

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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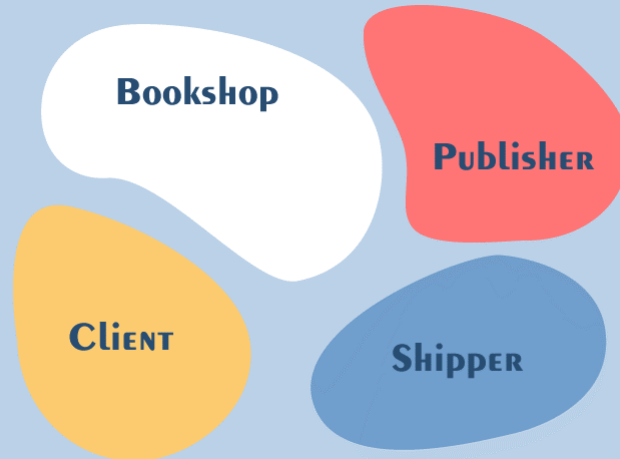
WHAT DO WE DIAGNOSE?

- 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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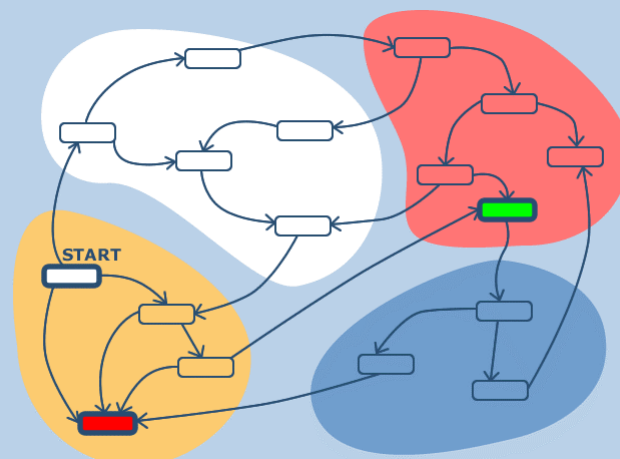
MOTIVATING EXAMPLE: ONLINE BOOK SALES



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MOTIVATING EXAMPLE: ONLINE BOOK SALES



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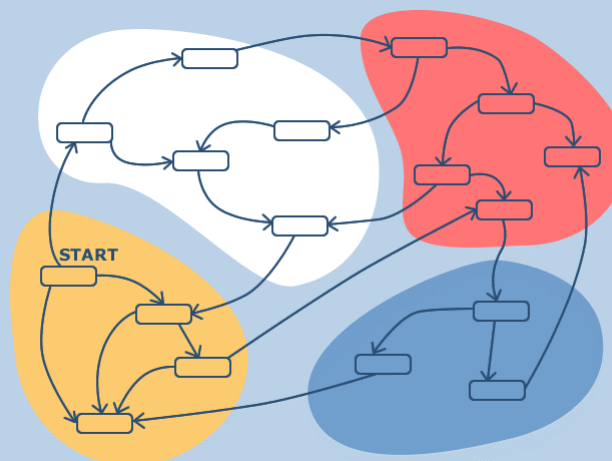
MODEL-BASED DIAGNOSIS of WSs

- **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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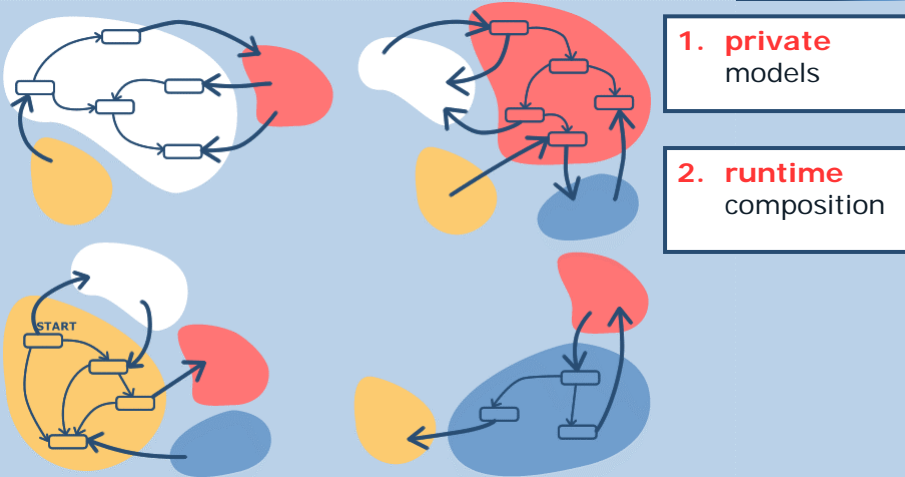
A COMPLETE STATIC MODEL DOES NOT EXIST



