
ANITI
ARTIFICIAL & NATURAL INTELLIGENCE
TOULOUSE INSTITUTE
"Diagnosis" Chair
Louise Travé-Massuyès
SCIENTIFIC DIRECTOR : NICHOLAS ASHER
COORDINATING INSTITUTION : UNIVERSITÉ FÉDÉRALE TOULOUSE MIDI-PYRÉNÉES
Université Fédérale
Toulouse Midi-Pyrénées
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“Diagnosis” Chair
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Synergistic transformations in model based and data based diagnosis
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Chair and co-chairs

Louise Travé-Massuyès

CNRS Research Director
LAAS-CNRS, University of Toulouse
http://homepages.laas.fr/louise
Diagnosis theories, Model-Based Diagnosis, Data-Based Diagnosis, Machine Learning, Monitoring and Health Management, Diagnosability, Sensor placement, Diagnosis architectures, Qualitative models and qualitative reasoning formalisms

+ DISCO team (LAAS-CNRS)

Nathalie Barbosa Roa

Data scientist and Big Data engineer
Continental Automotive France SAS
https://www.linkedin.com/in/nathaliebarbosaroa/
Fault detection, data-based, time series, manufacturing, machine learning

Xavier Pucel

Research engineer
ONERA / DTIS, University of Toulouse
https://sites.google.com/view/xavier-pucel/accueil
Autonomous robots, diagnosis, decision, verification and validation, planning and scheduling

Elodie Chanthery

Assistant Professor
LAAS-CNRS, INSA, University of Toulouse
https://homepages.laas.fr/echanthe/
Diagnosis, prognosis, hybrid systems, autonomous systems, distributed systems

Diagnosis

The process of identifying or determining the nature and root cause of a failure, problem, or disease from the symptoms resulting from selected measurements, checks or tests.

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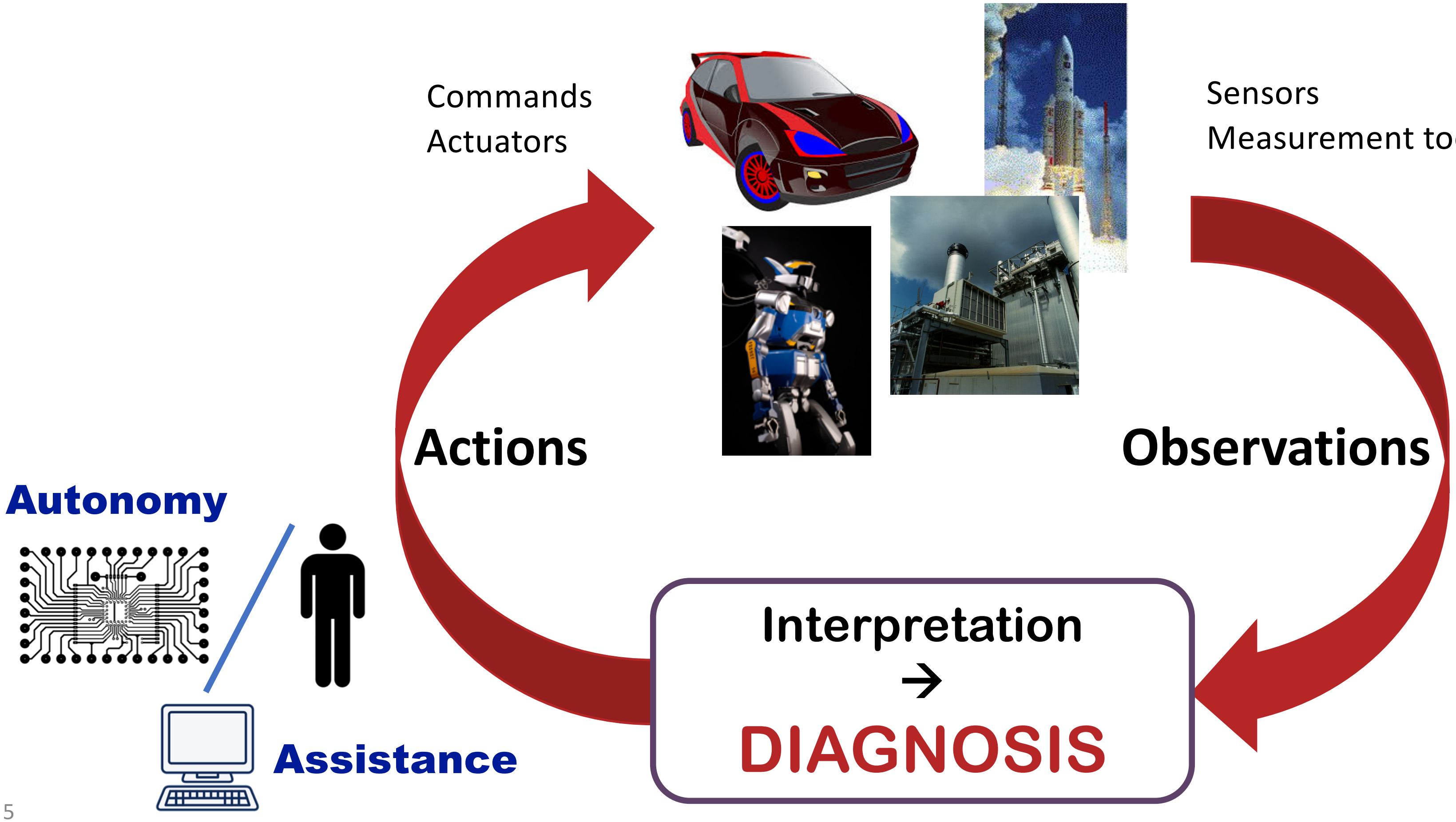
Diagnosis in the decision loop



