

Curso

# A Tour In Process Mining

## *From Practice to Algorithmic Challenges*

*Josep Carmona (UPC)*

Red de Excelencia en Ingeniería del Software Dirigida por Modelos  
Lunes, 5 de Febrero, 2018 – Barcelona



***Wil van der Aalst*** - Eindhoven University of Technology, The Netherlands

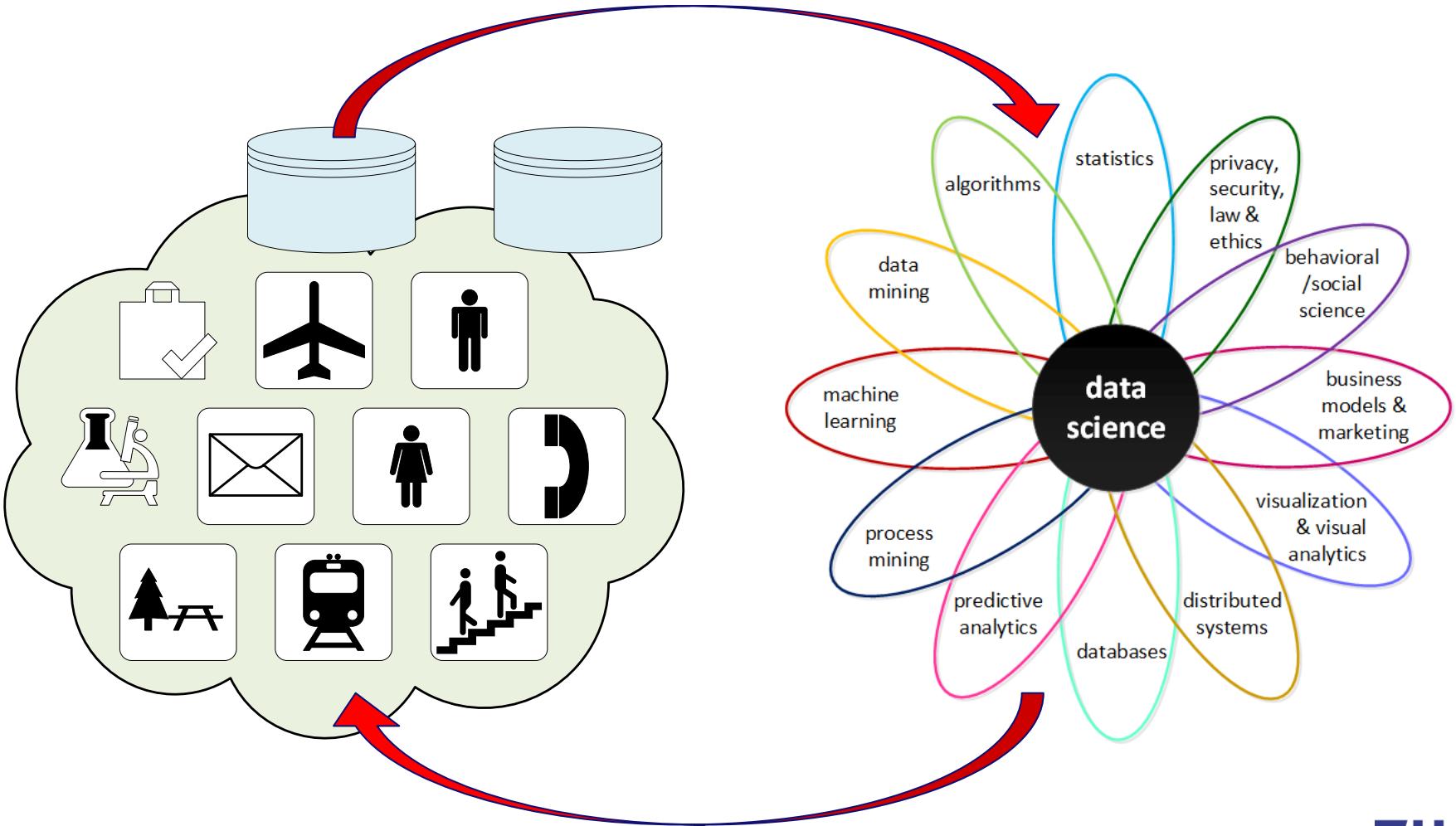
***Josep Carmona*** - Universitat Politècnica de Catalunya, Barcelona, Spain

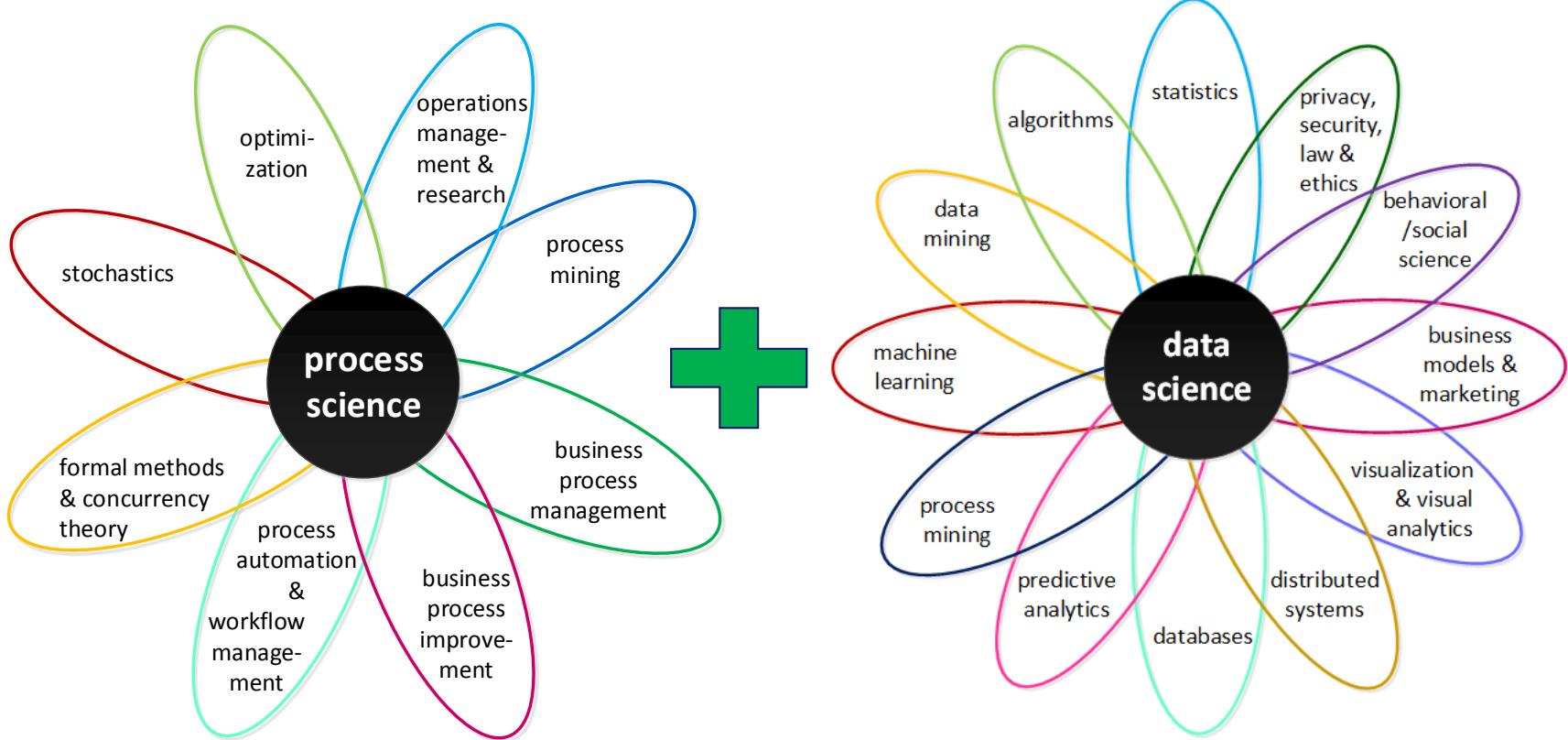
***Thomas Chatain*** - LSV, ENS Cachan, CNRS, INRIA, Cachan, France

***Boudewijn van Dongen*** - Eindhoven University of Technology, The Netherlands

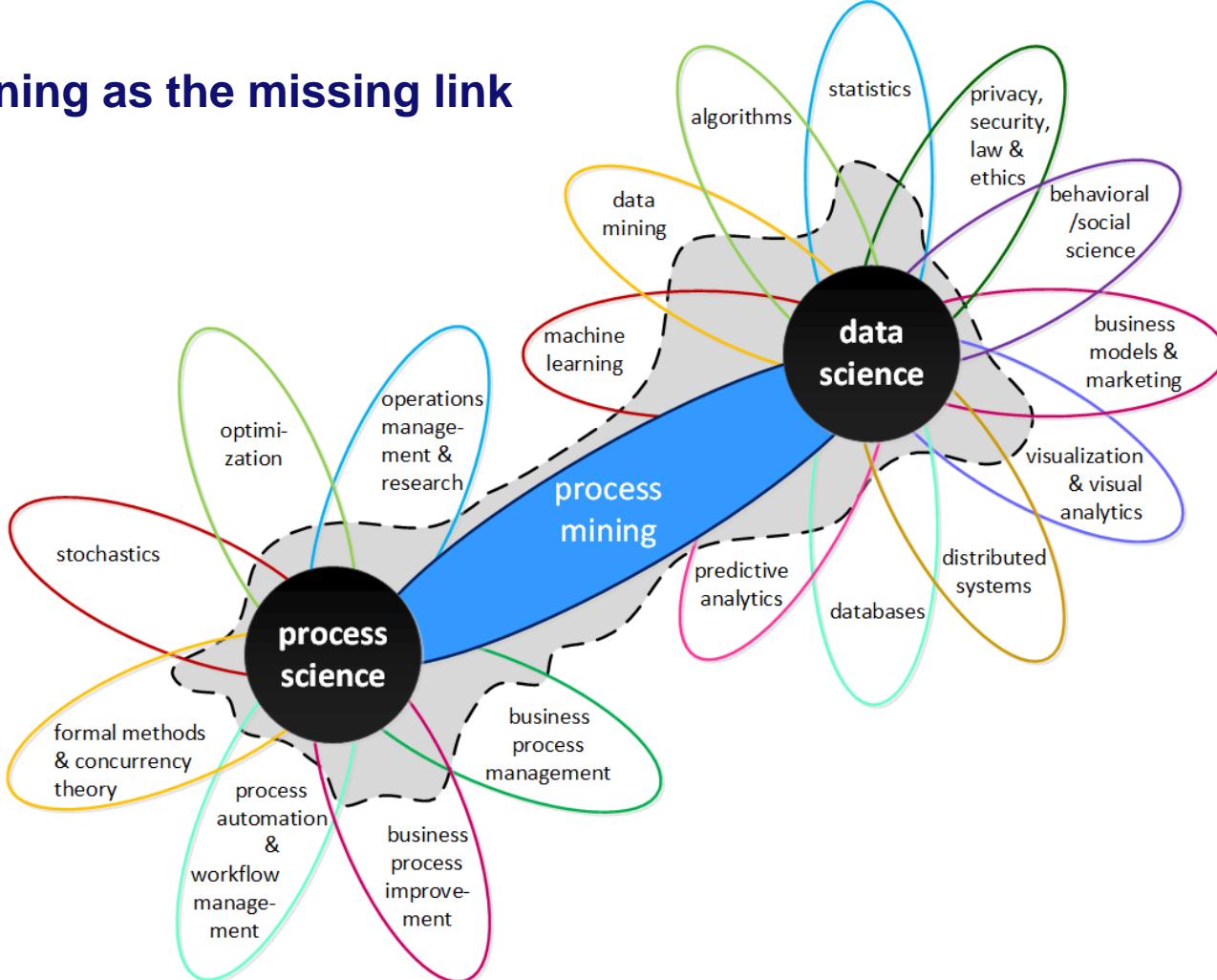
# Programma

- **Module I: A Practical Introduction to Process Mining (1h)** - Introduction to process mining with demos of commercial tools (highlighting the incredible relevance and the limitations of existing tools). (10-11)
- **Module II: Discovering Process Models (1.5h)** - Metrics and desired features. Process discovery with inductive mining as an example of scalable discovery technique. [Opt: Process discovery with region-based approaches] (11.10-12.40)
- **Module III: Conformance Checking (1h)** - Token Replay. Alignments. Selected techniques for the computation of alignments. Alignments applications. (12.50-14)
- **Module IV: Enhancement (1.5h)** - Model Repair. Decision Point Analysis. Performance Analysis. Social Network Analysis. (15-16.30)
- **Module V: ‘Bring Your Own Data’ Session (16:30h - ?)**





# process mining as the missing link



# **Process mining: Spreadsheets for behavior**

# Spreadsheet: Killer App for early computers

C11 <(L) TOTAL			
	A	B	C
1	ITEM	NO.	UNIT
2	---	---	---
3	MUCK RAKE	43	12.95
4	BUZZ CUT	15	6.75
5	TOE TONER	250	49.95
6	EYE SNUFF	2	4.95
7			-----
8		SUBTOTAL	13155.50
9		9.75% TAX	1282.66
10			-----
11		TOTAL	14438.16
12			
13			
14			
15			
16			
17			
18			
19			
20			

- VisiCalc (killer app for Apple II, Oct. 1979)
- Lotus 1-2-3 (killer app for IBM PC 1983)
- Microsoft Excel (1985)



# Spreadsheet: Static data

Screenshot of a Microsoft Excel spreadsheet titled "sales". The spreadsheet contains static data about product sales, including quantity, price, and total price, and includes two charts: a bar chart and a pie chart.

**Data:**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	product	quantity	price	total price												
2	iPhone 6s	2	€ 699.00	€ 1,398.00												
3	iPhone 6s Plus	1	€ 799.00	€ 799.00												
4	iPhone 5s	3	€ 599.00	€ 1,797.00												
5	iPad mini 4	2	€ 399.00	€ 798.00												
6	iPad Air 2	1	€ 499.00	€ 499.00												
7	iPhone 6s Plus	2	€ 799.00	€ 1,598.00												
8	iPad Air 2	2	€ 499.00	€ 998.00												
9	iPhone 6s Plus	1	€ 799.00	€ 799.00												
10	iPhone 6s	1	€ 699.00	€ 699.00												
11	iPhone 6s Plus	2	€ 799.00	€ 1,598.00												
12	iPhone 5s	2	€ 599.00	€ 1,198.00												
13	iPad mini 4	1	€ 399.00	€ 399.00												
14	iPad Air 2	3	€ 499.00	€ 1,497.00												
15	iPhone 5s	3	€ 599.00	€ 1,797.00												
16	iPhone 6s Plus	1	€ 799.00	€ 799.00												
17	iPad Air 2	4	€ 499.00	€ 1,996.00												
18	<b>total</b>	<b>31</b>	<b>€ 18,669.00</b>													
19																
20	<b>average price</b>	<b>€ 602.23</b>														
21																
22																
23																

**Summarized Data:**

product	Sum of total price	Sum of quantity
iPad Air 2	4990	10
iPad mini 4	1197	3
iPhone 5s	4792	8
iPhone 6s	2097	3
iPhone 6s Plus	5593	7
<b>Grand Total</b>	<b>18669</b>	<b>31</b>

**Charts:**

- Bar Chart:** Titled "sales". The Y-axis represents the sum of total price (0 to 6000). The X-axis lists products: iPad Air 2, iPad mini 4, iPhone 5s, iPhone 6s, and iPhone 6s Plus. The chart shows the following approximate values:
  - iPad Air 2: ~5200
  - iPad mini 4: ~1200
  - iPhone 5s: ~5000
  - iPhone 6s: ~2200
  - iPhone 6s Plus: ~5800
- Pie Chart:** Titled "sales (items)". The chart shows the distribution of sales by product type:
  - iPad Air 2: ~45%
  - iPad mini 4: ~5%
  - iPhone 5s: ~20%
  - iPhone 6s: ~15%
  - iPhone 6s Plus: ~25%

**Toolbars and Status Bar:**

- Clipboard: Copy, Paste, Format Painter
- Font: Bold, Italic, Underline, Font Color (Yellow), Alignment, Number, Conditional Formatting, Format as Table, Cell Styles, Insert, Delete, Format, Cells, Editing.
- Cells: Fill, Clear, Sort & Filter, Find & Select.
- Status Bar: 100%, 100%.

# Spreadsheet: Static data

The screenshot shows a Microsoft Excel spreadsheet titled "sales (items)". The data is organized into two main sections: a static header table and a dynamic data table.

**Static Header Table:** Located at the top left, it has columns for "product", "quantity", "price", and "total price". The "product" column lists various Apple devices: iPhone 6s, iPhone 6s Plus, iPhone 5s, iPad mini 4, iPad Air 2, and iPhone 6s Plus. The "quantity" column shows the count of each item sold, ranging from 1 to 4. The "price" column lists the individual price for each item, and the "total price" column calculates the total price for each row.

	product	quantity	price	total price
1	iPhone 6s	2	€ 699.00	€ 1,398.00
2	iPhone 6s Plus	1	€ 799.00	€ 799.00
3	iPhone 5s	3	€ 599.00	€ 1,797.00
4	iPad mini 4	2	€ 399.00	€ 798.00
5	iPad Air 2	1	€ 499.00	€ 499.00
6	iPhone 6s Plus	2	€ 799.00	€ 1,598.00
7	iPad Air 2	2	€ 499.00	€ 998.00
8	iPhone 6s Plus	1	€ 799.00	€ 799.00
9	iPhone 6s	1	€ 699.00	€ 699.00
10	iPhone 6s Plus	2	€ 799.00	€ 1,598.00
11	iPhone 5s	2	€ 599.00	€ 1,198.00
12	iPad mini 4	1	€ 399.00	€ 399.00
13	iPad Air 2	3	€ 499.00	€ 1,497.00
14	iPhone 5s	3	€ 599.00	€ 1,797.00
15	iPhone 6s Plus	1	€ 799.00	€ 799.00
16	iPad Air 2	4	€ 499.00	€ 1,996.00
17				
18	total	31	€ 18,669.00	
19				
20	average price	€ 602.23		
21				
22				
23				

**Dynamic Data Table:** Located below the static header, this table uses the same structure: "product", "quantity", "price", and "total price". It contains 7 rows of data, each corresponding to one of the 7 rows in the static header table. The "product" column lists the same items as the static header, and the "quantity", "price", and "total price" columns show the same values as the static header table.

	product	quantity	price	total price
1	iPhone 6s	2	€ 699.00	€ 1,398.00
2	iPhone 6s Plus	1	€ 799.00	€ 799.00
3	iPhone 5s	3	€ 599.00	€ 1,797.00
4	iPad mini 4	2	€ 399.00	€ 798.00
5	iPad Air 2	1	€ 499.00	€ 499.00
6	iPhone 6s Plus	2	€ 799.00	€ 1,598.00
7	iPad Air 2	3	€ 499.00	€ 1,497.00

**Filter Bar:** At the bottom of the screen, there is a filter bar with dropdown menus for "2", "mini 4", "5s", "6s", and "6s Plus".

**Toolbar:** The top of the screen features a standard Excel toolbar with icons for Copy, Paste, Format Painter, Clipboard, Font, Alignment, Number, Conditional Formatting, Format as Table, Cell Styles, Insert, Delete, Format, Fill, Clear, Sort & Filter, Find & Select, and Editing.

# Spreadsheet: Static data

S13

fact

product	quantity	price	total price
iPhone 6s	2	€ 699.00	€ 1,398.00
iPhone 6s Plus	1	€ 799.00	€ 799.00
iPhone 5s	3	€ 599.00	€ 1,797.00
iPad mini 4	2	€ 399.00	€ 798.00
iPad Air 2	1	€ 499.00	€ 499.00
iPhone 6s Plus	2	€ 799.00	€ 1,598.00
iPad Air 2	2	€ 499.00	€ 998.00
iPhone 6s Plus	1	€ 799.00	€ 799.00
iPhone 6s	1	€ 699.00	€ 699.00
iPhone 6s Plus	2	€ 799.00	€ 1,598.00
iPhone 5s	2	€ 599.00	€ 1,198.00
iPad mini 4	1	€ 399.00	€ 399.00
iPad Air 2	3	€ 499.00	€ 1,497.00
iPhone 5s	3	€ 599.00	€ 1,797.00
iPhone 6s Plus	1	€ 799.00	€ 799.00
iPad Air 2	4	€ 499.00	€ 1,996.00
<b>total</b>	<b>31</b>	<b>€ 18,669.00</b>	
<b>average price</b>	<b>€ 602.23</b>		

1	product	quantity	price	total price
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7	iPhone 6s	1	€ 699.00	€ 699.00
8	iPhone 6s Plus	2	€ 799.00	€ 1,598.00
9	iPhone 5s	3	€ 599.00	€ 1,797.00
10	iPad Air 2	2	€ 499.00	€ 998.00
11	iPhone 6s Plus	1	€ 799.00	€ 799.00
12	iPhone 6s	1	€ 699.00	€ 699.00
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18	iPhone 6s Plus	1	€ 799.00	€ 799.00
19	iPad Air 2	4	€ 499.00	€ 1,996.00
20	<b>total</b>	<b>31</b>	<b>€ 18,669.00</b>	
21	<b>average price</b>	<b>€ 602.23</b>		

sales (items)

Pad Air 2  
Pad mini 4  
Phone 5s  
Phone 6s  
Phone 6s Plus

2 mini 4 5s 6s 6s Plus

Ready sales

# Spreadsheet: Static data

S13	product	quantity	price	total price
1	iPhone 6s	2	€ 699.00	€ 1,398.00
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8	iPad Air 2	2	€ 499.00	€ 998.00
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18	total	31	€ 18,669.00	
20	average price	€ 602.23		

1	product	quantity	price	total price
2	iPhone 6s	2	€ 699.00	€ 1,398.00
3	iPhone 6s Plus	1	€ 799.00	€ 799.00
4	iPhone 5s	3	€ 599.00	€ 1,797.00
5	iPad mini 4	2	€ 399.00	€ 798.00
6	iPad Air 2	1	€ 499.00	€ 499.00
7	iPhone 6s Plus	2	€ 799.00	€ 1,598.00

# Spreadsheet: Static data

Screenshot of a Microsoft Excel spreadsheet titled "sales". The spreadsheet contains data about various Apple products and their sales performance.

The data is organized into three main sections:

- Product Data:** A table showing individual product sales with columns for product name, quantity, and price.
- Summary Data:** A table showing totals for each product category (Sum of total price and Sum of quantity).
- Grand Total:** A row summarizing the overall sales figures.

Annotations highlight specific data points:

- A green callout box labeled "total value" points to the cell containing the Grand Total value of **18,669.00**.
- A green callout box labeled "31 items sold" points to the cell containing the Grand Total quantity of **31**.
- A green callout box labeled "average" points to the cell containing the average price of **€ 602.23**.
- A green callout box labeled "distribution" points to a pie chart titled "sales (items)" showing the distribution of sales by product type.

Below the spreadsheet, there are two charts:

- A bar chart titled "sales" comparing the sum of total price for different products.
- A pie chart titled "sales (items)" showing the distribution of sales by product type.

Excel ribbon tabs visible at the top include: Home, Insert, Page Layout, Formulas, Data, Page Break Preview, and View.

	product	quantity	price
1	iPhone 6s	2	€ 699.00
2	iPhone 6s Plus	1	€ 799.00
3	iPhone 5s	3	€ 599.00
4	iPad mini 4	2	€ 399.00
5	iPad Air 2	1	€ 499.00
6	iPhone 6s Plus	2	€ 799.00
7	iPhone 6s	9	€ 999.00
8	iPhone 5s	9	€ 799.00
9	iPad mini 4	9	€ 699.00
10	iPhone 6s	9	€ 999.00
11	iPhone 6s Plus	9	€ 1,199.00
12	iPhone 5s	9	€ 1,199.00
13	iPad mini 4	4	€ 399.00
14	iPad Air 2	4	€ 499.00
15	iPhone 5s	3	€ 599.00
16	iPhone 6s Plus	1	€ 799.00
17	iPad Air 2	4	€ 499.00
18	<b>total</b>	<b>31</b>	<b>€ 18,669.00</b>
19			
20	<b>average price</b>	<b>€ 602.23</b>	
21			
22			
23			

product	Sum of total price	Sum of quantity
iPad Air 2	4990	10
iPad mini 4	1197	3
iPhone 5s	4792	8
iPhone 6s	2097	3
iPhone 6s Plus	5593	7
<b>Grand Total</b>	<b>18669</b>	<b>31</b>

sales

sales (items)

average

total value

31 items sold

distribution

# Spreadsheet: Static data

S13

## How to analyze operational processes?

	A
1	product
2	iPhone 6s
3	iPhone 6s
4	iPhone 5s
5	iPad mini 4
6	iPad Air 2
7	iPhone 6s Plus
8	iPad Air 2
9	iPhone 6s Plus
10	iPhone 6s
11	iPhone 6s Plus
12	iPhone 5s
13	iPad mini 4
14	iPad Air 2
15	iPhone 5s
16	iPhone 6s Plus
17	iPad Air 2
18	<b>total</b>
	31
	<b>€ 18,669.00</b>
19	
20	<b>average price</b> € 602.23
21	
22	
23	

sales

Device	Sum of total price	Sum of quantity
iPad Air 2	~5200	~1000
iPad mini 4	~1200	~300
iPhone 5s	~5000	~800
iPhone 6s	~2200	~300
iPhone 6s Plus	~5800	~700

Device	Percentage
iPad Air 2	~35%
iPad mini 4	~5%
iPhone 5s	~20%
iPhone 6s	~15%
iPhone 6s Plus	~25%

# Process Mining: Spreadsheet for behavior

A	B		C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody	2007/09/11 13:26:29.000
4	185783	050 Plannen afspraak 1e inspectie	somebody	2007/09/11 13:29:34.000
5	185783	060 Aanmaken bevestigingbrief / huuropzeggingform.	somebody	2007/09/11 13:41:36.000
6	185783	070 Is 1e inspectie uitgevoerd ?	somebody	2007/09/24 08:39:32.000
7	185783	100 Gereedmelden 1e insp. / Voorcalculatie maken	somebody	2007/09/24 08:41:26.000
8	185783	120 Plannen eindinspectie	somebody	2007/09/24 08:51:00.000
9	185783	400 Is eindinspectie uitgevoerd ?	somebody	2007/09/24 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody	2007/09/24 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody	2007/09/24 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody	2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody	2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:19.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody	2007/09/24 11:01:58.000
17	185783	150 Is er sprake van ZAV ?	somebody	2007/09/24 11:37:33.000
18	185783	180 Aanpassen woningwaardering	somebody	2007/09/24 11:37:44.000
19	185783	190 Harmoniseren huurprijs	somebody	2007/09/24 11:40:01.000
20	185783	205 Bepalen kandidaat huurder	somebody	2007/09/24 11:47:42.000
21	185783	170 Aanpassen plattegrond	somebody	2007/09/24 12:10:58.000
22	185783	520 Aanmaken 2e in gebreke stelling	somebody	2007/10/30 11:45:53.000
23	185783	530 Aanmaken werkopdracht	somebody	2007/10/30 11:46:09.000
24	185783	540 Worden er bonussen/ kosten toegekend ?	somebody	2007/10/30 11:46:36.000
25	185783	550 Vastleggen bonussen / kosten	somebody	2007/10/30 11:53:00.000
26	185783	240 Registreren voorl. huurovereenkomst +afdrukken	somebody	2007/11/28 12:34:23.000
27	185783	260 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

- Input: events (“things that have happened”)
- Mandatory per event:
  - case identifier
  - activity name
  - timestamp/date
- Optional
  - resource
  - transaction type
  - costs
  - ...

