Managing Flexibility Challenges for Composite Service Scenarios, Technologies, Tools

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Part 1: Introduction

Part 2: Process-Aware Information Systems

Part 3: Flexibility Issues

Part 4: Flexibility Support for Pre-specified Process Models

Part 5: Loosely-specified Process Models
Current situation in many enterprises:
- users interact with monolithic, function-centric application systems
- processes only in the users’ minds – with only partial process knowledge
• **Service-oriented Architectures**
  ○ modularization → invokable application services
Introduction

- **Service-oriented Architectures**
  - modularization invokable application services

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Introduction

• **Service-oriented Architectures**
  - modularization of invokable application services
  - combined by explicitly defined processes
  - whose execution is supported by a process-aware information system
Introduction

- **Goals of Service-oriented Architectures**
  - improving process quality
  - increasing **flexibility**
  - ...

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A Simple Healthcare Process

HIS

Registration

Patient information

Orders Placed

Orders Filled

examination orders

RIS

PACS

Report Repository

Report

Diagnostic Workstation

Film Lightbox

Film Folder

Film

Film

Image Manager & Archive

imaged retrieved

Images

Acquisition Modality

acquisition completed

acquisition completed

Acquisition

Modality

modalitv worklist

procedure scheduled

Prefetch any relevant prior studies

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Business Process Lifecycle
Process-aware Information System

- **Process Composer**
  - Create Process Schema
  - Modify Process Schema
  - Check Process Schema
  -...

- **Process Repository**
  - Process Models
  - Application Components

- **Process Execution Engine**
  - Instance 1
  - Instance 2
  - Instance 3
  - Instance 4
  - Instance 5
  - Instance 6
  - Instance 7
  - Instance 8
  - Instance 9
  - Instance 10
  - Instance 11
  - Instance 12
  - Instance 13
  - Instance 14

- **Process-aware Information System (PAIS)**
  - Late Modeling
  - Admin. API
  - Validation
  - Web Clnt API
  - Exceptions
  - Modeling API
  - Audit Trail
  - Dyn. Change API
  - Time Mgmt
  -...

- **Process Engineer**

- **Users**

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A Process Model and Related Instances

Process Schema $S$

- **Patient Admission** → **Anamnesis & Clinical Examination** → **X-ray** → **Non Operative Therapy** → **Discharge & Documentation**
- **Patient Admission** → **Sonography** → **MRT** → **Non Operative Therapy 1** → **Discharge & Documentation**

- **clinicalSuspicionOfCruciateRupture = “Yes”** → **Operative Treatment**

Execution Trace:

- $\sigma_1 = \langle \text{“Patient Admission”}, \text{“Anamnesis & Clinical Examination”}, \text{“X-ray”} \rangle$
- $\sigma_2 = \langle \text{“Patient Admission”}, \text{“Anamnesis & Clinical Examination”}, \text{“Non Operative Therapy”} \rangle$

Activity States:
- ▲ Enabled
- ✔ Completed
- ✗ Skipped

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Guideline:
After admission, a patient should not be discharged without making the appointment for his next visit.

$$G(\text{Admit\_patient} \rightarrow (\text{not Release\_patient} \cup \text{Make\_next\_appointment}))$$
Example

The activities CT and Inform patient are on different branches of an XOR-Block
Process model to be checked

Generated counterexample:
Execution path and corresponding process context violating the constraint
Levels of Process Model Correctness

- Compliance Violation
- Deadlock
- Lifelock
- Impossible Data-flow
- Inconsistency
- Missing End Event
- Wrong Flows

**Semantic Correctness**
(Business Process Compliance)

- Behavioral Correctness
(Soundness)

- Syntactical Correctness
Process-Aware Information Systems
Business vs. IT Level
A Real-World Modeling Scenario
Business IT Alignment Gap

Business Level

Business Process

IT Level

System Process

Evaluate
Affected Parts

Service
getPDMData

Service
getPLData

HT_evaluate_parts

Service
store_Evaluation

[BBR13a, BBR13b]
Need for Integrated Process Modeling

Change Management Process in the Automotive Domain (simplified)

Business process

Request Change → Evaluated Affected Parts → Specify Changes → Evaluate Changes → Make Decision → Record Decision → Implement Change

