

MSc Computer Science

# COMP702 Design & Specification

---

Open-Source Temporal Networks Library

Seán O'Callaghan

# Overview



UNIVERSITY OF  
LIVERPOOL

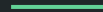
Introduction

Specification

Design

Timeline

Requirements



# Introduction

---

# Why?

Open-source Temporal Networks Library written in Python.

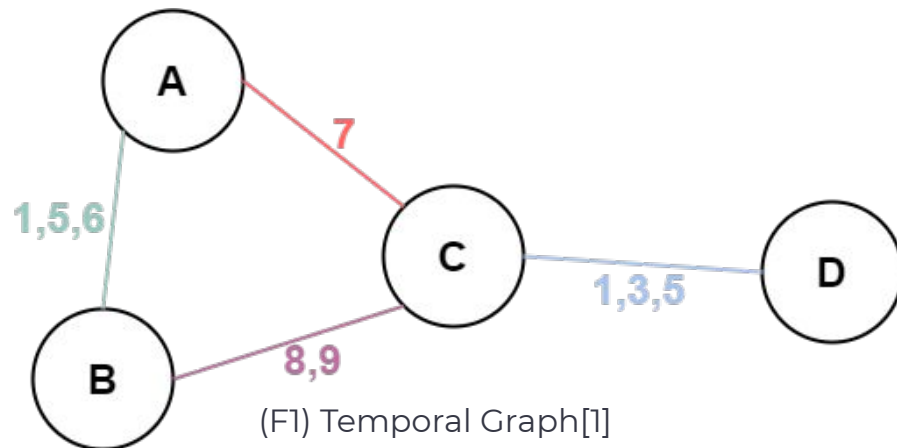
# Temporal Network

A temporal network is defined as a network whose links change over time.

Many real-world systems can be modelled as temporal networks [2,3].

The modelling and analysis of such networks can provide useful information.

A purposeful, convenient library to enable this analysis would be advantageous.



# Open-source

Enables collaboration

Potential for rapid development

Promotes knowledge share

NetworkX [4]



(F2) NetworkX logo[4]

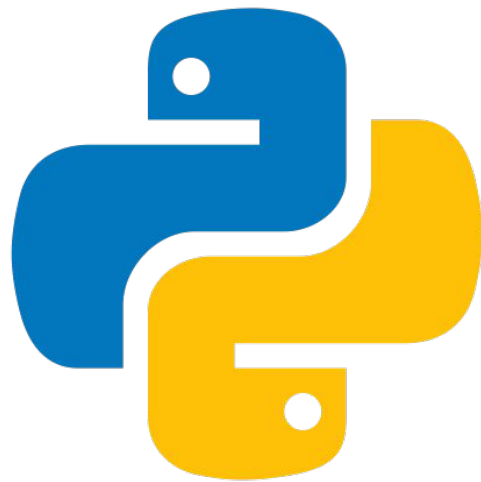
# Python

High-level, powerful

Easy to learn

Productive

Popular



(F3) Python logo[5]

# Specification

---



# What?

Aim

Core functionality

Extendable functionality

Language & platform

Open-source



(F4) Package specs[6]

# Core functionality

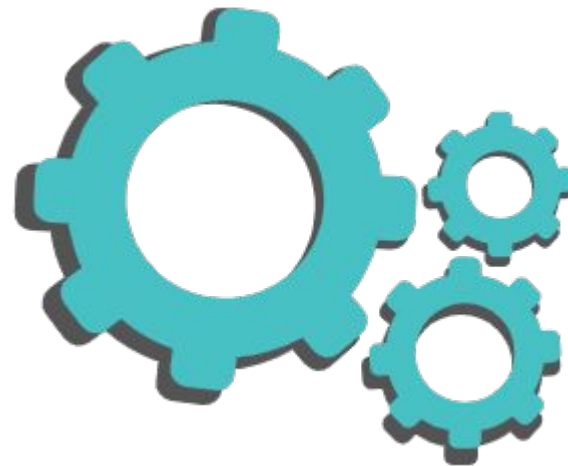
Input handling

Graph creation & generation

Graph functions

Graph visualization

Graph analysis



(F5) Core functionality[6]

