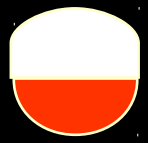
Zawansowane Modelowanie i Analiza Systemów Informatycznych (l-8)



Polsko-Japońska Wyższa Szkoła Technik Komputerowych
Katedra Systemów Informacyjnych
2013

We will cover

- **Motivation, historical overview, trends and new applications for workflows technology**
- **Overview of WF Technology**
- **WFMS - architectural issues,**
- **Business Process and constraints specification,**
- **Verification of business process model,**
- **Dynamic process modifications**
- **Exceptions handling**
- **Business process evolution**
- **Temporal constraints and their maintenance**
- **User Issues, change of the work practices**
- **Potential limitations of WFMSs**

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**

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

The BPM fever – Hype or Necessity

- **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 $1.3 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

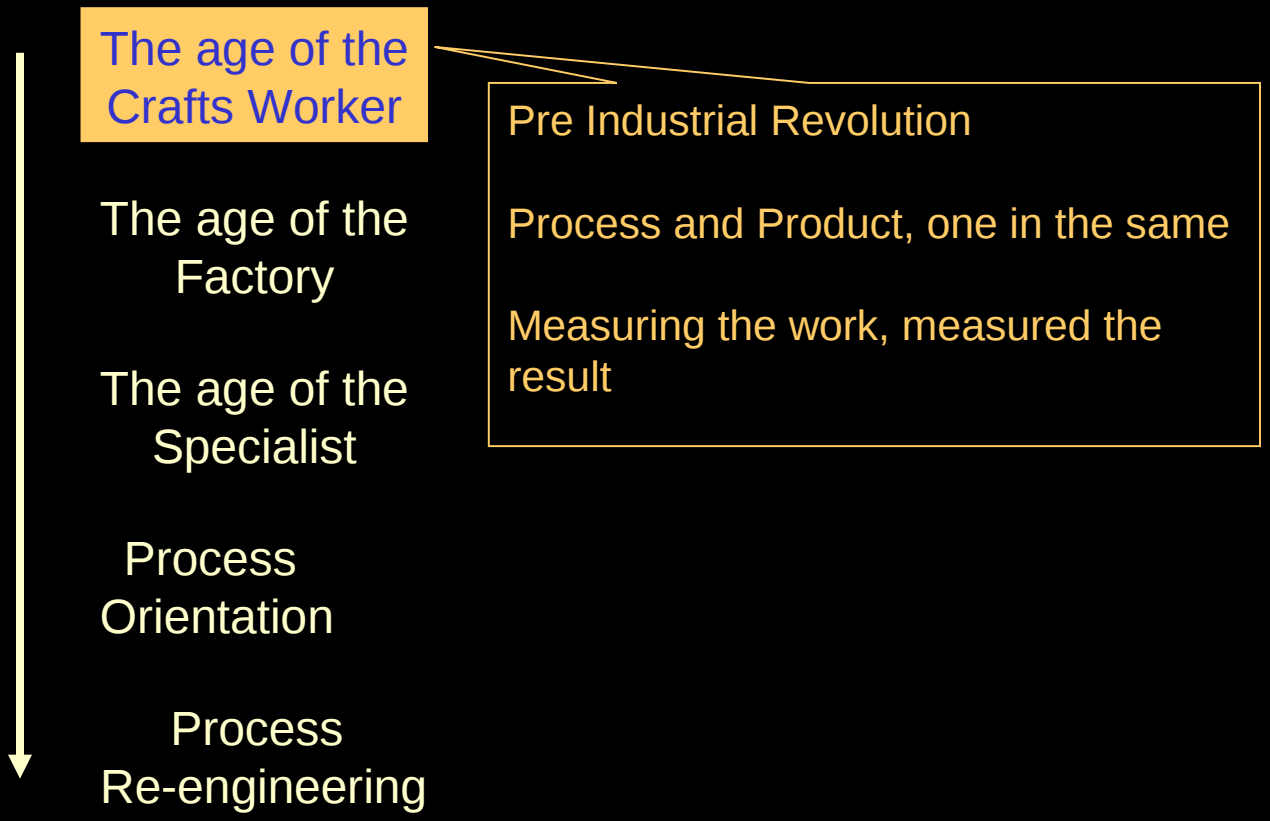
- **To understand the reasons, we need to first**
  - **Understand the meaning of "process orientation"**
    - Why process orientation is important, what benefits does it bring
  - **Understand how successful "process enabled" technologies work, e.g. Workflow Management Systems**
    - What are the technical and business challenges in successful deployment of these technologies
  - **Understand core BPM functionality**
    - What are the basic terms and concepts
    - What are the core functions

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**
  - **Fulfil a business contract or satisfy a specific customer need**
  - ***Description* of an organization's activities implemented (primarily) as information processes**

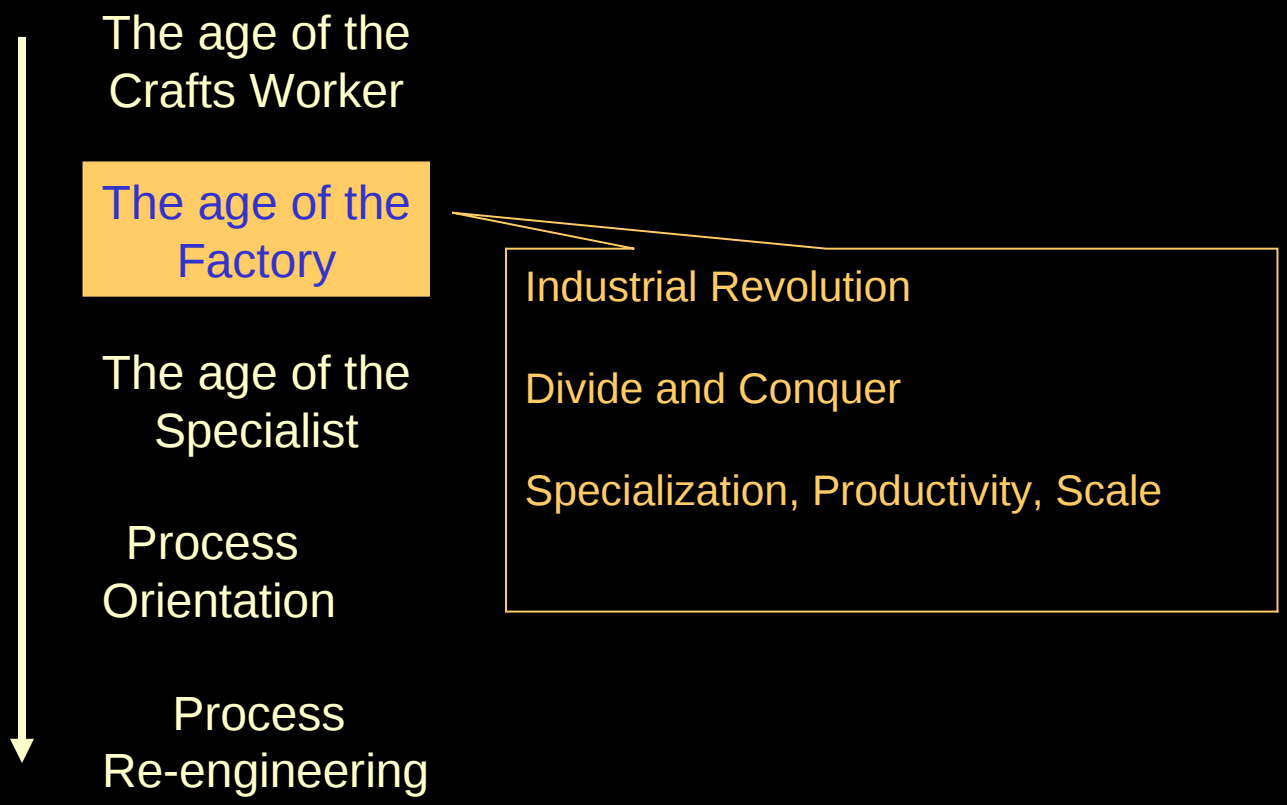
Georgakopoulos et al, 1995

History of Process Orientation

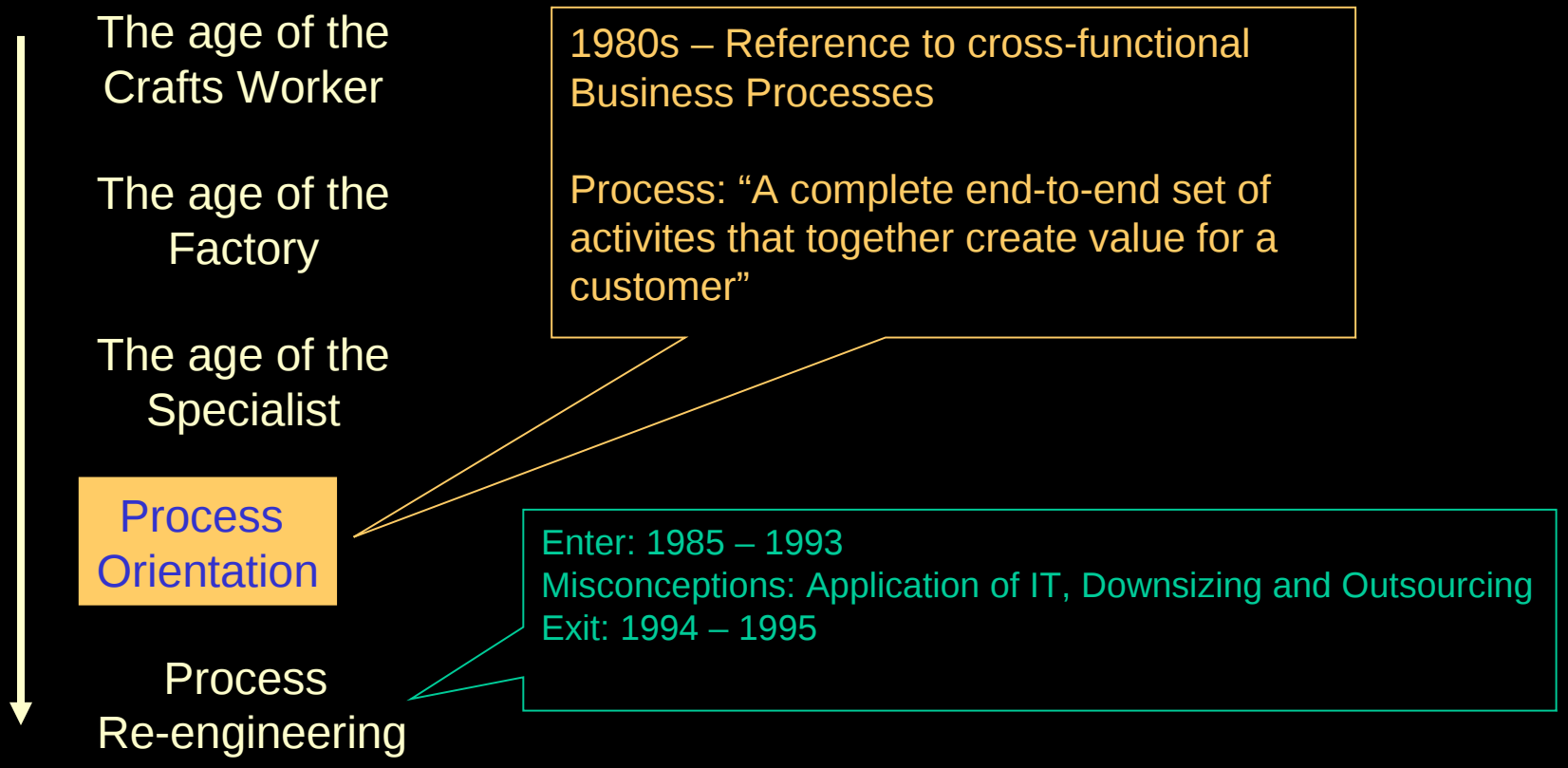


Source: Sharp and Mcdermott (2000)

History of Process Orientation



History of Process Orientation



Process Orientation

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

Origins of Workflow Systems

- **Office Automation**
- **Database Management**
- **E-Mail**
- **Document Management**
- **Software Process Management**
- **Business Process Modelling**
- **Enterprise Modelling and Architecture**

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)

Example Applications

- **Insurance policy/claims processing (AVEMCO)**
- **Loan request handling**
- **Travel expense approvals**
- **Bug reporting and resolution**
- **Project proposal preparation**
- **System monitoring and exception handling**
- **System administration (e.g., DBA activities)**
- **Call centre management**
- **Advertising campaign management (Young & Rubicam)**
- **New product development (SC Johnson Professional)**
- **Healthcare claims (Empire Blue Cross Blue Shield)**
- **Order management (Microsoft)**
- **Business licensing (Clark County)**
- **Software process management**
- **Scientific computation – grid computing**

Not just business processes !

What's New

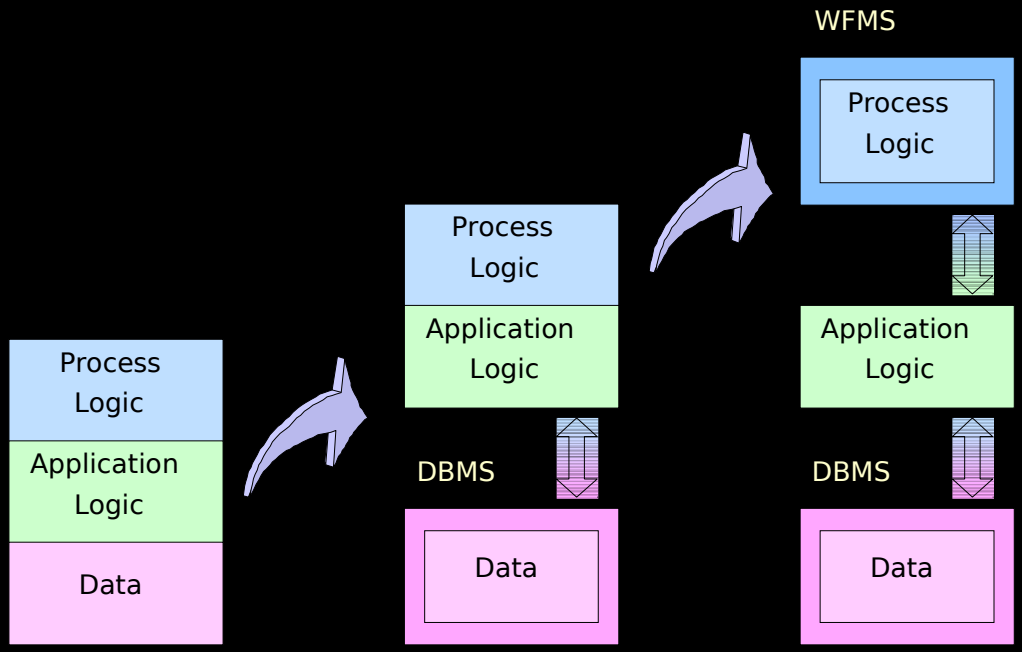
- **Flow of work (workflow) already exists in most business processes … nothing new**
- **Integration of the critical factors of an enterprise: people, infrastructure, processes ... already recognized**
- **Binding the "Islands of Automation" … next logical step after advances in computing power, connectivity and global shift towards integrated solutions**

What's New

- **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**



Some Informal Definitions

- **". . . (workflow) works hand in glove with business process improvements to automate, trace, and control processes and enable collaboration in the workplace."**

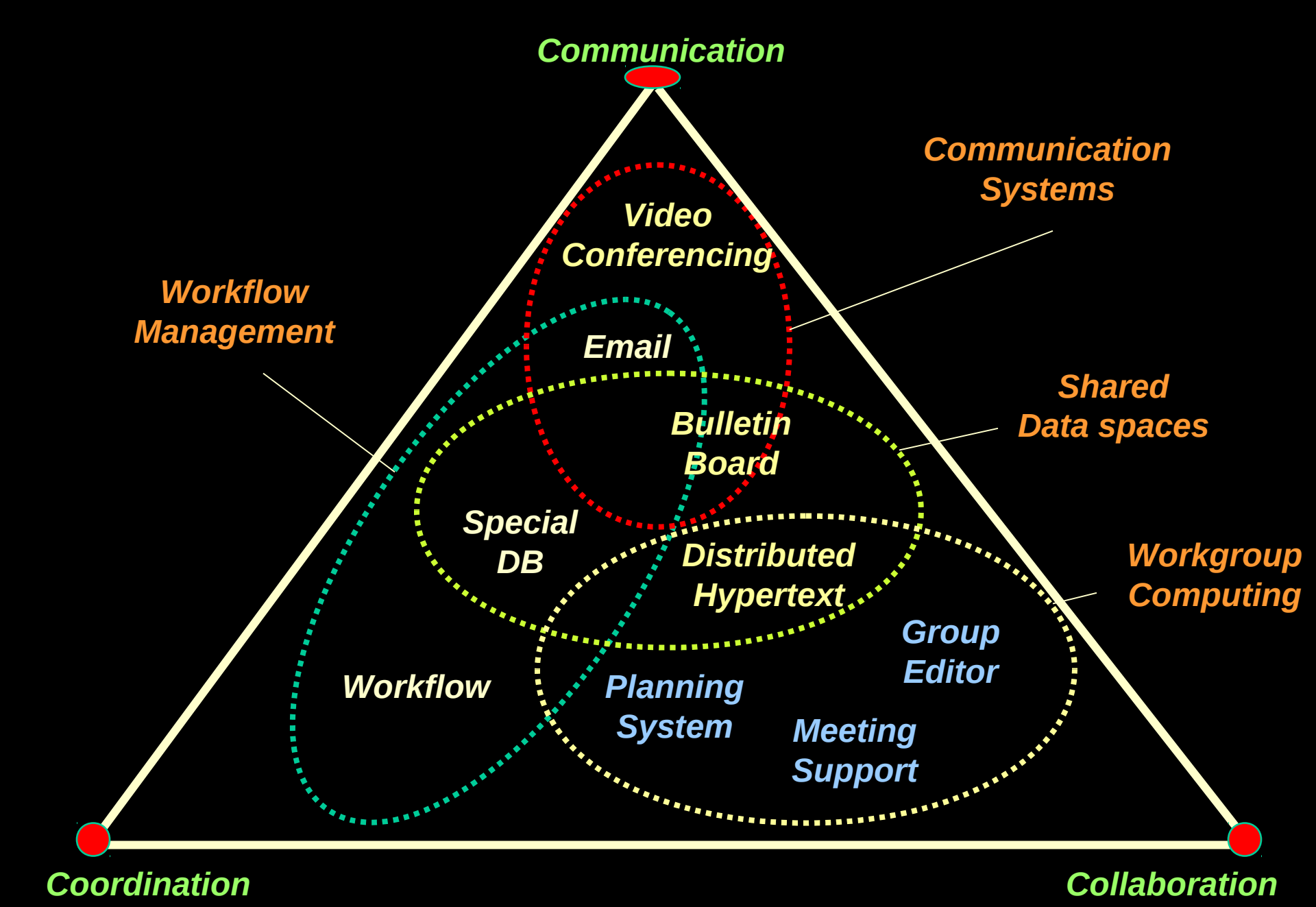
- **"We call the operational aspects of a business process - the sequence of tasks and who performs the tasks, the information flow to support the tasks, and the tracking and reporting mechanisms that measure and control them - the workflow."**

Some Informal Definitions

- **“Workflow software is designed to improve business processes by providing the technology enabler for automating these aspects of the workflow: routing work in the proper sequence, providing access to the data and documents required by the individual work performers, and tracking all aspects of the process execution.”**

- **“The main purpose of a workflow tool is to allow the process logic to be modified separately from the task logic embedded in the user applications.”**

(BIS Strategic Decisions)


Communication
Communication Systems
Video Conferencing
Workflow Management
Email
Shared Data spaces
Bulletin Board
Special DB
Distributed Hypertext
Workgroup Computing
Group Editor
Workflow
Planning System
Meeting Support
Coordination
Collaboration

Workflow Classification

- ***Ad-hoc*** **workflows do not have a well-defined process model to follow. The execution path is more or less determined at runtime, and is basically controlled by humans. These are generally not mission critical, and accomplish the flow of information among people within the organization.**

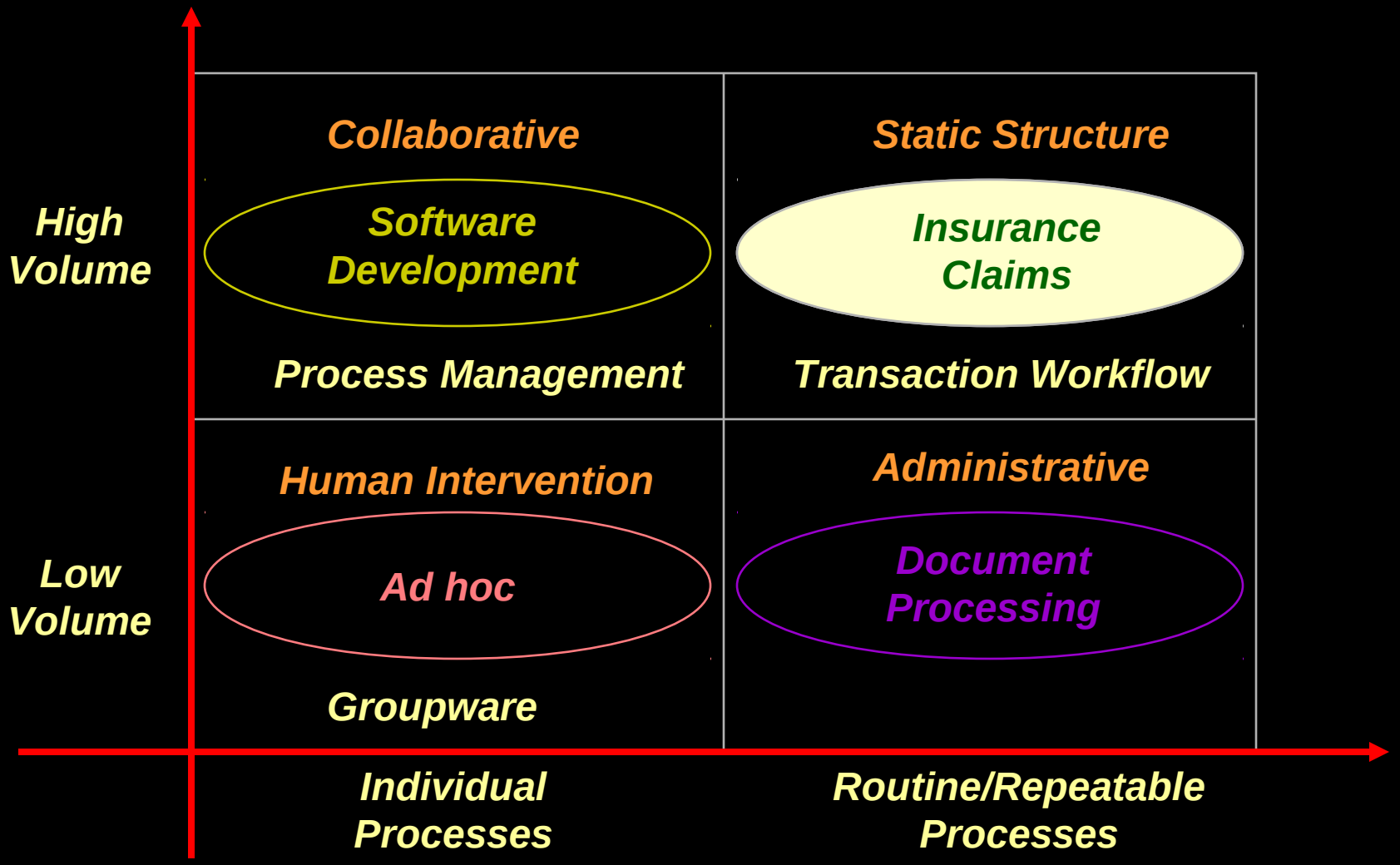
- ***Production*** **workflows are also predictable and repetitive. They have well defined process models. These usually involve a number of information systems that may be heterogeneous and distributed. Production workflow management systems are thus, more complex and critical than ad-hoc or administrative.**

Workflow Classification

- ***Administrative*** **workflows are based on simple, repetitive and predictable processes. The ordering and coordination of tasks can thus be automated. However, these too, like ad-hoc workflows, do not involve complex information processing systems, and are generally not mission critical.**

- ***Collaborative*** **workflows are characterized by high mission criticality. They are mostly controlled by humans, and lack a well-defined process model. Thus most of the task ordering and coordination is determined at runtime by the workflow participants.**

Workflow Application Segments



Technology Aspects

WFMSs incorporate many technologies

- **Database management**
- **Client server computing**
- **Heterogeneous distributed computing**
- **Mobile computing**
- **Graphical user interfaces**
- **App (legacy and new) and subsystem integration**
- **Messaging**
- **Document management**

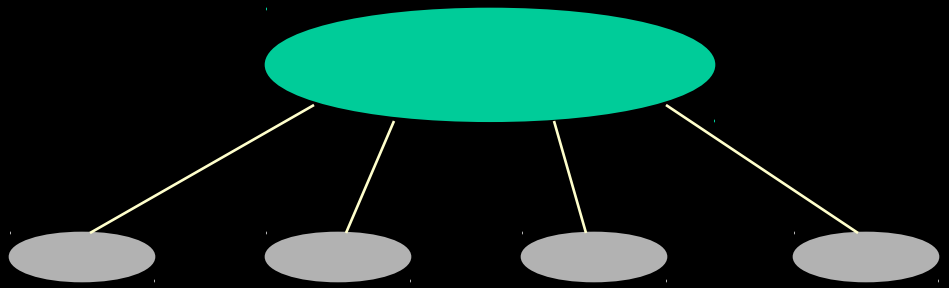
Technology Aspects

- **Several issues arise**
- **Reliability**
- **Scalability**
  - **(# of clients,**
  - **# of processess,**
  - **# of instances, . . .**
- **Cultural and human aspects**

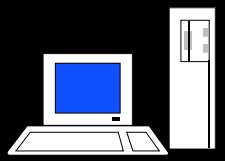
Three Dimensions of Workflow

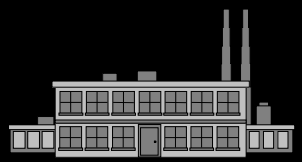
Process

Organisation



Infrastructure





Challenges

- **Consider collaboration between heterogeneous systems at the process level**
- **Provide better monitoring functions and tools to oversee many different views on the process**
- **Provide a mechanism to support process modifications allowing for collaborative style of work**

Challenges

- **Finding novel applications for web based IS systems with business process semi-automation**

- **Coping with success factors**
  - **Reliability**
  - **Scalability (# of clients, # of processes, # of instances, . . .)**
  - **Cultural and human aspects**

Core BPM Functions

- **A clear separation of Process, Application, and Data aspects of enterprise systems with minimal overlap**
- **Status, instance, and context management are an intrinsic part of overall process management architecture**
- **Process Modeling is an integral and essential part of systems development and deployment lifecycle**
- **Business processes are primarily captured through modeling and business logic is primarily implemented through coding of application components.**

Core BPM Functions

- **Application components have minimal direct awareness of one another and also have minimal direct awareness of "where and how" they are being utilized in BPM layer**

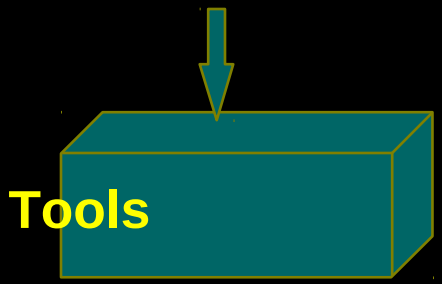
- **BPM takes the primary responsibility to achieve business objectives through configuration, coordination, collaboration, and integration of application components**

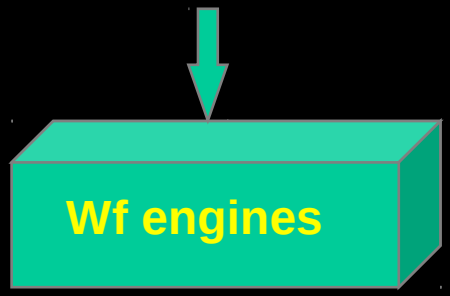
- **Similar BPM principles are applied in achieving intra-application, application to application, system to system, as well as business to business integration**

Workflow Management Issues

- Design
- Specification
- Correctness
- Verification

- Transactionable Workflows
- Scheduling
- Execution
- Monitoring





Terminology

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

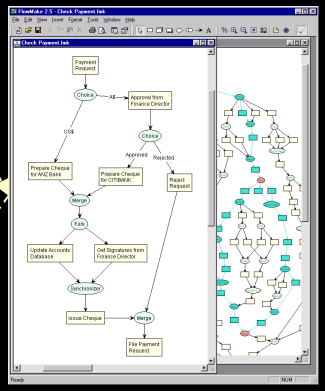
Source: Workflow Management Coalition (1999) Terminology and Glossary.

Workflow Model

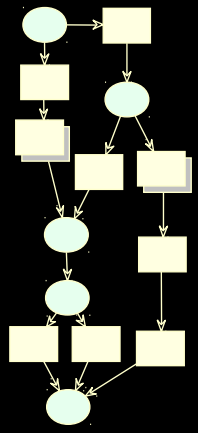
- **A business process model is a description of an organization's activities in terms of tasks, agents, rules and procedures and is engineered to fulfill a business goal**
- **A workflow model is a mapping of the business process into a form which supports automated manipulation**
  - **The workflow 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 Model

Business Process



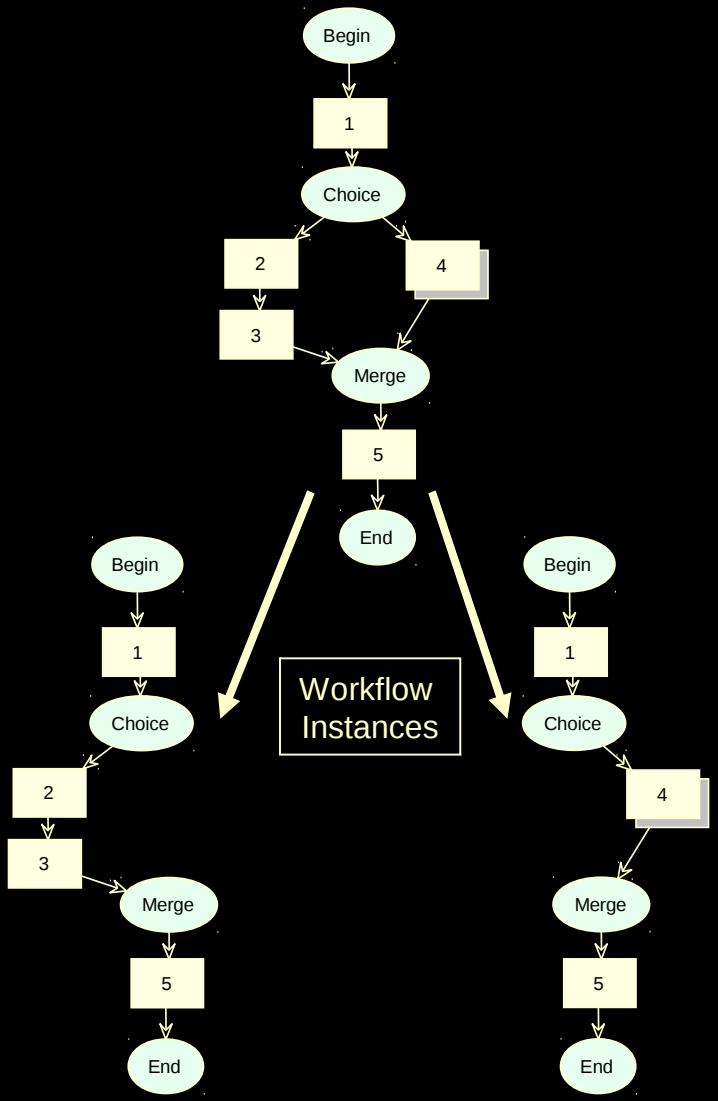
Workflow Modelling Tool



Workflow Model

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.**



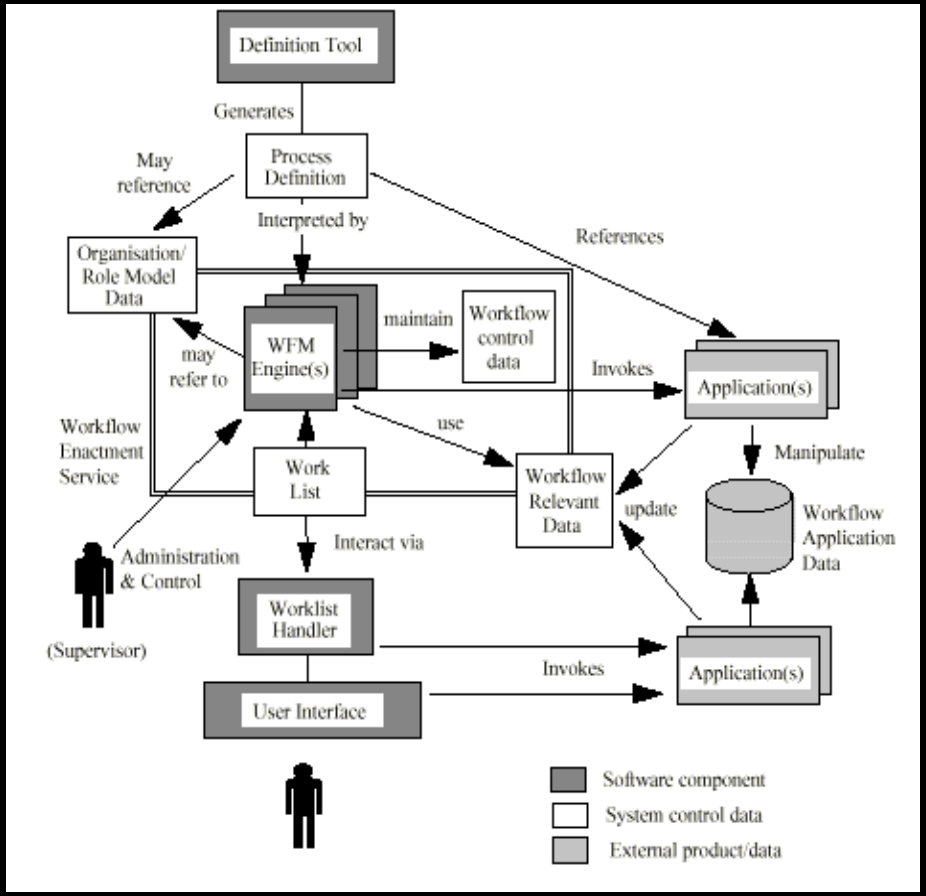
Workflow Execution

- **Workflow execution refers to**
  1. The creation of workflow instances
  2. The scheduling of workflow activities
  3. The invocation of workflow applications

- **Terms associated with workflow execution**
  - **Workflow Management System**
  - **Workflow Engine**
  - **Workflow Scheduler**
  - **Workflow Enactment Service**

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.

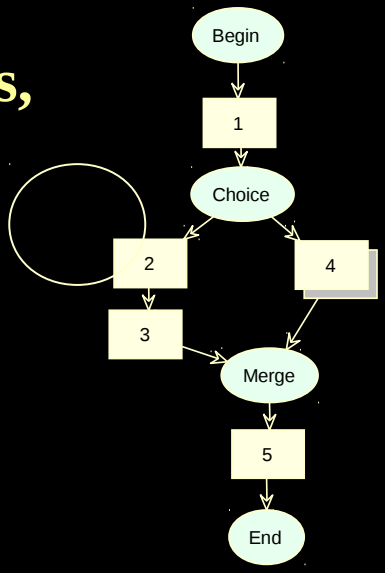


Workflow Management Data

- **Process Definition**
- **Workflow Control Data**
- **Workflow Relevant Data**
- **Workflow Application Data**
- **Organizational Data**

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**

Processing Entity

User

Client

Agent

Actor

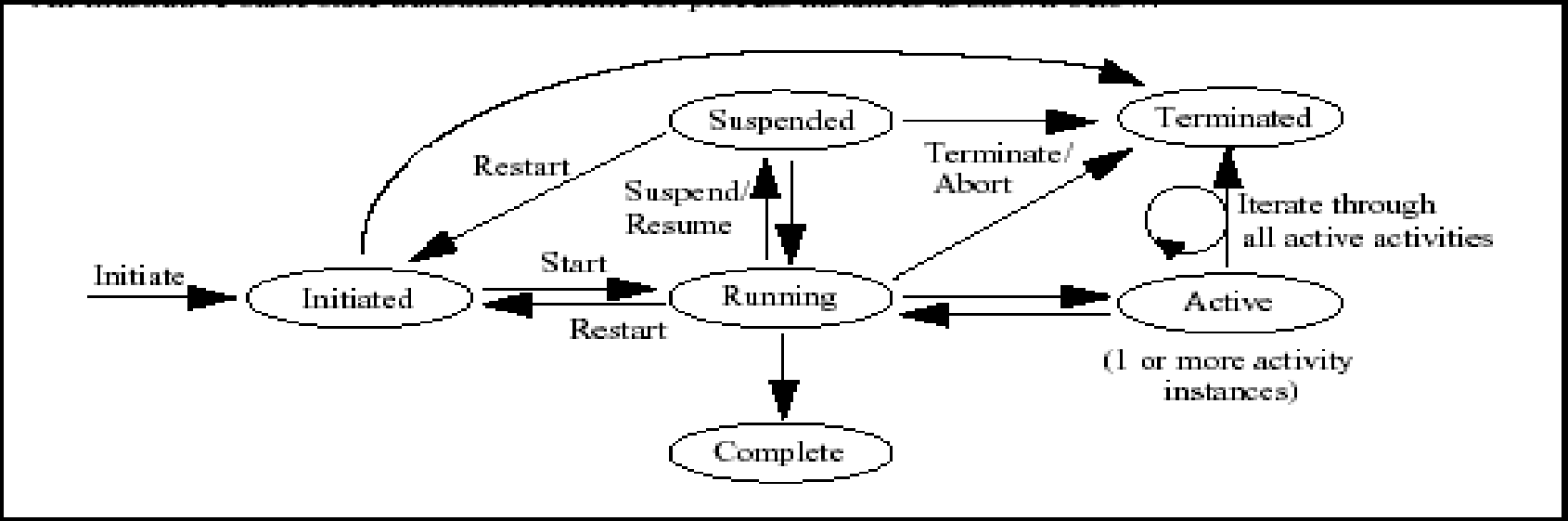
Performer

Activity Work Item

- **The representation of the work to be processed by an activity within a workflow instance.**
  - **Once initiated within an instance, an activity becomes a work item**
  - **Activity and work item are representations of the same unit of work but at build and run time respectively**
  - **An activity may generate one or more work items which together represent the work to be undertaken**
- **Related terms:**
  - **Work list**
  - **Work list Handler**

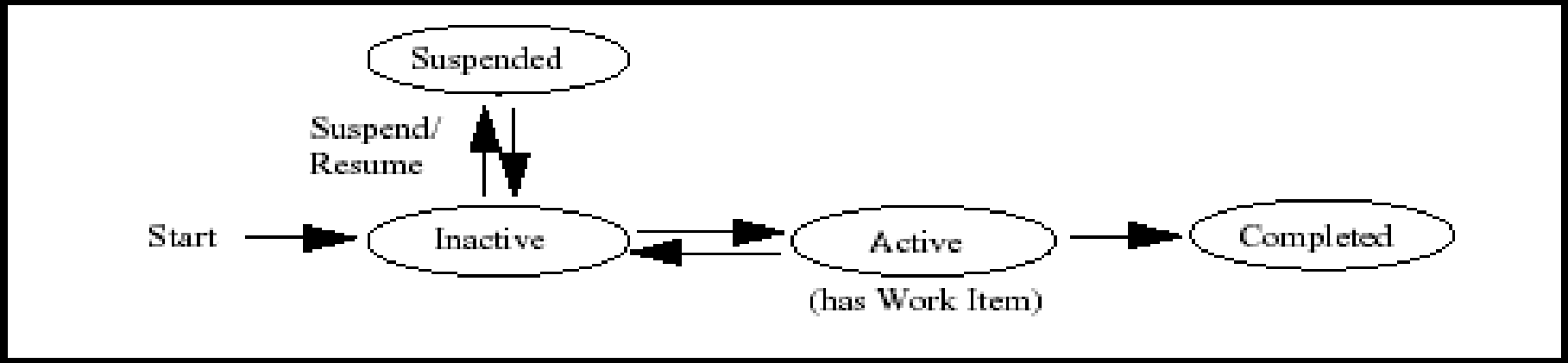
Workflow State

- **A representation of the internal conditions defining the status of a process instance at a particular point in time**
- **WFMS maintains this status as part of the workflow control data**