System process

HT_Request Change → Service_getPDMData → HT_evaluate parts → Service_store_Evaluation → HT_refine_change_request → HT_decide_change_request → Service_doc_change_PDM → Service_doc_change_parts_list → Service_MarkPartsAsChangeable

HT = Human Task

[BBR13a, BBR13b]
Need for Integrated Process Modeling

Business process

1. Request Change
2. Evaluate Affected Parts
3. Specify Changes
4. Evaluate Changes
5. Make Decision
6. Record Decision
7. Implement Change

System process

- HT_Request Change
- Service_getPDMData
- Service_getPLData
- HT_evaluate parts
- store_Evaluation
- change_request
- change_request
- Service_doc_change_parts_list
- Changeable

Relationships between business and system level need to be made explicit

HT = Human Task
Need for Integrated Process Modeling

Business process

Request Change → Evaluate Affected Parts → Specify Changes → Evaluate Changes → Make Decision → Record Decision → Implement Change

Process Model Transformations between Business and IT Level

- **Type 1**: relabel
- **Type 2**: split
- **Type 3**: merge
- **Type 4**: insert
- **Type 5**: skip

Relationships between business and system level need to be made explicit

System process

- **HT_Request_Change**
- **Service_getPDMData**
- **HT_evaluate_parts**
- **Service_store_Evaluation**
- **HT_refine_change_request**
- **HT_decide_change_request**
- **Service_doc_change_PDM**
- **Service_doc_change_parts_list**
- **Service_MarkPartsAsChangeable**
Need for Integrated Process Modeling

**Challenge: Flexible Handling of Top-Down and Bottom-Up Changes**

**Business process**
- Request Change → Evaluate Affected Parts → Specify Changes → Evaluate Changes → Make Decision → Record Decision → Implement Change

**Transformation model**
- HT_Request Change → Service_getPDMData → Service_getPLData → HT_change_announcement → Service_store_Evaluation → HT_refine_change_request → HT_decide_change_request → Service_doc_change_PDM → Service_doc_change_parts_list → Service_MarkPartsAsChangeable

**System process**
- HT_Request Change → Service_getPDMData → HT_evaluate_parts → Service_store_Evaluation → HT_refine_change_request → HT_decide_change_request → Service_doc_change_PDM → Service_doc_change_parts_list → Service_MarkPartsAsChangeable

HT = Human Task

---

**Need for Integrated Process Modeling**

- **Challenge:** Flexible Handling of Top-Down and Bottom-Up Changes
Flexibility and Process Evolution

Business process

1. Request Change
2. Evaluate Affected Parts
3. Specify Changes
4. Evaluate Changes
5. Make Decision
6. Record Decision
7. Implement Change

Transformation model

Type 1

Request Change

HT_Request_Change

Service_getPDMData

Evaluate Affected Parts

Service_change_announcement

Type 2

Specify Changes

HT_refine_change_request

Service_store_Evaluation

Service_getPLData

Evaluate Changes

Type 3

Make Decision

HT_decide_change_request

Record Decision

Service_doc_change_PDM

Implement Change

Service_MarkPartsAs_Changeable

System process

HT_Request_Change

Service_getPDMData

Service_getPLData

Service_change_announcement

HT_evolve_parts

Service_store_Evaluation

HT_refine_change_request

HT_decide_change_request

Service_doc_change_PDM

Service_doc_change_parts_list

Service_MarkPartsAs_Changeable

HT = Human Task

Estimate Costs

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Flexibility and Process Evolution

**Business process**
- Request Change
- Evaluate Affected Parts
- Specify Changes
- Evaluate Changes
- Estimate Costs
- Make Decision
- Record Decision
- Implement Change

**Transformation model**
- Request Change
- Evaluate Affected Parts
- Specify Changes
- Evaluate Changes
- Estimate Costs
- Make Decision
- Record Decision
- Implement Change

**Service**
- Service_getPDMData
- Service_getPLData
- Service_change_announcement
- Service_store_Evaluation
- Service_refine_change_request
- Service_decide_change_request
- Service_doc_change_PDM
- Service_doc_change_parts_list
- Service_MarkPartsAs_Changeable

