Business Process Configuration and Services

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www.processmining.org
Service-Oriented Computing

- Shift from tightly coupled systems to loosely coupled services.
- Software exposed as services through a standardized set of platform independent interfaces.

**Publish**: Service Producers register their service in the SOA registry. Web Services Description Language (WSDL) is used to describe a service.

**Discovery**: Service Consumers make a request for a service in the SOA registry. Universal Description, Discovery and Integration (UDDI) standard is used for locating a service in the registry.

**Communication**: Simple Object Access Protocol (SOAP) is used for facilitating communication between Service Providers and Consumers.

Figure taken from: [http://blog.krawler.com/tag/uddi/](http://blog.krawler.com/tag/uddi/).
Buy-Side versus Sell-Side

service A
service B
service C
service D

service requestor
service provider

buy side
sell side
buy side
sell side
buy side
sell side
buy side
sell side
Enterprise Service Bus (ESB)

ESB provides a distributable communications and integration backbone to realize SOC

Service oriented architectures: approaches, technologies and research issues Mike P. Papazoglou · Willem-Jan van den Heuvel (2007)
Web Services Technology Stack

- transport
  - TCP/IP, HTTP

- messaging
  - SOAP, XML

- description
  - WSDL

- executable business processes
  - WS-BPEL

- quality of service, ...
  - WS-Transaction WS-Coordination WS-XX

- discovery
  - UDDI

- business process modeling
  - BPMN
Processes As Glue

service 1
service 2
service 3
service 4
service n
Orchestration is concerned with the composition of services seen from the viewpoint of single service.
Choreography is concerned with the composition of such services seen from a global viewpoint focusing on the common and complementary observable behavior. Choreography is particularly relevant in a setting where there is not a single coordinator.
Composing Processes and Applications: integrating disparate technologies, processes, people, etc.
Services at different levels

Service oriented architectures: approaches, technologies and research issues Mike P. Papazoglou · Willem-Jan van den Heuvel (2007)
SaaS, PaaS, IaaS, …
Software as a Service (SaaS)

- SaaS also referred to as "on-demand software" is a software delivery model in which software and associated data are centrally hosted on the cloud.
- SaaS solutions are typically accessed by users using a thin client via a web browser.
Platform as a Service

- The consumer creates the software using tools and libraries from the provider.
- The consumer also controls software deployment and configuration settings.
- The provider provides the networks, servers and storage.
Infrastructure as a Service (IaaS)

- IaaS offers computers – often as virtual machines –, raw storage, firewalls, load balancers, and networks.
- Sometimes referred to as "Hardware as a Service".
- To deploy their applications, IaaS users install operating system images on the machines as well as their application software.
- The user is responsible for patching and maintaining the operating systems and application software.
It is not just about technology ...
Not just about technology/infrastructure

Processes

Dealing with variability

Process variants/configuration

Cross-organizational process mining
The need for configurable process models: CoSeLoG project

+/- 430 Dutch municipalities
The need for configurable process models: Suncorp case

End to end process has between 250-1000 process steps

- Product Dev: 25+ steps
- Sales: 50+ steps
- Service: 75+ steps
- Claims: 100+ steps

Sources: Guidewire reference models, GIO CISSS Project, CI US&S P4PI Project

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500 steps

30 variations

Thanks to Marcello La Rosa
Two variants of the same process ...
Variation points... in the cloud
Cloud computing
Traditional Situation

IS = Information System
E = Event log
M = Models
Example
Acknowledgement of an Unborn Child

- Same but different …
- “Couleur Locale”
- Different from NVVB models.
- Configurable process models!
Using SaaS Technology

IS-SaaS = Information System (using a SaaS-based BPMS)
E = Event log
CM = Configurable Models
C = Configuration
Process Mining: Before

- Processes Municipality 1
- Processes Municipality 2
- Processes Municipality n
Process Mining: After

cross-organizational process mining
Some quotes from Michelangelo

- “Every block of stone has a statue inside it and it is the task of the sculptor to discover it.”
- “I saw the angel in the marble and carved until I set him free.”
- “Carving is easy, you just go down to the skin and stop.”
Life is about making choices …
Time and artifacts

- **Design time** *(generic model, i.e., is not released for instantiation)*
- **Configuration time** *(specific model, i.e., can be instantiated)*
- **Instantiation time** *(specific model + instance)*
- **Run time** *(specific model + instance + state/partial trace)*
- **Auditing time** *(specific model + instance + full trace)*
• In The Netherlands, …
• In Brisbane, …
• When the sun shines, …
• On Sunday, …
• When very busy, …
• For these customers, …
• …
Hiding and blocking

