main

August 27, 2023

0.1 Import event log

```
[129]: import pm4py
       import pandas as pd
       import numpy as np
       import matplotlib.pyplot as plt
       import seaborn as sns
       import warnings
       %matplotlib inline
       warnings.filterwarnings('ignore')
```

```
[109]: domestic_path = 'data/DomesticDeclarations.xes'
       international_path = 'data/InternationalDeclarations.xes'

       log= pm4py.read_xes(domestic_path);
```

```
parsing log, completed traces ::   0%|          | 0/10500 [00:00<?, ?it/s]
```

0.2 Statistical Analysis of Event Data

```
[124]: log.head(10)
```

```
[124]:                        id  org:resource                  concept:name  \
       0         st_step 86794_0  STAFF MEMBER          SUBMITTED by EMPLOYEE
       1         st_step 86793_0  STAFF MEMBER  FINAL_APPROVED by SUPERVISOR
       2  dd_declaration 86791_19        SYSTEM               Request Payment
       3  dd_declaration 86791_20        SYSTEM               Payment Handled
       4         st_step 86798_0  STAFF MEMBER          SUBMITTED by EMPLOYEE
       5         st_step 86799_0  STAFF MEMBER      APPROVED by PRE_APPROVER
       6         st_step 86797_0  STAFF MEMBER  FINAL_APPROVED by SUPERVISOR
       7  dd_declaration 86795_19        SYSTEM               Request Payment
       8  dd_declaration 86795_20        SYSTEM               Payment Handled
       9         st_step 86804_0  STAFF MEMBER          SUBMITTED by EMPLOYEE

                   time:timestamp      org:role            case:id  \
       0 2017-01-09 08:49:50+00:00      EMPLOYEE  declaration 86791
       1 2017-01-09 10:27:48+00:00    SUPERVISOR  declaration 86791
       2 2017-01-10 08:34:44+00:00     UNDEFINED  declaration 86791
```

```
3 2017-01-12 16:31:22+00:00     UNDEFINED  declaration 86791
4 2017-01-09 09:26:14+00:00      EMPLOYEE  declaration 86795
5 2017-02-22 09:29:21+00:00  PRE_APPROVER  declaration 86795
6 2017-02-23 07:14:45+00:00    SUPERVISOR  declaration 86795
7 2017-03-06 13:07:25+00:00     UNDEFINED  declaration 86795
8 2017-03-13 16:30:59+00:00     UNDEFINED  declaration 86795
9 2017-01-09 10:13:33+00:00      EMPLOYEE  declaration 86800

   case:concept:name case:BudgetNumber    case:DeclarationNumber  case:Amount
0  declaration 86791      budget 86566  declaration number 86792    26.851205
1  declaration 86791      budget 86566  declaration number 86792    26.851205
2  declaration 86791      budget 86566  declaration number 86792    26.851205
3  declaration 86791      budget 86566  declaration number 86792    26.851205
4  declaration 86795      budget 86566  declaration number 86796   182.464172
5  declaration 86795      budget 86566  declaration number 86796   182.464172
6  declaration 86795      budget 86566  declaration number 86796   182.464172
7  declaration 86795      budget 86566  declaration number 86796   182.464172
8  declaration 86795      budget 86566  declaration number 86796   182.464172
9  declaration 86800      budget 86566  declaration number 86801   320.646137
```

[146]:
```
# show rows where case:id not equal case:concept:name
log[log['case:id'] != log['case:concept:name']]
```

[146]:
```
Empty DataFrame
Columns: [id, org:resource, concept:name, time:timestamp, org:role, case:id,
case:concept:name, case:BudgetNumber, case:DeclarationNumber, case:Amount]
Index: []
```

It looks like case_id and case_concept_name columns are the same.

