Mapping **ontology** with **probabilistic relational models**: an application to *transformation processes*

C. Manfredotti[1], C. Baudrit[2], J. Dibie-Barthélemy[1], P-H. Wuillemin[3]

[1]INRA AgroParisTech, Paris, FR,

[2]INRA IMIT, Bordeaux, FR,

[3]Sorbonne Universites, UPMC, CNRS, LIP6, Paris, FR

Motivation

Reasoning   about   Transformation processes

- Prediction
- Diagnose
- Control
- Suggestion

- Microorganisms production
- Stabilization processes
- Biological experiments
- Chemical experiments
- …

cooking recipe: well known transformation process

A recipe:

Aunt lila's snowball cookies
Ingredients:
- ½ lb Butter
- 2c grounded Nuts
- 2c all purpose Flour
- 4 tb Sugar
- 2 ts Vanilla
- to roll Powdered Sugar

Preparation:
- Preheat oven to 350 degrees
- Cream sugar and butter until fluffy
- Add vanilla and nuts
- To this add flour gradually
- Roll into small balls
- Place on baking sheet
- Bake 15 to 20 min
- Roll baked balls in powdered sugar while still warm

http://wikitaaable.loria.fr/index.php/Aunt_lila%27s_snowball_cookies

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Desiderata

Reasoning about a transformation process taking into account:

- Its <u>complexity</u>: multiple concepts related to each other (*operations, products, devices*)

- Its <u>dynamicity</u>: sequence of "chained" (often long) operations
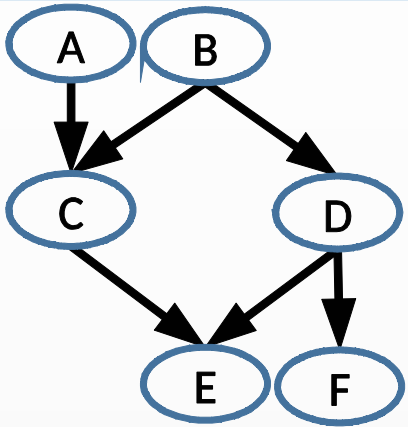
- Its <u>uncertainty</u>