Configuration = limiting behavior!
Configurable Process Models

C-EPC
C-Petri Net
C-YAWL
C-BPEL

---

EPC
Petri Net
YAWL
BPEL

---

Configuration

Blocking
Hiding

LTS

GUIDELINE
ERS = ON, if
- long term contract
- goods and conditions are specified

REQUIRED:
IPS = ON Þ ERS = ON

Consignment / pipeline liability is created
Consignment / pipeline liabilities are to be settled

Invoicing plans require settlement
Invoicing Plan Settlement

Release Invoice
manually

Payment must be effectes

Invoice posted and not blocked for release
Release Invoice automatically

Goods receipts to be settled automatically
Evaluated Receipt Settlement (ERS)

Invoice transmitted for vendor’s records

Goods receipt posted
Invoice received
Service accepted
Purchase order created

Material is released
Invoice posted and blocked for release

Payment must be effectes

Invoice posted and not blocked for release
Release Invoice automatically

---

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Inheritance of dynamic behavior

Reference Model

Inheritance of dynamic behavior

Inheritance

Configuration

Subclass

Superclass

Variant A

Variant B

SUPERCLASS

Configuration

Reference Model

SUPERCLASS
Configuration Techniques

- **Blocking** (removing an option)
- **Hiding** (skipping activities)

Blocking and hiding are the essential concepts of configuration.

“Every block of stone has a statue inside it and it is the task of the sculptor to discover it.”
Example: C-YAWL

ports (inflow)

ports (outflow)

Blocking
Activating
Hiding

www.processconfiguration.com
Example Configuration "Travel Agency"

- **Receive order**
- **Book train ticket**
- **Book reduction card**
- **Book hotel**
- **Select payment method**
- **Credit card payment**
- **Cash payment**
- **Send documents**
- **Collect documents**
- **Cancel booking**

- a1, a2
- b1
- c1, c2

Port activation:
- a1 = port a1 is activated
- b1 = port b1 is blocked
- c1 = port c1 is skipped

- a2 = all ports activated
- b2 = port b2 is activated
- c2 = all ports blocked
- = all ports skipped
- a3, b3, c3 = port x is skipped

- a4 = all ports blocked
- b4 = port b4 is skipped

- a5 = port a5 is blocked
- b5 = all ports blocked
- c5 = all ports skipped
Example Configuration "Internet Shop"
Transforming a port configuration into YAWL
Example Configuration "Travel Agency"
Example Configuration "Internet Shop"
C-YAWL is just an example ...

C-EPC, C-PN, C-BPEL, C-SAP, ...

SAP WebFlow/Business Workflow
Questions

- Is a configuration correct?
- Is there a correct configuration?
- How to autocomplete a configuration?
- How to create a configurable model given a set of variants?

Configurable Model + Configuration = Configured model
Definition 2 (Extended Petri net). An extended Petri net is a tuple \((P, T, F, W, A, L, R, H)\), where:

- \((P, T, F)\) is a basic Petri net,
- \(W \subseteq F \rightarrow \mathbb{N} \setminus \{0\}\) is an (arc) weight function,
- \(A \subseteq A\) is a set of (activity) labels,
- \(L \subseteq T \rightarrow A \cup \{\tau\}\) is a labeling function,
- \(R \subseteq T \rightarrow 2^P\) is a function defining reset arcs, and
- \(H \subseteq T \rightarrow 2^P\) is a function defining inhibitor arcs.


- There is a single source place \(i\), i.e., \(\{p \in P \mid p = \emptyset\} = \{i\}\).
- There is a single sink place \(o\), i.e., \(\{p \in P \mid p \cdot = \emptyset\} = \{o\}\).
- Every node is on a path from \(i\) to \(o\), i.e., for any \(n \in P \cup T\): \((i, n) \in F^*\) and \((n, o) \in F^*\).
- There is no reset arc connected to the sink place, i.e., \(\forall t \in T \ o \not\in R(t)\).

Definition 15 (Classical soundness). Let \(N = (P, T, F, W, A, L, R, H)\) be a WF-net. \(N\) is sound if and only if the following three requirements are satisfied:

- Option to complete: \(\forall M \in R(N, [i])\) \([o] \in R(N, M)\).
- Proper completion: \(\forall M \in R(N, [i])\) \((M \geq [o]) \Rightarrow (M = [o])\).
- No dead transitions: \(\forall t \in T \ \exists M \in R(N, [i])\) \((N, M)[t]\).
Configurable WF-net: WF-net with option to block or hide transitions.

