Ambient Intelligence

<< More than the sum of its devices, the Internet of Things [Ambient Intelligence] links technologies together to create new services and opportunities. >>

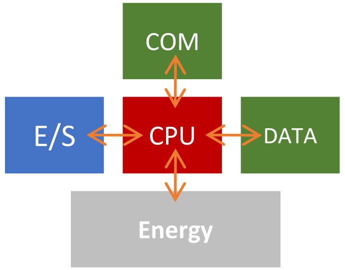


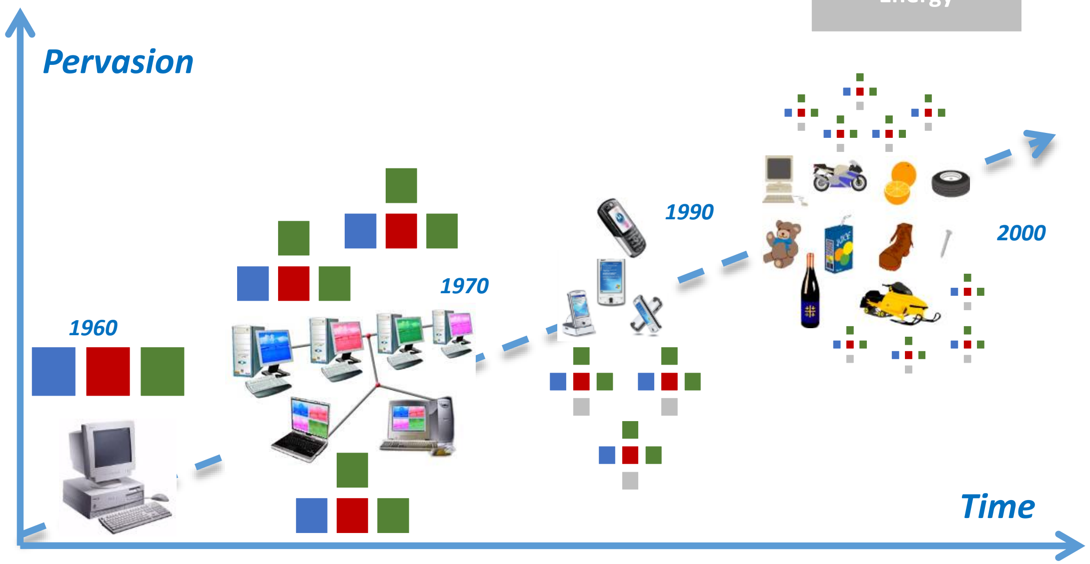

Ubiquitous Computing (1991)

« Silicon-based information technology, is far from having become part of the environment »

- Everytime, Everywhere, but in Everything
- Ubiquitous Computing is a Post distributed Distributed Computing
- After networks of distributed computers, mobiles computers, it's time for distributed things and smart objects

From Von Neumann Computer Model to Smart Objects ....





Our approach : OPPORTUNISTIC Sofware

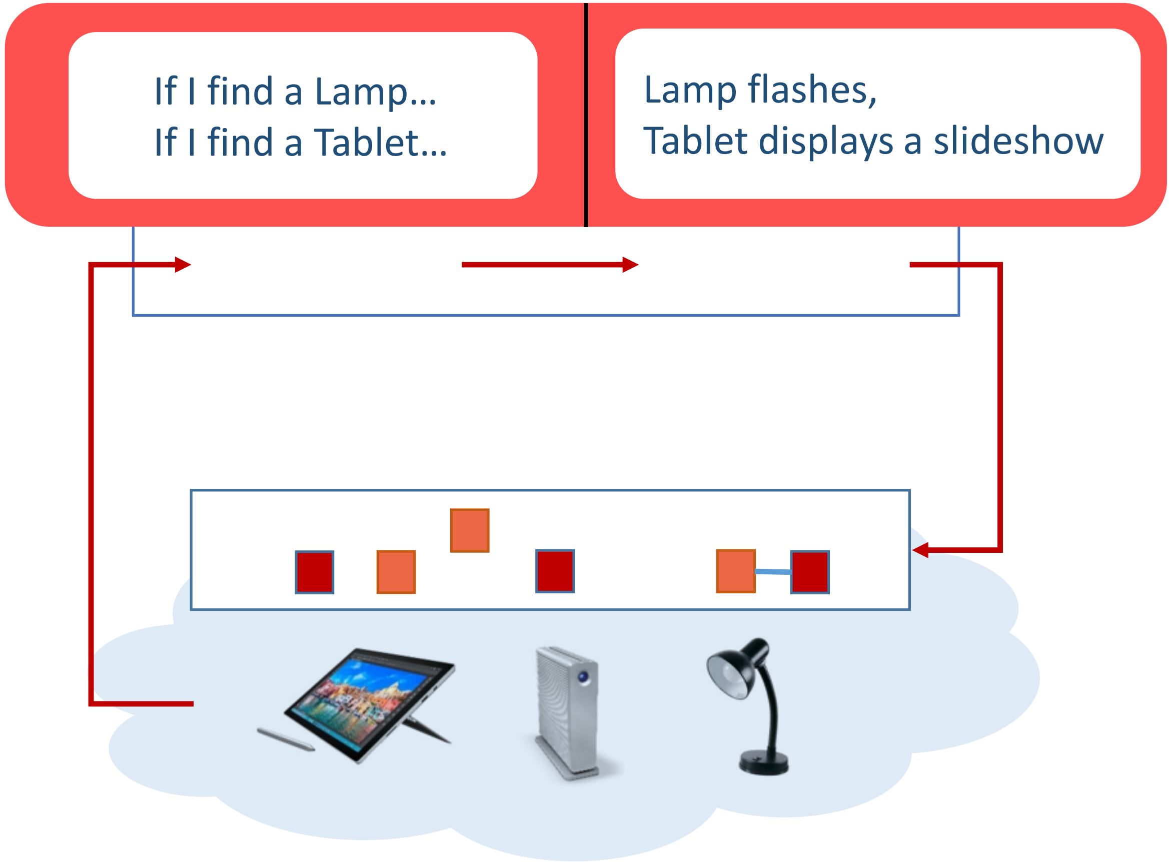
Example : Assisted Living for elderly people

- Assisted Living, new services for elderly people
- Here is a way to provide solicitation service for an apathic person
- Best effort means Opportunistic Software

Opportunistic Software : Principles and Challenges (1/2)

- Application Models as a pair of rules to:
  - Dynamically find among all the available web service on devices (WSD), those relevant for a specific application,
  - Compose these WSD to provide such a specific application

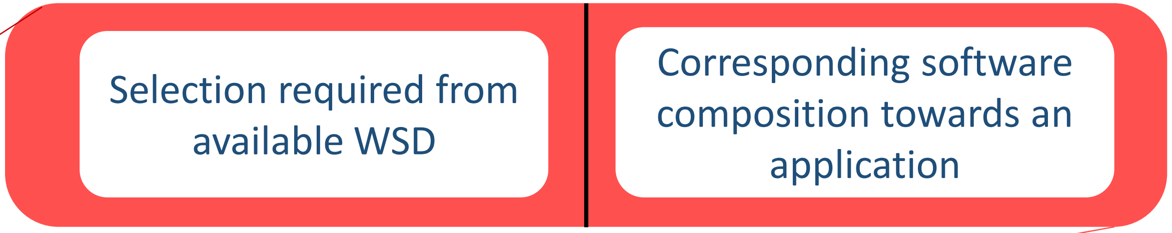
« Best effort » to deploy an application:
- *flashing a lamp*
- *displaying a diaporama on a tablet*

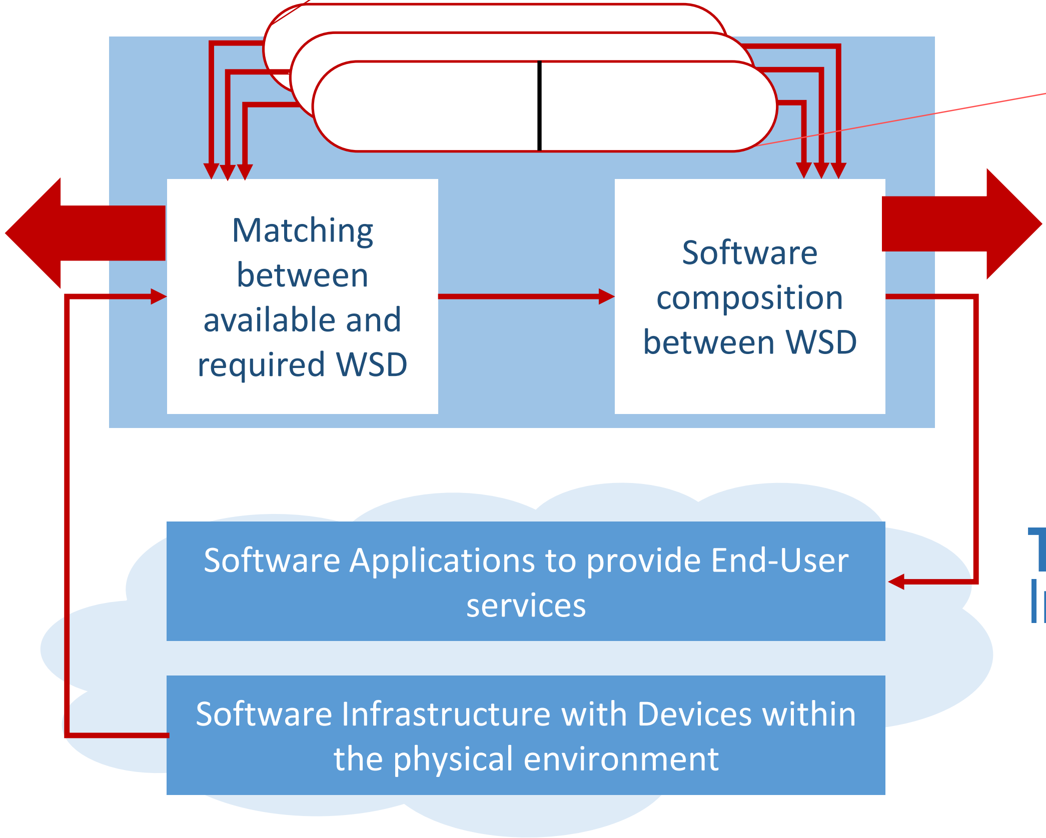


Opportunistic Software : Principles and Challenges

Principles : Opportunistic Composition

- Models of Applications as a pair of rules





1 **Semantic Matching**
Heterogeneity *and*
Interoperability

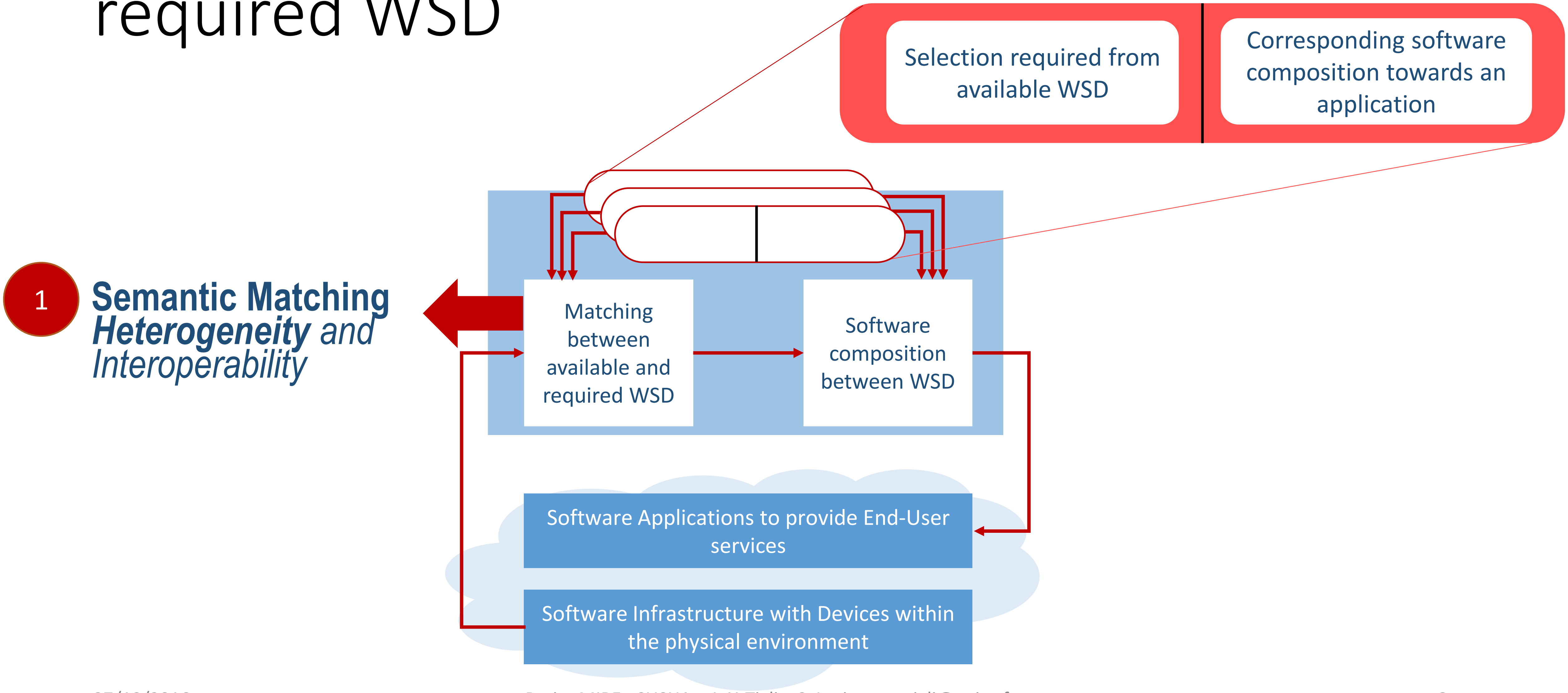
2 **Software Composition of multiple applications sharing physical devices**

Technological heterogeneity and Interoperability :

WoT and **WSD** : **Web Service** for Things (WoT) and **Device** (WSD)

First Challenge : Semantic Matching between available and required services on devices

