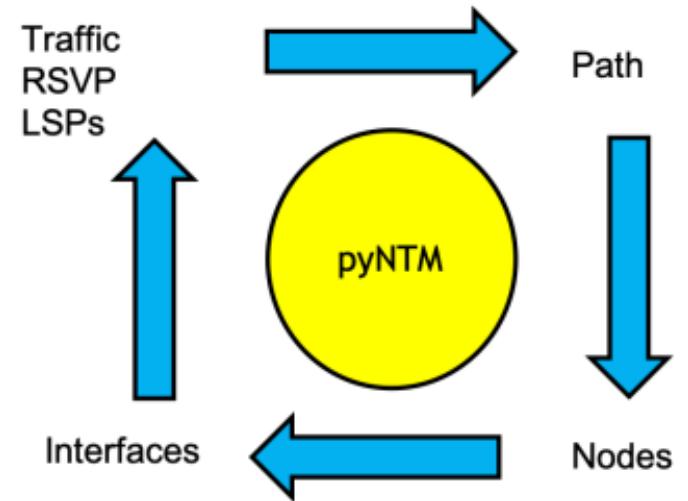


Model, Simulate, Understand

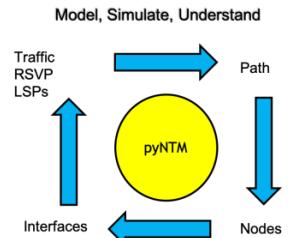


PYNTM VISUALIZATION TRAINING

pyNTM V3.4
Training v1

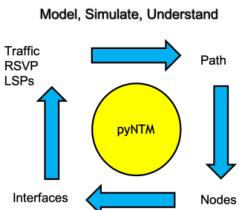
About the WeatherMap

- It's a beta feature
 - It requires *dash* and *dash-cytoscape* python3 packages to be explicitly installed
- Allows users to visualize data
 - Selected Interface
 - Demand path(s)
 - RSVP LSP path(s)
- Designed to allow the user to quickly move between related traffic Demands, Interfaces, and LSPs



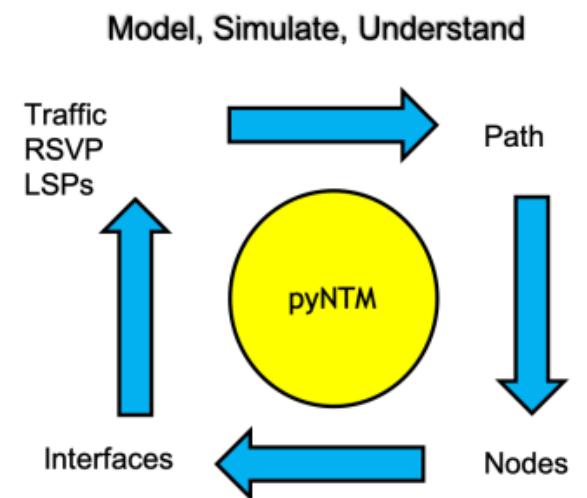
TRAINING CONTENTS

- How to create a visualization using WeatherMap
- WeatherMap visual components overview
- Live Exercise 1: creating a visualization and reading the map
- Live Exercise 2: Demand operations
 - Selecting a demand
 - Path visualization
 - Finding interfaces the demand transits
 - Related LSPs



- Live Exercise 3: Interface operations
 - Selecting an interface
 - Finding demands that transit the interface
 - Finding LSPs that transit the interface
- Live Exercise 4: LSP operations
 - Selecting an LSP
 - Path visualization
 - Finding demands on the LSP
 - Finding interfaces the LSP transits
- Live Exercise 5:
 - Failed Object Visualization
 - Interpreting concurrent visualizations

Visualization via WeatherMap



Before we begin . . .

- This training will walk you through a series of live exercises at the python3 command line
- These exercises will use the following data files to build the models
 - igp_shortcuts_model_mult_lsps_in_path_parallel_links_2.csv
 - sample_network_model_file.csv
- These data files are available in the pyNTM training repo in the training_exercise_files folder
 - https://github.com/tim-fiola/TRAINING---network_traffic_modeler_py3-pyNTM-/tree/master/training_exercise_files

Visualization via WeatherMap (beta)

- Starting in pyNTM 3.0, there is a beta visualization capability
- Requires explicit import of python3 dash and dash-cytoscape packages
- Make sure the model is converged!

model1.update_simulation() ← model1 is the Model object

- The WeatherMap class provides the visualization
 - Takes Model object as argument
- Produces interactive graph in browser
 - Interactive legend
 - Draggable Nodes and Interface endpoints
 - Demand and RSVP LSP path visualization
 - Easy to search for and select Interfaces, Demands, and LSPs
- Uses a Node's lat/lon (y,x) attributes to position Node on layout

```
pip3 install dash
```

```
pip3 install dash-cytoscape
```

```
[>>> from pyNTM.weathermap import WeatherMap
```

```
>>> wm = WeatherMap(model1)
>>>
>>> wm.create_weathermap()

*** NOTE: The make_visualization_beta function is a beta feature. It may not have been as extensively tested as the pyNTM code in general. The API calls for this may also change more rapidly than the general pyNTM code base.
```

