

DX 05 - Pacific Grove,  
California, June 1-3, 2005

## COOPERATIVE Model-based Diagnosis of Web Services

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## Web Services and Diagnosis (I)

- **Web Service:**
  - **web-based** application that provides a service to a user
  - the user can be a **human**, a **client application**, or another **Web Service**
  - **complex** WSs provide a service by integrating and composing the activities of other (basic) WSs
  - Some examples:
    - plane ticket reservation → online travel planner
    - computer monitor seller → computer configurator
  - Web Services also used to model **internal business processes** of a company

## Web SERVICES AND DIAGNOSIS (2)

- We do **not** want to do **debugging**.
- **Runtime tracking** of an error source
  - failures mostly due to mishandled exceptions, lack of robustness, unpredicted behavior of one of the involved entities
  - quality of service failures (not tackled in this work)
- Final goal: **recovery**
  - find a way to provide the service in spite of the error
  - try to keep as low as possible the overhead for the user
- Current practice:
  - direct symptom handling (only for some error types)
  - no attempt at identifying causes
  - mostly: "unable to provide service, try again"

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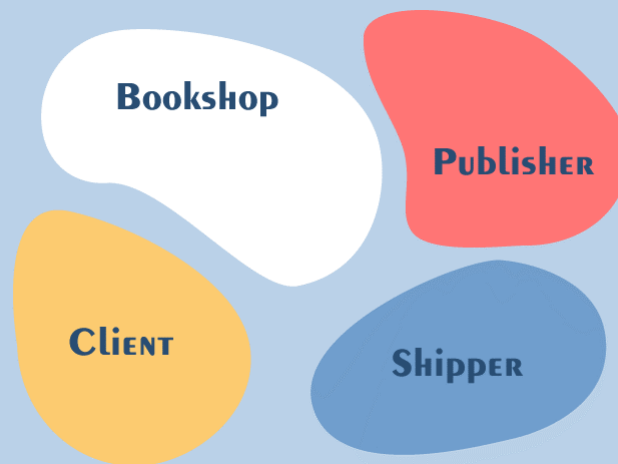
## WHAT DO WE DIAGNOSE?

- We diagnose a **conversation**.
  - A complex service results from the interaction between multiple basic service → **conversation**
  - A **conversation** is a set of partially ordered **activities** carried out by different (basic) **services**.
    - internal activities
    - communications between services
- Component-oriented qualitative models:
  - **component** ↔ **activity**
  - **system structure** ↔ **data i/o between activities**
  - **fault** ↔ **activity error**

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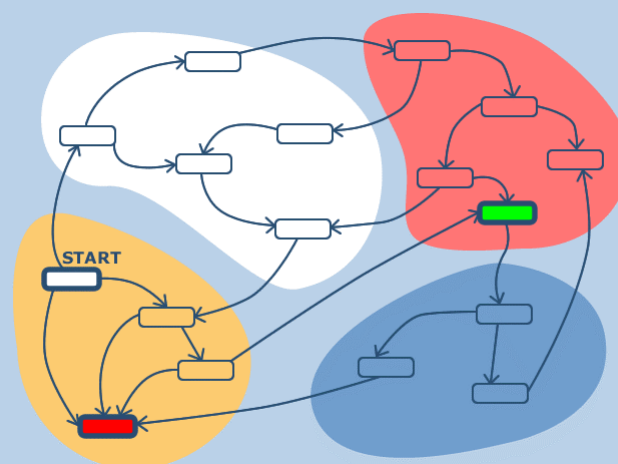
## MOTIVATING example: online book sales



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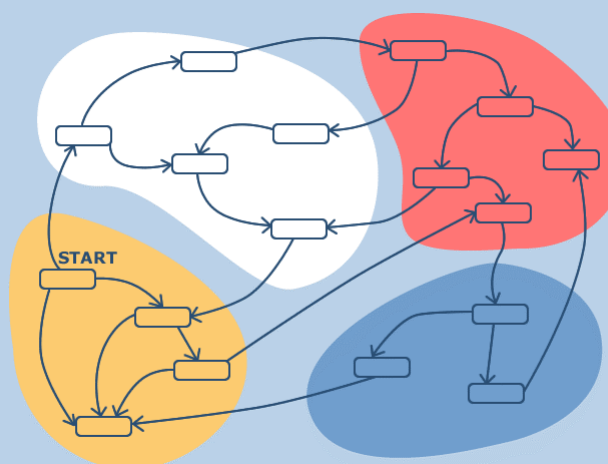
## Model-Based Diagnosis of WSs

