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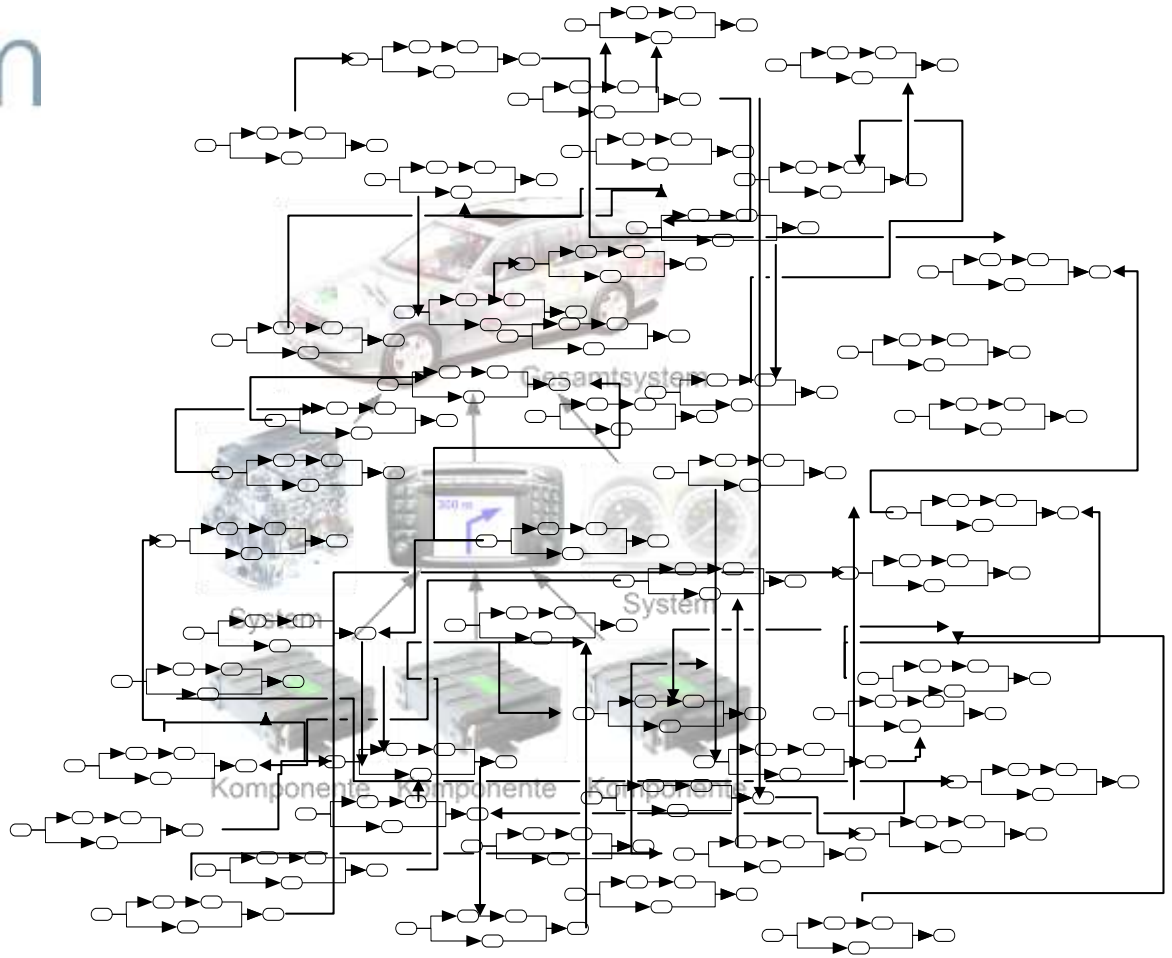
ARISTAFLOW



Taking an Engineering Perspective on Process-Aware Information Systems

Manfred Reichert

www.uni-ulm.de/dbis

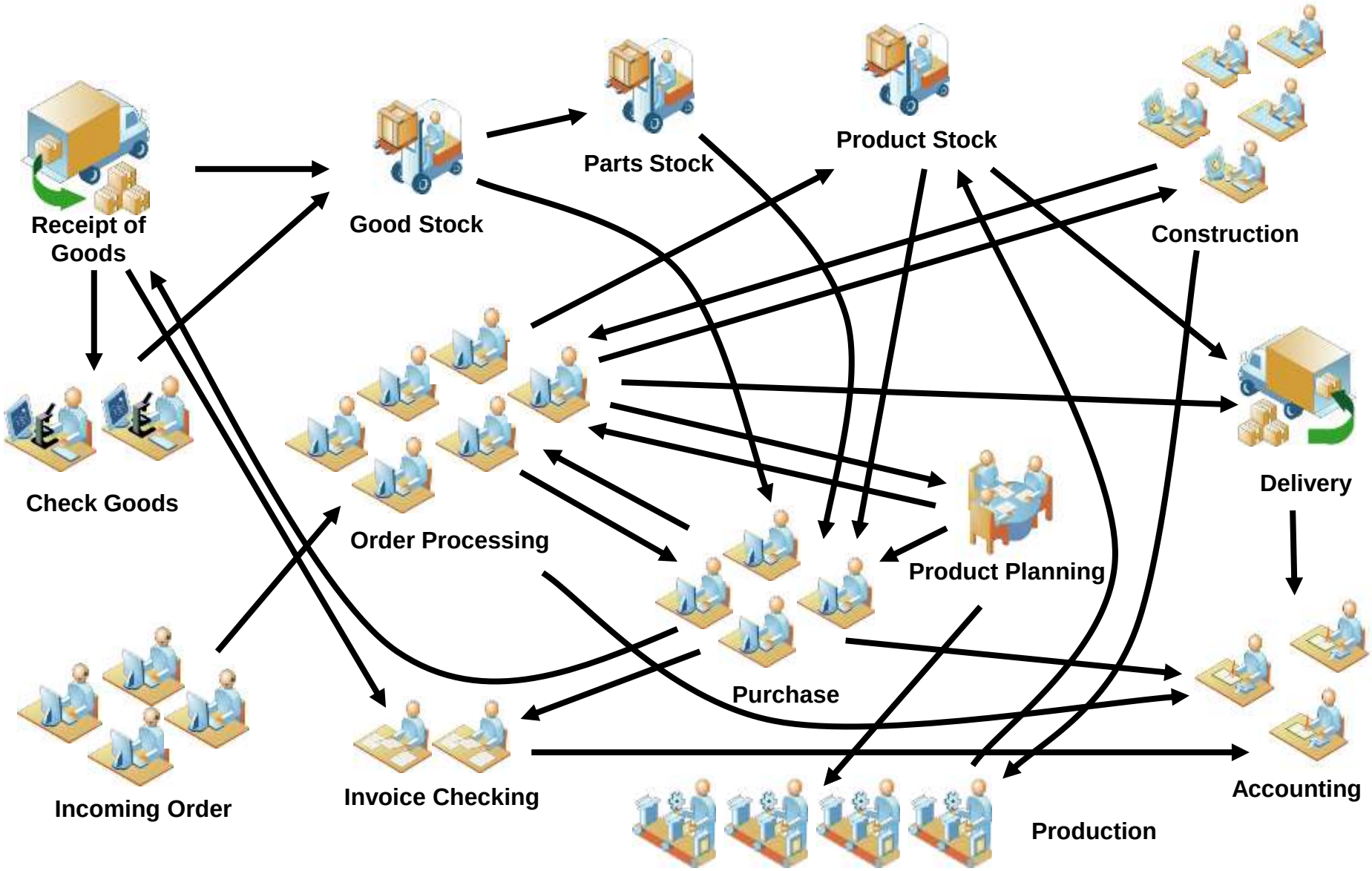
Process-Aware Information Systems

Business Process Management

Business Process Management (BPM) is a **discipline**
involving any combination of
modeling, **automation**, **execution**,
control, **measurement,** and **optimization**
of business activity flows,
in support of enterprise goals,
spanning IT systems, employees, customers and partners
within and beyond the enterprise boundaries.

Source: K. Swenson, BPM'14 Keynote

Process Environments (1)



Process Environments (2)

Registration

HIS

patient information

Orders Placed

examination orders

Orders Filled

RIS

report

Report Repository

report

report

Diagnostic Workstation

Film Lightbox

PACS

images retrieved

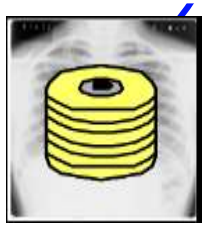


Image Manager & Archive

Film Folder

procedure scheduled

Prefetch any relevant prior studies

modality worklist

Acquisition Modality

images stored

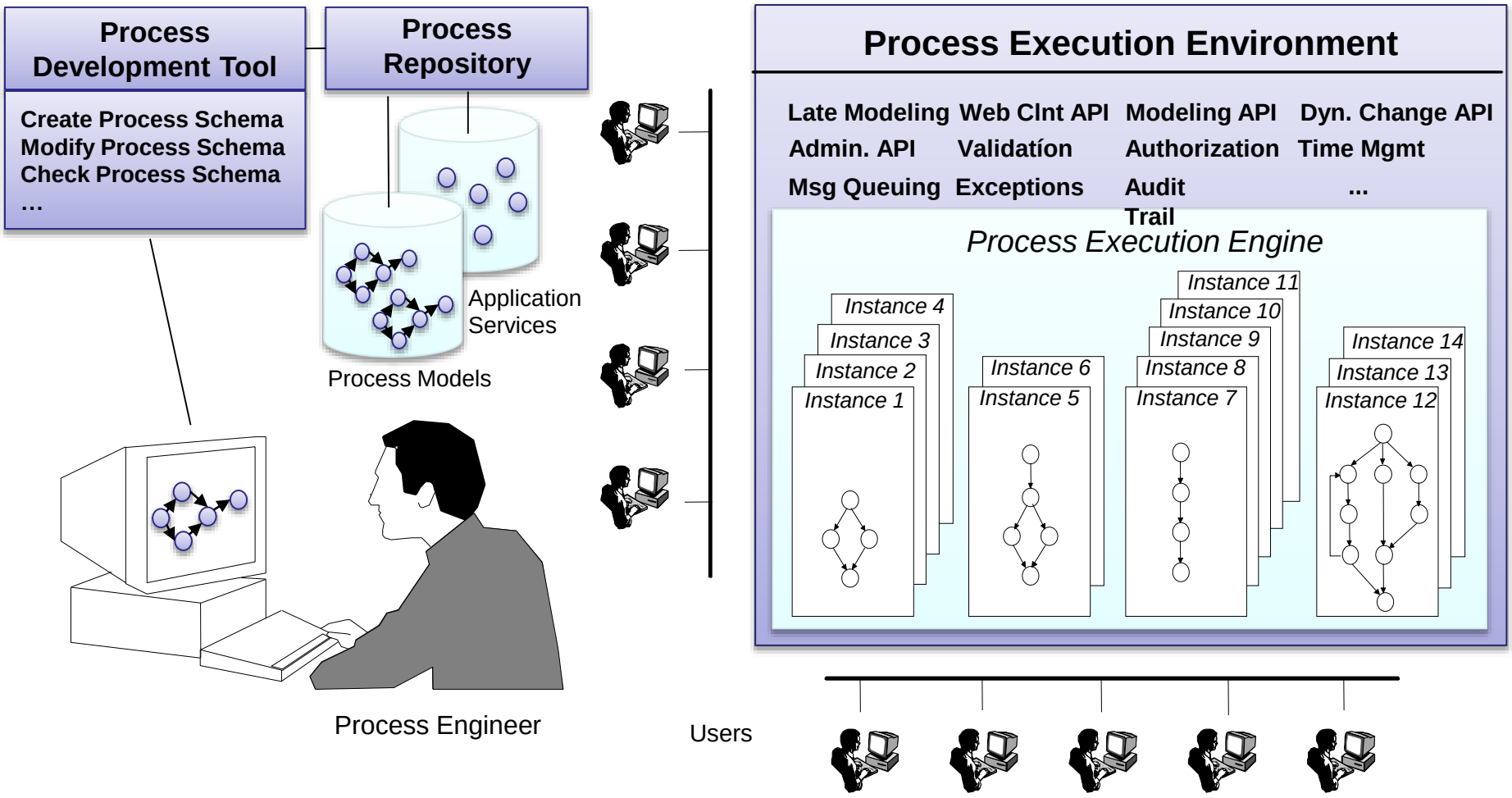
acquisition completed

acquisition completed

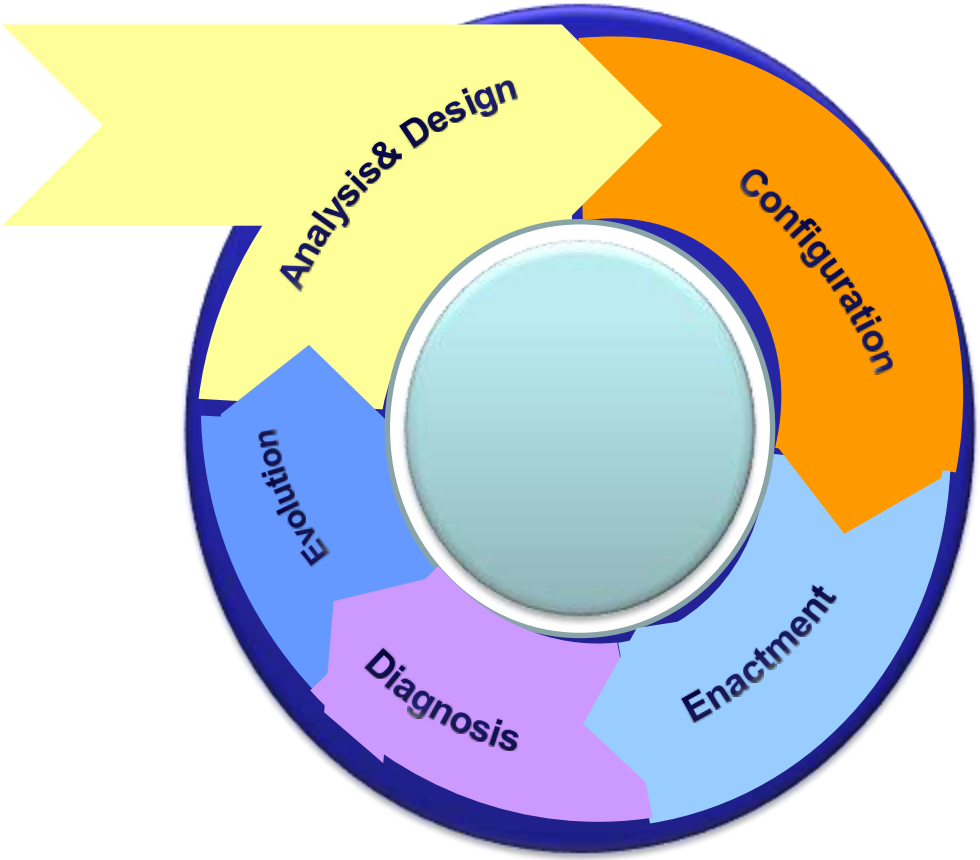
images printed

Film

Process-Aware Information System (PAIS)



Business Process Lifecycle



Potential and Actual Usage of PAIS

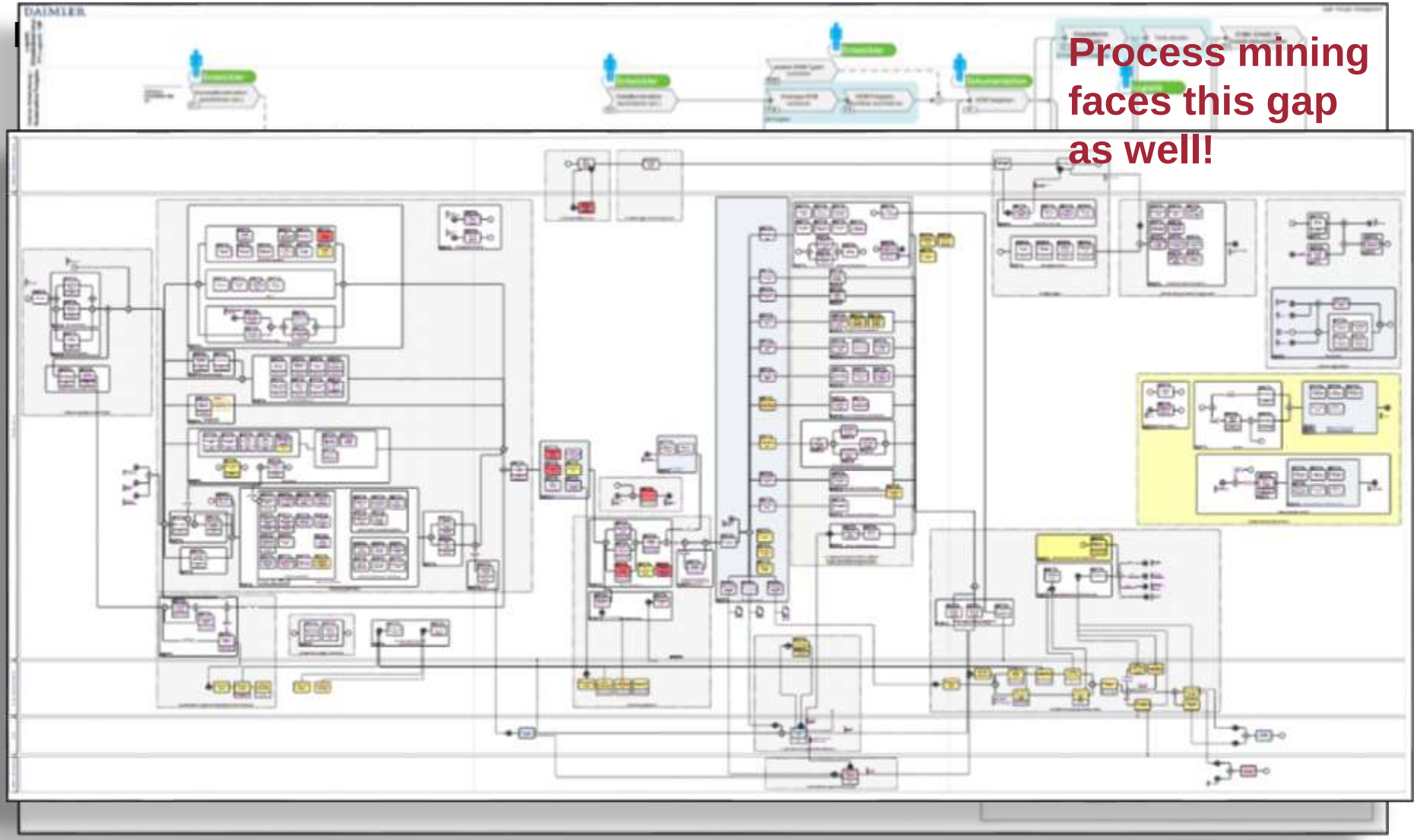
Huge discrepancy between the potential and the actual support of business processes by IT systems!

Why are PAIS not widely used in practice?

An incomplete reflection on major reasons hampering the widespread use of PAIS

Reason 1: The Business IT Alignment Gap

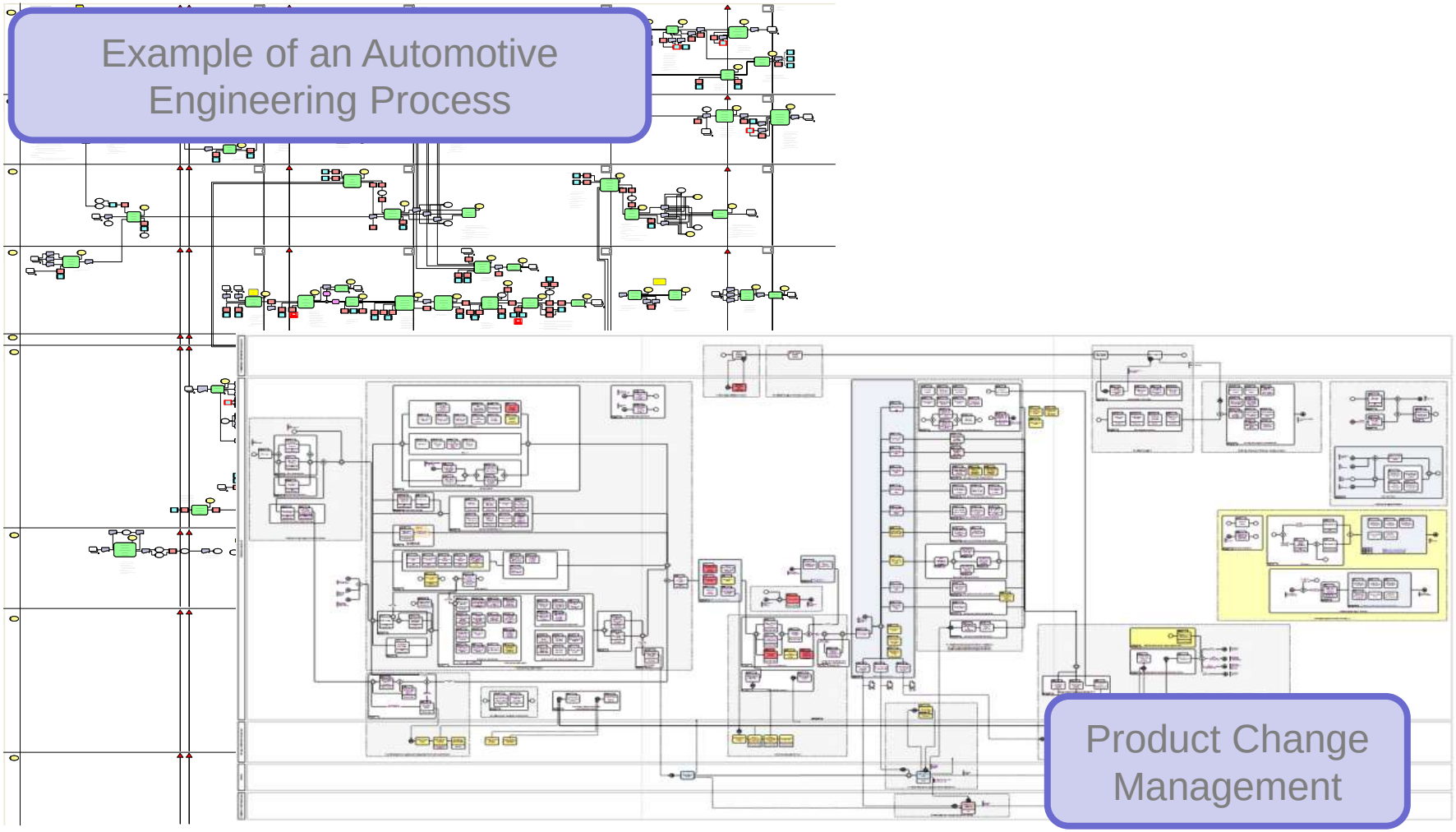
Reason 1: The Business IT Alignment Gap



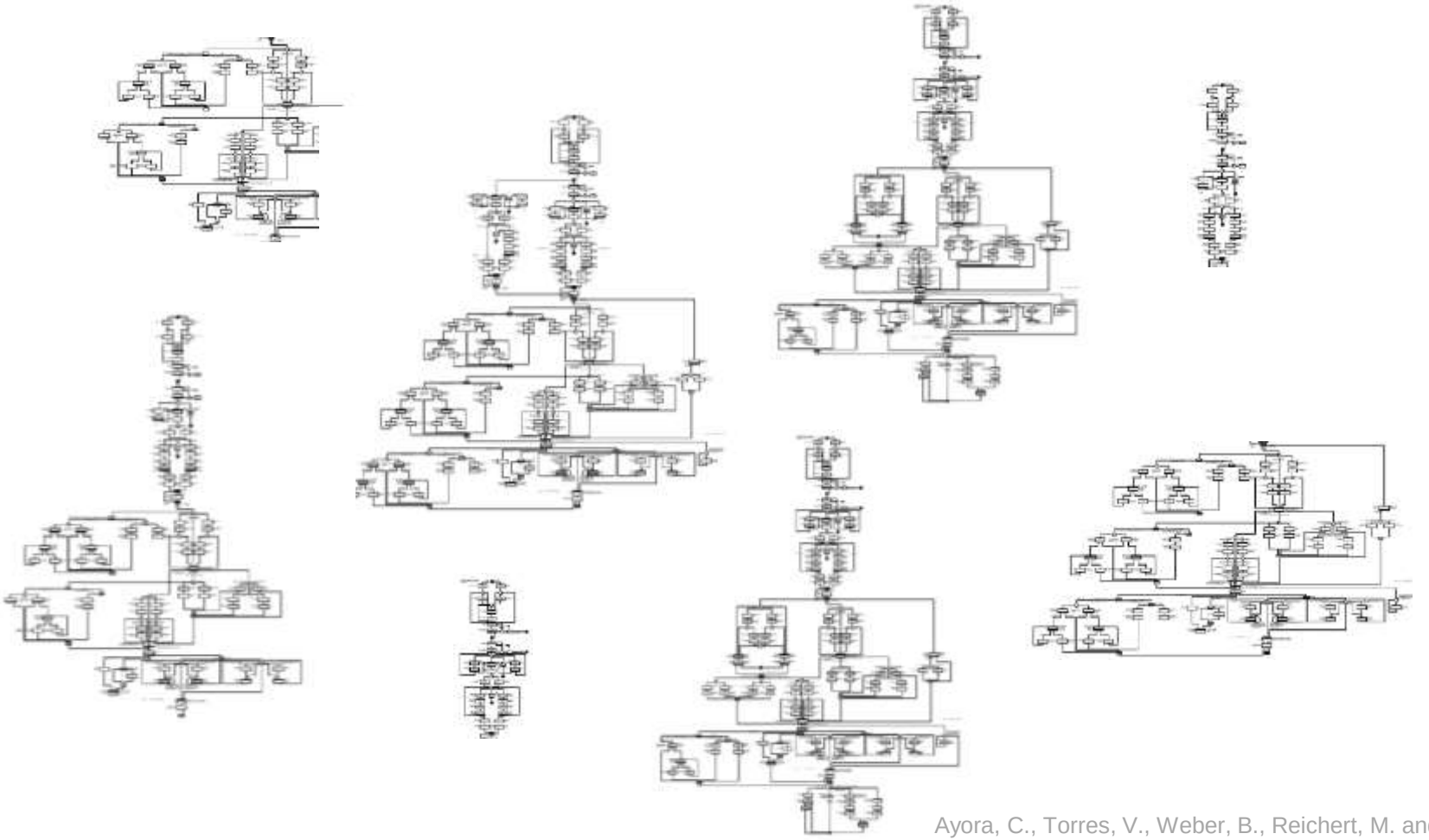
Reason 2:
Underestimating the Complexity of Real World Processes

- Most PAISs are only able to support rather simple processes
- But: Real-world processes are often very complex, e.g.,
  - Large processes
  - High business process variability
  - Large collective process structures
  - Intra-organizational vs. cross-organizational processes
  - Large numbers of process instances to be handled
  - …

