A geospatial relational database schema for interdependent network analysis and modelling

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Overview

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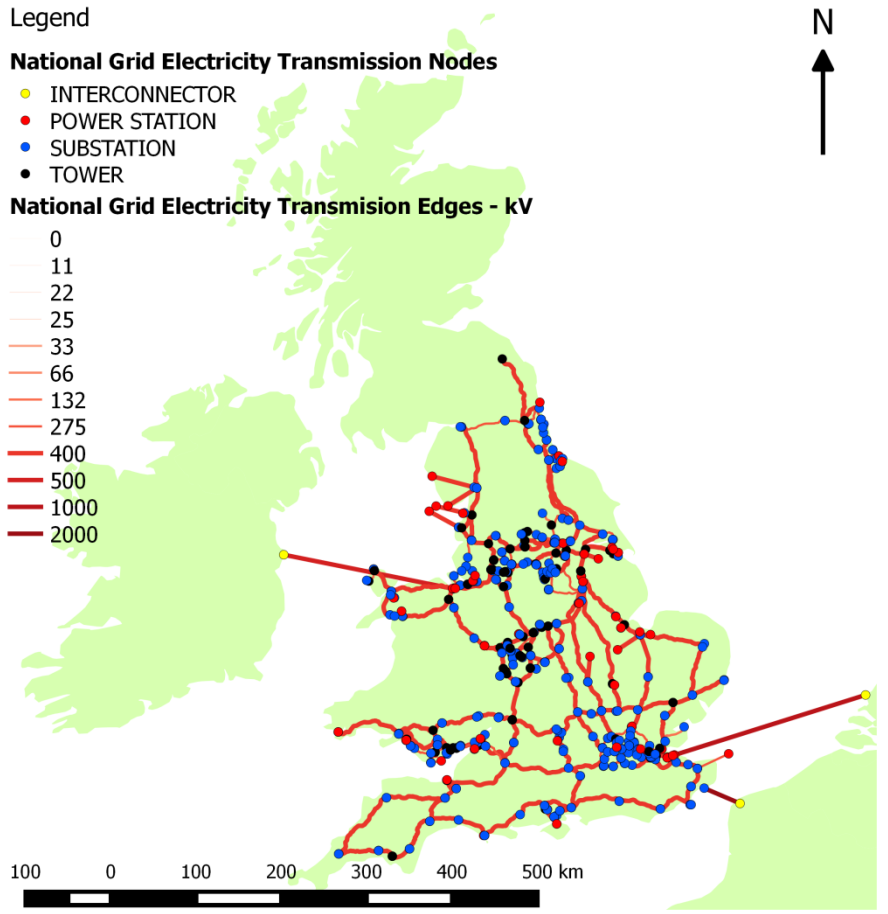


nationalgrid

Introduction

- *"National Infrastructure (NI) systems…provide essential services to the economy and contribute to human wellbeing"* [1]

