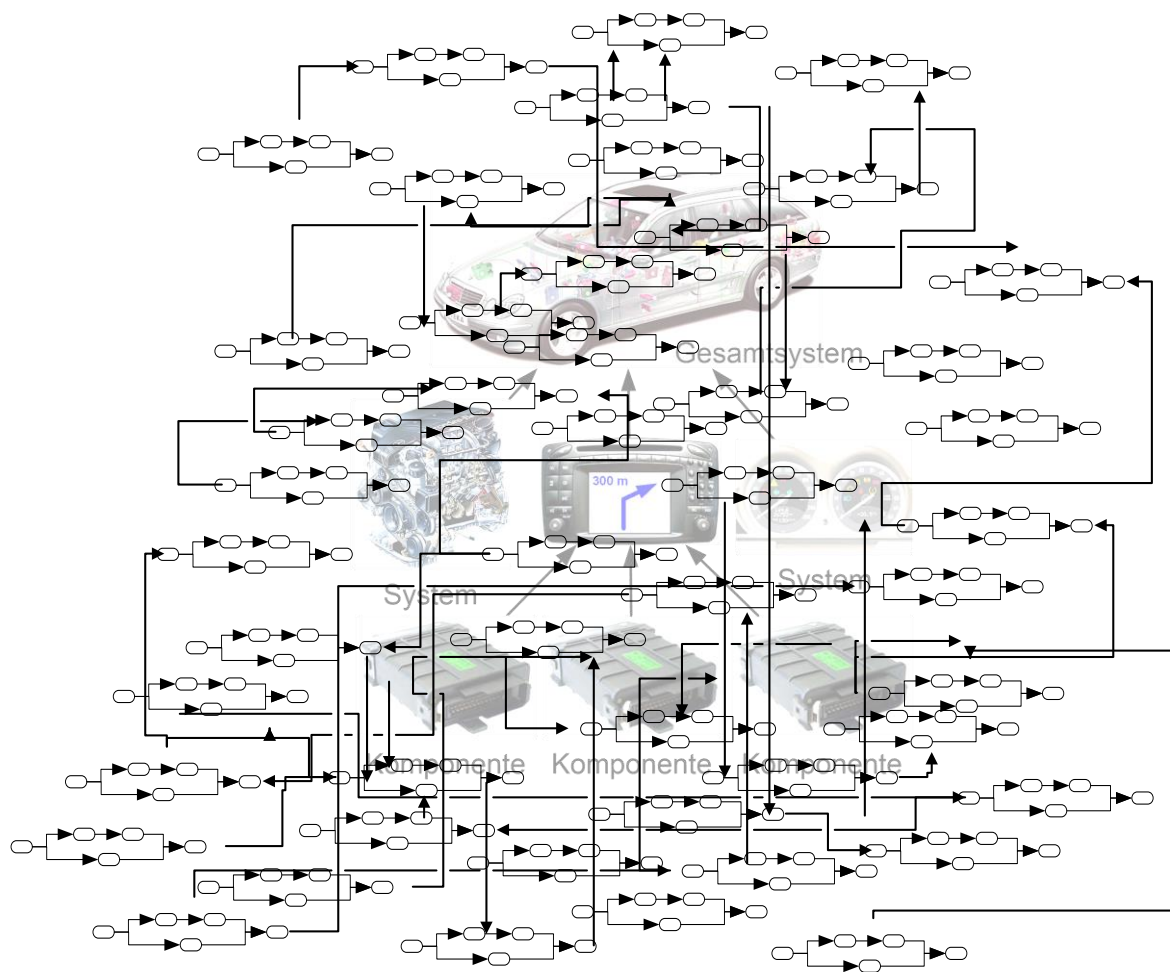
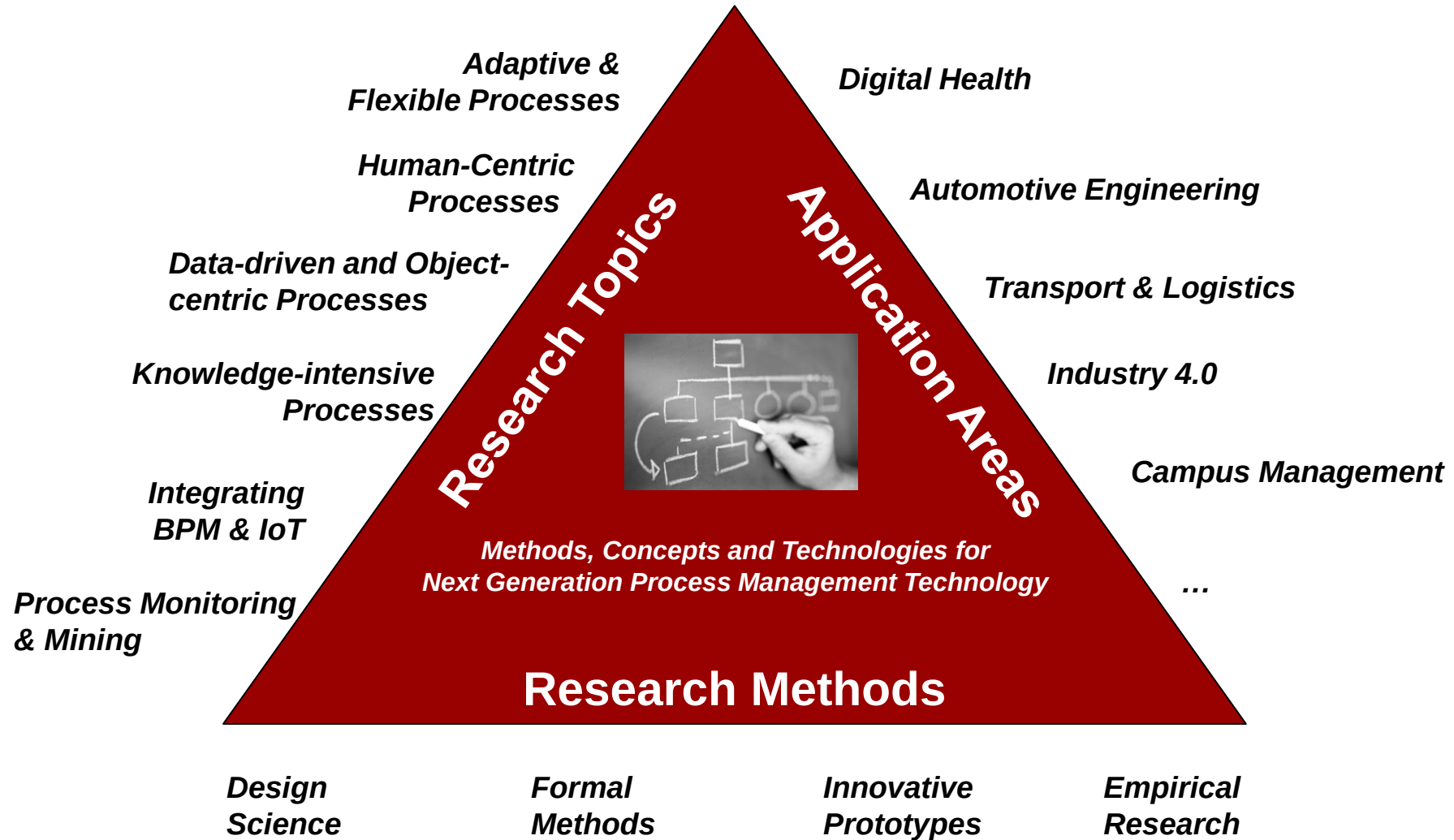




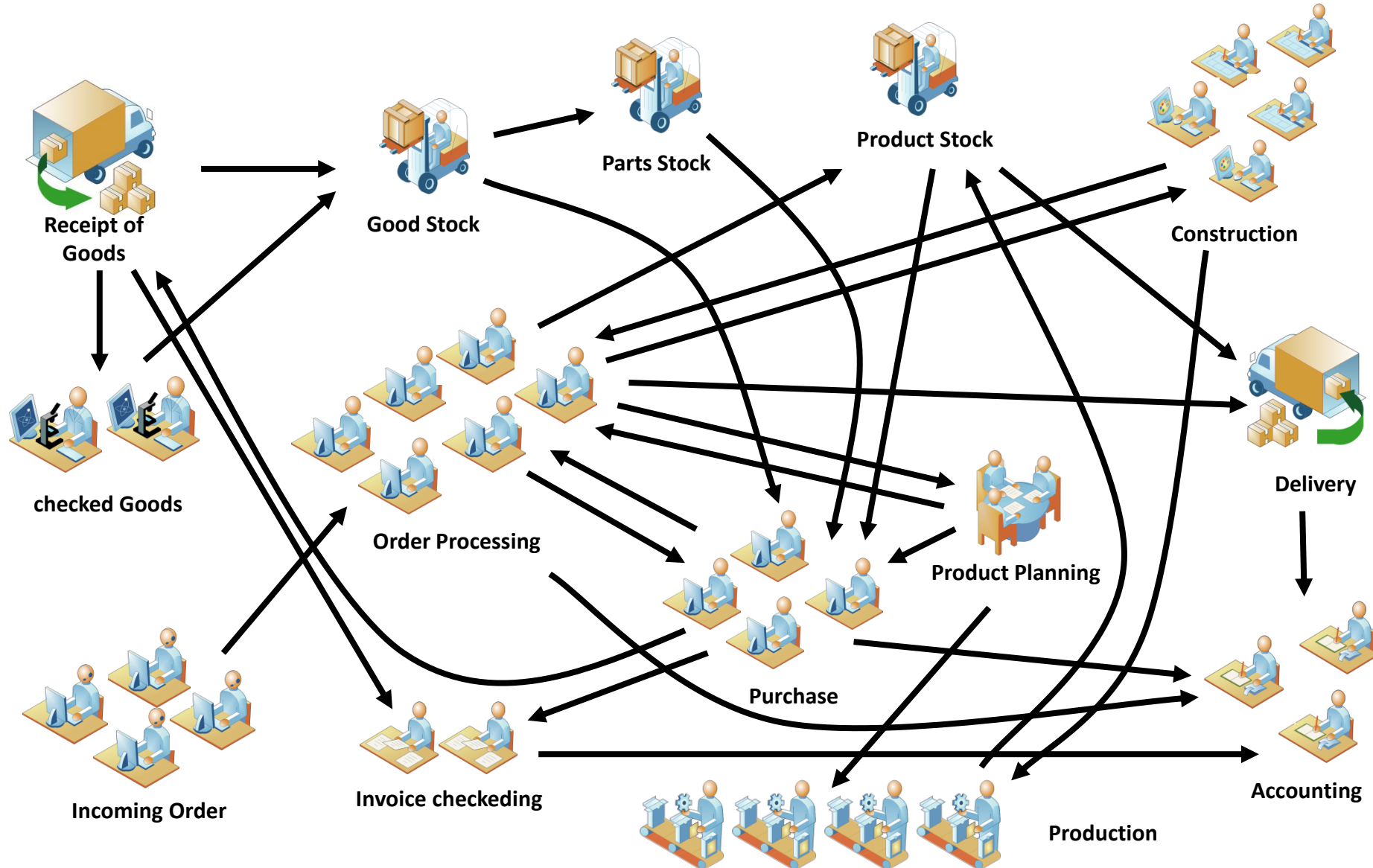
From Activity- to Object-centric Business Process Support: Challenges, Technologies, Applications

Manfred Reichert

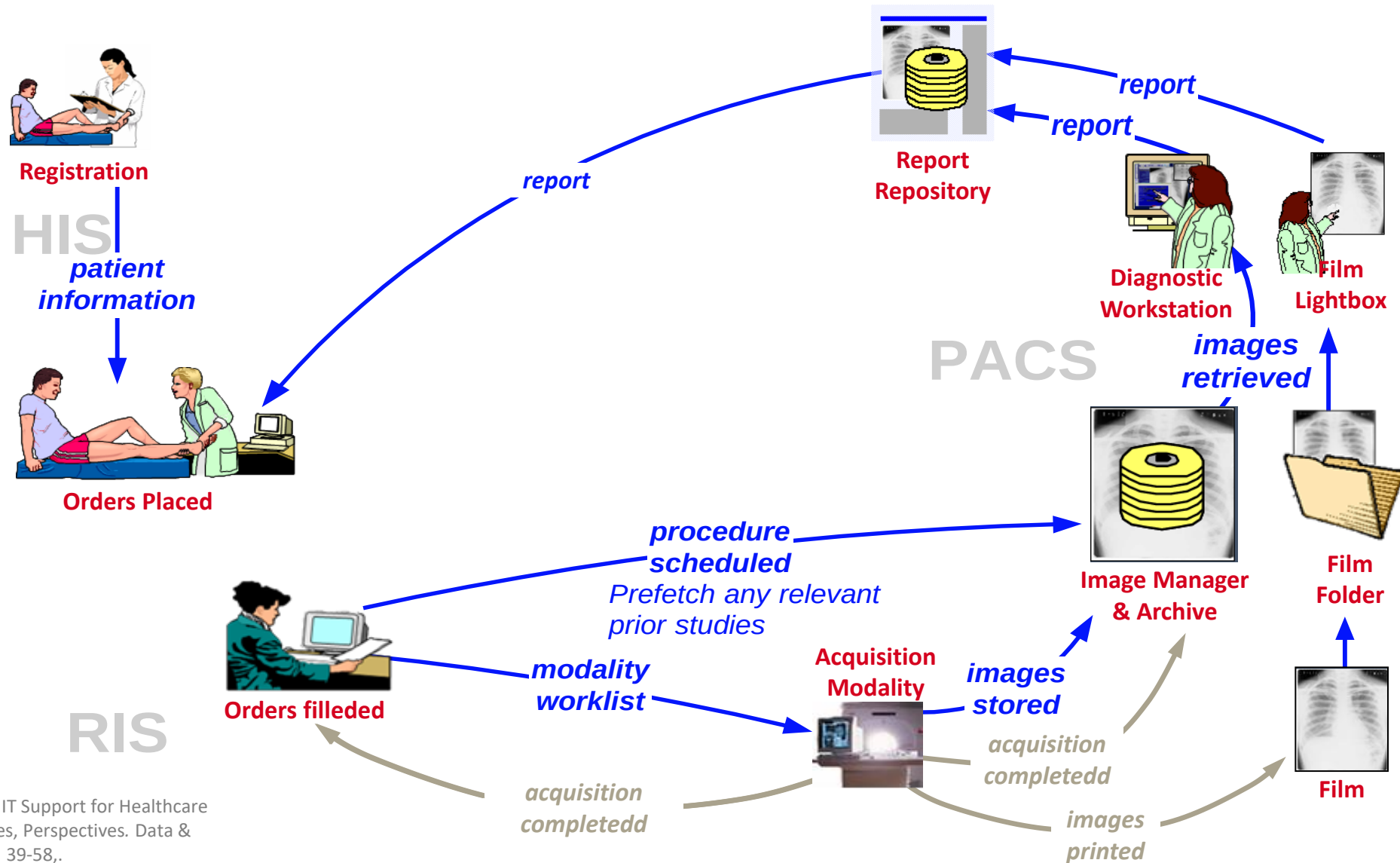
Process Science Research at Ulm University



Scenario 1: Traditional Business Processes



Scenario 2: Healthcare Processes & Application Integration



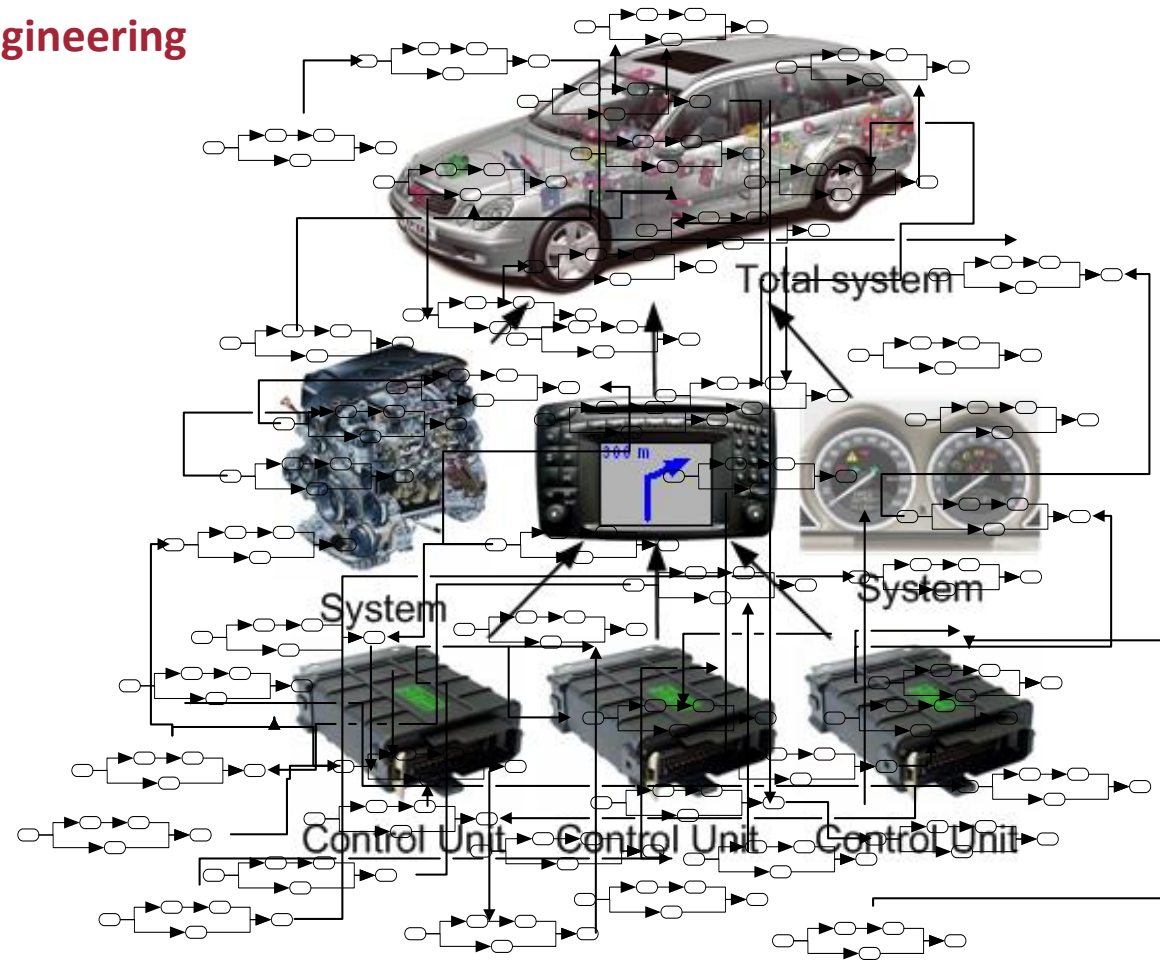
Scenario 3: Mobile Processes – Here, There and Everywhere



The full potential of labor can be utilized only if there is mobility in labor. Paul Hoffman

