From Theory to Practice –
Transferring Innovative BPM Research to Industrial Practice

Manfred Reichert
Introduction

ADEPT – A Decade of Research on Flexible Process-Aware Information Systems and its Transfer to Practice

Large Processes in the Automotive Industry and Technologies to Support them

Conclusions
Introduction

- Processes can become very large and complex
- Thousands of concurrently executed process instances
- High need for flexibility in all phases of the process lifecycle
- Support for application integration is fundamental
- Correctness and robustness are crucial features of any process-aware information systems
- Integrated support of all phases of the process lifecycle required
Introduction: PAIS Build-Time

Process Schema S

Execution Trace:
\[ \sigma_1 = \langle \text{„Patient Admission”, „Anamnesis & Clinical Examination”, „X-ray”} \rangle \]

Activity States: ▲ Activated ✔ Completed ✗ Skipped

Execution Trace:
\[ \sigma_2 = \langle \text{„Patient Admission”, „Anamnesis & Clinical Examination”, „Non Operative Therapy”} \rangle \]
Semantic Correctness
(Business Process Compliance)

Behavioral Correctness
(Soundness)

Syntactical Correctness

PAIS: Levels of Correctness

Compliance Violation

Inconsistency

Release patient
Make next appointment

Deadlock
Lifelock
Impossible Data-flow

PAIS: Levels of Compliance

Wrong Flows

Missing End Event

PAIS: Levels of Correctness
Introduction: PAIS Run-Time
Introduction: PAIS Lifecycle

1. Create Process Schema
2. Create Instances
3. Process Execution
4. Execution Log
5. Evolve Process Schema

Schema S:

- A
- B
- C
- D
- E

Instance I₁:

- A
- B
- C
- D
- E

Evolve Process Schema
Create Process Schema

Process engineer / Process administrator

Process Monitoring

Introduction

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Large Processes in the Automotive Industry and Technologies to Support them

Conclusions
ADEPT: Challenges

- Migrate running instances?
- Deal with conflicts between ad-hoc changes and schema changes at type level
- Good idea! Let it be the new process version!
ADEPT: Challenges

Need for Process Evolution

Need for Monitoring and Analyzing Dynamic Processes

Execution Log

Create Instances

Process engineer / Process administrator

Schema S:

Schema S':

Need for Process Variant Configuration

Need for Ad-hoc Deviations

ADEPT: Challenges

1. Create Process Schema
2. Create Instances
3. Process Execution
4. Execution Log
5. Evolve Process Schema
ADEPT: Ad-hoc Changes

Exceptional case – we need an additional lab test!

The Users' View

ADEPT: Ad-hoc Changes

System’s View

Process Type Level

Process Schema S

- Patient Admission
- Anamnesis & Clinical Examination
- Non Operative Therapy
- X-ray
- MRT
- Sonography
- Initial Treatment & Operation Planning
- Operative Treatment
- Discharge & Documentation

- Activity
- XOR-Split/Join
- AND-Split/Join

Process Instance Level

- Process Instance I1
- Process Instance I2

Execution Trace:
\[ \sigma_1 = \langle \text{Patient Admission}, \text{Anamnesis & Clinical Examination}, \text{X-ray} \rangle \]

Execution Trace:
\[ \sigma_2 = \langle \text{Patient Admission} \rangle \]

ADEPT: Ad-hoc Changes

Process Type Level

Process Schema $S$

$\text{Patient Admission}$ $\rightarrow$ $\text{Anamnesis & Clinical Examination} 
\rightarrow$ $\text{X-ray}$  
\rightarrow $\text{Non Operative Therapy}$

$\text{XOR-Split/Join}$

For patient "Mozart" the MRT activity needs to be skipped due to his cardiac pacemaker.