Semantic Matching between available and required WSD

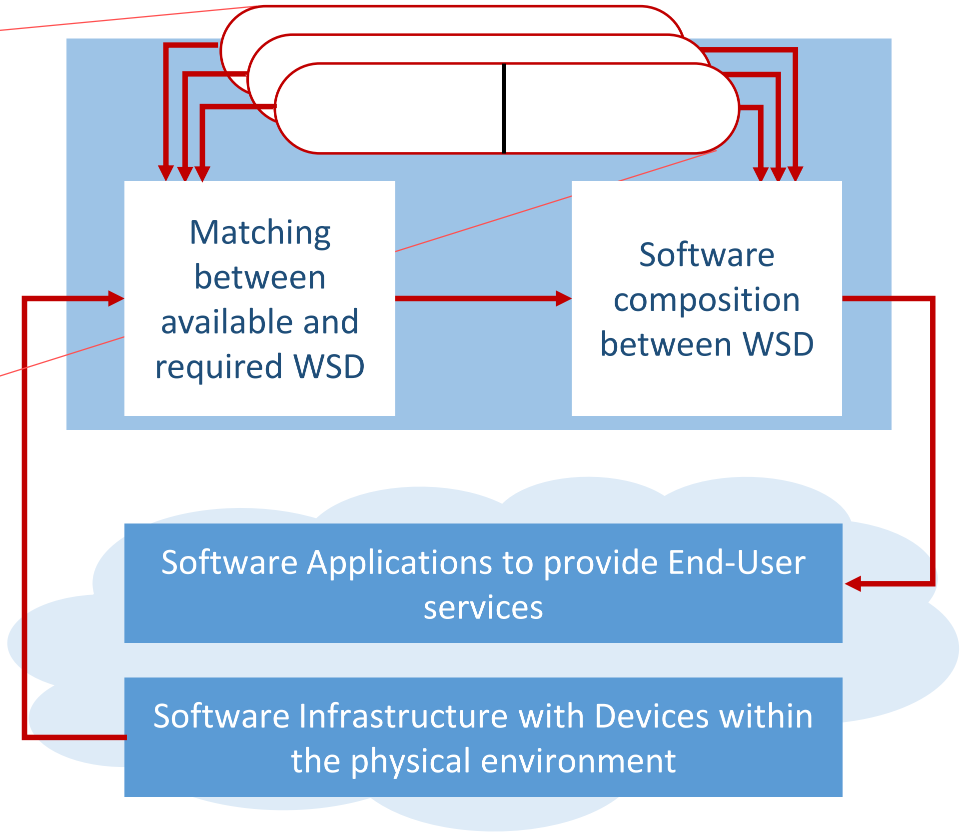


Our first approach

Syntactic alignment between available WSD

LAMP : Lamp*
DISPLAY : Tablet*
NAS : Nas*

```
LAMP.switch()
DISPLAY.slideshow(
NAS.File("C:/test.sld")
)
```



Matching is based on regular expressions on naming

Experimental Platform where we go (1/2)

WSD formally described from a common ontology (TBox)

SPARQL queries !!!!

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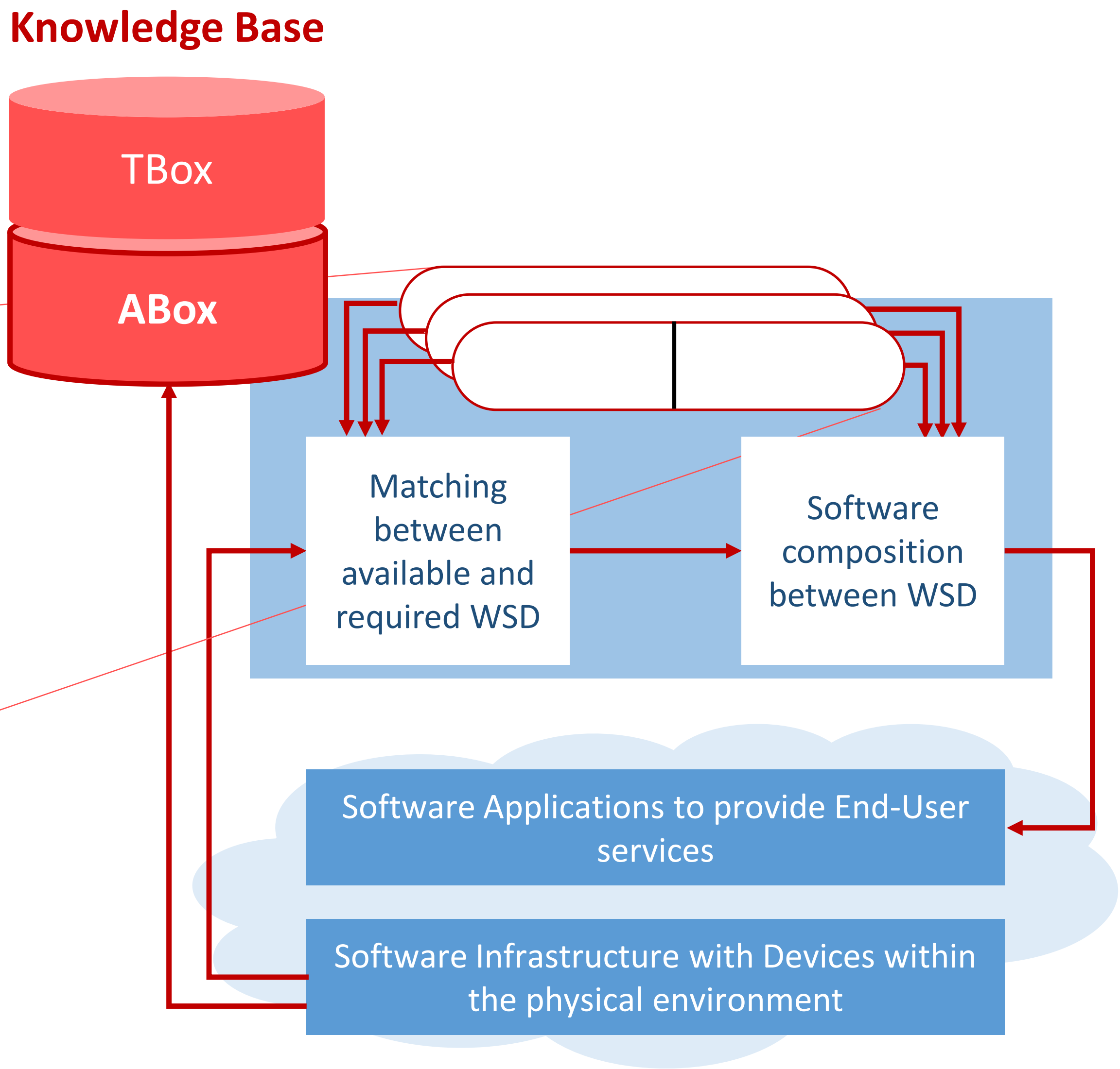
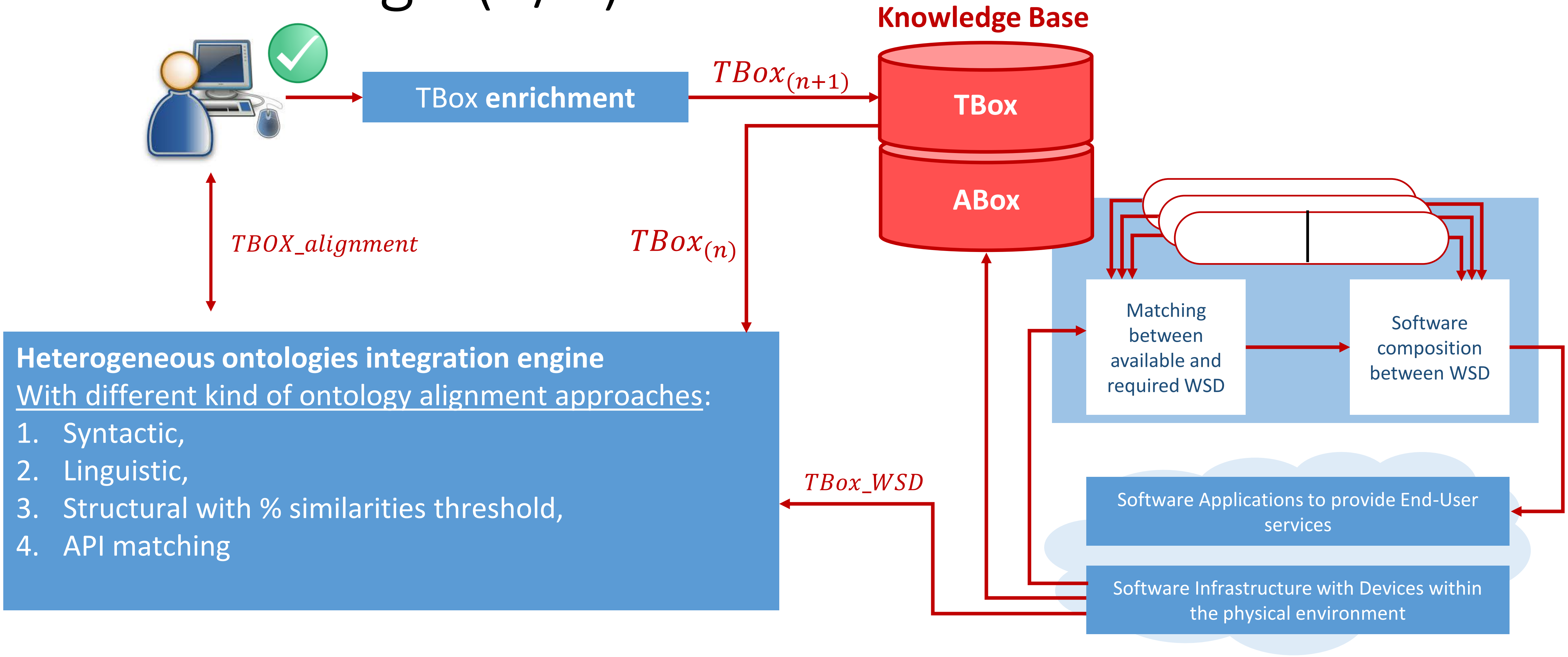


Matching is based on SPARQL queries

Experimental Platform where we go (2/2)



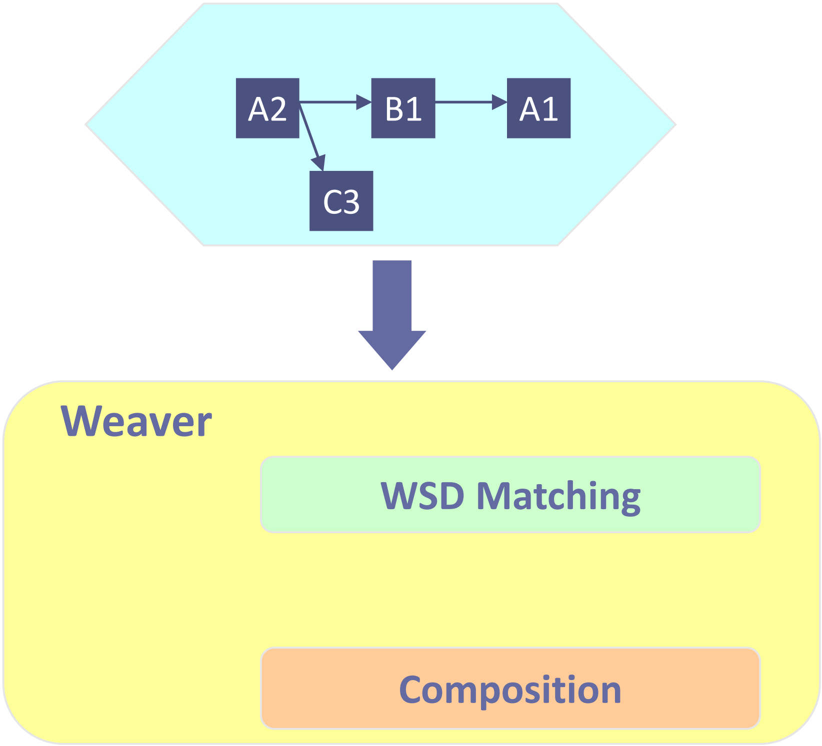
Our future works for semantic matching

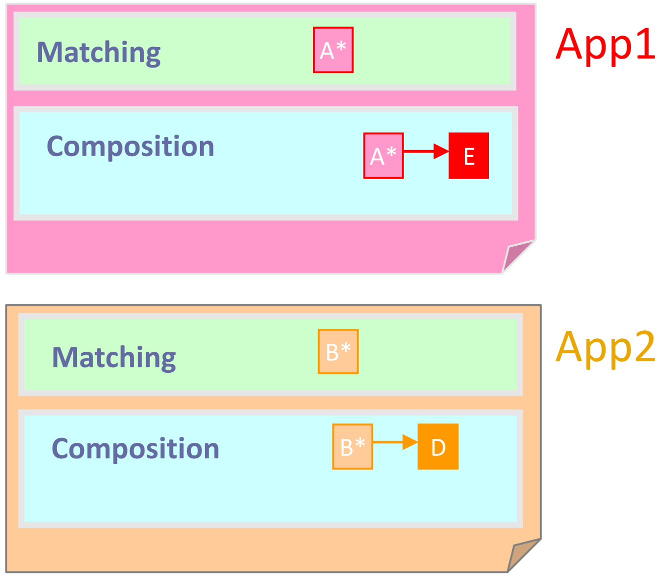
- Structural with % similarities threshold,
- API matching

Second Challenge : Software Composition of multiple applications with shared Physical Devices

How to manage conflicts between Applications

Illustration with regular expression matching





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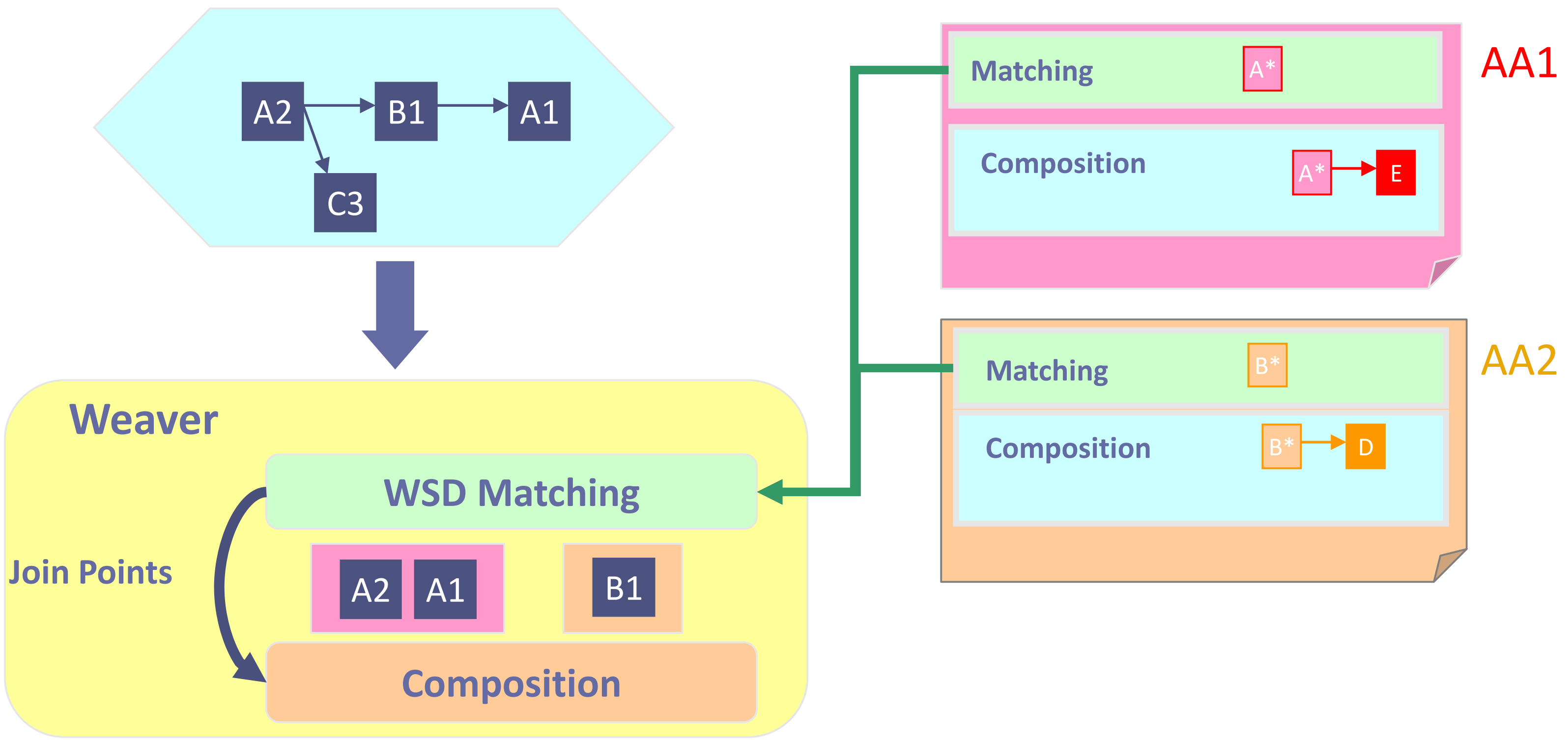