Scenario 4: Large Collective Process Structures

Automotive Engineering

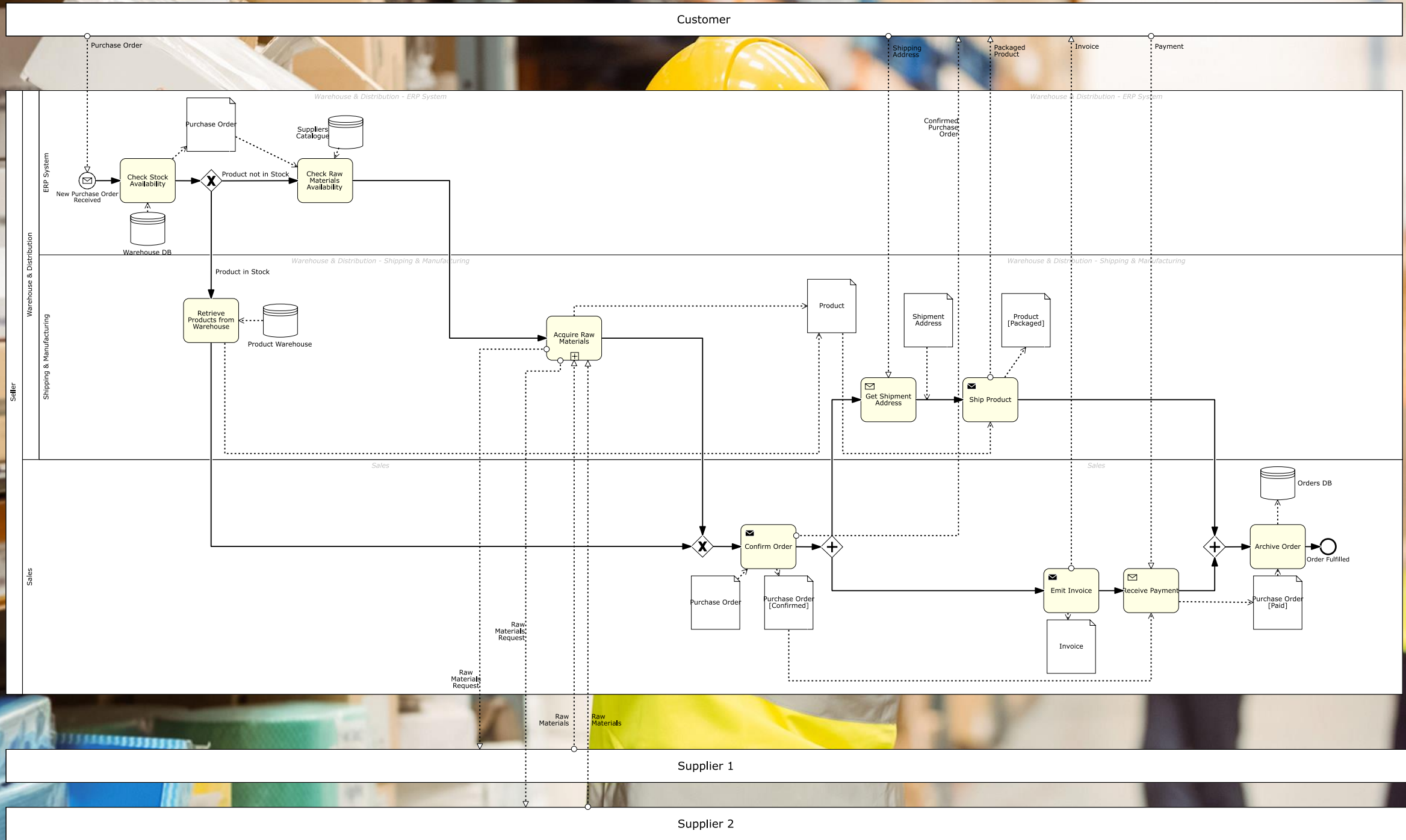




**Scenario 5:
Cyber-Physical Processes (Industry 4.0)**

**Scenario 6:
Logistics & Human /
Robot Integration**

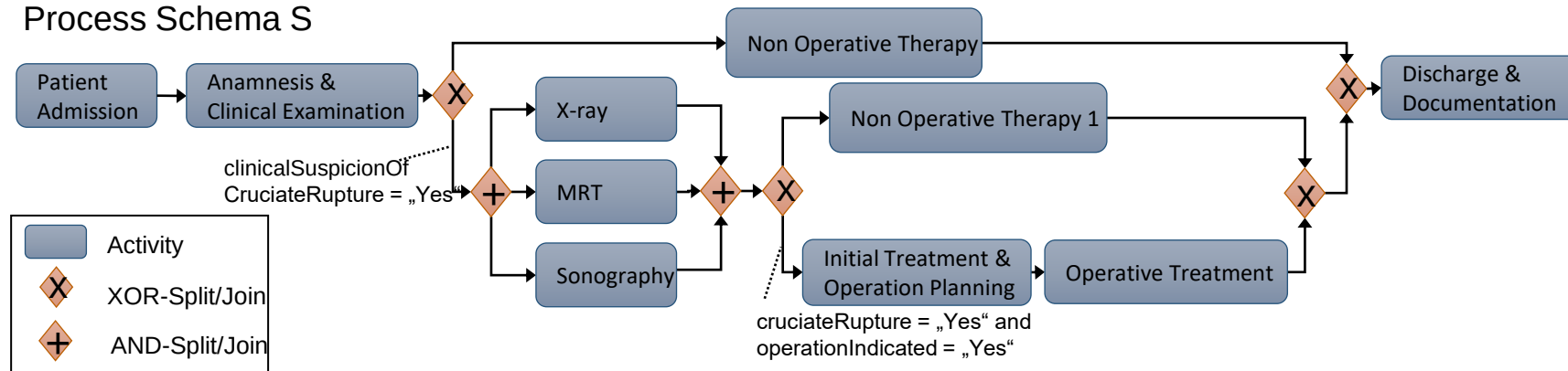




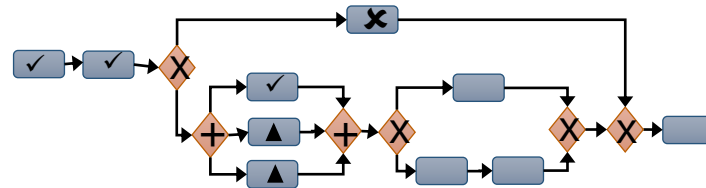


Process-Aware Software Systems

Process Schema S



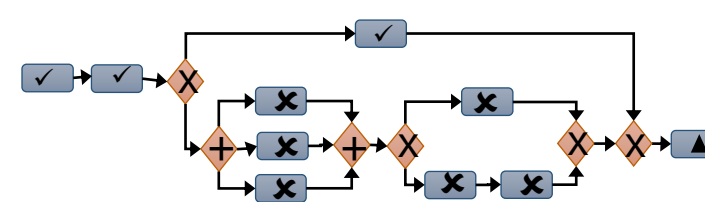
Process Instance I1



Execution Trace:

$\sigma_1 = \langle \text{„Patient Admission“}, \text{„Anamnesis & Clinical Examination“}, \text{„X-ray“} \rangle$

Process Instance I2

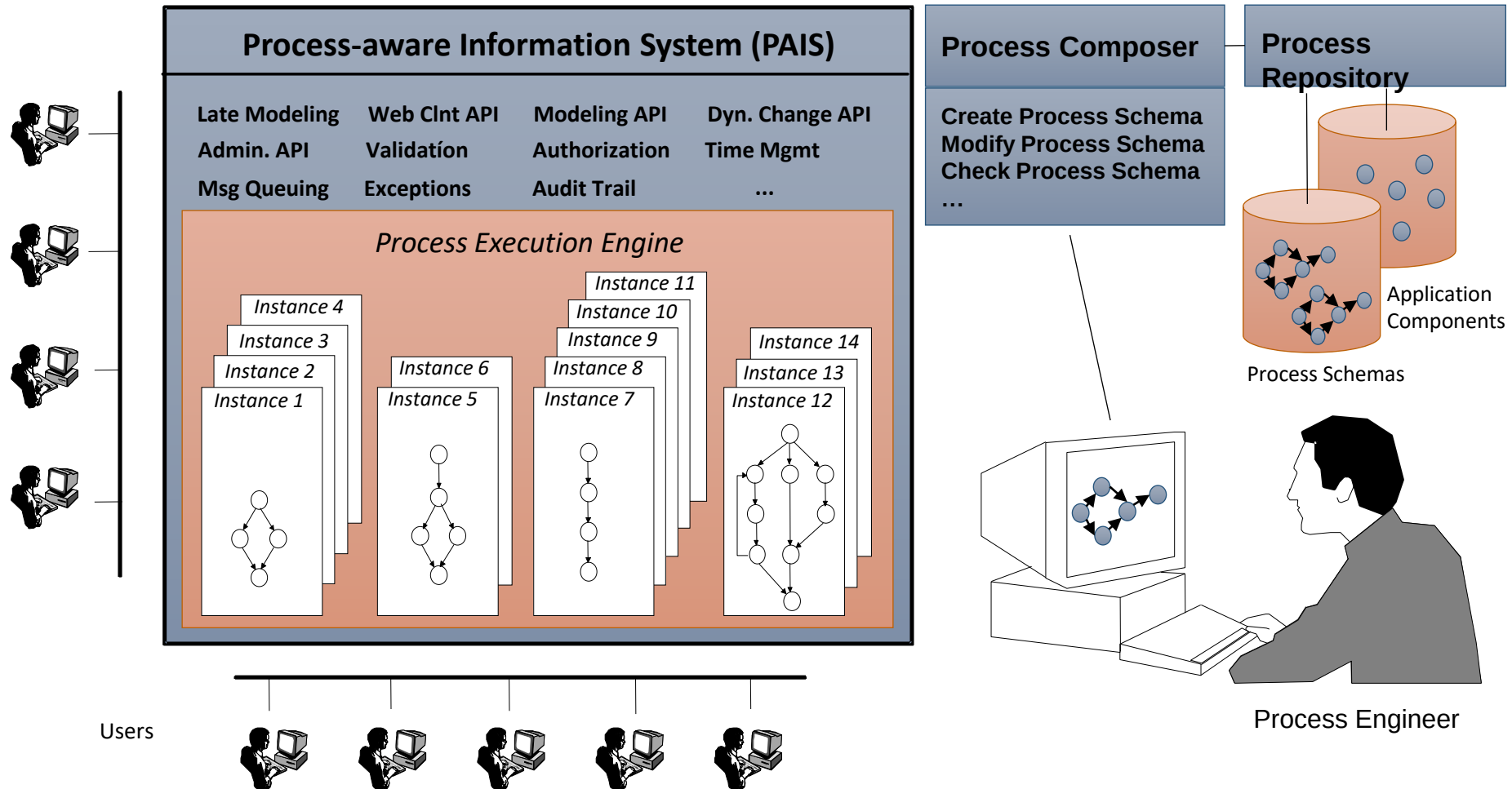


Execution Trace:

$\sigma_2 = \langle \text{„Patient Admission“}, \text{„Anamnesis & Clinical Examination“}, \text{„Non Operative Therapy“} \rangle$

Activity States: ▲ Activated ✓ Completed X Skipped

Process-Aware Software Systems







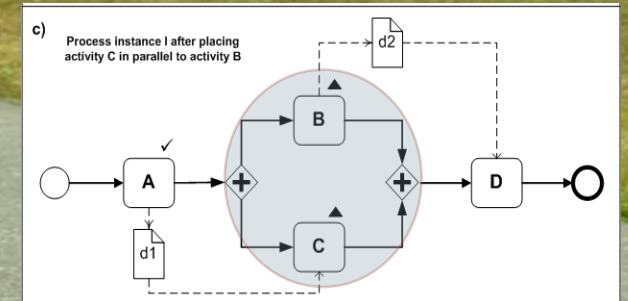
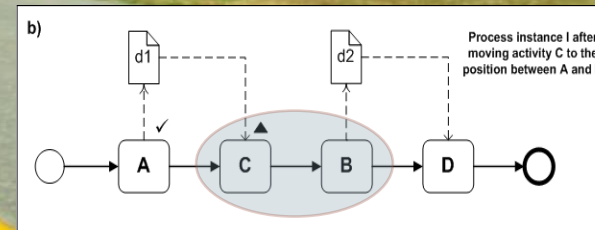
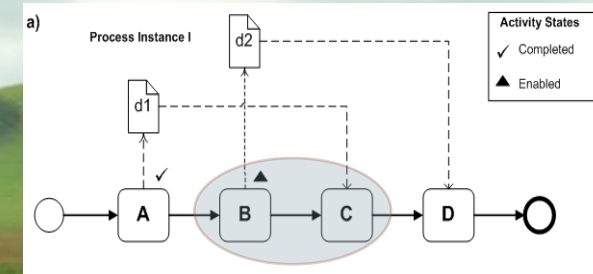


How to meet real-world flexibility requirements?

Our approach: Adaptive BPM Software / ADEPT

ADEPT – Enforcement vs. Guidance + Flexibility

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.

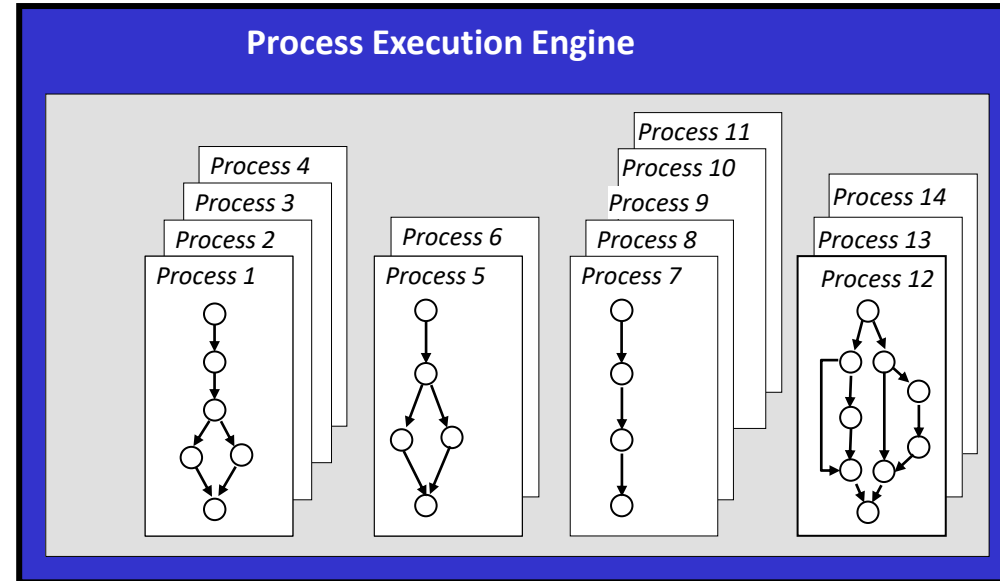
Weber B, Reichert M, Rinderle-Ma, S (2008) *Change Patterns and Change Support Features - Enhancing Flexibility in Process-Aware Information Systems*. Data and Knowledge Engineering, 66(3): 438-466

Reichert, M and Dadam, P (1998) *ADEPTflex-Supporting Dynamic Changes of Workflows Without Losing Control*. J of Intelligent Information Systems, 10(2): 93-129

ADEPT – Enforcement vs. Guidance + Flexibility

ADEPT

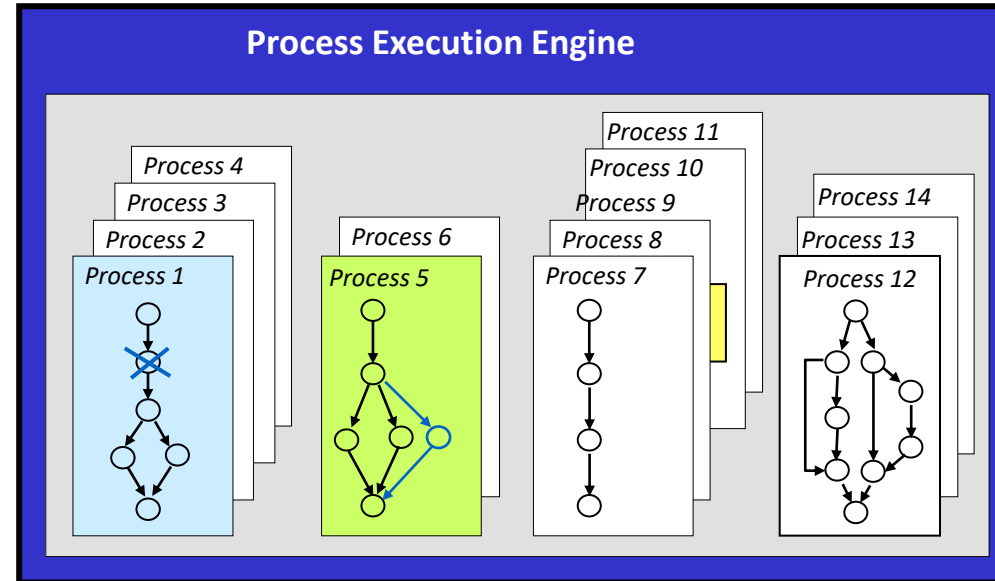
Individually adaptable
Process Instances



ADEPT – Enforcement vs. Guidance + Flexibility

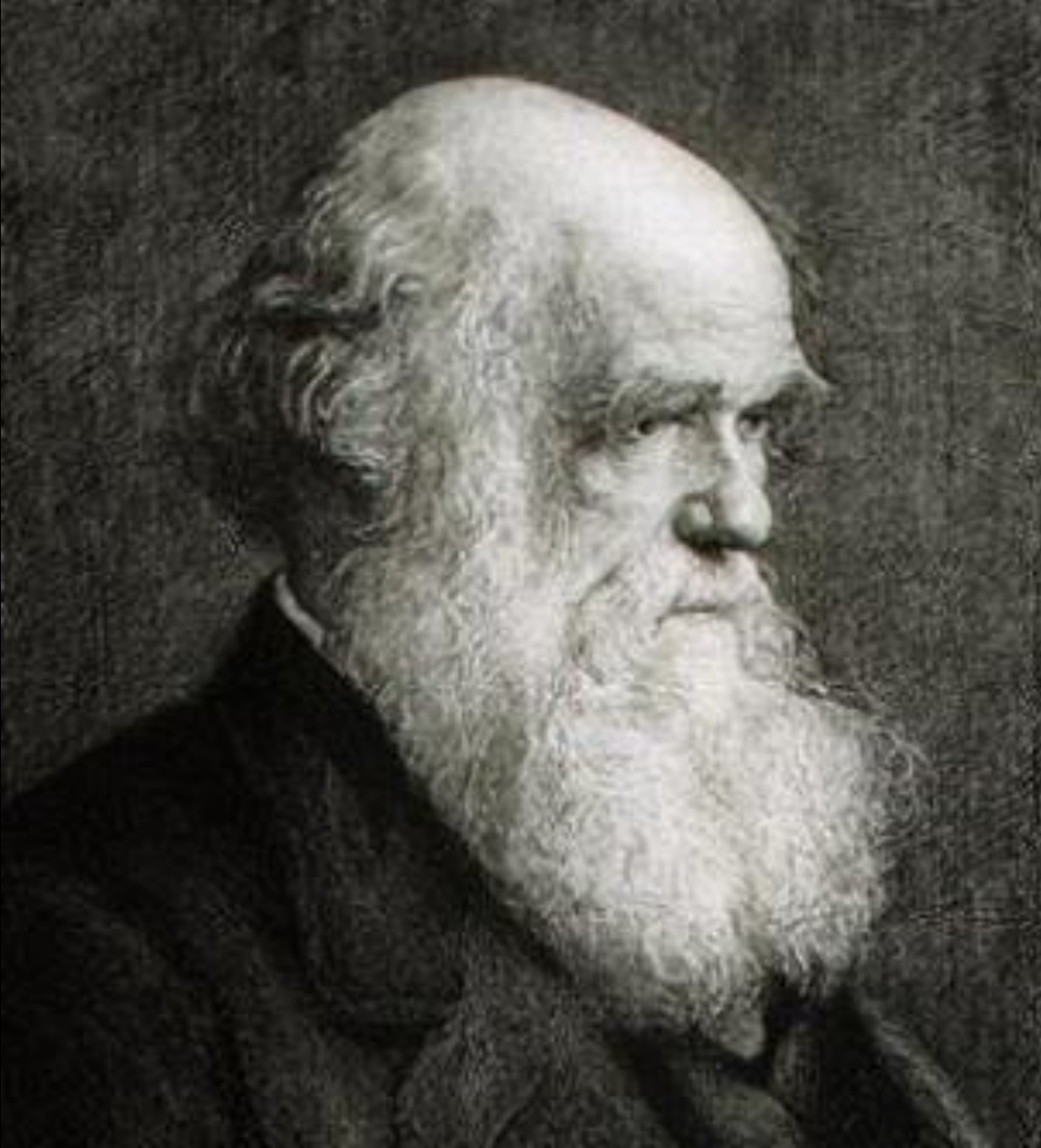
ADEPT

**Individually adaptable
Process Instances**



Achievements:

- Correctness-by-construction
- Well-defined correctness criteria for ad-hoc changes at runtime
- Efficient, build-in consistency checks (no bad surprises)
- Support of a high number of change patterns
- API for accomplishing ad-hoc changes



