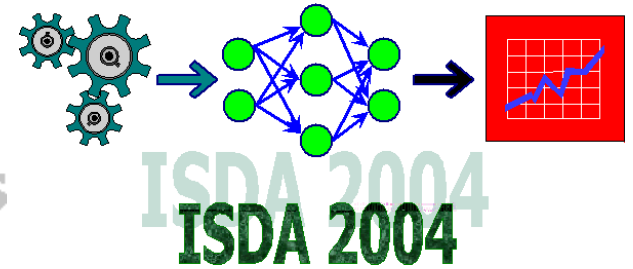




Intelligent Systems Design and Applications



Process model-based Dynamic Bayesian Networks for Prognostic

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Content

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- Prognosis process development
- Probabilistic model development
- Case study
- Conclusion

Introduction

- Industrial systems more and more complex
 - Competition and high demand of customers
 - Difficulties to optimise system/product performances
 - One solution : Maintenance
- Proactive maintenance strategy
- Prognosis process
 - Prognostic is defined as the ability to “predict and prevent” possible fault or system degradation before failures occur
 - Principle
 - ❖ Identify the current state of the system (at time t)
 - ❖ Predict the future state of the system (at time $t + \Delta t$)
 - ❖ (Decision making)

Prognosis process development

■ Methodology

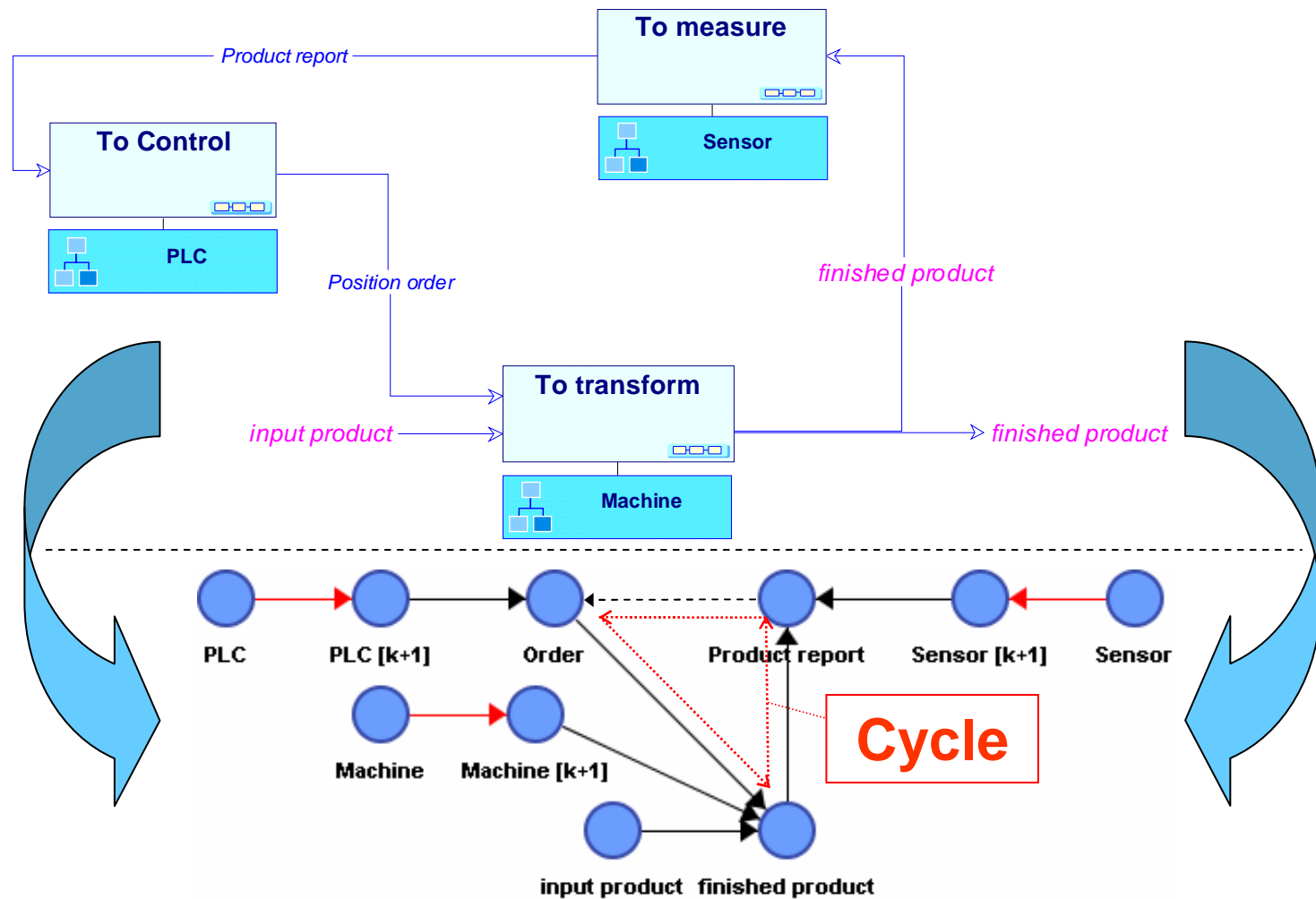
- Process and flow based approach
 - ❖ Functional/Dysfunctional reasoning
 - ❖ Hierarchical structure
- Elaboration of the probabilistic network
 - ❖ Formalism: BN/DBN
 - ❖ Generic rules to transform the process model into a probabilistic one
- Design of the monitoring for prognosis architecture
 - ❖ DBN variables associated to indicators
 - ❖ Monitoring / Storage

