

Windows Implementation of PgRouting to find Shortest Path using Dijkstra's Algorithm for Varanasi Road Network

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Abstract—Many route mapping were done with the help of API of Google maps but does not provide geospatial Routing functionality like overlay, interpolation etc. This project aims to find the shortest path between two or more points by using multipath Dijkstra's algorithm via PgRouting. Dijkstra's algorithm provides advantages on time required for selecting network and building graph over the algorithm speed. In that case A-star is always preferred over Dijkstra's algorithm. Dijkstra's algorithm has a computational complexity of $O(n^2)$ with a network consisting of n nodes. This Project explains the steps to prepare the data by converting shape files into SQL files and import it into PostgreSQL/PostGIS, make routing topology, indexes, and queries, dynamically assign costs by PgRouting, and write a custom function 'plpgsql' using PL/pgSQL (Procedural programming structured query language) supported by PostgreSQL. This report provides all geospatial functions with dynamic support via PgRouting which allows many clients, like Quantum GIS and Udig represents client visualization for modification of data and attributes for instantly reflecting changes via PgRouting. PgRouting Provides a framework by which cost parameters are calculated dynamically. This paper specifies routing of Varanasi city roads using Dijkstra's algorithm and PgRouting. This article focuses on dynamic routing on the complex network like Varanasi City over the web mapping application so that Client can easily find their shortest route along with Cost parameters.

Keywords: Geographic Information System (GIS), Web Services, PostgreSQL/PostGIS, Dijkstra's Algorithm, PgRouting, GeoServer.

1. INTRODUCTION

With the excessive needs of applications of Geoinformatics, GIS and their web based applications has been increasing day by day. Travelling is a necessity of daily life .Network Analysis provides a function for many fields i.e. Traffic tourism, Telecommunications and so on. Network Analysis faces lots of problem in a complex network. Most of peoples (especially in developing countries like India) facing lots of problem on public transportation like railway, bus, mini-bus, ferry even after they had their own vehicle. The reason is

unawareness of complicated road network. People always want to easily gather all the information for unvisited destination and reach as soon as possible. They actually prefer easily reachable and most economical route compared to other route for their destination. Route selection provides a time saving and easily accessible shortest route between origin and destination. Sometimes a longer route can be more convenient than a shorter route, in order to avoid various difficulties like traffic, restrictions. A good knowledge provides a sophisticated routing of road network along with relative cost. As the user makes queries for shortest route from one node to another, System generates route accordingly on the basis of input factors e.g. cost, time and so on. We have seen many applications including Google maps which show shortest path between two points. But in our application it is not only the shortest path distance in general geographic sense but it also provides cost parameter dynamically including time and the capacity of the line. We propose a road-routing web based geographic information system which helps to find a shortest path between source and destination in order to optimize it by implementing new technologies through which cost parameters are calculated dynamically with the help of PgRouting.

Earlier PgRouting enables only Dijkstra's algorithm for shortest path searching. So at that time PgRouting was named as PgDijkstra. After that it was extended to provide routing functionality via various algorithms i.e. a-star and enabling low level interface to algorithms. It makes possible of use of diverse data, algorithms etc. with the help of WebGIS that helps in spreading it over the web. WebGIS communicates through interfaces for finding shortest path. Shortest path algorithm provides a minimum weight route between source and destination and building graph. In this article, a shortest path is found by using Dijkstra's algorithm Proposed by Edsger Dijkstra in 1959. This algorithm provides precise

results compare to previous algorithm. It follows many steps for searching minimum cost path among ordered path. First step is to explore search region and expand it. Second step is to obtain network topology information i.e. connection between arcs and provide more optimal analysis result for huge data. It is beneficial for saving lot of memory and proves easily gathering information from huge nodes. The architecture is shown in Fig. 1:-

