

# Business Process Management (BPM)

## Process Monitoring and Mining

Fabrizio Maggi

*(based on lecture material by Marlon Dumas, Wil van der Aalst and Ana Karla Alves de Medeiros*

*<http://www.processmining.org>)*

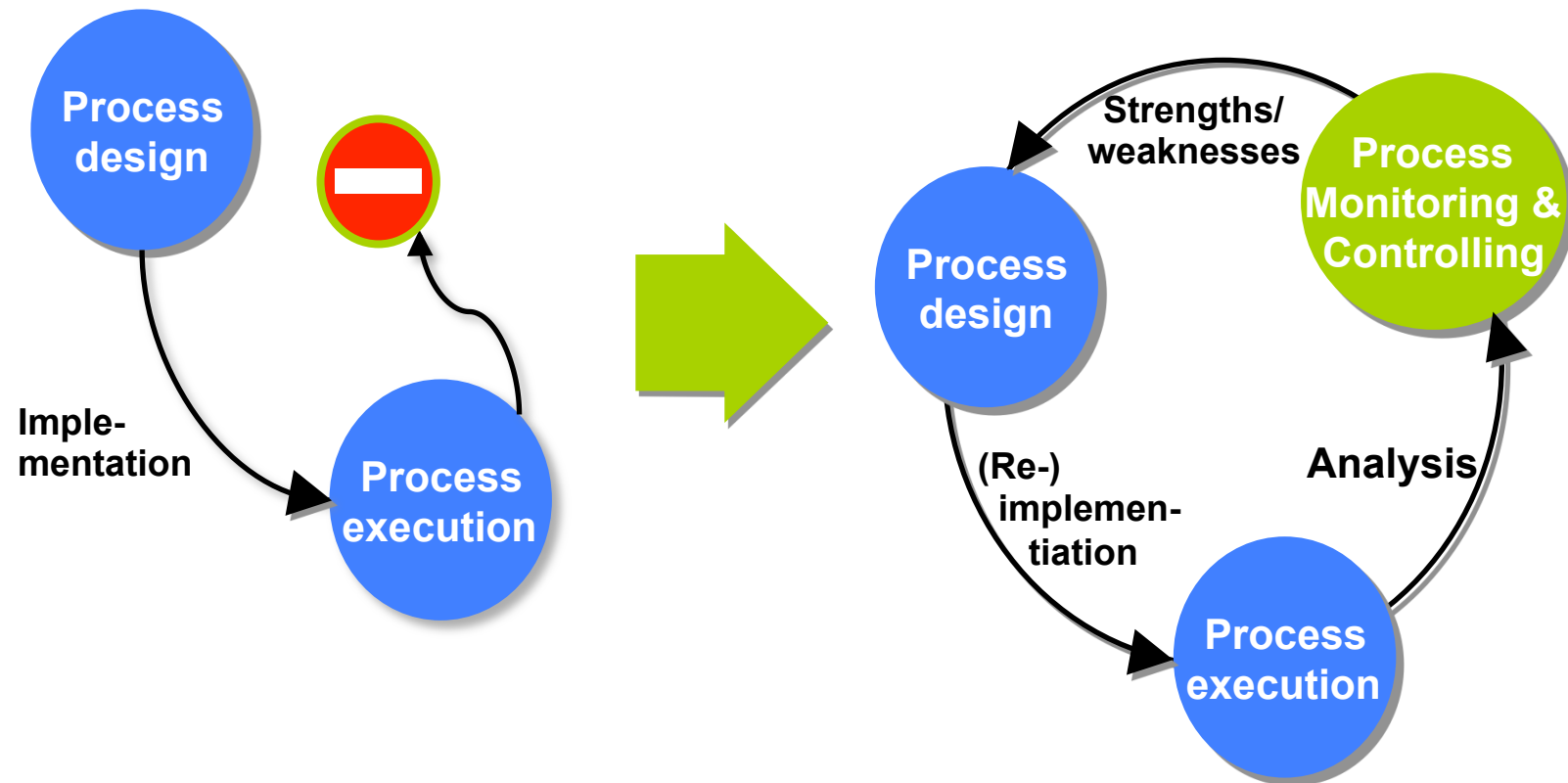


# Business Process Lifecycle Management

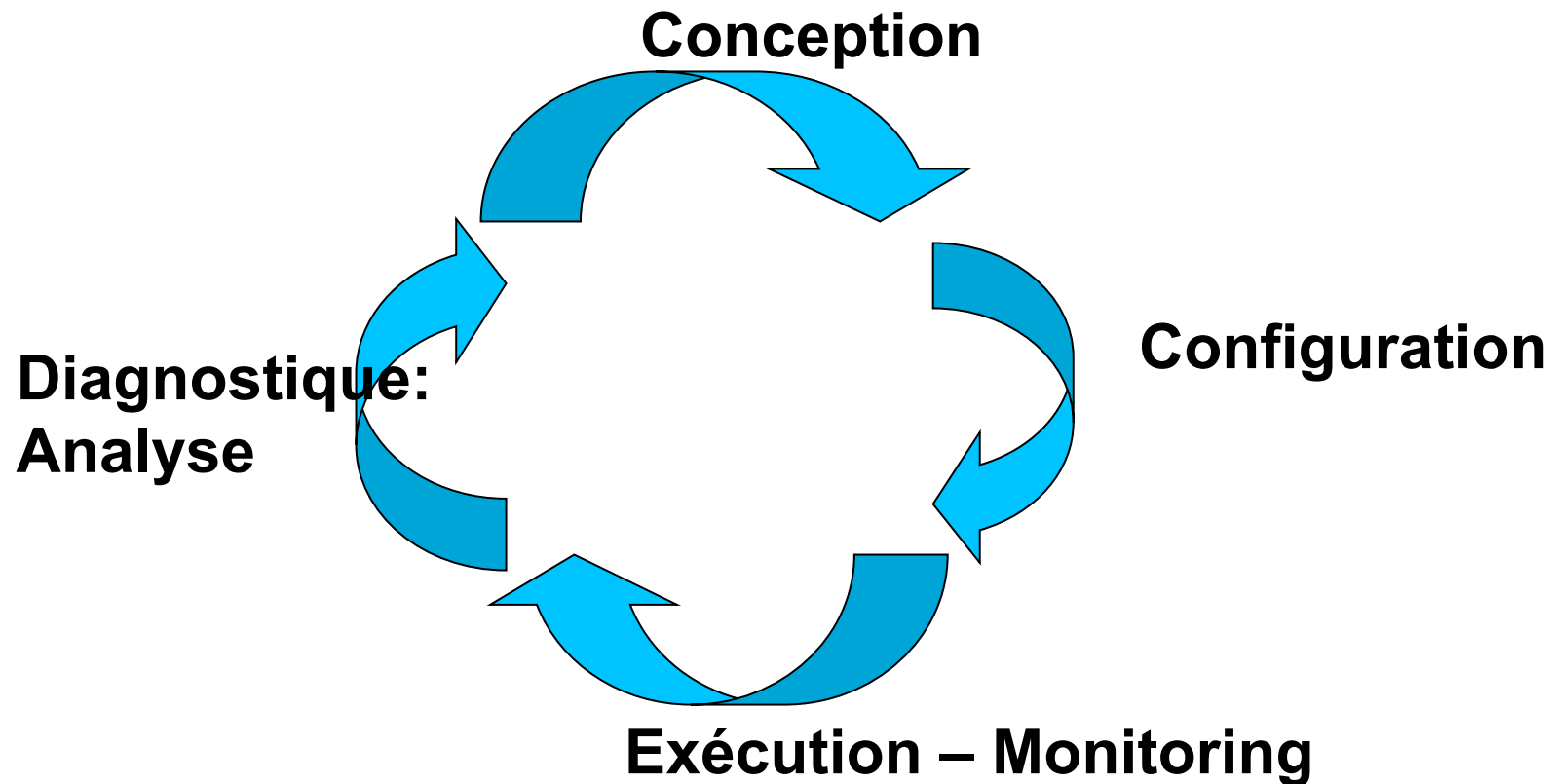
- Process identification
- Process modelling (as-is)
- Process analysis
- Process improvement (to-be)
- Process implementation
- Process execution
- **Process monitoring**



