

Mineração de Processos:

O elo que faltava na gestão de processos de negócio

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UTL



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Bem-vindo ao Técnico!

adquire conhecimento + estimula a tua criatividade

Eventos

26 de Set. 2009 **Festival Voo Livre'09 - Covilhã**

25 de Set. 2009 **Seminário de Tecnologias de Informação na Promoção das Áreas Protegidas (TIPAP-2009)**

7 a 8 de Set. 2009 **CEI2009 - Encontro Nacional do Colégio de Engenharia Informática da Ordem dos Engenheiros**

7 a 7 de Set. 2009 **Sessão de Homenagem ao Professor João Martins**

Notícias

IST Press edita o Livro "Ecologia Industrial: princípios e ferramentas"
18 de Set. 2009

IST Press edita o Livro "Análise Complexa e Equações Diferenciais"
18 de Set. 2009

Encontro "O contributo de Bolonha na prossecução da Qualidade no Ensino Superior", dia 21 de Outubro de 2009
17 de Set. 2009

3ª Edição do Livro "Vitruvius-Tratado de Arquitectura"
16 de Set. 2009



Localização

Campus Alameda
Campus Taguspark

Iniciativas + Recursos

Observatório de Empregabilidade
Recrutamento
Biblioteca
Transporte "Alameda-Taguspark"
Webmail

Subscrever as feeds de RSS

Siga o Técnico no Twitter

História do IST

- 1911: fundado com os cursos de Engenharia de Minas, Civil, Mecânica, Electrotécnica e Química
- 1930s: construção do campus da Alameda



"Engenho e Obra", Dom Quixote



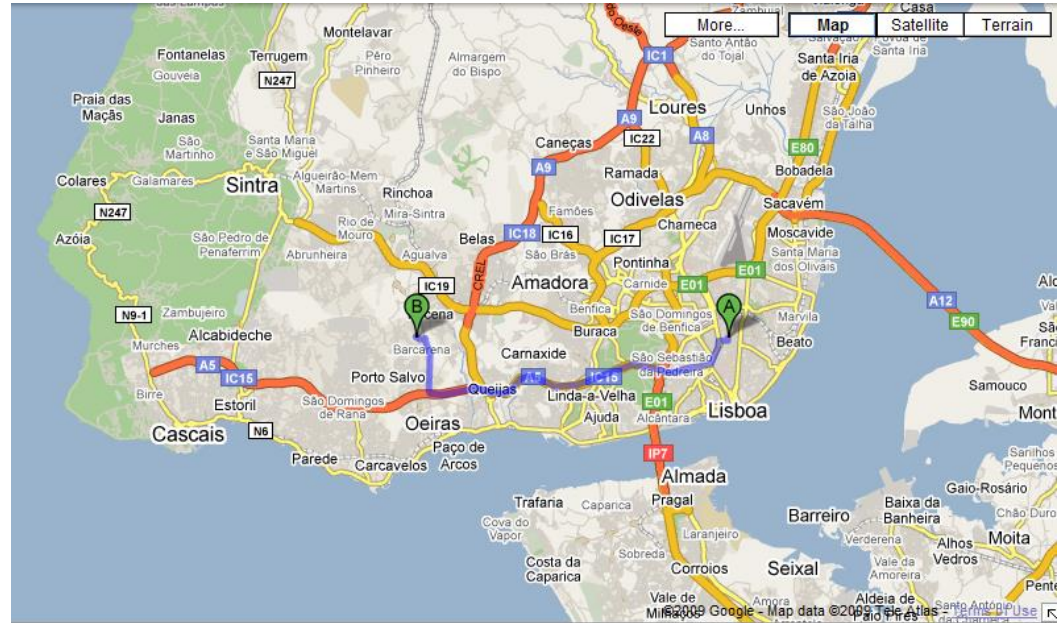
Bing Maps

História do IST

- 1930s: integra a Universidade Técnica de Lisboa (UTL)
- 1950-1970: desenvolvimento dos centros de pesquisa
- 1970: cursos passam de 6 para 5 years (no presente: 3+2)
- 1990s: construção do campus do Taguspark (Oeiras)



Bing Maps



Google Maps

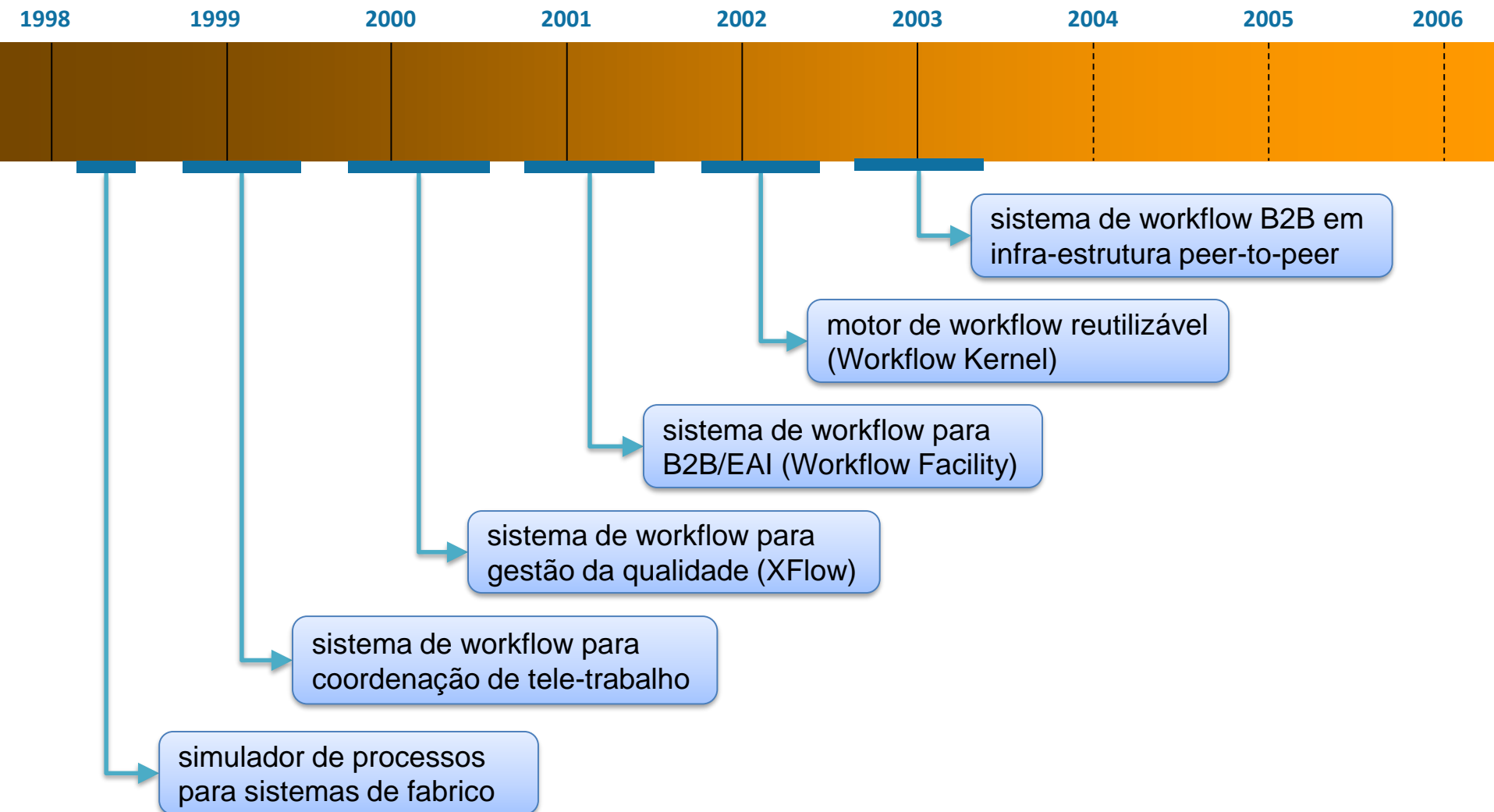
Pesquisa na UTL

- Várias escolas, várias disciplinas
 - física, química, matemática
 - economia, gestão, ciências humanas
 - biologia, biotecnologia, bioinformática
 - ambiente e sustentabilidade
 - saúde e ciências do desporto
 - arquitectura, urbanismo, transportes
 - ...

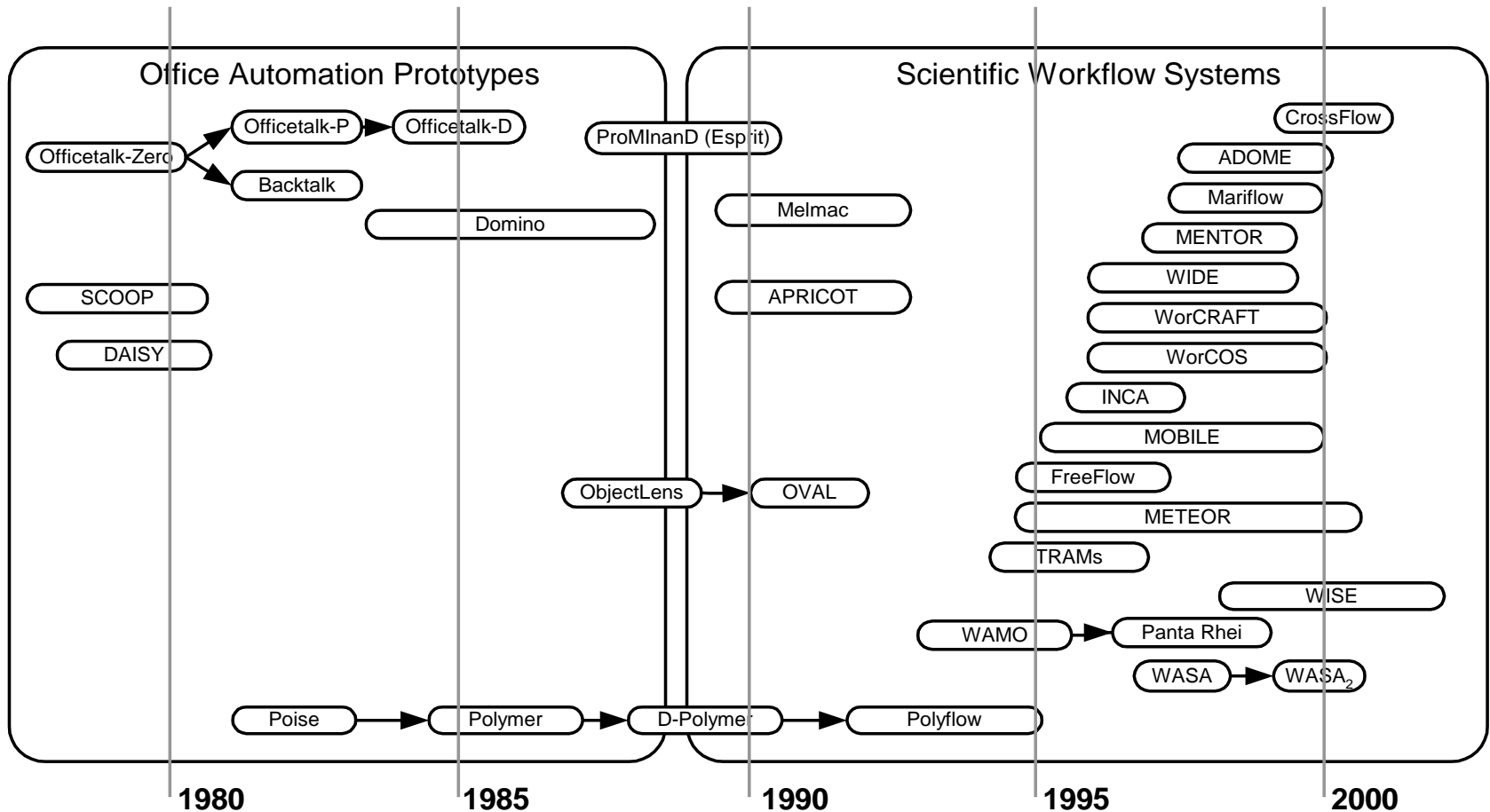


Manuel S. Pereira (Ed.)
622 pgs, Springer 2007

A minha pesquisa, no passado

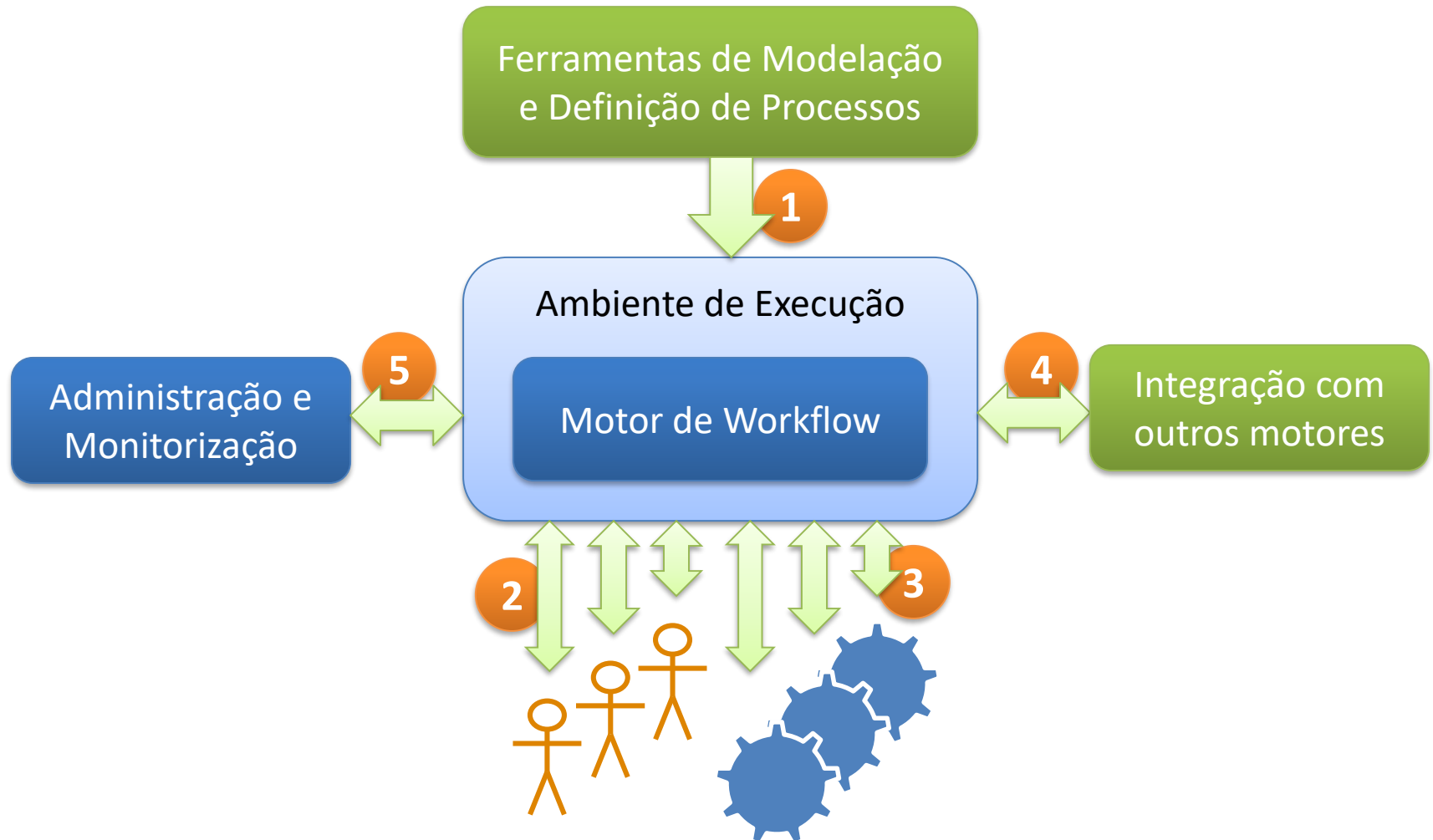


Pesquisa em sistemas de workflow

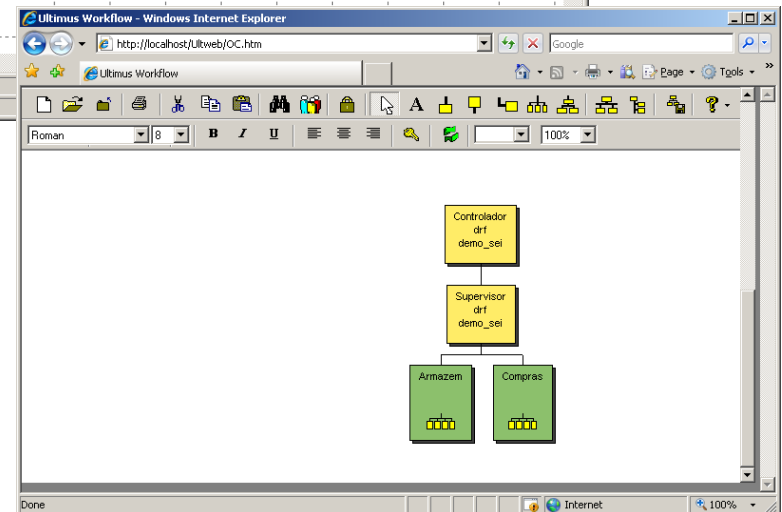
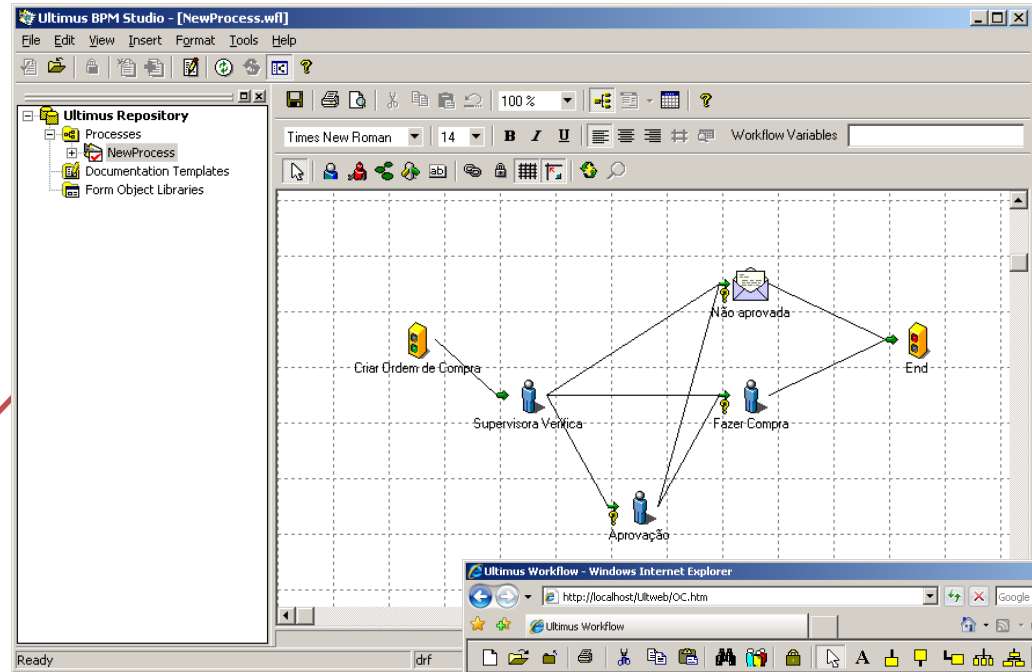


(Fonte: M. zur Muehlen, 2003)

Sistemas de workflow



Sistemas de workflow

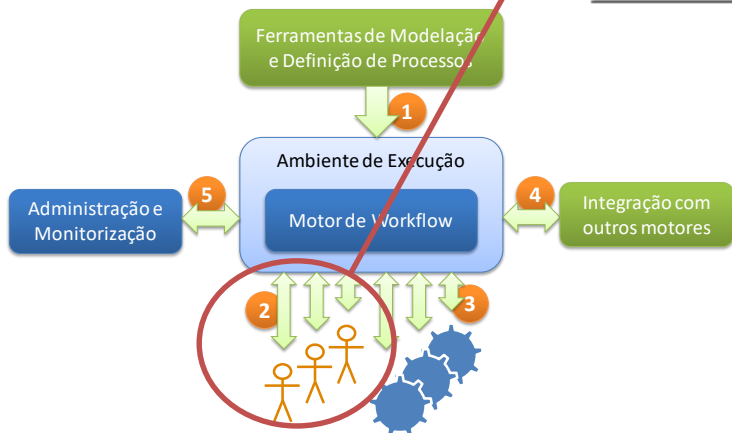


Sistemas de workflow

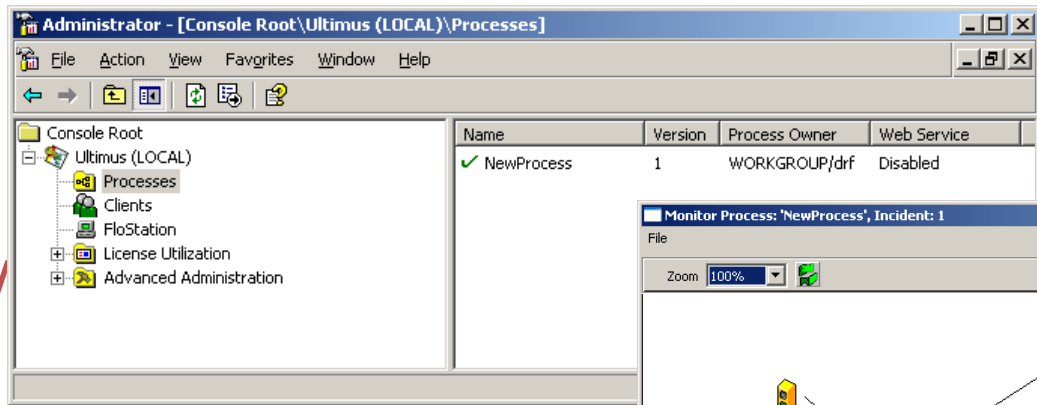
The image displays two overlapping browser windows from the Ultimus Workflow system. The top window, titled "Ultimus Workflow - Windows Internet Explorer", shows a dashboard with a navigation bar (Iniciar, Caixa de Entrada, Completas, Arquivo) and a table of process instances. The table has columns for "Nome do Processo", "Sumário", "Incidente n°", "Passo", "Prioridade", "Intervalo", and "Cliente".

Nome do Processo	Sumário	Incidente n°	Passo	Prioridade	"Intervalo"	Cliente
✓ NewProcess		1	Aprovação	9		drf
✓ NewProcess		1	Supervisora Ver ...	9		drf
✓ NewProcess		1	Criar Ordem de ...	9		drf

The bottom window, titled "NewProcess, 0 : Criar Ordem de Compra - Windows Internet Explorer", displays a form for creating a purchase order. The form includes fields for "Nome", "Email", "Produto", "Preço", and "Quantidade".



Sistemas de workflow



Monitor Process: 'NewProcess', Incident: 1

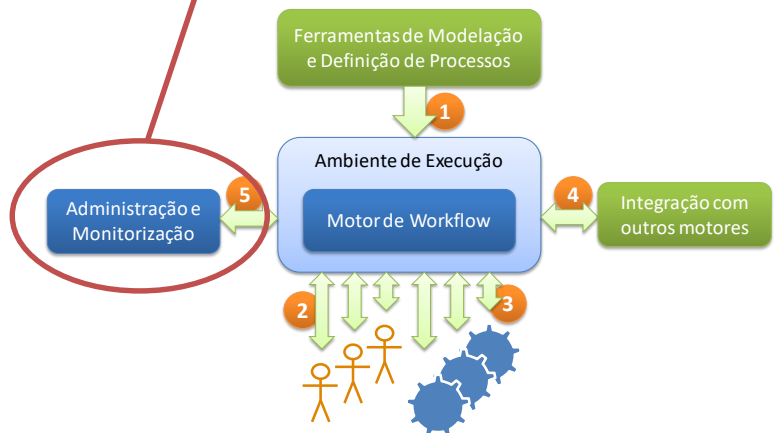
Zoom: 100%

Workflow Diagram:

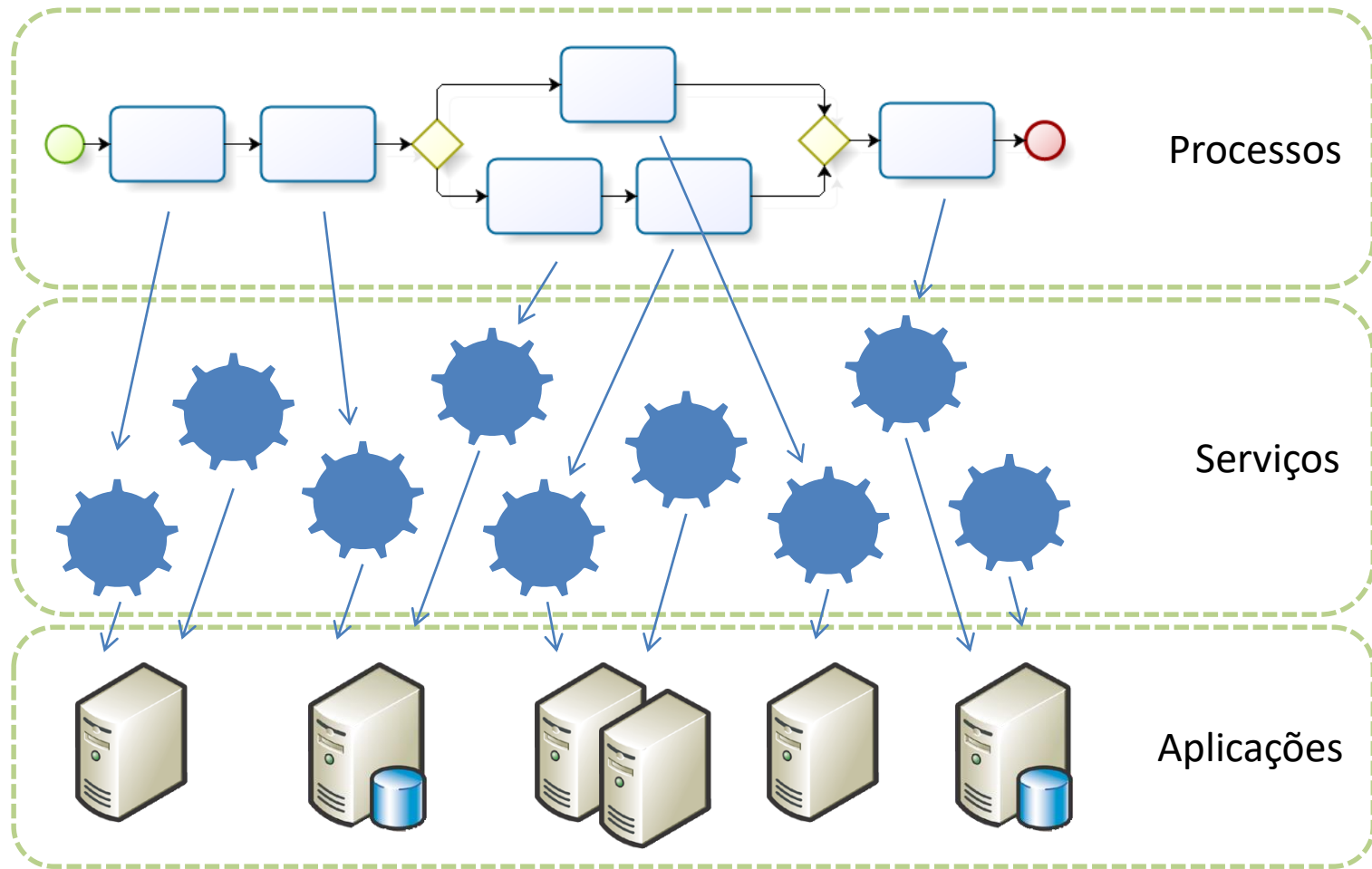
```

    graph TD
      Start[demo_sei\Armazen] --> S1[Supervisora Verifica VICTORIA/drf]
      S1 --> S2[Aprovação VICTORIA/drf]
      S1 --> S3[Não aprovada VICTORIA_FLOBOT]
      S2 --> S3
      S3 --> End[End]
      S3 --> S4[Fazer Compra]
      S4 --> S1
  
```

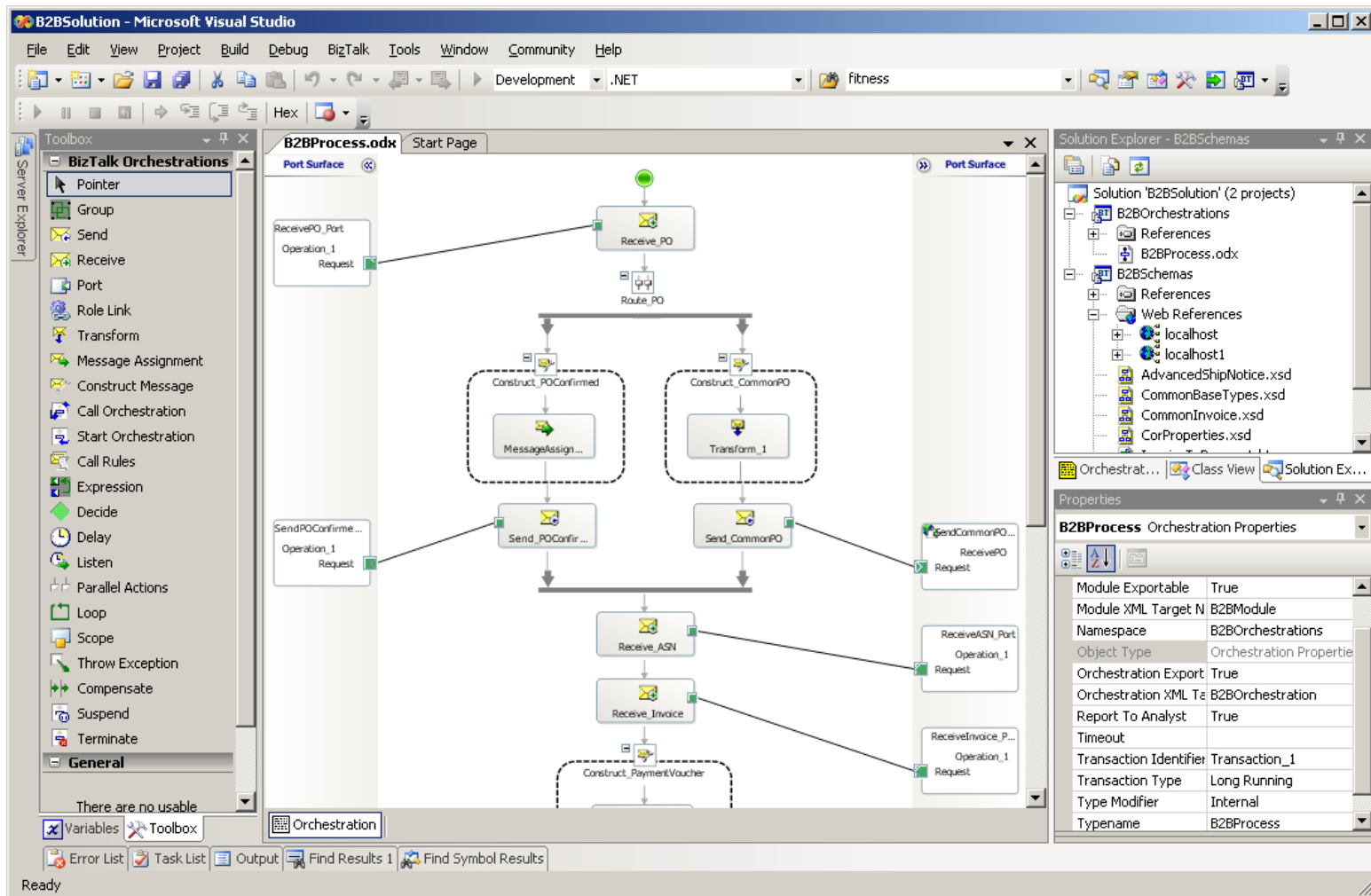
	Client	Step	Start Time	End Time	Status
1	VICTORIA/drf	Criar Ordem de Compra	01-04-2008 8:59:48	01-04-2008 8:59:48	[Complete]
2	VICTORIA/drf	Supervisora Verifica	01-04-2008 8:59:49	01-04-2008 9:01:18	[Complete]
3	VICTORIA/drf	Aprovação	01-04-2008 9:01:18	01-04-2008 9:02:57	[Complete]
4	VICTORIA_FLOBOT	Não aprovada	01-04-2008 9:02:58	01-04-2008 9:03:13	[Complete]
5					
6					
7					
8					