2*3=6 possible configurations
Configuration 1: AA

- Start
- Register request
- Examine thoroughly
- Examine casually
- Check ticket
- Decide
- Pay compensation
- Reject request
- Reinitiate request
- End
Configuration 2: AH

- **Start**: Register Request
- **Examine Thoroughly**
- **Examine Casually**
- **Check Ticket**
- **Decide**
- **Pay Compensation**
- **Reject Request**
- **Reinitiate Request**
- **End**

Diagram:

- Start node connected to 'Register Request'
- 'Examine Thoroughly' connected to 'Register Request'
- 'Examine Casually' connected to 'Register Request'
- 'Check Ticket' connected to 'Register Request'
- 'Decide' connected to 'Register Request'
- 'Pay Compensation' connected to 'Register Request'
- 'Reject Request' connected to 'Register Request'
- 'Reinitiate Request' connected to 'Register Request'
- 'End' connected to 'Register Request'
Configuration 3: HA
Configuration 4: HH
Configuration 5: BA

![Diagram of process configuration 5: BA]

- **a**: Start register request
- **b**: Examine thoroughly
- **c**: Examine casually
- **d**: Check ticket
- **e**: Decide
- **f**: Reinitiate request
- **g**: Pay compensation
- **h**: Reject request

Flowchart: Start -> a (Register Request) -> b (Examine Thoroughly) -> c (Examine Casually) -> d (Check Ticket) -> e (Decide) -> g (Pay Compensation) -> h (Reject Request) -> End
Configuration 6: BH

- Start register request
- Examine thoroughly
- Examine casually
- Decide
- Pay compensation
- Reject request
- Reinitiate request
- End

Diagram showing the flow of actions and decision points in the process.
Creating a configured model

1. Hide/block transitions
2. Remove dead parts
3. Remove $\tau$ transitions without changing the behavior (normally according to branching bisimulation, but here we only require the weaker trace equivalence)
4. Remove implicit places
5. Output the resulting configured WF-net

A configuration is valid if the resulting configured WF-net is sound.
Can $t_3$ be blocked?

**Not Valid!**

**Deadlock!**
Block $t_1$ and hide $t_3$?

Valid configuration!
Block $t_4$ also?

Invalid configuration!
How many valid configurations?

2*1*2*3=12 valid configurations
(e cannot be blocked)
How many valid configurations?

The diagram shows a Petri net with places and transitions. Each place is labeled with a letter: p1, p2, p3, p4, p5, p6, p7. Each transition is labeled with a letter: t1, t2, t3, t4, t5, t6. The transitions have arrows pointing to the places, indicating the possible firing sequences.

The valid configurations are:

1. p1, p2, p3, p4, p5, p6, p7
2. p1, p2, p3, p4, p5, p6, t6
3. p1, p2, p3, p4, p5, t5, p7
4. p1, p2, p3, p4, t4, p7
5. p1, p2, t3, p7

The number of valid configurations is 5.
Example of a valid configuration: ABAA
Example of an invalid configuration: ABBB
A configurable model defines a family of process variants

- Start
- Register request
- Examine
  - Thoroughly
  - Casually
- Check ticket
- Decide
- Pay compensation
- Reject request
- Reinitiate request
- End
Merging variants into a configurable model
Compare to process mining (same forces apply)

Both are about merging behaviors: one at the trace level and the other at the model level. Note that models can be viewed as sets of traces.
Quality dimensions when merging variants into a configurable process model

- **fitness**
  - “able to generate original variants”

- **simplicity**
  - “Occam’s razor”

- **generalization**
  - “not overfitting the set of variants”

- **precision**
  - “not underfitting the set of variants”
Create a configurable WF-net able to generate these WF-nets

Minimal requirement: variants should correspond to valid configurations.
Configurable process model
Recreating the original variants

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</tr>
<tr>
<td>A</td>
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Remember: Process Discovery Using State-Based Regions

event log

01011001101101001
0111110110100011
0110011110111000
01101100100101100

start

p1

b

d

e

end

p2

c

p3

p4

011011001101101001
0111110110100011
0110011110111000
01101100100101100
Event logs, transition systems, Petri nets, configurable process models

- event log
- transition system
- Petri net

construct

can generate
Configurable model can (indirectly) generate the union of all observed behaviors
Route 3

merged Petri net

configurable Petri net

event log transition system Petri net
event log transition system Petri net
event log transition system Petri net
event log transition system Petri net
Different routes provide (in principle) similar results
Cross-organizational mining
From one to many organizations

- More than 80,000 organizations are using Salesforce
- More than 1 million organizations are using Google Apps
- All 430 Dutch municipalities are implementing the same set of processes
- All 94 U.S. District Courts in the United States share the same set of workflows
- All car-rental offices of Hertz, Avis, …
- …
Consider $n$ organizations

- Process 1
  - Event log 1
  - Process model 1
- Process 2
  - Event log 2
  - Process model 2
- ... (repeated $n-2$ times)
- Process $n$
  - Event log $n$
  - Process model $n$
Cross-organizational process mining

![Diagram showing process models and event logs](image-url)
Pure model-based

\[ \text{PM}_1 + \text{PM}_2 + \ldots + \text{PM}_n = \text{CM} \]
Pure log-based

\[ \alpha(EL_1 + EL_2 + \ldots + EL_n) = CM \]
How to find and characterize differences among processes using event logs?

