

## Question 1

(a)

Import log-flat.xes to ProM. Click the eye symbol to view resource.



This results in the following view:



From it we can read

- the time period (1) covered by the event log, which is from 13.01.2010 to 03.01.2014
- the number of cases, events and activities of the log (2), being 4580, 21348 and 14 respectively (note that activities appear in ProM as event classes)

To gain more information on the activities we click the summary tab in the left which results in the following view:

The screenshot shows the 'Log Summary' interface. On the left, a sidebar contains 'Dashboard', 'Inspector', and 'Summary' (highlighted with a red arrow). The main area is divided into two sections. The top section, 'All events', shows a table of 14 event classes with their absolute occurrences. The bottom section, 'Start events', shows a table of 6 start event classes with their absolute occurrences. The 'End events' section is also visible but empty.

Class	Occurrences (absolute)
Take in charge ticket	5060
Resolve ticket	4983
Assign seriousness	4938
Closed	4574
Wait	1463
Require upgrade	119
Insert ticket	118
Create SW anomaly	67
Resolve SW anomaly	13
Schedule intervention	5
VERIFIED	3
INVALID	2
RESOLVED	2
DUPLICATE	1

Class	Occurrences (absolute)
Assign seriousness	4384
Insert ticket	118
Take in charge ticket	74
Resolve ticket	2
Create SW anomaly	1
Wait	1

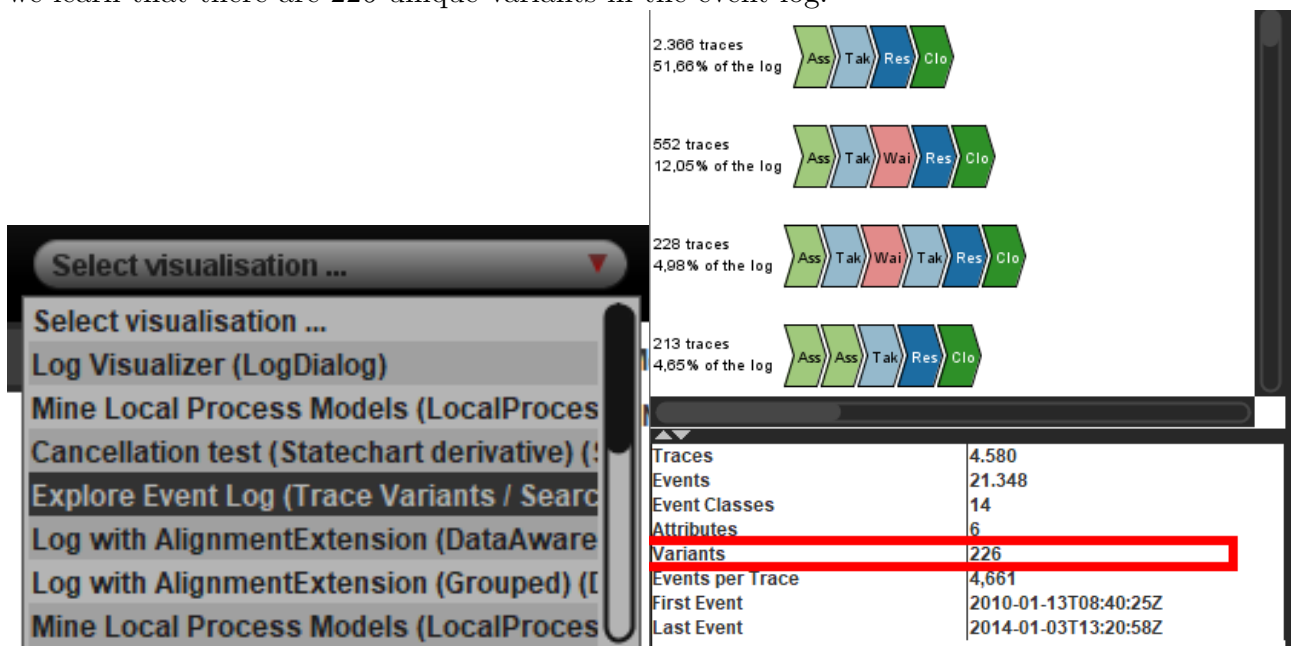
  

Class	Occurrences (absolute)
Closed	4557
Resolve ticket	10
Wait	8
Require upgrade	3
Take in charge ticket	1
VERIFIED	1

From (3) we get a table of occurrence frequencies for each activity. From (4) we get a table of occurrence frequencies for each start activity. From (5) we get a table of occurrence frequencies for each end activity.

To determine the number of unique trace variants we click on 'Select visualization' and select 'Explore Event Log'

Under this view all trace variants are listed and some further information is given. From this we learn that there are 226 unique variants in the event log.



98% of tickets taken in charge are resolved ( $\frac{4983}{5060}$ ). The variants seem to be quite diverse ( $\frac{1}{20}$  ratio of cases to variants, although distributed very unevenly).

From (4) we also observe that a quite high number of cases start with "illegal" activities (so not 'Assign seriousness' or 'Insert ticket'). It strikes out, that people managed in 74 cases to start their tickets with the "illegal" activity 'Take in charge ticket', while in comparison only 118 cases begin with the activity 'Insert ticket'.

(b)

From the introduction we learned that every trace has to start with 'Insert ticket' or 'Assign seriousness' and ends with 'Closed'. Therefore every trace that does not begin/end with these events must have started/ended outside of our observed time period, making it incomplete.

To filter out incomplete traces we go on the 'Actions' tab, select 'Filter Log using Simple Heuristics' and press 'Start'. In the first dialogue we just click 'Next'. In the next dialogue

window we select 'Insert ticket' as our only start event and click 'Next'.

**Start events**  
Only instances starting with a green event will be used.

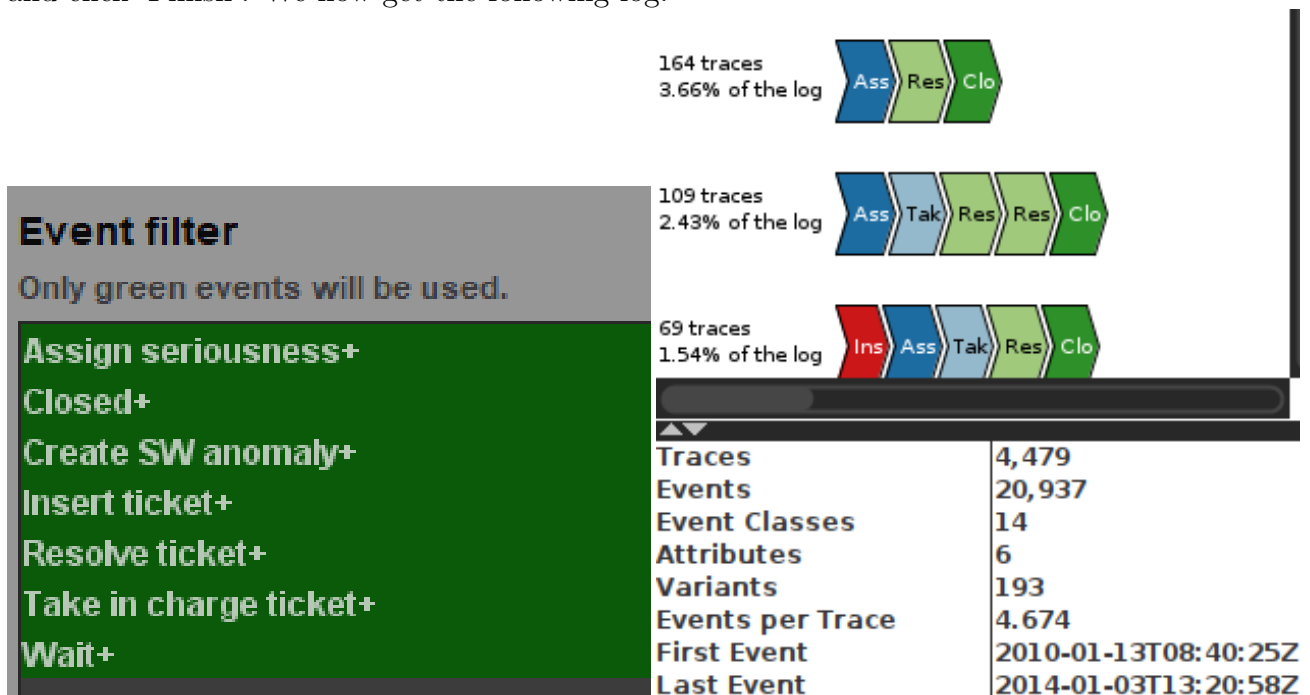
- Assign seriousness+
- Create SW anomaly+
- Insert ticket+**
- Resolve ticket+
- Take in charge ticket+
- Wait+

For the end events we only select 'Closed' and click 'Next'.

