Behavior as Composite Structure:
(Onto)Logical Behavior Modeling

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National Institute of Standards and Technology

Overview

- Motivation
- Composite structure
- Behaviors as composites
- UML (lack of) support
- (Onto)logical modeling
- Summary

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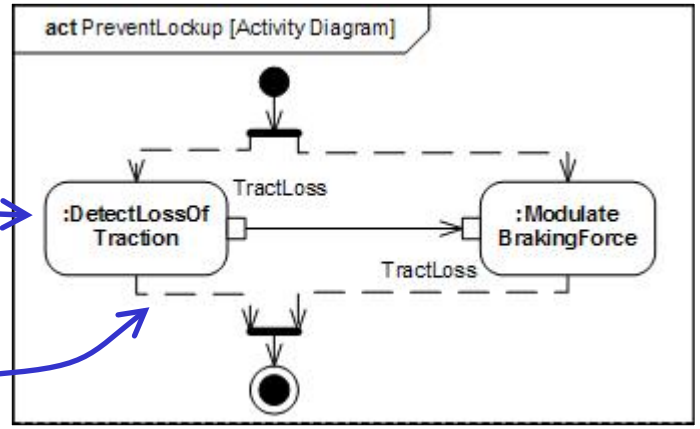
Problem

- **UML has three behavior diagrams.**
  - **Activity, state, interaction.**
- **Very little integration or reuse between them.**
  - **Three underlying metamodels.**
  - **Three representations of temporal order.**
- **Triples the effort of learning UML and building analysis tools for it.**

Solution

- **Treat behaviors as assemblies of other behaviors.**
  - **Like objects are assemblies of other objects.**
- **Assembly = UML internal structure**
  - **Pieces represented by properties.**
  - **Put together by connectors.**
- **Put all behavior diagrams on the same underlying behavior assembly model.**

Behaviors as Composite Structure

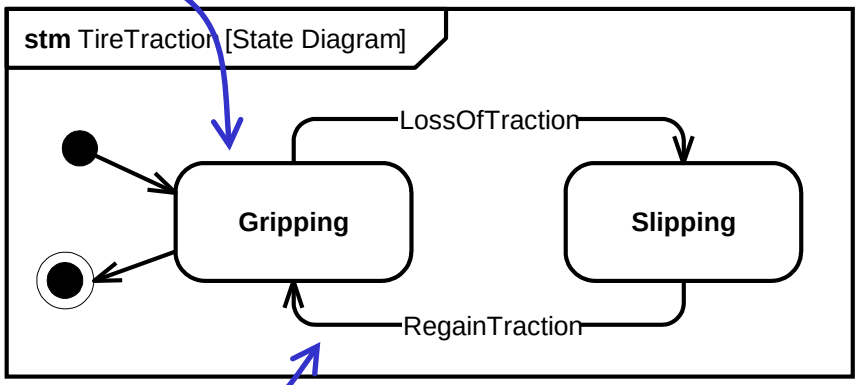


Property

Connector

Activity

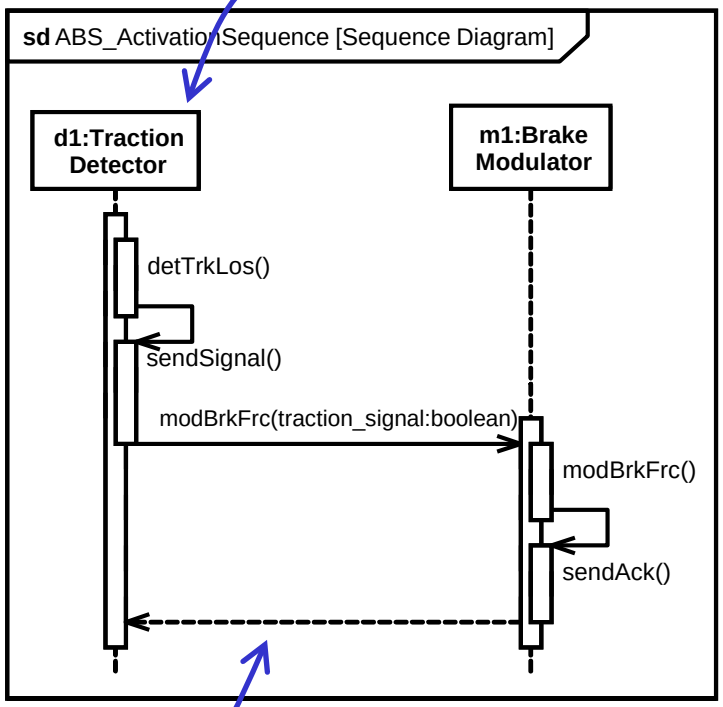
Property



Connector

State Machine

Property



Connector

Interaction

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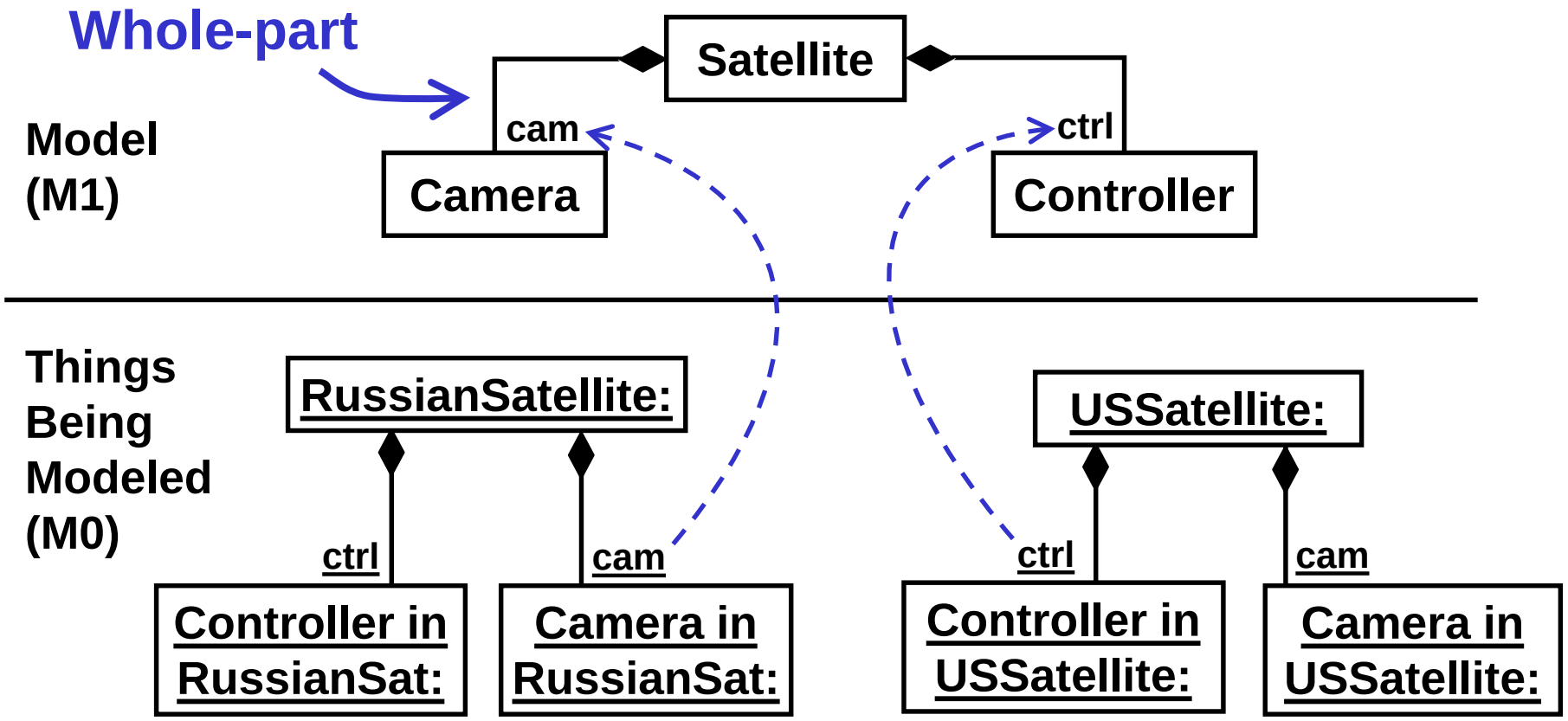
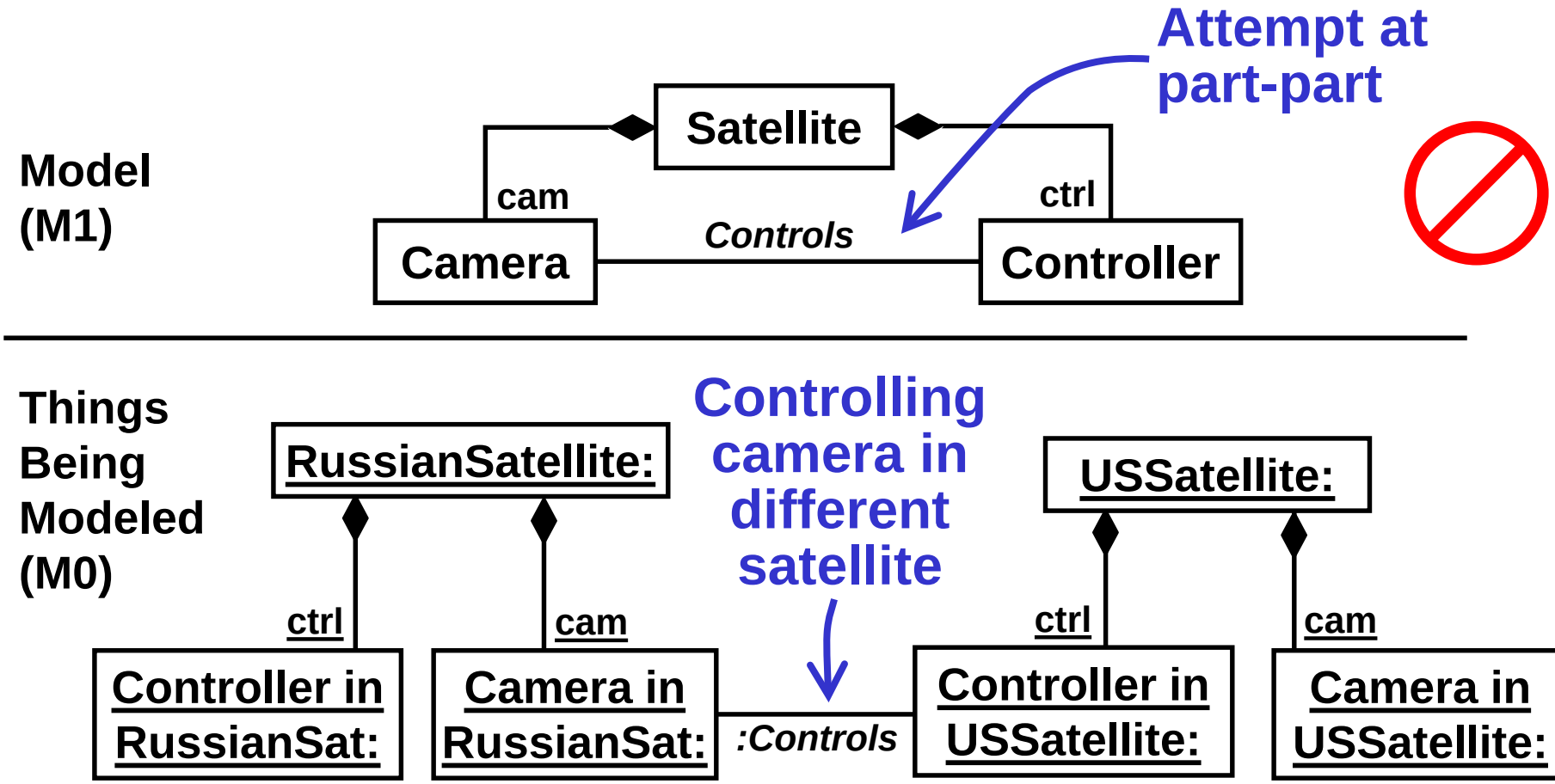
Whole-Part

