CVE_Analysis_2

December 6, 2020

[362]:
```
import os
import json
from neo4j import GraphDatabase
import codecs
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
sns.set_theme(style="whitegrid")
import glob
from matplotlib.colors import ListedColormap
import numpy as np
```

[363]:
```
base_dir = '/Users/janamian/Documents/workstation/ucsd_dse_program/fall_2019/
 ↪docker_vol/saba-ja/workstation/dse_203_2020/project/
 ↪dse_203_final_project_fall_2020/data'
```

[364]:
```
nvdcve_files = sorted(glob.glob(os.path.join(base_dir, 'nvd_data','nvdcve-1.1*.
 ↪json')), reverse=True)
```

[365]:
```
for val in nvdcve_files:
    print(val.split('/')[-1])
```

```
nvdcve-1.1-2020.json
nvdcve-1.1-2019.json
nvdcve-1.1-2018.json
nvdcve-1.1-2017.json
nvdcve-1.1-2016.json
nvdcve-1.1-2015.json
nvdcve-1.1-2014.json
nvdcve-1.1-2013.json
nvdcve-1.1-2012.json
nvdcve-1.1-2011.json
nvdcve-1.1-2010.json
nvdcve-1.1-2009.json
nvdcve-1.1-2008.json
nvdcve-1.1-2007.json
nvdcve-1.1-2006.json
nvdcve-1.1-2005.json
```

```
nvdcve-1.1-2004.json
nvdcve-1.1-2003.json
nvdcve-1.1-2002.json
```

[366]:
```
# ##############
# Read all CWE data
# Read all NVD CVE Json files
# ##############
with open(os.path.join(base_dir, 'cwe_data', 'cwec_v4.2.json')) as f:
    cwe = json.load(f)

nvd_list = []
for file_addr in nvdcve_files:
    with open(file_addr) as f:
        nvd_list.append(json.load(f))
```

[367]:
```
def trendline(xd, yd, order=1, c='r', alpha=1, Rval=False):
    """Make a line of best fit"""

    #Calculate trendline
    coeffs = np.polyfit(xd, yd, order)

    intercept = coeffs[-1]
    slope = coeffs[-2]
    power = coeffs[0] if order == 2 else 0

    minxd = np.min(xd)
    maxxd = np.max(xd)

    xl = np.array([minxd, maxxd])
    yl = power * xl ** 2 + slope * xl + intercept

    #Plot trendline
    plt.plot(xl, yl, c, alpha=alpha, linestyle='--')

    #Calculate R Squared
    p = np.poly1d(coeffs)

    ybar = np.sum(yd) / len(yd)
    ssreg = np.sum((p(xd) - ybar) ** 2)
    sstot = np.sum((yd - ybar) ** 2)
    Rsqr = ssreg / sstot

    if not Rval:
        #Plot R^2 value
        plt.text(0.8 * maxxd + 0.2 * minxd, 0.65 * np.max(yd) + 0.4 * np.
↪min(yd),
```

```
                f'R^2 = {Rsqr:0.2f}\nm = {slope:0.0f}')
    else:
        #Return the R^2 value:
        return Rsqr
```

[368]:
```
def get_related_cwe(data_list):
    # CVE object
    resultw = []
    if not isinstance(data_list['problemtype']['problemtype_data'], list):
        print(data_list['problemtype']['problemtype_data'])
        raise ValueError

    if len(data_list['problemtype']['problemtype_data']) != 1:
        print(data_list['problemtype']['problemtype_data'])
        raise ValueError

    for val in data_list['problemtype']['problemtype_data'][0]['description']:
        resultw.append(val['value'])
    return resultw

def get_reference_url(data_list):
    result = []
    for val in data_list['references']['reference_data']:
        result.append(val['url'])
    return result

def get_tags(data_list):
    result = []
    for val in data_list['references']['reference_data']:
        for val2 in val['tags']:
            result.append(val2)

    return result

def get_description_data(data_list):
    result = []
    for val in data_list['description']['description_data']:
        if val['lang'] == 'en':
            result.append(val['value'])
    return result

def get_cpe_match(cpe_match_list):
    result = []
    try:
        for val in cpe_match_list['cpe_match']:
            result.append(val['cpe23Uri'])
    except KeyError:
```

```
        pass
    return result

def get_impacted_configuration(data_list):
    result = []
    for val in data_list['nodes']:

        result.extend(get_cpe_match(val))

        if 'children' in val.keys():
            for val2 in val['children']:
                result.extend(get_cpe_match(val2))

    return result

cve_clean_result = []
total_cwes = 0
total_cves = 0
for nvd_obj in nvd_list:
    for cve_obj in nvd_obj['CVE_Items']:
        published_date = cve_obj['publishedDate']
        yy = published_date.split('-')[0]
        if int(yy) < 2000:
            continue

        modified_date = cve_obj['lastModifiedDate']

        cve_id = cve_obj['cve']['CVE_data_meta']['ID']
        total_cves += 1

        related_cwe_list = get_related_cwe(cve_obj['cve'])
        if len(related_cwe_list) == 0:
            related_cwe_list = ['NVD-no-analysis']
            total_cwes += 1
#             print(cve_id)
        else:
            total_cwes += len(related_cwe_list)

        description = get_description_data(cve_obj['cve'])
        reference_url = get_reference_url(cve_obj['cve'])
        tags = get_tags(cve_obj['cve'])

        try:
            cvss_base_score =␣
 ↪cve_obj['impact']['baseMetricV3']['cvssV3']['baseScore']
            cvss_base_severity =␣
 ↪cve_obj['impact']['baseMetricV3']['cvssV3']['baseSeverity']
```

```
        except KeyError:
            cvss_base_score = 'unknown'
            cvss_base_severity = 'unknown'

        impacted_config = get_impacted_configuration(cve_obj['configurations'])

        cve_clean_result.append({
            'cve_id': cve_id,
            'related_cwe_list':related_cwe_list,
            'description': description,
            'reference_url':reference_url,
            'tags':tags,
            'cvss_base_score': cvss_base_score,
            'cvss_base_severity':cvss_base_severity,
            'impacted_config': impacted_config,
            'published_date': published_date,
            'modified_date': modified_date
         })
```

[369]:
```
counter = {}
for val in cve_clean_result:
    year = val['published_date'].split('-')[0]
    c = counter.get(year, 0)
    c += 1
    counter[year] = c

data = {'year':[], 'count':[]}
for key, value in counter.items():
    data['year'].append(int(key))
    data['count'].append(value)

cve_count_df = pd.DataFrame(data)
cve_count_df.sort_values(by=['year'], ascending=True, inplace=True)
cve_count_df.rename(columns={'count':'number_of_reported_cve'}, inplace=True)
cve_count_df.set_index('year', drop=True, inplace=True)
```

[370]:
```
cve_count_df
```

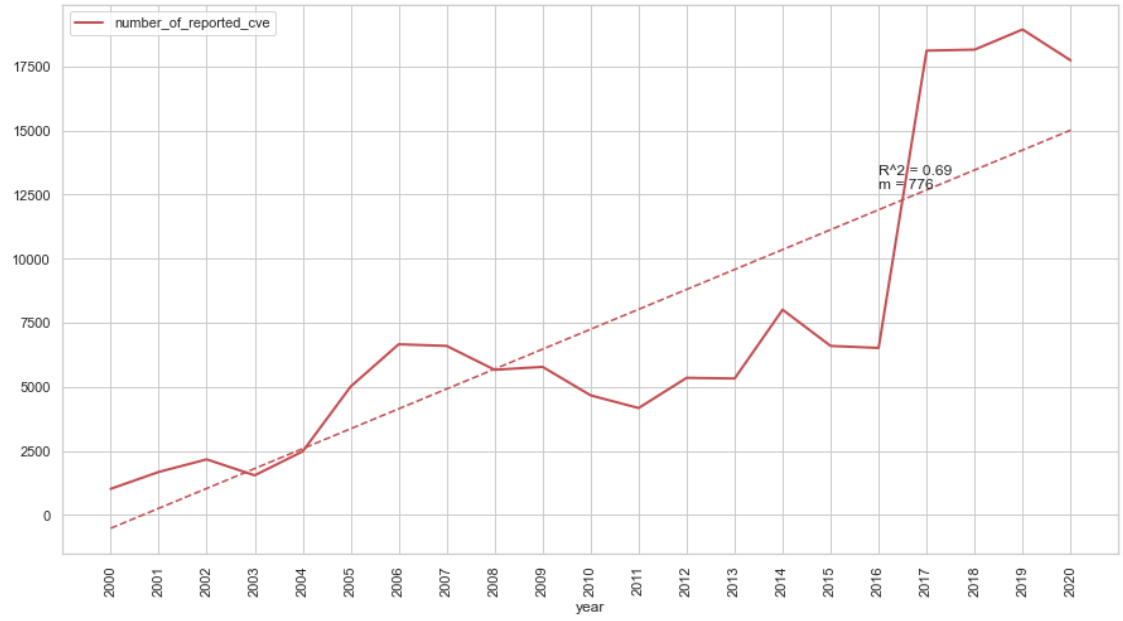
[370]:

year	number_of_reported_cve
2000	1020
2001	1679
2002	2170
2003	1548
2004	2479
2005	5010
2006	6659

