



An open source relational database schema and system for the analysis of large scale spatially-interdependent infrastructure networks

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Overview

- Introduction
- Technology
- Database schema
- Python wrapper
- Applications
- Summary
- Contacts and Links



— National Grid Gas
— National Grid Electricity

nationalgrid



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Introduction

- Store, model, represent and analyse various regional and national scale spatial networks
 - Robust solution for storage of large scale data and networks
 - Creation of attributed networks
 - Representation of dependencies and interdependencies between networks
 - Access to complex graph-theory based analyses and tools
- Combination of stable open source packages to provide solution for multiple network modelling tasks
 - Open source generalised cost transport model
 - Modelling UK infrastructure networks, and failure



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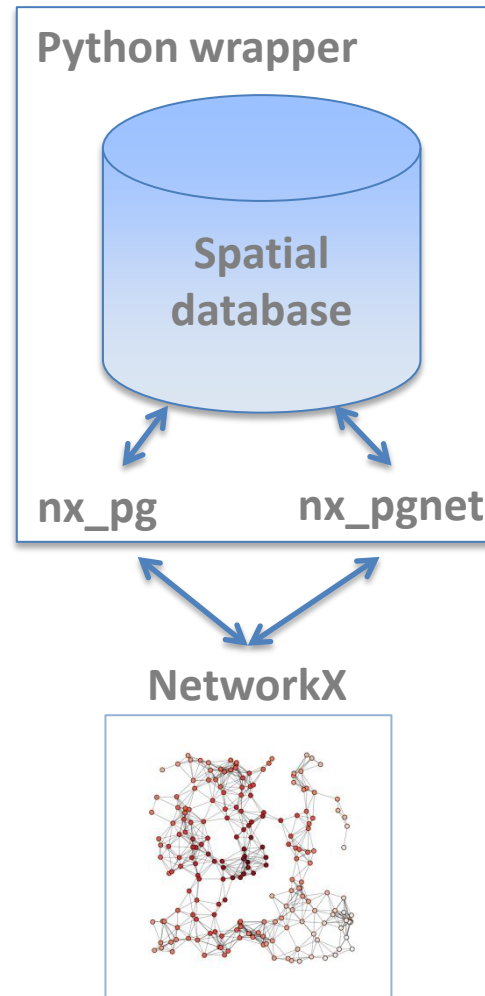
Technology

- Database

- PostgreSQL (9.0.3) + PostGIS (1.5)
- pgAgent (3.0.0) + pgAdmin (1.12.2)
- PL/pgSQL
- OGR + Pscycopg2 drivers

- Wrapper

- Python (2.6.5+)
- GDAL + OGR
- NetworkX (1.6)



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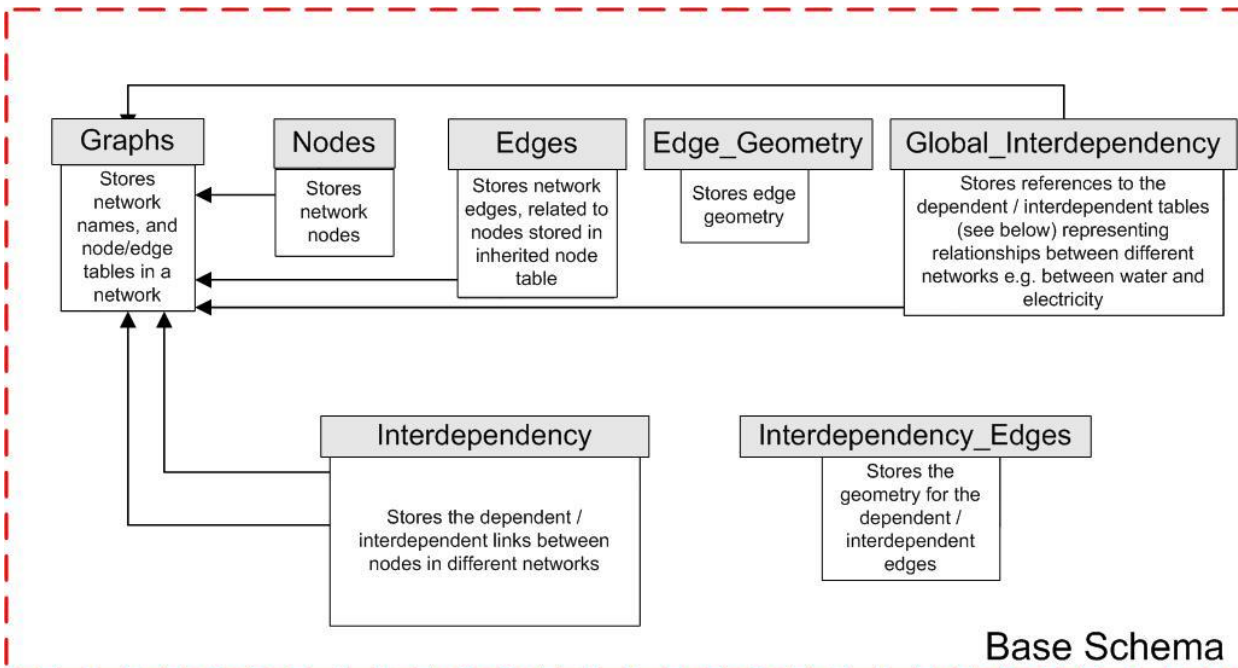
Database schema - introduction