Underestimating the Complexity of Real World Processes:
Large Process Models



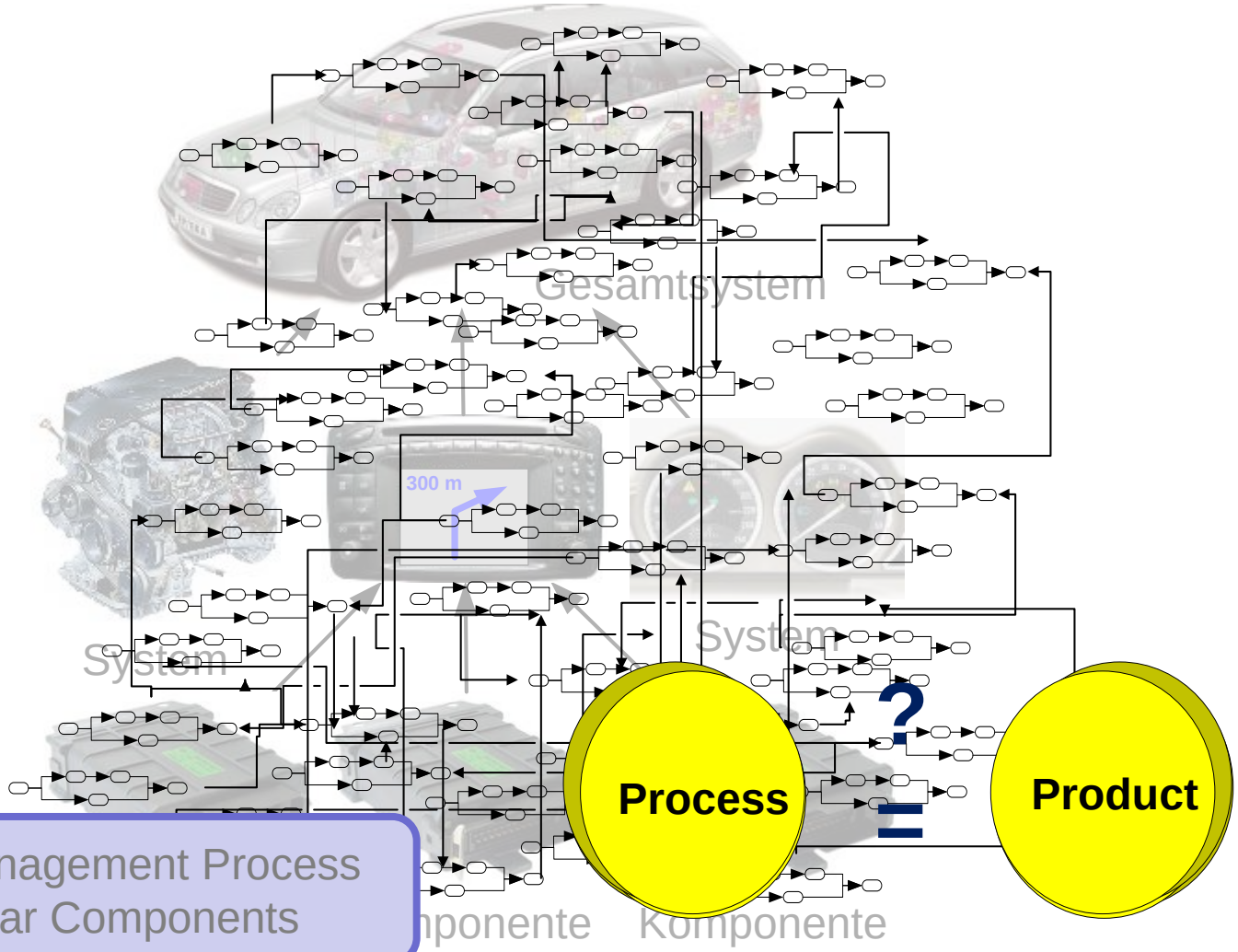
Underestimating the Complexity of Real World Processes:
Business Process Variability



[La Rosa et al]

Ayora, C., Torres, V., Weber, B., Reichert, M. and Pelechano, V. (2015) *VIVACE: A Framework for the Systematic Evaluation of Variability Support in Process-Aware Information Systems.* Information and Software Technology, Vol. 57, pp. 248-276

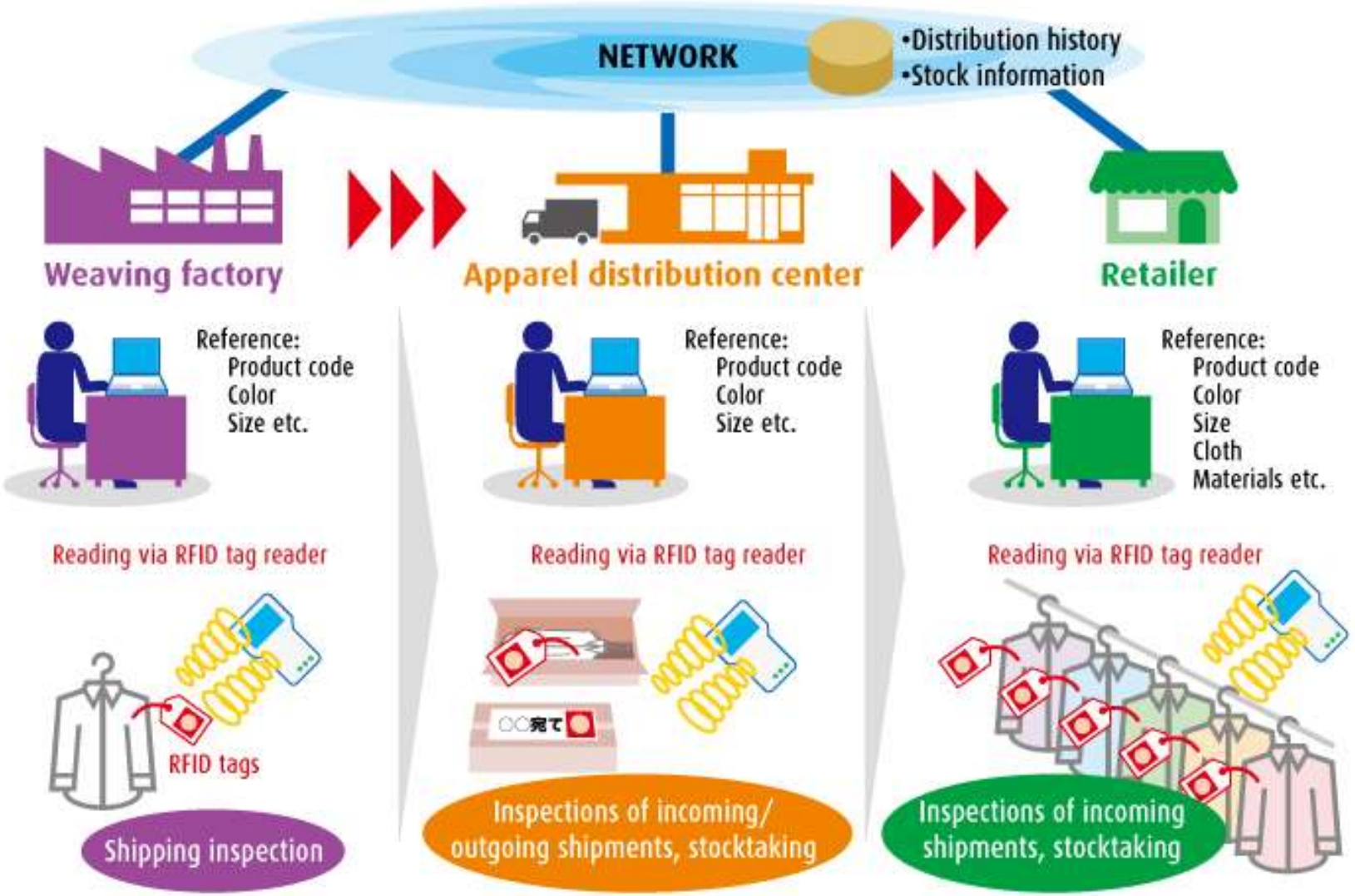
Underestimating the Complexity of Real World Processes:
Large Collective Process Structures



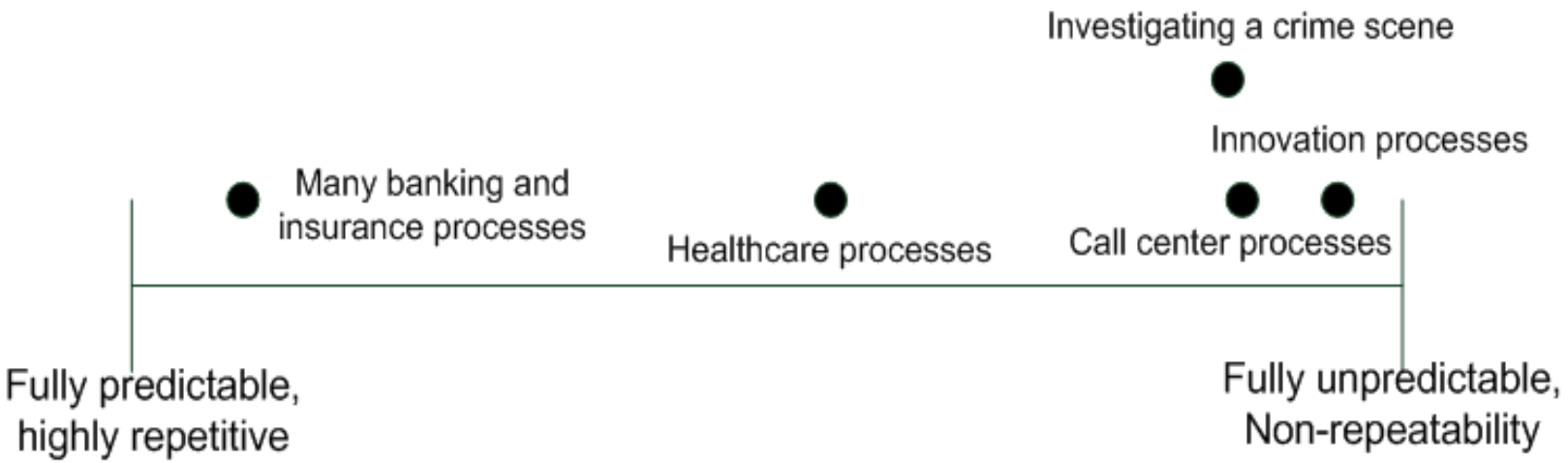
Release Management Process for E/E Car Components

D. Müller, M. Reichert, J. Herbst: A New Paradigm for the Enactment and Dynamic Adaptation of Data-Driven Process Structures. CAiSE 2008: 48-63

Underestimating the Complexity of Real World Processes:
Processes may cross organizational borders



Underestimating the Complexity of Real World Processes:
Structured vs. Unstructured Processes



Processes on the right side of the spectrum are mostly knowledge-intensive

Underestimating the Complexity of Real World Processes:
Structured vs. Unstructured Processes

❑ **Routine processes**

- Interdisciplinary cooperation among different people and organizational units to perform routine work

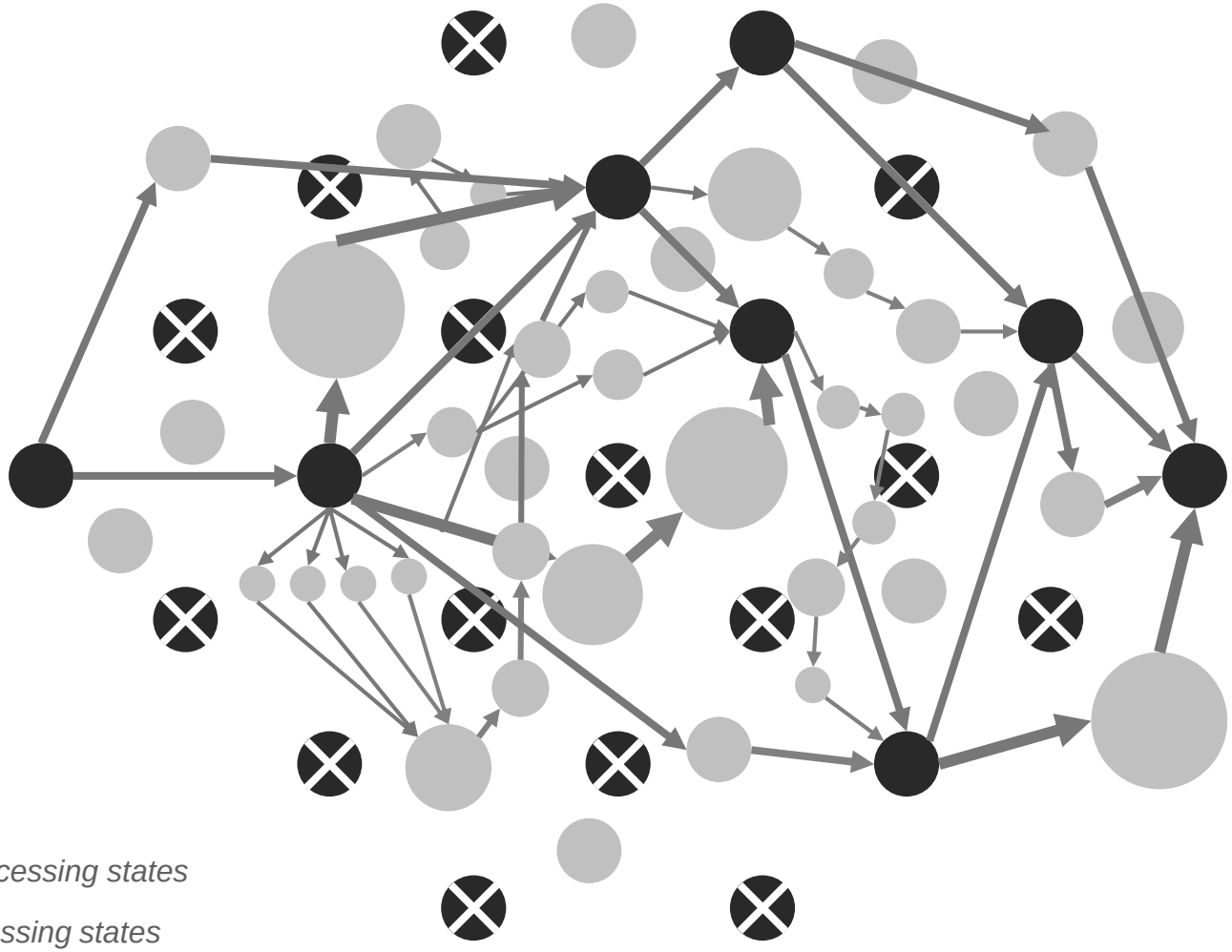
❑ **Knowledge-intensive processes**

- Guided by available information
- Dependent on domain-specific knowledge
- Uncertainty, goal-orientation, emergence of work, evidenced guidelines, …

N. Mundbrod, F. Beuter, M. Reichert (2015) Supporting Knowledge-intensive Processes Through Integrated Task Lifecycle Support. EDOC 2015

Lenz, Richard and Reichert, Manfred (2007) *IT Support for Healthcare Processes - Premises, Challenges, Perspectives..* Data and Knowledge Engineering, 61(1): 39-58, Elsevier.

Underestimating the Complexity of Real World Processes:
Structured vs. Unstructured Processes



pre-defined processing states

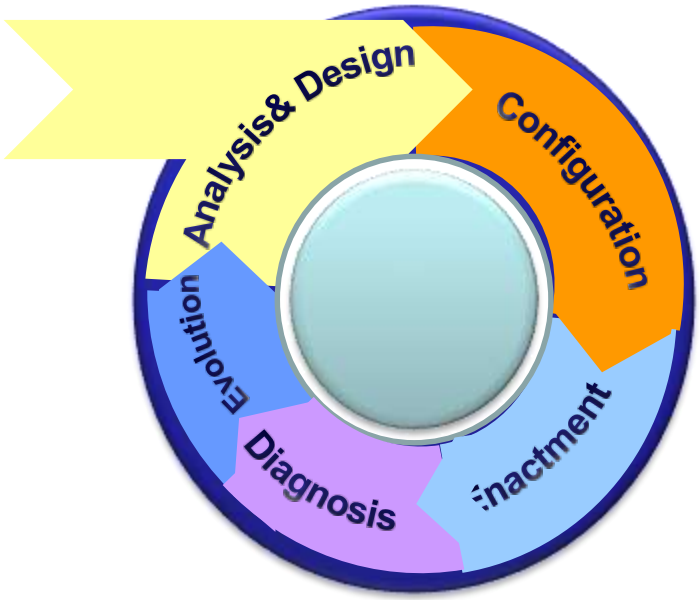
forbidden processing states

optional processing states

activities

Reason 3: Immaturity of PAIS-Enabling Technologies

- Existing PAIS-enabling technologies are by far too immature to properly support the described process scenarios
- Usually, commercial technologies not cover …
  - all process lifecycle phase
  - all relevant process perspectives (behavior, data, resources, time, …)
  - both intra- and cross-organizational processes
  - the full spectrum of processes, including well-structured as well as unstructured business processes
  - …
- Missing or insufficient integration of processes, data, and users!



Reason 4: Vendor-Driven Technology Evolution

- The evolution of the PAIS market has been driven by software vendors, less by their customers!
- There is a naive belief in the use-fulness of (de-facto) standards, e.g.,
  - WfMC
  - WS-BPEL, BPEL4People
  - BPMN 2.0
  - CMMN
  - …

Many problems in practice!

Reason 5: The "Lost Opportunity" of BPM Research

- There is a gap between BPM theory and its transfer to industrial practice
- BPM research (cf. BPM use cases) focuses too much on process models and process model discovery, while neglecting issues related to …
  - PAIS engineering & implementation
  - PAIS architectures
  - Process enactment
  - …

Reason 5: The "Lost Opportunity" of BPM Research

The missing engineering perspective, e.g.,

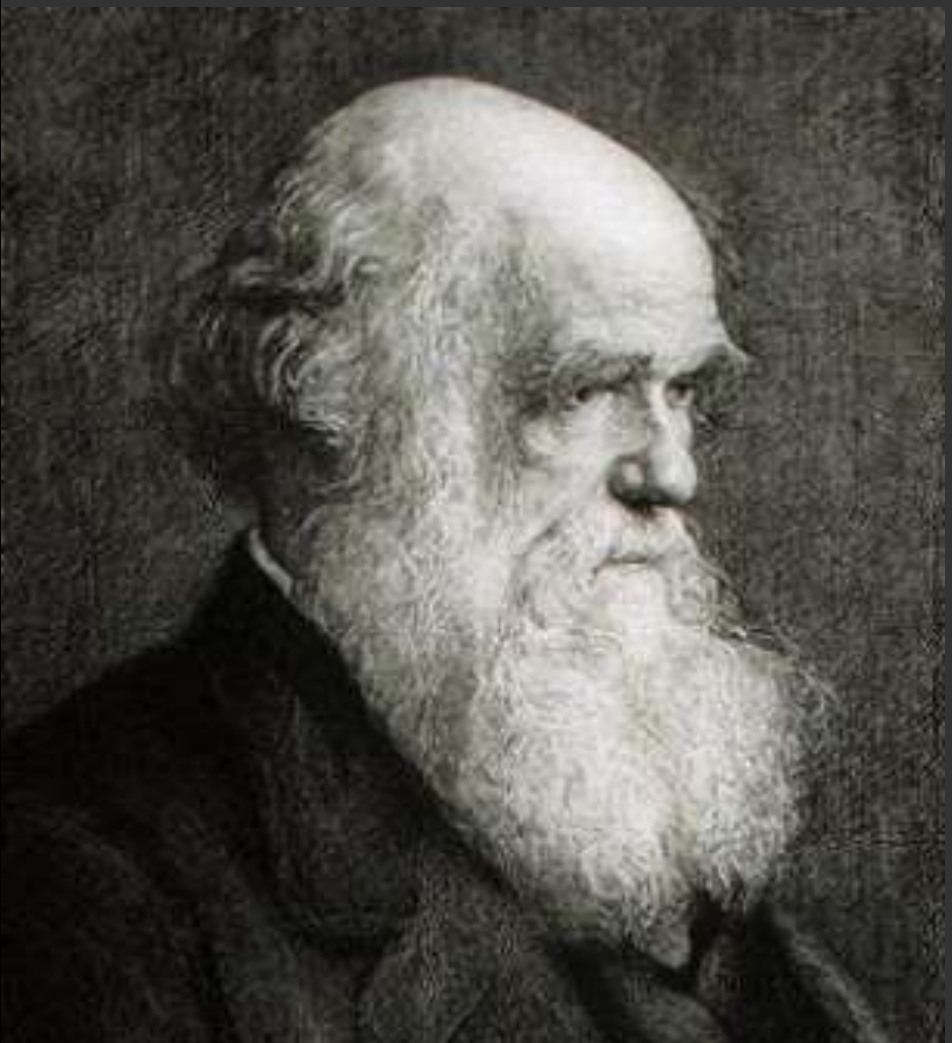
- **Process modeling**: For a long time, BPM research has focused on the **product of process modeling** rather than on the **process of process modeling**
  ⇒ **Why is the latter important as well?**
- **Process variability**: There exist many techniques for representing process variability as well as for configuring process variants!
  ⇒ **But: How to model a process family?**
- **PAIS architectures**: Non-functional PAIS properties are not properly considered, e.g., scalability, robustness, extensibility, usability, maintainability, …

Reason 6: Process Rigidity as Barrier to Entry

Enforcement:
Guardrails (on a road) prevent deviation, but also prevent anything not predicted.

Guidance: Guidelines (on a road) show people where to go, but do not prevent deviations if they are necessary.

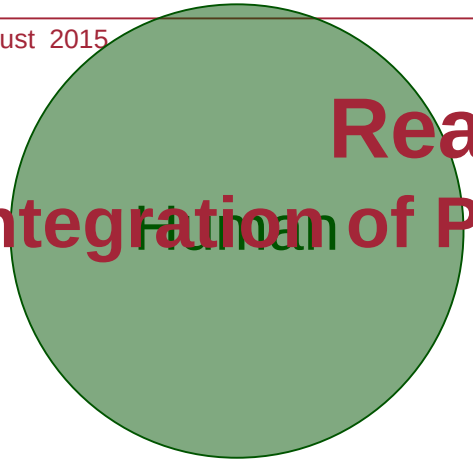
Reason 7:
Inability to Evolve Implemented Processes



”It is not the strongest of the species that survives, not the most intelligent that survives. It is the one that is the most adaptable to change.“

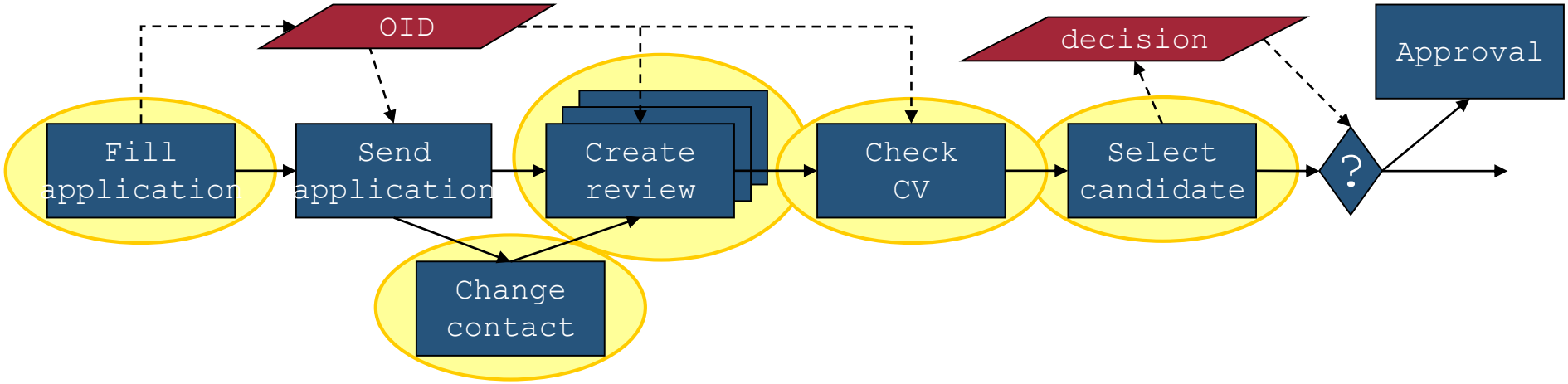
Charles Darwin

Reason 8:
Improper Integration of Processes, Data and Humans



⇒ limitations of activity-centric processes (next slide)

Reason 8:
Improper Integration of Processes, Data and Humans



Data may only be accessed when executing activities!

Missing or incomplet context information (context tunneling)!

No optional activities!

No control whether semantic business goals have been reached!

Isolated enactment of process instances!

Insufficient asynchronous execution of sub-processes!

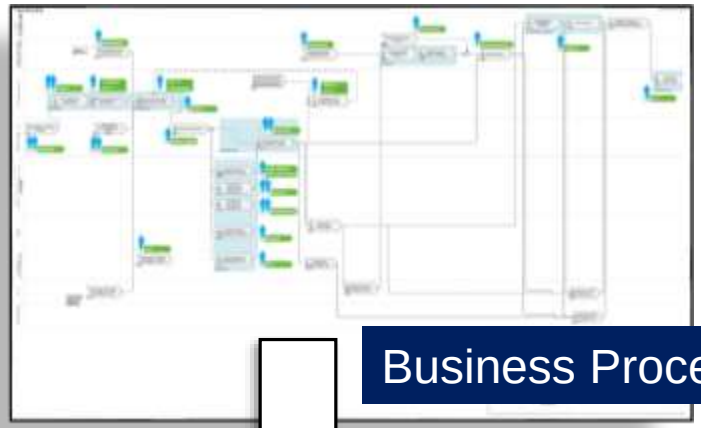
… there are many more reasons why PAIS fail in practice!