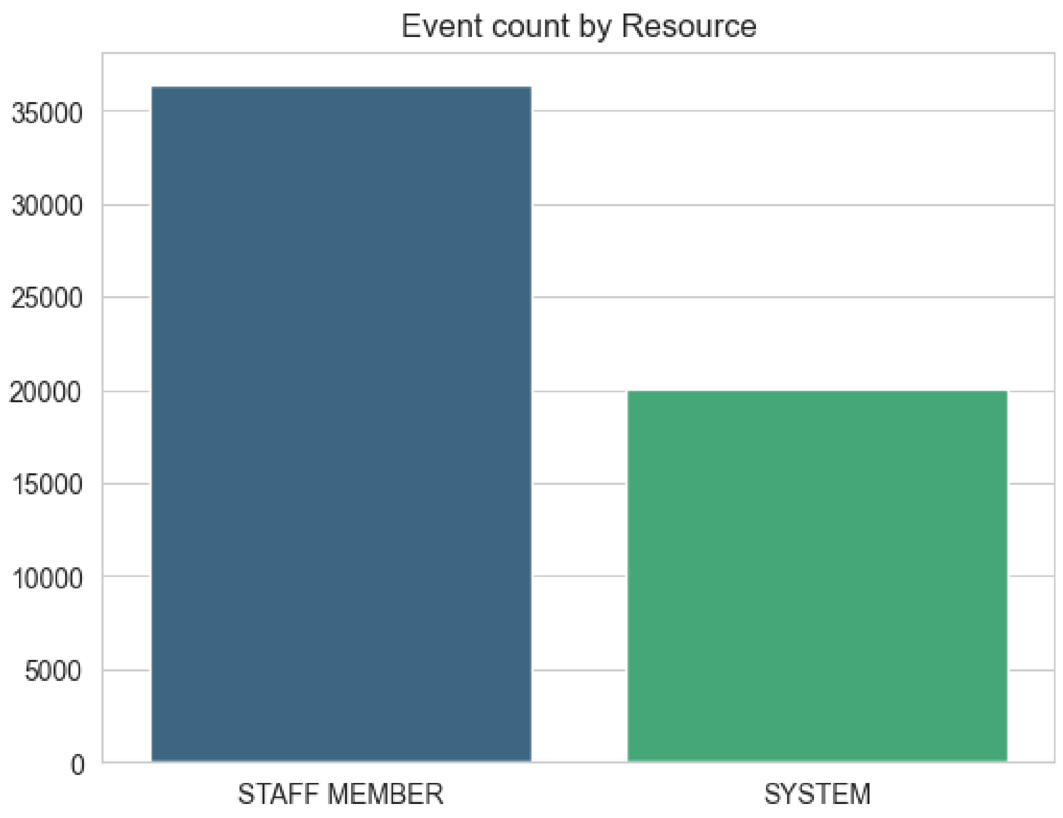
[111]:
```
# to improve readability we trim the word 'Declaration' out of concept:name␣
 ↪column, if it exists
log['concept:name'] = log['concept:name'].str.replace('Declaration ', '')
```

[145]:
```
# pick random case
case_ids = log['case:id'].unique()
random_case = log[log['case:id'] == np.random.choice(case_ids)]
random_case = random_case.sort_values(by='time:timestamp')
random_case
```

