A Note on Routing Methods to Determine the Shortest Path in Transport Networks

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Abstract -. **The routing of vehicles in complex urban or regional systems is a task that needs to be solved in numerous transportation-oriented applications. The objectives of the presented research are to examine existing routing algorithms used for finding the shortest path between the nodes in transport networks and to analyse the implementation possibilities and efficiency of routing algorithms in web-based geographical information systems. This paper describes the process and approaches used for routing algorithm analysis emphasizing transportation planning in interactive web-based planning, analysis and simulation solutions.**

***Keywords*—Routing algorithms, shortest path, Dijkstra's algorithm**

I. INTRODUCTION

The development progress of private and public transportation networks as well as infrastructure leads to an increase in demand for efficient methods and algorithms to solve the actual tasks and problems of transportat4ion planning and control. Transportation systems are increasingly complex systems incorporating diverse travel modes and services; therefore, the need to integrate and efficiently operate these systems poses a challenge to planners and operators[1] . By using new technologies and applications, as well as development assistance and evaluation tools prior to field implementation in transportation systems, it is possible to find a solution to this complex problem area. One of the actual tasks that needs to be solved in numerous transportation-oriented applications is the routing of vehicles or persons. The basic concept of routing algorithms is to model the specific problem in a suitable graph and to compute the shortest path to solve it. While it is simple to come up with an algorithm that just solves the problem, it is much more difficult to engineer an efficient routing algorithm. This paper describes the process and approaches used for routing algorithm analysis emphasizing transportation planning in interactive web-based planning, analysis and simulation solutions. The objectives of the presented research are to examine existing routing algorithms used for finding the shortest path between the nodes in transport networks and to analyse the implementation possibilities and efficiency of routing algorithms in web-based geographical information system.

II. ROUTING ALGORITHMS FOR TRANSPORTATION PLANNING

A. Classification of Routing Algorithms

theory, multiple routing algorithms can be used for solving the shortest path problem. This paper focuses on four well-known methods classified as the shortest path algorithms [2]:

- Dijkstra;
- Bellman–Ford;
- Floyd–Warshall;
- A* (A star).

These shortest path algorithm have different structure,functionality and working principles depending on used graph types,edge directions,edge weights,graph density and other parameters. Some algorithm functionalities are overlapping in the case when they are derived from the same base algorithm. For example, the A* algorithm is an extended version of Dijkstra, adding possibility to use heuristics to determine the order of node searching [3]. The Bellman–Ford [4] and Floyd–Warshall [5],[6] algorithms are used to compute all possible paths in the graph. This functionality can be used in the so-called graph pre- processing. However, the searching of all possible paths requires more computational resources than single path searching does. This aspect is considered when algorithms are compared in the analysis carried out in this study. The research presented in this paper focuses on the analysis of the necessary computational resources – time and memory – needed for algorithms to find the shortest path in diverse contextual situations. The theoretical behaviour of each algorithm can be calculated using the big O notation [7].This gives only the worst- and best-case scenario results using graph size measurements. In transportation planning, the route properties between sources and destinations can change multiple times as the route passes through dense regions like cities and through highways that are considered scattered regions. Therefore, the analysis results of routing algorithms using real-life geographical data may significantly differ from the theoretically estimated results.

1) Dijkstra algorithm: Classical Dijkstra algorithm is a process of finding the path with the lowest cost (i.e. usually refers to the shortest path) from one node to all nodes in a city map. Its computation complexity is O (n2) with n being the number of nodes in network [8]. Dijkstra is one of the optimal algorithms based on labeling method. In addition, other labeling algorithms like Bellman-Ford-Moore, incremen-tal Graph, threshold, topological ordering, etc. are also used to find shortest path. F. Benjamin [9] states that for finding the shortest path from one-to-one problem, it is worthwhile to consider Dijkstra algorithm since this algorithm is terminated as soon as the destination node is labeled, which also means that the shortest path is found. The other algorithms can only find optimal path when full shortest path tree is calculated meaning that shortest paths to all the nodes in the graph are found. Therefore, for searching the shortest path for one-to-all problem, incremental Graph is more efficient. Dijkstra's algorithm finds a shortest path tree from a single source node, by building a set of nodes that have minimum distance from the source.

