Module 1: Exploratory Data Analysis in One Dimension

Vectorized Data Structures

What are they?

Vectorized Data Structures let you perform operations on your data all at once

Advantages of Vectorized Data Structures

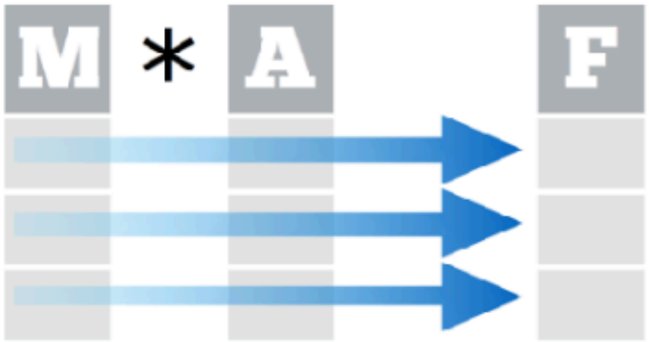
- More readable and simpler code
- Allows the module to optimize for CPU and Memory usage
- Pass serialized objects from one system to another

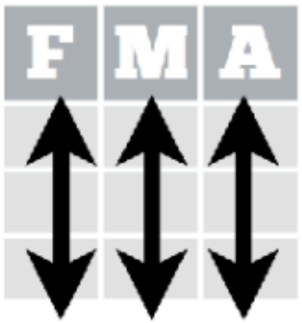
```
for x in range(0, len( data )):
    data[x] = data[x] + 1
```

```
for x in range(0, len( data )):
    data[x] = data[x] + 1
```

```
odds = evens + 1
```

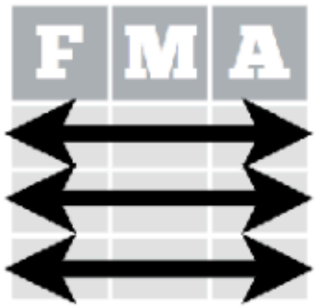
F = M * A





Each **variable** is saved in its own **column**

&



Each **observation** is saved in its own **row**

No loops

Dimensions	Name	Description
1	Series	Indexed 1 dimensional data structure
1	Timeseries	Series using timestamps as an index
2	DataFrame	A two dimensional table
~~3~~	~~Panel~~	~~A three dimensional mutable data structure~~

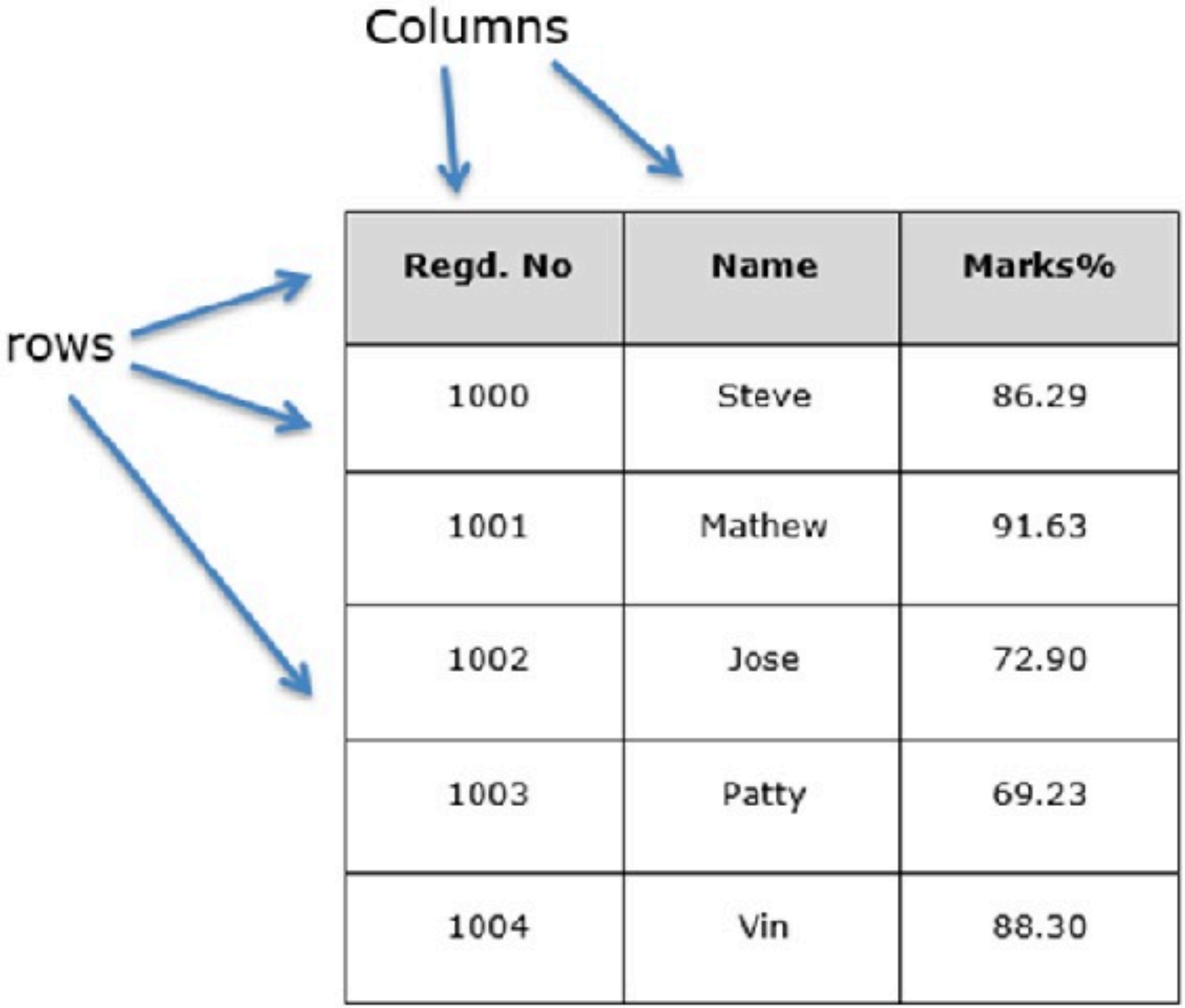


Image Source:

The Series Object

A Series is like a list

A Series is like a list or a dictionary

A Series is like a list or a dictionary but BETTER!!