Our ontology

- Extends SUMO
- Borrows from WTC
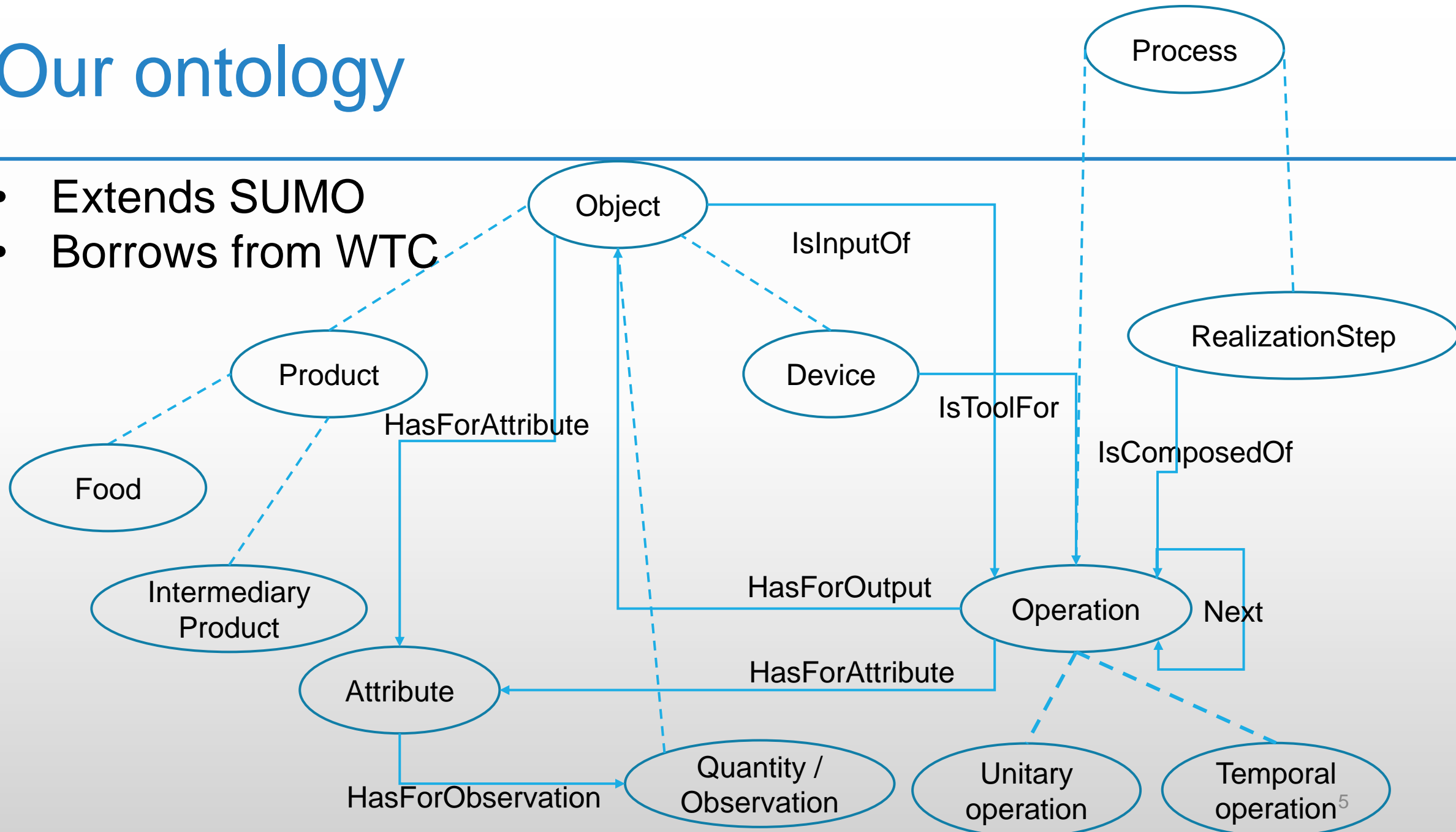
Recipe preparation graph
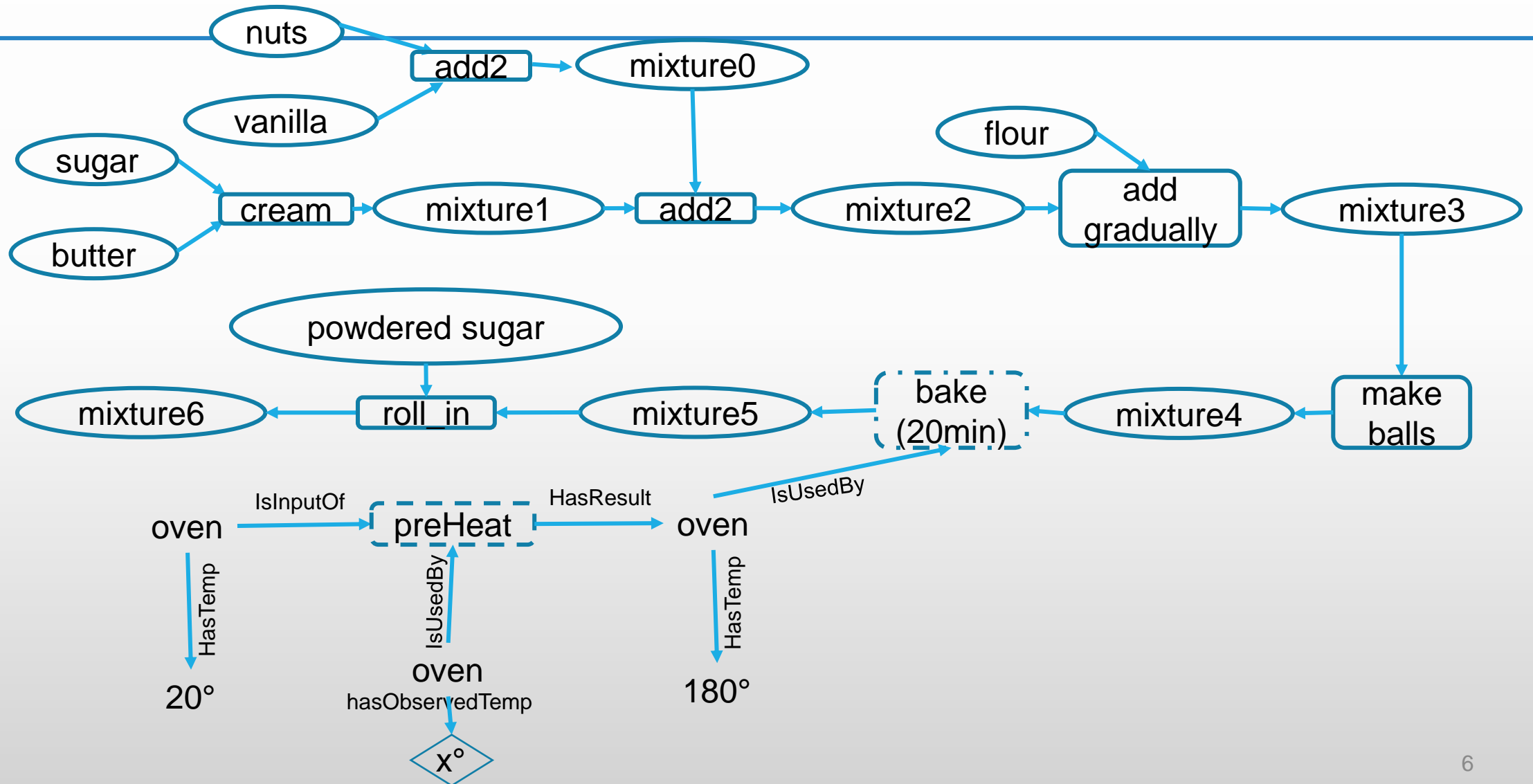
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- Its <u>uncertainty</u>