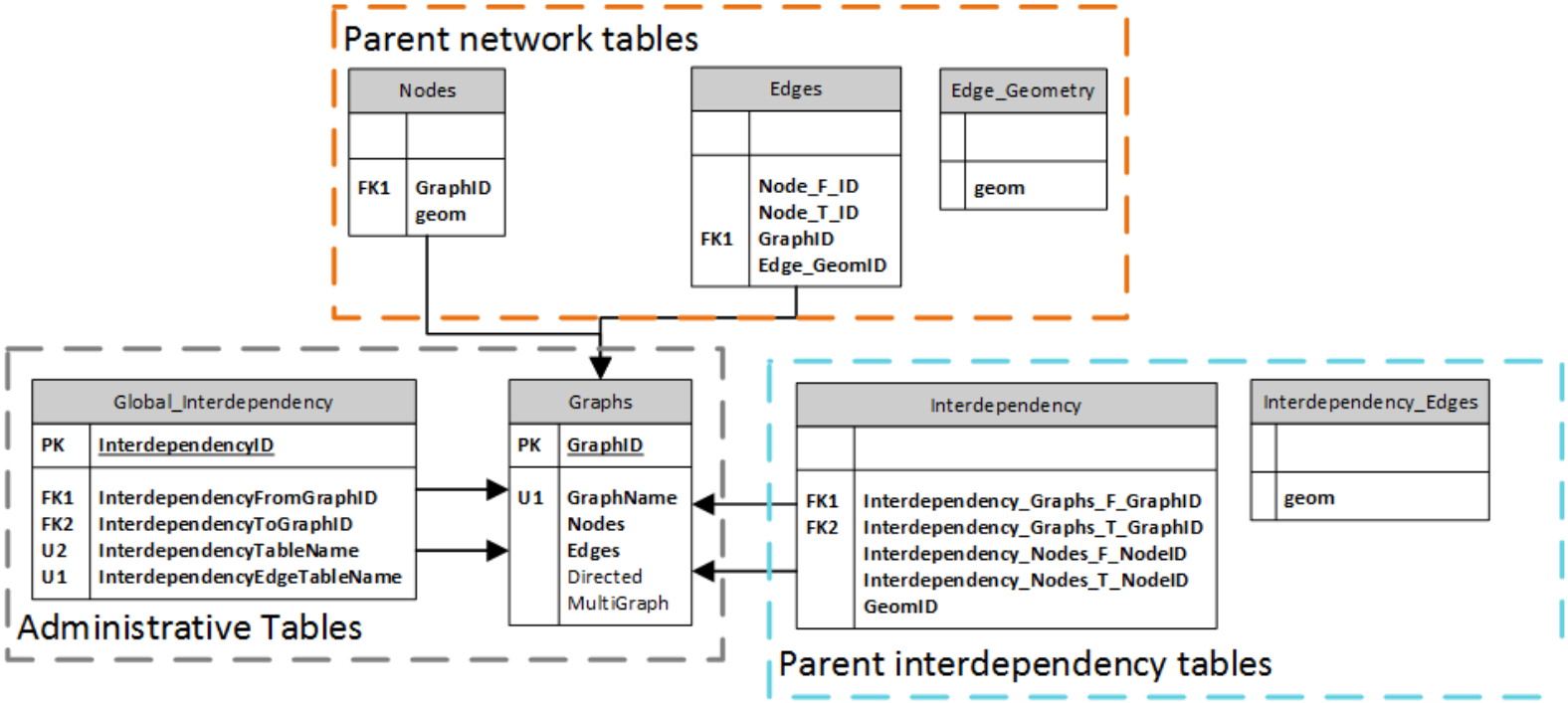
- Understanding relationships and interdependencies between different infrastructure networks is a significant challenge [2]

- Model, store and use various regional and national-scale spatial networks
  - Store network topology, geometry and attribution
  - Representation of dependencies between networks
  - Access to complex graph-theory based analyses and tools