Objectives

- Increased safety
  - Ability to avoid catastrophic or critical events for installations, stakeholders, and the environment
- Increased reliability
  - Ability to perform a function under given conditions for a given period of time
- Increased availability
  - Ability to perform a function at a given time under given conditions

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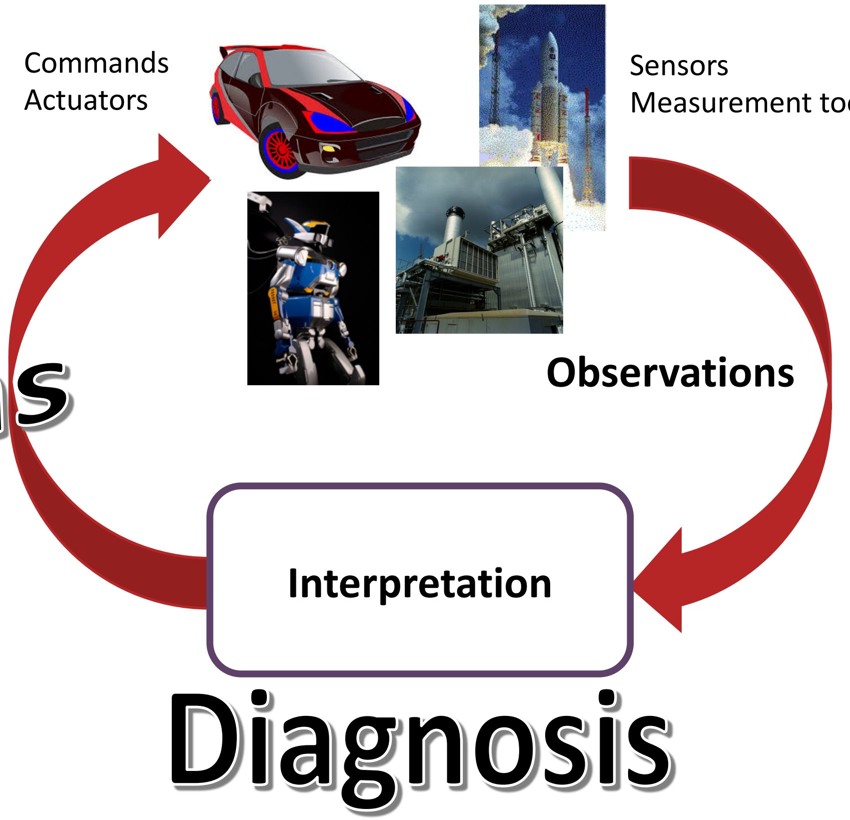
Appropriate/optimized actions