  → We map the ontology with a PRM
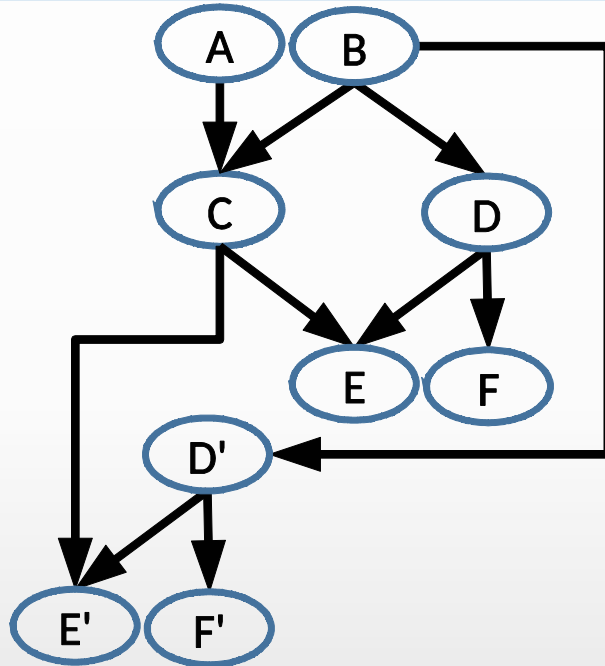
Bayesian Networks
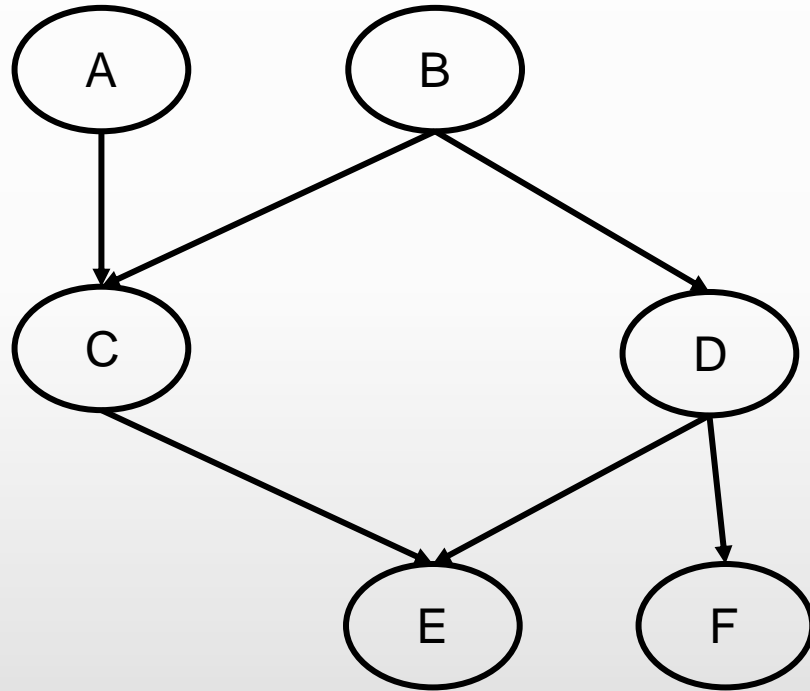
1. Quantify uncertainty over the domain with probability

2. Represent the domain with a set of variables

3. Express the full joint probability distribution of the variables in a smart way using conditional probability (in)dependence

Probabilistic Relational Models[*]

Bayesian Network

PRMs extend BN with a relational structure between (potentially repeated) fragments of BN called classes.

Class: DAG over a set of inner attributes and a set of outer attributes from other classes referenced by reference slots
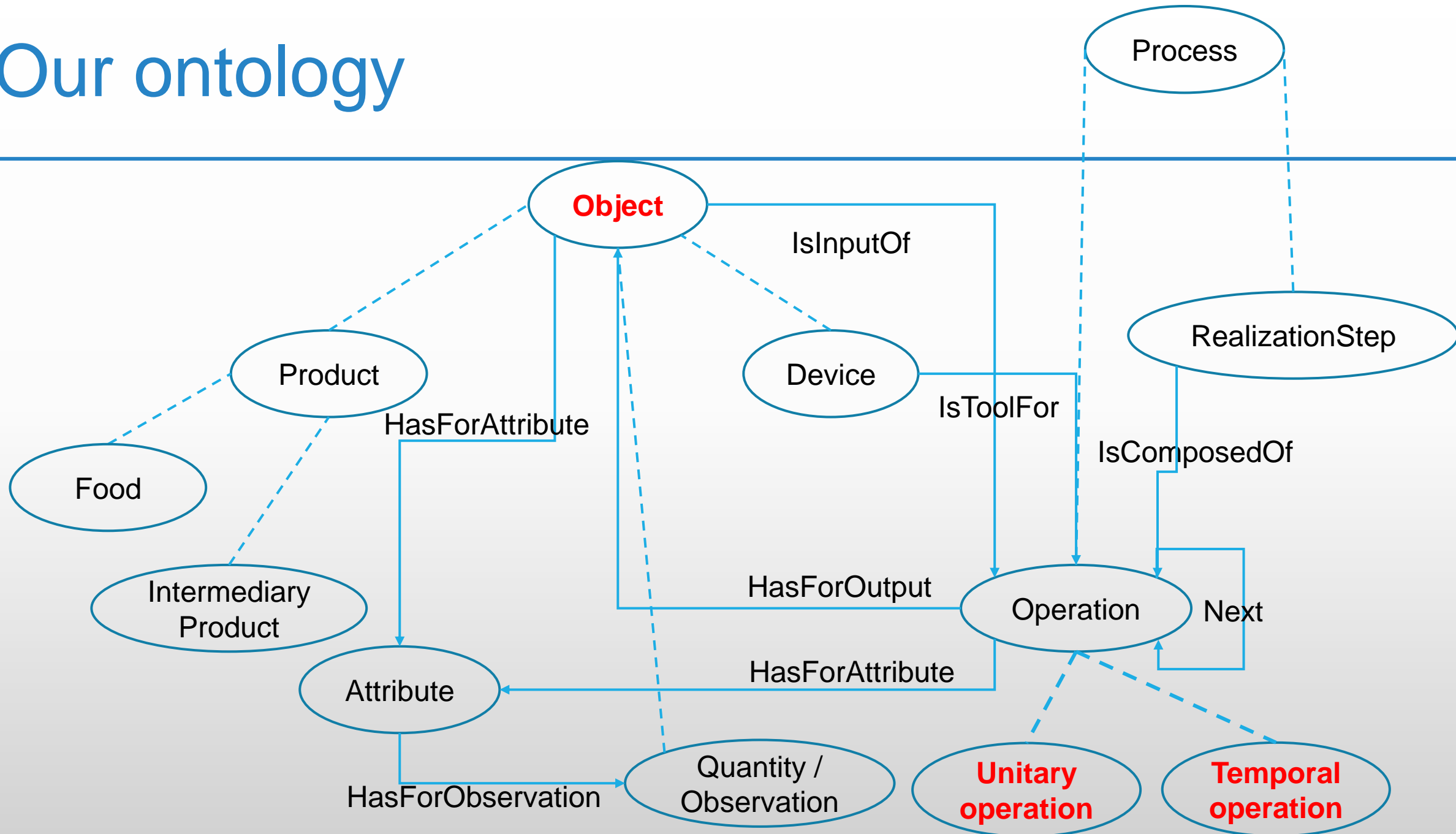
Relational schema: a set of classes, associated with attributes and reference slots .