Towards More Advanced PAIS Taking an Engineering Perspective

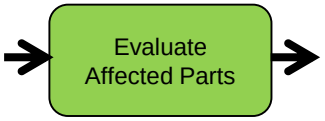
Bridging the Business IT Alignment Gap

Bridging the Business IT Alignment Gap

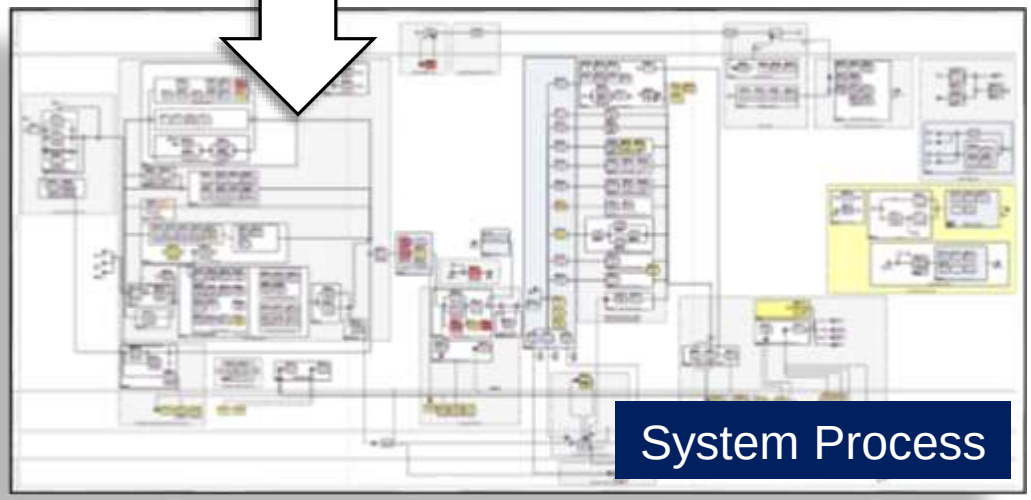
Business Level



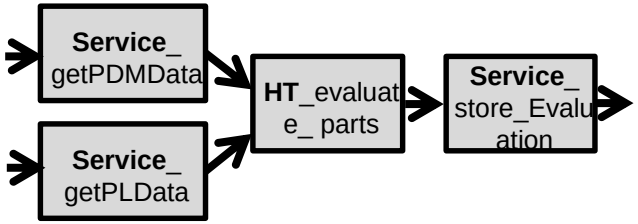
Business Process



IT Level

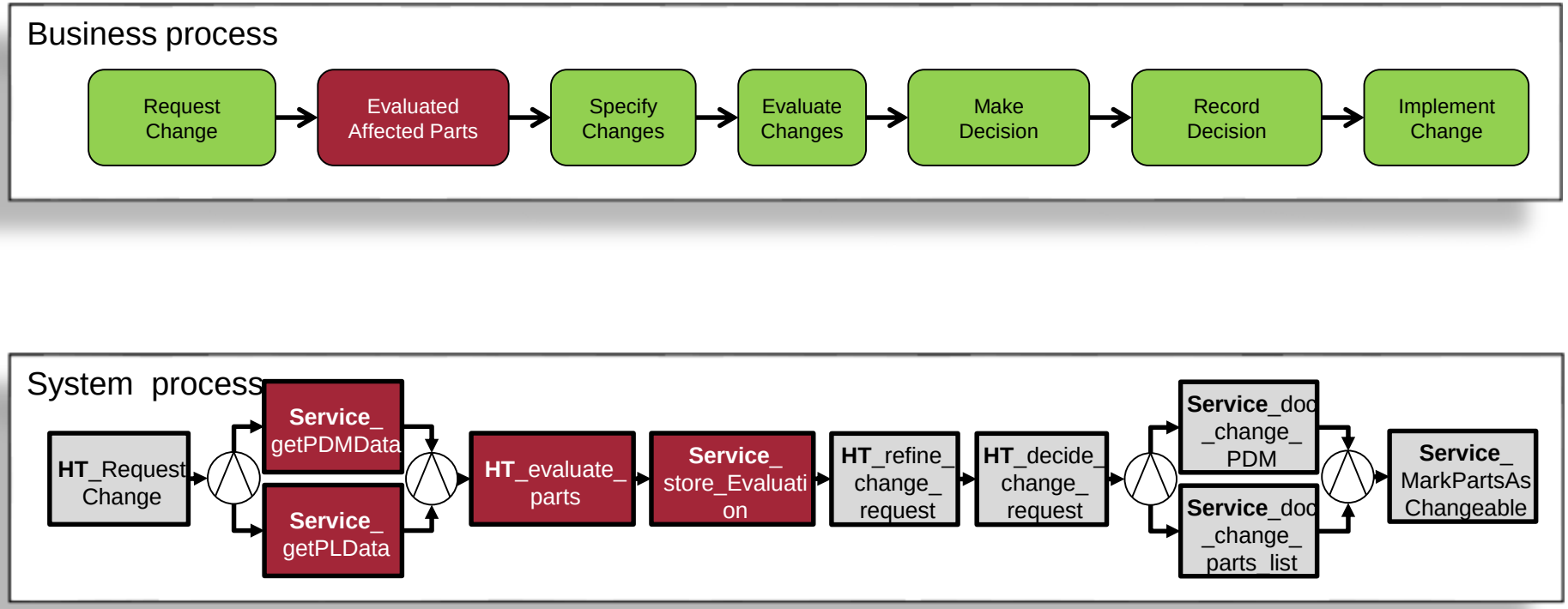


System Process



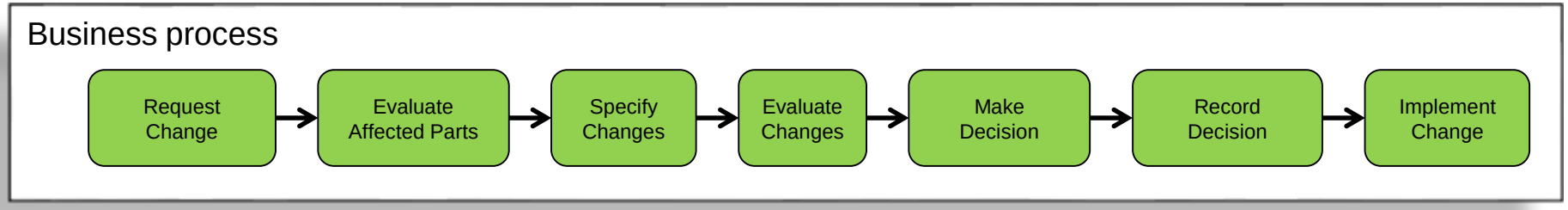
Bridging the Business IT Alignment Gap

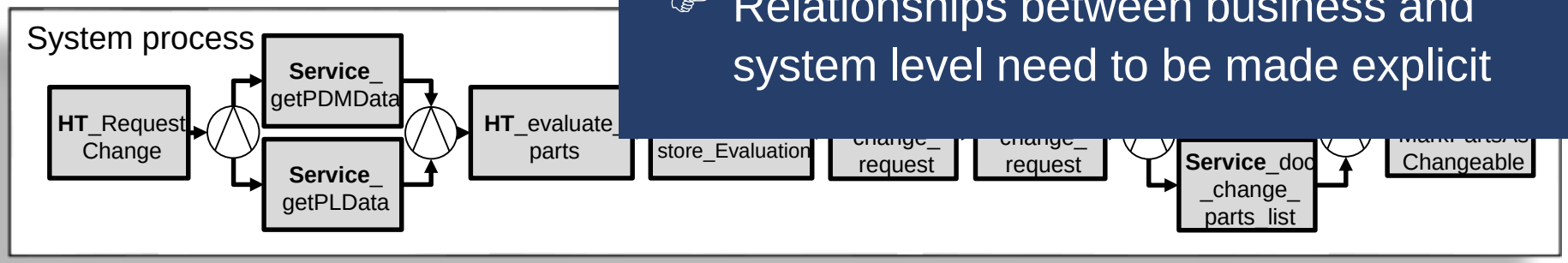
Change Management Process in the Automotive Domain (simplified)



HT = Human Task

Bridging the Business IT Alignment Gap

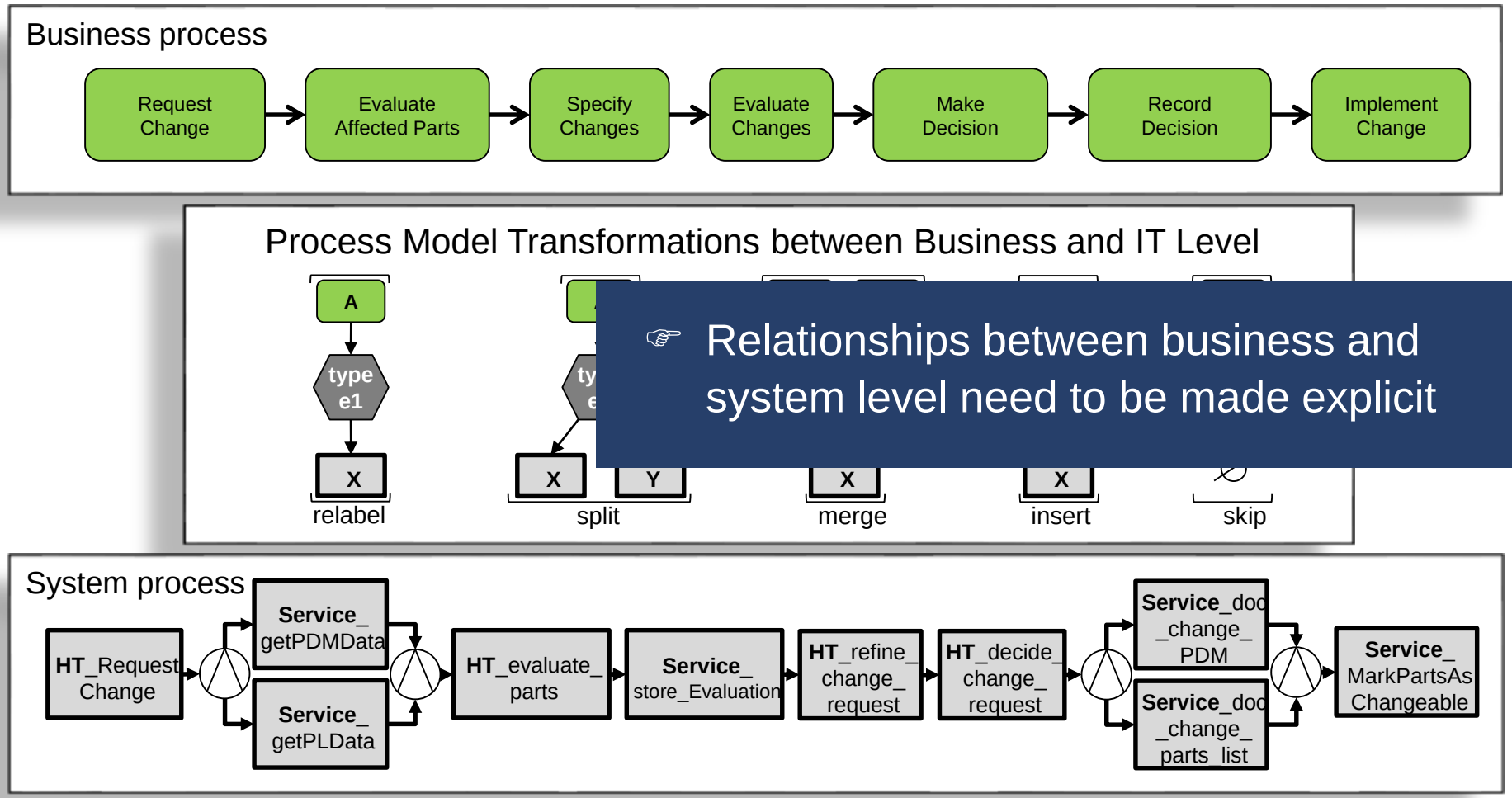




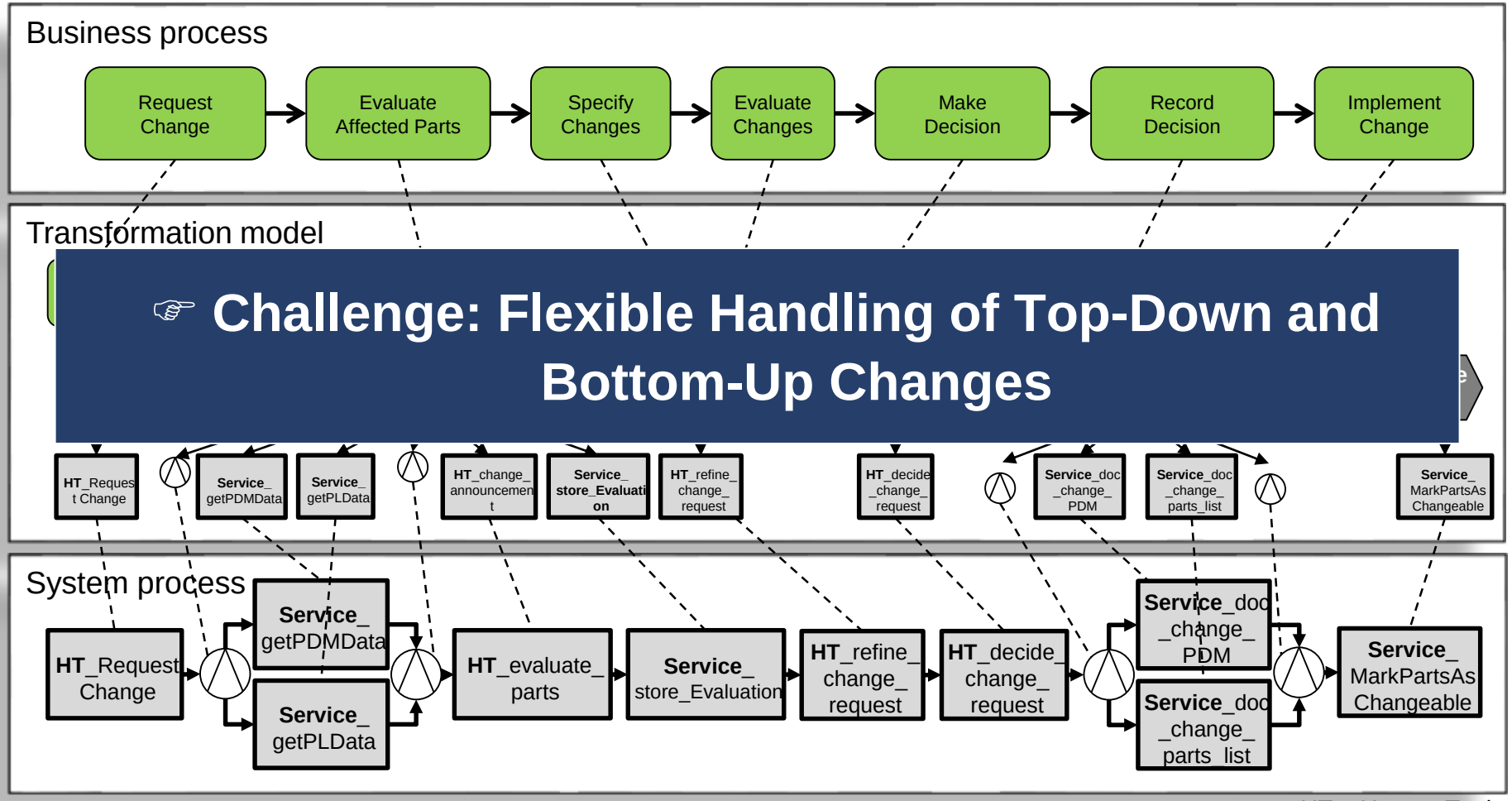
☞ Relationships between business and system level need to be made explicit

HT = Human Task

Bridging the Business IT Alignment Gap

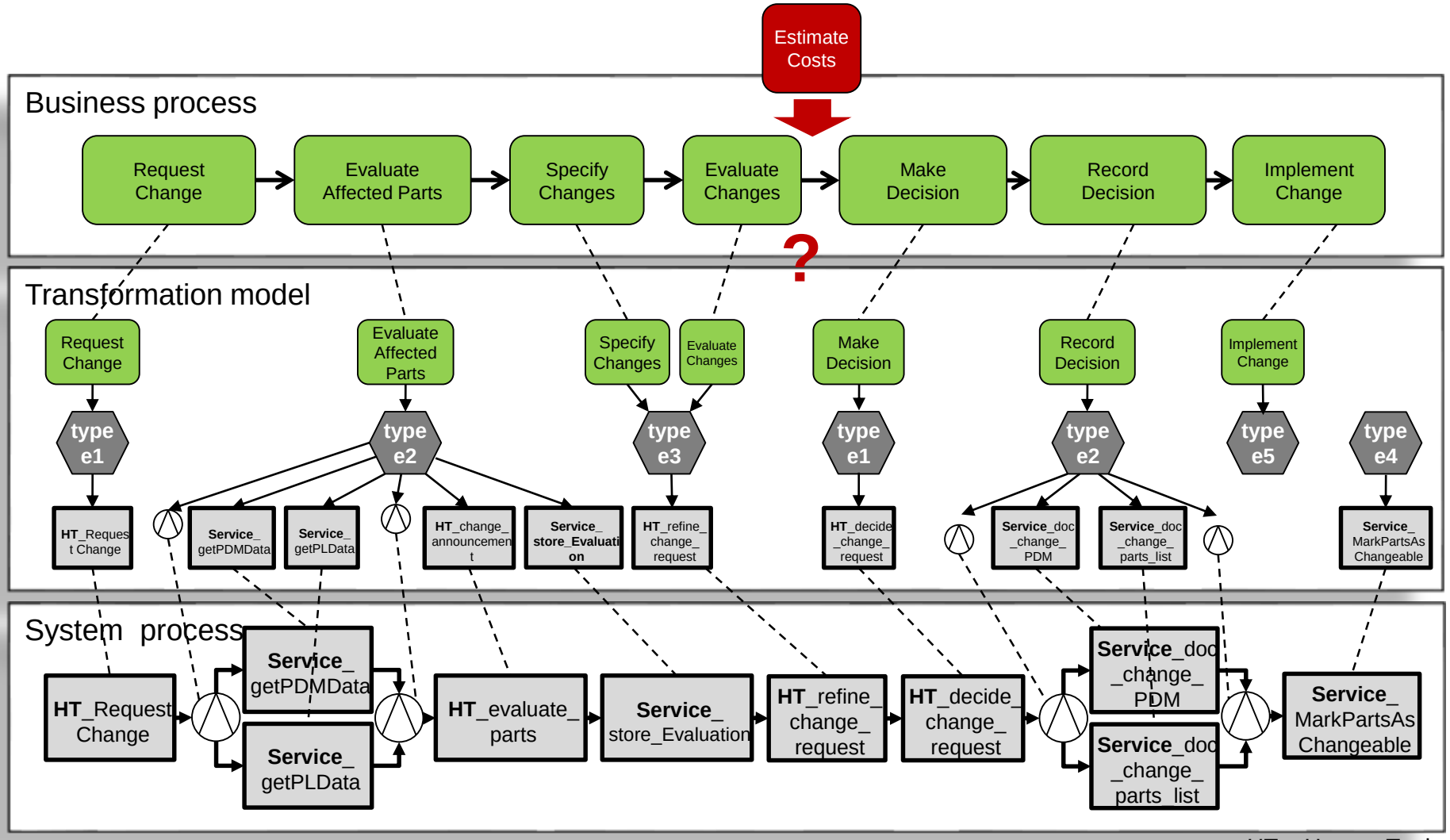


Bridging the Business IT Alignment Gap



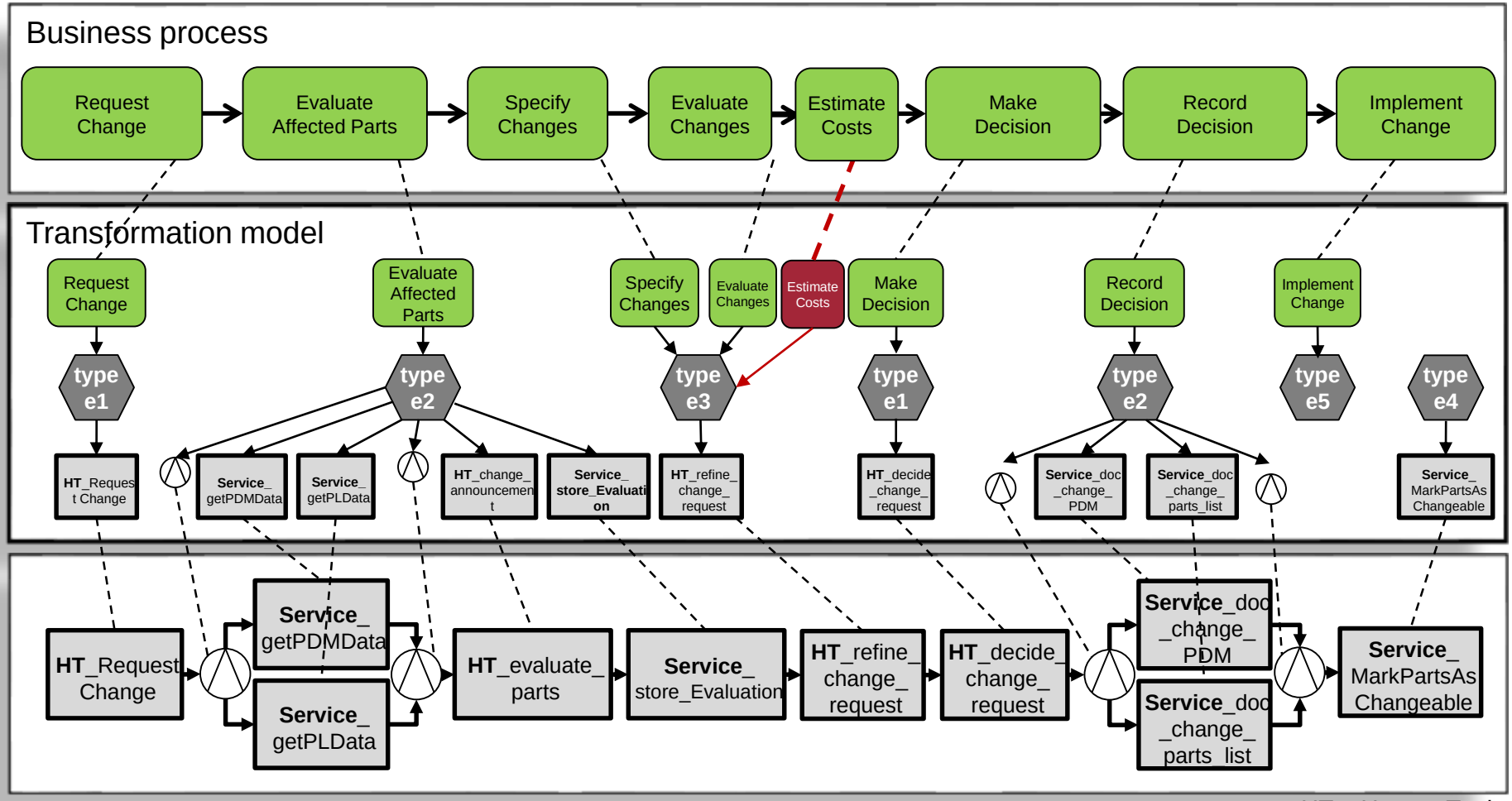
HT = Human Task

Bridging the Business IT Alignment Gap



HT = Human Task

Bridging the Business IT Alignment Gap



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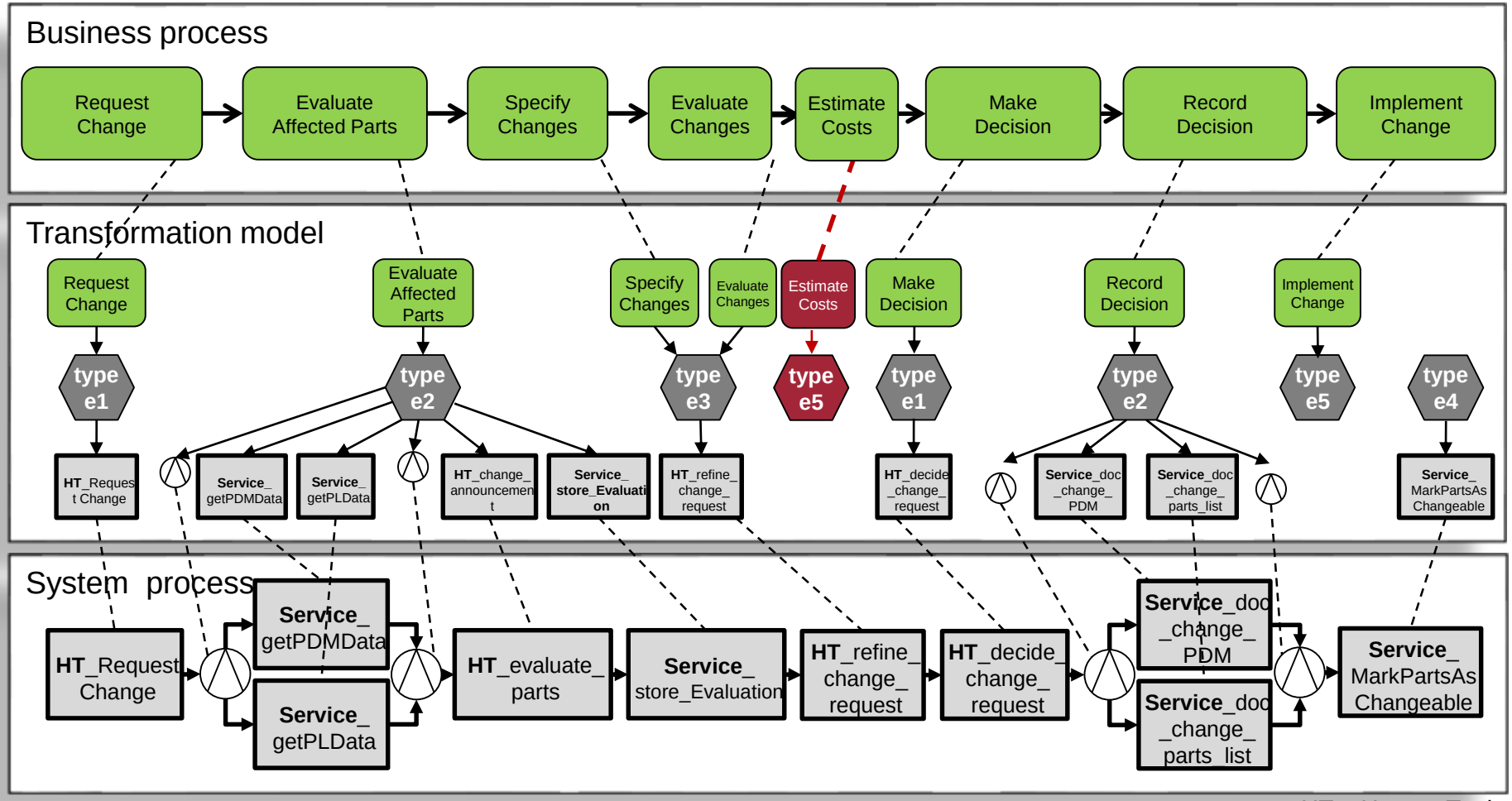
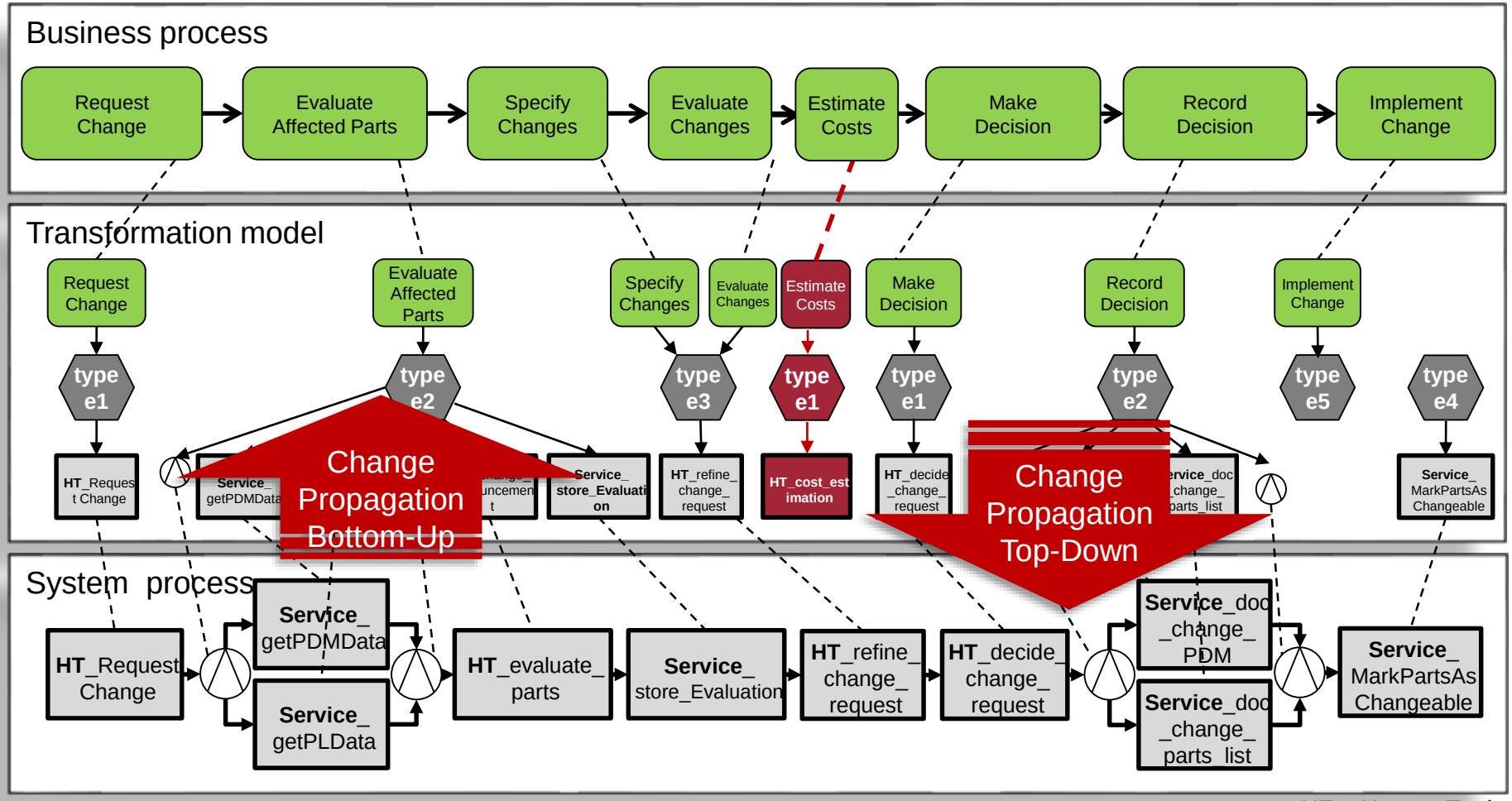
Bridging the Business IT Alignment Gap



