

Group Assignment

Analysis of a Traffic Fine Management Process

Group 7

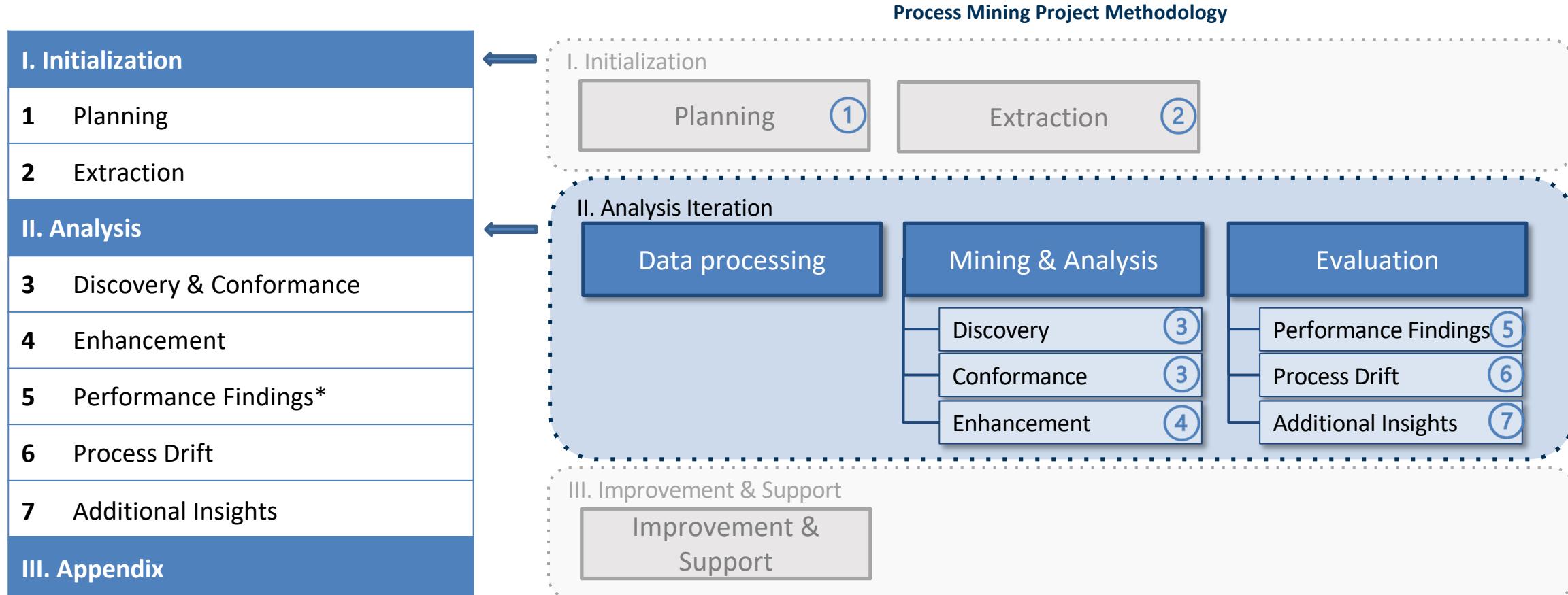
Huyen Thi Thanh Tran – 1726356
Siyuan Chen - 1824879
Xi Yu - 1725013
Xiaojian Ding - 1821829
Yongyi Zheng - 1823267

Mannheim, 26th November 2021



Agenda

The Process Mining Project Methodology is applied to guide the execution of this process mining project. The project is sectioned into 3 main phases. However, for the purpose of this project, we mainly focus on executing the second phase: Analysis.



Remark: *Performance Findings is used to represent the second task Conformance Checking to avoid confusion with Conformance in Mining & Analysis.

Initialization - Planning



Research Goal

Gain insights of the recorded traffic fine management process of the Italian police.

From these insights, **recommendations** are suggested to further enhance the business process.



Research Question

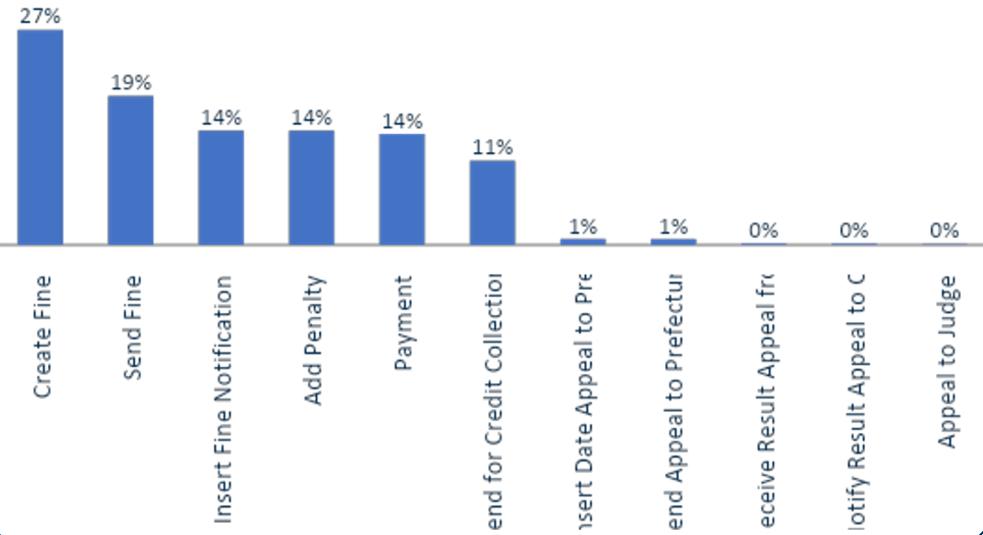
Whether the process model reflects the desired business process.

- Discover the process model from the event log
- Perform quality check to choose the best process model
- Further enhance the current process based on insights and rationality

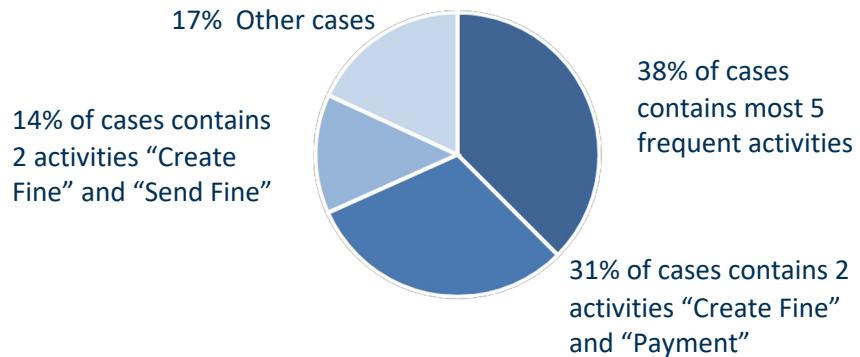
Initialization - Extraction

- The recorded data is extracted from the police information system, which is then processed and downloaded as the form of event logs from 4TU. Research Data: "Road Traffic Fine Management Process"
- The event log comprises of **150,370 cases** of the management of road traffic fines **from January 2000 to June 2013**. There are 561,740 events with **11 different activities** with several involved resources.

Relative Frequency of Activities



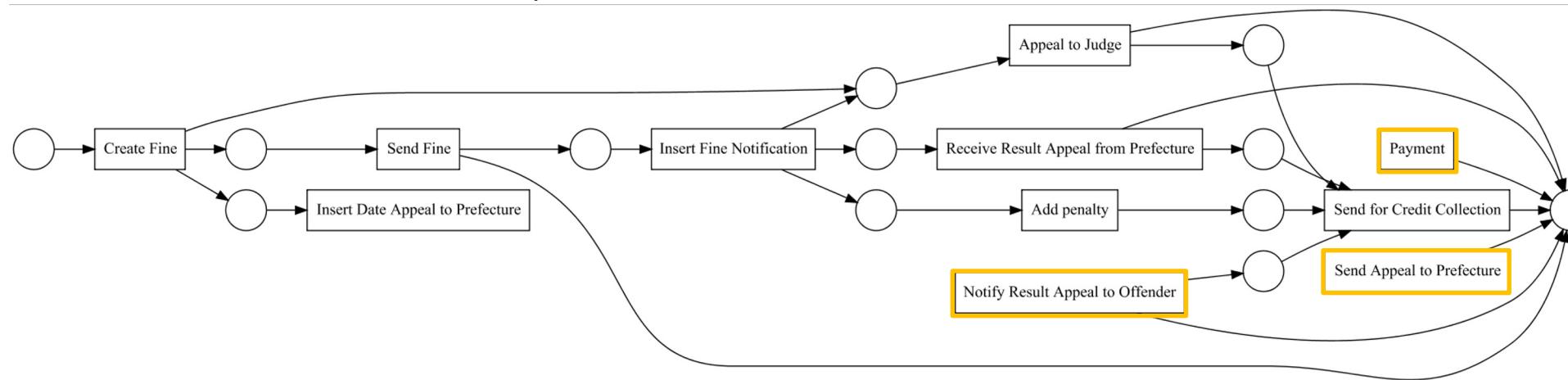
Event Log Cases Characteristic



Analysis - Process Discovery & Conformance

a) Alpha Mining Algorithm

- The as-is process is derived from the automated process discovery tool based on recorded events.
- The first approach is to discover the process is based on the **Alpha Mining Algorithm**. Using ProM, we arrive at a process model as illustrated in the below diagram.
- Overall, the Petri Net covers all recorded activities. However, it contains dead transitions and is not a sound workflow net since there are some activities “Payment”, “Notify Result Appeal to Offender” and “Send Appeal to Prefecture” that cannot be reached from initial marking.
- Besides, in general, Alpha Mining Algorithm has some drawbacks that it cannot detect loop of 1 and 2, be prone to recognize implicit places that make the process more complicated, cannot detect local dependencies and skipping steps, which might not reveal some hidden behaviors in the true process.



Analysis - Process Discovery & Conformance

b) Inductive Mining Algorithm

- To overcome the limitation of Alpha Mining Algorithm, inductive mining algorithm is utilized.
- 4 criteria (Replay Fitness, Precision, Generalization and Simplicity) are checked to assess the quality of process models with different noise thresholds. ([Appendix I](#) provides detailed data mining results)
- As indicated in the chart below, **inductive mining model with noise threshold 0.30** stands out from other process models.

Noise Threshold	Replay Fitness	Precision	Generalization	Average FPG*	Simplicity**
0.10	0.98235	0.50665	0.99074	0.82658	Low
0.20	0.98234	0.50276	0.99114	0.82541	Moderate
0.30	0.93218	0.69298	0.99220	0.87245	Moderate
0.40	0.78439	0.81229	0.99280	0.86316	Moderate

Remark:

*Average FPG refers to the average value of Replay Fitness, Precision and Generalization.

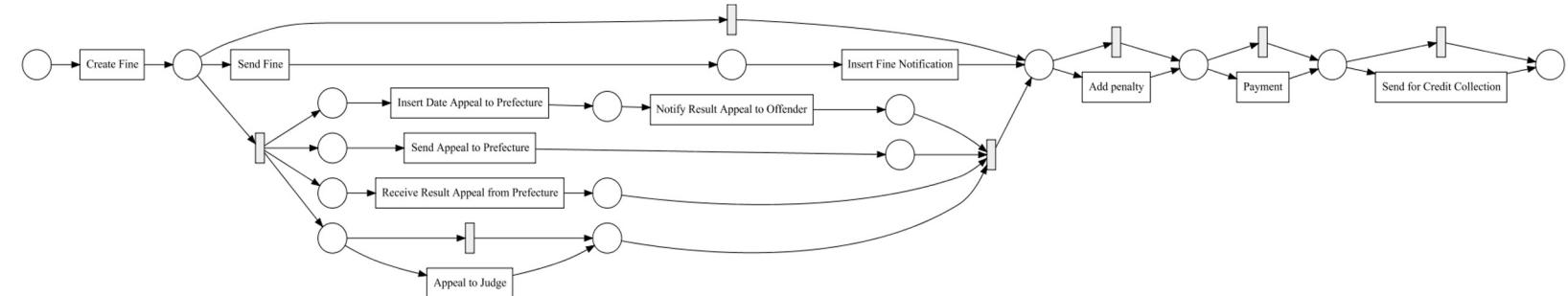
**Simplicity is evaluated based on the number of silent transitions: high (0-5), moderate (6-10), low (10-15).

