Who is *Mario Tokoro*?

- 1975 Ph.D from Keio University (Extensible Language) for Hardware Design)
- 1977 Inveted Acknowledging Ethernet
- 1979 Visiting Assistant Professor at University of Waterloo (Computer Networks)
- 1980 Visiting Assistant Professor at CMU (Distributed Systems)
- 1983 Keio S&Tnet
- 1984 Associate Professor at Keio University
- 1986 Concurrent Smalltalk
- 1987 *Object-Ornented Concurrent Programming* (MIT Press)
- 1988 *Introduction to Computing Systems* (Iwanami Publishing Co.)
- 1988 Established Sony Computer Science Laboratories, Inc.
- 1991 Professor at Keio University
- 1991 Object Oriented OS Aperios（Sony AIBO、Digital Sattelite TV,…）
- 1991~ Mobile Internet Protocol VIP, Real Time Protocol RtP, Computational Field Model, Real-Time Distributed Object, etc…)
- 1997 Move from Keio to Sony, assumed as Corporate SVP
- 2000 Assumed to be CTO and promoted Architecture-based CE development and Linux based common software platform
- 2004 In charge of Innovation Strategy Office of Sony Corp.
- 2006 JST/CREST DEOS Project Supervisor
- 2007 Retired from Sony Corp (concentrating Sony CSL)
- 2008 Published *Open Systems Science* (NTT Publishing CO.）

IFIP WG 10.4 Dependable Computing and Fault Tolerance

Challenge to Open Systems Dependability

January 22, 2010

Mario Tokoro
Sony Computer Science Laboratories, Inc.

Background

- Japan Science and Technology Agency selected *Dependability* as one of its strategic research areas in 2005 and launched *Dependable Embedded OS Project* in 2006.
- The budget is about $50M total over 7 years.
- Surprisingly, I was assigned as the Project Supervisor! (maybe because the theme is not pure research but for practical applications and I have background of both academia and industry)
- Then, the story begins….

What is Dependability?

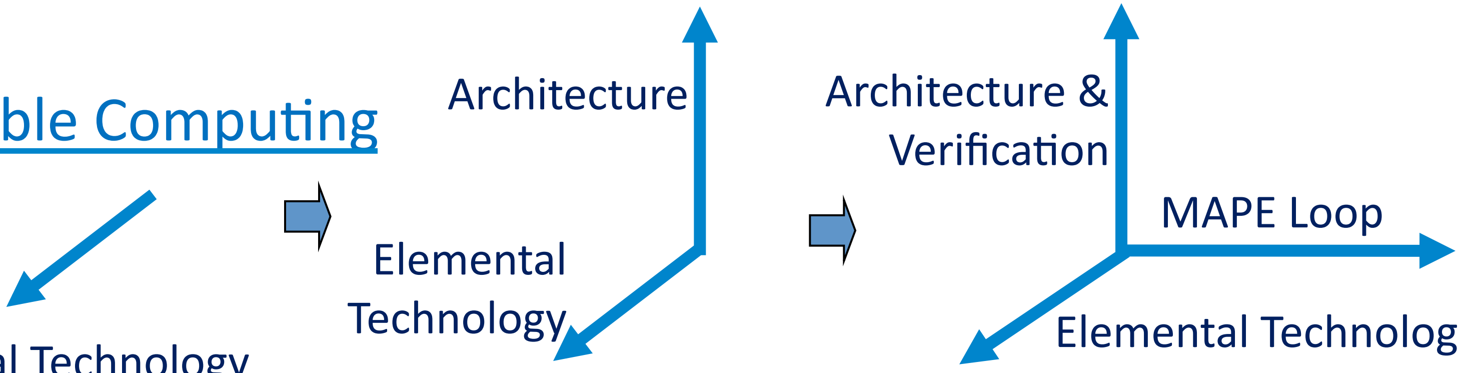
- In the spring of 2006, we chose 5 research teams (Ishikawa, Tokuda, Nakajima, Sato, and Maeda) for 5 years and started discussion of *What is Dependability*. (We selected 4 additional teams in 2008.)
  - Dependability is Reliability? Or, Safety?
  - Dependability is Security? Or, combination of these?
  - How can we treat human factors?
  - How can we cope with networking?
  - The famous Avizienis paper covers all aspects of Dependability?
- A lot of discussions, but No answer!!!!!!!!!!!!!!!!

Then, what are Threats?

- Safety is freedom from injury or risk....
- Security is freedom from danger and harm....
- Security is to protect our daily life, property, privacy and life
  - From physical damage (natural disaster, accident, misuse,…) and aging
  - From malicious attack
  - From design, manufacturing, and operation errors
  - From unexpected ways of use, …
- Can we really get rid of these threats?

What are the history of Dependability and Safety?

Dependable Computing



Elemental Technology

Reliability (computers)

Architecture

Elemental Technology

RAS/RASIS (online systems)

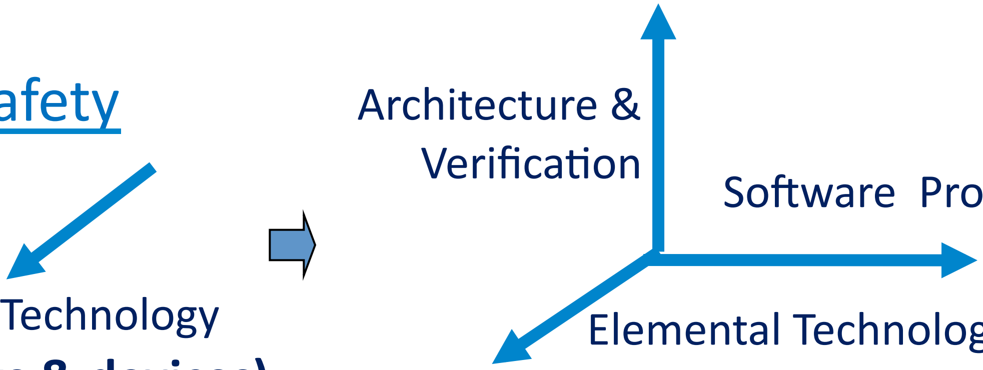
Architecture & Verification

MAPE Loop

Elemental Technology

Autonomic (networked services)

Functional Safety



Elemental Technology

Safety (parts & devices)

