Manufacturing Engineering

Ontological Behavior Modeling for UML:

Behavior as Composite Structure

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NIST

Overview

- Semantics generally.
- Ontological approaches.
- Behaviors as composites
  - Generalization
  - Composition
  - Events
  - Participants
  - Flows (object flow and messaging)
    - External Participants
    - Flow Ordering
    - Composition with Flows and Participants (Bindings)

“Semantics” Defined

- **When using a language:**
  - **How systems will behave (M0) when they are built according to a user model (M1).**
- **When specifying a language:**
  - **How to tell which M0 system behaviors conform to which M1 models.**

Standardized Semantics: Goal

- **Multiple users of the same model …**
  - **… should have the same expectation of how systems will behave when built according to model.**
- **Multiple implementers of same modeling language tools …**
  - **… should have the same expectations as the users.**

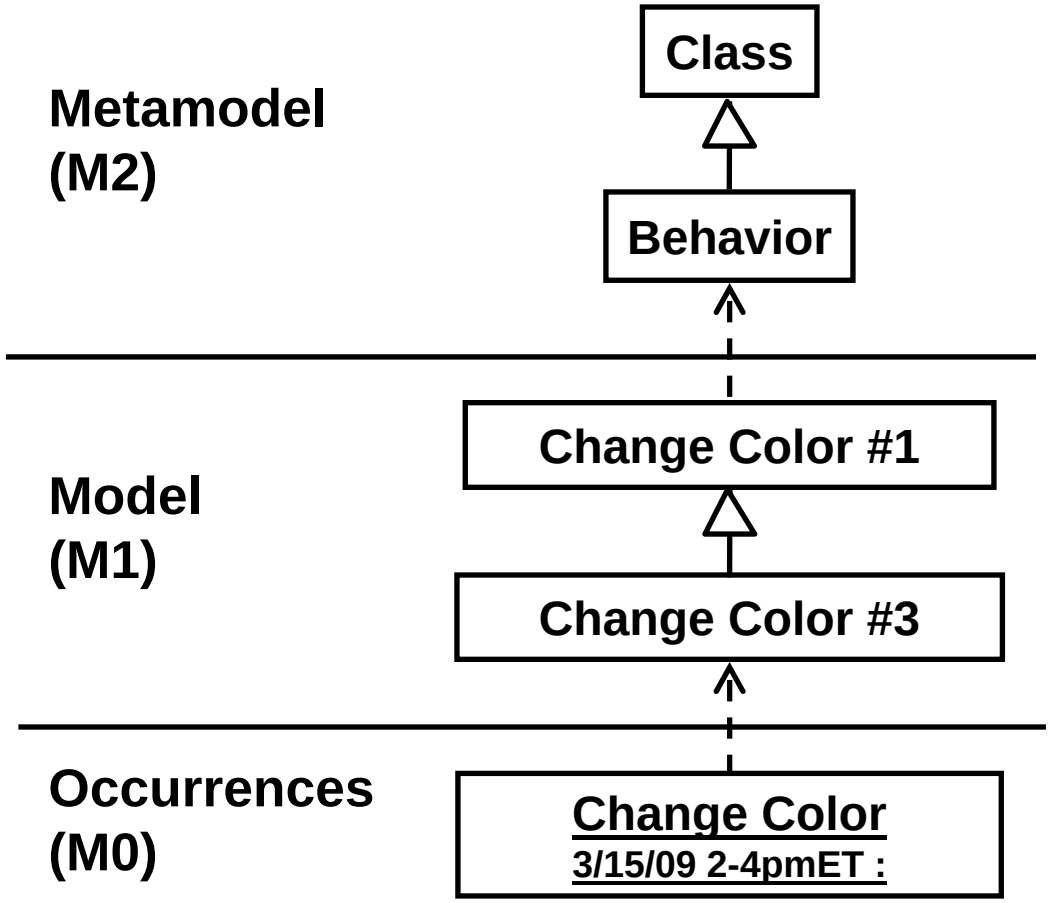
Standardized Semantics: How?

- **Common practice and communication.**
- **Informal documentation with examples.**
- **Reference implementations.**
- **Compliance testing.**
- **Formal documentation, sometimes mathematical.**

Ontological Specifications

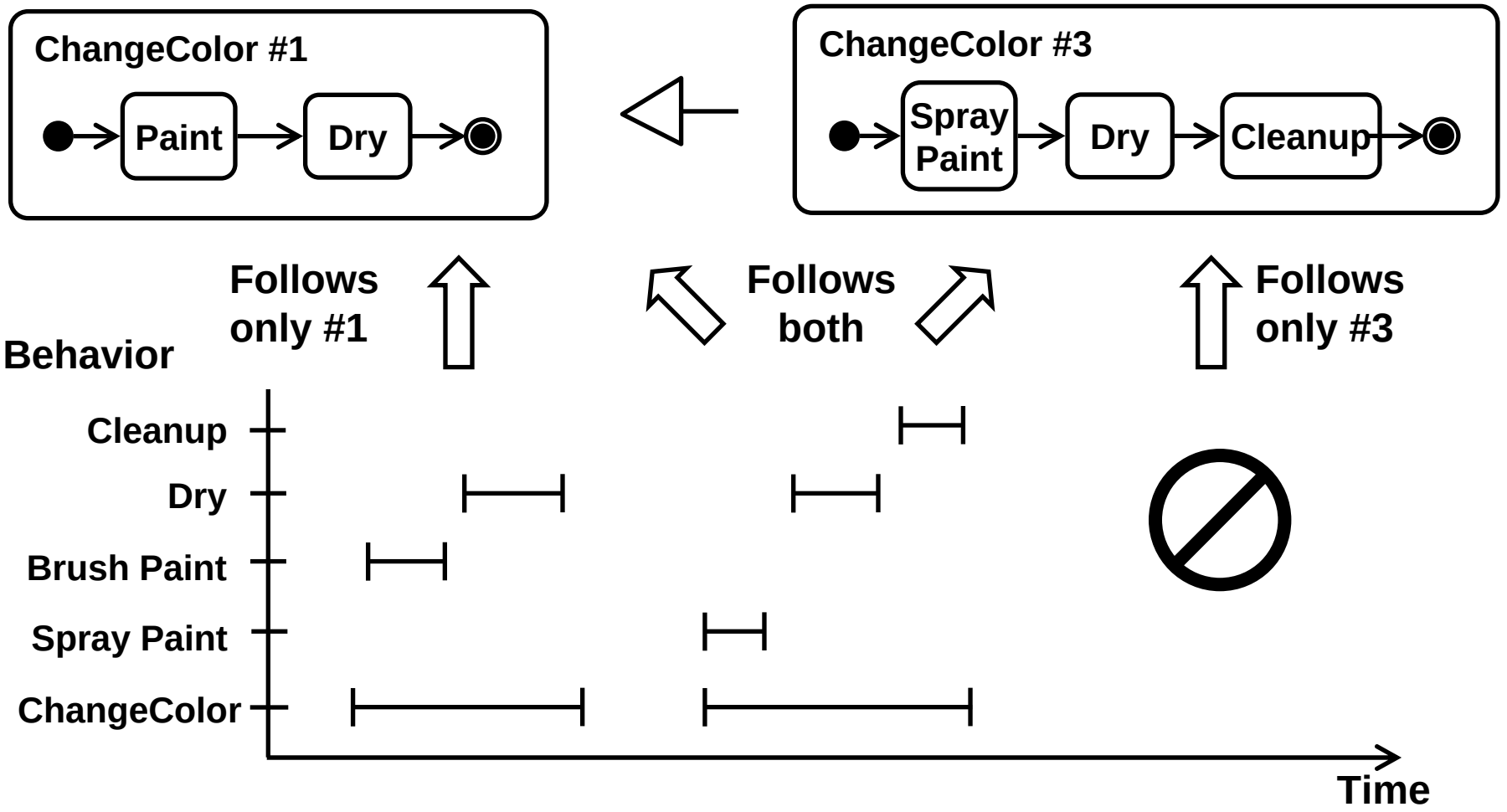
- **Formality a matter of degree:**
  - **Ratio of structure to informal text.**
- **Ontological approach:**
  - **Build up thin layers of structural elements that have simple definitions.**
- **Advantages:**
  - **Reference implementations and compliance tests not needed, but easier to construct.**
  - **Helps consolidate common practice and communication.**
  - **Already used at OMG: specializing metamodels, and profiles.**