2007	6596
2008	5664
2009	5778
2010	4667
2011	4172
2012	5351
2013	5324
2014	8008
2015	6595
2016	6517
2017	18113
2018	18154
2019	18938
2020	17736

[371]:
```
print(cve_count_df['number_of_reported_cve'].sum())
cve_count_df.plot(kind='line', color='r',figsize=(15,8), linewidth=2)
plt.xticks(cve_count_df.index,rotation=90);
plt.rc('xtick', labelsize=15)
plt.rc('ytick', labelsize=15)
trendline(list(cve_count_df.index),␣
 ↪list(cve_count_df['number_of_reported_cve']), c='r')
```

152178



[372]:
```
cve_count_df.index
```

[372]:
```
Int64Index([2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010,
            2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020],
           dtype='int64', name='year')
```

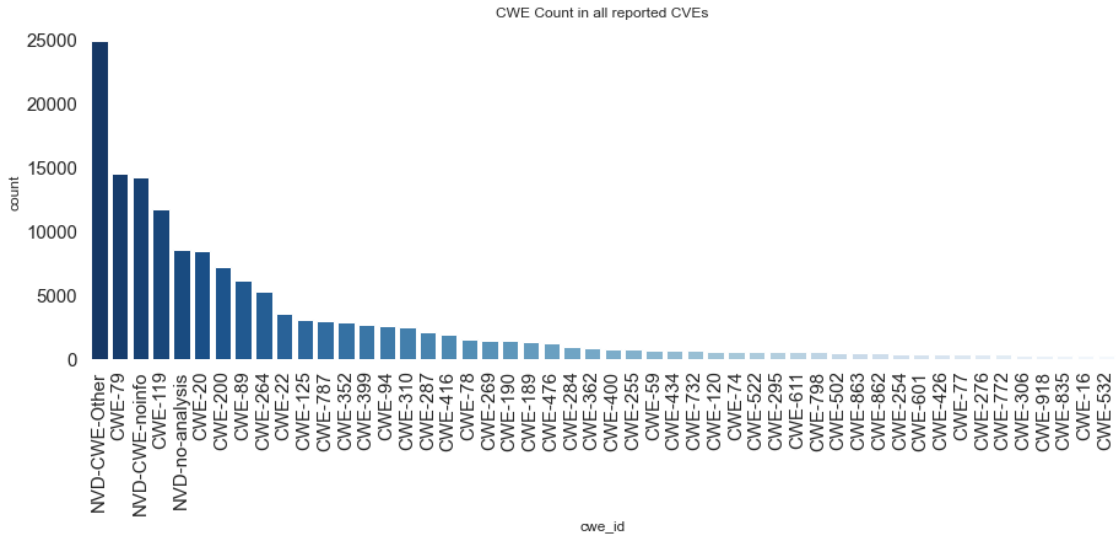
[373]:
```
print('Total CVEs: ', len(cve_clean_result))
print('Total CWEs in CVEs: ', total_cwes)
```

```
Total CVEs:  152178
Total CWEs in CVEs:  154169
```

[374]:
```
# ##############
# Count CWEs causing CVE
# ##############

cwe_count = {}
for val in cve_clean_result:
    for cwe in val['related_cwe_list']:
        cwe_c = cwe_count.get(cwe, 0)
        cwe_c += 1
        cwe_count[cwe] = cwe_c
```

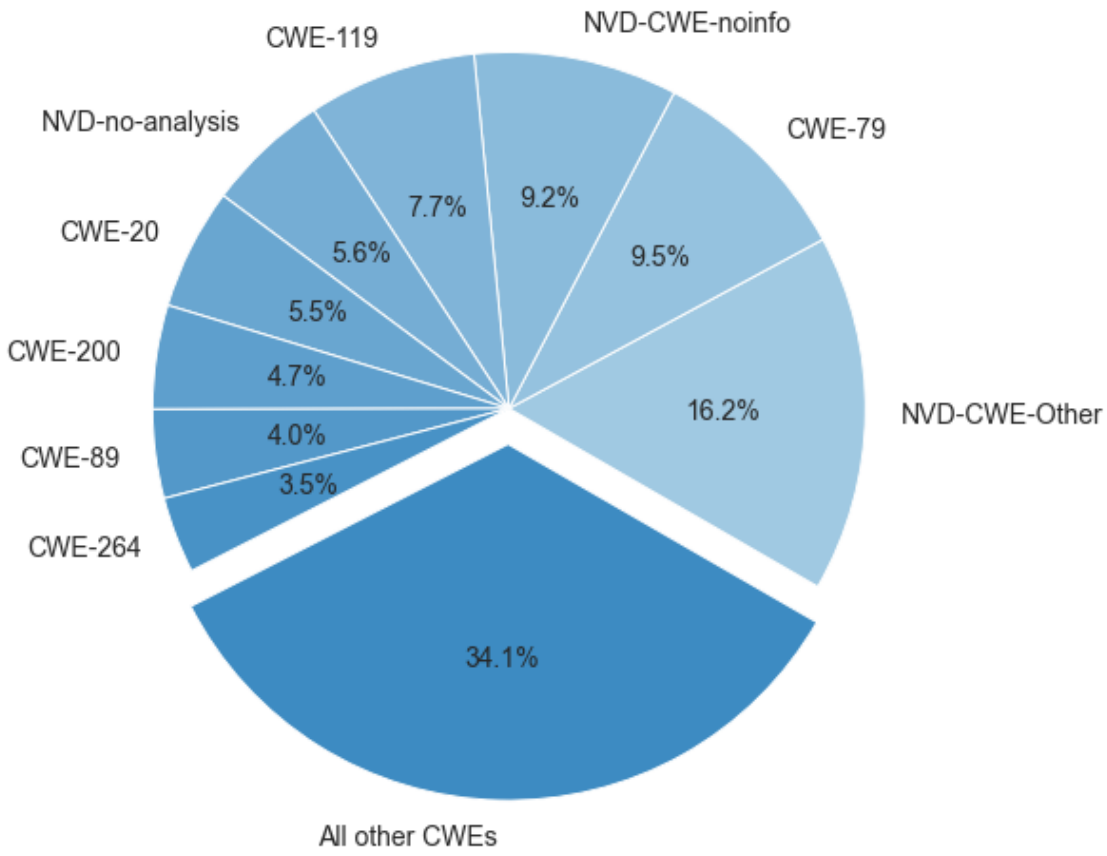
[375]:
```
data = {'cwe_id':[], 'count':[]}
for key, value in cwe_count.items():
    data['cwe_id'].append(f'{key}')
    data['count'].append(value)

cwe_count_df = pd.DataFrame(data)
cwe_count_df.sort_values(by=['count'], ascending=False, inplace=True)
cwe_count_df.reset_index(drop=True, inplace=True)
cwe_count_filtered_gt_n = cwe_count_df[cwe_count_df['count'] >= 250]
```

[376]:
```
fig = plt.figure(figsize=(15,5))
ax = sns.barplot(x="cwe_id", y="count", palette="Blues_r",␣
 ↪data=cwe_count_filtered_gt_n, ci=None);
plt.title('CWE Count in all reported CVEs')
plt.setp(ax.get_xticklabels(), rotation=90);
plt.rc('xtick', labelsize=15)
plt.rc('ytick', labelsize=15)
plt.rc('figure', titlesize=15)
plt.grid(False)
plt.box(on=None)
```



[377]:
```
less_than_n_cwe = cwe_count_df[cwe_count_df['count'] < 5000]['count'].sum()
```

[378]:
```
labels = list(cwe_count_df[cwe_count_df['count'] >= 5000]['cwe_id'])
labels.append('All other CWEs')
sizes = list(cwe_count_df[cwe_count_df['count'] >= 5000]['count'])
sizes.append(less_than_n_cwe)
fig1, ax1 = plt.subplots(figsize=(8,8))
ax1.pie(sizes,
        explode=(0, 0, 0, 0, 0, 0, 0, 0, 0, 0.1),
        labels=labels,
        autopct='%1.1f%%',
        shadow=False,
        startangle=-30,
        textprops={'fontsize': 14},
        colors=sns.color_palette("Blues_d", 20))

ax1.axis('equal')

plt.show()
```



[379]:
```
sum(sizes)
```

[379]:
```
154169
```

[380]:
```
column_names = []
column_names.extend(labels)
cve_to_cwe_per_year_df = pd.DataFrame(columns=column_names,␣
↪index=list(range(1988,2021)))
cve_to_cwe_per_year_df.fillna(0, inplace=True)
for val in cve_clean_result:
    year_val = int(val['published_date'].split('-')[0])
    for cwe in val['related_cwe_list']:
        if cwe in column_names:
            cwe_count = cve_to_cwe_per_year_df.loc[year_val, cwe]
            cve_to_cwe_per_year_df.loc[year_val, cwe] = cwe_count + 1
        else:
            cwe_count = cve_to_cwe_per_year_df.loc[year_val, 'All other CWEs']
            cve_to_cwe_per_year_df.loc[year_val, 'All other CWEs'] = cwe_count␣
↪+ 1
```