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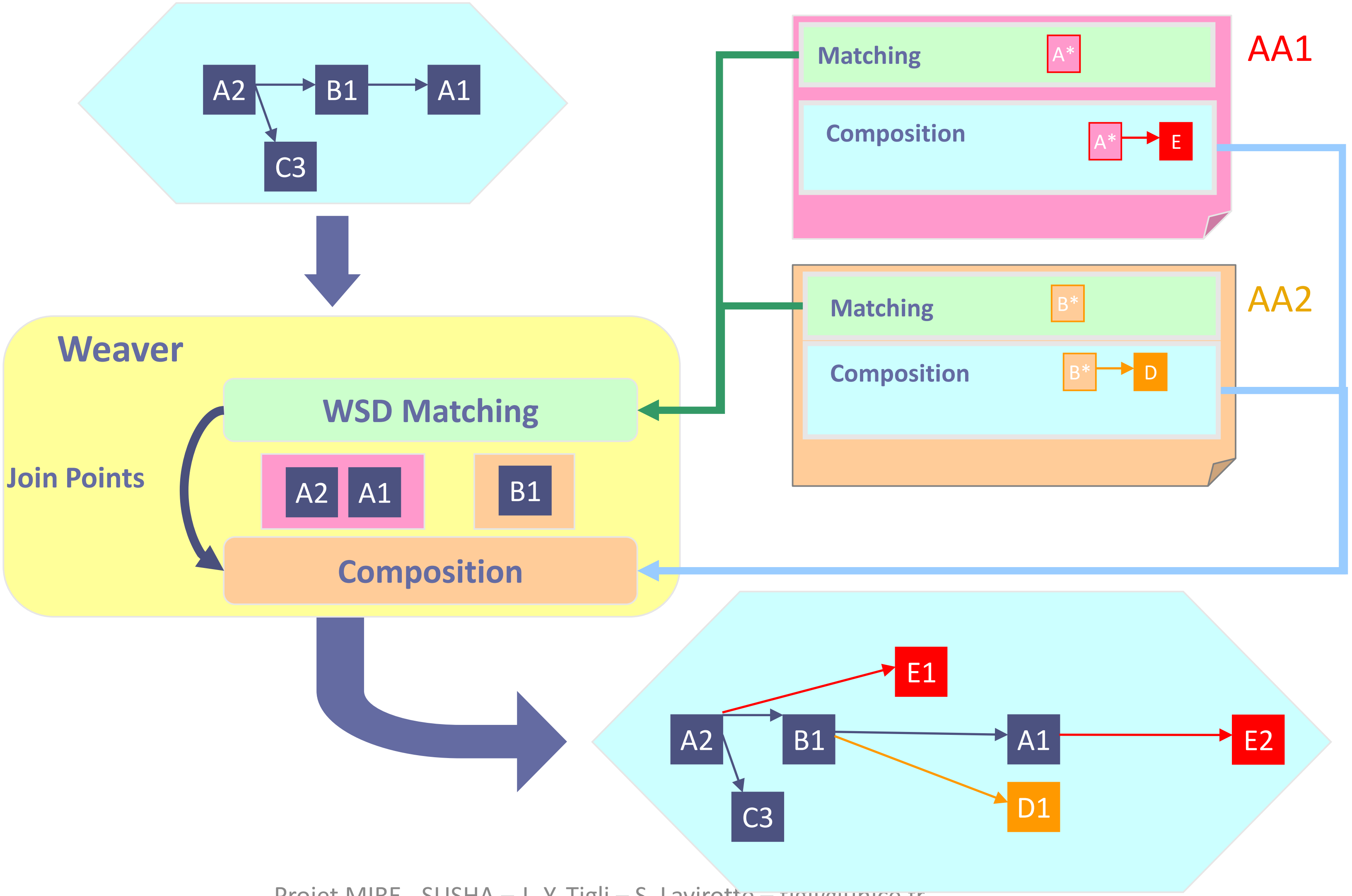
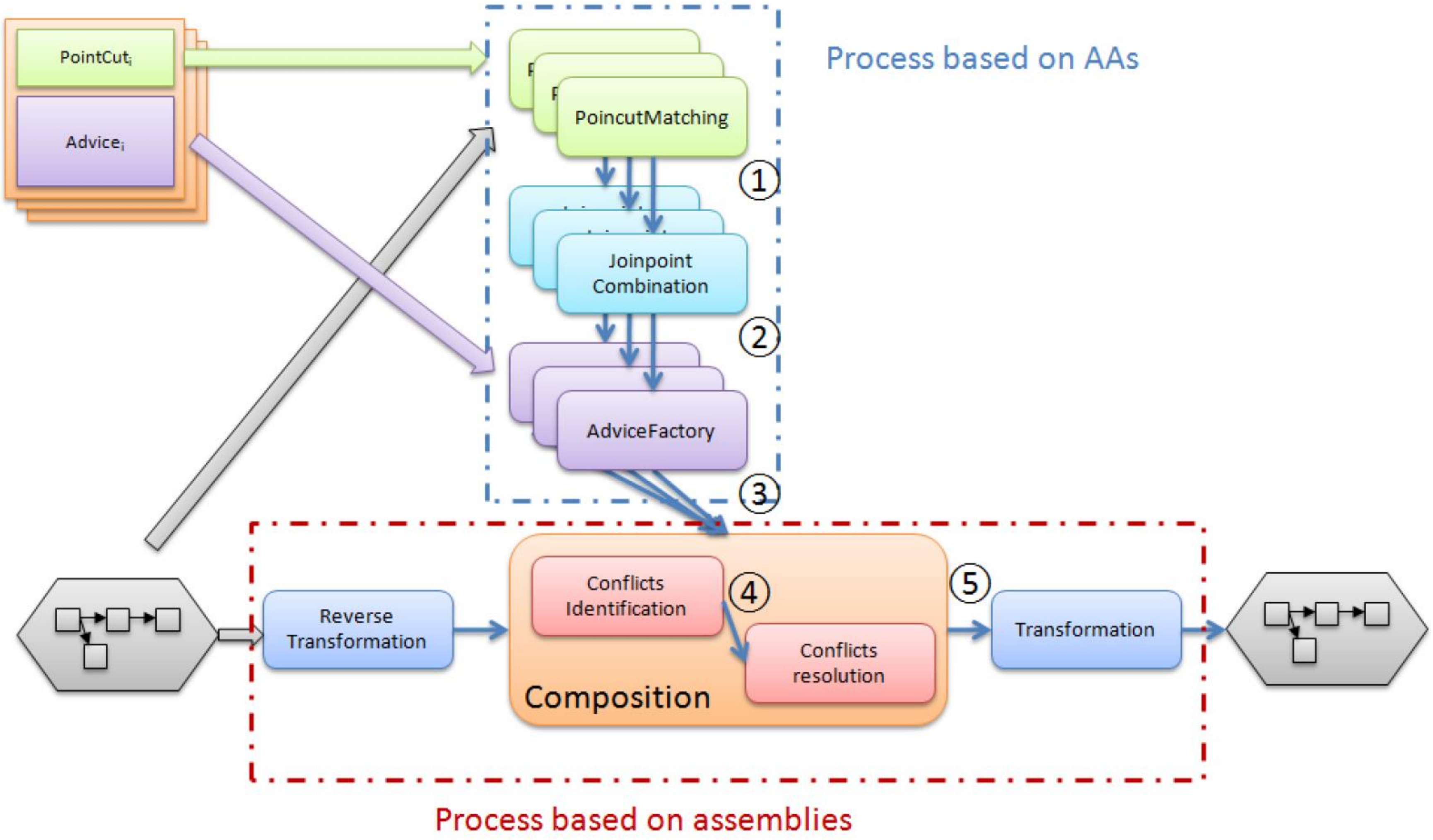


Complete Algorithm of one adaptation Cycle

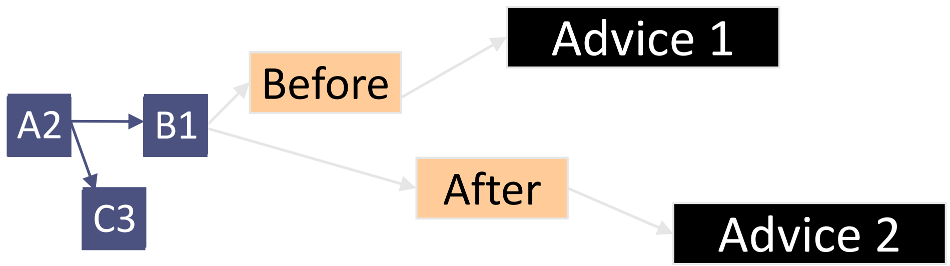


Two kinds of composition between applications around shared devices

✓ **Blackbox Advices :**

- **External composition between advices**

```
SCHEMA Ex (observed):
observed.^Out1 -> Bcomp.do;  CALL /* before
observed.^Out2 -> CALL ; Bcomp.do; /* after
```



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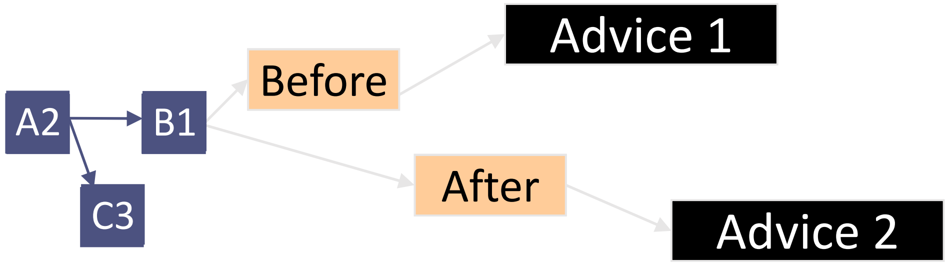
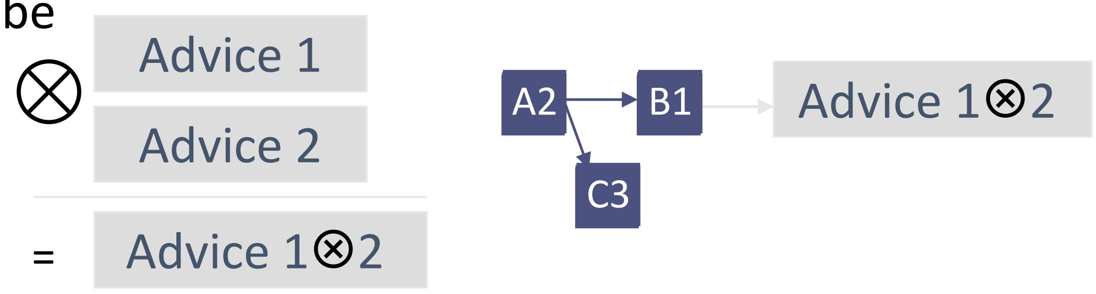


- Greybox Advices :
  - We partly know the semantic of the advice
  - Advices are mergeabe

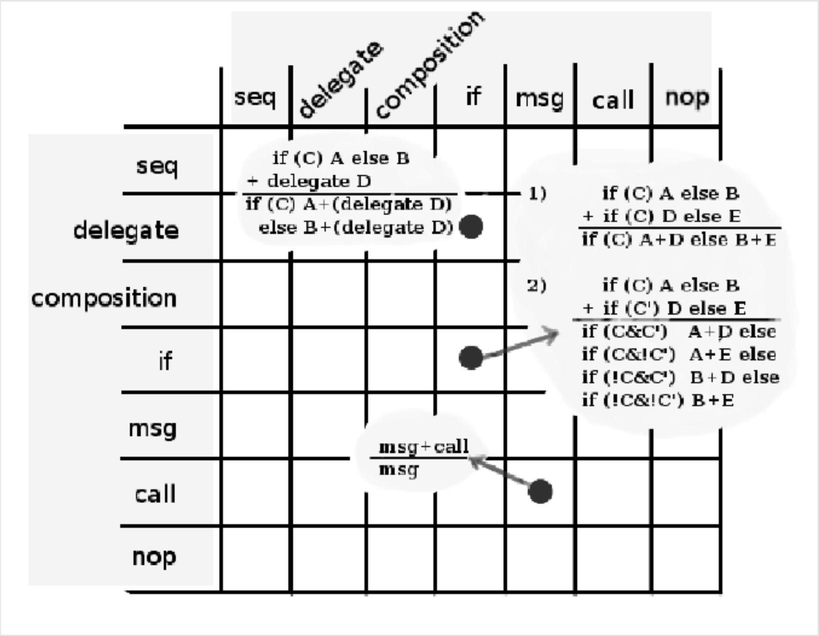
```
SCHEMA Ex (observed, timeout):
    observed.^Out ->
           ( IF ( timeout.Check ) CALL )
    timeout.Check ->
           ( timeout.Start ; CALL      )
```



Merge Logic

- Merge Logic,

Operators [Daniel Cheung, Ph. D. Thesis]



- Merge Properties

Properties Proof [Daniel Cheung, Ph. D. Thesis]

