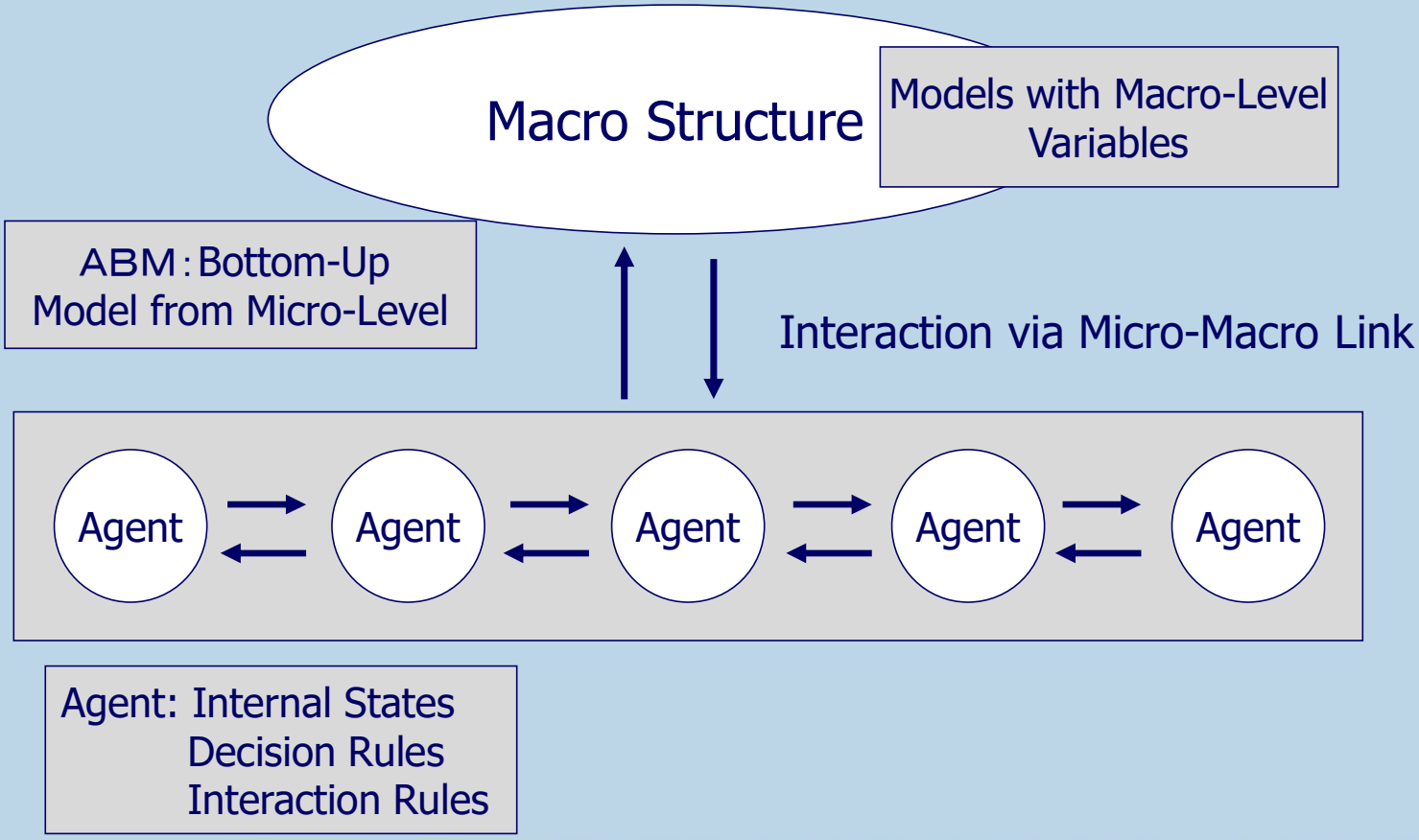
Agent-Based Modeling/Simulation

- Uncovering Activities of Bounded Rational Agents
- No experiments have been allowed in a real world
- Agent Based Modeling enables organizational experiments that is impossible otherwise
- Impossible to experiment & to make verification difficult



GEAR

Basic Mechanism for Agent-Based Modeling



GEAR

Gaming Simulation

- Target dynamical environments caused by players' decision changes
- Cope with randomness and unpredictable factors
- Explain case like backgrounds, lectures,…
- Debrief & discuss after game playing

