# Introduction: Processes, information systems, and transition systems

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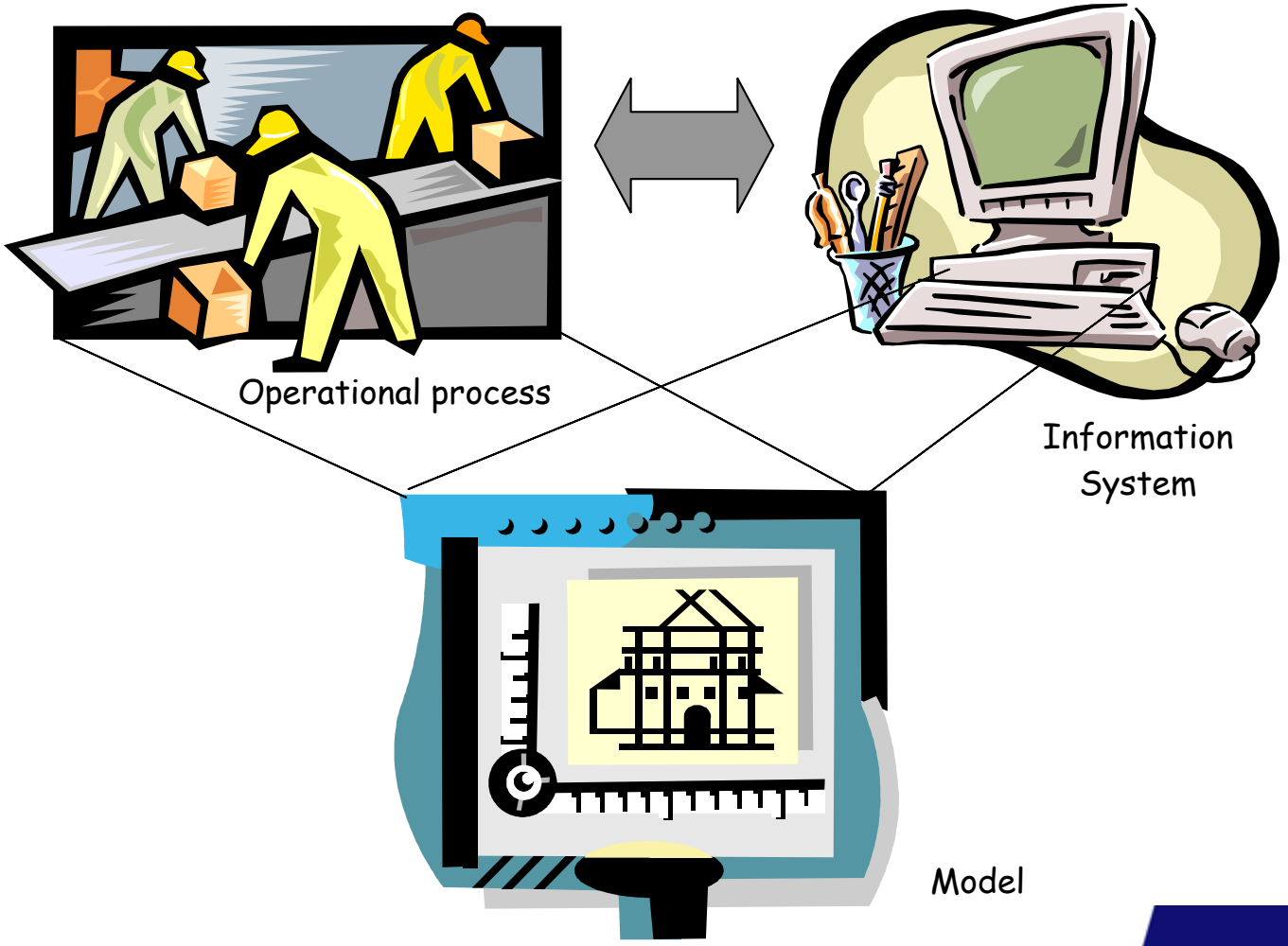
Where innovation starts

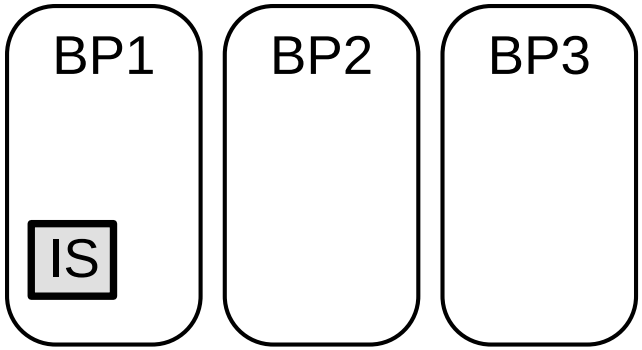
# Outline

- On the relation between processes, systems, and models
- Basic model: Transition systems
- Process models versus object/data models
- Petri nets and other process modeling languages
- Applications/tools
- Process-aware information systems: Trends

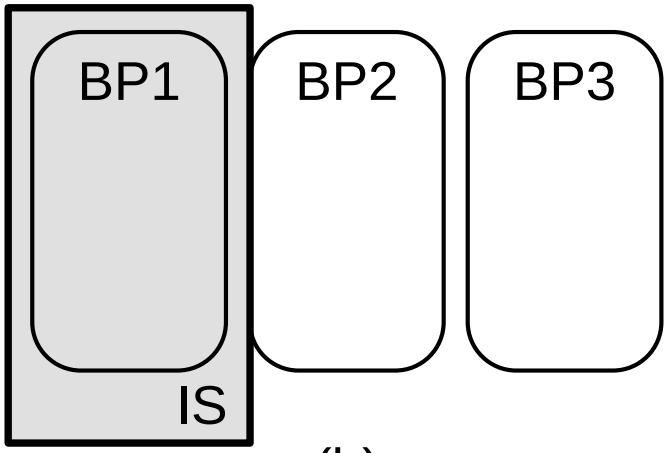
# On the relation between processes, systems, and models



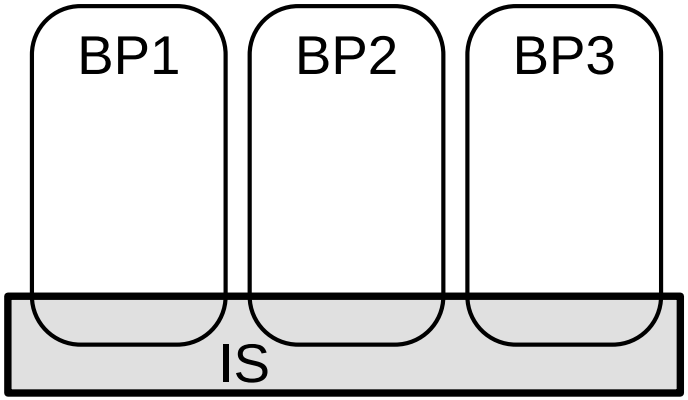
# On the relation between information systems and processes



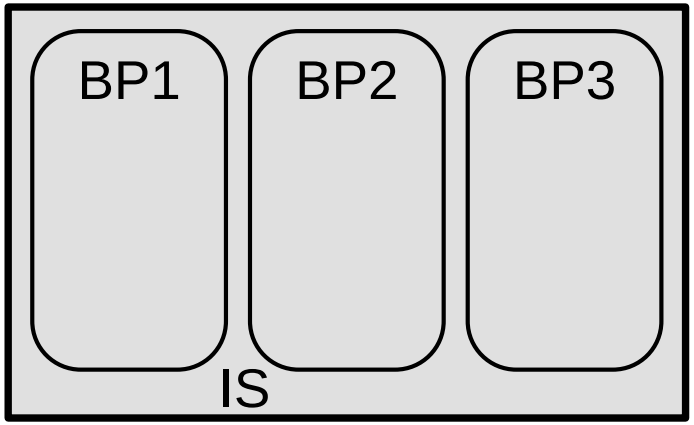

(a)



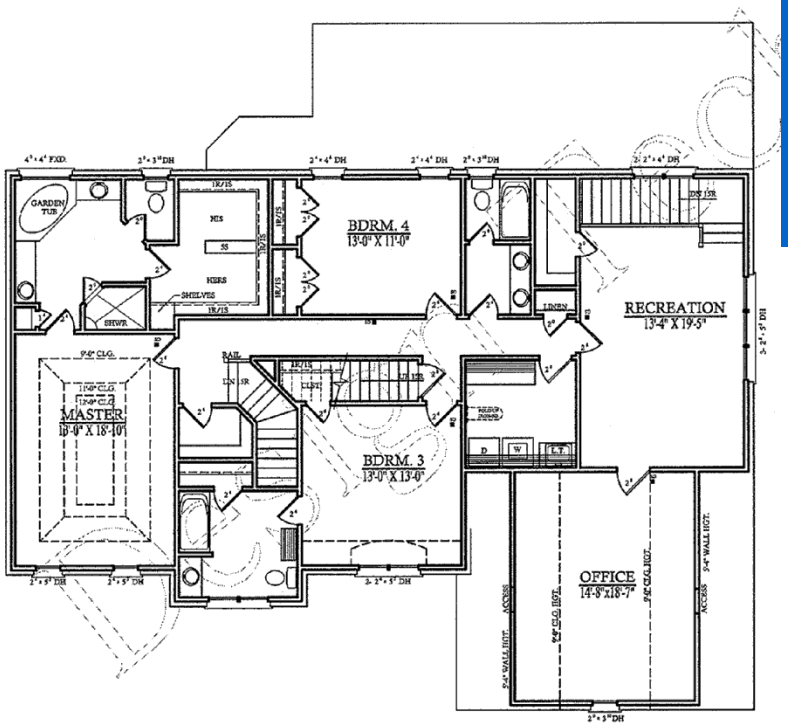

(b)




(c)




(d)



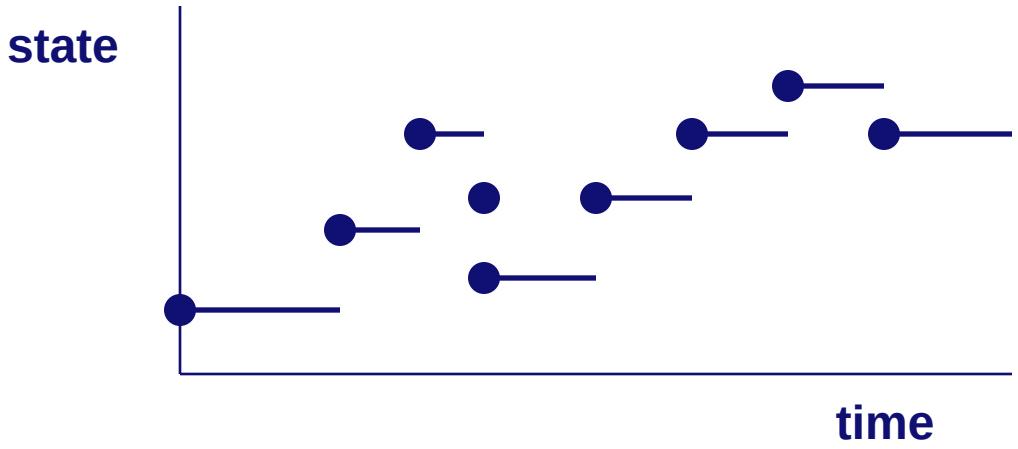

**Three good reasons for making a process model:**

- **gain insight**
  for a better understanding of the system
- **analysis**
  validation and verification
- **specification**
  a blue print for construction

# Basic model: Transition systems

- **Any *discrete dynamic system* can be described as a *transition system*.**
- **Low level model: Mother of all (process) models.**
- **Elements:**
  - **State**
  - **Transition**
  - **State space**
  - **Transition relation**

# Discrete dynamic systems




- Y-axis is state space.
- Bullets are transitions (no continuous changes, only discrete ones).
- One possible execution: Transition relation is not described.

# Definitions

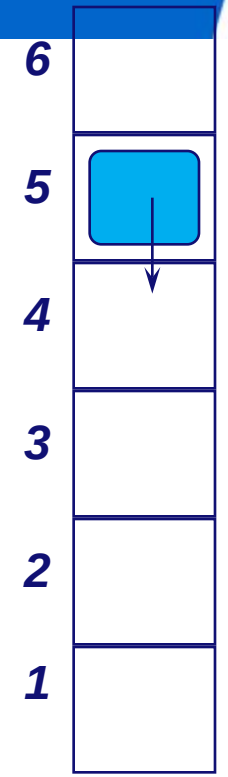
- **A transition system is specified by a pair $(S, TR)$**
  - **$S$ is the state space**
  - **$TR \subseteq S \times S$ is the transition relation**
- **The elements of *S* (state space) are states.**
- **The elements of *TR* (transition relation) are transitions.**

***1) Model a light bulb with three states (on, off, broken).***

***2) Model a queue in a supermarket.***

# Example: Elevator

- ***State space:*** $S =$
  $\{ (floor, direction) \in IN \times \{-1,0,1\} \mid$
  $(1 \leq floor \leq 6) \wedge$
  $(floor = 1) \Rightarrow (direction \geq 0) \wedge$
  $(floor = 6) \Rightarrow (direction \leq 0) \}$
- ***Transition relation:*** $TR =$
  $\{((1,0),(1,1)), ((1,1),(2,1)), ((1,1),(2,0)), \ldots$

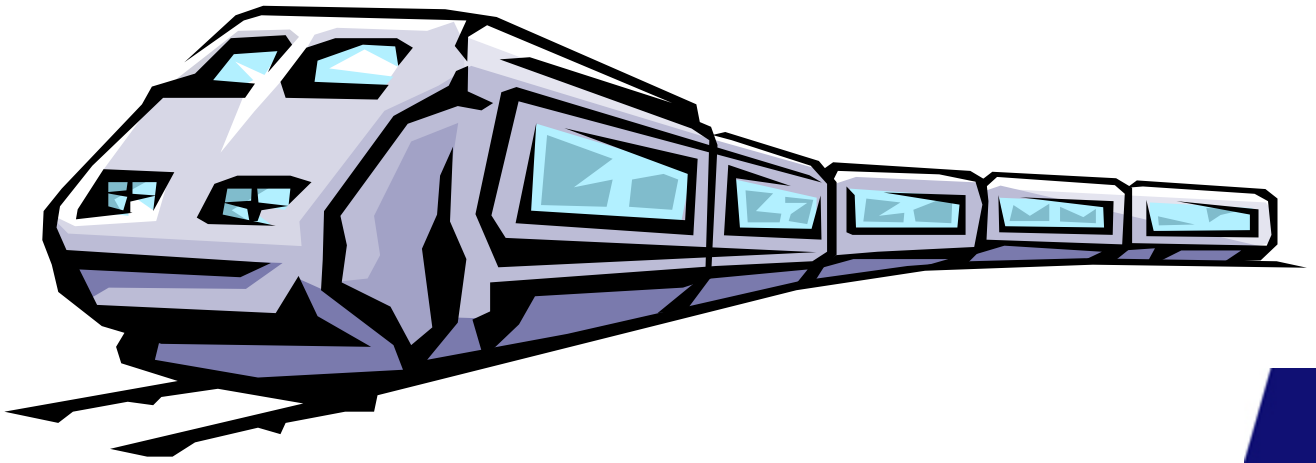



***Describe transition relation formally.***

***Give graphical representation.***

# Exercise: Make transition system

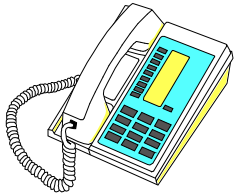
- **Consider a circular railroad system with 4 tracks (0,1,2,3) and 2 trains (A,B). No two trains should be at the same track at the same time. Trains can only move clockwise.**
- **Imagine how this would be if there are 50 tracks or more complex rules like claiming the next track or keeping tracks free in-between trains.**



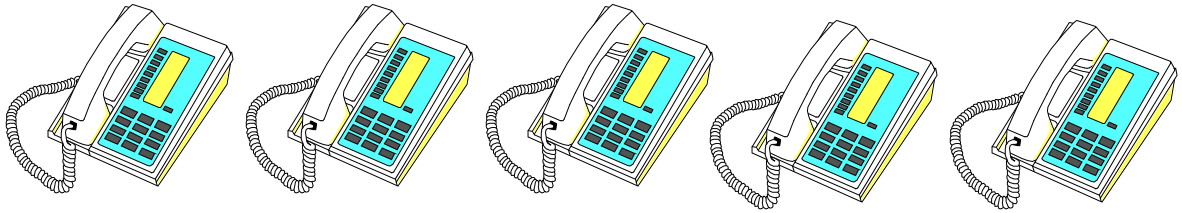
# Exercise

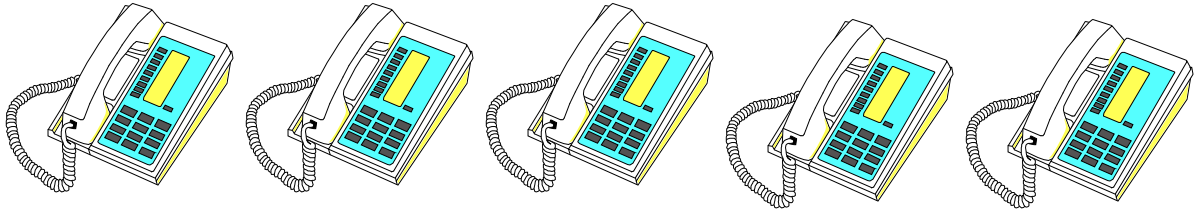

- **Consider two parallel queues in a supermarket**
- **Describe transition relation formally.**
- **Give graphical representation.**