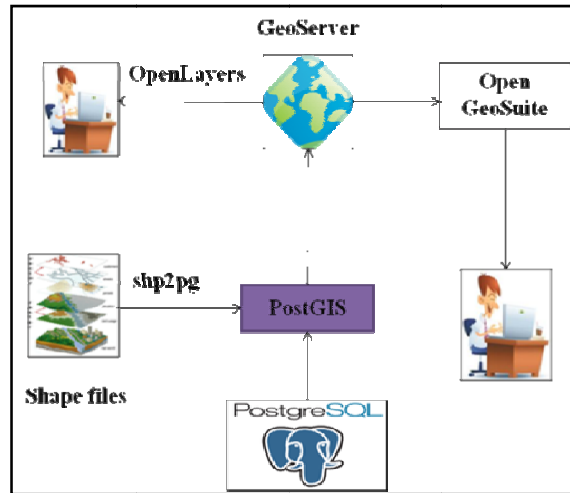


Fig. 1: Architecture of Project

Dijkstra's algorithm calculates the length of shortest route among all routes between two vertices included in a graph. The working of this algorithm has been explained using six steps.

- i. Choose search region providing set S of vertices and select source and destination vertices.
- ii. Initialize source node to zero which is solved and identify rest unsolved node connected to source node which is assumed as origin.
- iii. Calculate candidate distance by adding distance to the solved node and length of arc connecting between solved and unsolved nodes.
- iv. After that algorithm chooses smallest candidate distance.
- v. Then unsolved is changed into solved node.
- vi. If there will be tie in candidate distance, then choose arbitrary.
- vii. Repeat these steps with all unsolved node until the destination is reached.

This WebGIS based systems provides the information of specific areas between two points, source and destination, including sequence, node, edge, cost information.

A lots of work and research paper have been earlier done for optimize and planning route but there are fewer works has been done on the route finding problem. Route finding process can be designed using new methodologies. So, here this

research paper discussed and solved one of the problem of route finding. This paper has been focussed on the dynamically representing route on the basis of cost parameters using Dijkstra's algorithm. With the help of this routing, modification for various heuristics is made easily accessible. It also enhances and solved the problem described in earlier methodologies. This article also helps in creating a creating conceptual model for route finding and easily modification of various heuristics. In the next section, implementation of some previous has been explained.

2. LITERATURE REVIEW

To increase the performance of earlier route finding system and provide cost effective route, transport network based on multi modes and information system based on multi agent provides the solution of problem of human transport needs. A conceptual model has been designed to enhance the performance and accuracy of earlier implemented route finding system (Chiu et al., 2005). A new dynamic restricted algorithm based on direction and area has been developed for large network containing many nodes and arcs and provides benefits of using it by combining with other algorithm e.g. Dijkstra's algorithm (Xi et al., 2006). Introducing practical example of PgRouting on OpenStreetMap road network data provides an explanation of all steps including routing queries, cost assigning and modifying results (Kastl et al., 2009). An improved algorithm by extending PgRouting has been implemented to obtain the road conditions at the destination and provide emergency route decision planning by calculating travel time consumption of route on the basis of location and situations of accidents (Chosumrong et al., 2012). Complexity of road network and heavy traffic always tends to a big challenge for finding shortest path. Instead of these problems, a system has been designed for Colombo city to provide a shortest route for future date according to present road condition, traffic conditions, road closures etc. by using Geographic Information system (GIS), ASP.net and GPRS technology (Firdhous et al., 2012). PgRouting application in road and highway level provides a quick speed, fast execution and convenient operation for the shortest path finding application and wide application in optimizing path. On the basis of this absorption, it provides a benefit of travelling salesman problem solution and highway grade analysis (Zhang and He, 2012). Web based 3D indoor routing system on the OpenStreetMap datasets has been developed using new HTML (Hypertext Multiple Language) extension and XML3D (Extensible Markup Language) (Goetz, 2012). Comparing of different open source tools in the world of WebGIS provides different technical support, documentation and unique weighted professional services (Akbari and Peikar, 2014). PgRouting always provide good results with Dijkstra's algorithm. A comparison of performance of Dijkstra's shortest path calculation and Neo4j graph database for OpenStreetMap (OSM) dataset provides large transportation network based shortest path algorithm where memory is not an issue (Miler et

al., 2014). To avoid obstacles in road network and provide alternative route a web based GIS platform has been developed using modified Dijkstra's algorithm with PgRouting on the OpenStreetMap road network (Yusoff et al., 2014).