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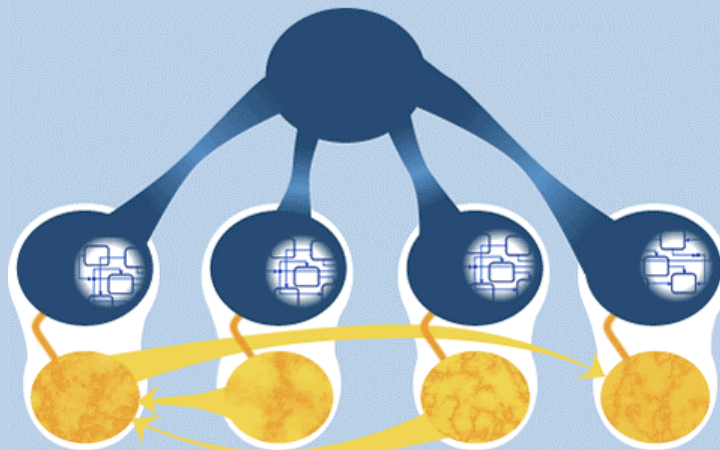
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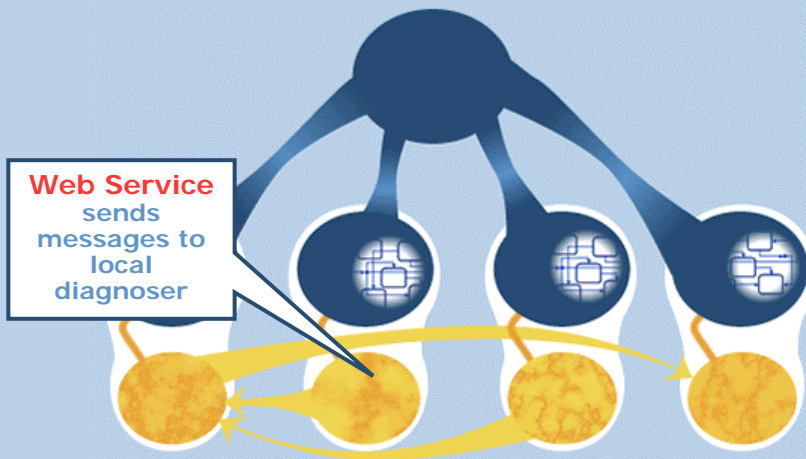
DECENTRALIZED DIAGNOSIS



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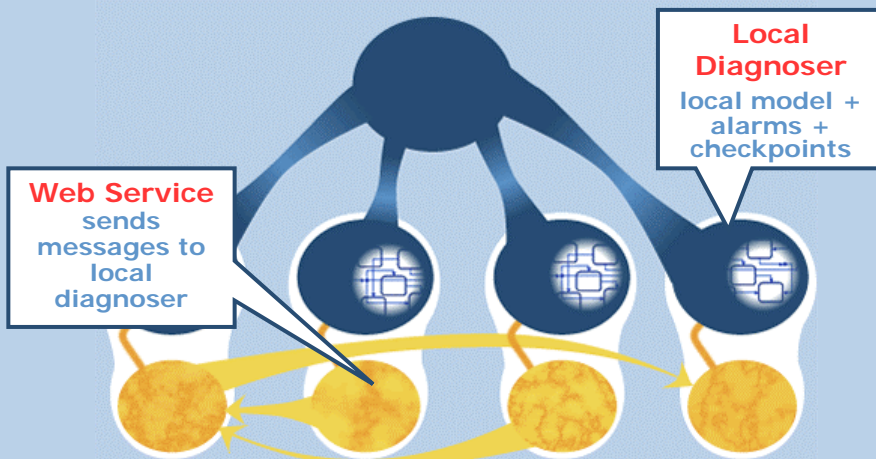
DECENTRALIZED DIAGNOSIS