- **Model** of an activity expresses:
  - how **errors on input data** affect the **correctness of output data** (**ok** mode)
  - how an **error in activity execution** can affect the **correctness of output data** (**abnormal** mode)
  - pure **deviation** models:
    - a variable for each i/o data piece with domain {**ok**,**ab**}
- **Observations:**
  - alarms raised by a service
  - diagnosers receive and log messages between services
  - the model maps **alarms** and **checks** on logged messages to hypotheses on data correctness

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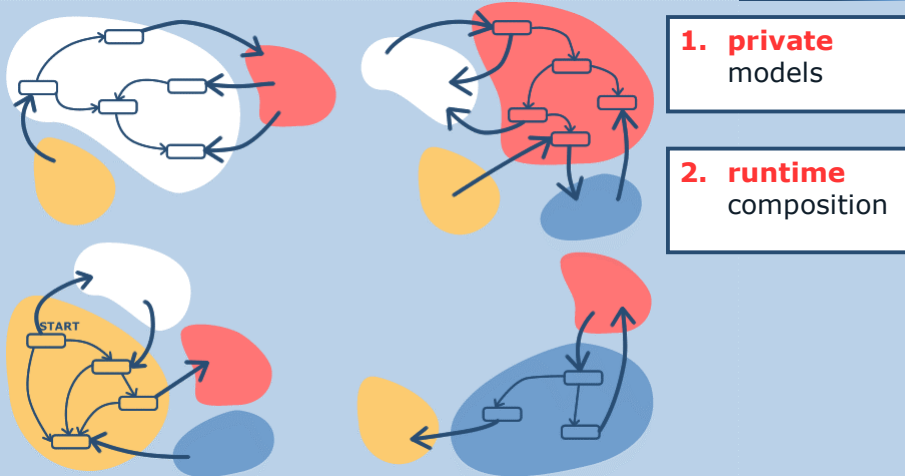
## A COMPLETE STATIC MODEL DOES NOT EXIST



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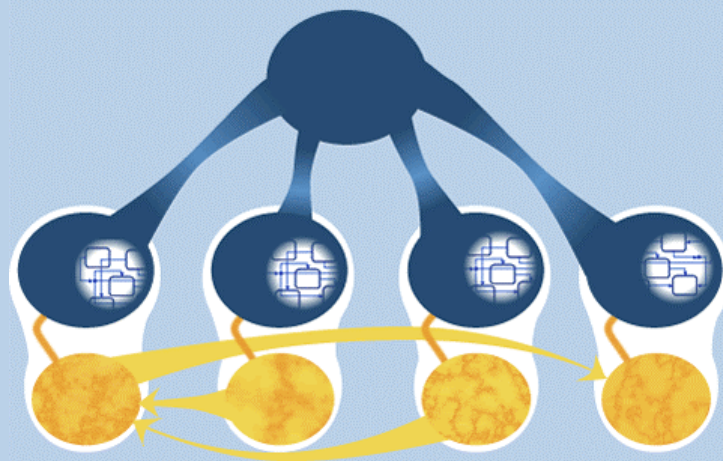
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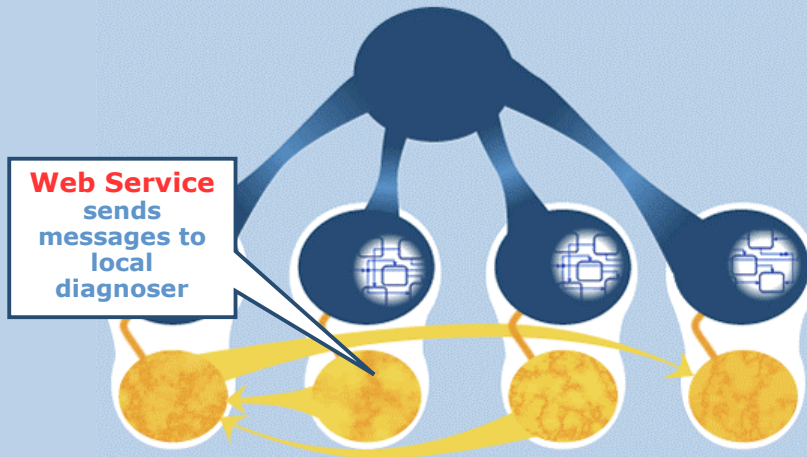
## DECENTRALIZED DIAGNOSIS