Process Instance Level

Process Instance $I_1$

Execution Trace: $\sigma_1 = \langle \text{Patient Admission}, \text{Anamnesis & Clinical Examination}, \text{X-ray} \rangle$

Process Instance $I_2$

Execution Trace: $\sigma_2 = \langle \text{Patient Admission} \rangle$

ADEPT: Ad-hoc Changes

Process Type Level

Process Schema S

- Patient Admission
- Anamnesis & Clinical Examination
- Non Operative Therapy
- X-ray
- MRT
- Sonography
- Discharge & Documentation
- Operative Treatment
- Initial Treatment & Operation Planning

Activity
- XOR-Split/Join
- AND-Split/Join

Process Instance Level

Process Instance I1

- Execution Trace:
  \( \sigma_1 = \{ \text{Patient Admission}, \text{Anamnesis & Clinical Examination}, \text{X-ray} \} \)

Process Instance I2

- Execution Trace:
  \( \sigma_2 = \{ \text{Patient Admission} \} \)

ADEPT: Ad-hoc Changes

Execution Trace:
\[ \sigma_3 = \left< \text{"Patient Admission"}, \text{"Anamnesis & Clinical Examination"}, \text{"MRT"}, \text{"X-ray"}, \text{"Sonography"} \right> \]

Process Instance I3

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

ADEPT: Ad-hoc Changes

Solution for many fundamental research issues!

Formal foundation of the ADEPT technology!

ADEPT: Ad-hoc Changes

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

Process Instance $I_1$, $\text{Delete}(I_1, \text{MRT})$

- $\text{pd}_{c_1} = \text{The treatment of cruciate ruptures routinely includes a magnetic resonance tomography (MRT), an X-ray and a sonography. However, for a particular patient the MRT may have to be skipped as the respective patient has a cardiac pacemaker.}$
- $\text{qaSet}_{c_1} = \{(\text{Does the patient have a cardiac pacemaker?}, \text{Patient.problemList.hasPacemaker} = \text{'Yes'})\}$
- $\text{sol}_{c_1} = \text{<Delete(S1, MRT)>}$
- $\text{freq}_{c_1} = 1$

1. Changes are rather costly
2. Variants are difficult to maintain

Derive a new reference process model from the variants such that:

Less adaptations are needed in future!
ADEPT: Process Schema Evolution

Process engineer / Process administrator

Execution Log

Process Monitoring

Instance I:

Schema S:

A \rightarrow B \rightarrow C \rightarrow E

D

A

B

C

E

Need for Process Evolution

Create Instances

Process Execution Log

Need for Process Evolution

Create Instances

Process Execution
ADEPT: Process Schema Evolution

ADEPT Process Management System

- Std Client API
- Web Client API
- Modeling API
- Dynamic Change API
- Admin. API
- Role Management
- Authorization Time Management
- Message Queuing
- Recovery
- Audit Trail

![Diagram showing ADEPT Process Management System](image)

The Users' View

- ADEPT Process Composer
  - Create Process Template
  - Modify Process Template
  - Check Process Template

Repository

- Process Templates
- Application Components

Repository

Check Instance Status

Users

- Process Designer / Process Administrator

**ADEPT Process 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

**ADEPT Process Management System**

1. 4.377 instances can be automatically migrated
2. 1.117 instances have proceeded too far
3. 123 instances cannot be automatically migrated

**Notes**

- 4.377 instances can be automatically migrated
- 1.117 instances have proceeded too far
- 123 instances cannot be automatically migrated

**ADEPT Process Management System**
ADEPT: Process Schema Evolution

System's View

Schema S:

<table>
<thead>
<tr>
<th>Get order</th>
<th>Collect data</th>
<th>Confirm order</th>
<th>Pack goods</th>
<th>Deliver goods</th>
</tr>
</thead>
</table>

S':

<table>
<thead>
<tr>
<th>Get order</th>
<th>Collect data</th>
<th>Confirm order</th>
<th>Pack goods</th>
<th>Deliver goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make invoice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I₁:

| ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓ | ✓ | ✓ | ✓ | ✓ |

I₂:

| ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓ | ✓ | ✓ | ✓ | ✓ |

Iₙ:

| ✓ | ✓ | ✓ | ✓ | ✓ |
| ✓ | ✓ | ✓ | ✓ | ✓ |

Process instance not state compliant with S'
(remains being executed according to S)