# Design

---

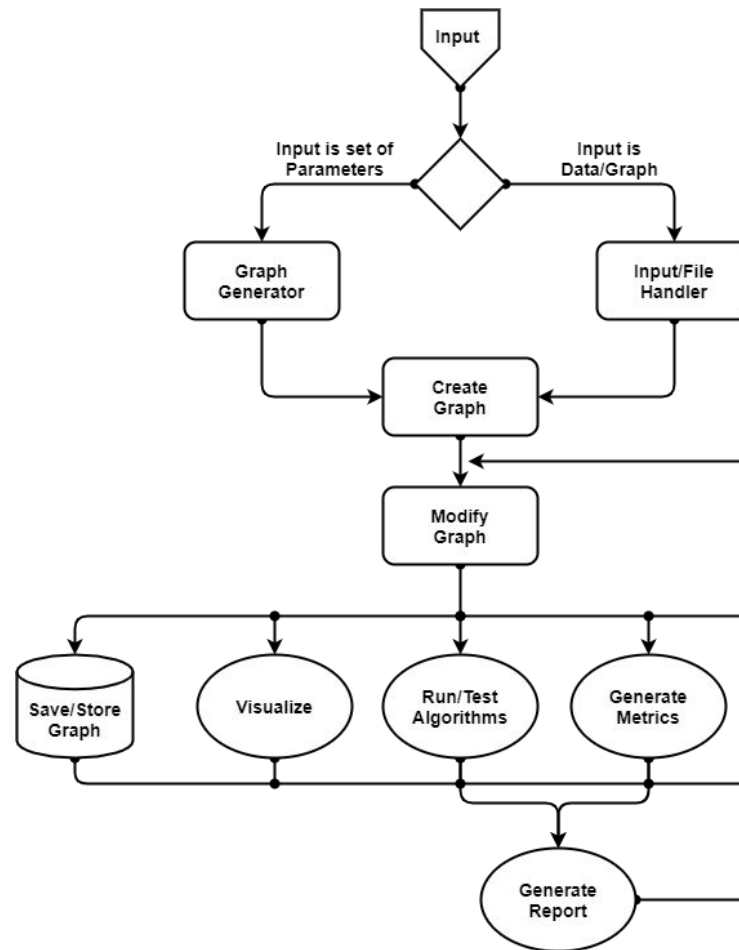
# Design Flowchart

Input Handling

Graph Structure

Graph analysis & storage

Graph metrics



(F6) Flowchart[1]

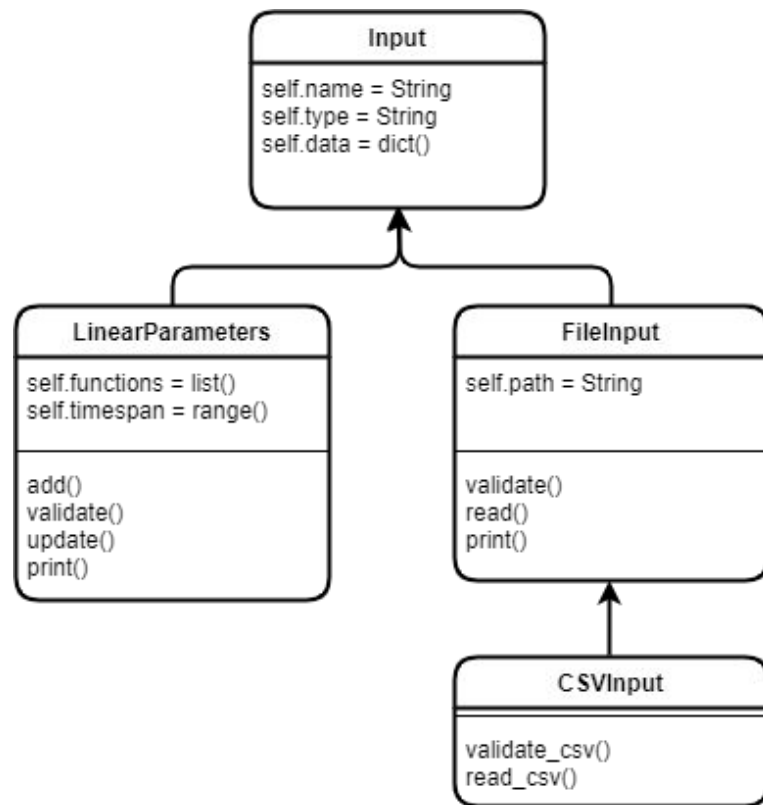
# Input Handling

```
class CSVInput(Input):  
    """  
    A class which handles CSV-based temporal network/data inputs.  
    """  
  
    def __init__(self, name, atype, path):  
        super().__init__(name, atype)  
        self.path = path  
        self.data = {}  
        self.read()  
  
    def read(self):  
        with open(self.path, newline='') as csvfile:  
            reader = csv.DictReader(csvfile)  
            n = 0  
            data = {}  
            for row in reader:  
                data[n] = {}  
                data[n]['source'] = row['source']  
                data[n]['sink'] = row['sink']  
                data[n]['time'] = row['time']  
                n += 1  
            self.data = data
```