**End events**  
Only instances ending with a green event will be used.

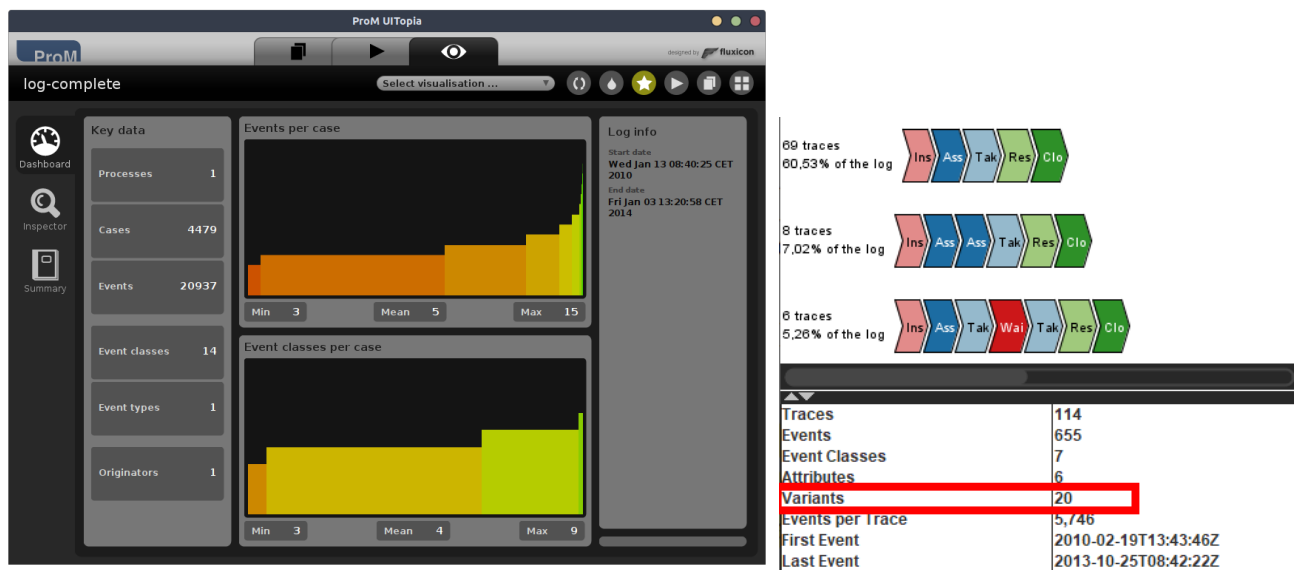
- Closed+**
- Wait+

Since we do not want to filter out any other events we select 100% of events in Event Filter and click 'Finish'. We now get the following log:



(c)

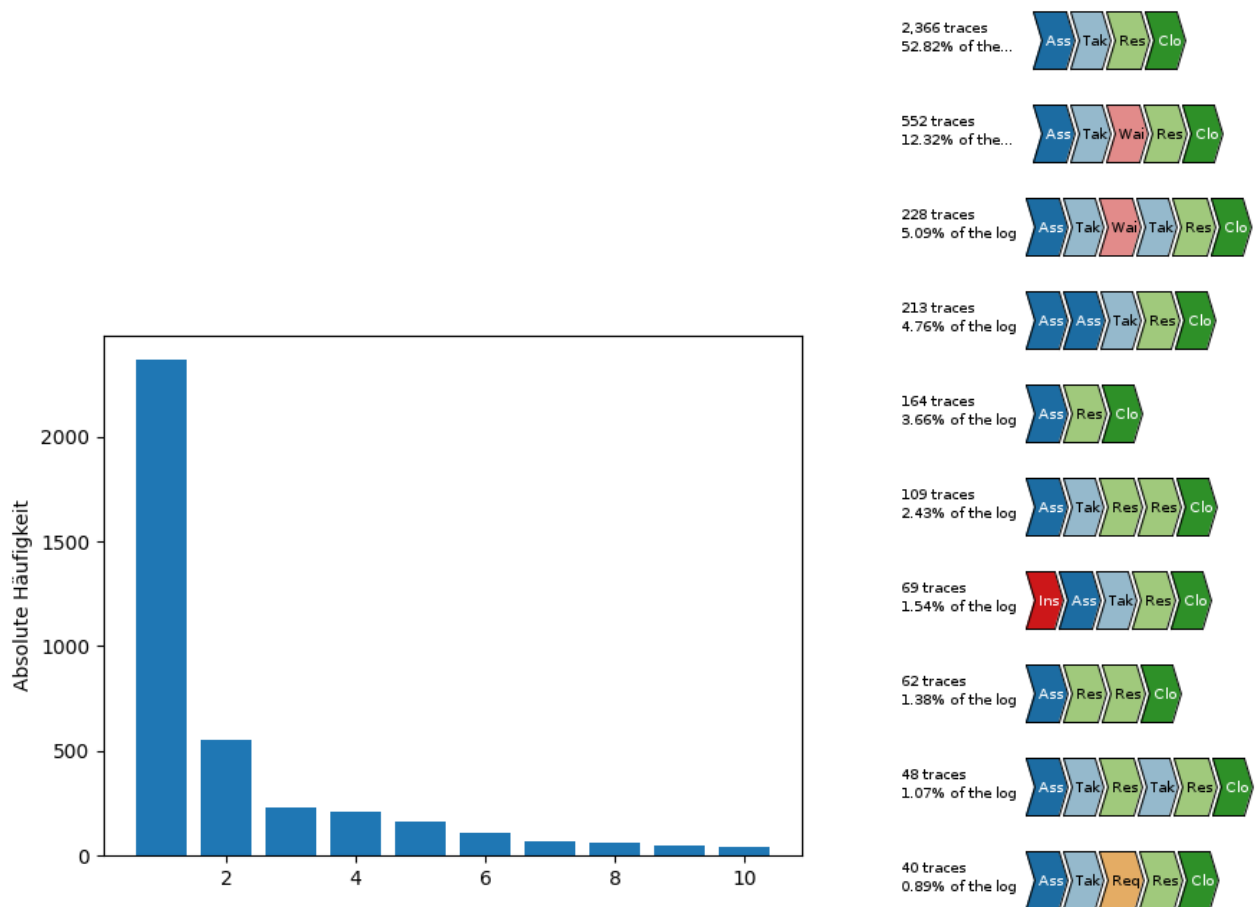
1. As in (a) we inspect the overview of *log-complete* to find 114 cases, 655 events and 7 activities. Also just like in (a) we select the visualization 'Explore Event Log' to find out there are 20 unique trace variants.



2. Just like in (a) we look at 'Summary' to find a table of activities along with their frequency of occurrence:



3. We read the counts of the top 10 traces from the Event Log Explorer in RapidMiner, and plugged those values into a short python script to create the following bar chart.

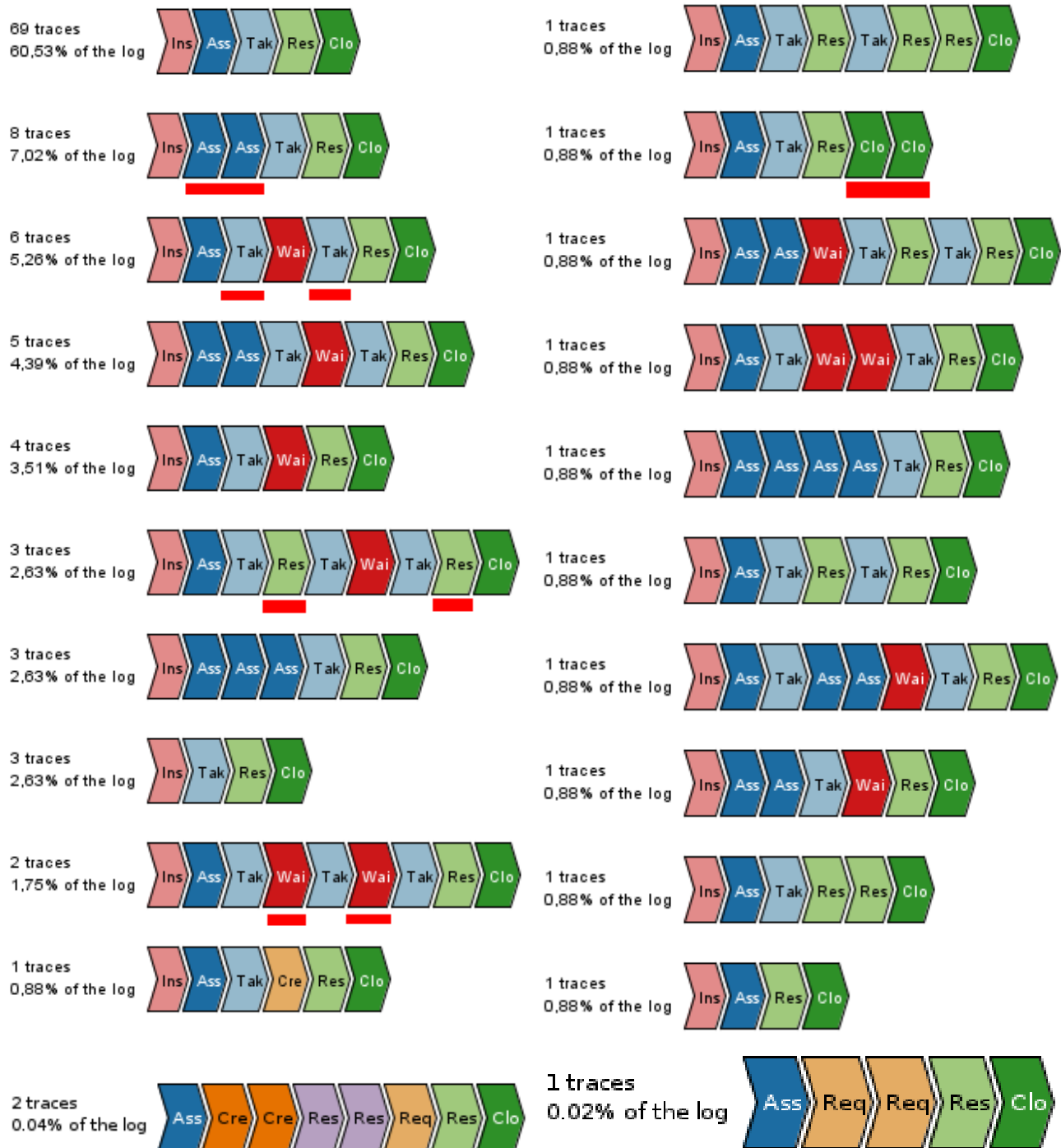


4. We apply the 'Add Throughput Time as Trace Attribute (In place)' plugin to *log-complete* and select 'DAYS' as the resolution to be used for the elapsed time. We then select the visualization 'Dotted Chart' on the result. To retrieve minimum, maximum and average trace durations we select 'T: throughputtime' as Attribute Statistics and get the following rounded result:

- minimum trace duration: 31 days
- maximum trace duration: 60 days
- average trace duration: 41 days



5. To find out which activities appear more than once in at least one trace we again take a look at the 'Explore Event Log' visualization:



The tasks that appear more than once (as marked in the visualization) are

- Ass: Assign seriousness
- Tak: Take in charge ticket
- Res: Resolve ticket
- Wai: Wait
- Clo: Closed
- Cre: Create SW Anomaly
- Req: Require Update

**(d)**

1. We choose Pie Charts for these visualization. For *Ticket type* distribution we choose **TICKET TYPE** as dimension:

```
"case_table_csv"."TICKET TYPE"
```

and **COUNT(TICKET TYPE)** as KPI:

```
COUNT("case_table_csv"."TICKET TYPE")
```

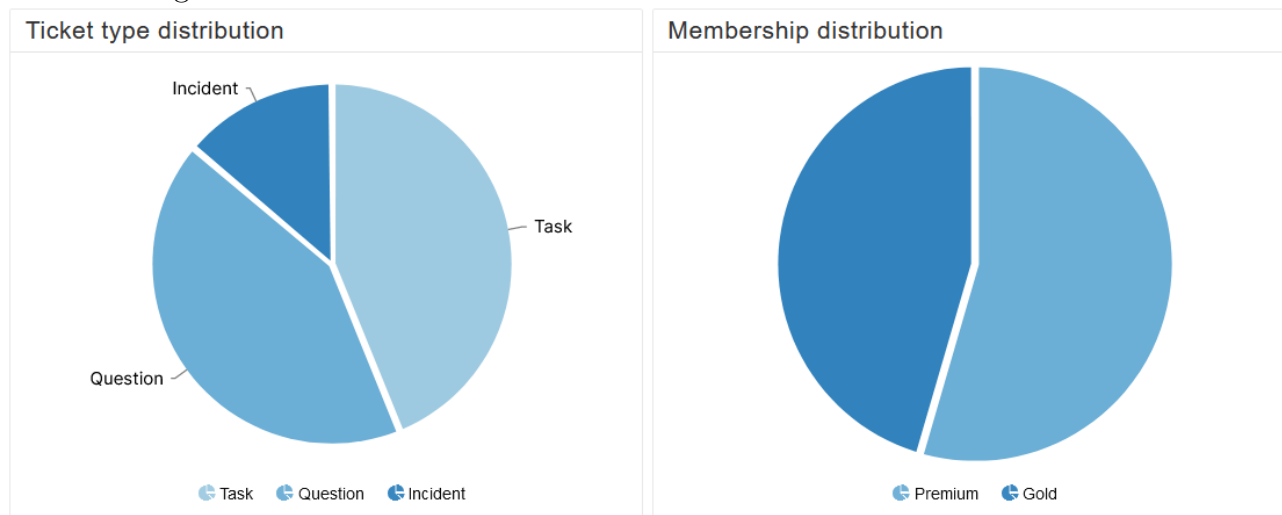
For *Membership* distribution we choose **MEMBERSHIP** as dimension:

```
"case_table_csv"."MEMBERSHIP"
```

and **COUNT(MEMBERSHIP)** as KPI:

```
COUNT("case_table_csv"."MEMBERSHIP")
```

The resulting distribution visualization can be seen below.



2. We obtained the column chart titled 'Total workload per ressource' by using

```
"event_table_csv"."RESOURCE"
```

as dimension and

```
COUNT("event_table_csv"."ACTIVITY")
```

as KPI. The x-Axis shows the resources 1-8 in ascending order, the y-Axis shows the summed number of activities handled by the given resource.

3. We created the column chart named 'Throughput times distribution' by selecting the total throughput time in days as our dimension:

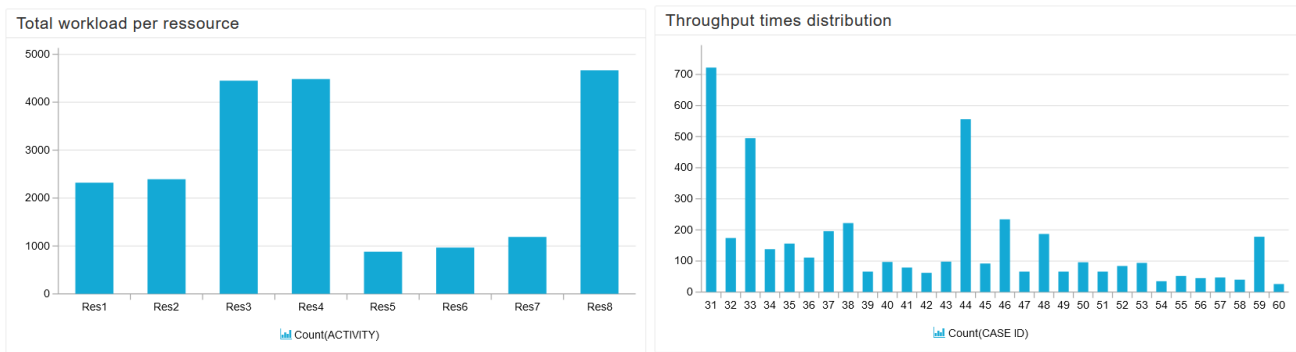
```
CALC_THROUGHPUT(ALL_OCCURRENCE['Process Start'] TO ALL_OCCURRENCE['Process End'], REMAP_
```

and selecting

```
COUNT("case_table_csv"."CASE ID")
```

as our KPI. The x-Axis shows the throughput time in days and the y-Axis shows the number of cases with a given throughput time.

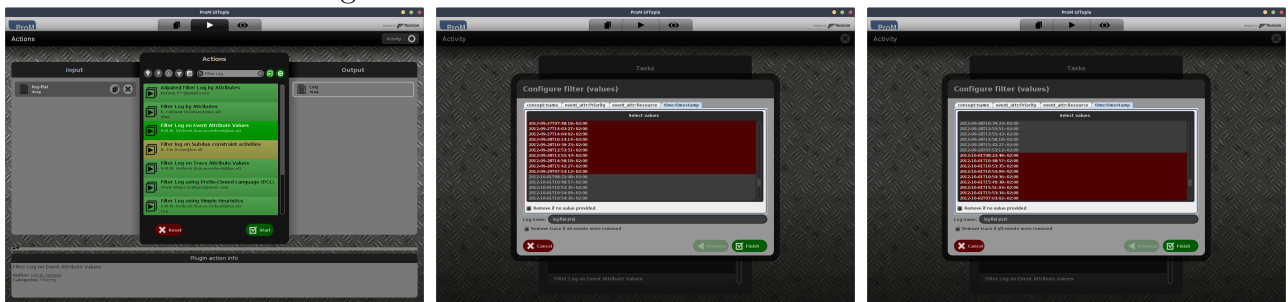




## Question 2

(a)

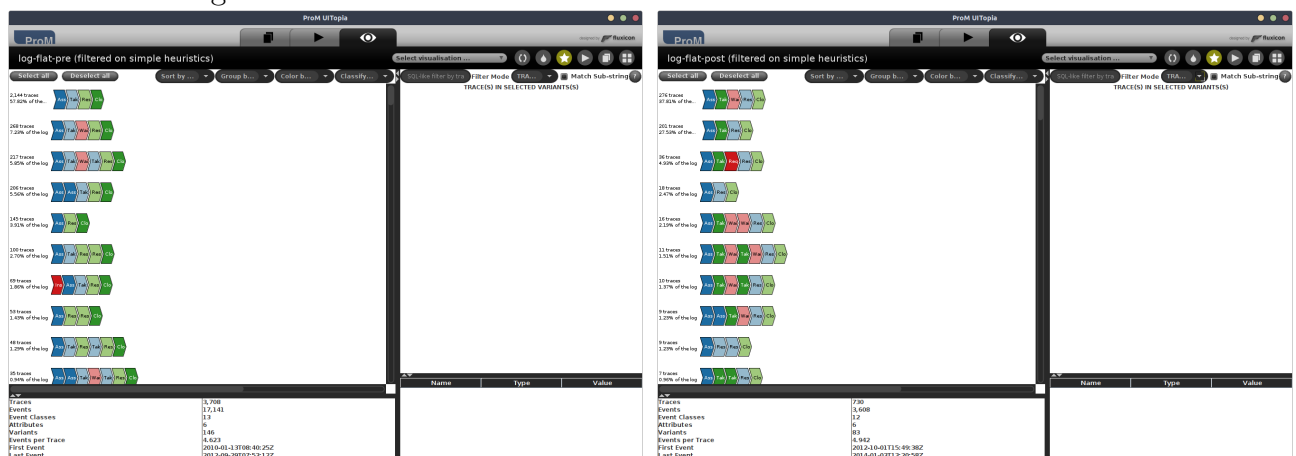
We can split the event log into two event logs using the plugin 'Filter Log on Event Attribute Values' with the following selections:



Afterwards, we can apply our filtering to only allow valid traces, as seen before.