HT = Human Task
Flexibility and Process Evolution

**Business process**
- Request Change
- Evaluate Affected Parts
- Specify Changes
- Evaluate Changes
- Estimate Costs
- Make Decision
- Record Decision
- Implement Change

**Transformation model**
- Request Change
- Evaluate Affected Parts
- Specify Changes
- Evaluate Changes
- Estimate Costs
- Make Decision
- Record Decision
- Implement Change

**System process**
- HT_Request Change
- Service_getPDMData
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- Service_doc_change_parts_list
- Service_MarkPartsAs_Changeable

HT = Human Task
Flexibility Issues
Processes on the right side of the spectrum are mostly **knowledge-intensive**

- **Unpredictability:** Course of action depends on situation-specific parameters
- **Non-repeatability:** Two process instances hardly look the same
- **Emergence:** Future course of action depends on knowledge gained through activity execution
Variability is typical for many domains and requires that processes are handled differently depending on the particular context.

Drivers
- Product and service variability
- Differences in regulations
- Different customer groups
- Temporal differences
Looseness

- Knowledge-intensive processes cannot be fully pre-specified, but require loose specifications

- Drivers
  - Unpredictability
  - Non-Repeatability
  - Emergence

Example: Treatment Processes in a Hospital
Adaptation

- Ability to adapt the process and its structure to temporary events

- Drivers
  - Special Situations
  - Exceptions

- Anticipation of Adaptation
  - Planned
  - Unanticipated

Example: Examination Procedures in a Hospital

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• Ability of the implemented process to change when the business process evolves

• Drivers

![Diagram showing the relationship between external and internal factors affecting real-world process evolution and PAIS system design errors, technical problems, and poor internal quality.]

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Flexibility Issues along the Process Lifecycle

Traditional Process Lifecycle Support

1. Need for Process Evolution
2. Create Instances
3. Process Execution
4. Execution Log
5. Process Monitoring

Need for Variability Support
Need for Looseness of Process Specifications
Need for Process Adaptation (Support for Planned and Unplanned Exceptions / Special Cases)

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<table>
<thead>
<tr>
<th>Flexibility Need</th>
<th>Dimension</th>
<th>Technological Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variability</td>
<td></td>
<td>Configuration</td>
</tr>
<tr>
<td>Looseness</td>
<td></td>
<td>Loosely-specified processes</td>
</tr>
<tr>
<td>Adaptation</td>
<td>Planned</td>
<td>Exception Handling</td>
</tr>
<tr>
<td></td>
<td>Unplanned</td>
<td>Ad-hoc Changes</td>
</tr>
<tr>
<td>Evolution</td>
<td>Deferred</td>
<td>Versioning</td>
</tr>
<tr>
<td></td>
<td>Evolution</td>
<td>Process Instance Migration</td>
</tr>
<tr>
<td></td>
<td>Immediate</td>
<td>Refactoring</td>
</tr>
<tr>
<td></td>
<td>Evolution</td>
<td>Monitoring, Analysis and Mining</td>
</tr>
</tbody>
</table>
Flexibility Support for Pre-Specified Process Models

Process Configuration and Process Variants
Example: Vehicle Repair Process

Conclusion: Many processes with different variants, depending on the process context.
Context-Driven Process Configuration

Business Area
- Daimler Financial Services
- Daimler Trucks
- Daimler Buses
- Mercedes-Benz Vans
- Mercedes-Benz Cars

Vehicle Type
- LKW
- Van
- Bus
- PKW

Brand
- Fuso
- Smart
- Mercedes-Benz

Variant 1
Variant 2
Variant 3
...
...
Conclusion: Both approaches can be supported by commercial BPM tools, but do not enable transparent and explicit management of process variants.
Two Main Approaches for Capturing Process Variability

- Structural Approaches
- Behavioral Approaches
Structural Process Configuration

Base process

Variant specific adjustments

INSERT IF country = Italy

Configured process variant

DELETE IF brand = Smart

DELETE IF brand = Smart

INSERT IF country = Italy
Structural Process Configuration

Base Process with Options

Option 1
DELETE Process fragment

Option 2
INSERT Process fragment

Choosing and applying 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”

DELETE Process fragment

INSERT Process fragment

CONTEXT DEPENDENCY:
IF Maintenance = “No”