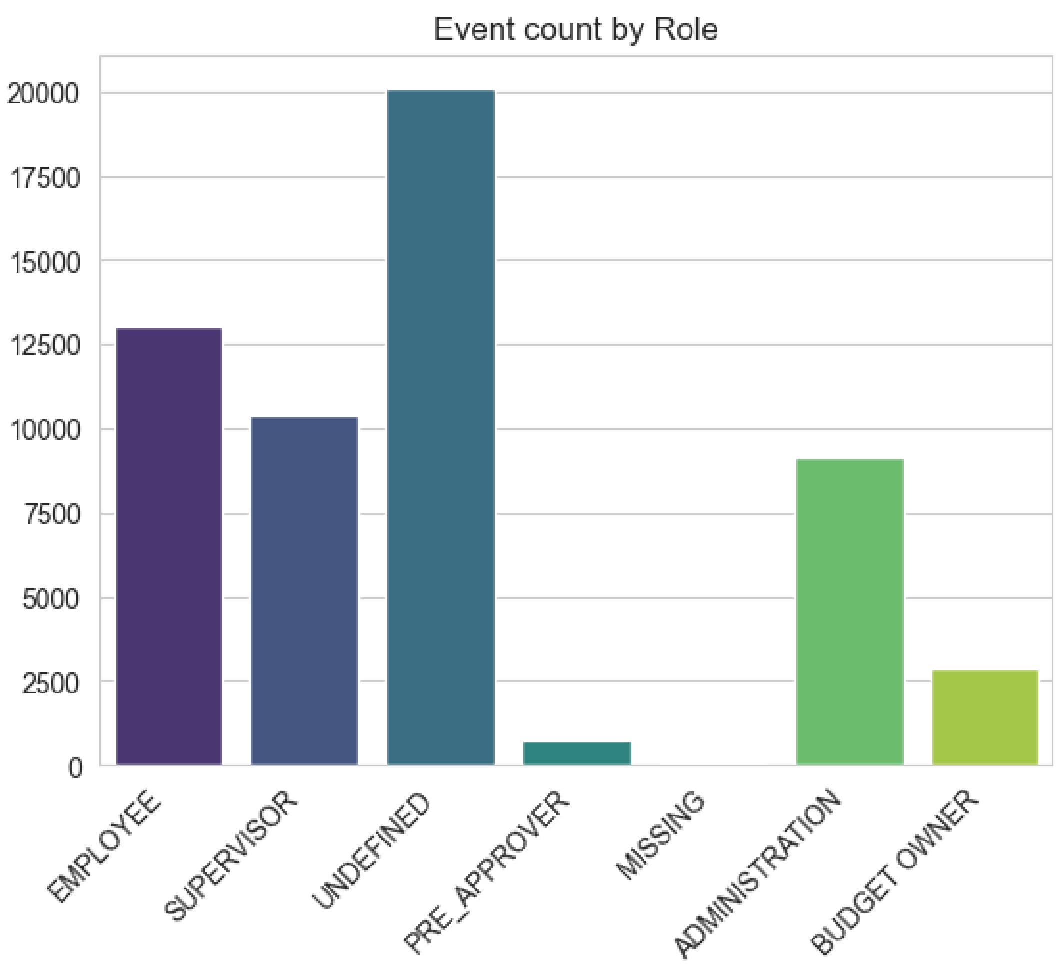
[145]:
```
                             id  org:resource                 concept:name  \
25109          st_step 111985_0  STAFF MEMBER        SUBMITTED by EMPLOYEE
25110          st_step 111983_0  STAFF MEMBER    APPROVED by ADMINISTRATION
25111          st_step 111984_0  STAFF MEMBER  FINAL_APPROVED by SUPERVISOR
25112  dd_declaration 111981_19        SYSTEM               Request Payment
25113  dd_declaration 111981_20        SYSTEM               Payment Handled
```

```
                 time:timestamp         org:role            case:id  \
25109 2018-05-01 13:15:53+00:00         EMPLOYEE  declaration 111981
25110 2018-05-01 13:16:16+00:00   ADMINISTRATION  declaration 111981
25111 2018-05-01 13:47:09+00:00       SUPERVISOR  declaration 111981
25112 2018-05-03 07:11:20+00:00        UNDEFINED  declaration 111981
25113 2018-05-07 15:31:13+00:00        UNDEFINED  declaration 111981

        case:concept:name case:BudgetNumber     case:DeclarationNumber  \
25109  declaration 111981      budget 86566  declaration number 111982
25110  declaration 111981      budget 86566  declaration number 111982
25111  declaration 111981      budget 86566  declaration number 111982
25112  declaration 111981      budget 86566  declaration number 111982
25113  declaration 111981      budget 86566  declaration number 111982

       case:Amount
25109    23.696543
25110    23.696543
25111    23.696543
25112    23.696543
25113    23.696543
```

