
Workshop - FOSS4G routing with pgRouting tools, OpenStreetMap road data and GeoExt Manual

Release 1

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INTRODUCTION

Abstract

[pgRouting](#) adds routing functionality to [PostGIS](#). This introductory workshop will show you how. It gives a practical example of how to use [pgRouting](#) with [OpenStreetMap](#) road network data. It explains the steps to prepare the data, make routing queries, assign costs and use [GeoExt](#) to show your route in a web-mapping application.

Navigation for road networks requires complex routing algorithms that support turn restrictions and even time-dependent attributes. [pgRouting](#) is an extendible open-source library that provides a variety of tools for shortest path search as extension of PostgreSQL and PostGIS. The workshop will explain about shortest path search with [pgRouting](#) in real road networks and how the data structure is important to get faster results. Also you will learn about difficulties and limitations of [pgRouting](#) in GIS applications.

To give a practical example the workshop makes use of OpenStreetMap data of Barcelona. You will learn how to convert the data into the required format and how to calibrate the data with “cost” attributes. Furthermore we will explain the difference of the main routing algorithms “Dijkstra”, “A-Star” and “Shooting-Star”. By the end of the workshop you will have a good understanding of how to use [pgRouting](#) and how to get your network data prepared.

To learn how to get the output from rows and columns to be drawn on a map, we will build a basic map GUI with [GeoExt](#). We listened to the students feedback of the last year’s and want to guide you through the basic steps to build a simple browser application. Our goal is to make this as easy as possible, and to show that it’s not difficult to integrate with other FOSS4G tools. For that reason we selected [GeoExt](#), which is a JavaScript library providing the groundwork for creating web-mapping applications based on [OpenLayers](#) and [Ext](#).

Note:

- Workshop level: intermediate
- Attendee’s previous knowledge: SQL (PostgreSQL, PostGIS), Javascript, HTML
- Equipments: This workshops will make use of the GIS LiveDVD if possible. Otherwise it will require VirtualBox installed to load a virtual machine image.

Presenter

- *Daniel Kastl* is founder and CEO of [Georepublic UG](#) and works in Germany and Japan. He is moderating and promoting the [pgRouting](#) community and development since 4 years, and he’s an active OSM contributor in Japan.
- *Frédéric Junod* works at the Swiss office of [Campnocamp](#) for about five years. He’s an active developer of many open source GIS projects from the browser ([GeoExt](#), [OpenLayers](#)) to the server world ([MapFish](#), [Shapely](#), [TileCache](#)) and he is member of the [pgRouting](#) PSC.

Daniel and Frédéric are the authors of the previous [pgRouting](#) workshops, that have been held at FOSS4G events in Canada and South Africa and at local conferences in Japan.

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ABOUT

Todo

introduction paragraph for about

2.1 pgRouting

pgRouting is an extension of PostGIS and adds routing functionality to PostGIS/PostgreSQL. pgRouting is a further development of pgDijkstra (by [Camptocamp SA](#)). It was extended by [Orkney Inc.](#), and is currently developed and maintained by [Georepublic](#).

pgRouting provides functions for:

- Shortest Path Dijkstra: routing algorithm without heuristics
- Shortest Path A-Star: routing for large datasets (with heuristics)
- Shortest Path Shooting-Star: routing with turn restrictions (with heuristics)
- Traveling Salesperson Problem (TSP)
- Driving Distance calculation (Isolines)

Advantages of the database routing approach are:

- Accessible by multiple clients through JDBC, ODBC, or directly using PL/pgSQL. The clients can either be PCs or mobile devices.
- Uses PostGIS for its geographic data format, which in turn uses OGC's data format Well Known Text (WKT) and Well Known Binary (WKB). This allows usage of existing open * data converters.
- Open Source software like qGIS and uDig can modify the data/attributes,
- Data changes can be reflected instantaneously through the routing engine. There is no need for precalculation.
- The "cost" parameter can be dynamically calculated through SQL and its value can come from multiple fields or tables.

pgRouting project website: <http://www.pgrouting.org>

2.2 OpenStreetMap

"OpenStreetMap is a project aimed squarely at creating and providing free geographic data such as street maps to anyone who wants them." "The project was started because most maps you think of as free actually have legal or technical restrictions on their use, holding back people from using them in creative, productive or unexpected ways." <http://wiki.openstreetmap.org/index.php/Press>

