Homework 2

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1 Introduction

In this assignment I have to analyze for a financial institute data and make suggestions for the company. The event log is taken from the information system while it is running.
All researches were done with ProM as ecpected from us. The data contains three types of activities (taken from the Assignment):

1. Event names that start with "App_" refer to status changes of applications. People make applications for a loan online.
2. Event names that start with "P_" refer to status changes of proposals, i.e. if the financial institute sees an opportunity to sell a loan to a customer, a proposal is sent to the customer.
3. Events that start with "W_" refer to activities performed by employees in the process, for example the call-center employees

The data was analyzed in several steps to get a better idea of the process and to make recommendations. Firstly I had a look at the data itself, secondly I split the data in 3 seperate models to better understand the processes. Based on this I had a look at the proposal c-net and created my own lifecylce. In the next steps I had a look at the application and workflow lifecycle searching for bottlenecks and possible optimizationsteps. Concluding I also explored the influence of the requested amount on the decisions taken, if there are employees having more influence on the outcome of a case and compared the thoughput times of nonapproved and approved cases.

2 General insights about the data set

The given data set is generated between 1st Oct 2011 0:38:44 (Saturday) and 14th Mar 2012 16:04:54 (Wednesday) and contains 13087 cases with 262200 events executed. One case contains minimal 3 events and maximal 175. In average 20.035 events.
There are 4366 different variants of cases. There are 36 different events possible "W_Complete_Application + COMPLETE" (9.141%), "W_Complete_Application + START" (8.967%), "W_Quotations + COMPLETE" (8.763%), "W_Quotations + START" (8.545%), "App_Fully_Submission + COMPLETE" (4.991%), "App_Incomplete_Submission + COMPLETE" (4.991%), "W_Handeling_Incomplete_Dossiers + COMPLETE" (4.35%), "W_Handeling_Incomplete_Dossiers + START" (4.348%), "W_Validation + COMPLETE" (3.011%), "W_Validation + START" (3.01%), "App_Rejection + COMPLETE" (2.912%), "W_Complete_Application + SCHEDULE" (2.811%), "App_Pre_Acceptation + COMPLETE" (2.81%), "P_Initiation + COMPLETE" (2.681%), "P_Selection + COMPLETE" (2.681%), "P_Sending + COMPLETE" (2.681%), "W_Quotations + SCHEDULE" (2.53%), "W_Handling_Leads + COMPLETE" (2.249%), "W_Handling_Leads + START" (2.249%), "App_Acceptation + COMPLETE" (1.95%), "W_Validation + SCHEDULE" (1.916%), "App_Finalization + COMPLETE" (1.913%), "W_Handling_Leads + SCHEDULE" (1.82%), "P_Cancellation + COMPLETE" (1.394%), "P_Returning + COMPLETE" (1.317%), "App_Cancellation + COMPLETE" (1.071%), "W_Handeling_Incomplete_Dossiers + SCHEDULE" (0.909%), "App_Initiation + COMPLETE" (0.857%), "App_Approving + COMPLETE" (0.857%), "App_ Registration + COMPLETE" (0.857%), "P_Acceptation + COMPLETE" (0.855%), "P_Rejection + COMPLETE" (0.306%), "W_Fraud_ Detection + COMPLETE" (0.103%), "W_Fraud_Detection + START" (0.103%), "W_Fraud_Detection + SCHEDULE" (0.047%) and "W_Changing_Contact_Details + SCHEDULE" (0.005%).
The complete, start and shedule are more details about the state of the event. Just about the Workflow events I have more information about the state.
All processes start in "App_Fully_Submission + COMPLETE" (100.0%).
The processes can end in 13 different events:
"App_Rejection + COMPLETE" (26.202%), "W_Validation + COMPLETE" (20.975%), "W_Handling_Leads + COMPLETE" (17.07%), "W_Complete_Application + COMPLETE" (14.816%), "W_Quotations + COMPLETE" (9.849%), "App_Cancellation + COMPLETE" (5.005%), "W_Handeling_Incomplete_Dossiers + COMPLETE" (3.454%), "P_ Cancellation + COMPLETE" (2.132%), "W_Fraud_Detection + COMPLETE" (0.436%), "W_Changing_Contact_Details +

SCHEDULE" (0.031%), "W_Validation + START" (0.015%), "App_Registration + COMPLETE" (0.008%) and "W_Quotations + START" (0.008%).
What you already see here, is that the process not always ended like expected, because the log is taken from the running system. All the process ending with a start event are probably not done now.

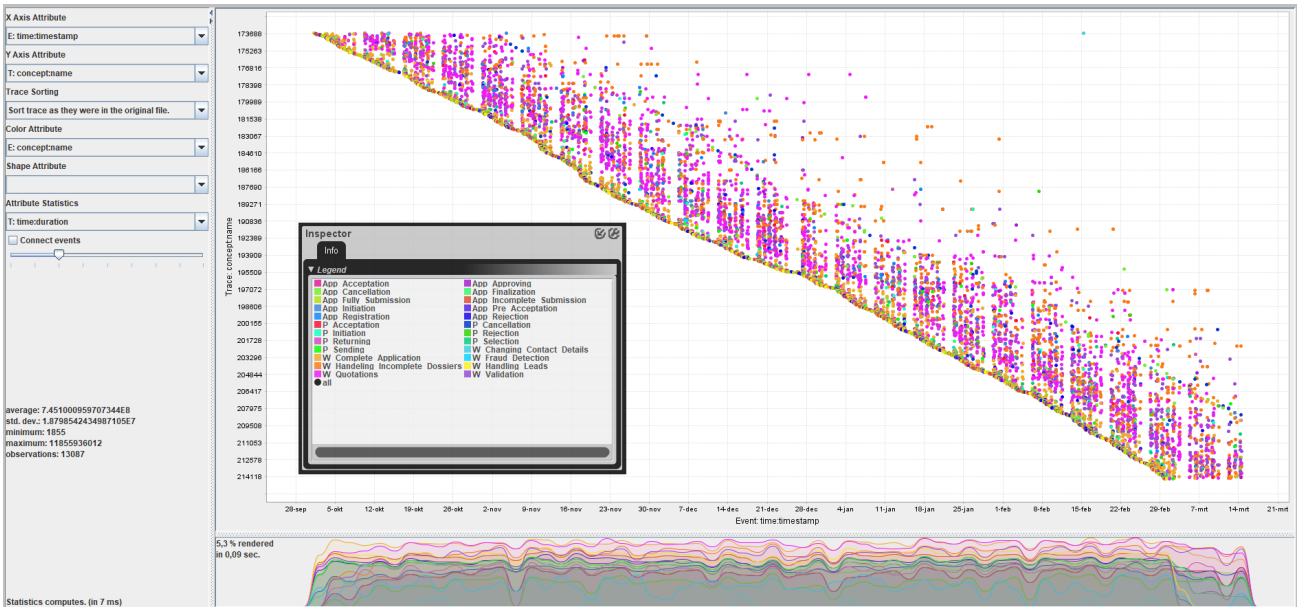


Figure 1: Dotted chart of the data set

Having a look at the whole data, figure 1 it can be seen, that there are just the following events executed at sundays: "W_Complete_ Application", "W_Handling_Leads", "App_Incomplete_Submission", "P_Cancellation", "App_Fully_Submission" and "App_Rejection". Furthermore is there a constant input of new cases. The events are mostly executed the same amount of times just "W_Fraud_Detection" and "W_Changing_Contact_Details" have really deeps and ups. What is not surprising, because both are outlier behavior actions.

3 Process Models

In the first part I will give different models there conformances. In the end I will have a look at the bottlenecks and give first recommendations.

3.1 Steps for exploring the models

For exploring a good model of a data set I first filtered the data with the **Filter log on event attribute names** tool for extracting the required. Then I used **Interactive data heuristic miner** and **Inductive Miner** on the filtered data set to discover different models. After comparing the outcomes I decided to concentrate on **Interactive data heuristic miner** and their directly followed graphs and petri nets for understanding the lifecycle. I think the petri net is the best with basic configuration and just different frequency filters. The conformance checking where done with **Replay a log on Petri Net for conformance analysis** tool on the petri net and the filtered data. For the precision check I applied the **Multi-perspective Process Explorer** tool on the petri net and the filtered data and chose "show precision mode" in the tool with basic configuration.

3.2 Application data set

Just the events beginning with "App_..." are required. The resulting data set is saved as "Filtered App".

3.2.1 General details of the data set

The data set is collected between the 1st of 0ct 2011 (Saturday), 00:38:44 and the 14th of Mar 2012 (Wednesday), 15:33:57. It contains 13087 cases with 60849 executed events.
10 different events appear (occurences relative), all events are complete so I deleted this extra information: "App_Fully_Submission" (21.507%), "App_Incomplete_Submission" (21.507%), "App_Rejection" (12.547%), "App_Pre_Acceptation" (12.107%), "App_Acceptation" (8.403%), "App_Finalization" (8.242%), "App_Cancellation" (4.613%), "App_Initiation" (3.691%), "App_Approving" (3.691%) and "App_Registration" (3.691%). Just "APP_Fully_Submission" appears to be a start event. However there are 8 end events possible: "App_Rejection" (58.34%), "App_Cancellation" (21.449%), "App_Initiation" (8.573%), "App_Registration" (6.014%), "App_Approving" (2.575%), "App_Finalization" (2.499%), "App_Pre_Acceptation" (0.527%) and "App_Acceptation" (0.023%).

A trace contains maximal 8 different events and minimal 3. The mean is 4.65. In total there are 17 different variants of traces.

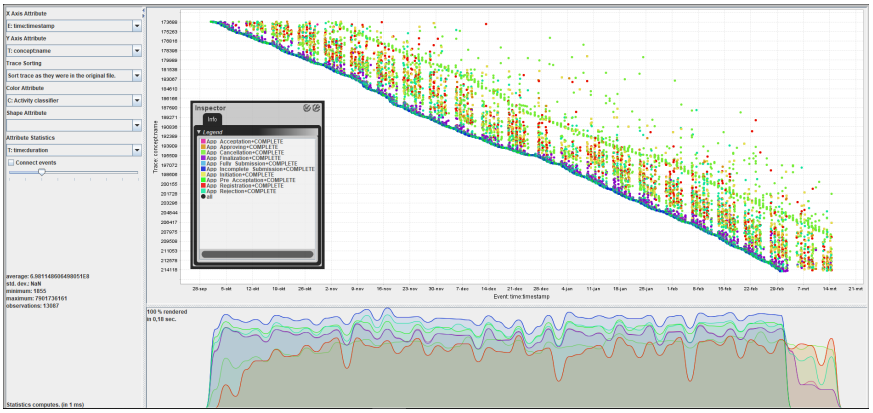
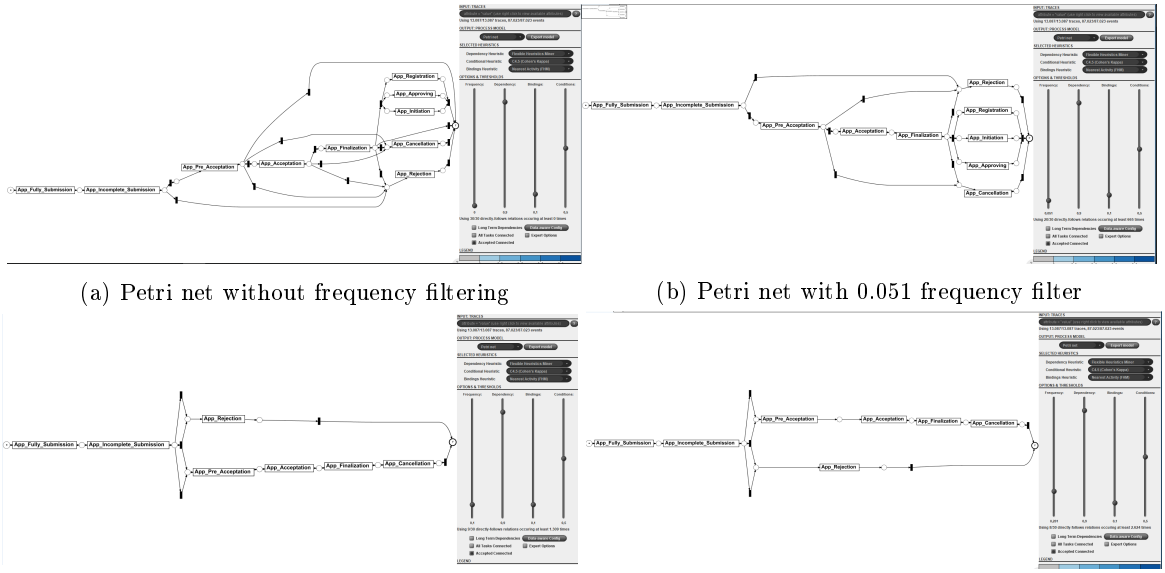


