Mining Software Repositories: OpenStack Nova Project.

Goal

The goal of this tool and analysis is to help in capturing insights from the commits on a project repo, in this case: the openstack nova project repo. This will help in understanding the project as well as provide guidiance to contributors and maintainers.

Objectives

The following questions will be answered:

- Find the most actively modified module?
- How many commits occured during the studied period?
- How much churn occurred during the studied period? Churn is defined as the sum of added and removed lines by all commits.

NB: This workflow is responsible for the pre-processing, analysis, and generation of insight from the collected data. It is assumed that the automated collection of the data via the script accessible in thesame folder with this notebook has been completed. The collected data will be loaded here before the other process in the workflow executes.

Required imports:

In [1]:
```
# Built-in libraries
import json
import os

# The normal data science ecosystem libraries
# pandas for data wrangling
import pandas as pd

# Plotting modules and libraries required
import matplotlib as mpl
import matplotlib.pyplot as plt
```

Required settings:

In [2]:
```
# Settings:
# 1. Command needed to make plots appear in the Jupyter Notebook
%matplotlib inline

# 2. Command needed to make plots bigger in the Jupyter Notebook
plt.rcParams['figure.figsize']= (12, 10)

# 3. Command needed to make 'ggplot' styled plots- professional and yet good looking theme.
plt.style.use('ggplot')

# 4. This will make the plot zoomable
# mpld3.enable_notebook()
```

Other utility functions for data manipulation

In [3]:
```
# Utility data manipulation functions

# 1. Extract path parameters from filename
def get_path_parameters(dframe):
     filename = os.path.basename(dframe["filename"])
     filetype = os.path.splitext(dframe["filename"])[1]
     directory = os.path.dirname(dframe["filename"])

     return directory, filename, filetype
```

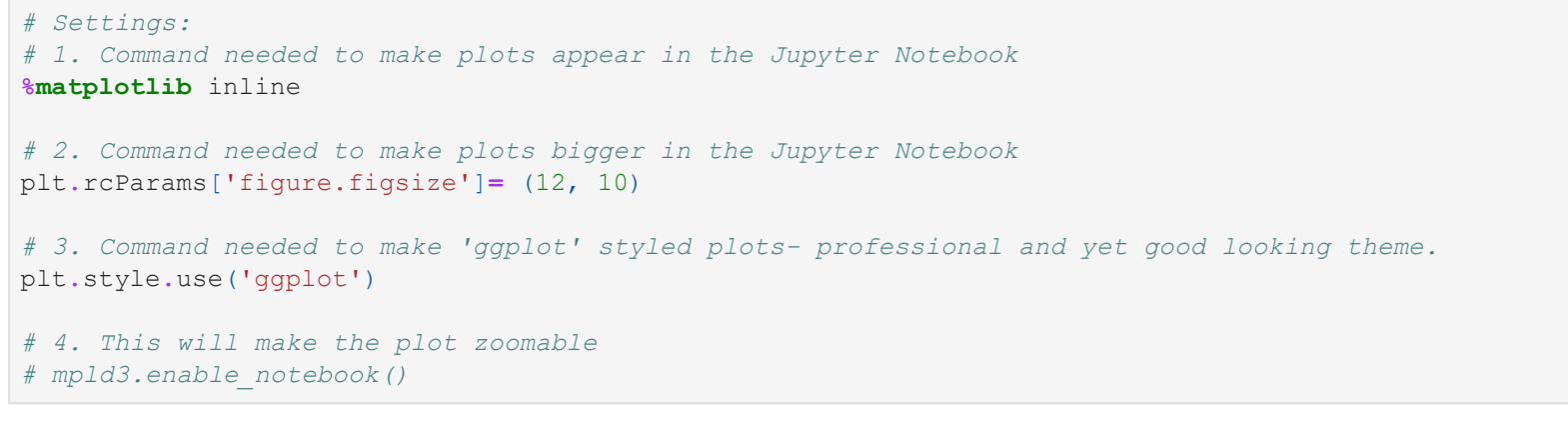
1. Loading the data

In [4]:
```
# Open and load json file
with open('data.json', encoding="utf8") as file:
    data = json.load(file)
    print("data loaded successfully")
```

```
data loaded successfully
```

Data normalization

The collected commit data is a semi-structured json which has nested data similar to the image below. Files is a list of file objects. The loaded data will be normalized into a flat table using pandas.json_normalize.