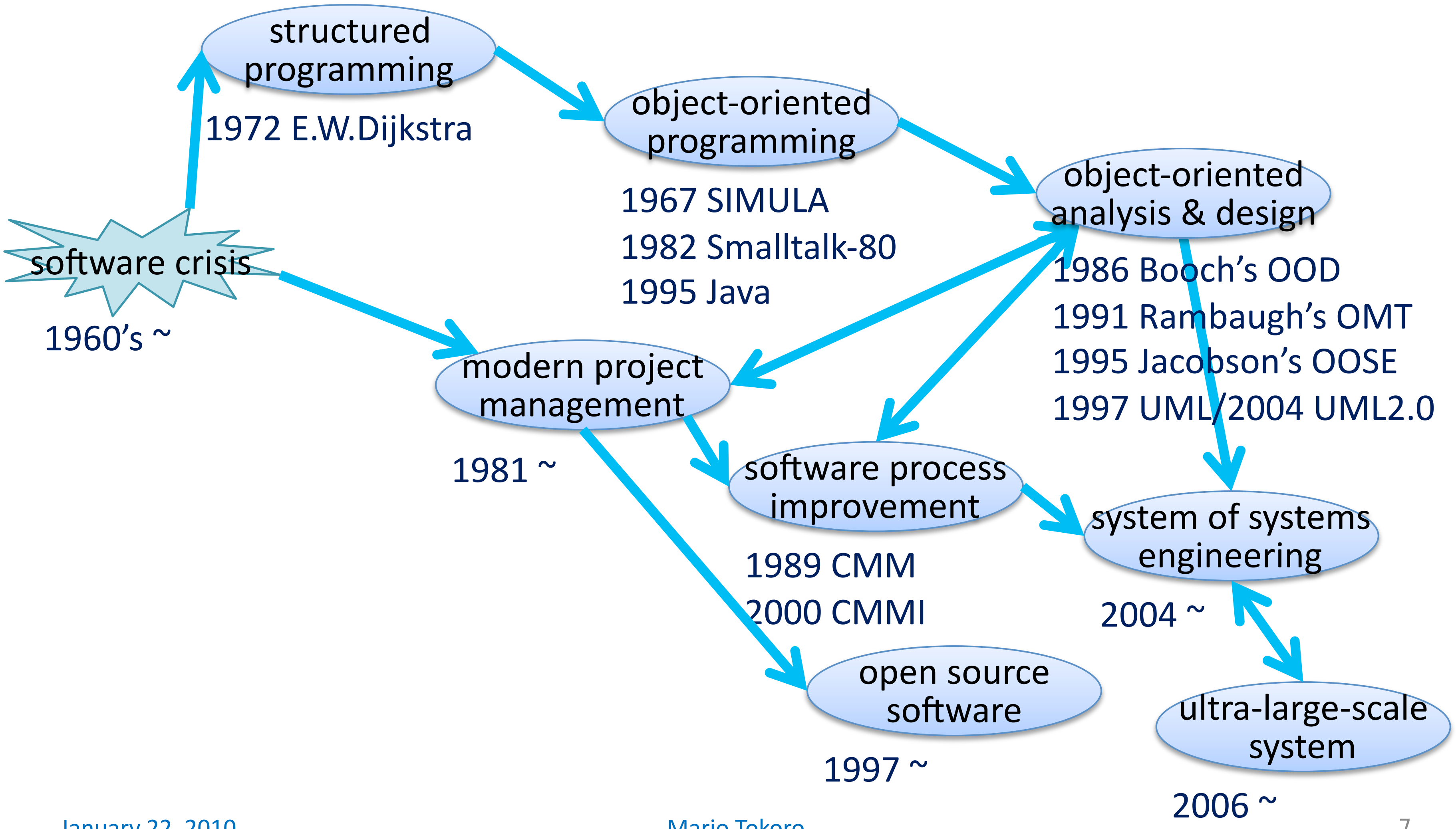
Architecture & Verification

Software Processes

Elemental Technology

Functional Safety (computer controlled system)

What is the history of Software Engineering?



Standards and Guides

- Standards
  - IEC 61508: Functional Safety
  - IEC 60300-1: Dependability Management
  - IEC 60300-2: Dependability Program Elements and Tasks
  - ISO/IEC 12207: Software Life Cycle Processes
  - ISO/IEC 15288:System Life Cycle Processes
  - etc.
- Guides
  - CMMI: Capability Maturity Model Integration
  - DO-178B: Software Considerations in Airborne Systems and Equipment Certification
  - MISRA-C: Guidelines for the Use of the C Language in Vehicle Based Software
  - IEC 61713: Software Dependability through the Software Life-Cycle Processes – Application Guide
  - IEC 62347: Guidance on System Dependability Specifications
  - etc.

What are the Demands?

- Demands for the dependability of huge, complex, integrated systems
  - which are connected through networks that may cause security and integrity problems
  - which include black box software resulted by legacy codes and off-the-shelf components
- Demands for coping with environmental and requirement changes in operation
  - functions, user interfaces, performance, etc
  - networks and services on networks
- Consciousness to performance/cost over lifecycle
- Increased accountability to service/system providers

Can We Satisfy Such Demands?

- Can we consider all the events that would happen in the system’s life cycle?
- Can incidents are really avoidable?
- How can we assure that our system is dependable?

⋮

- Can we really build a dependable system?
- Can we prove that a system is dependable?

Maybe Not….

- We need to shift our viewpoint from
  - *Designing a system to prove its dependability*
- to
  - *The way of Implementing and operating a system*
  - *and explaining satisfactorily in case of incidents*.

- That is, *Risk Management* and *Accountability* become the main issue.

Do We Need a New Approach?

