A process reverse engineering approach using the Process and Observation Ontology and Probabilistic Relational Models

Application to composite food packaging

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Problem

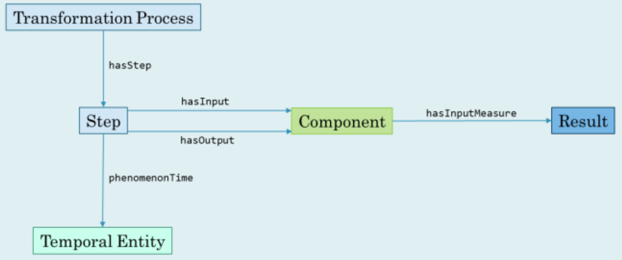
Expert Knowledge

Experimental Data

Expert interviews

Expert Query

Ontology

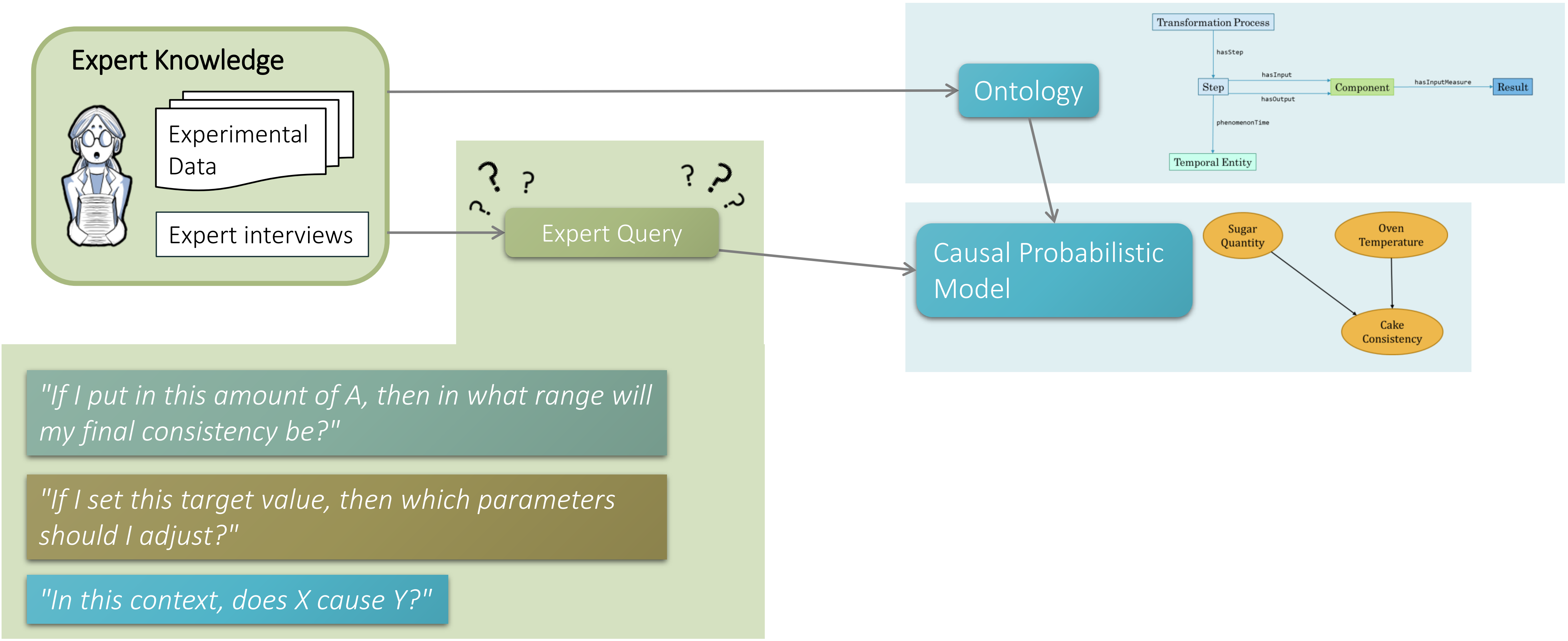


"If I put in this amount of A, then in what range will my final consistency be?"

"If I set this target value, then which parameters should I adjust?"

"In this context, does X cause Y?"

