

## Business Process Management

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## The BPM fever – Hype or Necessity

- Business Process Management (BPM) has been identified as the “number one business priority”
- BPM high on the agenda of major enterprise software corporations (SAP, Oracle, PeopleSoft)
- Building “Business Process Capability” is seen as a major challenge for senior executives within the coming years  
Source: Wharton (2005) Survey; ITJ Contribution: The 2005 CIO Agenda, Garner, 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-Keller 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.

## Why is BPM a key driver in business & IT solutions

- To understand the reasons, we need to first
  - Understand the meaning of “process orientation”
    - Why process orientation is important, what benefits does it bring
  - Understand how successful “process enabled” technologies work, e.g. Workflow Management Systems
    - What are the technical and business challenges in successful deployment of these technologies

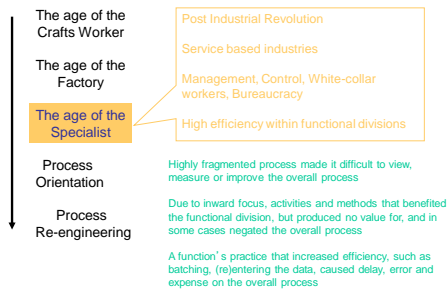
→ Plan for this Lecture

## What is the “Process”

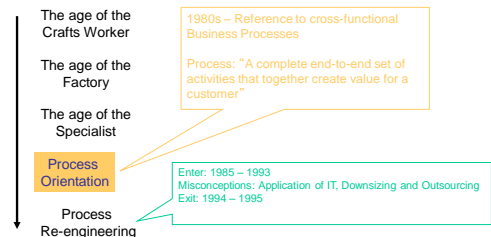
- Material Processes
  - Move, store, transform, measure and assemble physical objects
  - Implement Manual tasks
- Information Processes
  - Create, process, manage and provide information
  - Implement automated and partially automated tasks
- Business Processes
  - Fulfill a business contract or satisfy a specific customer need
  - Description of an organization's activities implemented (primarily) as information processes

Georgopoulos et al. 1995

## History of Process Orientation



## History of Process Orientation



## Process Orientation

- Re-engineering didn't survive, but process orientation did!
- Merging of process management methods
  - Continuous Process Improvement (CPI)
  - Total Quality Management (TQM)
  - Business Process Re-engineering (BPR)
- Closer integration of business process management with process support systems

## Workflow Management Systems

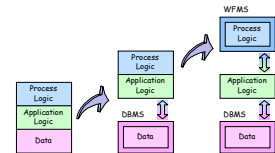
## Workflow Systems

A Workflow is defined as the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules

(Workflow Management Coalition)

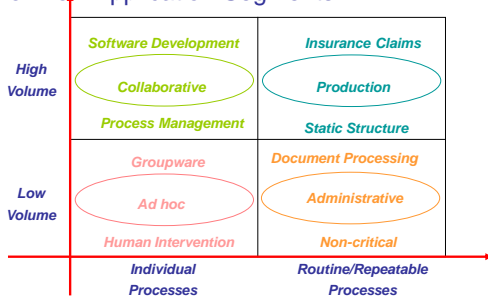
## What's New

- Flow of work (workflow) already exists in most business processes ... nothing new
- Integration of the critical factors of an enterprise: people, infrastructure, processes ... already recognized
- Binding the "Islands of Automation" ... next logical step after advances in computing power, connectivity and global shift towards integrated solutions
- Workflow systems provide a "Process-Centric" approach ... introduces a new quality in workflow management



- DBMS takes data management functionality out of application programs
- WFMS takes process logic out of application logic

## Workflow Application Segments



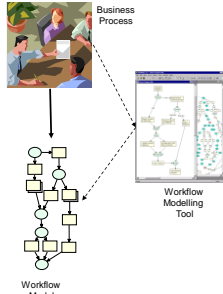
## Terminology

- Workflow Model
- Workflow Instance
- Workflow Activity
- Workflow Participant
- Workflow Management System (WFMS)

