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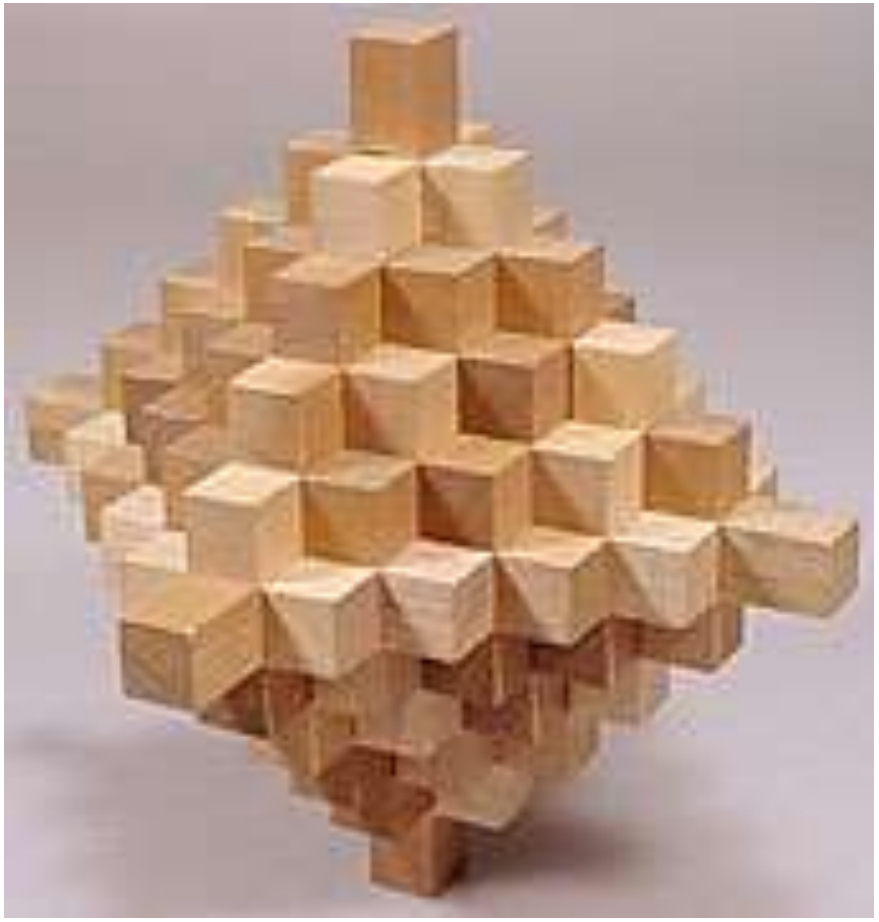
How to Capture Context and Context-dependent Behavior

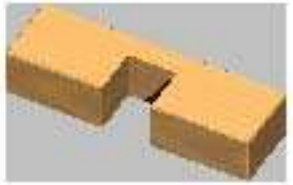
Tetsuo Tamai (Hosei University)

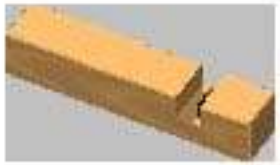
Kumiki Project Series

- Grant-in-Aid for Scientific Research (KAKEN)
  - Sponsored by MEXT (Ministry of Education, Culture, Sports, Sciences and Technology)
- Kumiki 1 (2001/10-2006/3)
- Kumiki 2 (2006/4-2010/3)
- Kumiki 3 (2010/4-2014/3)

Kumiki (組木)







Kumiki 1

- "High Reliability Component-Based Software Engineering"
- Members:
  T. Tamai*, E. Shibayama, H. Masuhara, S. Nakajima, N. Ubayashi, A. Igarashi

Major Objectives

- How to design components and composition
- How to enhance reliability of components and systems integrating components

Approaches

- Clean and flexible modularization to conquer structural complexity
- Formal reasoning to conquer behavioral complexity

