Model-Based Diagnosability Analysis for Web Services

Stefano Bocconi[1], Claudia Picardi[1], Xavier Pucel[2], Daniele Theseider Dupré[3] and Louise Travé-Massuyès[2]

1)Università di Torino, Dipartimento di Informatica
2)LAAS-CNRS, Université de Toulose
3)Università del Piemonte Orientale, Dipartimento di Informatica

Talk Outline

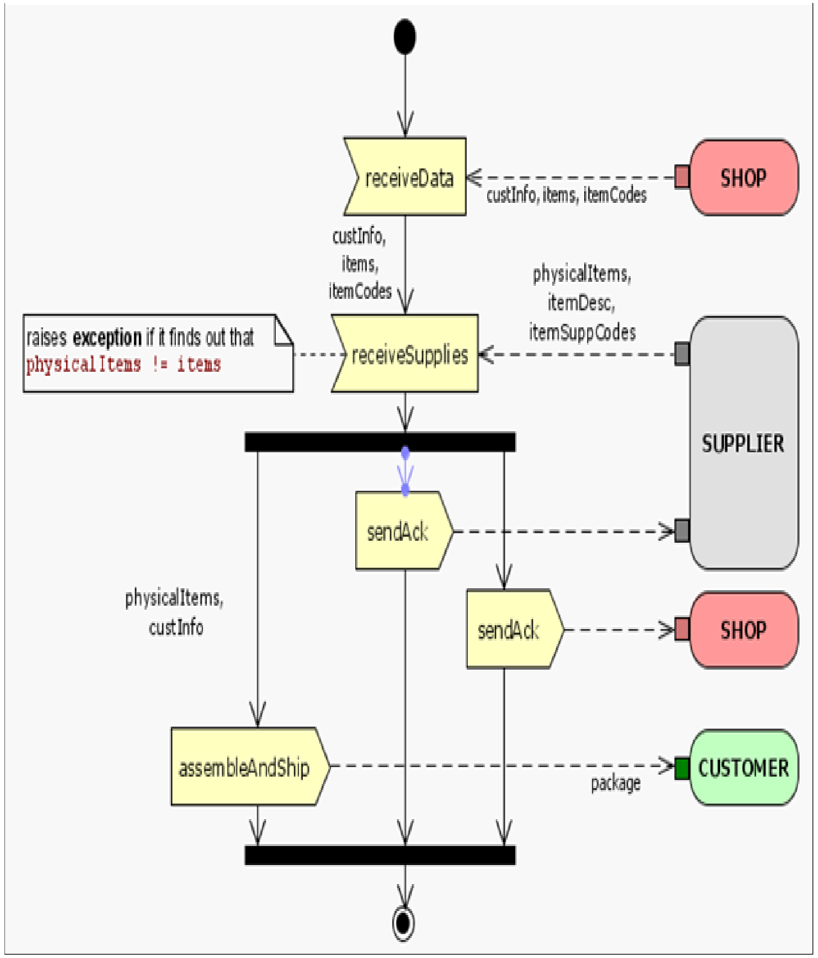
- Motivation
- Background knowledge
- Diagnosability approach
- Example
- Conclusions

Motivation

- When a system shows *symptoms* of malfunctioning, diagnosis determines which *faults* are the cause, allowing repair actions to be applied
- Diagnosability determines which faults can be determined at runtime
- In order for diagnosis to be effective at runtime, diagnosability analysis should be performed at design time

Web Services

- Composition of several simpler services, composed of activities
- The overall model is not known since single models are visible only to owners
- An activity can raise an exception, whose cause is in a different activity