ADEPT: Process Schema Evolution

System's View

Schema S:
- get order
- collect data
- compose order
- confirm order
- pack goods
- deliver goods

I₁:
- ✓
- ✔
- ✗

I₂:
- ✓
- ✔
- ✗

Iₙ:
- ✓
- ✔
- ✗

S':
- make invoice
- confirm order
- pack goods
- send invoice
- deliver goods

Indispensable:
- General, Formal Correctness Criterion
- Analogy: DBMS Concurrency Control
  "Serializability Principle"

Process instance not compliant with S'

ADEPT: Extended Process Lifecycle Support

ADEPT: Implementing the Framework

ADEPT: Implementing the Framework

ADEPT: Implementing the Framework

ADEPT: Clinical Pathway Support

Flexible Support of Clinical Pathways with ADEPT

Partners:
Jan Neuhaus, Claudia Reuter
Fraunhoferinstitut Dortmund
ADEPT: Disaster Management

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

ADEPT: Transfering ADEPT to Practice
The AristaFlow BPM Suite

www.aristaflow-forum.de
Another Contribution: Comparing PAIS Flexibility Frameworks (1)

Change Patterns

Patterns for Decision Deferral

- **Traditional Workflow**: Need for User Experience is low, Degree of Decision Deferral is low. Specification needs to be completed before execution can start.

- **Multi-instance Activities**: Need for User Experience is high, Degree of Decision Deferral is low. Process model can contain placeholders whose content is selected during run-time.

- **Late Binding**: Need for User Experience is high, Degree of Decision Deferral is medium. Process model can contain placeholders whose content is modeled during run-time.

- **Late Modeling**: Need for User Experience is high, Degree of Decision Deferral is medium. Process model is iteratively composed during run-time considering existing constraints.

- **Late Composition**: Need for User Experience is high, Degree of Decision Deferral is high. Process model is iteratively composed during run-time considering existing constraints. Number of activity instances can be specified at run-time.
Another Contribution: Comparing PAIS Flexibility Frameworks (3)

**Change Support Features**

<table>
<thead>
<tr>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schema Evolution, Version Control and Instance Migration</td>
</tr>
<tr>
<td>Support for Instance-Specific Changes</td>
</tr>
<tr>
<td>Correctness of Changes</td>
</tr>
<tr>
<td>Traceability and Analysis of Changes</td>
</tr>
<tr>
<td>Access Control of Changes</td>
</tr>
<tr>
<td>Change Reuse</td>
</tr>
<tr>
<td>Change Concurrency Control</td>
</tr>
<tr>
<td>Refactoring Support for Process Models</td>
</tr>
</tbody>
</table>
**Another Contribution: Comparing PAIS Flexibility Frameworks (4)**

<table>
<thead>
<tr>
<th>Primitive / Pattern</th>
<th>Change Primitives</th>
<th>Adaptation Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADEPT2 / CBRFlow</strong></td>
<td><strong>CAKE</strong></td>
<td><strong>HOON</strong></td>
</tr>
<tr>
<td>PR1 – Add Node</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>PR2 – Remove Node</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>PR3 – Add Edge</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>PR4 – Remove Edge</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>PR5 – Move Edge</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td><strong>CAKE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HOON</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MOVE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>P of F</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WASA2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WIDE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>YAWL + Worklets / Exlets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flower</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Staffware</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Introduction

ADEPT – A Decade of Research on Flexible Process-Aware Information Systems and its Transfer to Practice

Large Processes in the Automotive Industry and Technologies to Support them

• Large Process Models
• Large Process Collections
• Large Process Structures

Conclusions
The Daimler BPM Round Table
Introduction

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Large Processes in the Automotive Industry and Technologies to Support them

