

TomTom for Business Process Management: When will I be home?

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Systems (BIS 2009), Poznan, Poland 27-29 April 2009

prof.dr.ir. Wil van der Aalst

www.processmining.org



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Where innovation starts



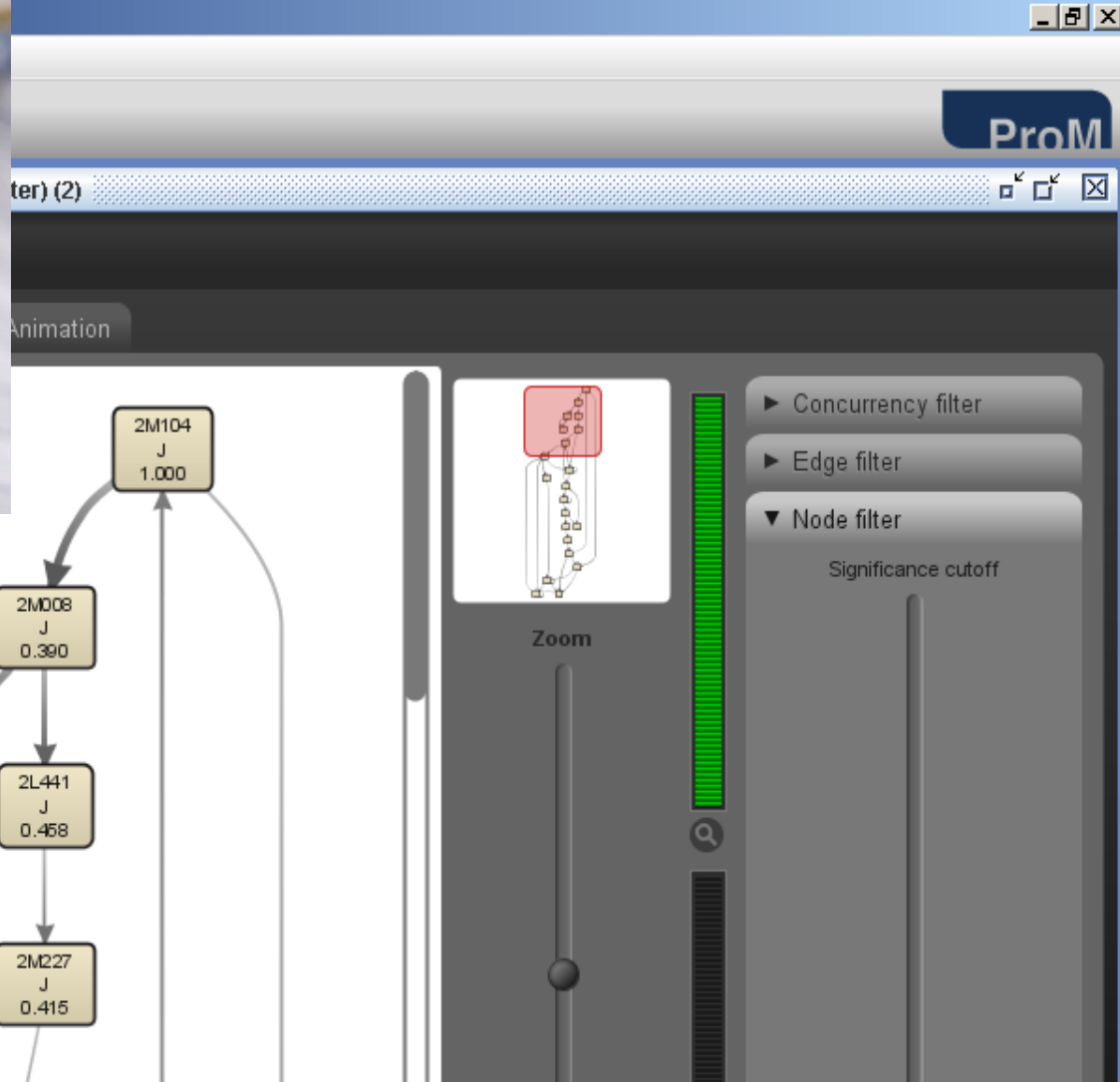


0110110011110010110001001101101111011011001010010011100
0110110110110001001101101111011011001010010011100

Process Mining



- **Process discovery:** "What is really happening?"
- **Conformance checking:** "Do we do what was agreed upon?"
- **Performance analysis:** "Where are the bottlenecks?"
- **Process prediction:** "Will this case be late?"
- **Process improvement:** "How to redesign this process?"
- **Etc.**



- Process discovery: "What is the real curriculum?"
- Conformance checking: "Do students meet the prerequisites?"
- Performance analysis: "Where are the bottlenecks?"
- Process prediction: "Will a student complete his studies (in time)?"
- Process improvement: "How to redesign the curriculum?"

Today's information systems are really crappy compared to a TomTom system!



- Good maps?
- Navigation by PowerPoints?
- Traffic information?
- Where is the next fuel station?
- Who is in charge?
- Seamless zoom?
- Customizable views?
- When will the destination be reached?

Process Mining

A step towards TomTom functionality for business processes

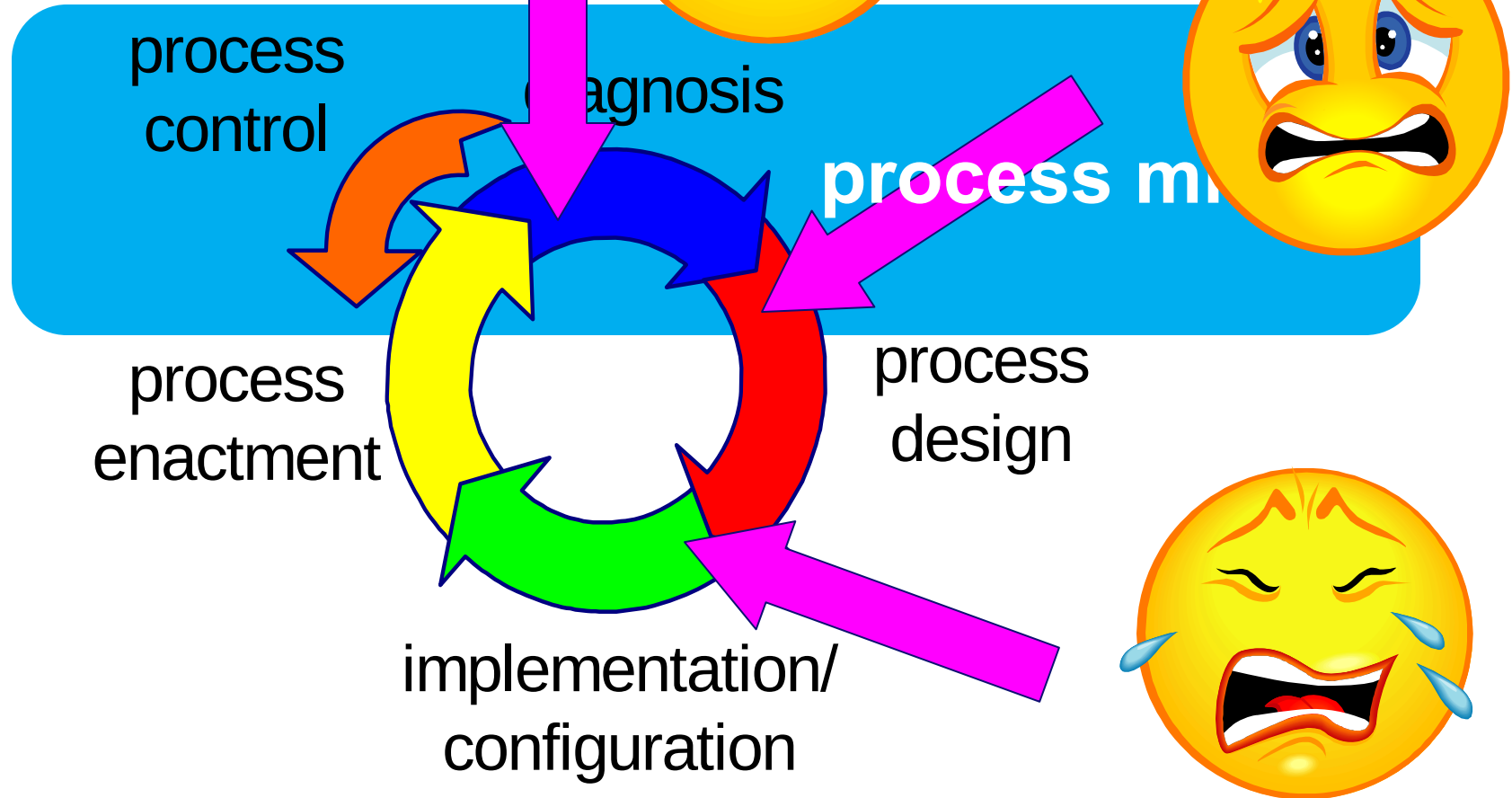


TU/e

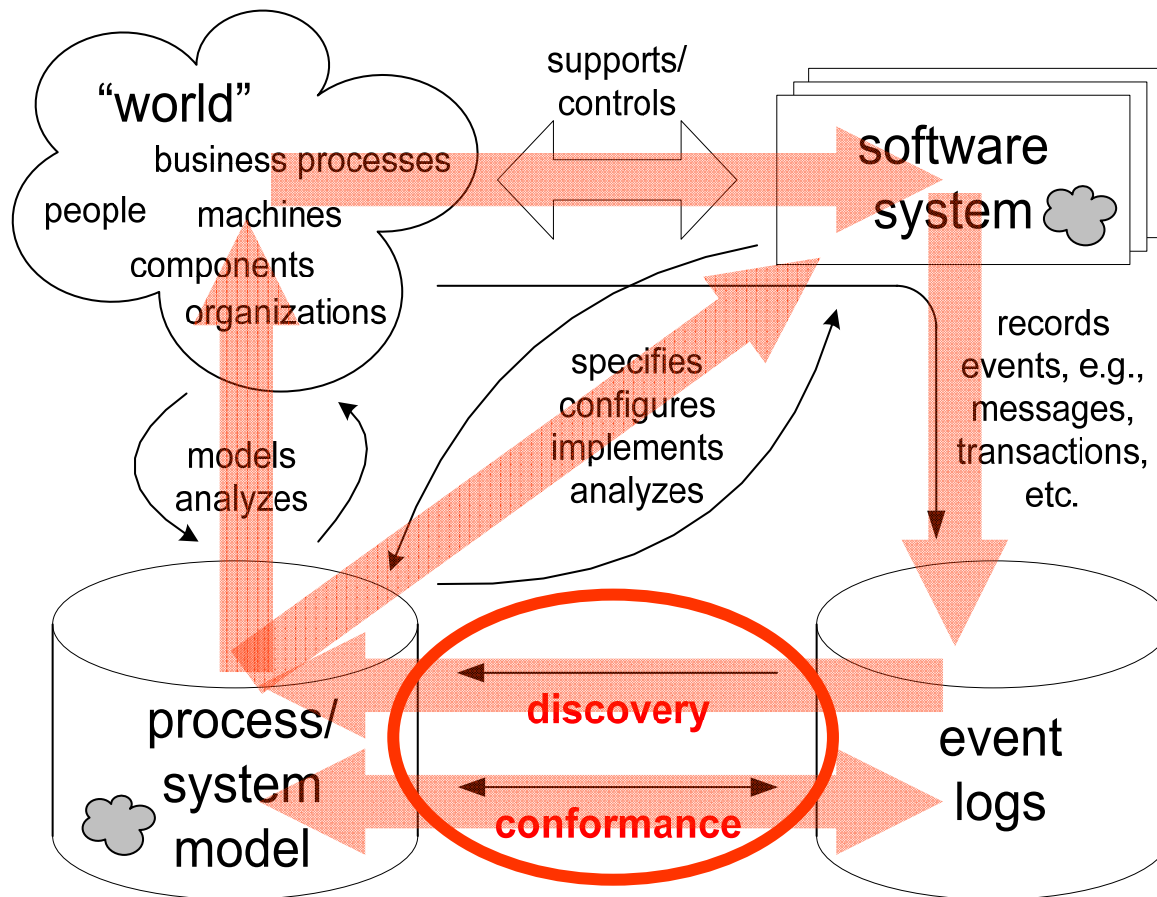
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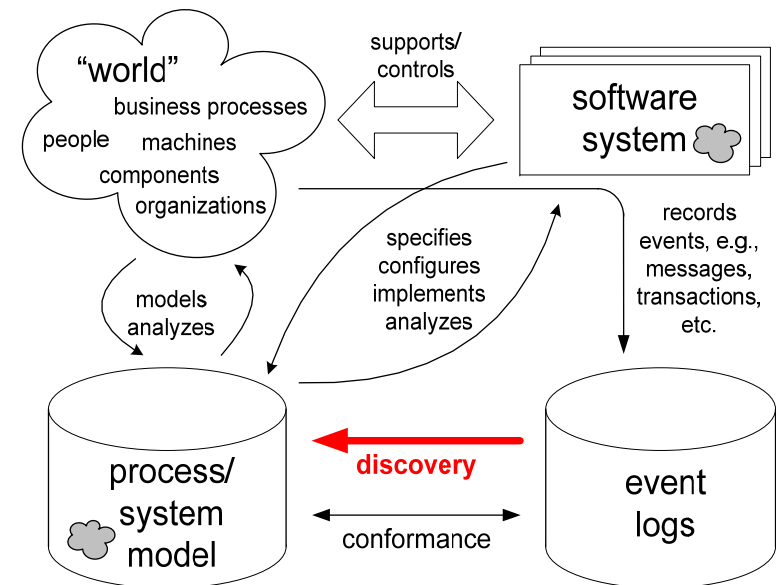
Where to start?