- **Whole-part relationships can modeled as associations.**

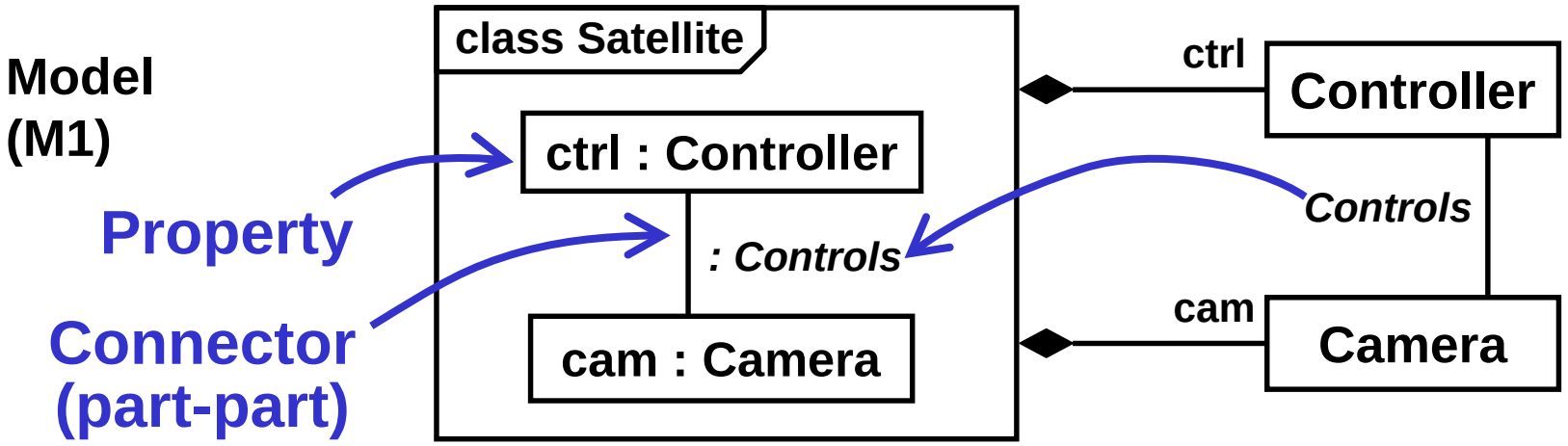


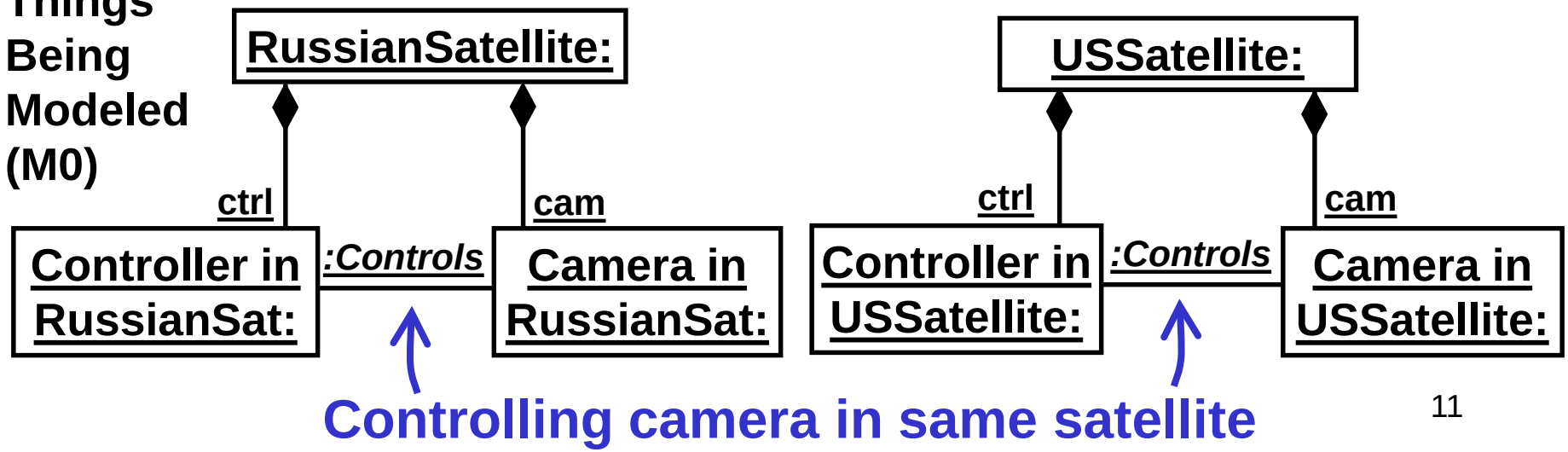
Part-Part, Not

- **Part-part relationships cannot be represented by associations.**



UML Composite Structure





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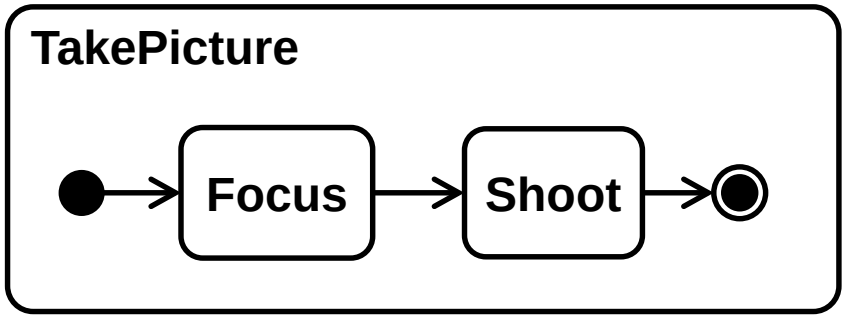
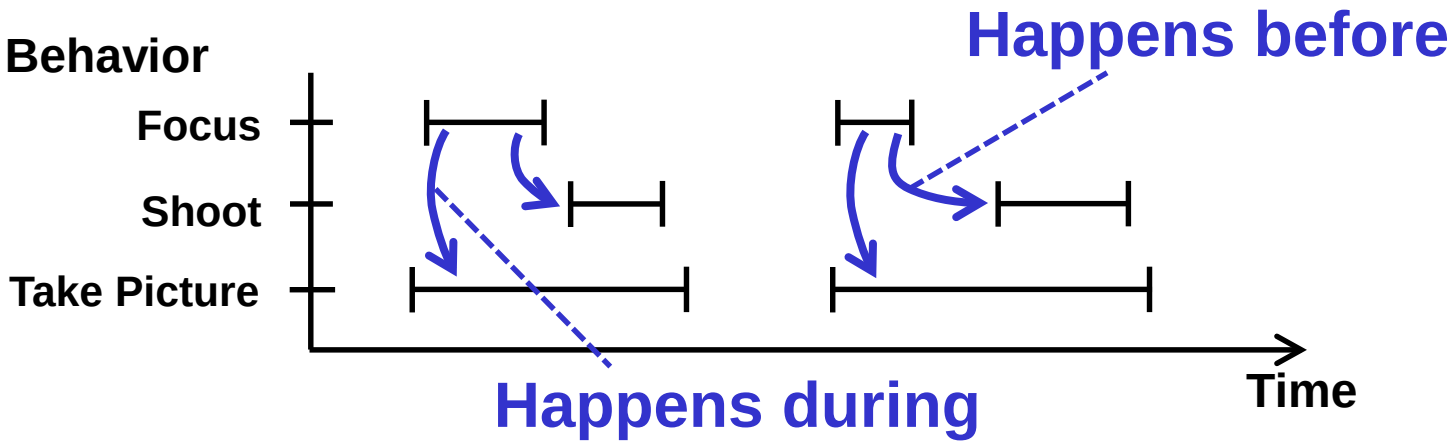
Behavior

Model (M1)

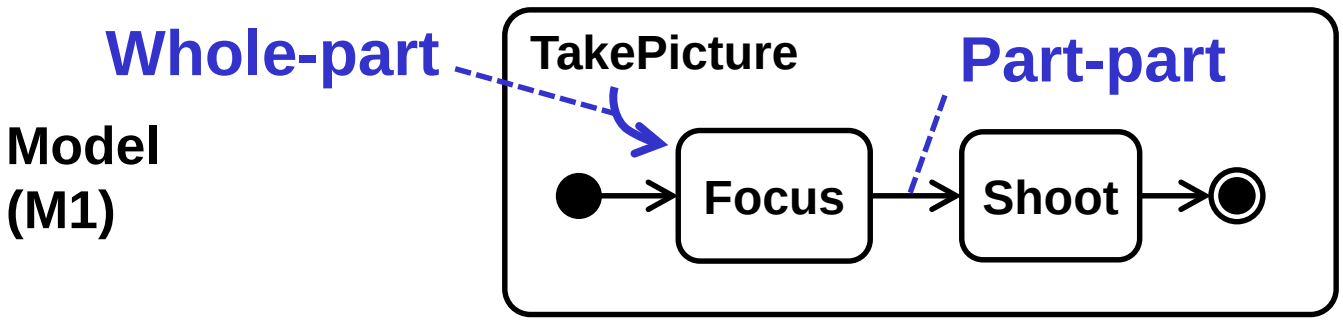


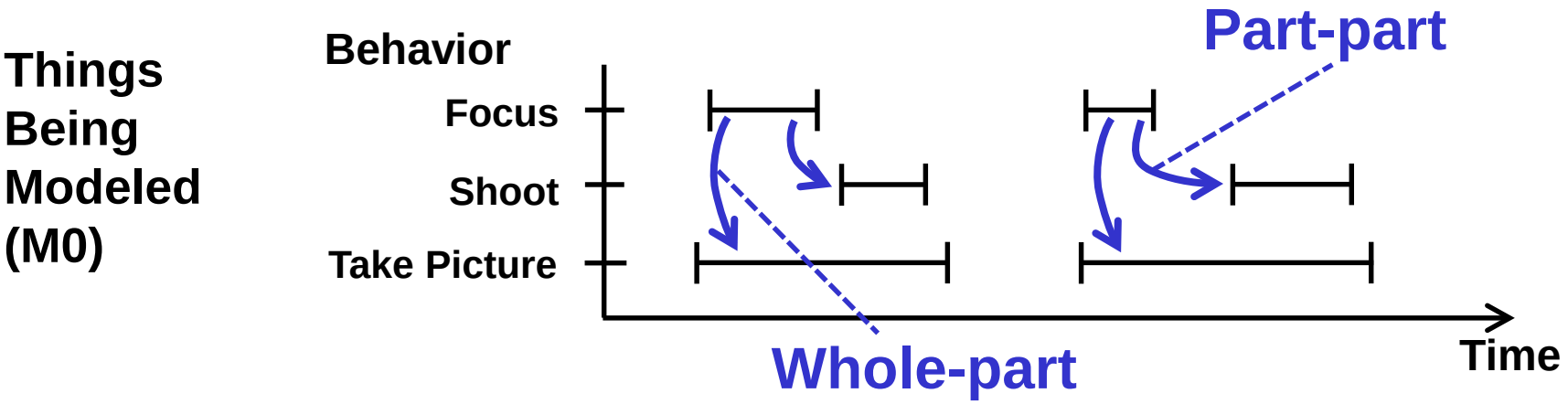
Things Being Modeled (M0)



- **Behavior model "things" happening over time.**
  - **With temporal relations (time constraints) between them.**

