# Freedom of Information Requests in the Region of Waterloo

"*The Waterloo Region strives to be open, transparent and accountable to citizens. Through a number of projects and initiatives, the Region is empowering citizens to become m government information.*" [https://www.regionofwaterloo.ca/en/regional-government/open-government.aspx (https://www.regionofwaterloo.ca/en/regional-government/open-g

One of those initiatives is *Open Data*. With this, the Region shares its data for everyone to use and republish with few restrictions. The data is provided in machine-readable forr

While searching the Region's Open Data Portal, one finds the *Freedom of Information Requests* (*FOIR*) data set. This data set spans 18 years. https://rowopendata-rmw.openda (https://rowopendata-rmw.opendata.arcgis.com/)

So let's find what this set holds and see if one can use machine learning to predict the outcome of a request based on the decisions made between 1999 and 2016.

## Importing, cleaning, and getting to know the data

First, let's import few must have libraries for such task:

- pandas - to be able to work work dataframes
- matplot and seaborn - to make plots
- numpy - for scientific computing

In [247]:
```
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
import seaborn as sns
```

Files are similarly named, e.g., *Freedom_of_Information_Requests__1999.csv*, except that they have different years, from 1999 to 2016. So let's add them to a pandas datafram

In [2]:
```
counter = 0
year_first = 1999
year_last = 2016
df = {}    # Dataframe of dataframes
for y in range(year_first, year_last+1):
    file = 'data/Freedom_of_Information_Requests__' + str(y) + '.csv'
    df[counter] = pd.read_csv(file, encoding='utf-8')
    counter += 1
```

In [3]:
```
# Number of files read and turned into dataframes
len(df)
```

Out[3]: 18

Here is how the first few lines of the first file look like,

In [4]:
```
df[0].head(3)
```

Out[4]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision | OBJECTID |
|---|---|---|---|---|---|---|
| **0** | 99001 | General Information | Business | Minutes of Service Delivery Subcommittee of ES... | Partly exempted | 0 |
| **1** | 99002 | General Information | Business | Public Health inspection reports for the {loca... | All disclosed | 1 |
| **2** | 99003 | General Information | Business | Public Health inspection records for {location... | Partly exempted | 2 |

Let's find out if all the files have the same number of columns:

In [5]:
```
for y in range(0, len(df)):
    print(df[y].shape)
```

```
(27, 6)
(19, 6)
(25, 6)
(20, 6)
(24, 6)
(22, 6)
(22, 6)
(23, 6)
(24, 6)
(30, 6)
(39, 6)
(29, 6)
(43, 6)
(41, 6)
(33, 6)
(30, 6)
(43, 6)
(82, 6)
```

In [6]:
```
# Number of columns of the first file
df[0].shape[1]
```

Out[6]:
```
6
```

While all the files have the same number of columns, it is possible that over the years, those columns would not be the same, that the structure of those files has changed. We
all those files into a single stacked dataframe.

In [7]:
```
# How does one get the name of the columns? Call df.columns.values
columnsNamesArr = df[0].columns.values
print(columnsNamesArr)
print(columnsNamesArr[5])
```

```
['Request_Number' 'Request_Type' 'Source' 'Summary_of_Request' 'Decision'
 'OBJECTID']
OBJECTID
```

In [8]:
```
# Start an array with the names of the columns for all the files.
columnsNamesArr = {}
for y in range(0, len(df)):
    columnsNamesArr[y] = df[y].columns.values
```

In [9]:
```
# Find out if they have the same columns or not.
for i in range(0, len(df)-1):
    for j in range(0, df[0].shape[1]):
        assert columnsNamesArr[i][j] == columnsNamesArr[i + 1][j],\
        "The column names are different at (%d, %d) and (%d, %d): '%s' vs. '%s'" %\
        ( i, j, i + 1, j, columnsNamesArr[i][j], columnsNamesArr[i + 1][j])
```

```
---------------------------------------------------------------------------
AssertionError                            Traceback (most recent call last)
<ipython-input-9-b1181b5ce2e0> in <module>()
      2 for i in range(0, len(df)-1):
      3     for j in range(0, df[0].shape[1]):
----> 4         assert columnsNamesArr[i][j] == columnsNamesArr[i + 1][j],        "The column names are different at (%d
( i, j, i + 1, j, columnsNamesArr[i][j], columnsNamesArr[i + 1][j])
      5

AssertionError: The column names are different at (14, 0) and (15, 0): 'Request_Number' vs. 'Request_Number:'
```

In [10]:
```
# Let's do the same, but this time, use all lower case, and strip spaces and colons.
for i in range(0, len(df)-1):
    for j in range(0, df[0].shape[1]):
        assert columnsNamesArr[i][j].lower().strip(' :') == columnsNamesArr[i + 1][j].lower().strip(' :'), \
        "The column names are still different at (%d, %d) and (%d, %d): '%s' vs. '%s'" %\
        ( i, j, i + 1, j, columnsNamesArr[i][j], columnsNamesArr[i + 1][j])
```

In [11]:
```
# As an example of what the stripping does:
i = 14
j = 0
print("The column name of (%d, %d) before .lower().strip(' :') is '%s', and after is '%s'." %\
        (i, j, columnsNamesArr[i][j], columnsNamesArr[i][j].lower().strip(' :')))

print("The column name of (%d, %d) before .lower().strip(' :') is '%s', and after is '%s'." %\
        (i + 1, j, columnsNamesArr[i + 1][j], columnsNamesArr[i + 1][j].lower().strip(' :')))
```

```
The column name of (14, 0) before .lower().strip(' :') is 'Request_Number', and after is 'request_number'.
The column name of (15, 0) before .lower().strip(' :') is 'Request_Number:', and after is 'request_number'.
```

In [12]:
```
df[0].columns.values[0]
```

Out[12]:
```
'Request_Number'
```

Now that we know that all columns are the same, let's consolidate the names directly in the dataframe:

In [13]:
```
for i in range(0, 18):
    for j in range(0, df[0].shape[1]):
        df[i].columns.values[j] = df[i].columns.values[j].strip(' :')
```

In [14]:
```
# Check if it worked
i = 14
j = 0
print(df[i].columns.values[j])
print(df[i + 1].columns.values[j])
```

```
Request_Number
Request_Number
```

We can now proceed to concatenate the dataframes into a single one:

In [15]:
```
adf = pd.concat(df, ignore_index=True)
```

In [16]:
```
# Check shape
adf.shape
```

Out[16]:
```
(576, 6)
```

In [17]:
```
adf.head(29)
```

Out[17]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision | OBJECTID |
|---|---|---|---|---|---|---|
| 0 | 99001 | General Information | Business | Minutes of Service Delivery Subcommittee of ES... | Partly exempted | 0 |
| 1 | 99002 | General Information | Business | Public Health inspection reports for the {loca... | All disclosed | 1 |
| 2 | 99003 | General Information | Business | Public Health inspection records for {location... | Partly exempted | 2 |
| 3 | 99004 | General Information | Public | Public Health inspection records for {address ... | All disclosed | 3 |
| 4 | 99005 | General Information | Business | Vendor list report with total of year-to-date ... | All disclosed | 4 |
| 5 | 99006 | Personal Information | Public | Public Health inspection file for {name remove... | All disclosed | 5 |
| 6 | 99007 | General Information | Public | Scope of work and deliverables sections of con... | All disclosed | 6 |
| 7 | 99008 | General Information | Public | Number of contracts and dollar amount of contr... | Withdrawn | 7 |
| 8 | 99009 | Personal Information | Public | Public Health inspection report regarding a co... | All disclosed | 8 |
| 9 | 99010 | General Information | Business | Phase I environmental site assessment regardin... | Withdrawn | 9 |
| 10 | 99011 | General Information | Business | Complete fiscal year end vendor report for yea... | Partly non-existent | 10 |
| 11 | 99012 | Personal Information | Public | A complete copy of Income Maintenance client f... | All disclosed | 11 |
| 12 | 99013 | General Information | Individual by Agent | Rabies control records related to dog bite aff... | Partly exempted | 12 |
| 13 | 99014 | Personal Information | Public | Home Child Care Provider file for {name remove... | Partly exempted | 13 |
| 14 | 99015 | General Information | Business | Records relating to complaint about {location ... | All disclosed | 14 |
| 15 | 99016 | Personal Information | Public | Financial records documenting {name removed} e... | All disclosed | 15 |
| 16 | 99017 | Personal Information | Public | Minutes and notes relating to {name removed} m... | Partly exempted | 16 |
| 17 | 99018 | General Information | Business by Agent | All files relating to tendering, construction,... | Withdrawn | 17 |
| 18 | 99019 | General Information | Public | List of all radio frequencies used by Region o... | Forwarded out | 18 |
| 19 | 99020 | General Information | Business | Copies of purchase orders for last 12 months i... | Withdrawn | 19 |
| 20 | 99021 | Personal Information | Public | {Name removed} personnel file for the period 1... | Withdrawn | 20 |
| 21 | 99022 | Personal Information | Public | Complaint dated November 1, 1999 in {name remo... | Partly exempted | 21 |
| 22 | 99023 | General Information | Business | All reports, studies and documents pertaining ... | No record exists | 22 |
| 23 | 99024 | Personal Information | Public | Home Child Care Provider file for {name remove... | Partly exempted | 23 |
| 24 | 99025 | General Information | Individual by Agent | By-Law officer's notes regarding charges again... | No record exists | 24 |
| 25 | 99026 | General Information | Public | List of all taxi license owners in the City of... | Nothing disclosed | 25 |
| 26 | 99027 | Personal Information | Public | Complaint regarding alleged fraud accusation m... | Withdrawn | 26 |
| 27 | 2000001 | General Information | Business by Agent | Correspondence from 1996 to 1997 regarding Sha... | Withdrawn | 0 |
| 28 | 2000002 | General Information | Business | Quotation Q99-1154 bidders and pricing informa... | Withdrawn | 1 |

In [18]:
```
adf.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 576 entries, 0 to 575
Data columns (total 6 columns):
Request_Number        576 non-null int64
Request_Type          576 non-null object
Source                576 non-null object
Summary_of_Request    576 non-null object
Decision              576 non-null object
OBJECTID              576 non-null int64
dtypes: int64(2), object(4)
memory usage: 27.1+ KB
```

On further inspection, the OBJECTID column is just the order number in which the request arrived in a particular year, without any further meaning. So I will proceed to drop tha

In [19]:
```
adf = adf.drop(columns=['OBJECTID'])
```

In [20]:
```
adf.head(3)
```

Out[20]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| 0 | 99001 | General Information | Business | Minutes of Service Delivery Subcommittee of ES... | Partly exempted |
| 1 | 99002 | General Information | Business | Public Health inspection reports for the {loca... | All disclosed |
| 2 | 99003 | General Information | Business | Public Health inspection records for {location... | Partly exempted |

Before diving into the Machine Learning aspect of this, one needs to know the data better!

*Request_Number* has the file number, unique to each case. *Summary_of_Request* has, as the name says, the summarized version of the request, written by a clerk at the office

For the columns, *Request_Type*, *Source*, and *Decision*, it seems that we have a limited number of options, so let's see how many unique values they have.

Let's start with *Request_Type*:

In [21]:
```
adf.Request_Type.unique()
```

Out[21]:
```
array(['General Information', 'Personal Information', 'Correction',
       'Personal Information/General Information',
       'Personal Health Information/General Information',
       'Personal Health Information',
       'Personal Health Information/General Informaiton',
       'General Records', 'Personal', 'General ',
       'Personal Health Information ', 'General', 'Personal '],
      dtype=object)
```

We see that given typos and extra white spaces, these categories can be combined.

In [22]:
```
adf['Request_Type'] = adf['Request_Type'].str.strip()
print(adf.Request_Type.nunique())
adf.Request_Type.value_counts()
```

```
10
```

Out[22]:
```
General Information                                283
Personal Information                               110
General                                             76
Personal                                            47
General Records                                     36
Personal Health Information/General Information     16
Personal Health Information                          3
Correction                                           2
Personal Information/General Information             2
Personal Health Information/General Informaiton      1
Name: Request_Type, dtype: int64
```

In [23]:
```
adf['Request_Type'] = adf['Request_Type'].str.replace('Informaiton', 'Information')
```

On further inspection (see below), one finds out that the terminology evolved over time. For example, in the early years, it was called *General Information*, then later on it was ca
nowadays, it is called just *General*.

In [24]:
```
adf[(adf['Request_Type'] == 'General Information') | (adf['Request_Type'] == 'General Records')]
```

Out[24]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **0** | 99001 | General Information | Business | Minutes of Service Delivery Subcommittee of ES... | Partly exempted |
| **1** | 99002 | General Information | Business | Public Health inspection reports for the {loca... | All disclosed |
| **2** | 99003 | General Information | Business | Public Health inspection records for {location... | Partly exempted |
| **3** | 99004 | General Information | Public | Public Health inspection records for {address ... | All disclosed |
| **4** | 99005 | General Information | Business | Vendor list report with total of year-to-date ... | All disclosed |
| **6** | 99007 | General Information | Public | Scope of work and deliverables sections of con... | All disclosed |
| **7** | 99008 | General Information | Public | Number of contracts and dollar amount of contr... | Withdrawn |
| **9** | 99010 | General Information | Business | Phase I environmental site assessment regardin... | Withdrawn |
| **10** | 99011 | General Information | Business | Complete fiscal year end vendor report for yea... | Partly non-existent |
| **12** | 99013 | General Information | Individual by Agent | Rabies control records related to dog bite aff... | Partly exempted |
| **14** | 99015 | General Information | Business | Records relating to complaint about {location ... | All disclosed |
| **17** | 99018 | General Information | Business by Agent | All files relating to tendering, construction,... | Withdrawn |
| **18** | 99019 | General Information | Public | List of all radio frequencies used by Region o... | Forwarded out |
| **19** | 99020 | General Information | Business | Copies of purchase orders for last 12 months i... | Withdrawn |
| **22** | 99023 | General Information | Business | All reports, studies and documents pertaining ... | No record exists |
| **24** | 99025 | General Information | Individual by Agent | By-Law officer's notes regarding charges again... | No record exists |
| **25** | 99026 | General Information | Public | List of all taxi license owners in the City of... | Nothing disclosed |
| **27** | 2000001 | General Information | Business by Agent | Correspondence from 1996 to 1997 regarding Sha... | Withdrawn |
| **28** | 2000002 | General Information | Business | Quotation Q99-1154 bidders and pricing informa... | Withdrawn |
| **29** | 2000003 | General Information | Business by Agent | Public Health Inspection reports and records r... | Partly exempted |
| **32** | 2000006 | General Information | Public | Public Health Inspection report dated March 20... | All disclosed |
| **33** | 2000007 | General Information | Public | Submissions received by Regional Councillors r... | All disclosed |
| **36** | 2000010 | General Information | Business | Phase 1 environmental site assessments for {ad... | Withdrawn |
| **37** | 2000011 | General Information | Business | Copy of {company name removed} tender bid for ... | All disclosed |
| **38** | 2000012 | General Information | Business | Copies of purchase orders in range of $5,000 t... | Partly exempted |
| **42** | 2000016 | General Information | Public | Letter regarding pay equity plan to {name remo... | Forwarded out |
| **43** | 2000017 | General Information | Business | Public Health inspections, complaints and viol... | Partly exempted |
| **44** | 2000018 | General Information | Individual by Agent | Any and all records regarding a multi vehicle ... | Partly exempted |
| **45** | 2001019 | General Information | Business | Contract between {company name removed} and th... | All disclosed |
| **48** | 2001003 | General Information | Business by Agent | All records regarding St. Clements Pumping Sta... | Partly exempted |
| **...** | ... | ... | ... | ... | ... |
| **395** | 2013008 | General Records | Business | Proposal PQ2012-03 - Preston WWTP; notes, eval... | Partly exempted |
| **396** | 2013009 | General Records | Business | Proposal PQ2012-03 - Preston WWTP; all submiss... | Partly exempted |
| **397** | 2013010 | General Records | Media | Records related to the dismissal of {name and ... | Nothing disclosed |
| **398** | 2013011 | General Records | Business | Phase I environmental site assessment for {add... | Withdrawn |
| **399** | 2013012 | General Records | Public | Food-borne illness complaint records for {comp... | All disclosed |
| **400** | 2013013 | General Records | Media | Lease, negotiations and breakdown of costs for... | Partly exempted |
| **401** | 2013014 | General Records | Business | Pool and spa inspection records for {address r... | All disclosed |
| **402** | 2013015 | General Records | Individual by Agent | Arborist inspection, complaints, tree maintena... | Partly exempted |
| **403** | 2013016 | General Records | Individual by Agent | Multiple transportation operations and enginee... | All disclosed |
| **404** | 2013017 | General Records | Business | Identity and affiliation of freedom of informa... | All disclosed |
| **406** | 2013019 | General Records | Public | Information relating to the planning and costs... | Withdrawn |
| **410** | 2013023 | General Records | Individual by Agent | Contract with City of Guelph for organics proc... | Partly exempted |
| **413** | 2013026 | General Records | Public | All records related to contracts and/or fundin... | All disclosed |
| **414** | 2013027 | General Records | Individual by Agent | Occurrence report, notes, witness statements a... | Forwarded out |
| **416** | 2013029 | General Records | Individual by Agent | Records related to Official Plan Amendment 25 ... | Partly exempted |
| **417** | 2013030 | General Records | Individual by Agent | Video recording from Grand River Transit bus r... | All disclosed |
| **418** | 2013031 | General Records | Public | Contracts issued for the Waterloo Wastewater T... | Withdrawn |
| **419** | 2013032 | General Records | Public | Agreement between Region of Waterloo and Metro... | All disclosed |
| **420** | 2013033 | General Records | Business | Financial records and audited statements regar... | All disclosed |
| **422** | 2014002 | General Records | Individual by Agent | Camera recording at {address removed} from Sep... | No record exists |
| **423** | 2014003 | General Records | Media | Records related to the dismissal of {name and ... | Nothing disclosed |

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **428** | 2014008 | General Records | Business | Phase I environemntal site assesment for {addr... | Withdrawn |
| **429** | 2014009 | General Records | Business | 1998 Reconnaissance TCE Investigation for {add... | All disclosed |
| **434** | 2014014 | General Records | Public | Financial reporting, statements and audits for... | Partly non-existent |
| **436** | 2014016 | General Records | Public | Any and all records related to {organization n... | Nothing disclosed |
| **440** | 2014020 | General Records | Public | All correspondence between the Region of Water... | Partly exempted |
| **441** | 2014021 | General Records | Public | All records related to the possiblity of makin... | Nothing disclosed |
| **442** | 2014022 | General Records | Public | Any and all correspondence between the Regiona... | Partly exempted |
| **443** | 2014023 | General Records | Media | Project agreement between Region of Waterloo a... | Partly exempted |
| **450** | 2014030 | General Records | Individual by Agent | A file search for tobacco on {company name and... | All disclosed |

319 rows × 5 columns

In [25]:
```
adf[(adf['Request_Type'] == 'General Information') | (adf['Request_Type'] == 'General')]
```

Out[25]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **0** | 99001 | General Information | Business | Minutes of Service Delivery Subcommittee of ES... | Partly exempted |
| **1** | 99002 | General Information | Business | Public Health inspection reports for the {loca... | All disclosed |
| **2** | 99003 | General Information | Business | Public Health inspection records for {location... | Partly exempted |
| **3** | 99004 | General Information | Public | Public Health inspection records for {address ... | All disclosed |
| **4** | 99005 | General Information | Business | Vendor list report with total of year-to-date ... | All disclosed |
| **6** | 99007 | General Information | Public | Scope of work and deliverables sections of con... | All disclosed |
| **7** | 99008 | General Information | Public | Number of contracts and dollar amount of contr... | Withdrawn |
| **9** | 99010 | General Information | Business | Phase I environmental site assessment regardin... | Withdrawn |
| **10** | 99011 | General Information | Business | Complete fiscal year end vendor report for yea... | Partly non-existent |
| **12** | 99013 | General Information | Individual by Agent | Rabies control records related to dog bite aff... | Partly exempted |
| **14** | 99015 | General Information | Business | Records relating to complaint about {location ... | All disclosed |
| **17** | 99018 | General Information | Business by Agent | All files relating to tendering, construction,... | Withdrawn |
| **18** | 99019 | General Information | Public | List of all radio frequencies used by Region o... | Forwarded out |
| **19** | 99020 | General Information | Business | Copies of purchase orders for last 12 months i... | Withdrawn |
| **22** | 99023 | General Information | Business | All reports, studies and documents pertaining ... | No record exists |
| **24** | 99025 | General Information | Individual by Agent | By-Law officer's notes regarding charges again... | No record exists |
| **25** | 99026 | General Information | Public | List of all taxi license owners in the City of... | Nothing disclosed |
| **27** | 2000001 | General Information | Business by Agent | Correspondence from 1996 to 1997 regarding Sha... | Withdrawn |
| **28** | 2000002 | General Information | Business | Quotation Q99-1154 bidders and pricing informa... | Withdrawn |
| **29** | 2000003 | General Information | Business by Agent | Public Health Inspection reports and records r... | Partly exempted |
| **32** | 2000006 | General Information | Public | Public Health Inspection report dated March 20... | All disclosed |
| **33** | 2000007 | General Information | Public | Submissions received by Regional Councillors r... | All disclosed |
| **36** | 2000010 | General Information | Business | Phase 1 environmental site assessments for {ad... | Withdrawn |
| **37** | 2000011 | General Information | Business | Copy of {company name removed} tender bid for ... | All disclosed |
| **38** | 2000012 | General Information | Business | Copies of purchase orders in range of $5,000 t... | Partly exempted |
| **42** | 2000016 | General Information | Public | Letter regarding pay equity plan to {name remo... | Forwarded out |
| **43** | 2000017 | General Information | Business | Public Health inspections, complaints and viol... | Partly exempted |
| **44** | 2000018 | General Information | Individual by Agent | Any and all records regarding a multi vehicle ... | Partly exempted |
| **45** | 2001019 | General Information | Business | Contract between {company name removed} and th... | All disclosed |
| **48** | 2001003 | General Information | Business by Agent | All records regarding St. Clements Pumping Sta... | Partly exempted |
| **...** | ... | ... | ... | ... | ... |
| **536** | 2016043 | General | Individual | All emails, letters and meeting reports and no... | Information disclosed in part |
| **537** | 2016044 | General | Business | All information and/or documents pertaining to... | No records exist |
| **538** | 2016045 | General | Individual by agent | Whatever documentation you might have that my ... | Information disclosed in part |
| **543** | 2016050 | General | Individual | The winning proposal for P2016-13 for Multicul... | Withdrawn |
| **544** | 2016051 | General | Business | Records involving any environmental contaminat... | Withdrawn |
| **546** | 2016053 | General | Individual by agent | A copy of the video surveillance of Grand Rive... | Information disclosed in part |
| **547** | 2016054 | General | Individual by agent | Video from westbound stopped Grand River Trans... | Information disclosed in part |
| **550** | 2016057 | General | Individual | Information related to the spurline trail, spe... | All Information disclosed |
| **551** | 2016058 | General | Individual | All by-law complaints and investigations relat... | Abandoned |
| **552** | 2016059 | General | Individual by agent | Complete highway traffic act file and transcri... | Transferred |
| **553** | 2016060 | General | Individual | The status and timing sequence of the traffic ... | Abandoned |
| **556** | 2016063 | General | Individual | Total number of EMS calls; number of times eac... | All Information disclosed |
| **557** | 2016064 | General | Individual | Video from Grand River Transit Bus #8017 on Ro... | Information disclosed in part |
| **558** | 2016065 | General | Individual by agent | Employment file and other relevant financial i... | Withdrawn |
| **559** | 2016066 | General | Business | Records relating to environmental spills, repo... | All Information disclosed |
| **560** | 2016067 | General | Individual | Names of security guards working at the Ainsli... | All Information disclosed |
| **561** | 2016068 | General | Individual | List of contact information for all small drin... | Abandoned |
| **562** | 2016069 | General | Individual by agent | Copy of {name removed} rabies file including a... | Information disclosed in part |
| **563** | 2016070 | General | Business | Copy of the statements obtained from anyone di... | Information disclosed in part |
| **564** | 2016071 | General | Individual by agent | Video surveillance of bus accident on October ... | Abandoned |
| **565** | 2016072 | General | Individual by agent | Records with respect to any medical incidents ... | Information disclosed in part |

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **566** | 2016073 | General | Individual | A copy of the contractor evaluation forms for ... | Withdrawn |
| **567** | 2016074 | General | Individual | A copy of the contractor evaluation forms for ... | Withdrawn |
| **568** | 2016075 | General | Individual | A copy of the contractor evaluation forms for ... | Withdrawn |
| **569** | 2016076 | General | Business | Copy of the statements obtained from anyone di... | All Information disclosed |
| **570** | 2016077 | General | Business | Any records or any environmental concerns rega... | Information disclosed in part |
| **571** | 2016078 | General | Business | 3 reports completed for the Former Kitchener L... | All Information disclosed |
| **572** | 2016079 | General | Media | All records related to notices filed in connec... | No information disclosed |
| **574** | 2016081 | General | Business | Grand River Transit video surveillance for the... | Abandoned |
| **575** | 2016082 | General | Individual by agent | Grand River Transit video surveillance for bus... | All Information disclosed |

359 rows × 5 columns

It is the same case for *Personal Information* and *Personal*.

In [26]:
```
adf[(adf['Request_Type'] == 'Personal Information') | (adf['Request_Type'] =='Personal')]
```

Out[26]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **5** | 99006 | Personal Information | Public | Public Health inspection file for {name remove... | All disclosed |
| **8** | 99009 | Personal Information | Public | Public Health inspection report regarding a co... | All disclosed |
| **11** | 99012 | Personal Information | Public | A complete copy of Income Maintenance client f... | All disclosed |
| **13** | 99014 | Personal Information | Public | Home Child Care Provider file for {name remove... | Partly exempted |
| **15** | 99016 | Personal Information | Public | Financial records documenting {name removed} e... | All disclosed |
| **16** | 99017 | Personal Information | Public | Minutes and notes relating to {name removed} m... | Partly exempted |
| **20** | 99021 | Personal Information | Public | {Name removed} personnel file for the period 1... | Withdrawn |
| **21** | 99022 | Personal Information | Public | Complaint dated November 1, 1999 in {name remo... | Partly exempted |
| **23** | 99024 | Personal Information | Public | Home Child Care Provider file for {name remove... | Partly exempted |
| **26** | 99027 | Personal Information | Public | Complaint regarding alleged fraud accusation m... | Withdrawn |
| **30** | 2000004 | Personal Information | Public | Home Child Care Provider file for {name remove... | Withdrawn |
| **31** | 2000005 | Personal Information | Public | Public Health Inspection reports about food-bo... | Partly exempted |
| **34** | 2000008 | Personal Information | Public | Public Health Inspection reports and laborator... | Partly exempted |
| **35** | 2000009 | Personal Information | Public | Income Maintenance narrative notes from 1991 t... | Partly exempted |
| **39** | 2000013 | Personal Information | Business by Agent | Access to client/family data in Healthy Babies... | All disclosed |
| **41** | 2000015 | Personal Information | Individual by Agent | A complete copy of Ontario Works client file f... | Partly exempted |
| **46** | 2001001 | Personal Information | Public | Social Assistance client file for {name remove... | All disclosed |
| **47** | 2001002 | Personal Information | Public | All records about {name removed}, including fo... | Withdrawn |
| **52** | 2001007 | Personal Information | Individual by Agent | A copy of Ontario Works client file for {name ... | All disclosed |
| **66** | 2001021 | Personal Information | Public | Rent receipts from 1997 to present in Ontario ... | All disclosed |
| **67** | 2001022 | Personal Information | Public | Rent receipts from 1997 to present in Ontario ... | No record exists |
| **68** | 2001023 | Personal Information | Public | A copy of Ontario Works client file for {name ... | All disclosed |
| **70** | 2001025 | Personal Information | Individual by Agent | Home Child Care Provider file for {name removed}. | Partly exempted |
| **71** | 2002001 | Personal Information | Individual by Agent | A complete copy of Ontario Works client file f... | Partly exempted |
| **72** | 2002002 | Personal Information | Individual by Agent | Payment history from Social Assistance for {na... | All disclosed |
| **77** | 2002007 | Personal Information | Public | Records related to Trees By-law charge against... | Partly exempted |
| **80** | 2002010 | Personal Information | Public | Personal information for {name removed} in Com... | Partly exempted |
| **81** | 2002011 | Personal Information | Public | A copy of Ontario Works client file for {name ... | All disclosed |
| **84** | 2002014 | Personal Information | Public | All files related to {name removed} held by Wa... | Partly exempted |
| **94** | 2003004 | Personal Information | Individual by Agent | Records regarding alleged food borne illness a... | All disclosed |
| **...** | ... | ... | ... | ... | ... |
| **483** | 2015033 | Personal | Individual by agent | Complete Ontario Works file of {name removed} | No responsive records exist |
| **484** | 2015034 | Personal | Individual by agent | Complete Ontario Works file of {name removed} | Information disclosed in part |
| **486** | 2015036 | Personal | Individual by agent | Complete Ontario Works file of {name removed} | All information disclosed |
| **492** | 2015042 | Personal | Individual | Court documentation from 1996 to present; all ... | No responsive records exist |
| **493** | 2015043 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Information disclosed in part |
| **498** | 2016005 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Information disclosed in part |
| **499** | 2016006 | Personal | Individual by agent | All records concerning {name removed} in the p... | Withdrawn |
| **500** | 2016007 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Information disclosed in part |
| **503** | 2016010 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Abandoned |
| **506** | 2016013 | Personal | Individual | Any and all records, emails and correspondence... | Information disclosed in part |
| **507** | 2016014 | Personal | Individual for dependant | Grand River Transit video surveillance. | Abandoned |
| **512** | 2016019 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Information disclosed in part |
| **513** | 2016020 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Information disclosed in part |
| **514** | 2016021 | Personal | Individual by agent | Complete copy of the Ontario Works file for {i... | Abandoned |
| **517** | 2016024 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | No records exist |
| **518** | 2016025 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Information disclosed in part |
| **528** | 2016035 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Information disclosed in part |
| **530** | 2016037 | Personal | Individual by agent | Complete copy of the Ontario Works file for {n... | Abandoned |
| **533** | 2016040 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **534** | 2016041 | Personal | Individual | Copies of all records about me, which are retr... | Information disclosed in part |
| **539** | 2016046 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | Information disclosed in part |

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **540** | 2016047 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **541** | 2016048 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **542** | 2016049 | Personal | Individual | Any records documenting attendance at a Minis... | All Information disclosed |
| **545** | 2016052 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | Withdrawn |
| **548** | 2016055 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **549** | 2016056 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **554** | 2016061 | Personal | Individual | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **555** | 2016062 | Personal | Individual | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **573** | 2016080 | Personal | Individual by agent | Complete copy of Ontario Works file for {name ... | All Information disclosed |

157 rows × 5 columns

We can then proceed to combine those categories.

In [27]:
```
adf['Request_Type'] = adf['Request_Type'].str.replace('Personal Information', 'Personal')
```

In [28]:
```
adf['Request_Type'] = adf['Request_Type'].str.replace('General Information', 'General')
```

In [29]:
```
adf['Request_Type'] = adf['Request_Type'].str.replace('General Records', 'General')
```

In [30]:
```
print(adf.Request_Type.nunique())
adf.Request_Type.value_counts()
```

```
6
```

Out[30]:
```
General                                395
Personal                               157
Personal Health Information/General     17
Personal Health Information              3
Personal/General                         2
Correction                               2
Name: Request_Type, dtype: int64
```

How about other categories?

In [31]:
```
adf[(adf['Request_Type'] == 'Personal Health Information/General')
    | (adf['Request_Type'] =='Personal Health Information')
    | (adf['Request_Type'] =='Personal/General')]
```

Out[31]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decisi |
|---|---|---|---|---|---|
| **78** | 2002008 | Personal/General | Individual by Agent | Rabies incident report records regarding May 2... | All disclos |
| **89** | 2002019 | Personal/General | Individual by Agent | Food-borne illness incident records for {locat... | All disclos |
| **120** | 2004006 | Personal Health Information/General | Public | Rabies control investigation from April 2003 r... | Partly exempt |
| **127** | 2004013 | Personal Health Information/General | Individual by Agent | Rabies control investigation file. | Partly exempt |
| **152** | 2005016 | Personal Health Information/General | Individual by Agent | Food premise inspections of {location removed}... | All disclos |
| **158** | 2005022 | Personal Health Information/General | Individual by Agent | Rabies control investigation file regarding do... | Partly exempt |
| **169** | 2006011 | Personal Health Information | Public | Ambulance Call Report for Emergency Medical Se... | Withdra |
| **177** | 2006019 | Personal Health Information/General | Public | Rabies control investigation file. | All disclos |
| **182** | 2007001 | Personal Health Information/General | Public | Public Health investigation file regarding e-c... | Partly exempt |
| **186** | 2007005 | Personal Health Information/General | Public | Public Health investigation records regarding ... | Partly exempt |
| **189** | 2007008 | Personal Health Information/General | Individual by Agent | Rabies control investigation records affecting... | Partly exempt |
| **190** | 2007009 | Personal Health Information/General | Individual by Agent | Food borne illness investigation at {location ... | No record exi |
| **193** | 2007012 | Personal Health Information/General | Individual by Agent | Rabies control investigation regarding an inci... | Partly exempt |
| **222** | 2008017 | Personal Health Information/General | Individual by Agent | Rabies control investigation file. | Partly exempt |
| **230** | 2008025 | Personal Health Information/General | Individual by Agent | Emergency Medical Services and Waterloo Region... | All disclos |
| **242** | 2009007 | Personal Health Information/General | Individual by Agent | Records regarding cause of death and recalled ... | All disclos |
| **288** | 2010014 | Personal Health Information/General | Individual by Agent | Food-borne Illness investigation regarding e. ... | Partly exempt |
| **350** | 2012004 | Personal Health Information/General | Public | Rabies control investigation records regarding... | Partly exempt |
| **366** | 2012020 | Personal Health Information/General | Public | Rabies control investigation records. | Partly exempt |
| **383** | 2012037 | Personal Health Information/General | Individual by Agent | Rabies control inspection records for incident... | Partly exempt |
| **482** | 2015032 | Personal Health Information | Individual by agent | Investigation file and notes of Natan Somer, P... | Transferred to Region of Waterloo Public Hea |
| **487** | 2015037 | Personal Health Information | Individual | Copy of a report from the early 1990's about a... | Transferred to Region of Waterloo Public Hea |

While there may still be room to combine those categories even further, as *Personal Health Information/General* and *Personal Health Information* seem to involve cases of food-investigations, I chose not to.

This was given that if one takes a look at other requests involving the words *rabies* or *food borne* (see below), those requests turn out to be filed into other categories, such as g a clear difference, or whether it depends on the clerk filing the request, it is unknown to me.

In [32]:
```
adf[(adf['Summary_of_Request'].str.contains('rabies')) | (adf['Summary_of_Request'].str.contains('Rabies'))]
```

Out[32]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **12** | 99013 | General | Individual by Agent | Rabies control records related to dog bite aff... | Partly exempted |
| **78** | 2002008 | Personal/General | Individual by Agent | Rabies incident report records regarding May 2... | All disclosed |
| **101** | 2003011 | Personal | Individual by Agent | Rabies control records from an incident occurr... | Partly exempted |
| **102** | 2003012 | Personal | Individual by Agent | Rabies control records for incident that occur... | Forwarded out |
| **112** | 2003022 | General | Public | Rabies control investigation records regarding... | Partly exempted |
| **120** | 2004006 | Personal Health Information/General | Public | Rabies control investigation from April 2003 r... | Partly exempted |
| **127** | 2004013 | Personal Health Information/General | Individual by Agent | Rabies control investigation file. | Partly exempted |
| **143** | 2005007 | General | Individual by Agent | Owner name and address in rabies control inves... | Partly exempted |
| **146** | 2005010 | General | Business | Rabies control investigation file for incident... | Partly exempted |
| **158** | 2005022 | Personal Health Information/General | Individual by Agent | Rabies control investigation file regarding do... | Partly exempted |
| **177** | 2006019 | Personal Health Information/General | Public | Rabies control investigation file. | All disclosed |
| **189** | 2007008 | Personal Health Information/General | Individual by Agent | Rabies control investigation records affecting... | Partly exempted |
| **193** | 2007012 | Personal Health Information/General | Individual by Agent | Rabies control investigation regarding an inci... | Partly exempted |
| **204** | 2007023 | General | Individual by Agent | Rabies control inspection records involving ca... | Partly exempted |
| **222** | 2008017 | Personal Health Information/General | Individual by Agent | Rabies control investigation file. | Partly exempted |
| **256** | 2009021 | General | Public | Dog owner's identity contained in rabies contr... | All disclosed |
| **312** | 2011009 | General | Individual by Agent | Rabies control investigation file. | All disclosed |
| **350** | 2012004 | Personal Health Information/General | Public | Rabies control investigation records regarding... | Partly exempted |
| **366** | 2012020 | Personal Health Information/General | Public | Rabies control investigation records. | Partly exempted |
| **383** | 2012037 | Personal Health Information/General | Individual by Agent | Rabies control inspection records for incident... | Partly exempted |
| **562** | 2016069 | General | Individual by agent | Copy of {name removed} rabies file including a... | Information disclosed in part |

In [33]:
```
adf[(adf['Summary_of_Request'].str.contains('Food-borne'))
    | (adf['Summary_of_Request'].str.contains('Food borne'))
    | (adf['Summary_of_Request'].str.contains('food borne'))
    | (adf['Summary_of_Request'].str.contains('food-borne'))]
```

Out[33]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **31** | 2000005 | Personal | Public | Public Health Inspection reports about food-bo... | Partly exempted |
| **32** | 2000006 | General | Public | Public Health Inspection report dated March 20... | All disclosed |
| **34** | 2000008 | Personal | Public | Public Health Inspection reports and laborator... | Partly exempted |
| **89** | 2002019 | Personal/General | Individual by Agent | Food-borne illness incident records for {locat... | All disclosed |
| **94** | 2003004 | Personal | Individual by Agent | Records regarding alleged food borne illness a... | All disclosed |
| **129** | 2004015 | Personal | Individual by Agent | Food-borne illness incident records from {loca... | All disclosed |
| **152** | 2005016 | Personal Health Information/General | Individual by Agent | Food premise inspections of {location removed}... | All disclosed |
| **185** | 2007004 | General | Business by Agent | Food-borne illness investigation at {company r... | All disclosed |
| **190** | 2007009 | Personal Health Information/General | Individual by Agent | Food borne illness investigation at {location ... | No record exists |
| **201** | 2007020 | General | Business by Agent | Food-borne illness complaint investigation reg... | Partly exempted |
| **288** | 2010014 | Personal Health Information/General | Individual by Agent | Food-borne Illness investigation regarding e. ... | Partly exempted |
| **399** | 2013012 | General | Public | Food-borne illness complaint records for {comp... | All disclosed |

How about the *Source* column?

In [34]:
```
adf['Source'] = adf['Source'].str.strip()
print(adf.Source.nunique())
adf.Source.value_counts()
```

```
8
```

Out[34]:
```
Business                    198
Public                      132
Individual by Agent         107
Individual by agent          59
Individual                   40
Media                        20
Business by Agent            19
Individual for dependant      1
Name: Source, dtype: int64
```

In [35]:
```
adf['Source'] = adf['Source'].str.replace('Individual by agent', 'Individual by Agent')
```

Again, is Source Public == Source Individual? I think so. Pre-2015, there were no *Individual* requests, just *Public*. Post-2015, there are no *Public* requests, just *Individual*.