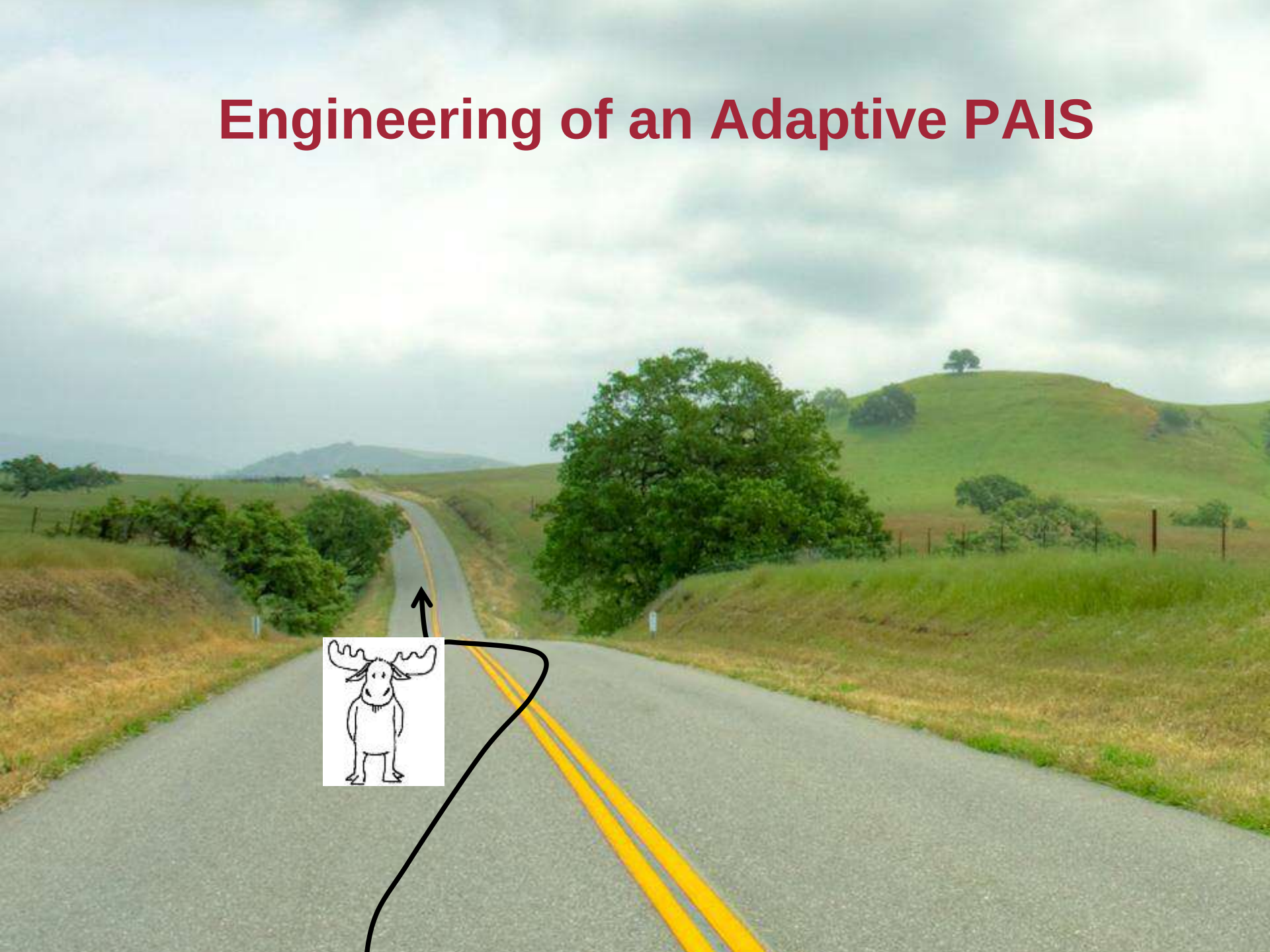
HT = Human Task

Bridging the Business IT Alignment Gap

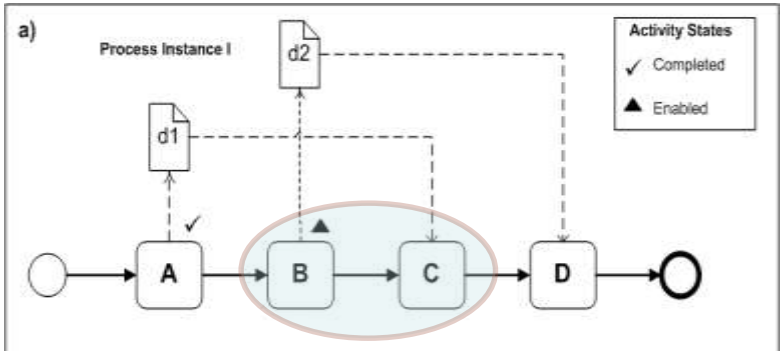


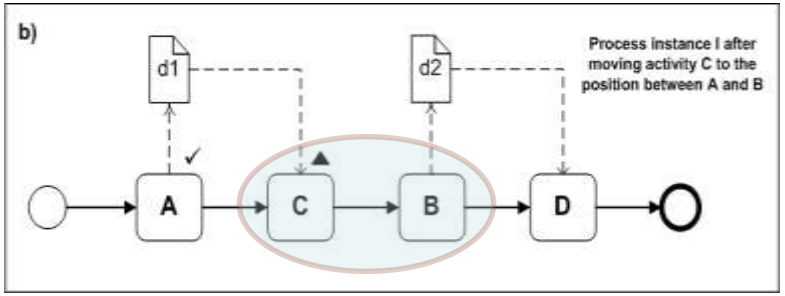
HT = Human Task

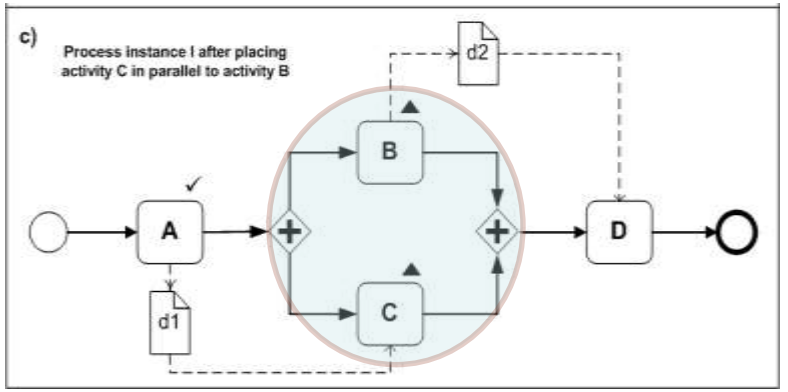
Engineering of an Adaptive PAIS



Background: Process Adaptation Support



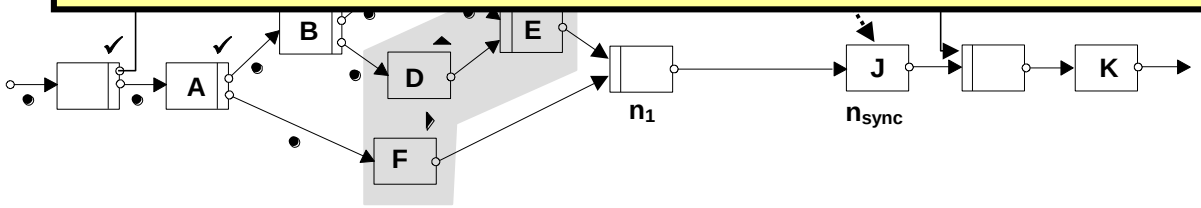




Background: Process Adaptation Support

Many other fundamental issues:

- Ensuring soundness of dynamic process changes
- Enabling adaptations based on model abstractions
- Providing proper end user assistance
- Balancing process flexibility and security



Reichert, Manfred and Dadam, Peter and Bauer, Thomas (2003) *Dealing with forward and backward jumps in workflow management systems.* Int'l Journal Software and Systems Modeling (SOSYM), 2(1): 37-58

Engineering of an Adaptive PAIS

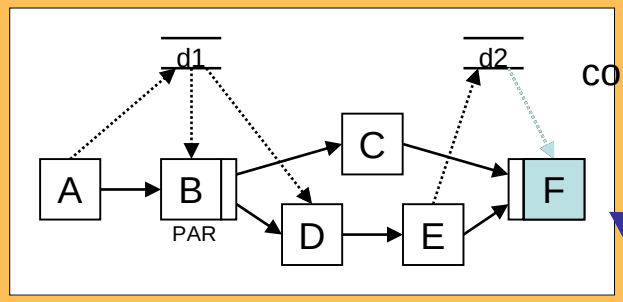

Developer


Process designer


End user

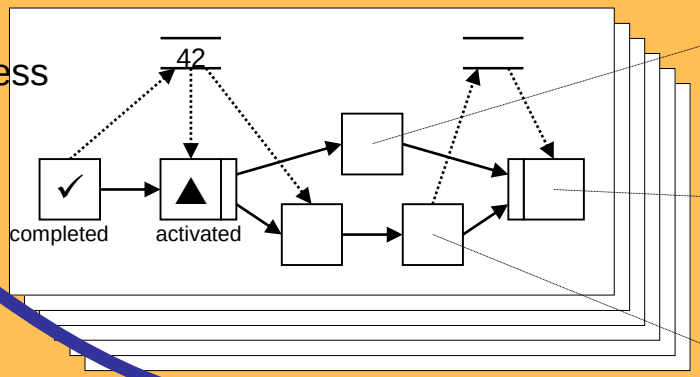

Administrator

process template



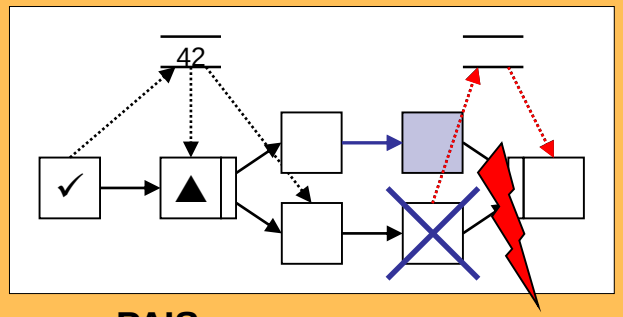
correctness

process instance



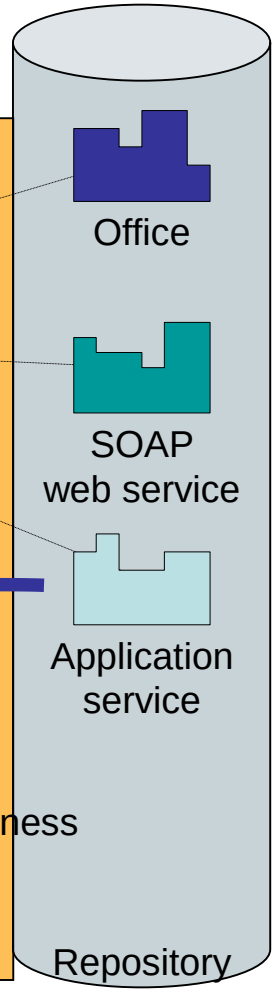
- process modeling
- process execution
- process monitoring
- appliation invocation („play“)
- application integration („plug“)
- process instance changes

Instance changes



correctness

PAIS

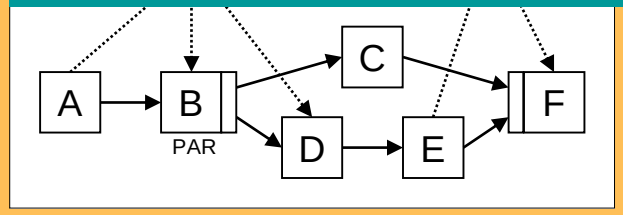


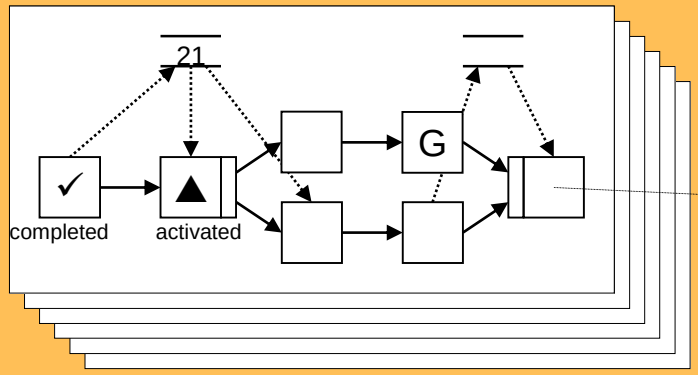
Engineering of an Adaptive PAIS

- process modeling
- process execution
- process monitoring
- appliation invocation („play“)
- application integration („plug“)
- process instance changes
- **process schema evolution**

End user

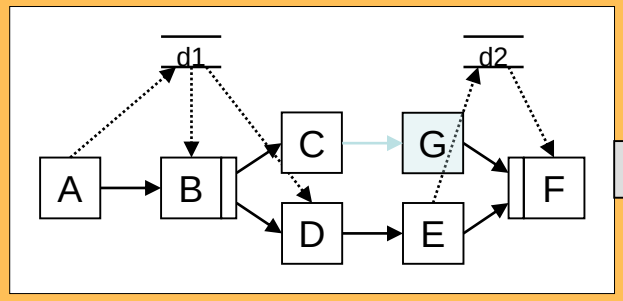
Administrator

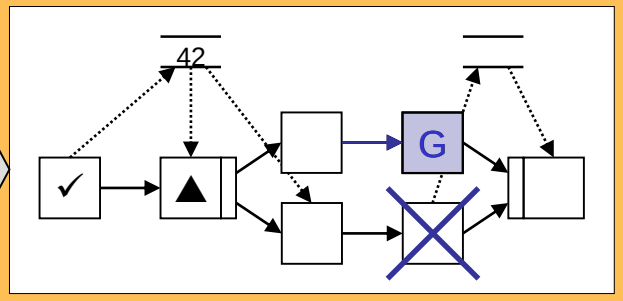




correctness

process schema evolution





correctness

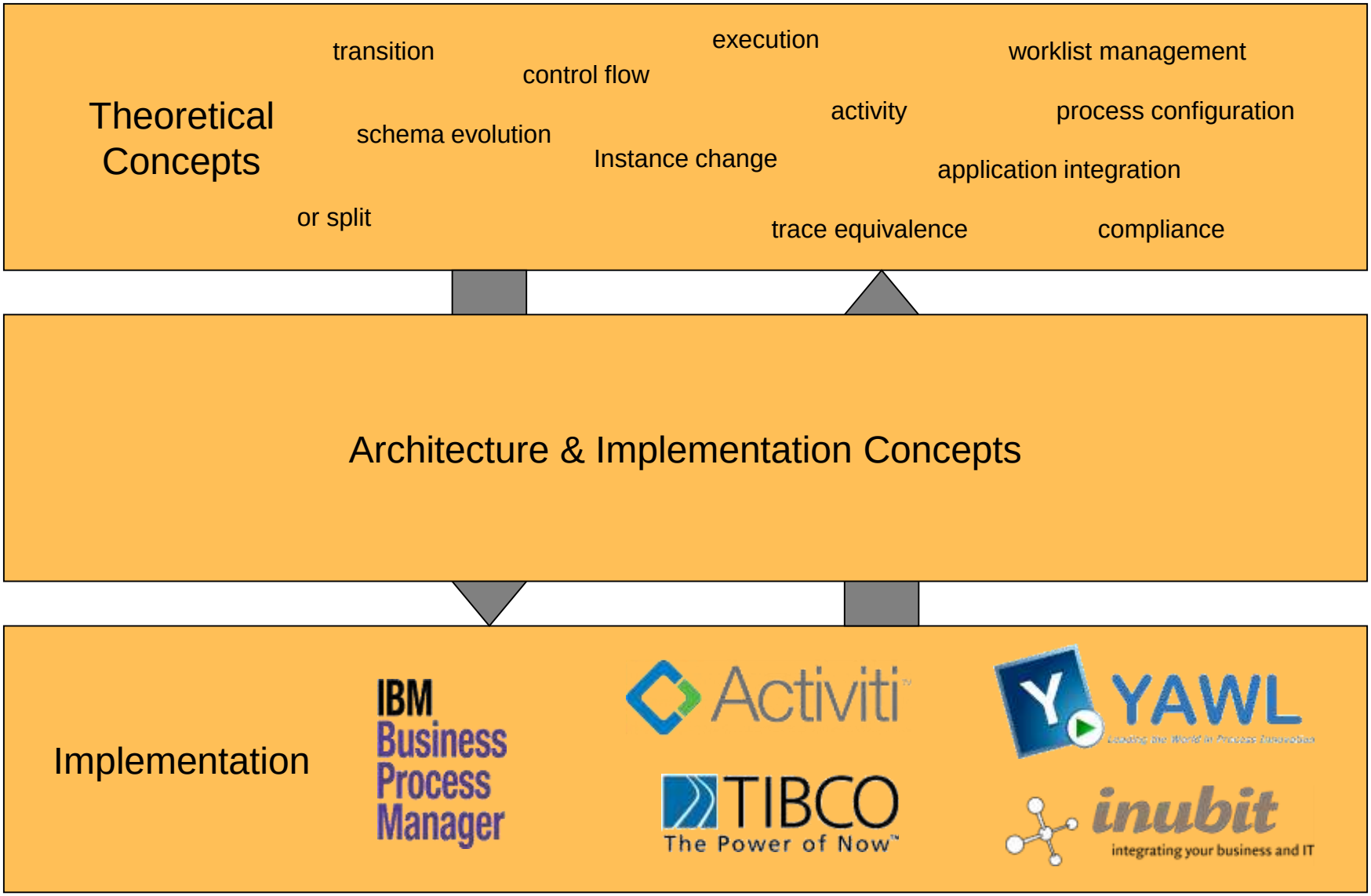
template change

change propagation

PAIS

Engineering of an Adaptive PAIS

From Theoretical Concepts to Running PAIS

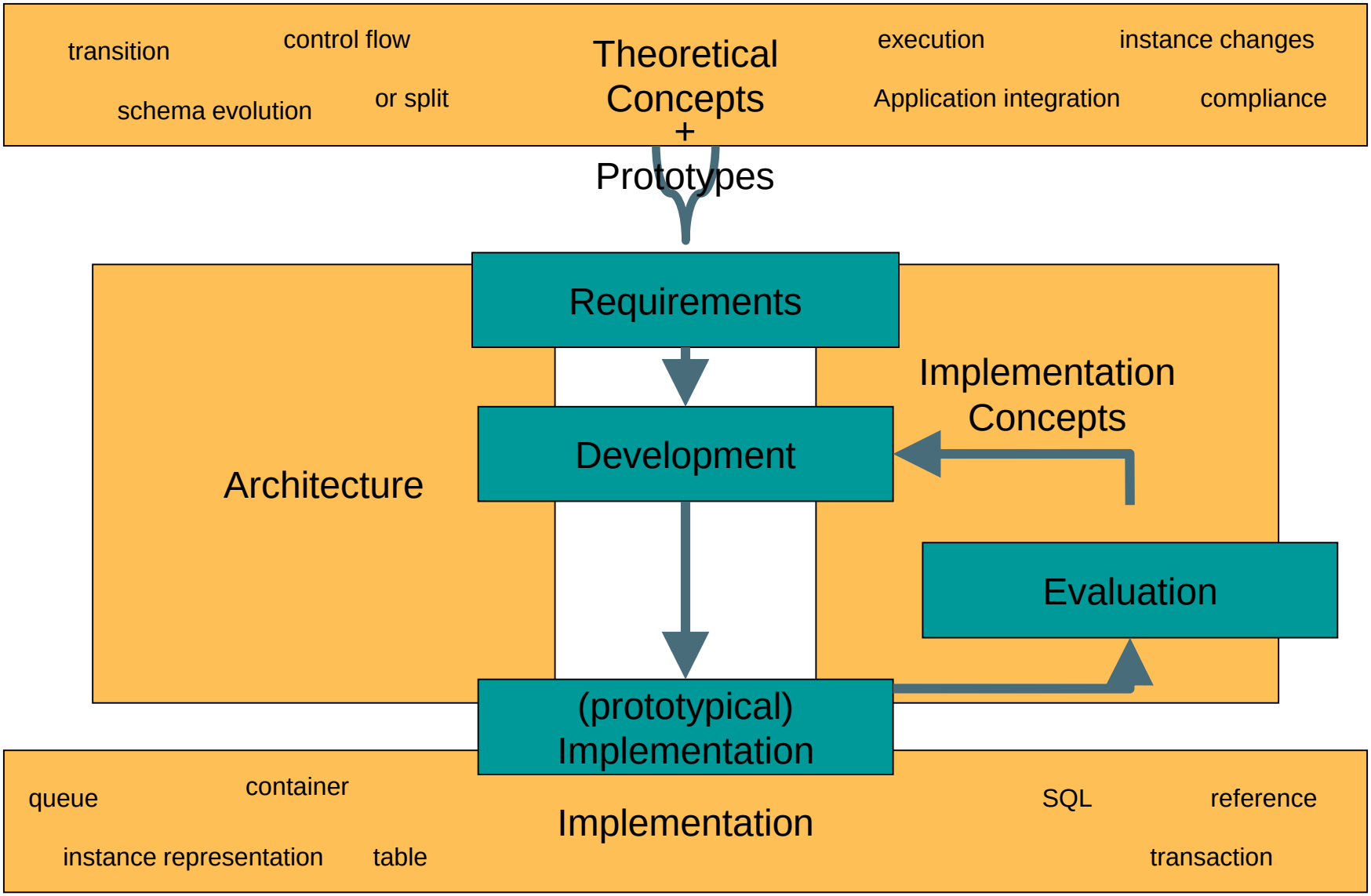


Engineering of an Adaptive PAIS

Analogy: Database Management Systems

Engineering of an Adaptive PAIS

From Theoretical Concepts to Running PAIS



Engineering of an Adaptive PAIS

Requirements Elicitation

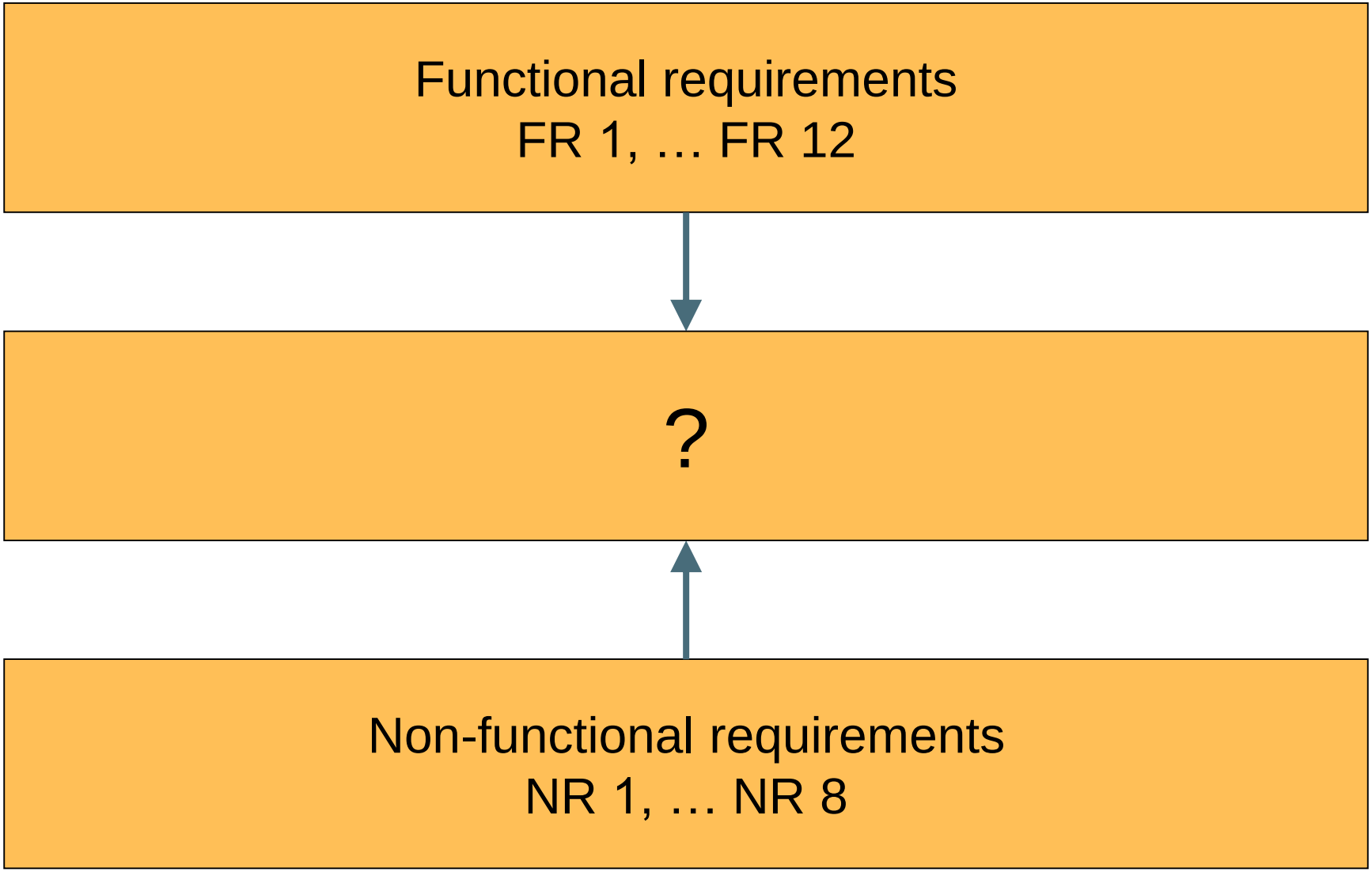
- FR 1 process execution
- FR 2 logging
- FR 3 resource modeling
- FR 4 worklist management
- FR 5 process monitoring
- FR 6 persistent storage
- FR 7 appliation invocation („play“)
- FR 8 process modeling
- FR 9 process adaptation
- FR 10 application integration („plug“)
- FR 11 process management & versioning
- FR 12 API & development framework