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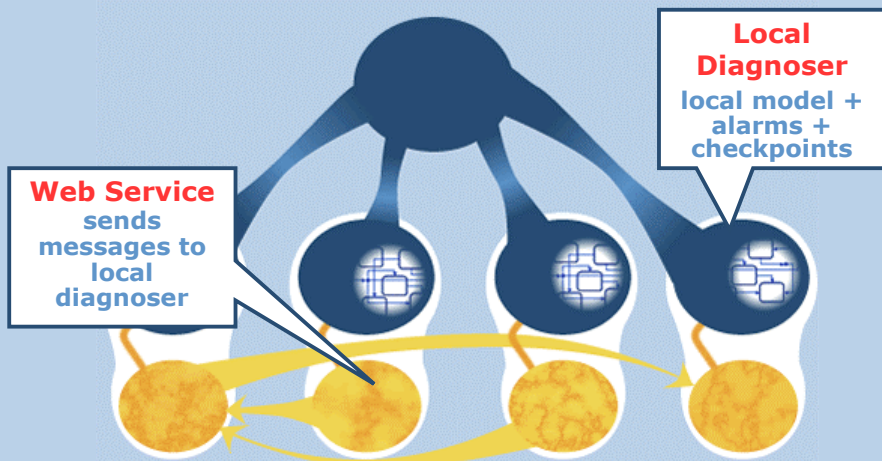
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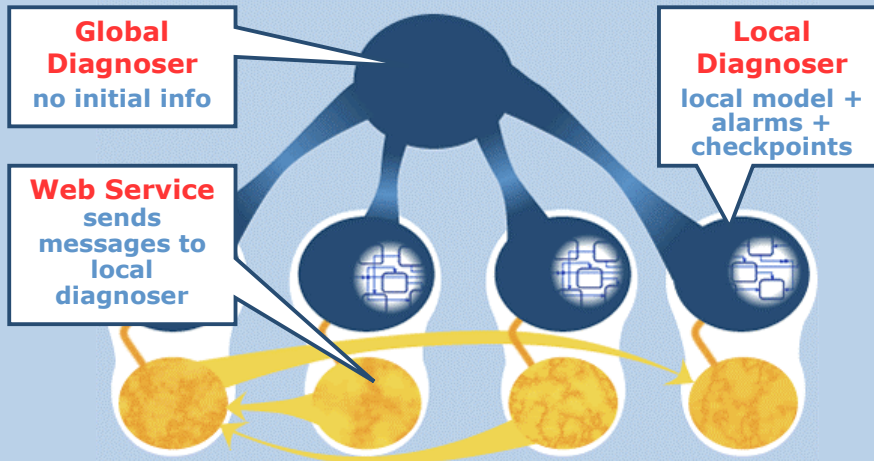
## DECENTRALIZED DIAGNOSIS



