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Department of Computer Science & Engineering
Bachelor of Technology, Capstone Project, Batch of 2021, Group 92

"Network Analysis of Financial Markets - Correlation Analytics"

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2020-2021

INTRODUCTION

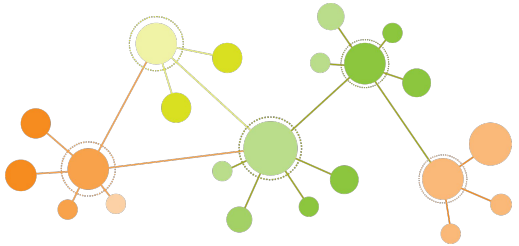
1. **Important Prerequisites and Keywords**
    - Financial Assets
    - Network/Graph Network/Graph Theory
    - *What makes a problem graph-like?*
    - *Community detection in Graph Networks*
    - *Correlation Analytics*
2. **Project Statement**
3. **What was our Aim?**
4. **Reasoning Behind Topic**

IMPORTANT PREREQUISITES & KEYWORDS

- **Financial Assets**

  An asset is a present economic resource controlled by the entity as a result of past events. An economic resource is a right that has the potential to produce economic benefits.

- **Network/Graph Network/Graph Theory**



What is a Network?

- Network = graph
- Informally a graph is a set of nodes joined by a set of lines or arrows.

fig. Network Graphs

Graph-based representations

- Representing a problem as a graph can provide a different point of view
- Representing a problem as a graph can make a problem much simpler
- More accurately, it can provide the appropriate tools for solving the problem

What is network theory?

- Network theory provides a set of techniques for analyzing graphs
- Complex systems network theory provides techniques for analyzing structure in a system of interacting agents, represented as a network
- Applying network theory to a system means using a graph-theoretic representation

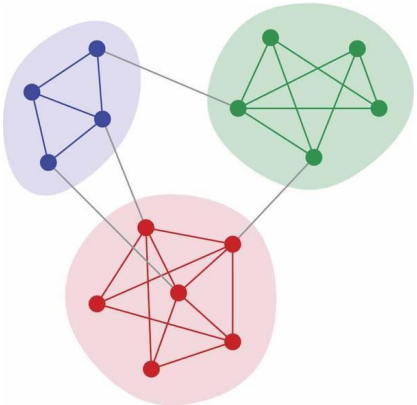
What makes a problem graph-like?

- There are two components to a graph Nodes and edges
- In graph-like problems, these components have natural correspondences to problem elements
- Entities are nodes and interactions between entities are edges
- Most complex systems are graph-like

Community detection in Graph Networks

In the study of complex networks, a network is said to have a community structure if the nodes of the network can be easily grouped into (potentially overlapping) sets of nodes such that each set of nodes is densely connected internally.

Correlation Analytics



- *Correlation analytics is a statistical method used to evaluate the strength of the relationship between two quantitative variables. A high correlation means that two or more variables have a strong relationship with each other, while a weak correlation means that the variables are hardly related.*
- *In graph networks, we sometimes use the correlation coefficient(CC) metric as an edge between two nodes. If CC is high (CC>0.5) we define the edge between two nodes otherwise not.*
- *CC ranges between -1 and 1. A positive value of CC indicates that the growth of two variables is directly proportional to each other while a negative value of C indicates that it is inversely proportional to each other.*

PROJECT STATEMENT

“Use such graph networks to implement time-dependent financial asset correlation networks.”

WHAT WAS OUR AIM?

➢To build a UI where user can construct correlation network of Nifty 50 stocks.

➢User can group stocks based on their similarity. (This is also called community detection or network clustering.)

➢User can see Correlation Heatmap, Correlation Network of stocks, & Clusters formed in network.

REASONING BEHIND TOPIC

➢Networks are a convenient way to represent systems of interacting entities. Many networks contain "communities" of nodes that are more densely connected to each other than to nodes in the rest of the network.

➢We can detect these communities by using different open-source graph clustering algorithms. However, in many applications, entities and/or interactions between entities evolve in time, such as financial market.

➢In financial markets, value of assets evolve over time and these assets sometimes interact or show similarity with other assets.

➢These financial entities and their similarities can be thought of nodes and edges respectively and can be used to construct networks.

➢We can use such networks to implement time-dependent financial asset correlation networks.

➢These are useful in order to capture important patterns, connections and anomalies in financial market.

