Module 2: Exploratory Data Analysis

Part 2: Two Dimensional Data

Exercise 1

For this exercise, you are given a Series of random numbers creatively names **`random_numbers`**. For the first exercise please do the following:

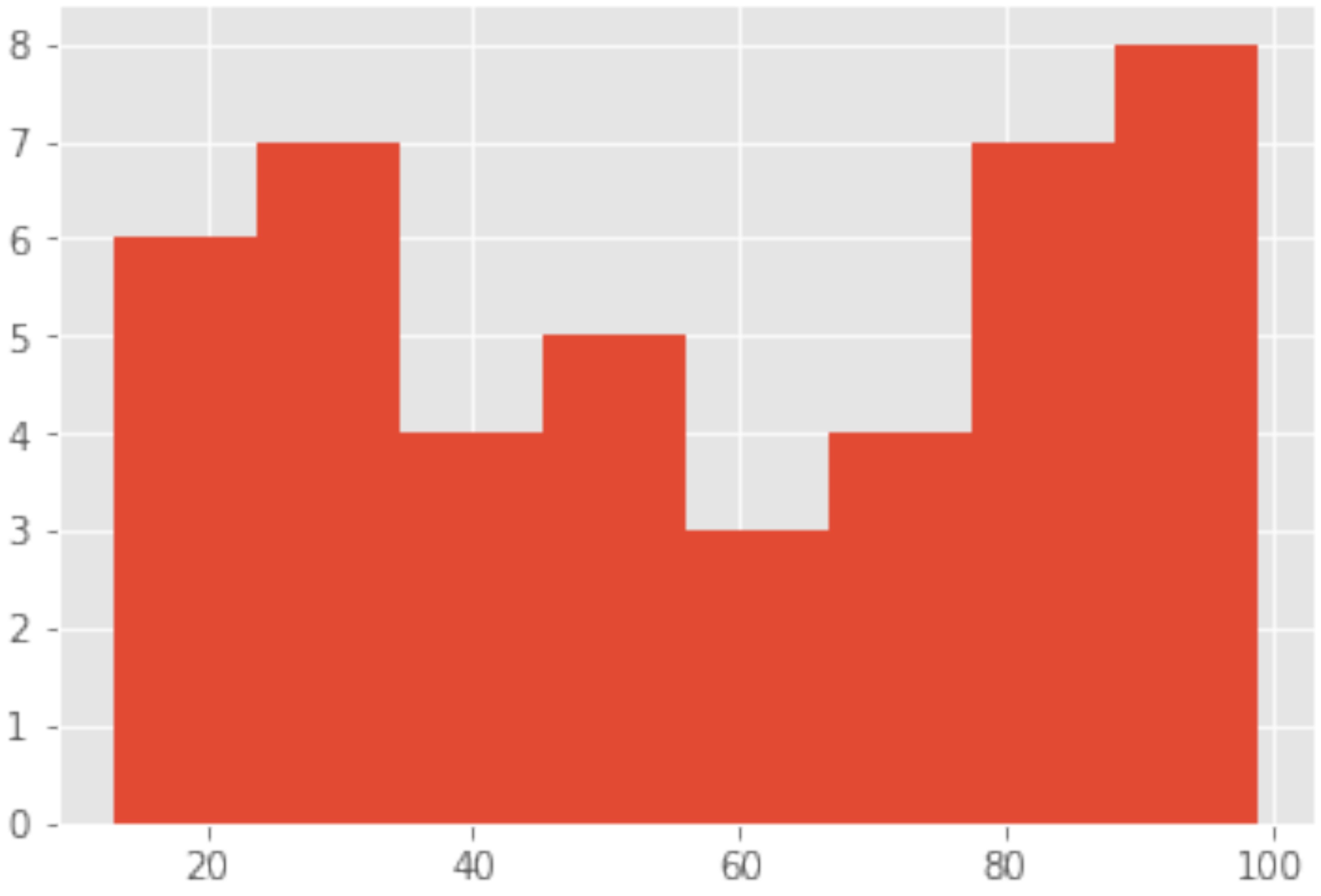
1. Remove all the numbers less than 10
2. Sort the series
3. Calculate the Tukey 5 number summary for this dataset
4. Count the number of even and odd numbers
5. Find the five largest and 5 smallest numbers in the series

Exercise 1

```
#Filter the Series
random_numbers = random_numbers[random_numbers >= 10]

#Sort the Series
random_numbers.sort_values(inplace=True)

#Calculate the Tukey 5 Number Summary
random_numbers.describe()

#Count the number of even and odd numbers
even_numbers = random_numbers[random_numbers % 2 == 0].count()
odd_numbers = random_numbers[random_numbers % 2 != 0].count()
print( "Even numbers: " + str(even_numbers))
print( "Odd numbers: " + str(odd_numbers))

#Find the five largest and smallest numbers
print( "Smallest Numbers:")
print( random_numbers.head(5))

print( "Largest Numbers:")
print( random_numbers.tail(5))
```

Exercise 2

```
random_numbers.hist(bins=8)
```



Exercise 3

```
phone_number_series = pd.Series(phone_numbers)

area_codes = phone_number_series.str.slice(1,4)
area_codes2 = phone_number_series.str.extract( ‘\((\d{3})\)')

area_codes.value_counts()
```

The Data Frame

```
df = pd.DataFrame( <data>, <index>, <column_names> )
```

CSV

```
df = pd.read_csv( <file> )

df = pd.read_csv( <url> )
```

Excel

```
df = pd.read_excel( <file>, sheetname=<sheetname> )
```

```
[
  {
   “changed":"2015-04-0300:00:00",
   "created":"2014-04-10 00:00:00”,
   “dnssec":"False",
   "expires":"2016-04-10 00:00:00”,
   “isMalicious":0,
   “url":"nuteczki.com"
  },
…
]
```

JSON

```
df = pd.read_json( <file> )
or
df = pd.read_json( <url> )
```

From a Database

```
df = pd.read_sql( <query>, <connection> )
```

Parquet

```
df = pd.read_parquet( <file> )
```

HTML

```
df = pd.read_html( <source> )
```

XML

```
import requests

user_agent_url = 'http://www.user-agents.org/allagents.xml'
xml_data = requests.get(user_agent_url).content
```

http://www.austintaylor.io/lxml/python/pandas/xml/dataframe/2016/07/08/convert-xml-to-pandas-dataframe/

XML

```
import xml.etree.ElementTree as ET

class XML2DataFrame:

    def __init__(self, xml_data):
        self.root = ET.XML(xml_data)

    def parse_root(self, root):
        return [self.parse_element(child) for child in iter(root)]

    def parse_element(self, element, parsed=None):
        if parsed is None:
            parsed = dict()
        for key in element.keys():
            parsed[key] = element.attrib.get(key)
        if element.text:
            parsed[element.tag] = element.text
        for child in list(element):
            self.parse_element(child, parsed)
        return parsed

    def process_data(self):
        structure_data = self.parse_root(self.root)
        return pd.DataFrame(structure_data)

xml2df = XML2DataFrame(xml_data)
xml_dataframe = xml2df.process_data()
```

http://www.austintaylor.io/lxml/python/pandas/xml/dataframe/2016/07/08/convert-xml-to-pandas-dataframe/

Log Files…

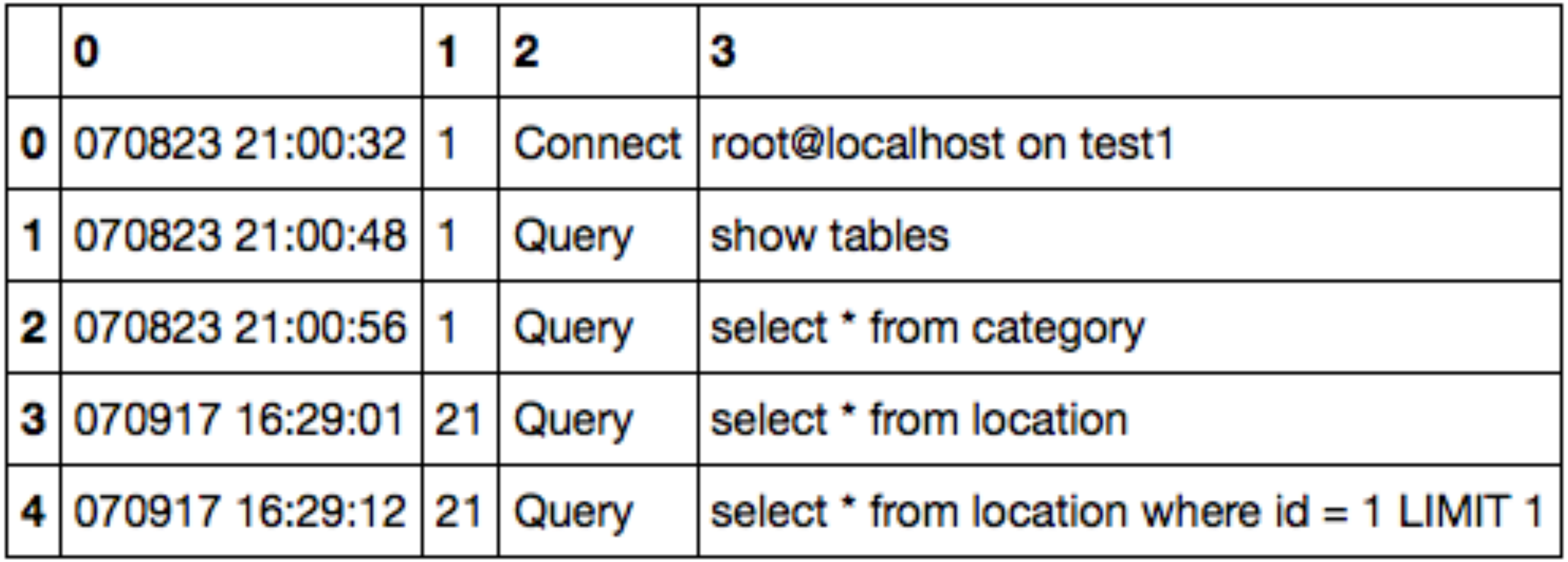
```
070823 21:00:32       1 Connect     root@localhost on test1
070823 21:00:48       1 Query       show tables
070823 21:00:56       1 Query       select * from category
070917 16:29:01      21 Query       select * from location
070917 16:29:12      21 Query       select * from location where id = 1 LIMIT 1
```

```
070823 21:00:32       1 Connect     root@localhost on test1
070823 21:00:48       1 Query       show tables
070823 21:00:56       1 Query       select * from category
070917 16:29:01      21 Query       select * from location
070917 16:29:12      21 Query       select * from location where id = 1 LIMIT 1
```

```
logdf = pd.read_table(‘../data/mysql.log’, names=['raw'])
```