OpenStreetMap uses a topological data structure:

- Nodes are points with a geographic position.
- Ways are lists of nodes, representing a polyline or polygon.
- Relations are groups of nodes, ways and other relations which can be assigned certain properties.
- Tags can be applied to nodes, ways or relations and consist of name=value pairs.
- This is how nodes, ways and relations are described in the OpenStreetMap XML file:

```
<?xml version='1.0' encoding='UTF-8'?>
<osm version='0.6' generator='xapi: OSM Extended API 2.0' ... >
  ...
  <node id='255405560' lat='41.4917468' lon='2.0257695' version='1'
        changeset='19117' user='efrainlarrea' uid='32823' visible='true'
        timestamp='2008-04-02T17:40:07Z'>
  </node>
  <node id='255405551' lat='41.4866740' lon='2.0302842' version='3'
        changeset='248452' user='efrainlarrea' uid='32823' visible='true'
        timestamp='2008-04-24T15:56:08Z'>
  </node>
  <node id='255405552' lat='41.4868540' lon='2.0297863' version='1'
        changeset='19117' user='efrainlarrea' uid='32823' visible='true'
        timestamp='2008-04-02T17:40:07Z'>
  </node>
  ...
  <way id='35419222' visible='true' timestamp='2009-06-03T21:49:11Z'
        version='1' changeset='1416898' user='Yodeima' uid='115931'>
    <nd ref='415466914' />
    <nd ref='415466915' />
    <tag k='highway' v='unclassified' />
    <tag k='lanes' v='1' />
    <tag k='name' v='Carrer del Progrés' />
    <tag k='oneway' v='no' />
  </way>
  <way id='35419227' visible='true' timestamp='2009-06-14T20:37:55Z'
        version='2' changeset='1518775' user='Yodeima' uid='115931'>
    <nd ref='415472085' />
    <nd ref='415472086' />
    <nd ref='415472087' />
    <tag k='highway' v='unclassified' />
    <tag k='lanes' v='1' />
    <tag k='name' v='carrer de la mecanica' />
    <tag k='oneway' v='no' />
  </way>
  ...
  <relation id='903432' visible='true' timestamp='2010-05-06T08:36:54Z'
        version='1' changeset='4619553' user='ivansanchez' uid='5265'>
    <member type='way' ref='56426179' role='outer' />
    <member type='way' ref='56426173' role='inner' />
    <tag k='layer' v='0' />
    <tag k='leisure' v='common' />
    <tag k='name' v='Plaça Can Suris' />
    <tag k='source' v='WMS shagrat.icc.cat' />
    <tag k='type' v='multipolygon' />
  </relation>
  ...
</osm>
```

The OSM data can be downloaded from OpenStreetMap website using an API (currently v0.6, see http://wiki.openstreetmap.org/index.php/OSM_Protocol_Version_0.6), or with some OSM tools like JOSM editor for example.

Also [CloudMade](http://download.cloudmade.com/europe/spain) offers extracts of maps from different places around the world. For data for Barcelona for example go to <http://download.cloudmade.com/europe/spain> and download:


```
wget http://download.cloudmade.com/europe/spain/spain.osm.bz2
```

2.3 osm2pgrouting

When using the osm2pgrouting converter (see later), we take only nodes and ways of types and classes specified in “mapconfig.xml” file to be converted to pgRouting table format:

```
<?xml version="1.0" encoding="UTF-8"?>
<configuration>
  <type name="highway" id="1">
    <class name="motorway" id="101" />
    <class name="motorway_link" id="102" />
    <class name="motorway_junction" id="103" />
    ...
    <class name="road" id="100" />
  </type>
  <type name="junction" id="4">
    <class name="roundabout" id="401" />
  </type>
</configuration>
```

Detailed description of all possible types and classes can be found here:
http://wiki.openstreetmap.org/index.php/Map_features.

For Cape Town the OpenStreetMap data is very comprehensive with many details. A compilation of the greater Cape Town area created with JOSM is available as capetown_20080829.osm.