LITERATURE SURVEY

- *Network Science in Financial Services* ***CONFERENCE*** *at Alan Turing Institute, London, 06 Dec 2019*

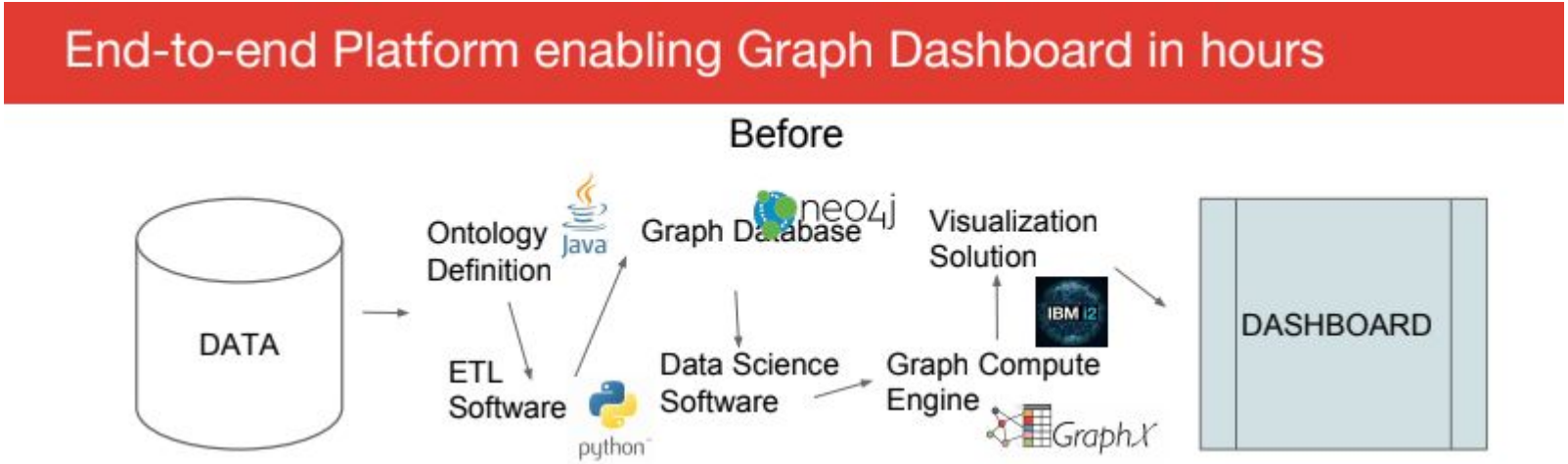
  This conference paper gave us the initial idea for project. It made us realize that we can model financial entities as network graphs.

- *Network Analysis of the Stock Market****,*** *Wenyue Sun, Chuan Tian, Guang Yang,* ***Project Report*** *from Stanford Network Analysis Platform (SNAP), 2015*

  This paper gave us the mathematics foundation behind our topic. We are referring this paper for calculation of correlations, forming adjacency matrices. To calculate correlation we used "Pearson Correlation Coefficient"

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\, n\Sigma x^2 - (\Sigma x)^2 \,][\, n\Sigma y^2 - (\Sigma y)^2 \,]}}$$

- **“Applications of Network Science in Finance”,** *Dr. Kimmo Soramaki* **CONFERENCE** at Big Data Finance Conference, London, October 2017
  http://bigdatafinance.eu/wp/wp-content/uploads/2017/07/Industrial-Applications-of-Network-Theory.pdf
  We are using this conference paper for high level understanding of system design for this topic.
  Like you can see in this diagram, any correlation analytics system needs dashboard, some data sources, graph compute engine(that is layer of software that creates graphs or networks from raw data), In our case we used python package named “Networkx”.