Problem


Expert Knowledge
Experimental Data
Expert interviews
Ontology
Transformation Process
hasStep
Step
hasInput
hasOutput
Component
hasInputMeasure
Result
phenomenonTime
Temporal Entity
Expert Query
Causal Probabilistic Model
Sugar Quantity
Oven Temperature
Cake Consistency
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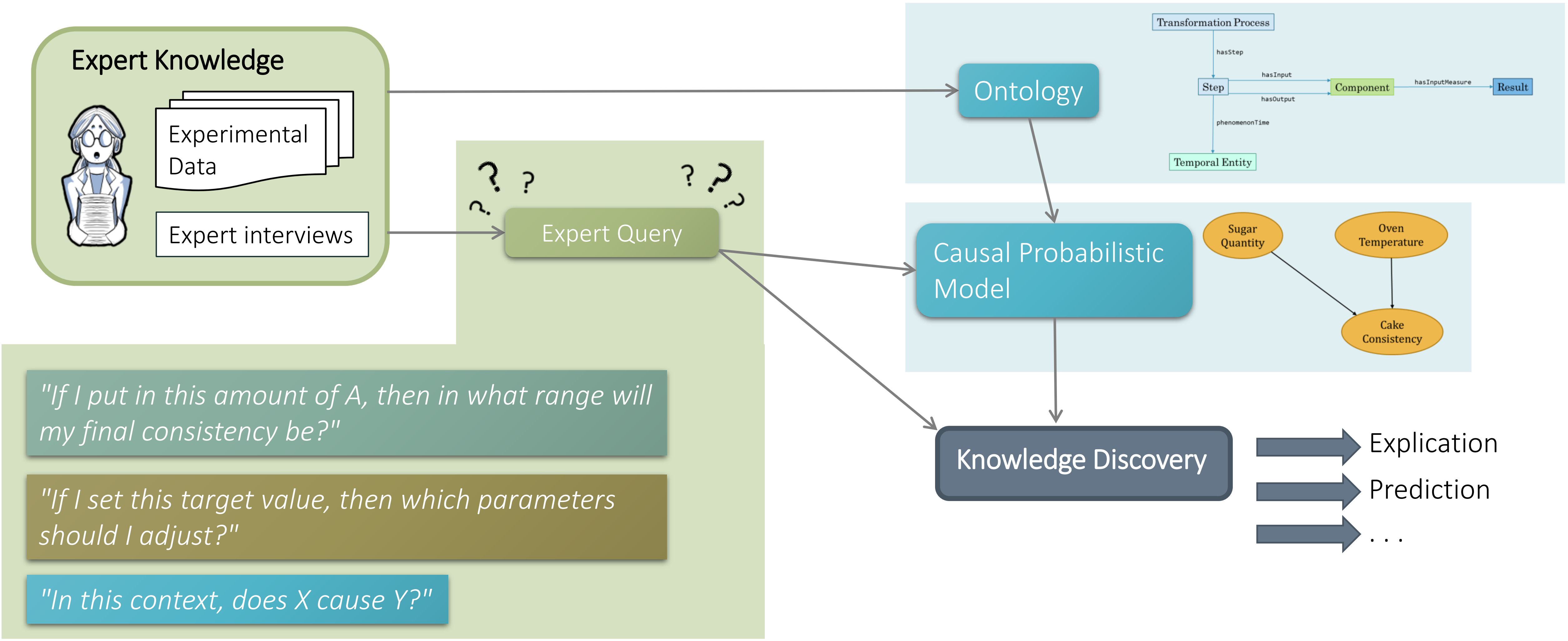
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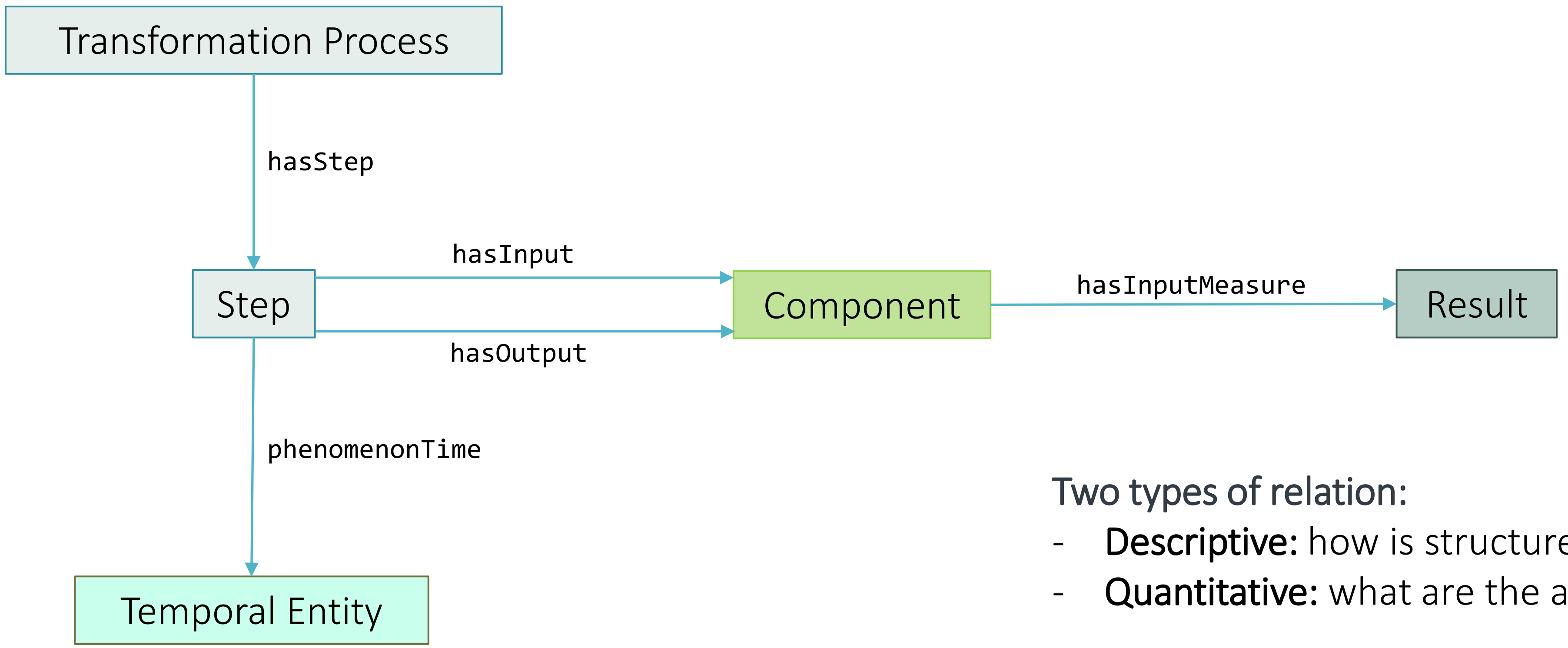
Knowledge Discovery
Explication
Prediction
. . .

