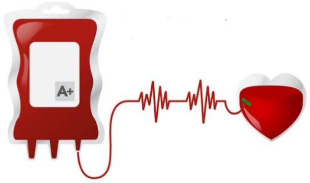


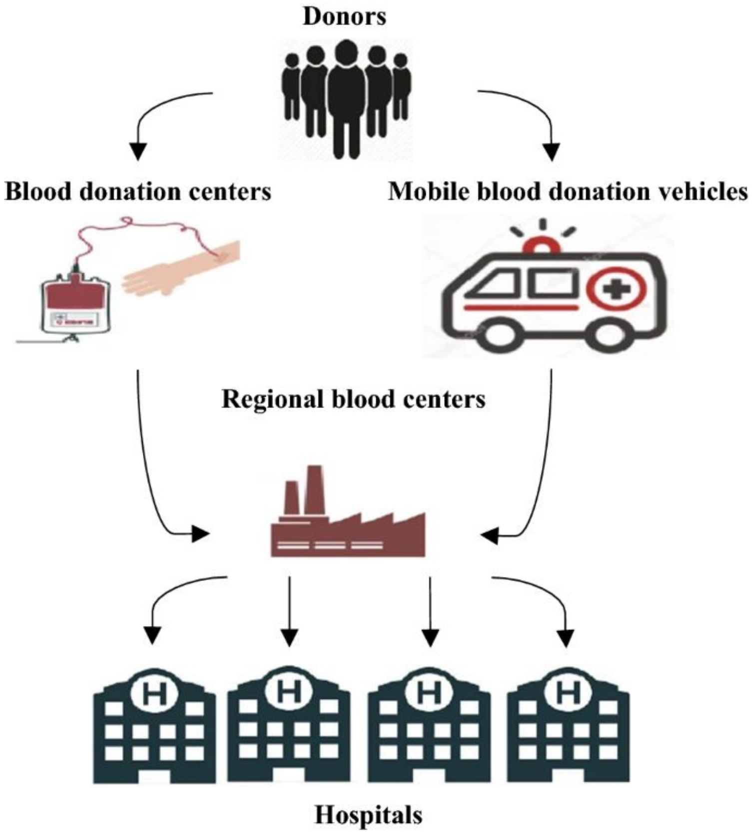
Healthcare Resource Allocation

Course: CS5800 - Algorithms, Prof. Jonathan Mwaura
Project Team: Krutik Bajariya, Rahil Jhaveri, Jheel Kamdar

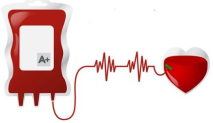
Context

- According to our exhaustive research we found that there is a tremendous amount of blood being tagged as 'waste' and is disposed of due to 'improper coordination between the blood banks and hospitals' with the given justification that they expired prior to their use.

- This shows a lack of management skills against the collection and disposition of the blood bags and is in desperate need of proper maintenance formulation.



Question



- *"How can healthcare facilities develop an efficient blood distribution plan using algorithms to minimize costs, maximize patient outcomes, find shortest routes from neighboring hospitals to meet blood requirements and save routes for future use?"*

Our Approach

- Create an efficient blood distribution strategy for healthcare facilities using:
  > Dijkstra's Single Source Shortest Path (SSSP) algorithm
  > Floyd-Warshall All Source Shortest Path (ASSP) algorithm
- Minimize costs and maximize patient outcomes by finding shortest routes from neighboring hospitals to meet blood requirements.
- Save routes for future use.
- Analyze and compare the algorithms for healthcare logistics optimization.