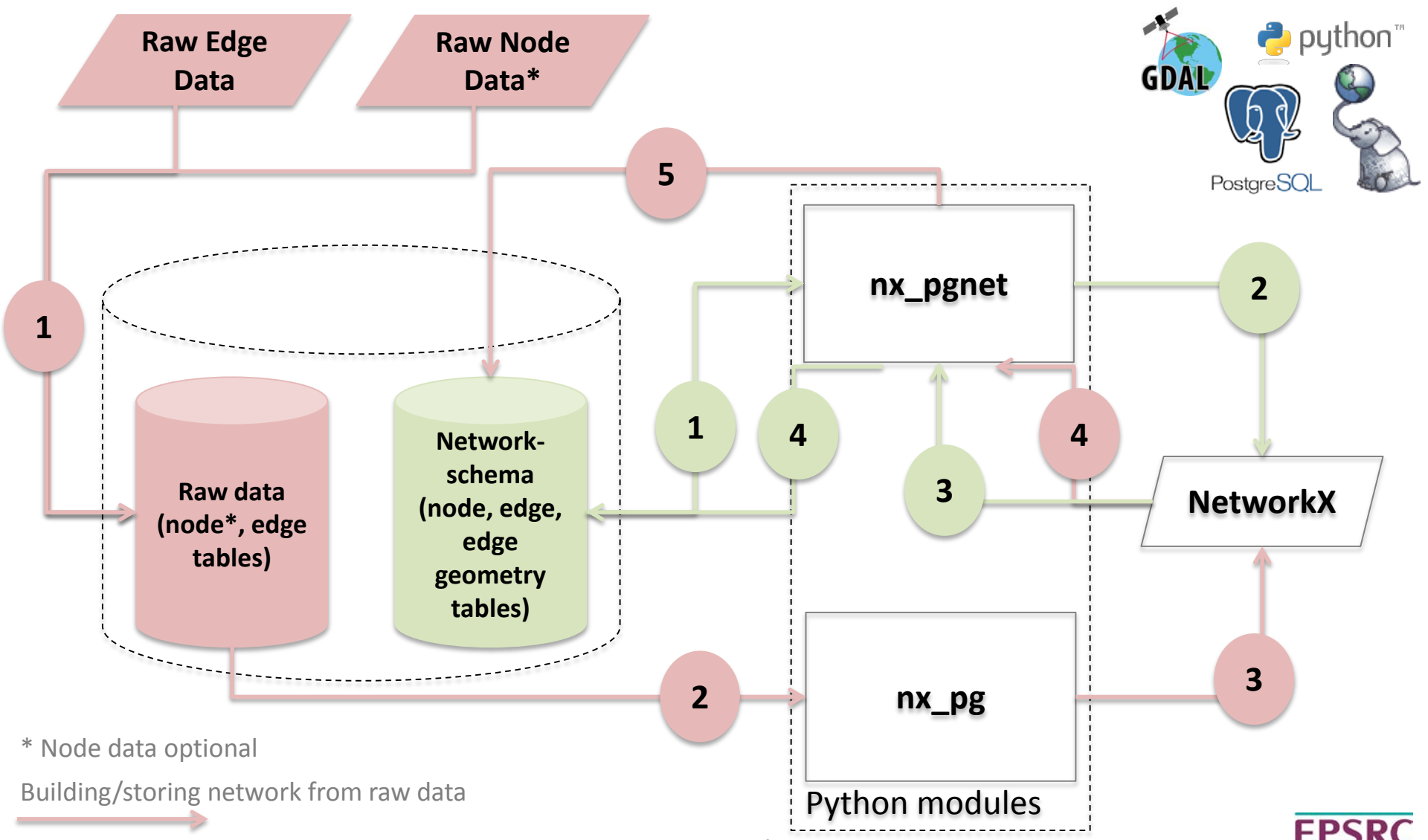
- Applications
  - Transport accessibility [3]
  - Faecal sludge management [4]
  - Interdependent network failure modelling

Database schema

- Use of mature relational database technologies; PostgreSQL and PostGIS
- Loosely-based around node/edge lists
- Table and attribute inheritance from base schema tables
- Three table groups; network, interdependency, administrative



Python modules – build network



* Node data optional

Building/storing network from raw data

Reading/using network from schema

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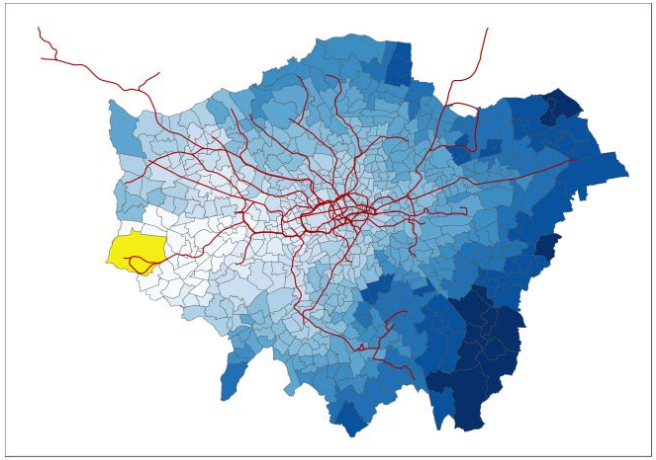
Application (1) – Transport accessibility

