Beyond Rigidity - Lifecycle Management for Dynamic Processes

BPM'07 Tutorial
27 September 2007
Brisbane, Australia

Shazia Sadiq
The University of Queensland, Australia
shazia@itee.uq.edu.au

Barbara Weber
University of Innsbruck, Austria
Barbara.Weber@uibk.ac.at

Manfred Reichert
University of Twente, Netherlands
m.u.reichert@utwente.nl

BPM'07 Tutorial
27 September 2007
1:30 PM – 3:30 PM

Beyond Rigidity - Lifecycle Management for Dynamic Processes

Abstract

The economic success of an enterprise increasingly depends on its ability to react to changes in its environment in a quick and flexible way. Recently, a new generation of process-aware information systems (PAIS) has emerged to provide this flexibility and to support dynamic processes. Similar to classical information systems development lifecycles, studies on life cycle support for dynamic business processes are often sweeping the issues pertaining to post deployment change management, under the banner of maintenance. However, the pervasiveness of dynamic changes in business processes warrants targeted attention.

This tutorial presents a review of the basic challenges and techniques that exist for life cycle management of dynamic processes. Our approach is to present ideal support for the needs of the various life cycle phases and then to deliberate on various developments from academia and industry in terms of their closeness to these needs, thus identifying open questions where relevant. A case study is presented which forms a motivational backbone for the whole tutorial. A detailed discussion of the process lifecycle structured around the three main phases of design, execution, and monitoring & analysis and proof-of-concept demonstrations are provided.

Outline

The tutorial is split into 3 parts covering the three phases of the process lifecycle:

Part I: Definitional Phase (by Shazia Sadiq):
- We discuss business process definition both from a management strategy perspective and from a means to realize executable processes.

Part II: Execution Phase (by Barbara Weber):
- We discuss challenges and solutions for flexible process execution and particularly motivate the importance of run-time process adaptability.

Part III: Monitoring & Analysis Phase (by Manfred Reichert):
- We discuss challenges and solutions related to the monitoring and analysis of process execution data.

Presenters Background

Shazia Sadiq
The University of Queensland, Australia
shazia@itee.uq.edu.au

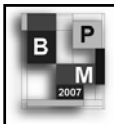
Shazia Sadiq is currently Senior Lecturer in the School of Information Technology and Electrical Engineering at The University of Queensland, Brisbane, Australia. She is part of the Data and Knowledge Engineering (DKE) research group and is involved in teaching and research in databases and information systems. Shazia holds a PhD from The University of Queensland in Information Systems and a Masters degree in Computer Science from the Asian Institute of Technology, Bangkok, Thailand. Her main research interests are innovative solutions for Business Process Management that span several technology areas including workflow systems, service oriented computing, messaging technologies, and deployment of large scale distributed devices. Shazia has contributed widely to the body of knowledge in the field of dynamic workflows and has published several papers on this topic.

Barbara Weber
University of Innsbruck, Austria
Barbara.Weber@uibk.ac.at

Barbara Weber is currently Assistant Professor in the Department of Computer Science at the University of Innsbruck, Austria. Here she also obtained her PhD degree. Barbara is a member of the Quality Engineering research group and is involved in teaching and research in business processes and workflow management. Her main research interests are agile and flexible processes and intelligent user support in flexible systems. This spans several technology areas including workflow management systems, case-based reasoning, process-oriented knowledge management, enterprise information systems, process mining, and agile software development. To allow for the exchange of ideas with practice she is engaged in third-party funded projects with partners from different domains (e.g., healthcare, logistics). In the area of dynamic workflows Barbara has published several papers on topics like integrated process lifecycle support and change patterns. Further, Barbara has been organizer of several international workshops like Proflex'06, ProGility'07 and BPI'07 as well as of a think tank on business agility at AGILE 2007, which are related to dynamic workflows.

Manfred Reichert
University of Twente, Netherlands
m.u.reichert@utwente.nl

Manfred holds a PhD in Computer Science and a Diploma in Mathematics. Currently, he is working as Associate Professor in the Information Systems Group at the University of Twente (UT), The Netherlands. At UT he is also leader of the strategic research orientation on e-health and member of the Management Board of the Centre for Telematics and Information Technology (CTIT), which is the largest ICT research institute in the Netherlands (with more than 400 researchers). Before Manfred joined UT in October 2004 he was working as Assistant Professor in the Institute for Databases and Information Systems at Ulm University, Germany. Here he also finished his PhD thesis on adaptive process management (with honors). His major research interests are next generation process management technology (e.g., adaptive processes, process lifecycle management, process visualization, data-driven workflows), service-oriented architectures (e.g., service interoperability, service change), and advanced applications for ICT solutions (e.g., e-health, automotive engineering). Together with Peter Dadam he pioneered the work on the ADEPT process management system. Manfred has been participating in numerous research projects in the BPM area and contributed numerous papers. Finally, he has co-organized international and national conferences and workshops.

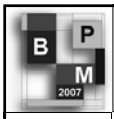


BPM 2007 Tutorial

Life Cycle Management for Dynamic Processes

Shazia Sadiq, The University of Queensland
Barbara Weber, University of Innsbruck
Manfred Reichert, University of Twente

27 Sep 2007
13.30 – 15.30



Presenters

- **Shazia Sadiq**
  The University of Queensland, Australia
  shazia@itee.uq.edu.au
- **Barbara Weber**
  University of Innsbruck, Austria
  Barbara.Weber@uibk.ac.at
- **Manfred Reichert**
  University of Twente, Netherlands
  m.u.reichert@utwente.nl

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Tutorial Plan

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

13:30 – 13:40	Challenges of the *Dynamic* Process
13:40 – 14:00	Definitional Phase
14:00 – 14:30	Execution Phase
14.30 – 15:00	Monitoring Phase
15.00 – 15.20	Summary, Q & A Session
15.20 – 15.30	Evaluation and Feedback

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Preaching to the converted!

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

The age of the Crafts Worker

The age of the Factory

The age of the Specialist

Process Orientation

Process Re-engineering

Sharp and McDermott (2000)

The BPM Fever–Hype or Reality

– Business Process Management (BPM) has been identified as the "number one business priority" and a major challenge for senior executives

Gartner EXPPremier (2005) Delivering IT's Contribution: The 2005 CIO Agenda. Gartner, January 2005.

– Increasingly, BPM is perceived as a way to align and increase the contribution of information systems to the business

Howard Smith, Peter Finger (2003) IT doesn't matter – Business Process Do. August 2003. Meghan-Kiffer Press 2003.

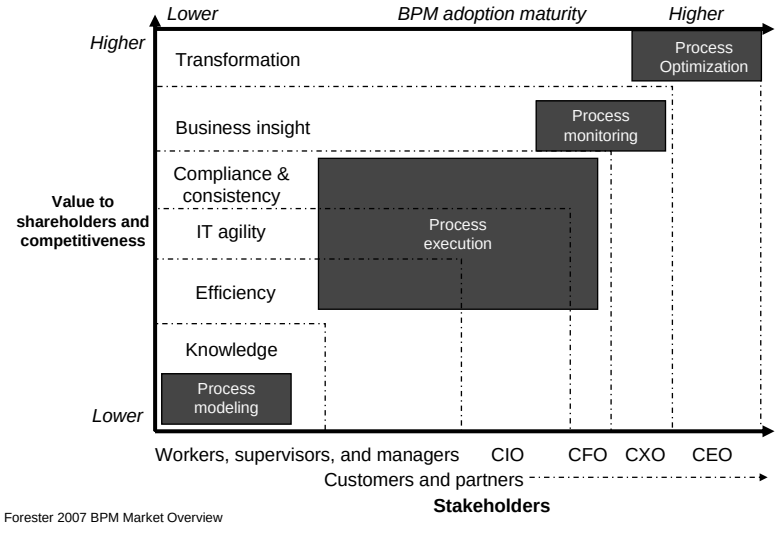
– Workflow management systems (a core segment in BPM solutions) and related BPM solutions will reach $1.1 billion by 2009 (at $416.4 million in 2003)

WinterGreen Research (2004) Business Process Management (BPM) Market Opportunities, Strategies, and Forecasts, 2004 to 2009.

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

The BPM value proposition

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

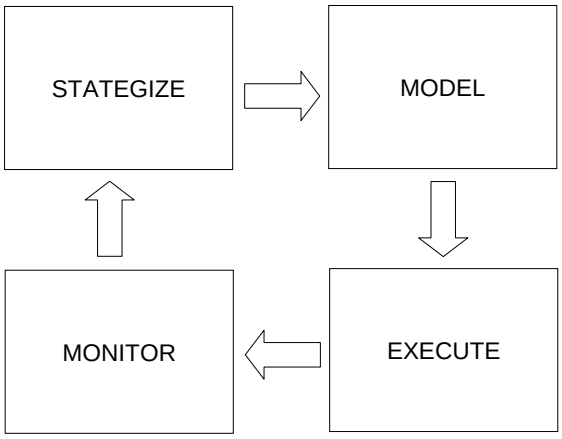


Forester 2007 BPM Market Overview

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Life Cycle

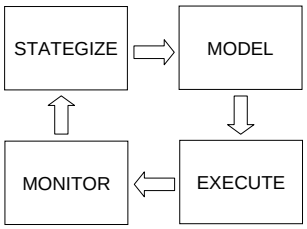
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

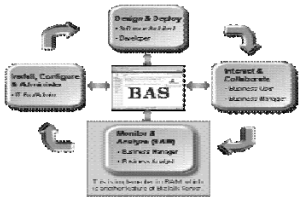
Process Life Cycle (variants)

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



IDS Scheer

BEA Systems



Microsoft Business Activity Services for Biztalk

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Reality Check

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Consider an organization **See-the-Bears Pty Ltd** that provides services for adventure travellers..
- See-the-Bears has specialized for Alaskan travels and organizes everything which is required for the customer's personal Alaskan adventure.
- This includes arranging transportation and accommodation as well as activities (e.g., flight seeing, hiking, etc.).
- See-the-Bears has a large network of partners (i.e., service provider) in different places in Alaska on whose services it can rely on.
- For example, it partners with a company offering a boat tour service at Glacier Bay or with a company offering flight seeing to Wrangell St. Elias Mountains).
- This allows See-the-Bears to let their customers choose from a wide variety of services and to consider the particular preferences of their customer when creating a plan for their customers' personal adventures prior to the journey.
- The payment for the adventure travel is handled by See-the-Bears in cooperation with different credit card service providers.

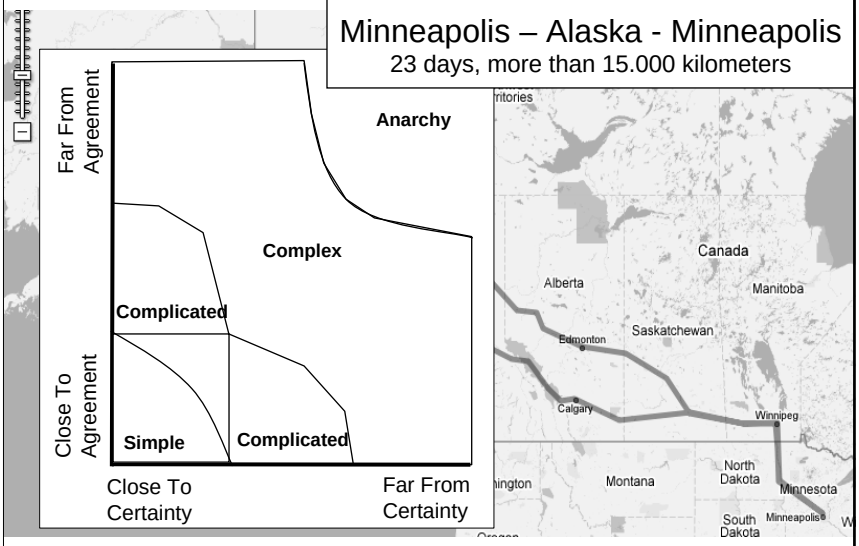
The competitive advantage of See-the-Bears is its ability to flexibly address customers' preferences (e.g., service variability) and its high responsiveness to change.

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Reality Check

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

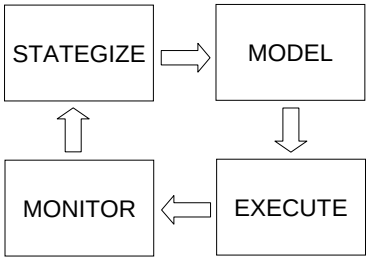
Minneapolis – Alaska - Minneapolis
23 days, more than 15.000 kilometers



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Business (Process Management) as Usual

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



- See-the-Bears does not offer out of the box travels to their customers, but ***flexibly composes a personal Alaskan adventure*** for each of its customers.
- Although See-the-Bears creates personal travel adventures for each of their customers taking their preferences into account, ***adaptations to the plan*** created prior / during the journey often become necessary.
- Depending on the customer the plan for the journey is not entirely fixed in advance. Instead, ***many decision are taken during the journey***.
- Some events like a road closure might not only affect a single customer of See-the-Bears, but many customers, and may last for long periods, thus See-the-Bears has to consider this situation when ***planning for new customers***.

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Characterizing Dynamic Processes

- Flexibility
  - Customization
  - Knowledge based

See-the-Bears does not offer out of the box travels to their customers, but ***flexibly composes a personal Alaskan adventure*** for each of its customers

- Adaptation
  - Exceptions
  - Ad-hocism

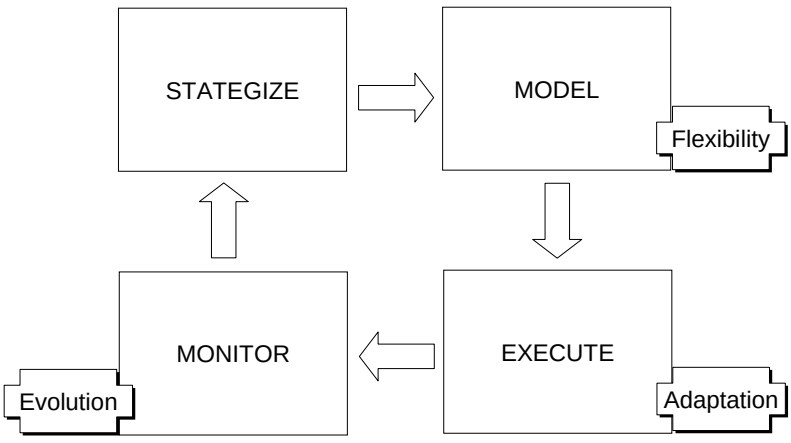
Depending on the customer the plan for the journey is not entirely fixed in advance. Instead, ***many decision are taken during the journey***.