Arquitecturas SOA

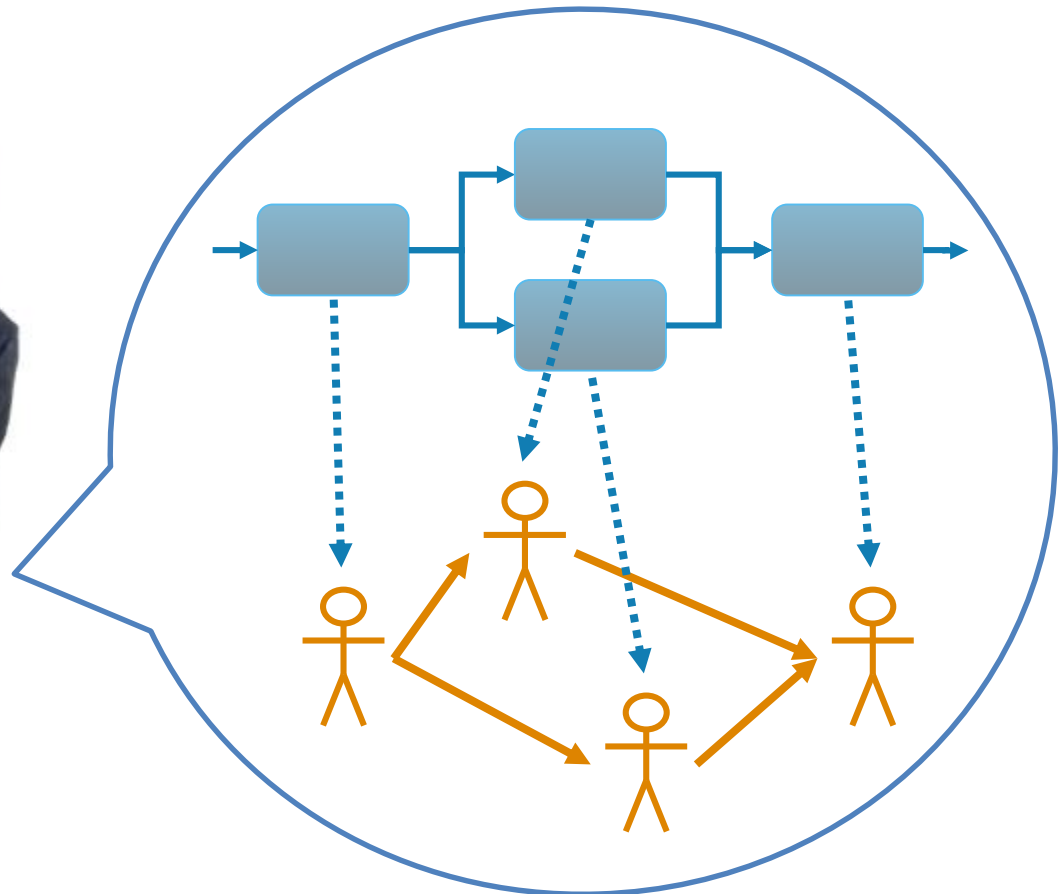


Arquitecturas SOA



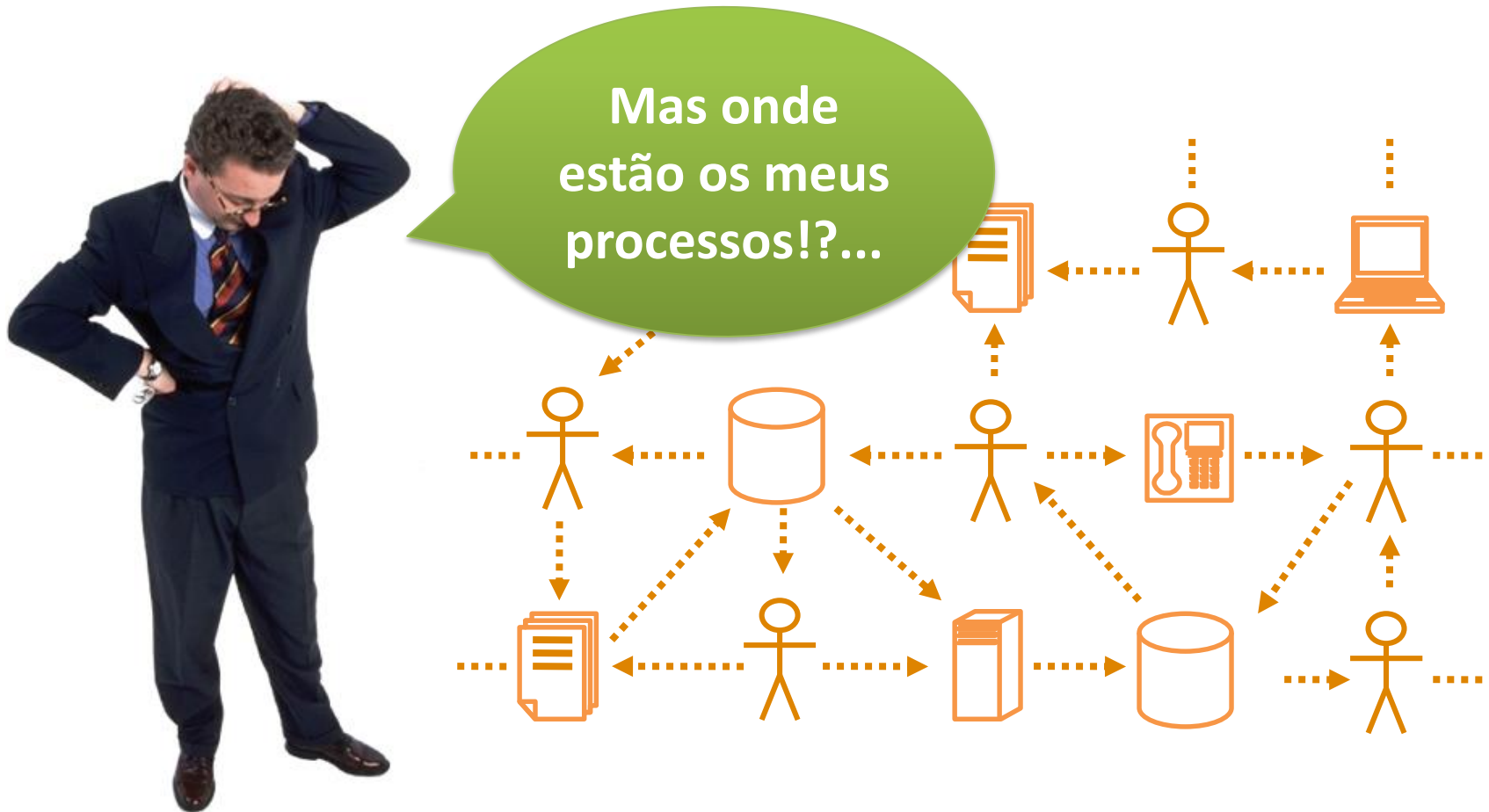
Processos

- um plano para a organização

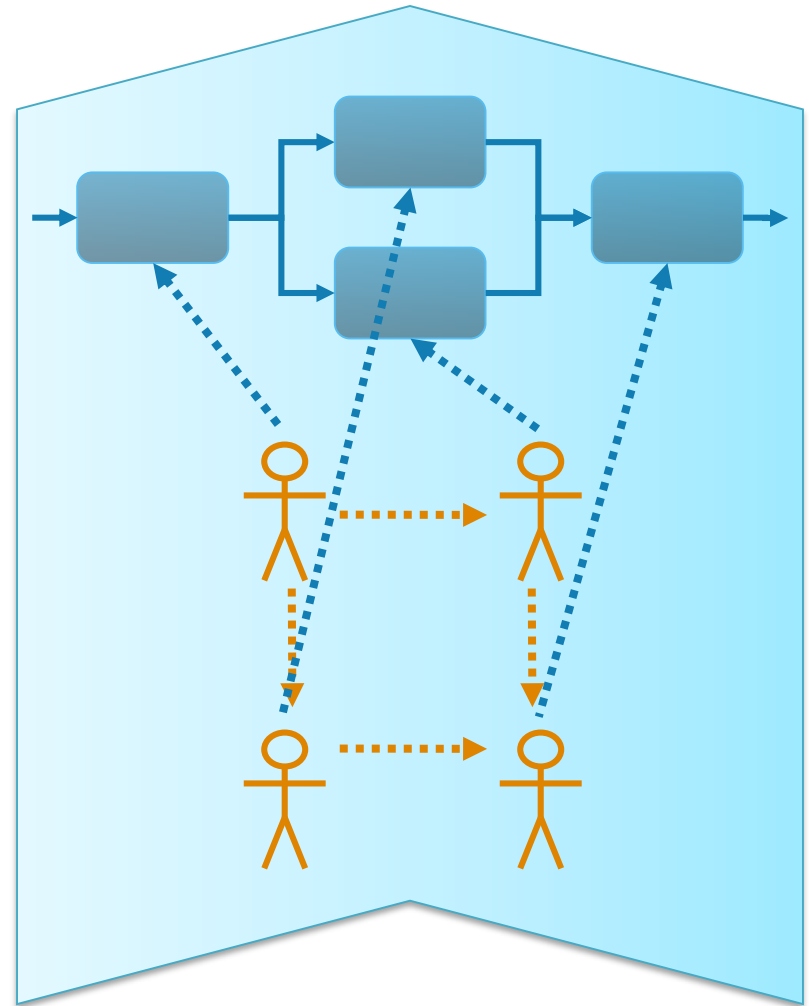
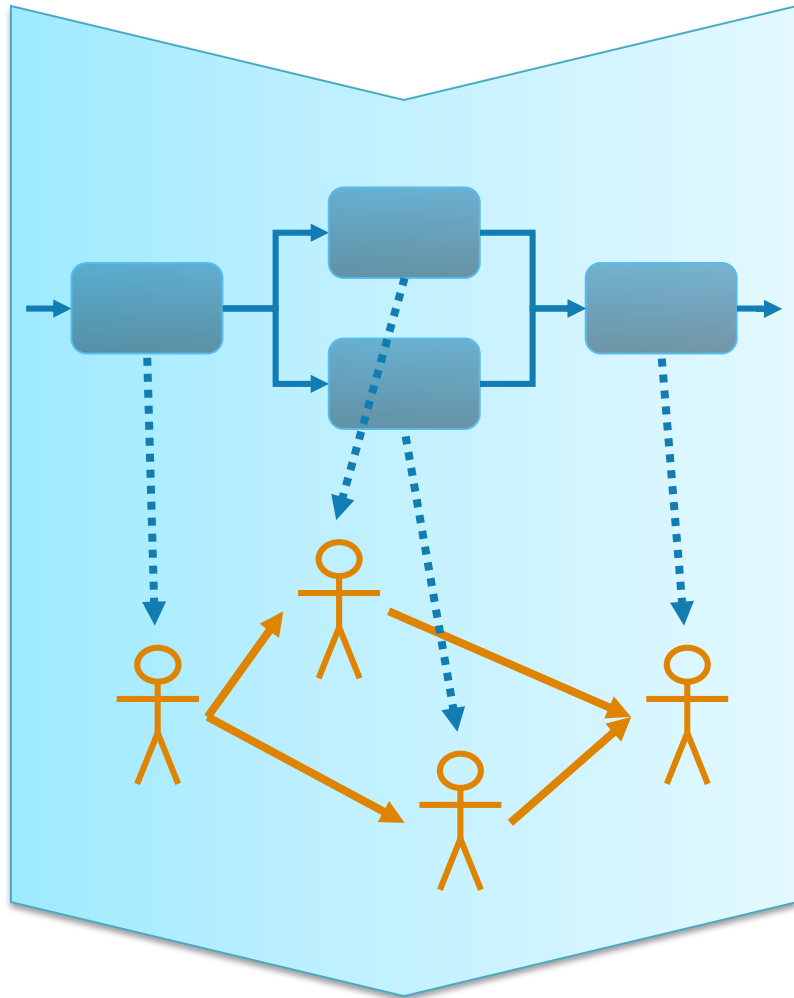


Processos

- um quebra-cabeças para a organização

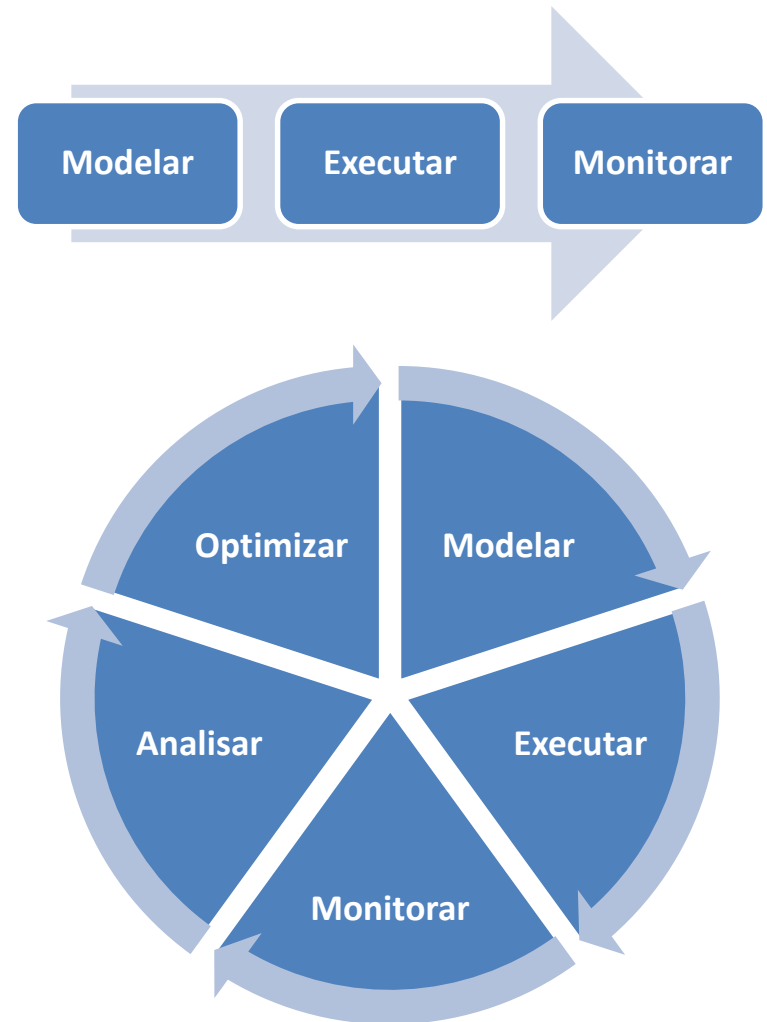


Top-down vs. bottom-up

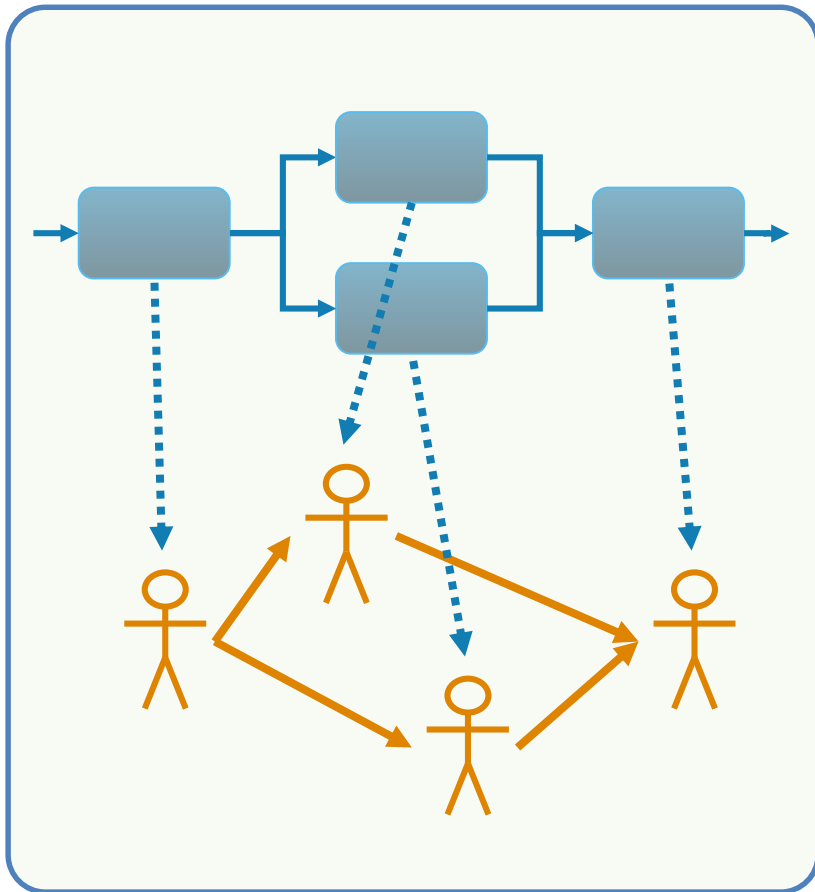


Sistemas de workflow e BPM

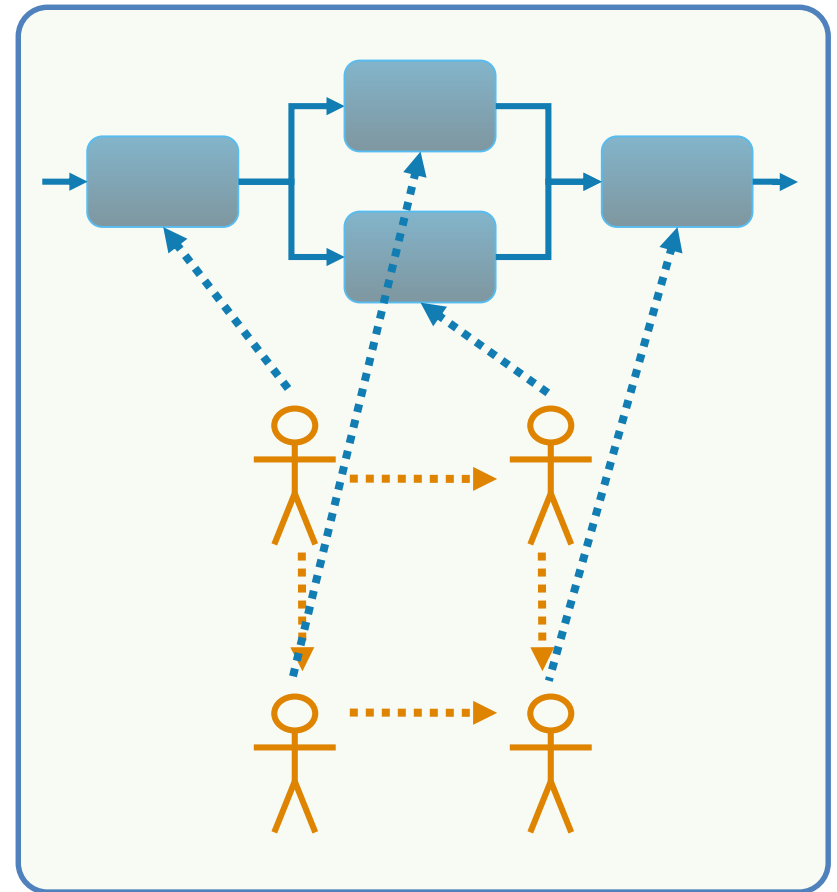
- Sistemas de workflow
 - permitem executar de forma automatizada um processo especificado
- Sistemas de BPM
 - dão suporte ao ciclo de vida de gestão e melhoria dos processos



Top-down vs. bottom-up

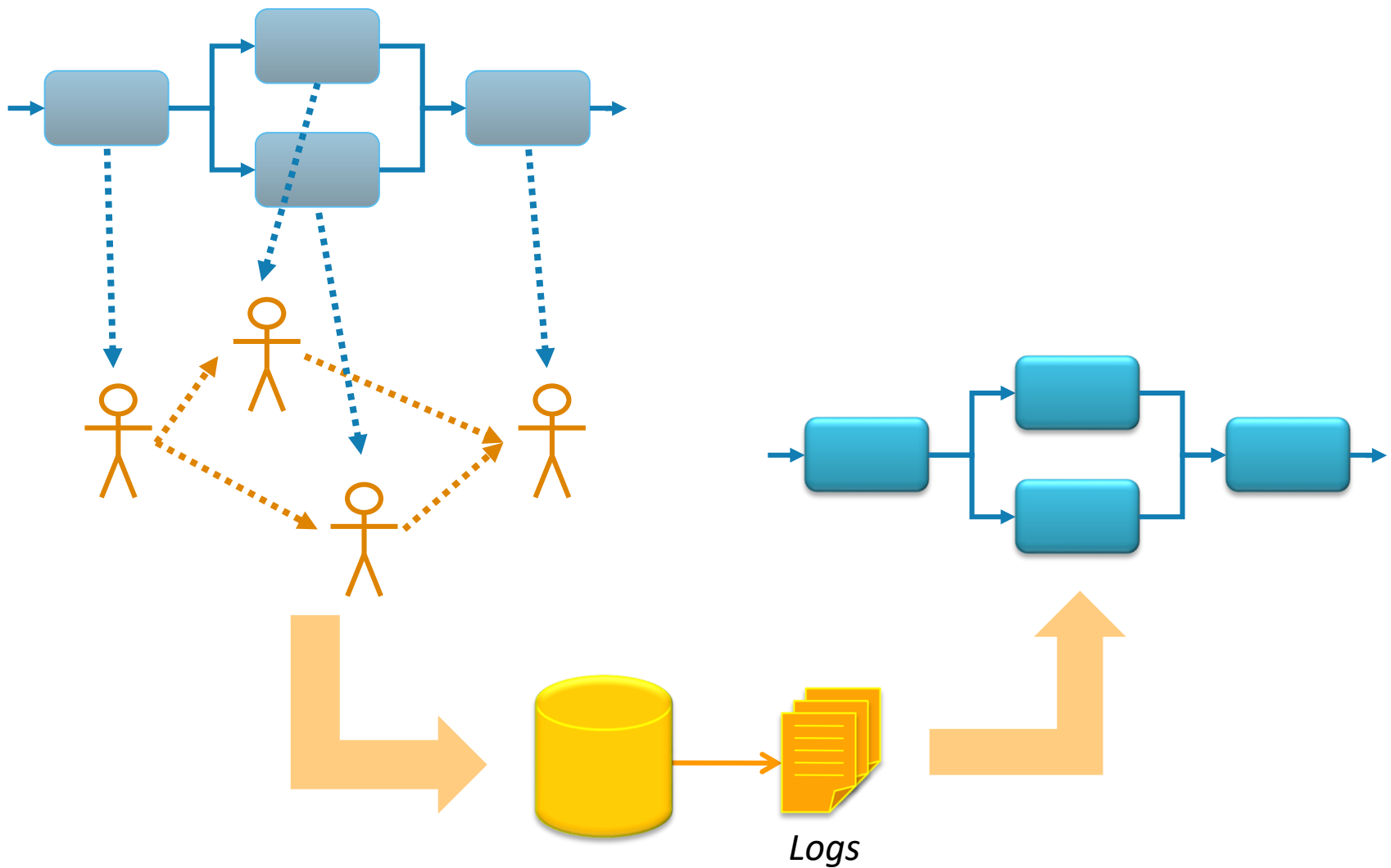


Problema resuelto!



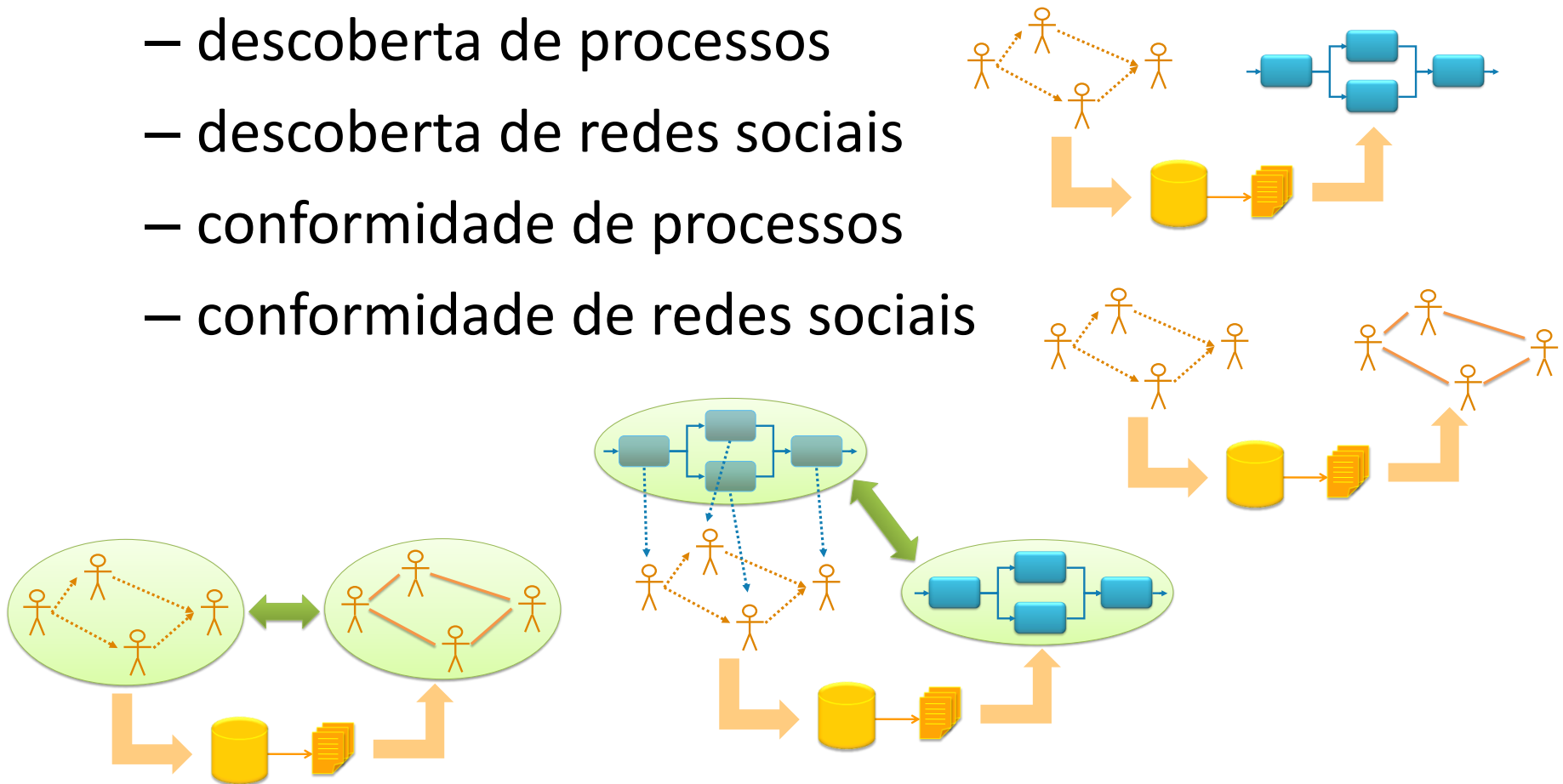
Problema por resolver...