For the event log pre 01.10.2012 we get 13 unique activities across 3708 cases, as a whole consisting of 6 variants.

For the event log post (including) 01.10.2012 we get 12 unique activities across 730 cases, as a whole consisting of 6 variants.



(b)

1. We apply the following workflow both for *log-pre-complete* and *log-post-complete*:

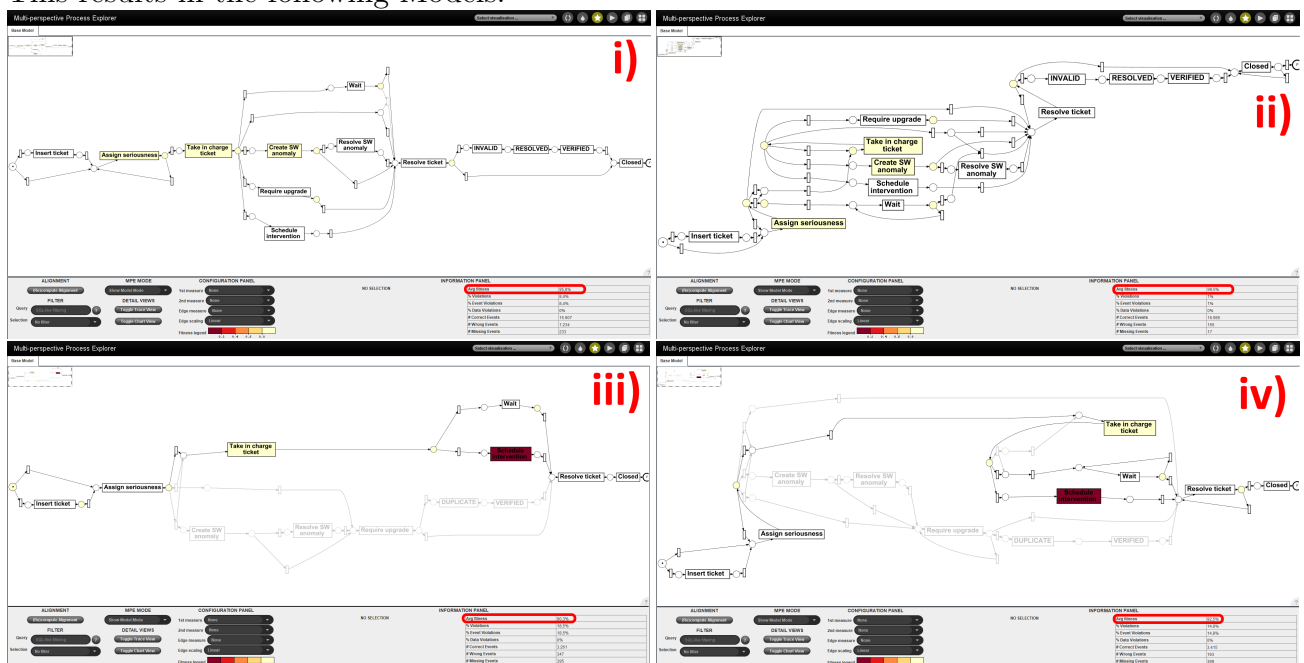
1. Apply plugin 'Interactive Data-aware Heuristic Miner (iDHM)'

2. Set 'Options & Thresholds' to  
All tasks connected: True

	i) ( <i>log-pre-complete</i> )	ii) ( <i>log-pre-complete</i> )	iii) ( <i>log-post-complete</i> )	iv) ( <i>log-post-complete</i> )
Frequency	0.1	0	0.1	0
Dependency	0.9	0.9	0.9	0.9
Bindings	0.1	0.1	0.1	0.1
Conditions	0.5	0.5	0.5	0.5

3. Select 'Petri net' as 'Output: Process Model' and click 'Export model'  
4. Use the log and the newly created Petri net as input for the 'Multi-perspective Process Miner' plugin

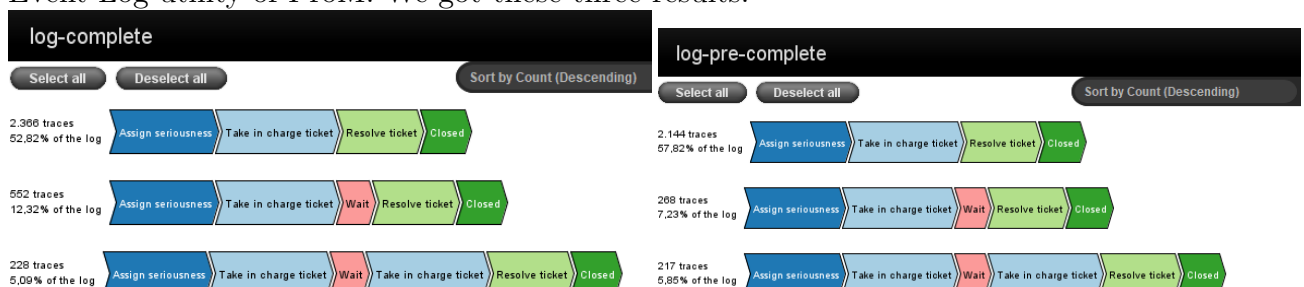
This results in the following Models:

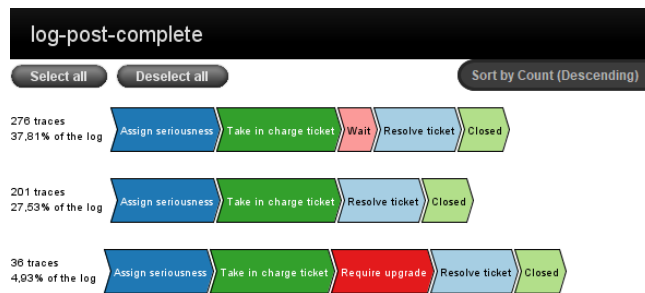


As we can see all these models exceed our fitness threshold of 90% and contain all activities occurring in their respective logs (*log-pre-complete* doesn't contain the activity DUPLICATE and *log-post-complete* doesn't contain the activities INVALID and RESOLVED).

(c)

1. We visualized the three most frequent trace variant and their frequencies with the Explore Event Log utility of ProM. We got these three results:





The first similarity observed between the three most frequent trace variants of all three event logs is, that they all start with the Assign seriousness and Take in charge ticket activities and finish with Resolve ticket and Closed. The second observation is the equality of the three most frequent trace variants of the *log-complete* and *log-pre-complete* event logs. This makes sense since most of the events of *log-complete* are in *log-pre-complete* and not in *log-post-complete*. This also explains the difference in absolute frequency of the most common trace variant between *log-complete* and *log-pre-complete* and the most frequent one of *log-post-complete* which differ by one order of magnitude. Another important difference is that in *log-complete* and *log-pre-complete* the most common trace variant has a relative frequency of over 50% whilst in *log-post-complete* the most common trace variants are more equally divided between the two most frequent traces with 38% and 28%. Finally the activity Require upgrade is only present in the three most common trace variants in the *log-post-complete* event log.

- All trace variants are replayable on both models:

	$\sigma_{compl}$	$\sigma_{pre}$	$\sigma_{post}$
$M_{pre}$	$\langle \text{Assign seriousness, Take in charge ticket, Resolve ticket, Closed} \rangle$	$\langle \text{Assign seriousness, Take in charge ticket, Resolve ticket, Closed} \rangle$	$\langle \text{Assign seriousness, Take in charge ticket, Wait, Resolve ticket, Closed} \rangle$
$M_{post}$	$\langle \text{Assign seriousness, Take in charge ticket, Resolve ticket, Closed} \rangle$	$\langle \text{Assign seriousness, Take in charge ticket, Resolve ticket, Closed} \rangle$	$\langle \text{Assign seriousness, Take in charge ticket, Wait, Resolve ticket, Closed} \rangle$

(d)

## Question 3

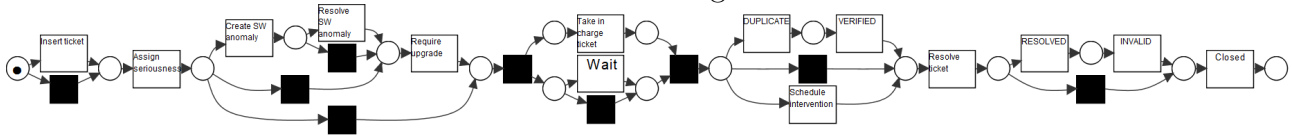
(a)

We use the Plugin 'Filter Log on Trace Attribute Values' to only select Tickets of type 'Task'. As visualization, we then choose 'Explore Event Log'. This gives us the table below:

Traces	2.018
Events	10.283
Event Classes	14
Attributes	6
Variants	201
Events per Trace	5.096
First Event	2010-01-13T12:30:37Z
Last Event	2014-01-03T13:20:58Z

From it, we can take that there are 2018 traces, 201 trace variants and 10283 events. We then apply the plugin 'Mine Petri net with Inductive Miner' on this filtered log and make sure we

choose 'Inductive Miner - Infrequent (IMf)' as our variant and set it to 20% by assigning the Noise threshold to 0.20. This results in the following Model:



(b)

We use the plugin 'Multi-perspective Process Explorer' on our Petri net from (a). This gives us the following information on fitness and precision:

		Avg activity precision		82,9%
		# Moves Observed		33.237
		# Moves Possible		40.096
		Avg fitness		92,3%
Avg fitness		% Violations		14,2%
% Violations		% Event Violations		14,2%
% Event Violations		% Data Violations		0%
% Data Violations		# Correct Events		8.966
# Correct Events		# Wrong Events		1.317
# Wrong Events		# Missing Events		166
# Missing Events				

We obtain the percentage of fitting traces by calculating 100% minus the percentage of violations (100% - 14.2%), resulting in 85,8% fitting traces. Alignment-based fitness (92.3%) and precision (82.9%) can be read from the tables above.

