

## PG ROUTING

pgRouting is a feature of the PostgreSQL database management system which offers geospatial routing capabilities. pgRouting utilizes the PostGIS extension, enabling geographic functionality in PostgreSQL. It provides multiple routing algorithms to determine paths on maps, considering factors like distance, cost, and obstacles.

Below are a few essential characteristics and capabilities of pgRouting:

1. **Methods for Determining Routes:** pgRouting offers various routing algorithms like Dijkstra, A\*, and Shooting-Star that are capable of addressing various routing scenarios like shortest route, driving distance, and others.
2. **Personalized Cost Functions:** Users have the option to create personalized cost functions that can impact routing choices by considering factors like travel duration, traffic situations, and road conditions.
3. **Limitations on Turns:** pgRouting includes support for turn restrictions, enabling a more accurate routing process by taking into account legal and physical limitations on specific maneuvers (e.g., no left turn).
4. **Distance Calculation:** The extension has the ability to determine distances for driving purposes starting from a specific point, aiding in defining service areas or catchment zones.
5. **Isochrones:** pgRouting is capable of producing isochrones, defining regions reachable within a specific time or distance from a given origin.
6. **Dynamic Segmentation:** With this function, roads can be divided into segments using different criteria, which is beneficial for thorough route analysis.
7. **Integration with PostGIS:** pgRouting utilizes the spatial functions and data types from PostGIS due to being developed on top of it, allowing for advanced geospatial analysis capabilities.
8. **Free Availability:** pgRouting is an open-source initiative, so it is freely accessible and can be altered and expanded by the public.

In general, pgRouting is a valuable tool for individuals working with geospatial data and requiring advanced routing features in a database.

## **Dijkstra Algorithm**

Dijkstra's algorithm is a popular algorithm used to find the shortest paths between nodes in a graph, which may represent, for example, road networks. It is a classic example of a greedy algorithm.

### ❖ Steps of Dijkstra's Algorithm

#### 1. Initialization:

- Start with a source node.
- Set the distance to the source node itself to 0 and to all other nodes to infinity.
- Create a priority queue to store nodes based on their tentative distances from the source.
- Mark all nodes as unvisited.

#### 2. Main Loop:

- While there are unvisited nodes:

1. Extract the node with the smallest tentative distance from the priority queue. This node is considered the "current node."

2. For the current node, consider all its unvisited neighbors. For each neighbor:

- Calculate the tentative distance from the source node by summing the current node's distance and the edge weight to the neighbor.

- If the calculated tentative distance of a neighboring node is less than its currently known distance, update the neighbor's distance and insert it into the priority queue.

3. Mark the current node as visited.

#### 3. Termination:

- The algorithm terminates when all nodes have been visited. The shortest paths from the source node to all other nodes are then known.

### ❖ Characteristics of Dijkstra's Algorithm

Greedy Approach: It always chooses the next node with the smallest known distance.

Optimality: It guarantees finding the shortest path from the source node to all other nodes in the graph.

Non-negative Weights: The algorithm assumes that all edge weights are non-negative.

Complexity

- Time Complexity
  - Space Complexity
- ❖ Usage with pgRouting

pgRouting extends PostgreSQL to provide geospatial routing capabilities, including Dijkstra's algorithm. You can utilize the `pgr_dijkstra` function to find the shortest path in a graph stored in a PostgreSQL database.

General Steps to Use pgRouting for Dijkstra's Algorithm

1. Prepare Your Data: Ensure your graph data is stored in a table with appropriate columns for source, target, and cost.
2. Run the Algorithm: Use the `pgr_dijkstra` function with a SQL query to extract the edges and specify the source and target nodes.

Input

- A SQL query to select edge data (id, source, target, cost).
- Source node ID.
- Target node ID.

Output:

- A set of rows representing the shortest path, including details such as the sequence of nodes and the total cost.