Mineração de processos



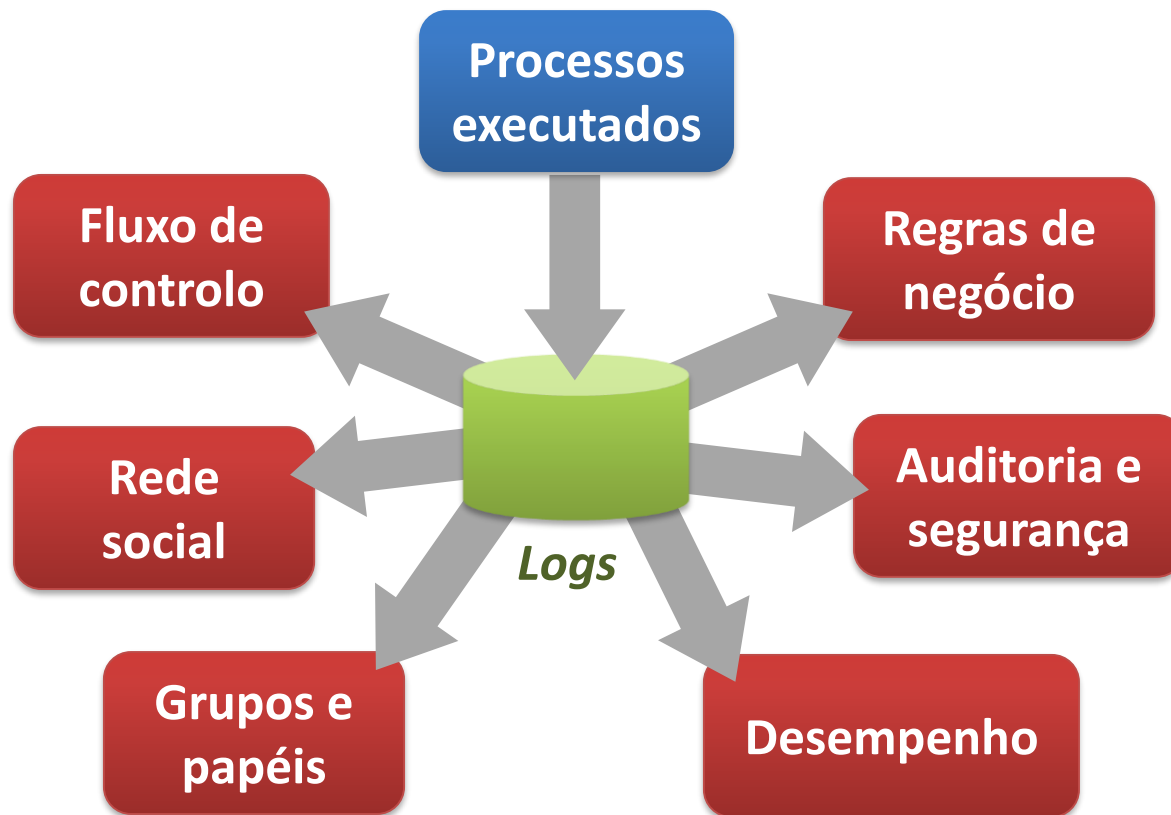
Mineração de processos

- Torna-se possível estudar:
 - descoberta de processos
 - descoberta de redes sociais
 - conformidade de processos
 - conformidade de redes sociais



Mineração de processos

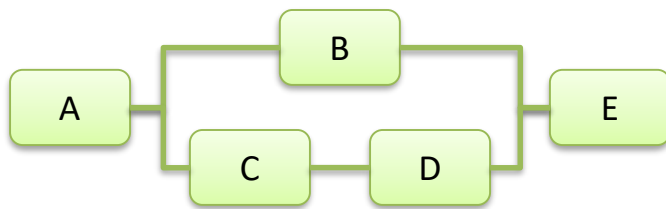
- Potencial da mineração de processos



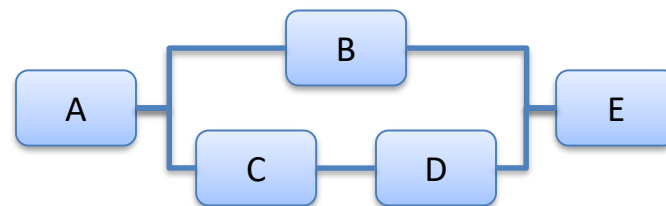
Mineração de processos

- Processos e instâncias (casos)

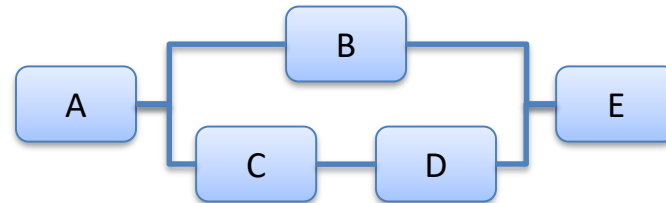
Modelo do processo



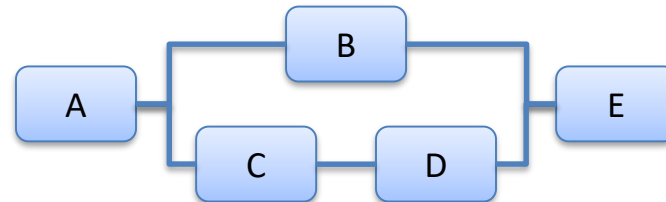
Instâncias do processo



Caso 1



Caso 2



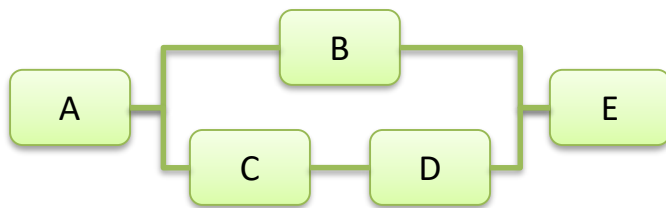
Caso 3



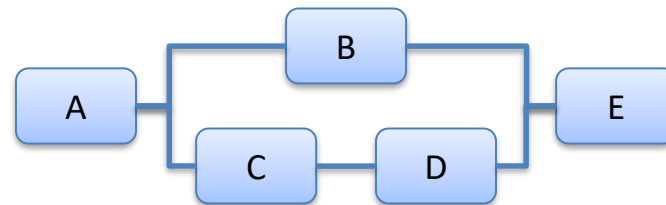
Mineração de processos

- Processos e instâncias (casos)

Modelo do processo



Instâncias do processo



Caso 1



Caso 4



Caso 5



Caso 6



Registo de eventos (*Log*)

Caso	Actividade	Utilizador	Data/hora
1	Preencher requisição	João	2010-03-29 10:15
1	Aprovar requisição	Ana	2010-03-30 09:05
1	Encomendar produto	João	2010-03-30 14:20
2	Preencher requisição	Mariana	2010-04-02 11:40
1	Receber mercadoria	Pedro	2010-04-05 08:00
1	Actualizar inventário	Pedro	2010-04-05 08:10
2	Aprovar requisição	Ana	2010-04-05 09:30
2	Arquivar requisição	Pedro	2010-04-06 12:20
1	Processar pagamento	Ana	2010-04-07 08:10
3	Preencher requisição	Mariana	2010-04-09 15:40
...

Registo de eventos (*Log*)

	Caso	Actividade	Utilizador	Data/hora	
Caso 1	1	Preencher requisição	João	2010-03-29 10:15	
	1	Aprovar requisição	Ana	2010-03-30 09:05	
	1	Encomendar produto	João	2010-03-30 14:20	
	2	Preencher requisição	Mariana	2010-04-02 11:40	Caso 2
Caso 1	1	Receber mercadoria	Pedro	2010-04-05 08:00	
	1	Actualizar inventário	Pedro	2010-04-05 08:10	
	2	Aprovar requisição	Ana	2010-04-05 09:30	Caso 2
	2	Arquivar requisição	Pedro	2010-04-06 12:20	
Caso 1	1	Processar pagamento	Ana	2010-04-07 08:10	
	3	Preencher requisição	Mariana	2010-04-09 15:40	Caso 3
	

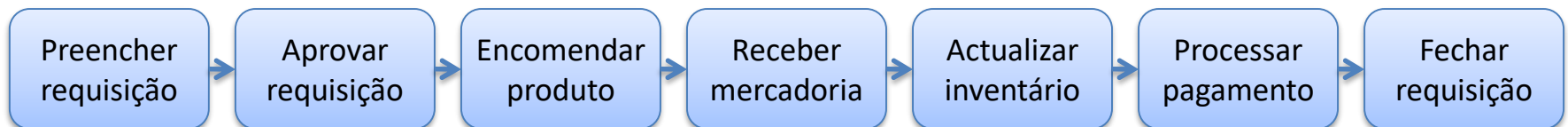
Mineração de processos

- Perspectivas de mineração
 - mineração do fluxo
 - mineração da rede social

Mineração do fluxo

- Caso 1

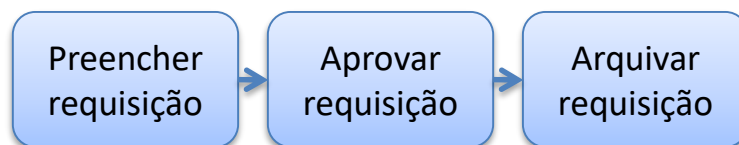
Caso	Actividade
1	Preencher requisição
1	Aprovar requisição
1	Encomendar produto
1	Receber mercadoria
1	Actualizar inventário
1	Processar pagamento
1	Fechar requisição



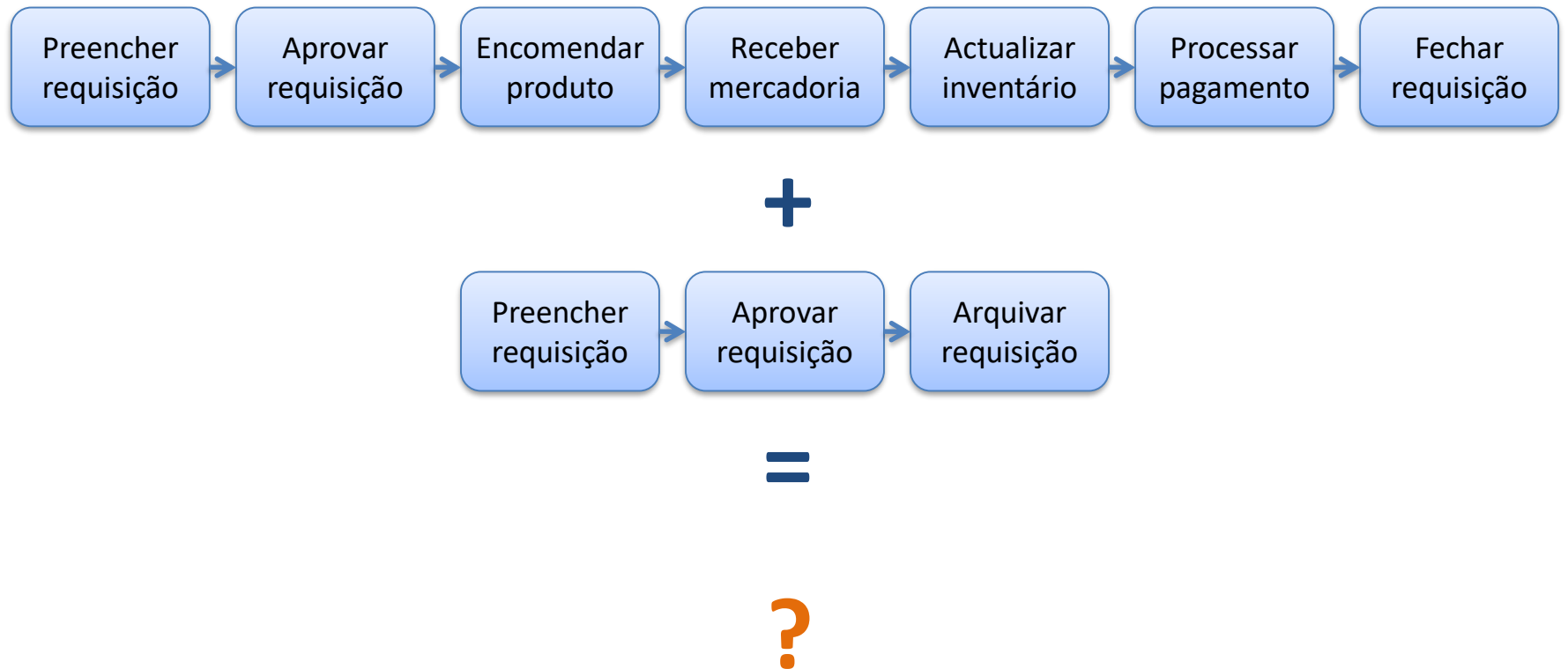
Mineração do fluxo

- Caso 2

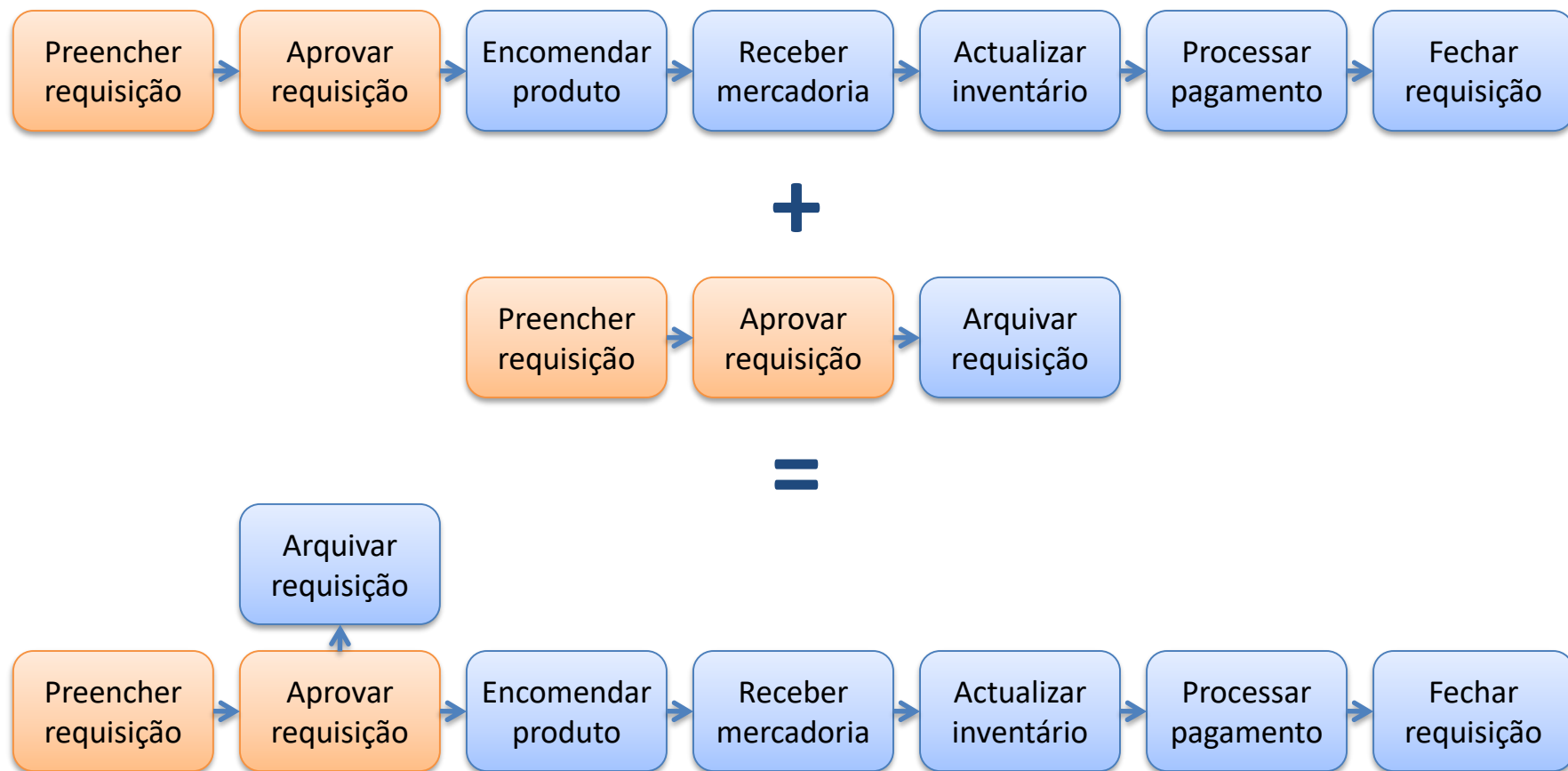
Caso	Actividade
2	Preencher requisição
2	Aprovar requisição
2	Arquivar requisição



Mineração do fluxo



Mineração do fluxo

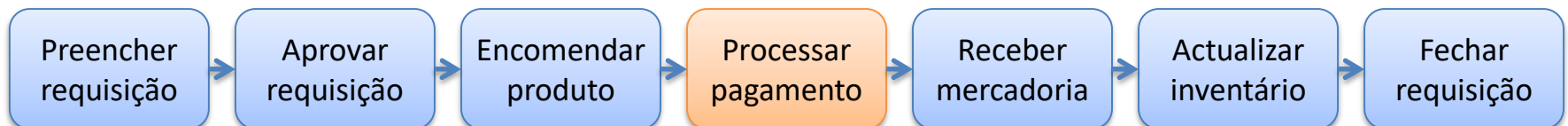


Mineração do fluxo

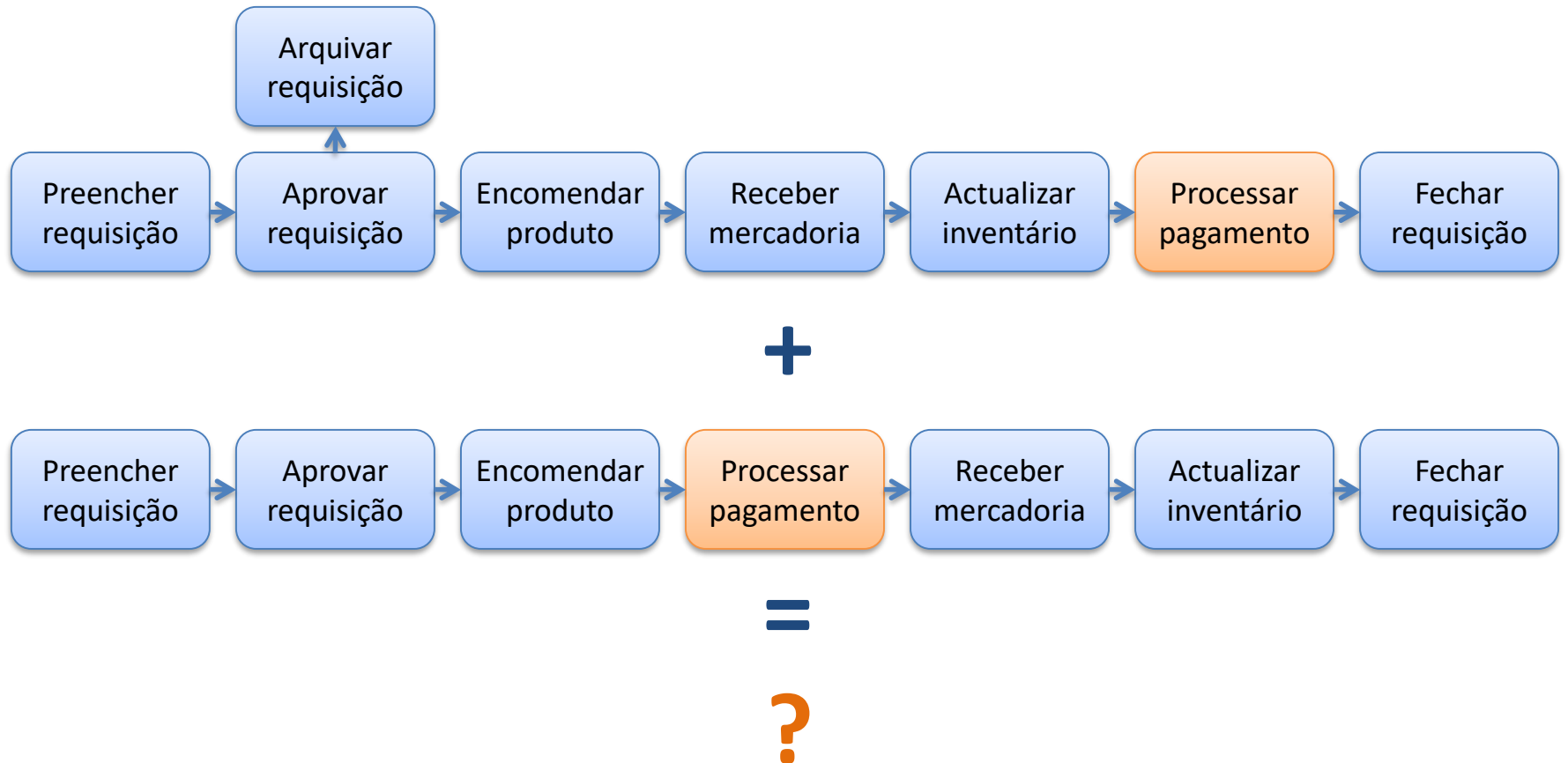
- Caso 3

Caso	Actividade
1	Preencher requisição
1	Aprovar requisição
1	Encomendar produto
1	Receber mercadoria
1	Actualizar inventário
1	Processar pagamento
1	Fechar requisição

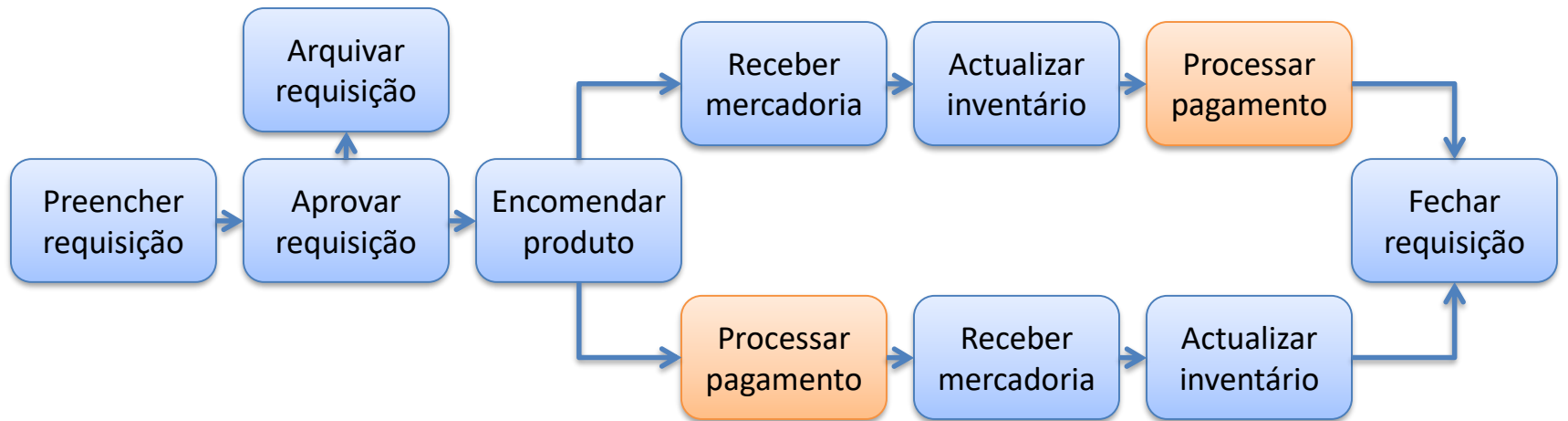
Caso	Actividade
3	Preencher requisição
3	Aprovar requisição
3	Encomendar produto
3	Processar pagamento
3	Receber mercadoria
3	Actualizar inventário
3	Fechar requisição



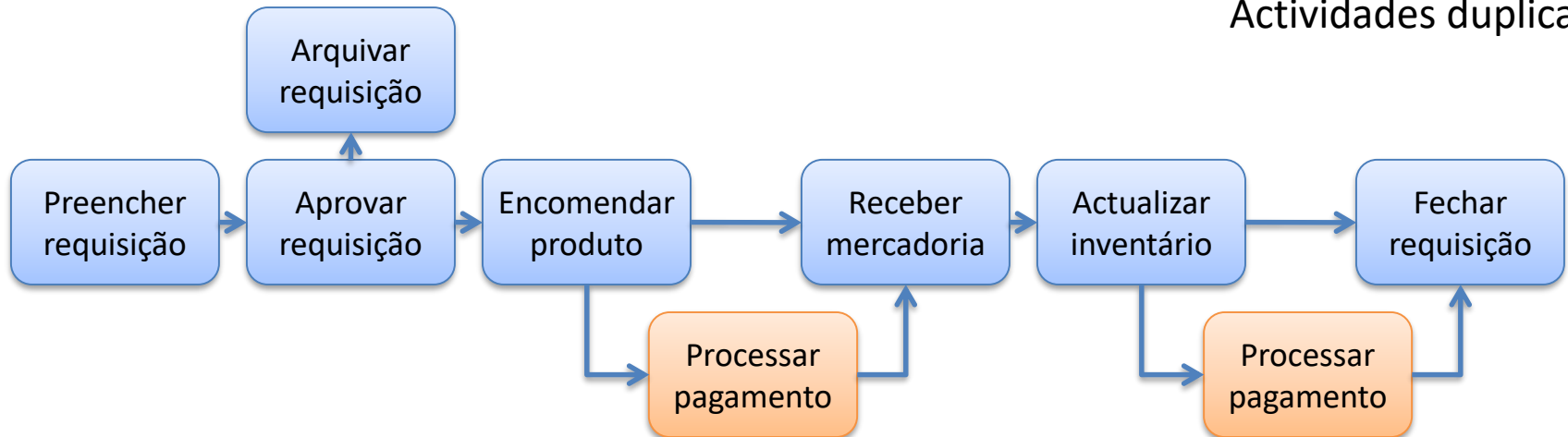
Mineração do fluxo



Mineração do fluxo

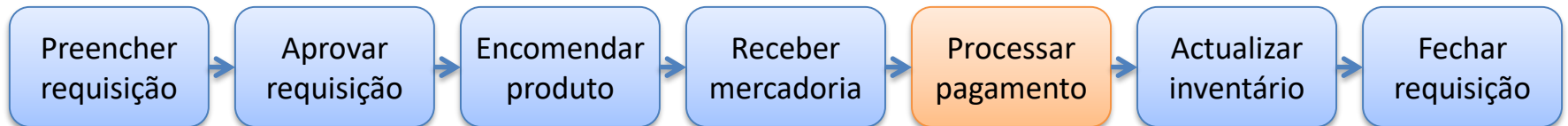
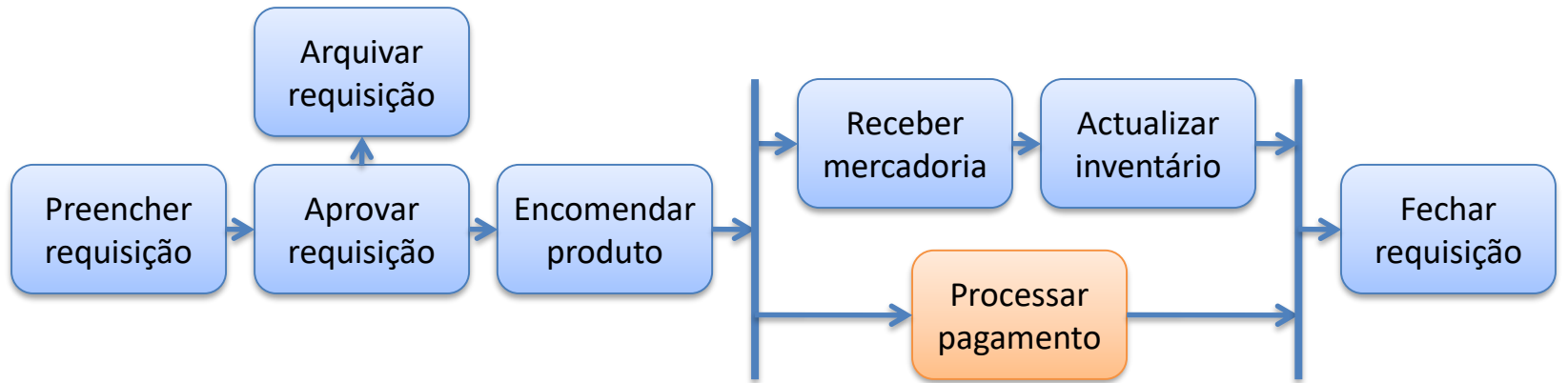


Actividades duplicadas



Dependências não-locais

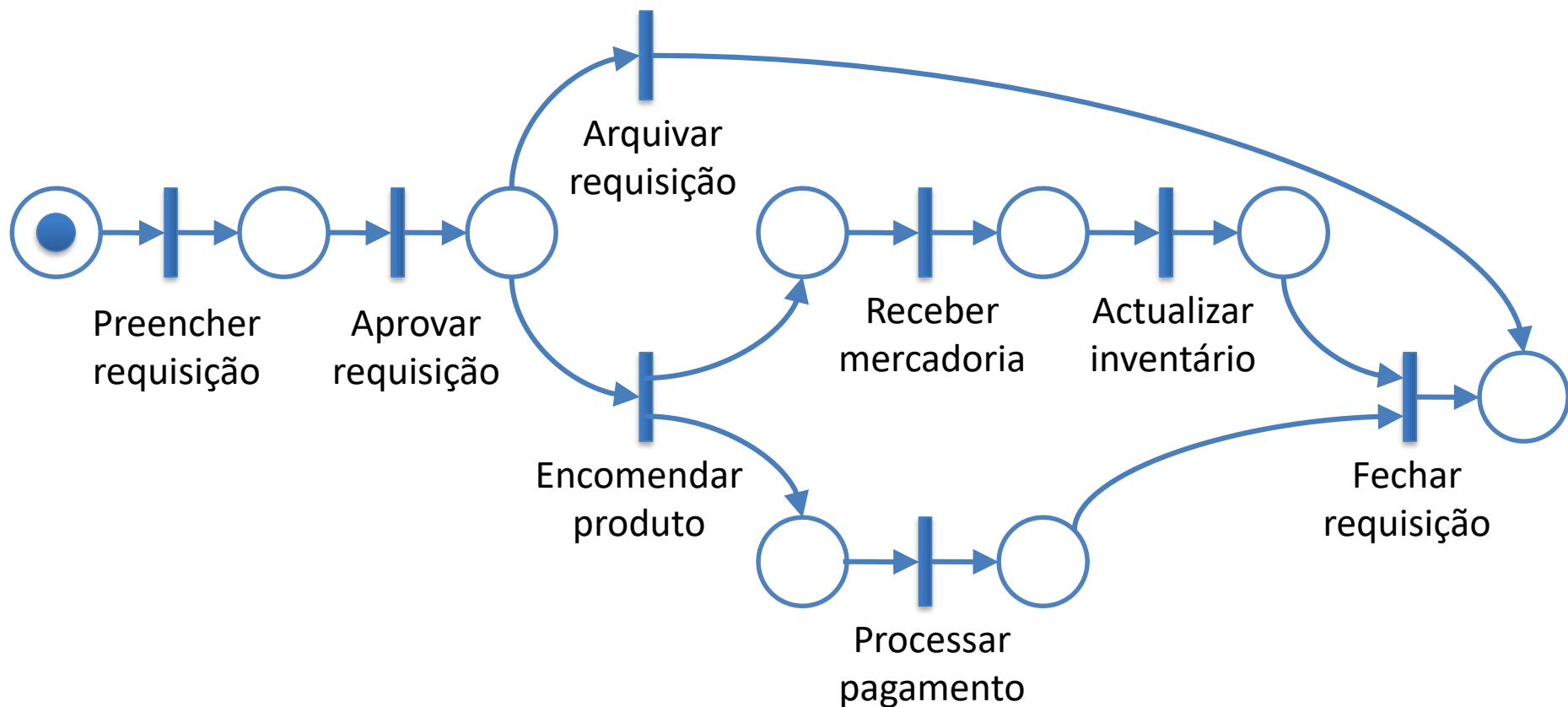
Mineração do fluxo



(possibilidade não observada no *log*)