Probabilistic network development (1)

- The probabilistic model goal
 - Mechanisms of inference
 - ❖ Propagation of the process degradation
 - ❖ Impact's determination of this degradation on the whole system.
- Formalism : Dynamic Bayesian Network (DBN)
 - Translation into three stages
 - ❖ Definition of nodes and states
 - ❖ Structure
 - ❖ Network parameters
 - **Acyclic structure required**

Probabilistic network development (2)

■ The cycle problem

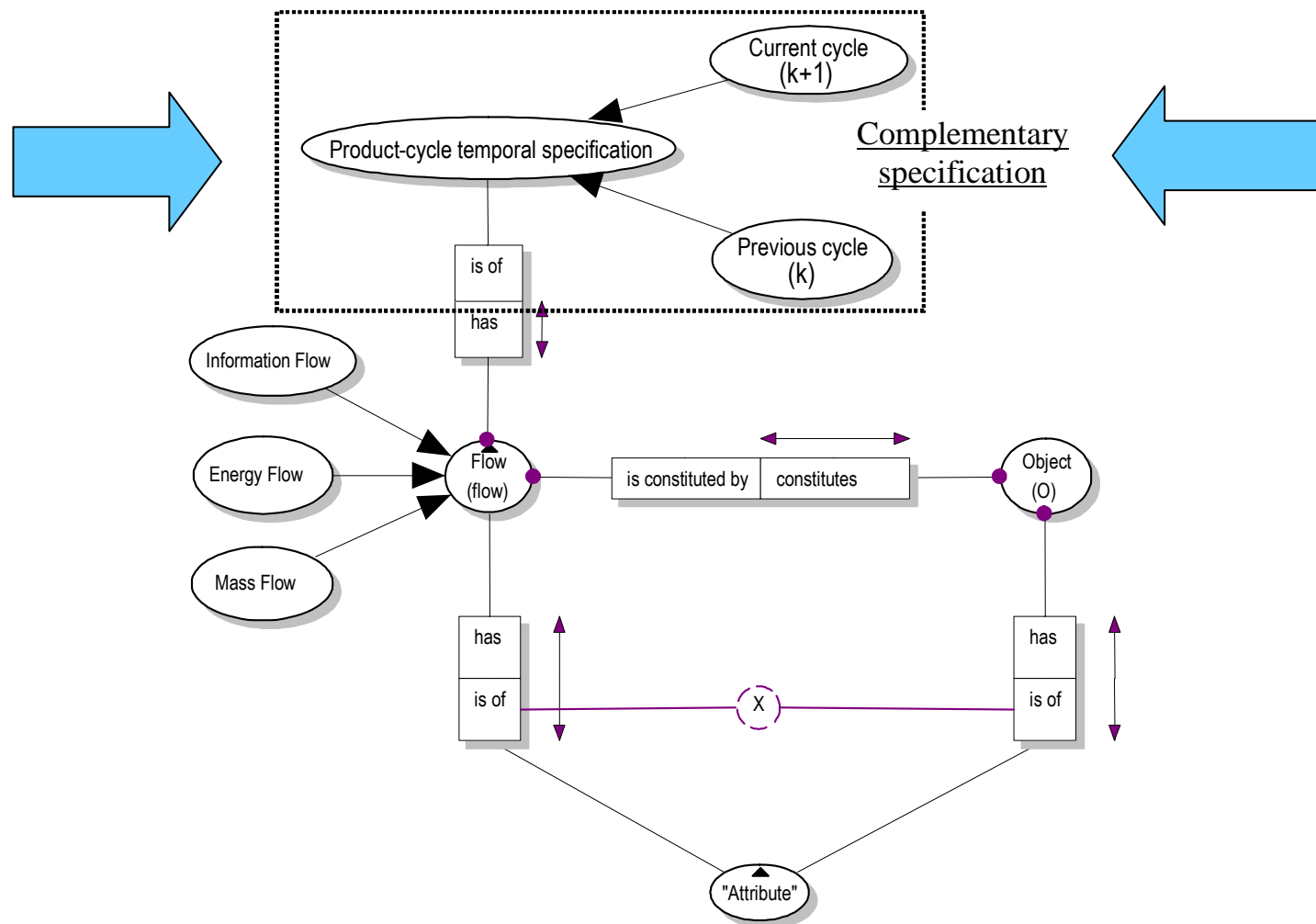


Probabilistic network development (3)

- What are the solutions to break cycles ?
 - Specifications during the design of process model
 - Set of rules to delete several edge
- First solution selected
 - The temporal dimension of flows is not always the same
 - Specification of a new flow characteristic

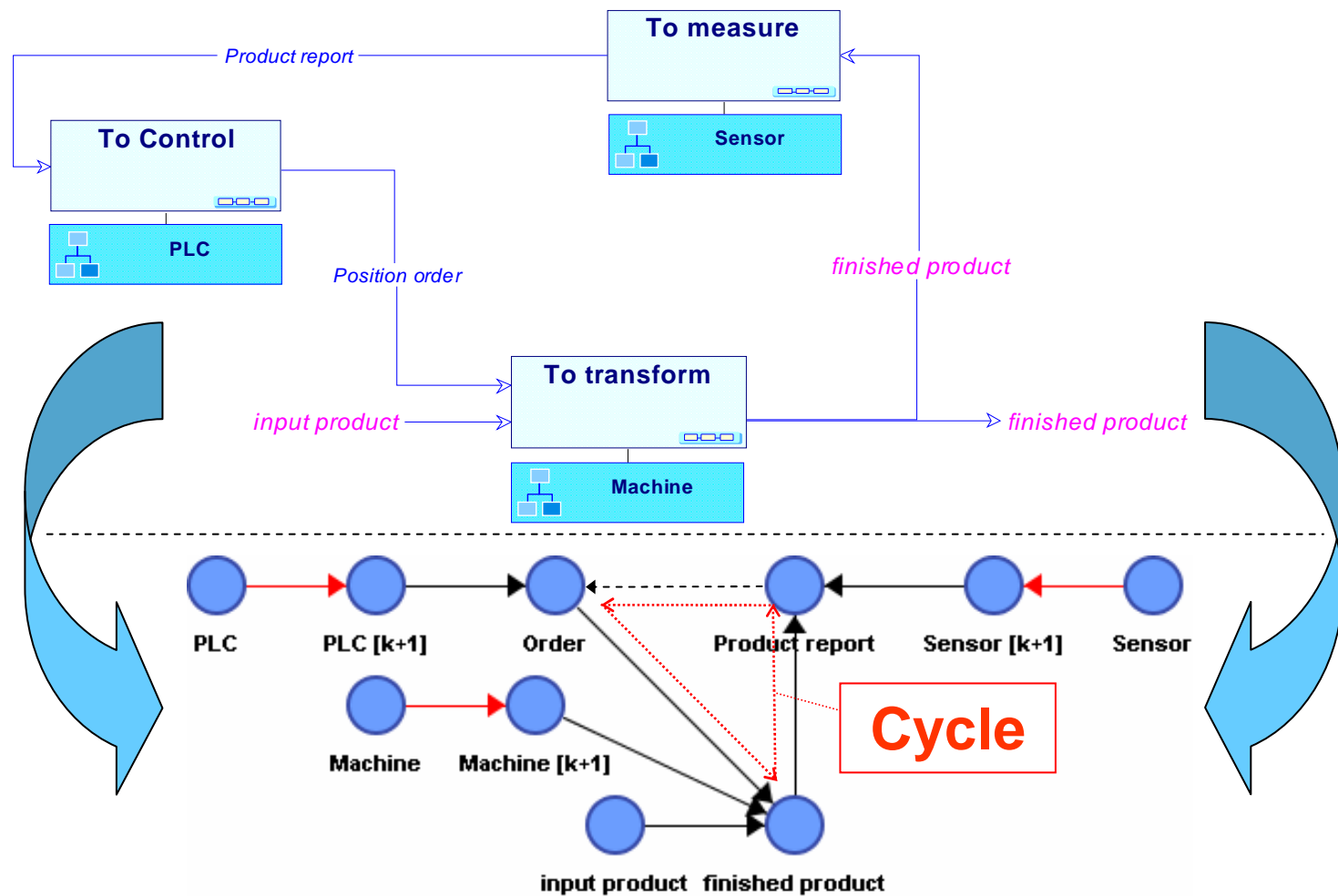
Probabilistic network development (4)