- Evolution
  - Improvement
  - Innovation

Some events like a road closure might not only affect a single customer of See-the-Bears, but many customers, and may last for long periods, thus See-the-Bears has to consider this situation when ***planning for new customers***.

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Life Cycle for the *Dynamic Process*



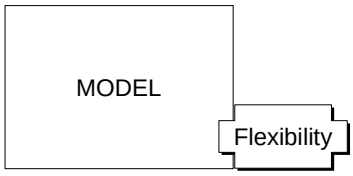
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Definitional Phase

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

Preparing models
Strategy definition/ Executable models

Preparing models for *dynamic* processes

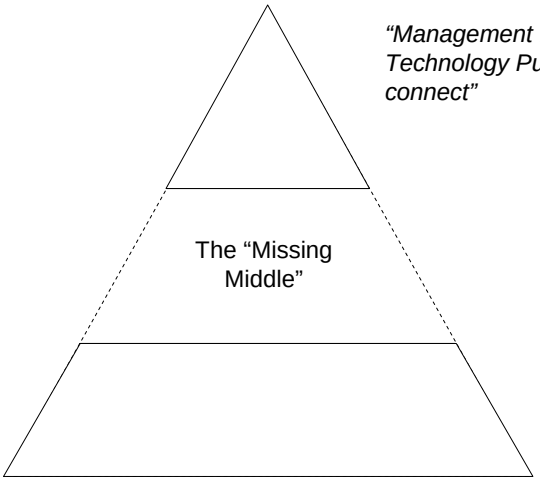


- **Flexibility**
  - **Customization**
  - **Knowledge based**
- Adaptation
  - Exceptions
  - Ad-hocism
- Evolution
  - Improvement
  - Innovation

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

The Notorious Business-IT Divide

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



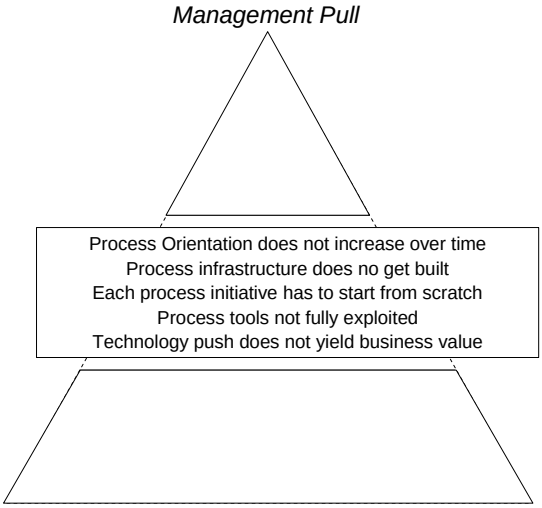
"Management Pull and Technology Push don't connect"

© Thomas Davenport
http://www.tomdavenport.com/

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

The Missing Middle

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



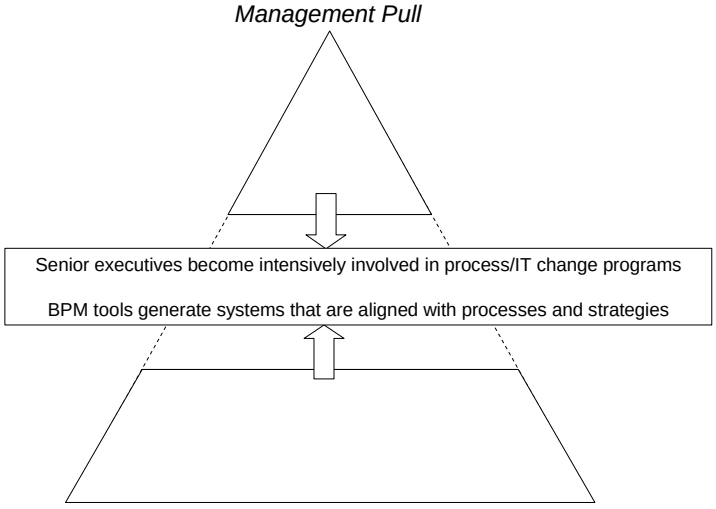
© Thomas Davenport
http://www.tomdavenport.com/

See also: www3.babson.edu/Bee/research/ipm/missingmiddle.cfm

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

S t r e t c h the Missing Middle

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



© Thomas Davenport
http://www.tomdavenport.com/

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Modelling
for Strategy Definition

Six Sigma
- Bill Smith (1986) Motorloa University

Porter's value chain
- Michael Porter (1985) Competitive Advantage: Creating and Sustaining Superior Performance.

Rummler's management theory
- Geary A. Rummler, Alan P. Brache (1990) Improving Performance: How to Manage the White Space in the Organization Chart. Jossey-Bass Publishers

SEI Capability Maturity Model Integration
- www.sei.cmu.edu/cmmi

Process Improvement
- Paul Harmon (2003) Business Process Change – A Manager's guide to Improving, redesigning and Automating Processes

Process Handbook
- Thomas Malone, Kevin Crowston, George herman ((2003) Organizing Business Knowledge – The MIT Process Handbook. The MIT Press.

Reference Models
- A. W. Scheer (1994) Business Process Engineering: reference Models for Industrial Enterprises. Springer.

Process Templates
- SAP Solution Maps. www.sap.com/solutions

→ *Mostly contributions from Management Science*

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Modelling
for Process Execution

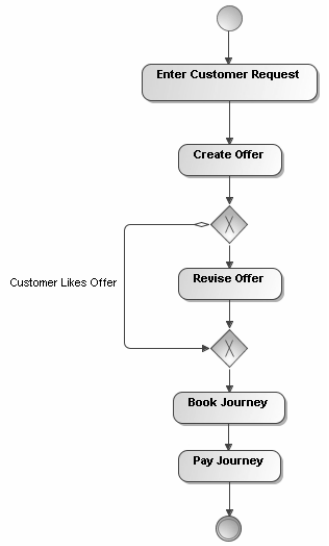
… Remaining discussion on Modelling for Process Execution

- The modelling landscape
  - Languages
  - Expressability and patterns
  - Discovery and mining
  - Tools
  - Standards

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Example – BPMN

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

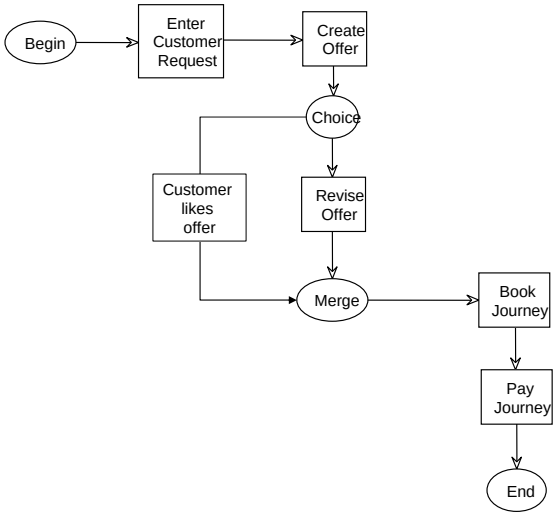


www.bpmn.org

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Example - FlowMake

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

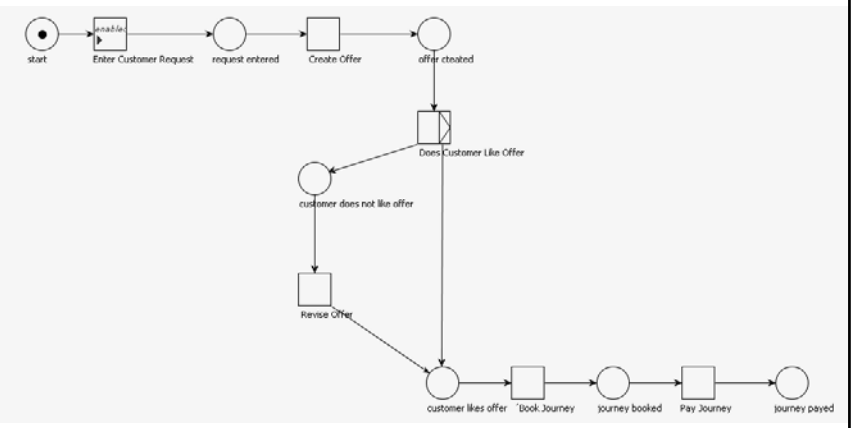


Sadiq & Orlowska (2001)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Example – Petri-nets

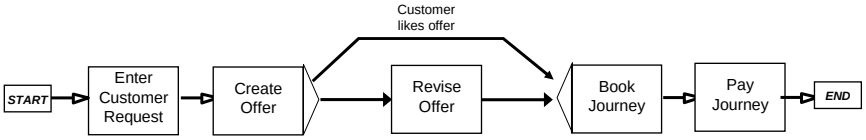
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Aalst (1998)

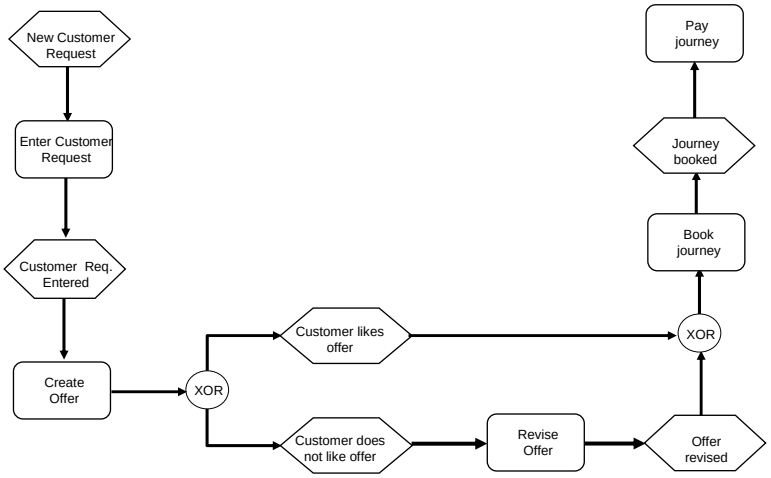
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Example - ADEPT



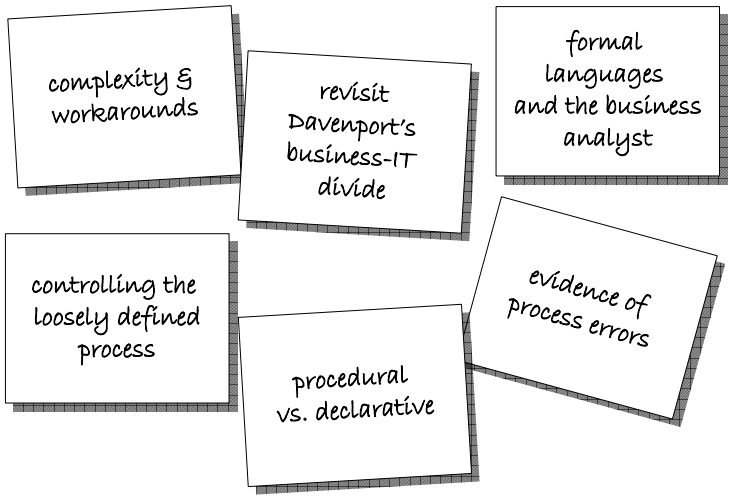
Reichert (2000)

Example – EPC



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

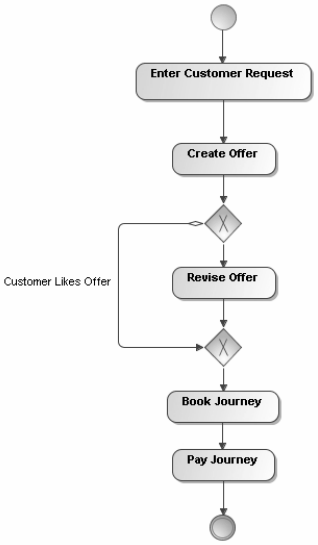
Usability vs. Expressability Debate



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Modelling the Dynamic Process

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



- See-the-Bears does not offer out of the box travels to their customers, but ***flexibly composes a personal Alaskan adventure*** for each of its customers.
- Although See-the-Bears creates personal travel adventures for each of their customers taking their preferences into account, ***adaptations to the plan*** created prior to the journey often become necessary.
- Depending on the customer the plan for the journey is not entirely fixed in advance. Instead, ***many decision are taken during the journey***.
- Some events like a road closure might not only affect a single customer of See-the-Bears, but many customers, and may last for long periods, thus See-the-Bears has to consider this situation when ***planning for new customers***.

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Selected Approaches

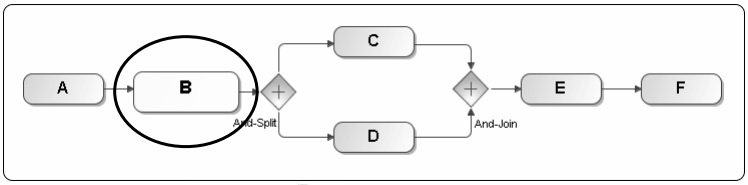
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Granularity Control
- Configuration
- Late Binding
- Late Modelling

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Granularity Control

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Make a phone call

Meet and decide

Complete list

Enter data

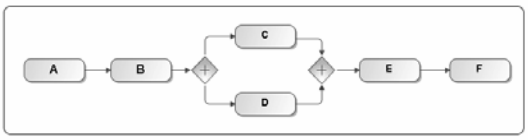
Do not control “flexible” activities through process control flow?