Figure 2: Dotted chart showing the time of events

In figure 2 the dotted chart can be seen. Having a closer look at this chart you see gaps, which are always on a sunday. Those gaps do not appear for "APP_Pre_Acceptation" and "APP_Incomplete_Submission". Furthermore in the lower left corner the following information can be found: average duration of a case, 8 days 1 hours 55 minutes and 14.86 seconds, and the maximum duration, 91 days 10 hours 55 minutes and 36.16 seconds. Both are given in milliseconds.

3.2.2 Discover and evaluate models of the application lifecycle



(a) Petri net without frequency filtering

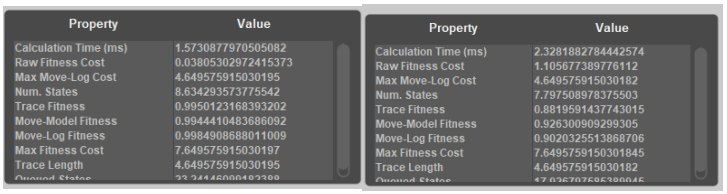
(b) Petri net with 0.051 frequency filter

(c) Petri net with 0.1 frequency filter

(d) Petri net with 0.2 frequency filter

Figure 3: Considered petri nets

To find an accurate model I tried different frequency filters, 3. First I chose the frequency 0.1 and had a look at the resulting petri net. I also checked 0.2 and 0.51 to get a better understanding of the model(not shown here is the petri net with 0.6 filtering, which was the next filtering after 0.1, that changed the net, but I decided, that it does not contain enough cases). For comparsion in the end I had also a look at the original petri net found by the **Interactive data heuristic miner**. In figure 3 the 4 considered petri nets can be seen. My first choice was the petri net with 0.1 as threshold for frequency, because it was a simple model that still tells us a lot about the main process (90% of the cases) and is not too specific (still has an acceptable generalization). Obviously the original graph does not fullfill the criterium of simplicity and also the graph with frequency 0.051 still looks not as simple. I do not consider the 0.2 filtering in the next steps, because it is the same petri net as the 0.1 filtered one.
The results of the conformance checking are shown in figure 4.
Having a look at the precision, figure 5, I could see, that the precision of 0.051 filtering is 100%, but of the 0.1 filtering just 88.1%. In combination with the results before, I came to the conclusion, that 0.1 filtering is not good enough as model and 0.051 would be good enough, but did not fullfill my simplicity criterium complete. Starting by 0.051 for filtering I again tried different frequency filters starting by 0.075 to find a model with a similar simplicity as the 0.1 frequency model, but a better conformance and precision than this simpel model. The best result I found was with 0.069 filtering. This model is simpel



Property	Value
Calculation Time (ms)	1.5730877970505082
Raw Fitness Cost	0.03805302972415373
Max Move-Log Cost	4.649575915030195
Num. States	8.634293573775542
Trace Fitness	0.9950123168393202
Move-Model Fitness	0.9944410483686092
Move-Log Fitness	0.9984908688011009
Max Fitness Cost	7.649575915030197
Trace Length	4.649575915030195

(a) Conformance for 0.051 frequency filter

Property	Value
Calculation Time (ms)	2.3281882784442574
Raw Fitness Cost	1.105677389776112
Max Move-Log Cost	4.649575915030182
Num. States	7.797508978375503
Trace Fitness	0.8819591437743015
Move-Model Fitness	0.926300909299305
Move-Log Fitness	0.9020325513868706
Max Fitness Cost	7.6495759150301845
Trace Length	4.649575915030182

(b) Conformance for 0.1 frequency filter

Figure 4: Conformance checking

Avg activity precision	100%
# Moves Observed	144.789
# Moves Possible	144.789
Avg fitness	99,6%
% Violations	0,8%
% Event Violations	0,8%
% Data Violations	0%
# Correct Events	60.849
# Wrong Events	0
# Missing Events	498

(a) Precision for 0.051 as frequency filter

Avg activity precision	88,1%
# Moves Observed	97.074
# Moves Possible	110.161
Avg fitness	88,6%
% Violations	21,7%
% Event Violations	21,7%
% Data Violations	0%
# Correct Events	52.096
# Wrong Events	8.753
# Missing Events	5.717

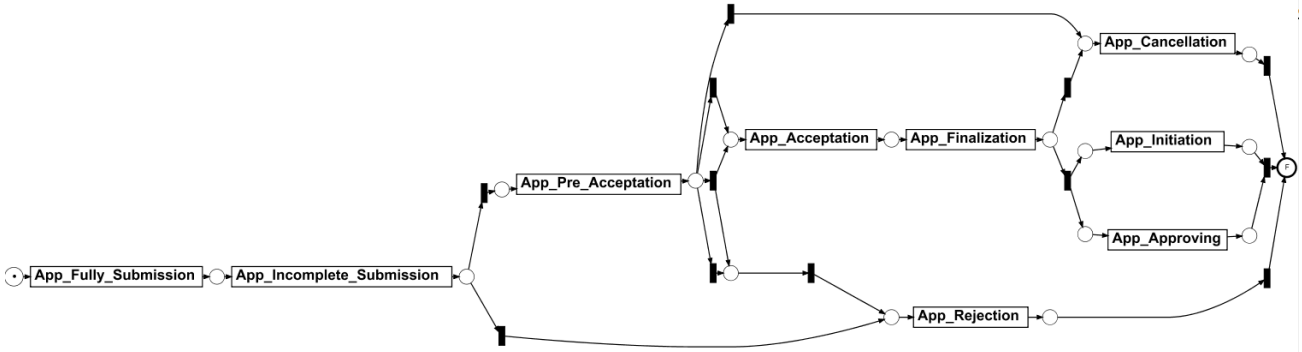
(b) Precision for 0.1 as frequency filter

Figure 5: Precision checking

Property	Value
Raw Fitness Cost	0.33223809887674755
Max Move-Log Cost	4.64957591503021
Num. States	8.79514021548101
Trace Fitness	0.9657921716262099
Move-Model Fitness	0.9944410483686092
Move-Log Fitness	0.9566108861210915
Max Fitness Cost	7.649575915030202
Trace Length	4.64957591503021
Queued States	22.11140826774671

Avg activity precision	94,8%
# Moves Observed	133.936
# Moves Possible	141.304
Avg fitness	96,6%
% Violations	7%
% Event Violations	7%
% Data Violations	0%
# Correct Events	57.772
# Wrong Events	3.077
# Missing Events	1.271

(a) Conformance and Precision



(b) Petri net

Figure 6: Frequency 0.069

enough to understand the main lifecycle, but still has good result for conformance (fitness 96.58%) and precision(94.8%),6. Based on this I decided to choose this petri net for the lifecycle of the application data.

3.2.3 Discussion of the lifecycle

Simplifying the discussion I will not write "App_.." in begin of all events, but every event mentioned in this section is from the application data set. To also have details about the occurency of the steps in the model I used the replay result, 7.

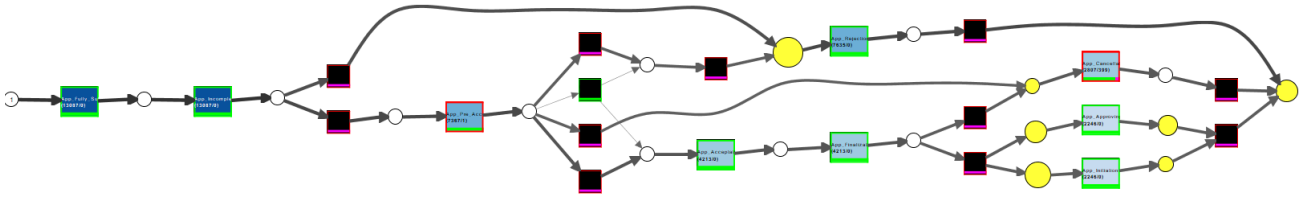


Figure 7: Replay on petri net with 0.069 frequency filter

The process always starts with "Fully_Submission" and "Incomplete_Submission" (13087 cases). After this there are two different outcomes:

1. "Rejection" (5719 cases, executed in total in 7365 cases)
2. "Pre_Acceptation" (7367 cases)

"Pre_Acceptation" has 4 different successor events

1. "Rejection" (1916 cases)
2. "Rejection" and "Acceptation" (0 cases)
3. "Acceptation" (4213 cases)
4. "Cancellation" (1239 cases)

"Acceptation" is followed by "Finalization" (4213). "Finalization" is followed in (1967 cases) by "Cancellation", which is in total executed 3206 times, and otherwise by "Approving" and Initation (2246 cases). All the differences between incoming and outcoming cases can be explained through the filtering by frequency for building the model.
Looking at the **Time between Transition matrix** of the replay result it can be seen, that the transition to "Approving" and "Initiation" need in average ~16 days, which is the second longest transition time. "Cancellation" has the worst transition time with in average ~20 days.

3.3 Proposal data

Just the events beginning with "P_..." are required. The resulting data set is saved as "Filtered P". Having a look in the data it was seen, that there were a lot of empty traces, so I filtered it again with the **Filter Log using Heuristics** tool, without applying any filter just everything to 100% and saved this as "Pdoublefiltered". I use the second data set in the next steps.

3.3.1 General Details of the data set

The data set is collected between the 1st of 0ct 2011 (Saturday), 10:44:40 and the 14th of Mar 2012 (Wednesday), 15:50:59 and contains 5015 cases with 31244 events. Looking at the visualization you can see that there are gaps in the workflow.
In figure 8 the dotted chart can be seen. When the gaps in the dotted chart are studied closely, it's clear that these gaps illustrate the situatioin on sundays. What does not show this behaviour so clear is "P_Cancellation" and "P_Initiation". Furthermore in the lower left corner the following information can be found: the average duration of a case, 17 days 4 hours 20 minutes and 24.85 seconds, the minimum duration is 667 milliseconds and the maximum duration 89 days 13 hours 10 minutes and 6.16 seconds. Both is given in milliseconds.
The data set has 7 events: "P_Initiation" (22.5%), "P_Sending" (22.5%), "P_Selection" (22.5%), "P_Cancellation" (11.698%), "P_Returning" (11.055%), "P_Acceptation" (7.179%) and "P_Rejection" (2.567%). There are 169 different variants of traces.
All traces start with "P_Selection". And the end events are distributed like this: "P_Acceptation" (44.726%), "P_Cancellation" (32.702%), "P_Rejection" (15.992%), "P_Sending" (4.806%) and "P_Returning" (1.775%).
Maximal 30 events are executed in a case and minimal 3. The mean of events per class is 6.23.