■ Formalization of the specification with ORM



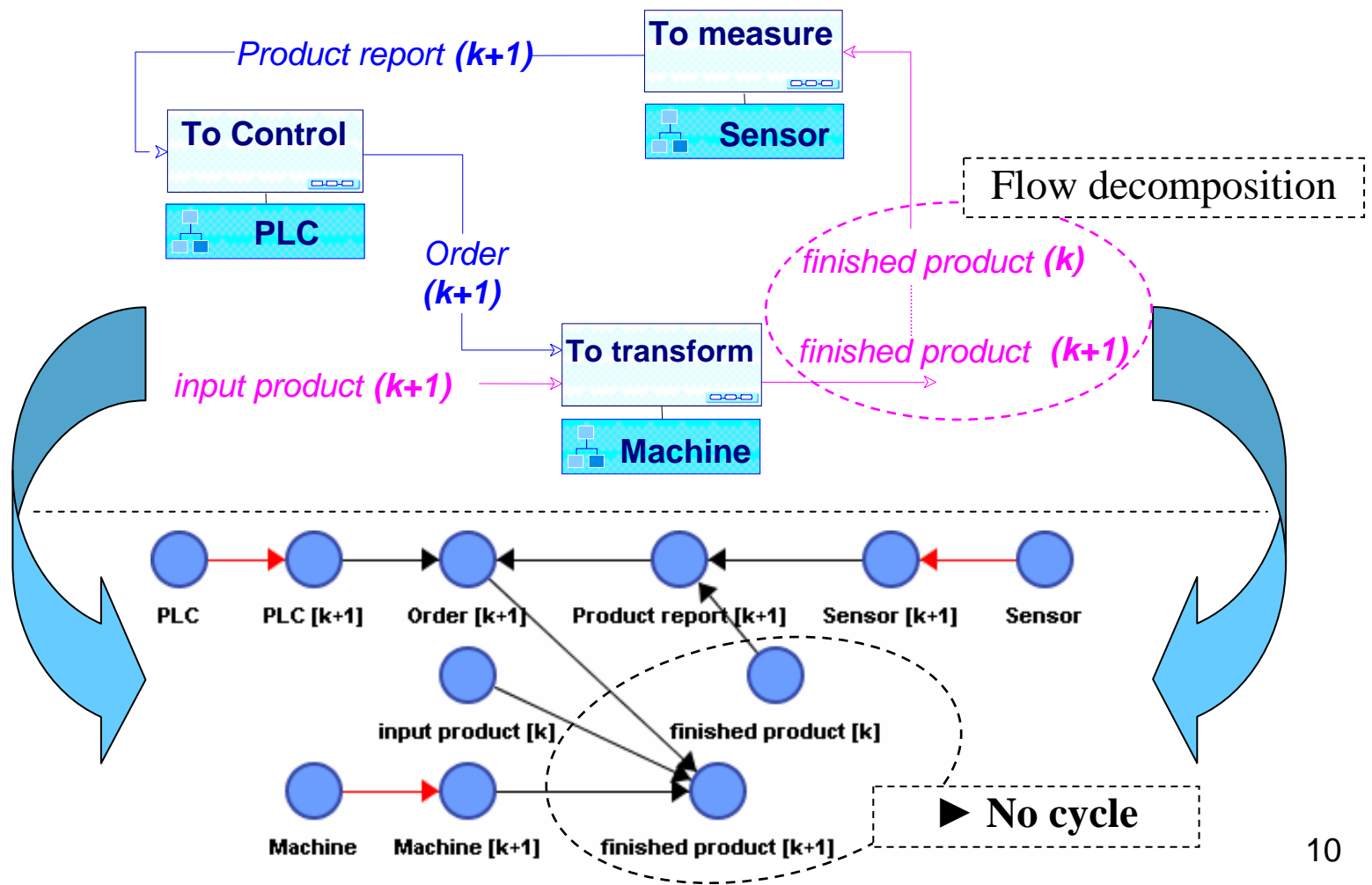
Probabilistic network development (2)