Example: UML Behaviors



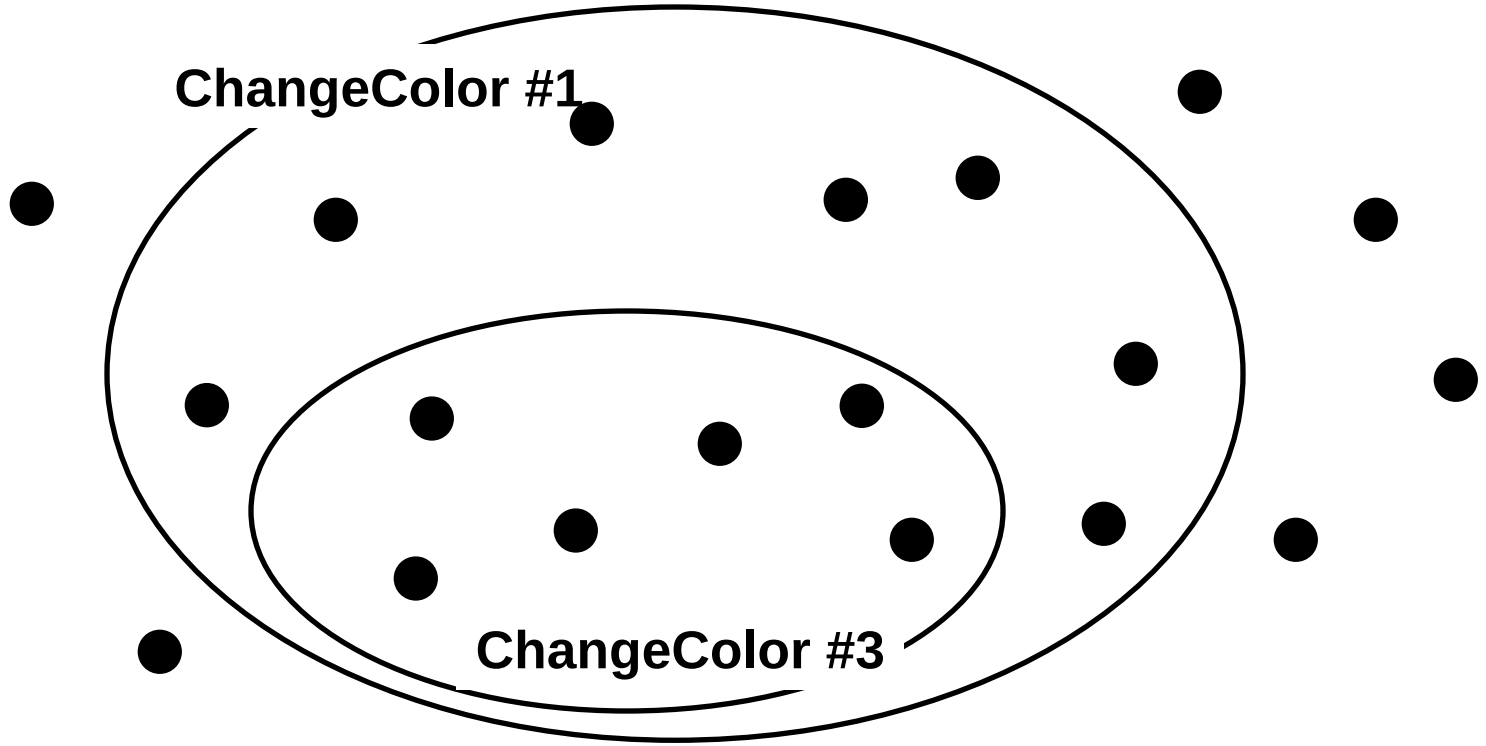
- **Behaviors are**
  - **layered on Classes at M2.**
  - **specialized at M1.**
  - ***occur* (execute, are performed) at M0.**

Behavior Generalization



- **UML definition of generalization:**
  - **Every occurrence (instance) of the specialized behavior (class) is an occurrence of the general behavior.**

Behavior Generalization



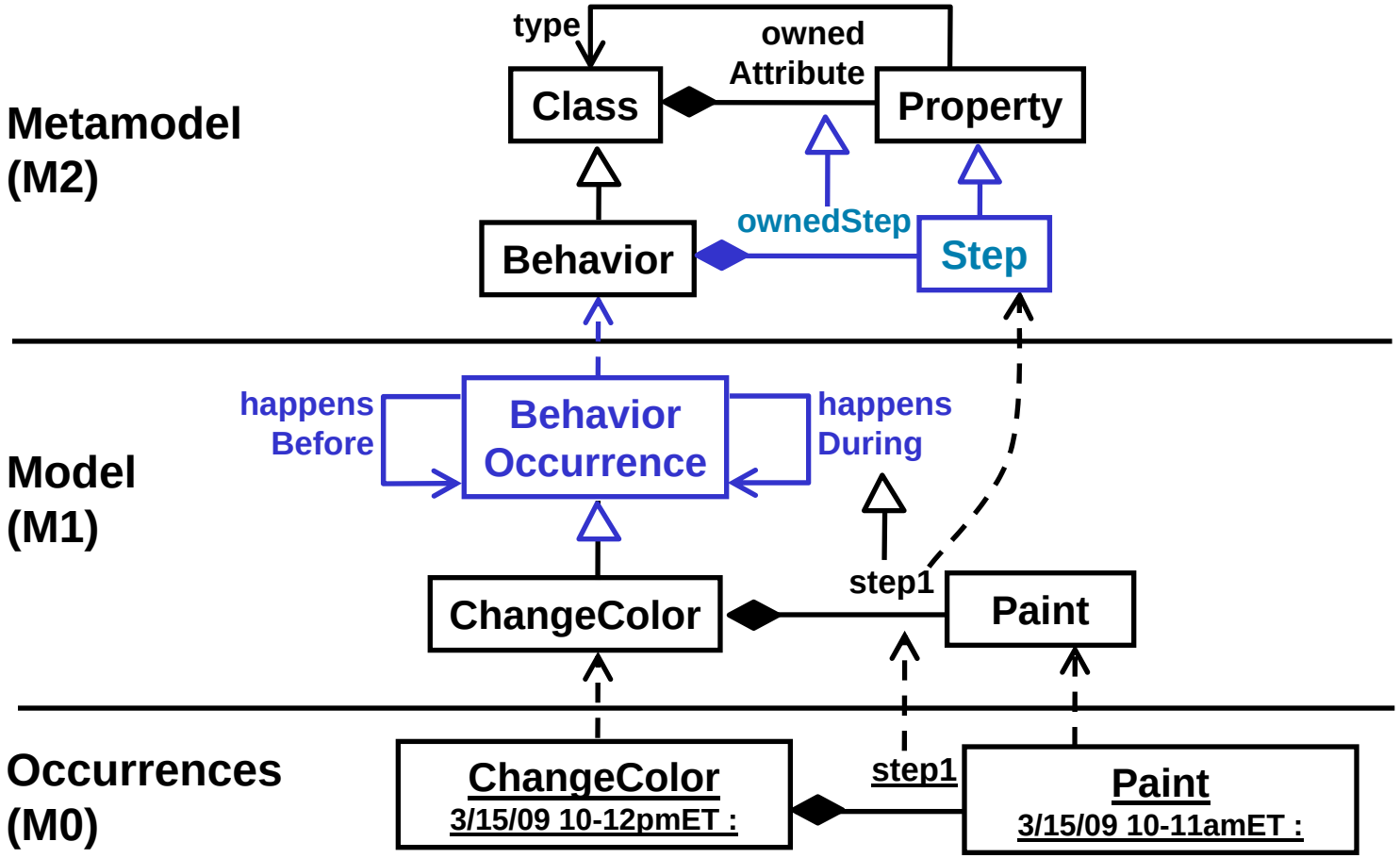
● = occurrence

- Venn diagram illustration of previous example.