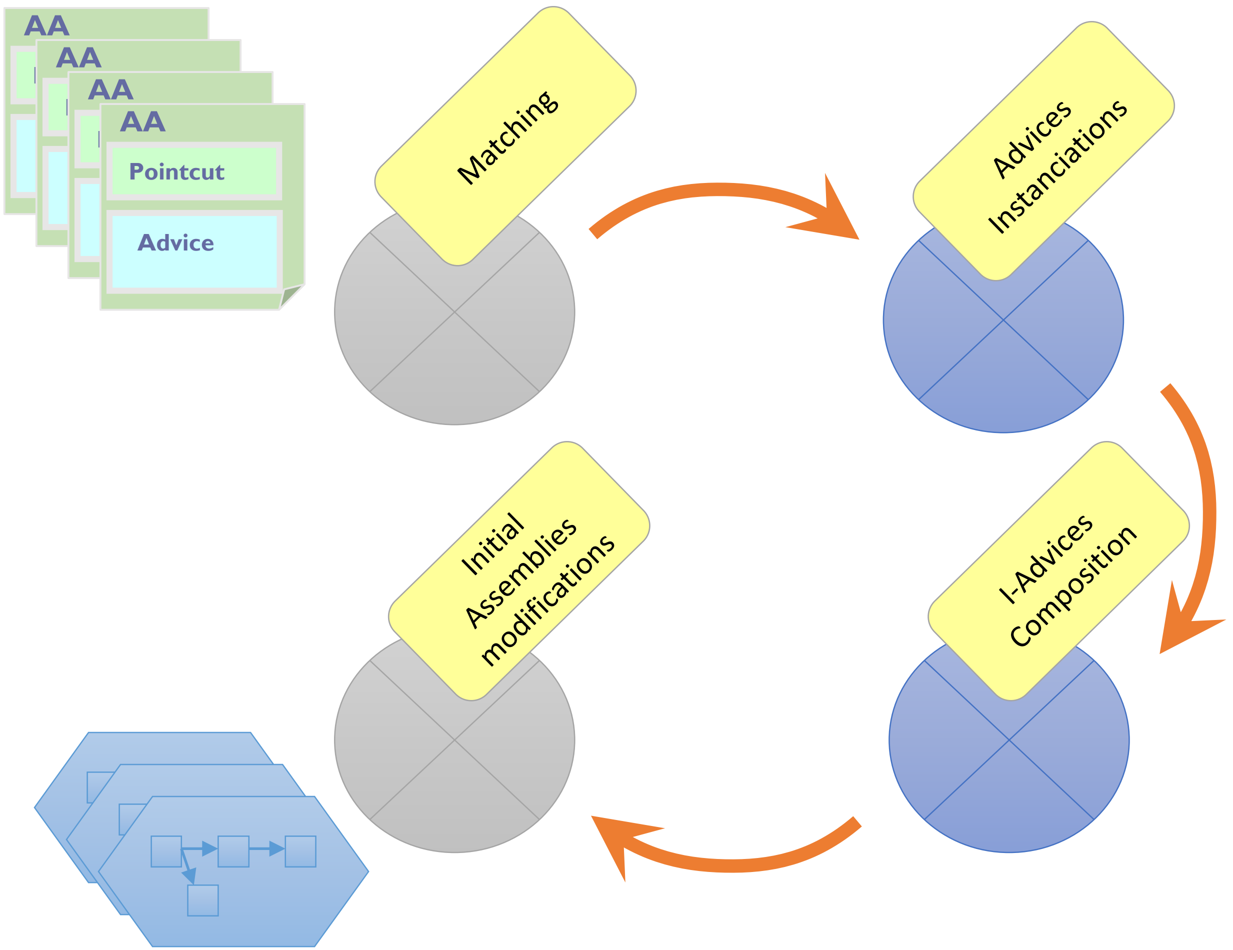
Commutativity : AA0 ⊗ AA1 = AA0 ⊗ AA1
Associativity : (AA0 ⊗ AA1) ⊗AA2 = AA0 ⊗ (AA1 ⊗ AA2)
Idempotence : AA0 ⊗ AA0 = AA0

Third Challenge : Is it reactive enough ?

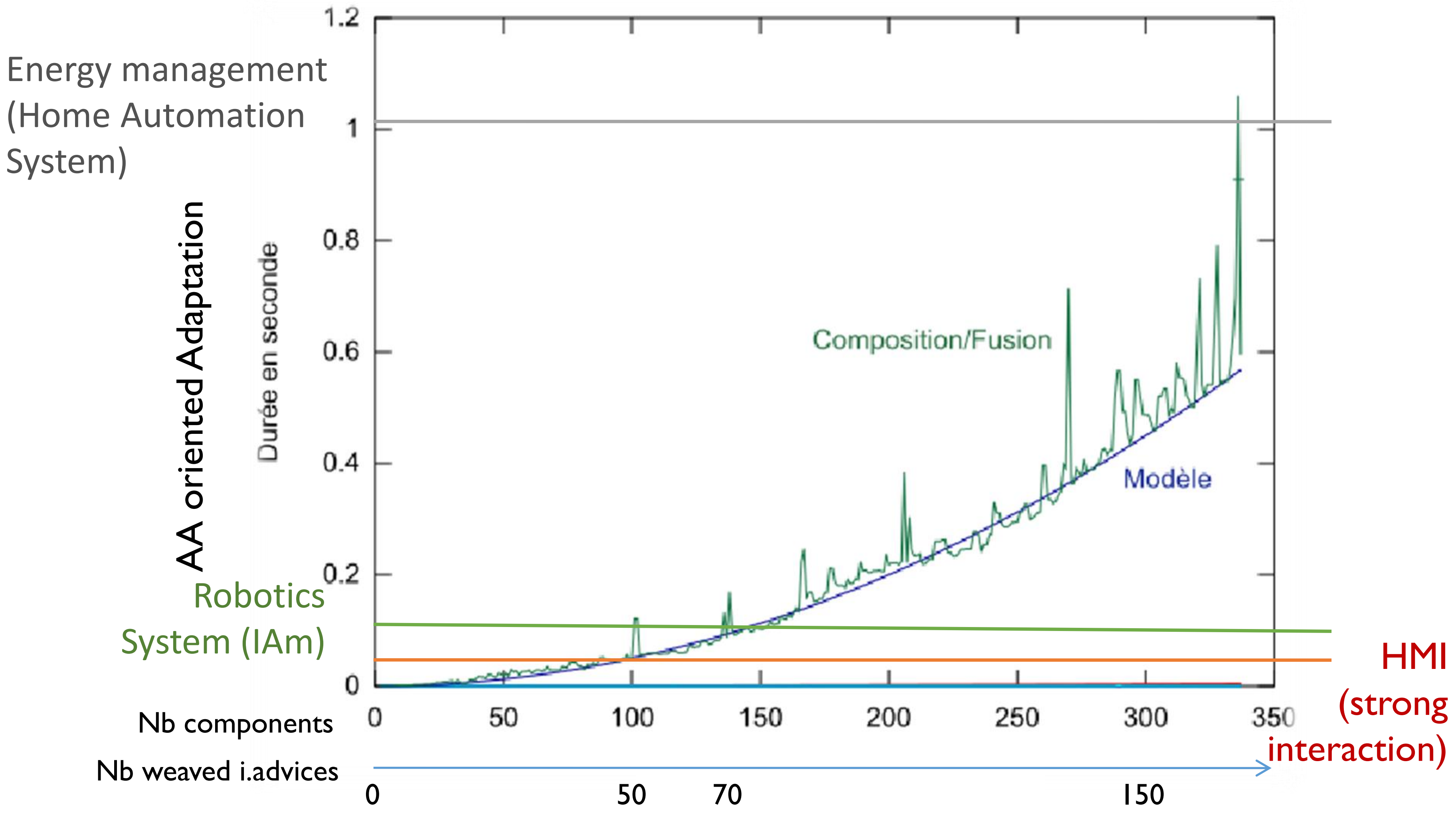
Response time model of one adaptation cycle

Seamless Services

Reactivity, response time and adaptation Cycle



Reactivity and Adaptation : Temporal Model and Experimental results



Application to seamless services

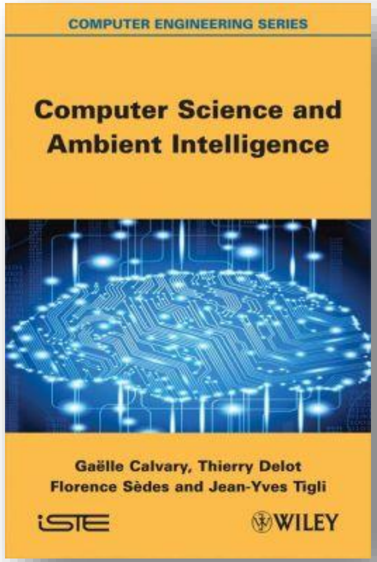
- ANR CONTINUUM Project
- http://continuum.unice.fr

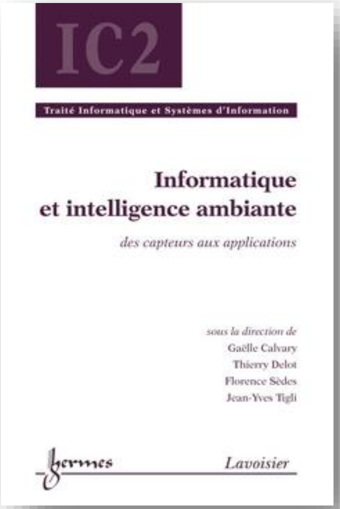
- See Video of IAm seamless applications for Hydran Man in the Water Industry

Some overview References

[2013] Gaëlle Calvary, Thierry Delot, Florence Sèdes, **Jean-Yves Tigli**, editors. “Computer Science and Ambient Intelligence” 335 pages, ISTE Ltd and Wiley & Sons Inc, March 2013, ISBN 978-1-84821-437-8

[2012] Gaëlle Calvary, Thierry Delot, Florence Sèdes, **Jean-Yves Tigli**. “Informatique et Intelligence Ambiante : des Capteurs aux Applications (Traité Informatique et Systèmes d'Information, IC2)” Hermes Science, July 2012, ISBN 2-7462-2981-1





One Ph. D. Current Work

G. Rocher

Advisor J.-Y. Tigli and N. Le Than

On the Behavioral Drift Estimation of Ubiquitous Computing Systems in Partially Known Environments

13th Annual International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services
November 28–December 1, 2016, Hiroshima, Japan

Gérald Rocher, Jean-Yves Tigli and Stéphane Lavirotte

NEW CHALLENGES, NEW IDEAS

sophia antipolis

dépasser les frontières

UNIVERSITÉ CÔTE D'AZUR

Introduction

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  - Technology *disappears* from view,
  - Ubiquitous applications interact *seamlessly* with users and their surroundings
  - …

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✓ Proliferation of connected objects in our surroundings,
✓ Ubiquitous applications operate in the physical environment via effectors & sensors.

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  - …

- … is not yet a reality
  - ✓ Proliferation of connected objects in our surroundings,
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  - ✗ Responsibility of the actions to be undertaken delegated to the users.

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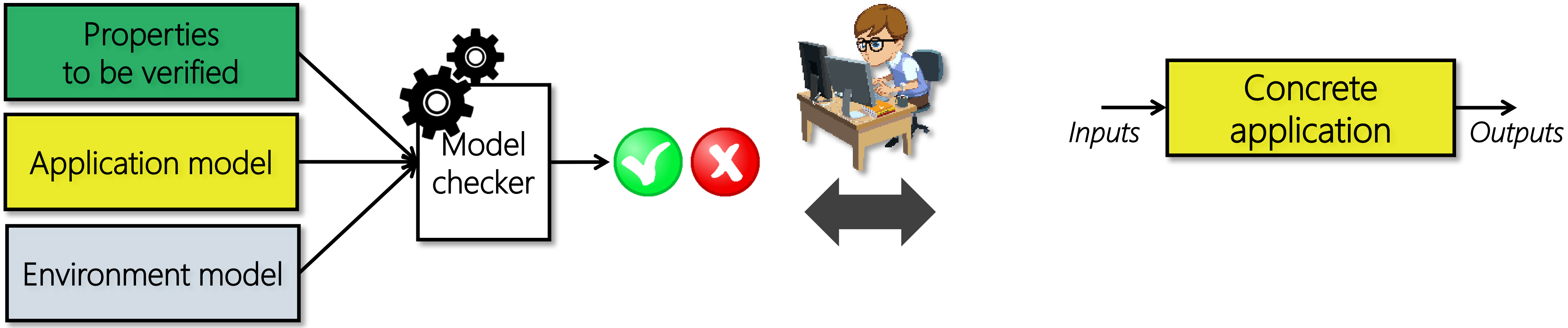
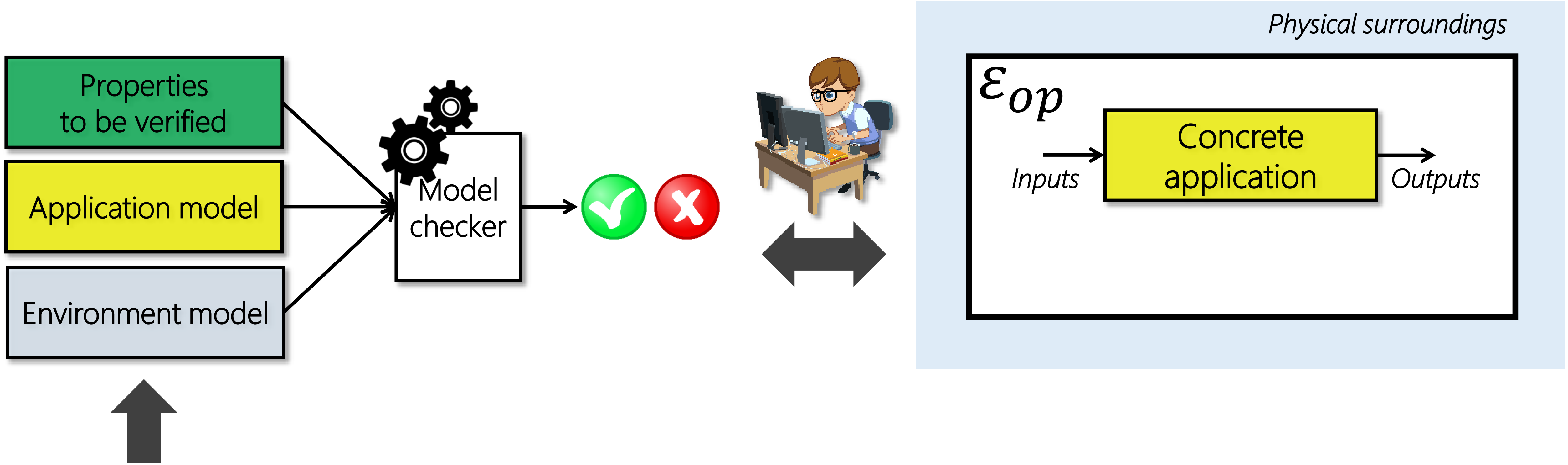
Problem statement

- Model Driven Engineering (MDE) technics used to *verify/predict* applications behavior.