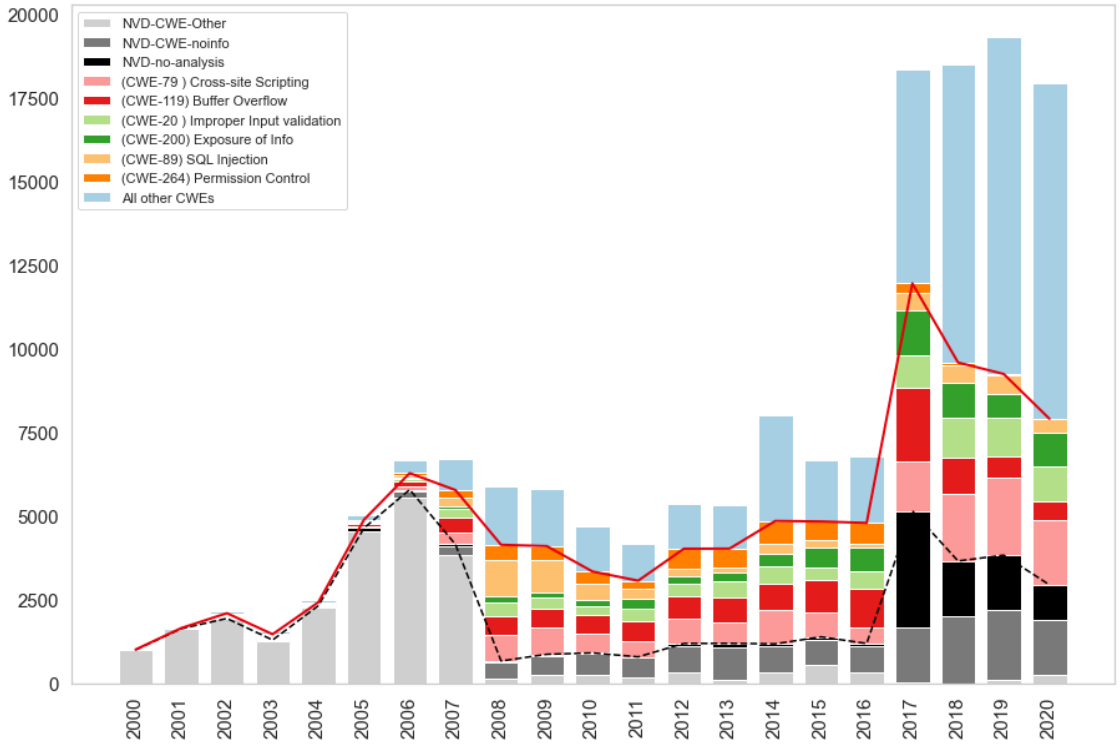
```
cve_to_cwe_per_year_df.rename(columns={
'CWE-79' : '(CWE-79 ) Cross-site Scripting',
'CWE-119': '(CWE-119) Buffer Overflow',
'CWE-20' : '(CWE-20 ) Improper Input validation',
'CWE-200': '(CWE-200) Exposure of Info',
'CWE-89' : '(CWE-89 ) SQL Injection',
'CWE-264': '(CWE-264) Permission Control'}, inplace=True)
```

[381]:
```
df_temp1 = cve_to_cwe_per_year_df[cve_to_cwe_per_year_df.index >=␣
↪2000][['NVD-CWE-Other', 'NVD-CWE-noinfo', 'NVD-no-analysis']]

line_data = df_temp1.sum(axis=1)
line_data_df_1 = line_data.to_frame().reset_index(drop=False)
line_data_df_1.rename(columns={'index':'year', 0:'NVD-CWE-Other'}, inplace=True)
line_data_df_1.astype(int)
line_data_df_1.set_index('year', drop=True, inplace=True)
NVD_CWE_Other_only = line_data_df_1
```

[382]:
```
df_temp2 = cve_to_cwe_per_year_df[cve_to_cwe_per_year_df.index >= 2000].
↪drop(['All other CWEs'], axis=1)
line_data = df_temp2.sum(axis=1)
line_data_df_2 = line_data.to_frame().reset_index(drop=False)
line_data_df_2.rename(columns={'index':'year', 0:'cwe_count'}, inplace=True)
line_data_df_2.astype(int)
line_data_df_2.set_index('year', drop=True, inplace=True)
majro_cwe_each_year = line_data_df_2
```

[383]:
```
width=0.75
filtered_years = cve_to_cwe_per_year_df[cve_to_cwe_per_year_df.index >= 2000]
fig, ax = plt.subplots(figsize=(15,10))
years = list(filtered_years.index)

nvd_1 = filtered_years['NVD-CWE-Other']
nvd_2 = filtered_years['NVD-CWE-noinfo']
nvd_3 = filtered_years['NVD-no-analysis']

cwe_79 = filtered_years['(CWE-79 ) Cross-site Scripting']
cwe_119 = filtered_years['(CWE-119) Buffer Overflow']
cwe_20 = filtered_years['(CWE-20 ) Improper Input validation']
cwe_200 = filtered_years['(CWE-200) Exposure of Info']
cwe_89 = filtered_years['(CWE-89 ) SQL Injection']
cwe_264 = filtered_years['(CWE-264) Permission Control']
all_other_cwe = filtered_years['All other CWEs']

ax.bar(years, nvd_1, width, label='NVD-CWE-Other', color='#CFCFCF') # '#B4D47B'
ax.bar(years, nvd_2, width, bottom=sum([nvd_1]), label='NVD-CWE-noinfo',␣
↪color='#797979')
```

```
ax.bar(years, nvd_3, width, bottom=sum([nvd_1, nvd_2]),␣
 ↪label='NVD-no-analysis', color='#000000')

ax.bar(years, cwe_79, width, bottom=sum([nvd_1, nvd_2, nvd_3]), label='(CWE-79␣
 ↪) Cross-site Scripting', color='#FB9A99')
ax.bar(years, cwe_119, width, bottom=sum([nvd_1, nvd_2, nvd_3, cwe_79]),␣
 ↪label='(CWE-119) Buffer Overflow', color='#E31B1B')
ax.bar(years, cwe_20, width, bottom=sum([nvd_1, nvd_2, nvd_3, cwe_79,␣
 ↪cwe_119]), label='(CWE-20 ) Improper Input validation', color='#B3DF89')
ax.bar(years, cwe_200, width, bottom=sum([nvd_1, nvd_2, nvd_3, cwe_79, cwe_119,␣
 ↪cwe_20]), label='(CWE-200) Exposure of Info', color='#33A02C')
ax.bar(years, cwe_89, width, bottom=sum([nvd_1, nvd_2, nvd_3, cwe_79, cwe_119,␣
 ↪cwe_20, cwe_200]), label='(CWE-89) SQL Injection', color='#FCC06F')
ax.bar(years, cwe_264, width, bottom=sum([nvd_1, nvd_2, nvd_3, cwe_79, cwe_119,␣
 ↪cwe_20, cwe_200, cwe_89]), label='(CWE-264) Permission Control',␣
 ↪color='#FF7F01')
ax.bar(years, all_other_cwe, width, bottom=sum([nvd_1, nvd_2, nvd_3, cwe_79,␣
 ↪cwe_119, cwe_20, cwe_200, cwe_89, cwe_264]), label='All other CWEs',␣
 ↪color='#A6CFE3')

ax.plot(years, NVD_CWE_Other_only, color='#000000', linestyle='--')
ax.plot(years, majro_cwe_each_year, color='#E8000B', linewidth=2)
ax.legend()
plt.xticks(years,rotation=90);
plt.grid(False)
# plt.box(on=None)
```

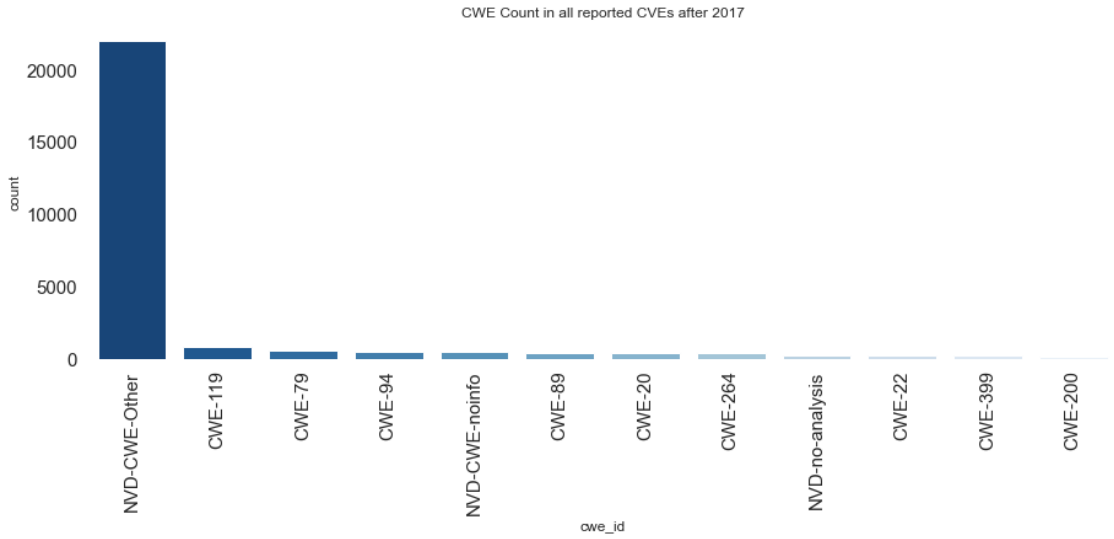


[384]:
```
# ##############
# Count CWEs causing CVE in 2017 and after only
# ##############
def count_the_cwes(years):
    cwe_count = {}
    for val in cve_clean_result:
        year = val['published_date'].split('-')[0]
        if year not in years:
            continue
        for cwe in val['related_cwe_list']:
            cwe_c = cwe_count.get(cwe, 0)
            cwe_c += 1
            cwe_count[cwe] = cwe_c
    return cwe_count
```