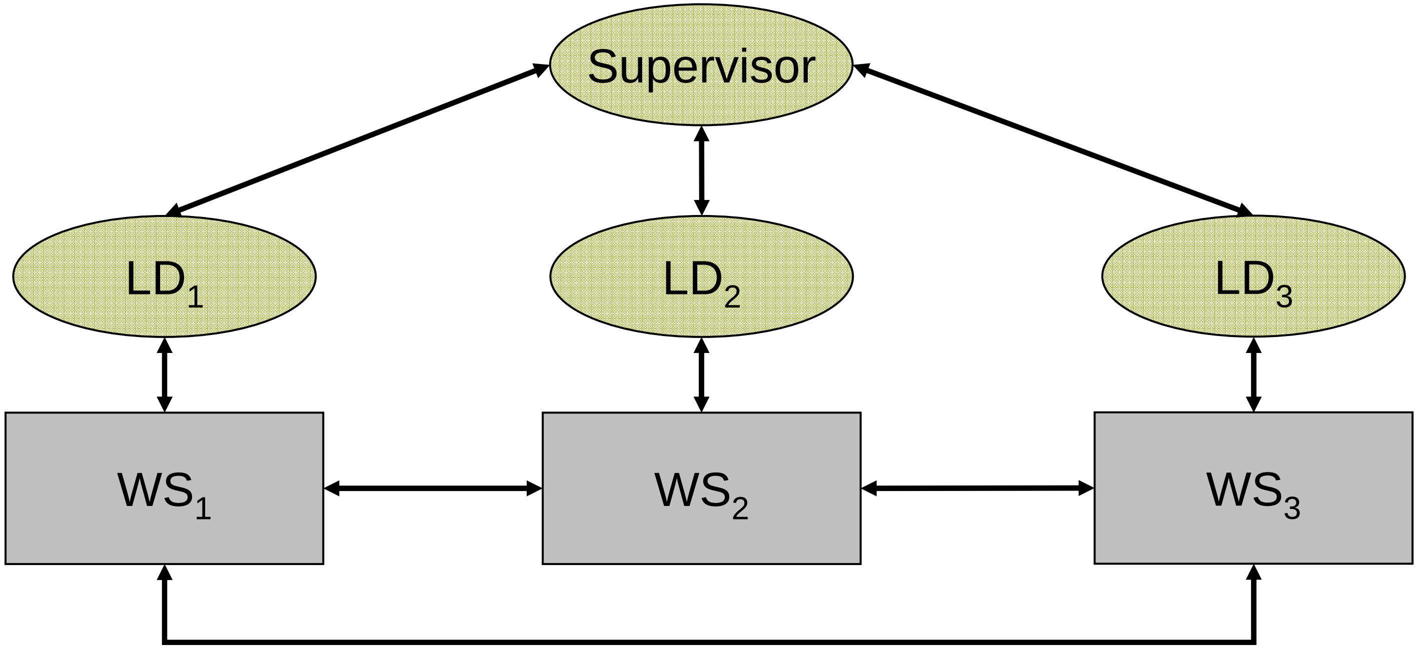


Model-based diagnosis

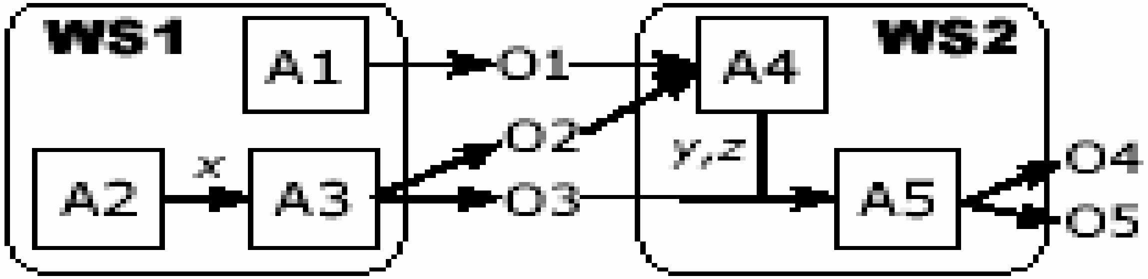
- Models are set of constraints over finite-valued variables that define:
  - The dependencies between input, fault mode and output variables of each single activity
  - The resulting workflow
- Consistency-based diagnosis: a diagnosis is an assignment of values to each activity fault mode variables that is consistent with observations

Architecture

Decentralized framework, composed of Local Diagnosers and a Supervisor. Models are private to WS and their LD