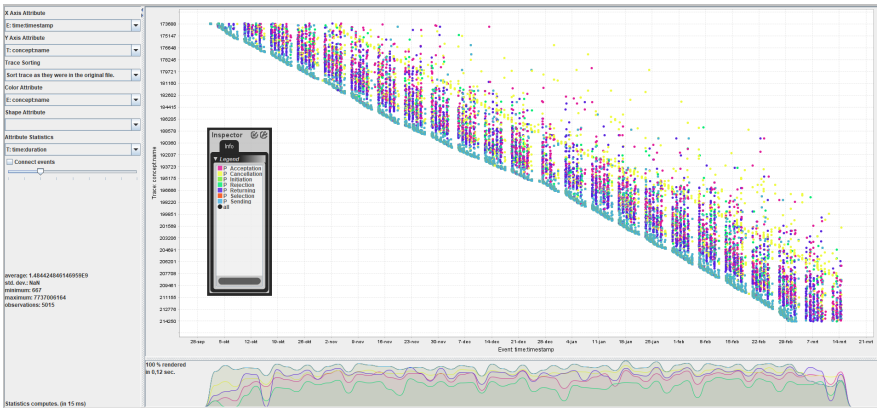
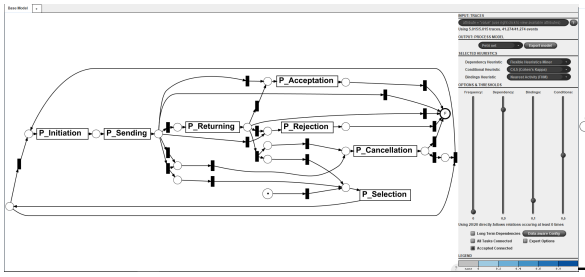
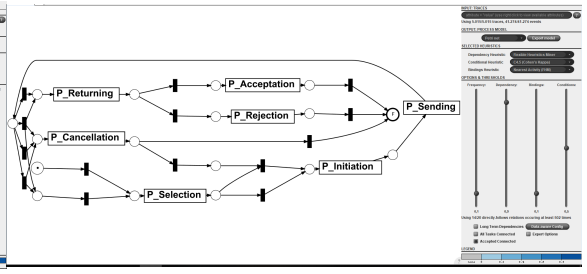


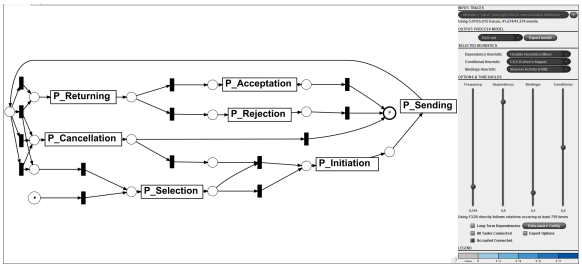
Figure 8: Dotted chart showing the time of events



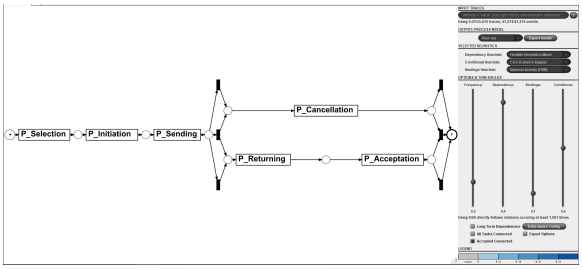
(a) Petri net without frequency filtering



(b) Directly followed graph 0.1 frequency filter



(c) Petri net for 0.151 frequency filter



(d) Petri net for 0.2 frequency filter

Figure 9: Considered petri nets

Property	Value
Raw Fitness Cost	0.20299102691924234
Max Move-Log Cost	6.230109670987042
Num. States	14.854237288135613
Trace Fitness	0.9824694366187957
Move-Model Fitness	0.9837550634114102
Move-Log Fitness	0.9894060148078491
Max Fitness Cost	10.230109670987057
Trace Length	6.230109670987042
Queued States	39.14217347956131

(a) Conformance for 0.151 as frequency filter

Property	Value
Raw Fitness Cost	1.84187437686939
Max Move-Log Cost	6.230109670987028
Num. States	11.126021934197395
Trace Fitness	0.8633619014528089
Move-Model Fitness	0.9655433698903272
Move-Log Fitness	0.8301506678744179
Max Fitness Cost	10.230109670987046
Trace Length	6.230109670987028
Queued States	23.692123629112654

(b) Conformance for 0.2 as frequency filter

Avg activity precision	79,6%
# Moves Observed	81.810
# Moves Possible	102.778
Avg fitness	98,4%
% Violations	3,2%
% Event Violations	3,2%
% Data Violations	0%
# Correct Events	30.740
# Wrong Events	504
# Missing Events	514

(c) Precision for 0.151 as frequency filter

Avg activity precision	91,9%
# Moves Observed	45.844
# Moves Possible	49.872
Avg fitness	85,6%
% Violations	28,5%
% Event Violations	28,5%
% Data Violations	0%
# Correct Events	23.202
# Wrong Events	8.042
# Missing Events	1.195

(d) Precision for 0.2 as frequency filter

Figure 10: Conformance and precision checking

3.3.2 Discover and evaluate models of the proposal lifecycle

Applying the steps on the proposal data set gave me in first instance 4 models I wanted to have a closer look at.
Because of simplicity reasons I picked out of those, figure 9, just the 0.151 and 0.2 filtered petri nets.
The conformance and precision outcomes(see in figure 10) told me, that the 0.2 frequency model (fitness 86.33%, precision 91.9%) has a better outcome for the precision as the 0.151 filtered model(precision 79.6%), but a worse for the fitness (98.25%). So I searched for an other model, which has a similar simplicity as the 0.2 and 0.151 filtered models and might have a better fitness or precision. The model fullfilling simplicity was 0.175 filtering, but the fitness was worse, than for 0.2 filtering. I tried this with several other filterings, but the best was 0.2 filtering, so I chose this one.

3.3.3 Discussion of the lifecycle

Simplifying the discussion I will not write "P_.." in begin of all events, but every event mentioned in this section is from the proposal data set.

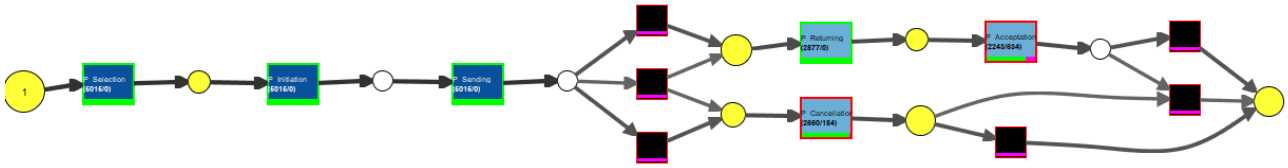


Figure 11: Replay on petri net with 0.2 frequency filter

5015 cases start with "Selection". Then "Initiation" event is performed (5015 cases). "Initiation" is followed by "Sending" (5015 cases), which has 3 different succesor actions.

1. "Returning" (2171 cases)
2. "Returning" and "Cancellation" (706 times)
3. "Cancellation" (2138 times)

"Returning" is in 2243 cases followed by "Acceptation". "Cancellation" and "Acceptation" have to be joined again if it was an end split before

3.4 Combined Model

For combined Models I first filtered the data to have a dataset with all proposal data combined with the application data. This data I filtered with Heuristic filter (all configurations to 100% and just deciding what the endstate is) with the outcomes/endstates "APP_rejected" or "APP_cancelled" or "APP_approved". I saved them under the names "Filtered P App with approv", "Filtered P App with canc" and "Filtered P App with rej".

3.4.1 Endstate APP_Approved

General Details of the data set
The data set is collected between the 1st of 0ct 2011 (Saturday), 12:36:08 and the 14th of Mar 2012 (Wednesday), 15:23:32. The set contains 301 and 4550 events executed.

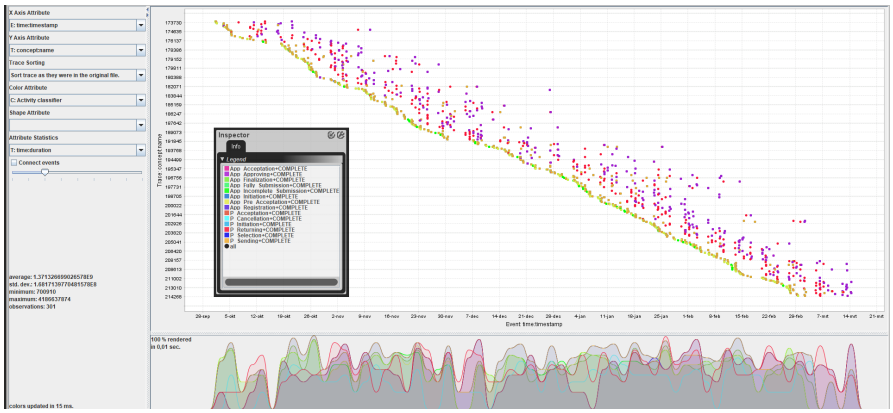


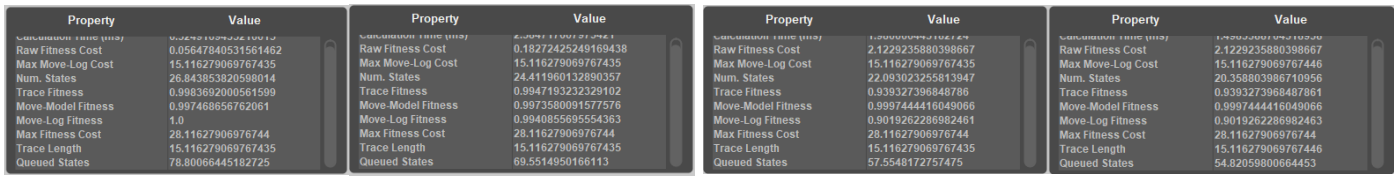
Figure 12: Dotted chart showing the time of events

In figure 12 the dotted chart can be seen. There is a gap visible on every sunday. This is more clearly to see, when changing the color to days of the week. There you can see, that it is always a sunday. Furthermore in the left lower corner the following

information can be found: average duration of a case is, 15 days 20 hours 55 minutes and 26.70 seconds, the minimal duration, 11 minutes and 40.91 seconds, and the maximum duration, 48 days 27 hours 23 minutes and 14.69 seconds. Those are given in milliseconds in the figure.
There are 14 different events: "P_Initiation" (10.0%), "P_Sending" (10.0%), "P_Selection" (10.0%), "P_Returning" (7.099%), "App_Pre_Acceptation" (6.615%), "App_Initiation" (6.615%), "App_Approving" (6.615%), "App_Registration" (6.615%), "App_Finalization" (6.615%), "App_Fully_Submission" (6.615%), "App_Incomplete_Submission" (6.615%), "App_Acceptation" (6.615%), "P_Acceptation" (6.593%), "P_Cancellation" (3.385%). The percentages are the relative occurences. There are 73 different variants of traces.
All events start with "App_Fully_Submission".
Maximal 34 events are executed in a case and minimal 12. The mean of events per class is 15.116.