- Previous approaches to huge, complex, ever-changing integrated systems were based on the *Closed Systems Hypothesis*
  - we supposed a system can be composed of *complete* components
  - we supposed we can know the *whole* system and the *behaviors* of the whole system
- However, the hypothesis *cannot* hold, due to
  - the *incompleteness* of specifications and implementations
  - the *uncertainty* of environment and requirement changes to systems in operation
- We may need to treat a system as *an Open System.*

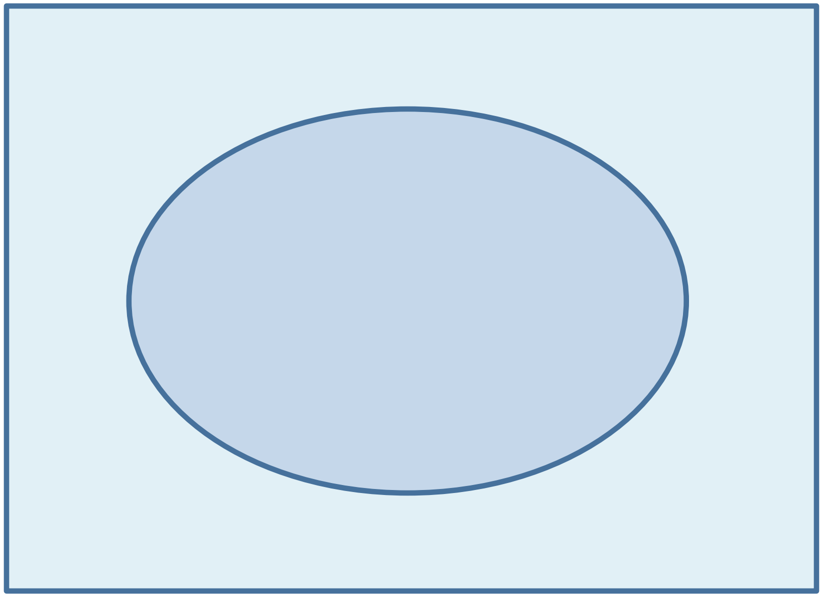
What are *Open Systems* and *Open Systems Dependability*?

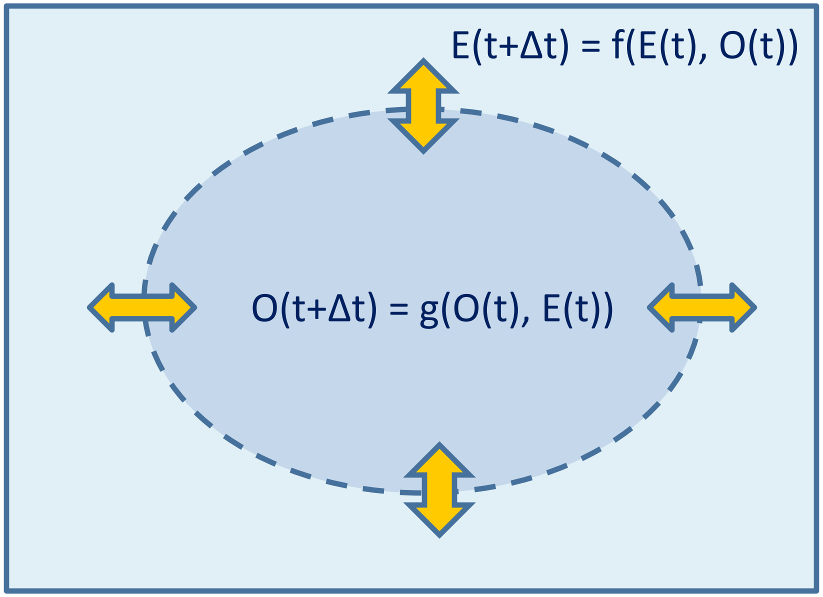
Closed Systems vs. Open Systems

External View

Closed Systems

Open Systems





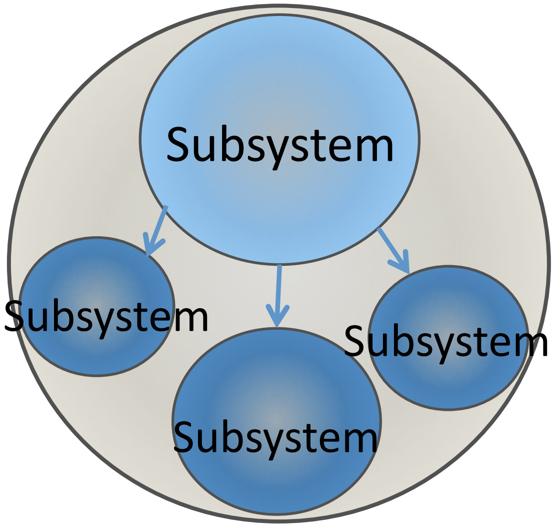
No interaction with outer world

Interaction with outer world by channels or membrane

Closed Systems vs. Open Systems

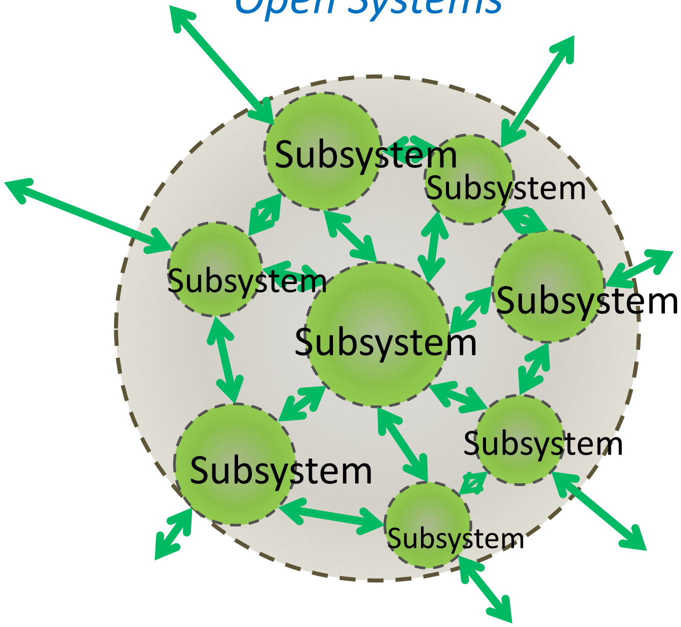
Internal View

Closed Systems



- Whole problems are solvable by dividing into elements and collecting answers from the elements.
- It consists of subsystems with simple structure.
- The structures, relations, boundary conditions, and functions of subsystems are statically defined.

Open Systems



- A system cannot simply be decomposed into subsystems. Entire behavior emerges from all interactions among subsystems.
- Time development and irreversible systems
- The structures, interactions, boundary conditions, and functions of each subsystems change dynamically.

Closed Systems vs. Open Systems
Summary

Closed Systems

- Simple closed system.
- (mainly) Equilibrium system.
- Reversible.
- Reproducible.
- Can be divided into elements.
- Can be halted.
- An n-body problem.
- Can take external observers' view.