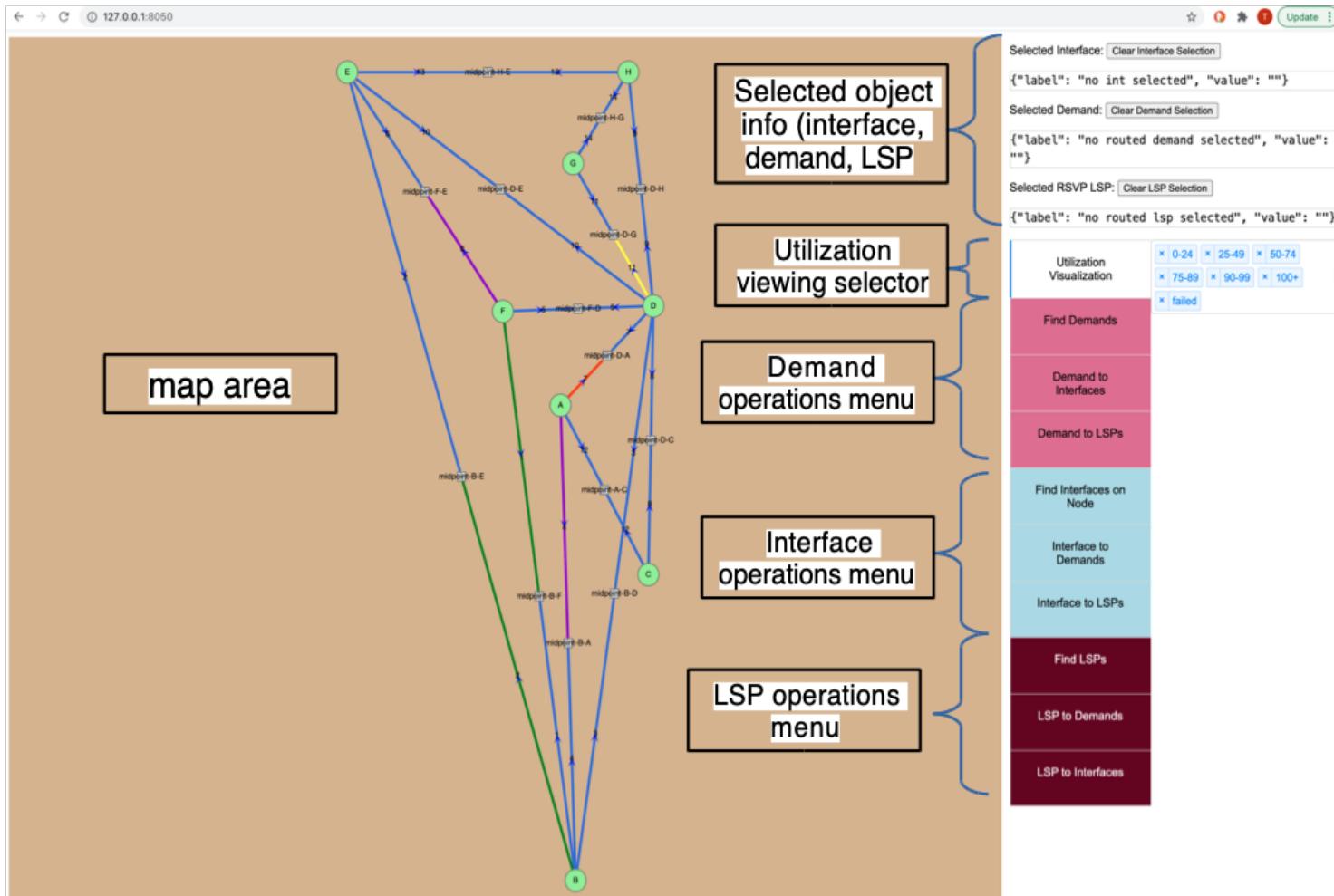
```
Visualization is available at http://127.0.0.1:8050/
```

```
Dash is running on http://127.0.0.1:8050/
```