2) A* algorithm: A* is considered as a variant of Dijkstra algorithm but it uses a heuristic function rather than optimal search mechanism. Hence, A* restricts the search space and reduces the computational time. In traffic application, the search space is restricted to the area where traffic congestion has changed. Examples of A* algorithms extension are RTA* and a LRTA* [10] proposed for real-time applications. They usually use the direct distance between current location and the destination as a heuristic function.

Road network:The road network is the system of interconnected roads designed to accommodate wheeled road going vehicles and pedestrian traffic.

Fig.1 shows the Delhi road map where various paths can be determined from Delhi to Moradabad. But using Dijkstra's we have to find the shortest path.

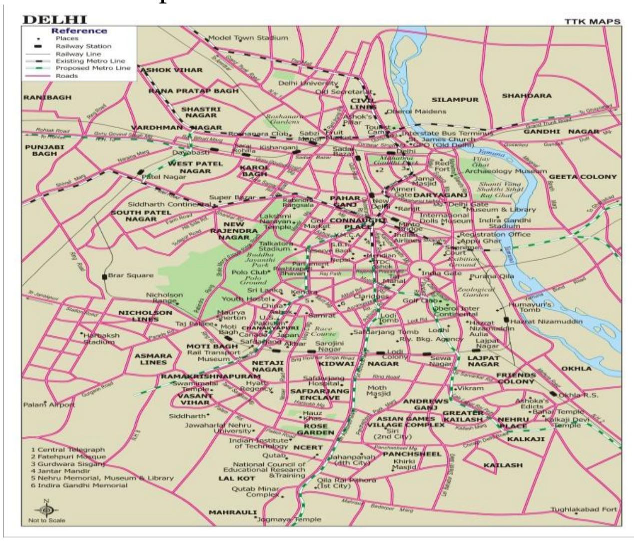

Fig.1 Delhi Road Map [11]

Social

The road network facilitates the movement of people allowing for social interaction. A high quality road network is essential not only for connecting key urban centres but for improving connectivity of more isolated local communities for whom many public transport options are limited or not available. Roads connect remote communities with the areas where employment options are more concentrated and services and facilities more readily available.

Economic

By connecting geographic locations, road networks facilitate the transport and movement of people, goods, and services, creating welfare. Road networks played a crucial role in the economic development of the 20th century, enabling relatively fast individual transportation for the masses from the second part of the 20th century. And although the development of air transportation and telecommunication networks started to compete with road networks during the later part of the 20th century, in most EU countries road transport still plays a crucial role in the national and local transportation networks.

Investments in road networks reduce the travel time between two locations increase the robustness of the transportation network and hence reduce the travel costs. These kind of effects are referred to as the so-called direct effects of road networks. The economic impact of road networks extend in most cases beyond these direct effects due to the further rounds of economic activity as a result of the efficient transportation of goods, skills and persons, the so-called indirect economic effects. The investment in road networks.However, do not just lead to positive effects. Apart from the necessary investments in terms of time and money, road networks fill up land and have negative social and environmental impacts such as congestion, traffic accidents, light and noise pollution, and (of course) air pollution. In order to assess if an investment in a road network has a positive effect on society, or to compare different alternatives of transport infrastructure, economic tools can be used to value the positive and negative direct, indirect and external effects of these alternatives. The difficulty with this kind of economic appraisal is first of all that it is not easy to measure the valuation of travel time, and secondly that new road infrastructure will generate road use that would not have been made without the investments, the so-called induced demand. A third problem is that especially external effects such as quality of life, the value nature, the value of no air pollution, are very difficult to be expressed in monetary terms.

Although road networks are hardly affected by security threats (crime, terrorism), it can happen that roads get blocked due to e.g. riots, bomb explosions, traffic flow management, etc. The economic impact of these kind of threats can be significant, especially in indirect terms since roads facilitate economic activities. Security measures can prevent these negative economic effects, for instance, by ensuring there are alternatives routes for traffic (traffic flow management). These security measures, however, also generate economic impact, especially when these measures limit the mobility of road users.

Mobility

The function of a road network is to facilitate movement from one area to another. As such, it has an important role to play in the urban environment to facilitate mobility. It furthermore determines the accessibility of an (urban) area (together with public transport options).