Flexibility ⟷ Control

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Configuration

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Parameter driven

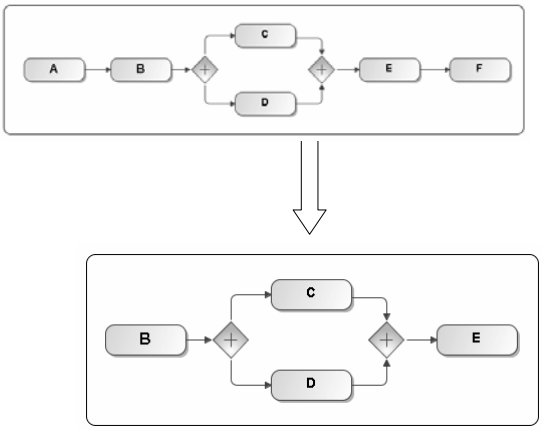
- *trip-category = “adv”*
- *duration < 2 weeks*
- *total cost <5K*

Rosemann & van der Aalst (2005)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Configuration

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Parameter driven

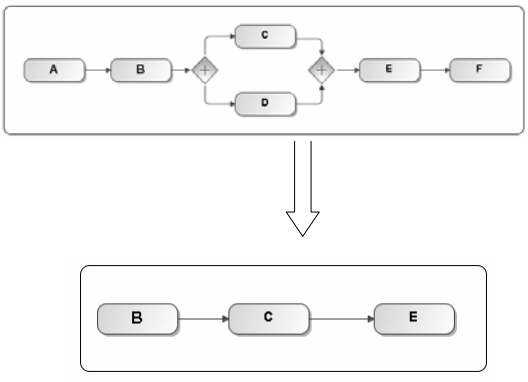
- ○ *trip-category = "adv"*
- ◎ *duration < 2 weeks*
- ○ *total cost <5K*

A	Off
B	On
C	On
D	On
E	On
F	Off
P	Off
Q	Off

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Configuration

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Parameter driven

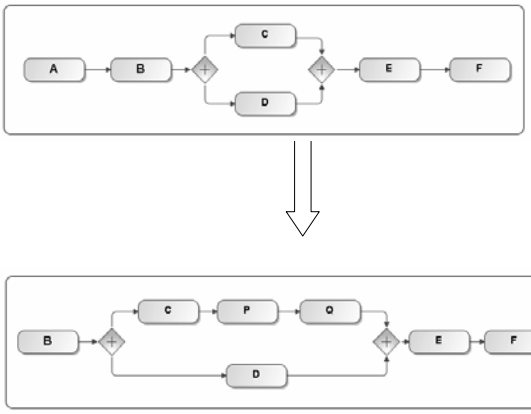
- ○ *trip-category = "adv"*
- ◎ *duration < 2 weeks*
- ◎ *total cost <5K*

A	Off
B	On
C	On
D	Off
E	On
F	Off
P	Off
Q	Off

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Configuration

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Parameter driven

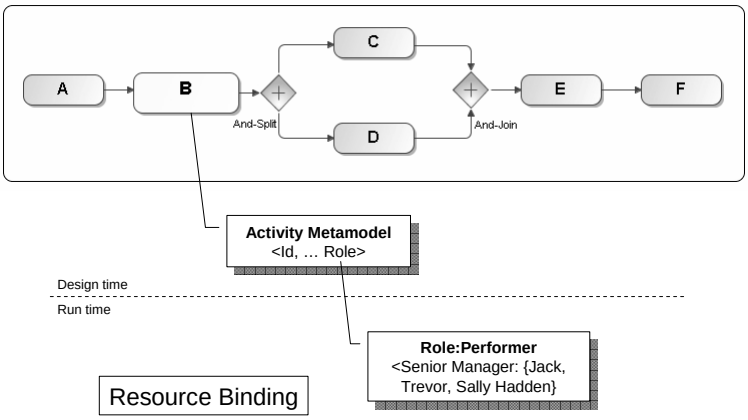
- ⊙ *trip-category = "adv"*
- ○ *duration < 2 weeks*
- ○ *total cost <5K*

A	Off
B	On
C	On
D	On
E	On
F	On
P	On
Q	On

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Binding

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

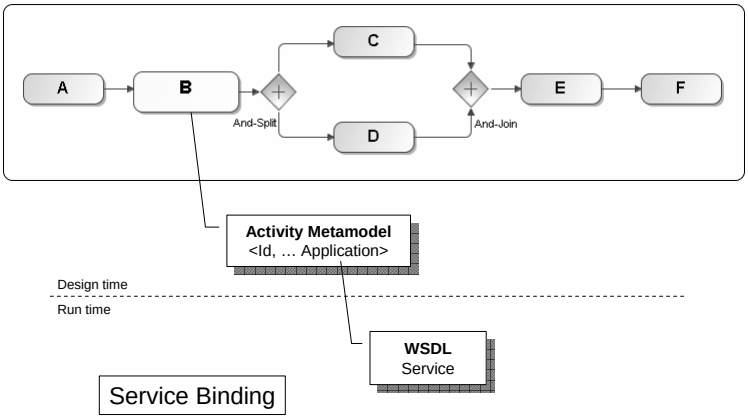


Resource Binding

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Binding

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

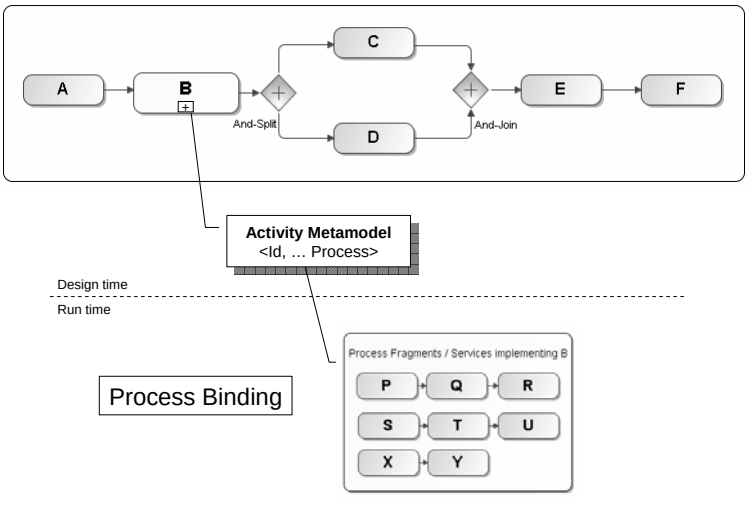


Service Binding

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Binding

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



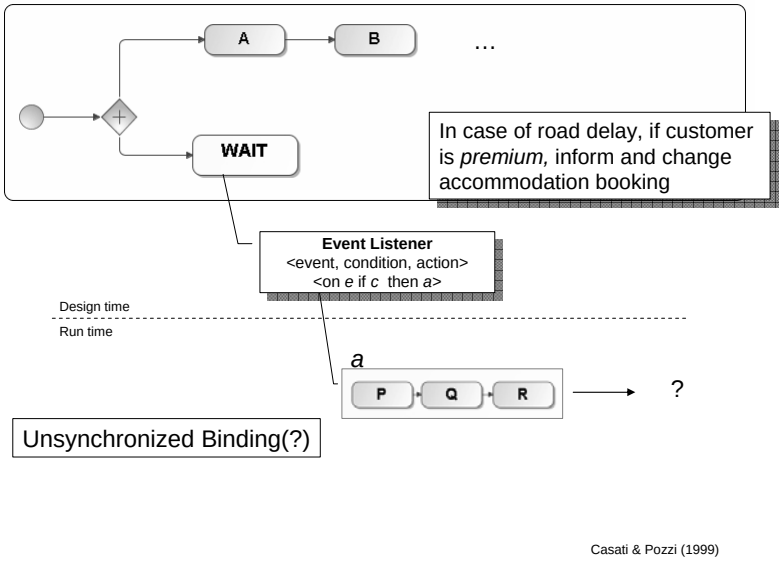
Process Binding

Adams et al (2006)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Asynchronous Events

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



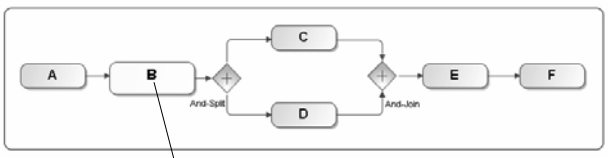
Unsynchronized Binding(?)

Casati & Pozzi (1999)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

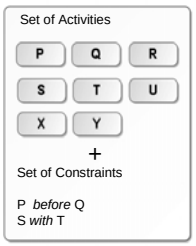
Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Pocket of Flexibility

+



Permit is required for skydiving

A maximum of 3 recreational activities can be selected from the package

Bear viewing trip must be organized by same transport provider

Total cost of stay at Denali not to exceed 3.5K

large no. of execution options

small no. of constraints

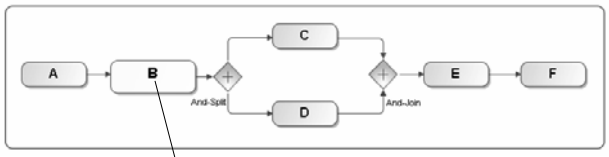
DECLARATIVE

Lu et al (2006)
Sadiq & Orlowska (2005)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Pocket of Flexibility

+

Set of Activities

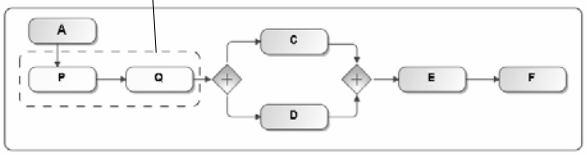
P Q R
S T U
X Y

+

Set of Constraints

P *before* Q
S *with* T

Instance Specific



large no. of execution options

small no. of constraints

DECLARATIVE

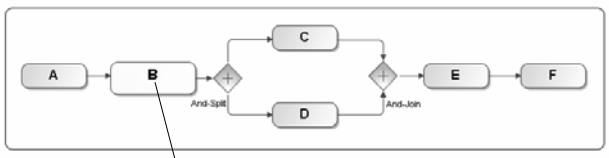
Lu et al (2006)

Sadiq & Orlowska (2005)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Pocket of Flexibility

+

Set of Activities

P Q R
S T U
X Y

+

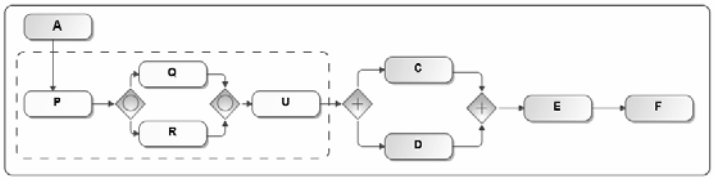
Set of Constraints

P *before* Q
S *with* T

large no. of execution options

of

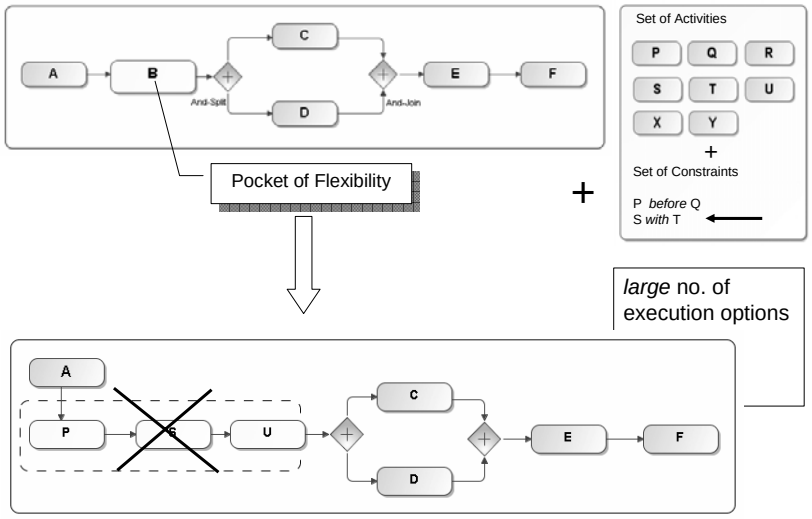
;



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

Issues at Build time

Constraint Modeling
- Scheduling
- Selection
- Resource
- …

Consistency checking
- Conflicts &
- Redundancies

Permit is required for skydiving

A maximum of 3 recreational activities can be selected from the package

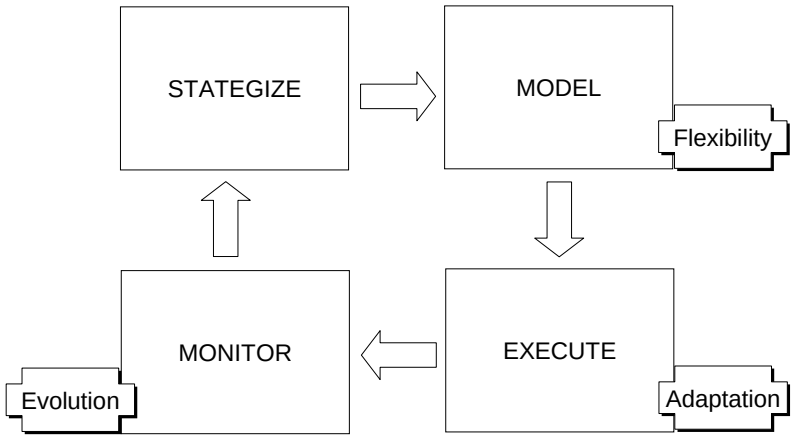
Bear viewing trip must be organized by same transport provider

Total cost of stay at Denali not to exceed US$3.5K

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Life Cycle for the *Dynamic Process*

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

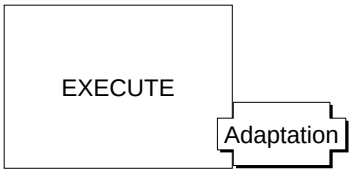
Execution Phase

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

Concretizing loosely specified models

Handling expected exceptions

Flexibly deviating from the pre-planned process



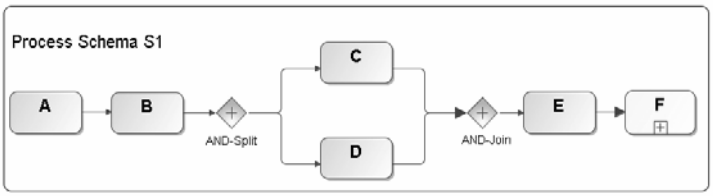
- Flexibility
  - Customization
  - Knowledge based
- **Adaptation**
  - **Exceptions**
  - **Ad-hocism**
- Evolution
  - Improvement
  - Innovation