The Series is the primary building block for all the other data structures we will discuss

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

Creating a Series

```
myData  = pd.Series( <data>, index=<index> )
```

Creating a Series

```
series1 = pd.Series( ['a','b','c','d','e'])
```

```
series2 = pd.Series({'firstName':'Charles',
'lastName':'Givre'})
```

Accessing a Series

```
series1 = pd.Series( ['a','b','c','d','e'])

print( series1 )
```

```
0    a
1    b
2    c
3    d
4    e
dtype: object
```

Accessing a Series

You can access items in a Pandas Series by index, similar to a python list. Just as in a regular list, indexing starts at zero.

```
series1 = pd.Series( ['a','b','c','d','e'])

      print( series1[3] )          d
```

Accessing a Series: Slicing

```
series1 = pd.Series( ['a','b','c','d','e'])
```

```
print( series1[1:3] )
```

```
1    b
2    c
dtype: object
```

Accessing a Series

```
series1 = pd.Series( ['a','b','c','d','e'])
```

```
print( series1[1:3] )
```

```
1    b
2    c
dtype: object
```

```
series2 = series1[1:3]
series2.reset_index( drop=True )
```

Accessing a Series

```
record = pd.Series(
    {‘firstname':'Charles',
     'lastname':'Givre',
    'middle':'classified' } )

record['firstname']                    Charles
```

Accessing a Series

```
record = pd.Series(
    {‘firstname':'Charles',
     'lastname':'Givre',
    'middle':'classified' } )

record[['firstname','lastname']]

firstname    Charles
lastname       Givre
dtype: object
```

Accessing a Series

```
record = pd.Series(
    {‘firstname':'Charles',
     'lastname':'Givre',
    'middle':'classified' } )

 record[0]

 Charles
```

Accessing a Series

```
randomNumbers = pd.Series(
 np.random.random_integers(1, 100, 50) )

randomNumbers.head()
0     48
1     34
2     84
3     85
4     58
dtype: int64
```

Accessing a Series

```
randomNumbers = pd.Series(
  np.random.random_integers(1, 100, 50) )

randomNumbers.tail( 7 )
43     66
44     66
45     43
46     55
47     99
48     82
49     19
dtype: int64
```

Filtering Data in a Series

```
randomNumbers [ <boolean condition> ]
randomNumbers [ randomNumbers < 10 ]
```

```
12     5
21     2
24     1
27     1
29     1
dtype: int64
```

Filtering Data in a Series

```
record.str.contains('Cha')
firstname     True
lastname     False
middle       False
dtype: bool

record[ record.str.contains('Cha') ]
firstname    Charles
dtype: object
```

String Functions

Function	Explanation
Series.str.contains(<pattern>)	Returns true/false if text matches a pattern
Series.str.count(<pattern>)	Returns number of occurrences of a pattern in a string
Series.str.extract(<pattern>)	Returns matching groups from a string
Series.str.find(<string>)	Returns index of first occurrences of a substring (Note: not regex)
Series.str.findall(<pattern>)	Returns all occurrences of a regex
Series.str.len()	Returns the length of text
Series.str.replace(<pat>, <replace>)	Replaces matches with a replacement string

Date/Time Operations

```
pd.to_datetime(<times>, format='<format string>')
```

Selected Date/Time Operations

Function	Explanation
`series.dt.year`	Returns the year of the date time
`series.dt.month`	Returns the month of the date time
`series.dt.day`	Returns the days of the date time
`series.dt.weekday`	Returns the day of the week
`series.dt.is_month_start`	Returns true if it is the first day of the month
`series.dt.strftime()`	Returns an array of formatted strings specified by a `date_format`

https://pandas.pydata.org/pandas-docs/stable/api.html#datetimelike-properties

Pandas Data Structures allow you to perform operations on your entire data set at once.

```
combinedSeries = series1.add( series2 )
```

```
def addTwo( n ):
    return n + 2

odds.apply( addTwo )
```

```
odds.apply( lambda x: x + 1 )
```

Questions?

In Class Exercise

Please take 30 minutes and complete

Worksheet 1.1: Working with One Dimensional Data

Exercise 1

```
email_series = pd.Series(emails)
filtered_emails =
email_series[email_series.str.contains('.edu')]
```

```
2           mdixon2@cmu.edu
11      jjonesb@arizona.edu
15     eberryf@brandeis.edu
```

```
accounts = filtered_emails.str.split('@').str[0]
```

```
2      mdixon2
11     jjonesb
15     eberryf
dtype: object
```

Exercise 2

```
pounds = pd.Series( weights )
kilos = pounds.apply( poundsToKilograms )
```

Exercise 3

```
IPData = pd.Series( hosts )
privateIPs = IPData[
   IPData.apply(
    lambda x : ip_address(x).is_private
    )]
```

Explore Your Data

- **Mean**: The mean is the average value of a set of numbers
- **Median**: The median is the middle value of an ordered set of numbers
- **Mode**: The mode is the value from a set which is repeated the most frequently.
- **Range**: Difference between minimum and maximum
- **Standard Deviation**: Measures dispersion in a data set. Close to zero indicates little dispersion.