2.4 GeoExt

Todo

GeoExt paragraph

INSTALLATION AND REQUIREMENTS

OSM2PGRROUTING IMPORT TOOL

This tool makes it easy to import OpenStreetMap data and use it with pgRouting. It creates topology automatically and creates tables for feature types and road classes. osm2pgrouting was primarily written by Daniel Wendt and is now hosted on the pgRouting project site: <http://pgrouting.postlbs.org/wiki/tools/osm2pgrouting>

How to install (Ubuntu 8.04)

Check out the latest version from SVN repository:

```
svn checkout http://pgrouting.postlbs.org/svn/pgrouting/tools/osm2pgrouting/trunk osm2pgrouting
```

Required packages/libraries:

1. PostgreSQL
2. PostGIS
3. pgRouting
4. Boost library
5. Expat library
6. libpq library

Note: if you already compiled pgRouting point 1. to 4. should already be installed.

Then compile

```
cd osm2pgrouting make
```

How to use

1. First you need to create a database and add PostGIS and pgRouting functions:

```
createdb -U postgres osm
createuser -U postgres plpgsql osm
```

```
psql -U postgres -f /usr/share/postgresql-8.3-postgis/lwpostgis.sql osm
psql -U postgres -f /usr/share/postgresql-8.3-postgis/spatial_ref_sys.sql osm
```

```
psql -U postgres -f /usr/share/postgresql-8.3-postgis/routing_core.sql osm
psql -U postgres -f /usr/share/postgresql-8.3-postgis/routing_core_wrappers.sql osm
psql -U postgres -f /usr/share/postgresql-8.3-postgis/routing_topology.sql osm
```

2. You can define the features and attributes to be imported from the OpenStreetMap XML file in the configuration file (default: mapconfig.xml)

1. Open a terminal window and run osm2pgrouting with the following parameters

```
./osm2pgrouting -file /home/foss4g/capetown_20080829.osm -conf mapconfig.xml -dbname osm -user postgres -clean
```

Other available parameters are:

- **required:**

-file <file> – name of your osm xml file

-dbname <dbname> – name of your database **-user** <user> – name of the user, which have write access to the database **-conf** <file> – name of your configuration xml file

- **optional:**

-host <host> – host of your postgresql database (default: 127.0.0.1)

-port <port> – port of your database (default: 5432)

-passwd <passwd> – password for database access **-clean** – drop previously created tables

1. Connect to your database and see the tables that have been created

```
psql -U postgres osm
```

List of relations

Schema | Name | Type | Owner

public	classes	table	postgres	public	geometry_columns	table						
postgres	public	nodes	table	postgres	public	spatial_ref_sys	table	postgres	public	types	table	
postgres	public	vertices_tmp	table	postgres	public	vertices_tmp_id_seq	sequence	postgres	public	ways	table	postgres

(8 rows) Note: If tables are missing you might have forgotten to add PostGIS or pgRouting functions to your database.

Let's do some more advanced routing with those extra information about road types and road classes.

LOAD YOUR NETWORK DATA AND CREATE A NETWORK TOPOLOGY

Some network data already comes with a network topology that can be used with pgRouting immediately. But usually the data is in a different format than we need for pgRouting. Often network data is stored in the Shape file format (.shp) and we can use PostGIS' shape2pgsql converter to import the data into the database. OpenStreetMap stores its data as XML and it has its own importing tools for PostgreSQL database.

Later we will use the osm2pgrouting converter. But it does much more than the basic steps for simple routing, so we will start this workshop with the minimum required attributes.

5.1 Load the network data

After creating the workshop database and adding the PostGIS and pgRouting functions to this database (see previous chapter), we load the sample data to our database:

```
psql -U postgres routing
\i /home/foss4g/ways_without_topology.sql
```

Note: The SQL dump file was made from a database which already had PostGIS functions loaded, so it will report errors during import that these functions already exist. You can ignore these errors.

Let's see which tables have been created:

```
\d
```

```

              List of relations
Schema |      Name      | Type | Owner
-----+-----+-----+-----
public | geometry_columns | table | postgres
public | spatial_ref_sys  | table | postgres
public | ways             | table | postgres
(3 rows)
```

```
\d ways
```

```

          Table "public.ways"
   Column   |      Type      | Modifiers
-----+-----+-----
gid         | integer        | not null
length      | double precision |
name        | character(200)  |
the_geom    | geometry        |
Indexes:
    "ways_pkey" PRIMARY KEY, btree (gid)
```

Check constraints:

```
"enforce_dims_the_geom" CHECK (ndims(the_geom) = 2)
"enforce_geotype_the_geom" CHECK (geometrytype(the_geom) =
                                'MULTILINESTRING'::text OR the_geom IS NULL)
"enforce_srid_the_geom" CHECK (srid(the_geom) = 4326)
```

Create network topology

Having your data imported into a PostgreSQL database usually requires one more step for pgRouting. You have to make sure that your data provides a correct network topology, which consists of links with source and target ID each.