Control

Planning

Maintenance

Actions



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Diagnosis

Detect inconsistencies w.r.t. a reference
Detect anomalies/faults, specific situations
Identify root causes
Estimate the internal state of a system

Identify and recommend
Determine responsabilities
...

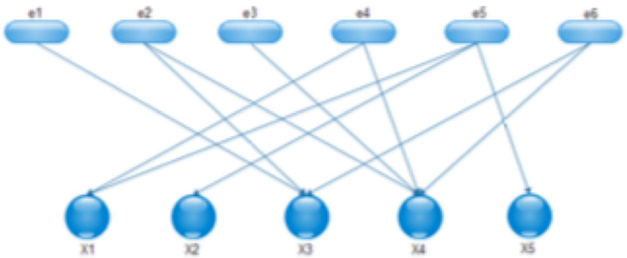
Model-based diagnosis

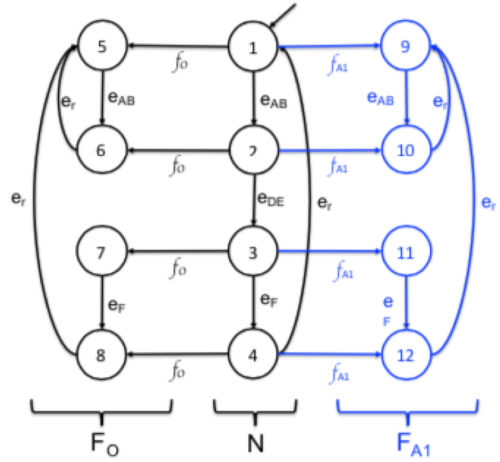
- Uses a model obtained from knowledge

Logical theory

COMPS = {A1, A2, M1, M2, M3}
SD = {ADD(x) ∧ ¬AB(x) ⇒ Output(x) = Input1(x) + Input2(x),
MULT(x) ∧ ¬AB(x) ⇒ Output(x) = Input1(x) × Input2(x),
ADD(A1), ADD(A2), MULT(M1), MULT(M2), MULT(M3),
Output(M1) = Input1(A1), Output(M2) = Input2(A1), …..
OBS = {Input1(M1) = 2, Input2(M1) = 3, Input1(M2) = 2, Input2(
Input1(M3) = 3, Input2(M3) = 2, Output(A1) = 10, Output(

Structural analysis





Estimation theory
Parity space theory

$$\dot{x}(t,p) = f(x(t,p), u(t), p),$$
$$y(t,p) = h(x(t,p), p),$$
$$x(t_0,p) = x_0 \in X_0,$$
$$p \in P \subset \mathcal{U}_p, \quad t_0 \leq t \leq T,$$