# Process Mining: Spreadsheet for behavior

A	B	C	D	
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000
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5	185783	060 Aanmaken 1e in gebreke stelling	somebody	2007/09/11 13:41:36.000
6	185783	070 Is 1e in gebreke stelling goed te maken	somebody	2007/09/24 08:39:32.000
7	185783	100 Gereedmaken voor oplevering	somebody	2007/09/24 08:41:26.000
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20	185783	205 Bepalen kandidaat huurder	somebody	2007/09/24 11:47:42.000
21	185783	170 Aanpassen plattegrond	somebody	2007/09/24 12:10:58.000
22	185783	520 Aanmaken 2e in gebreke stelling	somebody	2007/10/30 11:45:53.000
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row = event

- **Input: events (“things that have happened”)**
- **Mandatory per event:**
  - **case identifier**
  - **activity name**
  - **timestamp/date**
- **Optional**
  - **resource**
  - **transaction type**
  - **costs**
  - **...**

# Process Mining: Spreadsheet for behavior

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6	185783	070 Is 1e in gebreke goedkeurd ?	somebody	2007/09/24 08:39:32.000
7	185783	100 Gereedstellen voor oplevering	somebody	2007/09/24 08:41:26.000
8	185783	120 Plannen oplevering	somebody	2007/09/24 08:51:00.000
9	185783	400 Is een inspectie uitgevoerd ?	somebody	2007/09/24 10:55:56.000
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13	185783	110 Bepalen leegstandsoort	somebody	2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:19.000
16	185783	40 Aanmaken 1e in gebreke stelling	somebody	2007/09/24 11:01:58.000
17	185783	50 Is er sprake van ZAV ?	somebody	2007/09/24 11:37:33.000
18	185783	100 Aanpassen woningwaardering	somebody	2007/09/24 11:37:44.000
19	185783	150 Harmoniseren huurprijs	somebody	2007/09/24 11:40:01.000
20	185783	200 Bepalen kandidaat huurder	somebody	2007/09/24 11:47:42.000
21	185783	250 Bepassen plattegrond	somebody	2007/09/24 12:10:58.000
22	185783	300 Bepassen voorbereiding oplevering	somebody	2007/10/30 11:45:53.000
23	185783	350 Bepassen voorbereiding oplevering	somebody	2007/10/30 11:46:09.000
24	185783	400 Kosten toegekend ?	somebody	2007/10/30 11:46:36.000
25	185783	450 Kosten	somebody	2007/10/30 11:53:00.000
26	185783	500 Vereenkomst +afdrukken	somebody	2007/11/28 12:34:23.000
27	185783	200 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

row = event

case identifier

- Input: **events** (“things that have happened”)
- Mandatory per event:
  - **case identifier**
  - **activity name**
  - **timestamp/date**
- Optional
  - **resource**
  - **transaction type**
  - **costs**
  - ...

# Process Mining: Spreadsheet for behavior

A	B	C	D
1	Case ID	Activity	Resource Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody 2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody 2007/09/11 13:26:29.000
4	185783	050 Plannen oplevering 1e in gebreke	somebody 2007/09/11 13:29:34.000
5	185783	060 Aanmaken 1e in gebreke stelling	somebody 2007/09/11 13:41:36.000
6	185783	070 Is 1e in gebreke stelling goed teken	somebody 2007/09/24 08:39:32.000
7	185783	100 Geremoveerd	somebody 2007/09/24 08:41:26.000
8	185783	120 Plannen herstel	somebody 2007/09/24 08:51:00.000
9	185783	400 Is een inspectie uitgevoerd ?	somebody 2007/09/24 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody 2007/09/24 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody 2007/09/24 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody 2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody 2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody 2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody 2007/09/24 10:58:19.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody 2007/09/24 11:01:58.000
17	185783	150 Is er sprake van ZAV ?	somebody 2007/09/24 11:37:33.000
18	185783	160 Aanpassen woningwaardering	somebody 2007/09/24 11:37:44.000
19	185783	170 Harmoniseren huurprijs	somebody 2007/09/24 11:40:01.000
20	185783	180 Bepalen kandidaat huurder	somebody 2007/09/24 11:47:42.000
21	185783	190 Bepassen plattegrond	somebody 2007/09/24 12:10:58.000
22	185783	200 Oplevering 1e in gebreke stelling	somebody 2007/10/30 11:45:53.000
23	185783	210 Versturen huurbrief	somebody 2007/10/30 11:46:09.000
24	185783	220 Bepassen kosten huurder	somebody 2007/10/30 11:46:36.000
25	185783	230 Bepassen kosten huurder	somebody 2007/10/30 11:53:00.000
26	185783	240 Bepassen huurperiode	somebody 2007/11/28 12:34:23.000
27	185783	250 Is contract getekend en geld ontvangen ?	somebody 2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody 2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody 2007/12/12 11:19:41.000

row = event

case identifier

activity name

- Input: **events** (“things that have happened”)
- Mandatory per event:
  - **case identifier**
  - **activity name**
  - **timestamp/date**
- Optional
  - **resource**
  - **transaction type**
  - **costs**
  - ...

# Process Mining: Spreadsheet for behavior

A	B	C	D
1	Case ID	Activity	Resource Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody 2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody 2007/09/11 13:26:29.000
4	185783	050 Plannen oplevering 1e in gebreke	somebody 2007/09/11 13:29:34.000
5	185783	060 Aanmaken 1e in gebreke stelling	somebody 2007/09/11 13:41:36.000
6	185783	070 Is 1e in gebreke stelling goed teken	somebody 2007/09/24 08:39:32.000
7	185783	100 Gereedstellen voor oplevering	somebody 2007/09/24 08:41:26.000
8	185783	120 Plannen oplevering	somebody 2007/09/24 08:51:00.000
9	185783	400 Is de controles inspectie uitgevoerd ?	somebody 2007/09/24 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody 2007/09/24 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody 2007/09/24 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody 2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody 2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody 2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody 2007/09/24 10:58:14.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody 2007/09/24 11:01:00.000
17	185783	150 Is er sprake van ZAV ?	somebody 2007/09/24 11:37:10.000
18	185783	160 Aanpassen woningwaardering	somebody 2007/09/24 11:37:10.000
19	185783	170 Harmoniseren huurprijs	somebody 2007/09/24 11:40:00.000
20	185783	180 Bepalen kandidaat huurder	somebody 2007/09/24 11:47:40.000
21	185783	190 Bepassen plattegrond	somebody 2007/09/24 12:10:58.000
22	185783	200 Oplevering 1e in gebreke stelling	somebody 2007/10/30 11:10:00.000
23	185783	210 Bepassen kosten tijdelijke huur	somebody 2007/10/30 11:10:00.000
24	185783	220 Bepassen kosten tijdelijke huur	somebody 2007/10/30 11:10:00.000
25	185783	230 Bepassen kosten tijdelijke huur	somebody 2007/10/30 11:10:00.000
26	185783	240 Bepassen kosten tijdelijke huur	somebody 2007/11/28 12:00:00.000
27	185783	250 Is contract getekend en geld ontvangen ?	somebody 2007/12/10 10:44:56.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody 2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody 2007/12/12 11:19:41.000

row = event

case identifier

activity name

timestamp

- Input: **events** (“things that have happened”)
- Mandatory per event:
  - case identifier
  - activity name
  - timestamp/date
- Optional
  - resource
  - transaction type
  - costs
  - ...

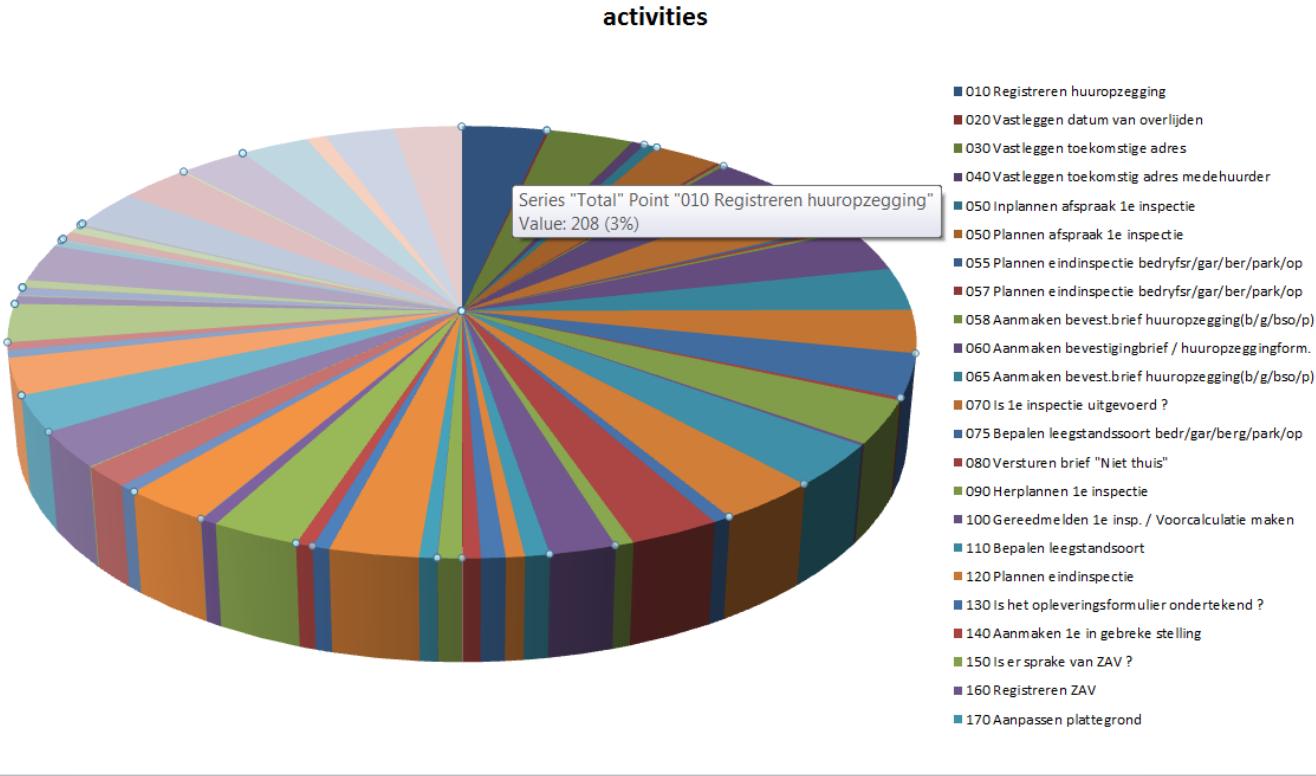
# Process Mining: Spreadsheet for behavior

A	B		C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody	2007/09/11 13:26:29.000
4	185783	050 Plannen oplevering 1e in gebreke	somebody	2007/09/11 13:27:00.000
5	185783	060 Aanpassen woningwaardering	somebody	2007/09/11 13:27:00.000
6	185783	070 Is 1e in gebreke te herstellen ?	somebody	2007/09/11 13:27:00.000
7	185783	100 Gereedmaken voor oplevering	somebody	2007/09/11 13:27:00.000
8	185783	120 Plannen oplevering	somebody	2007/09/11 13:27:00.000
9	185783	400 Is een inspectie uitgevoerd ?	somebody	2007/09/14 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody	2007/09/14 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody	2007/09/14 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody	2007/09/14 10:57:00.000
13	185783	110 Bepalen leegstandsoort	somebody	2007/09/14 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/14 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/14 10:58:10.000
16	185783	440 Aanmaken 1e in gebreke status	somebody	2007/09/14 11:01:00.000
17	185783	400 Is er sprake van ZAV ?	somebody	2007/09/14 11:37:00.000
18	185783	Aanpassen woningwaardering	somebody	2007/09/14 11:37:00.000
19	185783	Harmoniseren huurprijs	somebody	2007/09/14 11:40:00.000
20	185783	Bepalen kandidaat huurder	somebody	2007/09/14 11:47:40.000
21	185783	Bepassen plattegrond	somebody	2007/09/14 12:10:58.000
22	185783	Stellen huurcontract op	somebody	2007/10/30 11:00:00.000
23	185783	Wijzigen huurcontract	somebody	2007/10/30 11:00:00.000
24	185783	Aanpassen kosten huurcontract	somebody	2007/10/30 11:00:00.000
25	185783	Vereniging huurcontract	somebody	2007/10/30 11:00:00.000
26	185783	Opstellen huurcontract	somebody	2007/11/28 12:00:00.000
27	185783	200 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:50.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

- Input: **events** (“things that have happened”)
- Mandatory per event:
  - **case identifier**
  - **activity name**
  - **timestamp/date**
- Optional
  - **resource**
  - **transaction type**
  - **costs**
  - ...

# Process Mining: Spreadsheet for behavior

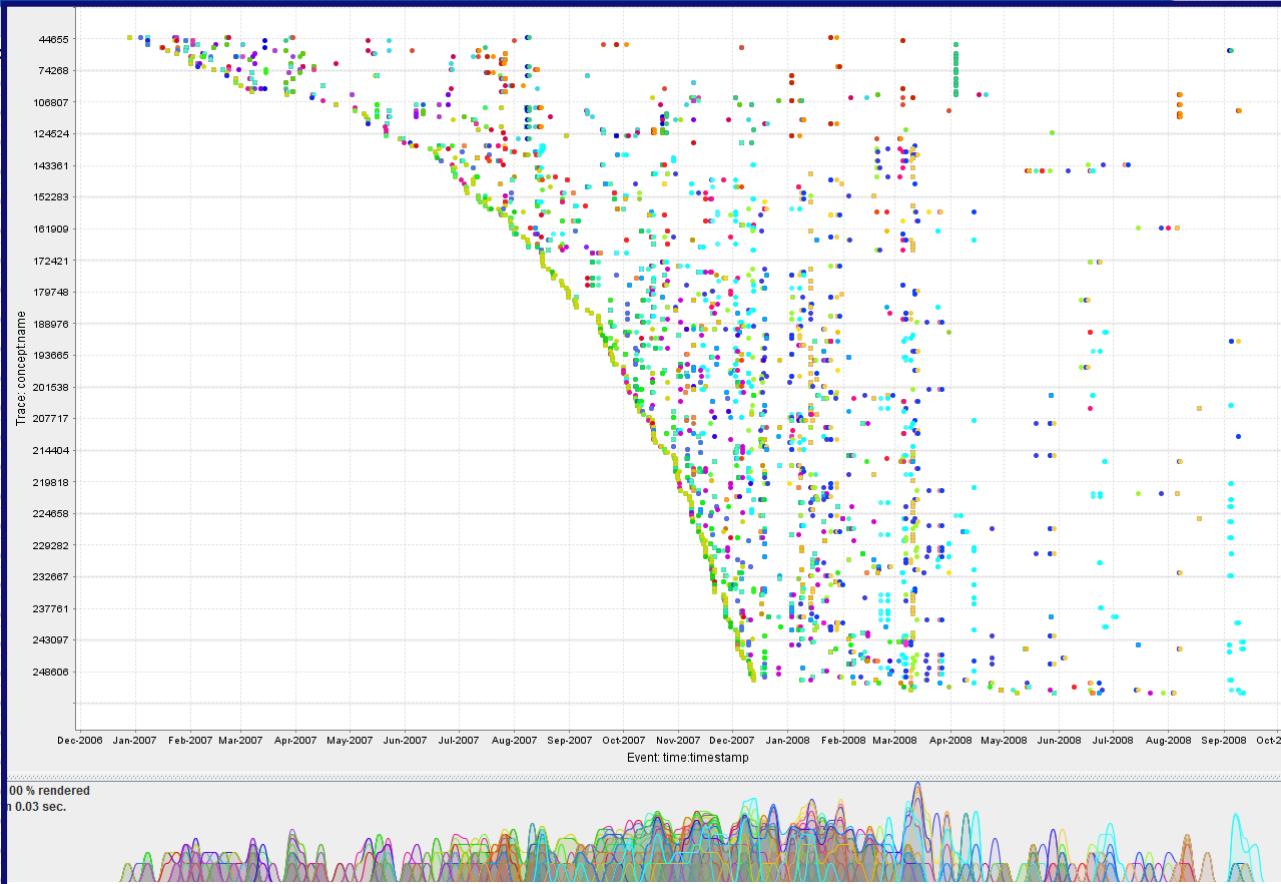
A	B	C	D
Case ID	Activity	Resource	Complete Timestamp
1	Case ID Activity		
2	185783 010 Registreren huuropzegging	somebody	2007/09/11 13:21:27-0000
3	185783 030 Vastleggen toekomstige adres	somebody	2007
4	185783 050 Plannen afspraak 1e inspectie	somebody	2007
5	185783 060 Aanmaken bevestigingbrief / huuropzeggingfo	somebody	2007
6	185783 070 Is 1e inspectie uitgevoerd ?	somebody	2007
7	185783 100 Gereedmelden 1e insp. / Voorcalculatie maker	somebody	2007
8	185783 120 Plannen eindinspectie	somebody	2007
9	185783 400 Is eindinspectie uitgevoerd ?	somebody	2007
10	185783 440 Zijn er nieuwe of niet herstelde gebreken ?	somebody	2007
11	185783 450 Krijgt de huurder tijd om te herstellen ?	somebody	2007
12	185783 500 Beoordelen/wijzigen leegstandsoort	somebody	2007
13	185783 110 Bepalen leegstandsoort	somebody	2007
14	185783 510 Is opleveringsformulier ondertekend ?	somebody	2007
15	185783 130 Is het opleveringsformulier ondertekend ?	somebody	2007
16	185783 140 Aanmaken 1e in gebreke stelling	somebody	2007
17	185783 150 Is er sprake van ZAV ?	somebody	2007
18	185783 180 Aanpassen woningwaardering	somebody	2007
19	185783 190 Harmoniseren huurprijs	somebody	2007
20	185783 205 Bepalen kandidaat huurder	somebody	2007
21	185783 170 Aanpassen plattegrond	somebody	2007
22	185783 520 Aanmaken 2e in gebreke stelling	somebody	2007
23	185783 530 Aanmaken werkopdracht	somebody	2007
24	185783 540 Worden er bonussen/ kosten toegekend ?	somebody	2007
25	185783 550 Vastleggen bonussen / kosten	somebody	2007
26	185783 240 Registreren voorl. huurovereenkomst +afdrukk	somebody	2007
27	185783 260 Is contract getekend en geld ontvangen ?	somebody	2007
28	185783 300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007
29	185783	somebody	2007
30	185783	somebody	2007
31	185783	somebody	2008
32	185783	somebody	2008
33	185783	somebody	2008
34	185783	somebody	2008
35	246926	somebody	2007
36	246926	somebody	2007
37	246926 050 Plannen afspraak 1e inspectie	somebody	2007
38	246926 060 Aanmaken bevestigingbrief / huuropzeggingfo	somebody	2007/12/07 12:31:57-0000



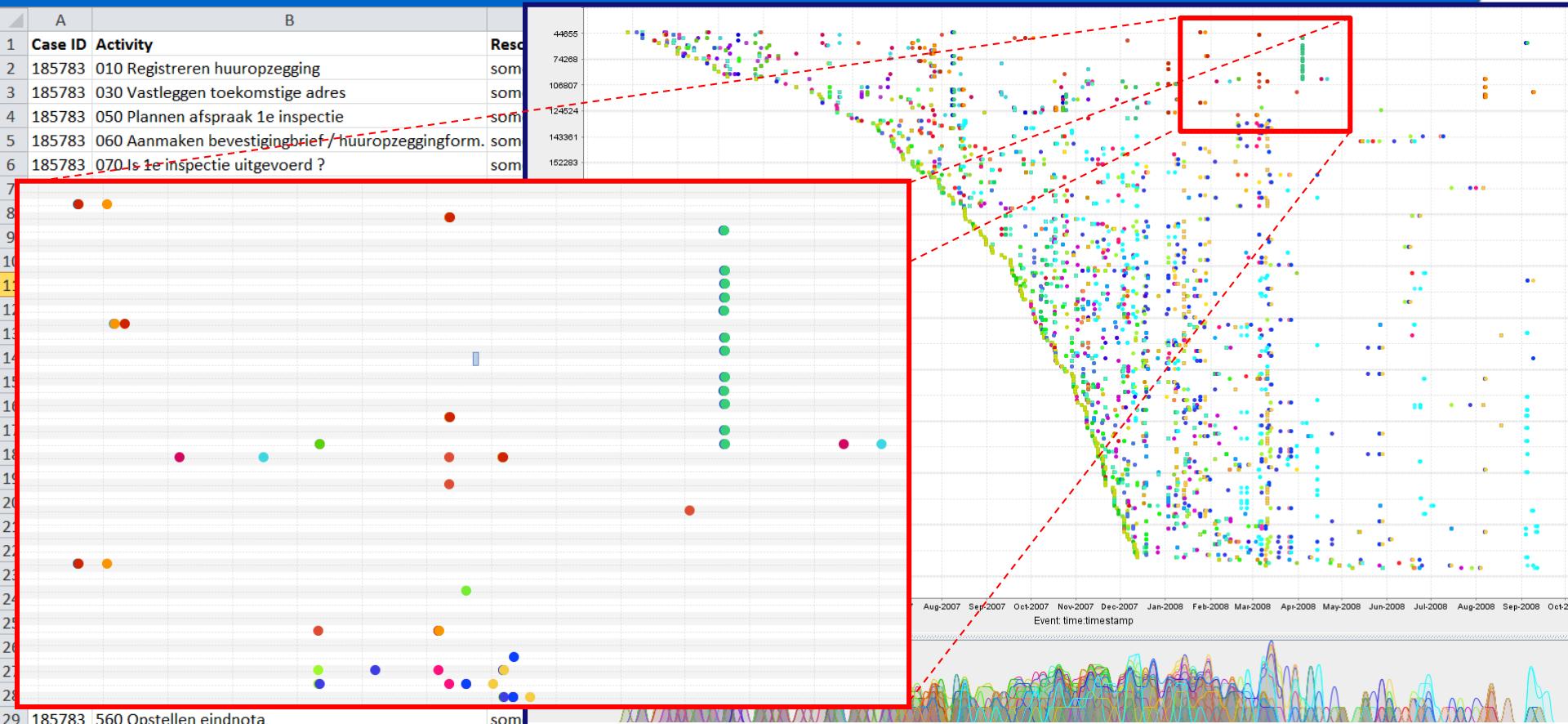
**208 cases  
5987 events  
74 activities**