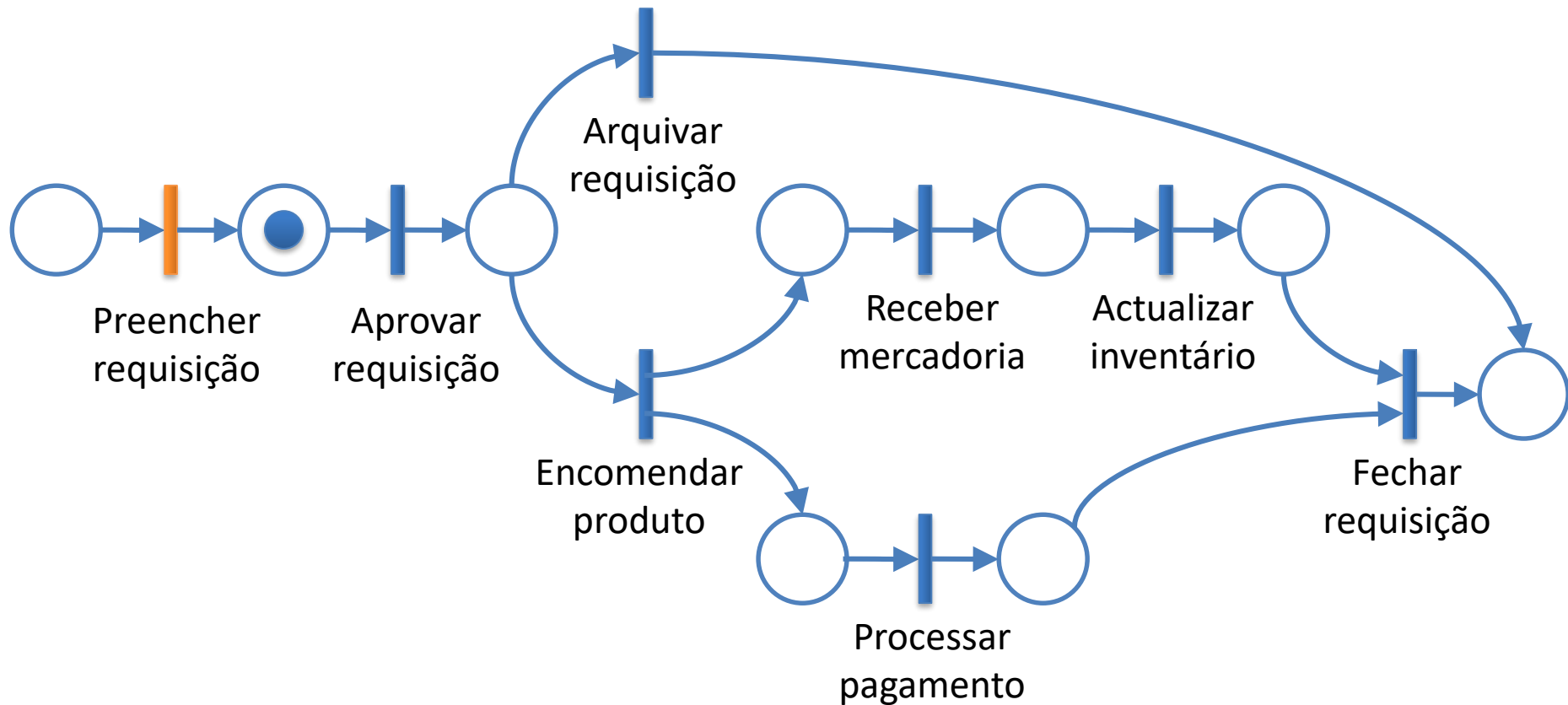
Mineração do fluxo

- Modelo em rede de Petri



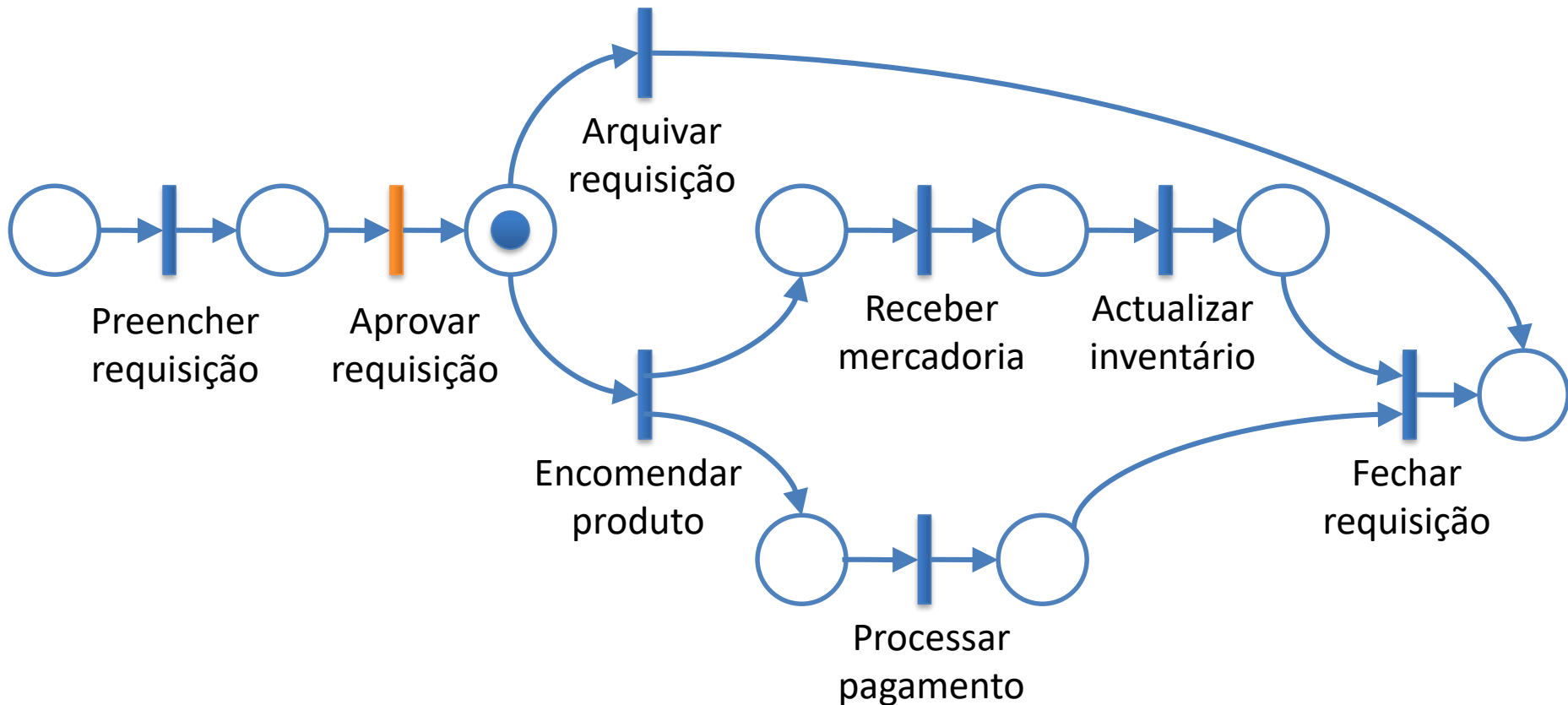
Mineração do fluxo

- Modelo em rede de Petri



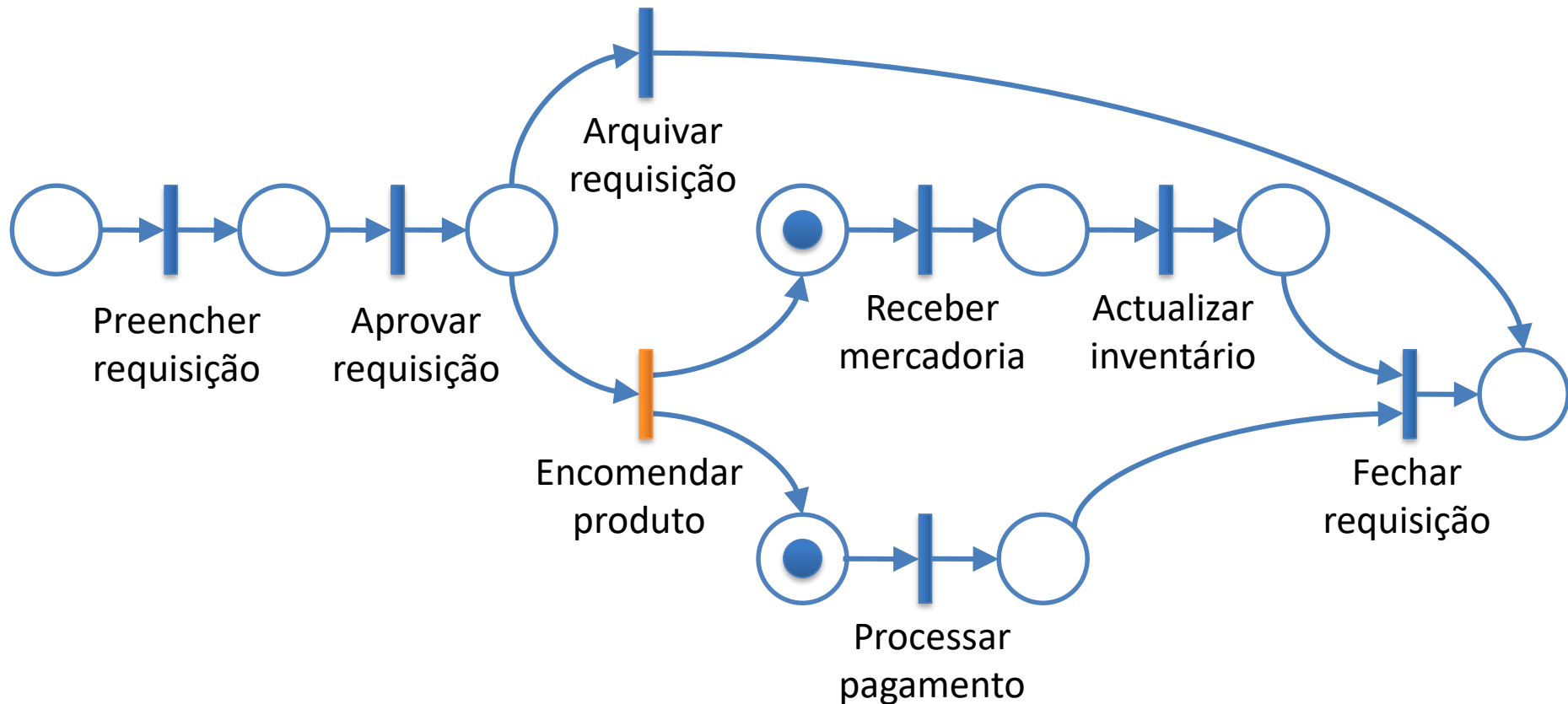
Mineração do fluxo

- Modelo em rede de Petri



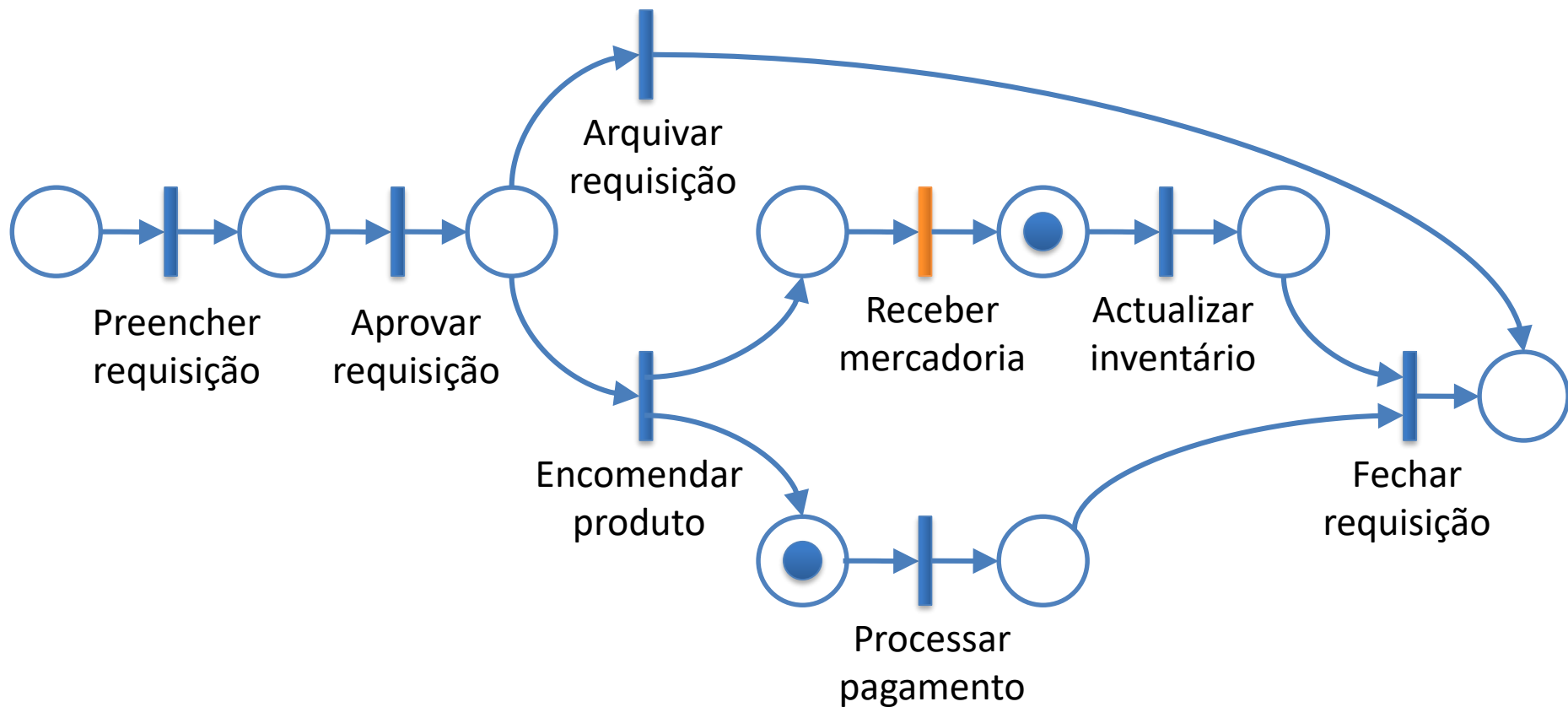
Mineração do fluxo

- Modelo em rede de Petri



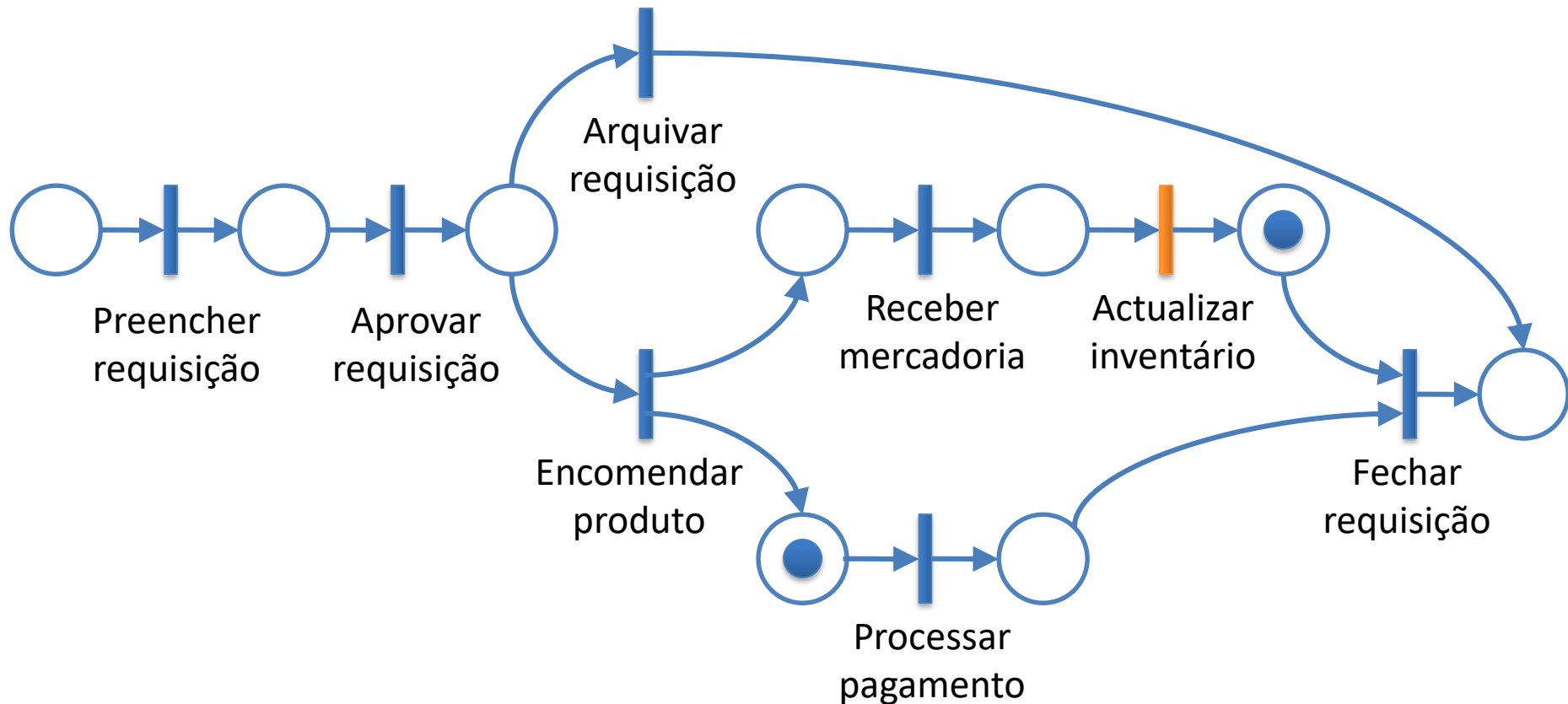
Mineração do fluxo

- Modelo em rede de Petri



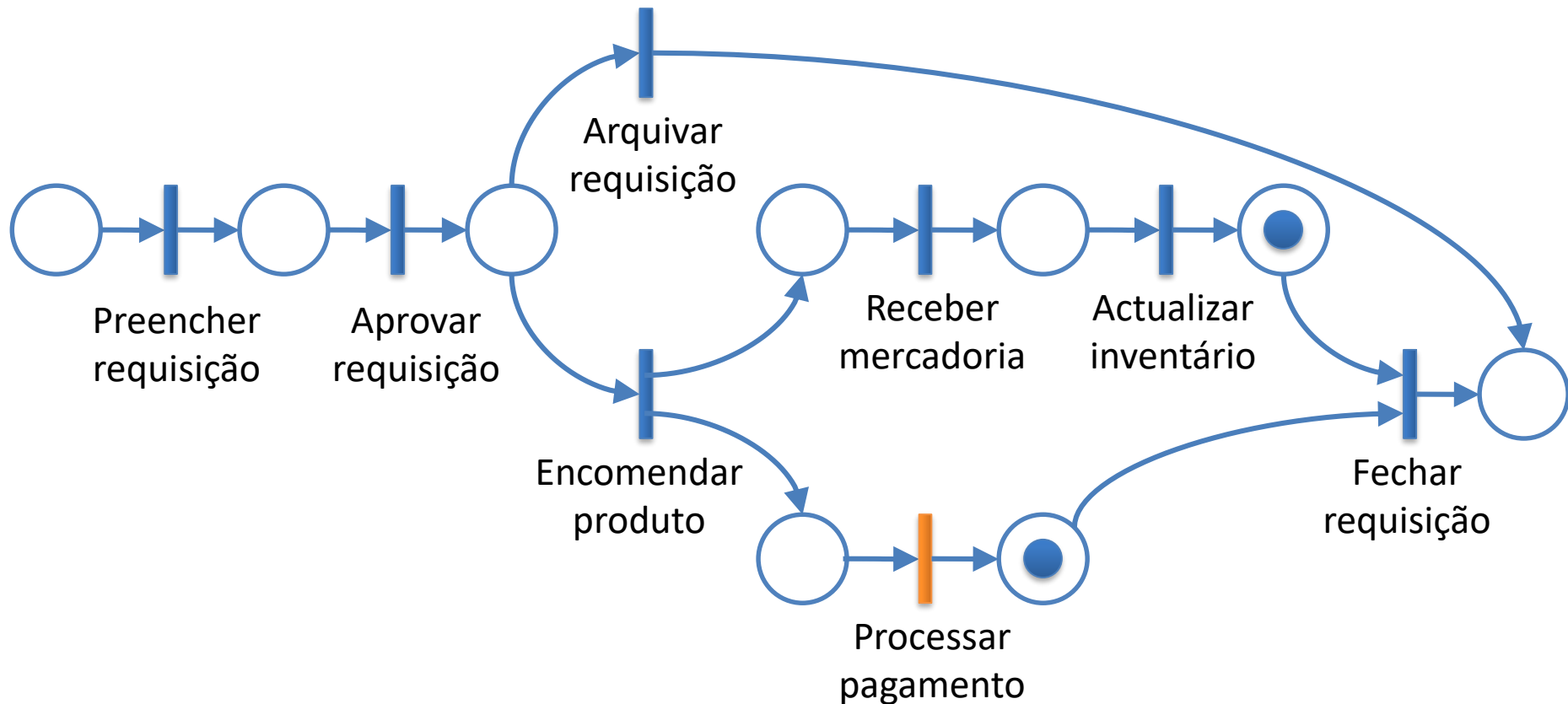
Mineração do fluxo

- Modelo em rede de Petri



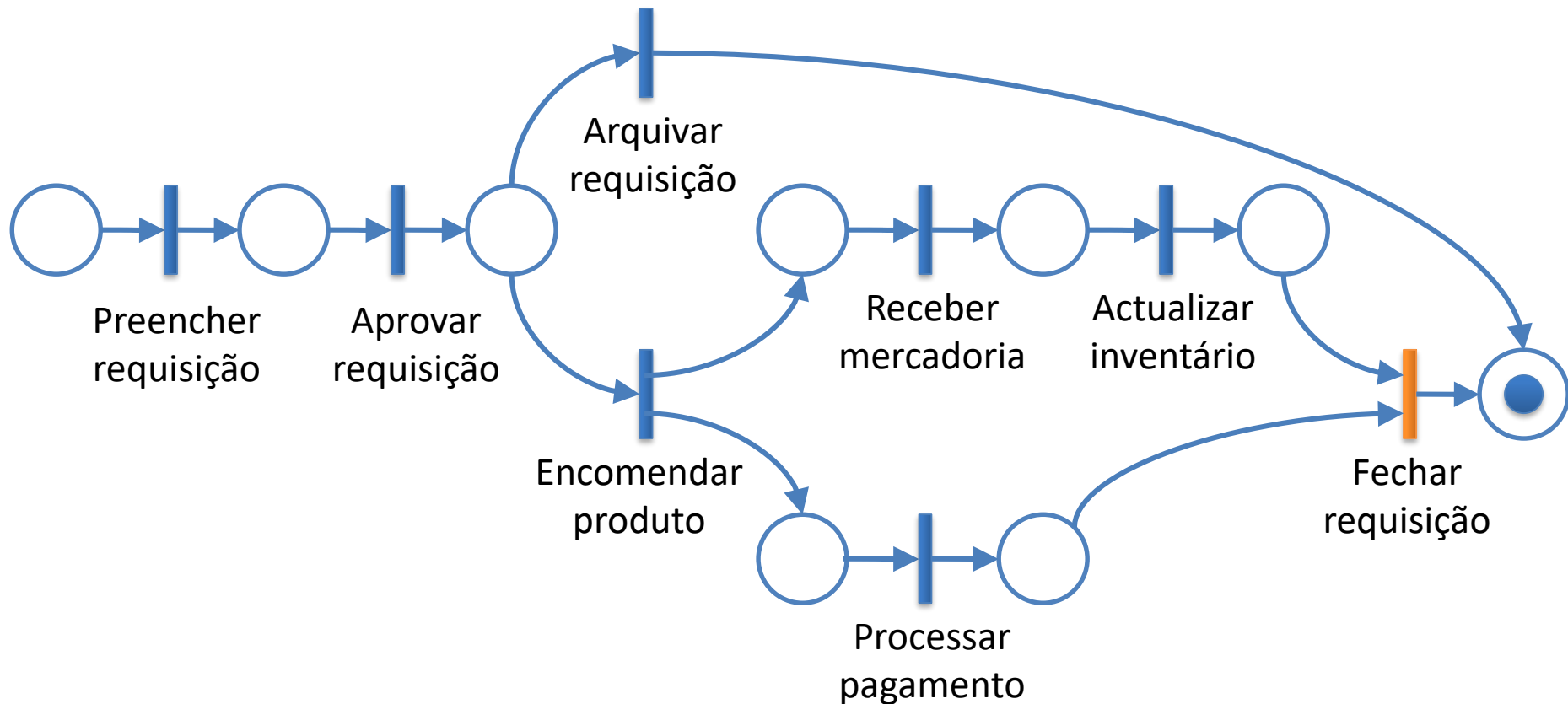
Mineração do fluxo

- Modelo em rede de Petri



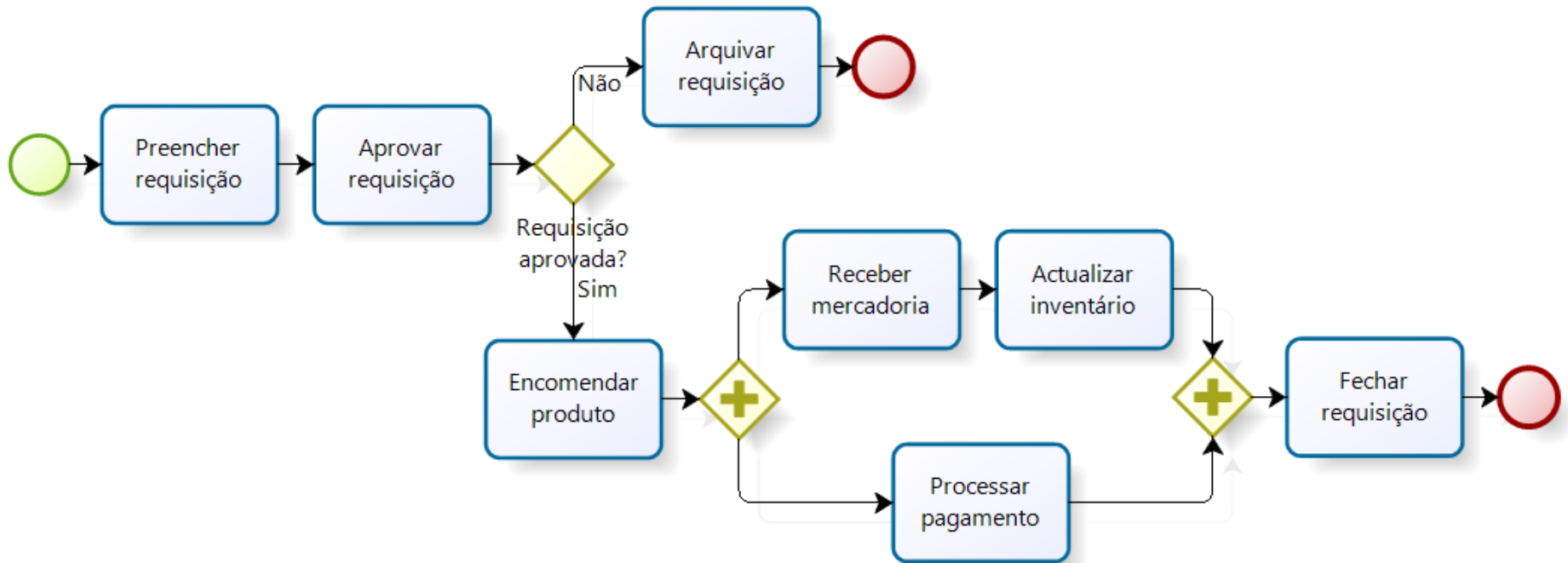
Mineração do fluxo

- Modelo em rede de Petri



Mineração do fluxo

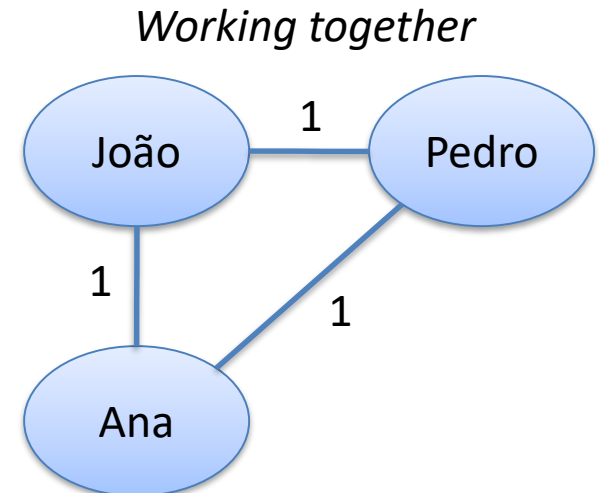
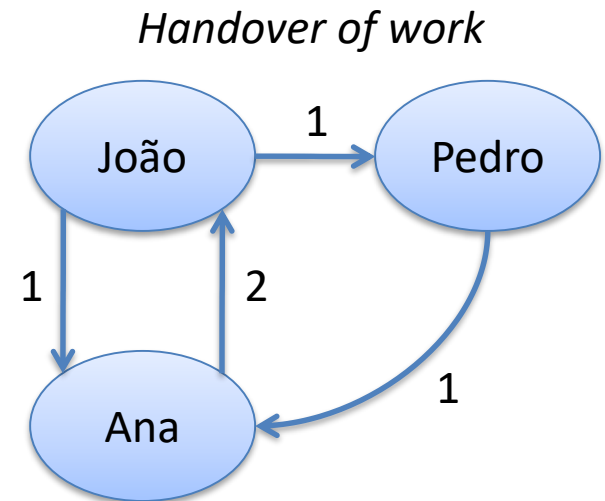
- Modelo em BPMN