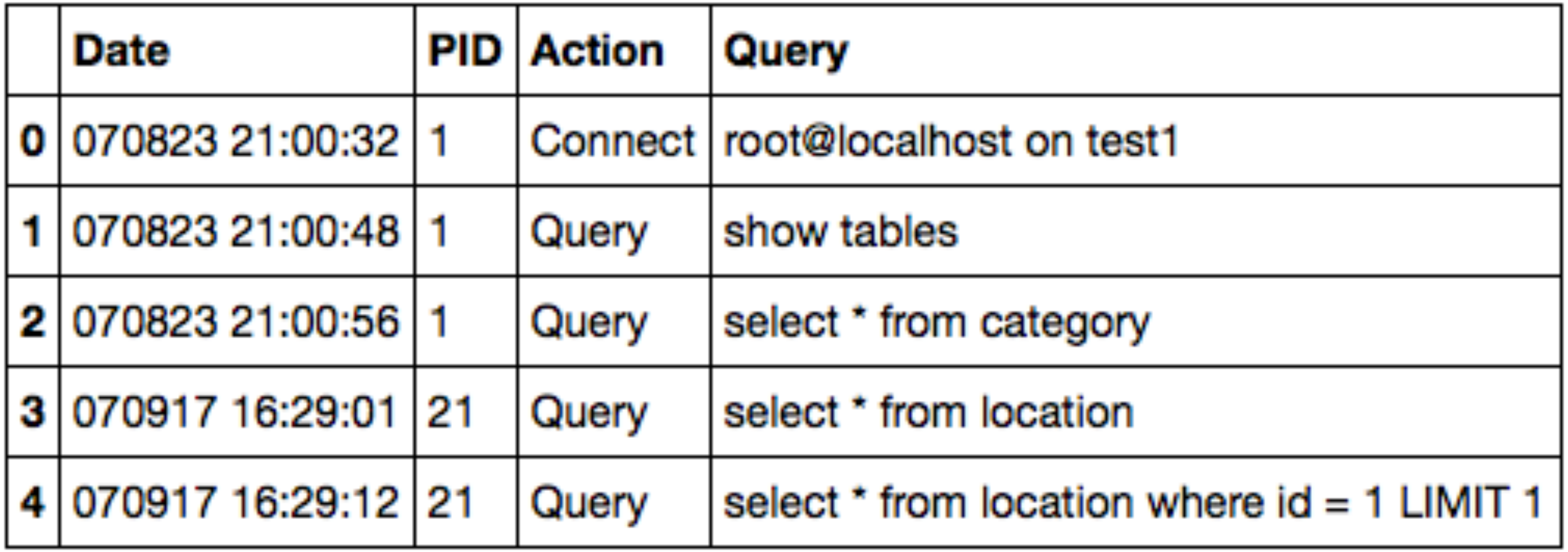
	raw
0	070823 21:00:32 1 Connect root@local...
1	070823 21:00:48 1 Query show tables
2	070823 21:00:56 1 Query select * f...
3	070917 16:29:01 21 Query select * f...
4	070917 16:29:12 21 Query select * f...

```
logdf = pd.read_table(‘../data/mysql.log’, names=[‘raw’])
logdf['raw'].str.extract('(\d{6}\s\d{2}:\d{2}:\d{2})\s+(\d+)\s(\S+)
\s(.+)', expand=False)
```



	0	1	2	3
0	070823 21:00:32	1	Connect	root@localhost on test1
1	070823 21:00:48	1	Query	show tables
2	070823 21:00:56	1	Query	select * from category
3	070917 16:29:01	21	Query	select * from location
4	070917 16:29:12	21	Query	select * from location where id = 1 LIMIT 1

```
logdf = pd.read_table(‘../data/mysql.log’, names=[‘raw’])
logdf['raw'].str.extract('(?P<date>\d{6}\s\d{2}:\d{2}:\d{2})\s+(?
P<PID>\d+)\s(?P<Action>\S+)\s(?P<Query>.+)', expand=False)
```



	Date	PID	Action	Query
0	070823 21:00:32	1	Connect	root@localhost on test1
1	070823 21:00:48	1	Query	show tables
2	070823 21:00:56	1	Query	select * from category
3	070917 16:29:01	21	Query	select * from location
4	070917 16:29:12	21	Query	select * from location where id = 1 LIMIT 1

Web Server Logs

APACHE
HTTP SERVER

Web Server Logs

```
195.154.46.135 - - [25/Oct/2015:04:11:25 +0100] "GET /linux/
doing-pxe-without-dhcp-control HTTP/1.1" 200 24323 "http://
howto.basjes.nl/" "Mozilla/5.0 (Windows NT 5.1; rv:35.0)
Gecko/20100101 Firefox/35.0"
```

Web Server Logs

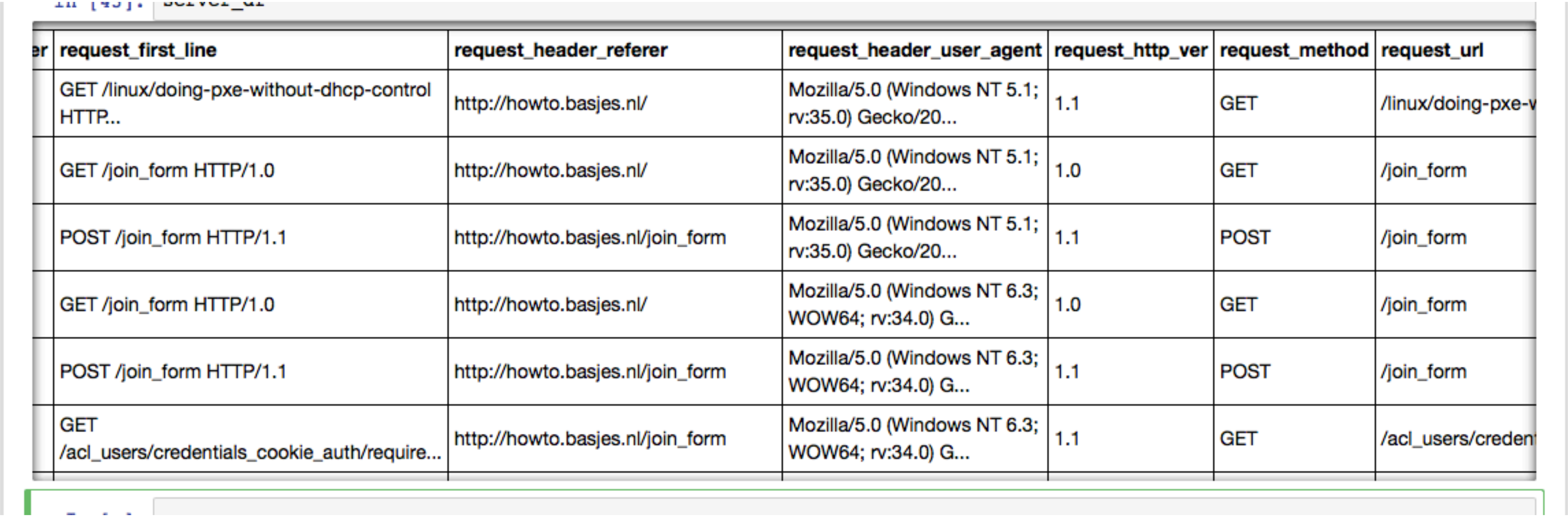
```
195.154.46.135 - - [25/Oct/2015:04:11:25 +0100] "GET /linux/
doing-pxe-without-dhcp-control HTTP/1.1" 200 24323 "http://
howto.basjes.nl/" "Mozilla/5.0 (Windows NT 5.1; rv:35.0)
Gecko/20100101 Firefox/35.0"
```

```
import apache_log_parser
line_parser = apache_log_parser.make_parser("%h %l %u %t
\"%r\" %>s %b \"%{Referer}i\" \"%{User-agent}i\"")
```

Web Server Logs

```
import apache_log_parser
line_parser = apache_log_parser.make_parser("%h %l %u %t
\"%r\" %>s %b \"%{Referer}i\" \”%{User-agent}i\”")

server_log = open(“../data/hackers-access.httpd”, "r")
parsed_server_data = []
for line in server_log:
    data = {}
    data = line_parser(line)
    parsed_server_data.append( data )

server_df = pd.DataFrame( parsed_server_data  )
```

Web Server Logs



er	request_first_line	request_header_referer	request_header_user_agent	request_http_ver	request_method	request_url
	GET /linux/doing-pxe-without-dhcp-control HTTP...	http://howto.basjes.nl/	Mozilla/5.0 (Windows NT 5.1; rv:35.0) Gecko/20...	1.1	GET	/linux/doing-pxe-v
	GET /join_form HTTP/1.0	http://howto.basjes.nl/	Mozilla/5.0 (Windows NT 5.1; rv:35.0) Gecko/20...	1.0	GET	/join_form
	POST /join_form HTTP/1.1	http://howto.basjes.nl/join_form	Mozilla/5.0 (Windows NT 5.1; rv:35.0) Gecko/20...	1.1	POST	/join_form
	GET /join_form HTTP/1.0	http://howto.basjes.nl/	Mozilla/5.0 (Windows NT 6.3; WOW64; rv:34.0) G...	1.0	GET	/join_form
	POST /join_form HTTP/1.1	http://howto.basjes.nl/join_form	Mozilla/5.0 (Windows NT 6.3; WOW64; rv:34.0) G...	1.1	POST	/join_form
	GET /acl_users/credentials_cookie_auth/require...	http://howto.basjes.nl/join_form	Mozilla/5.0 (Windows NT 6.3; WOW64; rv:34.0) G...	1.1	GET	/acl_users/creden

Windows Event Logs

```
pip install python-evtx
```

```
import Evtx.Evtx as evtx

xml = "<Events>"
with evtx.Evtx("window_event_log.evtx") as log:
    for record in log.records():
        xml += record.xml()
xml += "</Events>"
```

Nested Data?