Intro Stats: IQR

The **interquartile range** is a measure of where the “middle fifty” is in a data set. Where a range is a measure of where the beginning and end are in a set, **an interquartile range is a measure of where the bulk of the values lie.**

```
IQR = data.quantile(0.75) - data.quantile(0.25)
```

http://www.statisticshowto.com/probability-and-statistics/interquartile-range/

Intro Stats: Variance

The **variance** of a set of values, σ^2, is the average of the square of the difference of the values in the dataset from the dataset's mean.

$$\sigma^2 = \frac{\sum_{i=1}^{n} (x_i - \mu)^2}{n}$$

```
data.var(axis=0)
```

Intro Stats: Std. Deviation

The standard deviation, σ, is the square root of the variance:

We use the **standard deviation** much more regularly than the **variance** because it is on the same scale as the original data:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \mu)^2}{n}}$$

```
data.std(axis=0)
```

Intro Stats: Covariance

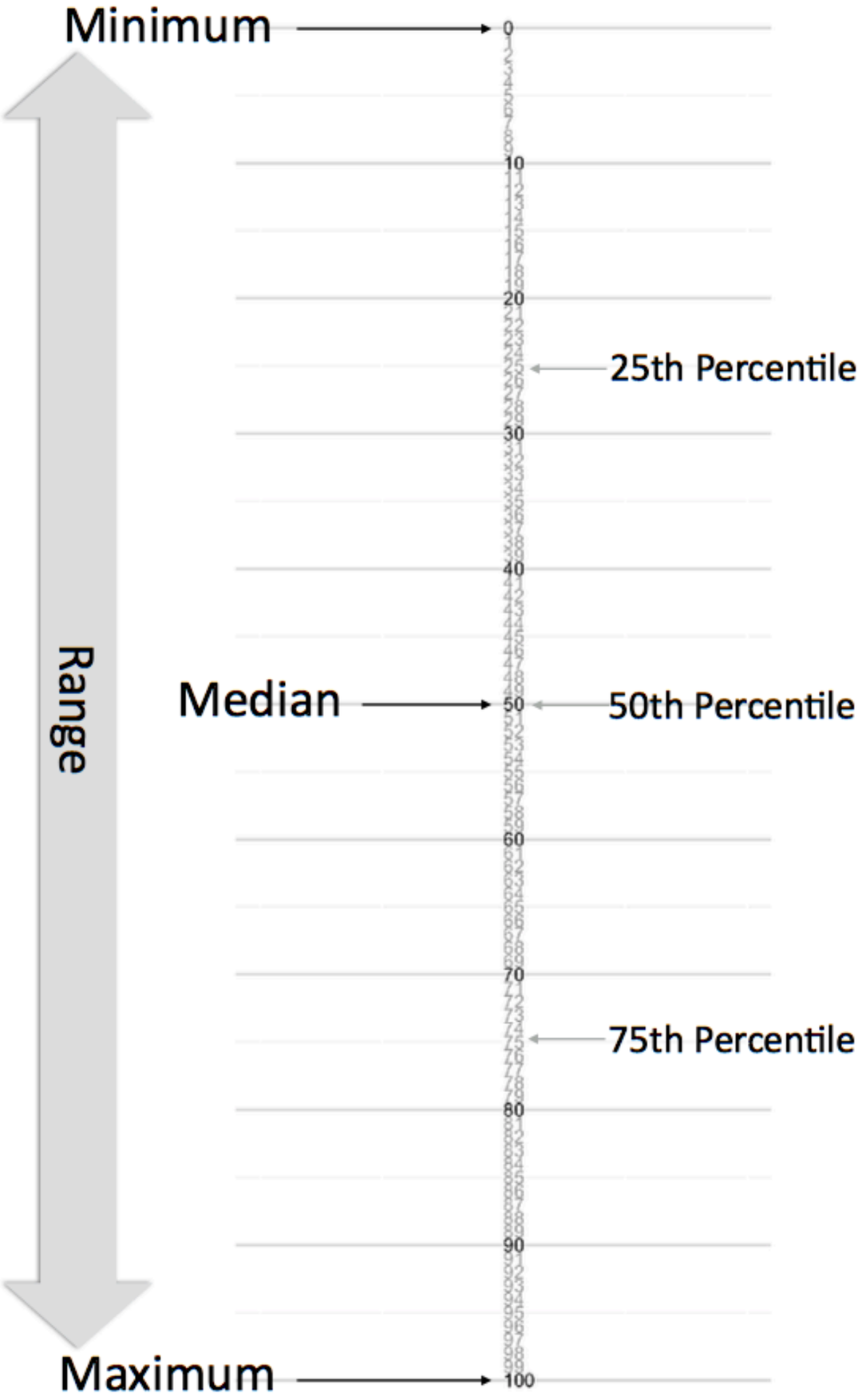
Covariance, like the variance, is a measure of spread, however it also measures how closely two datasets track each other.

- **Covariance** is a squared quantity, so it is not on the same scale as the mean
- **Covariance** of different pairs of variables can have completely different scales

$$Cov(x, y) = \frac{\sum_{i=1}^{n}(x_i - \mu_x)(y_i - \mu_y)}{n}$$

Tukey 5 Number Summary

- **Minimum:** The smallest value in the dataset
- **Lower Quartile:** Smallest 25% of the dataset
- **The Median:** The middle value of the dataset
- **Upper Quartile:** The largest 25% of the dataset
- **Maximum:** The largest value in the dataset


Minimum
0
10
20
25th Percentile
30
40
Median
50
50th Percentile
60
70
75th Percentile
80
90
Maximum
100
Range

`Series.abs()`	Absolute Value of the Series
`Series.count()`	Returns number of non-empty values in the series
`Series.max()`	Returns maximum value in the Series
`Series.mean()`	Returns the mean of a Series
`Series.median()`	Returns the median of a Series
`Series.min()`	Returns the minimum value in a Series
`Series.mode()`	Take a guess..
`Series.quantile([q])`	Returns the quantiles of a Series
`Series.sum`	Returns the sum of a series
`Series.std`	Returns the standard deviation of a Series

```
Series.describe()
```