# Process Mining: Spreadsheet for behavior

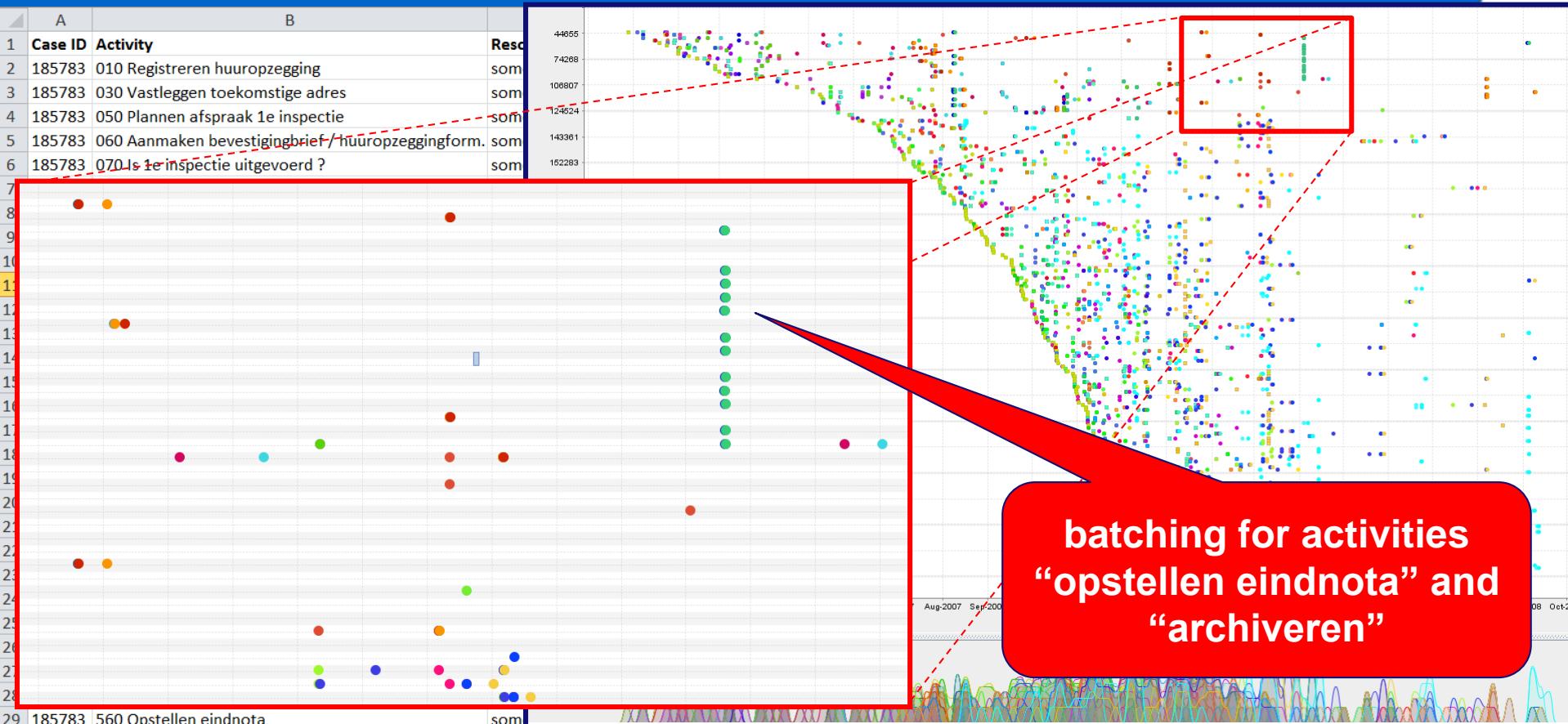
A	B	C	
1	Case ID	Activity	Responsible
2	185783	010 Registreren huuropzegging	som
3	185783	030 Vastleggen toekomstige adres	som
4	185783	050 Plannen afspraak 1e inspectie	som
5	185783	060 Aanmaken bevestigingbrief / huuropzeggingform.	som
6	185783	070 Is 1e inspectie uitgevoerd ?	som
7	185783	100 Gereedmelden 1e insp. / Voorcalculatie maken	som
8	185783	120 Plannen eindinspectie	som
9	185783	400 Is eindinspectie uitgevoerd ?	som
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	som
11	185783	450 Krijgt de huurder tijd om te herstellen ?	som
12	185783	500 Beoordelen/wijzigen leegstandsoort	som
13	185783	110 Bepalen leegstandsoort	som
14	185783	510 Is opleveringsformulier ondertekend ?	som
15	185783	130 Is het opleveringsformulier ondertekend ?	som
16	185783	140 Aanmaken 1e in gebreke stelling	som
17	185783	150 Is er sprake van ZAV ?	som
18	185783	180 Aanpassen woningwaardering	som
19	185783	190 Harmoniseren huurprijs	som
20	185783	205 Bepalen kandidaat huurder	som
21	185783	170 Aanpassen plattegrond	som
22	185783	520 Aanmaken 2e in gebreke stelling	som
23	185783	530 Aanmaken werkopdracht	som
24	185783	540 Worden er bonussen/ kosten toegekend ?	som
25	185783	550 Vastleggen bonussen / kosten	som
26	185783	240 Registreren voorl. huurovereenkomst +afdrukken	som
27	185783	260 Is contract getekend en geld ontvangen ?	som
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	som
29	185783	560 Opstellen eindnota	som



# Process Mining: Spreadsheet for behavior



# Process Mining: Spreadsheet for behavior





Loesje van  
der Aalst

desire line

Process Discovery

# Process Mining: Spreadsheet for behavior

A	B		C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody	2007/09/11 13:26:29.000
4	185783	050 Plannen afspraak 1e inspectie	somebody	2007/09/11 13:29:34.000
5	185783	060 Aanmaken bevestigingbrief / huuropzeggingform.	somebody	2007/09/11 13:41:36.000
6	185783	070 Is 1e inspectie uitgevoerd ?	somebody	2007/09/24 08:39:32.000
7	185783	100 Gereedmelden 1e insp. / Voorcalculatie maken	somebody	2007/09/24 08:41:26.000
8	185783	120 Plannen eindinspectie	somebody	2007/09/24 08:51:00.000
9	185783	400 Is eindinspectie uitgevoerd ?	somebody	2007/09/24 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody	2007/09/24 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody	2007/09/24 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody	2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody	2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:19.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody	2007/09/24 11:01:58.000
17	185783	150 Is er sprake van ZAV ?	somebody	2007/09/24 11:37:33.000
18	185783	180 Aanpassen woningwaardering	somebody	2007/09/24 11:37:44.000
19	185783	190 Harmoniseren huurprijs	somebody	2007/09/24 11:40:01.000
20	185783	205 Benennen kandidaat huurder	somebody	2007/09/24 11:47:42.000

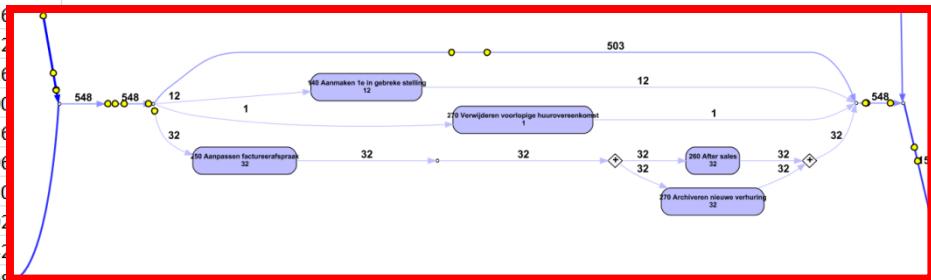
*process discovery*



27	185783	260 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

# Process Mining: Spreadsheet for behavior

A	B		C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody	2007/09/11 13:26:29.000
4	185783	050 Plannen afspraak 1e inspectie	somebody	2007/09/11 13:29:34.000
5	185783	060 Aanmaken bevestigingbrief / huuropzeggingform.	somebody	2007/09/11 13:41:30.000
6	185783	070 Is 1e inspectie uitgevoerd ?	somebody	2007/09/24 08:39:32.000
7	185783	100 Gereedmelden 1e insp. / Voorcalculatie maken	somebody	2007/09/24 08:41:20.000
8	185783	120 Plannen eindinspectie	somebody	2007/09/24 08:51:00.000
9	185783	400 Is eindinspectie uitgevoerd ?	somebody	2007/09/24 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody	2007/09/24 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody	2007/09/24 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody	2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody	2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:19.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody	2007/09/24 11:01:58.000
17	185783	150 Is er sprake van ZAV ?	somebody	2007/09/24 11:37:33.000
18	185783	180 Aanpassen woningwaardering	somebody	2007/09/24 11:37:44.000
19	185783	190 Harmoniseren huurprijs	somebody	2007/09/24 11:40:01.000
20	185783	205 Bepalen kandidaat huurder	somebody	2007/09/24 11:47:42.000



# *process discovery*

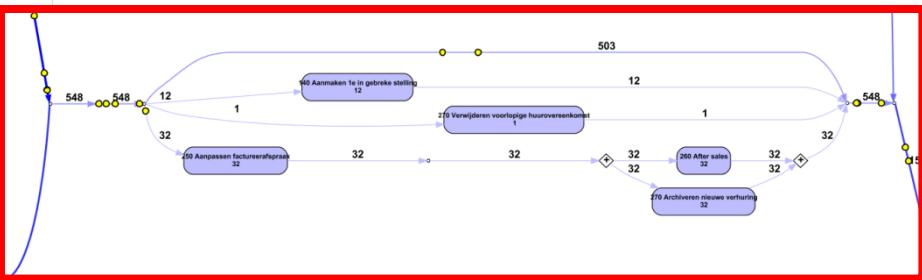


27	185783	260 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

# Process Mining: Spreadsheet for behavior

A	B		C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzagging	somebody	2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody	2007/09/11 13:26:29.000
4	185783	050 Plannen afspraak 1e inspectie	somebody	2007/09/11 13:29:34.000
5	185783	060 Aanmaken bevestigingbrief / huuropzaggingform.	somebody	2007/09/11 13:41:30.000
6	185783	070 Is 1e inspectie uitgevoerd ?	somebody	2007/09/24 08:39:32.000
7	185783	100 Opleveringsformulier / Voorbereiding maken	somebody	2007/09/24 08:41:26.000
8	185783	120 Is de voorbereiding gedaan ?	somebody	2007/09/24 08:51:00.000
9	185783	400 Is er sprake van gebreken ?	somebody	2007/09/24 10:55:56.000
10	185783	410 Is de gebreken opgelost ?	somebody	2007/09/24 10:56:06.000
11	185783	420 Is de gebreken hersteld ?	somebody	2007/09/24 10:56:10.000
12	185783	500 Aanmaken huurdersgegevens	somebody	2007/09/24 10:57:02.000
13	185783	110 Bepalen huurdersgegevens	somebody	2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:19.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody	2007/09/24 11:01:58.000
17	185783	150 Is er sprake van ZAV ?	somebody	2007/09/24 11:37:33.000
18	185783	180 Aanpassen woningwaardering	somebody	2007/09/24 11:37:44.000
19	185783	190 Harmoniseren huurprijs	somebody	2007/09/24 11:40:01.000
20	185783	205 Bepalen kandidaat huurder	somebody	2007/09/24 11:47:42.000

# *process discovery*



**NO  
modeling  
needed!**

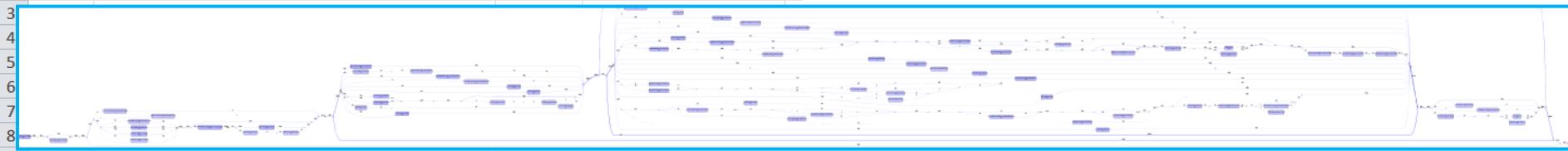


27	185783	260 ls contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

# Process Mining: Spreadsheet for behavior

A	B		C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000

*process discovery*

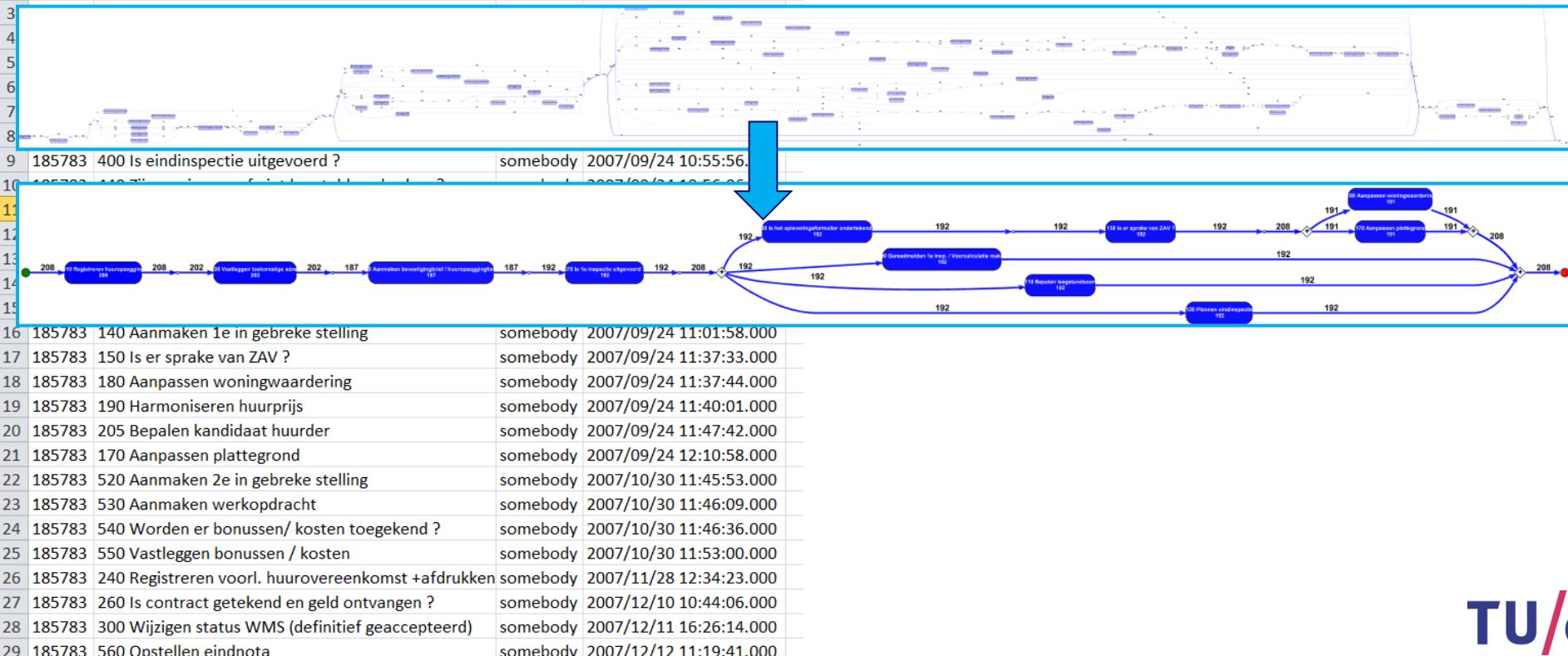


9	185783	400 Is eindinspectie uitgevoerd ?	somebody	2007/09/24 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody	2007/09/24 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody	2007/09/24 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody	2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody	2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:19.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody	2007/09/24 11:01:58.000
17	185783	150 Is er sprake van ZAV ?	somebody	2007/09/24 11:37:33.000
18	185783	180 Aanpassen woningwaardering	somebody	2007/09/24 11:37:44.000
19	185783	190 Harmoniseren huurprijs	somebody	2007/09/24 11:40:01.000
20	185783	205 Bepalen kandidaat huurder	somebody	2007/09/24 11:47:42.000
21	185783	170 Aanpassen plattegrond	somebody	2007/09/24 12:10:58.000
22	185783	520 Aanmaken 2e in gebreke stelling	somebody	2007/10/30 11:45:53.000
23	185783	530 Aanmaken werkopdracht	somebody	2007/10/30 11:46:09.000
24	185783	540 Worden er bonussen/ kosten toegekend ?	somebody	2007/10/30 11:46:36.000
25	185783	550 Vastleggen bonussen / kosten	somebody	2007/10/30 11:53:00.000
26	185783	240 Registreren voorl. huurovereenkomst +afdrukken	somebody	2007/11/28 12:34:23.000
27	185783	260 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

# Process Mining: Spreadsheet for behavior

A	B	C	D	
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000

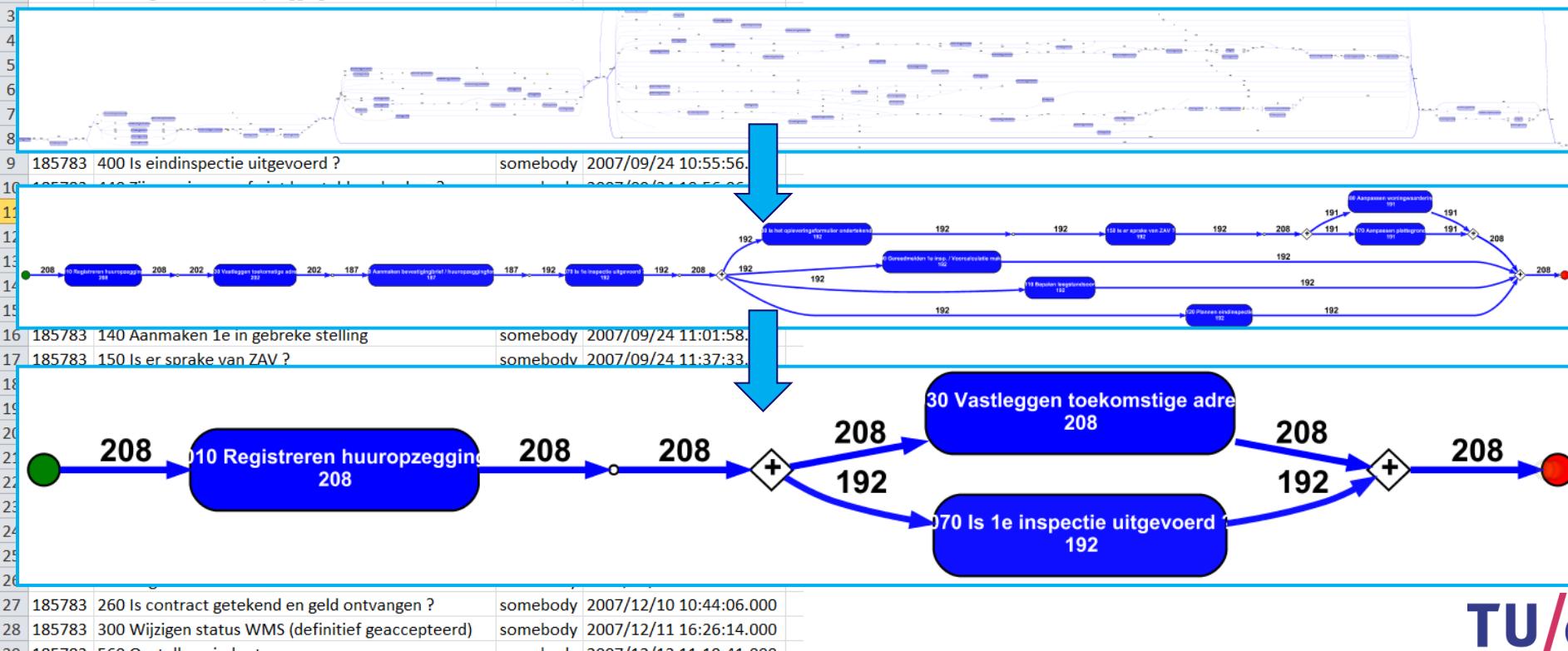
process discovery



# Process Mining: Spreadsheet for behavior

A	B	C	D	
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody	2007/09/11 13:21:27.000

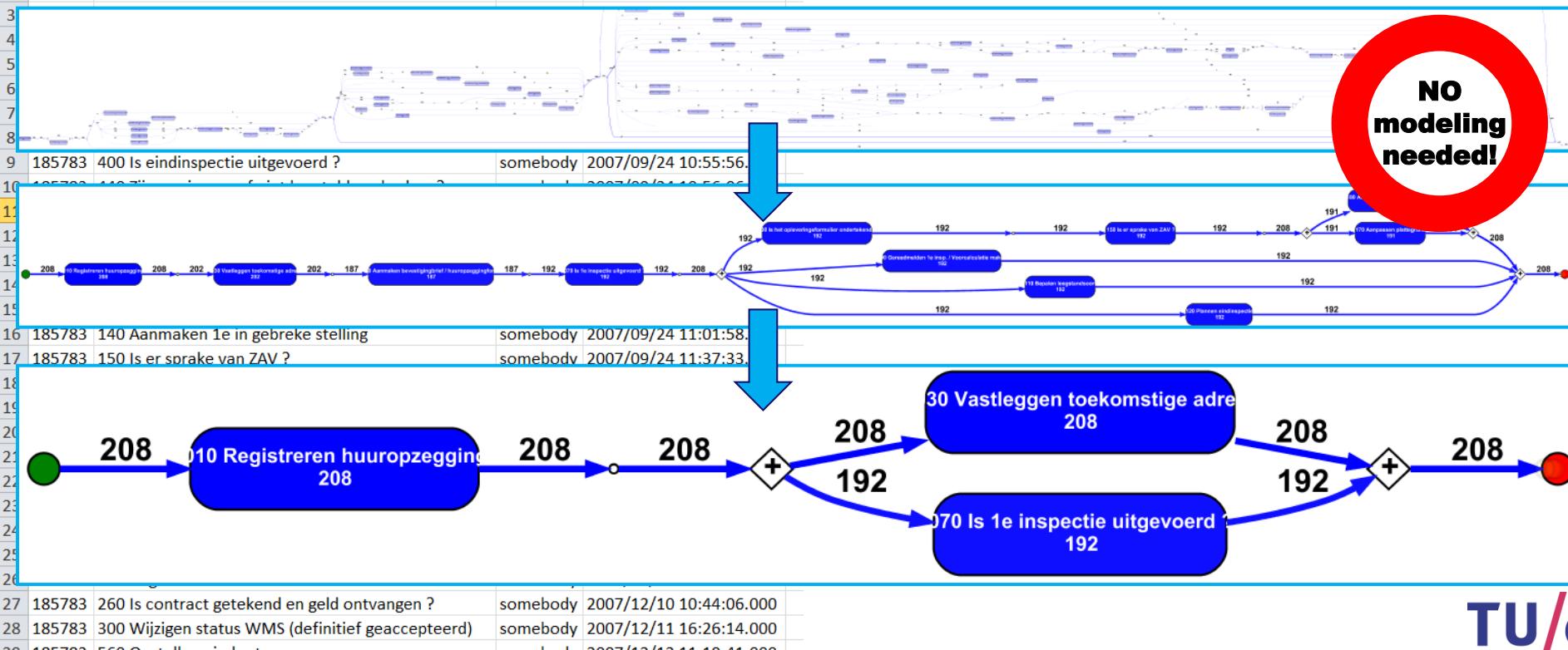
process discovery

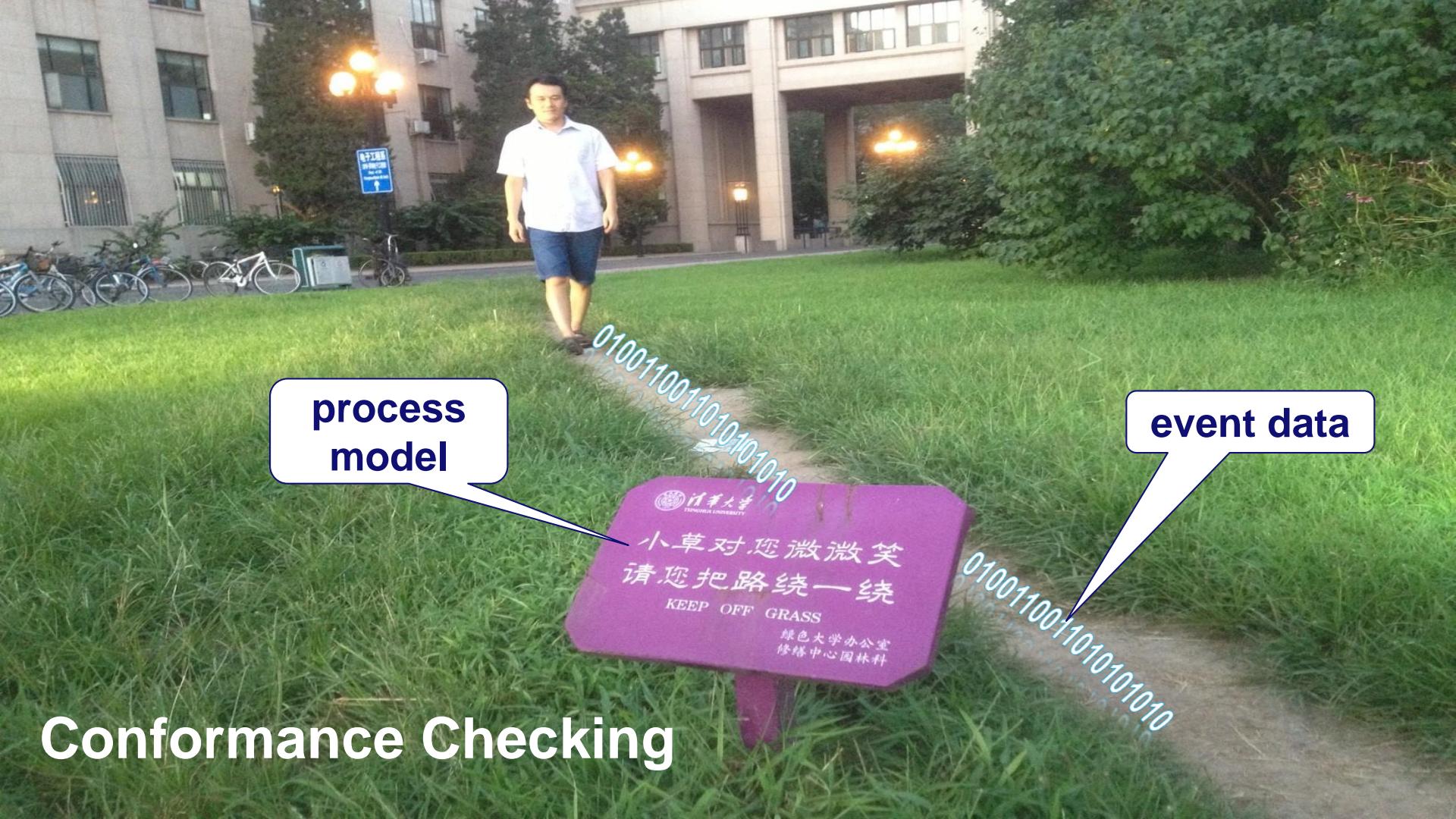


# Process Mining: Spreadsheet for behavior

	A	B	C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huropzegging	somebody	2007/09/11 13:21:27.000