DES diagnosis theory

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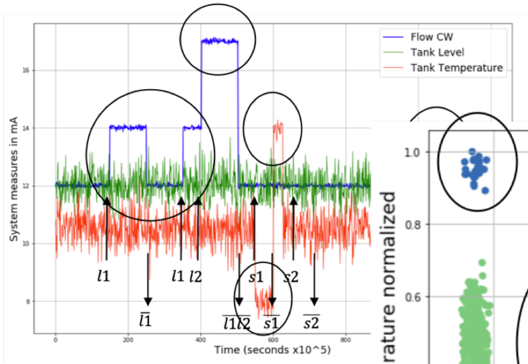
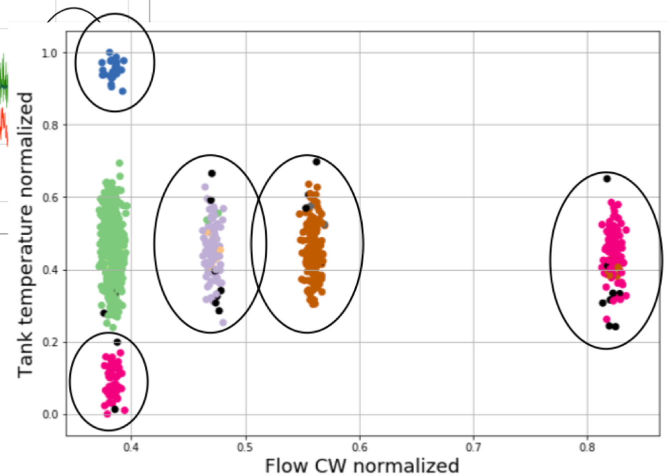
Data-based diagnosis

- Uses “only” data
  - Learning phase
  - Recognition phase

Signals (time series)



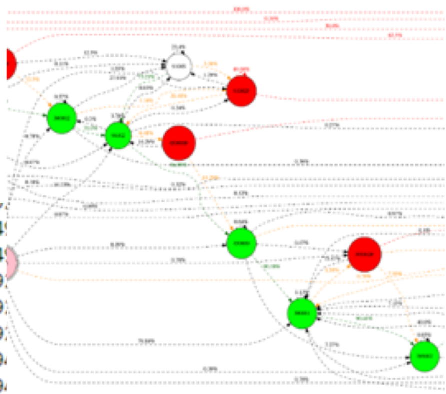
Categorical features



→ Classification/clustering

Logs

```
15  (300002,1550833696)     3  (91002F,154
16  (91005,1550834022)      4  (91002F,154
17  (91005,1550834070)      5  (91002,1549
18  (91002,1550834122)      6  (91002,1549
19  (450000,1550834241)     7  (91002,1549
20  (390001,1550839758)     8  (91002,1549
21  (395002,1550840248)     9  (91002,1549
22  (3950022,1550840250)   10  (91002,15494629
23  (445001,1550841568)    11  (91002,15495376
```



→ Temporal patterns

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Preference-Based State Estimation in Autonomous Systems

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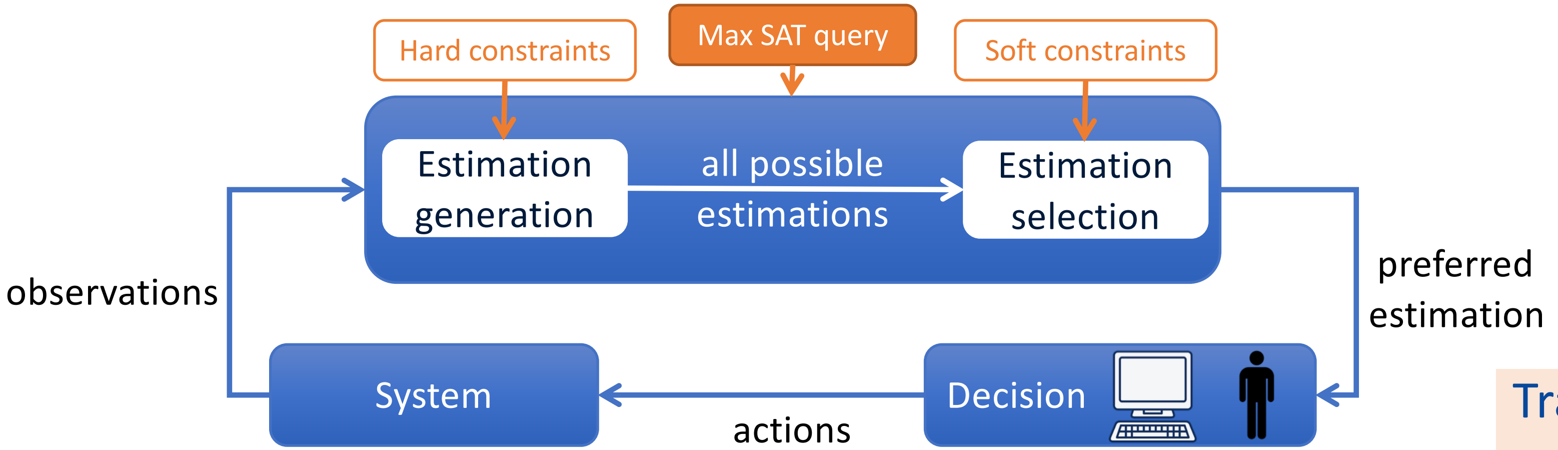
ONERA THE FRENCH AEROSPACE LAB