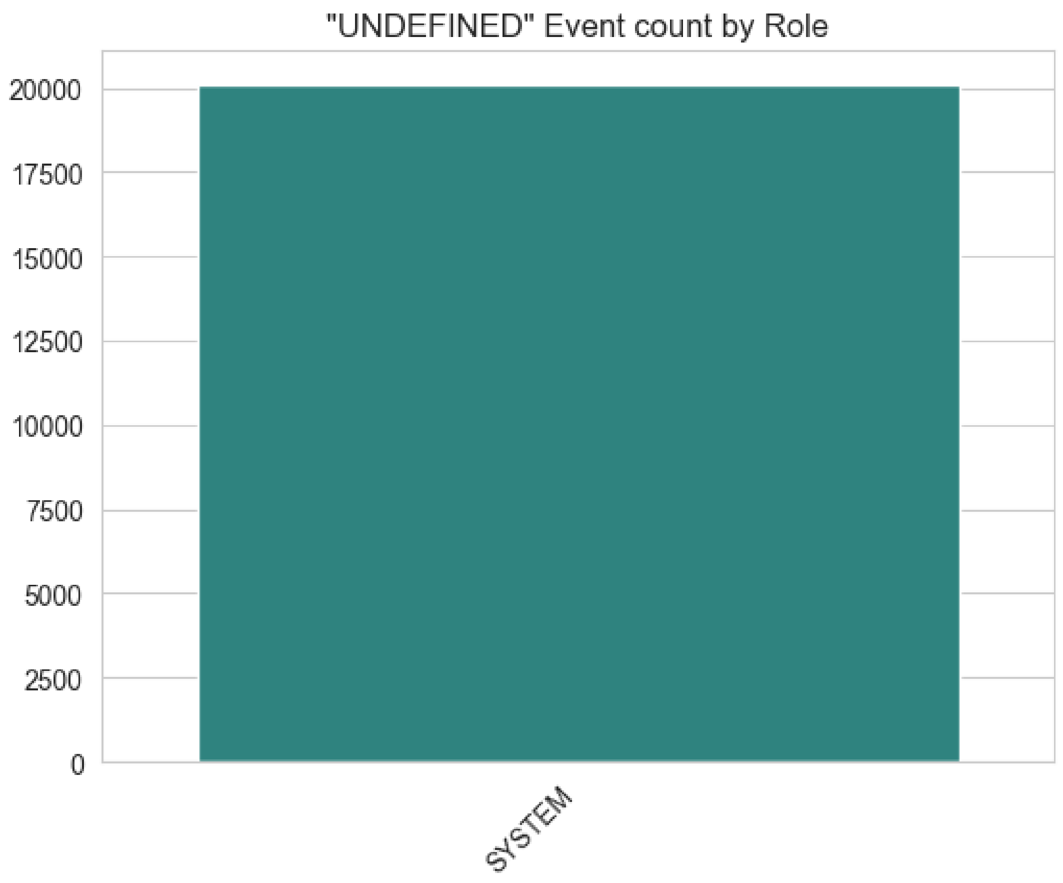
```
[113]: resources = log['org:resource'].unique()
       sns.countplot(x='org:resource', data=log, palette='viridis').set(title='Event␣
        ↪count by Resource', xlabel='', ylabel='');
```