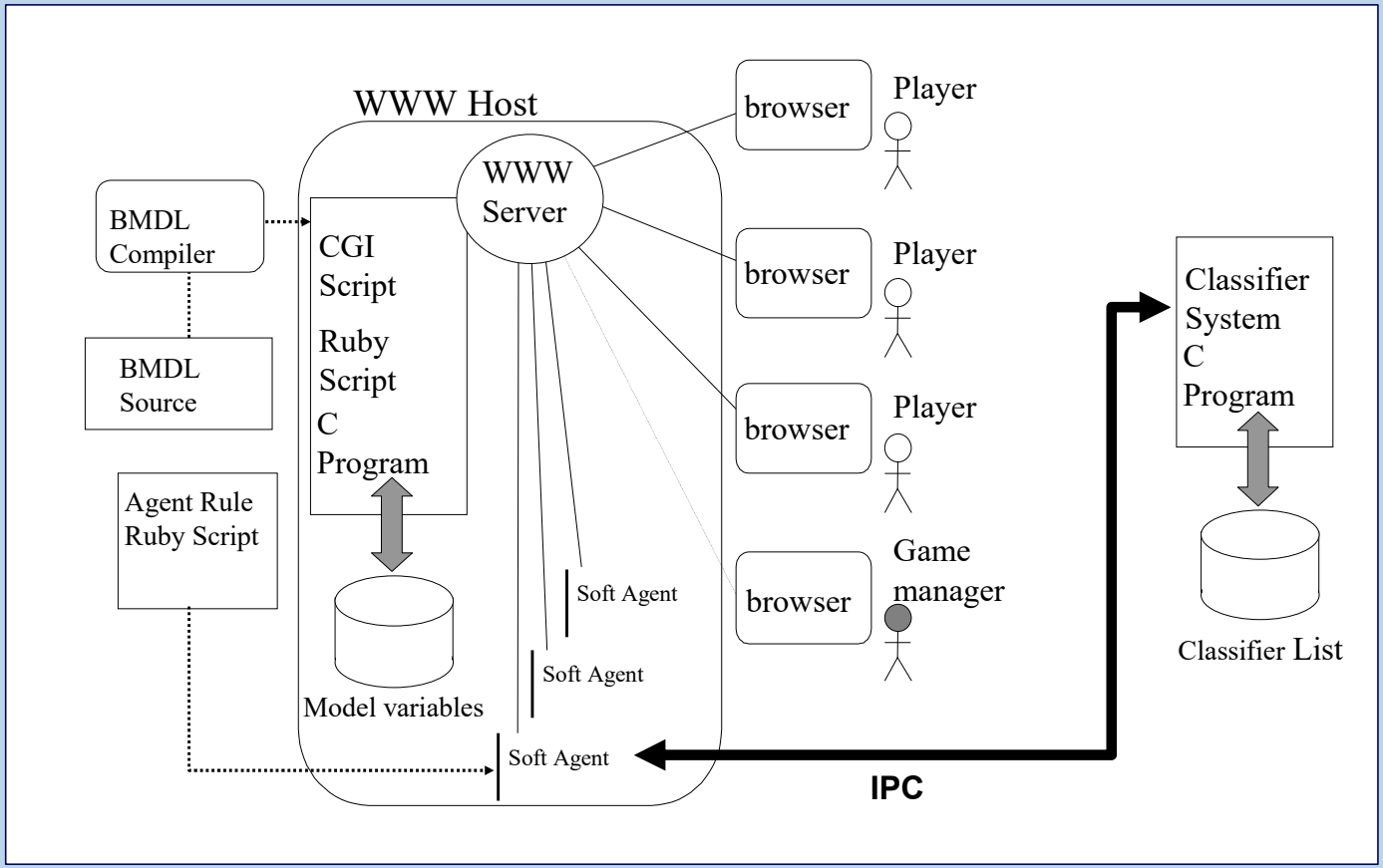
Board Game

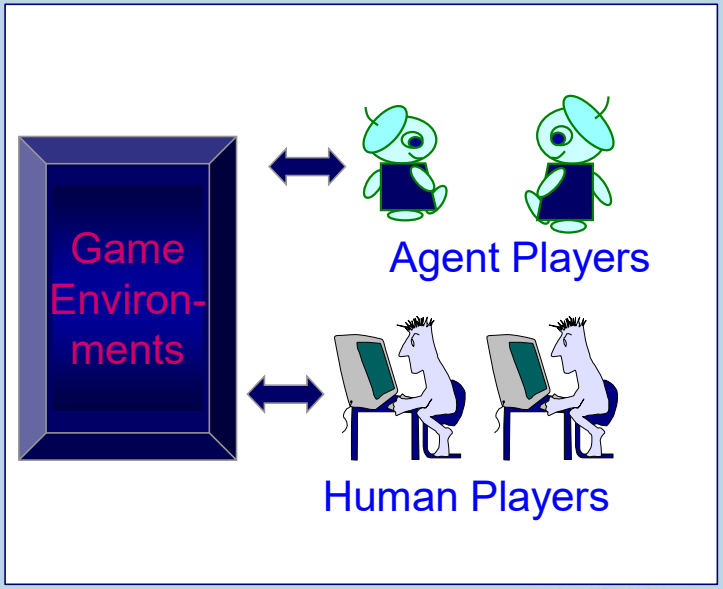
Computerized Gaming

Gaming Course

GEAR

Architecture of BMDS with Agent Function and Learning Program





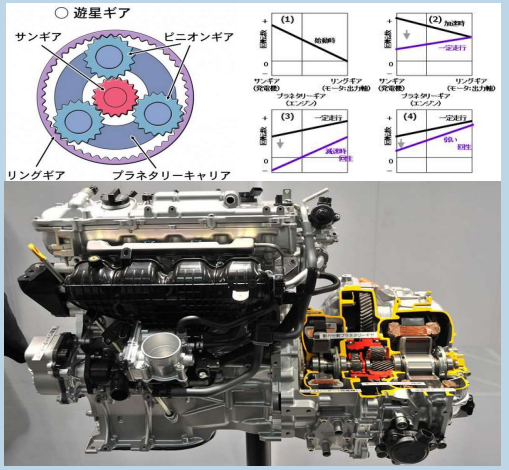
GEAR

AI & Advanced ITs

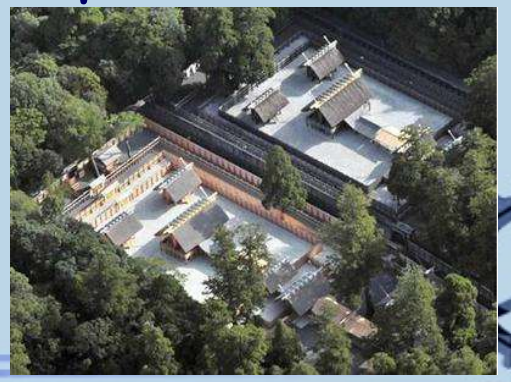
- Seemingly Intelligent Systems:
  - If Complete Information: Algorithm Design
    →Information Science
  - If Incomplete Information:
    Heuristics Implementation
    →Artificial Intelligence

