Causality Interfaces and Compositional Causality Analysis

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Chess Review
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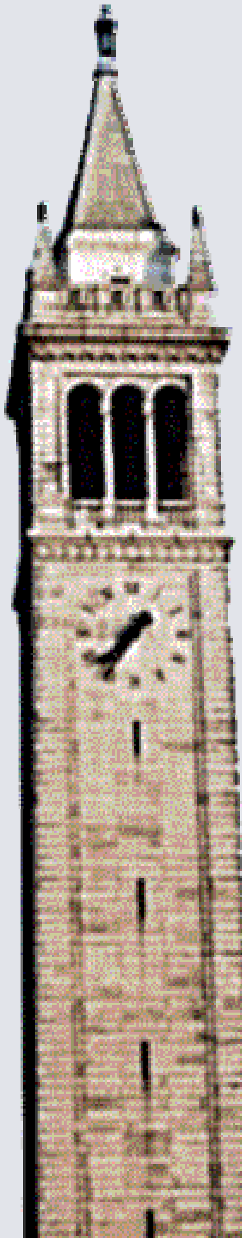
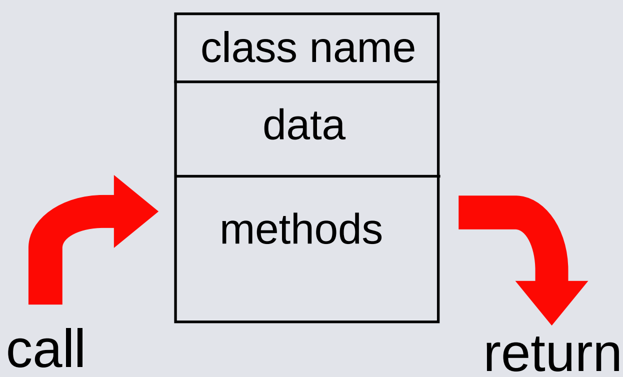
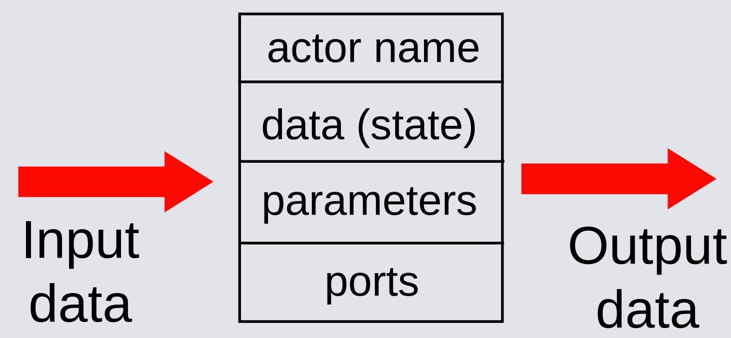


Actor-Oriented Design

- Actors are in charge of their own actions.
- Actors interact with each other by exchanging data through ports.
- The patterns of interactions between actors are called *model of computation*.



Object-Oriented



Actor-Oriented

Causality Interfaces

- A special family of behavioral interfaces that capture the causality properties of actors and their connections.

- Useful for determining constructive semantics of compositions under certain models of computation.
  - Synchronous Languages
  - Discrete-Event Models
  - Synchronous Dataflow

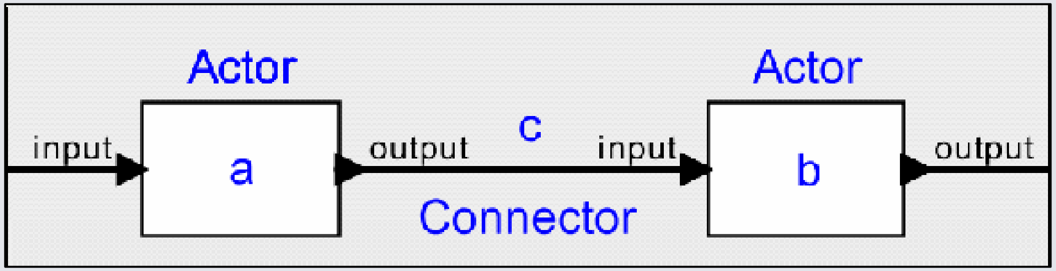
Causality Interfaces as Functions

- A function that maps a pair of ports to an element in the dependency set D.
  - For an actor:

$$\delta : P_i \times P_o \to D$$

  - For a connector:

$$\delta : P_o \times P_i \to D$$



Dependency Set

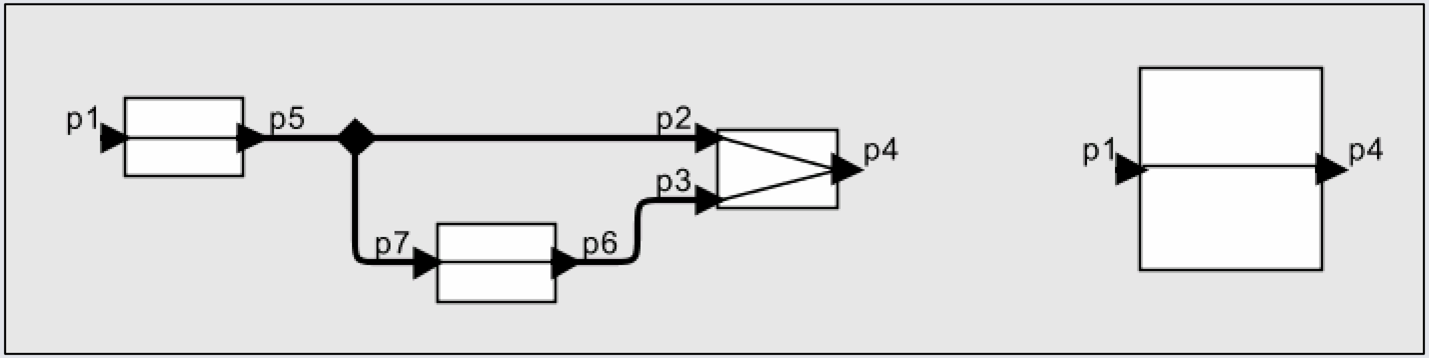
- Dependency set D is an ordered set with two binary operators $\oplus$ and $\otimes$.

- Synchronous Languages
  - D = {true, false}, false < true.
  - $\oplus$ is *logical and*, $\otimes$ is *logical or*.

- Discrete-Event Models
  - D = $\Re_{+} \cup \{\infty\}$, "<" as numerical ordering.
  - $\oplus$ is the *minimum* function, $\otimes$ is addition.

Compositional Analysis

- Use $\otimes$ operator for serial compositions and $\oplus$ operator for parallel compositions.



$$\delta(p_1, p_4) = \delta(p_1, p_5) \otimes (\delta(p_5, p_2) \otimes \delta(p_2, p_4)$$
$$\oplus\, \delta(p_5, p_7) \otimes \delta(p_7, p_6) \otimes \delta(p_6, p_3) \otimes \delta(p_3, p_4))$$

Determining Constructive Semantics

- A constructive behavior exists if there exists no port that has an immediate dependency on itself.

- Synchronous Languages
  - $\forall p \in P,\ \delta(p, p) > false$

- Discrete-Event Models
  - $\forall p \in P, \delta(p, p) > 0$

Conclusions

- An interface theory for causality interfaces of actors and their composition.
- An algebraic procedure to determine whether a composition has a constructive semantics.
- Applied to synchronous languages and discrete-event models.
- On-going work: synchronous dataflow, continuous time, rendezvous.
- Joint work with Prof. Edward A. Lee and Haiyang Zheng