network.csv

source	sink	time
a	e	2
d	b	9
a	c	10
b	c	9
d	c	7
b	d	6
e	b	4
a	d	7
d	c	8
b	c	10

(F7) CSVInput[1]



(F8) Input UML[1]

# Graph Structure

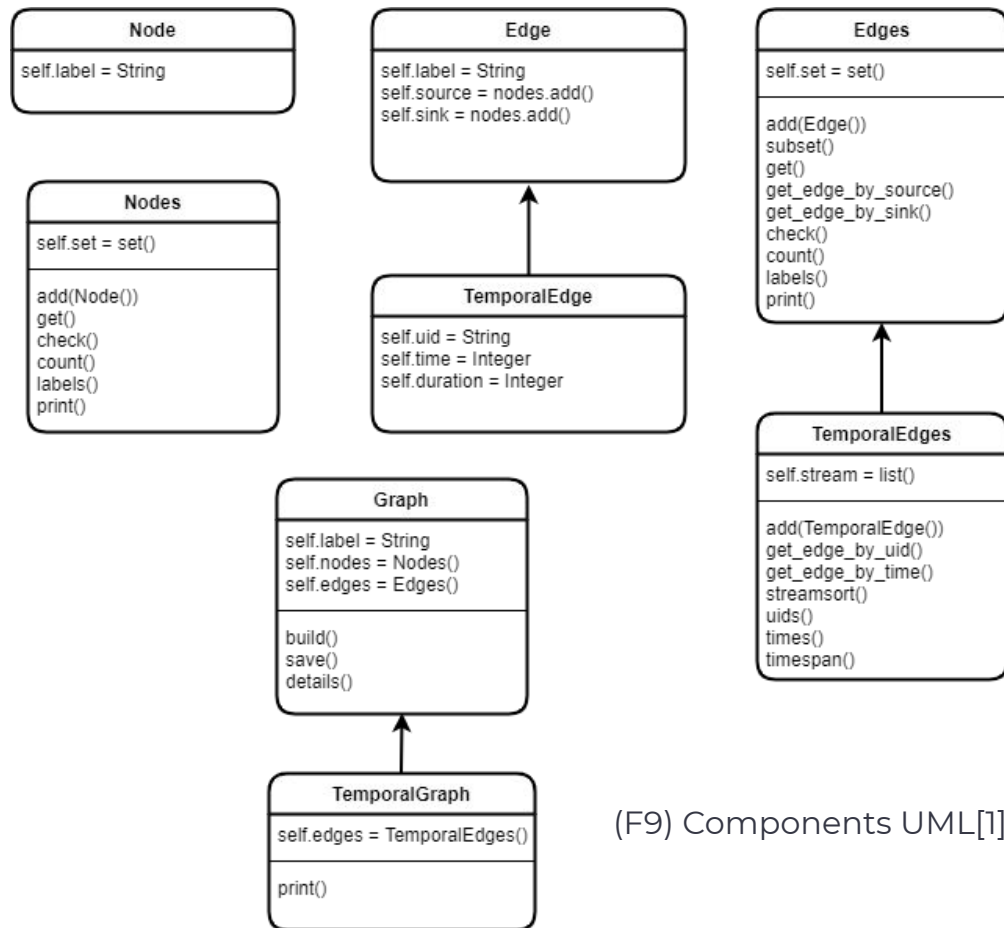
Node

Edge, TemporalEdge

Nodes

Edges, TemporalEdges

Graph, TemporalGraph



(F9) Components UML[1]