Analysis - Process Discovery & Conformance

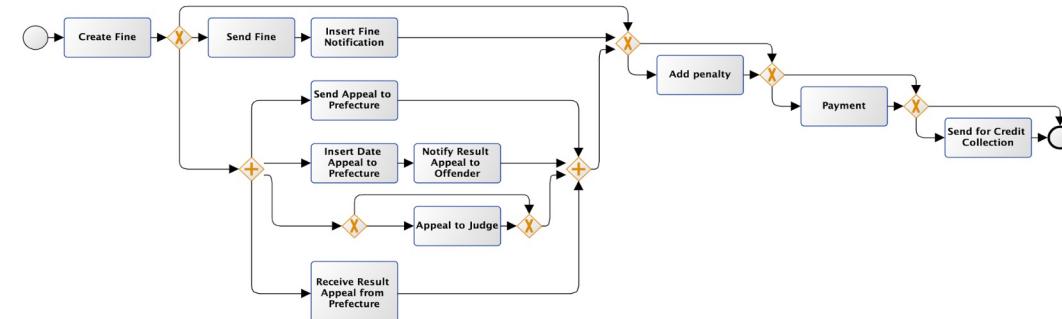
b) As-is Model: Inductive Miner Noise Threshold 0.30

- With ProM, the petri net of noise threshold 0.30 is further converted into initial BPMN diagram as the as-is model.
- For the next step, it is necessary to apply the 7 Process Modelling Guidelines (7PMG) based on 3 quality assurance criteria to produce the desired process model.

Inductive Miner
Petri Net
Noise Threshold 0.30

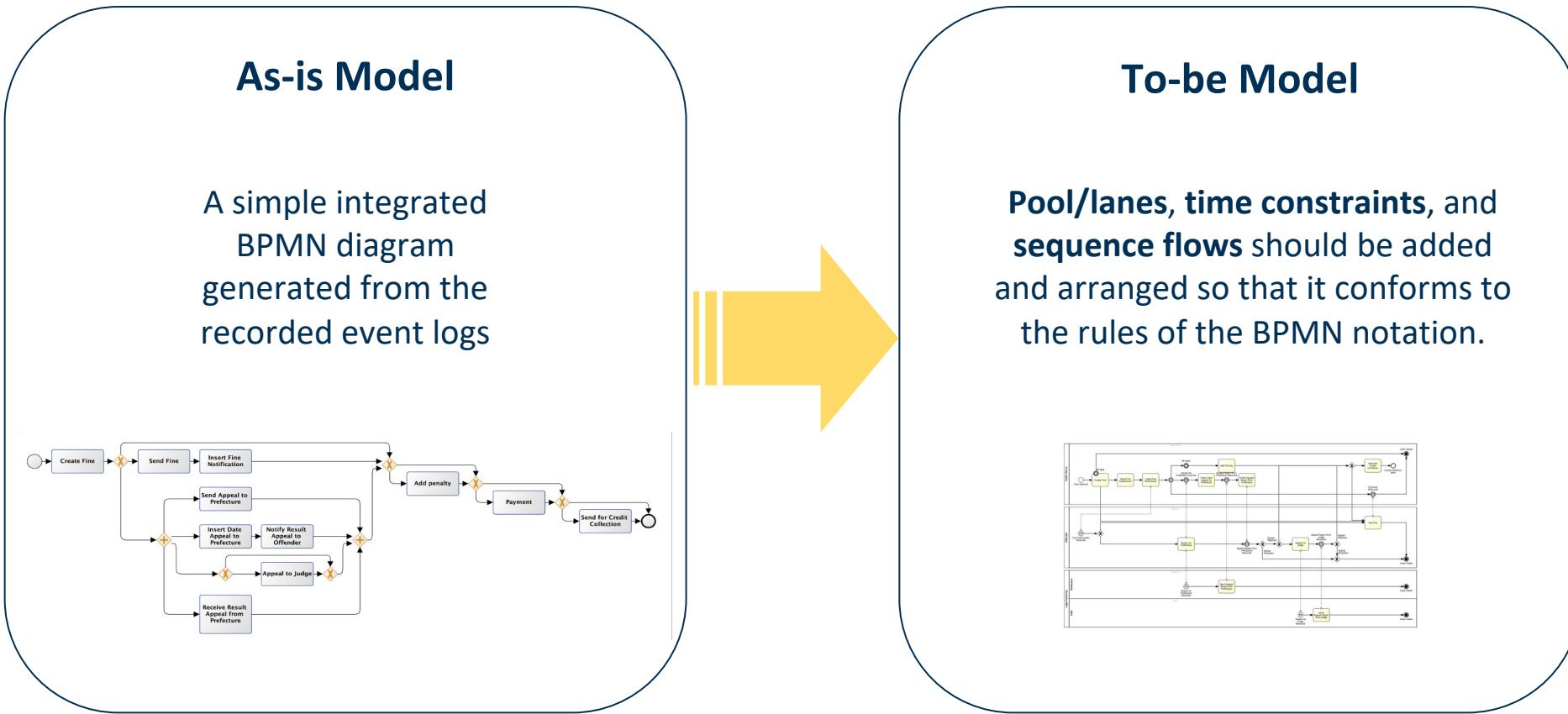


Converted
BPMN Diagram



Analysis - Process Enhancement

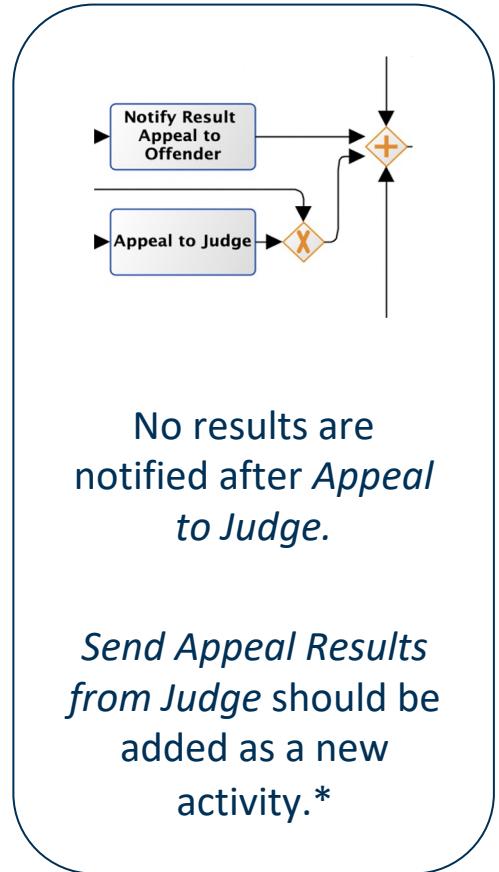
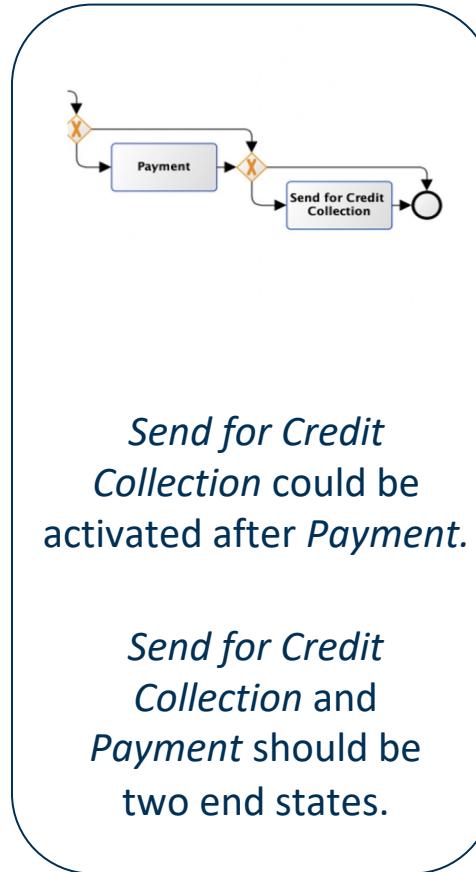
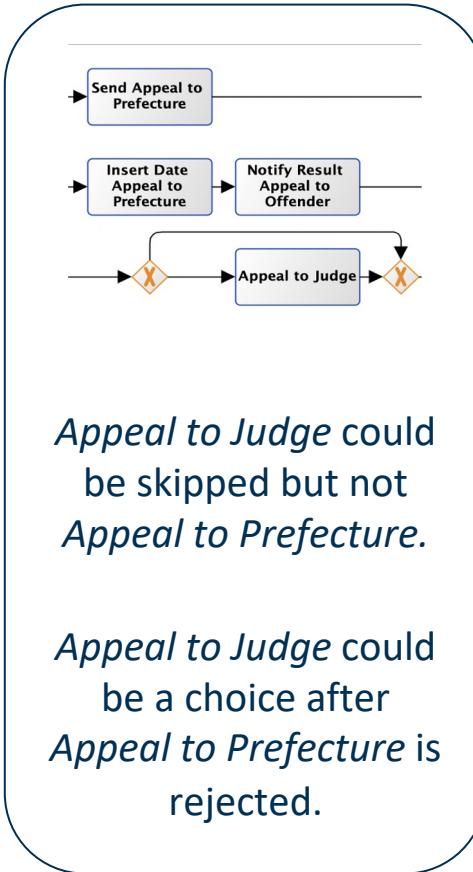
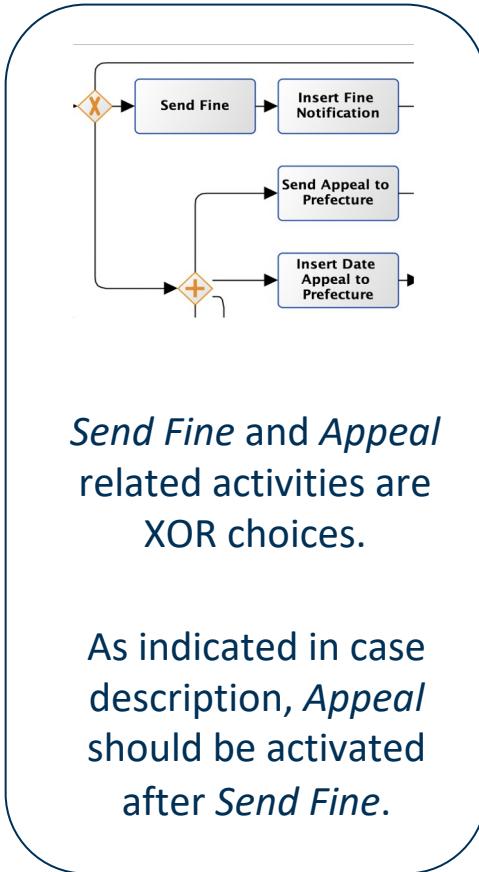
a) Model Quality Assurance: Syntactic Quality



Analysis - Process Enhancement

b) Model Quality Assurance: Semantic Quality

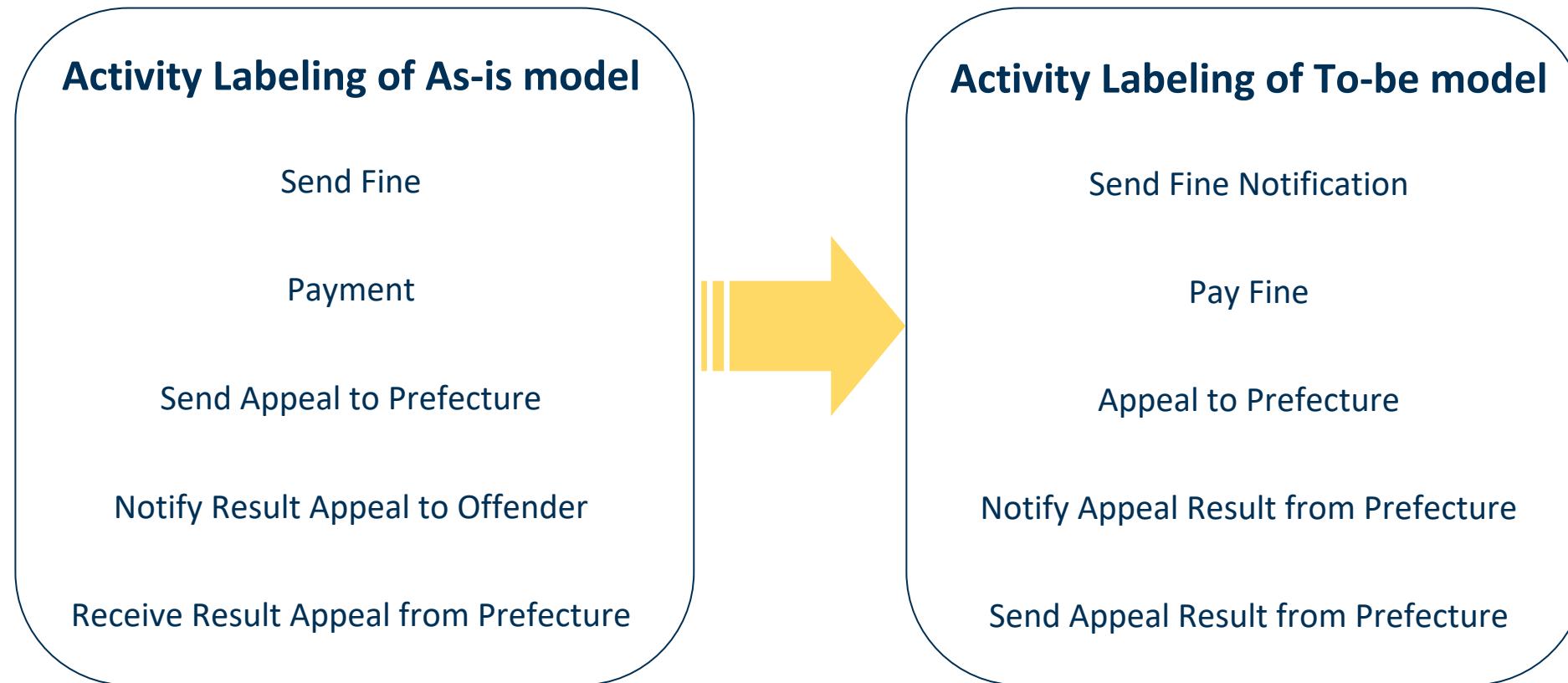
As-is
Scenario
↓
To-be
Scenario



Remark: *It is assumed that this is still a necessary activity that might just not be recorded in the event log from this system.

