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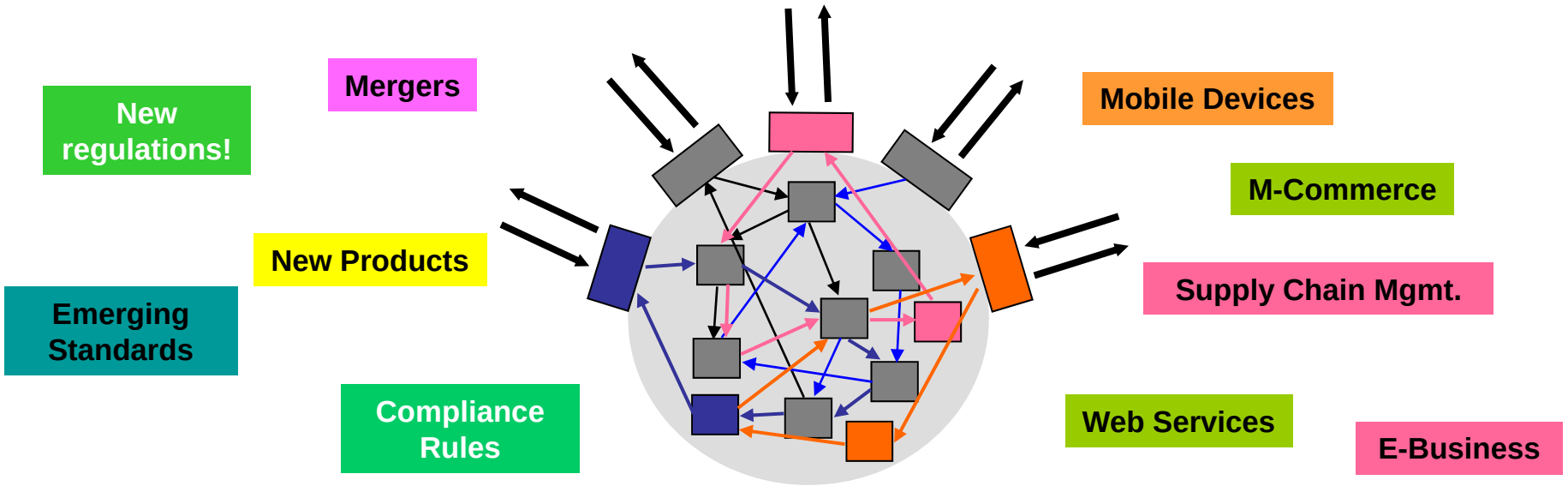
A Thing Called “Fluid Process”

Beyond Rigidity in Business Process Support

Manfred Reichert

Motivation

Permanent new "trends" – require new or adapted services ... which must be integrated

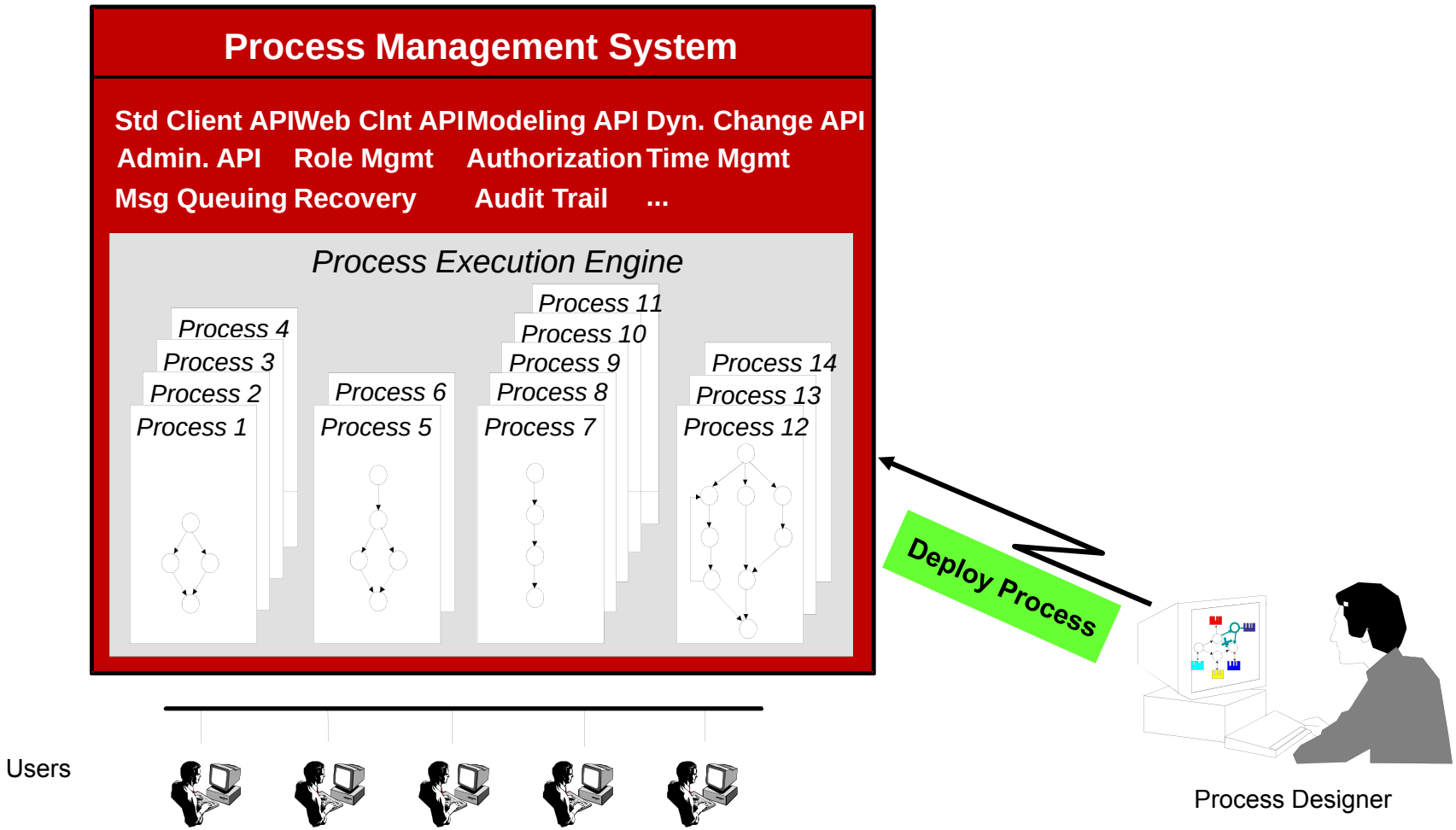


Issues:

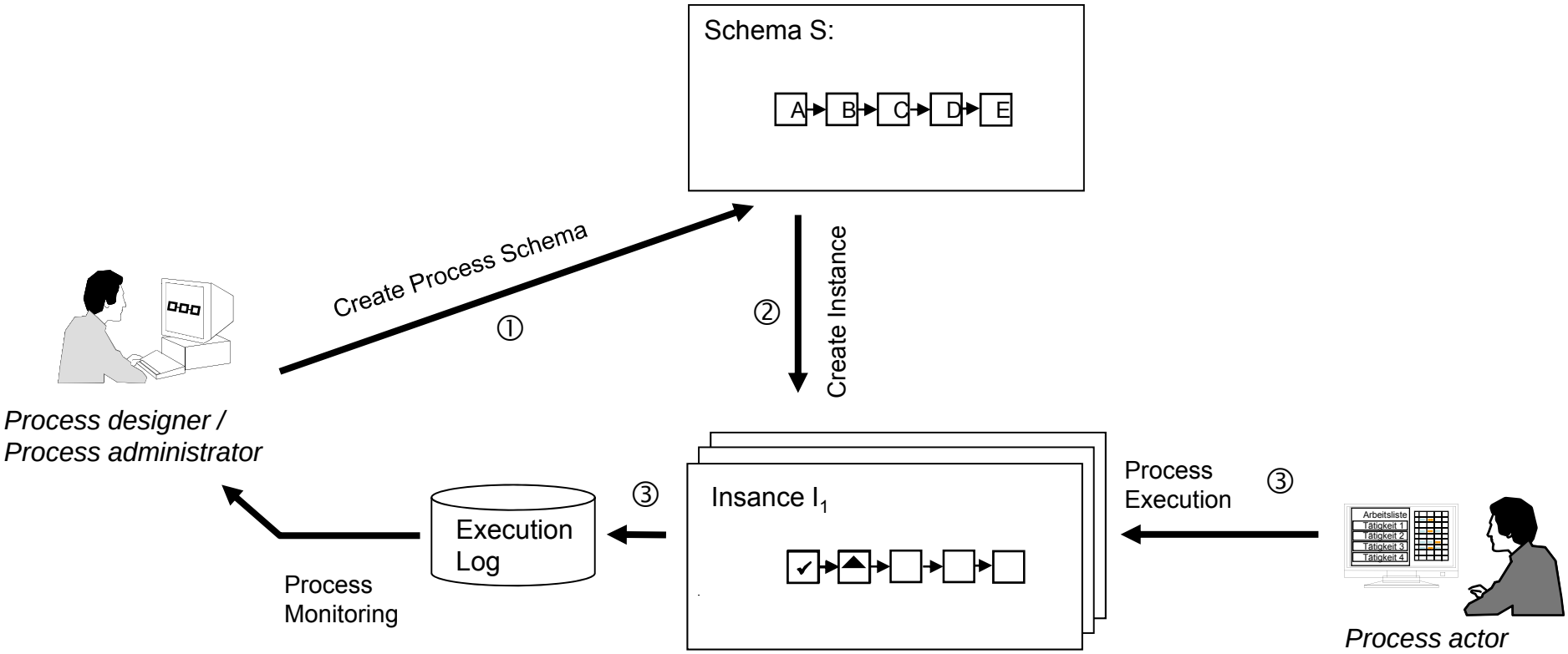
- How quickly can healthcare processes be implemented?
- At which costs? – With which error risk?
- How expensive will later process changes be?
- How to avoid the "maintenance trap"?

⇨ *Need for Process-awareness*

Motivation


Process Management System
Std Client API
Web Clnt API
Modeling API
Dyn. Change API
Admin. API
Role Mgmt
Authorization
Time Mgmt
Msg Queuing
Recovery
Audit Trail
...
Process Execution Engine
Process 1
Process 2
Process 3
Process 4
Process 5
Process 6
Process 7
Process 8
Process 9
Process 10
Process 11
Process 12
Process 13
Process 14
Deploy Process
Users
Process Designer

Motivation


Schema S:
A
B
C
D
E
Create Process Schema
①
②
Create Instance
Process designer /
Process administrator
Insance I_1
Process
Execution
③
③
Execution
Log
Process
Monitoring
Process actor
Process
Modeling
Process Configuration
& Implementation
Process
Execution
Process
Monitoring

Motivation

- Today's BPM tools are ill equipped to meet the aforementioned challenges due of their inherent brittleness and inflexibility
- Current tool generation implicitly embraces the "engineer – use " dichotomy inherited from traditional SE approaches; i.e., systems are first "engineered" and then "used" (or "operated")
- Maintenance and evolution activities are not regarded as part of operation, but rather as interruptions to the "in use" state
- Role of end users and process actors is not well understood!

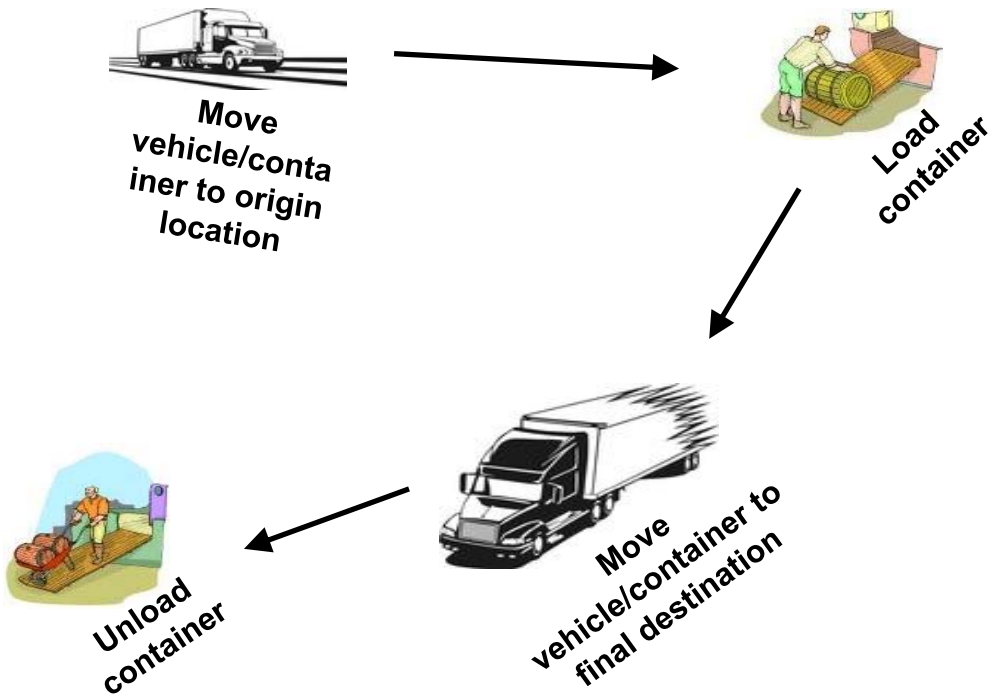
Real-world processes are "fluid"!

Why process instances need to be dynamically adaptable?

Why Process Instances Need to be Dynamically Adaptable?

Do we believe …

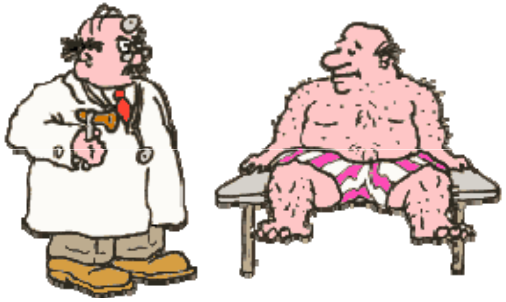
- that processes in the transportation domain can be completely pre-modeled?



Why Process Instances Need to be Dynamically Adaptable?

Or do we really believe …

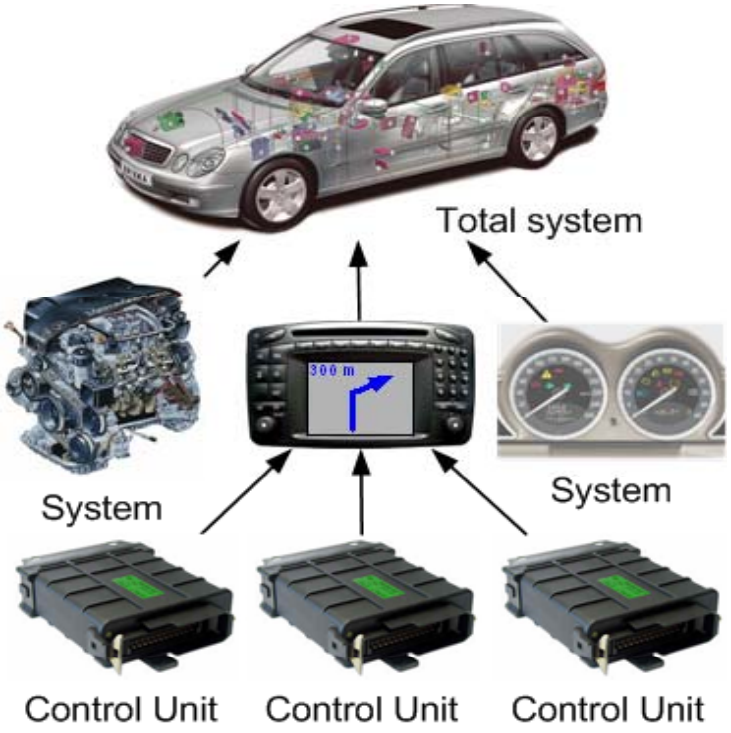
- that process-aware information systems (PAIS) can prescribe to a physician how to treat his or her patients?



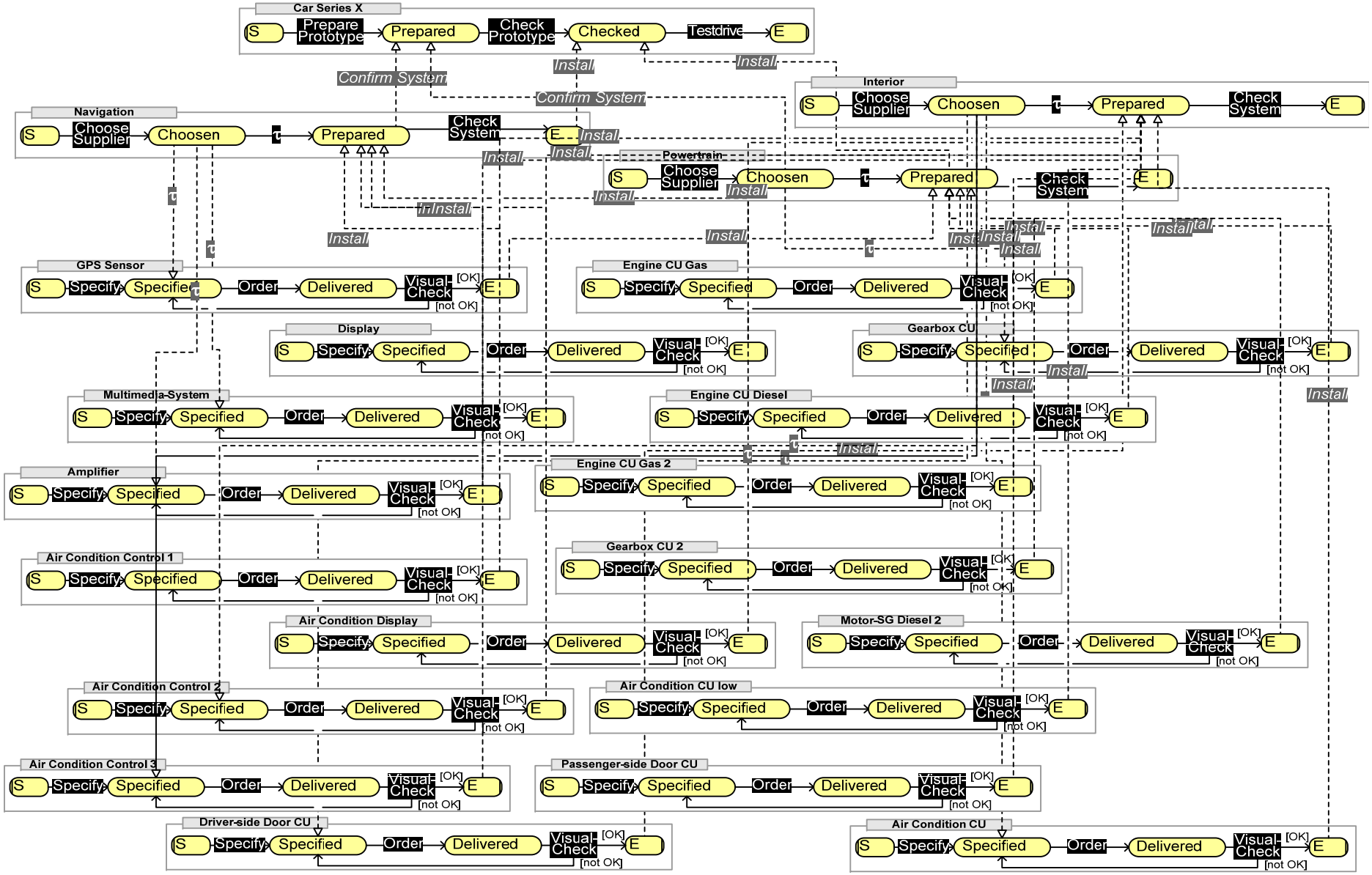
Why Process Instances Need to be Dynamically Adaptable?

Or do we really believe …

- that long-running engineering processes can be completely pre-modeled?



- Example: Release management for E/E-systems in a car
- 200 - 300 control devices to be systematically tested and released
- Requires the execution of hundreds up to thousands of processes
- Concurrent engineering ⇨ complex dependencies have to be considered


Car Series X
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Choose Supplier
Choosen
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Interior
Powertrain
GPS Sensor
Specify
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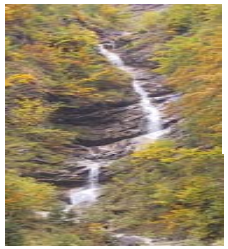
Order
Delivered
Visual Check
[OK]
[not OK]
Engine CU Gas
Display
Gearbox CU
Multimedia-System
Engine CU Diesel
Amplifier
Engine CU Gas 2
Air Condition Control 1
Gearbox CU 2
Air Condition Display
Motor-SG Diesel 2
Air Condition Control 2
Air Condition CU low
Air Condition Control 3
Passenger-side Door CU
Driver-side Door CU
Air Condition CU

Why Process Instances Need to be Dynamically Adaptable?

- The only feasible way to cope with these challenges is to dissolve the fundamental distinction between "engineering" and "use"; i.e., end users must be empowered to dynamically adapt or evolve processes

- This will lead us to a new class of processes – so called **fluid processes** whose "engineering" and "use" is intervoven

- *Fluid processes are continually being adapted and reformed to fit the actual needs and constraints of the situation in hand and to fulfill the overall goals of the involved organizations in the best possible way.*



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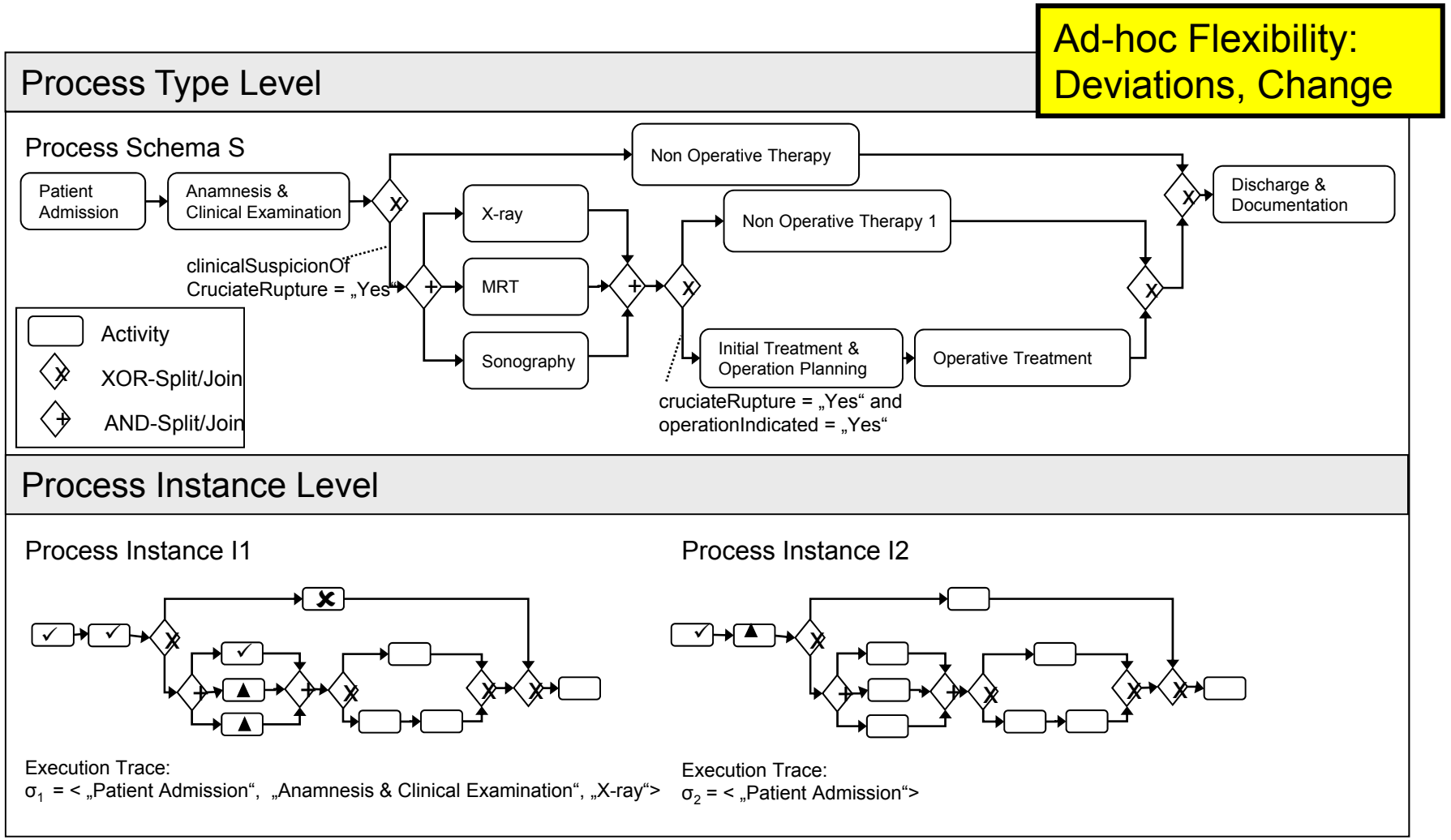
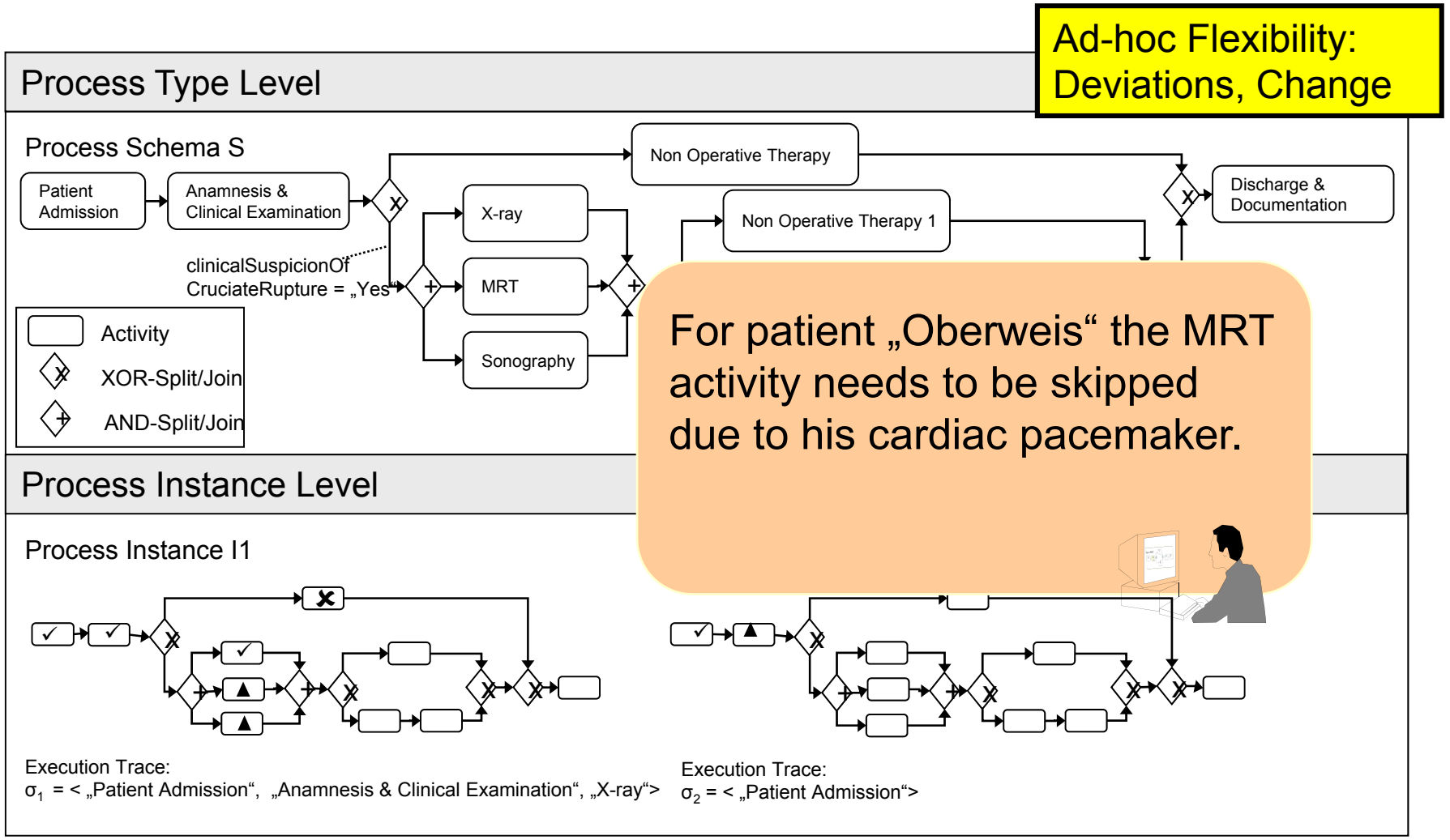
Adaptive Process Management Technology for Enabling Fluid Processes at Runtime