# Visualization

```
>>> graph.print()

  5 nodes;
  c a b e d

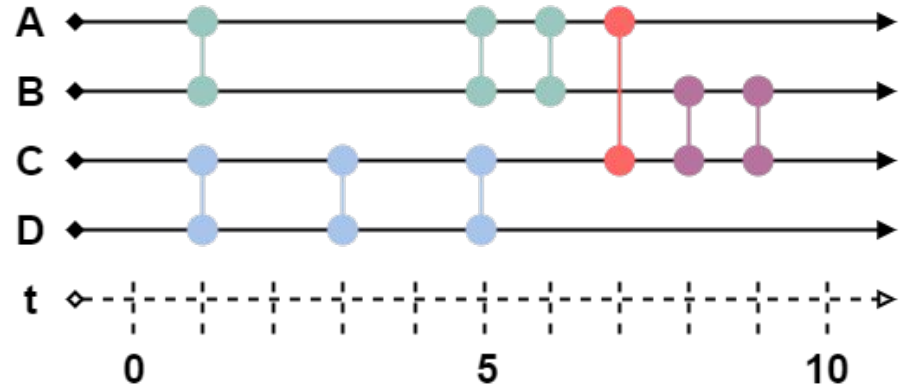
      ad db bc ac eb bd ae dc
2 | - - - - - - + -
4 | - - - - + - - -
6 | - - - - - + - -
7 | + - - - - - - +
8 | - - - - - - - +
9 | - + + - - - - -
10| - - + + - - - -

>>>
```

(F10) Edges-matrix[1]

(F11) Edges print[1]

```
def print(self, start=None, end=None):
    print("\n{:5} {}".format(" ", " ".join(self.labels())) )
    for i in self.timespan(start, end):
        active = self.get_edge_by_time(i).labels()
        if not active:
            continue
        row = ['-']*len(self.labels())
        for label in active:
            index = self.labels().index(label)
            row[index] = '+'
        print("{:3} | {}".format(i, " ".join(map(str, row))) )
    print()
```



(F12) Splice plot[1]

# Analysis

```
# calculate foremost time (to be added)
foremost = {}
a = graph.nodes.get('a')
start = graph.edges.firsttime()
end = graph.edges.lifetime()

for node in graph.nodes.set:
    foremost[node.label] = {}
    foremost[node.label]['time'] = float('inf')
    foremost[node.label]['source'] = ''

foremost[a.label]['time'] = start
foremost[a.label]['source'] = a.label

for edge in graph.edges.stream:
    if edge.time + edge.duration and edge.time >= foremost[edge.source.label]['time']:
        if edge.time + edge.duration < foremost[edge.sink.label]['time']:
            foremost[edge.sink.label]['time'] = edge.time + edge.duration
            foremost[edge.sink.label]['source'] = edge.source.label
        elif edge.time >= end:
            break
```

(F13) Foremost tree implementation[1]

**Algorithm:** Foremost time/foremost path algorithm (s4.2 [8], modified).

**Input:** An edge-stream representation of the graph, a time interval  $(t_\alpha, t_\omega)$ , a root node  $x$ .

**Output:** A foremost tree for root node  $x$ .

initialize  $\text{foremostTree}[v][\text{time}] = \infty$  for all  $v \in V$ ,  
 $\text{foremostTree}[x][\text{time}] = t_\alpha$ , and  $\text{foremostTree}[x][\text{source}] = x$ ;

**foreach** edge  $e = (u, v, t, \lambda)$  **in the edge stream do**

**if**  $t + \lambda \leq t_\omega$  **and**  $t \geq \text{foremostTree}[u][\text{time}]$  **then**

**if**  $t + \lambda < \text{foremostTree}[v][\text{time}]$  **then**

$\text{foremostTree}[v][\text{time}] \leftarrow t + \lambda$ ;