Activity State

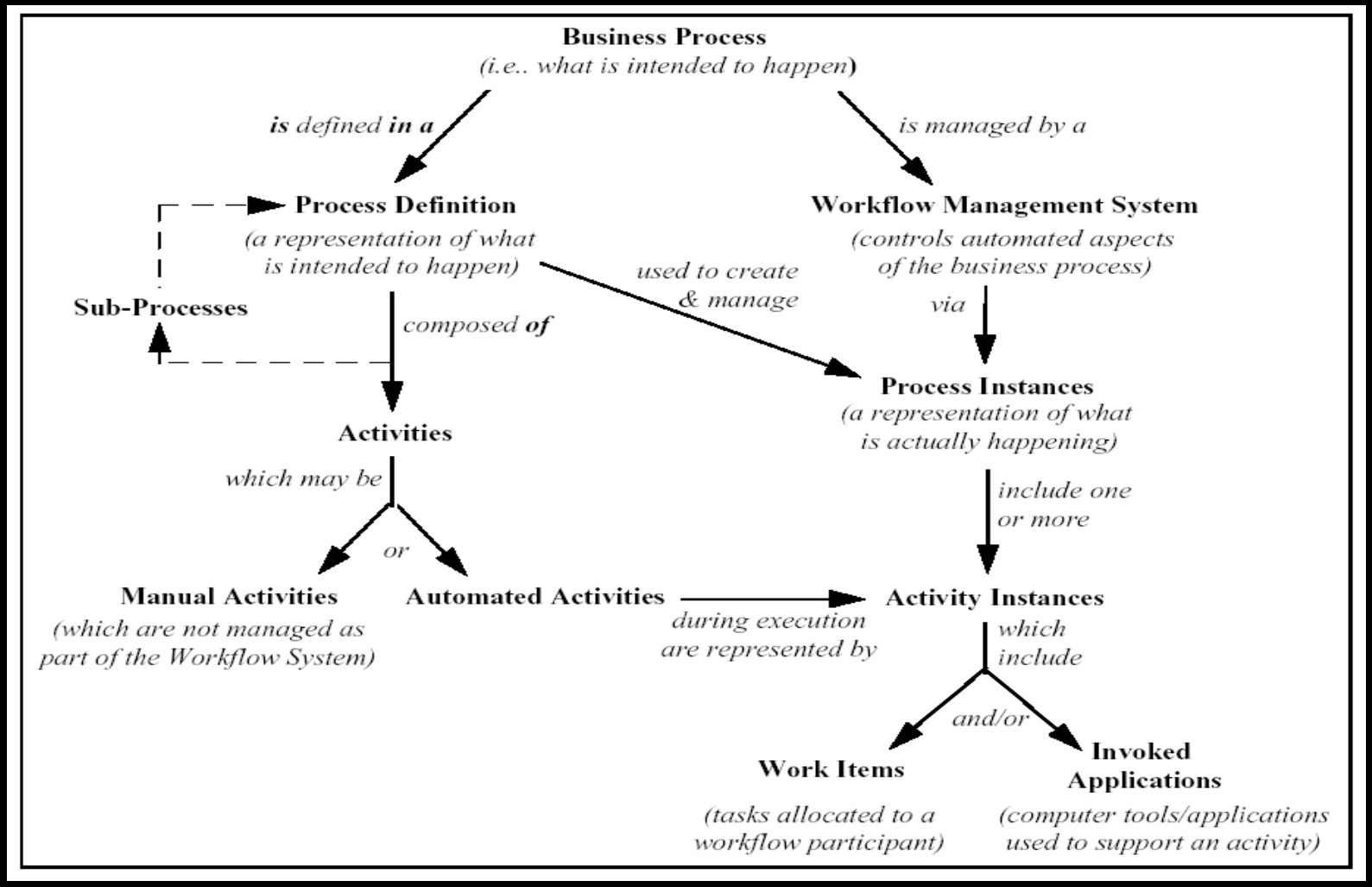
- **A representation of the internal conditions defining the status of an activity instance at a particular point in time**
- **Also maintained by WFMS as part of the workflow control data**



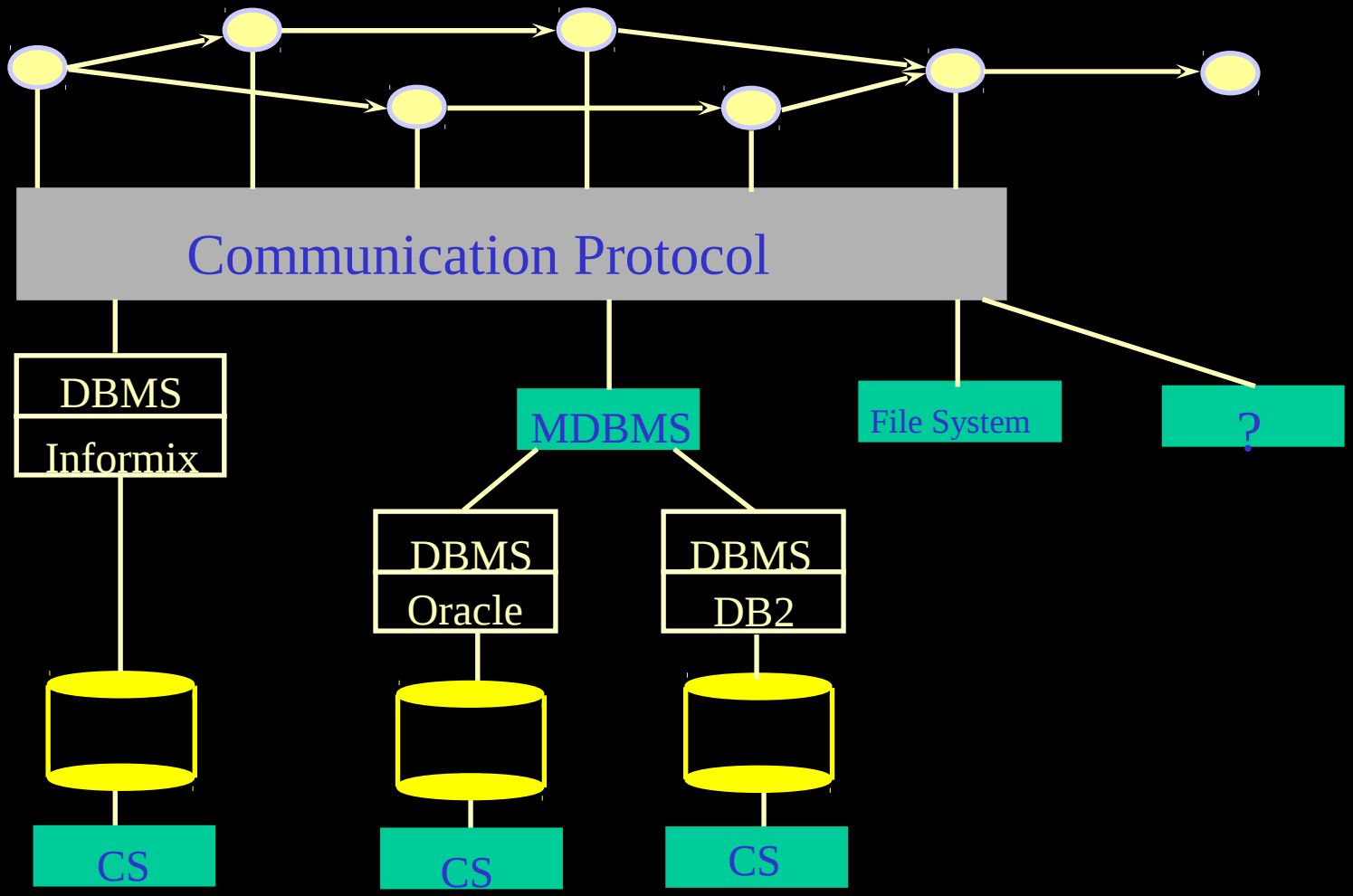
State Transition

- **A movement from one internal state (of a process or activity instance) to another within a workflow, reflecting a change in the status of the workflow**
- **A state transition may be in response to an external event, a user call, a routing decision, …**
- **State transitions are recorded in the workflow logs and represent data useful for audit, archiving & process improvement**

Relationships between Terms



Workflows Management Systems

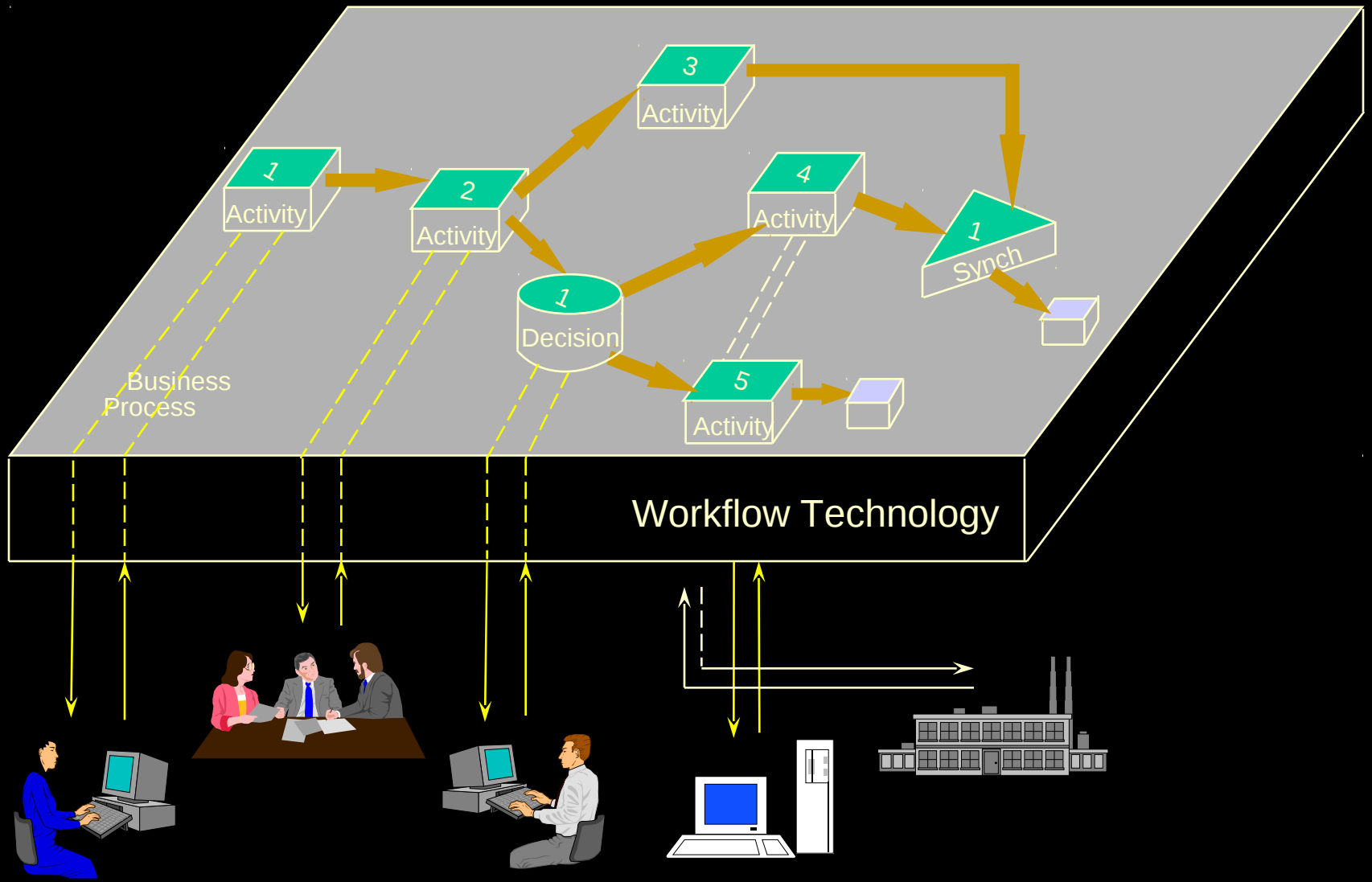


What did we gain?

With the introduction of WfMS a facility came up that allows for both:

- **Composing large distributed application systems out of smaller pieces which can be developed independently,**

- **Supporting real world business process concurrently performed by many different users exploiting various tools in a network,**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Business
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Workflow Technology

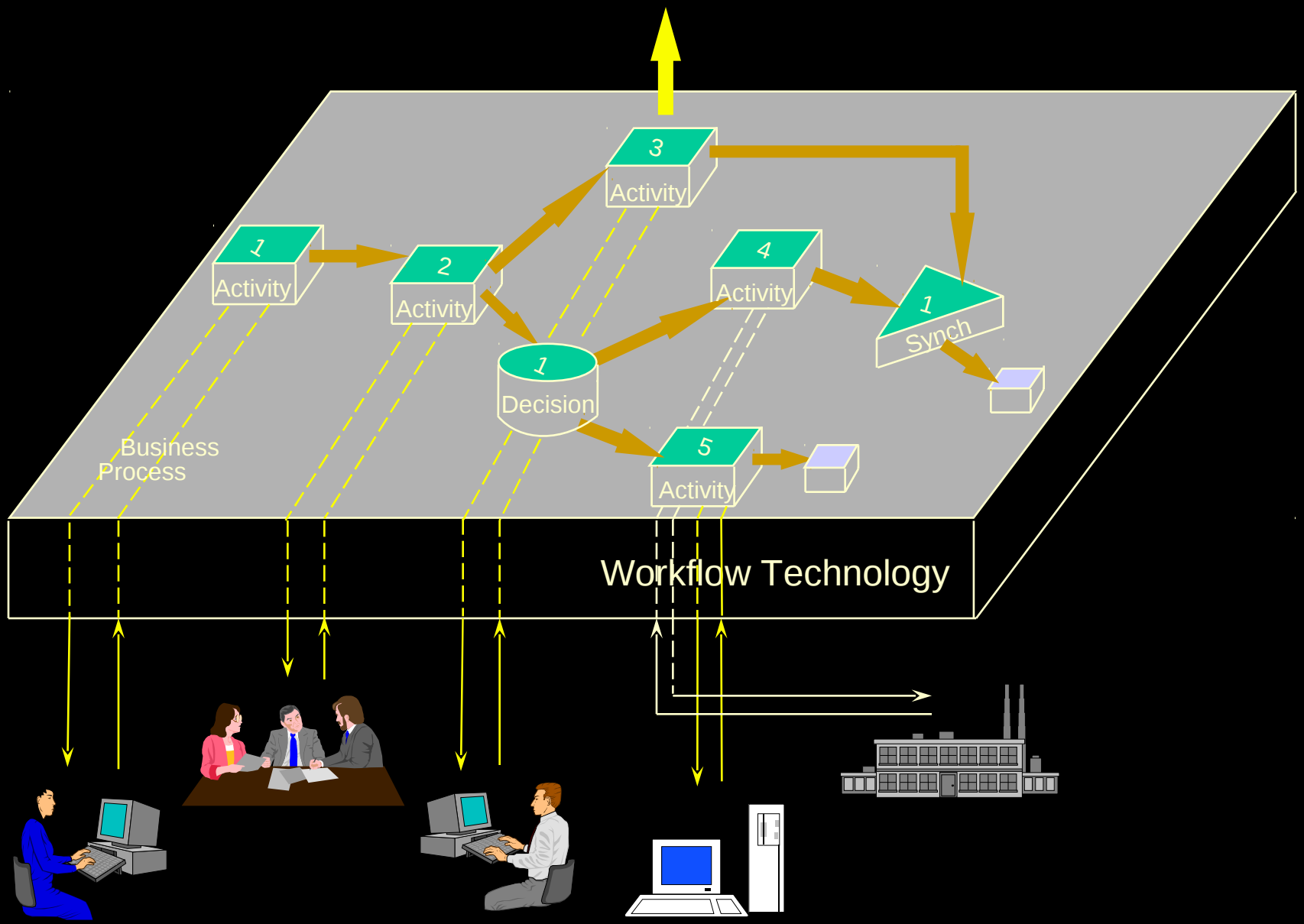
Technical Challenges

A flexible transaction concept is required to be added to the workflow management systems

- **Relaxation of ACID properties**
- **Modeling of transactionability in the presence of nesting**
- **Formalization of concepts**
- **Scheduling of transactionable business processing**
- **Semantic transaction nodes with compensation**

Technical Challenges

- **Provide a mechanism to support process modifications allowing for collaborative style of work,**
- **Consider collaboration between workflow heterogeneous systems at the process level and WFMS level,**
- **Provide better monitoring functions and tools to over see many different views on the process,**
- **Consider a novel application for web based IS systems with business process semi-automation**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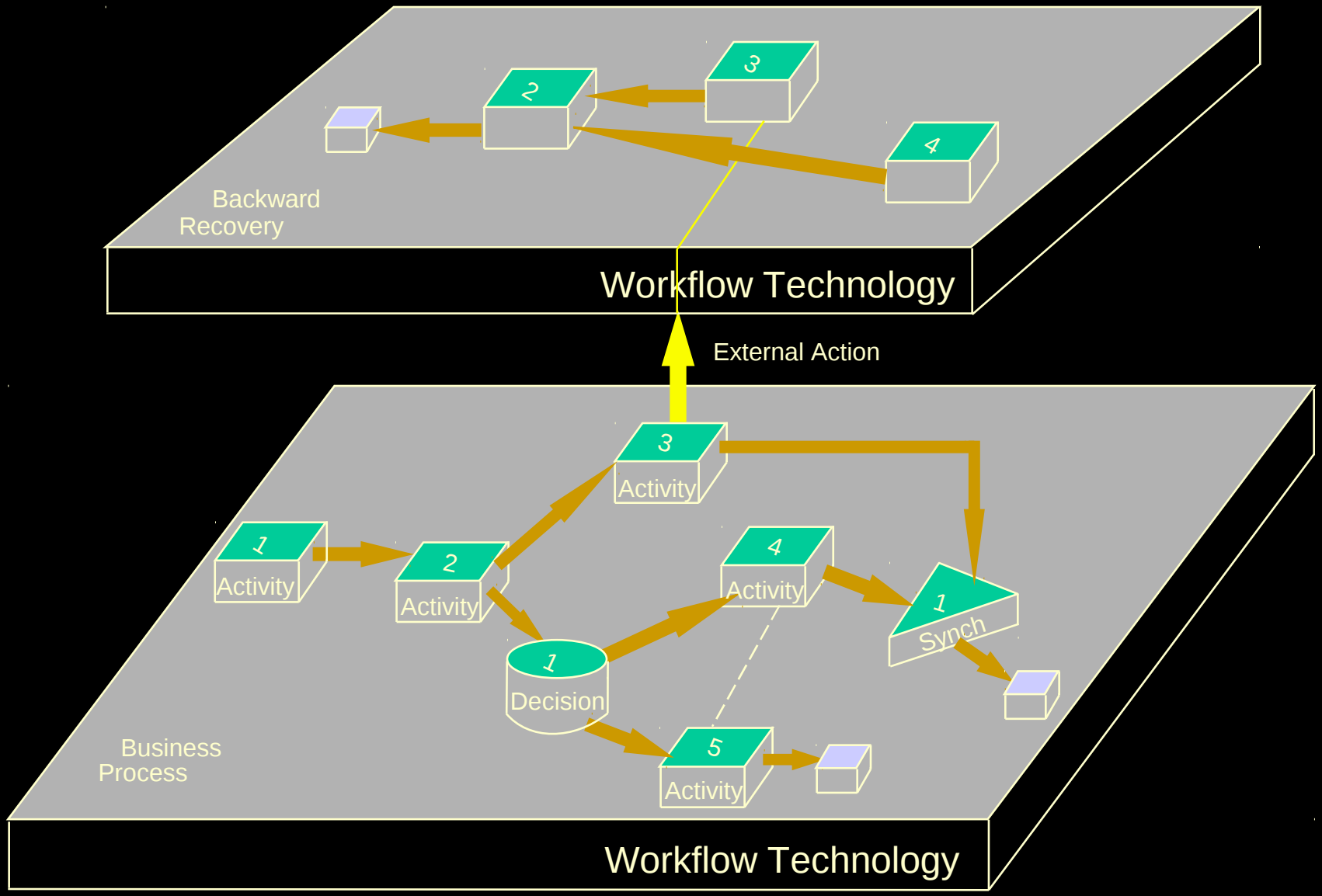
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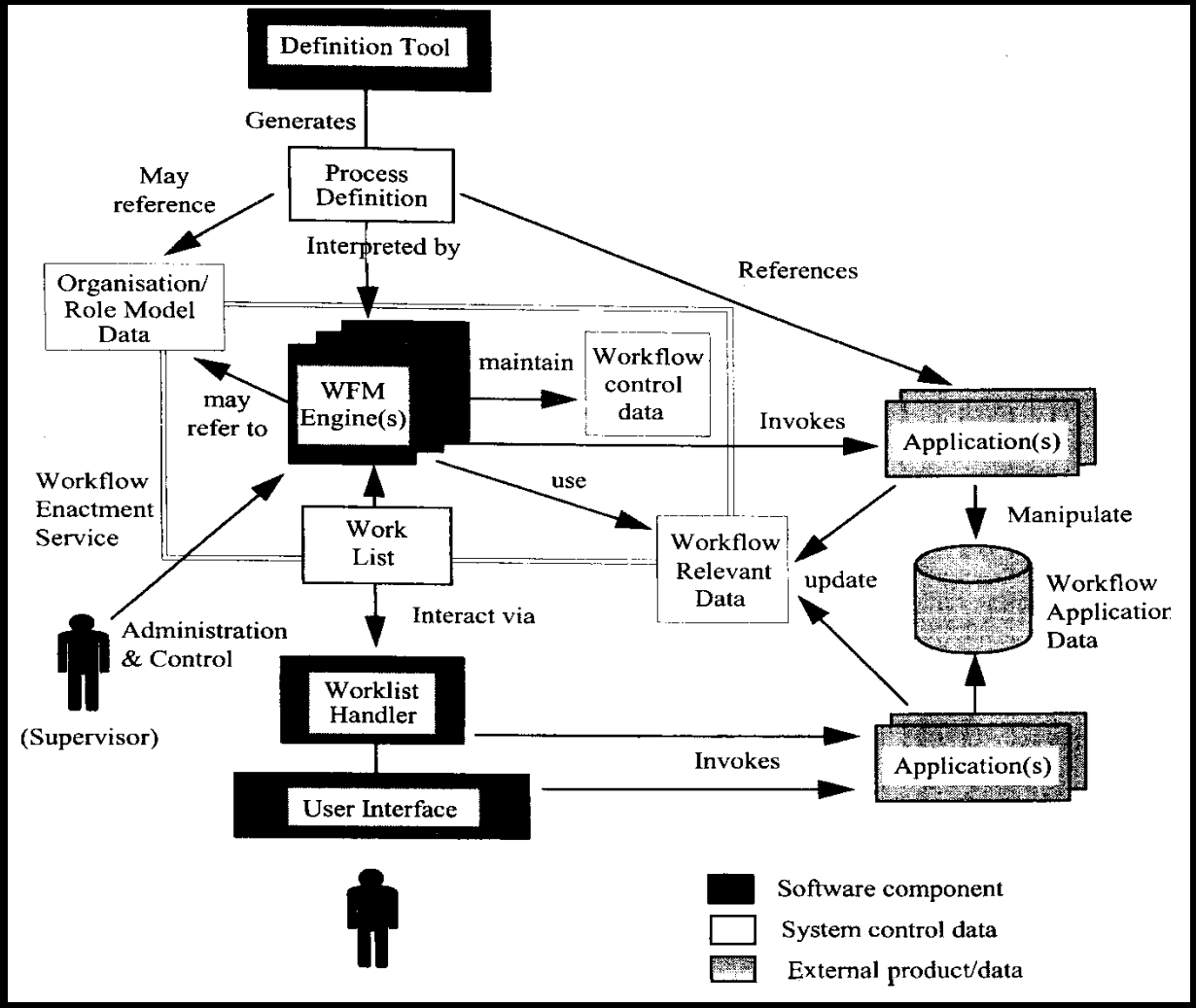
A summary of WF Technology Solutions

- **A new solutions for business process automation,**
- **Many products on the market in last few year,**
- **No all business processes suitable for WfMS,**
- **The recent change of the underlining concepts moving towards light weight solutions,**
- **Great prospects within B2B and all e-business solutions,**

WF Technology - architectural issues

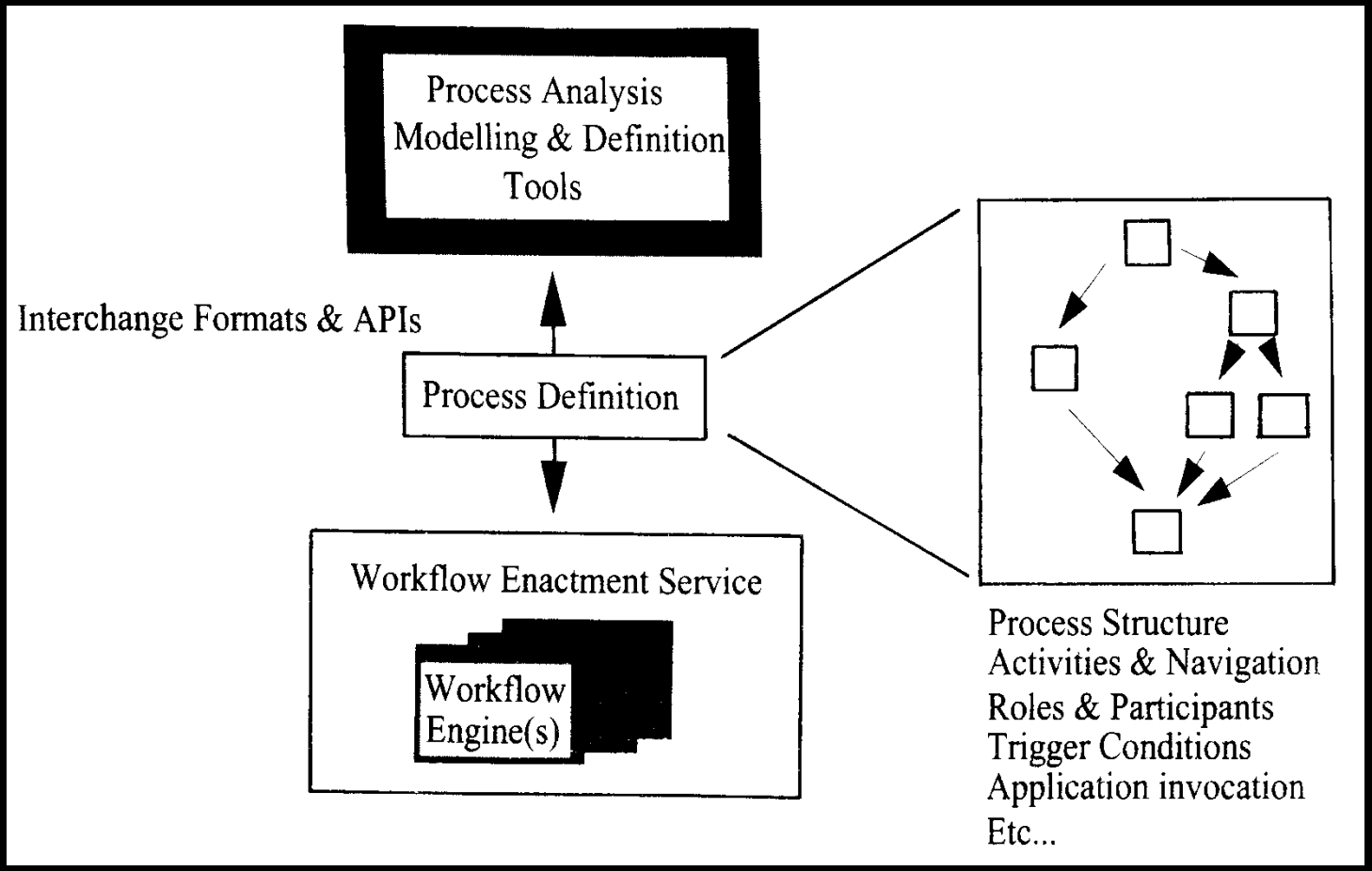
- **Generic product structure**
- **Process definition**
- **Process definition meta model**
- **Client applications**
- **Invoked applications**
- **Interoperability**
- **Administration and monitoring**