■ The translation without specification



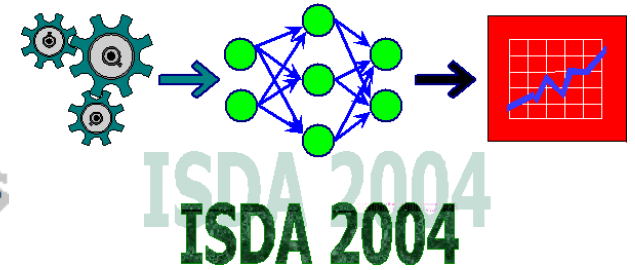
Probabilistic network development (2)

■ The translation with specification





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Case study

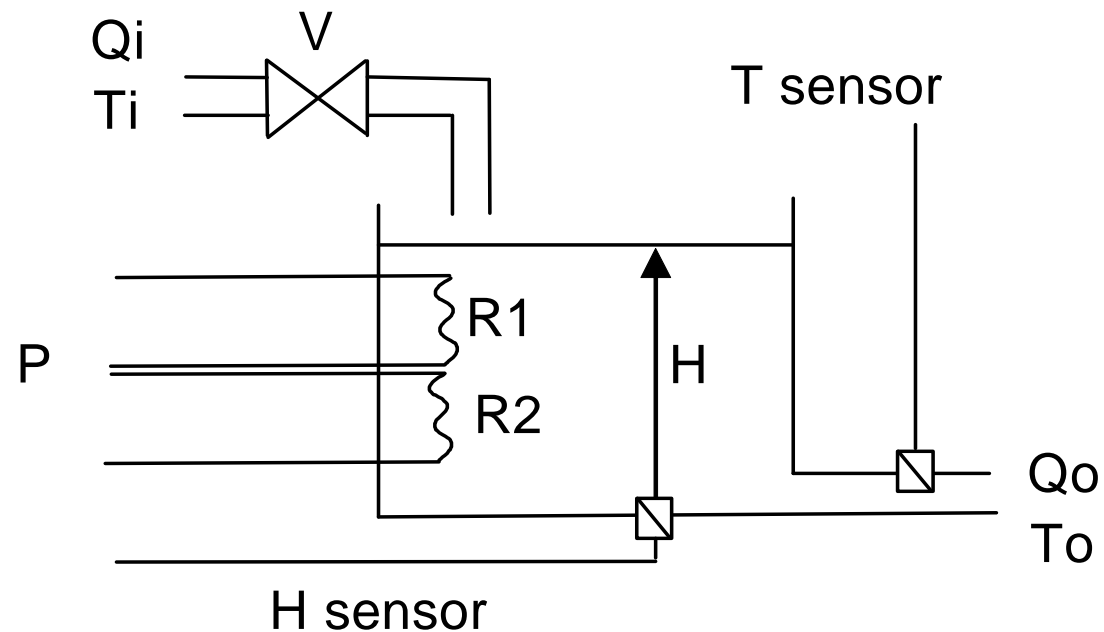


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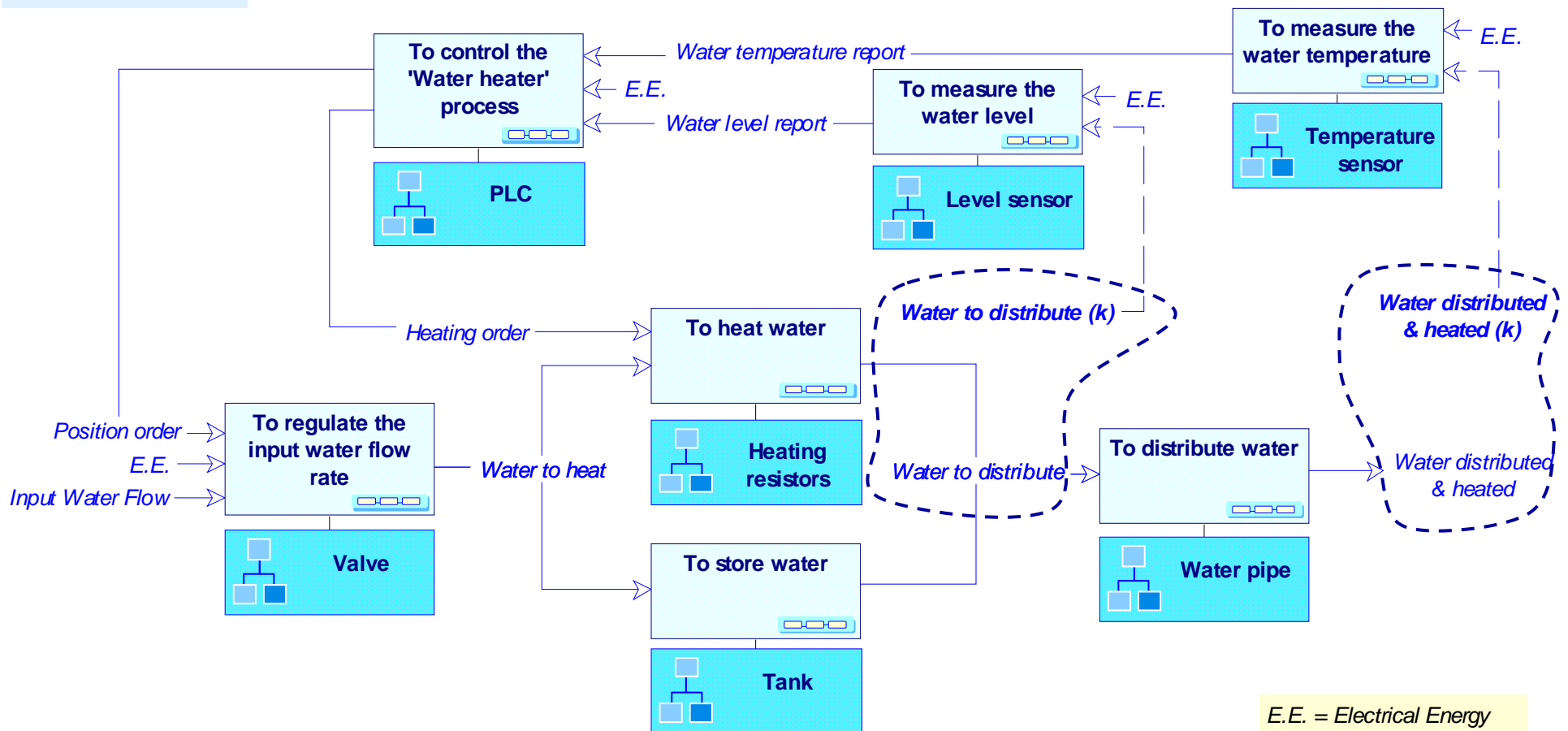
Case study

■ Water heater (Physical process)