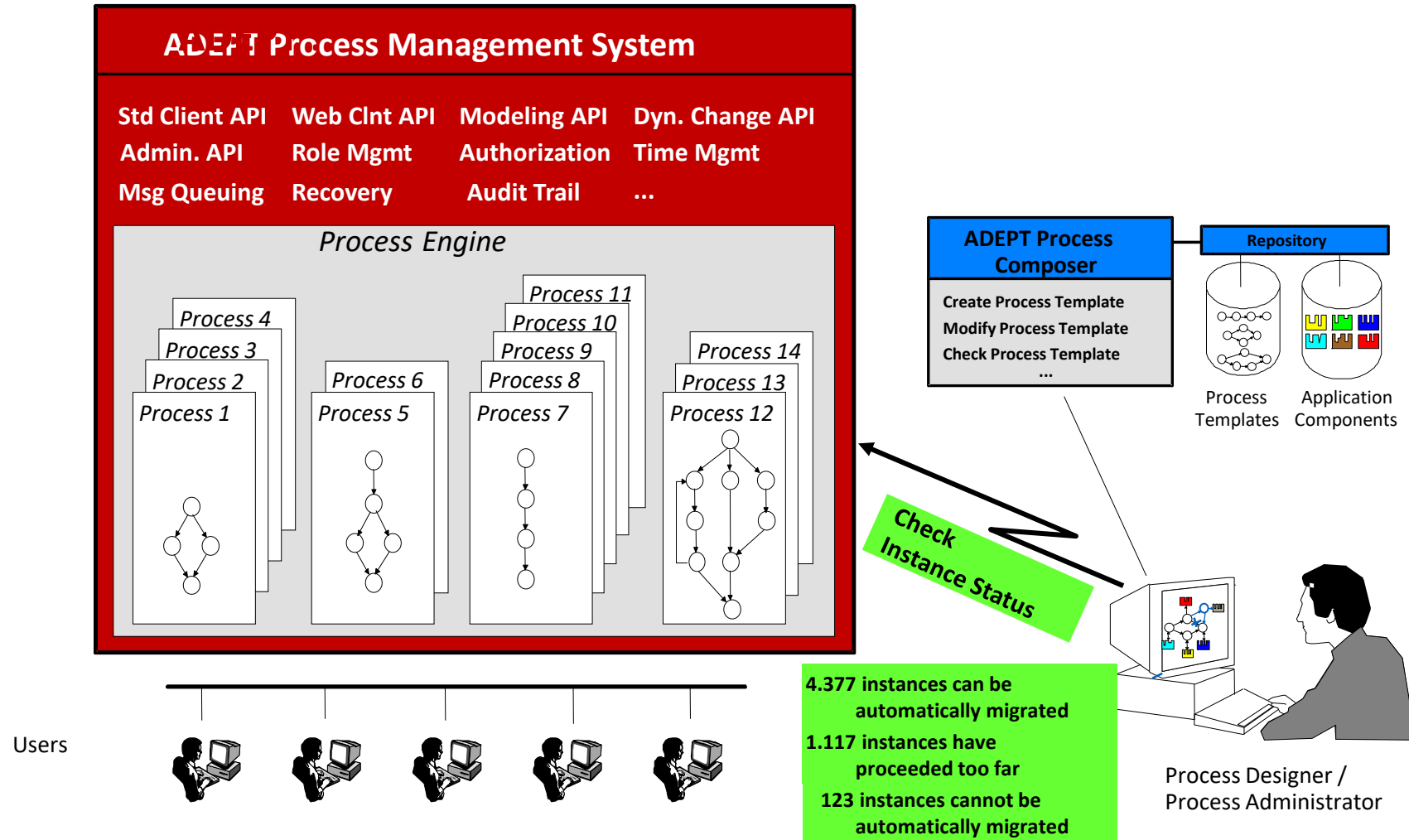
ADEPT Process Evolution

**Ability to quickly change the
implemented process when
the business process evolves**

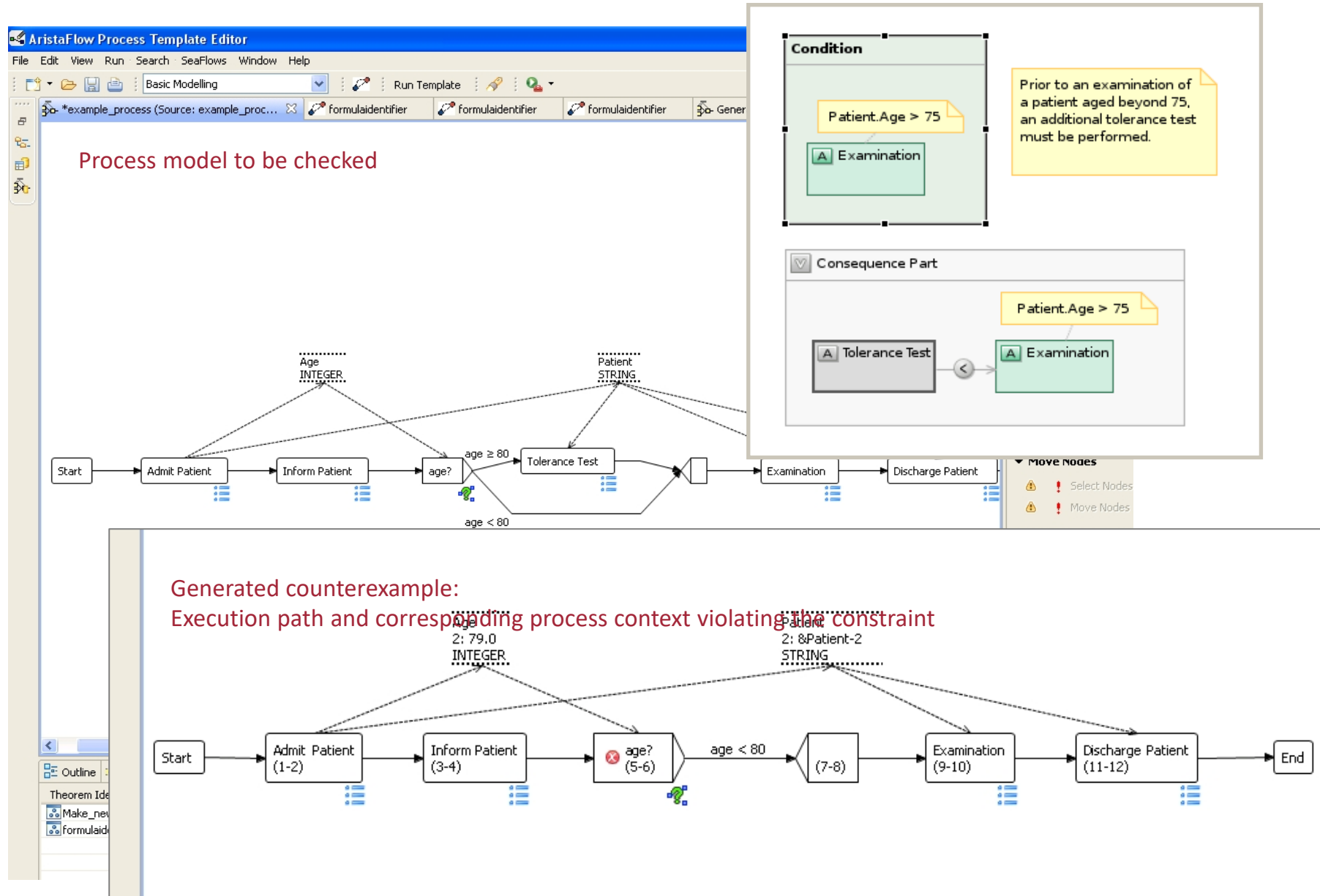
*It is not the strongest of the species
that survives, not the most intelligent
that survives. It is the one that is the
most adaptable to change.*

C. Darwin

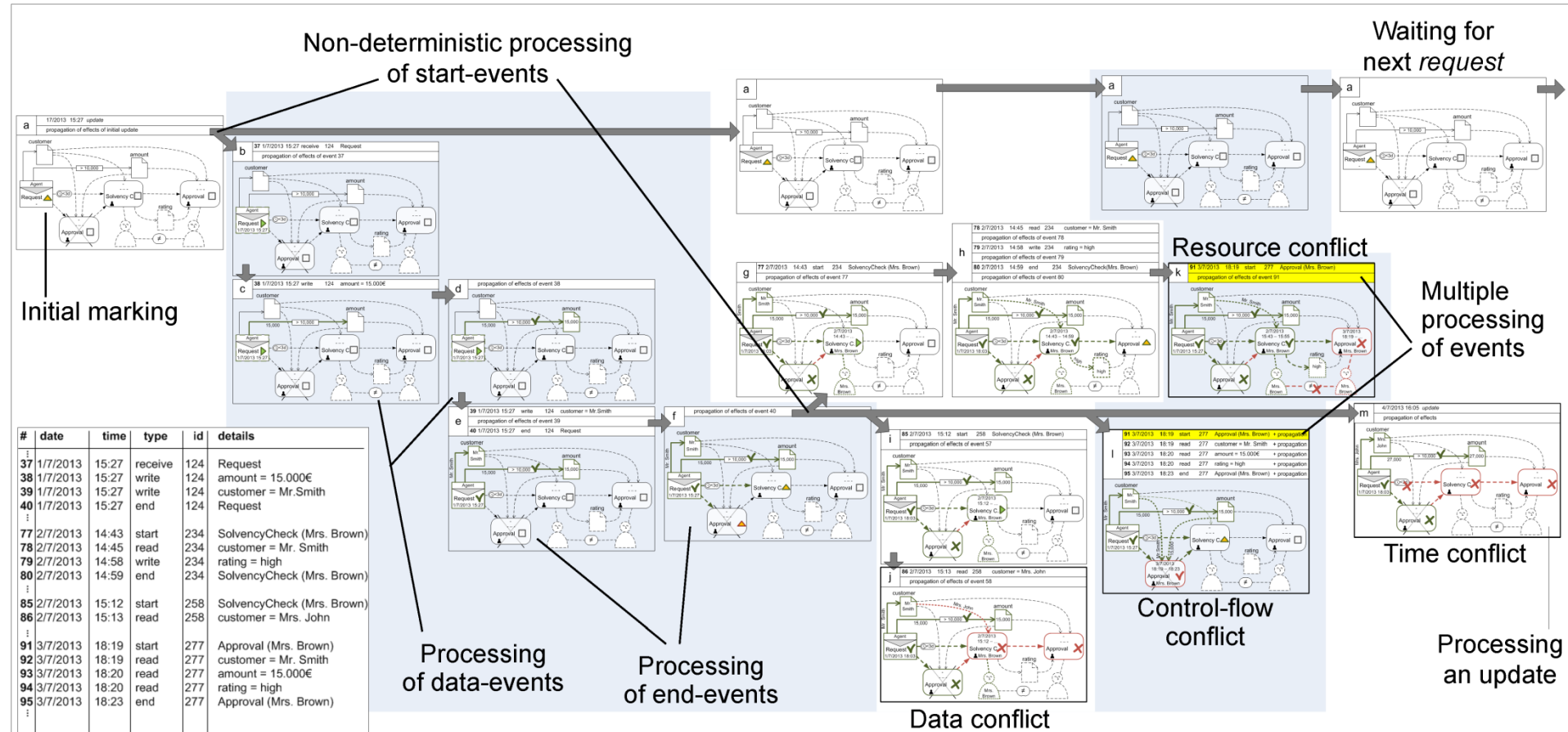
ADEPT – Process Evolution



SeaFlows: Process Compliance



C³Pro: Multi-Perspective Compliance Monitoring

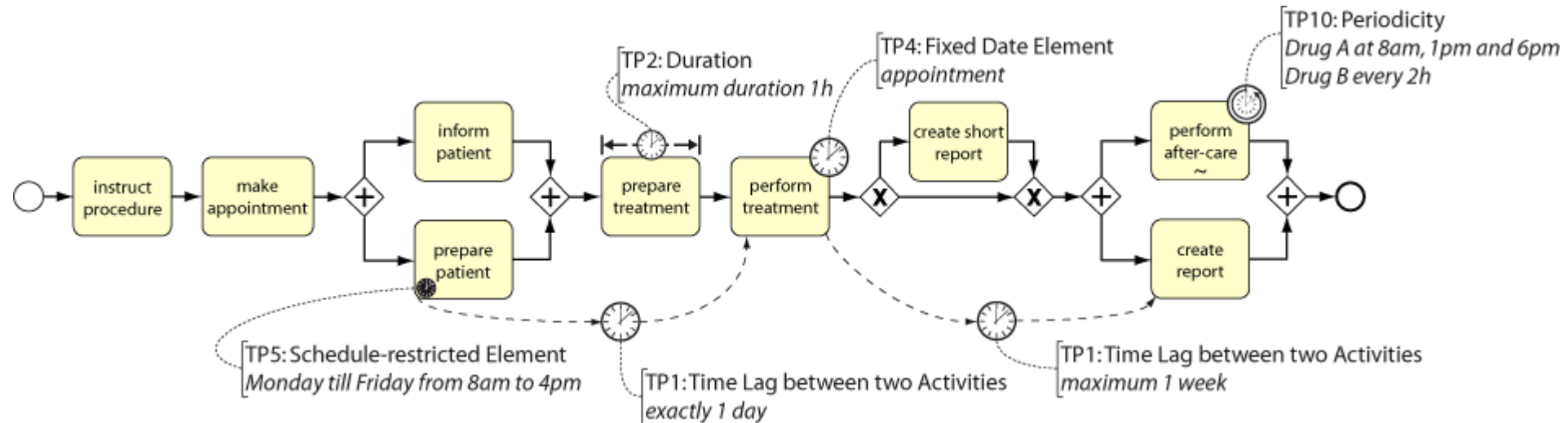


D. Knuplesch, M. Reichert, A. Kumar (2015): Visually Monitoring Multiple Perspectives of Business Process Compliance. BPM 2015: 263-279

Knuplesch, David and Reichert, Manfred (2017) *A Visual Language for Modeling Business Process Compliance Rules*. Software & Systems Modeling, Springer, Vol. 16, pp. 715-736

Knuplesch, David and Reichert, Manfred and Kumar, Akhil (2017) *A framework for visually monitoring business process compliance*. Information Systems, Elsevier, Vol. 64, pp. 381-409

ATAPIS: Time-Aware Processes

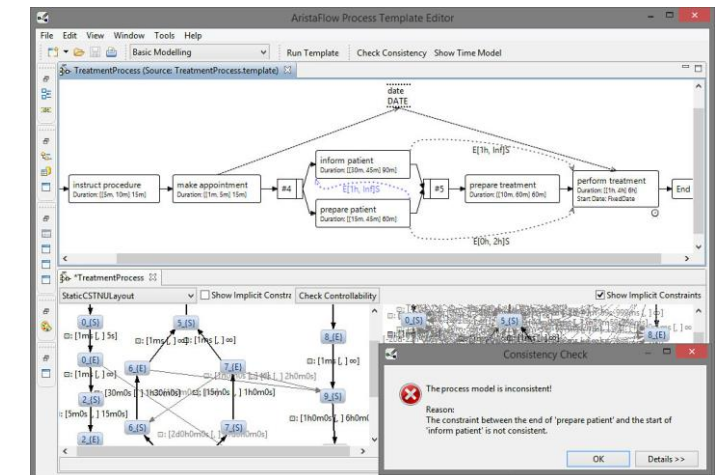


Lanz A., Weber B., Reichert, M. (2014): Time-Patterns for Process-Aware Information Systems. Requirements Engineering, 19(2): 113-141

Lanz A., Reichert M., Weber B. (2016): Process Time Patterns – A Formal Foundation. Information Systems, 57:38-68

Lanz A., Reichert M. (2014) Dealing with Changes of Time-Aware Processes. BPM 2014, pp. 217-233

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



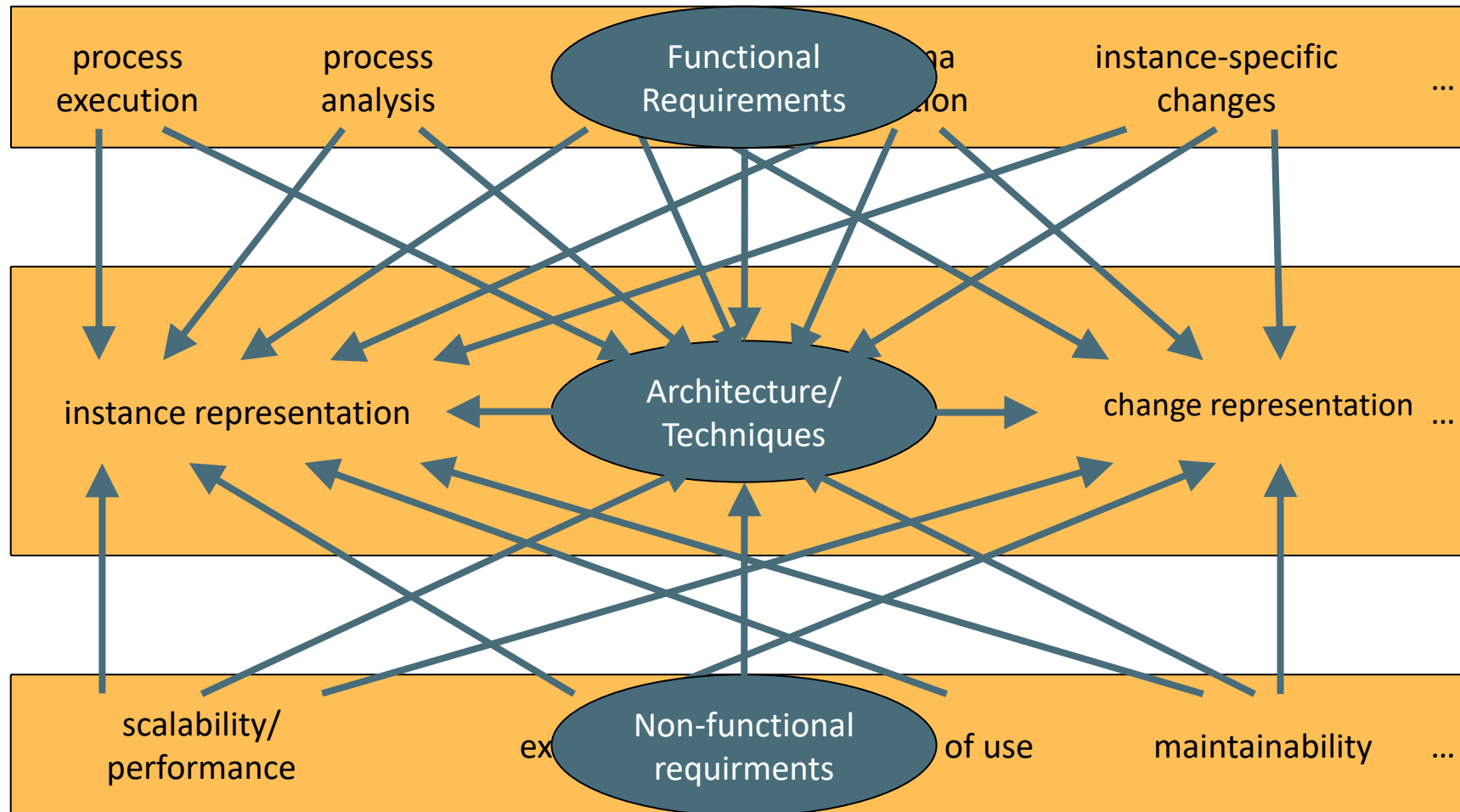
ADEPT – Engineering the Adaptive BPM Software

- ▶ 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 application 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

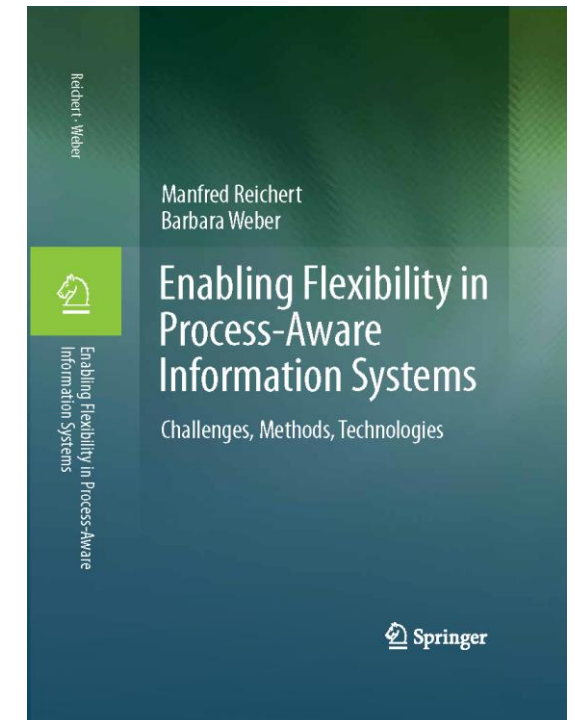
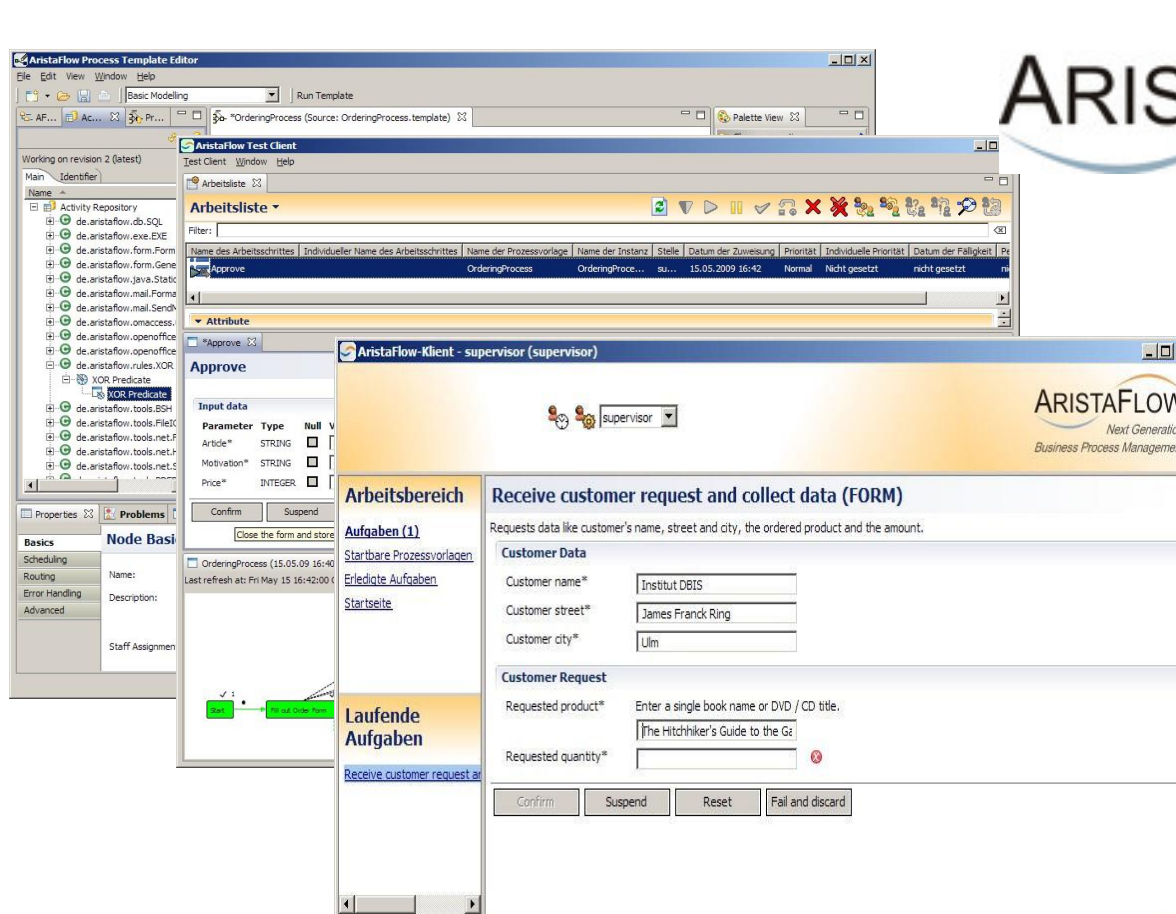
- ▶ NR 1 scalability/performance
- ▶ NR 2 robustness
- ▶ NR 3 extensibility
- ▶ NR 4 ease of use
- ▶ NR 5 independence/modularity
- ▶ NR 6 reuse/non-redundancy
- ▶ NR 7 maintainability
- ▶ NR 8 ability to evolve/flexibility

- ▶ DIN ISO 9126
(software quality, product quality)