- NR 1 scalability/performance
- NR 2 robustness
- NR 3 extensibility
- NR 4 ease of use
- NR 5 independence/modularity
- NR 6 reuse/non-redundancy
- NR 7 maintainability
- NR 8 ability to evolve/flexibility

- DIN ISO 9126
  (software quality, product quality)

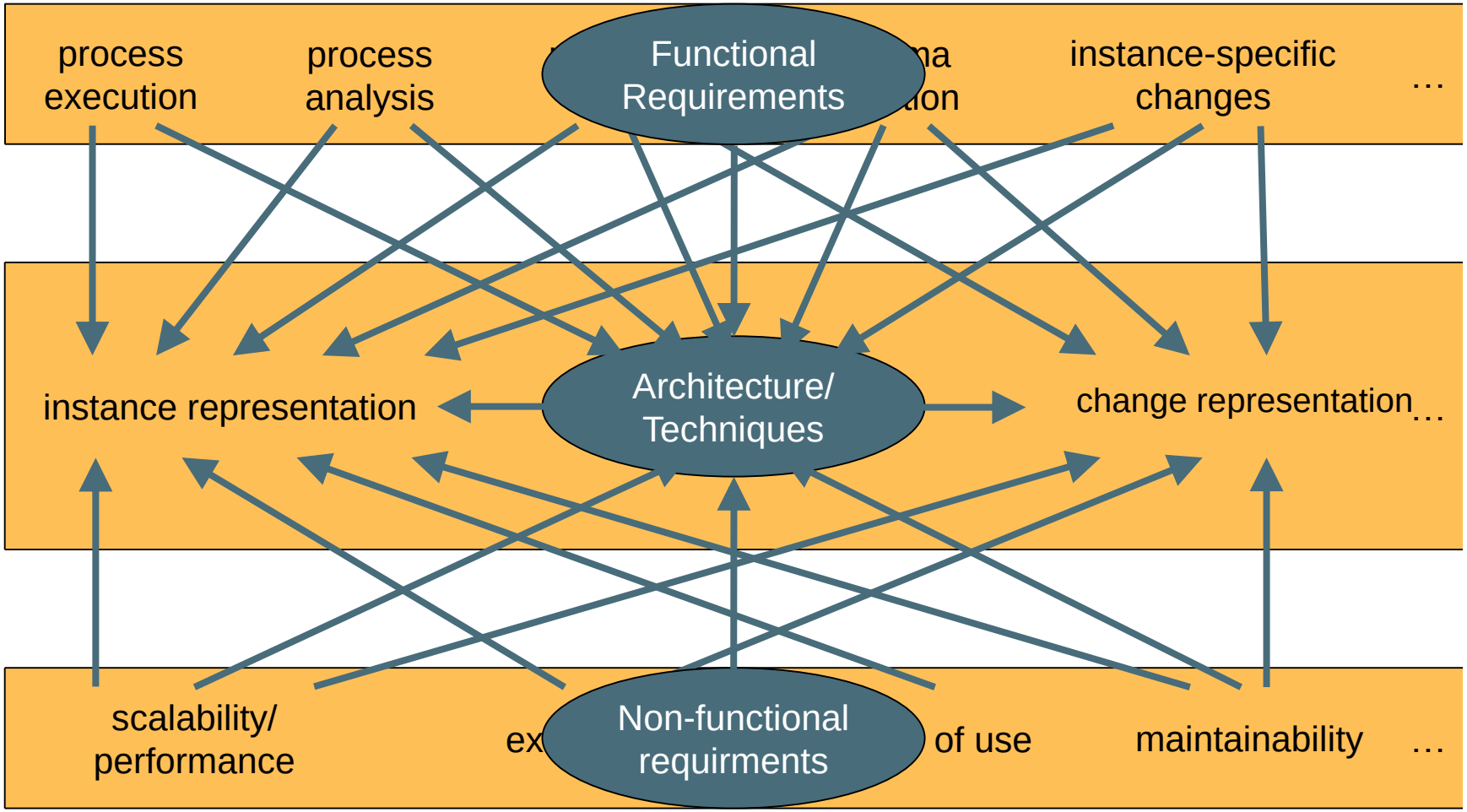
Engineering of an Adaptive PAIS

Architecture Design



Engineering of an Adaptive PAIS

Architecture Design

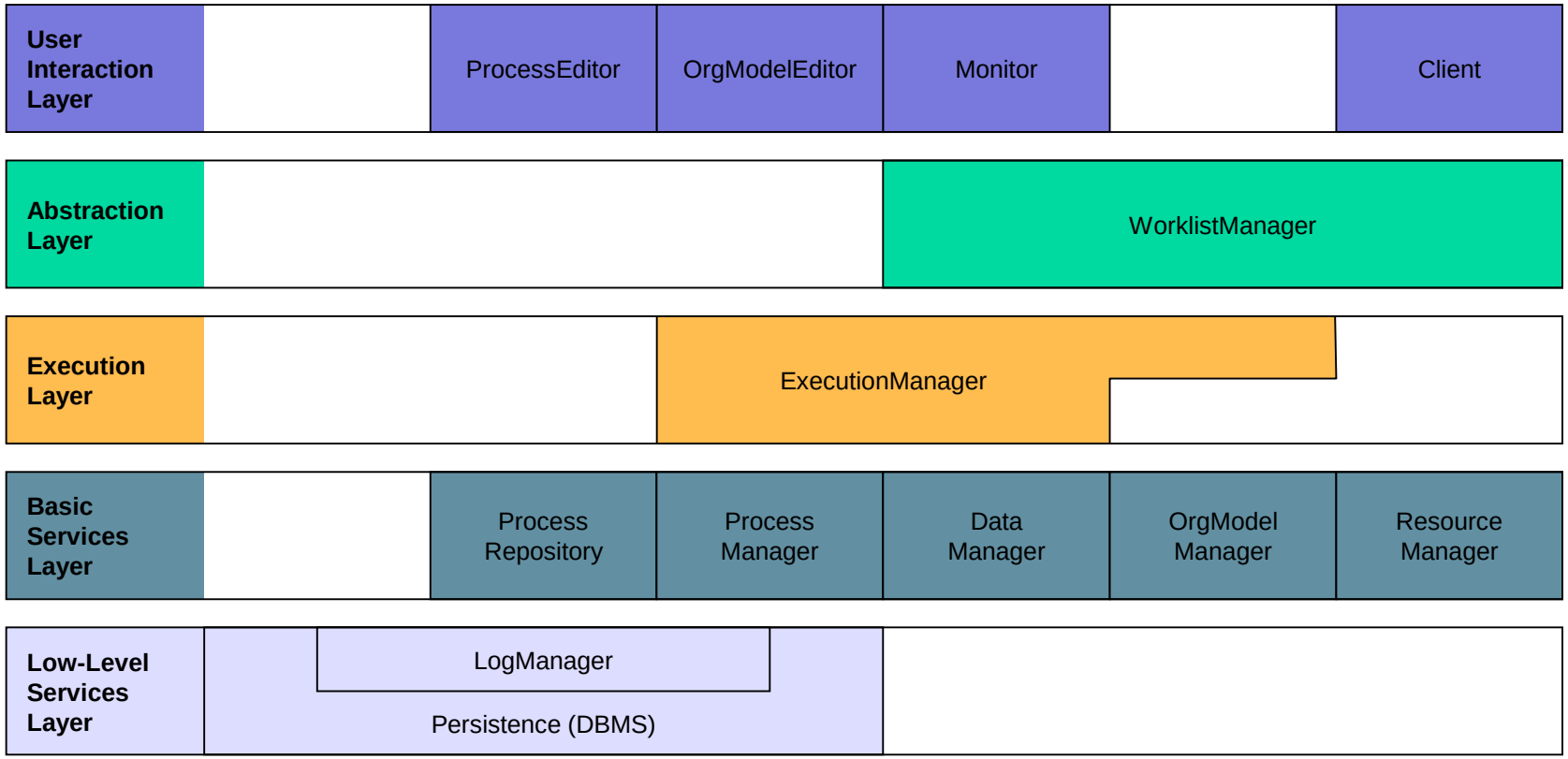


Engineering of an Adaptive PAIS

Basic Architecture

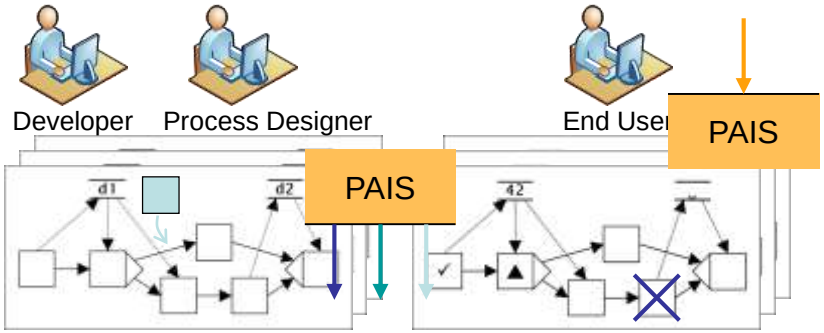
Functional requirements

1 2 3 4 5 6 7 8 9 10 11 12 13



Engineering of an Adaptive PAIS

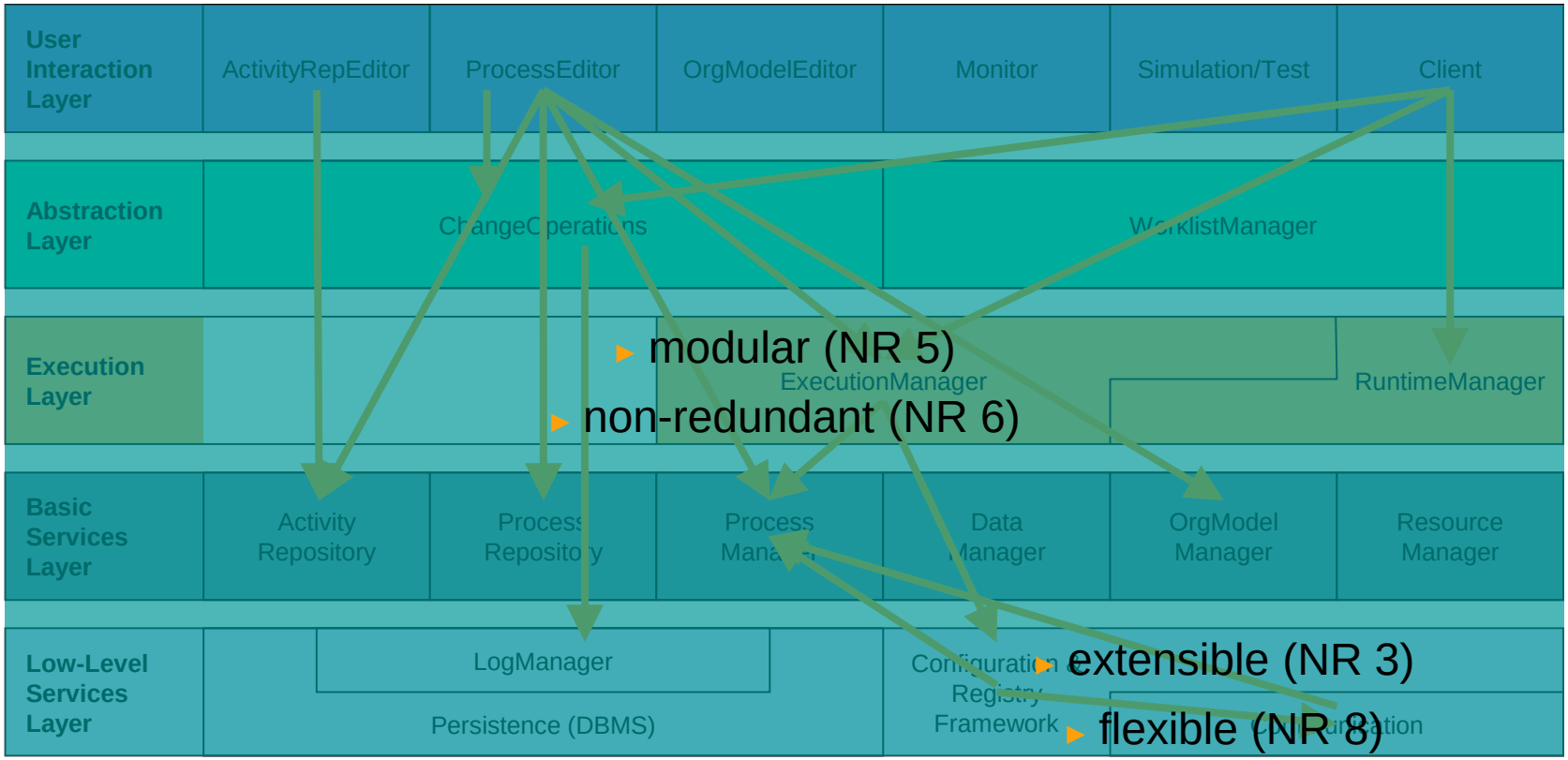
Advanced Architecture



Functional requirements

1 2 3 4 5 6 7 8 9 10 11 12 13

FR 13 Programming interfaces / Devlopment framework

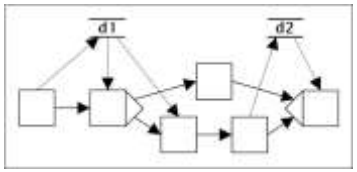


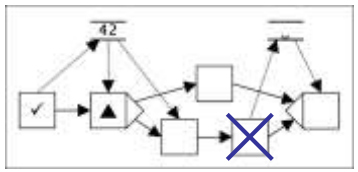
Engineering of an Adaptive PAIS

Advanced Architecture: Instance-specific Changes

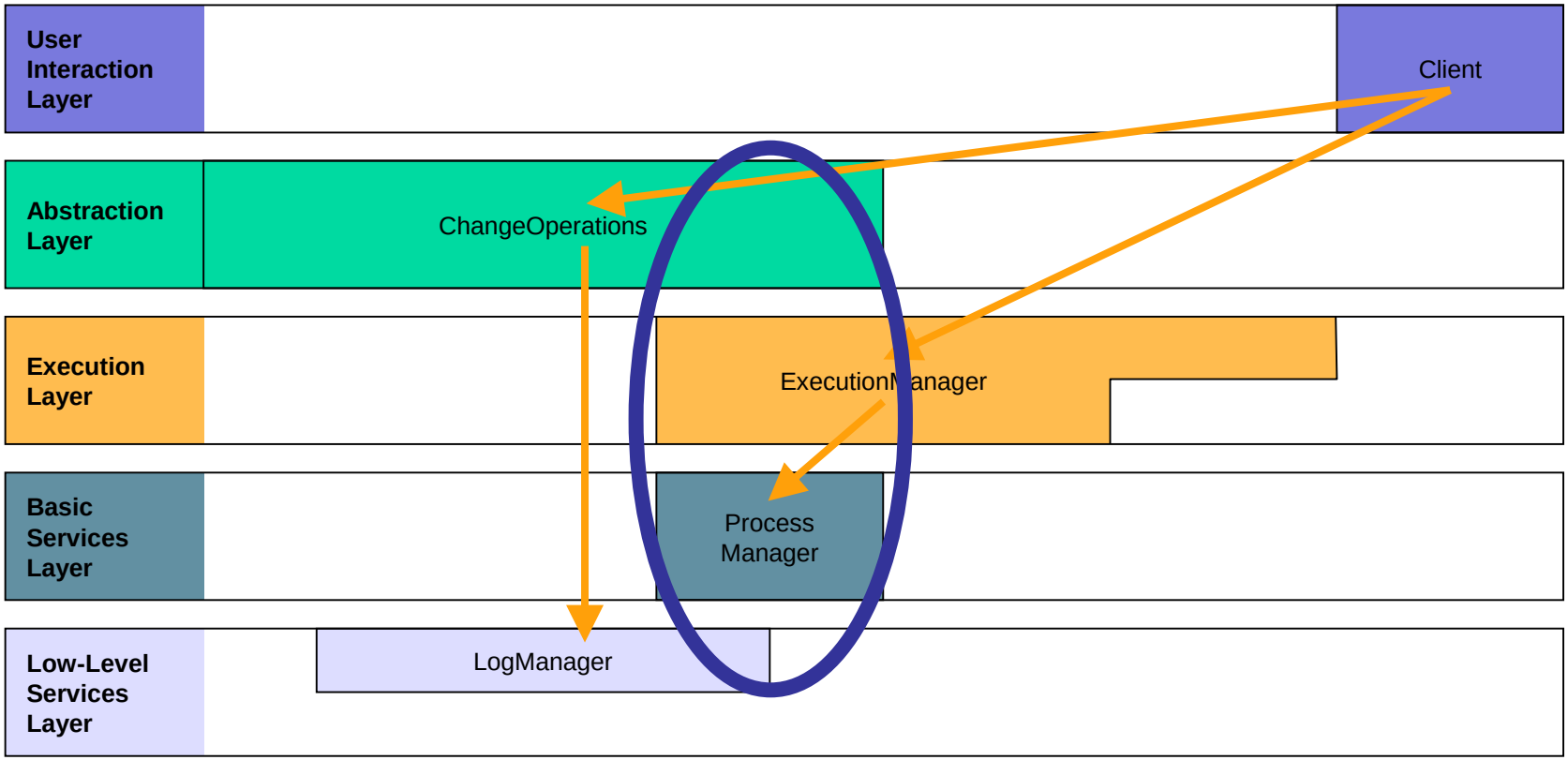
Process Designer

End User





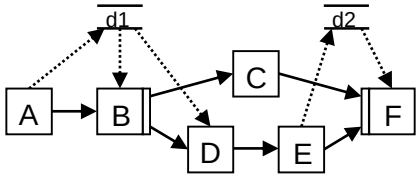
- Ease of use, high flexibility
- Schema and state correctness
- Isolated changes
- Potentially large numbers of changed instances



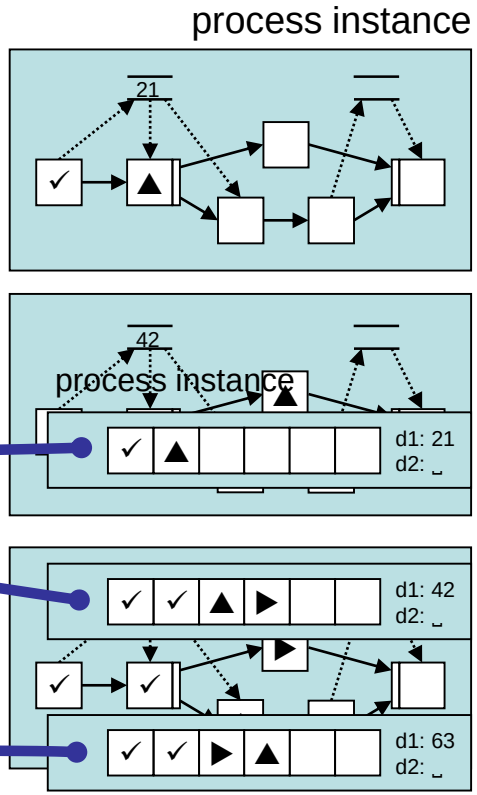
Engineering of an Adaptive PAIS

Selected Implementation Concepts: Instance Representation

- Linkage process instance – process template
  - template clones (VG-1)
  - template references (VG-2)



process template



	VG-1	VG-2
memory usage (NR 1)	-	++
schema evolution (NR1, NR 4)	--	++
access (NR 1)	+	O
partitioning (NR 1)	+	++

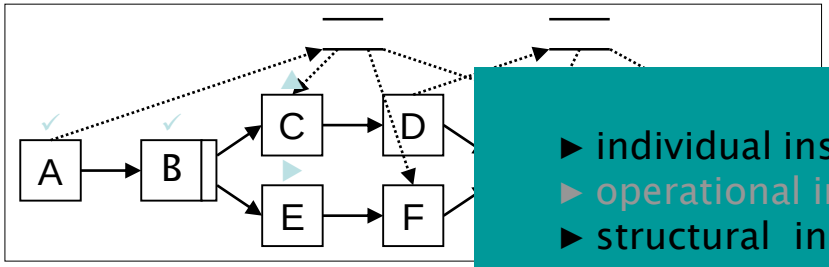
▲	ACT	activated
▶	RUN	running
✓	COMPL	completed

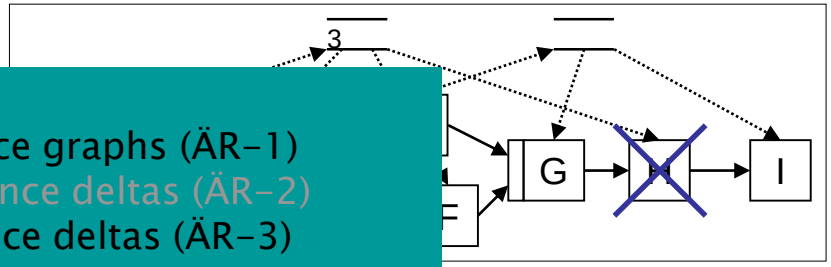
Engineering of an Adaptive PAIS

Selected Implementation Concepts: Representing Instance Changes

Process designer

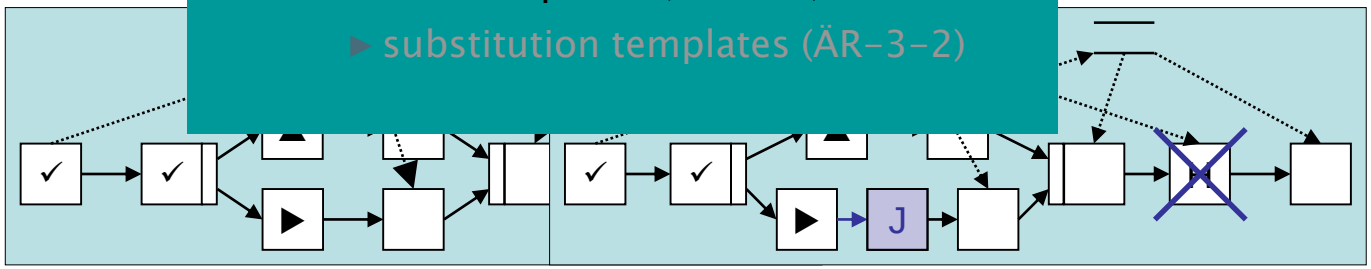
End user



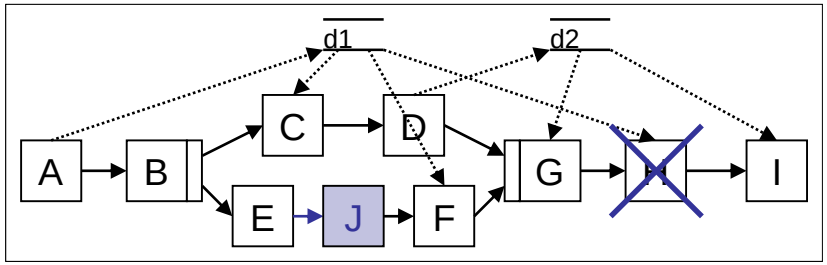


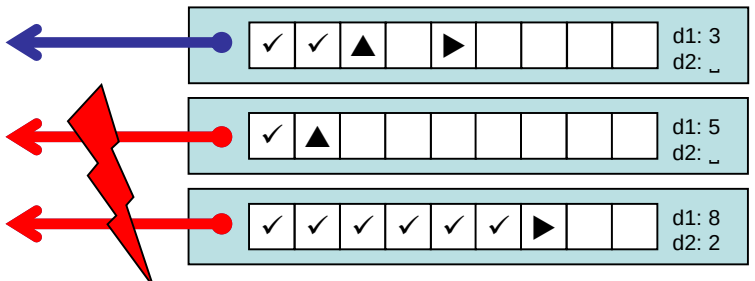
- individual instance graphs (ÄR-1)
- operational instance deltas (ÄR-2)
- structural instance deltas (ÄR-3)
  - sub-templates (ÄR-3-1)
  - substitution templates (ÄR-3-2)

template clone (VG-1)



template reference (VG-2)

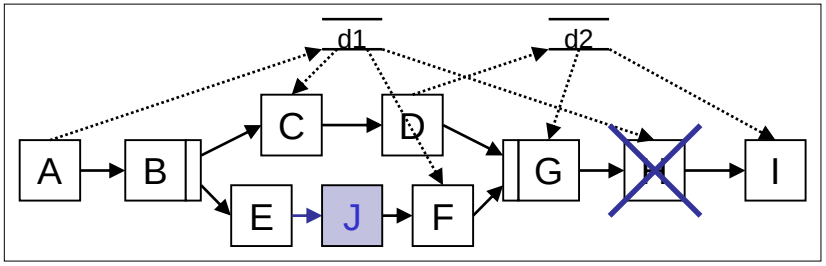




Engineering of an Adaptive PAIS

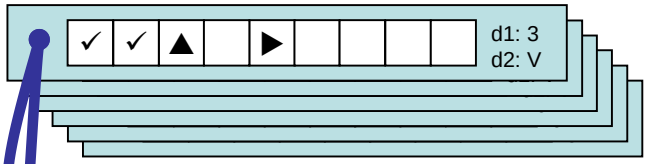
Selected Implementation Concepts: Representing Instance Changes

individual instance graphs (ÄR-1)