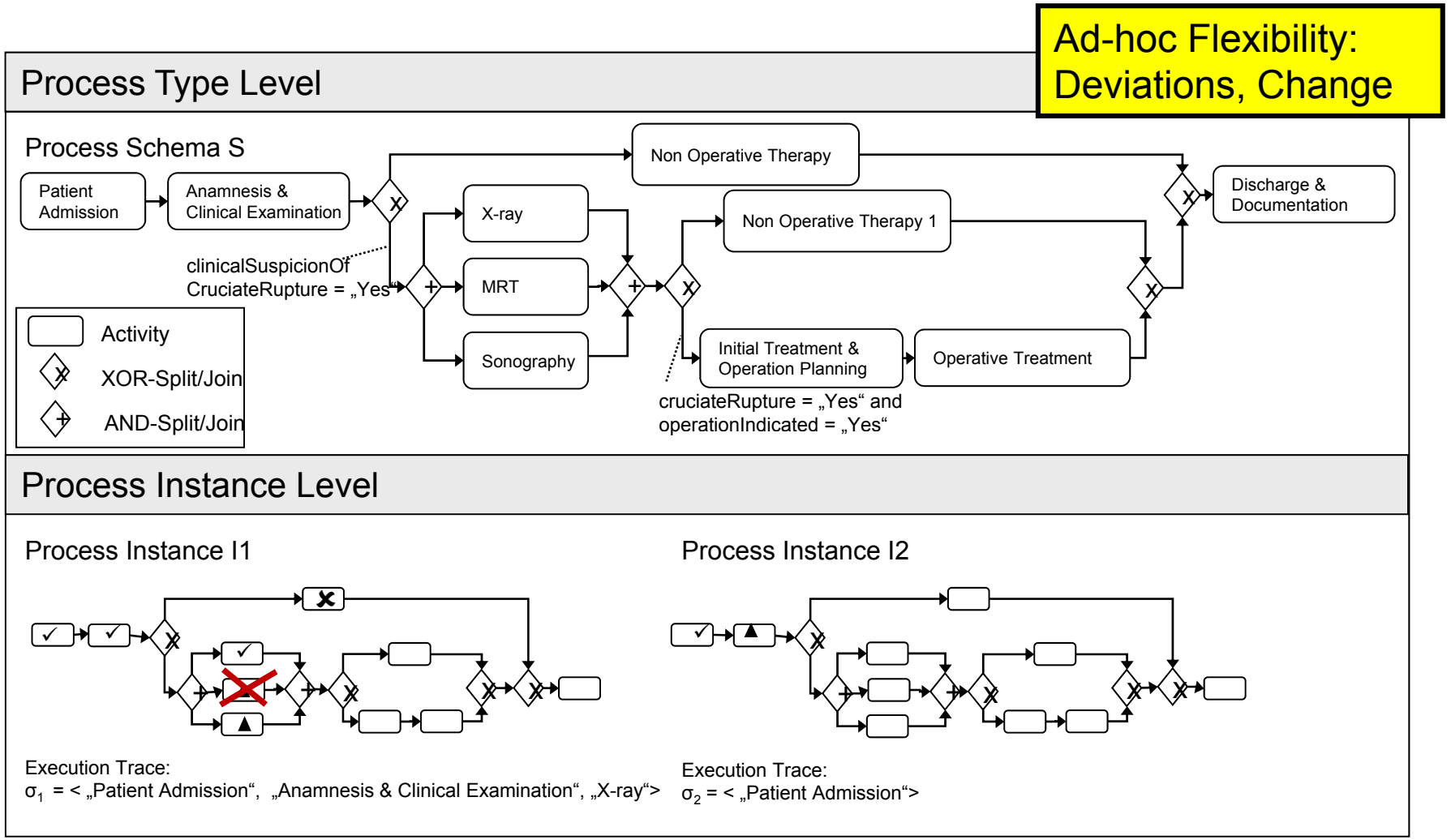
Ad-hoc Process Change



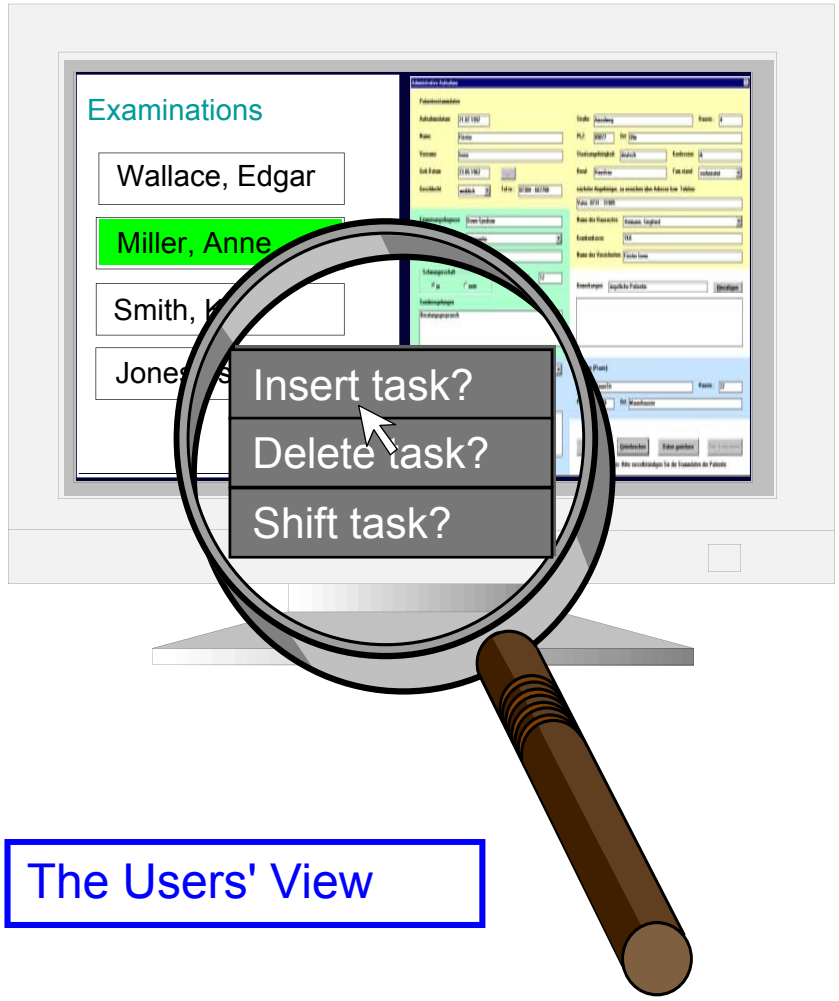
Ad-hoc Process Change



Ad-hoc Process Change

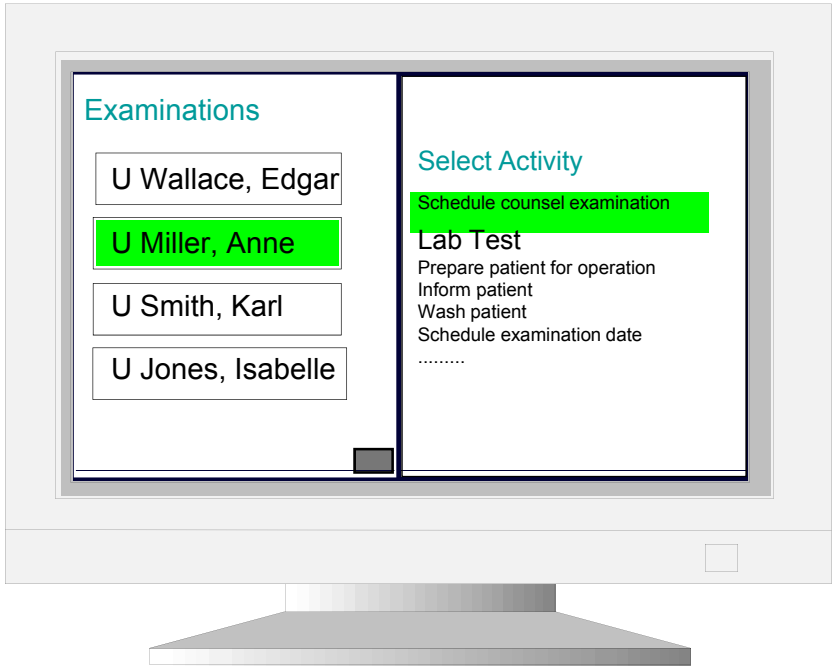


Ad-hoc Process Change (User's View)



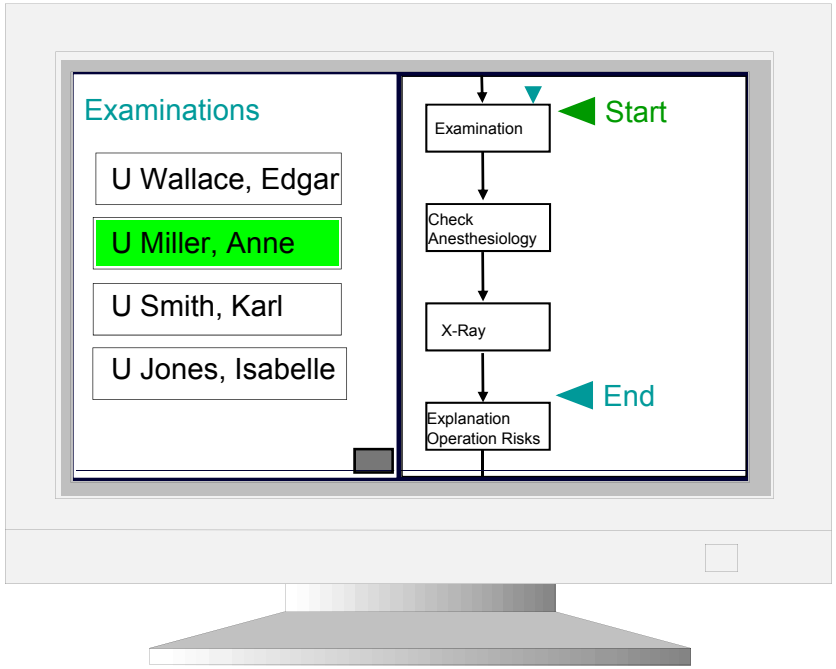
The Users' View

Ad-hoc Process Change (User's View)



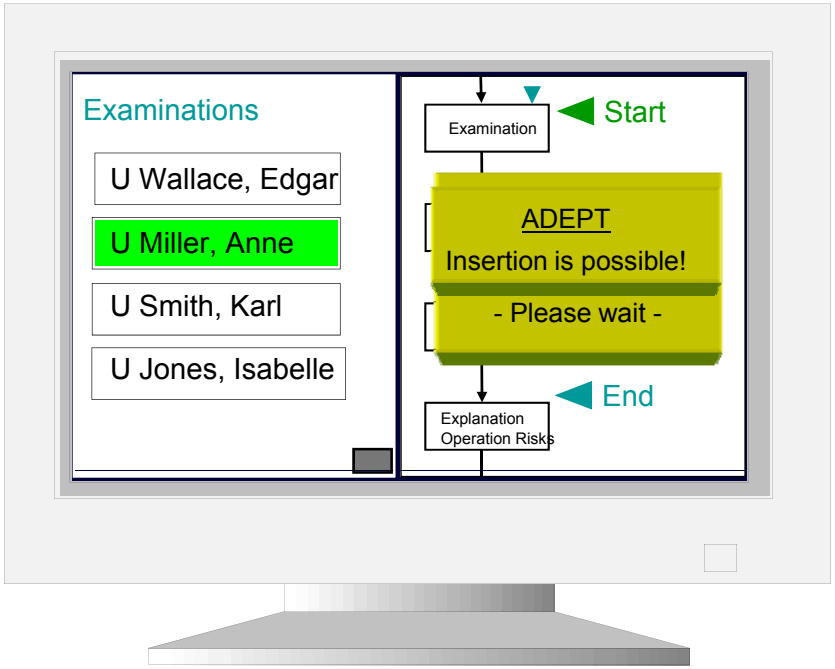
The Users' View

Ad-hoc Process Change (User's View)



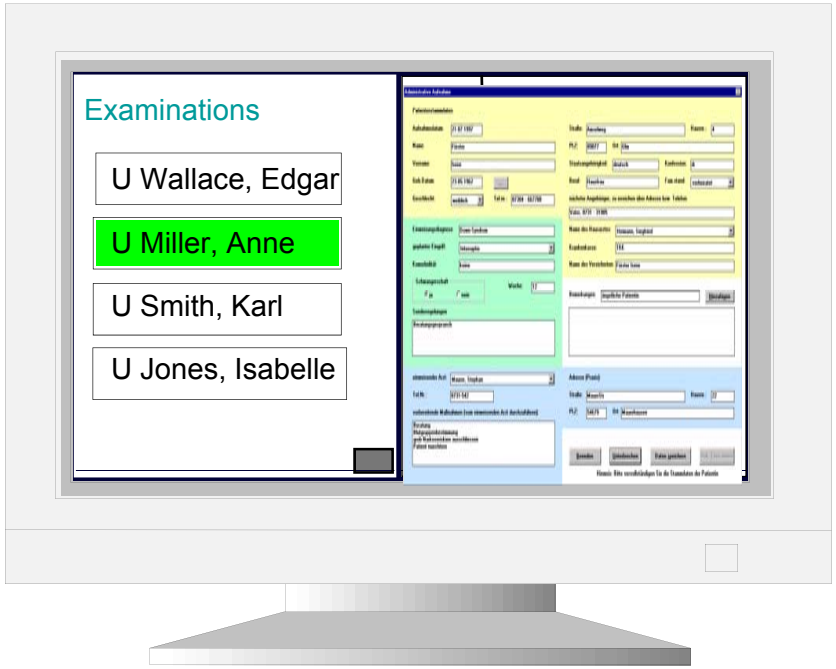
The Users' View

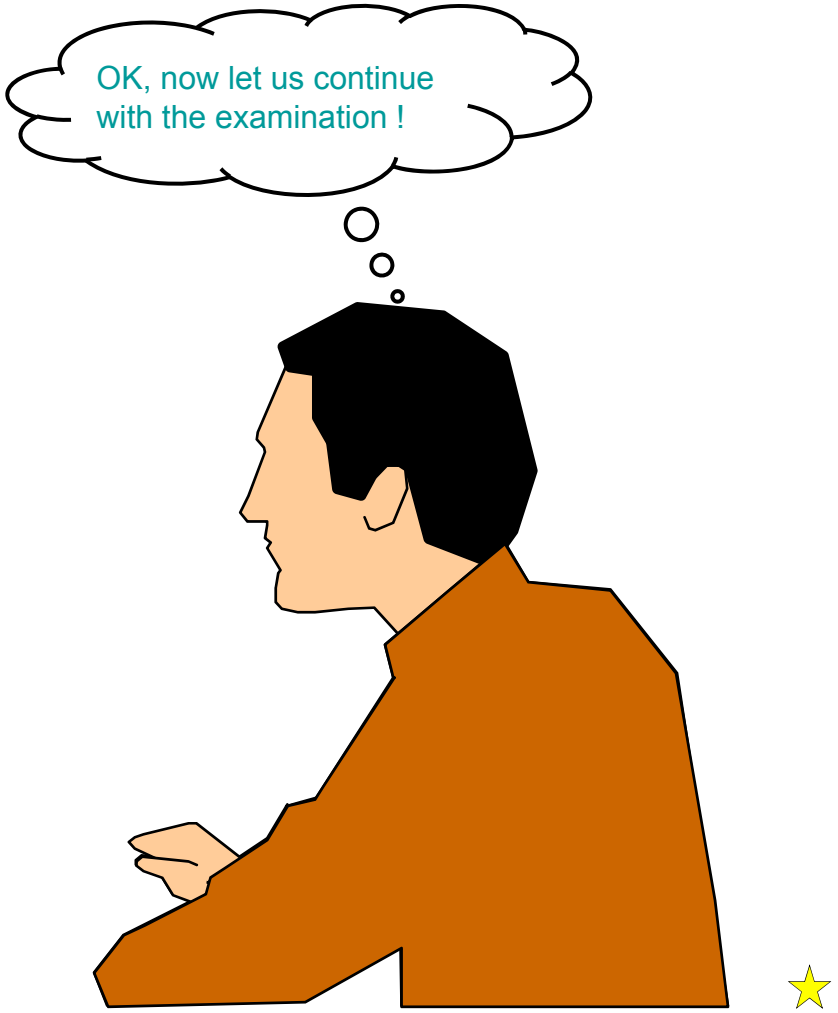
Ad-hoc Process Change (User's View)



The Users' View

Ad-hoc Process Change (User's View)



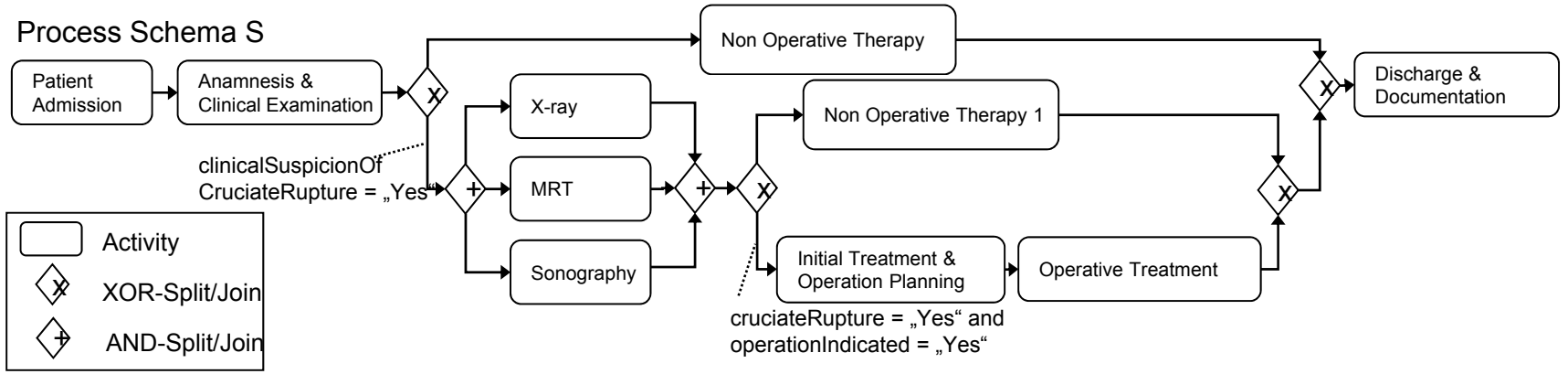


The Users' View

Ad-hoc Process Change: Correctness

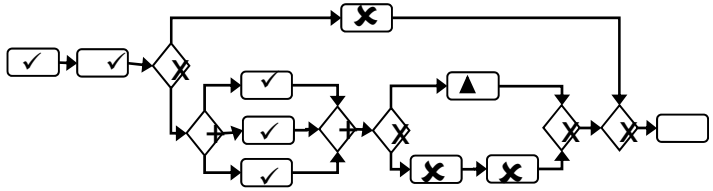
Process Type Level

Process Schema S



Process Instance Level

Process Instance I3

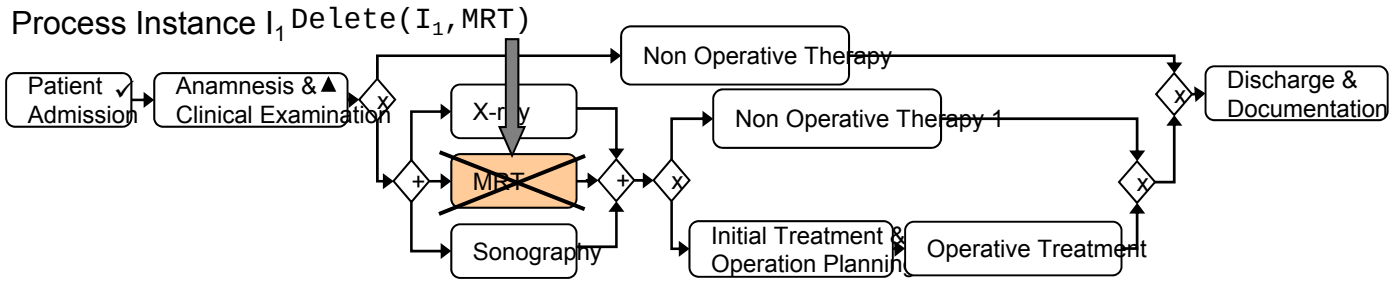


Execution Trace:
σ_3 = < „Patient Admission", „Anamnesis & Clinical Examination", „MRT", „X-ray", „Sonography">

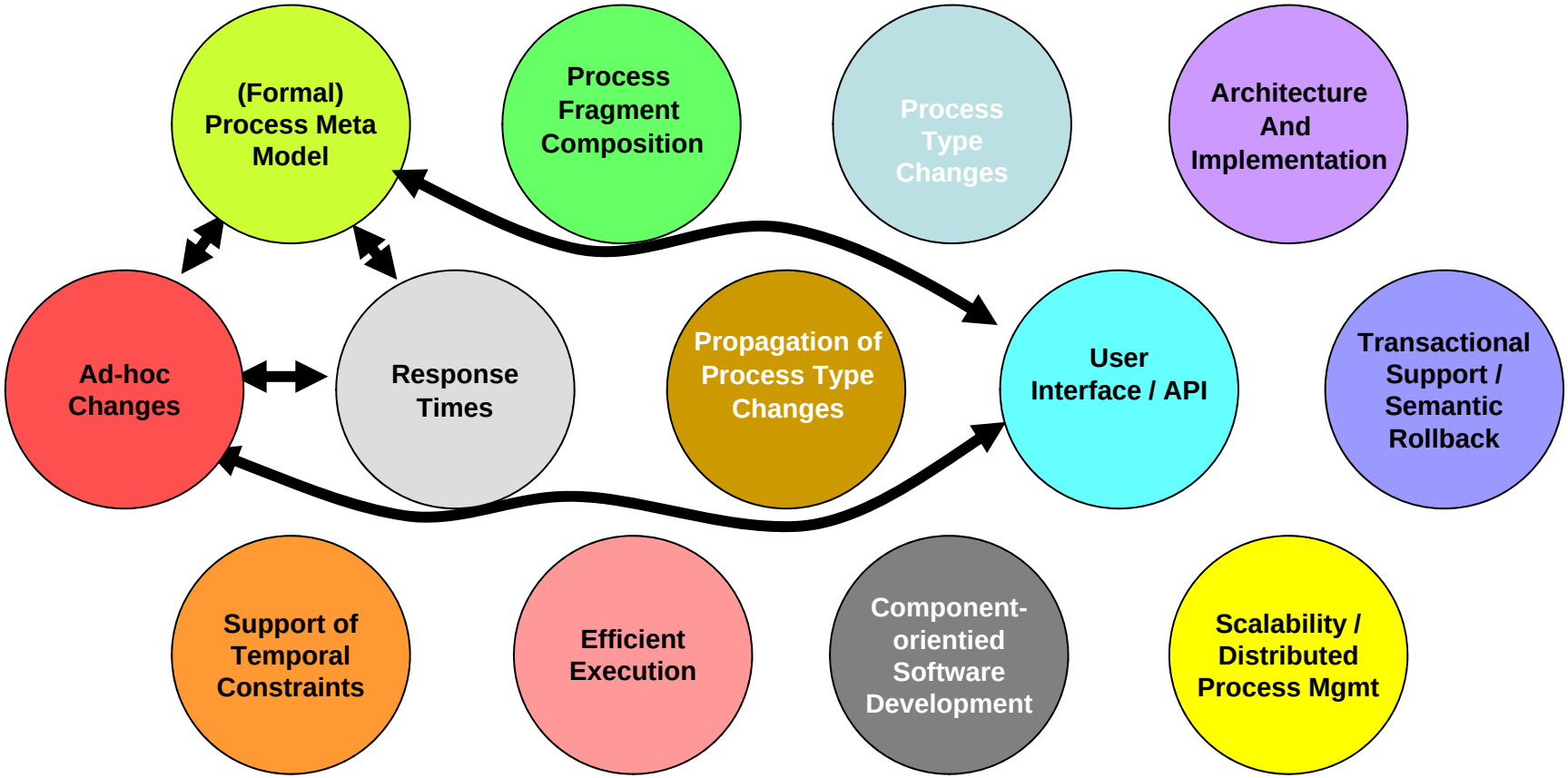
I3 is not compliant with change Delete (I3, MRT)