In [5]:
```
df = pd.json_normalize(data, "files", ["commit_node_id", "commit_sha", "commit_html_url", "commit_date" ])
```

2. Displaying current state of the data

In [6]:
```
# The first 3 rows
df.head(3)
```

Out[6]:

	sha	filename	status	additions	deletions	changes	
0	0438913de34e2751410da7a035e21b7e73325760	nova/exception.py	modified	4	0	4	https://github.com/
1	ae824e635cb508ecc9f97d0c4d23342267c0787a	nova/tests/unit/virt/libvirt/test_driver.py	modified	38	0	38	https://github.com/
2	d71d13ab3721422c013cff586e7c31326ae50e1c	nova/tests/unit/virt/libvirt/test_host.py	modified	8	0	8	https://github.com/

In [7]:
```
# The last 3 rows
df.tail(3)
```

Out[7]:

	sha	filename	status	additions	deletions	changes	
1970	5573c098a83d048ddc90b2f20a22fbde0b30430f	nova/db/main/legacy_migrations/versions/402_tr...	modified	68	59	127	https:
1971	48adcb07d6af188ced7acb6d7ddcbfbe8fec0489	nova/tests/unit/virt/vmwareapi/fake.py	modified	4	2	6	http
1972	0d8639f9ae83bb81df262d98d58a7ebd2109de41	nova/tests/unit/virt/vmwareapi/test_driver_api.py	modified	1	1	2	http