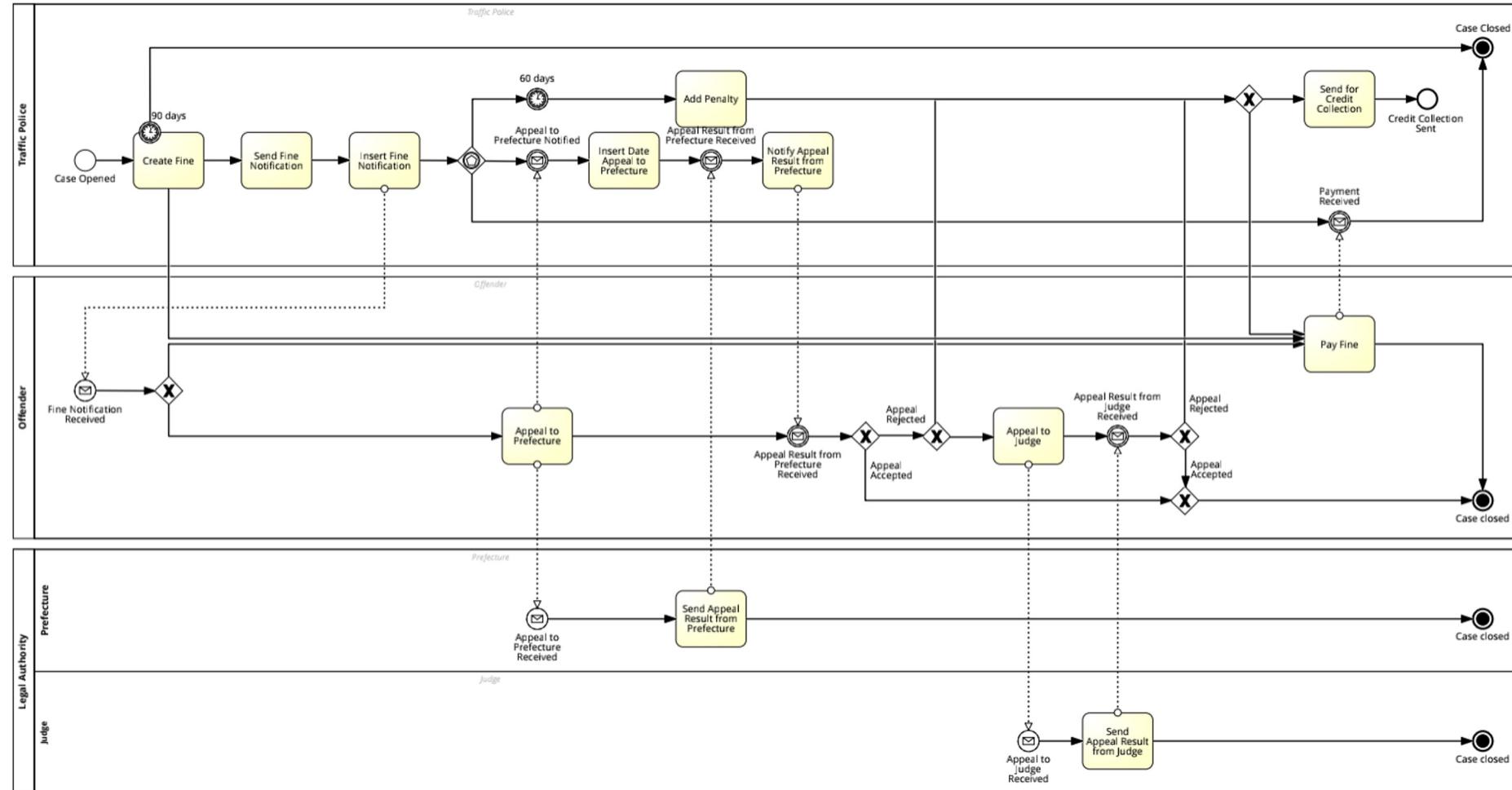
Analysis - Process Enhancement

c) Model Quality Assurance: Pragmatic Quality



Analysis - Process Enhancement

To-be BPMN Model Based On Case Description, Model Quality Check, And 7PMG



Analysis - Performance Findings

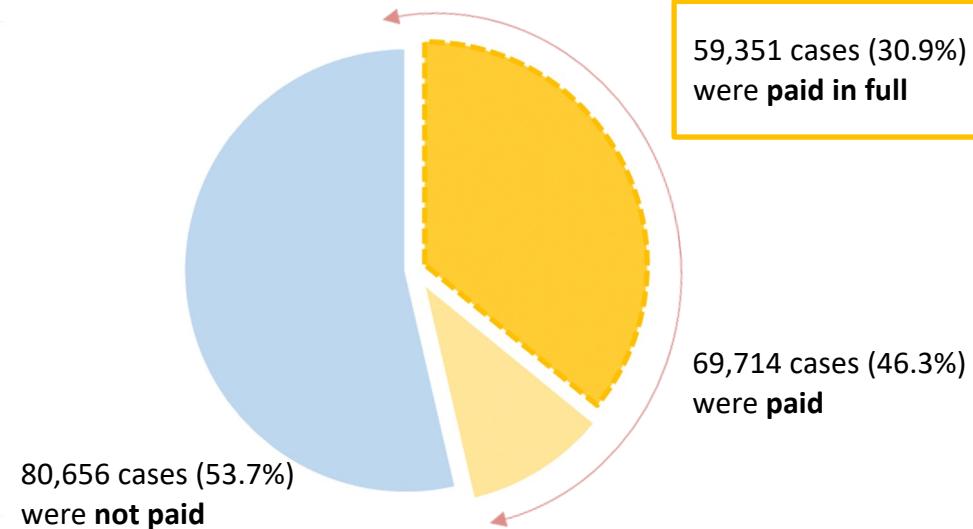
How Many Fines Are Actually Paid In Full?

- Converting the event logs into csv. format, the number of fines that was actually paid in full can be examined in excel.
- Comparing the total payment amount corresponding to the activity “Payment” with the total incurred amount in “Create Fine” and “Add penalty”, we could see that **59,351 cases (30.9%)** were paid (even exceed) the obligatory amount.
- Taking payment amount into consideration, we could see that fines with smaller amount are paid, those with larger amount remain unpaid.
- There are 101,127 cases (67.3%) with additional expenses incurred during the “Send Fine” activity, 6,808 (6.7%) of which even had paid extra to cover these expenses.


Average amount of fines +
penalty (all cases): **97.5**


Average fines + penalty of
those **paid in full**: **43.5**


Average fines + penalty of
those **not paid**: **126.1**

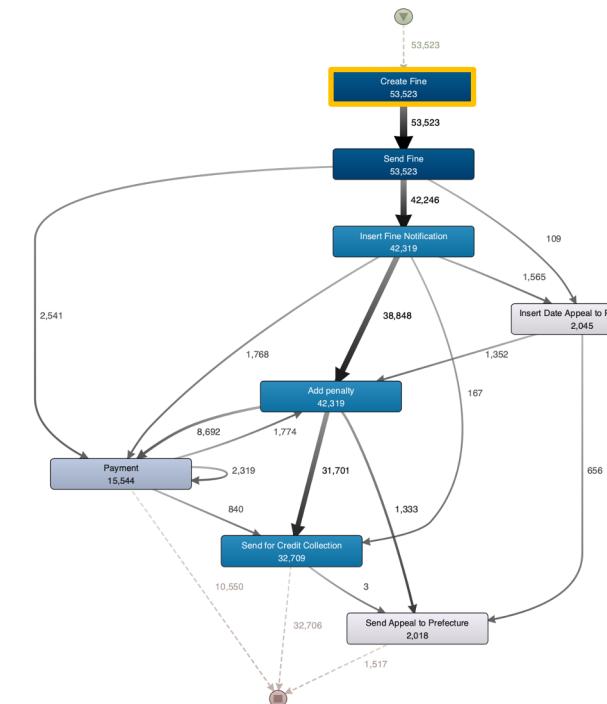
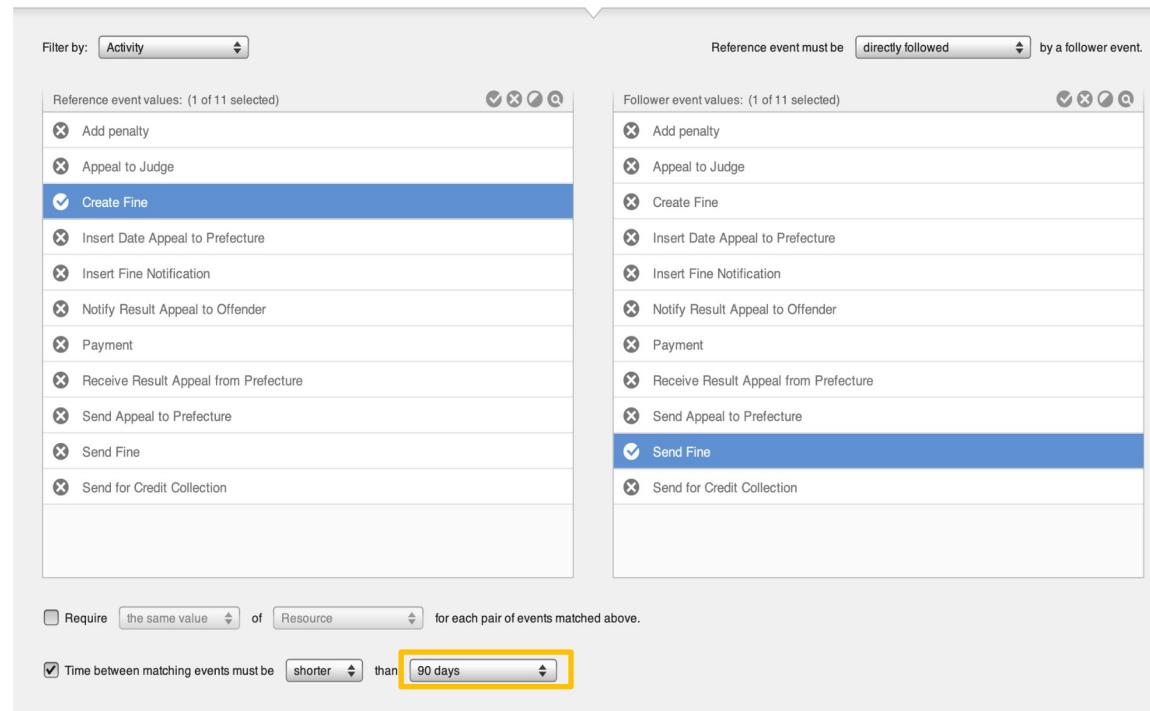


Case ID	Amount	TotalPaymentAmount	Difference
A1	35	0	35
A100	106.5	0	106.5
A10000	110	87	23
A10001	110	0	110
A10004	110	0	110
A10005	36	36	0
A10007	36	36	0
A10008	110	0	110
A10009	66	92	-26
A1001	63.5	0	63.5
A10010	110	0	110
A10011	110	0	110
A10012	36	0	36
A10015	110	0	110
A10018	66	35	31
A10019	110	0	110
A1002	63.5	0	63.5
A10021	110	0	110
A10022	22	22	0
A10023	110	0	110
A10024	36	36	0
A10025	110	0	110
A10026	110	0	110
A10029	36	36	0
A10030	22	22	0
A10033	110	87	23
A10034	110	0	110
A10041	36	0	36

Analysis - Performance Findings

Do The Cases In The Process Conform With The Time Constraints Imposed By The Law?

- By filtering the duration from "Create fine" to "Send Fine" within 90 days, we get **53,523 (35.6%)** cases that comply with the law.



Analysis - Performance Findings

Do the Cases in the Process Conform with the Time Constraints Imposed by the Law?

- By filtering the duration from "Insert Fine Notification" to "Appeal to Judge/Prefecture", we find that Appeal to Judge/Appeal to Prefecture appeared in **4,352 (2.9%)** cases.
- Among those cases, **790 (18.2%)** conform with the time constraints that the offender may only appeal to a judge/prefecture within 60 days.