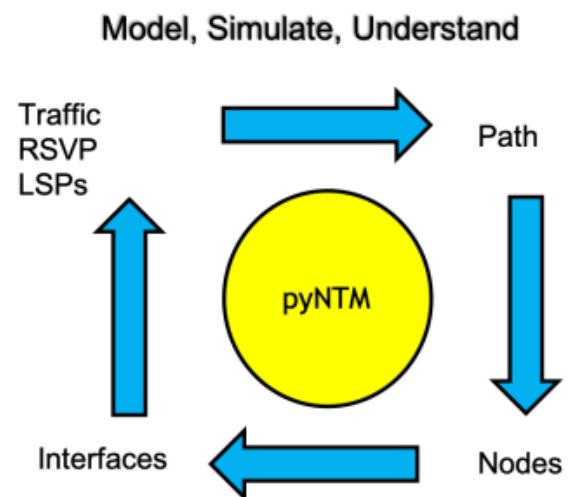
```
Dash is running on http://127.0.0.1:8050/
```

```
* Serving Flask app "pyNTM.weathermap" (lazy loading)
* Environment: production
WARNING: This is a development server. Do not use it in a production deployment.
Use a production WSGI server instead.
* Debug mode: off
* Running on http://127.0.0.1:8050/ (Press CTRL+C to quit)
```

WeatherMap Components



Live Exercise 1: creating a visualization and reading the map



Prerequisites for visualization

- Start your virtual environment (optional)
- The WeatherMap class requires the following 2 packages which are NOT installed with the pyNTM module:
 - dash
 - dash-cytoscape
- Install the packages above in your python3 or pypy3 interpreter
 - I've validated both packages work in pypy3 on MacBook Air running
 - If you find problems loading them in pypy3, please open a ticket on GitHub: https://github.com/tim-fiola/network_traffic_modeler_py3/issues
- Start python3 or pypy3
- Proceed to the next slide!

```
$ source venv/bin/activate
```

```
$ pip3 install dash
```

```
$ pip3 install dash-cytoscape
```

```
(venv) Timothys-Mini:test_3.0 timothyfiola$ python3
Python 3.8.7 (v3.8.7:6503f05dd5, Dec 21 2020, 12:45:15)
[Clang 6.0 (clang-600.0.57)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> 
```

Creating the model

- Import *FlexModel* from *pyNTM*
- Import *WeatherMap* from *pyNTM.weathermap*
 - Import from *pyNTM* directly will not work
- Create a *FlexModel* from *igp_shortcuts_model_mult_lsps_in_path_parallel_links_2.csv*
- Update the simulation via *update_simulation()* method
 - If the simulation is not updated, the visualization will not work properly

```
[>>> from pyNTM import FlexModel
[>>>
[>>> from pyNTM.weathermap import WeatherMap
[>>>
[>>> model = FlexModel.load_model_file('igp_shortcuts_model_mult_lsps_in_path_parallel_links_2.csv')
[>>>
[>>> model.update_simulation()
Routing the LSPs . .
Routing 1 LSPs in parallel LSP group D-F; 1/3
Routing 1 LSPs in parallel LSP group C-E; 2/3
Routing 2 LSPs in parallel LSP group B-D; 3/3
LSPs routed (if present) in 0:00:00.005473; routing demands now . .
Demand 10
Demands routed in 0:00:00.006720; validating model . . .
```