ADEPT – Engineering the Adaptive BPM Software

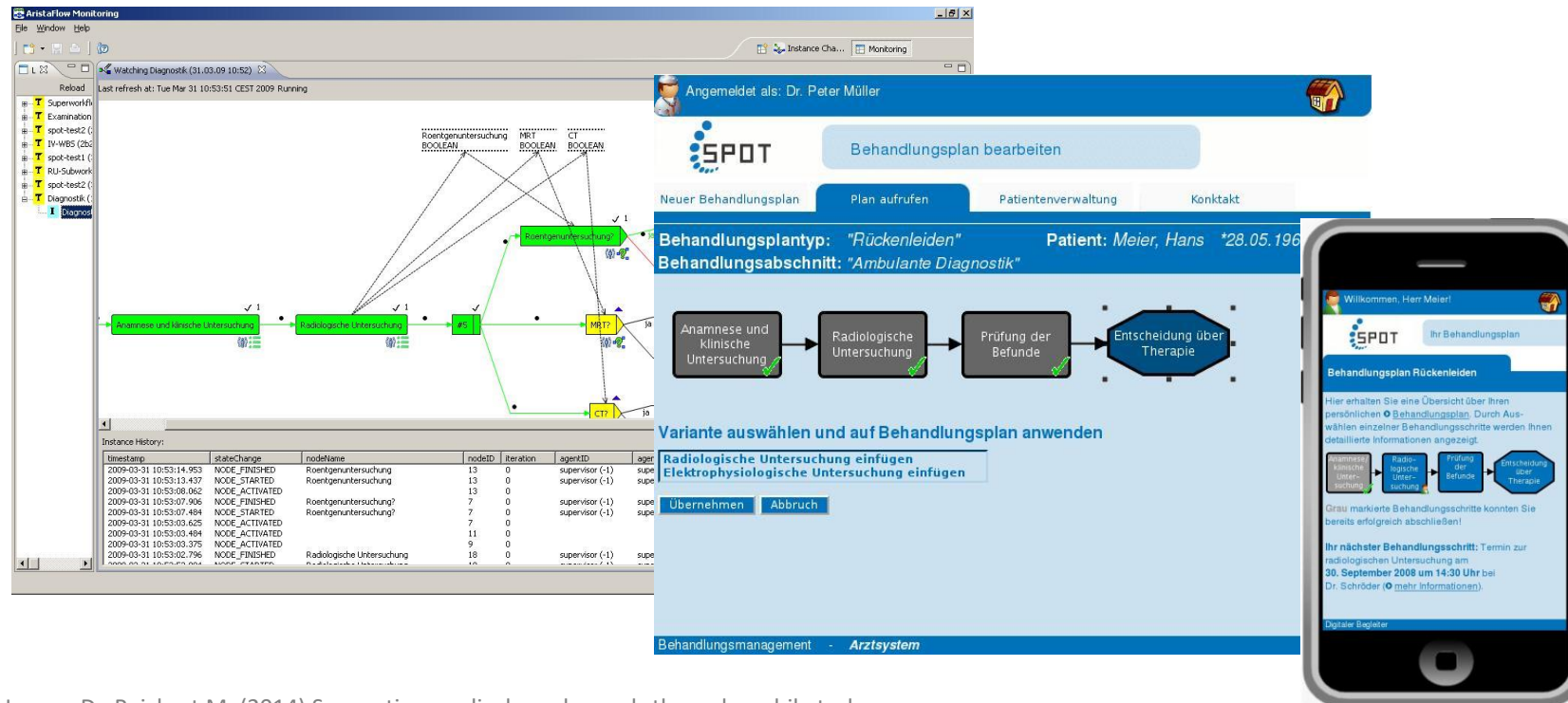


ADEPT – Transferring Adaptive BPMS to Industry



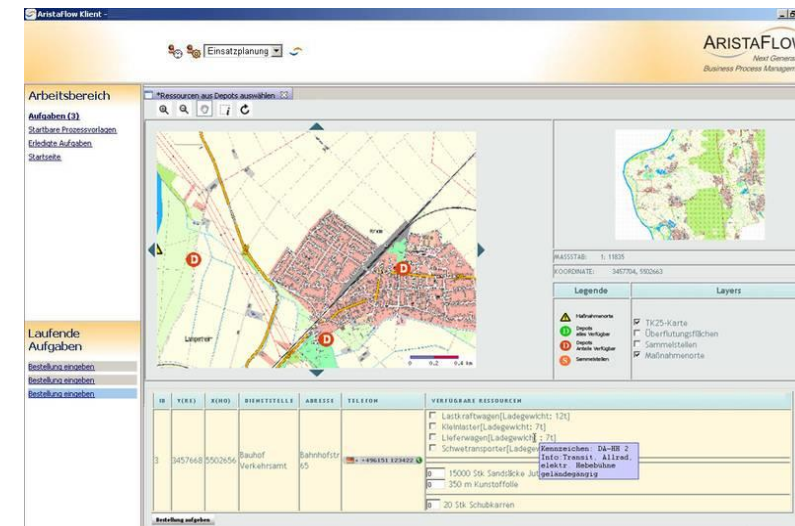
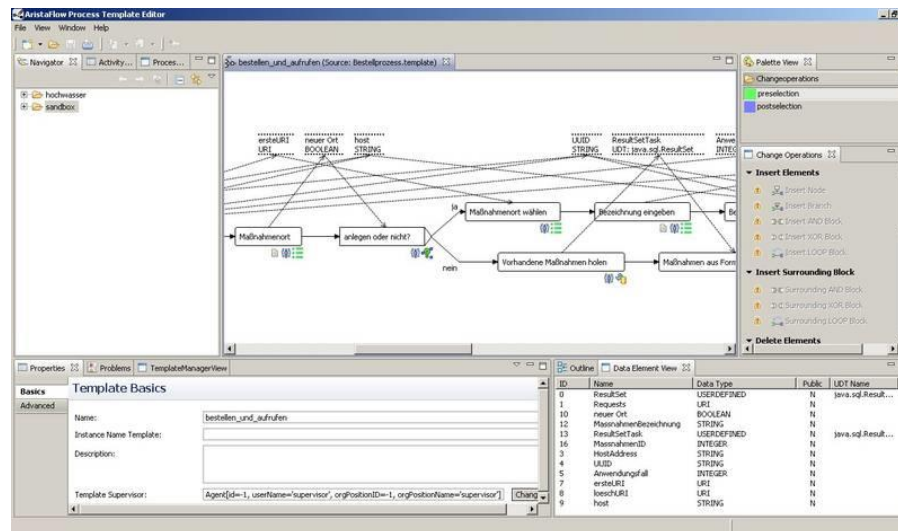
Advanced Applications of the AristaFlow BPM Suite

Clinical Pathway Support



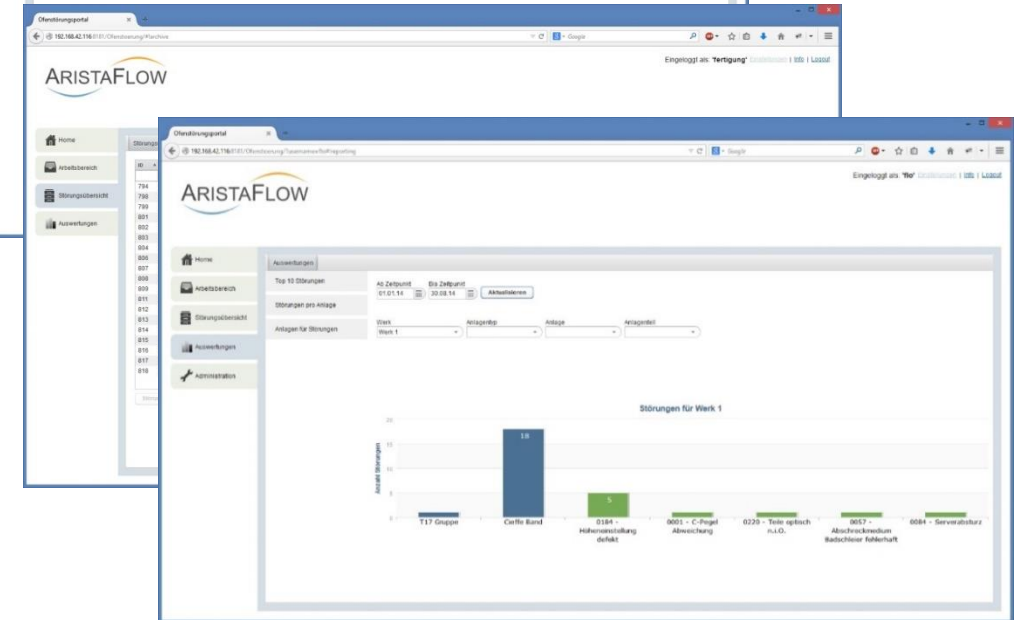
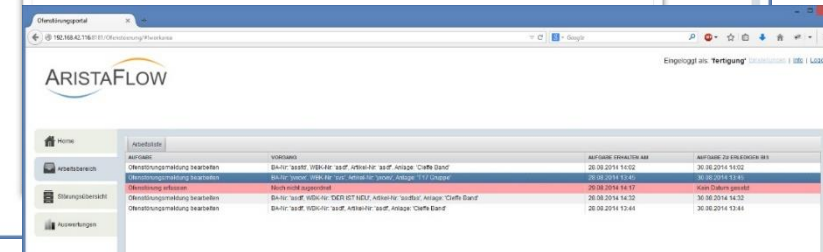
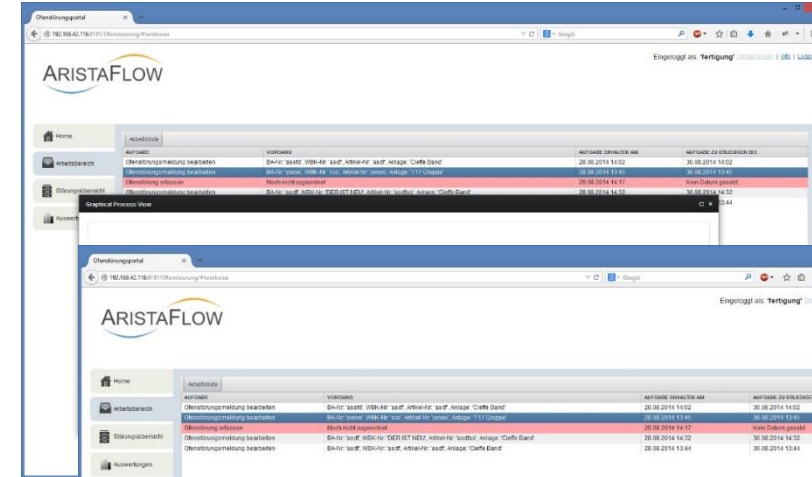
Advanced Applications of the AristaFlow BPM Suite

Process-driven Emergency Management for Water Infrastructures



Advanced Applications of the AristaFlow BPM Suite

IIoT-Driven Processes for Handling Malfunctions and Breakdowns in Plants with Industrial Furnaces



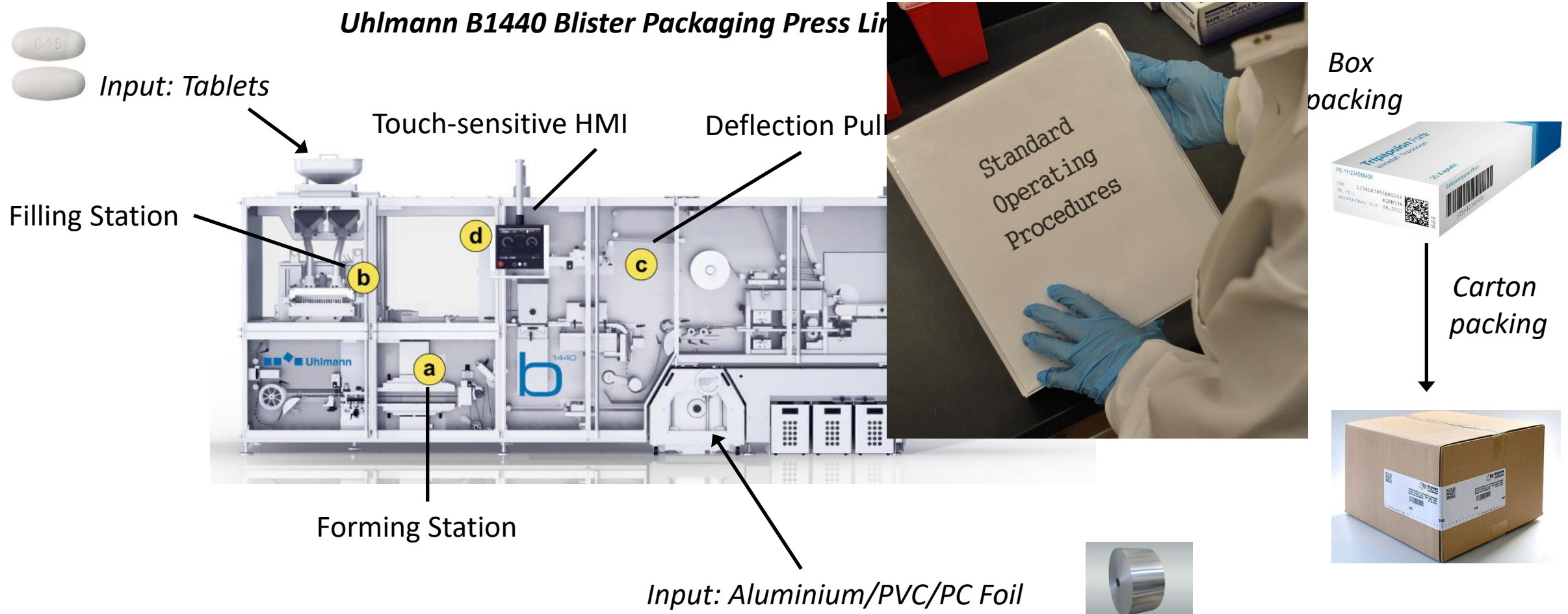
Advanced Applications of the AristaFlow BPM Suite

Managing Freight Wagon / Example: Maintenance Processes



Advanced Applications of the AristaFlow BPM Suite

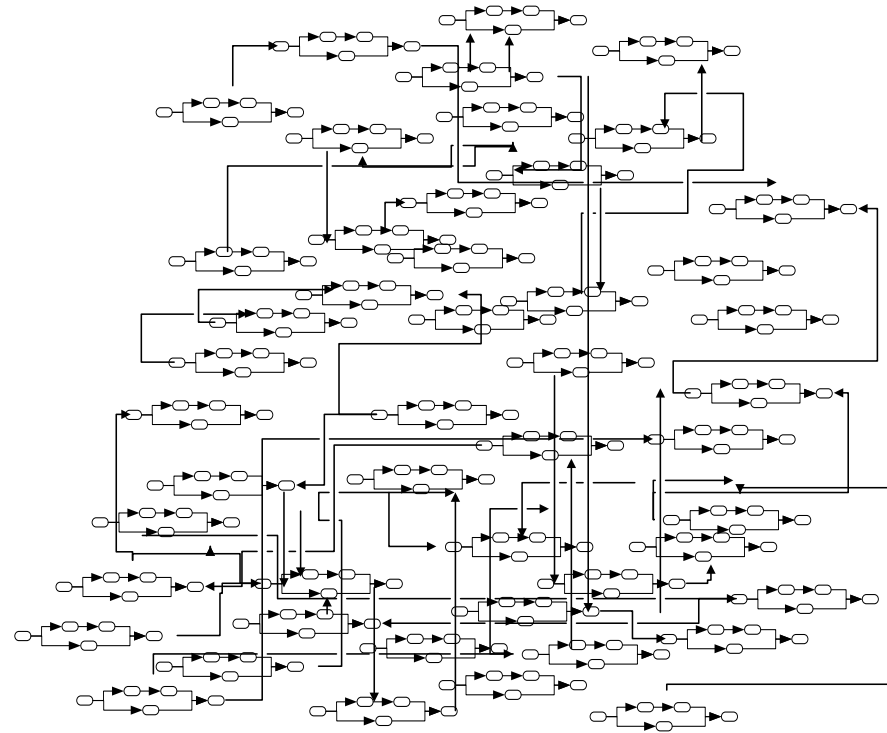
Smart Process Guidance with AristaFlow BPM Suite



Advanced Applications of the AristaFlow BPM Suite

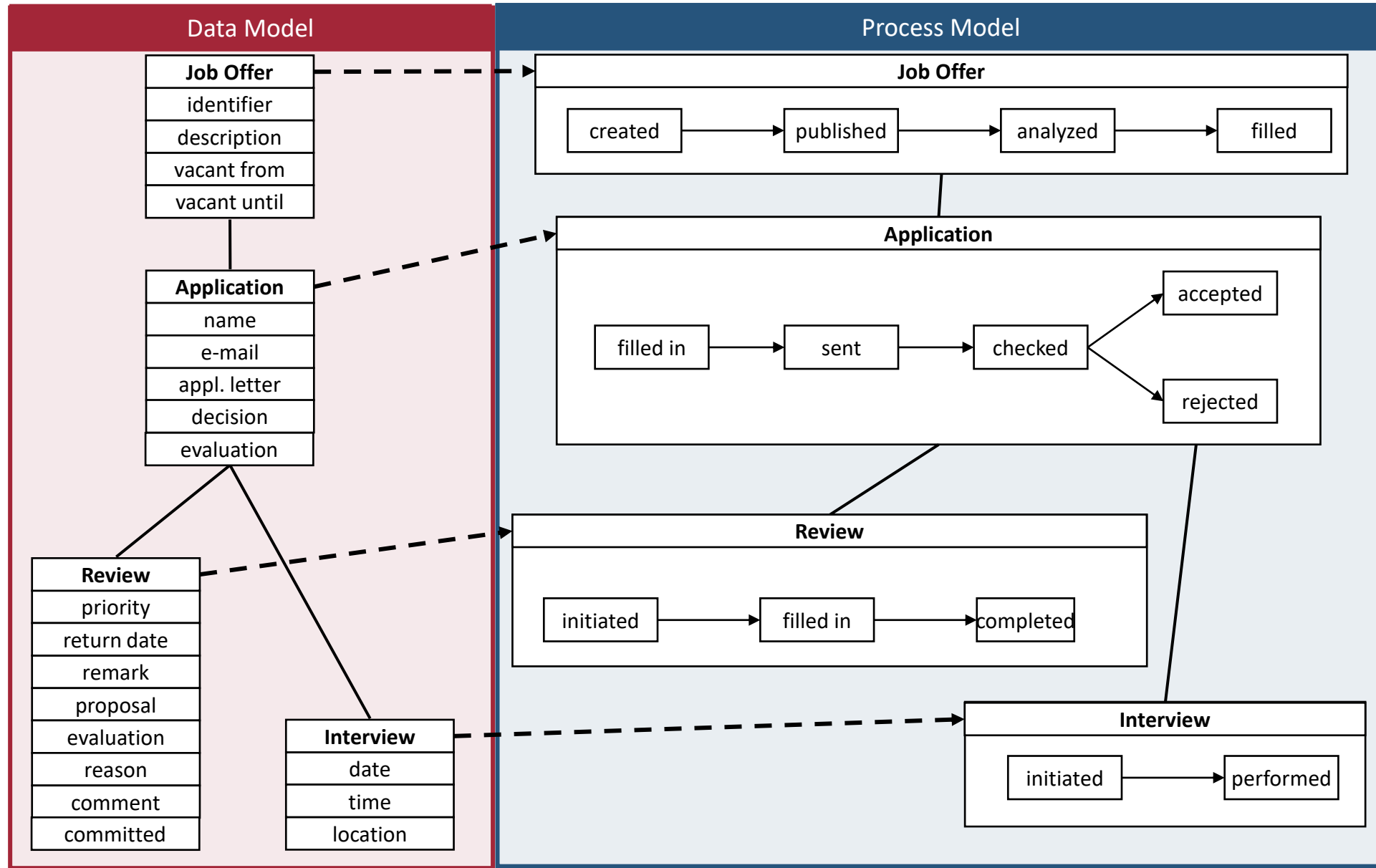
Smart Process Guidance with AristaFlow BPM Suite



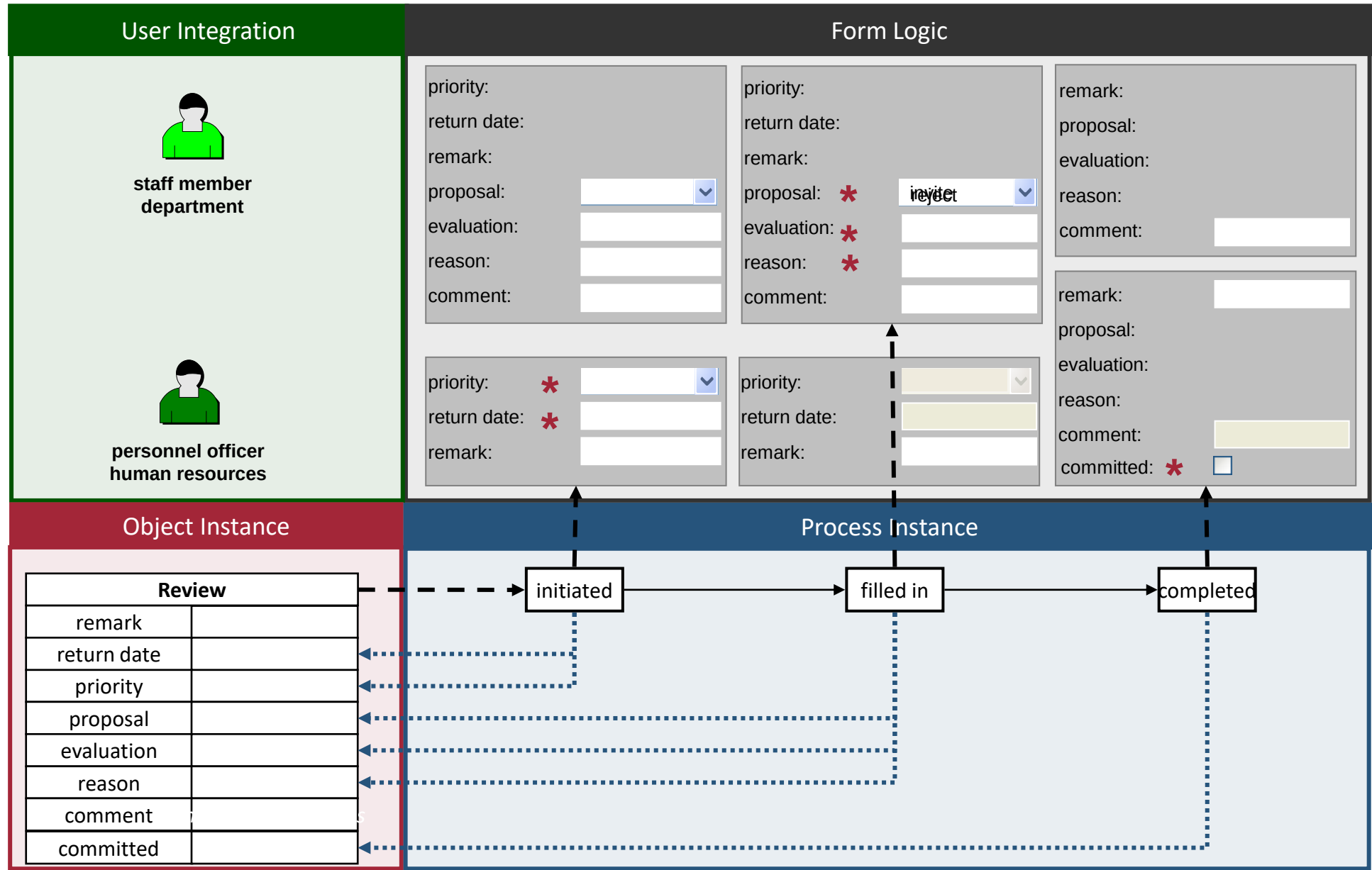


How to Increase the In-built Flexibility of BPM Systems?
→ Object-centric Processes (PHILharmonicFlows)