Generic Product Structure

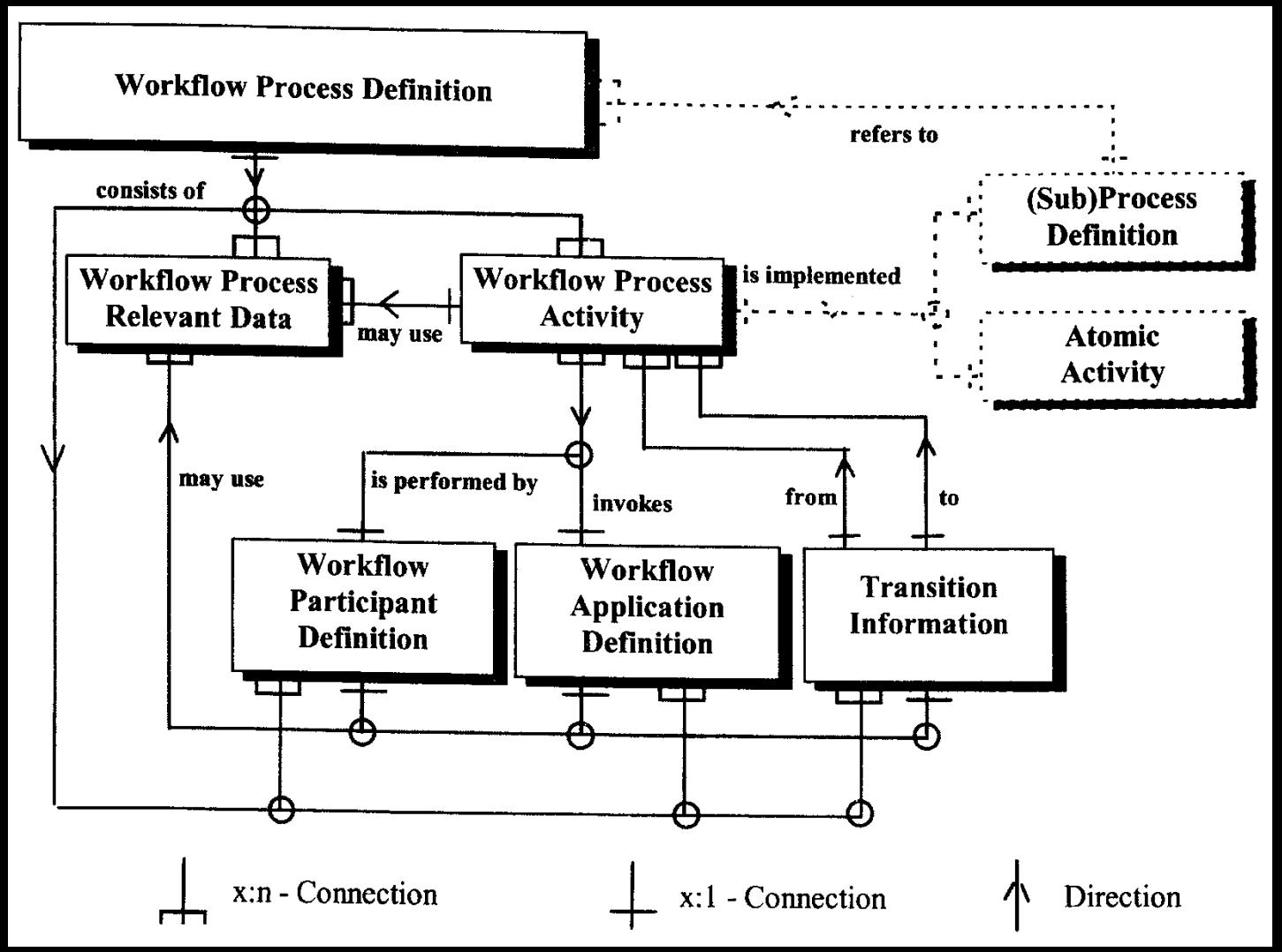


www.wfmc.org/standards/docs.htm

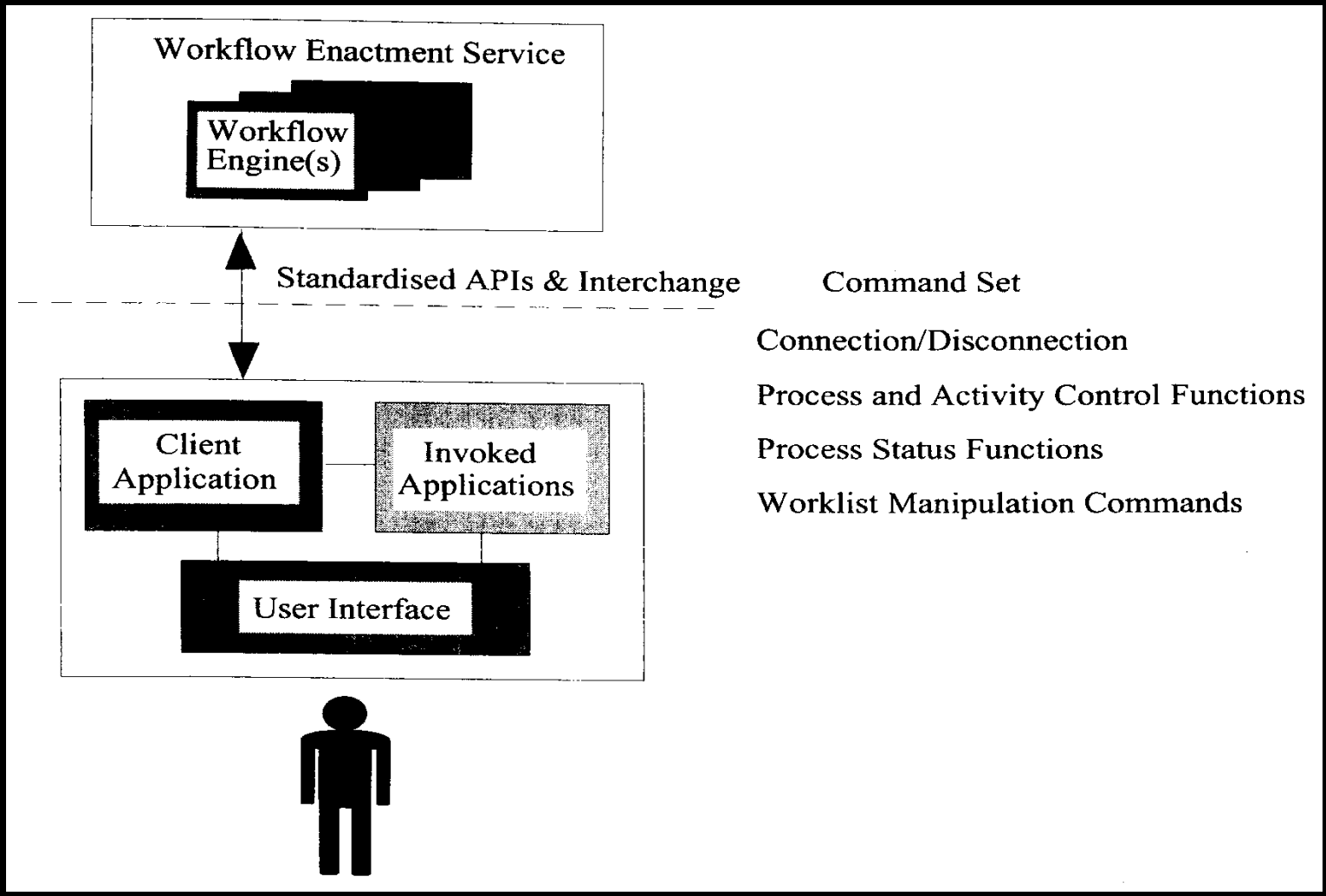
Process Definition



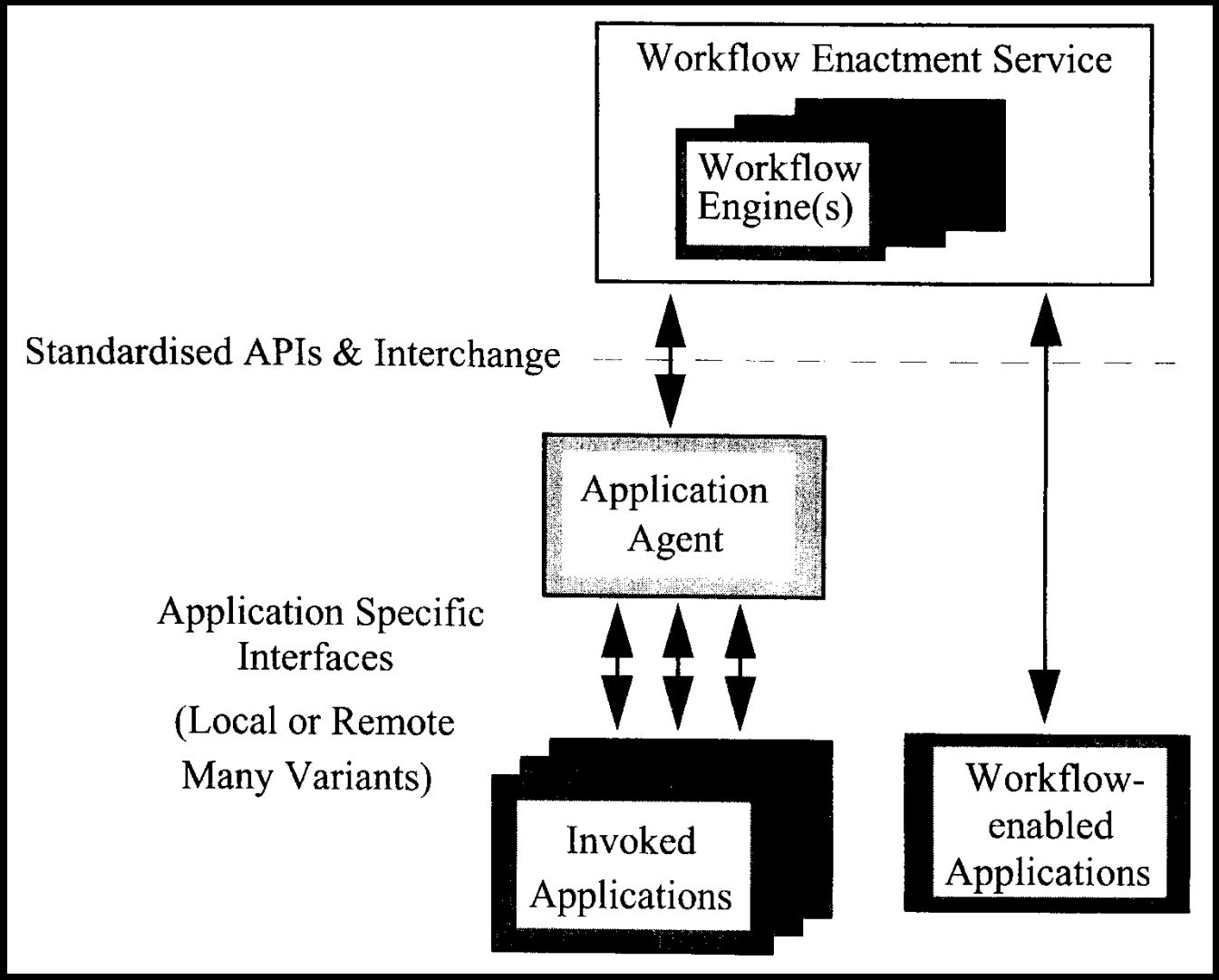
Process Definition Meta Model



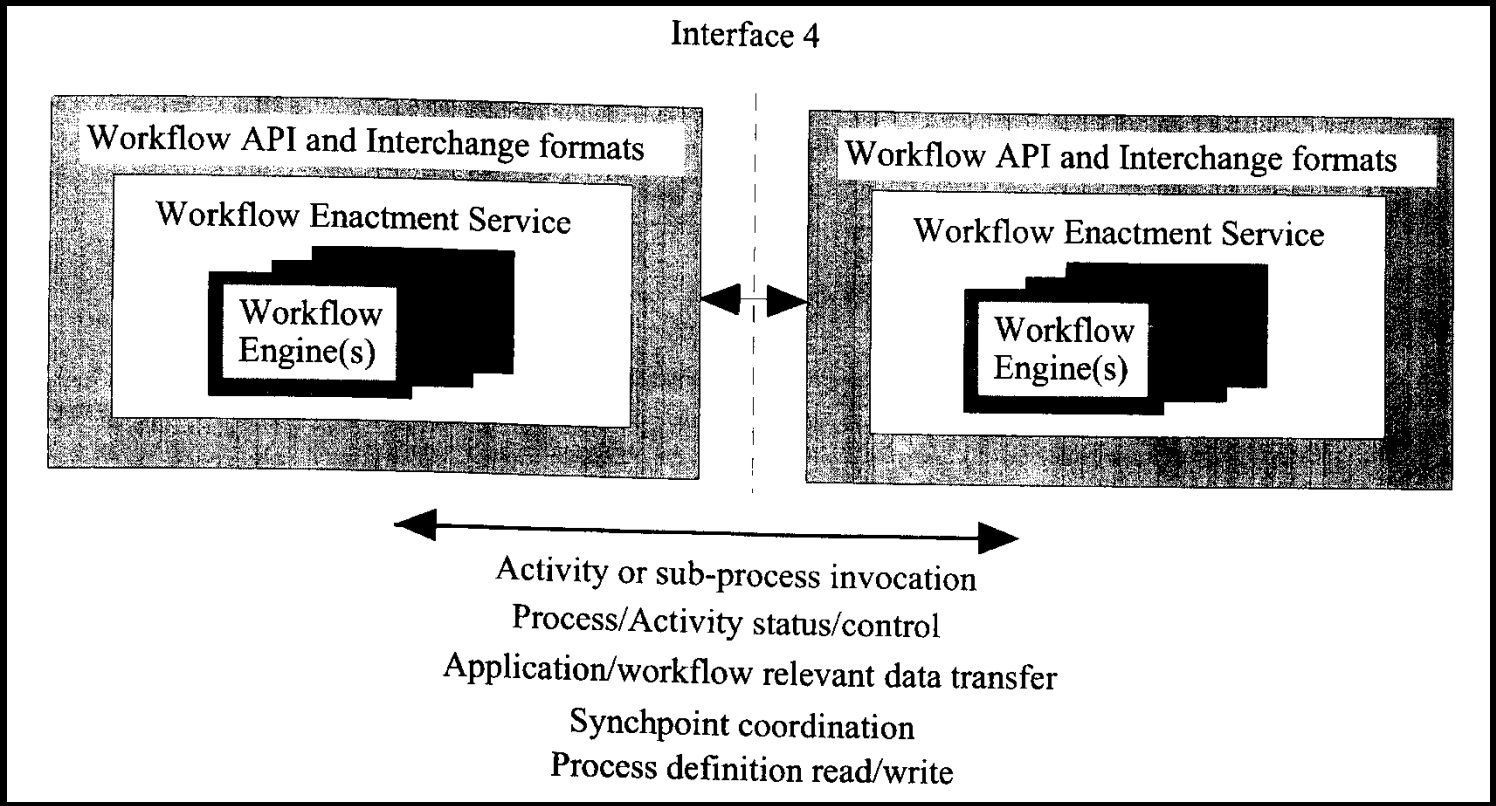
Client Applications



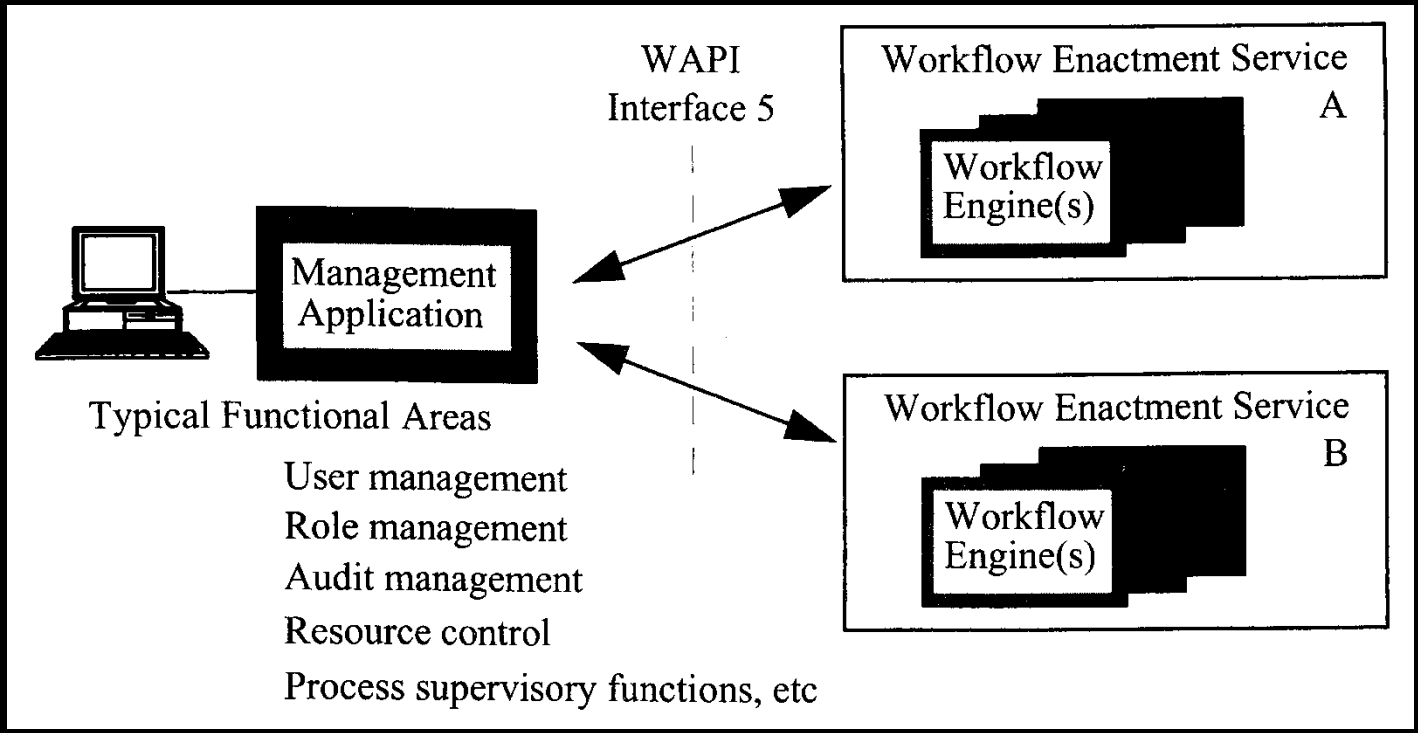
Invoked Applications



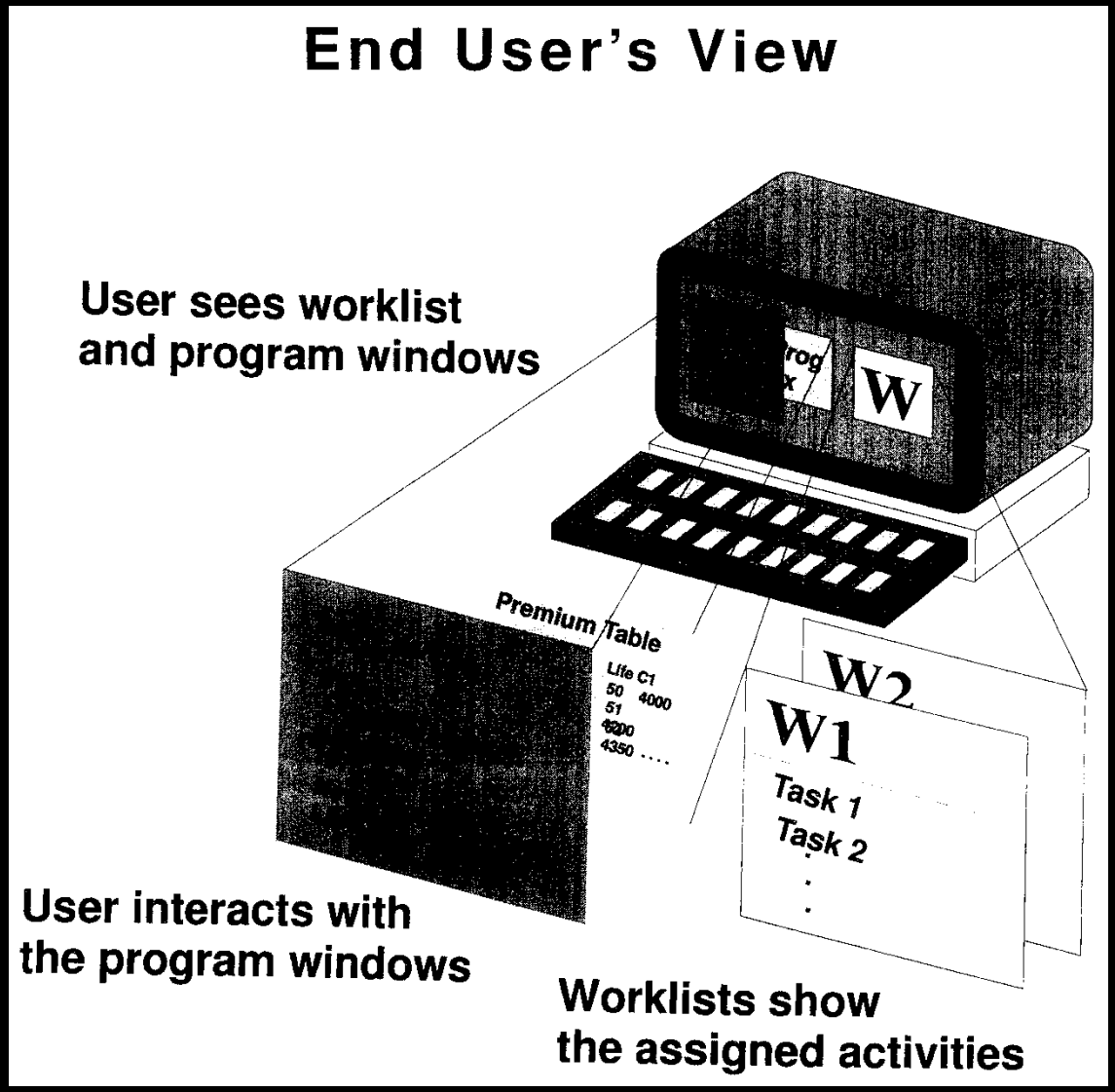
Interoperability



Process Execution



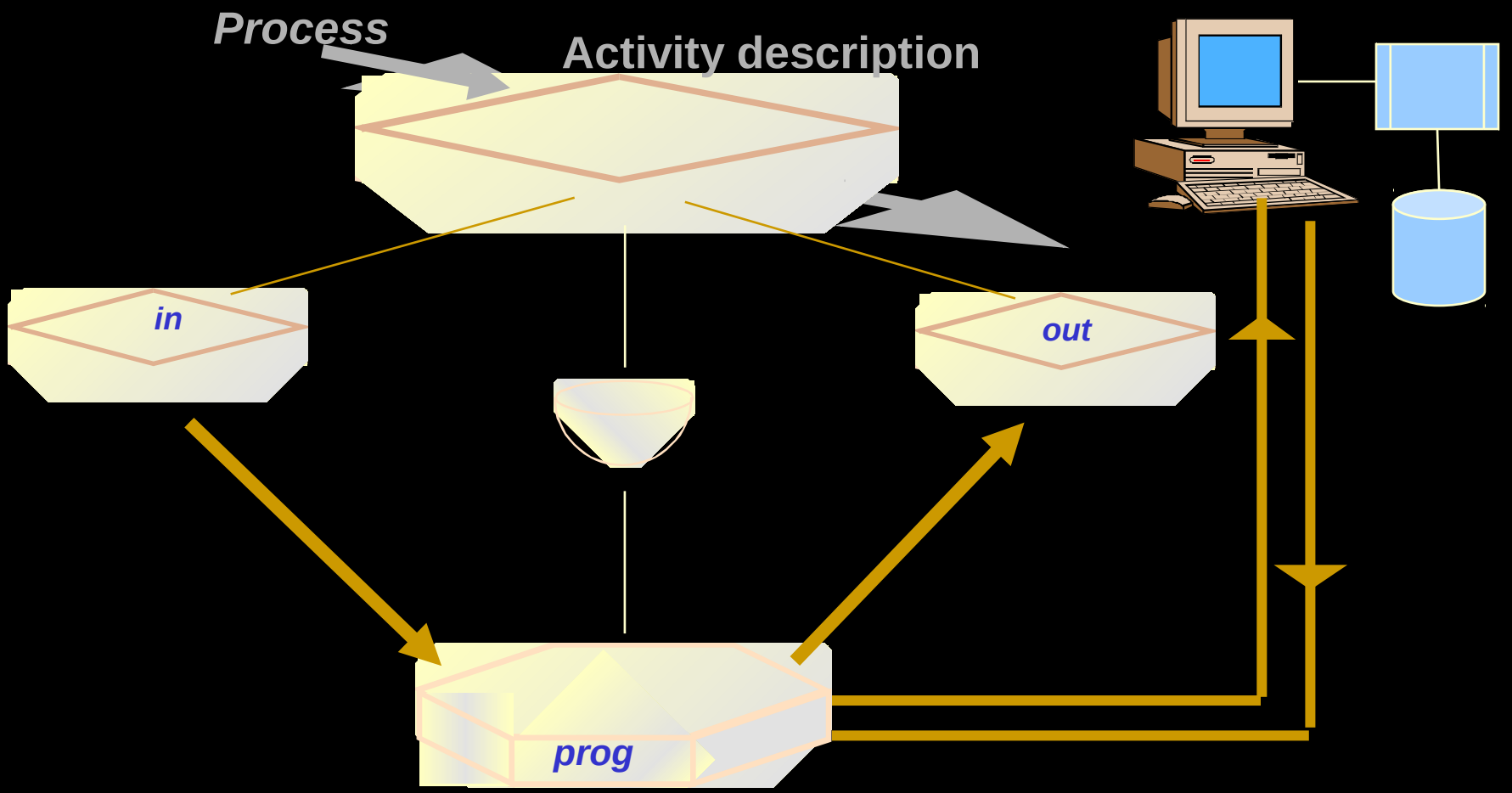
End User's View



Process Execution

- **User initiates instance**
- **The next activity (s) in the control flow is scheduled**
- **Activity appears on the work list of the designated workflow performer**
- **Performer starts the activity**
- **WFMS is notified on completion**
- **Completion of the activity triggers subsequent activity (s) in accordance with the control flow logic of the workflow model**

Activity Execution



Activity Execution

- **User starts activity,**
- **Activity describes program to be executed,**
- **Registered program is called,**
- **Program takes process relevant data from “in” and puts data into “out” data containers,**
- **Program communicates with user and processes the data**

Reading

- **Michael Hammer (1990) Reengineering Work: Don't Automate, Obliterate. Harvard Business Review, July August 1990. (Optional)**
- **Stefano Jablonski and Christoph Bussler Christoph (1996) Workflow Management – Modelling Concepts, Architecture and Implementation. Chapter 1.**
- **Dimitrios Georgakopoulos , Mark Hornick, Amit Sheth (1995) An Overview of Workflow Management: From Process Modelling to Workflow Automation Infrastructure**
- **Workflow Management Coalition (1999) Terminology and Glossary. Document No. WFMC-TC-1011, Feb 1999.**

Process Modeling 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

Elements of Process Design

Business mission, strategy, and goals

Business process

Information Systems

Presentation

Application logic

Data management

Source: Sharp and Mcdermott (2000)

Process Design Methodology

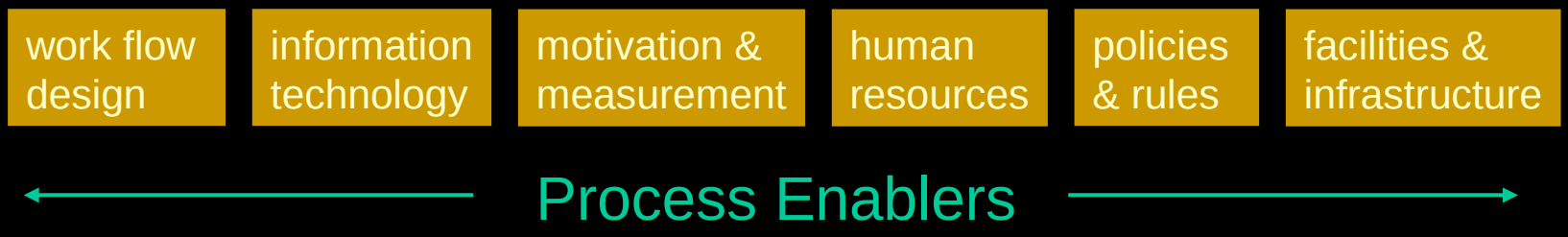
- **A methodology for process (re)design**
  - **Frame the process**
    includes identifying a business process, clarifying its boundaries, performing an initial assessment, and establishing goals for the redesigned process
  - **Understand the current (as-is) process**
    includes modelling its workflow, and performing a more specific assessment
  - **Design the new (to-be) process**
    includes devising potential improvements, assessing them, selecting the main characteristics of the process, and finally designing the new workflow
  - **Develop use-case scenarios**
    makes the transition into system requirements analysis by describing how process actors would interact with a system to complete tasks

Source: Sharp and Mcdermott (2000)

Process Enablers

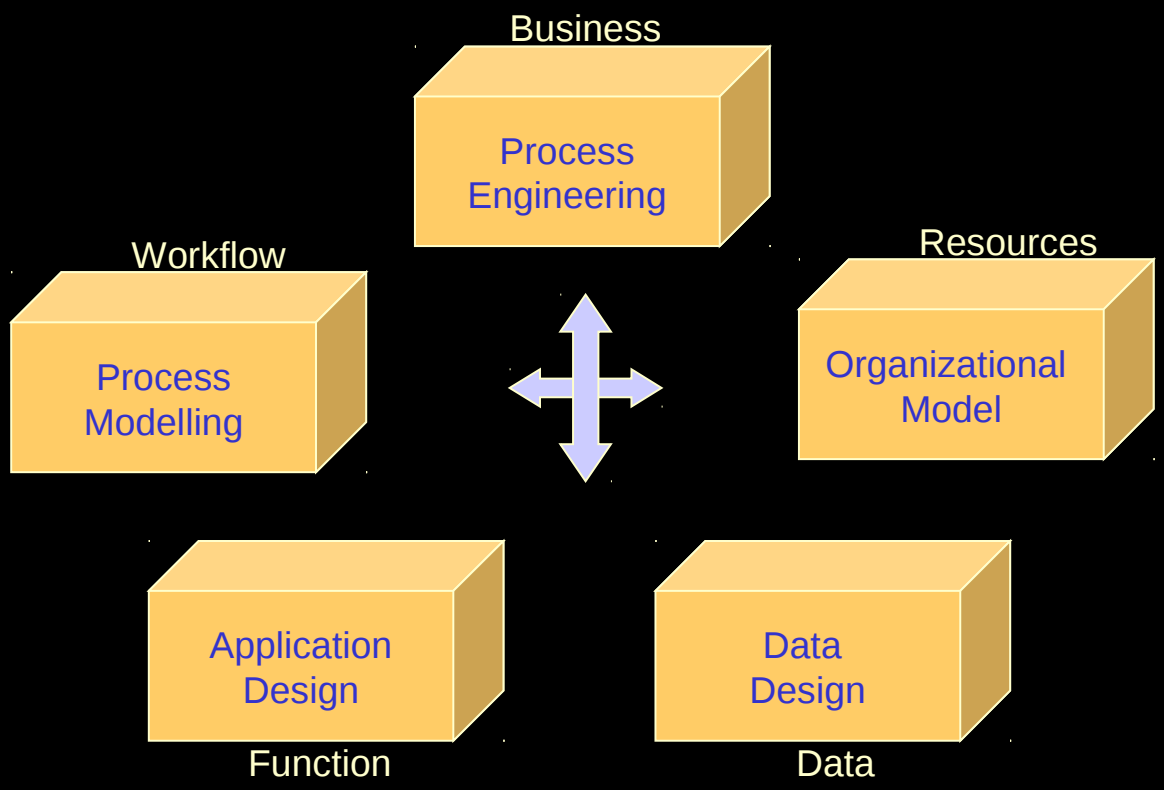
- **What are the factors that will help a process (design)**
  - **achieve intended results**
  - **meet performance targets**
  - **within application constraints**

Business Issues!



Source: Sharp and Mcdermott (2000)

Process Modelling Context



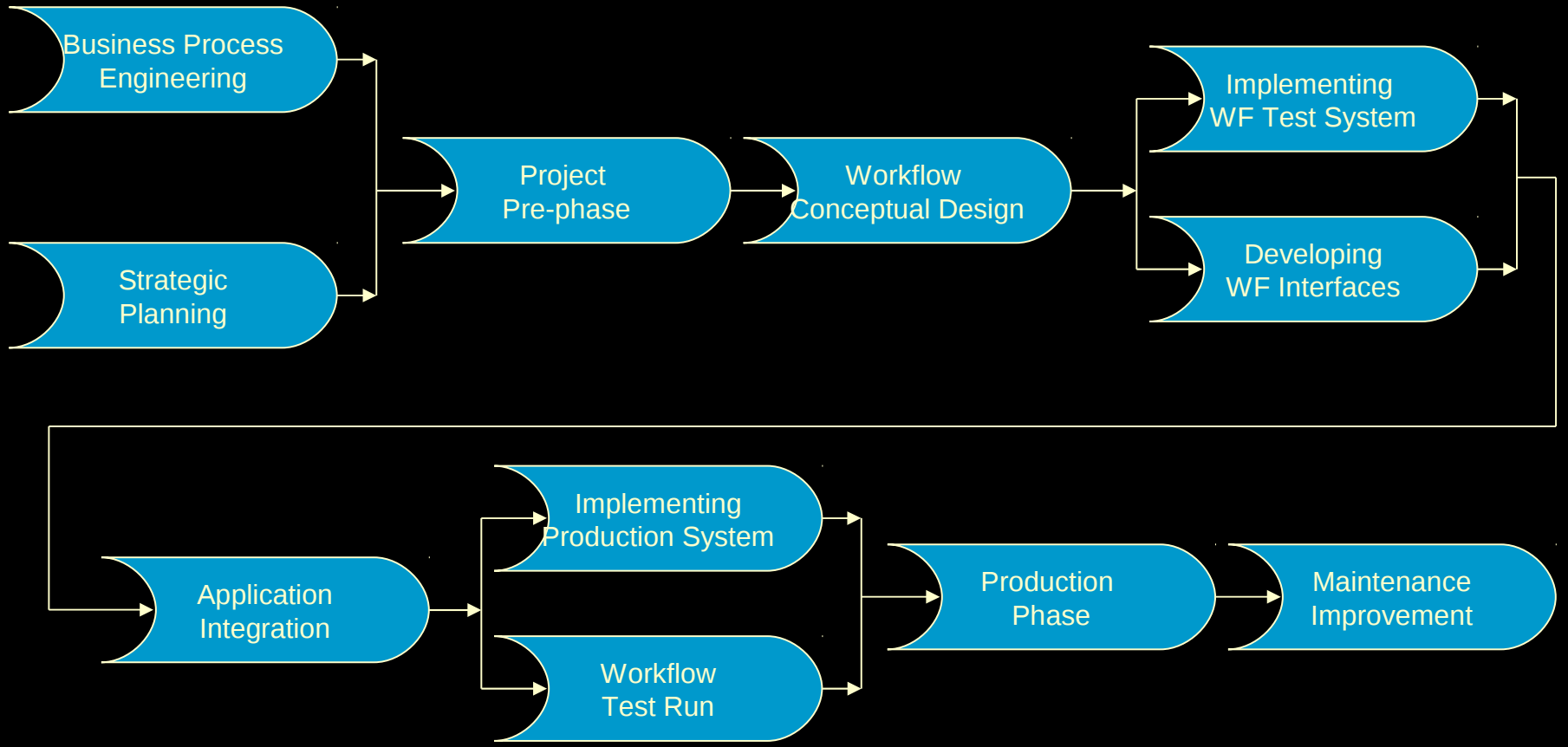
- **What is going to be done?**
- **Who is going to do it?**
- **How will it be done?**
- **Who is dependent on it being done?**
- **…?**

Source: Schal (1996)

Life of a Workflow Conception to Evolution

- Process (Re)engineering
- Workflow Modelling
  - Process modelling
  - Resource mapping
- Product Evaluation
  - Enabling technologies
  - Existing infrastructure
- WFMS configuration
  - Workflow interfaces
  - Application integration
- Workflow Definition
- Enactment
- Archiving and Monitoring
- Exception Handling
- Process Evolution

Workflow Implementation Process



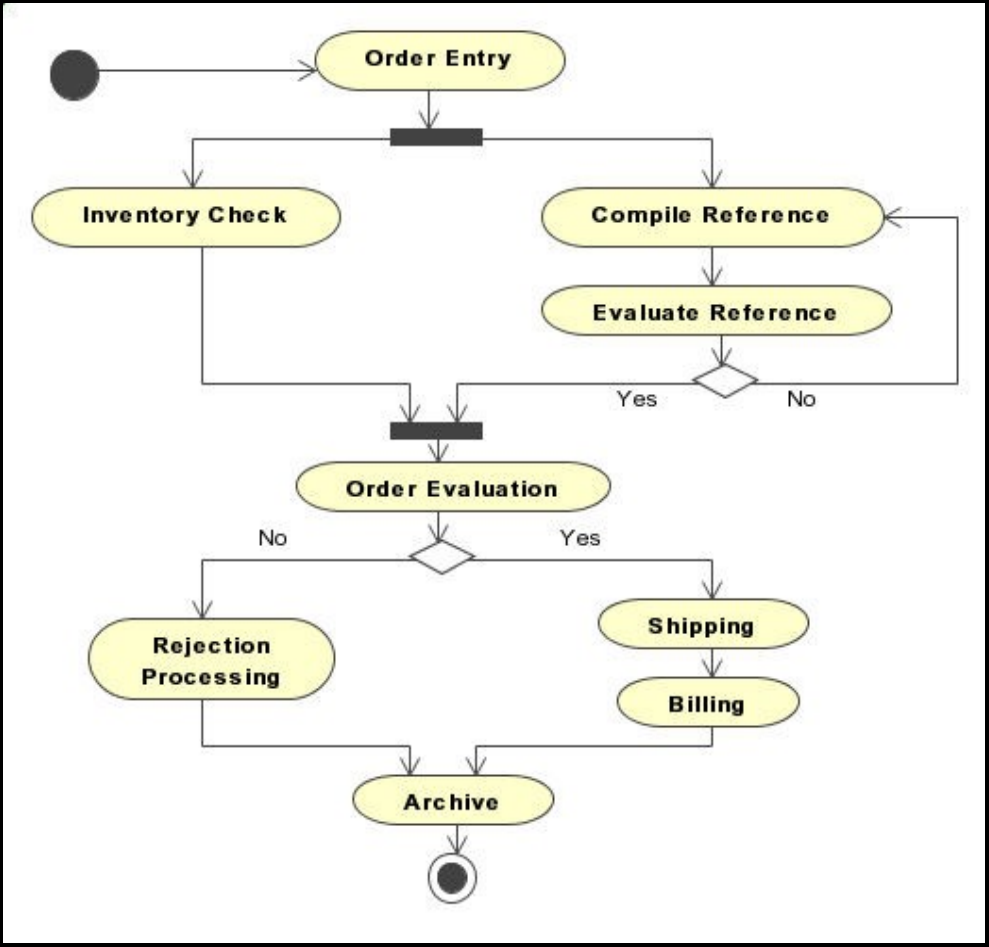
Source: Scheer, 2000

Process Modeling

- **Many languages invented within commercial and research communities**
  - **Communication based**
  - **Activity based**

- **Many interesting debates and results on expressability and verifiability**

Example



Source: Ellis (2001)

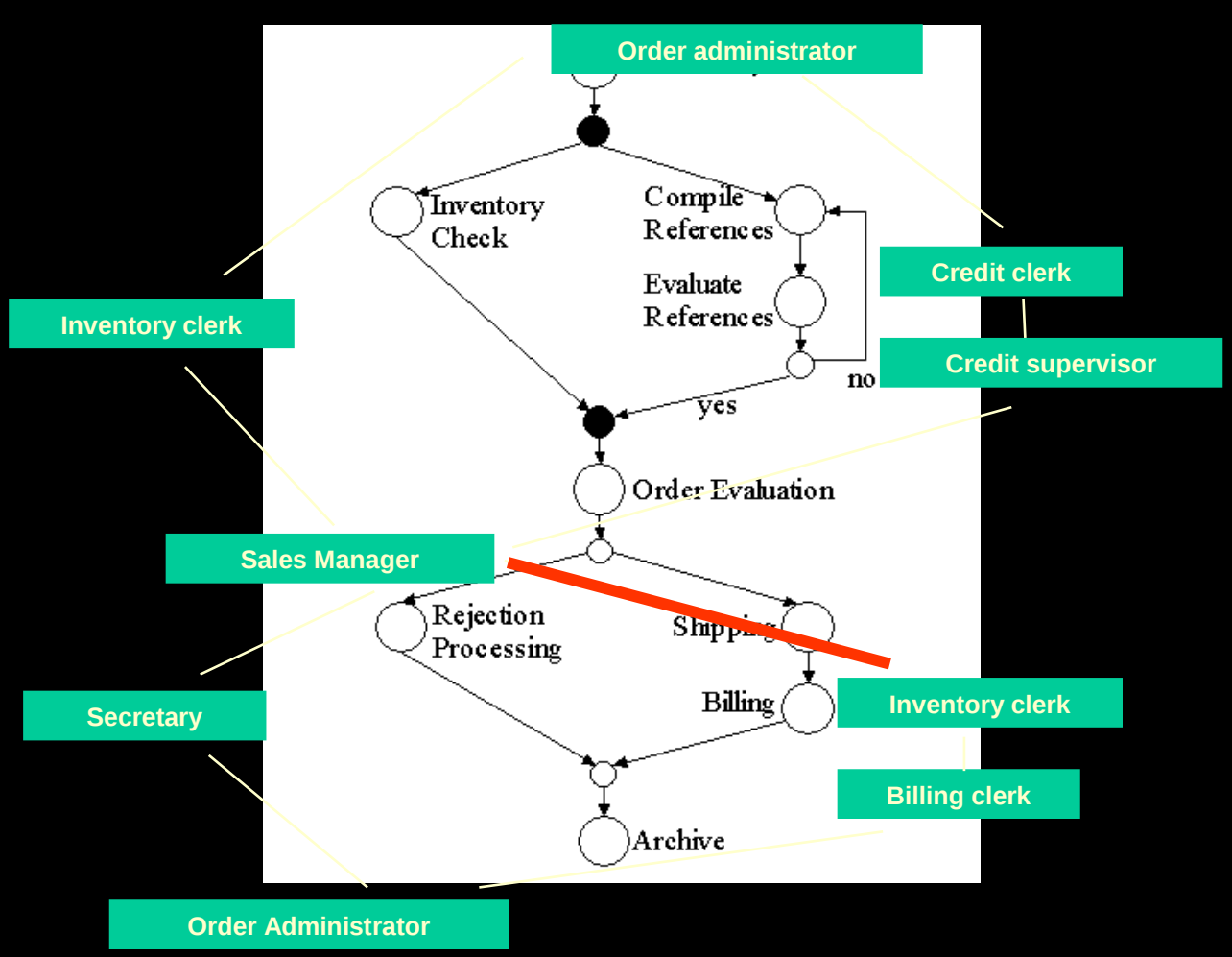
Communication Based Modelling

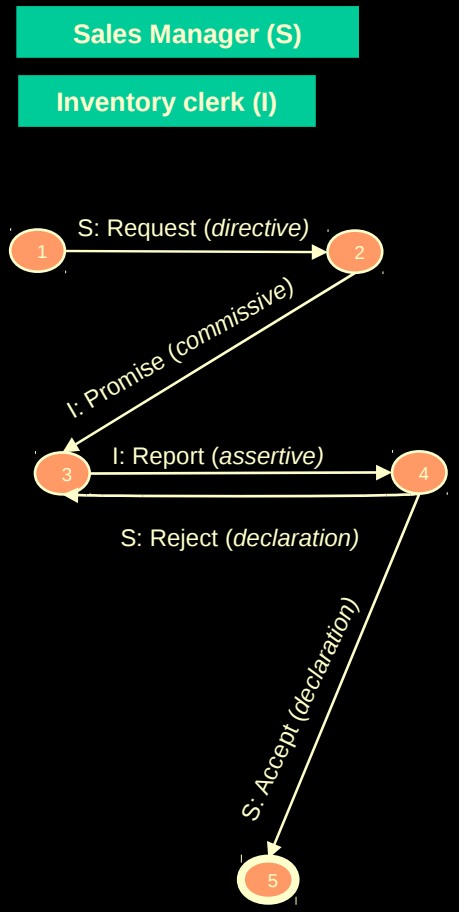
- **Basic Principles**
  - **Communication between process performers is the prime driver of the business process**
  - **All occurrences within the process are seen as a linguistic expression (*utterance)* between process performers**
    - Categories of utterances: assertive, directives, commissives, declarations, expressives (Searle, 1975)
    - Utterances are composed to form conversations: conversation for action, conversation for possibility, conversation for clarification, conversation for orientation (Winograd, 1987)

Communication Based Modelling (cont)

- **This *Language/action* perspective has been widely promoted as a framework for communication based modelling**
  - *Conversation for action* (and sometimes *conversation for possibility)* is the primary basis for these framework
- **Formal foundations**
  - **Speech act theory (John Austin, 1962; John Searle, 1969)**
- **Commercial success**
  - **Action workflow www.actiontech.com**

Example – Language/Action





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 (MQSeries), Forte, Action, Staffware, …**
  - **Consortium of Workflow Vendors at www.waria.com**
  - **Comparison of product modelling approaches at www.workflowpatterns.com**

Activity Based Modelling (cont)

- **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**
  - **Business Process Modelling Initiative www.bpmi.org**
  - **BPEL4WS**
  - **… too many ☹**

Workflow Modelling Perspectives

Primary

- **Functional**
- **Informational**
- **Behavioural**
- **Operational**
- **Organizational**

Secondary

- **Security**
- **Causality**
- **History**
- **Integrity**
- **Quality**

Source: Jablonski and Bussler (1996)

Primary Modelling Perspectives

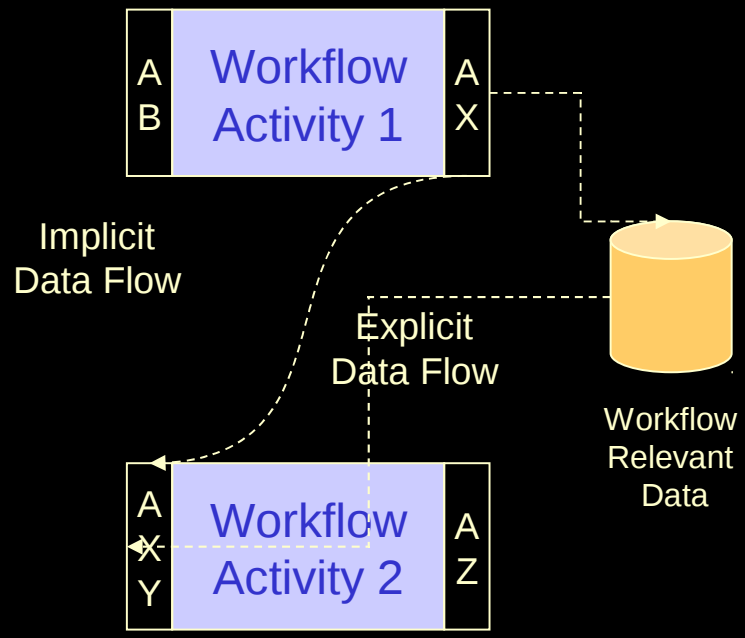
- **Functional**
  What is to be performed
- **Informational**
  What information is required
- **Behavioural**
  When it is performed
- **Operational**
  How it is performed
- **Organizational**
  Who performs it

Primary Modelling Perspectives

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

Primary Modelling Perspectives

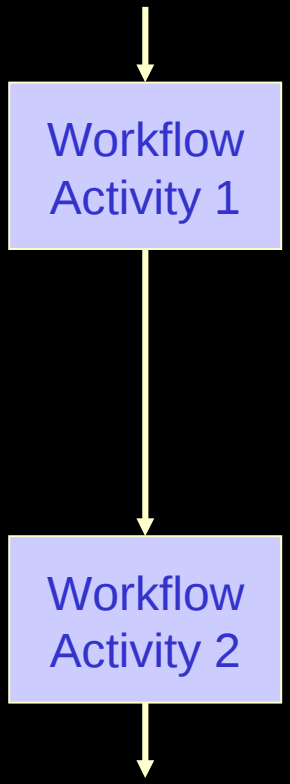
- **Informational**
  What information is required
  Input and Output data



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**
  - **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.]**

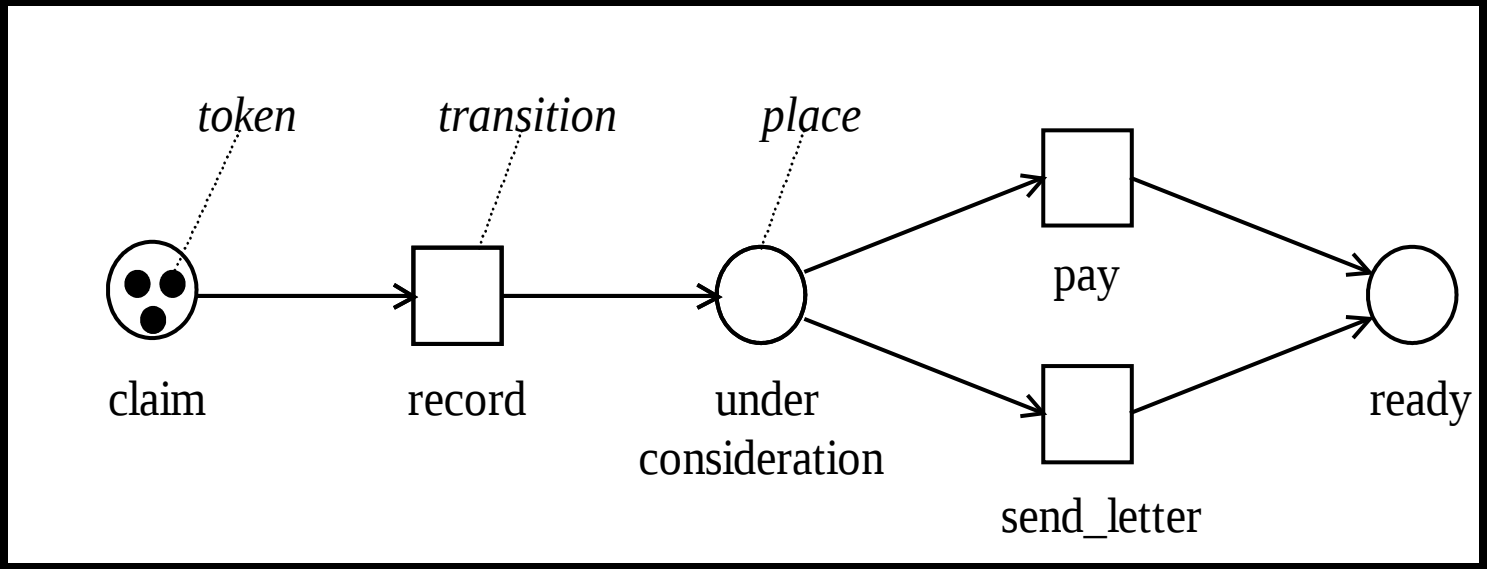
Source: Gerrit K. Janssens, Jan Verelst, Bart Weyn. (2000)

Formal Foundations of Activity based Modelling

- **Task Structures**
  - **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]**

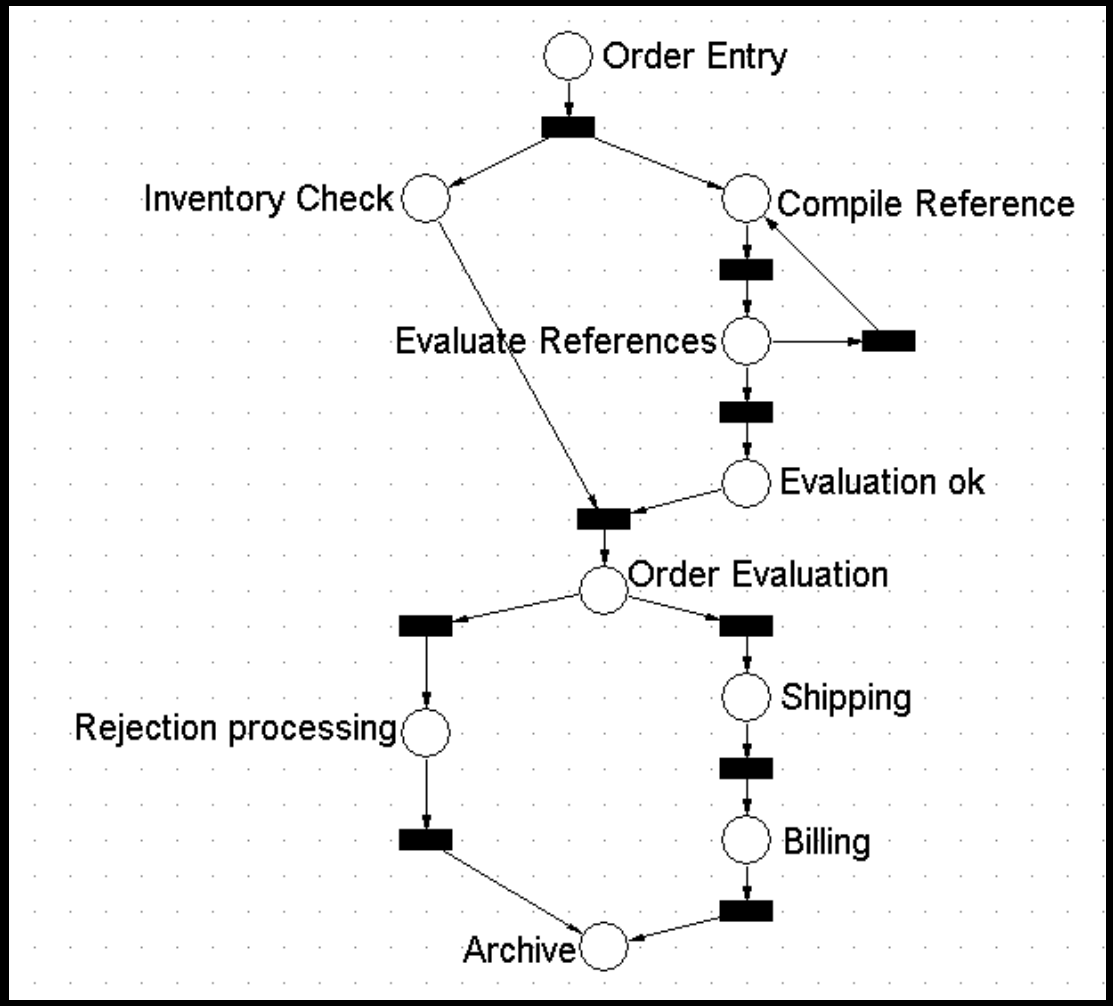
Source: vad der Aalst, ter Hofstede. (2000)