# *process discovery*





# Conformance Checking



desire line

very safe  
system

# Conformance Checking

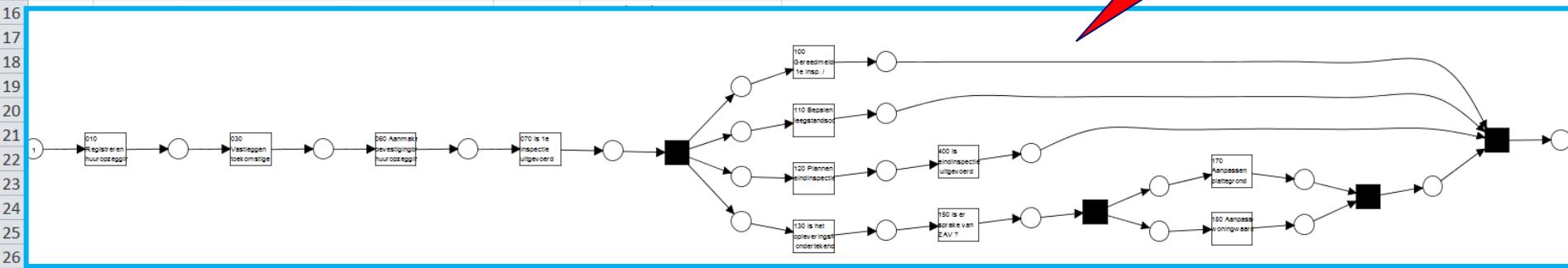
# Process Mining: Spreadsheet for behavior

A	B	C	D
1	Case ID	Activity	Resource Complete Timestamp
2	185783	010 Registreren huuropzegging	somebody 2007/09/11 13:21:27.000
3	185783	030 Vastleggen toekomstige adres	somebody 2007/09/11 13:26:29.000
4	185783	050 Plannen afspraak 1e inspectie	somebody 2007/09/11 13:29:34.000
5	185783	060 Aanmaken bevestigingbrief / huuropzeggingform.	somebody 2007/09/11 13:41:36.000
6	185783	070 Is 1e inspectie uitgevoerd ?	somebody 2007/09/24 08:39:32.000
7	185783	100 Gereedmelden 1e insp. / Voorcalculatie maken	somebody 2007/09/24 08:41:26.000
8	185783	120 Plannen eindinspectie	somebody 2007/09/24 08:51:00.000
9	185783	400 Is eindinspectie uitgevoerd ?	somebody 2007/09/24 10:55:56.000
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	somebody 2007/09/24 10:56:06.000
11	185783	450 Krijgt de huurder tijd om te herstellen ?	somebody 2007/09/24 10:56:10.000
12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody 2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody 2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody 2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody 2007/09/24 10:58:19.000

*conformance checking*



discovered or  
hand-made

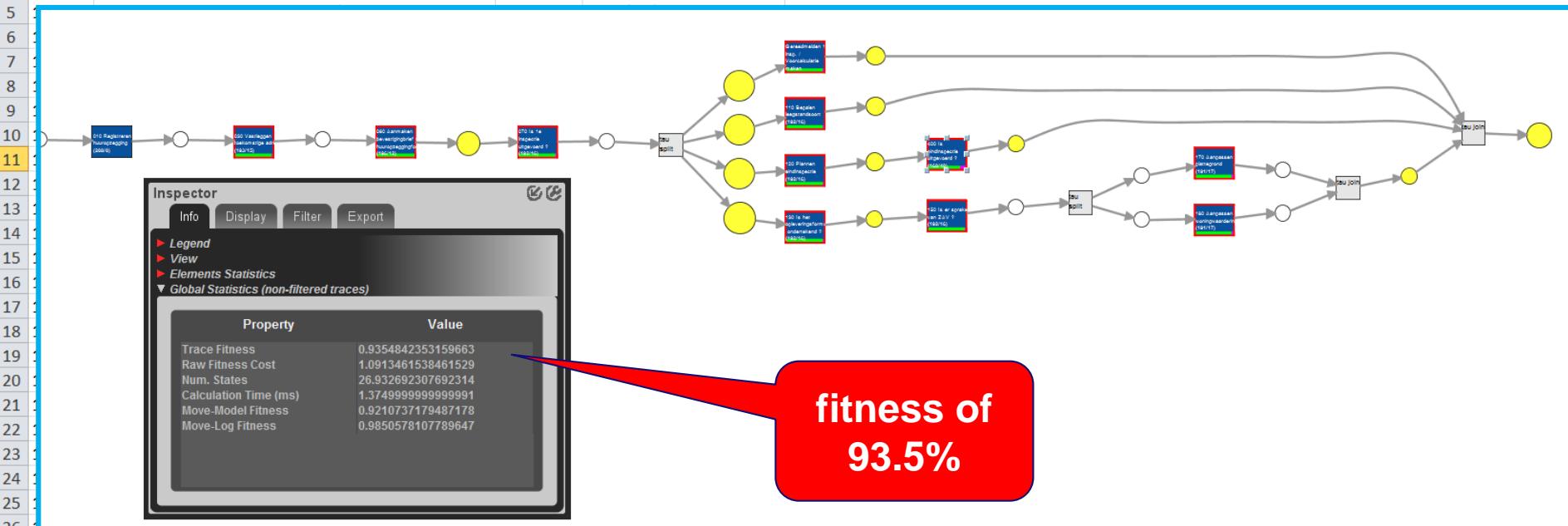


27	185783	260 Is contract getekend en geld ontvangen ?	somebody 2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody 2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody 2007/12/12 11:19:41.000

# Process Mining: Spreadsheet for behavior

A	B	C	D
1	Case ID	Activity	Resource
2	185783	010 Registreren huuropzagging	somebody
3	185783	030 Vastleggen toekomstige adres	somebody
4	185783	050 Plannen afspraak 1e inspectie	somebody

*conformance checking*

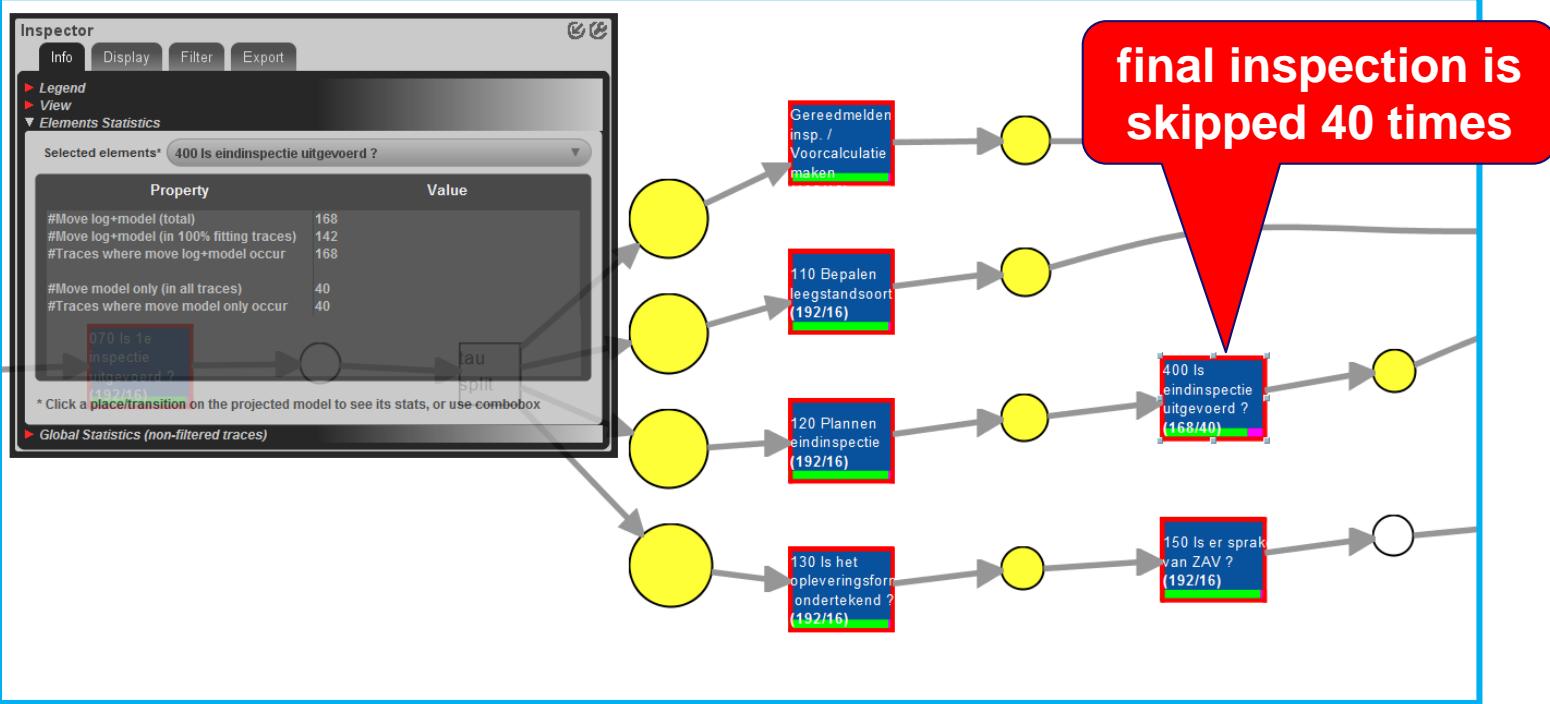


27	185783	260 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

# Process Mining: Spreadsheet for behavior

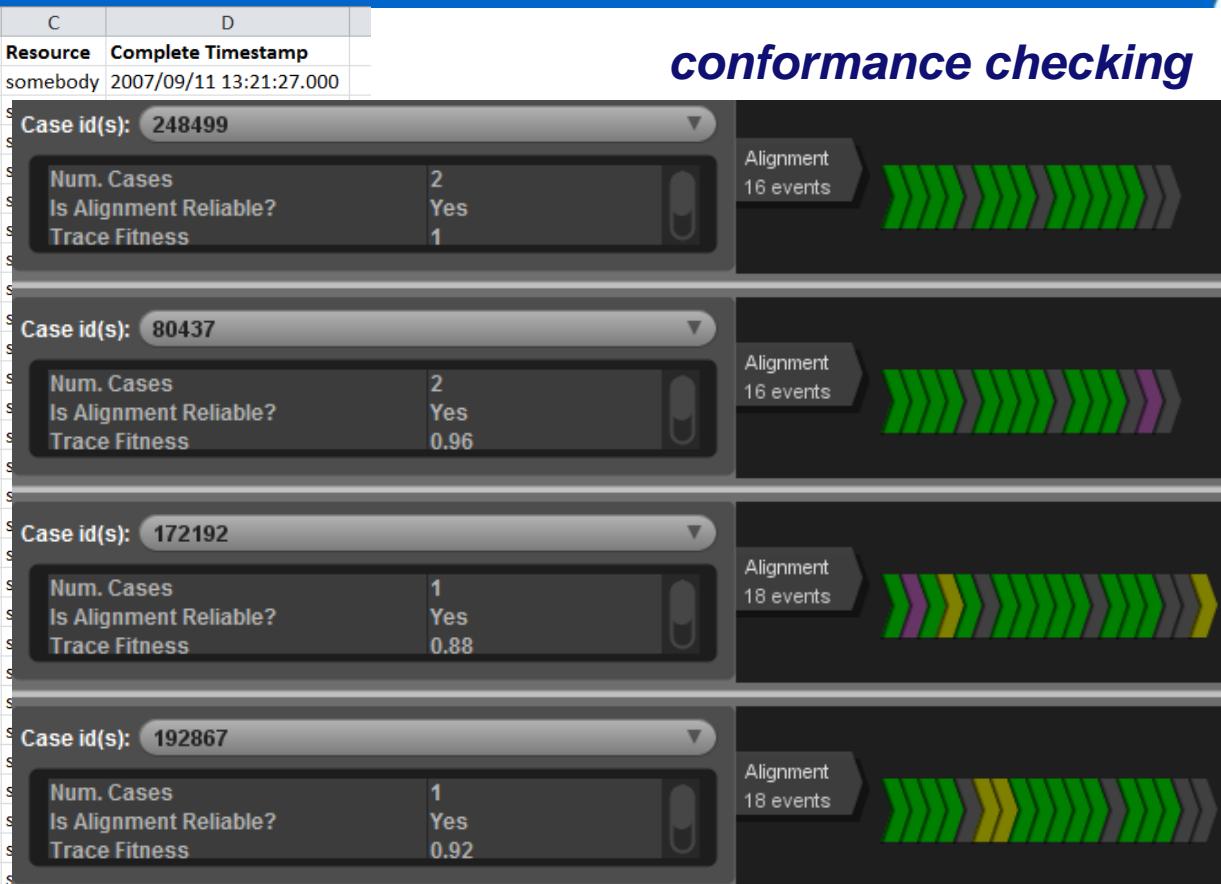
A	B	C	D
1	Case ID	Activity	Resource
2	185783	010 Registreren huuropzagging	somebody
3	185783	030 Vastleggen toekomstige huurperiode	somebody
4	185783	050 Plannen afspraak	somebody
5	185783	060 Aanmaken bevestiging	somebody
6	185783	070 Is 1e inspectie uitgevoerd?	somebody
7	185783	100 Gereedmelden 1e inspectie	somebody
8	185783	120 Plannen eindinspectie	somebody
9	185783	400 Is eindinspectie uitgevoerd?	somebody
10	185783	440 Zijn er nieuwe of bestaande huurders?	somebody
11	185783	450 Krijgt de huurder een voorkeur?	somebody
12	185783	500 Beoordelen/wijzigen huurtermijn	somebody
13	185783	110 Bepalen leegstandsoorzaak	somebody
14	185783	510 Is opleveringsformulier correct?	somebody
15	185783	130 Is het opleveringsformulier correct?	somebody
16	185783	140 Aanmaken 1e in gesprek?	somebody
17	185783	150 Is er sprake van ZAV?	somebody
18	185783	180 Aanpassen woningstatus	somebody
19	185783	190 Harmoniseren huurtermijn	somebody
20	185783	205 Bepalen kandidaat	somebody
21	185783	170 Aanpassen plattegrond	somebody
22	185783	520 Aanmaken 2e in gesprek?	somebody
23	185783	530 Aanmaken werkoort	somebody
24	185783	540 Worden er bonuspunten toegekend?	somebody
25	185783	550 Vastleggen bonuspunten	somebody
26	185783	240 Registreren voorlating	somebody
27	185783	260 Is contract getekend en geld ontvangen?	somebody
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody
29	185783	560 Opstellen eindnota	somebody

conformance checking



# Process Mining: Spreadsheet for behavior

A	B
1	Case ID Activity
2	185783 010 Registreren huuropzegging
3	185783 030 Vastleggen toekomstige adres
4	185783 050 Plannen afspraak 1e inspectie
5	185783 060 Aanmaken bevestigingbrief / huuropzeggingform.
6	185783 070 Is 1e inspectie uitgevoerd ?
7	185783 100 Gereedmelden 1e insp. / Voorcalculatie maken
8	185783 120 Plannen eindinspectie
9	185783 400 Is eindinspectie uitgevoerd ?
10	185783 440 Zijn er nieuwe of niet herstelde gebreken ?
11	185783 450 Krijgt de huurder tijd om te herstellen ?
12	185783 500 Beoordelen/wijzigen leegstandsoort
13	185783 110 Bepalen leegstandsoort
14	185783 510 Is opleveringsformulier ondertekend ?
15	185783 130 Is het opleveringsformulier ondertekend ?
16	185783 140 Aanmaken 1e in gebreke stelling
17	185783 150 Is er sprake van ZAV ?
18	185783 180 Aanpassen woningwaardering
19	185783 190 Harmoniseren huurprijs
20	185783 205 Bepalen kandidaat huurder
21	185783 170 Aanpassen plattegrond
22	185783 520 Aanmaken 2e in gebreke stelling
23	185783 530 Aanmaken werkopdracht
24	185783 540 Worden er bonussen/ kosten toegekend ?
25	185783 550 Vastleggen bonussen / kosten
26	185783 240 Registreren voorl. huurovereenkomst +afdrukken
27	185783 260 Is contract getekend en geld ontvangen ?
28	185783 300 Wijzigen status WMS (definitief geaccepteerd)
29	185783 560 Opstellen eindnota



# Process Mining: Spreadsheet for behavior

	A	B	C	D
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzegging		
3	185783	030 Vastleggen toekomstige adres		
4	185783	050 Plannen afspraak 1e inspectie		
5	185783	060 Aanmaken bevestigingbrief / huuropzegging		
6	185783	070 Is 1e inspectie uitgevoerd ?		
7	185783	100 Gereedmelden 1e insp. / Voorbereiding		
8	185783	120 Plannen eindinspectie		
9	185783	400 Is eindinspectie uitgevoerd ?		
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?		
11	185783	450 Krijgt de huurder tijd om te herstellen ?		
12	185783	500 Beoordelen/wijzigen leegstandsoort		
13	185783	110 Bepalen leegstandsoort		
14	185783	510 Is opleveringsformulier ondertekend ?		
15	185783	130 Is het opleveringsformulier ondertekend ?		
16	185783	140 Aanmaken 1e in gebreke stelling		
17	185783	150 Is er sprake van ZAV ?		
18	185783	180 Aanpassen woningwaardering		
19	185783	190 Harmoniseren huurprijs		
20	185783	205 Bepalen kandidaat huurder		
21	185783	170 Aanpassen plattegrond		
22	185783	520 Aanmaken 2e in gebreke stelling		
23	185783	530 Aanmaken werkopdracht		
24	185783	540 Worden er bonussen/ kosten toegekend ?		
25	185783	550 Vastleggen bonussen / kosten		
26	185783	240 Registreren voorl. huurovereenkomst +afdrukken		
27	185783	260 Is contract getekend en geld ontvangen ?		
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)		
29	185783	560 Opstellen eindnota		

move on model  
(something should have happened, but did not)

conformance checking



# Process Mining: Spreadsheet for behavior

A	B	C	D
1	Case ID	Activity	Resource
2	185783	010 Registreren huuropzegging	
3	185783	030 Vastleggen toekomstige adres	
4	185783	050 Plannen afspraak 1e inspectie	
5	185783	060 Aanmaken bevestigingbrief / huuropzegging	
6	185783	070 Is 1e inspectie uitgevoerd ?	
7	185783	100 Gereedmelden 1e insp. / Voorbereiding	
8	185783	120 Plannen eindinspectie	
9	185783	400 Is eindinspectie uitgevoerd ?	
10	185783	440 Zijn er nieuwe of niet herstelde gebreken ?	
11	185783	450 Krijgt de huurder tijd om te herstellen ?	
12	185783	500 Beoordelen/wijzigen leegstandsoort	
13	185783	110 Bepalen leegstandsoort	
14	185783	510 Is opleveringsformulier ondertekend ?	
15	185783	130 Is het oplevering	
16	185783	140 Aanmaken 1e in	
17	185783	150 Is er sprake van	
18	185783	180 Aanpassen won	
19	185783	190 Harmoniseren l	
20	185783	205 Bepalen kandid	
21	185783	170 Aanpassen plat	
22	185783	520 Aanmaken 2e in	
23	185783	530 Aanmaken werkpersone	
24	185783	540 Worden er bonussen/ kosten toegekend ?	
25	185783	550 Vastleggen bonussen / kosten	
26	185783	240 Registreren voorl. huurovereenkomst +afdrukken	
27	185783	260 Is contract getekend en geld ontvangen ?	
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	
29	185783	560 Opstellen eindnota	

*conformance checking*

move on model  
(something should have happened, but did not)

Case id(s): 80437

Num. Cases 2  
Is Alignment Reliable? Yes  
Trace Fitness 0.96

move on log  
(something happened that should not happen)

Case id(s): 192867

Num. Cases 1  
Is Alignment Reliable? Yes  
Trace Fitness 0.92



# Process Mining: Spreadsheet for behavior

A B C D

Case ID	Activity	Resource	Complete Timestamp
185783	Opzegging	somebody	2007/09/11 13:21:27.000
185783	Bestrijdiging adres	somebody	2007/09/11 13:26:29.000
185783	Bele inspectie	somebody	2007/09/11 13:29:34.000

**NO modeling needed!**

performance analysis

bottleneck

average flowtime is 1.92 months

Inspector			
Info Display Filter Export			
<b>Legend</b>			
<b>View</b>			
<b>Element Statistics</b>			
<b>Global Statistics</b>			
Case Property		Value	
#Cases	208	#Perfectly-fitting cases	142
#Non-fitting cases	66	#Properly started cases	208
Case Throughput time (avg)	1.92 months	Case Throughput time (min)	7.80 min
Case Throughput time (max)	10.86 months	Case Throughput time (std. dev)	1.50 months
Observation period	18.81 months		

185783 240 Registreren voorl. huurovereenkomst +afdrukken somebody 2007/11/28 12:34:23.000  
185783 260 Is contract getekend en geld ontvangen ? somebody 2007/12/10 10:44:06.000  
185783 300 Wijzigen status WMS (definitief geaccepteerd) somebody 2007/12/11 16:26:14.000  
185783 560 Opstellen eindnota somebody 2007/12/12 11:19:41.000

TU/e

# Process Mining: Spreadsheet for behavior

A	B	C	D	
1	Case ID	Activity	Resource	Complete Timestamp
2	185783	010 Registreren huuropzagging	somebody	2007/12/12 11:19:41.000
3	185783	030 Vastleggen toekomstige adres	somebody	2007/12/12 11:19:41.000
4	185783	050 Plannen voorval 1e inspectie	somebody	2007/12/12 11:19:41.000
5	185783	060 A		
6	185783	070 Is		
7	185783	100 G		
8	185783	120 P		
9	185783	400 Is		
10	185783	440 Zi		
11	185783	450 K		
12	185783	500 B		
13	185783	110 B		
14	185783	510 Is		
15	185783	130 Is		
16	185783	140 A		
17	185783	150 Is		
18	185783	180 A		
19	185783	190 H		
20	185783	205 B		
21	185783	170 A		
22	185783	520 A		
23	185783	530 A		
24	185783	540 W		
25	185783	550 V		
26	185783	240 R		
27	185783	260 Is		
28	185783	300 W		
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

performance analysis

waiting time of 15.74 days

NO modeling needed!