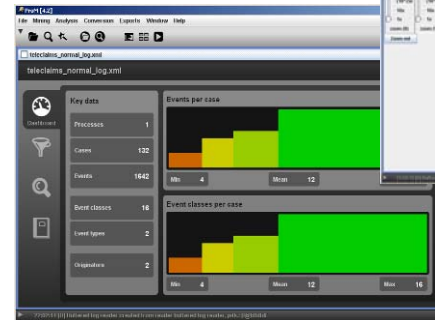
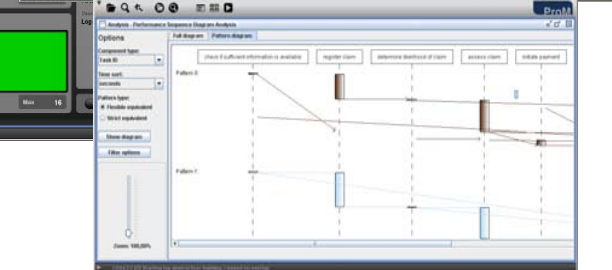
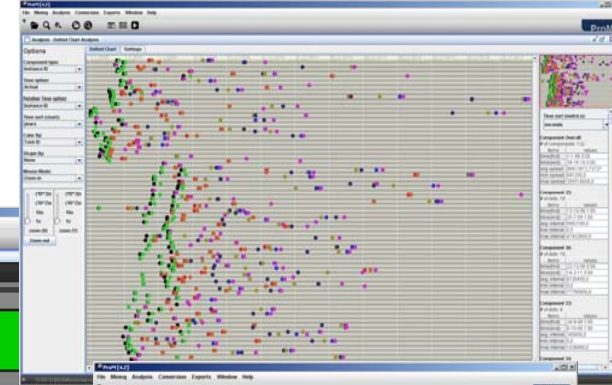
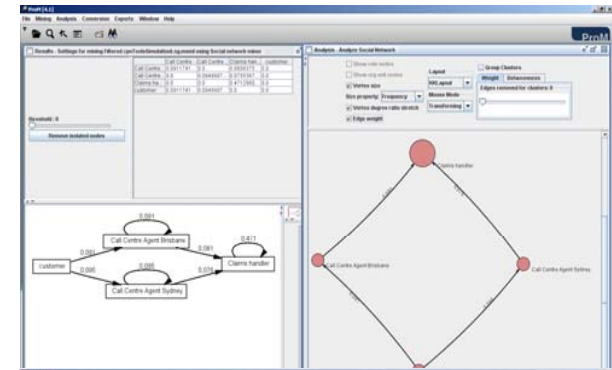
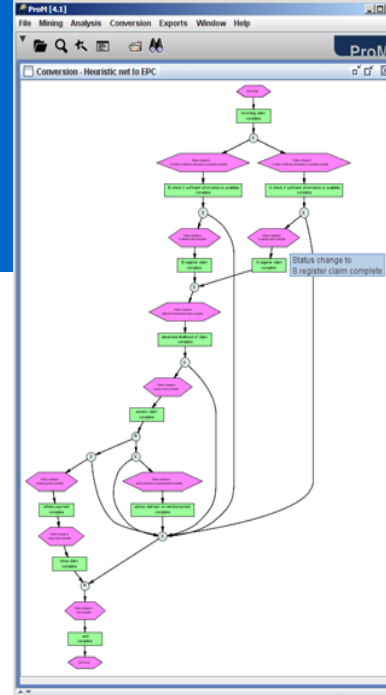


Process mining: Linking events to models



Discovery

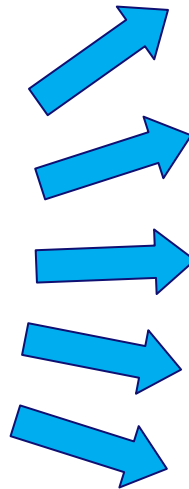




MXML Log

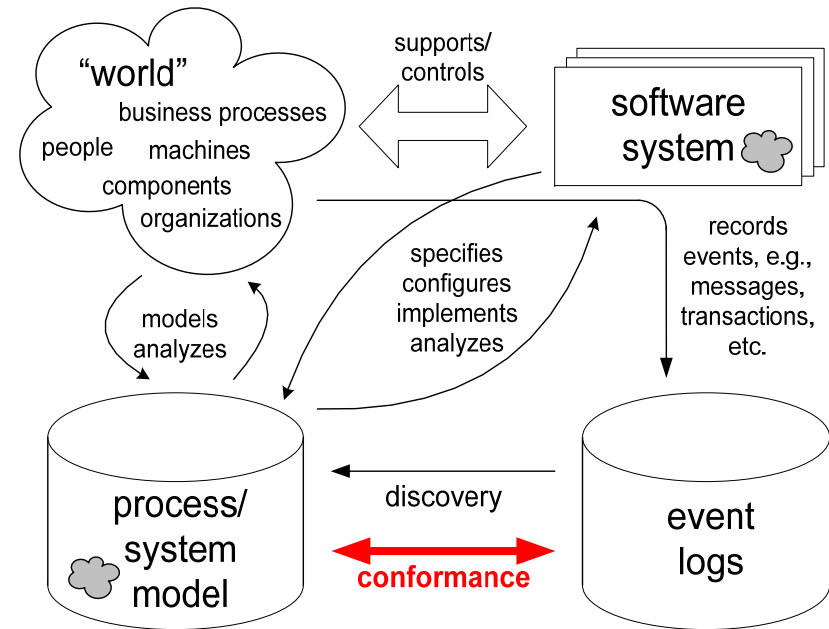
- **instances:** 3512

- **audit trail entries:** 46138



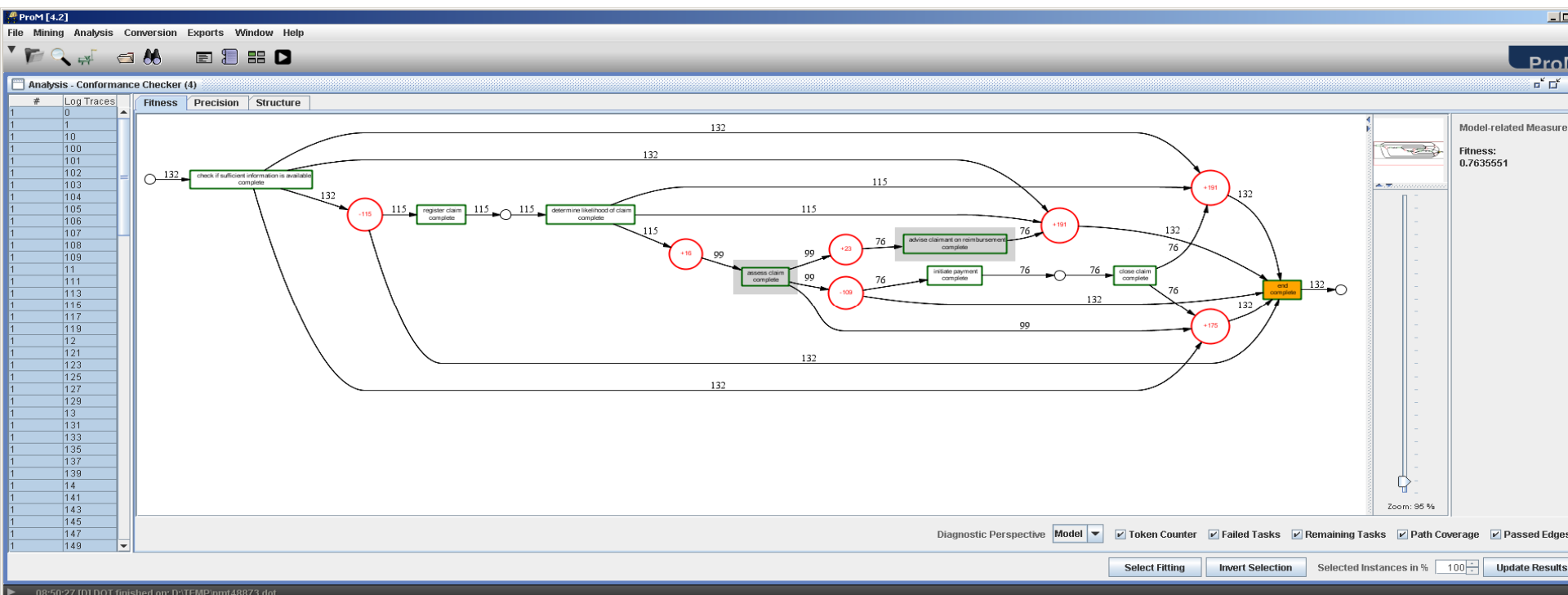
ProM supports +40 types of model discovery!

Conformance Checking



Conformance Checking

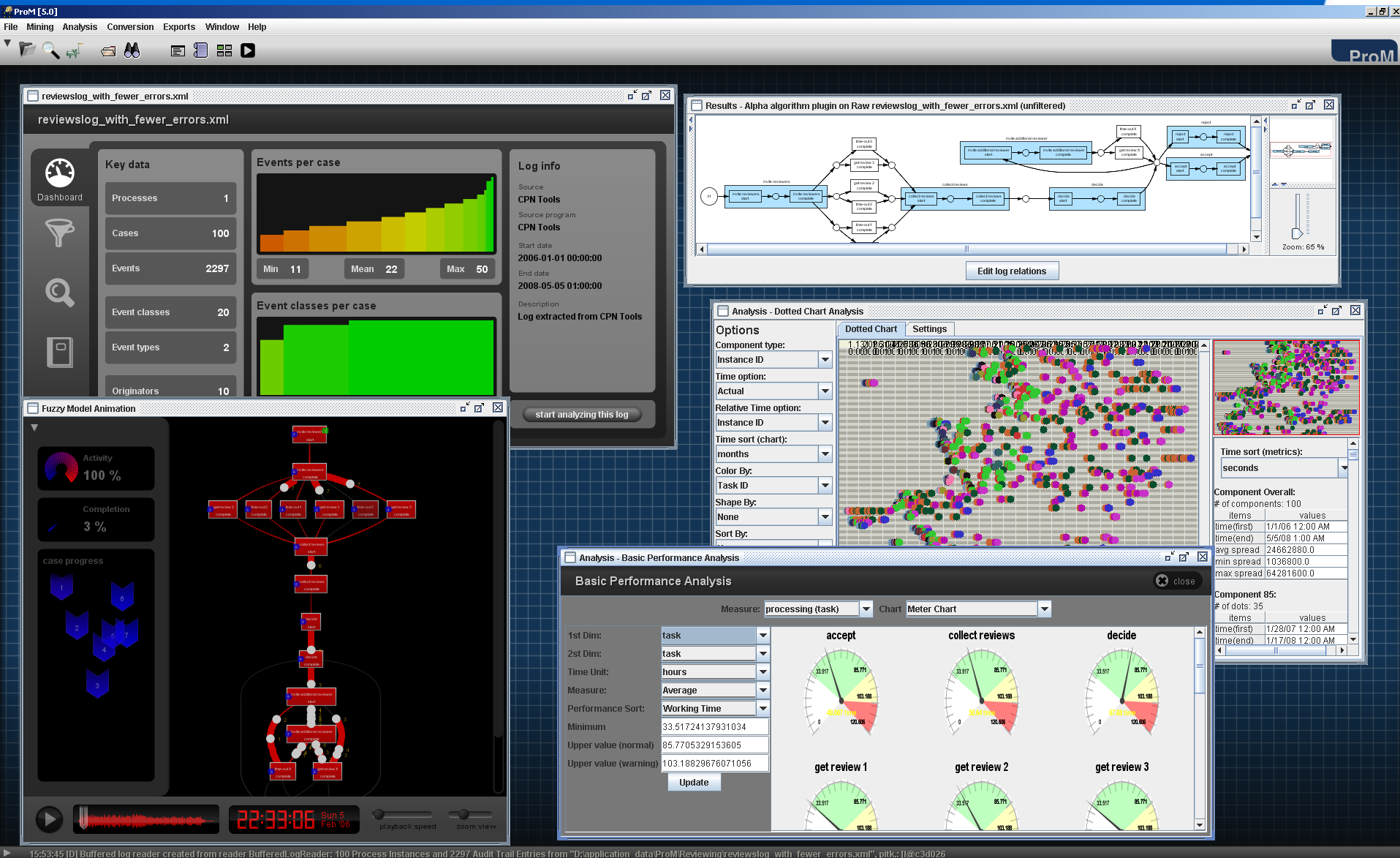
- Compare process model and event log: highlight deviations and measure conformance.
- Compare constraints/business rules and event logs: check e.g. the 4-eyes principle.



Tool support



Screenshot of ProM 5.0



Business Intelligence Tools?

- **Business Objects (SAP)**
- **Cognos Business Intelligence (IBM)**
- **Oracle Business Intelligence**
- **Hyperion (Oracle)**
- **SAS Business Intelligence**
- **Microsoft Business Intelligence**
- **SAP Business Intelligence (SAP BI)**
- **Jaspersoft (Open Source Business Intelligence)**
- **Pentaho BI Suite (Open Source)**
-



- Dashboards, reports, scorecards, ...
- Slicing and dicing, data mining, ...

Process Mining Software



Futura Reflect



BPM|one



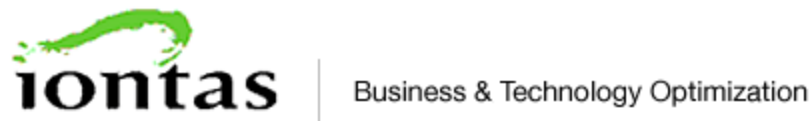
Comprehend



ARIS Process Performance Manager



Interstage Automated Business Process Discovery & Visualization



Process Discovery Focus



Enterprise Visualization Suite

Process Mining: Applications

A decorative graphic on the right side of the slide. It features a glowing red waveform, similar to an ECG or signal trace, set against a black background. Below the waveform, there are lines of green binary code (0s and 1s) that appear to be scrolling or floating.