- Artificial Intelligence:
  - Strong AI
  - Weak AI

Algorithm Design

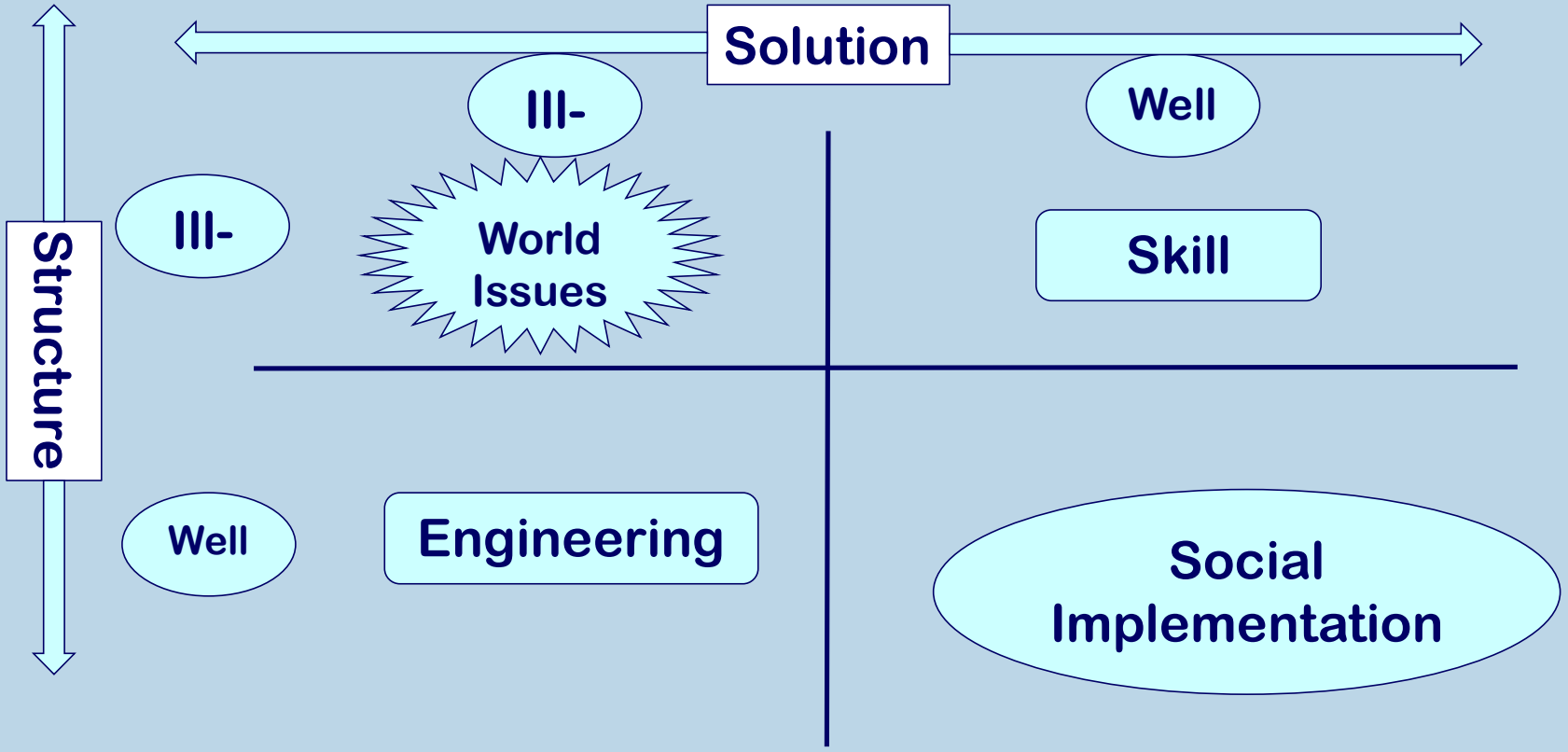


Expertise Transfer



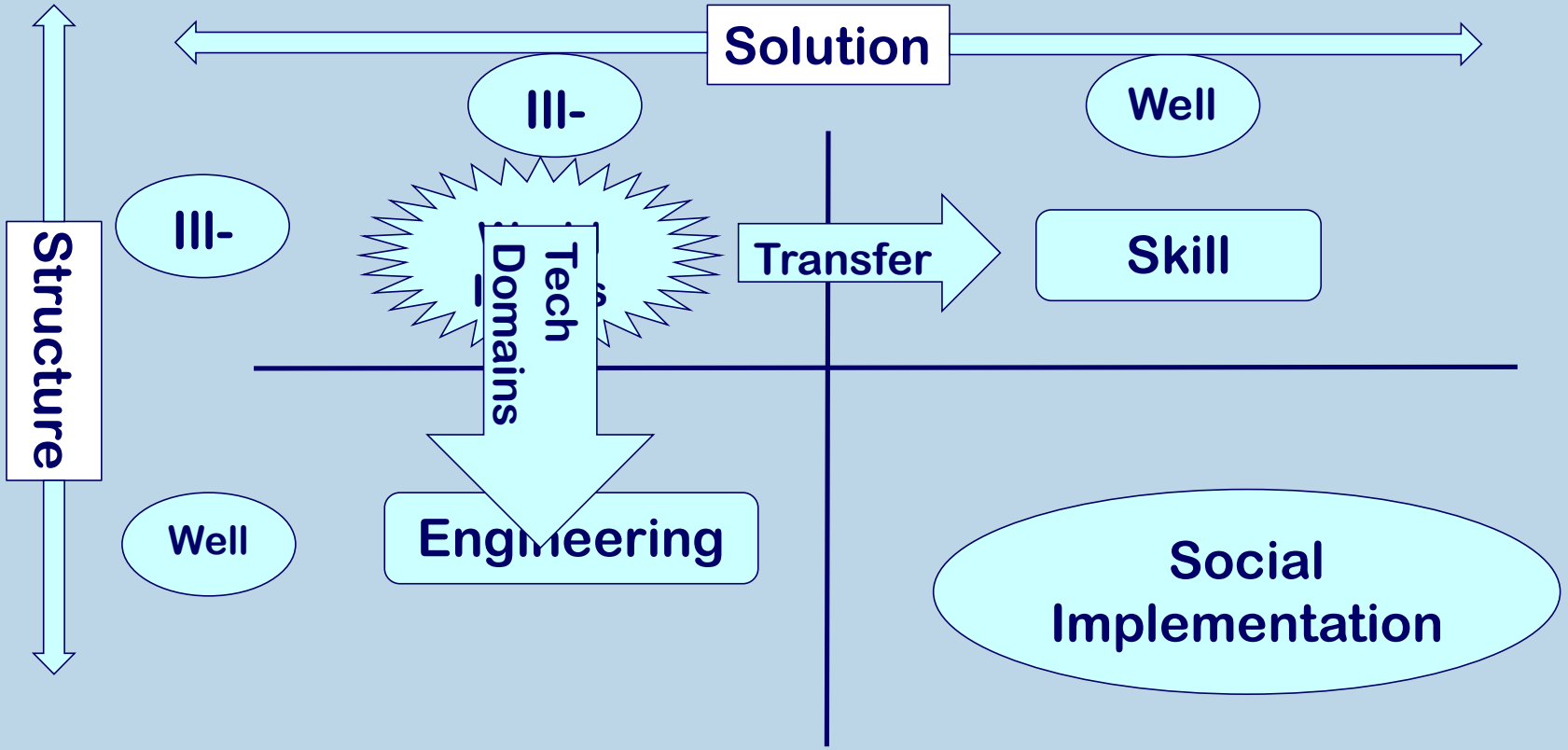
GEAR

Solving Socio-Technical Problems



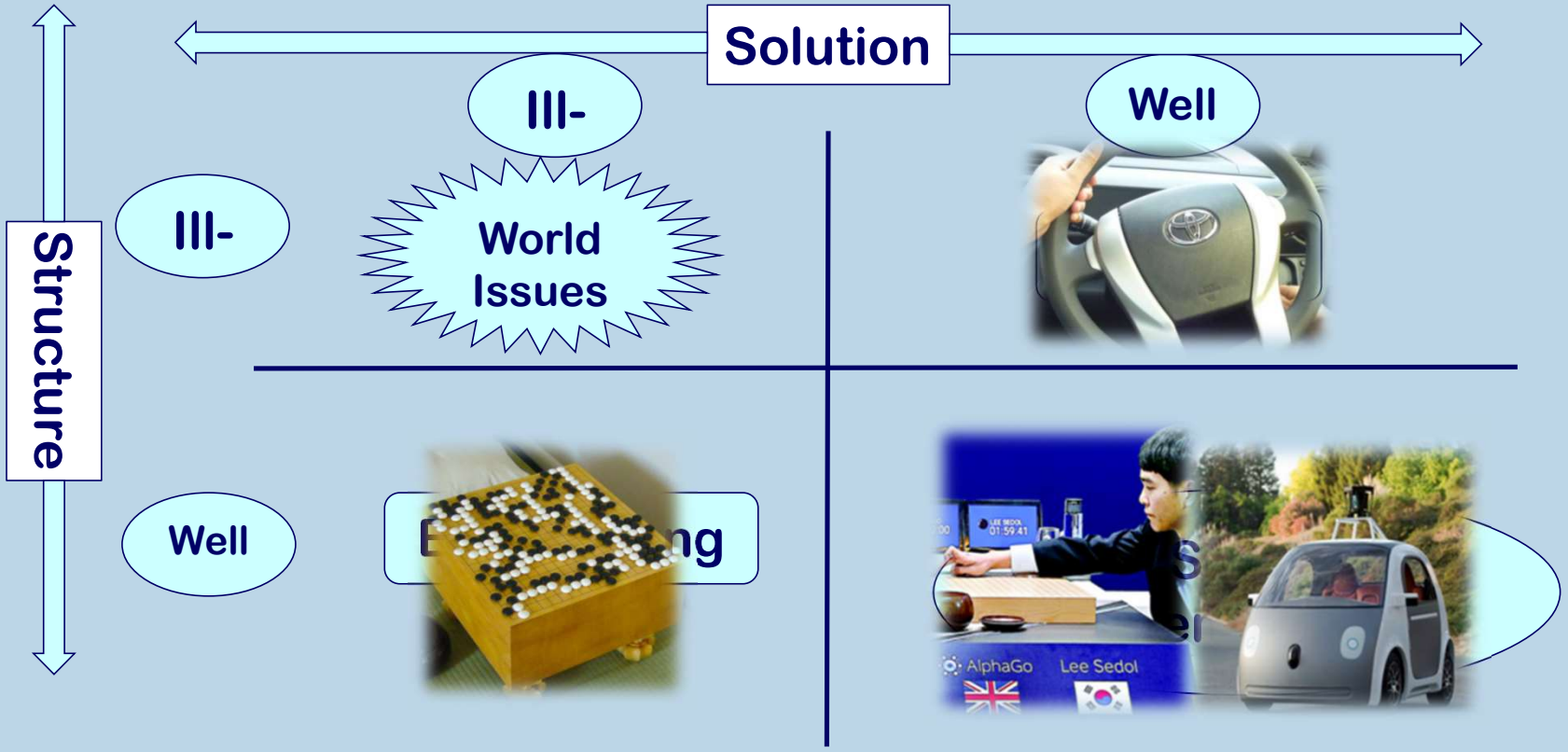
GEAR