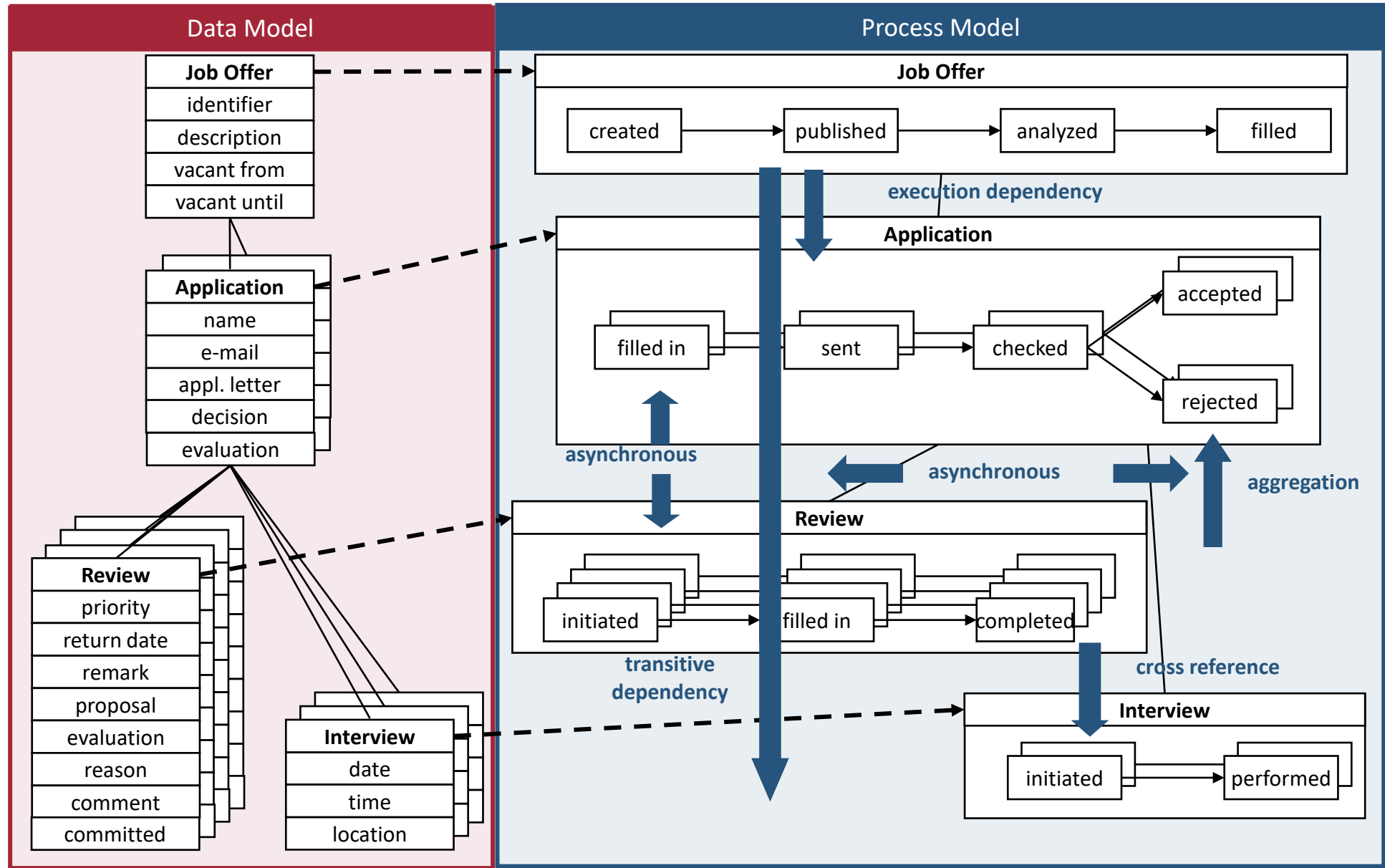
Object-Centric Processes



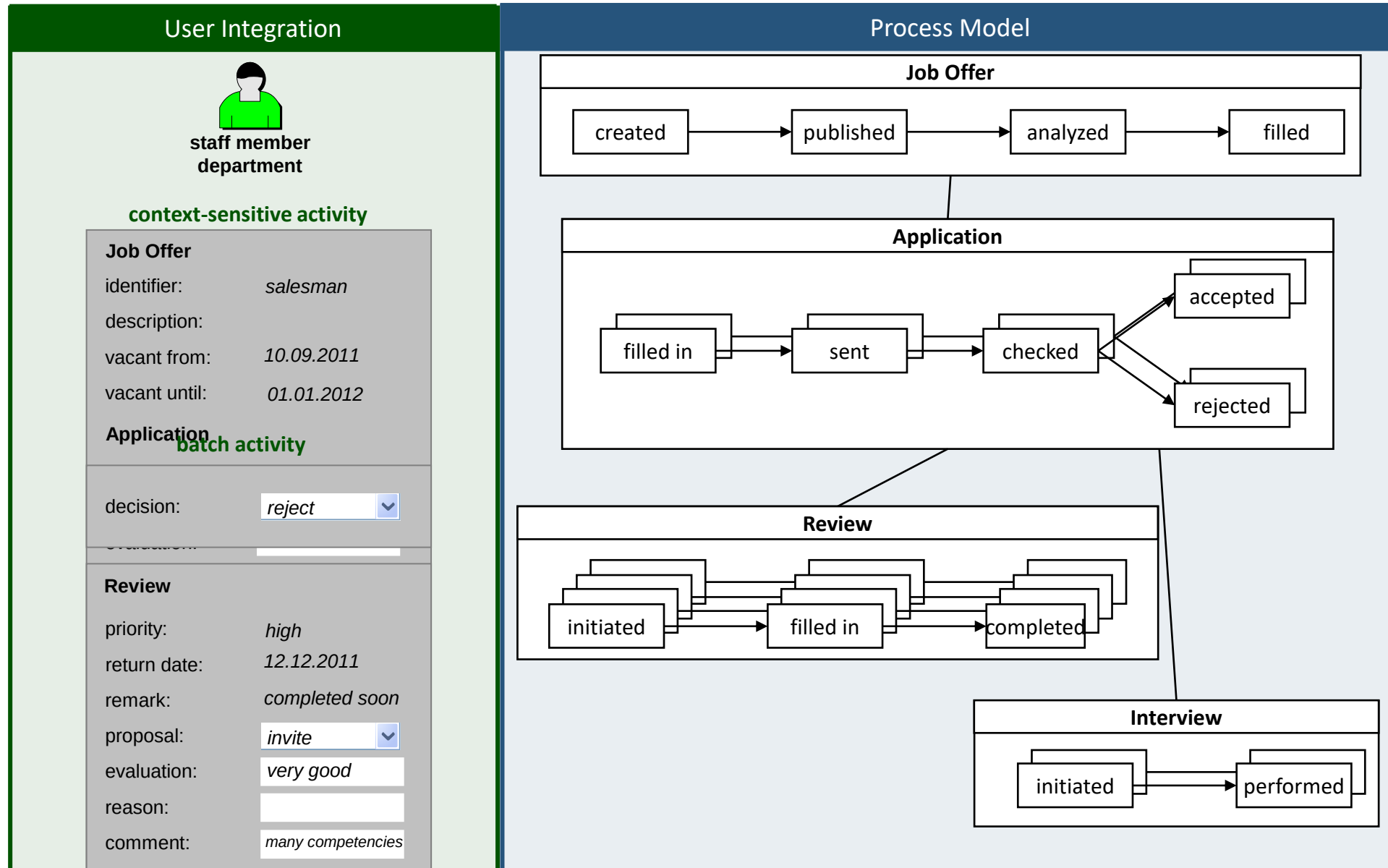
Object-Centric Processes: Object Behavior