Discover and evaluate models of lifecycle with Endstate APP_Approved

Like for approved and proposal I first checked different frequency filter setting to have a first idea, which models fullfill simplicity. Then for every chosen frequency in begin I checked conformance and precision.



Property	Value
Raw Fitness Cost	0.05647840531561462
Max Move-Log Cost	15.116279069767435
Num. States	26.843853820598014
Trace Fitness	0.9983692000561599
Move-Model Fitness	0.997468656762061
Move-Log Fitness	1.0
Max Fitness Cost	28.11627906976744
Trace Length	15.116279069767435
Queued States	78.80066445182725

(a) Conformance for 0 as frequency filter

Property	Value
Raw Fitness Cost	0.1827242524916943 8
Max Move-Log Cost	15.116279069767435
Num. States	24.411960132890357
Trace Fitness	0.9947193232329102
Move-Model Fitness	0.997358091577576
Move-Log Fitness	0.9940855695554363
Max Fitness Cost	28.11627906976744
Trace Length	15.116279069767435
Queued States	69.5514950166113

(b) Conformance for 0.1 as frequency filter

Property	Value
Raw Fitness Cost	2.1229235880398667
Max Move-Log Cost	15.116279069767435
Num. States	22.093023255813947
Trace Fitness	0.939327396848786
Move-Model Fitness	0.9997444416049066
Move-Log Fitness	0.9019622286982461
Max Fitness Cost	28.11627906976744
Trace Length	15.116279069767435
Queued States	57.5548172757475

(c) Conformance for 0.2 as frequency filter

Property	Value
Raw Fitness Cost	2.1229235880398667
Max Move-Log Cost	15.116279069767446
Num. States	20.358803986710956
Trace Fitness	0.9393273968487861
Move-Model Fitness	0.9997444416049066
Move-Log Fitness	0.9019622286982463
Max Fitness Cost	28.11627906976744
Trace Length	15.116279069767446
Queued States	54.82059800664453

(d) Conformance for 0.3 as frequency filter

Avg activity precision	85,4%
# Moves Observed	9.206
# Moves Possible	10.785
Avg fitness	99,9%
% Violations	0,4%
% Event Violations	0,4%
% Data Violations	0%
# Correct Events	4.550
# Wrong Events	0
# Missing Events	17

(e) Precision for 0 as frequency filter

Avg activity precision	91,1%
# Moves Observed	8.477
# Moves Possible	9.307
Avg fitness	99,5%
% Violations	1,2%
% Event Violations	1,2%
% Data Violations	0%
# Correct Events	4.512
# Wrong Events	38

(f) Precision for 0.1 as frequency filter

Avg activity precision	91,7%
# Moves Observed	6.622
# Moves Possible	7.224
Avg fitness	93,1%
% Violations	14%
% Event Violations	14%
% Data Violations	0%
# Correct Events	3.912
# Wrong Events	638

(g) Precision for 0.2 as frequency filter

Avg activity precision	93,8%
# Moves Observed	6.321
# Moves Possible	6.742
Avg fitness	93,1%
% Violations	14%
% Event Violations	14%
% Data Violations	0%
# Correct Events	3.912
# Wrong Events	638
# Missing Events	1

(h) Precision for 0.3 as frequency filter

Figure 13: Conformance and precision checking

	Frequency			
	0	0.1	0.2	0.3
Simplicity	-	-	+	++
Fitness	99.84	99.47	93.93	93.93
Precision	93.3	94.5	91.7	94.8

Figure 14: Results for approved as endstate

Based on the results, 14 or detailed in 13, I chose the model with 0.3 filtering. This one has a high simplicity, but still has surprisingly good results.

Discussion of the model

In figure 15 the petri net and the result of the replat can be seen. It is hard to clearly read the details, but I describe it in detail here.
All 301 cases start with the same 4 events: "App_Fully_Submission" →"App_Incomplete_Submission" →"App_Pre_ Acceptation" →"App_Acceptation". Then there are two events parallel: "App_Finalization" and "P_Selection". Before and after those actions are events skipped in the model, that occur in the original log. Afterwards "P_Initiation" →"P_Sending" →"P_Returning" are executed in all cases. Again 3 events are parallel "App_Registration", "App_Registration" (just in 300 cases and "App_Initiation". The last event is "App_Approving".
When I controlled the time matrix for the transitions I saw, that there are a lot of transitions taking place between 12 and 16 days.

3.4.2 Endstate APP_Cancelled

General Details of the data set

The data set is collected between the 1st of Oct 2011 (Saturday), 09:45:25 and the 14th of Mar 2012 (Wednesday), 15:30:47. The set contains 1937 and 13524 events executed.
In figure 16 the corresponding dotted chart can be seen. On every sunday there are just two events executed "App_Pre_ Acceptation" and "App_Incomplete_Submission". Furthermore in the left lower corner the following information can be found: the average duration of a case is, 16 days 22 hours 23 minutes and 7.31 seconds, the minimal duration, 1 minute

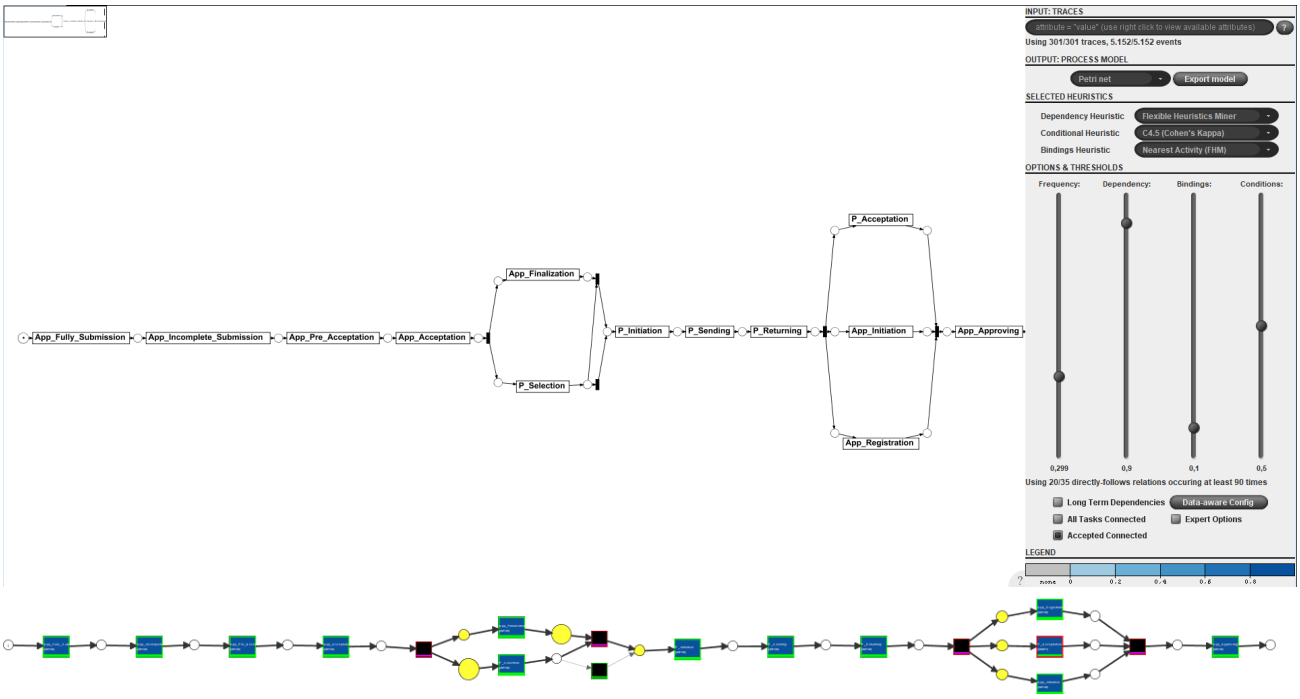


Figure 15: Endstate APP_Approved

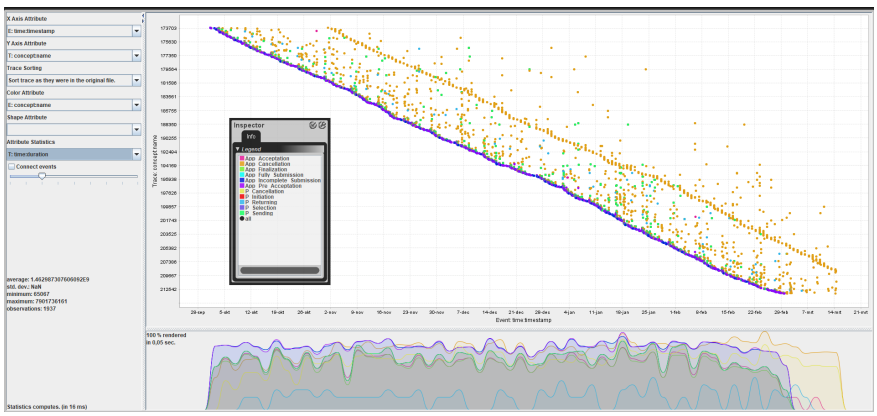


Figure 16: Dotted chart showing the time of events

and 5.067 seconds, and the maximum duration, 90 days 3 hours 48 minutes and 38.29 seconds. All three values are given in milliseconds in the figure.
There are 11 different events (relative occurences): "App_Cancellation" (14.323%), "App_Fully_Submission" (14.323%), "App_Incomplete_Submission" (14.323%), "App_Pre_Acceptation" (14.315%), "P_Cancellation" (7.572%), "P_Initiation" (7.572%), "P_Sending" (7.572%), "P_Selection" (7.572%), "App_Acceptation" (6.182%), "App_Finalization" (5.694%) and "P_Returning" (0.555%). There are 46 different variants of traces.
All traces start with "App_Fully_Submission"
A maximum of 32 events is executed in a case and minimal 3. The mean of events per class is 6.982.

Discover and evaluate models of lifecycle with Endstate APP_Cancelled

Property	Value
Raw Fitness Cost	0.0077439339184305666
Max Move-Log Cost	6.981930820857002
Num. States	12.124419204956126
Trace Fitness	0.9995928343230528
Move-Model Fitness	0.9998709344346928
Move-Log Fitness	0.9995866631242819
Max Fitness Cost	10.98193082085699
Trace Length	6.981930820857002
Queued States	34.35312338668043

(a) Conformance for 0 as frequency filter

Property	Value
Raw Fitness Cost	0.5978316985028395
Max Move-Log Cost	6.981930820856996
Num. States	10.267423851316451
Trace Fitness	0.9684136338918854
Move-Model Fitness	0.9998709344346928
Move-Log Fitness	0.9583292678960829
Max Fitness Cost	10.981930820856986
Trace Length	6.981930820856996
Queued States	26.758389261744984

(b) Conformance for 0.1 as frequency filter

Property	Value
Raw Fitness Cost	0.07330924109447608
Max Move-Log Cost	6.981930820856996
Num. States	11.489932885906036
Trace Fitness	0.9939118070900884
Move-Model Fitness	0.9998709344346928
Move-Log Fitness	0.9902526005007463
Max Fitness Cost	10.981930820856986
Trace Length	6.981930820856996
Queued States	31.979865771812108

(c) Conformance for 0.49 as frequency filter

Avg activity precision	92,5%
# Moves Observed	27.179
# Moves Possible	29.383
Avg fitness	100%
% Violations	0,1%
% Event Violations	0,1%
% Data Violations	0%
# Correct Events	13.510
# Wrong Events	14
# Missing Events	1

(d) Precision for 0 as frequency filter

Avg activity precision	94,6%
# Moves Observed	19.322
# Moves Possible	20.435
Avg fitness	96,6%
% Violations	8,6%
% Event Violations	8,6%
% Data Violations	0%
# Correct Events	12.367
# Wrong Events	1.157
# Missing Events	1

(e) Precision for 0.1 as frequency filter

Avg activity precision	91,8%
# Moves Observed	24.136
# Moves Possible	26.306
Avg fitness	99,3%
% Violations	1%
% Event Violations	1%
% Data Violations	0%
# Correct Events	13.383
# Wrong Events	141
# Missing Events	1

(f) Precision for 0.49 as frequency filter

Figure 17: Conformance and precision checking

	Frequency		
	0	0.049	0.1
Simplicity	-	+	++
Fitness	99.96	99.39	96.84
Precision	92.5	91.8	94.6

Figure 18: Results for cancelled as endstate

Like for APP_Approved I checked different configurations and based on the results, 18 in more detail 17, I decided to pick 0.1 filtered frequency model. The fitness and precision is still higher than 90%, but it is also the most simpel model.