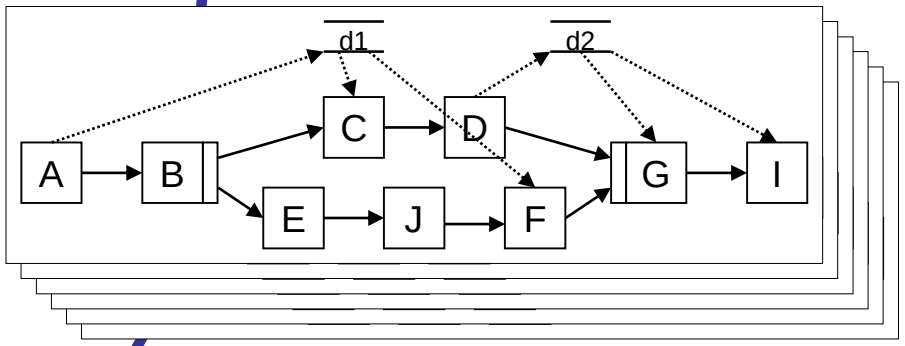


resulting process template

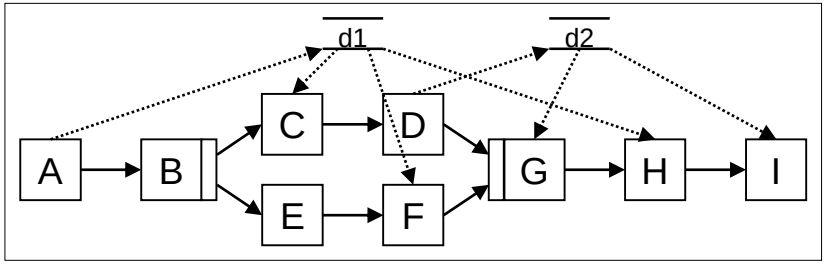
process instance



individual instance graph



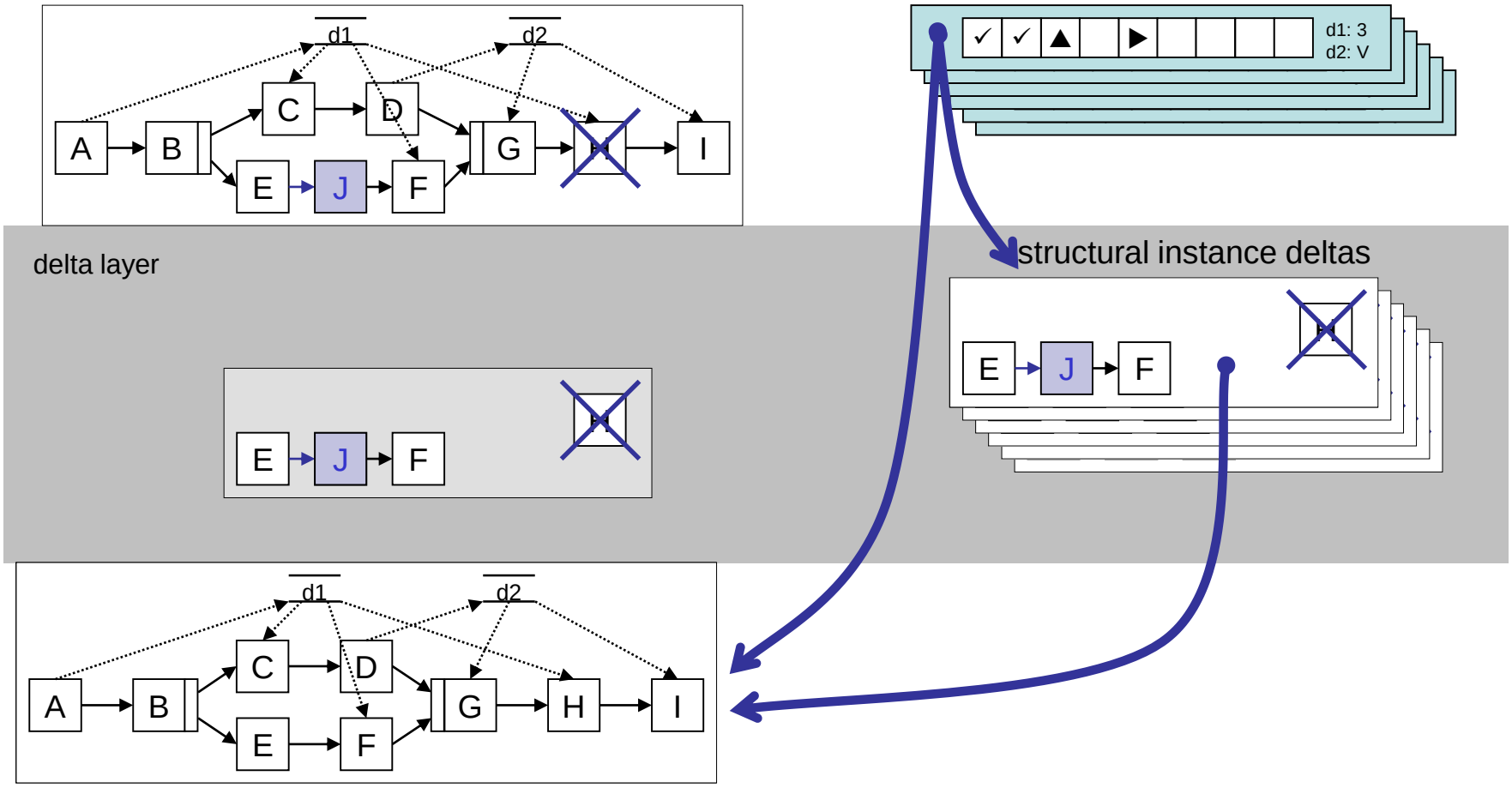
process template



Engineering of an Adaptive PAIS

Selected Implementation Concepts: Representing Instance Changes

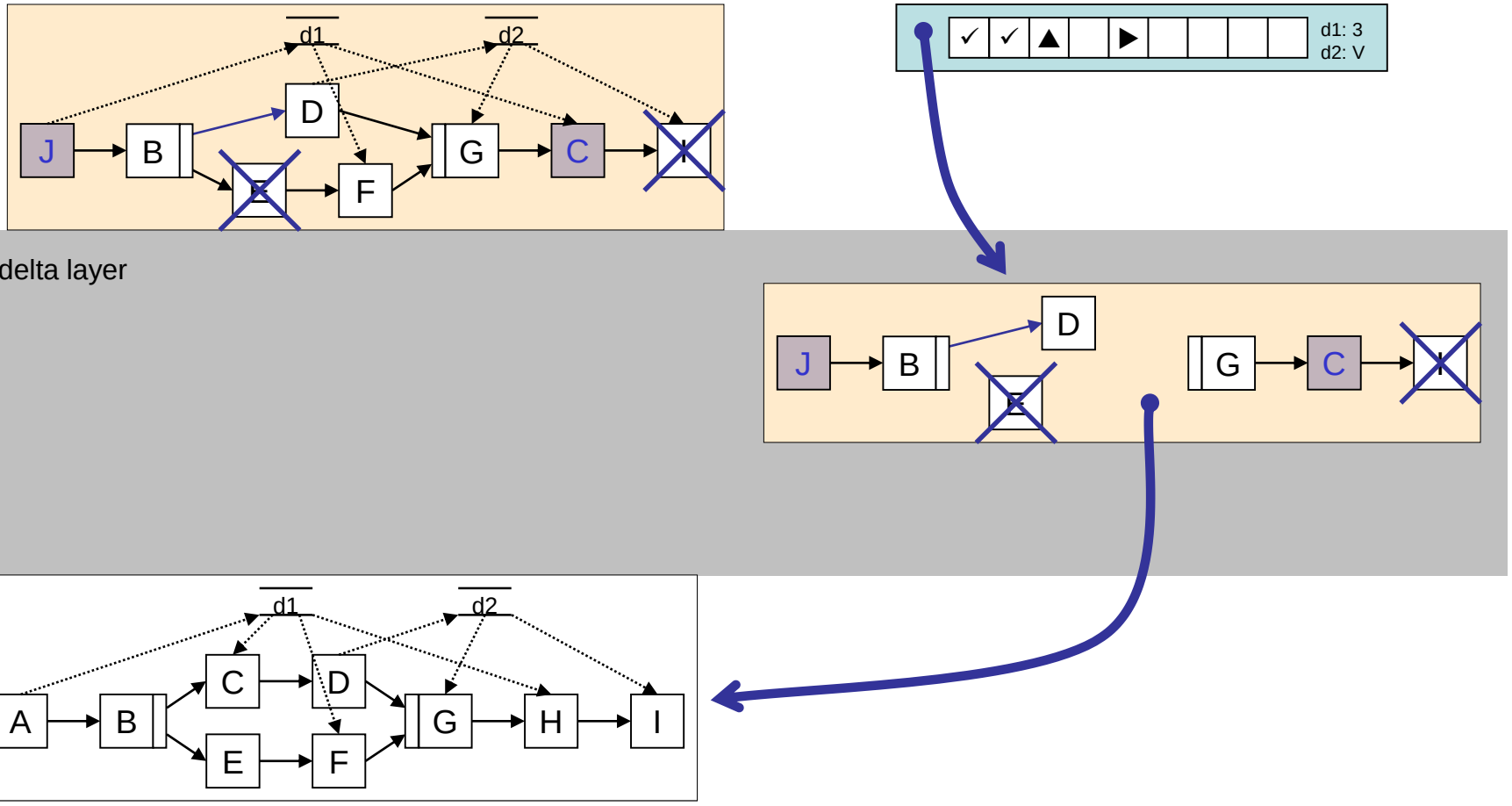
structural instance deltas (ÄR-3)



Engineering of an Adaptive PAIS

Selected Implementation Concepts: Representing Instance Changes

Complex changes when using ÄR-3

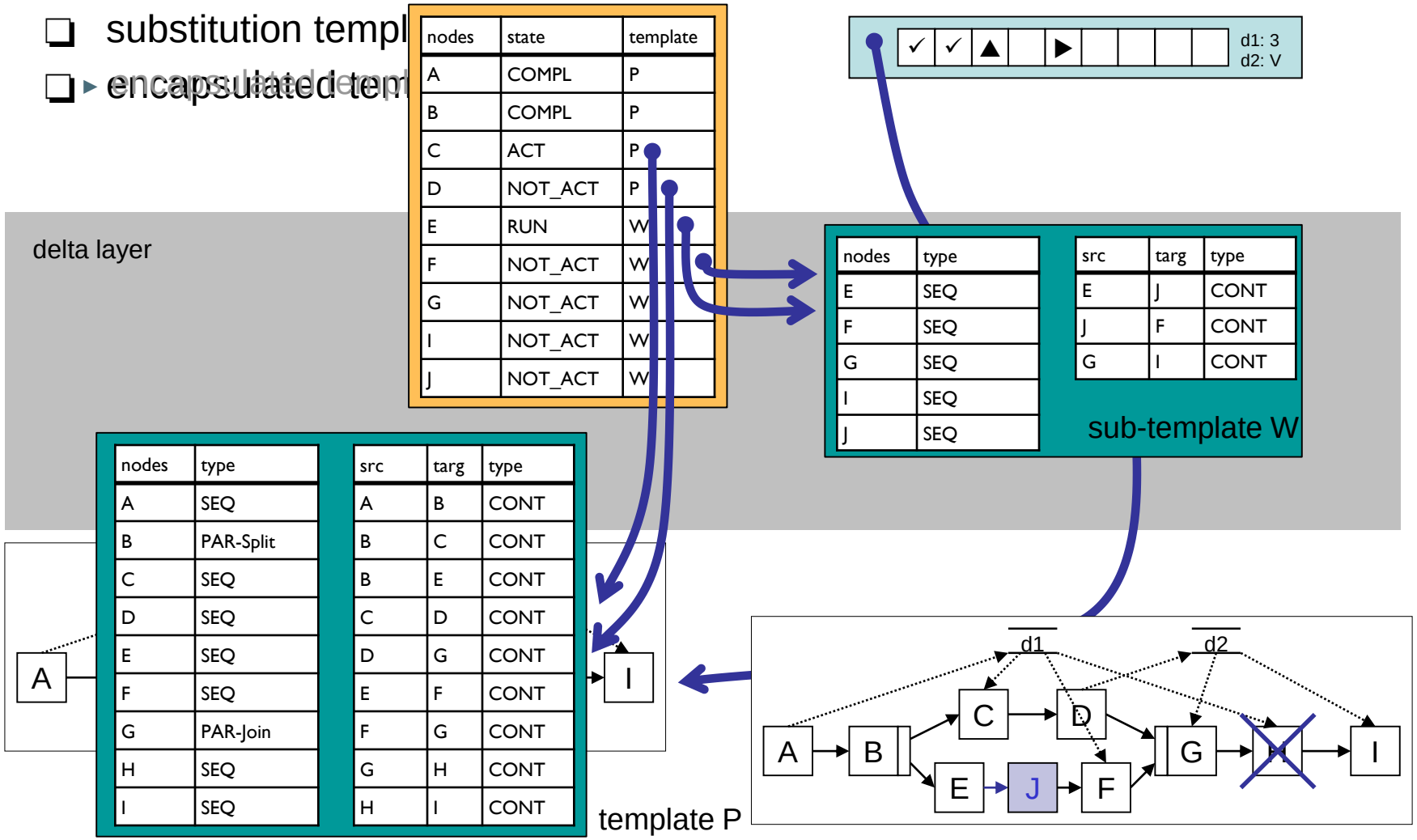


Engineering of an Adaptive PAIS

Selected Implementation Concepts: Representing Instance Changes

Implementation

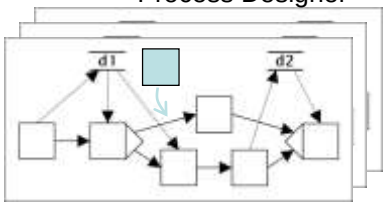
- substitution templ
- encapsulated temp

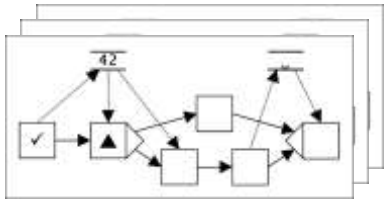


Engineering of an Adaptive PAIS

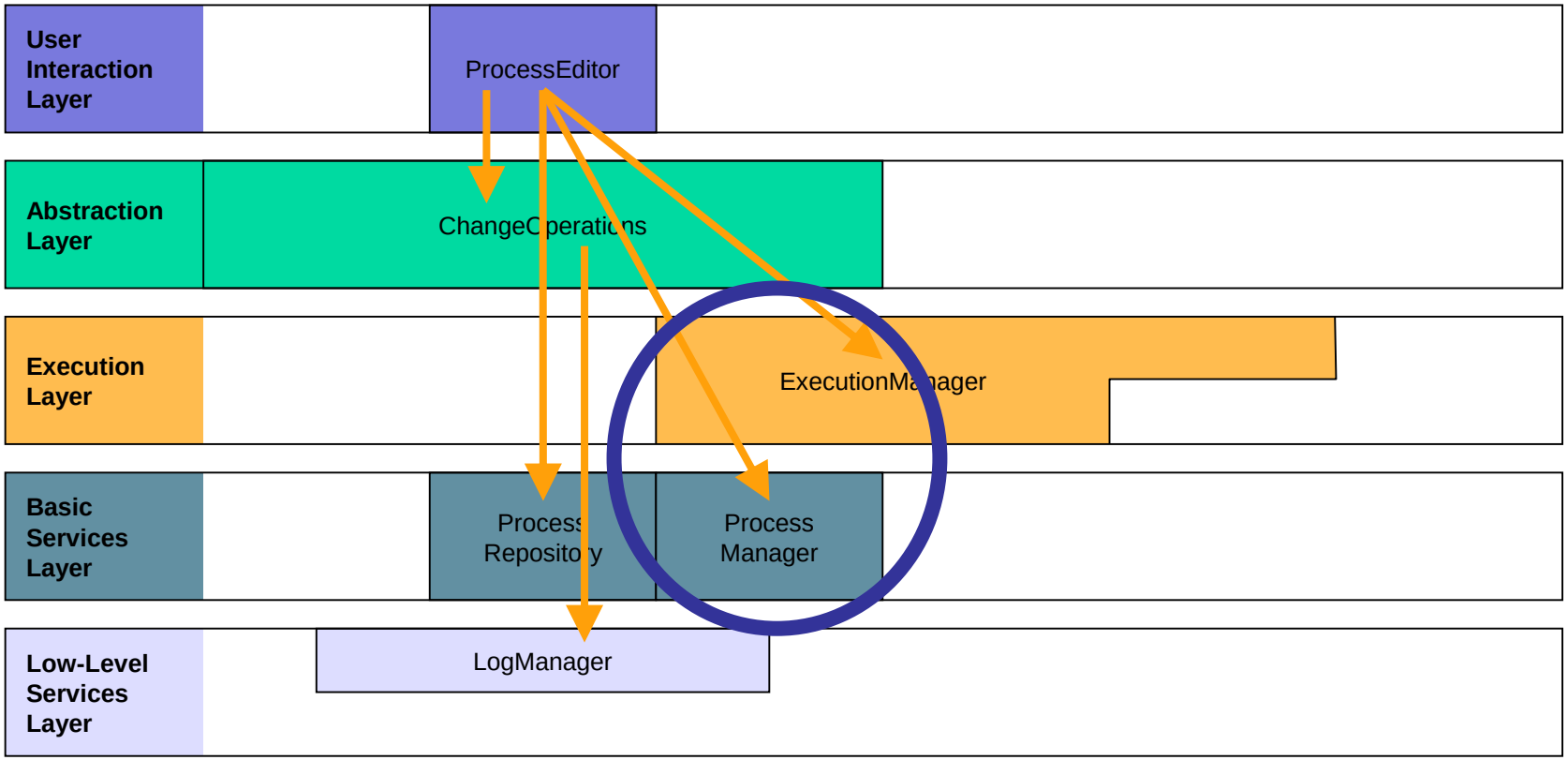
Advanced Architecture: Process Schema Evolution

Process Designer





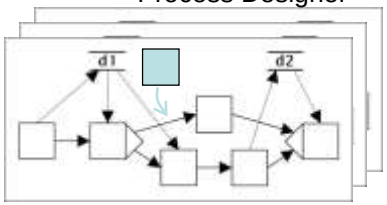
- Ease of use
- Correctness (e.g. state compliance)
- (Efficient) Migration of a potentially large number of process instances

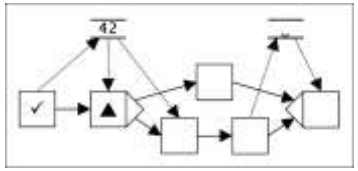


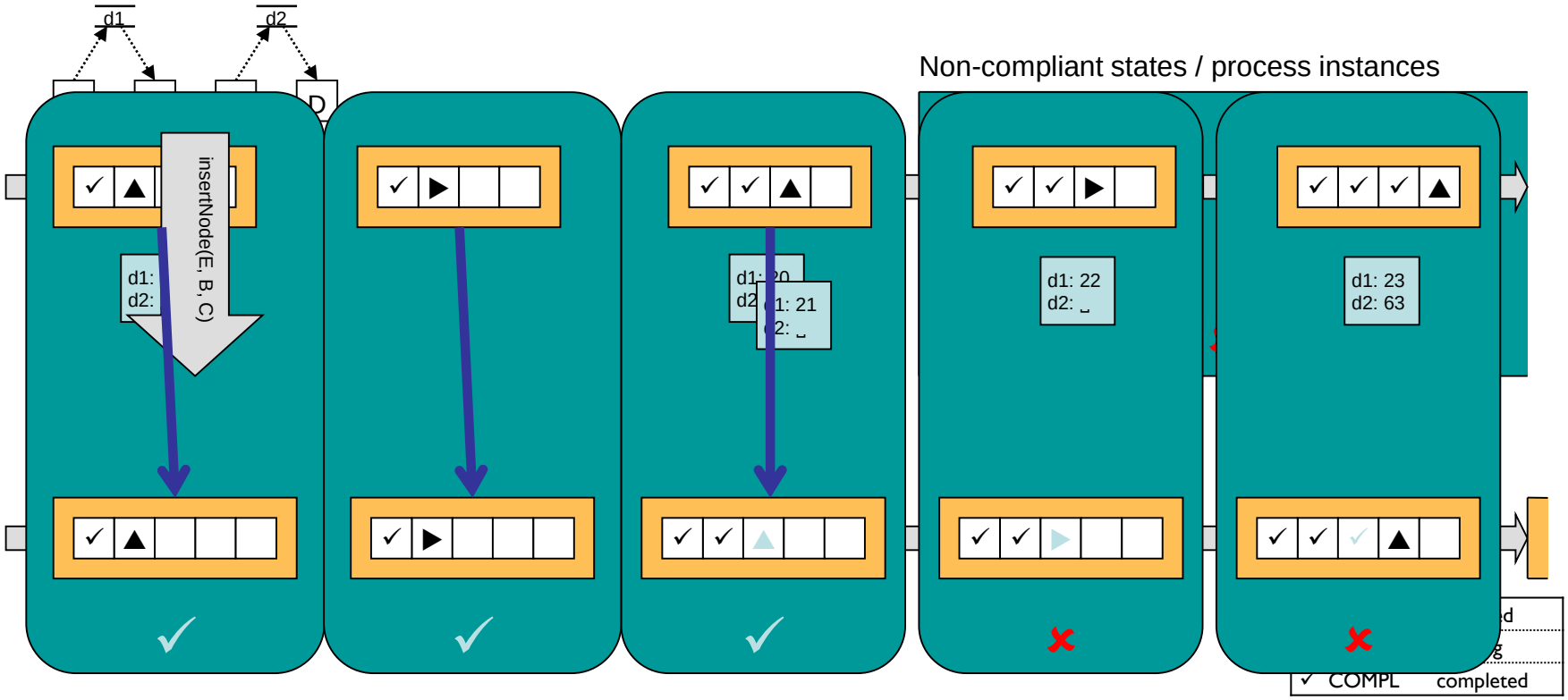
Engineering of an Adaptive PAIS

Process Schema Evolution: State-based Instance Clustering

Process Designer

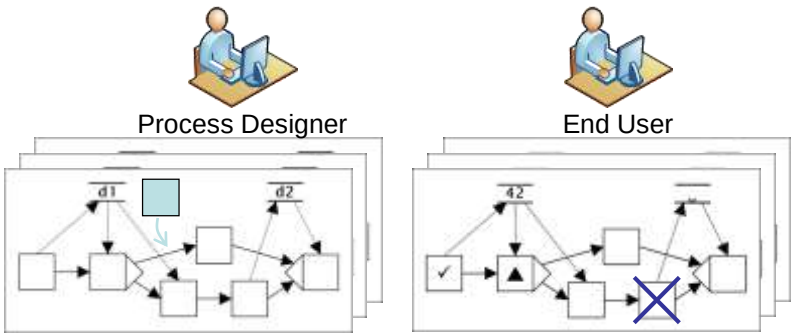




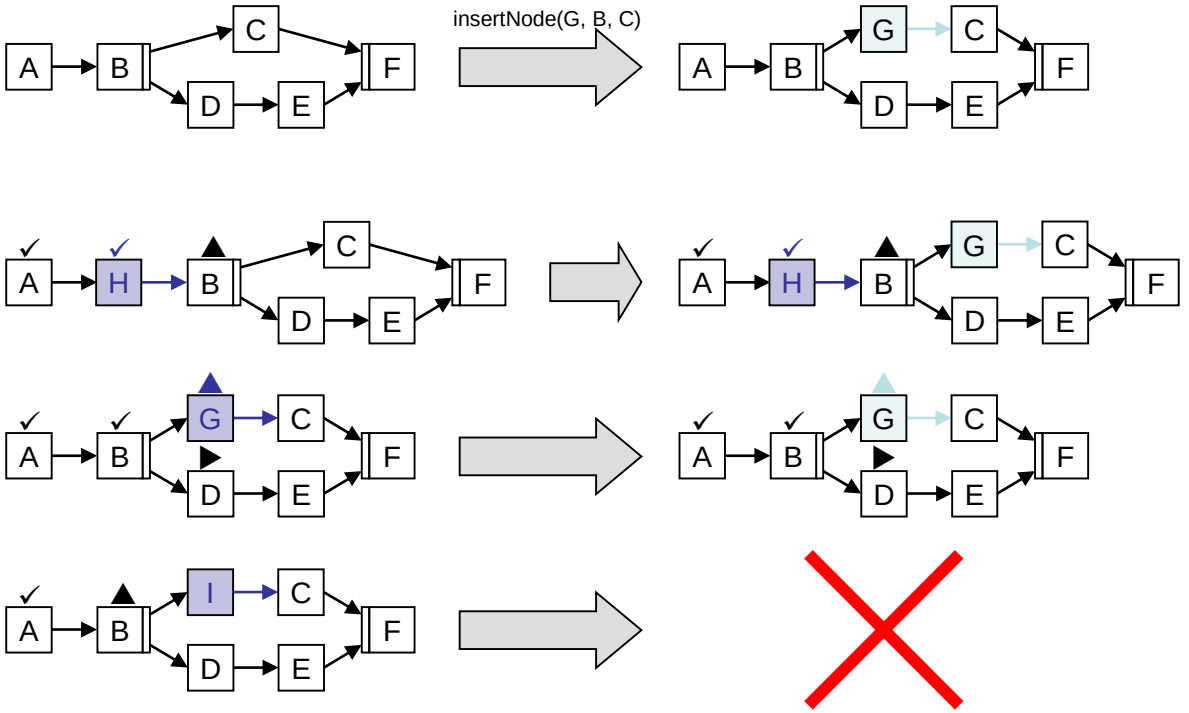


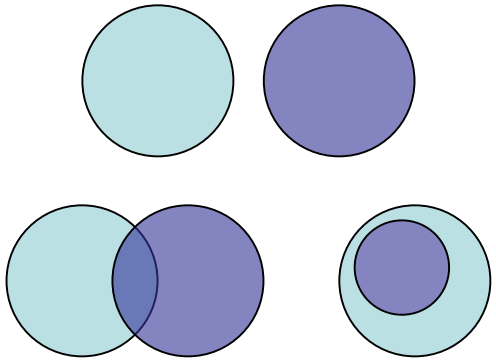
Engineering of an Adaptive PAIS

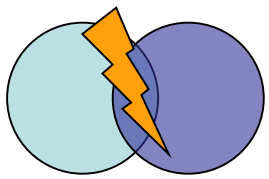
Combing Instance Adaptation and Schema Evolution



- Additionally considering structural correctness
- Minimality of changes
- Coping with conflicting (e.g. non-disjoint) changes at type and instance level
- Equality of process activities
- Efficiently dealing with large numbers of biased process instances