# Process Monitoring and Controlling



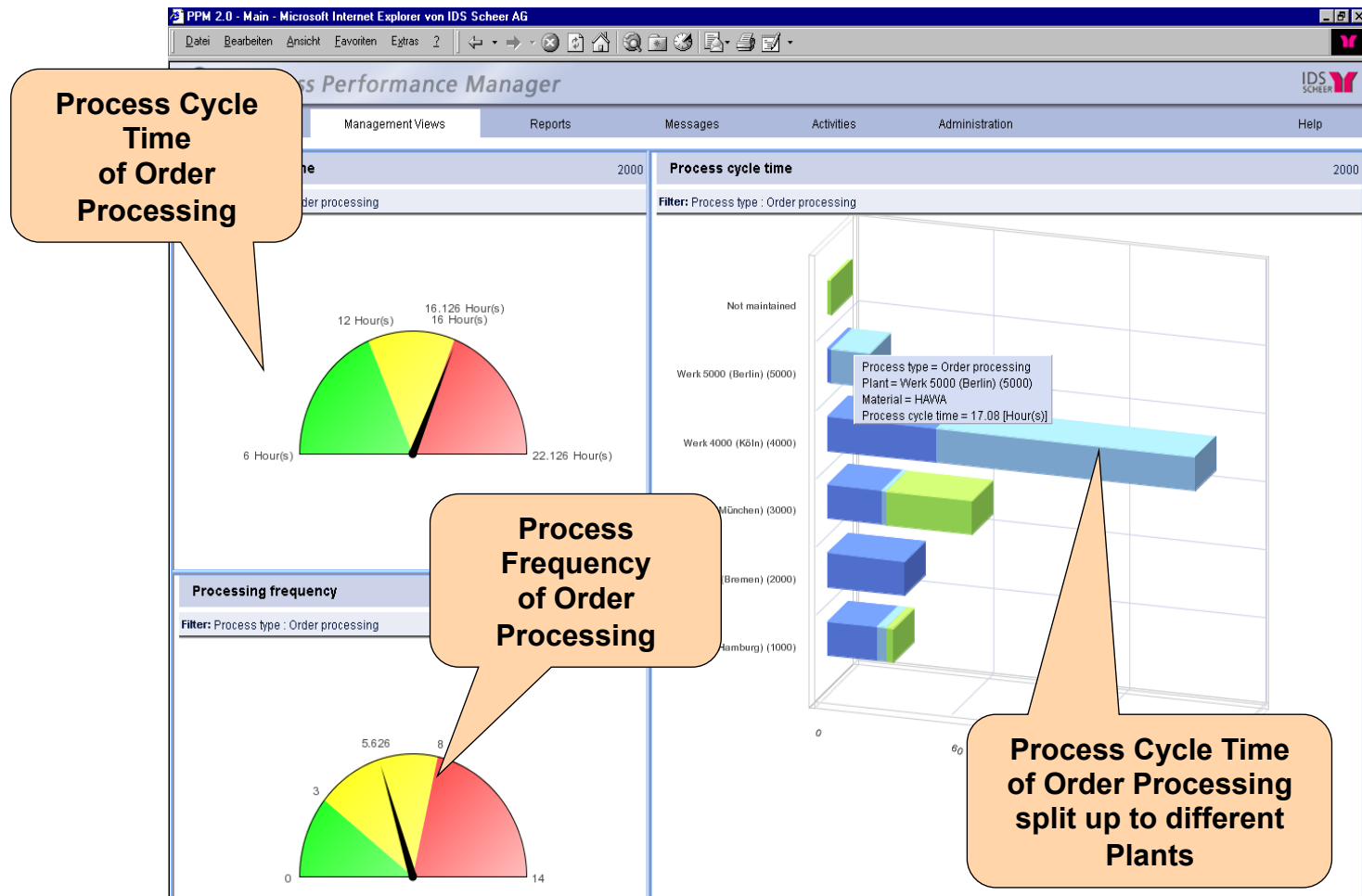
# Cycle de vie d'un processus (2) : le cercle vertueux



# Types of Process Monitoring

- *Runtime Monitoring (Business Activity Monitoring)*
  - Viewing the load of the process
  - Identifying problematic cases
  - Identifying late cases (risk of missing deadlines), etc.
- *Post-mortem Monitoring (aka Business Process Analytics)*
  - Performance KPIs: cycle times, resource utilization, error rates, ...
  - Identification of bottlenecks
- See for example:
  - BizAgi BAM: [http://wiki.bizagi.com/en/index.php?title=Analysis\\_Reports\\_BAM](http://wiki.bizagi.com/en/index.php?title=Analysis_Reports_BAM)
  - Analytics: [http://wiki.bizagi.com/en/index.php?title=Analysis\\_Reports\\_Analytics](http://wiki.bizagi.com/en/index.php?title=Analysis_Reports_Analytics)

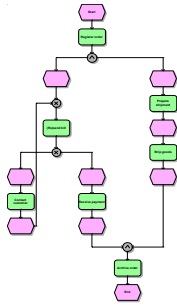
# Process Monitoring: Dashboards



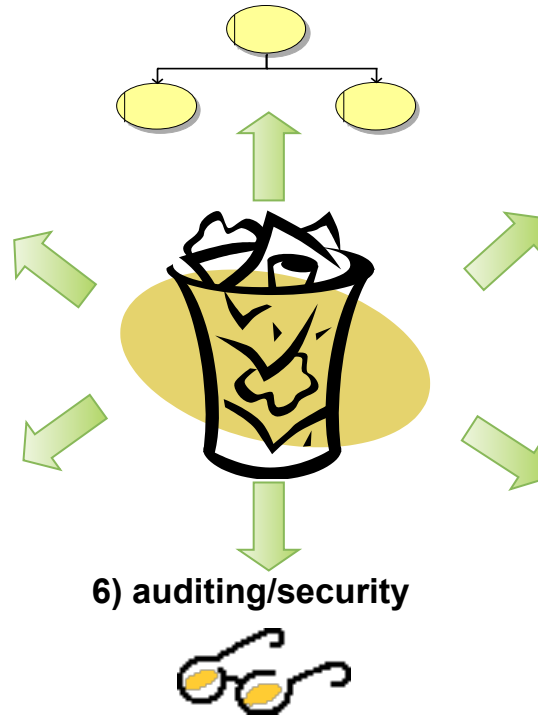
IDS (2003)