Ad-hoc Process Change: User Assistance

- Annotating changes with information about the reasons for the change
- Retrieval of similar past changes based on context information
- Reuse of changes through PAIS



The ADEPT Approach



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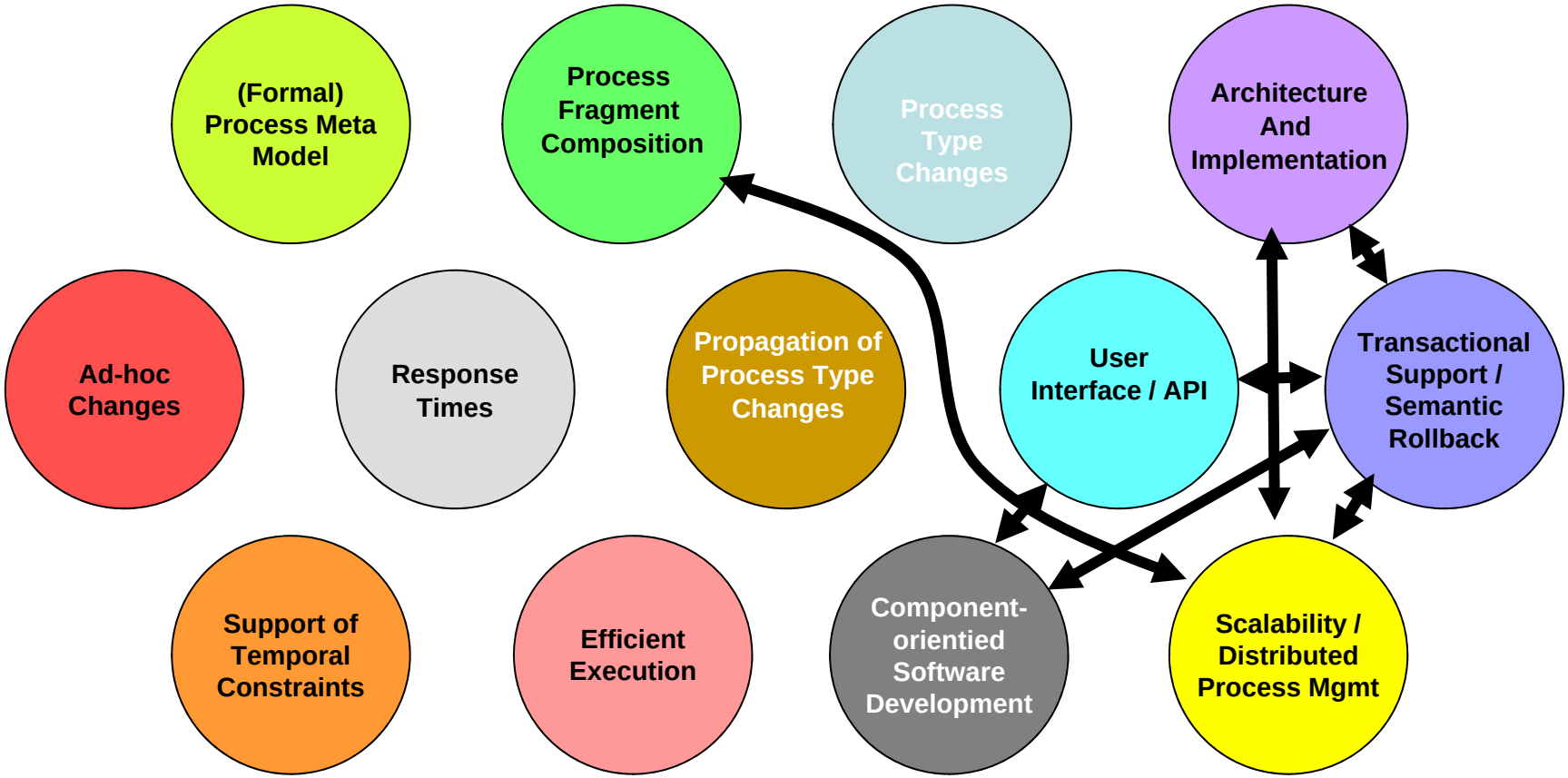
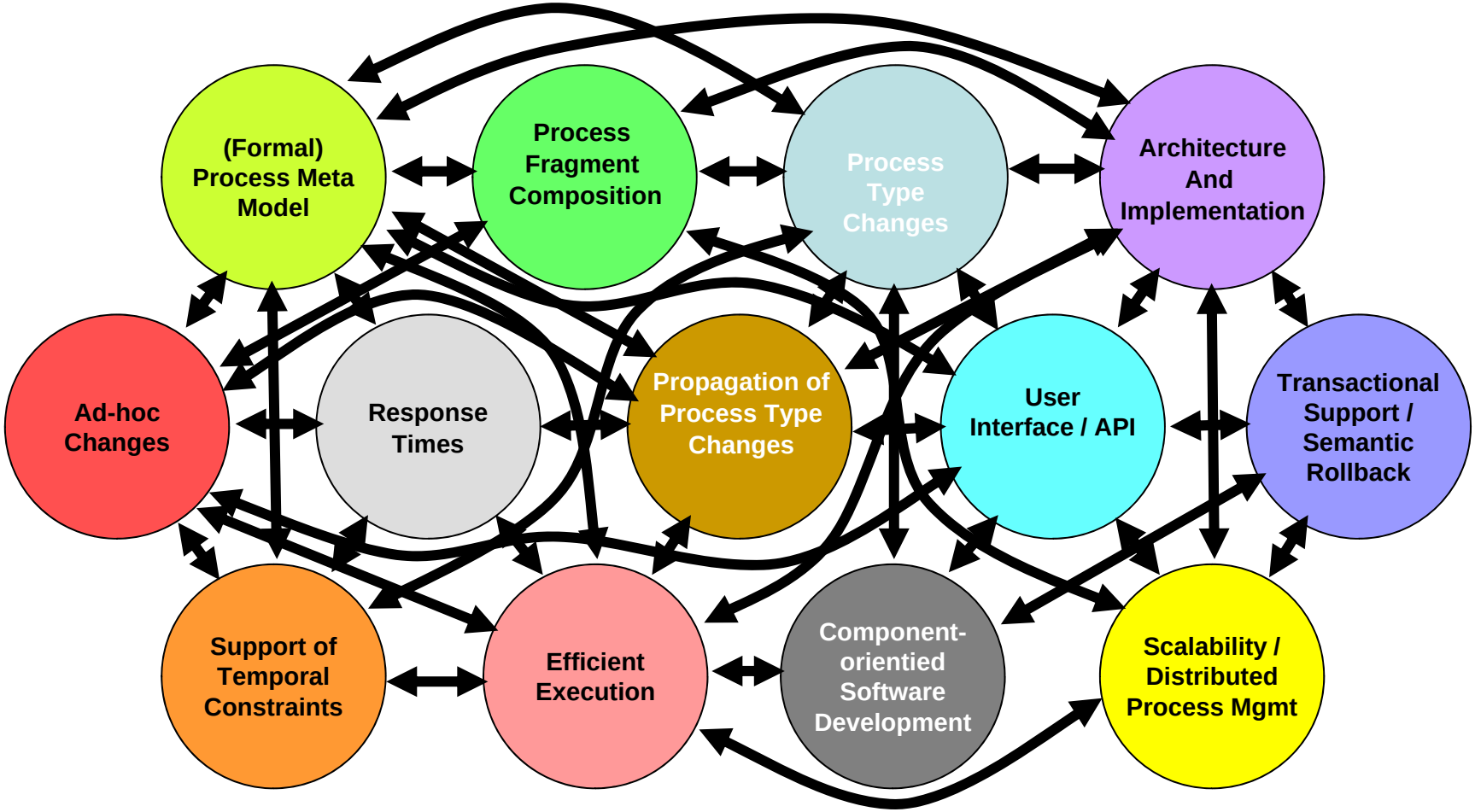


The ADEPT Approach

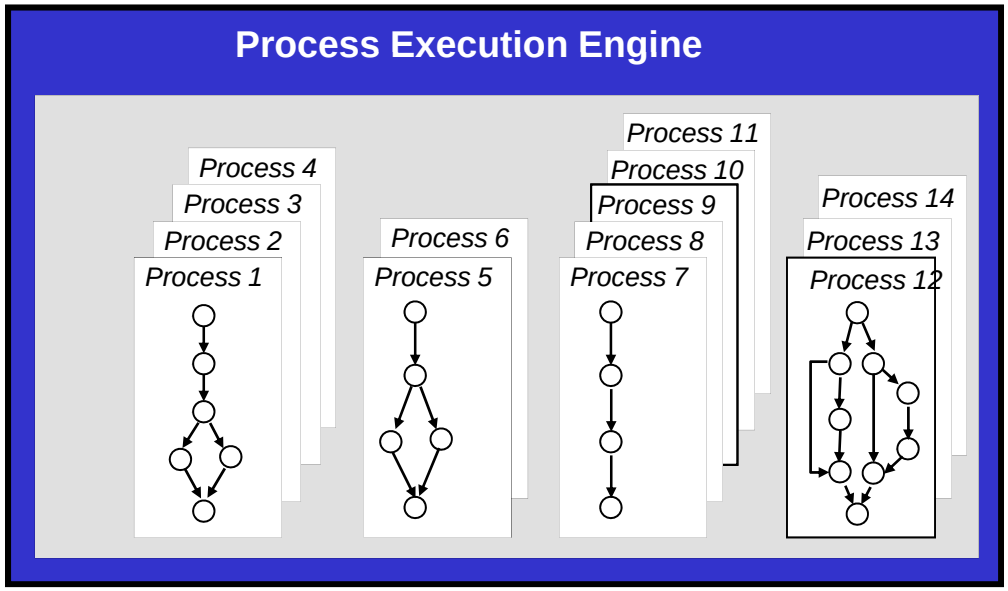


The ADEPT Approach

ADEPT :

Individually adaptable Process Instances

Process Instance = (individual) "Process Program"

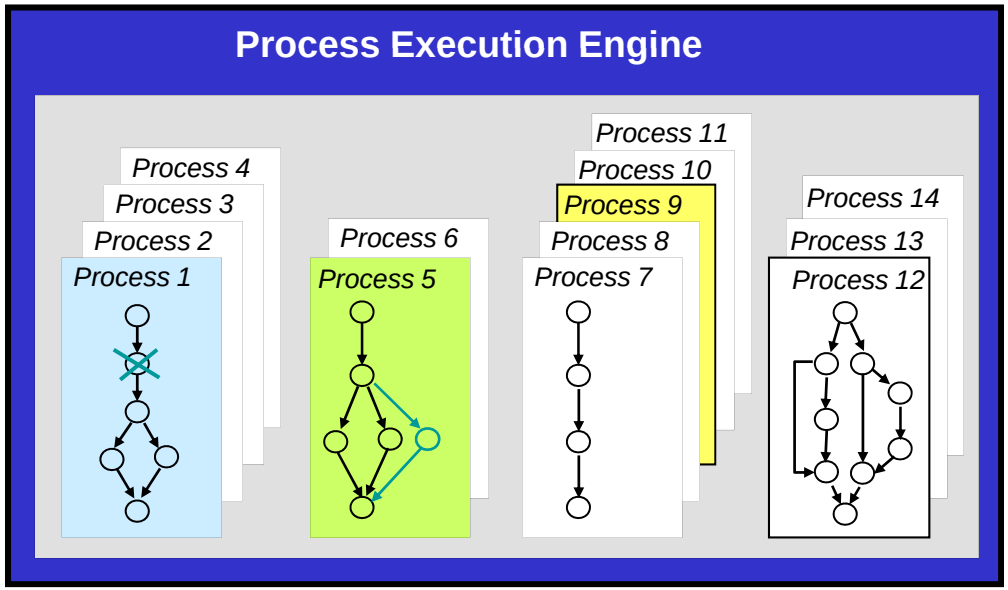


The ADEPT Approach

ADEPT :

Individually adaptable Process Instances

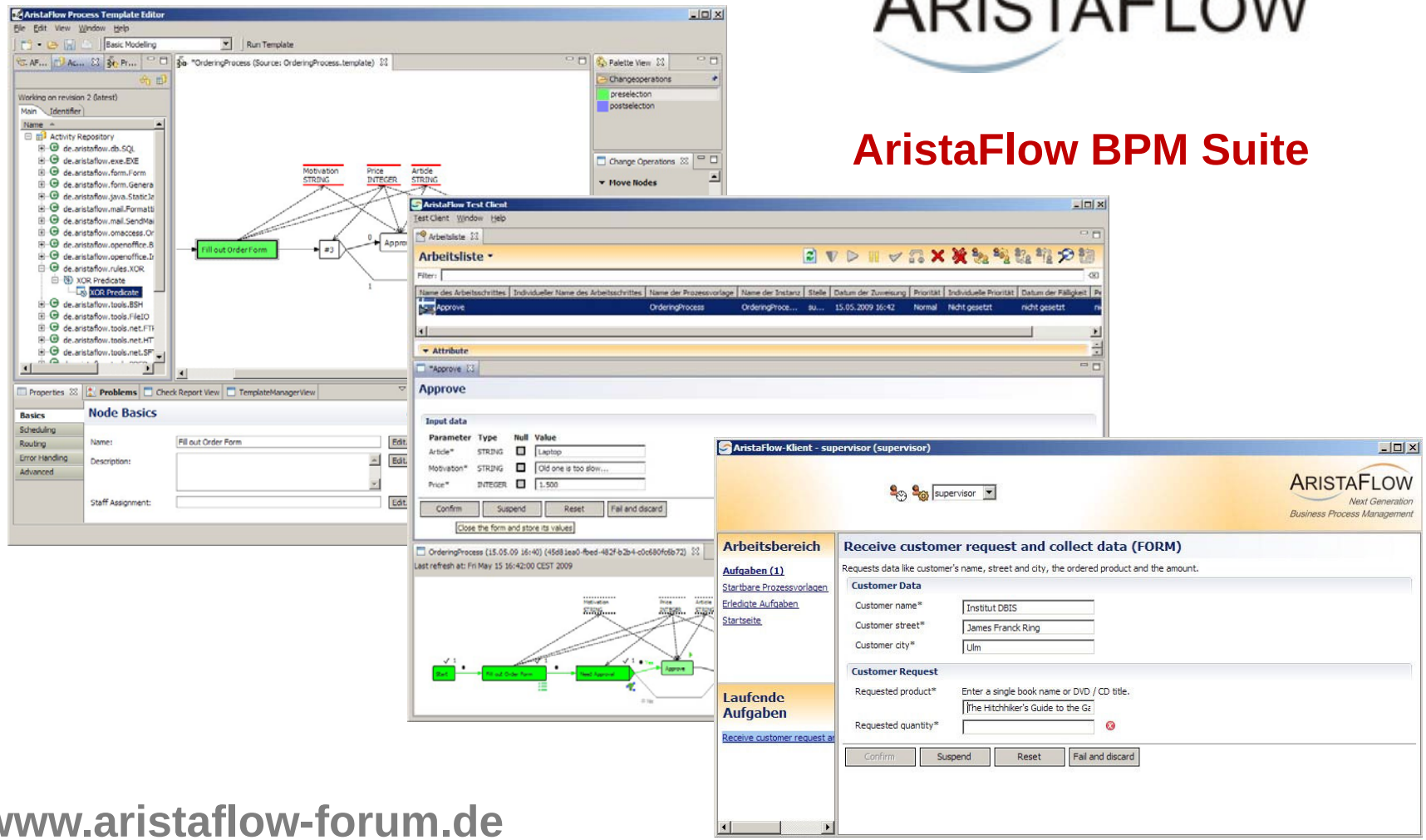
Process Instance = (individual) "Process Program"



Achievements:

- **Formal process meta model** (expressive + restricted enough)
- **Formal Criteria for Change Correctness** (incl. „Theorems & Proofs")
- **Efficient, build-in consistency checks** („no bad surprise")
- **Support of a high number of change patterns**
- **API for accomplishing ad-hoc changes**

The ADEPT Approach



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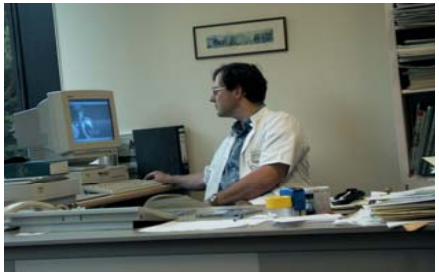
Applying the ADEPT / AristaFlow Technology in Practice

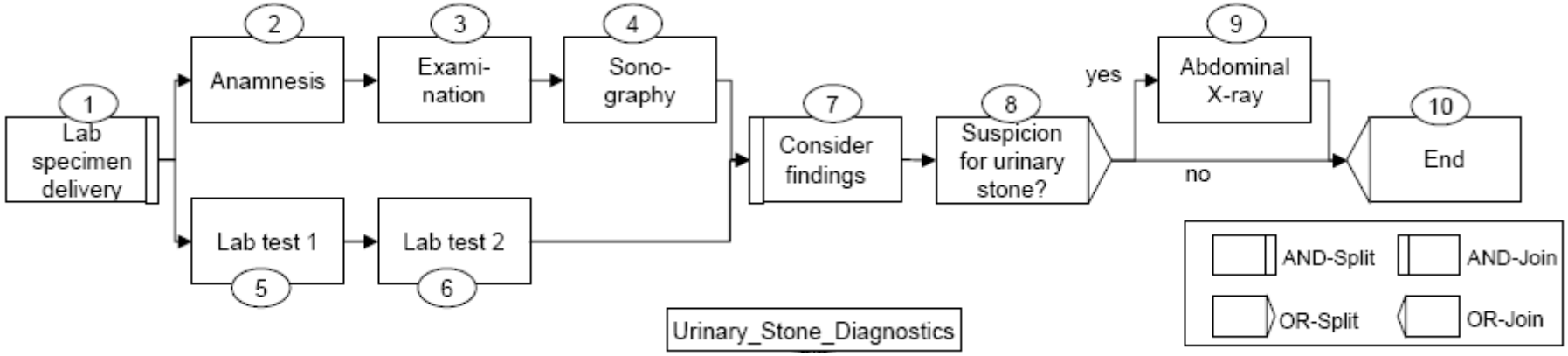
Enabling "Fluid Processes" with ADEPT: The Spot Project



Flexible Support of Clinical Pathways with ADEPT

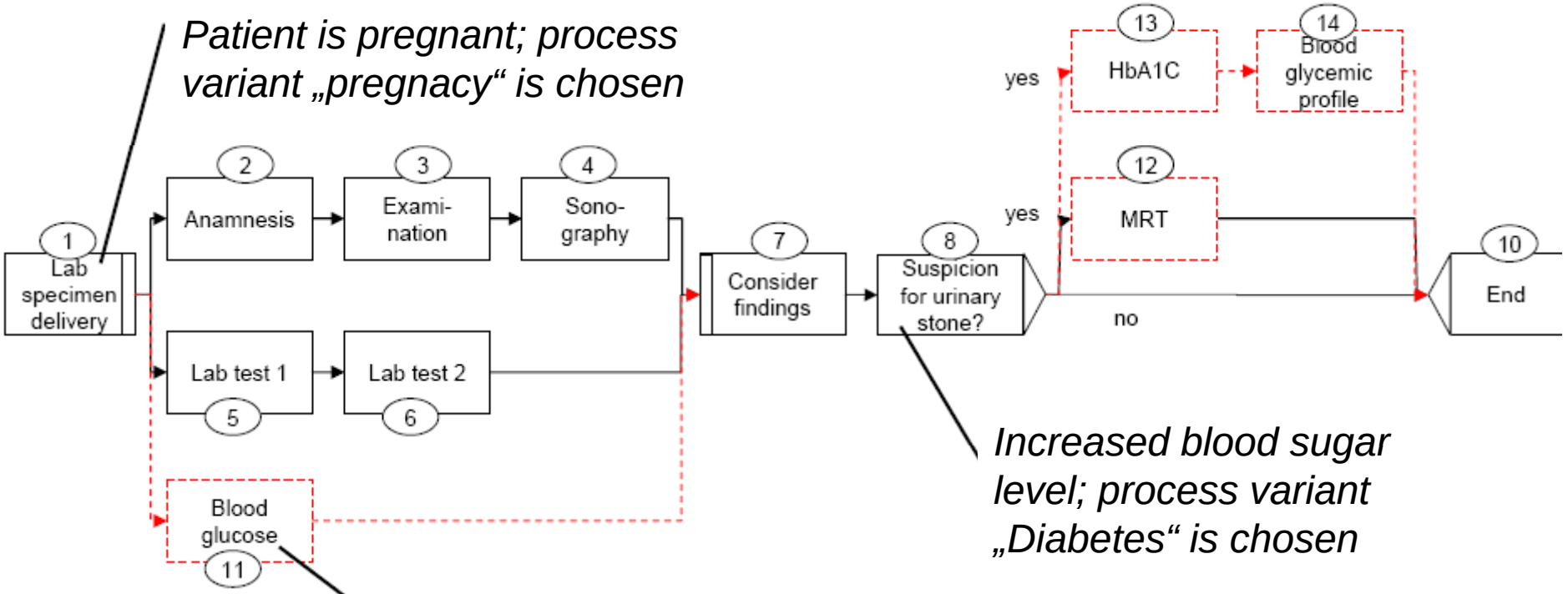
Partners:

Jan Neuhaus, Claudia Reuter
Fraunhoferinstitut Dortmund



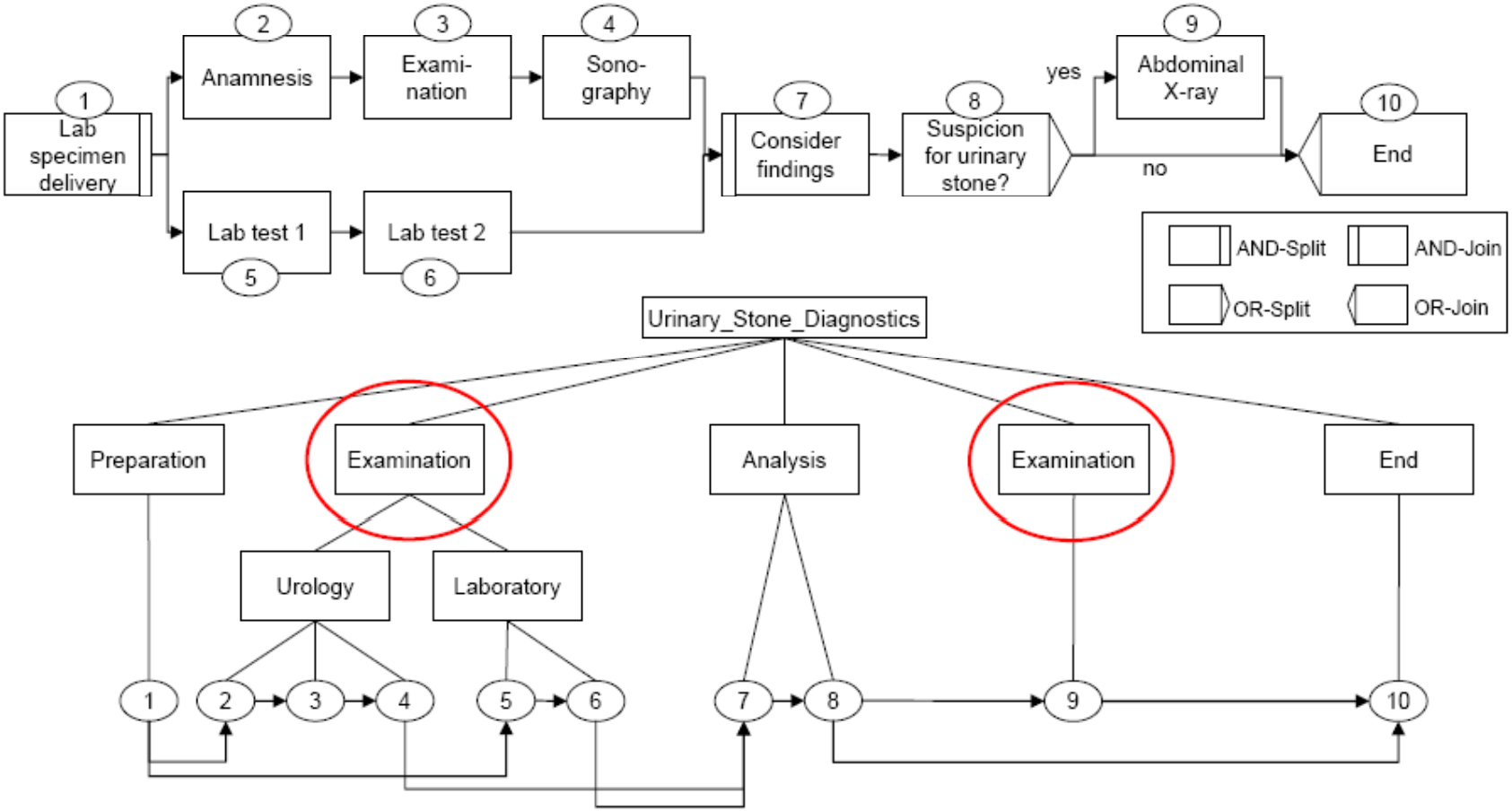
Enabling "Fluid Processes" with ADEPT: The Spot Project

Clinical pathways constitute "Fluid Processes" which need to be statically and/or dynamically configured to fit to the patient's current situation!