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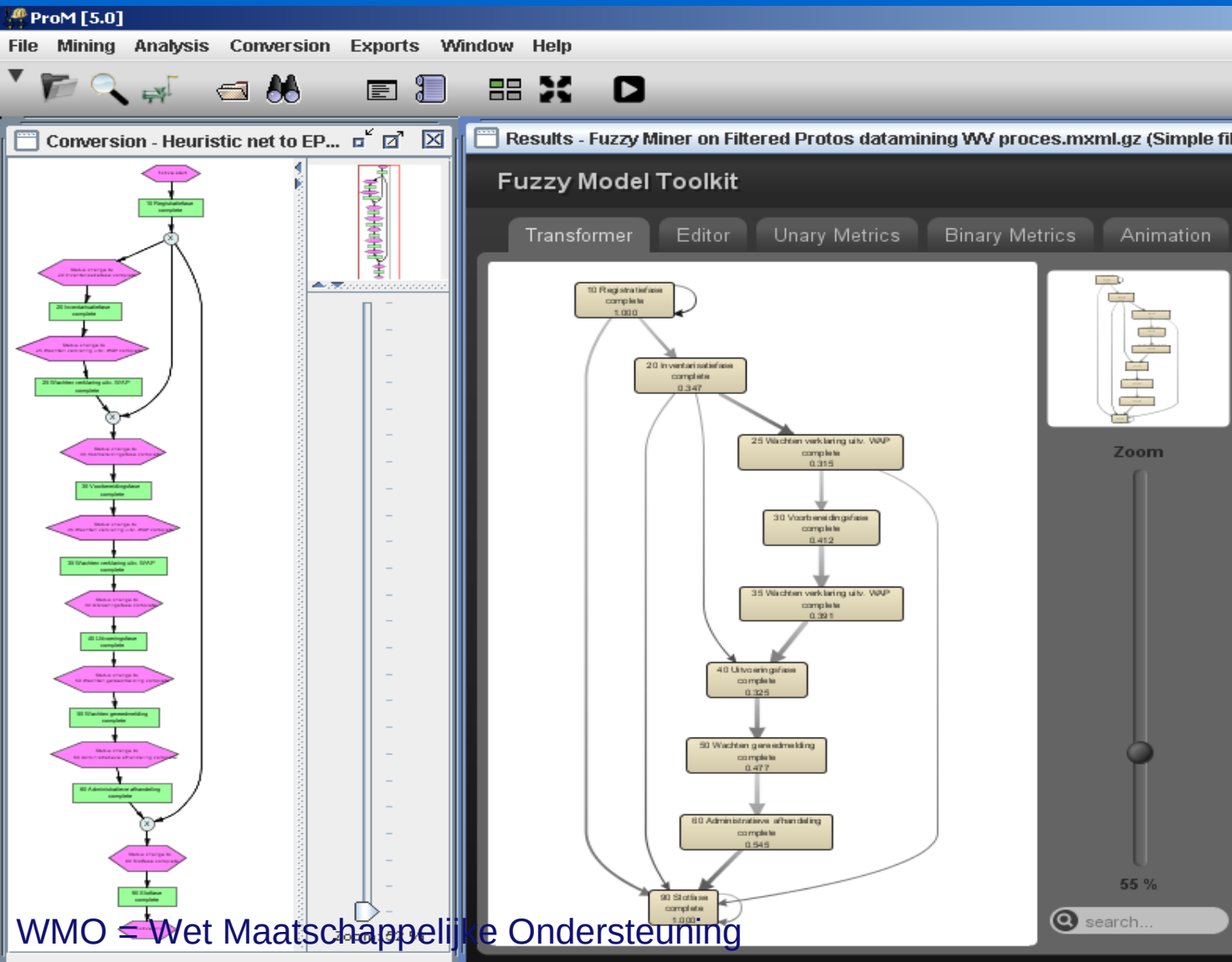
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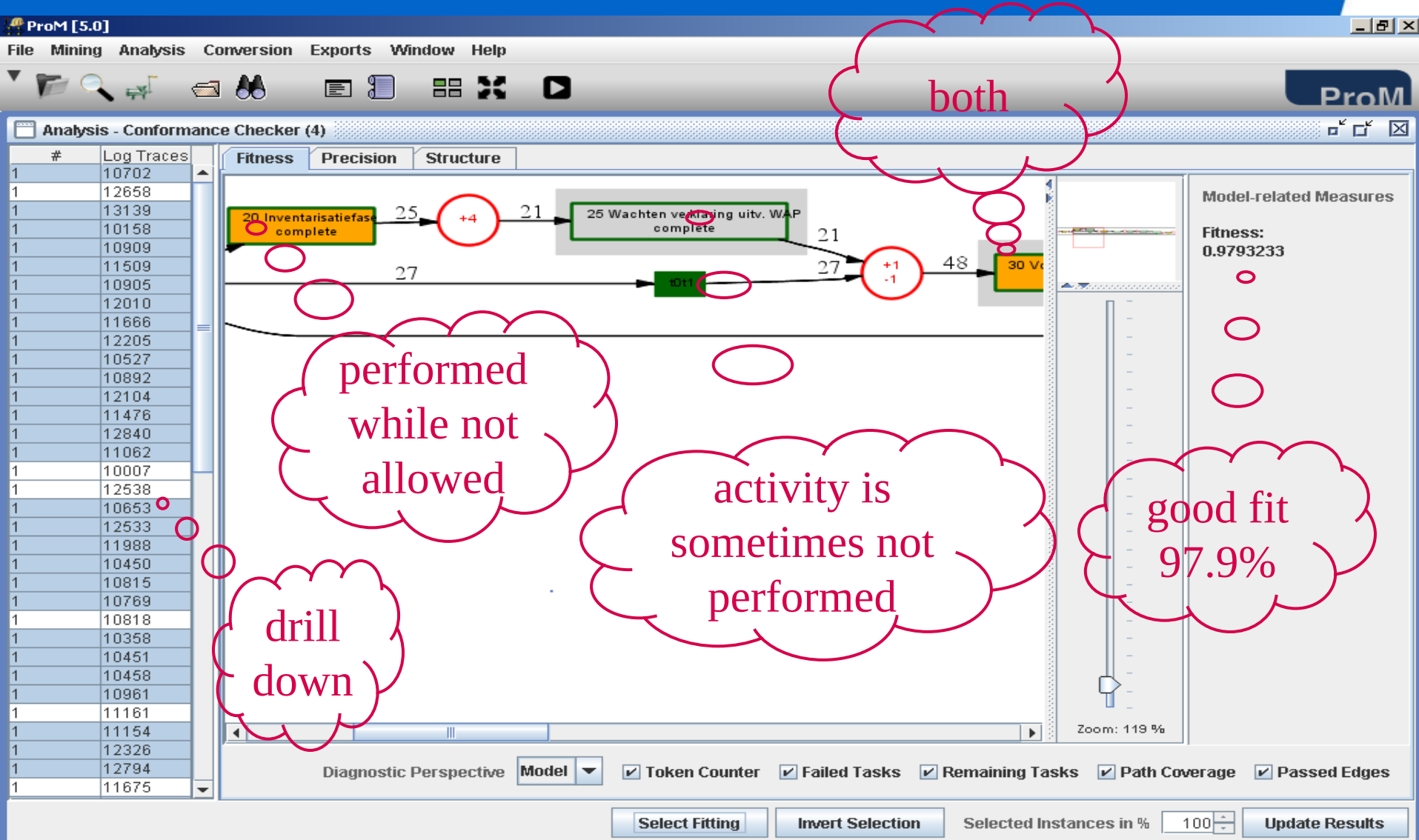
Where did we apply process mining?

- **Municipalities** (e.g., Alkmaar, Heusden, Harderwijk, etc.)
- **Government agencies** (e.g., Rijkswaterstaat, Centraal Justitieel Incasso Bureau, Justice department)
- **Insurance related agencies** (e.g., UWV)
- **Banks** (e.g., ING Bank)
- **Hospitals** (e.g., AMC hospital, Catharina hospital)
- **Multinationals** (e.g., DSM, Deloitte)
- **High-tech system manufacturers and their customers** (e.g., Philips Healthcare, ASML, Thales)
- **Media companies** (e.g. Winkwaves)
- ...

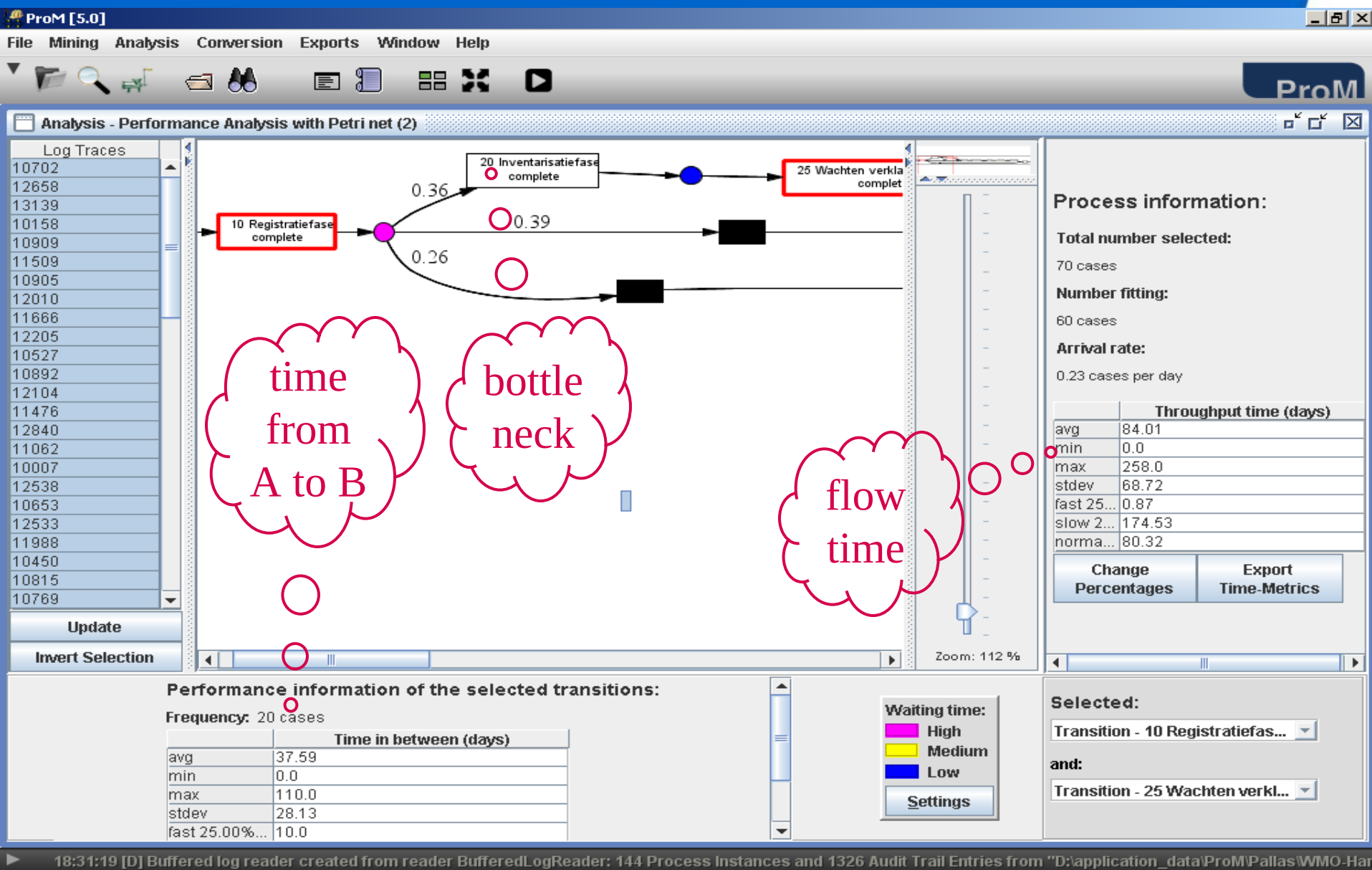
Example: WMO process of a Dutch Municipality