If your network data doesn't have such network topology information already you need to run the "assign_vertex_id" function. This function assigns a source and a target ID to each link and it can "snap" nearby vertices within a certain tolerance.:

```
assign_vertex_id('<table>', float tolerance, '<geometry column>', '<gid>')
```

First we have to add source and target column, then we run the assign_vertex_id function ... and wait.:

```
ALTER TABLE ways ADD COLUMN source integer;
ALTER TABLE ways ADD COLUMN target integer;
SELECT assign_vertex_id('ways', 0.00001, 'the_geom', 'gid');
```

Warning: The dimension of the tolerance parameter depends on your data projection. Usually it's either "degrees" or "meters". Because OSM data has a very good quality for Cape town we can choose a very small "snapping" tolerance: 0.00001 degrees

5.2 Add indices

Fortunately we didn't need to wait too long because the data is small. But your network data might be very large, so it's a good idea to add an index on source, target and geometry column.:

```
CREATE INDEX source_idx ON ways(source);
CREATE INDEX target_idx ON ways(target);
CREATE INDEX geom_idx ON ways USING GIST(the_geom GIST_GEOMETRY_OPS);
```

After these steps our routing database look like this:

```
\d
```

```

              List of relations
Schema |          Name          |  Type   | Owner
-----+-----+-----+-----
public | geometry_columns      | table   | postgres
public | spatial_ref_sys       | table   | postgres
public | vertices_tmp          | table   | postgres
public | vertices_tmp_id_seq   | sequence | postgres
public | ways                  | table   | postgres
(5 rows)
```

```
\d ways
```

```

          Table "public.ways"
   Column   |      Type      | Modifiers
-----+-----+-----
gid         | integer        | not null
length     | double precision |

```



```
name      | character(200) |
the_geom  | geometry       |
source    | integer        |
target    | integer        |
```

Indexes:

```
"ways_pkey" PRIMARY KEY, btree (gid)
```

Check constraints:

```
"enforce_dims_the_geom" CHECK (ndims(the_geom) = 2)
```

```
"enforce_geotype_the_geom" CHECK (geometrytype(the_geom) =  
                                'MULTILINESTRING'::text OR the_geom IS NULL)
```

```
"enforce_srid_the_geom" CHECK (srid(the_geom) = 4326)
```

Now we are ready for routing with Dijkstra algorithm!

SHORTEST PATH SEARCH

Todo

Add chapter introduction for Shortest Path Search

6.1 Dijkstra algorithm

Dijkstra algorithm was the first algorithm implemented in pgRouting. It doesn't require more attributes than source and target ID, and it can distinguish between directed and undirected graphs. You can specify if your network has "reverse cost" or not.

```
shortest_path( sql text,
               source_id integer,
               target_id integer,
               directed boolean,
               has_reverse_cost boolean )
```

Note:

- Source and target IDs are vertex IDs.
- Undirected graphs ("directed false") ignores "has_reverse_cost" setting
- Shortest Path Dijkstra core function

6.1.1 Core

Each algorithm has its core function (implementation), which is the base for its wrapper functions.

```
SELECT * FROM shortest_path('
    SELECT gid as id,
           source::integer,
           target::integer,
           length::double precision as cost
    FROM ways',
    10, 20, false, false);
```

vertex_id	edge_id	cost
10	293	0.0059596293824534
9	4632	0.0846731039249787
3974	4633	0.0765635090514303
2107	4634	0.0763951531894937
...
20	-1	0

(63 rows)

6.1.2 Wrapper

Wrapper WITHOUT bounding box

Wrapper functions extend the core functions with transformations, bounding box limitations, etc.. Wrappers can change the format and ordering of the result. They often set default function parameters and make the usage of pgRouting more simple.

```
SELECT gid, AsText(the_geom) AS the_geom
FROM dijkstra_sp('ways', 10, 20);
```

gid	the_geom
293	MULTILINESTRING((18.4074149 -33.9443308,18.4074019 -33.9443833))
4632	MULTILINESTRING((18.4074149 -33.9443308,18.4077388 -33.9436183))
4633	MULTILINESTRING((18.4077388 -33.9436183,18.4080293 -33.9429733))
...	...
762	MULTILINESTRING((18.4241422 -33.9179275,18.4237423 -33.9182966))
761	MULTILINESTRING((18.4243523 -33.9177154,18.4241422 -33.9179275))