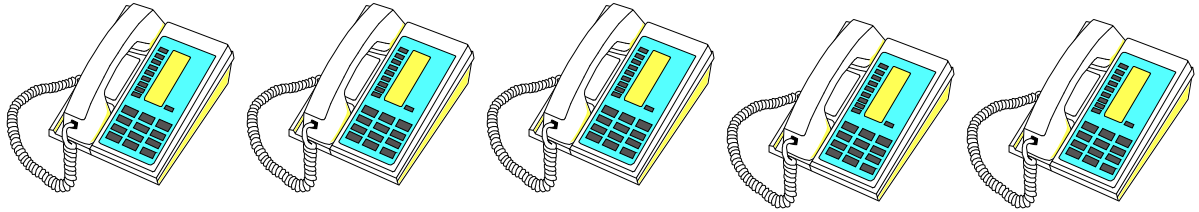
# State explosion problem



***50 states***







***$50^{15}$ = +/- 305175781250000000000000 states***

# Large state spaces ...

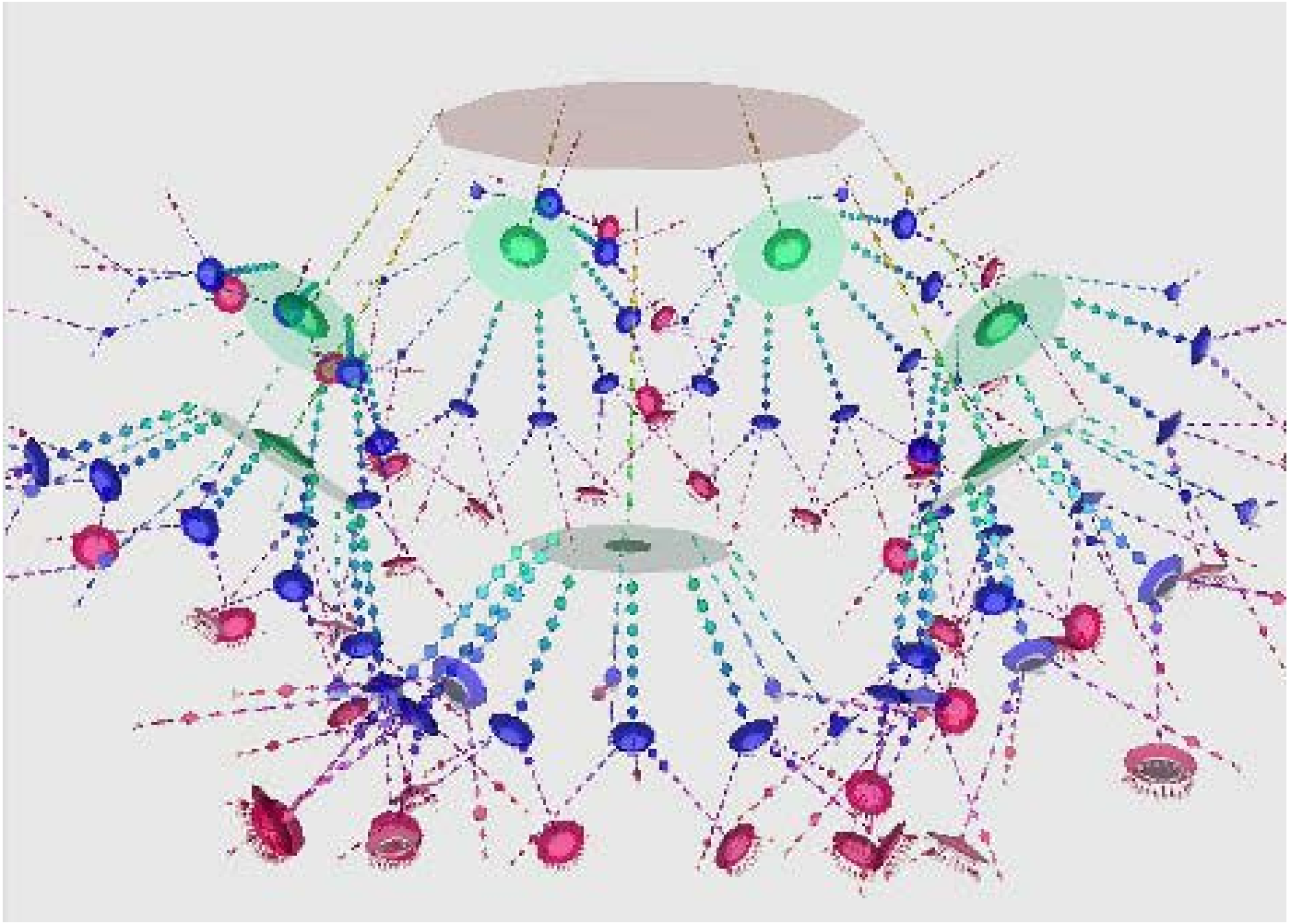
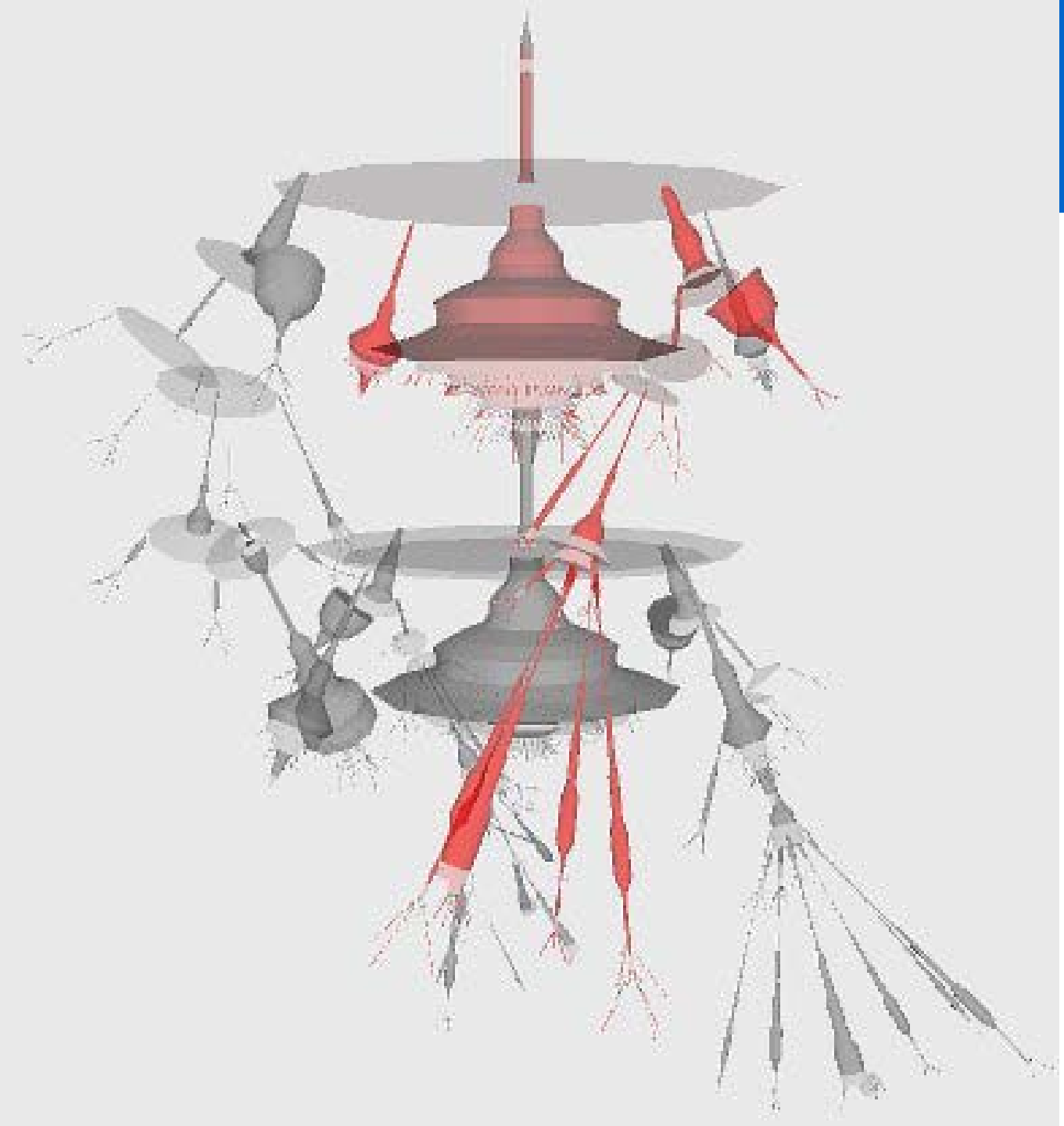


*Figure taken from Frank van Ham*

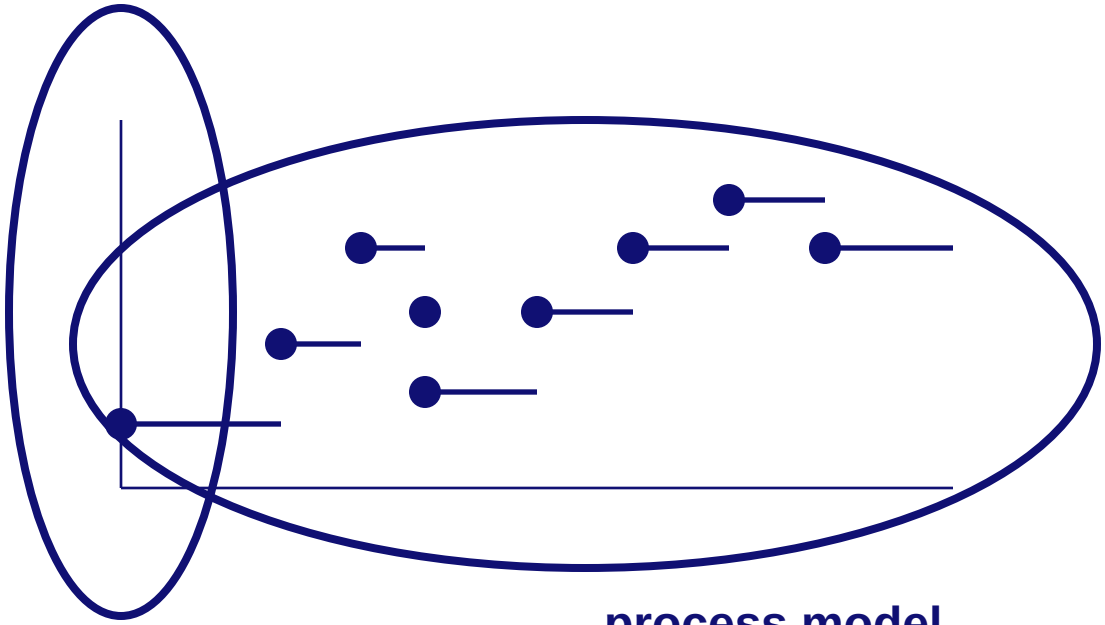
**communication protocol ($10^6$ states)**



**link layer of the IEEE1394 standard (FireWire) simulated using two communication nodes and a bus (25,000 states)**

# Process models versus object/data models

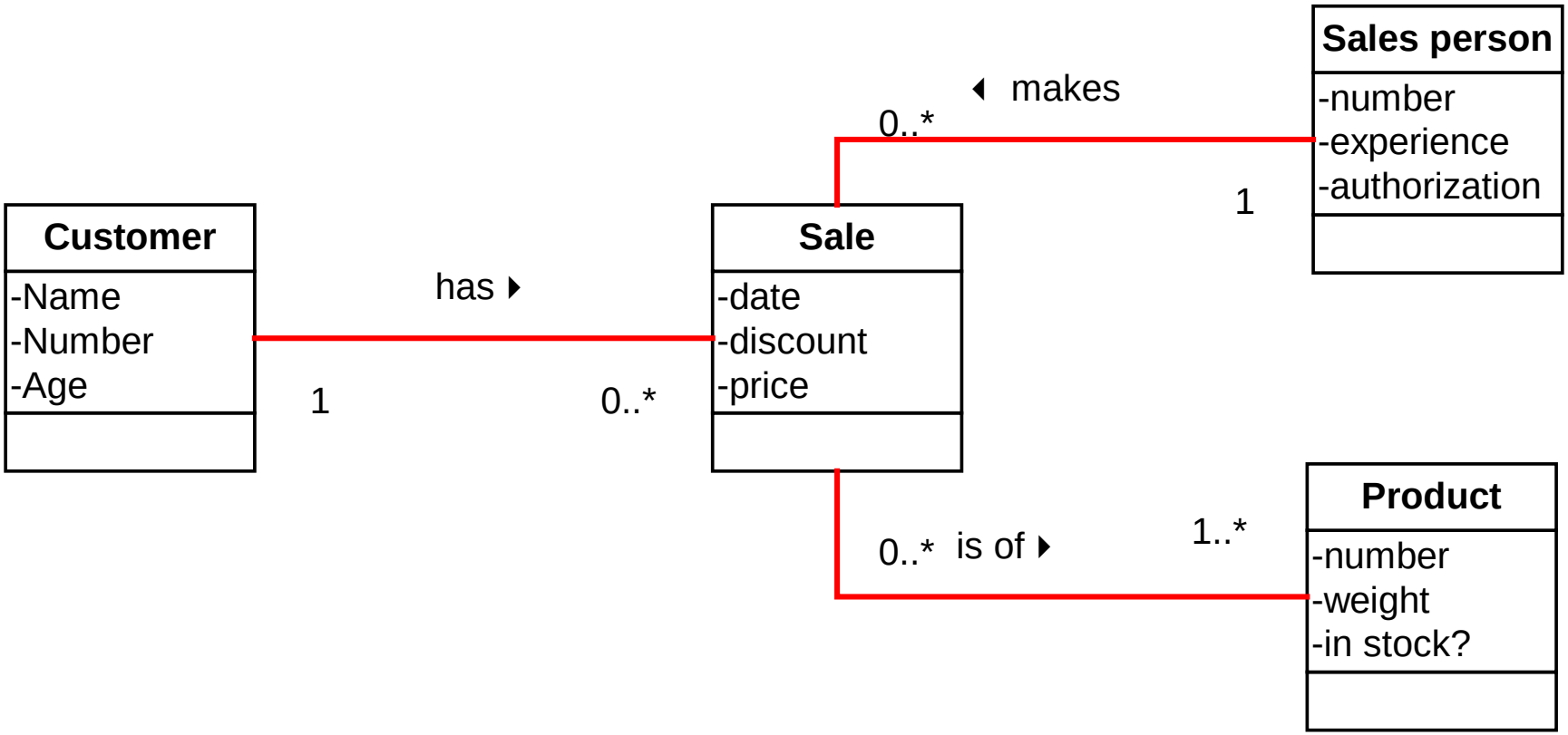
**object/data model**



**process model**

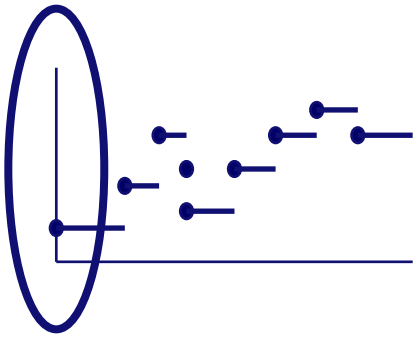
*system model = process model + data/object model*

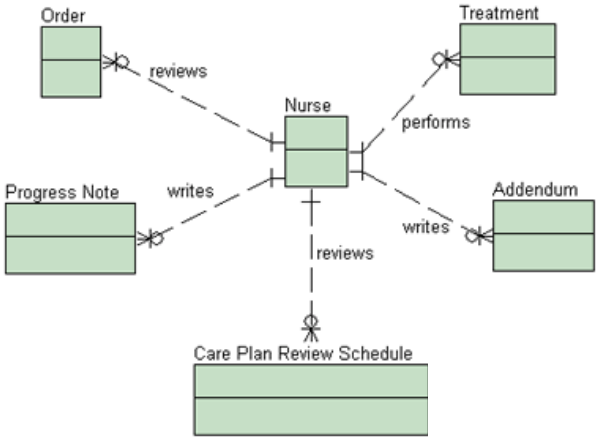
# Example of a data/object model: A UML class diagram

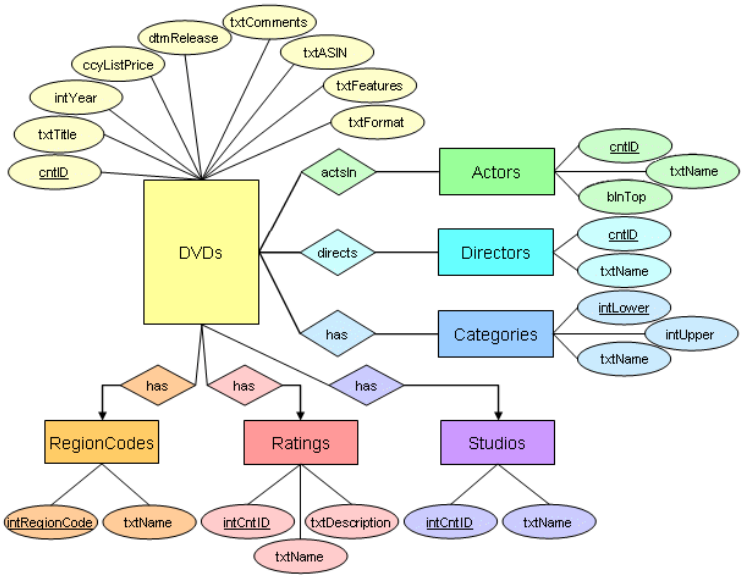


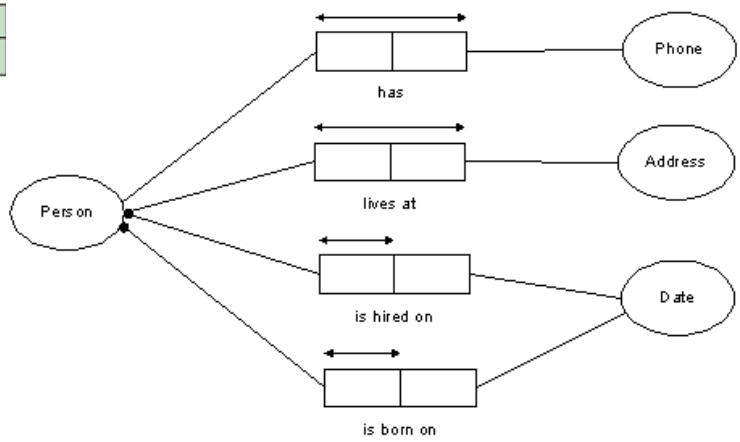
# Other data/object modeling techniques

- **Entity-Relationship (ER) diagrams**
- **Crow's Foot diagrams**
- **NIAM/ORM diagrams**