Inspector

Legend

View

Element Statistics

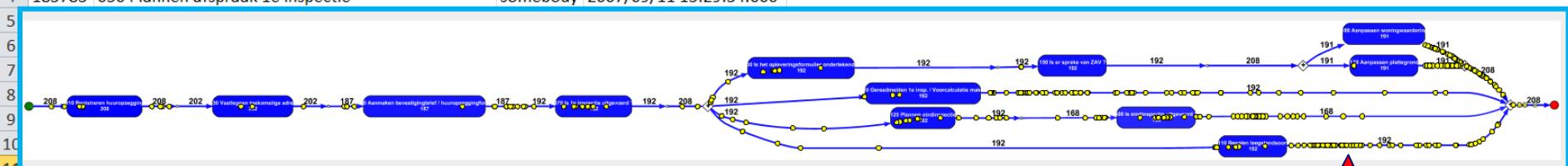
Selected elements\* sink 5

Property	Min.	Max.	Avg.	Std. Dev	Freq.
Waiting time	6.00 seconds	9.10 months	15.74 days	24.52 days	192
Synchronization time	0.00 ms	0.00 ms	0.00 ms	0.00 ms	192
Sojourn time	6.00 seconds	9.10 months	15.74 days	24.52 days	192

# Process Mining: Spreadsheet for behavior

A	B	C	D
1	Case ID	Activity	Resource
2	185783	010 Registreren huuropzagging	somebody
3	185783	030 Vastleggen toekomstige adres	somebody
4	185783	050 Plannen afspraak 1e inspectie	somebody

*animating reality*



12	185783	500 Beoordelen/wijzigen leegstandsoort	somebody	2007/09/24 10:57:02.000
13	185783	110 Bepalen leegstandsoort	somebody	2007/09/24 10:57:42.000
14	185783	510 Is opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:08.000
15	185783	130 Is het opleveringsformulier ondertekend ?	somebody	2007/09/24 10:58:19.000
16	185783	140 Aanmaken 1e in gebreke stelling	somebody	2007/09/24 11:01:58.000
17	185783	150 Is er sprake van ZAV ?	somebody	2007/09/24 11:37:33.000
18	185783	180 Aanpassen woningwaardering	somebody	2007/09/24 11:37:44.000
19	185783	190 Harmoniseren huurprijs	somebody	2007/09/24 11:40:01.000
20	185783	205 Bepalen kandidaat huurder	somebody	2007/09/24 11:47:42.000
21	185783	170 Aanpassen plattegrond	somebody	2007/09/24 12:10:58.000
22	185783	520 Aanmaken 2e in gebreke stelling	somebody	2007/10/30 11:45:53.000
23	185783	530 Aanmaken werkopdracht	somebody	2007/10/30 11:46:09.000
24	185783	540 Worden er bonussen/ kosten toegekend ?	somebody	2007/10/30 11:46:36.000
25	185783	550 Vastleggen bonussen / kosten	somebody	2007/10/30 11:53:00.000
26	185783	240 Registreren voorl. huurovereenkomst +afdrukken	somebody	2007/11/28 12:34:23.000
27	185783	260 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
28	185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
29	185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

**NO  
modeling  
needed!**

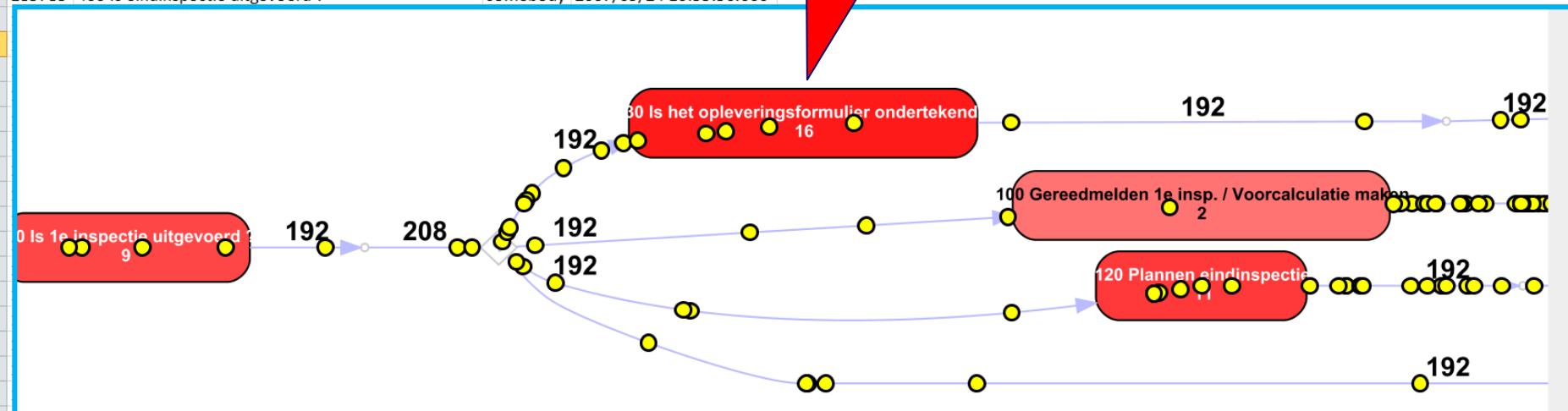
**real cases**

# Process Mining: Spreadsheet for behavior

A	B	C	D
1	Case ID	Activity	Resource
2	185783	010 Registreren huuropzegging	somebody
3	185783	030 Vastleggen toekomstige adres	somebody
4	185783	050 Plannen afspraak 1e inspectie	somebody
5	185783	060 Aanmaken bevestigingbrief / huuropzeggingform.	somebody
6	185783	070 Is 1e inspectie uitgevoerd ?	somebody
7	185783	100 Gereedmelden 1e insp. / Voorcalculatie maken	somebody
8	185783	120 Plannen eindinspectie	somebody
9	185783	400 Is eindinspectie uitgevoerd ?	somebody

16 cases are queueing

animating reality



185783	240 Registreren voorl. huurovereenkomst +afdrukken	somebody	2007/11/28 12:34:23.000
185783	260 Is contract getekend en geld ontvangen ?	somebody	2007/12/10 10:44:06.000
185783	300 Wijzigen status WMS (definitief geaccepteerd)	somebody	2007/12/11 16:26:14.000
185783	560 Opstellen eindnota	somebody	2007/12/12 11:19:41.000

# Event data

# Event data may come from ...

# Event data may come from ...

- **a database system (e.g., patient data in a hospital),**

# Event data may come from ...

- **a database system (e.g., patient data in a hospital),**
- **a comma-separated values (CSV) file or spreadsheet,**

# Event data may come from ...

- a database system (e.g., patient data in a hospital),
- a comma-separated values (CSV) file or spreadsheet,
- a transaction log (e.g., a trading system),
- a business suite/ERP system (SAP, Oracle, etc.),
- a message log (e.g., from IBM middleware),
- an open API providing data from websites or social media, ...

# An example log

student name	course name	exam date	mark
Peter Jones	Business Information systems	16-1-2014	8
Sandy Scott	Business Information systems	16-1-2014	5
Bridget White	Business Information systems	16-1-2014	9
John Anderson	Business Information systems	16-1-2014	8
Sandy Scott	BPM Systems	17-1-2014	7
Bridget White	BPM Systems	17-1-2014	8
Sandy Scott	Process Mining	20-1-2014	5
Bridget White	Process Mining	20-1-2014	9
John Anderson	Process Mining	20-1-2014	8
...	...	...	...

case id

activity name

timestamp

other data

# Another event log: order handling

order number	activity	timestamp	user	product	quantity
9901	register order	22-1-2014@09.15	Sara Jones	iPhone5S	1
9902	register order	22-1-2014@09.18	Sara Jones	iPhone5S	2
9903	register order	22-1-2014@09.27	Sara Jones	iPhone4S	1
9901	check stock	22-1-2014@09.49	Pete Scott	iPhone5S	1
9901	ship order	22-1-2014@10.11	Sue Fox	iPhone5S	1
9903	check stock	22-1-2014@10.34	Pete Scott	iPhone4S	1
9901	handle payment	22-1-2014@10.41	Carol Hope	iPhone5S	1
9902	check stock	22-1-2014@10.57	Pete Scott	iPhone5S	2
9902	cancel order	22-1-2014@11.08	Carol Hope	iPhone5S	2

case id

activity name

timestamp

resource

other data

# Another event log: patient treatment

patient	activity	timestamp	doctor	age	cost
5781	make X-ray	23-1-2014@10.30	Dr. Jones	45	70.00
5541	blood test	23-1-2014@10.18	Dr. Scott	61	40.00
5833	blood test	23-1-2014@10.27	Dr. Scott	24	40.00
5781	blood test	23-1-2014@10.49	Dr. Scott	45	40.00
5781	CT scan	23-1-2014@11.10	Dr. Fox	45	1200.00
5833	surgery	23-1-2014@12.34	Dr. Scott	24	2300.00
5781	handle payment	23-1-2014@12.41	Carol Hope	45	0.00
5541	radiation therapy	23-1-2014@13.57	Dr. Jones	61	140.00
5541	radiation therapy	23-1-2014@13.08	Dr. Jones	61	140.00

case id

activity name

timestamp

resource

other data

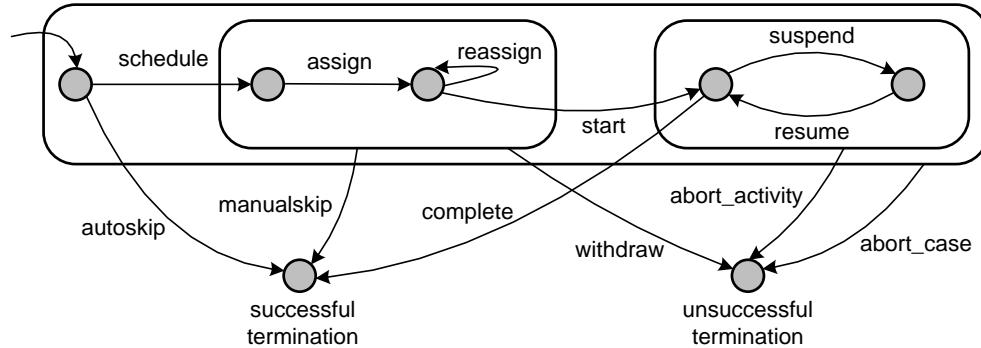
# Minimal requirements in terms of a CSV file

- Each row corresponds to an event.
- There are at least three columns:
  - Case id (patient id, order number, claim number, ...)
  - Activity name (approve, reject, request, send, ...)
  - Timestamp (2015-08-18T06:36:40, ...)
- There may be many other (optional) columns: resource, transaction type, age, costs, etc.

order number	activity	timestamp	user	product	quantity
9901	register order	22-1-2014@09.15	Sara Jones	iPhone5S	1
9902	register order	22-1-2014@09.18	Sara Jones	iPhone5S	2

# Extensions

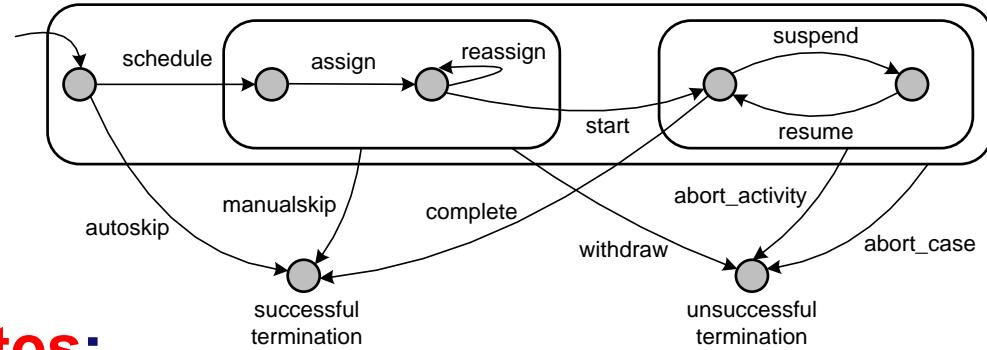
- **Transactional information on activity instances:**  
An event can represent  
a **start, complete,**  
**suspend, resume,**  
**abort, etc.**



# Extensions

- **Transactional information on activity instances:**

An event can represent a **start, complete, suspend, resume, abort**, etc.



- **Case versus event attributes:**

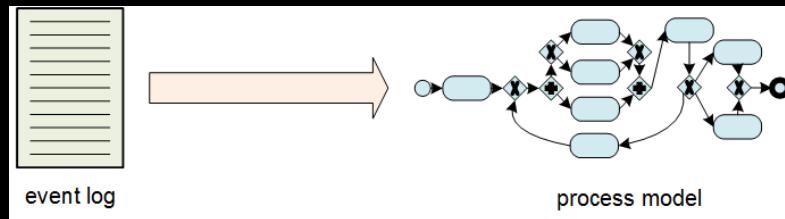
- case attributes do not change, e.g., the birth date or gender of a patient,
- event attributes are related to a particular step in the process.

# XES (eXtensible Event Stream)

- Adopted by the **IEEE Task Force on Process Mining**.
- The format is supported by tools such as **ProM** and **Disco** (used in this course).
- Predecessors: **MXML** and **SA-MXML**.
- Conversion from other formats (**CSV**) is easy if the right data are available.
- **XML syntax** and **OpenXES library** available.
- See [www.xes-standard.org](http://www.xes-standard.org).



# Process discovery algorithms



A black metal street signpost stands vertically against a background of a bright blue sky filled with wispy white clouds. Three directional signs extend from the post at different angles. The top-left sign is white with a black border and the words "THIS WAY" in bold, black, sans-serif capital letters. The top-right sign is grey with a black border and the words "THAT WAY" in bold, black, sans-serif capital letters. The bottom-left sign is white with a black border and the words "ANOTHER WAY" in bold, black, sans-serif capital letters.

**THIS WAY**

**THAT WAY**

**ANOTHER WAY**

A black metal street signpost stands vertically against a background of a bright blue sky filled with wispy white clouds. Three directional signs extend from the post at different angles. The top-left sign is white with a black border and the words "THIS WAY" in bold, black, sans-serif capital letters. The top-right sign is grey with a black border and the words "THAT WAY" in bold, black, sans-serif capital letters. The bottom-left sign is white with a black border and the words "ANOTHER WAY" in bold, black, sans-serif capital letters.

**THIS WAY**

**THAT WAY**

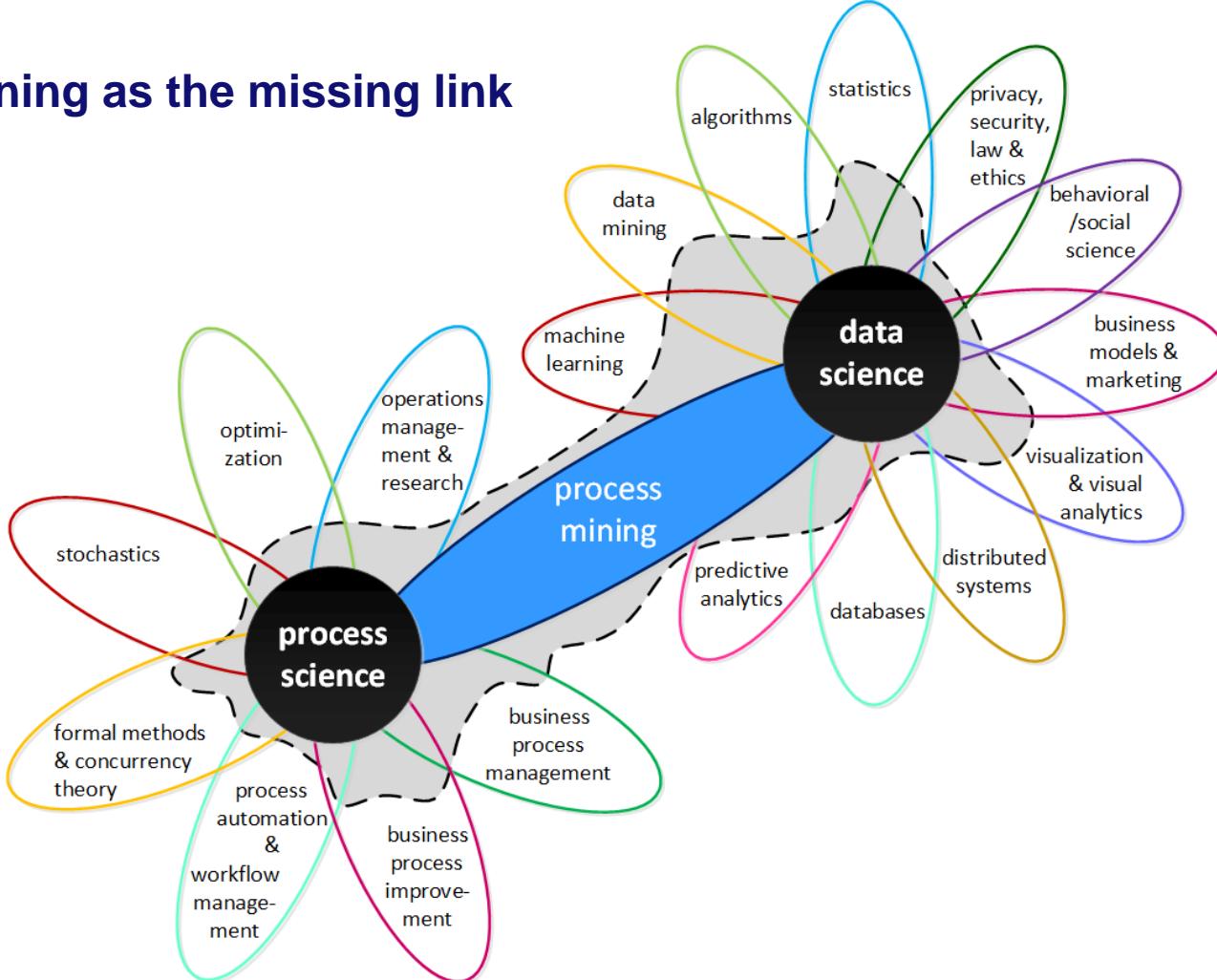
**ANOTHER WAY**

# Characteristics

1. **Representational bias (class of target models)**
2. **Ability to deal with noise/infrequent/incomplete behavior**
3. **Formal guarantees (in the limit, rediscoverability)**
4. **Scalability**
5. **Approach used:**
  - Direct algorithmic (alpha-family, heuristic/fuzzy miner)
  - Region-based (language/state-based)
  - Generic/evolutionary
  - Inductive

# **How process mining compares to data mining**

# process mining as the missing link



# Connecting things: Process mining as super glue

- **Data – Process**
- **Business – IT**
- **Business Intelligence – Business Process Management**
- **Performance – Compliance**
- **Runtime – Design time**
- ...



# Process Mining Versus Data Mining

- Both start from **data**.
- Data mining techniques are typically **not process-centric**.
- Topics such as **process discovery, conformance checking, and bottleneck analysis** are **not addressed by traditional data mining techniques**.

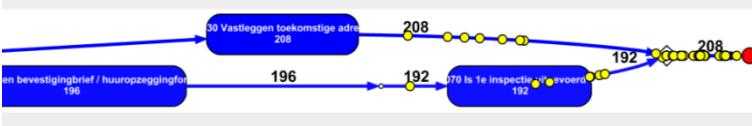
# Process Mining Versus Data Mining

- End-to-end process models and concurrency are essential for process mining.
- Process mining assumes event logs where events have timestamps and refer to cases (process instances).
- Process mining and data mining need to be combined for more advanced questions.

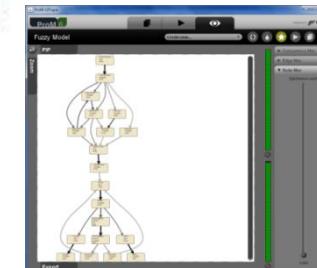
# Tooling and industry collaboration

# Process Mining Software





**1500+ plug-ins available covering the whole process mining spectrum**



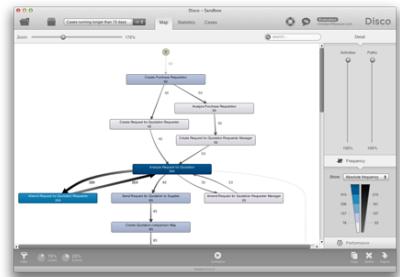
**>130k downloads**





# Disco

perceptive software  
a Lexmark company



# minit



Rialto  
extra

# QPR

Quality. Processes. Results.

ICARO  
TECH

# XMPRO

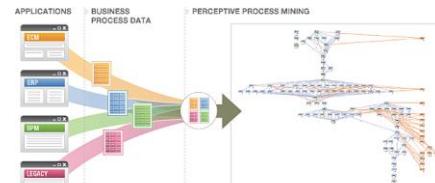
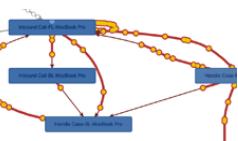
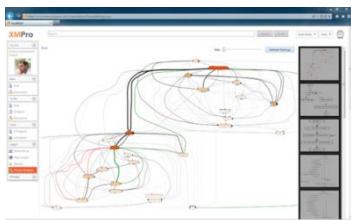
GET BETTER AT GETTING WORK DONE



# my i nvenio

# FUJITSU

celonis  
process mining



TU/e

# Links to some tools

Short name	Full name of tool	Version	Vendor	Webpage
Celonis	Celonis Process Mining	4	Celonis GmbH	<a href="http://www.celonis.de">www.celonis.de</a>
Disco	Disc	1.9.5	Fluxicon	<a href="http://www.fluxicon.com">www.fluxicon.com</a>
EDS	Enterprise Discovery Suite	4	StereOLOGIC Ltd	<a href="http://www.stereologic.com">www.stereologic.com</a>
Fujitsu	Interstage Business Process Manager Analytics	12.2	Fujitsu Ltd	<a href="http://www.fujitsu.com">www.fujitsu.com</a>
Icaro	Icaro EVERFlow	1	Icaro Tech	<a href="http://www.icarotech.com">www.icarotech.com</a>
Icris	Icris Process Mining Factory	1	Icris	<a href="http://www.processminingfactory.com">www.processminingfactory.com</a>
LANA	LANA Process Mining	1	Lana Labs	<a href="http://www.lana-labs.com">www.lana-labs.com</a>
Minit	Minit	1	Gradient ECM	<a href="http://www.minitlabs.com">www.minitlabs.com</a>
myInvenio	myInvenio	1	Cognitive Technology	<a href="http://www.my-invenio.com">www.my-invenio.com</a>
Perceptive	Perceptive Process Mining	2.7	Lexmark	<a href="http://www.lexmark.com">www.lexmark.com</a>
ProcessGold	ProcessGold Enterprise Platform	8	Processgold International B.V.	<a href="http://www.processgold.com">www.processgold.com</a>
ProM	ProM	6.6	Open Source hosted at TU/e	<a href="http://www.promtools.org">www.promtools.org</a>
ProM Lite	ProM Lite	1.1	Open Source hosted at TU/e	<a href="http://www.promtools.org">www.promtools.org</a>
QPR	QPR ProcessAnalyzer	2015.5	QPR	<a href="http://www.qpr.com">www.qpr.com</a>
RapidProM	RapidProM	4.0.0	Open Source hosted at TU/e	<a href="http://www.rapidprom.org">www.rapidprom.org</a>
Rialto	Rialto Process	1.5	Exeura	<a href="http://www.exeura.eu">www.exeura.eu</a>
SNP	SNP Business Process Analysis	15.27	SNP Schneider-Neureither & Partner AG	<a href="http://www.snp-bpa.com">www.snp-bpa.com</a>
PPM	webMethods Process Performance Manager	9.9	Software AG	<a href="http://www.softwareag.com">www.softwareag.com</a>

**Disco - New project**

event\_log\_10000\_cases +17 Map Statistics Cases

Academic w.m.p.v.daalst@tue.nl Disco

Statistics views

- Overview Global statistics
- Activity Activity classes
- product Other attribute
- prod-price Other attribute
- query Other
- ad Other

**Overview**  
Global statistics

Events over time Active cases over time Case variants Events per case Case duration

Events 63,763  
Cases 10,000  
Activities 8  
Median case duration 13.9 d  
Mean case duration 14.9 d  
Start 05.01.2015 09:00:07  
End 31.12.2019 14:46:02

**Log timeline**

Cases (10000)	Variants (9)	Variant	Started	Finished	Duration
		7	05.01.2015 09:00:07	26.01.2015 16:42:28	21 days, 7 hours
		1	05.01.2015 10:18:21	15.01.2015 15:52:30	10 days, 5 hours
		4	05.01.2015 11:54:49	09.01.2015 18:38:58	4 days, 6 hours
		3	05.01.2015 14:07:45	22.01.2015 13:18:30	16 days, 23 hours
		1	05.01.2015 15:33:38	12.01.2015 17:27:36	7 days, 1 hour
		5	05.01.2015 17:25:23	02.02.2015 12:31:09	27 days, 19 hours
		4	05.01.2015 19:08:53	15.01.2015 14:56:54	9 days, 19 hours
		9	05.01.2015 21:54:00	13.01.2015 15:49:53	7 days, 17 hours
		4	06.01.2015 07:25:13	15.01.2015 11:27:50	9 days, 4 hours
		1	06.01.2015 10:09:51	15.01.2015 19:15:18	9 days, 9 hours
		1	06.01.2015 11:37:49	14.01.2015 09:14:28	7 days, 21 hours
		4	06.01.2015 13:33:45	14.01.2015 11:30:05	7 days, 21 hours
		4	06.01.2015 15:25:38	13.01.2015 12:25:34	6 days, 20 hours
		2	06.01.2015 17:09:23	22.01.2015 18:59:10	16 days, 1 hour
		3	06.01.2015 18:36:53	22.01.2015 14:39:39	15 days, 20 hours
		8	06.01.2015 21:26:54	26.01.2015 17:16:02	19 days, 19 hours
		1	07.01.2015 04:42:36	16.01.2015 10:17:14	9 days, 5 hours
		3	07.01.2015 10:10:58	21.01.2015 17:31:29	14 days, 7 hours
		8	07.01.2015 11:40:04	28.01.2015 10:27:12	20 days, 22 hours
		9	07.01.2015 13:38:15	13.01.2015 13:22:15	5 days, 23 hours
		1	07.01.2015 15:34:37	19.01.2015 09:11:23	11 days, 17 hours
		1	07.01.2015 17:27:21	16.01.2015 09:09:25	8 days, 15 hours
		5	07.01.2015 19:12:50	03.02.2015 14:34:33	26 days, 19 hours
		6	07.01.2015 22:01:54	19.01.2015 13:15:02	11 days, 15 hours
		8	08.01.2015 07:12:36	28.01.2015 10:41:14	20 days, 3 hours
		3	08.01.2015 09:55:59	26.01.2015 15:52:42	18 days, 5 hours
		6	08.01.2015 12:10:05	15.01.2015 13:54:59	7 days, 1 hour
		1	08.01.2015 13:38:17	14.01.2015 12:30:26	5 days, 22 hours
		5	08.01.2015 15:34:42	02.02.2015 14:10:36	24 days, 22 hours
		2	08.01.2015 17:27:31	29.01.2015 11:26:06	20 days, 17 hours
		3	08.01.2015 19:12:09	26.01.2015 14:16:02	17 days, 19 hours
		4	08.01.2015 22:02:32	20.01.2015 10:35:40	11 days, 12 hours