# Beyond Monitoring – Process Mining

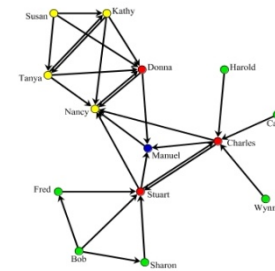
2) process model



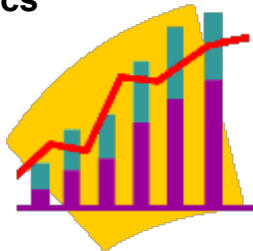
3) organizational model



4) social network



1) basic performance metrics

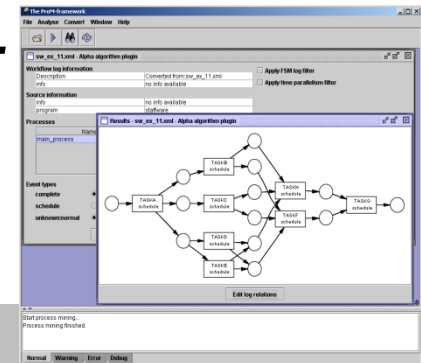


5) performance characteristics



*If ...then ...*

6) auditing/security

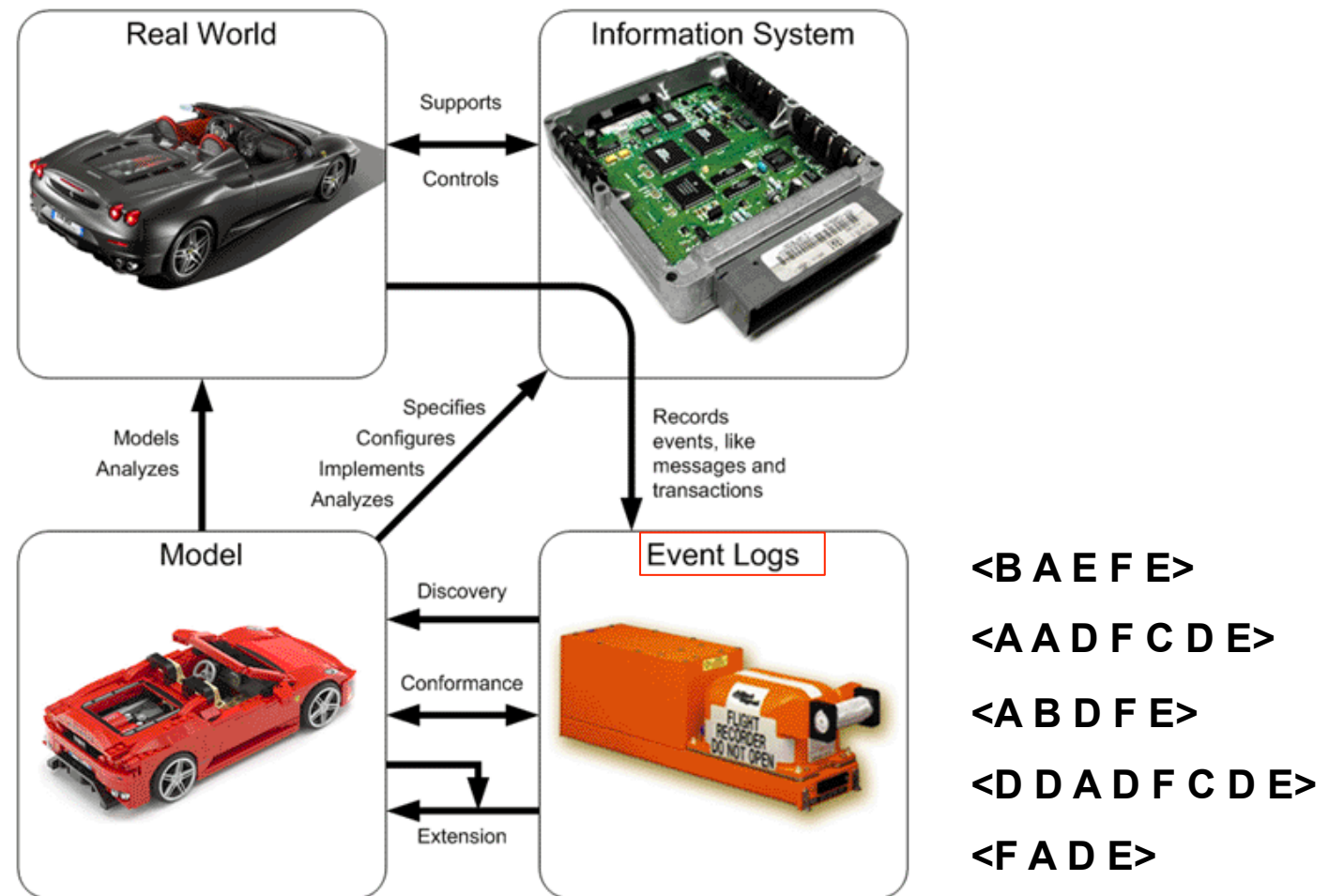


# Process Mining Tools

- ARIS Process Performance Manager
- Percetive Reflect
- Fujitsu Interstage (BPM Analytics)
- ProM



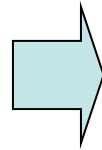
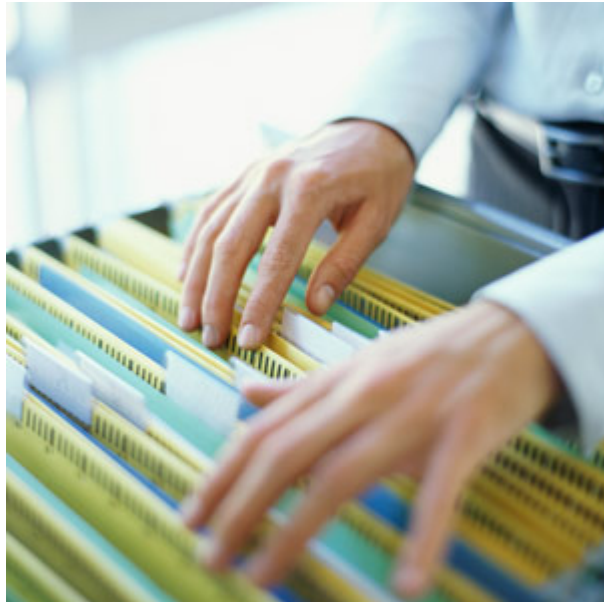
# Starting point: Event Logs



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Case ID	Task Name	Originator	Timestamp	Case ID	Task Name	Originator	Timestamp
1	File Fine	Anne	20-07-2004 14:00:00	3	Reminder	John	21-08-2004 10:00:00
2	File Fine	Anne	20-07-2004 15:00:00	2	Process Payment	system	22-08-2004 09:05:00
1	Send Bill	system	20-07-2004 15:05:00	2	Close case	system	22-08-2004 09:06:00
2	Send Bill	system	20-07-2004 15:07:00	4	Reminder	John	22-08-2004 15:10:00
3	File Fine	Anne	21-07-2004 10:00:00	4	Reminder	Mary	22-08-2004 17:10:00
3	Send Bill	system	21-07-2004 14:00:00	4	Process Payment	system	29-08-2004 14:01:00
4	File Fine	Anne	22-07-2004 11:00:00	4	Close Case	system	29-08-2004 17:30:00
4	Send Bill	system	22-07-2004 11:10:00	3	Reminder	John	21-09-2004 10:00:00
1	Process Payment	system	24-07-2004 15:05:00	3	Reminder	John	21-10-2004 10:00:00
1	Close Case	system	24-07-2004 15:06:00	3	Process Payment	system	25-10-2004 14:00:00
2	Reminder	Mary	20-08-2004 10:00:00	3	Close Case	system	25-10-2004 14:01:00

# Starting point: Event Logs



**unified event log  
(MXML or XES  
format)**

**event logs, audit trails,  
databases, message  
logs, etc.**

# ProMimport

...choose from more than 20 import filter plug-ins for all kinds of log-producing systems, like:

WebSphere, FLOWer, Staffware, PeopleSoft, Eastman, Subversion, CVS, Apache, Aris PPM, CPN Tools,...

...and many more!

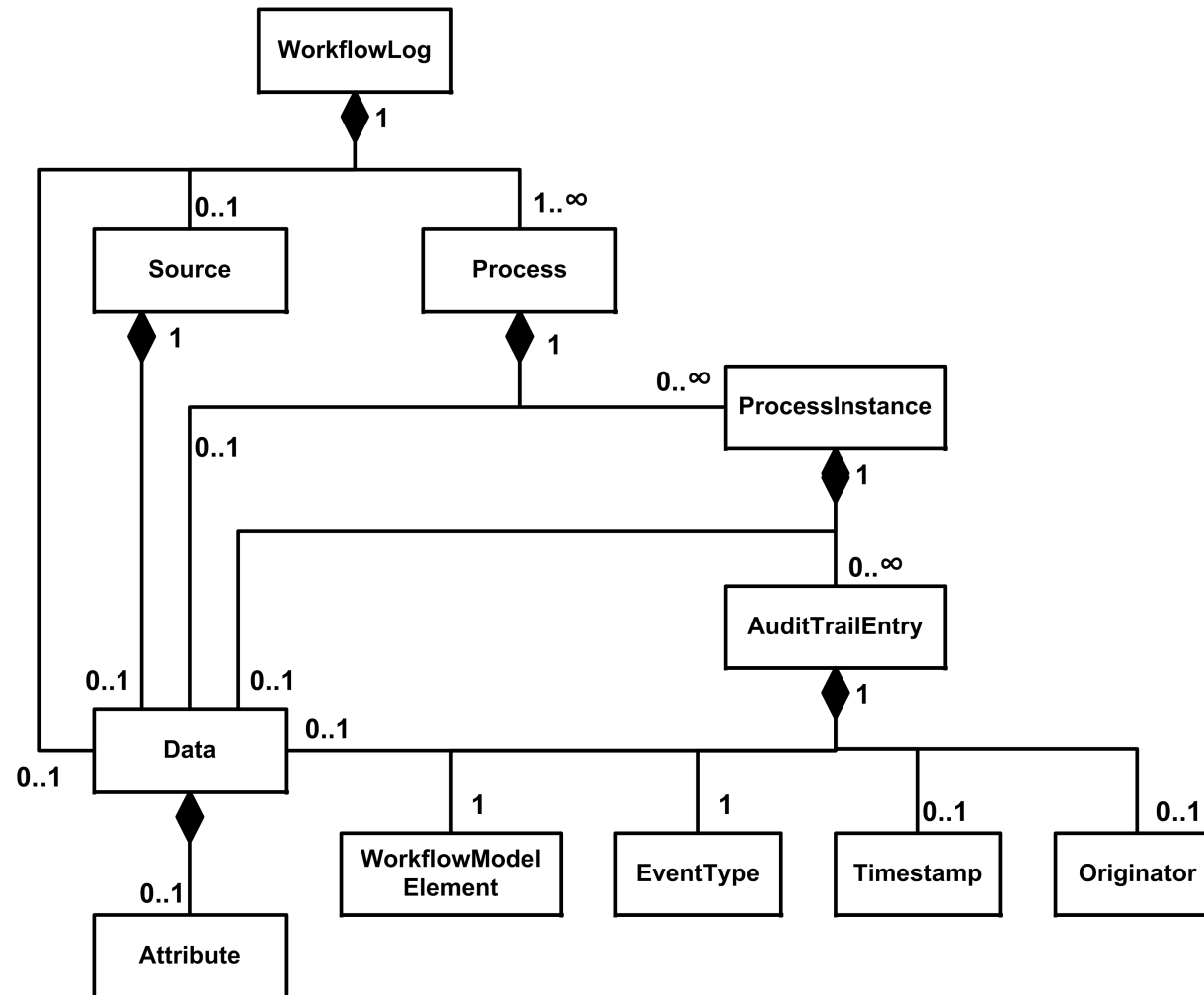
The screenshot shows the ProM Import Framework (V 7.0) interface. On the left, a sidebar lists various import filters, including MXML Pipe, Adept Demonstrator, Eastman, Apache 2, Test Driver, General Csv file, PeopleSoft, Subversion, SAP R/3, Protos file, WebSphere PC (selected), CPN Tools, Noldus Observer XT, and YawIDB. The main window displays the configuration for the 'WebSphere PC' filter. It includes fields for Filter name, Description, and Author(s). Below these are buttons for Start, Abort, Reset, and Help. The 'Output as' section shows 'mxmml.gz' and a path to 'J:\Users\christian'. A 'change...' button and an 'Anonymizer...' button are also present. A 'Console' tab and a 'Filter properties' tab are visible. The 'Filter properties' tab shows a table of properties and their values.