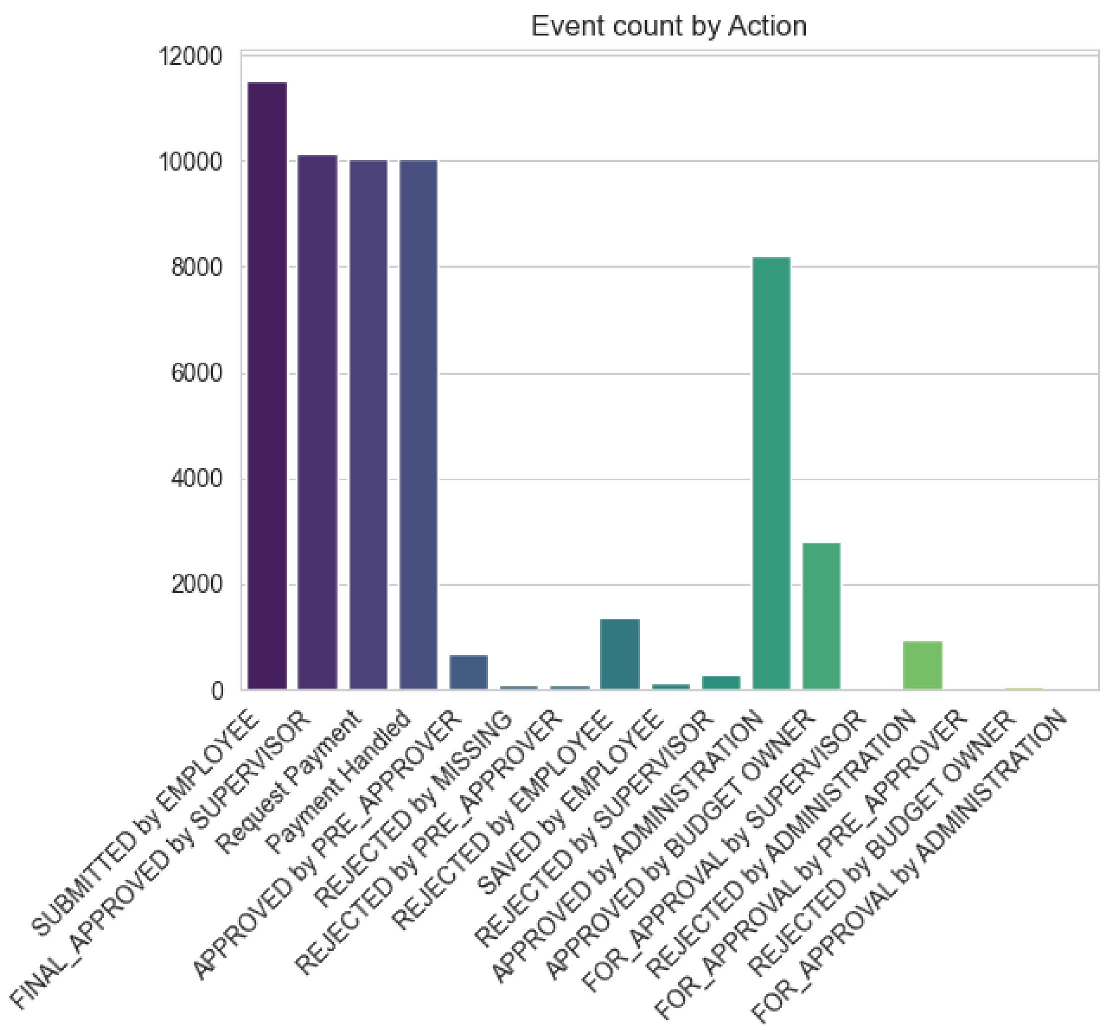
```
[114]: roles = log['org:role'].unique()
       sns.countplot(x='org:role', data=log, palette='viridis').set(title='Event count␣
        ↪by Role', xlabel='', ylabel='')
       plt.xticks(rotation=45, ha='right');
```



