Coupled Interface Modules for Heterogeneous Composition

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Chess Review
November 21, 2005
Berkeley, CA
Semantic Units and DSMLs

- DSMLs define a *structural semantics* or abstract syntax via a metamodel.

  ![Diagram of Model Construction](image1)

  **From a metamodel**

  **Model Construction**

  *(via GME)*

  **To a model**

  **Semantic Mapping**

  *(via graph transformation)*

- Semantic units map models to initial conditions of an abstract state machine (ASM)

  ![Diagram of Semantic Units](image2)

- Can leverage well-understood properties of FSMs while preserving domain specificity.
Is Composition Easy?

- The major problem is not expressiveness of automata composition, but rather the difficulty of unifying events (tags) while preserving abstractions.

- We can check if the system blocks by performing a liveness analysis, but this ignores the obvious causality information, and is computationally harder.

- We lost abstractions by completely relying on automata composition, thus reducing problems to (generally) difficult reachability analysis.
Composition Through Interfaces

- Composition through interfaces allows us to insert another mathematical framework for describing semantics of communication that preserves the abstractions.

- From this perspective, there are already many existing candidates for a mathematical framework. We focus on the operational approaches.


Coupled Interface Modules

- Automata based methods have had success (e.g. Ptolemy II, Chic, Gratis II/GME), but, in general, do not scale. Other methods show promise, but lack mathematical maturity and generalizations.
- We propose to ground heterogeneous composition with the powerful machinery of linear algebra. Specifically, we use a generalization of vector spaces, called a module, to describe interfaces.

Components are composed through synchronous product of automata, and tensor products of interfaces and operations. One consequence: Interfaces can be factored.

Example of an interaction rule:

\[ (A^T M \Pi^k(i)P) = \|\Pi^k(i)P\| \]