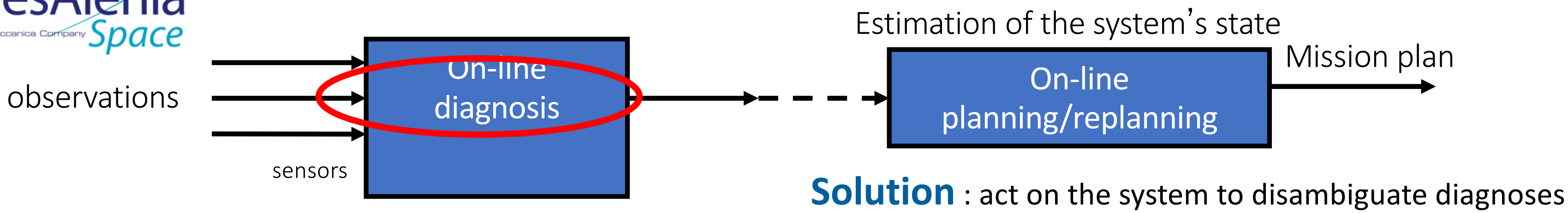
- Select only one estimation
  - Conditional selection strategy
    - Optimistic / conservative
  - Depends on previous estimated state + observation
    - E.g. previous symptom occurrences

Short explanations	Incremental
Avoid surprise (no backtrack)	Handle intermittent phenomena

Trackability:

- Possible inconsistency between observation and previous estimations → **blocking paths**
- A **trackable** system accepts a non blocking estimator

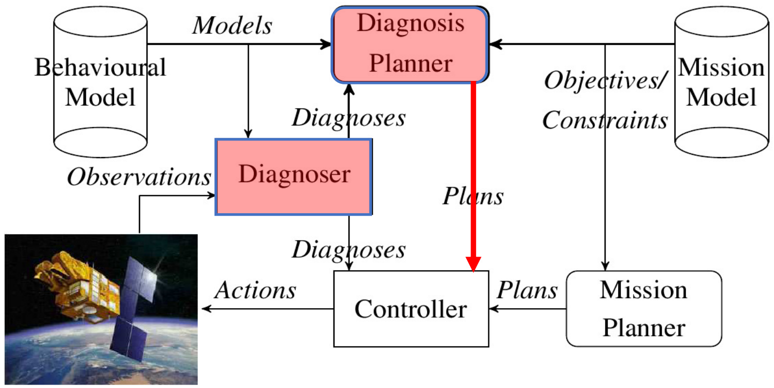
Coupling Diagnosis and Planning for active diagnosis