In [36]:
```
adf[(adf['Source'] == 'Public') | (adf['Source'] == 'Individual')]
```

Out[36]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **3** | 99004 | General | Public | Public Health inspection records for {address ... | All disclosed |
| **5** | 99006 | Personal | Public | Public Health inspection file for {name remove... | All disclosed |
| **6** | 99007 | General | Public | Scope of work and deliverables sections of con... | All disclosed |
| **7** | 99008 | General | Public | Number of contracts and dollar amount of contr... | Withdrawn |
| **8** | 99009 | Personal | Public | Public Health inspection report regarding a co... | All disclosed |
| **11** | 99012 | Personal | Public | A complete copy of Income Maintenance client f... | All disclosed |
| **13** | 99014 | Personal | Public | Home Child Care Provider file for {name remove... | Partly exempted |
| **15** | 99016 | Personal | Public | Financial records documenting {name removed} e... | All disclosed |
| **16** | 99017 | Personal | Public | Minutes and notes relating to {name removed} m... | Partly exempted |
| **18** | 99019 | General | Public | List of all radio frequencies used by Region o... | Forwarded out |
| **20** | 99021 | Personal | Public | {Name removed} personnel file for the period 1... | Withdrawn |
| **21** | 99022 | Personal | Public | Complaint dated November 1, 1999 in {name remo... | Partly exempted |
| **23** | 99024 | Personal | Public | Home Child Care Provider file for {name remove... | Partly exempted |
| **25** | 99026 | General | Public | List of all taxi license owners in the City of... | Nothing disclosed |
| **26** | 99027 | Personal | Public | Complaint regarding alleged fraud accusation m... | Withdrawn |
| **30** | 2000004 | Personal | Public | Home Child Care Provider file for {name remove... | Withdrawn |
| **31** | 2000005 | Personal | Public | Public Health Inspection reports about food-bo... | Partly exempted |
| **32** | 2000006 | General | Public | Public Health Inspection report dated March 20... | All disclosed |
| **33** | 2000007 | General | Public | Submissions received by Regional Councillors r... | All disclosed |
| **34** | 2000008 | Personal | Public | Public Health Inspection reports and laborator... | Partly exempted |
| **35** | 2000009 | Personal | Public | Income Maintenance narrative notes from 1991 t... | Partly exempted |
| **40** | 2000014 | Correction | Public | Correction of two narrative note entries in {n... | Correction refused |
| **42** | 2000016 | General | Public | Letter regarding pay equity plan to {name remo... | Forwarded out |
| **46** | 2001001 | Personal | Public | Social Assistance client file for {name remove... | All disclosed |
| **47** | 2001002 | Personal | Public | All records about {name removed}, including fo... | Withdrawn |
| **49** | 2001004 | General | Public | Location and subsidy paid by the Region of Wat... | All disclosed |
| **51** | 2001006 | General | Public | Location of contaminated sites near {address r... | Partly non-existent |
| **53** | 2001008 | General | Public | Names of contractors and quotes for Request fo... | All disclosed |
| **56** | 2001011 | General | Public | Receipts or other records regarding sale of tr... | No record exists |
| **58** | 2001013 | General | Public | Technical and operating manuals for laser spee... | Withdrawn |
| **...** | ... | ... | ... | ... | ... |
| **490** | 2015040 | General | Individual | Report compiled by Public Health Inspector, Ca... | Information disclosed in part |
| **492** | 2015042 | Personal | Individual | Court documentation from 1996 to present; all ... | No responsive records exist |
| **495** | 2016002 | General | Individual | Any and all records related to Sand Hills Co-o... | Abandoned |
| **496** | 2016003 | General | Individual | Copies of public health inspection reports for... | Information disclosed in part |
| **497** | 2016004 | General | Individual | Dollars spent on homelessness prevention progr... | All Information disclosed |
| **506** | 2016013 | Personal | Individual | Any and all records, emails and correspondence... | Information disclosed in part |
| **511** | 2016018 | General | Individual | 1) Records for the past two years up to most c... | All Information disclosed |
| **515** | 2016022 | General | Individual | 1) What was the scheduled shift for Paramedics... | All Information disclosed |
| **516** | 2016023 | General | Individual | Health Department records, for the property lo... | No records exist |
| **520** | 2016027 | General | Individual | Follow up to request 2016018 for 1) Traffic S... | No additional records exist |
| **524** | 2016031 | General | Individual | Video of parking lot at Waterloo Region Museum... | No records exist |
| **527** | 2016034 | General | Individual | Any Correspondence between the City of Cambrid... | All Information disclosed |
| **529** | 2016036 | General | Individual | Logs/records of the status and timing of the t... | Abandoned |
| **532** | 2016039 | General | Individual | Any and all records including emails, faxes, a... | Information disclosed in part |
| **534** | 2016041 | Personal | Individual | Copies of all records about me, which are retr... | Information disclosed in part |
| **536** | 2016043 | General | Individual | All emails, letters and meeting reports and no... | Information disclosed in part |
| **542** | 2016049 | Personal | Individual | Any records documenting attendance at a Minis... | All Information disclosed |
| **543** | 2016050 | General | Individual | The winning proposal for P2016-13 for Multicul... | Withdrawn |
| **550** | 2016057 | General | Individual | Information related to the spurline trail, spe... | All Information disclosed |
| **551** | 2016058 | General | Individual | All by-law complaints and investigations relat... | Abandoned |
| **553** | 2016060 | General | Individual | The status and timing sequence of the traffic ... | Abandoned |

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **554** | 2016061 | Personal | Individual | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **555** | 2016062 | Personal | Individual | Complete copy of Ontario Works file for {name ... | Information disclosed in part |
| **556** | 2016063 | General | Individual | Total number of EMS calls; number of times eac... | All Information disclosed |
| **557** | 2016064 | General | Individual | Video from Grand River Transit Bus #8017 on Ro... | Information disclosed in part |
| **560** | 2016067 | General | Individual | Names of security guards working at the Ainsli... | All Information disclosed |
| **561** | 2016068 | General | Individual | List of contact information for all small drin... | Abandoned |
| **566** | 2016073 | General | Individual | A copy of the contractor evaluation forms for ... | Withdrawn |
| **567** | 2016074 | General | Individual | A copy of the contractor evaluation forms for ... | Withdrawn |
| **568** | 2016075 | General | Individual | A copy of the contractor evaluation forms for ... | Withdrawn |

172 rows × 5 columns

In [37]:
```
adf['Source'] = adf['Source'].str.replace('Public', 'Individual')
```

In [38]:
```
print(adf.Source.nunique())
adf.Source.value_counts()
```

```
6
```

Out[38]:
```
Business                    198
Individual                  172
Individual by Agent         166
Media                        20
Business by Agent            19
Individual for dependant      1
Name: Source, dtype: int64
```

Let's look at the *Decision* column.

In [39]:
```
adf['Decision'] = adf['Decision'].str.strip()
print(adf.Decision.nunique())
adf.Decision.value_counts()
```

```
21
```

Out[39]:
```
All disclosed                                   160
Partly exempted                                 102
Withdrawn                                        79
No records exist                                 51
Information disclosed in part                    50
Partly non-existent                              23
Nothing disclosed                                20
All Information disclosed                        16
No record exists                                 15
Abandoned                                        13
All information disclosed                        13
Forwarded out                                    12
No responsive records exist                      11
Non-existent                                      3
Transferred to Region of Waterloo Public Health   2
Request withdrawn                                 1
Transferred                                       1
Correction granted                                1
No information disclosed                          1
Correction refused                                1
No additional records exist                       1
Name: Decision, dtype: int64
```

We will again merge categories.

In [40]:
```
adf['Decision'] = adf['Decision'].str.replace('All disclosed', 'All information disclosed')
```

In [41]:
```
adf['Decision'] = adf['Decision'].str.replace('All Information disclosed', 'All information disclosed')
```

In [42]:
```
adf['Decision'] = adf['Decision'].str.replace('Nothing disclosed', 'No information disclosed')
```

In [43]:
```
adf['Decision'] = adf['Decision'].str.replace('Withdrawn', 'Request withdrawn')
```

In [44]:
```
adf['Decision'] = adf['Decision'].str.replace('No record exists', 'No records exist')
```

In [45]:
```
adf['Decision'] = adf['Decision'].str.replace('No responsive records exist', 'No records exist')
```

In [46]:
```
adf['Decision'] = adf['Decision'].str.replace('Non-existent', 'No records exist')
```

In [47]:
```
adf['Decision'] = adf['Decision'].str.replace('Forwarded out', 'Transferred')
```

In [48]:
```
adf['Decision'] = adf['Decision'].str.replace('Transferred to Region of Waterloo Public Health', 'Transferred')
```

In [49]:
```
# Up to 2015, it was called Partly exempted, now it is known as 'Information disclosed in part'
adf['Decision'] = adf['Decision'].str.replace('Partly exempted', 'Information disclosed in part')
```

In [50]:
```
adf[(adf['Decision'] == 'No additional records exist')]
```

Out[50]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision |
|---|---|---|---|---|---|
| **520** | 2016027 | General | Individual | Follow up to request 2016018 for 1) Traffic S... | No additional records exist |

In [51]:
```
print(adf.Decision.nunique())
adf.Decision.value_counts()
```

```
11
```

Out[51]:
```
All information disclosed        189
Information disclosed in part    152
Request withdrawn                 80
No records exist                  80
Partly non-existent               23
No information disclosed          21
Transferred                       15
Abandoned                         13
Correction granted                 1
Correction refused                 1
No additional records exist        1
Name: Decision, dtype: int64
```

As one can see, of the 576 requests, information was not disclosed for only 21. This is a highly imbalanced case. So, before taking another approach, such as condensing all th partially, and nothing disclosed), I would like to take a deeper look at the data as is.

## Decisions and Source of the Request

Let's see the distribution of decisions made based on who is making the request.

In [52]:
```
# By making use of the groupby() function, one can come up with a table. For example, if the source is 'Business':
adf_business_groupby_Decision = adf[adf['Source'] == 'Business'].groupby('Decision')\
                                .count()[['Source']]
adf_business_groupby_Decision
```

Out[52]:

| Decision | Source |
|---|---|
| **Abandoned** | 3 |
| **All information disclosed** | 64 |
| **Information disclosed in part** | 36 |
| **No information disclosed** | 2 |
| **No records exist** | 43 |
| **Partly non-existent** | 10 |
| **Request withdrawn** | 38 |
| **Transferred** | 2 |

In [395]:
```
# As for all the 576 decisions
adf_groupbyDecision = adf.groupby('Decision').count()[['Source']]
adf_groupbyDecision
```

Out[395]:

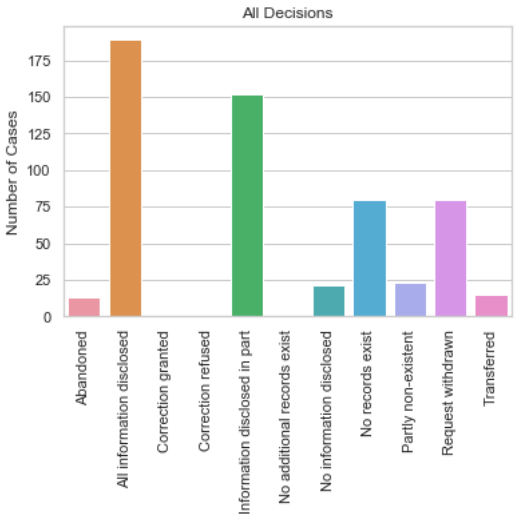
| Decision | Source |
|---|---|
| Abandoned | 13 |
| All information disclosed | 189 |
| Correction granted | 1 |
| Correction refused | 1 |
| Information disclosed in part | 152 |
| No additional records exist | 1 |
| No information disclosed | 21 |
| No records exist | 80 |
| Partly non-existent | 23 |
| Request withdrawn | 80 |
| Transferred | 15 |

In [399]:
```
adf_groupbyDecision.index
```

Out[399]:
```
Index(['Abandoned', 'All information disclosed', 'Correction granted',
       'Correction refused', 'Information disclosed in part',
       'No additional records exist', 'No information disclosed',
       'No records exist', 'Partly non-existent', 'Request withdrawn',
       'Transferred'],
      dtype='object', name='Decision')
```

In [402]:
```
# Bar plot of all decisions made
columns = list(adf_groupbyDecision.index)

sns.set(style="whitegrid")
ax = sns.barplot(x=columns, y='Source', data=adf_groupbyDecision)
ax.set(ylabel='Number of Cases', title='All Decisions')
plt.xticks(rotation=90)
```

Out[402]:
```
(array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10]),
 <a list of 11 Text xticklabel objects>)
```



In [56]:
```
# Let's create a matrix of Decision vs Source

# Source Type:
# Business                    198
# Individual                  172
# Individual by Agent         166
# Media                        20
# Business by Agent            19
# Individual for dependant      1

df_byDecision = {}

source_types = []
for i in range (0, len(adf.Source.unique())):
    source_types.append(adf.Source.unique()[i])

decision_types = []
for i in range (0, len(adf.Decision.unique())):
    decision_types.append(adf.Decision.unique()[i])

counter = 0

for source in source_types:
    temp_df = adf[adf['Source'] == source].groupby('Decision').count()[['Source']]
    df_byDecision[counter] = temp_df.T    # Transpose
    if len(df_byDecision[counter].columns) != len(decision_types):
        for column in decision_types:
            if column not in df_byDecision[counter].columns:
                df_byDecision[counter][column] = 0

    df_byDecision[counter].rename(index={'Source': source}, inplace=True)
    df_byDecision[counter].rename
    counter += 1

#print(len(df_byDecision))

df_byDecision = pd.concat(df_byDecision, sort=True)

df_byDecision
```

Out[56]:

| | | Abandoned | All information disclosed | Correction granted | Correction refused | Information disclosed in part | No additional records exist | No information disclosed | No |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Business | 3 | 64 | 0 | 0 | 36 | 0 | 2 | |
| 1 | Individual | 5 | 56 | 1 | 1 | 45 | 1 | 10 | |
| 2 | Individual by Agent | 4 | 63 | 0 | 0 | 56 | 0 | 1 | |
| 3 | Business by Agent | 0 | 4 | 0 | 0 | 6 | 0 | 2 | |
| 4 | Media | 0 | 2 | 0 | 0 | 9 | 0 | 6 | |
| 5 | Individual for dependant | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |

We have now created a multi-index array:

In [57]:
```
df_byDecision.index
```

Out[57]:
```
MultiIndex(levels=[[0, 1, 2, 3, 4, 5], ['Business', 'Business by Agent', 'Individual', 'Individual by Agent', 'Individua
           labels=[[0, 1, 2, 3, 4, 5], [0, 2, 3, 1, 5, 4]])
```

So, let's reset index to be the Source:

In [58]:
```
df_byDecision = df_byDecision.reset_index(level=0, drop=True)
```

In [60]:
```
df_byDecision
```

Out[60]:

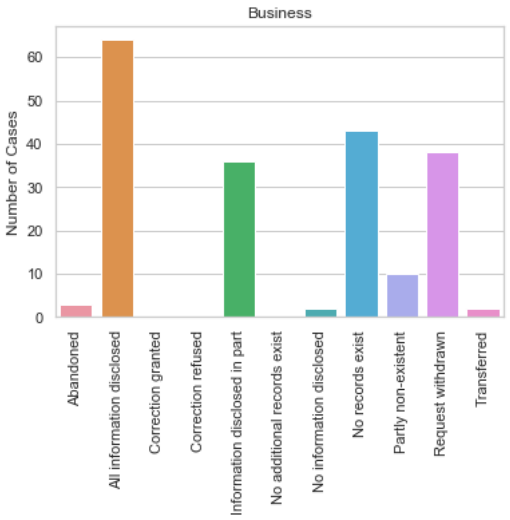
| | Abandoned | All information disclosed | Correction granted | Correction refused | Information disclosed in part | No additional records exist | No information disclosed | No r |
|---|---|---|---|---|---|---|---|---|
| **Business** | 3 | 64 | 0 | 0 | 36 | 0 | 2 | |
| **Individual** | 5 | 56 | 1 | 1 | 45 | 1 | 10 | |
| **Individual by Agent** | 4 | 63 | 0 | 0 | 56 | 0 | 1 | |
| **Business by Agent** | 0 | 4 | 0 | 0 | 6 | 0 | 2 | |
| **Media** | 0 | 2 | 0 | 0 | 9 | 0 | 6 | |
| **Individual for dependant** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |

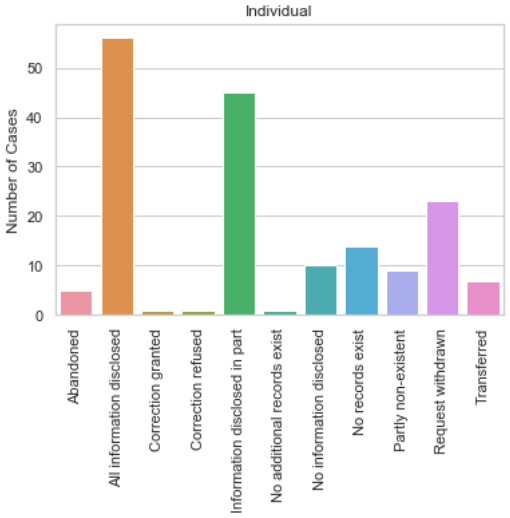
In [59]:
```
df_byDecision.index
```

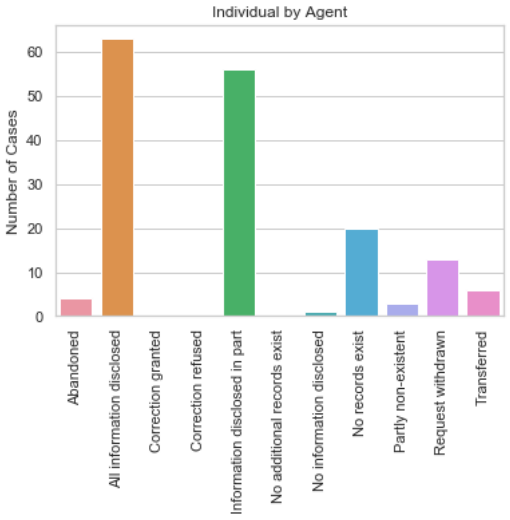
Out[59]:
```
Index(['Business', 'Individual', 'Individual by Agent', 'Business by Agent',
       'Media', 'Individual for dependant'],
      dtype='object')
```

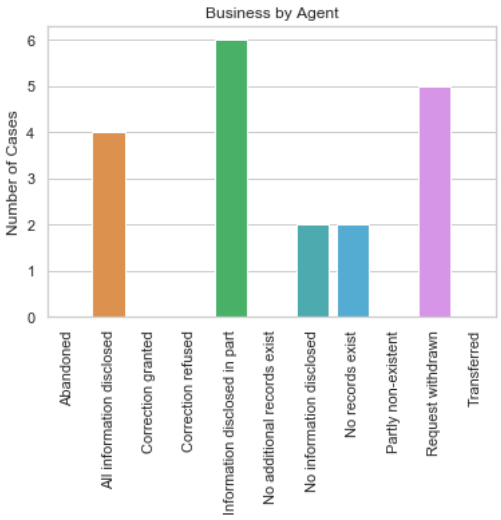
In [62]:

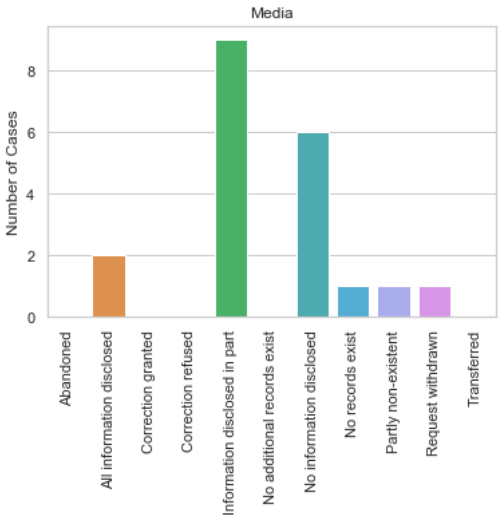
```
# Visualizing the data just obtained, for each of the sources

counter = 0

for source in source_types:
    sns.set(style="whitegrid")
    ax = sns.barplot(data=df_byDecision[counter: counter + 1])
    ax.set(ylabel='Number of Cases', title=source)
    plt.xticks(rotation=90)
    plt.show()
    counter += 1
```

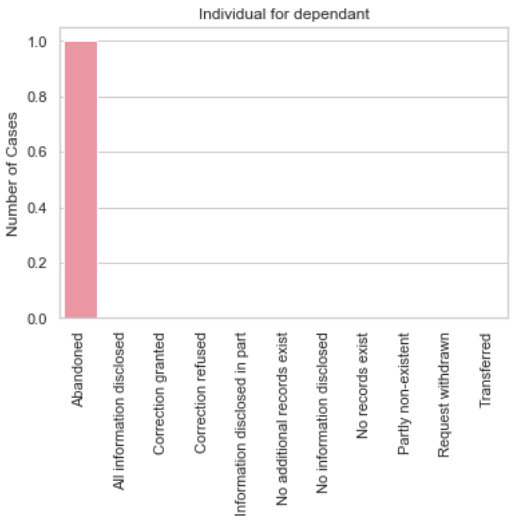

Business
Number of Cases
0
10
20
30
40
50
60
Abandoned
All information disclosed
Correction granted
Correction refused
Information disclosed in part
No additional records exist
No information disclosed
No records exist
Partly non-existent
Request withdrawn
Transferred


Individual
Number of Cases
0
10
20
30
40
50
Abandoned
All information disclosed
Correction granted
Correction refused
Information disclosed in part
No additional records exist
No information disclosed
No records exist
Partly non-existent
Request withdrawn
Transferred


Individual by Agent
Number of Cases
0
10
20
30
40
50
60
Abandoned
All information disclosed
Correction granted
Correction refused
Information disclosed in part
No additional records exist
No information disclosed
No records exist
Partly non-existent
Request withdrawn
Transferred




Another useful view from the same data is looking at each type of decision for all the sources (the inverse of what we jsut did above.)

In [63]:
```
# Let's create a matrix of Source vs Decision

df_byEntity = {}

for decision in decision_types:
    temp_df = adf[adf['Decision'] == decision].groupby('Source').count()[['Decision']]
    df_byEntity[counter] = temp_df.T
    if len(df_byEntity[counter].columns) != len(source_types):
        for column in source_types:
            if column not in df_byEntity[counter].columns:
                df_byEntity[counter][column] = 0

    df_byEntity[counter].rename(index={'Decision': decision}, inplace=True)
    df_byEntity[counter].rename
    counter += 1

df_byEntity = pd.concat(df_byEntity, sort=True)

df_byEntity
```

Out[63]:

| | | Business | Business by Agent | Individual | Individual by Agent | Individual for dependant | Media |
|---|---|---|---|---|---|---|---|
| **6** | **Information disclosed in part** | 36 | 6 | 45 | 56 | 0 | 9 |
| **7** | **All information disclosed** | 64 | 4 | 56 | 63 | 0 | 2 |
| **8** | **Request withdrawn** | 38 | 5 | 23 | 13 | 0 | 1 |
| **9** | **Partly non-existent** | 10 | 0 | 9 | 3 | 0 | 1 |
| **10** | **Transferred** | 2 | 0 | 7 | 6 | 0 | 0 |
| **11** | **No records exist** | 43 | 2 | 14 | 20 | 0 | 1 |
| **12** | **No information disclosed** | 2 | 2 | 10 | 1 | 0 | 6 |
| **13** | **Correction refused** | 0 | 0 | 1 | 0 | 0 | 0 |
| **14** | **Correction granted** | 0 | 0 | 1 | 0 | 0 | 0 |
| **15** | **Abandoned** | 3 | 0 | 5 | 4 | 1 | 0 |
| **16** | **No additional records exist** | 0 | 0 | 1 | 0 | 0 | 0 |

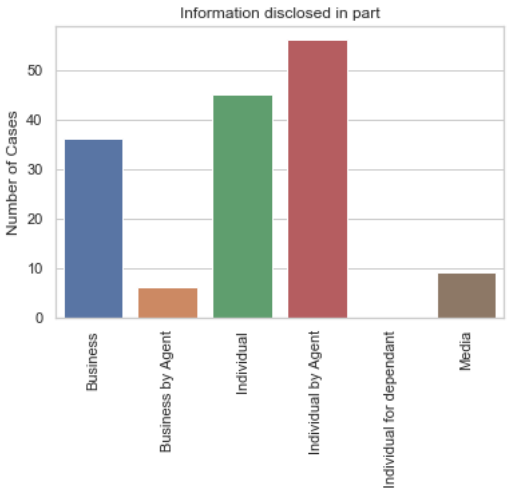
In [64]:
```
# Resetting index to remove multi-indexing
df_byEntity = df_byEntity.reset_index(level=0, drop=True)
df_byEntity
```

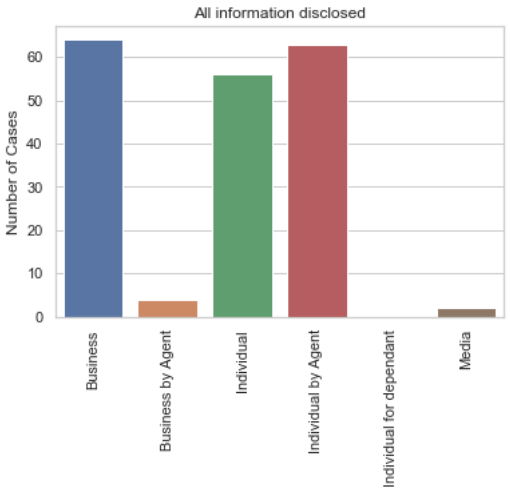
Out[64]:

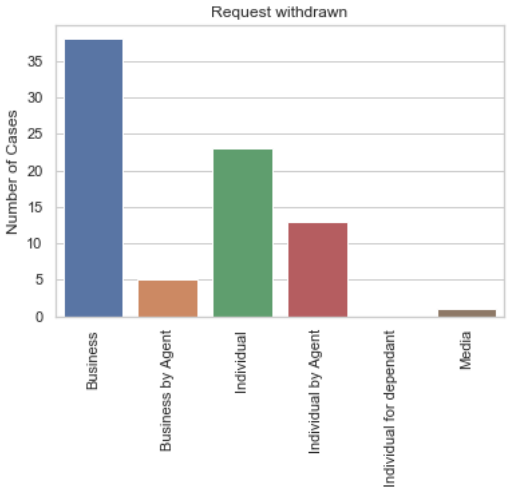
| | Business | Business by Agent | Individual | Individual by Agent | Individual for dependant | Media |
|---|---|---|---|---|---|---|
| **Information disclosed in part** | 36 | 6 | 45 | 56 | 0 | 9 |
| **All information disclosed** | 64 | 4 | 56 | 63 | 0 | 2 |
| **Request withdrawn** | 38 | 5 | 23 | 13 | 0 | 1 |
| **Partly non-existent** | 10 | 0 | 9 | 3 | 0 | 1 |
| **Transferred** | 2 | 0 | 7 | 6 | 0 | 0 |
| **No records exist** | 43 | 2 | 14 | 20 | 0 | 1 |
| **No information disclosed** | 2 | 2 | 10 | 1 | 0 | 6 |
| **Correction refused** | 0 | 0 | 1 | 0 | 0 | 0 |
| **Correction granted** | 0 | 0 | 1 | 0 | 0 | 0 |
| **Abandoned** | 3 | 0 | 5 | 4 | 1 | 0 |
| **No additional records exist** | 0 | 0 | 1 | 0 | 0 | 0 |

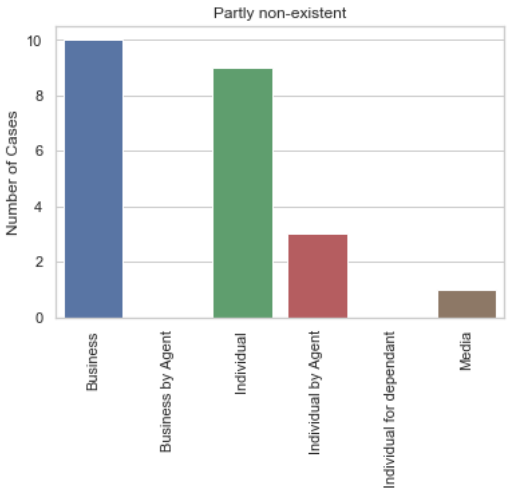
In [65]:

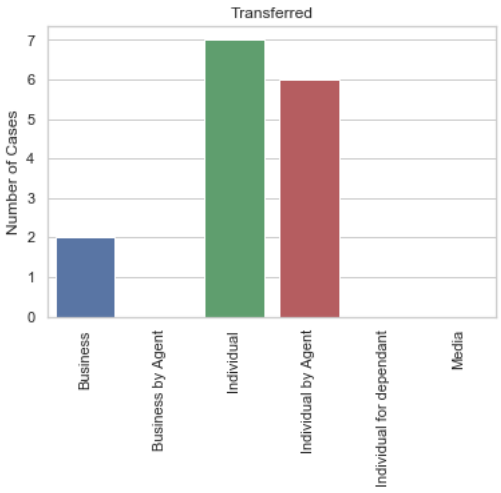
```
counter = 0

for decision in decision_types:
    sns.set(style="whitegrid")
    ax = sns.barplot(data=df_byEntity[counter: counter + 1])
    ax.set(ylabel='Number of Cases', title=decision)
    plt.xticks(rotation=90)
    plt.show()
    counter += 1
```

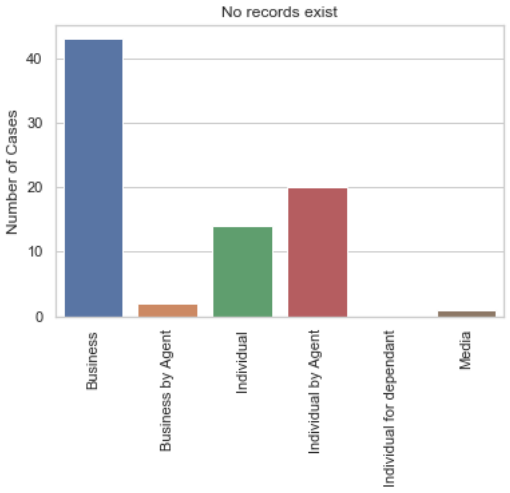

Information disclosed in part
Number of Cases
0
10
20
30
40
50
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media

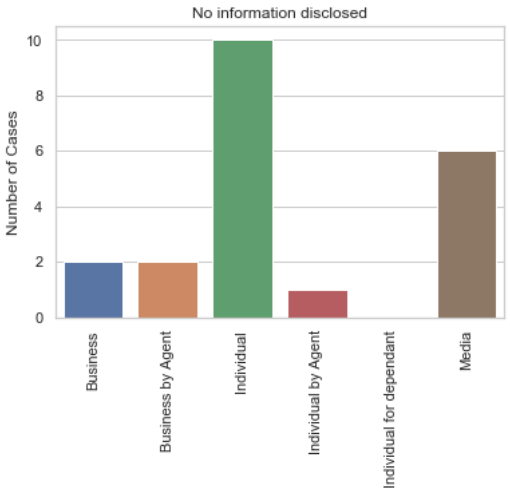

All information disclosed
Number of Cases
0
10
20
30
40
50
60
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media

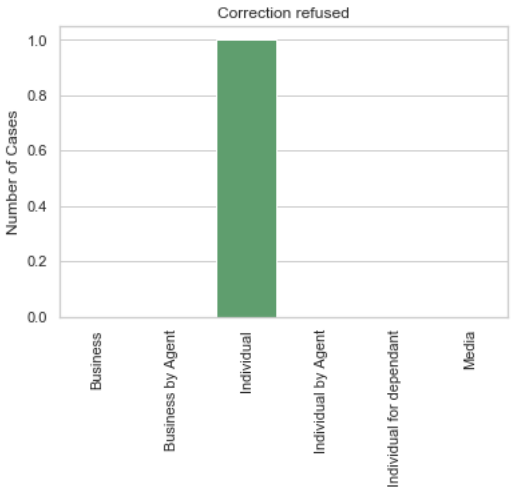

Request withdrawn
Number of Cases
0
5
10
15
20
25
30
35
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media

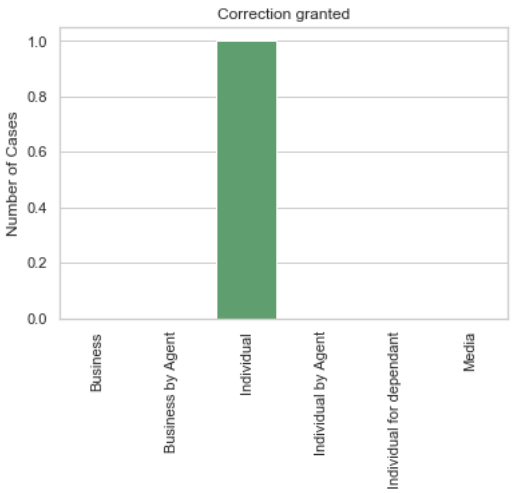

Partly non-existent
Number of Cases
0
2
4
6
8
10
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media

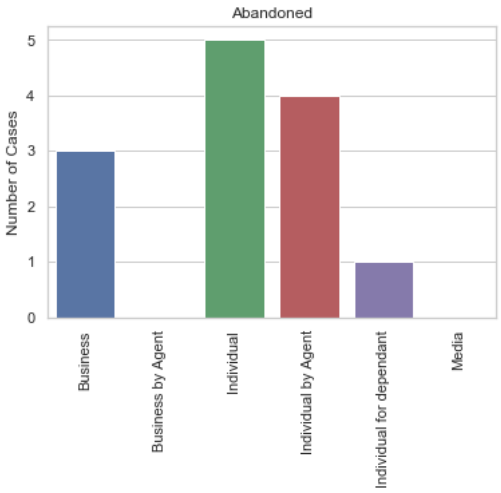

Transferred
Number of Cases
0
1
2
3
4
5
6
7
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media

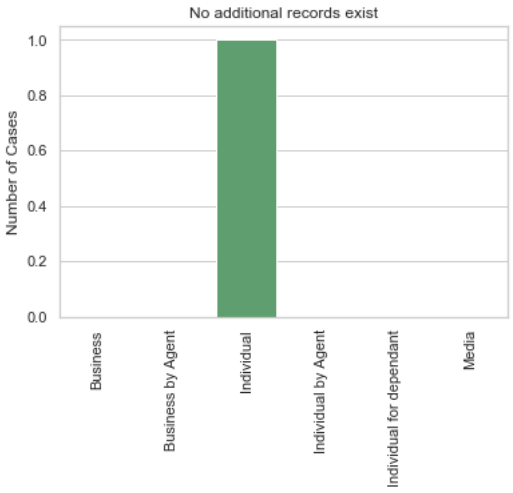

No records exist
Number of Cases
0
10
20
30
40
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media


No information disclosed
Number of Cases
0
2
4
6
8
10
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media


Correction refused
Number of Cases
0.0
0.2
0.4
0.6
0.8
1.0
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media


Correction granted
Number of Cases
0.0
0.2
0.4
0.6
0.8
1.0
Business
Business by Agent
Individual
Individual by Agent
Individual for dependant
Media




Another approach could be to drop the columns where there is no decision made. Meaning, when it was not on the hands of the person granting a decision, such as a request
important to note that the subset is still unbalanced.

In [66]:
```
sub_df_byDecision = df_byDecision.drop(columns=['Abandoned', 'Correction granted', 'Correction refused',
                                                'No additional records exist', 'No records exist',
                                                'Partly non-existent', 'Request withdrawn', 'Transferred'])
```

In [67]:
```
sub_df_byDecision
```

Out[67]:

| | All information disclosed | Information disclosed in part | No information disclosed |
|---|---|---|---|
| **Business** | 64 | 36 | 2 |
| **Individual** | 56 | 45 | 10 |
| **Individual by Agent** | 63 | 56 | 1 |
| **Business by Agent** | 4 | 6 | 2 |
| **Media** | 2 | 9 | 6 |
| **Individual for dependant** | 0 | 0 | 0 |

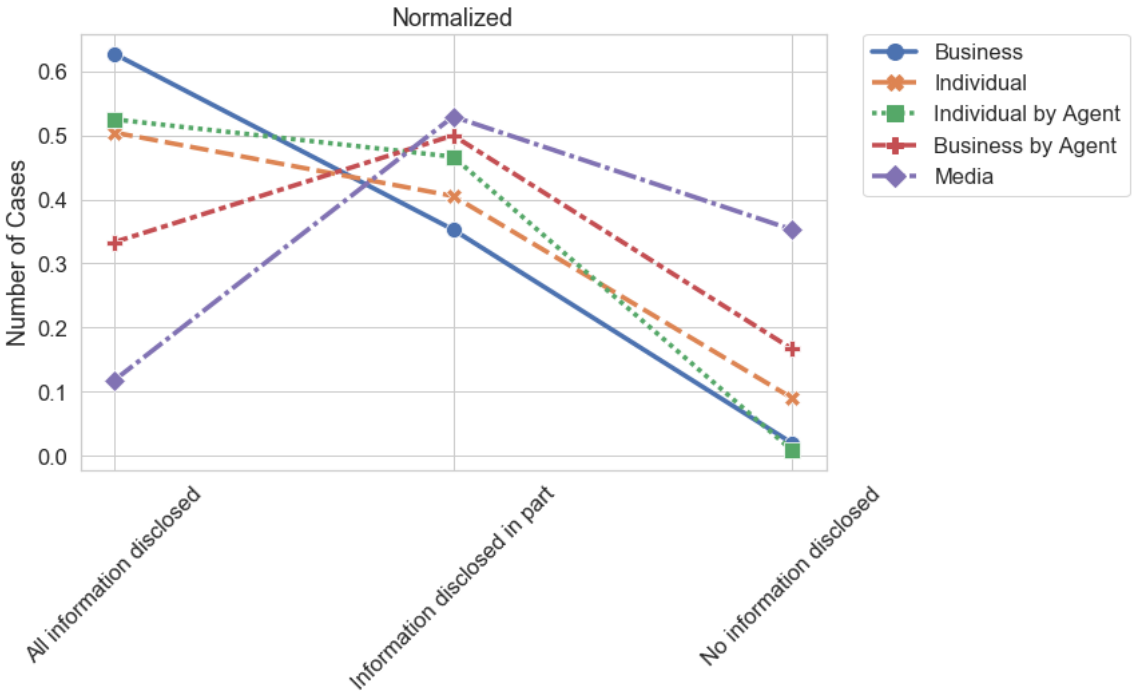
In [68]:
```
# Normalizing the subset by row - that is, each row (source) adds up to 100%
norm_sub_df_byDecision = sub_df_byDecision.div(sub_df_byDecision.sum(axis=1), axis=0)
norm_sub_df_byDecision
```

Out[68]:

| | All information disclosed | Information disclosed in part | No information disclosed |
|---|---|---|---|
| **Business** | 0.627451 | 0.352941 | 0.019608 |
| **Individual** | 0.504505 | 0.405405 | 0.090090 |
| **Individual by Agent** | 0.525000 | 0.466667 | 0.008333 |
| **Business by Agent** | 0.333333 | 0.500000 | 0.166667 |
| **Media** | 0.117647 | 0.529412 | 0.352941 |
| **Individual for dependant** | NaN | NaN | NaN |

In [394]:
```
#sns.set_palette("husl")
sns.set_palette("deep")
# And plotting the decisions for each of the sources
plt.figure(figsize=(10, 6))
sns.set_context("notebook", font_scale=1.5, rc={"lines.linewidth": 3.5, "lines.markersize": 12.0})
ax = sns.lineplot(data=norm_sub_df_byDecision.T, markers=True)
ax.set(ylabel='Number of Cases', title='Normalized')
plt.xticks(rotation=45)
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

Out[394]:
```
<matplotlib.legend.Legend at 0x1a37707080>
```

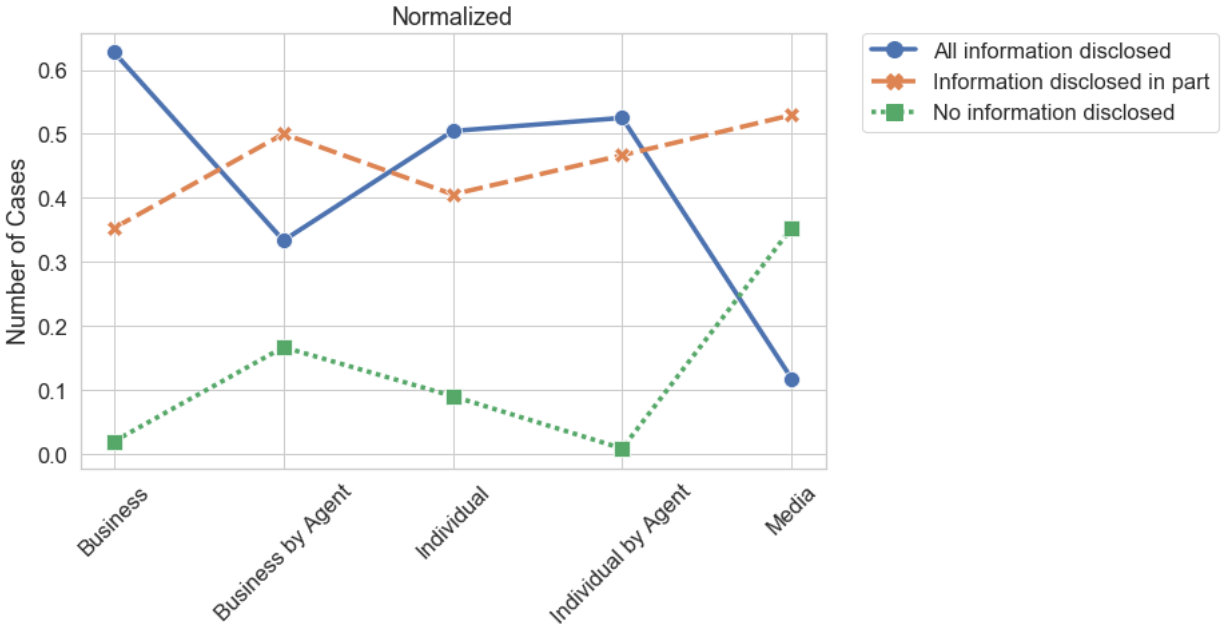



With this view, one sees that business do better, followed by individuals by agent. Media, having few requests, does not do well.

Plotting the decisions for each of the sources (transposed of previous plot - each source adds up to 100%.)

In [259]:
```
plt.figure(figsize=(10, 6))
sns.set_context("notebook", font_scale=1.5, rc={"lines.linewidth": 3.5, "lines.markersize": 12.0})
ax = sns.lineplot(data=norm_sub_df_byDecision, markers=True)
ax.set(ylabel='Number of Cases', title='Normalized')
plt.xticks(rotation=45)
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

Out[259]:
```
<matplotlib.legend.Legend at 0x1a2592e630>
```




And looking at the same data but with some stacked or grouped bar plots!