Slot chain: a sequence of reference slots, allows to put in relation attributes of objects that are indirectly related.

* Nir Friedman, Lise Getoor, Daphne Koller, Avi Pfeffer: Learning Probabilistic Relational Models. IJCAI 1999: 1300-1309
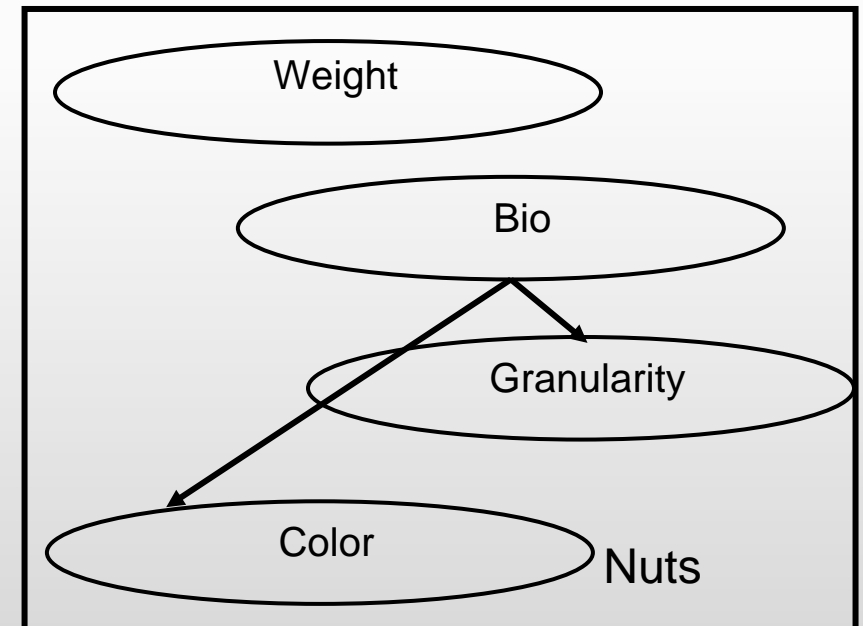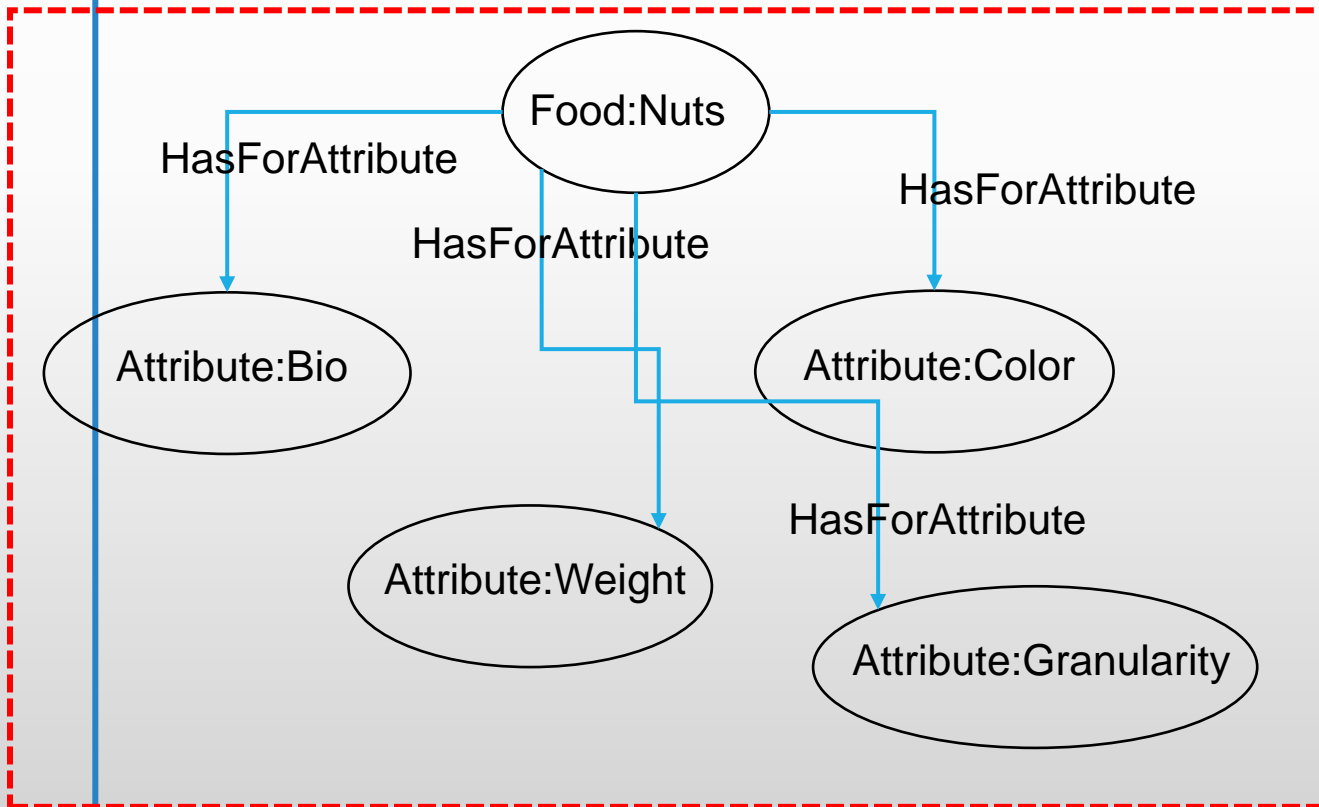
Our ontology