[385]:
```
# ##############
# CWEs color constants
# ##############
NVDCWEOther_COLOR = '#CFCFCF'
NVDCWEnoinfo_COLOR = '#797979'
NVDnoanalysis_COLOR = '#000000'
```

[386]:
```
data = {'cwe_id':[], 'count':[]}
for key, value in count_the_cwes(['2000', '2001', '2002', '2003', '2004',␣
 ↪'2005', '2006', '2007']).items():
    data['cwe_id'].append(f'{key}')
    data['count'].append(value)

cwe_count_df = pd.DataFrame(data)
cwe_count_df.sort_values(by=['count'], ascending=False, inplace=True)
cwe_count_df.reset_index(drop=True, inplace=True)
cwe_count_filtered_gt_n = cwe_count_df[cwe_count_df['count'] >= 200]
```

[387]:
```
fig = plt.figure(figsize=(15,5))
ax = sns.barplot(x="cwe_id", y="count", palette="Blues_r",␣
 ↪data=cwe_count_filtered_gt_n, ci=None);
plt.title('CWE Count in all reported CVEs after 2017')
plt.setp(ax.get_xticklabels(), rotation=90);
plt.rc('xtick', labelsize=15)
plt.rc('ytick', labelsize=15)
plt.rc('figure', titlesize=15)
plt.grid(False)
plt.box(on=None)
```



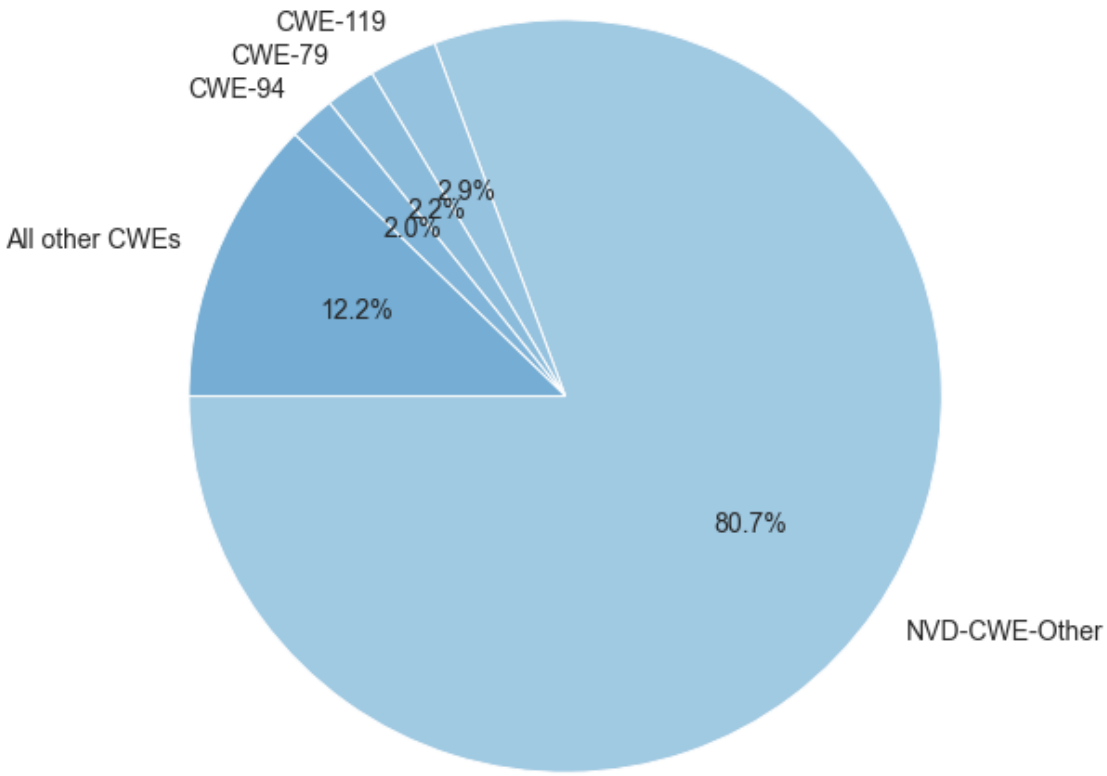
[388]:
```
len(sizes)
```

[388]: 10

[389]:
```
def graph_cwe_count_chart(limit, angle, colors=sns.color_palette("Blues_d",␣
 ↪20)):
    less_than_n_cwe = cwe_count_df[cwe_count_df['count'] < limit]['count'].sum()
```

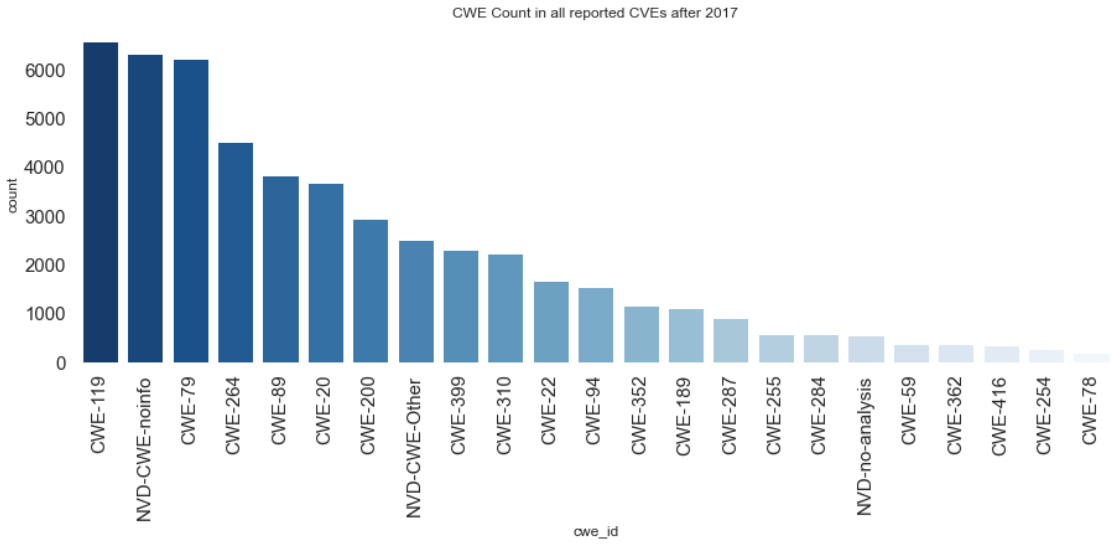
```
    labels = list(cwe_count_df[cwe_count_df['count'] >= limit]['cwe_id'])
    labels.append('All other CWEs')
    sizes = list(cwe_count_df[cwe_count_df['count'] >= limit]['count'])
    sizes.append(less_than_n_cwe)
    fig1, ax1 = plt.subplots(figsize=(8,8))
    ax1.pie(sizes,
    #         explode=(0, 0, 0, 0, 0, 0, 0, 0, 0, 0.1),
            labels=labels,
            autopct='%1.1f%%',
            shadow=False,
            startangle=angle,
            textprops={'fontsize': 14},
            colors=colors)

    ax1.axis('equal')

    plt.show()
```