Major Results

- Component & composition design
  - Collaboration Model: Epsilon (T.Tamai et al.)
  - Aspect Oriented Model (H.Masuhara et al.)
- Formal verification
  - Model checking component framework (Nakajima & Tamai)
  - Variant parametric type system (A.Igarashi)

Kumiki 2

- "Aspect-Oriented Software Development for Productivity and Reliability"
- Members:
  T. Tamai*, S. Chiba, H. Masuhara,
  S. Nakajima, N. Ubayashi, A. Igarashi

Motivation

- Software is in everywhere but getting invisible ever more.
- Much pressure on software providers w.r.t. shorter development cycle, variety of versions and high reliability

Our Approach

- Clear modularization
  - modules corresponding to features and concerns
  - clear boundary
  - correct internal structure and behavior
  - flexible composition
  - method for assuring safety and reliability of systems as composites

Targets & Results

- Propose new design methods, languages and verification methods for AOP
- Develop aspects for security, redundancy and other measures for reliability
- Integrate methods and tools to establish AOSD methodology covering requirements to evolution

Kumiki 3

- "Modularization integrating hierarchical and crosscutting concerns in the post-aspect-orientation era"
- Members:
  S. Chiba*, H. Masuhara, T. Tamai,
  S. Nakajima, N. Ubayashi, A. Igarashi,
  T. Kamina

Target

- New language mechanism integrating hierarchical and cross-cutting modularization
  - Predicate dispatching mechanism
  - Context Oriented Programming
- Supporting theory
- Modeling method

Background

- AOP has been producing practical results but not so widely accepted in industry as OOP.
- The reason may be complexity brought by two different modularization mechanisms for cross-cutting and hierarchical concerns.

Work divisions

- Modeling
  - Tamai, Nakajima
- Design & Implementation
  - Chiba, Masuhara, Ubayashi
- Theory
  - Igarashi, Kamina
- International collaborator: Robert Hirschfeld