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

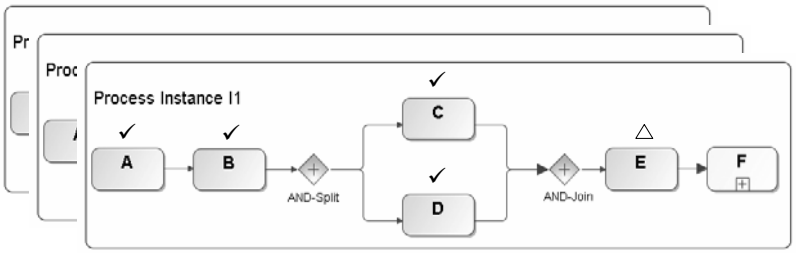
System Perspective

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



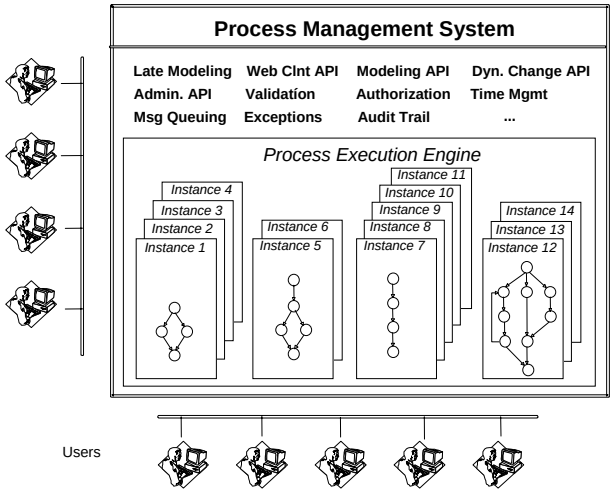
- Process Instance Level



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

System Perspective

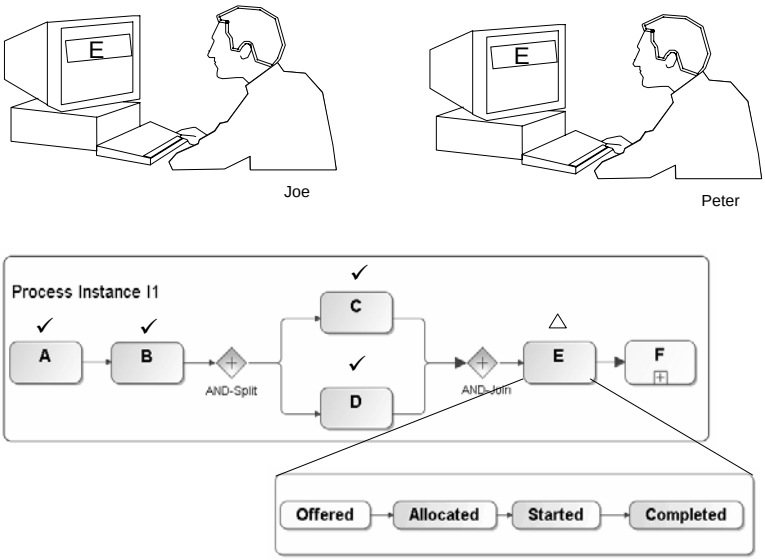
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

User Perspective

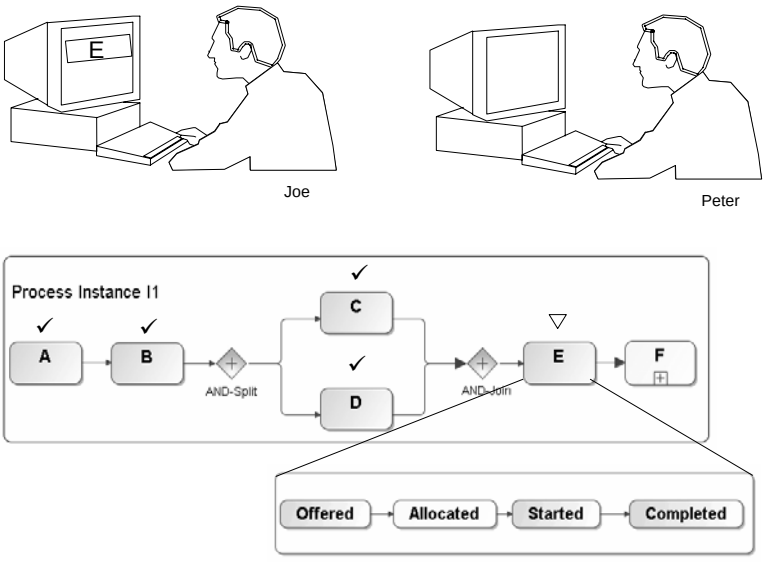
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

User Perspective

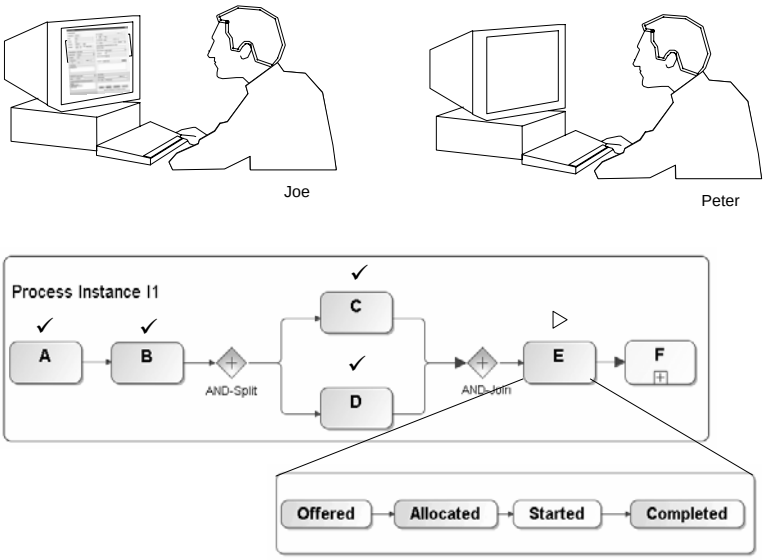
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

User Perspective

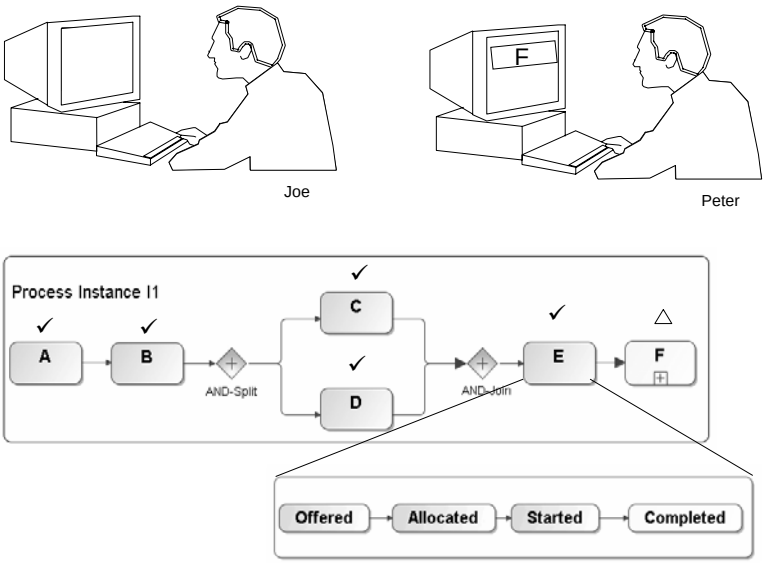
Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

User Perspective

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

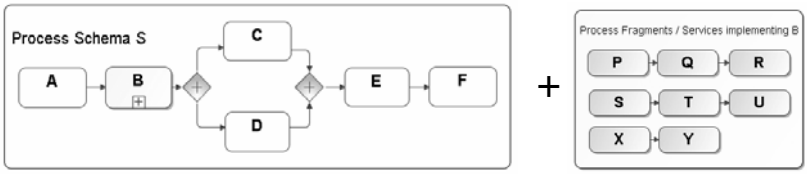


Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

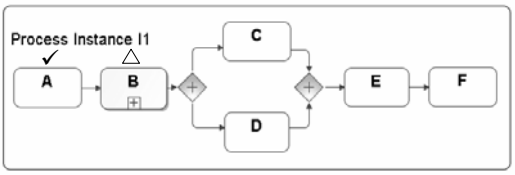
Late Binding

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



- Process Instance Level

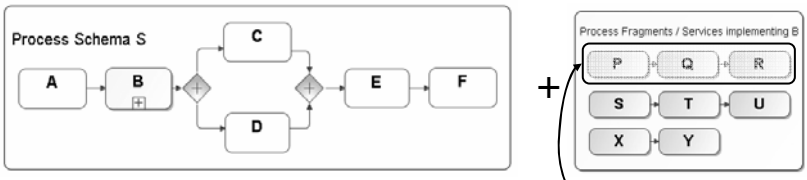


Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

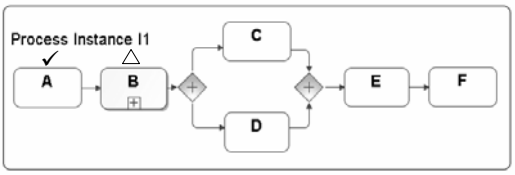
Late Binding

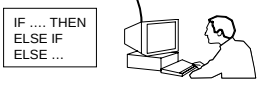
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



- Process Instance Level





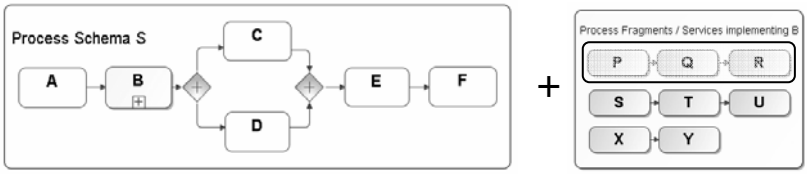
Selection based on rules or user decisions

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

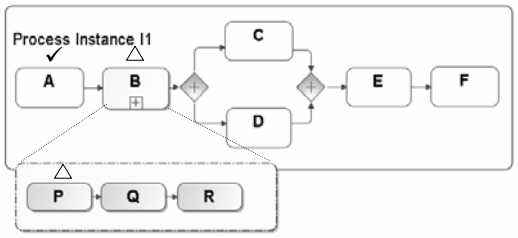
Late Binding

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



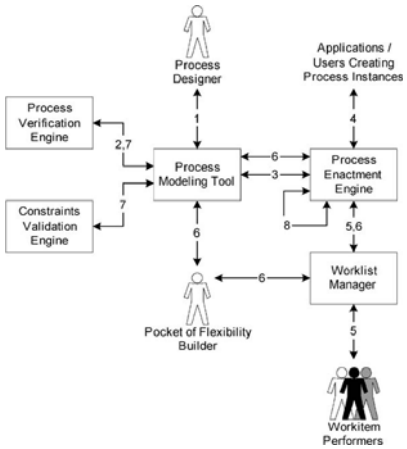
- Process Instance Level



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



<u>Issues at Run time</u>

Dynamic Build

Instance Template Validation

Lu et al (2006)

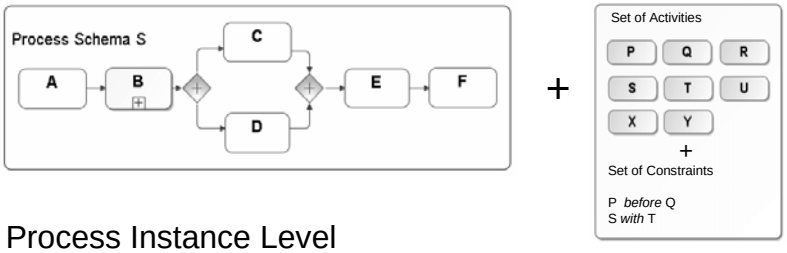
Sadiq & Orlowska (2005)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

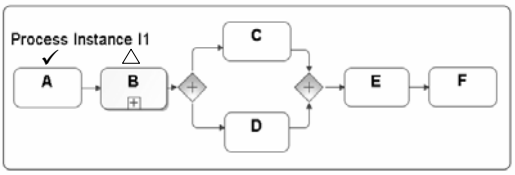
Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



- Process Instance Level

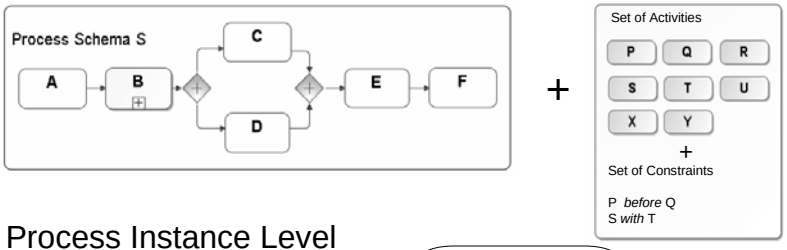


Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

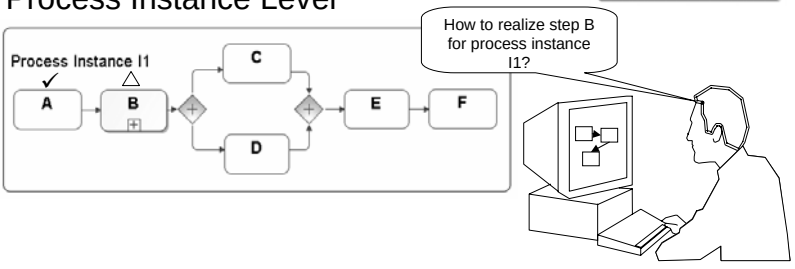
Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