[390]:
```
graph_cwe_count_chart(500, -180)
```

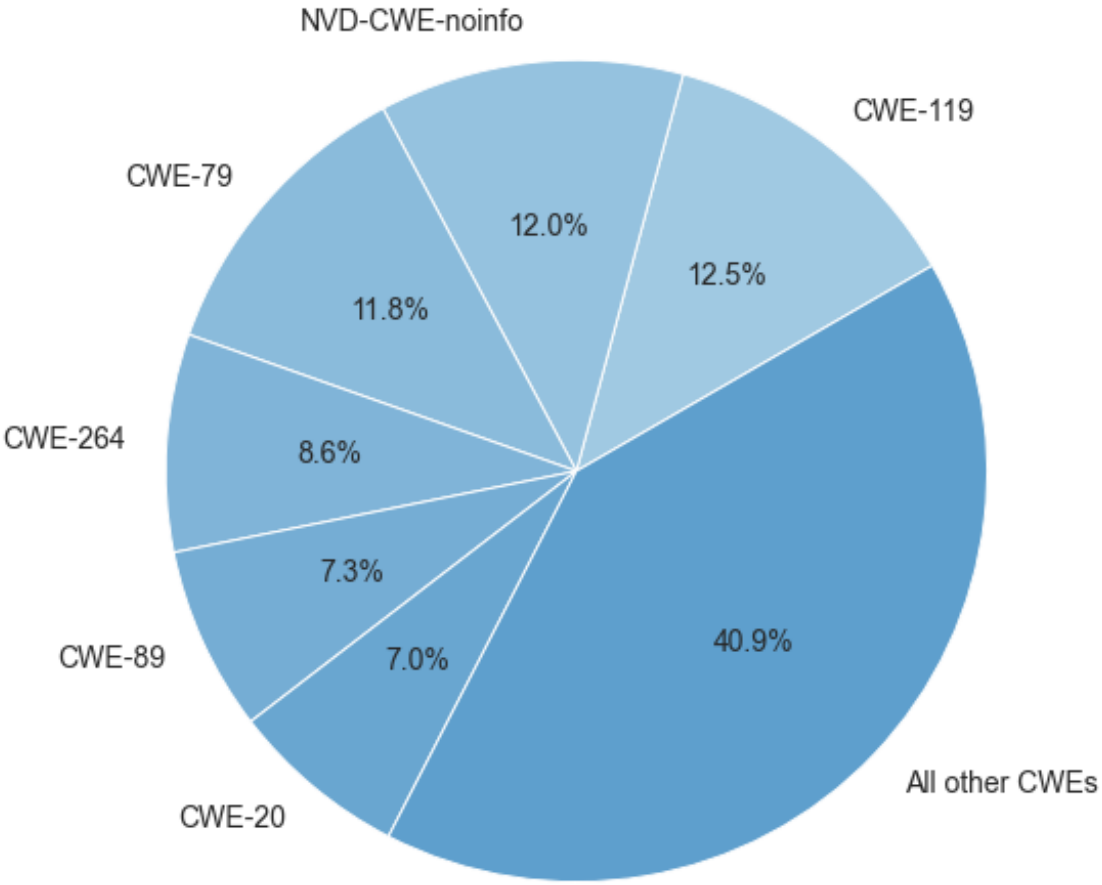


[391]:
```
data = {'cwe_id':[], 'count':[]}
for key, value in count_the_cwes(['2008', '2009', '2010', '2011',␣
 ↪'2012','2013', '2014', '2015', '2016']).items():
    data['cwe_id'].append(f'{key}')
    data['count'].append(value)

cwe_count_df = pd.DataFrame(data)
cwe_count_df.sort_values(by=['count'], ascending=False, inplace=True)
cwe_count_df.reset_index(drop=True, inplace=True)
cwe_count_filtered_gt_n = cwe_count_df[cwe_count_df['count'] >= 200]
```

[392]:
```
fig = plt.figure(figsize=(15,5))
ax = sns.barplot(x="cwe_id", y="count", palette="Blues_r",␣
 ↪data=cwe_count_filtered_gt_n, ci=None);
plt.title('CWE Count in all reported CVEs after 2017')
plt.setp(ax.get_xticklabels(), rotation=90);
plt.rc('xtick', labelsize=15)
plt.rc('ytick', labelsize=15)
plt.rc('figure', titlesize=15)
plt.grid(False)
plt.box(on=None)
```



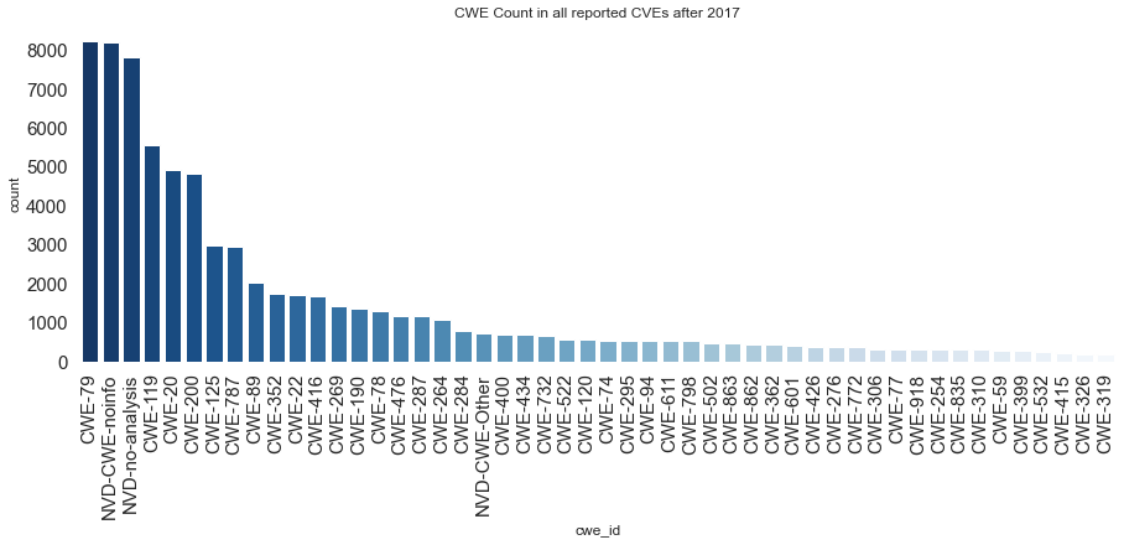
[393]:
```
graph_cwe_count_chart(3000, 30)
```



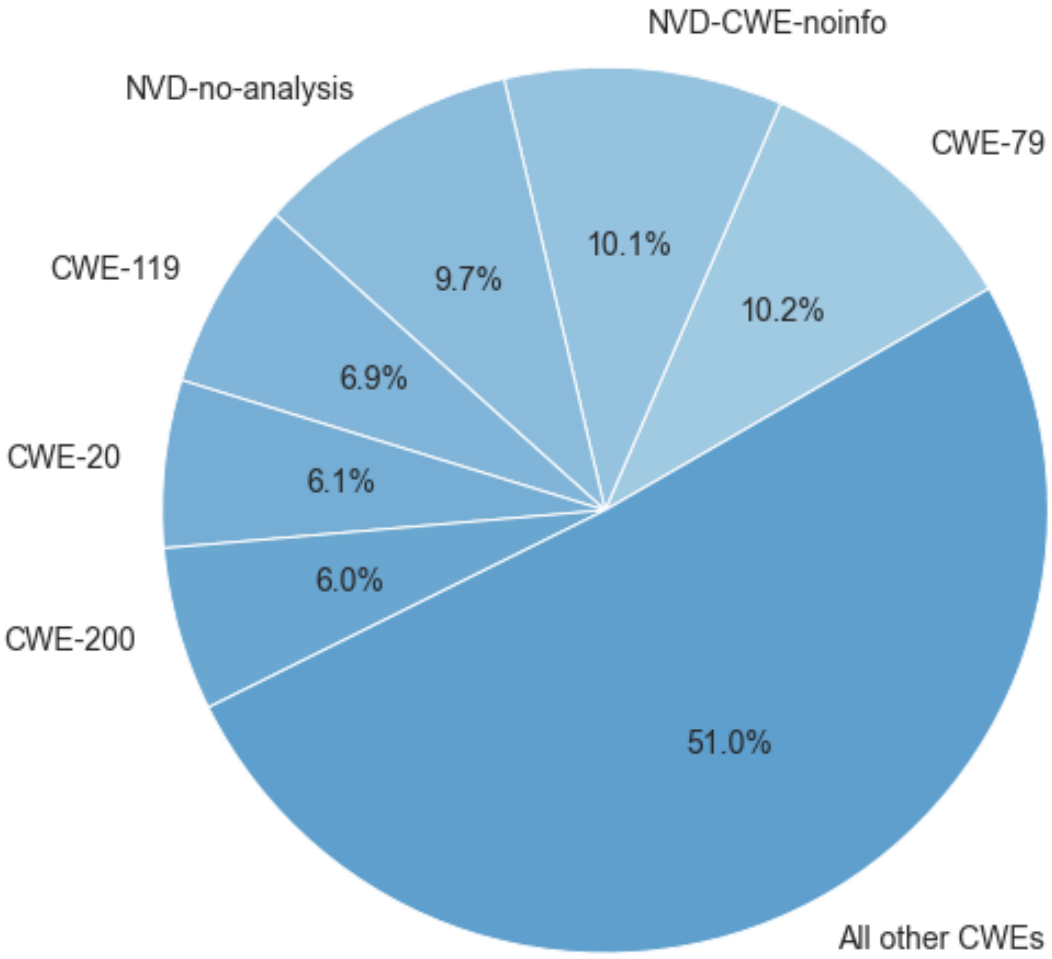
[394]:
```
data = {'cwe_id':[], 'count':[]}
for key, value in count_the_cwes(['2016', '2017', '2018', '2019','2020']).
 ↪items():
    data['cwe_id'].append(f'{key}')
    data['count'].append(value)

cwe_count_df = pd.DataFrame(data)
cwe_count_df.sort_values(by=['count'], ascending=False, inplace=True)
cwe_count_df.reset_index(drop=True, inplace=True)
cwe_count_filtered_gt_n = cwe_count_df[cwe_count_df['count'] >= 200]
```