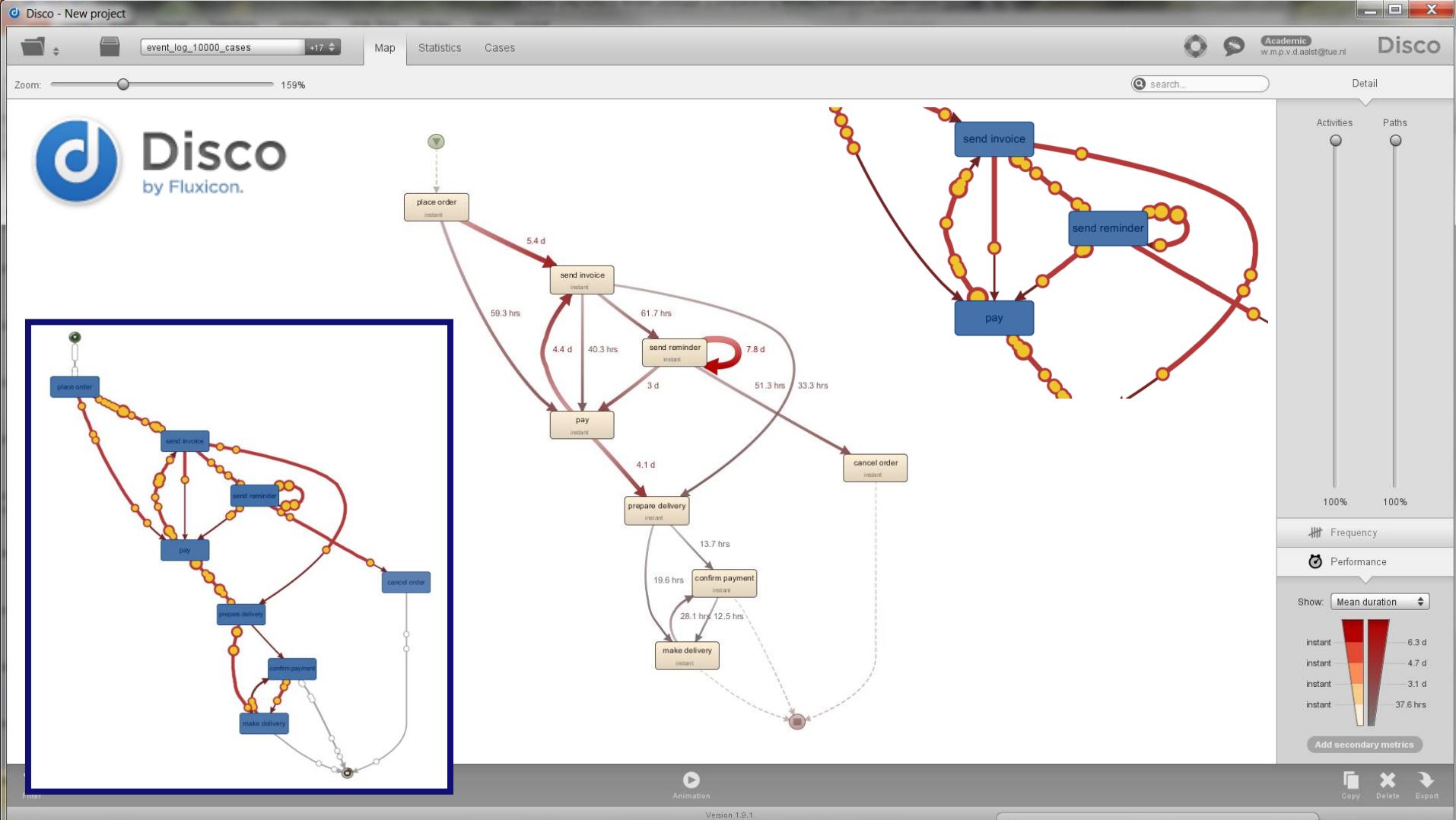
**Diagram**

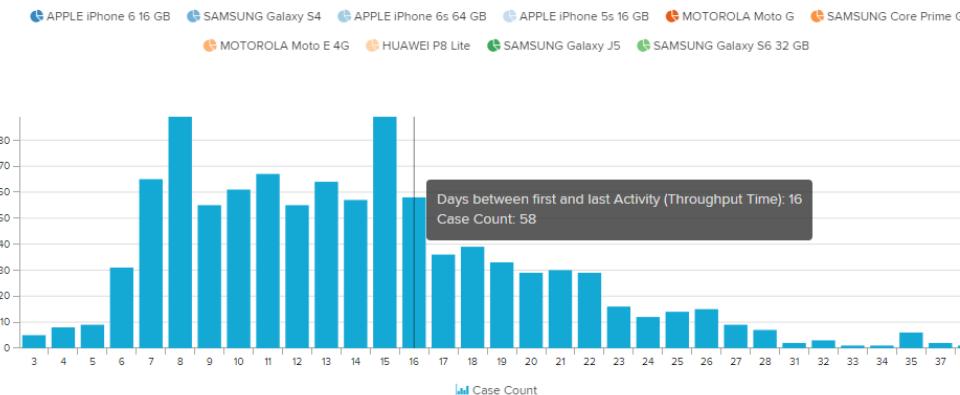
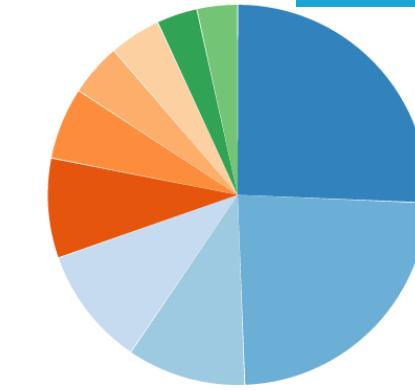
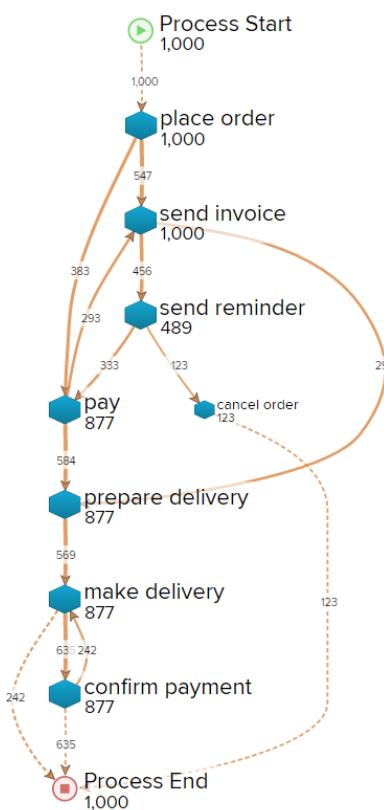
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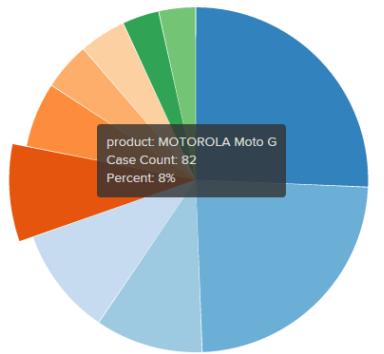
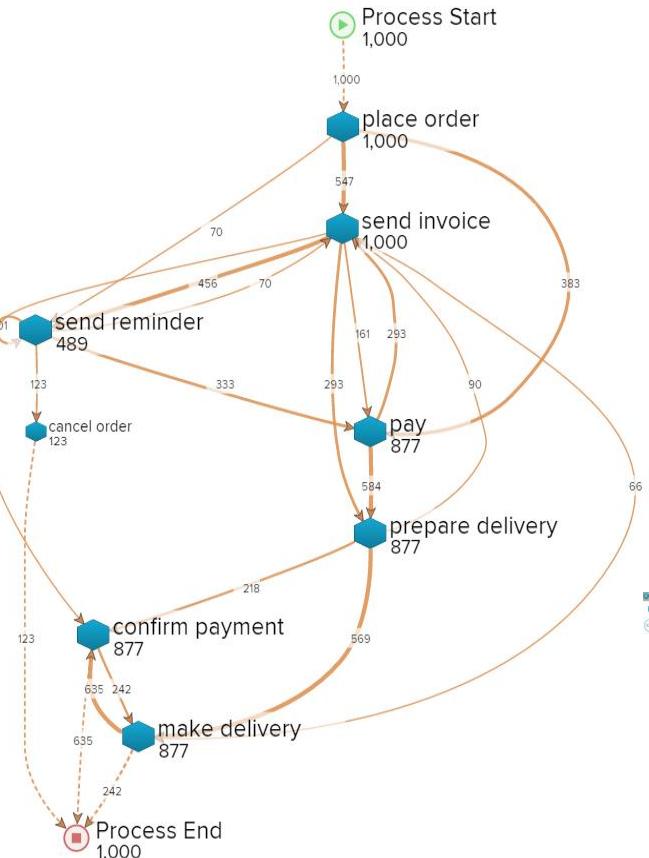
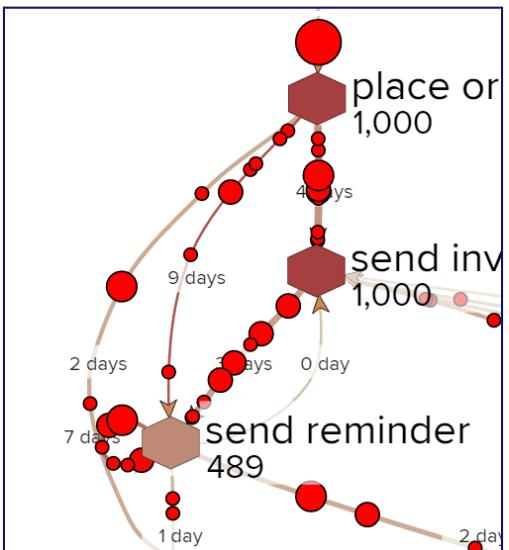
graph TD
    A[place order] --> B[send invoice]
    B --> C[pay]
    C --> D[send reminder]
    D --> E[prepare delivery]
    E --> F[confirm payment]
    F --> G[main delivery]
    G --> H[cancel order]
    H --> I[place order]
    