Example



M_1	O_1
ok	ok
ab	ab

Activity A_1

M_2	X
ok	ok
ab	ab

Activity A_2

M_3	X	O_2	O_3
ok	ok	ok	ok
ok	ab	ab	ab
ab	ok	ab	ab
ab	ab	ok	ab

Activity A_3

M_4	O_1	O_2	Y	Z
ok	ok	ok	ok	ok
ok	ab	ok	ok	ab
ab	ok	ok	ab	ok
ab	ab	ok	ab	ab
ok	ok	ab	ok	ok
ok	ab	ab	ok	ab
ab	ok	ab	ab	ok
ab	ab	ab	ab	ab

Activity A_4

M_5	Y	Z	O_3	O_4	O_5
ok	ok	ok	ok	ok	ok
ok	ok	ab	ok	ok	ok
ok	ab	ok	ok	ab	ab
ok	ab	ab	ok	ok	ab
ab	ok	ok	ok	ok	ab
ab	ok	ab	ok	ab	ok
ab	ab	ok	ok	ab	ab
ab	ab	ab	ok	ab	ab
ok	ok	ok	ab	ok	ok
ok	ok	ab	ab	ok	ok
ok	ab	ok	ab	ab	ab
ok	ab	ab	ab	ok	ab
ab	ok	ok	ab	ok	ab
ab	ok	ab	ab	ab	ok
ab	ab	ok	ab	ab	ab
ab	ab	ab	ab	ab	ab

Activity A_5

Data flow

- INPUT from Supervisor to LD: set of hypotheses projected over the LD local variables
- LD calculates with an operation called Extend (**Ext**) the set of hypotheses consistent with its model.
- OUTPUT from LD to Supervisor: the set of hypotheses projected over fault mode, observable and interface variables.

General diagnosability

- Consequences of faults on observables (calculated with **Ext**)
- Fault mode: complete state of all the activities in the composite WS
  - Each activity can be either *ok* or *ab* 2^n fault modes for n activities
- Full diagnosability: each fault mode provides a unique pattern of observables
  - comparisons to be made:

$$2^{n-1}(2^n - 1)$$

Our approach to diagnosability

- Discriminability: Two fault modes are *discriminable* if their patterns of observables (calculated with **Ext**) are disjoint.
- Partial fault mode *(pfm)*: an assignment to **some** of the fault mode variables (3^n possible pfm)
- Incremental approach using *pfms*
  - Each step *i* reuses info calculated at step *i-1*
  - Full analysis can be completed before step *n*
  - Worst case comparisons at step *i*:

$$2^{i-1}(2^i - 1)\frac{n!}{(n-i)!\,i!}$$

Pfms: definitions

- rank(*pfm*): number of assigned variables in *pfm*
- domain(*pfm*): set of assigned variables in *pfm*
- alternative *pfm*s: same domain, at least one variable different
- pfm_1 is a refinement of pfm_2 if
  - rank(pfm_1) > rank(pfm_2) and
  - pfm_1 projected on domain(pfm_2) is equal to pfm_2

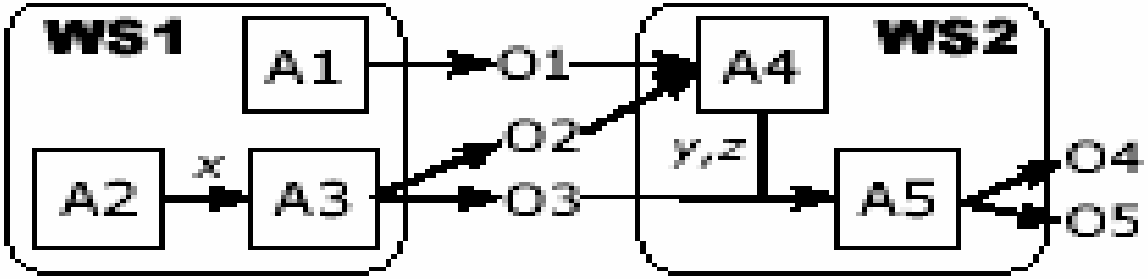
Pfms: properties

- Property 1: **Ext** needs only to be calculated on *pfms* of rank 1, since **Ext**($pfm_1 \wedge pfm_2$) = **Ext**(pfm_1)$\wedge$ **Ext**(pfm_2)
- Property 2: If pfm_1 is discriminable from pfm_2 , all their refinements are discriminable
- Property 3: If at rank k pfm_1 and pfm_2 are not discriminable and **Ext**(pfm_1), **Ext**(pfm_2) do not contain m, then also $pfm_1 \wedge m$ is not discriminable from $pfm_2 \wedge m$