Discussion of the model

In figure 19 the petri net and the result of the replay can be seen.
All cases start with "App_Fully_Submission" →"App_Incomplete_Submission" →"App_Pre_Acceptation" (this is just executed in 1936 cases). Then in 1167 cases "App_Cancellation" follows directly. Otherwise "App_Acceptation" (770 cases), followed by "P_Selection" and "App_Finalization" in random order. After those are executed, "P_Initiation" →"P_Sending" →"P_Cancellation" →"App_Cancellation" is executed.
The time transition matrix showed me, that the transition to "App_Finalization" and "P_Cancellation" took the most time (between 17 and 22.5 days).

3.4.3 Endstate APP_Rejected

General Details of the data set

The data set was collected between the 1st of 0ct 2011 (saturday), 08:11:08 and the 14th of Mar 2012 (Wednesday), 15:20:23. The set contains 7252 and 26691 events executed.
In figure 20 the dotted chart can be seen. On every sunday there are just two events executed "App_Rejection" and "App_Incomplete_Submission". Furthermore in the left lower corner the following information can be found: the average duration of a case is, 1 days 6 hours 50 minutes and 35.01 seconds, the minimal duration, 1.855 seconds, and the maximum duration, 76 days 22 hours 42 minutes and 38.05 seconds. All three values are given in milliseconds in the figure.
There are 12 different events (relative occurences): "App_Rejection" (27.17%), "App_Fully_Submission" (27.17%), "App_Incomplete_Submission" (27.17%), "App_Pre_Acceptation" (5.744%), "P_Initiation" (1.997%), "P_Sending" (1.997%),

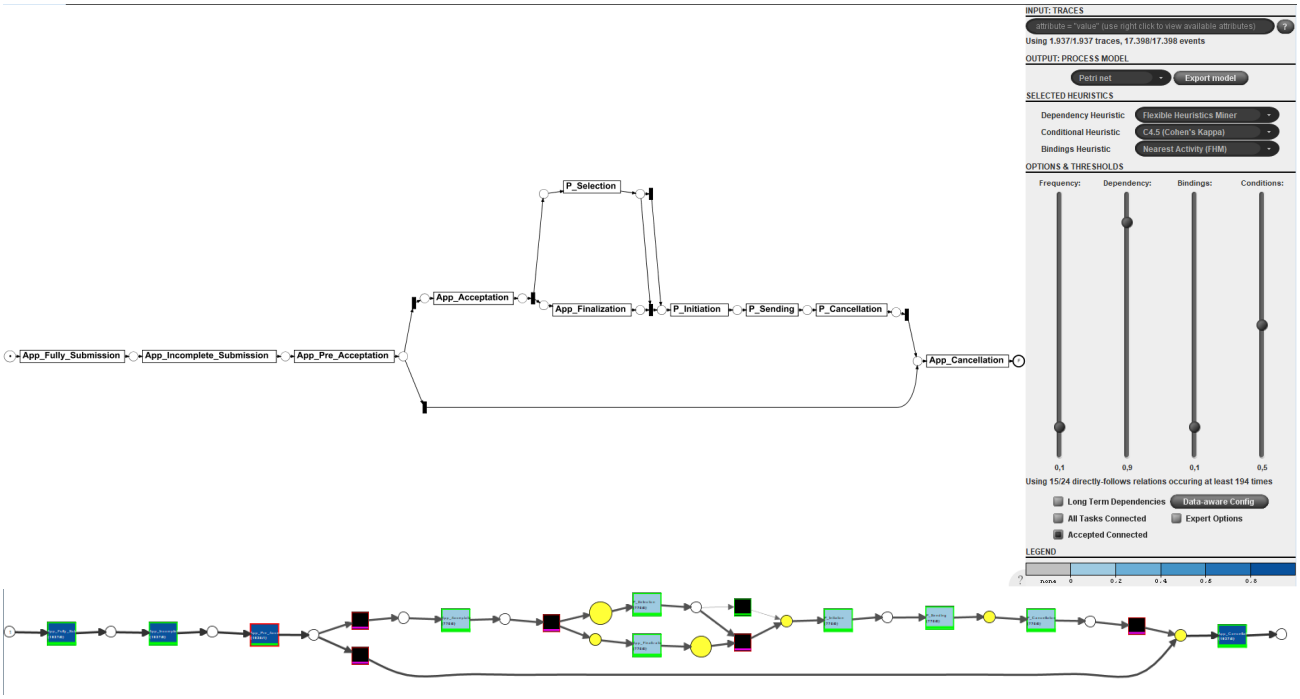


Figure 19: Endstate APP_Cancelled

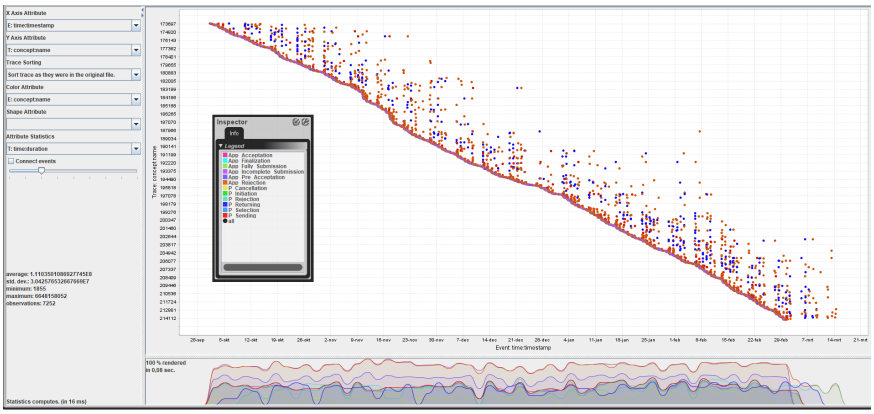


Figure 20: Dotted chart showing the time of events

"P_Selection" (1.997%), "App_Acceptation" (1.678%), "App_Finalization" (1.57%), "P_Rejection" (1.57%), "P_Returning" (1.51%), "P_Cancellation" (0.427%). There are 30 different variants of traces.
All traces start with "App_Fully_Submission"
A maximum of 12 events is executed in a case and minimal 3. The mean of events per class is 3.681.

Discover and evaluate models of lifecycle with Endstate APP_Rejected

The last analysis is of the models ending in APP_Rejected. In the first step I checked different frequency filters and decided based on simplicity and traceability I had to take a closer look at 0, 0.025 and 0.1.

Property	Value
Raw Fitness Cost	0.001378929950358521 8
Max Move-Log Cost	3.680501930501929
Num. States	6.2908163265306145
Trace Fitness	0.9999337770668272
Move-Model Fitness	1.0
Move-Log Fitness	0.9999224956696762
Max Fitness Cost	6.680501930501955
Trace Length	3.680501930501929
Queued States	16.795642581356855

(a) Conformance for 0 as frequency filter

Property	Value
Raw Fitness Cost	0.07046332046332046
Max Move-Log Cost	3.680501930501929
Num. States	6.069635962493104
Trace Fitness	0.996007457570132
Move-Model Fitness	0.9997367497367499
Move-Log Fitness	0.9953041799004244
Max Fitness Cost	6.680501930501942
Trace Length	3.680501930501929
Queued States	15.96759514616656

(b) Conformance for 0.025 as frequency filter

Property	Value
Raw Fitness Cost	0.4691119691119695
Max Move-Log Cost	3.680501930501924
Num. States	5.42277992277992
Trace Fitness	0.969075486490227
Move-Model Fitness	1.0
Move-Log Fitness	0.9611143286112941
Max Fitness Cost	6.6805019305019515
Trace Length	3.680501930501924
Queued States	14.056949806949813

(c) Conformance for 0.1 as frequency filter

Avg activity precision	99,3%
# Moves Observed	49.127
# Moves Possible	49.467
Avg fitness	100%
% Violations	0%
% Event Violations	0%
% Data Violations	0%
# Correct Events	26.681
# Wrong Events	10
# Missing Events	0

(d) Precision for 0 as frequency filter

Avg activity precision	98,7%
# Moves Observed	45.468
# Moves Possible	46.089
Avg fitness	99,6%
% Violations	1,9%
% Event Violations	1,9%
% Data Violations	0%
# Correct Events	26.201
# Wrong Events	490
# Missing Events	21

(e) Precision for 0.025 as frequency filter

Avg activity precision	100%
# Moves Observed	39.326
# Moves Possible	39.326
Avg fitness	96,7%
% Violations	12,7%
% Event Violations	12,7%
% Data Violations	0%
# Correct Events	23.289
# Wrong Events	3.402
# Missing Events	0

(f) Precision for 0.1 as frequency filter

Figure 21: Conformance and precision checking

	Frequency		
	0	0.025	0.1
Simplicity	-	+	+++
Fitness	1.00	99.60	96.91
Precision	99.3	98.7	100

Figure 22: Results for cancelled as endstate

Based on 22, detailed in figure 21, I chose 0.1 filtered frequency model as the best. It is really easy to follow and has a good fitness.

Discussion of the model

In figure 23 the model and the replay can be seen.
The process starts with "App_Fully_Submission" →"App_Incomplete_Submission" (7252 cases). This is or followed directly by "App_Rejection" (5719 cases) or first by "App_Pre_Acceptation" (1533 cases) and then "App_Rejection". No details presented for "App_Rejection" due to filtering.
The worst transition is with 5.51 days from "App_Pre_Acceptation" to "App_Rejection".

3.5 C-net of the proposal process

Based on the results of my analysis of the model before I chose the same frequency filtering for the C-net of the proposal process.
In figure 24 I show three C-nets of the proposal process for comparsion. 24a is the one I picked and I will discuss in detail. In 24b the original C-net of the process is to see and obviously it is much more complicated and not so intuitive than the filtered one. Just for comparsion I also checked the 0.151 filtered c-net and there you can see, that in real data a loop can be found between Sending, Cancellation, Initiation and Selection. So this behaviour makes the processes probably slower.

3.5.1 Analysis of the C-net

For simplicity reasons I will not write "P_" as prefix of every activity.
The first thing I did is having a look at the maximum number of bindings. This is for sending with 3 possible bindings. The input is always from initiation, but there are 3 different outputs possible. All trace possibilities:
These 5 pathes are also what you would expect a little bit, but you clearly see, that there are missing details. But depending on the further results those pathes are the main pathes.