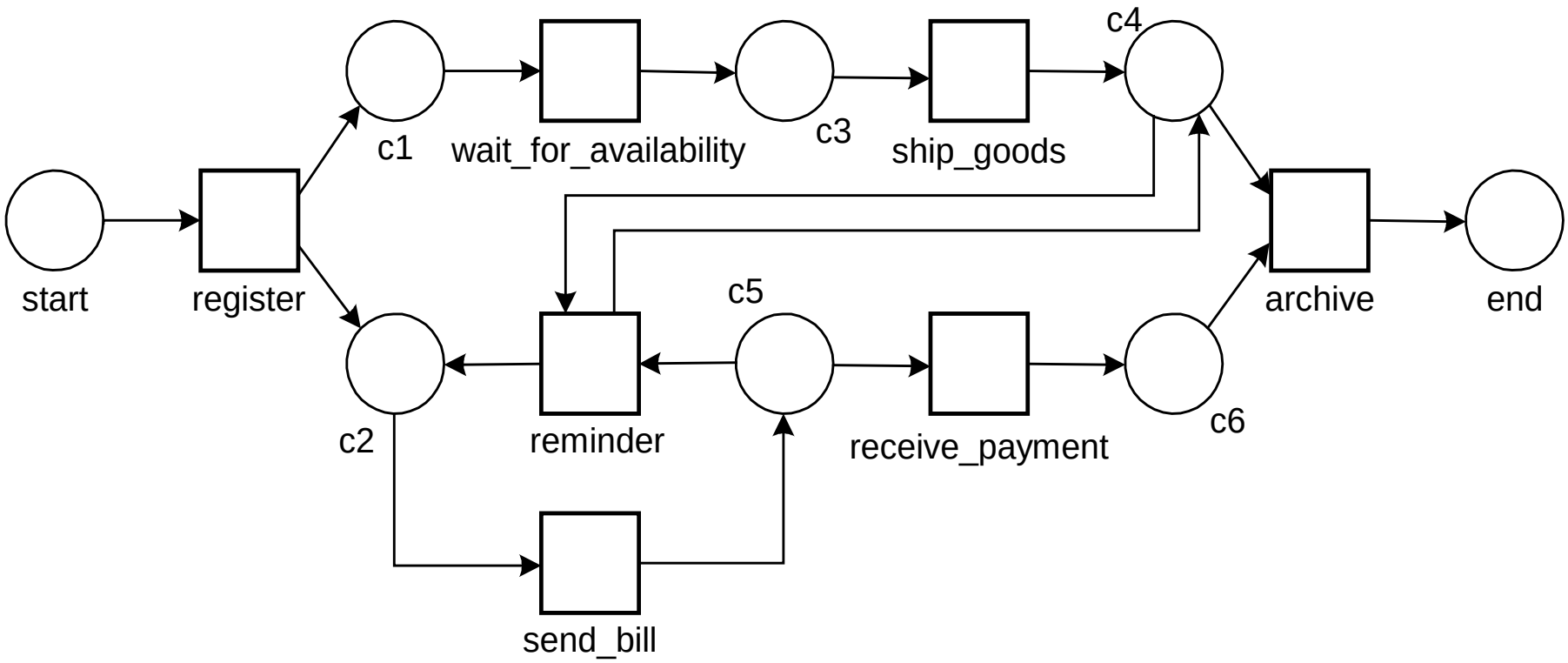




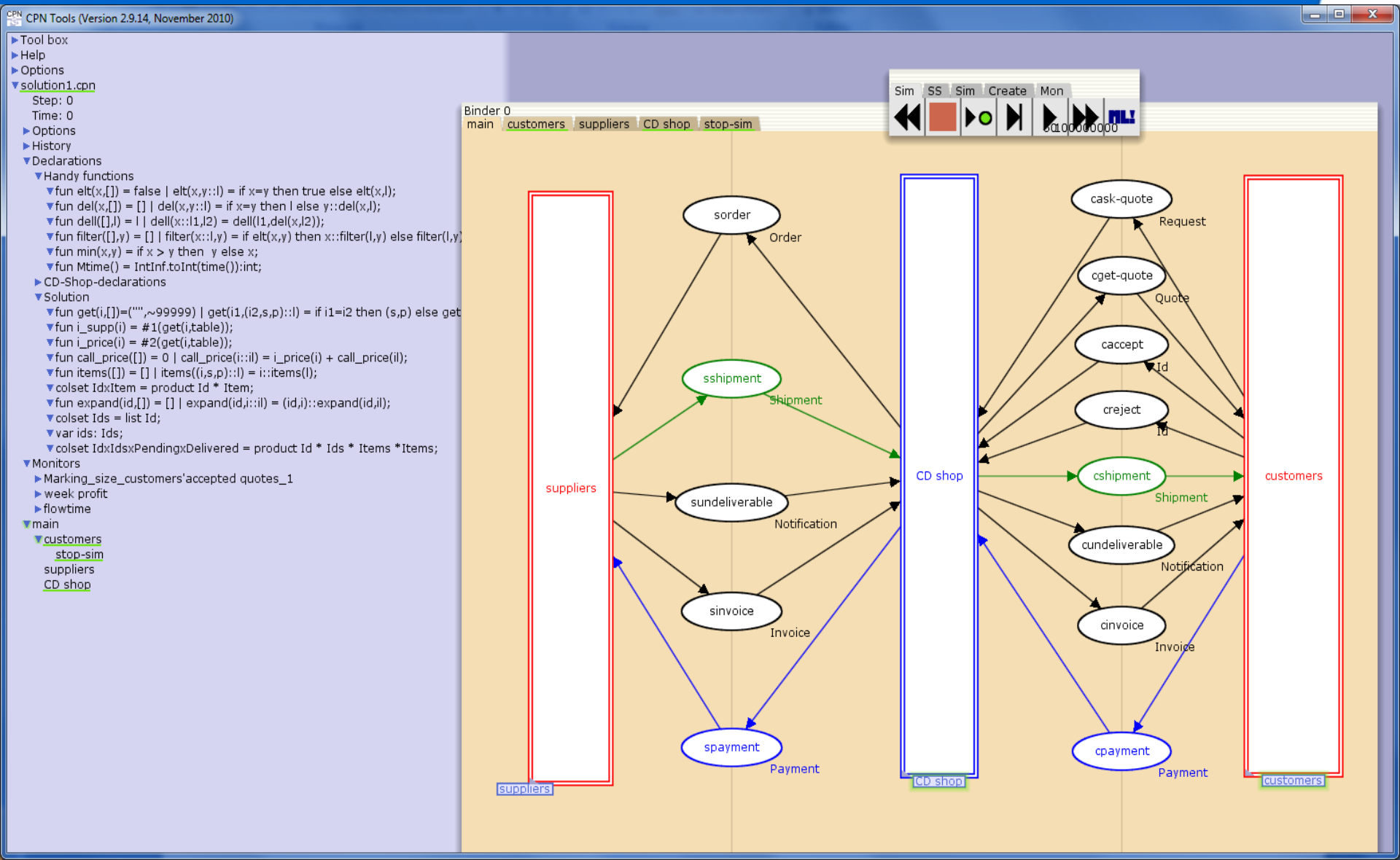



# Example of a process model: A Petri net modeling order processing

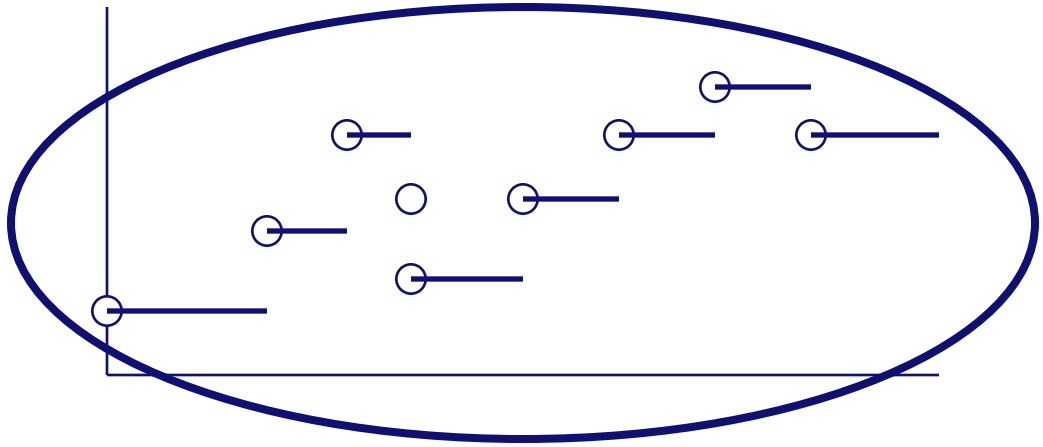


# CPN Tools 3 (download from cpntools.org)



# Other process modeling techniques

- **UML activity/statechart diagrams**
- **Event-driven Process Chains (EPCs)**
- **IDEF/DFD diagrams**
- **BPMN/BPEL**
- **Etc.**



# Applications of process modeling in concrete products

- Business modeling tools: Protos, ARIS, ...
- Simulation tools: ExSpect, Arena, Simula, ...
- Verification tools: Woflan, ...
- Petri net tools: Design CPN, CPN Tools, …
- Workflow management systems: Staffware, COSA, MQSeries Workflow, BPM|one, ...
- Enterprise resource planning systems: SAP, Baan, JD Edwards, Oracle, PeopleSoft, ...
- Project planning tools: Microsoft project, ...
- Web services languages: BPML, BPEL4WS, ...
- ...