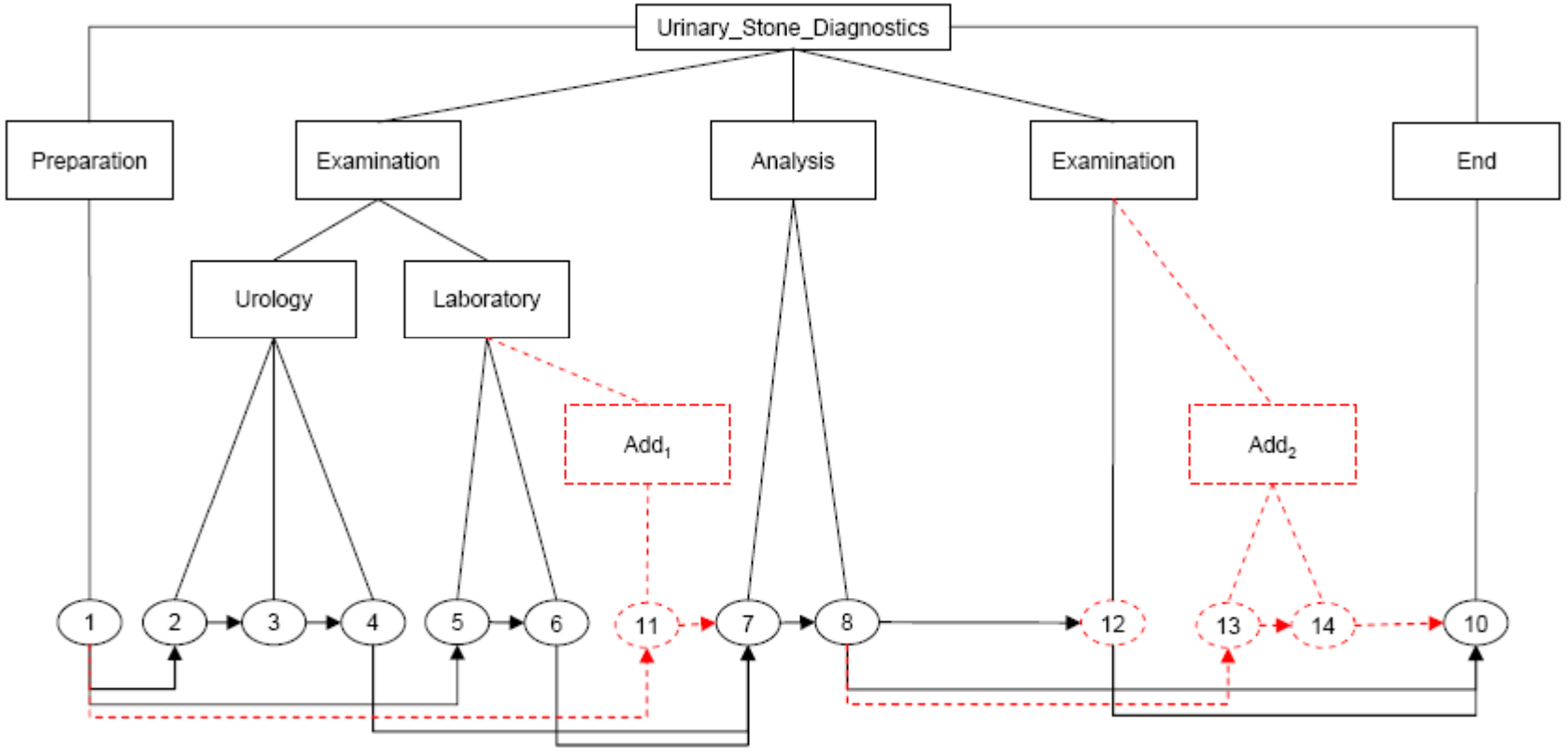
Enabling "Fluid Processes" with ADEPT: The Spot Project

The *Process Structure Tree* - Providing abstraction to end users



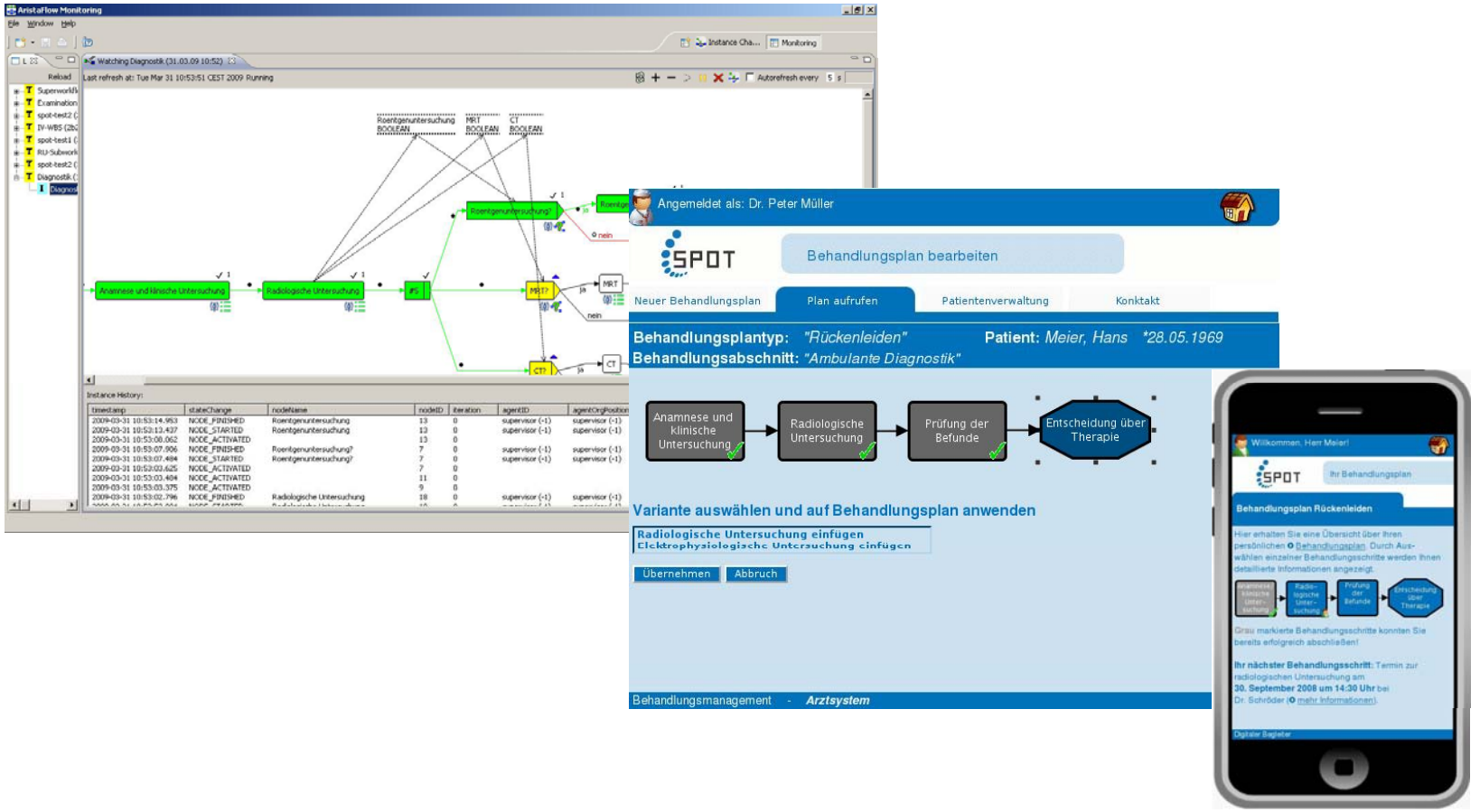
Enabling "Fluid Processes" with ADEPT: The Spot Project

The *Process Structure Tree* representing the patient-specific pathway!



Enabling "Fluid Processes" with ADEPT: The Spot Project

Proof-of-Concept Implementation Based on the ADEPT System

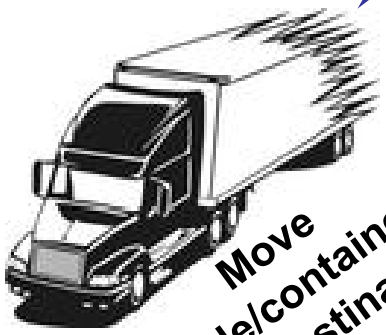


Enabling "Fluid Processes" with ADEPT: The MTCT Project

Move vehicle/container to origin location

Load container

Possible unexpected events: new client request arrival, delayed vehicles, technical problems



Move vehicle/container to final destination

Unload container

The MTCT System for Managing Container Transporation

Partners: University of Montreal

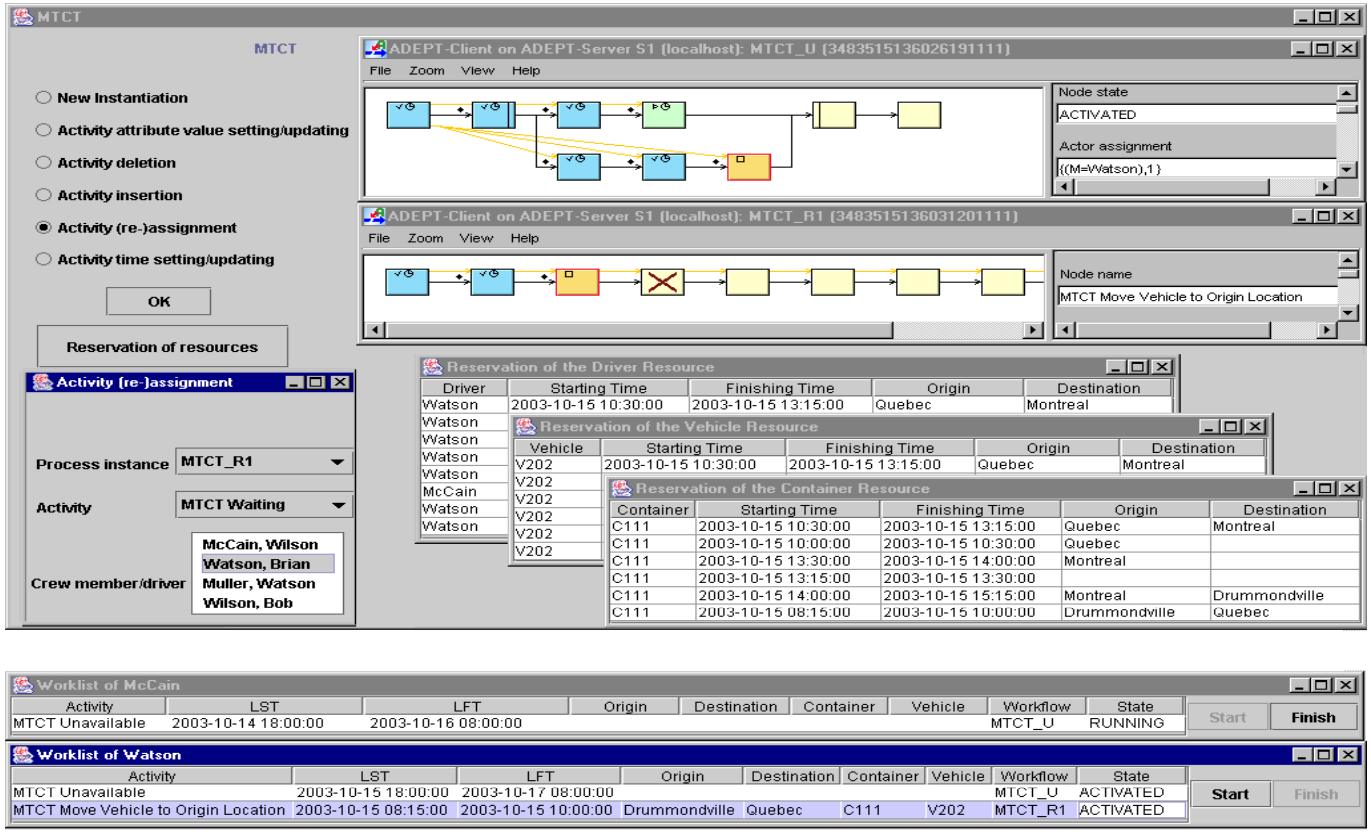
Enabling "Fluid Processes" with ADEPT: The MTCT Project

The MTCT System for the Flexible Management of Container Transportation

- Based on a transportation system framework
- Functionality:
  - Modeling and enacting the processing of client requests for container transportation (i.e., complex processes)
  - Tracking and monitoring the progress of the processes accomplishing these client requests
  - Identifying the activities to be (dynamically) composed and executed; e.g., attach/detach container to/from vehicle, move vehicle to location, load/unload container, wait at location
- Processing of client requests for container transportation
  - Dynamic creation and adaptation of specific sequences of interdependent activities; Use of ADEPT technology
  - dynamic structural modifications of process instances, e.g., adding a transfer to an already planned client request processing

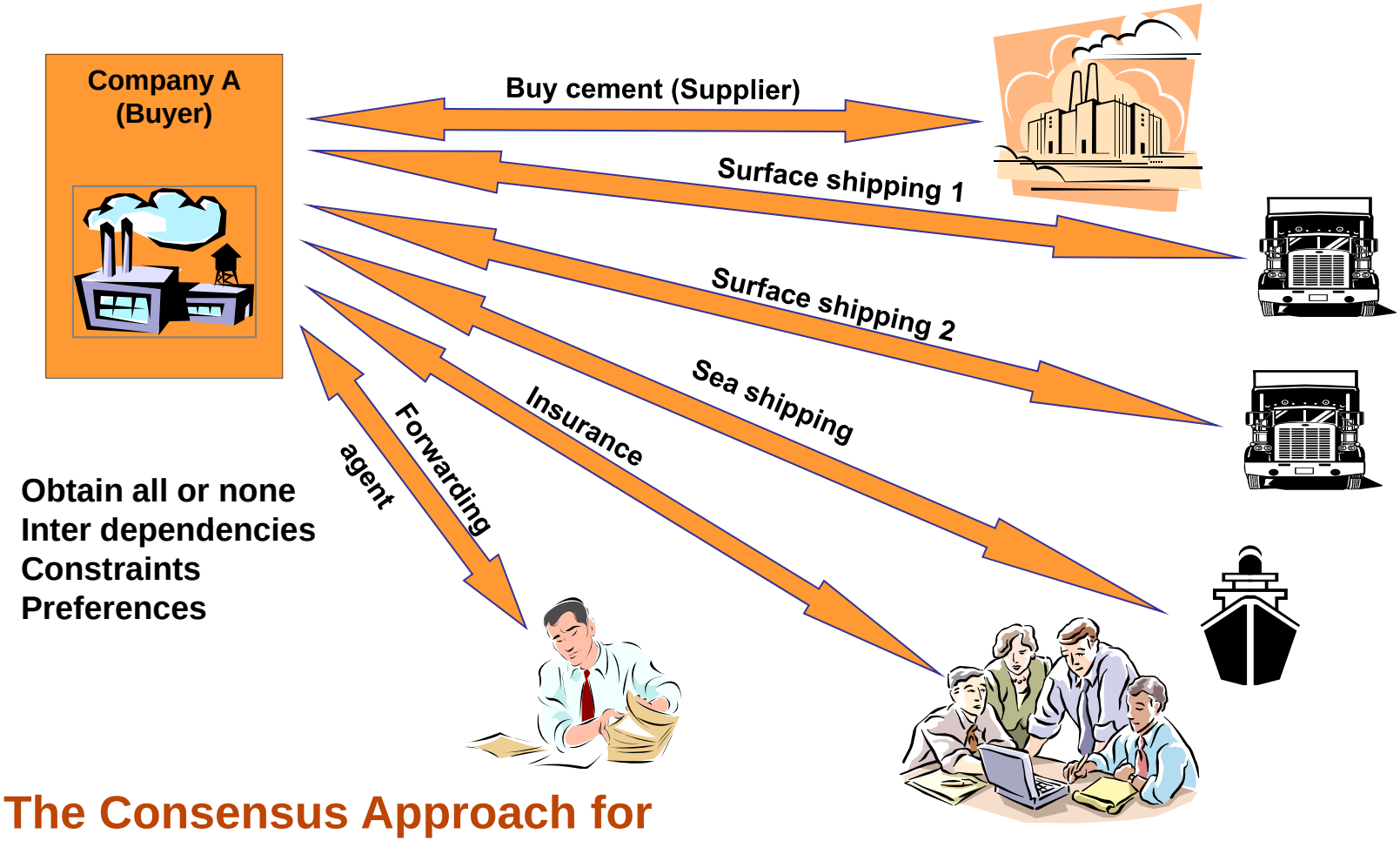
Enabling "Fluid Processes" with ADEPT: The MTCT Project

Proof-of-Concept Implementation Based on the ADEPT System



S. Bassil, R. Keller, P. Kropf: Workflow-oriented System for the Management of Container Transportation: Challenges and Architecture. In: BPM'04 *Conference*, Potsdam, 2004

Enabling "Fluid Processes" with ADEPT: The Consensus Project



The Consensus Approach for Supporting E-Negotiations

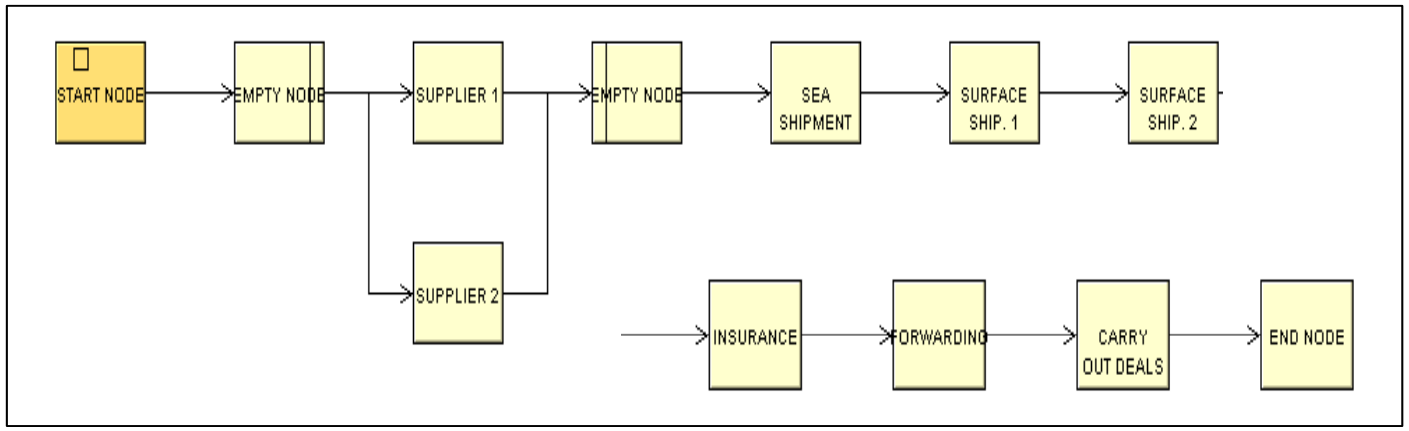
Partners: University of Montreal

Enabling "Fluid Processes" with ADEPT: The Consensus Project

Proof-of-Concept Implementation Based on the ADEPT System

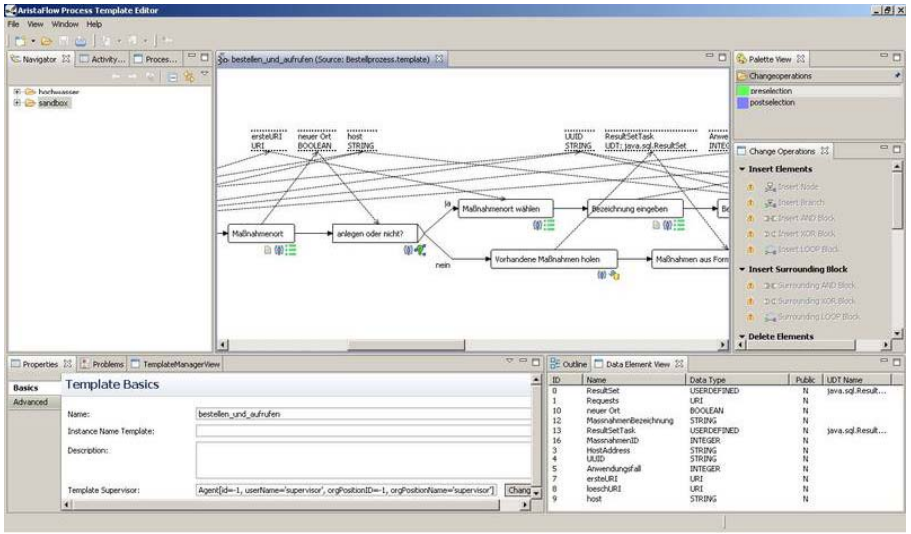
- Supports dynamism in (combined) e-negotiations; it is possible to dynamically …
  - insert a new negotiation
  - move a negotiation
  - remove already scheduled activities

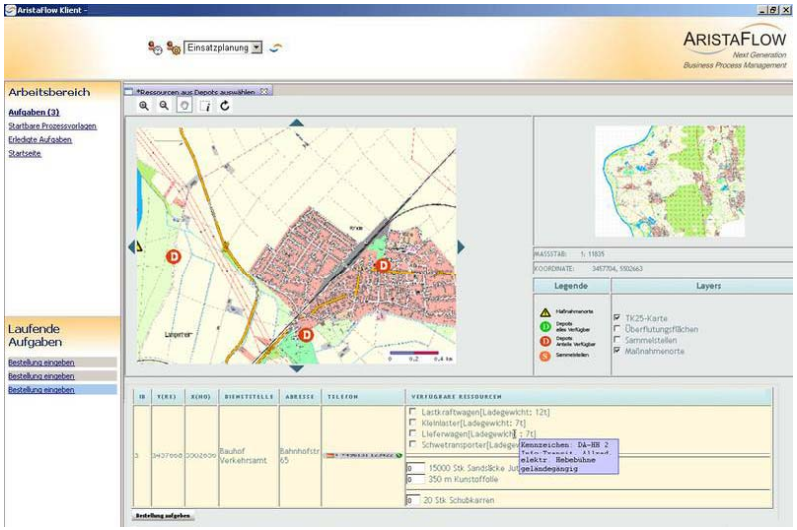
S. Bassil, M. Benyoucef, R. Keller, P. Kropf (2002). Addressing Dynamism in E-negotiations by Workflow Management Systems. Proc. *DEXA'02 Workshops*



Enabling "Fluid Processes" with ADEPT: Disaster Management

Process-aware, Cooperative Emergency Management for Water Infrastructures
Partner: TU Darmstadt





A. Wagenknecht; U. Rüppel: Improving Resource Management In Flood Response With Process Models and Web GIS. In: 16th TIEMS Conf., 2009

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Linh Thao Ly
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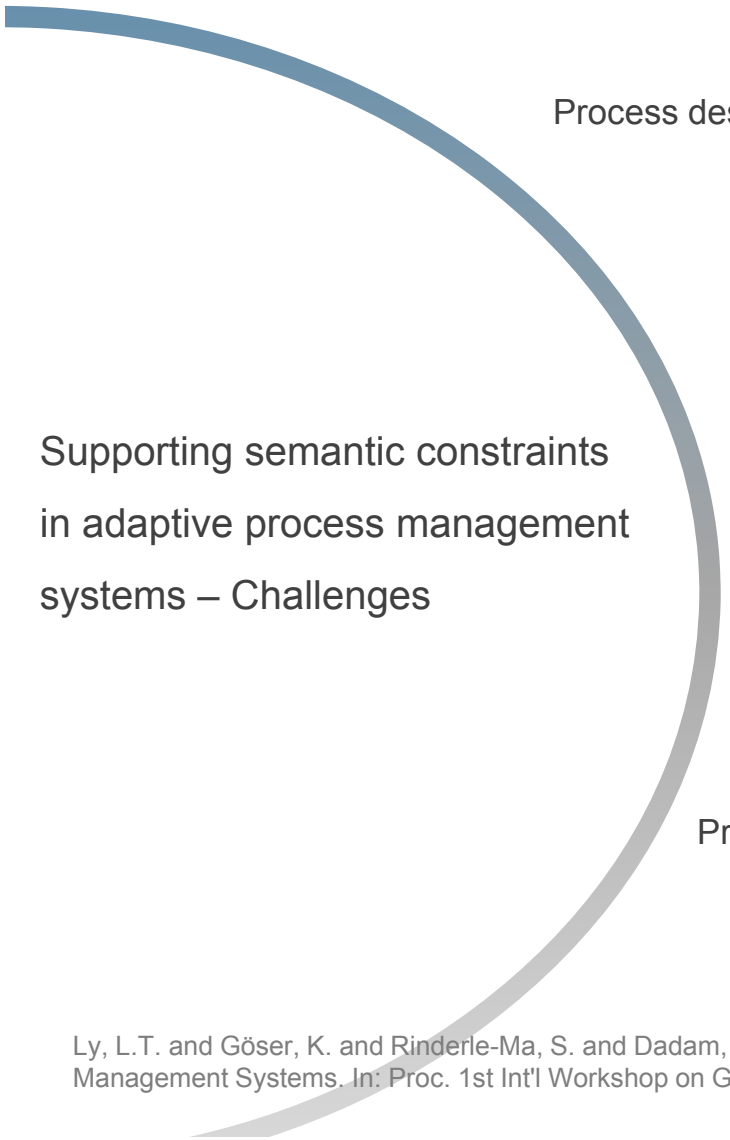
Semantically Constraining Possible Adaptations in Fluid Processes



Supporting semantic constraints in adaptive process management systems – Challenges

Constraint modeling

How to model semantic constraints, such as compliance rules, adequately?

Process design

How to ensure that process models meet compliance requirements?

Process execution

How to ensure that flexible ad-hoc process adaptations do not introduce incompliance?

Process evaluation

How to trace compliance violations and benefit from past process executions?