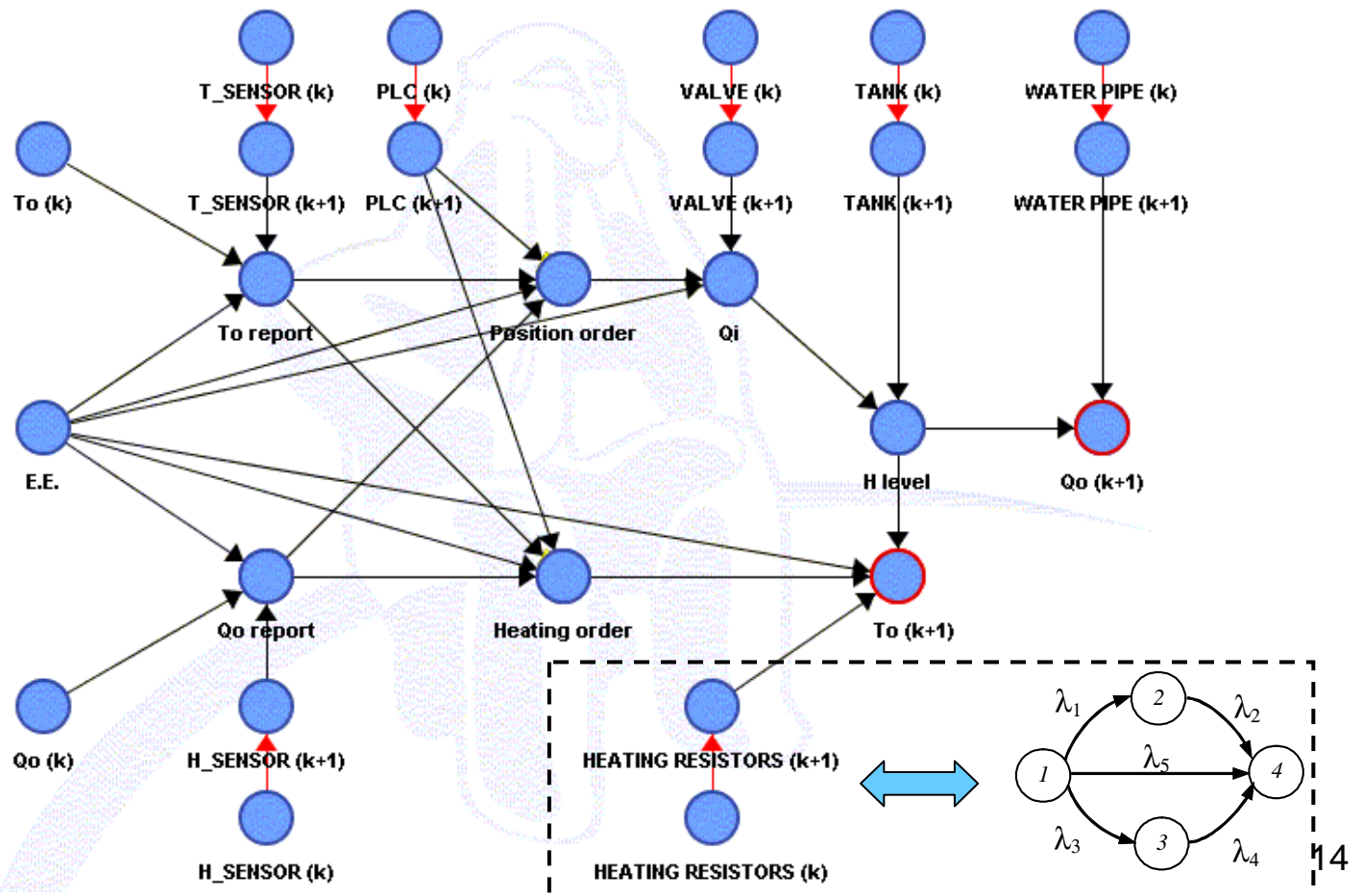
Case study

Water heater (Process model)



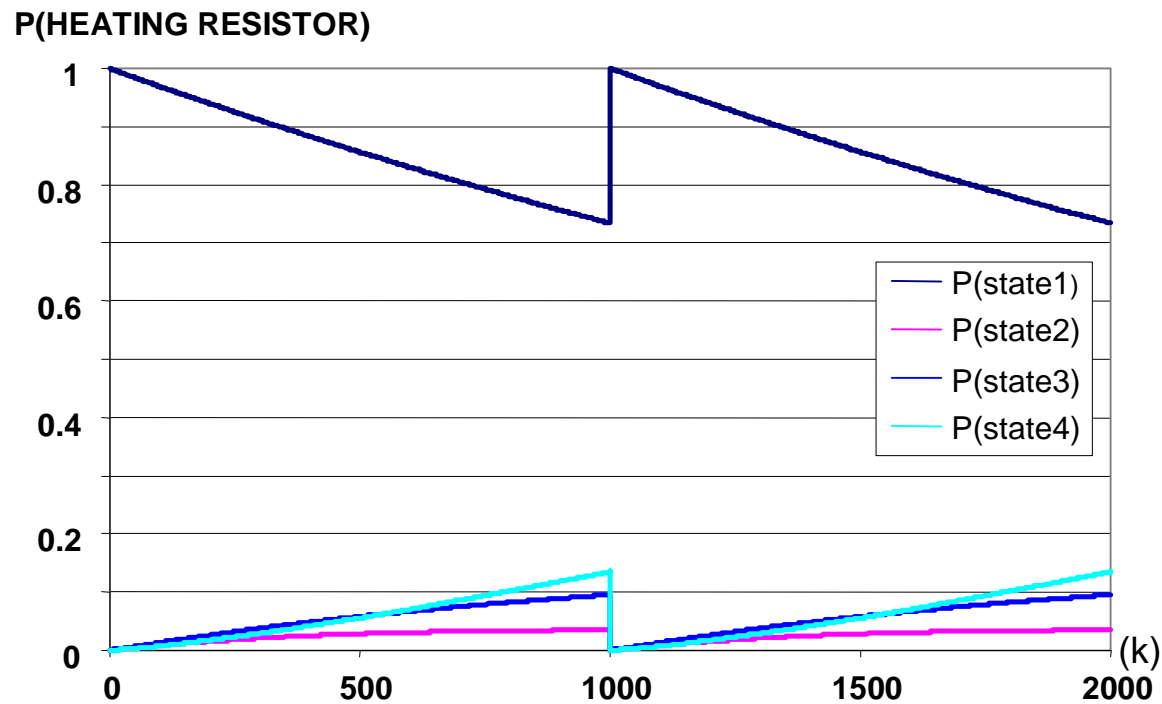
Case study

Water heater (Probabilistic model - DBN)