- Parent Tables

- Graphs
- Nodes
- Edges / Edge_Geometry
- Global Interdependency
- Interdependency / Interdependency_Edges

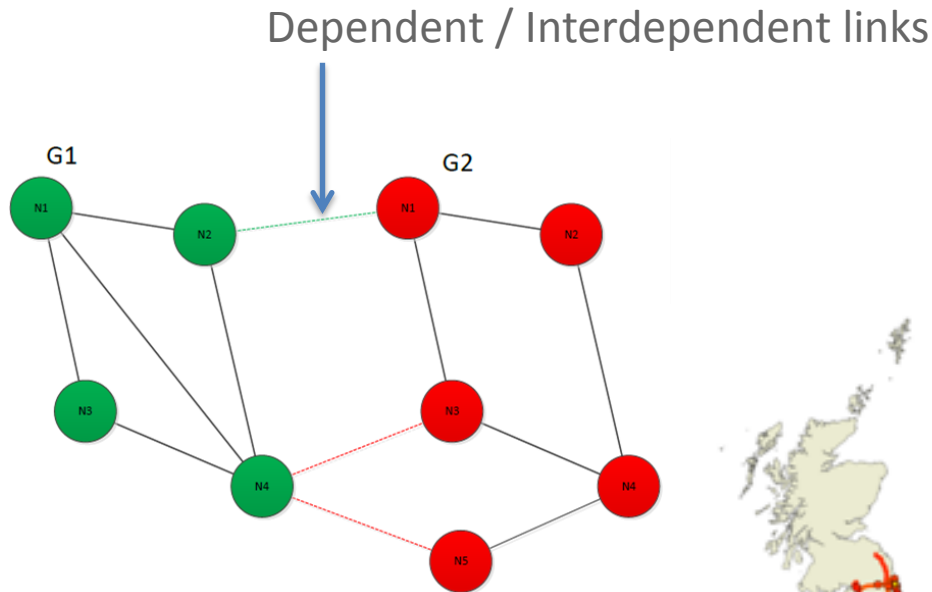
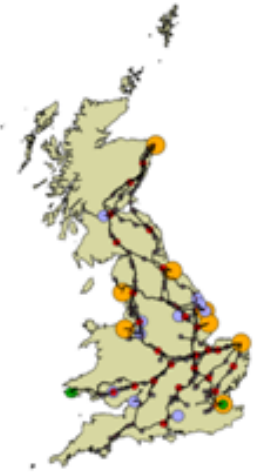


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Database schema – an example