Behavior Composition

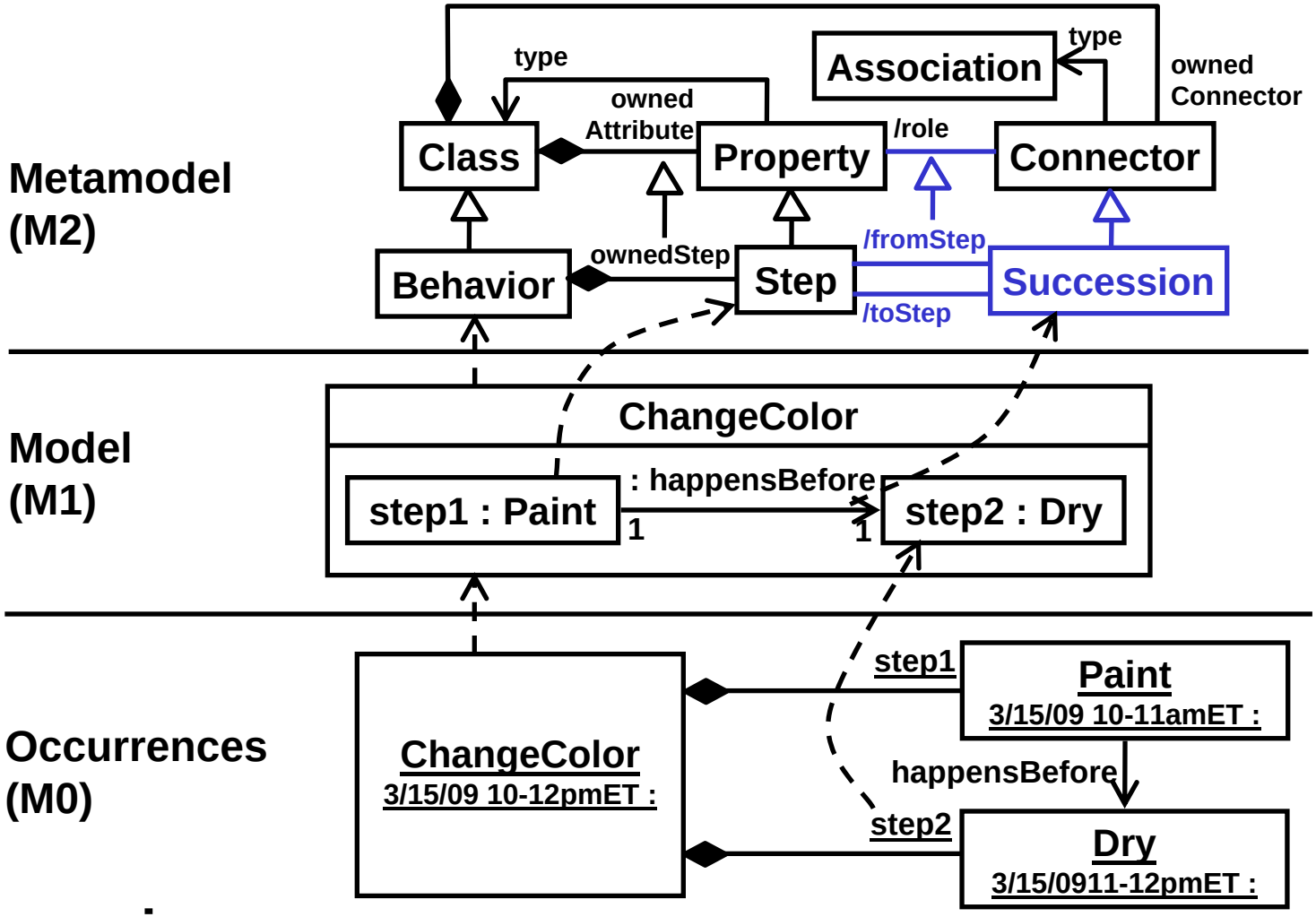
- **Whole-part**
  - **Activities have actions.**
  - **State machines have state behaviors and submachines.**
  - **Interactions have interaction uses, messages and actions.**
- **Part-part**
  - **Activities have control flow between actions.**
  - **State Machines have transitions between states.**
  - **Interactions have general orderings between messages.**

Whole-part for Behaviors



- **Steps:**
  - layered on Properties at M2.
  - typed by behaviors at M1, and specialized from general temporal relation.
  - have “suboccurrences” as values at M0.

Part-part for Behaviors

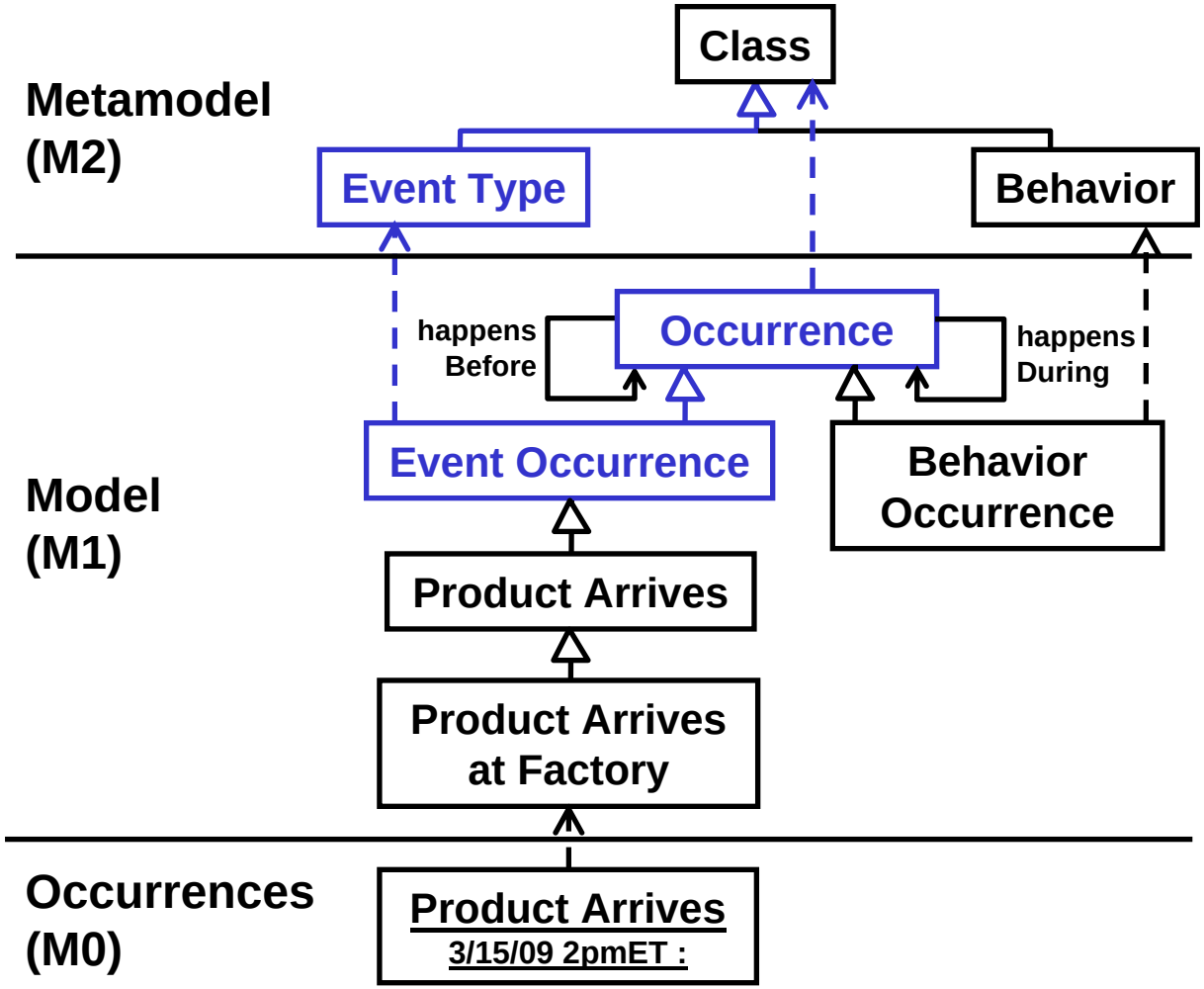


- **Successions:**
  - **layered on Connectors at M2.**
  - **typed by general temporal relation at M1.**
  - **result in links between suboccurrences at M0.**

Events

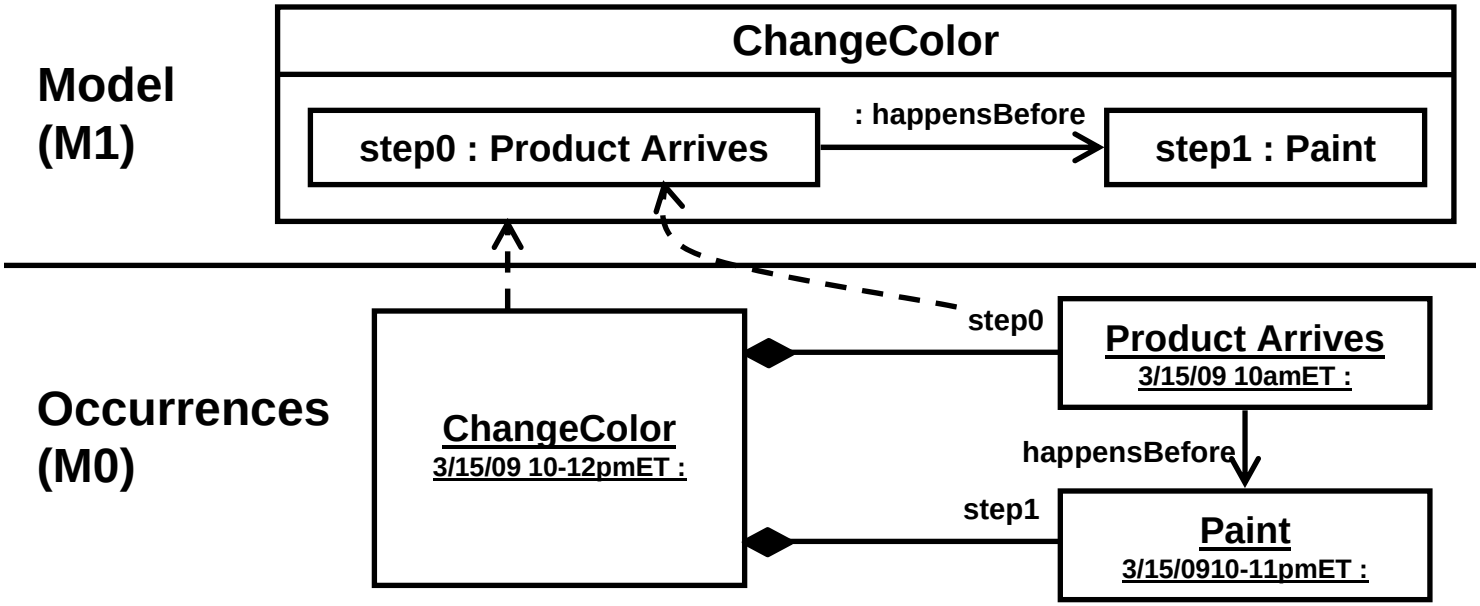
- **Events are alot like behaviors:**
  - **They occur at particular times at M0.**
  - **Can be specified by types at M1, which can be subtyped.**
  - **Can be parts of behaviors.**
  - **Can be specified to happen in a certain order under those behaviors.**
- **UML has:**
  - **A common abstract syntax for events, but they are not types.**
  - **Some semantics in Common Behavior not based on classes …**
  - **… used to varying degrees in the semantics of the other kinds of behaviors.**