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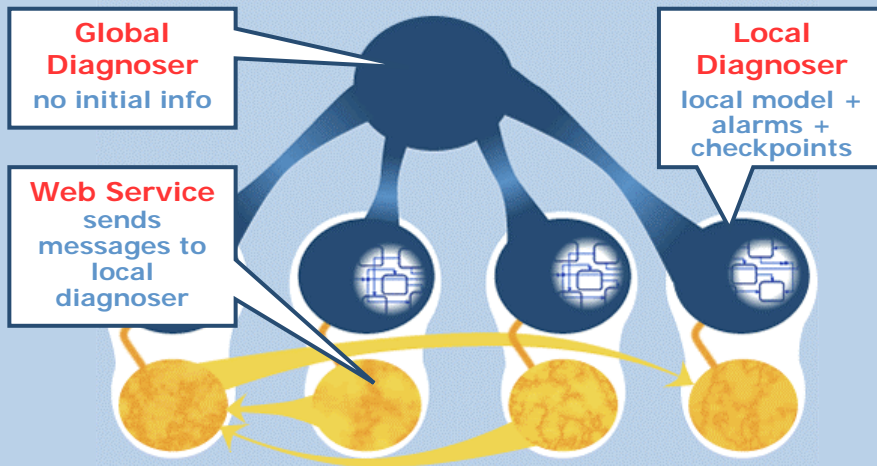
DECENTRALIZED DIAGNOSIS



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DECENTRALIZED DIAGNOSIS



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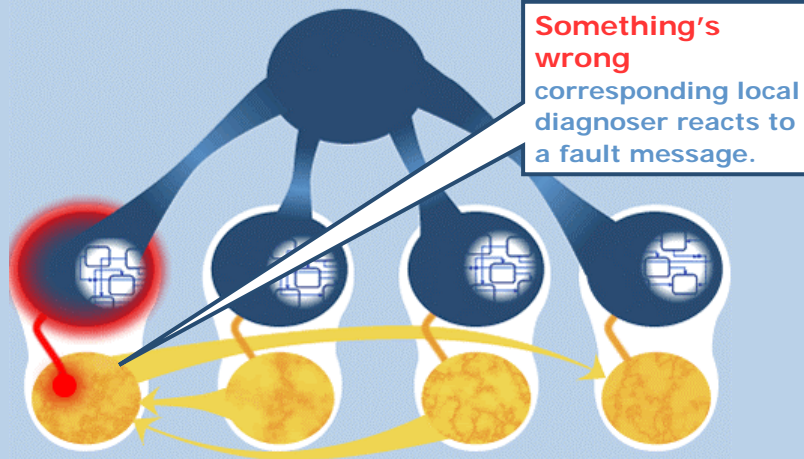
OUR APPROACH

- **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 diagnosticians meet the specifications of their operations
 - the algorithm **merges** information from local diagnosticians and **decides** which local diagnosticians to contact.
- We **do not** provide:
 - **algorithms** for local diagnosticians.