Solving Socio-Technical Problems



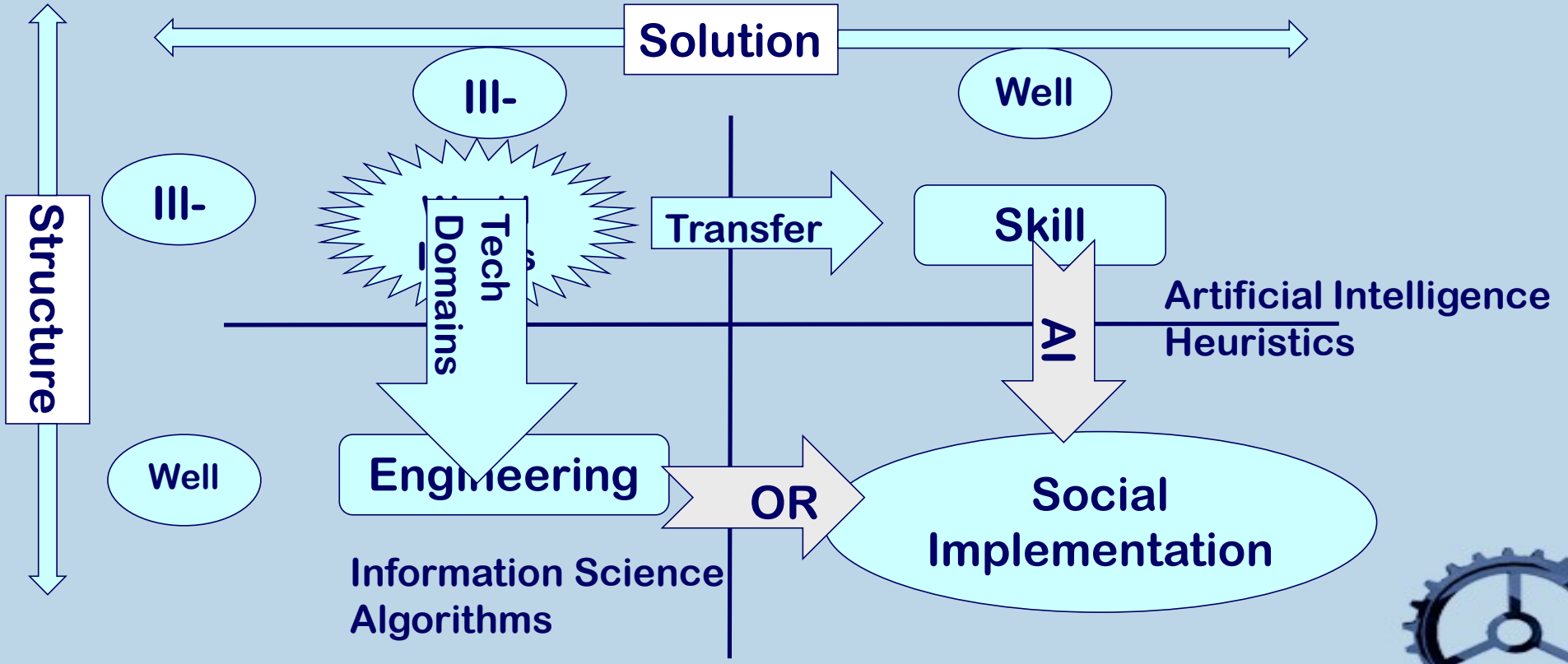
GEAR

Solving Socio-Technical Problems



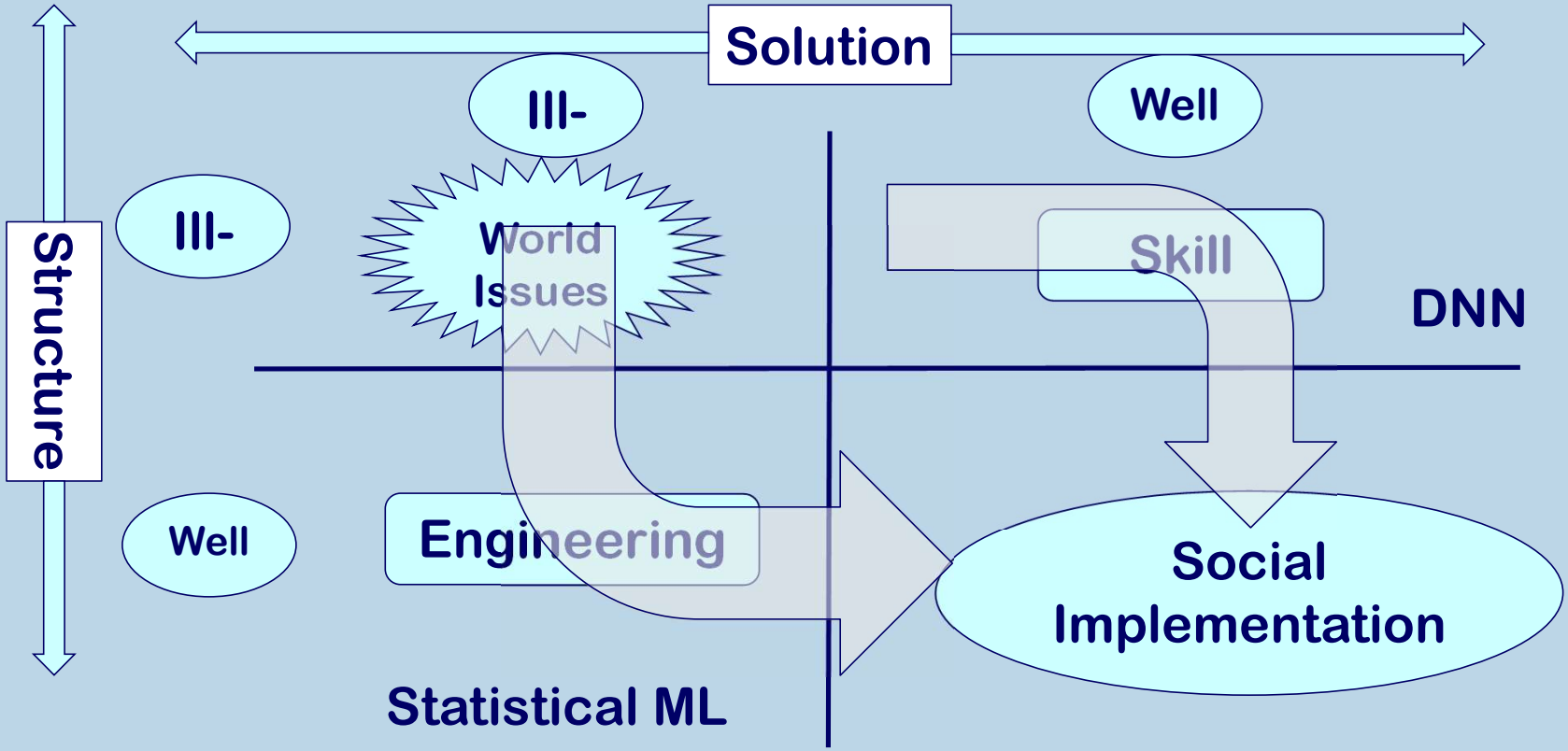
GEAR

Solving Socio-Technical Problems



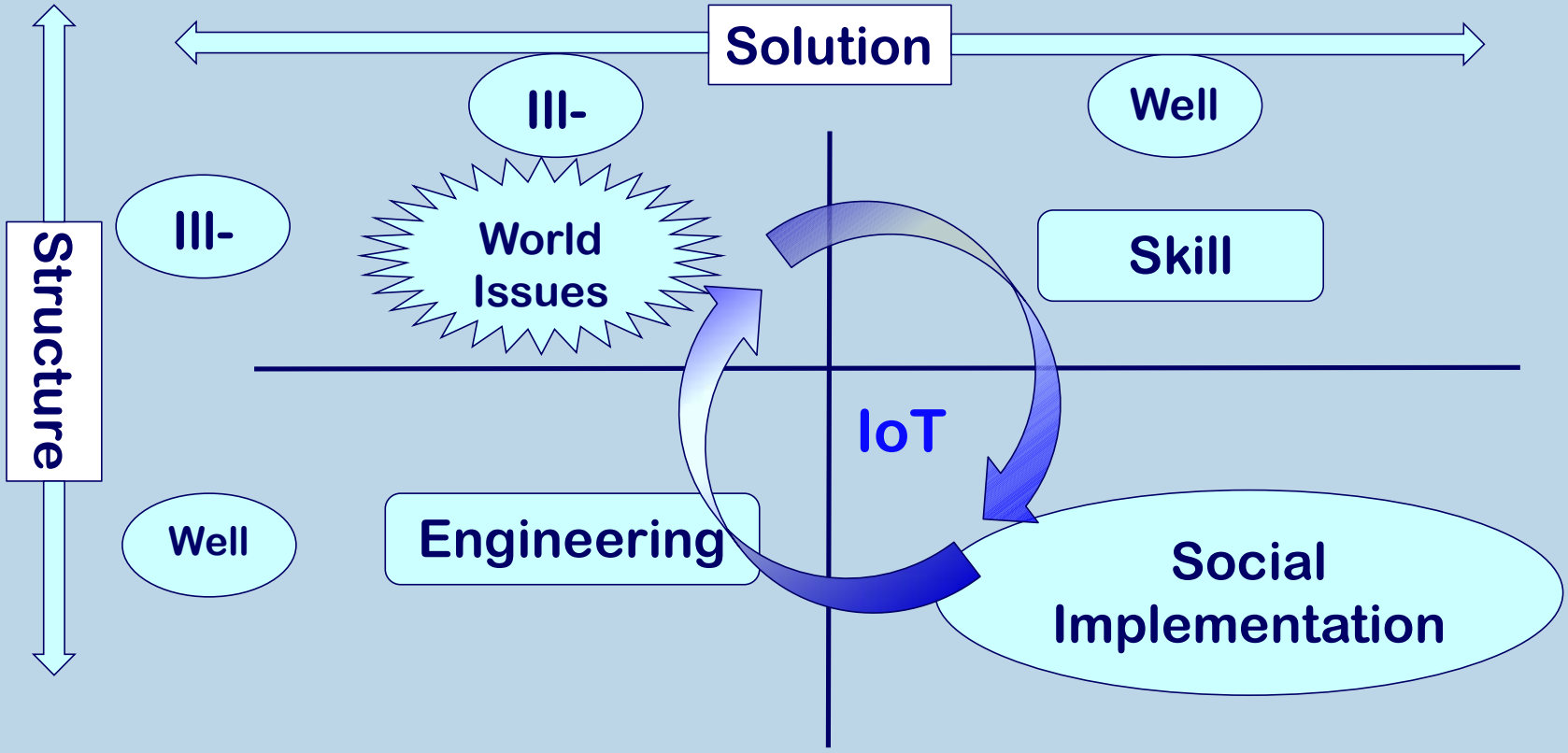
GEAR

Solving Socio-Technical Problems