Nested Data?

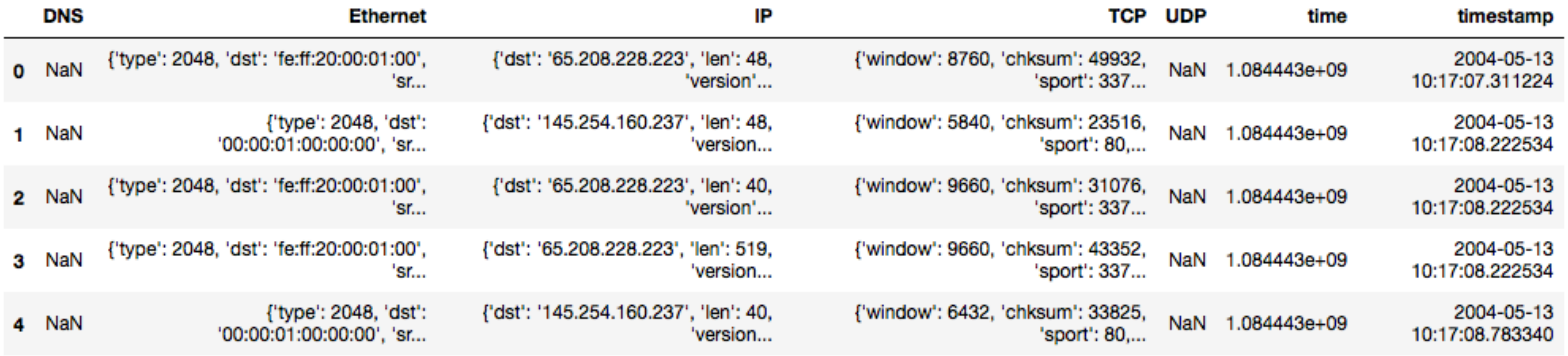
```
{"time": 1084443427.311224,
 "timestamp": "2004-05-13T10:17:07.311224",
"IP": {
   "version": 4,
   "ttl": 128,
   "proto": 6,
   "options": [],
   "len": 48,
   "dst": "65.208.228.223",
   "frag": 0,
   "flags": 2, "src": “145.254.160.237",
   "chksum": 37355
   },
   "Ethernet": {"src": "00:00:01:00:00:00", "type": 2048, "dst": “fe:ff:20:00:01:00"},
   …
```

Nested Data

```
pd.read_json( 'nested_data.json' )
```

Nested Data

```
pd.read_json( 'nested_data.json' )
```



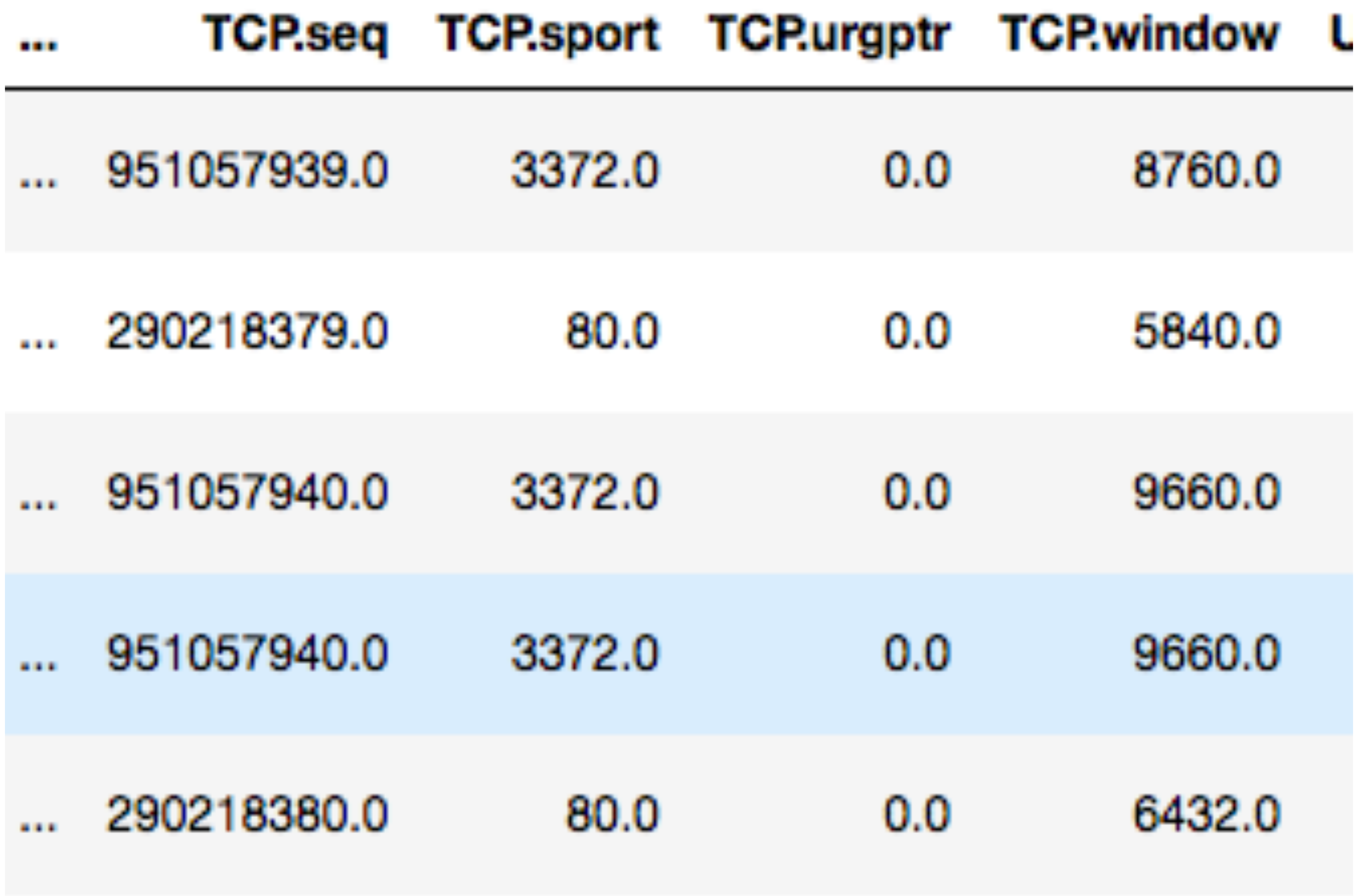
	DNS	Ethernet	IP	TCP	UDP	time	timestamp
0	NaN	{'type': 2048, 'dst': 'fe:ff:20:00:01:00', 'sr...	{'dst': '65.208.228.223', 'len': 48, 'version'...	{'window': 8760, 'chksum': 49932, 'sport': 337...	NaN	1.084443e+09	2004-05-13 10:17:07.311224
1	NaN	{'type': 2048, 'dst': '00:00:01:00:00:00', 'sr...	{'dst': '145.254.160.237', 'len': 48, 'version...	{'window': 5840, 'chksum': 23516, 'sport': 80,...	NaN	1.084443e+09	2004-05-13 10:17:08.222534
2	NaN	{'type': 2048, 'dst': 'fe:ff:20:00:01:00', 'sr...	{'dst': '65.208.228.223', 'len': 40, 'version'...	{'window': 9660, 'chksum': 31076, 'sport': 337...	NaN	1.084443e+09	2004-05-13 10:17:08.222534
3	NaN	{'type': 2048, 'dst': 'fe:ff:20:00:01:00', 'sr...	{'dst': '65.208.228.223', 'len': 519, 'version...	{'window': 9660, 'chksum': 43352, 'sport': 337...	NaN	1.084443e+09	2004-05-13 10:17:08.222534
4	NaN	{'type': 2048, 'dst': '00:00:01:00:00:00', 'sr...	{'dst': '145.254.160.237', 'len': 40, 'version...	{'window': 6432, 'chksum': 33825, 'sport': 80,...	NaN	1.084443e+09	2004-05-13 10:17:08.783340

Nested Data

```
from pandas.io.json import json_normalize
import json
import pandas as pd

with open('nested.json') as data_file:
    pcap_data = json.load(data_file)

df = pd.DataFrame( json_normalize(pcap_data) )
```

Nested Data

```
df = pd.DataFrame( json_normalize(pcap_data) )
```



...	TCP.seq	TCP.sport	TCP.urgptr	TCP.window	U
...	951057939.0	3372.0	0.0	8760.0	
...	290218379.0	80.0	0.0	5840.0	
...	951057940.0	3372.0	0.0	9660.0	
...	951057940.0	3372.0	0.0	9660.0	
...	290218380.0	80.0	0.0	6432.0	

ElasticSearch & Splunk

ElasticSearch & Splunk

```
pip install huntlib
```

```
e = ElasticDF(
  url="https://localhost:9200",
  ssl=True,
  username="myuser",
  password="mypass"
)
df = e.search_df(
  lucene="proto:tcp AND port:80",
  index="myindex-*",
  days=1,
  normalize=False
)
```

```
s = SplunkDF(
  host="<splunk_ip>",
  username="myuser",
  password="mypass"
)
df = s.search_df(
  spl='search index=win_events src="10.9.*.*"',
  start_time=datetime.now()-timedelta(days=2),
  end_time=datetime.now()
)
```

Manipulating a DataFrame

```
series = df['column1']
```

Returns a **series**

```
df['ip'].value_counts().head()
```

Two ways of accessing columns

```
series = df['column1']
```

```
series = df.column1
```