- 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
Import nx_pgnet
rail= nx_pgnet.read(conn).pgnet('GLA_Rail')
costs = nx.all_pairs_dijkstra_path_length(rail,
    weight='link_cost')
```

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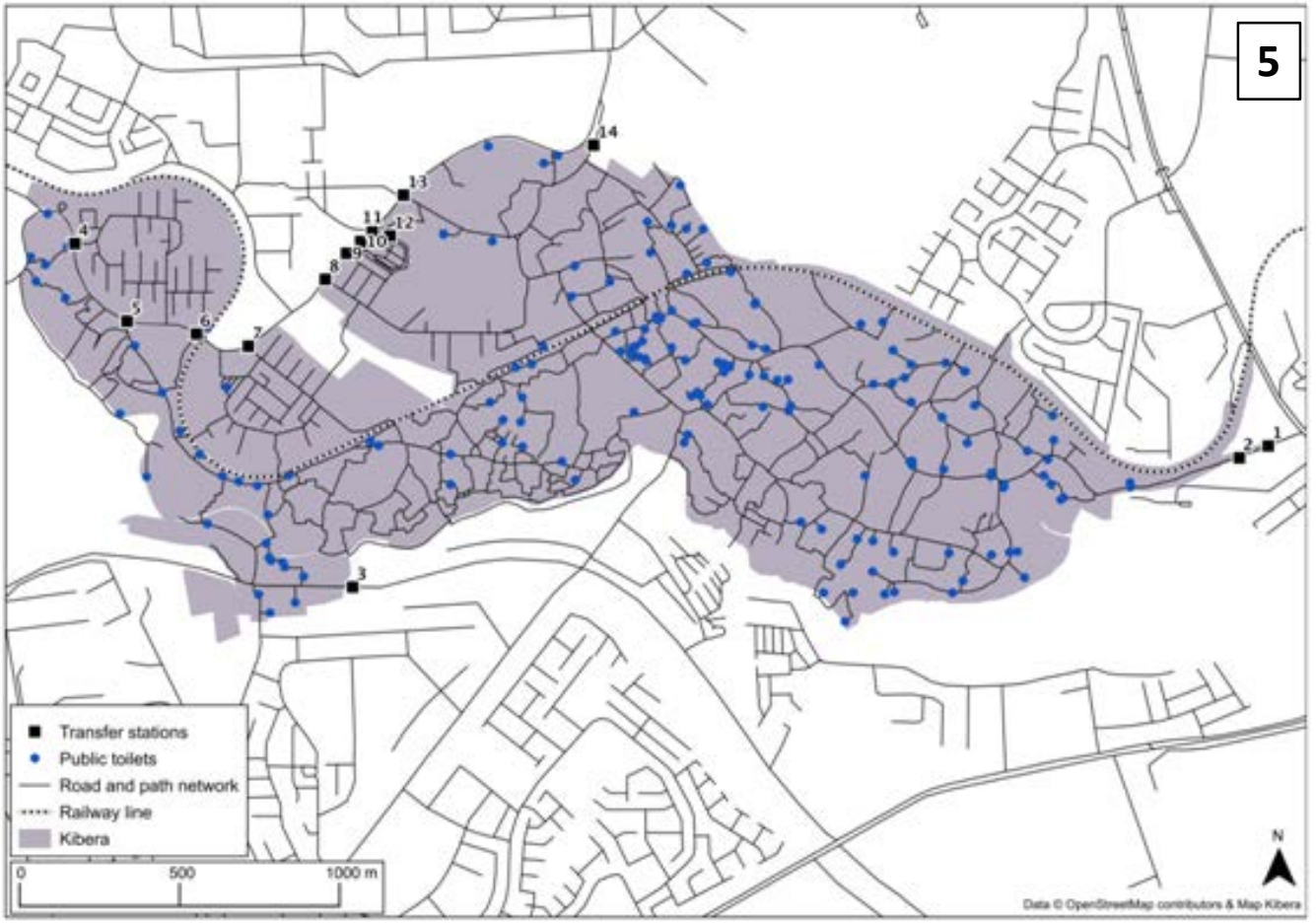
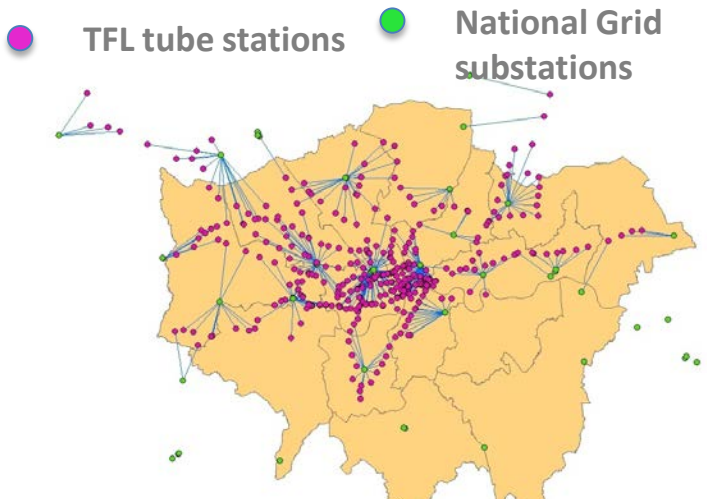
Applications (2) – Sludge Management

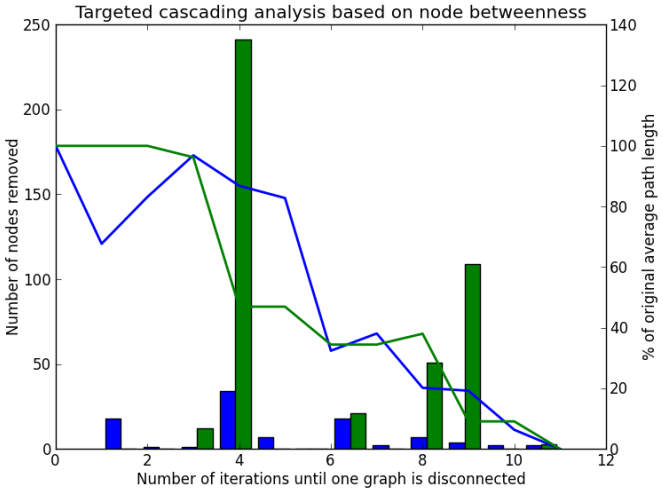
- Optimisation of faecal sludge removal and disposal over road network in informal settlements
- Assessment of use of single or multiple transfer stations to act as intermediary between public toilets and treatment facilities
- Shortest-path analyses conducted, using travel times and distances, alongside equipment and labour costs



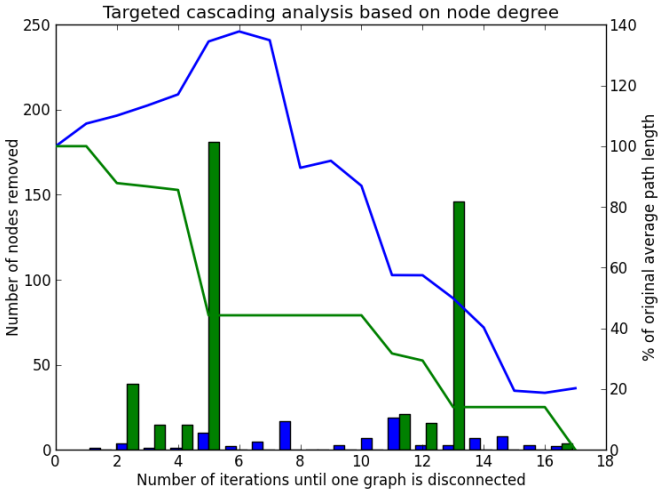
Application (3) – Modelling failure

- Understanding dependencies between transport (rail) and power supply
- Compares methods of simulating attacks on substations (targeted and random)