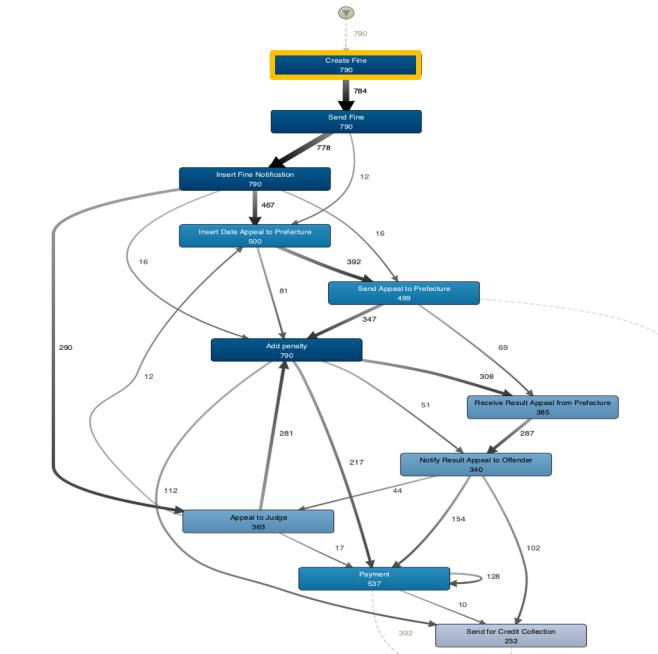
Filter by: Activity

Reference event must be eventually followed by a follower event.

Reference event values: (1 of 11 selected)	Follower event values: (2 of 11 selected)
<input checked="" type="checkbox"/> Add penalty	<input checked="" type="checkbox"/> Appeal to Judge
<input checked="" type="checkbox"/> Appeal to Judge	<input checked="" type="checkbox"/> Create Fine
<input checked="" type="checkbox"/> Create Fine	<input checked="" type="checkbox"/> Insert Date Appeal to Prefecture
<input checked="" type="checkbox"/> Insert Date Appeal to Prefecture	<input checked="" type="checkbox"/> Insert Fine Notification
<input checked="" type="checkbox"/> Insert Fine Notification	<input checked="" type="checkbox"/> Notify Result Appeal to Offender
<input checked="" type="checkbox"/> Notify Result Appeal to Offender	<input checked="" type="checkbox"/> Payment
<input checked="" type="checkbox"/> Payment	<input checked="" type="checkbox"/> Receive Result Appeal from Prefecture
<input checked="" type="checkbox"/> Receive Result Appeal from Prefecture	<input checked="" type="checkbox"/> Send Appeal to Prefecture
<input checked="" type="checkbox"/> Send Appeal to Prefecture	<input checked="" type="checkbox"/> Send Fine
<input checked="" type="checkbox"/> Send Fine	<input checked="" type="checkbox"/> Send for Credit Collection

Require the same value of Resource for each pair of events matched above.

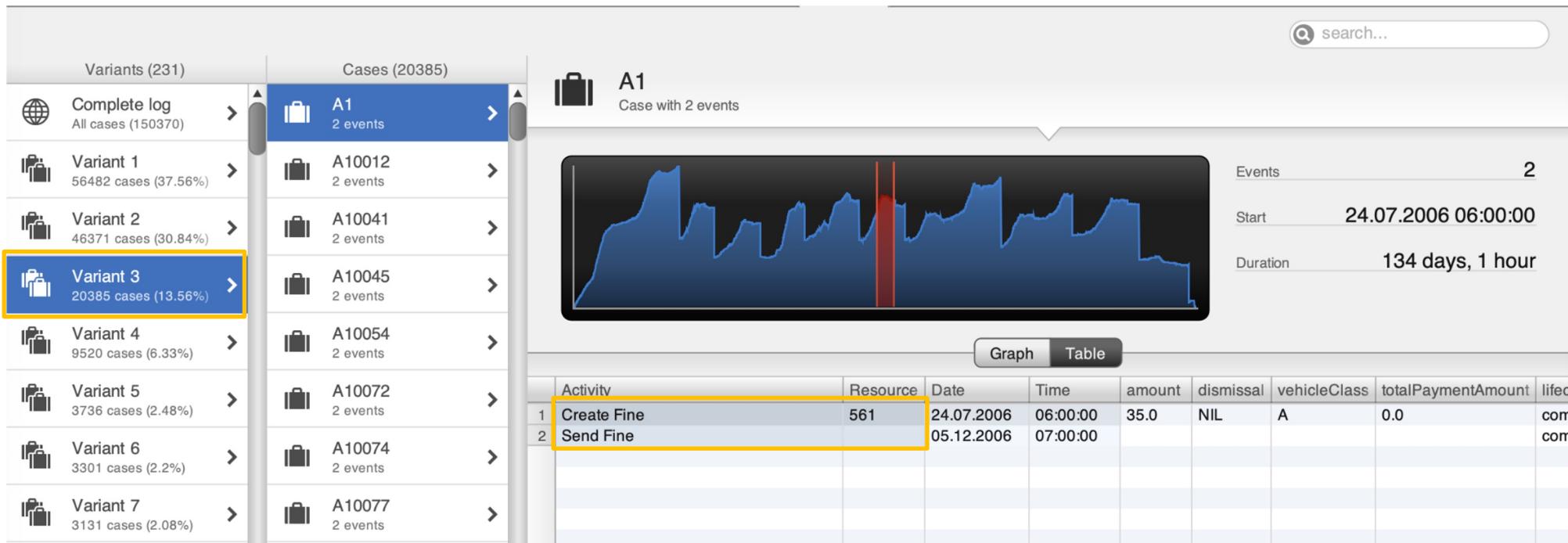
Time between matching events must be shorter than **60 days**



Analysis - Performance Findings

Problematic Behaviour I - Incomplete Cases

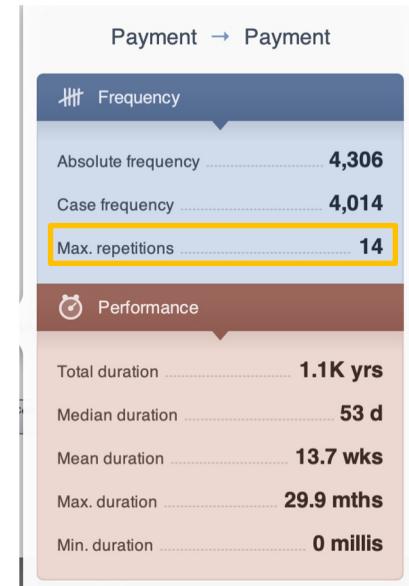
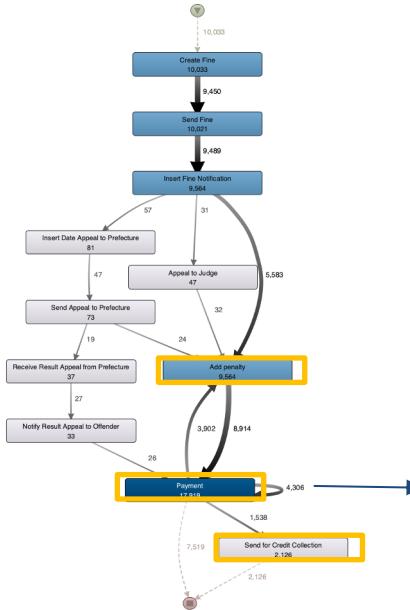
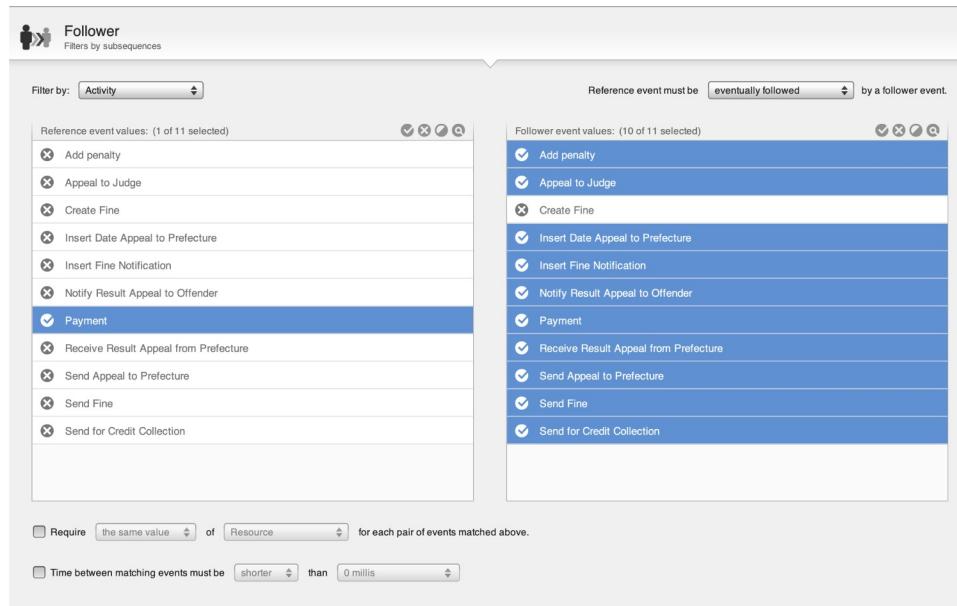
- Some process was executed incompletely.
- In over **13%** of the cases, the fines are created and sent, however they are neither paid, added penalty nor sent to credit collection.
- Possible explanation could be errors occurred during logging the process, the process was executed incorrectly etc.



Analysis - Performance Findings

Problematic Behaviour II - After Payment

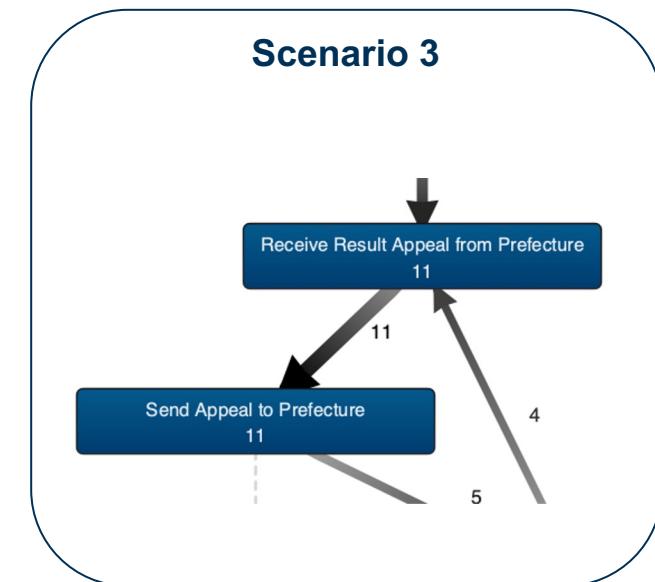
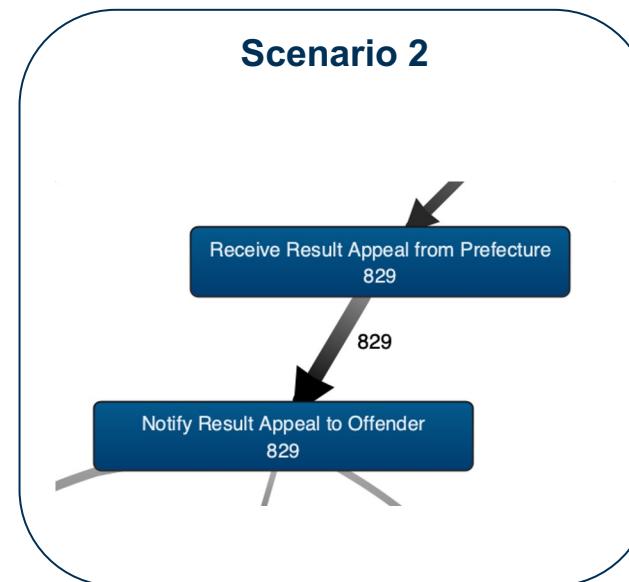
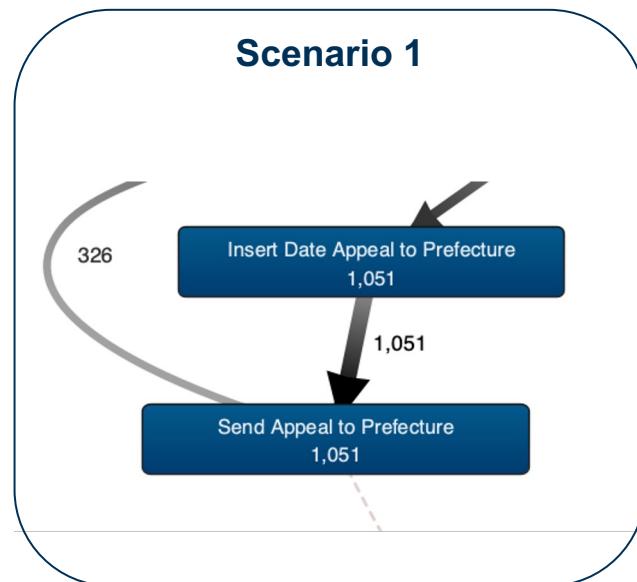
- In the BPMN model, Payment is an end state, however, irrational activities are observed after payment.
- In approximately **6%** of the cases, Payment is eventually followed by all activities except for Create Fine (In all cases, create fine is the initiating activity). The most common paths directly after Payment are **payment itself (maximum 14 repetitions), add penalty, send for credit collection**.
- Possible explanation could be payment in term, pay at the same time when a penalty was added for the delay, or credit due to delayed payment, etc.