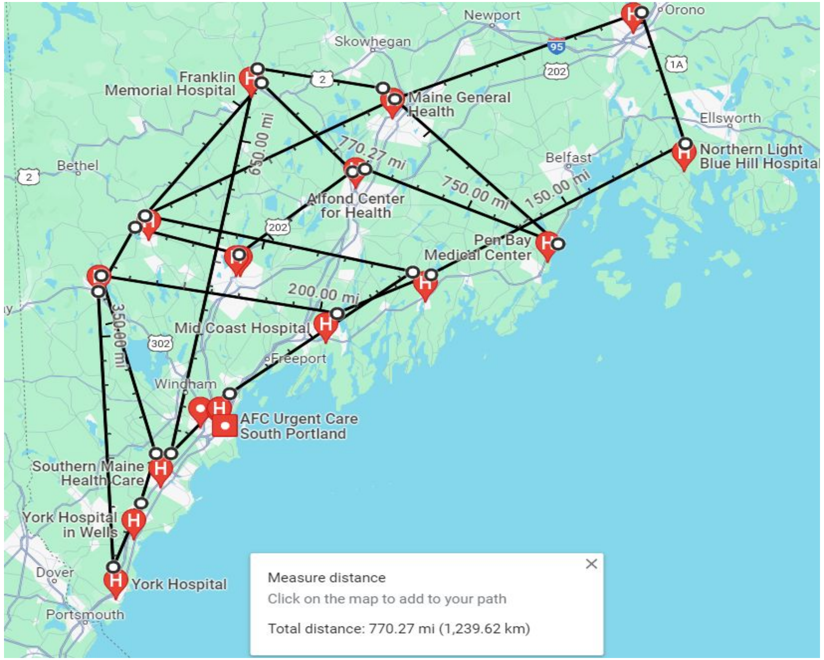
Data Set

- For this particular project, we got our dataset from kaggle.
- Focused only on 3 features from the 34 available features i.e. Longitude, Latitude & Name of Hospitals
- Filtered hospitals that are only in the state of Maine (49 Hospitals).
- Used Geodesic Distance calculation os the weight of connections between affiliated medical institutes.

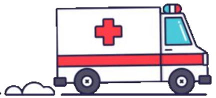
Sample Data

	NAME	LATITUDE	LONGITUDE
2843	BRIDGTON HOSPITAL	44.046139	-70.713748
2844	CALAIS COMMUNITY HOSPITAL	45.177589	-67.268016
2845	CARY MEDICAL CENTER	46.879578	-68.008320
2846	CENTRAL MAINE MEDICAL CENTER	44.101737	-70.214518
2847	CHARLES A DEAN MEMORIAL HOSPITAL	45.458876	-69.611331
2848	DOROTHEA DIX PSYCHIATRIC CENTER	44.817799	-68.741420
2849	DOWN EAST COMMUNITY HOSPITAL	44.713969	-67.475855
2850	EASTERN MAINE MEDICAL CENTER	44.808660	-68.750777
2851	FRANKLIN MEMORIAL HOSPITAL	44.626633	-70.162867
2852	HEALTHSOUTH - MAINE MEDICAL CENTER, LLC	43.666322	-70.291861
2853	HOULTON REGIONAL HOSPITAL	46.133846	-67.843623
2854	LINCOLN HEALTH	44.026129	-69.530661
2855	MAINE MEDICAL CENTER	43.652990	-70.276021
2856	MAINEGENERAL MEDICAL CENTER	44.362584	-69.780446

CSV File



Representing the data as a Graph



Single Source Shortest Path Algorithm

Why Dijkstra's (Adjacency Matrix)?

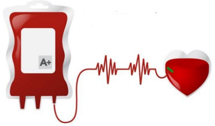
- Provides the SSSP in O(V + ElogV) time.
- Implemented for dense graphs the edges will be V^2
- Since our medical facility network is dense, adjacency matrix is much more suitable. The space consumed would be $O(V^2)$.
- The time taken would be $O(V + V^2 \log V)$ which is $O(V^2 \log V)$ for each vertex.
- Efficient to manage Blood SCM in case of emergencies when there is limited info, change in route and one time SSSP calculation.

All Source Shortest Path Algorithm

Why Floyd-Warshall?

- Provides the ASSP in $O(V^3)$ time.
- Useful to store the paths after calculating the shortest distance between any 2 medical facilities.
- The application of Floyd-Warshall allows to manage Blood supply in any scenario provided there are no changes in paths or network.
- Since our network is denser, it is efficient as all paths can be stored in $O(V^2)$ space.