In [8]:
```
# Summary of the dataframe
df.info()
```

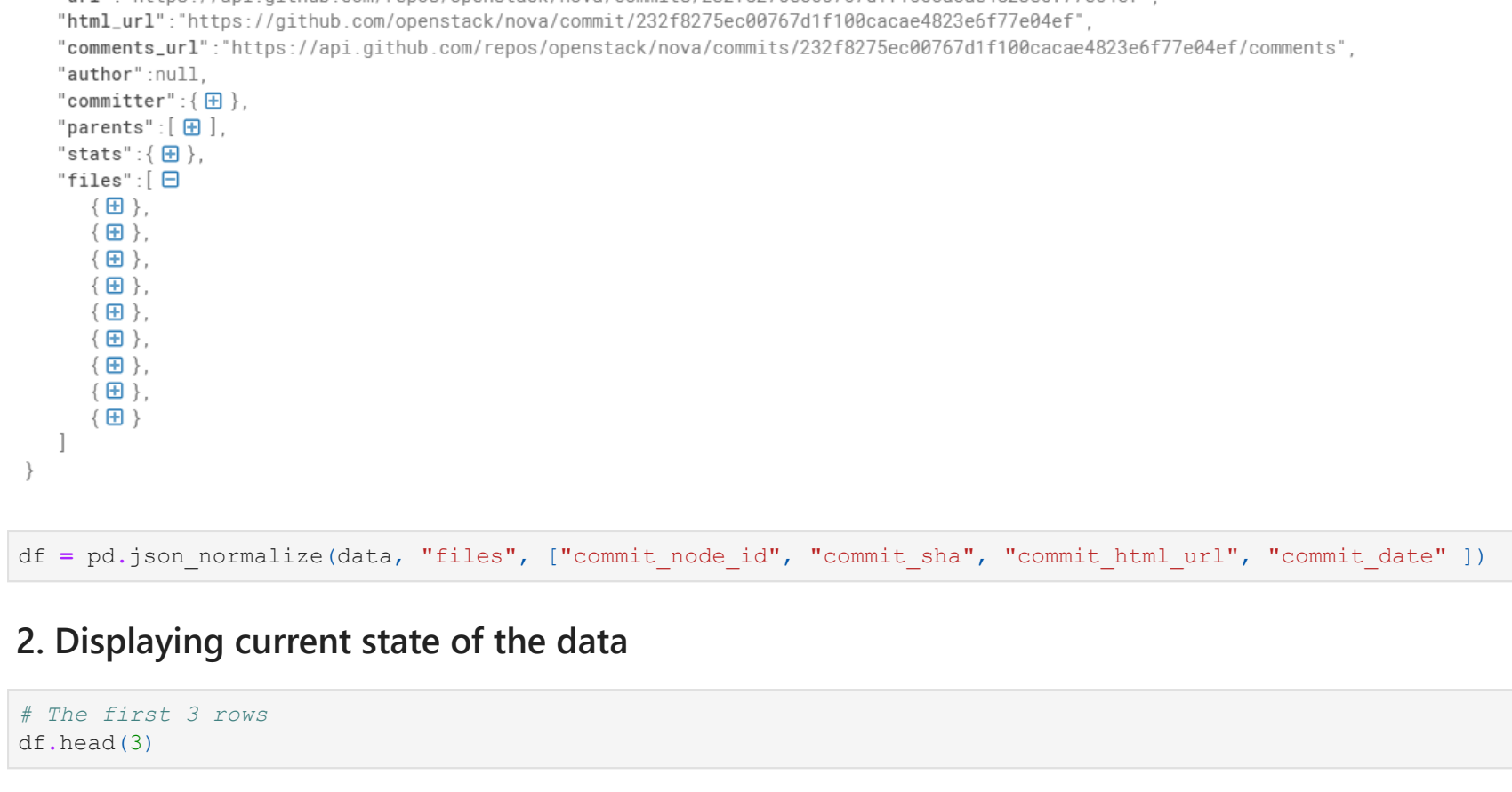
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1973 entries, 0 to 1972
Data columns (total 15 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   sha                1973 non-null   object
 1   filename           1973 non-null   object
 2   status             1973 non-null   object
 3   additions          1973 non-null   int64
 4   deletions          1973 non-null   int64
 5   changes            1973 non-null   int64
 6   blob_url           1973 non-null   object
 7   raw_url            1973 non-null   object
 8   contents_url       1973 non-null   object
 9   patch              1965 non-null   object
 10  previous_filename  8 non-null      object
 11  commit_node_id     1973 non-null   object
 12  commit_sha         1973 non-null   object
 13  commit_html_url    1973 non-null   object
 14  commit_date        1973 non-null   object
dtypes: int64(3), object(12)
memory usage: 231.3+ KB
```

3 Verify data

In [9]:
```
# Let us manually examine atleast one commit and see if the present rows are correct.
# We use the most recent commit as at the development time.
# Pls note that this commit will not be part of commits after 6 month from today February 17th, 2022
commit = '3a14c1a4277a9f44b67e080138b28b680e5e6824'
df[df["commit_sha"] == commit]
```

Out[9]:

	sha	filename	status	additions	deletions	changes	
36	08006e2b92a44b709b3ef6171cfb9a95519c8f5e	nova/compute/api.py	modified	18	4	22	https://github.com/ope
37	79a62da21a6d4e768b48f8be3c44e39b9bcd3a83	nova/tests/unit/compute/test_api.py	modified	30	0	30	https://github.com/ope
38	ef5582543a2ac953179e5dbc3e493e69c9bc84bf	releasenotes/notes/bug-1960401-504eb255253d966...	added	8	0	8	https://github.com/ope



4. Data cleaning

In [10]:
```
# Removing columns not needed for the analysis
columns = ['previous_filename', 'patch', 'contents_url', 'raw_url', 'commit_node_id']
df.drop(columns, inplace=True, axis=1)
```

In [11]:
```
# Generating and adding extra columns
df[["directory", "file_name", "file_type"]] = df.apply(lambda x: get_path_parameters(x), axis=1, result_type="e
```

In [12]:
```
# Delete the previous filename column as it is no longer required
df.drop("filename", inplace=True, axis=1)
```

In [13]:
```
# Rename columns
df.rename(columns={"sha": "file_sha", "status": "file_status", "additions":"no_of_additions", "deletions": "no_
```

In [14]:
```
# Optimising the data frame by correcting the data types.
# This will also make more operations possible on the data frame