Source: Workflow Management Coalition (1999) Terminology and Glossary

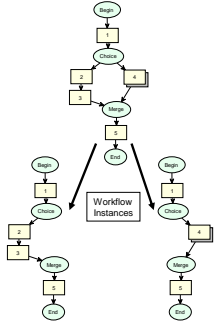
## Workflow Model

- A business process model is a description of an organization's activities in terms of tasks, agents, rules and procedures and is engineered to fulfill a business goal
- A workflow model is a mapping of the business process into a form which supports automated manipulation
  - The workflow model is a definition of the **tasks**, **ordering**, **data**, **resources**, and other aspects of the process.
  - This is also referred to as the workflow schema or type.
  - Most, if not all, workflow models are defined as graphs which depict the flow or ordering of the tasks involved in the process, together with a description of other task properties.
  - A workflow model is defined in a **workflow modelling tool**. Also known as process definition tool.
  - A given tool will support a given **workflow definition language**.



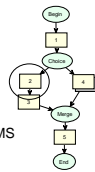
## Workflow Instance

- A workflow instance, denotes a particular occurrence of the business process as defined by the workflow model.
- For example, we can define an admission workflow that handles student admission applications in a university. A particular application for admission represents an instance of the admission workflow.
- Different instances of the same workflow may perform a different subset of workflow tasks, i.e. they may have different execution paths in the workflow graph.
- An **instance type** is the set of instances that follow the same execution path through the workflow model.



## Workflow Activity

- Description of a unit of work that forms a logical step within a process
  - Manual Activity (send an email, dispatch items, visit a site, ...)
  - Automated Activity (execute a database transaction, invoke application, ...)
- The WFMS initiates the workflow activity
- The workflow activity notifies the WFMS upon completion
- What the activity actually does is beyond the scope of the WFMS



## Workflow Participant

- A resource that performs the work represented by a workflow activity
- Generally applied to human resource, but may also refer to a machine based resource, such as an underlying application

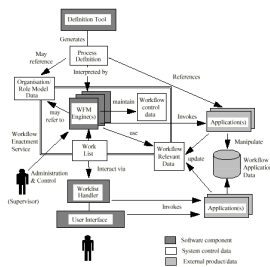


## Workflow Management System

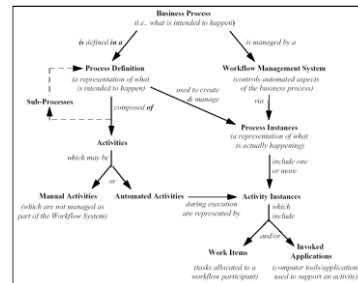
A system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications.

Workflow execution refers to

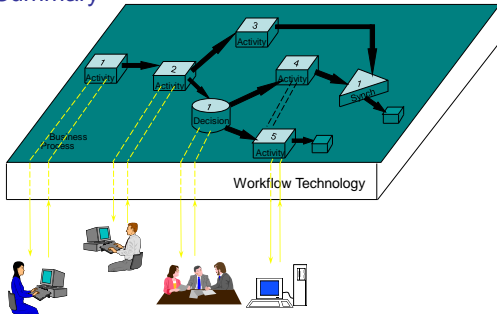
- The creation of workflow instances
- The scheduling of workflow activities
- The invocation of workflow applications



## Relationships between Terms



## Summary



## Workflow Management and Web Services

- Business activities (applications) can be exposed as web services
- Huge potential for process management of cross-organizational activities (due to loose coupling)
- Many initiatives in web services to realize this potential
  - Web services composition
  - Web services orchestration
  - Web services choreography

## Process Modelling and Verification

## Importance of modelling and analysis in BPM

- Process modelling lies at the very centre of successful BPM, but what are we modelling?
  - Business processes
    - \* Improving business operations
    - \* Add value for the customer
    - \* Best practices
    - \* ...business drivers
  - Representation of business processes in IT frameworks
    - \* Does this representation truly represent the intended business process
- All technological support for BPM will depend on this representation – **it is critical to get it right!**
  - What language is adopted for the representation
  - Does the language have any formal foundations
  - What is the expressability of the language
  - Can we define a correctness criteria for models constructed in this language, i.e. when is the model considered *correct*
  - Do we have a means of analysing these models
    - \* Verifying that they are correct
    - \* Simulating the behaviour