Open Systems

- Open complex system.
- Temporal developmental system.
- Irreversible.
- One-time only (non-reproducible)
- Cannot be divided into elements.
- Need to keep alive; cannot stop.
- An n-system problem.
- Can take only the internal observers view.

Open Systems Dependability (1)

Target and Objective

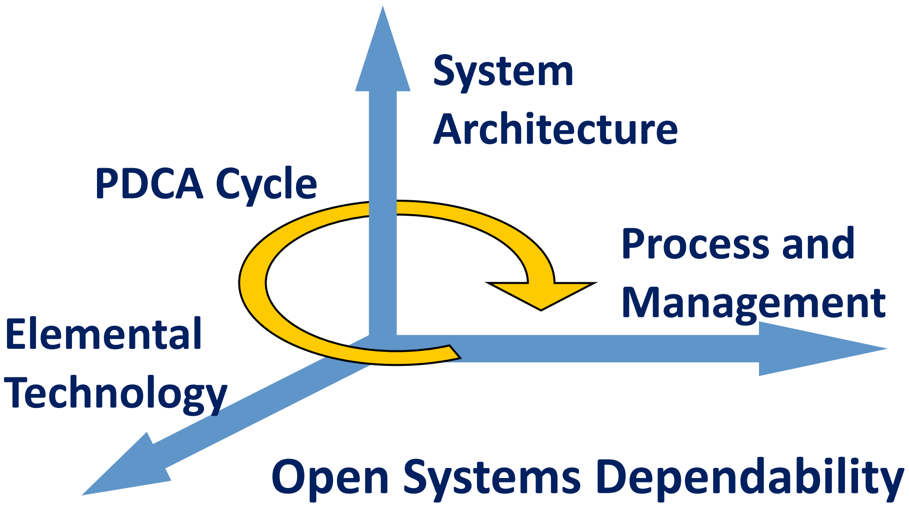
- A huge, complex, ever-changing, integrated system can be seen as an open system
- It has the potential for incidents due to
  - the *incompleteness* of specifications and implementations
  - the *uncertainty* of environment and requirement changes to systems in operation
- We need to secure dependability of a huge, complex, ever-changing integrated system over lifecycle in a practical way, based on the perspective of Open Systems

Open Systems Dependability (2)
Definition

- Dependability is the degree of *Accountability*
- Accountability is secured by showing *evidences* of having done and doing *Risk Management in best effort*
  - to provide *expected services continuously*,
  - to manage quickly and properly *to minimize damages* when an incident occurs
  - to take countermeasures *never to let the same incidents occur again*

Open Systems Dependability (3)
Technological Elements for Achievement

- Open Systems Dependability is achieved by
  1. elemental technology,
  2. architecture, and
  3. process and management