Petri-Nets

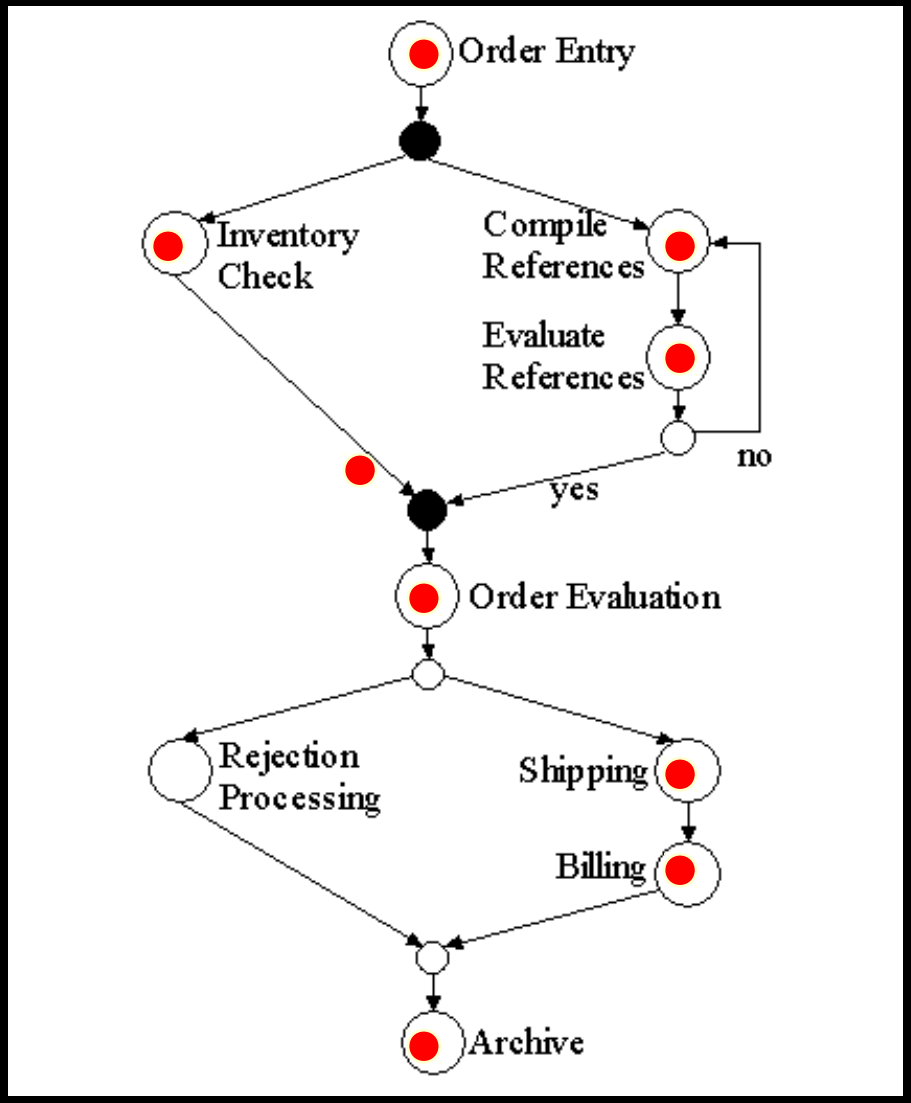


Source: http://tmitwww.tm.tue.nl/staff/wvdaalst/Petri_nets/pn_tutorial.htm

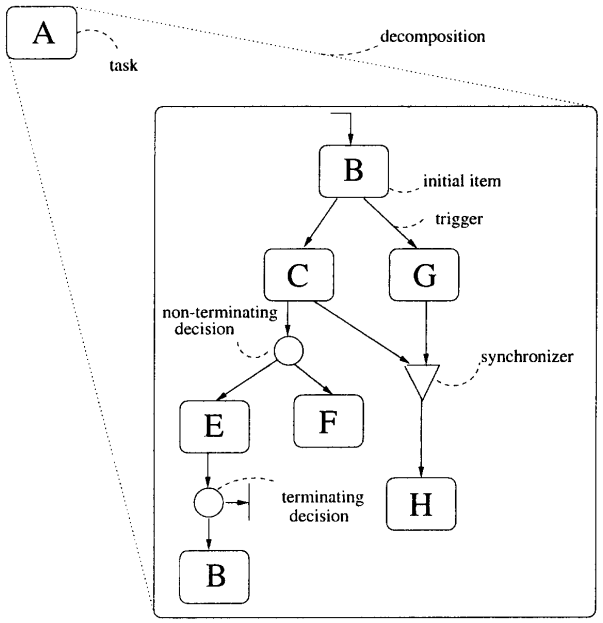
Example – Petri-Net



Petri-net Tokens and Workflow Enactment



Task Structures



Definition 1 Formally, a Task Structure $W = (\mathcal{X}, \mathcal{U}, \mathcal{T}, \mathcal{S}, \mathcal{D}, \mathcal{D}_t, \mathsf{Trig}, \mathsf{Name}, \mathcal{I})$ without decomposition consists of the following components:

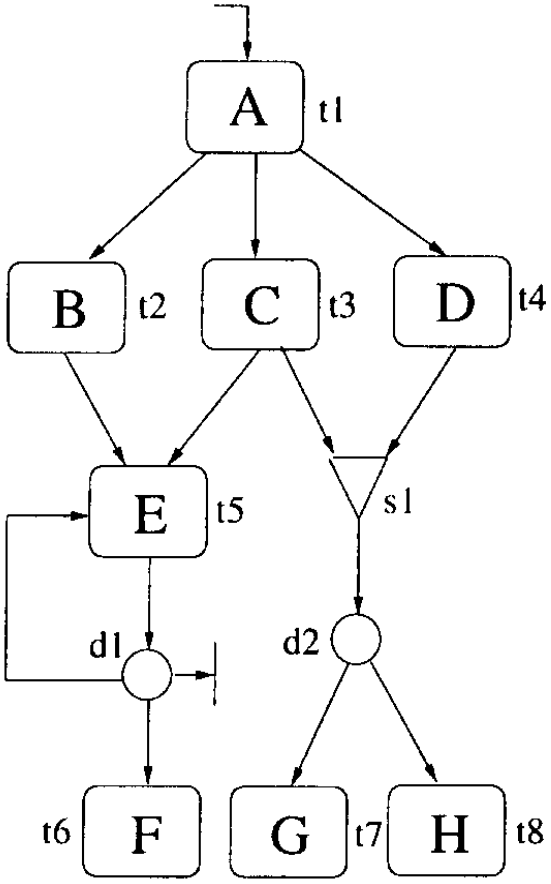
1. A set $\mathcal{X}$ of task objects. $\mathcal{X}$ is the union of a set of synchronizers $\mathcal{S}$, a set of tasks $\mathcal{T}$ and a set of decisions $\mathcal{D}$. In $\mathcal{D}$ we distinguish a subset $\mathcal{D}_t$ consisting of the terminating decisions. For convenience, we define the set $\mathcal{U}$, the set of non-synchronizers, as $\mathcal{T} \cup \mathcal{D}$.

2. A relation $\mathsf{Trig} \subseteq \mathcal{X} \times \mathcal{X}$ of triggers, capturing which task object can start which other task object(s) (if any).

3. A function $\mathsf{Name}: \mathcal{T} \rightarrow \mathcal{N}$ yielding the name of a task, where $\mathcal{N}$ is a set of names.

4. A subset $\mathcal{I}$ of the set of non-synchronizers $\mathcal{U}$, consisting of the initial items.

Example - Task Structures



$$
\begin{aligned}
\mathcal{X} &= \{t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8, s_1, d_1, d_2\}, \\
\mathcal{T} &= \{t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8\}, \\
\mathcal{S} &= \{s_1\}, \\
\mathcal{D} &= \{d_1, d_2\}, \\
\mathcal{D}_t &= \{d_1\}.
\end{aligned}
$$

Further, t_1 Trig t_2, t_1 Trig t_3, t_1 Trig t_4, t_2 Trig t_5, t_3 Trig t_5 etc, and Name(t_1) = A, Name(t_2) = B, etc. Finally, $\mathcal{I} = \{t_1\}$. □

A Simple Graphical Workflow Language

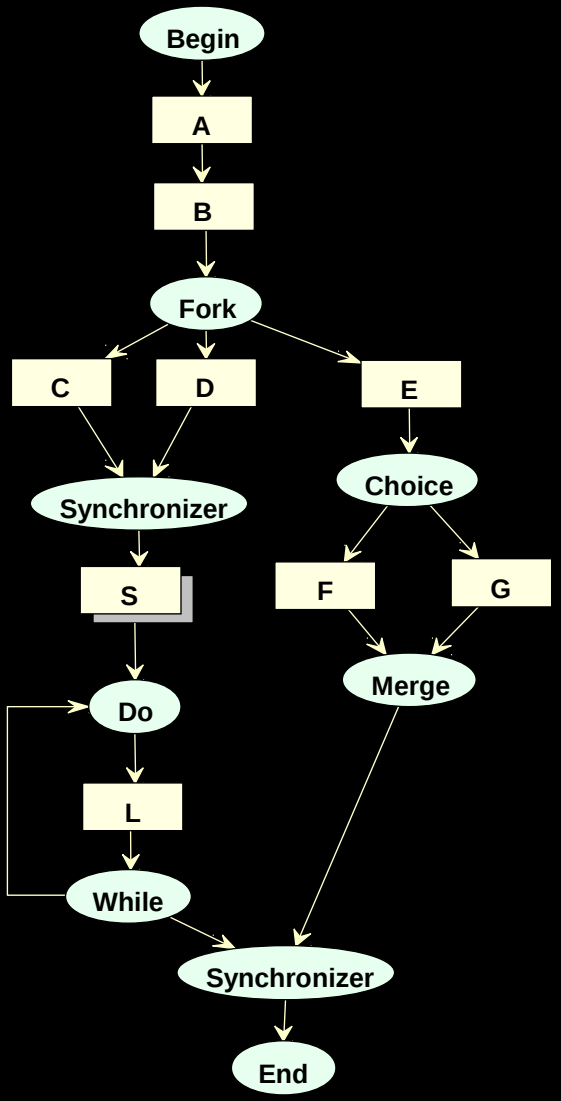
- **Generic language with a small number of constructs**
- **Sufficient expressiveness for a wide variety of process requirements**
- **Simplicity provides rigorous analysis and verifiability**
- **Developed jointly by DSTC and UQ researchers (1995 – 2001)**
- **Supported by a process modelling and verification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

Fundamental Modeling Aspects

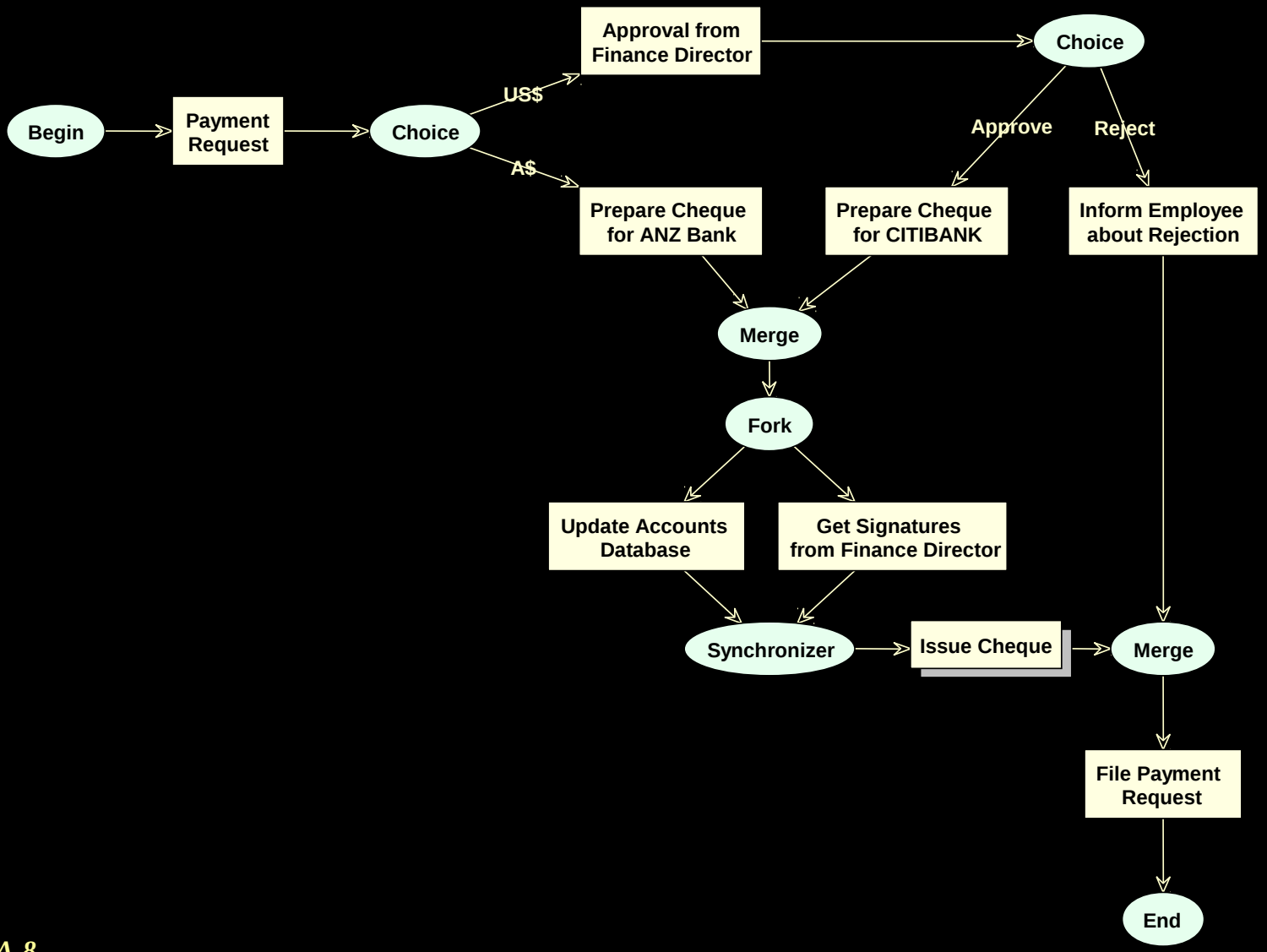
- **Structure**
  - **Control Flow**
- **Data**
  - **Input and Output**
- **Time**
  - **Deadlines and Durations**
- **Resources**
  - **Applications, Roles, Performers**

Core Structures

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

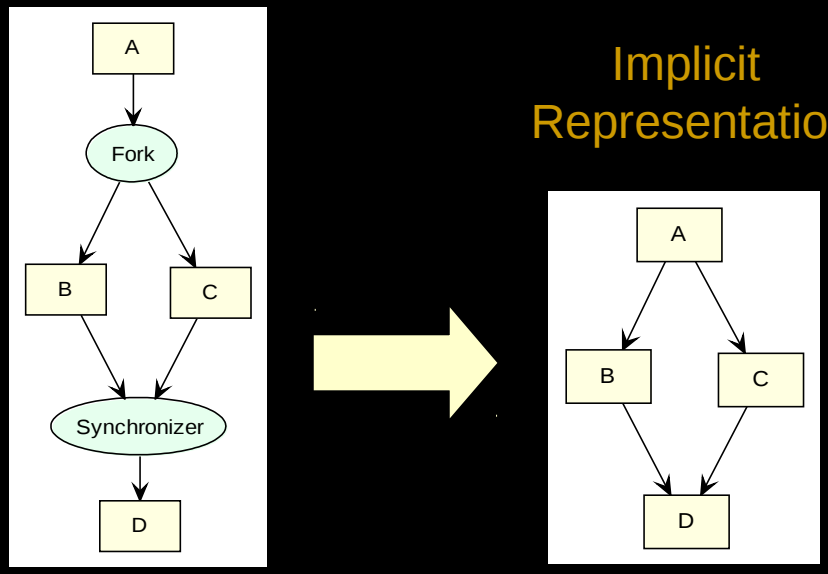


Example


Begin
Payment Request
Choice
US$
A$
Approval from Finance Director
Choice
Approve
Reject
Prepare Cheque for ANZ Bank
Prepare Cheque for CITIBANK
Inform Employee about Rejection
Merge
Fork
Update Accounts Database
Get Signatures from Finance Director
Synchronizer
Issue Cheque
Merge
File Payment Request
End

Alternative Modelling Approach

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



Mapping from Explicit to Implicit Representation

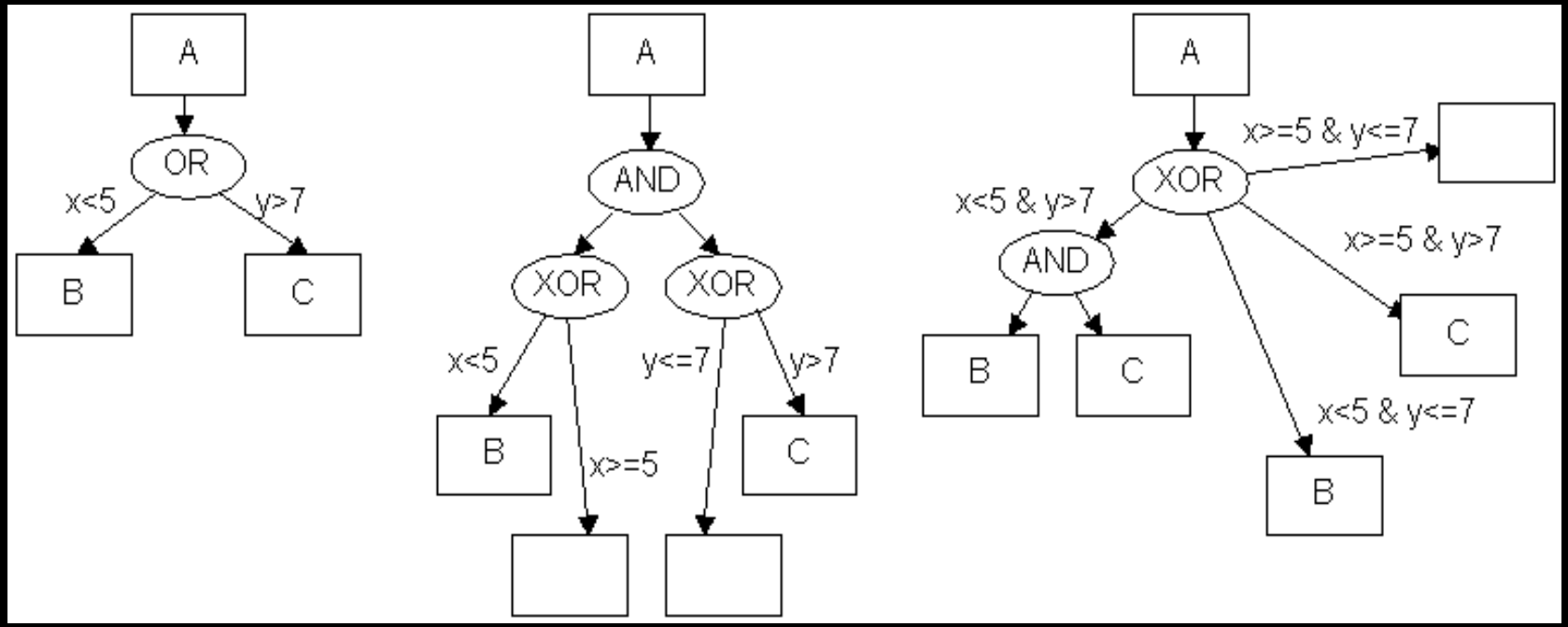
Extended Modelling Structures

- **Multiple choice**
- **Multiple merge**
- **N-out-of-M join**
- **Implicit Termination**

Source:http://tmitwww.tm.tue.nl/research/patterns/

Multiple Choice

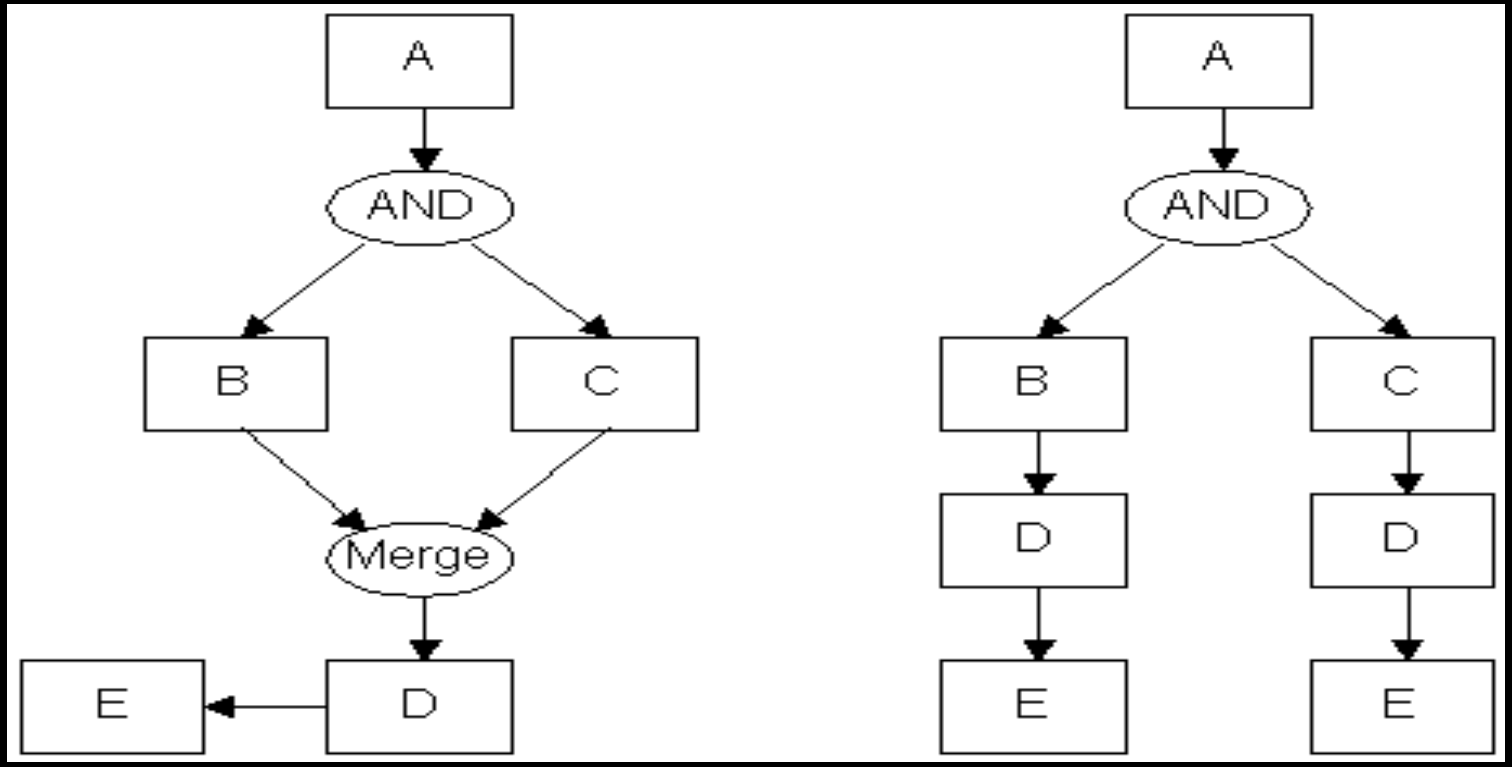
The choice of braches after an or-split is not exclusive



Multiple Merge

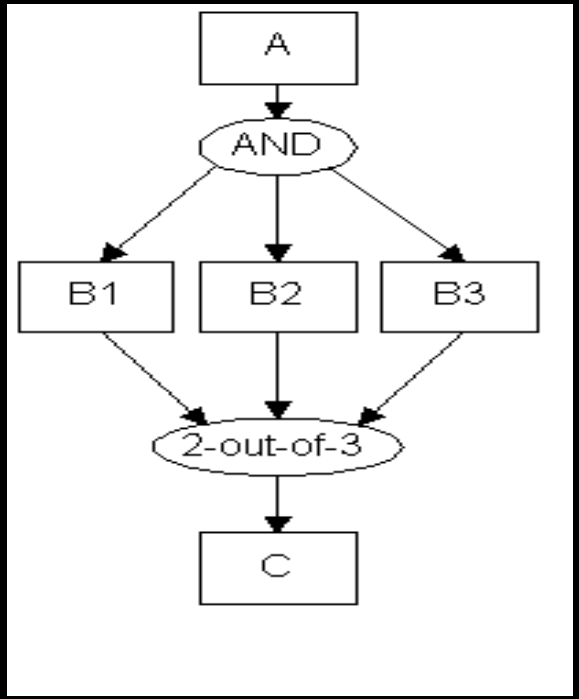
The merge can have more than one incoming branch

Subsequent activities will be activated as many times



N-out-of-M Join

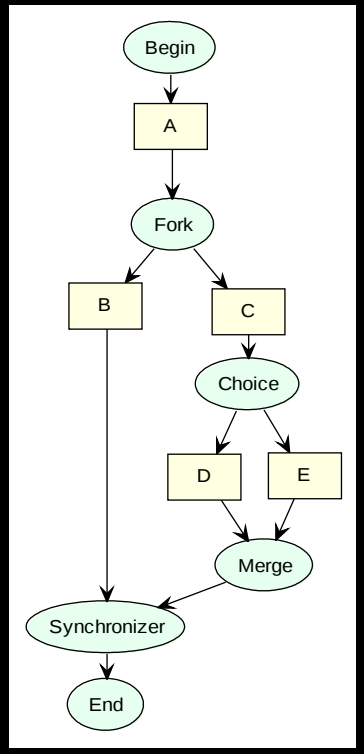
Waits for a given number of braches and then ignores (cancels) the remaining

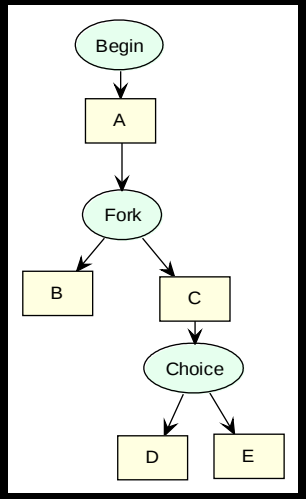


Implicit Termination

Process is complete when there are no active activities left

Explicit, unique terminating node





{B, D, E} represent terminating nodes (activities)

Language Syntax

Core Modelling Structures for Explicit representation

- Let G = <N, F> be a graph where
  N: Finite Set of Nodes,
  F: Flow Relation $F \subseteq N \times N$
- $\forall$ $\forall$ n $\in$ N, NodeType: n $\rightarrow$ {Coordinator, Task}
- $N = C \cup T$, $C \cap T = \phi$ where C: Set of Coordinator Nodes, T: Set of Task Nodes
- $\forall$ $\forall$ n $\in$ C, CoordType: n $\rightarrow$ {Fork, Synchronize, Choice, Merge, Begin, End, Do, While}
- Let P be a directed path in G, such that
  P = {n1, n2, …, nk}, (ni, ni+1) $\in$ F for i = 1, 2, …, k-1
- Let Nat : Set of Natural Numbers, NId : Set of Node Identifiers
- $\forall$ $\forall$ n $\in$ N, I: N $\rightarrow$ Nat, I(n) : Number of incoming flows for node n
- $\forall$ $\forall$ n $\in$ N, O: N $\rightarrow$ Nat, O(n) : Number of outgoing flows for node n

Structural Specification

A Workflow is a Directed Acyclic Graph (DAG) W = <N, F> such that

$\exists$ n $\in$ C, s.t. I(n) = 0 $\wedge$ ($\neg\exists$ m $\in$ N, s.t. I(m) = 0 $\wedge$ m $\neq$ n), we call this Begin Node n0 and CoordType (n0) = Begin

$\exists$ n $\in$ C, s.t. O(n) = 0 $\wedge$ ($\neg\exists$ m $\in$ N, s.t. O(m) = 0 $\wedge$ m $\neq$ n), we call this End Node nf and CoordType (nf) = End

$\forall$ n $\in$ N, $\exists$ P, s.t. P = {n0, …n, …, nf }

$\forall$ n $\in$ C, I(n) $\geq$ 2 $\vee$ O(n) $\geq$ 2 where n $\neq$ n0 and n $\neq$ nf

$\forall$ n $\in$ T, I(n) + O(n) > 1 where n $\neq$ n0 and n $\neq$ nf

$\forall$ n $\in$ T, TaskType: T $\rightarrow$ {Activity, SubProcess}, Activity represents a single task and SubProcess represent nesting.

FlowMake

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

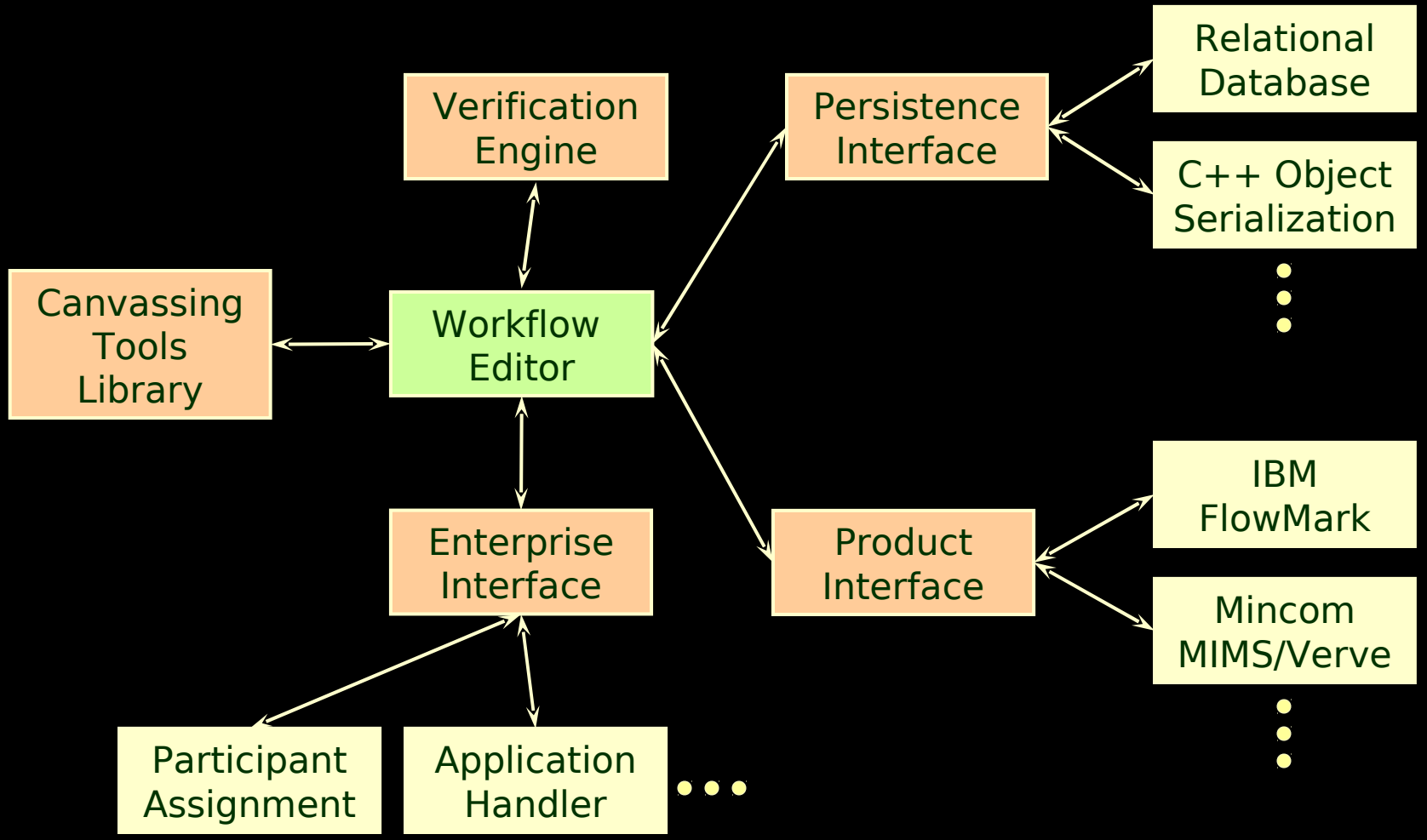
Business Process Modeling Issues

- **Many languages invented with individual product developments,**
- **Petri Nets - most research (academic) papers,**
- **Little impact of the basic research on products architects decisions,**
- **We adopted a simple, expressible language to illustrate the main concepts,**

The FlowMake

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

Flowmake 2.5 - Components



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

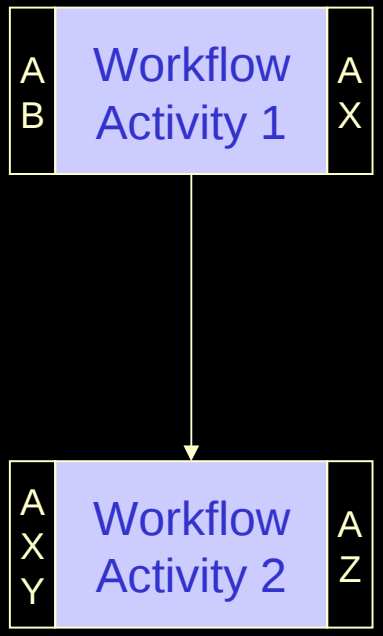
- **An activity node cannot have more than one incoming/outgoing flows (explicit representation)**
- **Reachablity of nodes (Graph must not be disconnected)**
- **Multiple (initial) final activities**

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

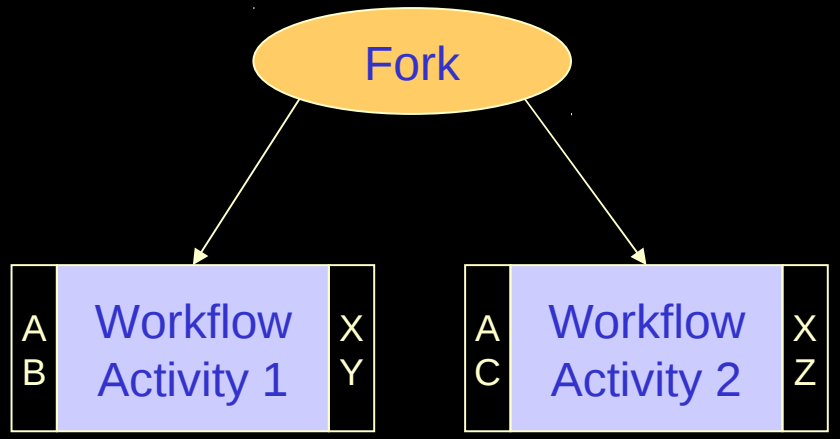
- **Data Conflicts**
  - **Missing data**
  - **Lost data**
- **Temporal Conflicts**
- **Resource Conflicts**



Missing data:
Where is Y coming from

Data, Time and Resource Conflicts

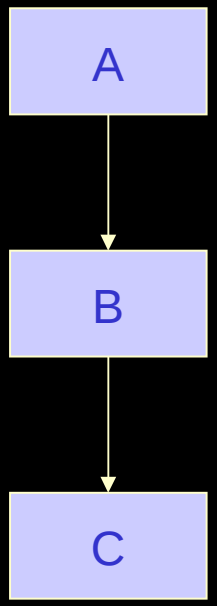
- **Data Conflicts**
  - **Missing data**
  - **Lost data**
- **Temporal Conflicts**
- **Resource Conflicts**



Lost data:
What will be the value of X

Data, Time and Resource Conflicts

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

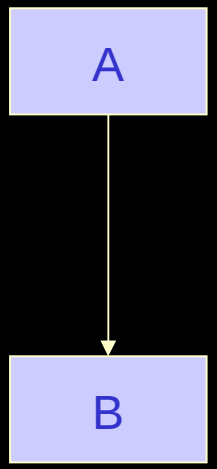


Duration Constraint:
Minimum time is 7 hours

Interdependent Constraint:
Must be completed within 3 hours after completion of task A

Data, Time and Resource Conflicts

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



Duration Constraint:
Minimum time is 3 days
<Started on 1/1/02>

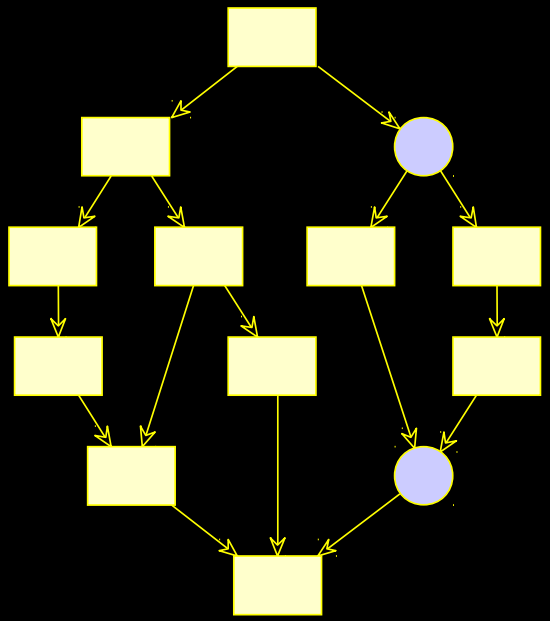
Deadline Constraint:
Must be completed by
2/1/02

Data, Time and Resource Conflicts

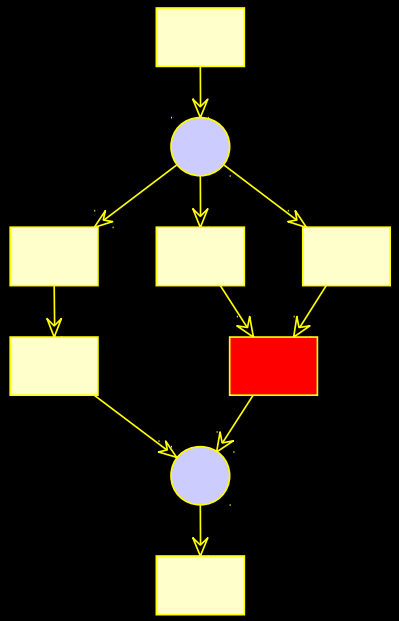
- **Data Conflicts**
- **Temporal Conflicts**
- **Resource Conflicts**
  - **Incomplete specification**
    - Role is assigned to activities, but no participants are bound to that role
  - **Access and Role Conflicts**
    - Participant does not have access to activity A, but is assigned a role that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

Structural Conflicts

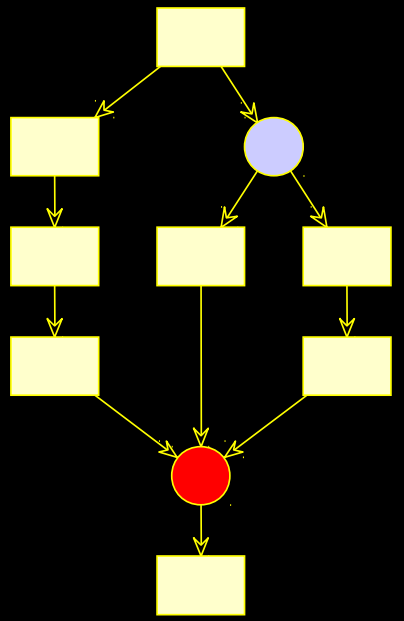
- **Deadlock: Synchronizing alternative paths**
- **Lack of synchronization: Merging concurrent paths**