Property	Value
DbName	BPEDB
DbServer	machine.domain.org
DbPort	1527
DbUser	dbusername
DbPassword	dbuserpassword
useEventsActivity	TRUE
useEventsProcessInstan...	TRUE
useEventsProcessTemp...	FALSE
useEventsControlFlow	TRUE
useEventsDataModifica...	FALSE
useEventsWorkItem	TRUE
defaultOriginator	system

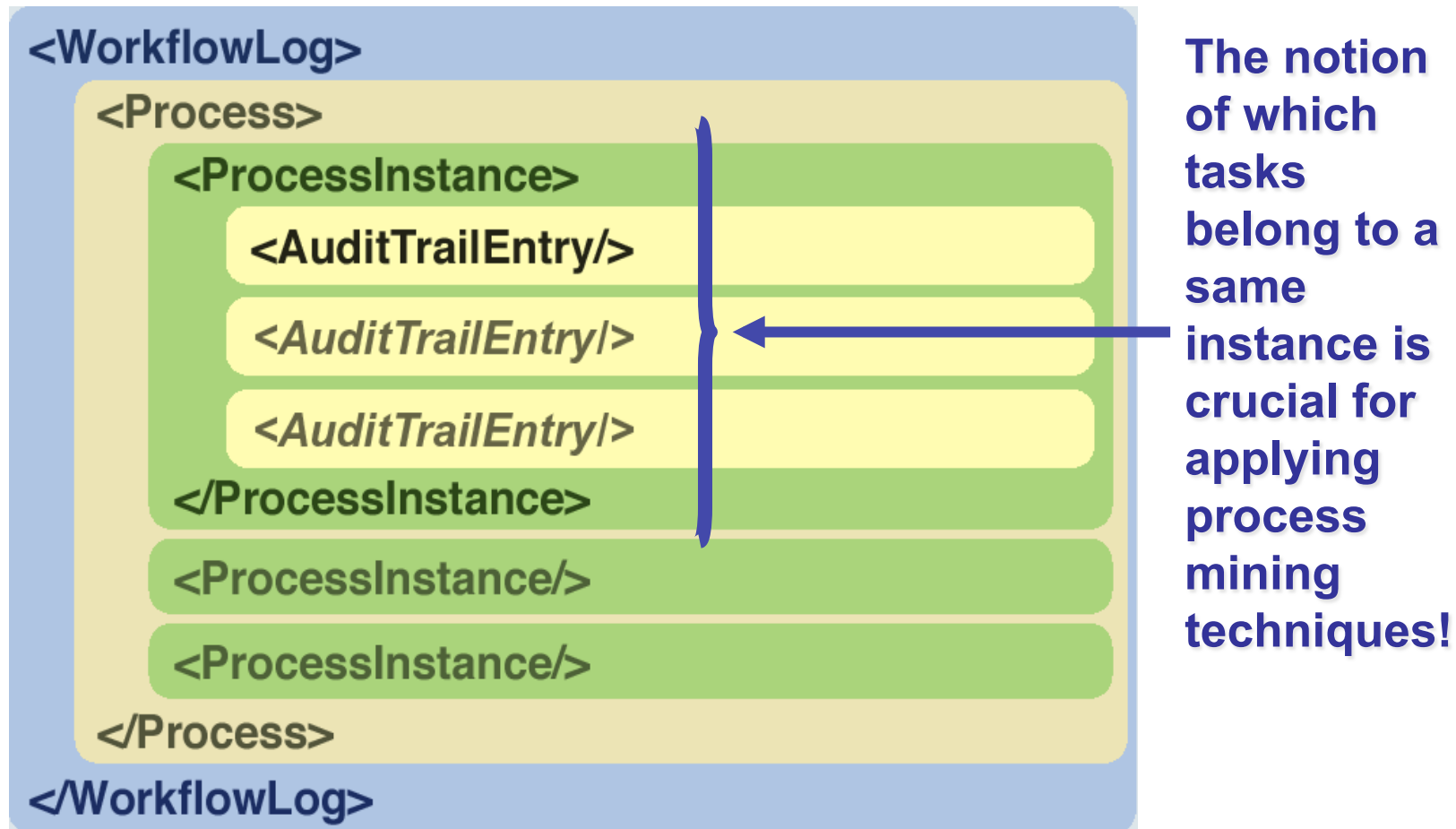
Callouts highlight the following features:

- integrated user help**: Points to the 'Help' button.
- Convenient log anonymization**: Points to the 'Anonymizer...' button.
- Persistent and user-friendly configuration**: Points to the 'Filter properties' tab.