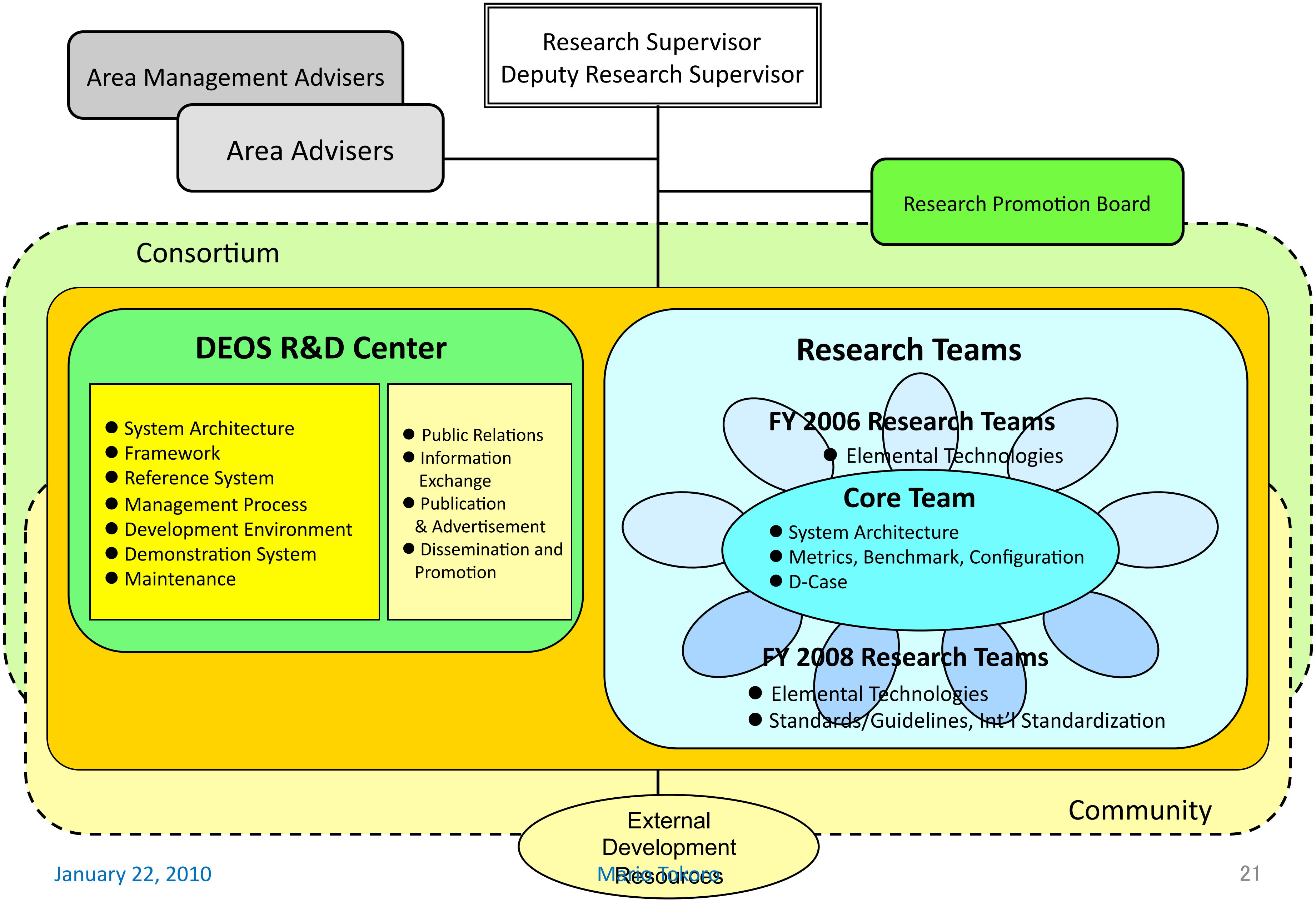
Open Systems Dependability

DEOS Project

Dependable OS for Embedded Systems Aiming at Practical Applications

- A project under Japan Science and Technology Agency (JST)
- Roughly $50M in total over 7 years started in 2006
- 5 teams selected in 2006 and 4 teams in 2008
- To develop Dependable Embedded OS based on the notion of Open Systems Dependability
- Based on Linux (for users' adaptability)
- To make publicly available in 2014 through consortium
- R&D Center (DEOSC) was established in 2007 for supporting development, integrating technologies developed by the teams, and promoting the use.
- The first interim evaluation was made Sep. 2009.

Organization



Research Supervisor
Deputy Research Supervisor

Area Management Advisers

Area Advisers

Research Promotion Board

Consortium

DEOS R&D Center

- System Architecture
- Framework
- Reference System
- Management Process
- Development Environment
- Demonstration System
- Maintenance

- Public Relations
- Information Exchange
- Publication & Advertisement
- Dissemination and Promotion

Research Teams

FY 2006 Research Teams

- Elemental Technologies

Core Team

- System Architecture
- Metrics, Benchmark, Configuration
- D-Case

FY 2008 Research Teams

- Elemental Technologies
- Standards/Guidelines, Int'l Standardization

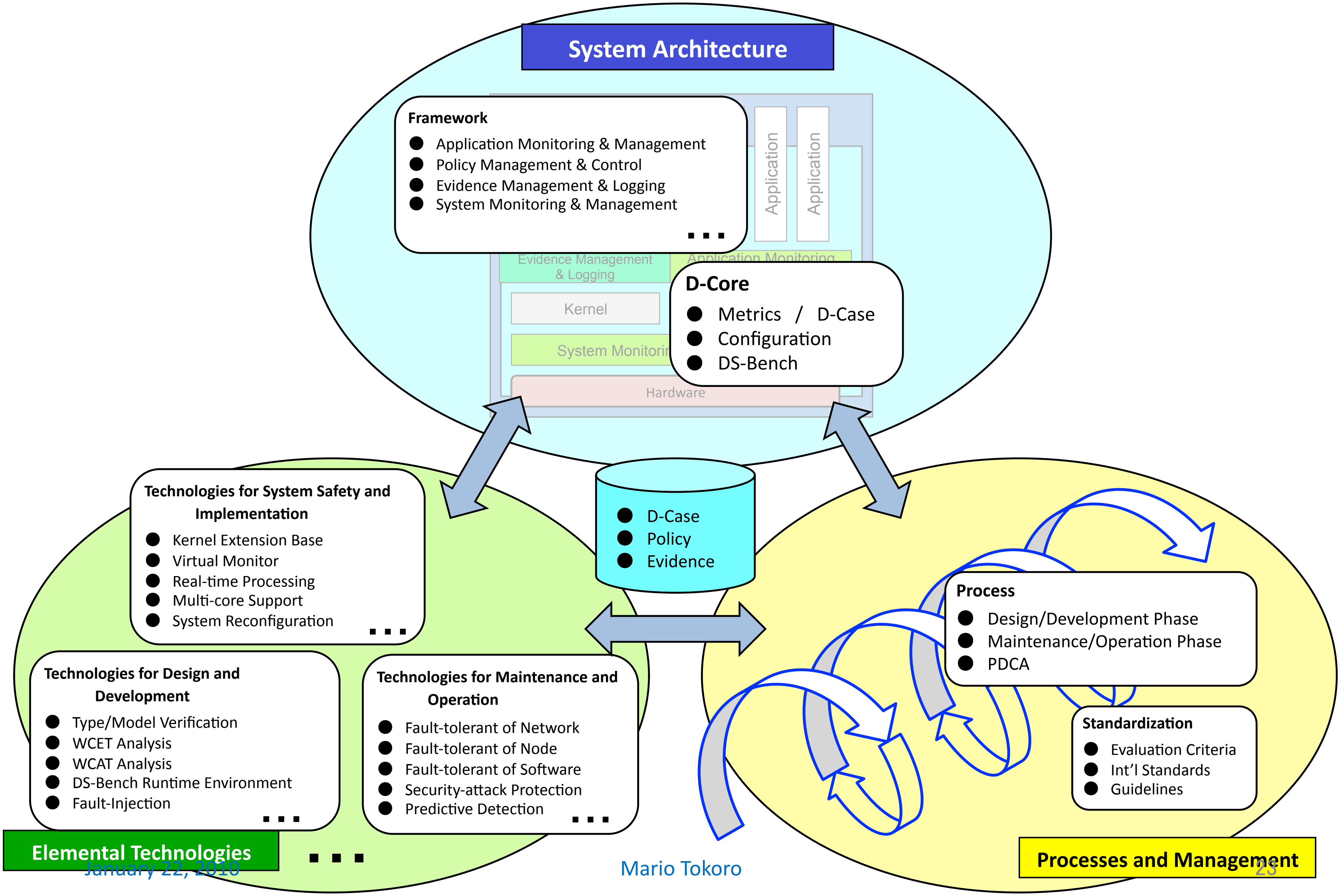
Community

External Development Resources

R&D Items

- Elemental Technologies
  - P-Bus as a standard interface for verified kernel modules,
  - VM for multi-core processors; for monitoring, logging, and countermeasures
  - Type/Model-based verification
  - Precise real-time scheduling and power management
- System Architecture
  - The framework (Systems design guideline in conjunction with Monitoring, Logging, Management Policy, etc.)
  - D-Core (Dependability Case for stakeholder agreements, configuration manager, DS-Benchmarking, etc.) which can be used also for system changes in operation
- Management Processes
  - Processes for PDCA (using available software processes, etc)
  - Processes for Risk Management
  - Standardization for Accountability (risk management with evidence) with Dependability Level

Realizing Open Systems Dependability



System Architecture

Framework
- ● Application Monitoring & Management
- ● Policy Management & Control
- ● Evidence Management & Logging
- ● System Monitoring & Management