Correct



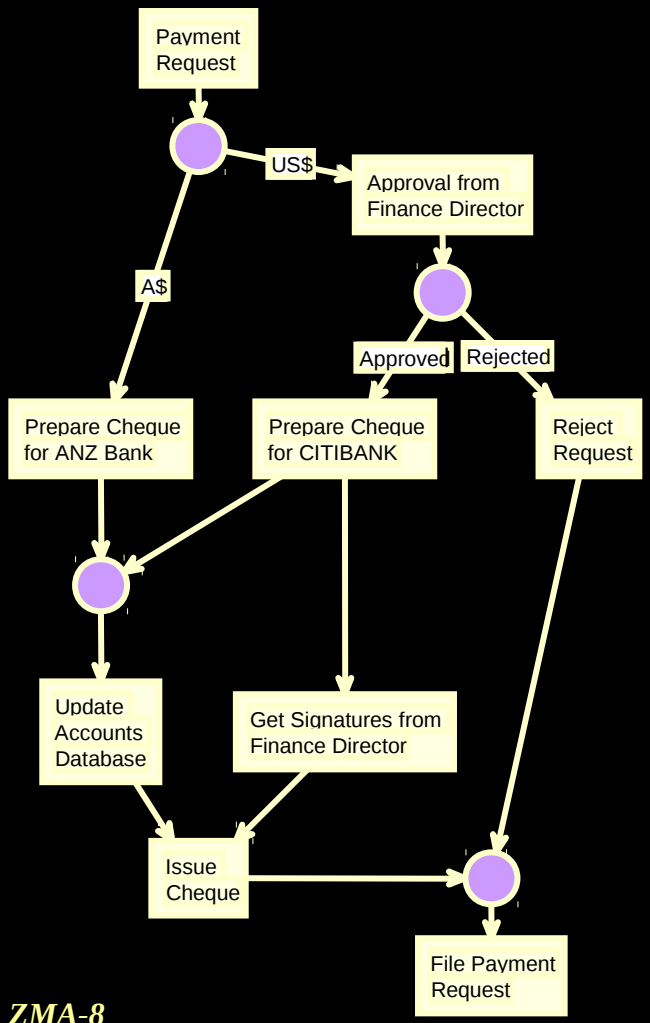
Deadlock

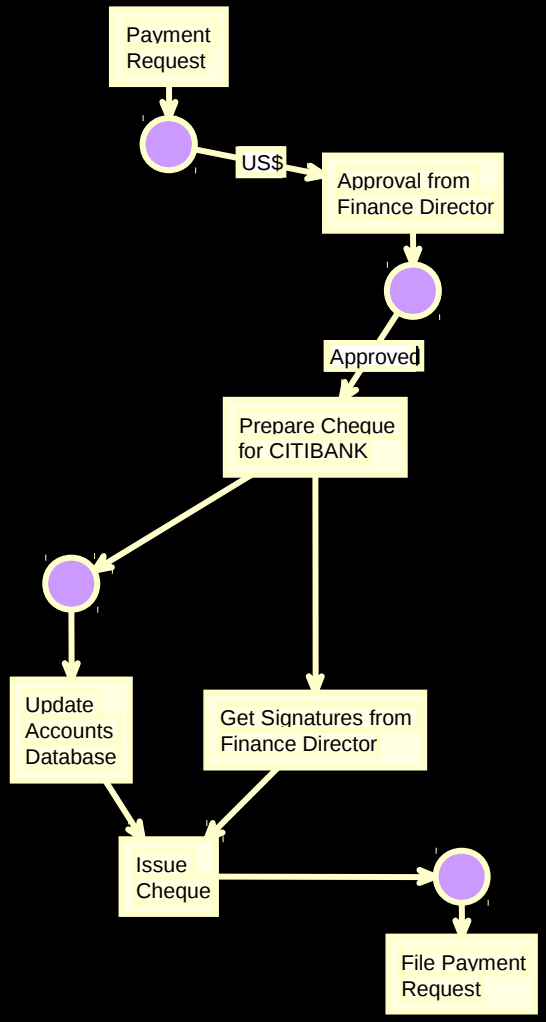


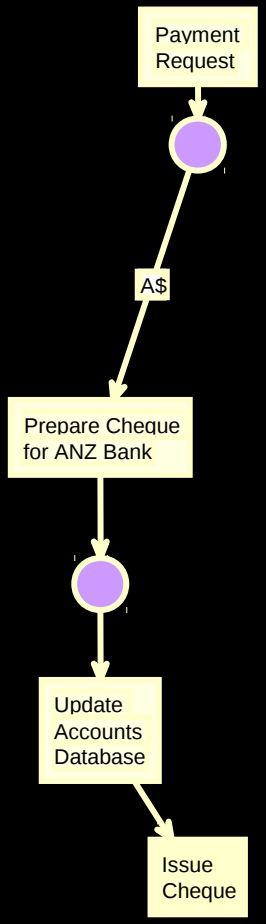
Lack of Synchronization

Wykład 11 – Model verification and migration

Deadlocks

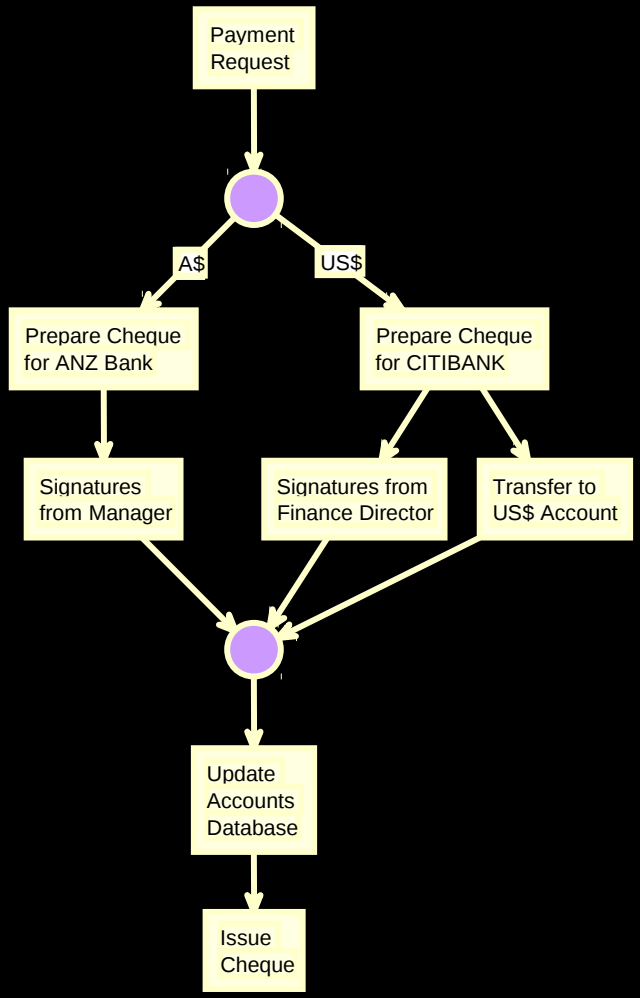


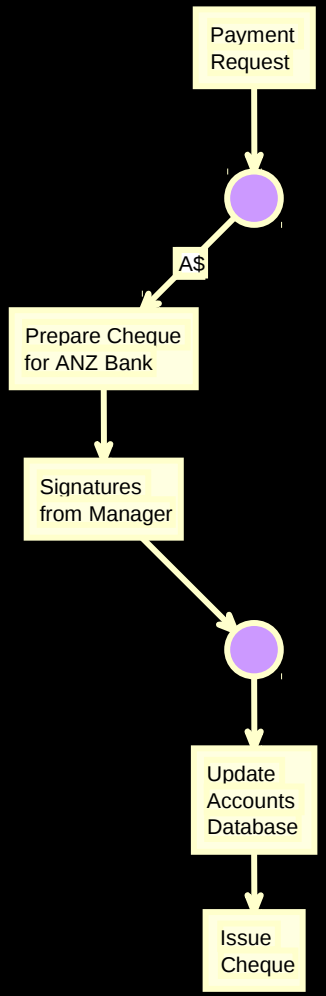


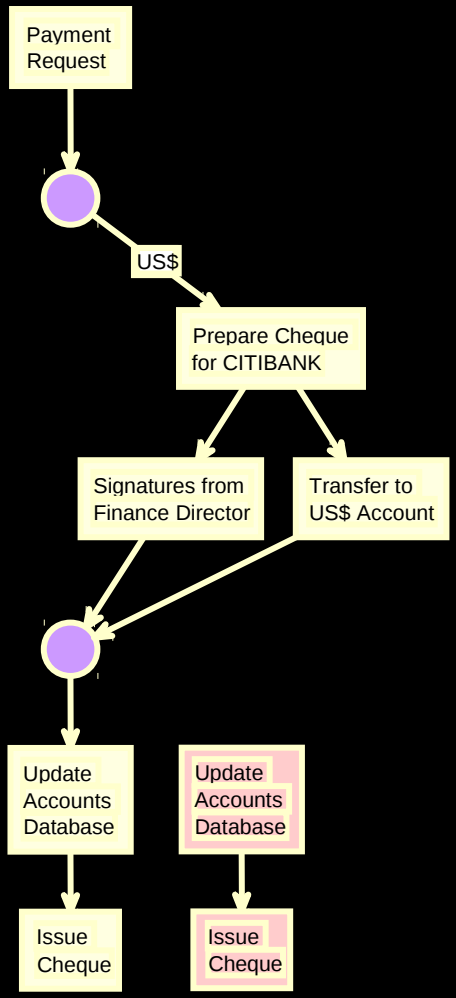


Deadlock!

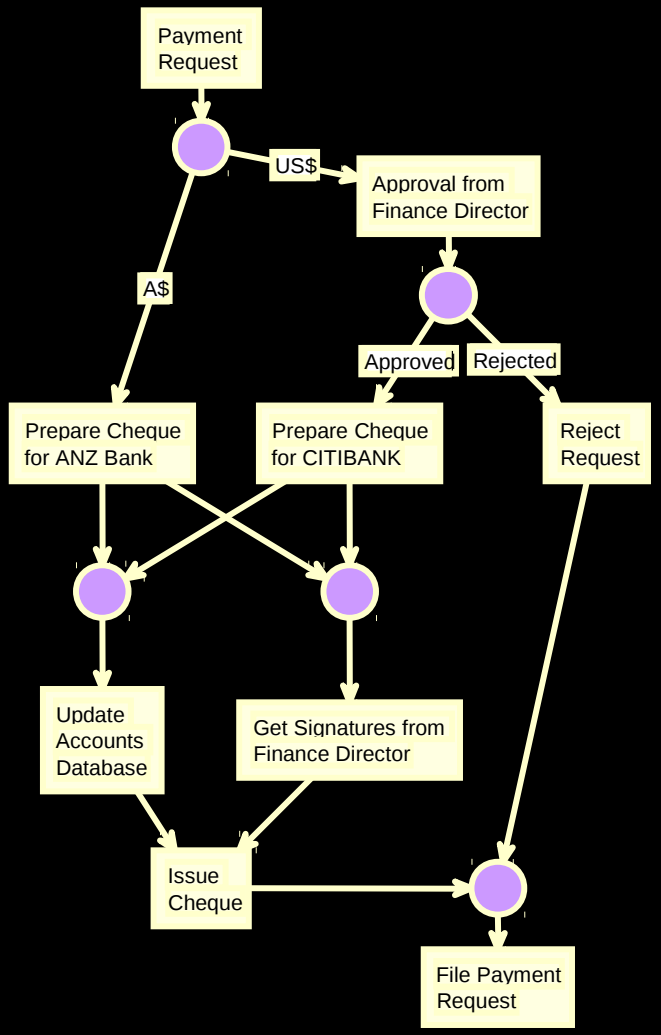
Lack of Synchronization

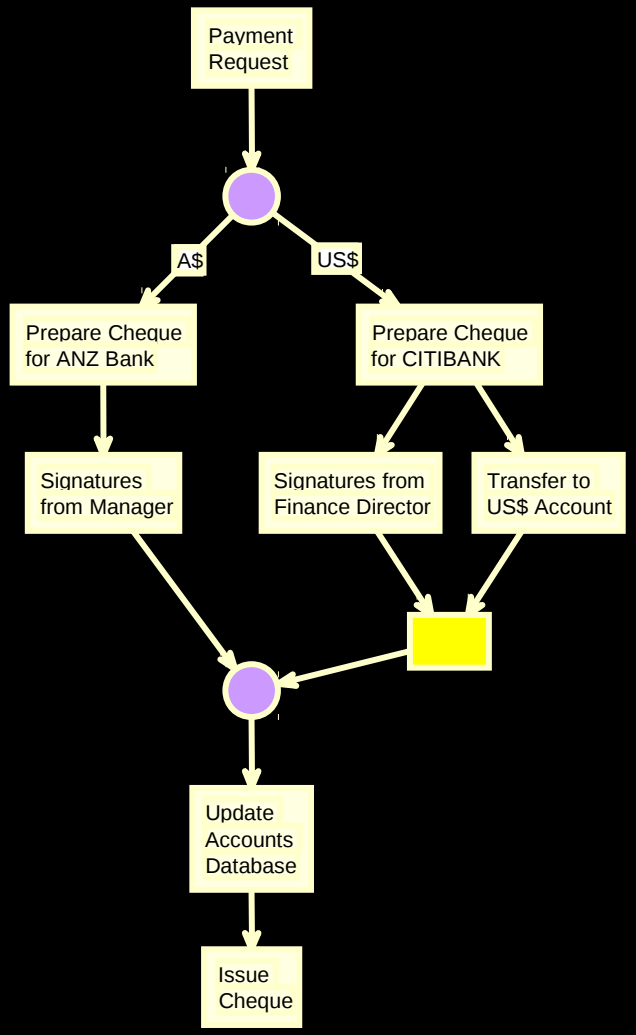






Correct Workflow Models



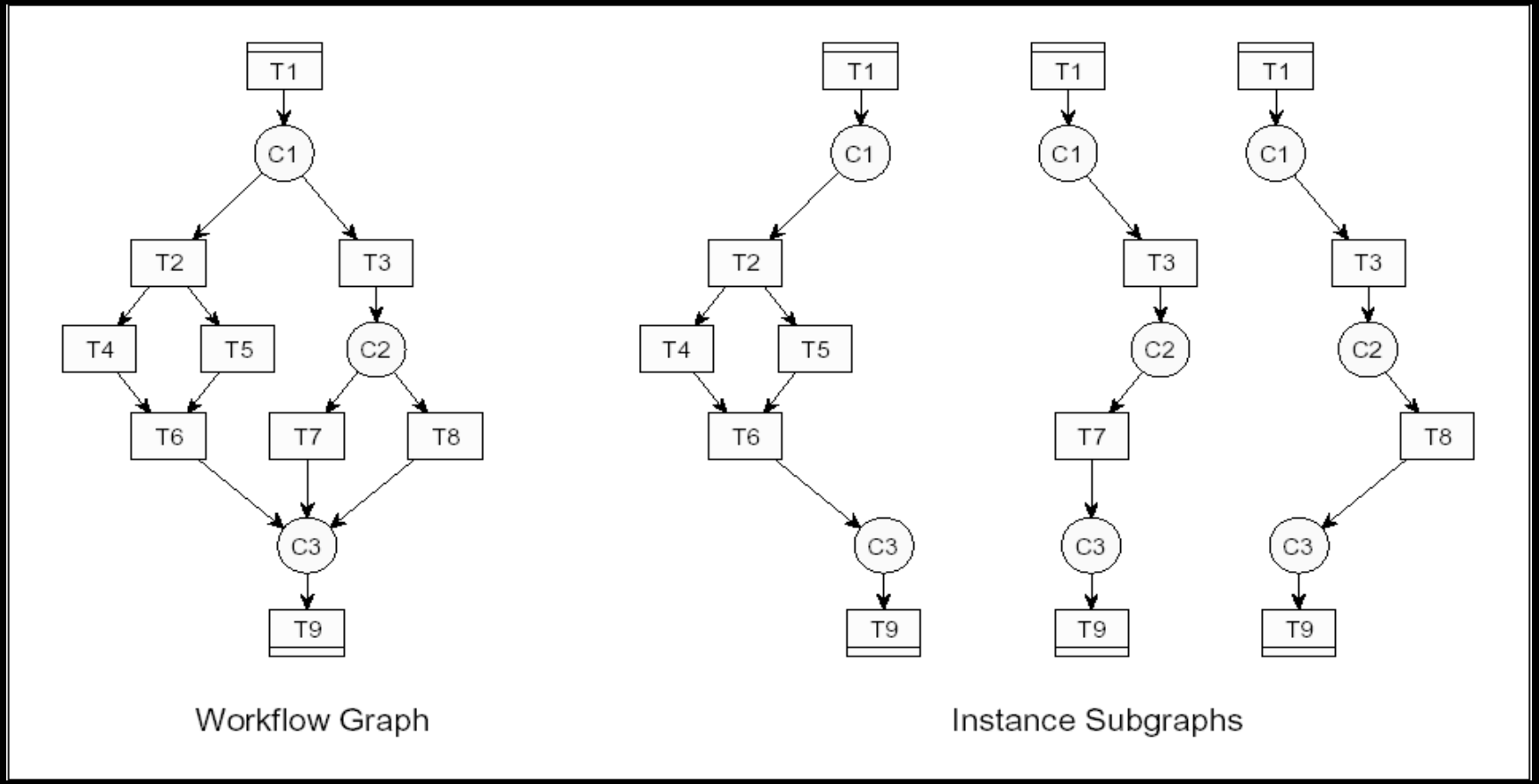


Control Flow Verification

Based on the concept of an instance subgraphs

- **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 subgraph that contains more than one incoming nodes of a merge node.**

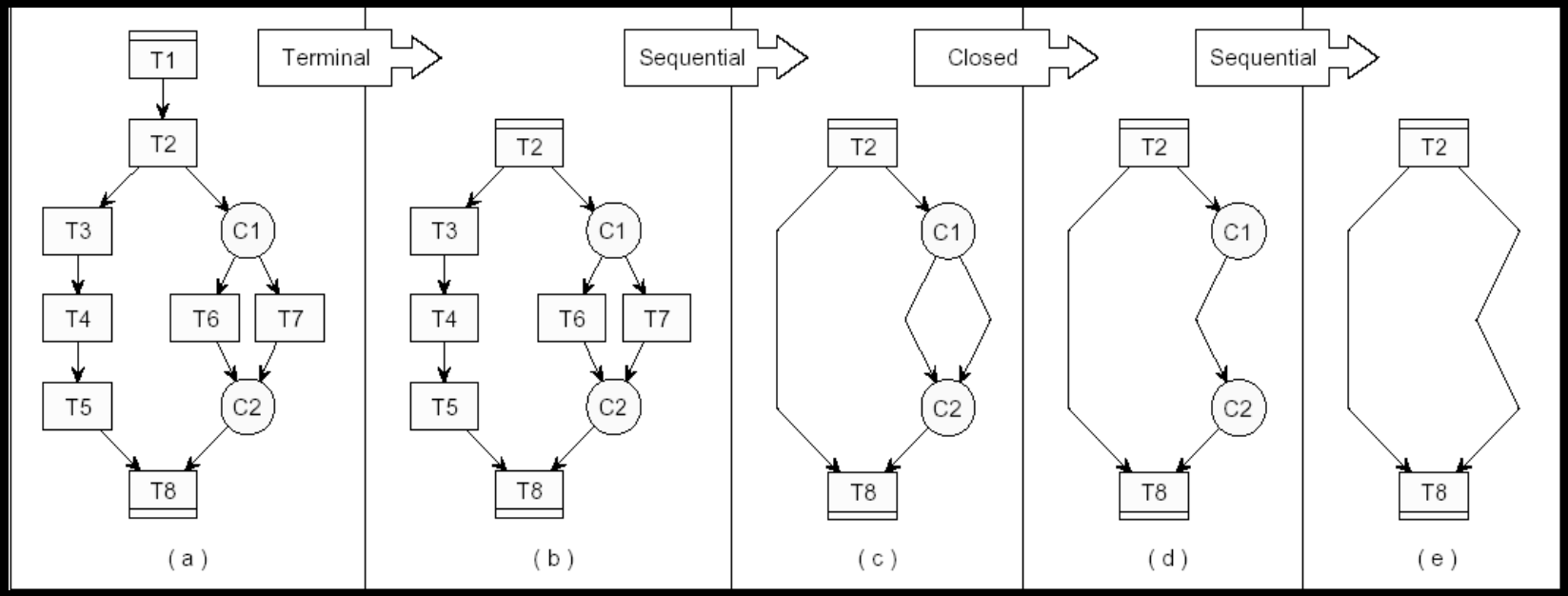
CF Verification based on Reduction

- **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**

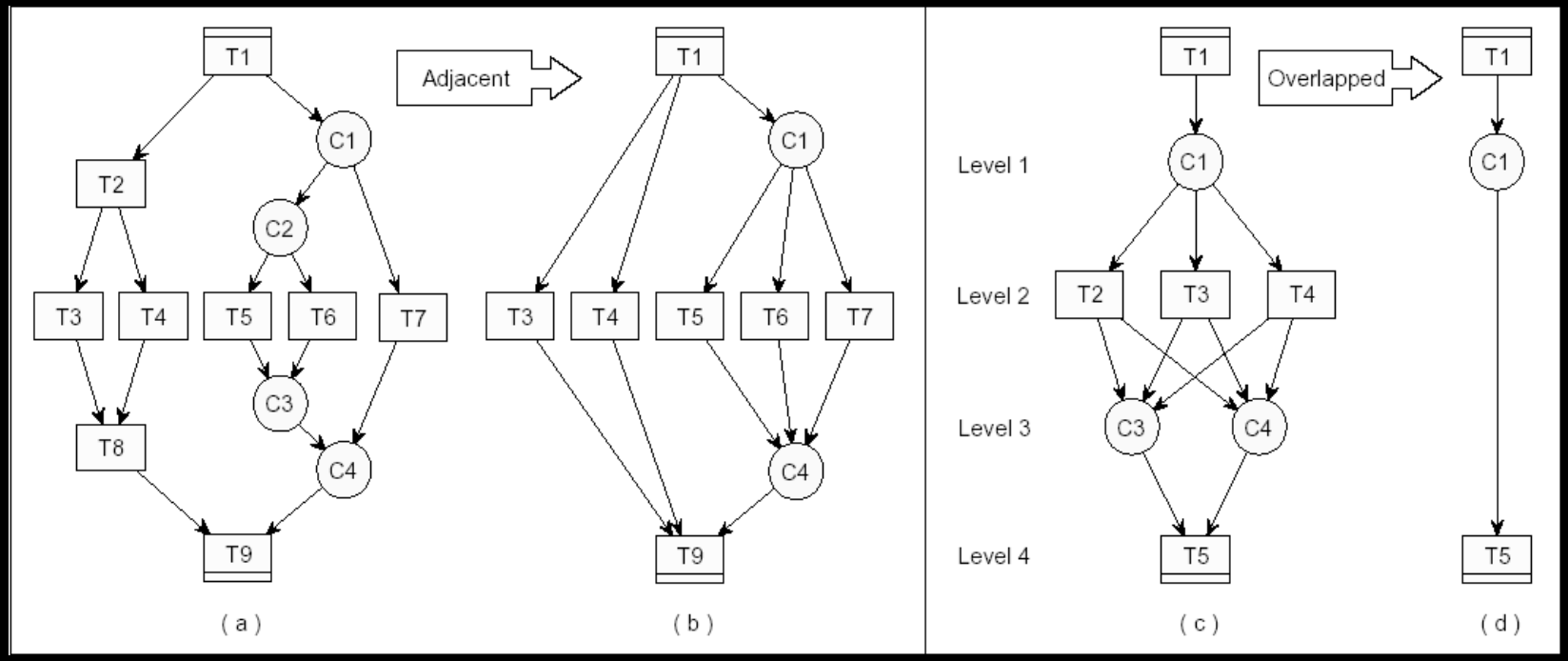
Reduction Rules

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

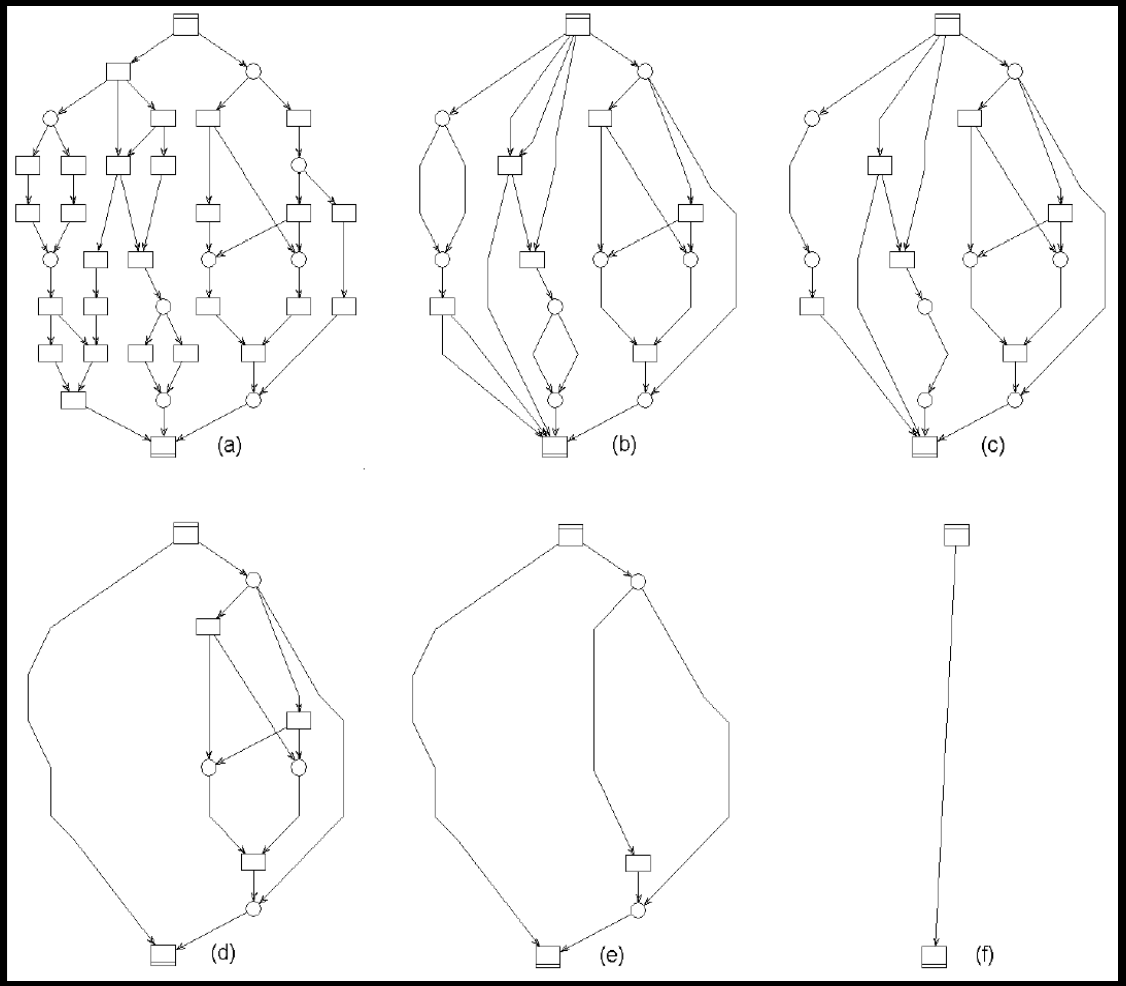
Applying Reduction Rules



Applying Reduction Rules

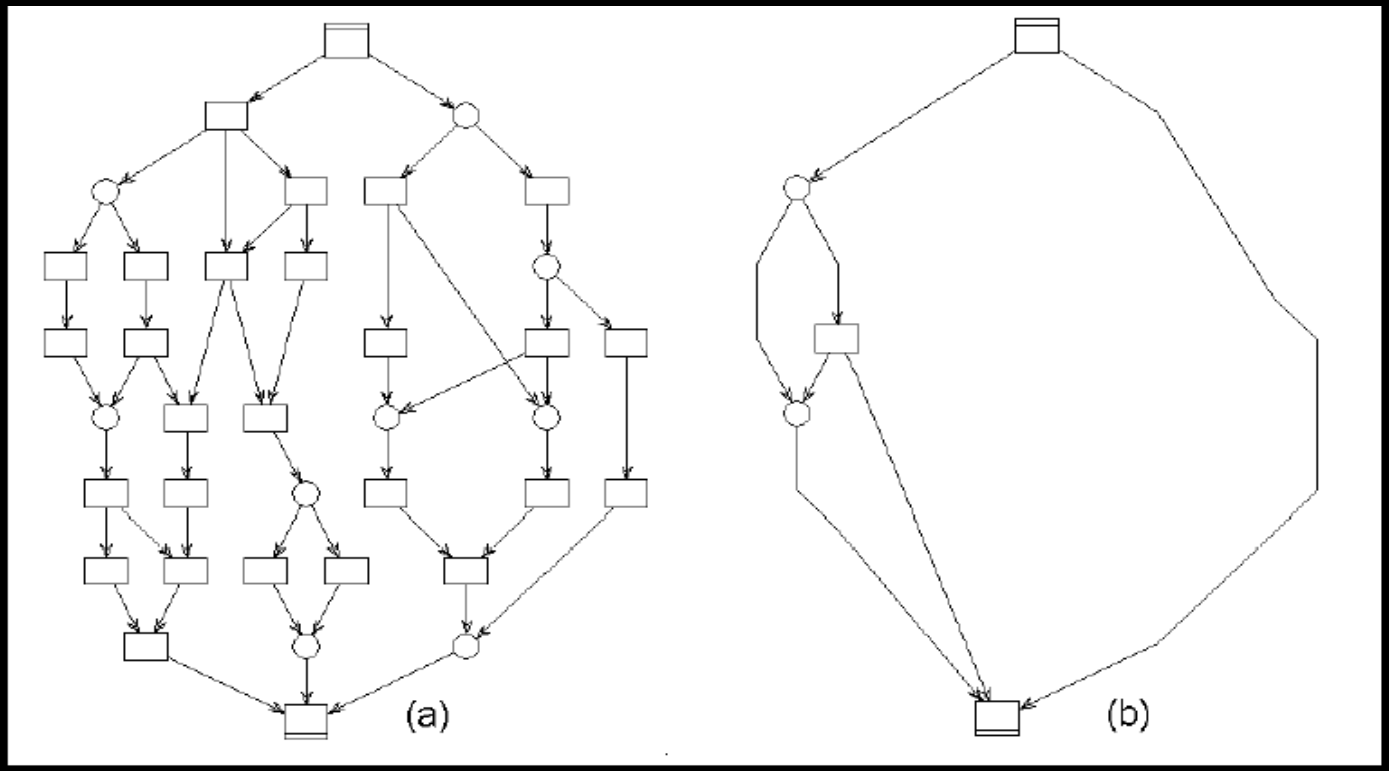


Reduction Algorithm



Reducing a Structurally Correct Workflow Graph

Reduction Algorithm



Reducing a Structurally Incorrect Workflow Graph

Suggested Reading

- **Jablonski and Bussler (1996) Workflow Management – Modelling Concepts, Architecture and Implementation. Chapter 6**
- **Wasim Sadiq and Maria E. Orlowska. On Capturing Process Requirements of Workflow Based Business Information Systems. Proceedings of the 3rd International Conference on Business Information Systems (BIS '99) , Poznan, Poland, 14-16 April 1999. pp. 195-209. Springer-Verlag.**
- **www.workflowpatterns.com**
- **Wasim Sadiq and Maria E. Orlowska. Analysing Process Models using Graph Reduction Techniques. Information Systems, Vol. 25, No. 2, pp. 117-134, 2000. Elsevier**

Practise Exercises

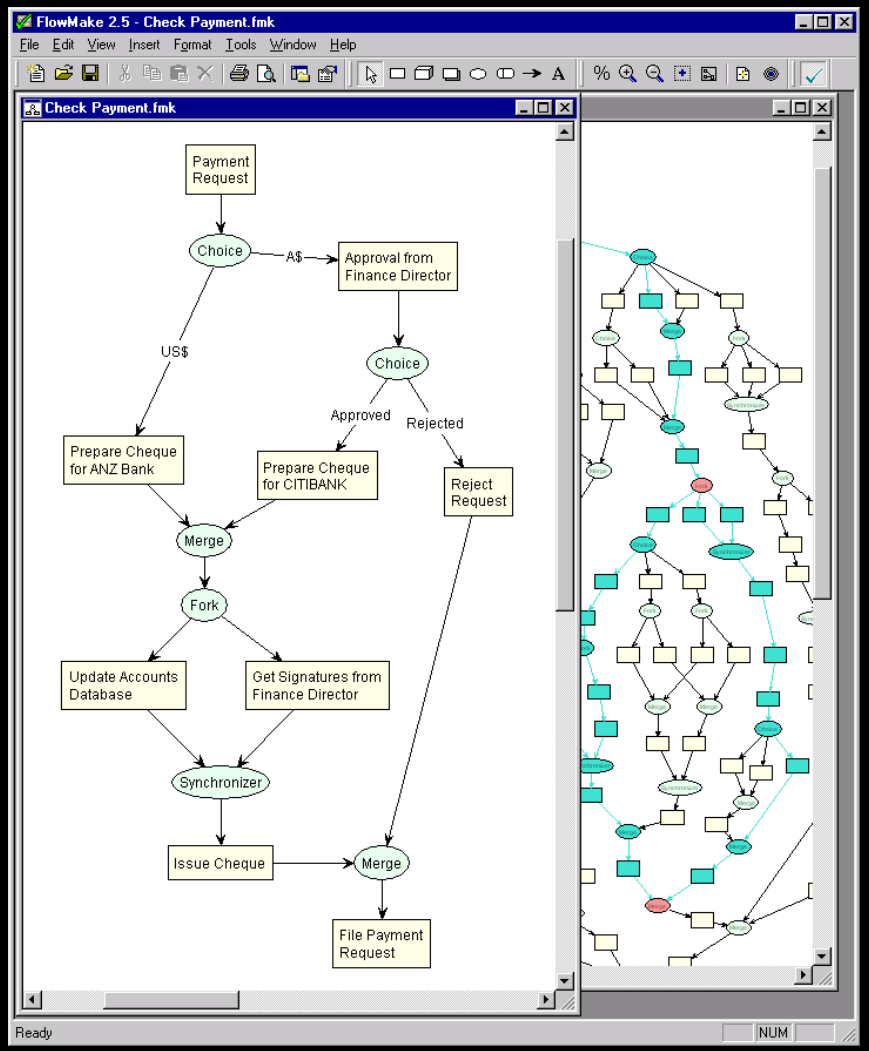
1. **Think of examples where the core modelling structures would not be sufficient (Hint: see www.workflowpatterns.com , but think of “new” examples)**

Exercise

- **For the example you gave in Exercise 1, construct a workflow model using the FlowMake language.**
- **Ensure that your model is free from structural errors.**
- **List the workflow performers (humans or systems) that will perform respective workflow activities in you model**
- **Identify meaningful time constraints that may apply to your model**

FlowMake: Demonstration

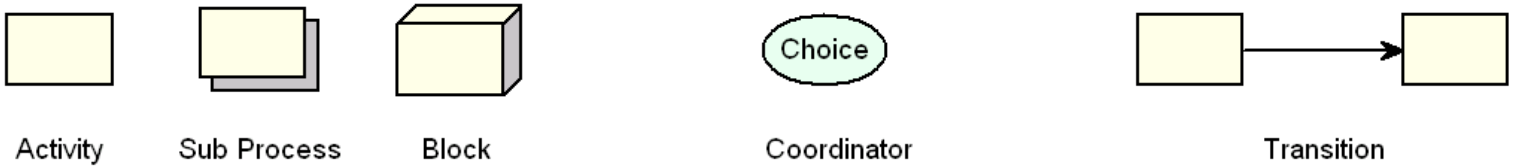
- **Developed in Microsoft Visual C++ / MFC**
- **Fast and compact**
- **User-friendly WF Editor**
- **Verification and Analysis**
- **Object-oriented design**
- **Easily extensible**
- **Implements DSTC research**
- **Product interfaces**



FlowMake 2.5 - [Modelling Language.fmk]

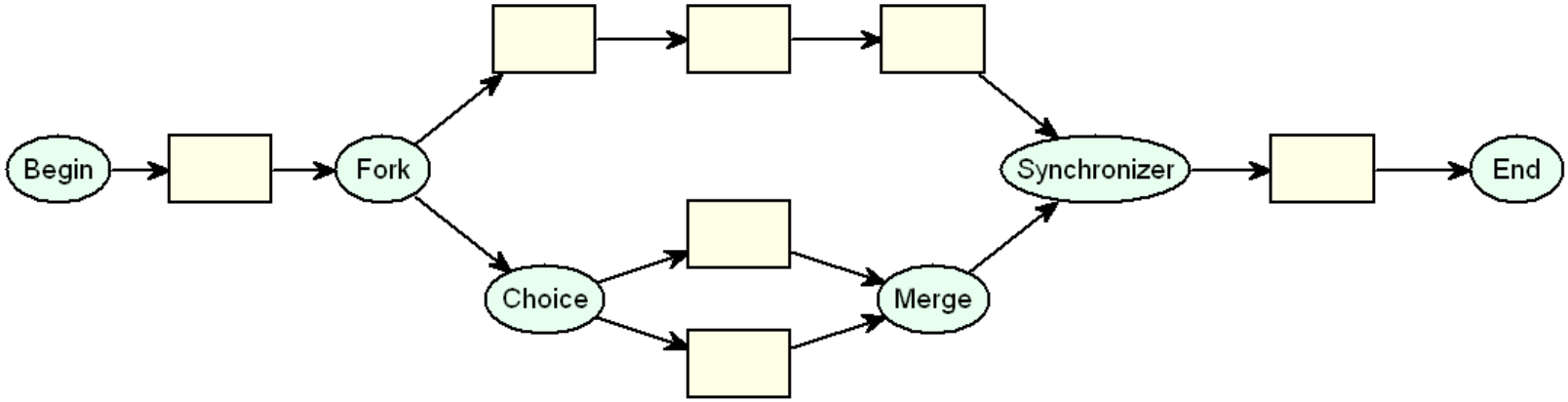
File Edit View Insert Format Tools Window Help

Modelling Objects

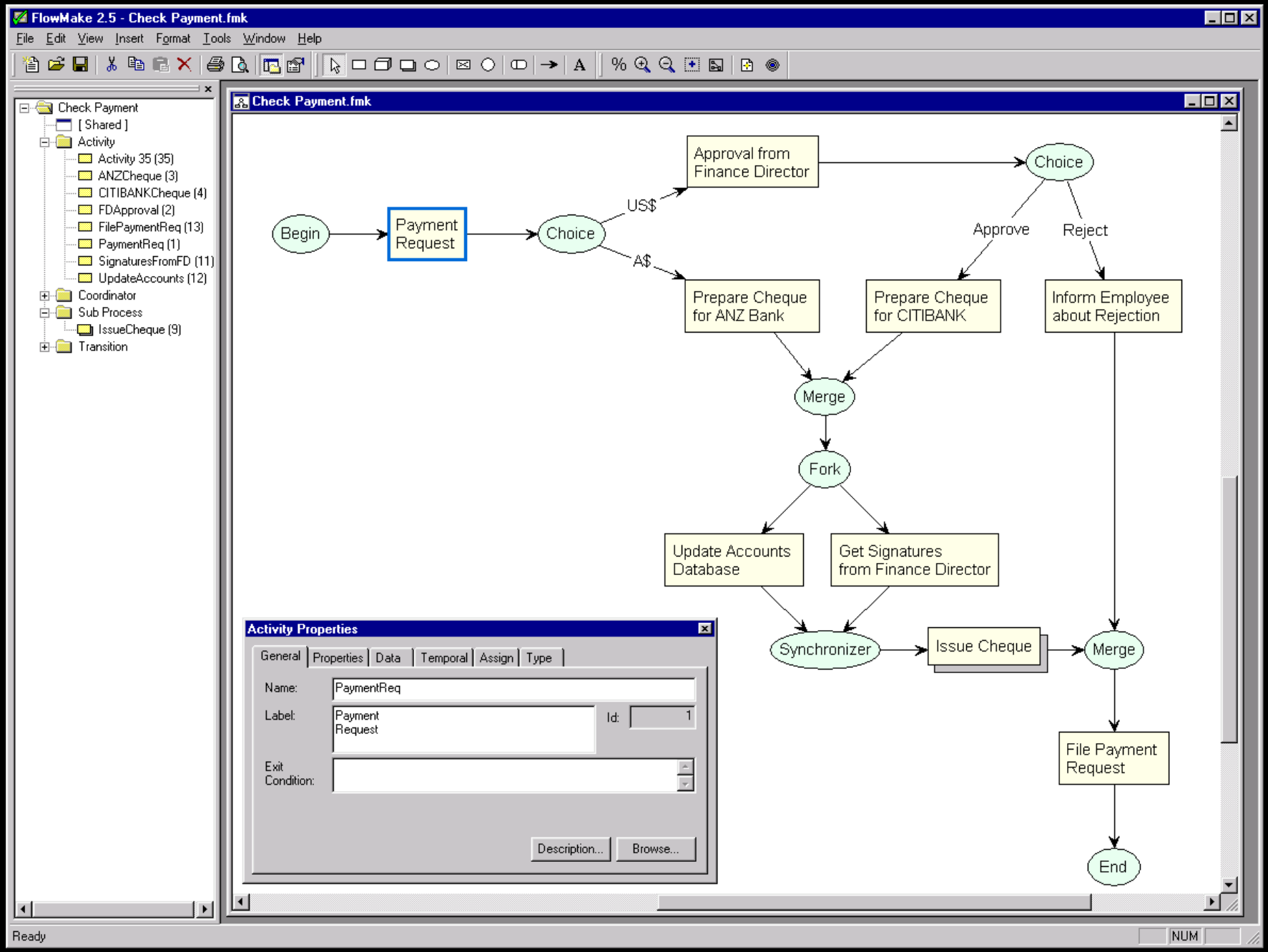


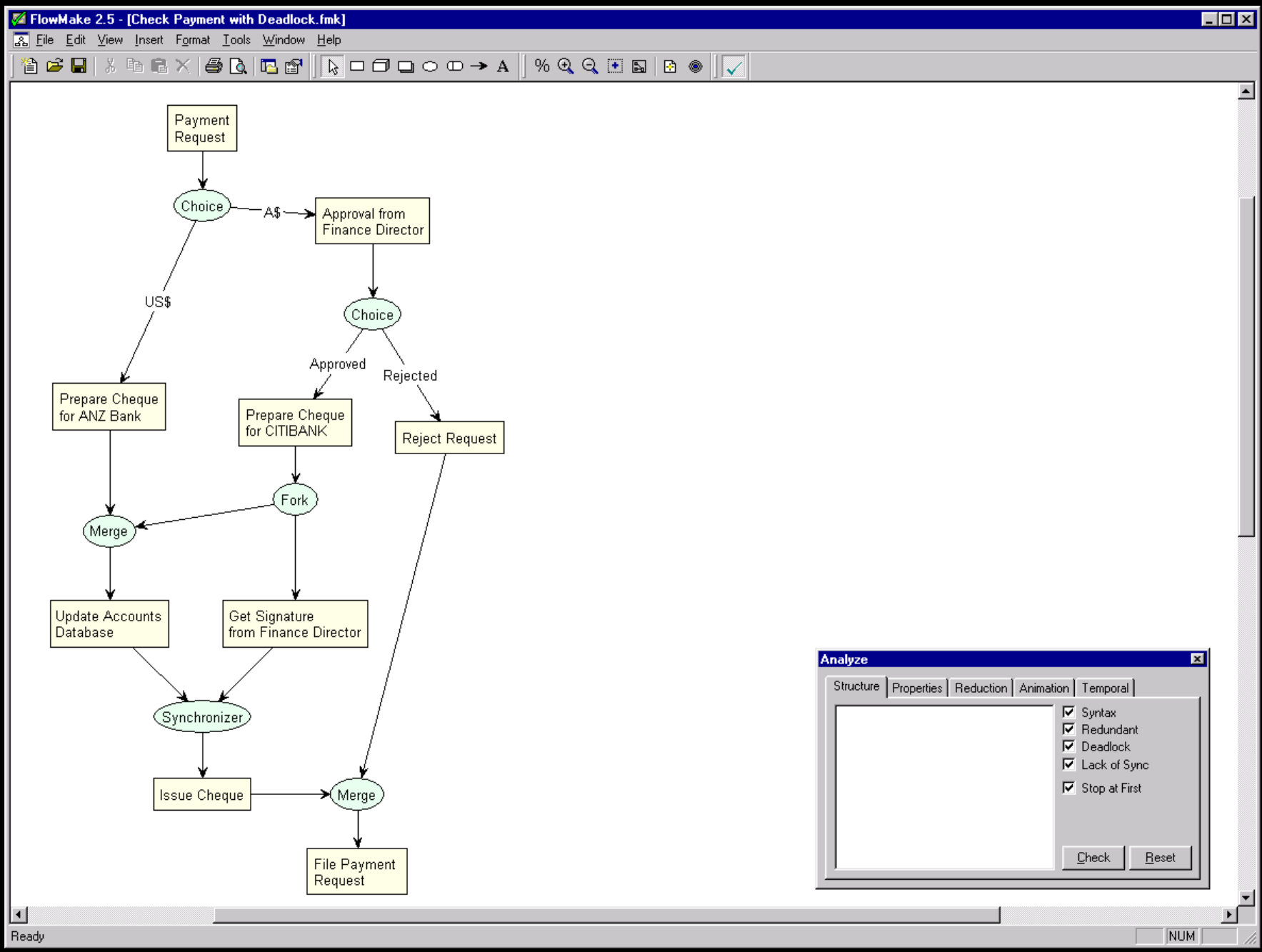
Activity Sub Process Block Coordinator Transition