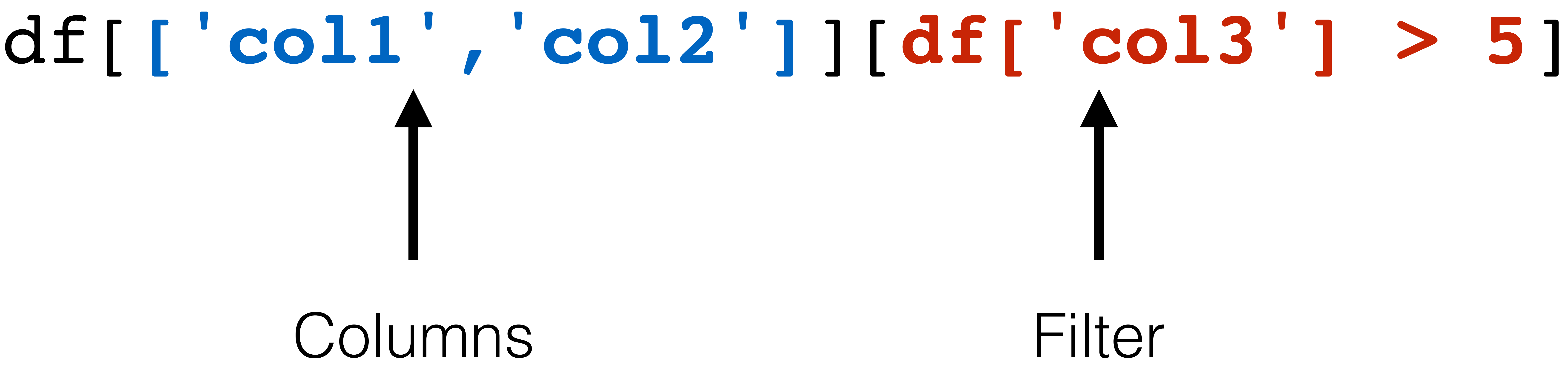
Don't use the dots!

```
df = df[['column1','column2','column3']]
```

Returns a DataFrame

Filtering a DataFrame

```
df[<boolean condition>]
```



```
df[['col1','col2']][df['col3'] > 5]
```

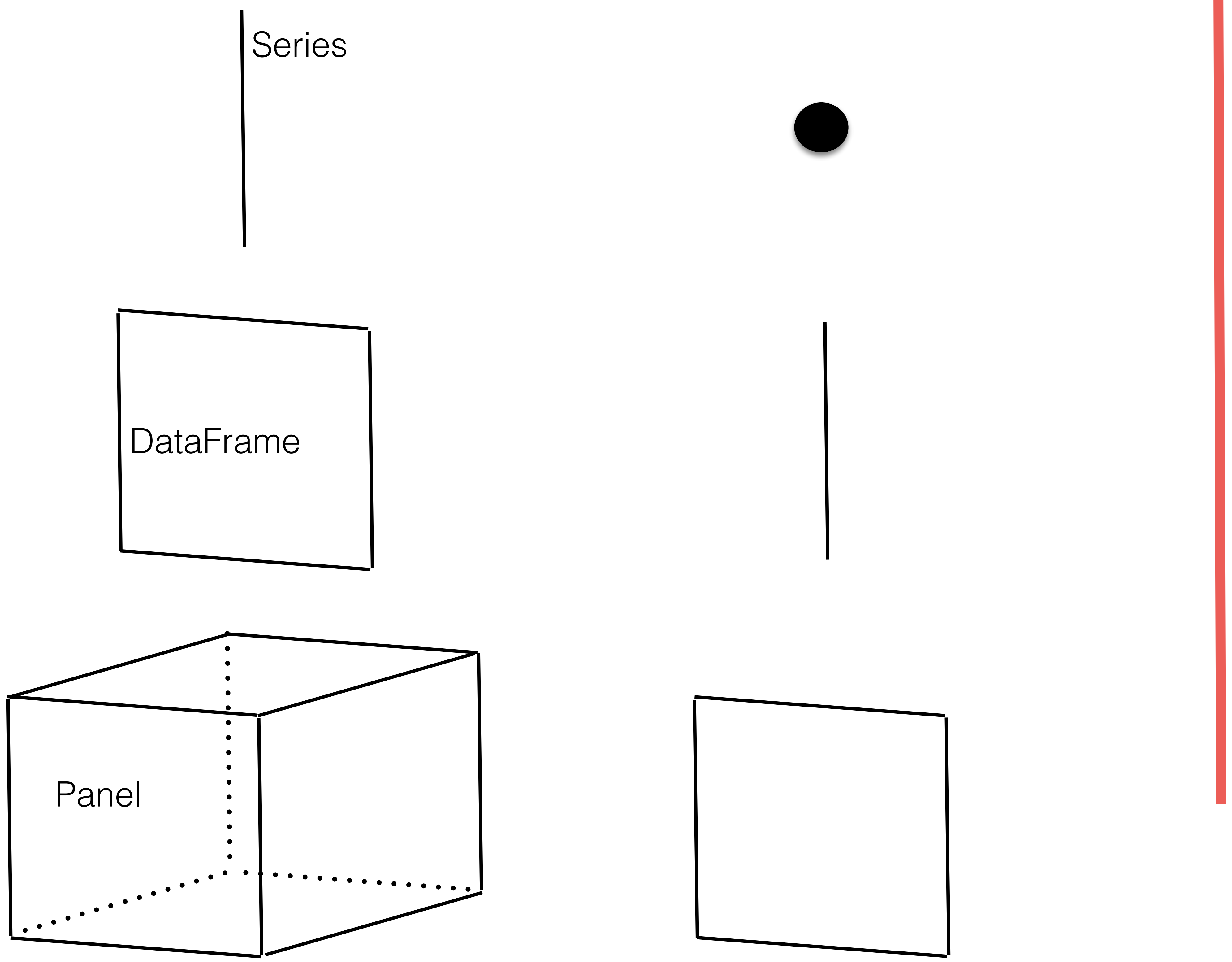
Columns

Filter

```
data.loc[<index>]
data.loc[<list of indexes>]
data.sample(<n>)
data.apply( <function> )
```

IF
Call Apply On...

THEN
Function
Receives



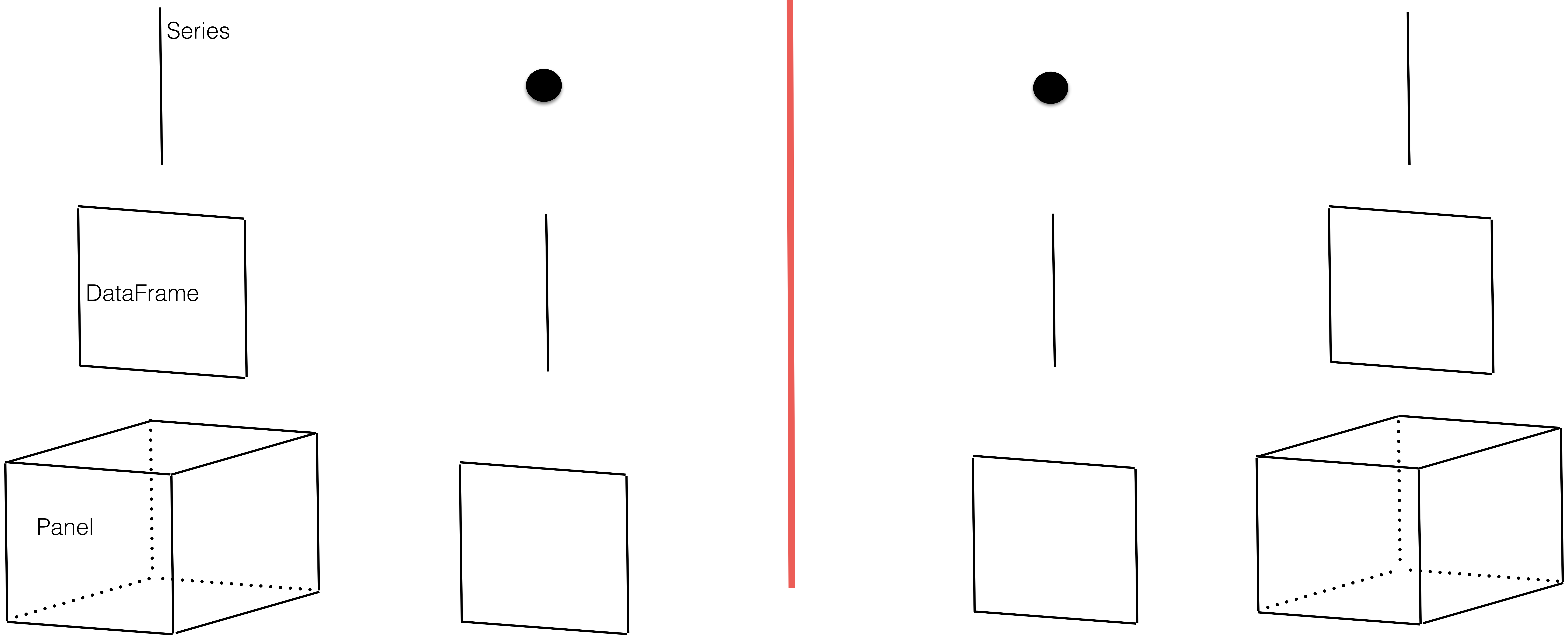
`data.apply( <function> )`

IF
Call Apply On...

THEN
Function
Receives

IF
Function
Returns

THEN
Apply
Returns...