Mapping Object

We map the concept object and its sub-concepts product, device and observation into a class (*class object*).
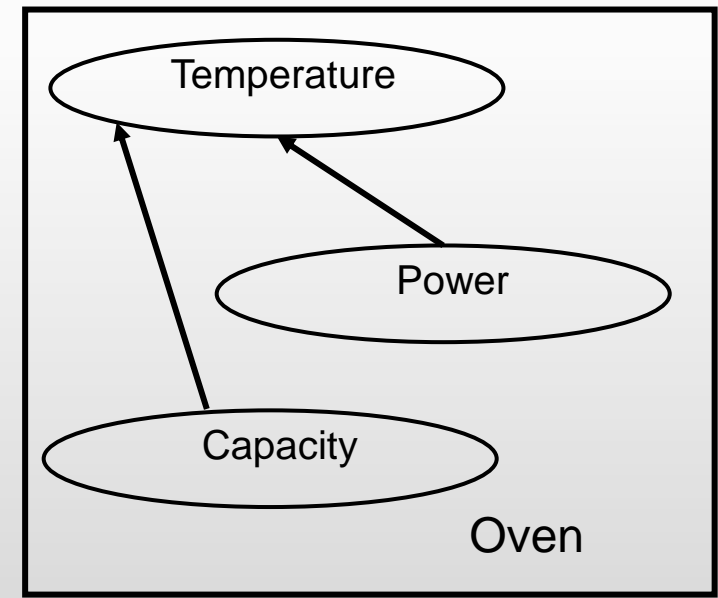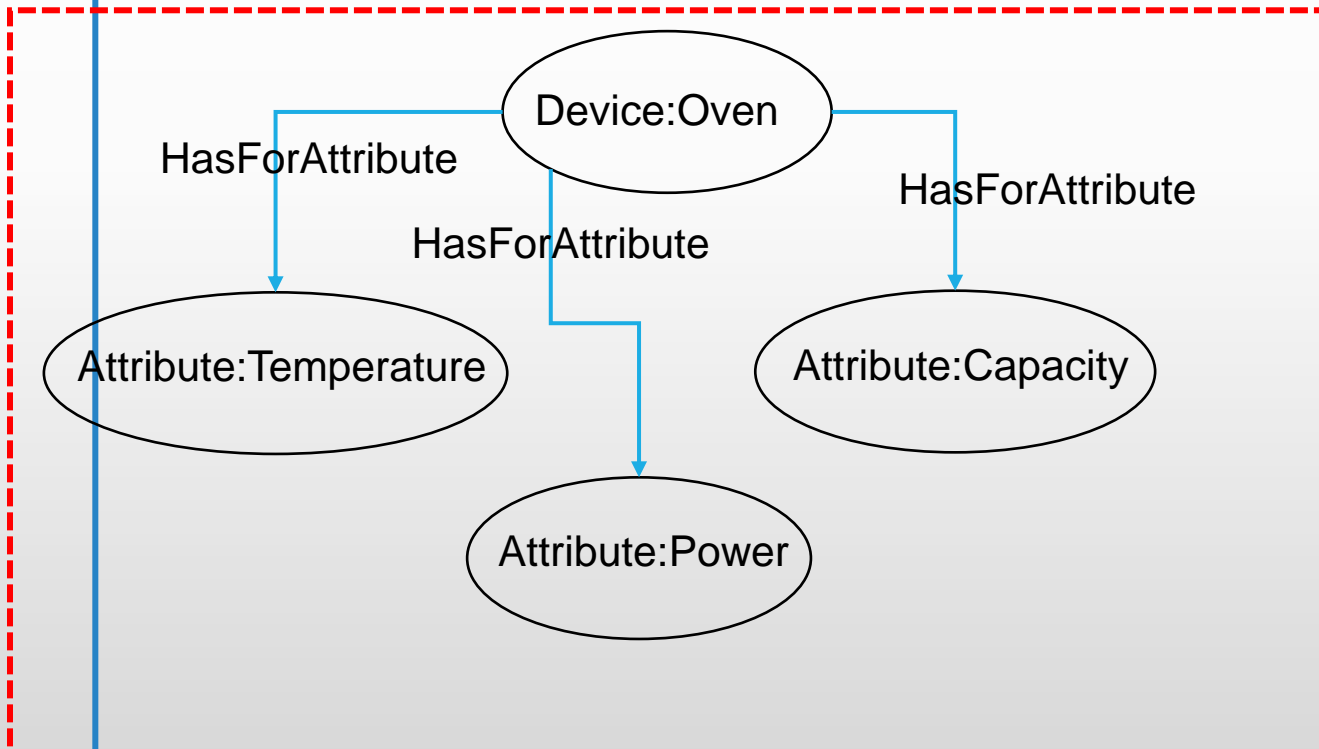
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Mapping Unitary Operation

We propose to represent the concept **unitary operation** by the *class operation*:

(1) a DAG over

- the reference slots to access to the properties of the classes mapping the input and the device object(s) of the operation
- an attribute for each property of the operation
- the attributes representing the properties of the output object(s) of the operation;

(2) a probability distribution over the attributes representing the properties of the output object(s) given the values of the attributes of the input and the device objects.