…

D-Core
- ● Metrics / D-Case
- ● Configuration
- ● DS-Bench

- ● D-Case
- ● Policy
- ● Evidence

Technologies for System Safety and Implementation
- ● Kernel Extension Base
- ● Virtual Monitor
- ● Real-time Processing
- ● Multi-core Support
- ● System Reconfiguration

…

Technologies for Design and Development
- ● Type/Model Verification
- ● WCET Analysis
- ● WCAT Analysis
- ● DS-Bench Runtime Environment
- ● Fault-Injection

…

Technologies for Maintenance and Operation
- ● Fault-tolerant of Network
- ● Fault-tolerant of Node
- ● Fault-tolerant of Software
- ● Security-attack Protection
- ● Predictive Detection

…

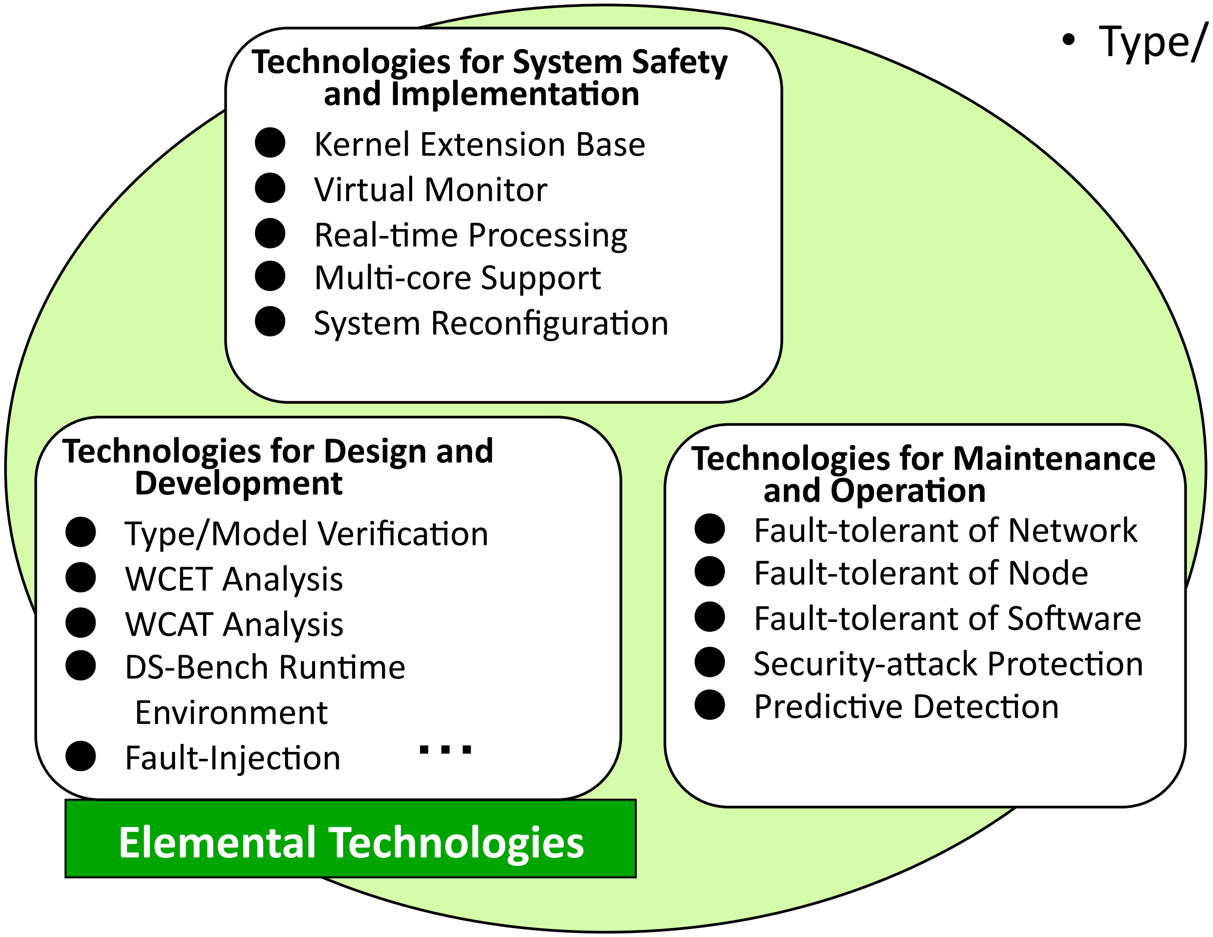
Elemental Technologies …

Process
- ● Design/Development Phase
- ● Maintenance/Operation Phase
- ● PDCA

Standardization
- ● Evaluation Criteria
- ● Int'l Standards
- ● Guidelines

Processes and Management

Elemental Technologies



Technologies for System Safety and Implementation

- Kernel Extension Base
- Virtual Monitor
- Real-time Processing
- Multi-core Support
- System Reconfiguration

Technologies for Design and Development

- Type/Model Verification
- WCET Analysis
- WCAT Analysis
- DS-Bench Runtime Environment
- Fault-Injection