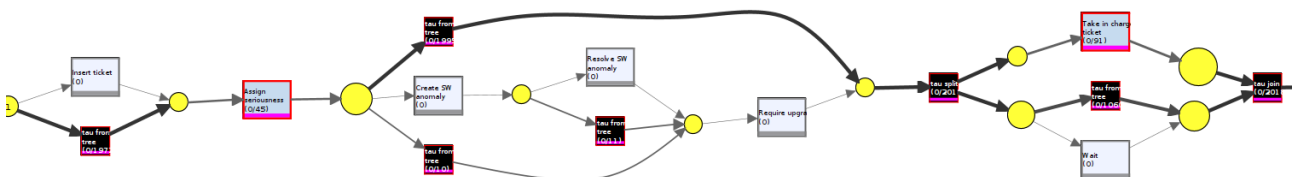
By using the inductive miner again and adjusting the infrequency parameter to 10% we obtain a process model with better fitness, precision and more perfectly fitting traces than before. The stats of the new model can be seen below:

Avg activity precision	83,6%
# Moves Observed	35.324
# Moves Possible	42.242
Avg fitness	92,4%
% Violations	14%
% Event Violations	14%
% Data Violations	0%
# Correct Events	8.985
# Wrong Events	1.298
# Missing Events	169

(c)

We used the plugin 'Align Log and Model for Repair (global costs)' for this subtask. We used the default values.

### Move on Model



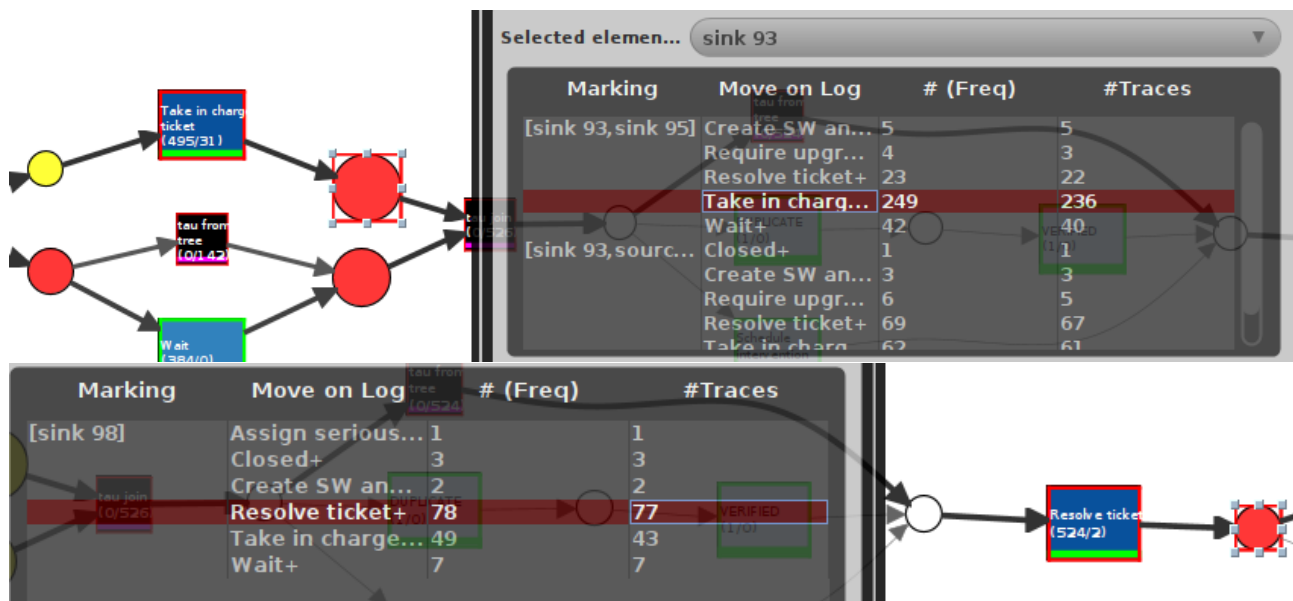
Moves on Model occur obviously at every hidden transition (since they aren't in the log) and the activities of 'Assign seriousness', 'Take in charge ticket', 'Resolve ticket', 'Closed'. The later two just have fairly few moves on logs and are acceptable in the model, since there are cases with tickets still in progress in the log.

The first two activities are important for improving the model or even the ticketing system. We

see that not every case executes Assign seriousness. Perhaps this transition should be skipable by a tau-transition. However, the assignment introduction states that either 'Insert ticket' or 'Assign seriousness' should be executed first. Therefore, the model could also have an option between both in the beginning, instead of putting one behind the other.

That 'Take in charge ticket' was moved on the model 91 times should also be noted. That the model set this action in parallel with 'Wait' seems problematic. It should be possible to wait any time in the ticketing process in order to execute some activity later on.

## Move on Log



We can analyze Moves on Logs by clicking on the big places in the visualization. As one can see, the transitions 'Take in charge ticket' and 'Resolve ticket' experience the most moves on log in the model. We used the Movement Container Filter to only allow traces with moves on logs in these transitions.

## Question 4

(a)

We created the following OLAP Table:

CASE ID	TICKET TYPE	MEMBERSHIP	PRIORITY	RESOURCE OF STARTING ...	NUMBER OF ACTIVE CASE...	Decision
Case 1	Question	Gold	Normal	Res4	18	False/No-Wait
Case 10	Task	Premium	Normal	Res4	18	False/No-Wait
Case 100	Task	Premium	Normal	Res3	18	False/No-Wait
Case 1000	Incident	Gold	Urgent	Res8	18	False/No-Wait
Case 1001	Task	Premium	Normal	Res4	18	False/No-Wait
Case 1002	Task	Gold	High	Res3	18	False/No-Wait
Case 1003	Task	Premium	Normal	Res4	18	False/No-Wait
Case 1004	Incident	Premium	Normal	Res4	18	False/No-Wait
Case 1005	Task	Premium	Normal	Res3	18	False/No-Wait
Case 1006	Question	Gold	High	Res4	18	False/No-Wait
Case 1007	Task	Premium	Normal	Res3	18	False/No-Wait
Case 1008	Task	Gold	High	Res8	18	False/No-Wait
Case 1009	Task	Premium	High	Res8	18	True/Wait
Case 101	Question	Premium	Normal	Res3	18	False/No-Wait
Case 1010	Task	Premium	Normal	Res4	18	False/No-Wait
Case 1011	Question	Gold	Normal	Res8	18	False/No-Wait
Case 1012	Incident	Premium	Normal	Res8	18	False/No-Wait
Case 1013	Question	Premium	Normal	Res4	18	False/No-Wait
Case 1014	Task	Premium	Normal	Res4	18	True/Wait
Case 1015	Incident	Gold	Normal	Res8	18	False/No-Wait
Case 1016	Question	Gold	High	Res8	18	False/No-Wait
Case 1017	Task	Premium	Normal	Res4	18	True/Wait
Case 1018	Task	Premium	Normal	Res4	18	False/No-Wait
Case 1019	Task	Premium	Normal	Res8	18	True/Wait
Case 102	Question	Gold	Normal	Res3	18	False/No-Wait
Case 1020	Task	Premium	Normal	Res4	18	True/Wait
Case 1021	Question	Premium	Normal	Res3	18	False/No-Wait
Case 1022	Question	Premium	Normal	Res8	18	False/No-Wait
Case 1023	Task	Premium	Normal	Res3	18	False/No-Wait
Case 1024	Task	Gold	High	Res4	18	False/No-Wait
Case 1025	Task	Premium	Normal	Res4	18	True/Wait
Case 1026	Task	Premium	Normal	Res8	18	False/No-Wait
Case 1027	Task	Premium	Normal	Res3	18	True/Wait
Case 1028	Task	Gold	High	Res4	18	False/No-Wait
Case 1029	Question	Gold	Normal	Res3	18	False/No-Wait
Case 103	Task	Premium	Normal	Res4	18	True/Wait

For this, we used the following PQL Queries in the order of columns in the image left to right:

```
"case_table_csv"."CASE ID"
```

```
"case_table_csv"."MEMBERSHIP"
```

```
"case_table_csv"."TICKET TYPE"
```

```
"event_table_csv"."PRIORITY"
```

```
PU_FIRST ( "case_table_csv", "event_table_csv"."RESOURCE")
```