- Process Instance Level

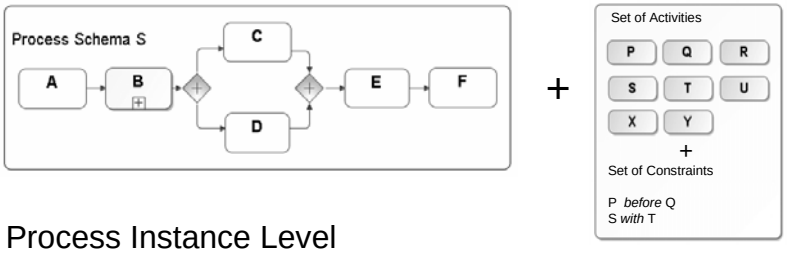


Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

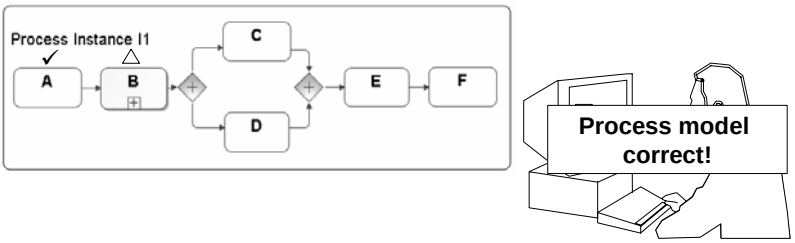
Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



- Process Instance Level

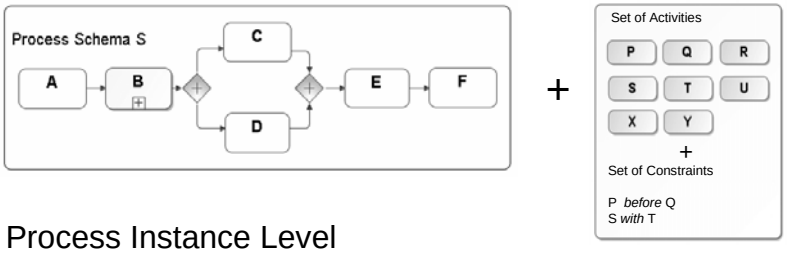


Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

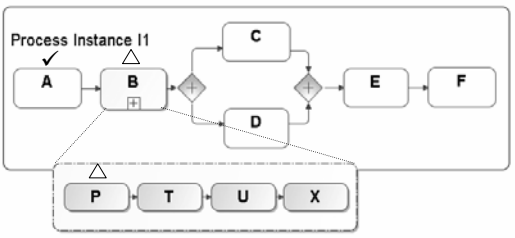
Late Modeling

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level

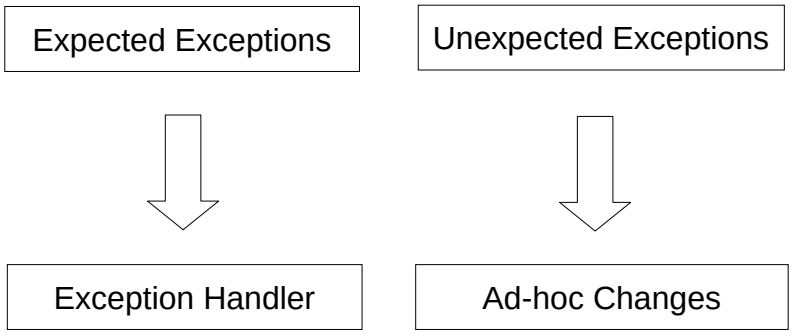


- Process Instance Level



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

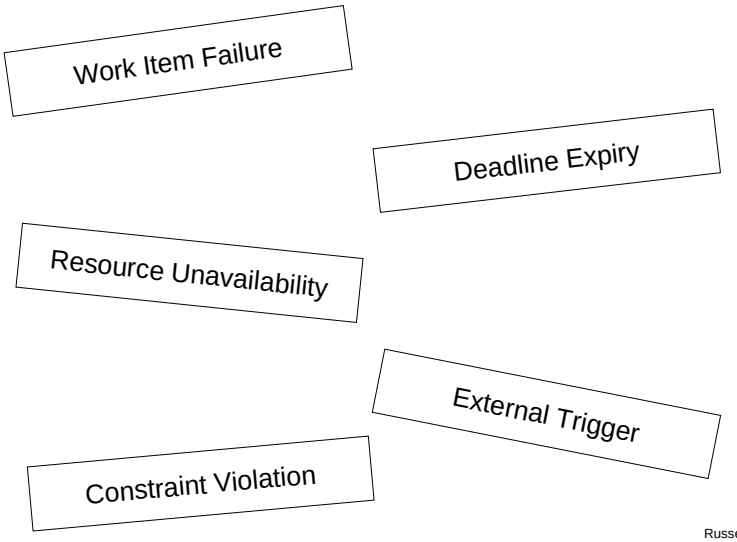
Dealing with Exceptions



Reichert et al. (2003)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Expected Exceptions

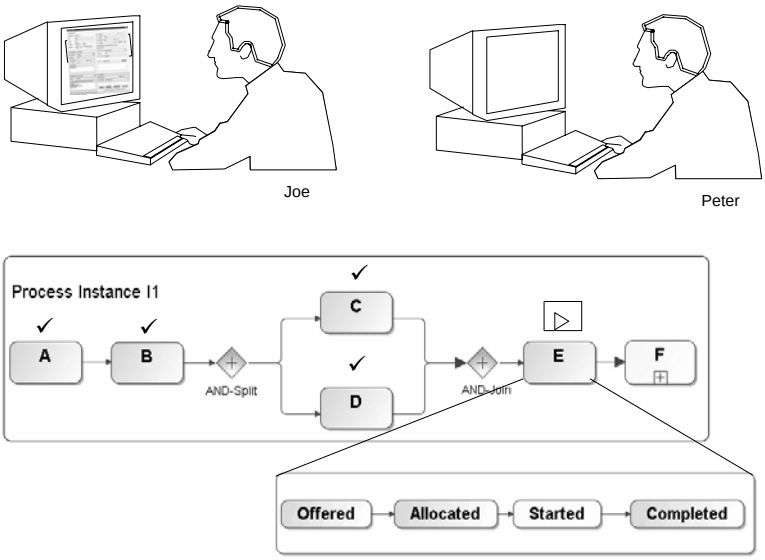


Russel et al. (2006)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Expected Exceptions

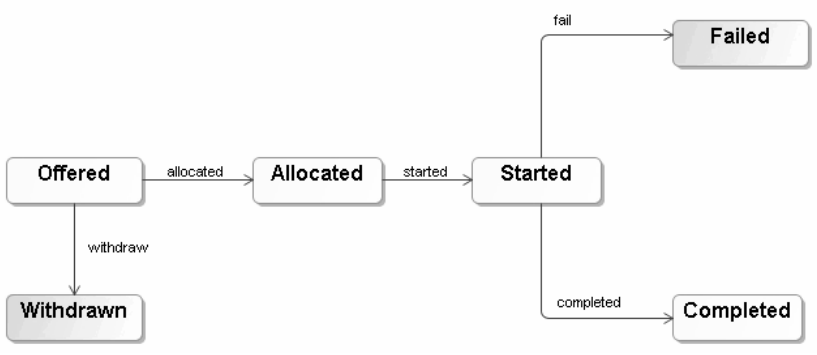
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Expected Exceptions

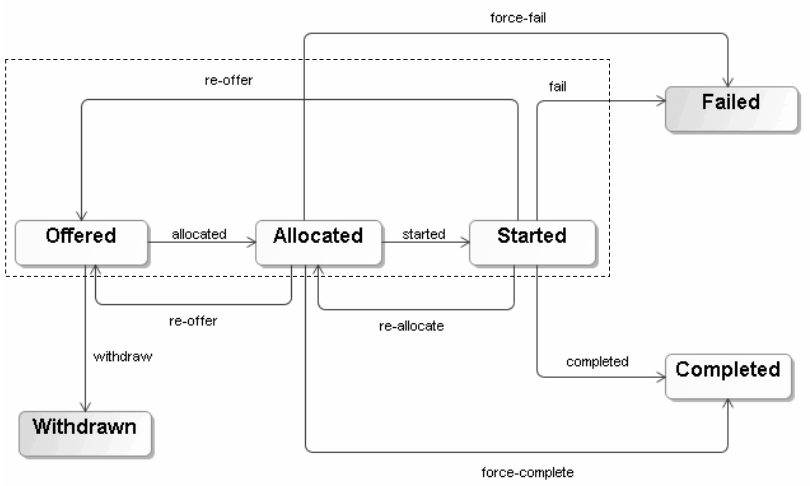
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Expected Exceptions

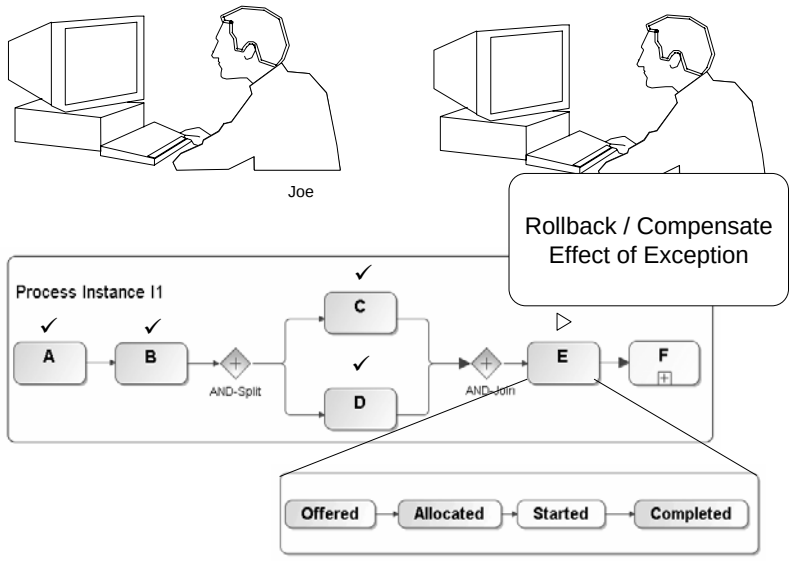
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

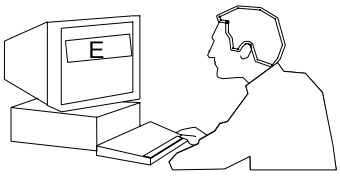
Expected Exceptions

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

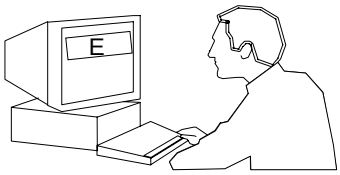


Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

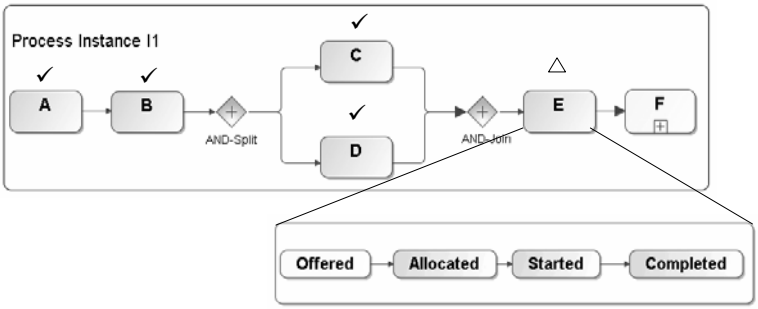
Expected Exceptions



Joe



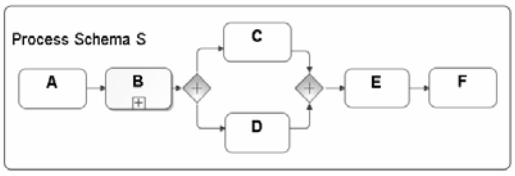
Peter



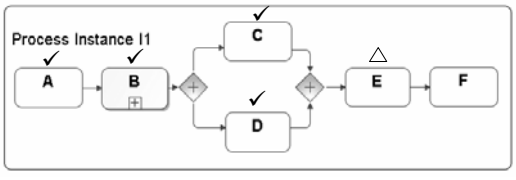
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Ad-hoc Changes

- Process Type Level



- Process Instance Level



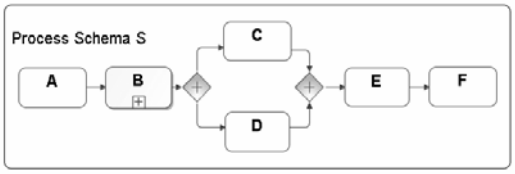
Reichert et al. (1998), Reichert et al. (2003)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Ad-hoc Changes

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

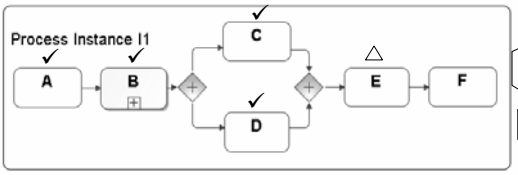
- Process Type Level



- Process Instance Level

Insert X before E

Replace F by Z

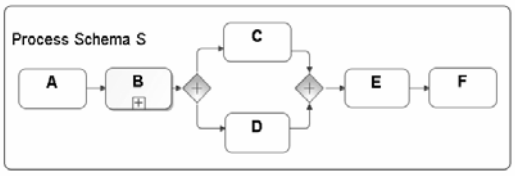


Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

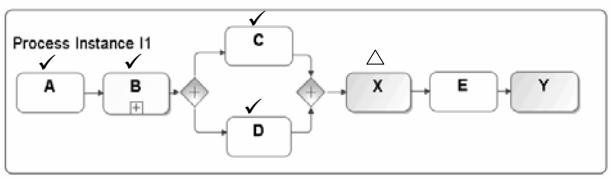
Ad-hoc Changes

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



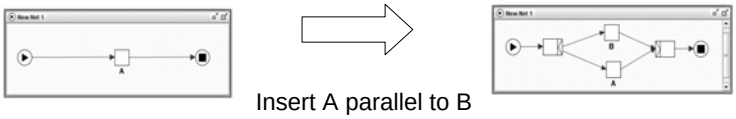
- Process Instance Level



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Cost of Change

- Change Operations vs. Change Primitives



Insert A parallel to B

Change Patterns	Change Primitives
1 High-Level Change Operation	**9 Change Primitives**