…

Technologies for Maintenance and Operation

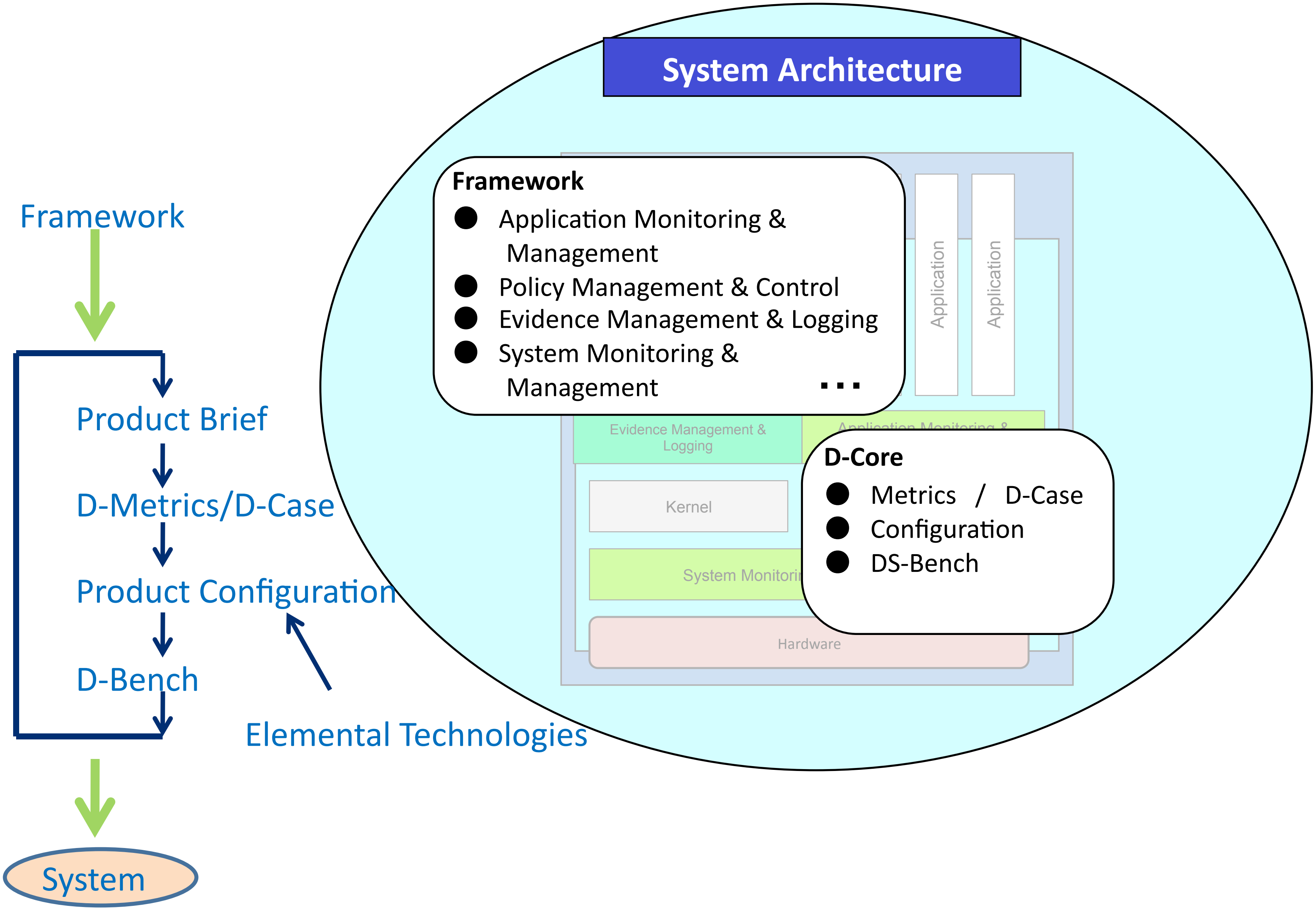
- Fault-tolerant of Network
- Fault-tolerant of Node
- Fault-tolerant of Software
- Security-attack Protection
- Predictive Detection

Elemental Technologies

Main technologies:

- P-Bus
- VM for multi-core processors
- Type/Model-based verification

System Architecture



Framework

Product Brief

D-Metrics/D-Case

Product Configuration

D-Bench

Elemental Technologies

System

System Architecture

Framework

- ● Application Monitoring & Management
- ● Policy Management & Control
- ● Evidence Management & Logging
- ● System Monitoring & Management