CONTEXT DEPENDENCY:
IF security critical = “Yes”
Structural Process Configuration
Two Main Approaches for Capturing Process Variability

- Structural Approaches
- Behavioral Approaches
Behavioral Process Configuration
Flexibility Support for Pre-Specified Process Models

Exception Handling
Process Adaptations

Planned

Exception Handling

Unplanned

Ad-hoc Changes

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Exception Handling in PAIS

I will skip respective techniques for handling planned exceptions in this tutorial and refer to our text book instead!
Flexibility Support for Pre-Specified Process Models
Handling Unforeseen Exceptions
User View on an Ad-hoc Process Change

Exception – We need an additional lab test!

… the “user” might be also an intelligent software agent (e.g., AgentWork)

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Behavioral Changes Require Structural Process Model Adaptations
Structural Process Model Adaptations: Change Patterns
Behavioral Changes Require Adaptations of the Process Instance State

Dynamic Change Bug

![Diagram of Dynamic Change Bug](image)

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Behavioral Changes Require Adaptations of the Process Instance State

**Diagram a)**
- Process Instance I
- Activity States:
  - Completed
  - Enabled

**Diagram b)**
- Process instance I after moving activity C to the position between A and B

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Behavioral Changes Require Adaptations of the Process Instance State
Ensuring Dynamic Correctness

May the depicted schema change be propagated to the process instance?

Need for general correctness criterion

⇒ State Compliance

[ReDa98, RRW08a, RRD04a, RRD04b]
Ensuring Dynamic Correctness

Ad-hoc changes must also not affect business process compliance (e.g., SeaFlows)

How to assist users in applying ad-hoc changes (e.g., CBRFlow, ProCycle)?

How to automate such instance changes (e.g., AgentWork)

Further challenges:
- How to efficiently check for state compliance?
- How to efficiently migrate process instances?

[RRD04a, RRD04b]
The ADEPT Framework

Solution for many fundamental research issues!

Formal foundation of the ADEPT technology!

jumpForward(CFS_instance, G, J, ...)

The ADEPT Framework
... and its transfer to industrial practice
Challenge: Adapting Large Process Structures

see Corepro and Proclets projects
Flexibility Support for Pre-Specified Process Models

Process Schema Evolution
How to deal with running process instances when evolving the original process schema?
Scenario 1 - No Version Control

- Schema is overwritten and instances are migrated

Type change overwrites schema S

Process Schema S

```
A + B ➔ C ➔ D ➔ E ➔ F
```

Insert X between A and B
Insert Y between C and AND-Join1

Process Schema S'

```
A ➔ X ➔ B ➔ C ➔ D ➔ E ➔ F
```

Process Instance I1

```
A + B ➔ C ➔ D ➔ E ➔ F
```

Process Instance I2

```
A + B ➔ C ➔ D ➔ E ➔ F
```

Change is propagated to all running process instances

Inconsistent state

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Scenario 2 - Version Control

- Co-existence of instances of different schema versions

*Type change results into a new version of schema S*

**Process Schema S**

**Process Schema S’**

**Old instances remain with schema S**

- Instances created from S (before schema evolution)
- Instances created from S’ (after schema evolution)

- Insert X between A and B
- Insert Y between C and AND-Join1

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Scenario 3 – Instance Migration

- Compliant instances are migrated to the new schema

*Type change results into a new version of schema S*

**Migration of compliant process instances to S’**

- Process Instance I1
  - Process Instance I2

- Process Instance I2 not compliant with S’
Lifecycle Support in adaptive PAISs

1. Create Process Schema
2. Create Instances
3. Process Execution
4. Process Monitoring
5. Evolve Process Schema
6. Instance-specific Change
7. Change Propagation

Exception: Delete (I₁, E)

Schema S:
- A
- B
- C
- D
- E

Instance I₁:
- A
- B
- C
- D
- E

Change Log
Execution Log

Process engineer / Process administrator

Process participant
Loosely Specified Processes
Loosely specified Processes

- To deal with unpredictability, non repeatability and emergence loosely specified processes keep (parts) of the process unspecified during build-time

- Loosely specified processes are characterized by decision deferral taxonomy of decision deferral
Late Selection Pattern