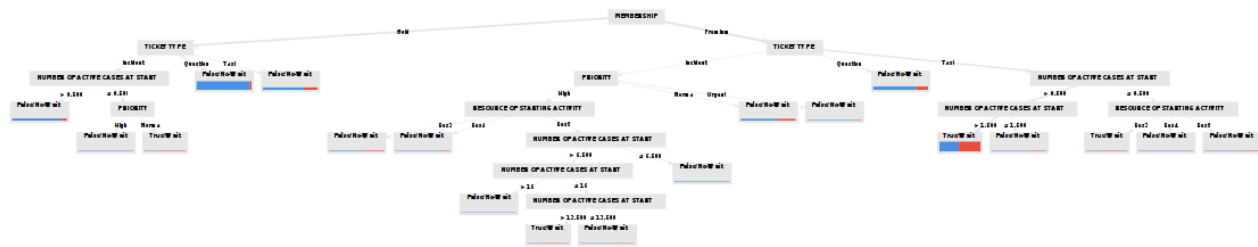
```
RUNNING_SUM (
  CASE WHEN MATCH_PROCESS_REGEX("event_table_csv"."ACTIVITY", 'Closed'$) = 1 THEN 0
  ELSE 1
  END
)
```

```
CASE WHEN
MATCH_PROCESS_REGEX ( "event_table_csv"."ACTIVITY", 'Wait' ) = 1 THEN 'True/Wait'
ELSE 'False/No-Wait'
END
```

(b)

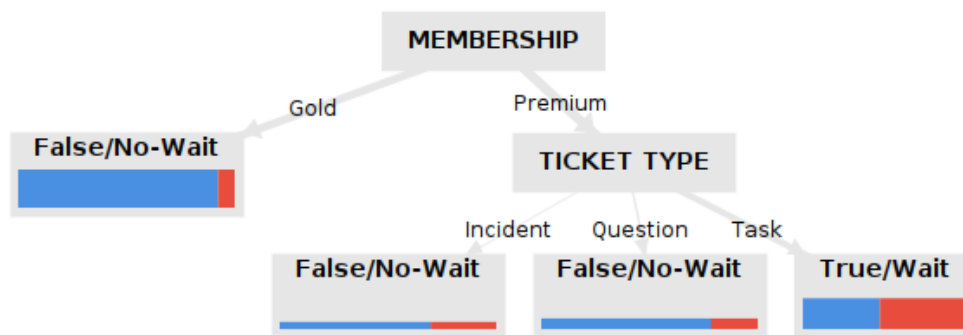
First, we export the OLAP Table and import it into RapidMiner as described in Instruction 2. The resulting decision tree is evidently too large to fit into a PDF, thus we have added the description in the Appendix:

July 3, 2022



We found that some tasks using Resource 3 would wait, even if they were the only task running at creation. From the tree we can also observe that some high priority incidents (using Resource 3 or 8) would have to wait depending on the number of active cases at start, although there does not seem to be any connection to the prior predictor variables.

After removing the attribute 'number of active cases at start', we get a much more simplified, but comprehensible Decision Tree:



Here we see that about half the Premium Tasks will have to wait, while for all other tickets waiting is less likely.

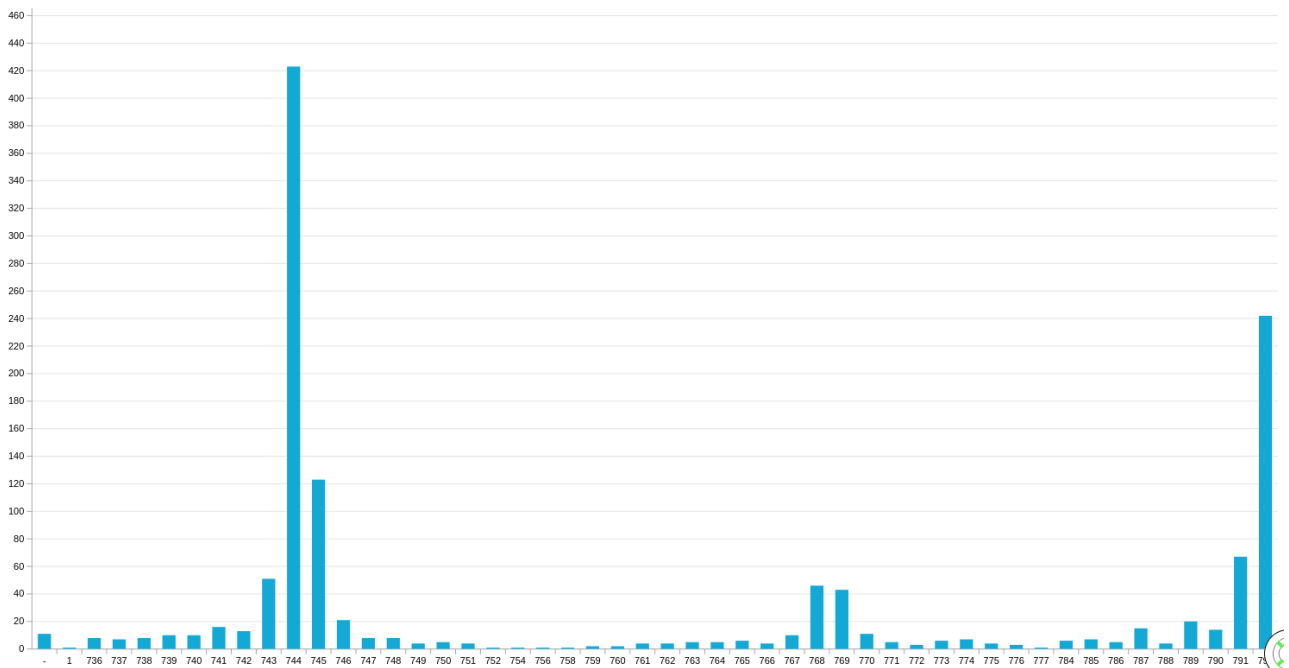
## Question 5

(a)

Similarly to 1d), we created a new column chart. Here, we used the following Dimension:

```
CASE WHEN MATCH_PROCESS_REGEX("event_table_csv"."ACTIVITY", 'Closed'$) = 1
THEN CALC_THROUGHPUT(
CASE_START TO CASE_END,
REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP", HOURS)
)
ELSE CALC_THROUGHPUT(
CASE_START TO LAST_OCCURRENCE['Resolve ticket'],
REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP", HOURS)
)
END
```

Using the Case Count as a Dimension, we got the following chart. Note that this is just a tiny section of the entire chart. There are cases with throughput times up to 1440h:

**(b)**

We applied the `Quantile` function on the real throughput times (see above) for 0.3 and 0.7, respectively (here for 0.3):

```

QUANTILE(CASE WHEN MATCH_PROCESS_REGEX("event_table_csv"."ACTIVITY", 'Closed'$) = 1
THEN CALC_THROUGHPUT(
CASE_START TO CASE_END,
REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP", HOURS)
)
ELSE CALC_THROUGHPUT(
CASE_START TO LAST_OCCURRENCE['Resolve ticket'],
REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP", HOURS)
)
END, 0.3)

```

For the 0.3-quantile we got 795h, for the 0.7-quantile 1079h.

**(c)**

Approach equivalent to Question 4a). We used the following PQL queries:

```
"case_table_csv"."CASE ID"
```

```
"case_table_csv"."TICKET TYPE"
```

```
"case_table_csv"."MEMBERSHIP"
```

```
"event_table_csv"."PRIORITY"
```

```
CASE
```

```

WHEN (CASE WHEN MATCH_PROCESS_REGEX("event_table_csv"."ACTIVITY", 'Closed'$) = 1
THEN CALC_THROUGHPUT(
CASE_START TO CASE_END,

```



```

REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP",HOURS)
)
ELSE CALC_THROUGHPUT(
CASE_START TO LAST_OCCURRENCE['Resolve ticket'],
REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP",HOURS)
)
END) < 795 THEN 'Short'

WHEN (CASE WHEN MATCH_PROCESS_REGEX("event_table_csv"."ACTIVITY", 'Closed'$) = 1
THEN CALC_THROUGHPUT(
CASE_START TO CASE_END,
REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP",HOURS)
)
ELSE CALC_THROUGHPUT(
CASE_START TO LAST_OCCURRENCE['Resolve ticket'],
REMAP_TIMESTAMPS("event_table_csv"."TIMESTAMP",HOURS)
)
END) < 1079 THEN 'Medium'

ELSE 'Long'

END

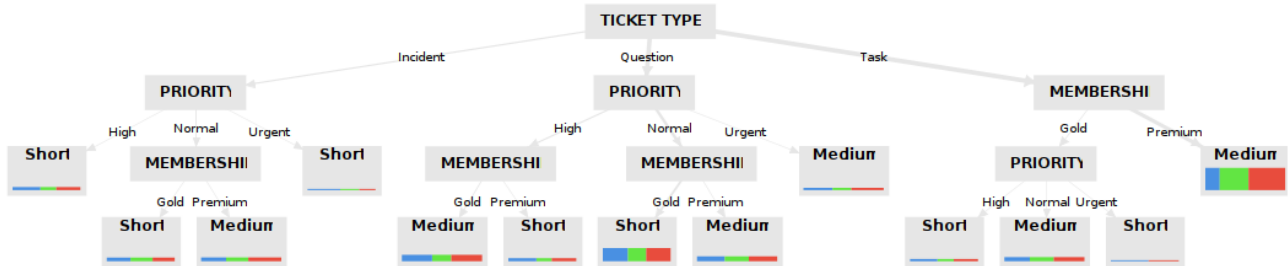
```