Mineração da rede social

- Caso 1

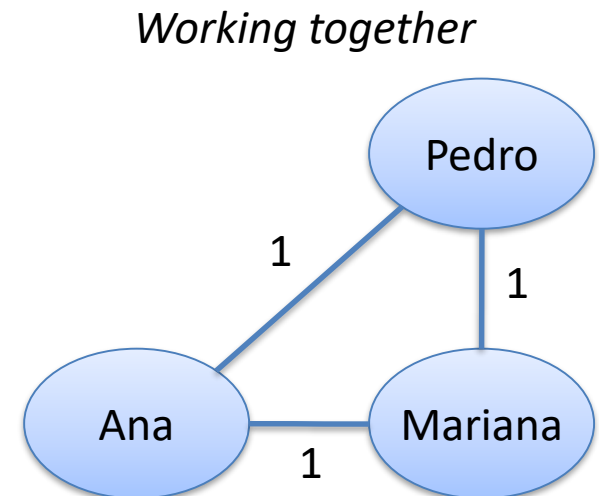
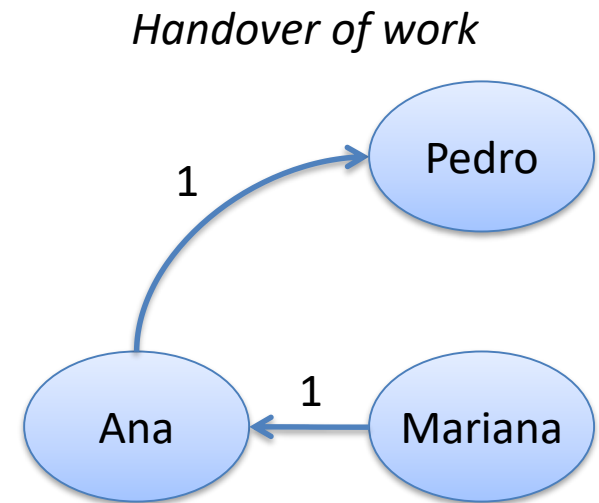
Caso	Actividade	Utilizador
1	Preencher requisição	João
1	Aprovar requisição	Ana
1	Encomendar produto	João
1	Receber mercadoria	Pedro
1	Actualizar inventário	Pedro
1	Processar pagamento	Ana
1	Fechar requisição	João



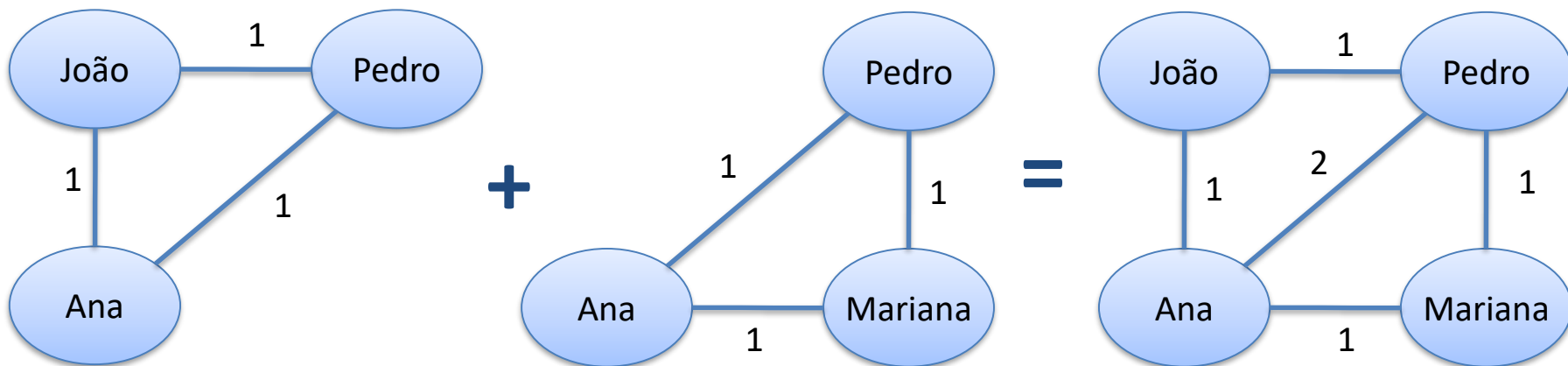
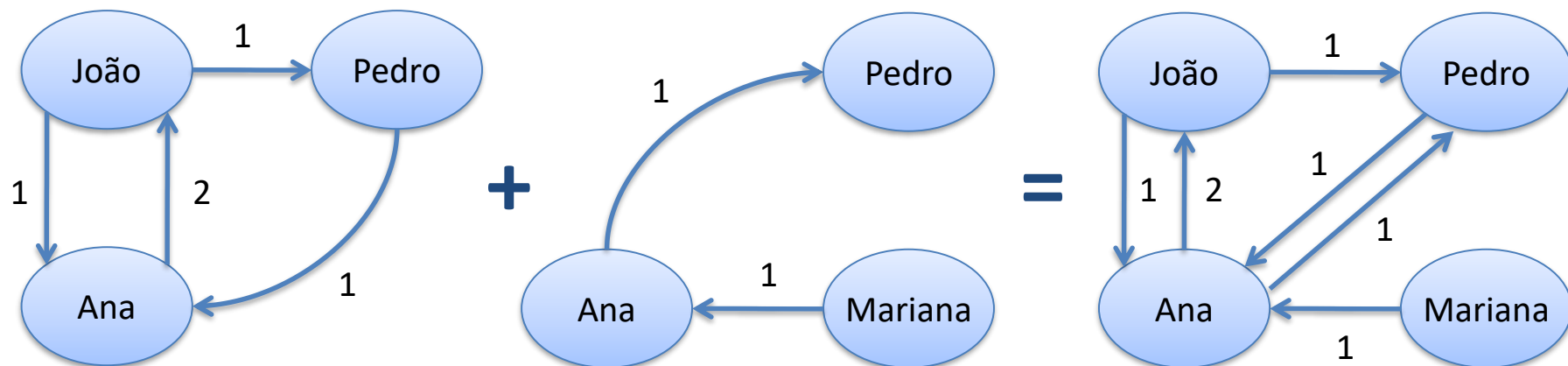
Mineração da rede social

- Caso 2

Caso	Actividade	Utilizador
2	Preencher requisição	Mariana
2	Aprovar requisição	Ana
2	Arquivar requisição	Pedro



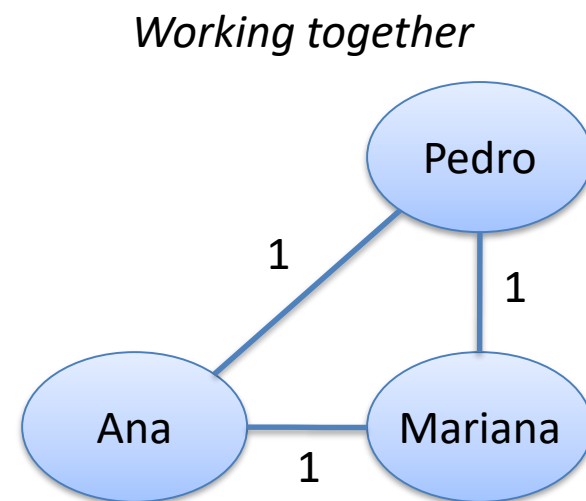
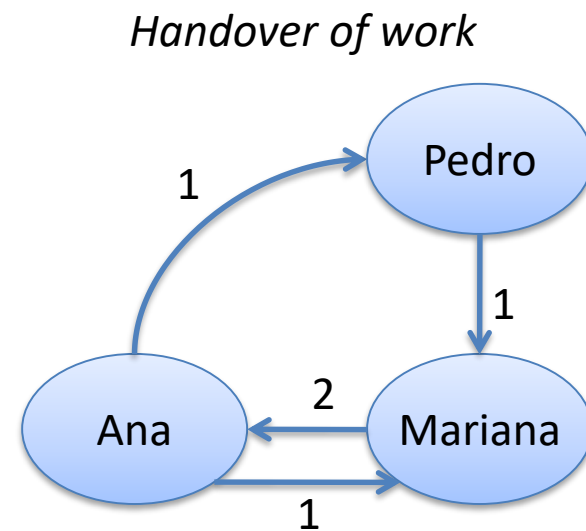
Mineração da rede social



Mineração da rede social

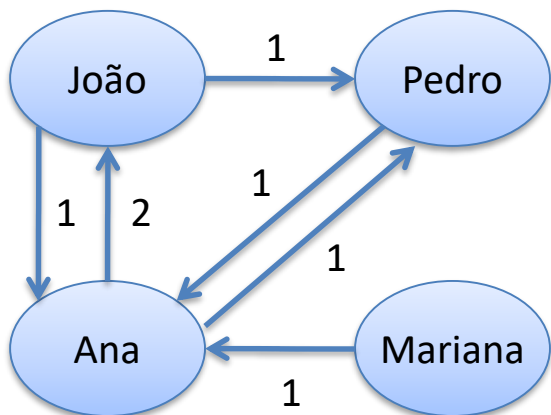
- Caso 3

Caso	Actividade	Utilizador
3	Preencher requisição	Mariana
3	Aprovar requisição	Ana
3	Encomendar produto	Mariana
3	Processar pagamento	Ana
3	Receber mercadoria	Pedro
3	Actualizar inventário	Pedro
3	Fechar requisição	Mariana

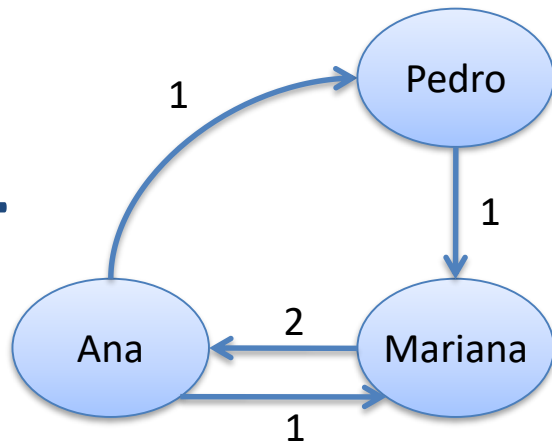


Mineração da rede social

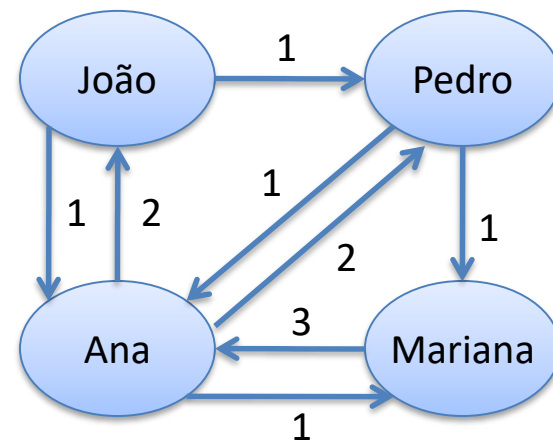
Casos 1 e 2



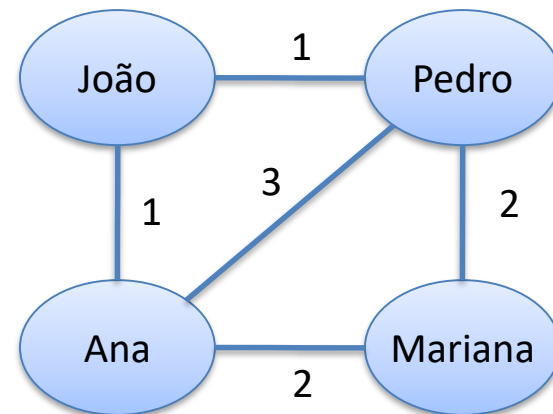
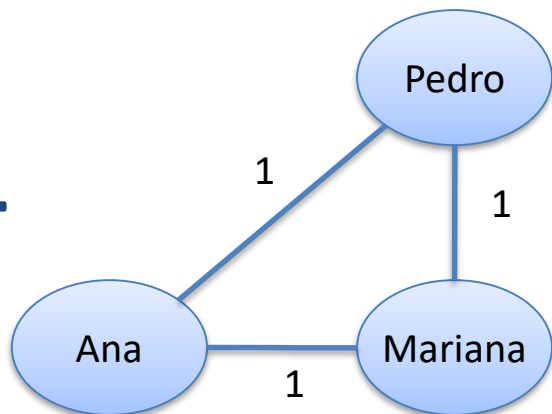
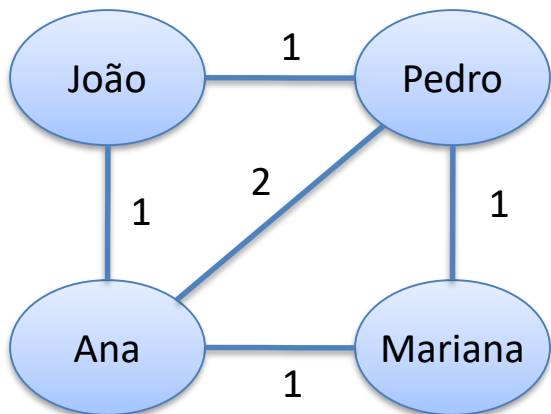
Caso 3



Handover of work

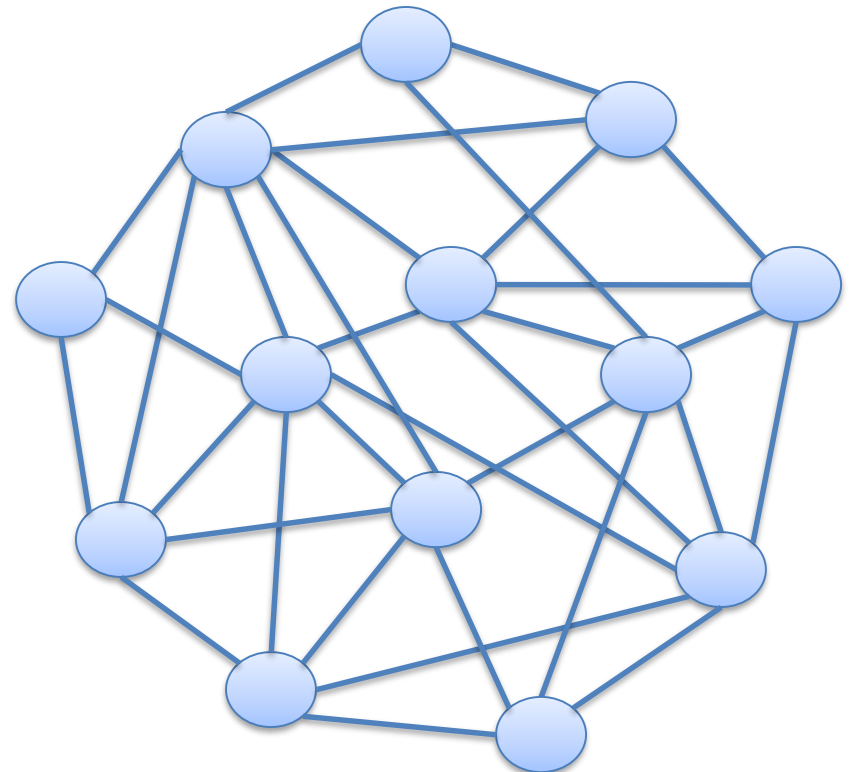
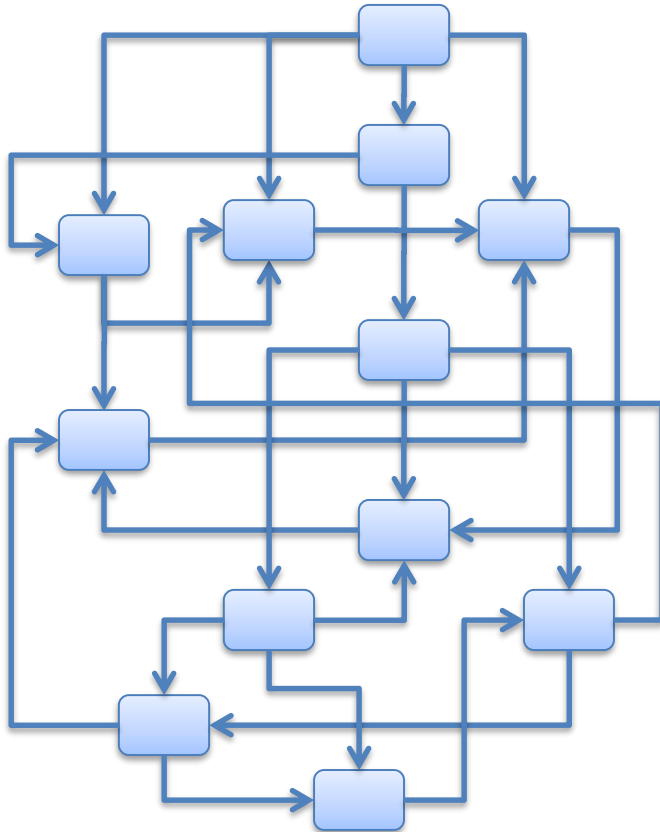


Working together



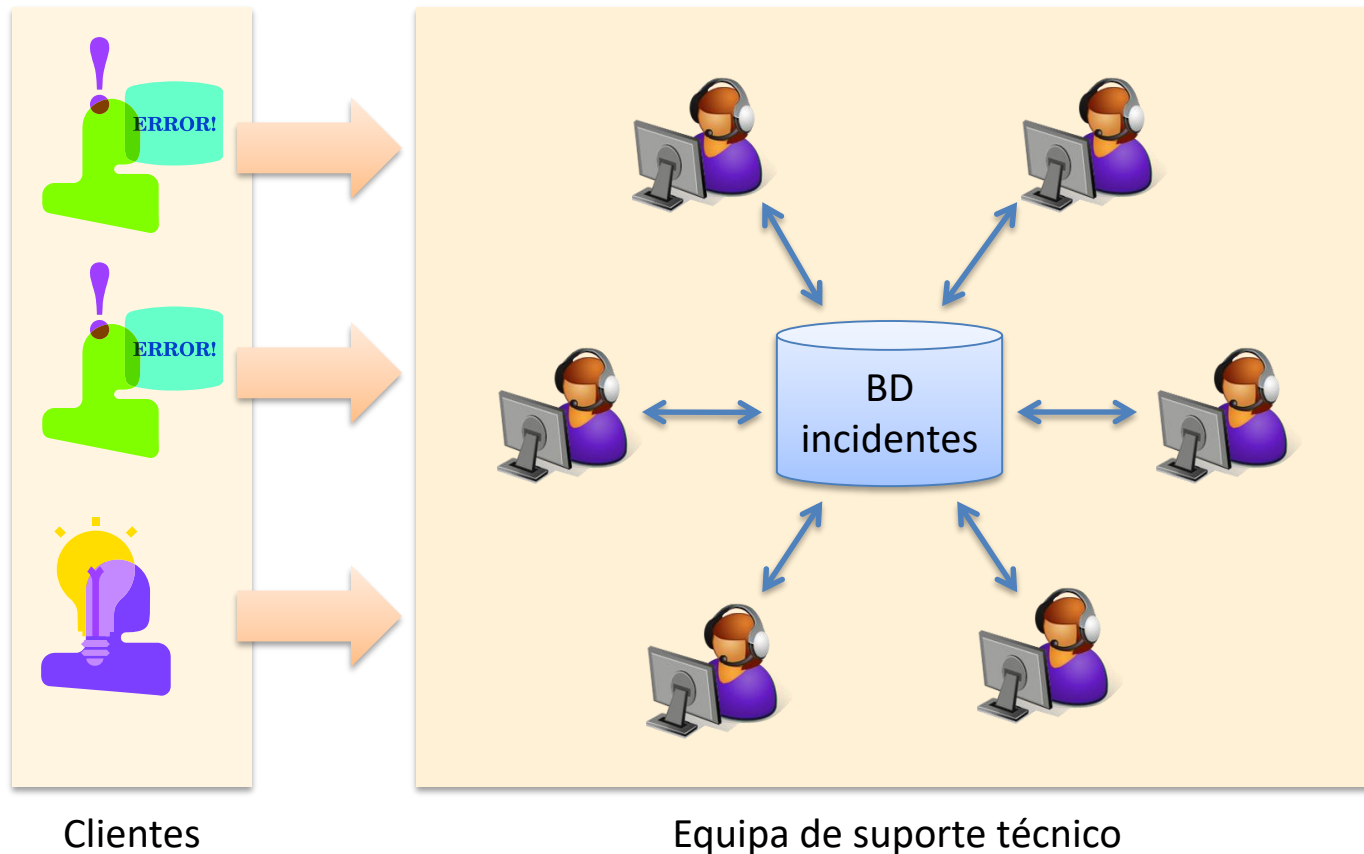
Mineração de processos

- Em aplicações reais, podemos ter modelos complexos e muito confusos



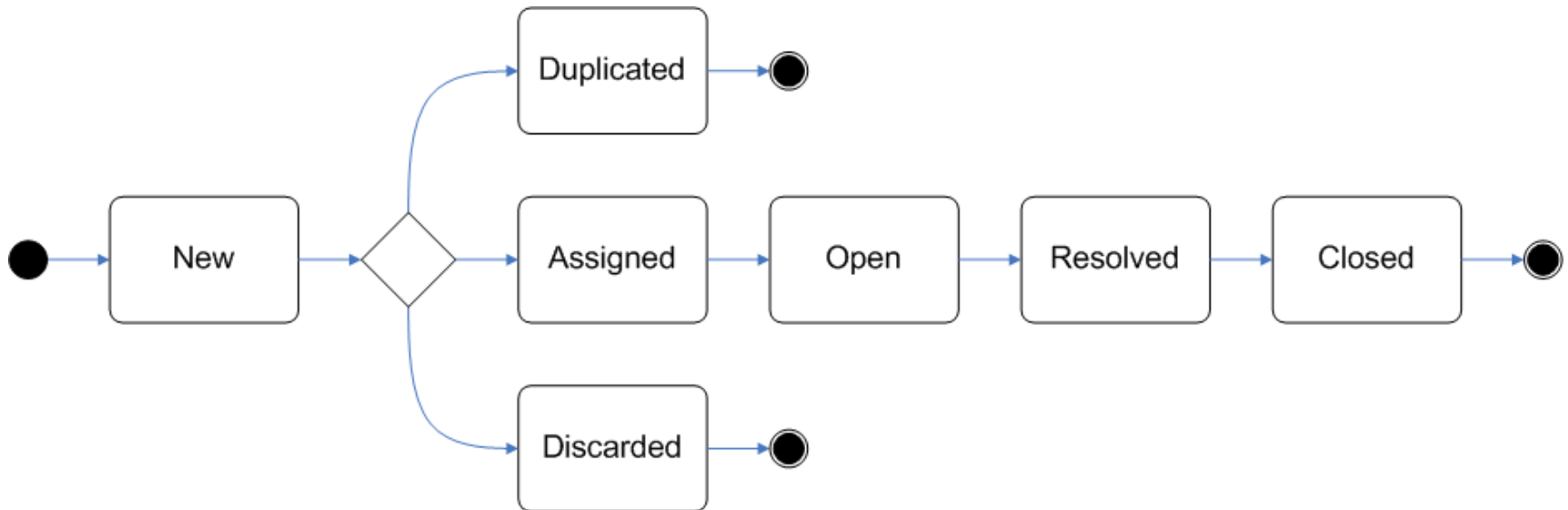
Caso práctico I

- Suporte técnico de um produto de software



Caso práctico I

- Estado dos incidentes

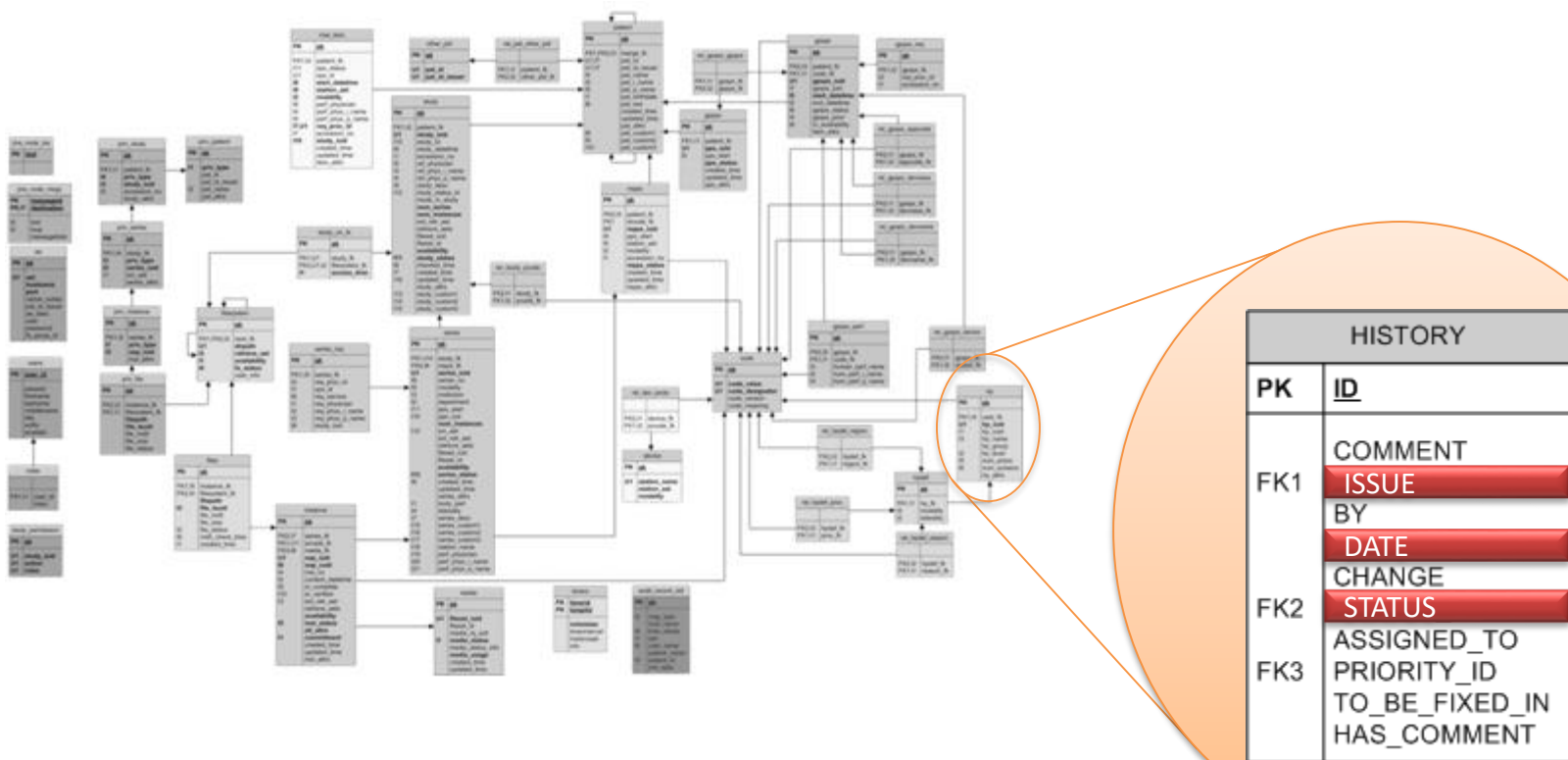


Recording. Matching. Classification. Diagnosis. Resolution. Closure.