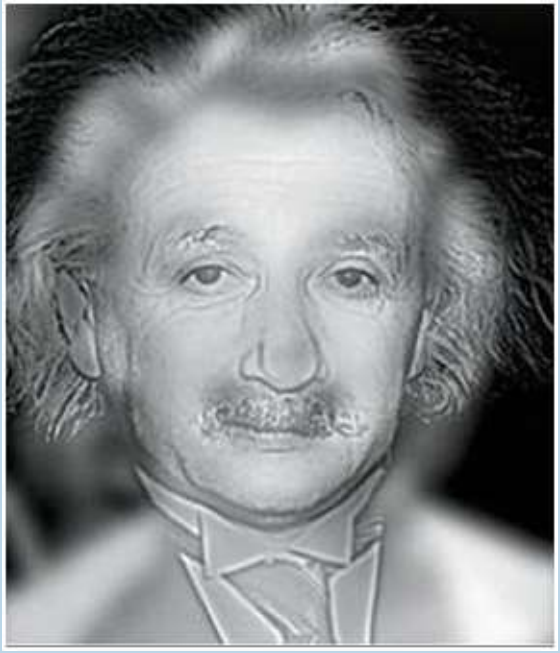
GEAR

Solving Socio-Technical Problems

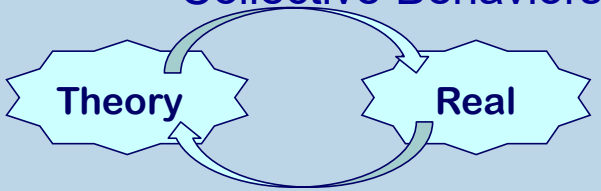


GEAR

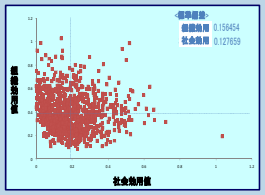
Two Faces of Research and Implementation of Socio-Technical Problems