In Class Exercise:

Please complete Worksheet 2.1: Exploring Two Dimensional Data

Exercise 1

#Data1

```
{“first_name":{“0":"Robert","1":"Steve","2":"Anne","3":"Alice"},
“last_name":{"0":"Hernandez","1":"Smith","2":"Raps","3":"Muller"},
“birthday":{"0":"5\\/3\\/67","1":"8\\/4\\/84","2":"9\\/13\\/
91","3":"4\\/15\\/75"}
}
```

```
df1 = pd.read_json('../data/data1.json')
```

Exercise 1

#Data2

```
{“0”:{"first_name":"Robert","last_name":"Hernandez","birthday":"5\\/3\
\/67"},
“1":{"first_name":"Steve","last_name":"Smith","birthday":"8\\/4\\/
84"},
“2":{"first_name":"Anne","last_name":"Raps","birthday":"9\\/13\\/91"},
"3":{"first_name":"Alice","last_name":"Muller","birthday":"4\\/15\\/
75"}}
```

```
df2 = pd.read_json('../data/data2.json', orient='index')
```

Exercise 1

#Data3

```
[
{“first_name":"Robert","last_name":"Hernandez","birthday":"5\\/3\\/
67"},
{"first_name":"Steve","last_name":"Smith","birthday":"8\\/4\\/84"},
{"first_name":"Anne","last_name":"Raps","birthday":"9\\/13\\/91"},
{"first_name":"Alice","last_name":"Muller","birthday":"4\\/15\\/75"}]
```

```
df3 = pd.read_json('../data/data3.json',
orient='columns')
```

Exercise 1

#Data4

```
{“columns":["first_name","last_name","birthday"],
“index":[0,1,2,3],
"data":[["Robert","Hernandez","5\\/3\\/67"],["Steve","Smith","8\\/4\\/
84"],["Anne","Raps","9\\/13\\/91"],["Alice","Muller","4\\/15\\/75"]]}
```

```
df4 = pd.read_json('../data/data4.json', orient='split')
```

Exercise 2

```
#Write the functions
def get_os(x):
    user_agent = parse(x)
    return user_agent.os.family

def get_browser(x):
    user_agent = parse(x)
    return user_agent.browser.family
```

Exercise 2

```
#Apply the functions to the dataframe
server_df['os'] =
server_df['request_header_user_agent'].apply( get_os )
server_df['browser'] =
server_df['request_header_user_agent'].apply( get_browser )
```

Exercise 2

```
#Apply the functions to the dataframe
server_df['os'] =
server_df['request_header_user_agent'].apply( get_os )
server_df['browser'] =
server_df['request_header_user_agent'].apply( get_browser )
```

```
#Get the top 10 values
server_df['os'].value_counts().head(10)
```

Exercise 2

```
#Get the top 10 values
server_df['os'].value_counts().head(10)
```

```
Windows 7        2041
Windows Vista     500
Windows XP        423
Windows 8.1       221
Linux             125
Mac OS X           80
Chrome OS          60
Ubuntu              6
```

Exercise 3

```
bots = pd.read_csv('../data/dailybots.csv')
gov_bots = bots[['botfam', 'hosts']][bots['industry'] ==
"Government/Politics"]

gov_bots.groupby('botfam', as_index=False).sum()
```

Questions?

1	2	3
4	5	6
7	8	9

```
data.T
```

1	4	7
2	5	8
3	6	9

```
#Gets you the sum of columns
data.sum( axis=0 )

#Gets you the sum of the rows
data.sum( axis=1 )
```

```
DataFrame.drop(labels,
axis=0,
level=None,
inplace=False,
errors='raise')¶
```

Merging Data Sets

Union

Union

Series 1

Index	Value
0	6
1	4
2	2
3	3

GTK CYBER

GET ON THE FAST TRACK

Union

Series 1

Index	Value
0	6
1	4
2	2
3	3

Series 2

Index	Value
0	7
1	5
2	3
3	4

Union

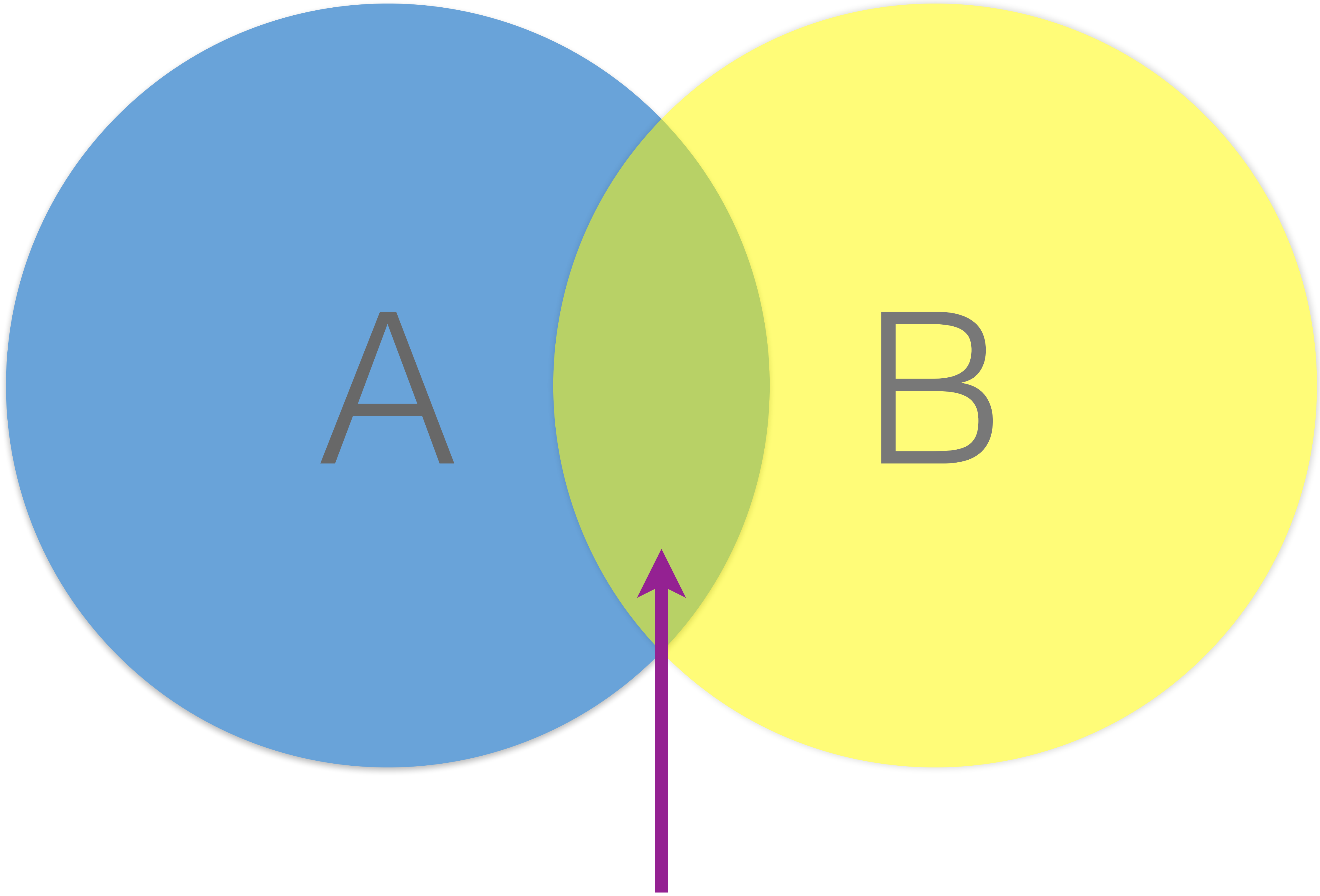
combinedSeries

Index	Value
0	6
1	4
2	2
3	3
4	7
5	5
6	3
7	4

```
combinedSeries = pd.concat(
                          [series1, series2],
                          ignore_index=True )
```

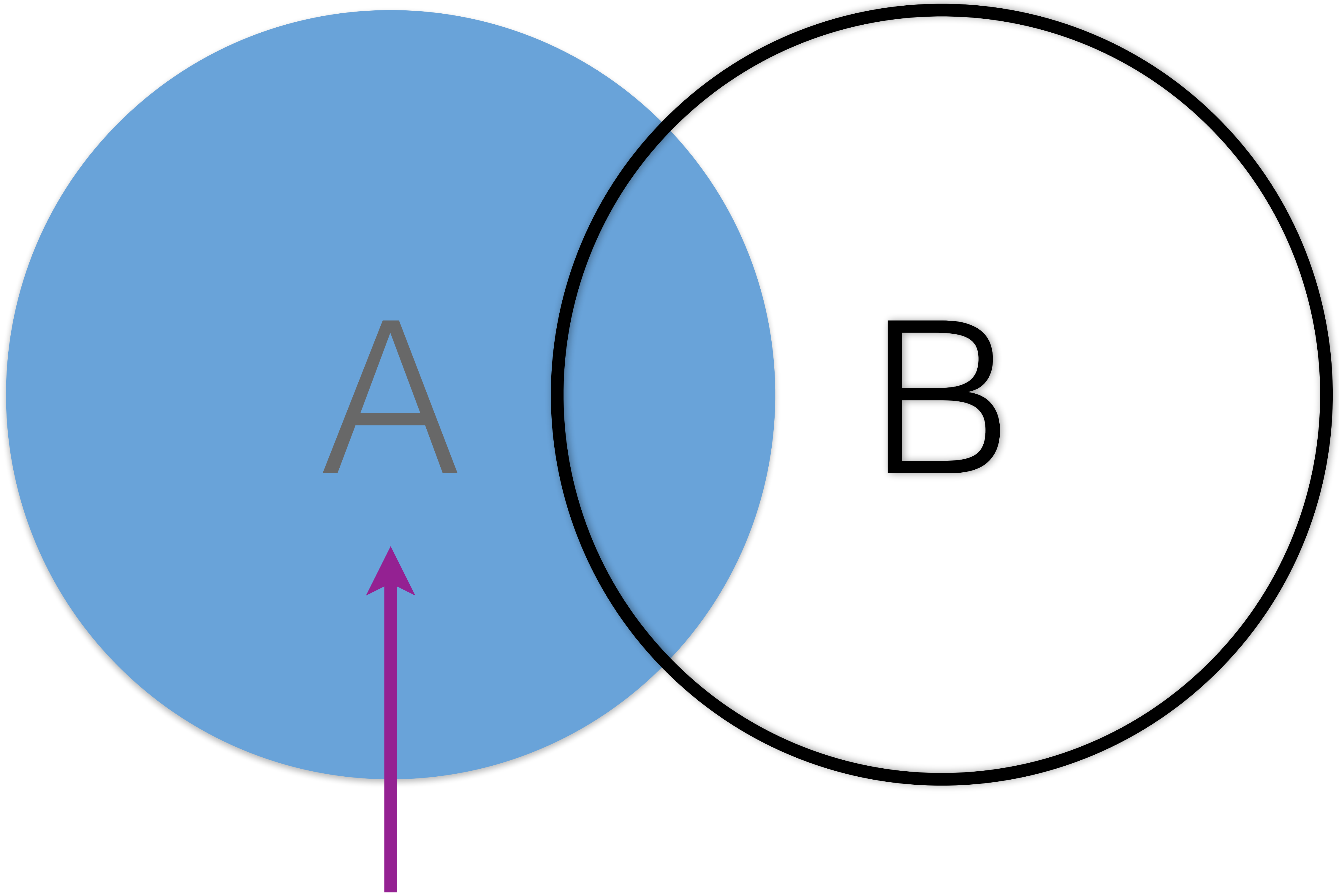
Joins

Inner Join (Intersection)