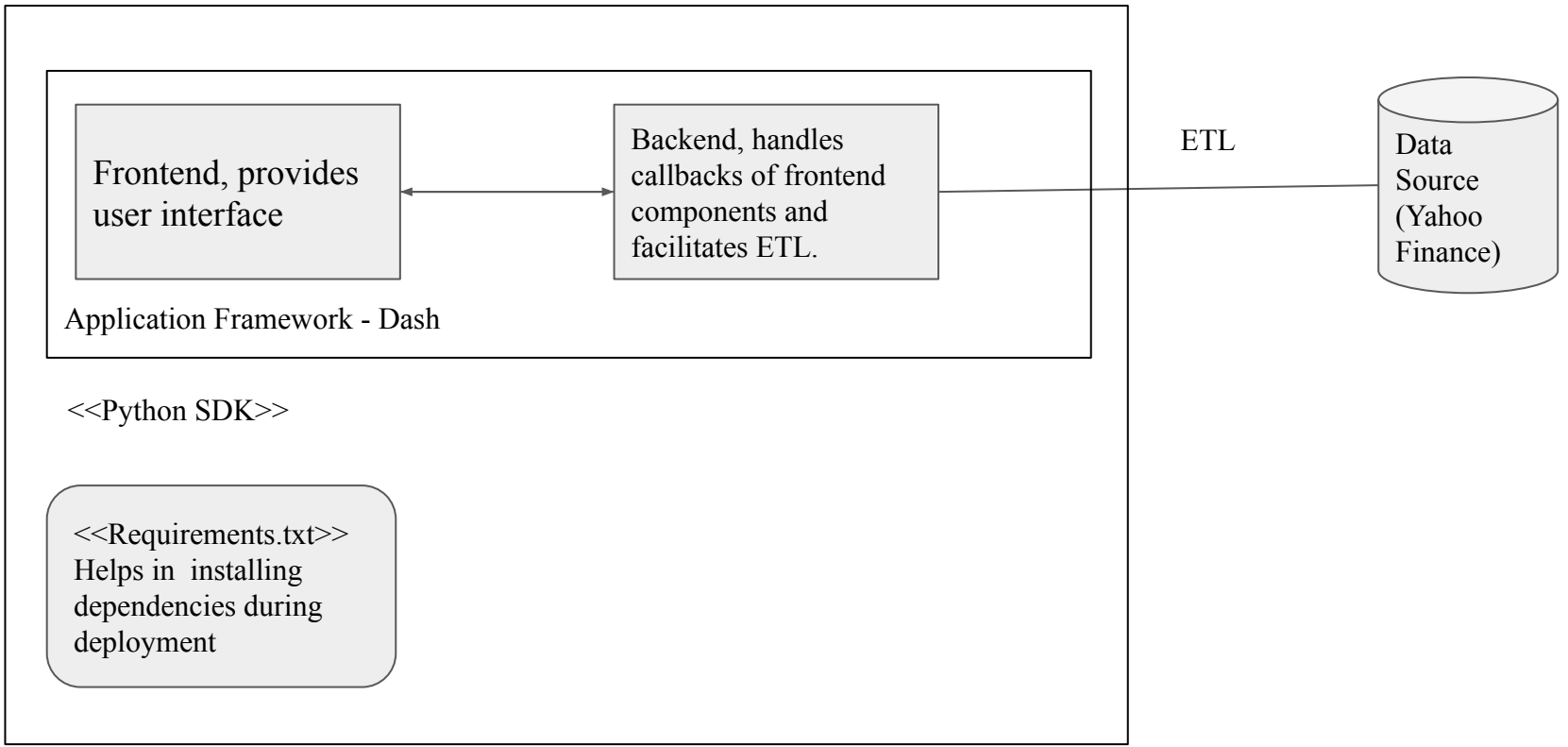
PROJECT METHODOLOGY

With Jupyter Notebook

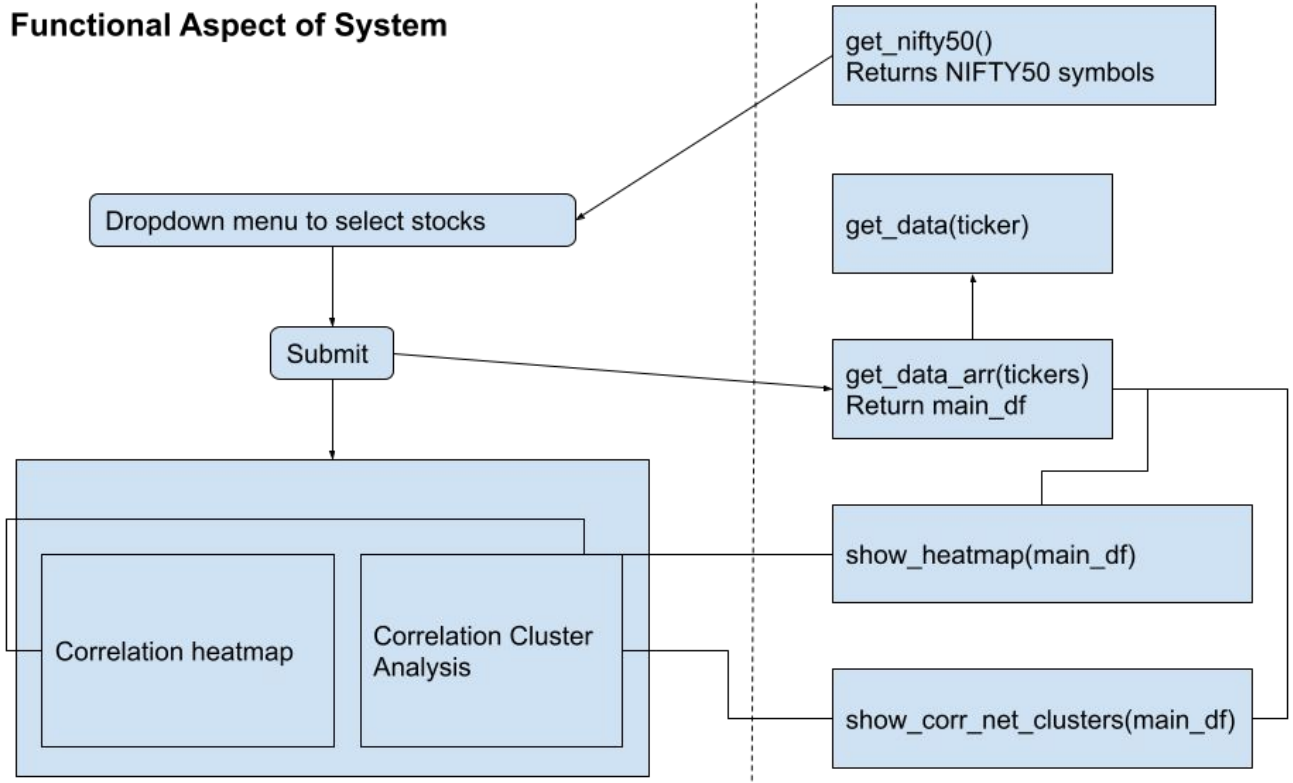
https://colab.research.google.com/drive/1qlScmcgnfVie3BBDQvzhTFZwvNnoUbm2?usp=sharing

SYSTEM ARCHITECTURE

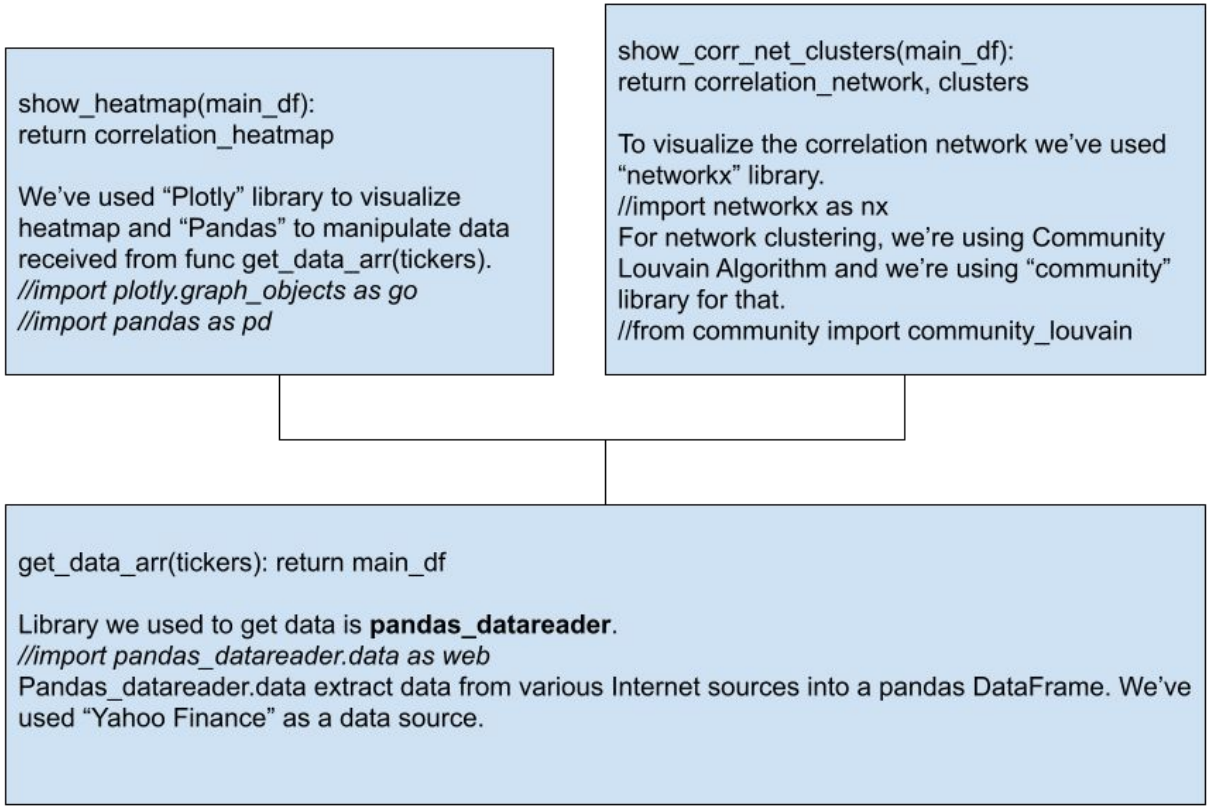
System View at Modular Level(Based on files, folder, underlying software.)