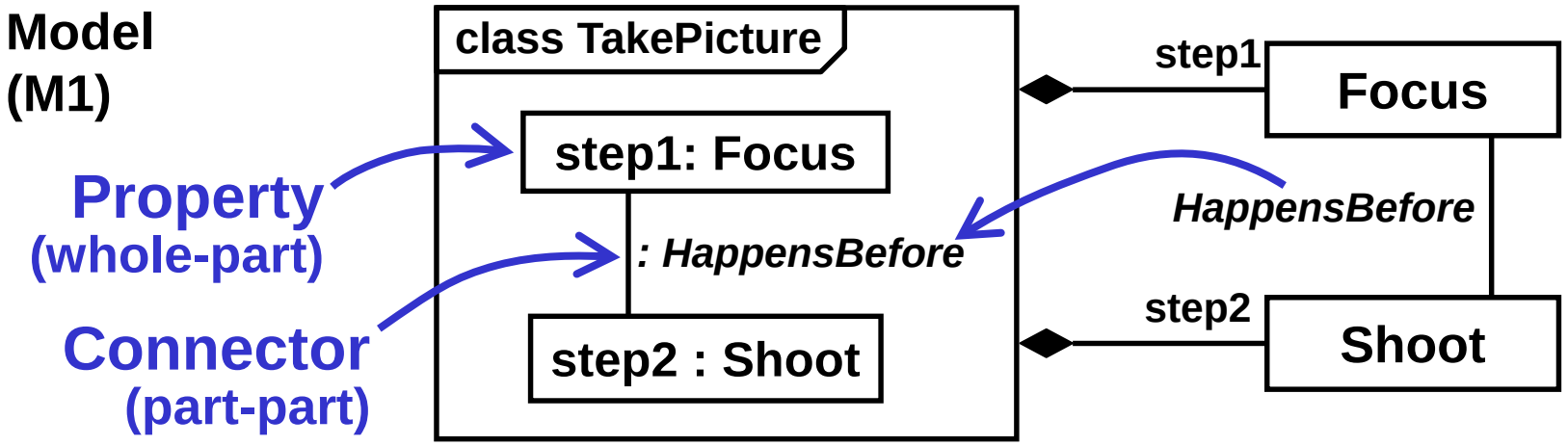
Behavior as Composite Structure

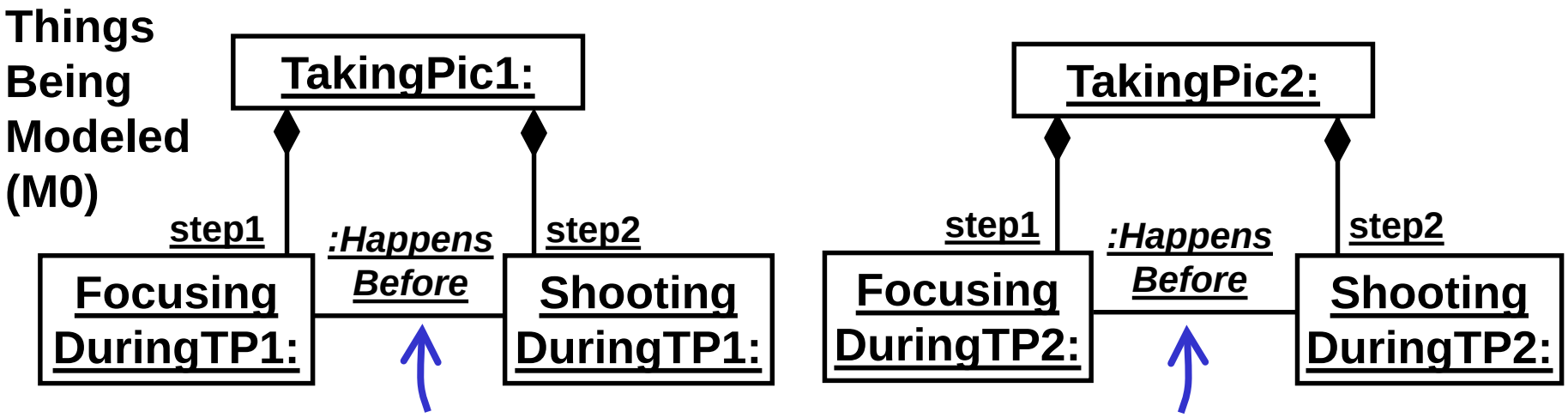




- **Composite structure relations are temporal:**
  - **Whole-part = happens during.**
  - **Part-part = happens before.**