$\text{foremostTree}[v][\text{source}] \leftarrow u$ ;

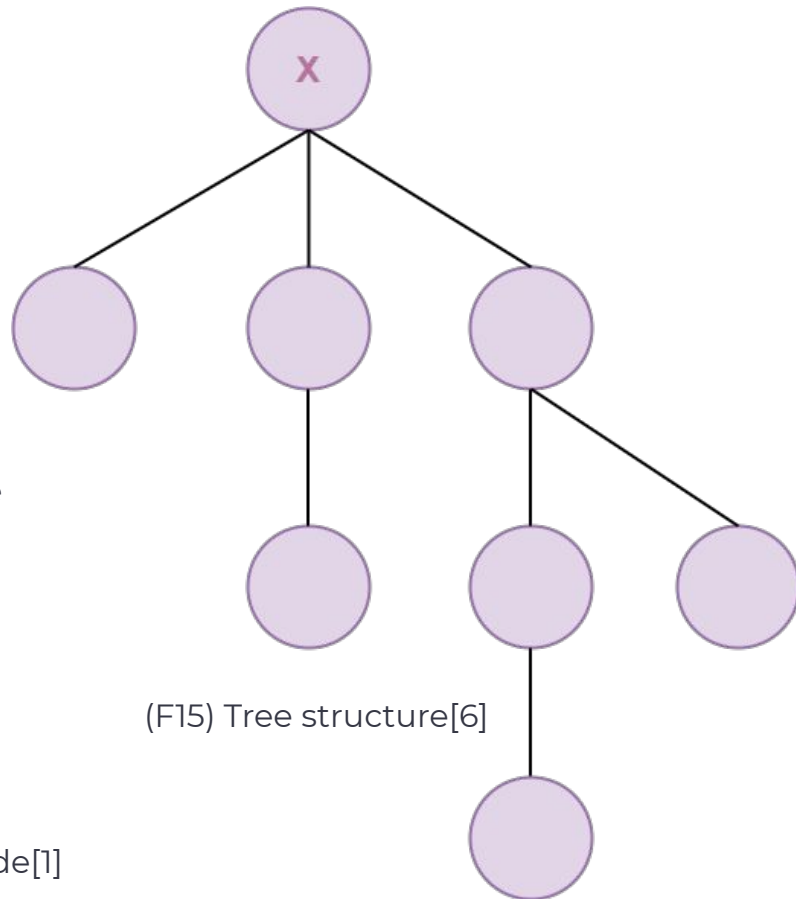
**else if**  $t \geq t_\omega$  **then**

**break**;

**end**

**return**  $\text{foremostTree}$  for root node  $x$ ;

(F14) Foremost tree pseudo-code[1]



(F15) Tree structure[6]



# Evaluation

Standardized testing format

Suitable temporal networks test case(s)

## A simple unit test

```
1 # test_port1.py
2
3 import unittest
4 from portfolio1 import Portfolio
5
6 class PortfolioTest(unittest.TestCase):
7     def test_buy_one_stock(self):
8         p = Portfolio()
9         p.buy("IBM", 100, 176.48)
10        assert p.cost() == 17648.0
```

```
1 $ python -m unittest test_port1
2 .
3 -----
4 Ran 1 test in 0.000s
5
6 OK
```

(F16) Unit test[7]



(F17) Transport Network[8]

# Open-source checklist

Code

Documentation

License

Library name



## Starting an Open Source Project

Learn more about the world of open source and get ready to launch your own project.