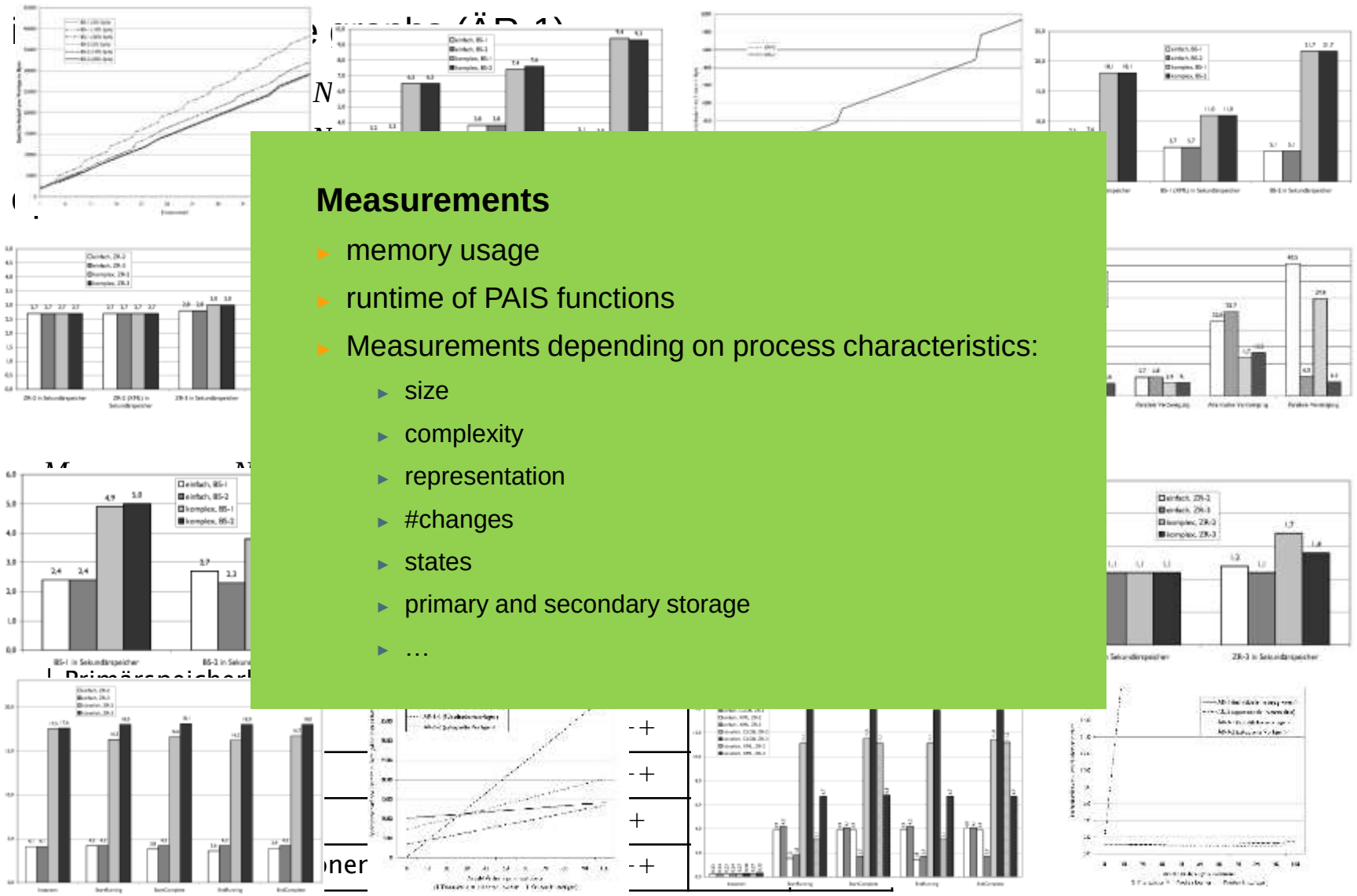






Engineering of an Adaptive PAIS

Assessing Implementation Concepts

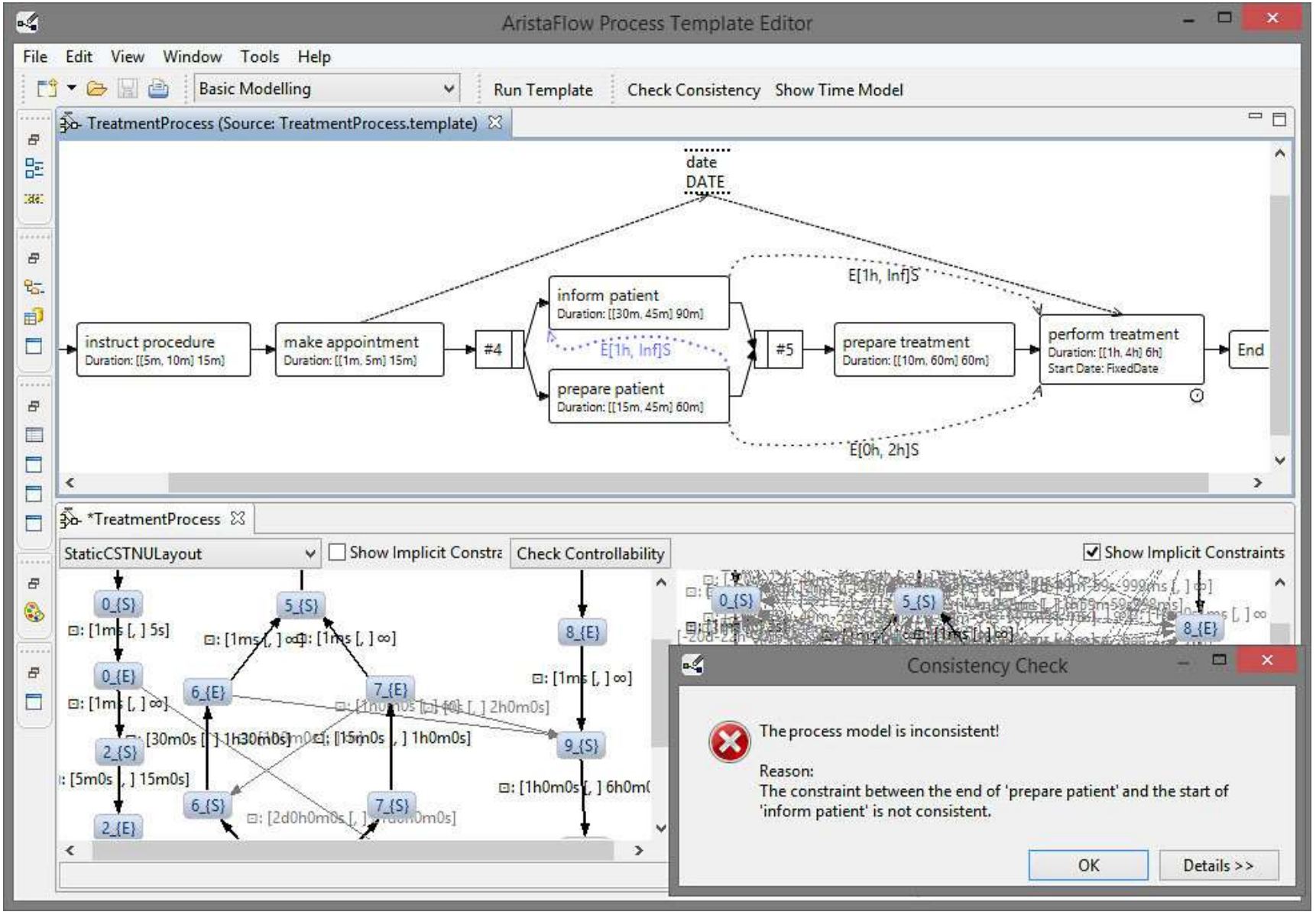


Measurements

- memory usage
- runtime of PAIS functions
- Measurements depending on process characteristics:
  - size
  - complexity
  - representation
  - #changes
  - states
  - primary and secondary storage
  - …

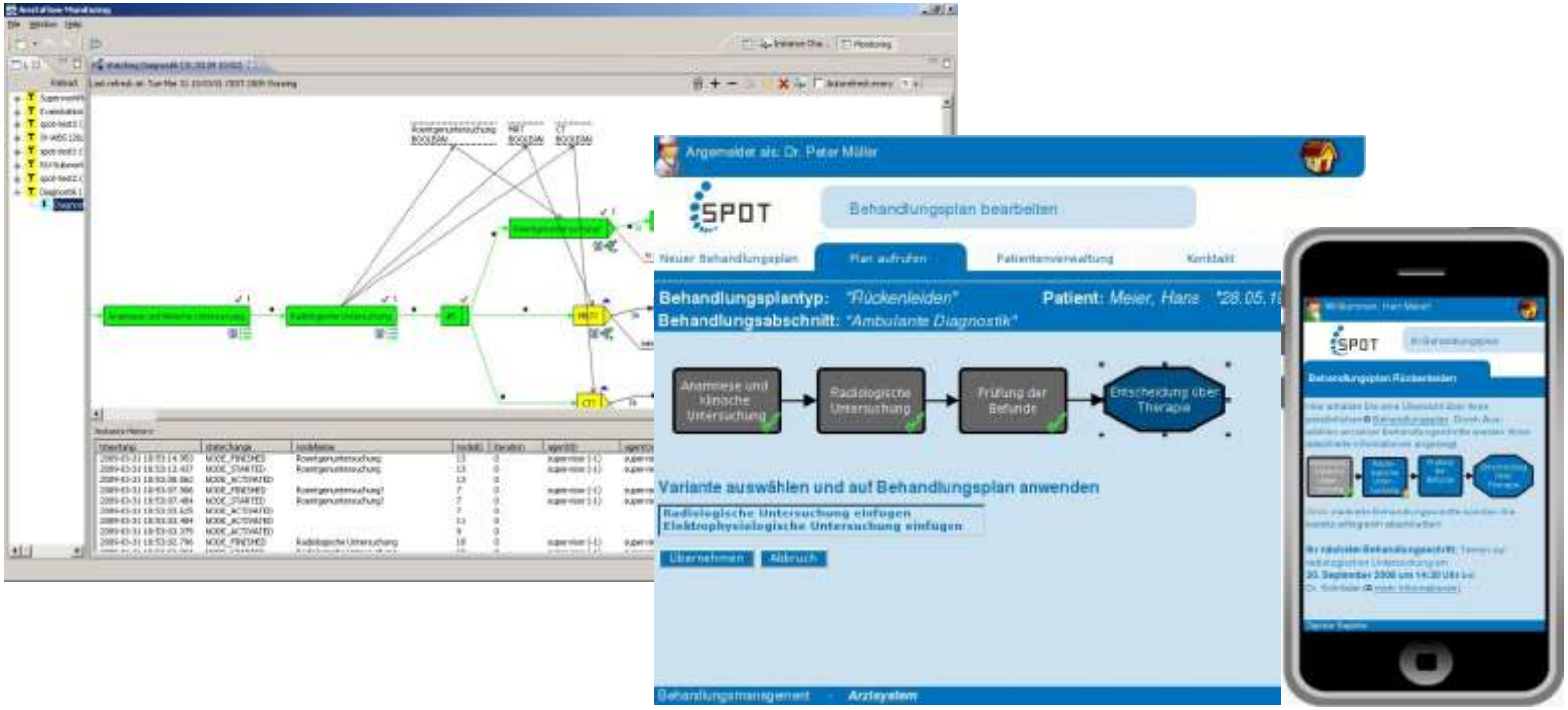
The AristaFlow BPM Suite – A Successful Research Transfer

Applying AristaFlow in our own Research



Lanz A., Posenato R., Combi C., Reichert, M. (2014): Controllability of Time-Aware Processes at Run-Time, Proc. CoopIS'14, pp. 39-56

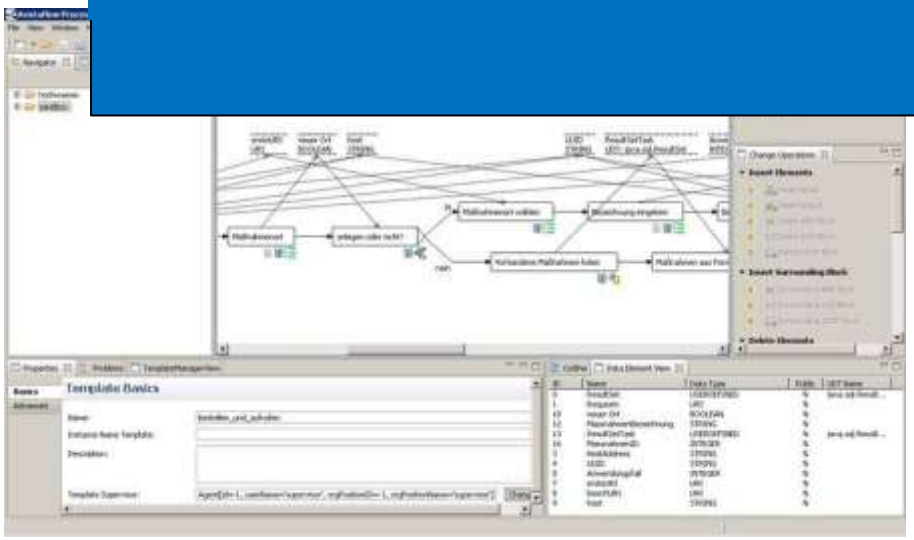
PAIS Engineering based on AristaFlow
Clinical Pathway Support



PAIS Engineering based on AristaFlow
Disaster Management with AristaFlow BPM Suite

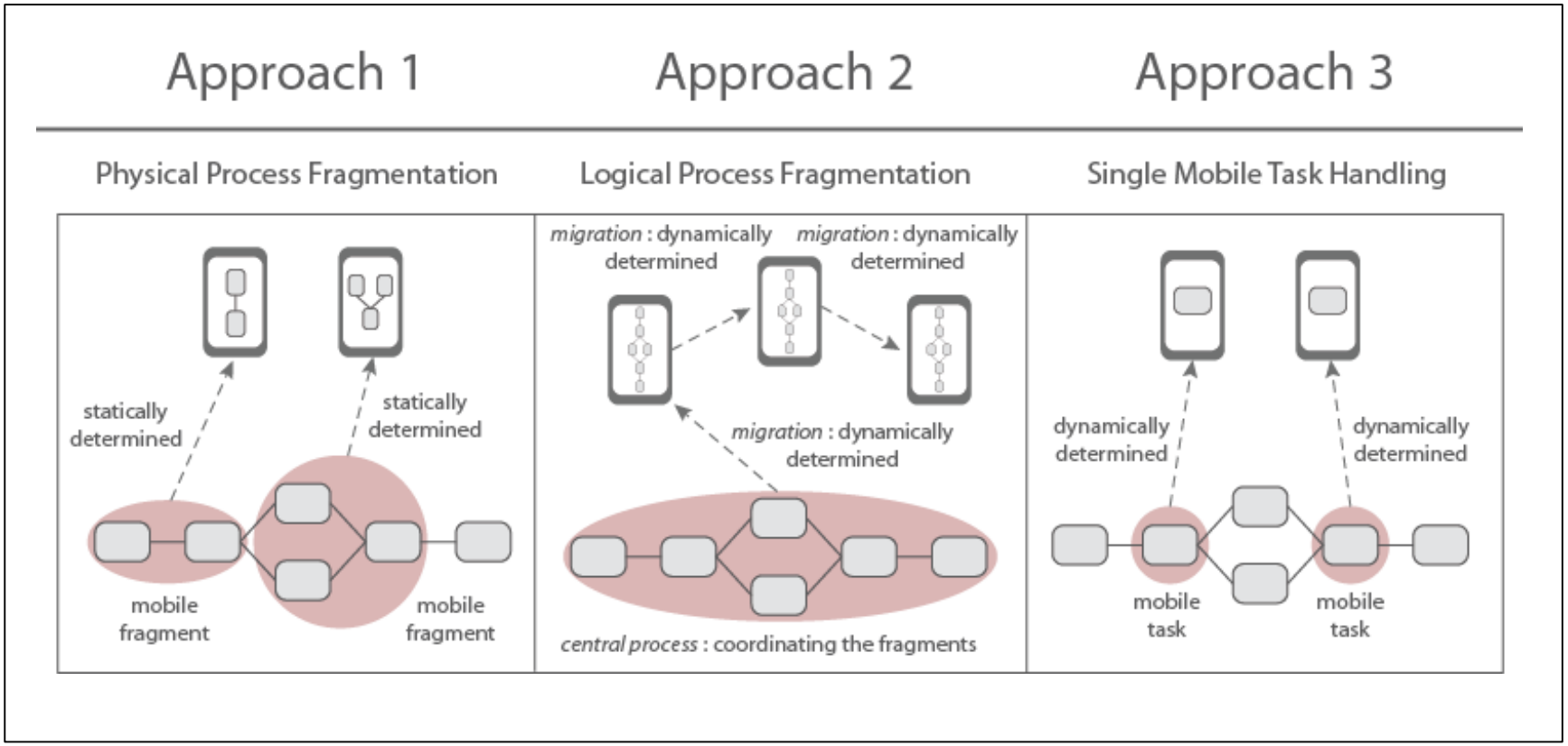
Process-aware, Cooperative Emergency Management for Water Infrastructures

Lessons Learned?



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

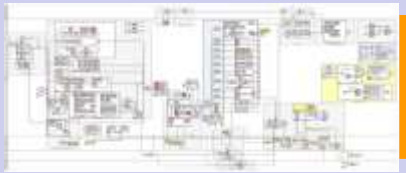
AristaFlow goes Mobile:
Mobile Process and Task Support



AristaFlow goes Mobile:
Mobile Process and Task Support

Process Management System

controls



Context-specific execution of mobile activities, offline mode…

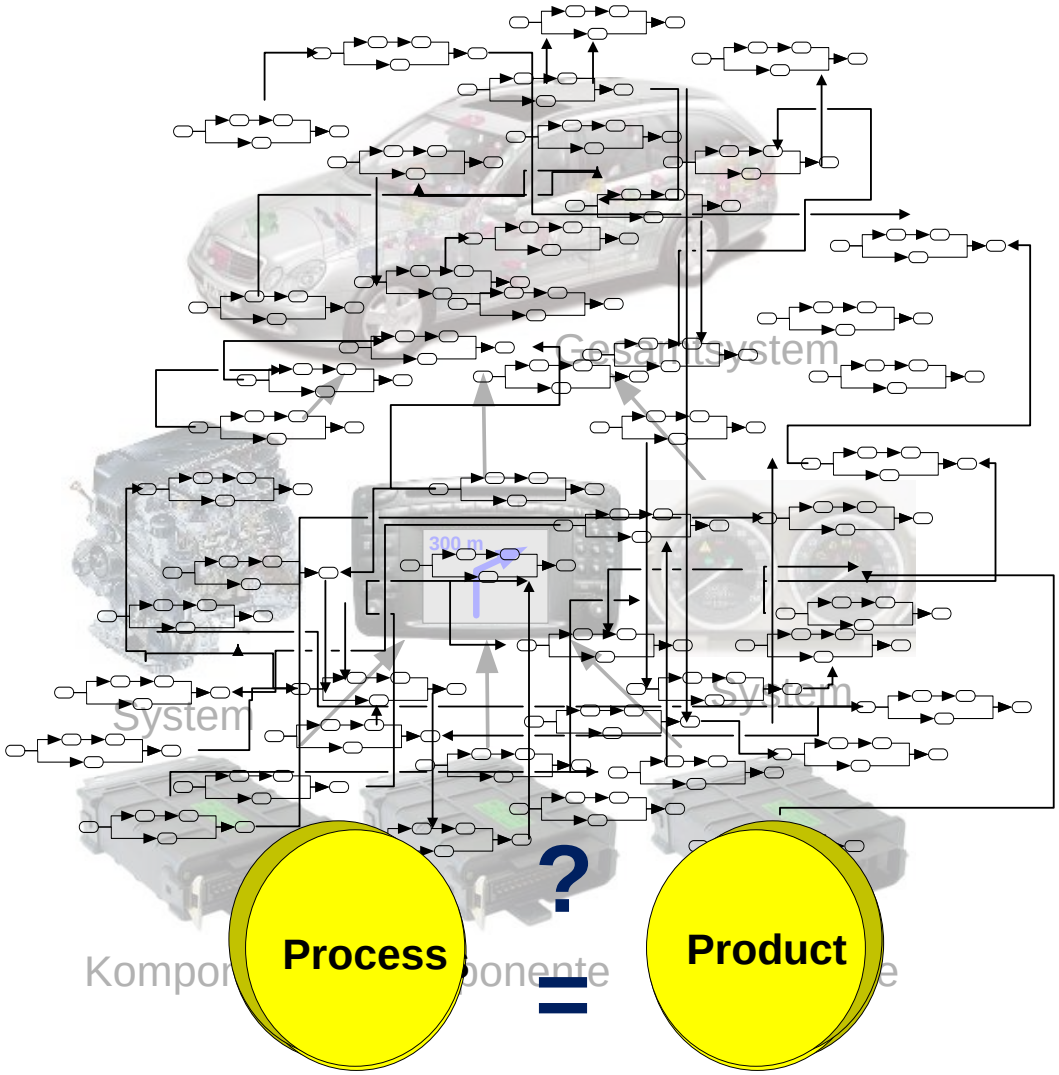
GSM, GPRS,UMTS
W-LAN

Assignment of mobile activities (protocol-based)

connection abortion, device error, user behavior, resources

Patient treatment

Dealing with Real-World Adaptive Collective Process Structures



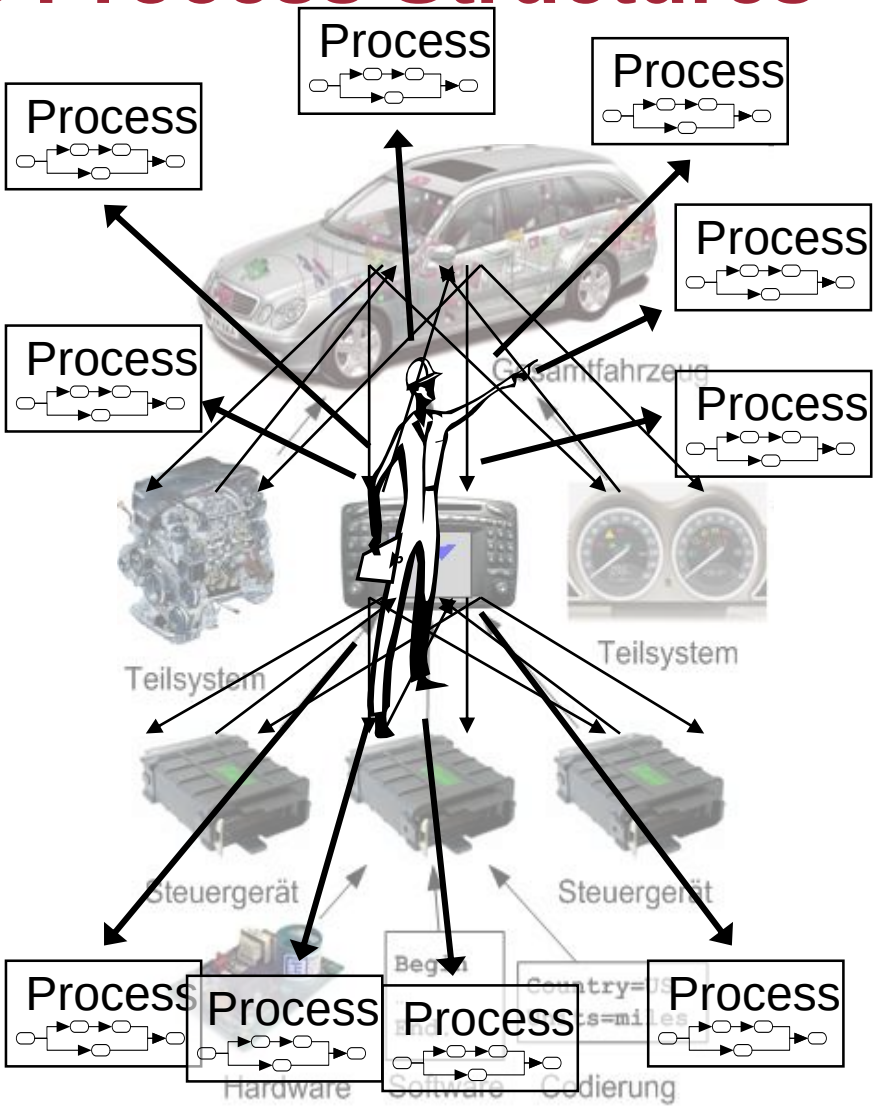
Dealing with Real-World Adaptive Collective Process Structures