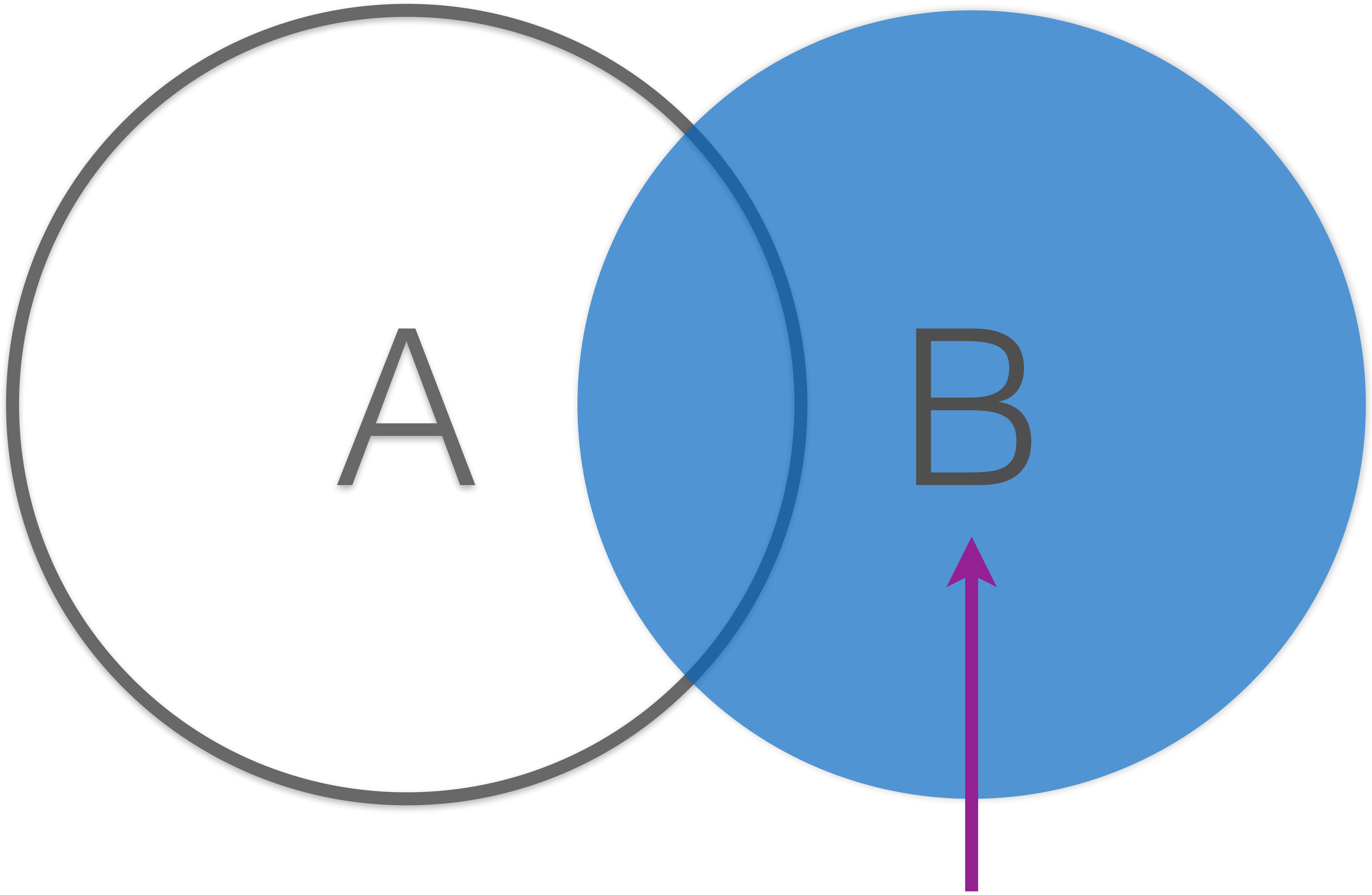
Inner Join

Left Join



Left Join

Right Join



Right Join

```
pd.merge( leftData, rightData )
pd.merge( leftData,
          rightData,
          how="<join type>" )
```

```
pd.merge( leftData, rightData,
how="<join type>" )
```

Option	SQL Equivalent	Description
inner	INNER JOIN	Intersection
left	LEFT OUTER JOIN	Returns items in Set A, but not in Set B
right	RIGHT OUTER JOIN	Returns items in Set B, but not in Set A
outer	FULL OUTER JOIN	Returns the union of both sets

```
pd.merge( leftData, rightData,
    how="<join type>",
    on=<field list> )
```

Grouping and Aggregating Data

Grouping and Aggregating Data

date	src_ip	dst_ip	port
2018-06-21	192.168.20.2	10.10.4.1	80
2018-06-21	192.168.20.1	10.10.4.2	443
2018-06-21	192.168.20.2	10.10.5.1	80
2018-06-22	192.168.20.2	10.10.4.1	80

```
df.groupby(field or list of fields)
```

Grouping and Aggregating Data

date	src_ip	dst_ip	port
2018-06-21	192.168.20.2	10.10.4.1	80
2018-06-21	192.168.20.1	10.10.4.2	443
2018-06-21	192.168.20.2	10.10.5.1	80
2018-06-22	192.168.20.2	10.10.4.1	80

```
df.groupby('src_ip')['port'].count()
```

src_ip	count
192.168.20.1	1
192.168.20.2	3

Grouping and Aggregating Data

date	src_ip	dst_ip	port
2018-06-21	192.168.20.2	10.10.4.1	80
2018-06-21	192.168.20.1	10.10.4.2	443
2018-06-21	192.168.20.2	10.10.5.1	80
2018-06-22	192.168.20.2	10.10.4.1	80

```
df.groupby(['date','src_ip'])['port'].count()
```

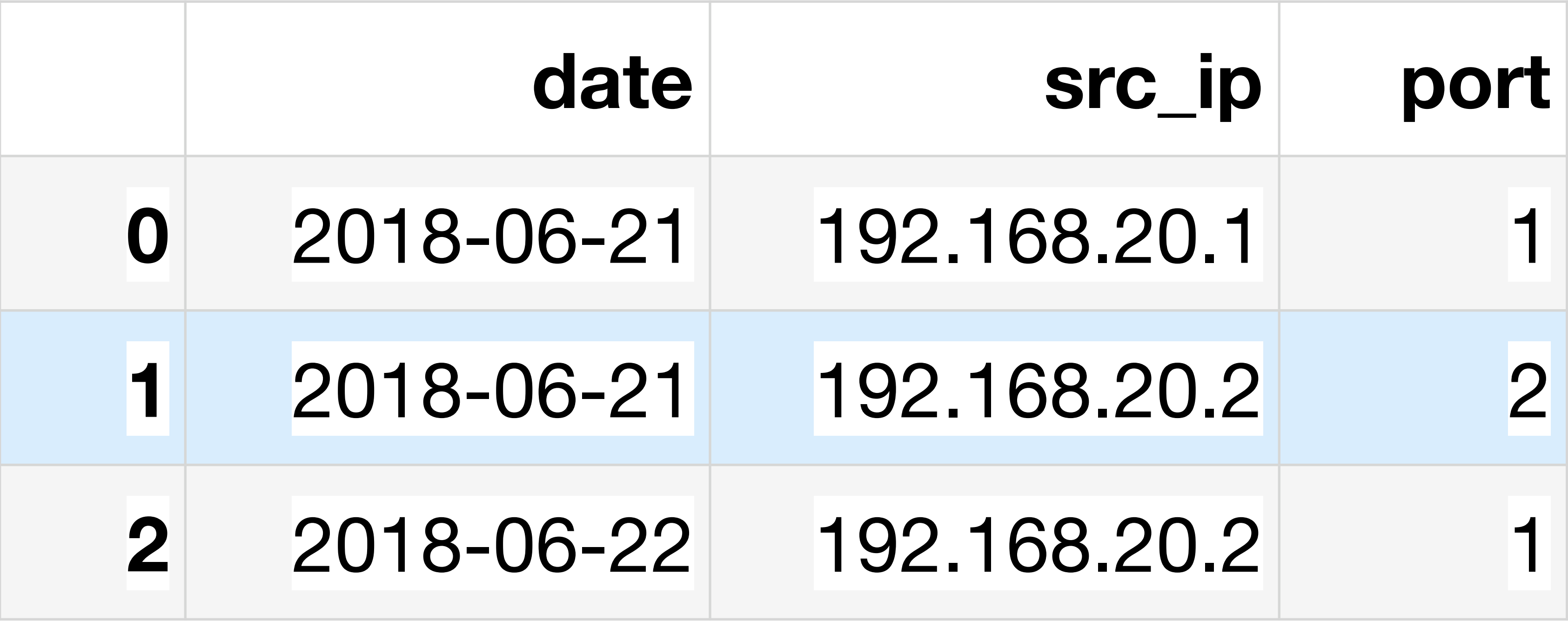
Multi-Index

```
date          src_ip
2018-06-21    192.168.20.1     1
              192.168.20.2     2
2018-06-22    192.168.20.2     1
```