Event Types and Occurrences



- **Event types are:**
  - **layered on Classes at M2.**
  - **specialized at M1 (temporal relations promoted).**
  - **occur at M0.**

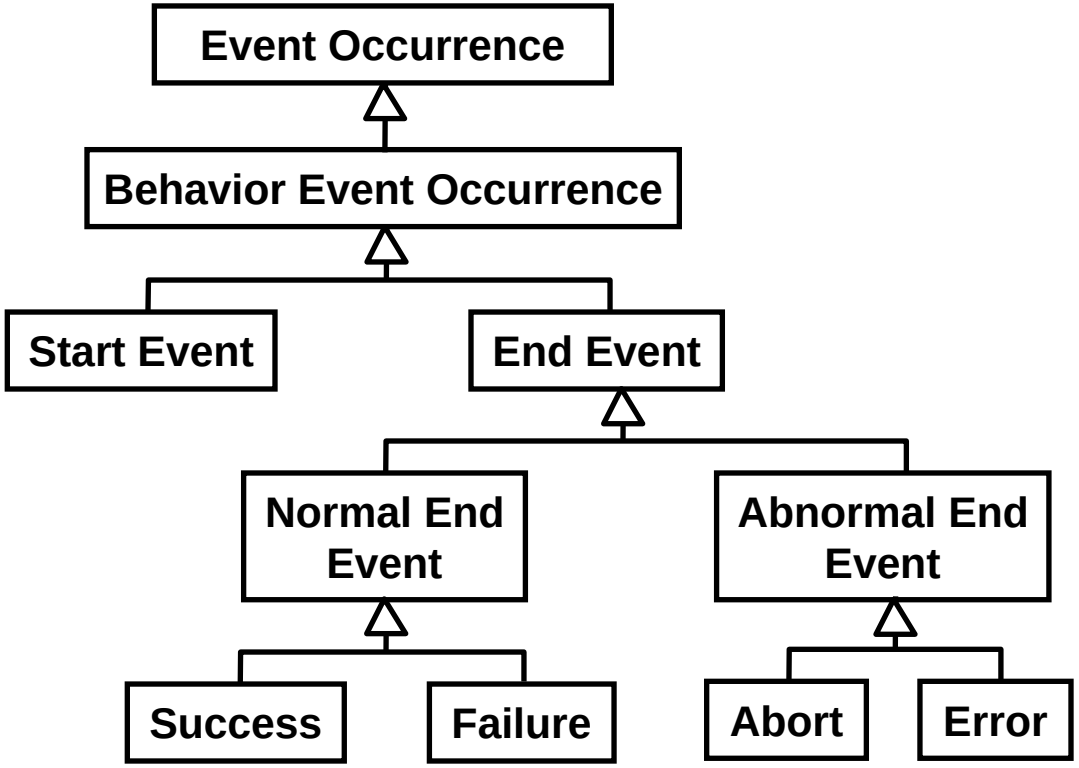
Events in Behavior



- **Event types can be types of properties …**
- **… which are ordered by successions.**

Behavior Events

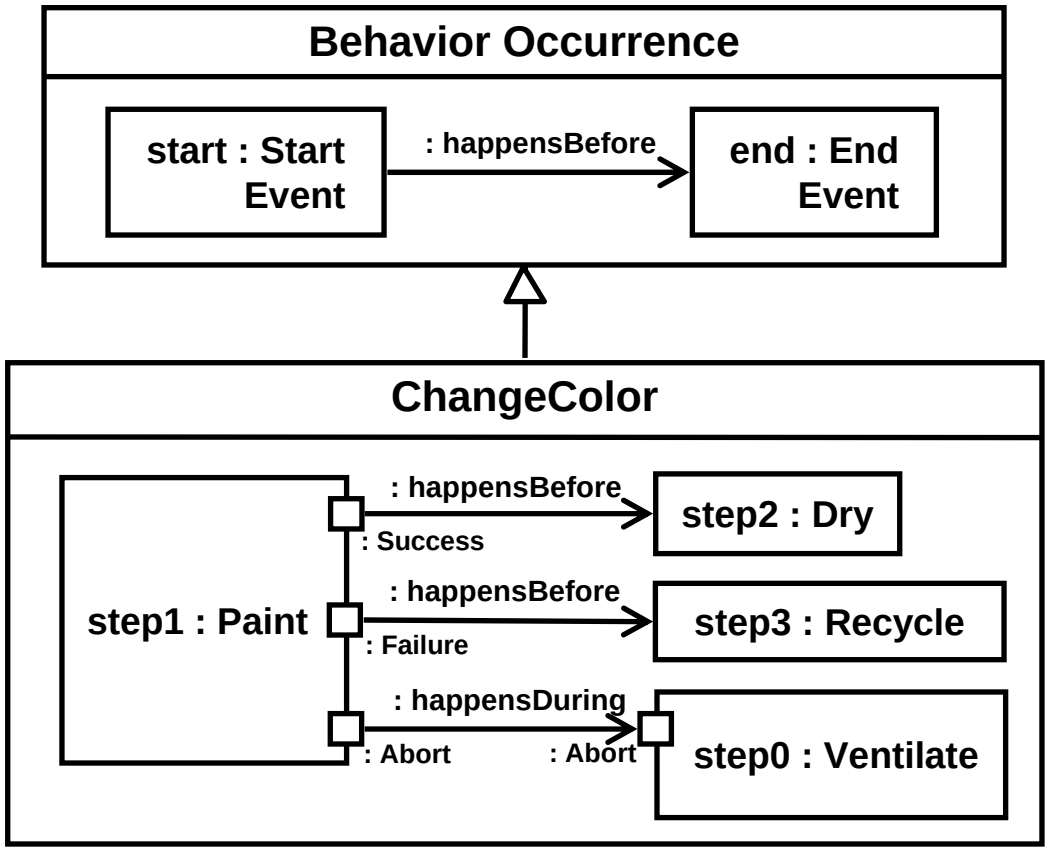
Model (M1)



- **Behaviors have specialized events for their lifecycle ...**

Behavior Events as Parts

Model (M1)