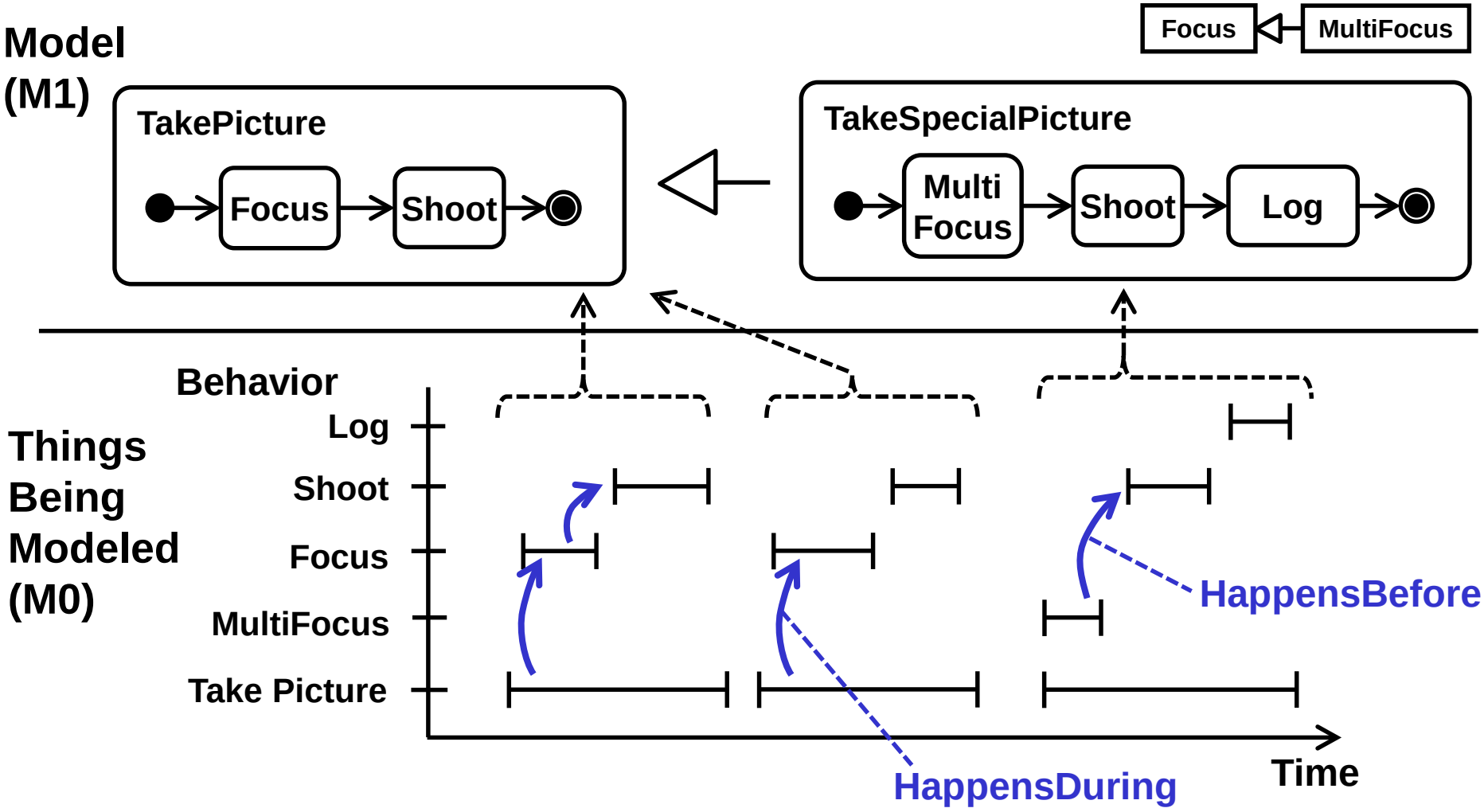
Behavior as Composite Structure





Focusing before shooting in same taking picture

Generalizing Composite Structure



- **Constraints are inherited in UML**
  - **including temporal constraints.**