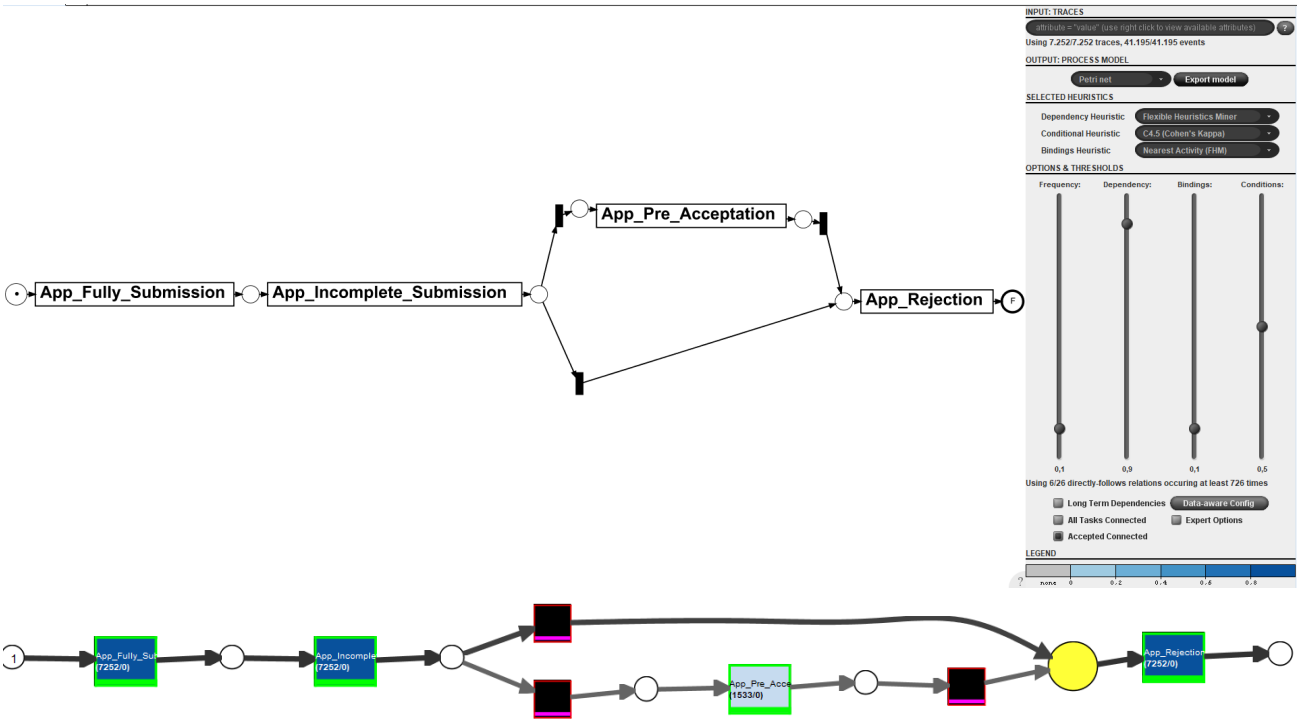
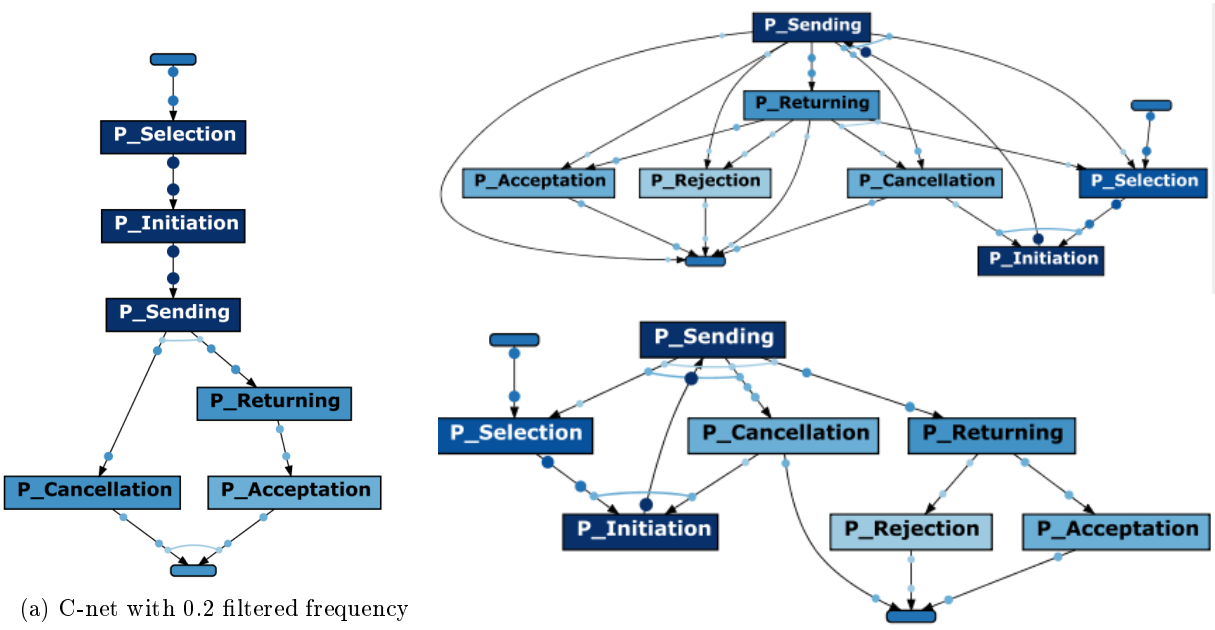


Figure 23: Endstate APP_Rejected



(a) C-net with 0.2 filtered frequency

(b) C-net without filtered frequency and with 0.151 filtering

Figure 24: C-Nets of the proposal process

- Selection →Initiation →Sending →
  - Returning →Acceptation →Done
  - Cancellation →Returning →Acceptation →Done
  - Returning →Acceptation →Cancellation →Done
  - Returning →Cancellation →Acceptation →Done
  - Cancellation →Done

3.6 Own Petri net of the proposal process

Based on the petri-net I chose I constructed the following petri-net, which also reflects the process I would expect.

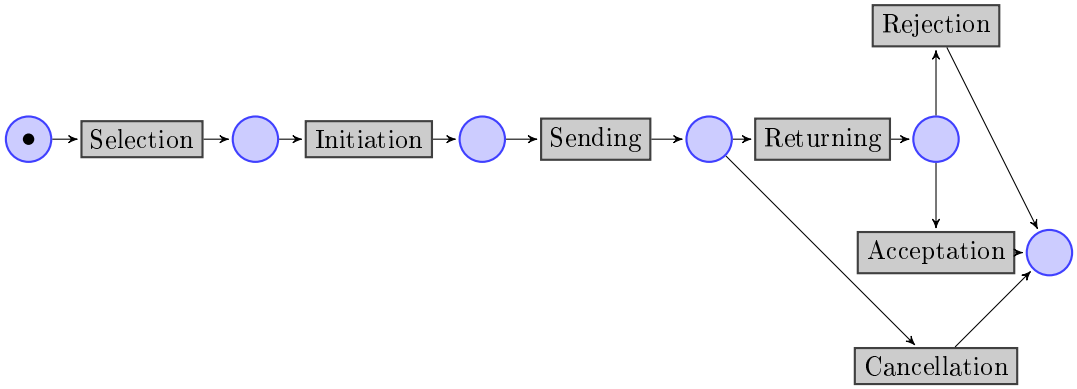


Figure 25: Own petri-net

3.7 Analysis of the performance of Application and work process

Just the events beginning with "App_..." or "W_..." are required. The resulting data set is saved as "Filtered Work and App". I also just considered the workdataset (data beginning with "W_..") saved as "Filtered Work"

3.7.1 General Details of the data set

The data set is collected between the 1st of 0ct 2011 (saturday), 00:38:44 and the 14th of Mar 2012 (Wednesday), 16:04:54 and contains 13087 cases with 230956 events.

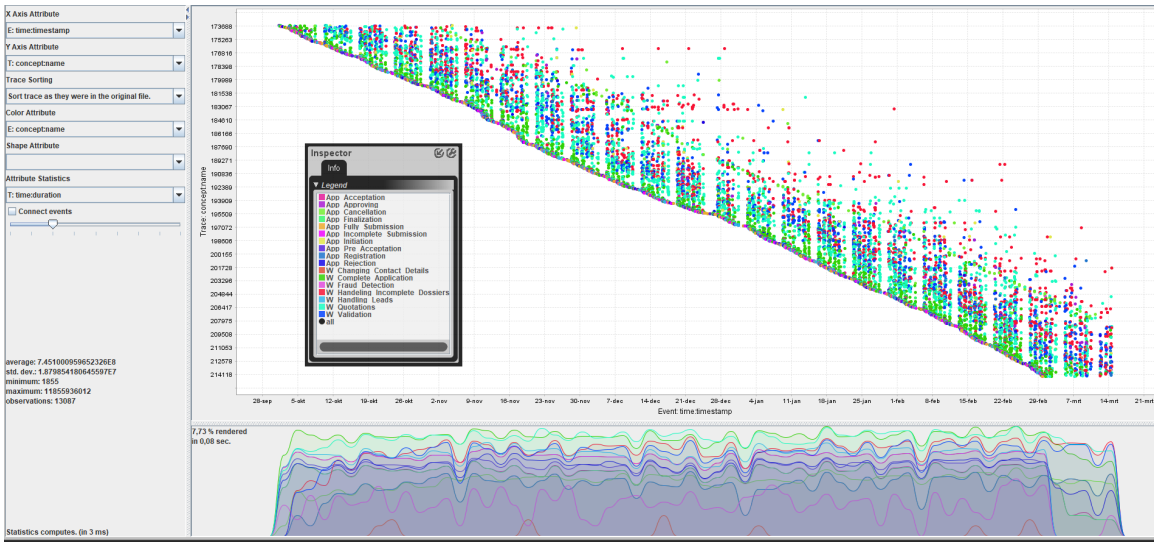


Figure 26: Dotted chart showing the time of events

In figure 26 the dotted chart can be seen. Having a closer look at this I saw again gaps on sunday. On sundays just "App_Incomplete_Submission" and "App_Rejection" is been executed. Furthermore is in the left below corner to see what is the average duration of a case, 8 days 14 hours 58 minutes and 20.10 seconds, the minimum duration, 13.087 seconds, and the maximum duration, 137 days 5 hours 18 minutes and 56.01 seconds. Both is given in milliseconds.
The data set has 29 events (occurence relative): "W_Complete_Application + COMPLETE" (10.377%), "W_Complete_Application + START" (10.18%), "W_Quotations + COMPLETE" (9.948%), "W_Quotations + START" (9.701%), "App_Fully_Submission + COMPLETE" (5.666%), "App_Incomplete_Submission + COMPLETE" (5.666%), "W_Handeling_Incomplete_Dossiers + COMPLETE" (4.939%), "W_Handeling_Incomplete_Dossiers + START" (4.936%), "W_Validation + COMPLETE" (3.418%), "W_Validation + START" (3.417%), "App_Rejection + COMPLETE" (3.306%), "W_Complete_Application + SCHEDULE" (3.192%), "App_Pre_Acceptation + COMPLETE" (3.19%), "W_Quotations + SCHEDULE" (2.872%), "W_Handling_Leads + COMPLETE" (2.554%), "W_Handling_Leads + START" (2.553%), "App_Acceptation + COMPLETE" (2.214%), "W_Validation + SCHEDULE" (2.175%), "App_Finalization + COMPLETE" (2.171%), "W_Handling_Leads + SCHEDULE" (2.066%), "App_Cancellation + COMPLETE" (1.215%), "W_Handeling_Incomplete_Dossiers + SCHEDULE" (1.032%), "App_Initiation + COMPLETE" (0.972%), "App_Approving + COMPLETE" (0.972%), "App_Registration + COMPLETE" (0.972%), "W_Fraud_Detection + COMPLETE" (0.117%), "W_Fraud_Detection

+ START" (0.117%), "W_Fraud_Detection + SCHEDULE" (0.054%), "W_Changing_Contact_Details + SCHEDULE" (0.005%)
There are 3668 different variants of traces. Maximal 162 events are executed in a case and minimal 3. The mean of events per class is 17.648.
All cases start with "App_Fully_Submission", but there are 12 different outcomes: "App_Rejection + COMPLETE" (26.202%), "W_Validation + COMPLETE" (20.975%), "W_Handling_Leads + COMPLETE" (17.07%), "W_Complete_Application + COMPLETE" (14.816%), "W_Quotations + COMPLETE" (9.895%), "App_Cancellation + COMPLETE" (7.091%), "W_Handeling_Incomplete_Dossiers + COMPLETE" (3.454%), "W_Fraud_Detection + COMPLETE" (0.436%), "W_Changing_Contact_Details + SCHEDULE" (0.031%), "W_Validation + START" (0.015%), "App_Registration + COMPLETE" (0.008%), "W_Quotations + START" (0.008%). The processes, which end with a started or sheduled event, are part of a not ending cases. Those appear so unfrequent, that they will not have further influence.