Grouping and Aggregating Data

date	src_ip	dst_ip	port
2018-06-21	192.168.20.2	10.10.4.1	80
2018-06-21	192.168.20.1	10.10.4.2	443
2018-06-21	192.168.20.2	10.10.5.1	80
2018-06-22	192.168.20.2	10.10.4.1	80

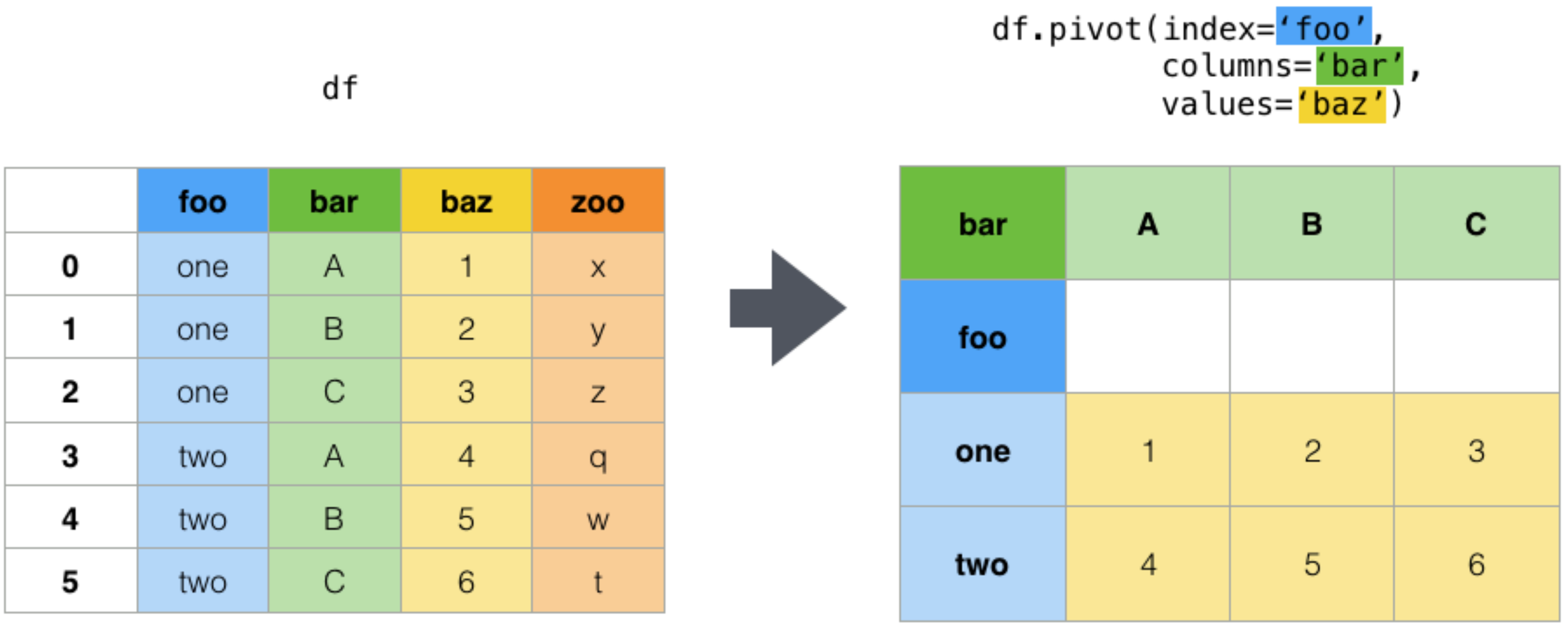
```
df.groupby(['date','src_ip'], as_index=False)
['port'].count()
```



	date	src_ip	port
0	2018-06-21	192.168.20.1	1
1	2018-06-21	192.168.20.2	2
2	2018-06-22	192.168.20.2	1

Grouping Functions

Pivot



df

	foo	bar	baz	zoo
0	one	A	1	x
1	one	B	2	y
2	one	C	3	z
3	two	A	4	q
4	two	B	5	w
5	two	C	6	t

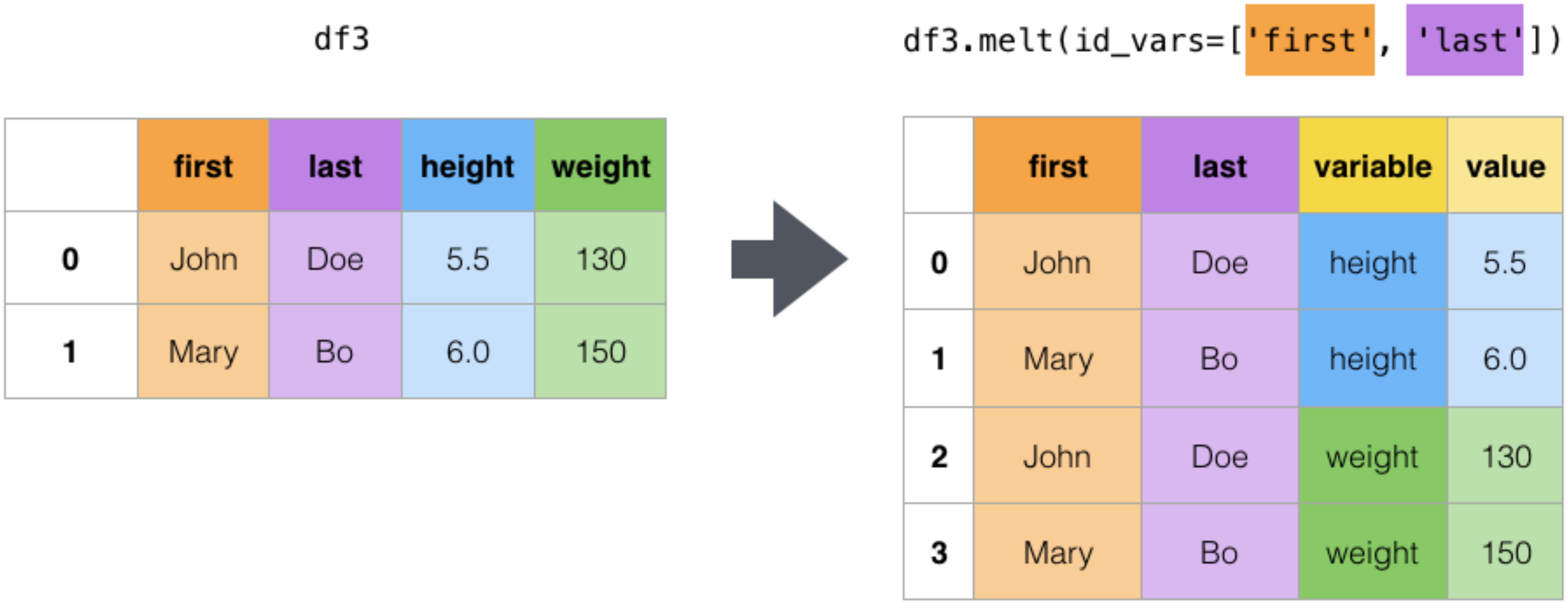
```
df.pivot(index='foo',
         columns='bar',
         values='baz')
```

bar	**A**	**B**	**C**
foo			
one	1	2	3
two	4	5	6

http://jalammar.github.io/visualizing-pandas-pivoting-and-reshaping/

Grouping Functions

Melt



```
df3
```

	first	last	height	weight
0	John	Doe	5.5	130
1	Mary	Bo	6.0	150

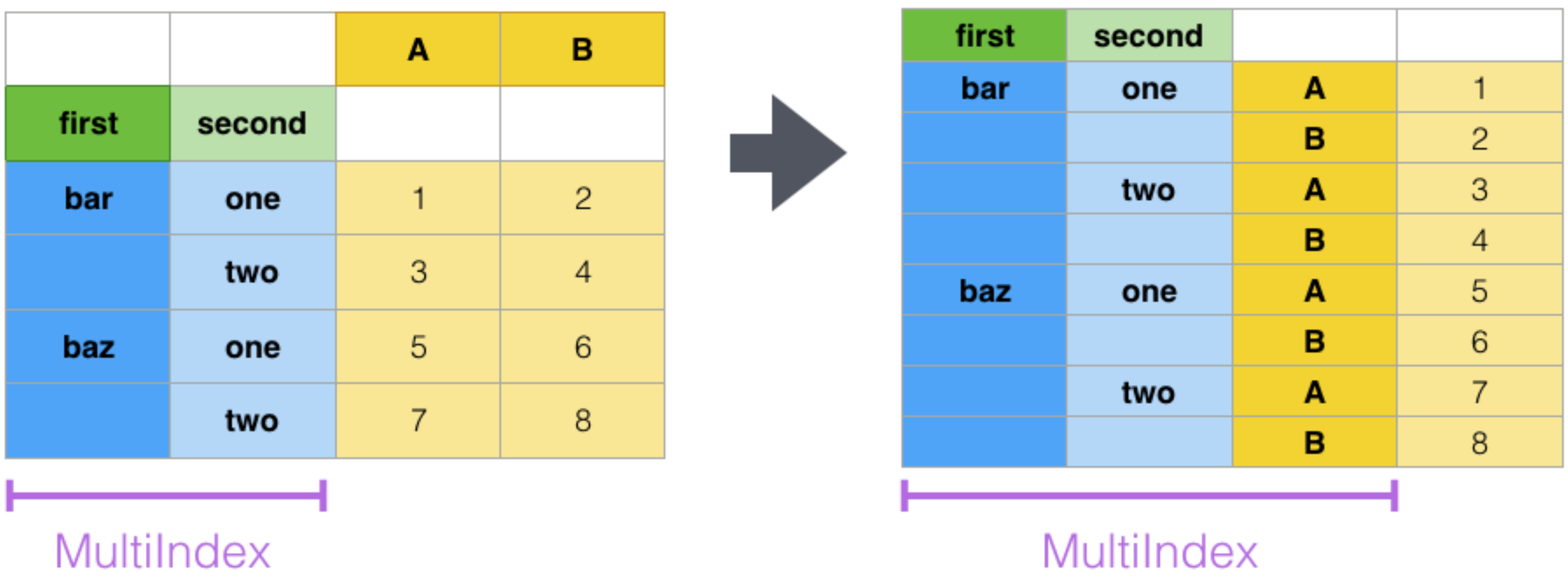
```
df3.melt(id_vars=['first', 'last'])
```