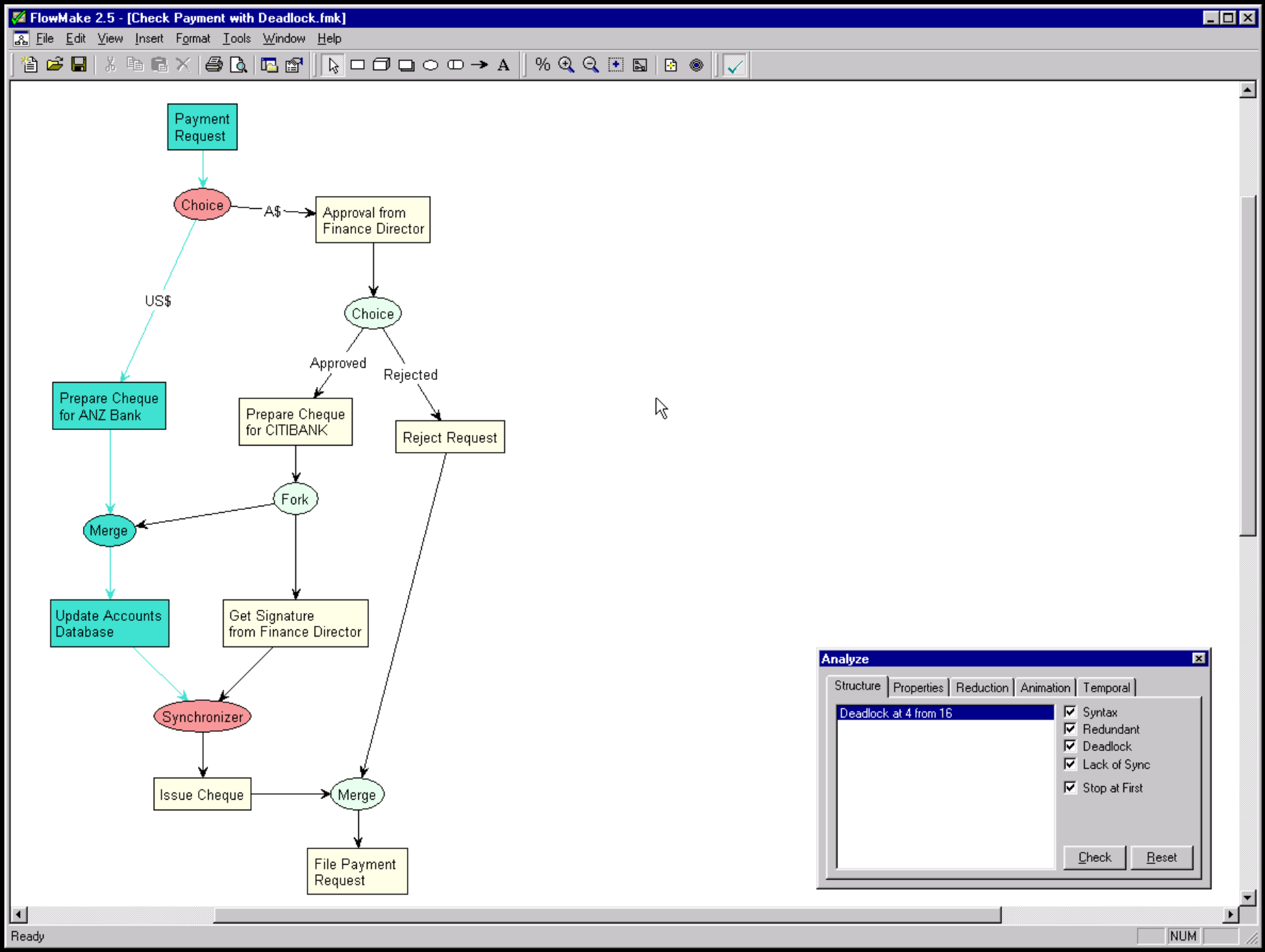
Core Modelling Structures

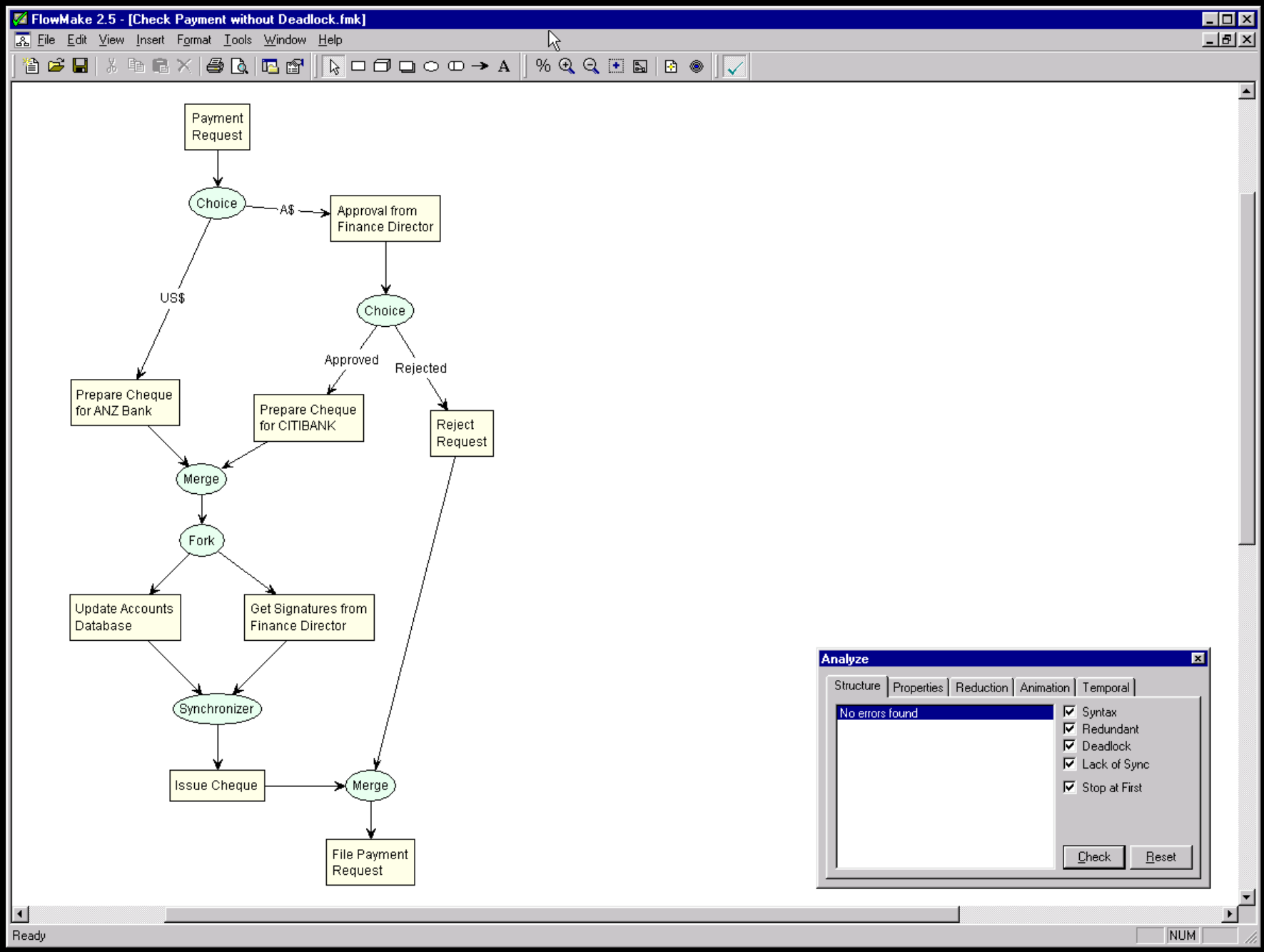


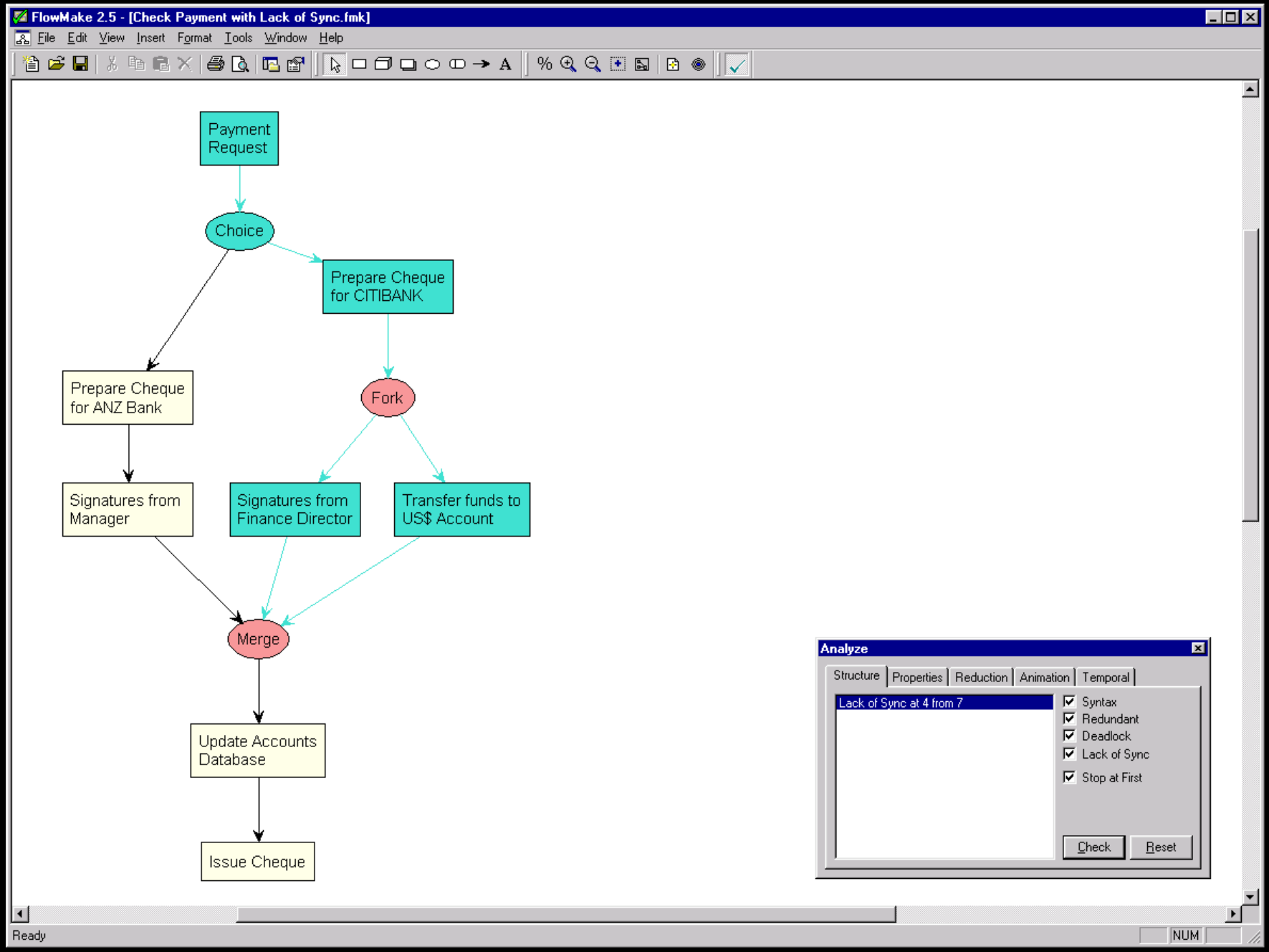
Ready NUM

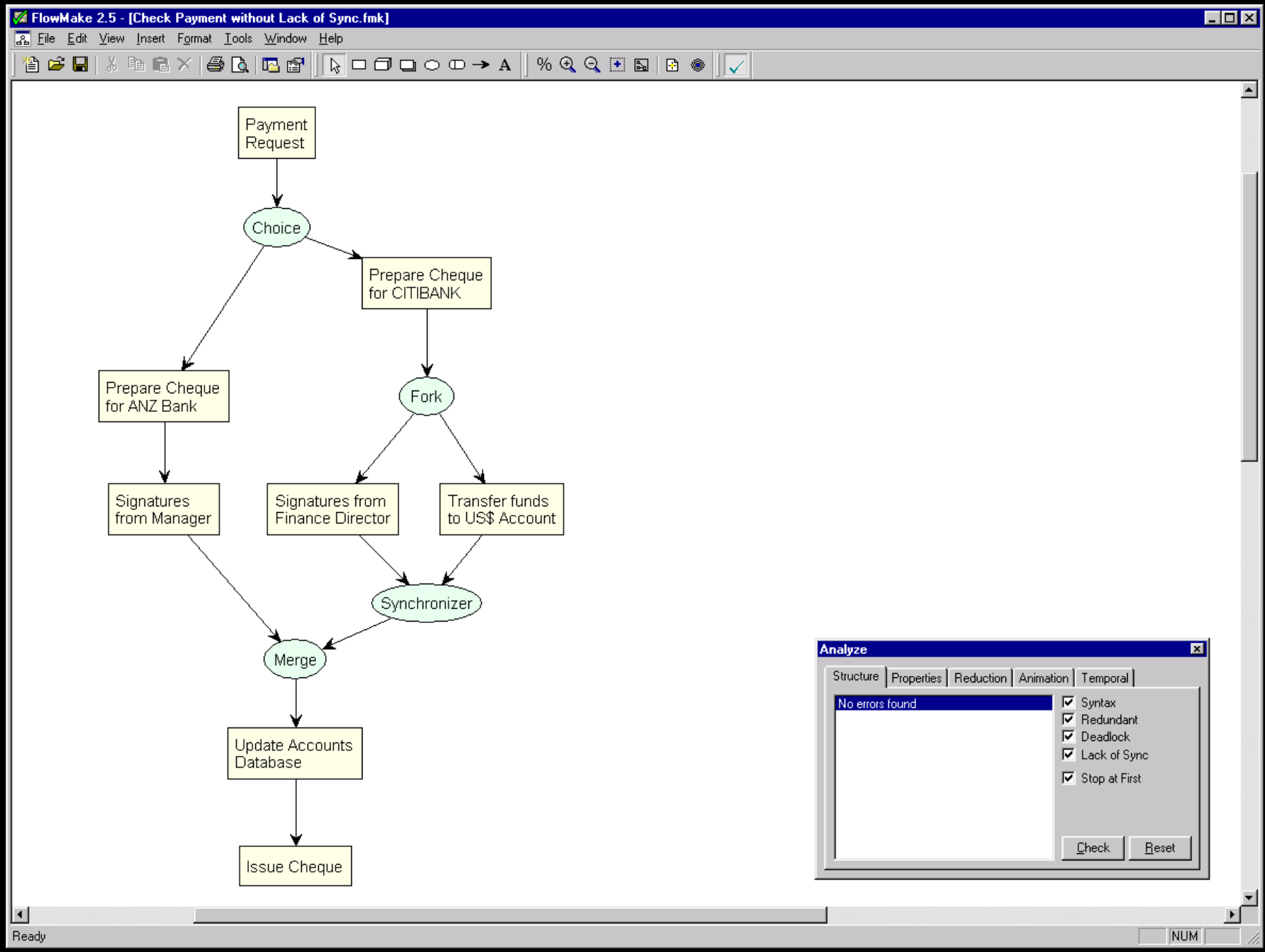

FlowMake 2.5 - Check Payment.fmk
File Edit View Insert Format Tools Window Help
Check Payment
[Shared]
Activity
Activity 35 (35)
ANZCheque (3)
CITIBANKCheque (4)
FDApproval (2)
FilePaymentReq (13)
PaymentReq (1)
SignaturesFromFD (11)
UpdateAccounts (12)
Coordinator
Sub Process
IssueCheque (9)
Transition
Check Payment.fmk
Begin
Payment Request
Choice
US$
A$
Approval from Finance Director
Choice
Approve
Reject
Prepare Cheque for ANZ Bank
Prepare Cheque for CITIBANK
Inform Employee about Rejection
Merge
Fork
Update Accounts Database
Get Signatures from Finance Director
Synchronizer
Issue Cheque
Merge
File Payment Request
End
Activity Properties
General Properties Data Temporal Assign Type
Name: PaymentReq
Label: Payment Request
Id: 1
Exit Condition:
Description...
Browse...
Ready
NUM

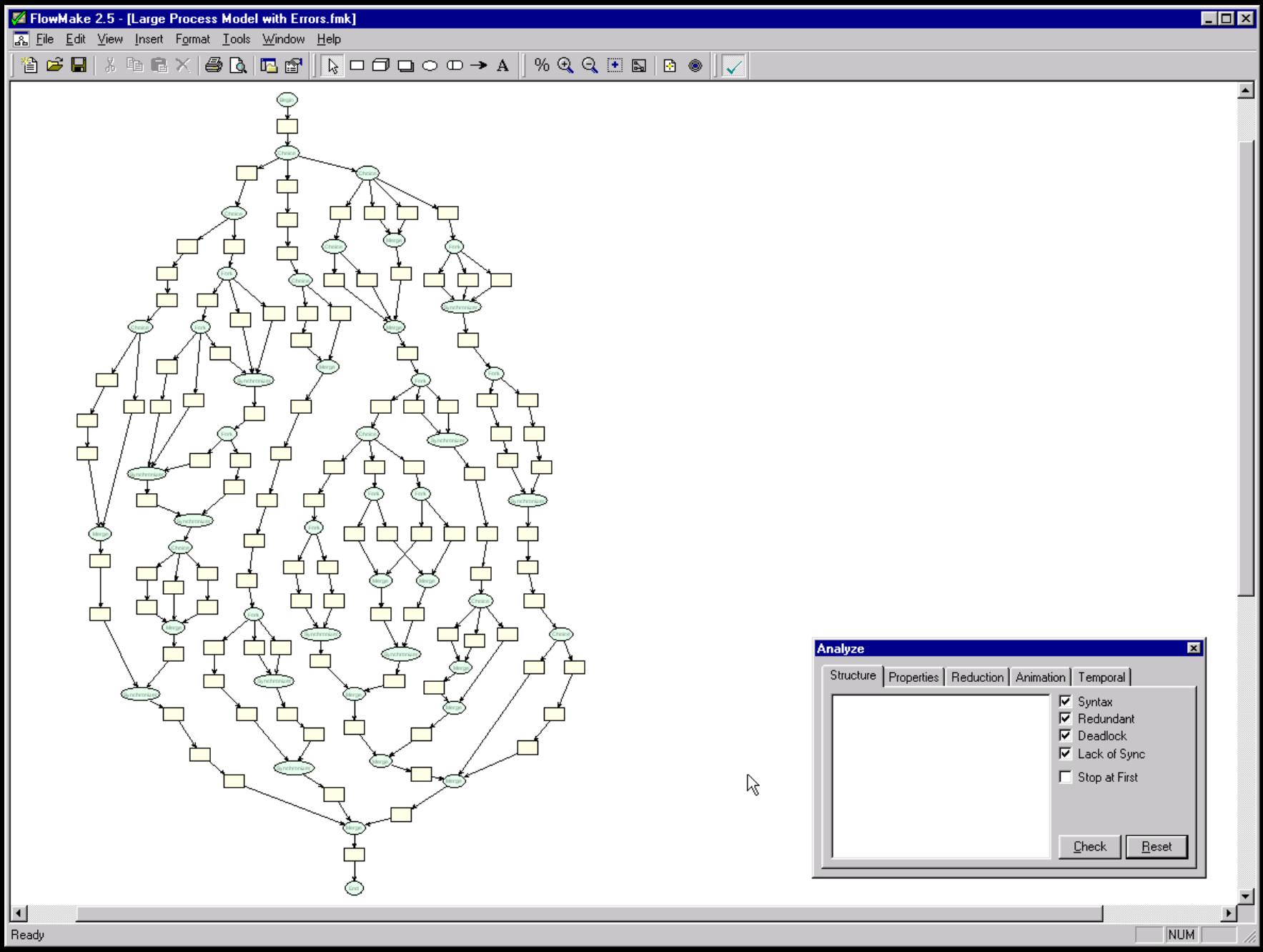

FlowMake 2.5 - [Check Payment with Deadlock.fmk]
File Edit View Insert Format Tools Window Help
Payment Request
Choice
A$
Approval from Finance Director
US$
Choice
Approved
Rejected
Prepare Cheque for ANZ Bank
Prepare Cheque for CITIBANK
Reject Request
Fork
Merge
Update Accounts Database
Get Signature from Finance Director
Synchronizer
Issue Cheque
Merge
File Payment Request
Analyze
Structure
Properties
Reduction
Animation
Temporal
Syntax
Redundant
Deadlock
Lack of Sync
Stop at First
Check
Reset
Ready
NUM

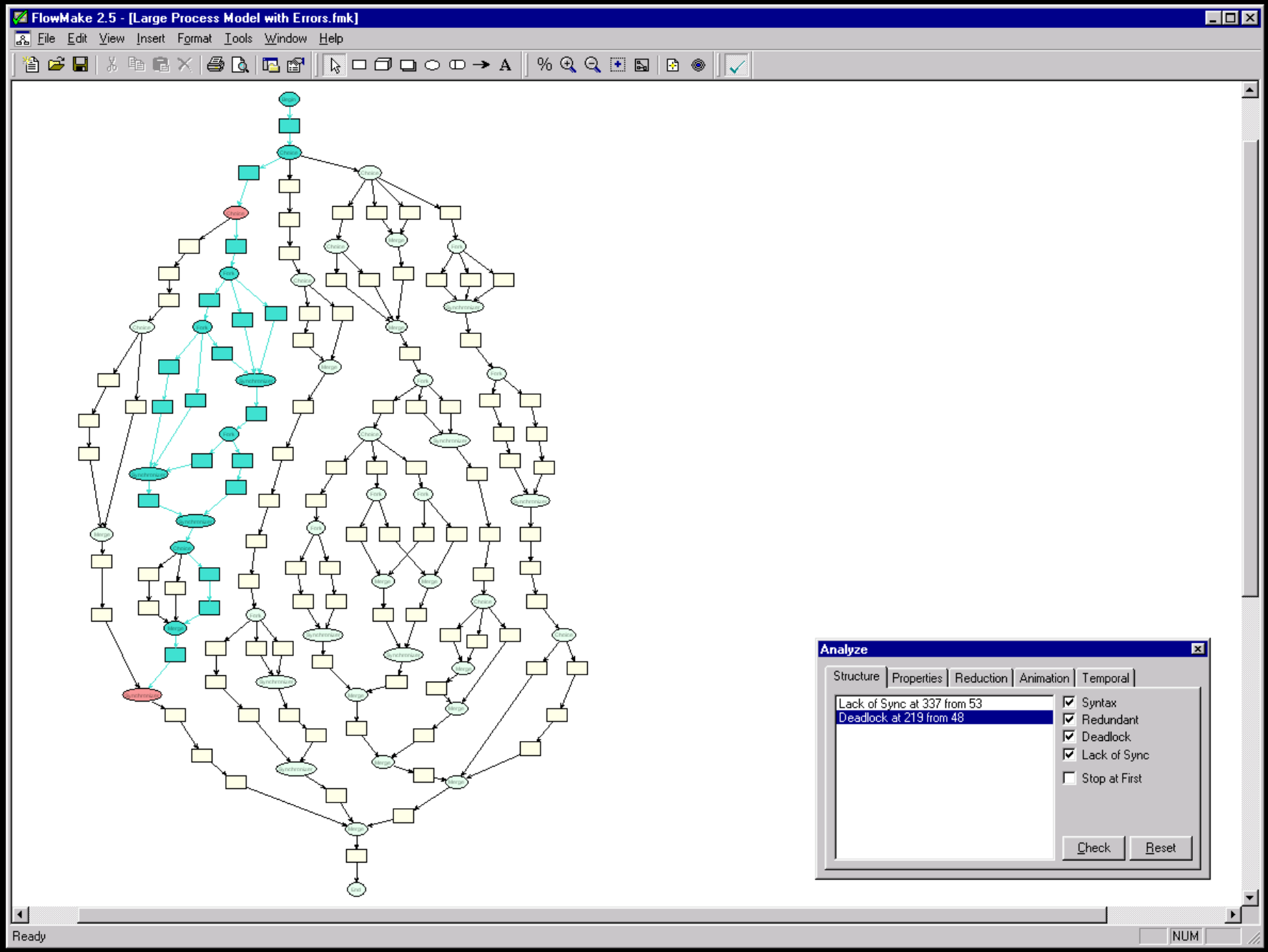

FlowMake 2.5 - [Check Payment with Deadlock.fmk]
File Edit View Insert Format Tools Window Help
Payment Request
Choice
A$
Approval from Finance Director
US$
Choice
Approved
Rejected
Prepare Cheque for ANZ Bank
Prepare Cheque for CITIBANK
Reject Request
Fork
Merge
Update Accounts Database
Get Signature from Finance Director
Synchronizer
Issue Cheque
Merge
File Payment Request
Analyze
Structure
Properties
Reduction
Animation
Temporal
Deadlock at 4 from 16
Syntax
Redundant
Deadlock
Lack of Sync
Stop at First
Check
Reset
Ready
NUM

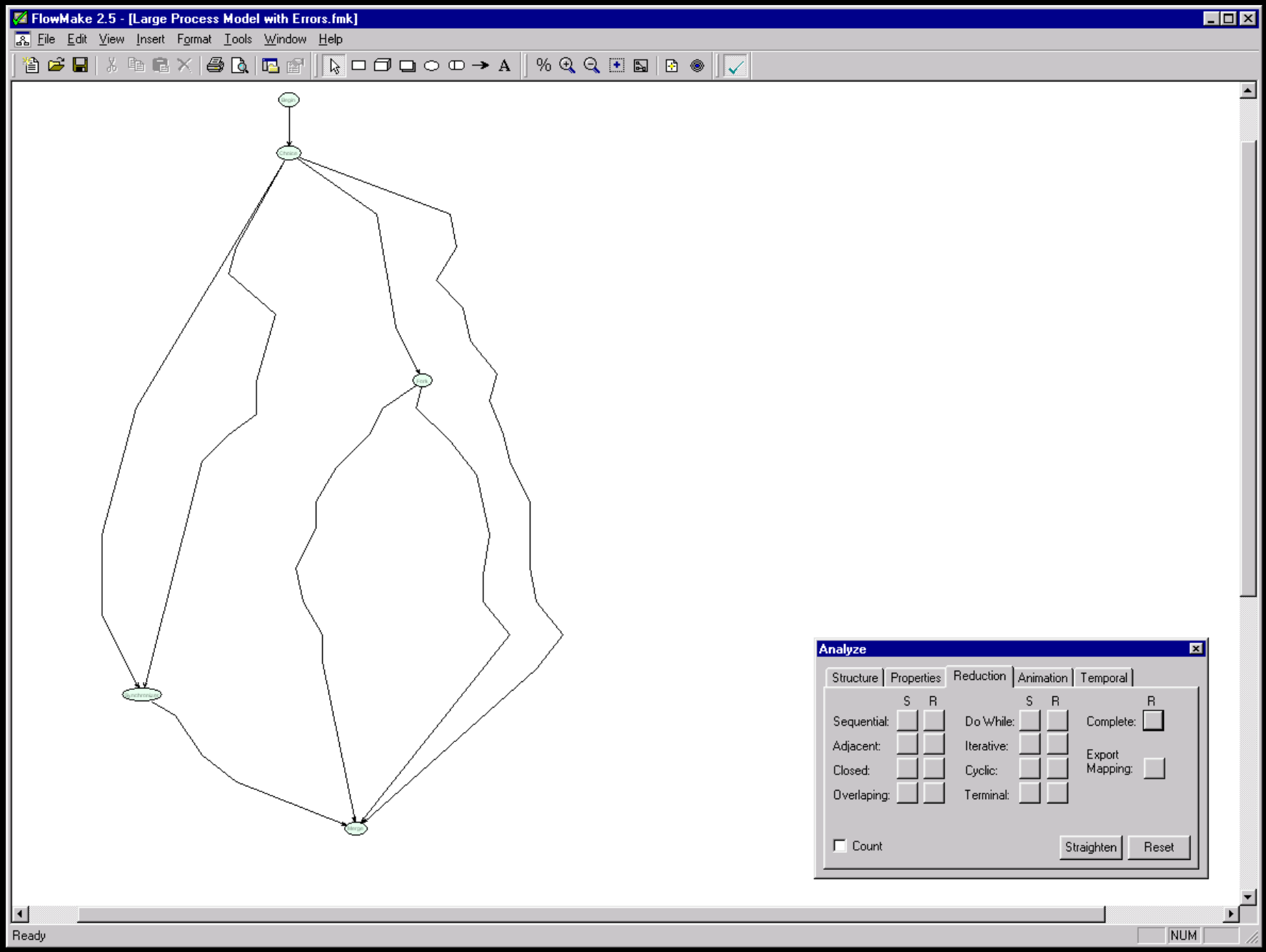

FlowMake 2.5 - [Check Payment without Deadlock.fmk]
File Edit View Insert Format Tools Window Help
Payment Request
Choice
A$
Approval from Finance Director
US$
Choice
Approved
Rejected
Prepare Cheque for ANZ Bank
Prepare Cheque for CITIBANK
Reject Request
Merge
Fork
Update Accounts Database
Get Signatures from Finance Director
Synchronizer
Issue Cheque
Merge
File Payment Request
Analyze
Structure
Properties
Reduction
Animation
Temporal
No errors found
Syntax
Redundant
Deadlock
Lack of Sync
Stop at First
Check
Reset
Ready
NUM

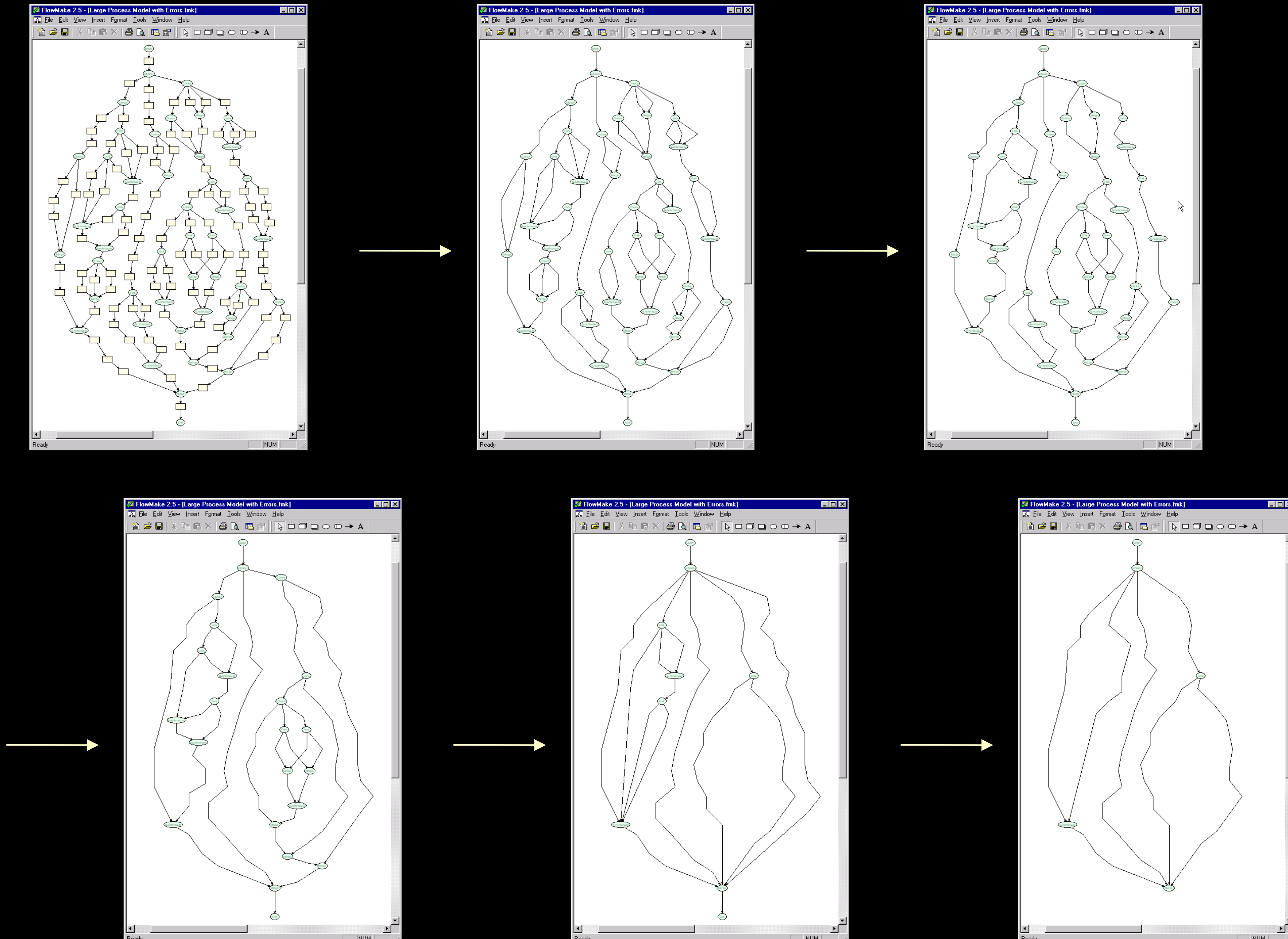

FlowMake 2.5 - [Check Payment with Lack of Sync.fmk]
File Edit View Insert Format Tools Window Help
Payment Request
Choice
Prepare Cheque for CITIBANK
Prepare Cheque for ANZ Bank
Fork
Signatures from Manager
Signatures from Finance Director
Transfer funds to US$ Account
Merge
Update Accounts Database
Issue Cheque
Analyze
Structure
Properties
Reduction
Animation
Temporal
Lack of Sync at 4 from 7
Syntax
Redundant
Deadlock
Lack of Sync
Stop at First
Check
Reset
Ready
NUM


FlowMake 2.5 - [Check Payment without Lack of Sync.fmk]
File Edit View Insert Format Tools Window Help
Payment Request
Choice
Prepare Cheque for CITIBANK
Prepare Cheque for ANZ Bank
Fork
Signatures from Manager
Signatures from Finance Director
Transfer funds to US$ Account
Synchronizer
Merge
Update Accounts Database
Issue Cheque
Analyze
Structure
Properties
Reduction
Animation
Temporal
No errors found
Syntax
Redundant
Deadlock
Lack of Sync
Stop at First
Check
Reset
Ready
NUM

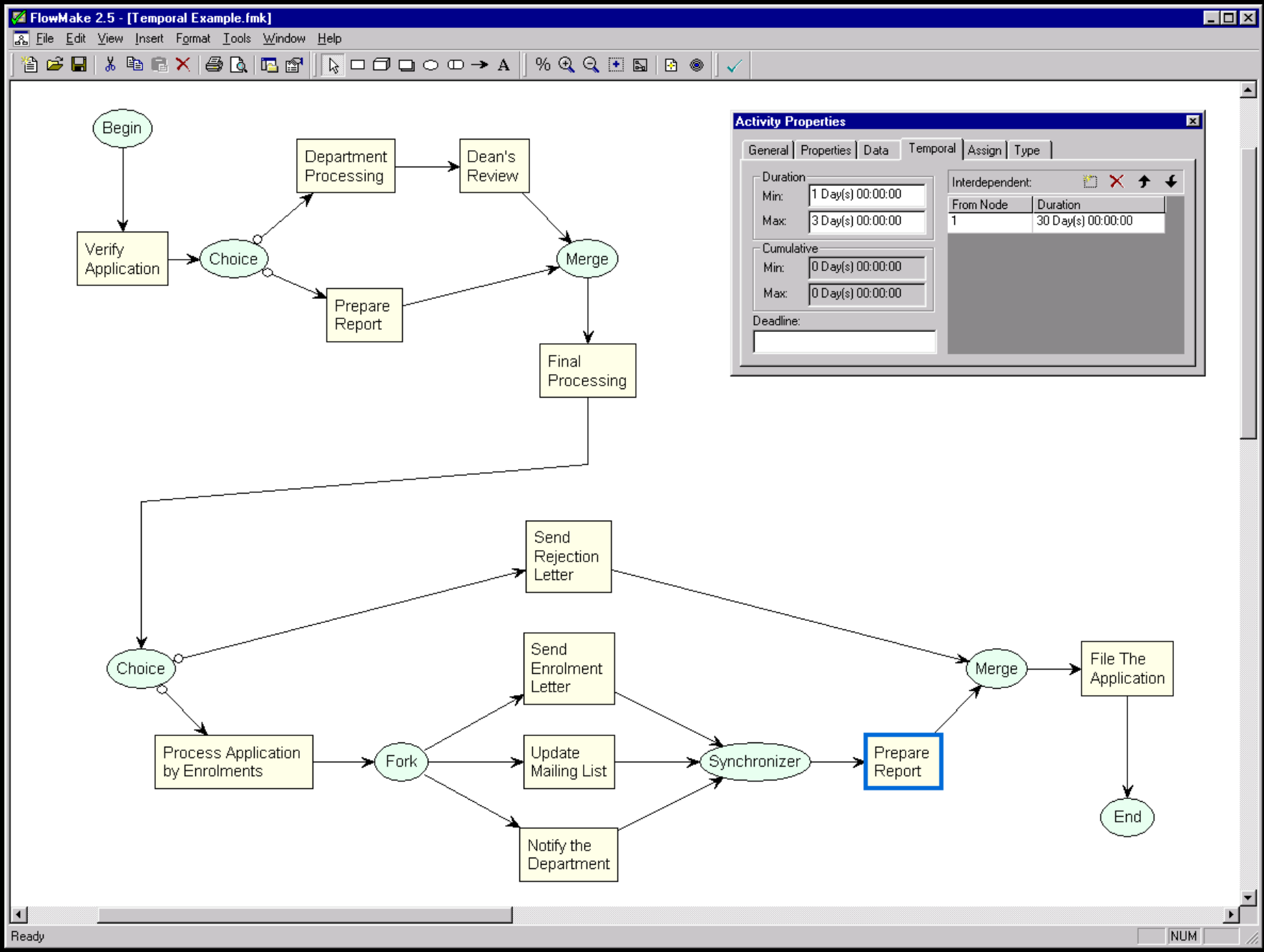

FlowMake 2.5 - [Large Process Model with Errors.fmk]
File Edit View Insert Format Tools Window Help
Analyze
Structure Properties Reduction Animation Temporal
Syntax
Redundant
Deadlock
Lack of Sync
Stop at First
Check Reset
Ready
NUM