Process and Observation Ontology



Two types of relation:
- **Descriptive:** how is structured the process
- **Quantitative:** what are the associated values

→ Cannot deal with complex uncertain reasonning

http://quantum.agroparistech.fr/PO2/

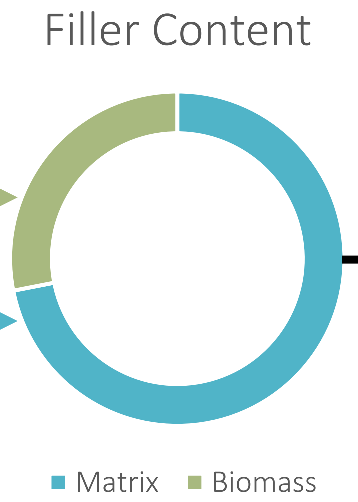
Application to composite food packaging

Biomass *Urban parc wastes, vine shoot fibers, …*

Cacteristics:
- Composition
- Granulometry

Matrix

Cacteristics:
- Permeability
- Mechanical
- Thermodynamic
- Calorimetric



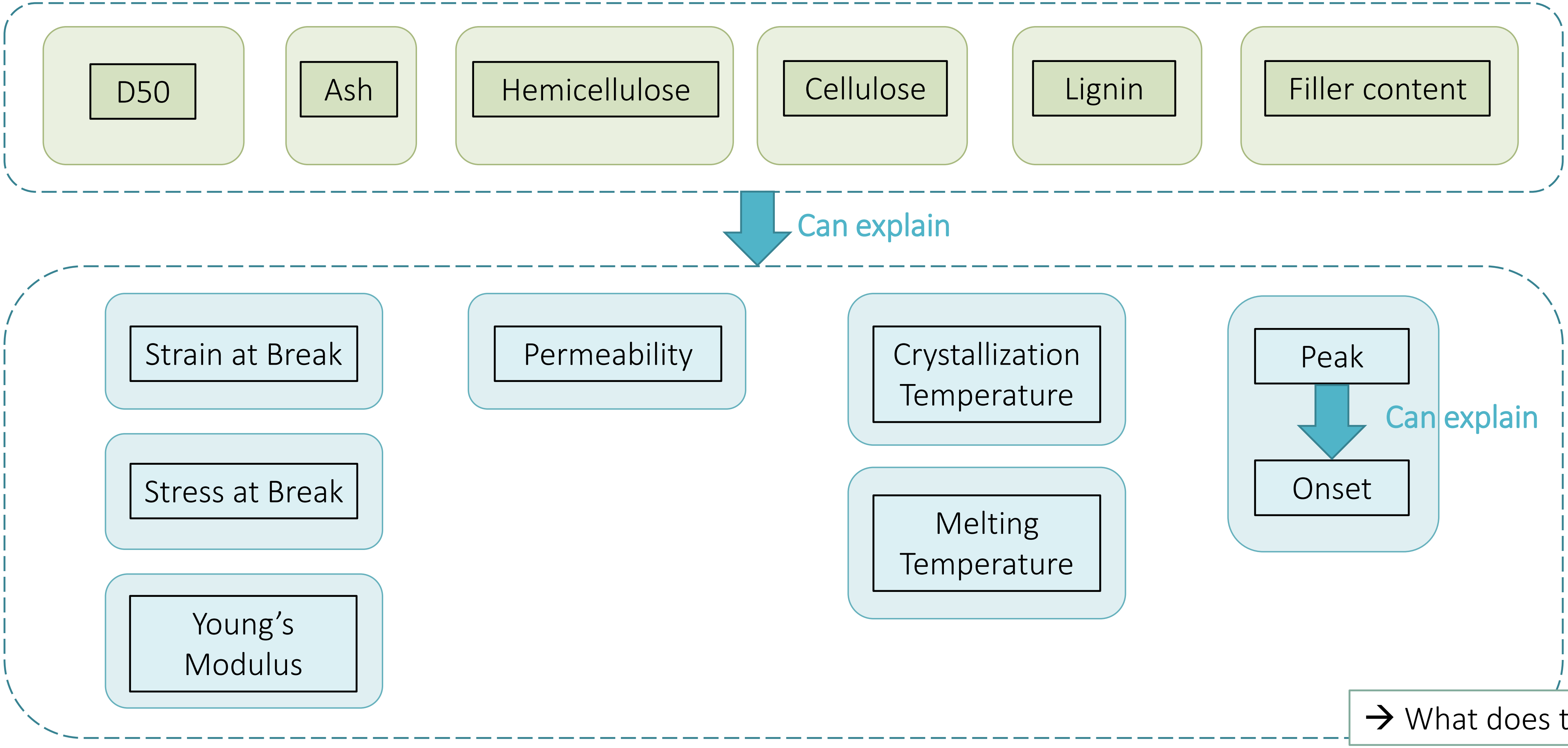
Packaging

Cacteristics:
- Permeability
- Mecanical
- Thermodynamic
- Calorimetric

→ 81 experiments

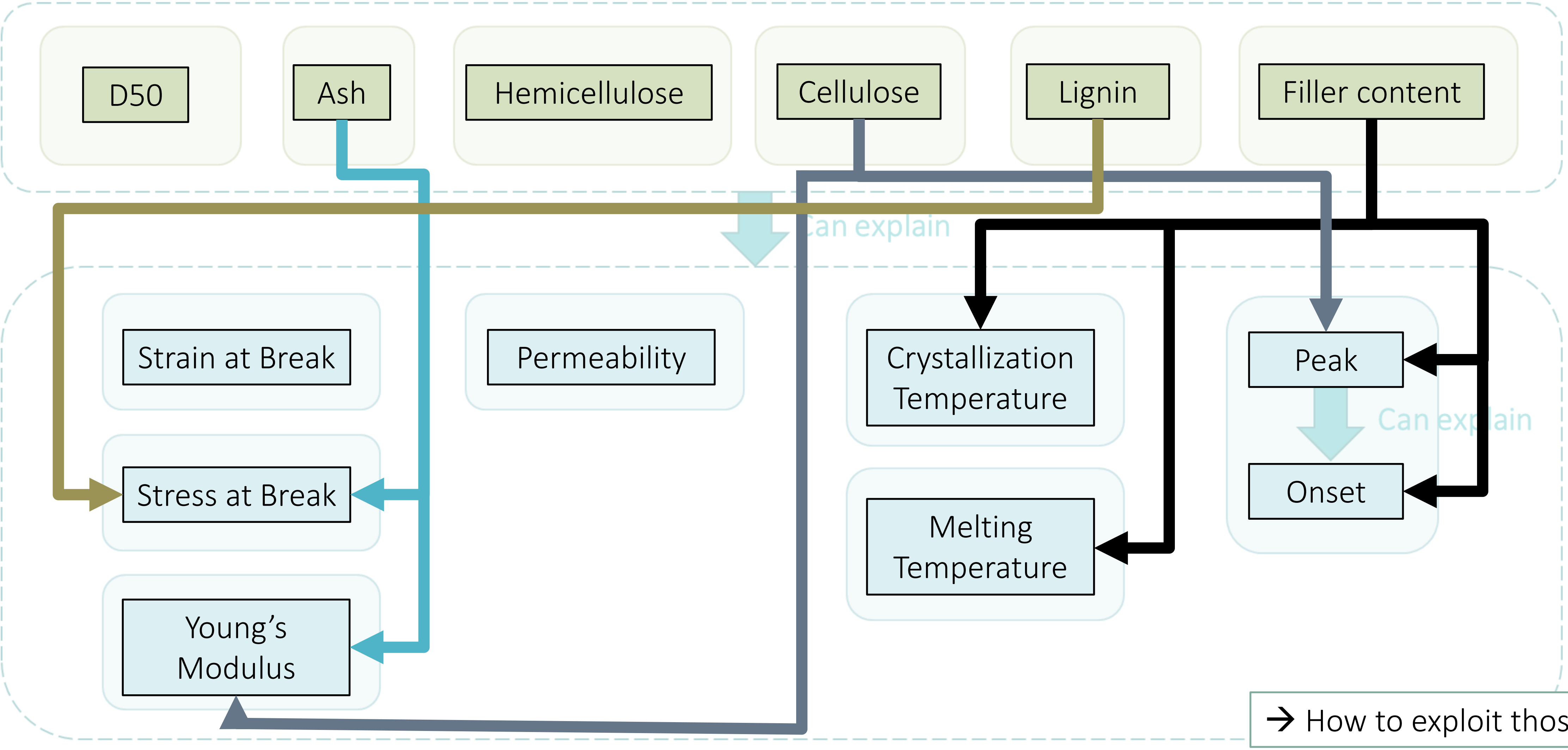
→ How to express the biomass impact over the final product?