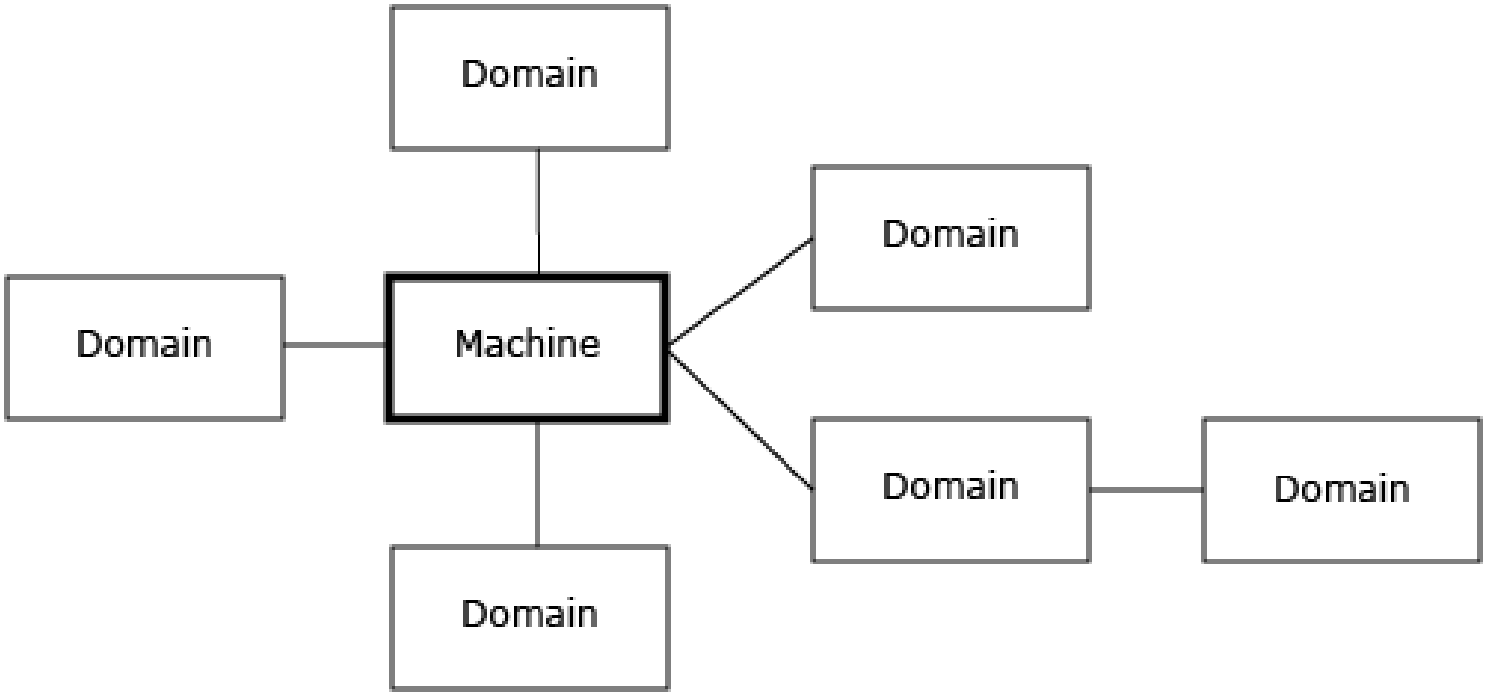
Results

- Modularization mechanism
  - Language GluonJ extending predicate dispatching
  - Type theory for GluonJ
- Extending Context-Oriented Programming
  - Language EventCJ integrating COP and event-driven mechanism
  - Fundamental language model L, integrating method dispatching by class and by layer (with R. Hirschfeld)
- UML4COP: modeling method for COP
- CJAdviser: debugging tool for COP

What is Context?

- Context diagram in "Structured Analysis" and "Problem Frame"
  - relation between the system to be developed and the outer world where the system be deployed.

Context Diagram of Problem Frame



by Fred the Oyster

Recent Focus on "Context Change"

- context change as
  - driving force for behavior adaptation
- motivation
  - mobile computing
  - ubiquitous (pervasive) computing
- context-awareness is required to adaptive systems

Example Problems

- [Kamina et al. 2015]
  - Conference guide system
  - CJEdit program editor
  - Maze-solving robot simulator
- [Sutcliffe et al. 2006]
  - e-Mail for cognitively disabled users
  - Navigation support system
- [Tamai & Monpratarnchai 2014]
  - Traffic jam monitoring

What Determines Context?

- Location
  - GPS, indoor/outdoor, floor/room/section, home/office, …
- Time
  - season, day/night, weekday/weekend, …
- Natural environment
  - temperature, weather, …
- Technical environment
  - online/local, device type, battery status, …
- Social environment/personal properties

How Does it Affect Behavior?

- In COP,
  - layers to modularize context-dependent behavior
  - layers dynamically activated/deactivated