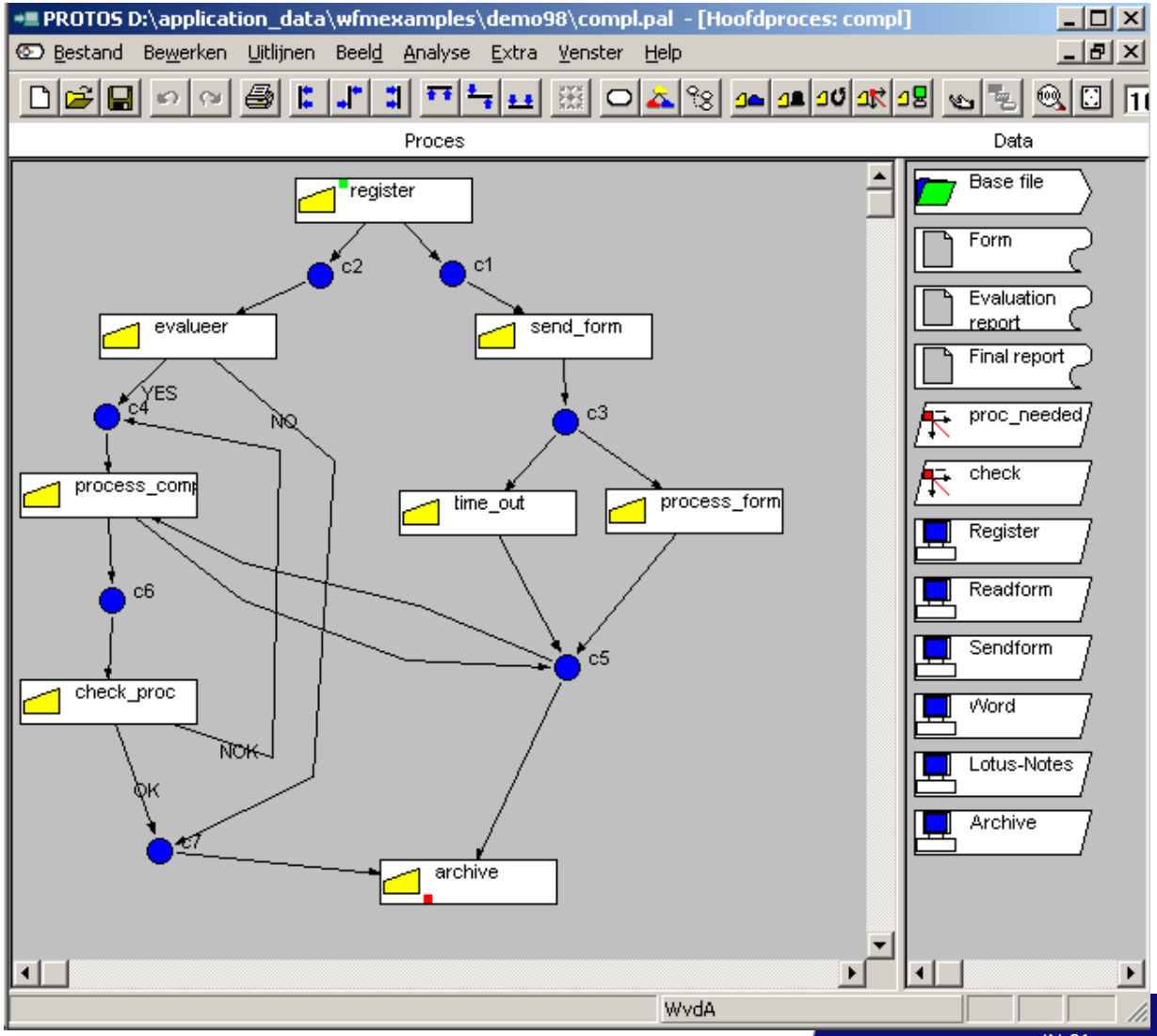
# Business process modeling tools

Pallas Athena
PROCESS MANAGEMENT

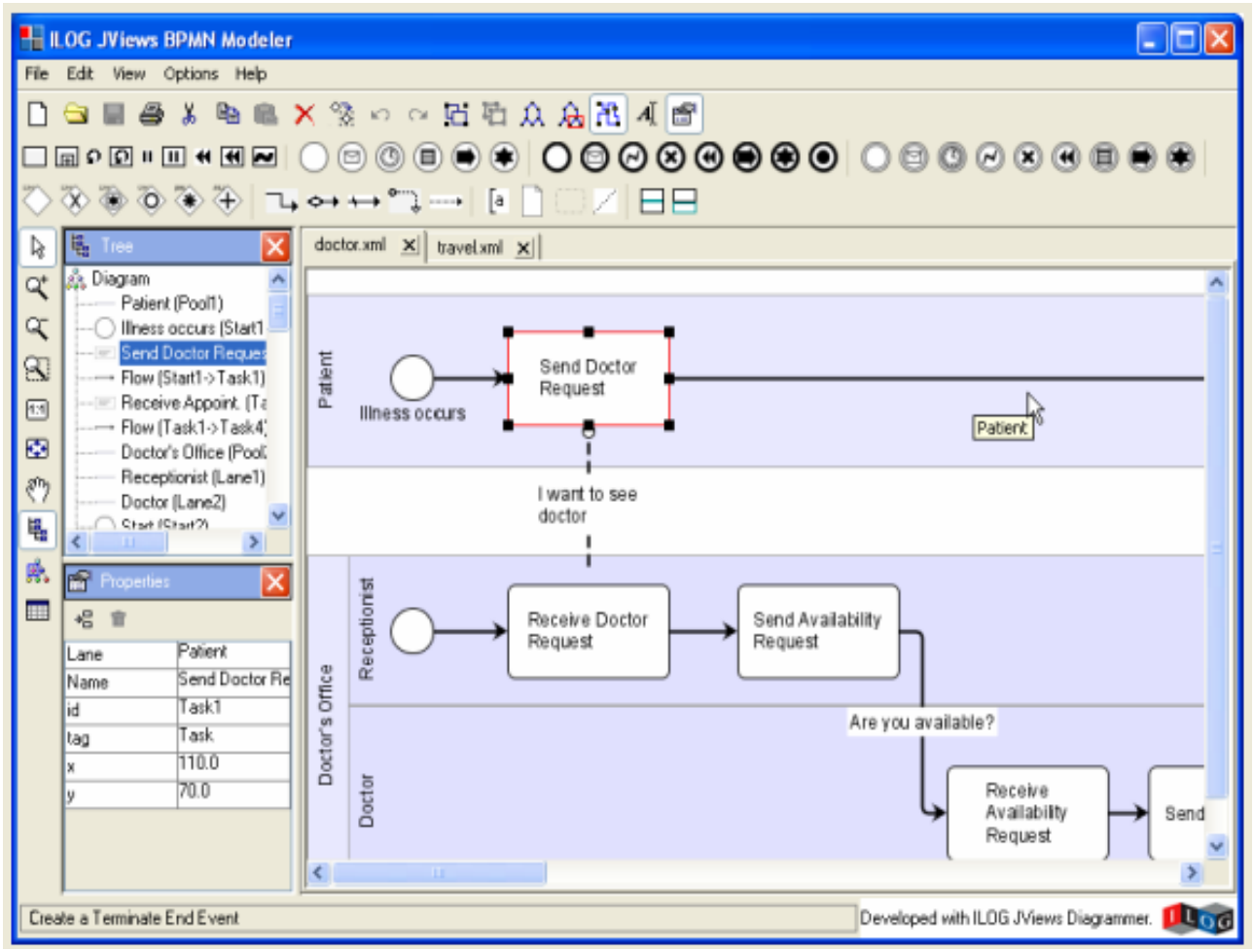
***Protos***

***Design, communication, (export to) analysis and/or implementation***

**Based on Petri nets**



# Business process modeling tools (2)



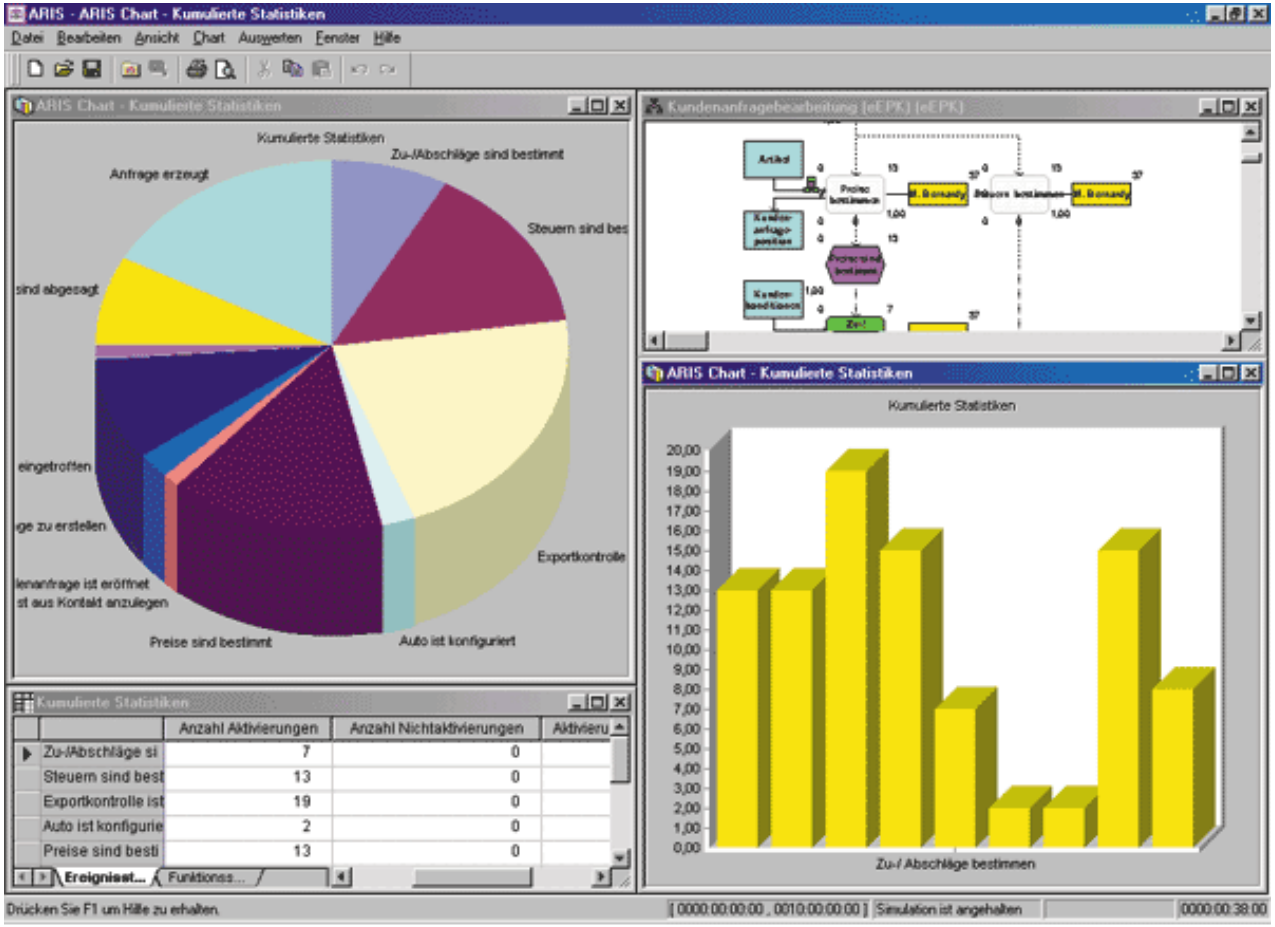
# Business process modeling tools (3)

IDS SCHEER
Business Process Excellence

***ARIS***

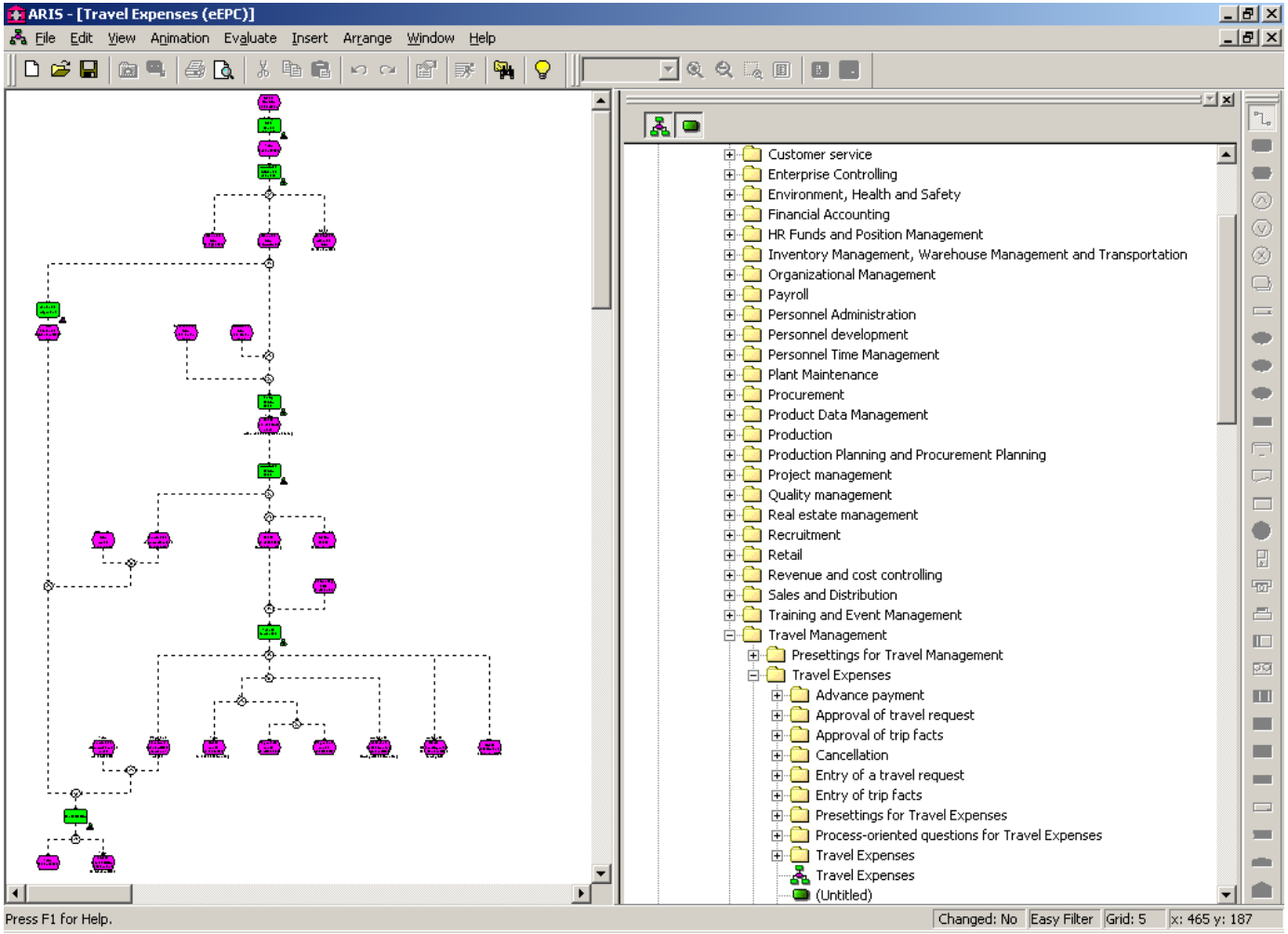
***Design, communication, (export to) analysis and/or implementation, import of real data.***

**Based on EPCs**



# Business process modeling tools (4)

ARIS Platform




**SAP reference model (>600 EPCs)**

# Business process modeling tools (5)


Gather customer requirements | Signavio - Mozilla Firefox

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http://academic.signavio.com/p/editor?id=629c7ce6d21047eda22f0033ec604d2c

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Explorer | Signavio Gather customer requirements | ...

SIGNAVIO · ORYX Not logged on

Shape Repository

BPMN (Complete)