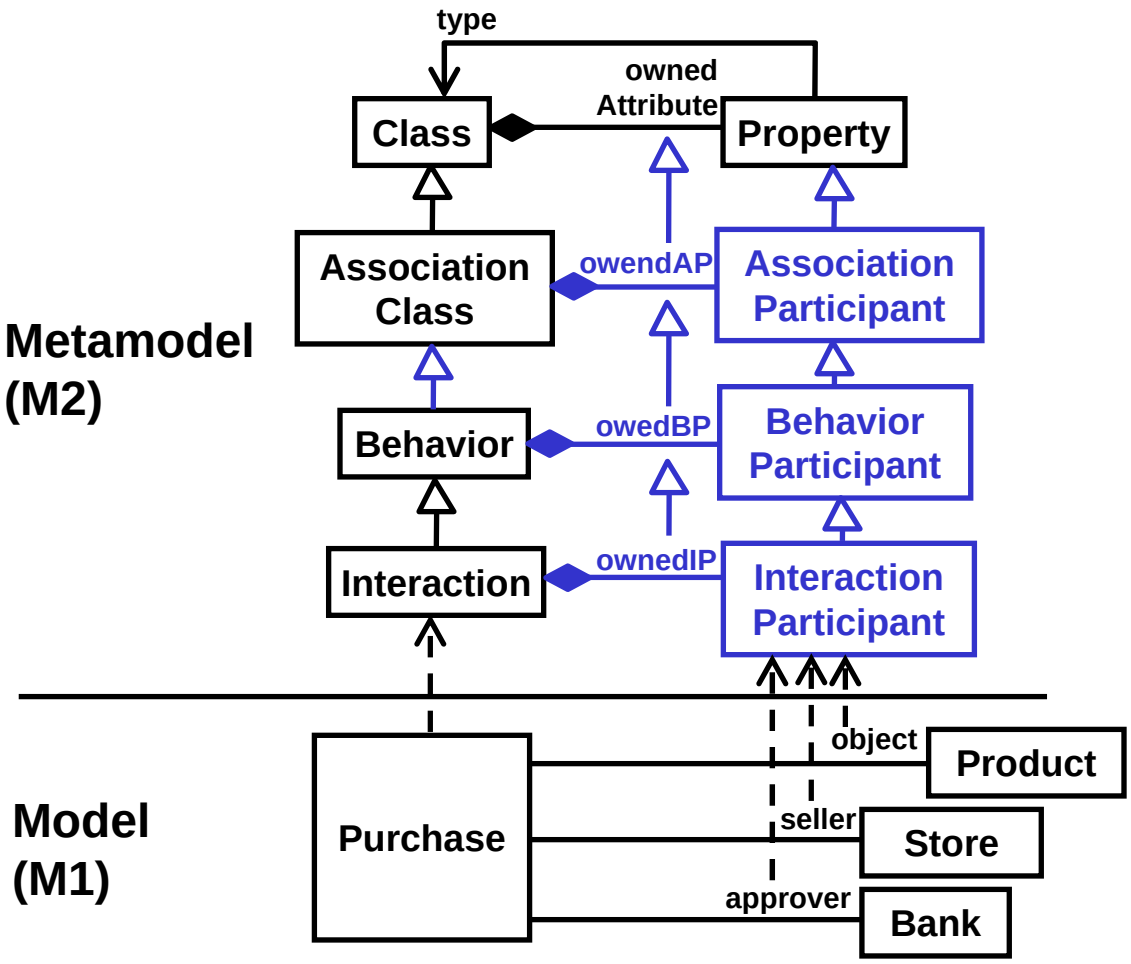


- … which can by the types of “port” properties ...
- … that are ordered by successions.

Participants

- **Behaviors involve objects that behave.**
  - **Interactions have lifelines.**
  - **Activities have object nodes, variables, and partitions.**
  - **Behaviors have parameters.**
- **Association involve objects that are linked.**
- **Behaviors are associations between their participants.**

Participant Properties

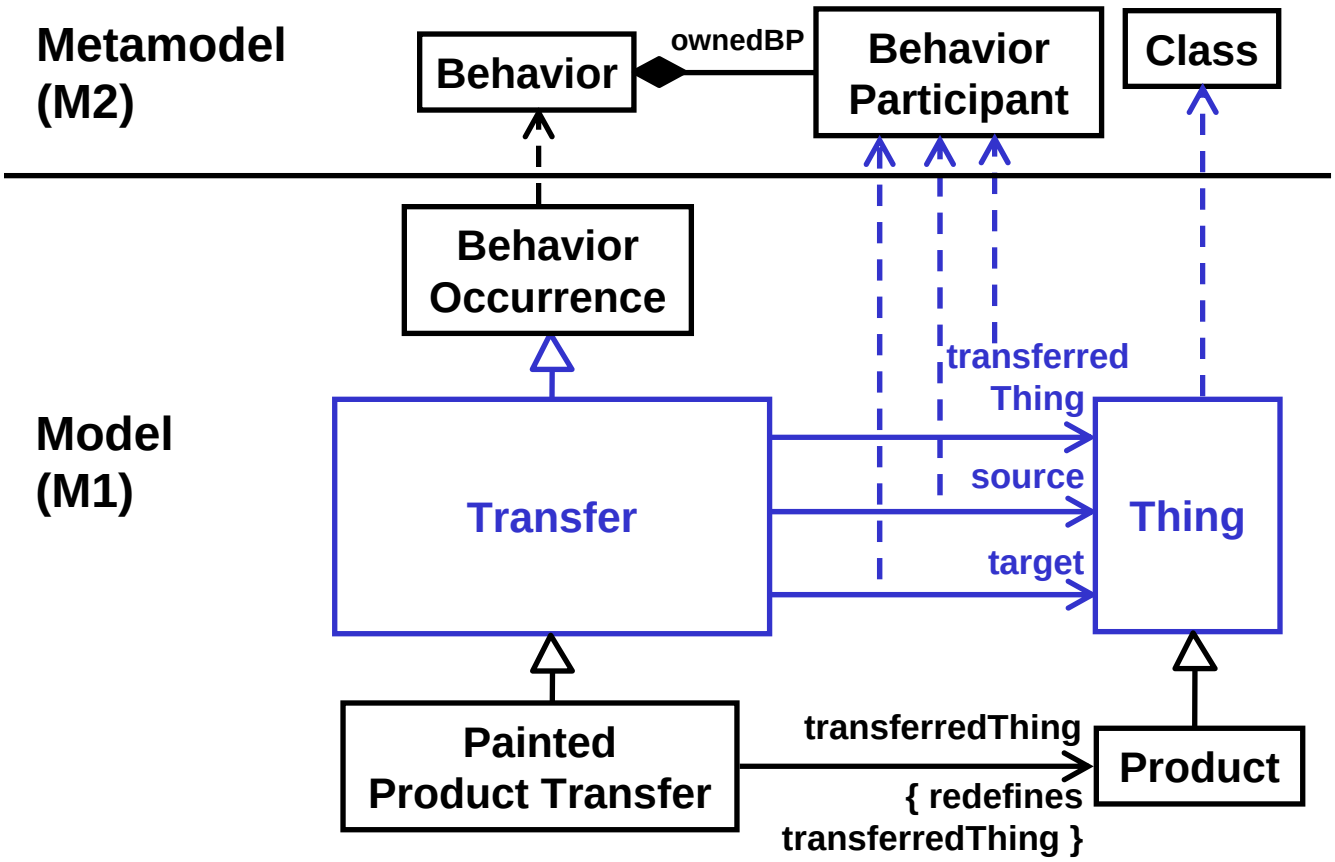


- **Participants:**
  - **layered on Properties at M2.**
  - **assigned participant types at M1.**
  - **have individual values at M0 on occurrences / links.**

Object Flows and Messaging

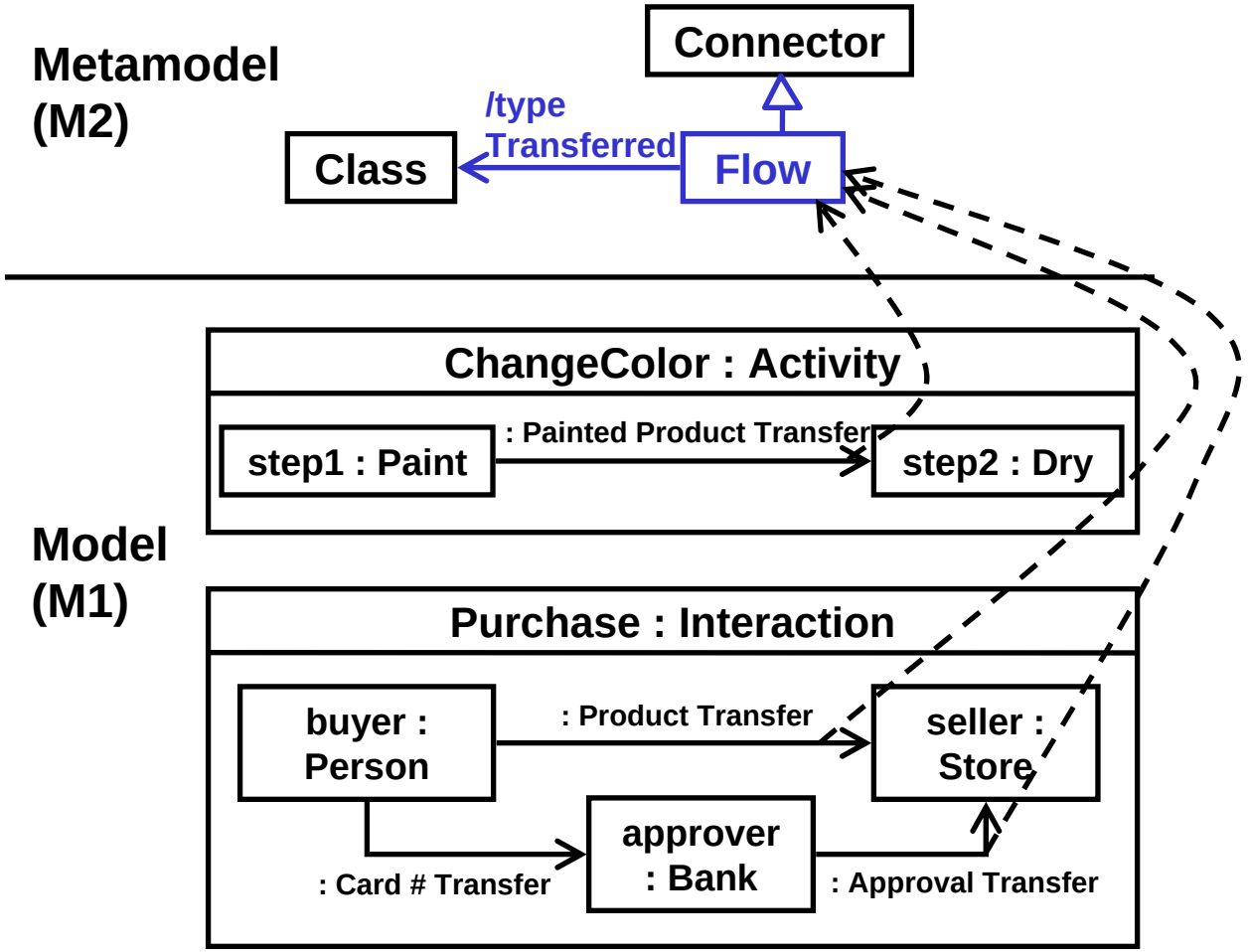
- **Specify transfer of entities at M0.**
  - **Activities have object flows linking pins on actions.**
  - **Interactions have messages linking lifelines.**
- **Transfers take time, they are behavior occurrences.**
  - **Start when entity begins flowing, or message leaves the sender.**
  - **End when entity stops flowing, or message arrives at receiver.**