Analysis - Performance Findings

Problematic Behaviour III - Appeal to Prefecture Related Activities

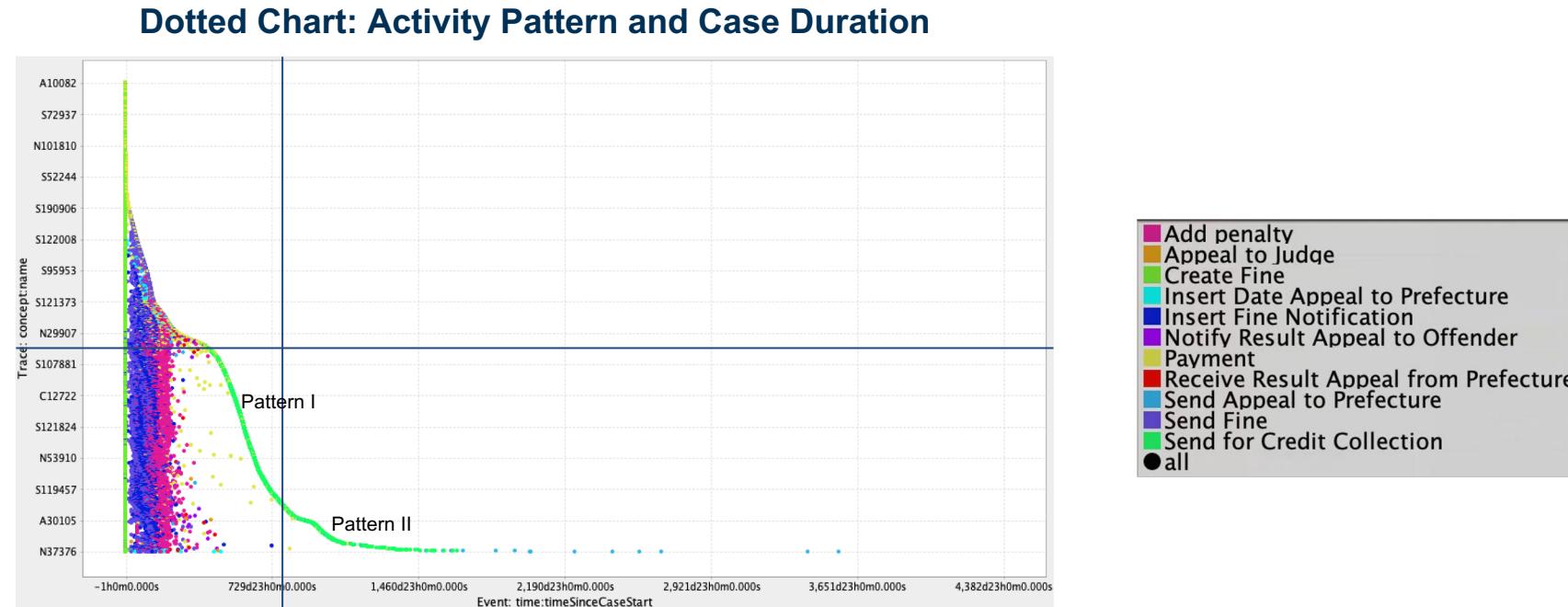
- The desired sequence is: **Send Appeal to Prefecture, Insert Date Appeal to Prefecture, Notify Result Appeal to Offender, Receive Result Appeal from Prefecture.**
- However, random order of Appeal to Prefecture related activities are observed, as is shown in the below scenarios.
- Possible explanation could be a lack of synchronization between the departments / officials in charge of various procedures of the fine management process.



Analysis - Process Drift

Execution of Send for Credit Collection

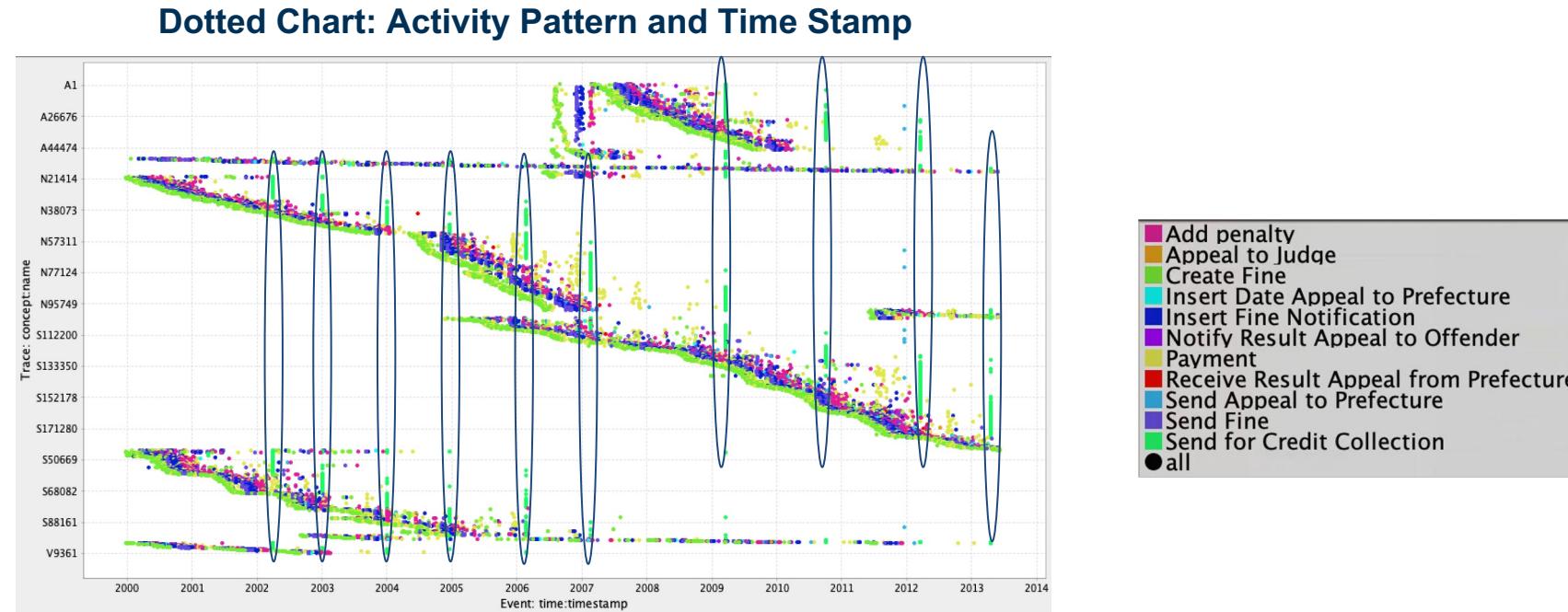
- As indicated by the dotted chart below, if all the cases start at the same point of time, **60%** of the cases which do not involve "Send for Credit collection" take shorter time (the upper part), while those end with "Send for Credit collection" last much longer (the lower part).
- The execution of "Send for Credit collection" shows two patterns. Either it is executed **in a more condensed time period at an earlier stage(Pattern I)**, or it is handled **at a random time** later (Pattern II), which indicates there might be a process drift.



Analysis - Process Drift

Execution of Send for Credit Collection

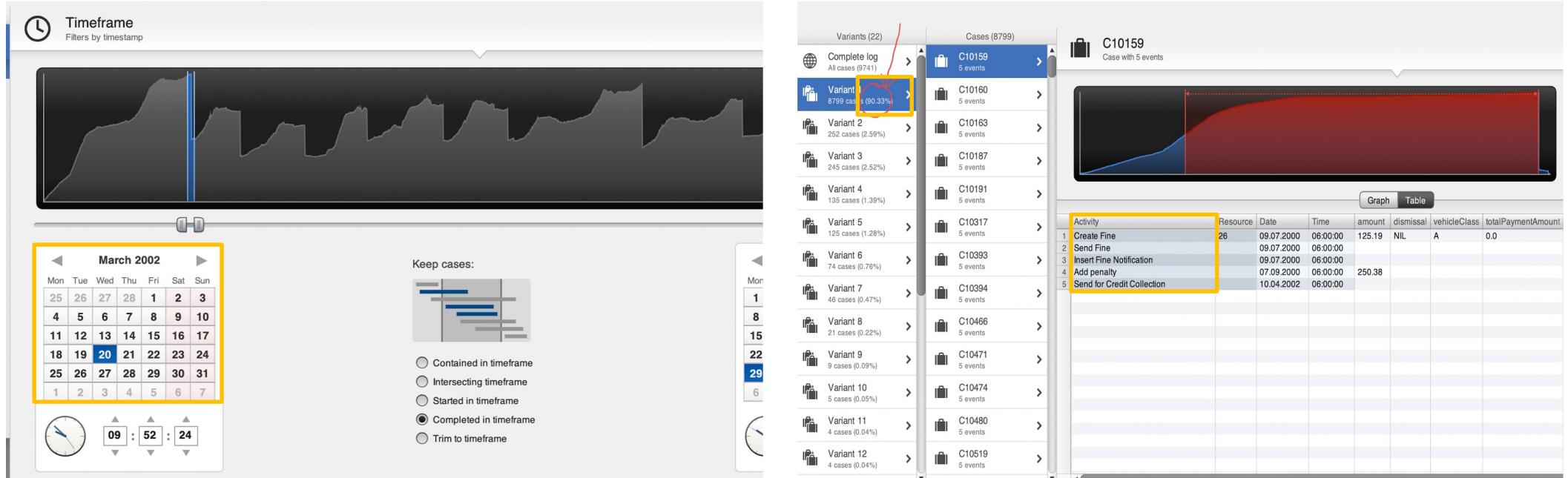
- Taking a closer look at the execution of the activities and exact time stamp, we could clearly see that there is indeed a process drift concerning “Send for Credit collection”.
- **Regular activity batches for “Send for Credit collection”** are observed, however, only starting from 2002.
- From **2002 to 2007**, “Send for Credit collection” is executed once a year, either at the beginning or the end of the year. From **2007 and onwards**, the time interval becomes larger, but still on a regular basis.



Analysis - Process Drift

Execution of Send for Credit Collection

- When deep diving into the turning point in 2002, we could see that on **20th of March** there was a sharp drop of active cases, and **90% of the closed cases follow the same trace: Create Fine, Send Fine, Insert Fine Notification, Add Penalty and Send for Credit Collection.**
- This further validates our assumption of a process drift: starting from a certain point of time, the traffic police handles cases containing unpaid fines in a centralized way when there are a large number of active cases.

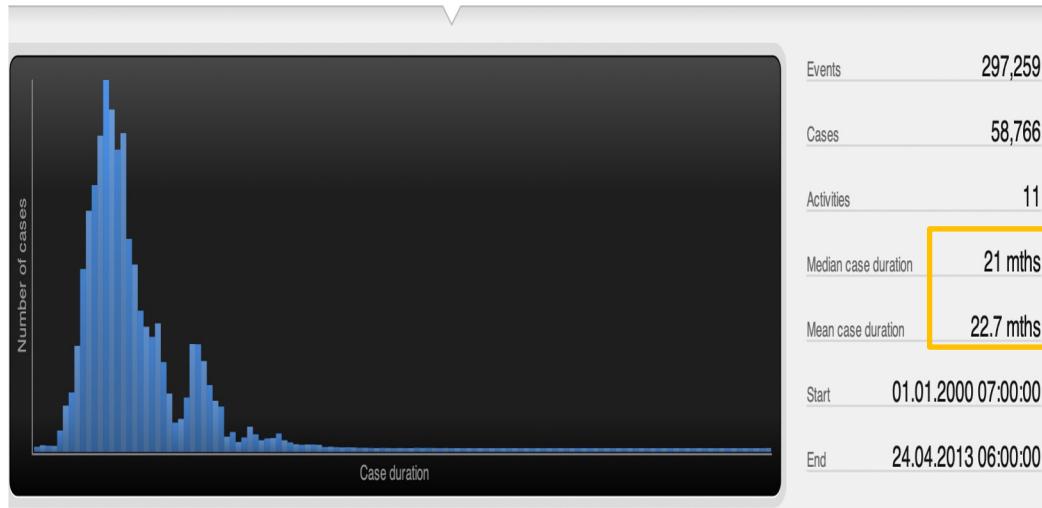


Analysis - Process Drift

Execution of Send for Credit Collection

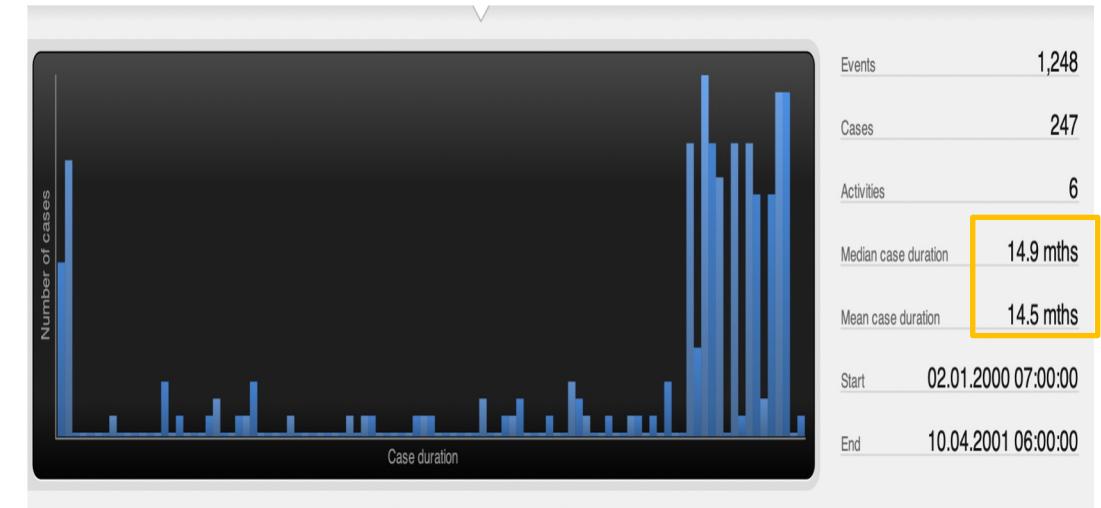
- Before March 2020, cases containing unpaid fines are handled differently.
- For most cases, “Send for Credit Collection” were executed after the cases had not been processed for more than 1 year 9 months. (Echo back to Pattern II on Slide 18)
- After the adaption, cases are handled more efficiently. (Echo back to Pattern I on Slide 18)

Case Duration before March 2002



Before March 2020, case duration centralises at 1 year 9 months.