In [289]:
```
norm_sub_df_byDecision
```

Out[289]:

| | All information disclosed | Information disclosed in part | No information disclosed |
|---|---|---|---|
| **Business** | 0.627451 | 0.352941 | 0.019608 |
| **Individual** | 0.504505 | 0.405405 | 0.090090 |
| **Individual by Agent** | 0.525000 | 0.466667 | 0.008333 |
| **Business by Agent** | 0.333333 | 0.500000 | 0.166667 |
| **Media** | 0.117647 | 0.529412 | 0.352941 |
| **Individual for dependant** | NaN | NaN | NaN |

In [294]:
```
# Individual for dependent does not have any of these cases.
norm_sub_df_byDecision = norm_sub_df_byDecision.drop('Individual for dependant')
```

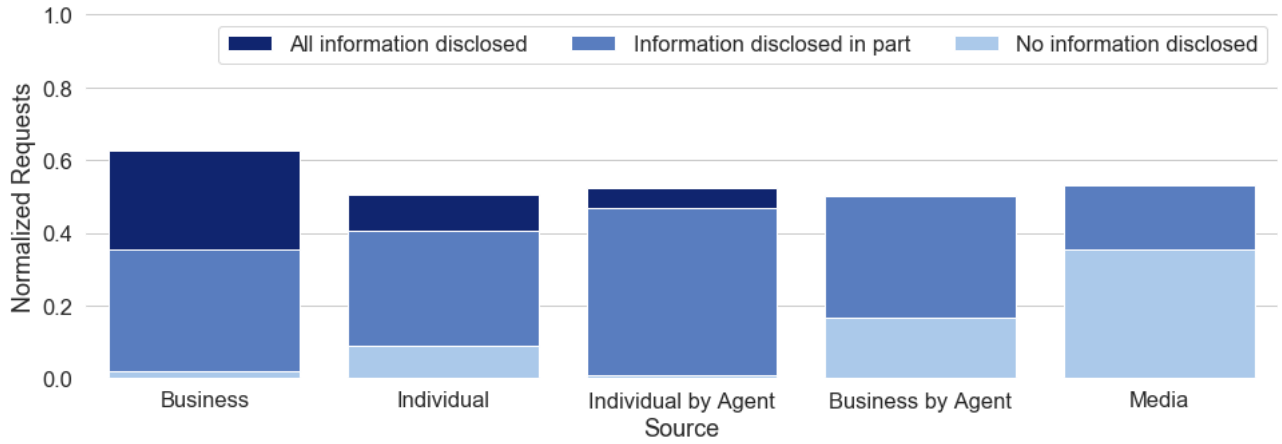
In [295]:
```
norm_sub_df_byDecision.index
```

Out[295]:
```
Index(['Business', 'Individual', 'Individual by Agent', 'Business by Agent',
       'Media'],
      dtype='object')
```

In [296]:
```
categ = list(norm_sub_df_byDecision.index)
categ
```

Out[296]:
```
['Business', 'Individual', 'Individual by Agent', 'Business by Agent', 'Media']
```

In [314]:
```
categ = list(norm_sub_df_byDecision.index)

f, ax = plt.subplots(figsize=(16, 5))

sns.set_color_codes('dark')
sns.barplot(y='All information disclosed', x=categ, data=norm_sub_df_byDecision,
            label='All information disclosed', color="b")

sns.set_color_codes('muted')
sns.barplot(y='Information disclosed in part', x=categ, data=norm_sub_df_byDecision,
            label='Information disclosed in part', color="b")

sns.set_color_codes('pastel')
sns.barplot(y='No information disclosed', x=categ, data=norm_sub_df_byDecision,
            label='No information disclosed', color="b")

ax.legend(ncol=3, loc="upper right", frameon=True)
ax.set(ylim=(0, 1), xlabel="Source",
       ylabel="Normalized Requests")
sns.despine(left=True, bottom=True)
```




In [333]:
```
norm_sub_df_byDecision
```

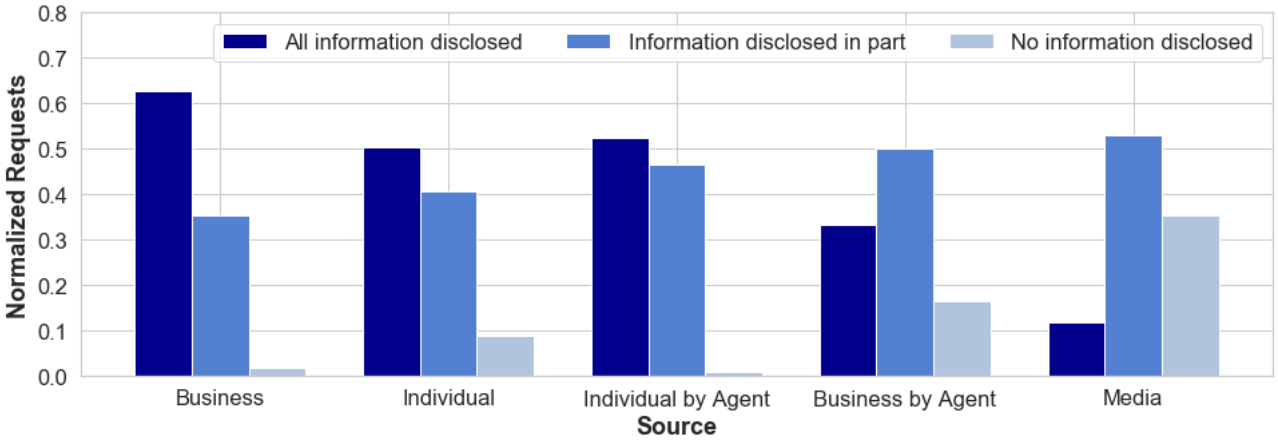
Out[333]:

| | All information disclosed | Information disclosed in part | No information disclosed |
|---|---|---|---|
| **Business** | 0.627451 | 0.352941 | 0.019608 |
| **Individual** | 0.504505 | 0.405405 | 0.090090 |
| **Individual by Agent** | 0.525000 | 0.466667 | 0.008333 |
| **Business by Agent** | 0.333333 | 0.500000 | 0.166667 |
| **Media** | 0.117647 | 0.529412 | 0.352941 |

In [369]:
```
norm_sub_df_byDecision['All information disclosed'].values.tolist()
```

Out[369]:
```
[0.6274509803921569,
 0.5045045045045045,
 0.525,
 0.3333333333333333,
 0.11764705882352941]
```

In [383]:
```
categ = list(norm_sub_df_byDecision.index)

plt.subplots(figsize=(16, 5))

# Set width of bar
barWidth = 0.25

# Set height of bar
bars1 = norm_sub_df_byDecision['All information disclosed'].values.tolist()
bars2 = norm_sub_df_byDecision['Information disclosed in part'].values.tolist()
bars3 = norm_sub_df_byDecision['No information disclosed'].values.tolist()

# Set position of bar on X axis
r1 = np.arange(len(bars1))
r2 = [x + barWidth for x in r1]
r3 = [x + barWidth for x in r2]

# Make the plot
plt.bar(r1, bars1, color='darkblue', width=barWidth, edgecolor='white', label='All information disclosed')
plt.bar(r2, bars2, color='#5480d2', width=barWidth, edgecolor='white', label='Information disclosed in part')
plt.bar(r3, bars3, color='#b0c4de', width=barWidth, edgecolor='white', label='No information disclosed')

# Add xticks on the middle of the group bars
plt.xlabel('Source', fontweight='bold')
plt.xticks([r + barWidth for r in range(len(bars1))], categ)

# Create legend & Show graphic
plt.legend(ncol=3, loc="upper right", frameon=True)
plt.ylabel('Normalized Requests', fontweight='bold')
plt.ylim(0,0.8)
plt.show()
```




There are some interesting features in these plots.

- Business get the most cases where the information is fully disclosed and the least with no disclosed information.
- Media is the other way around.
- Individuals by Agent fare better than individuals without one, however, the opposite is true for business and business by agents.

And another view for the same data can be done by exchanging the axes, i.e., by finding the source for each of the decisions. We need to start the table form scratch, to drop t made by the clerks.

In [70]:
```
sub_df_byEntity = df_byEntity.drop(['Abandoned', 'Correction granted', 'Correction refused',
                                    'No additional records exist', 'No records exist',
                                    'Partly non-existent', 'Request withdrawn', 'Transferred'], axis=0)
```

In [71]:
```
sub_df_byEntity
```

Out[71]:

| | Business | Business by Agent | Individual | Individual by Agent | Individual for dependant | Media |
|---|---|---|---|---|---|---|
| **Information disclosed in part** | 36 | 6 | 45 | 56 | 0 | 9 |
| **All information disclosed** | 64 | 4 | 56 | 63 | 0 | 2 |
| **No information disclosed** | 2 | 2 | 10 | 1 | 0 | 6 |

In [264]:
```
sub_df_byEntity = sub_df_byEntity.drop(columns='Individual for dependant')
sub_df_byEntity
```

Out[264]:

| | Business | Business by Agent | Individual | Individual by Agent | Media |
|---|---|---|---|---|---|
| **Information disclosed in part** | 36 | 6 | 45 | 56 | 9 |
| **All information disclosed** | 64 | 4 | 56 | 63 | 2 |
| **No information disclosed** | 2 | 2 | 10 | 1 | 6 |

In [403]:
```
# Normalizing by row, i.e, by type of decision. Decisions add up to 100%
norm_sub_df_byEntity = sub_df_byEntity.div(sub_df_byEntity.sum(axis=1), axis=0)
```

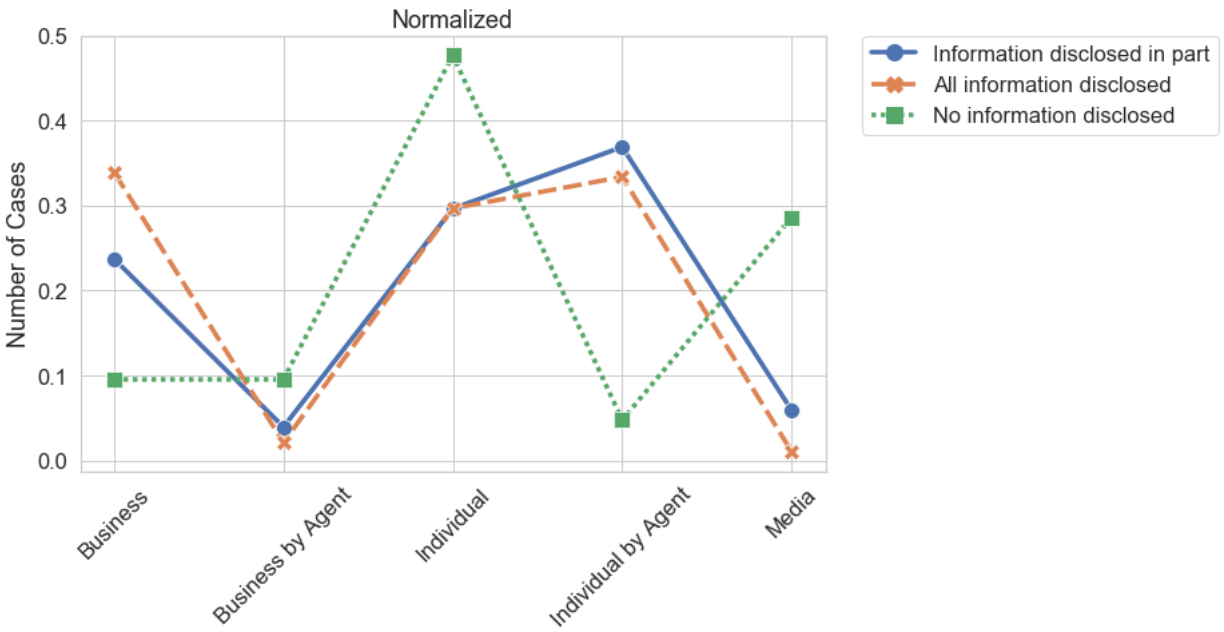
In [266]:
```
norm_sub_df_byEntity
```

Out[266]:

| | Business | Business by Agent | Individual | Individual by Agent | Media |
|---|---|---|---|---|---|
| **Information disclosed in part** | 0.236842 | 0.039474 | 0.296053 | 0.368421 | 0.059211 |
| **All information disclosed** | 0.338624 | 0.021164 | 0.296296 | 0.333333 | 0.010582 |
| **No information disclosed** | 0.095238 | 0.095238 | 0.476190 | 0.047619 | 0.285714 |

In [272]:
```
# Decisions add up to 100%
plt.figure(figsize=(10, 6))
sns.set_context("notebook", font_scale=1.5, rc={"lines.linewidth": 3.5, "lines.markersize": 12.0})
ax = sns.lineplot(data=norm_sub_df_byEntity.T, markers=True)
ax.set(ylabel='Number of Cases', title='Normalized')
plt.xticks(rotation=45)
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

Out[272]: `<matplotlib.legend.Legend at 0x1a35f32f60>`

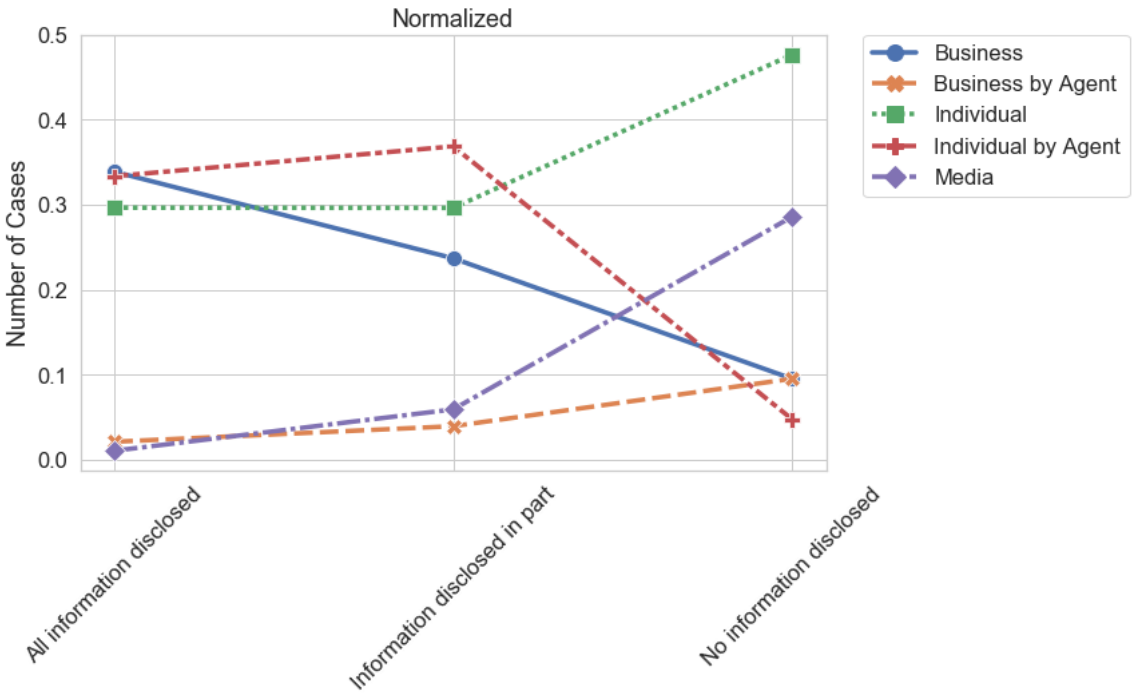



- Of the requests where all the information was disclosed, 35% belong to business, 30% to individuals, and 33% to individuals by agents.
- For partially disclosed information, 37% were for individuals by agents, 30% for individuals, and 25% for businesses.
- Almost 50% of the requests where no information was disclosed were made by individuals, and 30% were made by the media.

And transposing those results, again, each type of decision adds up to 100%.

In [404]:
```
plt.figure(figsize=(10, 6))
sns.set_context("notebook", font_scale=1.5, rc={"lines.linewidth": 3.5, "lines.markersize": 12.0})
ax = sns.lineplot(data=norm_sub_df_byEntity, markers=True)
ax.set(ylabel='Number of Cases', title='Normalized')
plt.xticks(rotation=45)
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

Out[404]:
```
<matplotlib.legend.Legend at 0x1a37504630>
```




Now, doing a grouped bar plot for all the decisions.

In [405]:
```
df_byDecision
```

Out[405]:

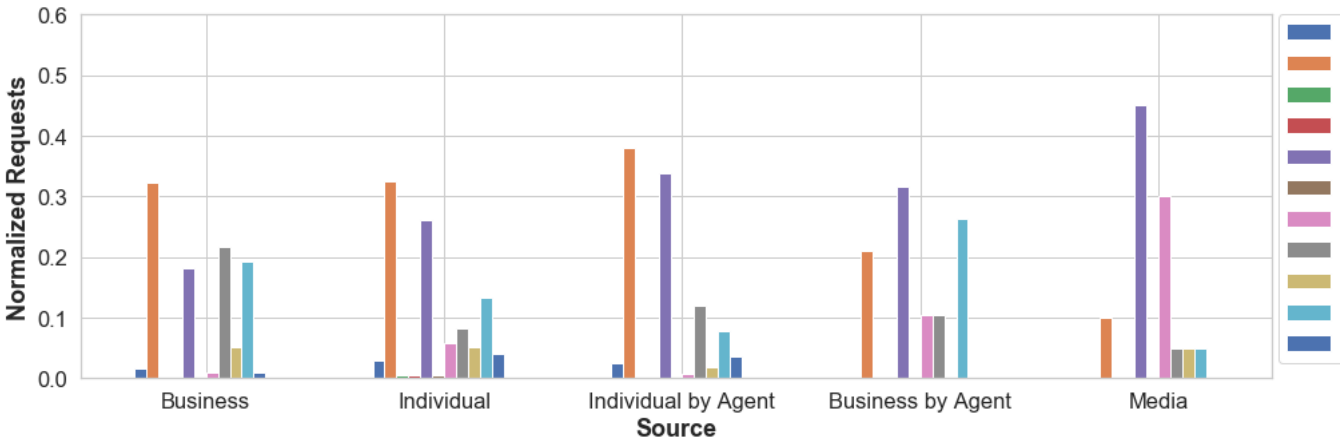
| | Abandoned | All information disclosed | Correction granted | Correction refused | Information disclosed in part | No additional records exist | No information disclosed | No r |
|---|---|---|---|---|---|---|---|---|
| **Business** | 3 | 64 | 0 | 0 | 36 | 0 | 2 | |
| **Individual** | 5 | 56 | 1 | 1 | 45 | 1 | 10 | |
| **Individual by Agent** | 4 | 63 | 0 | 0 | 56 | 0 | 1 | |
| **Business by Agent** | 0 | 4 | 0 | 0 | 6 | 0 | 2 | |
| **Media** | 0 | 2 | 0 | 0 | 9 | 0 | 6 | |
| **Individual for dependant** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |

In [408]:
```
# Normalizing the subset by row - that is, each row (source) adds up to 100%
norm_df_byDecision = df_byDecision.div(df_byDecision.sum(axis=1), axis=0)
norm_df_byDecision = norm_df_byDecision.drop('Individual for dependant')
norm_df_byDecision
```

Out[408]:

| | Abandoned | All information disclosed | Correction granted | Correction refused | Information disclosed in part | No additional records exist | No information disclosed | No re |
|---|---|---|---|---|---|---|---|---|
| **Business** | 0.015152 | 0.323232 | 0.000000 | 0.000000 | 0.181818 | 0.000000 | 0.010101 | 0.2 |
| **Individual** | 0.029070 | 0.325581 | 0.005814 | 0.005814 | 0.261628 | 0.005814 | 0.058140 | 0.0 |
| **Individual by Agent** | 0.024096 | 0.379518 | 0.000000 | 0.000000 | 0.337349 | 0.000000 | 0.006024 | 0.1 |
| **Business by Agent** | 0.000000 | 0.210526 | 0.000000 | 0.000000 | 0.315789 | 0.000000 | 0.105263 | 0.1 |
| **Media** | 0.000000 | 0.100000 | 0.000000 | 0.000000 | 0.450000 | 0.000000 | 0.300000 | 0.0 |

In [491]:
```
categ = list(norm_df_byDecision.index)

dec_norm_df_byDecision = norm_df_byDecision.columns.values.tolist()

plt.subplots(figsize=(16, 5))

# Set width of bar
barWidth = 0.05

bars = []

# Set height of bar
for dec in dec_norm_df_byDecision:
    bars.append(norm_df_byDecision[dec])

rs = []
r = np.arange(len(bars[0]))
rs.append(r)
# Set position of bar on X axis
for bw in range(1, len(bars)):
    rn = [x + barWidth for x in r]
    rs.append(rn)
    r = rn

# Make the plot
counter = 0

for dec in dec_norm_df_byDecision:
    plt.bar(rs[counter], bars[counter], width=barWidth, edgecolor='white', label=dec)
    counter += 1

# Add xticks on the middle of the group bars
center_lb = len(dec_norm_df_byDecision)/2
plt.xlabel('Source', fontweight='bold')
plt.xticks([r + center_lb*barWidth for r in range(len(bars[0]))], categ)

# Create legend & Show graphic
plt.legend(bbox_to_anchor=(1.005, 1), loc=2, borderaxespad=0.)
plt.ylabel('Normalized Requests', fontweight='bold')
plt.ylim(0, 0.6)
plt.show()
```




And if we drop decisions that have less than 15 instances:

In [467]:
```
norm_df_byDecision_over15 = df_byDecision.copy()

dec_norm_df_byDecision_over15 = norm_df_byDecision_over15.columns.values.tolist()

todrop = []

for dec in dec_norm_df_byDecision_over15:
    if norm_df_byDecision_over15[dec].sum(axis=0) < 15:
        todrop.append(dec)

for decs in todrop:
    norm_df_byDecision_over15 = norm_df_byDecision_over15.drop(columns=decs)

norm_df_byDecision_over15
```

Out[467]:

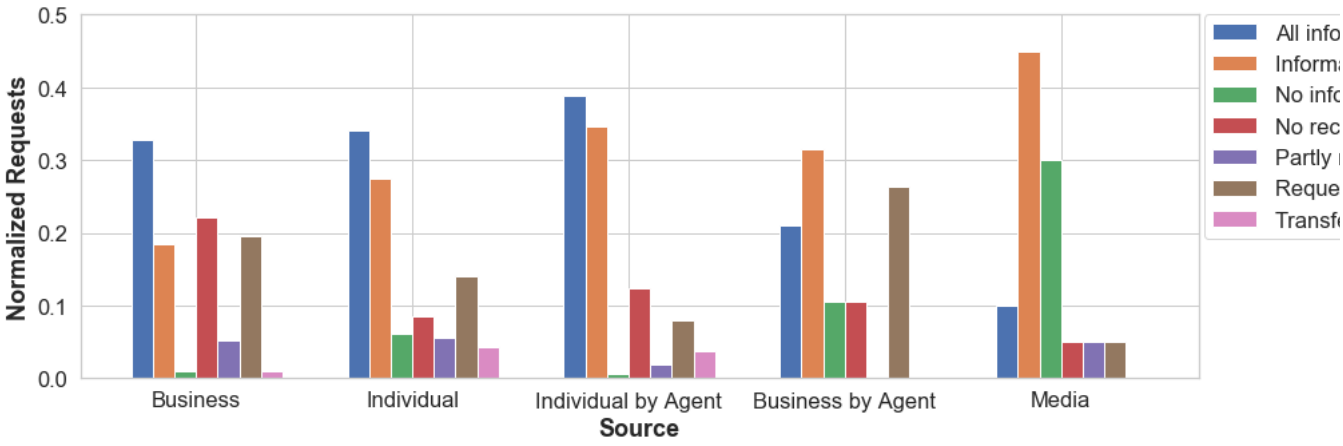
| | All information disclosed | Information disclosed in part | No information disclosed | No records exist | Partly non-existent | Request withdrawn | Tr |
|---|---|---|---|---|---|---|---|
| **Business** | 64 | 36 | 2 | 43 | 10 | 38 | |
| **Individual** | 56 | 45 | 10 | 14 | 9 | 23 | |
| **Individual by Agent** | 63 | 56 | 1 | 20 | 3 | 13 | |
| **Business by Agent** | 4 | 6 | 2 | 2 | 0 | 5 | |
| **Media** | 2 | 9 | 6 | 1 | 1 | 1 | |
| **Individual for dependant** | 0 | 0 | 0 | 0 | 0 | 0 | |

In [470]:
```
# Normalizing the subset by row - that is, each row (source) adds up to 100%
norm_df_byDecision_over15 = norm_df_byDecision_over15.drop('Individual for dependant')
norm_df_byDecision_over15 = norm_df_byDecision_over15.div(norm_df_byDecision_over15.sum(axis=1), axis=0)
norm_df_byDecision_over15
```

Out[470]:

| | All information disclosed | Information disclosed in part | No information disclosed | No records exist | Partly non-existent | Request withdrawn | Transfe |
|---|---|---|---|---|---|---|---|
| **Business** | 0.328205 | 0.184615 | 0.010256 | 0.220513 | 0.051282 | 0.194872 | 0.01 |
| **Individual** | 0.341463 | 0.274390 | 0.060976 | 0.085366 | 0.054878 | 0.140244 | 0.04 |
| **Individual by Agent** | 0.388889 | 0.345679 | 0.006173 | 0.123457 | 0.018519 | 0.080247 | 0.03 |
| **Business by Agent** | 0.210526 | 0.315789 | 0.105263 | 0.105263 | 0.000000 | 0.263158 | 0.00 |
| **Media** | 0.100000 | 0.450000 | 0.300000 | 0.050000 | 0.050000 | 0.050000 | 0.00 |

In [492]:
```
categ = list(norm_df_byDecision_over15.index)

dec_norm_df_byDecision_over15 = norm_df_byDecision_over15.columns.values.tolist()

plt.subplots(figsize=(15, 5))

# Set width of bar
barWidth = 0.1

bars = []

# Set height of bar
for dec in dec_norm_df_byDecision_over15:
    bars.append(norm_df_byDecision_over15[dec])

rs = []
r = np.arange(len(bars[0]))
rs.append(r)
# Set position of bar on X axis
for bw in range(1, len(bars)):
    rn = [x + barWidth for x in r]
    rs.append(rn)
    r = rn

# Make the plot
counter = 0

for dec in dec_norm_df_byDecision_over15:
    plt.bar(rs[counter], bars[counter], width=barWidth, edgecolor='white', label=dec)
    counter += 1

# Add xticks on the middle of the group bars
plt.xlabel('Source', fontweight='bold')
center_lb = len(norm_df_byDecision_over15)/2
plt.xticks([r + center_lb*barWidth for r in range(len(bars[0]))], categ)

# Create legend & Show graphic
plt.legend(bbox_to_anchor=(1.005, 1), loc=2, borderaxespad=0.)
plt.ylabel('Normalized Requests', fontweight='bold')
plt.ylim(0, 0.5)
plt.show()
```




# NLP

Now we proceed to analize the actual *Summary_of_Requests*. For this, we turn to Natural Language Processing libraries, such as NLTK and spaCy, and the help of sklearn.

Broadly generalizing, there are few steps one needs to do before analyzing any text:

- Tokenize the text: Break the text in single words, i.e., tokens.
- Remove any unwanted characters, such as returns (\n), and punctuation, such as "-", "...", """.
- Remove URLs or replace them by a word, say, "URL".
- Remove screen names or replace the '@' by a word, say, "screen_name".
- Remove capitalization of words.
- Remove words with less than 4 characters.
- Remove "stopwords", i.e., the most common words in a language. These words probably won't help classifying our text, examples are articles such as , 'a', 'the', 'and'. Th words.
- Lemmatization, which is the process of grouping together the inflected forms of a word so they can be analysed as a single item, identified by the word's lemma, or diction

In [74]:
```
import string
import re
import spacy
import nltk

from spacy.lang.en import English
parser = English()
from sklearn.feature_extraction.stop_words import ENGLISH_STOP_WORDS
from nltk.corpus import stopwords

from nltk.stem import WordNetLemmatizer
wordnet_lemmatizer = WordNetLemmatizer()

from nltk.corpus import wordnet as wn

# To make word clouds
from wordcloud import WordCloud, STOPWORDS, ImageColorGenerator

# look at the most common item in a list
from collections import Counter
```

In [75]:
```
nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /Users/bertaerodriguez-
[nltk_data]     milla/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

Out[75]:
```
True
```

Generating a larger stop words list, a combination of the stop words of NLTK, scikit learn, and wordcloud. And adding also a symbols list.

In [870]:
```
STOPLIST = set(stopwords.words('english') + list(ENGLISH_STOP_WORDS) + list(STOPWORDS))
SYMBOLS = " ".join(string.punctuation).split(" ") + ["-", "...", "”", "``", ",", ".", ":", "''"]
```

Defining a function that tokenizes, and cleans by removing white spaces, words with less than three characters, stopwords, and other specified symbols. This version also inclu

In [871]:
```
def tokenize_lemm_rmstop_Text(sample):
    lda_tokens = []
    tokens = parser(sample)
    for token in tokens:
        if token.orth_.isspace():
            continue
        elif token.like_url:
            lda_tokens.append('URL')
        elif token.orth_.startswith('@'):
            lda_tokens.append('SCREEN_NAME')
        else:
            lda_tokens.append(token)
    lemmas = []
    for tok in lda_tokens:    # spaCy lemmatization
        lemmas.append(tok.lemma_.lower().strip() if tok.lemma_ != "-PRON-" else tok.lower_)
    lda_tokens = lemmas
    lda_tokens = [tok for tok in lda_tokens if len(tok) > 3]
    lda_tokens = [tok for tok in lda_tokens if tok not in STOPLIST]
    lda_tokens = [tok for tok in lda_tokens if tok not in SYMBOLS]
    return lda_tokens
```

And one that just tokenizes the text.

In [872]:
```
def tokenize_rmSym_Text(sample):
    lda_tokens = []
    tokens = parser(sample)
    for token in tokens:
        if token.orth_.isspace():
            continue
        elif token.like_url:
            lda_tokens.append('URL')
        elif token.orth_.startswith('@'):
            lda_tokens.append('SCREEN_NAME')
        else:
            lda_tokens.append(token)
    low = []
    for tok in lda_tokens:
        low.append(tok.text.lower().strip())
    lda_tokens = low
    lda_tokens = [tok for tok in lda_tokens if tok not in SYMBOLS]
    return lda_tokens
```

Function than removes carriage returns and line breaks.

In [78]:
```
def cleanText(text):
    text = text.strip().replace("\n", " ").replace("\r", " ")
    return text
```

Function that gets the lemma of a word using NLTK.

In [79]:
```
# NLTK lemma
def get_lemma(word):
    lemma = wn.morphy(word)
    if lemma is None:
        return word
    else:
        return lemma
```

Combining the tokenizer, which includes the lemmatizer, and clean functions. We won't use the NLKT one. This function, prepares a text in general, it will serve for our future an

In [740]:
```
def prepare_text_tlc(text):
    text = cleanText(text)
    tokens = tokenize_lemm_rmstop_Text(text)
    #tokens = [get_lemma(token) for token in tokens]
    return tokens
```

And isolating the summary of requests into a panda series,

In [81]:
```
all_text = adf['Summary_of_Request']
print(all_text[:10])
print("No. of requests %d" % len(all_text))
```

```
0    Minutes of Service Delivery Subcommittee of ES...
1    Public Health inspection reports for the {loca...
2    Public Health inspection records for {location...
3    Public Health inspection records for {address ...
4    Vendor list report with total of year-to-date ...
5    Public Health inspection file for {name remove...
6    Scope of work and deliverables sections of con...
7    Number of contracts and dollar amount of contr...
8    Public Health inspection report regarding a co...
9    Phase I environmental site assessment regardin...
Name: Summary_of_Request, dtype: object
No. of requests 576
```

## N-grams and Word Clouds

With the purpose of finding out which are the most common words (unigrams) and phrases consisting of 2, 3, or n-words (bigrams, trigrams, and n-grams), it is easier if one co
string.

In [495]:
```
# Merging all the requests into a single line
all_text_merged = ''

for lines in range(0,len(all_text)):
    all_text_merged = all_text_merged + ' ' + all_text[lines]
```

In [498]:
```
print(all_text_merged[:200])    # Showing just 200 characters
```

```
 Minutes of Service Delivery Subcommittee of ESCAC for period of January 1, 1997 to January 13, 1999. Public Health insp
d}, Kitchener for the past 3 years. Publi
```

Now that we have a single string, let's get the unigrams, bigrams (two consecutive words), and trigrams (three consecutive words.)

In [84]:
```
# Preparing text and getting unigrams
tokens = prepare_text_tlc(all_text_merged)
unigrams = tokens
```

In [85]:
```
print(unigrams[:25])
print("No. of unigrams %d" % len(unigrams))
```

```
['minutes', 'service', 'delivery', 'subcommittee', 'escac', 'period', 'january', '1997', 'january', '1999', 'public', 'h
on', 'remove', 'kitchener', 'past', 'year', 'public', 'health', 'inspection', 'record', 'location', 'remove']
No. of unigrams 6013
```

In [86]:
```
bigrams = nltk.bigrams(unigrams)
trigrams = nltk.trigrams(unigrams)

unigrams_counter = Counter(unigrams)
bigrams_counter = Counter(bigrams)
trigrams_counter = Counter(trigrams)
```

And showing the top ten most common grams,

In [87]:
```
print("No. of unique unigrams: %d" % len(unigrams_counter))
for unigram in unigrams_counter.most_common(10):
    print(unigram)
```

```
No. of unique unigrams: 1147
('remove', 284)
('file', 150)
('address', 123)
('removed}.', 123)
('ontario', 121)
('waterloo', 119)
('environmental', 115)
('copy', 110)
('site', 110)
('assessment', 107)
```

In [88]:
```
print("No. of unique bigrams: %d" % len(bigrams_counter))
for bigram in bigrams_counter.most_common(10):
    print(bigram)
```

```
No. of unique bigrams: 3420
(('address', 'remove'), 112)
(('ontario', 'works'), 102)
(('environmental', 'site'), 98)
(('site', 'assessment'), 97)
(('phase', 'environmental'), 97)
(('assessment', 'address'), 83)
(('copy', 'ontario'), 81)
(('complete', 'copy'), 78)
(('file', 'removed}.'), 77)
(('client', 'file'), 71)
```

In [89]:
```
print("No. of unique trigrams: %d" % len(trigrams_counter))
for trigram in trigrams_counter.most_common(10):
    print(trigram)
```

```
No. of unique trigrams: 4316
(('environmental', 'site', 'assessment'), 97)
(('phase', 'environmental', 'site'), 96)
(('site', 'assessment', 'address'), 82)
(('assessment', 'address', 'remove'), 80)
(('copy', 'ontario', 'works'), 79)
(('complete', 'copy', 'ontario'), 72)
(('ontario', 'works', 'client'), 67)
(('works', 'client', 'file'), 66)
(('client', 'file', 'removed}.'), 55)
(('address', 'remove', 'kitchener'), 36)
```

Visualizing the word cloud with a maximum of 100 words

In [90]:
```
wordcloud1 = WordCloud(
                stopwords=STOPLIST,
                background_color='white',
                width=2000,
                height=1000,
                max_words=100
            ).generate(" ".join(unigrams))
plt.figure(figsize=(10, 5))
plt.imshow(wordcloud1, interpolation="bilinear", aspect='auto')
plt.axis('off')
plt.show()
```


And with no collocations, this is, with no bigrams, we get something that features the word "remove" quite prominently.

In [91]:
```
wordcloud2 = WordCloud(
                stopwords=STOPLIST,
                background_color='white',
                width=1000,
                height=500,
                collocations=False,
                max_words=100
            ).generate(" ".join(unigrams))
plt.figure(figsize=(10, 5))
plt.imshow(wordcloud2, interpolation="bilinear", aspect='auto')
plt.axis('off')
plt.show()
```


## N-grams and Word Clouds after removing phrases that include "*{ ... removed}*"

So, why is the word "remove" so important? It turns out, many of these requests have names of people or locations that needed to be removed for privacy reasons. So, let's re account by using regular expressions.

In [92]:
```
# {address removed}, {name removed} {names removed} {location removed} {company name removed}
# {intersection removed}
# {request number removed}

new_stop_words = []
regex_phrase = r'(?:\{\w+\s*\w*\s*\w*\s*\w*\s*\w*\s*\w*\}|\(\w+\s*\w*\s*\w*\s*\w*\s*\w*\s*\w*\}|\{\w+\s*\w*\s*\w*\s*\w*\s*\w*\
ed\)|\{\w+\s*\w*\s*\w*\s*\w*\s*\w*\s*\w*\{)'
'''
# Somehow splitting the regEx chain changes the output!
regex_phrase = r'(?:\{\w+\s*\w*\s*\w*\s*\w*\s*\w*\s*\w*\}|\
                  \(\w+\s*\w*\s*\w*\s*\w*\s*\w*\s*\w*\}|\
                  \{\w+\s*\w*\s*\w*\s*\w*\s*\w*\s*\w*\)|\
                  \{\w+\s*\w*\s*\w*\s*\w*\s*\w*\s*\w*\{|\(\w+\s*removed\)|\
                  )'
'''

matches = re.findall(regex_phrase, all_text_merged)
for match in matches:
    #print(match)
    new_stop_words.append(match)

# Change array to a set to remove duplicates
new_stop_words = set(new_stop_words)
# Turn back to a list
new_stop_words = list(new_stop_words)
print("No. of phrases to be removed: ", len(new_stop_words))    # 33
print(new_stop_words)
```

```
No. of phrases to be removed:  33
['{locations removed}', '{companies removed}', '{company names removed}', '(name removed}', '{request number removed}',
oved}', '{developer removed}', '{company name removed}', '{street name removed}', '{addresses removed}', '{institutions
section removed}', '{date removed}', '{organization name removed}', '{location removed}', '{address}', '{Name removed}',
removed}', '(name removed)', '{company name and address removed}', '{facility removed}', '(address removed}', '{restaura
tion removed)', '{restaurant name removed}', '{orgnization name removed}', '{individual by agent}', '{name removed{', '{
```

In [93]:
```
all_text_merged_removed = all_text_merged

# Replace phases by nothing
for stop in new_stop_words:
    all_text_merged_removed = all_text_merged_removed.replace(stop, '')
```

In [94]:
```
all_text_merged_removed[:500]
```

Out[94]:
```
"a Minutes of Service Delivery Subcommittee of ESCAC for period of January 1, 1997 to January 13, 1999. Public Health ir
r the past 3 years. Public Health inspection records for , Cambridge for the past 2 years. Public Health inspection recc
dours in 1994. Vendor list report with total of year-to-date purchases at fiscal year end for 1996, 1997, and 1998. Publ
rding requester's dismis"
```

So, let's find the unigrams, bigrams, trigrams, and n-grams (4-5 words), and their most commom occurrences, with this new text.

In [95]:
```
tokens_rm = prepare_text_tlc(all_text_merged_removed)
```

In [96]:
```
unigrams_rm = tokens_rm
unigrams_counter_rm = Counter(unigrams_rm)
print("No. of unique unigrams: %d" % len(unigrams_counter_rm))
for unigram in unigrams_counter_rm.most_common(10):
    print(unigram)
```

```
No. of unique unigrams: 1139
('file', 150)
('ontario', 121)
('waterloo', 119)
('environmental', 115)
('copy', 110)
('site', 110)
('assessment', 107)
('record', 104)
('works', 102)
('phase', 99)
```

In [97]:
```
bigrams_rm = nltk.bigrams(unigrams_rm)
bigrams_counter_rm = Counter(bigrams_rm)
print("No. of unique bigrams: %d" % len(bigrams_counter_rm))
for bigram in bigrams_counter_rm.most_common(20):
    print(bigram)
```

```
No. of unique bigrams: 3314
(('ontario', 'works'), 102)
(('environmental', 'site'), 98)
(('site', 'assessment'), 97)
(('phase', 'environmental'), 97)
(('copy', 'ontario'), 84)
(('complete', 'copy'), 78)
(('client', 'file'), 71)
(('works', 'client'), 67)
(('region', 'waterloo'), 45)
(('works', 'file'), 33)
(('assessment', 'kitchener'), 30)
(('file', 'complete'), 28)
(('public', 'health'), 26)
(('assessment', 'waterloo'), 25)
(('record', 'regard'), 24)
(('assessment', 'cambridge'), 22)
(('river', 'transit'), 21)
(('grand', 'river'), 21)
(('kitchener', 'phase'), 20)
(('rabies', 'control'), 19)
```

In [98]:
```
trigrams_rm = nltk.trigrams(unigrams_rm)
trigrams_counter_rm = Counter(trigrams_rm)
print("No. of unique trigrams: %d" % len(trigrams_counter_rm))
for trigram in trigrams_counter_rm.most_common(20):
    print(trigram)
```

```
No. of unique trigrams: 4062
(('environmental', 'site', 'assessment'), 97)
(('phase', 'environmental', 'site'), 96)
(('copy', 'ontario', 'works'), 81)
(('complete', 'copy', 'ontario'), 74)
(('ontario', 'works', 'client'), 67)
(('works', 'client', 'file'), 66)
(('ontario', 'works', 'file'), 33)
(('site', 'assessment', 'kitchener'), 30)
(('file', 'complete', 'copy'), 24)
(('site', 'assessment', 'waterloo'), 22)
(('site', 'assessment', 'cambridge'), 22)
(('grand', 'river', 'transit'), 21)
(('kitchener', 'phase', 'environmental'), 20)
(('assessment', 'kitchener', 'phase'), 18)
(('public', 'health', 'inspection'), 16)
(('rabies', 'control', 'investigation'), 14)
(('waterloo', 'phase', 'environmental'), 13)
(('client', 'file', 'complete'), 13)
(('works', 'file', 'complete'), 12)
(('food', 'bear', 'illness'), 12)
```

In [99]:
```
everygrams_rm = nltk.everygrams(unigrams_rm, min_len=4, max_len=4)
everygrams_counter_rm = Counter(everygrams_rm)
print("No. of unique everygrams size 4: %d" % len(everygrams_counter_rm))
for everygram in everygrams_counter_rm.most_common(10):
    print(everygram)
```

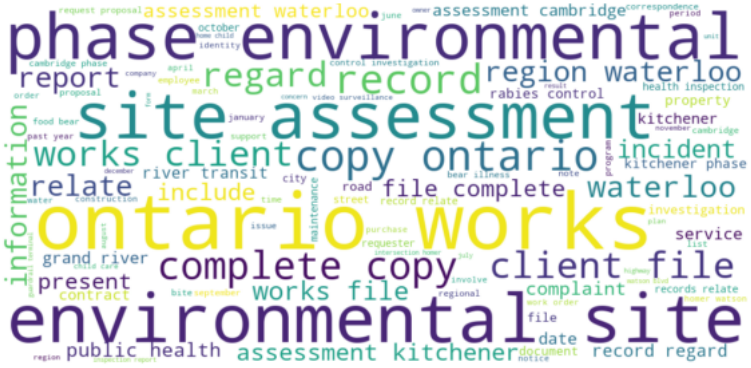
```
No. of unique everygrams size 4: 4396
(('phase', 'environmental', 'site', 'assessment'), 96)
(('complete', 'copy', 'ontario', 'works'), 72)
(('ontario', 'works', 'client', 'file'), 66)
(('copy', 'ontario', 'works', 'client'), 59)
(('environmental', 'site', 'assessment', 'kitchener'), 30)
(('file', 'complete', 'copy', 'ontario'), 23)
(('environmental', 'site', 'assessment', 'cambridge'), 22)
(('environmental', 'site', 'assessment', 'waterloo'), 22)
(('copy', 'ontario', 'works', 'file'), 22)
(('kitchener', 'phase', 'environmental', 'site'), 20)
```

In [100]:
```
everygrams_rm_5 = nltk.everygrams(unigrams_rm, min_len=4, max_len=5)
everygrams_counter_rm_5 = Counter(everygrams_rm_5)
print("No. of unique everygrams size 4 or 5: %d" % len(everygrams_counter_rm_5))
for everygram in everygrams_counter_rm_5.most_common(50):
    print(everygram)
```