df = df.astype({'file_sha': 'str', 'file_status': 'category', 'no_of_additions':'int', 'no_of_deletions':'int',
df['commit_date'] = pd.to_datetime(df['commit_date'], infer_datetime_format=True)
```

In [15]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1973 entries, 0 to 1972
Data columns (total 12 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   file_sha         1973 non-null   object
 1   file_status      1973 non-null   category
 2   no_of_additions  1973 non-null   int32
 3   no_of_deletions  1973 non-null   int32
 4   changes          1973 non-null   int32
 5   blob_url         1973 non-null   object
 6   commit_sha       1973 non-null   object
 7   commit_html_url  1973 non-null   object
 8   commit_date      1973 non-null   datetime64[ns, UTC]
 9   directory        1973 non-null   object
 10  file_name        1973 non-null   object
 11  file_type        1973 non-null   category
dtypes: category(2), datetime64[ns, UTC](1), int32(3), object(6)
memory usage: 135.8+ KB
```

A. Basic Analysis and Visualization

1. Total number of commits that occured during the studied period.

In [16]:
```
# value_counts returns a series object counting all unique values.
# the 1st value being the most frequently occuring i.e. the commit with highest no of file changes.
df["commit_sha"].value_counts()
```

Out[16]:
```
f3d48000b139ec38d92da276a43a8387f76cbc89    83
0e0196d979cf1b8e63b9656358116a36f1f09ede    83
ccef1940bf92da7441beb6b88fa9f998b1e9b2b2    36
d2a5fe5621d6ff1ae8ba5087049e0c4347592cf6    21
ac21c6674c8444edc5afd25b7d63936182fe3580    21
                                            ..
e2b1581d8c4f03cecca770aabb8e6123a7bef93a     1
f318f822fcf6dec4c3cd9b7e5111f3e1371aa51a     1
61b169d40f7df3c9ea782b3cf2ac96d3fbdceef2     1
f024490e95c2bdb8072247e9907c6aa1475c80d8     1
e28afc564700a1a35e3bf0269687d5734251b88a     1
Name: commit_sha, Length: 467, dtype: int64
```

In [17]:
```
print("The total no. of processed commits is: {commits_total}".format(commits_total = len(df["commit_sha"].valu
```

```
The total no. of processed commits is: 467
```