BPMN 1.2

Activities

Task

Collapsed Subprocess

Expanded Subprocess

Gateways

Swimlanes

Artifacts

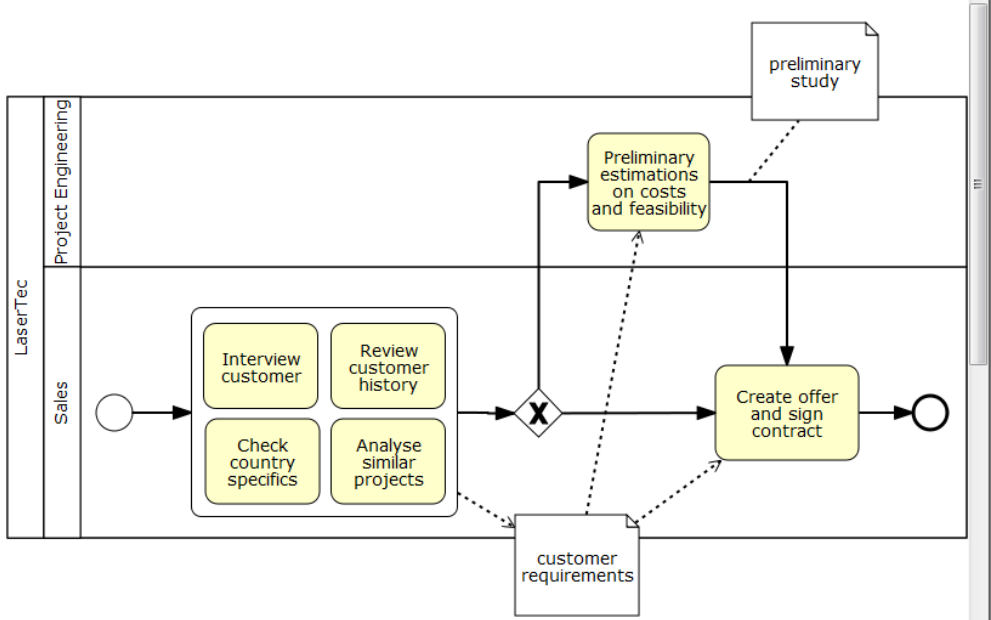
Start Events

Catching Intermediate Events

Throwing Intermediate Events

End Events

Connecting Objects



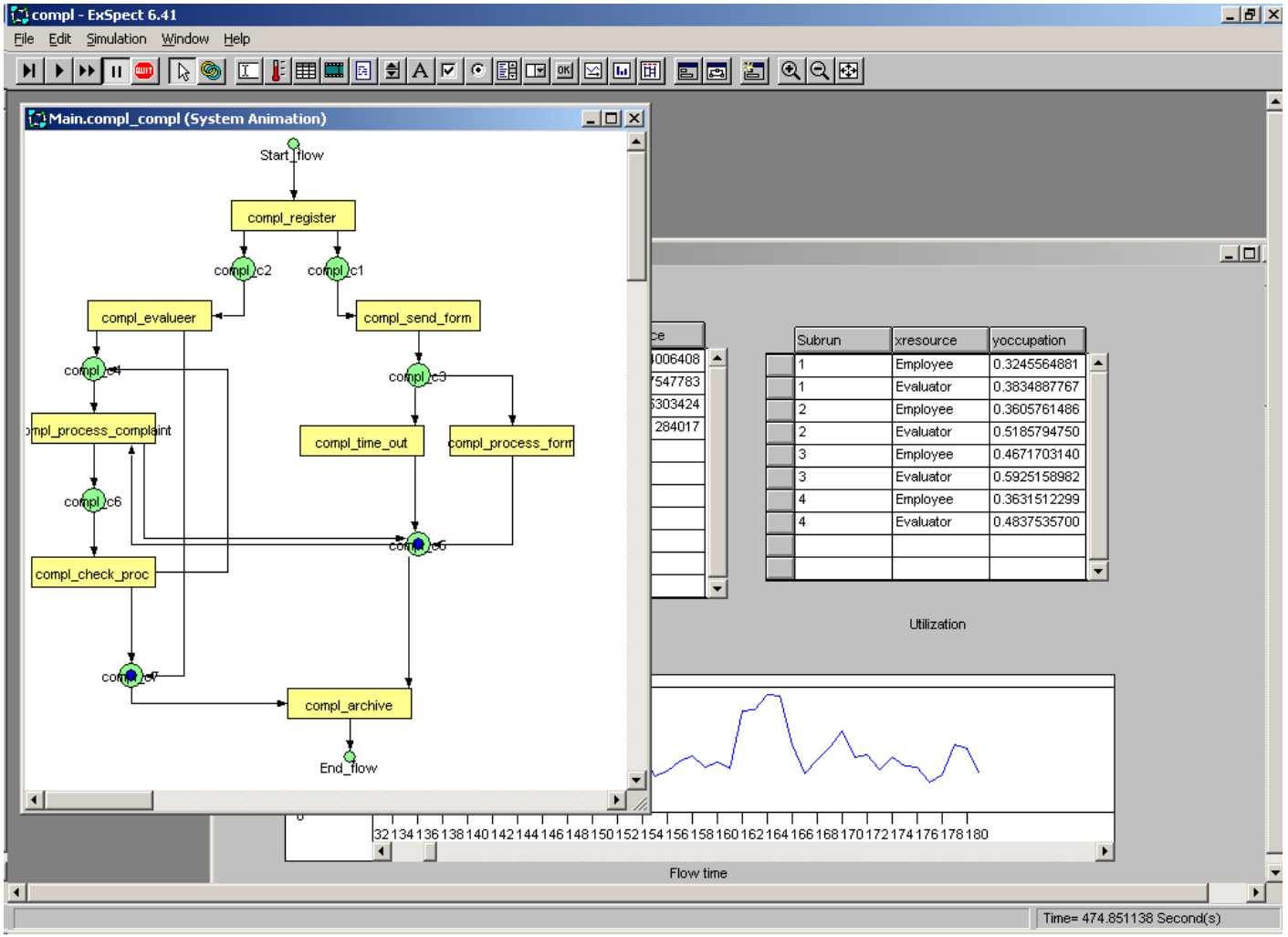

Done

# Simulation tools

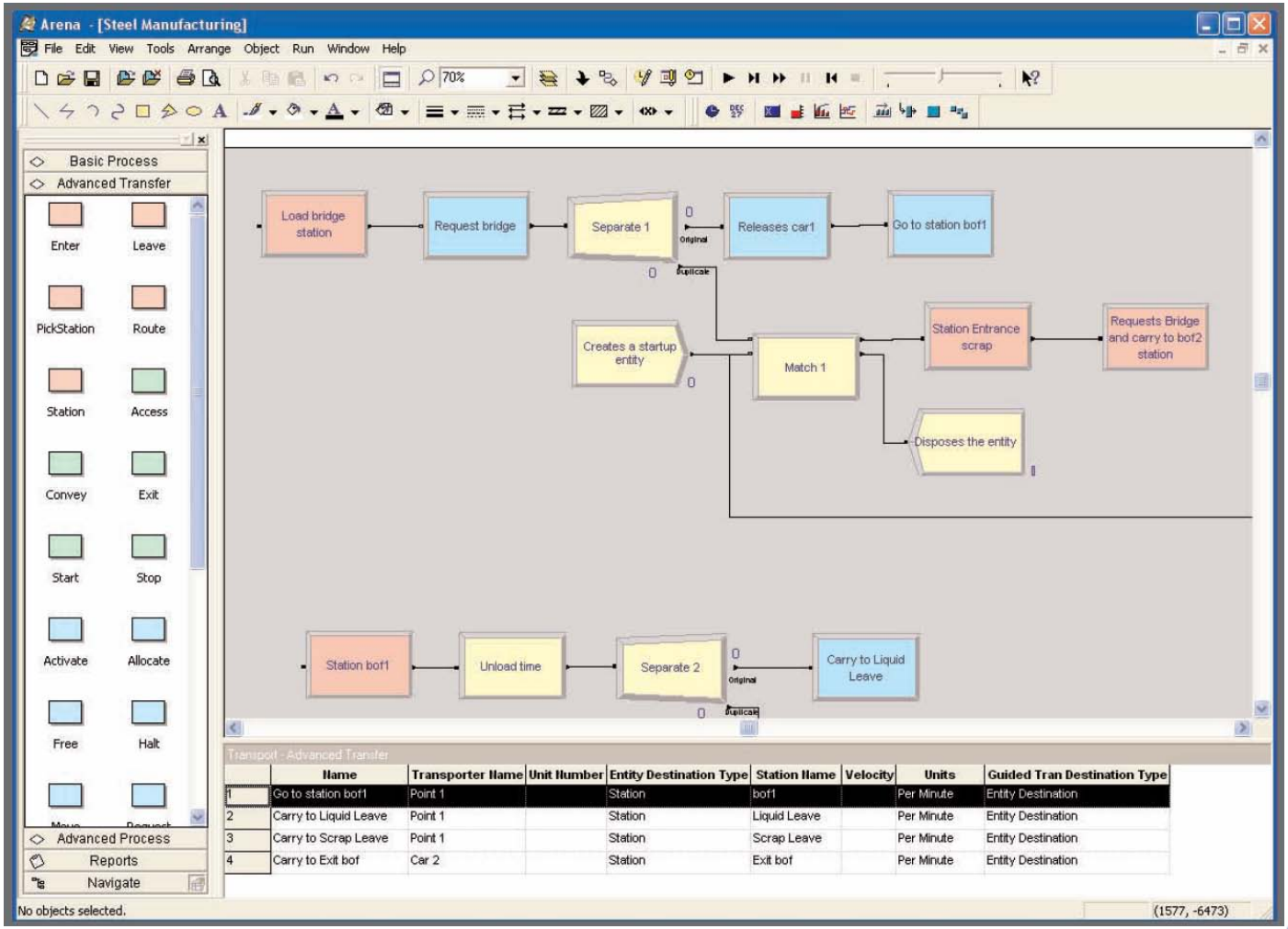
***ExSpect***

***Rapid prototyping, performance analysis, validation, gaming.***

**Based on Petri nets.**



# Simulation tools (2)




***Arena***

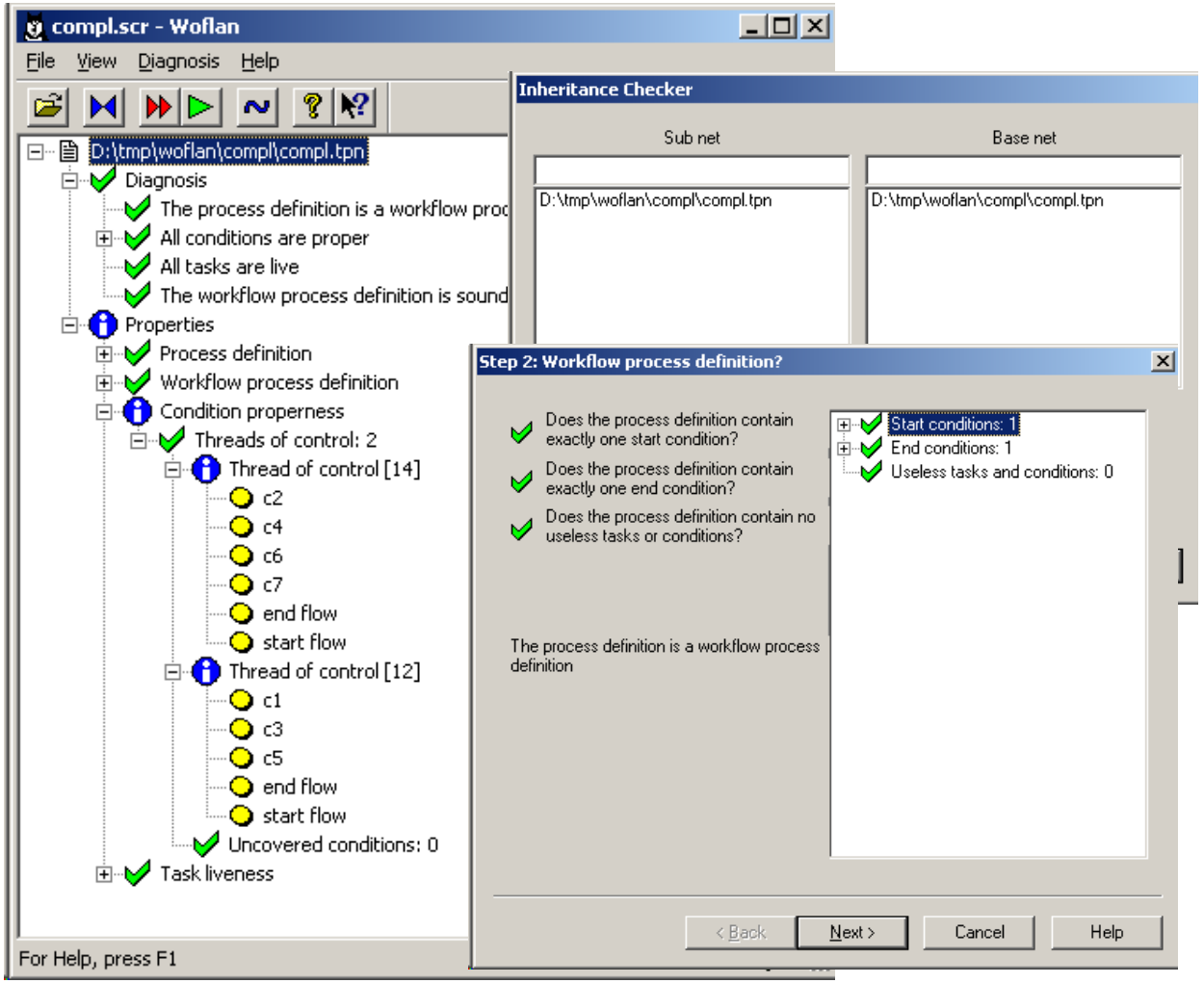
Rockwell Automation

# Verification tools

***Woflan***

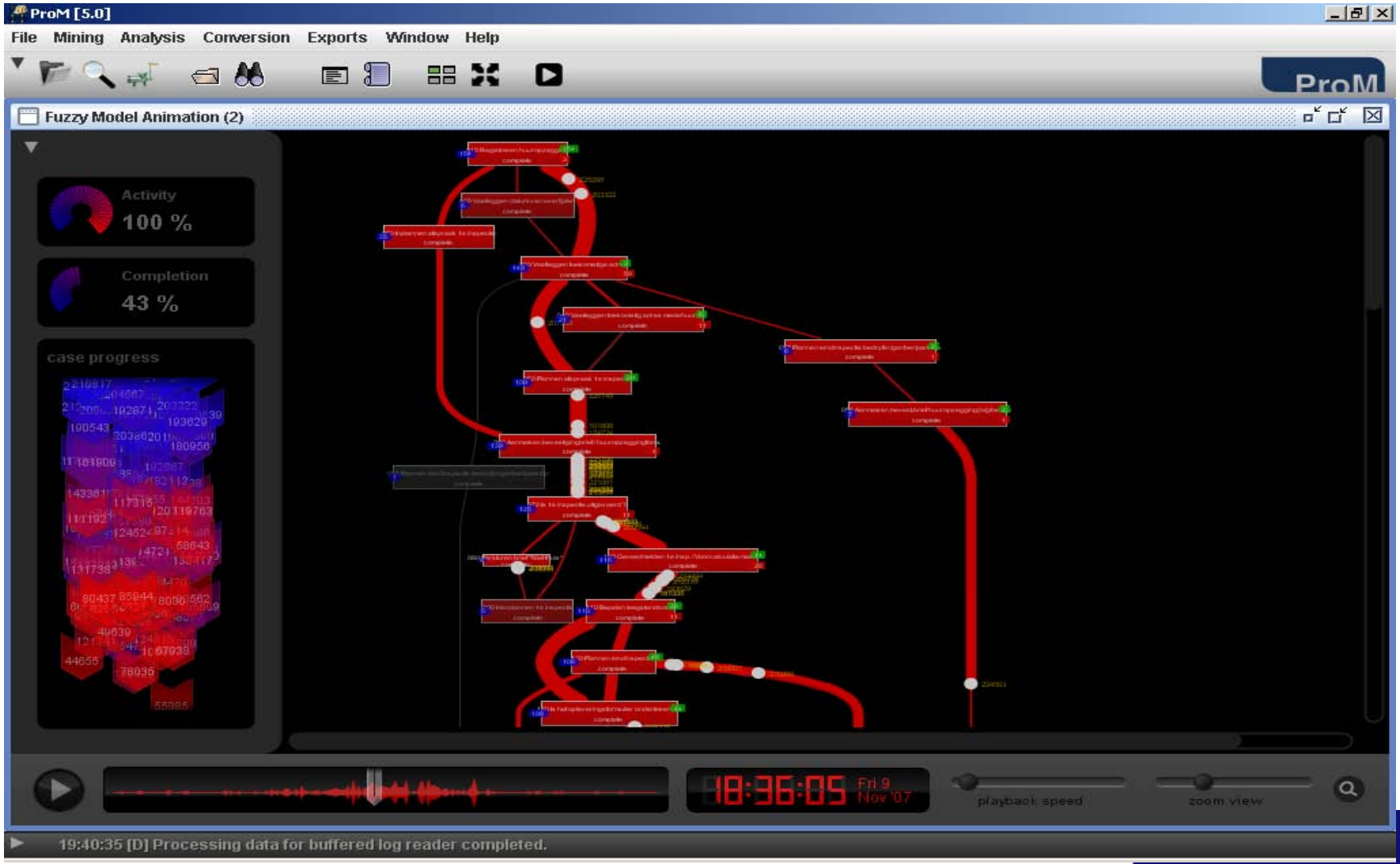
***Detecting errors.***

**Based on Petri nets.**

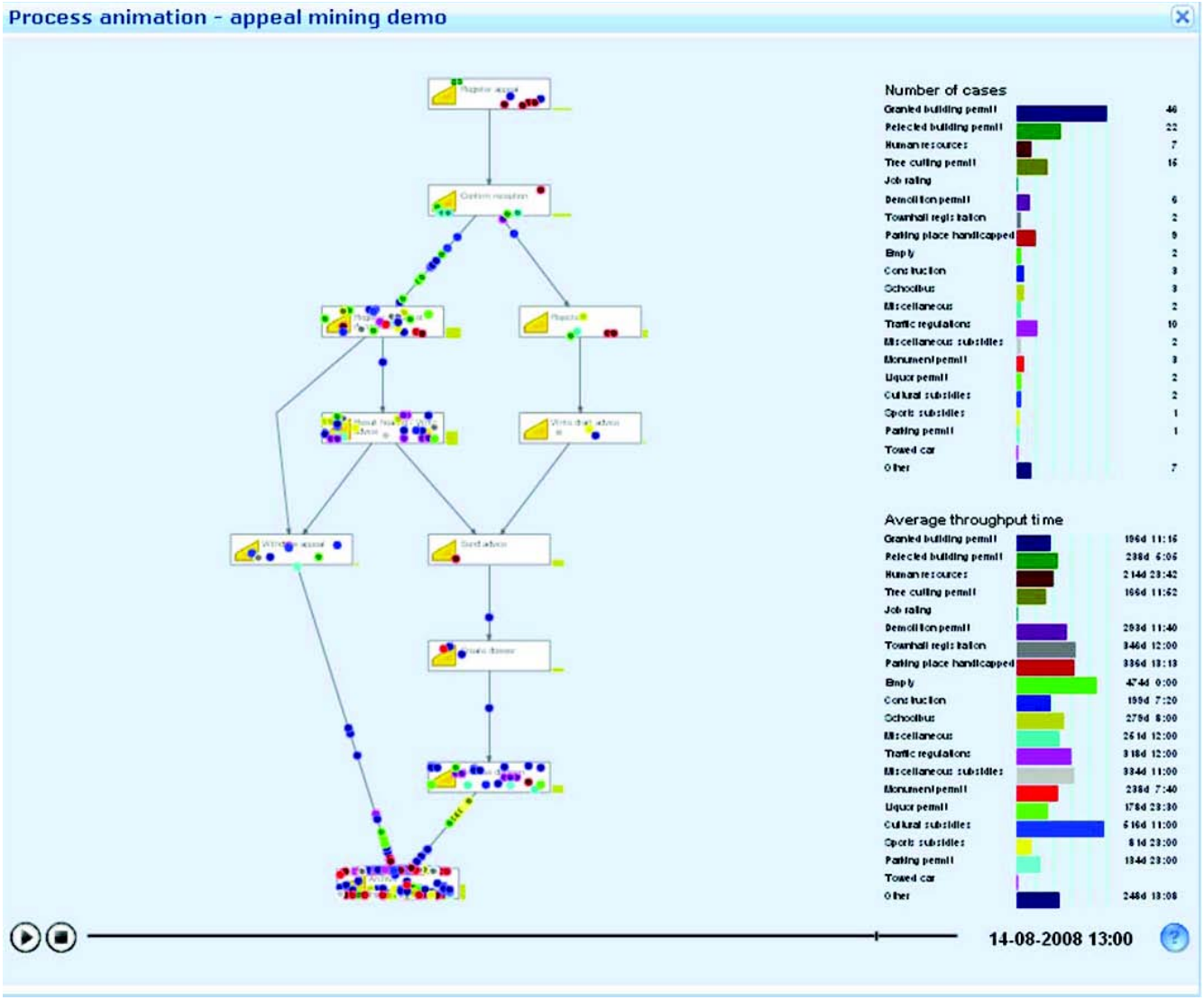


# Process Mining tools (1)

process mining workbench



# Process mining tools (2)

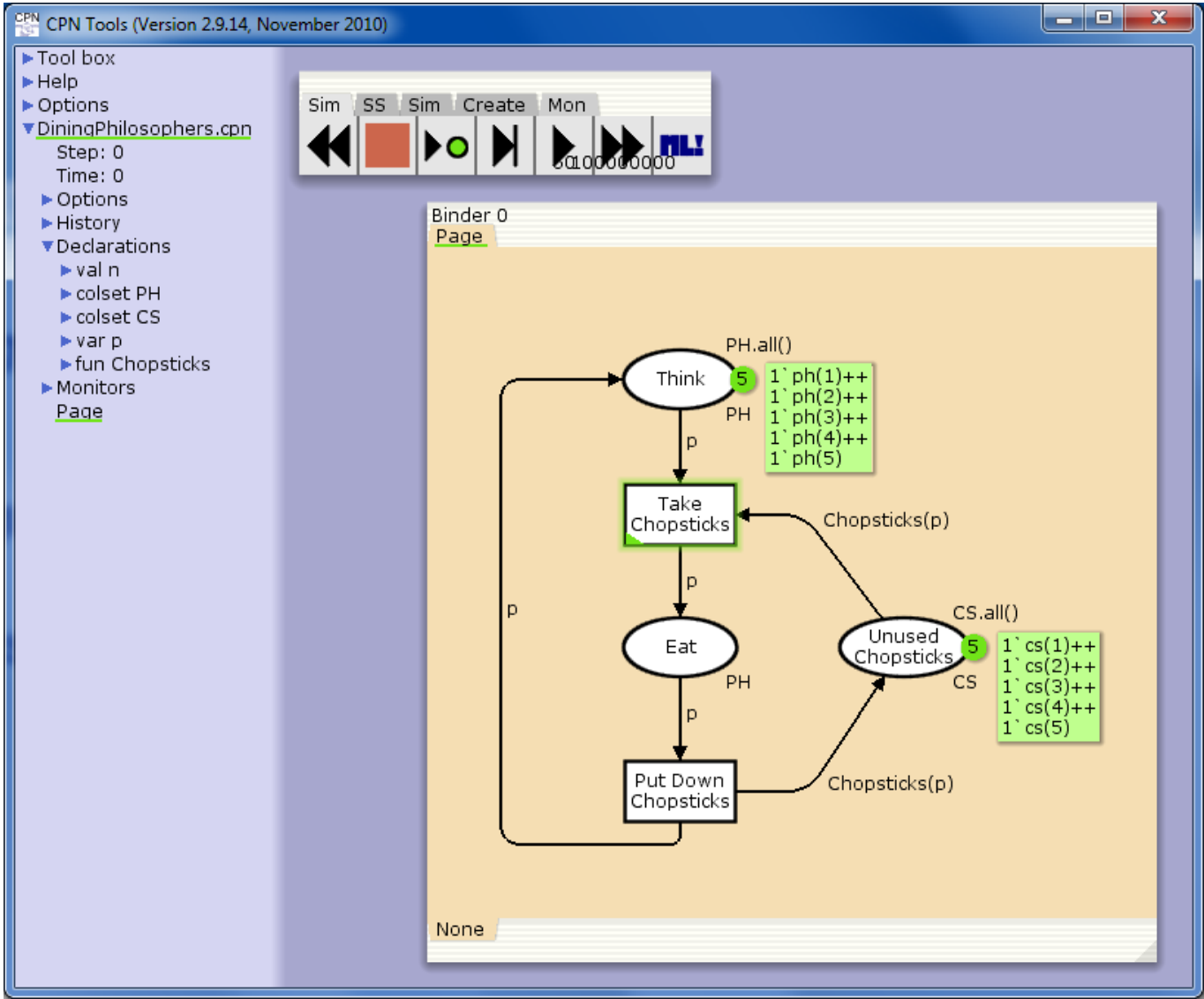


# Petri net tools

***CPN Tools***

***Design and analysis***

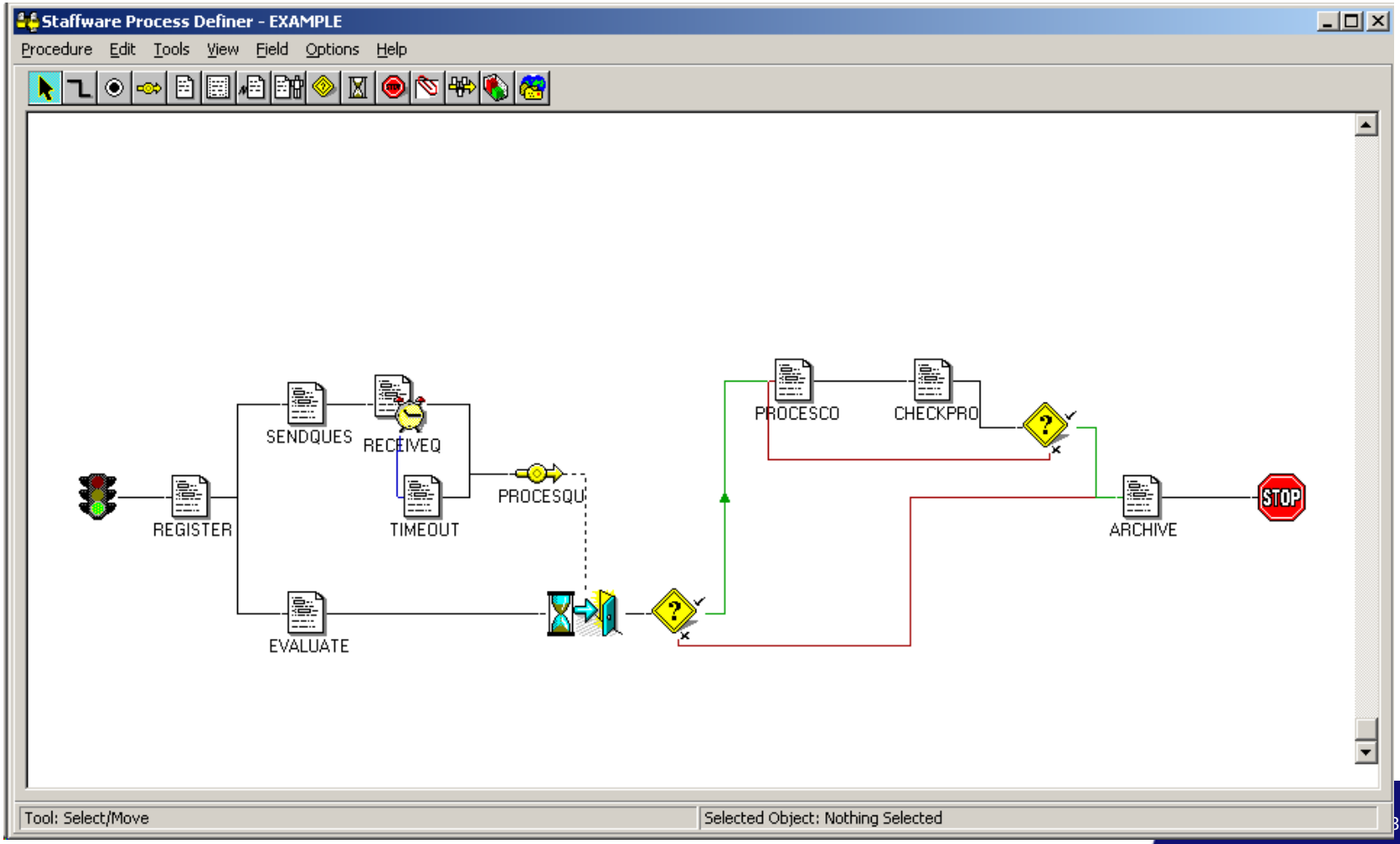
**Based on Petri nets.**



# Workflow management systems

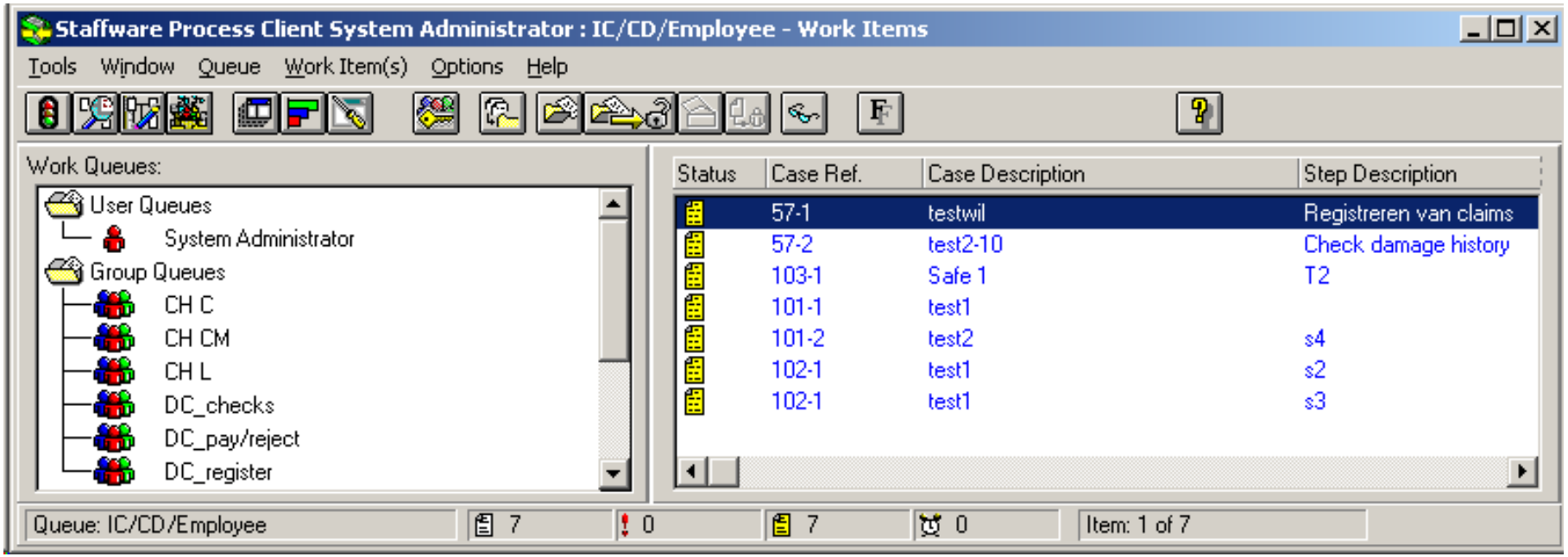