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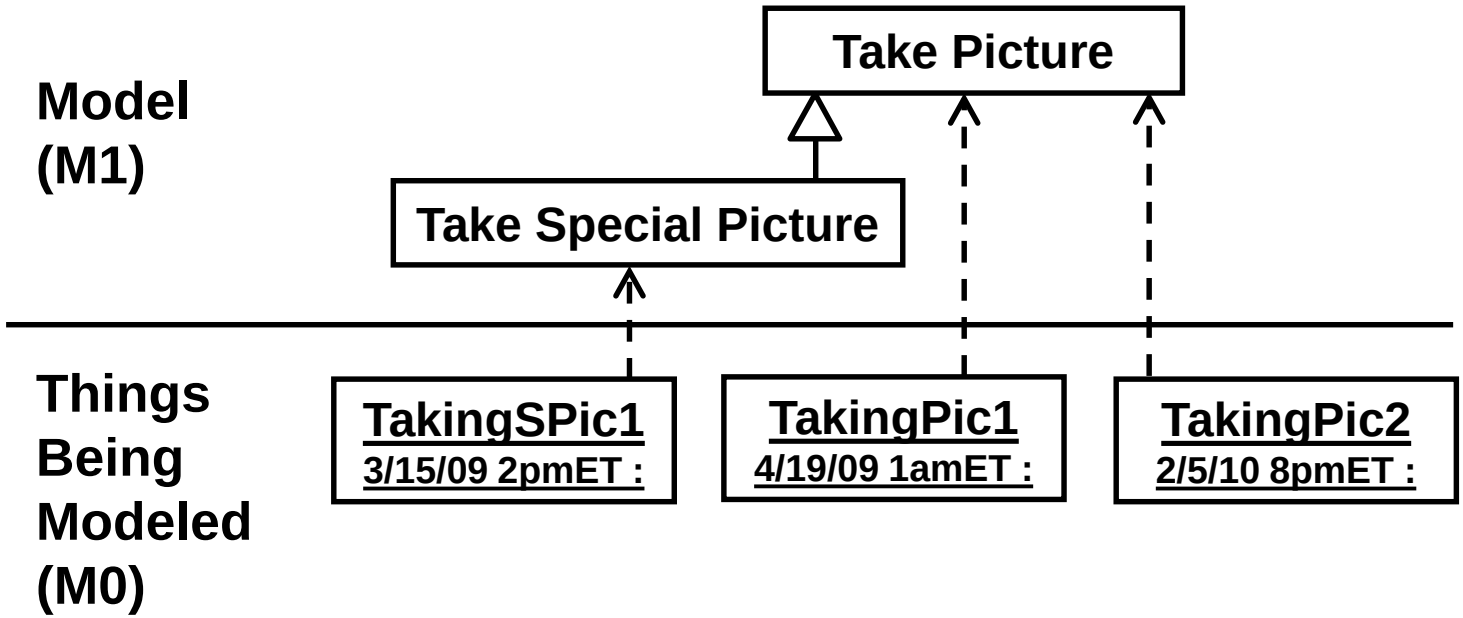
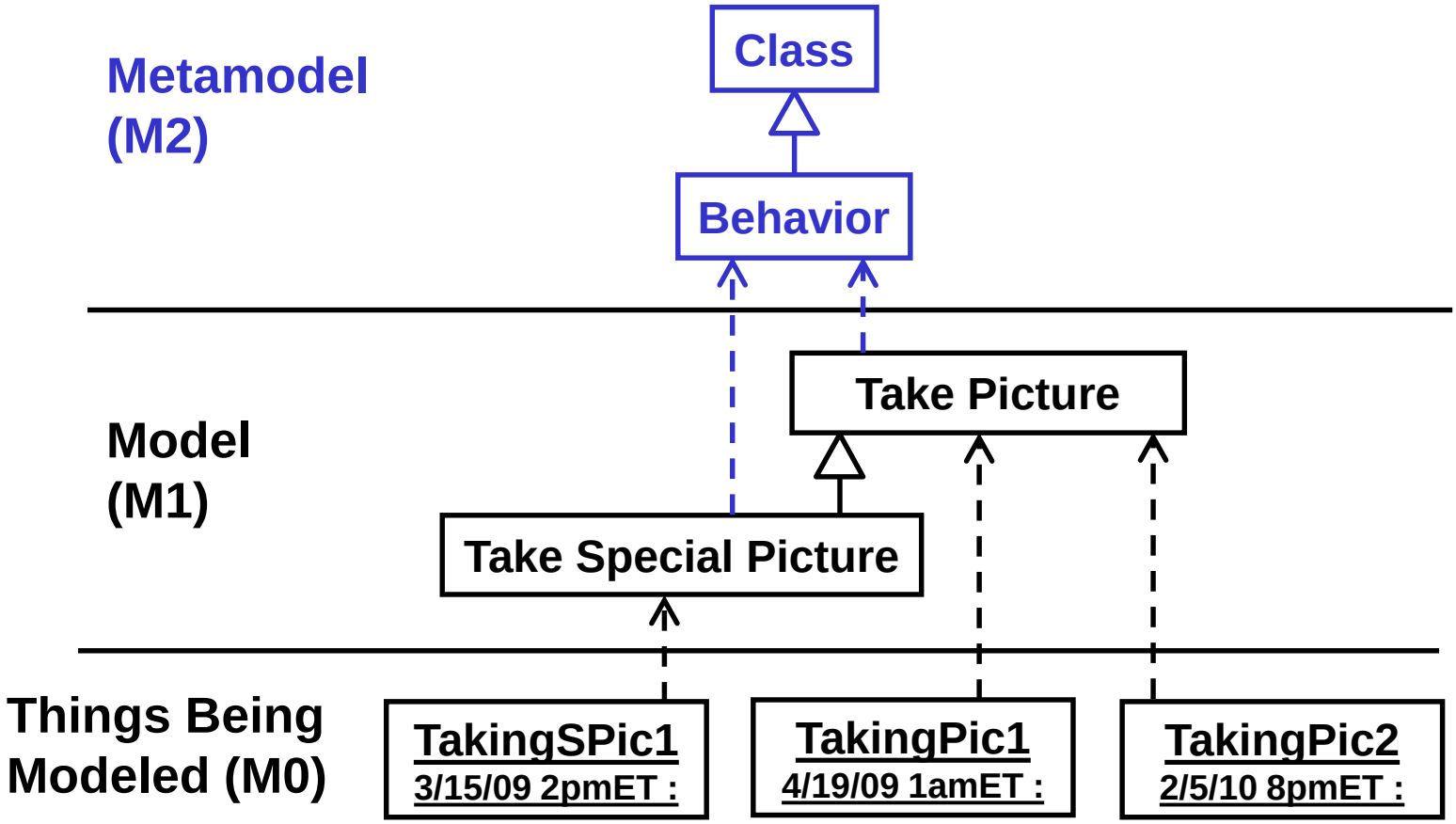
Behaviors are Classes in UML



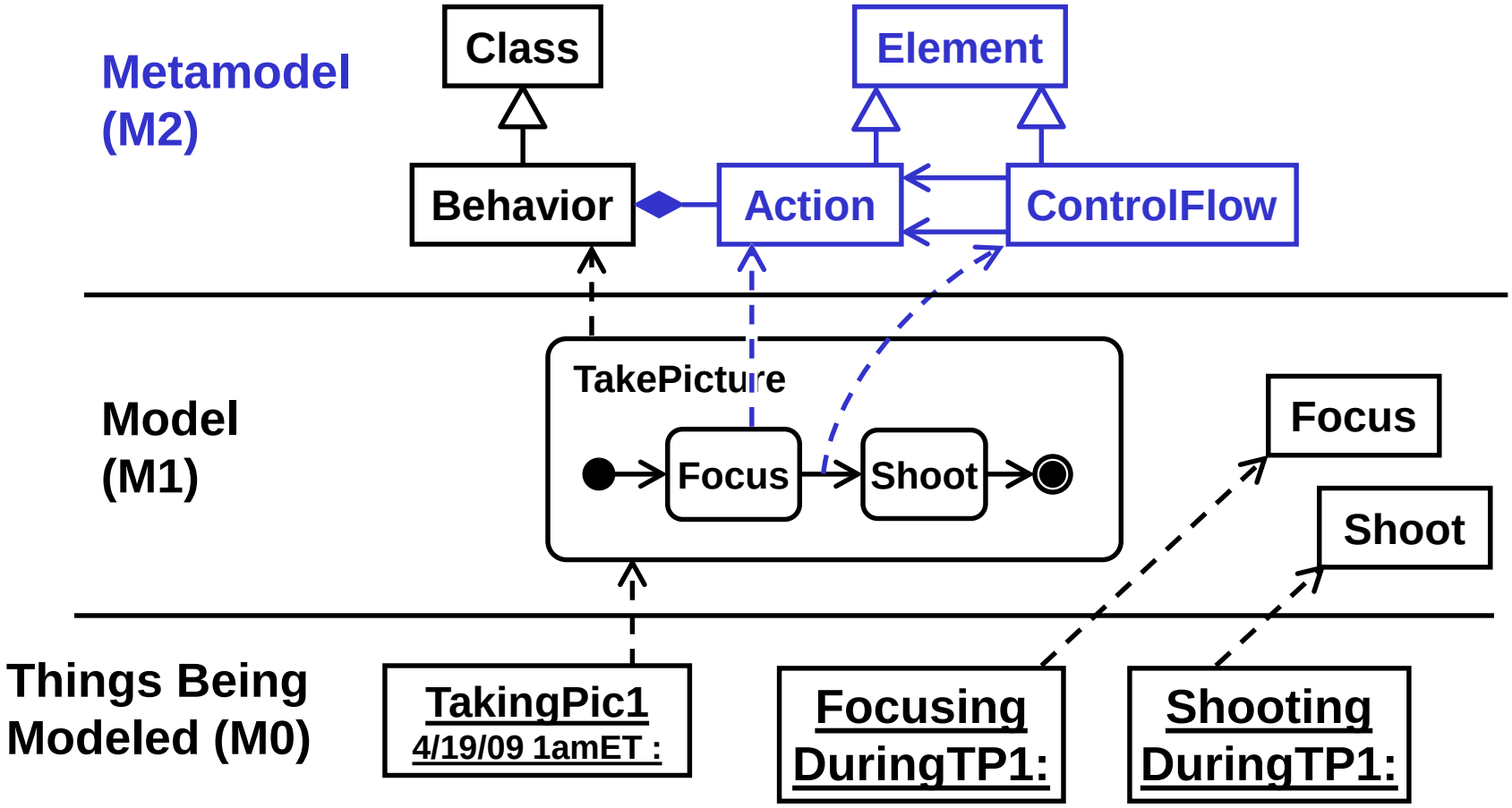
- **Things being modeled are executions (instances) of behavior.**