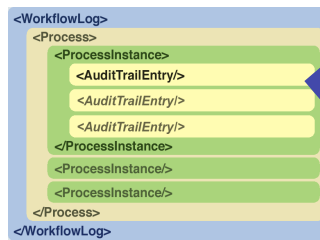
# Event Log: MXML format



# Event Log: MXML format



# Event Log: MXML format



**<AuditTrailEntry>**

**<WorkflowModelElement/>** *Task A* **</Wf.M.E.>**

**<EventType>** *complete* **</EventType>**

**<TimeStamp>** *2005-10-26T12:37:33...* **</TimeStamp>**

**<Originator>** *John Doe* **</Originator>**

**<Data>**

**<Attribute name="x">** *1* **</Attribute>**

**<Attribute name="y">** *whatever* **</Attribute>**

**</Data>**

**</AuditTrailEntry>**

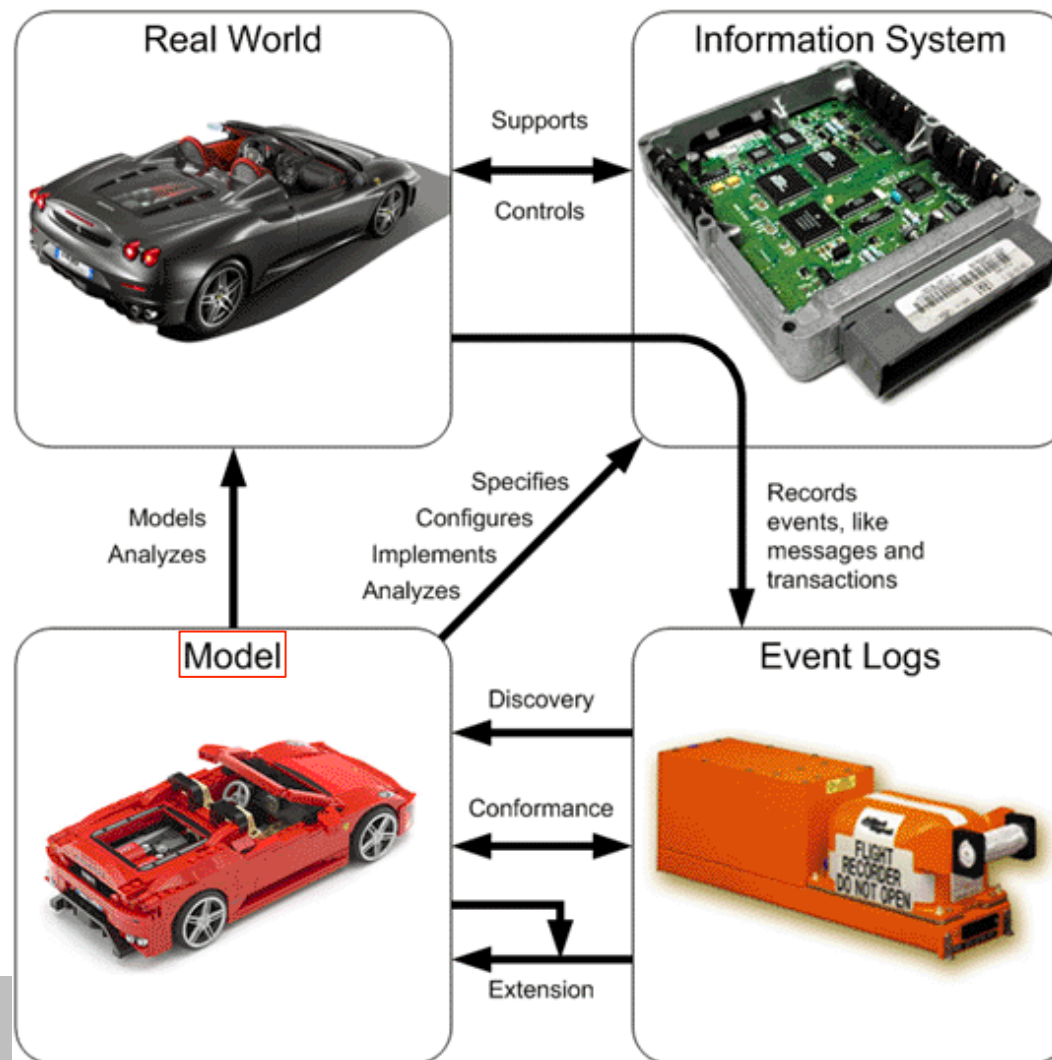
**Compulsory fields!**

# Event Log: MXML format

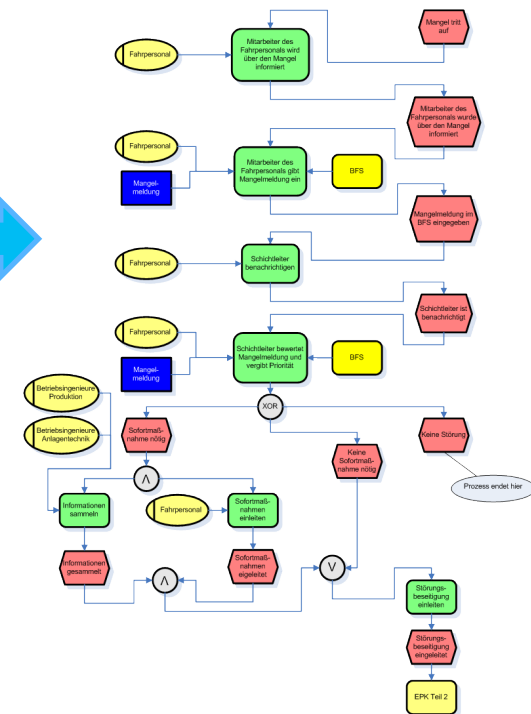
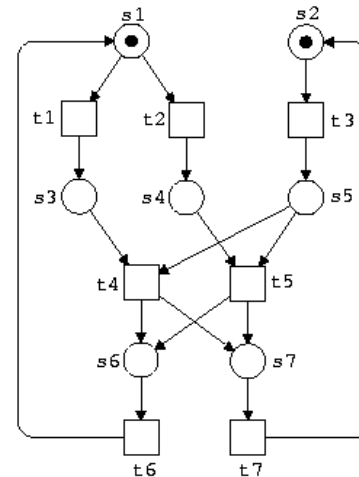
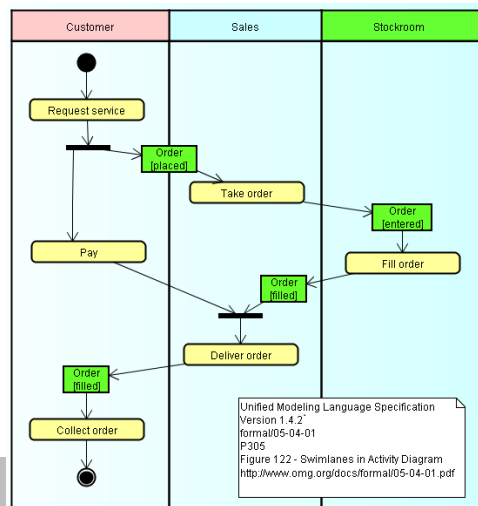
```
<WorkflowLog xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://is.tm.tue.nl/research/processmining/WorkflowLog.xsd">
  <Data>
    <Attribute name="app.name">MXMLib</Attribute>
    <Attribute name="app.version">1.9</Attribute>
    <Attribute name="java.vendor">Sun Microsystems Inc.</Attribute>
    <Attribute name="java.version">1.6.0_30</Attribute>
  </Data>
  <Source program="XES MXML serialization"/>
  <Process id="Compliant tracesAnonymous log imported from Isala.xez" description="process with id Compliant tracesAnonymous log imported from Isala.xez">
    <Data>
      <Attribute name="concept:name">Compliant tracesAnonymous log imported from Isala.xez</Attribute>
      <Attribute name="creator">Fluxicon Nitro</Attribute>
      <Attribute name="library">Fluxicon Octane</Attribute>
      <Attribute name="lifecycle:model">standard</Attribute>
    </Data>
    <ProcessInstance id="3340952" description="instance with id 3340952">
      <Data>
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        <Attribute name="creator">Fluxicon Nitro</Attribute>
      </Data>
      <AuditTrailEntry>
        <Data>
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          <Attribute name="ActiviteitCode">39859</Attribute>
          <Attribute name="ActiviteitOmschrijving">Cysto-Urethrosapie</Attribute>
          <Attribute name="AfdelingCode">W857</Attribute>
          <Attribute name="Bronstysteem">IVA</Attribute>
          <Attribute name="DBC_DatasetCS">0306|__11.__02.__30.__323</Attribute>
          <Attribute name="DBC_DatasetCSOmschrijving">Reguliere zorg.Haematurie.Blaastumor.endolum. endoscop. oper. kl.</Attribute>
        </Data>
        <WorkflowModelElement>Cysto-urethrosapie</WorkflowModelElement>
        <EventType>complete</EventType>
        <Timestamp>2010-06-01T08:30:00.000+02:00</Timestamp>
        <Originator>526521</Originator>
      </AuditTrailEntry>
      <AuditTrailEntry>
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          <Attribute name="ActiviteitCode">190011</Attribute>
          <Attribute name="ActiviteitOmschrijving">Eerste Polikliniekbezoek</Attribute>
        </Data>
      </AuditTrailEntry>
    </ProcessInstance>
  </Process>
</WorkflowLog>
```



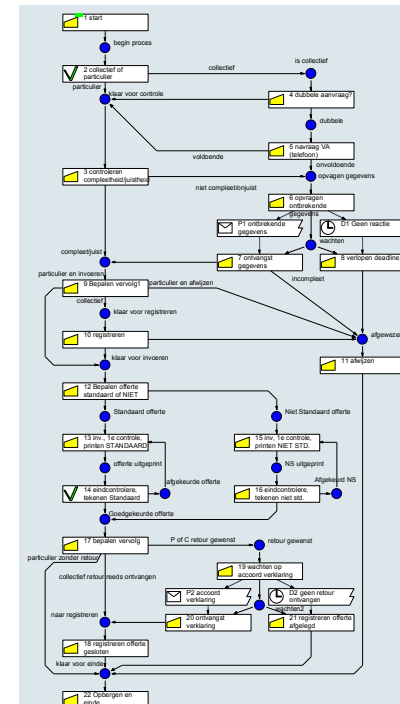
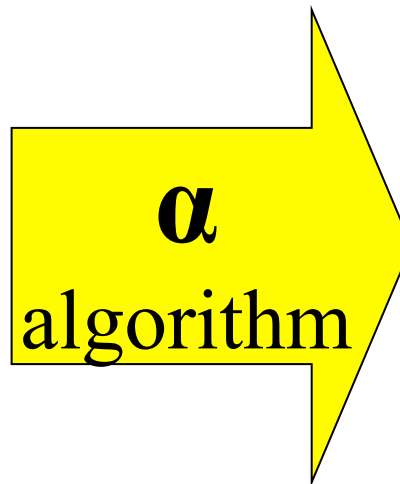
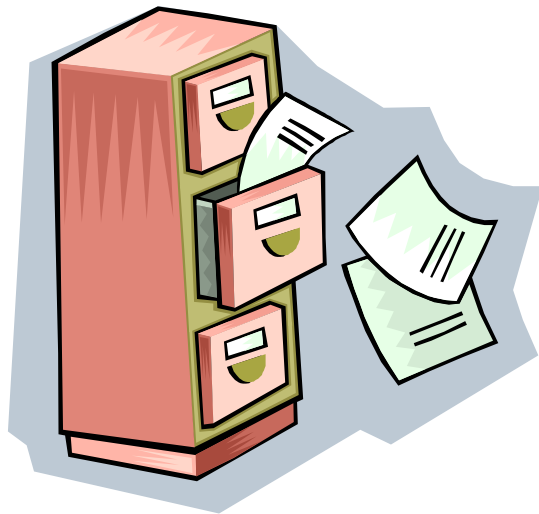
# Process Mining