Series.describe()

```
>>> random_numbers.describe()
count     50.000000
mean      50.620000
std       30.102471
min        1.000000
25%       25.500000
50%       54.000000
75%       73.000000
max       99.000000
dtype: float64
```

```
names = pd.Series(
['Jim','Bob',
'Bob','Steve','Jim,'Jane','Steph','Emma','Rachel'])

names.describe()
```

```
names = pd.Series(
['Jim','Bob',
'Bob','Steve','Jim,'Jane','Steph','Emma','Rachel'])

names.describe()
```

```
count        9
unique       7
top        Jim
freq         2
dtype: object
```

Finding Unique Values

```
unique_nums = []
for key, value in random_numbers.iteritems():
    if value not in unique_nums:
        unique_nums.append(value)
```

NO!!!

```
series.drop_duplicates()
series.unique()
```

Counting Unique Occurrences

```
series.value_counts()
```

```
series.value_counts(bins=5)
```

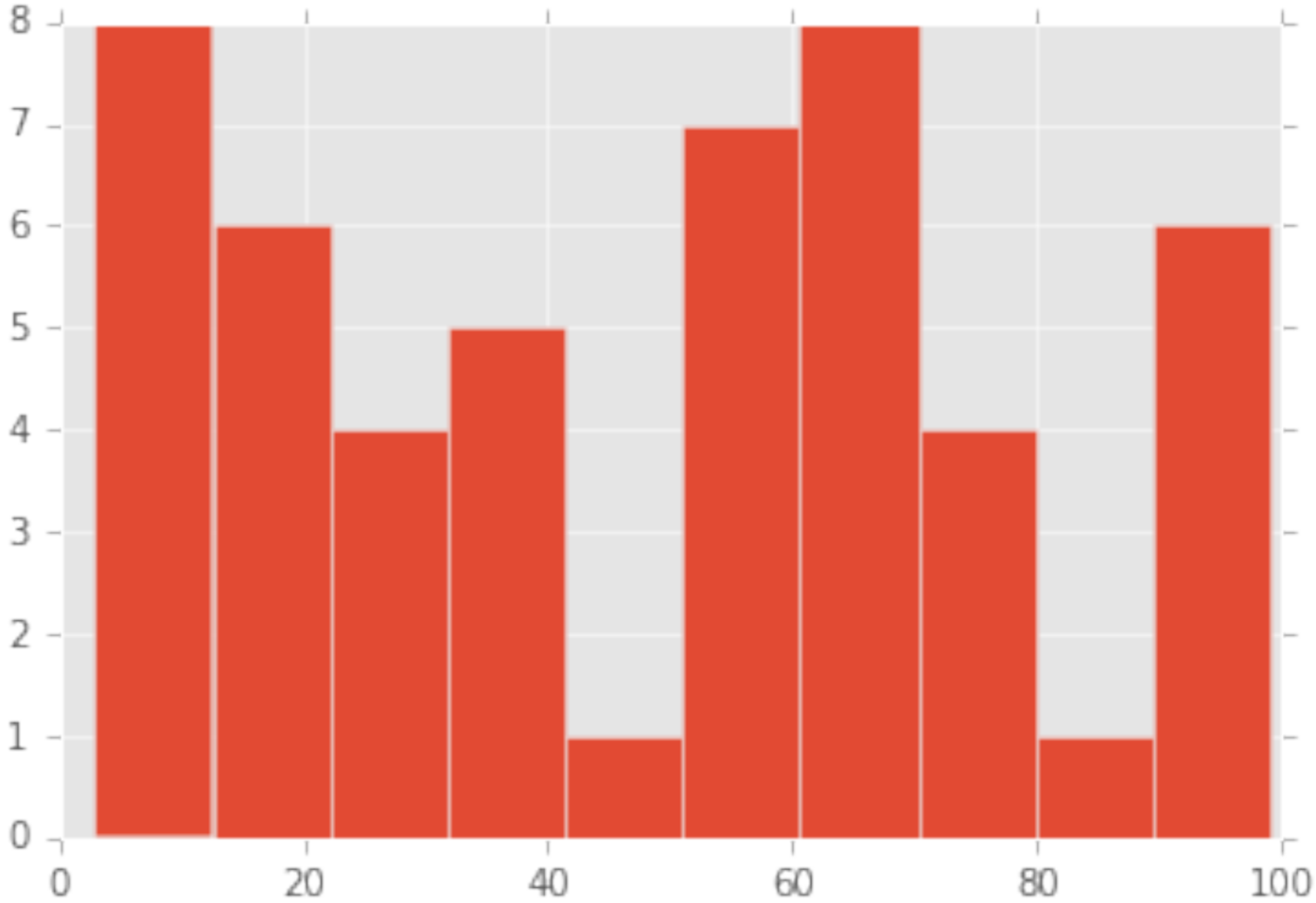
```
series.value_counts(bins=5,
normalize=True)
```

```
series.value_counts(bins=5,
                    normalize=True,
                    dropna=False)
```