CASE ID	TICKET TYPE	MEMBERSHIP	PRIORITY	Performance class
Case 1	Question	Gold	Normal	Short
Case 10	Task	Premium	Normal	Long
Case 100	Task	Premium	Normal	Long
Case 1000	Incident	Gold	Urgent	Medium
Case 1001	Task	Premium	Normal	Medium
Case 1002	Task	Gold	High	Short
Case 1003	Task	Premium	Normal	Medium
Case 1004	Incident	Premium	Normal	Short
Case 1005	Task	Premium	Normal	Long
Case 1006	Question	Gold	High	Long
Case 1007	Task	Premium	Normal	Long
Case 1008	Task	Gold	High	Medium
Case 1009	Task	Premium	High	Medium
Case 101	Question	Premium	Normal	Long
Case 1010	Task	Premium	Normal	Medium
Case 1011	Question	Gold	Normal	Long
Case 1012	Incident	Premium	Normal	Short
Case 1013	Question	Premium	Normal	Medium
Case 1014	Task	Premium	Normal	Short
Case 1015	Incident	Gold	Normal	Short
Case 1016	Question	Gold	High	Long
Case 1017	Task	Premium	Normal	Medium
Case 1018	Task	Premium	Normal	Long
Case 1019	Task	Premium	Normal	Short
Case 102	Question	Gold	Normal	Long
Case 1020	Task	Premium	Normal	Long
Case 1021	Question	Premium	Normal	Medium
Case 1022	Question	Premium	Normal	Short
Case 1023	Task	Premium	Normal	Short
Case 1024	Task	Gold	High	Medium
Case 1025	Task	Premium	Normal	Long
Case 1026	Task	Premium	Normal	Medium
Case 1027	Task	Premium	Normal	Medium
Case 1028	Task	Gold	High	Short
Case 1029	Question	Gold	Normal	Short
Case 103	Task	Premium	Normal	Medium

(d)

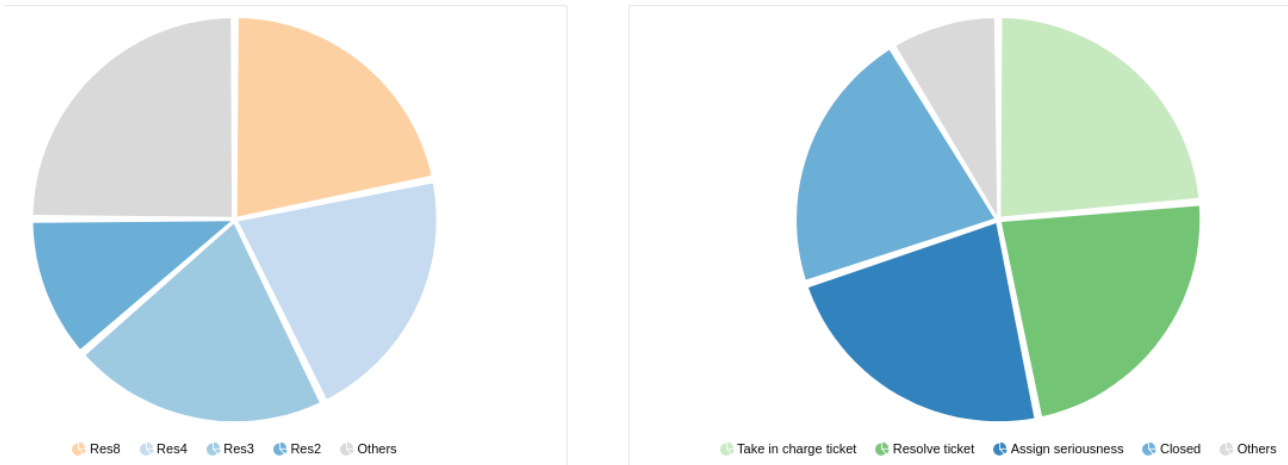
First, we export the OLAP Table and import it into RapidMiner as described in Instruction 2. Even after setting the parameters of the Decision Tree algorithm to extreme values (minimal gain at 1.0E-6), we could not find any clear variable that predicts the outcome of the performance class in any way. Thus, we conclude that the performance class (and thus the real

throughput time) has no strong correlation with neither Priority nor Ticket Type. The only thing noticeable was, that close to half the Tasks stemming from Premium Memberships were Medium rated in real throughput time.



## Question 6

(a)



For the left Pie Chart we used "event\_table\_csv"."RESOURCE" as the Dimension and COUNT("event\_table\_csv"."RESOURCE") as the KPI.

For the right Pie Chart we used "event\_table\_csv"."ACTIVITY" as the Dimension and COUNT("event\_table\_csv"."RESOURCE") as the KPI.

(b)

RESOURCE	Assign seri...	Wait	Insert ticket	Resolve tic...	Create SW...	Take in ch...	Resolve S...	Closed	Require U...	RESOLVED	VERIFIED	Schedule i...	INVALID	DUPLICATE
Res1	0	0	0	0.00043668...	0	0	0	0.00196506...	0.01310043...	0.00021834...	0	0.00043668...	0.00021834...	0
Res2	0	0	0	0.00109170...	0	0	0	0.00174672...	0.01222707...	0.00021834...	0.00043668...	0.00065502...	0.00021834...	0.000218...
Res3	0.34388646...	0.04825327...	0.01026200...	0.35262008...	0.00174672...	0.21310043...	0.00109170...	0	0	0	0	0	0	0
Res4	0.35807860...	0.05087336...	0.00829694...	0.34126637...	0.00065502...	0.21834061...	0.00043668...	0	0	0	0	0	0	0
Res5	0.00371179...	0.05262008...	0	0.00349344...	0.00240174...	0.12969432...	0	0	0	0	0	0	0	0
Res6	0.00371179...	0.05611353...	0	0.00305676...	0.00436681...	0.14323144...	0	0	0	0	0	0	0	0
Res7	0.00240174...	0.05873362...	0	0.00545851...	0.00327510...	0.18930131...	0	0	0	0	0	0	0	0
Res8	0.36637554...	0.05109170...	0.00720524...	0.37838427...	0.00218340...	0.21091703...	0.00131004...	0	0	0	0	0	0	0

SOURCE("event\_table\_csv"."RESOURCE")

```
1 SUM(CASE WHEN SOURCE ( "event_table_csv"."ACTIVITY" ) = '[ACTIVITY]' THEN
  1 ELSE 0 END) / 4580
```

Replace [ACTIVITY] with each of the 14 Activities for the corresponding Dimensions. 4580 is the number of cases obtained by COUNT\_TABLE("case\_table\_csv").

(c)

Attribute	cluster_0	cluster_1	cluster_2	id	label
Assign seriousness	0.003	0.356	0	1	cluster_2
Wait	0.056	0.050	0	2	cluster_2
Insert ticket	0	0.009	0	3	cluster_1
Resolve ticket	0.004	0.357	0.001	4	cluster_1
Create SW anomaly	0.003	0.002	0	5	cluster_0
Take in charge ticket	0.154	0.214	0	6	cluster_0
Resolve SW anomaly	0	0.001	0	7	cluster_0
Closed	0	0	0.002	8	cluster_1
Require Upgrade	0	0	0.013		
RESOLVED	0	0	0.000		
VERIFIED	0	0	0.000		
Schedule intervention	0	0	0.001		
INVALID	0	0	0.000		
DUPLICATE	0	0	0.000		

We observed that Resources 3,4,8 were the only ones that executed 'Insert Ticket' and 'Resolve SW anomaly', thus forming cluster 1, which's centroid also reflects this. Resources 1,2 were the only ones to close any tickets (amongst other Activities), forming cluster 2. Resources 5,6,7 did none of these Activities, but also called Activities that Resources in cluster 1 called.

(d)

RESOURCE_FROM	RESOURCE_TO	Handover
Res1	Res1	0.0032751091703056767
Res1	Res2	0.002183406113537118
Res1	Res3	0.00240174672489083
Res1	Res4	0.0034934497816593887
Res1	Res5	0.0002183406113537118
Res1	Res6	0.0006550218340611354
Res1	Res7	0.0006550218340611354
Res1	Res8	0.0034934497816593887
Res2	Res1	0.0017467248908296944
Res2	Res2	0.004366812227074236
Res2	Res3	0.0028384279475982535
Res2	Res4	0.0028384279475982535
Res2	Res5	0.0002183406113537118
Res2	Res7	0.0008733624454148472
Res2	Res8	0.003930131004366812
Res3	Res1	0.15807860262008733
Res3	Res2	0.16179039301310044
Res3	Res3	0.1665938864628821
Res3	Res4	0.1646288209606987
Res3	Res5	0.06506550218340611
Res3	Res6	0.07052401746724891
Res3	Res7	0.026200873362445413
Res3	Res8	0.15807860262008733
Res4	Res1	0.15960698689956332
Res4	Res2	0.15655021834061136
Res4	Res3	0.15676855895196506
Res4	Res4	0.17074235807860262
Res4	Res5	0.07074235807860262
Res4	Res6	0.07510917030567686
Res4	Res7	0.023799126637554586
Res4	Res8	0.1646288209606987
Res5	Res1	0.003056768558951965
Res5	Res2	0.004148471615720524
Res5	Res3	0.0665938864628821
Res5	Res4	0.05982532751091703
Res5	Res5	0.015065502183406113

```
SOURCE("event_table_csv"."RESOURCE")
```

```
TARGET("event_table_csv"."RESOURCE")
```

```
1 COUNT(SOURCE("event_table_csv"."ACTIVITY")) / 4580
```

4580 is the number of cases obtained by `COUNT_TABLE("case_table_csv")`.

The graph illustrates the relationships between eight resource nodes (Res1 to Res8). The nodes are represented by gray rectangles. Directed edges (arrows) connect the nodes, with numerical weights indicating the strength of the relationships. Self-loops are present on Res4, Res5, Res6, and Res7. The graph is complex, with many interconnections and varying weights.