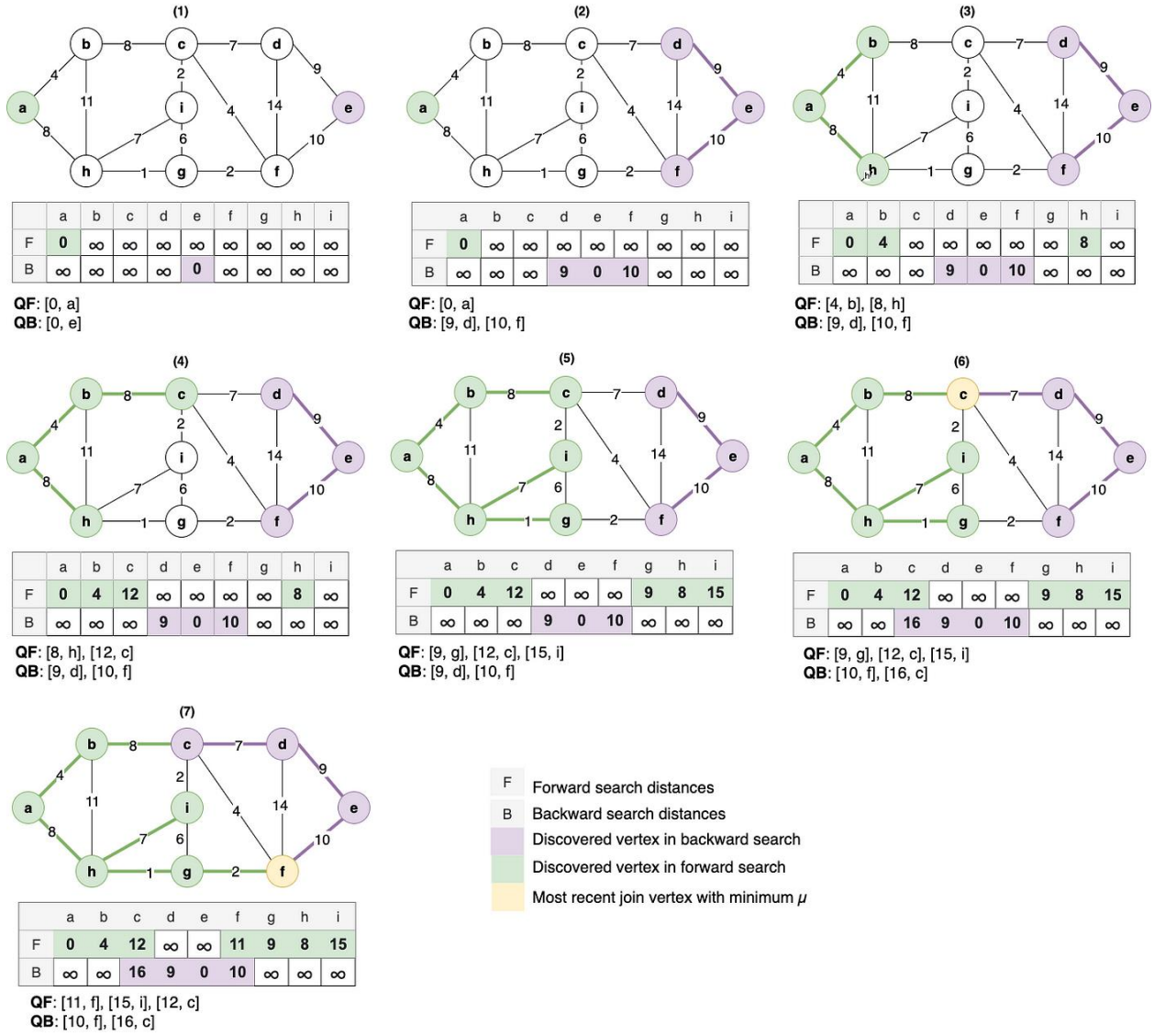


Figure 1: Dijkstra Algorithm

## Steps involved in Pgrouting for our mini-project:

Firstly, all the required files were downloaded and modified as listed or specified.

- osm2po is both, a converter and a routing engine. osm2po's converter parses OpenStreetMap's XML-Data and makes it routable.
- Other applications like java, PostGIS and QGIS were preinstalled.

Modification in Osm2po Config:

```
File Edit View
wtr.flaglist = car, bike, foot, rail, ferry, poly

# Only convert ways with these flags. If finalMask is not set,
# any flag is valid. However, a way with class<=0 or flags<=0 is invalid
# and will be ignored.
# -----
# !!!      MAJOR CHANGE IN 5.2.72      !!!
# -----
# Use "," instead of "|" to list alternatives.
# Use "&" instead of "&" for binary OR-operations.
# From now on complex masks like "bike|foot&goodgrade" must be written
# as "bike,foot|goodgrade, which is consequent and more intuitive!

wtr.finalMask = car,foot,bike
#wtr.finalMask = car,bike

# In some rare cases it can be useful to prevent Ways from being
# processed by the segmenter and to exclude them from the road network.
# Converting streets and polygons in one pass is such a case, but this
# should be avoided. Declare the corresponding indicator flag here.

wtr.polyMask = poly

# osm2po needs to know the anchor-tag and some default values if not tagged.
# To avoid ambiguities configure a well chosen priority.
# Main-Tag definitions. Params 1-4:
# 1) priority
# 2) class identifier (1-127)
# 3) default speed in kmh
# 4) flags (optional) - allowed transportation types

wtr.tag.highway.motorway =      1, 11, 120, car
wtr.tag.highway.motorway_link = 1, 12, 30, car
wtr.tag.highway.trunk =        1, 13, 90, car
wtr.tag.highway.trunk_link =   1, 14, 30, car
wtr.tag.highway.primary =      1, 15, 70, car
wtr.tag.highway.primary_link = 1, 16, 30, car
wtr.tag.highway.secondary =    1, 17, 60, car

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```

```
File Edit View

#####
#
# POSTPROCESSORS
#
#####

postp.0.class = de.osm2po.plugins.postp.PgRoutingWriter
#postp.0.writeMultilineStrings = true
#postp.1.class = de.osm2po.plugins.postp.PgVertexWriter
#postp.2.class = de.osm2po.plugins.postp.PgPolyWayWriter
#postp.3.class = de.osm2po.plugins.postp.PgPolyRelWriter

#postp.4.class = de.osm2po.postp.SndExtensionBuilder
#postp.5.class = de.osm2po.postp.UndExtensionBuilder
#postp.6.class = de.osm2po.postp.MigExtensionBuilder
#postp.6.id = 0
#postp.6.maxlevel = 3, 1.0

#postp.7.class = de.osm2po.sd.postp.3dGraphBuilder

# PgWriter usually create sql files. Enable the following
# parameter to redirect them to stdout (console) e.g.:

#postp.1.pipeOut = true

# Tip 1:
# If you want this program to be one link in a transformation chain
# e.g. curl | bcat | osm2po | psql
# you must set both, log.0.to-err and postp.0.pipeOut=true.
# log.0 is supposed to be a LogConsoleWriter.
# It is recommended to run curl, bcat and psql in silent/quiet mode.
# Example (one line):
# curl -s -L http://download.goeffabrik.de/europe/germany/hamburg-latest.osm.bz2 |
# bcat -c |
# java -jar osm2po-core.jar prefix=hh postp.0.pipeOut=true log.0.to-err
#          postp.0.class=de.osm2po.plugins.postp.PgRoutingWriter |
# psql -q -U myuser -s -d mydb

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```

After making the necessary modifications, we use **command prompt** to initialize our project.