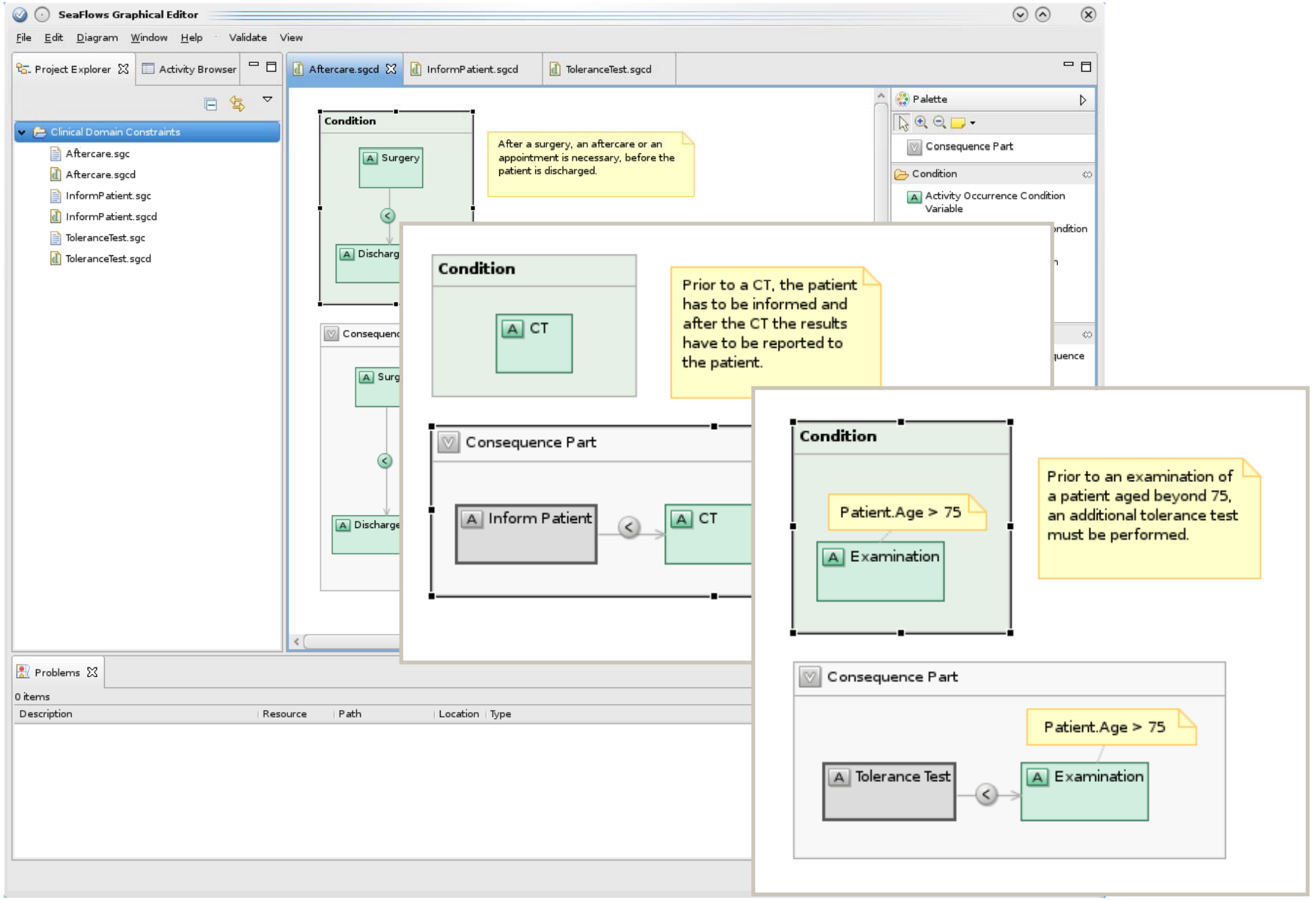
Ly, L.T. and Göser, K. and Rinderle-Ma, S. and Dadam, P. (2008) Compliance of Semantic Constraints - A Requirements Analysis for Process Management Systems. In: Proc. 1st Int'l Workshop on Governance, Risk and Compliance GRCIS'08), Montpellier, France.

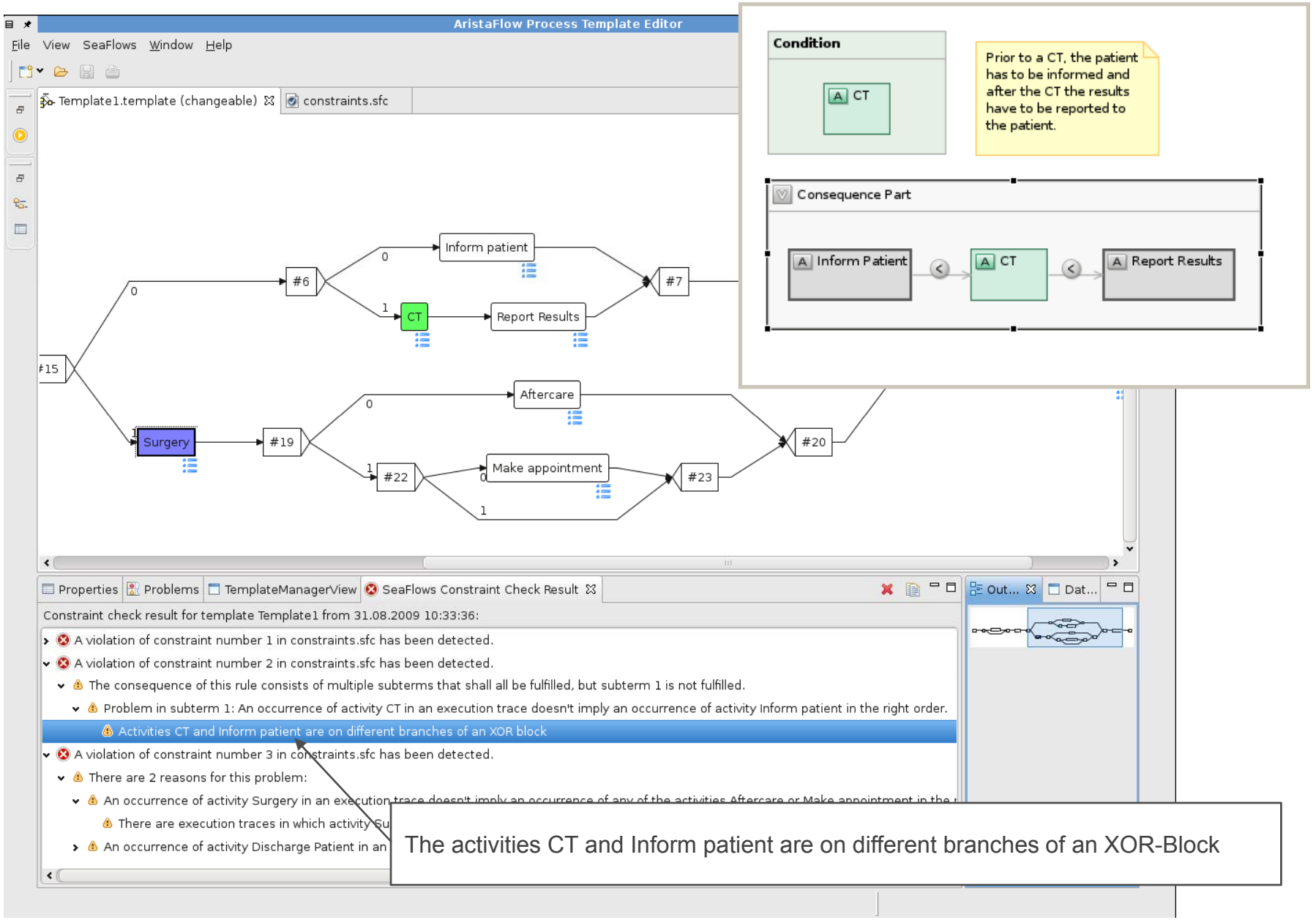
SeaFlows

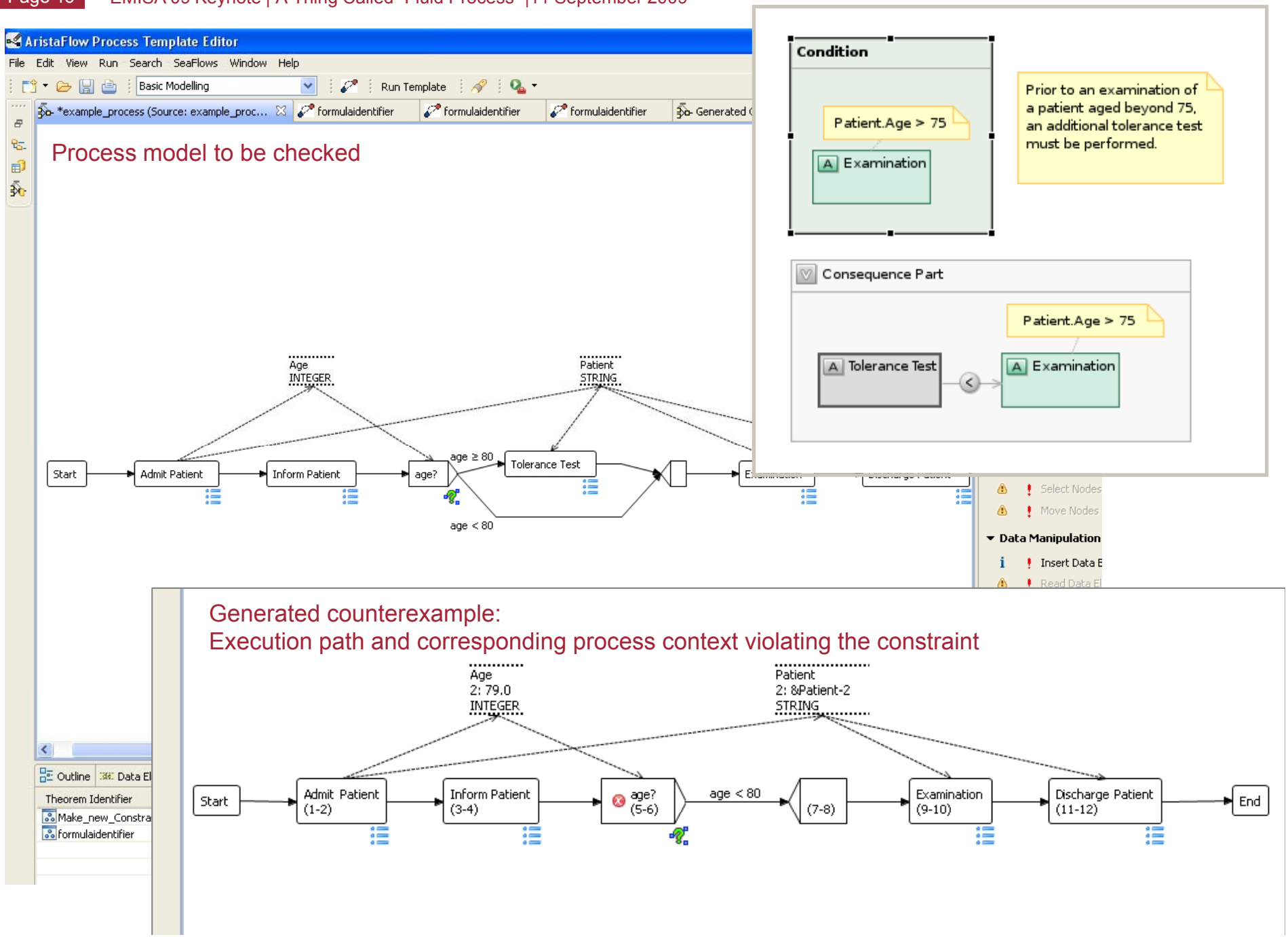
some impressions

Constraint modeling	Intuitive modeling of semantic constraints using a visual logic-based formalism
Process design	Enrichment of process models with semantic constraints
	Verification of process models against imposed constraints using graph algorithms and model checking (static verification)
	Helpful validation reports and visualization of counterexamples
Process execution	Runtime verification of dynamic constraints (dynamic verification)
	Integrated verification of ad-hoc process changes with regard to compliance
	Flexible overriding of constraints if necessary
Process evaluation	Documentation of constraint violations and constraint overriding enables traceability and process mining

Ly, Linh Thao and Rinderle-Ma, Stefanie and Göser, Kevin and Dadam, Peter (2009) On Enabling Integrated Process Compliance with Semantic Constraints in Process Management Systems. Information Systems Frontiers
Ly, Linh Thao and Rinderle, Stefanie and Dadam, Peter (2008) Integration and verification of semantic constraints in adaptive process management systems. Data and Knowledge Engineering , Vol. 64, No. 1, pp. 3-23


SeaFlows Graphical Editor
File Edit Diagram Window Help Validate View
Project Explorer
Activity Browser
Clinical Domain Constraints
Aftercare.sgc
Aftercare.sgcd
InformPatient.sgc
InformPatient.sgcd
ToleranceTest.sgc
ToleranceTest.sgcd
Aftercare.sgcd
InformPatient.sgcd
ToleranceTest.sgcd
Palette
Consequence Part
Condition
Activity Occurrence Condition Variable
Condition
Surgery
After a surgery, an aftercare or an appointment is necessary, before the patient is discharged.
Condition
CT
Prior to a CT, the patient has to be informed and after the CT the results have to be reported to the patient.
Consequence Part
Inform Patient
CT
Condition
Patient.Age > 75
Examination
Prior to an examination of a patient aged beyond 75, an additional tolerance test must be performed.
Consequence Part
Patient.Age > 75
Tolerance Test
Examination
Problems
0 items
Description
Resource
Path
Location
Type


AristaFlow Process Template Editor
File View SeaFlows Window Help
Template1.template (changeable)
constraints.sfc
Condition
CT
Prior to a CT, the patient has to be informed and after the CT the results have to be reported to the patient.
Consequence Part
Inform Patient
CT
Report Results
Inform patient
#6
#7
CT
Report Results
#15
Aftercare
Surgery
#19
#20
#22
Make appointment
#23
Properties
Problems
TemplateManagerView
SeaFlows Constraint Check Result
Constraint check result for template Template1 from 31.08.2009 10:33:36:
A violation of constraint number 1 in constraints.sfc has been detected.
A violation of constraint number 2 in constraints.sfc has been detected.
The consequence of this rule consists of multiple subterms that shall all be fulfilled, but subterm 1 is not fulfilled.
Problem in subterm 1: An occurrence of activity CT in an execution trace doesn't imply an occurrence of activity Inform patient in the right order.
Activities CT and Inform patient are on different branches of an XOR block
A violation of constraint number 3 in constraints.sfc has been detected.
There are 2 reasons for this problem:
The activities CT and Inform patient are on different branches of an XOR-Block


AristaFlow Process Template Editor
File Edit View Run Search SeaFlows Window Help
Basic Modelling
Run Template
*example_process (Source: example_proc...
formulaidentifier
formulaidentifier
formulaidentifier
Generated
Process model to be checked
Age
INTEGER
Patient
STRING
Start
Admit Patient
Inform Patient
age?
age ≥ 80
Tolerance Test
age < 80
Condition
Patient.Age > 75
Examination
Prior to an examination of a patient aged beyond 75, an additional tolerance test must be performed.
Consequence Part
Patient.Age > 75
Tolerance Test
Examination
Select Nodes
Move Nodes
Data Manipulation
Insert Data E
Read Data El
Outline
Data El
Theorem Identifier
Make_new_Constra
formulaidentifier
Generated counterexample:
Execution path and corresponding process context violating the constraint
Age
2: 79.0
INTEGER
Patient
2: &Patient-2
STRING
Start
Admit Patient
(1-2)
Inform Patient
(3-4)
age?
(5-6)
age < 80
(7-8)
Examination
(9-10)
Discharge Patient
(11-12)
End

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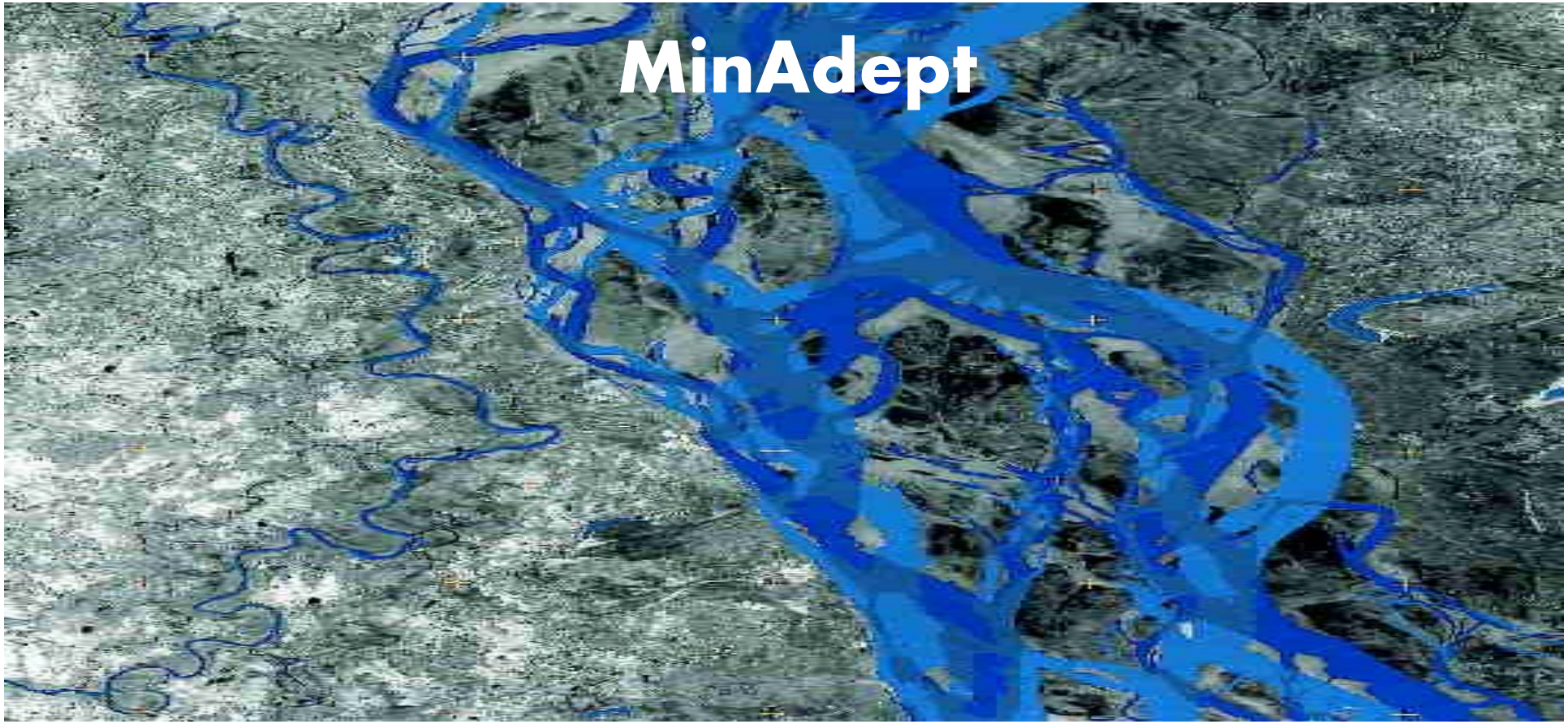
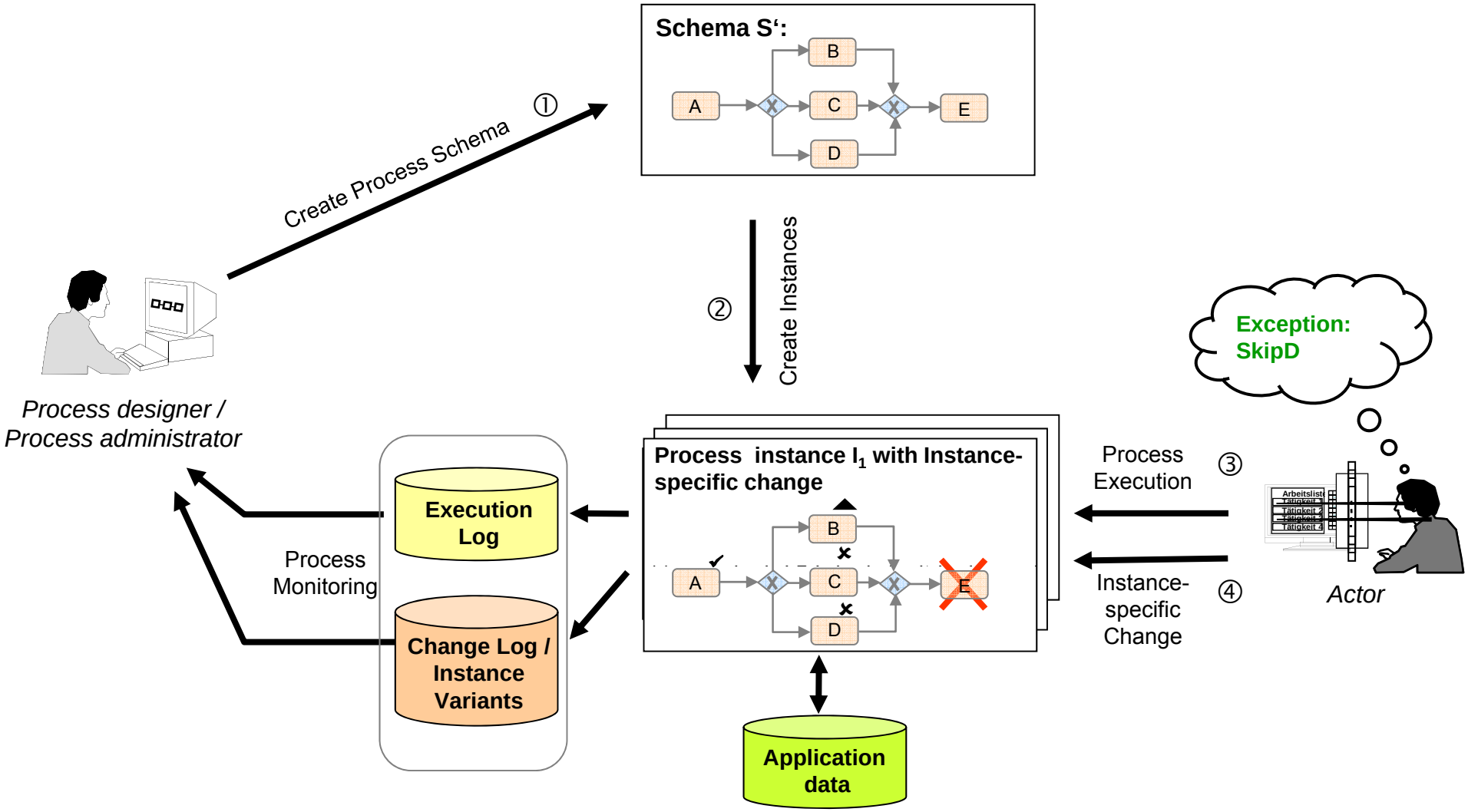


Changes in the Jamuna river (a branch of the Brahmaputra) in Bangladesh between March 1987 (shown in dark blue) and March 1989 (shown in light blue) and superimposed on a SPOT satellite basemap. Change monitoring made it possible to model the river's course and behaviour and to undertake preliminary studies to control flooding.

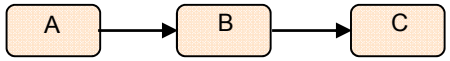
Monitoring and Mining Fluid Processes

Monitoring and Mining "Fluid Processes"



Execution and Change Logs of "Fluid Processes"

Original Schema S

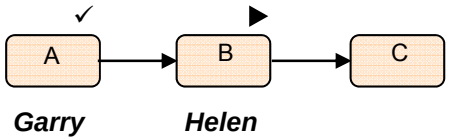



```
Instance 4711
Activity  Event             User    Timestamp
          Instance Started  Garry   2007/09/08 15:00
A         Started           Garry   2007/09/08 15:30
A         Completed         Garry   2007/09/08 15:45
B         Started           Helen   2007/09/10 11:00
X         Started           Fritz   2007/09/11 09:01
```

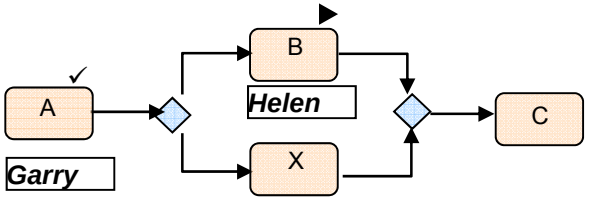
```
Change Log Instance 4711 on Schema S

Change TX Applied Changes : User:Timestamp

001 InsertFragment[S;X,A,C]:Helen:2007/09/10 12:02
002 ReplaceFragment(S;C,Z):Jim:2007/09/11 09:31
```

Process Instance 4711

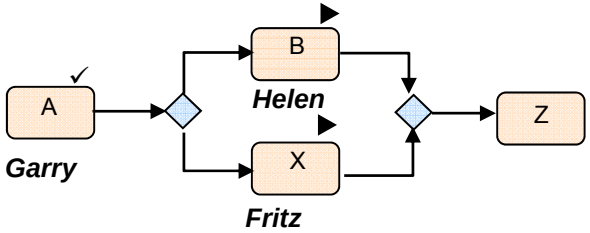
2007/09/10 11:00



2007/09/10 13:00



2007/09/11 10:00

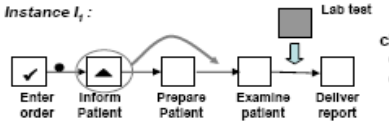


Change Analysis – A Simple Approach

Fluid processes with instance-specific change logs

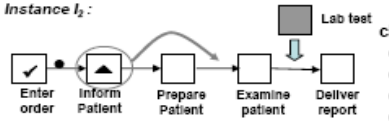
Change Logs

Instance I_1 :



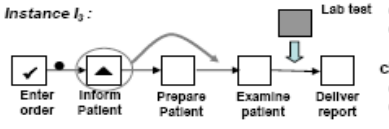
cL_{I1} = (
op1:=insert(S, Lab test, Examine Patient, Deliver report),
op2:=move(S, Inform Patient, Prepare Patient, Examine Patient))

Instance I_2 :



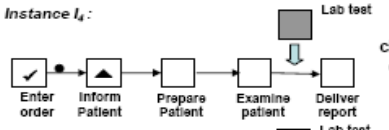
cL_{I2}(S) = (
op3:=insert(S, xRay, Inform Patient, Prepare Patient),
op4:=delete(S, xRay),
op5:=delete(S, Inform Patient),
op6:=insert(S, Inform Patient, Examine Patient, Deliver Report),
op2 =move(S, Inform Patient, Prepare Patient, Examine Patient),
op1 =insert(S, Lab Test, Examine Patient, Deliver Report))

Instance I_3 :



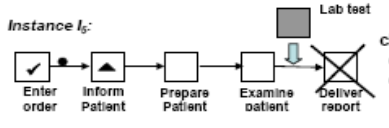
cL_{I1} = (
op2 =move(S, Inform Patient, Prepare Patient, Examine Patient),
op1 =insert(S, Lab test, Examine Patient, Deliver report))

Instance I_4 :