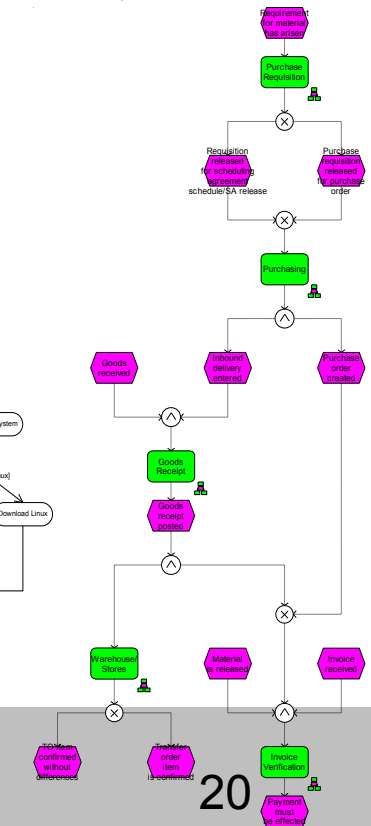
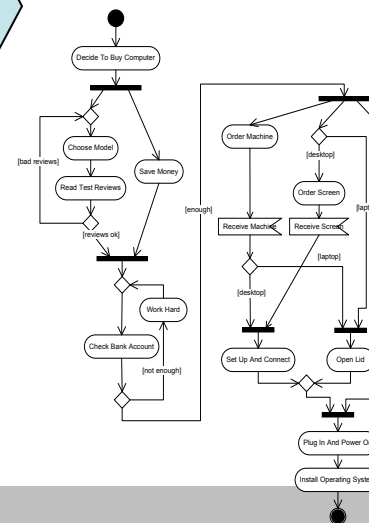
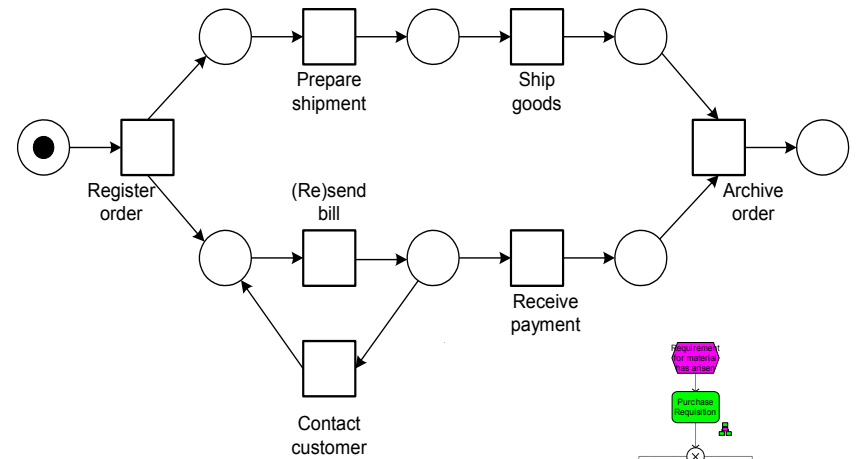
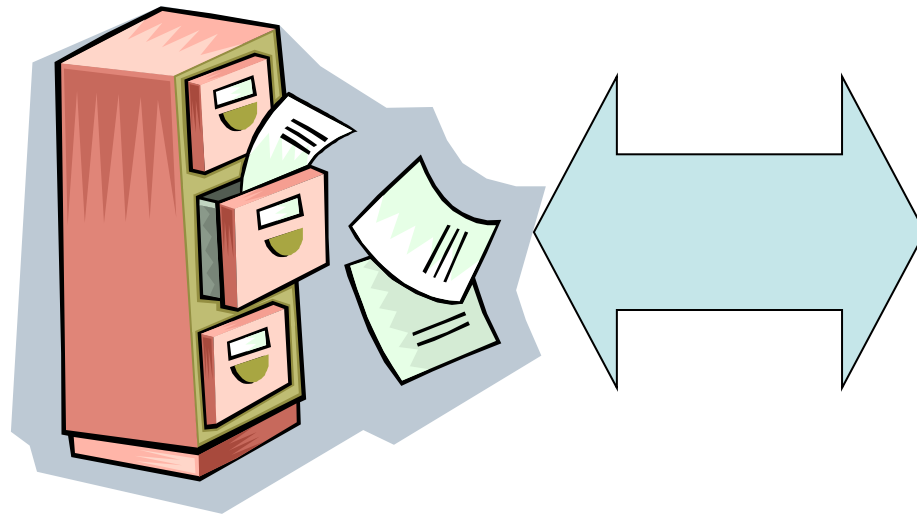
# Process Models



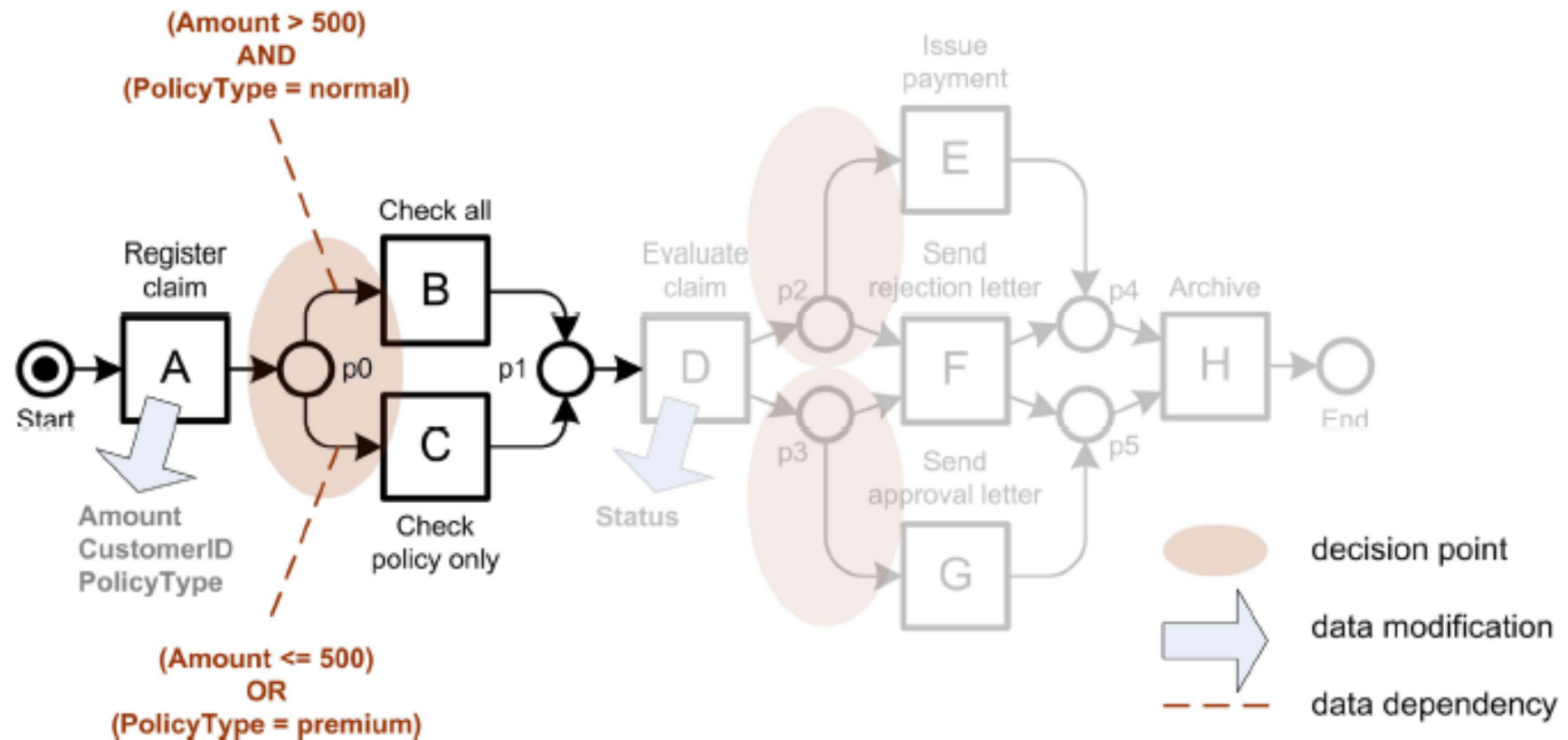
# Process discovery



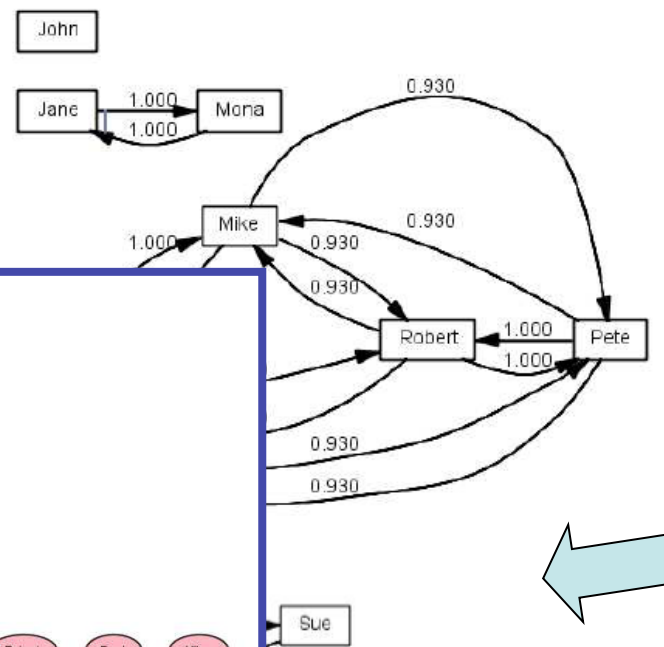
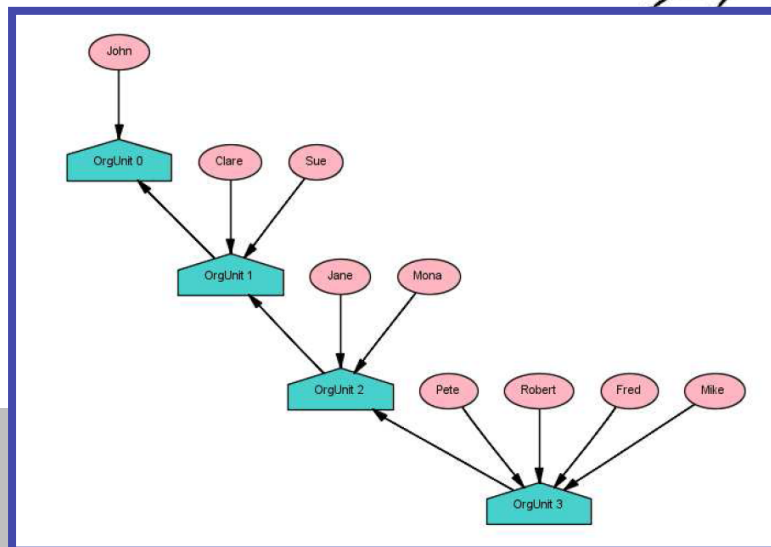
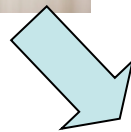
# Conformance Checking