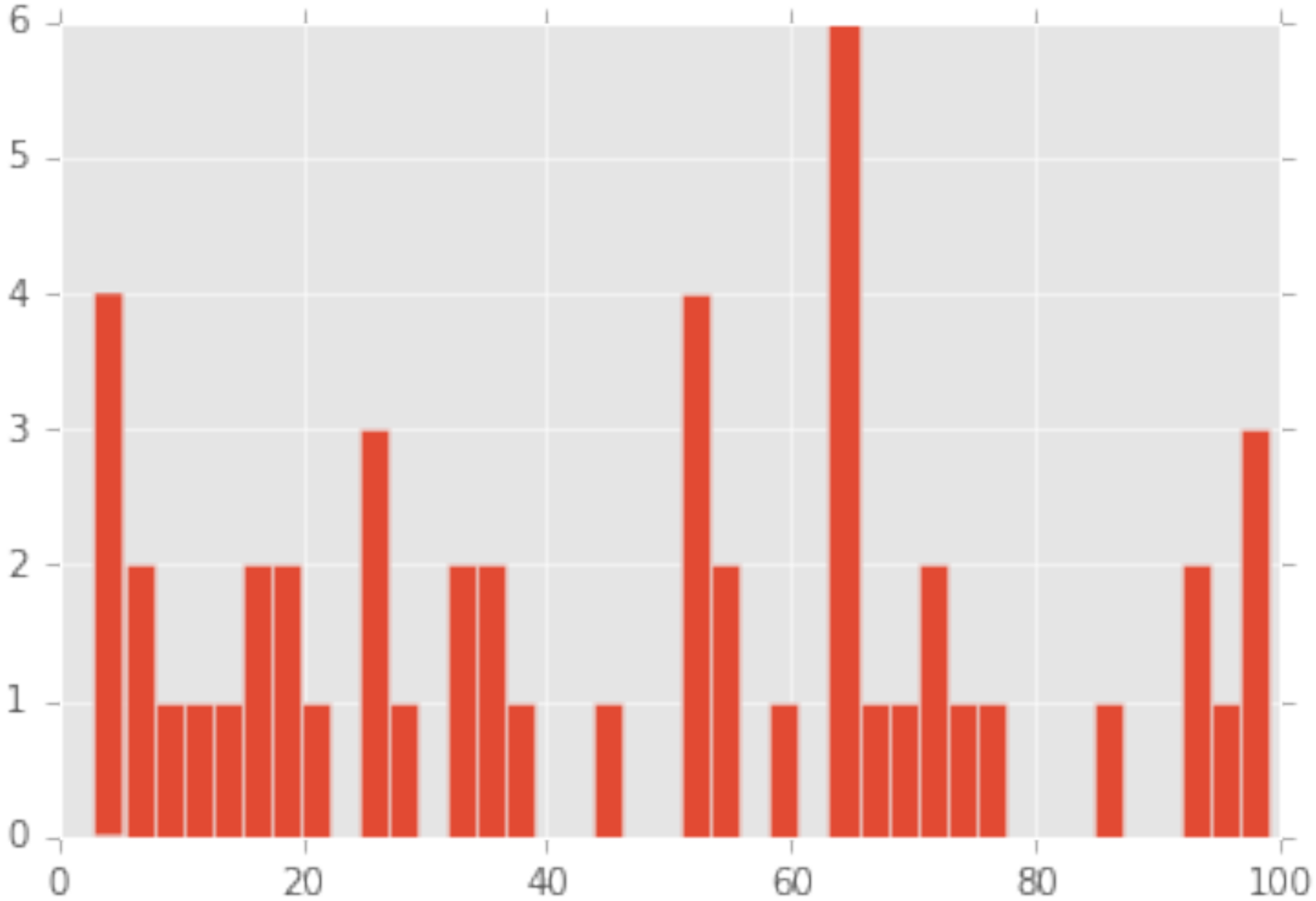
```
In [7]: area_codes2.value_counts()

Out[7]: 833    7
        811    5
        822    5
        899    3
        844    3
        855    2
        dtype: int64
```

```
series.hist()
```

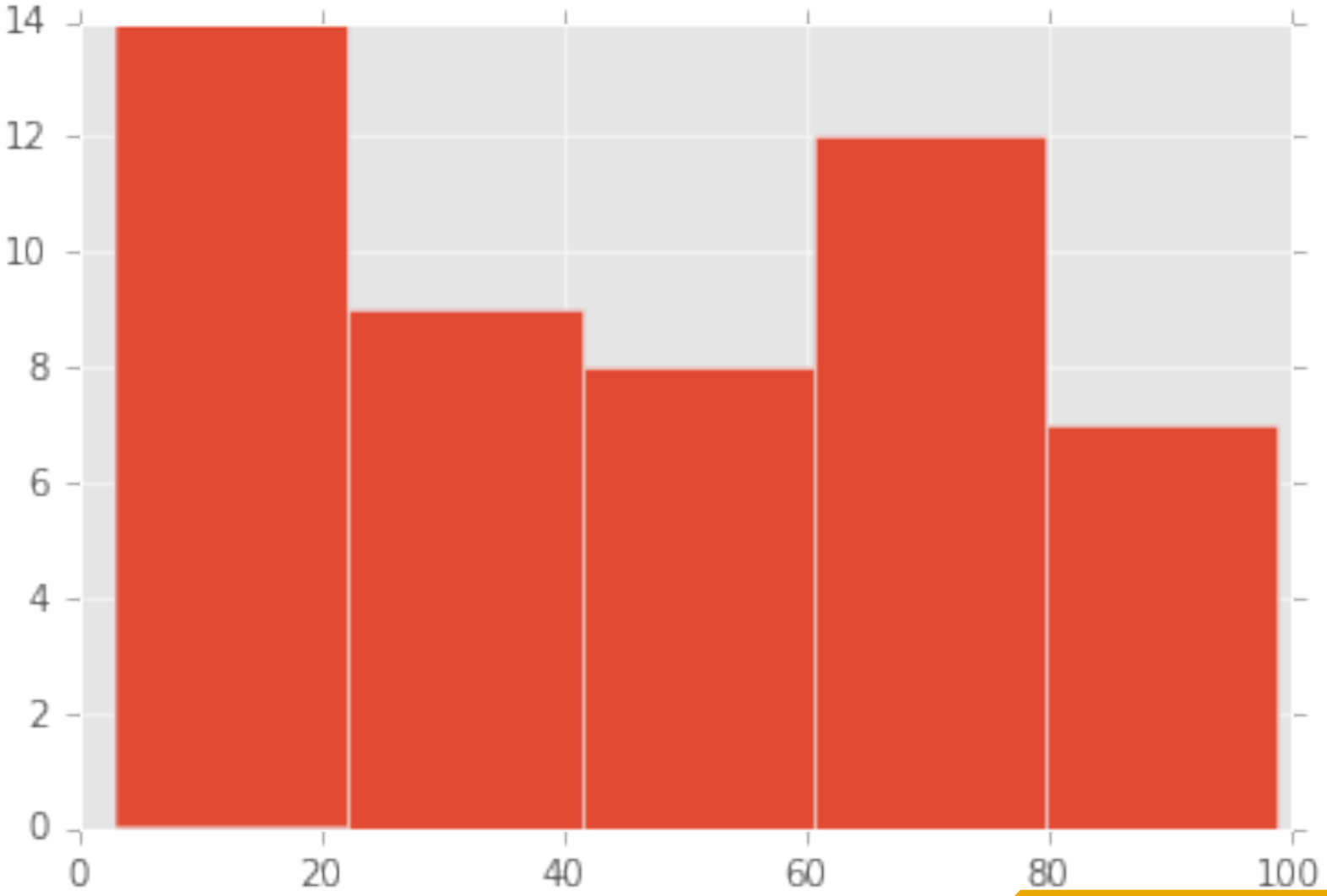
series.hist()