…

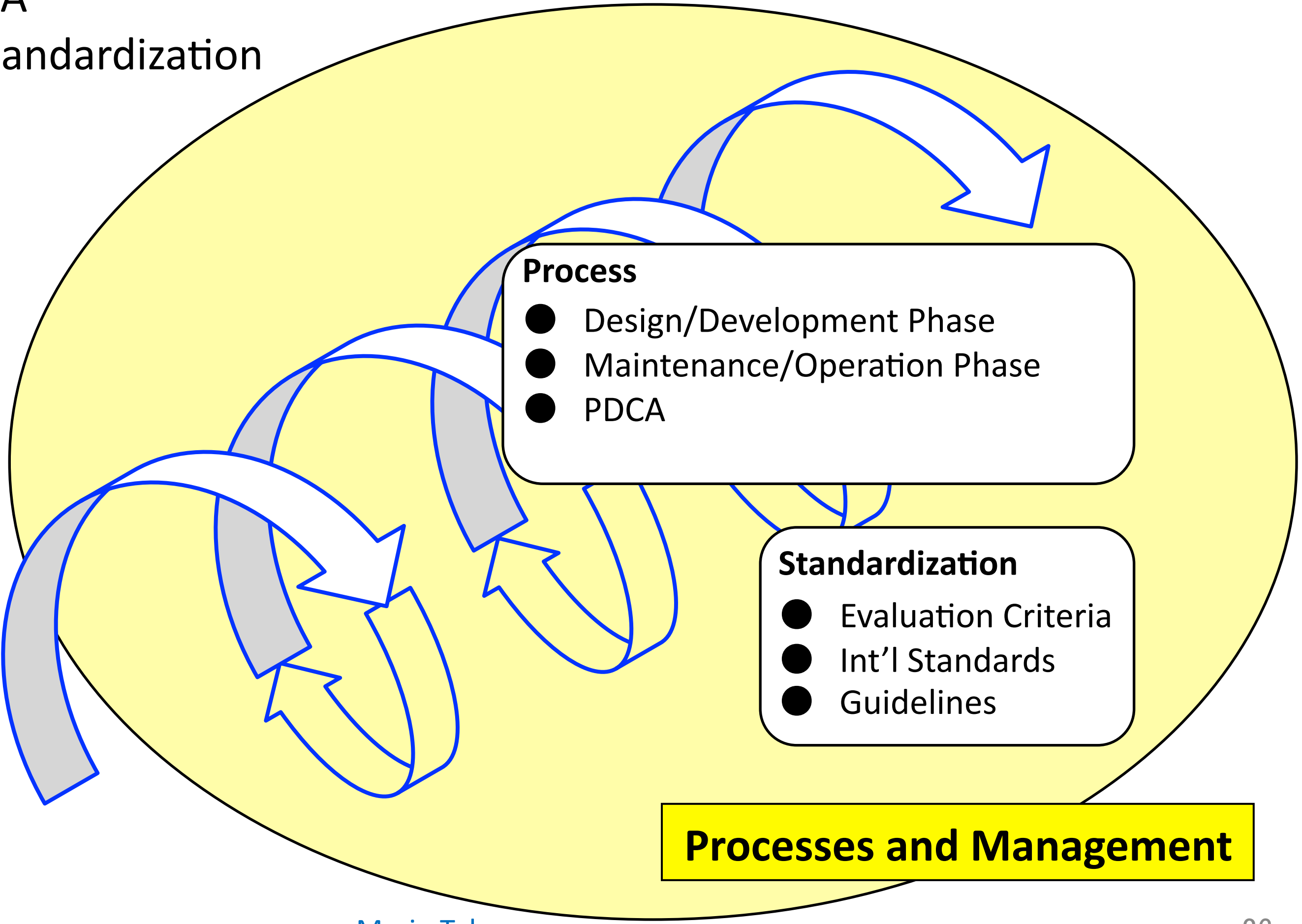
D-Core

- ● Metrics / D-Case
- ● Configuration
- ● DS-Bench

Management Processes

Main Technologies

- Use available processes
- Process for PDCA
- Contribute to standardization



Process

- ● Design/Development Phase
- ● Maintenance/Operation Phase
- ● PDCA

Standardization

- ● Evaluation Criteria
- ● Int’l Standards
- ● Guidelines

Processes and Management

Schedule

- Sep. 2010: setting up users group
- Sep. 2011: first completion of *Framework* and *Reference System*; and drafting first *standard specification of PDCA process and management*
- Mar. 2014: second completion of *Framework*, *D-Case*, and *Reference System* taking feedbacks from consortium members; second drafting *standard specification of PDCA process and management*; all the activities will be transferred to the consortium

Summary

- We proposed a new perspective for a huge, complex, ever-changing integrated system as an *open system*
- A huge and complex system inherently has incident factors due to *incompleteness* and *uncertainty*
- We proposed a new approach called *Open Systems Dependability*
- Open Systems Dependability is the degree of *Accountability which* is secured by showing *evidences* of having done and doing *Risk Management in best effort*
- Open Systems Dependability is achieved by *elemental technologies, architecture,* and *process and management*
- We are proving our perspective and method through the *DEOS project*

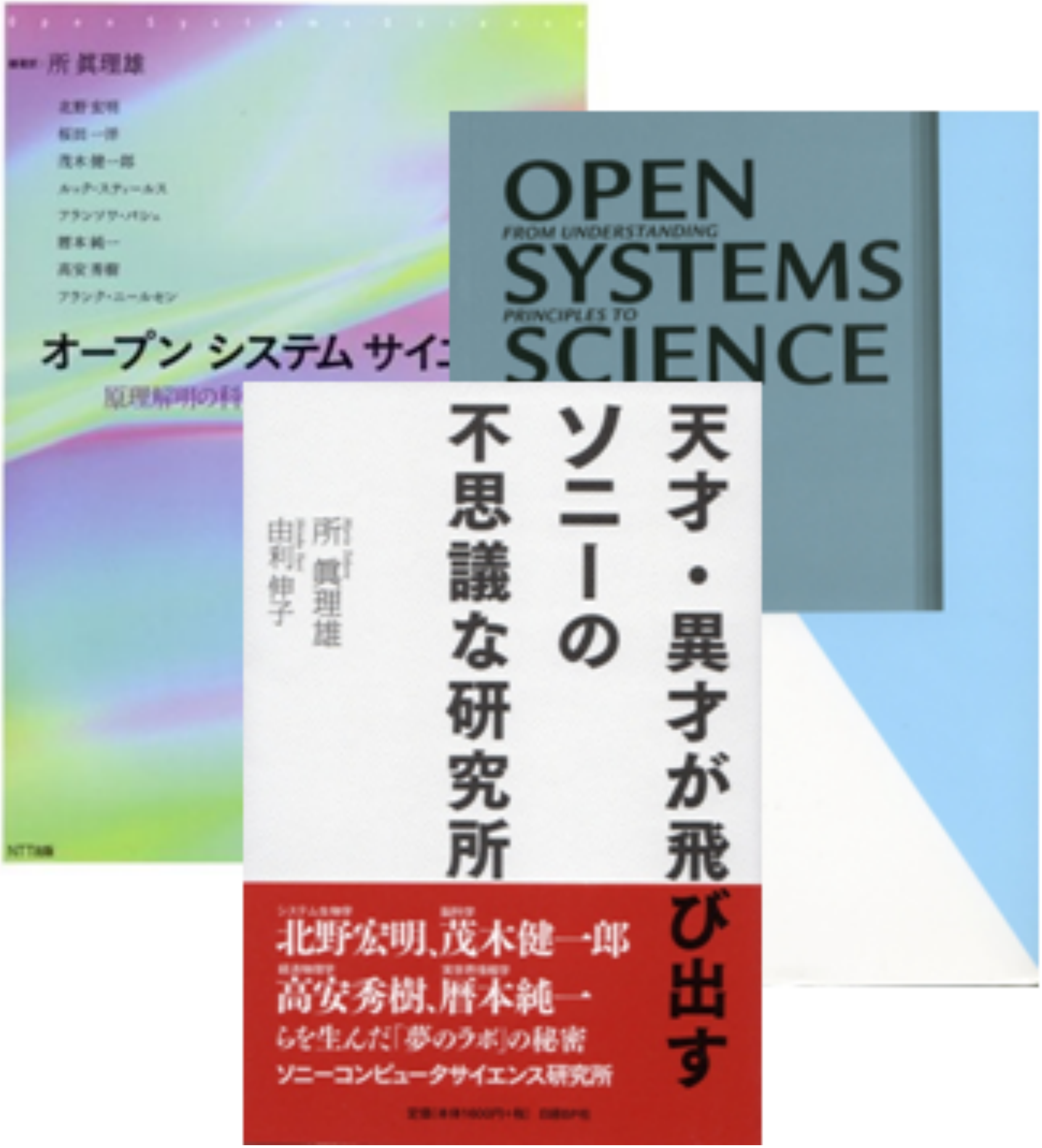
Thank you

JST/DEOS Project
http://www.jst.go.jp/kisoken/crest/en/category/area04-4.html

JST/DEOS Center
http://www.dependable-os.net/index-e.html

Sony Computer Science Laboratories, Inc.
http://www.sonycsl.co.jp

Thank you



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原理解明の科

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FROM UNDERSTANDING
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天才・異才が飛び出す
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