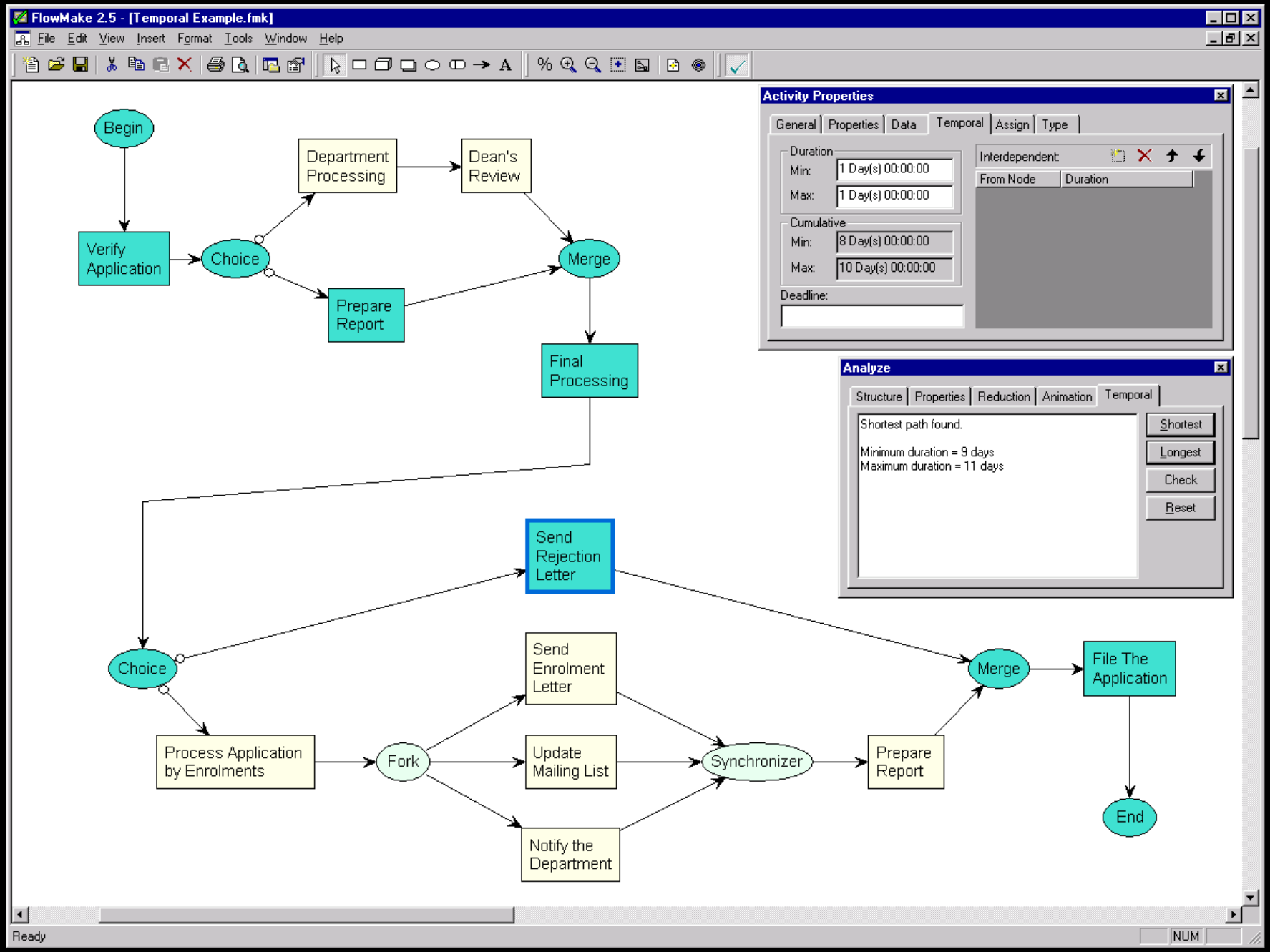

FlowMake 2.5 - [Large Process Model with Errors.fmk]
File Edit View Insert Format Tools Window Help
Analyze
Structure Properties Reduction Animation Temporal
Lack of Sync at 337 from 53
Deadlock at 219 from 48
Syntax
Redundant
Deadlock
Lack of Sync
Stop at First
Check
Reset
Ready
NUM


FlowMake 2.5 - [Large Process Model with Errors.fmk]
File Edit View Insert Format Tools Window Help
Analyze
Structure Properties Reduction Animation Temporal
S R
Sequential:
Adjacent:
Closed:
Overlaping:
Do While:
Iterative:
Cyclic:
Terminal:
Complete:
Export Mapping:
Count
Straighten
Reset
Ready
NUM


FlowMake 2.5 - [Large Process Model with Errors.fmk]
File Edit View Insert Format Tools Window Help
Ready
NUM

ZMA-8


FlowMake 2.5 - [Temporal Example.fmk]
File Edit View Insert Format Tools Window Help
Begin
Verify Application
Choice
Department Processing
Dean's Review
Prepare Report
Merge
Final Processing
Activity Properties
General Properties Data Temporal Assign Type
Duration
Min: 1 Day(s) 00:00:00
Max: 3 Day(s) 00:00:00
Cumulative
Min: 0 Day(s) 00:00:00
Max: 0 Day(s) 00:00:00
Deadline:
Interdependent:
From Node Duration
1 30 Day(s) 00:00:00
Send Rejection Letter
Choice
Send Enrolment Letter
Process Application by Enrolments
Fork
Update Mailing List
Synchronizer
Prepare Report
Merge
File The Application
Notify the Department
End
Ready
NUM


FlowMake 2.5 - [Temporal Example.fmk]
File Edit View Insert Format Tools Window Help
Begin
Verify Application
Choice
Department Processing
Dean's Review
Prepare Report
Merge
Final Processing
Activity Properties
General Properties Data Temporal Assign Type
Duration
Min: 1 Day(s) 00:00:00
Max: 1 Day(s) 00:00:00
Cumulative
Min: 8 Day(s) 00:00:00
Max: 10 Day(s) 00:00:00
Deadline:
Interdependent:
From Node Duration
Analyze
Structure Properties Reduction Animation Temporal
Shortest path found.
Minimum duration = 9 days
Maximum duration = 11 days
Shortest
Longest
Check
Reset
Send Rejection Letter
Choice
Send Enrolment Letter
Process Application by Enrolments
Fork
Update Mailing List
Synchronizer
Prepare Report
Merge
File The Application
Notify the Department
End
Ready
NUM

Conclusions

- **Some limited verification capabilities have been discussed,**
- **Integration of more aspects such as data flow, constraints and temporal aspects requires more research,**
- **Fundamental problem - product dependent concepts and notions for process specification,**

Dynamic Aspects of Workflows

Dynamic Aspects of Workflows

- **Dynamic Modifications to Business Process Specification,**
- **Exceptions Handling,**
- **Business Process Evolution,**

Process Execution

- **User starts activity,**
- **Activity describes program to be executed,**
- **Registered program is called,**
- **Program takes process relevant data from “in” and puts data into “out” data containers,**
- **Program communicates with user and processes the data,**

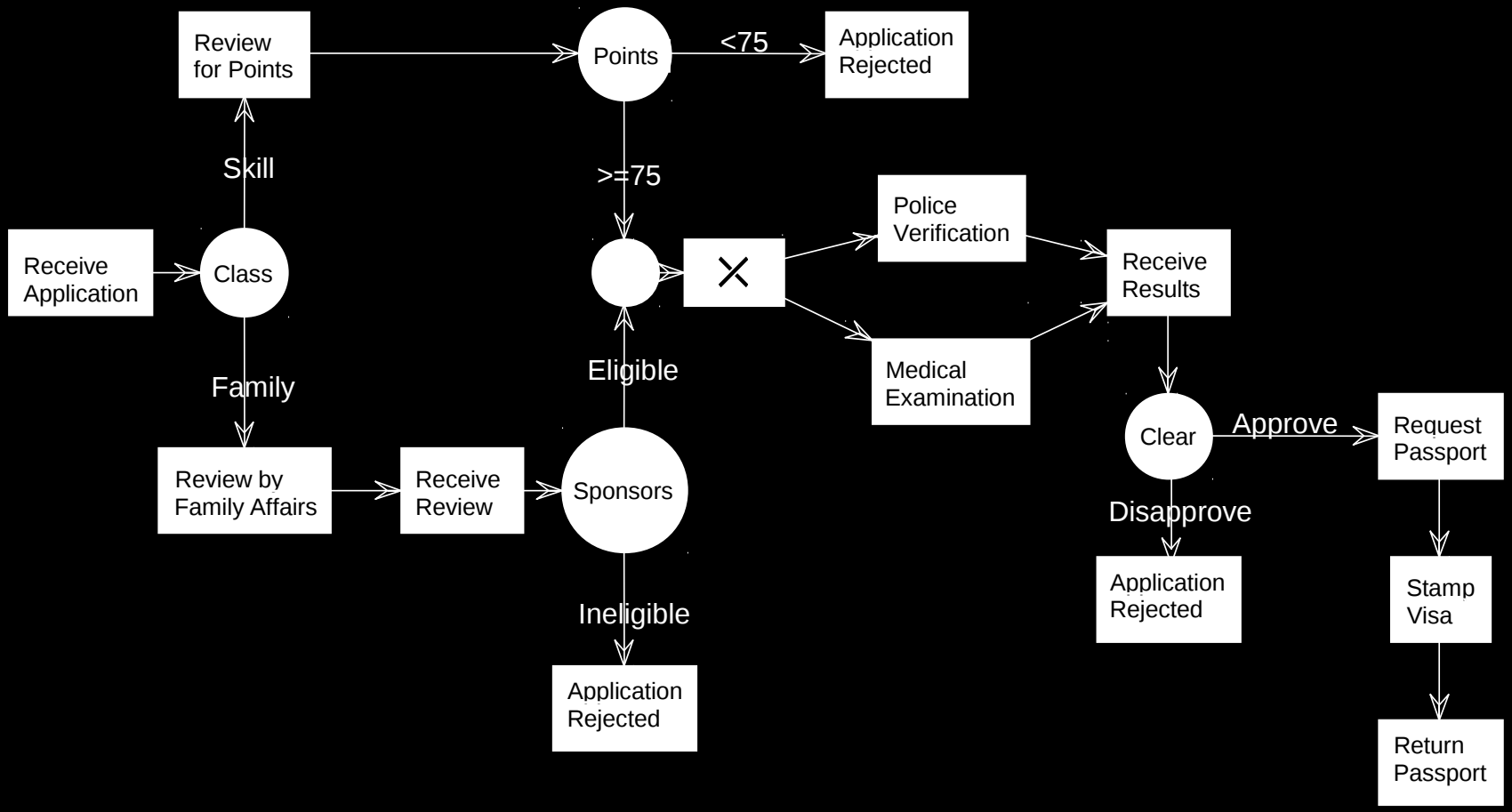
Effects of Business Process Change

- **Flush** — **Current instances are allowed to complete**
- **Abort** — **Some instances are terminated before completion**
- **Migrate** — **Instances are ‘switched’ to new model**
- **Adapt** — **Some instances have to be treated differently from the model**
- **Build** — **Instance execution defines the model**

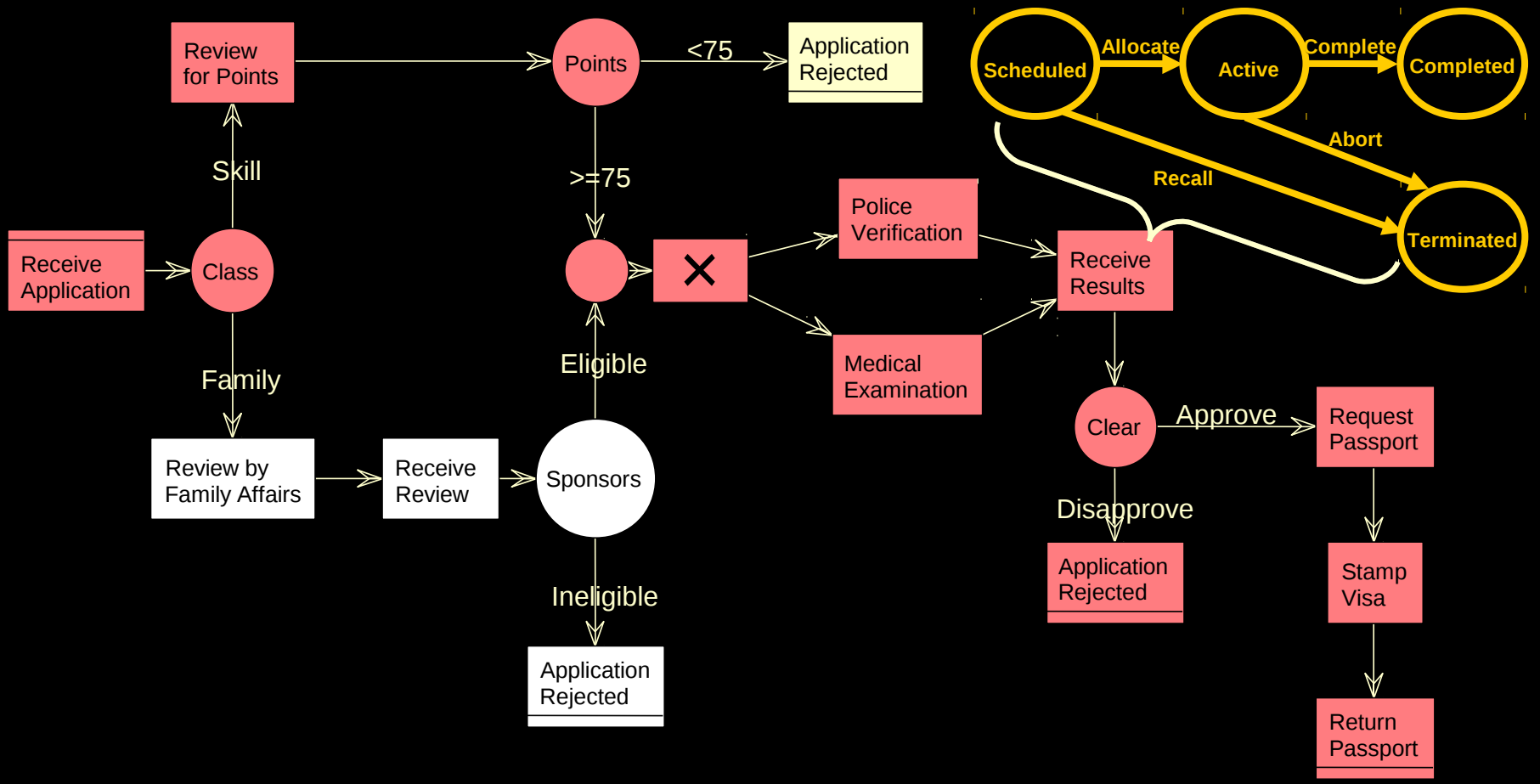
Scope of the Policies

Policy	Model Changed?	Affected Instances	Compliant Instances
Flush	Y	None	-
Abort	Y/N	Some	None
Migrate	Y	All	Some
Adapt	N	Some	Some
Build	Y	All	All

Immigration Process



Immigration Process Instance



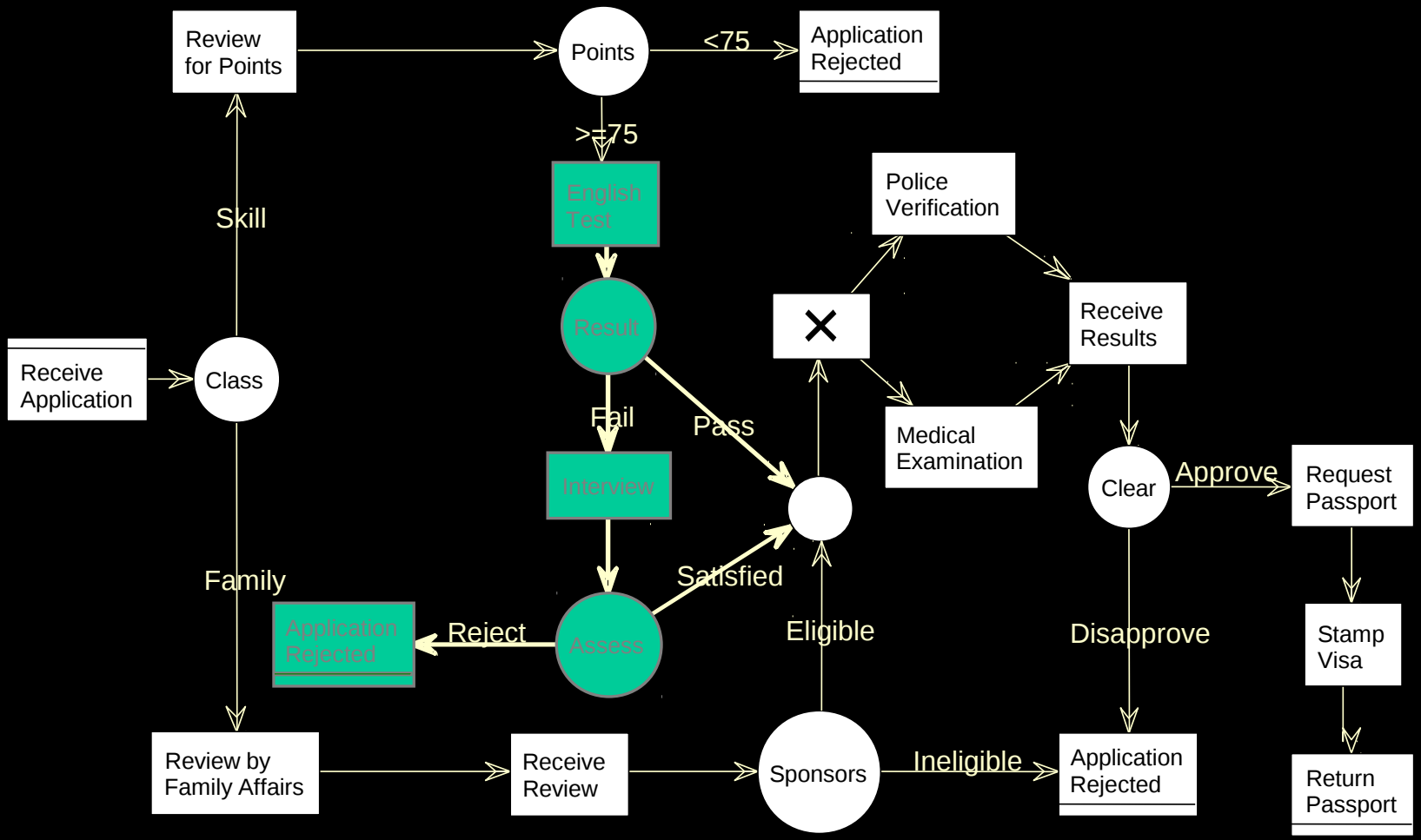
Methodology Phases

- **Defining**
  - **Policy**
  - **Affected Instances**
  - **Changes to the model**
- **Conforming**
  - **Instance Grouping**
  - **Compliance Graphs**
- **Enacting**

Defining the Change

- **Modification Policy:**
  - **Migrate**
- **Affected Instances:**
  - **All**
- **Changes to the Process Model:**
  - **Must be known**
  - **Must be verified**
- **Changing the workflow graph**
  - **Add new tasks**
  - **Delete existing tasks**
  - **Modify order of execution**
  - **Modify task properties**

Modified Workflow



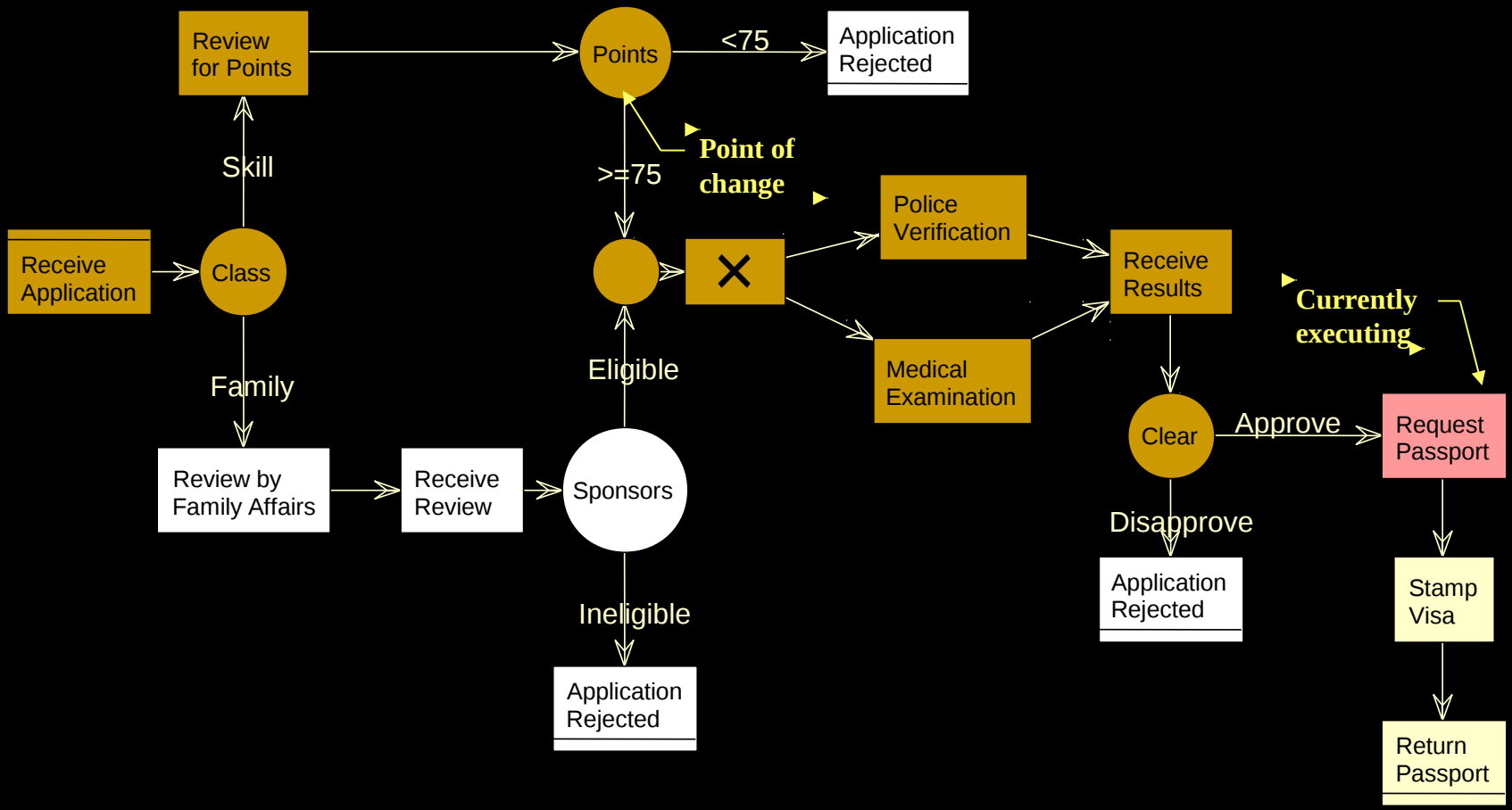
Conforming to the Change

- **Instance Grouping**
  - **Stage**
  - **Compliance**
  - **Class**
- **Compliance graph generation**
  - **Compensation Tasks**
  - **Plug Point**

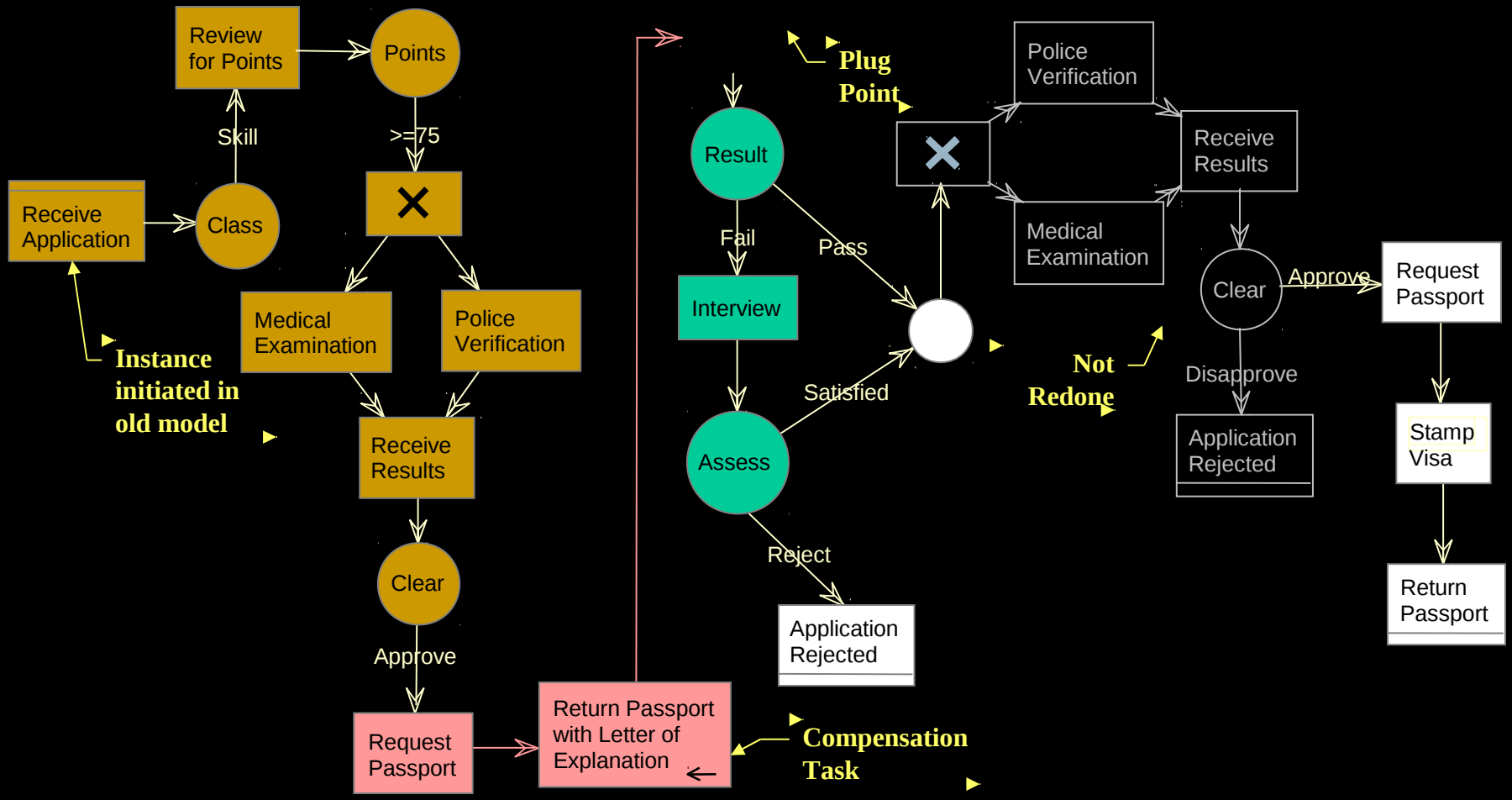
Enacting the Change

- **Handling workflow execution during the transition period**
  - **Instances may follow old model**
  - **New instances will follow new model**
  - **Affected instances will follow compliance graphs**

Affected Instance



Compliance Graph



Specification and verification of temporal constraints

- **Temporal constraints**
  - **specification**
  - **verification**
  - **maintenance**

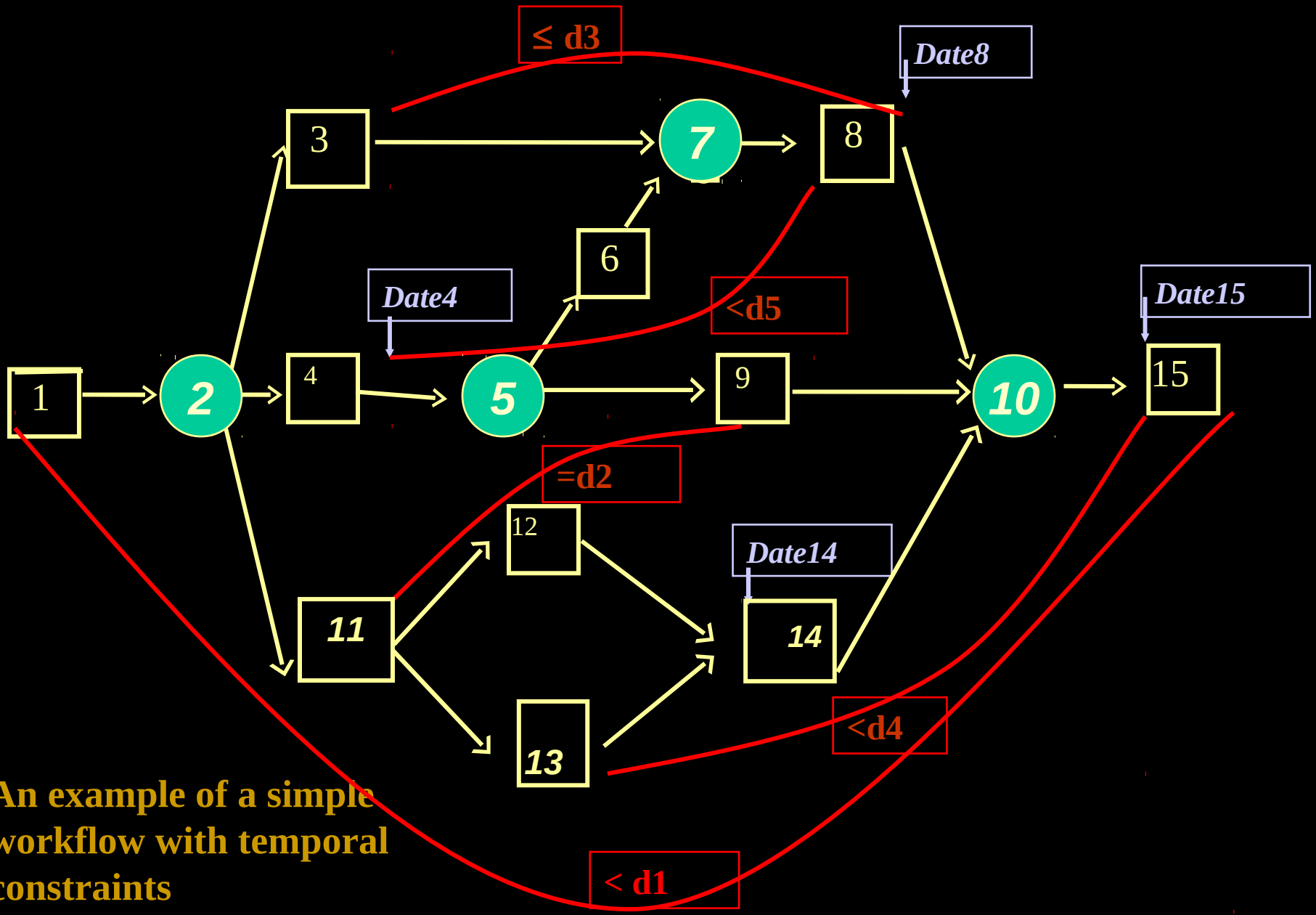
A Framework for Time Management

- **Identification, classification and formal modeling of temporal constraints**
- **Verification of temporal constraints during workflow build time**
  - **Duration and Verification Algorithms**
  - **Visualization of relative time (Duration space)**
- **Time management during run-time;**
  - **Dynamic verification of temporal constraints**
  - **Visualization of absolute time (Instantiation space)**
  - **Run time prediction and scheduling,**
- **Temporal support for exception handling, reactive scheduling and dynamic structural modification,**

Temporal Constraints

- **Basic temporal constraints (duration constraints)**
- **Absolute deadline constraints**
- **Relative deadline constraints (interdependent temporal constraints)**

A temporal constraint is consistent with a given workflow model if and only if based on the syntax of the model and expected minimum and maximum duration of workflow tasks, the temporal constraint can be satisfied (a simplified definition)



An example of a simple workflow with temporal constraints

Summary

- **There is a limited support offered by current products for enforcement, verification and monitoring of temporal constraints,**
- **Many specific types of constraints dependent on the application domain,**
- **Substantial research has been completed - see references,**

Limitations

- **User Issues**
  - **Change of the work practices**
- **Potential limitations of Workflows Management Systems**

Workflows Features and Benefits

- **Specially relevant to B2B and eB context,**
  - **Potentially improve productivity,**
  - **Provide continuous monitoring,**
  - **Resource planing and scheduling,**
  - **Potentially easier restructuring of Business Process,**
  - **More precision and better quality of service,**

Limitations

- **WFMS too restrictive,**
  - **too hard to modify business process dynamically,**
  - **too inflexible,**

The Problem

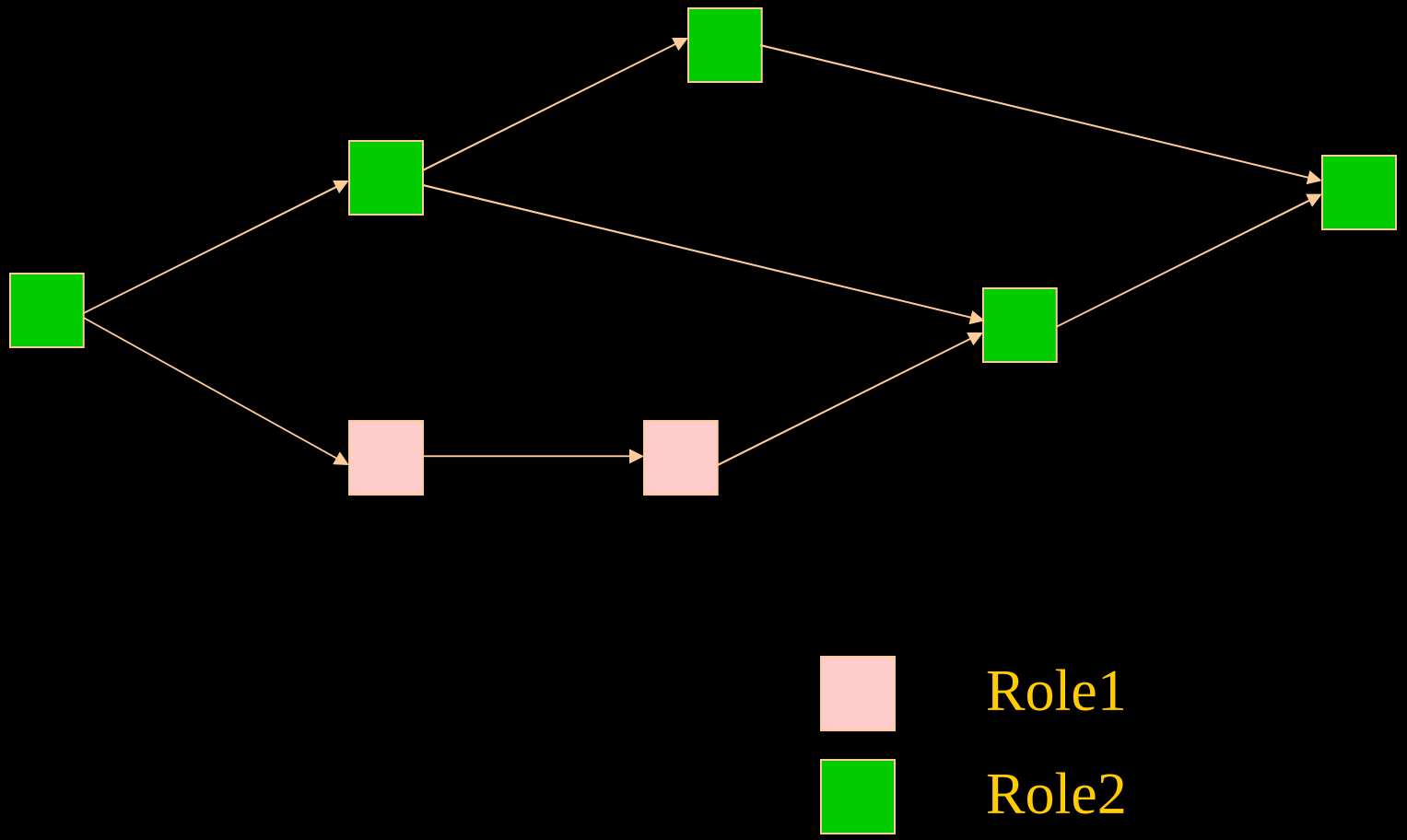
- **Generally,**
  - **Too little focus on the end user – too much on the functional specification,**
  - **No methodology for a complete design,**
- **Main focus on process specification language and meta model,**
- **Uniform treatment of the concept of the process vs process instance,**

Notion of a 'role'

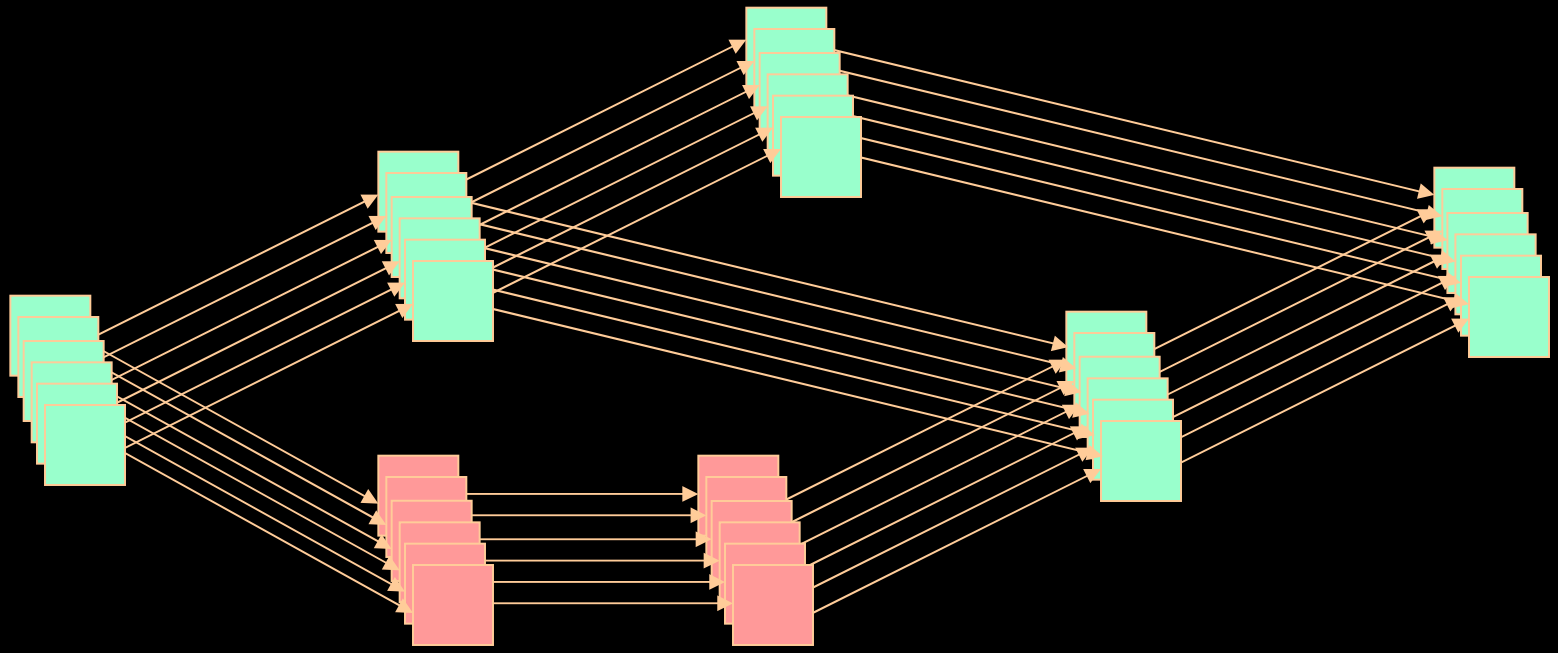
- **Mainly used to specify who is responsible/capable/privileged to execute an activity,**
- **A source of a serious problem -**
  - **A little concern, if any, about the typical work practice for an activity - - what is a good instance for one agent doesn't have to be good instance for other agents involved in the same process**

Examples - orders in e-commerce business, assessment marked by a teaching fellow, etc