• Large Process Models

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• Large Process Structures

Conclusions
The Challenge: Dealing with Large Process Models
Dealing with Large Process Models: Need for an Advanced Visualization Framework
The Proviado Visualization Framework

abstracting information (process views)

adapting visual appearance (symbols, colors, ...)

adapt display form (diagram, form, table, text, ...)
Proviado: Process Model Abstraction - Example
Some Requirements:

- Reduce complexity of (large) process models
- Aggregate or eliminate certain process information in a given application context
- Cover all process perspectives: behavior, data, …
Proviado: Process Model Abstraction – Basic Operations (2)

**Reduction**
- Eliminate activities
- Simplify the resulting schema
- Remove adjacent satellite objects

**Aggregation**
- Aggregate activities
- Aggregate adjacent objects if required
Proviado: Process Model Abstraction – High-Level Operations

Example:
ShowMyActivities

<table>
<thead>
<tr>
<th>Step 1</th>
<th>High-Level Operation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ShowMyActivities(user X)</td>
</tr>
<tr>
<td></td>
<td>• Define predicate pred:</td>
</tr>
<tr>
<td></td>
<td>Find all activities where actor X is not involved in</td>
</tr>
<tr>
<td></td>
<td>• Evaluate pred:</td>
</tr>
<tr>
<td></td>
<td>S = {C,D,E,F,I,J,K,L,P}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2</th>
<th>Multi-aspect Operation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reduce(S)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3</th>
<th>Single-aspect Operation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reducer(S)</td>
</tr>
<tr>
<td></td>
<td>• Find SESE components</td>
</tr>
<tr>
<td></td>
<td>S_1 = {C,D,E}, S_2 = {F},</td>
</tr>
<tr>
<td></td>
<td>S_3 = {I,J,K}, S_4 = {L},</td>
</tr>
<tr>
<td></td>
<td>S_5 = {P}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Elementary Operations:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RedSESE S_1</td>
</tr>
<tr>
<td></td>
<td>RedSESE S_2</td>
</tr>
<tr>
<td></td>
<td>RedSESE S_3</td>
</tr>
<tr>
<td></td>
<td>RedSESE S_4</td>
</tr>
<tr>
<td></td>
<td>RedSESE S_5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5</th>
<th>Simplification Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Proviado: Process Model Abstraction – Summary

Proviado ...

- offers a powerful mechanism for creating and visualizing process model abstractions (i.e., process views)
- enables a high degree of flexibility in respect to the artefacts created (based on parameterizable view-building operations)
- considers all process perspectives, e.g., control and data flow, process attributes, process logs
- has a well-defined formal foundation
The Proviado Visualization Framework

abstracting information (process views)

adapting visual appearance (symbols, colors, ...)

adapt display form (diagram, form, table, text, ...)
Proviado: Adjusting the Visual Appearance of Process Models

Visualization templates

Visualization template defines
1. symbol to be used
2. data to be displayed
3. application context
**Proviado: Adjusting the Visual Appearance of Process Models**

Creating a process visualization

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**Proviado: Adjusting the Visual Appearance of Process Models**

Creating a process visualization

---
Proviado: Abstraction + Visual Configuration

Personalized Visualization
The Proviado Visualization Framework

- abstracting information (process views)
- adapting visual appearance (symbols, colors, ...)
- adapt display form (diagram, form, table, text, ...)

The Proviado Visualization Framework provides a framework for visualizing data in various forms, allowing for the abstracting of information and adapting its visual appearance to enhance understanding.
Proviado: Supporting Different Display Forms for Process Models
Proviado: Supporting Different Display Forms for Process Models
The Proviado Visualization Framework: Achievements
Introduction

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Conclusions
The Challenge: Dealing with Large Process Model Collections
… and a Particular Challenge: Managing Process Variants

- **a) Standardized Repair Process**
  - Reception → Diagnosis → Repair → Hand Over
  - Maintenance

- **b) Variant 1: Simple Problem Repair**
  - Reception → Diagnosis → Repair → Hand Over
  - Duration = 2

- **c) Variant 2: Security Critical Repair**
  - Reception → Diagnosis → Repair → Final Check → Hand Over
  - Maintenance