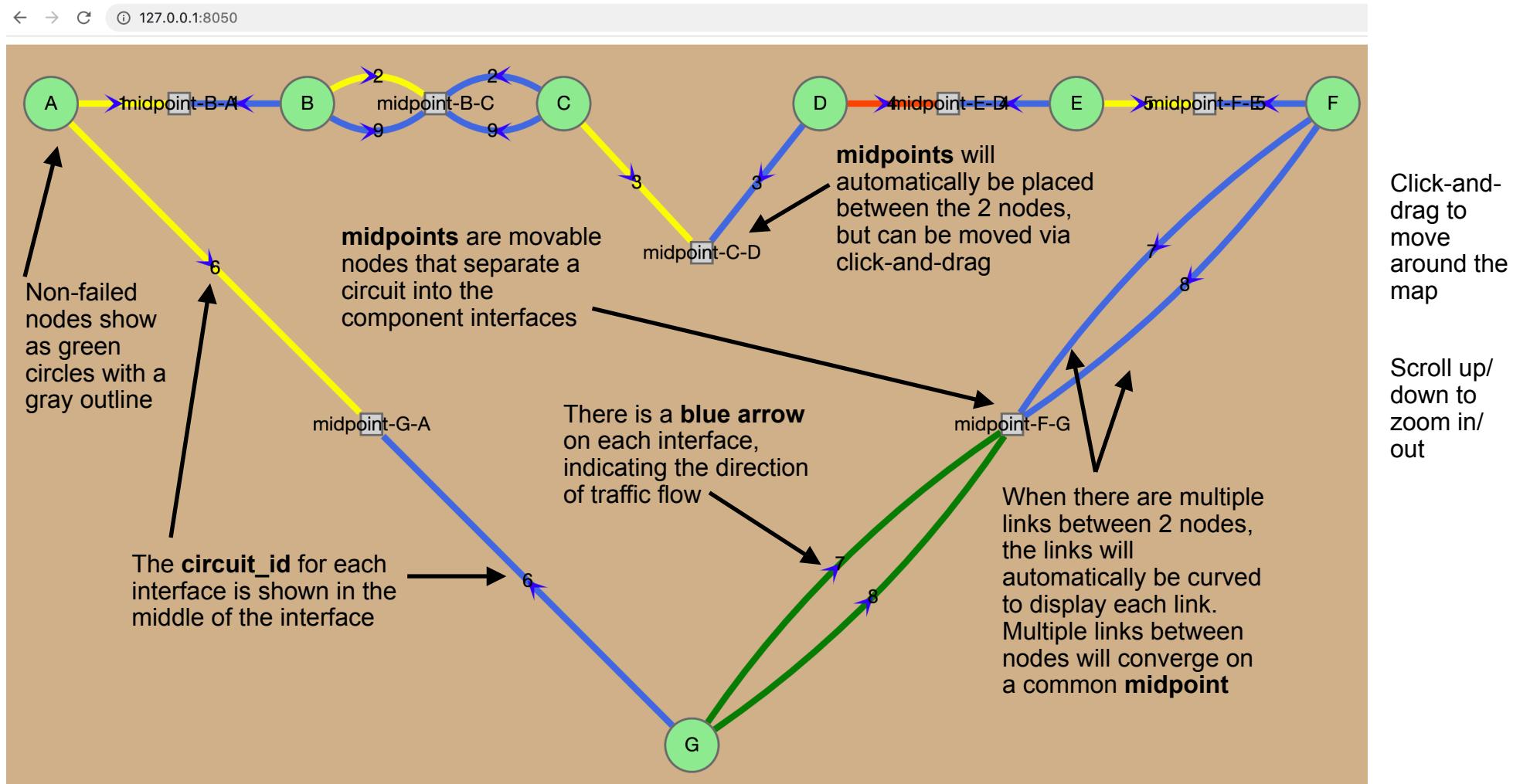
Creating a WeatherMap class

- Create a *WeatherMap* class
- Optional - modify the spacing factor
 - The `spacing_factor` affect how much space will be between nodes on the map
 - The nodes in the *WeatherMap* will be placed according to the lon/lat (x, y) values for the Node
 - For maps where there is little variance in the x,y values of the nodes, a larger **`spacing_factor`** may make the map easier to use by increasing the spacing between the nodes