(62 rows)

Wrapper WITH bounding box

You can limit your search area by adding a bounding box. This will improve performance especially for large networks.

```
SELECT gid, AsText(the_geom) AS the_geom
FROM dijkstra_sp_delta('ways', 10, 20, 0.1);
```

gid	the_geom
293	MULTILINESTRING((18.4074149 -33.9443308,18.4074019 -33.9443833))
4632	MULTILINESTRING((18.4074149 -33.9443308,18.4077388 -33.9436183))
4633	MULTILINESTRING((18.4077388 -33.9436183,18.4080293 -33.9429733))
...	...
762	MULTILINESTRING((18.4241422 -33.9179275,18.4237423 -33.9182966))
761	MULTILINESTRING((18.4243523 -33.9177154,18.4241422 -33.9179275))

(62 rows)

Warning: The projection of OSM data is “degree”, so we set a bounding box containing start and end vertex plus a 0.1 degree buffer for example.

6.2 A-Star algorithm

A-Star algorithm is another well-known routing algorithm. It adds geographical information to source and target of each network link. This enables the shortest path search to prefer links which are closer to the target of the search.

6.2.1 Prerequisites

For A-Star you need to prepare your network table and add latitude/longitude columns (x1, y1 and x2, y2) and calculate their values.

```
ALTER TABLE ways ADD COLUMN x1 double precision;
ALTER TABLE ways ADD COLUMN y1 double precision;
ALTER TABLE ways ADD COLUMN x2 double precision;
ALTER TABLE ways ADD COLUMN y2 double precision;

UPDATE ways SET x1 = x(startpoint(the_geom));
UPDATE ways SET y1 = y(startpoint(the_geom));

UPDATE ways SET x2 = x(endpoint(the_geom));
UPDATE ways SET y2 = y(endpoint(the_geom));

UPDATE ways SET x1 = x(PointN(the_geom, 1));
UPDATE ways SET y1 = y(PointN(the_geom, 1));

UPDATE ways SET x2 = x(PointN(the_geom, NumPoints(the_geom)));
UPDATE ways SET y2 = y(PointN(the_geom, NumPoints(the_geom)));
```

Note: “endpoint()” function fails for some versions of PostgreSQL (ie. 8.2.5, 8.1.9). A workaround for that problem is using the “PointN()” function instead:

6.2.2 Core

Shortest Path A-Star function is very similar to the Dijkstra function, though it prefers links that are close to the target of the search. The heuristics of this search are predefined, so you need to recompile pgRouting if you want to make changes to the heuristic function itself.

```
shortest_path_astar( sql text,
                    source_id integer,
                    target_id integer,
                    directed boolean,
                    has_reverse_cost boolean )
```

Note:

- Source and target IDs are vertex IDs.
- Undirected graphs (“directed false”) ignores “has_reverse_cost” setting
- Example of A-Star core function

```
SELECT * FROM shortest_path_astar('
    SELECT gid as id,
           source::integer,
           target::integer,
           length::double precision as cost,
           x1, y1, x2, y2
    FROM ways',
    10, 20, false, false);
```

vertex_id	edge_id	cost
10	293	0.0059596293824534
9	4632	0.0846731039249787
3974	4633	0.0765635090514303
...

```
20 | -1 | 0  
(63 rows)
```

6.2.3 Wrapper

Wrapper function WITH bounding box

Wrapper functions extend the core functions with transformations, bounding box limitations, etc..

```
SELECT gid, AsText(the_geom) AS the_geom  
FROM astar_sp_delta('ways', 10, 20, 0.1);
```

gid	the_geom
293	MULTILINESTRING((18.4074149 -33.9443308,18.4074019 -33.9443833))
4632	MULTILINESTRING((18.4074149 -33.9443308,18.4077388 -33.9436183))
4633	MULTILINESTRING((18.4077388 -33.9436183,18.4080293 -33.9429733))
...	...
762	MULTILINESTRING((18.4241422 -33.9179275,18.4237423 -33.9182966))
761	MULTILINESTRING((18.4243523 -33.9177154,18.4241422 -33.9179275))

(62 rows)

Note: There is currently no wrapper function for A-Star without bounding box, since bounding boxes are very useful to increase performance. If you don't need a bounding box Dijkstra will be enough anyway.