Expert Knowledge Expression
Definition of precedence constraints



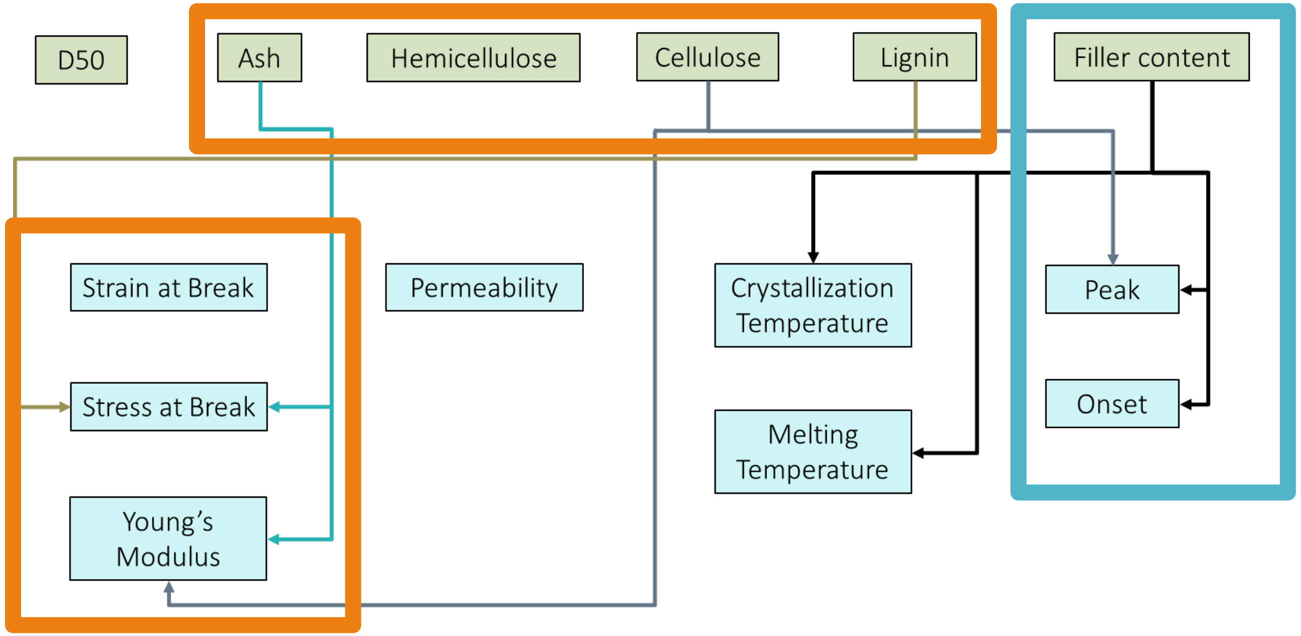
→ What does this tell us?

Causal Bayesian Network



→ How to exploit those results?