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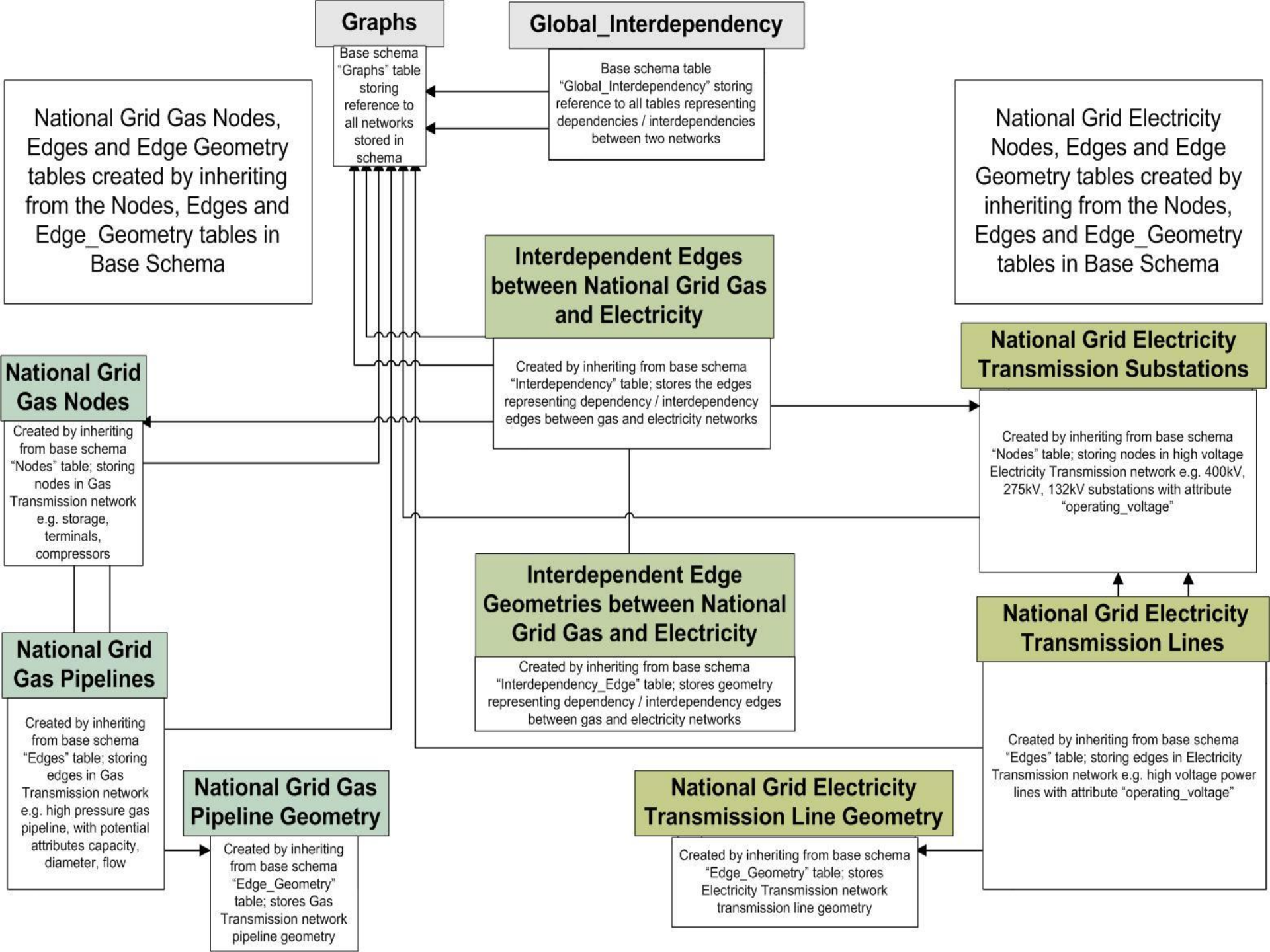
Initial interdependencies to consider¹:

- Physical
- Geographic



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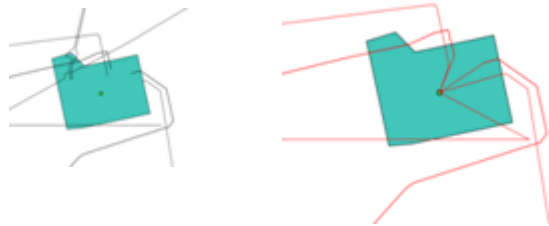
Database schema – functions

- **Administrative functions:**

- Used for the creation of instance tables and constraints between them

- **Simple pre-processing functions:**

- Connect a node to the nearest point on an edge based on an attribute matching
- Find the nearest neighbour node of network B from a node in network A
- Link node A and node B by an attribute
- Find the nearest point on each line segment to every node