`parallelInsert (S, A, B)`	`Add Node (3x)`
	`Move Edge (2x)`
	`Add Edge (4x)`

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Adaptation Patterns

Adding / Deleting Fragments
- **AP1:** Insert Process Fragment
- **AP2:** Delete Process Fragment

Moving / Replacing Fragments
- **AP3:** Replace Process Fragment
- **AP4:** Move Process Fragment
- **AP5**: Swap Process Fragment
- **AP14:** Copy Process Fragment

Adding / Removing Levels
- **AP6**: Extract Sub Process
- **AP7**: Inline Sub Process

Adapting Control Dependencies
- **AP8:** Embed Process Fragment in Loop
- **AP9:** Parallelize Activities
- **AP10:** Embed Process Fragment in Conditional Branch
- **AP11:** Add Control Dependency
- **AP12:** Remove Control Dependency

Changing Transition Conditions
- **AP13:** Update Condition

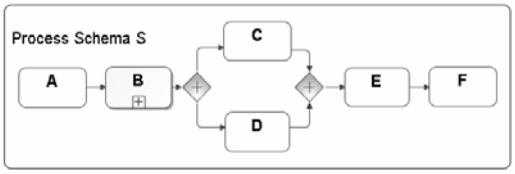
Weber, Rinderle and Reichert (2007)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

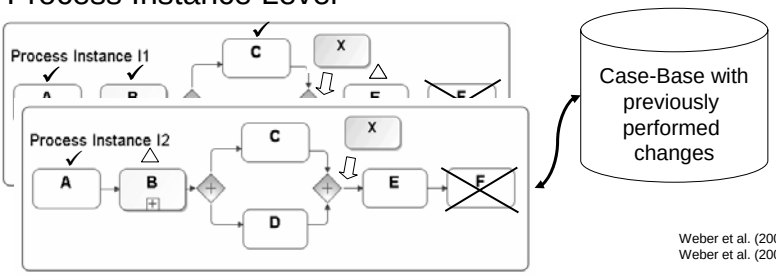
Change Reuse

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

- Process Type Level



- Process Instance Level

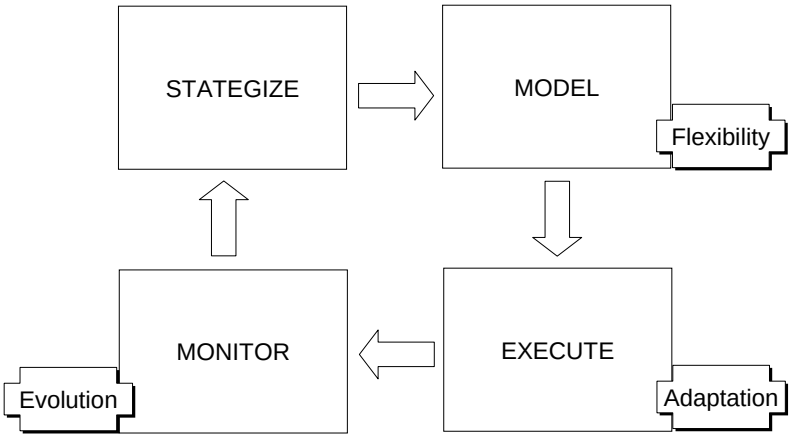


Weber et al. (2004)
Weber et al. (2006)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Life Cycle for the *Dynamic Process*

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Monitoring Phase

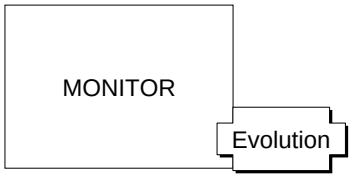
Ensuring traceability of dynamic processes

Real-time monitoring and control

Diagnosing and mining of dynamic processes

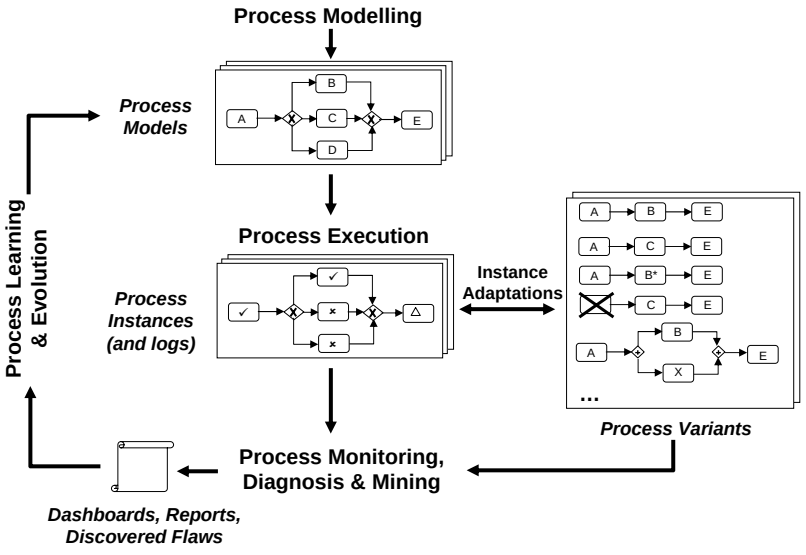
Managing change policies and process evolution

- Flexibility
  - Customization
  - Knowledge based
- Adaptation
  - Exceptions
  - Ad-hocism
- **Evolution**
  - **Improvement**
  - **Innovation**



Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Monitoring



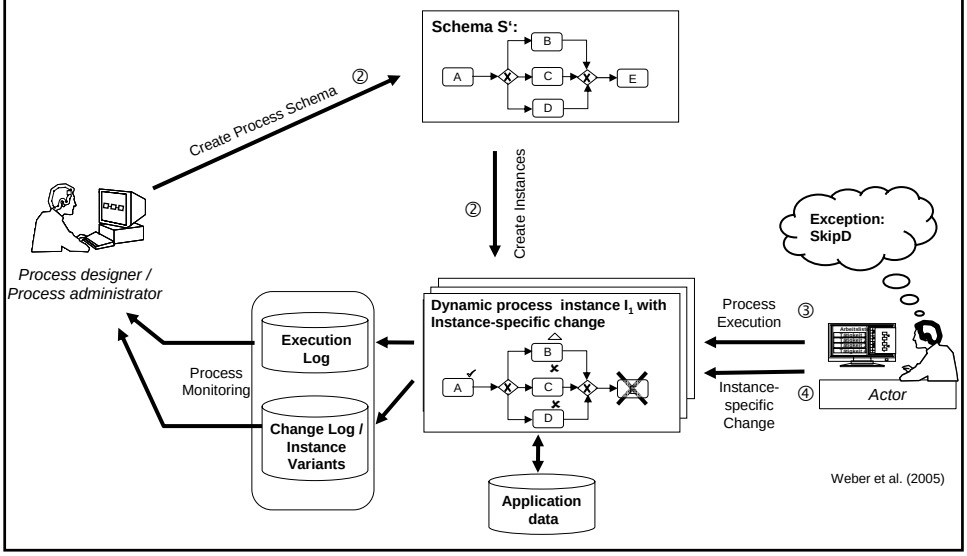
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Relevant Issues

- Dynamic processes provide significant runtime data
- Promising perspectives with respect to process analyses, process intelligence and process evolution
- But: systems enabling dynamic processes are more vulnerable to misuse
- Relevant issues, e.g.
  - Execution & change traceability
  - Real-time monitoring & control
  - Process diagnosing and mining, process compliance
  - Change policy management and process evolution

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Traceability



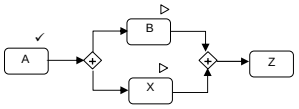
Weber et al. (2005)

Traceability

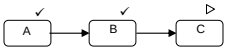
Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Execution Logs

Process Instance 4711



Process Instance 4723




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

Instance 4723
Activity  Event            User    Timestamp
          Instance Started John    2007/08/02 10:47
A         Started          John    2007/08/02 11:47
A         Completed        John    2007/08/02 12:44
B         Started          Helen   2007/08/04 09:11
B         Completed        Helen   2007/08/04 14:09
C         Started          Garry   2007/08/07 16:53
```

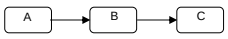

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Traceability

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Change Logs + Process Variants

Original Schema S

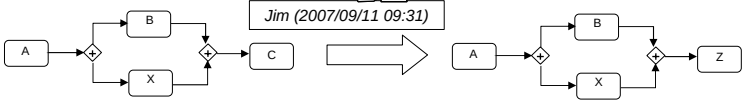


ADD X PARALLEL TO B

Helen (2007/09/10 12:02)

REPLACE C by Z

Jim (2007/09/11 09:31)




```
Change Log
Instance 4711 on Schema S

Change TX Applied Changes:
          User:Timestamp

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

Rinderle. Jurisch, and Reichert (2007)
Rinderle, Reichert, Jurisch and Kreher (2006)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Traceability

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Execution & Change Logs allow to …

- reconstruct the structure and the state of a particular process instance at any point in time (⇨ next slide)
- monitor, analyze and diagnose a collection of completed and/or running instances
- identify those processes instances which deviate from the originial process schema
- learn from these instance-specific changes and to derive optimized process models
- check for process compliance (i.e., to check whether a particular process instance meets certain control objectives)
- …

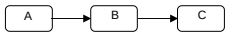
Traceability

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Execution & Change Logs: Reproducibility of Variants