Problem statement

- Assume ***deterministic/controlled*** behavior while operating in the environment



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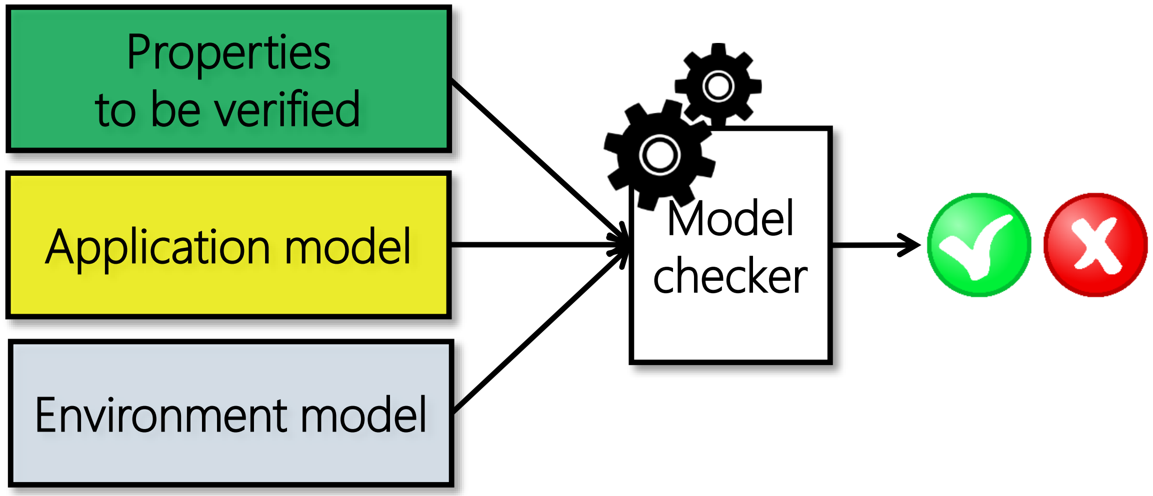
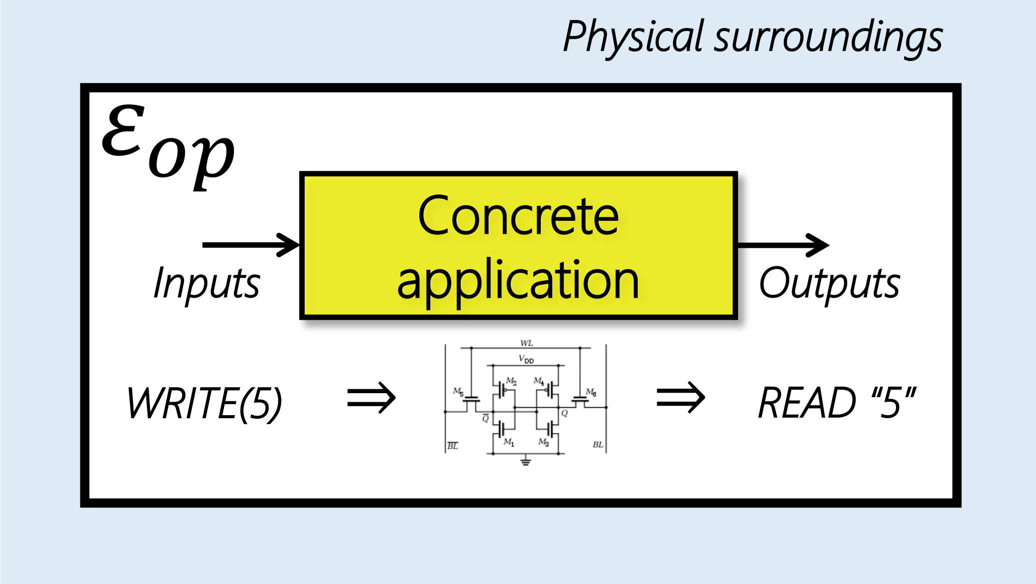
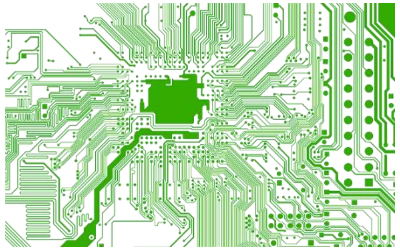


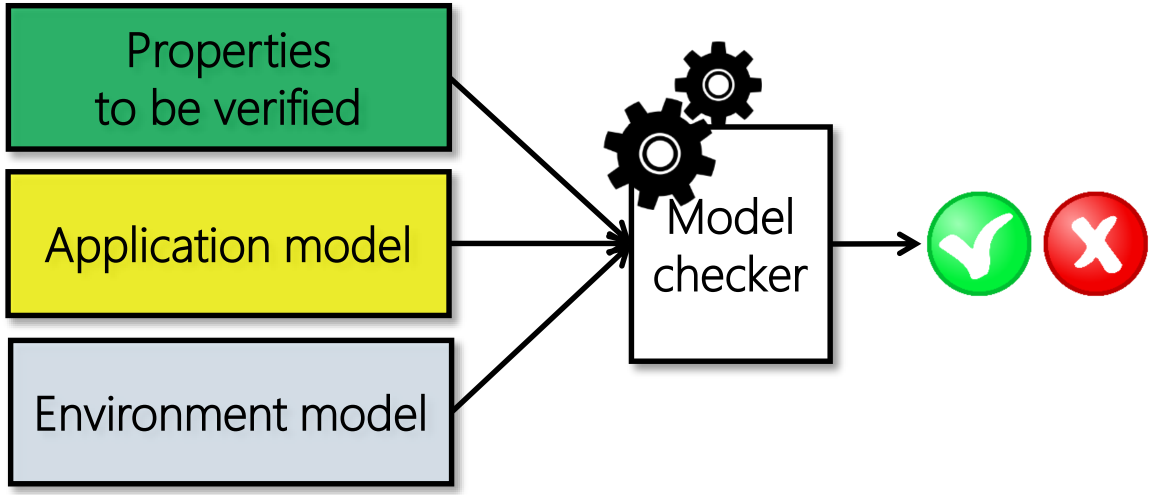


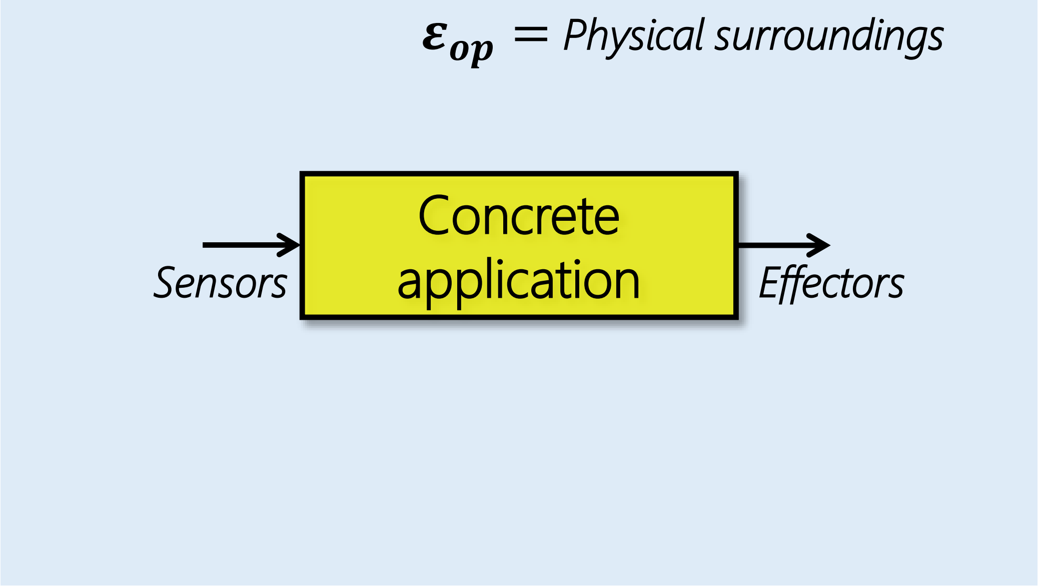
What You Set Is What You Get!



Problem statement

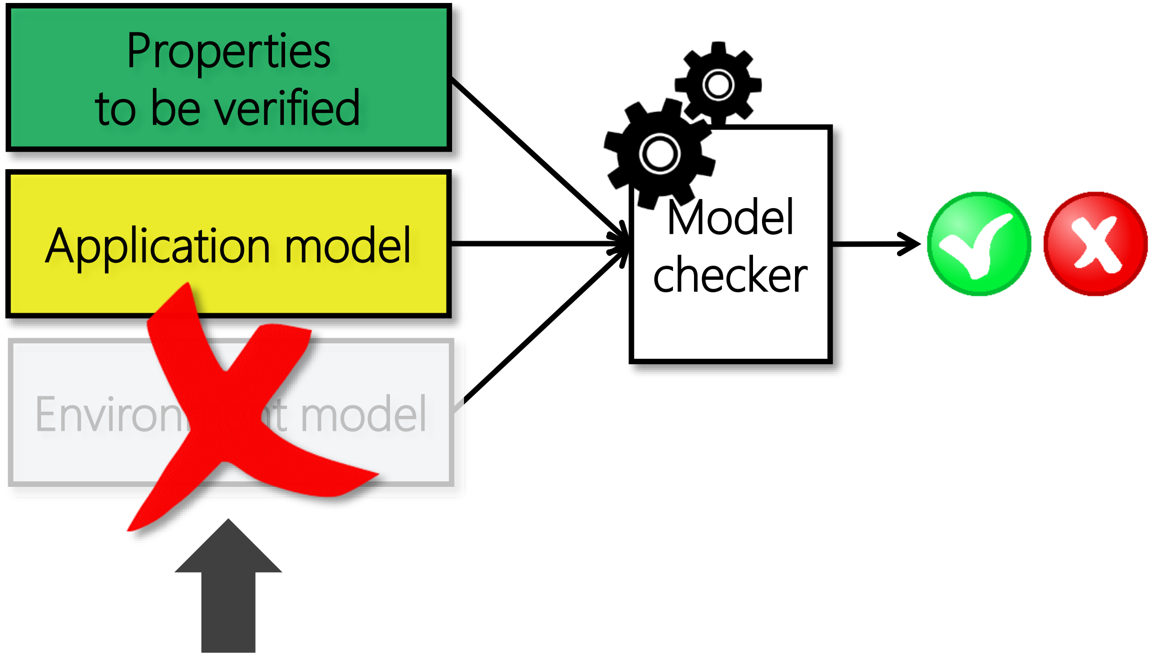
- However, the physical environment is open and subject to *uncertainties*...

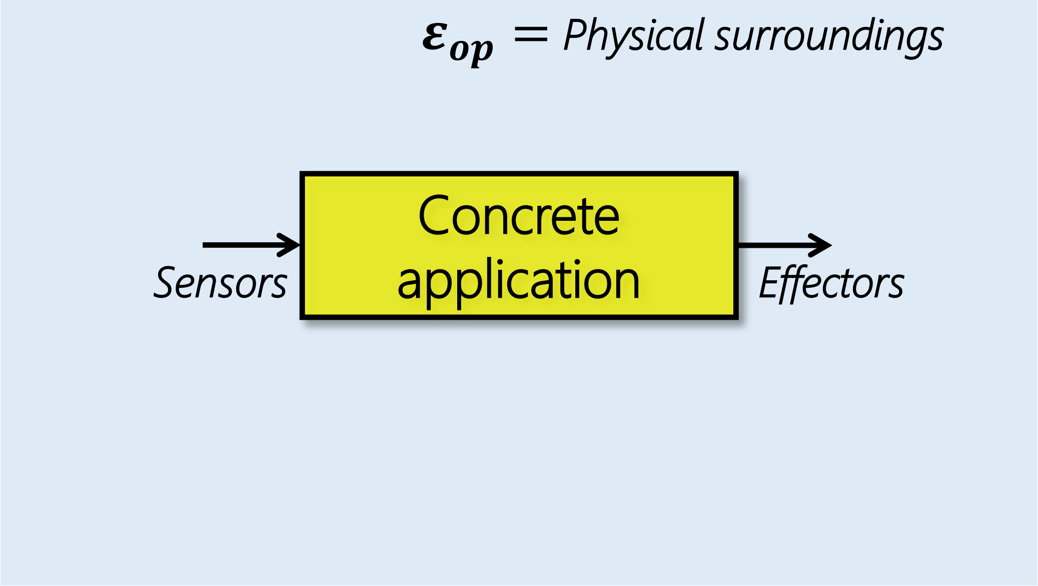




Problem statement

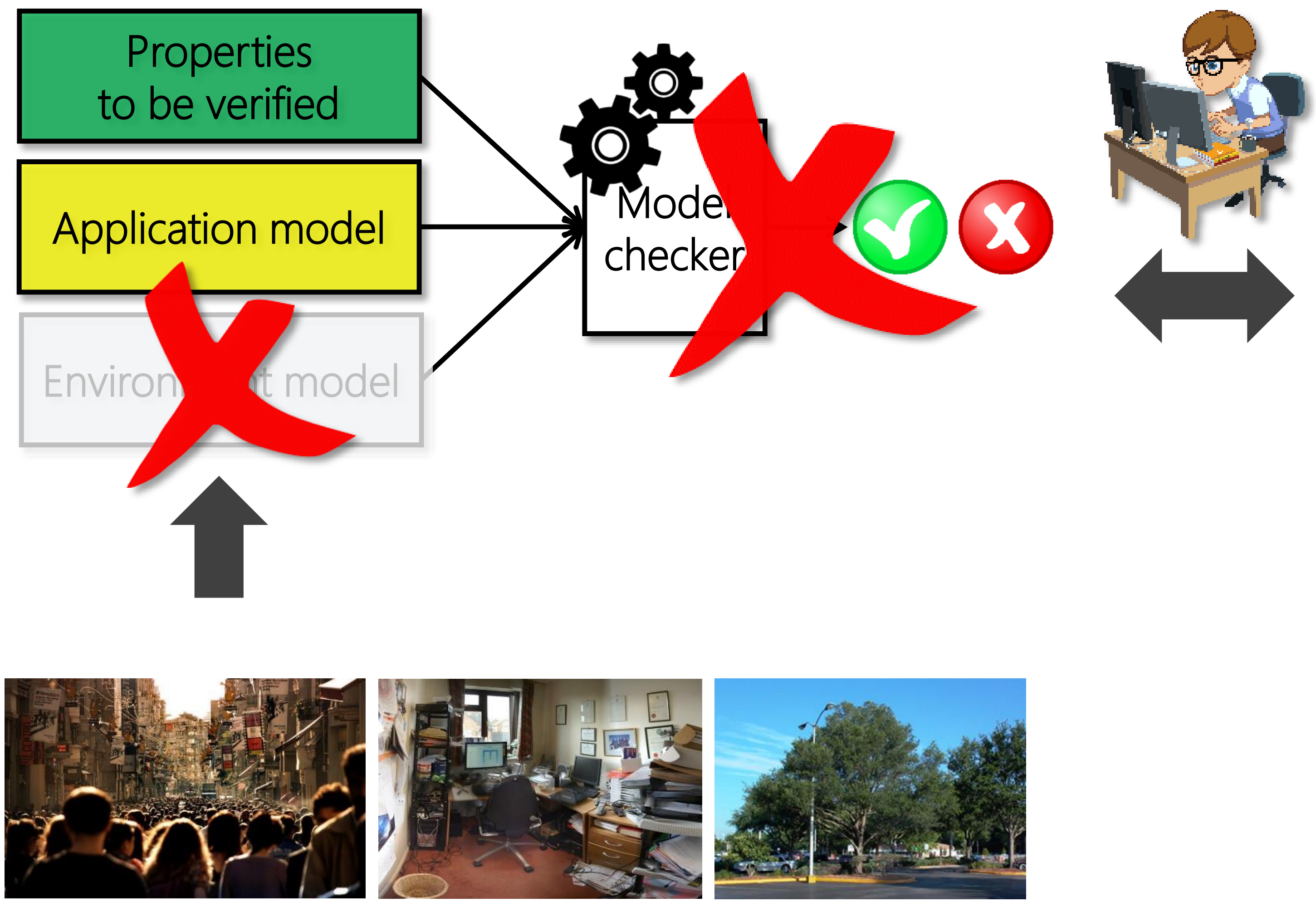
- … that cannot be accurately and entirely modeled.