```
No. of unique everygrams size 4 or 5: 9014
(('phase', 'environmental', 'site', 'assessment'), 96)
(('complete', 'copy', 'ontario', 'works'), 72)
(('ontario', 'works', 'client', 'file'), 66)
(('copy', 'ontario', 'works', 'client'), 59)
(('copy', 'ontario', 'works', 'client', 'file'), 59)
(('complete', 'copy', 'ontario', 'works', 'client'), 51)
(('environmental', 'site', 'assessment', 'kitchener'), 30)
(('phase', 'environmental', 'site', 'assessment', 'kitchener'), 30)
(('file', 'complete', 'copy', 'ontario', 'works'), 23)
(('file', 'complete', 'copy', 'ontario'), 23)
(('environmental', 'site', 'assessment', 'cambridge'), 22)
(('environmental', 'site', 'assessment', 'waterloo'), 22)
(('copy', 'ontario', 'works', 'file'), 22)
(('phase', 'environmental', 'site', 'assessment', 'waterloo'), 22)
(('phase', 'environmental', 'site', 'assessment', 'cambridge'), 22)
(('complete', 'copy', 'ontario', 'works', 'file'), 21)
(('kitchener', 'phase', 'environmental', 'site'), 20)
(('kitchener', 'phase', 'environmental', 'site', 'assessment'), 20)
(('assessment', 'kitchener', 'phase', 'environmental'), 18)
(('assessment', 'kitchener', 'phase', 'environmental', 'site'), 18)
(('site', 'assessment', 'kitchener', 'phase'), 18)
(('environmental', 'site', 'assessment', 'kitchener', 'phase'), 18)
(('site', 'assessment', 'kitchener', 'phase', 'environmental'), 18)
(('waterloo', 'phase', 'environmental', 'site'), 13)
(('ontario', 'works', 'client', 'file', 'complete'), 13)
(('client', 'file', 'complete', 'copy', 'ontario'), 13)
(('works', 'client', 'file', 'complete'), 13)
(('works', 'client', 'file', 'complete', 'copy'), 13)
(('client', 'file', 'complete', 'copy'), 13)
(('waterloo', 'phase', 'environmental', 'site', 'assessment'), 13)
(('ontario', 'works', 'file', 'complete'), 12)
(('site', 'assessment', 'waterloo', 'phase', 'environmental'), 11)
(('file', 'phase', 'environmental', 'site'), 11)
(('cambridge', 'phase', 'environmental', 'site', 'assessment'), 11)
(('file', 'phase', 'environmental', 'site', 'assessment'), 11)
(('cambridge', 'phase', 'environmental', 'site'), 11)
(('assessment', 'waterloo', 'phase', 'environmental'), 11)
(('environmental', 'site', 'assessment', 'waterloo', 'phase'), 11)
(('assessment', 'waterloo', 'phase', 'environmental', 'site'), 11)
(('site', 'assessment', 'waterloo', 'phase'), 11)
(('assessment', 'cambridge', 'phase', 'environmental'), 10)
(('site', 'assessment', 'cambridge', 'phase', 'environmental'), 10)
(('works', 'client', 'file', 'phase'), 10)
(('environmental', 'site', 'assessment', 'cambridge', 'phase'), 10)
(('assessment', 'cambridge', 'phase', 'environmental', 'site'), 10)
(('ontario', 'works', 'client', 'file', 'phase'), 10)
(('complete', 'ontario', 'works', 'file'), 10)
(('site', 'assessment', 'cambridge', 'phase'), 10)
(('client', 'file', 'phase', 'environmental', 'site'), 9)
(('works', 'client', 'file', 'phase', 'environmental'), 9)
```

And just for the fun of visualizing it, wordclouds!

In [101]:
```
wordcloud3 = WordCloud(
                stopwords=STOPLIST,
                background_color='white',
                width=1000,
                height=500,
                max_words=100
            ).generate(" ".join(unigrams_rm))
plt.figure(figsize=(10, 5))
plt.imshow(wordcloud3, interpolation="bilinear", aspect='auto')
plt.axis('off')
plt.show()
```




And without bigrams:

In [102]:
```
wordcloud4 = WordCloud(
                stopwords=STOPLIST,
                background_color='white',
                width=1000,
                height=500,
                collocations=False,
                max_words=100
            ).generate(" ".join(unigrams_rm))
plt.figure(figsize=(10, 5))
plt.imshow(wordcloud4, interpolation="bilinear", aspect='auto')
plt.axis('off')
plt.show()
```


## Most-used Phrases and Decisions

Looking at the n-grams, one finds phrases that commonly appear throughout the requests:

- "Ontario Works" appears in 8 out of the top 20 n-grams.
- "Environmental site (assessment)" as "Environmental site" or "Site assessment" appears in 11 of the top 20.

... And those word combinations make up the top 50!

Using bigrams, other few phrases come to light:

- "Grand River Transit" as "Grand River" or "River Transit"
- "Rabies control" or "control investigation"
- "(Public) Health inspection"
- "Food bear" or "bear illness" (Lemmatize version of "Food-borne illness")

Based on these phrases, we try to find if there is a pattern concerning the *Decision*.

Since we will be working with prepared and processed text, we will just add that cleaned, tokenized, and lemmatized text as a column, called "Edited_Summary" to a new data

In [103]:
```
tokenized_adf = adf.copy()
```

In [104]:
```
new_col = []
for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Summary_of_Request'][index]
    for stop in new_stop_words:
        if stop in current_line:
            current_line = current_line.replace(stop, '')
    line_tokens = prepare_text_tlc(current_line)

    rejoined_text =  "".join([" " + i if not i.startswith("'") and i not in string.punctuation
                              else i for i in line_tokens]).strip()
    new_col.append(rejoined_text)

tokenized_adf['Edited_Summary'] = new_col
```

In [105]:
```
tokenized_adf.head(5)
```

Out[105]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision | Edited_Summar |
|---|---|---|---|---|---|---|
| **0** | 99001 | General | Business | Minutes of Service Delivery Subcommittee of ES... | Information disclosed in part | minutes service delivery subcommittee escac pe. |
| **1** | 99002 | General | Business | Public Health inspection reports for the {loca... | All information disclosed | public health inspection report kitchener past. |
| **2** | 99003 | General | Business | Public Health inspection records for {location... | Information disclosed in part | public health inspection record cambridge past. |
| **3** | 99004 | General | Individual | Public Health inspection records for {address ... | All information disclosed | public health inspection record cambridge rela. |
| **4** | 99005 | General | Business | Vendor list report with total of year-to-date ... | All information disclosed | vendor list report total year date purchase fi. |

While looking at the n-grams, we noted that there are few recurrent phrases and its variations:

- 'ontario works', 'complete copy ontario works client file'
- 'environmental site', 'site assessment', 'environmental site assessment'
- 'grand river', 'river transit', 'grand river transit'
- 'public health', 'health inspection', 'public health inspection'
- 'rabies control', 'control investigation', 'rabies control investigation'
- 'food bear', 'bear illness', 'food bear illness'

So, if we are to determine a decision probability based on these phrases, which ones are we going to use?

For the first one, 'ontario works' will encompass most of the requests. For the others, let's find out which phrase represents the majority.

In [521]:
```
# Arrays to store the 'Request_Number's
s1_array = []
s2_array  = []
s3_array  = []

string1 = 'environmental site'
string2 = 'site assessment'
string3 = 'environmental site assessment'

for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Edited_Summary'][index]
    if string1 in current_line:
        s1_array.append(tokenized_adf['Request_Number'][index])
    if string2 in current_line:
        s2_array.append(tokenized_adf['Request_Number'][index])
    if string3 in current_line:
        s3_array.append(tokenized_adf['Request_Number'][index])

s1_set = set(s1_array)
s2_set = set(s2_array)
s3_set = set(s3_array)

if s1_set != s2_set:
    print("s1 is not equal to s2")
if s2_set != s3_set:
    print("s2 is not equal to s3")
if s1_set != s3_set:
    print("s1 is not equal to s3")

diff_set = s1_set.symmetric_difference(s2_set)

for index in range(0, len(tokenized_adf)):
    rn = tokenized_adf['Request_Number'][index]
    if rn in diff_set:
        print("Request Number:", rn, "Text:", tokenized_adf['Edited_Summary'][index])
```

```
s1 is not equal to s2
s1 is not equal to s3
Request Number: 2016077 Text: record environmental concern regard elmsdale drive include information contain environment
```

'*environmental site*' is the one that includes the most requests, so let's use that phrase.

In [517]:
```
# Arrays to store the 'Request_Number's
s1_array = []
s2_array  = []
s3_array  = []

string1 = 'grand river'
string2 = 'river transit'
string3 = 'grand river transit'

for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Edited_Summary'][index]
    if string1 in current_line:
        s1_array.append(tokenized_adf['Request_Number'][index])
    if string2 in current_line:
        s2_array.append(tokenized_adf['Request_Number'][index])
    if string3 in current_line:
        s3_array.append(tokenized_adf['Request_Number'][index])

s1_set = set(s1_array)
s2_set = set(s2_array)
s3_set = set(s3_array)

if s1_set != s2_set:
    print("s1 is not equal to s2")
if s2_set != s3_set:
    print("s2 is not equal to s3")
if s1_set != s3_set:
    print("s1 is not equal to s3")

diff_set = s1_set.symmetric_difference(s2_set)
print(diff_set)

for index in range(0, len(tokenized_adf)):
    rn = tokenized_adf['Request_Number'][index]
    if rn in diff_set:
        print("Request Number:", rn, "; Text:", tokenized_adf['Edited_Summary'][index])
```

```
set()
```

All options give the same result, so let's use the the full phrase, '*grand river transit*'.

In [523]:
```
# Arrays to store the 'Request_Number's
s1_array = []
s2_array  = []
s3_array  = []

string1 = 'public health'
string2 = 'health inspection'
string3 = 'public health inspection'


for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Edited_Summary'][index]
    if string1 in current_line:
        s1_array.append(tokenized_adf['Request_Number'][index])
    if string2 in current_line:
        s2_array.append(tokenized_adf['Request_Number'][index])
    if string3 in current_line:
        s3_array.append(tokenized_adf['Request_Number'][index])


s1_set = set(s1_array)
s2_set = set(s2_array)
s3_set = set(s3_array)

if s1_set != s2_set:
    print("s1 is not equal to s2")
if s2_set != s3_set:
    print("s2 is not equal to s3")
if s1_set != s3_set:
    print("s1 is not equal to s3")

diff_set = s1_set.symmetric_difference(s2_set)

#print(diff_set)

for index in range(0, len(tokenized_adf)):
    rn = tokenized_adf['Request_Number'][index]
    if rn in diff_set:
        print("Request Number:", rn, "Text:", tokenized_adf['Edited_Summary'][index])
```

```
s1 is not equal to s2
s1 is not equal to s3
Request Number: 2002009 Text: competition file 2002 public health nurse sexual health
Request Number: 2002010 Text: personal information competition file 2002 public health nurse sexual health
Request Number: 2003002 Text: information regard public health nurse staff qualification perform sexual health counsel
Request Number: 2003012 Text: rabies control record incident occur deal halton public health
Request Number: 2006009 Text: public health record regard contamination investigation
Request Number: 2006021 Text: public health investigation record regard kitchener
Request Number: 2007001 Text: public health investigation file regard coli 0157 outbreak requester home care
Request Number: 2007005 Text: public health investigation record regard requester daughter coli 0157 infection home chil
Request Number: 2015032 Text: investigation file note natan somer public health inspector regard investigation salmonell
Request Number: 2015040 Text: report compile public health inspector carolyn biglow bite place night october 2015
```

'*public health* seems to broaden the topics, so, let's stick to *public health inspection* instead.

In [525]:
```
# Arrays to store the 'Request_Number's
s1_array = []
s2_array  = []
s3_array  = []

string1 = 'rabies control'
string2 = 'control investigation'
string3 = 'rabies control investigation'

for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Edited_Summary'][index]
    if string1 in current_line:
        s1_array.append(tokenized_adf['Request_Number'][index])
    if string2 in current_line:
        s2_array.append(tokenized_adf['Request_Number'][index])
    if string3 in current_line:
        s3_array.append(tokenized_adf['Request_Number'][index])

s1_set = set(s1_array)
s2_set = set(s2_array)
s3_set = set(s3_array)

if s1_set != s2_set:
    print("s1 is not equal to s2")
if s2_set != s3_set:
    print("s2 is not equal to s3")
if s1_set != s3_set:
    print("s1 is not equal to s3")

diff_set = s1_set.symmetric_difference(s2_set)

print(diff_set)

for index in range(0, len(tokenized_adf)):
    rn = tokenized_adf['Request_Number'][index]
    if rn in diff_set:
        print("Request Number:", rn, "Text:", tokenized_adf['Edited_Summary'][index])
```

```
s1 is not equal to s2
s1 is not equal to s3
{2012037, 2003011, 2003012, 99013, 2007023}
Request Number: 99013 Text: rabies control record relate bite affect report bite involve
Request Number: 2003011 Text: rabies control record incident occur january 2003 kitchener
Request Number: 2003012 Text: rabies control record incident occur deal halton public health
Request Number: 2007023 Text: rabies control inspection record involve august 2007
Request Number: 2012037 Text: rabies control inspection record incident occur
```

Let's use *'rabies control'.

In [526]:
```
# Arrays to store the 'Request_Number's

s1_array = []
s2_array  = []
s3_array  = []

string1 = 'food bear'
string2 = 'bear illness'
string3 = 'food bear illness'

for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Edited_Summary'][index]
    if string1 in current_line:
        s1_array.append(tokenized_adf['Request_Number'][index])
    if string2 in current_line:
        s2_array.append(tokenized_adf['Request_Number'][index])
    if string3 in current_line:
        s3_array.append(tokenized_adf['Request_Number'][index])

s1_set = set(s1_array)
s2_set = set(s2_array)
s3_set = set(s3_array)

if s1_set != s2_set:
    print("s1 is not equal to s2")
if s2_set != s3_set:
    print("s2 is not equal to s3")
if s1_set != s3_set:
    print("s1 is not equal to s3")

diff_set = s1_set.symmetric_difference(s2_set)

print(diff_set)


for index in range(0, len(tokenized_adf)):
    rn = tokenized_adf['Request_Number'][index]
    if rn in diff_set:
        print("Request Number:", rn, "Text:", tokenized_adf['Edited_Summary'][index])
```

```
set()
```

All sets are the same, so let's use 'food bear illness'.

Now that we know which phrases to use, let's analyze the decisions based on those.

In [106]:
```
# Looking at acceptance rates based on the following phrases
# 'ontario works'
# 'environmental site'
# 'grand river transit'
# 'rabies control'
# 'public health inspection'
# 'food bear illness'

list_commom_phrases = {'ontario works', 'environmental site',
                       'grand river transit', 'public health inspection',
                       'rabies control', 'food bear illness'}
```

Making a matrix of the number of decisions for each of these phrases,

In [107]:
```
# Defining the unique decisions as our rows of our new dataframe
counter_rows = np.append(tokenized_adf.Decision.unique(), 'All')

# Starting a dataframe with such rows, and the common phrases as columns. Set initial values of zero
counter_df = pd.DataFrame(0, index=counter_rows, columns=list_commom_phrases)

# Changing values to occurances based on decisions
for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Edited_Summary'][index]
    current_decision = tokenized_adf['Decision'][index]
    for phrase in list_commom_phrases:
        if phrase in current_line:
            counter_df[phrase]['All'] = counter_df[phrase]['All'] + 1
            counter_df[phrase][current_decision] = counter_df[phrase][current_decision] + 1

counter_df
```

Out[107]:

| | grand river transit | public health inspection | food bear illness | rabies control | environmental site | ontario works |
|---|---|---|---|---|---|---|
| **Information disclosed in part** | 4 | 8 | 4 | 15 | 5 | 31 |
| **All information disclosed** | 10 | 6 | 7 | 3 | 24 | 41 |
| **Request withdrawn** | 1 | 1 | 0 | 0 | 22 | 10 |
| **Partly non-existent** | 0 | 0 | 0 | 0 | 7 | 5 |
| **Transferred** | 0 | 0 | 0 | 1 | 0 | 1 |
| **No records exist** | 0 | 1 | 1 | 0 | 40 | 11 |
| **No information disclosed** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Correction refused** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Correction granted** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Abandoned** | 2 | 0 | 0 | 0 | 0 | 3 |
| **No additional records exist** | 0 | 0 | 0 | 0 | 0 | 0 |
| **All** | 17 | 16 | 12 | 19 | 98 | 102 |

In [110]:
```
# Total number of requests with this phrases
total_w_phrases = counter_df[11:12].sum(axis=1)
```

What fraction of entries have these phrases?

In [111]:
```
total_w_phrases/tokenized_adf.shape[0]
```

Out[111]:
```
All    0.458333
dtype: float64
```

So, 46% of the requests made over 18 years involve one of the following phrases: 'ontario works', 'environmental site', 'grand river transit', 'public health inspection', 'rabies cc

In order to normalize the results, we should remove the "All" column.

In [112]:
```
counter_df_Dec = counter_df.drop('All')
```

In [113]:
```
counter_df_Dec_byDecision = counter_df_Dec.div(counter_df_Dec.sum(axis=0), axis=1)
counter_df_Dec_byDecision
```

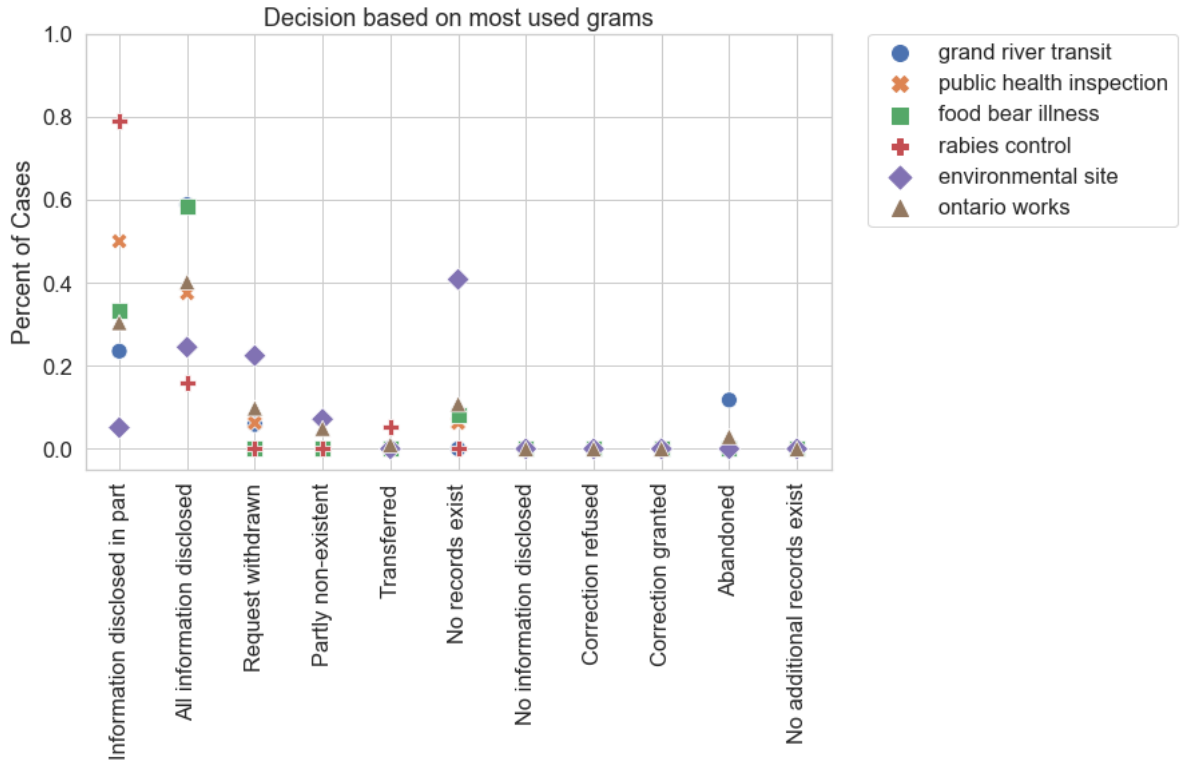
Out[113]:

| | grand river transit | public health inspection | food bear illness | rabies control | environmental site | ontario works |
|---|---|---|---|---|---|---|
| **Information disclosed in part** | 0.235294 | 0.5000 | 0.333333 | 0.789474 | 0.051020 | 0.303922 |
| **All information disclosed** | 0.588235 | 0.3750 | 0.583333 | 0.157895 | 0.244898 | 0.401961 |
| **Request withdrawn** | 0.058824 | 0.0625 | 0.000000 | 0.000000 | 0.224490 | 0.098039 |
| **Partly non-existent** | 0.000000 | 0.0000 | 0.000000 | 0.000000 | 0.071429 | 0.049020 |
| **Transferred** | 0.000000 | 0.0000 | 0.000000 | 0.052632 | 0.000000 | 0.009804 |
| **No records exist** | 0.000000 | 0.0625 | 0.083333 | 0.000000 | 0.408163 | 0.107843 |
| **No information disclosed** | 0.000000 | 0.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| **Correction refused** | 0.000000 | 0.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| **Correction granted** | 0.000000 | 0.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| **Abandoned** | 0.117647 | 0.0000 | 0.000000 | 0.000000 | 0.000000 | 0.029412 |
| **No additional records exist** | 0.000000 | 0.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |

Now we can make a plot of the results.

In [114]:
```
plt.figure(figsize=(10, 6))
sns.set_context("notebook", font_scale=1.5, rc={"lines.linewidth": 3.5, "lines.markersize": 12.0})
ax = sns.scatterplot(data=counter_df_Dec_byDecision, markers=True)
ax.set(ylabel='Percent of Cases', title='Decision based on most used grams', ylim=(-0.05, 1))
plt.xticks(rotation=90)
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

Out[114]: <matplotlib.legend.Legend at 0x1a2a649748>




And to make the results clearer, we remove the zero values. We do this by replacing them with 'NaN' values, since seaborn would not plot those points.

In [1034]:
```
nan_counter_df = counter_df_Dec_byDecision.copy()
```

In [1035]:
```
nan_counter_df = nan_counter_df.replace(0.0, 'NaN')
```

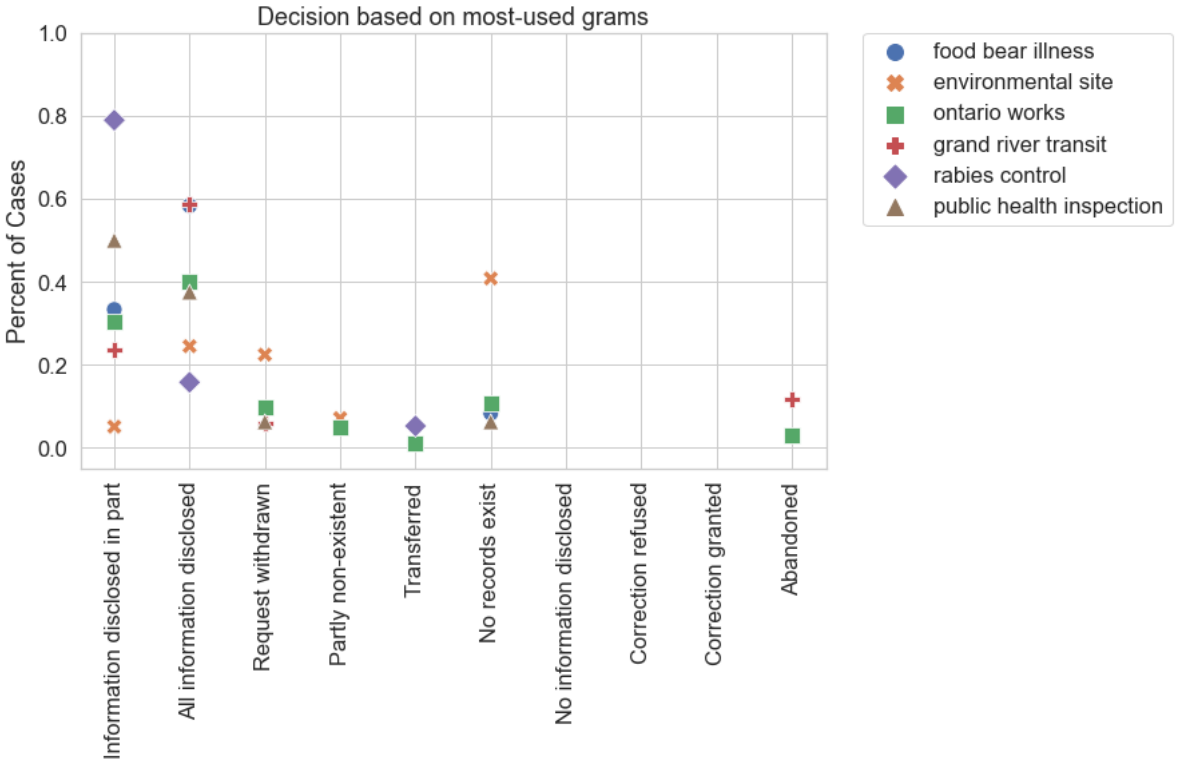
In [1036]:
```
nan_counter_df
```

Out[1036]:

| | food bear illness | environmental site | ontario works | grand river transit | rabies control | public health inspection |
|---|---|---|---|---|---|---|
| **Information disclosed in part** | 0.333333 | 0.0510204 | 0.303922 | 0.235294 | 0.789474 | 0.5 |
| **All information disclosed** | 0.583333 | 0.244898 | 0.401961 | 0.588235 | 0.157895 | 0.375 |
| **Request withdrawn** | NaN | 0.22449 | 0.0980392 | 0.0588235 | NaN | 0.0625 |
| **Partly non-existent** | NaN | 0.0714286 | 0.0490196 | NaN | NaN | NaN |
| **Transferred** | NaN | NaN | 0.00980392 | NaN | 0.0526316 | NaN |
| **No records exist** | 0.0833333 | 0.408163 | 0.107843 | NaN | NaN | 0.0625 |
| **No information disclosed** | NaN | NaN | NaN | NaN | NaN | NaN |
| **Correction refused** | NaN | NaN | NaN | NaN | NaN | NaN |
| **Correction granted** | NaN | NaN | NaN | NaN | NaN | NaN |
| **Abandoned** | NaN | NaN | 0.0294118 | 0.117647 | NaN | NaN |
| **No additional records exist** | NaN | NaN | NaN | NaN | NaN | NaN |

In [1037]:
```
plt.figure(figsize=(10, 6))
sns.set_context("notebook", font_scale=1.5, rc={"lines.linewidth": 3.5, "lines.markersize": 12.0})
ax1 = sns.scatterplot(data = nan_counter_df, markers=True)
ax1.set(ylabel='Percent of Cases', title='Decision based on most-used grams', ylim=(-0.05, 1))
plt.xticks(rotation=90)
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

Out[1037]: <matplotlib.legend.Legend at 0x1a36d5b780>




In [542]:
```
dash_counter_perc_df  = counter_df_Dec.div(counter_df_Dec.sum(axis=0)/100, axis=1).round(decimals=2)
```

In [544]:
```
dash_counter_perc_df = dash_counter_perc_df.replace(0.0, '--')
```

In [545]:
```
dash_counter_perc_df
```

Out[545]:

| | food bear illness | environmental site | ontario works | grand river transit | rabies control | public health inspection |
|---|---|---|---|---|---|---|
| **Information disclosed in part** | 33.33 | 5.1 | 30.39 | 23.53 | 78.95 | 50 |
| **All information disclosed** | 58.33 | 24.49 | 40.2 | 58.82 | 15.79 | 37.5 |
| **Request withdrawn** | -- | 22.45 | 9.8 | 5.88 | -- | 6.25 |
| **Partly non-existent** | -- | 7.14 | 4.9 | -- | -- | -- |
| **Transferred** | -- | -- | 0.98 | -- | 5.26 | -- |
| **No records exist** | 8.33 | 40.82 | 10.78 | -- | -- | 6.25 |
| **No information disclosed** | -- | -- | -- | -- | -- | -- |
| **Correction refused** | -- | -- | -- | -- | -- | -- |
| **Correction granted** | -- | -- | -- | -- | -- | -- |
| **Abandoned** | -- | -- | 2.94 | 11.76 | -- | -- |
| **No additional records exist** | -- | -- | -- | -- | -- | -- |

It is interesting to note that none of these phrases got a single "No information disclosed" decision. In summary, 46% of all of our data contains these phrases, and of those ph

- "*Food bear illness*": 92% of the cases got full or partial information disclosed, with 8% where no information exists.
- "*Environmental site*": there was no information for 41% of the cases, for 22% of the cases the request was withdrawn. Full or partial information was given to 30%, while th existent information.
- "*Ontario Works*": 70% got full or partial information disclosed, 13% of the cases were abandoned or withdrawn, information did not exist for 11%, while 5% had only partia transferred.
- "*Grand River Transit*": 82% of cases got a full or partial information disclosed, while 18% of the cases were abandoned or withdrawn.
- "*Rabies control*" got about 95% with all or partially information disclosed, and 5% of the cases were tranferred.
- "*Public health Inspection*": 88% got full or partial information disclosed, 6% had no records, and 6% of the requests were withdrawn.

## *Summary_of_Request* Statistics

It is be also interesting to see with how much data our ML algorith would be working. This is, what is the length of those "Summary_of_Request". Remember we don't get the f
the summary made by the clerk.

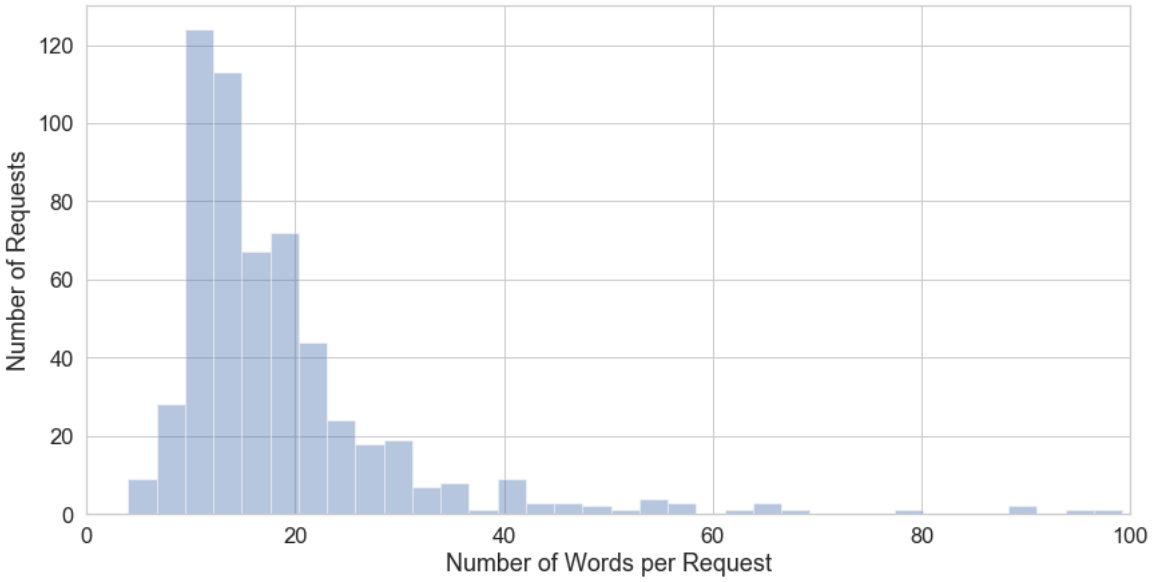
First, let's examine the full text we obtained directly from the files.

In [119]:
```
num_chars = []
num_words = []
counter = 0

for index in range(0, len(all_text)):
    chars_num = len(all_text[index])
    words_num = len(parser(all_text[index]))
    num_chars.append(chars_num)
    num_words.append(words_num)
    if words_num > 100:
        counter += 1
        print(all_text[index])
        #print(parser(all_text[index]))
        print("Number of characters: %d" % chars_num)
        number_words = parser(all_text[index])
        print("Number of words: %d \n" % words_num)
print("Total number of entries with more than 100 words: ", counter)
```

```
1. A copy of the successful proposal in response to the RFP C2014-39 for Tender Preparation, Contract Administration and
he Construction of the Waterloo Spur Line Trail from Regina Street in the City of Waterloo to Ahrens Street in the City
icipality of Waterloo on October 15, 2014.□ Please exclude any promotional material that may have been submitted with t
ietary. 2. The total number of submissions and the dollar value of the top three submissions for RFP C2014-39.
Number of characters: 586
Number of words: 106

1) Records for the past two years up to most current for the inspection, testing and maintaining of the traffic control
ection of Homer Watson Blvd. and Ottawa St. pursuant to "ONTARIO REGULATION 239/02 MINIMUM MAINTENANCE STANDARDS FOR MUN
(1).  2) Records for the past two years up to most current for the inspection, testing and maintaining of the conflict m
Watson Blvd. and Ottawa St. pursuant to "ONTARIO REGULATION 239/02 MINIMUM MAINTENANCE STANDARDS FOR MUNICIPAL HIGHWAYS"
for the past two years up to most current for the inspection, testing and maintenance of the red light camera system at
and Ottawa St.  4) Records for the past two years up to most current year for any corrective maintenance that needed
signal system sub-systems at the intersection of Homer Watson Blvd. and Ottawa St. 5) Records for the past two years up
tive maintenance that needed to take place for the conflict monitor(s) at the intersection of Homer Watson Blvd. and Ott
rs up to the most current year for any corrective maintenance that needed to take place for the red light camera system
d. and Ottawa St.
Number of characters: 1450
Number of words: 276

1) What was the scheduled shift for Paramedics {name removed} and {name removed} on Sunday June 28, 2015?
2) Was their unit responding to a call for service at that time?
3) The computer log data for Waterloo Region EMS indicating all calls for service on June 28, 2015 between 0600 and 0645
4) The computer log data, if it exists, which records the activation for that particular EMS vehicle□s emergency lights
hours.

Number of characters: 466
Number of words: 105

Follow up to request 2016018  for 1) Traffic Signal Intersection Preventative Maintenance records for the period of Janu
e inspection, testing and maintaining of the display sub-system, consisting of traffic signal and pedestrian crossing he
pport cables at the intersection of Homer Watson Blvd. and Ottawa St.  2) Signal Work Order records for the period of Ja
the inspection, testing and maintaining of the display sub-system, consisting of traffic signal and pedestrian crossing
support cables at the intersection of Homer Watson Blvd. and Ottawa St.
Number of characters: 707
Number of words: 130

A complete copy of all records, documents, and call logs for any 1) EMS attendances at Stampede Corral Bar located at 24
ario, N2G 4L1, with respect to medical attention needed by a patron of this bar from January 1, 2009 to January 1, 2016;
cated at 248 Stirling Street South, Kitchener, Ontario, N2G 4L2, with respect to any incidents of violence, injury, assa
2016.
Number of characters: 482
Number of words: 105

6 Environment reports: 1. 2011 Groundwater Monitoring, Inspection and Maintenance Program, Waterloo City Centre, CRA Jar
oring, Inspection and Maintenance Program, Waterloo City Centre, CRA April 8, 2011; 3. R-A-CV-86-02 Recommended Approach
ontaminated Soil at the Waterloo City Centre Site, Canviro 1986; 4. R-A-CV-86-03 Recommended Approach to Hydrogeological
Site Canviro 1986; 5. R-A-CV-87-04 Hydrogeologic Assessment of the Waterloo City Centre Site Canviro 1987; 6. R-A-CV-87-
rloo City Centre Site- Interim Report  Canviro 1987.
Number of characters: 689
Number of words: 140

Any records that evidence, reference, survey, or relate to the 1) purchase or installation of guardrail end terminal sys
alled on the roads and highways of the Region of Waterloo from 2005 to the present 2) performance of guardrail end termi
em 3) replacement of guardrail end terminal systems, including the ET Plus System 4) ownership or control of or responsi
al systems 5) payment and/or reimbursement and/or discount provided by federal, provincial, city, municipal, or other fu
ET Plus guardrail end terminal system 6) criteria, factors, or features considered in deciding which guardrail end termi
oad and highways of Waterloo Region and in deciding which guardrail end terminal systems to include on any approved or q
ctors, or features considered in deciding which guardrail end terminal system to purchase for use on road or highway pro
resent.
Number of characters: 1121
Number of words: 199

Total number of entries with more than 100 words:  7
```

In [120]:
```
np_num_words = np.array(num_words)
mean_words = np_num_words.mean()
median_words = np.median(num_words)

plt.figure(figsize=(14, 7))
plt.xlim(0, 100)
plt.xlabel('Number of Words per Request')
plt.ylabel('Number of Requests')
sns.distplot(num_words, bins=100, kde=False)

print("Average number of words per request is %f, while the median is %f" %(mean_words, median_words))
```

```
Average number of words per request is 20.491319, while the median is 15.000000
```




As for the tokenized version of it:

In [121]:
```
all_text_tokenized = tokenized_adf['Edited_Summary']
```

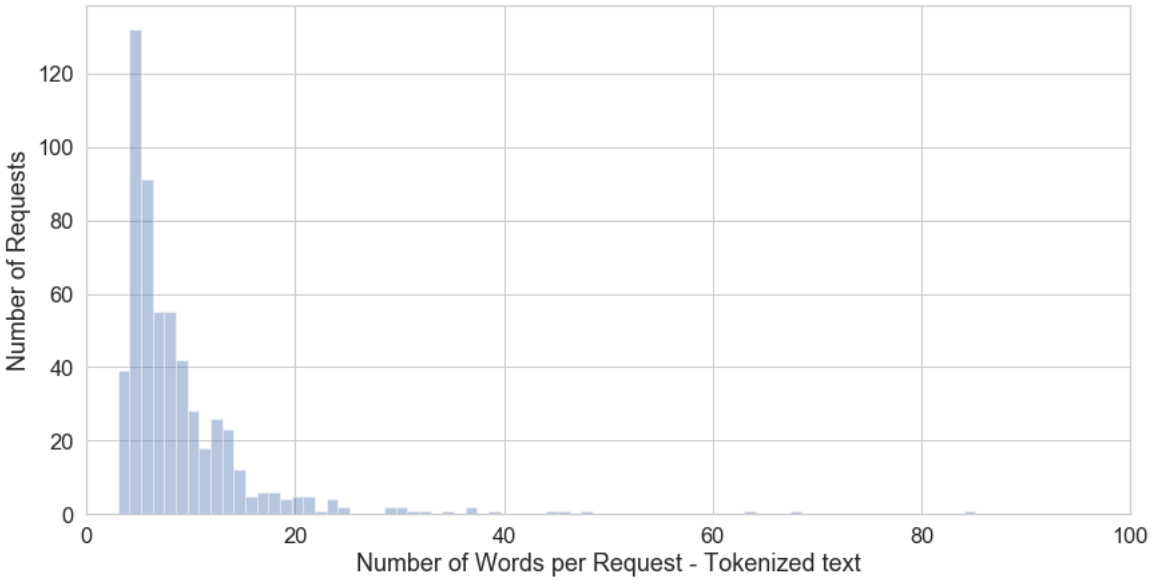
In [547]:
```
# Merging all the requests into a single line
all_text_tokenized_merged = ''

for lines in range(0, len(all_text_tokenized)):
    all_text_tokenized_merged = all_text_tokenized_merged + ' ' + all_text_tokenized[lines]

#all_text_tokenized_merged
# typos: phase environemntal site assesment
```

In [549]:
```
num_chars_t = []
num_words_t = []
small_req = []
counter = 0
counter_sm = 0

for index in range(0, len(all_text_tokenized)):
    chars_num_t = len(all_text_tokenized[index])
    words_num_t = len(parser(all_text_tokenized[index]))
    num_chars_t.append(chars_num_t)
    num_words_t.append(words_num_t)
    if words_num_t > 100:
        counter += 1
        print(all_text_tokenized[index])
        print("Number of characters: %d" % chars_num_t)
        number_words = parser(all_text_tokenized[index])
        print("Number of words: %d \n" % words_num_t)
    if words_num_t < 6:
        small_req.append(all_text_tokenized[index])
        counter_sm += 1

print("Total number of entries with more than 100 words: ", counter)
print("Total number of entries with less than 6 words: %d, which is %0.1f%% of the total number of requests"
      %(counter_sm, (100.*counter_sm / len(all_text_tokenized))))
```

```
records past year current inspection test maintain traffic control signal intersection homer watson blvd ottawa pursuant
tenance standards municipal highways section subsection records past year current inspection test maintain conflict moni
tawa pursuant ontario regulation 239/02 minimum maintenance standards municipal highways section subsection records past
ce light camera intersection homer watson blvd ottawa records past year current year corrective maintenance need place t
r watson blvd ottawa records past year current year corrective maintenance need place conflict monitor(s intersection hc
r current year corrective maintenance need place light camera intersection homer watson blvd ottawa
Number of characters: 894
Number of words: 114

Total number of entries with more than 100 words:  1
Total number of entries with less than 6 words: 171, which is 29.7% of the total number of requests
```

In [124]:
```
np_num_words_t = np.array(num_words_t)
mean_words_t = np_num_words_t.mean()
median_words_t = np.median(num_words_t)

plt.figure(figsize=(14, 7))
plt.xlim(0, 100)
plt.xlabel('Number of Words per Request - Tokenized text')
plt.ylabel('Number of Requests')
sns.distplot(num_words_t, bins=100, kde=False)

print("Average number of words per request is %f, while the median is %f" %(mean_words_t, median_words_t))
```