Behaviors are Classes in UML



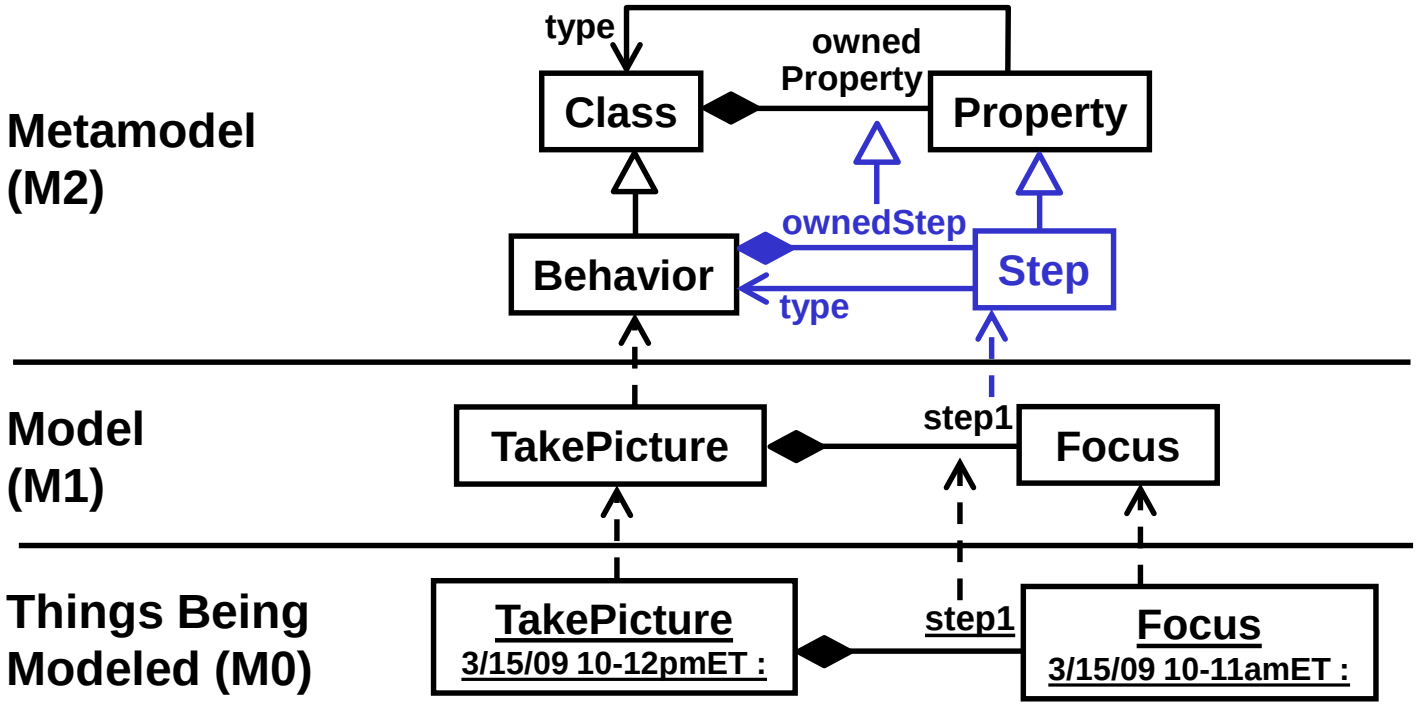
- **Things being modeled are executions (instances) of behavior.**

But No Properties & Connectors



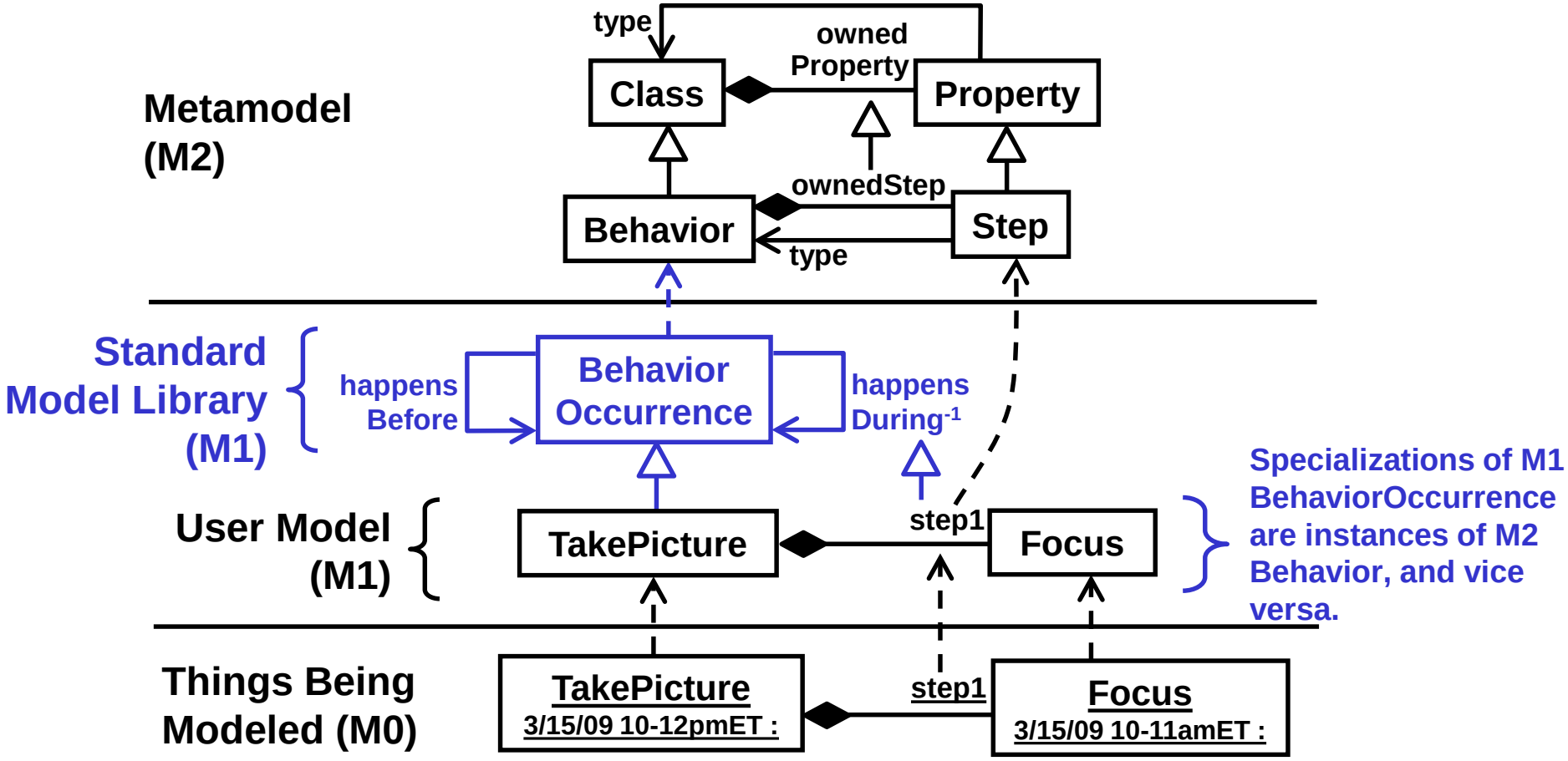
- **No links between things being modeled.**