Application to composite food packaging – Decision Making



The filler content has a direct impact over the thermal degradation temperatures

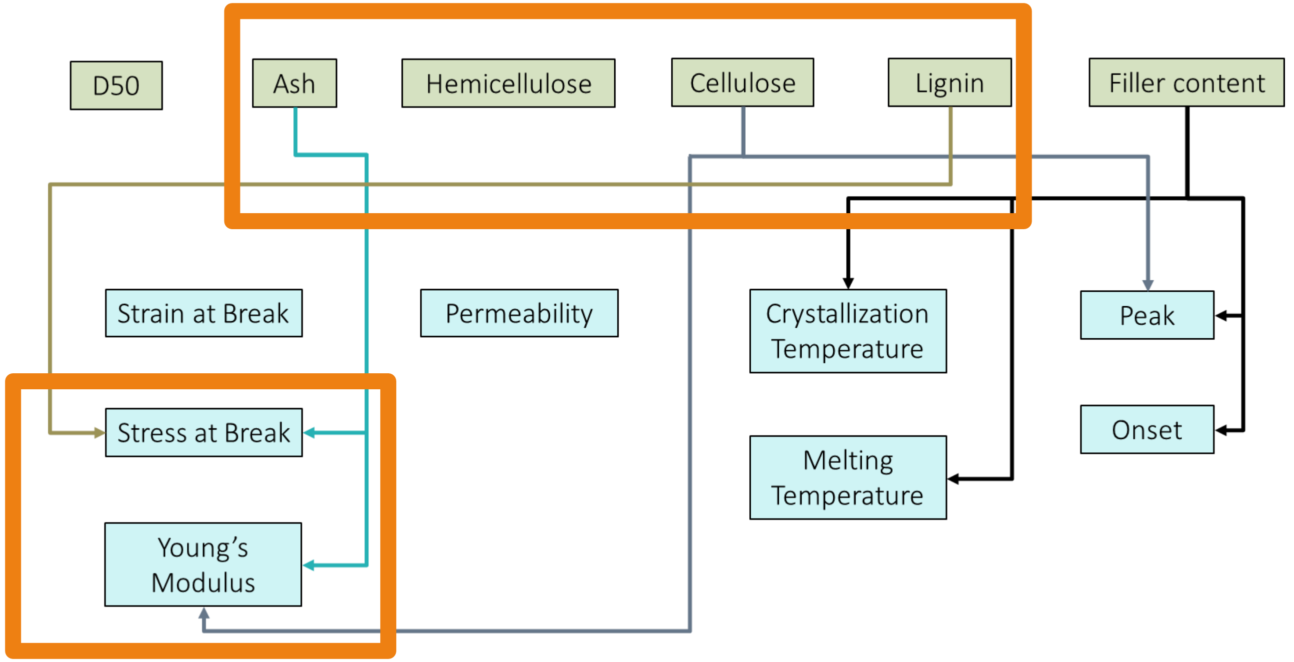
The composition has a direct impact over the mechanical properties

→ Which composition should I prefer if I want to optimize the packaging?
→ How the filler content influences the thermal degradation temperature?

Reverse Engineering (1)

Optimizing *Young Modulus* et *Stress at Break*

1. Identification of the relevant parameters



We intervene on the composition

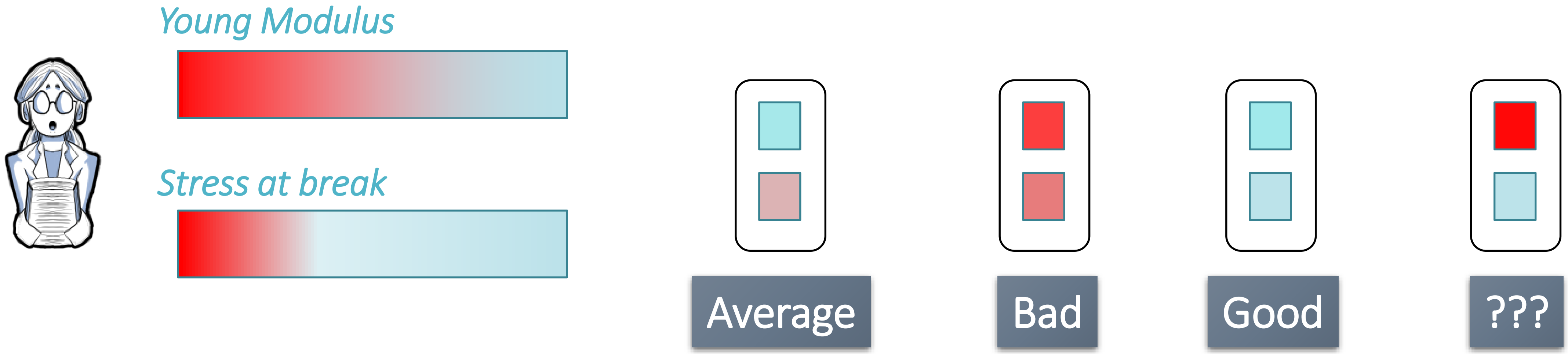
To influence the parameters

→ How to determinate our goal?

Reverse Engineering (2)