3.7.2 Bottlenecks of the workflow-net

Using the **Mine with inductive visual miner** I first explored the workflow process. The configuration were changed to 100% of the pathes and show paths and sojourn time in the first step.

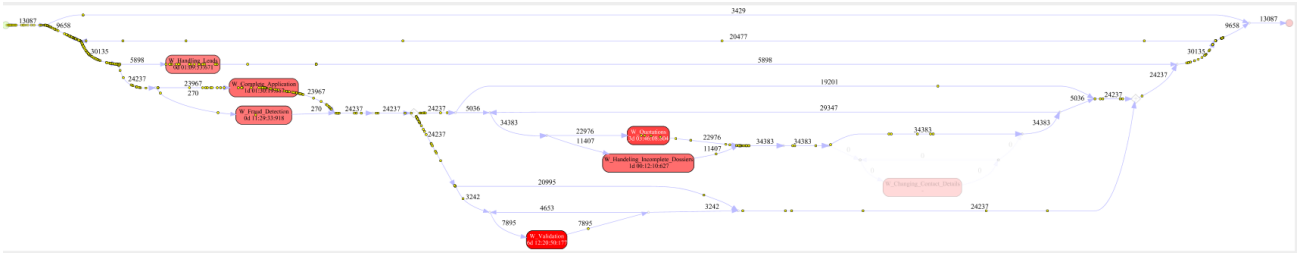


Figure 27: Workflow net with sojourn time

The dark red transitions are the transitions with a long preoceeding time, so our searched bottlenecks. The biggest problem we get from the "W_Validation" step (6 days 12 hours 20 minutes 50 seconds and 177 milliseconds). The second slow trensition is "W_Quotations" (3 days 3 hours 46 minutes 46 seconds 804 milliseconds). The rest is around 1 day. Having a look at the amount of times the two slow transitions has to be executed it is clear, that "W_Quotations" makes the process slow. Having a look at the event log visulization you can see, that in the 10 most common processes there are 2, appearing in 1.3% of the traces, that have at least one time "W_Quotations" and they also have "W_Validation" in it.
Changing the view to paths and queue lengths and having a look at the longest queues over time I had the same 2 as bottlenecks.
The next thing I controlloed was how many different persons this event can execute, but the result was that both event are executed by 53 for "W_Quotations" and 54 for "W_Validation". Conspicuous is, that for "W_Validation" the first most frequent appearing ressources execute the event in already 57% of the cases.

3.7.3 Recommendations based on the workflow-net

Having a look at the bottlenecks of the workflow-net it can be seen, that for the two bottlenecks a lot of the cases execute the events at least 2 times. This ist obviously to see, because there are just 3242 cases incoming to "W_Validation", but in total it is executed 7895 times. This make the waiting queue longer and so the overall executing time, too.
For "W_Quotations" the problem is similar.
So the first advice I would give is to overthink the procedure in both cases, such that it has to be done just one time, but then on a good manner. Also maybe the workload can be better spreaded if it is not specific or for "W_Validation" concentrated such that a few people know how to do it and just concentrate on this.

3.7.4 Bottlenecks of the application-net

Using the same tool I also had a look at the application process.

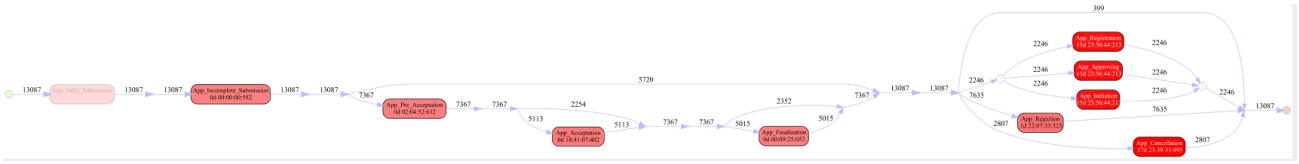


Figure 28: Application net with sojourn time

As to see in figure 28 the most events are done pretty fast, but the events in the end are really slow.
Having a closer look at this it can be seen, that the events there take roughly 16 days. "Cancellation" even takes almost 18 days.

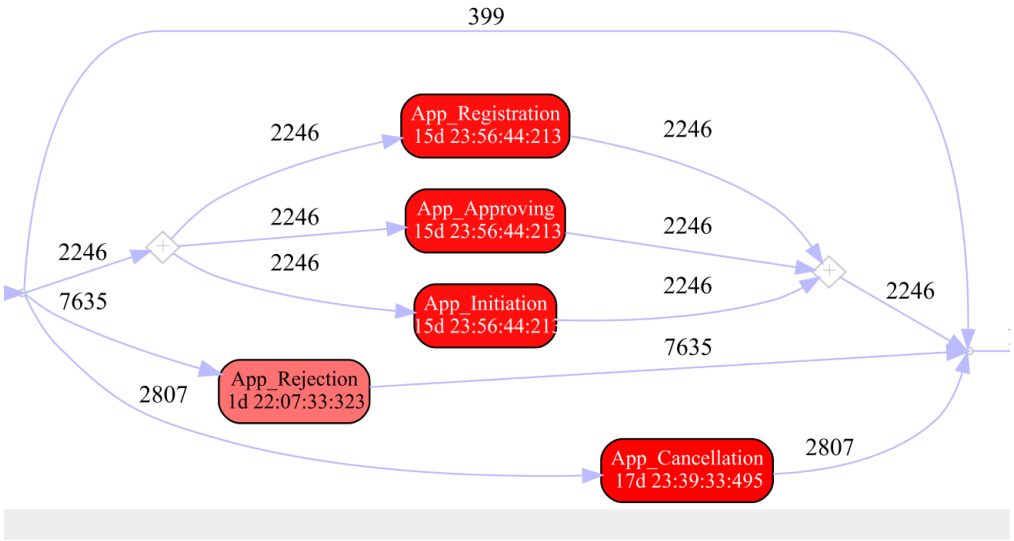


Figure 29: Zoomed in application net with sojourn time

Taking a look into the ressources used it is clear, that the work is concentrated on a few persons and not good distributed in between. ("App_Registration", "App_Approving", "App_Initiation" 9 of 61) Just "App_Cancellation" is done by 58 of 61, but it still takes a high amount of time. Probably, because the peoble are busy with other stuff.

3.7.5 Recommendations based on the application-net

Based on the results I would recommend to check, if there is a possibility to accelerate the decision steps.

3.7.6 Combined model

Just to be sure I also executed the process for the complete data set.

Figure 30: Application and workflow net with sojourn time

In figure 31 the whole net with the sojourn time can be seen. For better understanding I zoomed in at the different critical parts.

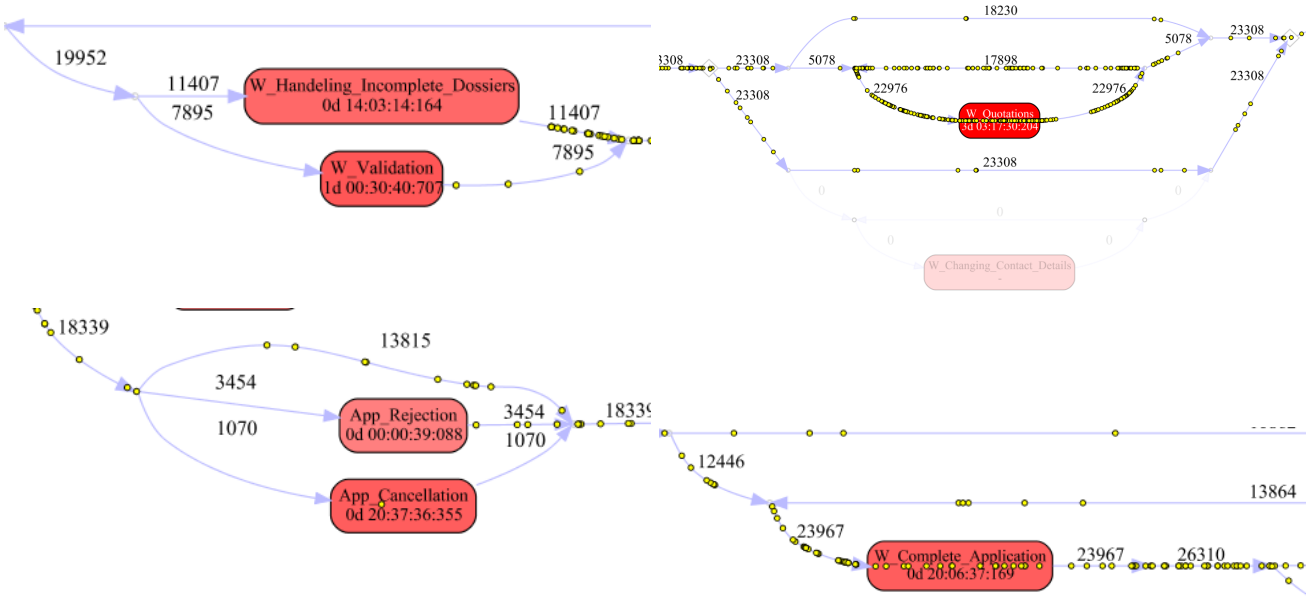


Figure 31: Application and workflow net with sojourn time

Like we expected the bottlenecks of the whole net are the same than for the two smaller ones. Just the sojourn times are smaller, because there are more events, that are executed in bettwen and the timestamps are closer to each other. Furthermore it is clear, that the workflow bottlenecks are worde, than the application bottlenecks. The amount of times those events have to be executed is for the workflow events much higher. This clarifys a little bit the high soujoun time, but the process has to be optimized on this parts.