Whole-part for Behaviors



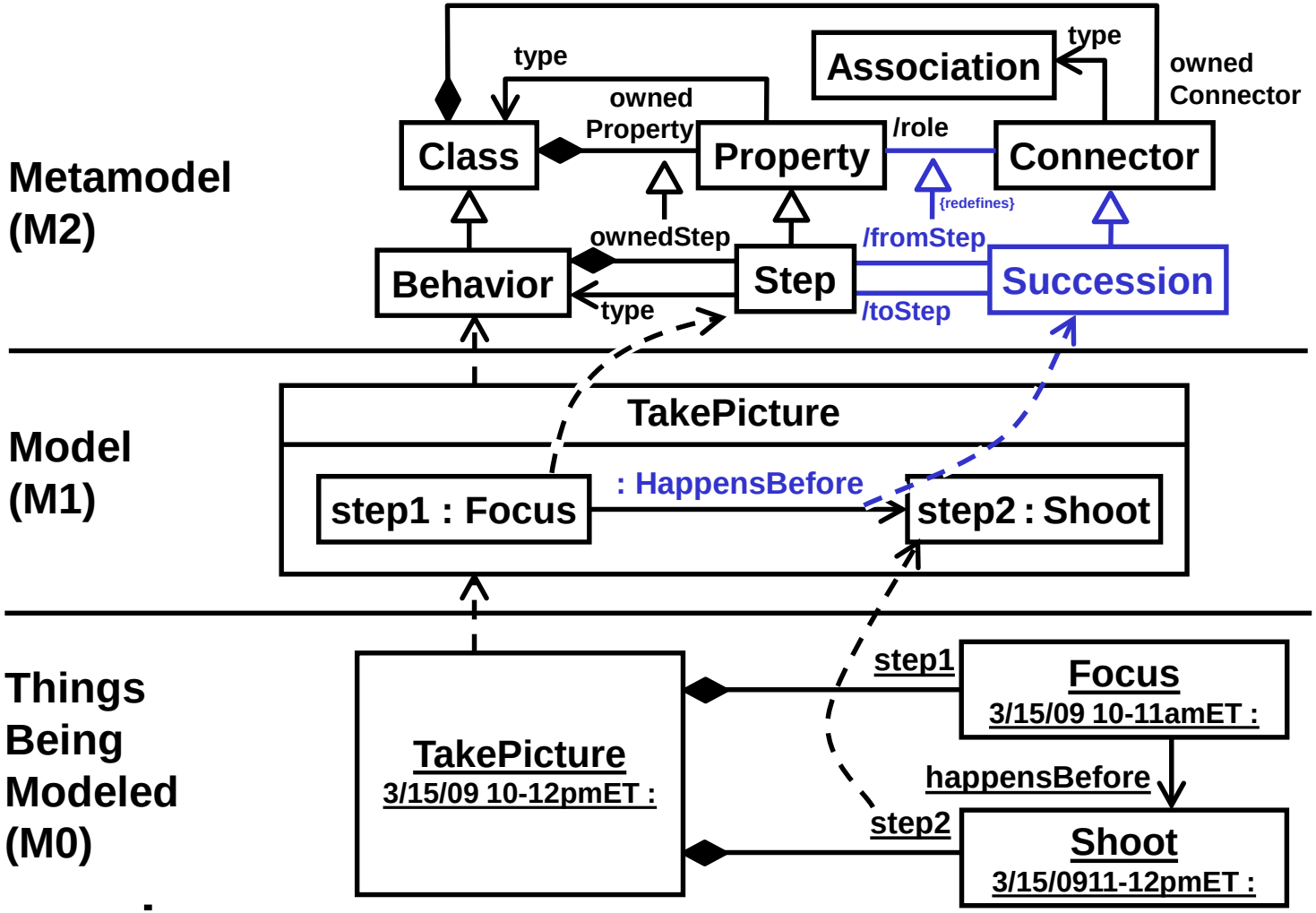
- **Steps:**
  - **Are properties ...**
  - **typed by behaviors at M1…**
  - **that have "suboccurrences" as values at M0.**

Whole-part for Behaviors



- **Steps:**
  - **Are properties ...**
  - **typed by behaviors at M1…**
  - **specialized from happensDuring^{-1} in a standard M1 library…**
  - **that have "suboccurrences" as values at M0.**

Part-part for Behaviors



- **Successions:**
  - Are connectors …
  - typed by happensBefore from a standard M1 library …
  - resulting in links between suboccurrences at M0.

Automated M1 Patterns

- **Such as**
  - **Typing properties by behaviors and …**
  - **… subsetting them from happensDuring^{-1}**
  - **… linking them with connectors typed by HappensBefore.**
- **Specified in a standard M2**
  - **In M2 Step and Succession …**
  - **… using OCL, etc.**
- **Applied at M1 during M2 instantiation …**
  - **… *automatically*.**
  - **Modelers & API users don't need to know.**

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The “O” Word

- **Has many meanings**
  - **Can spend more time defining it than doing it.**
- **Two meanings used here:**
  - **Start with the things being modeled (real, desired, imagined, simulated, etc).**
  - **Group (classify) those things by their commonalities.**

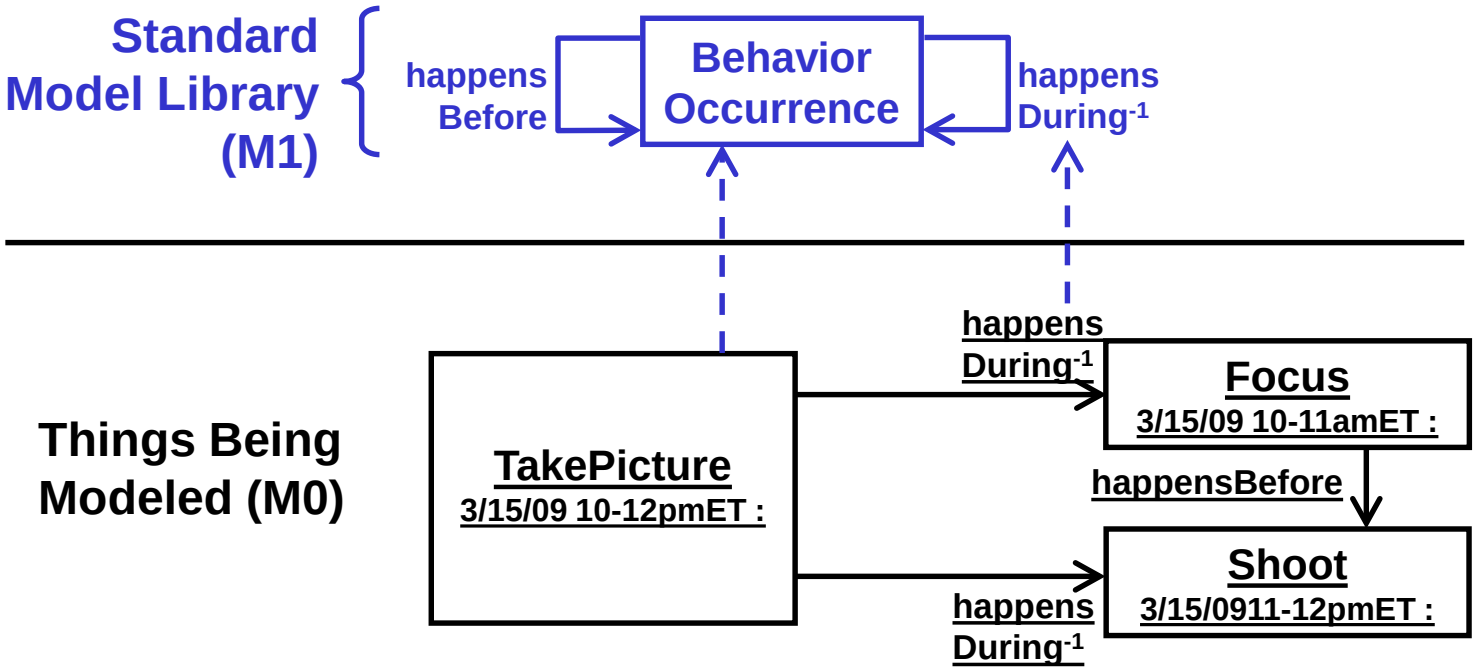
(Onto)Logical Modeling

- **Start with the things being modeled (M0), and works towards a language.**
  - **At OMG we normally start immediately with language (metamodels, M2).**
- **Look for commonalities among the things being modeled**
  - **Build model libraries (M1) capturing commonalities of those (M0) things.**
- **When modeling becomes too repetitive, capture M1 patterns in metamodels.**

Behavior: What's Being Modeled?