[395]:
```
fig = plt.figure(figsize=(15,5))
ax = sns.barplot(x="cwe_id", y="count", palette="Blues_r",␣
 ↪data=cwe_count_filtered_gt_n, ci=None);
plt.title('CWE Count in all reported CVEs after 2017')
plt.setp(ax.get_xticklabels(), rotation=90);
plt.rc('xtick', labelsize=15)
plt.rc('ytick', labelsize=15)
```

```
plt.rc('figure', titlesize=15)
plt.grid(False)
plt.box(on=None)
```



[396]:
```
graph_cwe_count_chart(3000, 30)
```



[397]:
```
# ##############
# Companies reporting CVEs
# ##############
company_counter = {}
product_counter = {}
company_impact_severity = {}
company_product_counter = {}

for val in cve_clean_result:
    impacted_cpe_list = val['impacted_config']
    impact_severity = val['cvss_base_severity']
    for val2 in impacted_cpe_list:
        company = val2.split(':')[3]
        product = val2.split(':')[4]
        company_product = f'{company}:{product}'
```

```
        c = company_counter.get(company, 0)
        c += 1
        company_counter[company] = c

        c = product_counter.get(product, 0)
        c += 1
        product_counter[product] = c

        c = company_product_counter.get(company_product, 0)
        c += 1
        company_product_counter[company_product] = c

        c_obj = company_impact_severity.get(company, {'LOW':0, 'MEDIUM':0,␣
↪'HIGH':0, 'CRITICAL':0, 'unknown':0})
        c_obj[impact_severity] = c_obj[impact_severity] + 1
        company_impact_severity[company] = c_obj
```

[398]:
```
data = {'company':[], 'count':[]}
for key, value in company_counter.items():
    data['company'].append(f'{key}')
    data['count'].append(value)

company_count_df = pd.DataFrame(data)
company_count_df.sort_values(by=['count'], ascending=False, inplace=True)
company_count_df.reset_index(drop=True, inplace=True)
company_count_filtered_gt_n = company_count_df[company_count_df['count'] >=␣
↪5000]
```

[399]:
```
print('Total impacted products: ', sum(company_count_df['count']))
```

```
Total impacted products:  1636445
```

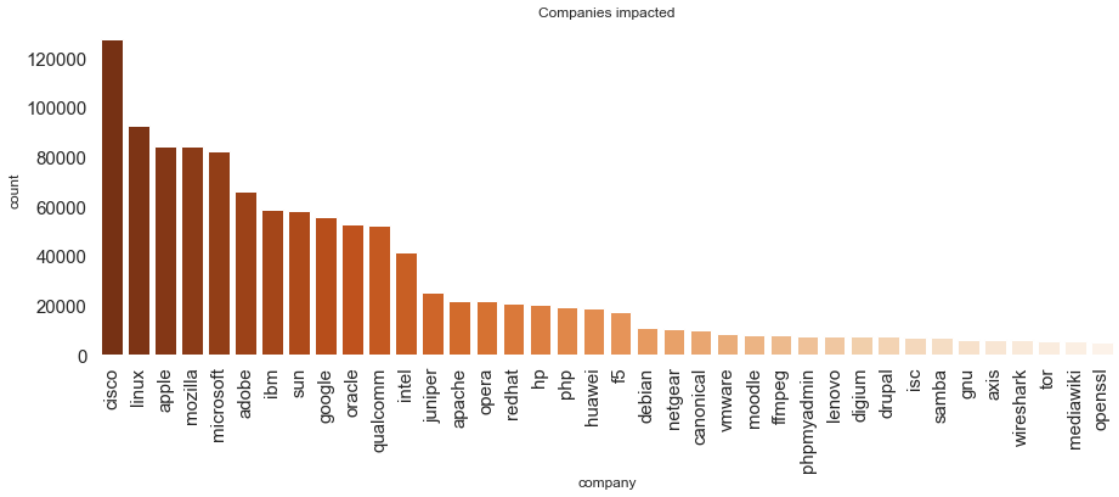
[400]:
```
company_count_filtered_gt_n
```

[400]:

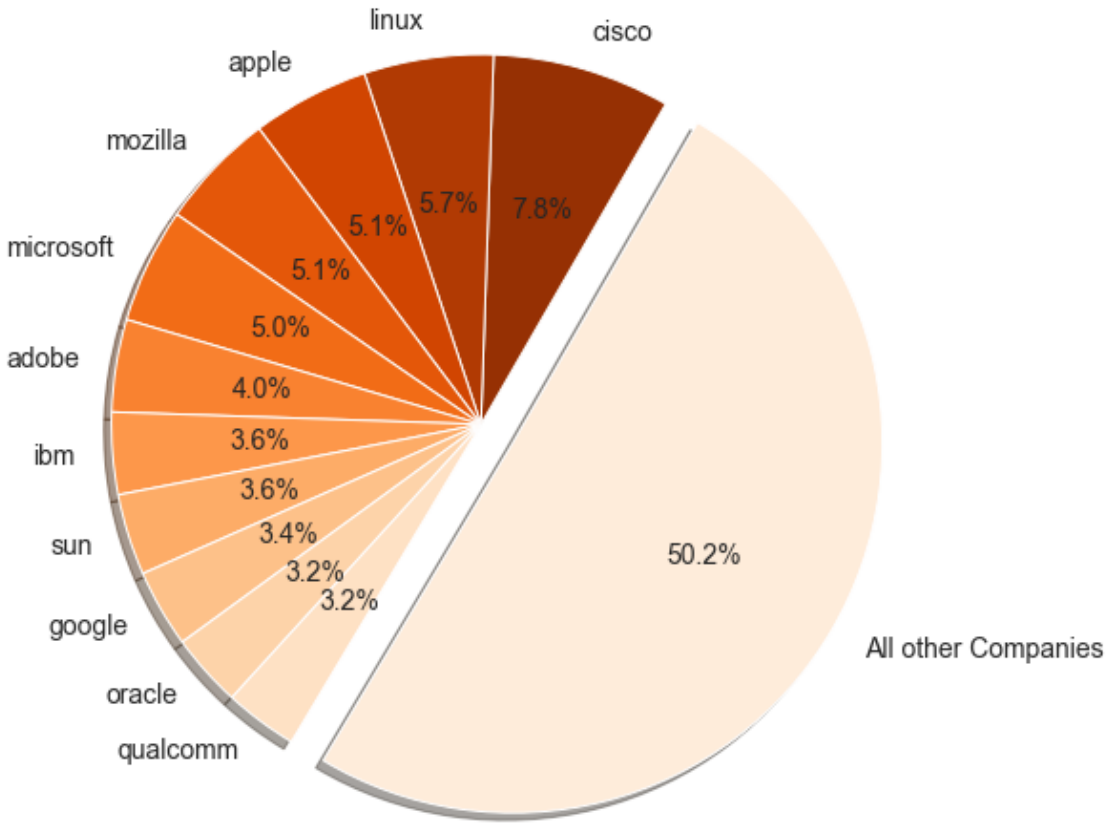
	company	count
0	cisco	127417
1	linux	92648
2	apple	84128
3	mozilla	84066
4	microsoft	82450
5	adobe	66114
6	ibm	58708
7	sun	58173
8	google	55781
9	oracle	52521
10	qualcomm	52218
11	intel	41546

12	juniper	25022
13	apache	21794
14	opera	21704
15	redhat	20702
16	hp	20434
17	php	19284
18	huawei	18894
19	f5	17081
20	debian	10733
21	netgear	10460
22	canonical	9757
23	vmware	8563
24	moodle	7845
25	ffmpeg	7815
26	phpmyadmin	7641
27	lenovo	7529
28	digium	7442
29	drupal	7208
30	isc	6868
31	samba	6829
32	gnu	5908
33	axis	5808
34	wireshark	5754
35	tor	5411
36	mediawiki	5390
37	openssl	5013

[401]:
```
fig = plt.figure(figsize=(15,5))
ax = sns.barplot(x="company", y="count", palette="Oranges_r",␣
 ↪data=company_count_filtered_gt_n, ci=None);
# plt.yscale('log')
plt.title('Companies impacted')
plt.setp(ax.get_xticklabels(), rotation=90);
plt.rc('xtick', labelsize=15)
plt.rc('ytick', labelsize=15)
plt.rc('figure', titlesize=15)
plt.grid(False)
plt.box(on=None)
```



[402]:
```
less_than_n_cwe = company_count_df[company_count_df['count'] < 50000]['count'].
 ↪sum()
labels = list(company_count_df[company_count_df['count'] >= 50000]['company'])
labels.append('All other Companies')
sizes = list(company_count_df[company_count_df['count'] >= 50000]['count'])
sizes.append(less_than_n_cwe)
explode = (0,0,0,0,0,0,0,0,0,0, 0.1)
# pie_chart_color_list=["#53AAC0", "#53AACC", "#69C5E0", "#8DDBEB", "#D1F5FA"]
# pie_chart_color_list=["#69C5EE", "#69C5E0", "#8DDBEB", "#D1F5FA","#69C5EE",␣
 ↪"#69C5E0", "#8DDBEB",  '#BFBFBD']
# pie_chart_color_list=["#53AACC",'#ffcc99' ,'#66b3ff','#99ff99','#ff9999']

fig1, ax1 = plt.subplots(figsize=(8,8))
#
# colors=pie_chart_color_list,

ax1.pie(sizes, labels=labels, autopct='%1.1f%%', colors=sns.
 ↪color_palette("Oranges_r", 12),
        shadow=True, startangle=60,  textprops={'fontsize': 14},␣
 ↪explode=explode)
ax1.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.

plt.show()
print(sum(sizes))
print(labels)
```




```
1636445
['cisco', 'linux', 'apple', 'mozilla', 'microsoft', 'adobe', 'ibm', 'sun',
'google', 'oracle', 'qualcomm', 'All other Companies']
```