The command used was:

```
C:\Windows\System32>java -jar D:\OSM2PO\osm2po-core-5.5.11-signed.jar cmd=c prefix=nepa D:\OSM2PO\nepal-latest.osm.pbf
```

This query initiated a process as:

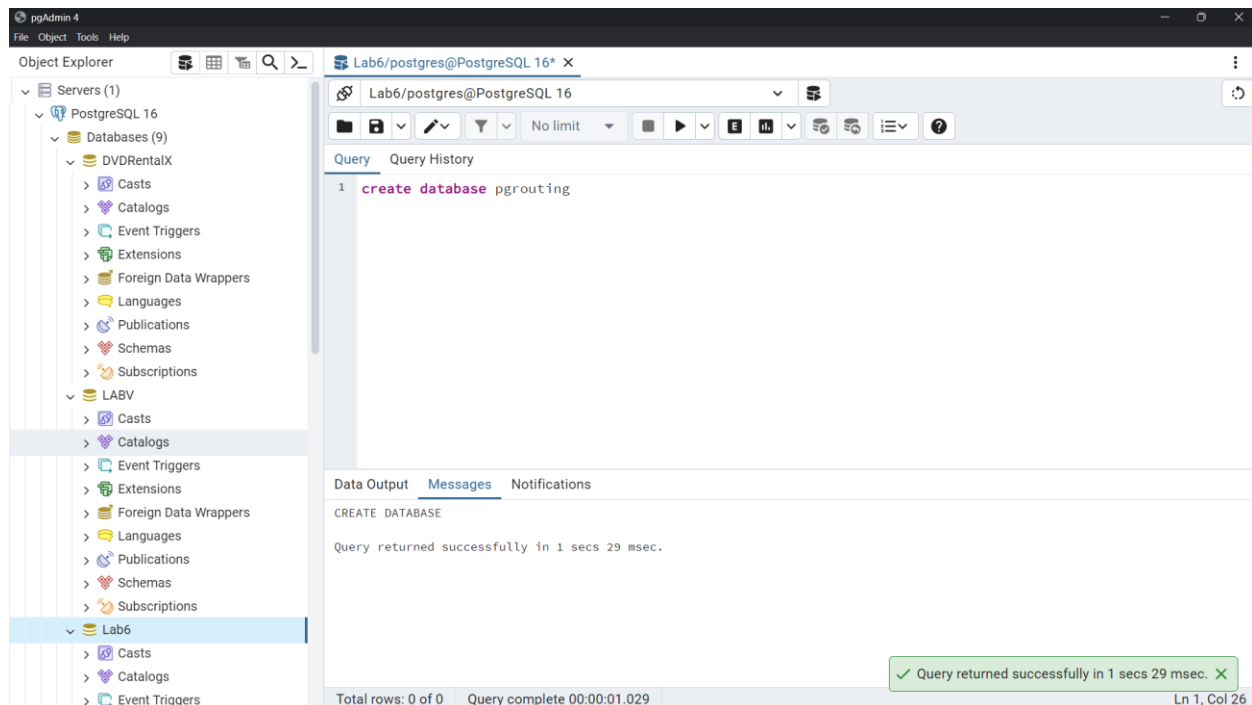
```
Administrator: Command Prompt
make copies, give exact copies of the original to anyone, distribute
it in its unmodified form via electronic means. You may not reverse
engineer, de-compile or disassemble it, rent, lease, lend or sell it.
This software is provided 'AS IS', without warranty of any kind,
so use it at your own risk.

INFO Reading Configuration from file:D:/OSM2PO/osm2po.config
INFO Plugin D:/OSM2PO/osm2po-plugins/osm2po-plugins-5.5.11.jar loaded
INFO Running osm2po-5.5.11 with cmd-tidy - 3,553M
INFO Java 1.8.0.411 (Oracle Corporation)
INFO Starting Tiler at Tue Jun 11 21:40:18 NPT 2024
INFO Reading from file:D:/OSM2PO/nepal-latest.osm.pbf
INFO File last modified at Mon Jun 10 21:19:43 NPT 2024
INFO Using parser de.cm.osm2po.plugins.parser.OsmPbfParser
INFO TileSize is 10x10 with a buffer of 1.0 - Prefilter is ON
INFO 67,239,327 of 67,239,327 nodes extracted - 3,523M
INFO 209,514 of 9,149,673 ways extracted - 3,150M
INFO 89 of 18,856 relations extracted - 3,108M
INFO Building set of referenced NodeIds
INFO Postprocessing 6,203,484 referenced nodes
INFO 6,203,484 nodes tiled.
INFO Tiler finished at Tue Jun 11 21:40:52 NPT 2024
INFO Starting Joiner at Tue Jun 11 21:40:52 NPT 2024
INFO Caching relations from tr_raw.2po - 3,528M
INFO 89 of 89 relations cached - 3,528M
INFO 6,203,484 of 6,203,484 nodes cached (N020E080) - 3,448M
INFO 404,323 of 404,323 nodes cached (N030E080) - 3,424M
INFO 209,514 of 209,514 ways read, 209,514 written
INFO Total 209,510 tiled, 4 shared
INFO 209,514 of 209,514 ways resolved.
INFO Joiner finished at Tue Jun 11 21:40:55 NPT 2024
INFO Starting Segmenter at Tue Jun 11 21:40:55 NPT 2024
INFO 571 of 571 WayNodes cached (SHARED) - 3,529M
INFO 6,187,394 of 6,463,135 WayNodes cached (N020E080) - 2,915M
INFO 209,320 ways analyzed, 397,169 segments created (N020E080) - 3,122M
INFO 330,748 vertices of 6,187,394 nodes written - 3,097M
INFO 15,517 of 15,717 WayNodes cached (N030E080) - 3,521M
INFO 190 ways analyzed, 241 segments created (N030E080) - 3,521M
INFO 231 vertices of 15,517 nodes written - 3,521M
INFO 4 ways analyzed, 4 segments created (SHARED) - 3,521M
INFO 8 vertices of 571 nodes written - 3,521M
INFO Segmenter finished at Tue Jun 11 21:40:57 NPT 2024
INFO Starting PostProcessor[0] at Tue Jun 11 21:40:57 NPT 2024
INFO de.cm.osm2po.plugins.postp.PgRoutingWriter
INFO Creating sql file nepa\nepa_2po_4pgr.sql
INFO 397,414 Segments written.
INFO commandline template:
psql -U [username] -d [dbname] -q - "C:\Windows\System32\nepa\nepa_2po_4pgr.sql"
INFO PostProcessor finished at Tue Jun 11 21:41:02 NPT 2024
INFO Config closed at 240611-21:41:02654

C:\Windows\System32>
```