How to merge process models into a single configurable model?

What are the effects of these differences on the performance of a process?

How to discover a configurable model from a collection of event logs?

How to derive the configuration for a process given a configurable model?

How to find and characterize differences using models / configurations?

How to find and characterize differences among processes using event logs?
Example: CoSeLog Project

- 10 municipalities: Coevorden, Emmen, Hellendoorn, Gemert-Bakel, Zwolle, Bergeijk, Bladel, Eersel, Reusel-De Mierden, and Oirschot.

- 8 processes: Gemeentelijke Basisadministratie Persoonsgegevens (GBA 3x), Melding Openbare Ruimte (MOR), Wet Algemene Bepalingen Omgevingsrecht (WABO 2x), Wet Maatschappelijke Ondersteuning (WMO), and Waardering Onroerende Zaken (WOZ).

- Papers:

- See www.win.tue.nl/coselog/
Similarity of process models

- Graph Edit Distance (GED) based similarity for one of the GBA processes:

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Correlates well with Structural Process Similarity (SPS).
Some aggregated results

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**Most consensus:**

- GBA2
- WMO

**Least consensus:**

- WABO2
- WOZ

**Average similarity values per process:**

- **GBA1:**
  - Man_A: 0.631
  - Man_B: 0.612
  - Man_C: 0.560
  - Man_D: 0.703
  - Man_E: 0.645
  - Man_F: 0.641
  - Man_G: 0.354
  - Man_H: 0.631
  - Man_I: 0.715
  - Man_J: 0.442

- **GBA2:**
  - Man_A: 0.766
  - Man_B: 0.821
  - Man_C: 0.667
  - Man_D: 0.602
  - Man_E: 0.807
  - Man_F: 0.771
  - Man_G: 0.751
  - Man_H: 0.821
  - Man_I: 0.725
  - Man_J: 0.821

- **GBA3:**
  - Man_A: 0.530
  - Man_B: 0.513
  - Man_C: 0.486
  - Man_D: 0.607
  - Man_E: 0.530
  - Man_F: 0.587
  - Man_G: 0.678
  - Man_H: 0.551
  - Man_I: 0.678
  - Man_J: 0.664

- **MOR:**
  - Man_A: 0.496
  - Man_B: 0.548
  - Man_C: 0.501
  - Man_D: 0.482
  - Man_E: 0.585
  - Man_F: 0.488
  - Man_G: 0.573
  - Man_H: 0.468
  - Man_I: 0.430
  - Man_J: 0.491

- **WABO1:**
  - Man_A: 0.501
  - Man_B: 0.483
  - Man_C: 0.602
  - Man_D: 0.776
  - Man_E: 0.818
  - Man_F: 0.662
  - Man_G: 0.818
  - Man_H: 0.818
  - Man_I: 0.818
  - Man_J: 0.818

- **WABO2:**
  - Man_A: 0.646
  - Man_B: 0.419
  - Man_C: 0.730
  - Man_D: 0.800
  - Man_E: 0.746
  - Man_F: 0.741
  - Man_G: 0.800
  - Man_H: 0.800
  - Man_I: 0.750
  - Man_J: 0.610

- **WMO:**
  - Man_A: 0.621
  - Man_B: 0.539
  - Man_C: 0.543
  - Man_D: 0.426
  - Man_E: 0.491
  - Man_F: 0.503
  - Man_G: 0.496
  - Man_H: 0.625
  - Man_I: 0.660
  - Man_J: 0.600

- **WOZ:**
  - Man_A: 0.507
  - Man_B: 0.448
  - Man_C: 0.447
  - Man_D: 0.601
  - Man_E: 0.562
  - Man_F: 0.616
  - Man_G: 0.600
  - Man_H: 0.600
  - Man_I: 0.600
  - Man_J: 0.600