staffware.
THE POWER OF PROCESS

## *Staffware workflow designer*



# Workflow management systems (2)

***Staffware worklist handler***




**Based on a vendor specific language.**

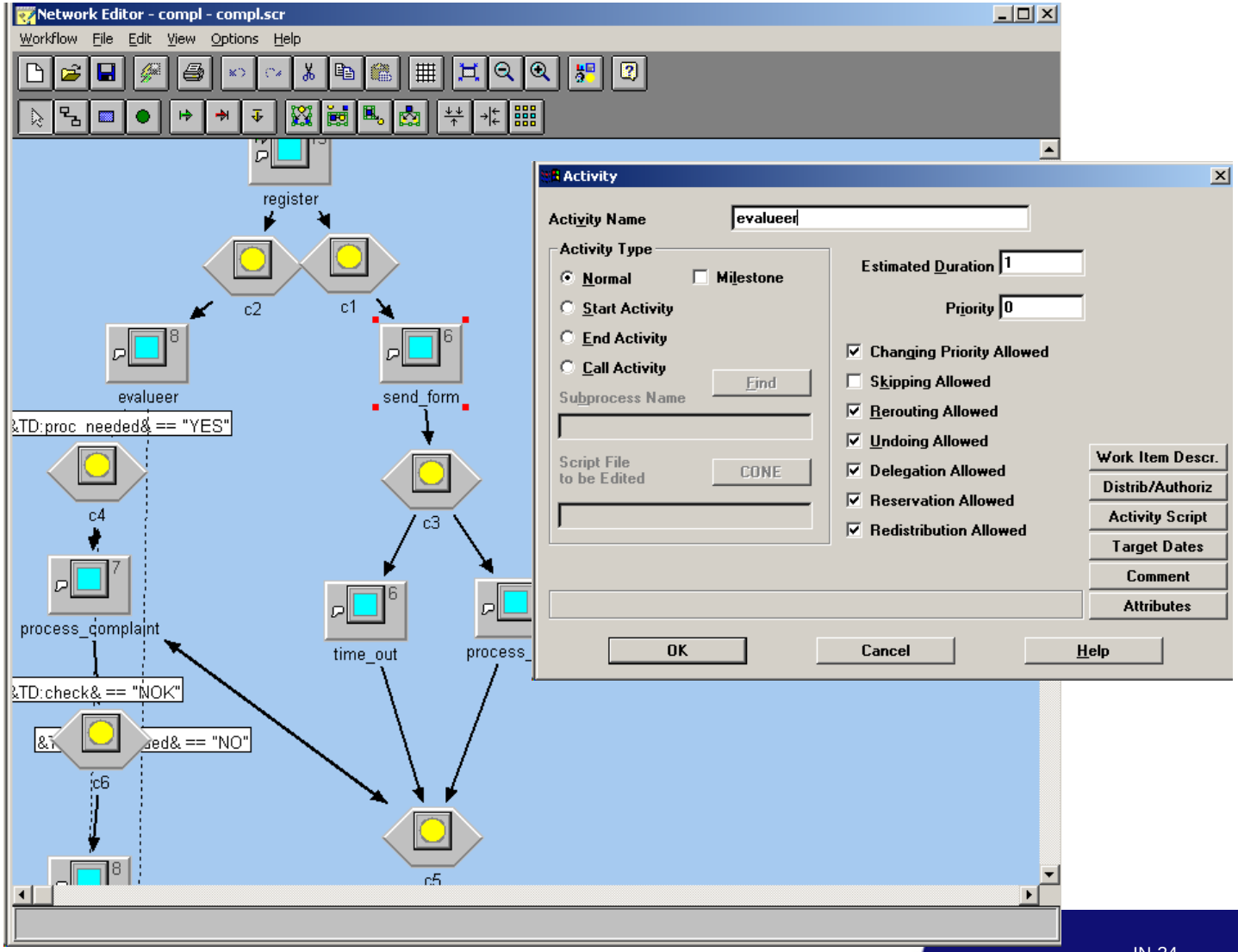
***Enactment***

# Workflow management systems (3)

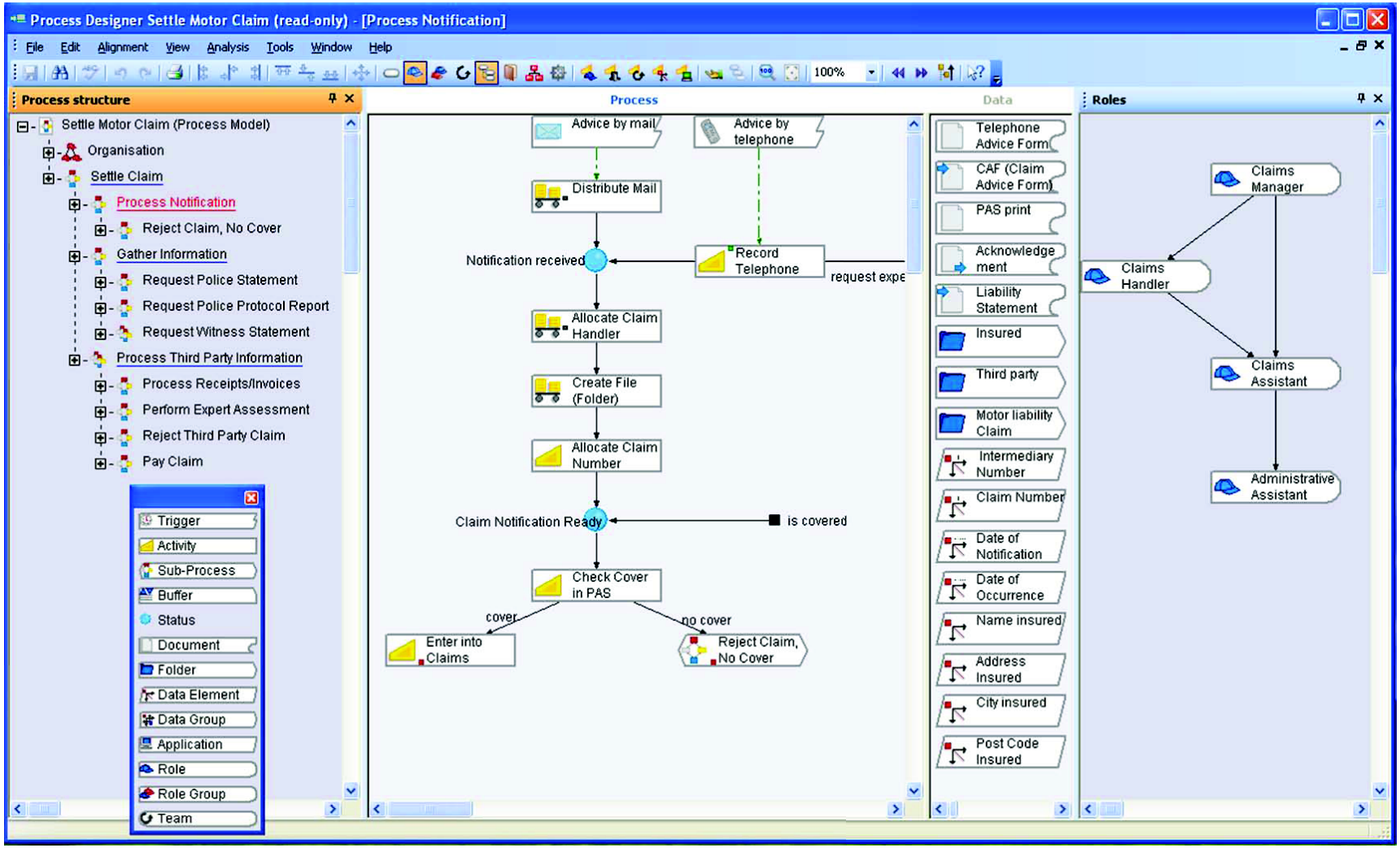
***COSA***

***Enactment***

**Based on Petri nets.**



# Workflow management systems (4)

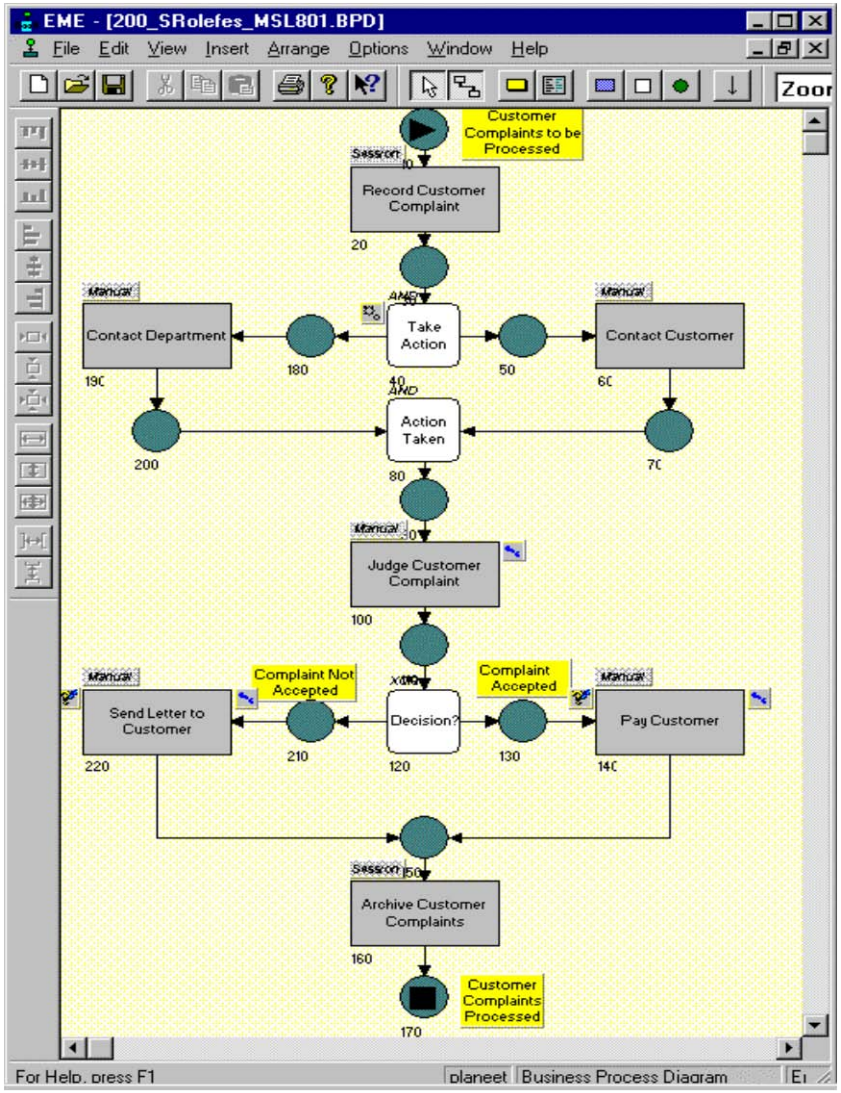


# Enterprise resource planning (ERP) systems

BaaN

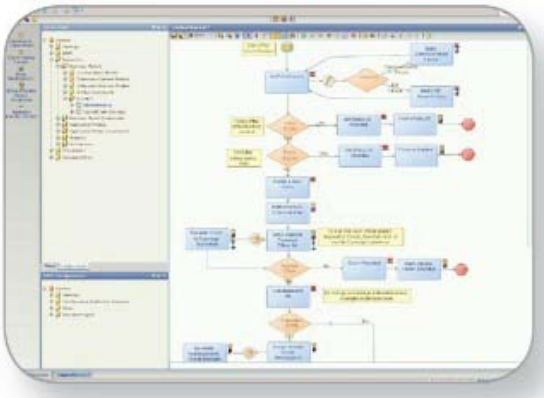
***Baan (DEM)***

***Design, training, configuration, and enactment***




**Based on Petri nets.**

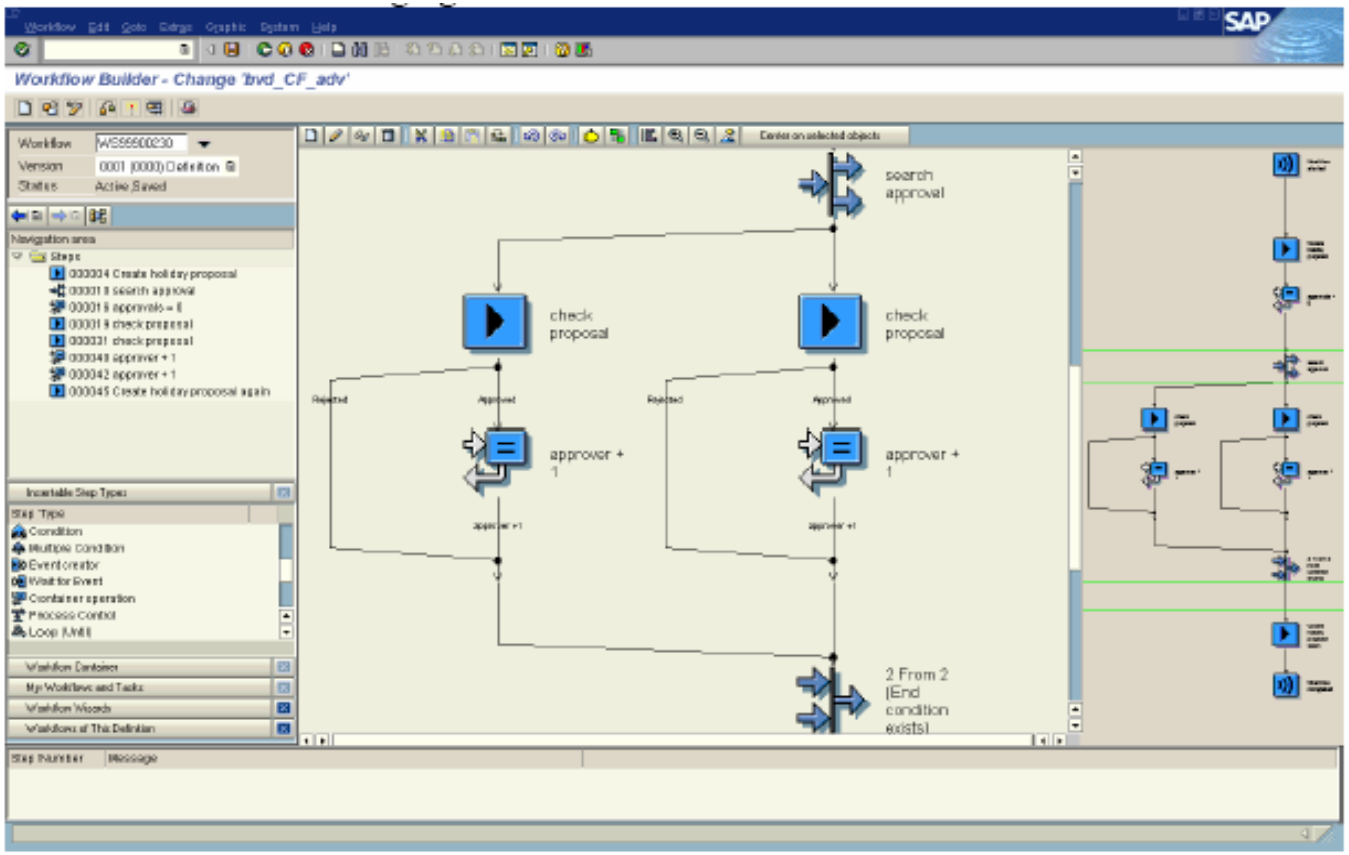
CORDYS



# Enterprise resource planning (ERP) systems (2)

***SAP (workflow)***

***Design, training, configuration, and enactment***



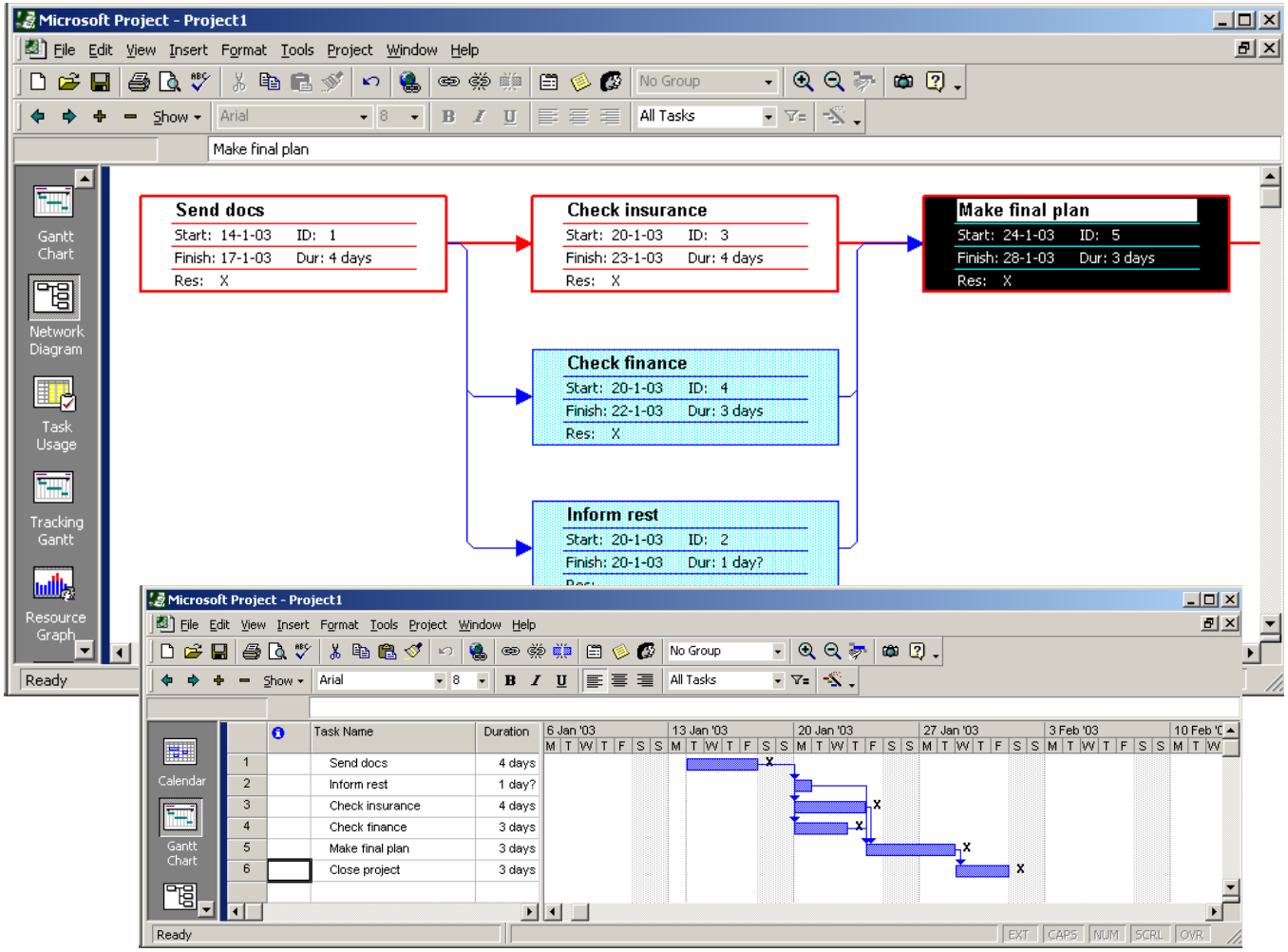

**Also EPC view**

# Project planning

***MS project***

***Planning***

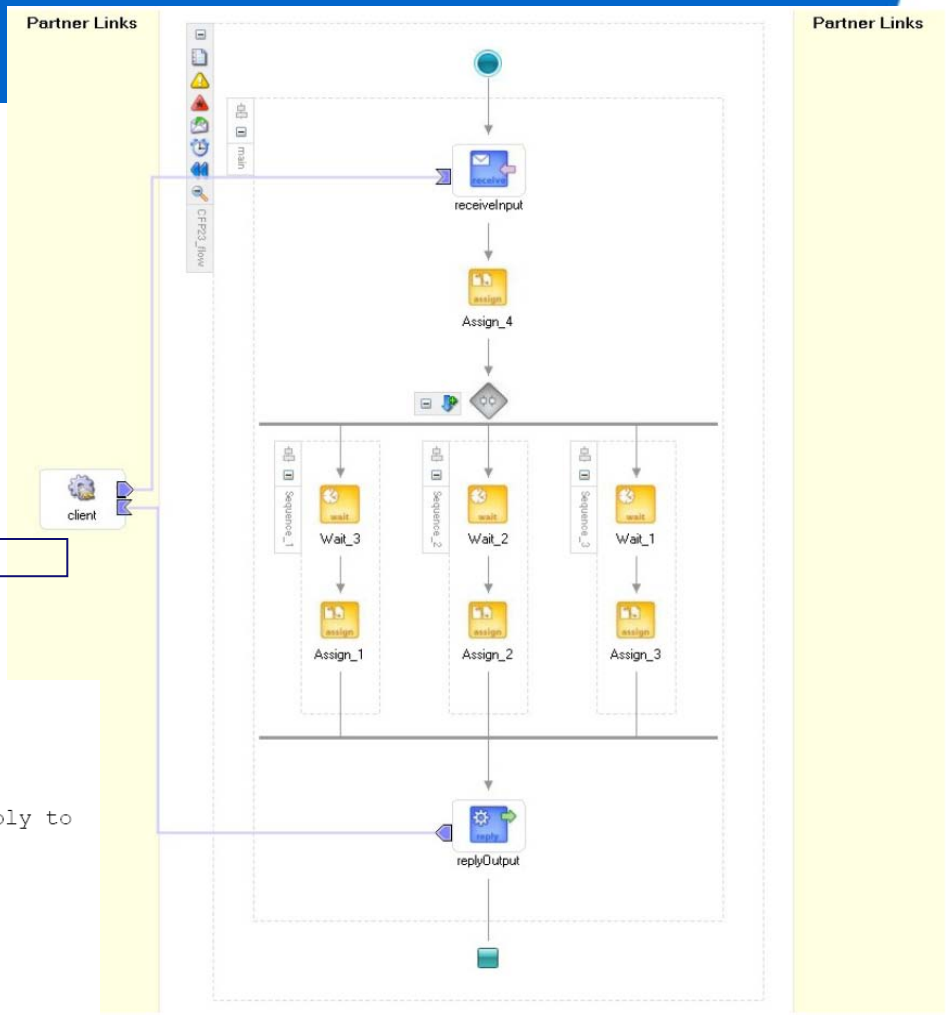