Connect edge end points to node

Connect closest point along line segment



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The Python wrapper - overview

- An interface between PostGIS and NetworkX
- Modules nx_pg/nx_pgnet provide read/write functions
- Database connections handled by OGR (GDAL)
 - `db_conn = ogr.Open("PG: host='localhost'
dbname='a_spatial_database'
user='postgres' password='password'")`
- Build a topological network from PostGIS tables
 - `network = nx_pg.read_pg(lines, points)`
- Store the network in PostGIS
 - `nx_pgnet.write(db_conn).pg_net(network)`



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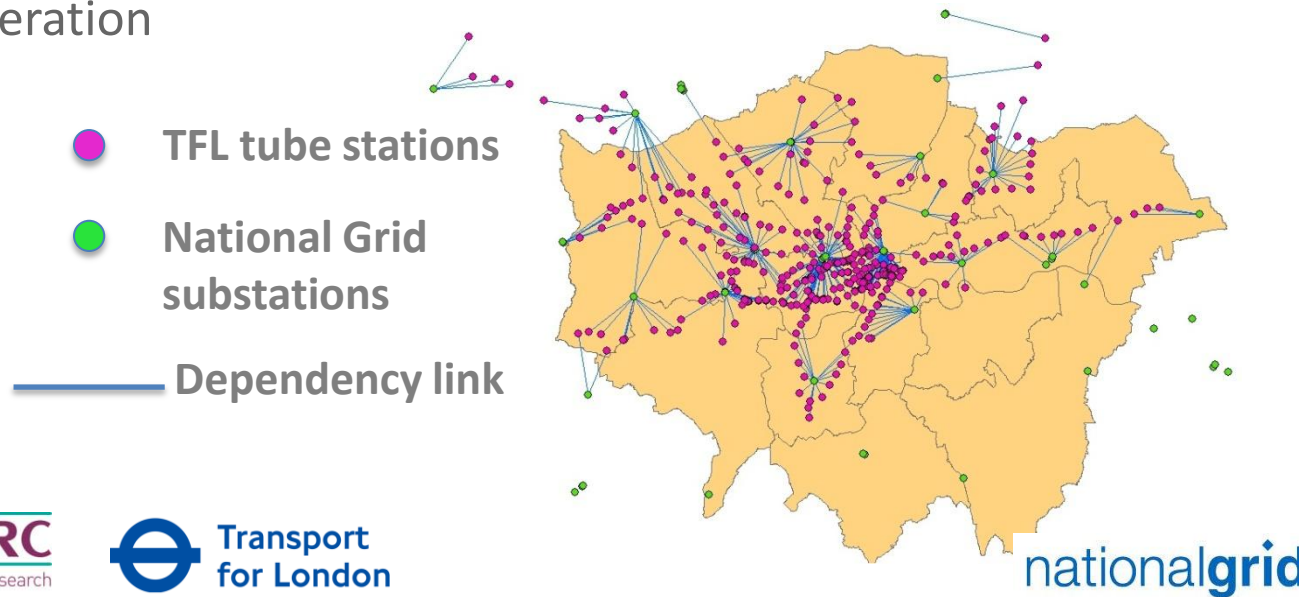


Application (1) – Modelling failure

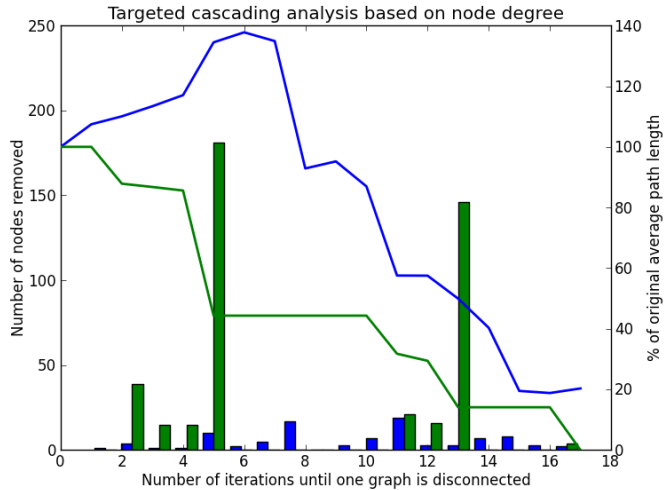
- Understanding dependencies between transport (rail) and power supply
 - Tube network: 466 edges, 437 nodes
 - Power network: 119 edges, 99 nodes
- Compares two methods of simulating a targeted attack on substations
- Node betweenness and degree recalculated on each iteration



