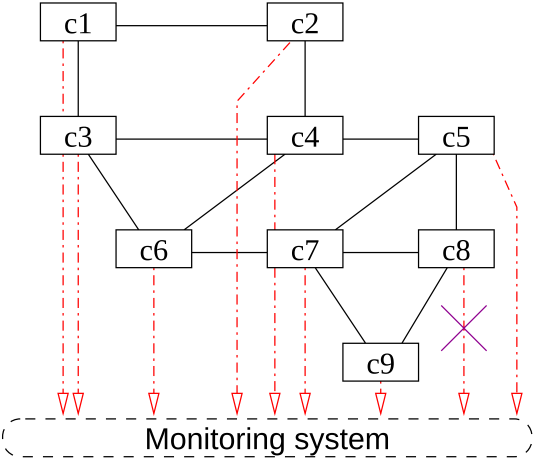
Diagnosis (09)

Uncertainties on the Observations

Alban Grastien
alban.grastien@rsise.anu.edu.au

Uncertainties on the Observations



- Partial order
- Loss of observations
- Sensor or channel failures
- Uncertainty on the message
- Masking

Modelling Uncertainties in the System

Solution

Each communication channel between the system to diagnose and the monitoring system is modelled as a component of the system

Problems

- A single buffer for one observation on a component that can emit k different observations requires k states: the size of the global model is multiplied by k for only one buffer!
- We usually have information about delays between emissions and receptions of observations: do we have to use timed automata?
- We do not want to diagnose the communication channels (otherwise, they would be part of the system)

Partially Ordered Sets

Partial Order

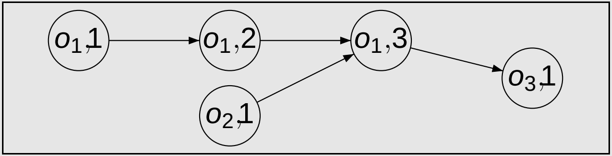
A partially ordered set is a pair $\langle E, \prec \rangle$ so that:

- $\forall e \in E,\ e \not\prec e$
- $\forall e_1 \in E,\ \forall e_2 \in E,\ e_1 \prec e_2 \Rightarrow e_2 \not\prec e_1$
- $\forall e_1 \in E,\ \forall e_2 \in E,\ \forall e_3 \in E,\ e_1 \prec e_2 \wedge e_2 \prec e_3 \Rightarrow e_1 \prec e_3$

Pencolé et al.

- The observations are a partial order set.
- A state of the diagnosis automaton is a pair $\langle s, o \rangle$ where s is a possible state of the system and o is a possible prefix of a sequence compatible with the observations

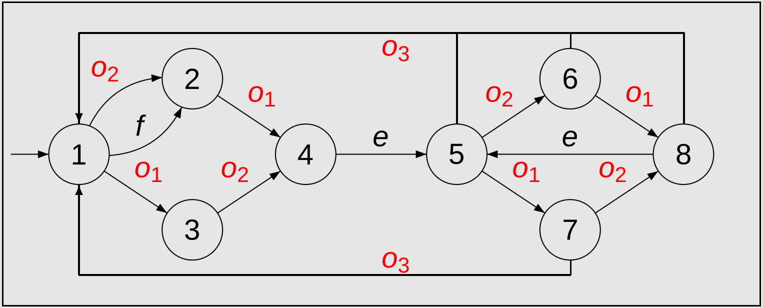
Example



Possible Sequences

- $\langle o_1, o_1, o_2, o_1, o_3 \rangle$
- $\langle o_1, o_2, o_1, o_1, o_3 \rangle$
- $\langle o_2, o_1, o_1, o_1, o_3 \rangle$

Example



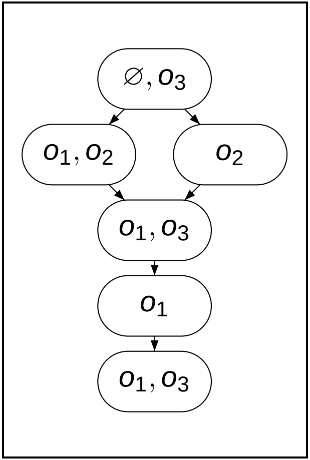
Lamperti and Zanella's Index Space

Deals both with partial order and uncertain observations

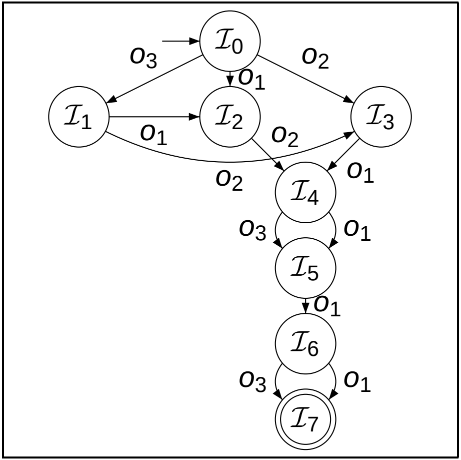
Observations

- The observation (without $\underline{s}$) is a partially ordered set of observation fragments
- An observation fragment N has a subset of $O \cup \{\varnothing\}$:
  - if $e \in N$, then e is one of the observable events that possibly generated the observation fragment
  - if $\varnothing \in N$, then possibly no observable event generated the observation fragment

Example



Observation



Index Space

Diagnosis

- A Silent Closure of s is the sub automaton that can be reached from the state s with unobservable transitions
- A Diagnosis State is a pair $\langle s, \mathcal{I} \rangle$ where s is a system state and $\mathcal{I}$ is an index
- There is a transition from $\langle s, \mathcal{I} \rangle$ to $\langle s', \mathcal{I}' \rangle$ labeled by e if
  - there exists a state s'' in the silent closure of s so that there is a transition from s'' to s' labeled by e, and
  - there is a transition from $\mathcal{I}$ to $\mathcal{I}'$ labeled by e on the index space
- Moreover, with each state is associated a diagnosis (a set of sets of fault modes)

Observation Automaton

- $OBS = \langle Q, E, T, I, F \rangle$
- Each trajectory on *OBS* ending in a state *F* is a possible sequence of emitted observations consistent with the observations received

What You Can Model With Automata

- Partial Order
- Uncertainty
- Loss of observations
- Sensor failure
- Masking

Automata Synchronisation

Let $A_1 = \langle Q_1, E_1, T_1, I_1, F_1\rangle$ and $A_2 = \langle Q_2, E_2, T_2, I_2, F_2\rangle$ be two automata. The synchronisation $A_1 \otimes A_2$ is an automaton $A = \langle Q, E, T, I, F\rangle$ so that:

- $Q = Q_1 \times Q_2$
- $E = E_1 \cup E_2$
- $T = \{\langle\langle s_1, s_2\rangle, e, \langle s_1', s_2'\rangle\rangle \mid$
  - $(e \in E_1 \wedge \langle s_1, e, s_1'\rangle \in T_1) \vee (e \notin E_1 \wedge s_1 = s_1')\wedge$
  - $(e \in E_2 \wedge \langle s_2, e, s_2'\rangle \in T_2) \vee (e \notin E_2 \wedge s_2 = s_2')$

  $\}$
- $I = I_1 \times I_2$
- $F = F_1 \times F_2$

Diagnosis by Observation Automaton

- *MOD* is an automaton that models the system (all the states are final)
- *OBS* is the observation automaton
- the diagnosis automaton is defined by $MOD \otimes OBS$

When the diagnosis automaton is computed, the diagnosis can be easily retrieved