Warning: The projection of OSM data is “degree”, so we set a bounding box containing start and end vertex plus a 0.1 degree buffer for example.

6.3 Shooting-Star algorithm

Shooting-Star algorithm is the latest of pgRouting shortest path algorithms. Its speciality is that it routes from link to link, not from vertex to vertex as Dijkstra and A-Star algorithms do. This makes it possible to define relations between links for example, and it solves some other vertex-based algorithm issues like “parallel links”, which have same source and target but different costs.

6.3.1 Prerequisites

For Shooting-Star you need to prepare your network table and add the “reverse_cost” and “to_cost” column. Like A-Star this algorithm also has a heuristic function, which prefers links closer to the target of the search.

```
ALTER TABLE ways ADD COLUMN reverse_cost double precision;  
UPDATE ways SET reverse_cost = length;  
  
ALTER TABLE ways ADD COLUMN to_cost double precision;  
  
ALTER TABLE ways ADD COLUMN rule text;
```

Shooting-Star algorithm introduces two new attributes

- **rule:** a string with a comma separated list of edge IDs, which describes a rule for turning restriction (if you came along these edges, you can pass through the current one only with the cost stated in to_cost column)

- **to_cost**: a cost of a restricted passage (can be very high in a case of turn restriction or comparable with an edge cost in a case of traffic light)

```
shortest_path_shooting_star( sql text,
                             source_id integer,
                             target_id integer,
                             directed boolean,
                             has_reverse_cost boolean )
```

Note:

- Source and target IDs are link IDs.
- Undirected graphs (“directed false”) ignores “has_reverse_cost” setting
- Example for Shooting-Star “rule”

Warning: Shooting* algorithm calculates a path from edge to edge (not from vertex to vertex). Column vertex_id contains start vertex of an edge from column edge_id.

To describe turn restrictions:

gid	source	target	cost	x1	y1	x2	y2	to_cost	rule
12	3	10	2	4	3	4	5	1000	14

... means that the cost of going from edge 14 to edge 12 is 1000, and

gid	source	target	cost	x1	y1	x2	y2	to_cost	rule
12	3	10	2	4	3	4	5	1000	14, 4

... means that the cost of going from edge 14 to edge 12 through edge 4 is 1000.

If you need multiple restrictions for a given edge then you have to add multiple records for that edge each with a separate restriction.

gid	source	target	cost	x1	y1	x2	y2	to_cost	rule
11	3	10	2	4	3	4	5	1000	4
11	3	10	2	4	3	4	5	1000	12

... means that the cost of going from either edge 4 or 12 to edge 11 is 1000. And then you always need to order your data by gid when you load it to a shortest path function..

6.3.2 Core

```
SELECT * FROM shortest_path_shooting_star('
    SELECT gid as id,
           source::integer,
           target::integer,
           length::double precision as cost,
           x1, y1, x2, y2,
           rule, to_cost
    FROM ways',
    293, 761, false, false);
```

```
vertex_id | edge_id |      cost
-----+-----+-----
      4232 |      293 | 0.0059596293824534
      3144 |      293 | 0.0059596293824534
      4232 |     4632 | 0.0846731039249787
      ... |      ... | ...
       51 |     761 | 0.0305298478239596
(63 rows)
```

6.3.3 Wrapper

Wrapper functions extend the core functions with transformations, bounding box limitations, etc..

```
SELECT gid, AsText(the_geom) AS the_geom
FROM shootingstar_sp('ways', 293, 761, 0.1, 'length', true, true);
```

```
gid | the_geom
-----+-----
 293 | MULTILINESTRING((18.4074149 -33.9443308,18.4074019 -33.9443833))
 293 | MULTILINESTRING((18.4074149 -33.9443308,18.4074019 -33.9443833))
4632 | MULTILINESTRING((18.4074149 -33.9443308,18.4077388 -33.9436183))
... | ...
 762 | MULTILINESTRING((18.4241422 -33.9179275,18.4237423 -33.9182966))
 761 | MULTILINESTRING((18.4243523 -33.9177154,18.4241422 -33.9179275))
(62 rows)
```

Note: There is currently no wrapper function for A-Star without bounding box, since bounding boxes are very useful to increase performance. If you don't need a bounding box Dijkstra will be enough anyway.