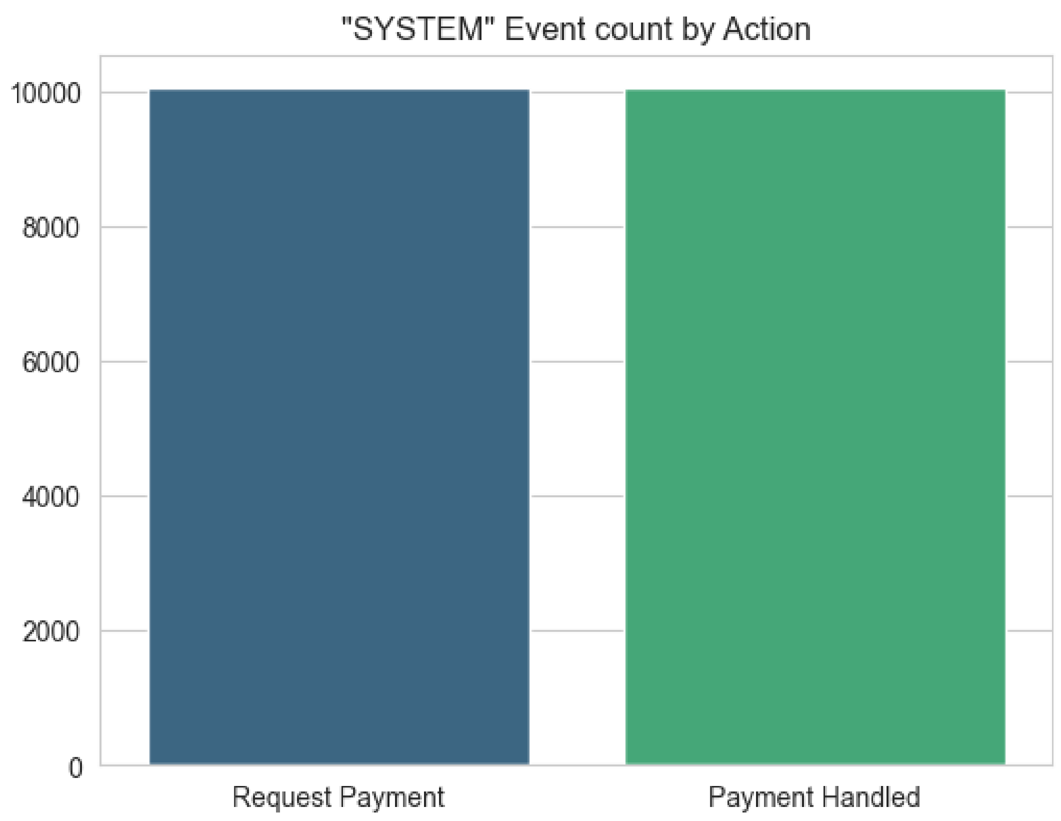
[115]:
```
log_i = log[log['org:role'] == 'UNDEFINED']
sns.countplot(x='org:resource', data=log_i, palette='viridis').
 ↪set(title='"UNDEFINED" Event count by Role', xlabel='', ylabel='')
plt.xticks(rotation=45, ha='right');
```