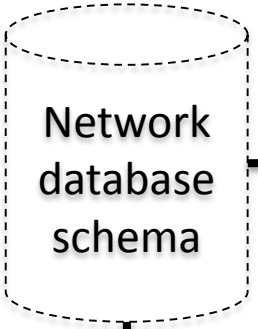
Attack on substations based upon **betweenness**

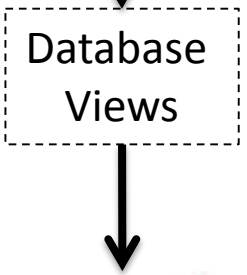


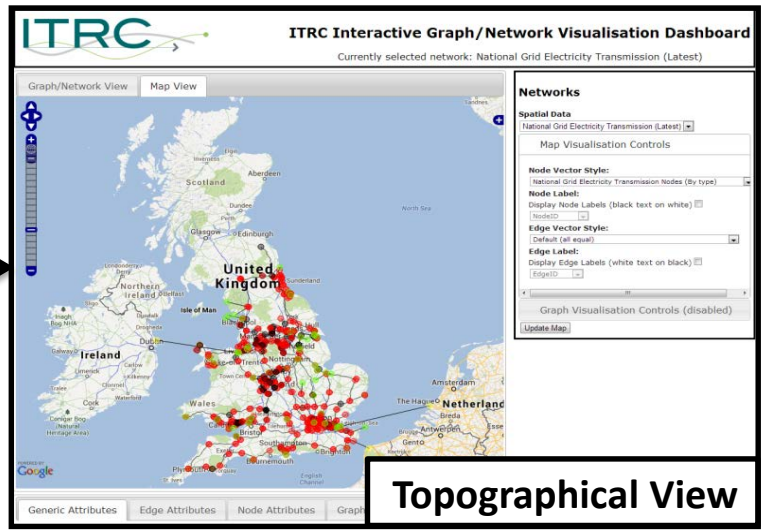
Attacks on substations based upon **degree**

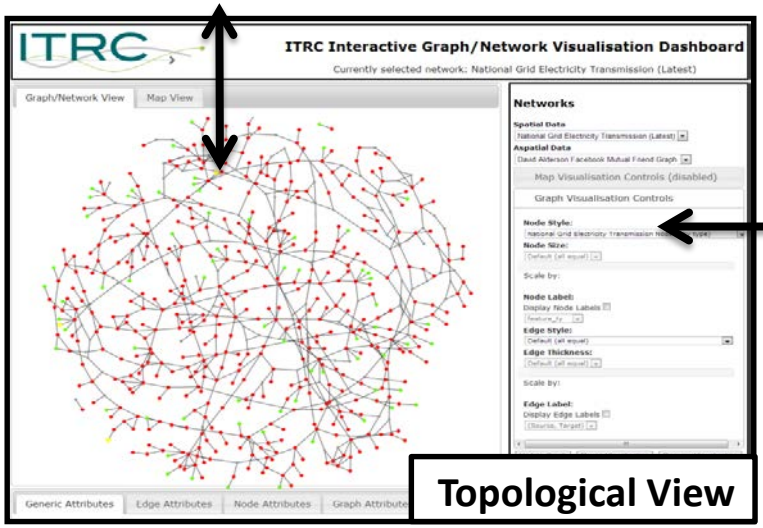
Transport for London nationalgrid

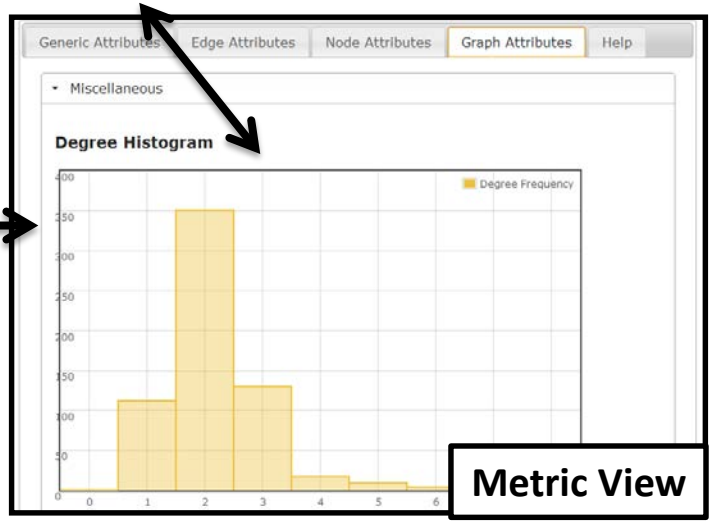
Visualisation – prototype…











Prototype network viewer:

- topographical, topological, metric views
- export graph from database as JSON, load into viewer
- use of network attributes for styling in both topographic and topological views

Summary

- *"…ensuring we have the right infrastructure in the right places is vital to allow our society and economy to function effectively."* [6]
- Model and store spatial networks to facilitate analysis of infrastructure networks
- Provide a mechanism for linking database technology with network analysis packages e.g. PostgreSQL + PostGIS <-> NetworkX
- Future directions:
  - Exploitation of network-schema in more diverse range of applications
  - Linking failure propagation examples to visualisation interface allowing user to "step-through" failure
  - "Truly" linked views between topological, topographic and metrics

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Contact and Links

- **Projects / Funding:**
  - 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 – ITRC (http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/I01344X/2)

- **School / Research Group:**
  - School of Civil Engineering and Geosciences, Newcastle University (www.ceg.ncl.ac.uk)
  - Geospatial Engineering Group @ Newcastle (http://research.ncl.ac.uk/geospatial/)
  - Geospatial Engineering Blog @ Newcastle (https://blogs.ncl.ac.uk/geospatialengineering/)
  - Centre for Earth Systems Engineering @ Newcastle (http://www.ncl.ac.uk/ceser/)
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