Object-Centric Processes: Object Interactions

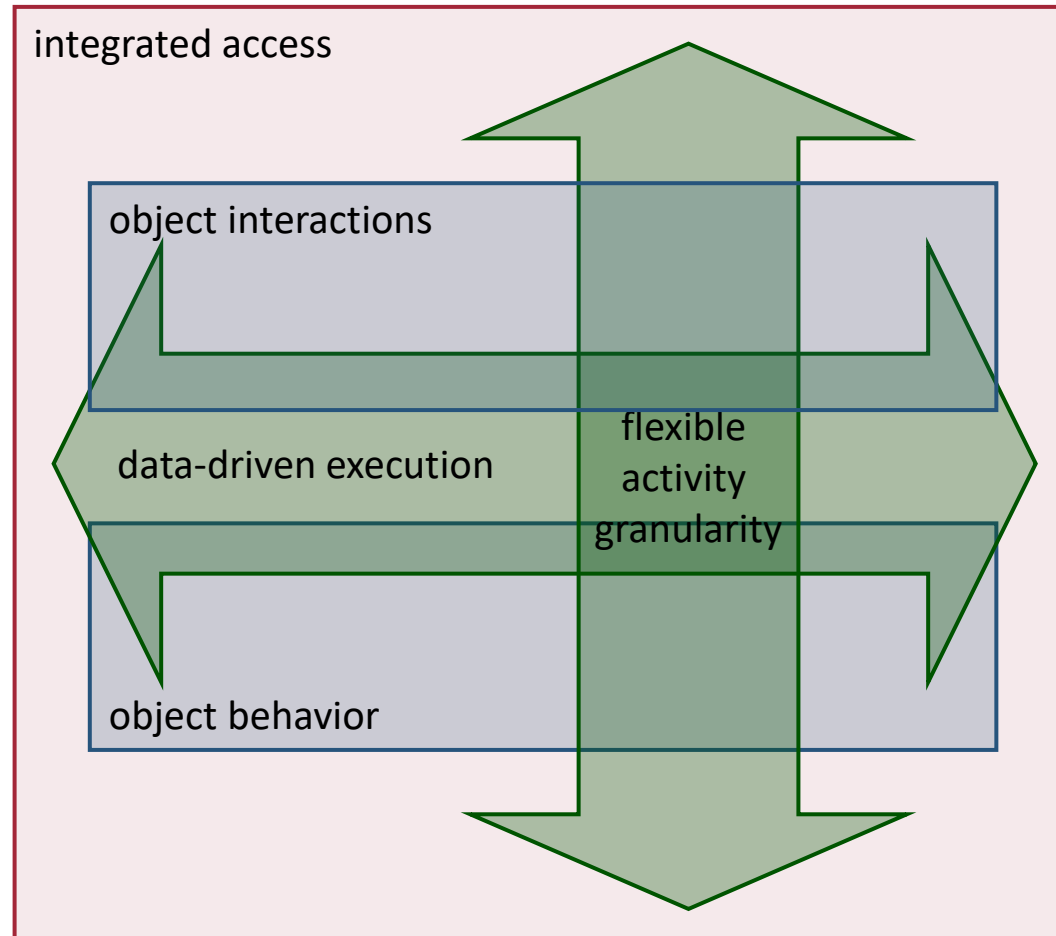


Object-Centric Processes: Flexible Activity Execution



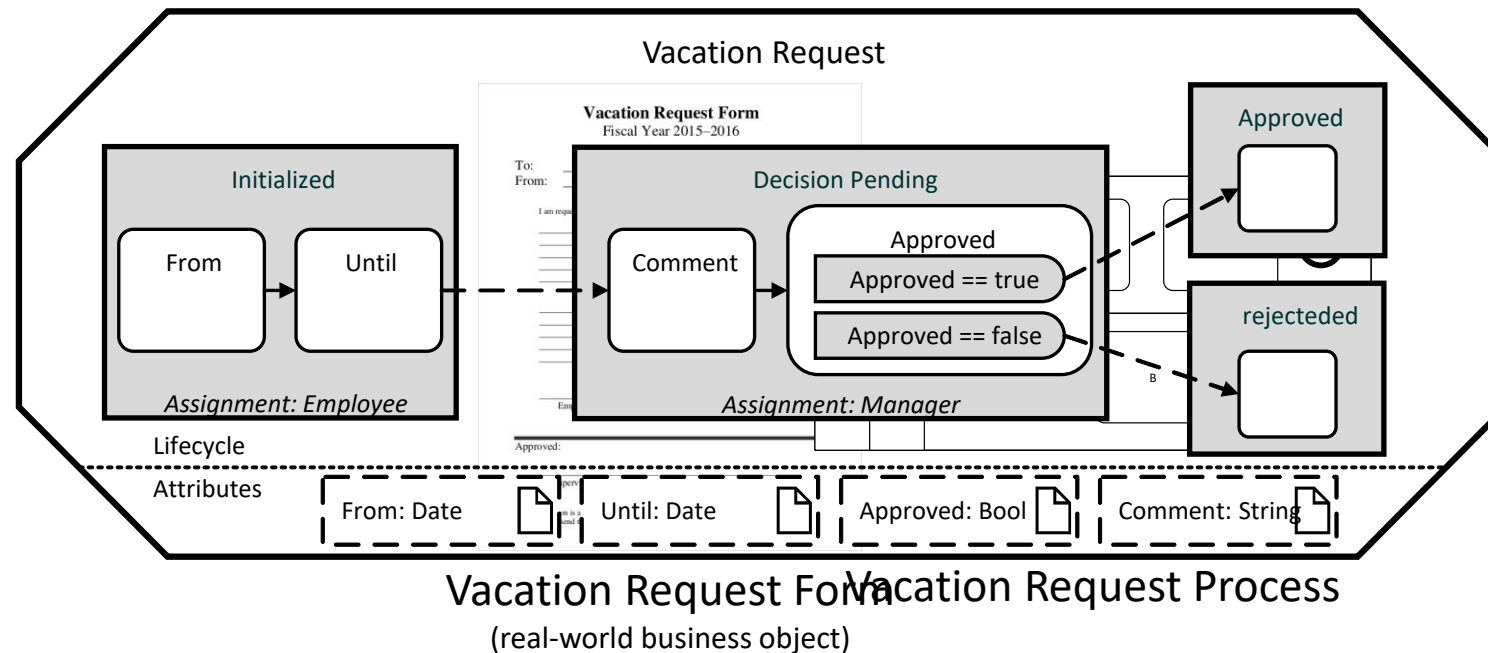
The PHILharmonicFlows Approach

An Object-Centric Approach to BPM



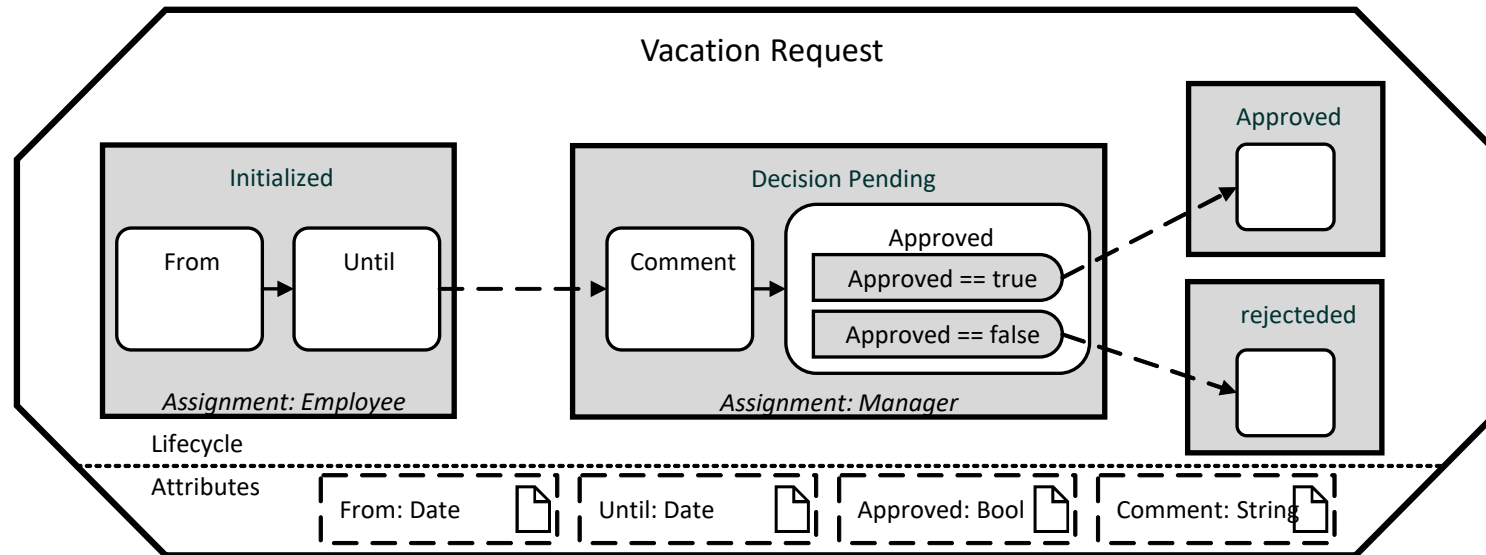
The PHILharmonicFlows Approach

Object Lifecycle Process: Modeling



The PHILharmonicFlows Approach

Object Lifecycle Process: Execution



Vacation Request – Init

From

Until

Submit

Vacation Request – Decision

From

Until

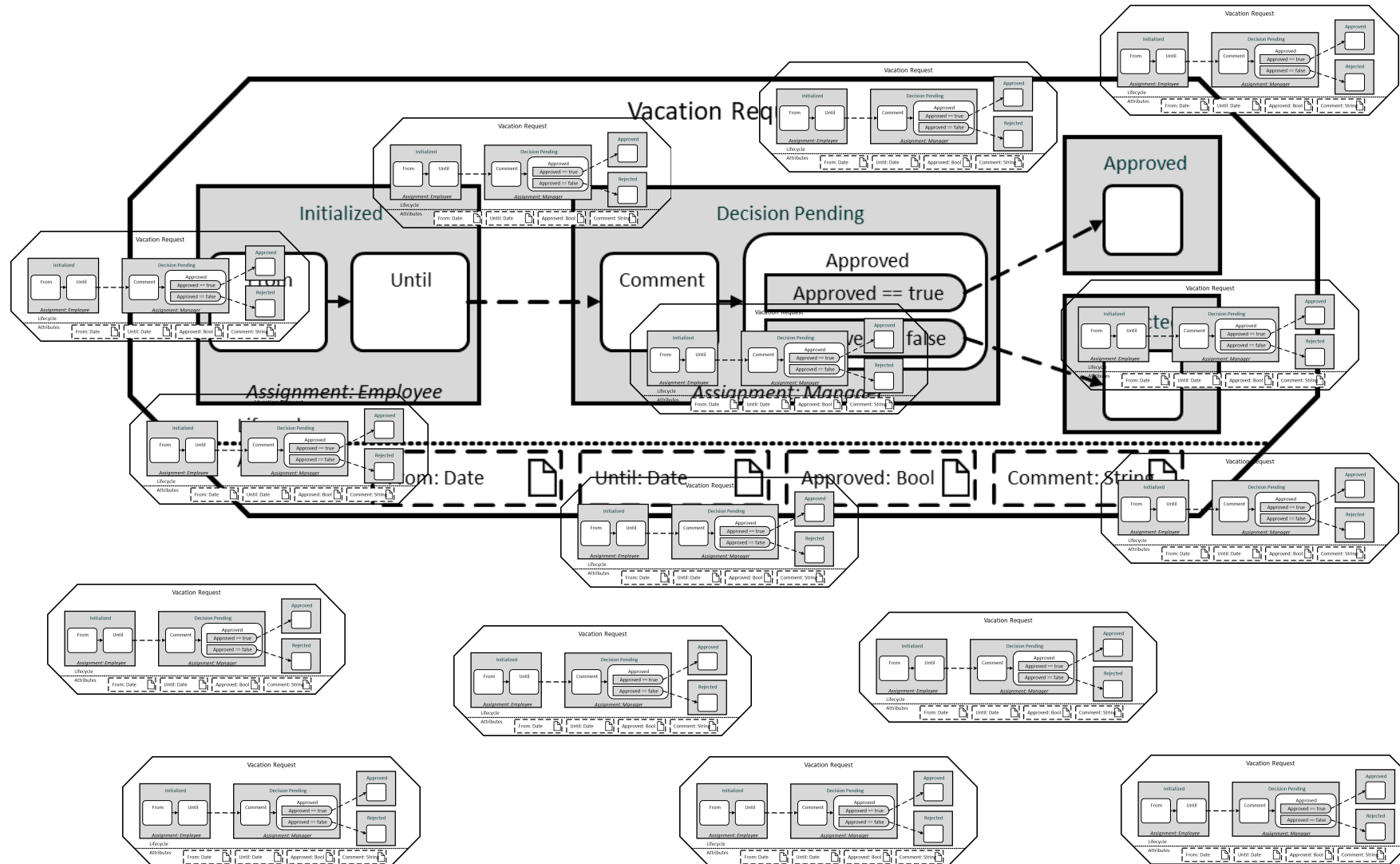
Approved

Comment

Submit

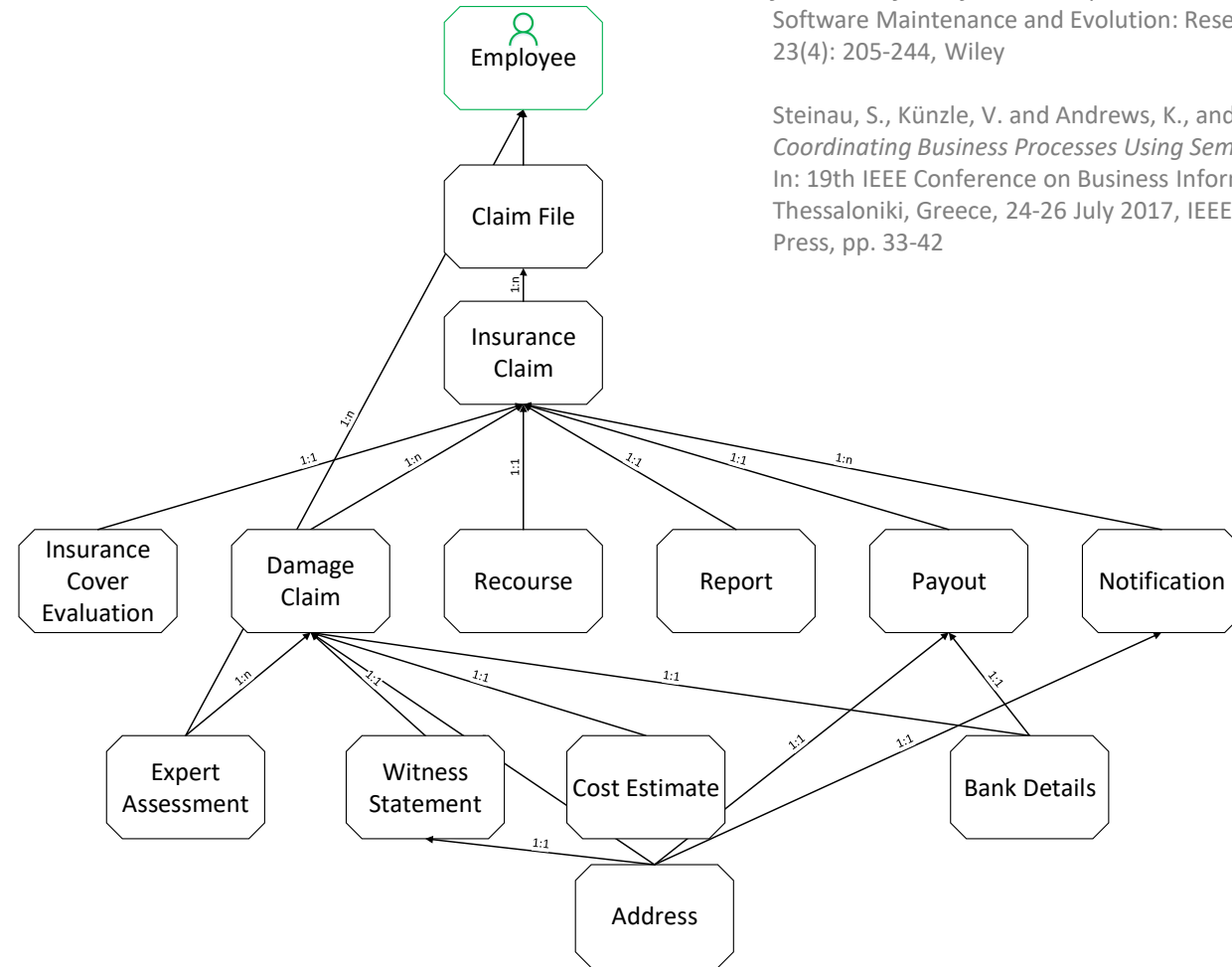
The PHILharmonicFlows Approach

Object Lifecycle Process: Execution



The PHILharmonicFlows Approach

Semantic Relationships

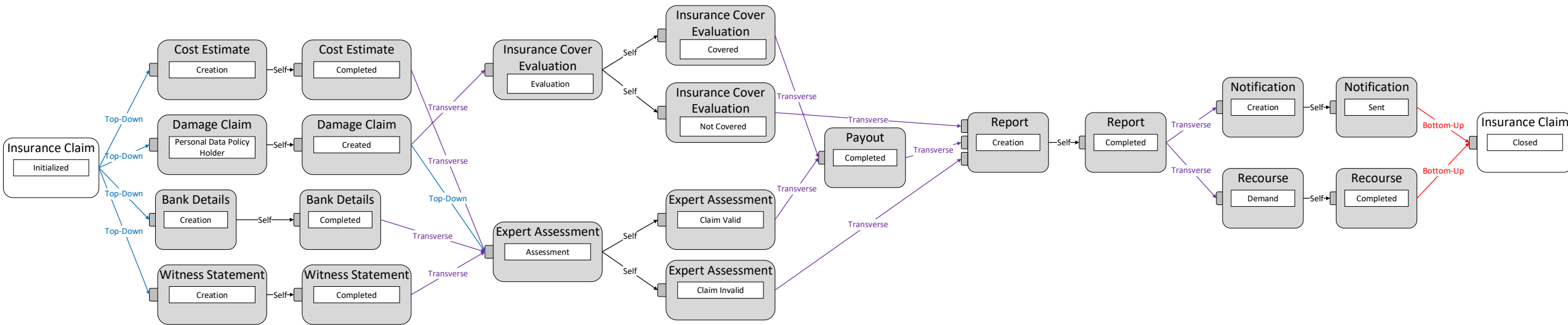


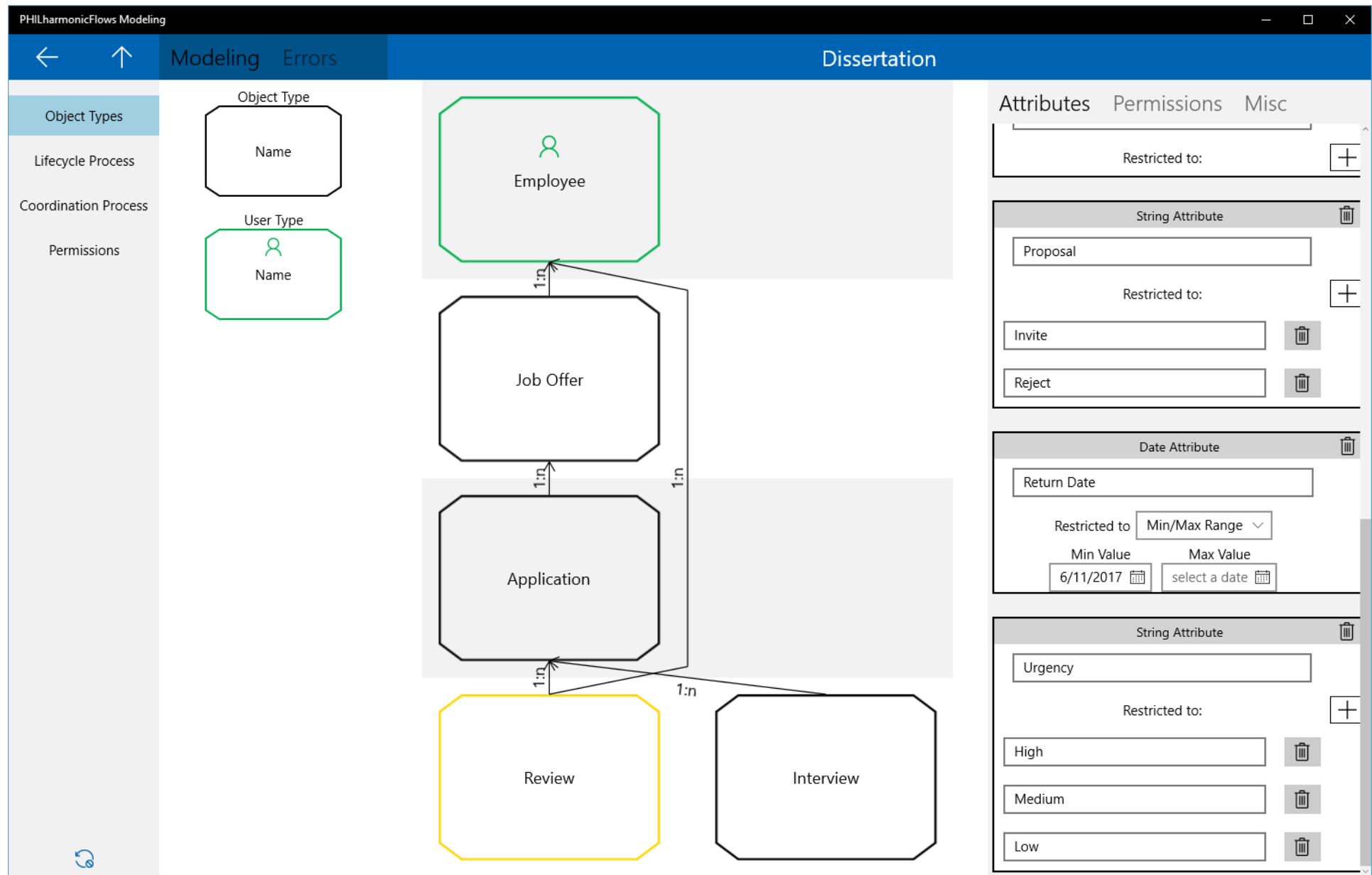
Künzle, V. and Reichert, M. (2011) *PHILharmonicFlows: towards a framework for Object-Centric process management*. Journal of Software Maintenance and Evolution: Research and Practice, 23(4): 205-244, Wiley

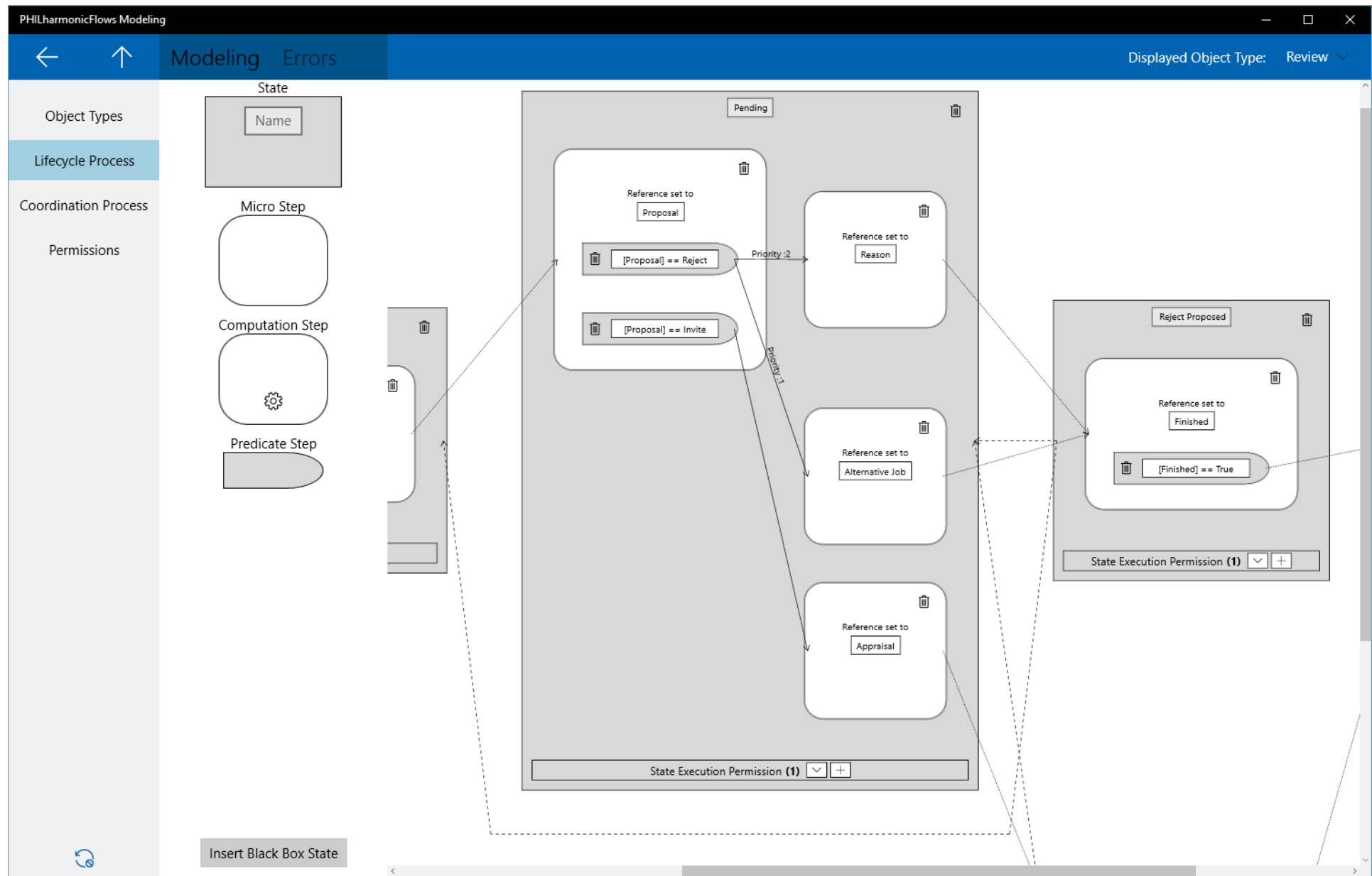
Steinau, S., Künzle, V. and Andrews, K., and Reichert, M. (2017) *Coordinating Business Processes Using Semantic Relationships*. In: 19th IEEE Conference on Business Informatics (CBI 2017), Thessaloniki, Greece, 24-26 July 2017, IEEE Computer Society Press, pp. 33-42

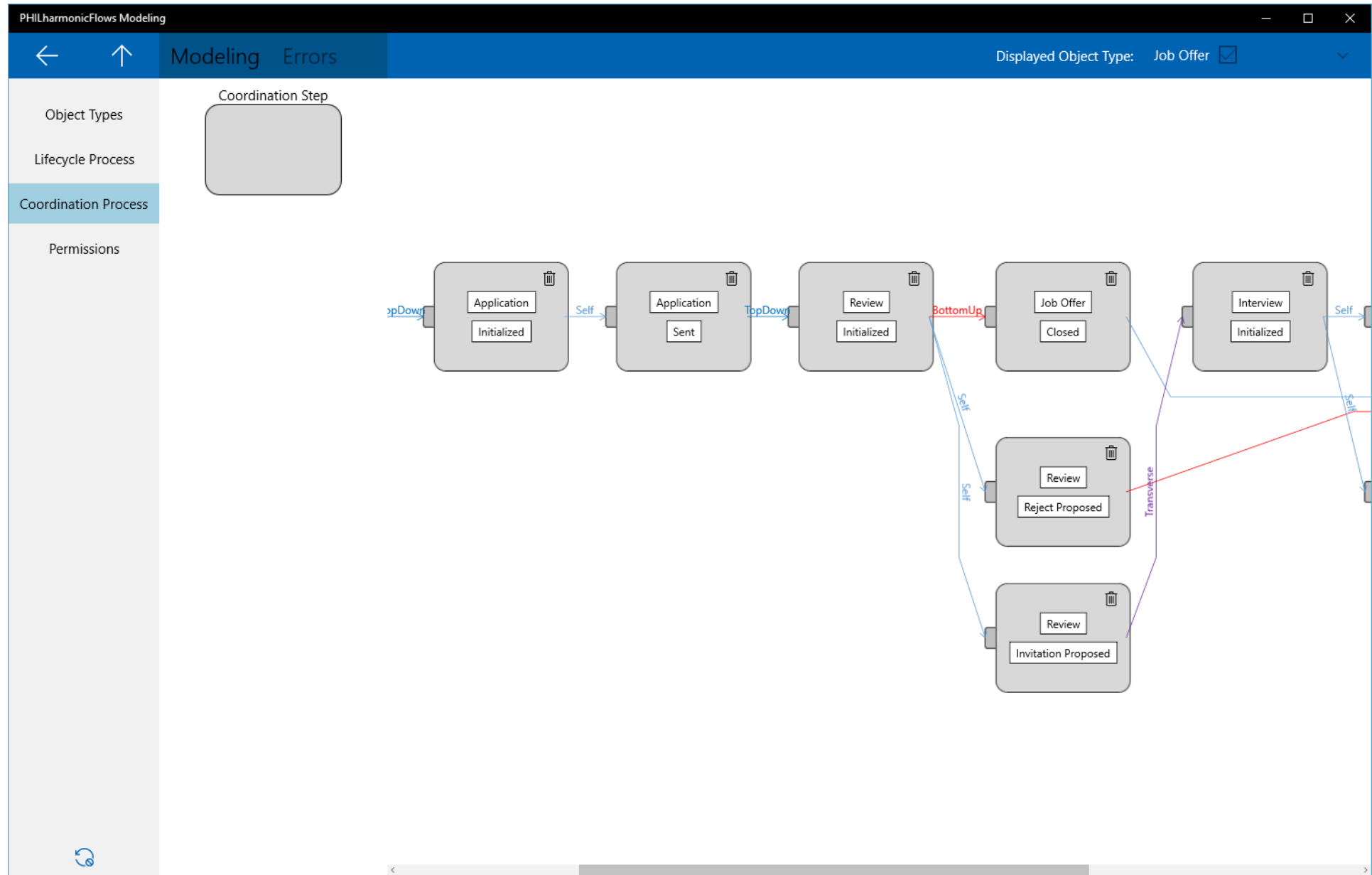
The PHILharmonicFlows Approach

Coordination Process









PHILharmonicFlows Runtime

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Administrator

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Worklist

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PHILharmonicFlows Runtime

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Link

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Dissertation

Filter

Administrator

Objects

Name

Application

State

Sent

Status

Running

Date Last Changed

6/11/2017 4:51:29 PM

Attribute Values

Review

Qualification

VFMRDL

AverageBreakTime

HHDXOW

Immediately Available?

True

Job Offer

Name

AQRV

Proficiencies

JDITP

Job Offer

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Review

Review	Initialized	Running	6/11/2017 4:49:28 PM	True
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Interview

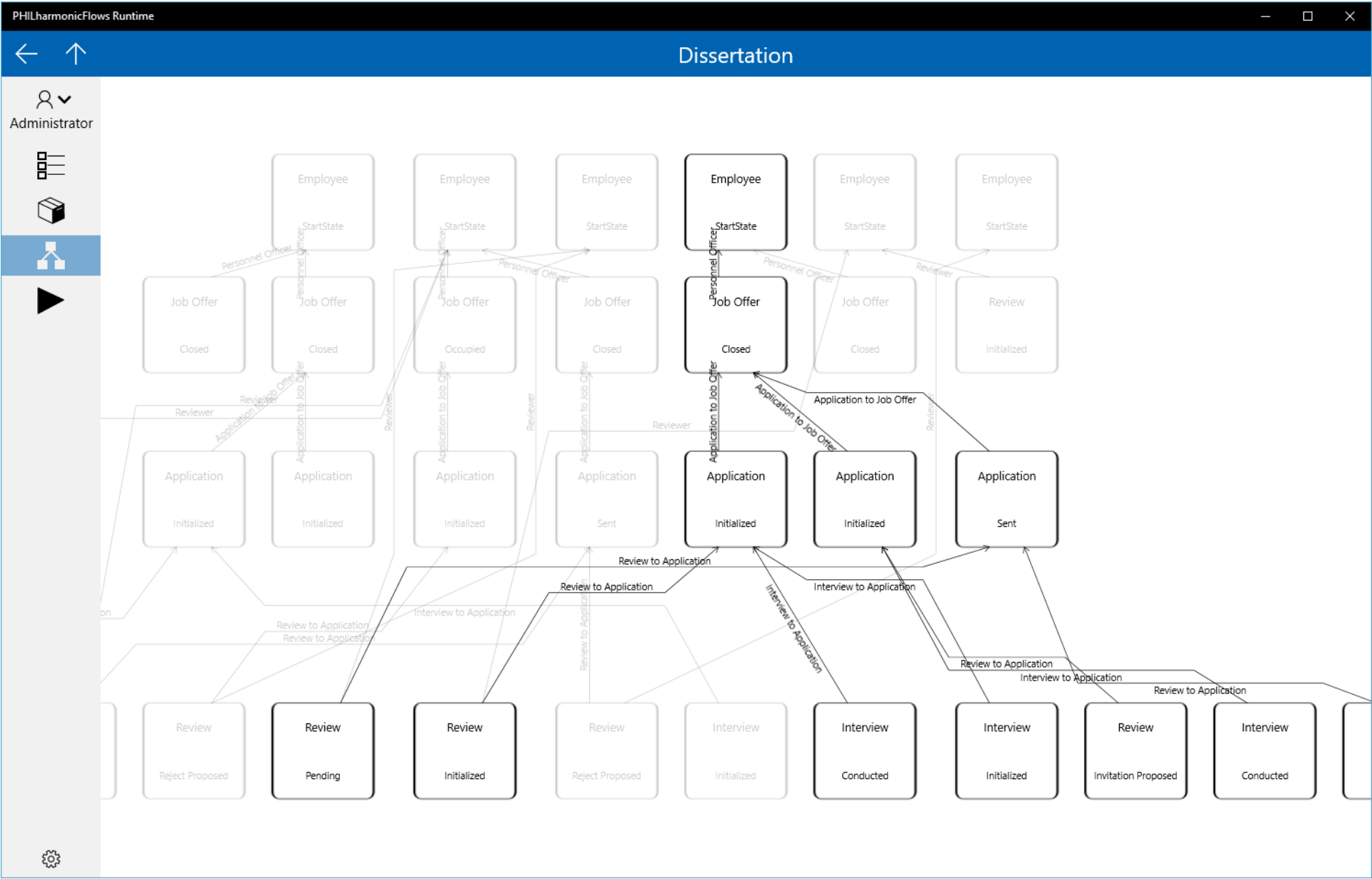
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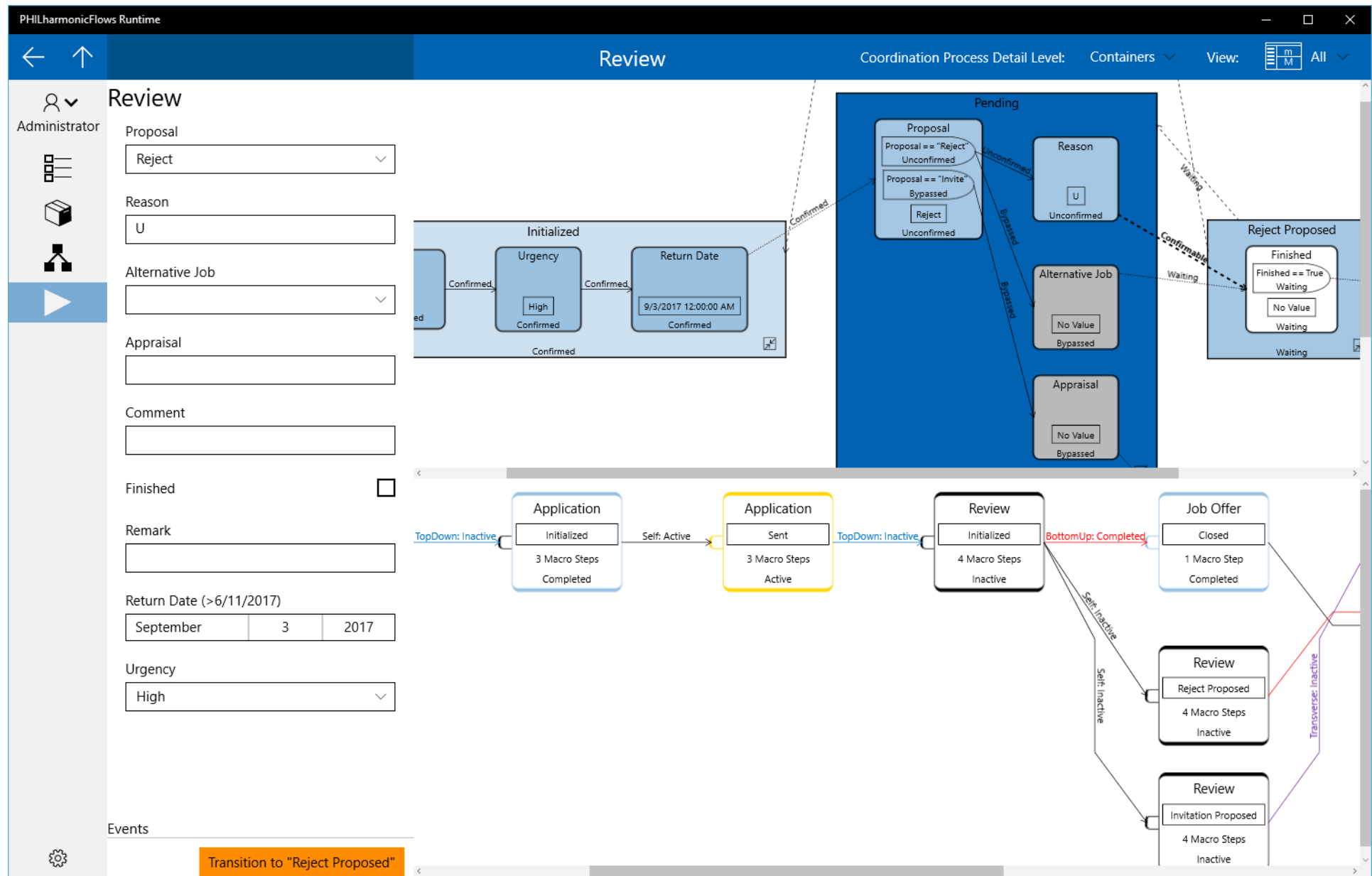
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Employee