```

**Filter** Copy Delete Export

Version 1.9.1







# Process map

event log 10000 ▾

Manage view

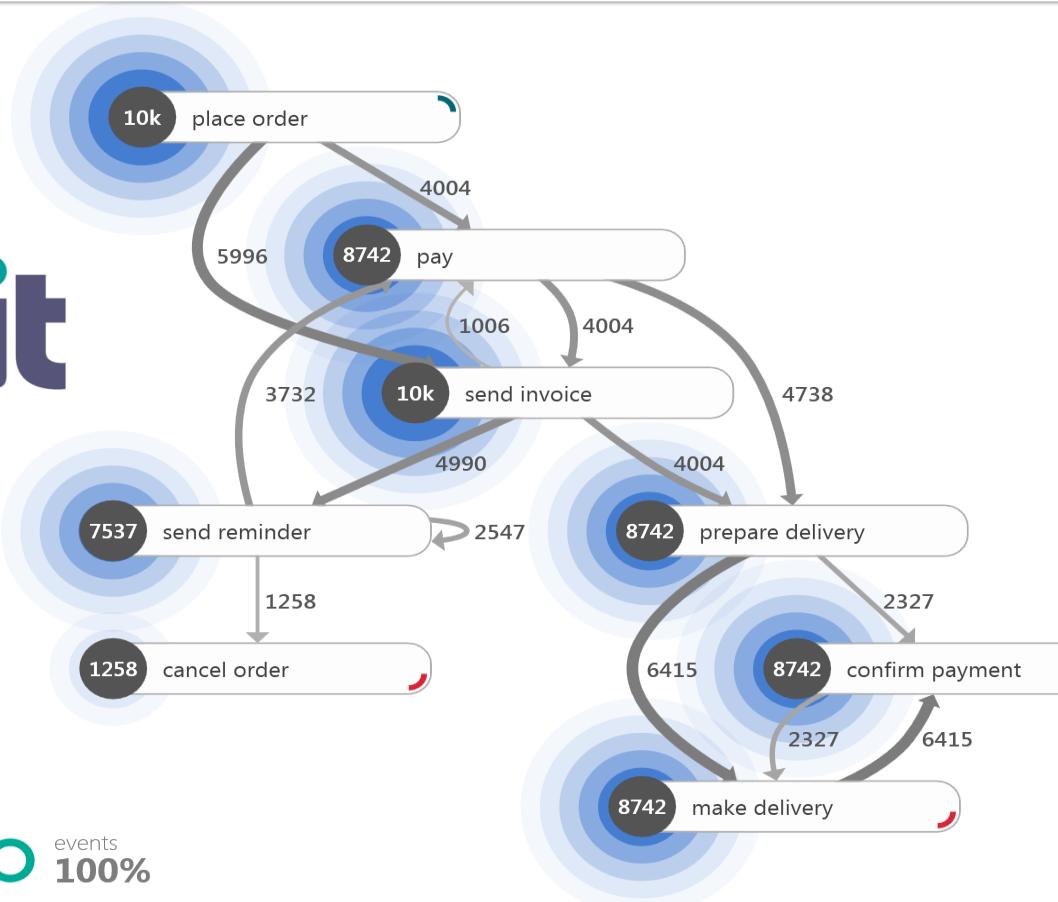
Project hub

Repository

Settings

 vanderAalstWil  
Trial

# minit

cases  
**100%**events  
**100%**

## Customize

 Process view Social view

Missing attribute of type Resource.

 Show terminal nodes Snap to backbone Left to right Highlight predecessor/successor activities

Activities

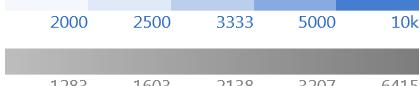
100 %

Paths

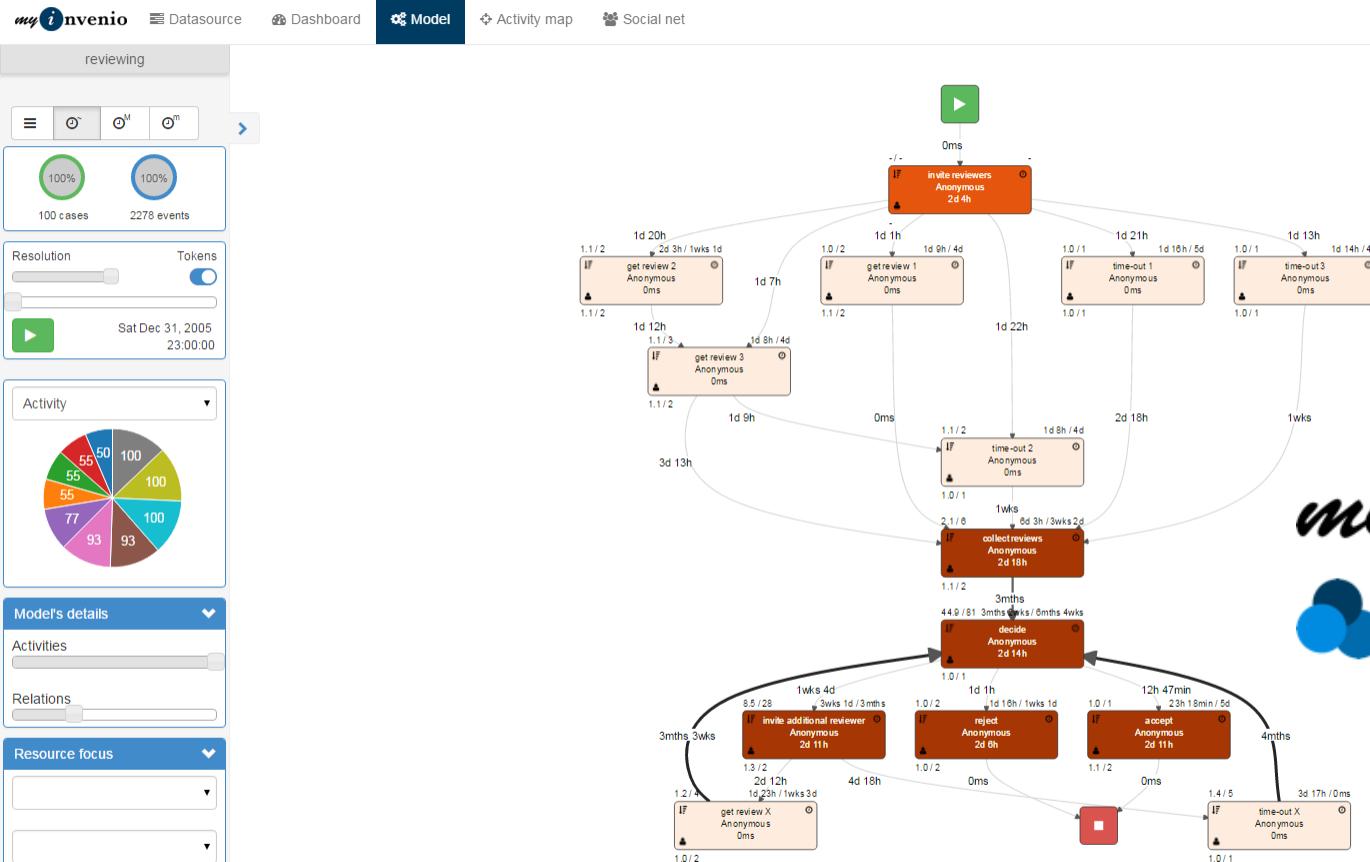
100 %

 Frequency Performance

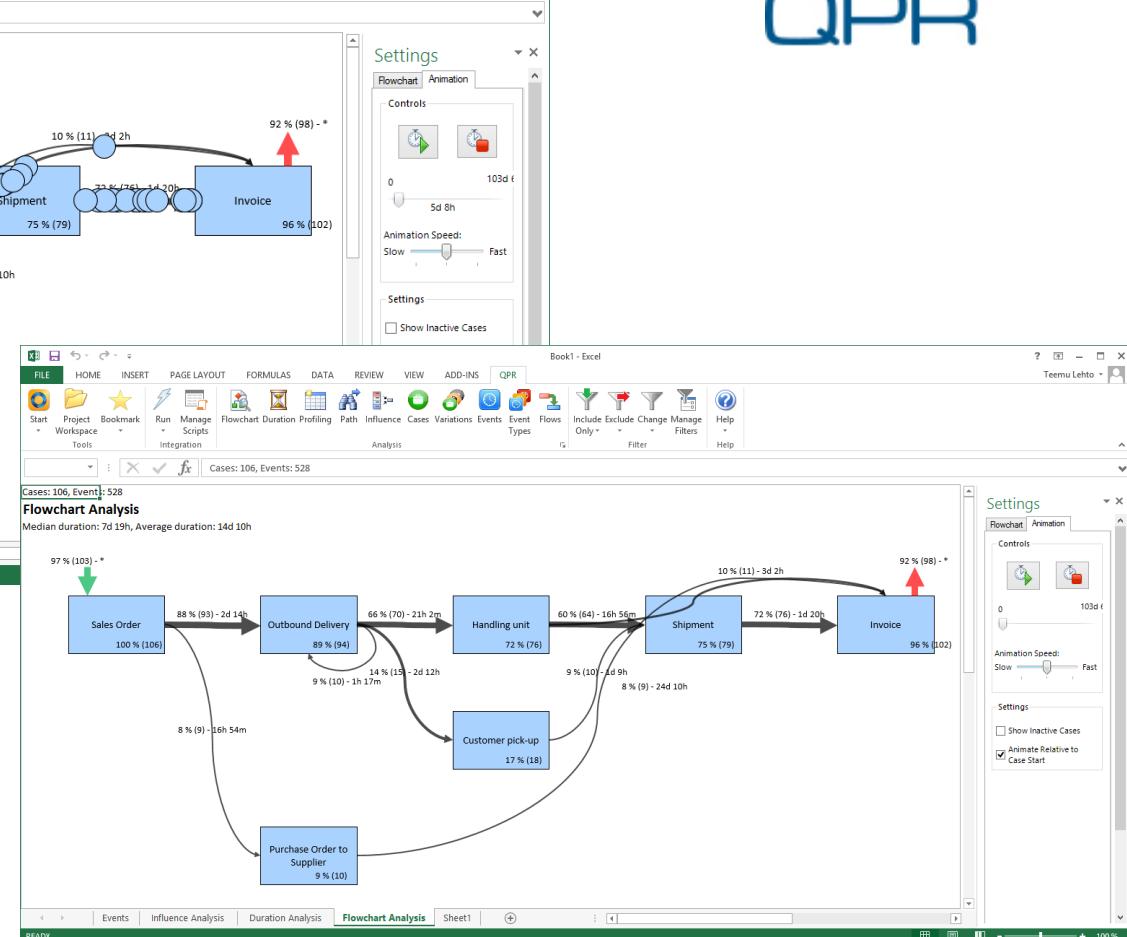
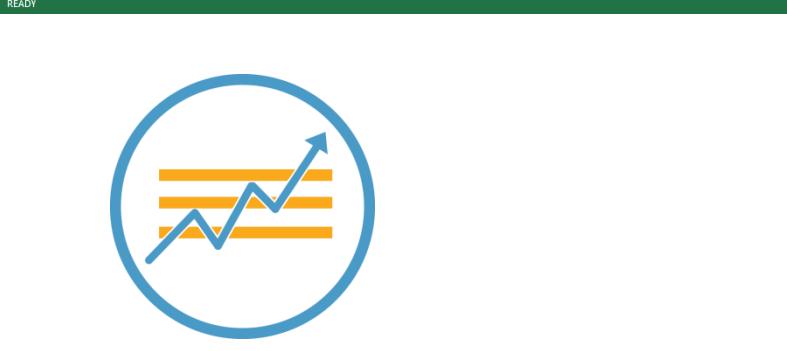
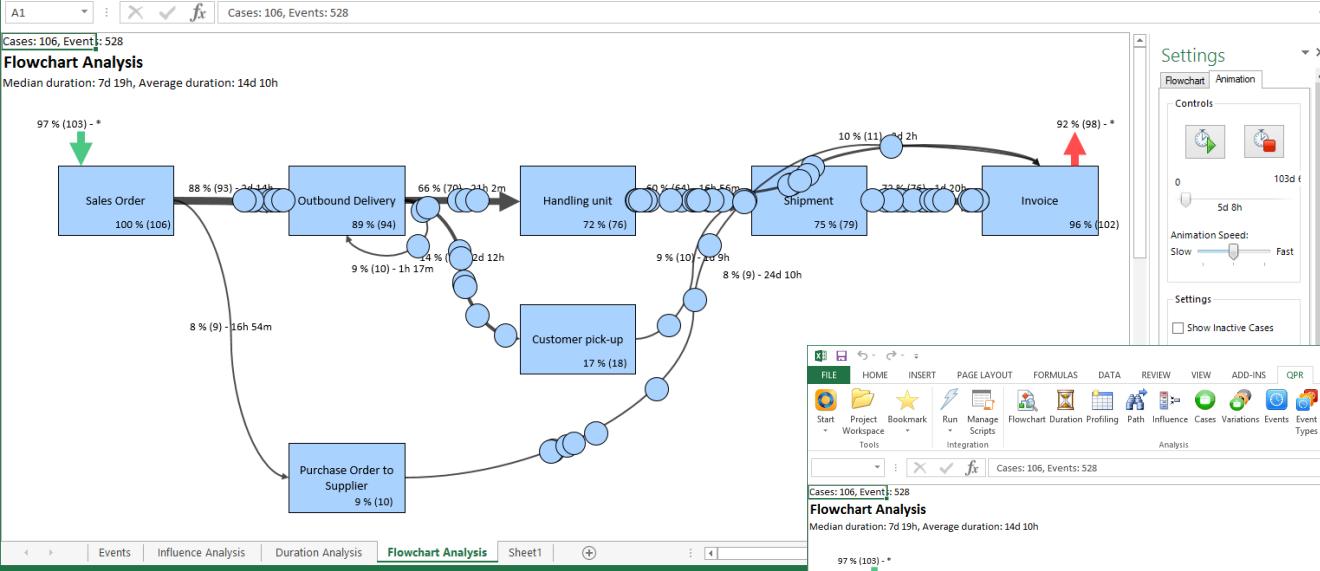
Event count

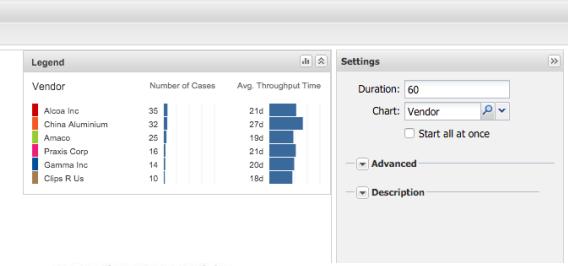
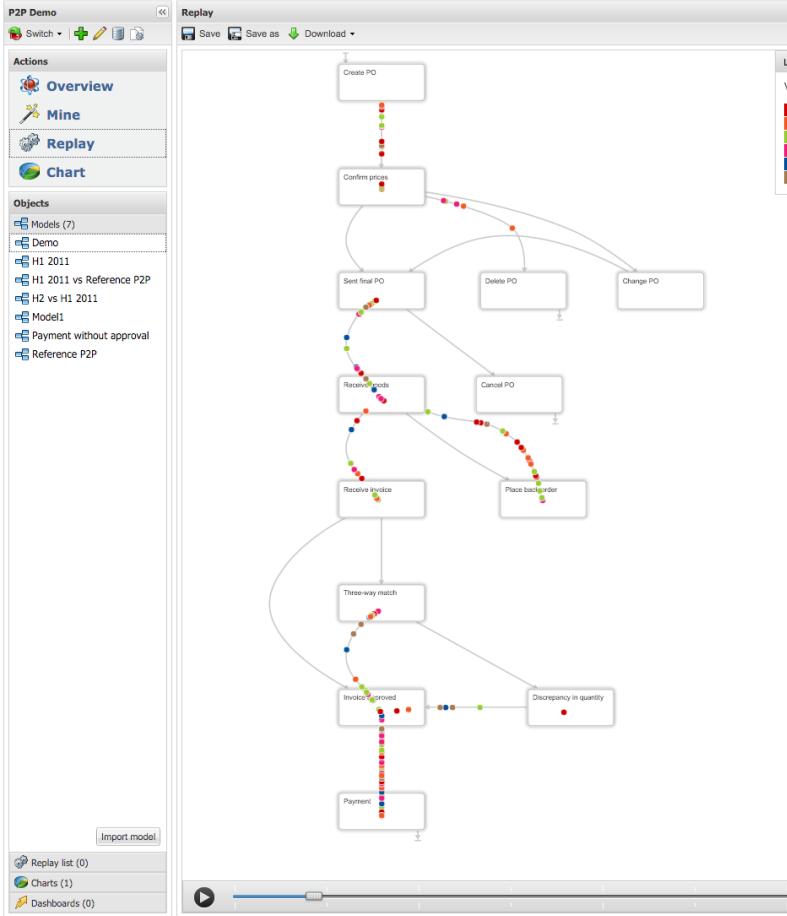


Visualize



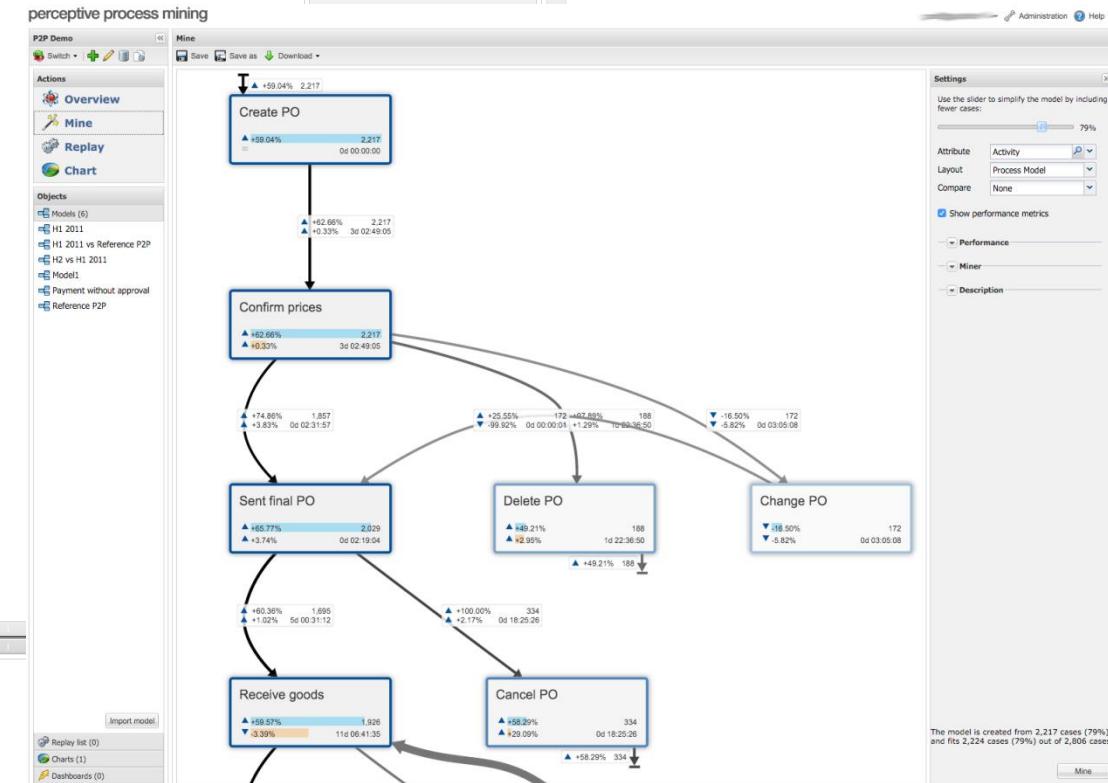
**my i nvenio**  
COGNITIVE TECHNOLOGY



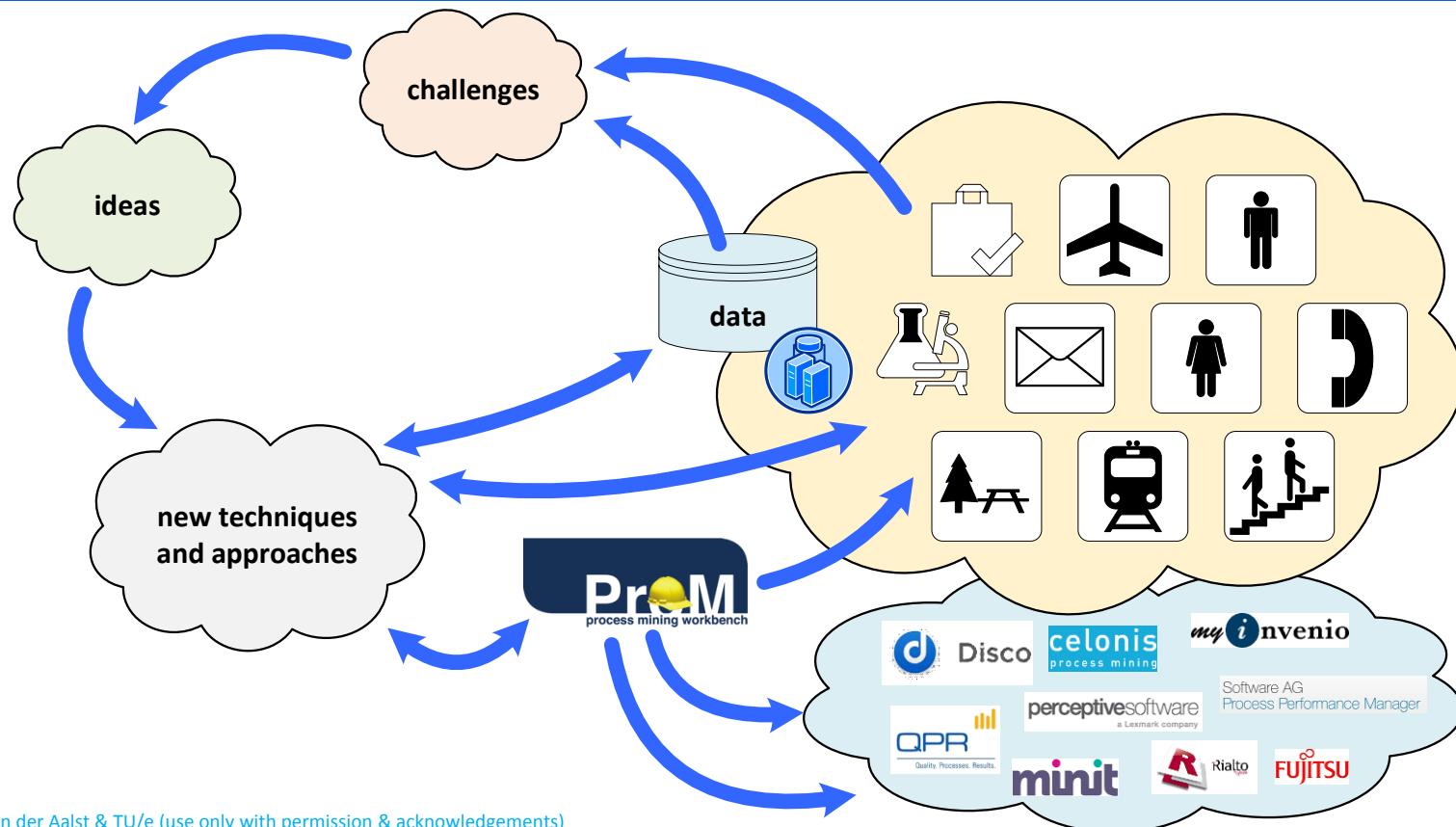


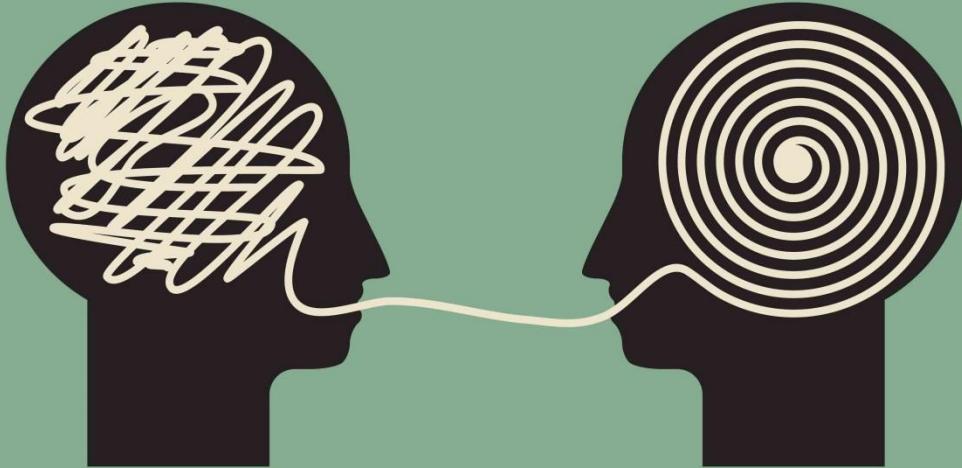
# Lexmark™

## Perceptive Process Mining



# Interaction with industry

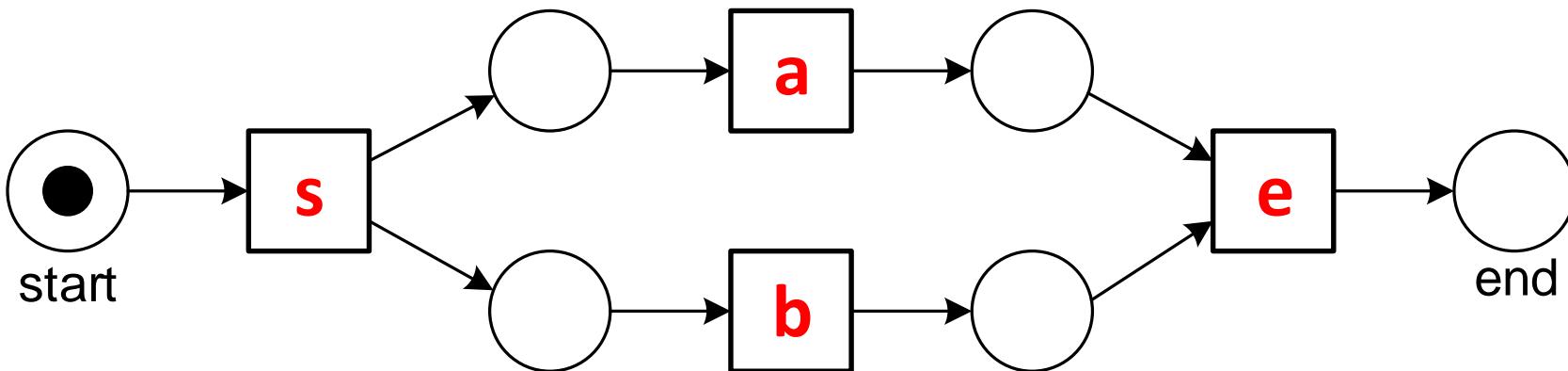


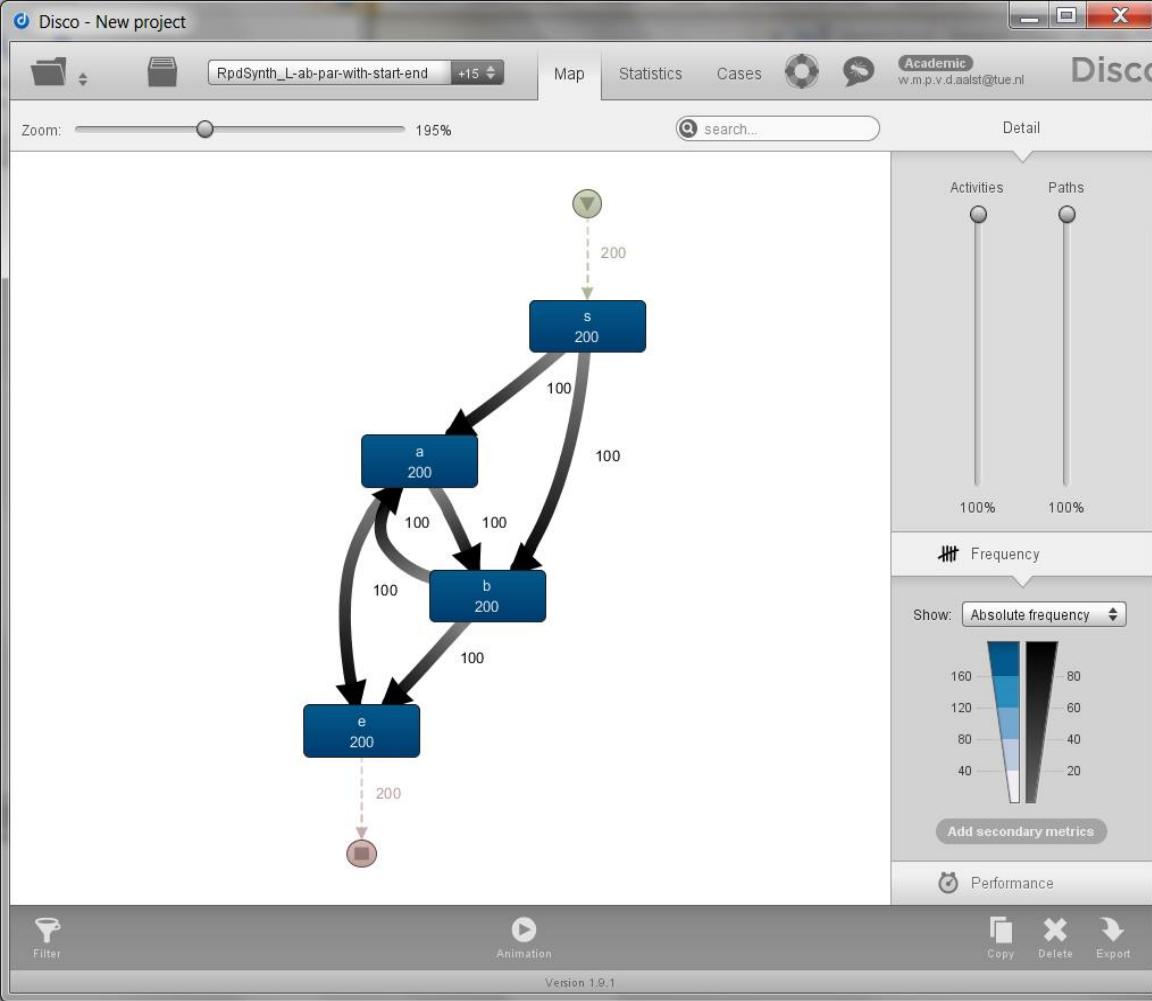


- Can I trust the results of process mining?
- How to interpret the results correctly?
- Alignments are a key technology!

Simple process model: starts with **s**,  
ends with **e**, **a** and **b** are executed  
once, **no loops**.

Event log:  
**100x sabe**  
**100x sbae**

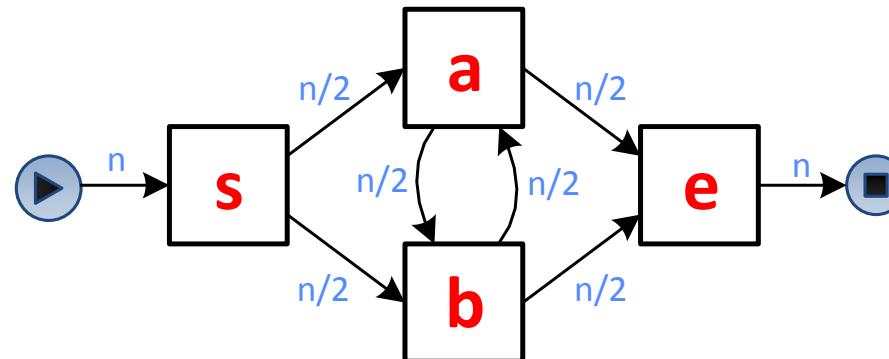
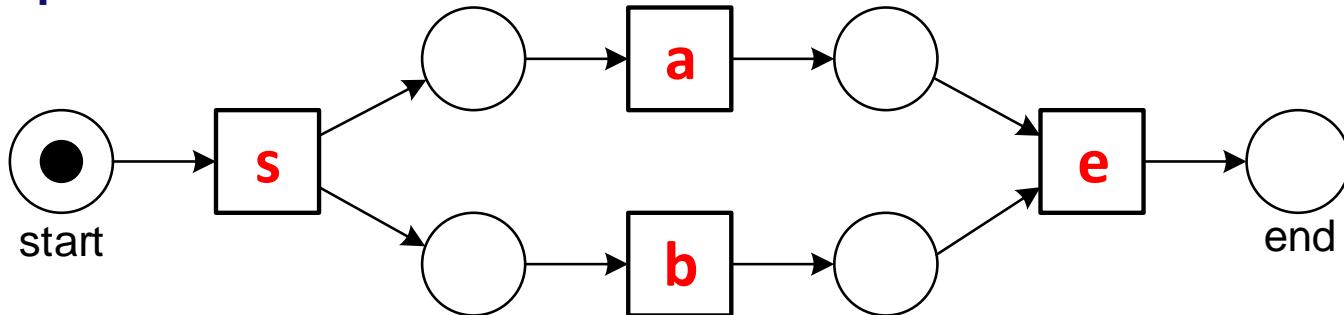




100x **sabe**  
100x **sbae**

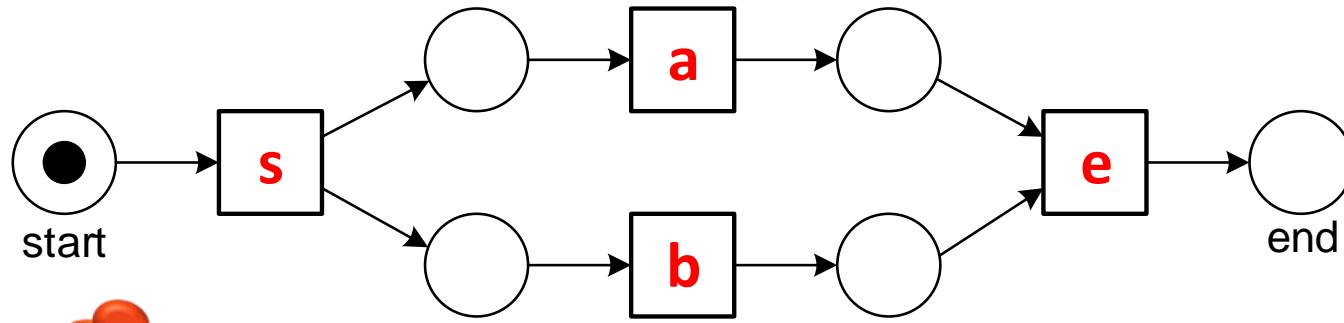


**Simple process model: starts with **s**,  
ends with **e**, **a** and **b** are executed  
once, no loops.**



**See the problem?**

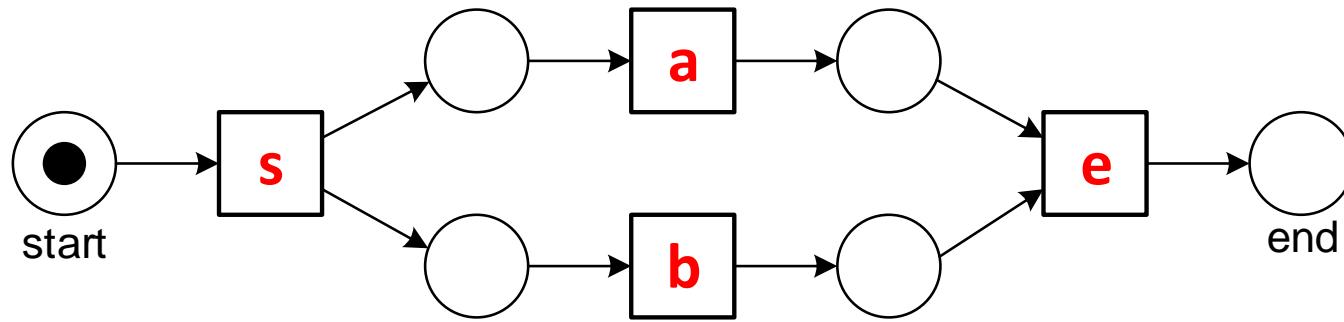
# Alignments are a key technology!



Not (well)  
supported  
by  
commercial  
tools

- Trace 1: **sabe** (OK)
- Trace 2: **sbae** (OK)
- Trace 3: **sae** (b is missing)
- Trace 4: **sabae** (two a's)
- Trace 5: **saae** (2 problems)

# Alignment for Trace 1: sabe



Reality:

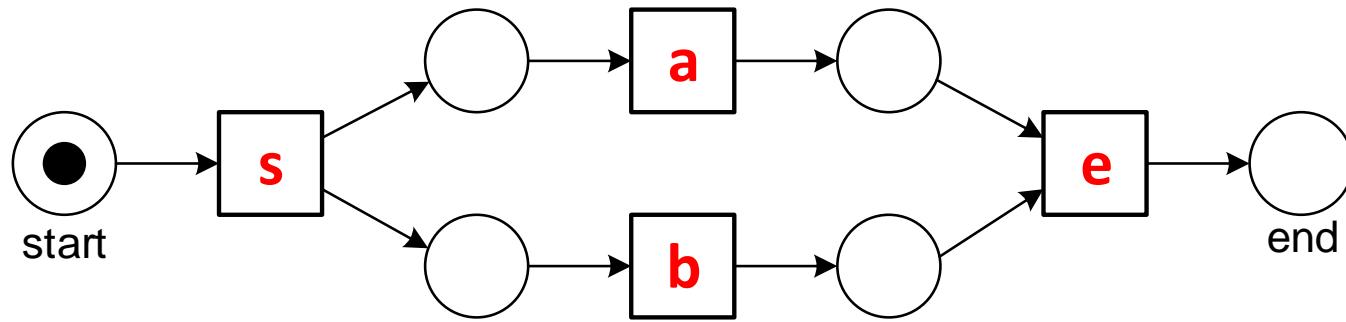
s	a	b	e
s	a	b	e

Model:

OK



# Alignment for Trace 2: sbae



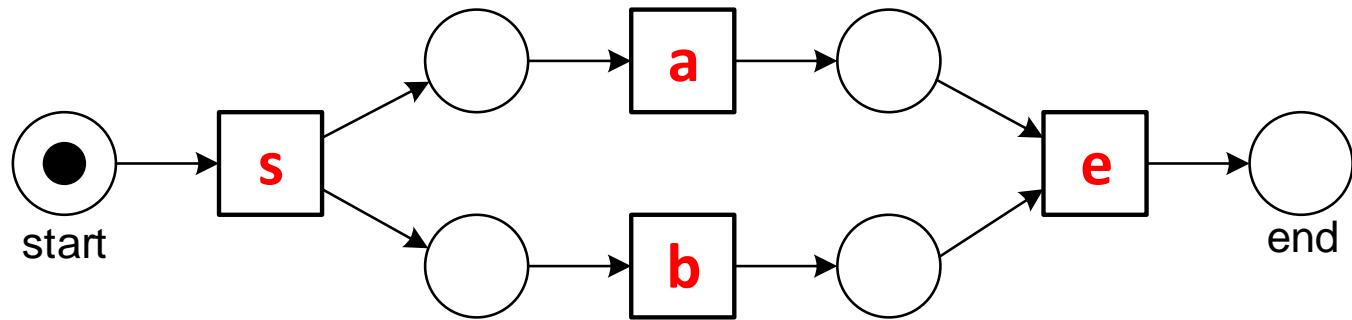
Reality:

s	b	a	e

Model:



# Alignment for Trace 3: sae



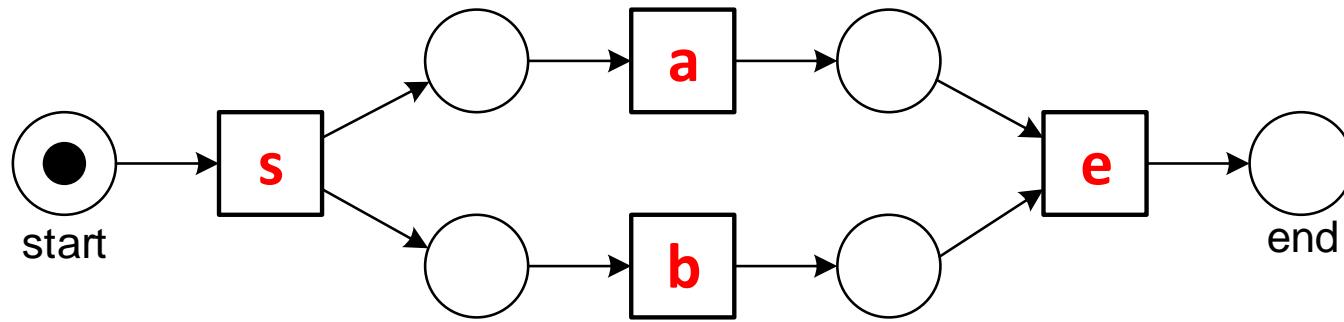
Reality:

s	a	X	e
s	a	b	e

Model:

b was  
skippe  
d

# Alignment for Trace 4: sabae



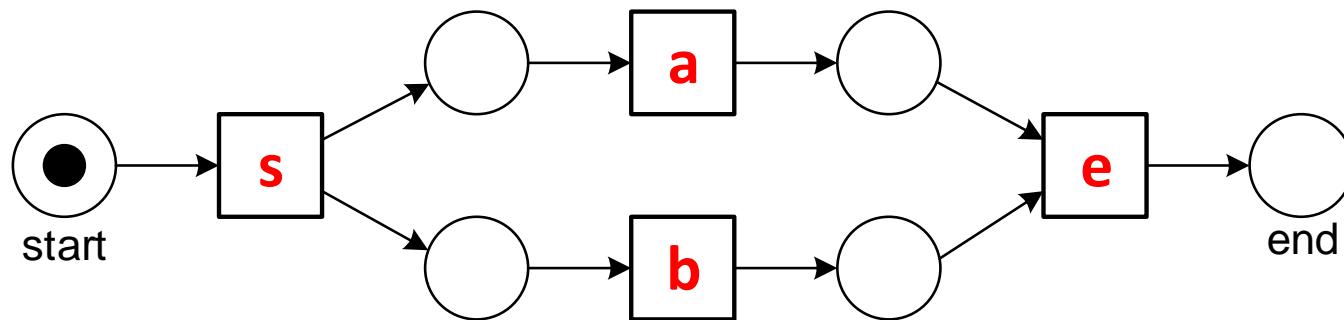
Reality:

s	a	b	a	e
s	a	b	X	e

Model:

Second  
a should  
not be  
there

# Alignment for Trace 5: saae



Reality:

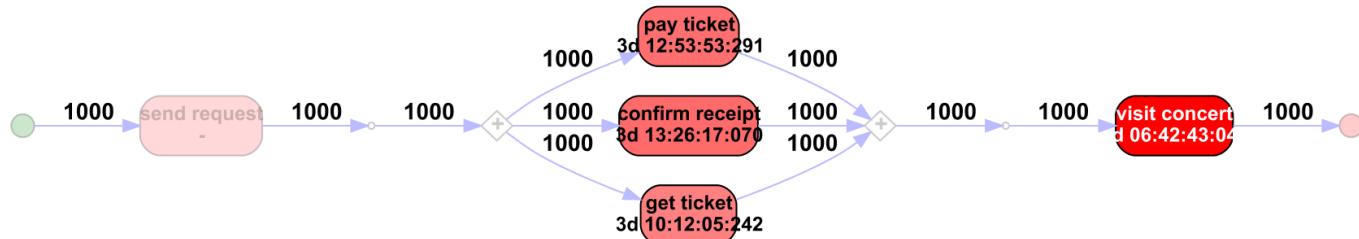
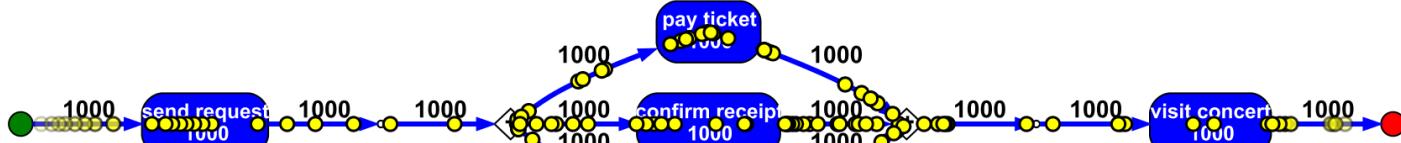
s	a	a	X	e
s	a	X	b	e

Model:

Second  
a  
instead  
of b

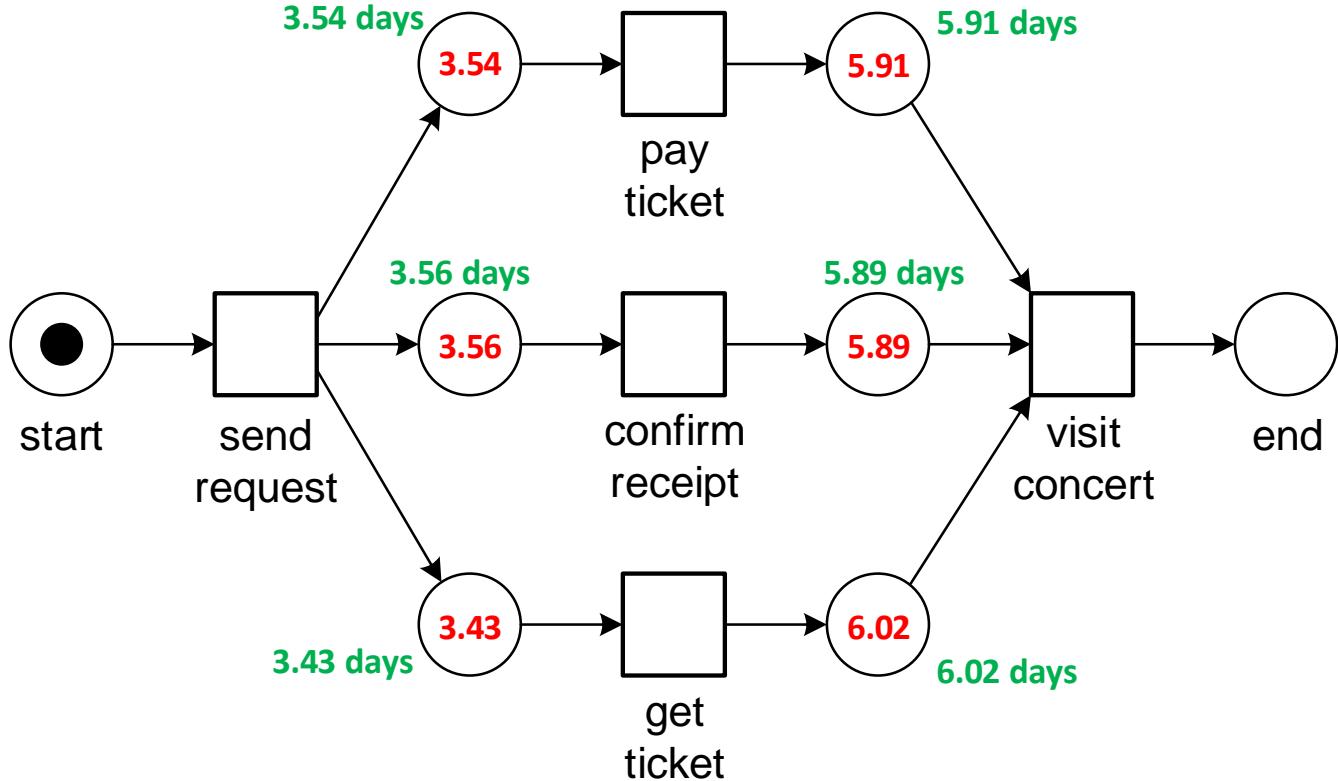
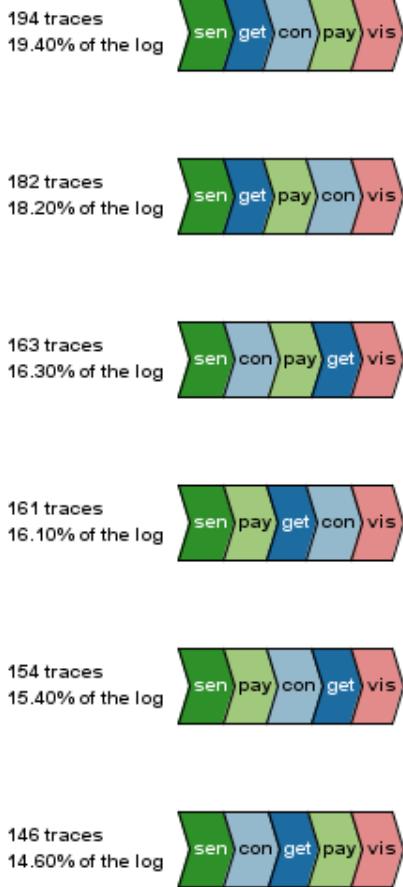
# Anonymous log imported from event\_log-concurrency-balanced-variable.xes

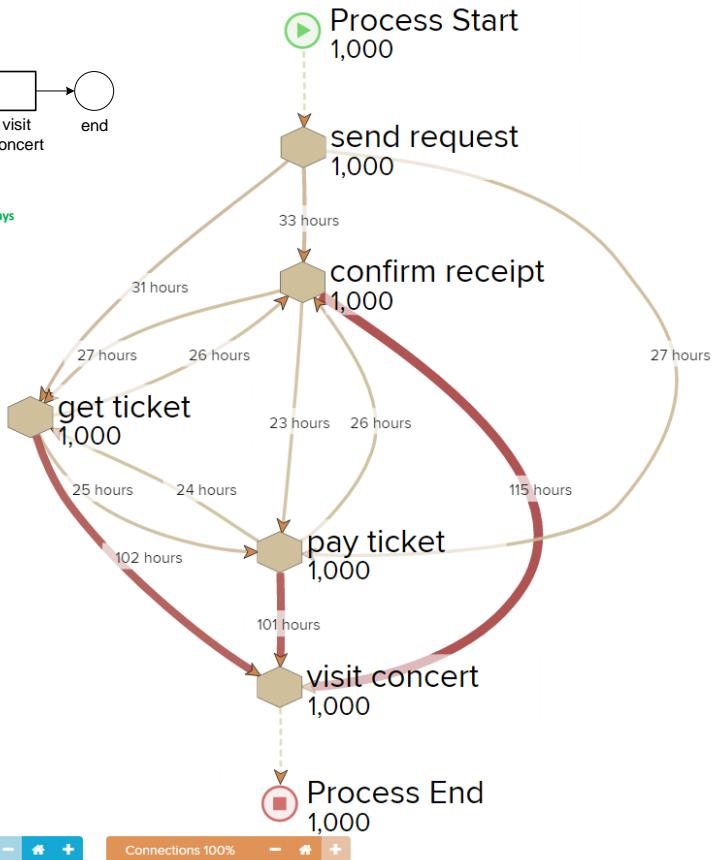
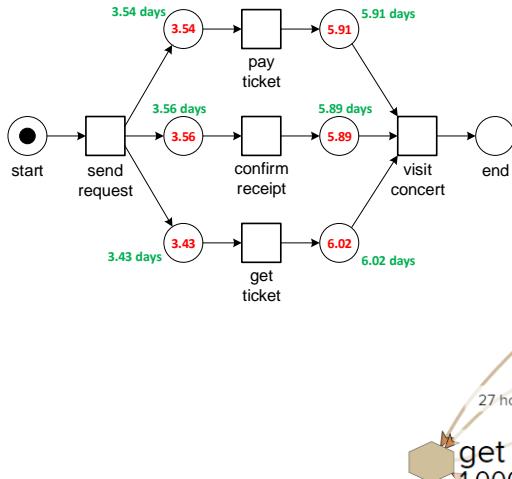
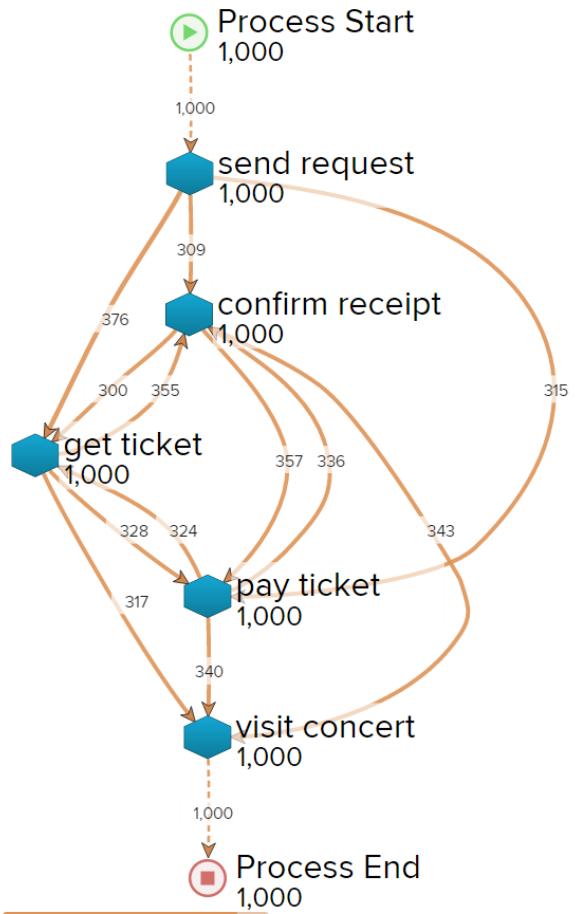
1000 traces  
5000 events

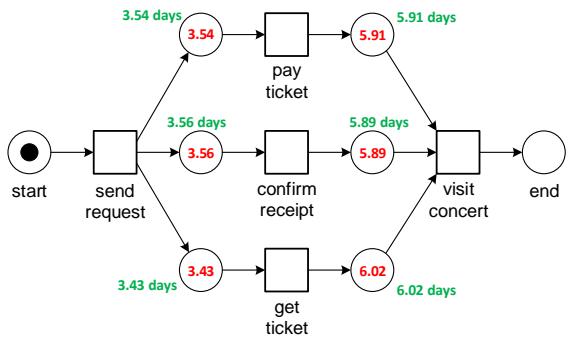
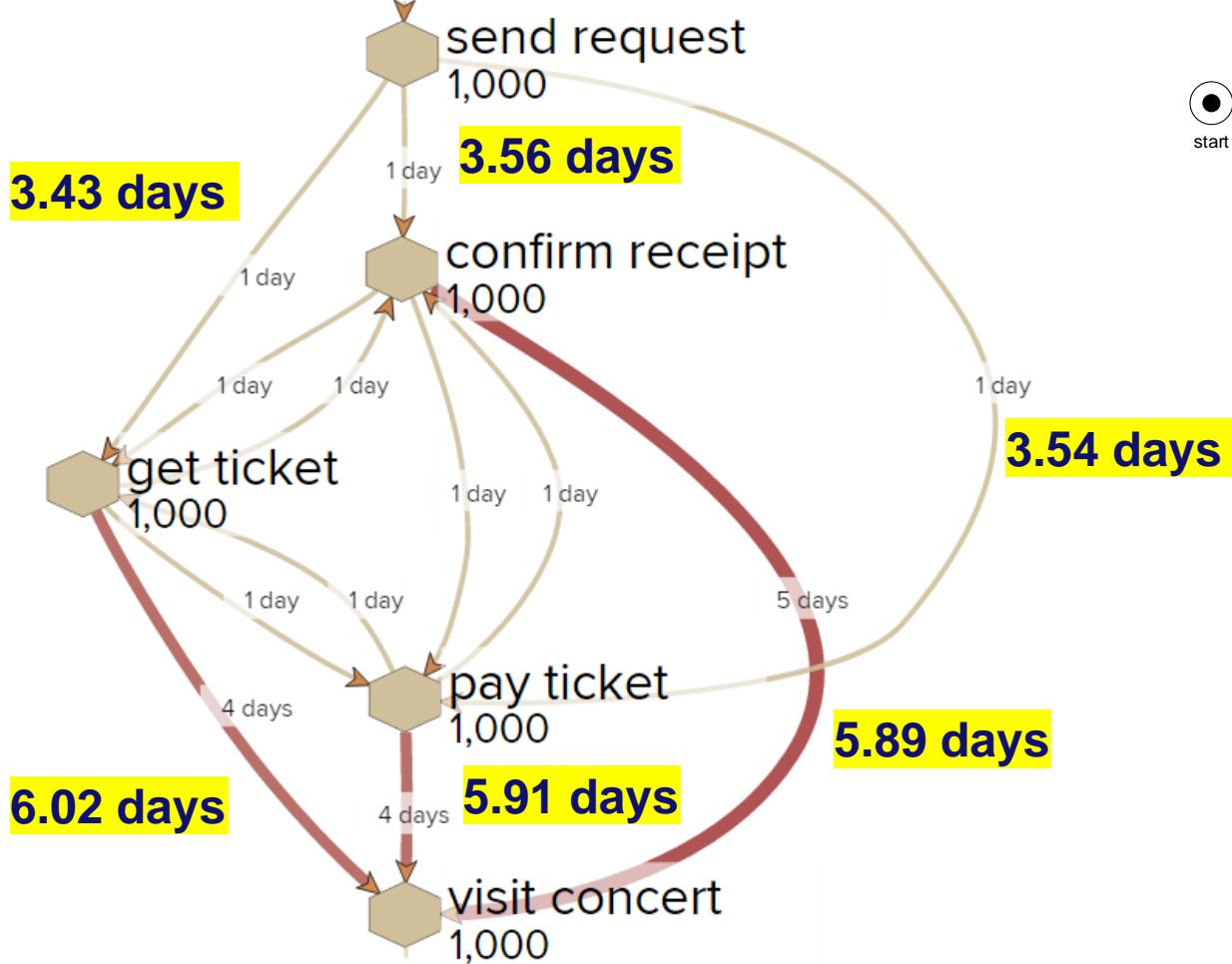


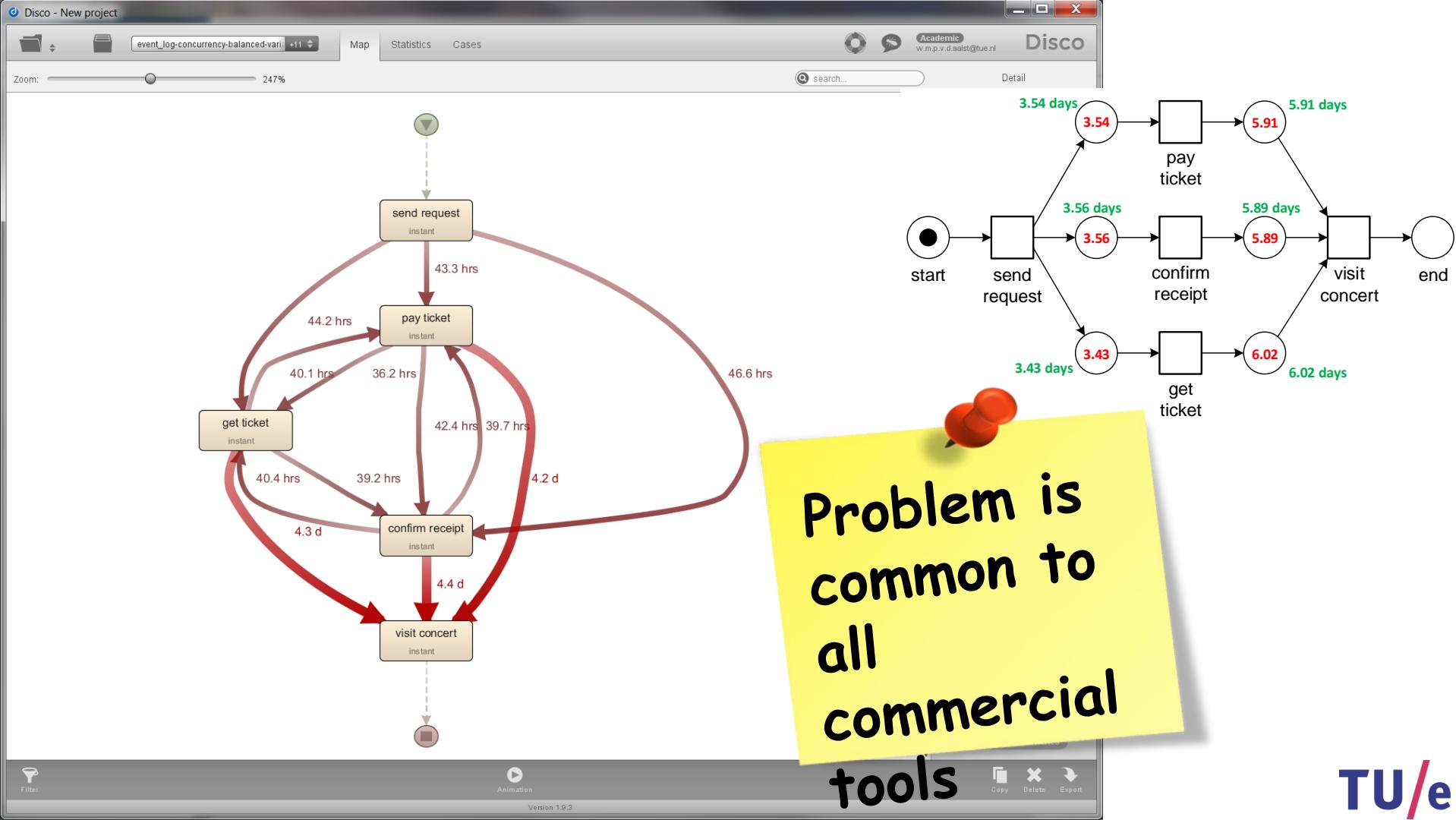
No alignments  
and/or  
concurrency:  
Performance  
diagnostics  