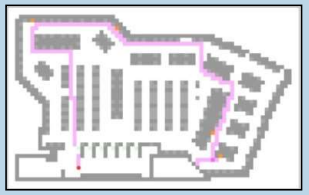


- Theoretical vs Real Issues
  - e.g., Game/Economics vs Collective Behaviors



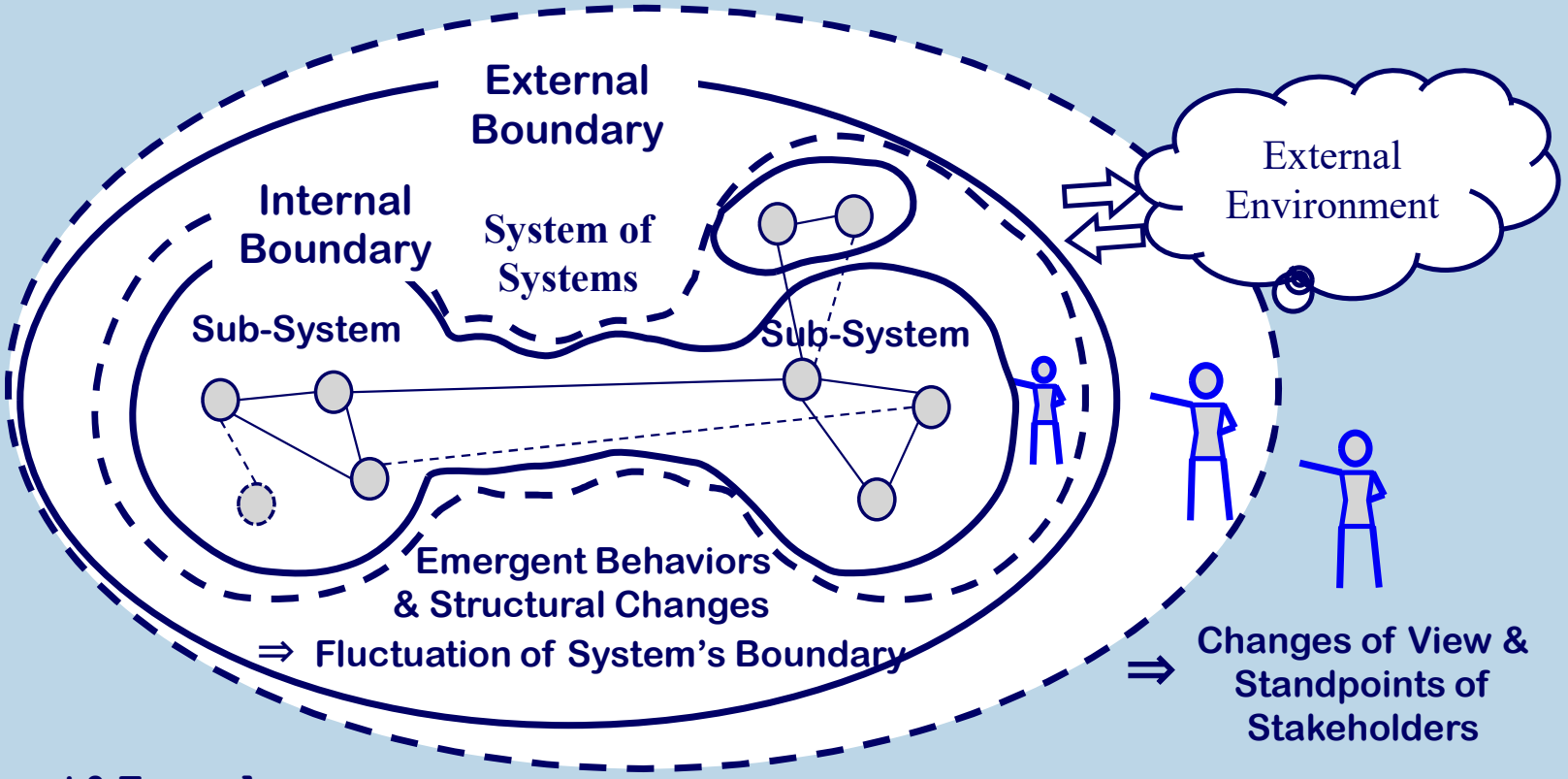
- Physical , Social, and Technical Time Scale
  - e.g., Eternal, One Century, and One Decade
- Validation vs Accreditation