Mapping Unitary Operation: an example
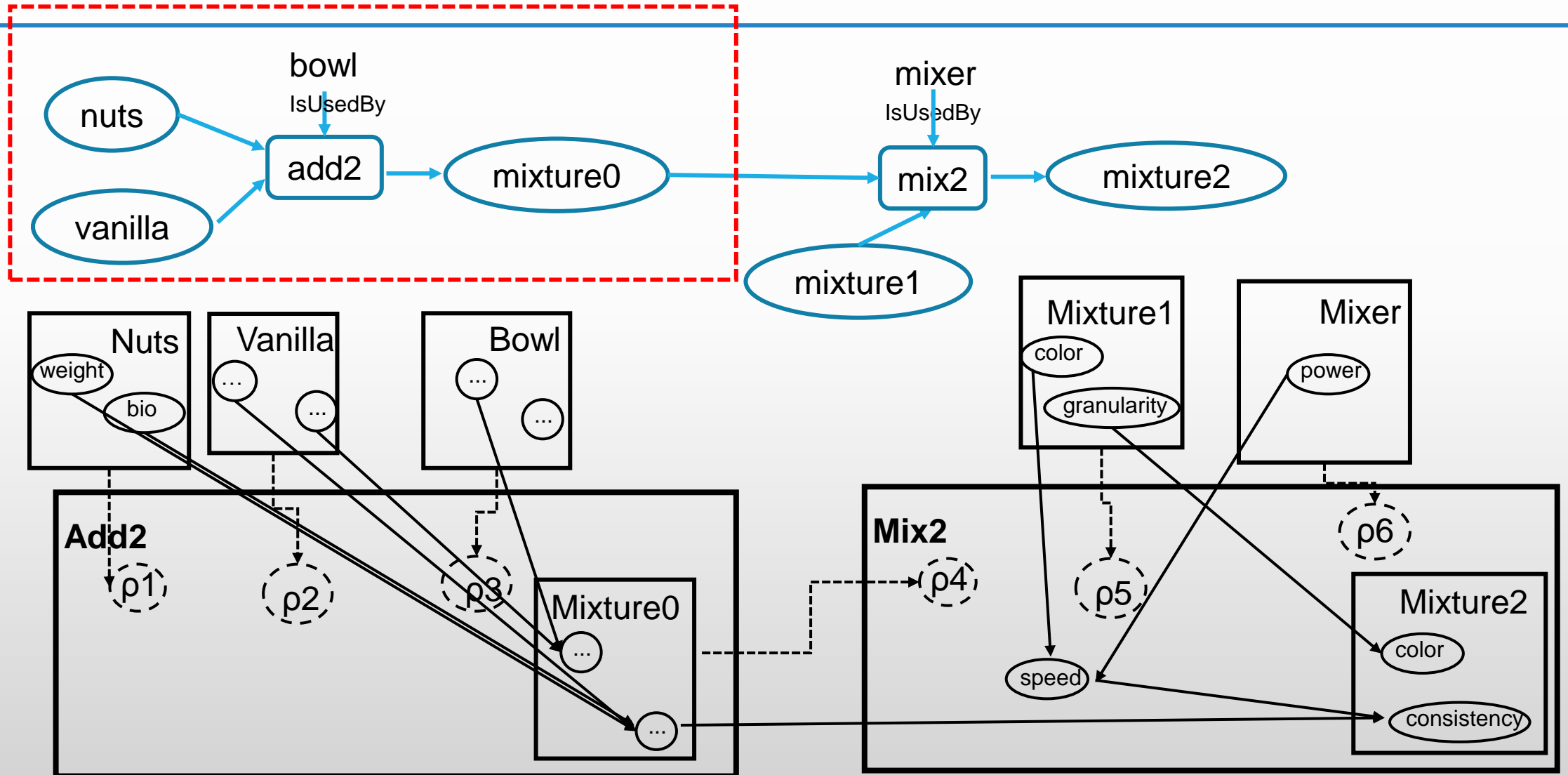
Mapping Temporal Operation

A *temporal operation class* maps a **temporal operation** as a pair of classes operation with a reference slot among them:

- one ($operation_0$) representing the dependencies between variables at the beginning of the operation and

- another ($operation_{->}$) representing the dependencies from the generic instant of time i to the next instant i+1, with a reference slot to itself.