[403]:
```
data = {'product':[], 'count':[]}
for key, value in product_counter.items():
    data['product'].append(f'{key}')
    data['count'].append(value)

product_count_df = pd.DataFrame(data)
product_count_df.sort_values(by=['count'], ascending=False, inplace=True)
product_count_df.reset_index(drop=True, inplace=True)
product_count_filtered_gt_n = product_count_df[product_count_df['count'] >=␣
↪5000]
```

[404]:
```
product_count_filtered_gt_n
```

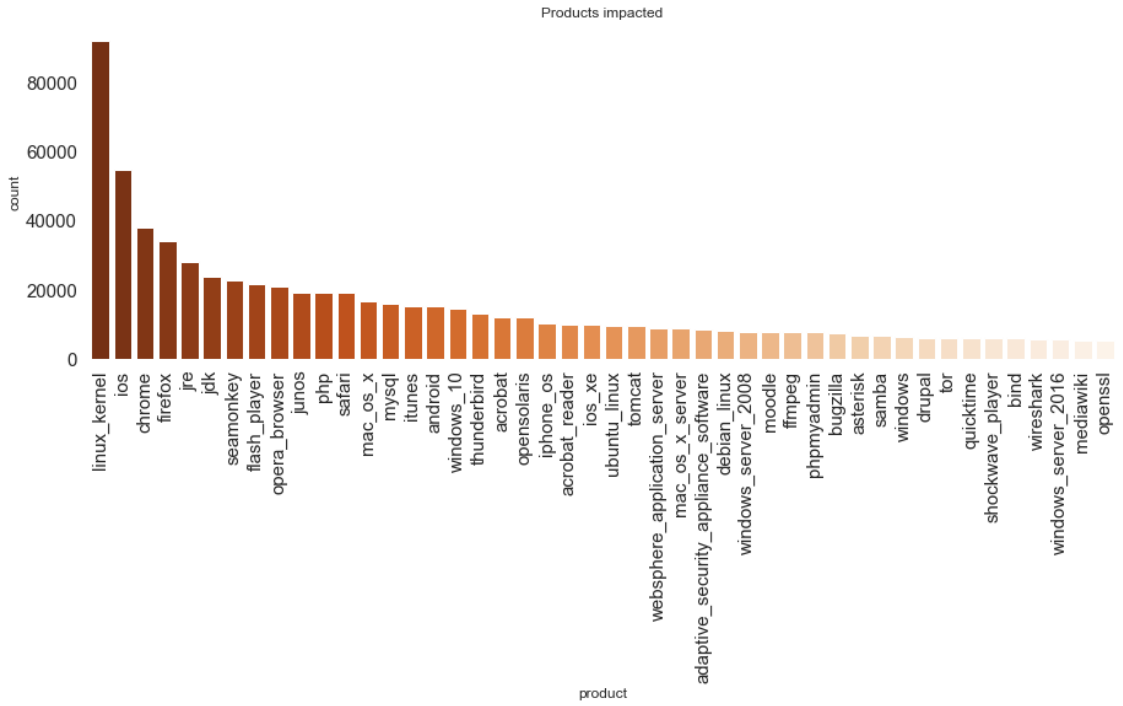
[404]:

	product	count
0	linux_kernel	92410
1	ios	54799

2	chrome	38318
3	firefox	34344
4	jre	28192
5	jdk	23900
6	seamonkey	22808
7	flash_player	21707
8	opera_browser	20975
9	junos	19218
10	php	19180
11	safari	19176
12	mac_os_x	16568
13	mysql	16174
14	itunes	15485
15	android	15414
16	windows_10	14651
17	thunderbird	13259
18	acrobat	12209
19	opensolaris	11929
20	iphone_os	10352
21	acrobat_reader	10025
22	ios_xe	9958
23	ubuntu_linux	9604
24	tomcat	9587
25	websphere_application_server	9059
26	mac_os_x_server	8977
27	adaptive_security_appliance_software	8360
28	debian_linux	8081
29	windows_server_2008	7869
30	moodle	7845
31	ffmpeg	7810
32	phpmyadmin	7644
33	bugzilla	7316
34	asterisk	6785
35	samba	6750
36	windows	6289
37	drupal	6188
38	tor	6174
39	quicktime	6174
40	shockwave_player	6124
41	bind	5878
42	wireshark	5754
43	windows_server_2016	5644
44	mediawiki	5365
45	openssl	5294

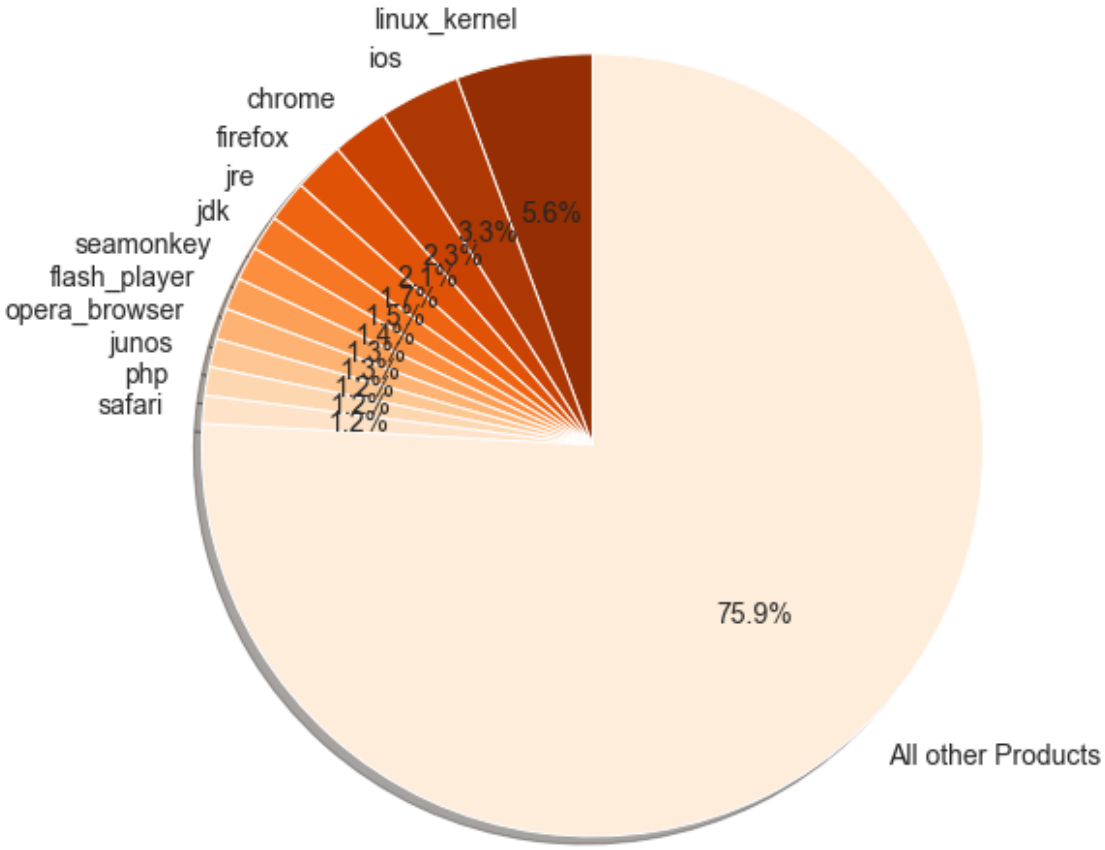
[405]:
```
fig = plt.figure(figsize=(15,5))
```

```
ax = sns.barplot(x="product", y="count", palette="Oranges_r",␣
 ↪data=product_count_filtered_gt_n, ci=None);
# plt.yscale('log')
plt.title('Products impacted')
plt.setp(ax.get_xticklabels(), rotation=90);
plt.rc('xtick', labelsize=15)
plt.rc('ytick', labelsize=15)
plt.rc('figure', titlesize=15)
plt.grid(False)
plt.box(on=None)
```