**Average similarity values per municipality:**

- **Man_A:**
  - GBA1: 0.556
  - GBA2: 0.546
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_B:**
  - GBA1: 0.556
  - GBA2: 0.509
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_C:**
  - GBA1: 0.546
  - GBA2: 0.559
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_D:**
  - GBA1: 0.546
  - GBA2: 0.559
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_E:**
  - GBA1: 0.556
  - GBA2: 0.546
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_F:**
  - GBA1: 0.556
  - GBA2: 0.546
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_G:**
  - GBA1: 0.556
  - GBA2: 0.546
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_H:**
  - GBA1: 0.556
  - GBA2: 0.546
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_I:**
  - GBA1: 0.556
  - GBA2: 0.546
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

- **Man_J:**
  - GBA1: 0.556
  - GBA2: 0.546
  - GBA3: 0.555
  - MOR: 0.555
  - WABO1: 0.551
  - WABO2: 0.552
  - WMO: 0.575
  - WOZ: 0.604

---

**With whom can/should I cooperate?**

- **Most consistent:** GBA2, MOR, WMO
- **Least consistent:** WABO2, WOZ

---

**What processes can/should be merged?**

- GBA1 and GBA2
- MOR and WABO1
- WMO and WOZ
Cross-Organizational Mining

<table>
<thead>
<tr>
<th>Log</th>
<th>PM 1</th>
<th>PM 2</th>
<th>PM 3</th>
<th>PM 4</th>
<th>Average Throughput Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log 1</td>
<td>1.0</td>
<td>0.6</td>
<td>0.8</td>
<td>0.4</td>
<td>10 days</td>
</tr>
<tr>
<td>Log 2</td>
<td>0.8</td>
<td>0.9</td>
<td>0.7</td>
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<td>40 days</td>
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<tr>
<td>Log 3</td>
<td>0.9</td>
<td>0.4</td>
<td>0.9</td>
<td>0.5</td>
<td>22 days</td>
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<tr>
<td>Log 4</td>
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<td>0.5</td>
<td>0.8</td>
<td>0.8</td>
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<td>Complexity</td>
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<td>20</td>
<td>10</td>
<td>26</td>
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</tbody>
</table>

model-model and log-log comparison are of course also possible
Four WABO processes (building permits)

(a) Process Model 1
(b) Process Model 2
(c) Process Model 3
(d) Process Model 4
### Some results

<table>
<thead>
<tr>
<th></th>
<th>PM 1</th>
<th>PM 2</th>
<th>PM 3</th>
<th>PM 4</th>
<th>Average Throughput Time</th>
<th>C.V.</th>
<th>SLA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Log 1</strong></td>
<td>1.0000</td>
<td>0.7788</td>
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<td>0.7232</td>
<td>190d 20h</td>
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<td>0.9487</td>
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<td>0.9740</td>
<td>0.8735</td>
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<tr>
<td><strong>Log 2</strong></td>
<td>0.7611</td>
<td>0.8404</td>
<td>0.8300</td>
<td>0.7398</td>
<td>112d 17h</td>
<td>0.9900</td>
<td>0.4470</td>
</tr>
<tr>
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<td>0.9286</td>
<td>1.0000</td>
<td>0.9231</td>
<td>0.7968</td>
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<td></td>
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<tr>
<td><strong>Log 3</strong></td>
<td>0.7048</td>
<td>0.7045</td>
<td>0.8202</td>
<td>0.6920</td>
<td>267d 04h</td>
<td>1.6423</td>
<td>0.2787</td>
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<tr>
<td></td>
<td>0.8571</td>
<td>0.9231</td>
<td>0.8462</td>
<td>0.8882</td>
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<tr>
<td><strong>Log 4</strong></td>
<td>0.8288</td>
<td>0.7892</td>
<td>0.8642</td>
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<td>1.0000</td>
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</tr>
</tbody>
</table>

- **Activities**: 28, 26, 24, 26
- **AND split/join**: 2/3, 1/1, 2/2, 2/2
- **XOR split/join**: 5/4, 4/4, 4/4, 3/4

- **Fitness value**
- **Precision**
- **Appropriateness**
- **Model complexity metrics**
- **Log-based metrics**
- **Variability**
- **Throughput time**
- **Ability to handle within 12 weeks**
<table>
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<th>C.</th>
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<td>0.8202</td>
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<td>1.6423</td>
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</tr>
</tbody>
</table>

|                  | PM 1 | PM 2 | PM 3 | PM 4 | | |
|------------------|------|------|------|------|| |
| Split/join       | 2/3  | 1/1  | 3/4  | 1/1  | | |
| XOR split/join   | 5/4  | 4/4  | 3/4  | 1/1  | | |
Conclusion

www.win.tue.nl/coselog/
www.processconfiguration.com
Exercises:
BPMS-instruction-12-configurable-process-models.ppt