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## DECENTRALIZED DIAGNOSIS



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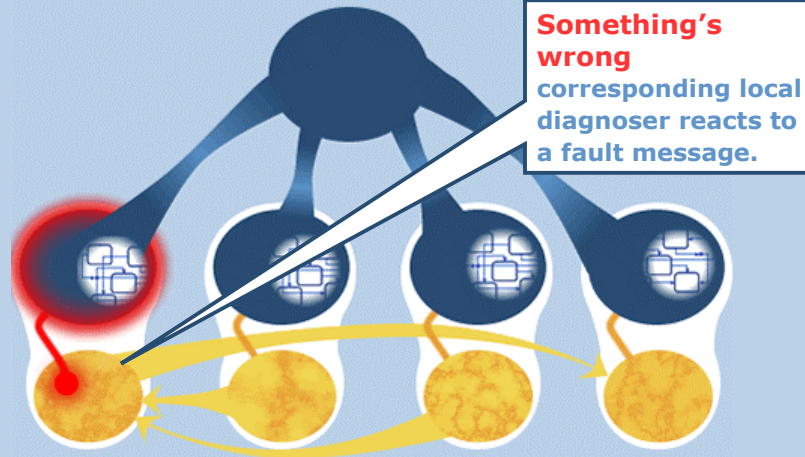
## OUR APPROACH

- **Consistency-based diagnosis** (with fault modes).
- We **do** provide:
  - a **specification** of local diagnoser operations
  - a **formal characterization** of local diagnoser operations
  - an **algorithm** for the Global Diagnoser
    - starts with no information on local services
    - the algorithm only assumes that local diagnosers meet the specifications of their operations
    - the algorithm **merges** information from local diagnosers and **decides** which local diagnosers to contact.
- We **do not** provide:
  - **algorithms** for local diagnosers.

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## STARTING DIAGNOSIS UPON ALARMS



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## STARTING DIAGNOSIS UPON ALARMS

- **Initial info:**
  - local **observations** (alarms + checkpoints) **OBS**
- **Compute:**
  - a set of **candidate diagnoses** → hypotheses of misbehaviour that explain **OBS**
    - **internal misbehaviour:** errors occurred inside the WS
    - **external misbehaviour:** errors in inputs received from other WSs (**blame on other services**)
  - **consequences** of each hypothesis on service outputs
    - can be used to validate/discard a candidate diagnosis

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## LOCAL CANDIDATE DIAGNOSIS



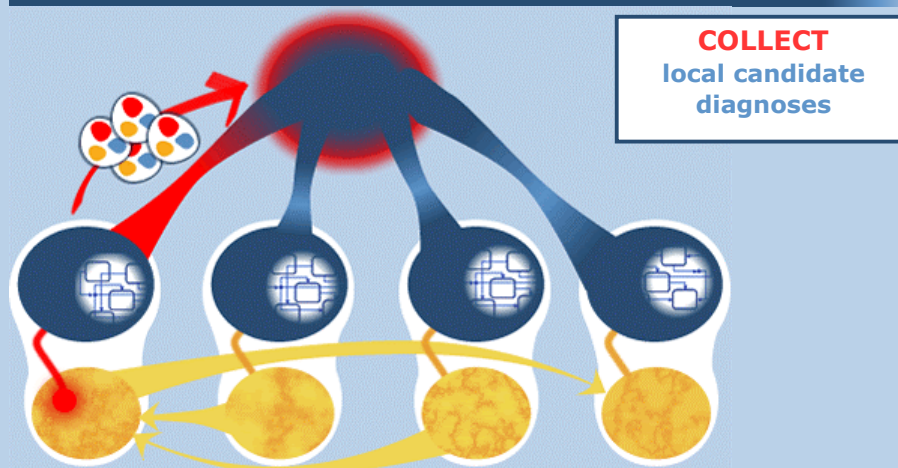
A **local candidate diagnosis** contains three elements:

-  hypotheses on local behaviour
-  blames on other (input) services
-  consequences of hypotheses on other (output) services

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## THE ROLE OF THE GLOBAL DIAGNOSER

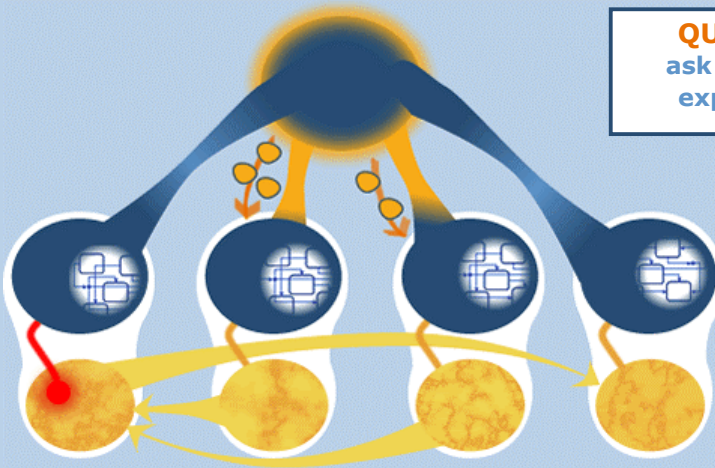


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## THE ROLE of THE Global DIAGNOSER