 - For maps with fewer nodes very spaced out, a smaller **`spacing_factor`** may be helpful
 - Default **`spacing_factor`** value is 3
- Use the `create_weathermap()` method to start the visualization
- Open a browser and go to <http://127.0.0.1:8050/>

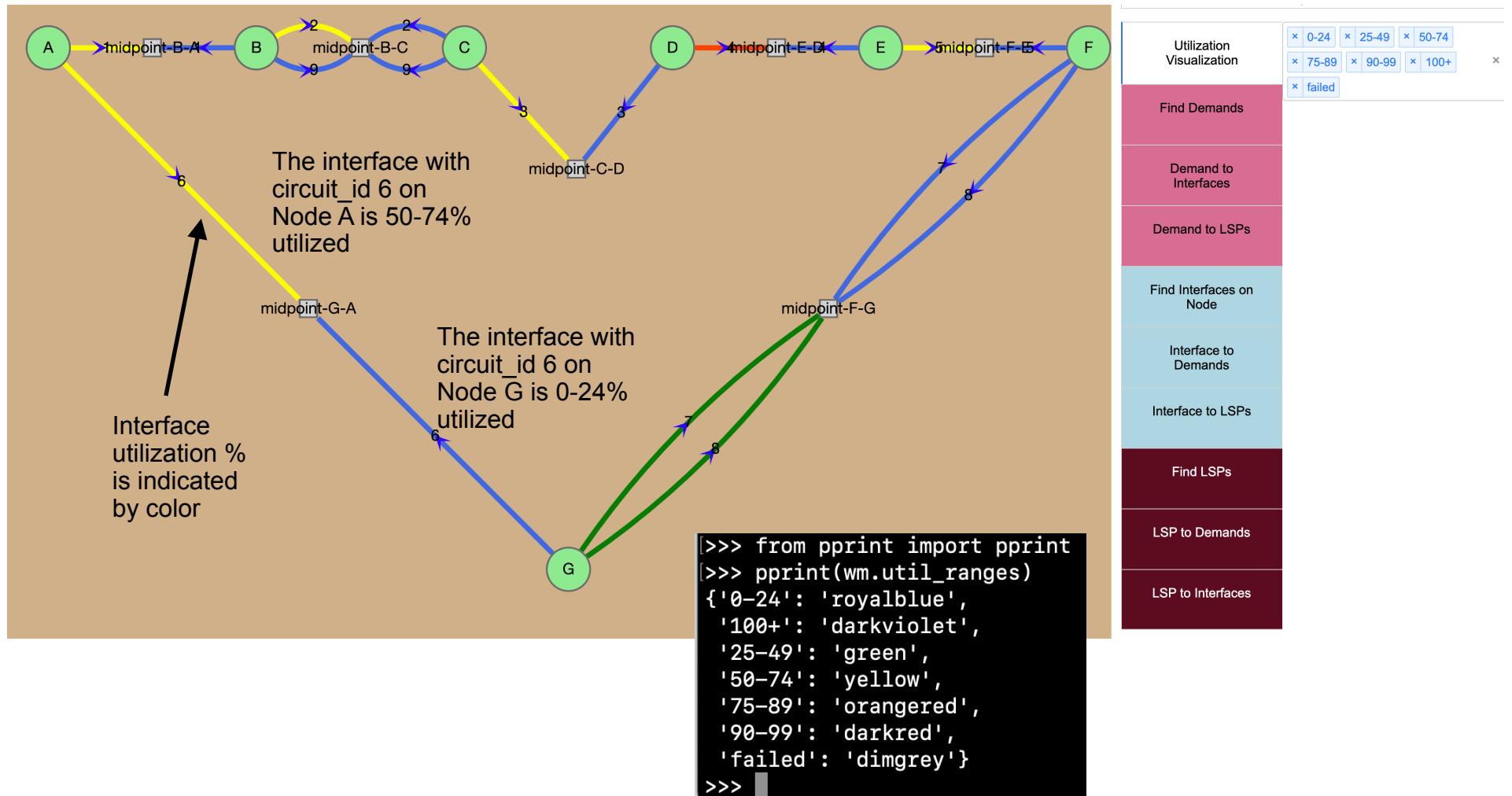
```
[>>> wm = WeatherMap(model)
[>>>
[>>> wm.spacing_factor
3
[>>>
[>>> wm.spacing_factor = 2
[>>>
[>>> wm.create_weathermap()
```