The red filter gives the final save location.

Once they have been saved and located, we use pgadmin to create database and load extensions  
pgrouting and postgis to create a table as:



pgAdmin 4

File Object Tools Help

Object Explorer

- FTS Configurations
- FTS Dictionaries
- FTS Parsers
- FTS Templates
- Foreign Tables
- Functions
- Materialized Views
- Operators
- Procedures
- Sequences
- Tables (1)
  - spatial\_ref\_sys
    - Columns (5)
    - Constraints
    - Indexes
    - RLS Policies
    - Rules
    - Triggers
  - Trigger Functions (2)
    - checkauthtrigger()
    - postgis\_cache\_bbox()
  - Types
  - Views
  - Subscriptions
  - postgis\_34\_aashish
  - postgis\_34\_sample
  - postgres

pgrouting/postgres@PostgreSQL 16\*

Query

```
1 create extension pgrouting
2
```

Query History

Scratch Pad

Data Output Messages Notifications

CREATE EXTENSION

Query returned successfully in 125 msec.

✓ Query returned successfully in 125 msec. ✕

Total rows: 0 of 0 Query complete 00:00:00.125 Ln 2, Col 1

pgAdmin 4

File Object Tools Help

Object Explorer

- Foreign Tables
- Functions
- Materialized Views
- Operators
- Procedures
- Sequences
- Tables (2)
  - nepa\_2po\_4pgr
  - spatial\_ref\_sys
    - Columns
    - Constraints
    - Indexes
    - RLS Policies
    - Rules
    - Triggers
  - Trigger Functions (2)
  - Types
  - Views
  - Subscriptions
  - postgis\_34\_aashish
  - postgis\_34\_sample
  - postgres
  - sdhms\_16
  - Login/Group Roles
  - Tablespaces (2)
    - pg\_default

