

# **ncl\_visualise**

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# 1 Introduction

The tool allows for the simulation of flow movements on a temporal scale and a spatial scale over a network. The network can then also be perturbed in a number of ways allowing for the network dynamics to be explored through the on-the-fly rerouting of affected flows and the statistics relating to this. This has been developed using a suite of open source tools in the python language with the main data source type being shapefiles.

## 1.1 Visualisation

The visualisation aspect of this tool allows networks to be visualised, built from a shapefile (or from the nx\_pgnnet database), then through the simulation of flows over the network the importance of each node and edge can be seen through its size. Where the flow value on a component is zero the feature is not displayed. On the other hand, the greater the size of the edge/node, the greater the flow through the component. Further to this, the time frame in which the flow over a component in the network is calculated can be set to a time frame, such as the last 10 minutes.

Flows take the form of an origin and a destination, simulating a flow/movement between two discrete junctions in the network. The selection of the origins and destinations can be done randomly, or through a csv of census flow data and the relevant census output zones. The flows are then also assigned a start time within the specified time frame, from the specified start time for the simulation. The flows are assigned a set of waypoints representing the shortest path through the network between their origin and destination, with the shortest path either based on the number of edges or weighted using length, travel time or some other attribute contained with the attributes of the loaded network. The flows then traverse the network as the simulation proceeds, with the flows moving at the speed of the edge they are traversing, or at the specified default speed. The time between the frames of the visualisation can be specified, allowing a range of detailed on not so detailed simulations to be run over varying time scales.

## 1.2 Failures

Whilst the simulation is running the network can be perturbed, with a plethora of options available with regard to the removal of nodes and edges from the network. Both nodes and edges can be removed during a single simulation, with options for the selection of those to remove including the component with the greatest flow, the node with the highest number of edges connected to it, or at random. There is also the option to use a shapefile to simulate a spatial hazard area in which all components will fail. The timing of the failure(s) can be set either manually, or randomly assigned within the time frame of the simulation.

## 2 Requirements

Python 2.6

NetworkX 1.6 or later (<https://networkx.github.io/>)

pyshp (<http://code.google.com/p/pyshp/>)

pygame (<http://www.pygame.org/news.html>)

## 3 Variables

### 3.1 Network building

net_source_shapefile ( <i>boolean</i> )
Set as <i>True</i> if using a shapefile as the source of network data. Set as <i>False</i> if utilising the database option through <i>nx_pgnet</i> .
length_att ( <i>text</i> )
This should define the edge attribute which is to be used for some of the calculations on the network. Set as <i>None</i> if no length attribute exists in the network.
speed_att ( <i>text</i> )
Set as the name of the edge attribute which contains a value for the speed of travel along the edge. It should be in Kilometres per hour. If not such field exists as part of the network, the simulation will use the default_speed variable. The default_speed variable will also be utilised where data is missing for some edges if it exists for others.
default_speed ( <i>integer</i> )
Used as the speed at which a flow can travel along an edge in kilometres per hour. Used if no data, or some data cannot be found in the edge attributes under the specified name (speed_att). Also used if speed_att is set to <i>None</i> .
shpfile_name ( <i>text</i> )
If net_source_shapefile is set to <i>True</i> , this should specify the location of the shapefile from which the network can be built.
db_parameters ( <i>dict</i> )
A dictionary of connection parameters to allow a connection to be established to a PostgreSQL/PostGIS database through <i>nx_pgnet</i> .

### 3.2 Flows

RANDOM_FLOWS ( <i>boolean</i> )
Set as <i>True</i> if flows are to be generated randomly with origins and destinations selected at random from the junctions in the network.
NUMBER_OF_FLOWS ( <i>integer</i> )
The number of flows to randomly created. Ignored if RANDOM_FLOWS is set as <i>False</i> .
ZONES ( <i>text</i> )
If RANDOM_FLOWS is set as <i>False</i> this should specify the zones which the flow data is grouped by. This is then used to identify those junctions which fall within each zone and can then be assigned to the flows.
FLOW_CSV ( <i>text</i> )
If RANDOM_FLOWS is set as <i>False</i> this should specify the csv file and its file path from which the flows can be loaded.

WEIGHT (*text*)

A weight to be used in the shortest path calculation. This should be an attribute which is found on all edges. Note, this currently does not consider the weights assigned to junctions.

### 3.3 Simulation parameters

STARTTIME (*datetime*)

The time when the simulation will begin. Takes the format of year, month, day, hour and minutes, all of which are integers. This is used for the assignment of a time for each flow to start and for the failures to occur.

SECONDS\_PER\_FRAME (*integer*)

The number of seconds per frame of the visualisation. Must be an integer.

FLOW\_COUNT\_TIME (*list*)

A list [*hours,minutes*]. This is the time frame from which the flow through the nodes and edges are calculated and then used to calculate the size of the nodes/edges in the visualisation. This is also used when calculating the node with the greatest flow during a targeted failure simulation.

HOURS\_TO\_RUN\_FOR (*float/integer*)

The time frame during which flows can start and failures can occur (thus simulation can last longer). Use an *integer* if the time is one hour or more. Use a *float* if the time frame is to less than one hour.

### 3.4 Outputs

PRINT\_STATS (*boolean*)

Set as *True* to print the stats following each failure in the python terminal window.

RECORD (*boolean*)

Set as *True* to record each time frame image and the stats following failures.

FILE\_PATH (*text*)

If RECORD set as *True*, this is the file path for the location of the saved time frame images. The name and file type should also be specified.

META\_FILE (*text*)

If RECORD is set as *True*, this should be set as the file path and name for the metadata from the simulation, including the results on flows of any failures.