GEAR

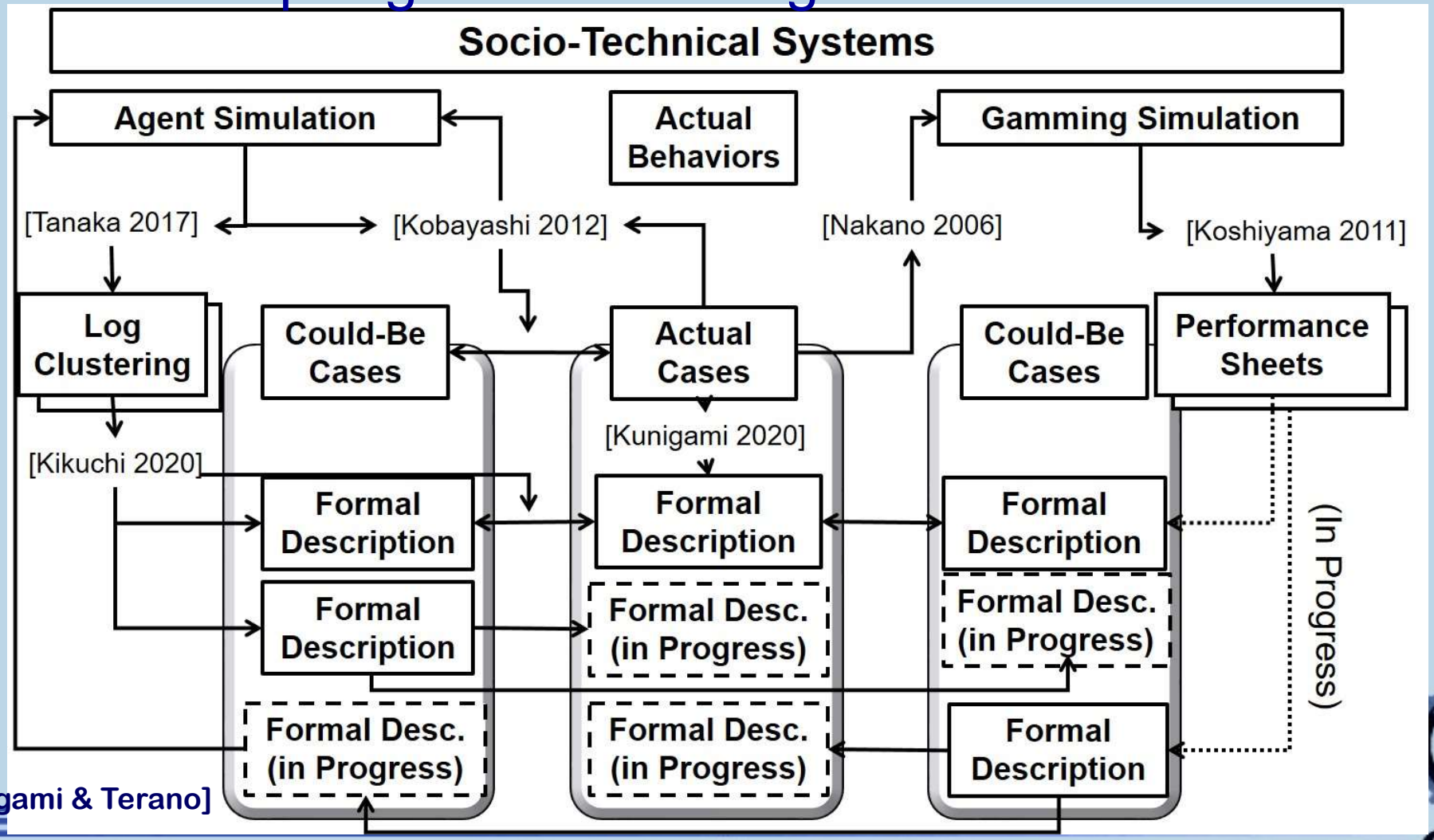
Fluctuation of Boundary and Stake-Holders of Socio-Technical Problems



[Kunigami & Terano]

GEAR

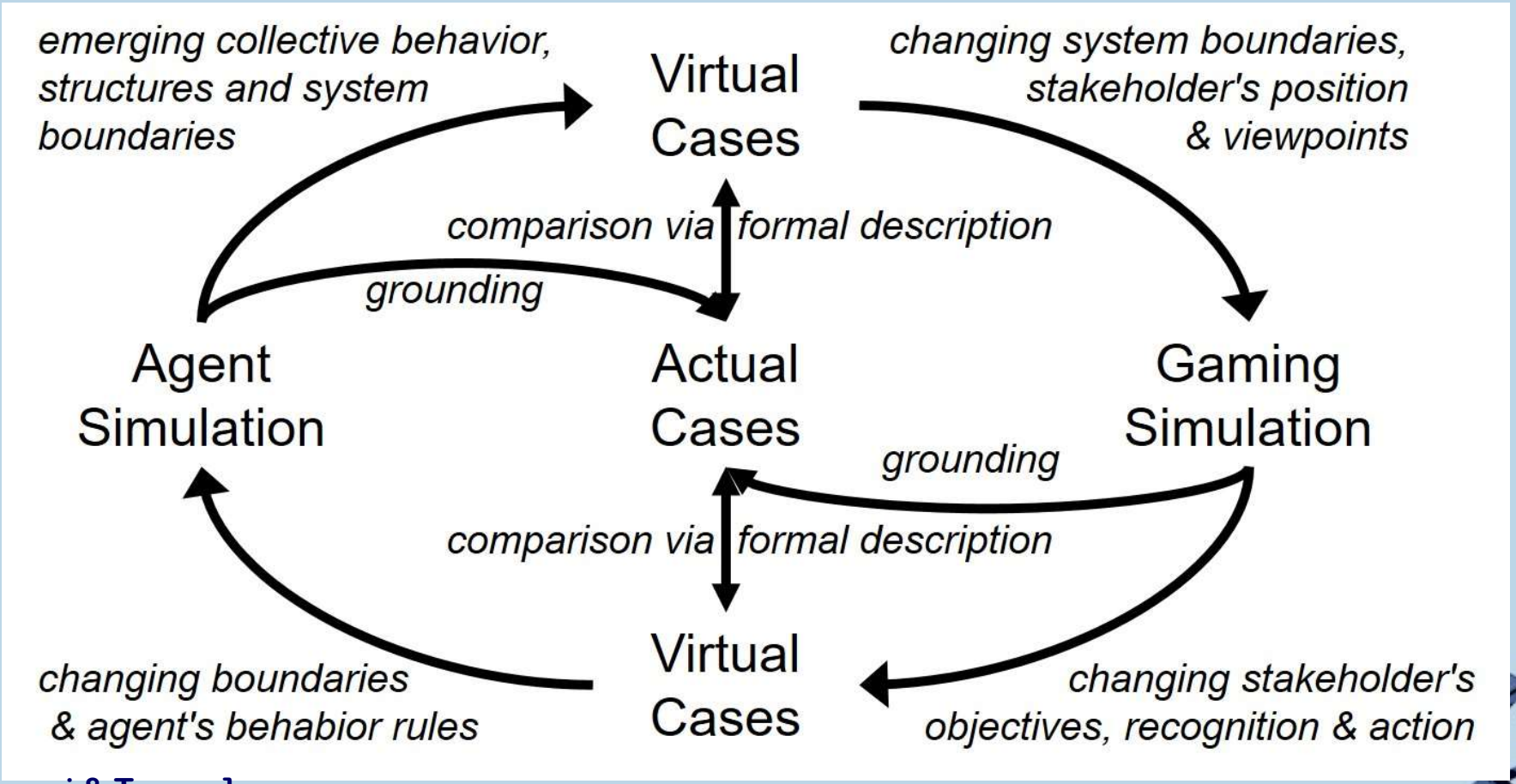
Relationship Agent - & Gaming-Simulation with Cases