(F18) Open-source[9]

# Notes

Initial library

Continuous time

Undirected graphs

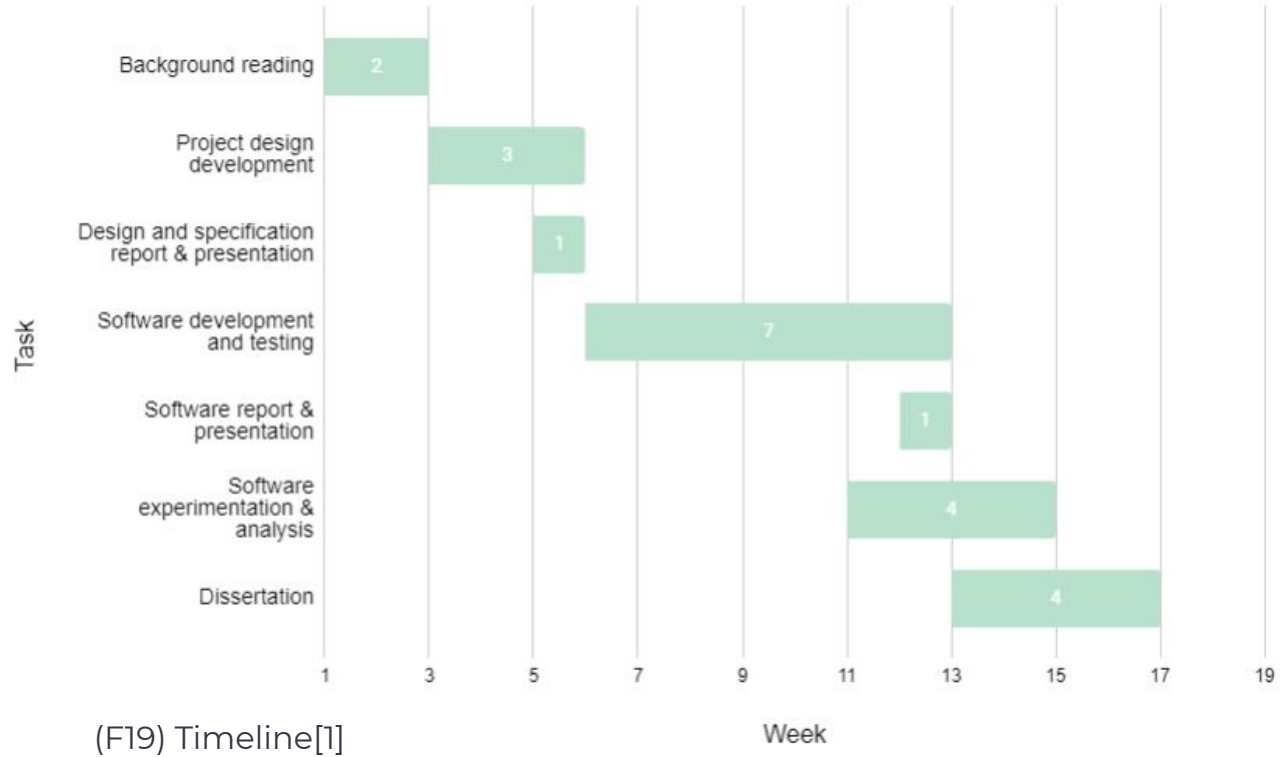
Modular architecture

Efficiency

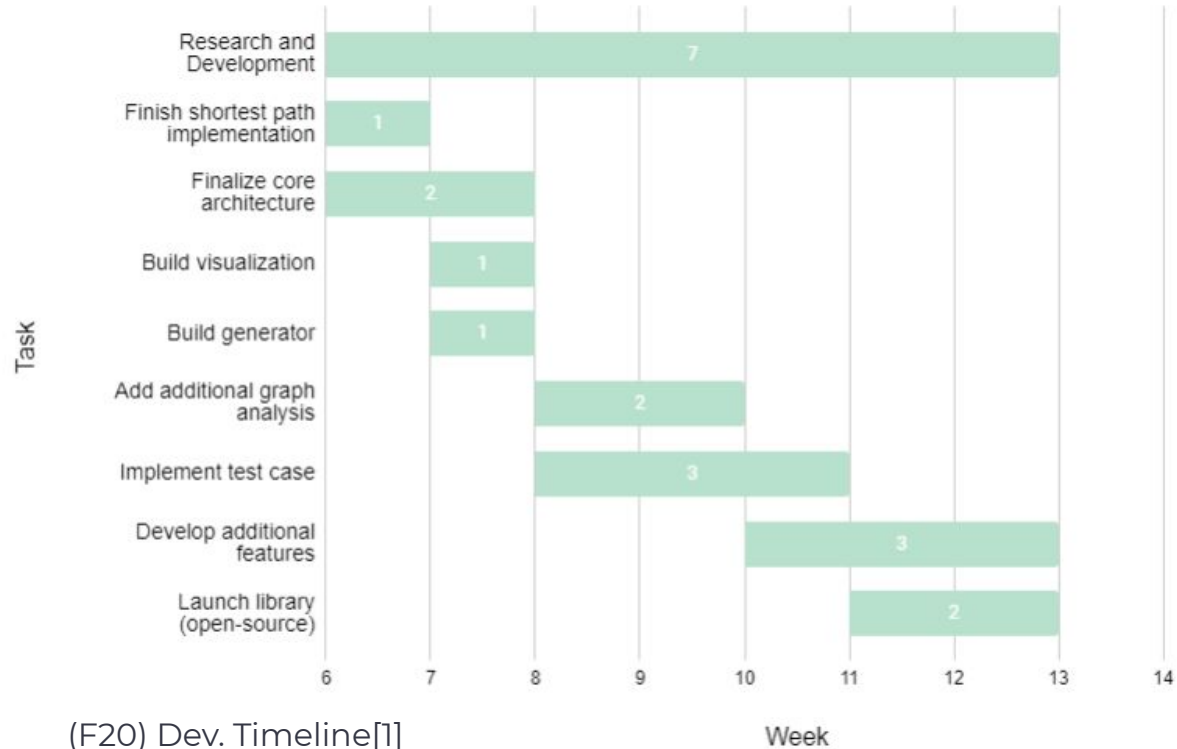
# Timeline

---

# When?



# Software development and testing



# Requirements

---

# With?

Python 3.7[5]

- Numpy[12]
- Matplotlib[13]

Git[11]

Github[10]

Open-source[9]



**Thanks!**

[1]

‘soca-git/COMP702-Temporal-Networks-Library’, *GitHub*. <https://github.com/soca-git/COMP702-Temporal-Networks-Library> (accessed Jul. 02, 2020).

[2]

J. Tang, M. Musolesi, C. Mascolo, and V. Latora, ‘Temporal distance metrics for social network analysis’, in *Proceedings of the 2nd ACM workshop on Online social networks*, Barcelona, Spain, Aug. 2009, pp. 31–36, doi: [10.1145/1592665.1592674](https://doi.org/10.1145/1592665.1592674).

[3]

S. Lee, L. E. C. Rocha, F. Liljeros, and P. Holme, ‘Exploiting Temporal Network Structures of Human Interaction to Effectively Immunize Populations’, *PLoS ONE*, vol. 7, no. 5, p. e36439, May 2012, doi: [10.1371/journal.pone.0036439](https://doi.org/10.1371/journal.pone.0036439).