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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



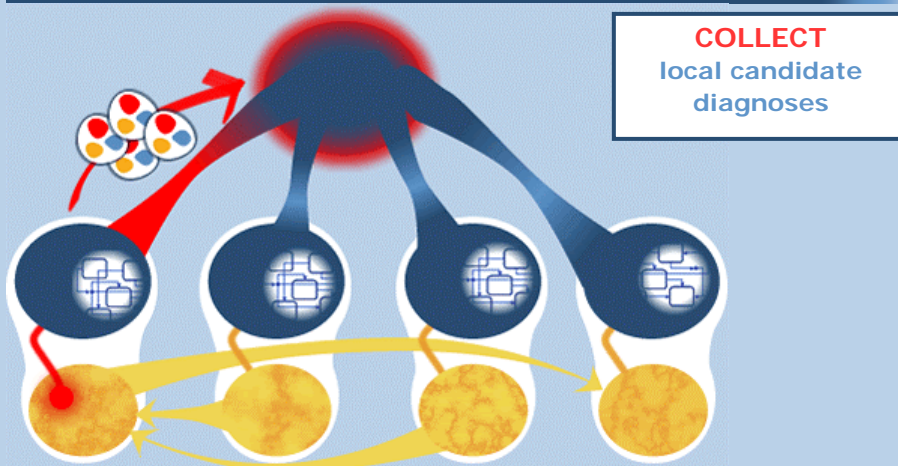
A **local candidate diagnosis** contains three elements:

-  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

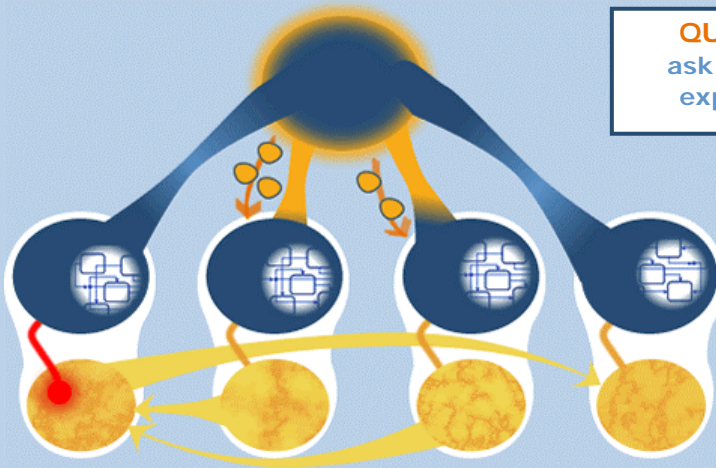


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The Role of THE Global DIAGNOSER

QUESTION
ask for blame
explanation

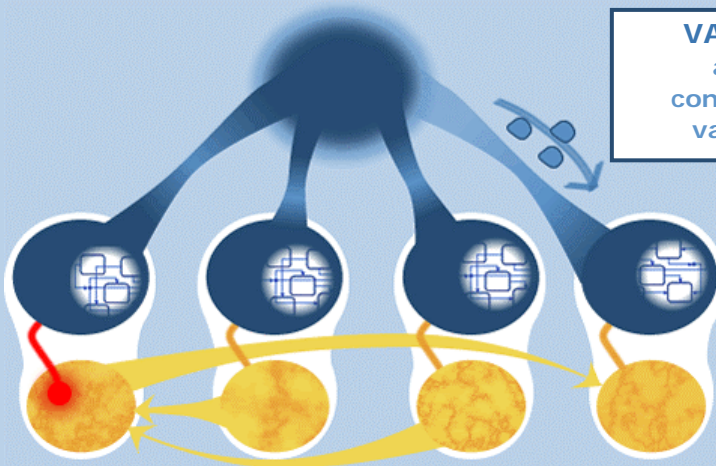


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The Role of THE Global DIAGNOSER

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 α is **admissible** in a model M_i if

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

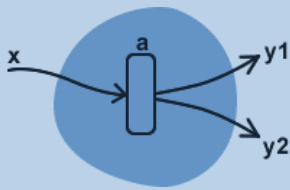
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THE EXTEND OPERATION (I)

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



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

M_i

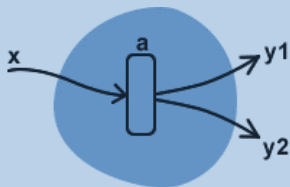
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a	x	y1	y2
ok	ok	ok	ok
ok	ab	ok,ab	ok,ab
ab	ok,ab	ok,ab	ok,ab