### 3.5 Failures

#### Failure setup

MANUAL ( <i>boolean</i> )
Select as <i>True</i> to specify the time(s) and type(s) of failure (node/edge) manually.
RANDOM_TIME ( <i>boolean</i> )
Select as <i>True</i> for random times to be generated for the failure(s) as specified through the state of the other variables (RANDOM_F, TARGETED, FLOW).
TIME_INTERVALS ( <i>integer</i> )
Specify the number of seconds between each failure, as specified through the failure variables (RANDOM_F, TARGETED, FLOW).
NUMBER_OF_FAILURES ( <i>integer</i> )
Specify the number of failures which are to occur in the simulation.

#### Failure parameters

RANDOM_F ( <i>boolean</i> )
Set as <i>True</i> if node(s)/edges are to be selected at random in the failure simulation.
TARGETED ( <i>boolean</i> )
Set as <i>True</i> if the nodes to be removed are to be chosen based on their FLOW value of their degree value.
FLOW ( <i>boolean</i> )
Set as <i>True</i> if to select nodes in the targeted methodology by the flow passing through them. The node with the greatest flow will be selected to be removed. The flow value used is based on the number of flows which have passed through the node in a set time frame prior to the failure, set by the FLOW_COUNT_TIME variable. Only this or DEGREE can be <i>True</i> .
DEGREE ( <i>boolean</i> )
Set as <i>True</i> if to select in the targeted methodology the node to remove based on the node with the highest degree. This is recalculated for each selection. Only this or FLOW can be <i>True</i> .
NODE_EDGE_DEGREE ( <i>text</i> )
Set as ' <i>NODE</i> ' to select only nodes to be removed during the simulation. Set as ' <i>EDGE</i> ' for only edges to be selected to fail during a simulation. Set as ' <i>NODE_EDGE</i> ' for either nodes or edges to be removed during a failure simulation.

## Spatial failure

GEO_FAILURE ( <i>boolean</i> )
Set as <i>True</i> to use a shapefile to simulate a spatial hazard which is then used to find those nodes and edges which fall within the area and thus fail.
SHP_FILE ( <i>text</i> )
Holds the file path to the shapefile for the geo failure.

## Flow rerouting

REASSIGN_START ( <i>boolean</i> )
Set as <i>True</i> to assign a new start junction where the original has failed and the flow concerned has yet to start. The new junction is chosen with the shortest 'as the crow flies' distance and if this is unsuitable, the flow is removed. There is no capacity to set a search distance or check multiple junctions.
REASSIGN_DEST ( <i>boolean</i> )
Set as <i>True</i> to assign a new destination to a flow where the original has failed. This is chosen using the shortest 'as the crow flies' distance and if unsuitable, the flow is removed. There is no capacity to set a search distance or check multiple junctions.

## 3.6 Visualisation

### Feature sizing

NODE_SCALE_FACTOR ( <i>integer</i> ) / EDGE_SCALE_FACTOR ( <i>integer</i> )
These values should be adjusted to the size of the nodes and edges in the simulation are suitable given the flow values passing through them. This can only be changed through a trial and error process.
FLOW_SIZE ( <i>integer</i> )
Set as the size of the flows shown on the network. To not show the flows set as zero.
FAILED_NODE_SIZE ( <i>integer</i> ) / FAILED_EDGE_SIZE ( <i>integer</i> )
Set for the size of the nodes/edges once these have failed as these can no longer be scaled based on the flow passing through them. Set as zero so they are not shown.
MIN_NODE_SIZE ( <i>integer</i> ) / MIN_EDGE_SIZE ( <i>integer</i> )
For active nodes/edges, set a minimum size which they will be shown as if there are flows passing over them. If no flows are passing over them the features will not be shown disregarding this value.
NODE_FAILURE_SCALE_RANGE ( <i>integer</i> ) / EDGE_FAILURE_SCALE_RANGE ( <i>integer</i> )
When a failure occurs the feature is highlighted. These variables allow the size at which the failure is highlighted to be set, from which the size decreases to the FAILED_NODE_SIZE/FAILED_EDGE_SIZE.

### Feature colouring

FLOW_COLOUR ( <i>RGB (integers)</i> )
Set this as the colour which the flows on the network are shown as. This uses standard RGB colour values.
NODE_ACTIVE_COLOUR ( <i>RGB (integers)</i> ) / EDGE_ACTIVE_COLOUR ( <i>RGB (integers)</i> )
Set as the colour of the active nodes and edges in the network. These will be used when the flow value is above zero over the set time period as defined by the FLOW_COUNT_TIME variable. This uses standard RGB colour values.
NODE_FAILURE_COLOUR ( <i>RGB (integers)</i> ) / EDGE_FAILURE_COLOUR ( <i>RGB (integers)</i> )
The colour of the failed nodes and edges. This uses standard RGB colour values.
GEO_FAILURE_COLOUR ( <i>RGB (integers)</i> )
The colour which will be used to fill the polygon representing a hazard in the simulation as used in the spatial failure method. Will only be used if GEO_FAILURE = True along with the associated requirements for this method. This uses standard RGB colour values.

### Ancillary data colouring

BACKGROUND_COLOUR ( <i>RGB (integers)</i> )
Set for the colour of the canvas. Will not be seen unless land data and river data are not fully interoperable of the extent of the simulation area. This uses standard RGB colour values.
LAND_COLOUR ( <i>RGB (integers)</i> )
The colour of the land in the simulation. This uses standard RGB colour values.
BUILDINGS_COLOUR ( <i>RGB (integers)</i> )
The colour of the buildings/data to be drawn on the map to provide added detail and act as a reference to the network simulation. This uses standard RGB colour values.
RIVER_COLOUR ( <i>RGB (integers)</i> )
The colour of any rivers in the simulation spatial extent. Used only if a river shapefile is provided for the simulation. This uses standard RGB colour values.