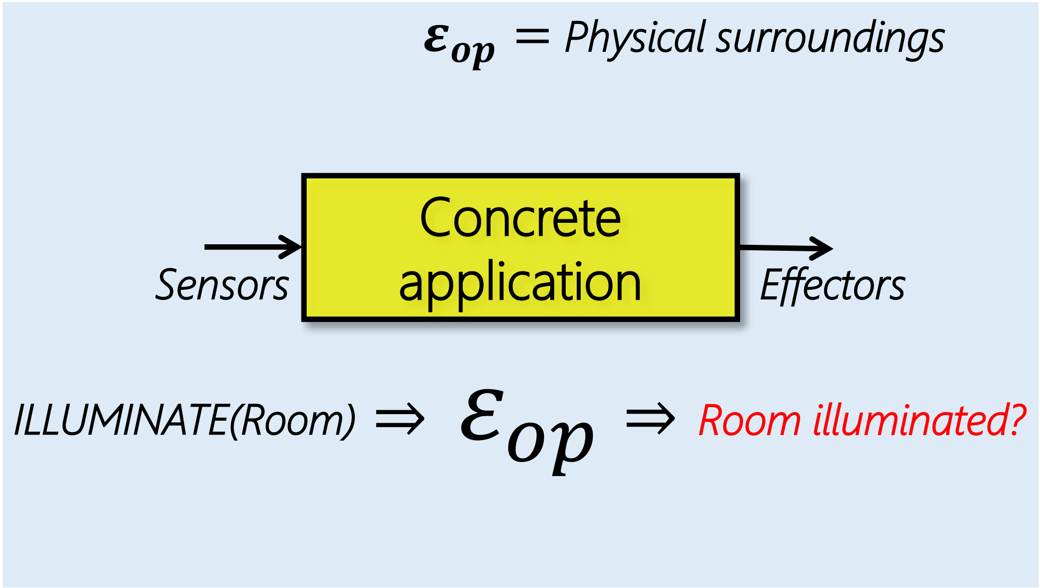




Problem statement

- In this context MDE technics are not well suited to verify/predict behavior.





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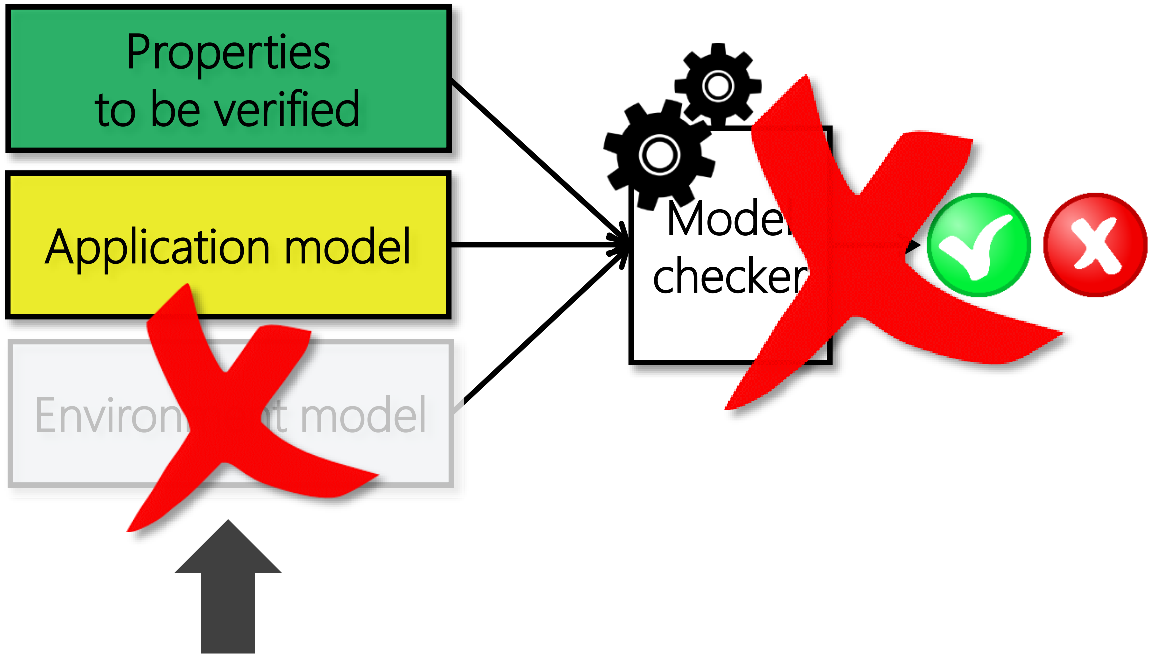

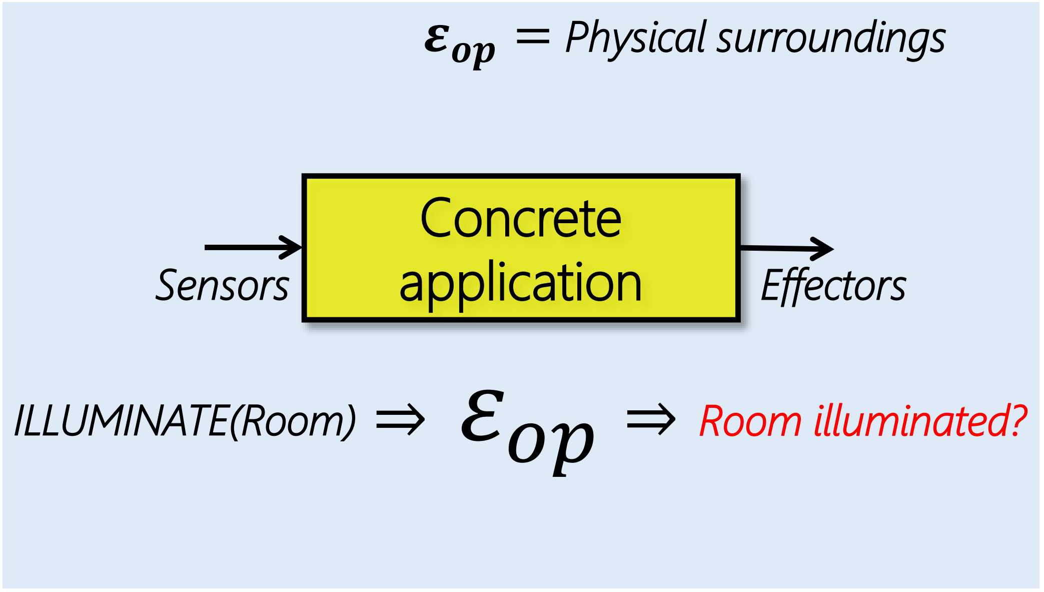

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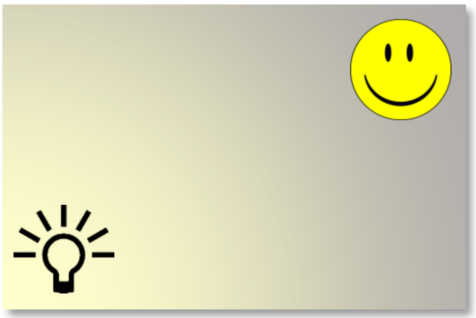
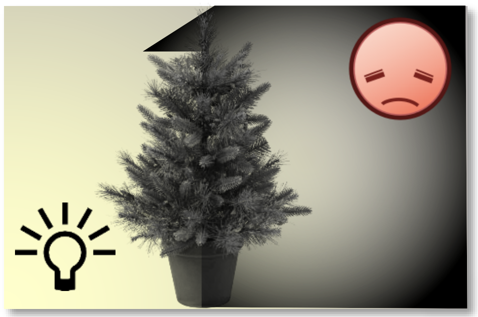
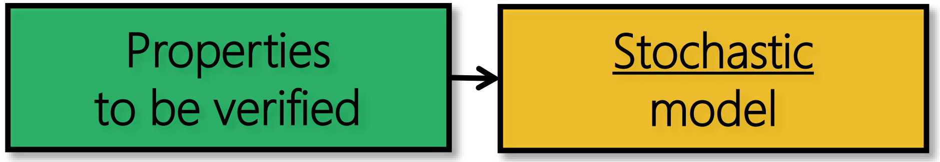
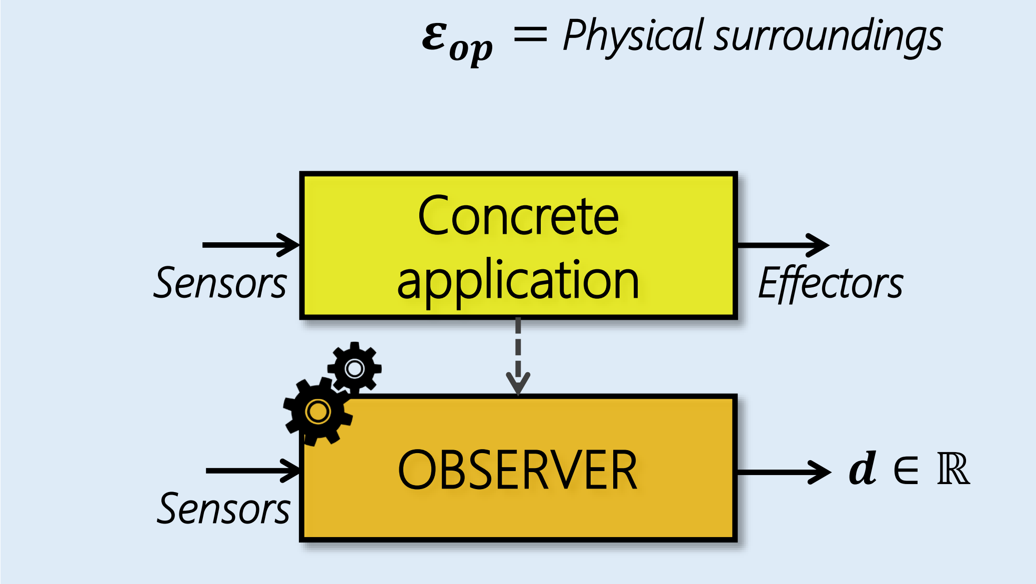