**cf. PERT/CPM**



# Web services

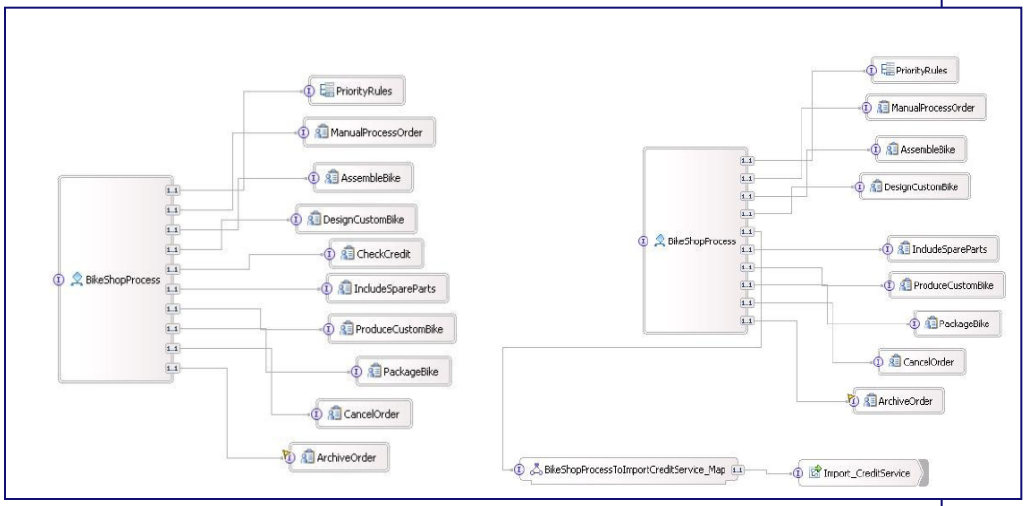
***Oracle BPEL***

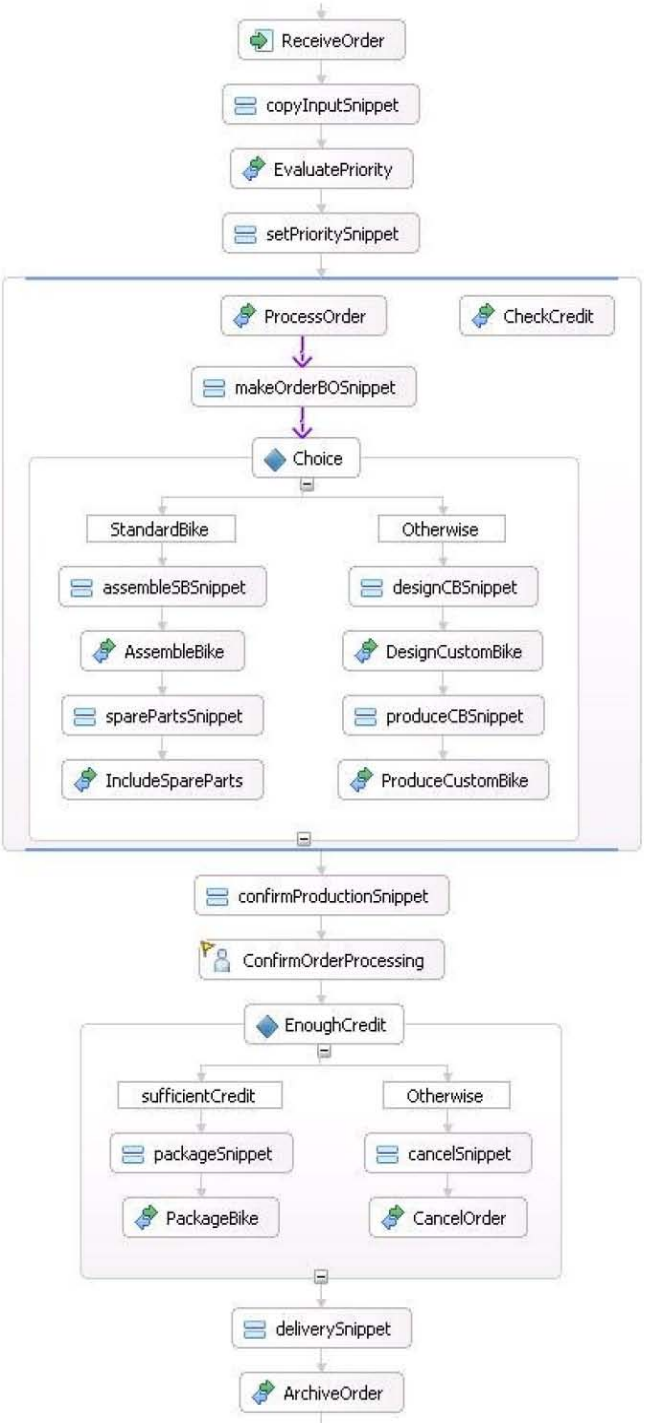
***Enactment based on BPEL standard***




```
  <sequence name="main"><!-- Receive input from requestor.
    Note: This maps to operation defined in CFP23_flow.wsdl
    -->
    <receive name="receiveInput" partnerLink="client"
portType="client:CFP23_flow" operation="process"
variable="inputVariable" createInstance="yes"/><!-- Generate reply to
synchronous request -->
    <assign name="Assign_4">
      <copy>
        <from variable="inputVariable" part="payload"
query="/client:CFP23_flowProcessRequest/client:input"/>
        <to variable="outputVariable" part="payload"
query="/client:CFP23_flowProcessResponse/client:result"/>
      </copy>
    </assign>
    <flow name="Flow_1">
      <sequence name="Sequence_3">
        <wait name="Wait_1" for="'PT1M'"/>
        <assign name="Assign_3">
          <copy>
```

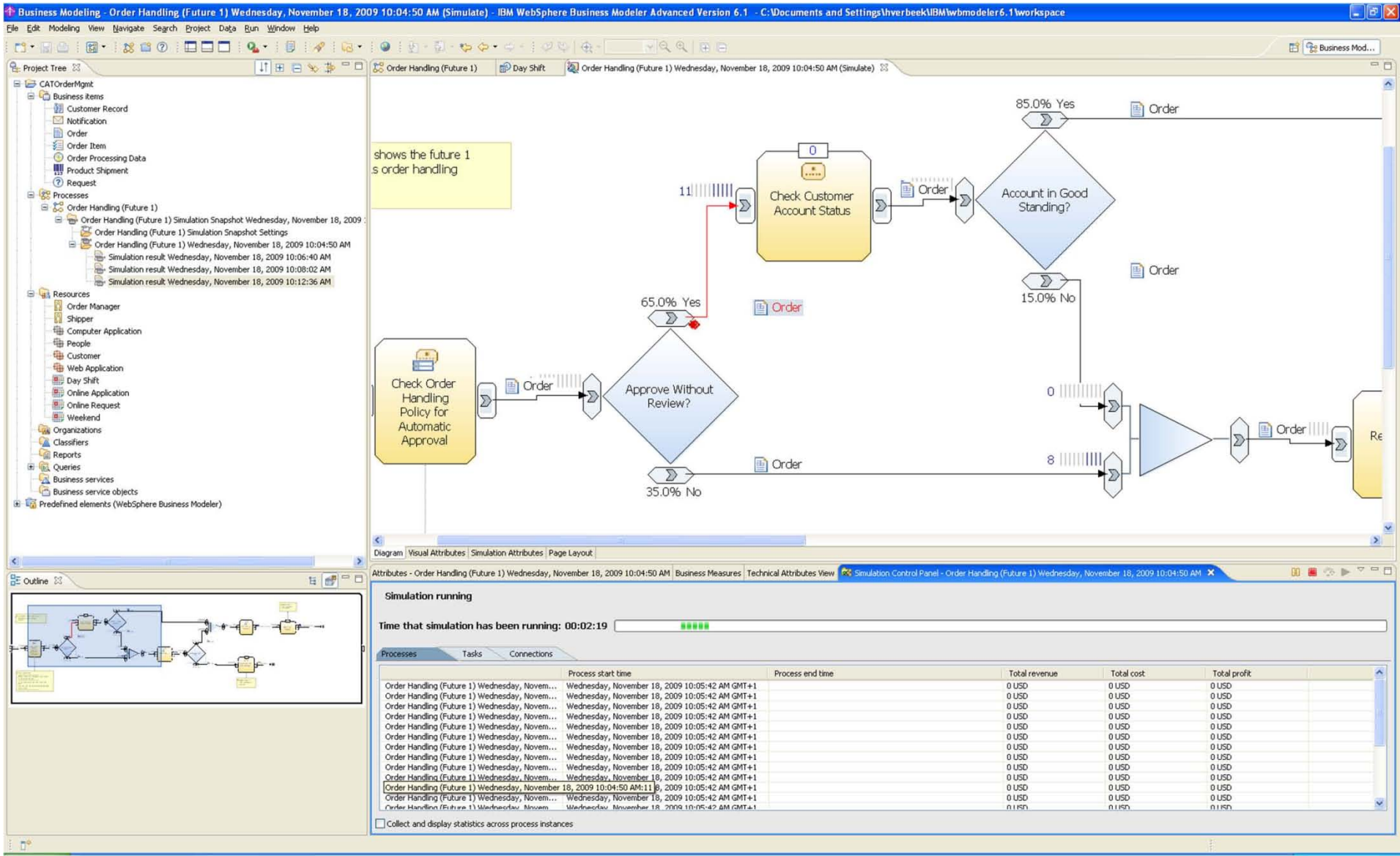
# IBM Websphere (also uses BPEL)