Case Duration after March 2002



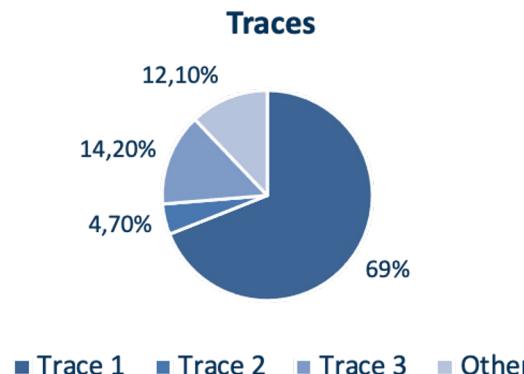
After March 2002, case duration demonstrates much more variation.

Analysis - Additional Insights

When Did People Pay Fine?

- **44.7%** of the cases (67,201) end with Payment. **Among those cases:**
- **69.0%** of the cases (46,371) recorded that people paid after fine had been created (Trace 1). This could be the case when traffic fine, e.g., parking ticket is physically handed over to the offender, so no fine will be sent via the system.
- Trace 2 is observed in **4.7%** of the cases (3,131) where Payment was activated after Create Fine and Send Fine.
- In **14.2%** of the cases (9,520), payment was made after a penalty is added (Trace 3).*

% of Cases End with Payment for Different



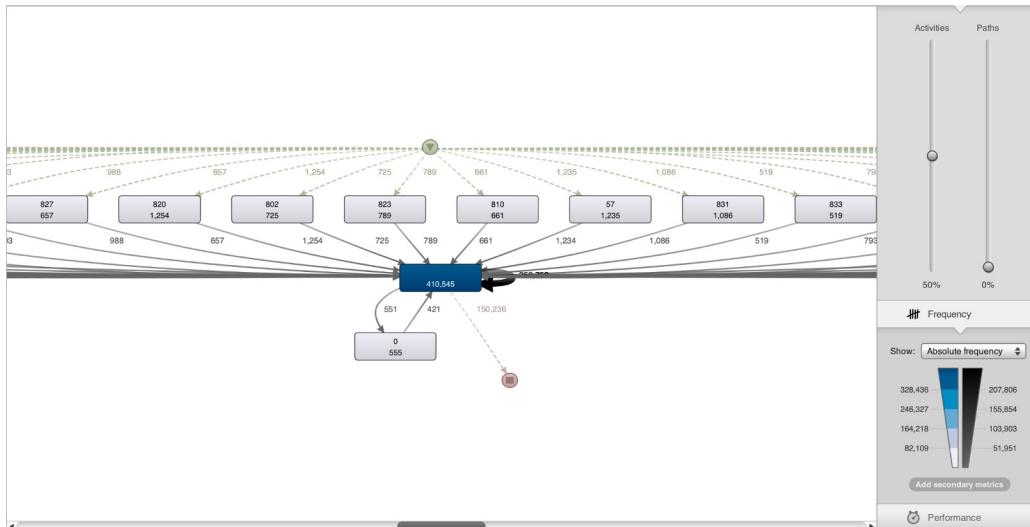
Remark: *Detailed setting of filters and analysis results can be found in [Appendix II](#).

Analysis - Additional Insights

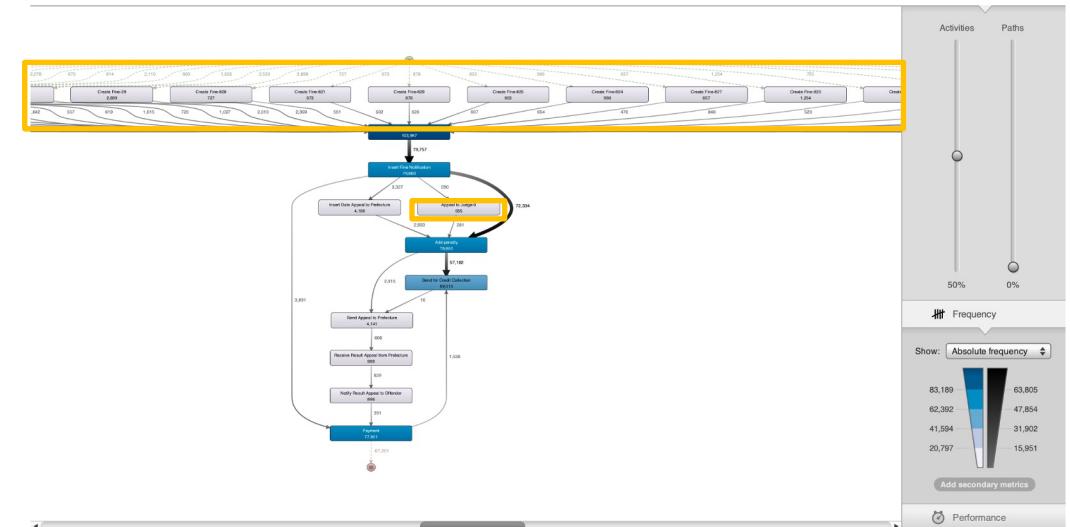
How is Resource Allocated?

- Looking at the social network which is based solely on the resource on the left side, we could see there is a large number of resources responsible of similar tasks. Resource 0 remains isolated.
- Adding activity into consideration, more interesting pattern is observed. **Resource is only recorded for Create Fine and Appeal to Judge.**
- While there are **147** resources responsible for Create Fine activity, Appeal to Judge activity is only assigned to **1** resource (0).

Social Network (Resource Only)



Social Network (Resource + Activity)

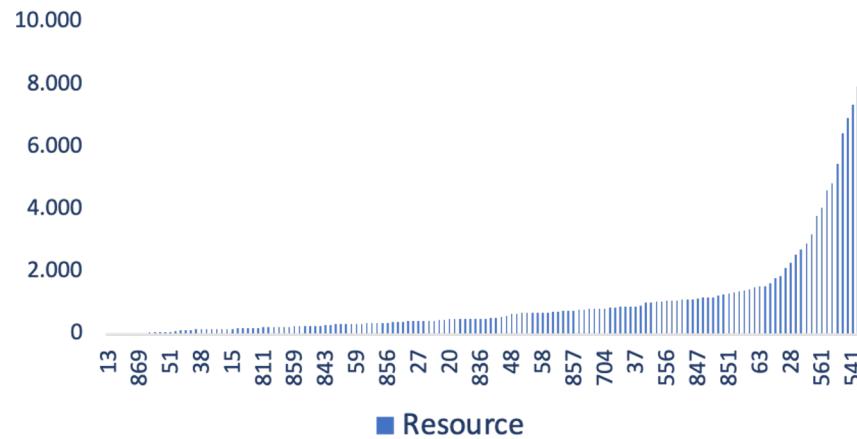


Analysis - Additional Insights

How is Resource Allocated?

- For Create Fine, cases are not evenly distributed. While some resources handle up to **85,000** cases, others handle only around **10** cases.
- However, no special distribution of cases regarding the different payment amount incurred is observed. Case distribution pattern for each resource resembles the overall case distribution with respect to different payment intervals.
- In order to obtain meaningful insights to enhance resource efficiency, a comprehensive and precise recording of resource is needed.

Case Distribution (Create Fine)



Case Distribution Regarding Payment Amount

Amount Interval	All Case	Resource									
		19	20	21	22	563	564	565	704	802	807
0-100	95372	2	269	238	169	840	613	565	499	649	214
100-200	42249	2	158	178	125	549	426	334	151	67	41
200-300	6340	1	21	56	19	2	2	0	22	0	0
300-400	2715	0	0	4	9	0	0	0	71	8	2
400-500	2745	0	13	6	28	0	0	0	64	0	0
500-600	16	0	0	0	0	0	0	0	0	0	0
600-700	12	0	0	0	0	0	0	0	0	0	0
700-800	30	0	0	0	0	0	0	0	0	0	0
800-900	18	0	0	0	0	0	0	0	0	0	0
900-1,000	109	0	1	1	0	0	0	0	2	0	0
1,000-1,500	447	0	5	0	1	0	0	0	1	0	0
1,500-2,000	81	0	0	2	0	0	0	0	3	1	0
2,000-10,000	234	0	0	3	0	0	0	0	1	0	0
>10,000	2	0	0	0	0	0	0	0	0	0	0