Build-time

Process Model $S$

Run-time

Process Instance $I_1$

Selected Placeholder Implementation

Repository of Potential Placeholder Implementations

Fragment 1

Fragment 2

Fragment 3

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Late Selection – The Worklets Approach

Casualty Treatment Process Model

- **Condition**
  - **Conclusion**
    - **true**
      - **Fever = True**
        - Treat Fever
      - **Wound = True**
        - Treat Wound
    - **false**
      - **AbdominalPain = True**
        - **Fracture = True**
          - **Pregnant = True**
            - **Rash = True**
              - **HeartRate > 190**
              - Treat Rash
            - **false**
              - Treat Fracture
        - **false**
          - Treat Abdominal Pain
    - **false**
      - Treat Fracture

- **Repository of Process Fragments**
  - **Admit Patient**
  - **Perform Triage**
  - **Treat Patient**
  - **Discharge Patient**
  - **Test Fever**
  - **Treat Fever**
  - **Treat Wound**
  - **Treat Abdominal Pain**
  - **Treat Fracture**
  - **Treat Labor**
  - **Treat Rash**
  - **Treat High Heart Rate**

[AHE+06]

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Late Modeling

**Build-time**

**Process Model S**

![Diagram showing process model S with nodes A, B, C, D, E, F, and a repository of process fragments P, Q, R, S, T, U, X, Y.]

**Run-time**

![Diagram showing run-time with nodes A, B, C, D, E, F, T, U, X, and a composed fragment.]

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Late Modeling – Pockets of Flexibility

Customer Relationship Management Model S

Constraints
- Any of the tests may be done, but only one at a time
- Approve Request is required to execute activity Conduct Site Visit

Examples of Sub-Process Fragments Producible for Placeholder Activity

[SSO01, SSO05]
### Ad-hoc Composition - Declare

#### A) Build-time

<table>
<thead>
<tr>
<th>Activity Templates</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>P, Q, R, S, T, U, X, Y</td>
<td></td>
</tr>
<tr>
<td>If T no X</td>
<td></td>
</tr>
</tbody>
</table>

#### B) Run-time

- **start(P)** to **complete(P)**
- **start(X)** to **complete(X)**
- **start(Y)** to **complete(Y)**
Summary & Outlook
Summary & Outlook

Good idea! Let it be the new process version!

Migrate running instances?

Deal with conflicts between ad-hoc and changes of the version
Summary & Outlook

Business Process Compliance

Cross-Organizational Processes

Change / Flexibility

Process-aware Information System

Running Instances / Process Engine

Process Models

Process Logs
Compatibility

Gynecologist
John Q. Public, M.D.

Women's Hospital
University Hospital of Anytown

Observe patient
Handle Birth

Process blood test’s results

Observe patient

Transfer patient

Forward results

Send blood sample

Blood test

Examine patient

Send results

Complications

Transfer patient

Results

Patient data

Sample

Results

Analysis

Dispatch results
Cross-organizational Compliance

Global Compliance Rule:
After a blood test, the blood sample has to be destroyed.

Assertion (laboratory):
Received blood samples will be analyzed.

Global Compliance Rule:
If an examination or the evaluation of a blood test indicate complications, the patient must be transferred and observed at the hospital.

Assertion (laboratory):
After analysis the blood sample is destroyed.
Cross-Organizational Processes: Change

Which running instances can switch to the new version?


References (Exception Handling)


References (Process Evolution)


References (Loosely-specified Processes)


[CaSa01] Fabio Casati, Ming-Chien Shan: **Dynamic and adaptive composition of e-services.** Inf. Syst. 26(3): 143-163 (2001)


van Elst; Andreas Lauer; Heiko Maus; Sven Schwarz; Michael Sintek, A.A.A.B.L.: **Frodo: A framework for distributed organizational memories. milestone 1: Requirements analysis and system architecture.** Dfki document (2001). URL http://www.dfki.unikl.de/dfkidok/publications/D/01/01/abstract.html

[Kli00] Justus Klingemann: **Controlled Flexibility in Workflow Management.** CAiSE 2000: 126-141


[SuWe03] Hilmar Schuschel, Mathias Weske: Integrated Workflow Planning and Coordination. DEXA 2003: 771-781

References (Declarative Workflows)