Performance Evaluation

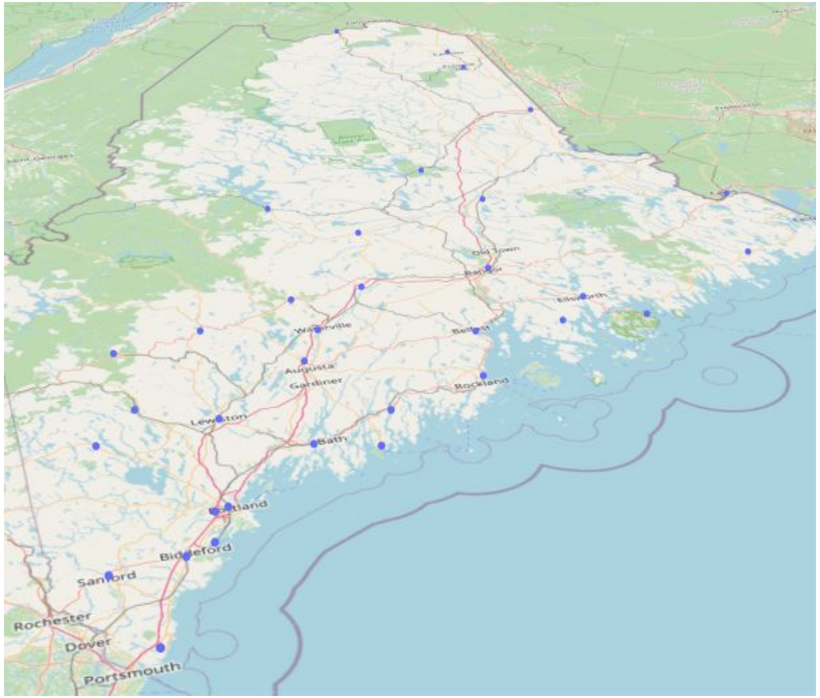


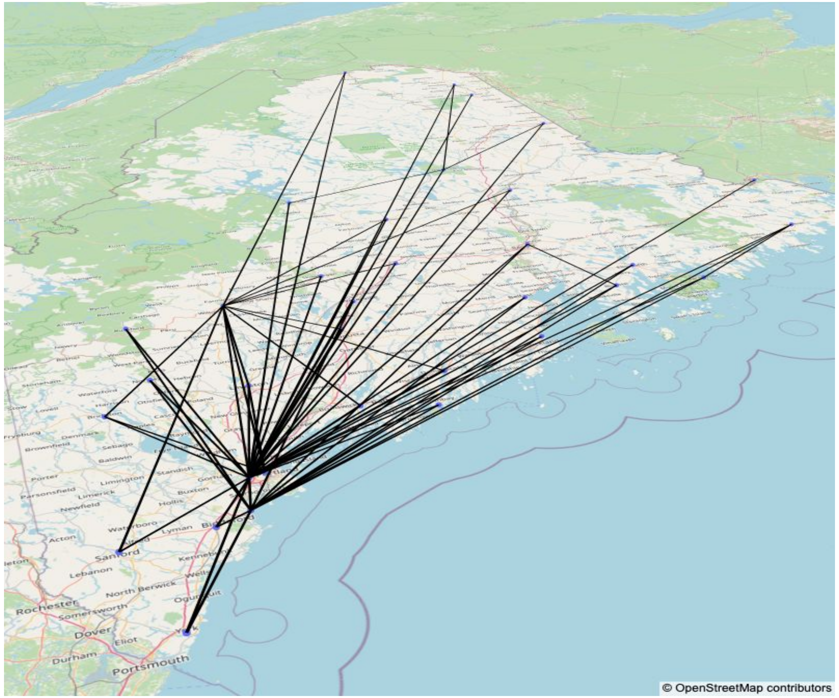
Dijkstra’s Algorithm:	Floyd Warshall’s Algorithm:
`33.1 ms ± 275 µs per loop (mean ± std. dev. of 10 runs, 100 loops each)`	`9.01 ms ± 70.8 µs per loop (mean ± std. dev. of 10 runs, 100 loops each)`

Dijkstra’s would take $O(V * V^2 \log V)$ time, i.e. Time Complexity of $O(V^3 \log V)$ for all the vertices.

The Floyd Warshall’s algorithm performs better than Dijkstra’s algorithm by a factor of nearly 4x. The reason is due to the $\log_2 V$ difference in their time complexities ($\log_2 49 = 5.62$ as there are 49 hospitals in our network).