[406]:
```
less_than_n_cwe = product_count_df[product_count_df['count'] < 17000]['count'].
 ↪sum()
labels = list(product_count_df[product_count_df['count'] >= 17000]['product'])
labels.append('All other Products')
sizes = list(product_count_df[product_count_df['count'] >= 17000]['count'])
sizes.append(less_than_n_cwe)
# explode = (0,0,0,0,0,0,0,0,0,0,0, 0.1)
# pie_chart_color_list=["#53AAC0", "#53AACC", "#69C5E0", "#8DDBEB", "#D1F5FA"]
# pie_chart_color_list=["#69C5EE", "#69C5E0", "#8DDBEB", "#D1F5FA","#69C5EE",␣
 ↪"#69C5E0", "#8DDBEB",  '#BFBFBD']
# pie_chart_color_list=["#53AACC",'#ffcc99' ,'#66b3ff','#99ff99','#ff9999']

fig1, ax1 = plt.subplots(figsize=(8,8))
```

```
#
# colors=pie_chart_color_list,

ax1.pie(sizes, labels=labels, autopct='%1.1f%%', colors=sns.
 ↪color_palette("Oranges_r",13),
        shadow=True, startangle=90,  textprops={'fontsize': 14}) #␣
 ↪explode=explode
ax1.axis('equal')

plt.show()
print(sum(sizes))
```




```
1636445
```

[514]:
```
most_impacted_comp = ['cisco', 'linux', 'apple', 'mozilla', 'microsoft',␣
 ↪'adobe', 'ibm', 'sun', 'google', 'oracle', 'qualcomm']

data = {'company': [],
        'CRITICAL': [],
```

```
        'HIGH': [],
        'MEDIUM': [],
        'LOW':[],
        'unknown': [],
        'Total_impacts_only': [],
        'Total_all': []}

for comp_name in company_impact_severity:
    if comp_name in most_impacted_comp:
        data['company'].append(comp_name)
        data['unknown'].append(company_impact_severity[comp_name]['unknown'])
        data['CRITICAL'].append(company_impact_severity[comp_name]['CRITICAL'])
        data['HIGH'].append(company_impact_severity[comp_name]['HIGH'])
        data['MEDIUM'].append(company_impact_severity[comp_name]['MEDIUM'])
        data['LOW'].append(company_impact_severity[comp_name]['LOW'])
        s1 = sum([company_impact_severity[comp_name]['LOW'],
                                company_impact_severity[comp_name]['MEDIUM'],
                                company_impact_severity[comp_name]['HIGH'],
                               ␣
 ↪company_impact_severity[comp_name]['CRITICAL']])
        s2 = company_impact_severity[comp_name]['unknown'] + s1
        data['Total_impacts_only'].append(s1)
        data['Total_all'].append(s2)
```

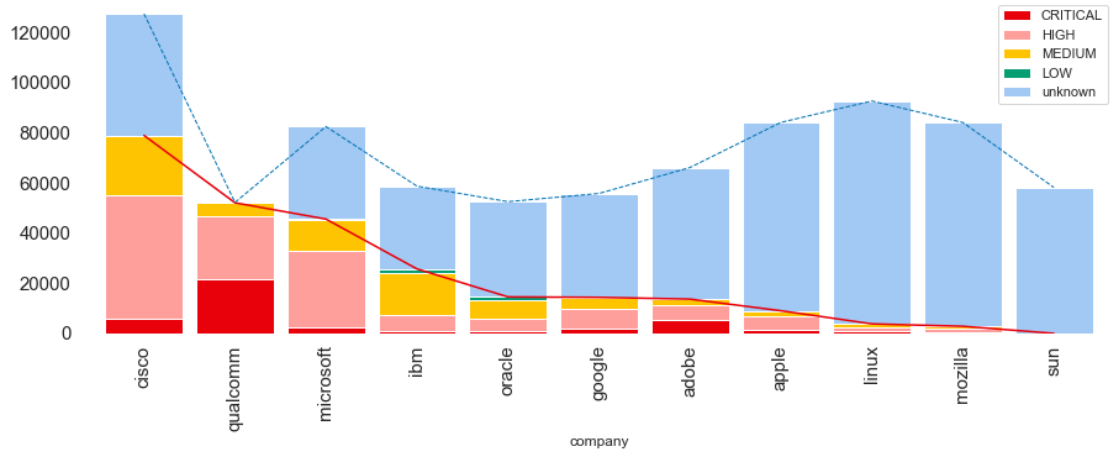
[515]:
```
company_impact_df = pd.DataFrame(data)
```

[517]:
```
company_impact_df.sort_values(by=['Total_impacts_only'], inplace=True,
                              ascending=False)
total_impacts_only = company_impact_df['Total_impacts_only']
total_all = company_impact_df['Total_all']

company_impact_df.drop(['Total_impacts_only', 'Total_all'], axis=1,␣
 ↪inplace=True)
```

[518]:
```
company_impact_df.set_index('company', drop=True, inplace=True)
```

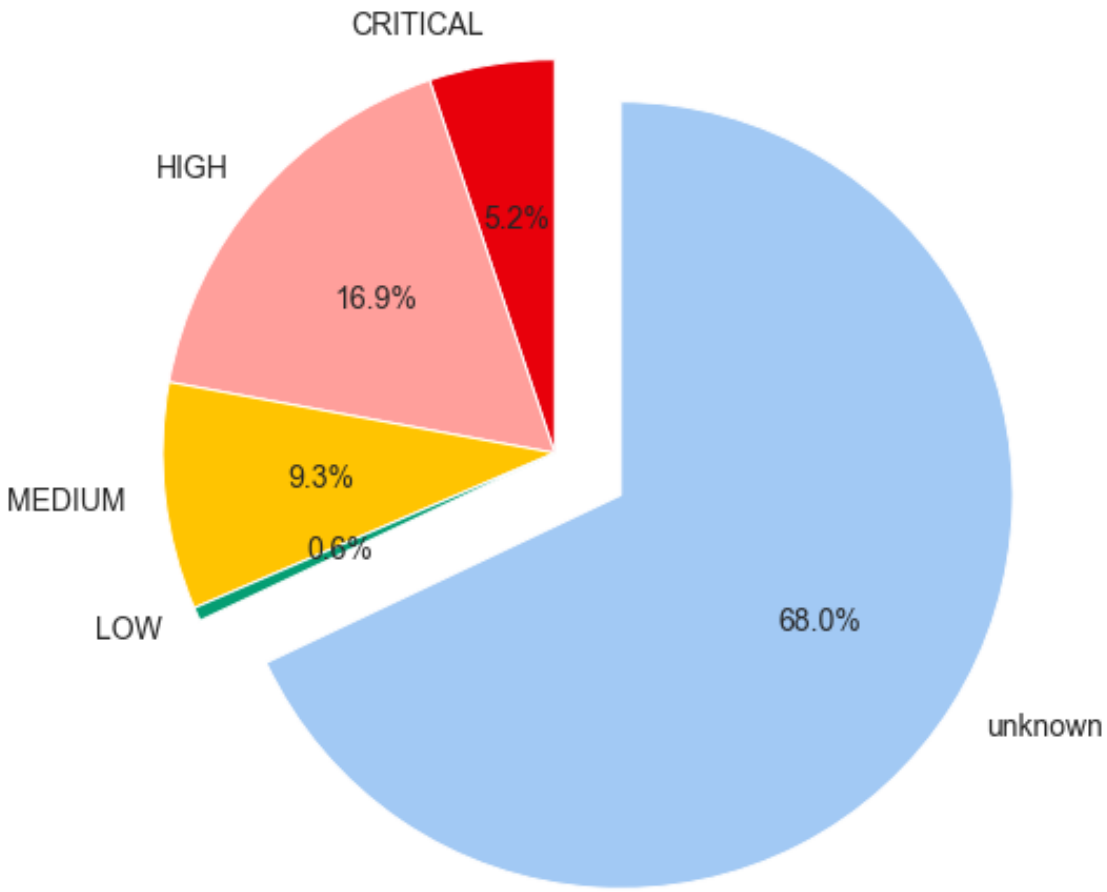
[535]:
```
ax = company_impact_df.plot(
    kind='bar', stacked=True,
    colormap=ListedColormap(
        ['#E8000B',
         '#FF9F9B',
         '#FFC401',
         '#059E73',
        '#A2C9F4'
        ]), width=0.85, figsize=(15,5));
```

```
ax.plot(company_impact_df.index, total_impacts_only, color='#E8000B',␣
 ↪linestyle='-')
ax.plot(company_impact_df.index, total_all, color='#0073B2', linewidth=1,␣
 ↪linestyle='--')
plt.grid(False)
plt.box(on=None);
```



[540]:
```
sizes = [company_impact_df['CRITICAL'].sum(),
         company_impact_df['HIGH'].sum(),
         company_impact_df['MEDIUM'].sum(),
         company_impact_df['LOW'].sum(),
         company_impact_df['unknown'].sum()]
labels = ['CRITICAL', 'HIGH', 'MEDIUM', 'LOW', 'unknown']
fig1, ax1 = plt.subplots(figsize=(8,8))

ax1.pie(sizes, labels=labels, autopct='%1.1f%%', colors=['#E8000B',
          '#FF9F9B',
          '#FFC401',
          '#059E73',
         '#A2C9F4'
         ],
         explode=(0,0,0,0,0.2),
         shadow=False, startangle=90,  textprops={'fontsize': 14}) #␣
 ↪explode=explode
ax1.axis('equal');
print(sum(sizes))
```

814224



[528]:
```
sizes
```

[528]: [42092, 137972, 75962, 4586, 553612]