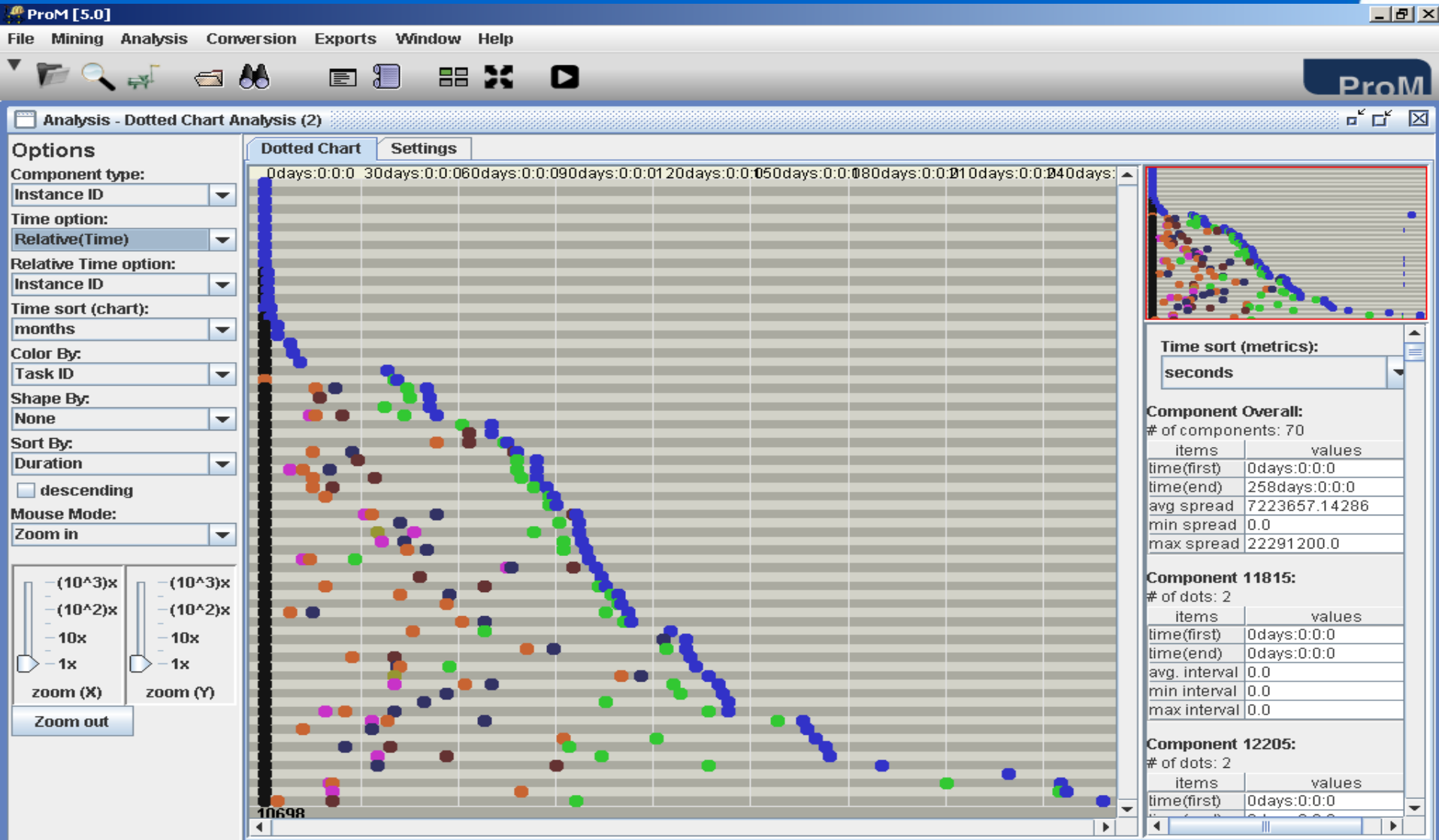
Conformance check of discovered model



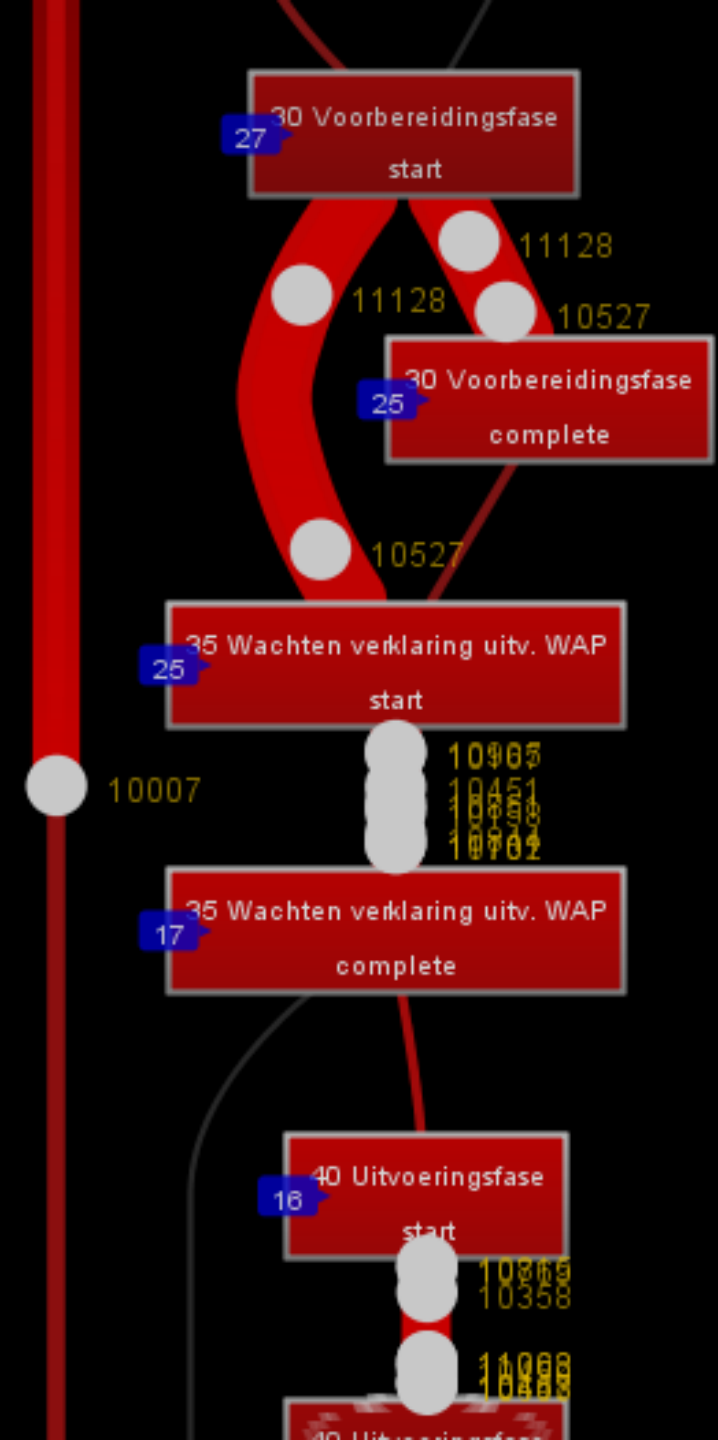
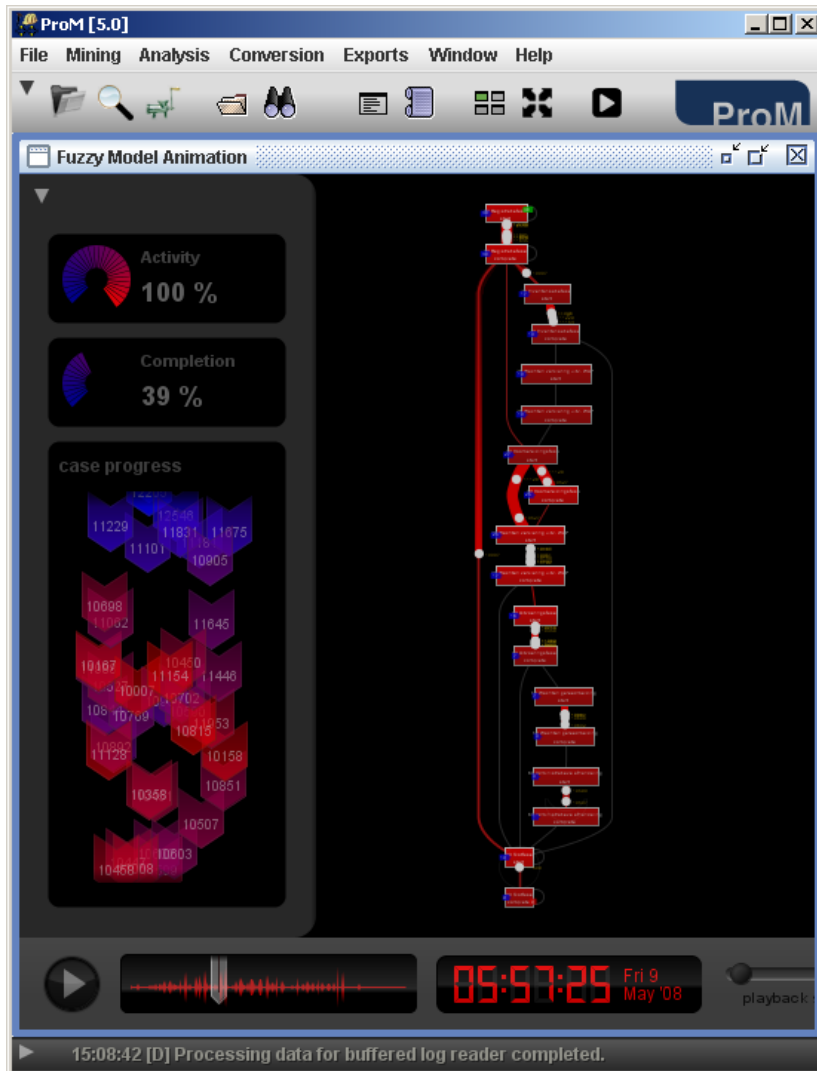
Performance analysis



Events sorted by duration



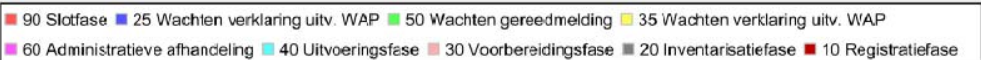
"Real" animation



ProM [5.0]

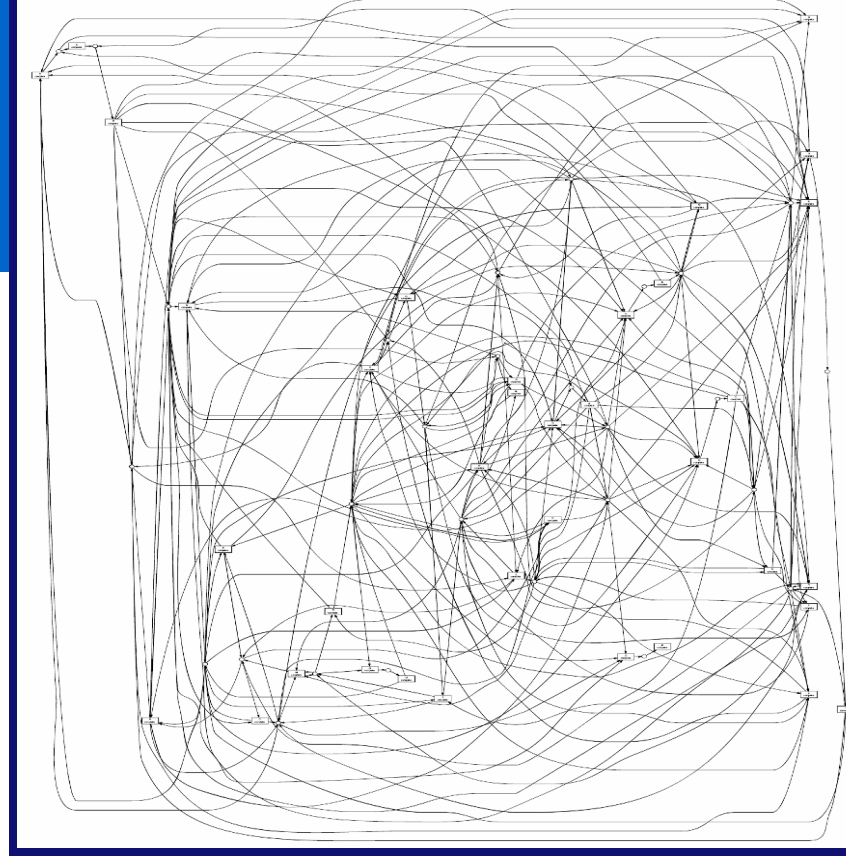
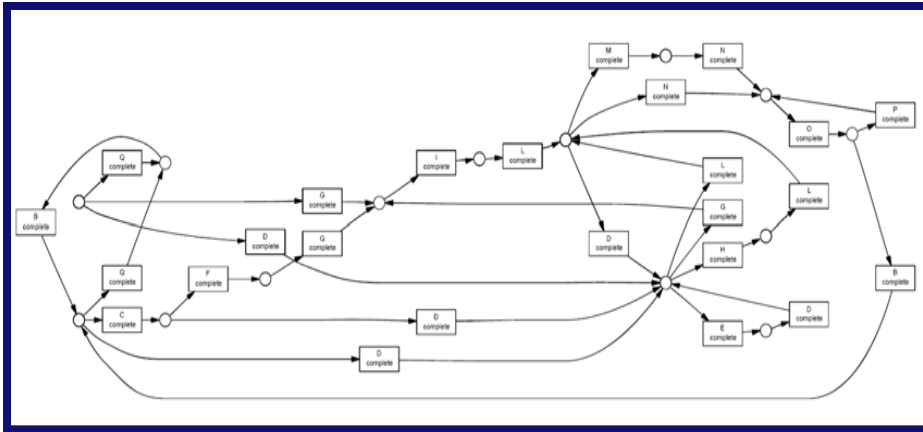
File Mining Analysis Conversion Exports Window Help

▼



Reality $\neq$ PowerPoint (or Visio)