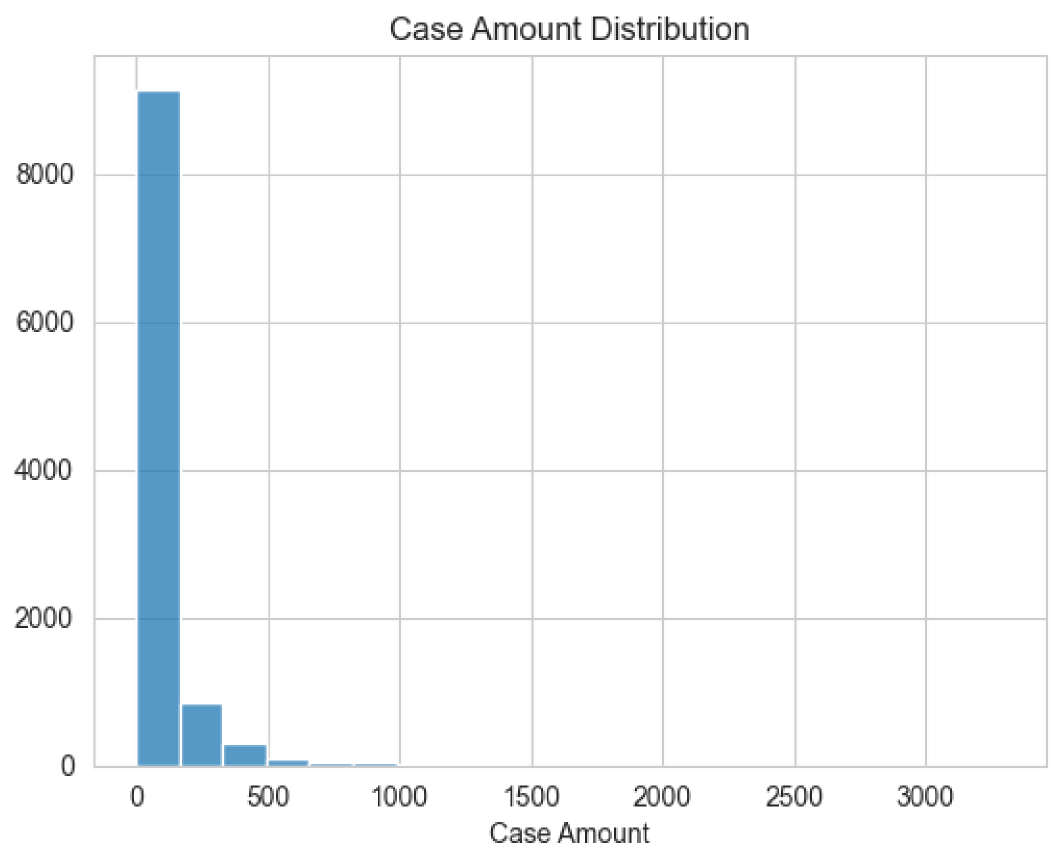
```
[116]: actions = log['concept:name'].unique()
       sns.countplot(x='concept:name', data=log, palette='viridis').set(title='Event␣
        ↪count by Action', xlabel='', ylabel='')
       plt.xticks(rotation=45, ha='right');
```



```
[117]: # System Events
       log_s = log[log['org:resource'] == 'SYSTEM']
       sns.countplot(x='concept:name', data=log_s, palette='viridis').
        ↪set(title='"SYSTEM" Event count by Action', xlabel='', ylabel='');
```



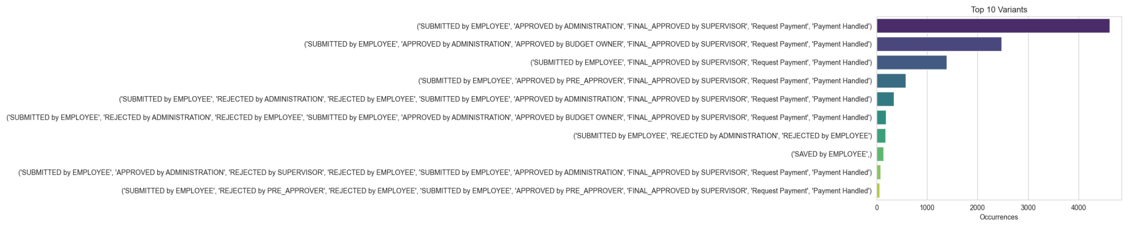
```
[118]: # case amount distribution for distinct case:id
       distinct_case_amounts = log.groupby('case:id')['case:Amount'].max()
       sns.histplot(distinct_case_amounts, kde=False, bins=20).set(title='Case Amount␣
        ↪Distribution', xlabel='Case Amount', ylabel='');
```



0.3 Process Discovery

Having mined the model we may vizualize it as a Process Tree or Petri Net.

[119]:
```
variants_dict = pm4py.get_variants(log)

variants_arr = []
idx = 1
for variant, n in variants_dict.items():
    variant_in_dict = {}
    variant_in_dict['variant_number'] = idx
    variant_in_dict['variant_count'] = n
    variant_in_dict['variant_trace'] = variant

    variants_arr.append(variant_in_dict)

    idx += 1


variants_df = pd.DataFrame(variants_arr)
variants_df = variants_df.sort_values(by='variant_count', ascending=False)

sns.barplot(x='variant_count', y='variant_trace', data=variants_df[:10],␣
↪palette='viridis').set(title='Top 10 Variants', xlabel='Occurrences',␣
↪ylabel='');
```