may be very  
misleading

# Anonymous log imported from event\_log-concurrency-balanced-variable.xes





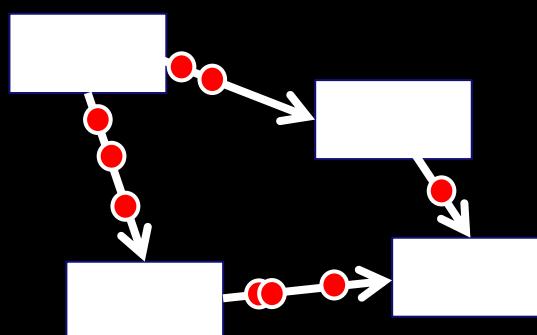




C11 < L > TOTAL

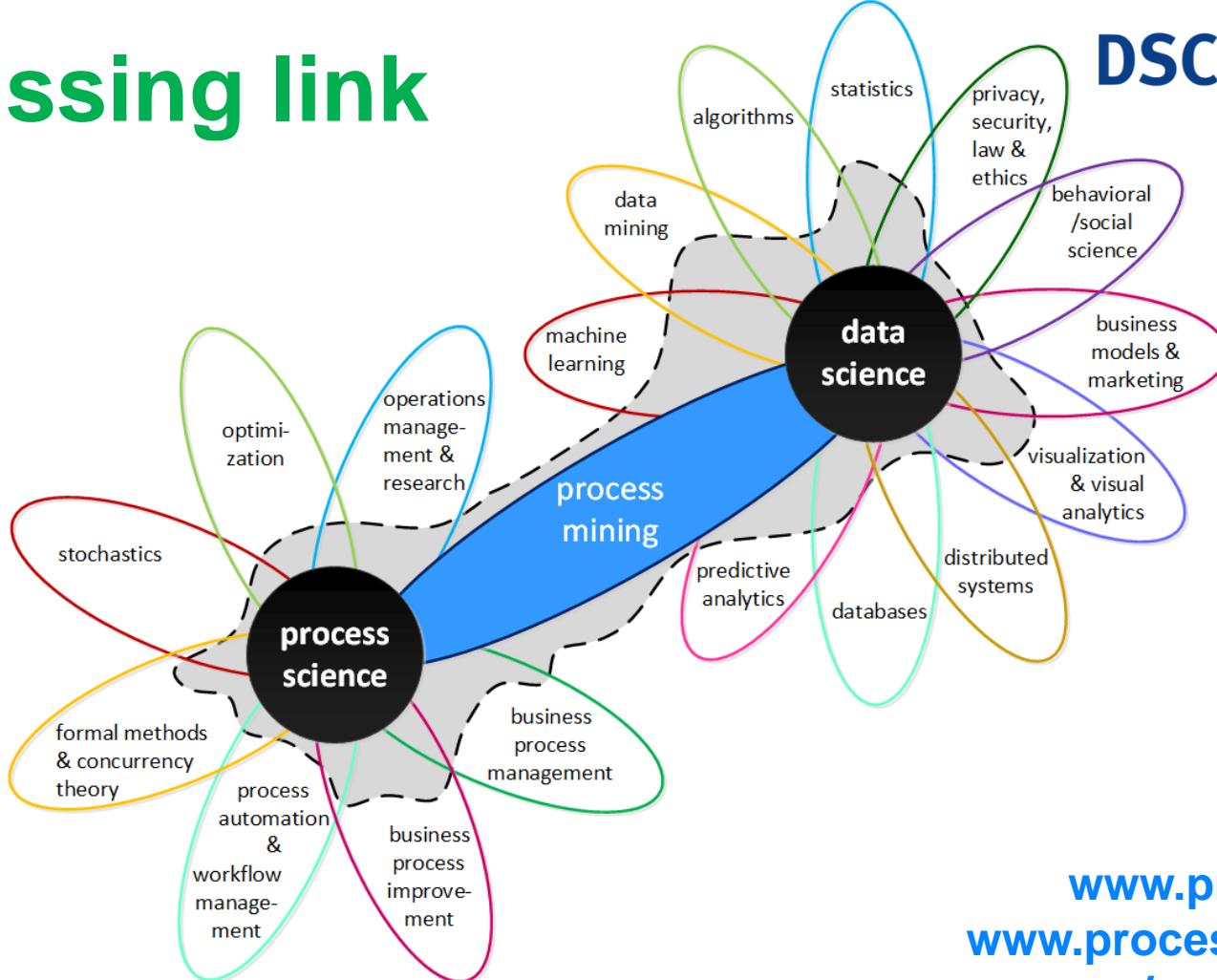
C1  
25

	A	B	C	D
	ITEM	NO.	UNIT	COST
1	MUCK RAKE	43	12.95	556.85
2	BUZZ CUT	15	6.75	101.25
3	TOE TONER	250	49.95	12487.50
4	EYE SNUFF	2	4.95	9.90
5				-----
6			SUBTOTAL	13155.50
7		9.75% TAX		1282.66
8			TOTAL	14438.16



# Summary

# The missing link



[www.promtools.org](http://www.promtools.org)

[www.processmining.org](http://www.processmining.org)

[www.coursera.org/course/procmin](http://www.coursera.org/course/procmin)



## Process Mining Data Science in Action

Starts  
every  
4  
weeks

Info MOOC: [www.coursera.org/course/procmin](http://www.coursera.org/course/procmin)

Wil van der Aalst

## Process Mining

Data Science in Action, *Second Edition*

This is the second edition of Wil van der Aalst's seminal book on process mining, which now discusses the field also in the broader context of data science and big data approaches. It includes several additions and updates, e.g. on inductive mining techniques, the notion of alignments, a considerably expanded section on software tools and a completely new chapter on process mining in the large. It is self-contained, while at the same time covering the entire process-mining spectrum from process discovery to predictive analytics.

After a general introduction to data science and process mining in Part I, Part II provides the basics of business process modeling and data mining necessary to understand the remainder of the book. Next, Part III focuses on process discovery as the most important process mining task, while Part IV moves beyond discovering the control flow of processes, highlighting conformance checking, and organizational and time perspectives. Part V offers a guide to successfully applying process mining in practice, including an introduction to the widely used open-source tool ProM and several commercial products. Lastly, Part VI takes a step back, reflecting on the material presented and the key open challenges.

Overall, this book provides a comprehensive overview of the state of the art in process mining. It is intended for business process analysts, business consultants, process managers, graduate students, and BPM researchers.

### Features and Benefits:

- First book on process mining bridging the gap between business process modeling and business intelligence, thus placing process mining within the rapidly growing field of data science
- Numerous additions and updates, e.g. on data quality, inductive mining techniques and the notion of alignments
- Includes a chapter on process mining for data scientists and computer scientists and a chapter on process mining for a broad audience in academia and industry, including the use of tools and the exploitation of process mining results

**Data science  
Big data  
Alignments  
Data quality  
Inductive mining  
Tooling**

<http://www.springer.com/9783662498507>

2nd Ed.

vander Aalst

Wil van der Aalst

# Process Mining

Data Science in Action

*Second Edition*

 Springer