Proposed approach

- We appeal on the control theory and the notion of state observer…

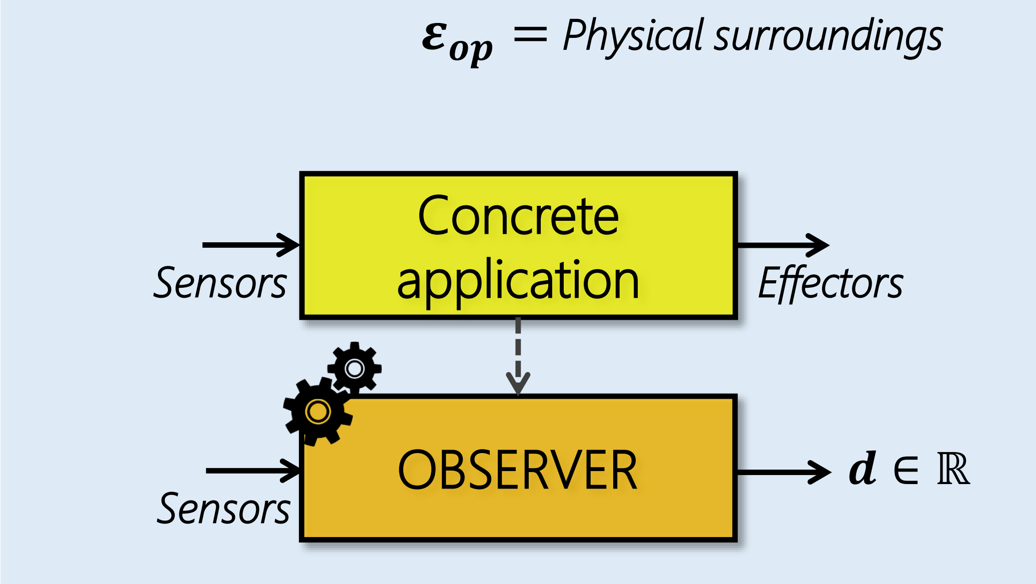




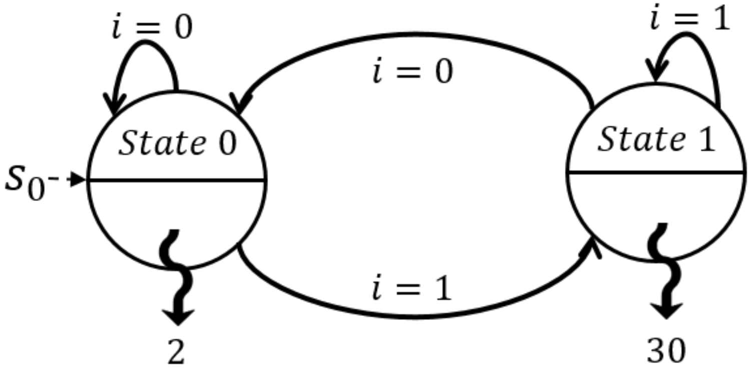
Proposed approach

- Ideally, the behavior of an application is supposed to be deterministic…

Properties to be verified → Stochastic model



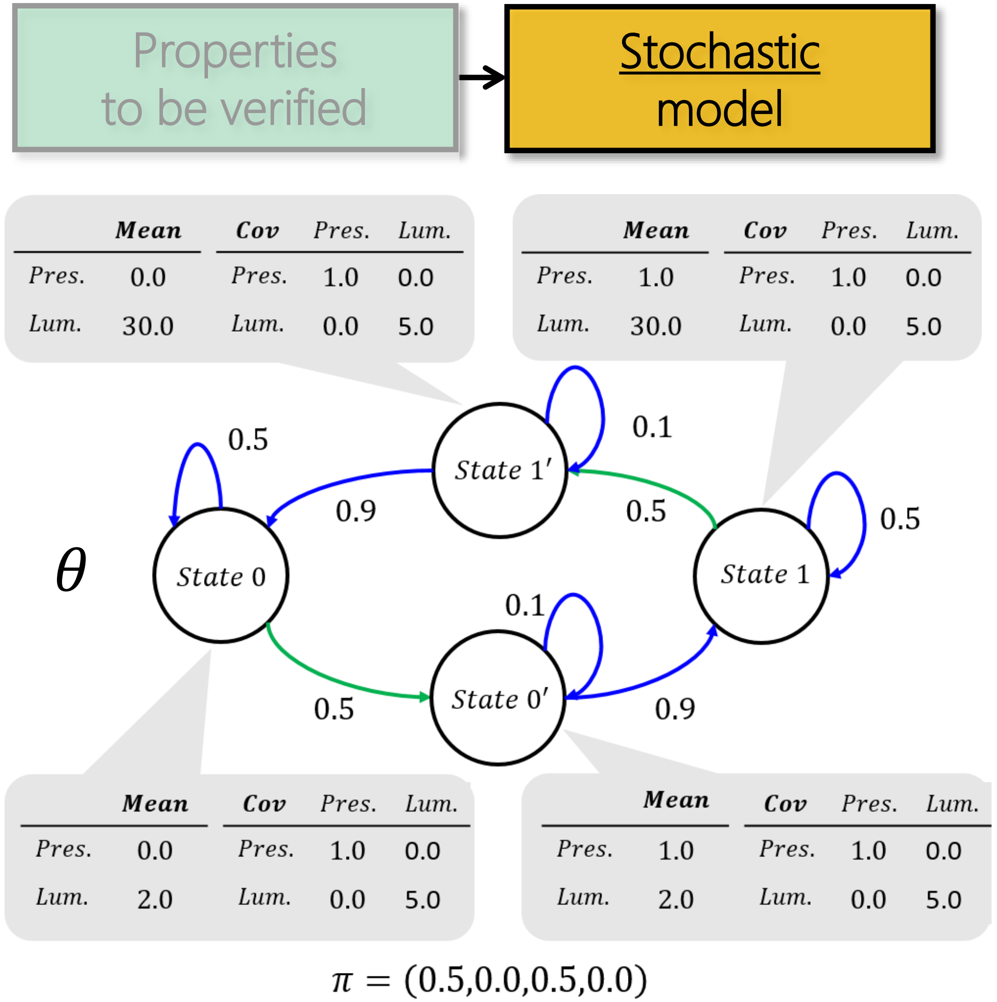
Input i (presence sensor)	Low luminosity (state 0)	High luminosity (state 1)
No presence detected	Conform	Non – conform
Presence detected	Non – conform	Conform

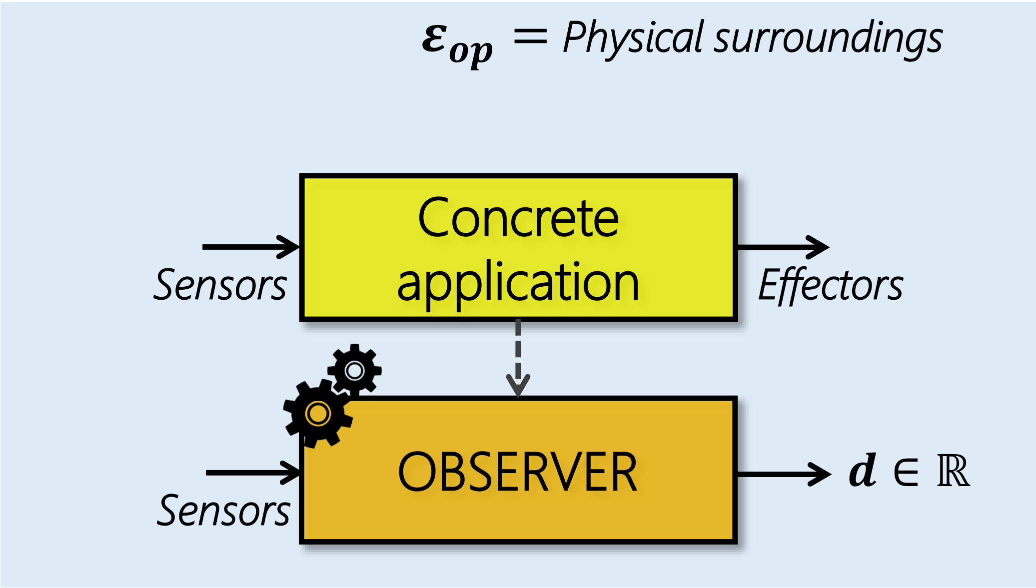


⇒ Deterministic Finite State Machine
⇒ Moore DFSA

Proposed approach

- … but more realistically, is subject to uncertainties leading to introduce <u>probabilities</u>.





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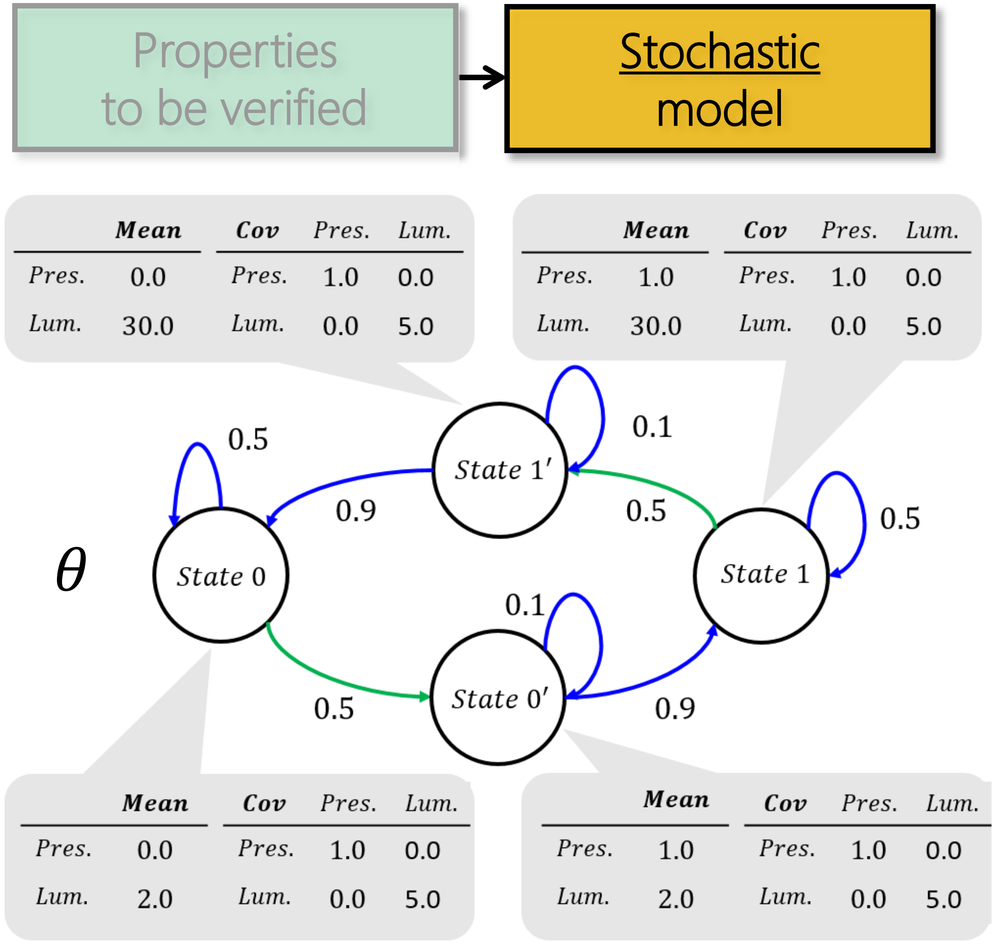
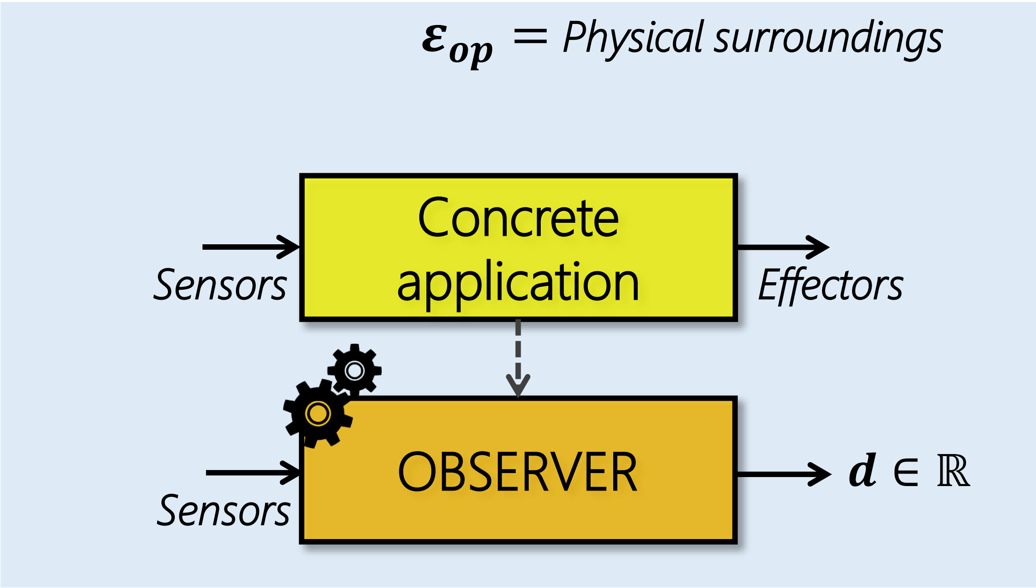


$\pi = (0.5, 0.0, 0.5, 0.0)$

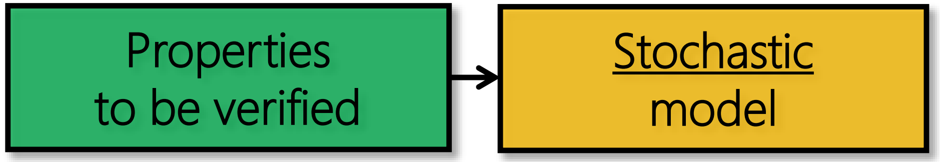
$\Rightarrow \mathbb{P}(y_1^T | \theta) \in \mathbb{R}$

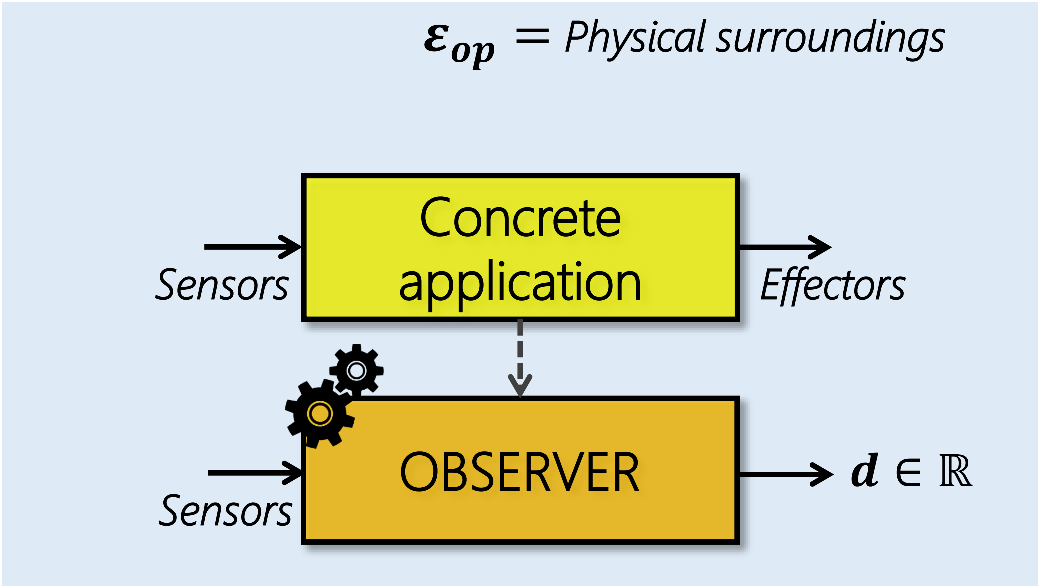


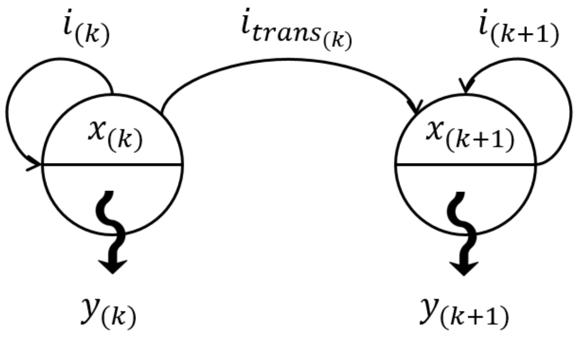
⇒ Continuous Density Hidden Markov Model
⇒ Parameters set by the user or learnt.