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Application (1) – Modelling failure



Degree: attacks on substations based upon degree:

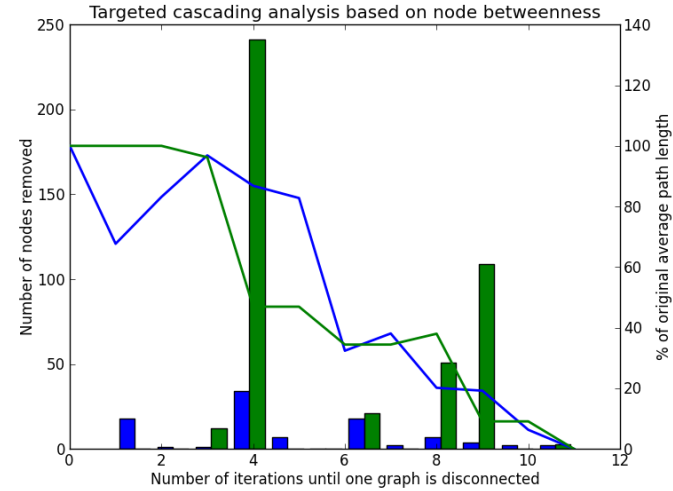
- larger impact on tube network



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Betweenness: attacks on substations based upon betweenness:

- targetted attack using betweenness is more *“effective”* than using degree

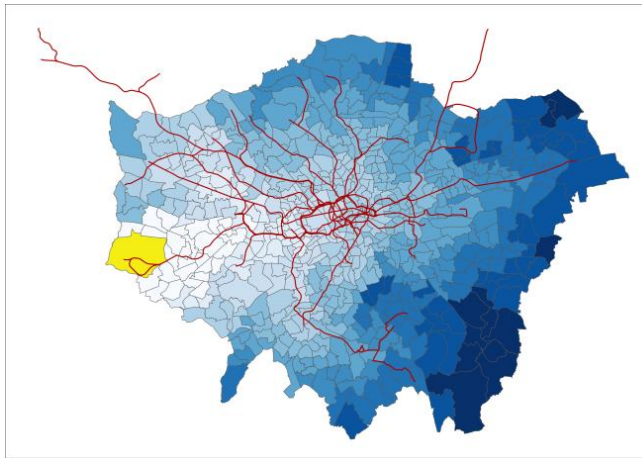


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Application (2) – Generalised cost

- Modelling of accessibility across urban areas
- Network models allow calculation of cost of travel
- Generalised cost computed
 - Travel time components
 - Monetary components



Generalised cost of travel in London via light rail network

- Pseudo-code example

```
import networkx as nx
```

```
roads = nx_pgnet.read(conn).pgnet('GLA_Roads')
```

```
costs = nx.all_pairs_dijkstra_path_length(roads,  
weight='link_cost')
```



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Summary

- Multiple challenges across many projects to represent, analyse and model spatial networks
- Creation of a network data model and modelling framework using open source tools and technologies
- The models, networks and network representations form part of a wider, open-source modelling framework being developed at Newcastle.
 - Open source generalised transport cost model
 - Regional and national-scale infrastructure network creation and storage
 - Representing infrastructure interdependencies and how failures propagate



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Contact and Links

- **Projects:**

- Infrastructure Transitions Research Consortium (www.itrc.org.uk)
- EPSRC Platform Grant in Earth Systems Engineering (<http://www.ncl.ac.uk/ceser/researchprogramme/>)
- EPSRC Platform Grants (<http://www.epsrc.ac.uk/funding/grants/capacity/platform/Pages/default.aspx>)

- **School / Research Group:**

- School of Civil Engineering and Geosciences, Newcastle University (www.ceg.ncl.ac.uk)
- Geospatial Engineering Group@ Newcastle (<http://www.ncl.ac.uk/ceg/research/geomatics/geospatialengineering/>)
- Centre for Earth Systems Engineering @ Newcastle (<http://www.ncl.ac.uk/ceser/>)



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Thank you.

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