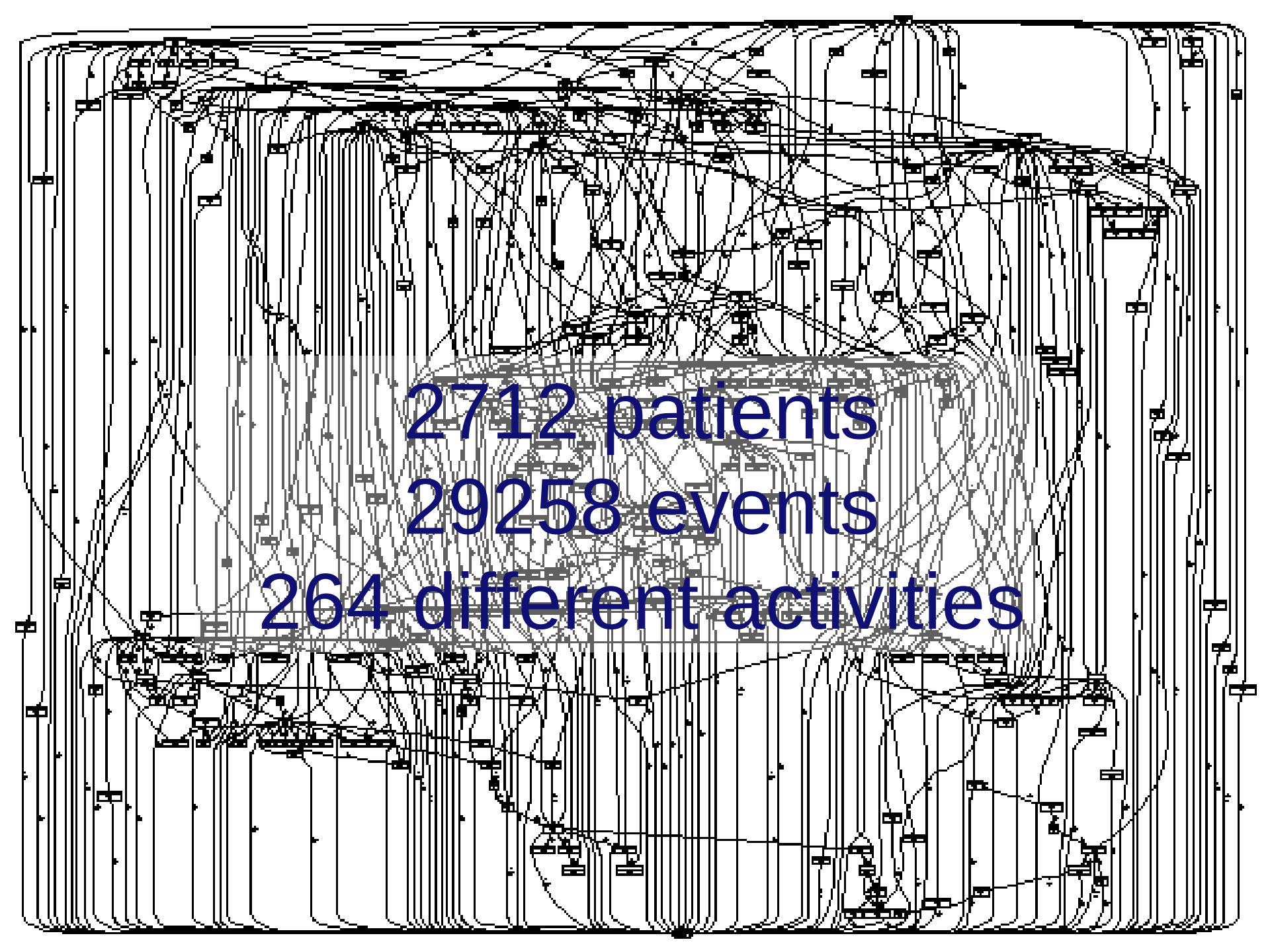
Process spectrum



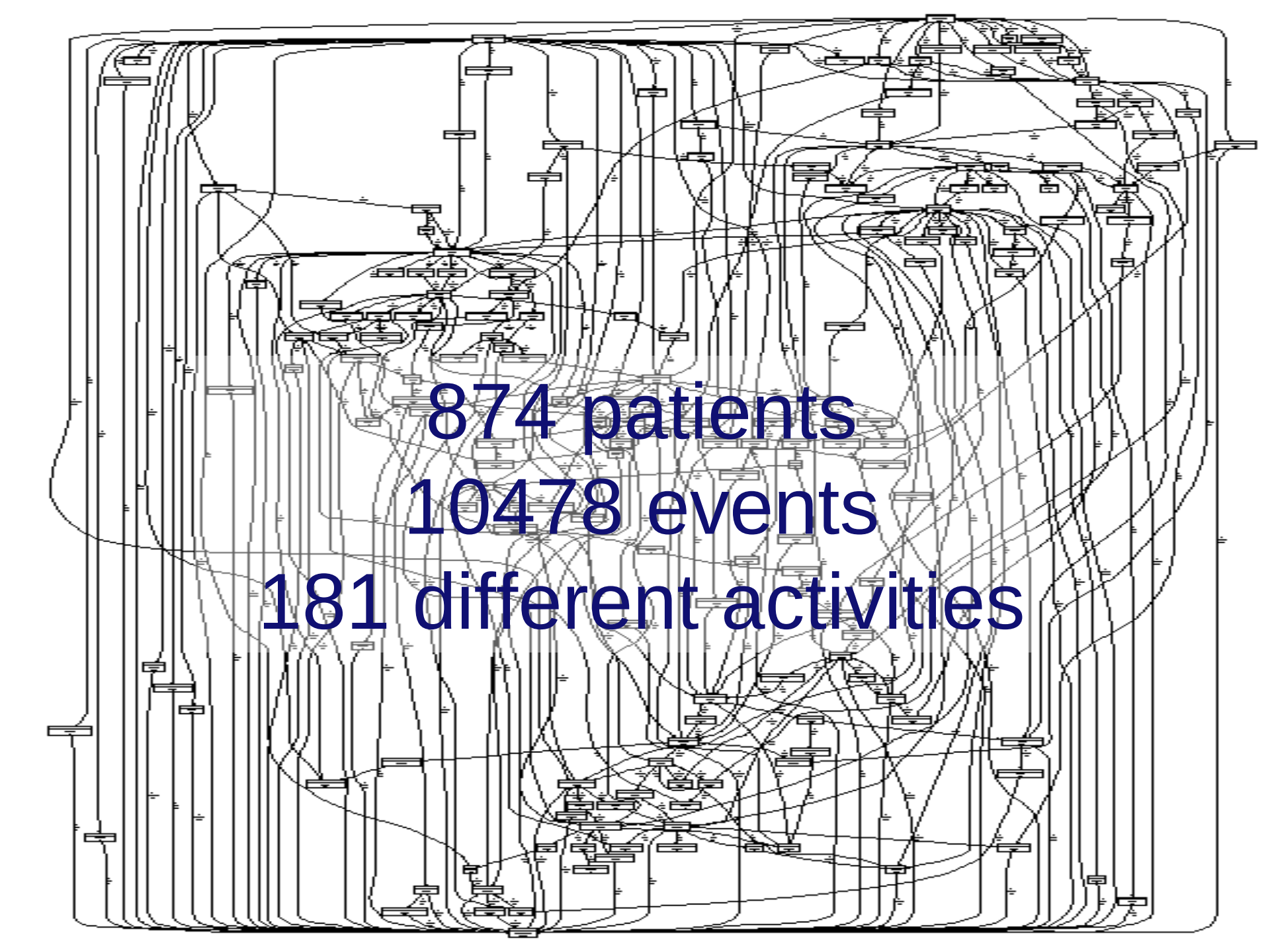
**structured
(Lasagna)**

**unstructured
(Spaghetti)**



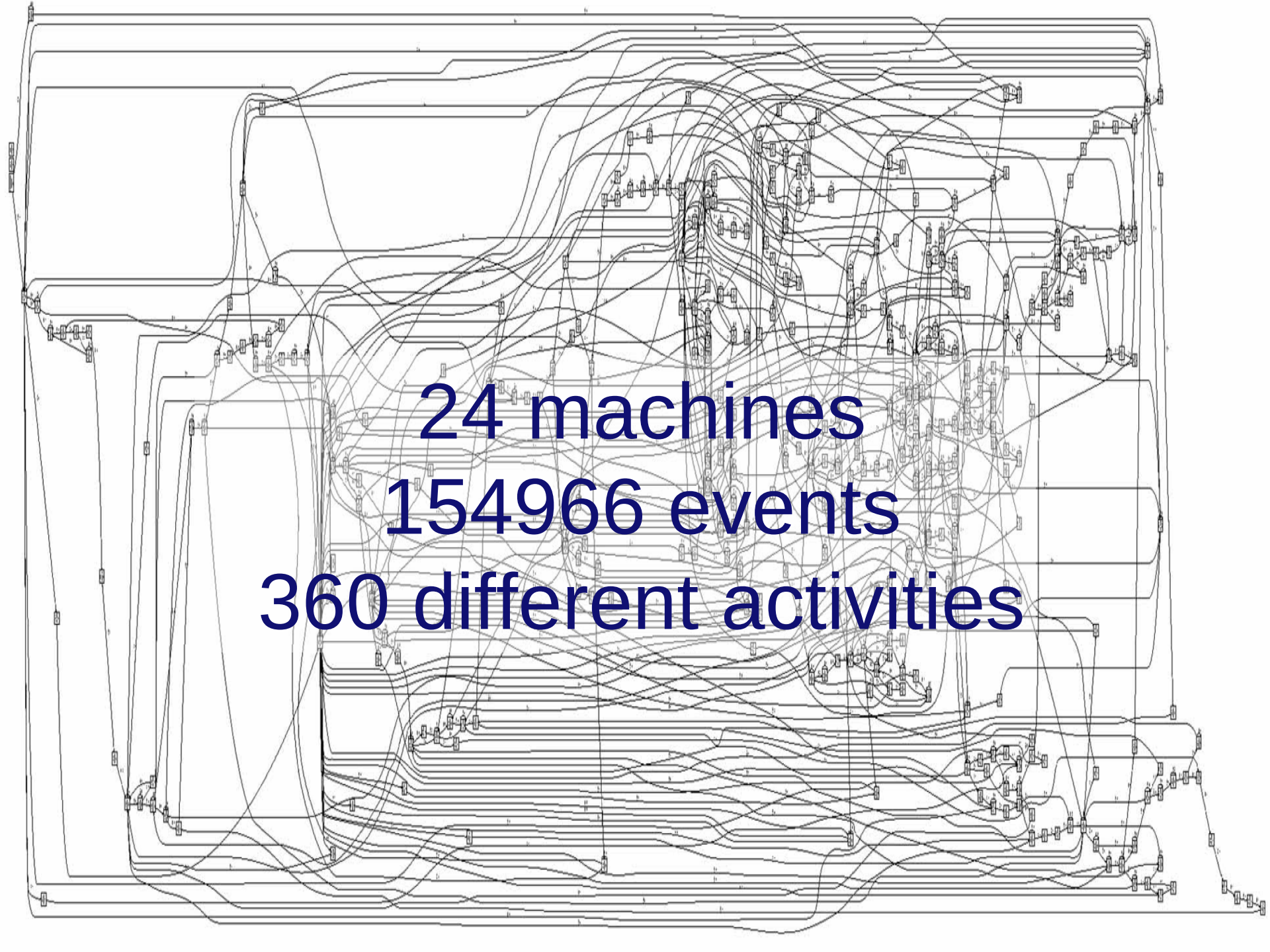


2712 patients
29258 events
264 different activities



874 patients
10478 events
181 different activities

The background image is a dense network graph. It consists of many small, rectangular nodes arranged in a somewhat regular grid-like pattern. These nodes are interconnected by a vast number of thin, black lines representing edges. The edges are both straight and curved, creating a complex web of connections across the entire frame. The overall impression is one of a highly interconnected system with a large volume of data points and relationships.



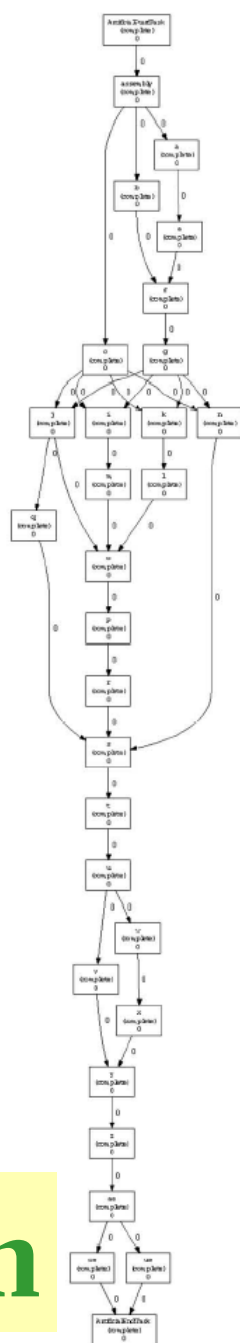
24 machines
154966 events
360 different activities

The background of the slide features a dense, intricate network diagram. It consists of numerous small, rectangular nodes arranged in a grid-like pattern. These nodes are interconnected by a vast number of thin, black lines, creating a complex web of connections. The lines vary in thickness and density, with some areas showing a high concentration of connections, particularly in the center and right-hand side of the diagram. The overall appearance is that of a large-scale data visualization or a complex circuit board layout.

#	Log Traces
1	0431
1	0278
1	0185
1	0466
1	0391
1	1722
1	1694
1	1256
1	1343
1	1981
1	1754
1	1662
1	1453
1	1298
1	1876
1	1656
1	1099
1	1919
1	1348
1	1596
1	1164
1	1032
1	1794
1	1160

100

a
complete



92

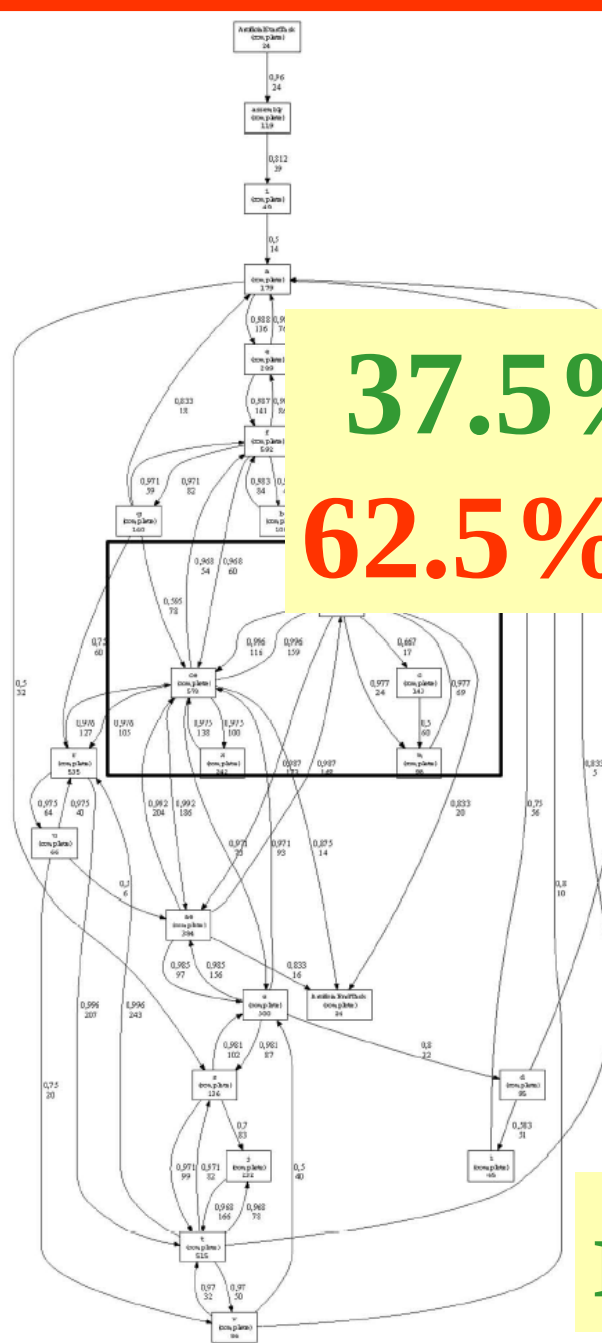
89

e
complete

instances

Diagnostic Perspective

design



Fitness:
0.37501124

37.5% OK
62.5% NOK

with Coverage ☒ Passed Edges

% 100 Update Results

reality

6σ ?

1σ !



Process Mining: TomTom for Business Processes



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Reflection



- Good maps?
- Navigation by PowerPoints?
- Traffic information?
- Where is the next fuel station?
- Who is in charge?
- Seamless zoom?
- Customizable views?
- When will the destination be reached?



ProM [5.0]

File Mining Analysis Conversion Exports Window Help

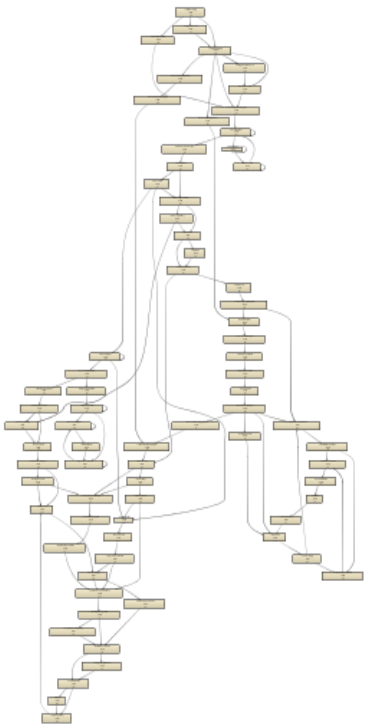
ProM

Results - Fuzzy Miner on Raw MiningBronbestand_Goed_Ontology.mxml (unfiltered)

Results - Fuzzy Miner on Raw MiningBronbestand_Goed_Ontology.mxml (unfiltered)

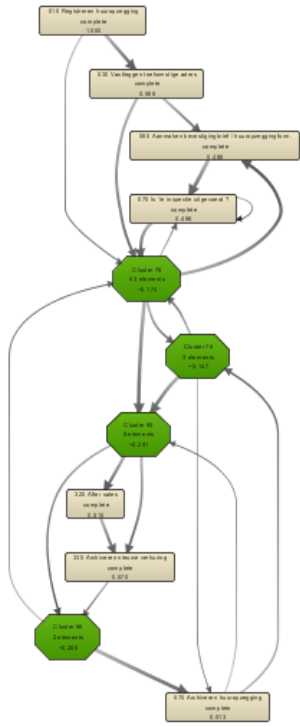
Fuzzy Model Toolkit

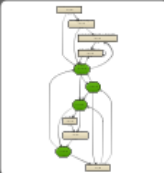
Transformer Editor Unary Metrics Binary Metrics Animation



Fuzzy Model Toolkit

Transformer Editor Unary Metrics Binary Metrics Animation




Zoom

41 %



search...

► Concurrency filter

► Edge filter

▼ Node filter

Significance cutoff



0.485

08:49:29 [M] Measured fuzzy conformance is 0.6839424087761667

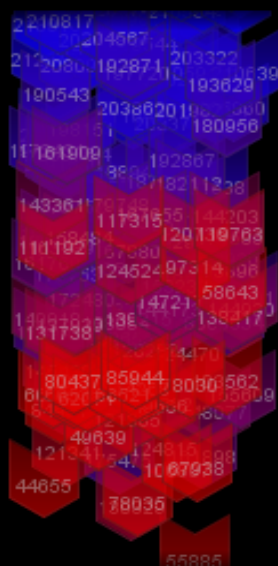


Fuzzy Model Animation (2)

Activity
100 %

Completion
43 %

case progress



18:36:05 Fri 9 Nov '07

playback speed

When will I be home?