Key connections and weights include:

- Res8 to Res1: 0.17
- Res8 to Res4: 0.16
- Res8 to Res5: 0.01
- Res8 to Res7: 0.16
- Res8 to Res6: 0.02
- Res8 to Res3: 0.07
- Res8 to Res2: 0.16
- Res4 to Res1: 0.16
- Res4 to Res5: 0.18
- Res4 to Res7: 0.07
- Res4 to Res6: 0.06
- Res4 to Res3: 0.16
- Res4 to Res2: 0.16
- Res5 to Res1: 0.01
- Res5 to Res7: 0.02
- Res5 to Res6: 0.16
- Res5 to Res3: 0.08
- Res5 to Res2: 0.07
- Res7 to Res1: 0.01
- Res7 to Res5: 0.01
- Res7 to Res6: 0.02
- Res7 to Res3: 0.02
- Res7 to Res2: 0.02
- Res6 to Res1: 0.02
- Res6 to Res5: 0.02
- Res6 to Res3: 0.07
- Res6 to Res2: 0.16
- Res3 to Res2: 0.16

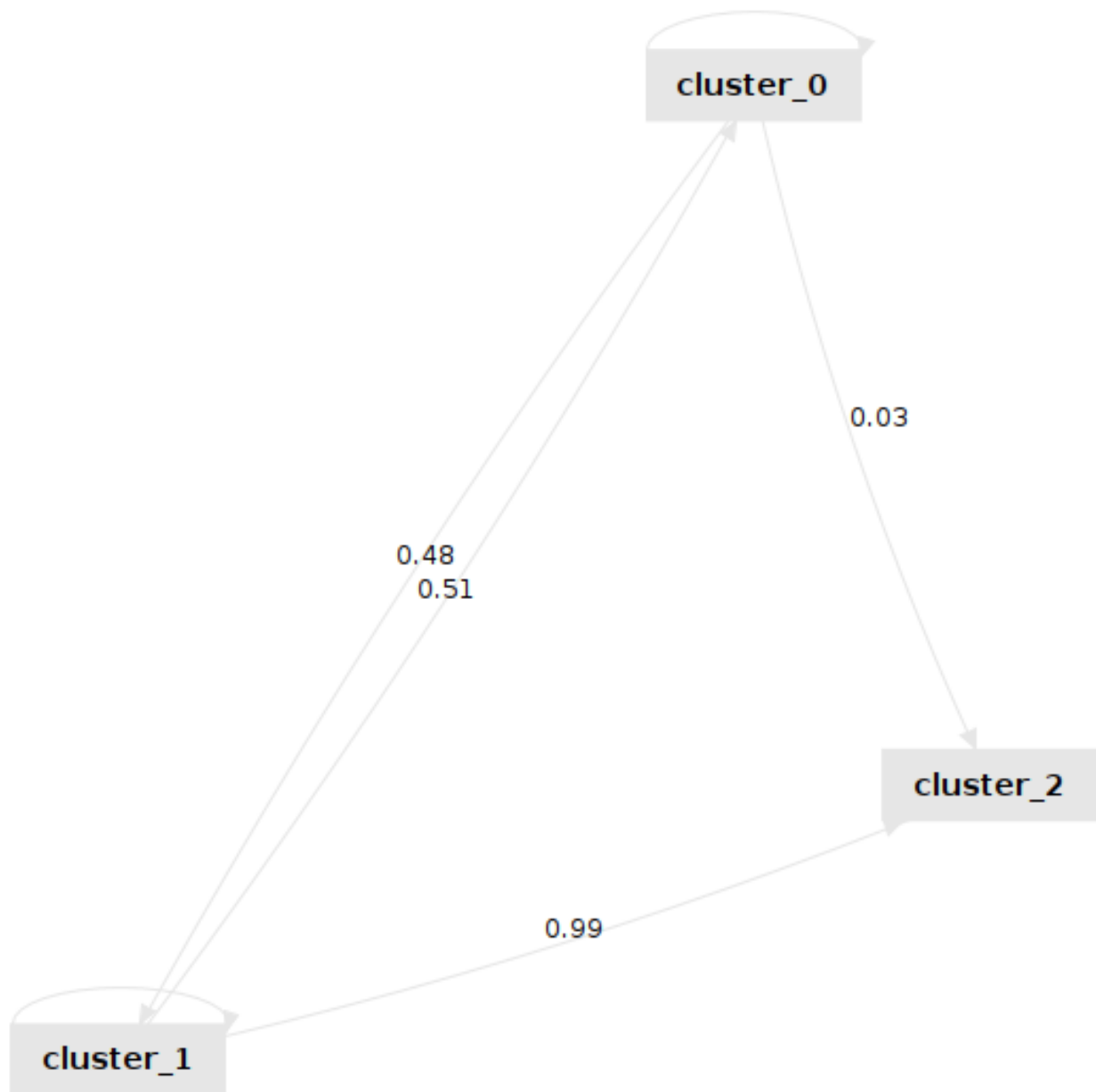
CLUSTER_FROM	CLUSTER_TO	Handoff
cluster_0	cluster_0	0.15152838427947599
cluster_0	cluster_1	0.4836244541484716
cluster_0	cluster_2	0.026419213973799125
cluster_1	cluster_0	0.5089519650655022
cluster_1	cluster_1	1.4661572052401746
cluster_1	cluster_2	0.9912663755458515
cluster_2	cluster_0	0.0026200873362445414
cluster_2	cluster_1	0.018995633187772927
cluster_2	cluster_2	0.011572052401746726

```
1 CASE WHEN SOURCE("event_table_csv"."RESOURCE") IN ('Res5', 'Res6', 'Res7') THEN
    'cluster_0'
2 WHEN SOURCE("event_table_csv"."RESOURCE") IN ('Res3', 'Res4', 'Res8') THEN '
    cluster_1'
3 ELSE 'cluster_2'
4 END
```

```
'cluster_0'  
2 WHEN SOURCE("event_table_csv"."RESOURCE") IN ('Res3', 'Res4', 'Res8') THEN '  
  cluster_1'  
3 ELSE 'cluster_2'  
4 END  
  
1 COUNT(SOURCE("event_table_csv"."ACTIVITY")) / 4580
```

4580 is the number of cases obtained by `COUNT_TABLE("case_table_csv")`.

(g)



## Appendix

Question 4b) Decision Tree description:

```

1 MEMBERSHIP = Gold
2 |   TICKET TYPE = Incident
3 | |   NUMBER OF ACTIVE CASES AT START > 0.500: False/No-Wait {False/No-
   |   Wait=266, True/Wait=27}
4 | |   NUMBER OF ACTIVE CASES AT START <= 0.500
5 | | |   PRIORITY = High: False/No-Wait {False/No-Wait=2, True/Wait=0}
6 | | |   PRIORITY = Normal: True/Wait {False/No-Wait=1, True/Wait=2}
7 |   TICKET TYPE = Question: False/No-Wait {False/No-Wait=1391, True/Wait=41}
8 |   TICKET TYPE = Task: False/No-Wait {False/No-Wait=262, True/Wait=89}
9 MEMBERSHIP = Premium
10 |   TICKET TYPE = Incident
11 | |   PRIORITY = High
12 | | |   RESOURCE OF STARTING ACTIVITY = Res3: False/No-Wait {False/No-
   |   Wait=19, True/Wait=11}
13 | | |   RESOURCE OF STARTING ACTIVITY = Res4: False/No-Wait {False/No-
   |   Wait=22, True/Wait=4}
14 | | |   RESOURCE OF STARTING ACTIVITY = Res8
15 | | | |   NUMBER OF ACTIVE CASES AT START > 6.500
16 | | | | |   NUMBER OF ACTIVE CASES AT START > 16: False/No-Wait {
   |   False/No-Wait=11, True/Wait=1}
17 | | | | |   NUMBER OF ACTIVE CASES AT START <= 16
18 | | | | | |   NUMBER OF ACTIVE CASES AT START > 13.500: True/Wait {
   |   False/No-Wait=1, True/Wait=2}
19 | | | | | |   NUMBER OF ACTIVE CASES AT START <= 13.500: False/No-
   |   Wait {False/No-Wait=8, True/Wait=3}
20 | | | | |   NUMBER OF ACTIVE CASES AT START <= 6.500: False/No-Wait {
   |   False/No-Wait=3, True/Wait=0}
21 | |   PRIORITY = Normal: False/No-Wait {False/No-Wait=147, True/Wait=75}
22 | |   PRIORITY = Urgent: False/No-Wait {False/No-Wait=13, True/Wait=1}
23 |   TICKET TYPE = Question: False/No-Wait {False/No-Wait=401, True/Wait=110}
24 |   TICKET TYPE = Task
25 | |   NUMBER OF ACTIVE CASES AT START > 0.500
26 | | |   NUMBER OF ACTIVE CASES AT START > 1.500: True/Wait {False/No-
   |   Wait=777, True/Wait=861}
27 | | |   NUMBER OF ACTIVE CASES AT START <= 1.500: False/No-Wait {False/
   |   No-Wait=4, True/Wait=2}
28 | |   NUMBER OF ACTIVE CASES AT START <= 0.500
29 | | |   RESOURCE OF STARTING ACTIVITY = Res3: True/Wait {False/No-Wait
   |   =2, True/Wait=4}
30 | | |   RESOURCE OF STARTING ACTIVITY = Res4: False/No-Wait {False/No-
   |   Wait=9, True/Wait=1}
31 | | |   RESOURCE OF STARTING ACTIVITY = Res8: False/No-Wait {False/No-
   |   Wait=5, True/Wait=2}

```