## Process Modeling

- Many languages invented within commercial and research communities
  - Communication based
  - Activity based
- Many interesting debates and results on expressability and verifiability

## Activity Based Modelling

- Basic Principles
  - Inter-activity dependency is the prime driver of the business process
- Formal Foundations
  - Petri Nets
  - Process Algebra
  - Logic
- Commercial Products
  - Flowmark (IBM MQSeries), Forte, Action, Staffware, Ultimus, Metastorm, Applan, Lombardi, SAP Workflow ...
  - Consortium of Workflow Vendors at [www.workflow.com](http://www.workflow.com)
  - Comparison of product modelling approaches at [www.workflowpatterns.com](http://www.workflowpatterns.com)
- Research Proposals
  - Adept, Wide, Mobile, METEOR, TRAMS, WAMO, ...
  - History of Workflow Research at <http://www.workflow-research.de/Research/index.html>
- Standards
  - Workflow Management Coalition [www.wfmc.org](http://www.wfmc.org)
  - BPMN – Business Process Modelling Notation
  - Business Process Modelling Initiative [www.bpmi.org](http://www.bpmi.org)
  - RosettaNet, ebXML, WSCI, BPEL4WS
  - ... too many ☺

## Workflow Modelling Perspectives

### Primary

- Functional
- Informational
- Behavioural
- Operational
- Organizational

### Secondary

- Security
- Causality
- History
- Integrity
- Quality

Source: Jablonski and Buntler (1996)

## Primary Modelling Perspectives

- **Functional**  
What is to be performed
- **Informational**  
What information is required
- **Behavioural**  
When it is performed
- **Operational**  
How it is performed
- **Organizational**  
Who performs it

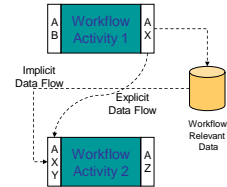
## Primary Modelling Perspectives

- **Functional**  
What is to be performed  
Activities and Sub-processes



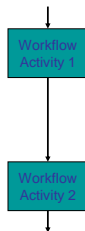
## Primary Modelling Perspectives

- **Informational**  
What information is required  
Input and Output data



## Primary Modelling Perspectives

- **Behavioural**  
When it is performed  
Control Flow
- Dependency between workflow activities
- Typical structures that represent this dependency:
  - Sequential execution
  - Concurrent execution
  - Alternative execution
  - ...
- **Temporal Constraints**
  - Durations (Single, Interval)
  - Deadlines (Absolute and Relative)
  - Interdependent time limits



## Primary Modelling Perspectives

- **Operational**  
How it is performed  
Workflow Relevant Applications
- Degree of modification (workflow aware applications)
- System support (manual or automated)
- Granularity (functional complexity)
- Scope (manipulating workflow control data or only application data)
- Coupling (integration between application and WFMS)
- Invocation mode (synchronously or asynchronously)
- Interaction mode (interactive or batch)

## Primary Modelling Perspectives

- **Organizational**  
Who performs it  
**Workflow Participants**
  - Organizational Structure (units & roles)
  - Organizational Population (people)
  - Organizational Policy
    - Selection
      - » All users in a given role
      - » Based on instance data
      - » Finding substitutes
      - » Load balancing
    - Notification
      - » All users satisfying the selection criteria are notified
    - Binding (Synchronizing)
      - » Typically 1-out-of-many

## Secondary Modelling Perspectives

- **Security**  
Who is allowed access  
Potential conflict with selection policies
- **Causality**  
Does the model abide by the business policies, rules and strategies
- **History**  
What happened during execution  
Audit trail / workflow logs
  - System context of Audit trail
    - » Queries on history (who performed this activity)
    - » Failure and recovery (determine last consistent state)
  - Application context of Audit trail
    - » Analysis (temporal constraints, participant loads, exceptions)
    - » Evolution and Improvement (semantic failures)