```
Average number of words per request is 9.338542, while the median is 7.000000
```




Seven words (7!), the median, is not much with which to work...

30% of the requests have 5 words or less. They are listed below.

In [125]:
```
small_req
```

Out[125]:
```
['records relate complaint cambridge',
 'personnel file period 1990/10/01 1999/10/31',
 'phase environmental site assessment kitchener',
 'home child care provider file',
 'identity owner close restaurant',
 'proposals pride network p2002',
 'contracts payment make region waterloo',
 'records mould growth home kitchener',
 'results tender t2003 carpet replacement',
 'records regard municipal regulation pesticide',
 'analysis sewage composition cambridge 2003',
 'email send cupe member refer',
 'record correspondence ontario works file',
 'rabies control investigation file',
 'social worker client file pertain',
 'phase environmental site assessment elmira',
 'phase environmental site assessment elmira',
 'phase environmental site assessment elmira',
 'phase environmental site assessment cambridge',
 'employee file attendance datum',
 'phase environmental site assessment cambridge',
 'record regard hepatitis outbreak waterloo',
 'rabies control investigation file',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment heidelberg',
 'food bear illness investigation',
 'incident report involve individual',
 'collision database electronic form',
 'identity complainant tree complaint',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment elmira',
 'shelter advertise contract independent contractor',
 'phase environmental site assessment kitchener',
 'work order invoice company',
 'phase environmental site assessment kitchener',
 'authority fluoridate water outside waterloo',
 'phase environmental site assessment kitchener',
 'subdivision file rp1694 wilmot township',
 'rabies control investigation file',
 'phase environmental site assessment cambridge',
 'ambulance reports relate waterloo',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment waterloo',
 'signal time kitchener',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment waterloo',
 'records support fluoridation',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment kitchener',
 'records relate draft backflow',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment waterloo',
 'winning blueprinting service 2010',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment elmira',
 'phase environmental site assessment baden',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment cambridge',
 'public health inspection waterloo',
 'phase environmental site assessment',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment waterloo',
 'phase environmental site assessment petersburg',
 'phase environmental site assessment cambridge',
 'phase environmental site assessment kitchener',
 'rabies control investigation file',
 'phase environmental site assessment kitchener',
 'phase environmental site assessment kitchener',
```

```
'phase environmental site assessment kitchener',
'phase environmental site assessment waterloo',
'winning blueprinting service 2011',
'environmental report submit subdivision application',
'phase environmental site assessment waterloo',
'phase environmental site assessment kitchener',
'phase environmental site assessment waterloo',
'phase environmental site assessment kitchener',
'phase environmental site assessment waterloo',
'phase environmental site assessment kitchener',
'phase environmental site assessment kitchener',
'phase environmental site assessment kitchener',
'phase environmental site assessment cambridge',
'phase environmental site assessment kitchener',
'phase environmental site assessment cambridge',
'phase environmental site assessment waterloo',
'phase environmental site assessment waterloo',
'phase environmental site assessment kitchener',
'phase environmental site assessment kitchener',
'phase environmental site assessment kitchener',
'phase environmental site assessment cambridge',
'phase environmental site assessment kitchener',
'phase environmental site assessment cambridge',
'phase environmental site assessment cambridge',
'winning blueprinting service 2012',
'phase environmental site assessment cambridge',
'phase environmental site assessment waterloo',
'phase environmental site assessment elmira',
'phase environmental site assessment kitchener',
'phase environmental site assessment cambridge',
'rabies control investigation record',
'phase environmental site assessment cambridge',
'phase environmental site assessment kitchener',
'phase environmental site assessment waterloo',
'phase environmental site assessment kitchener',
'property standard inspection regard kitchener',
'winning blueprinting service 2013',
'phase environmental site assessment',
'multiple transportation operation engineer record',
'phase environmental site assessment',
'pool inspection record',
'identity affiliation freedom information request',
'records pertain requester 1987 date',
'camera record september 2013',
'phase environemntal site assesment',
'1998 reconnaissance investigation report da-98',
'record relate 2001 present',
'record relate possiblity make complaint',
'project agreement region waterloo grandlinq',
'2416 outside video footage 2:00',
'2416 outside video footage 2:00',
'file search tobacco',
'copy complete ontario works file',
'copy complete ontario works file',
'complete ontario works file',
'complete ontario works file',
'complete ontario works file',
'complete ontario works file',
'complete ontario works file',
'complete ontario works file',
'complete ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'grand river transit video surveillance',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complete copy ontario works file',
'complaint investigation relate 2015',
'complete copy ontario works file',
'complete copy ontario works file',
'employment file relevant financial information',
'complete copy ontario works file']
```

In [126]:
```
df_small_req = pd.DataFrame({'Tokenized_Requests_lt_6': small_req})
```

Of those 171 *small requests*, some are the same type of requests. We break down the number and phases below. We only show those with more than 2 cases.

In [127]:
```
#df_small_req['Tokenized_Requests_lt_6'].unique()
print("Number of unique values: ", df_small_req['Tokenized_Requests_lt_6'].nunique())
df_small_req['Tokenized_Requests_lt_6'].value_counts().head(12)
```

```
Number of unique values:  62
```

Out[127]:
```
phase environmental site assessment kitchener    30
phase environmental site assessment waterloo     22
phase environmental site assessment cambridge    22
complete copy ontario works file                 21
complete ontario works file                       7
phase environmental site assessment elmira        6
rabies control investigation file                 4
phase environmental site assessment               3
2416 outside video footage 2:00                   2
copy complete ontario works file                  2
rabies control investigation record               1
incident report involve individual                1
Name: Tokenized_Requests_lt_6, dtype: int64
```

## POS Tagging

How about tag types? For this we will use spaCy.

One can do the analysis including empty spaces and punctuation. Instead, I chose to remove them first, therefore, we need to tokenize the text and then remove unwanted cha

However, the *nlp()* function of spaCy, the one that will provide the tags, requires a string. We will need to stitch back together the tokens.

In [873]:
```
# Tokenizing text, while removing symbols
full_text_tok = tokenize_rmSym_Text(all_text_merged)

# Merging all the tokens into a single line
full_text = ''

for words in range(0, len(full_text_tok)):
    full_text = full_text + ' ' + full_text_tok[words]
```

In [940]:
```
full_text_nlp = nlp(full_text)    # spaCy nlp()

tags = []    # Array where the spacy tags will be stored

for token in full_text_nlp:
    tags.append(token.tag_)

tags_df = pd.DataFrame(data = tags, columns=['Tags'])

print("Number of unique tag values: ", tags_df['Tags'].nunique())
print("Total number of words: ", len(tags_df['Tags']))

# Make a dataframe out of unique values
tags_value_counts = tags_df['Tags'].value_counts(dropna=True, sort=True)
tags_value_counts_df = tags_value_counts.rename_axis('Unique_Values').reset_index(name='Counts')

# And normalizing the count values
tags_value_counts_df['Normalized_Count'] = tags_value_counts_df['Counts'] / len(tags_df['Tags'])

tags_value_counts_df.head(10)

#spacy.explain(tags_value_counts_df['Unique_Values'][0])
```

```
Number of unique tag values:  37
Total number of words:  9875
```

Out[940]:

| | Unique_Values | Counts | Normalized_Count |
|---|---|---|---|
| **0** | NN | 3465 | 0.350886 |
| **1** | IN | 1615 | 0.163544 |
| **2** | JJ | 863 | 0.087392 |
| **3** | NNS | 857 | 0.086785 |
| **4** | DT | 590 | 0.059747 |
| **5** | CD | 582 | 0.058937 |
| **6** | VBN | 433 | 0.043848 |
| **7** | CC | 365 | 0.036962 |
| **8** | VBG | 243 | 0.024608 |
| **9** | NNP | 156 | 0.015797 |

Now, for those who can't remember what all of those tags mean, let's add the explanation as a new column called "Decoded" by using spacy's function *explain()*.

In [941]:
```
uv_decoded = []

for val in tags_value_counts_df['Unique_Values']:
    uv_decoded.append(spacy.explain(val))

tags_value_counts_df['Decoded'] = uv_decoded
tags_value_counts_df
```

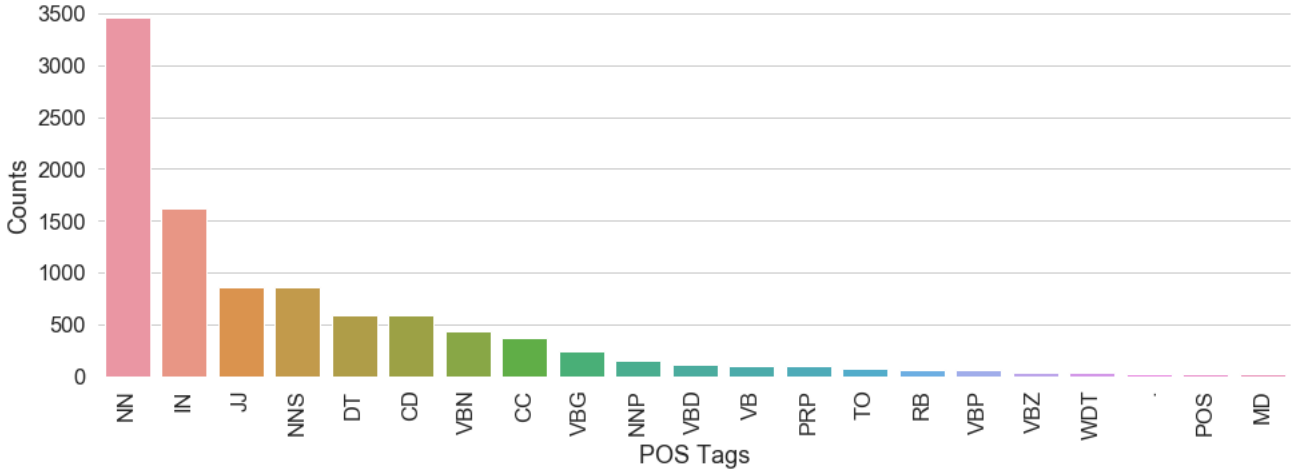
Out[941]:

| | Unique_Values | Counts | Normalized_Count | Decoded |
|---|---|---|---|---|
| **0** | NN | 3465 | 0.350886 | noun, singular or mass |
| **1** | IN | 1615 | 0.163544 | conjunction, subordinating or preposition |
| **2** | JJ | 863 | 0.087392 | adjective |
| **3** | NNS | 857 | 0.086785 | noun, plural |
| **4** | DT | 590 | 0.059747 | determiner |
| **5** | CD | 582 | 0.058937 | cardinal number |
| **6** | VBN | 433 | 0.043848 | verb, past participle |
| **7** | CC | 365 | 0.036962 | conjunction, coordinating |
| **8** | VBG | 243 | 0.024608 | verb, gerund or present participle |
| **9** | NNP | 156 | 0.015797 | noun, proper singular |
| **10** | VBD | 118 | 0.011949 | verb, past tense |
| **11** | VB | 103 | 0.010430 | verb, base form |
| **12** | PRP | 101 | 0.010228 | pronoun, personal |
| **13** | TO | 77 | 0.007797 | infinitival to |
| **14** | RB | 59 | 0.005975 | adverb |
| **15** | VBP | 59 | 0.005975 | verb, non-3rd person singular present |
| **16** | VBZ | 35 | 0.003544 | verb, 3rd person singular present |
| **17** | WDT | 35 | 0.003544 | wh-determiner |
| **18** | . | 27 | 0.002734 | punctuation mark, sentence closer |
| **19** | POS | 22 | 0.002228 | possessive ending |
| **20** | MD | 21 | 0.002127 | verb, modal auxiliary |
| **21** | WRB | 8 | 0.000810 | wh-adverb |
| **22** | RP | 7 | 0.000709 | adverb, particle |
| **23** | PRP$ | 7 | 0.000709 | pronoun, possessive |
| **24** | RBS | 4 | 0.000405 | adverb, superlative |
| **25** | JJS | 4 | 0.000405 | adjective, superlative |
| **26** | FW | 3 | 0.000304 | foreign word |
| **27** | AFX | 3 | 0.000304 | affix |
| **28** | WP | 3 | 0.000304 | wh-pronoun, personal |
| **29** | UH | 2 | 0.000203 | interjection |
| **30** | EX | 2 | 0.000203 | existential there |
| **31** | JJR | 1 | 0.000101 | adjective, comparative |
| **32** | XX | 1 | 0.000101 | unknown |
| **33** | PDT | 1 | 0.000101 | predeterminer |
| **34** | '' | 1 | 0.000101 | closing quotation mark |
| **35** | LS | 1 | 0.000101 | list item marker |
| **36** | | 1 | 0.000101 | None |

Given the range of values, it does not make much sense to plot anything under 20 occurances.

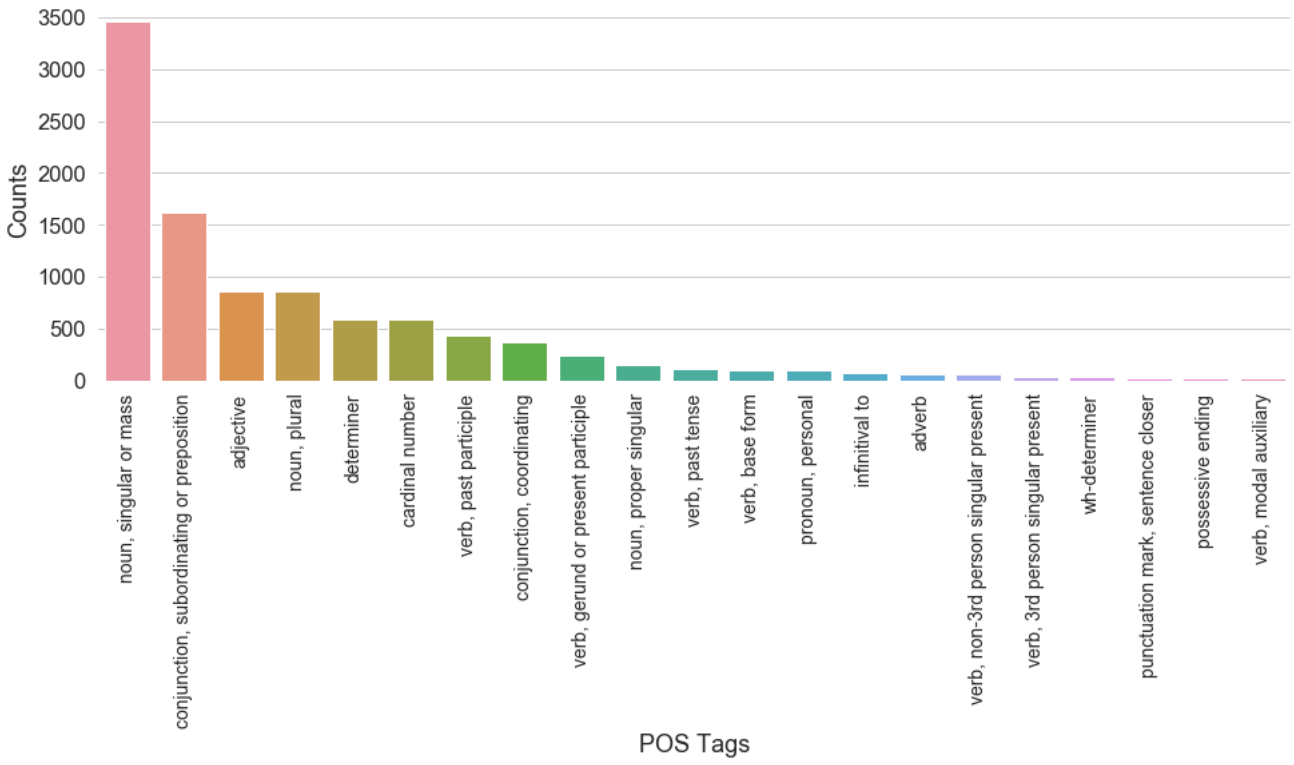
In [942]:
```
tags_value_counts_df_gt20 = tags_value_counts_df[tags_value_counts_df['Counts'] > 20]
```

In [943]:
```
categ = list(tags_value_counts_df_gt20['Unique_Values'])

f, ax = plt.subplots(figsize=(16, 5))

sns.set_color_codes('dark')
sns.barplot(y=tags_value_counts_df_gt20['Counts'], x=categ)
ax.set(xlabel="POS Tags", ylim=(0, 3500), ylabel="Counts")
plt.xticks(rotation=90)
sns.despine(left=True, bottom=True)
```



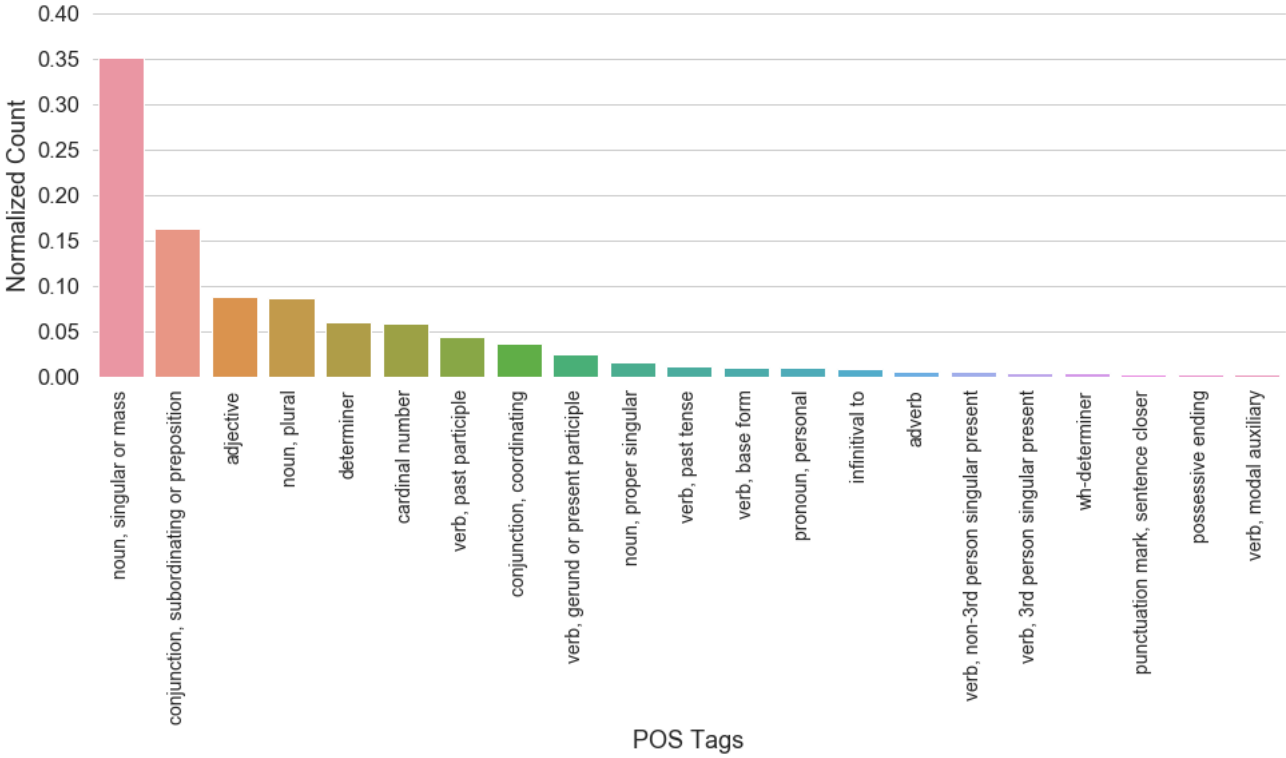

And to be more explicit, let's write the descriptions instead.

In [944]:
```
categ = list(tags_value_counts_df_gt20['Decoded'])

f, ax = plt.subplots(figsize=(16, 5))

sns.set_color_codes('dark')
sns.barplot(y=tags_value_counts_df_gt20['Counts'], x=categ)
ax.set(xlabel="POS Tags", ylim=(0, 3500), ylabel="Counts")
plt.xticks(rotation=90, fontsize=14)
sns.despine(left=True, bottom=True)
```




And with normalized values,

In [1040]:
```
categ = list(tags_value_counts_df_gt20['Decoded'])

f, ax = plt.subplots(figsize=(16, 5))

sns.set_color_codes('dark')
sns.barplot(y=tags_value_counts_df_gt20['Normalized_Count'], x=categ)
ax.set(xlabel="POS Tags", ylim=(0, 0.4), ylabel="Normalized Count")
plt.xticks(rotation=90, fontsize=14)
sns.despine(left=True, bottom=True)
```



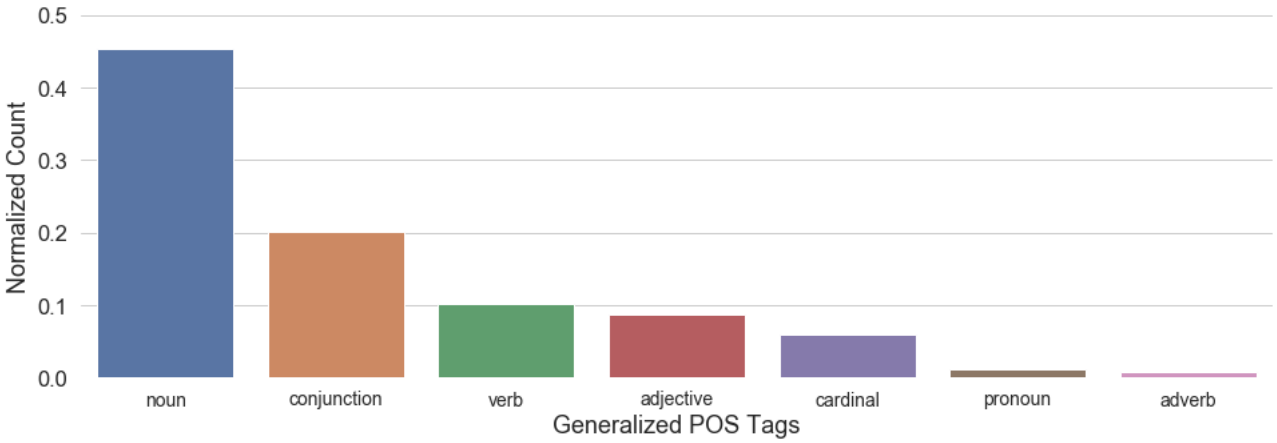

It is interesting to see how much text is composed of nouns (singular, plural,...), verbs (present, past,...), numbers, conjunctions, pronouns, adverbs, and adjectives.

In [985]:
```
pos_types = ['noun', 'pronoun', 'verb', 'adjective', 'adverb', 'conjunction', 'cardinal']

tag_tag = []
tag_count = []
tag_percent = []

for tag in pos_types:
    # Adding the columns that fit the constraint
    tag_array = tags_value_counts_df[(tags_value_counts_df['Decoded'].str.startswith(tag, na=False))].sum(axis=0)
    tag_tag.append(tag)
    # tag_array: [0]=Unique_Values, [1]=Counts, [2]=Normalized_Count, [3]=Decoded
    tag_count.append(tag_array[1])
    tag_percent.append(tag_array[2])

#print(tag_count)

d = {'Tags':tag_tag, 'Counts':tag_count, 'Normalized_Count':tag_percent}

tags_df = pd.DataFrame(d)
tags_df = tags_df.sort_values(by='Counts', ascending=False)
tags_df
```

Out[985]:

| | Counts | Normalized_Count | Tags |
|---|---|---|---|
| **0** | 4478 | 0.453468 | noun |
| **5** | 1980 | 0.200506 | conjunction |
| **2** | 1012 | 0.102481 | verb |
| **3** | 868 | 0.087899 | adjective |
| **6** | 582 | 0.058937 | cardinal |
| **1** | 108 | 0.010937 | pronoun |
| **4** | 70 | 0.007089 | adverb |

In [1044]:
```
categ = list(tags_df['Tags'])

f, ax = plt.subplots(figsize=(16, 5))

sns.set_color_codes('dark')
sns.barplot(y=tags_df['Normalized_Count'], x=categ)
ax.set(xlabel="Generalized POS Tags", ylim=(0, 0.5), ylabel="Normalized Count")
plt.xticks(rotation=0, fontsize=14)
sns.despine(left=True, bottom=True)
```




In summary, our corpus includes 45% nouns, 20% conjunctions, 10% verbs, 9% adjectives, 6% numbers, 1% pronouns, among others (9%).

## LSA and LDA Analysis using Bokeh, scikit-learn, and t-SNE

Following Susan Li's posts. We present here LSA and LDA analysis of the text.

In [252]:
```
from sklearn.manifold import TSNE
```

In [248]:
```
# LSA
from sklearn.decomposition import TruncatedSVD
```

In [552]:
```
# LDA
from sklearn.decomposition import LatentDirichletAllocation
```

In [256]:
```
from bokeh.plotting import figure, output_file, show
from bokeh.models import Label
from bokeh.io import output_notebook
output_notebook()
from bokeh.models import Range1d
```

(https://bokeh.pydata.org)

Bokeh 0.13.0 successfully loaded.

In [1105]:
```
import matplotlib.patheffects as path_effects
```

In [1093]:
```
# Susan Li's predefined functions

def get_keys(topic_matrix):
    '''
    returns an integer list of predicted topic
    categories for a given topic matrix
    '''
    keys = topic_matrix.argmax(axis=1).tolist()
    return keys

def keys_to_counts(keys):
    '''
    returns a tuple of topic categories and their
    accompanying magnitudes for a given list of keys
    '''
    count_pairs = Counter(keys).items()
    categories = [pair[0] for pair in count_pairs]
    counts = [pair[1] for pair in count_pairs]
    return (categories, counts)

def get_top_n_words(n, keys, document_term_matrix, tfidf_vectorizer):
    '''
    returns a list of n_topic strings, where each string contains the n most common
    words in a predicted category, in order
    '''
    top_word_indices = []
    for topic in range(n_topics):
        temp_vector_sum = 0
        for i in range(len(keys)):
            if keys[i] == topic:
                temp_vector_sum += document_term_matrix[i]
        temp_vector_sum = temp_vector_sum.toarray()
        top_n_word_indices = np.flip(np.argsort(temp_vector_sum)[0][-n:],0)
        top_word_indices.append(top_n_word_indices)
    top_words = []
    for topic in top_word_indices:
        topic_words = []
        for index in topic:
            temp_word_vector = np.zeros((1,document_term_matrix.shape[1]))
            temp_word_vector[:, index] = 1
            the_word = tfidf_vectorizer.inverse_transform(temp_word_vector)[0][0]
            topic_words.append(the_word.encode('ascii').decode('utf-8'))
        top_words.append(", ".join(topic_words))
    return top_words

def get_mean_topic_vectors(keys, two_dim_vectors):
    '''
    returns a list of centroid vectors from each predicted topic category
    '''
    mean_topic_vectors = []
    for t in range(n_topics):
        reviews_in_that_topic = []
        for i in range(len(keys)):
            if keys[i] == t:
                reviews_in_that_topic.append(two_dim_vectors[i])

        reviews_in_that_topic = np.vstack(reviews_in_that_topic)
        mean_review_in_that_topic = np.mean(reviews_in_that_topic, axis=0)
        mean_topic_vectors.append(mean_review_in_that_topic)
    return mean_topic_vectors

def get_median_topic_vectors(keys, two_dim_vectors):
    '''
    returns a list of median-centroid vectors from each predicted topic category
    '''
    median_topic_vectors = []
    for t in range(n_topics):
        reviews_in_that_topic = []
        for i in range(len(keys)):
            if keys[i] == t:
                reviews_in_that_topic.append(two_dim_vectors[i])

        reviews_in_that_topic = np.vstack(reviews_in_that_topic)
        median_review_in_that_topic = np.median(reviews_in_that_topic, axis=0)
        median_topic_vectors.append(median_review_in_that_topic)
    return median_topic_vectors
```

In [1094]:
```
colormap = np.array([
    "#1f77b4", "#aec7e8", "#ff7f0e", "#ffbb78", "#2ca02c",
    "#98df8a", "#d62728", "#ff9896", "#9467bd", "#c5b0d5",
    "#8c564b", "#c49c94", "#e377c2", "#f7b6d2", "#7f7f7f",
    "#c7c7c7", "#bcbd22", "#dbdb8d", "#17becf", "#9edae5" ])
colormap = colormap[:n_topics]
```

## Preprocessing text for LDA and LSA, using tf-idf vectorizer

In [1102]:
```
reindexed_data = tokenized_adf['Edited_Summary']    # Edited_Summary is tokenized, lemmatized, and without symbols and
tfidf_vectorizer = TfidfVectorizer(use_idf=True, smooth_idf=True)
reindexed_data = reindexed_data.values
document_term_matrix = tfidf_vectorizer.fit_transform(reindexed_data)
```

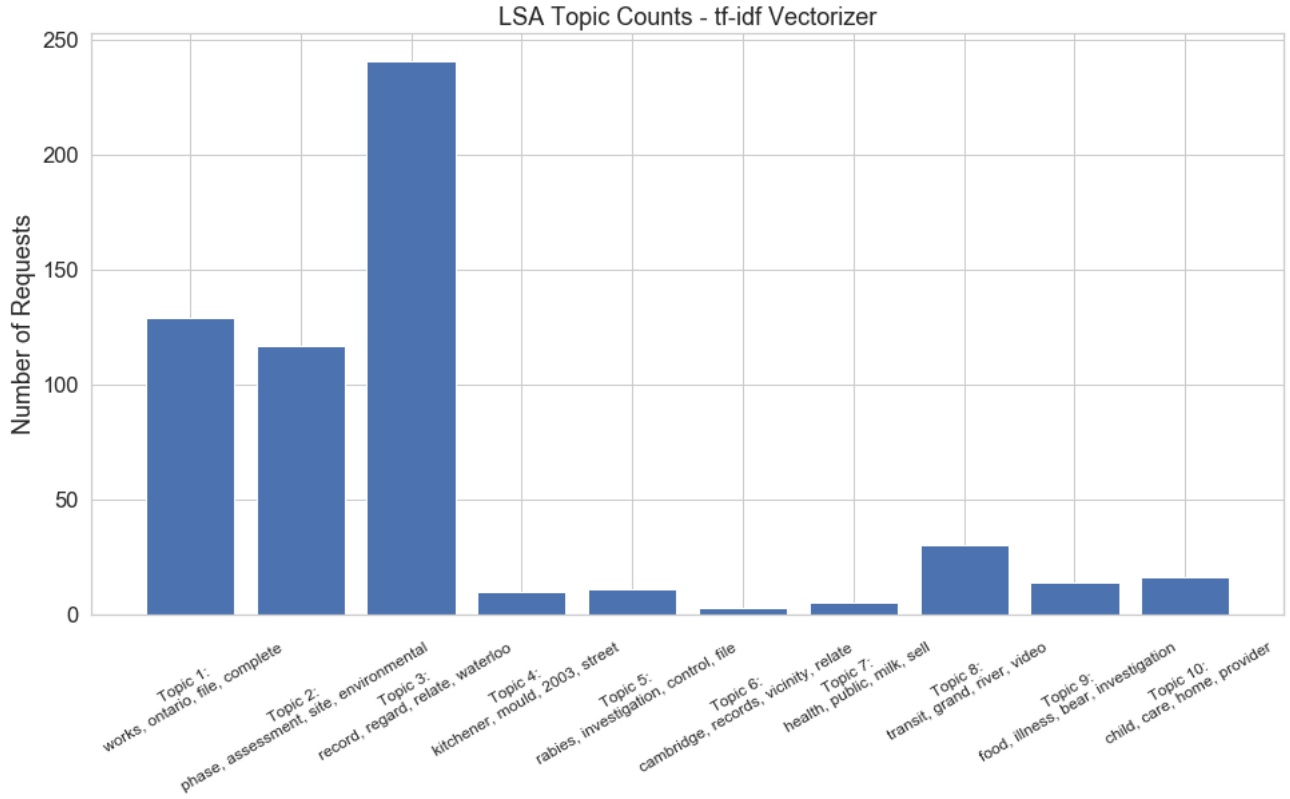
## LSA - scikit-learn - tf-idf vectorizer

Of the 10 topics found, five of the previously six discussed common phrases are included, except for "*Public Health Inspection*".

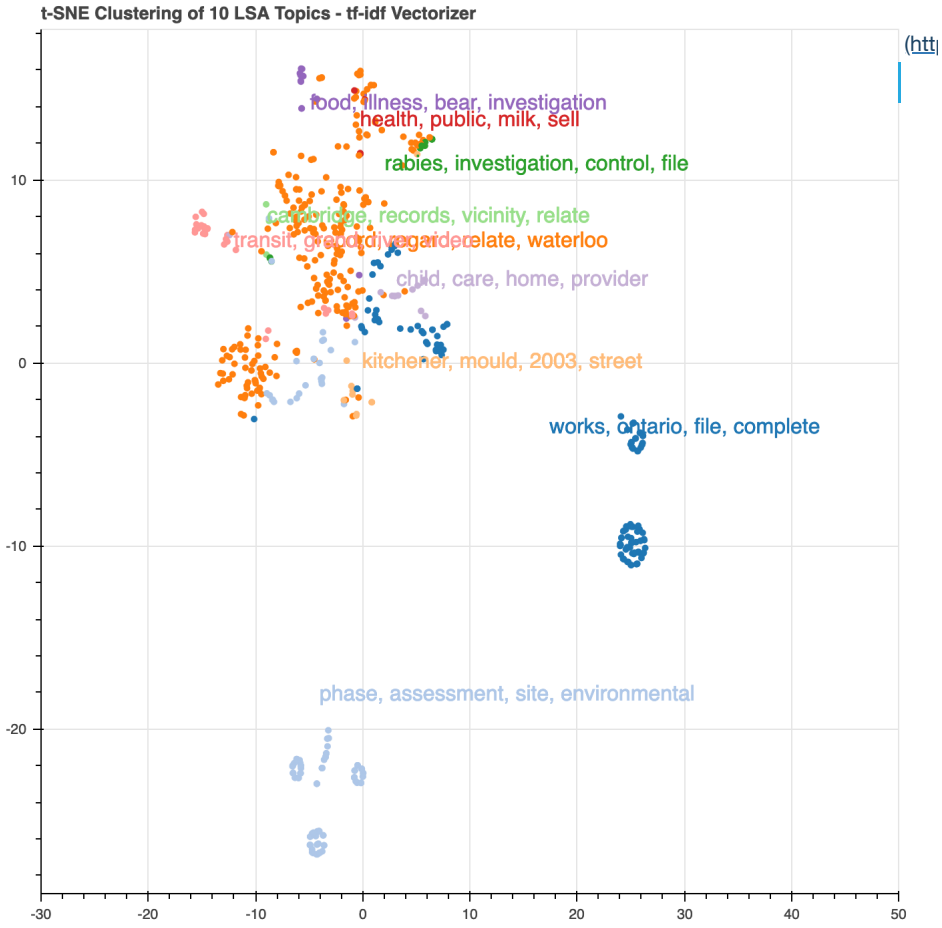
In [1119]:

```
n_topics = 10
lsa_model = TruncatedSVD(n_components=n_topics, random_state=42)
lsa_topic_matrix = lsa_model.fit_transform(document_term_matrix)

lsa_keys = get_keys(lsa_topic_matrix)
lsa_categories, lsa_counts = keys_to_counts(lsa_keys)
top_n_words_lsa = get_top_n_words(4, lsa_keys, document_term_matrix, tfidf_vectorizer)

for i in range(len(top_n_words_lsa)):
    print("Topic {}: ".format(i + 1), top_n_words_lsa[i])

# Plotting
labels = ['Topic {}: \n'.format(i + 1) + top_n_words_lsa[i] for i in lsa_categories]
fig, ax = plt.subplots(figsize=(16, 8))
ax.bar(lsa_categories, lsa_counts);
ax.set_xticks(lsa_categories);
ax.set_xticklabels(labels);
ax.set_ylabel('Number of Requests');
ax.set_title('LSA Topic Counts - tf-idf Vectorizer');
plt.xticks(rotation=30, fontsize=12)
plt.show();

#Bokeh and t-SNE
tsne_lsa_model = TSNE(n_components=2, perplexity=50, learning_rate=100,
                      n_iter=2000, verbose=1, random_state=42, angle=0.75)
tsne_lsa_vectors = tsne_lsa_model.fit_transform(lsa_topic_matrix)

top_4_words_lsa = get_top_n_words(4, lsa_keys, document_term_matrix, tfidf_vectorizer)
lsa_mean_topic_vectors = get_mean_topic_vectors(lsa_keys, tsne_lsa_vectors)

plot = figure(title="t-SNE Clustering of {} LSA Topics - tf-idf Vectorizer".format(n_topics),
              plot_width=700, plot_height=700, x_range=[-30,50])

plot.scatter(x=tsne_lsa_vectors[:,0], y=tsne_lsa_vectors[:,1], color=colormap[lsa_keys])

for t in range(n_topics):
    label = Label(x=lsa_mean_topic_vectors[t][0], y=lsa_mean_topic_vectors[t][1],
                  text=top_4_words_lsa[t], text_color=colormap[t])
    plot.add_layout(label)

show(plot)
```

```
Topic 1:  works, ontario, file, complete
Topic 2:  phase, assessment, site, environmental
Topic 3:  record, regard, relate, waterloo
Topic 4:  kitchener, mould, 2003, street
Topic 5:  rabies, investigation, control, file
Topic 6:  cambridge, records, vicinity, relate
Topic 7:  health, public, milk, sell
Topic 8:  transit, grand, river, video
Topic 9:  food, illness, bear, investigation
Topic 10:  child, care, home, provider
```




```
[t-SNE] Computing 151 nearest neighbors...
[t-SNE] Indexed 576 samples in 0.001s...
[t-SNE] Computed neighbors for 576 samples in 0.018s...
[t-SNE] Computed conditional probabilities for sample 576 / 576
[t-SNE] Mean sigma: 0.090932
[t-SNE] KL divergence after 250 iterations with early exaggeration: 50.772839
[t-SNE] KL divergence after 2000 iterations: 0.330207
```




While there seems to be defined clusters for *food bear illness*, *rabies*, *ontario works*, and *environmental site*, these last two also overlap with the *record regard relate waterloo* to other topics.

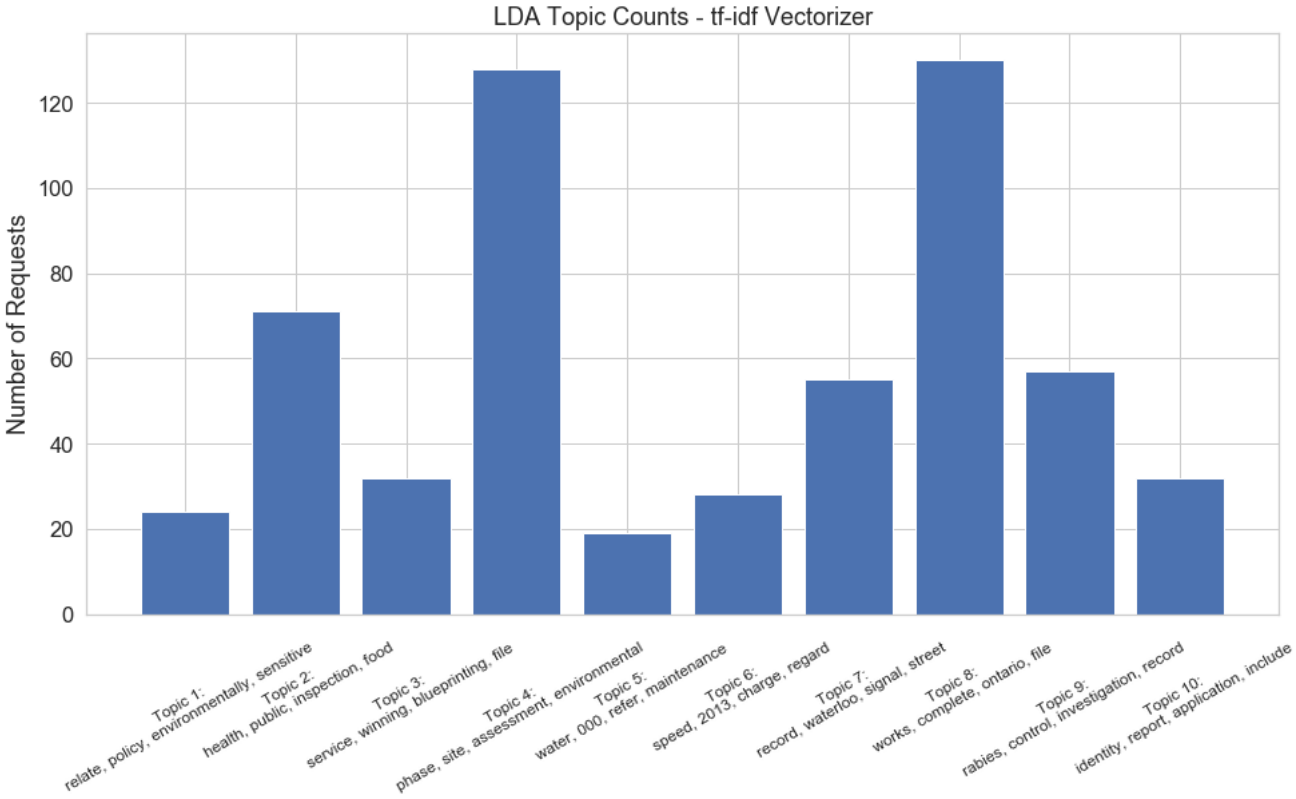
## LDA - scikit learn - tf-idf vectorizer

Of the 10 topics found, LDA found four of the previously six discussed common phrases are included, except for "*Grand River Transit*" and *food bear illness*.

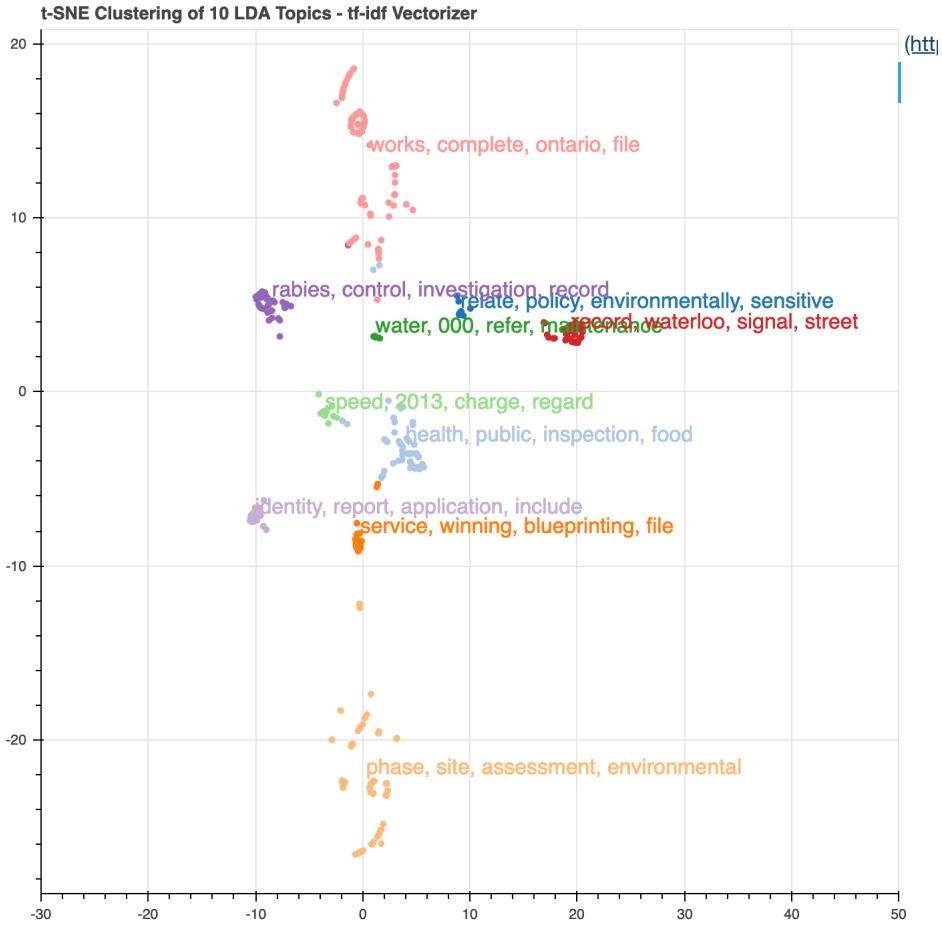
In [1085]:

```
n_topics = 10
lda_model_sk = LatentDirichletAllocation(n_components=n_topics,
                                         random_state=42, verbose=0)
lda_topic_matrix_sk = lda_model_sk.fit_transform(document_term_matrix)

lda_keys = get_keys(lda_topic_matrix_sk)
lda_categories, lda_counts = keys_to_counts(lda_keys)
top_n_words_lda = get_top_n_words(4, lda_keys, document_term_matrix, tfidf_vectorizer)


for i in range(len(top_n_words_lsa)):
    print("Topic {}: ".format(i + 1), top_n_words_lda[i])

labels = ['Topic {}: \n'.format(i + 1) + top_n_words_lda[i] for i in lda_categories]
fig, ax = plt.subplots(figsize=(16, 8))
ax.bar(lda_categories, lda_counts);
ax.set_xticks(lda_categories);
ax.set_xticklabels(labels);
ax.set_ylabel('Number of Requests');
ax.set_title('LDA Topic Counts - tf-idf Vectorizer');
plt.xticks(rotation=30, fontsize=12)
plt.show();


# Bokeh and t-SNE
tsne_lda_model = TSNE(n_components=2, perplexity=50, learning_rate=100,
                      n_iter=2000, verbose=1, random_state=42, angle=0.75)
tsne_lda_vectors = tsne_lda_model.fit_transform(lda_topic_matrix_sk)

top_4_words_lda = get_top_n_words(4, lda_keys, document_term_matrix, tfidf_vectorizer)
lda_mean_topic_vectors = get_mean_topic_vectors(lda_keys, tsne_lda_vectors)

plot = figure(title="t-SNE Clustering of {} LDA Topics - tf-idf Vectorizer".format(n_topics),
              plot_width=700, plot_height=700, x_range=[-30,50])

plot.scatter(x=tsne_lda_vectors[:,0], y=tsne_lda_vectors[:,1], color=colormap[lda_keys])

for t in range(n_topics):
    label = Label(x=lda_mean_topic_vectors[t][0], y=lda_mean_topic_vectors[t][1],
                  text=top_4_words_lda[t], text_color=colormap[t])
    plot.add_layout(label)

show(plot)
```

```
Topic 1:  relate, policy, environmentally, sensitive
Topic 2:  health, public, inspection, food
Topic 3:  service, winning, blueprinting, file
Topic 4:  phase, site, assessment, environmental
Topic 5:  water, 000, refer, maintenance
Topic 6:  speed, 2013, charge, regard
Topic 7:  record, waterloo, signal, street
Topic 8:  works, complete, ontario, file
Topic 9:  rabies, control, investigation, record
Topic 10:  identity, report, application, include
```




```
[t-SNE] Computing 151 nearest neighbors...
[t-SNE] Indexed 576 samples in 0.001s...
[t-SNE] Computed neighbors for 576 samples in 0.018s...
[t-SNE] Computed conditional probabilities for sample 576 / 576
[t-SNE] Mean sigma: 0.001239
[t-SNE] KL divergence after 250 iterations with early exaggeration: 48.165726
[t-SNE] KL divergence after 2000 iterations: 0.174454
```




t-SNE for LDA with tf-idf provides more defined clusters compared to LSA.

## Preprocessing text for LDA and LSA, using CountVectorizer

This time, let's use a CountVectorizer.

In [1090]:
```
reindexed_data = tokenized_adf['Edited_Summary']
count_vectorizer = CountVectorizer(ngram_range=(1, 5))
reindexed_data = reindexed_data.values
document_term_matrix = count_vectorizer.fit_transform(reindexed_data)
```

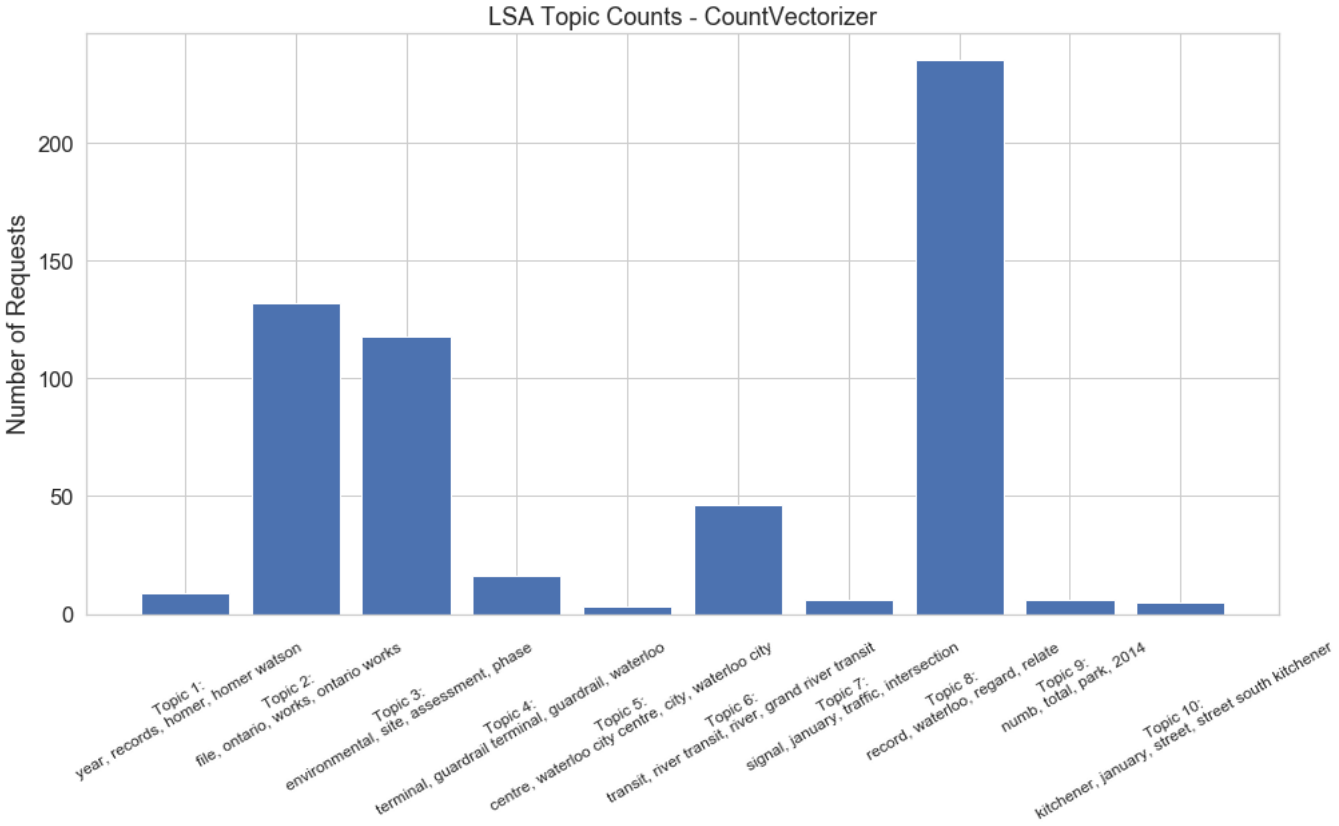
## LSA - scikit learn - CountVectorizer

It seems like LSA + CountVectorizer does not give better results. It did find three of the topics, but t-SNE gives overlapping clusters and the top topics include bigrams, too. An *Kitchener* are present in many requests, as expected, it is probably not a good idea for those to be topics themselves.

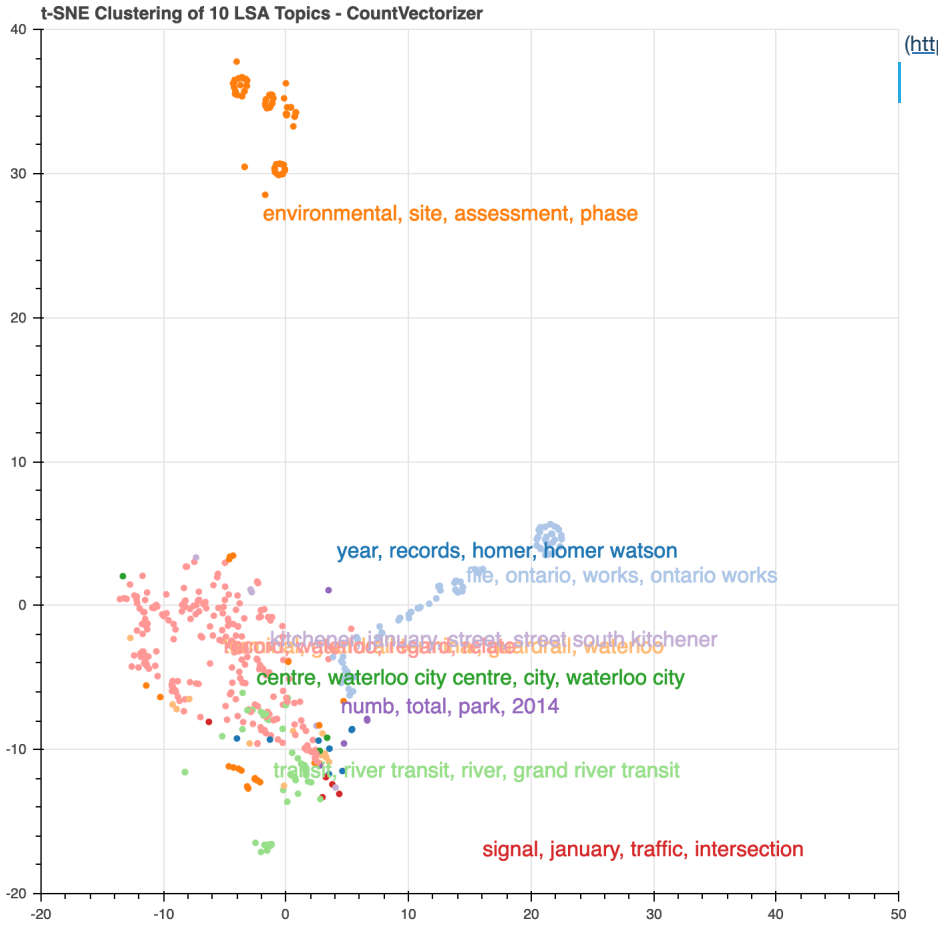
In [1091]:

```
n_topics = 10
lsa_model = TruncatedSVD(n_components=n_topics, random_state=42)
lsa_topic_matrix = lsa_model.fit_transform(document_term_matrix)

lsa_keys = get_keys(lsa_topic_matrix)
lsa_categories, lsa_counts = keys_to_counts(lsa_keys)
top_n_words_lsa = get_top_n_words(4, lsa_keys, document_term_matrix, count_vectorizer)

#print(len(top_n_words_lsa))

for i in range(len(top_n_words_lsa)):
    print("Topic {}: ".format(i + 1), top_n_words_lsa[i])

top_4_words = get_top_n_words(4, lsa_keys, document_term_matrix, count_vectorizer)
labels = ['Topic {}: \n'.format(i + 1) + top_4_words[i] for i in lsa_categories]
fig, ax = plt.subplots(figsize=(16, 8))
ax.bar(lsa_categories, lsa_counts);
ax.set_xticks(lsa_categories);
ax.set_xticklabels(labels);
ax.set_ylabel('Number of Requests');
ax.set_title('LSA Topic Counts - CountVectorizer');
plt.xticks(rotation=30, fontsize=12)
plt.show();

#Bokeh and t-SNE
tsne_lsa_model = TSNE(n_components=2, perplexity=50, learning_rate=100,
                      n_iter=2000, verbose=1, random_state=42, angle=0.75)
tsne_lsa_vectors = tsne_lsa_model.fit_transform(lsa_topic_matrix)

lsa_mean_topic_vectors = get_mean_topic_vectors(lsa_keys, tsne_lsa_vectors)

plot = figure(title="t-SNE Clustering of {} LSA Topics - CountVectorizer".format(n_topics), plot_width=700, plot_height
              x_range=[-20,50], y_range=[-20,40])

plot.scatter(x=tsne_lsa_vectors[:,0], y=tsne_lsa_vectors[:,1], color=colormap[lsa_keys])

for t in range(n_topics):
    label = Label(x=lsa_mean_topic_vectors[t][0], y=lsa_mean_topic_vectors[t][1],
                  text=top_n_words_lsa[t], text_color=colormap[t])
    plot.add_layout(label)

show(plot)
```

```
Topic 1:  year, records, homer, homer watson
Topic 2:  file, ontario, works, ontario works
Topic 3:  environmental, site, assessment, phase
Topic 4:  terminal, guardrail terminal, guardrail, waterloo
Topic 5:  centre, waterloo city centre, city, waterloo city
Topic 6:  transit, river transit, river, grand river transit
Topic 7:  signal, january, traffic, intersection
Topic 8:  record, waterloo, regard, relate
Topic 9:  numb, total, park, 2014
Topic 10:  kitchener, january, street, street south kitchener
```




```
[t-SNE] Computing 151 nearest neighbors...
[t-SNE] Indexed 576 samples in 0.000s...
[t-SNE] Computed neighbors for 576 samples in 0.015s...
[t-SNE] Computed conditional probabilities for sample 576 / 576
[t-SNE] Mean sigma: 0.236402
[t-SNE] KL divergence after 250 iterations with early exaggeration: 48.945583
[t-SNE] KL divergence after 1800 iterations: 0.282286
```



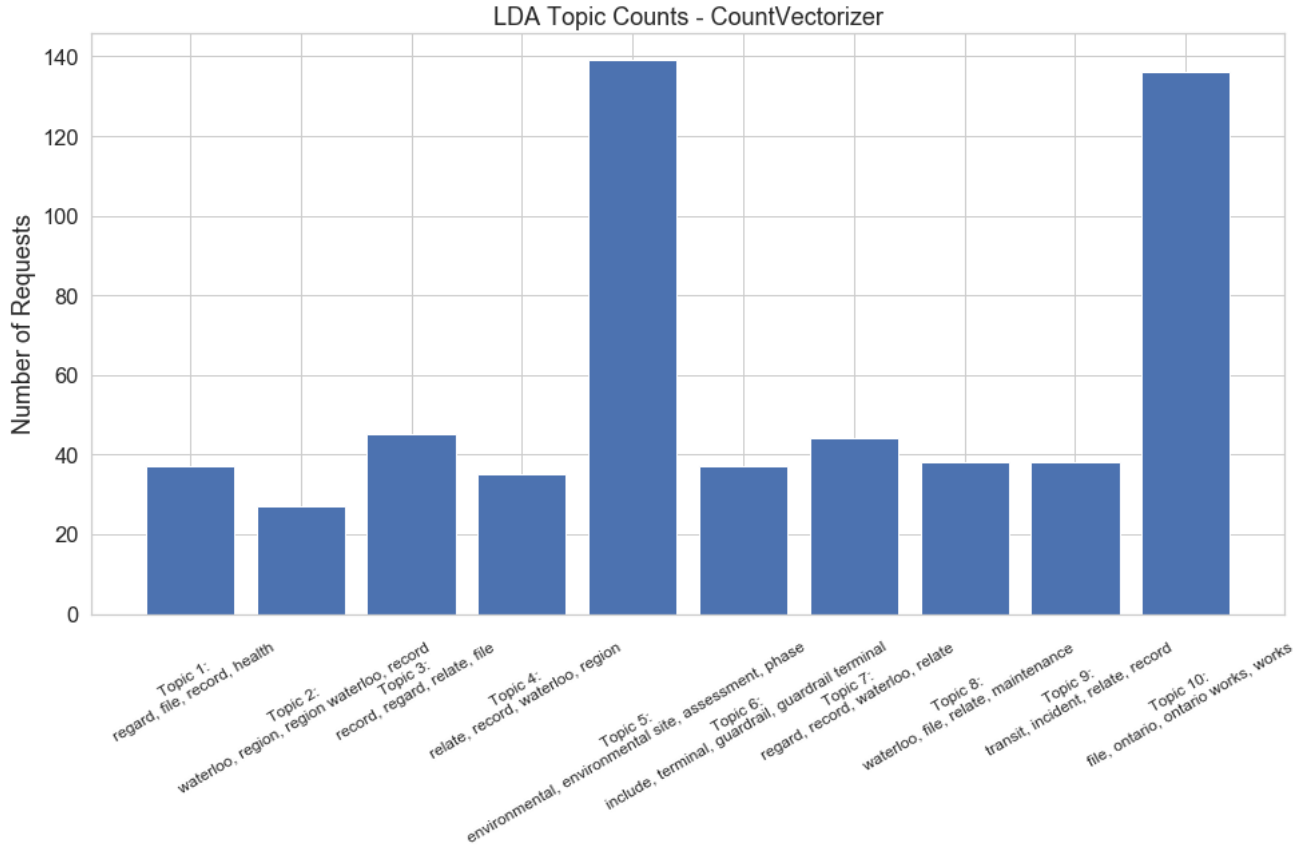

## LDA - scikit learn - CountVectorizer

While t-DNE gives more defined clusters for LSA + CountVectorizer, it is obvious by looking at the topics that this is not a good model for our data.

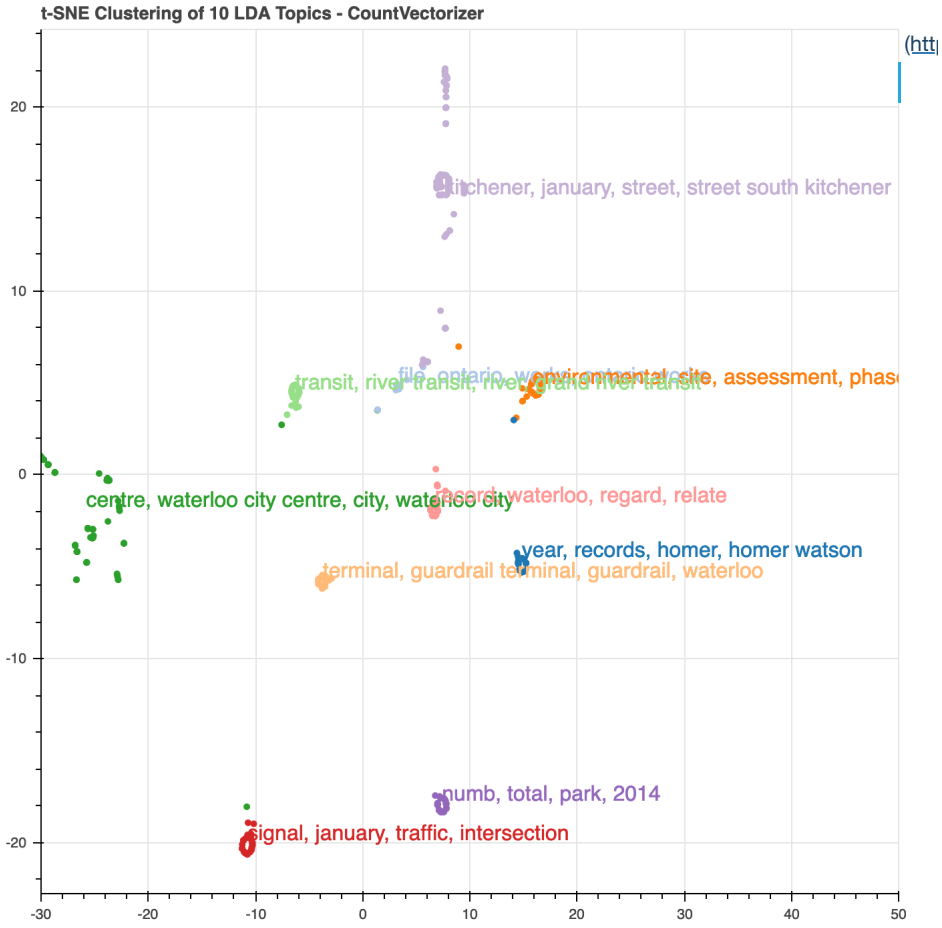
In [1082]:

```
n_topics = 10
lda_model_sk = LatentDirichletAllocation(n_components=n_topics,
                                         random_state=42, verbose=0)
lda_topic_matrix_sk = lda_model_sk.fit_transform(document_term_matrix)

lda_keys = get_keys(lda_topic_matrix_sk)
lda_categories, lda_counts = keys_to_counts(lda_keys)
top_n_words_lda = get_top_n_words(4, lda_keys, document_term_matrix, count_vectorizer)


for i in range(len(top_n_words_lsa)):
    print("Topic {}: ".format(i + 1), top_n_words_lda[i])

top_4_words = get_top_n_words(4, lda_keys, document_term_matrix, count_vectorizer)
labels = ['Topic {}: \n'.format(i + 1) + top_4_words[i] for i in lda_categories]
fig, ax = plt.subplots(figsize=(16, 8))
ax.bar(lda_categories, lda_counts);
ax.set_xticks(lda_categories);
ax.set_xticklabels(labels);
ax.set_ylabel('Number of Requests');
ax.set_title('LDA Topic Counts - CountVectorizer');
plt.xticks(rotation=30, fontsize=12)
plt.show();

# Bokeh and t-SNE
tsne_lda_model = TSNE(n_components=2, perplexity=50, learning_rate=100,
                      n_iter=2000, verbose=1, random_state=42, angle=0.75)
tsne_lda_vectors = tsne_lda_model.fit_transform(lda_topic_matrix_sk)

lda_mean_topic_vectors = get_mean_topic_vectors(lda_keys, tsne_lda_vectors)

plot = figure(title="t-SNE Clustering of {} LDA Topics - CountVectorizer".format(n_topics),
              plot_width=700, plot_height=700, x_range=[-30,50])

plot.scatter(x=tsne_lda_vectors[:,0], y=tsne_lda_vectors[:,1], color=colormap[lda_keys])

for t in range(n_topics):
    label = Label(x=lda_mean_topic_vectors[t][0], y=lda_mean_topic_vectors[t][1],
                  text=top_n_words_lsa[t], text_color=colormap[t])
    plot.add_layout(label)

show(plot)
```

```
Topic 1:  regard, file, record, health
Topic 2:  waterloo, region, region waterloo, record
Topic 3:  record, regard, relate, file
Topic 4:  relate, record, waterloo, region
Topic 5:  environmental, environmental site, assessment, phase
Topic 6:  include, terminal, guardrail, guardrail terminal
Topic 7:  regard, record, waterloo, relate
Topic 8:  waterloo, file, relate, maintenance
Topic 9:  transit, incident, relate, record
Topic 10:  file, ontario, ontario works, works
```




```
[t-SNE] Computing 151 nearest neighbors...
[t-SNE] Indexed 576 samples in 0.000s...
[t-SNE] Computed neighbors for 576 samples in 0.018s...
[t-SNE] Computed conditional probabilities for sample 576 / 576
[t-SNE] Mean sigma: 0.000000
[t-SNE] KL divergence after 250 iterations with early exaggeration: 45.079788
[t-SNE] KL divergence after 2000 iterations: 0.070793
```




## LDA Analysis using Gensim and pyLDAvis

### Gensim

Another tool for LDA analysis is gensim, an open-source library for unsupervised topic modeling and natural language processing. Gensim is specifically designed to handle lar streaming and incremental online algorithms, which differentiates it from most other machine learning software packages that target only in-memory processing.

In [1018]:
```
import gensim
import pyLDAvis.gensim    # To visualize our output
from gensim import corpora
```

In [1019]:
```
import warnings
warnings.filterwarnings('ignore')
```

In [1016]:
```
# 'Edited_Summary' has the tokens already, no need to preprocess or prepare the text

text_data = []
for index in range(0, len(tokenized_adf)):
    current_line = tokenized_adf['Edited_Summary'][index]
    line_tokens = prepare_text_tlc(current_line)
    text_data.append(line_tokens)
```

In [1017]:
```
#Convert document into the bag-of-words format
dictionary = corpora.Dictionary(text_data)
corpus = [dictionary.doc2bow(text) for text in text_data]

# To be able to save model to hard drive
import pickle
pickle.dump(corpus, open('data/corpus/corpus.pkl', 'wb'))
dictionary.save('data/gensim/dictionary.gensim')
```

Let's try extracting a different number of topics, from 3 to 15, and print the top 5 words of each.

In [1021]:
```
NUM_TOPICS = 3
ldamodel = gensim.models.ldamodel.LdaModel(corpus, num_topics=NUM_TOPICS, id2word=dictionary, passes=15)
ldamodel.save('data/gensim/model3.gensim')
topics = ldamodel.print_topics(num_words=5)
for topic in topics:
    print(topic)
```

```
(0, '0.048*"environmental" + 0.046*"site" + 0.045*"assessment" + 0.041*"phase" + 0.038*"waterloo"')
(1, '0.032*"record" + 0.028*"regard" + 0.020*"report" + 0.018*"health" + 0.017*"investigation"')
(2, '0.068*"file" + 0.056*"work" + 0.055*"ontario" + 0.050*"copy" + 0.046*"complete"')
```

In [1022]:
```
NUM_TOPICS = 5
ldamodel = gensim.models.ldamodel.LdaModel(corpus, num_topics=NUM_TOPICS, id2word=dictionary, passes=15)
ldamodel.save('data/gensim/model5.gensim')
topics = ldamodel.print_topics(num_words=5)
for topic in topics:
    print(topic)
```

```
(0, '0.072*"file" + 0.068*"ontario" + 0.066*"environmental" + 0.063*"assessment" + 0.063*"work"')
(1, '0.034*"record" + 0.028*"regard" + 0.023*"waterloo" + 0.019*"inspection" + 0.018*"year"')
(2, '0.033*"waterloo" + 0.032*"record" + 0.029*"region" + 0.023*"relate" + 0.020*"incident"')
(3, '0.024*"record" + 0.022*"regard" + 0.020*"river" + 0.020*"transit" + 0.019*"video"')
(4, '0.020*"file" + 0.015*"waterloo" + 0.014*"record" + 0.014*"road" + 0.013*"control"')
```

In [1023]:
```
NUM_TOPICS = 10
ldamodel = gensim.models.ldamodel.LdaModel(corpus, num_topics=NUM_TOPICS, id2word=dictionary, passes=15)
ldamodel.save('data/gensim/model10.gensim')
topics = ldamodel.print_topics(num_words=5)
for topic in topics:
    print(topic)
```

```
(0, '0.025*"record" + 0.020*"service" + 0.017*"2013" + 0.016*"relate" + 0.015*"regard"')
(1, '0.032*"proposal" + 0.026*"speed" + 0.025*"request" + 0.023*"provincial" + 0.020*"include"')
(2, '0.045*"record" + 0.043*"investigation" + 0.036*"regard" + 0.031*"rabies" + 0.031*"control"')
(3, '0.095*"file" + 0.092*"ontario" + 0.086*"work" + 0.085*"copy" + 0.073*"complete"')
(4, '0.038*"record" + 0.036*"transit" + 0.036*"grand" + 0.035*"river" + 0.027*"video"')
(5, '0.077*"health" + 0.065*"public" + 0.042*"inspection" + 0.026*"waterloo" + 0.023*"record"')
(6, '0.037*"waterloo" + 0.031*"region" + 0.028*"relate" + 0.022*"correspondence" + 0.017*"january"')
(7, '0.112*"environmental" + 0.107*"site" + 0.103*"assessment" + 0.096*"phase" + 0.039*"kitchener"')
(8, '0.035*"year" + 0.024*"waterloo" + 0.019*"past" + 0.019*"intersection" + 0.018*"region"')
(9, '0.030*"kitchener" + 0.022*"report" + 0.022*"road" + 0.022*"record" + 0.019*"service"')
```

In [1020]:
```
NUM_TOPICS = 15
ldamodel = gensim.models.ldamodel.LdaModel(corpus, num_topics=NUM_TOPICS, id2word=dictionary, passes=15)
ldamodel.save('data/gensim/model15.gensim')
topics = ldamodel.print_topics(num_words=5)
for topic in topics:
    print(topic)
```

```
(0, '0.147*"environmental" + 0.143*"site" + 0.141*"assessment" + 0.130*"phase" + 0.050*"kitchener"')
(1, '0.046*"transit" + 0.034*"grand" + 0.034*"river" + 0.022*"incident" + 0.019*"regard"')
(2, '0.031*"relate" + 0.030*"waterloo" + 0.022*"construction" + 0.021*"water" + 0.019*"region"')
(3, '0.036*"1996" + 0.031*"year" + 0.027*"child" + 0.024*"december" + 0.022*"1998"')
(4, '0.060*"control" + 0.058*"rabies" + 0.053*"investigation" + 0.044*"record" + 0.043*"file"')
(5, '0.030*"signal" + 0.028*"record" + 0.025*"intersection" + 0.024*"homer" + 0.024*"watson"')
(6, '0.030*"proposal" + 0.023*"request" + 0.021*"2016" + 0.020*"january" + 0.018*"2009"')
(7, '0.032*"waterloo" + 0.022*"record" + 0.018*"guardrail" + 0.018*"terminal" + 0.018*"include"')
(8, '0.032*"2001" + 0.026*"incident" + 0.026*"2004" + 0.024*"record" + 0.023*"illness"')
(9, '0.036*"record" + 0.034*"relate" + 0.027*"include" + 0.019*"report" + 0.018*"2015"')
(10, '0.029*"waterloo" + 0.021*"city" + 0.018*"relate" + 0.017*"record" + 0.016*"health"')
(11, '0.065*"record" + 0.032*"regard" + 0.025*"speed" + 0.020*"2013" + 0.018*"charge"')
(12, '0.061*"regard" + 0.059*"record" + 0.047*"health" + 0.044*"inspection" + 0.041*"public"')
(13, '0.141*"file" + 0.130*"ontario" + 0.125*"work" + 0.113*"complete" + 0.112*"copy"')
(14, '0.071*"waterloo" + 0.053*"region" + 0.037*"contract" + 0.033*"relate" + 0.022*"service"')
```

### pyLDAvis

pyLDAvis is a python library for interactive topic model visualization. It is designed to help users interpret the topics in a topic model that has been fit to a corpus of text data. T
from a fitted LDA topic model to inform an interactive web-based visualization.

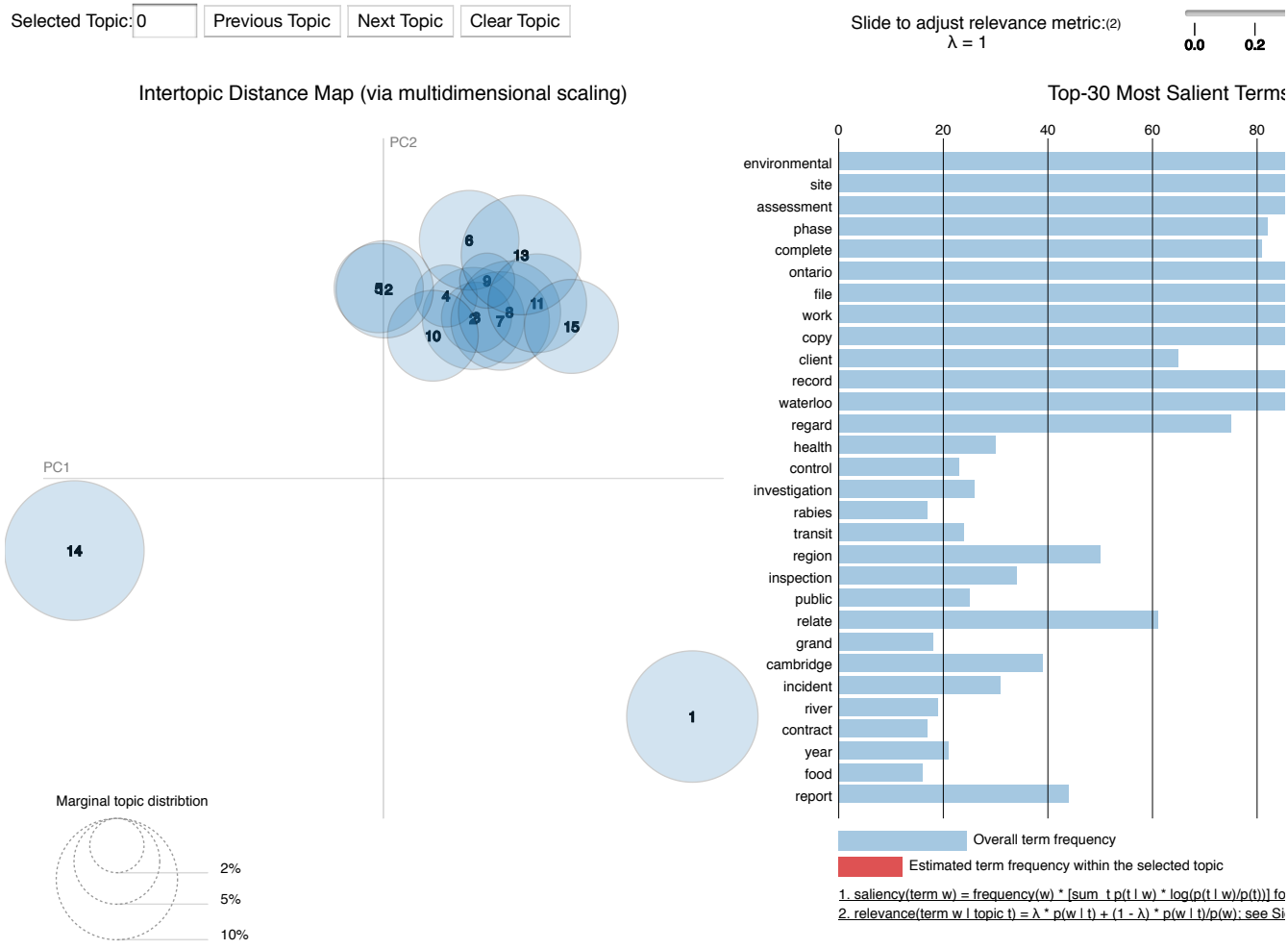
In [1024]:
```
pyLDAvis.enable_notebook()
```

In [1025]:
```
# We can load the dictionary and corpus from the files we already stored in the hard drive.
dictionary = gensim.corpora.Dictionary.load('data/gensim/dictionary.gensim')
corpus = pickle.load(open('data/corpus/corpus.pkl', 'rb'))
```

Let's now visualize our data for all the models, which range from 3 to 15 topics. It seems that perhaps 3-5 topics give the clearer distinction between topics in the distance map
topics should be more. Increasing the number of topics just brings up the issue that for our models, given the number of words and data we have, there is no clear separation c

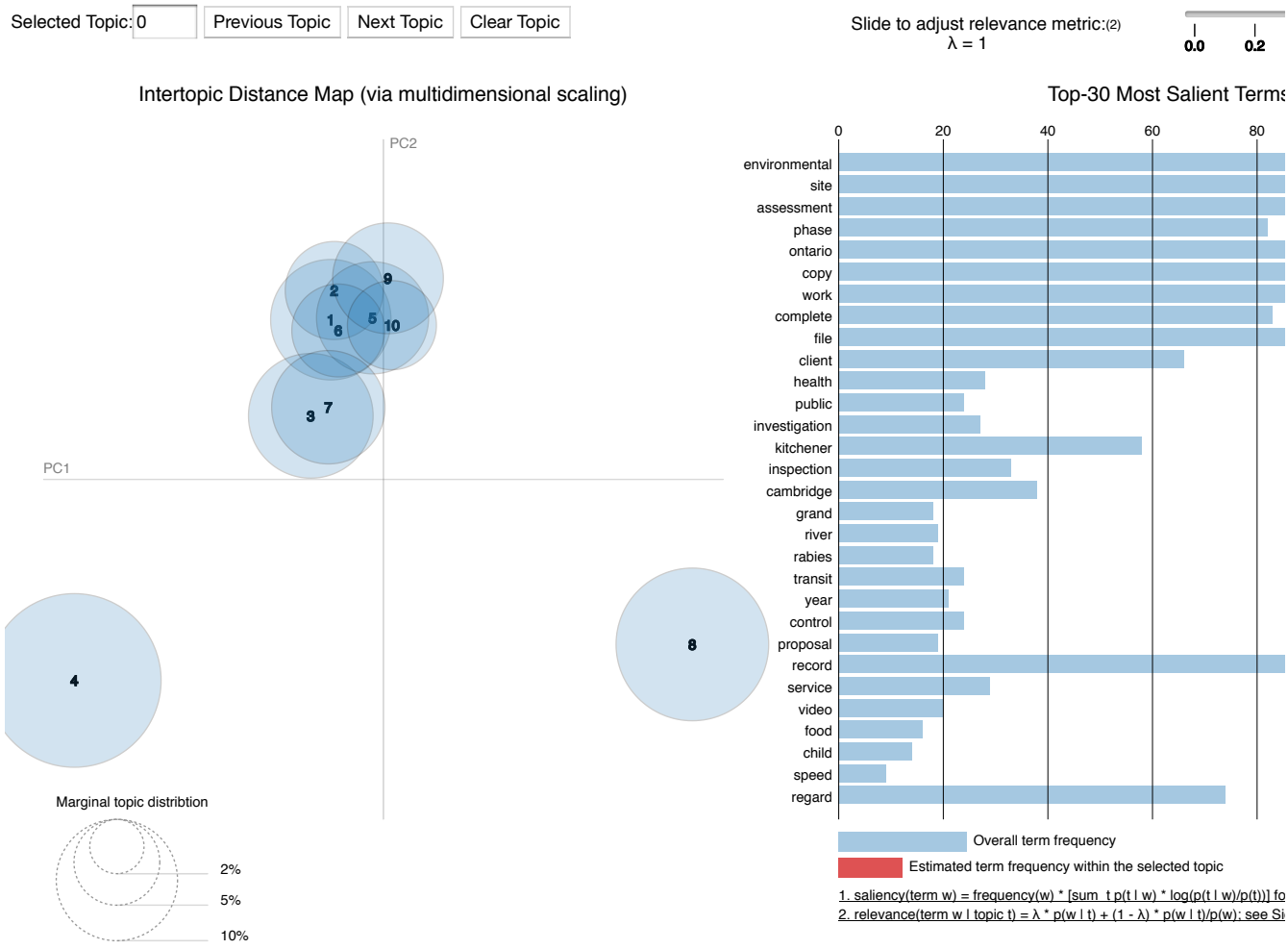
In [1026]:
```
lda = gensim.models.ldamodel.LdaModel.load('data/gensim/model15.gensim')
lda_display = pyLDAvis.gensim.prepare(lda, corpus, dictionary, sort_topics=False)
pyLDAvis.display(lda_display)
```

Out[1026]:



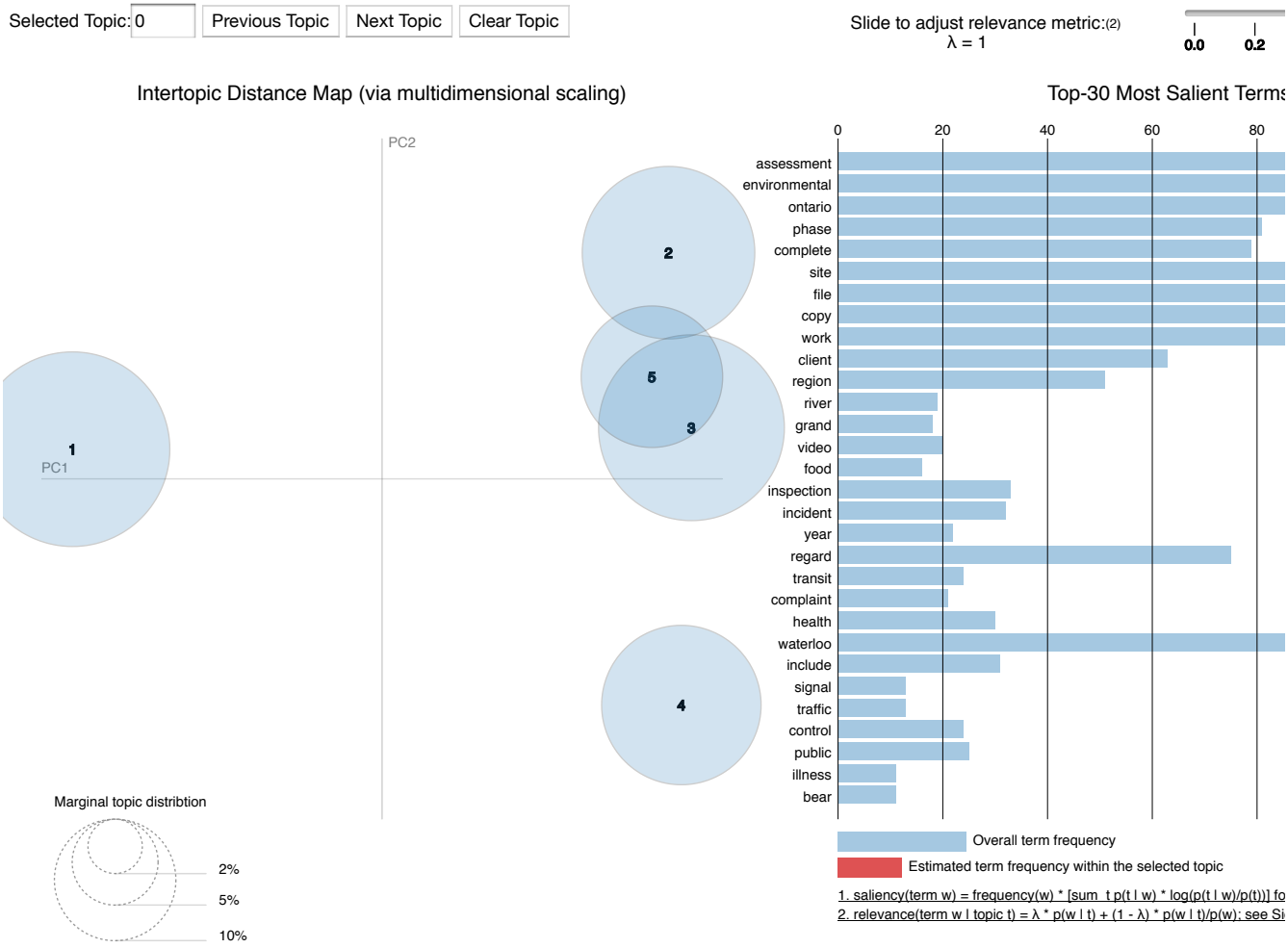
In [1027]:
```
lda = gensim.models.ldamodel.LdaModel.load('data/gensim/model10.gensim')
lda_display = pyLDAvis.gensim.prepare(lda, corpus, dictionary, sort_topics=False)
pyLDAvis.display(lda_display)
```

Out[1027]:



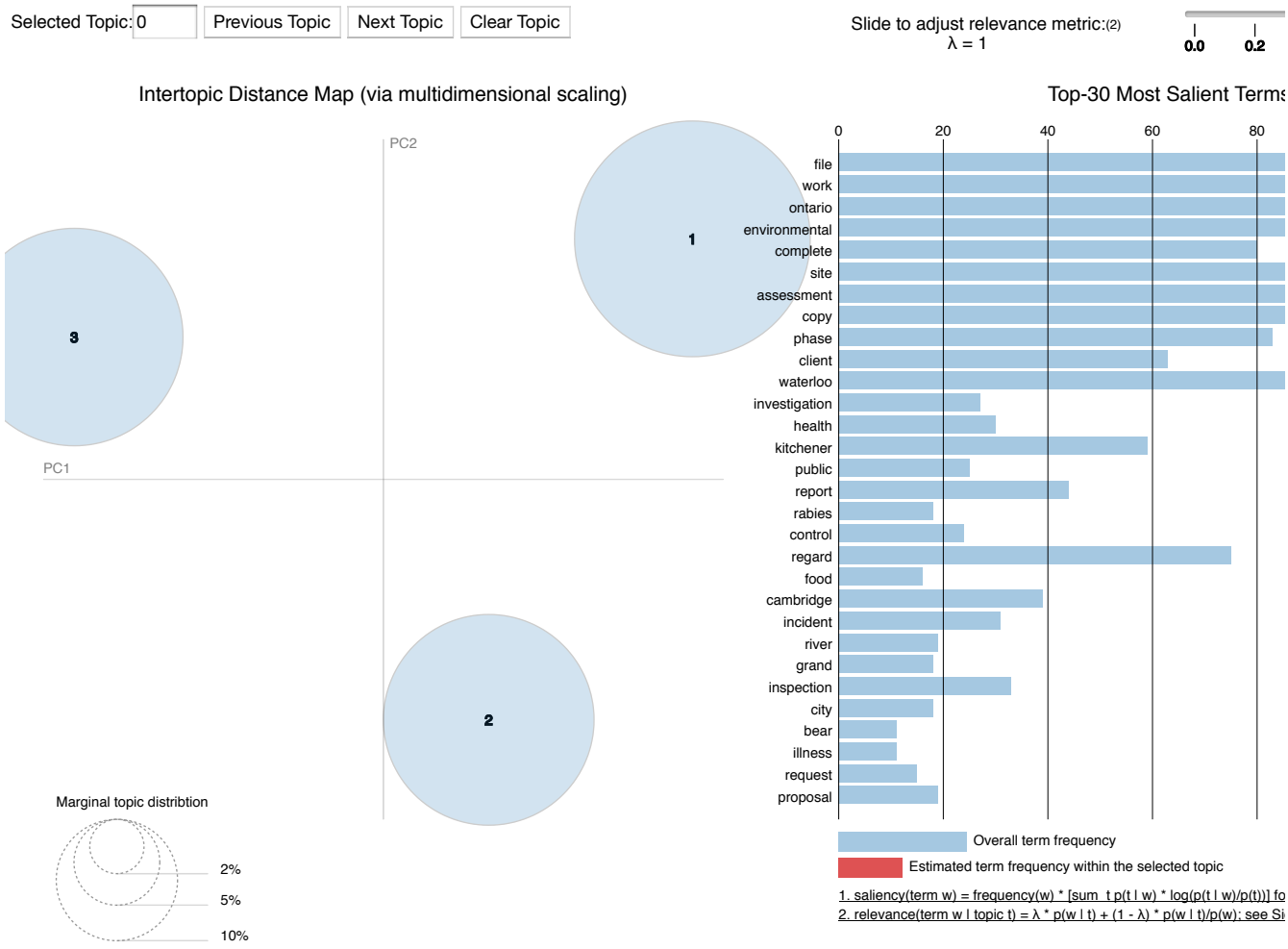
In [1028]:
```
lda = gensim.models.ldamodel.LdaModel.load('data/gensim/model5.gensim')
lda_display = pyLDAvis.gensim.prepare(lda, corpus, dictionary, sort_topics=False)
pyLDAvis.display(lda_display)
```

Out[1028]:



In [1029]:
```
lda = gensim.models.ldamodel.LdaModel.load('data/gensim/model3.gensim')
lda_display = pyLDAvis.gensim.prepare(lda, corpus, dictionary, sort_topics=False)
pyLDAvis.display(lda_display)
```

Out[1029]:




## LSI Analysis using Gensim

In [1100]:
```
NUM_TOPICS = 10
lsimodel = gensim.models.lsimodel.LsiModel(corpus, num_topics=NUM_TOPICS, id2word=dictionary)
lsimodel.save('data/gensim/model10_lsi.gensim')
topics = lsimodel.print_topics(num_words=5)
for topic in topics:
    print(topic)
```