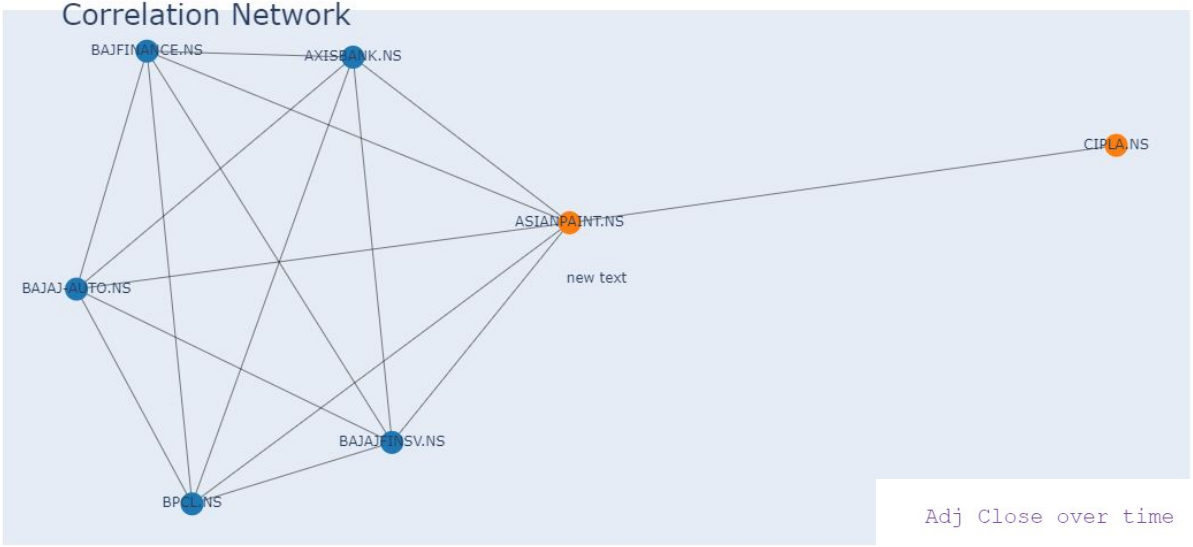
Functional Aspect of System



Data Aspect of System

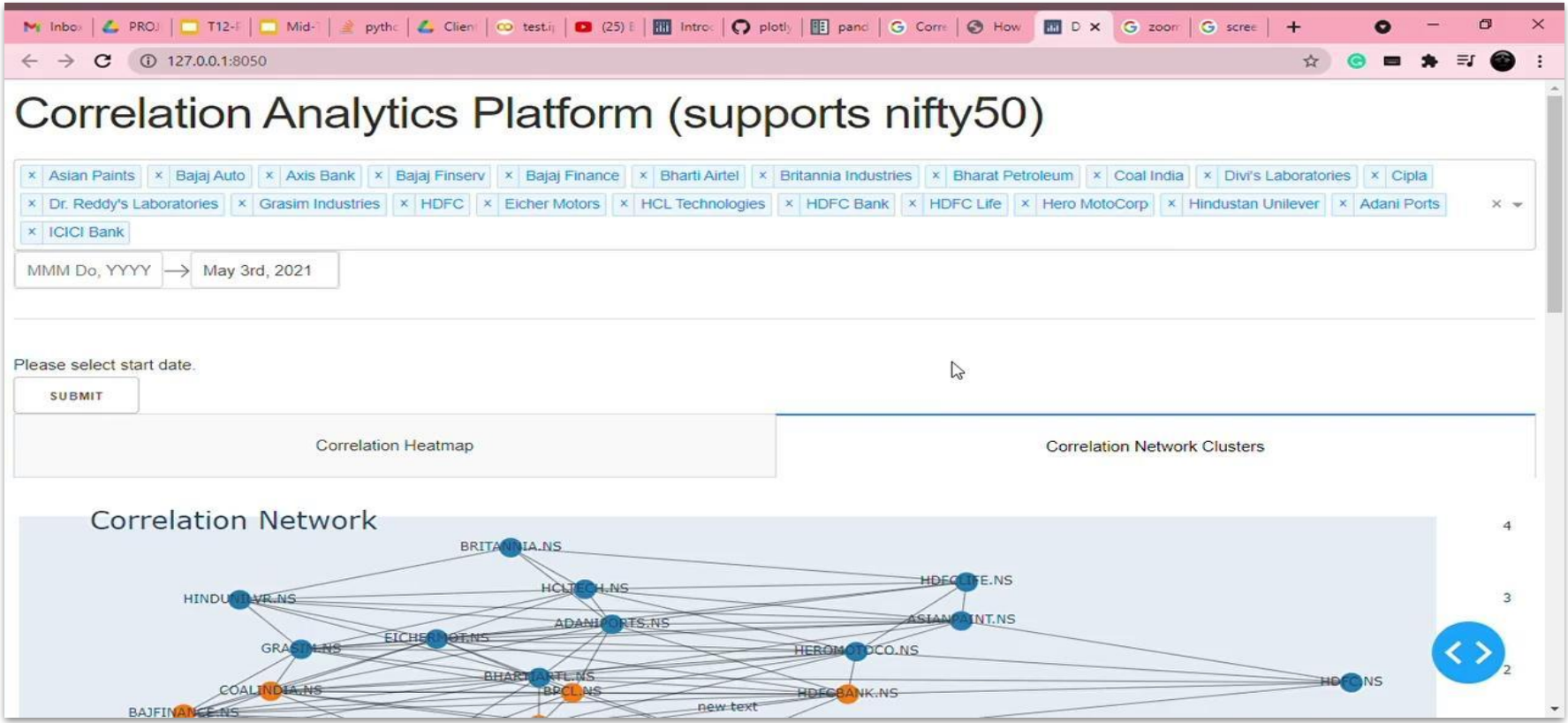


RESULTS


Correlation Network
BAJFINANCE.NS
AXISBANK.NS
CIPLA.NS
ASIANPAINT.NS
new text
BAJAJ-AUTO.NS
BAJAJFINSV.NS
BPCL.NS


Adj Close over time
Adj Close
12k
10k
8k
6k
4k
2k
0
Apr 11
2021
Apr 25
May 9
May 23
Jun 6
Jun 20
Time-line
ASIANPAINT.NS
AXISBANK.NS
BAJAJ-AUTO.NS
BAJFINANCE.NS
BAJAJFINSV.NS
BPCL.NS
CIPLA.NS