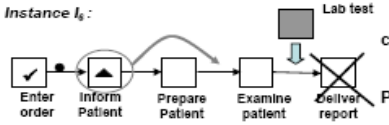
cL_{I4} = (
op1 =insert(S, Lab test, Examine Patient, Deliver report))

Instance I_5:



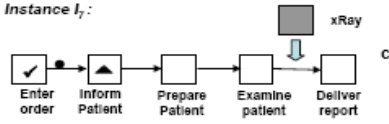
cL_{I5} = (
op1 =insert(S, Lab test, Examine Patient, Deliver report,
op7:=delete(S, Deliver report))

Instance I_6 :



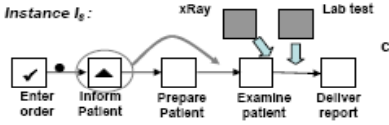
cL_{I6} = (
op1 =insert(S, Lab test, Examine Patient, Deliver report),
op2 =move(S, Inform Patient, Prepare Patient, Examine Patient),
op7 =delete(S, Deliver report))

Instance I_7 :



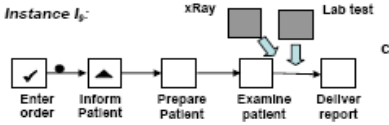
cL_{I7}(S) = (
op8:= insert(S, xRay, Examine Patient, Deliver report))

Instance I_8 :



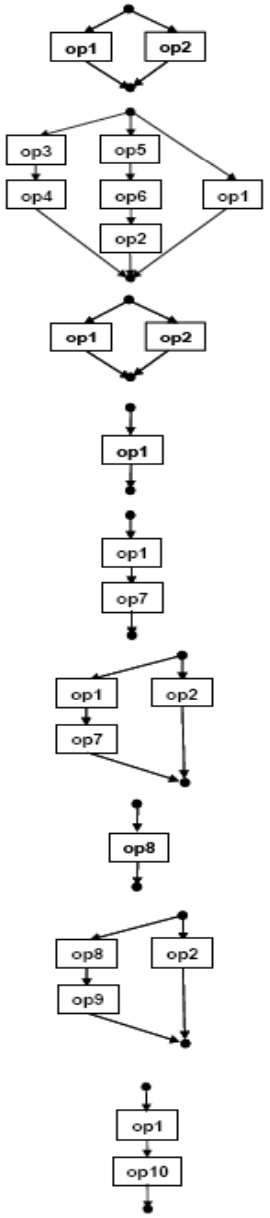
cL_{I8} = (
op2 =move(S, Inform Patient, Prepare Patient, Examine Patient),
op8 =insert(S, xRay, Examine patient, Deliver report),
op9:=insert(S, Lab test, xRay, Deliver report))

Instance I_9:



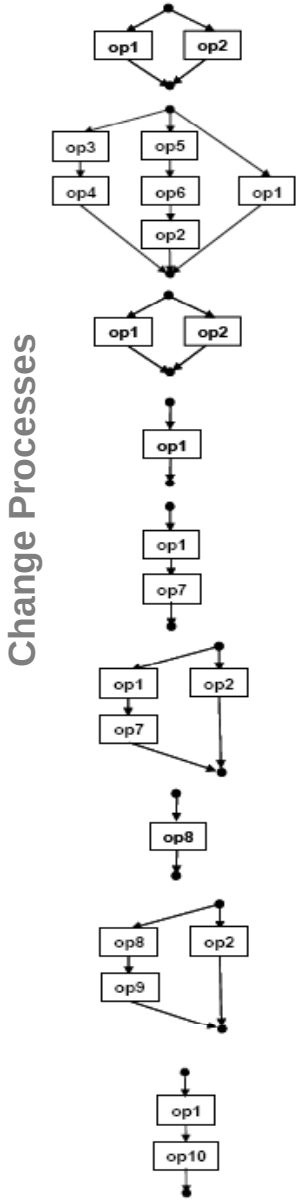
cL_{I8} = (
op1 =insert(S, Lab test, Examine Patient, Deliver report),
op10:=insert(S, xRay, Examine patient, Lab test))

Phase I

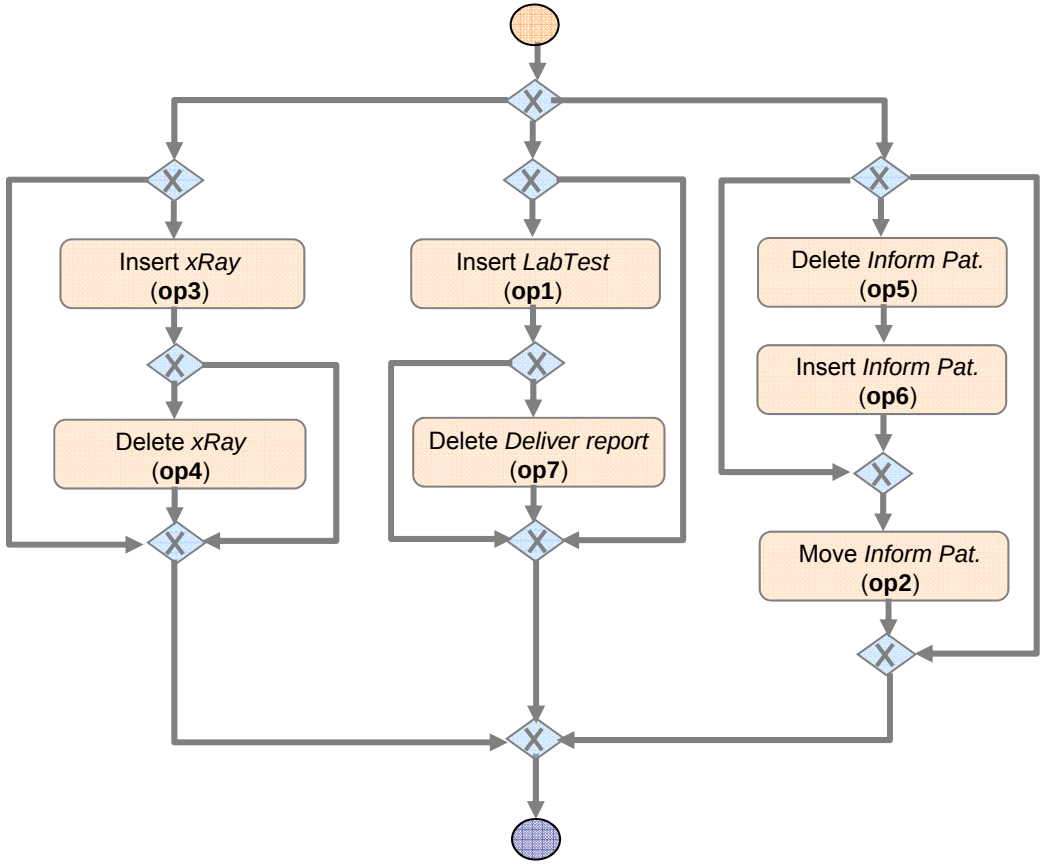


Change Processes

Change Analysis – A Simple Approach



Phase II

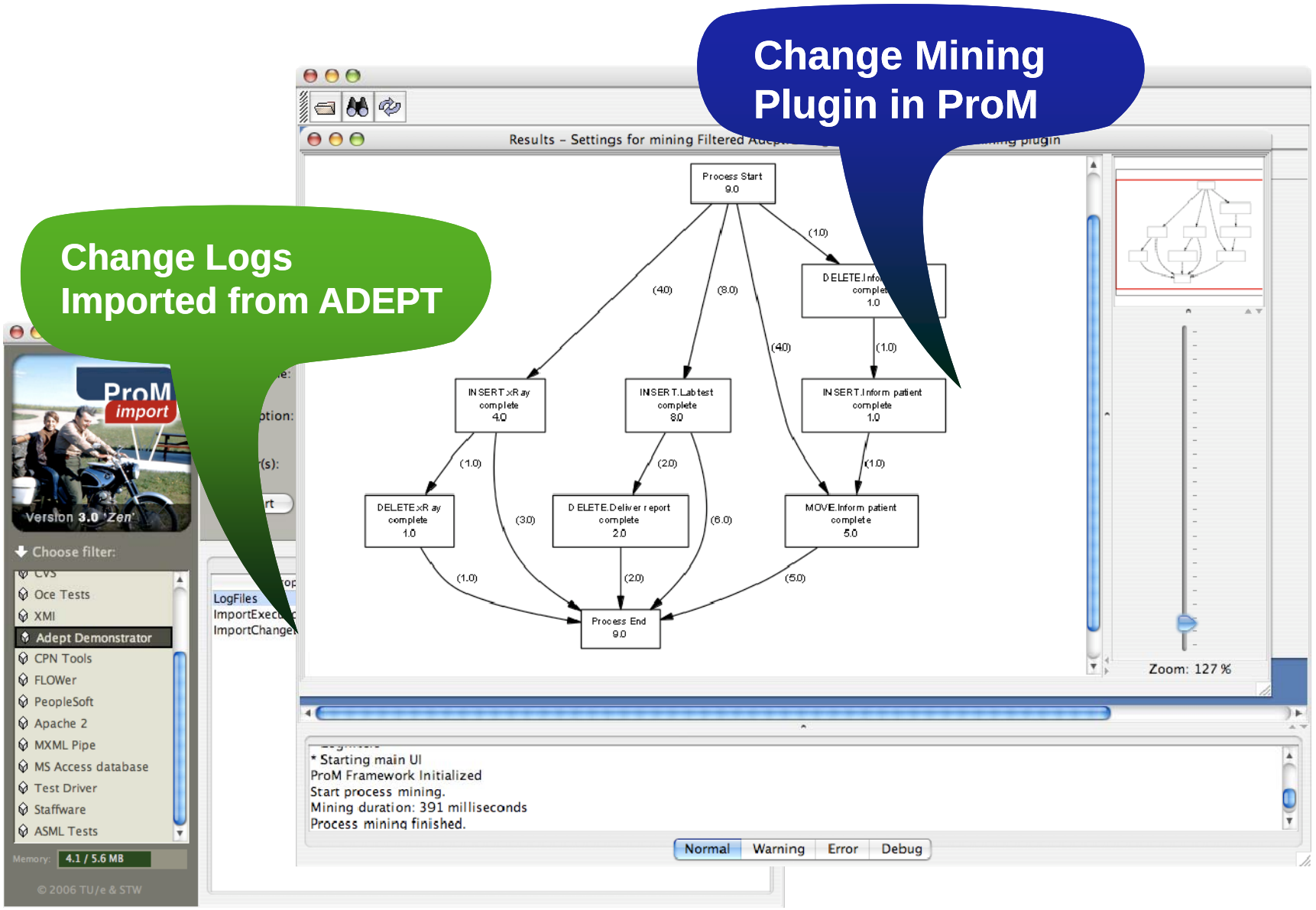


The discovered meta change process covers all changes applied to at least one of the given fluid process instances.

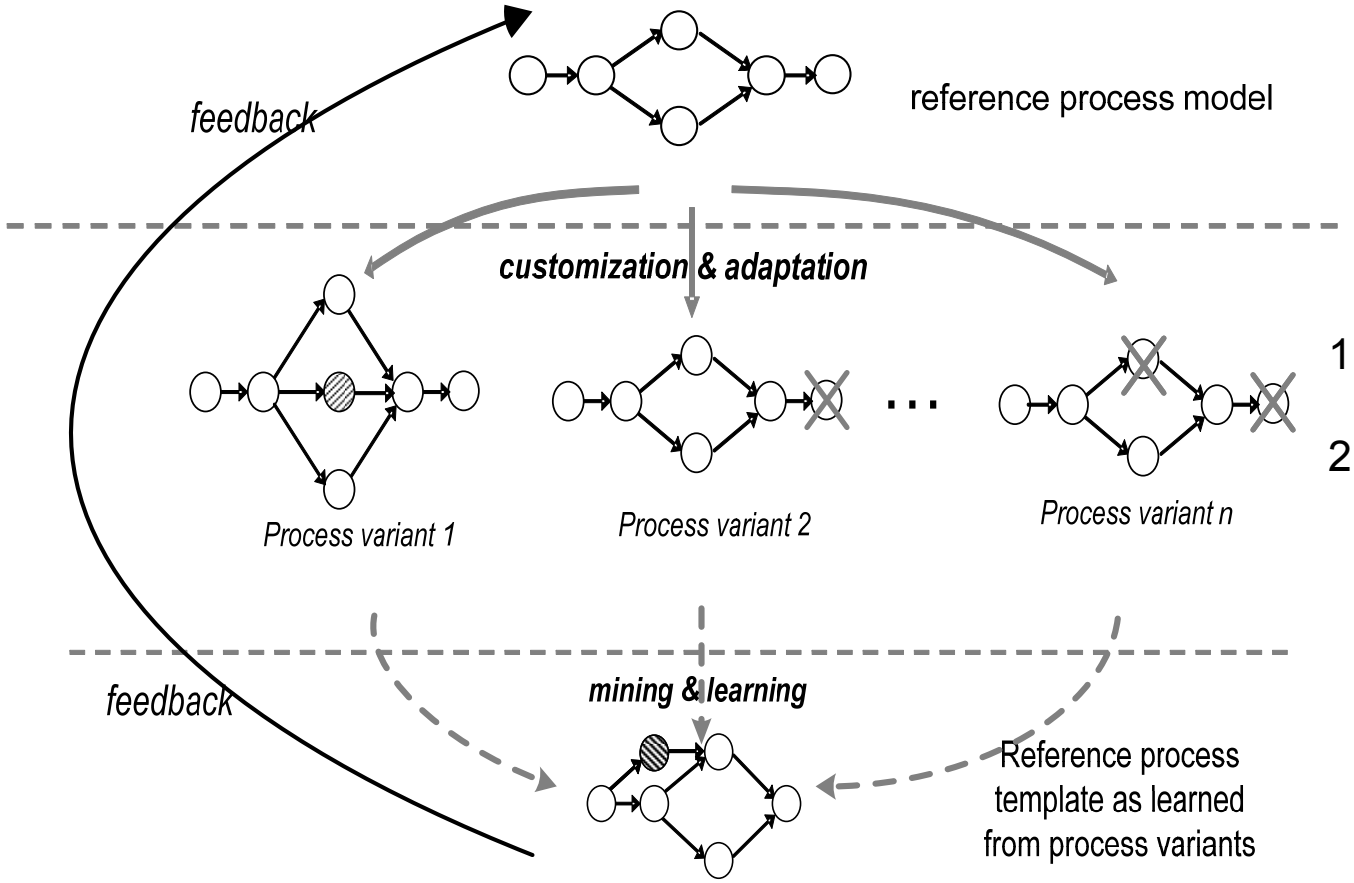
Günther, C.W.; Rinderle, S.; Reichert, M.; van der Aalst, W.M.P (2006): Change Mining in Adaptive Process Management Systems. *Proc. CoopIS'06,* LNCS 4275.

Günther, C.W.; Rinderle, S.; Reichert, M.; van der Aalst, W.M.P.; Recker, J. (2008): Using Process Mining to Learn from Process Changes in Evolutionary Systems. *Int'l J of Business Process Integration and Management*, 3(1):61-78

Change Analysis – A Simple Approach (Proof-of-Concept Prototype)



A More Advanced Approach: Process Variants Mining



1. Configurations are very costly
2. Variants are difficult to maintain

Derive a new reference process model from the the variants such that:
Less adaptations are needed in future!

Li, C.; Reichert, M.; Wombacher, A. (2008): Mining Based on Learning from Process Change Logs. *Proc. 4th Int'l Workshop on Business Process Intelligence*, Milan, LNBIP 17

Process Variants Mining: Basic Goal

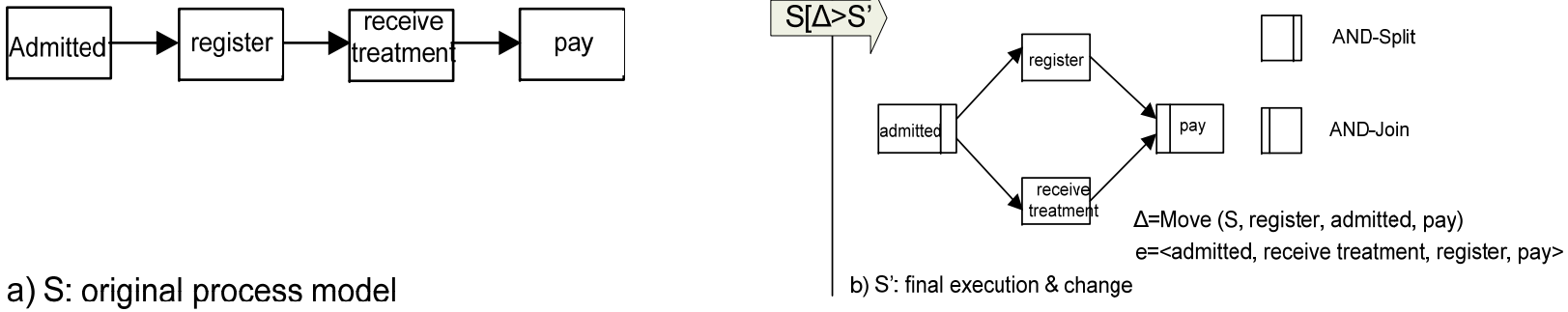
How to **discover a reference process model**

by mining a collection of **process (instance) variants**

in order to

reduce the need of future process adaptations?

Process Variants Mining: Bias and Distance



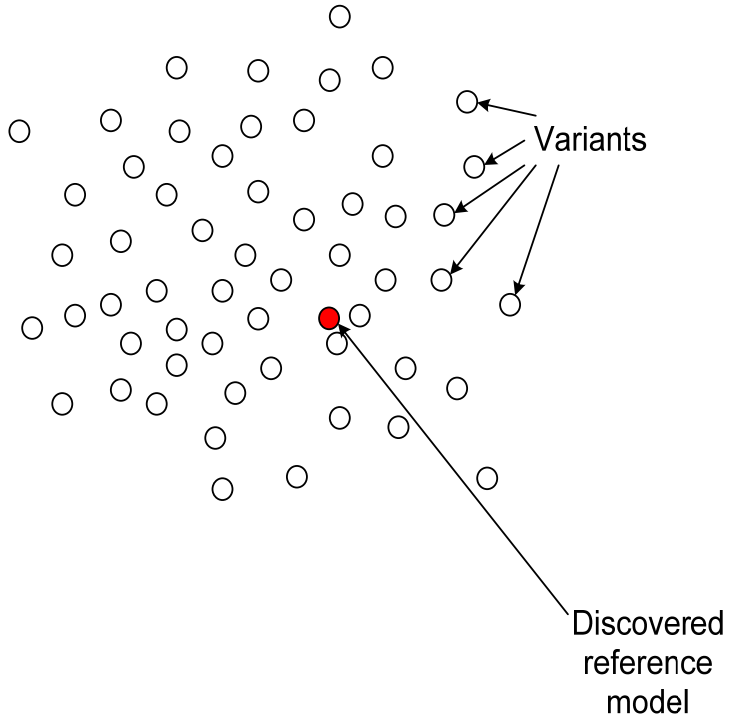
- Process Bias: Minimal set of high-level change operations needed to transform a given process model S into another model S'
- Process Distance: # change operations of any bias between S and S'; can be used to measure the complexity for process change

Li, C.; Reichert, M.; Wombacher, A. (2008) On Measuring Process Model Similarity based on High-level Change Operations. Proc. ER'08, Barcelona, LNCS 5231

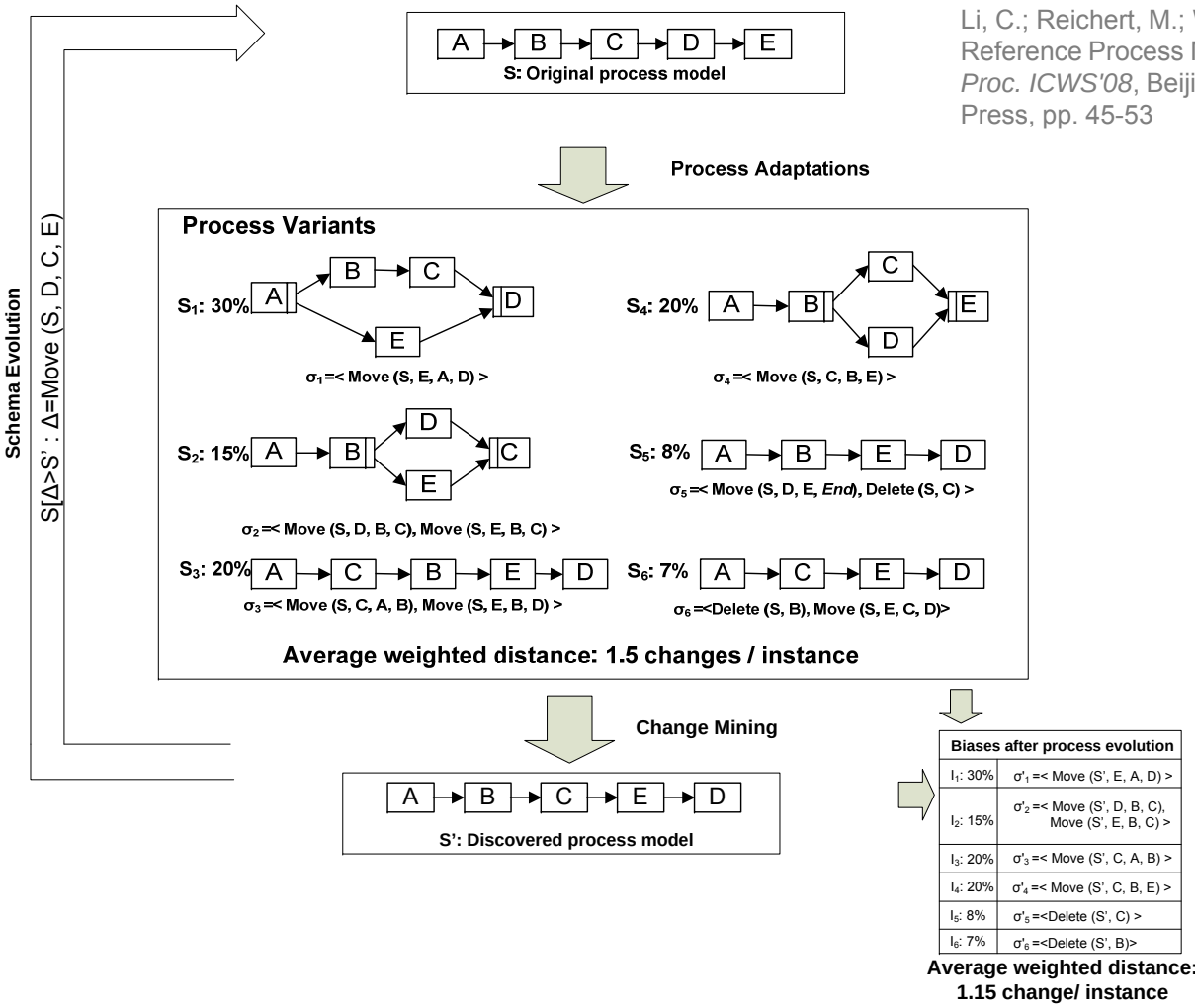
Process Variants Mining: Reformulated Basic Goal

How to **derive a reference process model** by mining the **a collection of process (instance) variants** which has **minimal average distance to the process variants?**

When representing a process (instance) variant as a "dot" in a 2- dimensional space, discovering a reference model logically corresponds to finding the "center" (for which the average distance is minimal to all "dots").