## Secondary Modelling Perspectives

- **Integrity**  
How to recover from failures  
Semantic and System failures
- **Quality**  
How to ensure "quality"  
Typically cost and time function

## Formal Foundations of Activity based Modelling

- **Petri Nets** Source: Geert K. Janssens, Jan Verlet, Bart Weyn, (2000)
  - WF Nets [Van der Aalst W.M.P.]
  - Information Control Nets [Ellis C.A., Nutt G. J.]
  - Temporal Constraint Petri Net [Adam N. R., et al]
  - Modular Process Nets [Wikarski D.]
  - Coloured Petri Nets [Merz M., et al]
  - Reconfigurable Nets [Badouel E., Oliver J.]
  - Higher Order Object Nets [Wikarski D., Han Y., Lowe M.]
- **Task Structures** Source: van der Aalst, ter Hofstede, (2000)
  - to describe and analyse problem solving processes [Bots 1989]
  - extended to meta-process modelling [Wijers & Heijes 1990, 1992]
  - semantics through process algebra [der Hofstede & Nieuwland, 1993]

## A Simple Graphical Workflow Language

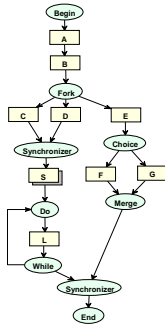
- Generic language with a small number of constructs
- Sufficient expressiveness for a wide variety of process requirements
- Simplicity provides rigorous analysis and verifiability
- Developed jointly by DSTC and UQ researchers (1995 – 2001)
- Supported by a process modelling and verification tool

## Fundamental Modeling Aspects

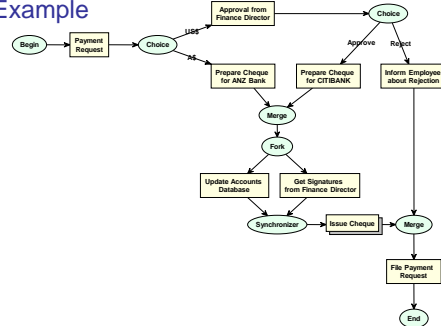
- **Structure**
  - Control Flow
- **Data**
  - Input and Output
- **Time**
  - Deadlines and Durations
- **Resources**
  - Applications, Roles, Performers

## Core Structures

- Sequence
- And Split
- And Join
- Or Split
- Or Join
- Nesting
- Iteration
- Termination

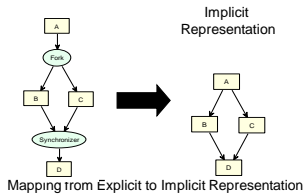


## Example



## Alternative Modelling Approach

- More intuitive ☺
- Less graph nodes ☺
- Implicit semantics ☺



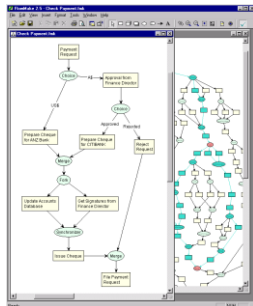
Mapping from Explicit to Implicit Representation

## FlowMake

- Modelling, Analysis and Verification of Workflow models
- Objectives
  - Simple modelling language
  - Correctness criteria
  - Verification algorithms
  - Modelling and verification tool

## FlowMake: Demonstration

- Developed in Microsoft Visual C++
- Fast and compact
- User-friendly WF Editor
- Verification and Analysis
- Object-oriented design
- Easily extensible
- Implements DSTC research
- Product interfaces



## Workflow Verification

- Semantic Verification  
Verify that the model is in conformance with the business process goals
- Syntactic Verification  
Verify that the model is in conformance with the grammar of the language
- Structural Verification  
Verify that the model will not lead to erroneous execution