(ITIL Incident Management)

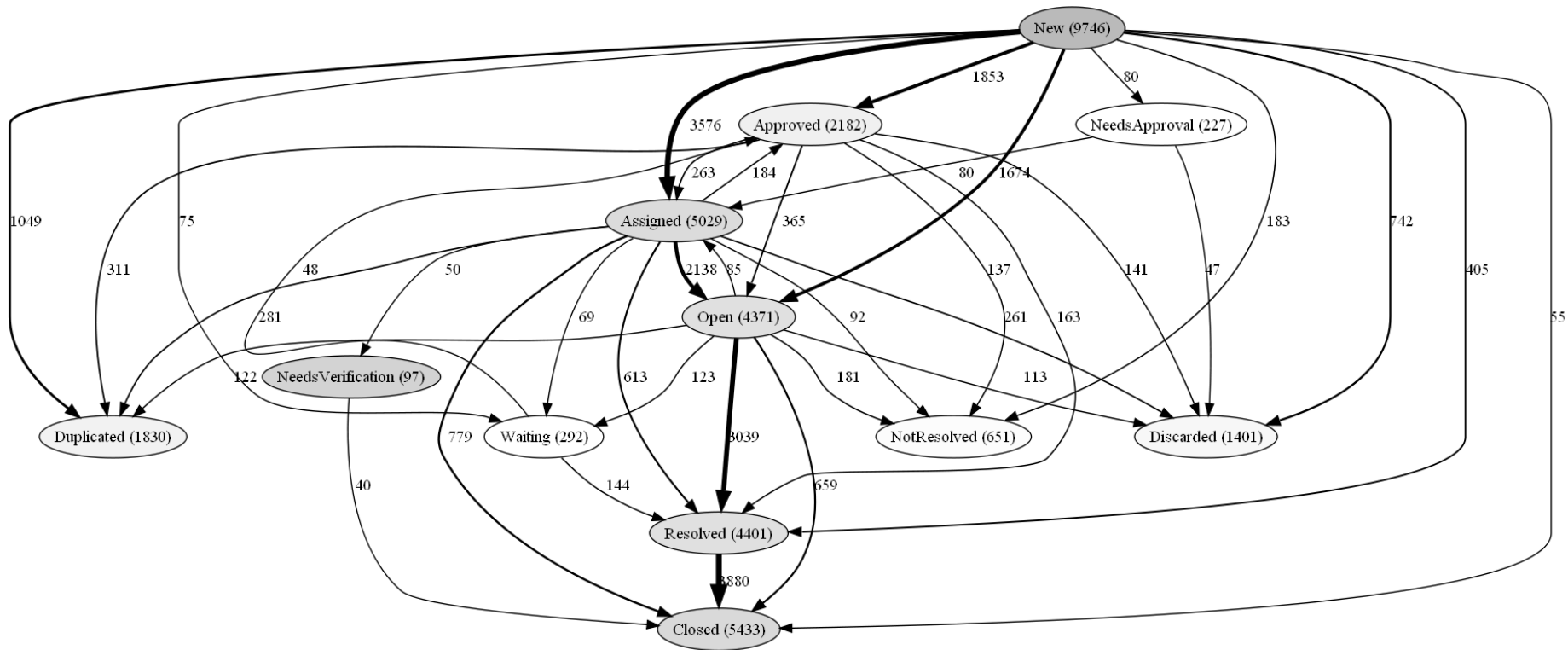
Caso prático I

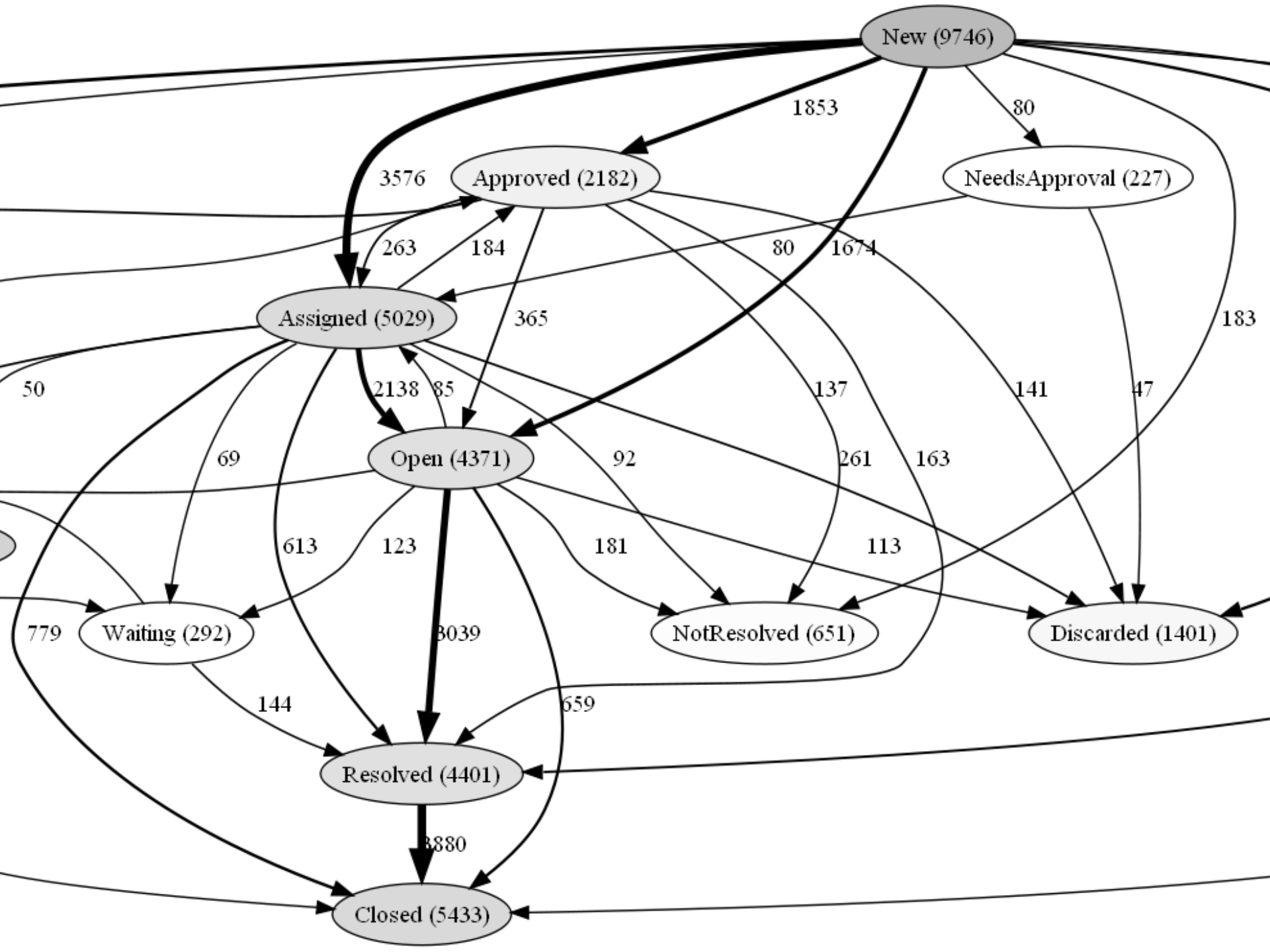
- Base de dados do sistema



Caso prático I

- Mineração do fluxo

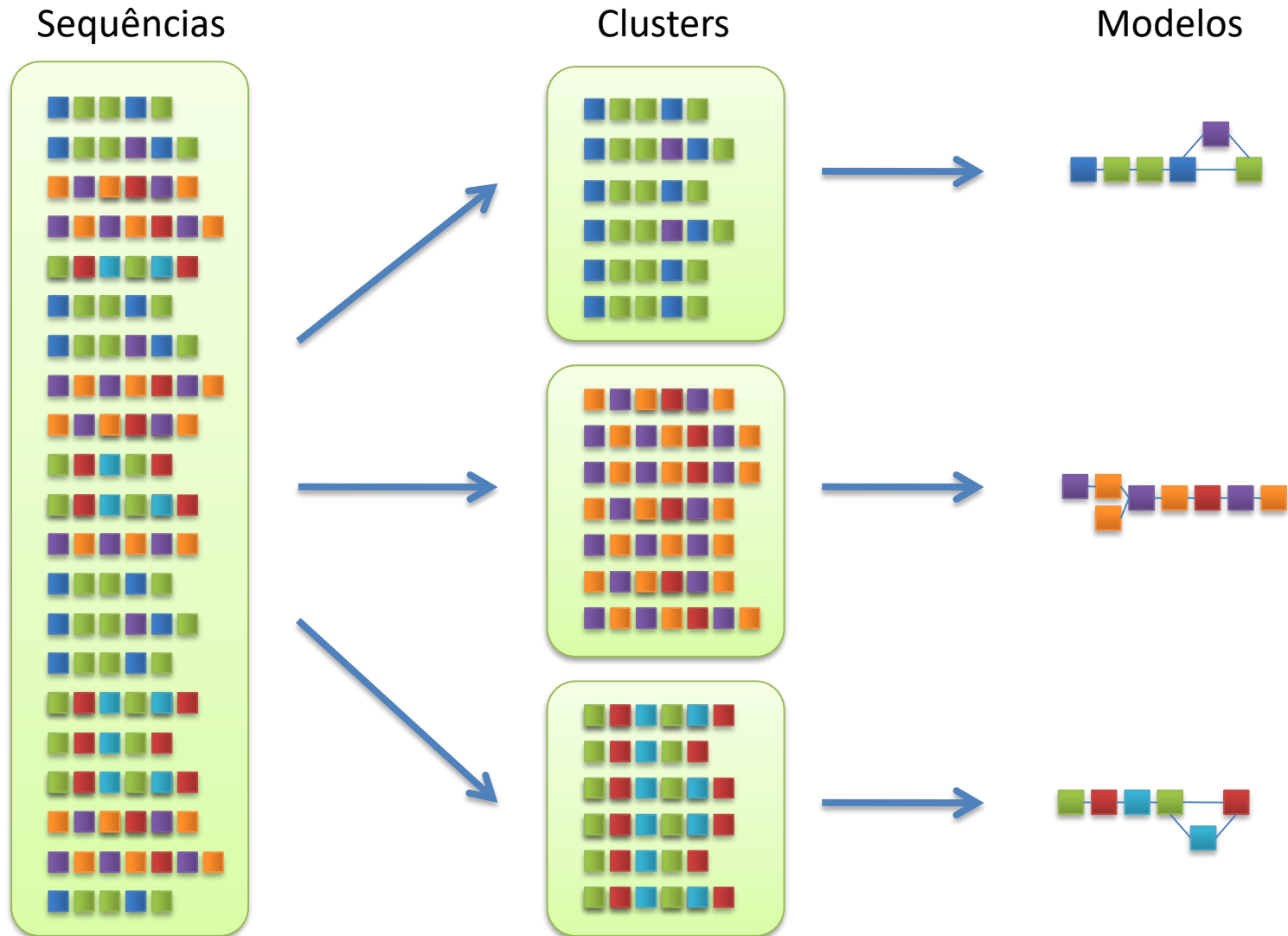




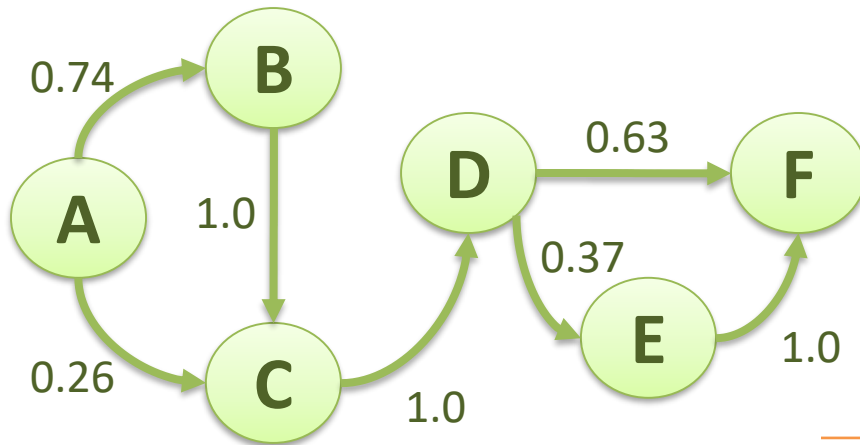
Mineração de processos

- Técnicas avançadas
 - clustering de sequências
 - clustering da rede social

Clustering de seqüências



Clustering de sequências

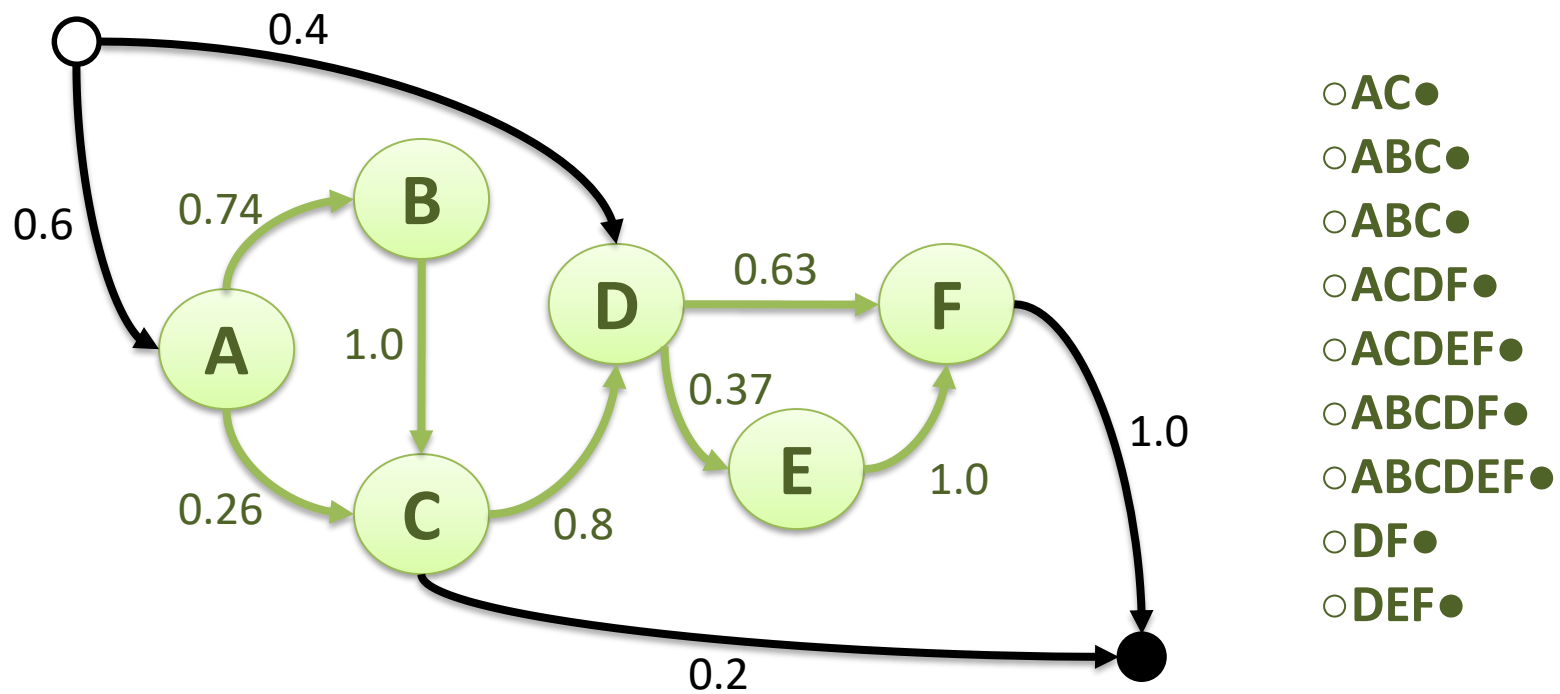


ABCDEF
ACDE
BCDF
CDF
DE
...

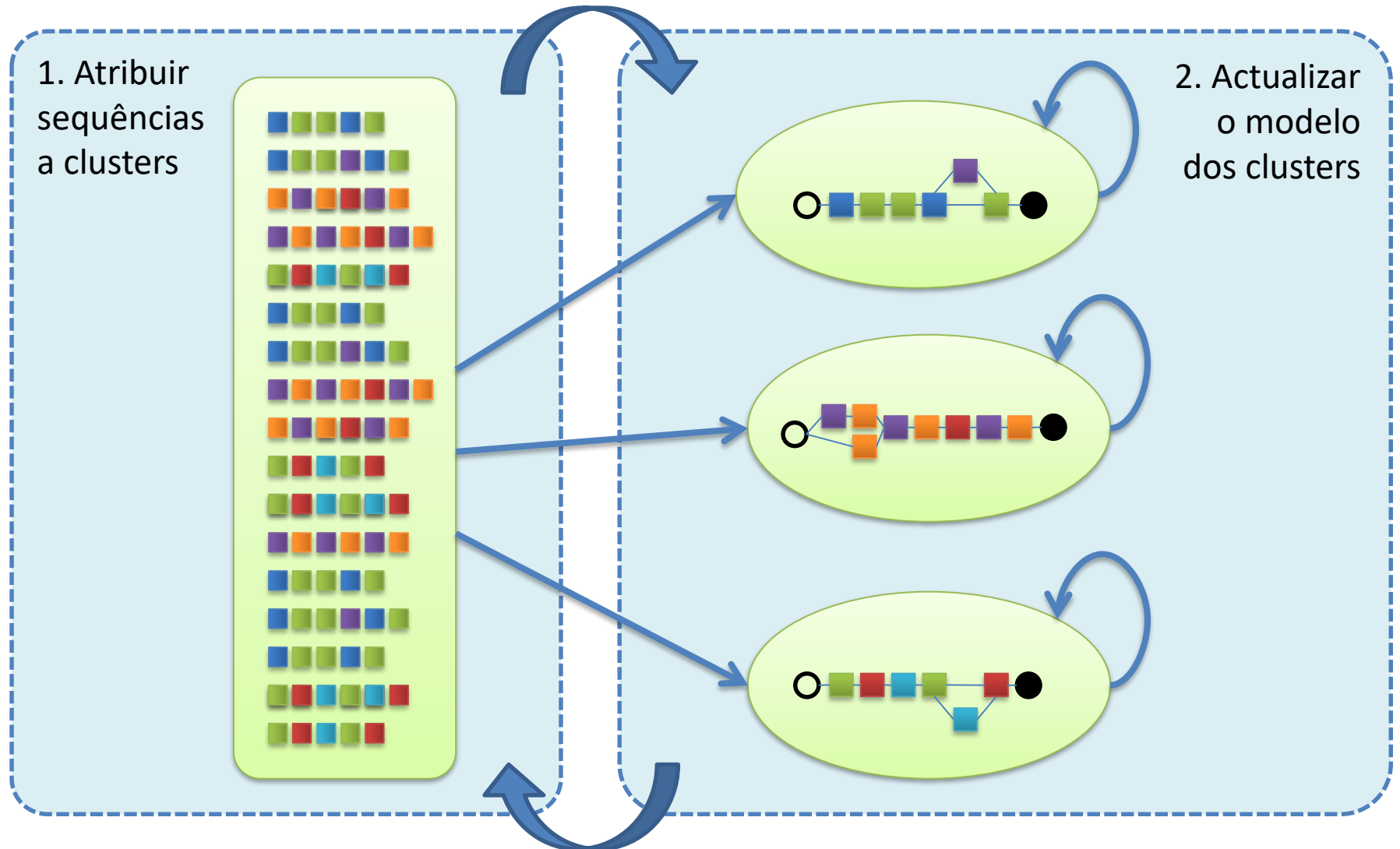
	A	B	C	D	E	F
A	-	0.74	0.26	-	-	-
B	-	-	1.0	-	-	-
C	-	-	-	1.0	-	-
D	-	-	-	-	0.37	0.63
E	-	-	-	-	-	1.0
F	-	-	-	-	-	-

Clustering de sequências

- estados de entrada (○) e de saída (●)



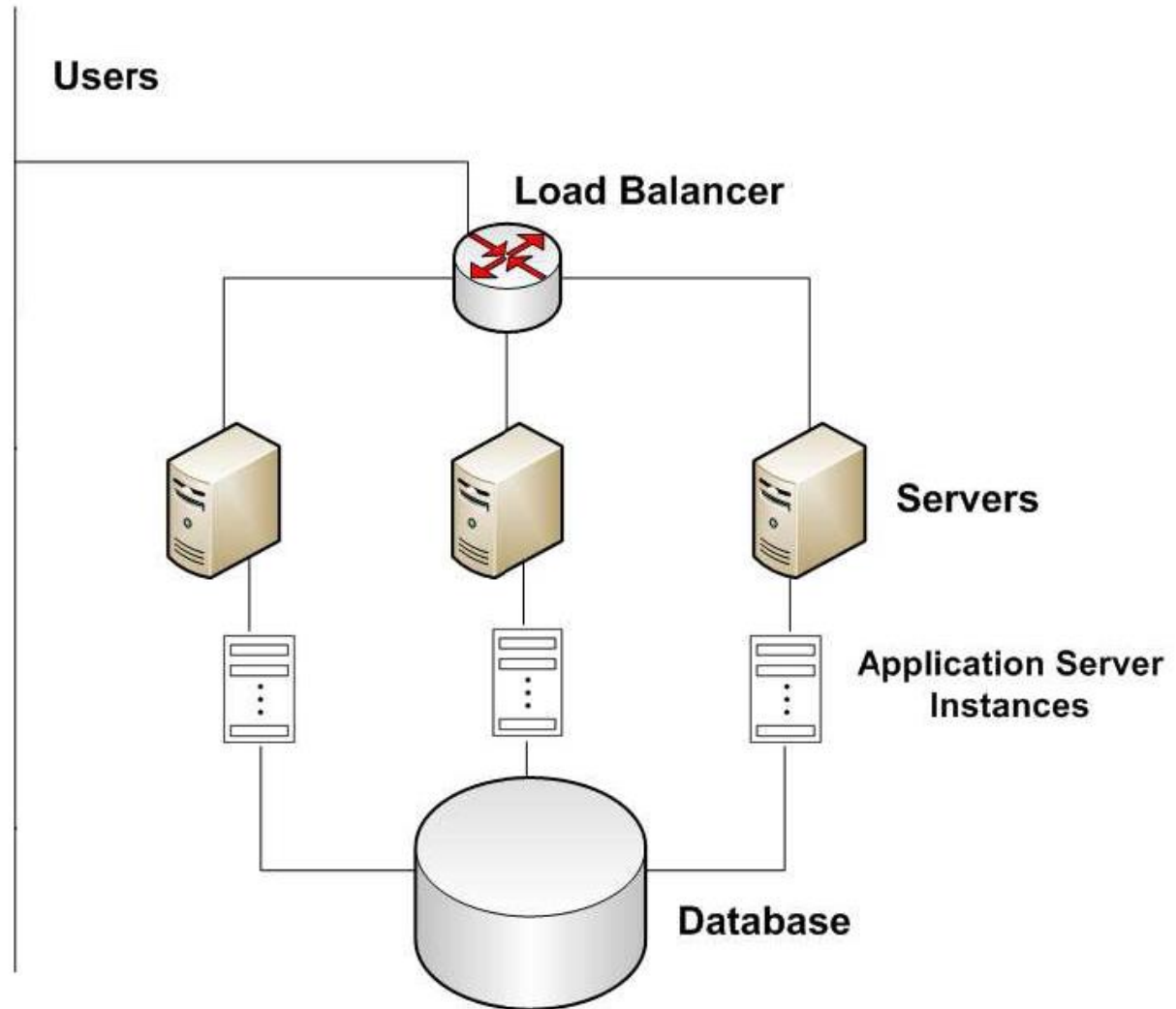
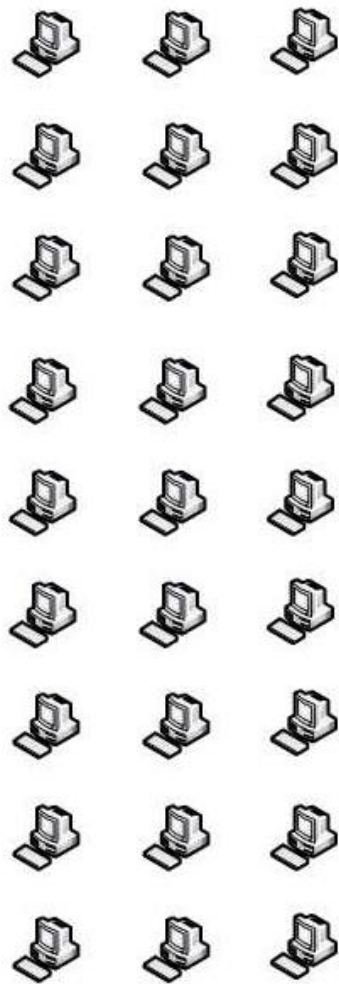
Clustering de sequências



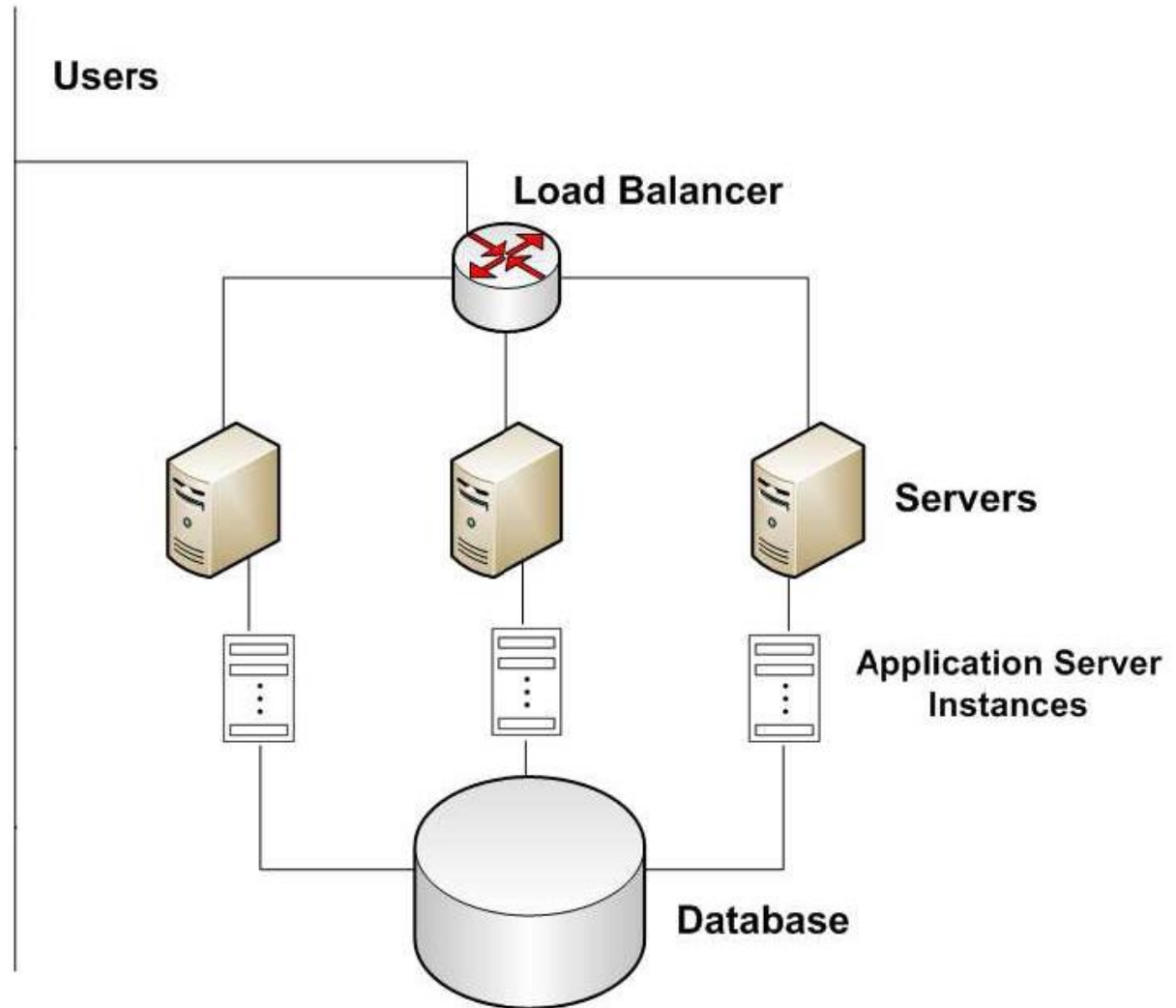
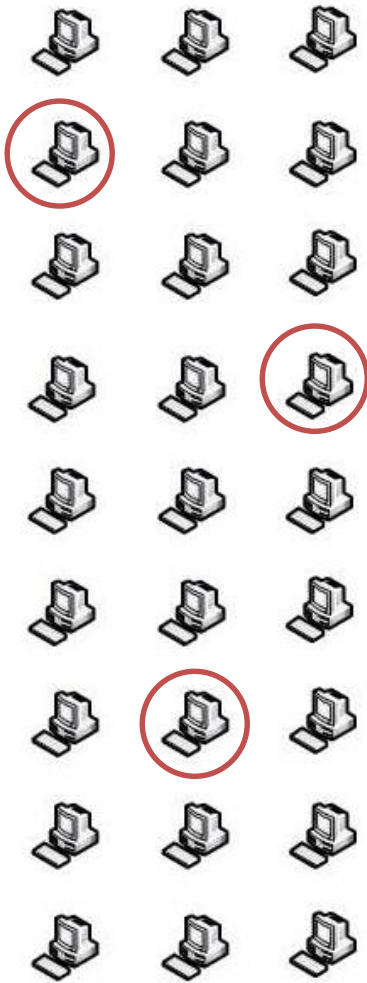
Caso prático II

- Administração pública
 - sistema TI de grande escala
 - replicação, redundância, balanceamento de carga
 - grande número de utilizadores em simultâneo
- Infra-estrutura
 - arquitectura cliente-servidor baseada em Java
 - aplicação Java nos clientes
 - servidor aplicacional de *Enterprise JavaBeans*

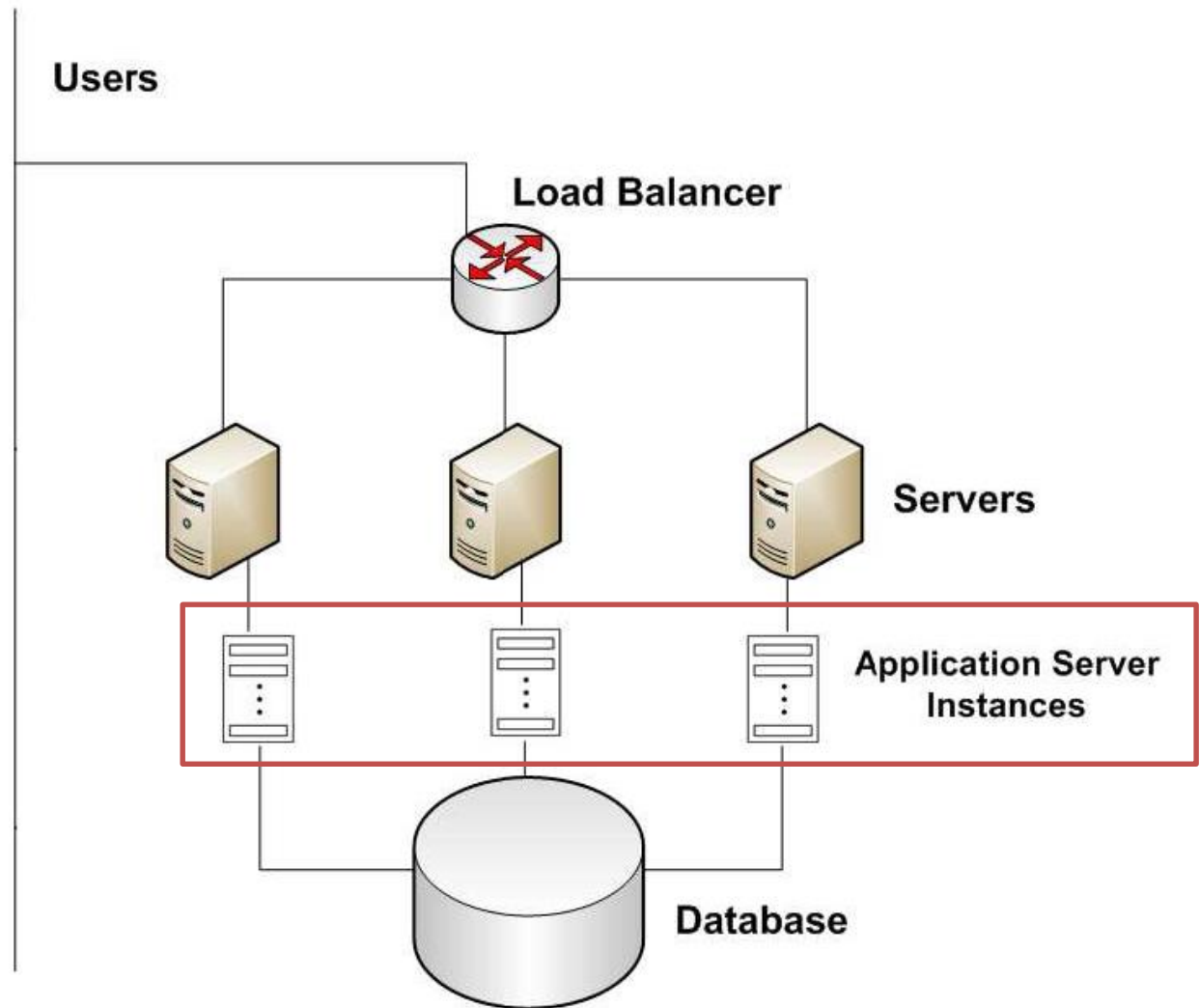
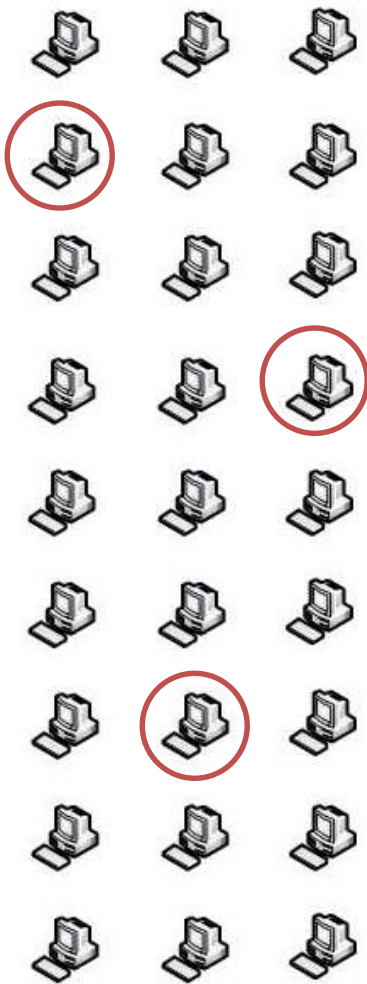
Caso práctico II