Process Variants Mining: Clustering Algorithm (1)



Li, C.; Reichert, M.; Wombacher, A. (2008) Discovering Reference Process Models by Mining Process Variants. *Proc. ICWS'08*, Beijing, China. IEEE Computer Society Press, pp. 45-53

Example: Clinical Pathways

Medical Guideline (narrative)

Formalization ①

Formalized medical guideline G

Dissemination ②

Disseminated medical guideline G

Feedback ⑩

domain-specific

Change pathway schema ⑧

Process Engineer

Medical pathway schema P'

Medical pathway schema P

Site-specific Adaptation ③

Process instantiation ④

Create new pathway schema ⑨

site-specific

Medical Staff

Process execution

Actual treatment process for patient p1

Instance start ⑥

Individual treatment plan for patient p1

Process instances (with ad-hoc changes)

Process instance change ⑤

Notify process engineer ⑦

change logs

patient treatment-specific

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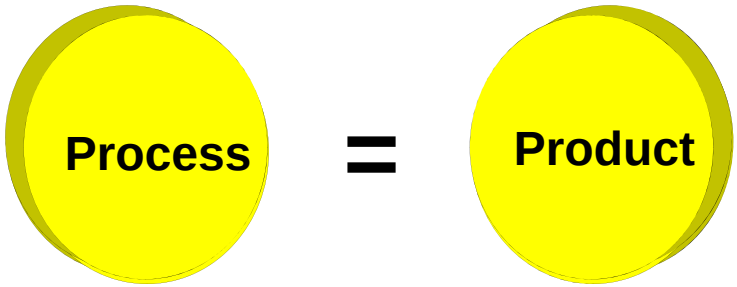
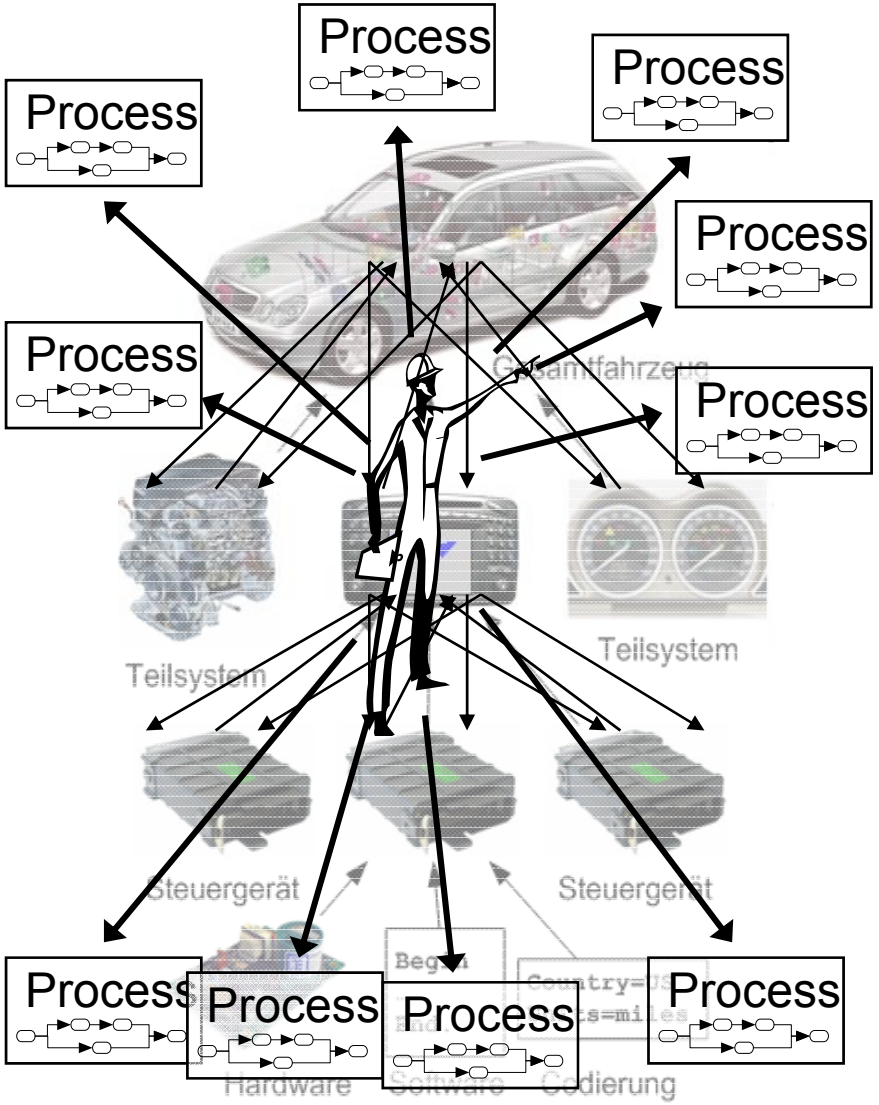
Enabling Data-driven Process Structures with COREPRO

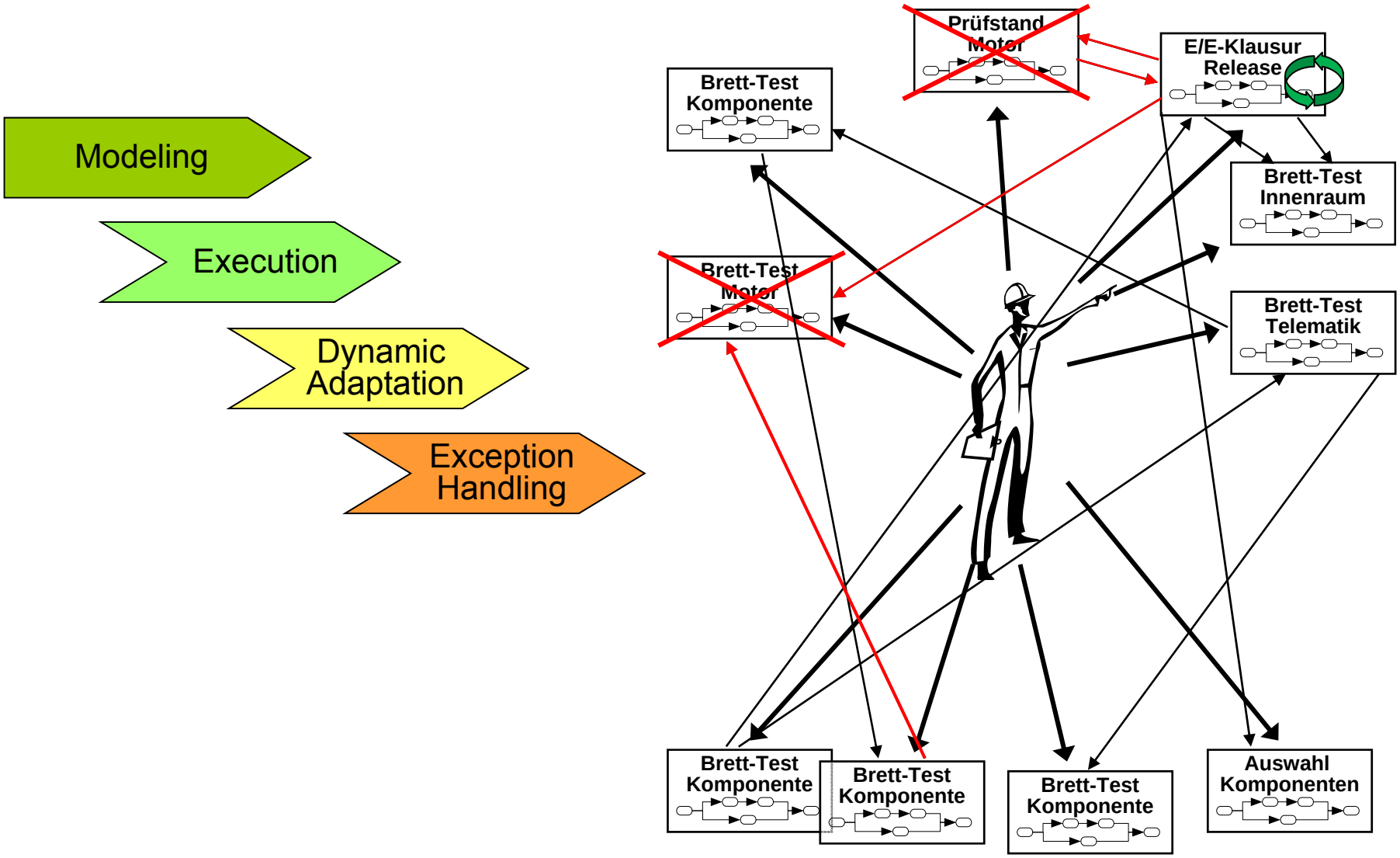
The COREPRO Approach: Motivation



Process structure needs to be adapted when product structure changes!



The COREPRO Approach: Motivation



The COREPRO Approach: Motivation

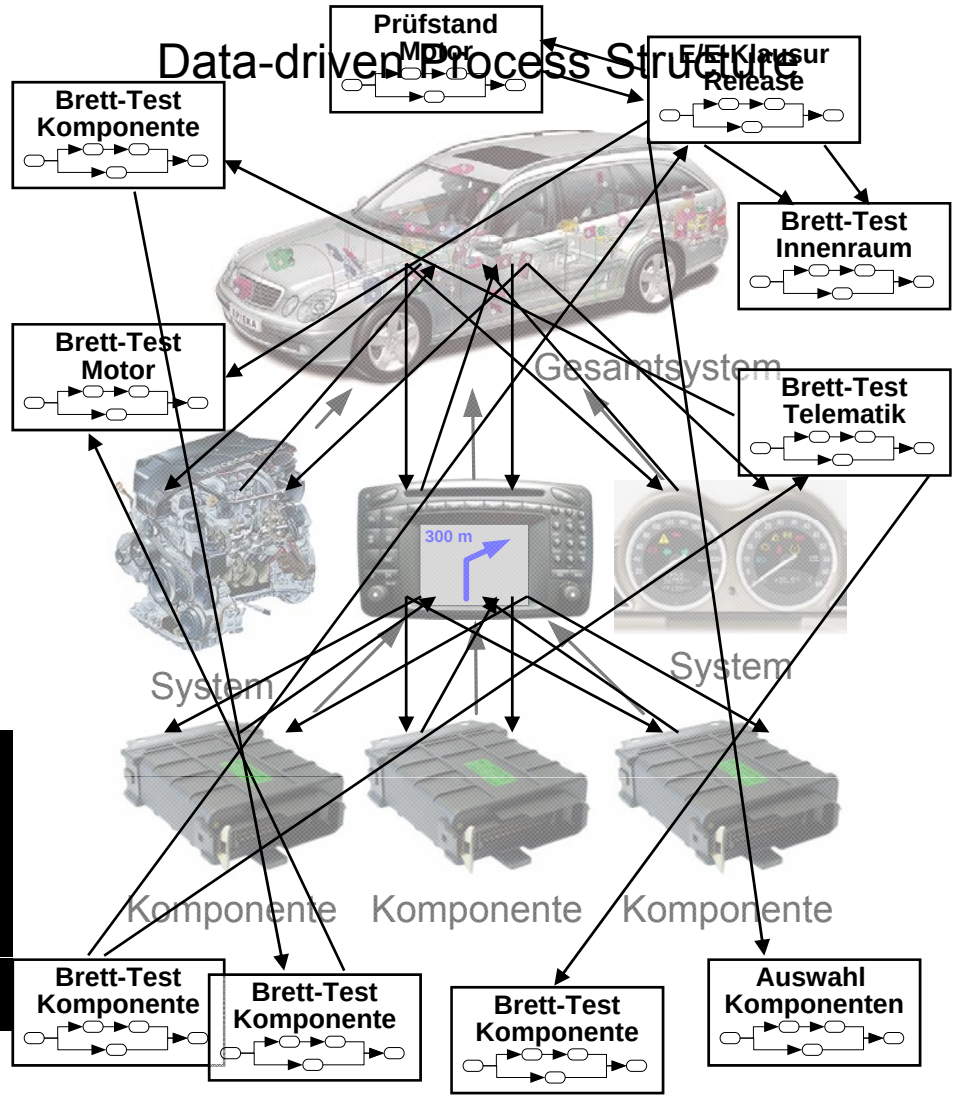
Modeling

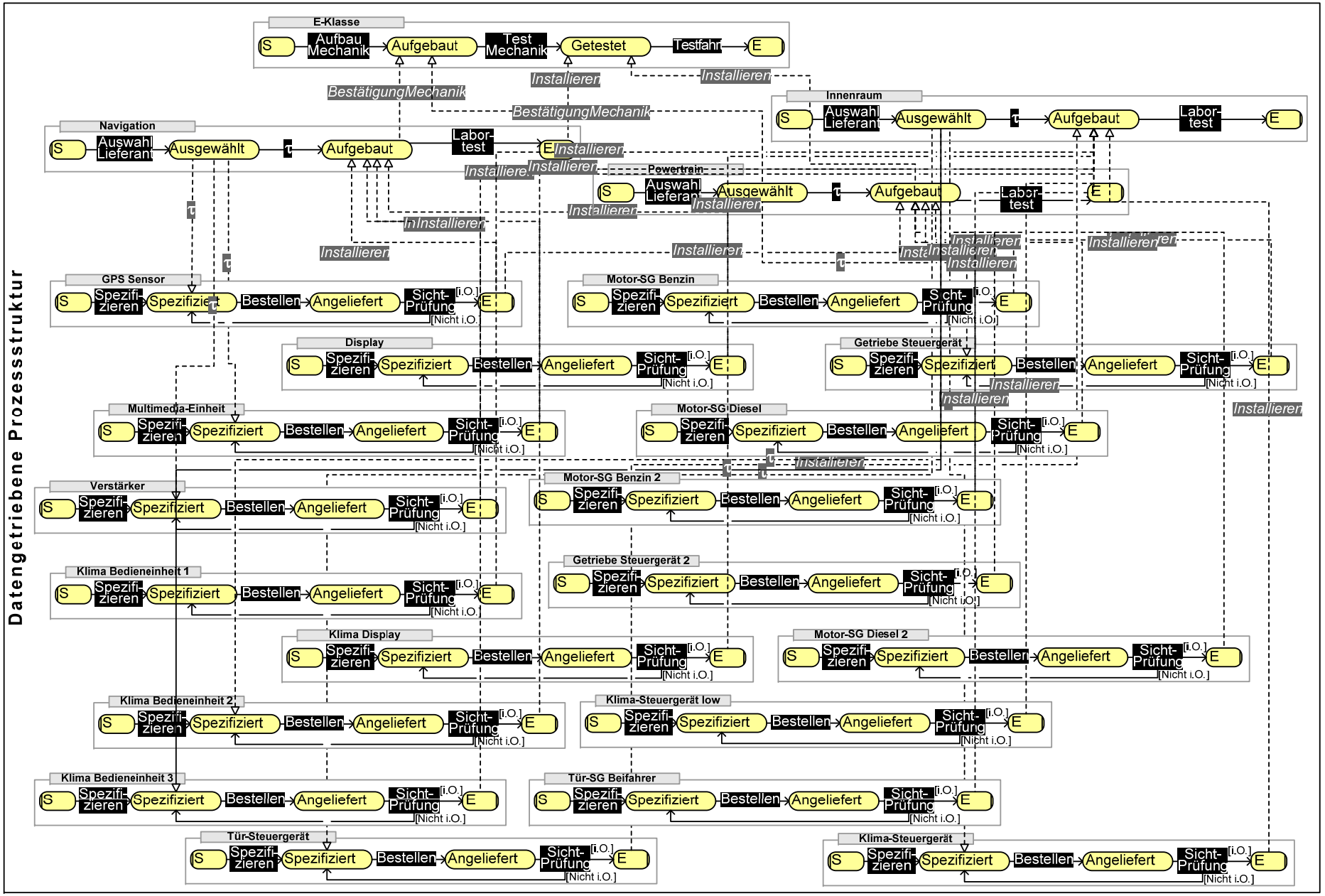
Execution

Dynamic Adaptation

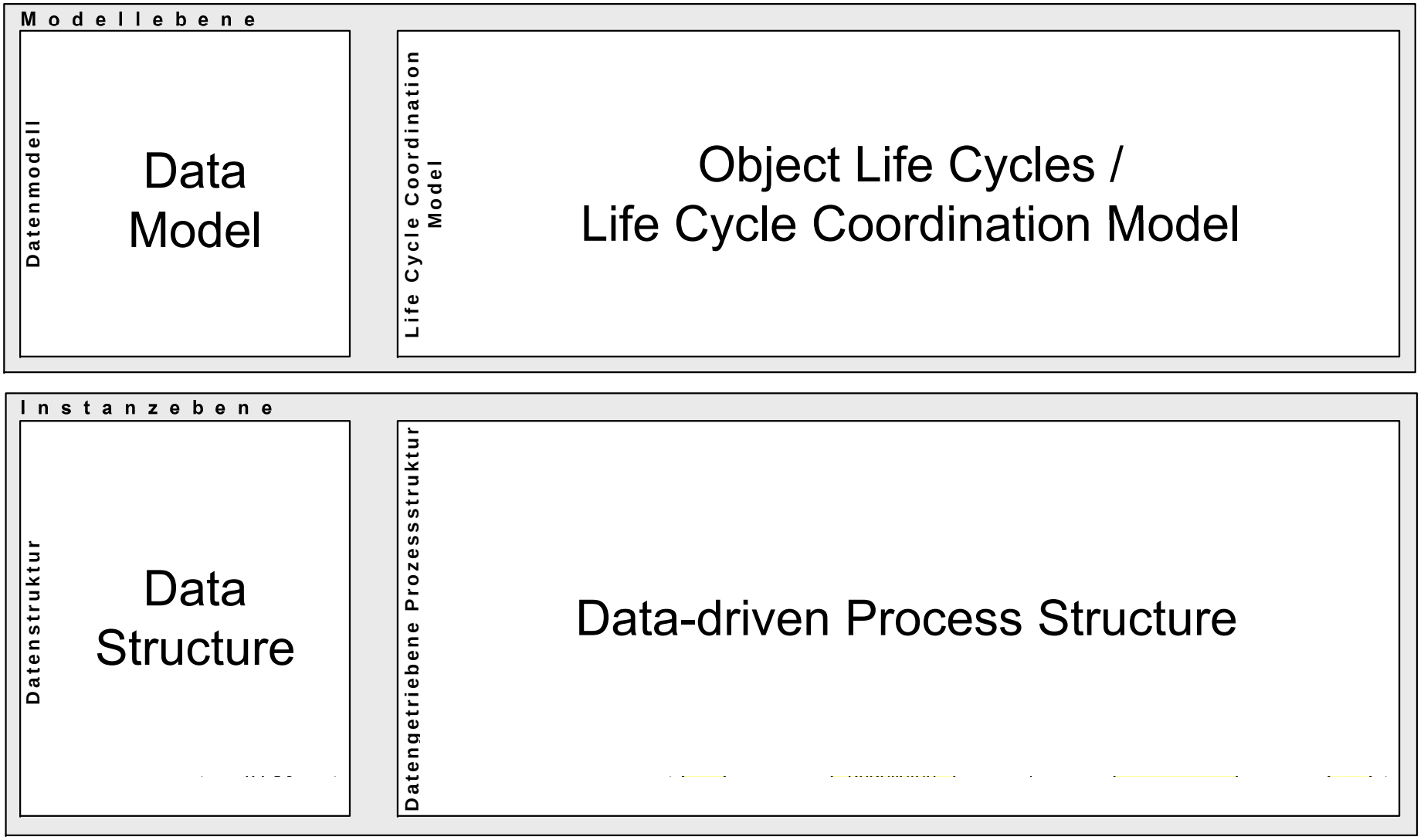
Exception Handlung

Corepro: Integrated Support of Data-driven Process Structures

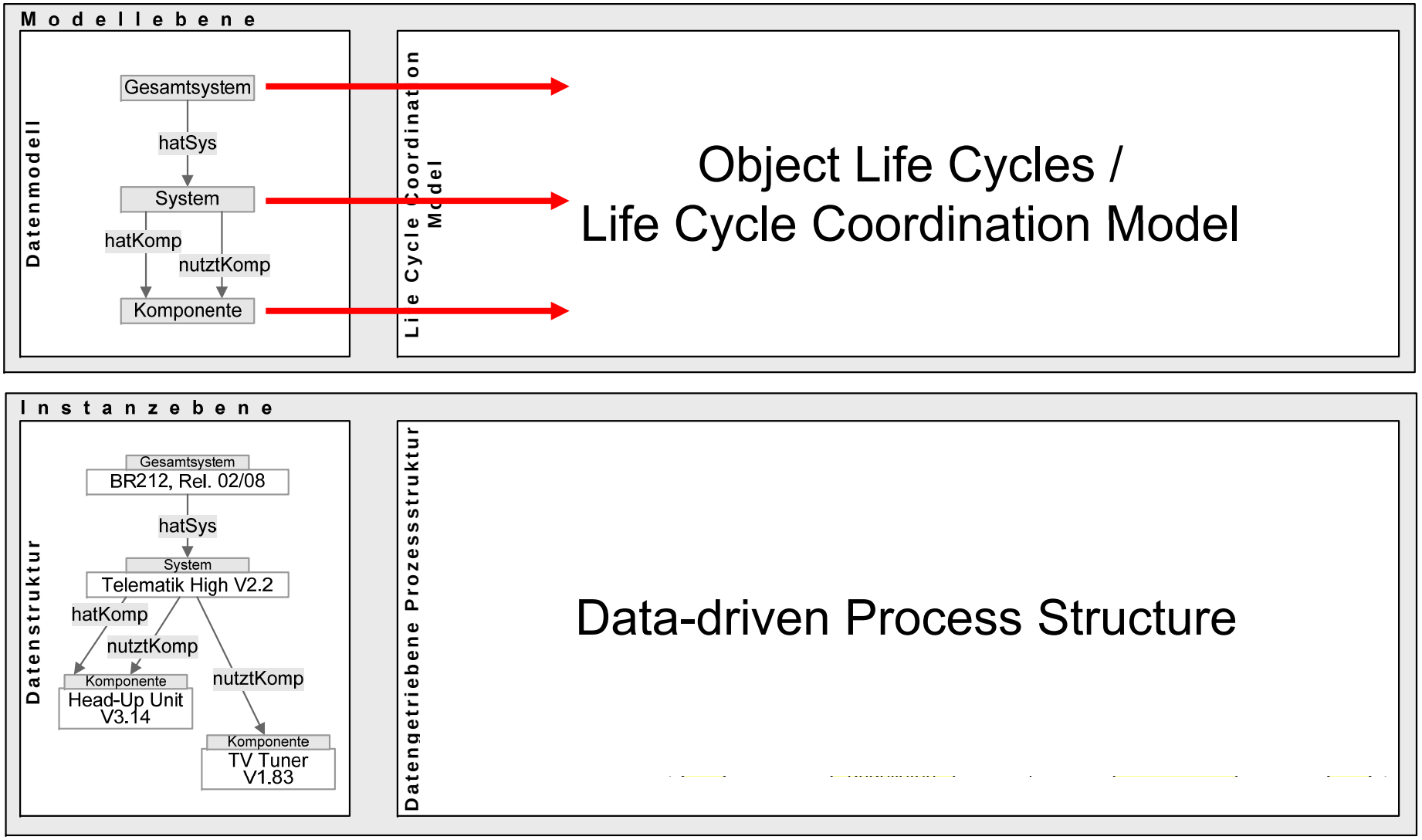



Datengetriebene Prozessstruktur
E-Klasse
S
Aufbau Mechanik
Aufgebaut
Test Mechanik
Getestet
Testfahrt
E
BestätigungMechanik
Installieren
Navigation
Auswahl Lieferant
Ausgewählt
Aufgebaut
Labor-test
Innenraum
Powertrain
GPS Sensor
Spezifi-zieren
Spezifiziert
Bestellen
Angeliefert
Sicht-Prüfung
[i.O.]
[Nicht i.O.]
Motor-SG Benzin
Display
Getriebe Steuergerät
Multimedia-Einheit
Motor-SG Diesel
Verstärker
Motor-SG Benzin 2
Klima Bedieneinheit 1
Getriebe Steuergerät 2
Klima Display
Motor-SG Diesel 2
Klima Bedieneinheit 2
Klima-Steuergerät low
Klima Bedieneinheit 3
Tür-SG Beifahrer
Tür-Steuergerät
Klima-Steuergerät

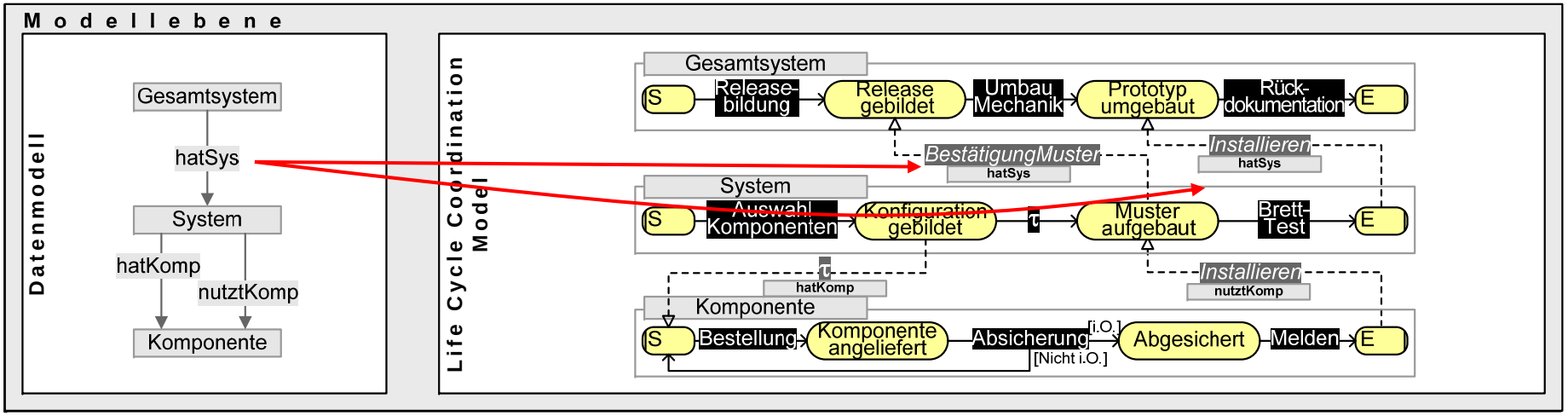
The COREPRO Approach: Data-driven Process Structures