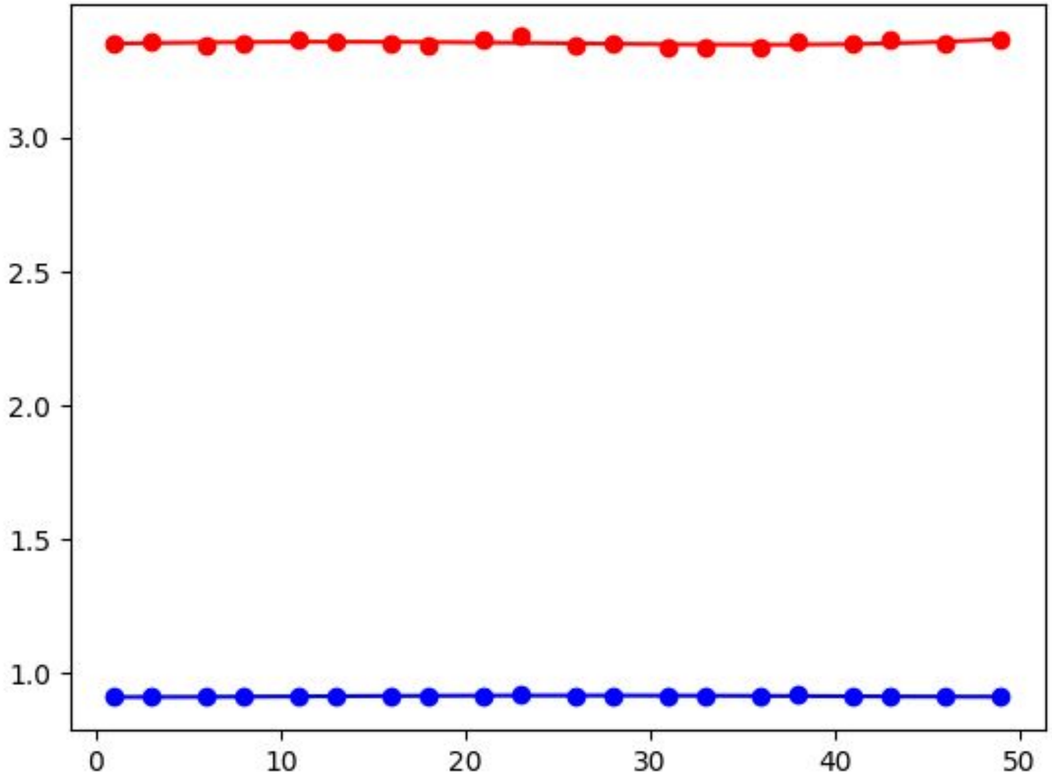
Results





Shortest Paths Visualization

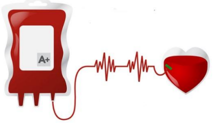
Conclusion



- Floyd Warshall's
- Dijkstra's

Single Point indicates the mean time consumed for 100 iterations.

Further Improvements



- **Fractional Knapsack and Shortest Path Algorithm:** use the ratio of blood availability to shortest path after considering the best possible transport mode (aerial, road, expressways, etc) as the weights of edges in the healthcare network.
- **Residual Graph Implementation:** considering the hospital with near expiry blood bags as sink, we can create residual paths to transfer as many bags to all hospitals in the network.
- Taking the **parameter of threshold** into account for each healthcare resource so there is minimum scarcity per node in our network.
- Apply our algorithm on **denser network in the decentralized architecture** maintaining transparency, ownership and usage of blood bags.

References

- Dataset: https://www.kaggle.com/datasets/andrewmvd/us-hospital-locations
- NCBI report: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8760027/#sec-a.g.etitle
- Distance Calc: https://geopy.readthedocs.io/en/stable/#module-geopy.distance
- Validity and Integrity check in Supply Chain Management using Blockchain, IJERT Volume 09, Issue 02 (February 2020) by P. Gor, D. Gosalia, R. Jhaveri and A. Gawade https://www.ijert.org/validity-and-integrity-check-in-supply-chain-management-using-blockchain

Hope you get inspired
& keep donating blood

Happy to answer any questions
Thank you