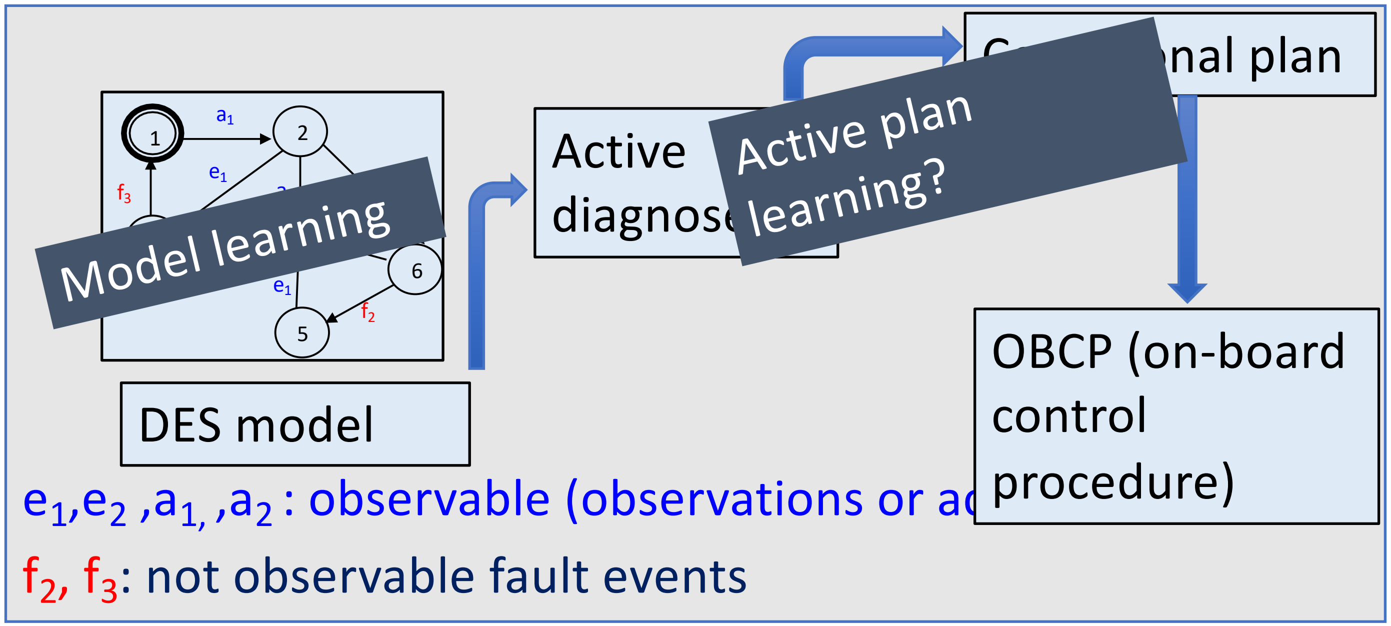


Solution : act on the system to disambiguate diagnoses

→ **Active Diagnosis**

Problem : lack of observations





Dynamic clustering and automatic learning of discrete event models

Two stages clustering

Novelty detection and cluster evolution

- A function $f(t - t_{lk})$ emulates an ageing process
- The attributes of the µclusters are updated with this function
- This process impacts cluster's density
- Ultimately, it results in cluster pattern evolution (moving, merging, splitting)