Visualization is available at <http://127.0.0.1:8050/>

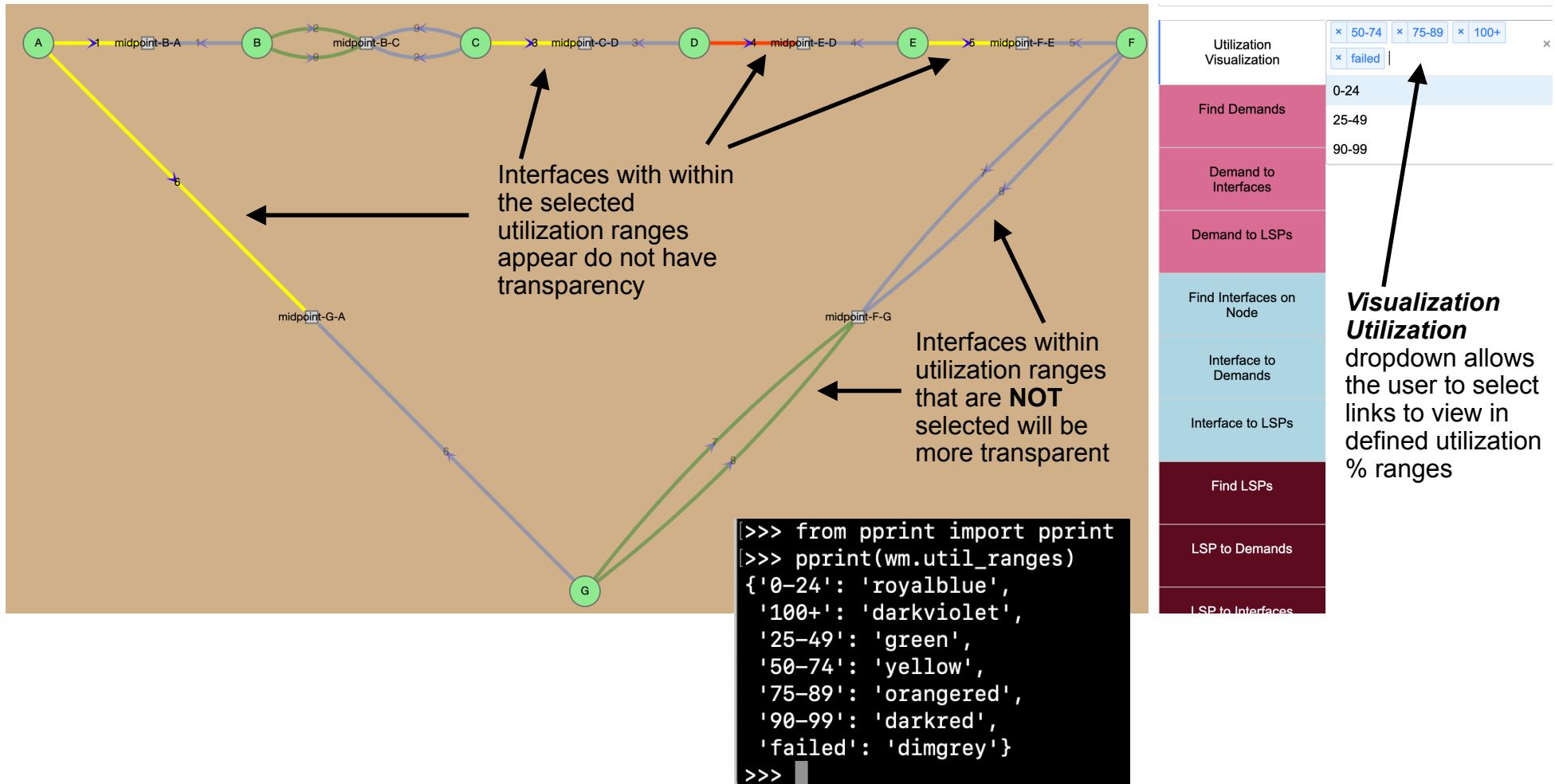
The map



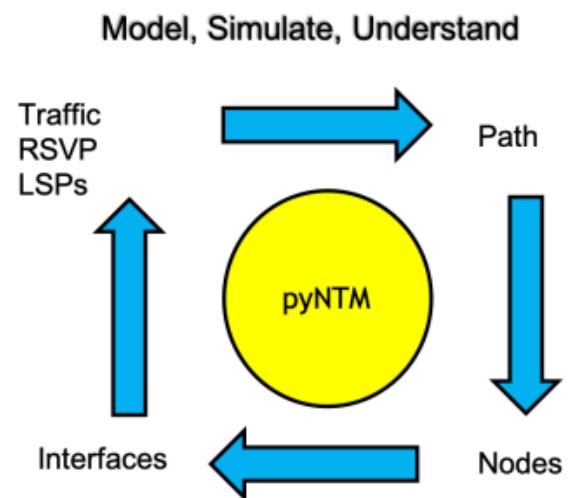
Link utilization



Utilization visualization selection



Live Exercise 2: Demand operations



Selecting a demand

Utilization Visualization	
Clear the source or destination selection by selecting the 'X' on the right side of the selection menu	
Find Demands	A Select a dest node
Demand to Interfaces	<input type="radio"/> no routed demand selected <input type="radio"/> Demand(source = A, dest = F, traffic = 100, name = 'dmd_a_f_1') <input checked="" type="radio"/> Demand(source = A, dest = C, traffic = 10, name = 'dmd_a_c_1')
Demand to LSPs	



Search for and select demands from the Find Demands tab

Selecting only a source or destination will dynamically update selections for demands sourced from or destined to the source or destination

Utilization Visualization	
Clear the source or destination selection by selecting the 'X' on the right side of the selection menu	
Find Demands	A Select a dest node
Demand to Interfaces	C F
Demand to LSPs	<input checked="" type="radio"/> Demand(source = A, dest = C, traffic = 10, name = 'dmd_a_c_1')



The options for source and destination will dynamically update to display only available sources/destinations based on the selected destination/source

Utilization Visualization	
Clear the source or destination selection by selecting the 'X' on the right side of the selection menu	
Find Demands	A F
Demand to Interfaces	<input type="radio"/> no routed demand selected <input type="radio"/> Demand(source = A, dest = F, traffic = 100, name = 'dmd_a_f_1')
Demand to LSPs	



Selecting a source and destination will show only the demands with the selected source and destination

Selecting a demand (continued)

The info about the selected demand will be shown in **Selected Demand** section

Selected Demand: [Clear Demand Selection](#)

```
{"source": "A", "dest": "C", "name": "dmd_a_c_1", "routed": true}
```

Selected RSVP LSP: [Clear LSP Selection](#)

```
{"label": "no routed lsp selected", "value": ""}
```

Select a demand from the list by clicking the radio button

Utilization Visualization
Clear the source or destination selection by selecting the 'X' on the right side of the selection menu

Find Demands

Demand to Interfaces

Demand to LSPs

A C

no routed demand selected
 Demand(source = A, dest = C, traffic = 10, name = 'dmd_a_c_1')

Clear the demand selection by clicking on the Clear Demand Selection button or by clicking the no routed demand selected radio button in the demand selection list