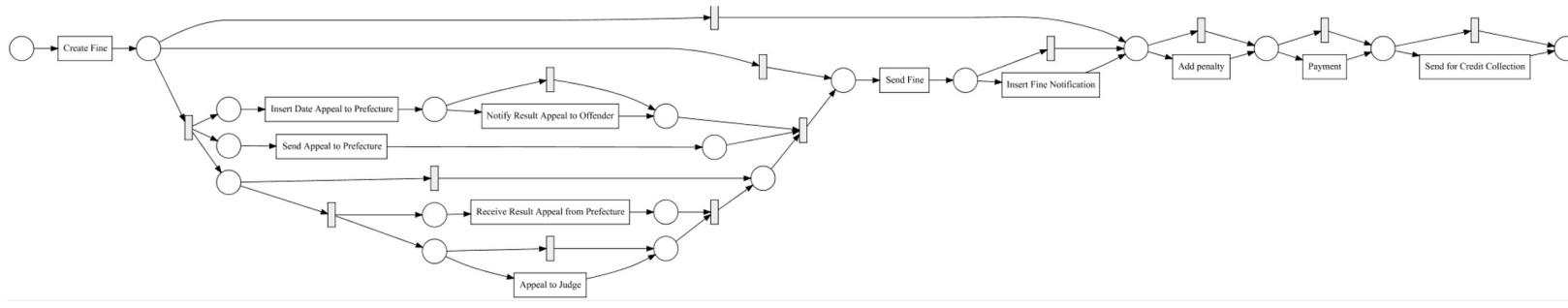
Appendix



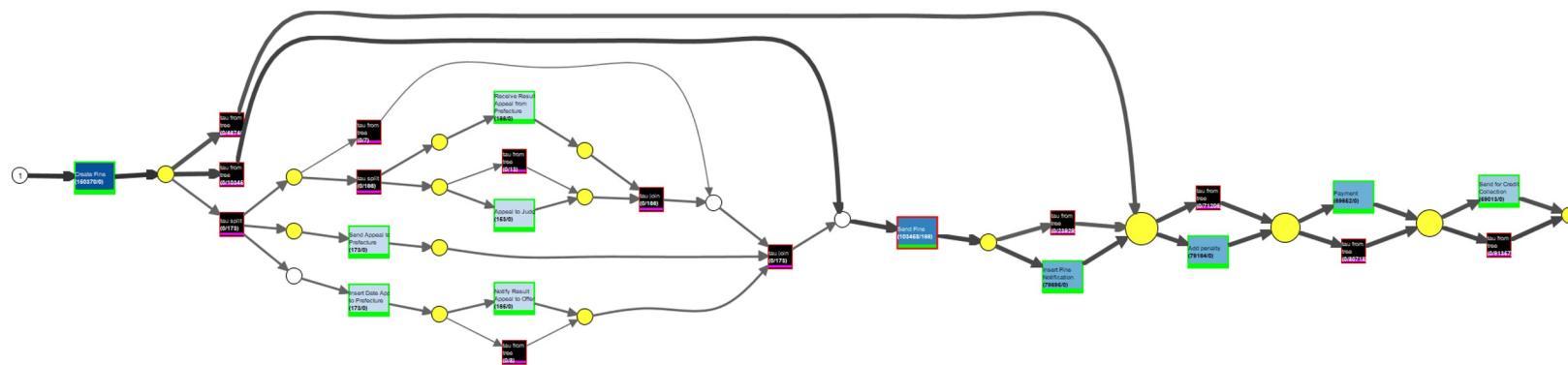
Appendix I

Quality check for optimal process model choice - Inductive Mining Noise 0.10

Petri Net



Fitness Replay



Quality Check

Fitness 0.98235

Precision 0.50665

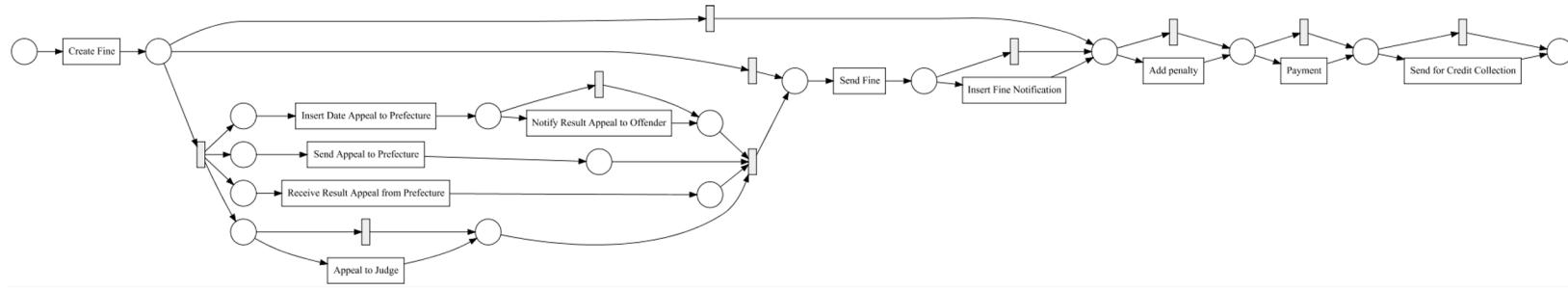
Generalization 0.99074

Simplicity
(silent
transitions) 13

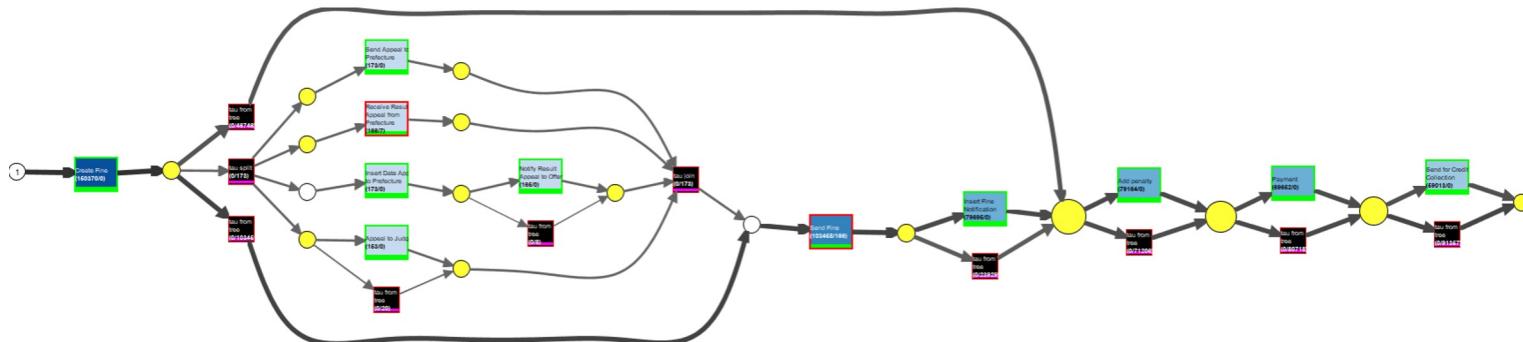
Appendix I

Quality check for optimal process model choice - Inductive Mining Noise 0.20

Petri Net



Fitness Replay



Quality Check

Fitness 0.98234

Precision 0.50276

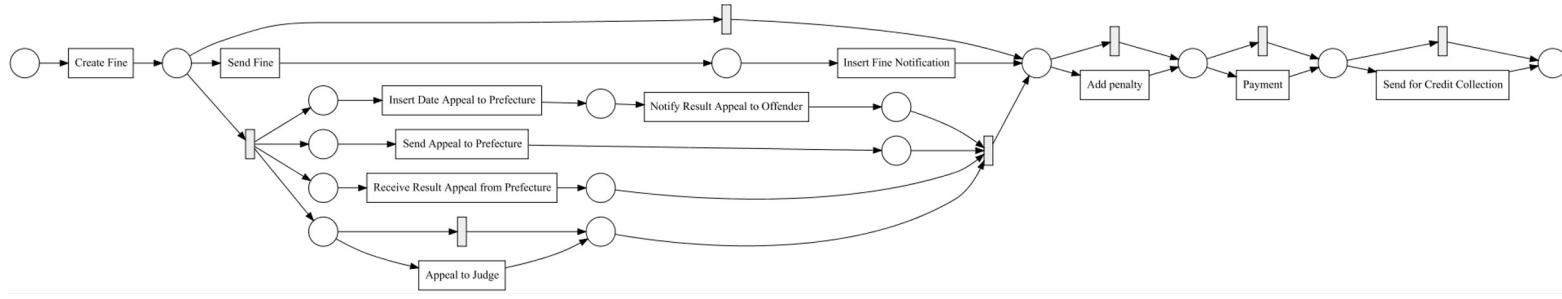
Generalization 0.99114

Simplicity
(silent
transitions) 10

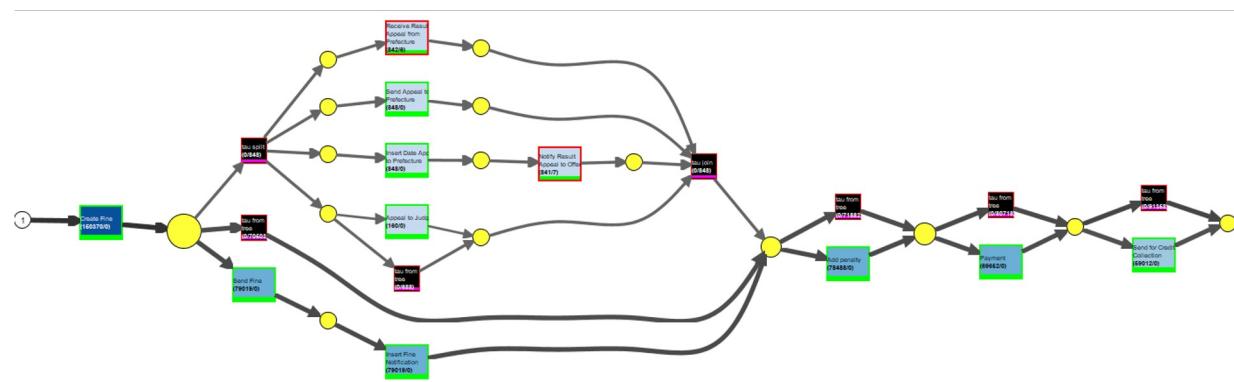
Appendix I

Quality check for optimal process model choice - Inductive Mining Noise 0.30

Petri Net



Fitness Replay



Quality Check

Fitness 0.93218

Precision 0.69298

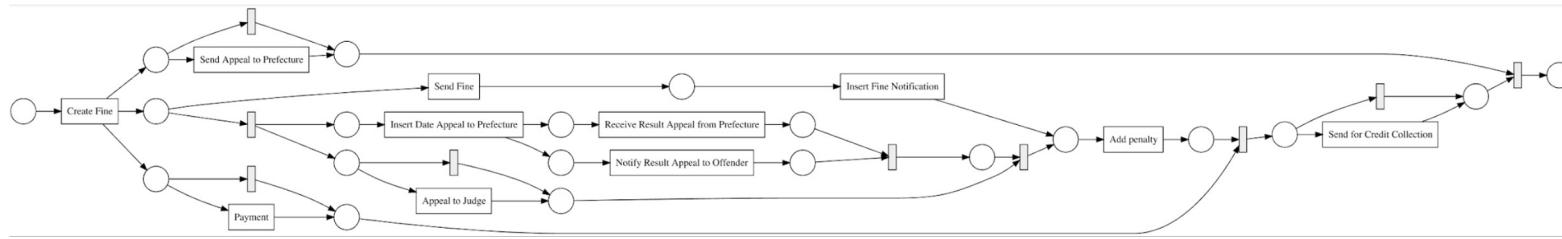
Generalization 0.99220

Simplicity
(silent
transitions) 7

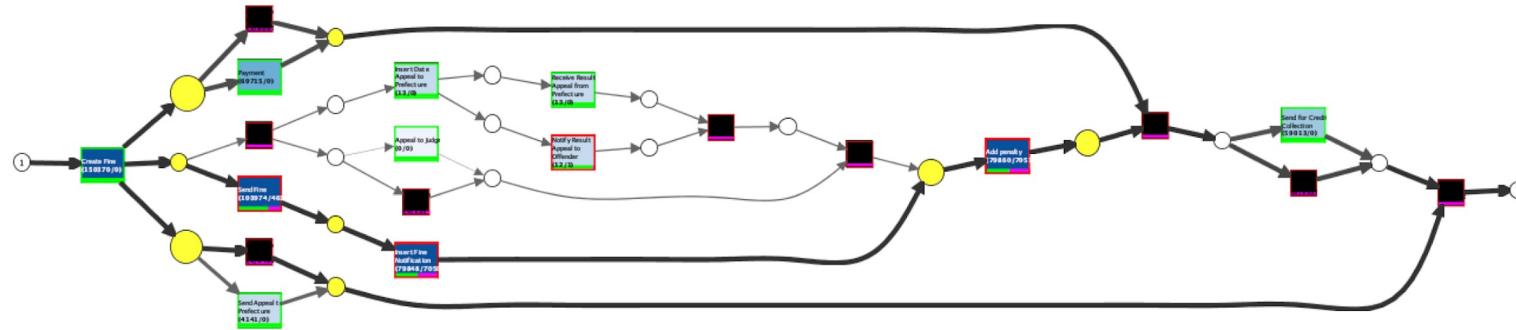
Appendix I

Quality check for optimal process model choice - Inductive Mining Noise 0.40

Petri Net



Fitness Replay



Quality Check

Fitness 0.78439

Precision 0.81229

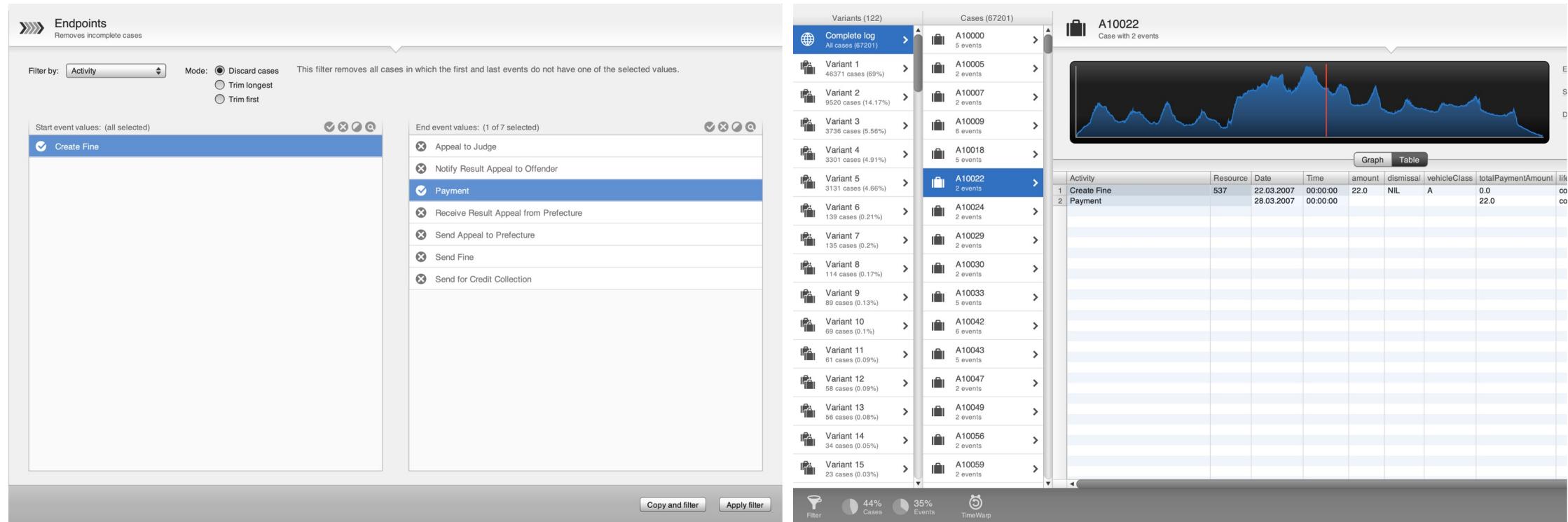
Generalization 0.99280

Simplicity
(silent
transitions) 9

Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Cases End with Payment



Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Path 1: Create Fine, Payment

The image displays two side-by-side screenshots of the Disco Filter software interface, illustrating the creation of a process insight.