pgrouting/postgres@PostgreSQL 16\*

public.nepa\_2po\_4pgr

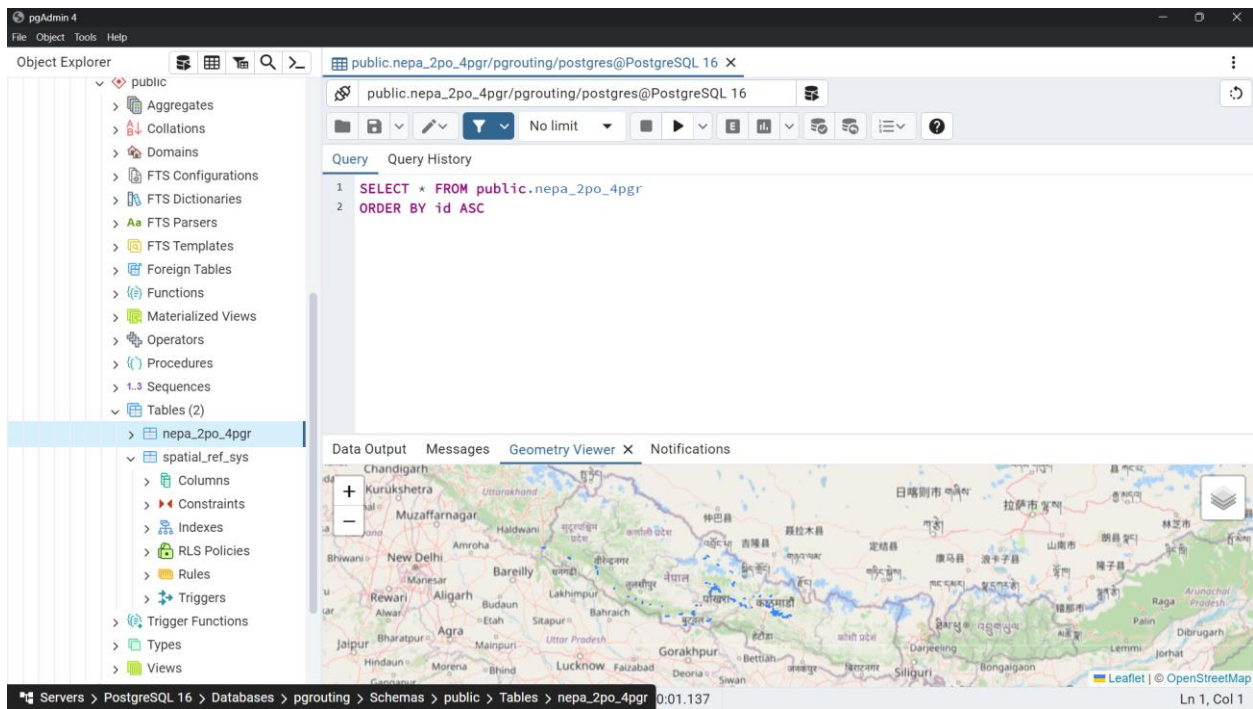
Query

```
1 -- Created by : osm2po-core
2 -- Version : 5.5.11
3 -- Author (c) : Carsten Moeller - info@osm2po.de
4 -- Date : Tue Jun 11 21:40:57 NPT 2024
5
6 SET client_encoding = 'UTF8';
7
8 DROP TABLE IF EXISTS nepa_2po_4pgr;
9 -- SELECT DropGeometryTable('nepa_2po_4pgr');
10
11 CREATE TABLE nepa_2po_4pgr(id integer, osm_id bigint, osm_name character varying, osm_meta character vary
12 SELECT AddGeometryColumn('nepa_2po_4pgr', 'geom_way', 4326, 'LINESTRING', 2);
13
14 INSERT INTO nepa_2po_4pgr VALUES
15 (1, 4825621, 'F26', NULL, 38921333, 3514581859, 15, 1, 9, 101850, 0.1079428, 70, 0.001542, 0.001542, 85.3
16 (2, 4825621, 'F26', NULL, 3514581859, 2169105896, 15, 1, 101850, 15596, 0.0772315, 70, 0.0011033, 0.00110
17 (3, 4825621, 'F26', NULL, 2169105896, 1280107732, 15, 1, 15596, 2774, 0.1806001, 70, 0.00258, 0.00258, 85
18 (4, 4825621, 'F26', NULL, 1280107732, 38921343, 15, 1, 2774, 10, 0.0063166, 70, 9.02E-5, 9.02E-5, 85.3828
19 (5, 4825630, 'कान्ति पथ', NULL, 31019141, 2126598729, 15, 1, 11, 116870, 0.1594507, 70, 0.0022779, 1000000.
20 (6, 4825630, 'कान्ति पथ', NULL, 2126598729, 1273136891, 15, 1, 116870, 12, 0.0061812, 70, 8.83E-5, 1000000.
21 (7, 4825671, 'यावही सादक', NULL, 268301866, 4723674796, 31, 3, 13, 14, 0.10744, 40, 0.002686, 1000000.0, 8
22 (8, 4839933, NULL, NULL, 7070924827, 3339466444, 43, 3, 15, 16, 0.0372763, 50, 7.455E-4, 1000000.0, 85.35
23 (9, 4839936, NULL, NULL, 5477725560, 31147572, 14, 1, 17, 18, 0.0527257, 30, 0.0017575, 1000000.0, 85.353
24 (10, 4839958, NULL, NULL, 31147586, 31147591, 14, 1, 19, 20, 0.0392227, 30, 0.0013074, 1000000.0, 85.3532
25 (11, 4840030, 'बनौसपुतली मार्ग', NULL, 4879891022, 2201363919, 21, 1, 21, 11745, 0.1545999, 60, 0.0025767, 0.
26 (12, 4840030, 'बनौसपुतली मार्ग', NULL, 2201363919, 1835392411, 21, 1, 11745, 8831, 0.1160054, 60, 0.0019334
```