```
(0, '-0.344*"record" + -0.272*"ontario" + -0.271*"year" + -0.233*"file" + -0.214*"work"')
(1, '0.400*"file" + 0.351*"work" + 0.346*"copy" + 0.319*"complete" + 0.317*"ontario"')
(2, '0.425*"site" + 0.423*"assessment" + 0.398*"environmental" + 0.362*"phase" + 0.336*"waterloo"')
(3, '0.318*"waterloo" + 0.306*"terminal" + 0.287*"guardrail" + 0.270*"region" + -0.239*"phase"')
(4, '-0.343*"guardrail" + -0.326*"terminal" + 0.317*"regard" + 0.233*"record" + -0.214*"plus"')
(5, '0.410*"waterloo" + 0.355*"city" + 0.316*"centre" + -0.247*"record" + 0.209*"canviro"')
(6, '0.454*"record" + -0.365*"transit" + -0.324*"river" + -0.323*"grand" + -0.197*"video"')
(7, '-0.438*"january" + -0.289*"support" + -0.268*"signal" + -0.224*"2014" + -0.219*"2016"')
(8, '-0.401*"employee" + -0.361*"park" + -0.275*"report" + -0.272*"incident" + -0.231*"total"')
(9, '0.401*"region" + 0.284*"waterloo" + -0.219*"report" + -0.197*"centre" + -0.196*"regard"')
```

# Machine Learning

Having taken a deep look at our text, we now proceed to try to predict the *Decision* based on the *Summary_of_Request* text. We move forward even though our colleague Scot data and found ML does not work very well given the size of our set. He, instead, proceeded to add the freedom of information requests from Toronto and surrounding areas.

But, hey, we are learning, so let's give ML a shot (again) given what we already know about the limitations of the data and the preprocessing we did. We also add other models

In [1289]:
```
from sklearn import metrics
from sklearn import preprocessing
from sklearn import svm
from sklearn import tree

from sklearn.base import TransformerMixin
from sklearn.datasets import make_blobs
from sklearn.ensemble import RandomForestClassifier
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.linear_model import LogisticRegression
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import MultinomialNB
from sklearn.neighbors import KNeighborsClassifier
from sklearn.pipeline import Pipeline
from sklearn.svm import LinearSVC
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier

import mlxtend
from mlxtend.plotting import category_scatter
from mlxtend.plotting import plot_decision_regions

import scikitplot as skplt

from xgboost import XGBClassifier
```

In [1290]:
```
from spacy import displacy
import en_core_web_sm
nlp = en_core_web_sm.load()
```

In [1291]:
```
class CleanTextTransformer(TransformerMixin):
    def transform(self, X, **transform_params):
        return [cleanText(text) for text in X]
    def fit(self, X, y=None, **fit_params):
        return self

def get_params(self, deep=True):
        return {}
```

As a reminder, we have 11 types of decisions in a unbalanced set.

In [1482]:
```
print(tokenized_adf['Decision'].value_counts())
```

```
All information disclosed        189
Information disclosed in part    152
No records exist                  80
Request withdrawn                 80
Partly non-existent               23
No information disclosed          21
Transferred                       15
Abandoned                         13
No additional records exist        1
Correction refused                 1
Correction granted                 1
Name: Decision, dtype: int64
```

We will be using two vectorizers for our analysis, CountVectorizer and tf-idf.

In [1483]:
```
count_vect = CountVectorizer(tokenizer=tokenize_lemm_rmstop_Text, ngram_range=(1, 5))
tfidf_vect = TfidfVectorizer(tokenizer=tokenize_lemm_rmstop_Text, ngram_range=(1, 5))
```

Let's choose the MultinomialNB model as a start,

In [1484]:
```
count_clf = MultinomialNB()
tfidf_clf = MultinomialNB()
```

and define a pipeline for our text, to clean it up, select and apply both the vectorizer and classifier.

In [1485]:
```
count_pipe = Pipeline([
    ('cleanText', CleanTextTransformer()),
    ('vectorizer', count_vect),
    ('clf', count_clf)
])

tfidf_pipe = Pipeline([
    ('cleanText', CleanTextTransformer()),
    ('vectorizer', tfidf_vect),
    ('clf', tfidf_clf)
])
```

We will work with our dataframe whose column '*Edited_Summary*' has the cleaned and tokenized text, where symbols and stopwords have been removed already.

In [1486]:
```
y = tokenized_adf['Decision']
```

In [1487]:
```
X1 = tokenized_adf['Edited_Summary']
X1_train, X1_test, y1_train, y1_test=train_test_split(X1, y, test_size=0.33, random_state=42)
```

We will train in 67% of the set, which is about 385 requests.

In [1488]:
```
len(X1_train), len (y1_train)
```

Out[1488]:
```
(385, 385)
```

In [1489]:
```
X1_train.sample(5)
```

Out[1489]:
```
31     public health inspection report food bear illn...
164    radio operations centre patrol diary february ...
342        phase environmental site assessment kitchener
523    records respect incident occur island grill je...
486                           complete ontario works file
Name: Edited_Summary, dtype: object
```

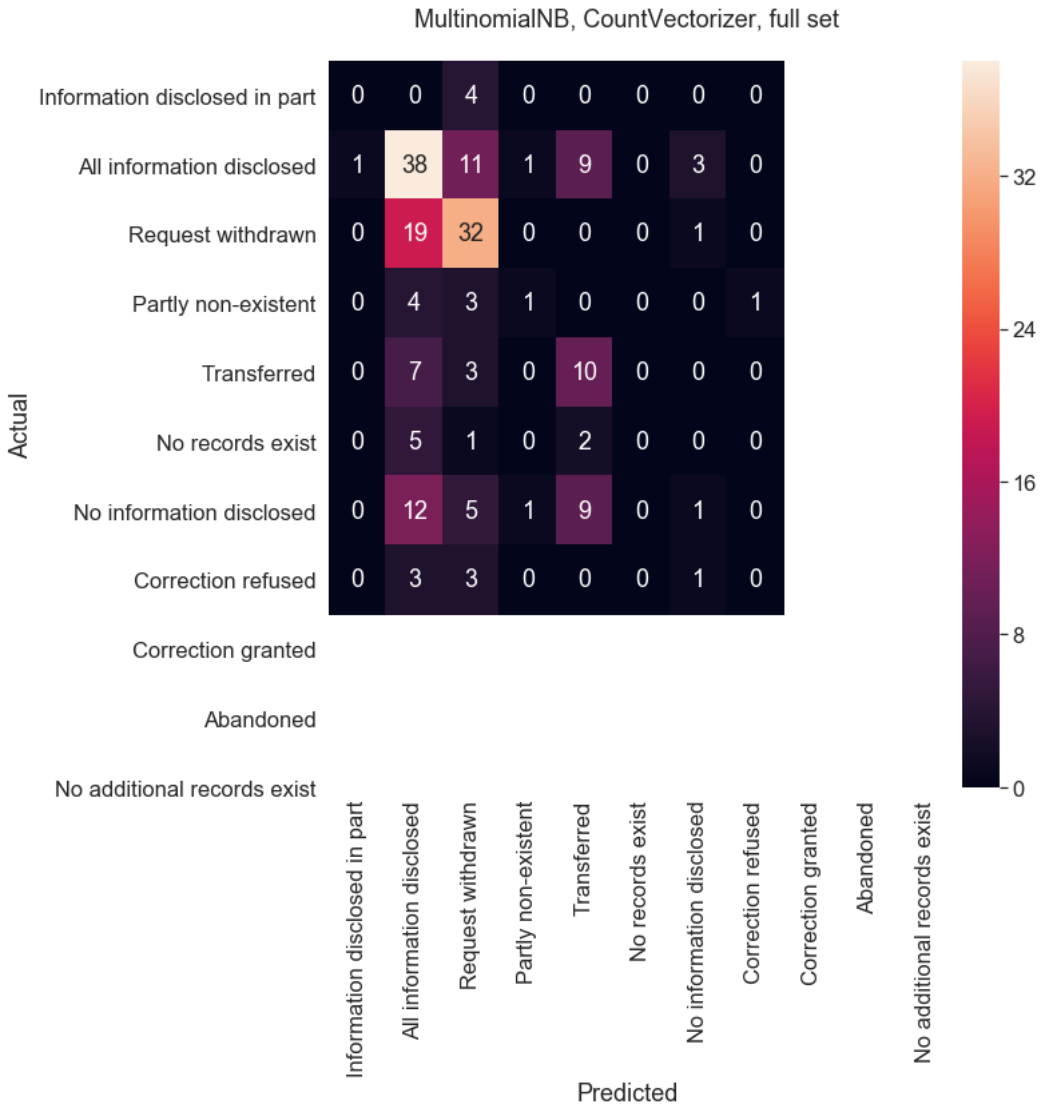
### CountVectorizer with MultinomialNB - full set of decisions

In [1490]:
```
count_pipe.fit(X1_train, y1_train)
count_preds = count_pipe.predict(X1_test)
print("Accuracy:", accuracy_score(y1_test, count_preds))
```

```
Accuracy: 0.4293193717277487
```

CountVectorizer with MultinomialNB gives about 43% accuracy, bummer! Let's look at the confusion matrix.

In [1491]:
```
count_conf_mat = confusion_matrix(y1_test, count_preds)
fig, ax = plt.subplots(figsize=(10, 10))
sns.heatmap(count_conf_mat, annot=True, fmt='d',
            xticklabels=tokenized_adf['Decision'].unique(), yticklabels=tokenized_adf['Decision'].unique())
plt.ylabel('Actual')
plt.xlabel('Predicted')
ax.set(title='MultinomialNB, CountVectorizer, full set\n')
plt.show()
```



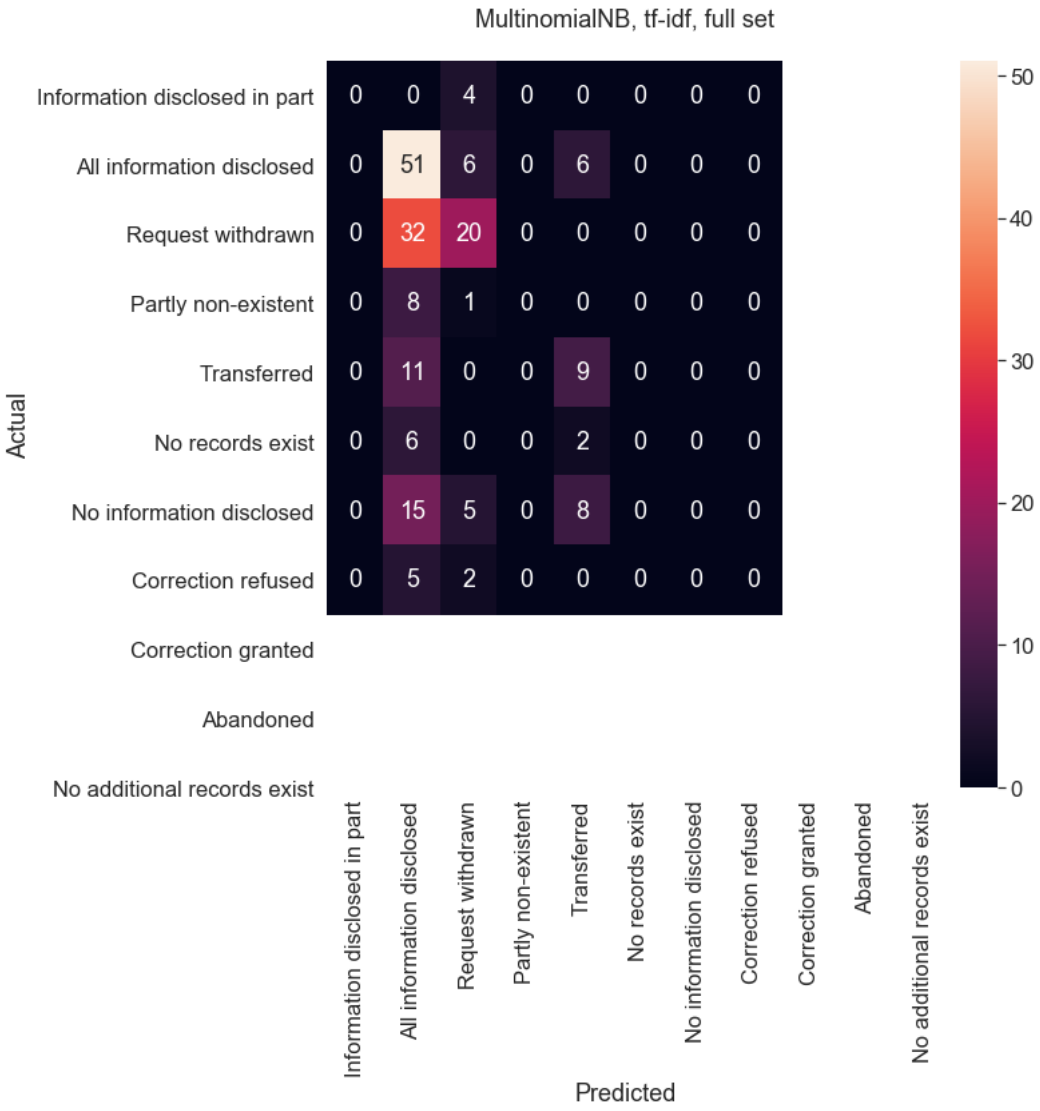

### tf-idf with LinearSVC - full set of decisions

In [1492]:
```
tfidf_pipe.fit(X1_train, y1_train)
tfidf_preds = tfidf_pipe.predict(X1_test)
print("Accuracy:", accuracy_score(y1_test, tfidf_preds))
```

```
Accuracy: 0.418848167539267
```

tf-idf with MultinomialNB gives about 42% accuracy, not better. Let's look at the confusion matrix.

In [1493]:
```
tfidf_conf_mat = confusion_matrix(y1_test, tfidf_preds)
fig, ax = plt.subplots(figsize=(10, 10))
sns.heatmap(tfidf_conf_mat, annot=True, fmt='d',
            xticklabels=tokenized_adf['Decision'].unique(), yticklabels=tokenized_adf['Decision'].unique())
plt.ylabel('Actual')
plt.xlabel('Predicted')
ax.set(title='MultinomialNB, tf-idf, full set\n')
plt.show()
```




By observing the matrix, we can see that it could not predict decisions that had few instances, like '*Correction granted*', which has only once instance, since it was in the trainir vice versa, but not both.

We decided to take 3 approaches to this:

a) Keep our set of decisions, except for the ones with less than 15 instances (just to keep '*Transferred*'.)

b) Binning all decisions into 3 basic categories, all, partial, or no information disclosed.

a) Remove cases with less than 15 cases and where a decision was not made, this, when the request was either '*Withdrawn*' or '*Abandoned*'.

## a) Using Decisions with more than 15 instances

In [1494]:
```
print(tokenized_adf['Decision'].value_counts())
```

```
All information disclosed        189
Information disclosed in part    152
No records exist                  80
Request withdrawn                 80
Partly non-existent               23
No information disclosed          21
Transferred                       15
Abandoned                         13
No additional records exist        1
Correction refused                 1
Correction granted                 1
Name: Decision, dtype: int64
```

In [1495]:
```
tokenized_adf_over15 = tokenized_adf.groupby('Decision').filter(lambda x: len(x) >= 15)
print(tokenized_adf_over15['Decision'].value_counts())
```

```
All information disclosed        189
Information disclosed in part    152
No records exist                  80
Request withdrawn                 80
Partly non-existent               23
No information disclosed          21
Transferred                       15
Name: Decision, dtype: int64
```

### Model comparison

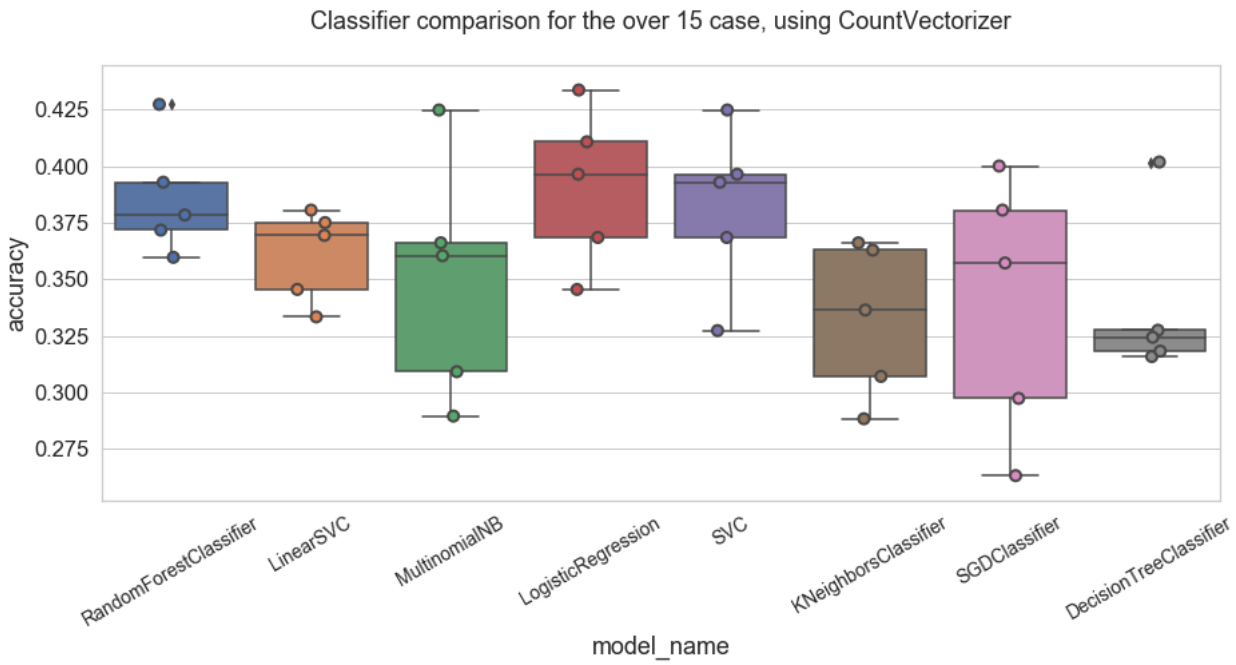
Now we will introduce a way to compare 8 classifiers at once, both numerically and visually. We start with CounterVectorizer, for both *balanced* and regular class weights, and t tf-idf.

In [1500]:
```
gb = []    # Setting up a array of dataframes to be put all the results together later on.
```

In [1501]:
```
count = CountVectorizer(min_df=3, ngram_range=(1, 4), tokenizer=tokenize_lemm_rmstop_Text)

features = count.fit_transform(tokenized_adf_over15['Edited_Summary'])
labels = tokenized_adf_over15['Decision']
features.shape
```

Out[1501]: (560, 539)

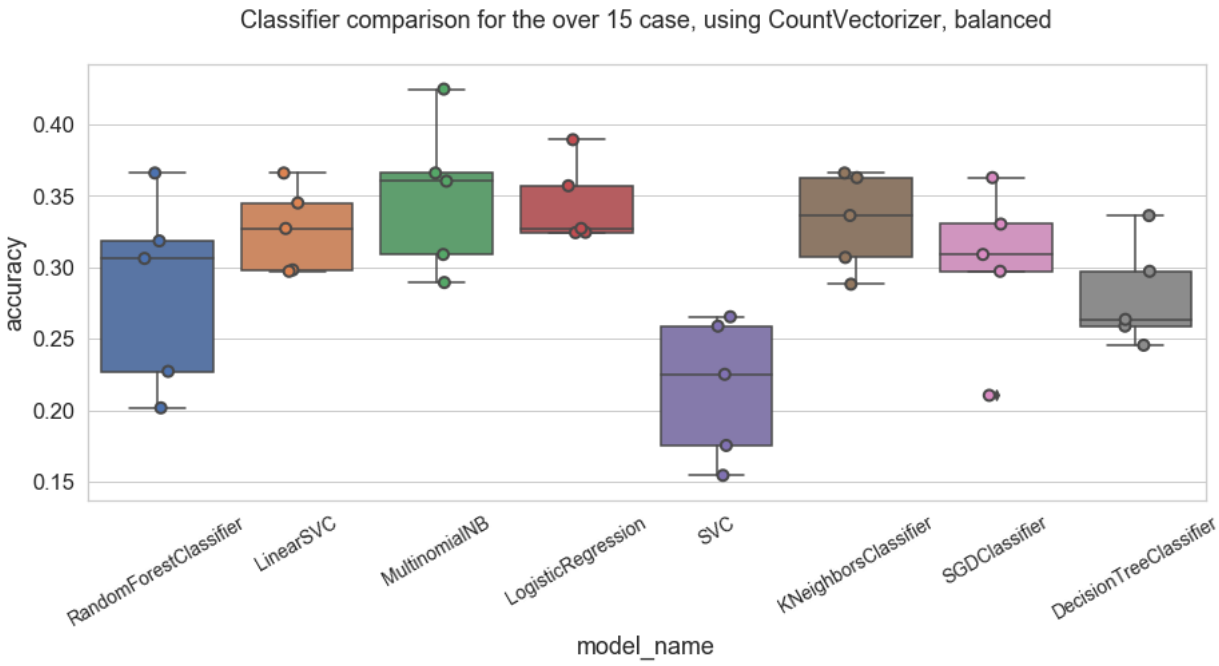
In [1502]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42),
    LinearSVC(),
    MultinomialNB(),
    LogisticRegression(random_state=42),
    SVC(gamma="scale"),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                  max_iter=5, tol=None),
    DecisionTreeClassifier()
]
CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the over 15 case, using CountVectorizer\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., ov15, CVec"}, inplace=True)
gb.append(gb_df)
gb_df
```




Out[1502]:

| model_name | Acc., ov15, CVec |
|---|---|
| DecisionTreeClassifier | 0.337503 |
| KNeighborsClassifier | 0.332115 |
| LinearSVC | 0.360738 |
| LogisticRegression | 0.390923 |
| MultinomialNB | 0.349955 |
| RandomForestClassifier | 0.385968 |
| SGDClassifier | 0.339626 |
| SVC | 0.381945 |

In [1503]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42, class_weight='balanced'),
    LinearSVC(class_weight='balanced'),
    MultinomialNB(),
    LogisticRegression(random_state=42, class_weight='balanced'),
    SVC(gamma="scale", class_weight='balanced'),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                  max_iter=5, tol=None, class_weight='balanced'),
    DecisionTreeClassifier(class_weight='balanced')
]
CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the over 15 case, using CountVectorizer, balanced\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., o15, CVec, bal."}, inplace=True)
gb.append(gb_df)
gb_df
```



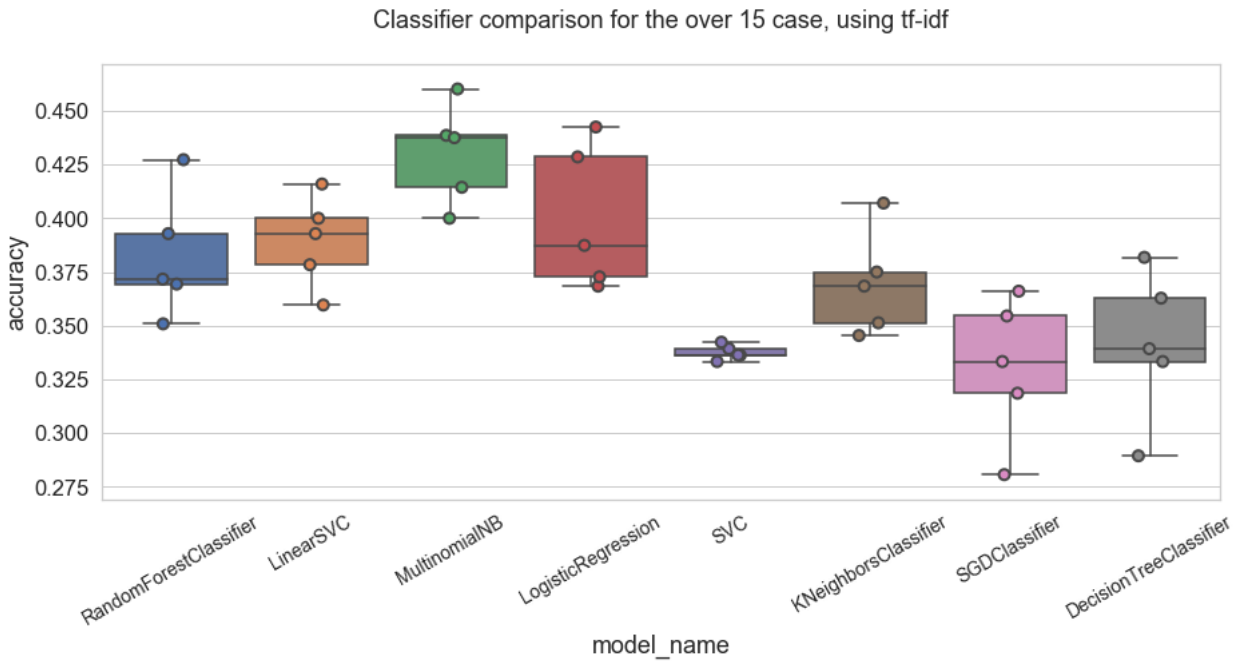

Out[1503]:

| model_name | Acc., o15, CVec, bal. |
|---|---|
| DecisionTreeClassifier | 0.280352 |
| KNeighborsClassifier | 0.332115 |
| LinearSVC | 0.326804 |
| LogisticRegression | 0.344536 |
| MultinomialNB | 0.349955 |
| RandomForestClassifier | 0.283998 |
| SGDClassifier | 0.302021 |
| SVC | 0.215925 |

In [1504]:
```
tfidf = TfidfVectorizer(sublinear_tf=True, min_df=3, norm='l2',
                        ngram_range=(1, 4), tokenizer=tokenize_lemm_rmstop_Text)

features = tfidf.fit_transform(tokenized_adf_over15['Edited_Summary'])
labels = tokenized_adf_over15['Decision']
features.shape
```

Out[1504]:
```
(560, 539)
```

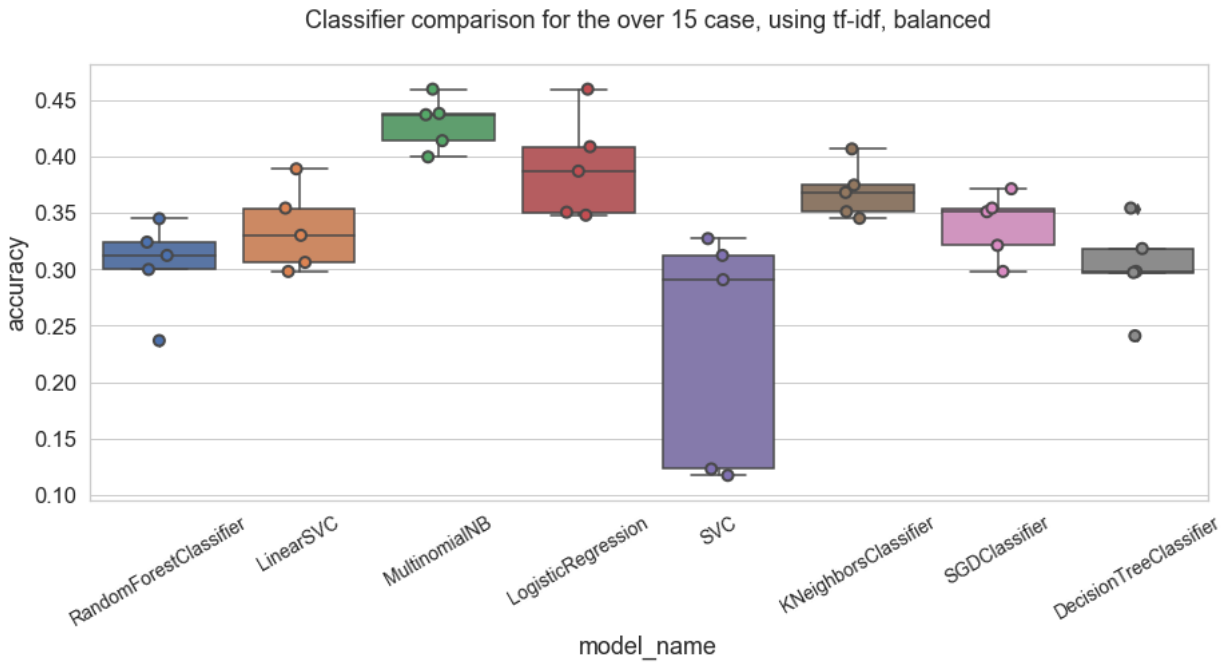
In [1505]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42),
    LinearSVC(),
    MultinomialNB(),
    LogisticRegression(random_state=42),
    SVC(gamma="scale"),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                  max_iter=5, tol=None),
    DecisionTreeClassifier()
]
CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the over 15 case, using tf-idf\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., o15, tf-idf"}, inplace=True)
gb.append(gb_df)
gb_df
```




Out[1505]:

| model_name | Acc., o15, tf-idf |
|---|---|
| DecisionTreeClassifier | 0.341349 |
| KNeighborsClassifier | 0.369461 |
| LinearSVC | 0.389363 |
| LogisticRegression | 0.399917 |
| MultinomialNB | 0.430138 |
| RandomForestClassifier | 0.382412 |
| SGDClassifier | 0.330647 |
| SVC | 0.337522 |

In [1506]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42, class_weight='balanced'),
    LinearSVC(class_weight='balanced'),
    MultinomialNB(),
    LogisticRegression(random_state=42, class_weight='balanced'),
    SVC(gamma="scale", class_weight='balanced'),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                  max_iter=5, tol=None, class_weight='balanced'),
    DecisionTreeClassifier(class_weight='balanced')
]
CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the over 15 case, using tf-idf, balanced\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., o15, tf-idf, bal."}, inplace=True)
gb.append(gb_df)
gb_df
```




Out[1506]:

| model_name | Accuracy, o15, tf-idf, bal. |
|---|---|
| DecisionTreeClassifier | 0.301949 |
| KNeighborsClassifier | 0.369461 |
| LinearSVC | 0.335767 |
| LogisticRegression | 0.391149 |
| MultinomialNB | 0.430138 |
| RandomForestClassifier | 0.303760 |
| SGDClassifier | 0.339450 |
| SVC | 0.234153 |

## Grid Search

MultinomialNB with tf-idf seems to do better. Therefore, we are going to show an example of the approach using GridSearch to find the best parameters for a classifier, in this c
vectorizer. We will find the scores and the confusion matrix.

Setting our training and test sets.

In [1507]:
```
y_s_over15 = tokenized_adf_over15['Decision']
```

In [1508]:
```
X_s_over15 = tokenized_adf_over15['Edited_Summary']
X_s_over15_train, X_s_over15_test, y_s_over15_train, y_s_over15_test=train_test_split(X_s_over15,
                                                    y_s_over15, test_size=0.33, random_state=42)
```

Finding parameters.

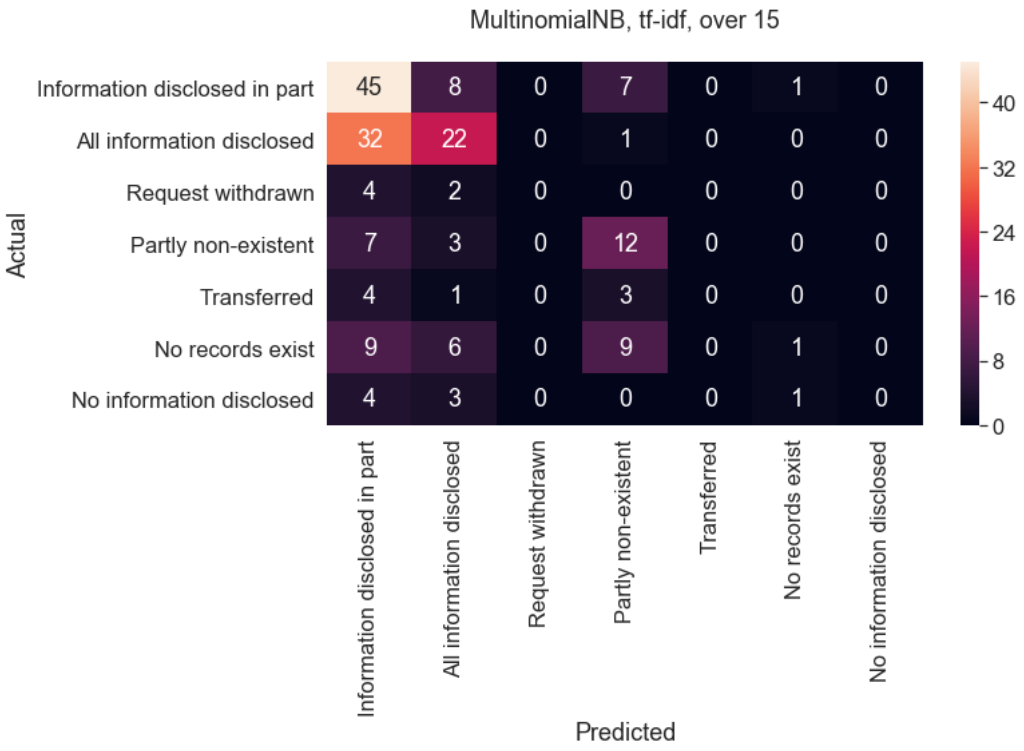
In [1509]:
```
tfidf_vect = TfidfVectorizer()
parameters = {'vectorizer__ngram_range': [(1, 2), (1, 3), (1, 4)],
              'clf__alpha': (1, 1e-1, 1e-2, 1e-3)
             }
tfidf_clf = MultinomialNB()
tfidf_pipe = Pipeline([
    ('vectorizer', tfidf_vect),
    ('clf', tfidf_clf)
])
gs_clf = GridSearchCV(tfidf_pipe, parameters, cv=5, iid=False, n_jobs=-1)
gs_clf = gs_clf.fit(X_s_over15_train, y_s_over15_train)
print("Best score: ", gs_clf.best_score_)
for param_name in sorted(parameters.keys()):
    print("%s: %r" % (param_name, gs_clf.best_params_[param_name]))
```

```
Best score:  0.4393272845875586
clf__alpha: 0.1
vectorizer__ngram_range: (1, 4)
```

Running our model with the parameters just found.

In [1510]:
```
tfidf_vect = TfidfVectorizer(ngram_range=(1, 4))
tfidf_clf = MultinomialNB(alpha=0.1)

tfidf_pipe.fit(X_s_over15_train, y_s_over15_train)
tfidf_preds = tfidf_pipe.predict(X_s_over15_test)
print("MultinomialNB Accuracy, tfidf, over 15 case:", accuracy_score(y_s_over15_test, tfidf_preds))

tfidf_conf_mat = confusion_matrix(y_s_over15_test, tfidf_preds)
fig, ax = plt.subplots(figsize=(10, 5))
label_names = tokenized_adf_over15['Decision'].unique()

sns.heatmap(tfidf_conf_mat, annot=True, fmt='d',
            xticklabels=label_names,
            yticklabels=label_names)

plt.ylabel('Actual')
plt.xlabel('Predicted')
ax.set(title='MultinomialNB, tf-idf, over 15\n')
plt.show()
print(classification_report(y_s_over15_test, tfidf_preds,
                            target_names=tokenized_adf_over15['Decision'].unique()))
```