series.hist(bins=40)

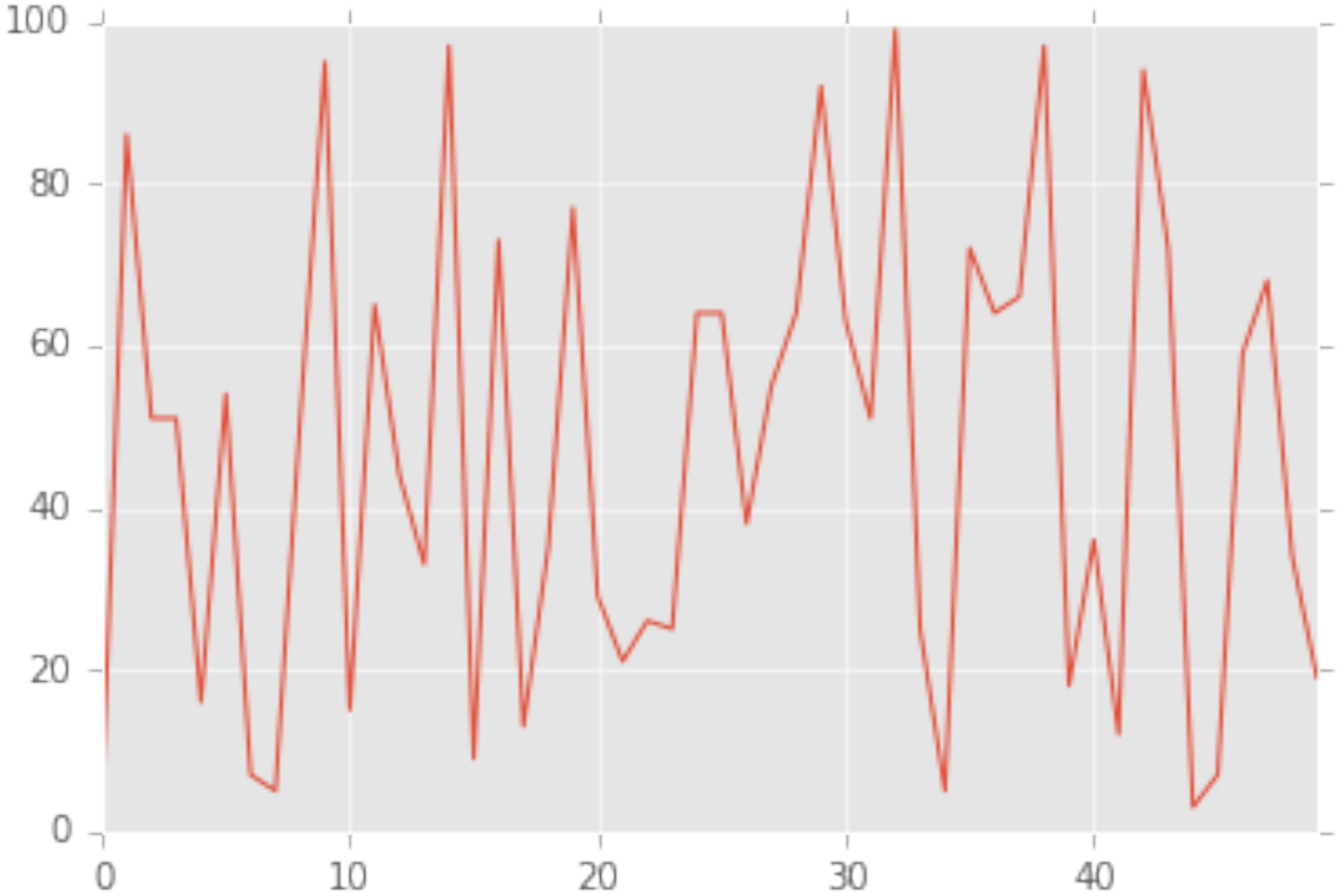


series.hist(bins=5)