## Syntactic Errors

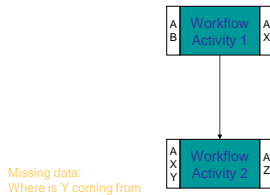
- An activity node cannot have more than one incoming/outgoing flows (explicit representation)
- Reachability of nodes (Graph must not be disconnected)
- Multiple (initial) final activities

## Structural Errors

- Mostly represent errors in control flow specification
- Incorrect specification of data, time and resources will also generate error in execution

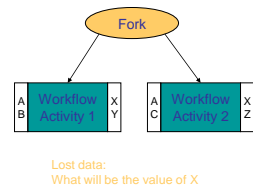
## Data, Time and Resource Conflicts

- Data Conflicts
  - Missing data
  - Lost data
- Temporal Conflicts
- Resource Conflicts



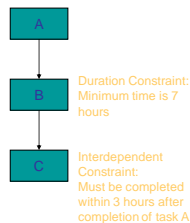
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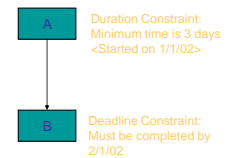
## Data, Time and Resource Conflicts

- Data Conflicts
- Temporal Conflicts
  - Temporal Consistency
    - Build Time
    - Run Time
- Resource Conflicts



## Data, Time and Resource Conflicts

- Data Conflicts
- Temporal Conflicts
  - Temporal Consistency
    - Build Time
    - Run Time
      - Instance Initiation
      - Decision points
- Resource Conflicts



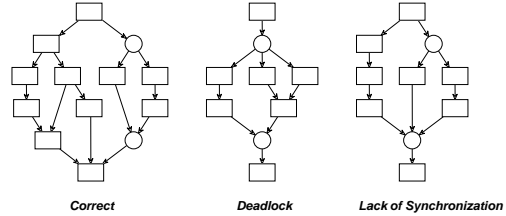
## Data, Time and Resource Conflicts

- Data Conflicts
- Temporal Conflicts
- Resource Conflicts
  - Incomplete specification
    - Role is assigned to activities, but no participants are bound to that role
  - Access and Role Conflicts
    - Participant does not have access to activity A, but is assigned a role that can perform activity A
  - Other ... ?

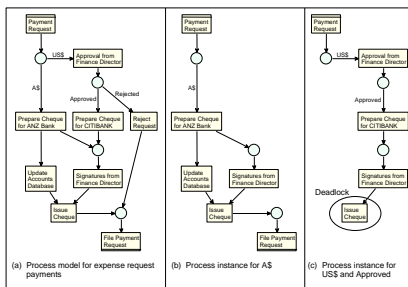
## Control Flow Conflicts

Note: Implicit representation

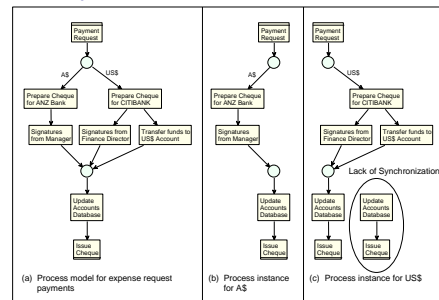
- Deadlock: Synchronizing alternative paths
- Lack of synchronization: Merging concurrent paths