Caso práctico II



Caso práctico II



Caso prático II

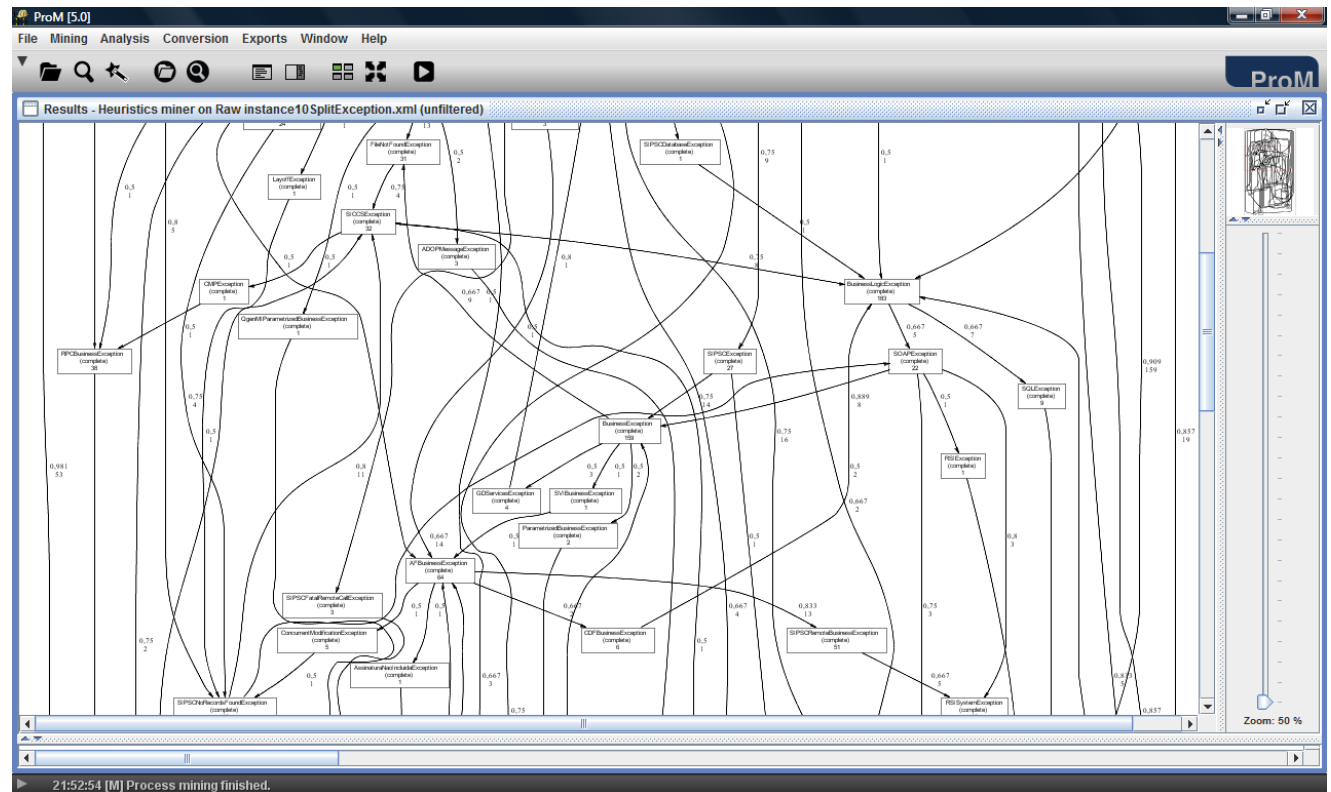
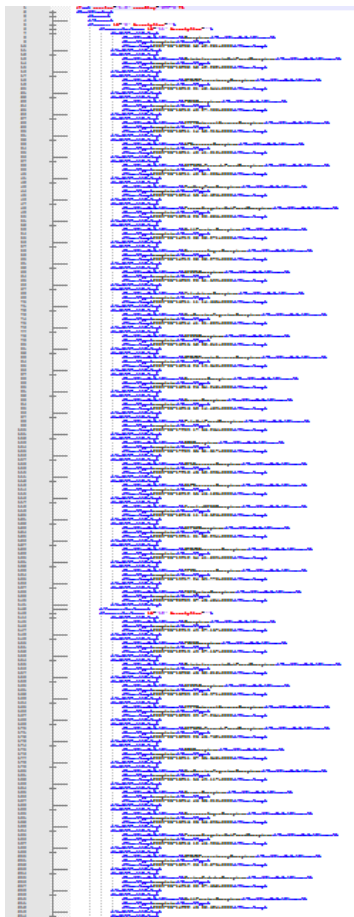
- Excerto do log

```
server.log_2009-03-13T09-40-29 2009-03-12T19:12:54.135+0000 _ThreadID=23; WSException
server.log_2009-03-13T09-40-29 2009-03-12T19:13:18.145+0000 _ThreadID=23; BusinessException
server.log_2009-03-13T09-40-29 2009-03-12T19:13:18.145+0000 _ThreadID=173; SystemException
server.log_2009-03-13T09-40-29 2009-03-12T19:14:20.189+0000 _ThreadID=21; BusinessException
server.log_2009-03-13T09-40-29 2009-03-12T19:14:20.189+0000 _ThreadID=21; EmptyResultException
server.log_2009-03-13T09-40-29 2009-03-12T19:18:34.128+0000 _ThreadID=17; EmptyResultException
server.log_2009-03-13T09-40-29 2009-03-12T19:18:34.128+0000 _ThreadID=17; NoRecordsFoundException
server.log_2009-03-13T09-40-29 2009-03-12T19:19:00.785+0000 _ThreadID=155; Exception
server.log_2009-03-13T09-40-29 2009-03-12T19:19:00.785+0000 _ThreadID=155; NoRecordsFoundException
server.log_2009-03-13T09-40-29 2009-03-12T19:20:20.339+0000 _ThreadID=410; AFException
server.log_2009-03-13T09-40-29 2009-03-12T19:21:09.291+0000 _ThreadID=172; ExtServiceException
server.log_2009-03-13T09-40-29 2009-03-12T19:21:09.292+0000 _ThreadID=172; BusinessException
```



Caso prático II

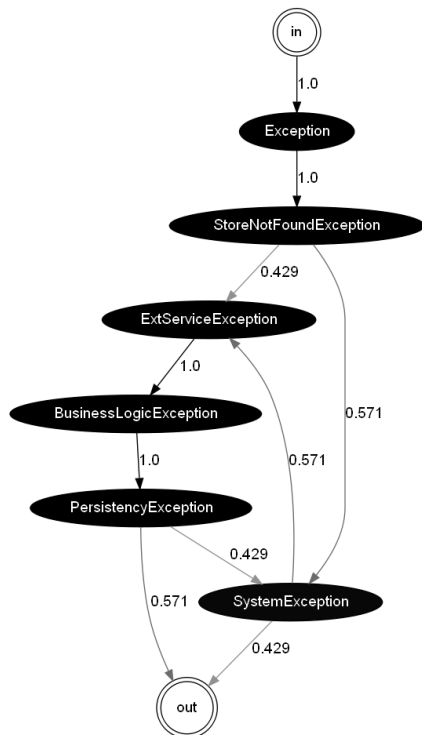
- Análise sem clustering de sequências



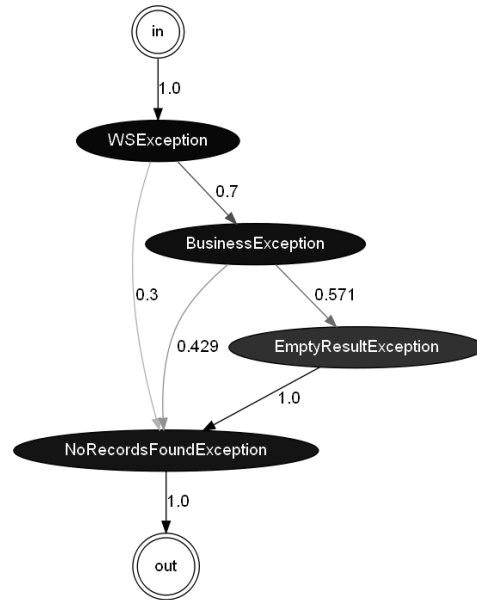
Caso prático II

- Análise com clustering de seqüências

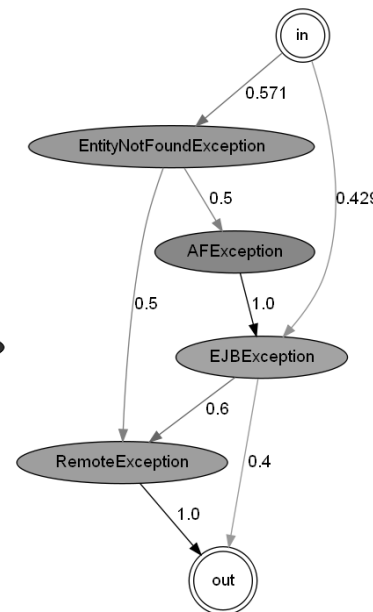
Cluster 1



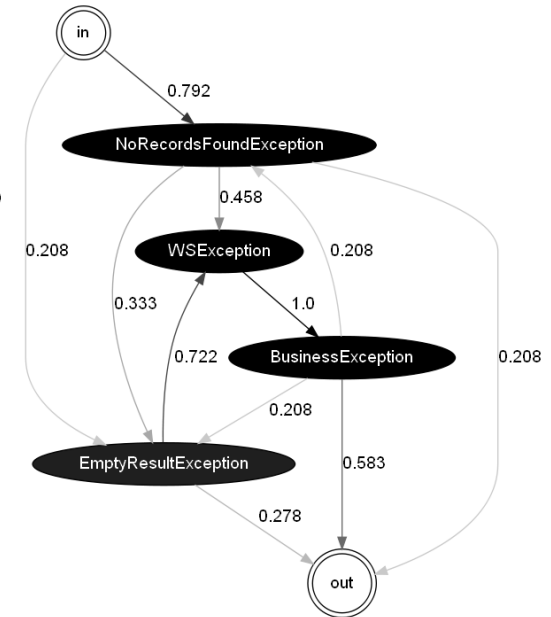
Cluster 2



Cluster 3

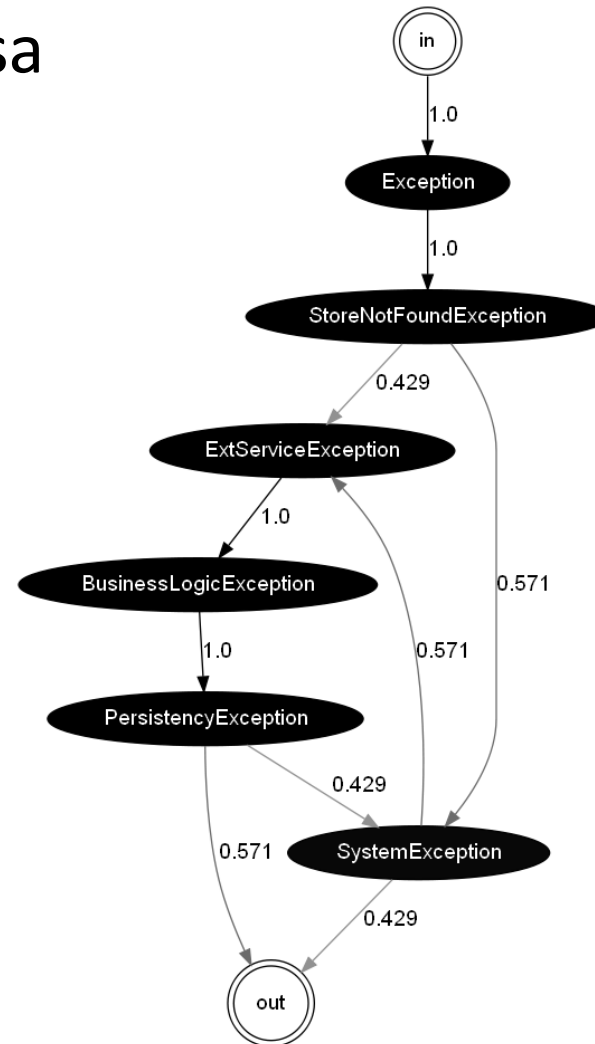


Cluster 4



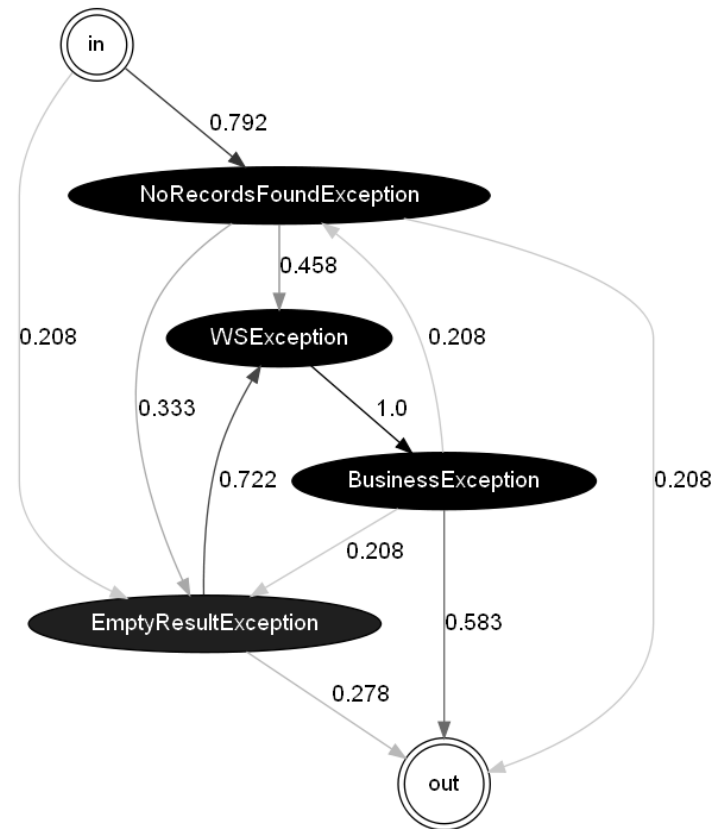
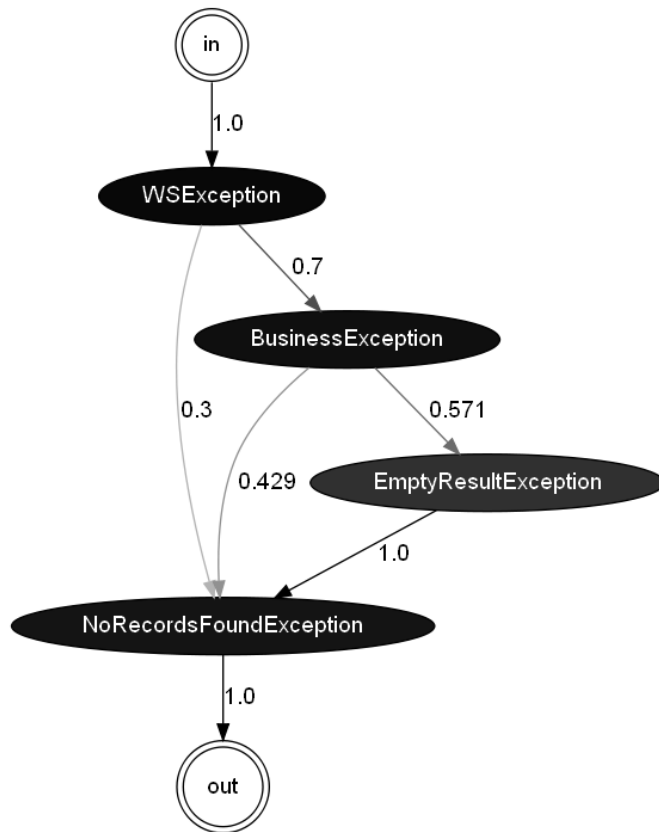
Caso prático II

- Cluster 1: item de pesquisa não encontrado



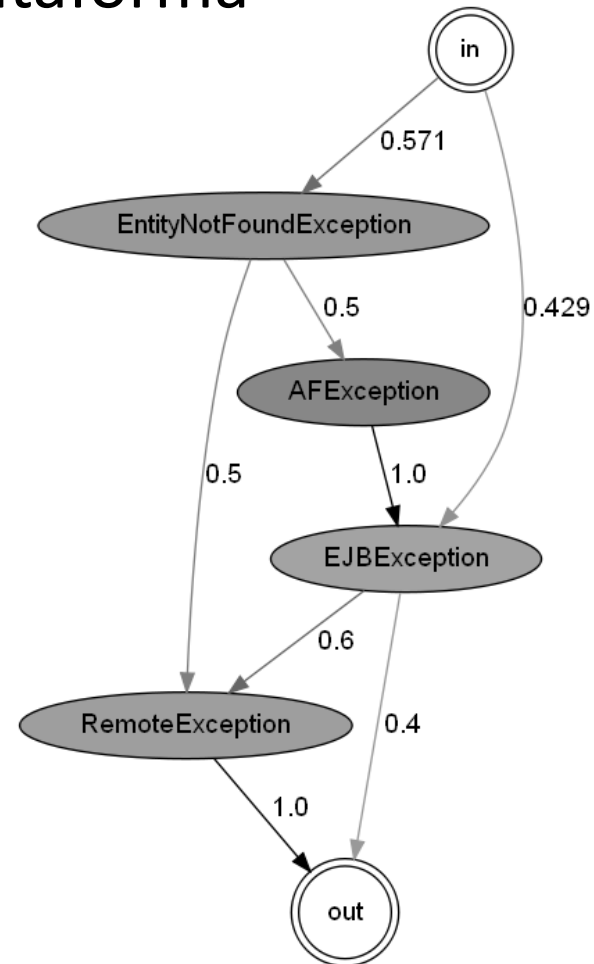
Caso prático II

- Clusters 2 e 4: exceções de web services e consultas à base de dados com resultado vazio

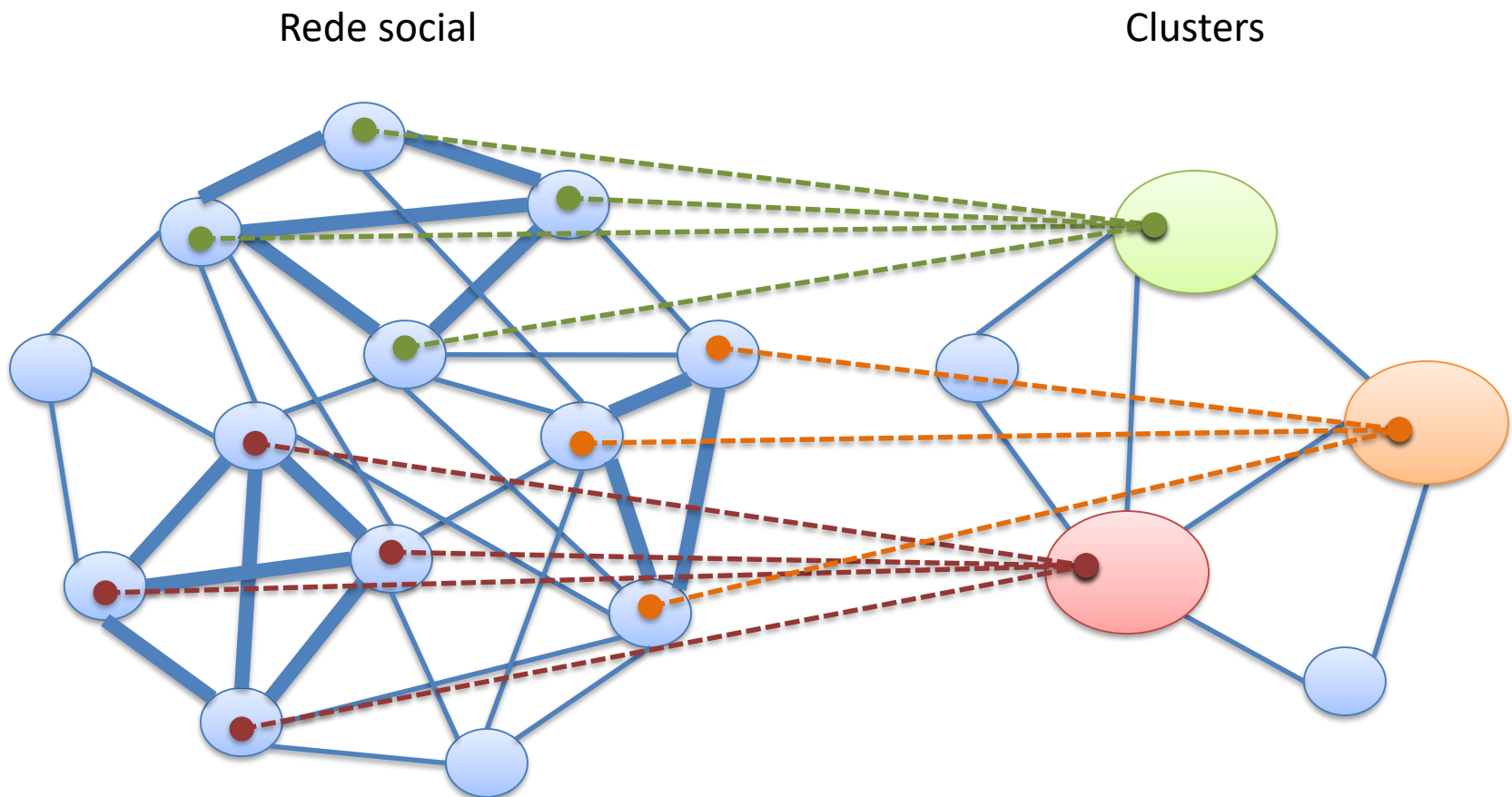


Caso prático II

- Clusters 3: exceções da plataforma em picos de carga

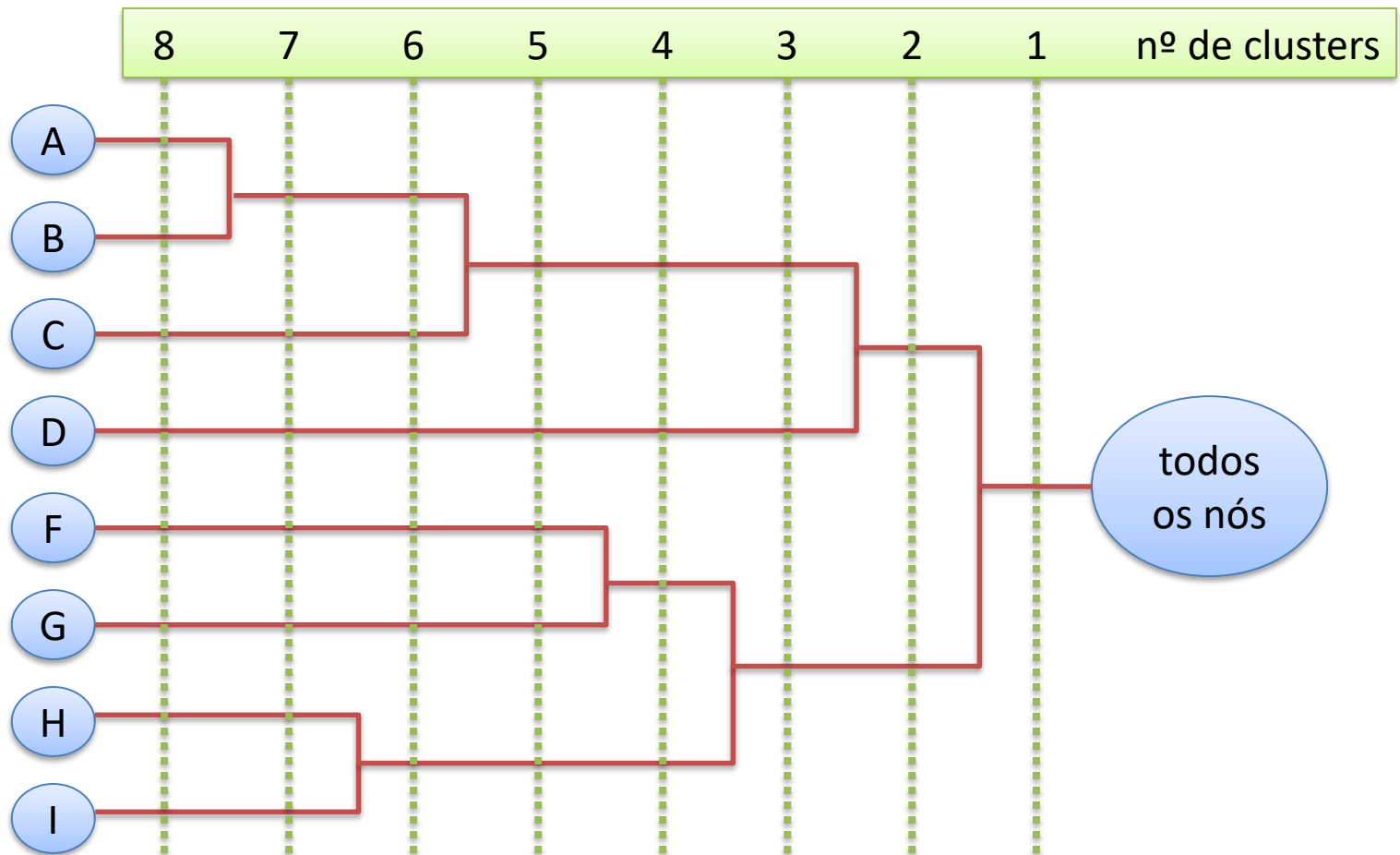


Clustering da rede social



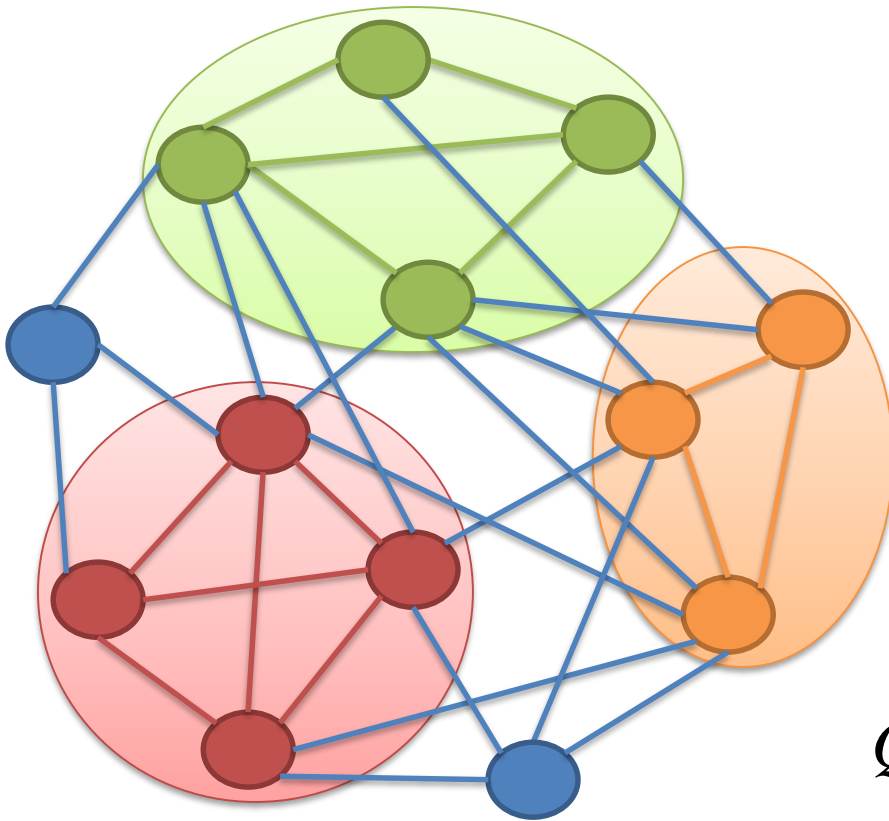
Clustering da rede social

- Clustering hierárquico



Clustering da rede social

- Modularidade



A_{ij} = matriz de adjacências

k_i = grau do nó i

m = soma das ligações da rede

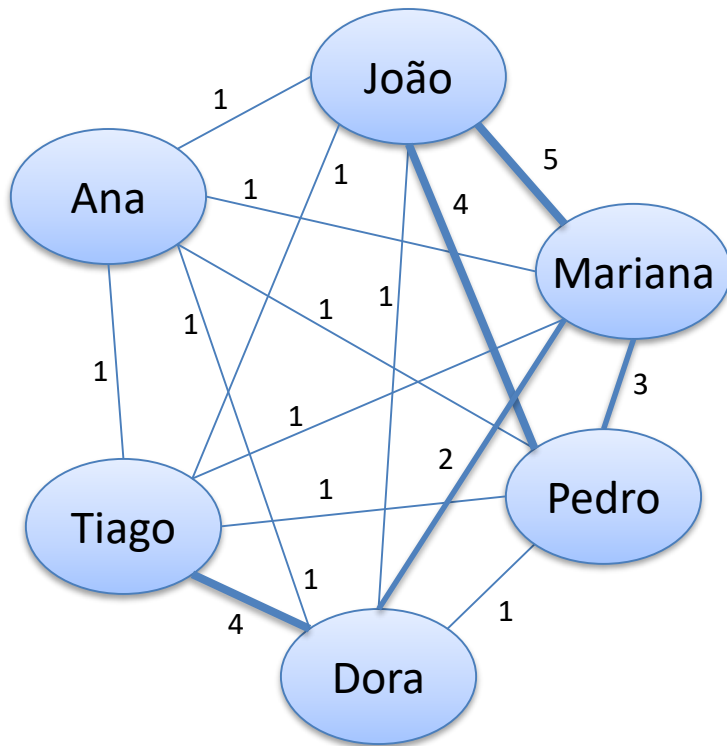
c_i = cluster do nó i

Modularidade Q

$$Q = \frac{1}{2m} \sum_{ij} \left(A_{ij} - \frac{k_i k_j}{2m} \right) \cdot \delta(c_i, c_j)$$