[Kunigami & Terano]

GEAR

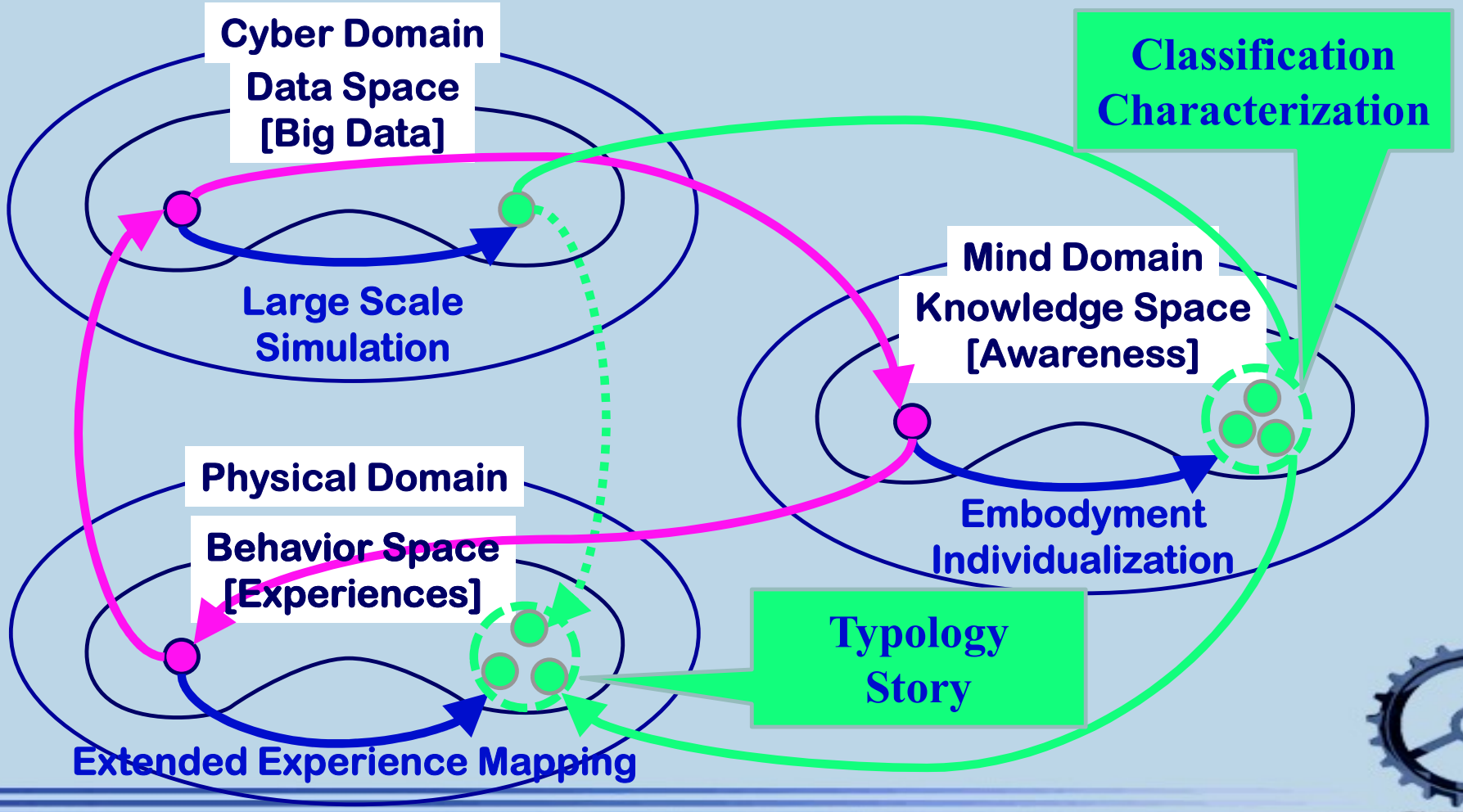
How to Integrate Cases, Games, & Agent Models



[Kunigami & Terano]

GEAR

Society5.0 Concept is not Enough



GEAR

Concluding Remarks

- Solving Socio-Technical Problem Matters
- Social System Implementation with AI/ML Technology is Immature
- Agent Modeling and Gaming Simulation with the Human-in-the-Loop is Essential in the Implementation
- Concepts of Society 5.0 are not Enough
- Agent Modeling, Gaming Modeling, Cases, and Participatory Approach will Make the Future!

GEAR

References

[1] Takao Terano: This Is How I Feel About Complex Systems. in Fernando Koch, Atsushi Yoshikawa, Shihan Wang, Takao Terano (eds.): *Evolutionary Computing and Artificial Intelligence Essays Dedicated to Takao Terano on the Occasion of His Retirement*, Springer, pp. 1-7, 2019.

[2] Takao Terano: A Perspective on Agent-Based Modeling in Social System Analysis in G. S. Metcalf et al. (eds.):*Handbook of Systems Sciences,*Springer,15pp. 2020, https://doi.org/10.1007/978-981-13-0370-8_5-1.

[3] Masaaki Kunigami, Takamasa Kikuchi, Hiroshi Takahashi, Takao Terano: A Formal, Descriptive Model for the Business Case of Managerial Decision-Making. In: Jezic G., Chen-Burger J. et.al (eds): *Agents and Multi-Agent Systems: Technologies and Applications* 2020. Springer, Singapore, https://doi.org/10.1007/978-981-15-5764-4_33.

[4] Masaaki Kunigami, Takao Terano: Amalgamating Agent and Gaming Simulation to Understand Social Technical Systems. in T. Kaneda, R. Hamada, T. Kumazawa (eds.): *Simulation and Gaming for Social Design*, Springer Translational System Sciences, Vol. 25, Chap 11, 2021.

[5] Akinobu Sakata, Takamasa Kikuchi, Ryuichi Okumura, Masaaki Kunigami, Atsushi Yoshikawa, Masayuki Yamamura, Takao Terano： A Basic Research to Develop a Method to Classify Game Logs and Analyze Them by Clusters. *Proc. IWACIII2021.*

[6] Takamasa Kikuchi and Hiroshi Takahashi: Analysis of the Influence of Inter-Generational Asset Inheritance on the Sustainability of Retirement Funds Using Social Simulation. *Proc. IWACIII2021.*

GEAR