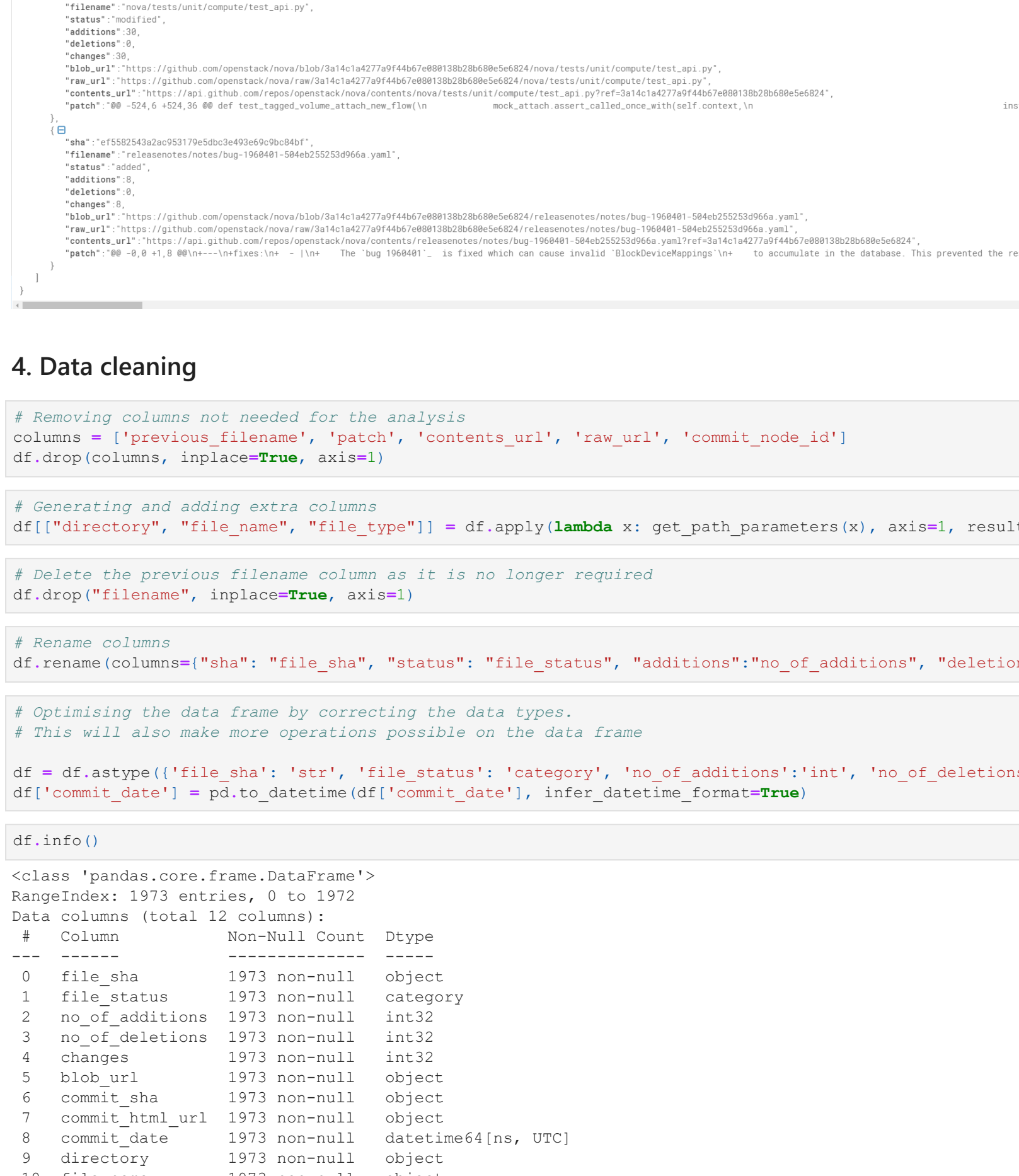
2. The 12 most modified files

In [18]:
```
df["file_name"].value_counts().head(12)
```

Out[18]:
```
driver.py                          77
api.py                             53
test_driver.py                     48
test_api.py                        44
neutron.py                         44
nova.py                            42
manager.py                         38
test_servers_resource_request.py   37
test_migrations.py                 36
test_neutron.py                    36
servers.py                         31
test_compute.py                    30
Name: file_name, dtype: int64
```

In [19]:
```
df["file_name"].value_counts().head(12).sort_values().plot.barh(figsize=(10, 9)); plt.axhline(0, color='k'); pl
```

Out[19]:
```
Text(0, 0.5, 'File Names')
```



3. The 12 most modified directories

In [20]:
```
# the term directory is used in place of module
df["directory"].value_counts().head(12)
```

Out[20]:
```
nova/tests/unit/compute              101
nova/tests/functional                 91
nova/compute                          79
nova/api/openstack/compute            79
                                      77
nova/tests/fixtures                   75
releasenotes/notes                    74
nova/virt/libvirt                     73
doc/source/admin                      61
nova/tests/unit/virt/libvirt          61
nova/tests/functional/regressions     59
nova/network                          52
Name: directory, dtype: int64
```

In [21]:
```
df["directory"].value_counts().head(12).sort_values().plot.pie(autopct='%1.1f%%', figsize=(20,8),
        shadow=True, startangle=90, ylabel="");plt.title('The 12 most modified modules')
```