Demand path visualization

The path for the selected demand will be shown on the map

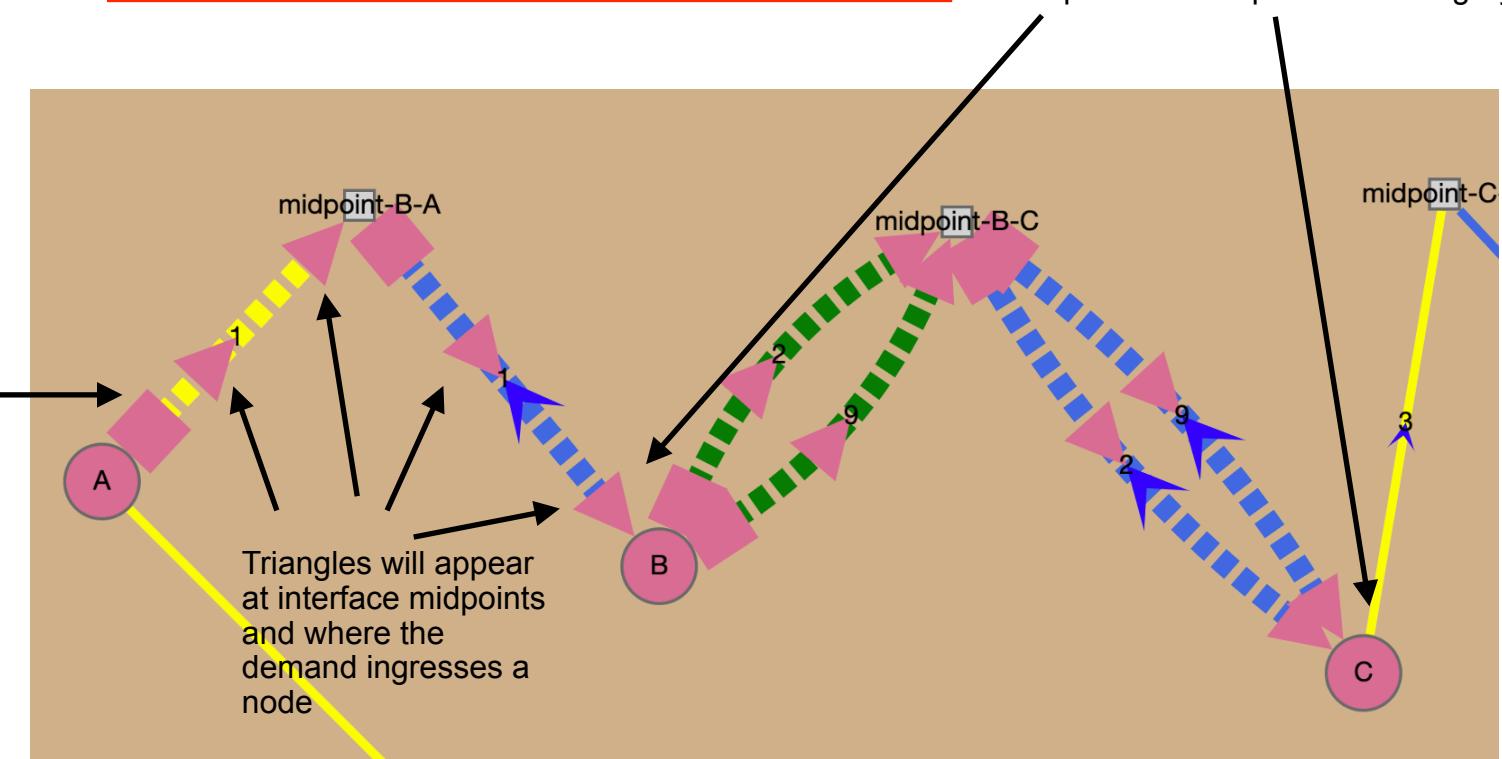
The demand path will be marked with pinkish **squares** and **triangles pointing in the direction of the demand's travel**

Squares will appear where the demand egresses the layer 3 node or midpoint node

Selected Demand:

```
{"source": "A", "dest": "C", "name": "dmd_a_c_1",  
"routed": true}
```

The layer 3 nodes in the demand's path will turn pinkish with a gray border



Finding interfaces the demand transits

Click on the **Demands to Interfaces** tab

Utilization Visualization

Find Demands

Demand to Interfaces

Demand to LSPs

- no int selected
- Interface(name = 'B-C', cost = 10, capacity = 100, node_object = Node('B'), remote_node_object = Node('C'), circuit_id = '2')
- Interface(name = 'A-B', cost = 10, capacity = 100, node_object = Node('A'), remote_node_object = Node('B'), circuit_id = '1')
- Interface(name = 'B-C_2', cost = 10, capacity = 100, node_object = Node('B'), remote_node_object = Node('C'), circuit_id = '9')

Select any interface by clicking the radio button by the interface

Selected Demand: [Clear Demand Selection](#)

```
{"source": "A", "dest": "C", "name": "dmd_a_c_1",  
"routed": true}
```

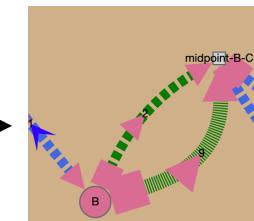
All interfaces the demand egresses will be shown