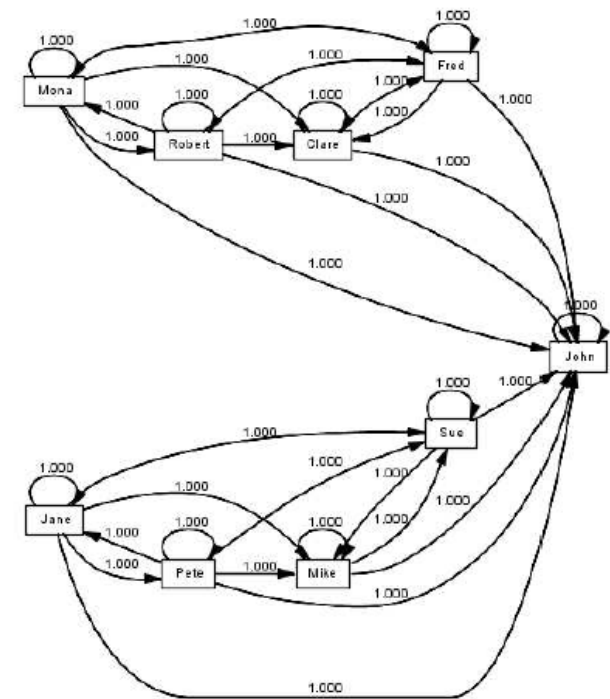
# Advanced Features: Decision mining



# Advanced Features: Social network mining

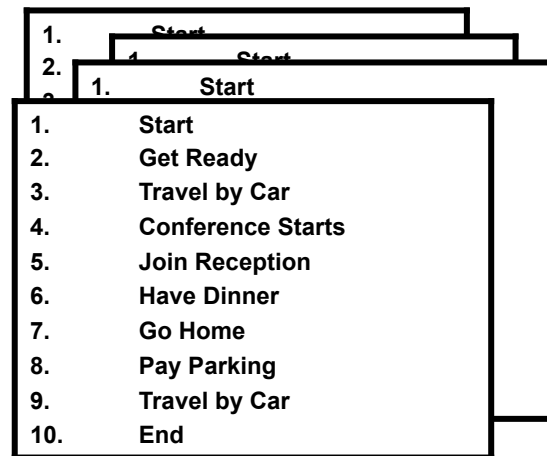


Doing similar task



(b) working together

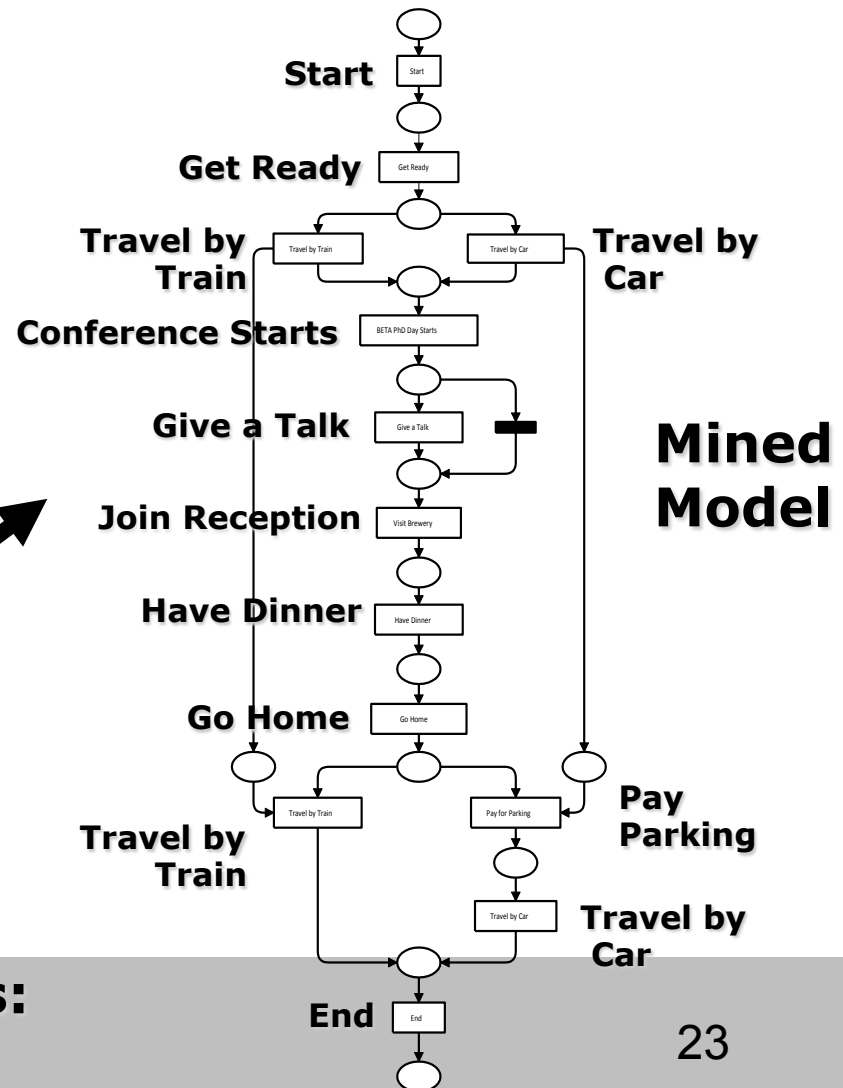
# Control-Flow Mining



Event Log

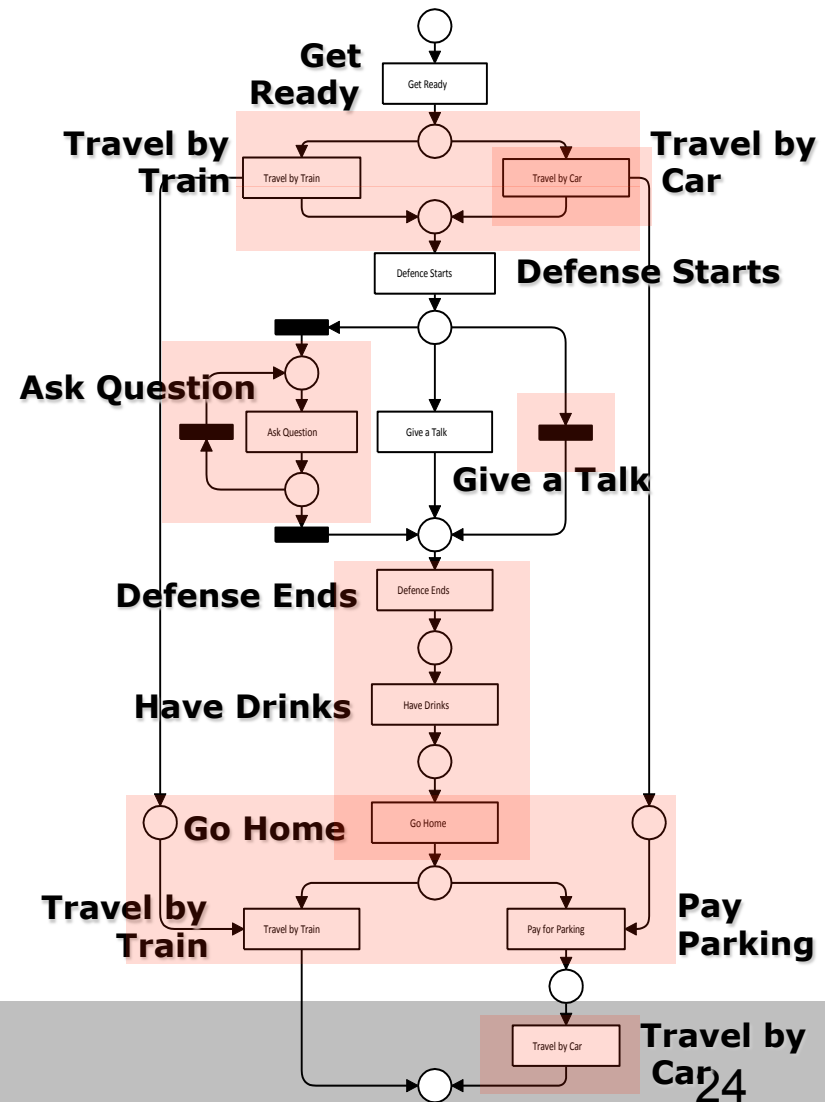


Discovery Techniques:  
**Control-Flow Mining**



# Mining Common Constructs

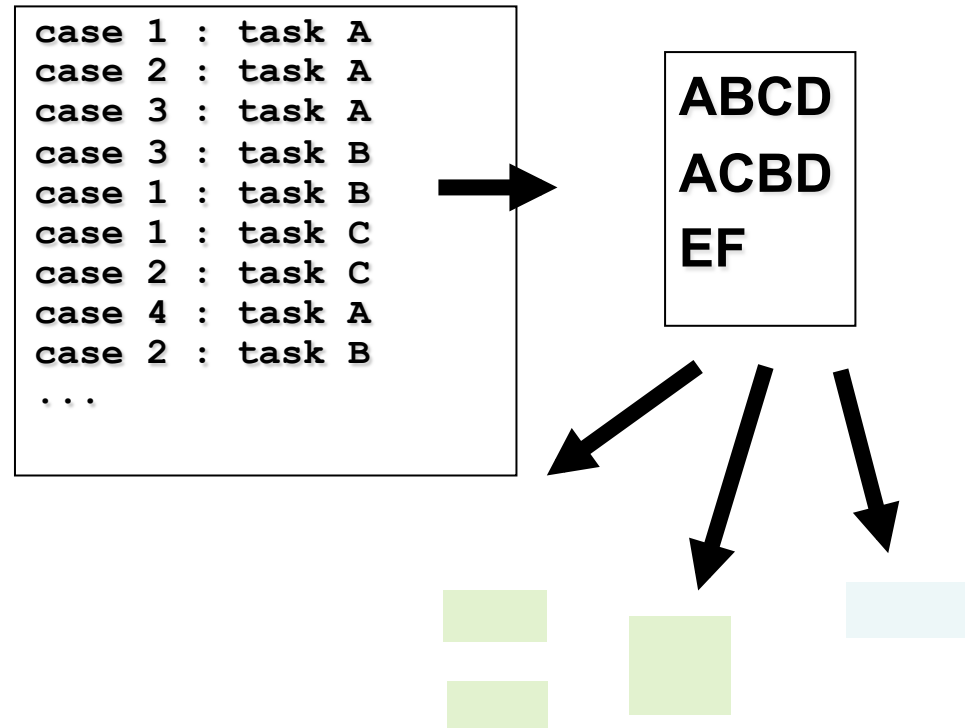
- Sequence
- Splits
- Joins
- Loops
- Non-Free Choice
- Invisible Tasks
- Duplicate Tasks





# $\alpha$ -algorithm

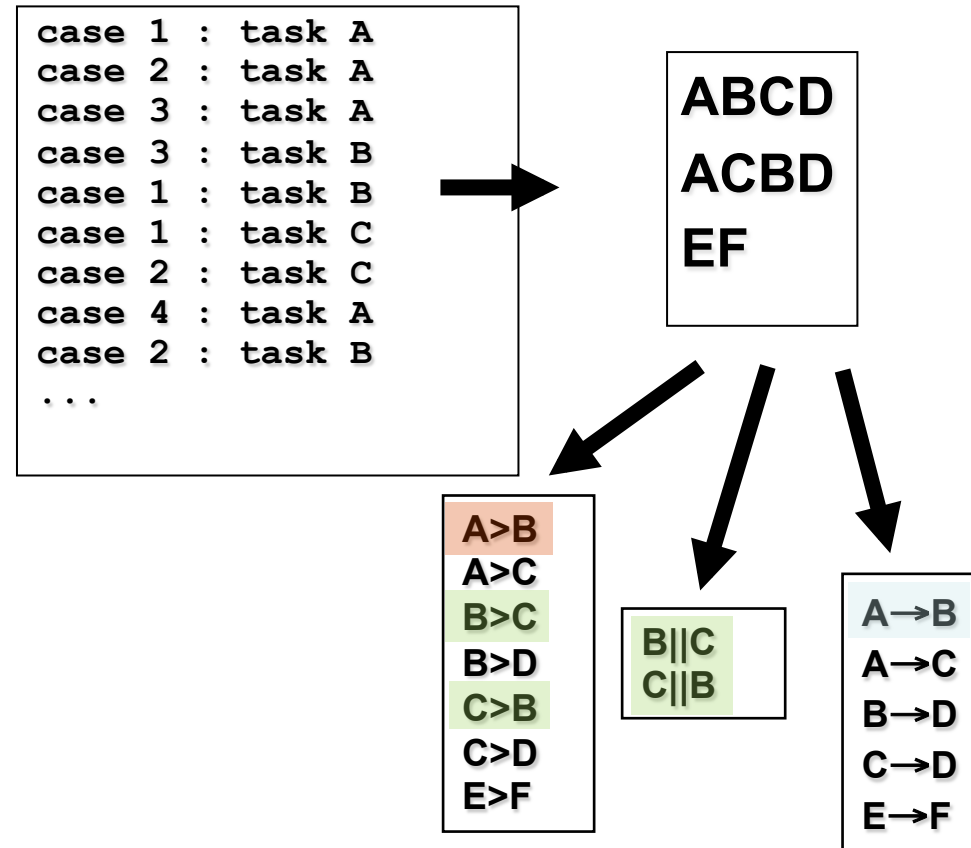
## Basic Idea: Ordering relations



# $\alpha$ -algorithm

## Basic Idea: Ordering relations

- **Direct succession:**  $x > y$  iff for some case  $x$  is directly followed by  $y$ .
- **Causality:**  $x \rightarrow y$  iff  $x > y$  and not  $y > x$ .
- **Parallel:**  $x || y$  iff  $x > y$  and  $y > x$
- **Unrelated:**  $x \# y$  iff not  $x > y$  and not  $y > x$ .