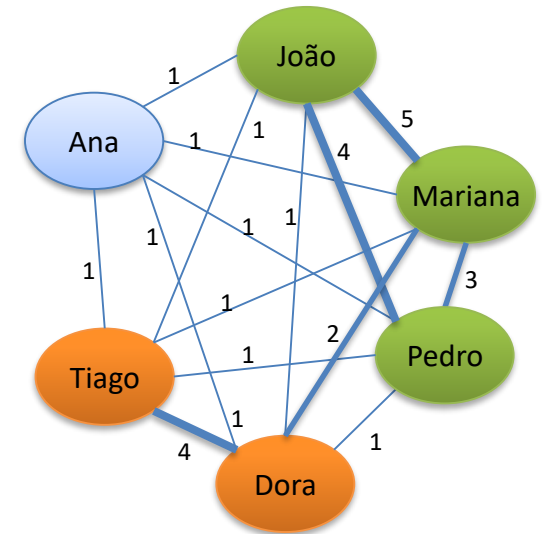
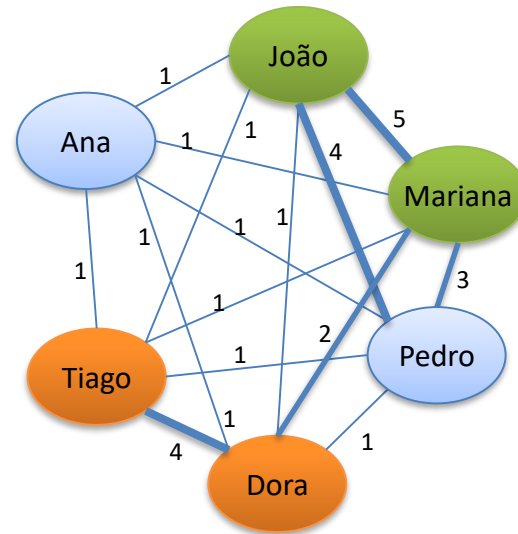
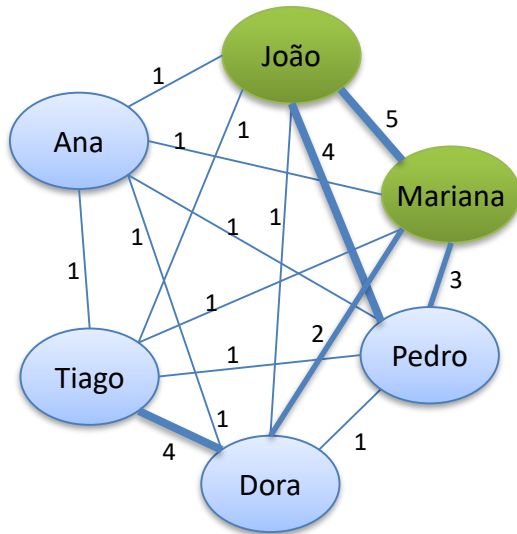
Clustering da rede social

- Exemplo



A_{ij}	João	Mariana	Pedro	Dora	Tiago	Ana
João	–	5	4	1	1	1
Mariana	5	–	3	2	1	1
Pedro	4	3	–	1	1	1
Dora	1	2	1	–	4	1
Tiago	1	1	1	4	–	1
Ana	1	1	1	1	1	–

Clustering da rede social



A_{ij}	J	M	P	D	T	A
J	-	5	4	1	1	1
M	5	-	3	2	1	1
P	4	3	-	1	1	1
D	1	2	1	-	4	1
T	1	1	1	4	-	1
A	1	1	1	1	1	-

$D = 5.0$ $Q = 0.087$

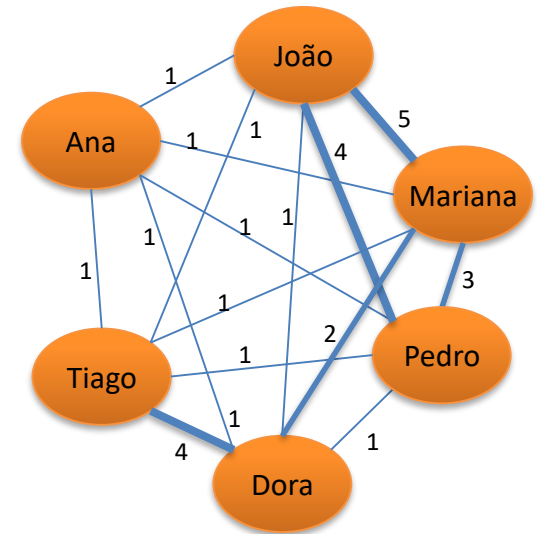
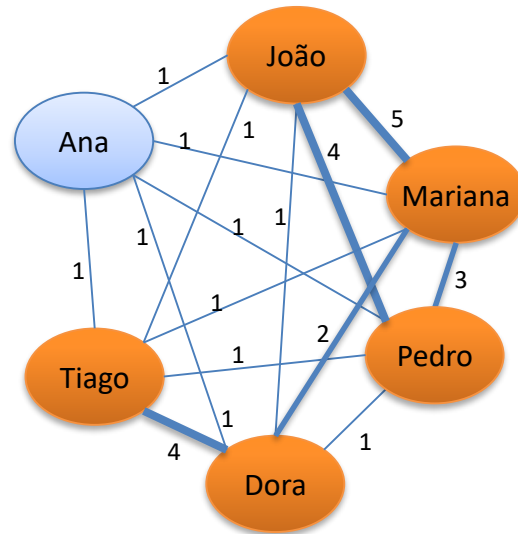
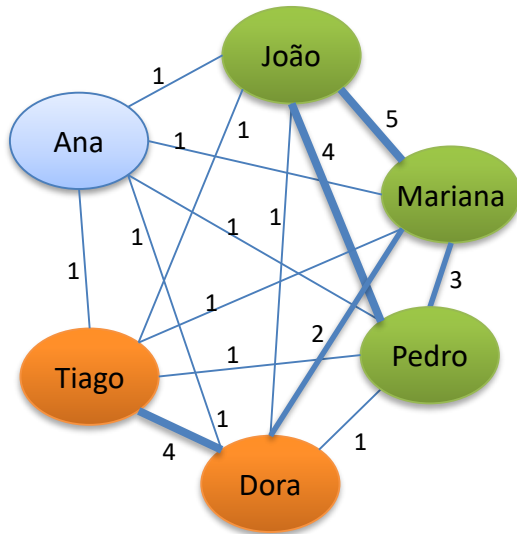
A_{ij}	J	M	P	D	T	A
J	-	5	4	1	1	1
M	5	-	3	2	1	1
P	4	3	-	1	1	1
D	1	2	1	-	4	1
T	1	1	1	4	-	1
A	1	1	1	1	1	-

$D = 4.0$ $Q = 0.184$

A_{ij}	J	M	P	D	T	A
J	-	5	4	1	1	1
M	5	-	3	2	1	1
P	4	3	-	1	1	1
D	1	2	1	-	4	1
T	1	1	1	4	-	1
A	1	1	1	1	1	-

$D = 3.5$ $Q = 0.281$

Clustering da rede social



A_{ij}	J	M	P	D	T	A
J	-	5	4	1	1	1
M	5	-	3	2	1	1
P	4	3	-	1	1	1
D	1	2	1	-	4	1
T	1	1	1	4	-	1
A	1	1	1	1	1	-

$$D = 3.5 \quad Q = 0.281$$

A_{ij}	J	M	P	D	T	A
J	-	5	4	1	1	1
M	5	-	3	2	1	1
P	4	3	-	1	1	1
D	1	2	1	-	4	1
T	1	1	1	4	-	1
A	1	1	1	1	1	-

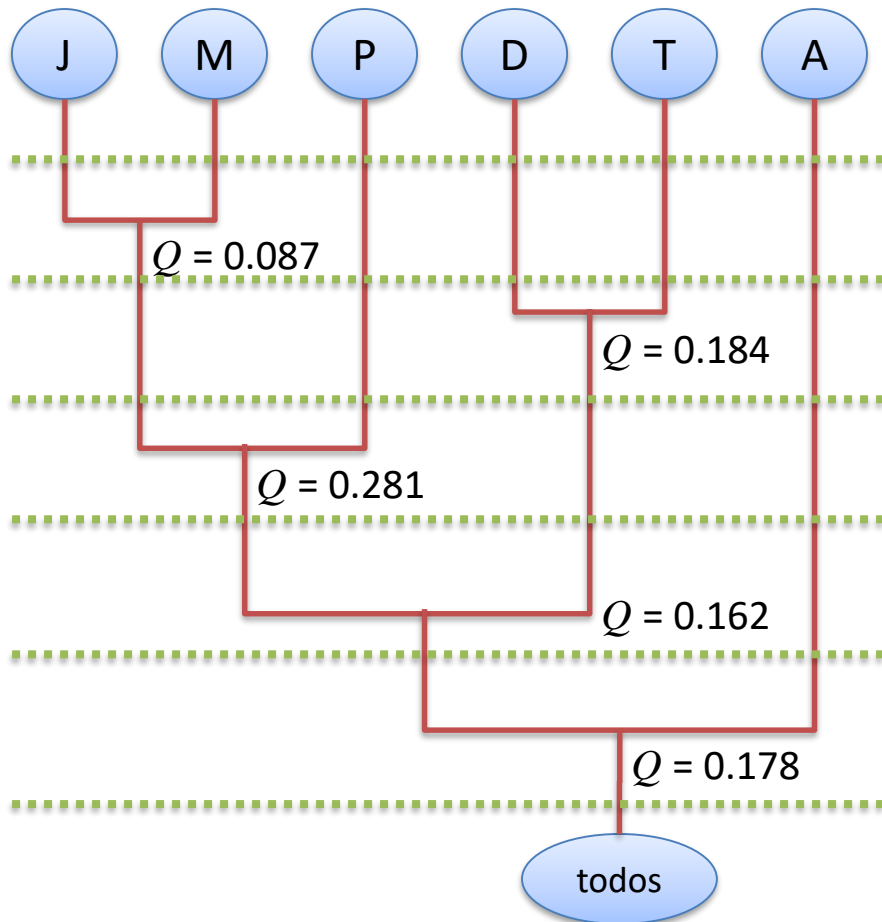
$$D = 1.167 \quad Q = 0.162$$

A_{ij}	J	M	P	D	T	A
J	-	5	4	1	1	1
M	5	-	3	2	1	1
P	4	3	-	1	1	1
D	1	2	1	-	4	1
T	1	1	1	4	-	1
A	1	1	1	1	1	-

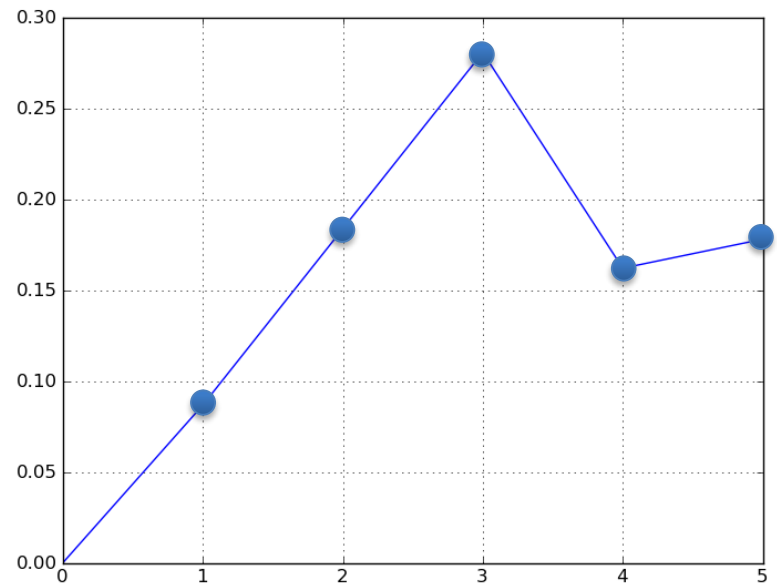
$$D = 1.0 \quad Q = 0.178$$

Clustering da rede social

- Exemplo



Modularidade Q por iteração

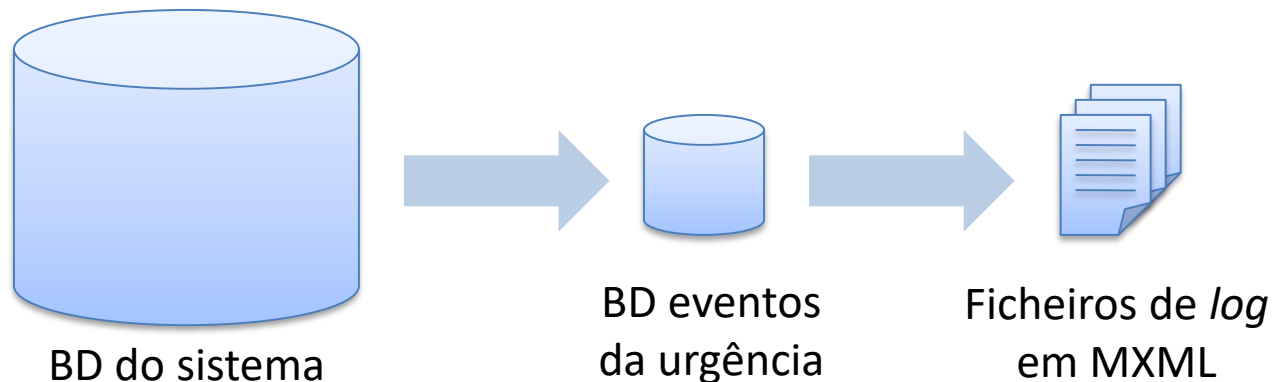


Caso prático III

- Hospital público
 - estudo dos *careflows* da urgência
 - cada paciente é um caso
 - pacientes sujeitos a triagem, consultas, exames, diagnósticos, tratamentos, etc.
 - processo pouco estruturado, objectivo era análise da rede social com a métrica *working together*
 - sistema de informação clínica desenvolvido internamente
 - base de dados com 400 tabelas e sem documentação

Caso prático III

- A partir da base de dados do sistema
 - criada uma base de dados mais pequena
 - extraídos vários ficheiros de *log*
 - desde 12 dias (14 MB)
 - até 6 meses (224 MB)



Caso prático III

- Exemplo de ficheiro MXML

```
<?xml version="1.0" encoding="utf-8"?>
<WorkflowLog>
  <Process id="Emergencia">
    <ProcessInstance id="24125085">
      <AuditTrailEntry>
        <Data>
          <Attribute name="Diagnostico">Tomografia Computorizada</Attribute>
          <Attribute name="Especialidade">Tarefeiros Emergencia</Attribute>
        </Data>
        <WorkflowModelElement>Req. Exame Imagiologia</WorkflowModelElement>
        <EventType>complete</EventType>
        <Timestamp>2009-01-09T05:35:48</Timestamp>
        <Originator>48074</Originator>
      </AuditTrailEntry>
      <AuditTrailEntry>
        ...
      </AuditTrailEntry>
    </ProcessInstance>
  </Process>
</WorkflowLog>
```


Caso práctico III

- Exemplo de ficheiro MXML

```
<?xml version="1.0" encoding="utf-8"?>
```

```
<WorkflowLog>
```

```
<Process id="Emergencia">
```

```
<ProcessInstance id="24125085">
```

```
caso
```

```
<AuditTrailEntry>
```

```
<Data>
```

```
<Attribute name="Diagnostico">Tomografia Computorizada</Attribute>
```

```
<Attribute name="Especialidade">Tarefeiros Emergencia</Attribute>
```

```
</Data>
```

```
actividade <WorkflowModelElement>Req. Exame Imagiologia</WorkflowModelElement>
```

```
<EventType>complete</EventType>
```

```
data/hora <Timestamp>2009-01-09T05:35:48</Timestamp>
```

```
utilizador <Originator>48074</Originator>
```

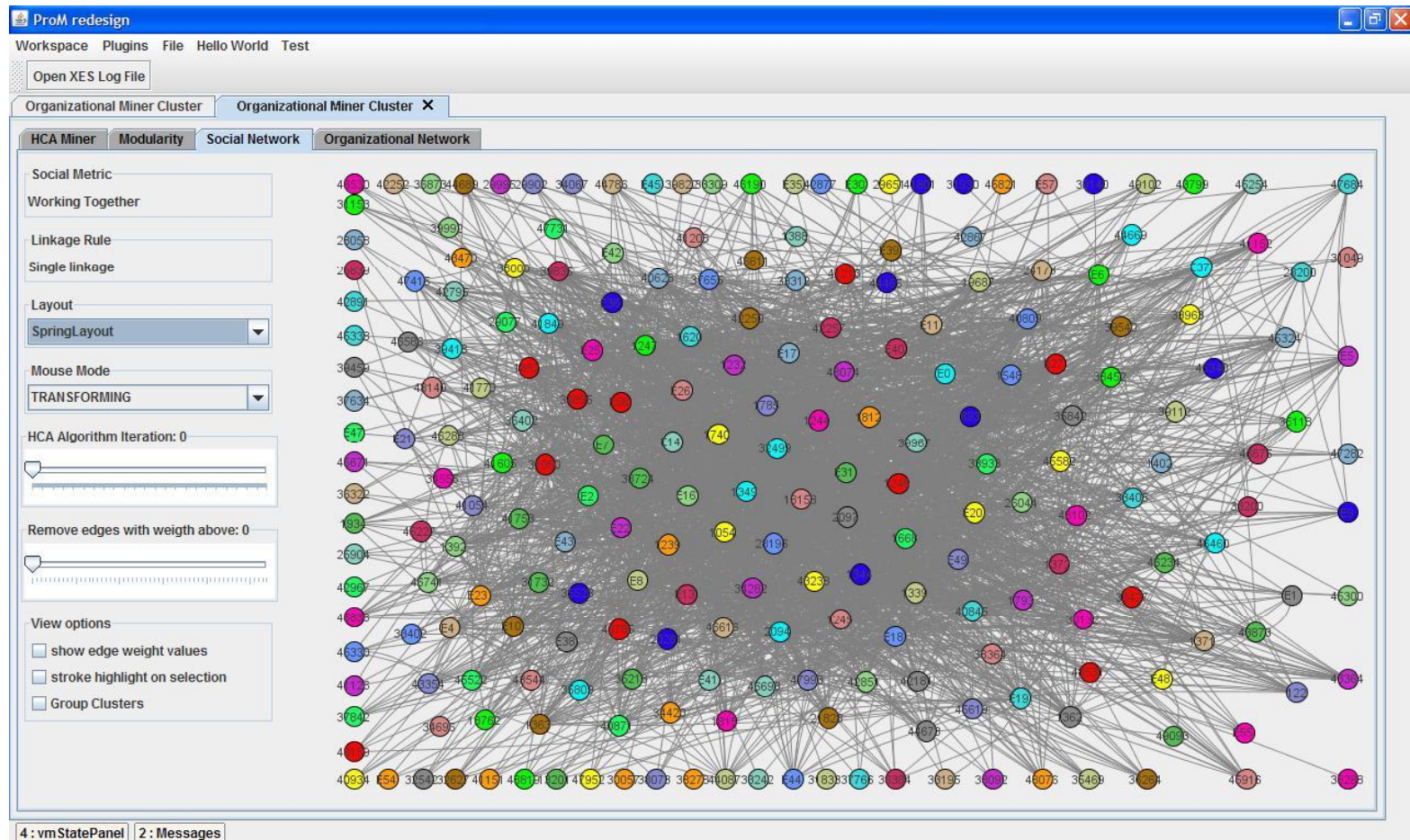
```
</AuditTrailEntry>
```

```
<AuditTrailEntry>
```

```
...
```

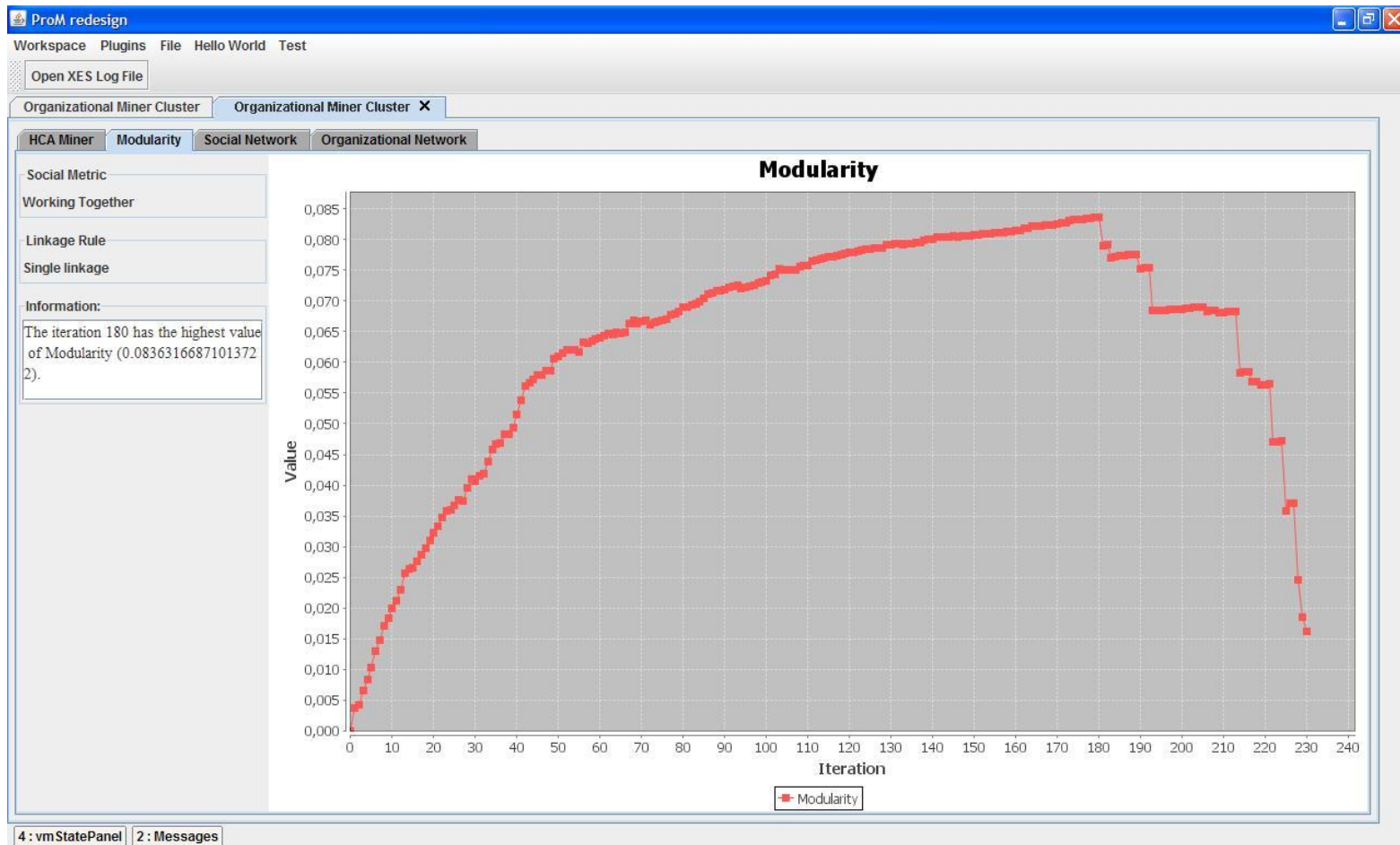
Caso práctico III

- Rede social com *log* de 12 dias



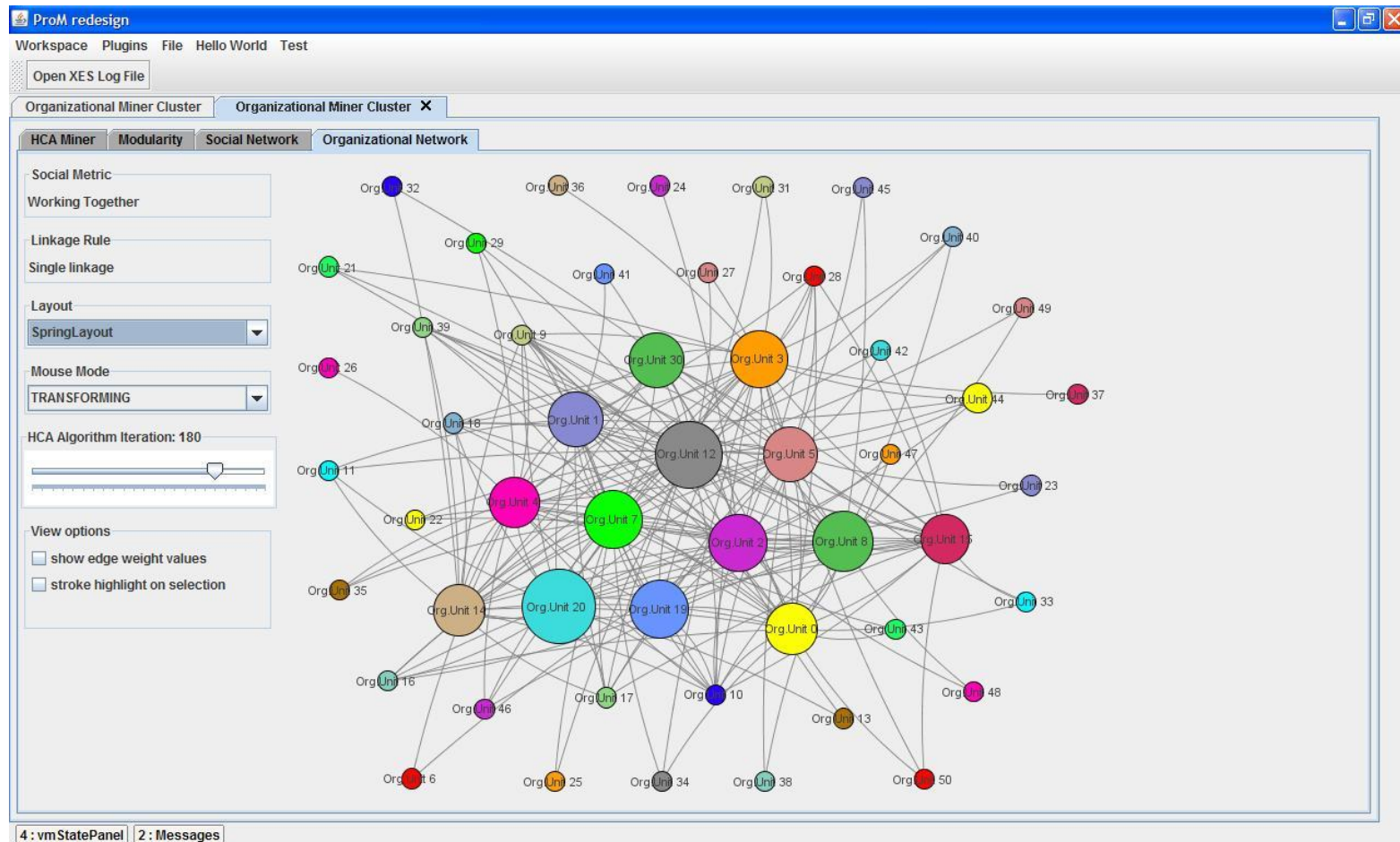
Caso práctico III

- Modularidade



Caso prático III

- Iteração nº 180



Ferramentas

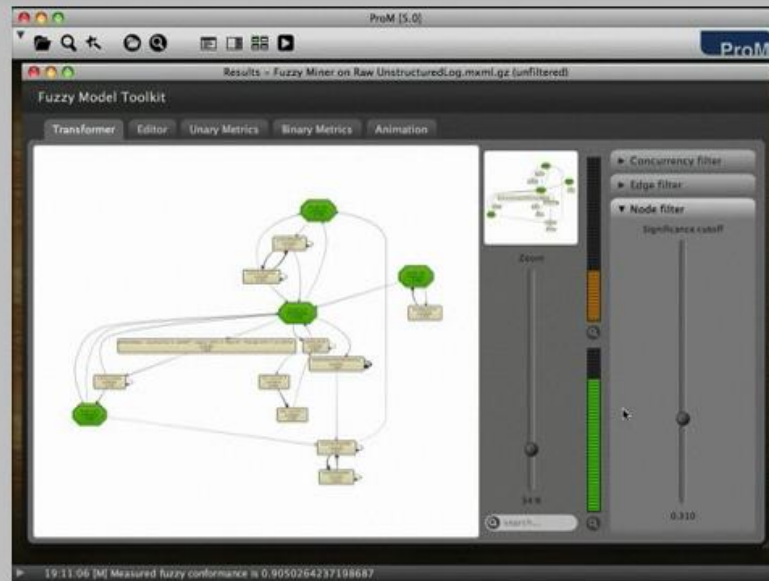
The image displays the ProM 5.0 software interface, which is used for process mining and organizational analysis. The main window is titled "Result - Sequence Clustering" and shows a Markov Chain diagram with nodes 'in', 'a', 'b', 'c', 'd', 'e', and 'out'. The transitions are labeled with probabilities: 'in' to 'a' (1.0), 'a' to 'b' (0.892), 'a' to 'c' (0.108), 'b' to 'd' (1.0), 'c' to 'd' (1.0), 'd' to 'e' (0.368), 'd' to 'out' (0.632), and 'e' to 'out' (1.0). A "Clusters" panel on the left lists Cluster 0 (262 Instances), Cluster 1 (136 Instances), and Cluster 2 (102 Instances). Below the Markov Chain, there are sliders for "Threshold: Node" and "Edge".

In the background, another window titled "ProM [5.0]" shows "Results - Heuristics miner on Raw instan...". This window displays a complex network diagram with various nodes and edges, representing process mining results. The status bar at the bottom of this window indicates "21:52:54 [M] Process mining finished."

Another window titled "ProM redesign" is visible, showing an "Organizational Miner Cluster" view. This view includes a "Social Network" tab and a "Social Metric" section with options like "Working Together", "Linkage Rule" (set to "Single linkage"), and "Layout" (set to "SpringLayout"). The "Mouse Mode" is set to "TRANSFORMING". The "HCA Algorithm Iteration" is 180. There are also "View options" for "show edge weight values" and "stroke highlight on selection". The main area of this window displays a large, complex network graph with nodes labeled "Org. Unit 1" through "Org. Unit 50" and "Org. 1" through "Org. 50".

ProM

<http://prom.win.tue.nl/tools/prom/> (T.U.Eindhoven)



Version **5.2**

The most powerful process mining toolkit, with a modern, user-friendly interface, an optimized event log handling system, and **more than 280** plugins included!

ProcessMining.org

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

(T.U.Eindhoven)

process mining research tools application

TU/e

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Tools

ProM

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Search

Research



Process mining techniques allow for extracting information from event logs. For example, the audit trails of a workflow management system or the transaction logs of an enterprise resource planning system can be used to discover models describing processes, organizations, and products. [Read more...](#)



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Tools



[ProM](#) is our generic open-source tool for implementing process mining tools in a standard environment. ProM uses the [Mining XML \(MXML\)](#) format for its input logs. [ProMimport](#) is our tool for the extraction of these logs from all kinds of popular information systems. [Read more...](#)

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Obrigado!

Questões?