Query History

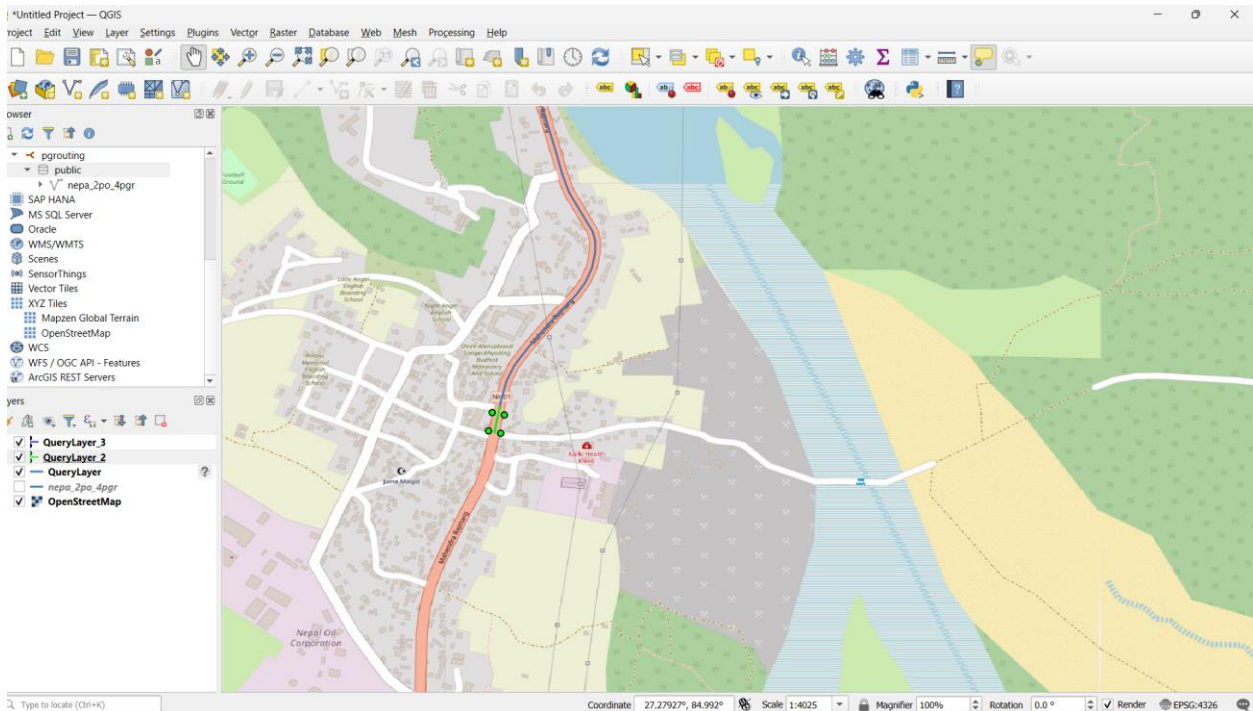
Ln 8, Col 18



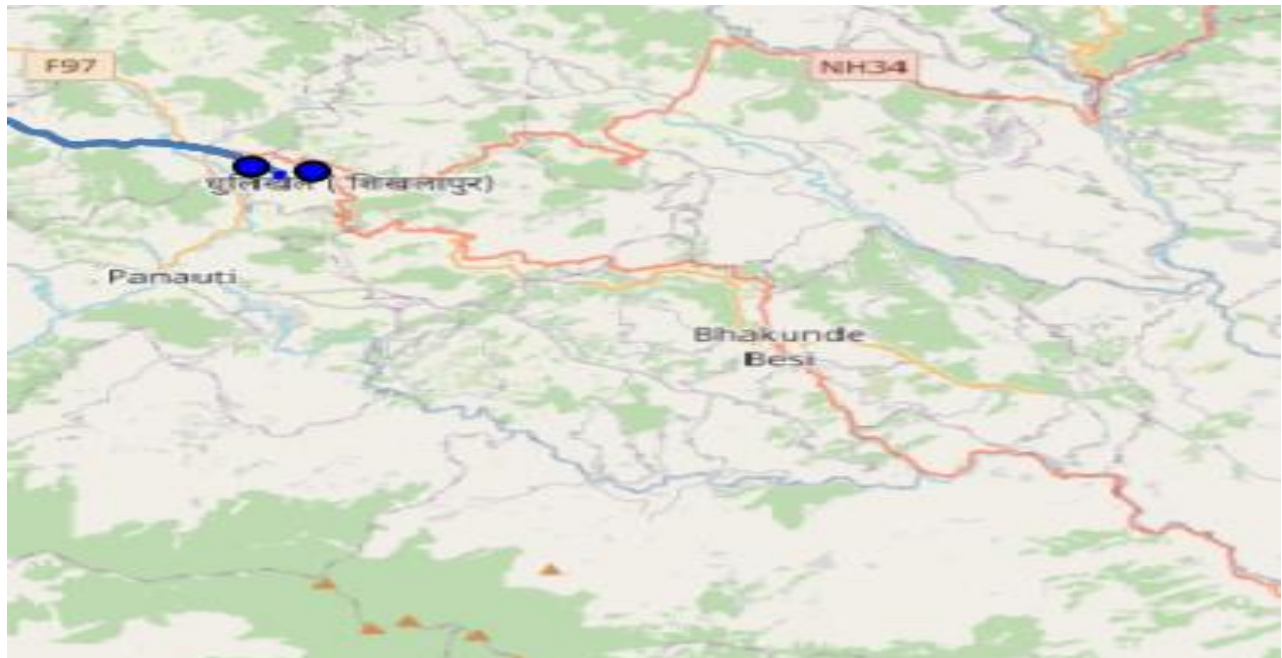


Once all the tables are created, we now perform pg routing by connecting it to QGIS.

The start point specified was Mahendra Highway:



The end point was specified upto the gate of Kathmandu University as:



The query used were:

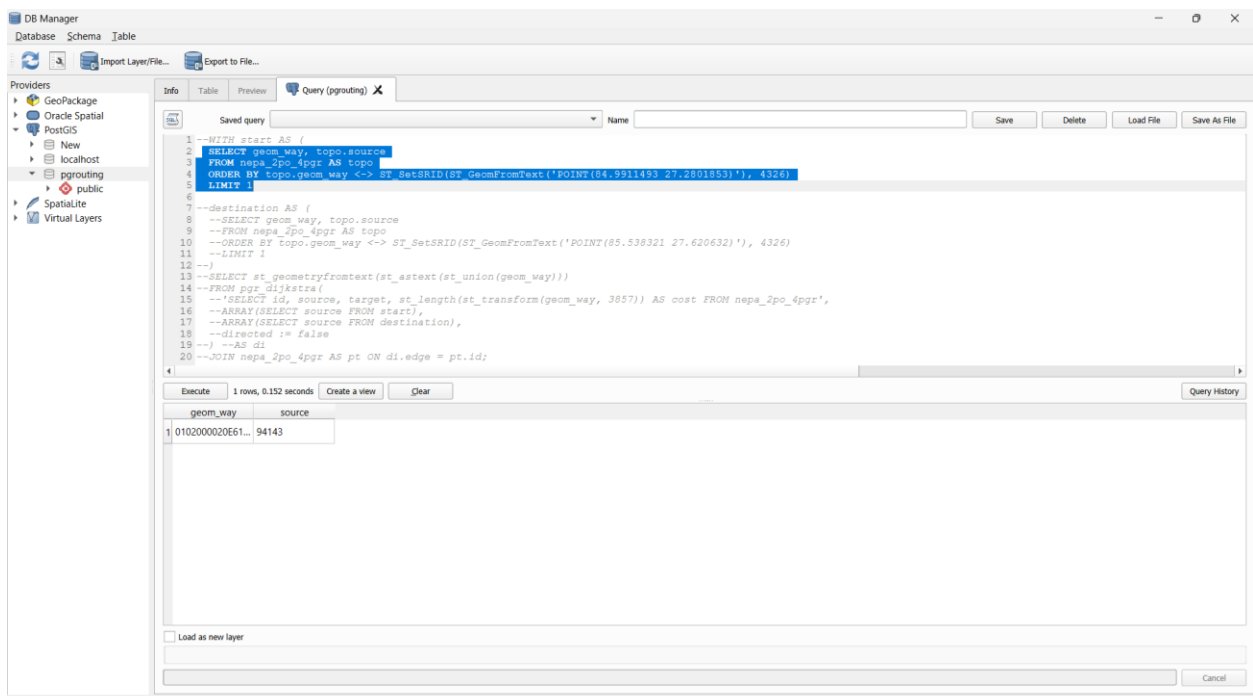


Figure 2: Source Point

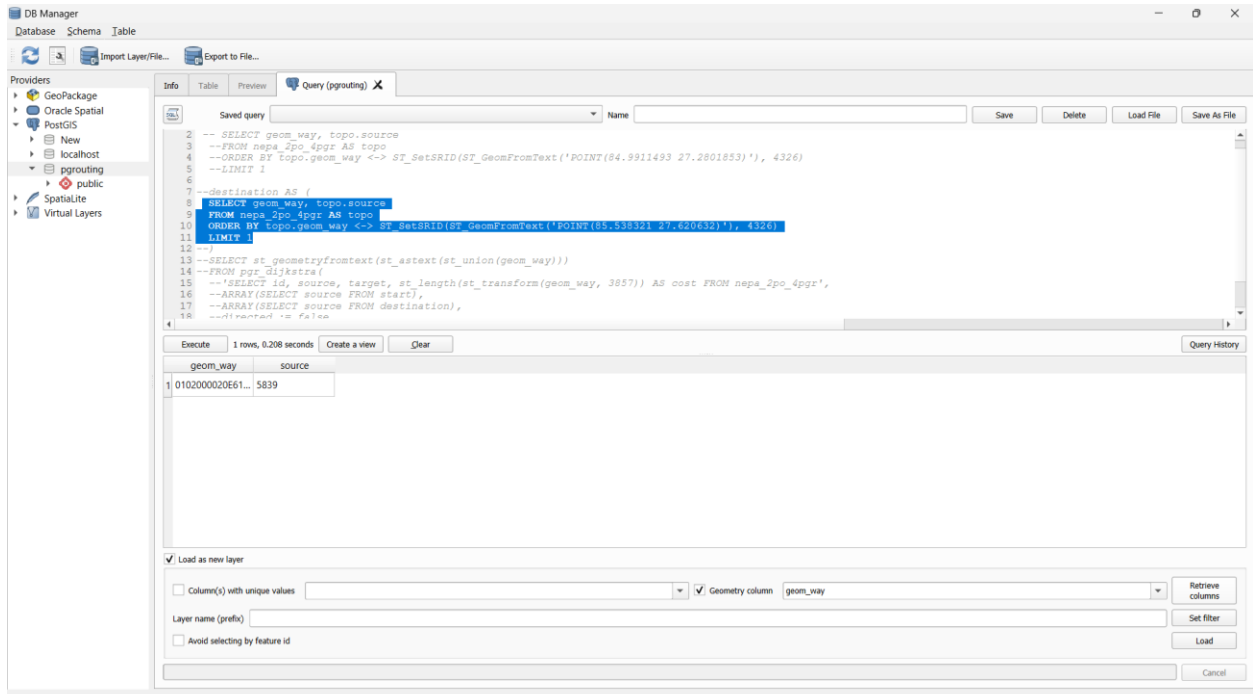


Figure 3: Destination Point

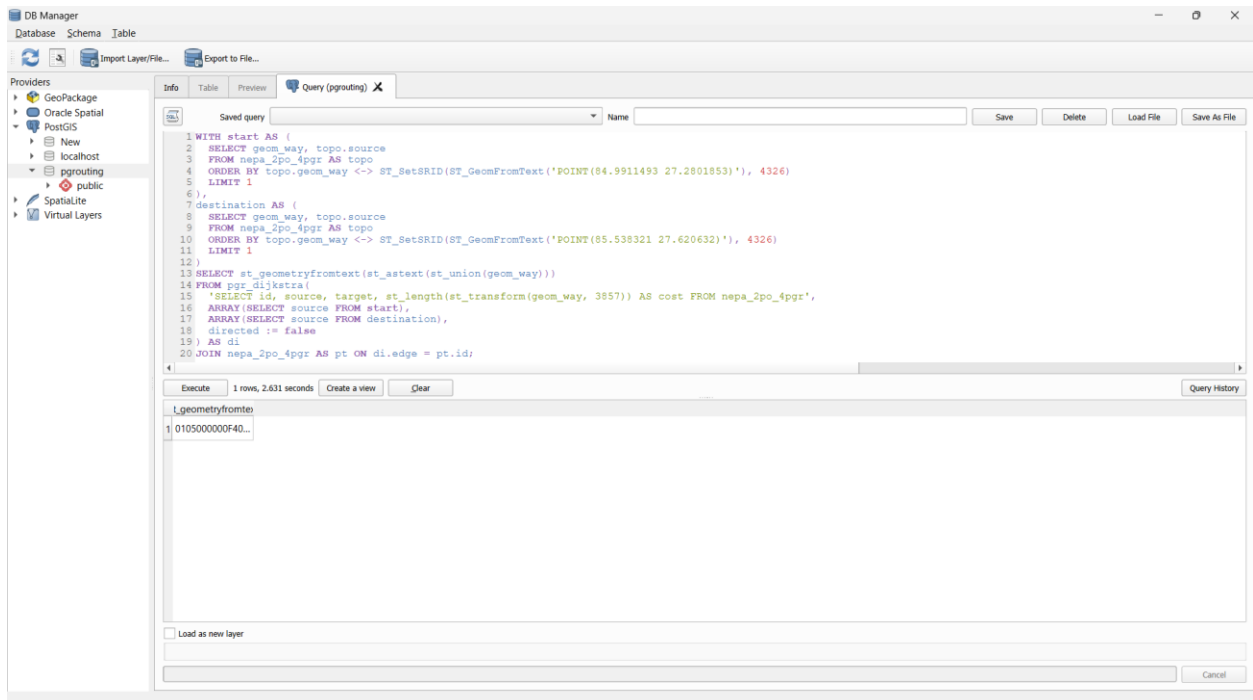