- **d) Variant 3: Security Critical and Simple Problem Repair**
  - Reception → Diagnosis → Repair → Final Check → Hand Over

- **Connectors**:
  - AND Connector
  - OR Connector
  - Activity Attribute = Value
… and a Particular Challenge: Managing Process Variants
... and a Particular Challenge: Managing Process Variants

Problem: Not all value combinations make sense!
… and a Particular Challenge: Managing Process Variants
The Provop Approach for Managing Process Variants

Base process

Variant specific adjustments

Configured process variant

INSERT IF country = Italy

DELETE IF brand = Smart
The Provop Approach for Managing Process Variants

Base Process with Options

Process Family

CURRENT CONTEXT:
- Maintenance = “Yes”
- security critical = “No”

CURRENT CONTEXT:
- Maintenance = “Yes”
- security critical = “Yes”

CURRENT CONTEXT:
- Maintenance = “No”
- security critical = “No”

CURRENT CONTEXT:
- Maintenance = “No”
- security critical = “Yes”
The Provop Approach for Managing Process Variants
Introduction

ADEPT – A Decade of Research on Flexible Process-Aware Information Systems and its Transfer to Practice

Large Processes in the Automotive Industry and Technologies to Support them

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Conclusions
The Challenge: Dealing with Large and Complex Process Structures
Automotive Engineering:

- Electrical control units (ECUs) become more and more important:
  - provide many safety-critical functions
  - fast implementation of changes: adjustments and bug fixes by flashing new software onto the ECU
- Modern cars comprise up to 70 ECUs; >10,000,000 LoC
- ECUs interconnected by up to 10 buses with 2 kilometers of wires
- 90% of car innovations enabled by E/E systems
The Challenge: Dealing with Large and Complex Process Structures

Current Problems in Automotive Engineering

- Up to 50% of all car breakdowns due to electrical / electronic problems

- Some facts
  - Many non-obvious dependencies between ECUs
  - Different life and development cycles of mechanics, hardware and software
  - Numerous ECU variants and versions

- Systematic verification and release management required
The Challenge: Dealing with Large and Complex Process Structures
The Corepro Project – Basic Approach

Data Model

Object Life Cycles / Life Cycle Coordination Model

Data Structure

Data-driven Process Structure
The Corepro Project – Basic Approach

**Modellebene**

- Gesamtsystem
- System
  - hatKomp
  - nutztKomp
  - Komponente

**Life Cycle Coordination Model**

- Object Life Cycles / Life Cycle Coordination Model

**Instanzebene**

- Gesamtsystem
  - BR212, Rev. 02/08
  - hatSys
  - System
    - Telematik High V2.2
      - hatKomp
      - nutztKomp
    - Komponente
      - Head-Up Unit V3.14
      - Komponente
        - TV Tuner V1.83

**Data-driven Process Structure**
The Corepro Project – Basic Approach

Data-driven Process Structure
The Corepro Project – Basic Approach
• 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 Project – Exception Handling
Introduction

ADEPT – A Decade of Research on Flexible Process-Aware Information Systems and its Transfer to Practice

Large Processes in the Automotive Industry and Technologies to Support them

Conclusions
Research of my Team

Methods, Concepts and Technologies for Next Generation Process Management Technology

Adaptivität & Flexibilität
Korrekttheit & Robustheit
Daten & Prozesse
Prozess- und Service-Varianten
Verteilung & Mobilität
Intelligente (Smarte) Prozesse
Healthcare & Psychology
Automotive Engineering
Software Engineering
Product Lifecycle Management
Sustainable Data
...
Research Projects

- Process Intelligence
- Data & File Management
- Human-Computer Interaction
- Process Infrastructure

- Process Engine
- Distributed
- Mobile Process
- Cross-organizational
- Process Support
- Digitalization
- E-Procurement
- AristaFlow
- ADEPTdistribution
- MARPLE
- C3Pro
- ENPROSO
www.process-flexibility.com