**QUESTION**  
ask for blame  
explanation

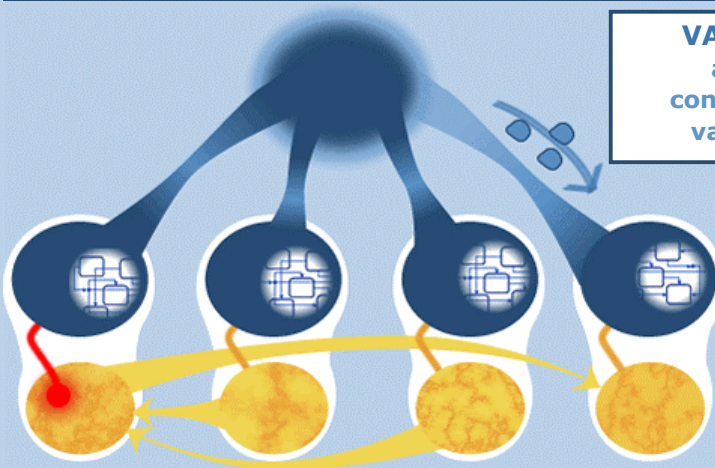


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## THE ROLE of THE Global DIAGNOSER

**VALIDATE**  
ask for  
consequence  
validation



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## LOCAL DIAGNOSERS - EXPLANATION

- Local diagnoser receives **blames**
- It produces local candidate diagnoses that explain **observations AND blames**.
  - additional hypotheses of internal misbehaviour
  - additional blames
  - additional consequences
- New **local candidate diagnoses**:
  - **merged** with the ones that originated the blame **by the global diagnoser**
- If **no explanation**:
  - the candidate diagnosis that originated the blame is **rejected by the global diagnoser**

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## LOCAL DIAGNOSERS - VALIDATION

- Local diagnoser receives **consequences**
- It **verifies** through local observations whether the predicted consequences hold.
- Produces:
  - **additional consequences** on other services
- If initial consequences **hold**:
  - **the global diagnoser adds new consequences** to the local candidate diagnosis that originated them.
- If initial consequences **do not hold**:
  - the candidate diagnosis that originated them blame is **rejected by the global diagnoser**.

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## CHARACTERIZATION of LOCAL DIAGNOSERS (I)

- Candidate diagnoses are represented by **partial assignments** to model variables
  - assignment of **ok** or **ab** value to variables representing internal activities
  - assignment of **ok** or **ab** value to model variables
- For both **explanation/validation**:
  - local diagnosers receive the parts of the assignments that concerns them
  - work by **extending** partial assignments
- Both can be characterized in the same way
  - **EXTEND** operation **explains** and **validates** at the same time.

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## THE EXTEND OPERATION (I)

**Def.** An assignment  $\alpha$  is **admissible** in a model  $M_i$  if

- $\alpha$  is **consistent** with  $M_i$
- the **restriction** of  $M_i \cup \alpha$  to variable **not assigned** in  $\alpha$  is **equivalent** to the restriction of  $M_i$  alone to the same variables.