An abstract graphic on a black background. It features several overlapping, glowing red and white wavy lines that resemble a signal or a heartbeat. Below these lines, there is a horizontal band of green binary code (0s and 1s) that appears to be scrolling or moving from right to left.

01001101101101101
110110110010
0010011011011011001010010011100

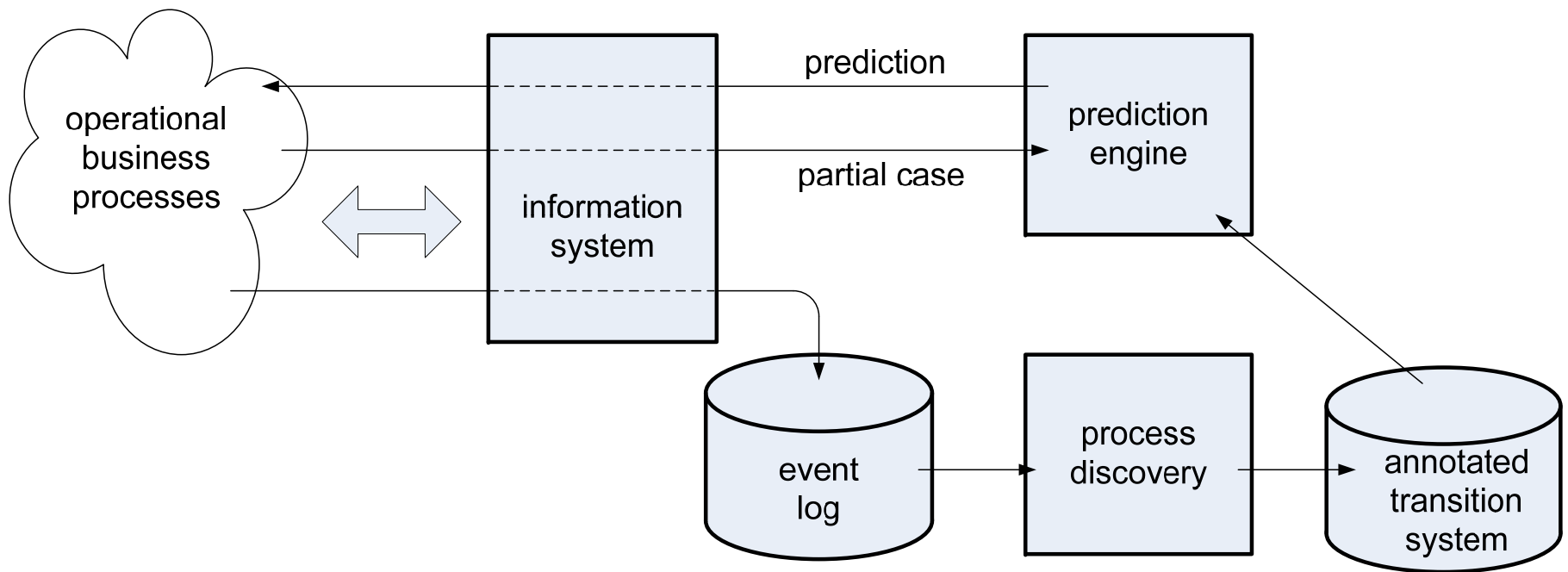
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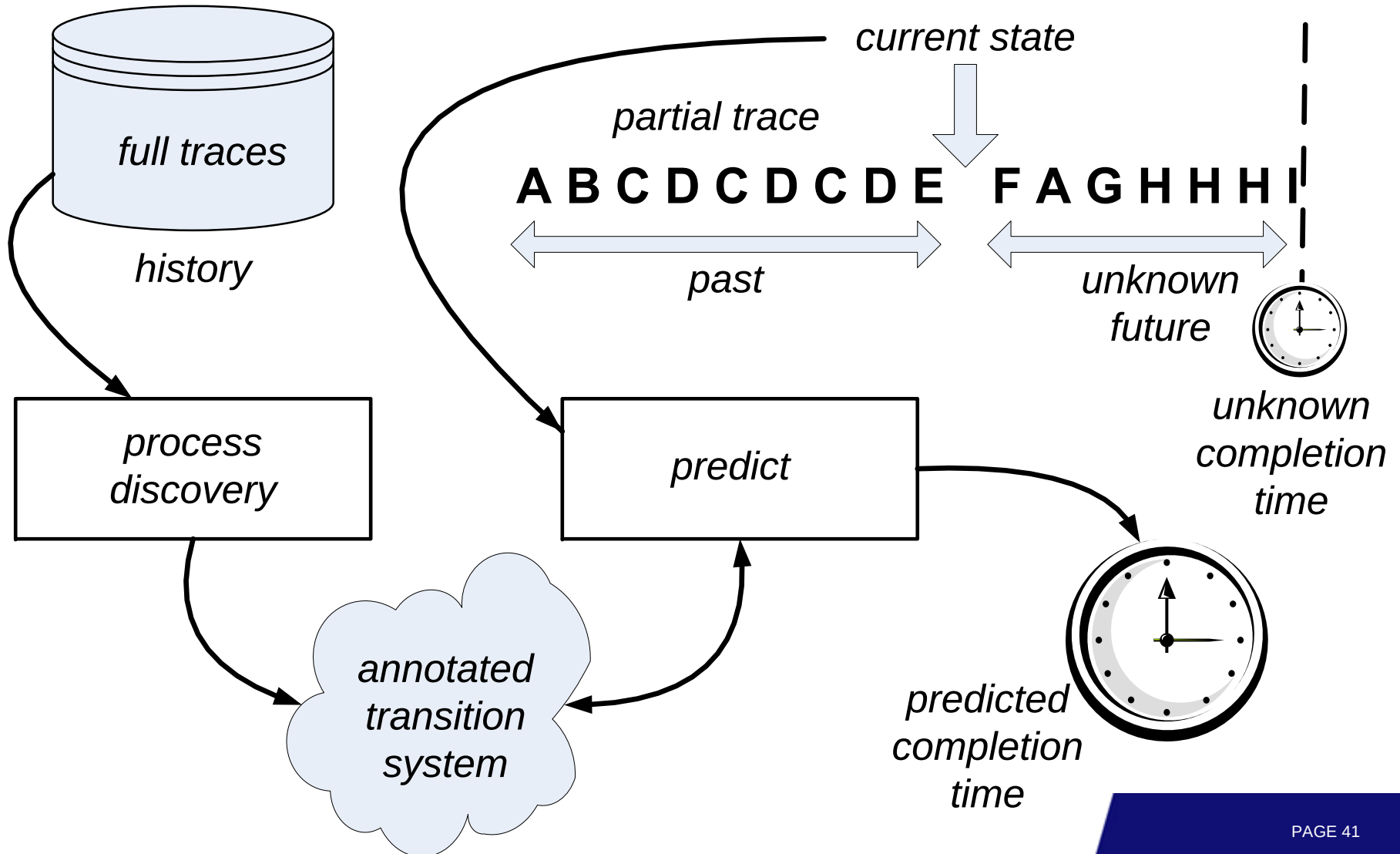
Where innovation starts



Approach



Input: partial trace and historic information



Input

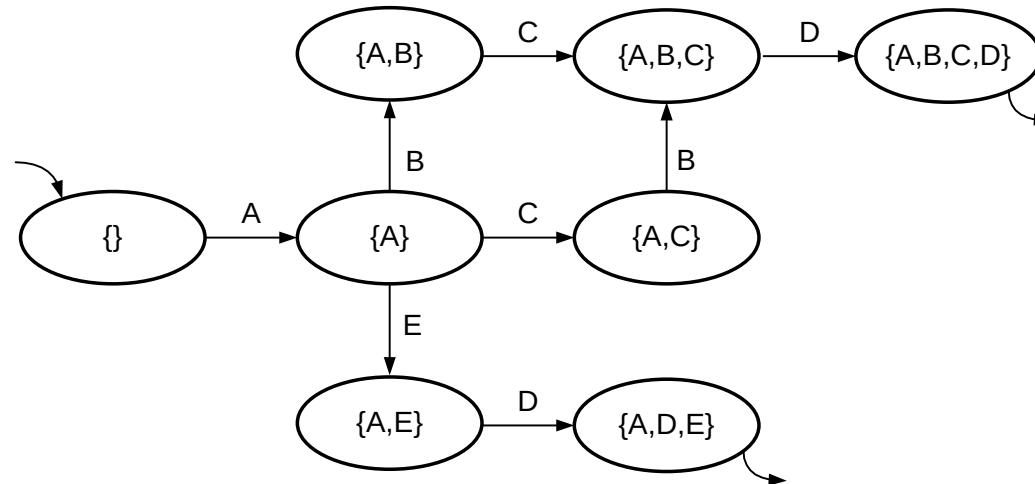
event id	properties				
	timestamp	activity	resource	cost	...
35654423	30-12-2008:11.10	A	John	300	...
35654424	30-12-2008:15.21	B	John	400	...
35654425	30-12-2008:15.35	C	John	100	...
35654426	30-12-2008:15.55	D	John	400	...
35655526	29-12-2008:16.15	A	Ann	300	...
35655527	30-12-2008:16.05	C	Ann	450	...
35655528	30-12-2008:16.25	B	Ann	150	...
35655529	31-12-2008:10.55	D	Ann	450	...
...	...	...	...	...	...



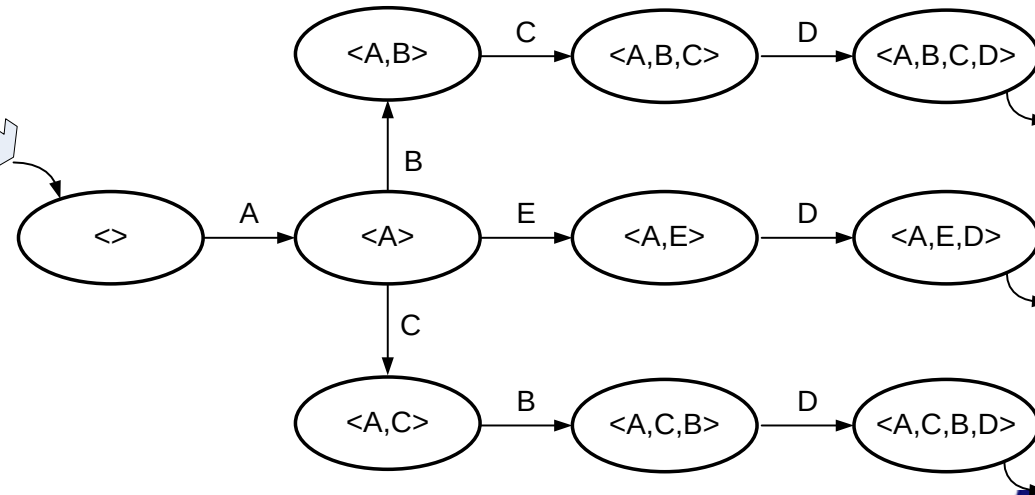
1	$\langle A^{00}, B^{06}, C^{12}, D^{18} \rangle$
2	$\langle A^{10}, C^{14}, B^{26}, D^{36} \rangle$
3	$\langle A^{12}, E^{22}, D^{56} \rangle$
4	$\langle A^{15}, B^{19}, C^{22}, D^{28} \rangle$
5	$\langle A^{18}, B^{22}, C^{26}, D^{32} \rangle$
6	$\langle A^{19}, E^{28}, D^{59} \rangle$
7	$\langle A^{20}, C^{25}, B^{36}, D^{44} \rangle$

Building transition systems

ABCD
ACBD
AED
ABCD
ABCD
AED
ACBD
...