```
MultinomialNB Accuracy, tfidf, over 15 case: 0.43243243243243246
```




| | precision | recall | f1-score | support |
|---|---|---|---|---|
| Information disclosed in part | 0.43 | 0.74 | 0.54 | 61 |
| All information disclosed | 0.49 | 0.40 | 0.44 | 55 |
| Request withdrawn | 0.00 | 0.00 | 0.00 | 6 |
| Partly non-existent | 0.38 | 0.55 | 0.44 | 22 |
| Transferred | 0.00 | 0.00 | 0.00 | 8 |
| No records exist | 0.33 | 0.04 | 0.07 | 25 |
| No information disclosed | 0.00 | 0.00 | 0.00 | 8 |
| micro avg | 0.43 | 0.43 | 0.43 | 185 |
| macro avg | 0.23 | 0.25 | 0.21 | 185 |
| weighted avg | 0.38 | 0.43 | 0.37 | 185 |

## b) Binning into 3 basic categories: all, partial, or no information disclosed

So, let's reduce the categories to three: all, partial, and no information disclosed. We'll bin them according to:

- All information disclosed (plus 'Correction granted')
- Information disclosed in part (plus 'Partly non-existent')
- No information disclosed (plus 'Transferred', 'No records exist', 'Correction refused', 'No additional records exist', 'Withdrawn', and 'Abandoned')

We will do this by adding a new column to our array, '*Sub_Decision*'.

In [1511]:
```
tokenized_adf.head(4)
```

Out[1511]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision | Edited_Summa |
|---|---|---|---|---|---|---|
| 0 | 99001 | General | Business | Minutes of Service Delivery Subcommittee of ES... | Information disclosed in part | minutes service delivery subcommittee escac pe |
| 1 | 99002 | General | Business | Public Health inspection reports for the {loca... | All information disclosed | public health inspection report kitchener pas |
| 2 | 99003 | General | Business | Public Health inspection records for {location... | Information disclosed in part | public health inspection record cambridge pas |
| 3 | 99004 | General | Individual | Public Health inspection records for {address ... | All information disclosed | public health inspection record cambridge rela |

In [1512]:
```
tokenized_adf['Sub_Decision'] = tokenized_adf['Decision']
```

In [1513]:
```
tokenized_adf.head(4)
```

Out[1513]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision | Edited_Summa |
|---|---|---|---|---|---|---|
| 0 | 99001 | General | Business | Minutes of Service Delivery Subcommittee of ES... | Information disclosed in part | minutes service delivery subcommittee escac pe |
| 1 | 99002 | General | Business | Public Health inspection reports for the {loca... | All information disclosed | public health inspection report kitchener pas |
| 2 | 99003 | General | Business | Public Health inspection records for {location... | Information disclosed in part | public health inspection record cambridge pas |
| 3 | 99004 | General | Individual | Public Health inspection records for {address ... | All information disclosed | public health inspection record cambridge rela |

Replacing our decisions for a generic version.

In [1514]:
```
pos_dec = {'Correction granted'}
part_dec = {'Partly non-existent'}
neg_dec = {'Request withdrawn', 'Transferred', 'No records exist', 'Correction refused', 'Abandoned',
           'No additional records exist'}
```

In [1515]:
```
for pos in pos_dec:
    tokenized_adf['Sub_Decision'] = tokenized_adf['Sub_Decision'].str.replace(
                                    pos,'All information disclosed')
```

In [1516]:
```
for part in part_dec:
    tokenized_adf['Sub_Decision'] = tokenized_adf['Sub_Decision'].str.replace(
                                    part,'Information disclosed in part')
```

In [1517]:
```
for neg in neg_dec:
    tokenized_adf['Sub_Decision'] = tokenized_adf['Sub_Decision'].str.replace(
                                    neg,'No information disclosed')
```

In [1518]:
```
tokenized_adf.head(11)
```

Out[1518]:

| | Request_Number | Request_Type | Source | Summary_of_Request | Decision | Edited_Sumr |
|---|---|---|---|---|---|---|
| 0 | 99001 | General | Business | Minutes of Service Delivery Subcommittee of ES... | Information disclosed in part | minutes service delivery subcommittee escac |
| 1 | 99002 | General | Business | Public Health inspection reports for the {loca... | All information disclosed | public health inspection report kitchener p |
| 2 | 99003 | General | Business | Public Health inspection records for {location... | Information disclosed in part | public health inspection record cambridge p |
| 3 | 99004 | General | Individual | Public Health inspection records for {address ... | All information disclosed | public health inspection record cambridge r |
| 4 | 99005 | General | Business | Vendor list report with total of year-to-date ... | All information disclosed | vendor list report total year date purchas |
| 5 | 99006 | Personal | Individual | Public Health inspection file for {name remove... | All information disclosed | public health inspection file regard reques |
| 6 | 99007 | General | Individual | Scope of work and deliverables sections of con... | All information disclosed | scope work deliverable section contract regi |
| 7 | 99008 | General | Individual | Number of contracts and dollar amount of contr... | Request withdrawn | number contract dollar contract region wate |
| 8 | 99009 | Personal | Individual | Public Health inspection report regarding a co... | All information disclosed | public health inspection report regard comp |
| 9 | 99010 | General | Business | Phase I environmental site assessment regardin... | Request withdrawn | phase environmental site assessment regard s |
| 10 | 99011 | General | Business | Complete fiscal year end vendor report for yea... | Partly non-existent | complete fiscal year vendor report year 199 |

In [1519]:
```
tokenized_adf['Sub_Decision'].unique()
```

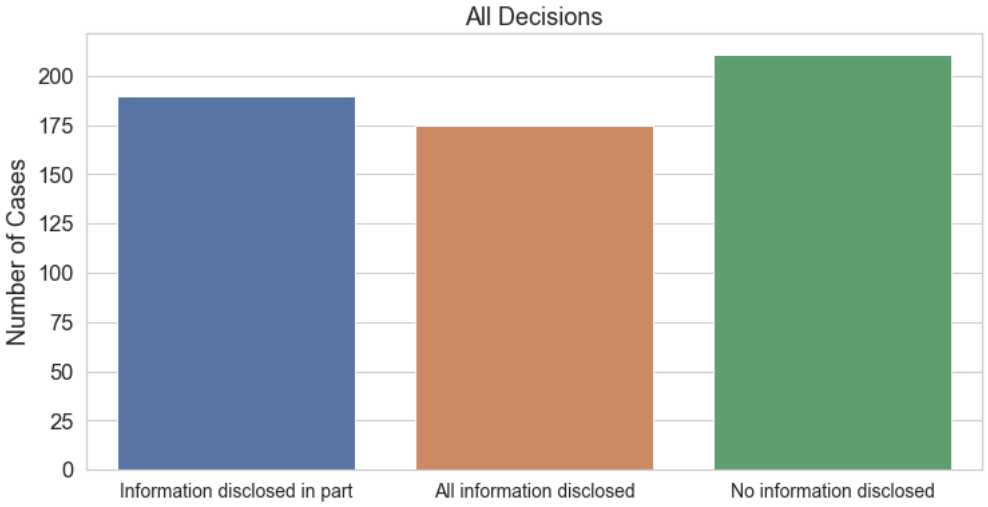
Out[1519]:
```
array(['Information disclosed in part', 'All information disclosed',
       'No information disclosed'], dtype=object)
```

In [1520]:
```
tokenized_adf.Sub_Decision.value_counts()
```

Out[1520]:
```
No information disclosed         211
All information disclosed        190
Information disclosed in part    175
Name: Sub_Decision, dtype: int64
```

In [1521]:
```
columns_sub = []
for i in range(0,tokenized_adf.Sub_Decision.nunique()):
    columns_sub.append(tokenized_adf.Sub_Decision.unique()[i])

tokenized_adf_groupbySubDecision = tokenized_adf.groupby('Sub_Decision').count()[['Source']]

fig, ax = plt.subplots(figsize=(12, 6))
sns.set(style="whitegrid", font_scale=1.5)
ax = sns.barplot(x=columns_sub, y='Source', data=tokenized_adf_groupbySubDecision)
ax.set(ylabel='Number of Cases', title='All Decisions')
plt.xticks(rotation=0, fontsize=14)
```

Out[1521]:
```
(array([0, 1, 2]), <a list of 3 Text xticklabel objects>)
```




And now our set seems more balanced.

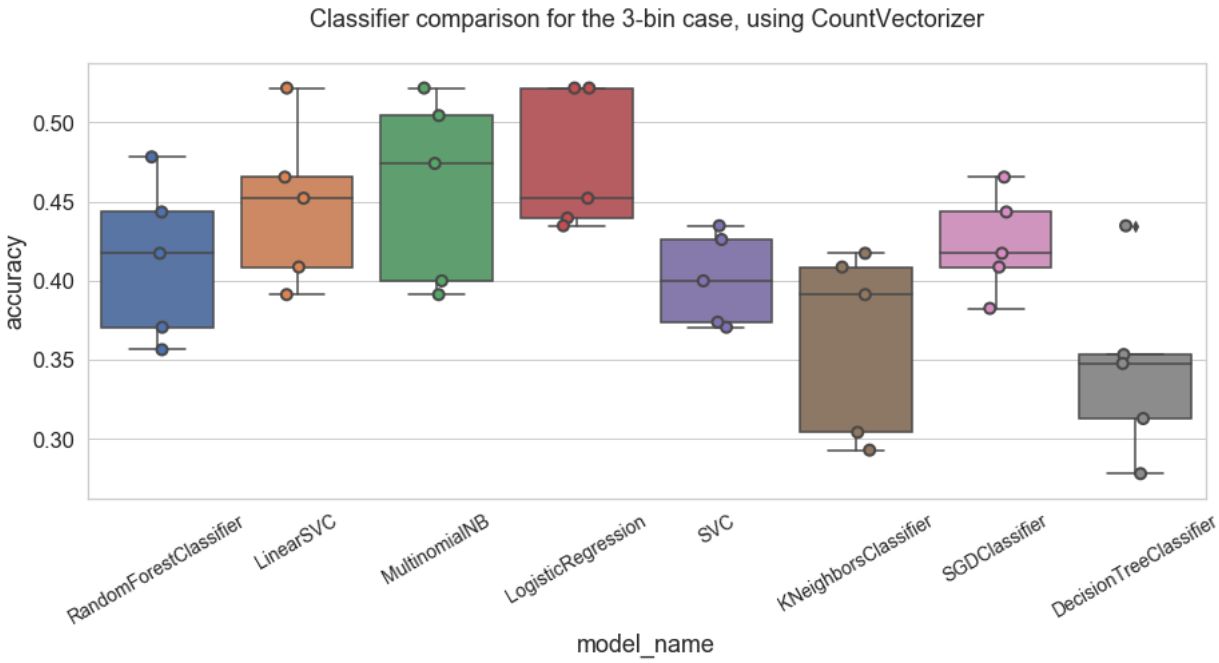
### Model comparison, 3-bin case

Let's compare eight different classifiers with two vectorizers, CountVectorizer and tf-idf.

In [1522]:
```
count = CountVectorizer(min_df=3, ngram_range=(1, 4), tokenizer=tokenize_lemm_rmstop_Text)

features = count.fit_transform(tokenized_adf['Edited_Summary'])
labels = tokenized_adf['Sub_Decision']
features.shape
```

Out[1522]:
```
(576, 564)
```

In [1523]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42), #, class_weight = 'balanced'),
    LinearSVC(), #class_weight='balanced'),
    MultinomialNB(),
    LogisticRegression(random_state=42),#, class_weight = 'balanced'),
    SVC(gamma="scale"),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                           max_iter=5, tol=None),
    DecisionTreeClassifier()
]
CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the 3-bin case, using CountVectorizer\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., 3b, CVec"}, inplace=True)
gb.append(gb_df)
gb_df
```



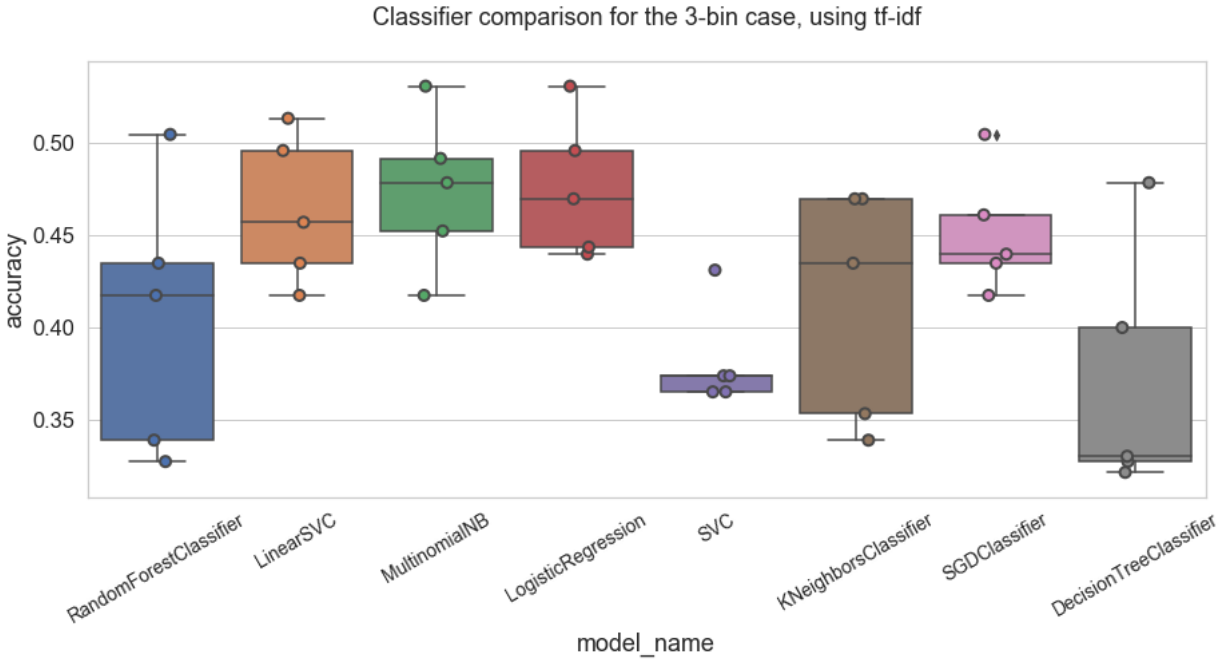

Out[1523]:

| model_name | Acc., 3b, CVec |
|---|---|
| DecisionTreeClassifier | 0.345472 |
| KNeighborsClassifier | 0.362969 |
| LinearSVC | 0.447886 |
| LogisticRegression | 0.474018 |
| MultinomialNB | 0.458306 |
| RandomForestClassifier | 0.413268 |
| SGDClassifier | 0.423538 |
| SVC | 0.401094 |

In [1524]:
```
tfidf = TfidfVectorizer(sublinear_tf=True, min_df=3, norm='l2',
                        ngram_range=(1, 4), tokenizer=tokenize_lemm_rmstop_Text)

features = tfidf.fit_transform(tokenized_adf['Edited_Summary'])
labels = tokenized_adf['Sub_Decision']
features.shape
```

Out[1524]:
```
(576, 564)
```

In [1525]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42),
    LinearSVC(),
    MultinomialNB(),
    LogisticRegression(random_state=42),
    SVC(gamma="scale"),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                           max_iter=5, tol=None),
    DecisionTreeClassifier()
]

CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the 3-bin case, using tf-idf\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., 3b, tf-idf"}, inplace=True)
gb.append(gb_df)
gb_df
```




Out[1525]:

| model_name | Acc., 3b, tf-idf |
|---|---|
| DecisionTreeClassifier | 0.371604 |
| KNeighborsClassifier | 0.413298 |
| LinearSVC | 0.463553 |
| LogisticRegression | 0.475757 |
| MultinomialNB | 0.473928 |
| RandomForestClassifier | 0.404648 |
| SGDClassifier | 0.451409 |
| SVC | 0.381859 |

It seems like LogisticRegression with tf-idf does slightly better this time. Let's find the best parameters and take a look at the confusion matrix and the scores.

In [1526]:
```
y_s = tokenized_adf['Sub_Decision']
```

In [1527]:
```
X_s = tokenized_adf['Edited_Summary']
X_s_train, X_s_test, y_s_train, y_s_test = train_test_split(X_s, y_s, test_size=0.33, random_state=42)
```

In [1528]:
```
len(X_s_train), len (y_s_train)
```

Out[1528]:
```
(385, 385)
```

In [1529]:
```
X_s_train.sample(5)
```

Out[1529]:
```
169    ambulance report emergency medical services 20...
170    signal time summary 2003/10/27 regard motor ve...
316    records relate sidewalk repair inspection comp...
183       phase environmental site assessment heidelberg
27     correspondence 1996 1997 regard shades water t...
Name: Edited_Summary, dtype: object
```

### GridSearch for LogisticRegression - tf-idf

Finding parameters.

In [1530]:
```
# tf-idf
tfidf_vect = TfidfVectorizer()
tfidf_clf = LogisticRegression()
tfidf_pipe = Pipeline([
    ('vectorizer', tfidf_vect),
    ('clf', tfidf_clf)
])

parameters = {'vectorizer__ngram_range': [(1, 2), (1, 3), (1, 4)],
              'clf__penalty' : ['l1', 'l2'],
              'clf__C' : np.logspace(-4, 4, 20),
              'clf__solver' : ['liblinear']
             }

gs_clf = GridSearchCV(tfidf_pipe, parameters, cv=5)
gs_clf = gs_clf.fit(X_s_train, y_s_train)
print("For MultinomialNB Classifier with tf-idf:\n")
print("Best score: ", gs_clf.best_score_)
for param_name in sorted(parameters.keys()):
    print("%s: %r" % (param_name, gs_clf.best_params_[param_name]))
```

```
For MultinomialNB Classifier with tf-idf:

Best score:  0.5142857142857142
clf__C: 78.47599703514607
clf__penalty: 'l2'
clf__solver: 'liblinear'
vectorizer__ngram_range: (1, 4)
```

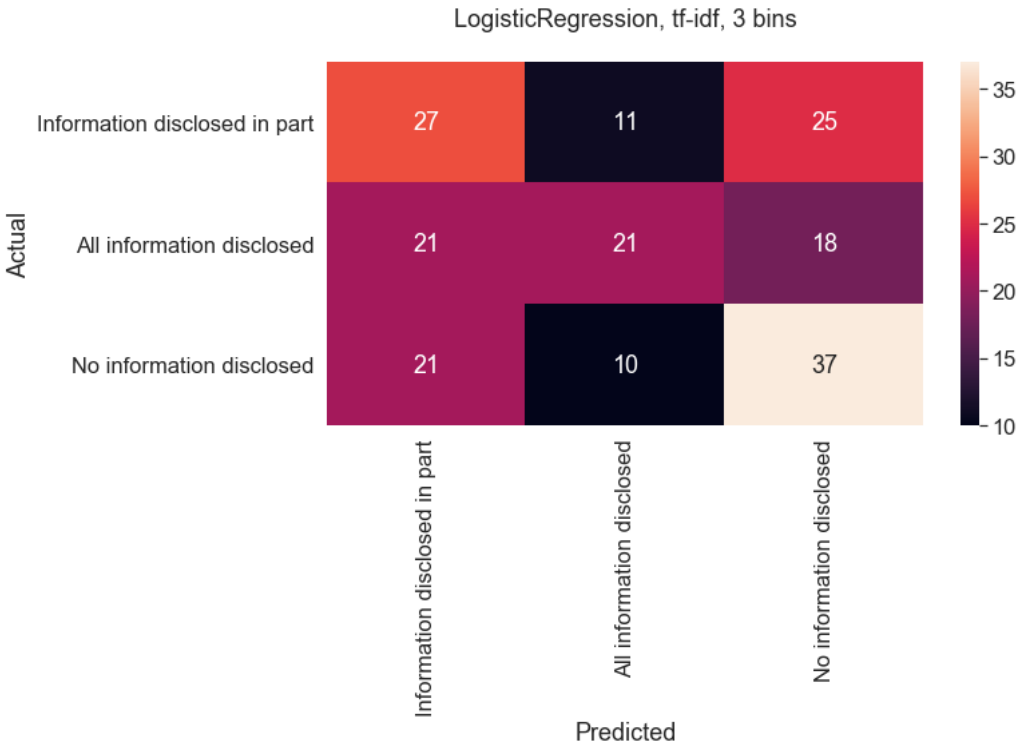
Running our model with the parameters just found.

In [1531]:
```
tfidf_vect = TfidfVectorizer(ngram_range=(1, 4))
tfidf_clf = LogisticRegression(C=78, penalty='l2', solver='liblinear')
tfidf_pipe.fit(X_s_train, y_s_train)
tfidf_preds = tfidf_pipe.predict(X_s_test)
print("LogisticRegression Accuracy - tfidf - 3 bins:", accuracy_score(y_s_test, tfidf_preds))
```

```
LogisticRegression Accuracy - tfidf - 3 bins: 0.44502617801047123
```

Finding confusion matrix and report.

In [1532]:
```
tfidf_conf_mat = confusion_matrix(y_s_test, tfidf_preds)
fig, ax = plt.subplots(figsize=(10, 5))
label_names = tokenized_adf['Sub_Decision'].unique()

sns.heatmap(tfidf_conf_mat, annot=True, fmt='d',
            xticklabels=label_names,
            yticklabels=label_names)

plt.ylabel('Actual')
plt.xlabel('Predicted')
ax.set(title='LogisticRegression, tf-idf, 3 bins\n')
plt.show()
print(classification_report(y_s_test, tfidf_preds,
                            target_names=tokenized_adf['Sub_Decision'].unique()))
```




```
                              precision    recall  f1-score   support

Information disclosed in part       0.39      0.43      0.41        63
    All information disclosed       0.50      0.35      0.41        60
     No information disclosed       0.46      0.54      0.50        68

                    micro avg       0.45      0.45      0.45       191
                    macro avg       0.45      0.44      0.44       191
                 weighted avg       0.45      0.45      0.44       191
```

## c) Removing cases with less than 15 cases and where a decision was not made

Let's call this dataframe 'independent'. Removing '*Withdrawn*' or '*Abandoned*' leaves us with 483 out of 576 total requests.

In [1533]:
```
tokenized_adf_indep = tokenized_adf_over15.copy()
```

In [1534]:
```
tokenized_adf_indep = tokenized_adf_indep[tokenized_adf_indep.Decision != 'Request withdrawn']
```

In [1535]:
```
tokenized_adf_indep = tokenized_adf_indep[tokenized_adf_indep.Decision != 'Abandoned']
```

In [1536]:
```
print(tokenized_adf_indep['Decision'].value_counts())
```

```
All information disclosed        189
Information disclosed in part    152
No records exist                  80
Partly non-existent               23
No information disclosed          21
Transferred                       15
Name: Decision, dtype: int64
```

In [1537]:
```
len(tokenized_adf_indep)
```

Out[1537]: 480

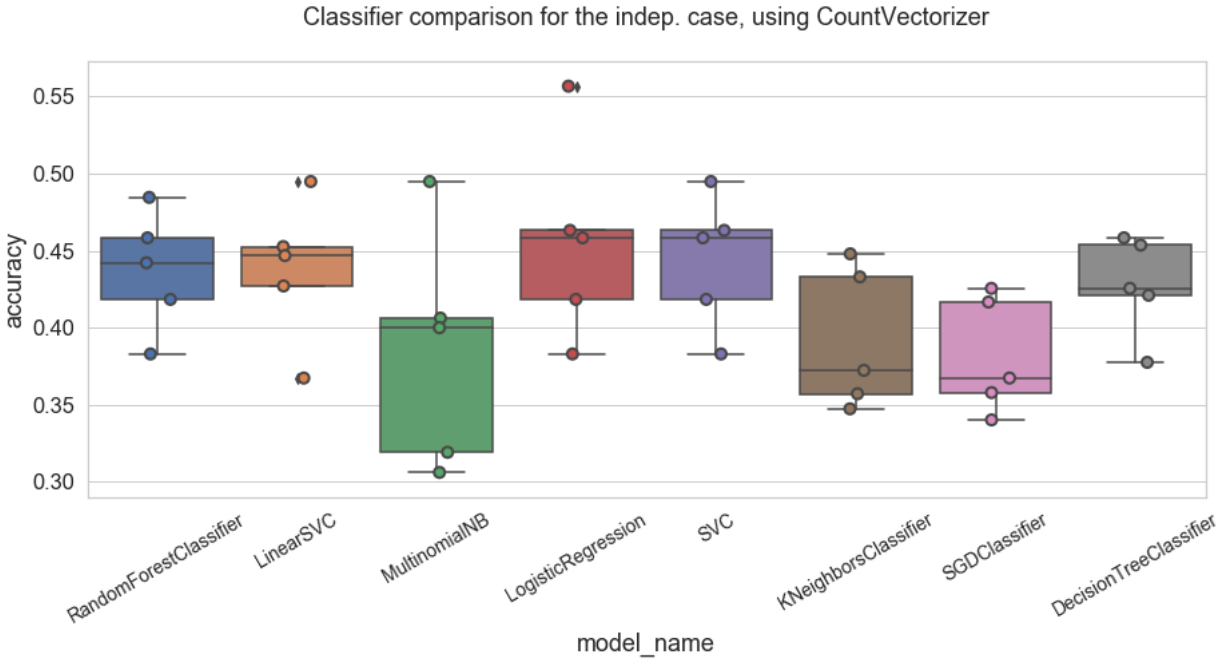
In [1538]:
```
len(tokenized_adf)
```

Out[1538]: 576

In [1539]:
```
count = CountVectorizer(min_df=3, ngram_range=(1, 4), tokenizer=tokenize_lemm_rmstop_Text)

features = count.fit_transform(tokenized_adf_indep['Edited_Summary'])
labels = tokenized_adf_indep['Decision']
features.shape
```

Out[1539]: (480, 470)

In [1540]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42),
    LinearSVC(),
    MultinomialNB(),
    LogisticRegression(random_state=42),
    SVC(gamma="scale"),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                           max_iter=5, tol=None),
    DecisionTreeClassifier()
]
CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the indep. case, using CountVectorizer\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., Ind., CVec"}, inplace=True)
gb.append(gb_df)
gb_df
```



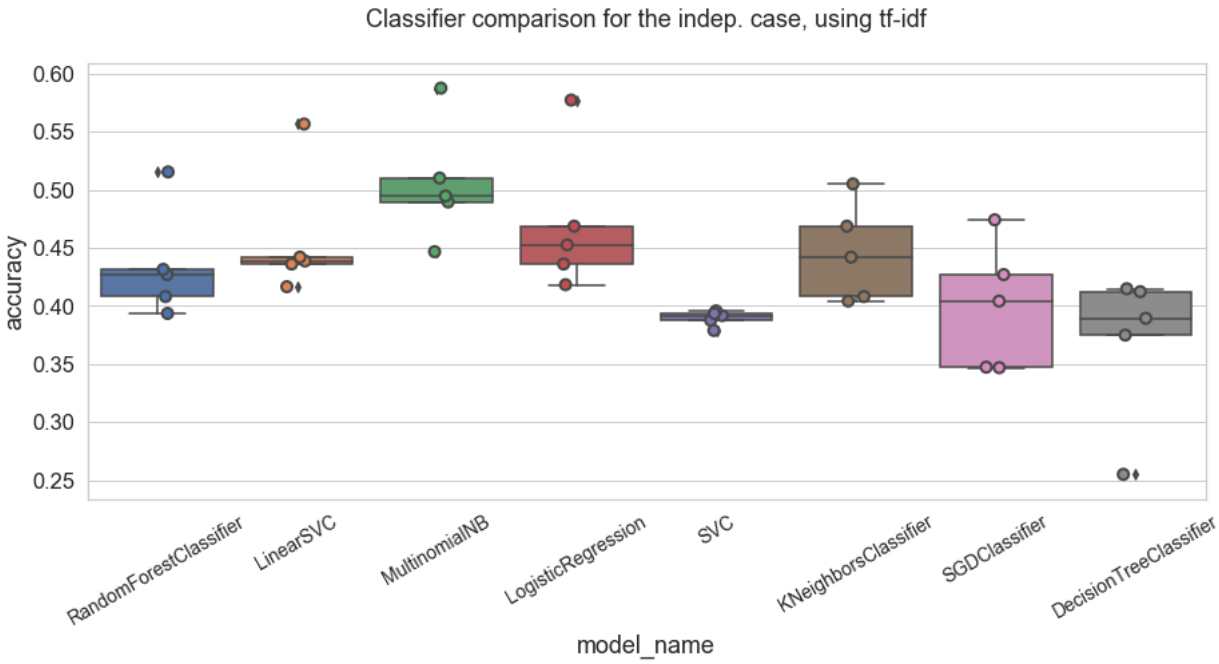

Out[1540]:

| | Acc., Ind., CVec |
|---|---|
| **model_name** | |
| **DecisionTreeClassifier** | 0.427215 |
| **KNeighborsClassifier** | 0.391552 |
| **LinearSVC** | 0.437743 |
| **LogisticRegression** | 0.455908 |
| **MultinomialNB** | 0.385273 |
| **RandomForestClassifier** | 0.437264 |
| **SGDClassifier** | 0.381529 |
| **SVC** | 0.443537 |

In [1541]:
```
tfidf = TfidfVectorizer(sublinear_tf=True, min_df=3, norm='l2',
                        ngram_range=(1, 4), tokenizer=tokenize_lemm_rmstop_Text)

features = tfidf.fit_transform(tokenized_adf_indep['Edited_Summary'])
labels = tokenized_adf_indep['Decision']
features.shape
```

Out[1541]: (480, 470)

In [1542]:
```
models = [
    RandomForestClassifier(n_estimators=200, max_depth=3,
                           random_state=42),
    LinearSVC(),
    MultinomialNB(),
    LogisticRegression(random_state=42),
    SVC(gamma="scale"),
    KNeighborsClassifier(),
    SGDClassifier(loss='hinge', random_state=42, penalty='l2',
                           max_iter=5, tol=None),
    DecisionTreeClassifier()
]

CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))
entries = []
for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_val_score(model, features, labels,
                                 scoring='accuracy', cv=CV)
    for fold_idx, accuracy in enumerate(accuracies):
        entries.append((model_name, fold_idx, accuracy))
cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_idx', 'accuracy'])


fig, ax = plt.subplots(figsize=(15,6))
sns.boxplot(x='model_name', y='accuracy', data=cv_df)
sns.stripplot(x='model_name', y='accuracy', data=cv_df,
              size=8, jitter=True, edgecolor="gray", linewidth=2)
ax.set(title='Classifier comparison for the indep. case, using tf-idf\n')
plt.xticks(rotation=30, fontsize=14)
plt.show()

gb_df = cv_df.groupby('model_name').accuracy.mean()
gb_df = gb_df.to_frame()
gb_df.rename(index=str, columns={"accuracy": "Acc., Ind., tf-idf"}, inplace=True)
gb.append(gb_df)
gb_df
```




Out[1542]:

| model_name | Acc., Ind., tf-idf |
|---|---|
| DecisionTreeClassifier | 0.369368 |
| KNeighborsClassifier | 0.445686 |
| LinearSVC | 0.458084 |
| LogisticRegression | 0.470648 |
| MultinomialNB | 0.505792 |
| RandomForestClassifier | 0.435181 |
| SGDClassifier | 0.399975 |
| SVC | 0.389581 |

It seems like MultinomialNB with tf-idf does better this time. Let's find the best parameters and take a look at the confusion matrix and the scores.

### GridSearch for MultinomialNB - tf-idf

Finding parameters.

In [1543]:
```
y_i = tokenized_adf_indep['Decision']
```

In [1544]:
```
X2 = tokenized_adf_indep['Edited_Summary']
X2_train, X2_test, y2_train, y2_test = train_test_split(X2, y_i, test_size=0.33, random_state=42)
```

In [1545]:
```
# tf-idf
tfidf_vect = TfidfVectorizer()
tfidf_clf = MultinomialNB()
tfidf_pipe = Pipeline([
    ('vectorizer', tfidf_vect),
    ('clf', tfidf_clf)
])

parameters = {'vectorizer__ngram_range': [(1, 2), (1, 3), (1, 4)],
              'clf__alpha': (1, 1e-1, 1e-2, 1e-3)
             }

gs_clf = GridSearchCV(tfidf_pipe, parameters, cv=5)
gs_clf = gs_clf.fit(X2_train, y2_train)
print("For MultinomialNB Classifier with tf-idf:\n")
print("Best score: ", gs_clf.best_score_)
for param_name in sorted(parameters.keys()):
    print("%s: %r" % (param_name, gs_clf.best_params_[param_name]))
```

```
For MultinomialNB Classifier with tf-idf:

Best score:  0.4766355140186916
clf__alpha: 0.1
vectorizer__ngram_range: (1, 4)
```

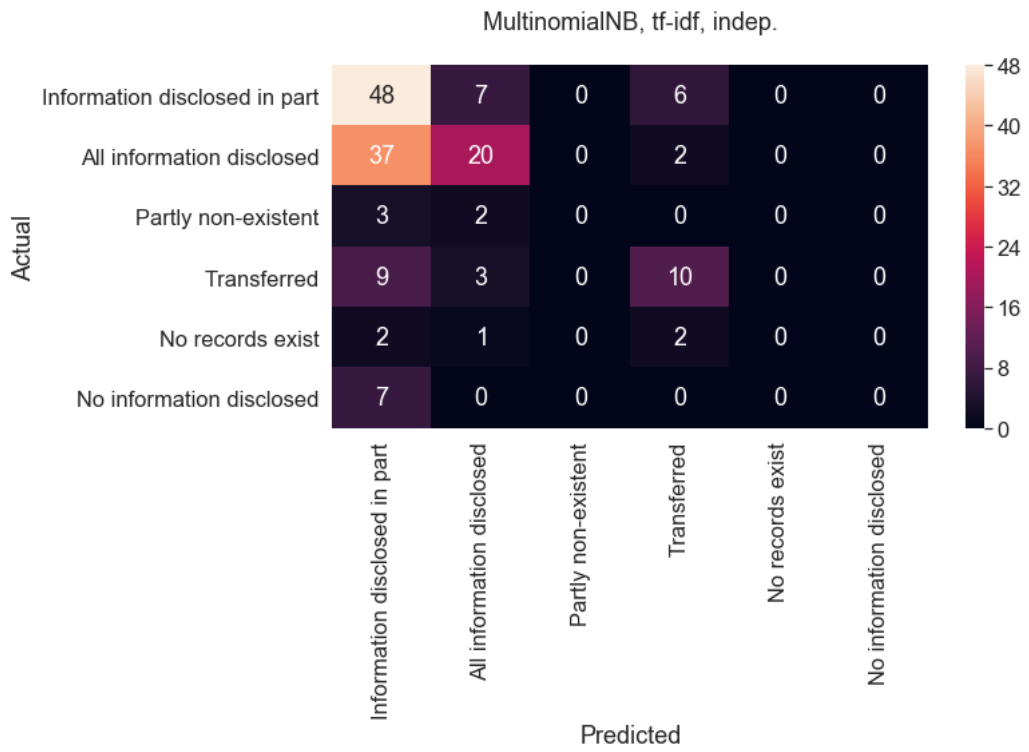
Running our model with the parameters just found.

In [1546]:
```
tfidf_vect = TfidfVectorizer(ngram_range=(1, 4))
tfidf_clf = MultinomialNB(alpha=0.1)
tfidf_pipe.fit(X2_train, y2_train)
tfidf_preds = tfidf_pipe.predict(X2_test)
print("MultinomialNB Accuracy - tfidf - indep:", accuracy_score(y2_test, tfidf_preds))
```

```
MultinomialNB Accuracy - tfidf - indep: 0.49056603773584906
```

Finding confusion matrix and report.

In [1547]:
```
tfidf_conf_mat = confusion_matrix(y2_test, tfidf_preds)
fig, ax = plt.subplots(figsize=(10, 5))
label_names = tokenized_adf_indep['Decision'].unique()

sns.heatmap(tfidf_conf_mat, annot=True, fmt='d',
            xticklabels=label_names,
            yticklabels=label_names)

plt.ylabel('Actual')
plt.xlabel('Predicted')
ax.set(title='MultinomialNB, tf-idf, indep.\n')
plt.show()
print(classification_report(y2_test, tfidf_preds,
                            target_names=tokenized_adf_indep['Decision'].unique()))
```




```
                              precision    recall  f1-score   support

Information disclosed in part       0.45      0.79      0.57        61
    All information disclosed       0.61      0.34      0.43        59
          Partly non-existent       0.00      0.00      0.00         5
                  Transferred       0.50      0.45      0.48        22
            No records exist        0.00      0.00      0.00         5
     No information disclosed       0.00      0.00      0.00         7

                    micro avg       0.49      0.49      0.49       159
                    macro avg       0.26      0.26      0.25       159
                 weighted avg       0.47      0.49      0.45       159
```

And putting all the accuracy scores together, and giving it some *Style* to make the results clearer.

In [1549]:
```
gb_all = pd.DataFrame()
```

In [1550]:
```
gb_all = pd.concat(gb, axis=1)
```

In [1564]:
```
gb_all
```

Out[1564]:

| model_name | Acc., ov15, CVec | Acc., o15, CVec, bal. | Acc., o15, tf-idf | Acc., o15, tf-idf, bal. | Acc., 3b, CVec | Acc., 3b, tf-idf | Acc., Ind., CVec | Acc., Ind., tf-idf |
|---|---|---|---|---|---|---|---|---|
| **DecisionTreeClassifier** | 0.337503 | 0.280352 | 0.341349 | 0.301949 | 0.345472 | 0.371604 | 0.427215 | 0.369368 |
| **KNeighborsClassifier** | 0.332115 | 0.332115 | 0.369461 | 0.369461 | 0.362969 | 0.413298 | 0.391552 | 0.445686 |
| **LinearSVC** | 0.360738 | 0.326804 | 0.389363 | 0.335767 | 0.447886 | 0.463553 | 0.437743 | 0.458084 |
| **LogisticRegression** | 0.390923 | 0.344536 | 0.399917 | 0.391149 | 0.474018 | 0.475757 | 0.455908 | 0.470648 |
| **MultinomialNB** | 0.349955 | 0.349955 | 0.430138 | 0.430138 | 0.458306 | 0.473928 | 0.385273 | 0.505792 |
| **RandomForestClassifier** | 0.385968 | 0.283998 | 0.382412 | 0.303760 | 0.413268 | 0.404648 | 0.437264 | 0.435181 |
| **SGDClassifier** | 0.339626 | 0.302021 | 0.330647 | 0.339450 | 0.423538 | 0.451409 | 0.381529 | 0.399975 |
| **SVC** | 0.381945 | 0.215925 | 0.337522 | 0.234153 | 0.401094 | 0.381859 | 0.443537 | 0.389581 |

Adding some functions that will *style* and color the dataframe.

In [1553]:
```
def color_above45_green(val):
    """
    Takes a scalar and returns a string with
    the css property `'color: green'` for above 0.45
    strings, black otherwise.
    """
    color = 'green' if val > 0.45 else 'black'
    return 'color: %s' % color
```

In [1555]:
```
def highlight_max(s):
    '''
    highlight the maximum in a Series yellow.
    '''
    is_max = s == s.max()
    return ['background-color: yellow' if v else '' for v in is_max]
```

In [1570]:
```
caption = 'Accuracy score for all the eight models, and 3 different cases\
         (ov15: over 15 requests, 3b: All decisions split into three bins, Ind.: over 15 and w/o Withdrawns and \
         Abandoned.) We also considered two different vectorizers, CountVectorizer (CVec) and tf-idf. Highest score per
         case is highlighted in yellow. Scores above 45% are shown in green.'
s = gb_all.style.\
    applymap(color_above45_green).\
    apply(highlight_max).\
    set_caption(caption)
s
```

Out[1570]:

Accuracy score for all the eight models, and 3 different cases (ov15: over 15 requests, 3b: All decisions split into three bins, Ind.: over 15 and w/o Withdrawns and Abandoned.) We also considered two different vectorizers, CountVectorizer (CVec) and tf-idf. Highest score per case is highlighted in yellow. Scores above 45% are shown in green.

| model_name | Acc., ov15, CVec | Acc., o15, CVec, bal. | Acc., o15, tf-idf | Acc., o15, tf-idf, bal. | Acc., 3b, CVec | Acc., 3b, tf-idf | Acc., Ind., CVec | Acc., Ind., tf-idf |
|---|---|---|---|---|---|---|---|---|
| **DecisionTreeClassifier** | 0.337503 | 0.280352 | 0.341349 | 0.301949 | 0.345472 | 0.371604 | 0.427215 | 0.369368 |
| **KNeighborsClassifier** | 0.332115 | 0.332115 | 0.369461 | 0.369461 | 0.362969 | 0.413298 | 0.391552 | 0.445686 |
| **LinearSVC** | 0.360738 | 0.326804 | 0.389363 | 0.335767 | 0.447886 | 0.463553 | 0.437743 | 0.458084 |
| **LogisticRegression** | 0.390923 | 0.344536 | 0.399917 | 0.391149 | 0.474018 | 0.475757 | 0.455908 | 0.470648 |
| **MultinomialNB** | 0.349955 | 0.349955 | 0.430138 | 0.430138 | 0.458306 | 0.473928 | 0.385273 | 0.505792 |
| **RandomForestClassifier** | 0.385968 | 0.283998 | 0.382412 | 0.30376 | 0.413268 | 0.404648 | 0.437264 | 0.435181 |
| **SGDClassifier** | 0.339626 | 0.302021 | 0.330647 | 0.33945 | 0.423538 | 0.451409 | 0.381529 | 0.399975 |
| **SVC** | 0.381945 | 0.215925 | 0.337522 | 0.234153 | 0.401094 | 0.381859 | 0.443537 | 0.389581 |

**We see that even though our results are not good (50% is the highest!), in general, for this case, Logistic Regression and Multinomial Naive Bayes classifiers, combir well as reducing the number of 'Decisions'.**