Mapping Temporal Operation (ctd.)
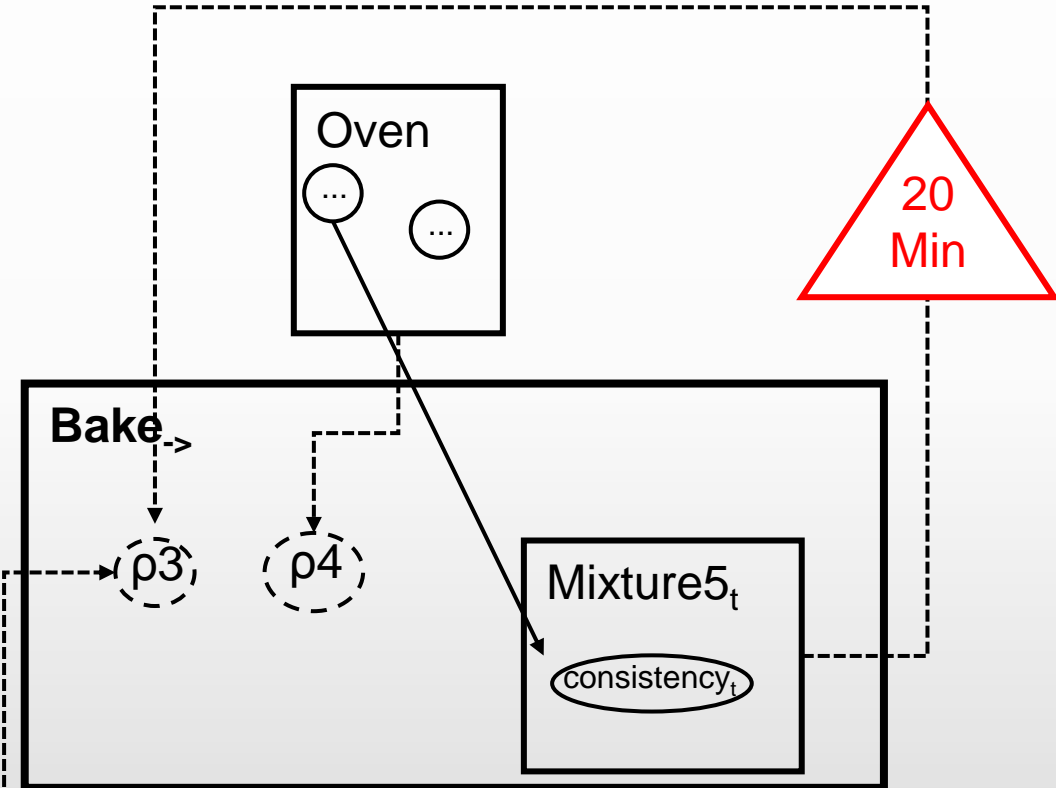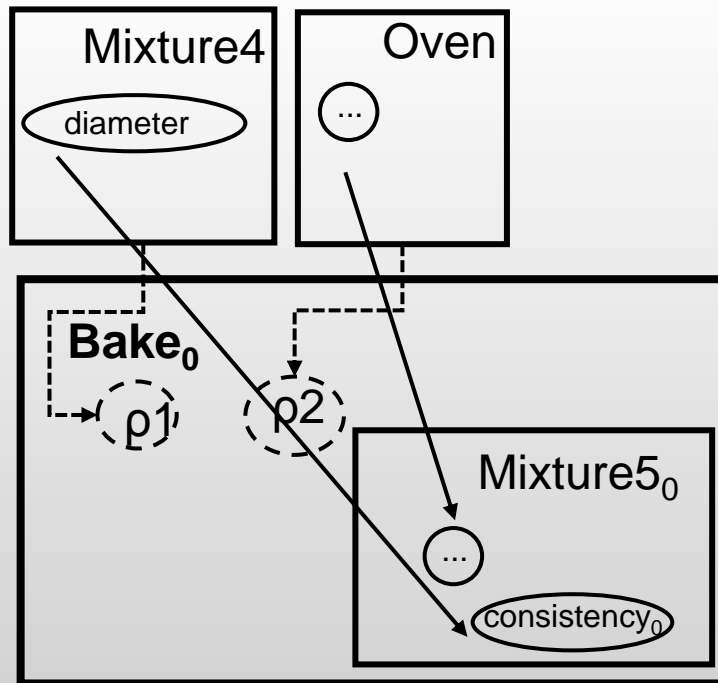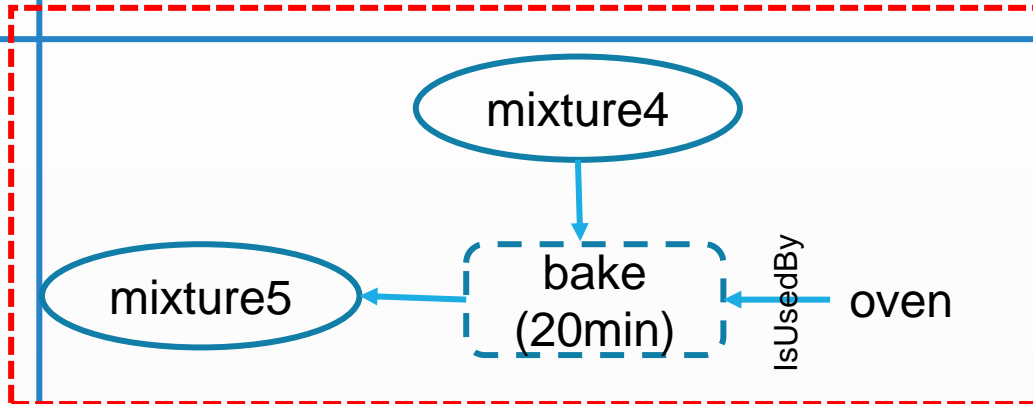
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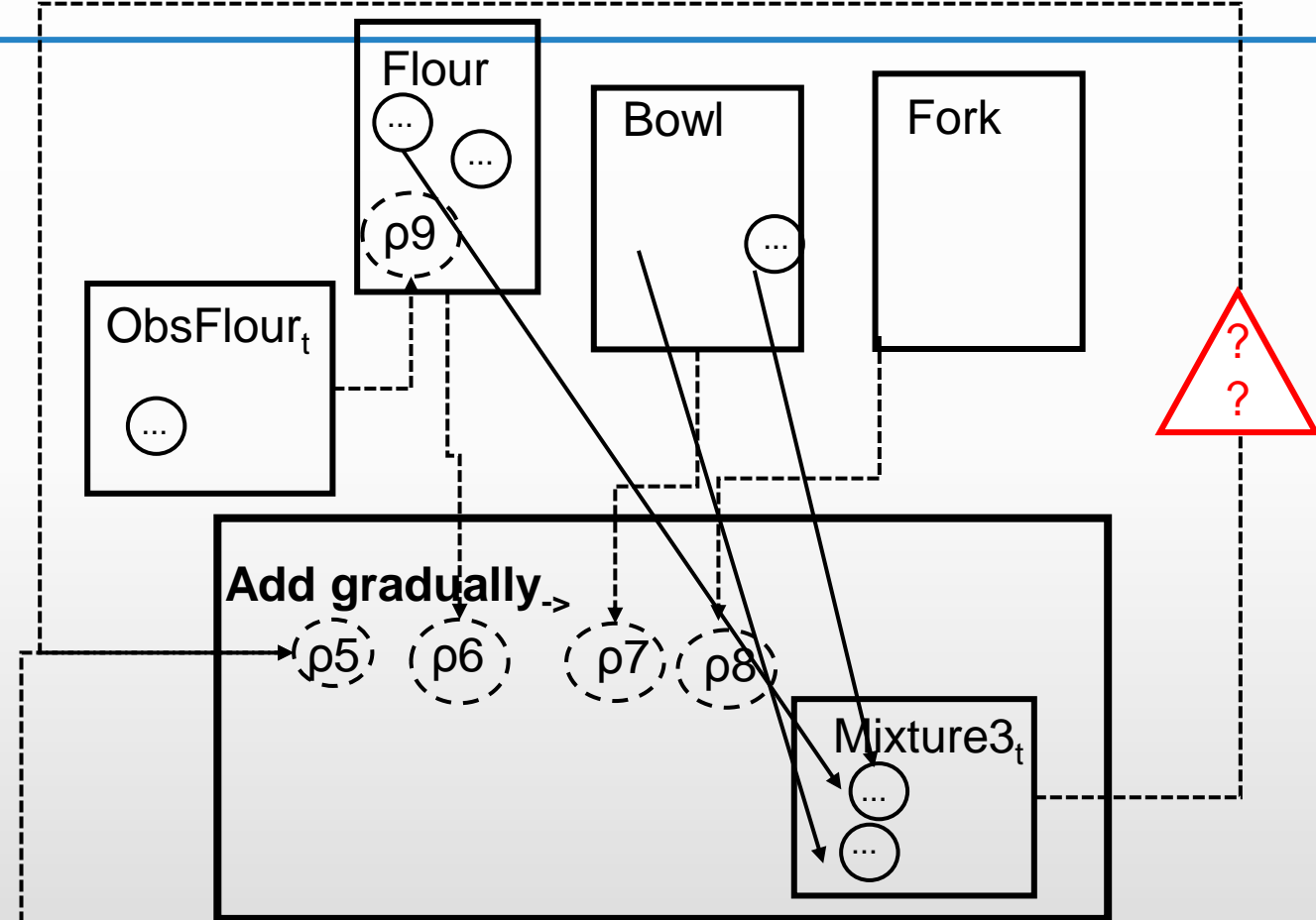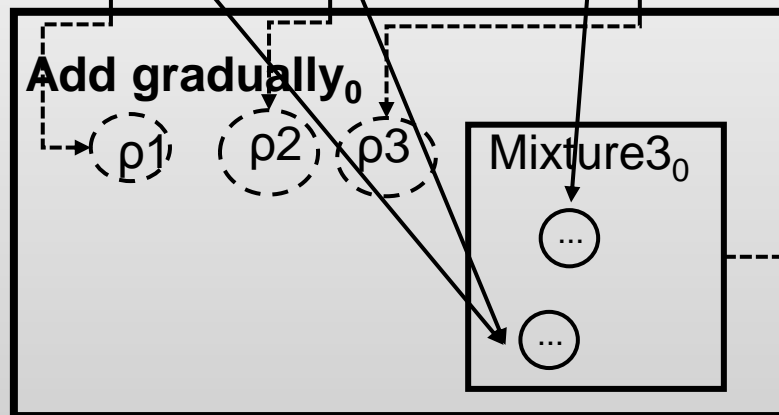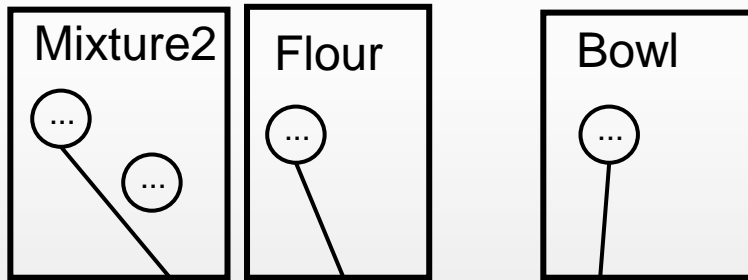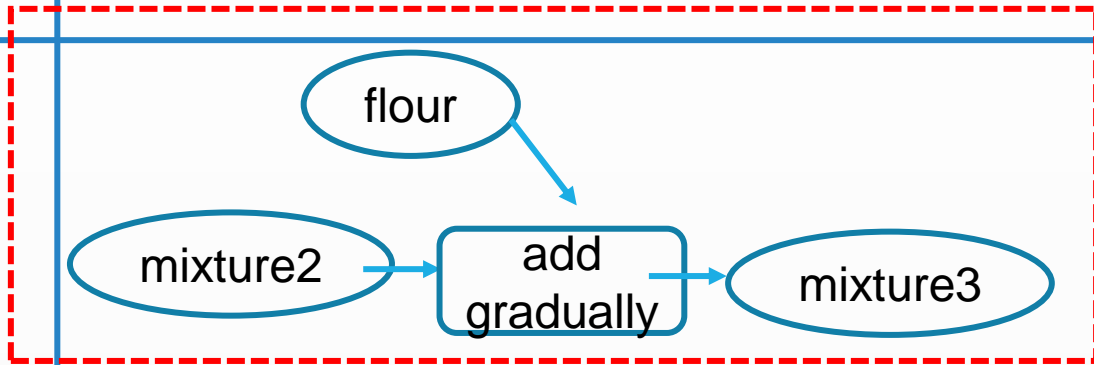
Concluding

Ontology for transformation processes ➡ PRMs relational schema

The two formalisms benefit from each other:

1. More precise ontology

   Adding one of ten products **doesn't matter** to the ontology

   Having one or ten children **matters** for the PRM

   Our ontology takes this into account (difficulty of the recipe)

2. Easier PRM learning

   Learning a PRM provided the relational schema obtained from the ontology is easier than learning the entire PRM from data with no additional info

Concluding

Ontology for transformation processes ➡ PRMs relational schema

Future works:

- Couple mapping with parameters learning

  ➡ *prediction*, *diagnose*, *control* and *suggestion*

- Microorganisms production and stabilization processes