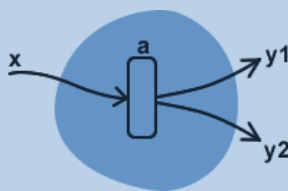
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a	x	y1	y2
ok	ok	ok	ok
ok	ab	ok,ab	ok,ab
ab	ok,ab	ok,ab	ok,ab

$M_i$

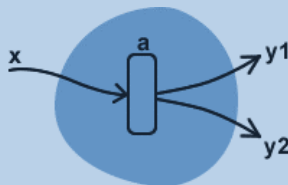
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ok	ab	ok,ab	ok,ab
ab	ok,ab	ok,ab	ok,ab

$M_i$

	a	x	y1	y2
$\alpha 1$	*	*	*	ab
$\alpha 2$	ok	ok	*	ab
$\alpha 3$	ab	*	*	ab

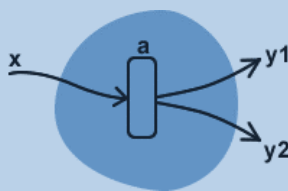
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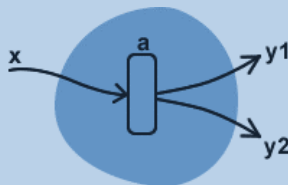
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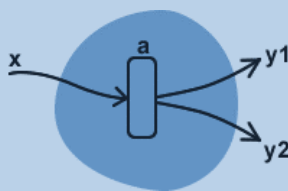
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ok	ab	ok,ab	ok,ab
ab	ok,ab	ok,ab	ok,ab

$M_i$

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## THE EXTEND OPERATION (II)

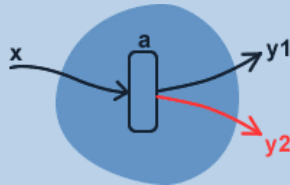
**Def.** Given an assignment  $\alpha$  and observations  $\omega$ , **EXTEND** computes **all minimal admissible extensions** of  $\alpha \cup \omega$

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## THE EXTEND OPERATION (II)

**Def.** Given an assignment  $\alpha$  and observations  $\omega$ , **EXTEND** computes **all minimal admissible extensions** of  $\alpha \cup \omega$



a	x	y1	y2
ok	ok	ok	ok
ok	ab	ok,ab	ok,ab
ab	ok,ab	ok,ab	ok,ab

$M_i$

a	x	y1	y2
*	*	*	ab

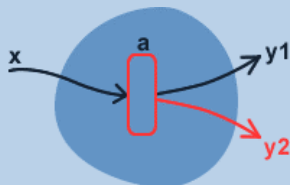
$\alpha$

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ok	ok	ok	ok
ok	ab	ok,ab	ok,ab
ab	ok,ab	ok,ab	ok,ab

$M_i$

a	x	y1	y2
*	*	*	ab

$\alpha$

a	x	y1	y2
ab	*	*	ab

Extensions

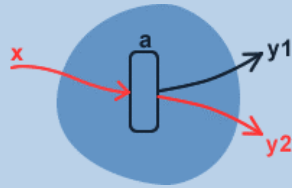
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$M_i$

a	x	y1	y2
*	*	*	ab

$\alpha$

a	x	y1	y2
ab	*	*	ab
*	ab	*	ab

Extensions

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## THE GLOBAL DIAGNOSER

- **EXTEND** defined as set of minimal admissible extensions:
  - allows to avoid unnecessary invocations
  - \* represents variables unworthy of further investigations
- The **global diagnoser**:
  - repeatedly invokes **EXTEND** on local diagnosers
  - A local diagnoser is invoked if:
    - another diagnoser assigned an **ab** value to one of its outputs (**blame** to explain)
    - another diagnoser assigned an **ok** or **ab** value to one of its inputs (**consequence** to validate)
  - until there is nothing to **explain/validate**
    - **EXTEND** may produce new blames and consequences, but may also **reject** an assignment
  - for a final assignment  $\alpha$ :
    - diagnosis  $D(\alpha) = \{a \mid a \text{ is an activity and } \alpha(a) = ab\}$

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## CONCLUSIONS AND FUTURE WORK

- **Advantages** of the approach:
  - **reduction** of communication overhead
    - **decentralized** VS purely distributed
    - does not explore the **whole model** if not necessary
  - possible to apply it also to **other types of systems**
    - as long as models are pure deviation models
  - **abstract models** of correctness propagation
    - could be at least partially **derived automatically** (to investigate)
- **Future work**:
  - exploit **coordination** mechanisms and coordination info
  - local diagnosers only characterized
    - propose **efficient algorithms** for local diagnosers