(a) transition system based on sets

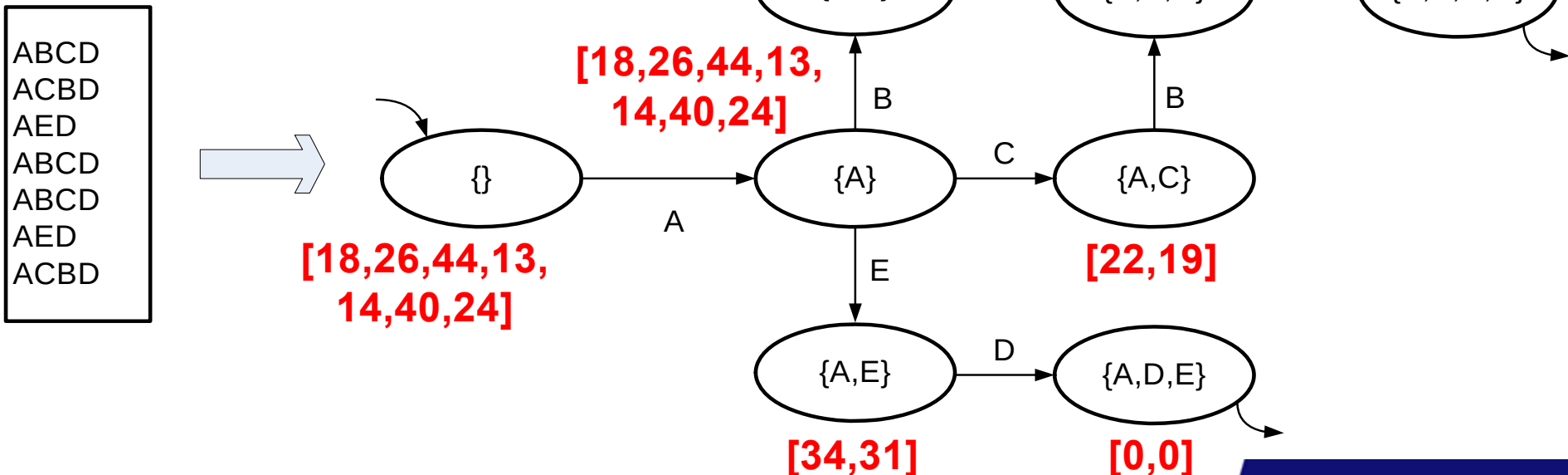


(b) transition system based on sequences

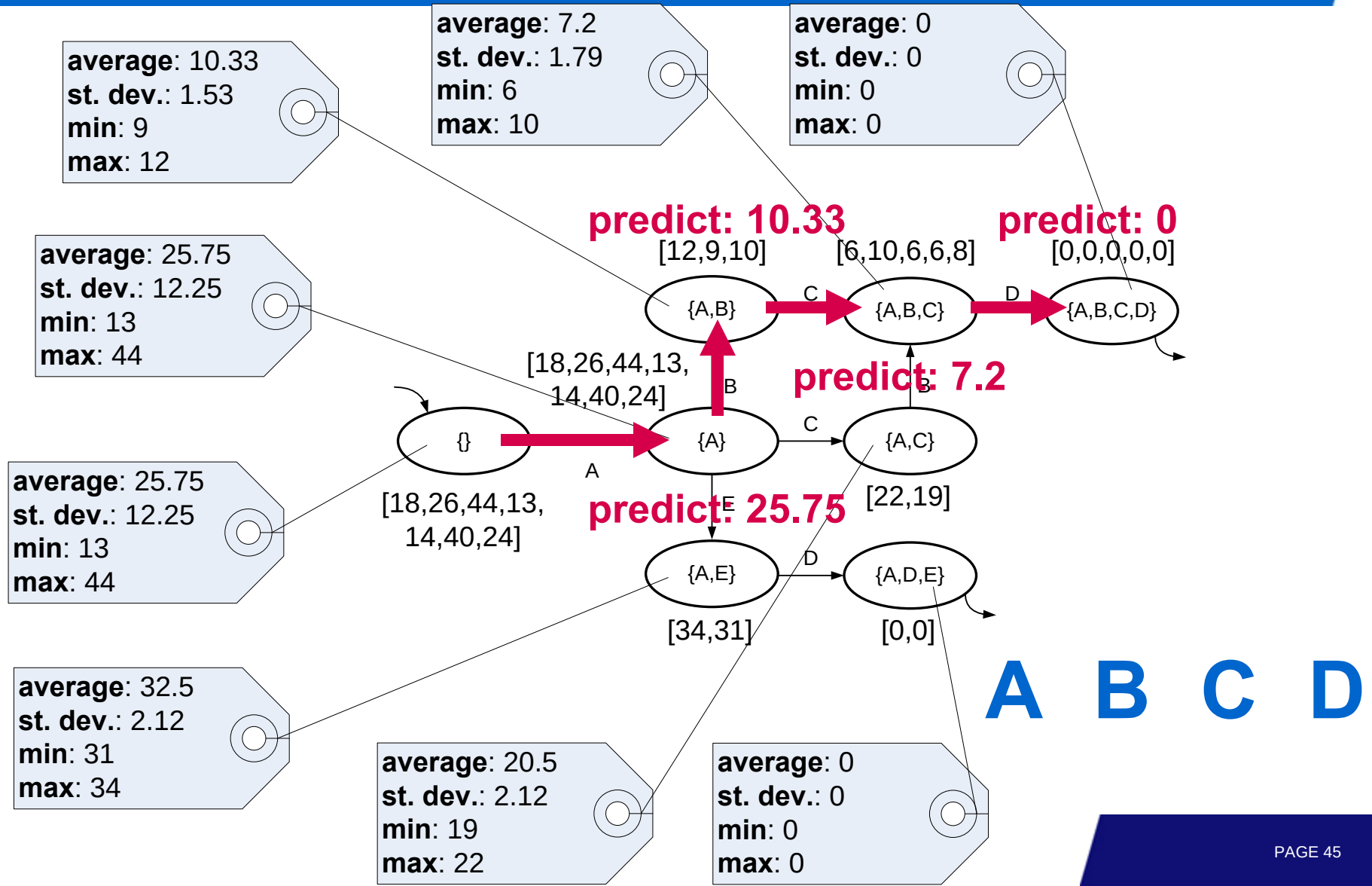
many
abstractions
are possible
and supported
by ProM's
FSM miner

Annotated transition system based on remaining time

1	$\langle A^{00}, B^{06}, C^{12}, D^{18} \rangle$
2	$\langle A^{10}, C^{14}, B^{26}, D^{36} \rangle$
3	$\langle A^{12}, E^{22}, D^{56} \rangle$
4	$\langle A^{15}, B^{19}, C^{22}, D^{28} \rangle$
5	$\langle A^{18}, B^{22}, C^{26}, D^{32} \rangle$
6	$\langle A^{19}, E^{28}, D^{59} \rangle$
7	$\langle A^{20}, C^{25}, B^{36}, D^{44} \rangle$



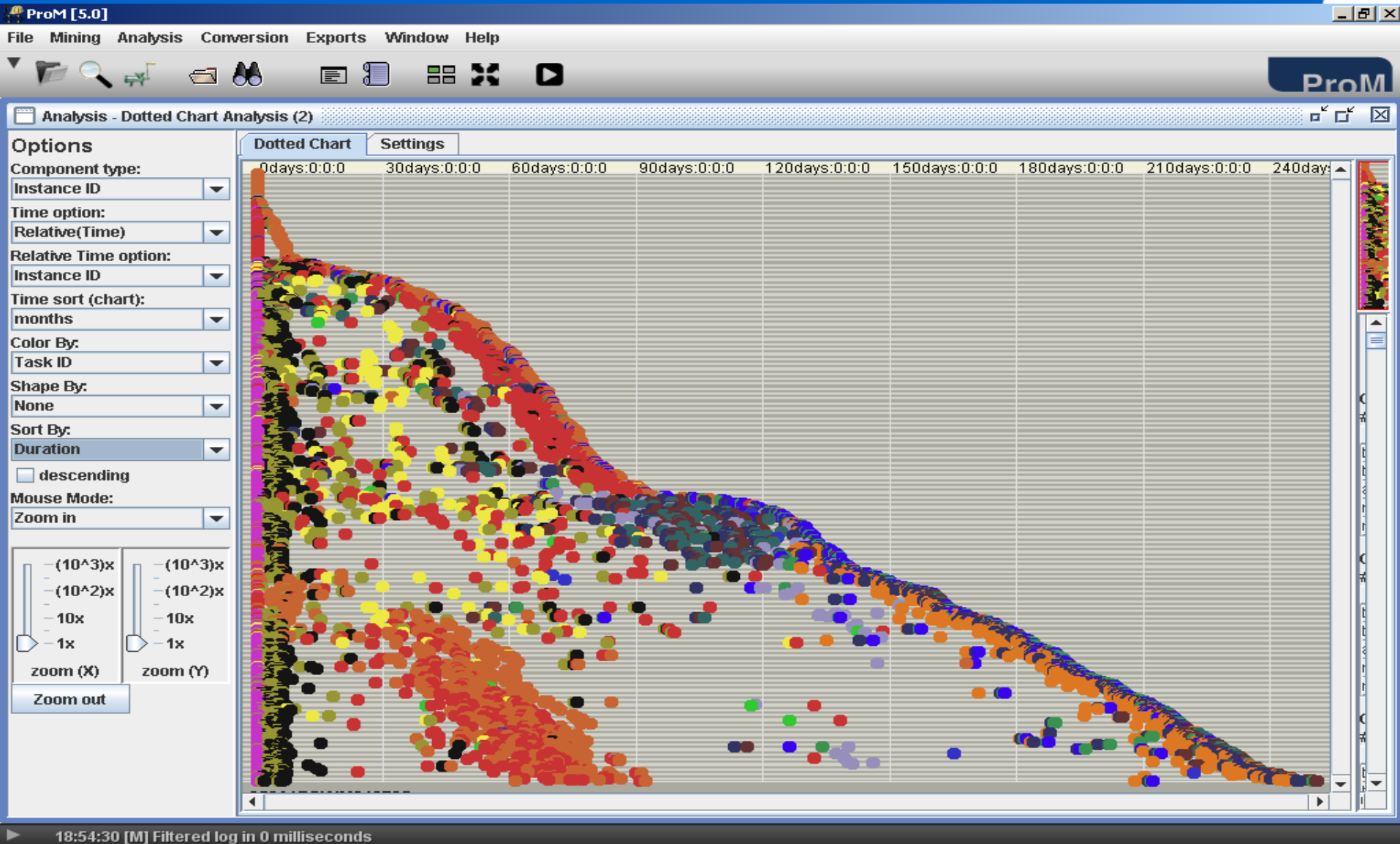
Predictive information



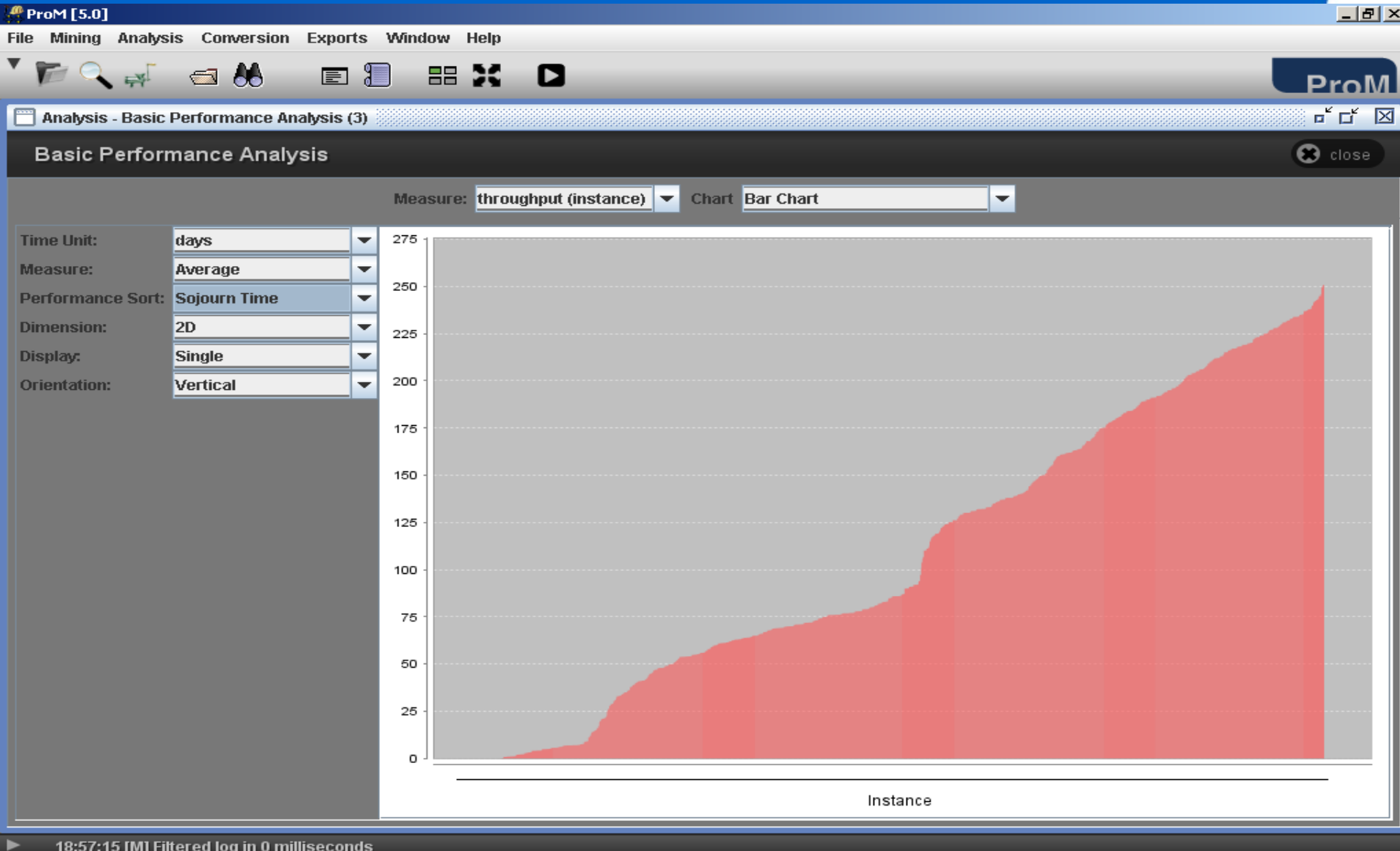
Example: WOZ process in Dutch Municipality