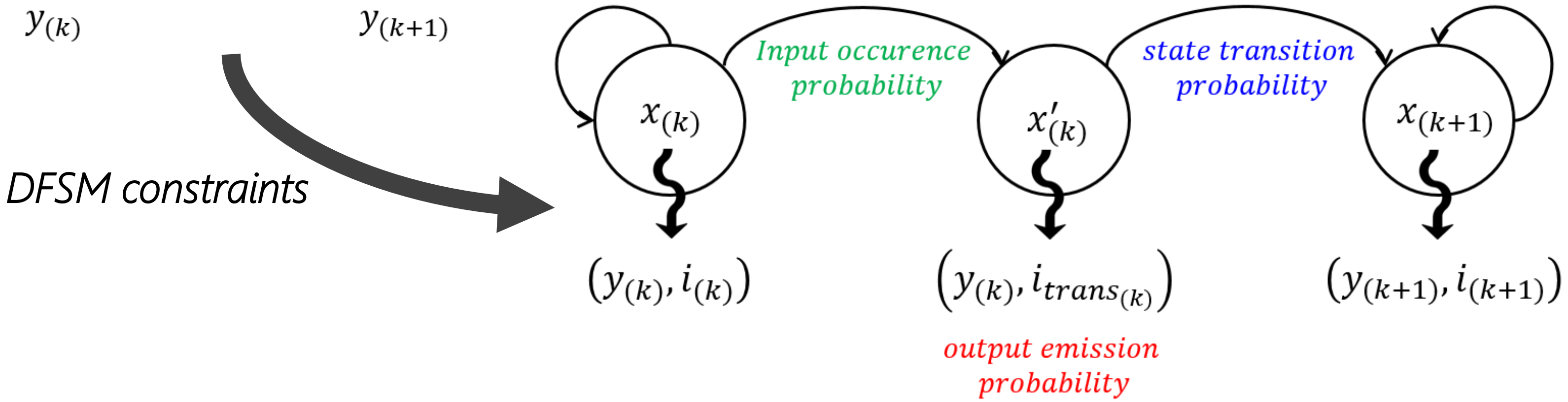
From deterministic to Probabilistic model

- Introducing input-occurrence and state-transition probabilities…

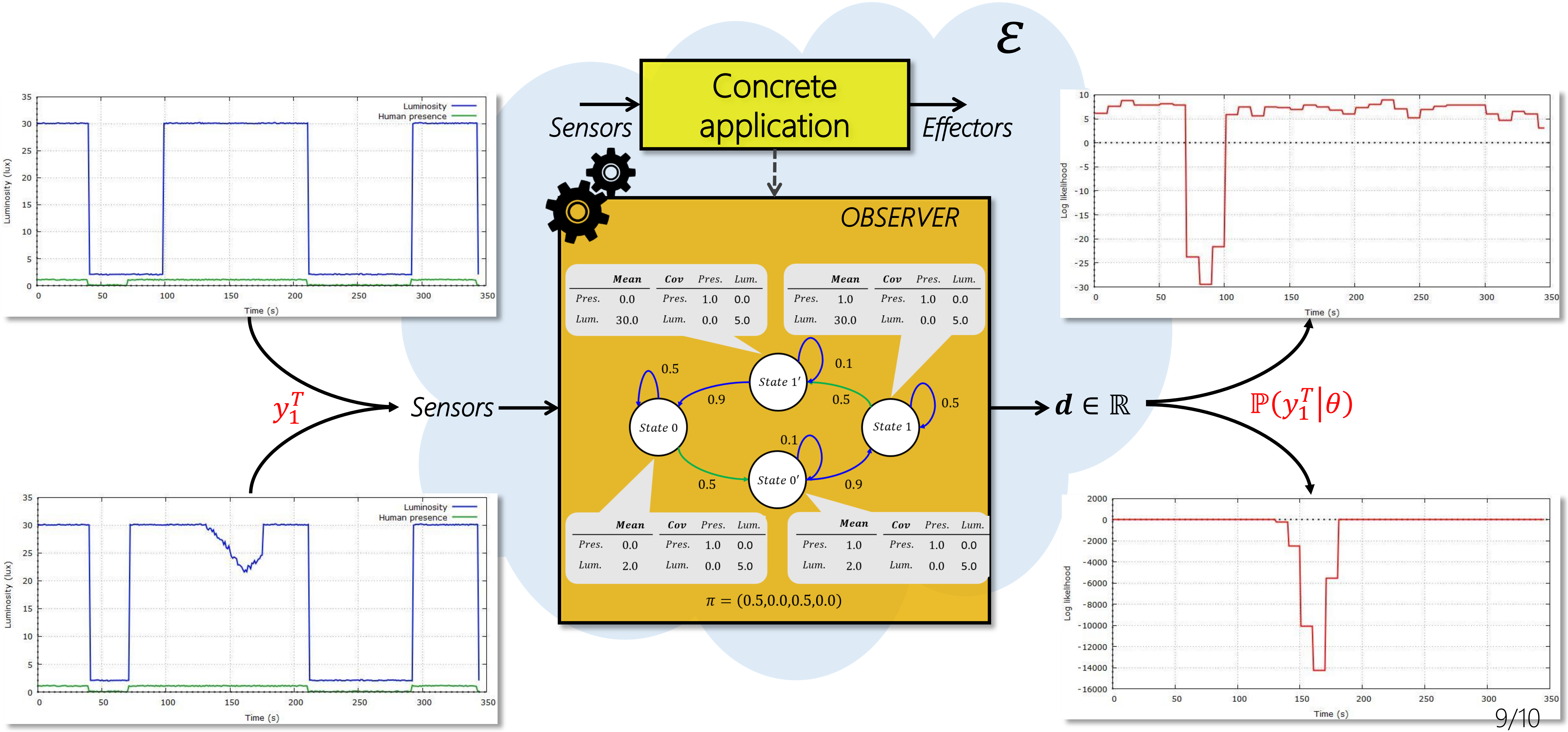








Experimentation results



Conclusion

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  - Provision ubiquitous systems with a run-time estimation ($\in \mathbb{R}$) of the applications behavioral conformity …
  - … that could be used in closed-loop systems (self-adaptiveness)

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- Contribution
  - Provision ubiquitous systems with a run-time estimation ($\in \mathbb{R}$) of the applications behavioral conformity …
  - … that could be used in closed-loop systems (self-adaptiveness).
- Future work
  - Scaling: address the state “explosion” problem,
  - Temporal constraints (physical process with inertia).

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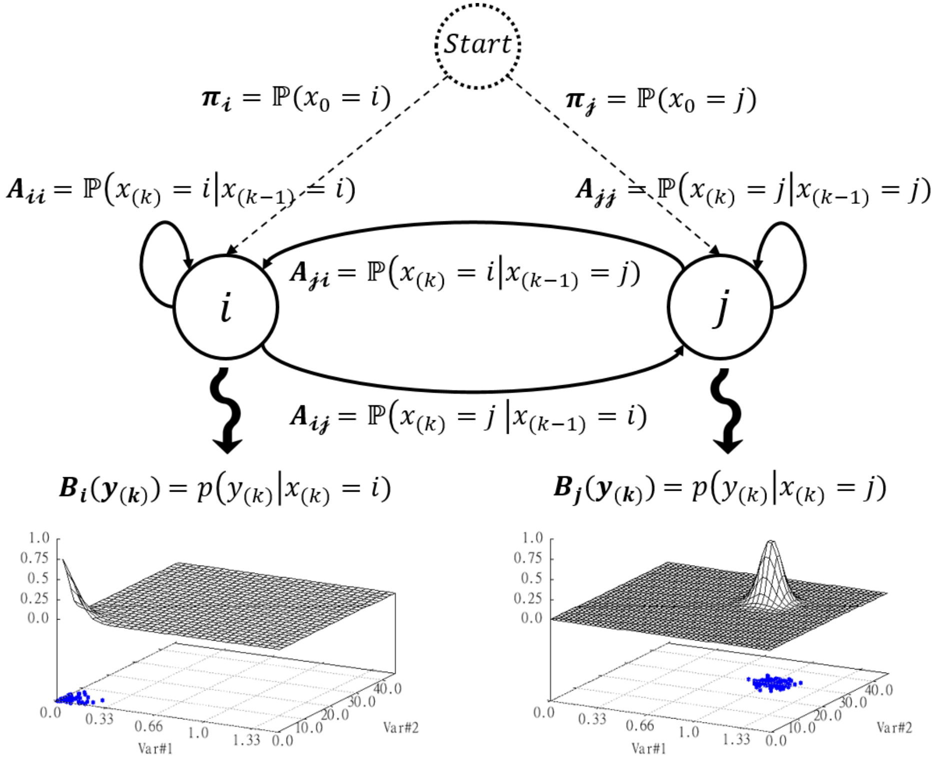
Thank you for your attention!

Gérald Rocher, Jean-Yves Tigli and Stéphane Lavirotte

Hidden Markov Model (HMM)

- $\theta = (A, B, \pi)$:
  - A, the $N \times N$ state-transition probability matrix (where N is the number of hidden states),
  - B, observation probability density functions (pdf) matrix,
  - π, the initial state distribution vector.

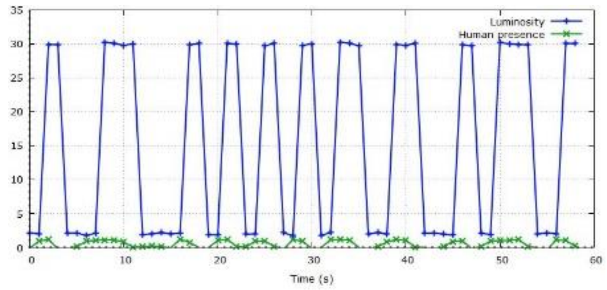


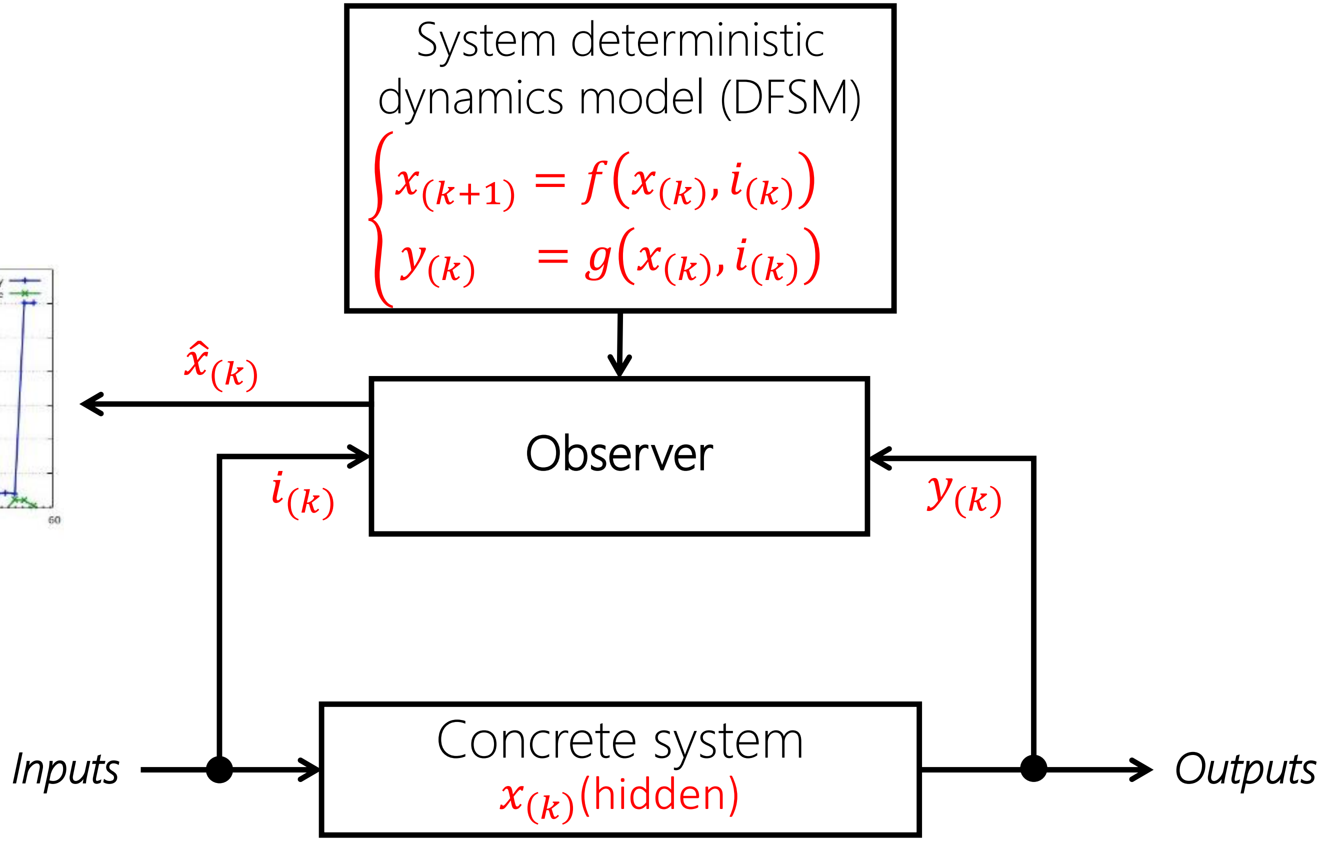
- Canonical problems
  1) **Given the model $\boldsymbol{\theta}$, compute the probability of an output sequence $\boldsymbol{y_1^T}$,**
  2) Given the model $\boldsymbol{\theta}$ and an output sequence $\boldsymbol{y_1^T}$, compute the most probable hidden state sequence $\boldsymbol{\hat{x}_1^T}$,
  3) Given an output sequence $\boldsymbol{y_1^T}$, compute the parameters of the model $\boldsymbol{\theta}$.

- Probabilities computation
  - State-transitions/initial distribution probabilities from DFSM constraints,
  - Considering multivariate normal density functions:
    - Mean values from DFSM emission values,
    - Variance/covariance values from users or learnt.

Deterministic state observer

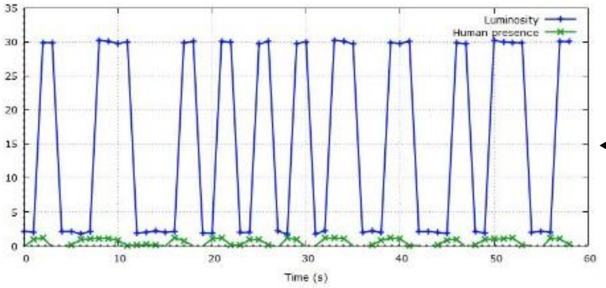
- Estimation of the state $\hat{x}$ of the system (hidden)
- <u>Deterministic system dynamics:</u>

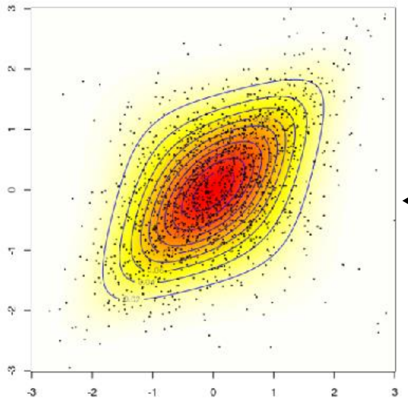




Probabilistic state observer

State sequence decoding ($\hat{x}_1^T$)





Probability of the observed sequence:
$\mathbb{P}(y_1^T|\theta)$

System deterministic model
(Moore DFSM)

$$\begin{cases} x_{(k+1)} = f(x_{(k)}, i_{(k)}) \\ y_{(k)} \quad = g(x_{(k)}) \end{cases}$$

Probabilistic model θ
(HMM)

$$\begin{cases} x_{(k+1)} \Rightarrow \mathbb{P}(x_{(k+1)}|x_{(k)}) \\ y_{(k)} \quad \Rightarrow \mathbb{P}(y_{(k)}|x_{(k)}) \end{cases}$$

$y_1^T = y_1, \dots, y_T$

$\mathcal{E}$

Sensing
Inputs

Concrete application

$x_{(k)}$(hidden)

Effecting
Outputs