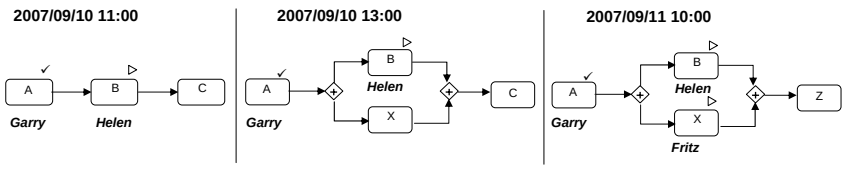
Original Schema S




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

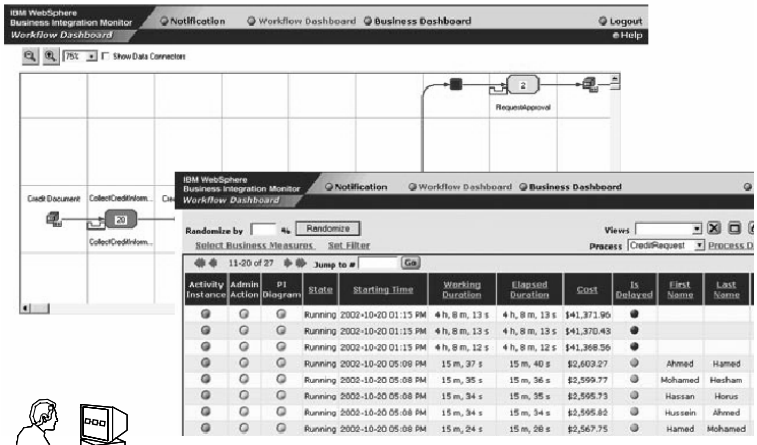
```
Change Log Instance 4711 on Schema S

Change TX Applied Changes : User:Timestamp

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

Process Instance 4711



Real-time Monitoring & Control

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary



Process administrator

Workflow dashboard

IBM (2003)

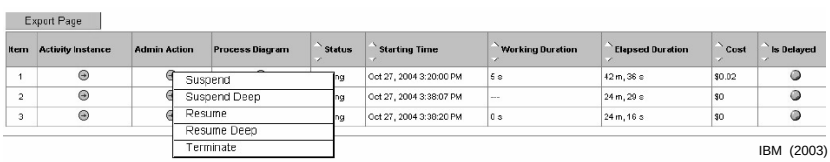
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Real-time Monitoring & Control

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Workflow dashboard

- operational console for running process instances
- aggregated overview of process instance collections
- monitoring and visualization of single process
- performing administrative and corrective actions on work items and process instances (suspend, reassign, change, etc.)
- connect with alerters and notification services (e.g., to deal with delays in the processing of work items)



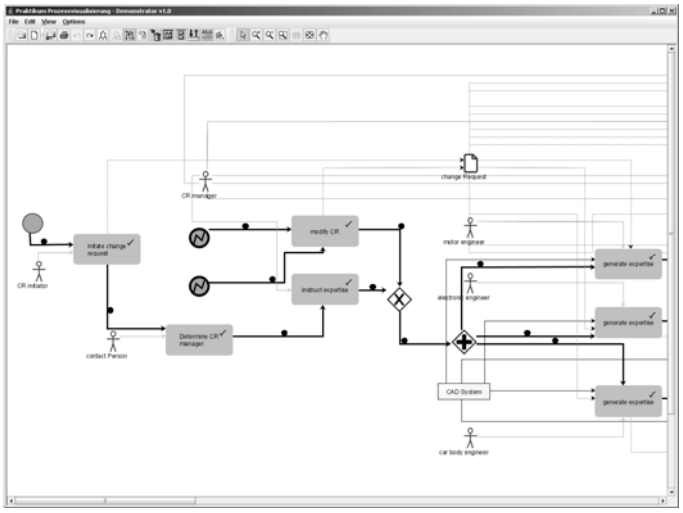
IBM (2003)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Real-time Monitoring & Control

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Monitoring and visualizing the progress of single instances

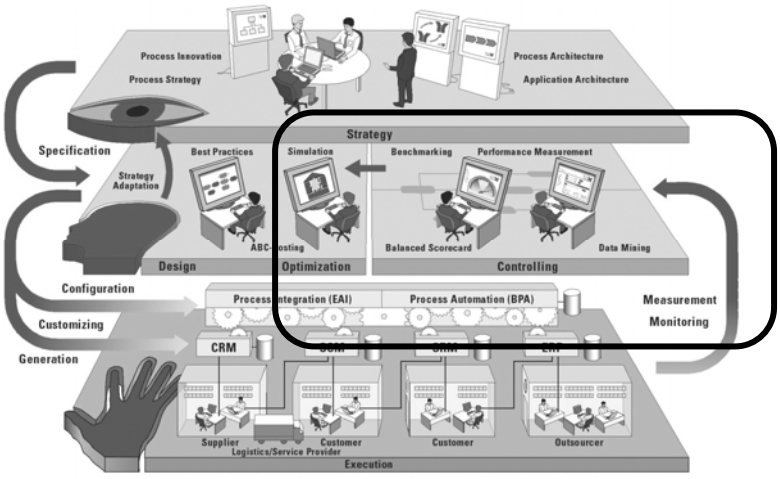


Bobrik et al(2006)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Diagnosing and Mining

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary



© IDS Scheer

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Diagnosing and Mining

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

process performance characteristics

compliance with control objectives

process performance analysis

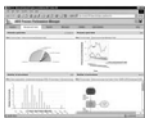
delta anlyses & constraint checking

Execution Logs
Change Logs
Application data

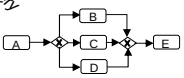
process instance data

process performance measurement

process discovery



process performance metrics



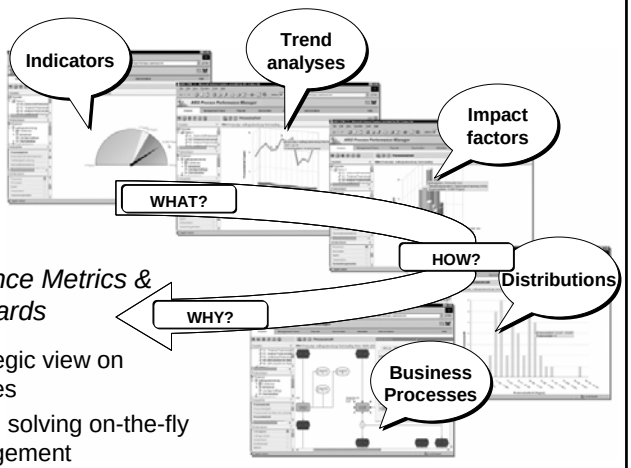
(improved) process models

Aalst and Weijters (2004), Aalst et al. (2007)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Diagnosing and Mining

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary



Process Perfomance Metrics & Business Dashboards

- High-level, strategic view on process instances
- Tactical problem solving on-the-fly for senior management
- Displaying of basic perfomance metrics

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Diagnosing and Mining

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Performance Metrics - Examples:

- **Process perspective**: *cycle times*, *waiting times, processing times,* and *synchronization time.*
  Examples:
  - *What average time does See-the-Bear need to process a customer request?*
  - *What is the maximum waiting time for activity "book boat tour for Glacier Bay"?*
  - *What percentage of customer requests is handled within 24 hours?*
  - *What is the minimum processing time of activity "plan transportation"?*
  - *How many times was a travelling plan dynamically adapted ? Which services were most sold? In how many cases was a trip aborted?*
  - *What are the average transporation costs for customers?*
  - *How many process instances have been handeled last year? How does their distribution look like?*
- **Resource perspective**: *frequencies, time, utilization, and variability.*
  Examples:
  - *How many times did Garry complete activity "book boat tour for Glacier Bay"?*
  - *How many times did Helen withdraw activity "book rental car"?*
  - *How much time did Garry work on instances of activity "plan transportation"?*
  - *How much time did people with role Manager work on this process?*
  - *What is resource usage distributed over a certain period of time?*
  - *How many times did Helen work for more than 1 hour without interruption?*

Process Diagnosing and Mining

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Performance Metrics – Analysis Options:

- **Resource & Organization Analysis:** extract information on resource and organization models
- **Aggregated Analysis:** Based on execution of process activities (average revenue, execution cost, idle cost, allocated resource cost, total cost, and profit)
- **Process Instance Analysis:** Based on individual dynamic process instances (resources allocated per activity instance, allocation duration, shortage, and cost)
- **Comparison Analysis:** Compare the weighted average analysis results for two processes

Process Diagnosing and Mining

Process Performance Characteristics

- Each dynamic process instance has a number of properties:
  - Resource that worked on a specific activity
  - Value of a characteristic data element (e.g., size of order, age of customer, number of flights per adventure trip, etc.)
  - Performance metrics of instance (e.g., processing time)

caseid	Act A	Act B	...	Act Z	Data D1	Data D2	...	Data D9	Proc time	Wait Time	Flow time
1	John	Mike		Anne	$50	20y		80%	12h	3d	3.5d
2	Clare	Jim		Ike	$75	15y		75%	6h	3d	3.25d
3	John	Mike		Clare	$55	20y		80%	18h	4d	4.75d
...	...	...	...	...	...	...	...	...	...	...	...

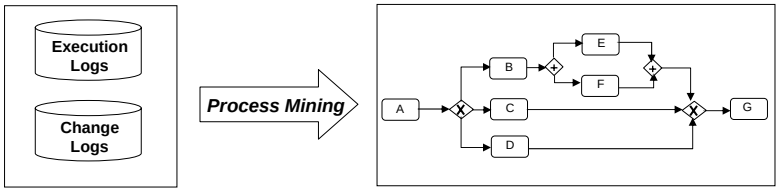
- Using data mining techniques it is possible to find relevant relations between these properties
- Examples:
  - If John and Mike work together, it takes longer.
  - Expensive cases require less processing

Aalst et al (2003)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Diagnosing and Mining

Process Mining based on Execution and/or Change Logs



Data from a collection of process instances

Process mining can be used for …

- discovering process models from execution logs (What is the process?)
- performing delta analyses and compliance checks (Are we doing what was specified? Are control objectives met?)
- discovering process optimizations based on execution and/or change logs

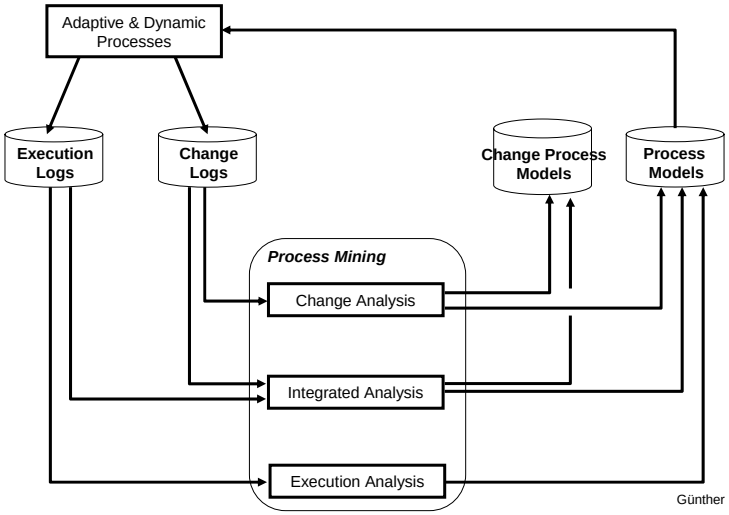
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Diagnosing and Mining

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Process Mining based on Execution and/or Change Logs



Günther et al (2006)

Process Diagnosing and Mining

Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary

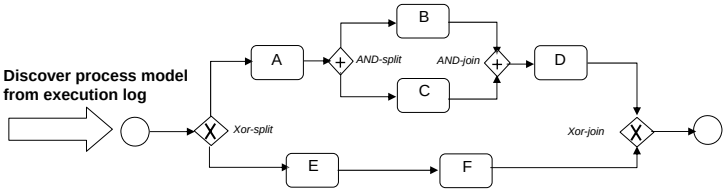
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

Execution log (simplified)