DEMO

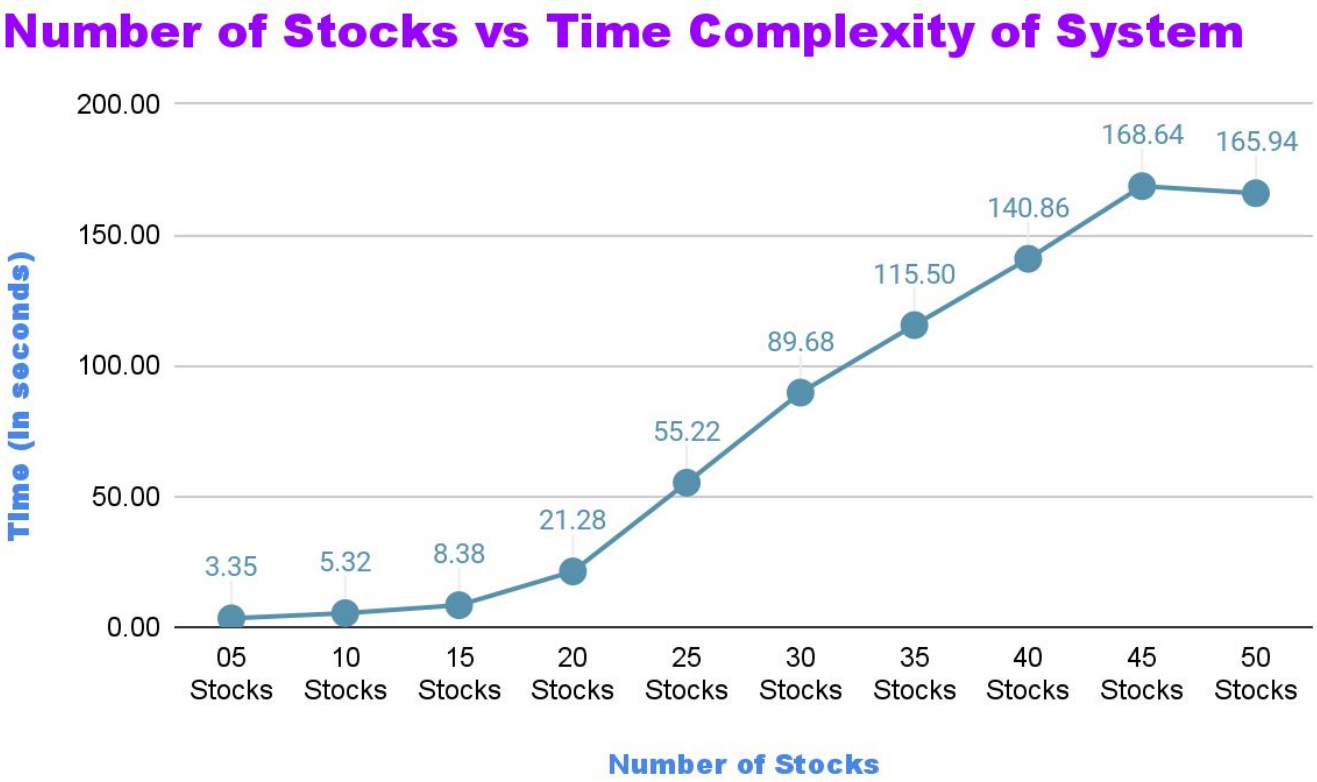

127.0.0.1:8050
Correlation Analytics Platform (supports nifty50)
Asian Paints
Bajaj Auto
Axis Bank
Bajaj Finserv
Bajaj Finance
Bharti Airtel
Britannia Industries
Bharat Petroleum
Coal India
Divi's Laboratories
Cipla
Dr. Reddy's Laboratories
Grasim Industries
HDFC
Eicher Motors
HCL Technologies
HDFC Bank
HDFC Life
Hero MotoCorp
Hindustan Unilever
Adani Ports
ICICI Bank
MMM Do, YYYY
May 3rd, 2021
Please select start date.
SUBMIT
Correlation Heatmap
Correlation Network Clusters
Correlation Network
BRITANNIA.NS
HCLTECH.NS
HDFCLIFE.NS
HINDUNILVR.NS
ADANIPORTS.NS
ASIANPAINT.NS
GRASIM.NS
EICHERMOT.NS
HEROMOTOCO.NS
BHARTIARTL.NS
COALINDIA.NS
BPCL.NS
HDFCBANK.NS
HDFC.NS
BAJFINANCE.NS
new text
4
3
2

PERFORMANCE ANALYSIS

►As we can see, the time it takes to perform correlation analytics of stocks linearly increases with number of input stocks.

►This is what we call scalability issue. The system we design works fine with small number of stocks.

►To scale such system, techniques like multithreading, Memoization will certainly help.



APPLICATIONS

- Creating New Asset Classes: With the help of correlation network clustering, we can create new asset classes based on assets' correlation with each other.
- Portfolio Space Reduction: One can apply a network clustering technique based on correlations to dramatically reduce the number of assets in a portfolio while still maintaining a sufficient level of diversification.

CONCLUSION

There are mainly three conclusions of this work:

1. We constructed a network to model the stock market based on time-lag correlation of the stock return.
2. The network was visualized to detect communities of stocks having high similarities.
3. The constructed network can be utilized for portfolio management, by selecting the stocks with high centralities.

REFERENCES

[1] Network Science in Financial Services CONFERENCE at Alan Turing Institute, London, 06 Dec 2019

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https://ideas.repec.org/a/taf/quantf/v1y2001i4p441-451.html

Thank You