Out[21]:
```
Text(0.5, 1.0, 'The 12 most modified modules')
```

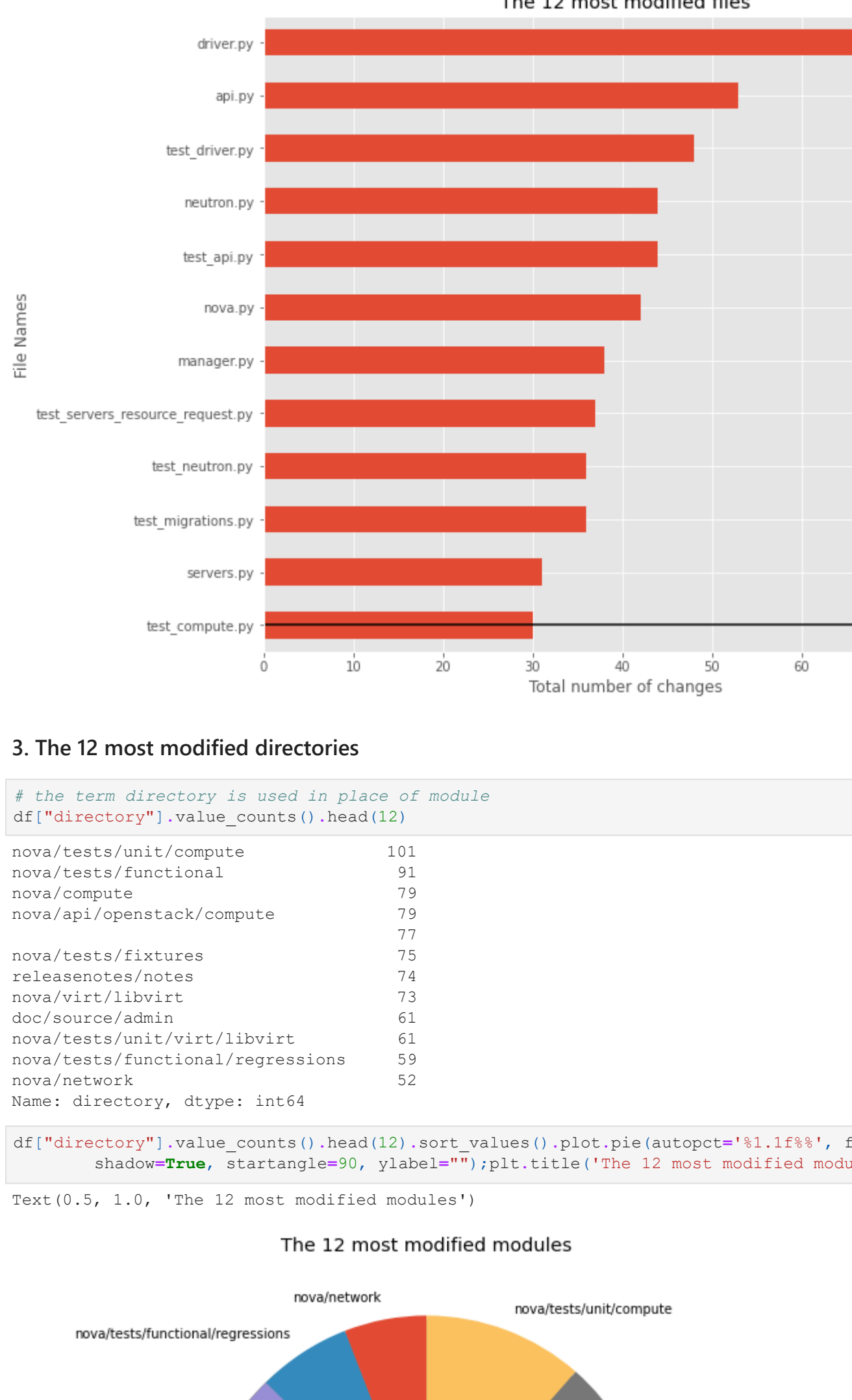
4. The most modified file types

In [22]:
```
df["file_type"].value_counts()
```

Out[22]:
```
.py      1557
.rst      167
.yaml     114
.json      31
.txt       31
.tpl       21
.ini       18
           10
.inc        8
.cfg        6
.mako       4
.sh         4
.conf       2
Name: file_type, dtype: int64
```

In [23]:
```
df["file_type"].value_counts().head().sort_values().plot.bar(figsize=(10, 8)); plt.axhline(0, color='k'); plt.t
```

Out[23]:
```
Text(0, 0.5, 'Total number of files')
```



5. Churn

In [24]:
```
# sum of all changes across all directories that occured during the period
df["changes"].sum()
```

Out[24]:
```
90284
```

B. Exploring activities at module level using aggregation operations

1. The total number of file modifications by directory i.e. no. of rows per directory. A row in df records a file change & the commit responsible

In [25]:
```
# the term directory is used in place of module
# thesame files may be modified in a particular directory by different commits
# we cant have rows where a particular commit modifies thesame file more than once
# Reveal the total no of changes in each directiory i.e. the no. of times the directory was modified.
grp1 = df.groupby(['directory']).size().sort_values(ascending=False).head(12)
grp1
```