## Basic Idea: Example

$$L_1 = [\langle a, b, c, d \rangle^3, \langle a, c, b, d \rangle^2, \langle a, e, d \rangle]$$

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$$L_1 = [\langle a, b, c, d \rangle^3, \langle a, c, b, d \rangle^2, \langle a, e, d \rangle]$$

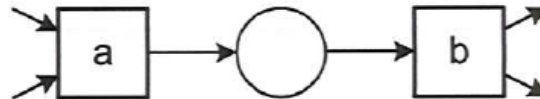
$$>_{L_1} = \{(a, b), (a, c), (a, e), (b, c), (c, b), (b, d), (c, d), (e, d)\}$$

$$\rightarrow_{L_1} = \{(a, b), (a, c), (a, e), (b, d), (c, d), (e, d)\}$$

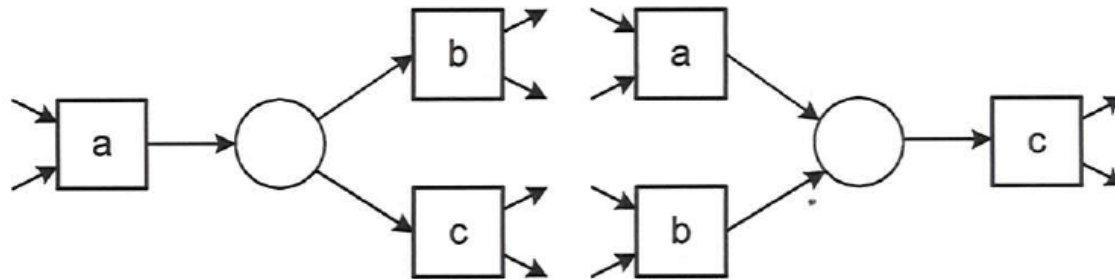
$$\#_{L_1} = \{(a, a), (a, d), (b, b), (b, e), (c, c), (c, e), (d, a), (d, d), (e, b), (e, c), (e, e)\}$$

$$\parallel_{L_1} = \{(b, c), (c, b)\}$$

# Basic Idea: Patterns

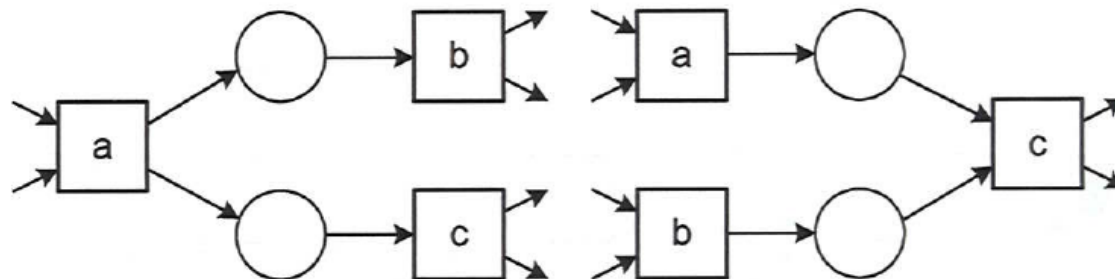


(a) sequence pattern:  $a \rightarrow b$



(b) XOR-split pattern:  
 $a \rightarrow b$ ,  $a \rightarrow c$ , and  $b \# c$

(c) XOR-join pattern:  
 $a \rightarrow c$ ,  $b \rightarrow c$ , and  $a \# b$



(d) AND-split pattern:  
 $a \rightarrow b$ ,  $a \rightarrow c$ , and  $b || c$

(e) AND-join pattern:  
 $a \rightarrow c$ ,  $b \rightarrow c$ , and  $a || b$