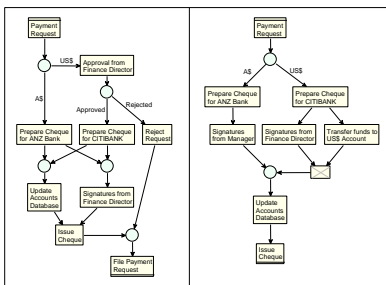
## Deadlocks



## Lack of Synchronization



## Correct Workflow Models

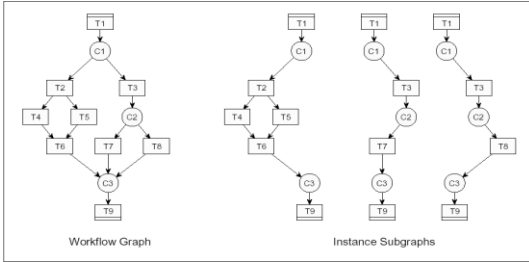


## Control Flow Verification

Based on the concept of an instance sub-graphs

- An instance sub-graph represents a subset of nodes (workflow tasks) that may be executed for a particular instance of a workflow
- It can be generated by visiting the nodes of a workflow graph on the basis of the semantics of underlying control flow constructs
- In the language under consideration, the "Choice" construct produces more than 1 instance sub-graph
- If there is one choice construct, then number of instance sub-graphs would be = number of outgoing flows of the choice coordinator
- Number of instance graphs increase exponentially with the number of choice-merge constructs
- A brute force method of generating all possible instance sub-graphs is not computationally effective

## Instance Sub-graphs



## Correctness Criteria

- Criteria 1: Deadlock free workflow graphs
  - A workflow graph is free of deadlock structural conflicts if it does not generate an instance sub-graph that contains only a proper subset of the incoming nodes of a synchronizer node
- Criteria 2: Lack of synchronization free workflow graphs
  - A workflow graph is free of lack of synchronization structural conflicts if it does not generate an instance sub-graph that contains more than one incoming nodes of a merge node.

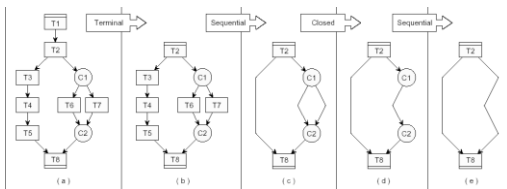
## CF Verification based on Reduction

- Remove all such structures within a workflow graph that are *definitely correct*
- A conflict-preserving reduction process is iteratively applied
- A structurally correct graph would reduce to an empty graph
- A workflow graph containing structural conflicts is not completely reduced

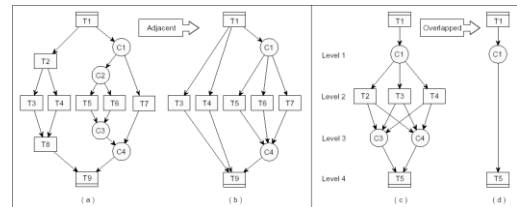
## Reduction Rules

- Terminal Reduction
- Sequential Reduction
- Adjacent Reduction
- Closed Reduction
- Overlapping Reduction

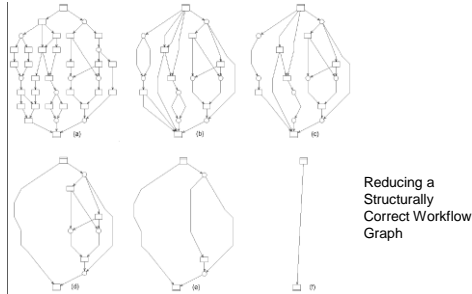
## Applying Reduction Rules



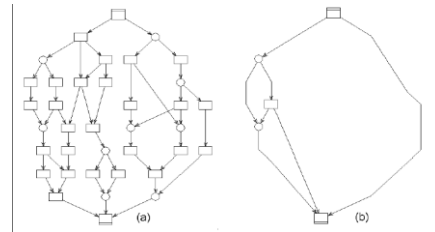
## Applying Reduction Rules



## Reduction Algorithm



## Reduction Algorithm



## Key Points

- Why businesses should get process aware
- What is the difference between BPM and enterprise applications
- What role can web services play in deployment of BPM
  
- Understand basic terminology in the field: workflow model, instance, activity; control flow, data flow; workflow performer, resource etc.
  
- How to map a simple business process into a workflow model using the FlowMake language
- Understand the basic constructs, correctness criteria/errors, and verification requirements of this language

## Suggested Reading

- Workflow Management Coalition. Workflow Reference Model [www.wfmc.org](http://www.wfmc.org)
- Wasim Sadiq and Maria E. Orlowska. Analysing Process Models using Graph Reduction Techniques. Information Systems, Vol. 25, No. 2, pp. 117-134, 2000. Elsevier Science. June 2000.