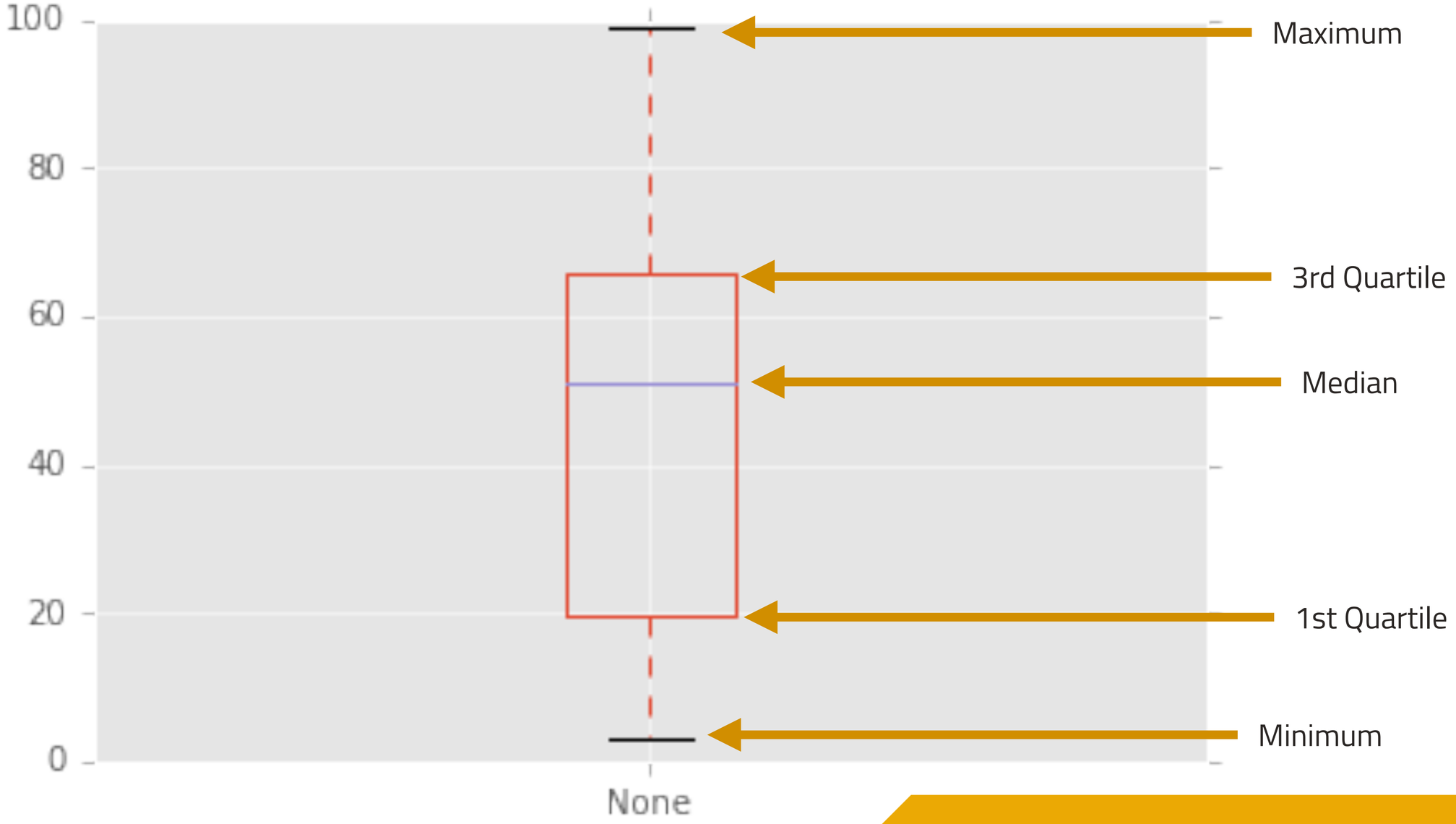


```
series.plot()
```

series.plot()