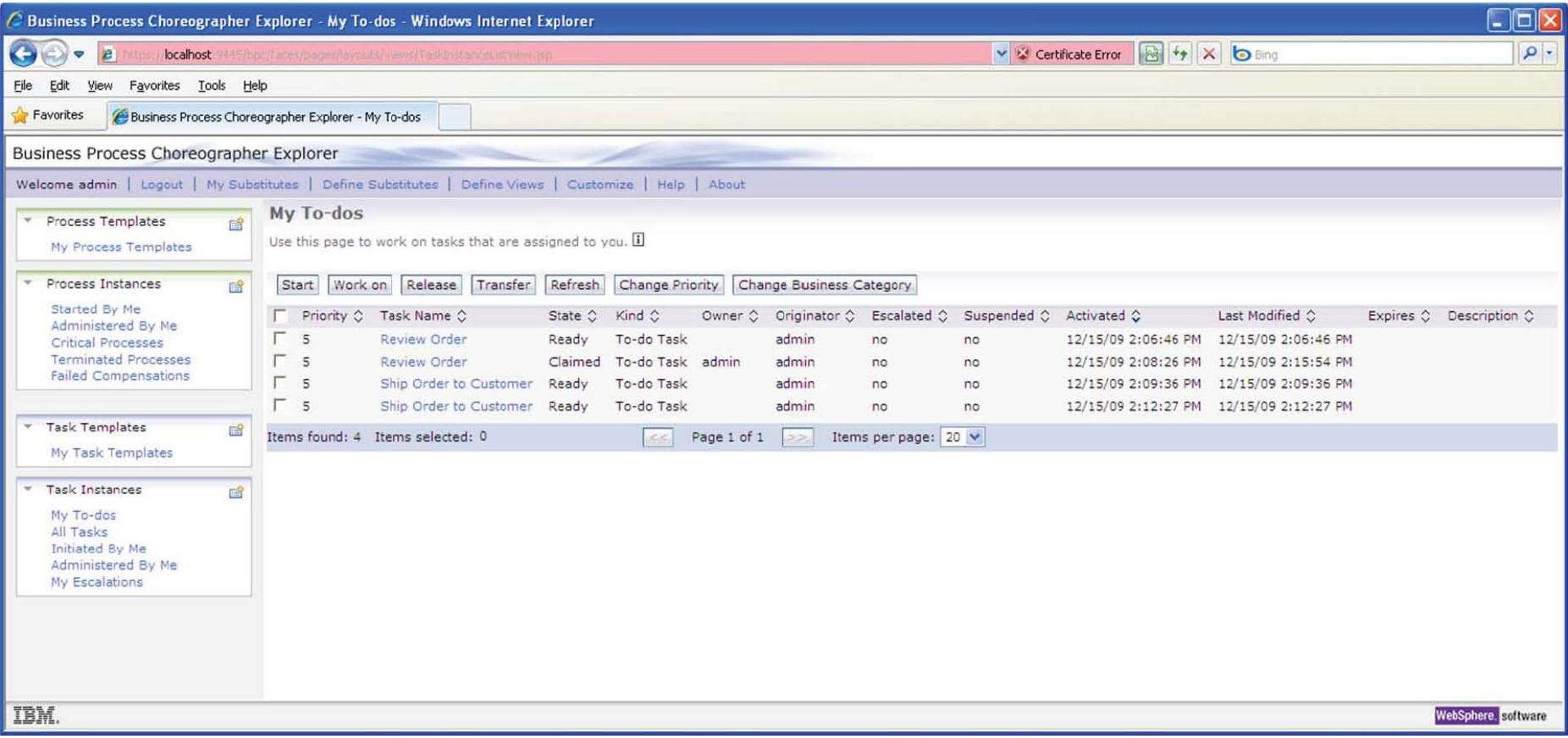




Powered by IBM WebSphere e-business software

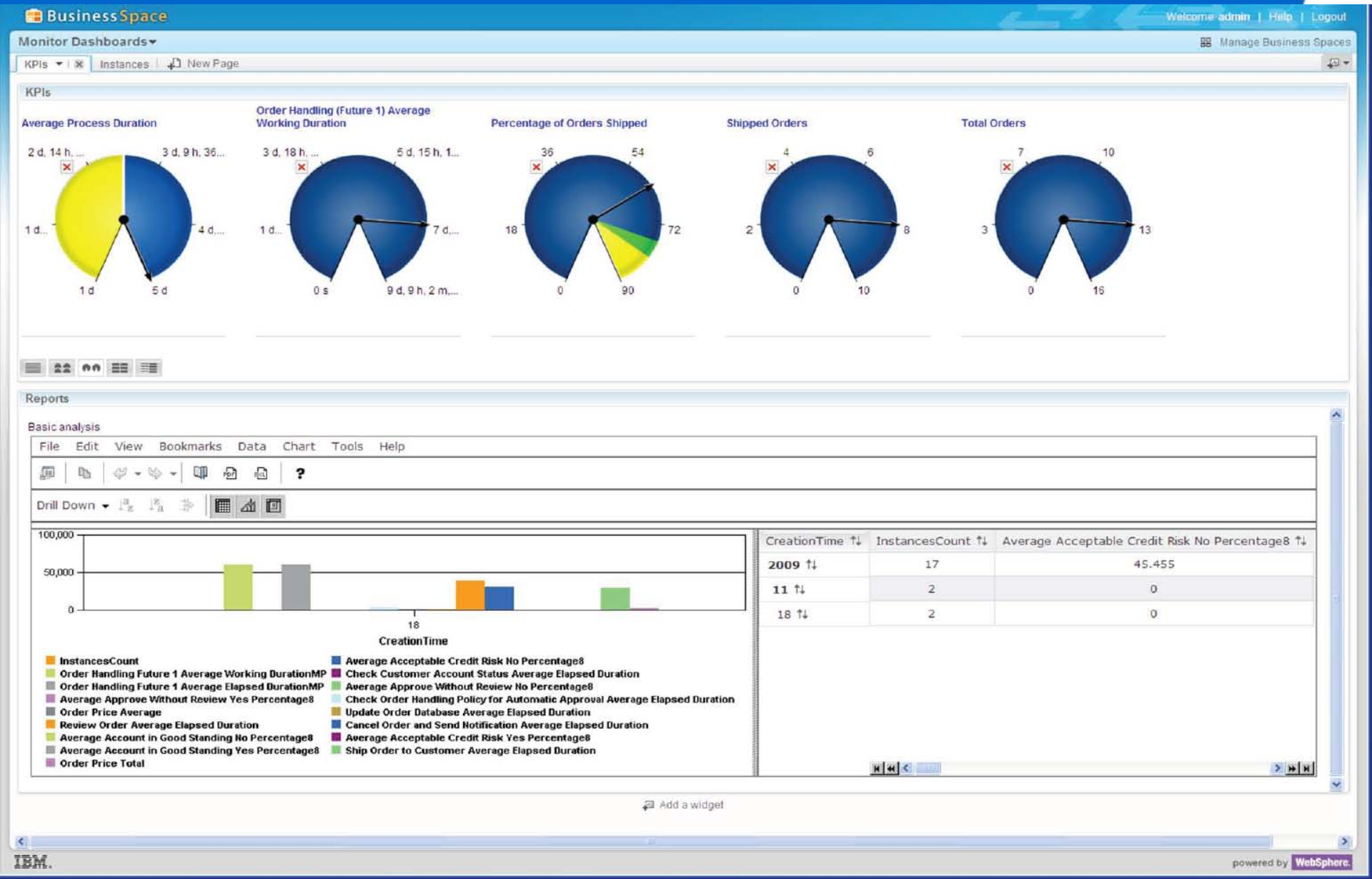
# WebSphere Business Modeler (flowcharts are translated into BPEL)



# Worklist in WebSphere



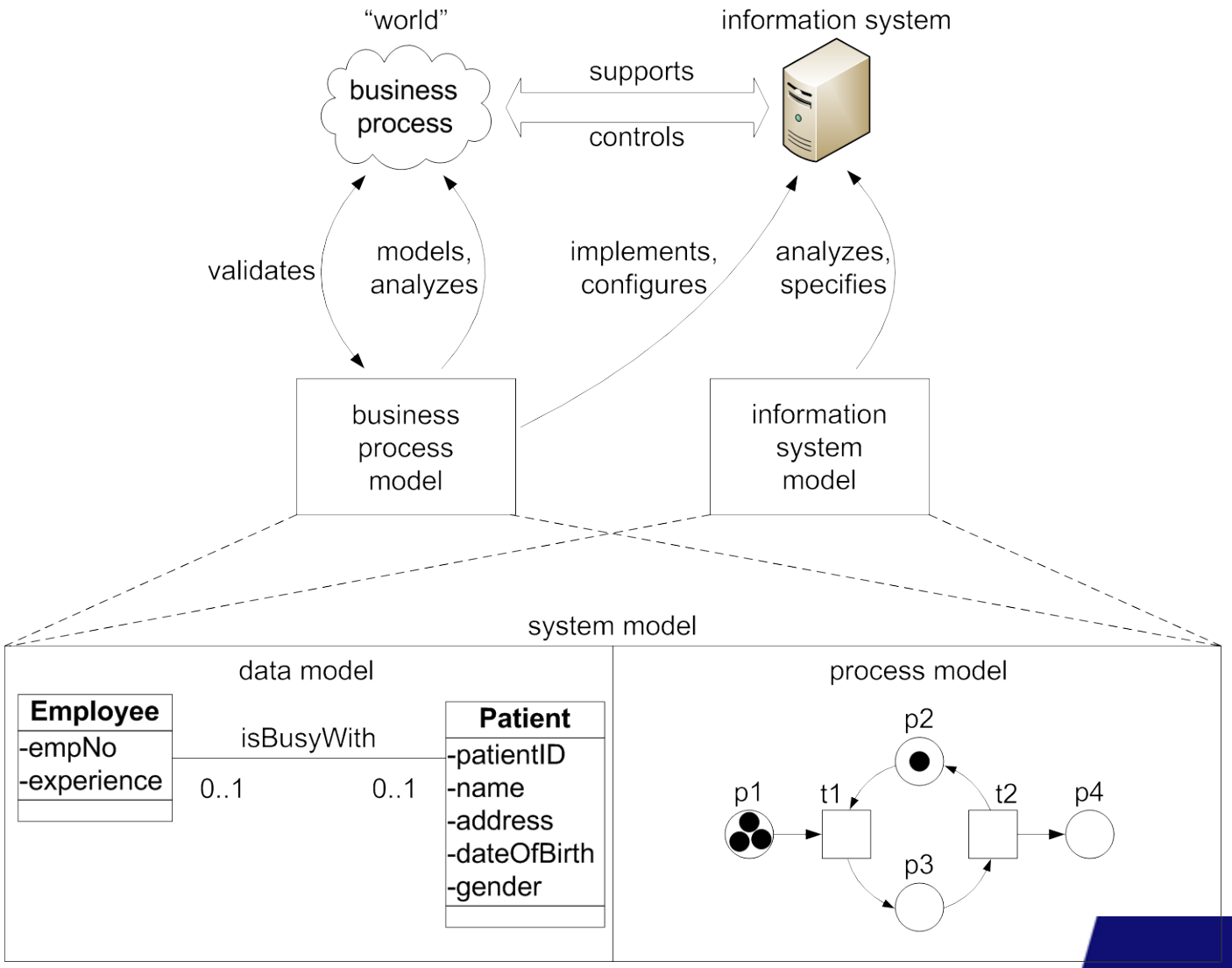
# Management information in WebSphere



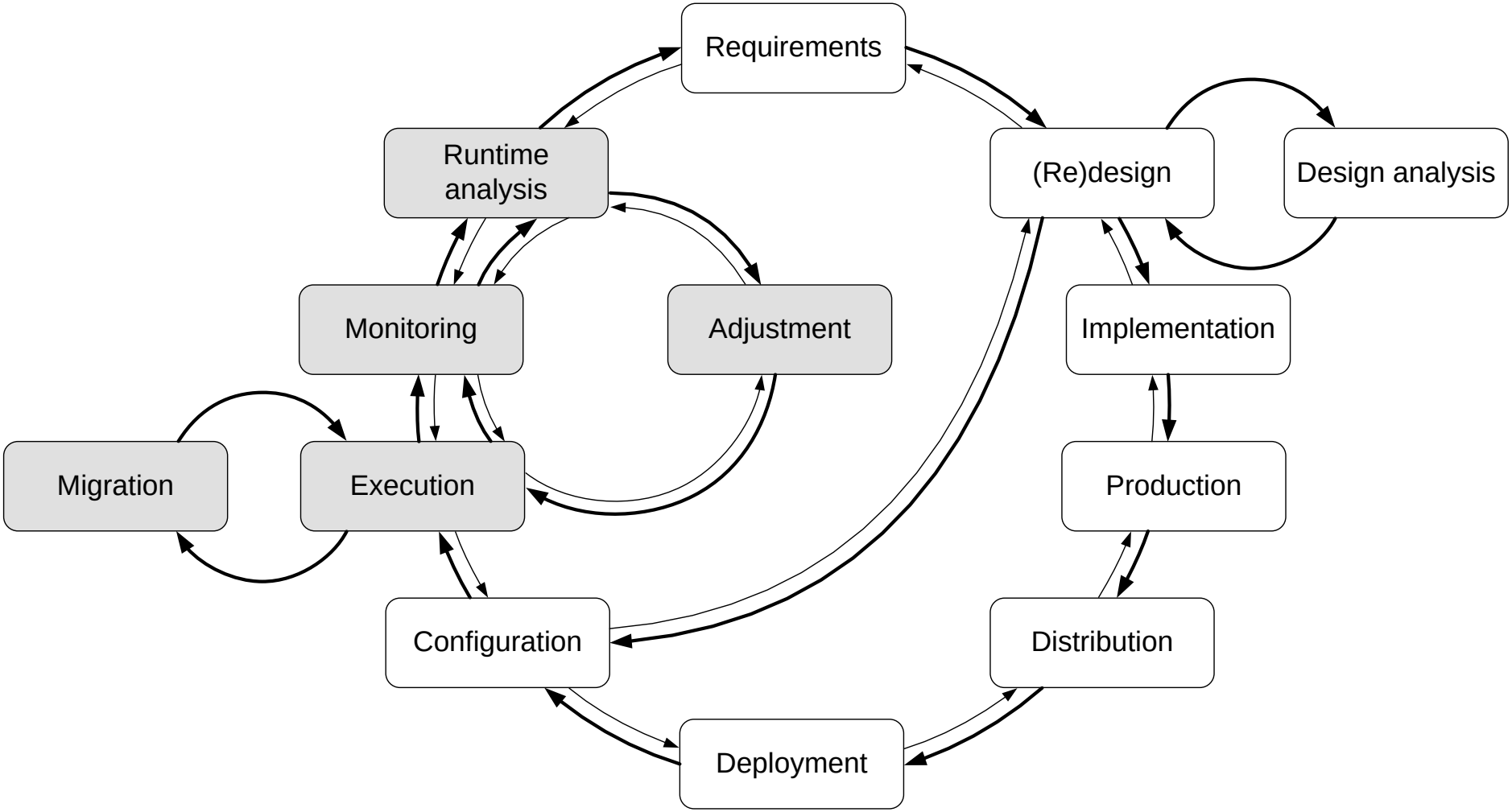
# As shown …

**processes & process models are everywhere!!**

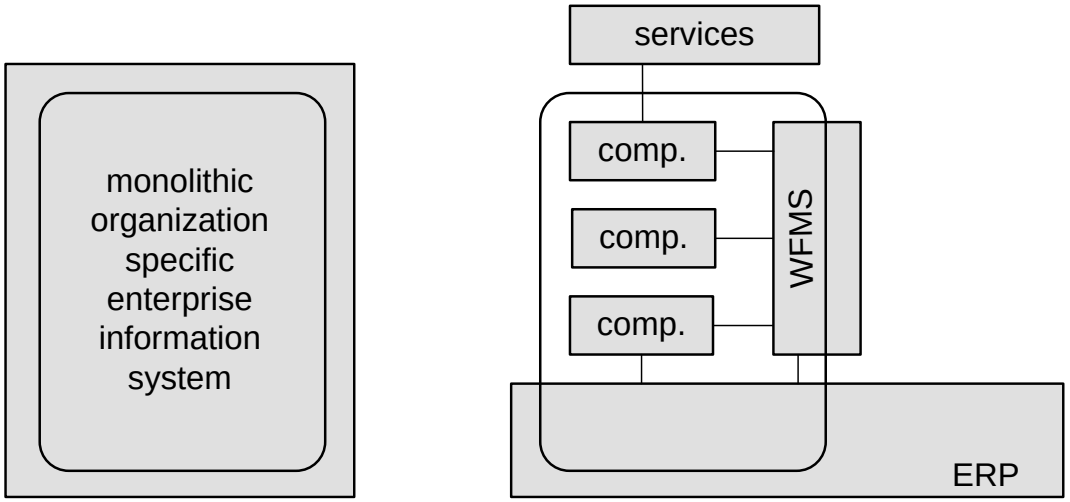
# Business process models versus information system models



# Lifecycle of Business Information Systems



# Some trends




Trend 1: from data orientation to process orientation

Trend 2: from programming to assembling

Trend 3: from programming to configuration

Trend 4: toward redesign and organic growth

# Preview

- Classical Petri net
- Extensions with
  - Color (data)
  - Time
  - Hierarchy
- Colored Petri Nets (CPN) language
- Analysis of processes
  - state-space analysis
  - structural methods
  - process mining
  - simulation
- Design patterns
- Other modeling techniques (UML, EPC, BPMN, ...)