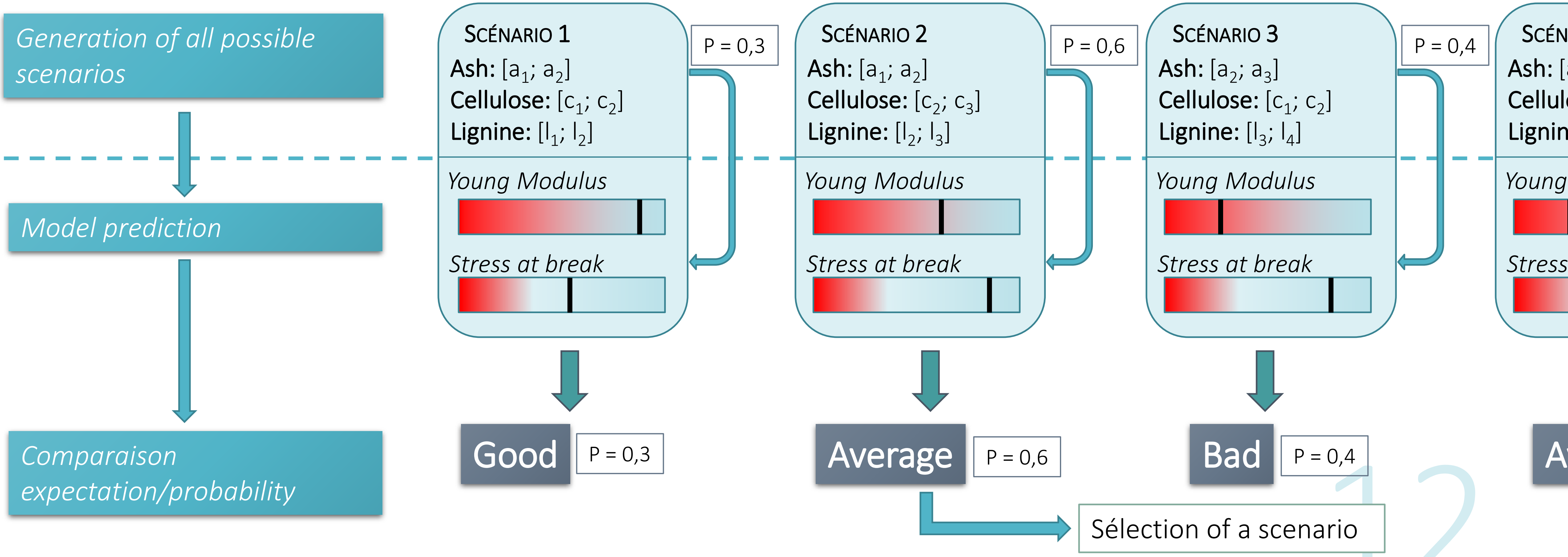
Optimizing *Young Modulus* et *Stress at Break*

2. Expression of the expert's expectations

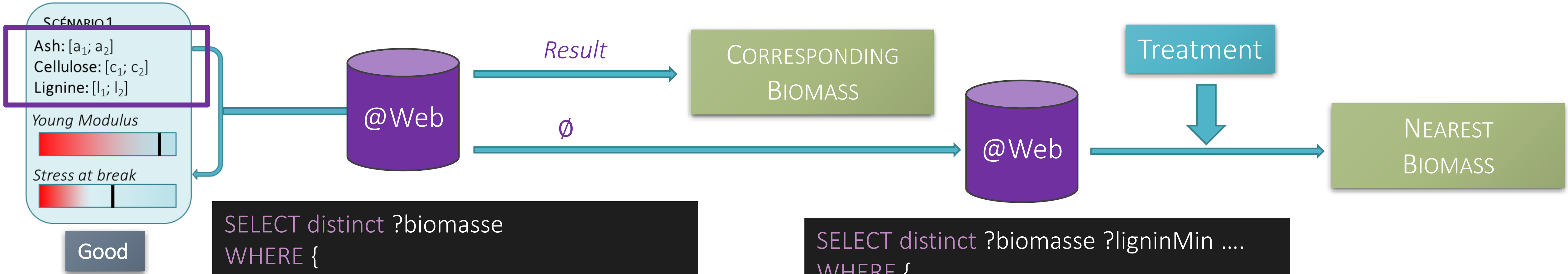


→ How to generate constraints to address the problem?

Reverse Engineering (3)



Reverse Engineering (4)




```
SELECT distinct ?biomasse
WHERE {
   # ...
 # Constraints on the quantities
   filter(?ligninMin >= "a1"^^xsd:float && ?ligninMax <= "a2"^^xsd:float)
   filter(?ashMin >= "c1"^^xsd:float && ?ashMax <= "c2"^^xsd:float)
   filter(?cellMin>= "l1"^^xsd:float && ?cellMax <= « l2"^^xsd:float)
 }
```

```
SELECT distinct ?biomasse ?ligninMin ....
WHERE {
   # ...
 # No constraint, we select everything
 }
```

Reverse Engineering (5)

Scenario Good

P = 0,82

Lignin: [19.4 ; 26.42]
Ash: [6.68 ; 24.67]
Cellulose: [25.59 ; 33.05]

CORRESPONDING BIOMASS

?biomasse	Rice Husk
?lignin	25,69
?ash	14,35
?cellulose	31,9

Scenario Good

P = 0,99

Lignin: [26.42 ; 49]
Ash: [6.68 ; 24.67]
Cellulose: [25.59 ; 33.05]