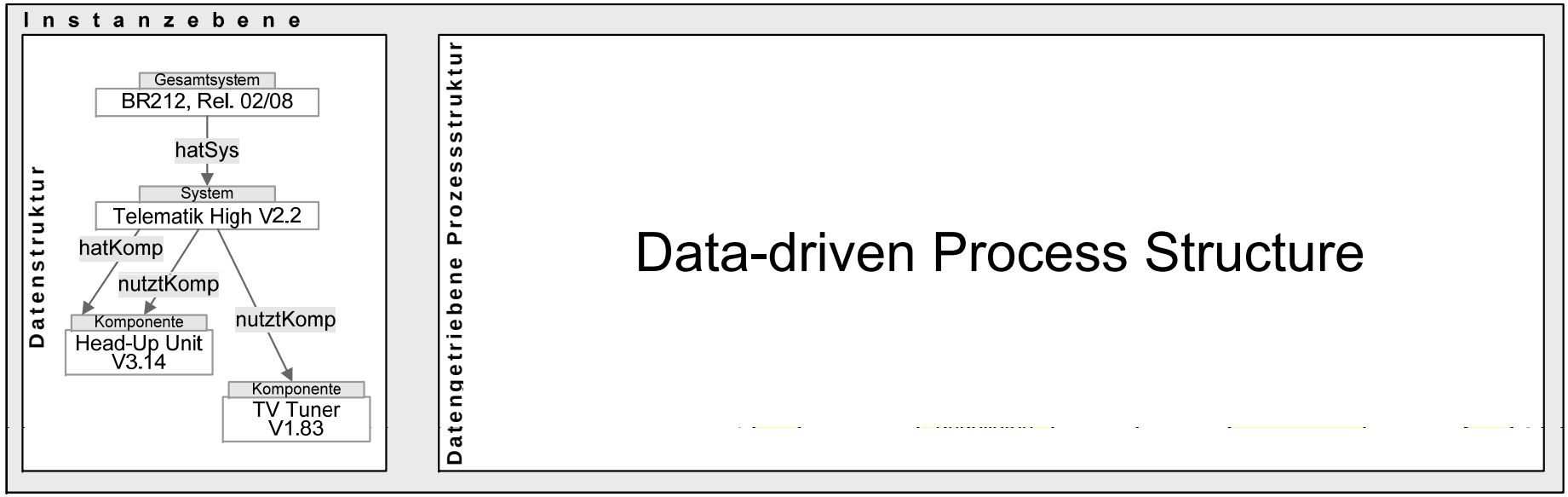


The COREPRO Approach: Data-driven Process Structures

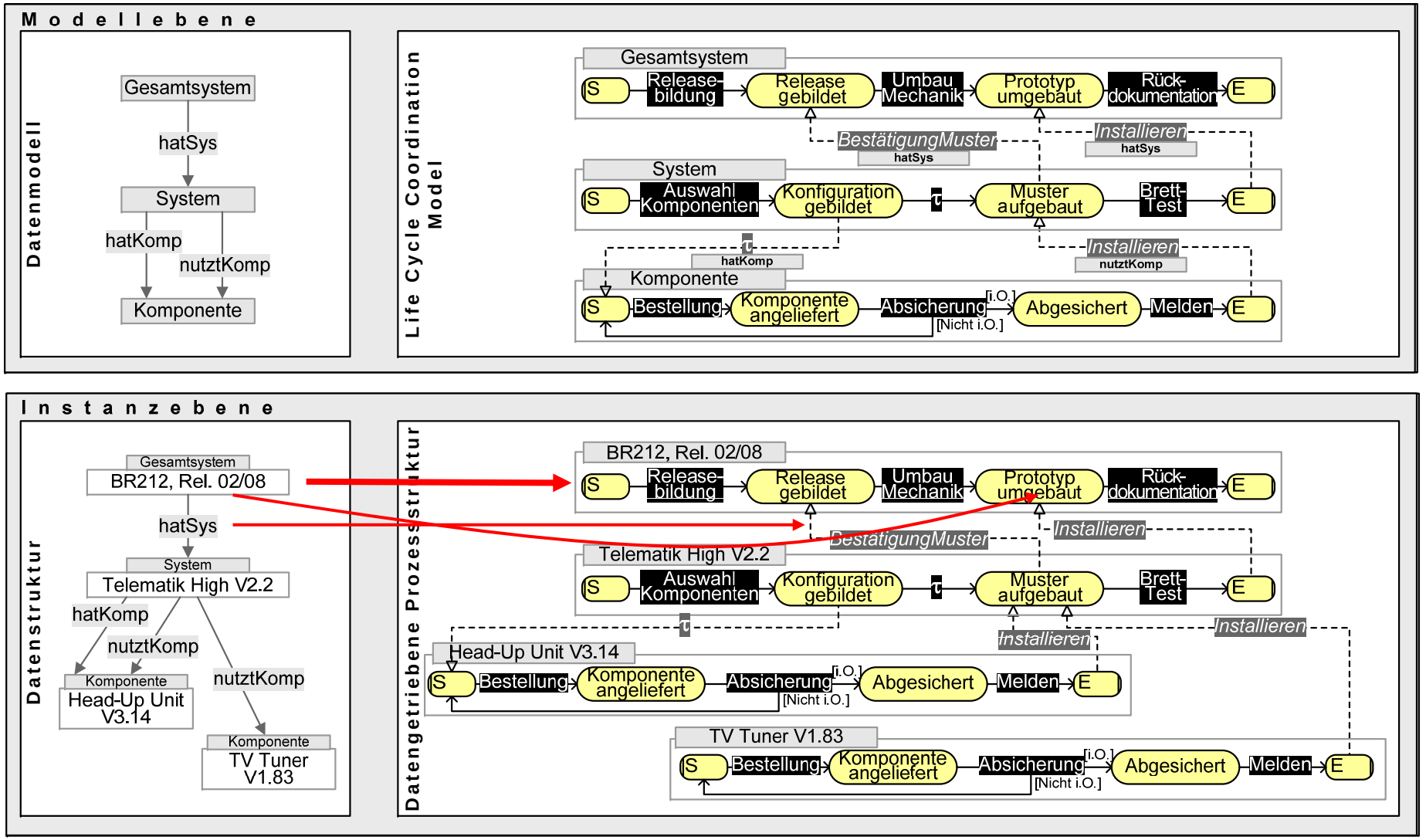


The COREPRO Approach: Data-driven Process Structures





The COREPRO Approach: Data-driven Process Structures



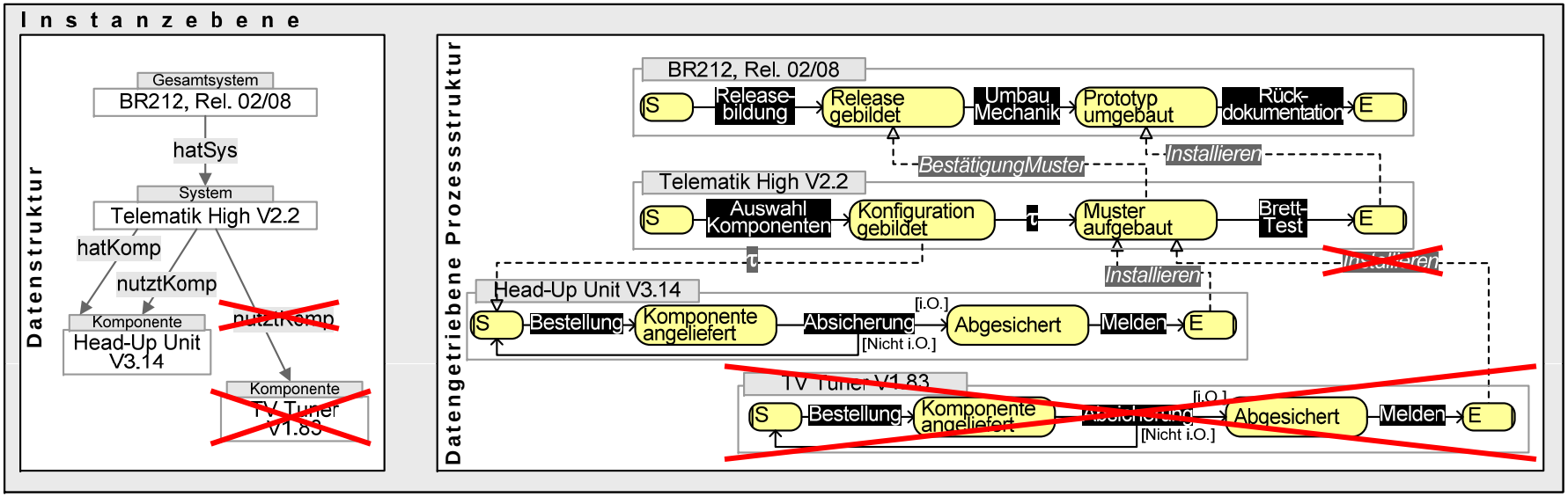
The COREPRO Approach: Data-driven Process Adaptations

Change Operation (Data Structure)

```
1) removeRelation(Telematik High
   V2.2, TV Tuner V1.83,
   nutztKomp);
2) removeObject(TV Tuner V1.83);
```

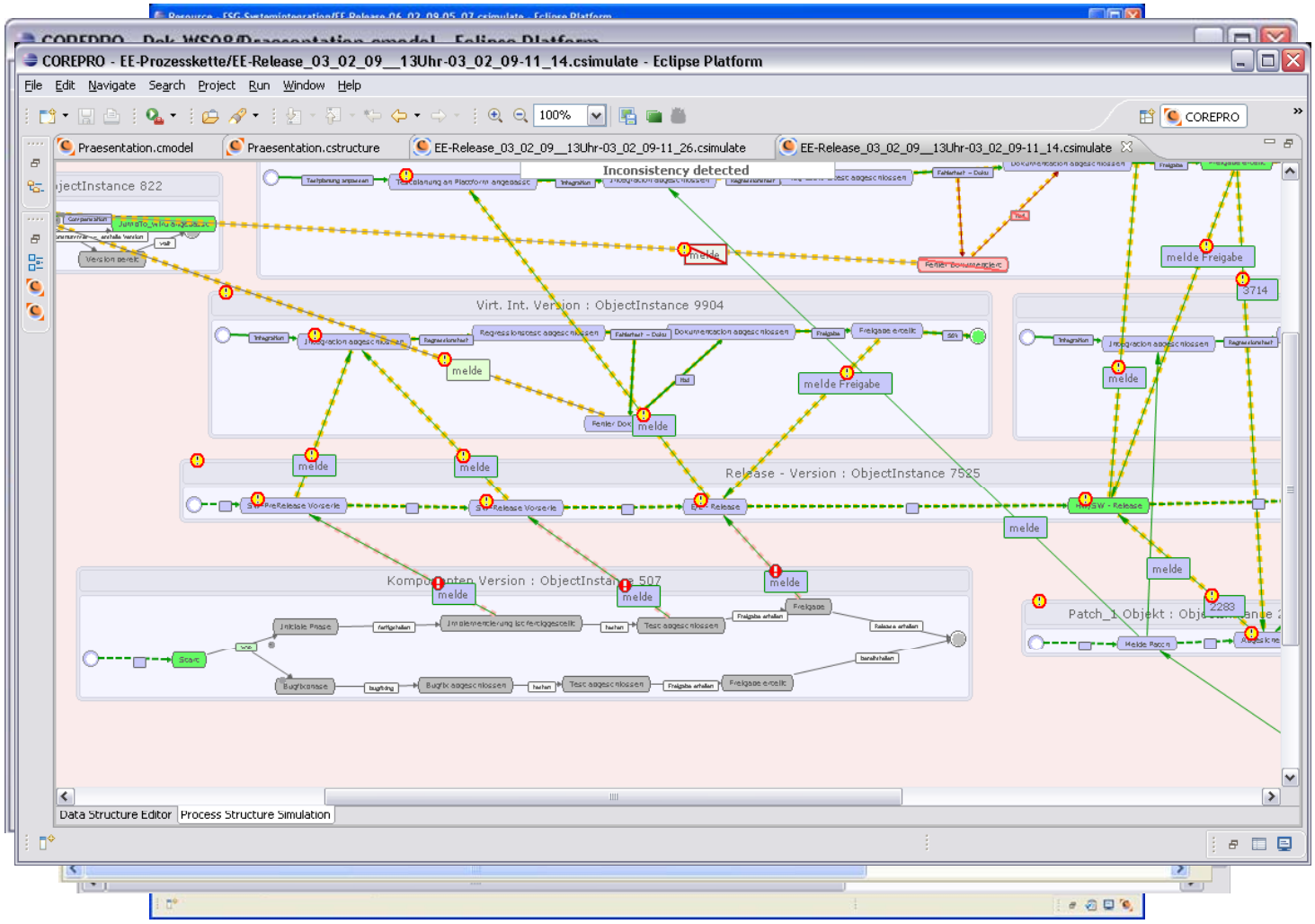
Change Operation (Process Structure)

```
1) removeExtTrans(Telematik High V2.2 .
   Muster Aufgebaut, Installieren, TV
   Tuner V1.83 . E);
2) removeOLC(Tuner V1.83);
```



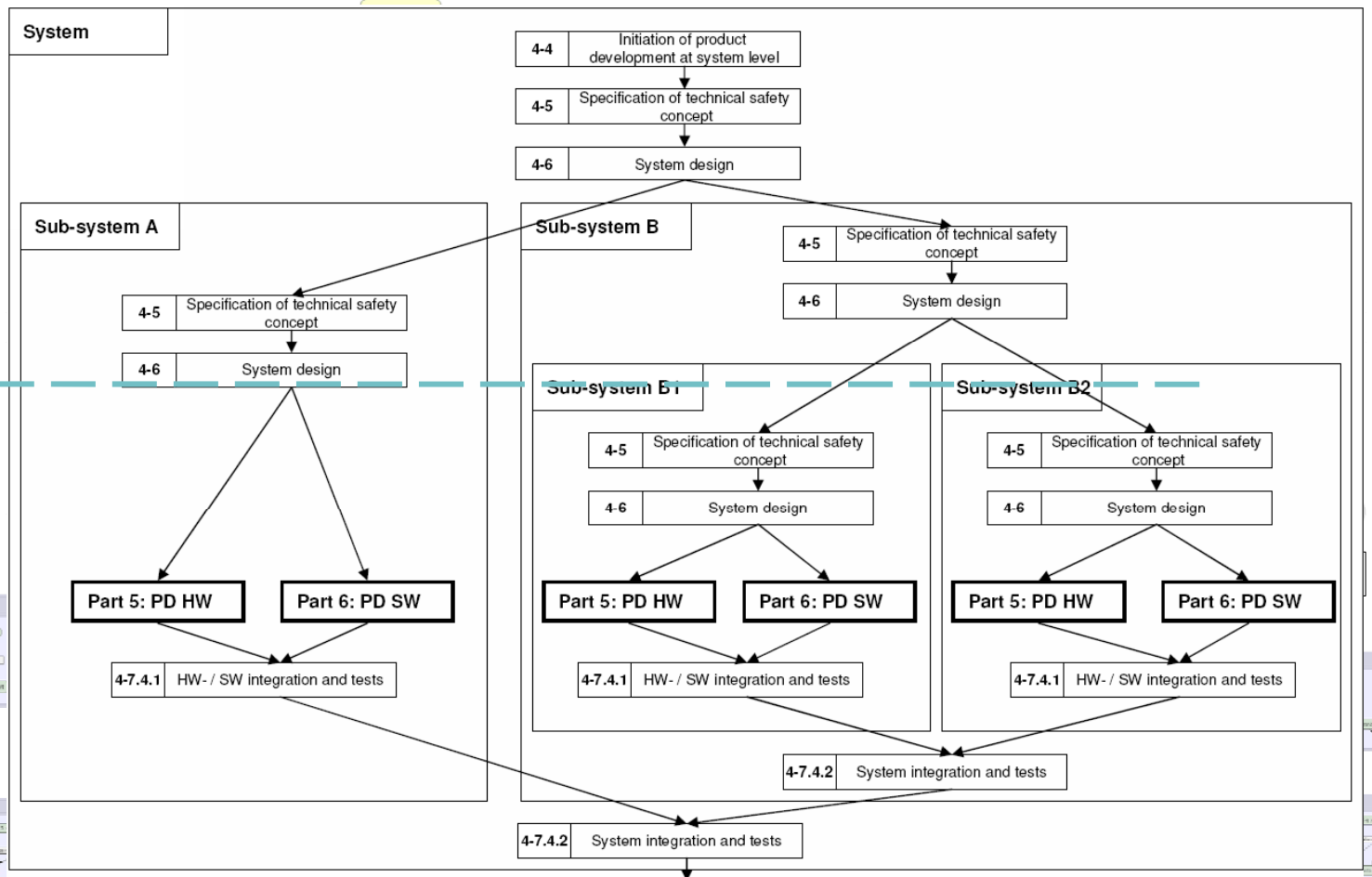
The COREPRO Approach: Proof-of-Concept Implemenation

- Auf Basis der Eclipse Plattform



Corepro: Case Study ISO 26262 (Road Vehicles – Functional Safety)

Instance Level: Data Flow Oriented Process Structure



PD = Product Development, HW = Hardware, SW = Software

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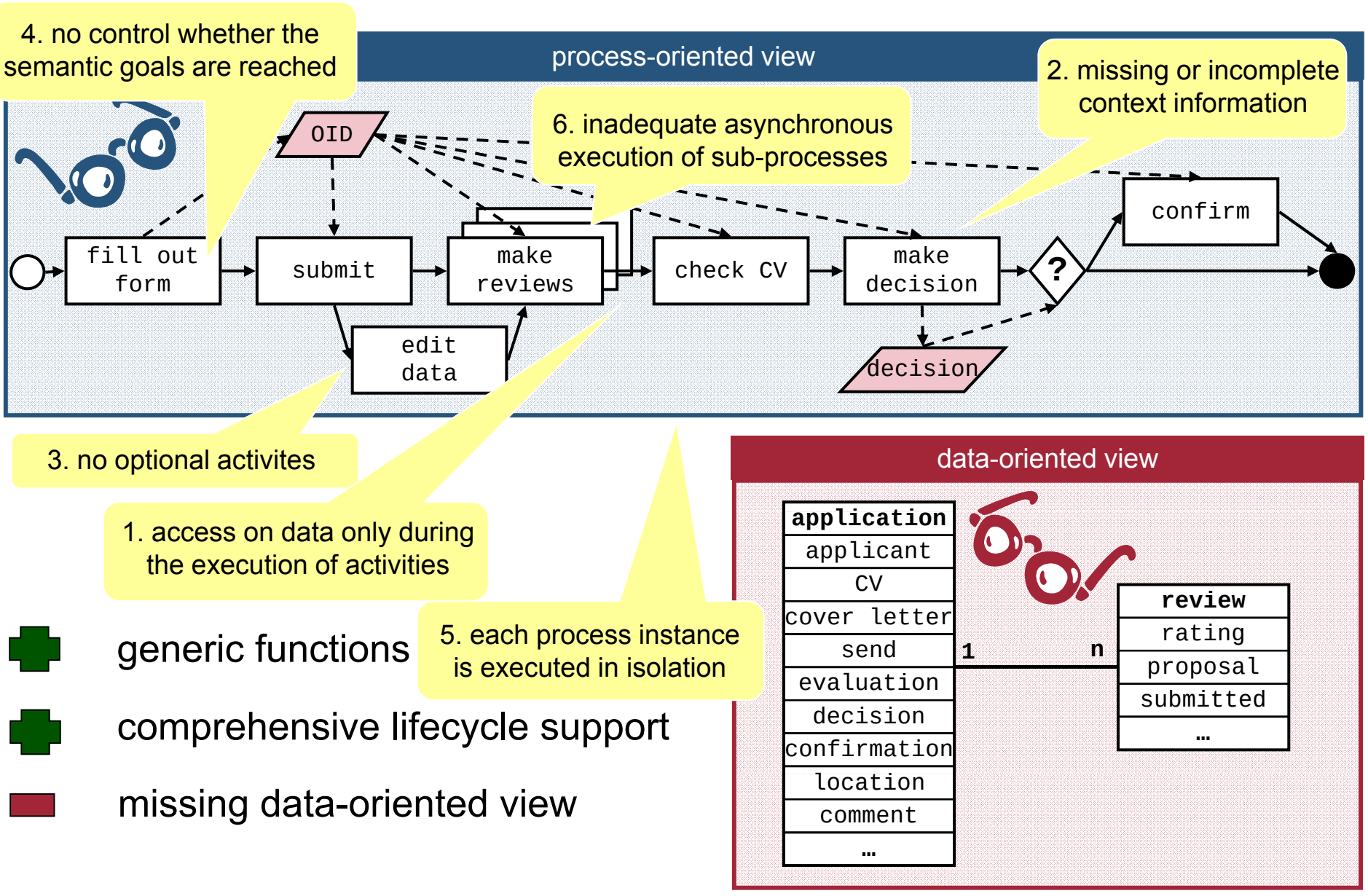
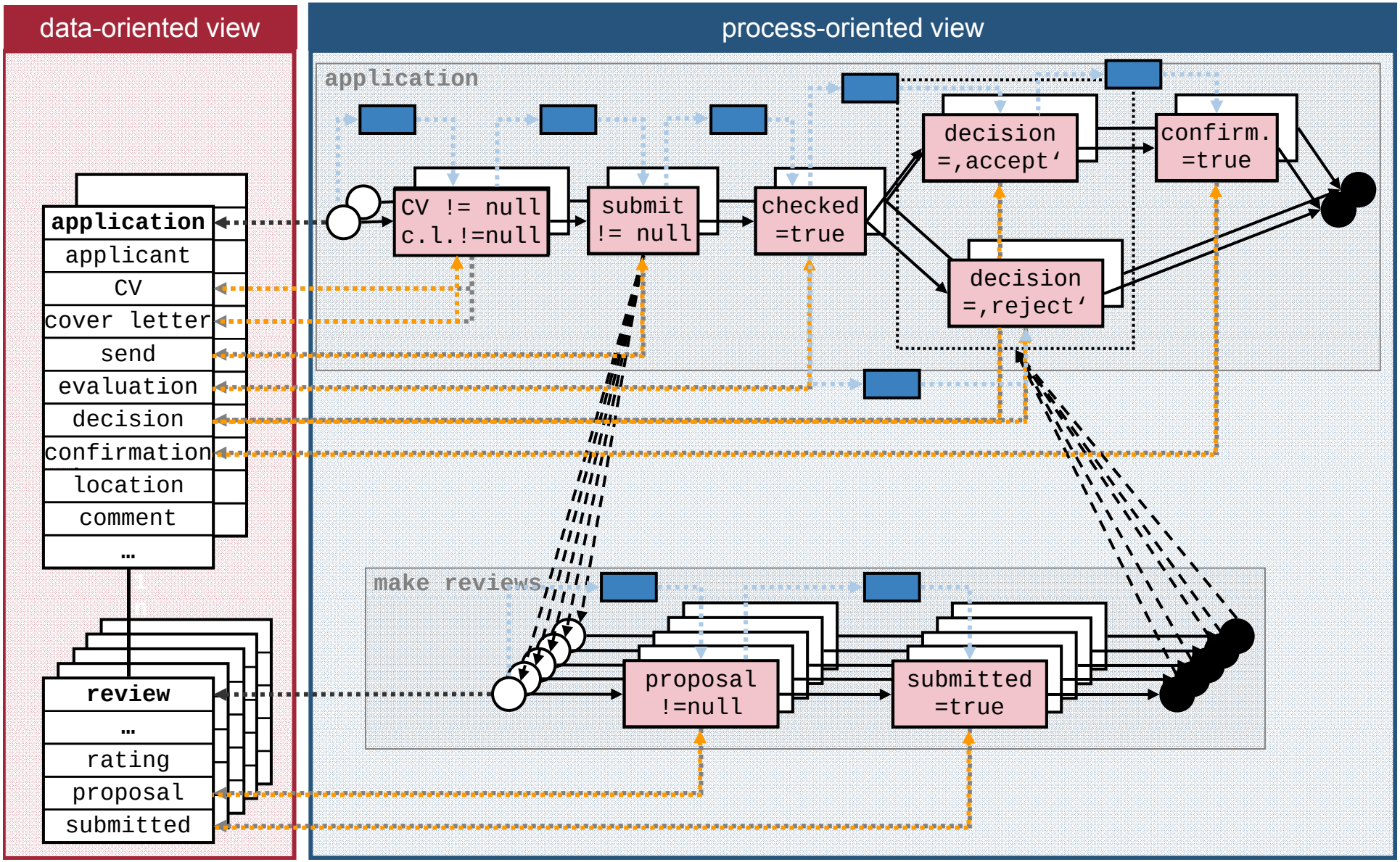
Object-aware Processes

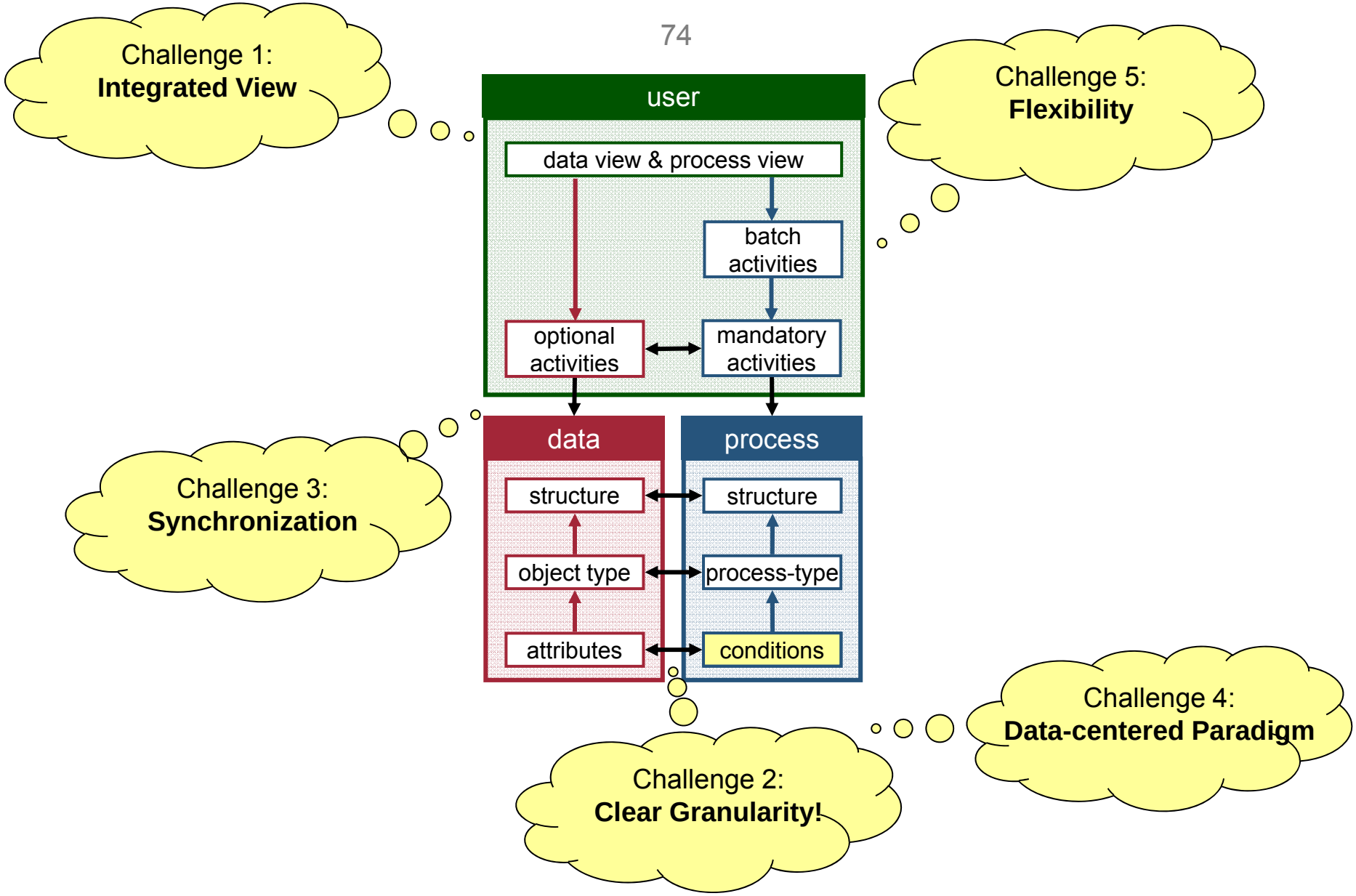
Data Handling in Existing WfMS



Philharmonic Flows: Object-aware Process Management



Philharmonic Flows: Object-aware Process Management



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Summary & Outlook

Summary & Outlook

business conditions vary with innovation pressure

business objectives vary with business conditions

business processes vary with business objectives

changing business processes will be a common business process in the future

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Summary & Outlook

Flexibility Support in most existing PAIS is like Teenager Sex!!

It's on everyone's mind all the time.
Everyone's talking about it all the time
Everyone's thinks everyone is doing it.
Almost no one is really doing it.
The few who are doing it:
Do it poorly
Think "sure it will be better the next time".
Are not practicing it safely

Everyone is bragging about their successes all the time, although very few have actually had any success

Anonymous