The capacity of a network is determined by its roads. The capacity of a road is the maximum number of vehicles that can pass a certain road section per hour. The capacity of a road is determined e.g. by its width, number of lanes and speed limit. If the traffic demand is larger than the road capacity, congestion will occur. When congestion is present, the road network cannot longer fullfill its task. Therefore, one tries to prevent or reduce congestion with traffic management measures.

Developing a good road network has many positive effects, such as stimulating the development of certain areas (commercial activities, urban development, creating jobs etc.). For security, good accessibility by the road network is also important, for example for good accessibility in case of incidents (see also incident management). However, the road network may also facilitate criminals to reach their target. This could be controlled with access control.

III LITERATURE SURVEY

Zhao (1997) distinguishes between route planning and route guidance as two key elements in vehicle location and navigation systems as part of ITS. Route planning is the process that helps vehicle drivers plan a route prior to driving a specific part of his or her journey. Route guidance is the real-time process of guiding the driver along the route generated by a route planner.

Huang et al. (1995) discriminates route guidance even further, distinguishing between centralized and decentralized route guidance. In the former, vehicles conduct their own path finding using on-board computers and static road maps in CD-ROMs, and applying heuristic search algorithms. Centralized route guidance relies on traffic management centers (TMC) to answer path queries submitted by vehicles linked to it.

In this case, Huang et al. (1995) describe a central server holding a materialized view of all shortest paths at that given time, accessed by lookup requests from the vehicles equipped with this system.

Although not explicitly stated, it can be assumed that this also is the case in the Advanced Traveler Information System (ATIS) detailed by Shekar and Fetterer (1996) or the ADVANCE project portrayed by both Revels (1998) and Zhao (1997). Boyce et al. (1997) provide a detailed evaluation study of the ADVANCE project for further reference.

IV CONCLUSION

In the presented research, routing algorithm suitability was analysed in the context of transportation planning. With the help of theses algorithm, we have analysed various methods and approaches for finding shortest path. From the results gathered and analysed in the current research, the following main conclusions can be drawn:

a) The existing routing algorithms provide different performance results in dense and scattered environments.

b) In dense environments, the Bellman–Ford algorithm shows the fastest execution time during the searching process of single shortest path, but in scattered situations– the Dijkstra's algorithm requires the least amount of computation time.

c) For searching the shortest path for one-to-all problem, incremental Graph is more efficient.

V REFERENCES

[1] T. Toledo, O. Cats, W. Burghout, and H. N. Koutsopoulos, "Mesoscopic Simulation for Transit Operations," Transp. Res. Part C Emerg. Technol., vol. 18, no. 6, pp. 896–908, Dec. 2010.

[2] D. Joyner, M. Van Nguyen, and D. Phillips, Algorithmic Graph Theory and Sage, Version 0.8-r1991, 2013, p. 304. [E-book] Available: https://code.google.com/p/graphbook/.

[3] P. E. Hart, N. J. Nilsson, and B. Raphael, "A Formal Basis for the Heuristic Determination of Minimum Cost Paths," Syst. Sci. Cybern. IEEE Trans., vol. 4, no. 2, pp. 100–107, 1968.

[4] R. Bellman, "On a Routing Problem," Q. Appl. Math., vol. 16, pp. 87– 90, 1958.

[5] R. W. Floyd, "Algorithm 97: Shortest path," Commun. ACM, vol. 5, no. 6, p. 345–, 1962.

[6] S. Warshall, "A Theorem on Boolean Matrices," J. ACM, vol. 9, no. 1, pp. 11–12, 1962.

[7] M. J. d. Smith, M. F. Goodchild, and P. A. Longley, Geospatial Analysis: A Comprehensive Guide to Principles, Techniques and Software Tools, 3rd Revise. Matador, 2009, p. 516.

[8] F. Zhan, Three fastest shortest path algorithms on real road networks: Data structures and procedures, Journal of Geographic Information and Decision Analysis, vol. 1, no. 1, pp. 70-82, 1997.3

[9] H. Kanoh, Dynamic route planning for car navigation systems using virus genetic algorithms, International Journal of Knowledge-based and Intelligent Engineering Systems, vol. 11, pp. 65-78, Jan. 2007.

[10] B. C. Dean, Continuous-Time Dynamic Shortest Path Alorithms. PhD thesis, MIT, 1999.

[11] http://1.bp.blogspot.com/-/Delhi-Road- Map.jpg