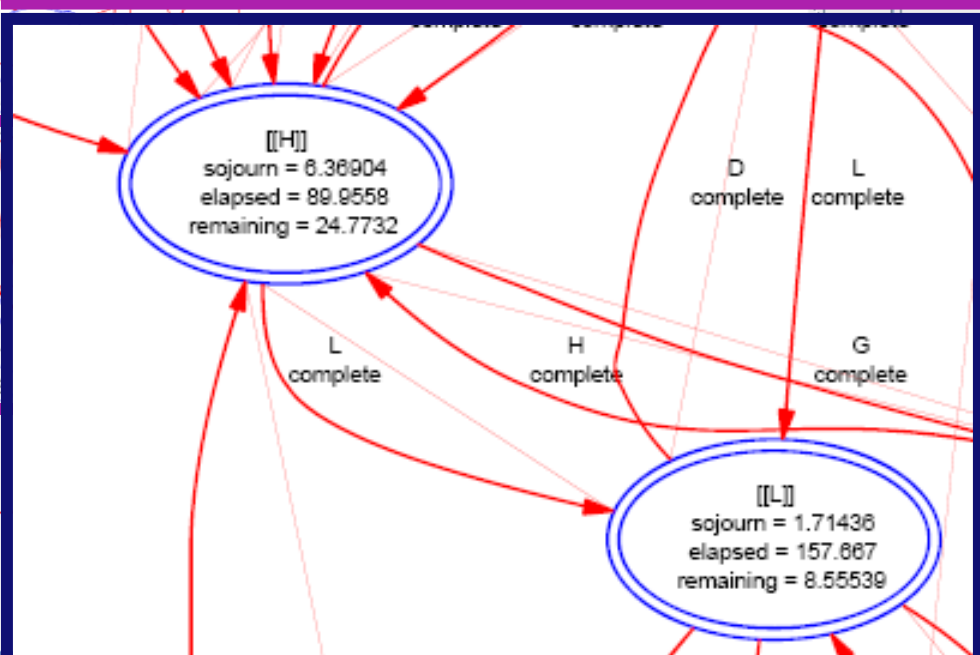
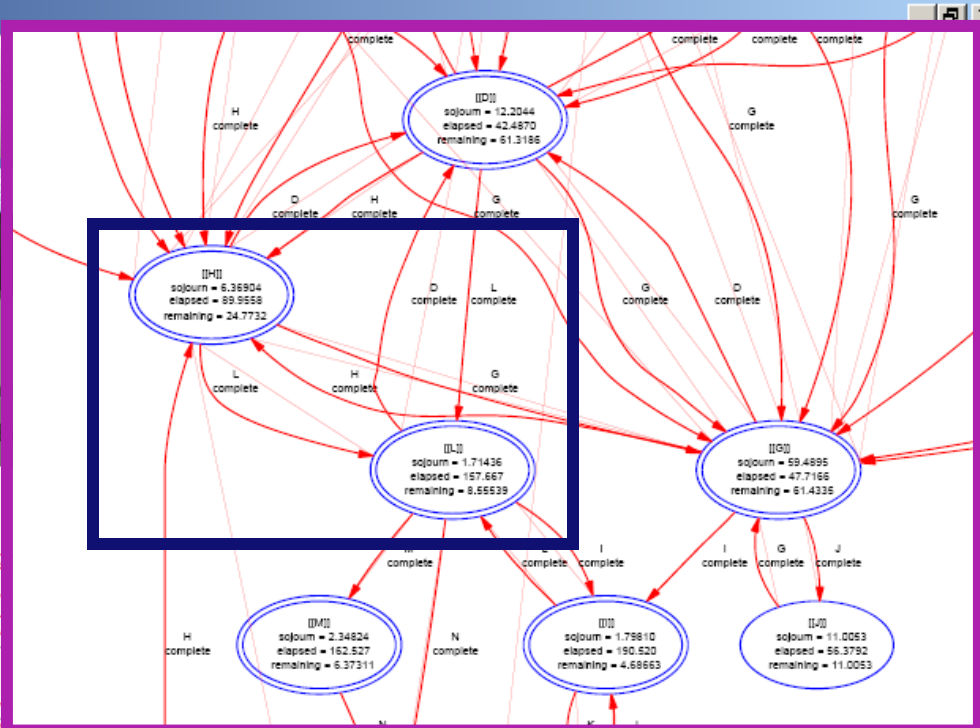
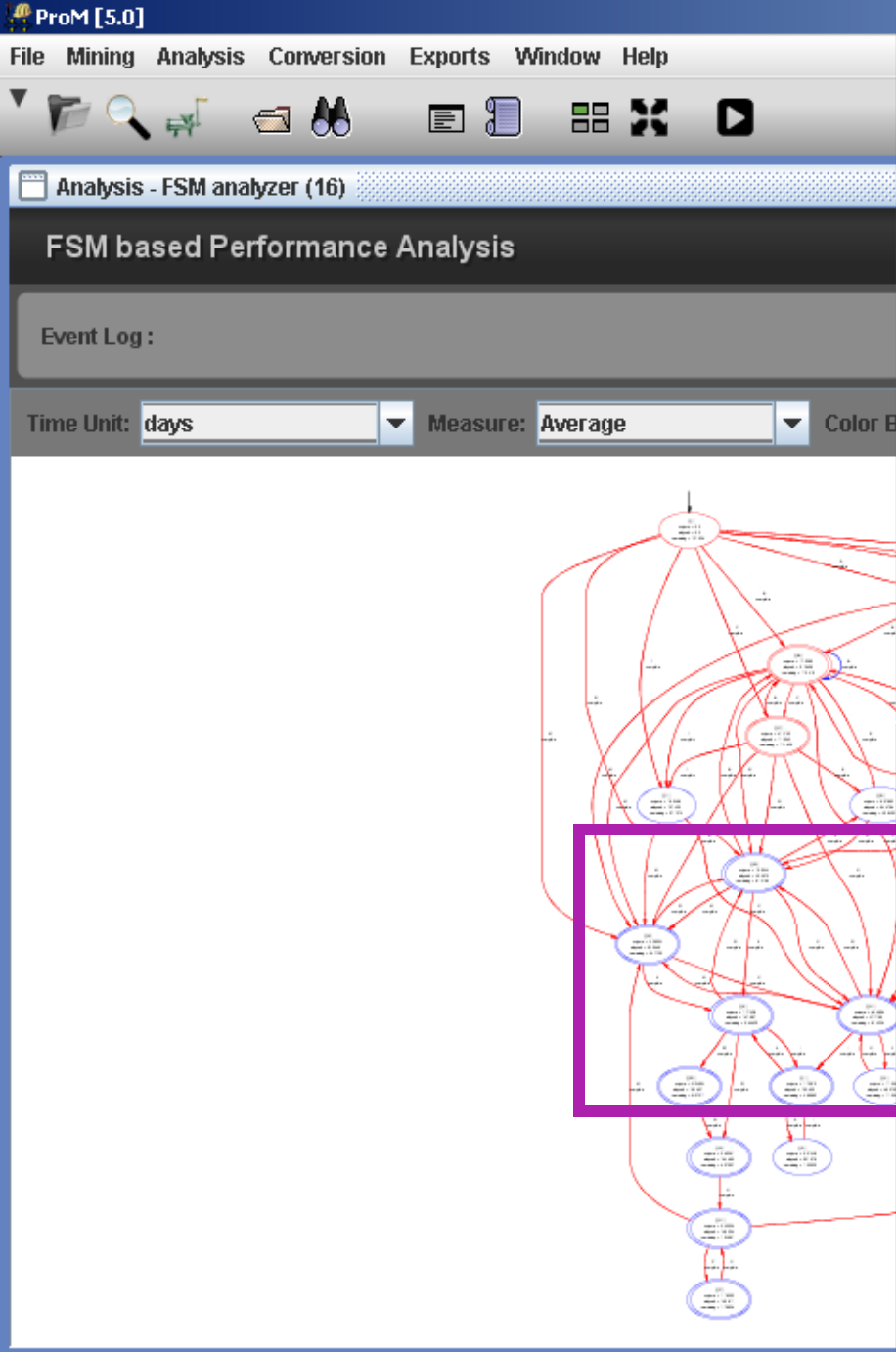


All 11985 events at a glance



Average flow time is 107 days (with a huge variation)





ProM

graph view text view

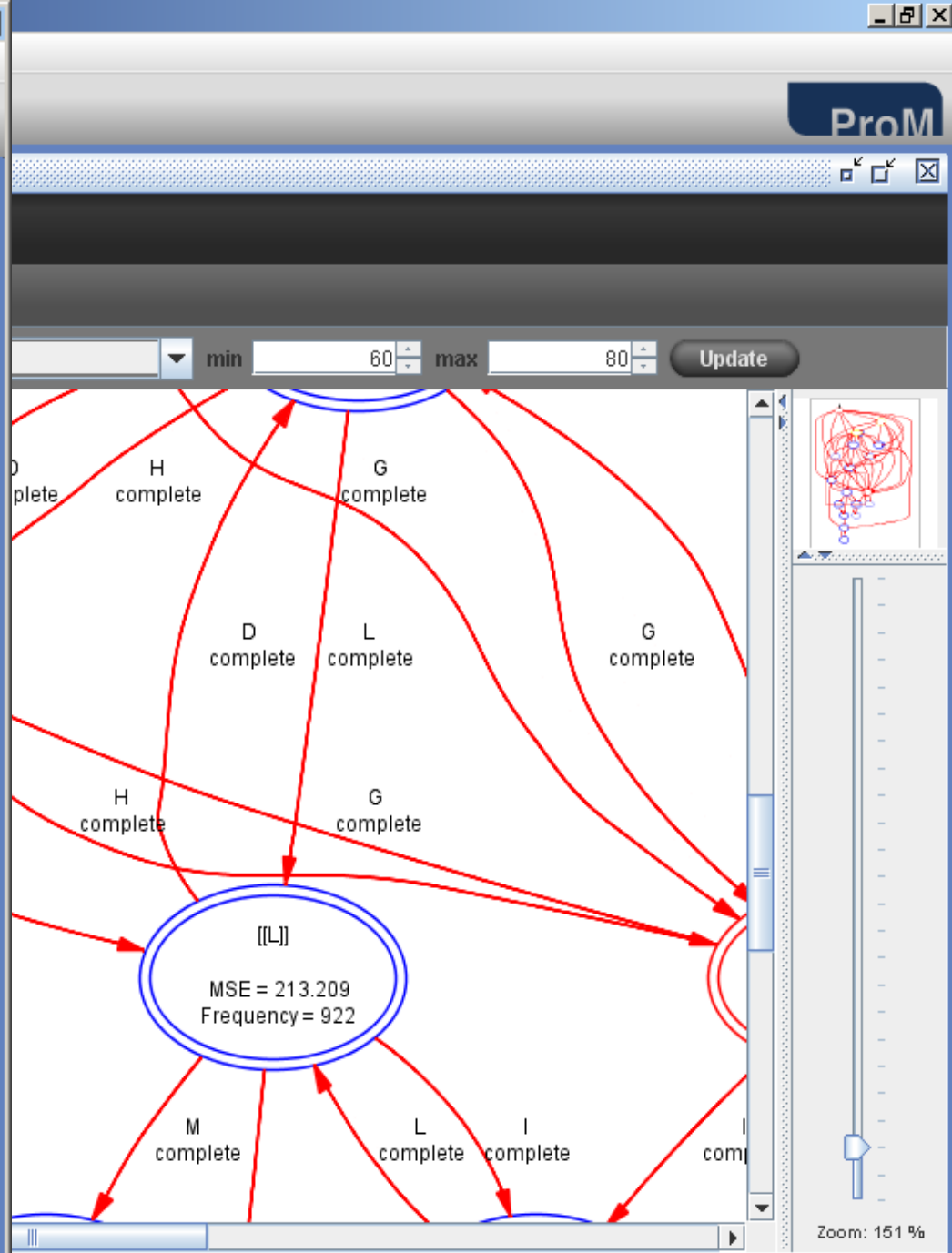
Mean Average Error (MAE)

rooted MSE

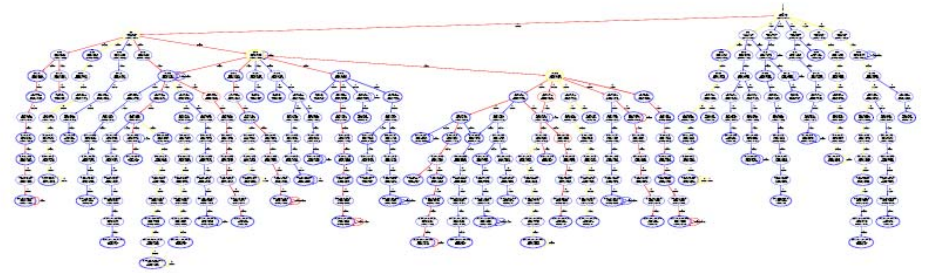
MAPE

[[B]]	2.3442	70.6320	702.14	1488
[[C]]	64.8881	72.8452	406.781	896
[[D]]	63.1935	69.4784	51727.3	1240
[[G]]	72.8231	74.6510	24.3339	1546
[[I]]	3.25089	5.59291	103.264	629
[[L]]	9.82483	14.6016	406.304	922
[[M]]	8.89983	13.6616	1331.10	866
[[N]]	7.74203	12.2609	1478.89	799
[[O]]	3.17161	9.07740	1351.93	932
[[P]]	2.98513	8.61544	554.336	709
[[F]]	34.0397	44.4393	52294.3	16
[[H]]	16.2393	22.9282	447.301	326
[[E]]	46.4377	55.1125	1232.75	27
[[Q]]	36.6227	47.2489	133.769	238
[[J]]	2.67055	2.67055	25.7842	2
[[K]]	0.0	0.0	0.0	1
overall(mean)	31.3298	37.1198	11359.0	18
overall(aggregated)				

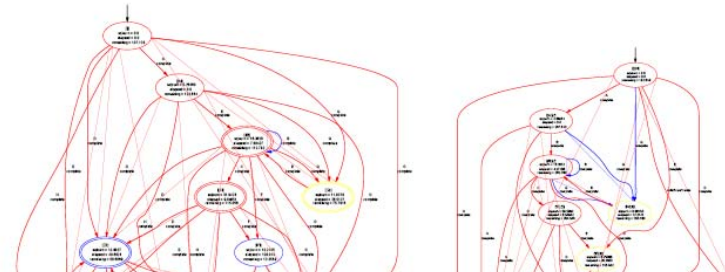
pmt35935.dot



Some results



(a) Set abstraction based on all activities



Abstraction	MAE	RMSE	MAPE
Set abstraction based on all activities (cf. Figure 17(a))	41.648	47.513	1505.07
Set abstraction based on last activity (cf. Figure 17(b))	43.080	49.666	1818.49
Set abstraction based on last activity and additional information related to the occurrence of “I” (cf. Figure 17(c))	17.129	23.550	900.07
Complete abstraction (cf. Figure 17(d))	63.391	74.965	7169.55
Simple heuristic: half of average total flow time (53.57 days)	61.750	75.505	6188.04



Conclusion

An abstract graphic on the right side of the slide. It features a glowing red sine wave against a black background. Below the wave, there are two lines of green binary code (0s and 1s) that appear to be floating or scrolling.

010011011011011011
110110110010
00100110110110110010010011100

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Conclusion

- The abundance of event data enables a wide variety of process mining techniques ranging from process discovery to conformance checking.
- A reality check for people that are involved in process modeling.
- TomTom functionality is already possible today!
- Check out ProM with its 250+ plug-ins.
- Contribute: case studies, plug-ins, etc.

Thanks!

cf. www.processmining.org

- Wil van der Aalst
- Peter van den Brand
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- Eric Verbeek
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- Anne Rozinat
- Minseok Song
- Ton Weijters
- Remco Dijkman
- Gianluigi Greco
- Antonella Guzzo
- Kristian Bisgaard Lassen
- Ronny Mans
- Jan Mendling
- Vladimir Rubin
- Kenny van Uden
- Irene Vanderfeesten
- Barbara Weber
- Lijie Wen
- Mercy Amiyo
- Carmen Bratosin
- Toon Calders
- Jorge Cardoso
- Ronald Crooy
- Florian Gottschalk
- Monique Jansen-Vullers
- Peter Khisa Wakholi
- Nicolas Knaak
- Sven Lambrechts
- Joyce Nakatumba
- Mariska Netjes
- Mykola Pechenizkiy
- Maja Pesic
- Hajo Reijers
- Stefanie Rinderle
- Domenico Saccà
- Helen Schonenberg
- Marc Voorhoeve
- Jianmin Wang
- Jan Martijn van der Werf
- Martin van Wingerden
- Jianhong Ye
- Huub de Beer
- Elena Casares
- Alina Chipaila
- Walid Gaaloul
- Martijn van Giessel
- Shaifali Gupta
- Thomas Hoffmann
- Peter Hornix
- René Kerstjens
- Ralf Kramer
- Wouter Kunst
- Laura Maruster
- Andriy Nikolov
- Adarsh Ramesh
- Jo Theunissen
- ...

Relevant WWW sites



- <http://www.processmining.org>
- [http:// promimport.sourceforge.net](http://promimport.sourceforge.net)
- <http://prom.sourceforge.net>
- <http://www.workflowpatterns.com>
- <http://www.workflowcourse.com>
- <http://www.vdaalst.com>



<http://www.senternovem.nl/innovatievouchers>
MKB 2.500 – 7.500 euro