```
I1:A
I2:A
I3:A
I3:B
I1:B
I1:C
I2:C
I4:A
I2:B
I2:D
I5:E
I4:C
I1:D
I3:C
I3:D
I4:B
I5:F
I4:D
```

I1, I3: ABCD - I2,I4: ACBD - I5: EF

Execution analysis - Example: Discover a *process model* (e.g., in terms of a BPMN diagram) based on the execution log and without prior knowledge about the structure of the process.

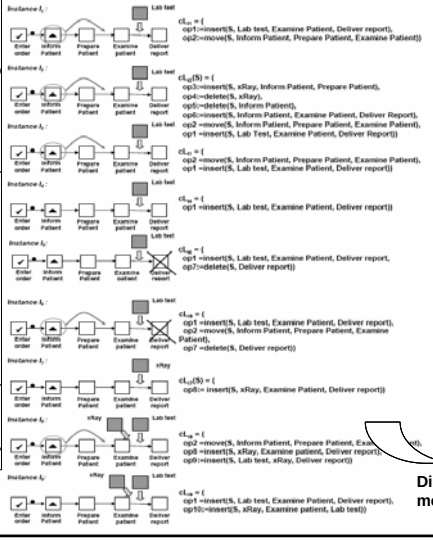


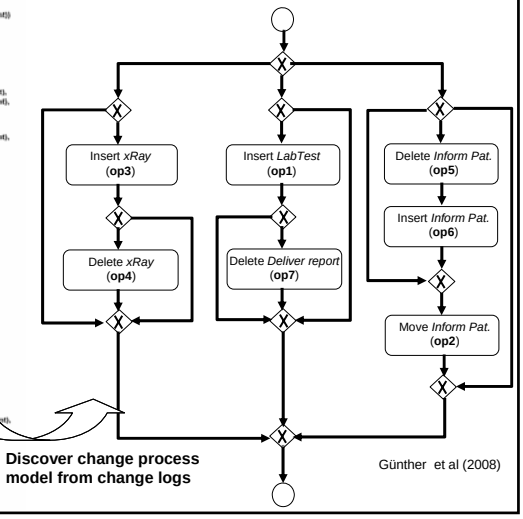
Aalst et al. (2003); Aalst et al (2004)

Process Diagnosing and Mining

Dynamic processes with instance-specific changes:

Change Analysis - Example: Discover a *meta change process* which covers all changes applied to dynamic process instances from a given collection.





Discover change process model from change logs

Günther et al (2008)

Process Evolution

- Process changes can be realized by adapting the process schema at the type level (process schema evolution)
- Challenge: How to deal with running process instances when adapting their original process schema?
- At least version control and co-existence of process instances running on the old and the new schema is needed.
- For long-running process instances, in addition, their controlled migration to the new schema version is often required.
- Correct behavior of process instances after their migration is a must!
- In the following slides, we sketch selected scenarios on this
  - Scenario 1: No version control
  - Scenario 2: Co-existence of instances running on the old / new schema
  - Scenario 3: Change propagation and instance migration

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente

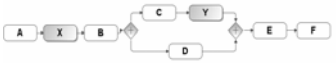
Scenario 1 – No Version Control

Type change overwrites schema S

Process Schema S

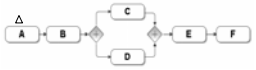
Schema Evolution

Process Schema S

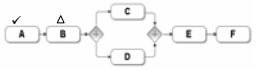


Instances I2 and I3 are in inconsistent states

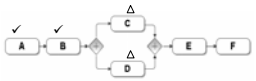
Process Instance I1



Process Instance I2

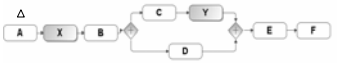


Process Instance I3

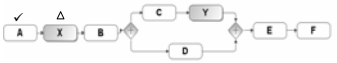


Change is propagated to all running process instances

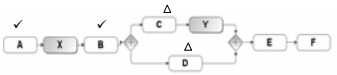
Process Instance I1



Process Instance I2



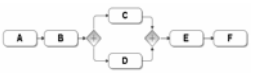
Process Instance I3



Scenario 2 – Co-Existence

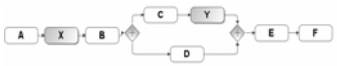
Type change results into a new version of schema S

Process Schema S



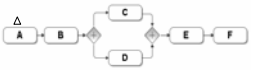
Schema Evolution

Process Schema S'

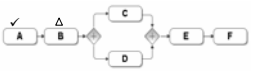


Old instances remain with schema S

Process Instance I1



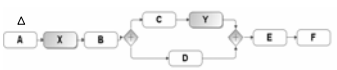
Process Instance I2



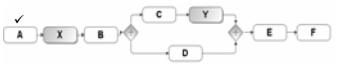
Process Instance I3

Instances created from S

Process Instance I4



Process Instance I5

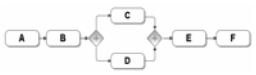


Instances created from S'

Scenario 3 – Instance Migration

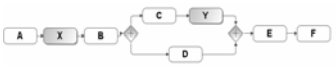
Type change results into a new version of schema S

Process Schema S



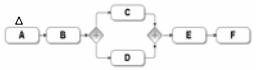
Schema Evolution

Process Schema S'

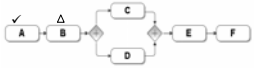


Migration of compliant process instances to S'

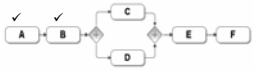
Process Instance I1



Process Instance I2



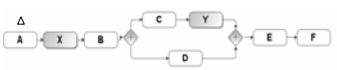
Process Instance I3



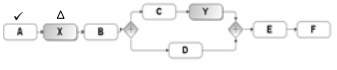
Non-compliant instances

Propagation of compliant process instances to schema S'

Process Instance I1



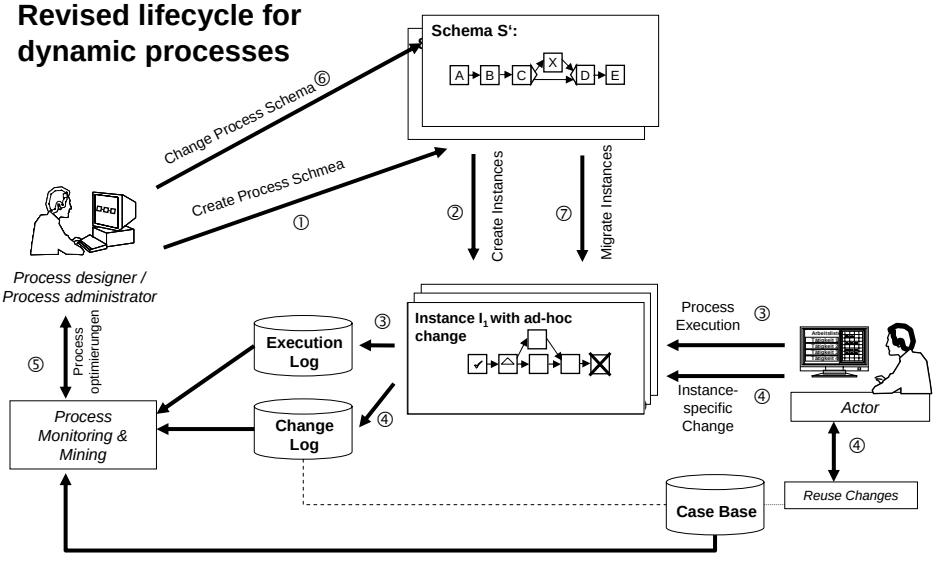
Process Instance I2

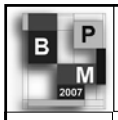


Reichert et al (2005),
Rinderle, Reichert and Dadam (2004)
Rinderle, Weber, Reichert and Wild (2005)

Summary

Revised lifecycle for dynamic processes





Summary

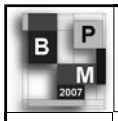
Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Current tool support for dynamic processes:

- Commercial Systems
  - Late Binding available in most commercial systems
  - Late Modeling and ad-hoc changes are not or only rudimentarily supported
- Academic Prototypes
  - Examples: ADEPT, CAKE2, CBRFlow, Pockets of Flexibility, Worklets, etc.
  - Most prototypes either focus on late binding / late modeling or ad-hoc changes

Weber & Reichert & Rinderle (2007)

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente



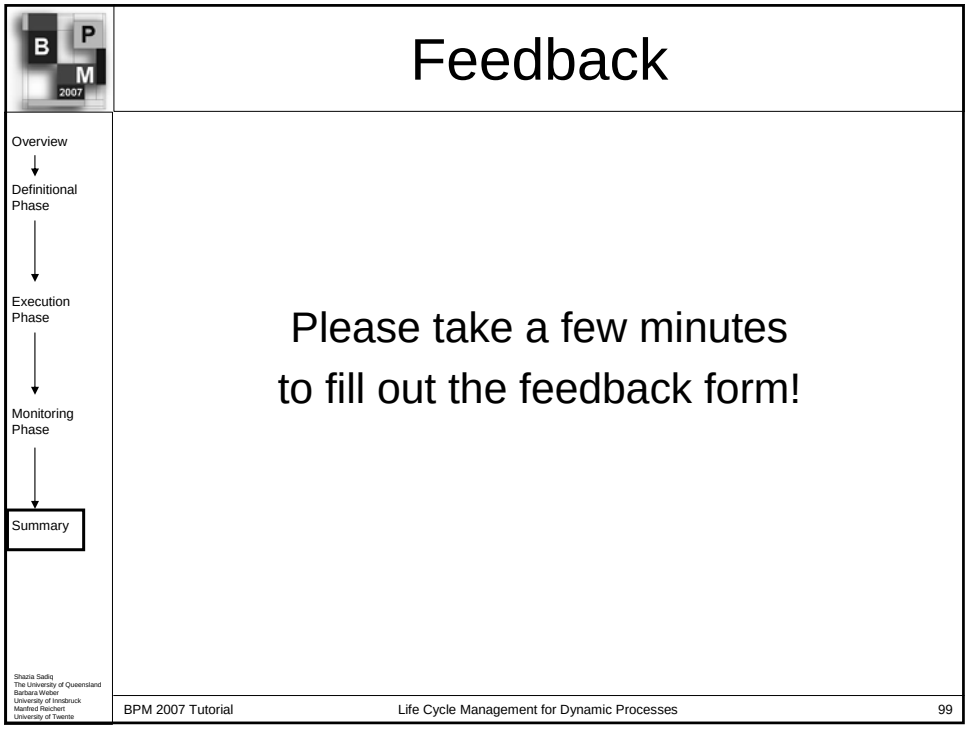
Summary

Overview
↓
Definitional Phase
↓
Execution Phase
↓
Monitoring Phase
↓
Summary

Some open research issues:

- Management of changes and process variants:
  - variant repositories
  - querying variants
  - learning from variants
- Role of dynamic processes for compliance management
- Dynamic processes for smart, ambient systems
- Dynamic processes in cross-organizational settings
- …

Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente


Feedback
Overview
Definitional Phase
Execution Phase
Monitoring Phase
Summary
Please take a few minutes
to fill out the feedback form!
Shazia Sadiq
The University of Queensland
Barbara Weber
University of Innsbruck
Manfred Reichert
University of Twente
BPM 2007 Tutorial
Life Cycle Management for Dynamic Processes
99

References

Sources from Industry and Practitioners

Davenport, Th. http://www.tomdavenport.com/

Forester 2007 BPM Market Overview

Gartner EXPPremier (2005) Delivering IT's Contribution: The 2005 CIO Agenda. Gartner, January 2005

WinterGreen Research (2004) Business Process Management (BPM) Market Opportunities, Strategies, and Forecasts, 2004 to 2009.

Harmon, P. (2003) Business Process Change – A Manager's guide to Improving, redesigning and Automating Processes

Menendez, M. (IBM Software Group): WebSphere Business Integration Modeler v 5.1, 2003

Malone, T.; Crowston, K.; Herman, G. (2003) Organizing Business Knowledge – The MIT Process Handbook. The MIT Press.

Porter, M. (1998) Competitive Advantage: Creating and Sustaining Superior Performance.

Rummler, G.A.; Brache, A.P. (1990) Improving Performance: How to Manage the White Space in the Organization Chart. Jossey-Bass Publishers

SAP Solution Maps. www.sap.com/solutions

Scheer, A.W. (1994) Business Process Engineering: reference Models for Industrial Enterprises. Springer.

Sharp, A.; McDermott, P. (2001) Workflow Modelling: Tools for Process Improvement and Application Development.

Smith, B. (1986) Motorloa University www.isixsigma.com

Smith, H.; Finger, P. (2003) IT doesn't matter – Business Process Do. August 2003. Meghan-Kiffer Press 2003.

Sources from Academia

Adams, M.J.; ter Hofstede, A.H.M.; Edmond, D.; van der Aalst, W.M.P. (2006): Worklets: A Service-Oriented Implementation of Dynamic Flexibility in Workflows. Proc. of the 14th Int'l Conf. on Cooperative Information Systems (CoopIS'06), LNCS 4275, pp. 291-308

Bobrik, R.; Bauer, T.; Reichert, M. (2006): Proviado – Personalized and Configurable Visualizations of Business Processes. Proc. 7th Int'l Conf. on Electronic Commerce and Web Technologies (EC-WEB'06), Krakow, Poland, LNCS 4082, 2006, pp. 61-71

Casati, F.; Pozzi, G. (1999): Modeling exceptional behaviors in commercial workflow management systems. Proc. CoopIS'99, pp.127 – 138.

Günther, C.W.; Rinderle, S.; Reichert, M.; van der Aalst, W.M.P (2006): Change Mining in Adaptive Process Management Systems. Proc. 14th Int'l Conf. on Coop. Information Systems (CoopIS'06), Montpellier, France, LNCS 4275, Nov. 2006, pp. 309-326.

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

Indulska, M.; Chong, S.; Bandara, W.; Sadiq, S.; Rosemann, M. (2007) Major Issues in Business Process Management: An Expert Perspective, In: Proceedings of the 15th European Conference on Information Systems. St Gallen, Switzerland, June 7-9, 2007.

Lu, R.; Sadiq, S.; Padmanabhan, V.; Governatori, G. (2006): Using a Temporal Constraint Network for Business Process Execution. In: Dobbie, G. and Bailey, J. (Eds.) Database Technology 2006, number 49 in Conference Research and Practice of Information Technology, Australian Computer Science Association, ACS

Lu, R.; Sadiq, S. (2006): Managing Process Variants as an Information Resource. Proc. 4th Int'l Conf. on Business Process Management (BPM2006), Vienna, Austria, 2006

Lu, R.; Sadiq, S. (2007): On the Discovery of Preferred Work Practice through Business Process Variants. Proc. 26th Int'l Conf. on Conceptual Modeling (ER'07), Nov 2007. Auckland, New Zealand.

Lu, R.; Sadiq, S. (2007): A Reference Architecture for Managing Business Process Variants. Proc. 9th Int'l Conference on Enterprise Information Systems (ICEIS2007) Funchal, Portugal, 2007

Rosemann, M.; van der Aalst, W.M.P. (2007) A Configurable Reference Modelling Language. Information Systems. Volume 32 , Issue 1 (March 2007) pp. 1-23

Reichert, M.; Dadam, P. (1998): ADEPT$_{flex}$-Supporting Dynamic Changes of Workflows Without Losing Control. J. Intell. Inf. Syst. 10(2): 93-129 (1998)

Reichert, M. (2000): Dynamic Changes in Workflow Management Systems. Ph.D. thesis, Ulm University, Germany, 2000

Reichert, M.; Dadam, P.; Bauer, T. (2003): Dealing With Forward and Backward Jumps in Workflow Management Systems. Int'l Journal Software and Systems Modeling, 2(1):37-58, 2003

Reichert, M.; Rinderle, S.; Kreher, U.; Dadam, P. (2005): *Adaptive Process Management with ADEPT2*. Proc. 21st Int'l Conf. on Data Engineering (ICDE'05), Tokyo, 2005

Rinderle, S.; Reichert, M.; Dadam, P. (2004): Flexible Support of Team Processes By Adaptive Workflow Systems. Distributed and Parallel Databases, 16(1):91-116 (2004)

Rinderle, S.; Reichert, M.; Dadam, P. (2004): Correctness Criteria For Dynamic Changes in Workflow Systems - A Survey. Data and Knowledge Engineering, Special Issue on Advances in Business Process Management, 50(1):9-34 (2004)

Rinderle, S.; Reichert, M.; Dadam, P. (2004): Disjoint and Overlapping Process Changes - Challenges, Solutions, Applications. Proc. 12th Int'l Conf. Cooperative Information Systems (CoopIS'04), Agia Napa, Cyprus, LNCS 3290, Oct. 2004, pp. 101-120.

Rinderle, S.; Weber, B.; Reichert, M; Wild, W. (2005): Integrating Process Learning and Process Evolution - A Semantics Based Approach. Proc. 3rd Int'l Conf. Business Process Management (BPM'05), Nancy, France, Sept. 2005, LNCS 3649, pp. 252-267

Rinderle, S.; Reichert, M.; Jurisch, M.; Kreher, U. (2006): On Representing, Purging, and Utilizing Change Logs in Process Management Systems. Proc. 4th Int'l Conf. Business Process Management (BPM'06), Vienna, Austria, LNCS 4102, 2006, pp. 241-256

Rinderle, S.; Jurisch, M.; Reichert, M. (2007): On Deriving Net Change Information From Change Logs – The DELTALAYER-Algorithm. Proc. 12th GI Conf. on Database Systems in Business, Technology and Web (BTW'07), Lecture Notes in Informatics P-103, Aachen, Germany, March 2007, pp. 364-381

Russell, N.; van der Aalst, W.M.P.; ter Hofstede, A.H.M (2006): Workflow Execption Patterns Proceedings of the 18th International Conference on Advanced Information Systems Engineering (CAiSE 06), LNCS 4001, pp. 288-302.

Sadiq, W. and Orlowska, M.E. (2000): Analysing Process Models using Graph Reduction Techniques. Information Systems, Vol. 25, No. 2, pp. 117-134, 2000.

Sadiq, S.; Sadiq, W.; Orlowska, M.E. (2005): A Framework for Constraint Specification and Validation in Flexible Workflows. Information Systems Vol. 30, No. 5, July 2005.

van der Aalst, W.M.P. (1998)**:** The Application of Petri Nets to Workflow Management. The Journal of Circuits, Systems and Computers, (1998)

van der Aalst, W.M.P.; van Dongen, B.F.; Herbst, J.; Maruster, L.; Schimm, G.; Weijters, A.J.M.M. (2003): Workflow Mining: A Survey of Issues and Approaches. Data and Knowledge Engineering , 47(2):237-267, 2003.

van der Aalst, W.M.P.; Weijters, A.J.M.M. (Eds.). Process Mining, Special Issue of Computers in Industry, Elsevier Science Publishers, Amsterdam, 2004.

van der Aalst, W.M.P.; Weijters, A.J.M.M.; Maruster, L. (2004): Workflow Mining: Discovering Process Models from Event Logs. IEEE Transactions on Knowledge and Data Engineering 16(9): 1128-1142 (2004)

van der Aalst, W.M.P.; Reijers, H.A.; Weijters, A. J. M. M.; van Dongen, B.F.; de Medeiros, A.K.A.; Song, M.; Verbeek, H.M.W. (2007): Business process mining: An industrial application. Inf. Syst. 32(5): 713-732

Weber, B.; Wild, W.; Breu, R. (2004): CBRFlow: Enabling Adaptive Workflow Management through Conversational Case-Based Reasoning. In: Proceedings of the 7th European Conference, ECCBR 2004, Madrid, Spain 2004, pp. 434-448.

Weber, B.; Reichert, M.; Rinderle, S.; Wild, W. (2005): Towards a Framework for the Agile Mining of Business Processes. 1st Int'l Workshop on Business Process Intelligence, Proc. BPM'05 Workshops, LNCS 3812, Nancy, France, Sept. 2005, pp. 191-202

Weber, B.; Reichert, M.; Wild, W. (2006): Case-Base Maintenance for CCBR-Based Process Evolution. Proc. ECCBR'06, pp. 106-120

Weber, B., Reichert, M., Rinderle, S. (2007): Change Patterns and Change Support Features in Process-Aware Information Systems. Proc. 19th Int'l Conf. on Advanced Inf. Systems Eng. (CAiSE'07), LNCS 4495, Trondheim, Norway, June 2007, pp. 574-588