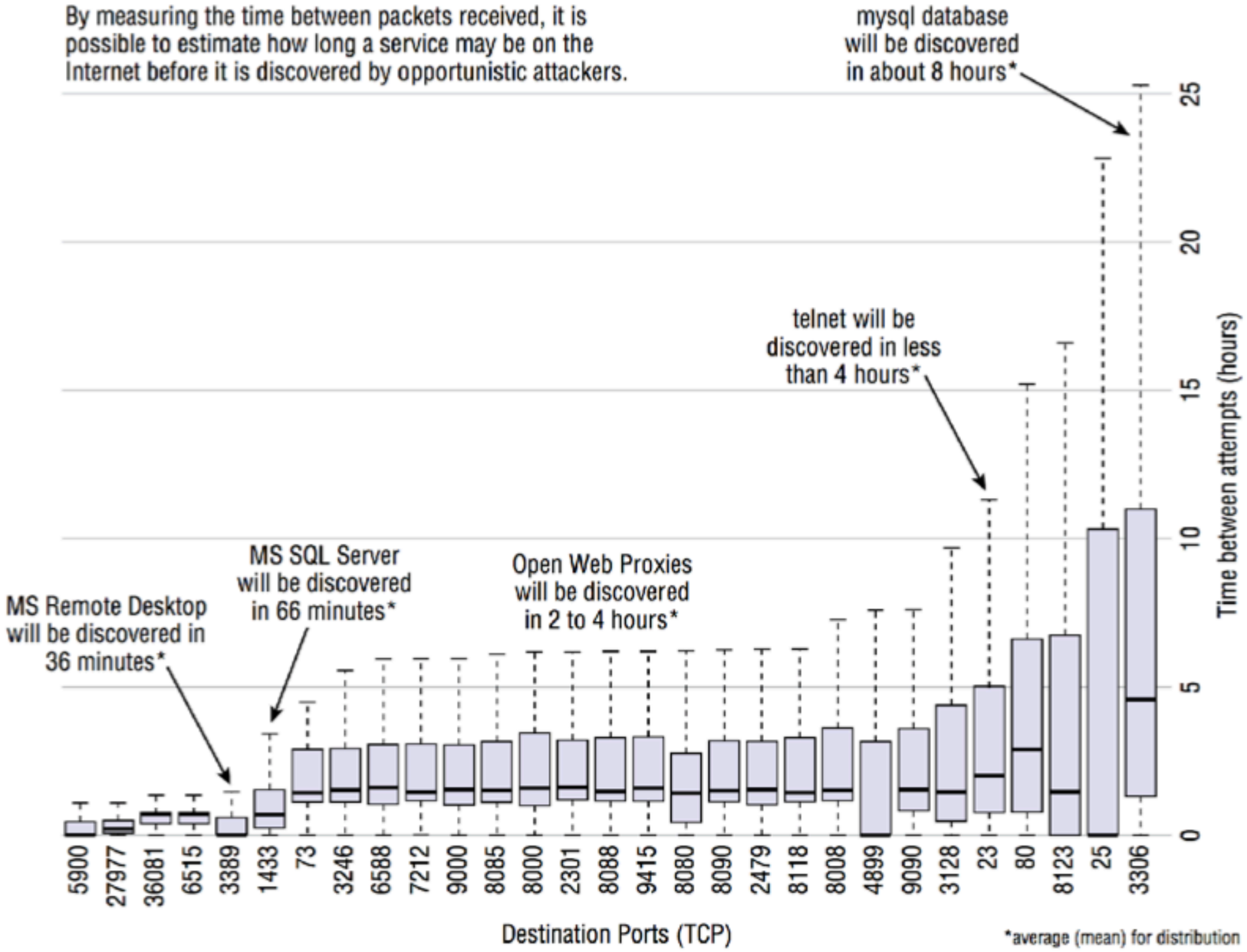


series.plot(kind='box')



How long will a service go undiscovered by opportunistic attackers?

By measuring the time between packets received, it is possible to estimate how long a service may be on the Internet before it is discovered by opportunistic attackers.

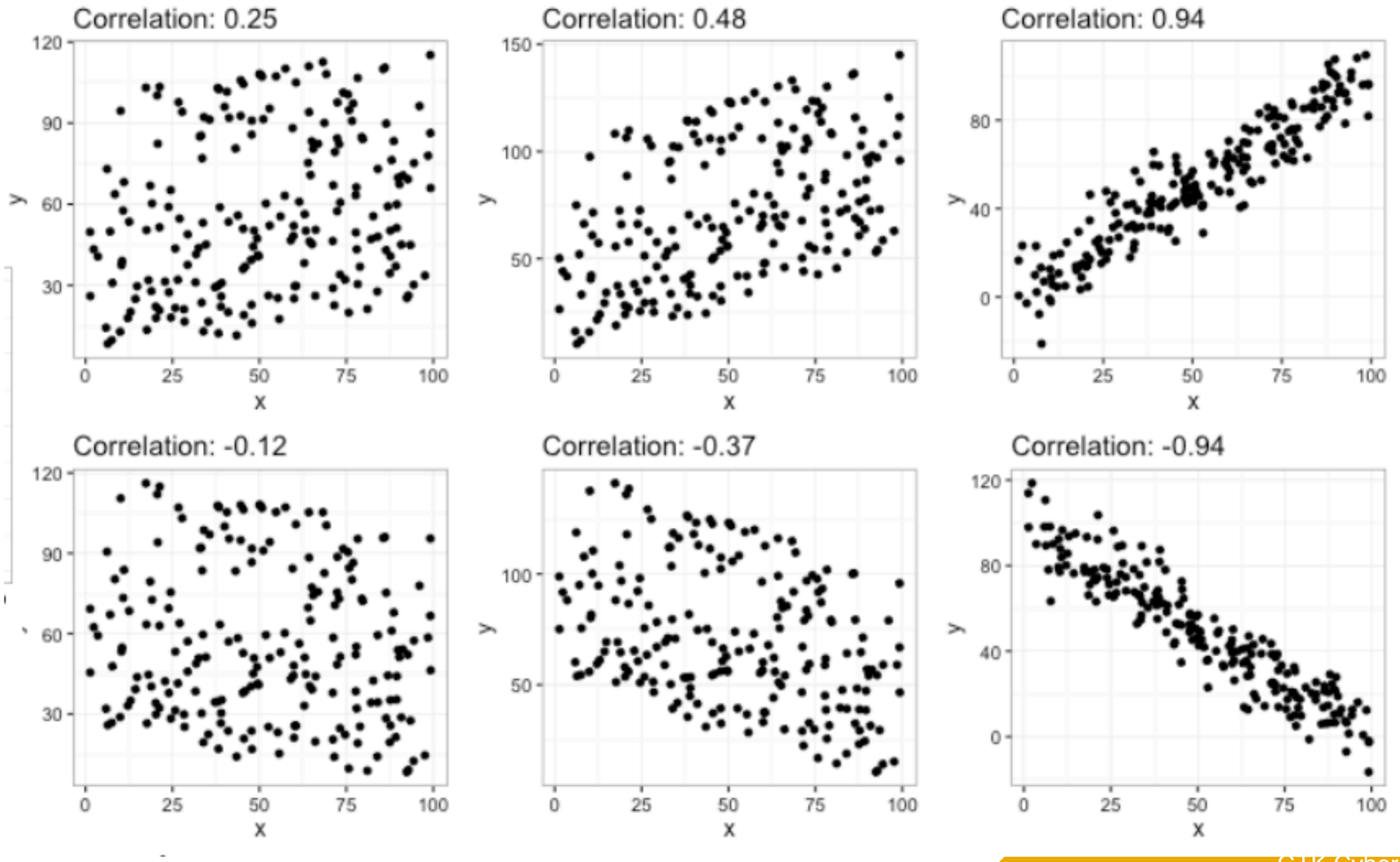


Correlations between Datasets

Correlations

- Measurement of the relationship between **two continuous variables**
- Output is between -1 and 1, with 1 being perfect correlation, -1 is perfect negative correlation, 0 is no correlation.
- Correlation measurement is referred to as r.

Correlations



Correlations

```
series1.corr( series2 )
```

Questions?

In Class Exercise

Please take 30 minutes and complete

Worksheet 1.2: Exploring One Dimensional Data