	first	last	variable	value
0	John	Doe	height	5.5
1	Mary	Bo	height	6.0
2	John	Doe	weight	130
3	Mary	Bo	weight	150

http://jalammar.github.io/visualizing-pandas-pivoting-and-reshaping/

Grouping Functions

Stack



```
df2
```

		A	B
first	second		
bar	one	1	2
	two	3	4
baz	one	5	6
	two	7	8

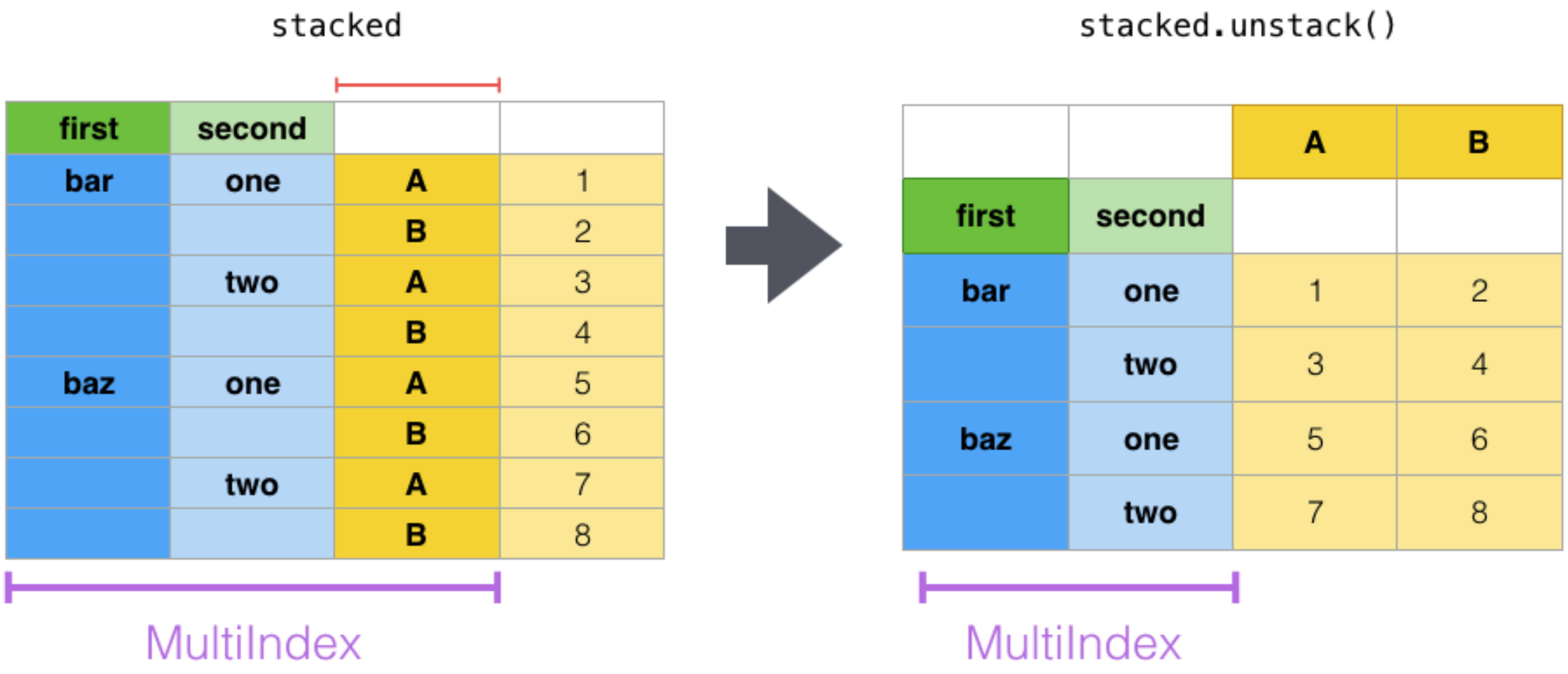
```
stacked = df2.stack()
```

first	second		
bar	one	A	1
		B	2
	two	A	3
		B	4
baz	one	A	5
		B	6
	two	A	7
		B	8

http://jalammar.github.io/visualizing-pandas-pivoting-and-reshaping/

Grouping Functions

Unstack



stacked

first	second		
bar	one	A	1
		B	2
	two	A	3
		B	4
baz	one	A	5
		B	6
	two	A	7
		B	8

MultiIndex

stacked.unstack()

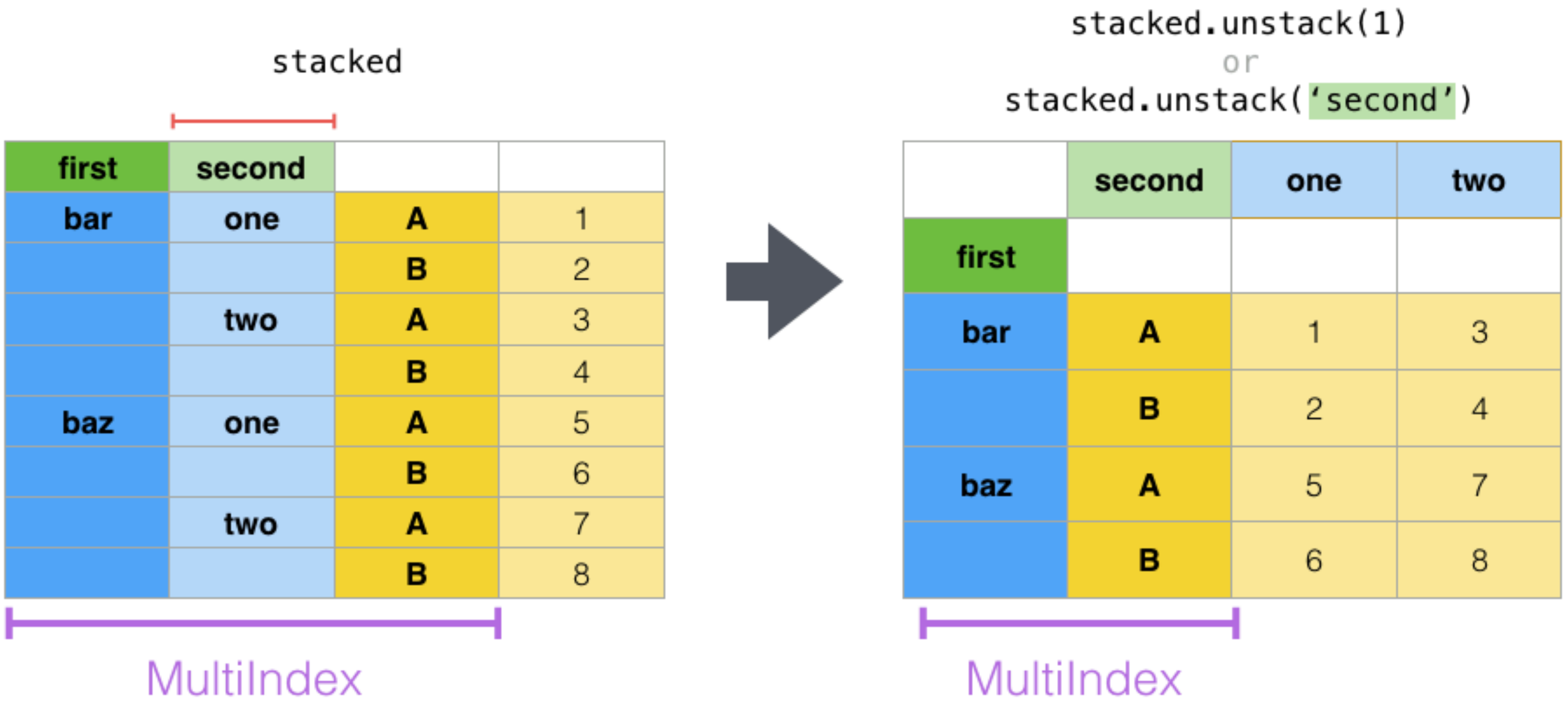
		A	B
first	second		
bar	one	1	2
	two	3	4
baz	one	5	6
	two	7	8

MultiIndex

http://jalammar.github.io/visualizing-pandas-pivoting-and-reshaping/

Grouping Functions

Unstack(1)



stacked

first	second		
bar	one	A	1
		B	2
	two	A	3
		B	4
baz	one	A	5
		B	6
	two	A	7
		B	8

MultiIndex

```
stacked.unstack(1)
or
stacked.unstack('second')
```

	second	one	two
first			
bar	A	1	3
	B	2	4
baz	A	5	7
	B	6	8

MultiIndex

http://jalammar.github.io/visualizing-pandas-pivoting-and-reshaping/

```
Series.dropna()
Series.fillna(value="<something>")
```

Another Approach: Drill

Another Approach: Drill

- Drill is an open source query engine which allows you to query many kinds of self-describing data using ANSI SQL.
- Drill is fast, scalable and extremely versatile.

Another Approach: Drill

Out of the box, Drill can query:

- Delimited Data (csv, tsv, psv)
- Apache log files
- Avro
- Parquet
- JSON
- PCAP
- Syslog
- And more…

There are extensions available on GitHub that allow you to query log files and other data.

Another Approach: Drill

Out of the box, Drill can connect to:

- MySQL (or any JDBC compliant database)
- Hadoop
- Kafka
- S3/Azure/Google Cloud
- HBase
- Hive
- MongoDB
- And others...

Another Approach: Drill

```
from pydrill.client import PyDrill

drill = PyDrill(host='localhost', port=8047)

if not drill.is_active():
    raise ImproperlyConfigured('Please run Drill first')

query = drill.query('''<Your query here>''')

df = query.to_dataframe()
```

Another Approach: Drill

```
SELECT src_port, dst_port, COUNT(*) AS packet_count
FROM dfs.test.`dns.pcap`
GROUP BY src_port, dst_port
ORDER BY packet_count DESC
```

In-Class Exercise

Please complete Worksheet 2.2: Exploratory Data Analysis