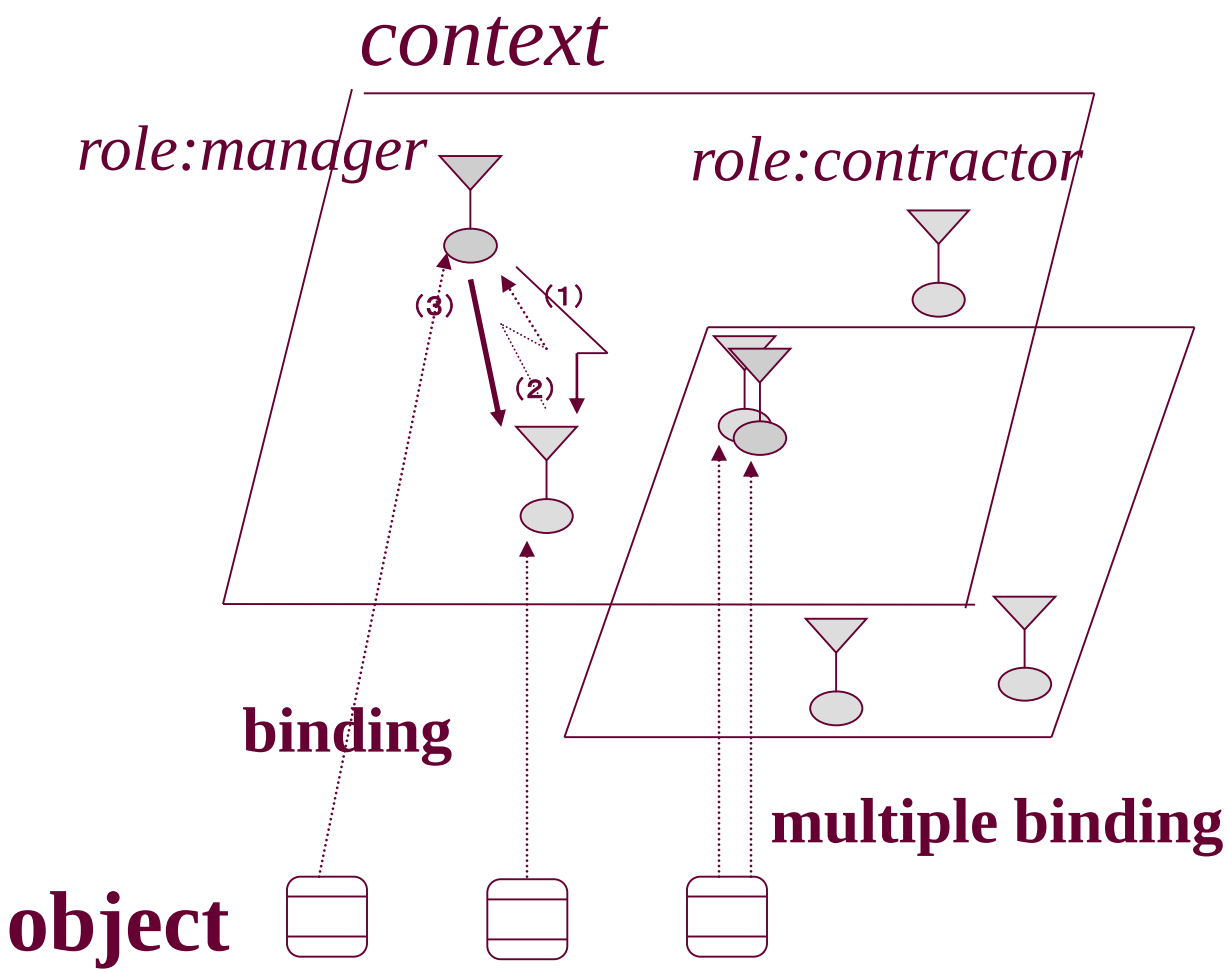
Interactive Context

- Context determined by actors within and their interaction
  - fit to social environment but also others e.g. location and time context of home/office
  - behavior of actors determined by their roles
    - wife & husband, employer & employee

Context and Roles

- Epsilon Model
  - Contexts encapsulate collaboration fields enclosing a set of roles.
  - Objects freely enter a context by binding to roles and leave a context by unbinding the ties to roles.
  - Objects can belong to multiple contexts at a time.
  - Contexts (with roles) are independent reuse components to be deployed separately from objects.

Context, Roles and Binding



How Context Changes

- By entering one context instance
- Switching from one context to another
- Context attribute values change

How Behavior Changes

- By entering a context and binding with a role, an object obtains new behavior of the role or changes its behavior by the overriding mechanism.

Example for Comparison

- "Has-network" context of the conference guide system
  - COP
    - HasNetwork layer is defined and condition for activation declared
    - A class declares the layer
  - Epsilon
    - Network context is defined with node roles
    - An object binds with a node role instance