Transfers



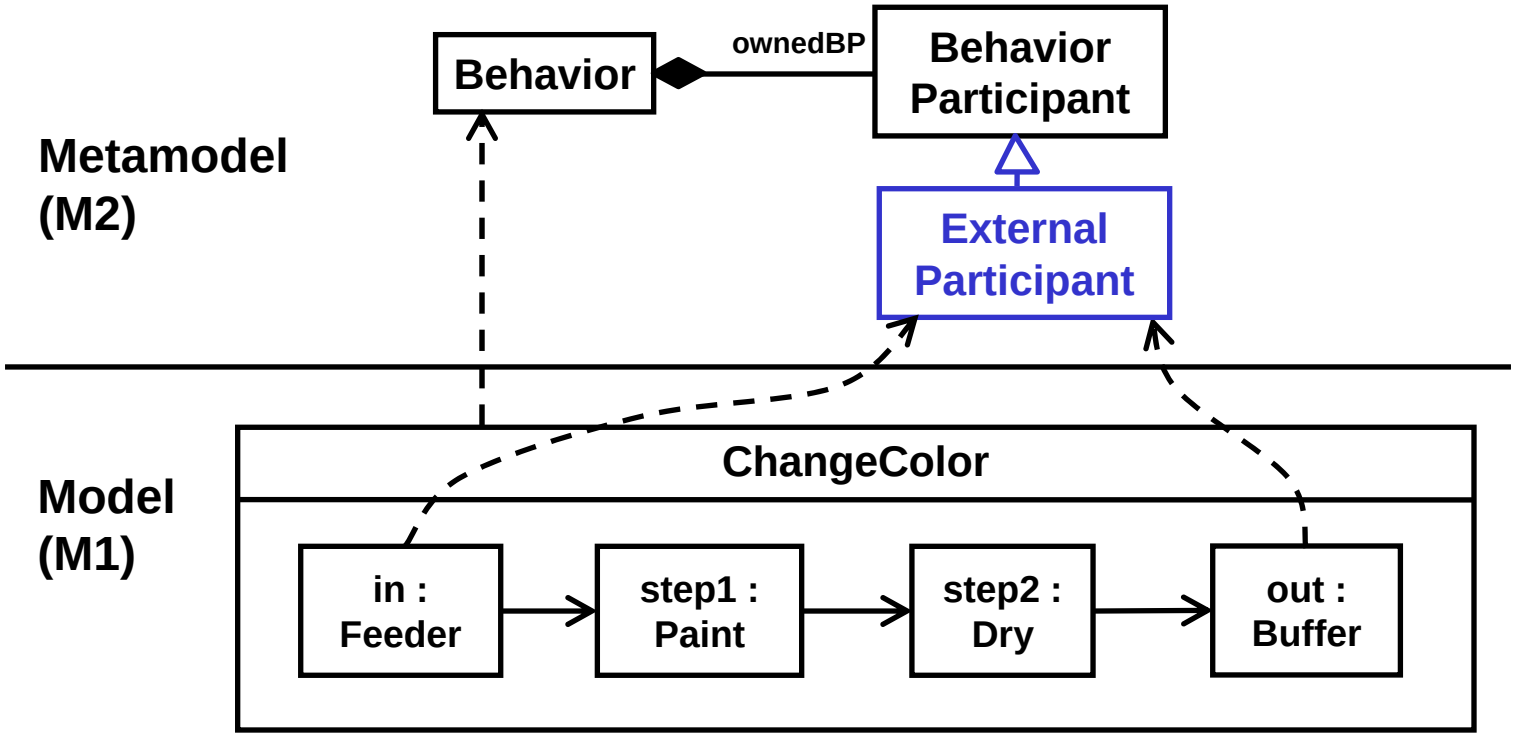
- **Transfers:**
  - a special kind of Behavior Occurrence at M1.
  - have participant properties, and are specialized at M1.
  - occur at M0 involving individuals that are values of participant properties.

Flows



- **Flows:**
  - **layered on Connectors at M2.**
  - **typed by transfers at M1.**
  - **have transfer occurrences as values at M0.**

External Participants

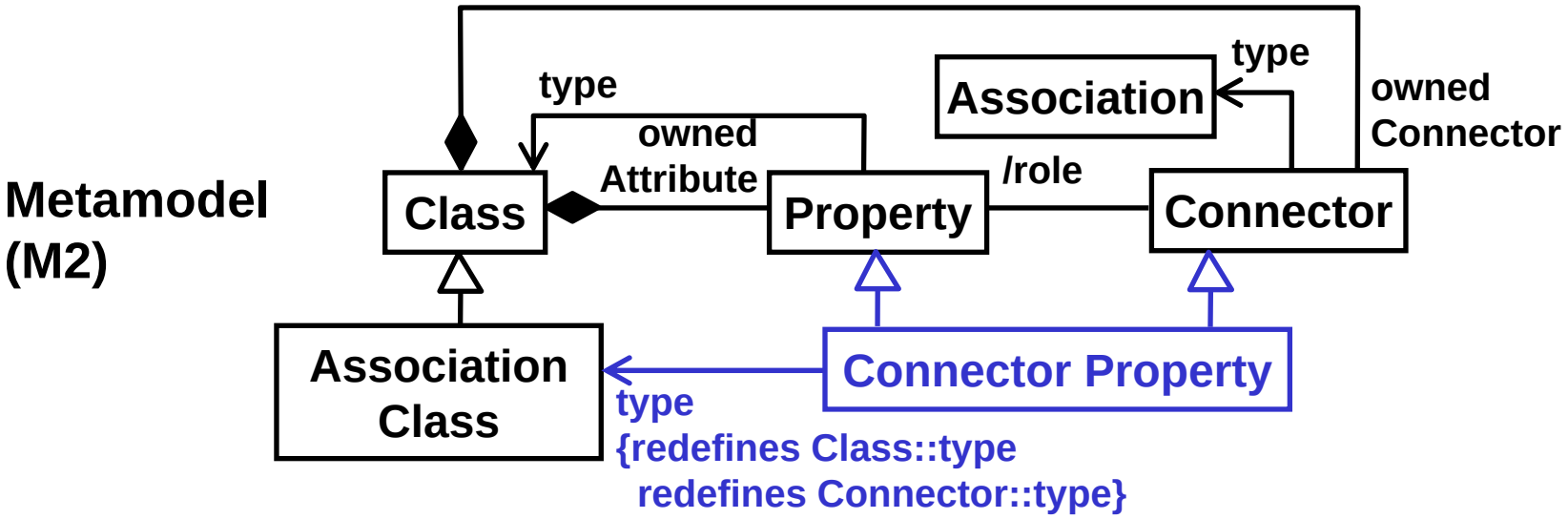


- **External participants:**
  - **layered on Behavior Participants at M2.**
  - **can be linked by flows at M1 for inputs and outputs.**
  - **result in occurrences of transferring at M0.**