Out[25]:
```
directory
nova/tests/unit/compute              101
nova/tests/functional                 91
nova/api/openstack/compute            79
nova/compute                          79
                                      77
nova/tests/fixtures                   75
releasenotes/notes                    74
nova/virt/libvirt                     73
nova/tests/unit/virt/libvirt          61
doc/source/admin                      61
nova/tests/functional/regressions     59
nova/network                          52
dtype: int64
```

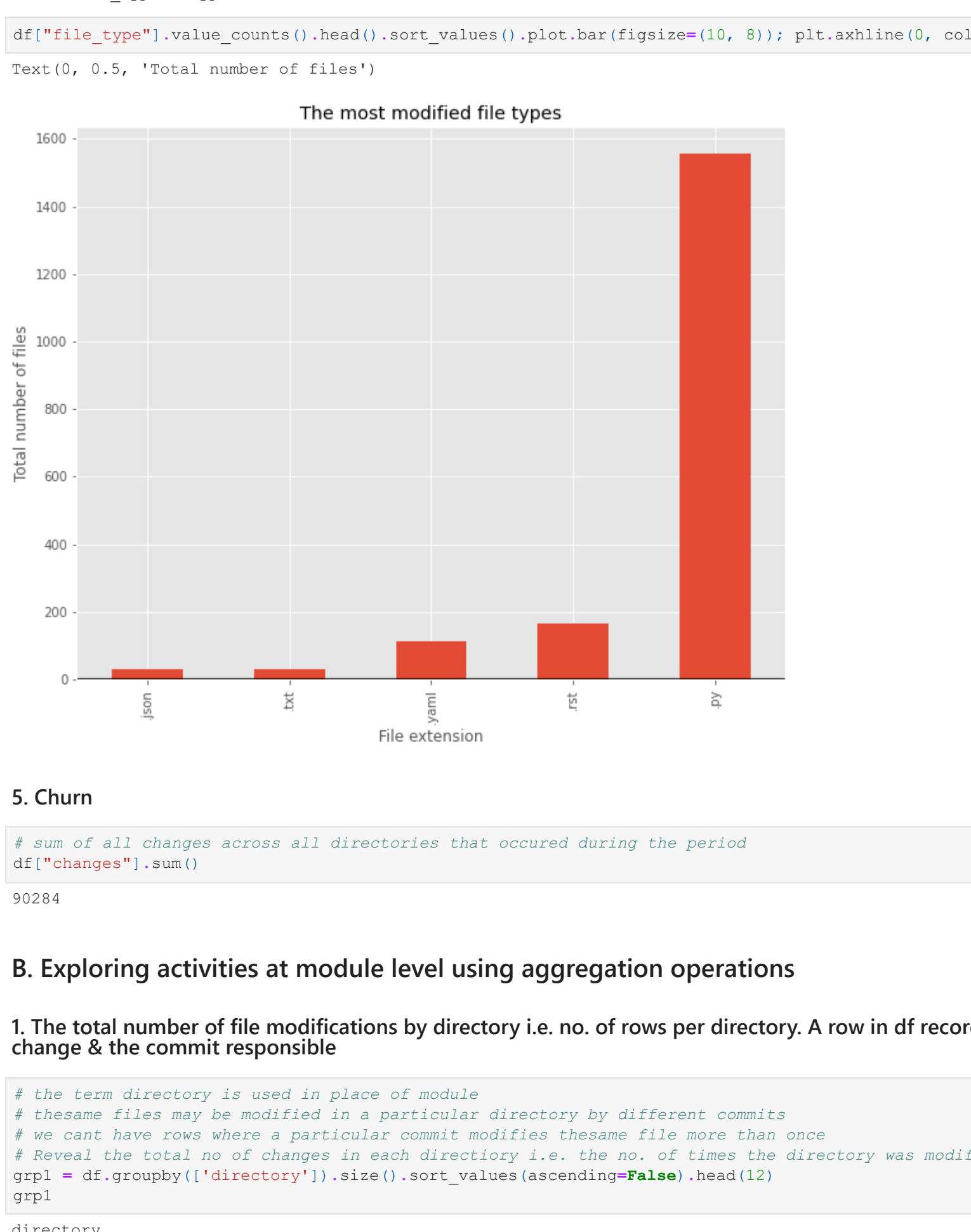
2. The total number of commits per directory