Modeling

Execution

Dynamic Adaptation

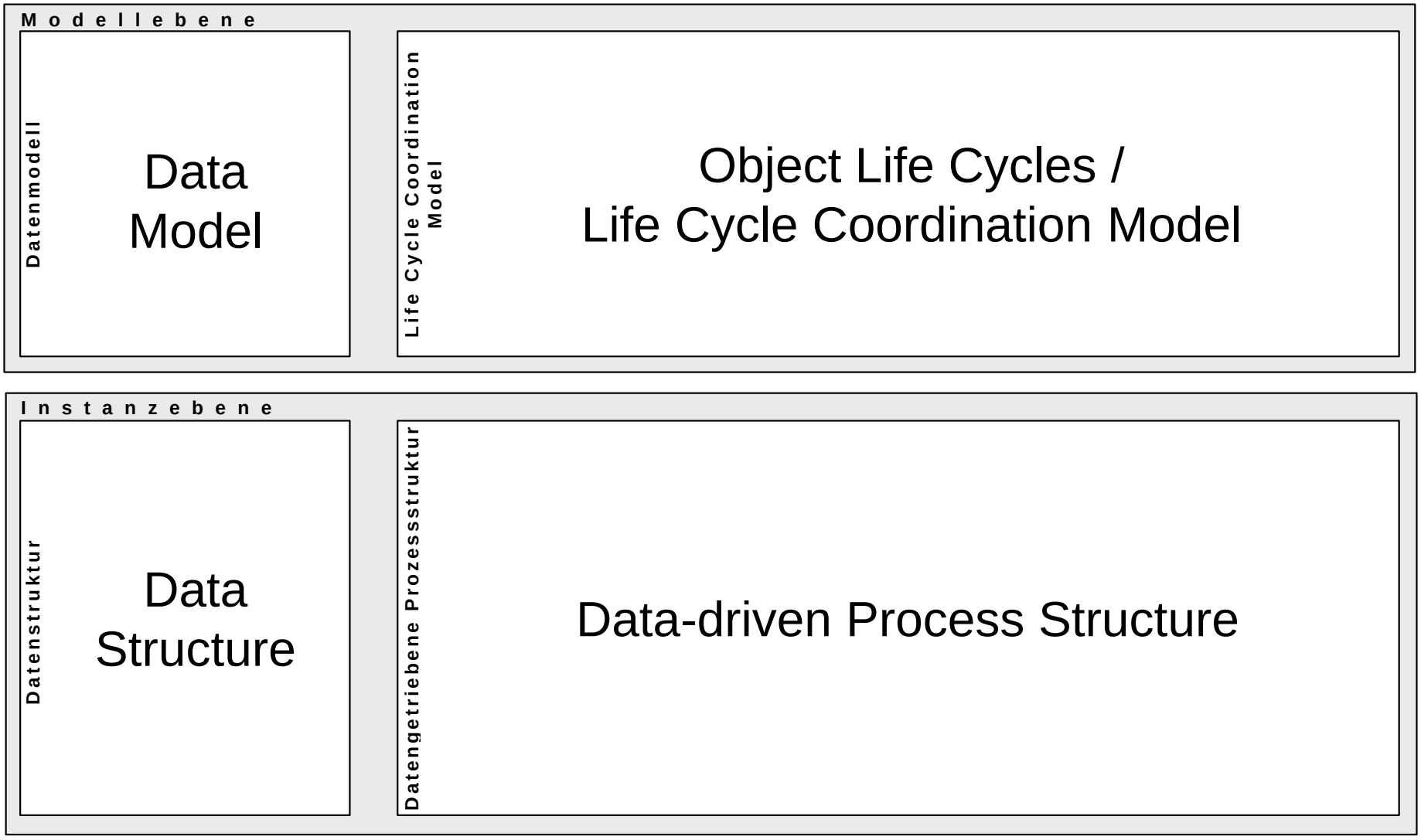
Exception Handling



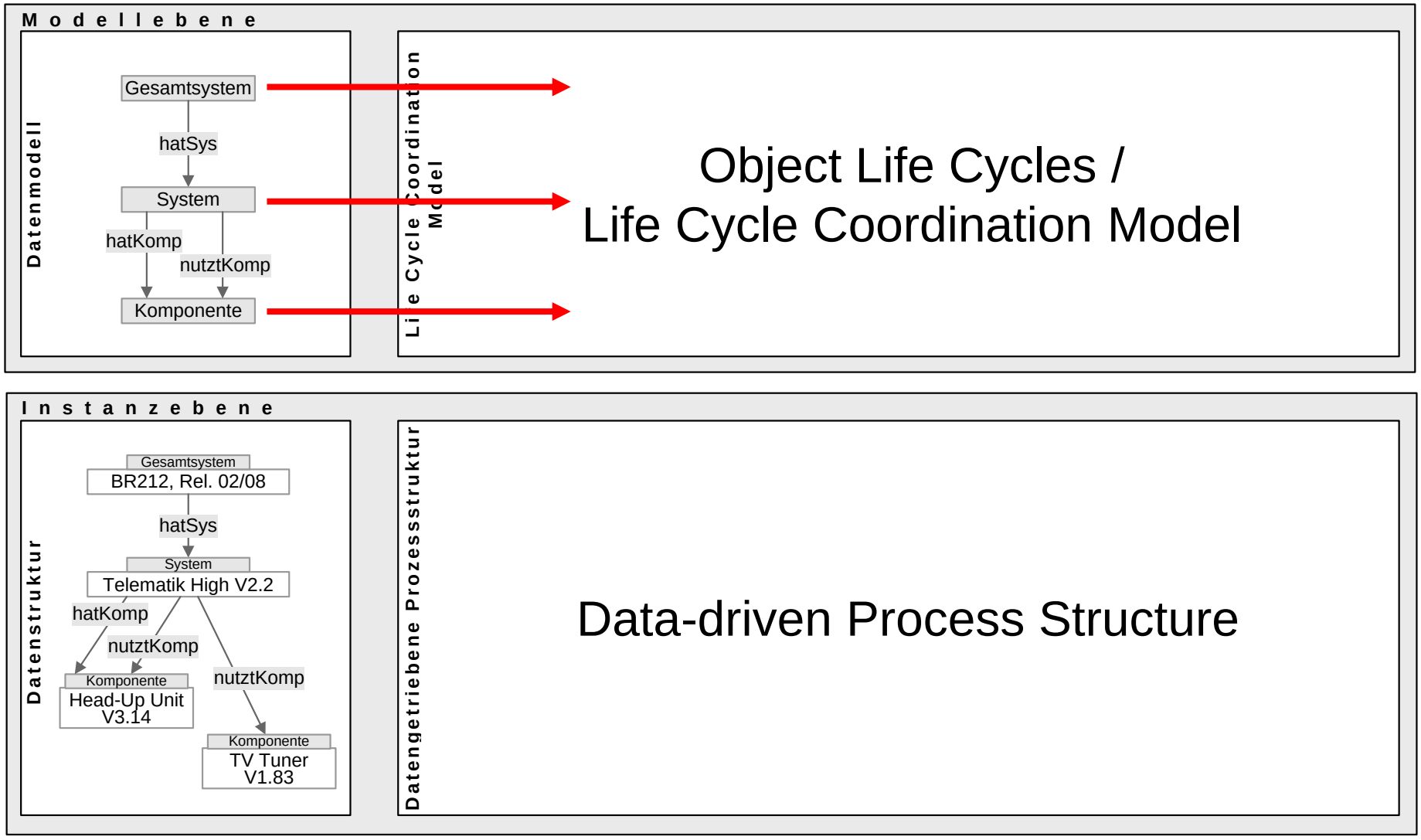
Process

Product

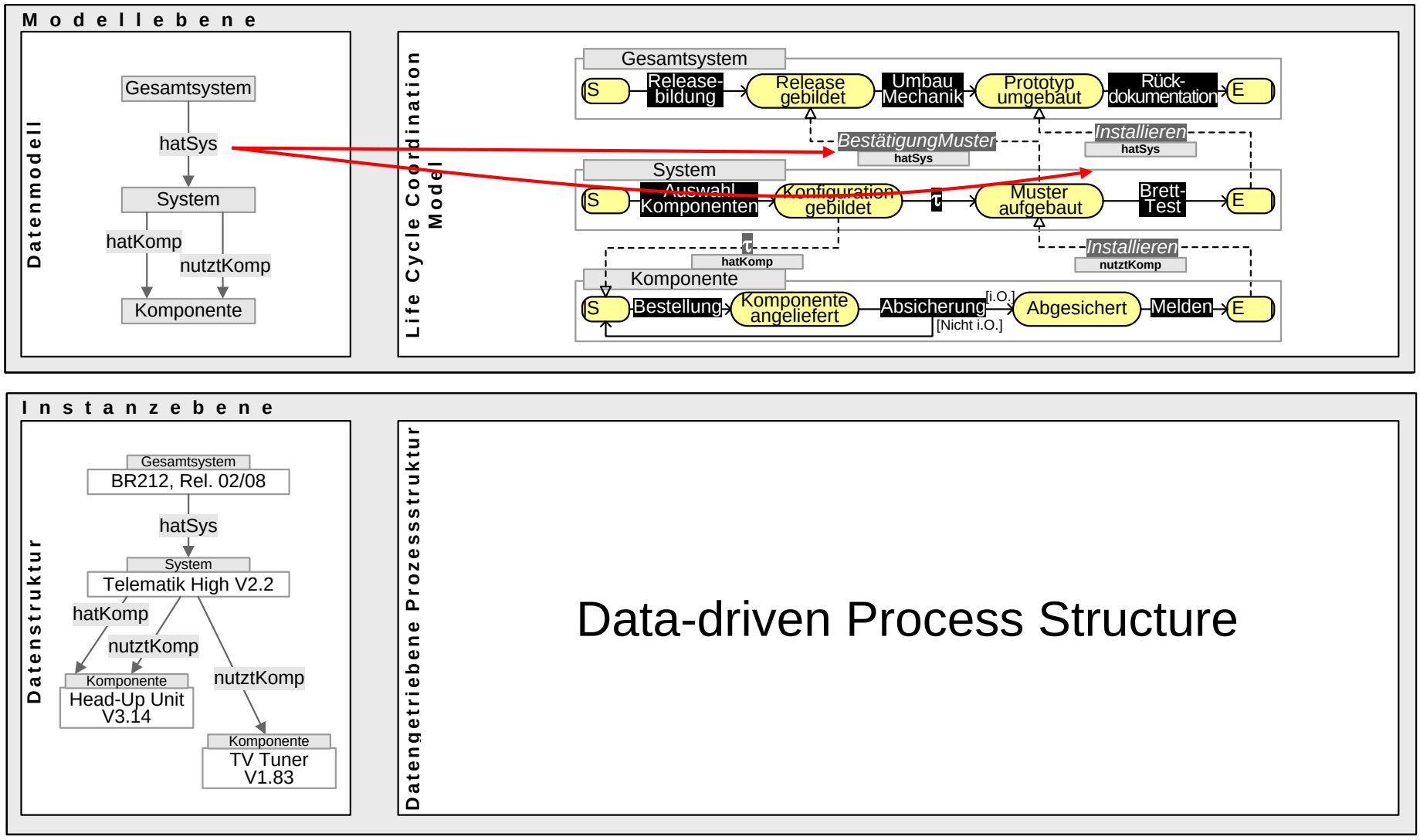
The Corepro Approach



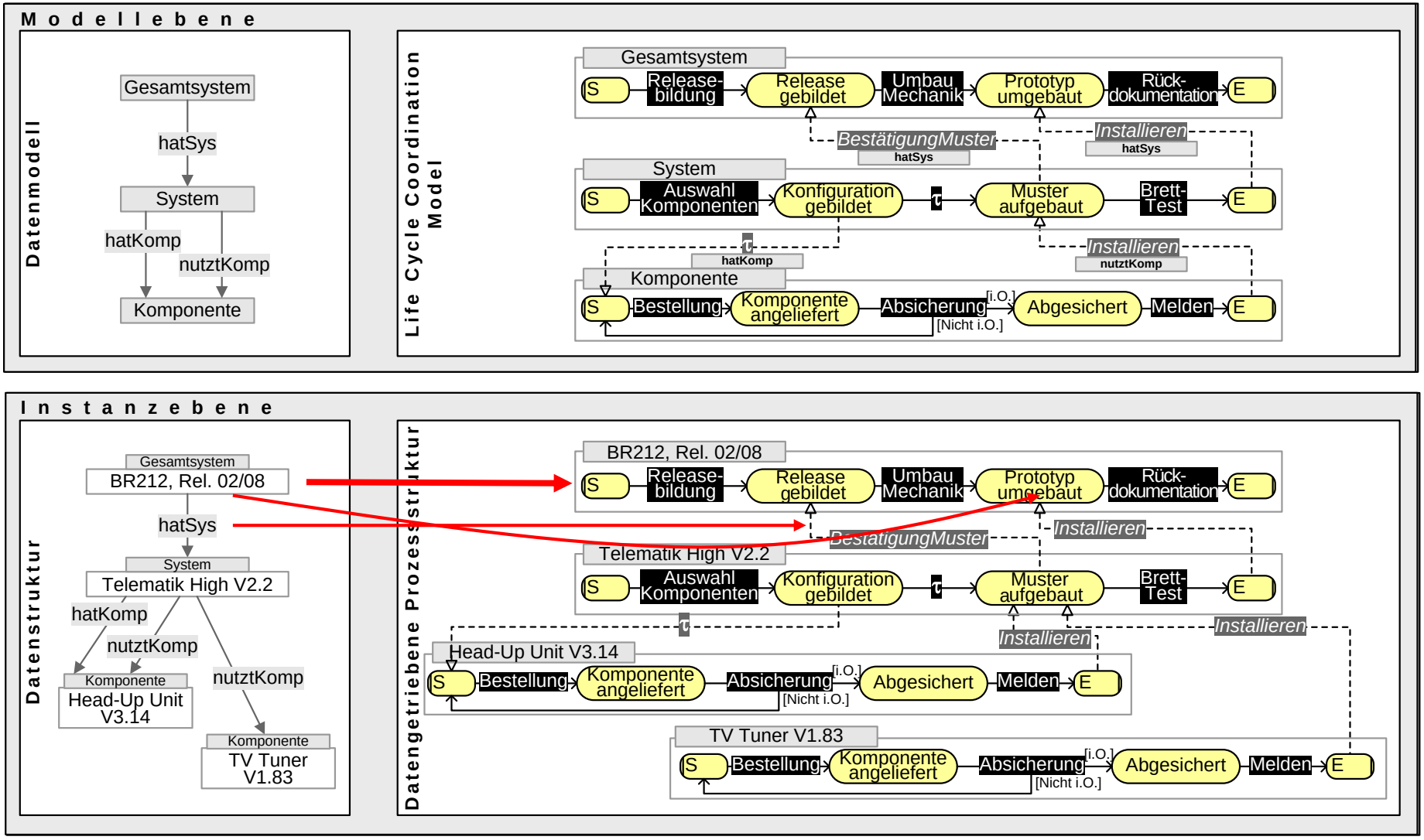
The Corepro Approach

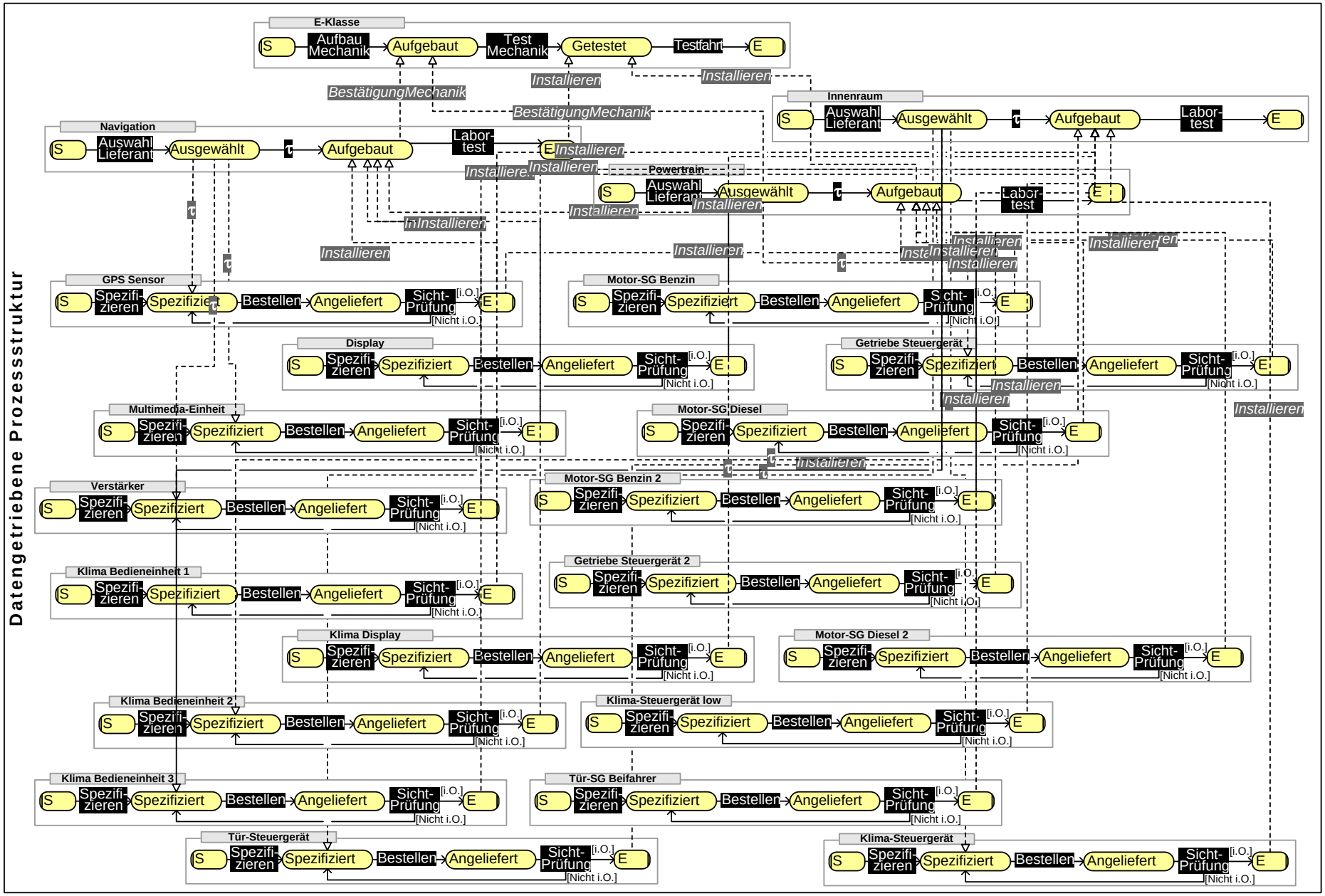


The Corepro Approach

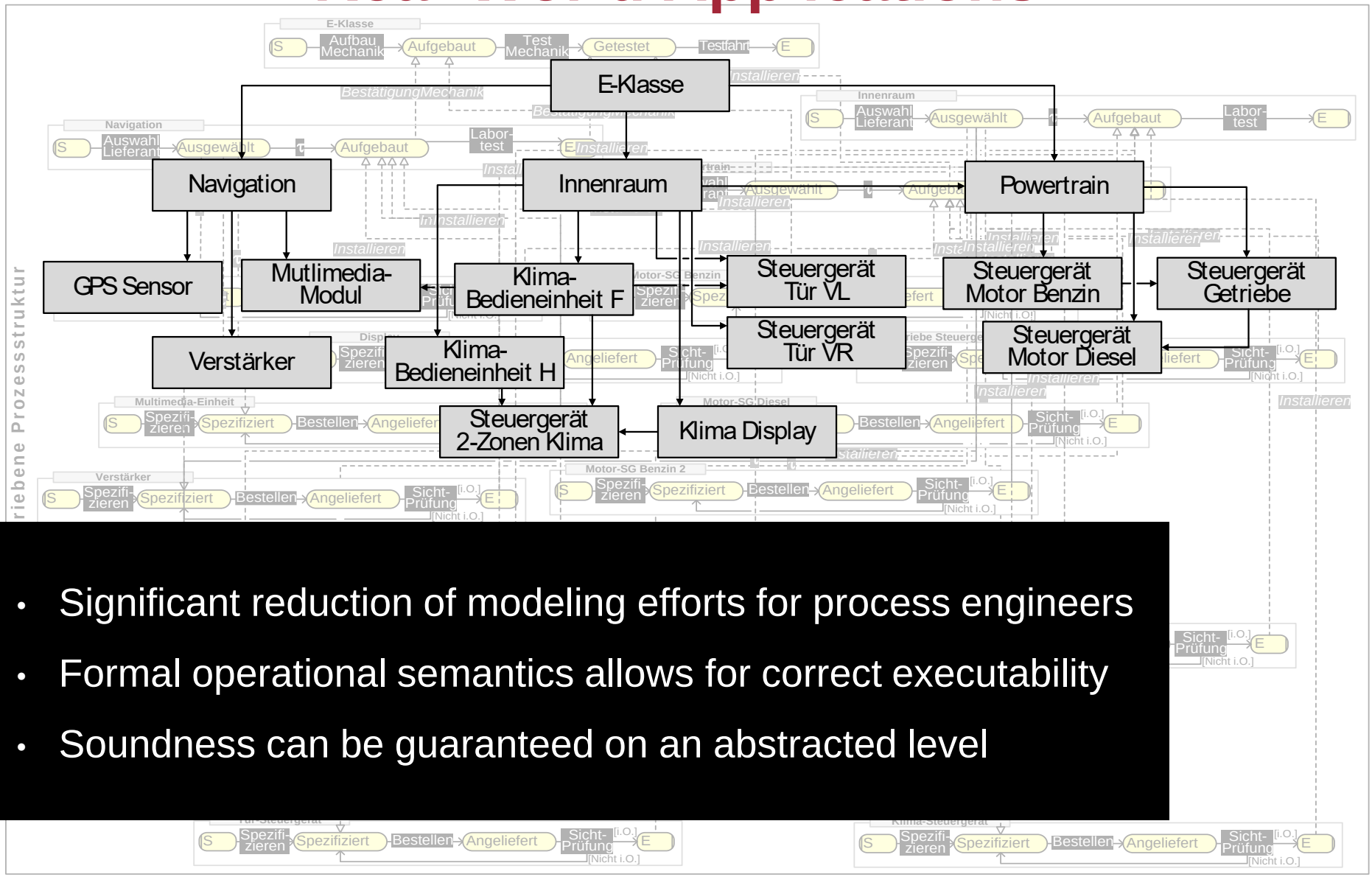


The Corepro Approach




Datengetriebene Prozessstruktur
E-Klasse
S
Aufbau Mechanik
Aufgebaut
Test Mechanik
Getestet
Testfahrt
E
Installieren
BestätigungMechanik
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

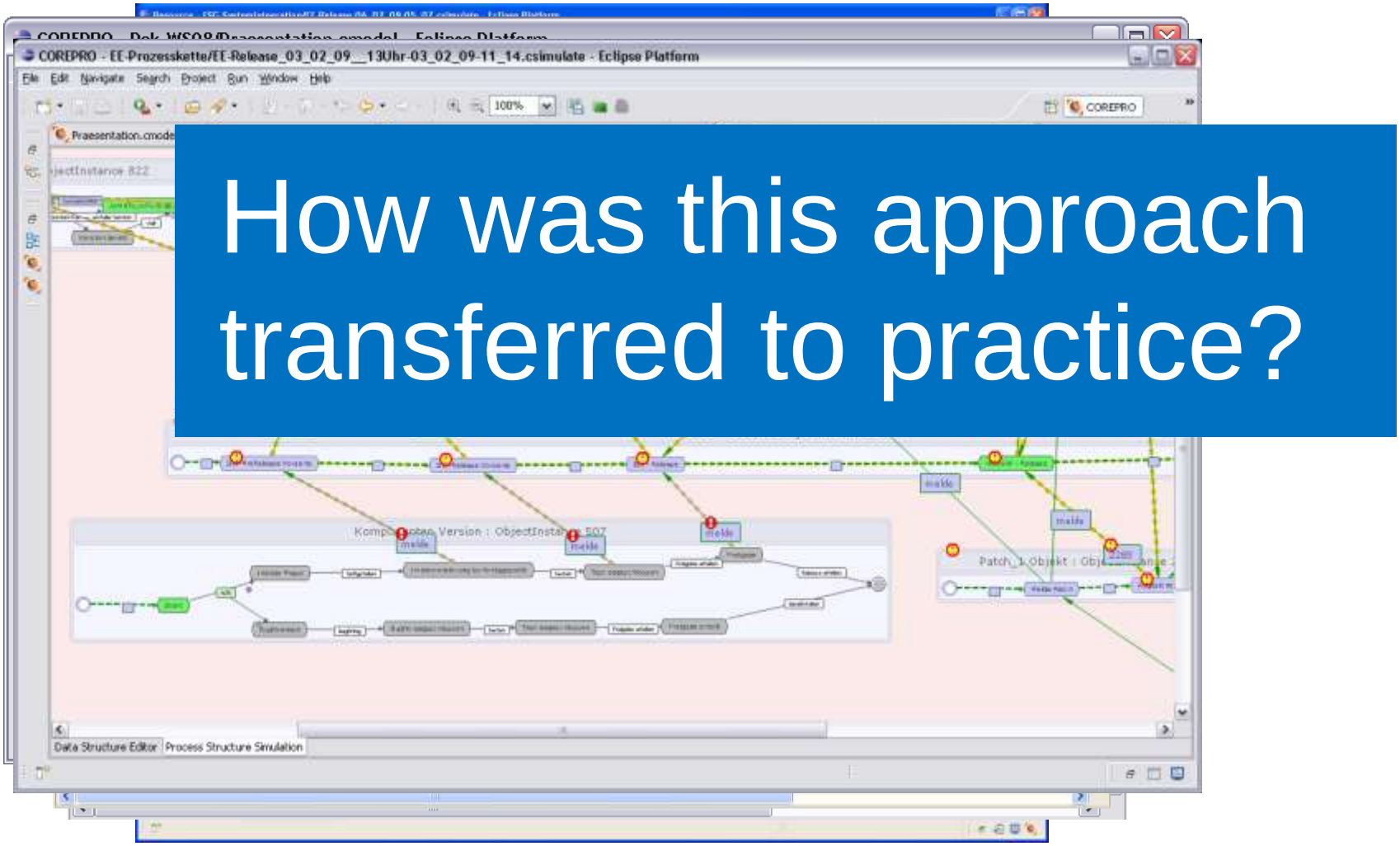
Real-World Applications



- Significant reduction of modeling efforts for process engineers
- Formal operational semantics allows for correct executability
- Soundness can be guaranteed on an abstracted level

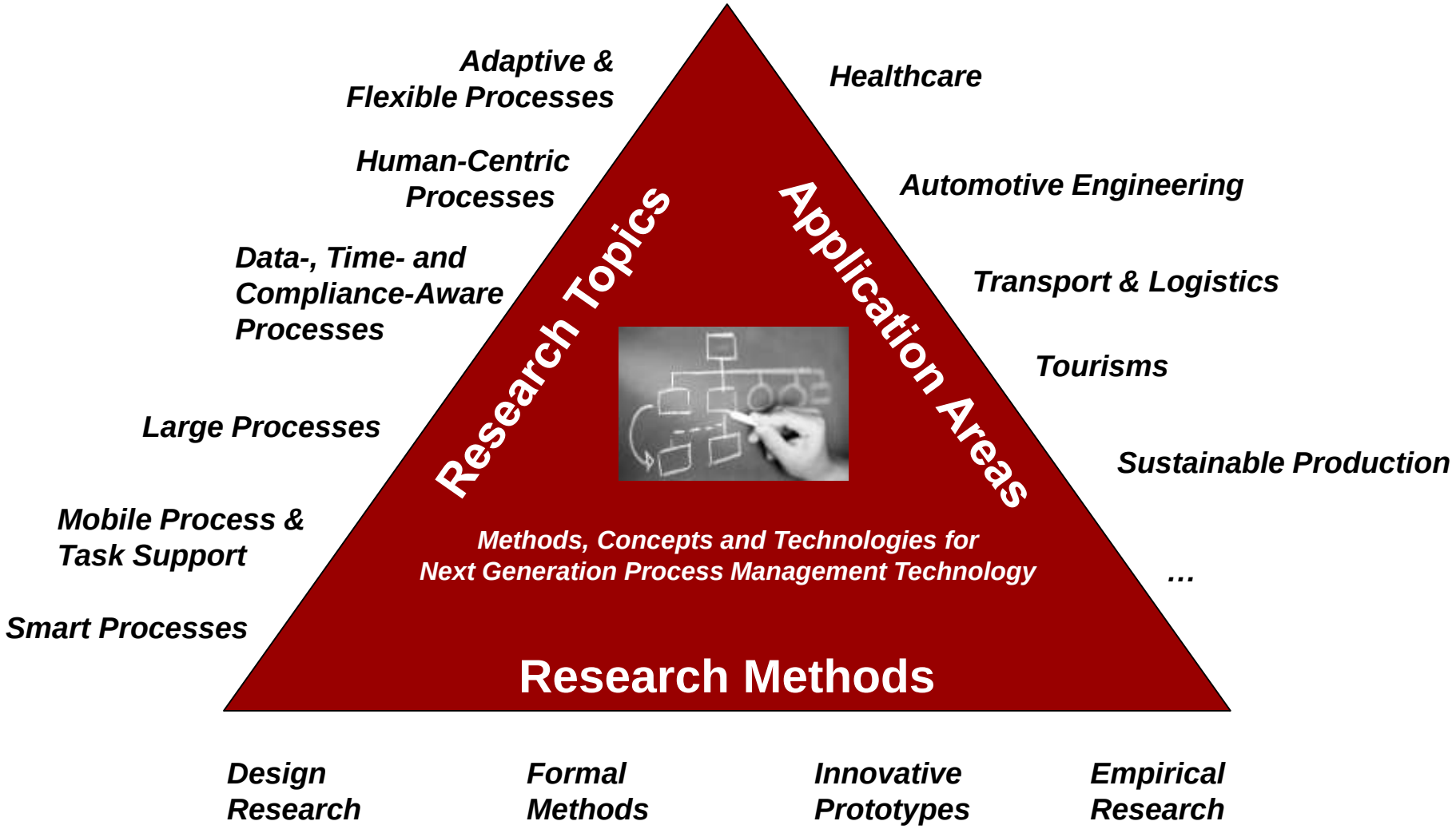
The Corepro Approach

Aut[illegible]sture



How was this approach transferred to practice?

Process Science at Ulm University



Conclusions & Discussion

Conclusions

- Lack of established principles, methods and techniques for the engineering of more advanced PAIS
- This lack hampers the use of PAIS in the large scale
- Huge gap between BPM theory and its transfer to practice
- Fundamental requirements to be met in the context of PAIS engineering
- Presentation of selected examples of successful PAIS engineering endeavours


Thank you!!