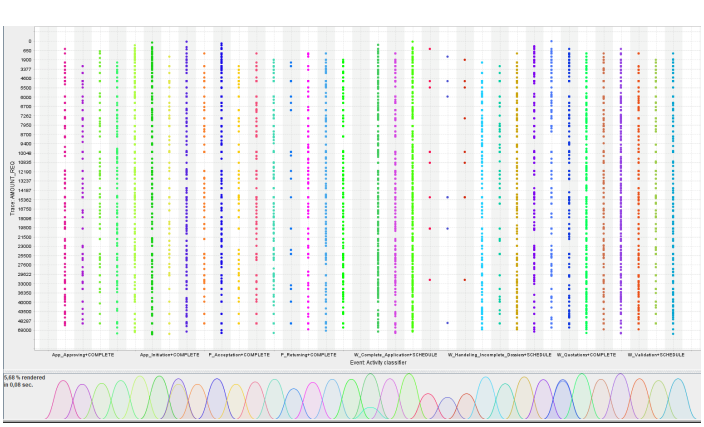
3.7.7 Recommendations based on the combined net

Noticeable is, that there are a lot of traces going back and the part has to be executed again. This makes the process slower and also increases the workload for the different steps. So this backloop should be rethinked.

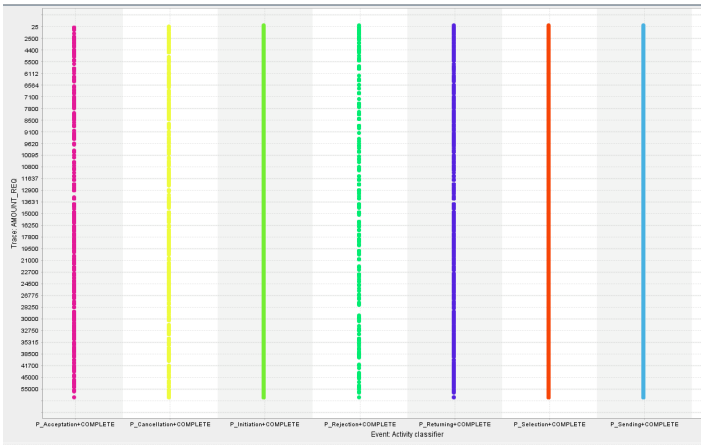
4 Further questions

4.1 Are some decisions in any of the models driven by the application's amount?

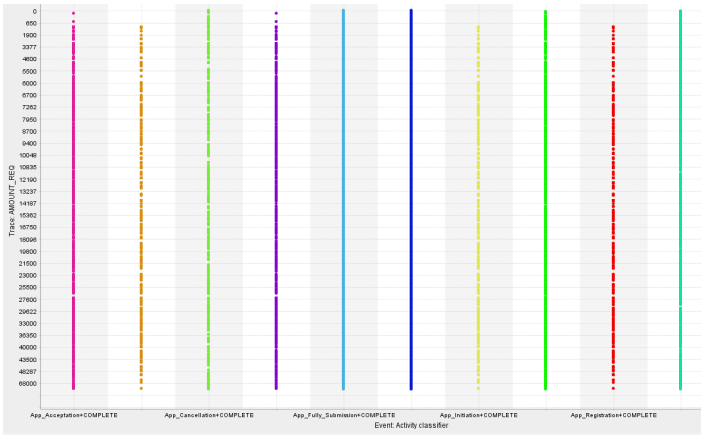
For answering this question I had a look at the dotted charts of the whole data set and the three filtered ones, "Filtered App", "Pdoubledfiltered", "Filtered Work". As x-axis I chose "C:Activity classifier" and y-axis "T:AMOUNT_REQ". Also I sorted the traces by the "AMOUNT_REQ". Just for the layout I changed the color to "C: Activity classifier".



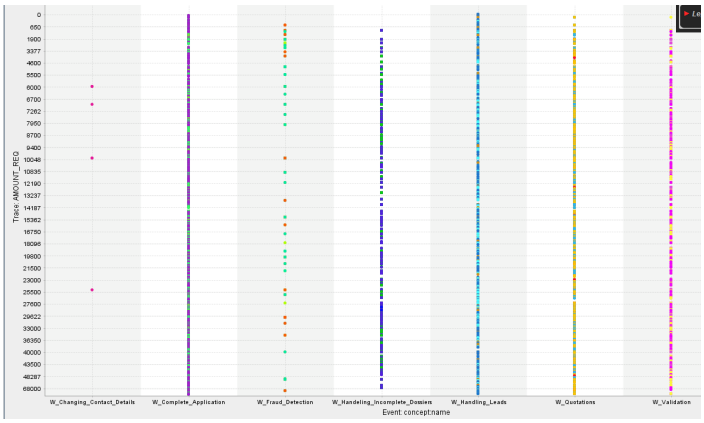
(a) Whole data set



(b) Proposal data set



(c) Application data set



(d) Workflow data set

Figure 32: Dotted chart for the application's amount

Figure 32 shows clearly, that there is **no correlation** between activity and requested amount.

4.2 Are there clear indications that the same employees are always involved in cases that are declined, approved or cancelled?

For this question I concentrate on the application data set and filter it three time: "Filtered App with approv", where as end event just "APP_Initation", "APP_Registration" and "APP_Approved" are possible as end event, based on the result of the 6th question before, where you can see, those three always happen together, "Filtered App with Rej", end event just "APP_Rejected" and "Filtered App with Canc"
Those filtered data sets I used for the **Interactive Data aware Heuristic Miner**, where I chose resource in place of activity to create a model.

4.2.1 Approved

To see what are the main resources used I had a look at the c-net.

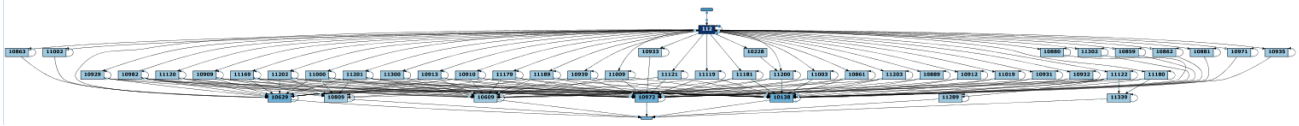
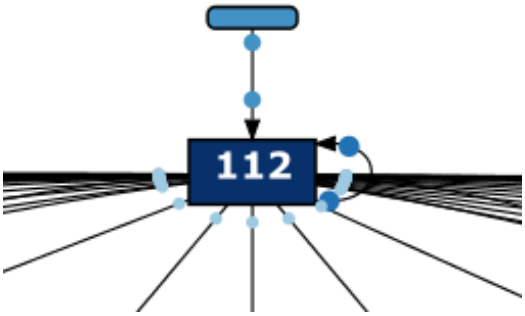
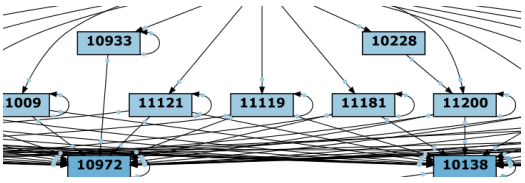


Figure 33: Causal net of the approved application lifecyle without filtering



(a) Beginning of the traces



(b) Middle of the traces

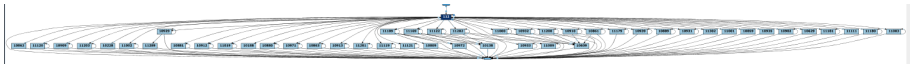
(c) End of the traces

Figure 34: Zoomed in the c-net

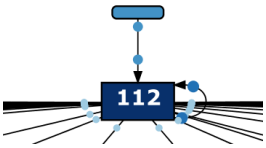
There are three parts prominent, 34:

1. All traces start via **112**, 34a
2. 2 resources, 10933 and 10228, just have two successors, 34b
3. 7 resources execute the last event, 34c

4.2.2 Rejected



(a) Causal net of the reject application lifecyle without filtering

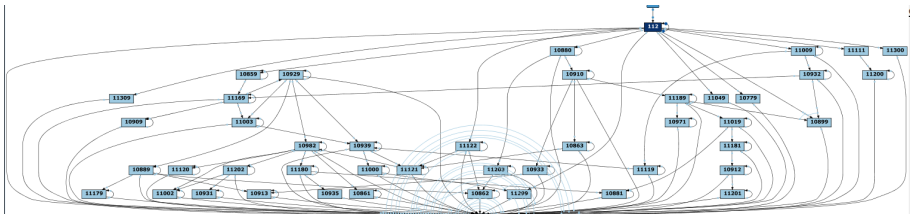


(b) Zoomed in the beginning of the c-net

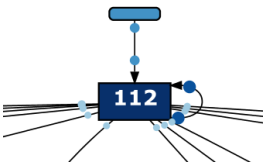
Figure 35: Rejection resource c-net

Figure 35a shows the whole c-net and in 35b it is more clear, that again **112** starts all traces.

4.2.3 Cancellation



(a) Causal net of the cancellation application lifecyle without filtering



(b) Zoomed in the beginning of the c-net

Figure 36: Cancellation resource c-net

Figure 36a shows the whole c-net and in 36b it is more clear, that again **112** starts all traces.

4.2.4 Control result with decision tree

To be completly sure about those results I exported the data as .csv file and imported them in RapidMiner.

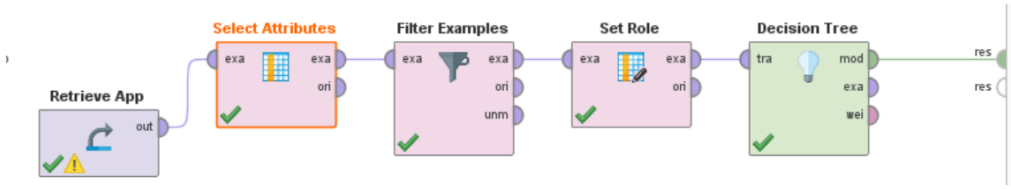


Figure 37: RapidMiner Process for mining a decision tree

The process I used is to see in figure 37. I retrieved the data selected just the event and amount attributed and filtered different possible outcomes. Mostly I concentrated on "App_Apprpoving" and "App_Rejection". The event was set as outcome and therefore a decision tree was mined. Hoewel I tried a lot of different configurations I always received as decision tree, that I always have to choose "App_Rejection". Most of the times it was independent of the requested amount and just this decision. The best other decision tree was for max depth 2 and no pruning.

Figure 38: Decision trees

The resulted decision trees, figure 38, made clear, that there is no corrleation between events and the requested amount.

4.2.5 Summary of those results

So what gets pretty clear is that **112** decides over the next steps in the beginning. Having a look at the resources following it gets obvious, that different ressources work on the 3 sorts of traces. So it seems to depend on 112, which decision will be made.

4.3 Comparsion of the throughput times

For this investigation I created a data set with the combination of rejected and cancelled traces, "Filtered App with rej and canc".
Then I looked the times up in the dotted chart like I did before.

	Minimum	Mean	Maximum
Approved	700910	$1.4393 * 10^9$	7419735534
Rejected of cancelled	1855	$5.613 * 10^8$	7901736161

Figure 39: Throughput times

In figure 39 it can be clearly seen, that an approved traces takes 2.56 time so much time, than a rejected or cancelled trace.

5 Conclusion

Recapping all results from the last parts I would say, that there a few points throughout the process, where it could be done better. There are 2 big bottlenecks in the process, which should be optimzied. Also the use of the resources could be optimized. For example could the workload be distributed better, such that everyone is doing close to the same amount of work for the steps. The difference between the fastest trace is much than the slowest one is really big, which should be analyzed in more detail for all process parts. But because of a lack of information about the details of the events and the process it is hard to give real recommedations. It is known, which persons are just working halftime or fulltime? Are there people, that just can do special tasks or are there tasks, that need special training?