M_i

	a	x	y1	y2
α_1	*	*	*	ab
α_2	ok	ok	*	ab
α_3	ab	*	*	ab

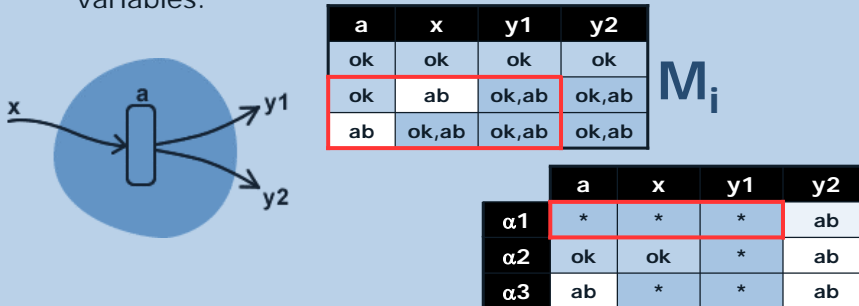
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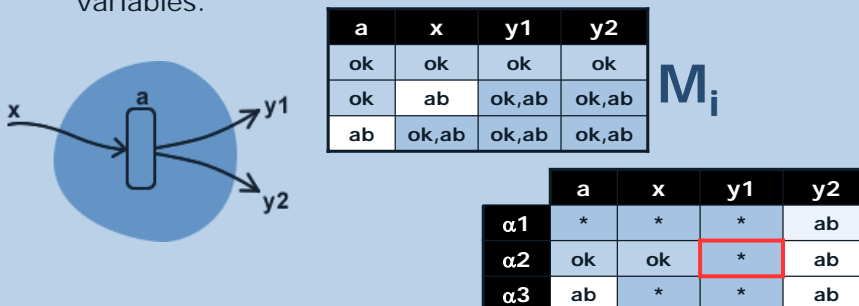
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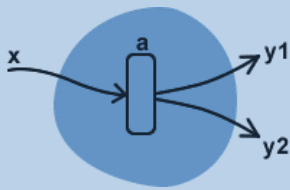
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a	x	y1	y2
ok	ok	ok	ok
ok	ab	ok,ab	ok,ab
ab	ok,ab	ok,ab	ok,ab

M_i

	a	x	y1	y2
α_1	*	*	*	ab
α_2	ok	ok	*	ab
α_3	ab	*	*	ab

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THE EXTEND OPERATION (II)

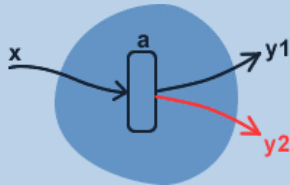
Def. Given an assignment α and observations ω , **EXTEND** computes **all minimal admissible extensions** of $\alpha \cup \omega$

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THE EXTEND OPERATION (II)

Def. Given an assignment α and observations ω , **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

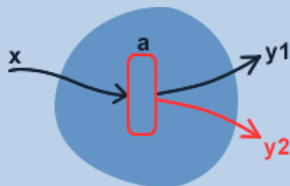
α

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THE EXTEND OPERATION (II)

Def. Given an assignment α and observations ω , **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

α

a	x	y1	y2
ab	*	*	ab

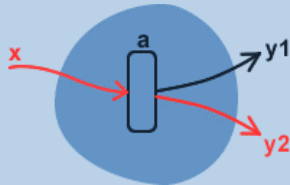
Extensions

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THE EXTEND OPERATION (II)

Def. Given an assignment α and observations ω , **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

α

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 α :
 - diagnosis $D(\alpha) = \{a \mid a \text{ is an activity and } \alpha(a) = ab\}$

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CLASSIFICATION WRT. MAIN POINTS

- **Supervisor** (the global diagnoser) but...
 - The global diagnoser does not compute in detail a global diagnosis
 - The global diagnoser does not receive all observations
 - The global diagnoser has a more abstract view of the system (and may not have any model)
- **Local Models**
- **On Line**
 - The global diagnoser may receive additional info from local diagnosers during the diagnostic process
- **Fault Localization / Diagnosis** (no tracking)
 - Depending on the model
- Can be turned into distributed

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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?

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