[4]

‘NetworkX — NetworkX documentation’. <https://networkx.github.io/> (accessed Jun. 30, 2020).

'Python Release Python 3.7.7', *Python.org*. <https://www.python.org/downloads/release/python-377/> (accessed Jul. 03, 2020).

'All your designs', *Canva*. <https://www.canva.com/folder/all-designs> (accessed Jul. 02, 2020).

'Ned Batchelder: Getting Started Testing'. <https://nedbatchelder.com/text/test0.html> (accessed Jul. 02, 2020).

London *et al.*, 'Free London travel maps', *visitlondon.com*.

<https://www.visitlondon.com/traveller-information/getting-around-london/london-maps-and-guides/free-london-travel-maps> (accessed Jul. 02, 2020).

'Starting an Open Source Project', *Open Source Guides*. <https://opensource.guide/starting-a-project/> (accessed Jun. 30, 2020).

'GitHub; Build software better, together', *GitHub*. <https://github.com> (accessed Jul. 02, 2020).

'Git'. <https://git-scm.com/> (accessed Jul. 02, 2020).

'NumPy'. <https://numpy.org/> (accessed Jul. 02, 2020).

‘Matplotlib: Python plotting — Matplotlib 3.2.2 documentation’. <https://matplotlib.org/index.html> (accessed Jul. 02, 2020).