3. IMPLEMENTATION

This implementation used both PgRouting and Dijkstra's algorithm to find shortest path with dynamically changing cost (weight). Better emergency routing systems has been provided by PgRouting with Dijkstra's algorithm. In this implementation, two main modules and two user modules has been used. Main module consists of core module and Web module while user module consists of application user and admin user. Shortest path computation by connecting GeoServer with database created by PostgreSQL/PostGIS is carried out by core module. Web module makes it available over the web by providing user interface via OpenLayers. Application and admin user is carried out on the client side and accessed through the web simultaneously.

The implementation of shortest path with dynamically updating cost depends on the transport network consisting of nodes, links and routes. Here, The Prerequisites are windows 7, an editor like Gedit or Mouse pad, GeoServer for the routing application and Internet connection. Here we have used latest PostgreSQL9.2.5 with PostGIS 2.0.0. Cost has been dynamically calculated with the help of latest PgRouting 2.0.

Cost may be a factor of time, distance and lots of attributes. PL/pgSQL is a procedural language used for performing complex computations, functions and triggers procedures.

Table 1: Software Specifications

| Technology Used | Version | Function |
|---|---------|--|
| PostgreSQL | 9.2.5 | Database |
| PostGIS | 2.1.1 | Spatial Database |
| ArcGIS | 10.0 | Coordinate Transformation |
| PgRouting | 2.0.0 | Routing |
| Open JUMP | 1.2.1 | Client, desktop GIS |
| GeoServer | 2.3.4 | Visualization/Web based client mapping application |
| Firefox | 5.0 | Web browser |
| PL/PgSQL | | Procedural language |
| OpenGeo Suite (GeoExplorer) /OpenLayers | 2.4.5 | For user interface |

Dijkstra's algorithm with aided PgRouting functionality provides shortest path finder system with dynamically changing cost. With this aided functionality four parameters are added automatically which is source_id, target_id, directed and has_reverse_cost. Source_id indicates starting point while

target_id indicates destination point. There are two Boolean variables i.e. directed and has_reverse_cost. If first is true, then the graph tends to be directed. If latter is true, then reverse_cost used in opposite direction. The reverse_cost stores all the cost of traversal edge in reverse direction.

First of all, a database has been loaded from the project data directory. This directory contains Shapefile of Varanasi (city_road_project4) for small sized network data which is basically known as database dumps. After that Shapefile has been copied into bin folder of PostgreSQL. The Shapefile city_road_project4 has been converted into sql file with the help of shp2pgsql in command prompt. After importing the database dump, PostGIS and PgRouting functions has been added to a database. Small sized sample network data with minimum number of attributes has been also loaded, which is being downloaded from sample data website. The pgr_createTopology has been used to create a network topology through which source and target or destination Id has been assigned for the linkage of road with vertices within a certain tolerance. Before creating network topology, source and target column has been added and wait for a minutes to hour depending upon network size. There are two columns which is automatically added after creating network topology. One column is geography_columns containing table records providing "geometry" attribute with its SRID information and other is vertices_tmp containing a list of all vertices or nodes of network. Here wrapper functions are used to improve core functions and performance of system. After that, the result has been transformed into a readable format. The shortest path and their description of their attributes are shown in Fig. 2 using GeoServer.