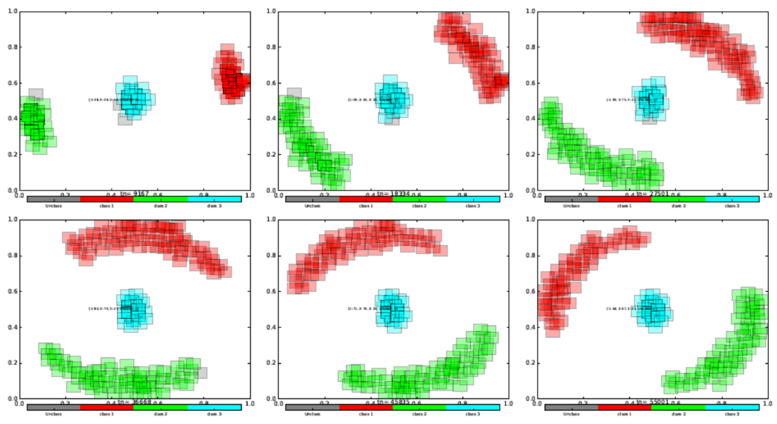
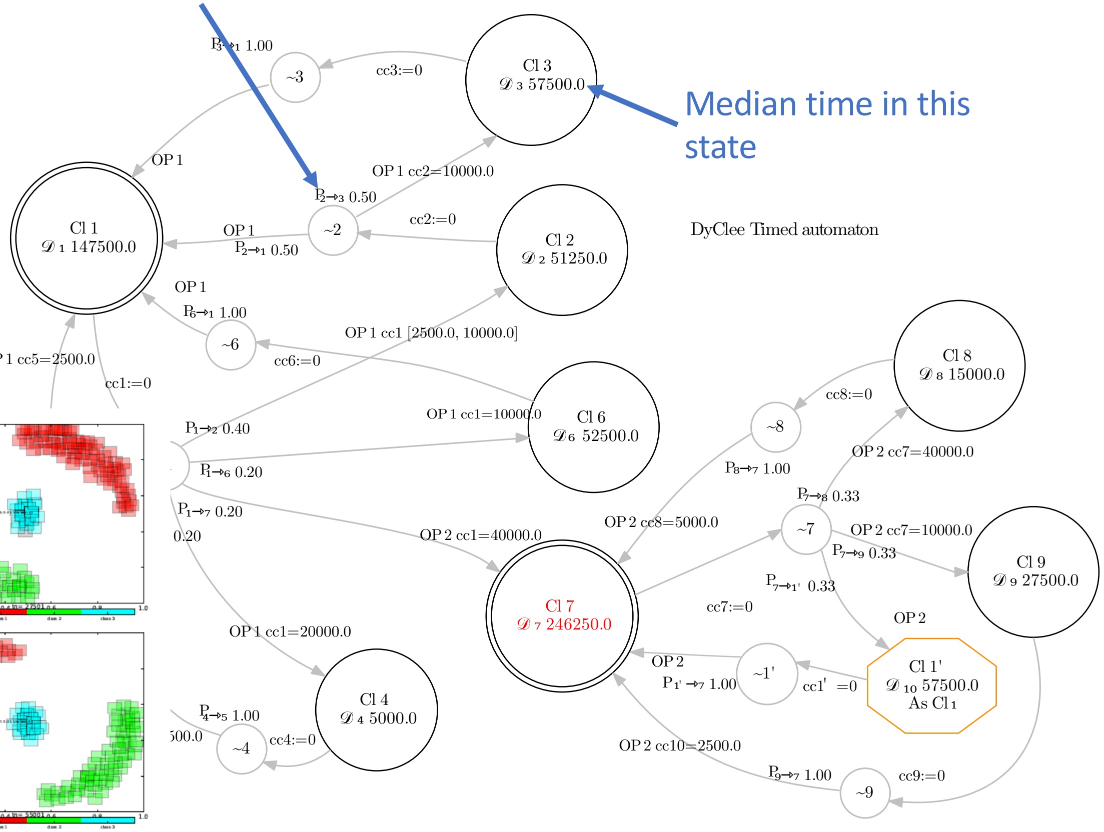


Figure 21: Concept Drift toy example

Probability of the transition

Median time in this state



Project of the chair

- Highlight and understand the correspondences that may exist between MBD and DBD techniques, in particular for feature generation and diagnosability analysis
- Integrate knowledge based models and learning
- Learn diagnosis models : abstract up data configurations and map them to symbolic or analytical models suitable for diagnosis reasoning

Project of the chair

- Integration of knowledge based models and learned models: heterogeneous and non structured data
- Diagnosability analysis
  - Diagnosability checks: situation signature learning
  - Joint analysis based on structural models and data
- Heterogeneous feature identification (selection and/or generation) in evolving environments
  - How and when ?
- Explanations related to diagnosis
  - not only what but why and how

→ Possible post doc topics

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Possible interactions with other chairs

- Joao Marques Silva : HYBRID SUBSYMBOLIC → SYMB.
- Leila Amgoud: HYBRID-ARGUMENT
- Jean-Michel Loubès: FAIR/ROBUST ML
- Hélène Fargier: INDUSTRIAL DESIGN with UNCERTAINTY and PREFERENCES
- …