Left Screenshot (Follower Filter):

- Title:** Follower
- Description:** Filters by subsequences
- Filter by:** Activity
- Reference event values:** (1 of 11 selected)
 - Add penalty
 - Appeal to Judge
 - Create Fine** (selected)
 - Insert Date Appeal to Prefecture
 - Insert Fine Notification
 - Notify Result Appeal to Offender
 - Payment
 - Receive Result Appeal from Prefecture
 - Send Appeal to Prefecture
 - Send Fine
 - Send for Credit Collection
- Follower event values:** (1 of 11 selected)
 - Add penalty
 - Appeal to Judge
 - Create Fine
 - Insert Date Appeal to Prefecture
 - Insert Fine Notification
 - Notify Result Appeal to Offender
 - Payment** (selected)
 - Receive Result Appeal from Prefecture
 - Send Appeal to Prefecture
 - Send Fine
 - Send for Credit Collection
- Buttons:** Copy and filter, Apply filter

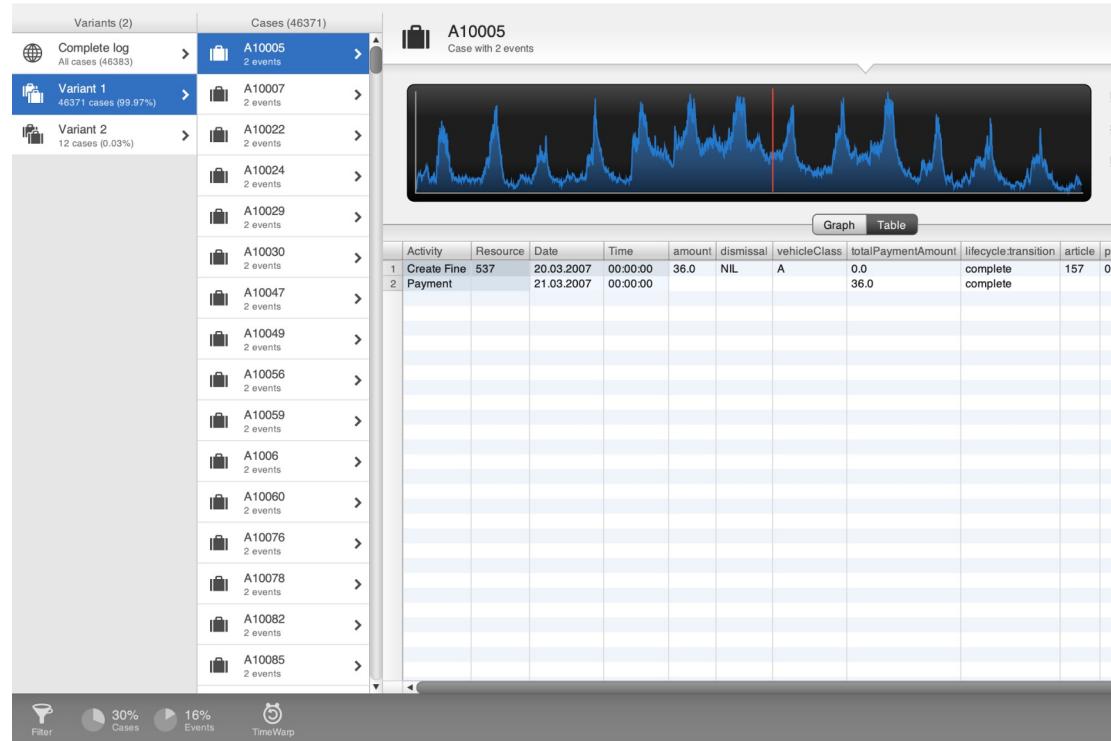
Right Screenshot (Attribute Filter):

- Title:** Attribute
- Description:** Removes events by attribute
- Filter by:** Activity
- Filtering mode:**
 - Keep selected
 - Mandatory
 - Forbidden** (selected)
- Text:** This filter removes all cases that have at least one event with one of the selected values.
- Event values:** (9 of 11 selected)
 - Add penalty
 - Appeal to Judge
 - Create Fine** (selected)
 - Insert Date Appeal to Prefecture
 - Insert Fine Notification
 - Notify Result Appeal to Offender
 - Payment** (selected)
 - Receive Result Appeal from Prefecture
 - Send Appeal to Prefecture
 - Send Fine
 - Send for Credit Collection
- Buttons:** Copy and filter, Apply filter

Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Path 1: Create Fine, Payment



Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Path 2: Create Fine, Send Fine, Payment

Follower
Filters by subsequences

Filter by: Activity

Reference event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine**
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Follower event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine**
- Send for Credit Collection

Reference event must be directly followed by a follower event.

Require the same value of Resource for each pair of events matched above.

Time between matching events must be shorter than 0 millis.

Copy and filter Apply filter

Follower
Filters by subsequences

Filter by: Activity

Reference event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine**
- Send for Credit Collection

Follower event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine**
- Send for Credit Collection

Reference event must be directly followed by a follower event.

Require the same value of Resource for each pair of events matched above.

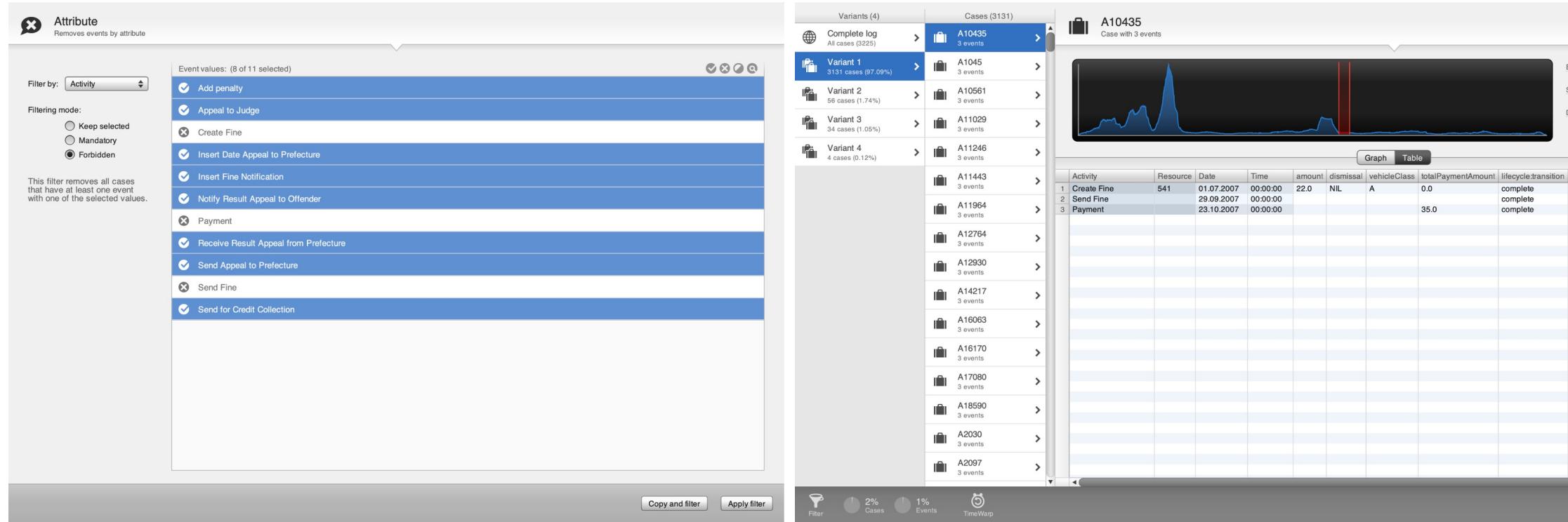
Time between matching events must be shorter than 0 millis.

Copy and filter Apply filter

Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Path 2: Create Fine, Send Fine, Payment



Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Path 3: Create Fine, Send Fine, Insert Fine Notification, Add Penalty, Payment

Follower
Filters by subsequences

Filter by: Activity

Reference event values: (1 of 11 selected)

- Create Fine
- Add penalty
- Appeal to Judge
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Follower event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Reference event must be directly followed by a follower event.

Require the same value of Resource for each pair of events matched above.

Time between matching events must be shorter than 0 millis

Copy and filter Apply filter

Follower
Filters by subsequences

Filter by: Activity

Reference event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Follower event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Reference event must be directly followed by a follower event.

Require the same value of Resource for each pair of events matched above.

Time between matching events must be shorter than 0 millis

Copy and filter Apply filter

Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Path 3: Create Fine, Send Fine, Insert Fine Notification, Add Penalty, Payment

Follower
Filters by subsequences

Filter by: Activity

Reference event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Follower event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Reference event must be directly followed by a follower event.

Require the same value of Resource for each pair of events matched above.

Time between matching events must be shorter than 0 millis

Copy and filter Apply filter

Follower
Filters by subsequences

Filter by: Activity

Reference event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Follower event values: (1 of 11 selected)

- Add penalty
- Appeal to Judge
- Create Fine
- Insert Date Appeal to Prefecture
- Insert Fine Notification
- Notify Result Appeal to Offender
- Payment
- Receive Result Appeal from Prefecture
- Send Appeal to Prefecture
- Send Fine
- Send for Credit Collection

Reference event must be directly followed by a follower event.

Require the same value of Resource for each pair of events matched above.

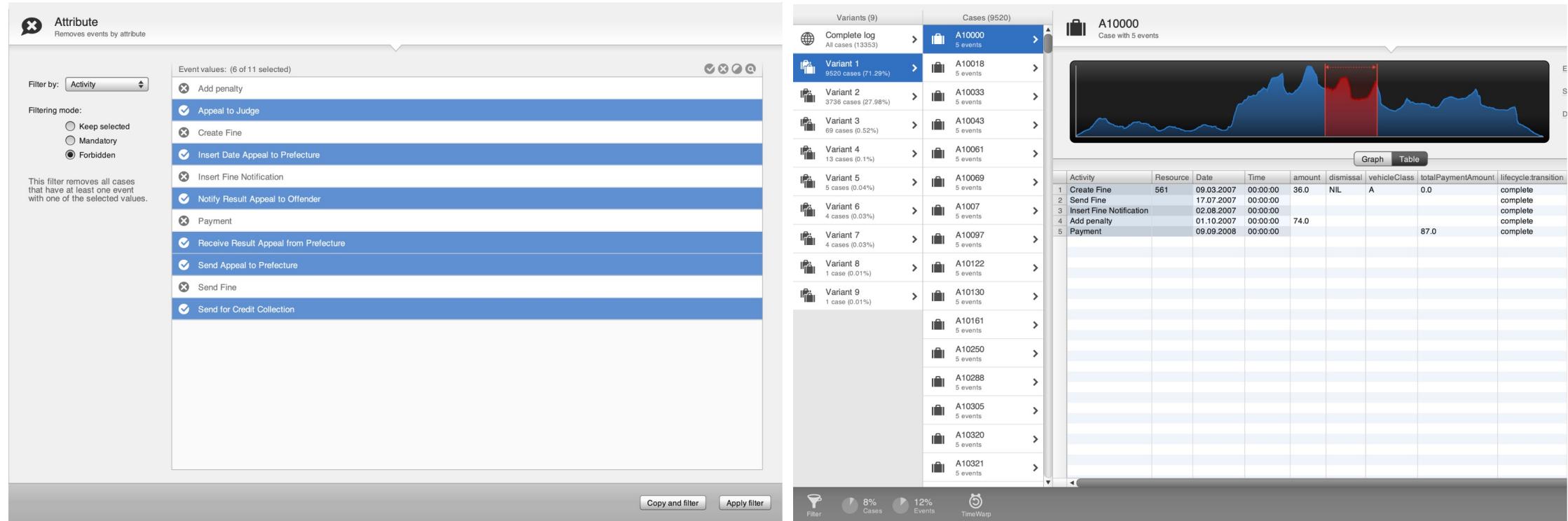
Time between matching events must be shorter than 0 millis

Copy and filter Apply filter

Appendix II

Disco Filter for Additional Insight: When Do People Pay Fine?

Path 3: Create Fine, Send Fine, Insert Fine Notification, Add Penalty, Payment



Appendix III

ProM Plugins Applied

Task	Plugin
Automated Process Mining	Alpha Minder, Mine Petri Net with Inductive Miner
Fitness	Replay a Log on Petri Net for Conformance Analysis
Precision	Measure Precision/Generalization
Generalization	Measure Precision/Generalization
BPMN Diagram Conversion	Convert Petri Net to BPMN Diagram
Process Drift	Project Log on DottedChart

IS 515 - Process Management & Analytics
Prof. Van der Aa & Prof. Rehse

**With the above process mining insights, we
are ready for the next steps in the process
life cycle.**