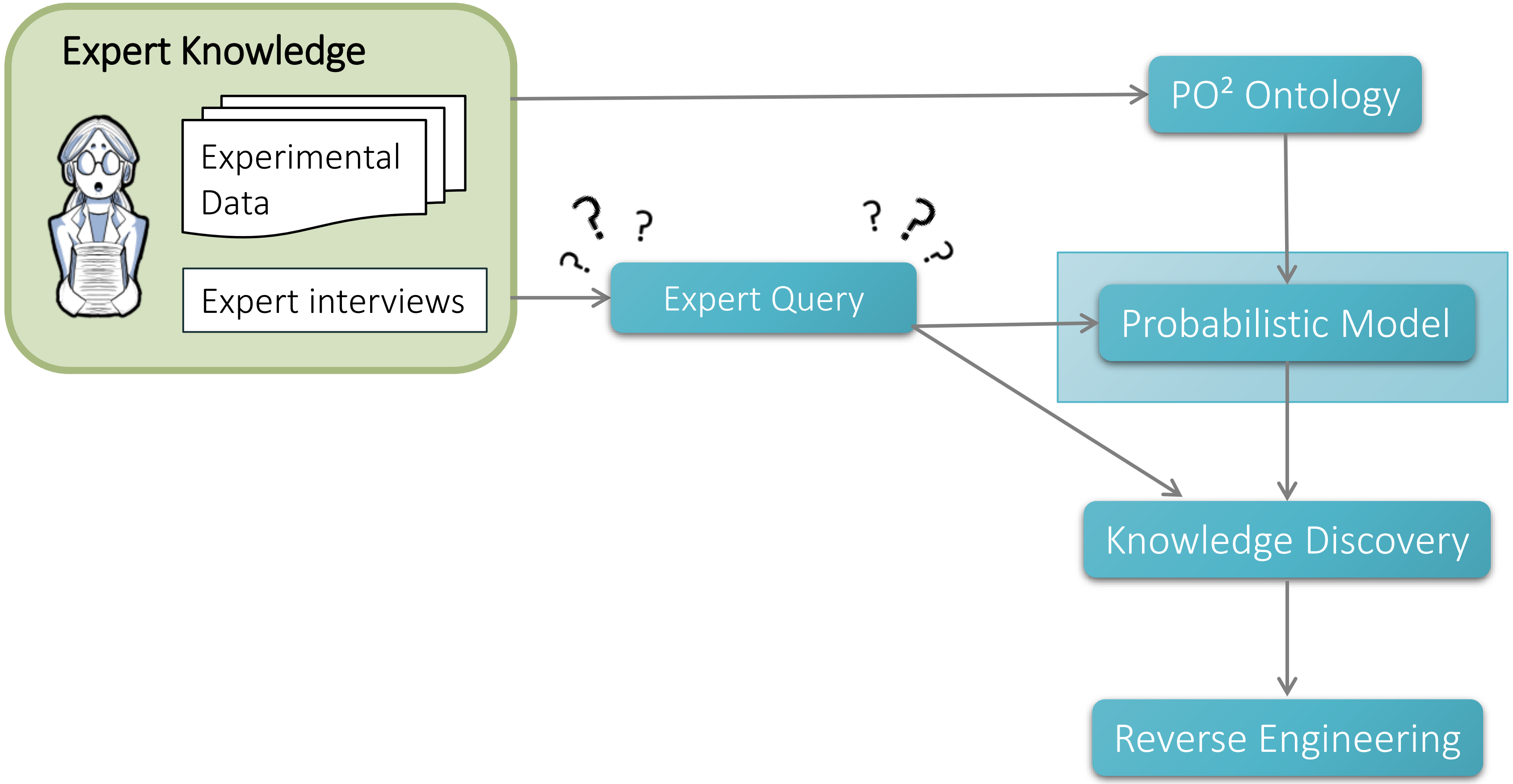
CORRESPONDING BIOMASS

Ø

NEAREST BIOMASS

```
Pas de resultat. Correspondance avec les matériaux présents:
pine_bark 5.26 {'lig': 27.33, 'ash': 1.44, 'cel': 20.6}
rice_husk 7.049999999999997 {'lig': 25.69, 'ash': 14.35, 'cel': 31.9}
hemp_core 14.973000000000003 {'lig': 24.0, 'ash': 1.157, 'cel': 32.59}
wheat_straw 15.19 {'lig': 23.04, 'ash': 4.71, 'cel': 35.4}
pine_sawdust 24.95 {'lig': 28.0, 'ash': 0.16, 'cel': 44.0}
flax_fibre 71.03999999999999 {'lig': 3.0, 'ash': 3.5, 'cel': 70.0}
```

In Conclusion



PyAgrum

1. Integration of expert knowledge as precedence constraints

2. Learning a model under causal influence

3. Simulation of scenarios with inference tools