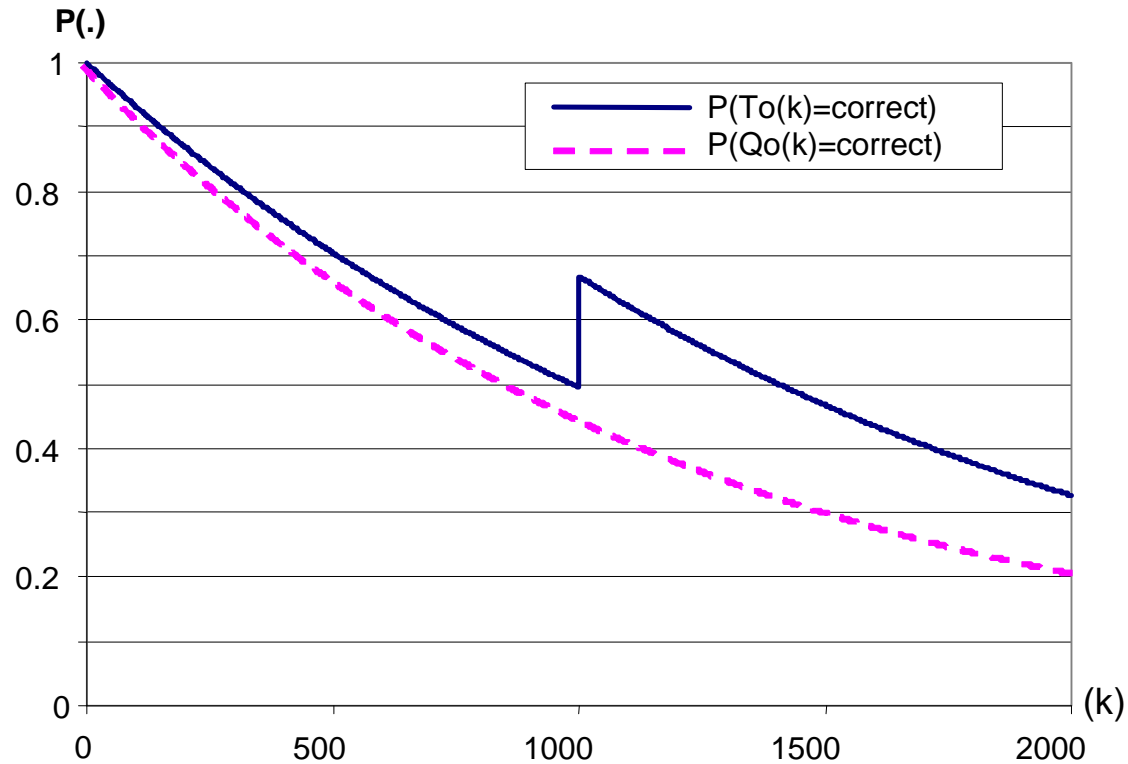
Case study

■ Water heater – Prognostic (1)



Case study

■ Water heater – Prognostic (2)

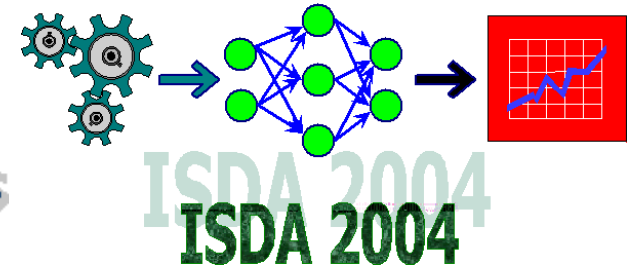


Conclusion

- The work presented in this paper explains why a methodology supporting prognosis process modelling should be formalized to take into account the characteristics and the constraints induced by its modelling tool
- Moreover, the integration of ORM specifications is in progress in our laboratory in order to develop a tool to assist the designer in developing its process & flow-based model.



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Questions



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