Warning: The projection of OSM data is “degree”, so we set a bounding box containing start and end vertex plus a 0.1 degree buffer for example.

ADVANCED USAGE OF PGROUTING

SHORTEST PATH SEARCH

An ordinary shortest path query with result usually looks like this:

```
SELECT * FROM shortest_path_shooting_star(
    'SELECT gid as id, source, target, length as cost, x1, y1, x2, y2, rule,
    to_cost, reverse_cost FROM ways', 1955, 5787, true, true);
```

Query result:

vertex_id	edge_id	cost
8134	1955	0.00952475464810279
5459	1956	0.0628075563112871
8137	1976	0.0812786367080268
5453	758	0.0421747270358272
5456	3366	0.0104935732514831
11086	3367	0.113400030221047
4416	306	0.111600379959229
4419	307	0.0880411972519595
4422	4880	0.0208599114366633
5101	612	0.0906859882381495
5102	5787	80089.8820919459

(11 rows)

That is usually called *SHORTEST* path, which means that a length of an edge is its cost.

Costs can be anything (“Weighted costs”)

But in real networks we have different limitations or preferences for different road types for example. In other words, we want to calculate *CHEAPEST* path - a path with a minimal cost. There is no limitation in what we take as costs.

When we convert data from OSM format using the `osm2pgrouting` tool, we get these two additional tables for road types and classes:

```
\d classes

 id | name
----+-----
  2 | cycleway
  1 | highway
  4 | junction
  3 | tracktype
```

\d types

id	type_id	name	cost
201	2	lane	1
204	2	opposite	1
203	2	opposite_lane	1
202	2	track	1
117	1	bridleway	1
113	1	bus_guideway	1
118	1	byway	1
115	1	cicleway	1
116	1	footway	1
108	1	living_street	1
101	1	motorway	0.2
103	1	motorway_junction	0.2
102	1	motorway_link	0.2
114	1	path	100
111	1	pedestrian	100
106	1	primary	100
107	1	primary_link	100
107	1	residential	100
100	1	road	0.7
100	1	unclassified	0.7
106	1	secondary	10
109	1	service	10
112	1	services	10
119	1	steps	10
107	1	tertiary	10
110	1	track	10
104	1	trunk	10
105	1	trunk_link	10
401	4	roundabout	10
301	3	grade1	15
302	3	grade2	15
303	3	grade3	15
304	3	grade4	15
305	3	grade5	15

Road class is linked with the ways table by class_id field. Cost values for classes table are assigned arbitrary.

```
UPDATE classes SET cost=15 WHERE id>300;
```

For better performance it is worth to create an index on id field of classes table.

```
CREATE INDEX class_idx ON ways (id);
```

The idea behind these two tables is to specify a factor to be multiplied with the cost of each link (usually length):

```
SELECT * FROM shortest_path_shooting_star(
    'SELECT gid as id, class_id, source, target, length*c.cost as cost,
      x1, y1, x2, y2, rule, to_cost, reverse_cost*c.cost as reverse_cost
    FROM ways w, classes c
    WHERE class_id=c.id', 1955, 5787, true, true);
```

Query result:

vertex_id	edge_id	cost
8134	1955	0.00666732825367195
5459	1956	0.043965289417901

```
8137 | 1992 | 0.126646230936747
5464 | 762 | 0.827868704808978
5467 | 763 | 0.16765902528648
... | ... | ...
9790 | 5785 | 0.00142107468268373
8548 | 5786 | 0.00066608685984761
16214 | 5787 | 0.0160179764183892
(69 rows)
```

We can see that the shortest path result is completely different from the example before. We call this “weighted costs”.

Another example is to restrict access to roads of a certain type:

```
UPDATE classes SET cost=100000 WHERE name LIKE 'motorway%';
```

Through subqueries you can “mix” your costs as you like and this will change the results of your routing request immediately. Cost changes will affect the next shortest path search, and there is no need to rebuild your network.

SERVER SIDE SCRIPTS WITH PHP

We will use a PHP script to make the routing query and send the result back to the web client.

The following steps are necessary:

Retrieve the start and end point coordinates. Find the closest edge to start/end point. Take either the start or end vertex of this edge (for Dijkstra/ A-Star) or the complete edge (Shooting-Star) as start of the route and end respectively. Make the Shortest Path database query. Transform the query result to XML and send it back to the web client.

GEOEXT BROWSER CLIENT