Algorithm

- Calculate **Ext**(pfm_i), i=1,n (property 1).
- Perform discriminability analysis rank by rank, by comparing each couple of alternative *pfms*. At rank 1 these are $\{(m_i=ok, m_i=ab), i=1,n\}$
- Each refinement of discriminable *pfms* at rank *i* does not need to be check at higher ranks (property 2).
- Each refinement of non-discriminable *pfms* at rank *i* does not need to be check at higher ranks when property 3 holds

Example



M_1	O_1
ok	ok
ab	ab

Activity A_1

M_2	X
ok	ok
ab	ab

Activity A_2

M_3	X	O_2	O_3
ok	ok	ok	ok
ok	ab	ab	ab
ab	ok	ab	ab
ab	ab	ok	ab

Activity A_3

M_4	O_1	O_2	Y	Z
ok	ok	ok	ok	ok
ok	ab	ok	ok	ab
ab	ok	ok	ab	ok
ab	ab	ok	ab	ab
ok	ok	ab	ok	ok
ok	ab	ab	ok	ab
ab	ok	ab	ab	ok
ab	ab	ab	ab	ab

Activity A_4

M_5	Y	Z	O_3	O_4	O_5
ok	ok	ok	ok	ok	ok
ok	ok	ab	ok	ok	ok
ok	ab	ok	ok	ab	ab
ok	ab	ab	ok	ok	ab
ab	ok	ok	ok	ok	ab
ab	ok	ab	ok	ab	ok
ab	ab	ok	ok	ab	ab
ab	ab	ab	ok	ab	ab
ok	ok	ok	ab	ok	ok
ok	ok	ab	ab	ok	ok
ok	ab	ok	ab	ab	ab
ok	ab	ab	ab	ok	ab
ab	ok	ok	ab	ok	ab
ab	ok	ab	ab	ab	ok
ab	ab	ok	ab	ab	ab
ab	ab	ab	ab	ab	ab

Activity A_5

Example

pfm	mode vars					observable vars				
	M_1	M_2	M_3	M_4	M_5	O_1	O_2	O_3	O_4	O_5
$m_1 = ok$	ok	$*$	$*$	ok	ok	ok	$*$	$*$	ok	ok
	ok	$*$	$*$	ok	ab	ok	$*$	$*$	ok	ab
	ok	$*$	$*$	ab	$*$	ok	$*$	$*$	ab	ab
$m_1 = ab$	ab	$*$	$*$	ok	ok	ab	$*$	$*$	ok	ok
	ab	$*$	$*$	ok	ab	ab	$*$	$*$	ab	ok
	ab	$*$	$*$	ab	ok	ab	$*$	$*$	ok	ab
	ab	$*$	$*$	ab	ab	ab	$*$	$*$	ab	ab
$m_2 = ok$	$*$	ok	ok	$*$	$*$	$*$	ok	ok	$*$	$*$
	$*$	ok	ab	$*$	$*$	$*$	ab	ab	$*$	$*$
$m_2 = ab$	$*$	ab	ok	$*$	$*$	$*$	ab	ab	$*$	$*$
	$*$	ab	ab	$*$	$*$	$*$	ok	ab	$*$	$*$

Number of comparisons

Rank	Full	Incremental -worst case	Incremental -example
1		5	5
2		60	10
3		280	3
4		600	-
5	496	496	-

Conclusions

- Framework for distributed diagnosability, when no overall model is available
- Incremental approach using partial assignments
- Analysis provides the same information as full diagnosability, likely requiring less operations
- Designer can stop at arbitrary rank if not interested in full diagnosability