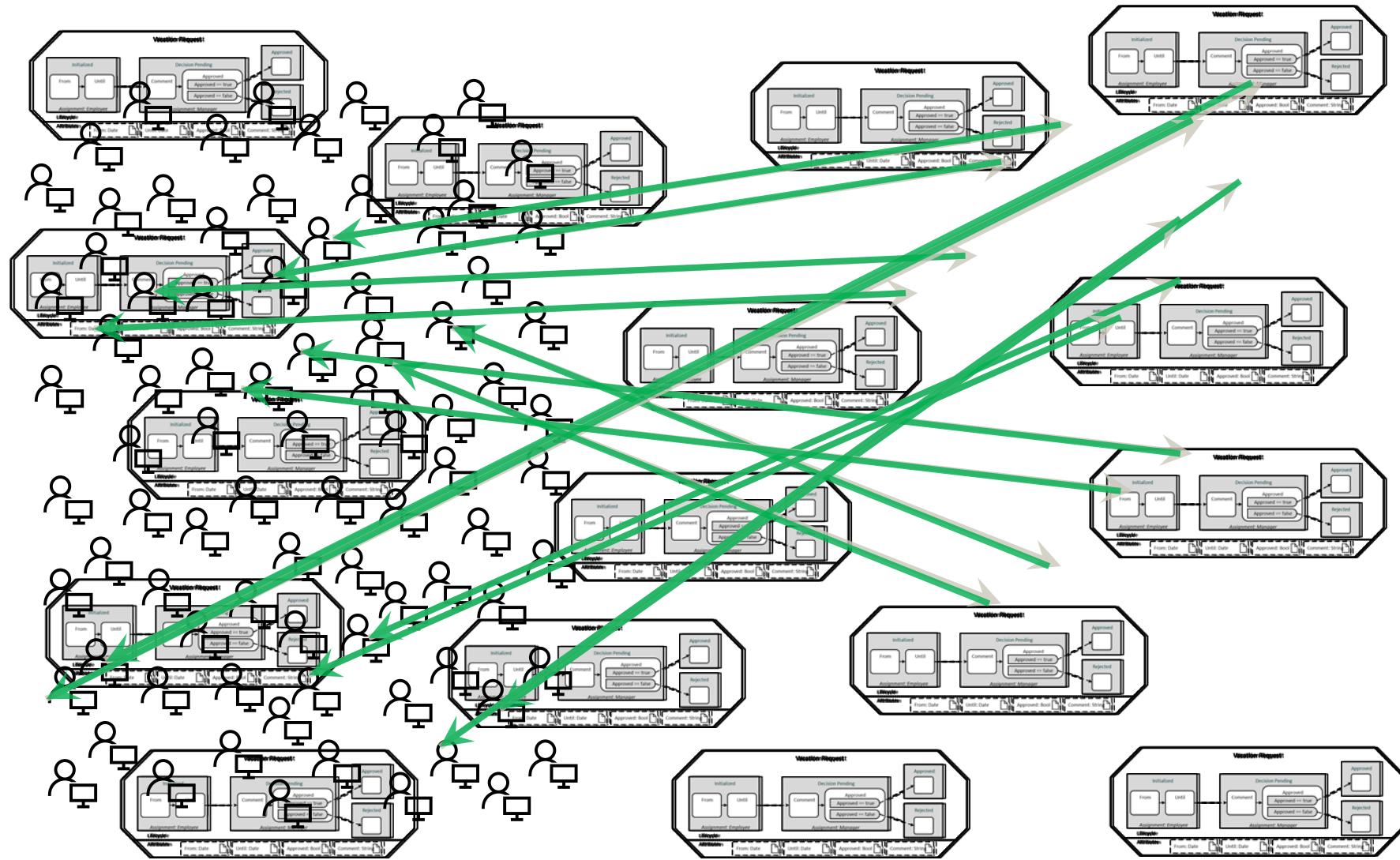
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Employee			6/11/2017	





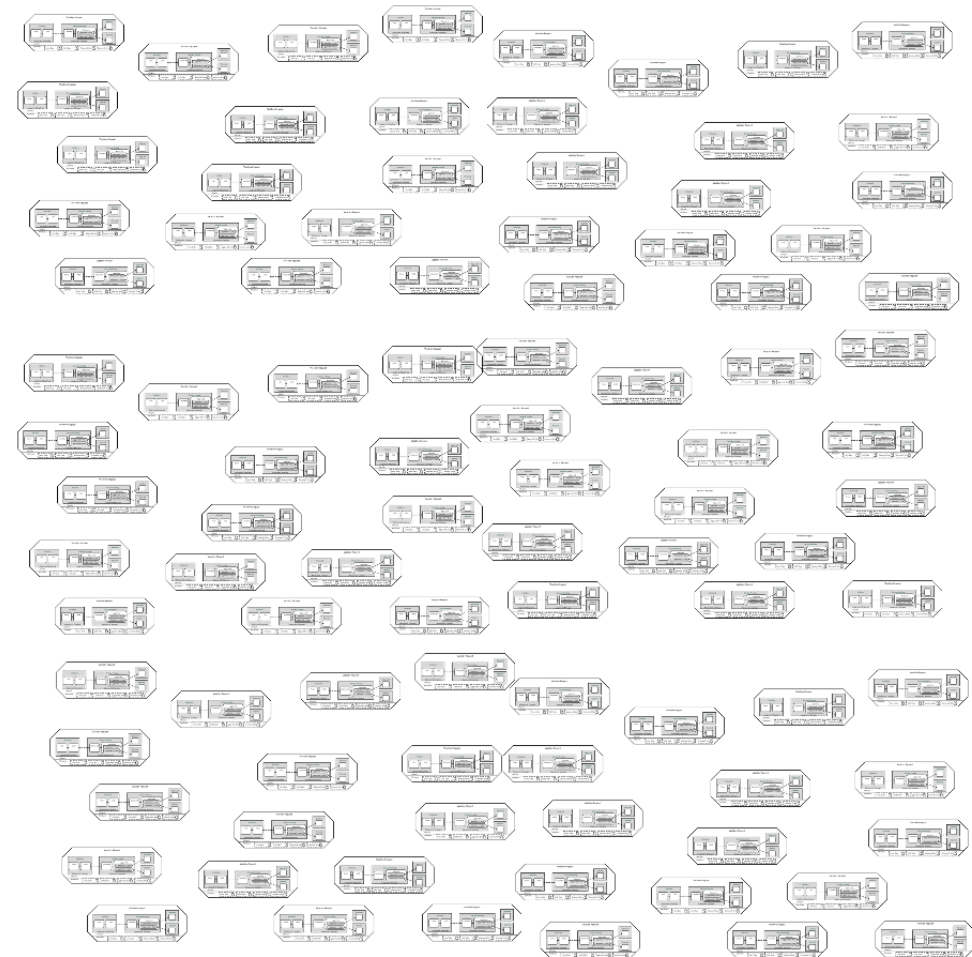
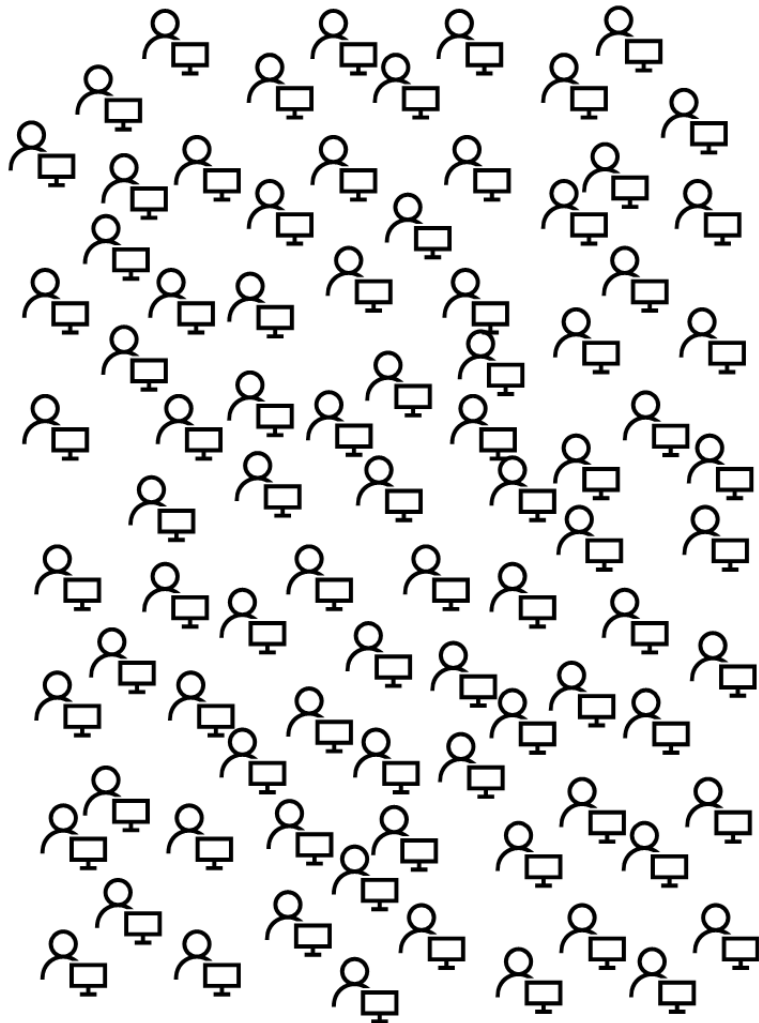
The PHILharmonicFlows Approach

Are Scalable Object-Centric Processes Technically Feasible?



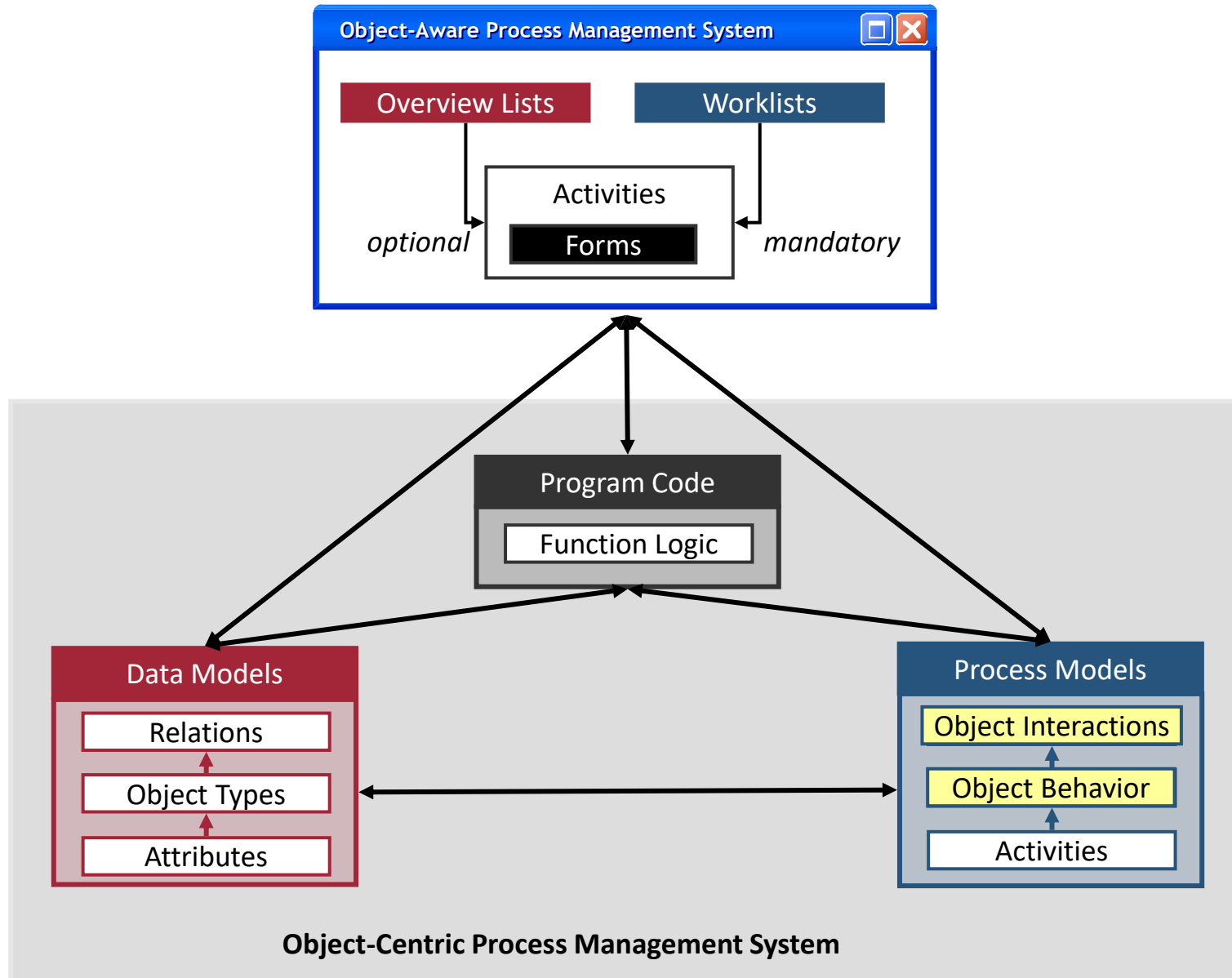
The PHILharmonicFlows Approach

Are Scalable Object-Centric Processes Technically Feasible?



Microservices-based Implementation

Object-Centric Process Management

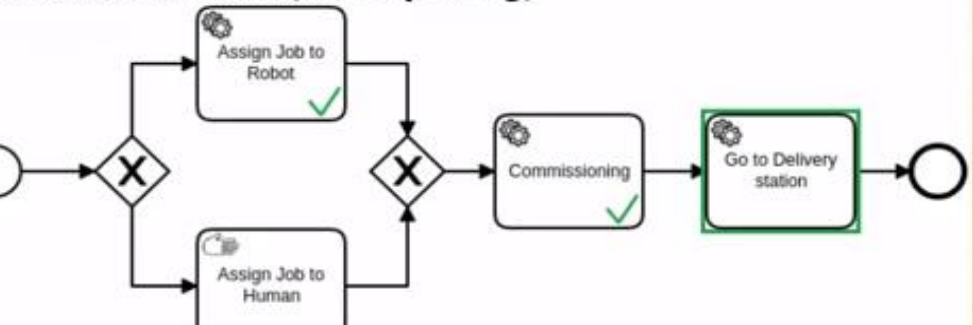




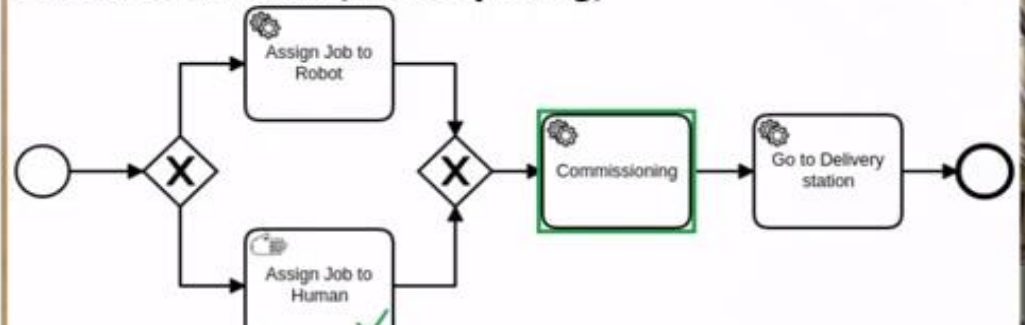
Advanced Applications of Object-Centric BPM

Flexible Support of Intralogistics Processes with Humans and Robots

Process instance 1 (robot picking)



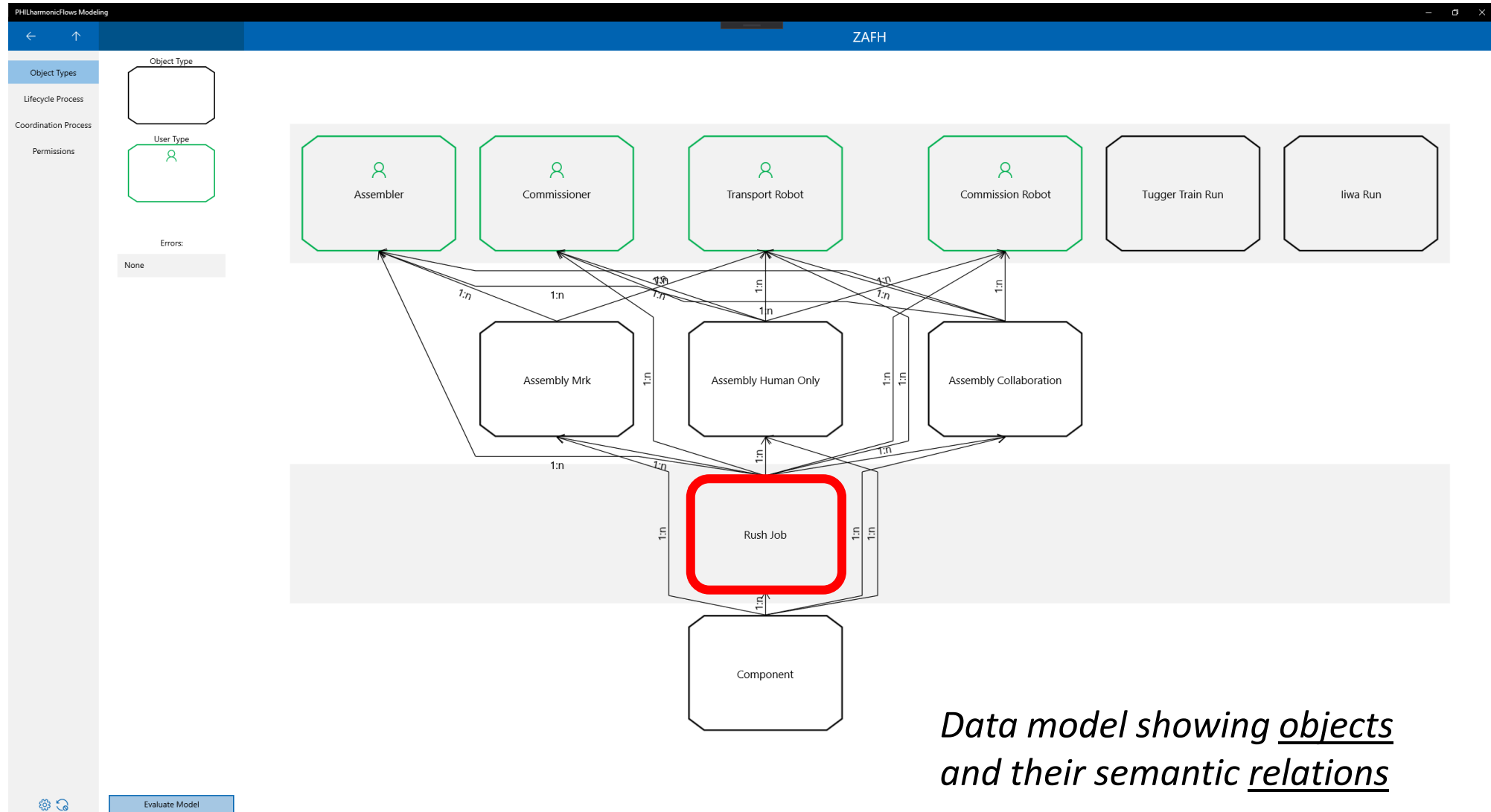
Process instance 2 (human picking)



The human worker performs picking, confirms the step via web interface and acknowledges the robot to wait for the next command from the process management system.