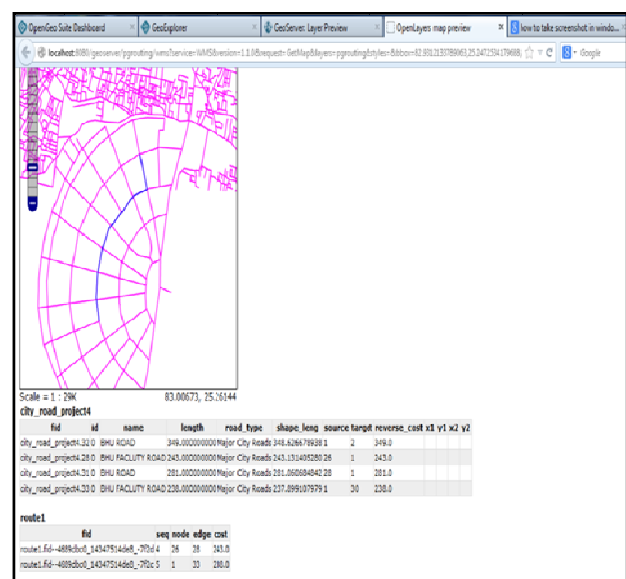


Fig. 2: Shortest path result and their details.

The result in QGIS can be visualized via DB Manager Plug-in by creating table route. A table has been created using query

by selecting source, target and length as cost. Source and target is taken as integer and length as double precision.

Fig. 3 shows the description of sequence, node, edge and cost of shortest path.

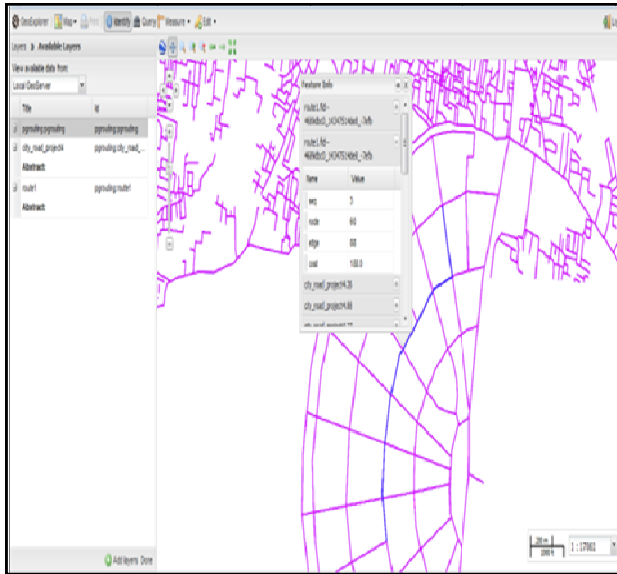


Fig. 3: Shortest path description using OpenGeo Suite (Geoexplorer).

Function output provides the description of vertex_id, edge_id and cost. The vertex_id enables the identifier of source and target vertex. The edge_id and cost contains identifier of crossed edge and cost of current edge.

4. CONCLUSIONS AND FUTURE WORK

With the increasing demand of routing application, this paper implements the used of PgRouting with Dijkstra's algorithm in Varanasi road network and proves a very efficient and convenient operation with dynamically updating cost. It is useful for traffic conditions, analyzing road conditions, Journey planner etc. It also expands and explores many routing functions used in PostgreSQL on the basis of three factors i.e. shortest, fastest, traffic free, alternative route in obstacles and natural route. The application has been implemented on web based platforms like GeoServer and Geoexplorer due to the high penetration of both technologies. It will create an added benefit at Varanasi city where traffic congestion is very high. On the technology based, we can develop one server named PyWPS and on that server we can implement PgRouting to find shortest path. The Future work will be development of web based system with enhanced

algorithm with comparatively low investment cost with increased processing and execution speed. High accuracy with good data quality in case of emergency response should be increased. Additional features e.g. future date, SMS, email alerts, hospitals, schools etc should be included.

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