Flow Ordering

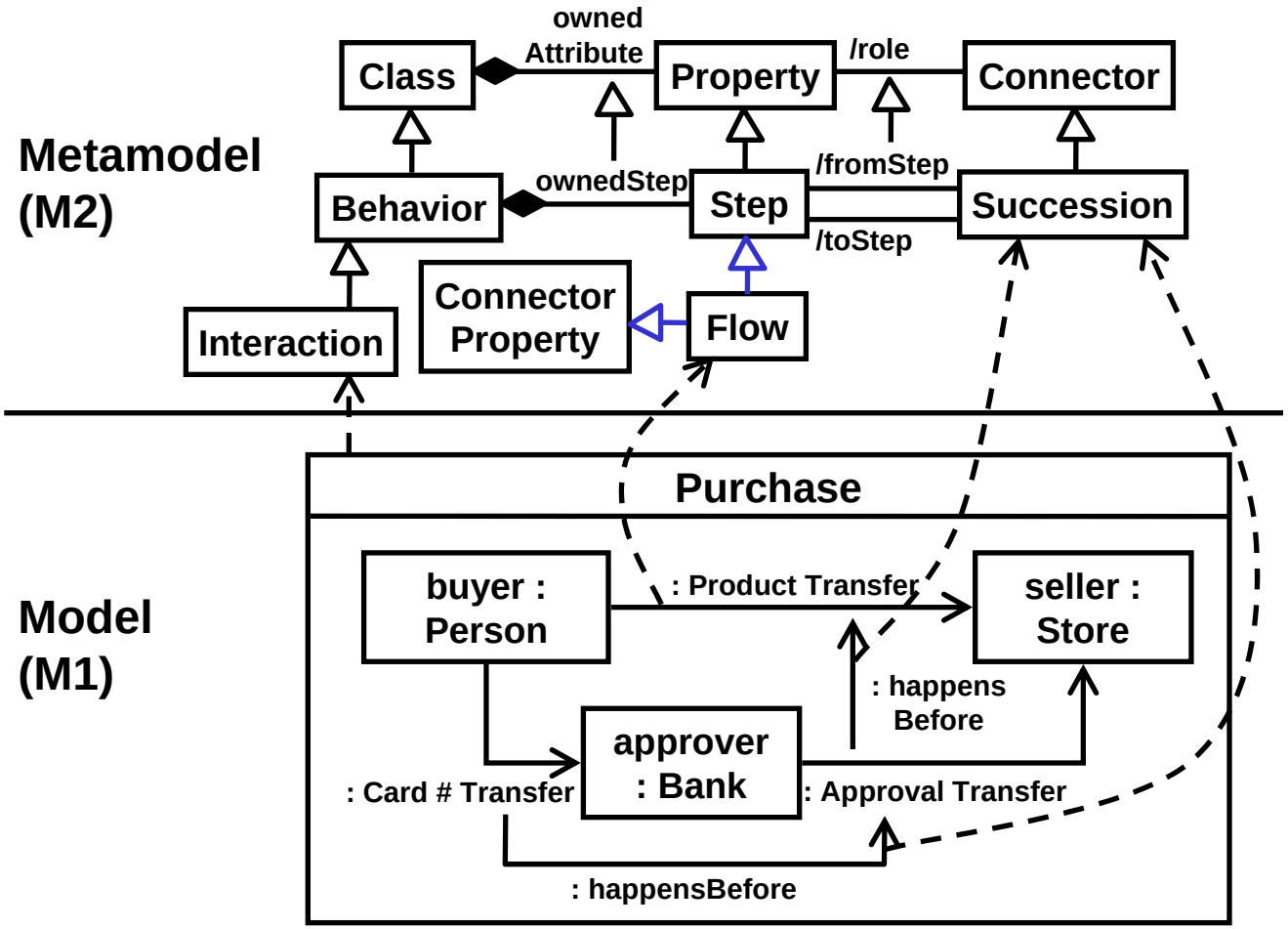
- **Some flows happen before others**
  - **Interactions order messages and interaction uses.**
  - **Protocol state machines specify allowed orders of operation calls and other protocols.**
  - **Activities order actions for sending and receiving messages.**
- **Requires successions between flows (connectors between connectors).**

Connector Properties



- **Connector Properties:**
  - **layered on Connectors and Properties at M2.**
  - **have association classes as types at M1.**
  - **have links as values at M0.**
- **M0 values are the links specified by the connector.**

Flow Properties



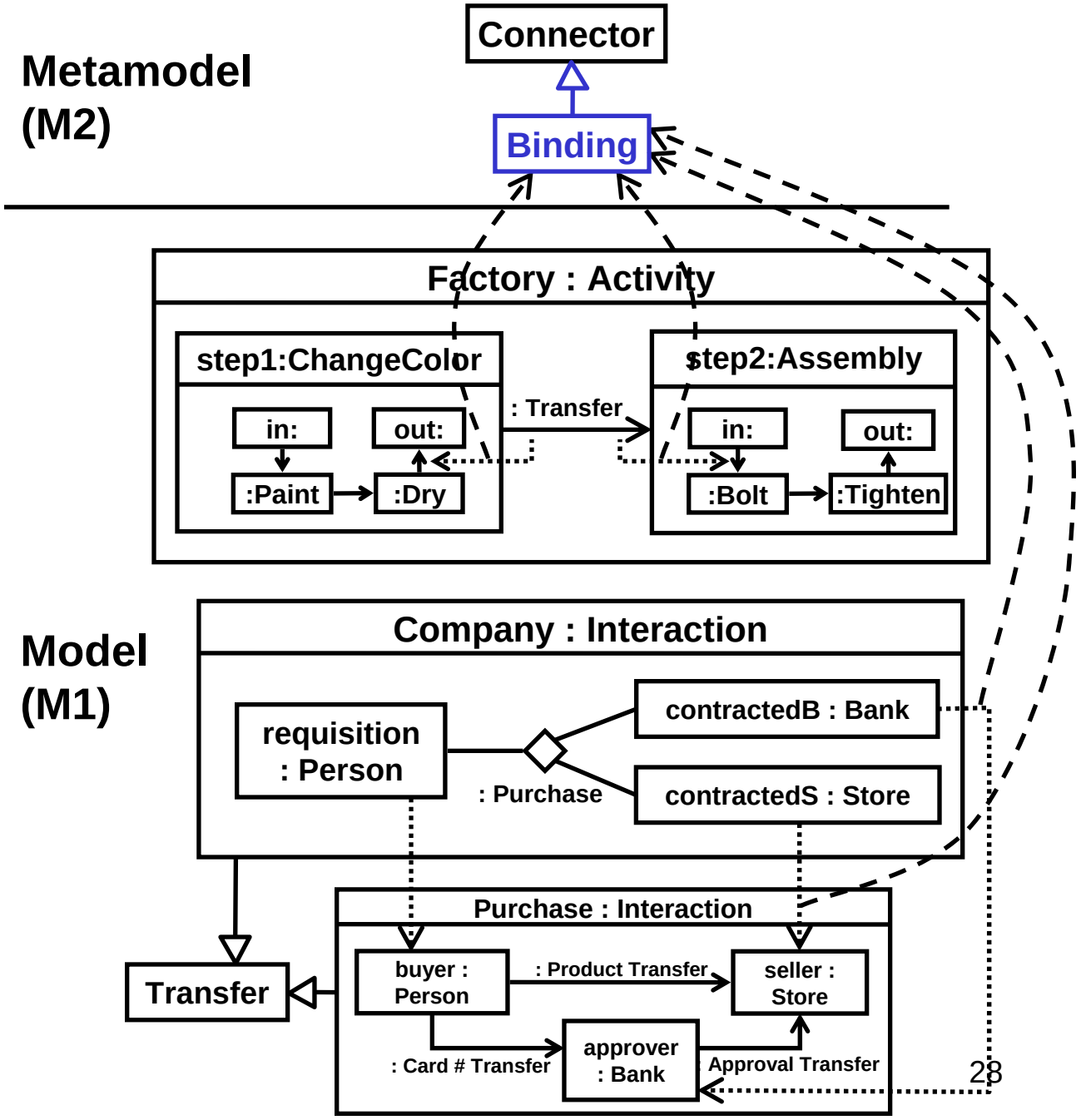
- **Flows:**
  - **layered on Connector Properties and Steps at M2.**
  - **connected by successions at M1.**
  - **have transfer occurrences as values at M0.**

Composition with Flows and Participants

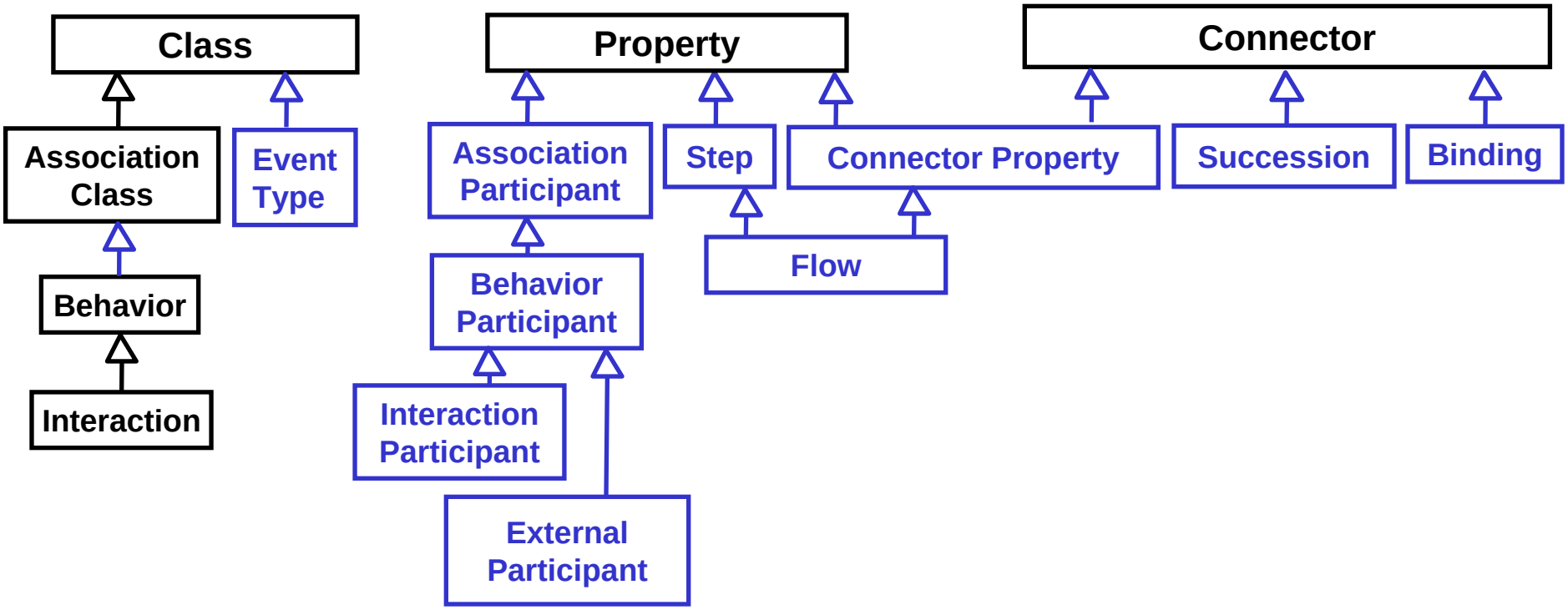
- **Flows are part of behavior composition.**
  - **Activities have pins matching behavior parameters.**
  - **Interactions have arguments matching behavior parameters, used with collaboration, and collaboration role bindings.**
- **Requires specifying equivalence between transfers.**