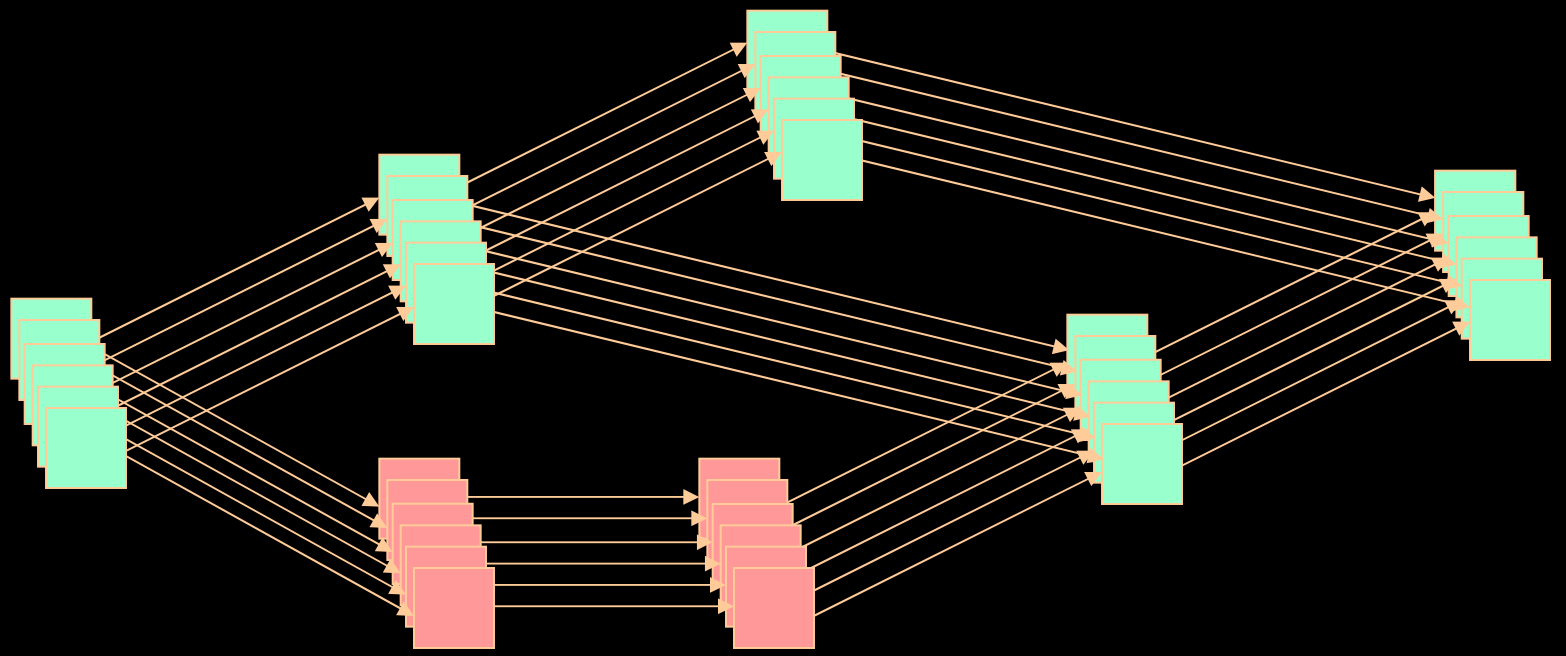
A Simple Process Definition



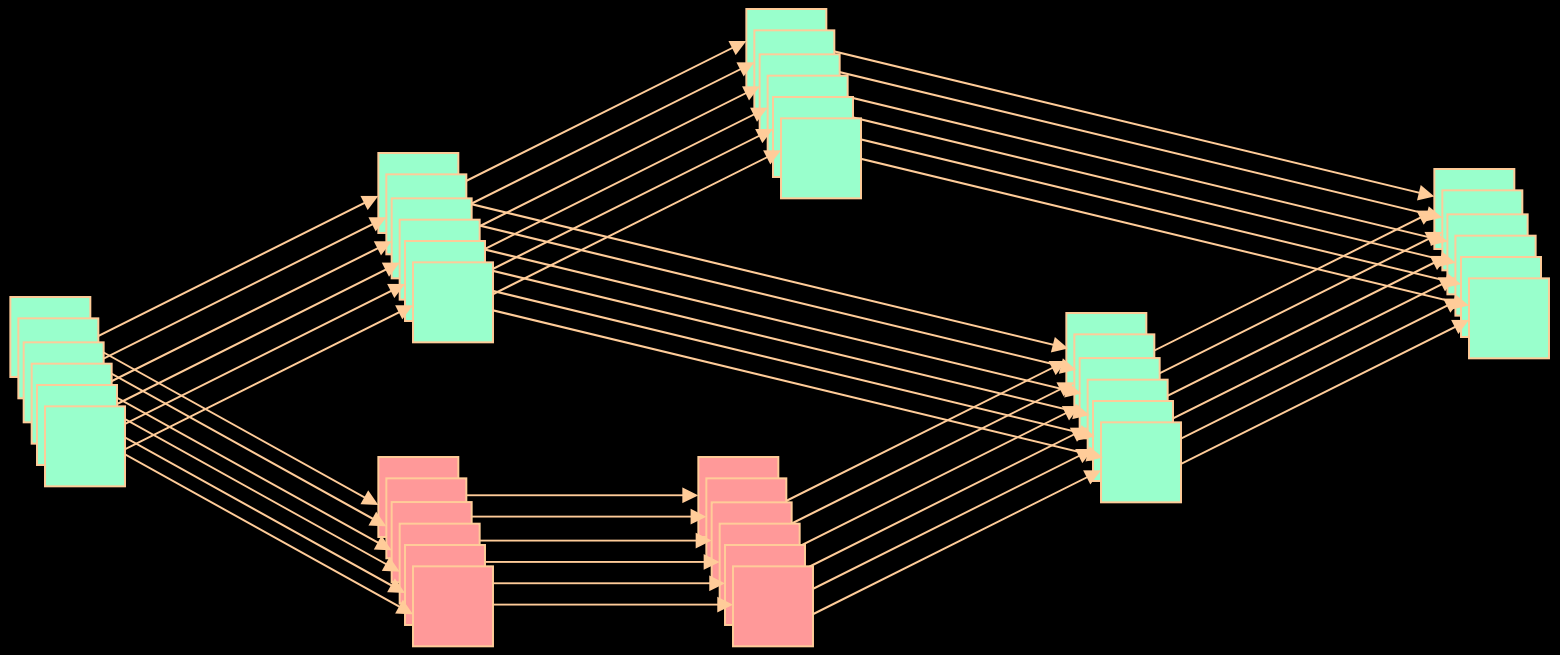
Process Execution



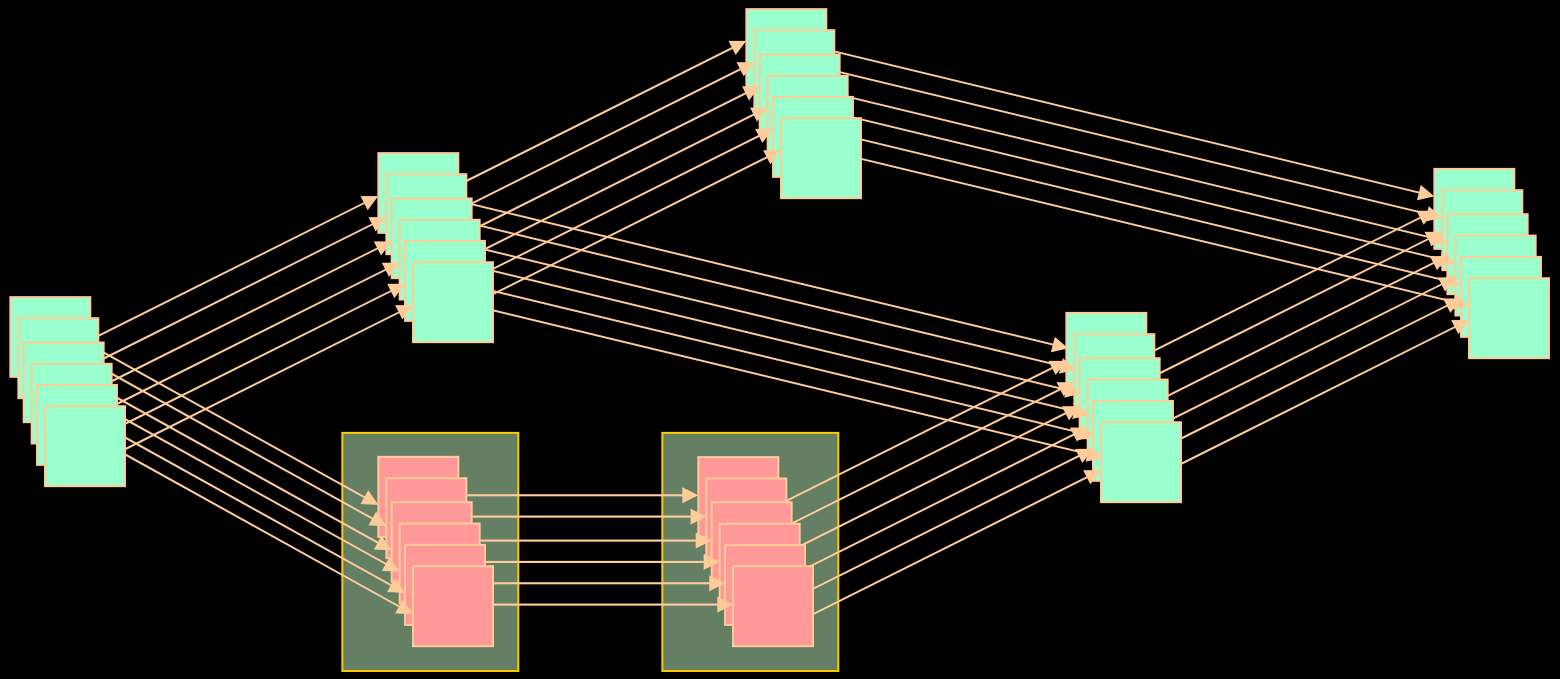
Other Instances Execution



Other Instances Execution



A Collection of Instances - an Activity



Generalization of the Issue

- **The main question is;**
  - **How to accommodate the user preferences in work practice to the WF process model?**
  - **It is easy to destroy the WF concept - synchronization problem, possible delays in execution,**
  - **Different finite state machine behind the activities for different agents – they should collaborate,**

A Possible solution

- **Decompose a process into role specific sub-processes,**
- **Introduce ‘connection points’,**
- **Design a protocol for WF collaboration,**
- **Optimize/modify the collaborative design,**
- **Incorporate into a methodology of WF design - beyond the grammar of the current specification languages,**

New Concepts Required

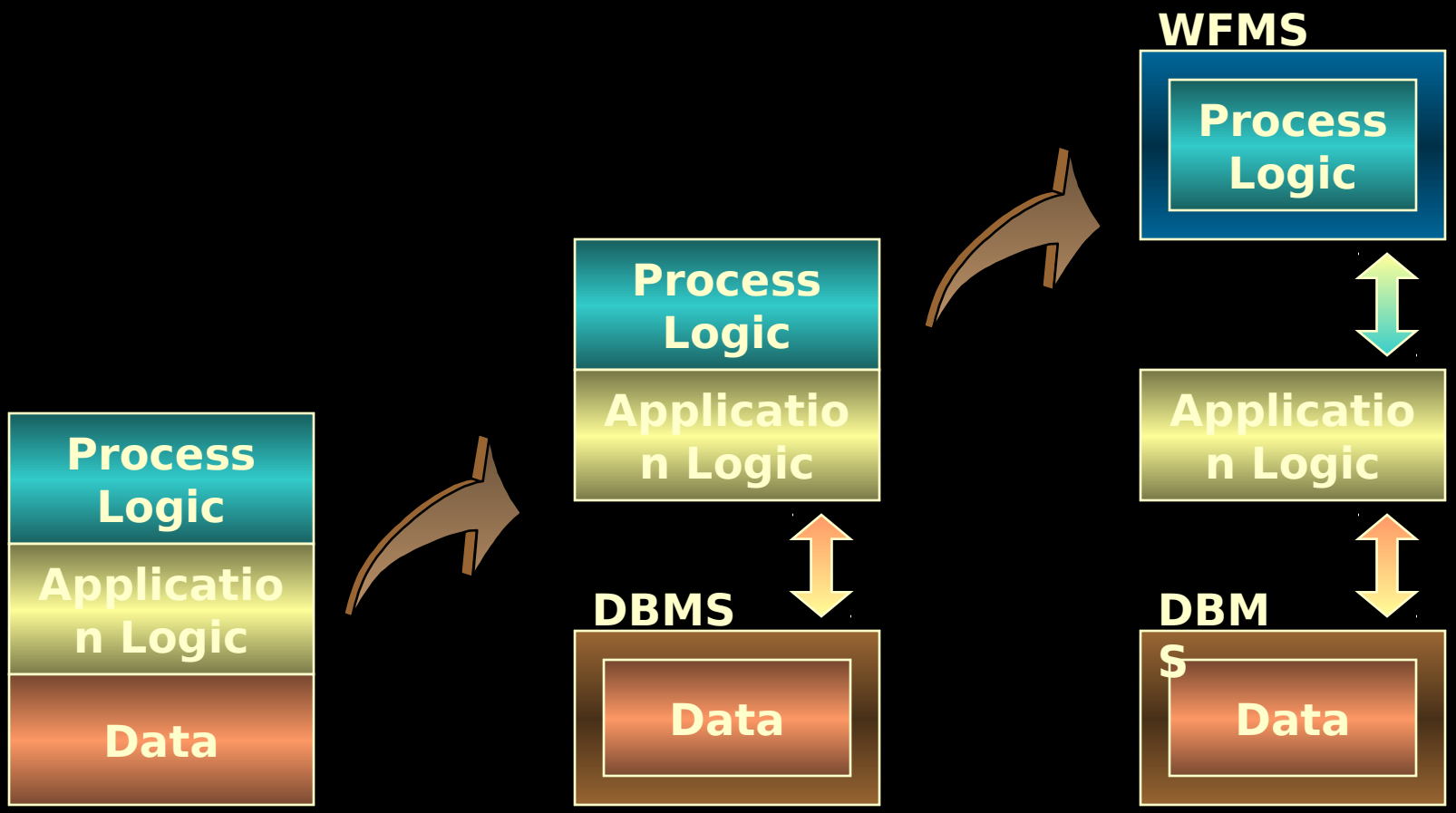
- **Connectors,**
- **Collaborative processes,**
- **Finite state machines behind the activities need to be examined,**
- **BP optimization concept - better understanding of time constraints, blocking as locking in DBs,**

This may impact on new engine architectures

Summary

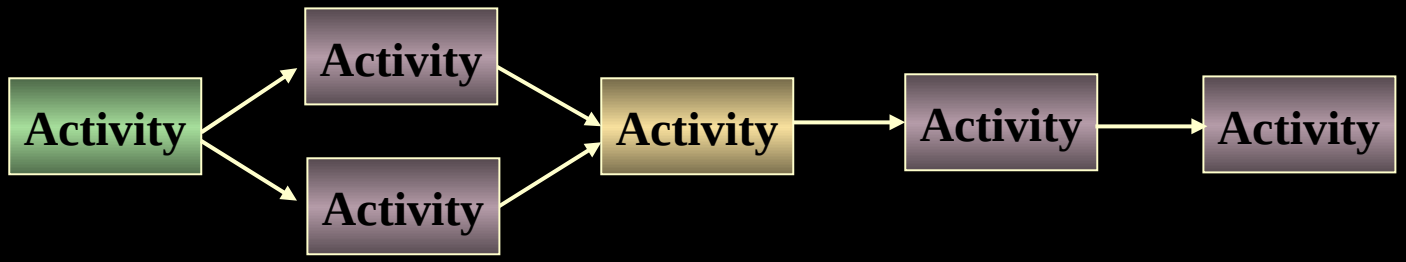
- **Many products,**
- **Many languages for process specification,**
- **Verification is important,**
- **Good potential for e-business and e-services,**
- **More needs to be done in this area,**

Key issue - Separation of Process Logic



Current Computational Model

- **Isolation of process logic triggers;**
  - **User initiated flow - reflecting activity/task progress**
  - **Workflow engine initiated flow- reflecting process progress**

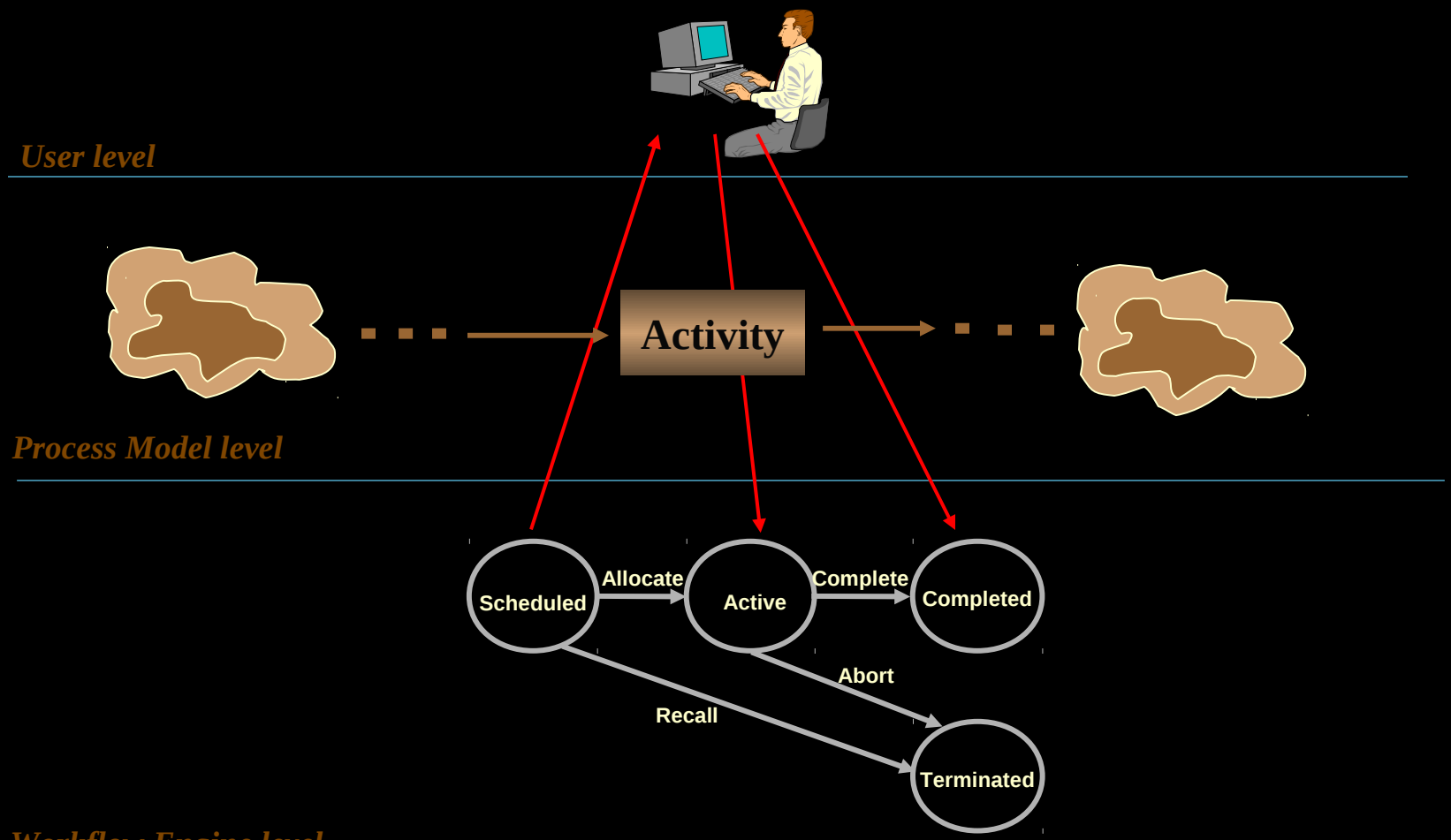


- Leads to many specialised language constructs,
- Provides several abstraction levels,

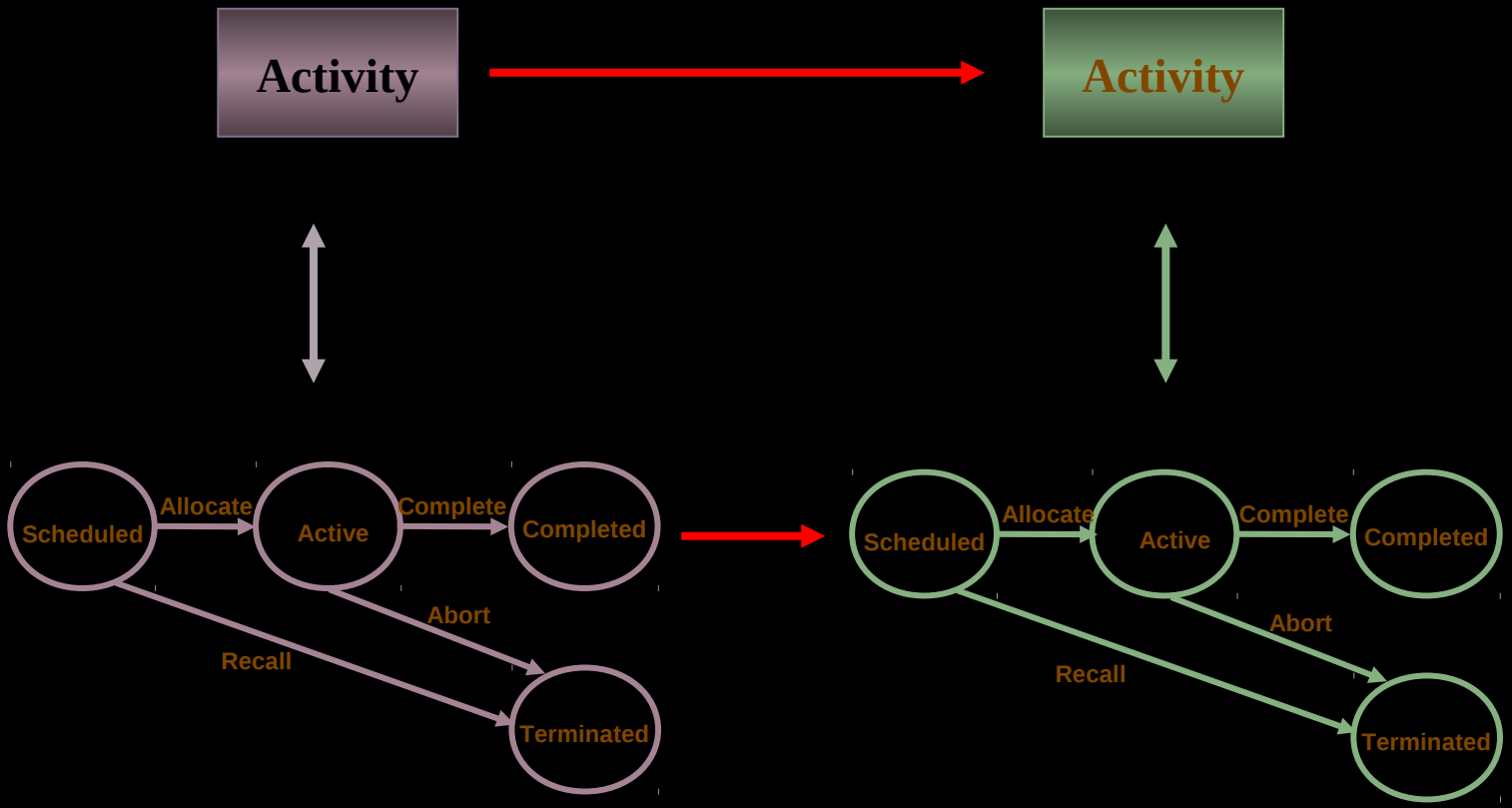
Current Computational Model (cont)

- **Each task has predefined, generic FSM,**
  - **Creates difficulty to map activity logic to engine readable states,**
  - **Provides a strict meaning of the process flow,**
- **Simplicity for the price of restrictions,**

Activity Execution



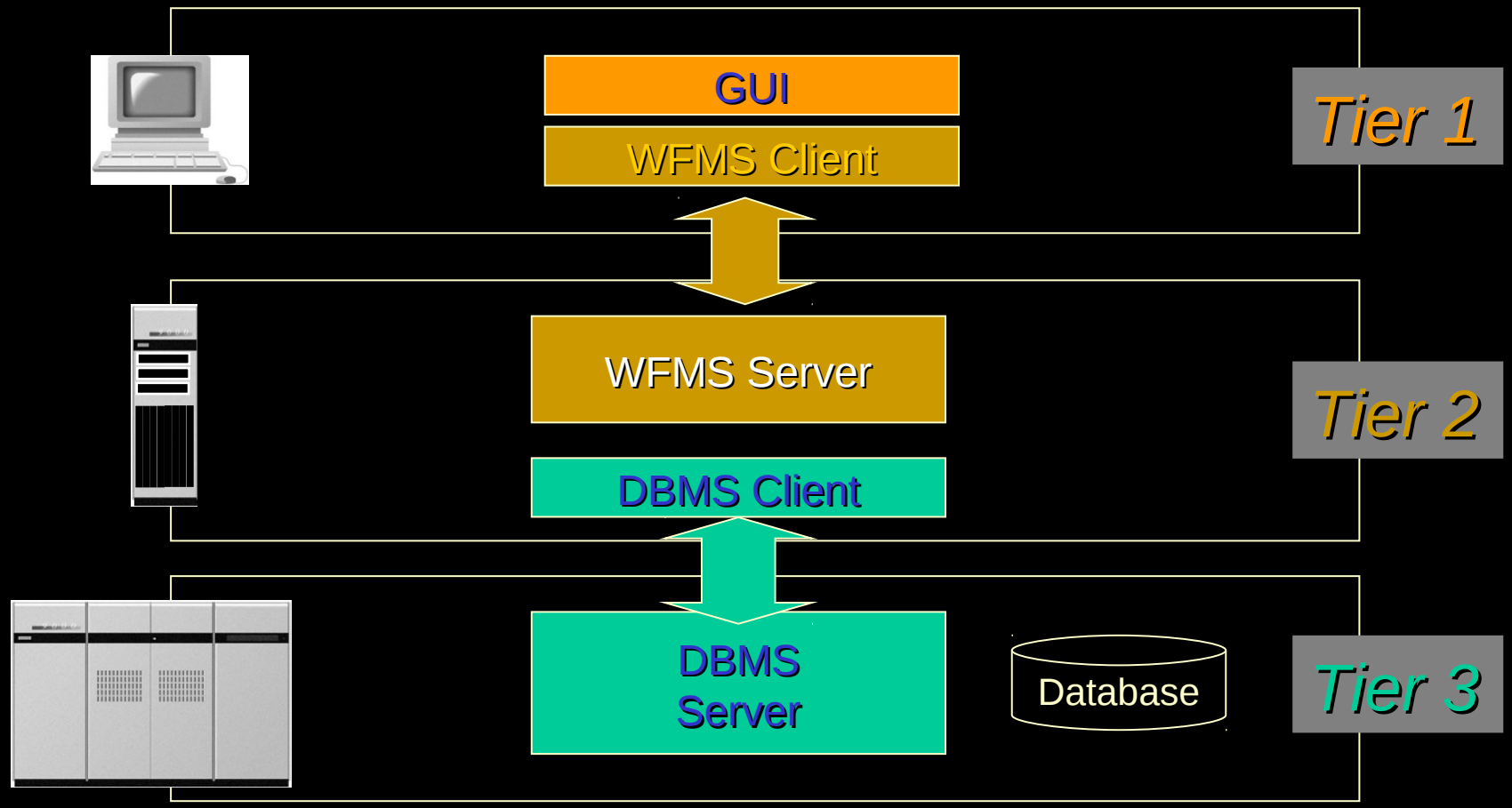
Process Execution



WfMS interoperability

- **More adoption more new problems**
- **As with dbs there is a class of new problems with integration of workflows**

WFMS 3 Tier System Structure



WFMS User Types

- **End Users**
- **Process Modellers (Business Analysts)**
- **Process Administrators**
- **System Administrators**
- **Customer Support**
- **External Users**

How Users Work with the WFMS

- **GUI Variants**
  - **WFMS propriety interface**
    - Operating System Metaphors (Windows Explorer)
  - **Desktop of another system (Lotus Notes)**
  - **Custom developed**

Working with WFMS

- **Working with Worklists**
  - **Pull Mode, Push Mode, Grab Mode**
- **Working with Activities**
  - **Typical functions: Start, Restart, Re-execute, Finish, Suspend, Resume, Terminate**
  - **Status queries**
  - **Transactional actions (repair, commit, compensate, …)**
- **Working with Processes**
  - **Start, Suspend, Resume, Query, Update**

Application Programming Interface

WFMS provides access to all data and functions via APIs

- **Worklist API**
- **Operation API**
- **Administration API**
- **Process API**
- **Audit Trail API**
- **Buildtime API**
- **Container API**

Programming Language

Messaging Interface

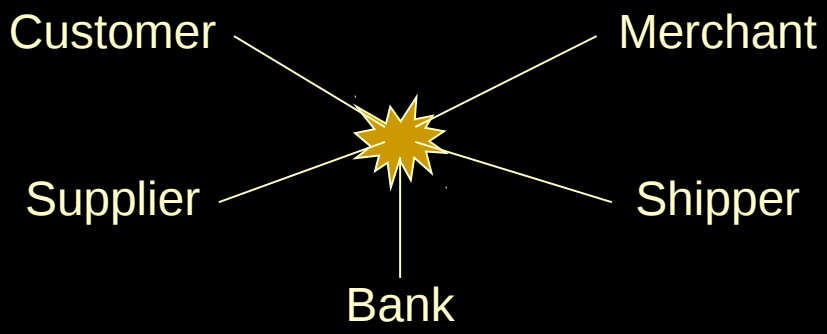
Working with other WFMSs

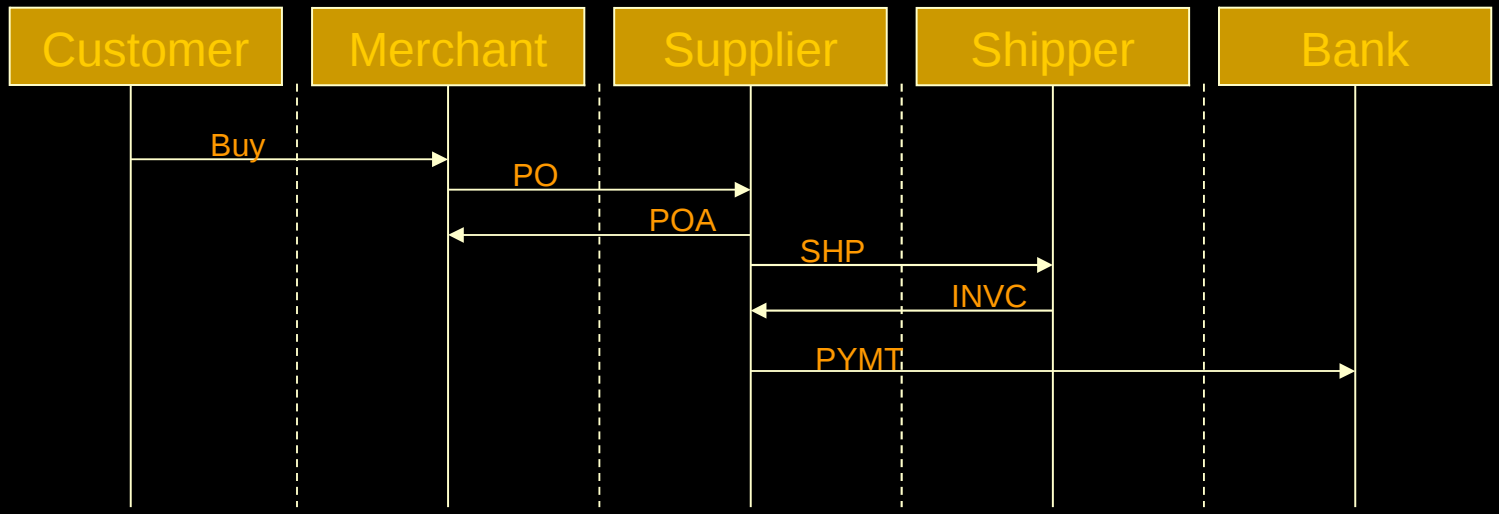
Virtual Organizations and E-Services

- **An enterprise that out sources *everything***
- **An entity composed of geographically dispersed workers (processes) who share their work and communicate only by electronic means**
- **Appears like a traditional enterprise to its customers, but the services and products it provides rely on the core business processes and resources of multiple constituent enterprises**
- **The member enterprises may be participating in a strategic alliance, or may collaborate only for the duration of one electronic commerce transaction**

Business processes of partner organizations need to coordinate
to meet collective goals

Collaborating Enterprises





Source: Christoph Bussler. Tutorial ER2001

Cross-Organizational Workflows

- **Cross-organizational, but integrated solution for business process management**
- **(Public) workflow composition from pre-existing (private) component processes owned and developed by independent organizations**
- **Presents challenges beyond stand-alone workflow systems**
  - **Modelling**
    - Composing global processes

Cross-Organizational Workflows (cont)

- **Execution**
  - Interoperability between heterogeneous WFMSs
    - Homogeneous WFMSs
      - » Support the same meta model
      - » WFMSs can exchange data directly since no translation is required
    - Heterogeneous WFMSs
      - » Need at least a common denominator in terms of interfaces
      - » Mapping of WFMSs meta models

Integration Technologies

BPMO - BPMO, Application - Application, Business - Business

*BO: Business Object
(Term used in SAP Enterprise Software)

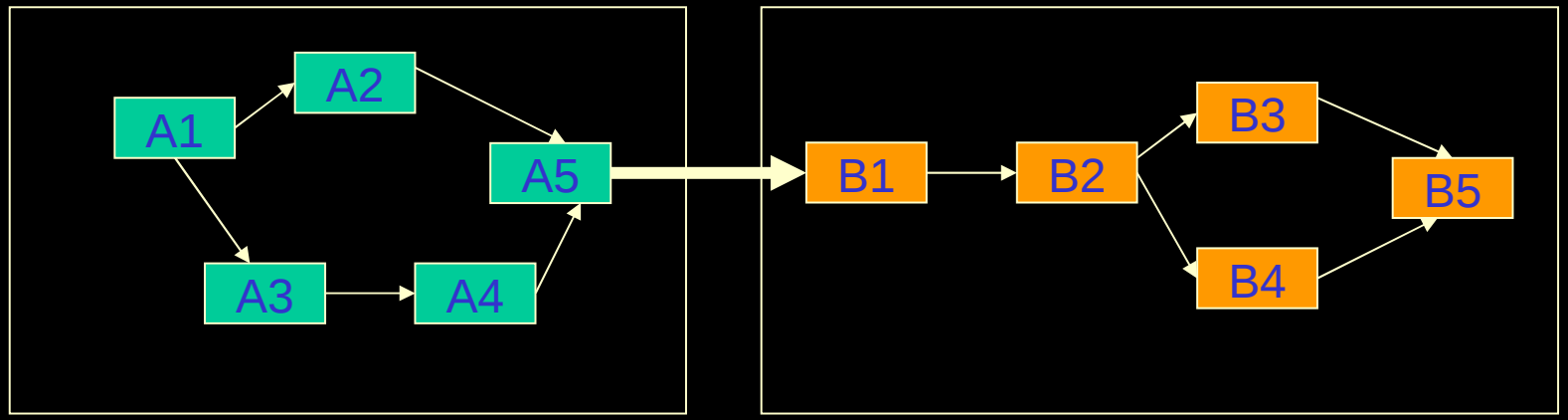
Process Interactions

- **Basic**
  - **Chained**
  - **Nested**
  - **Joint Invocations**
  - **Cross Synchronization**
- **Advanced**
  - **Determined jointly through Data, Time and Control**

Source: WFMC Reference Model

Basic Process Interactions

- **Chained**
- **Nested**
- **Joint Invocations**
- **Cross Synchronization**



Basic Process Interactions

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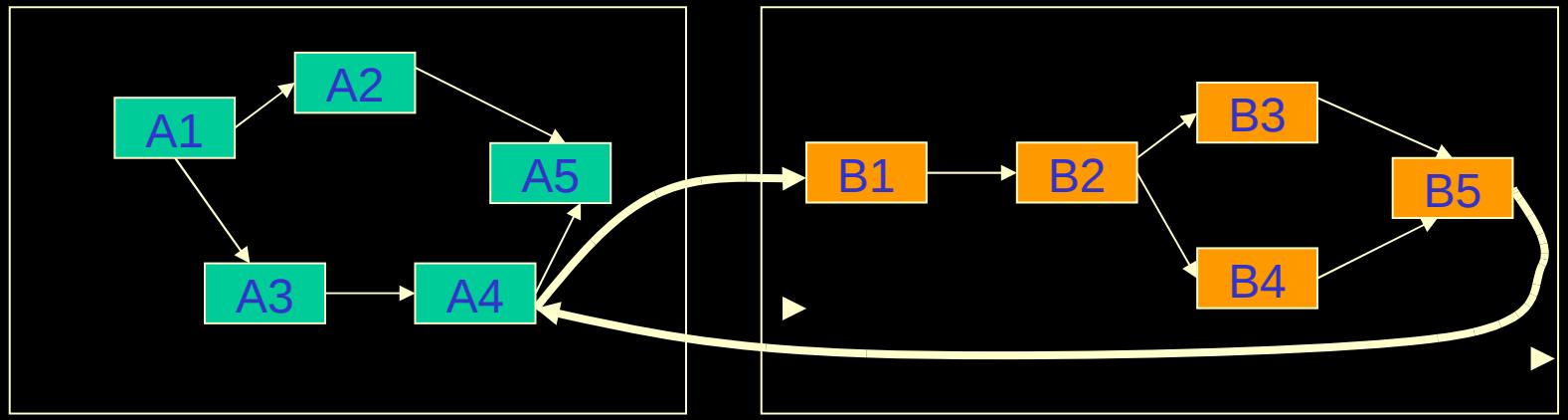

Basic Process Interactions

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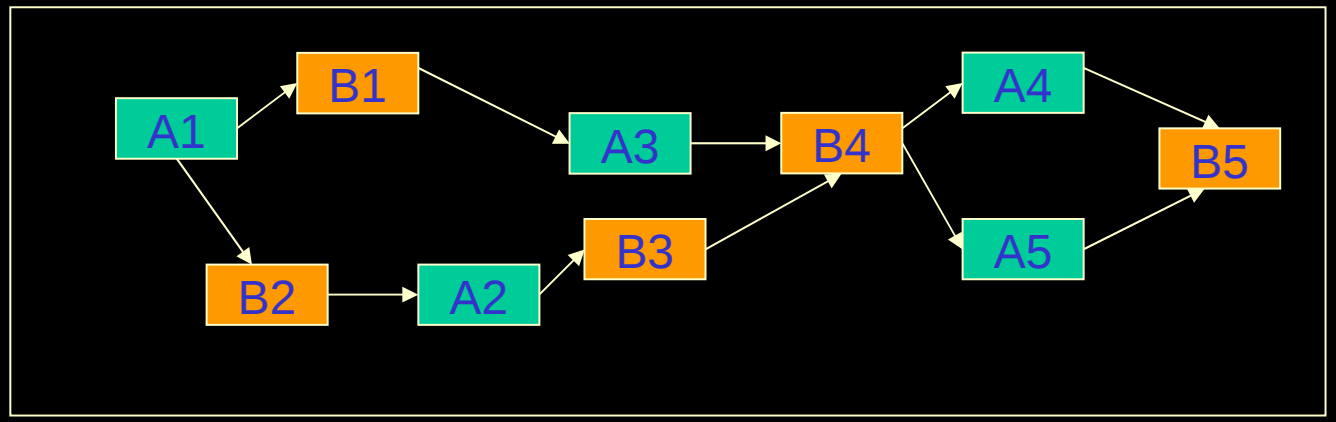

Basic Process Interactions

- **Chained**
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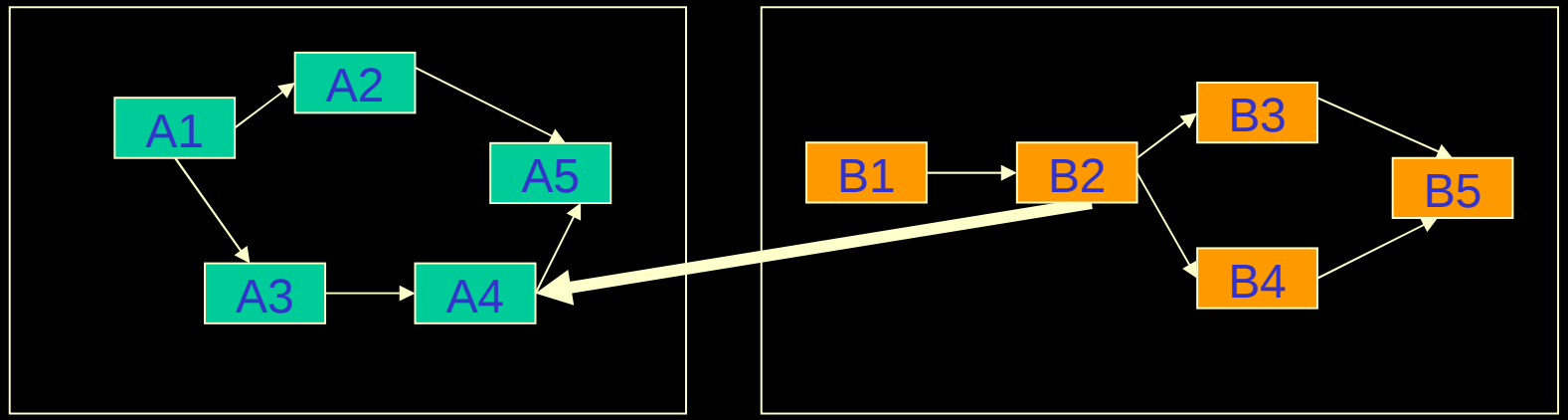

Advanced Process Interactions

Basic Concepts

- Event
  - Occurrence of business data that is of interest
- Trading Partner
  - Organization that participates in event exchange
- B2B Protocol
  - Specification of event exchange between trading partners over a network
- Back end Application
  - Application within trading partner that is source/destination of events
- Process management
  - Definition and execution of business processes describing integration behaviour

Problem Space

- B2B protocols
  - EDI, RosettaNet, Swift, …
- Network transport
  - SOAP, ebXML, EDIINT, …
- Security
  - Certificates, Authorization, Key Management
- Back end application integration
- Process management
  - Between and within trading partners

Reading

www.wfmc.org/standards/docs.htm

Go to

www.wfmc.org/standards/docs/Workflow_An_introduction.pdf