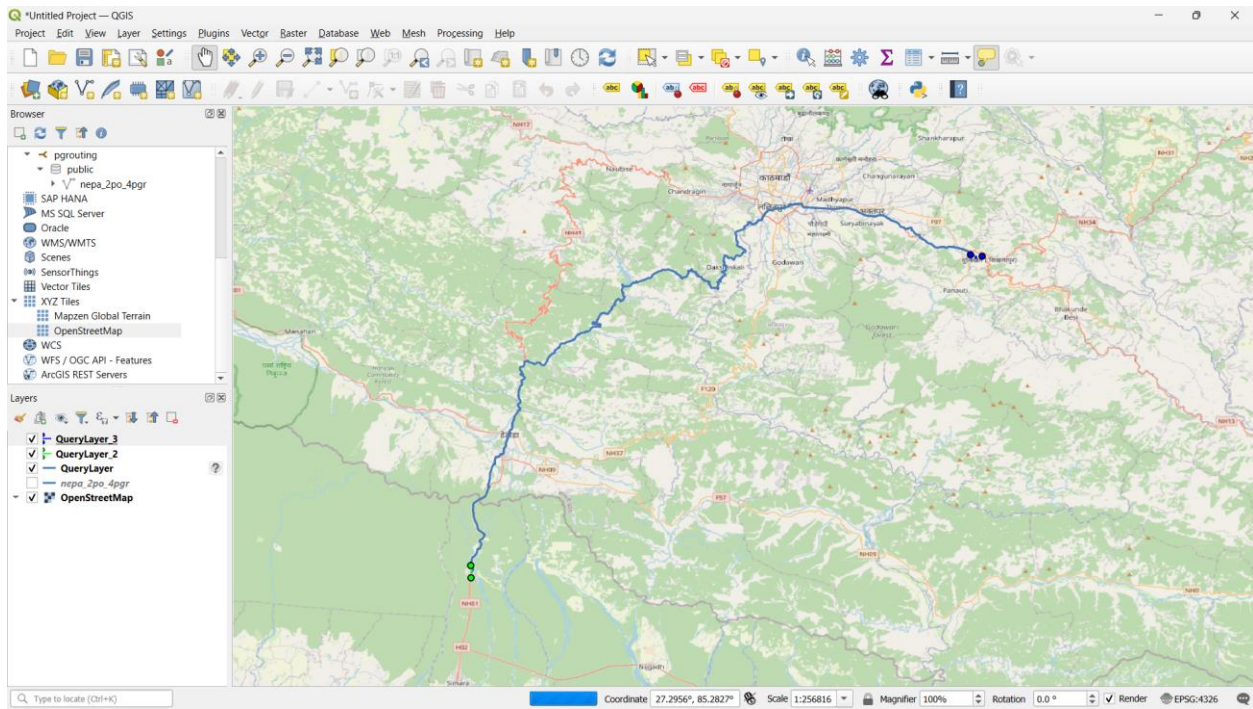


Figure 4: Main Query



**Figure 5: Shortest Route from Mahendra Rajmarga to Kathmandu University**