Advanced Applications of Object-Centric BPM

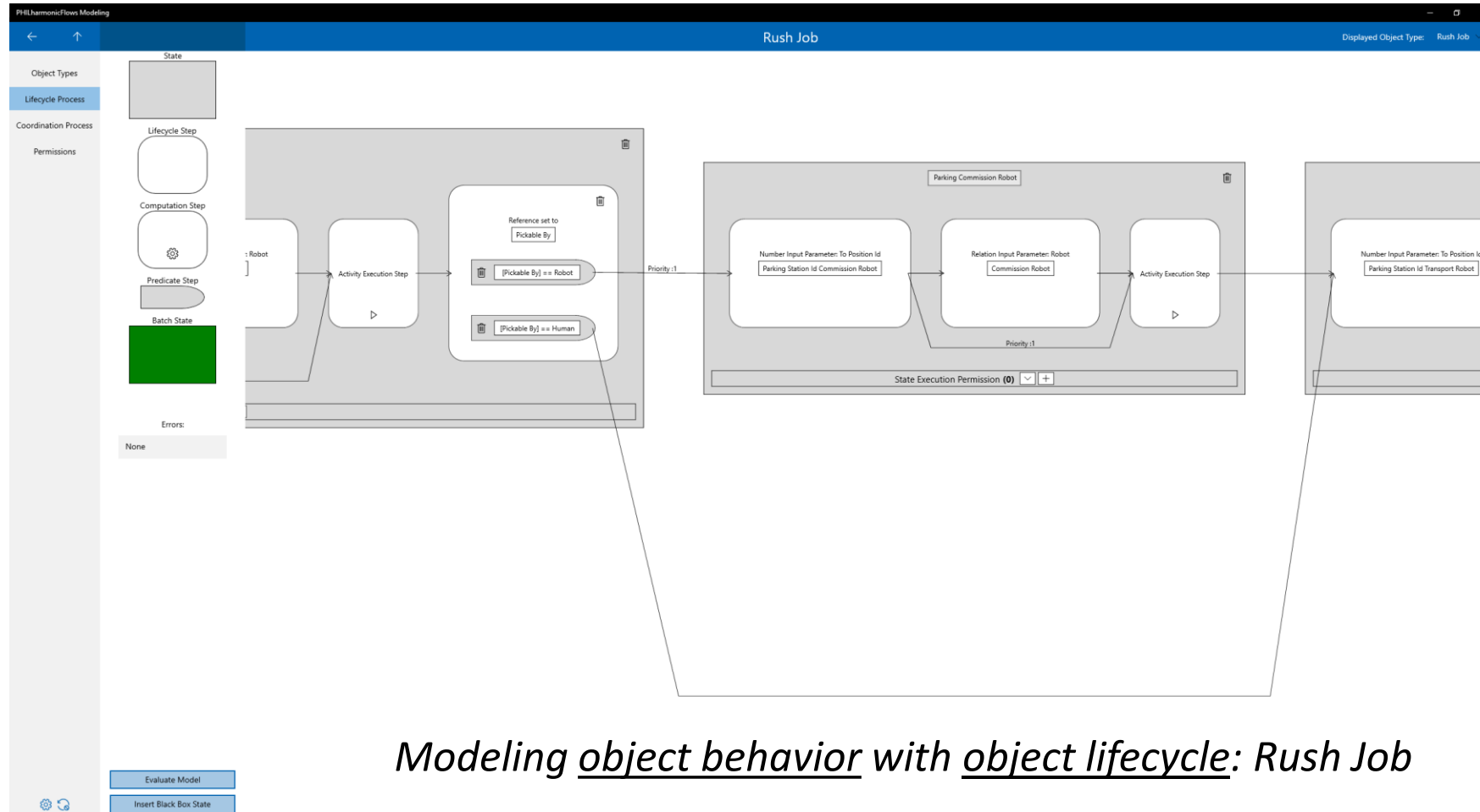
Flexible Support of Intralogistics Processes Involving Humans and Service Robots



Data model showing objects and their semantic relations

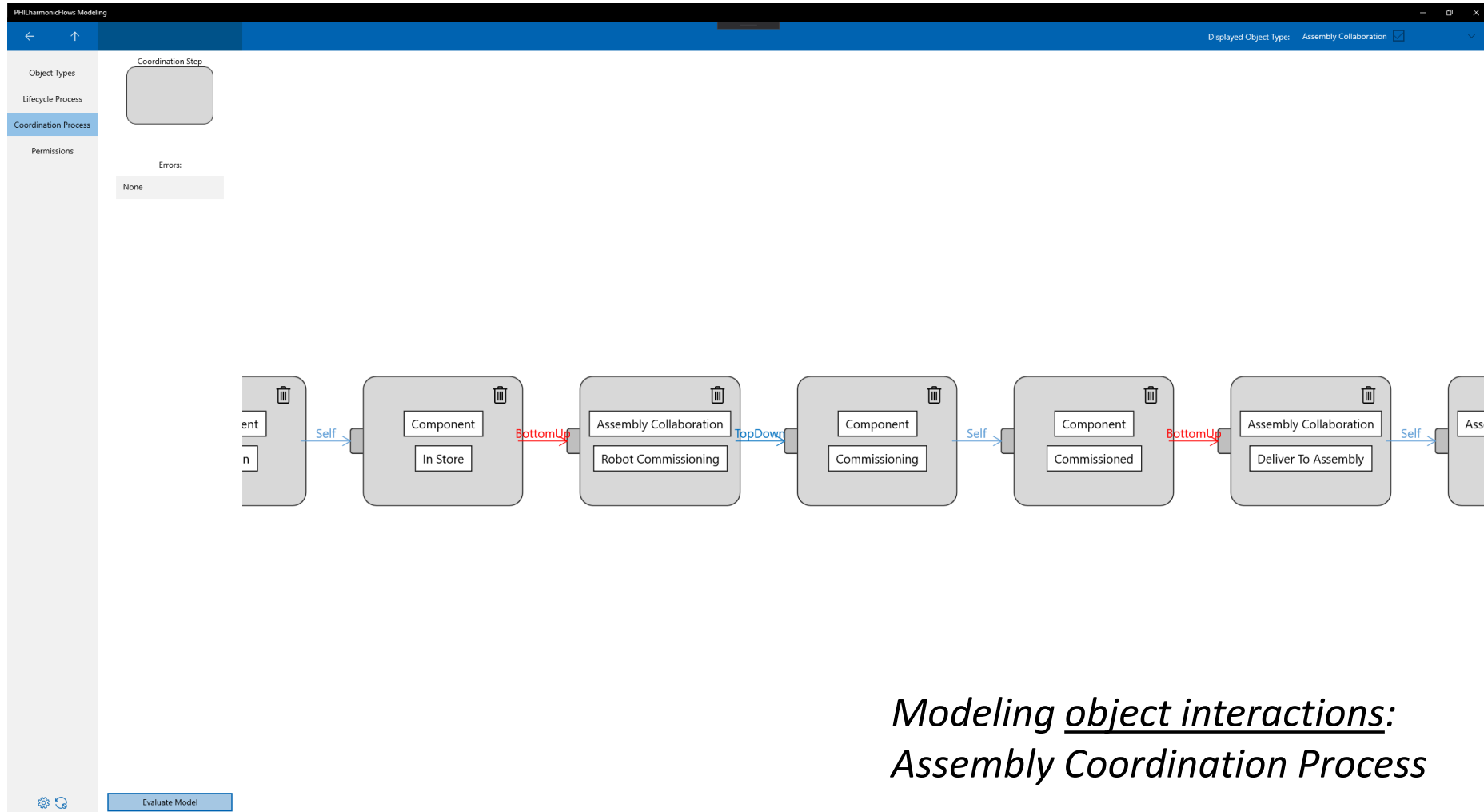
Advanced Applications of Object-Centric BPM

Flexible Support of Intralogistics Processes Involving Humans and Service Robots



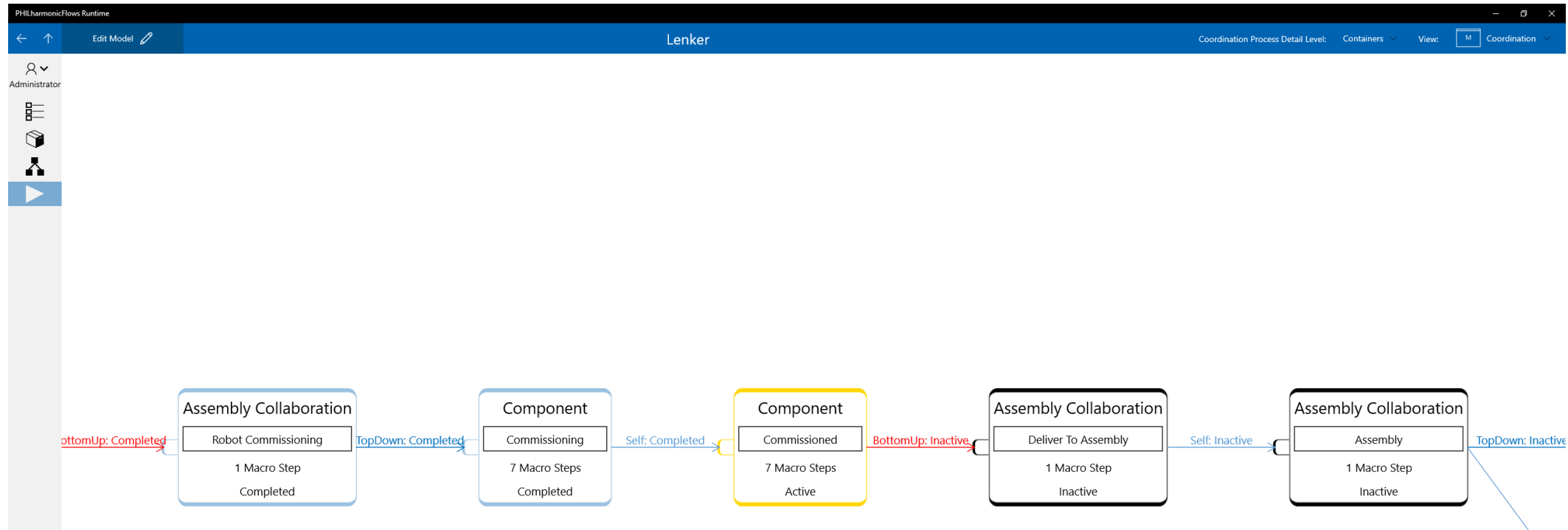
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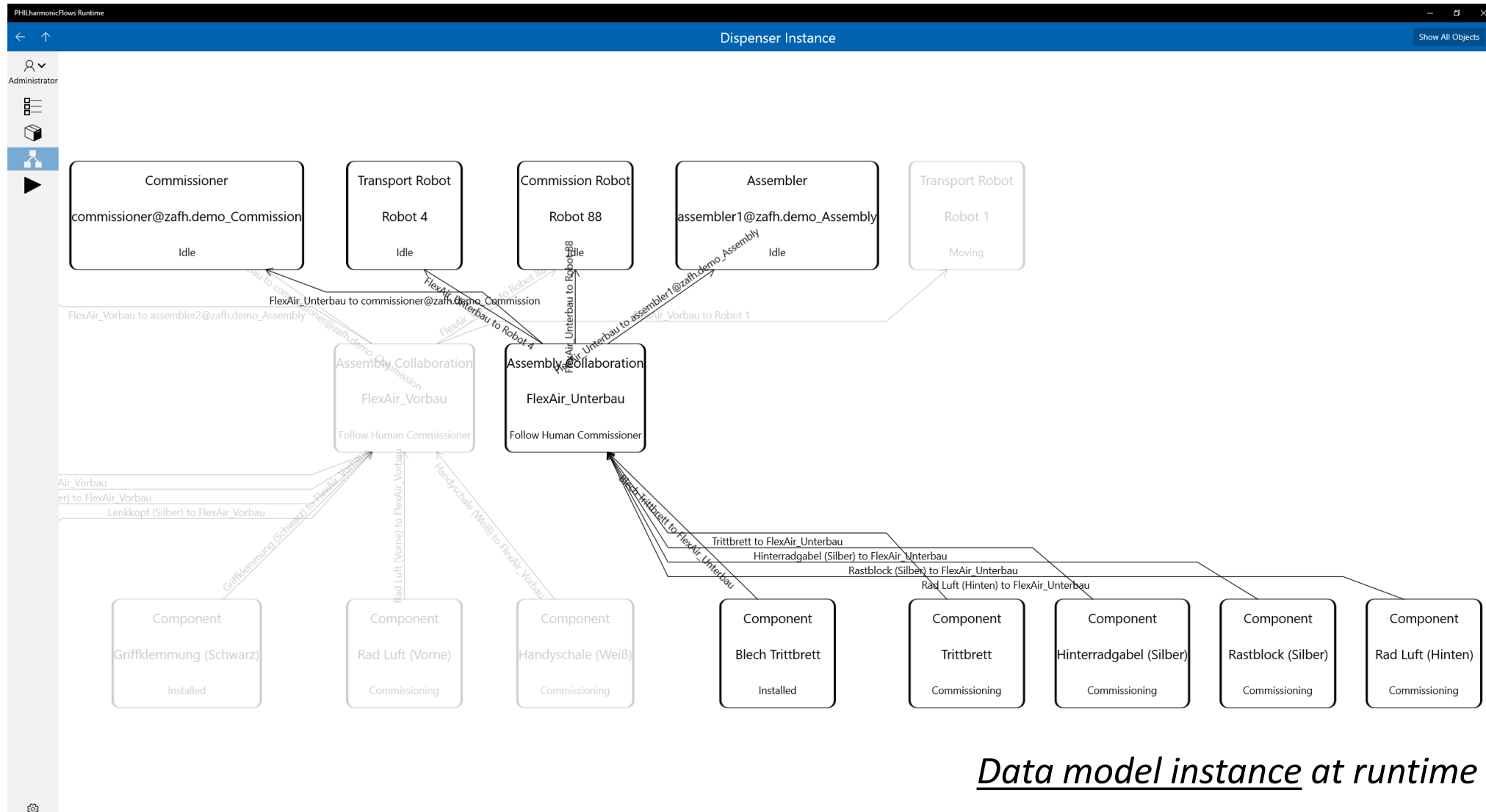
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*Coordinating object interactions at runtime:
Blocking assembly while waiting for commissioning*

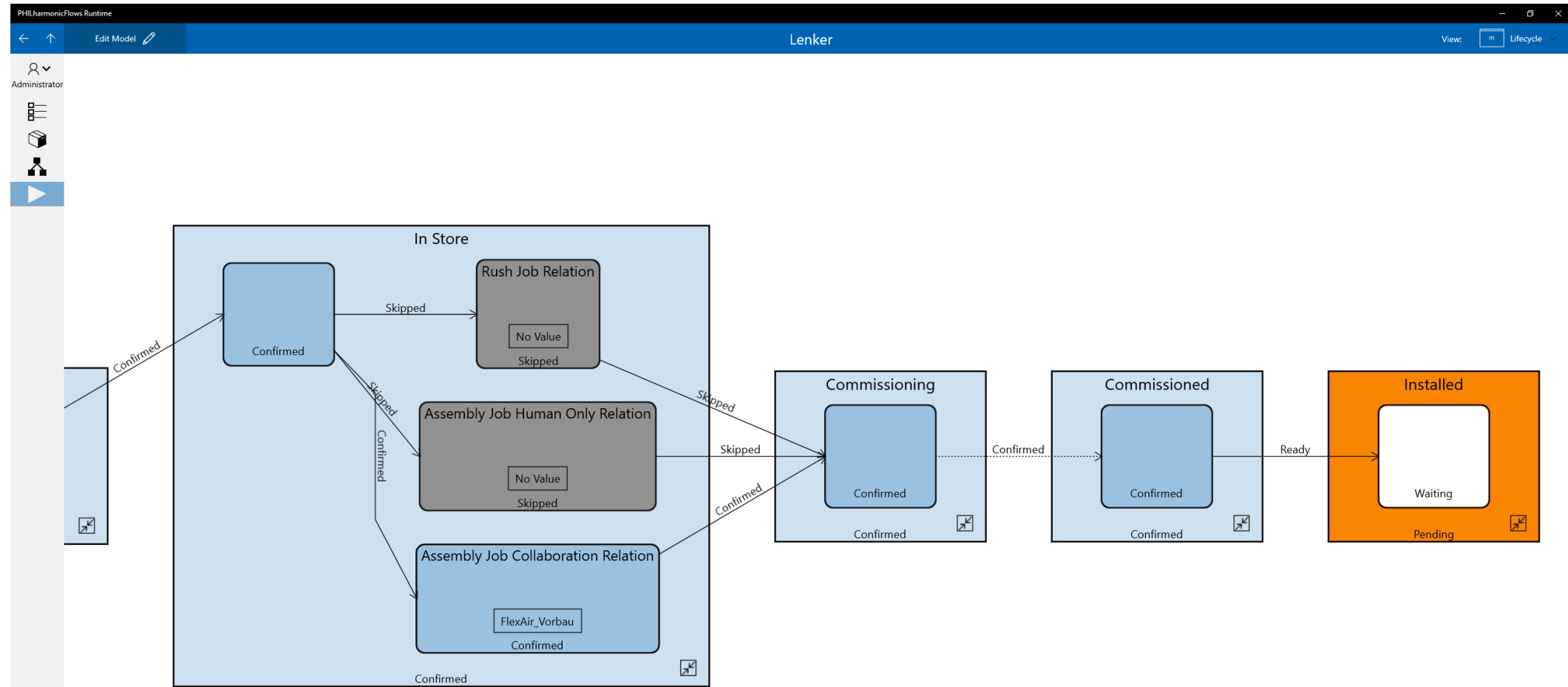
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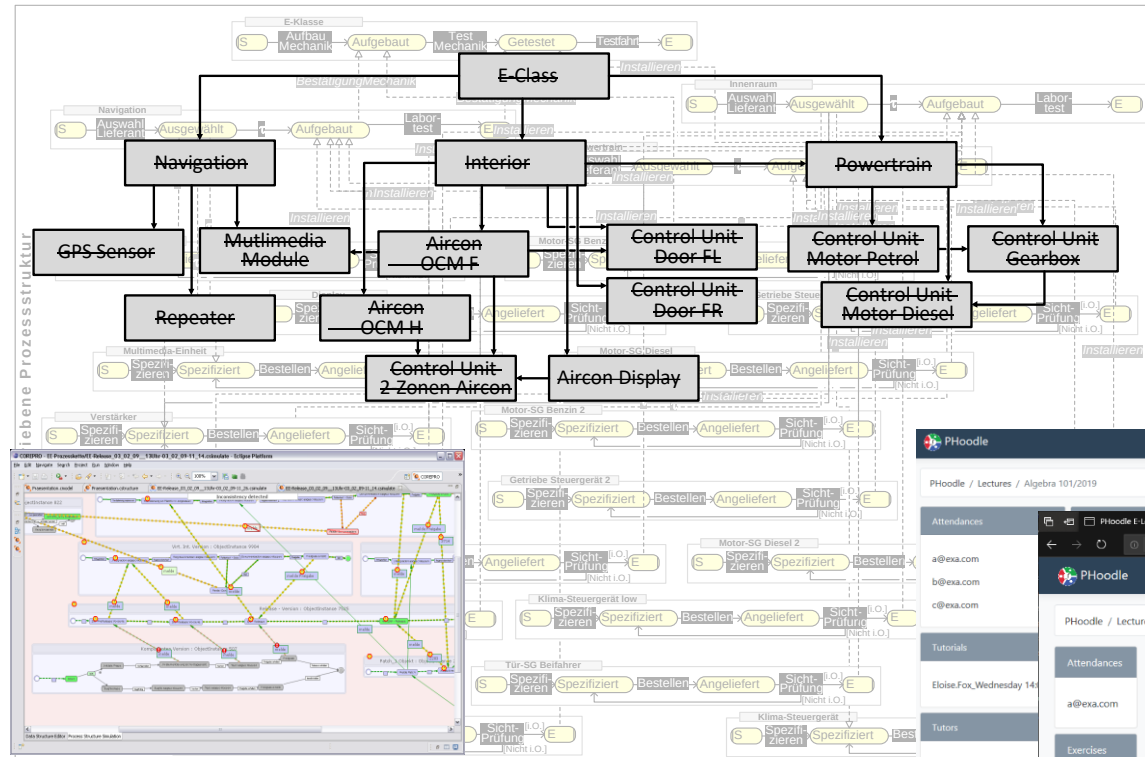
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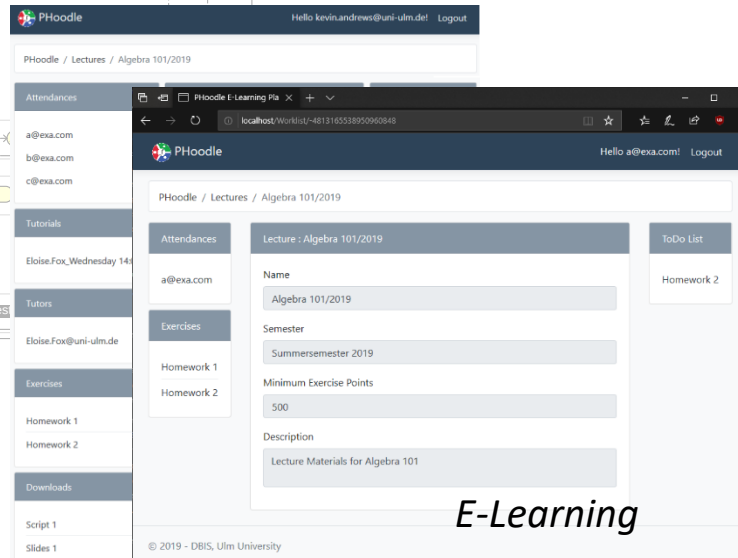
Executing a Component object lifecycle process instance at runtime

Advanced Applications of Object-Centric BPM

Other Sophisticated Examples



Automotive Engineering



E-Learning



Human Resource Management

Conclusions



- BPM needs good theories, methods, and technologies for contributing to the digital transformation!
- Object-centric BPMS offer a high degree of flexibility for automating business processes (i.e. engineering and runtime)!
- Flexible BPMS like AristaFlow and PHILharmonicFlows deliver the ability to manage work while dynamically adapting processes according to a contextual awareness and understanding of content, data, business and events.