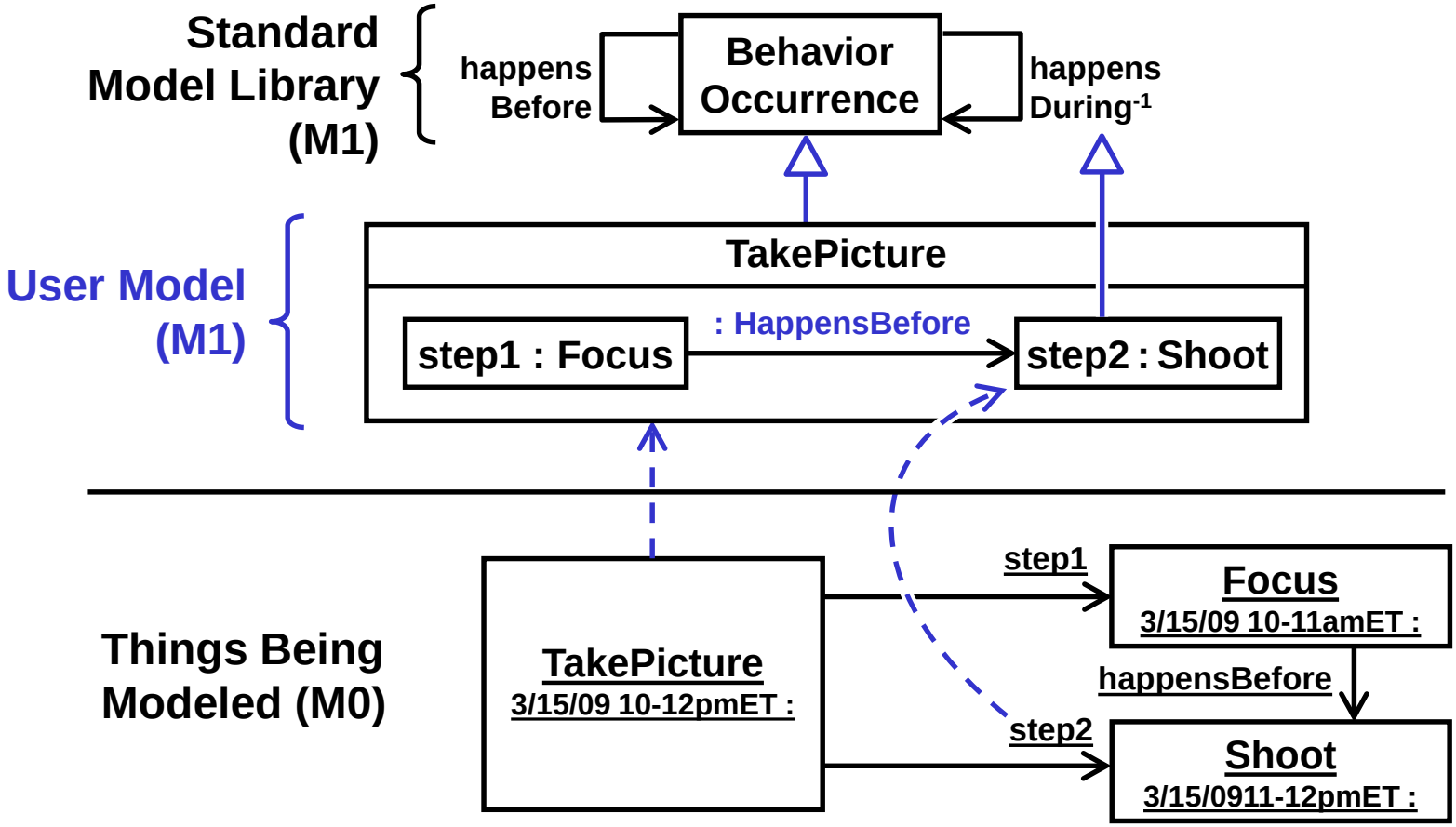
- "Things" that occur in time
  - Eg, taking a picture, focusing, etc.
  - Not "behaviors", "actions", etc.

Behavior: What's in Common?



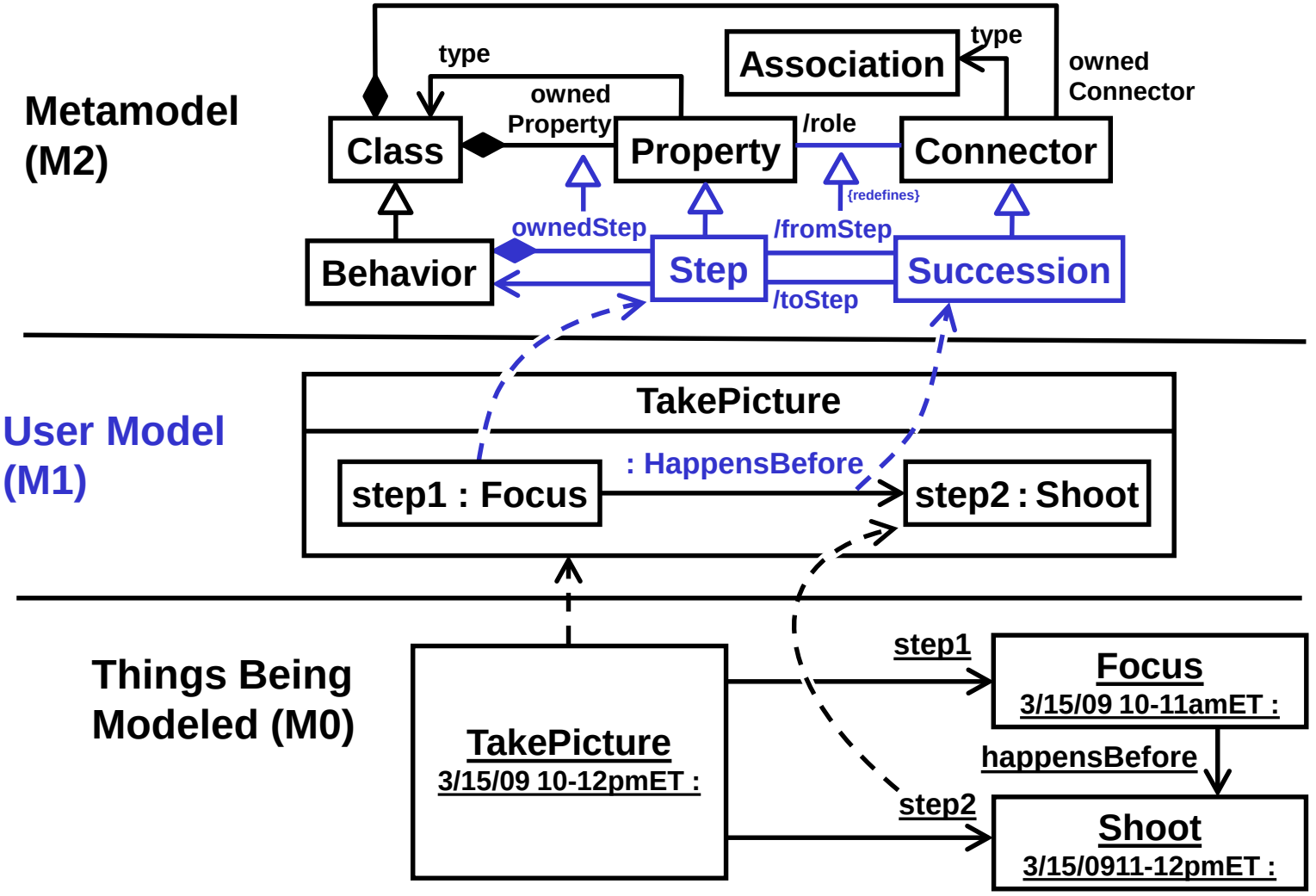
- **They happen before or during each other.**
  - **Construct M1 library for this.**
  - **Use it to classify things being modeled.**

Behavior: Use Library



- **Specialize library classes and subset/redefine library properties.**

Behavior: Too repetitive?



- **Capture M1 patterns in M2 elements.**
  - **Tools apply patterns automatically.**

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- **Unify UML's three behavior models with**
  - **Composite structure.**
  - **Model library for temporal relations.**
  - **Metamodel elements capturing patterns of using library, applied automatically.**
- **Simplifies metamodel with**
  - **More common behavior elements, fewer specializations.**
  - **Standard model library.**
- **Speeds learning and analysis integration.**

More Information

- **Additional slides**
  - **Starts with onto, includes interactions.**
  - **http://conradbock.org/bock-ontological-behavior-modeling-jpl-slides.pdf**
- **Paper: http://dx.doi.org/10.5381/jot.2011.10.1.a3**
- **Application to BPMN:http://conradbock.org/#BPDM**
- **KerML:**
  - **Contact Chas Galey charles.e.galey@lmco.com**