Bindings

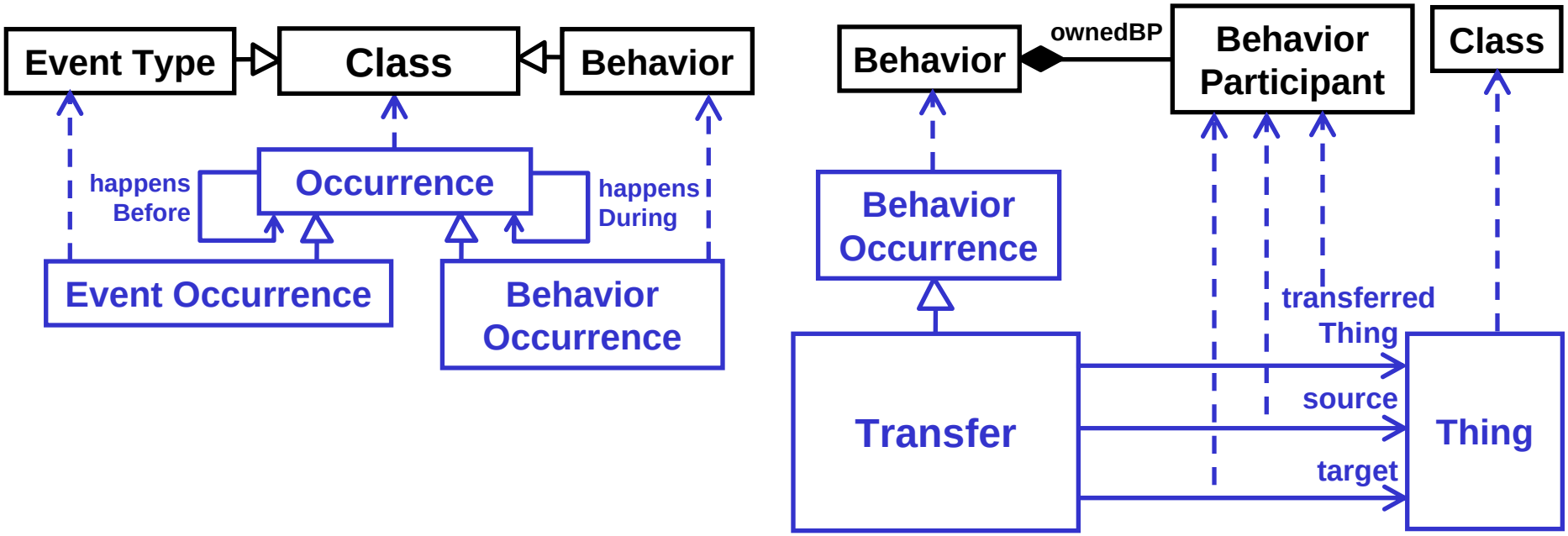
- layered on Connectors at M2.
- link flows and participants at M1.
- specify equivalence of transfers at M0.



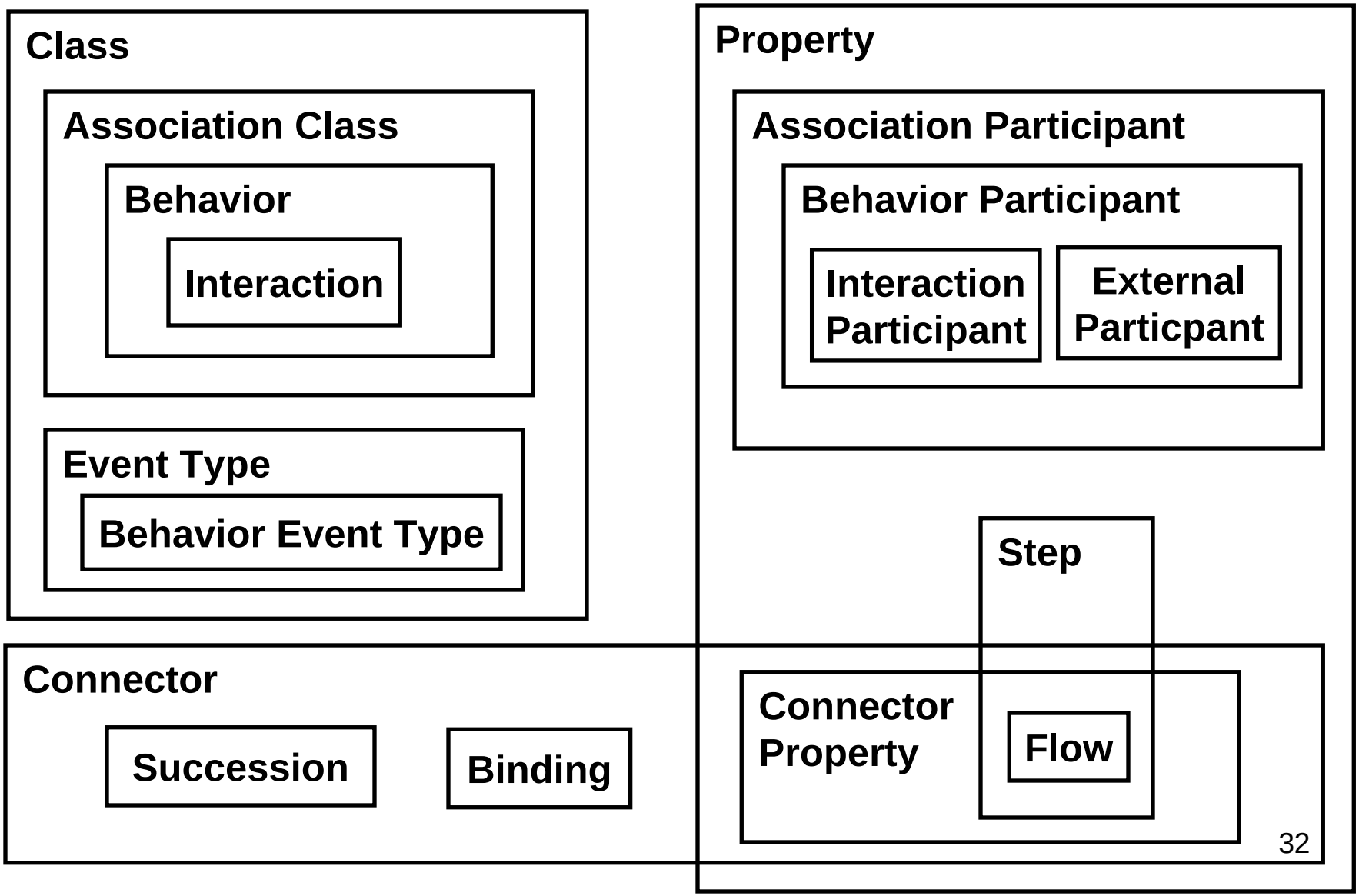
Metaclass Taxonomy



Model Library



Metaclass Taxonomy (CDGN)



Summary

- **Semantics determines when M0 elements conform to M1 models.**
- **Metamodels should**
  - **reflect common semantics among M1 model elements.**
  - **have thin layers of clearly defined abstractions.**
  - **be augmented with M1 libraries to capture the relationship to M0.**
- **Behavior as example:**
  - **M1 behaviors and events specify M0 occurrences.**
  - **Specialize from Kernel at M2, including from Class, Property, Connector, and Association Class.**
  - **Capture occurrences and temporal relations at M1.**