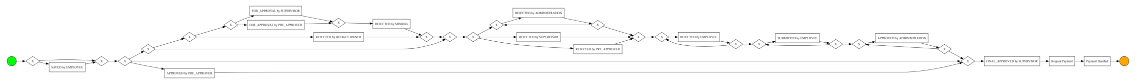


```
[120]: count_cases_top_10 = variants_df[:10]['variant_count'].sum()
print(f'Top 10 variants account for {count_cases_top_10:,} cases out of␣
↪{len(cases):,}.')
```

```
Top 10 variants account for 10,033 cases out of 10,500.
```

0.4 Check out BPMN Model

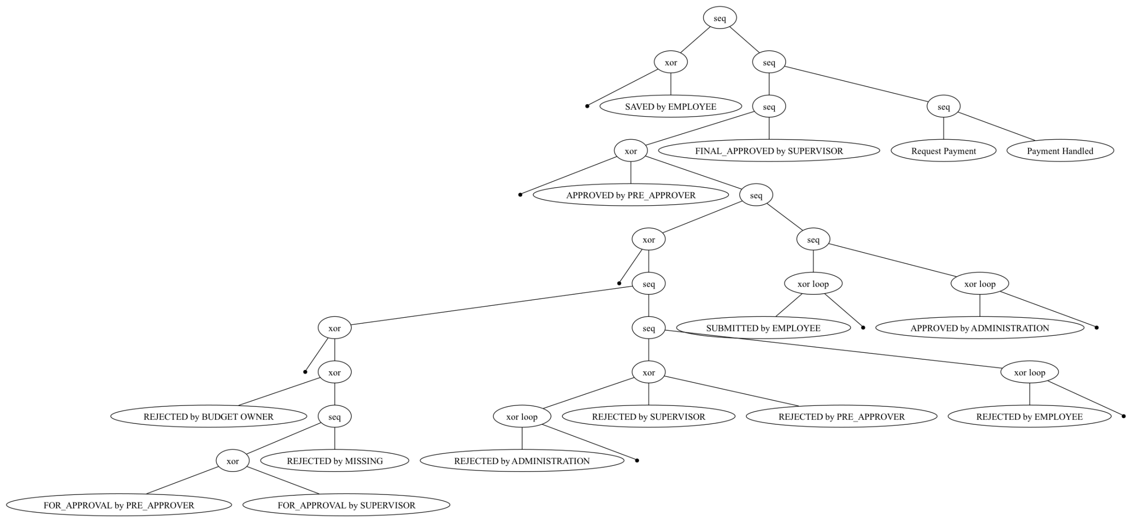
```
[171]: bpmn_model = pm4py.discover_bpmn_inductive(
    log=log,
    noise_threshold=.9,
    activity_key='concept:name',
    timestamp_key='time:timestamp',
    case_id_key='case:id'
)
pm4py.view_bpmn(bpmn_model)
```



In BPMN model "x" stands for choice. We may observe that algorithm mined a model with a lot of choices and shortcuts. But on the end of the process it needs to be approved by supervisor. Last two stepps are done by system.

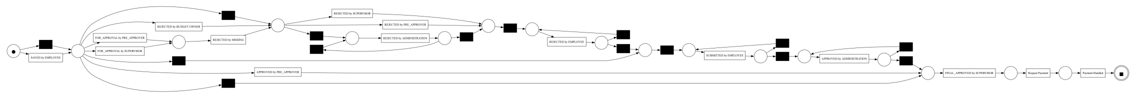
0.5 Process Tree

```
[180]: process_tree = pm4py.discover_process_tree_inductive(
    log=log,
    noise_threshold=.7,
    activity_key='concept:name',
    timestamp_key='time:timestamp',
    case_id_key='case:id'
)
pm4py.view_process_tree(process_tree)
```



0.6 Petri Net

```
[185]: p_net, im, fm = pm4py.discover_petri_net_inductive(
    log=log,
    noise_threshold=.7,
    activity_key='concept:name',
    timestamp_key='time:timestamp',
    case_id_key='case:id'
)
pm4py.view_petri_net(p_net, im, fm)
```



0.7 Statistics

TBD