In [26]:
```
# split data by column <directory>
# pass column <commit_sha> to indicate we want the number of unique values for that column
# apply .nunique() to count the number of unique values in that coulmn
grp2 = df.groupby('directory')['commit_sha'].nunique().sort_values(ascending=False).head(12)
grp2
```

Out[26]:
```
directory
nova/tests/functional           75
releasenotes/notes              74
nova/tests/unit/compute         68
nova/compute                    65
nova/tests/fixtures             64
nova/virt/libvirt               52
                                52
nova/tests/unit/virt/libvirt    49
nova                            42
nova/network                    41
doc/source/admin                40
nova/tests/unit/network         38
Name: commit_sha, dtype: int64
```

In [27]:
```
grp2.sort_values().plot.barh(figsize=(10, 8)); plt.axhline(0, color='k'); plt.title('Total number of commits by
```

Out[27]:
```
Text(0, 0.5, 'Directories')
```



3. The number of files by directory

In [28]:
```
# The number of unique file per directory
group_by = df.groupby('directory')['file_name'].nunique().sort_values(ascending=False).head(12)
group_by
```

Out[28]:
```
directory
releasenotes/notes                      41
nova/tests/functional/regressions       21
nova/api/openstack/compute              17
nova/tests/unit/api/openstack/compute   13
nova/tests/unit                         13
doc/source/admin                        13
nova/objects                            13
nova/tests/unit/compute                 12
nova/tests/fixtures                     10
nova/tests/unit/objects                 10
nova/tests/functional                   10
doc/source/reference                     9
Name: file_name, dtype: int64
```

4. The churn by directory

In [29]:
```
df.groupby('directory').sum().sort_values(by='changes', ascending=False).head(12)
```

Out[29]:

directory	no_of_additions	no_of_deletions	changes
nova/tests/functional	9333	6467	15800
doc/source/admin	6640	712	7352
nova/tests/unit/scheduler	3458	3514	6972
doc/source/user	32	3909	3941
nova/tests/unit/network	3000	488	3488
nova/scheduler	1595	1648	3243
nova/tests/fixtures	1729	729	2458
nova/tests/unit/compute	1673	778	2451
nova/tests/unit/api/openstack/compute	1480	944	2424
doc/source/admin/configuration	81	2213	2294
nova/db/main	412	1756	2168
nova/tests/unit/virt/libvirt	1574	448	2022

5. The churn by file name

In [30]:
```
df.groupby('file_name').sum().sort_values(by='changes', ascending=False).head(12)
```

Out[30]:

file_name	no_of_additions	no_of_deletions	changes
test_servers_resource_request.py	7260	1052	8312
test_servers.py	1550	5781	7331
cells.rst	2264	1678	3942
test_driver.py	1029	2704	3733
test_neutron.py	2934	430	3364
scheduling.rst	2886	30	2916
test_manager.py	2285	87	2372
driver.py	1018	1266	2284
models.py	327	1930	2257
schedulers.rst	7	2163	2170
manager.py	1496	437	1933
test_api.py	1016	782	1798

6. The churn by file type

In [31]:
```
df.groupby('file_type').sum().sort_values(by='changes', ascending=False).head(12)
```

Out[31]:

file_type	no_of_additions	no_of_deletions	changes
.py	45489	26069	71558
.rst	8005	7290	15295
.yaml	1215	131	1346
.json	562	20	582
.tpl	547	0	547
.ini	293	20	313
	38	140	178
.inc	95	39	134
.sh	62	63	125
.txt	46	52	98
.mako	72	8	80
.cfg	22	4	26

Findings

The following findings are as at the date of this analysis (18th February 2022).

The analysis reveals that the project is still actively maintained and development is primarily in Python. One key aspect of this project regularly improved is the compute resource and its associated APIs and it is important to note that with each update a high level of testing is carried out especially functional which can be seen from the number of commits and total churn for those directories. Also, while python code file has the highest number of modifications and is expected, significant levels of modification occur on restructuredText files indicating efforts towards technical documentation.