These are NOT explicit, ordered paths; they are the component interfaces for the demand's path(s)

The selected interface here will become the active **Selected Interface** (see the Interface Operations section for more info)

Selected Interface: [Clear Interface Selection](#)

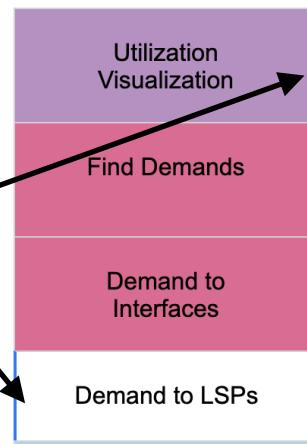
```
{"source": "B", "interface-name": "B-C_2", "dest":  
"C", "circuit_id": "9", "utilization %": 30.0, "cost":  
10}
```



Finding LSPs the demand transits

Click on the **Demands to LSPs** tab

Select any LSP by clicking the radio button by the interface



no routed lsp selected
 RSVP_LSP(source = D, dest = F, lsp_name = 'lsp_d_f_1')

Selected Demand: [Clear Demand Selection](#)

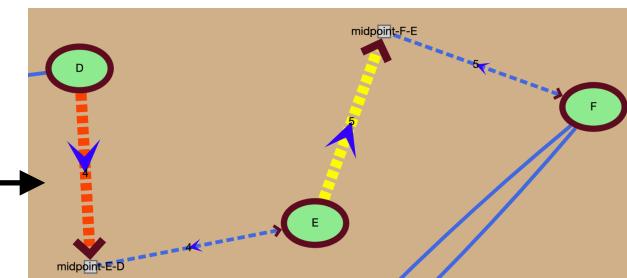
```
{"source": "D", "dest": "F", "name": "lsp_d_f_1", "routed": true}
```

All LSPs the demand transits will be shown, whether the demand takes the LSP(s) end-to-end or as an IGP shortcut

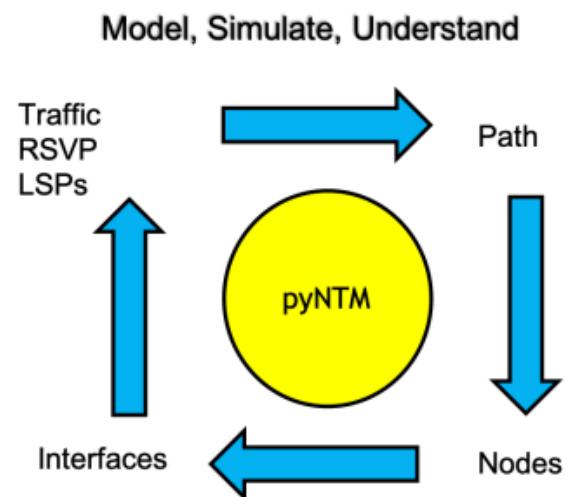
The selected LSP here will become the active **Selected RSVP LSP** (see the RSVP LSP Operations section for more info)

Selected RSVP LSP: [Clear LSP Selection](#)

```
{"source": "D", "dest": "F", "name": "lsp_d_f_1", "routed": true}
```

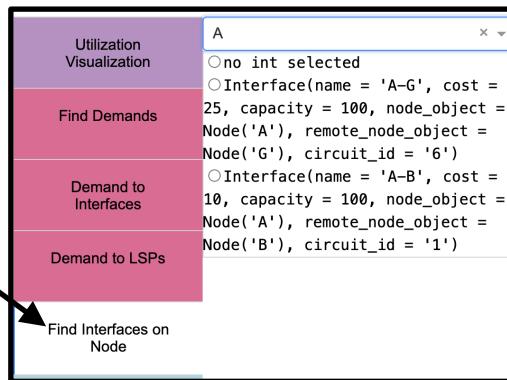


Live Exercise 3: Interface operations



Selecting an interface

Click on the Find Interfaces on Node tab —>select a Node —> select an Interface

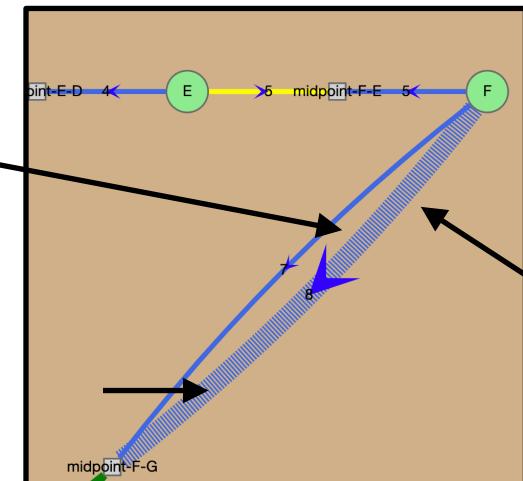


Selected Interface:

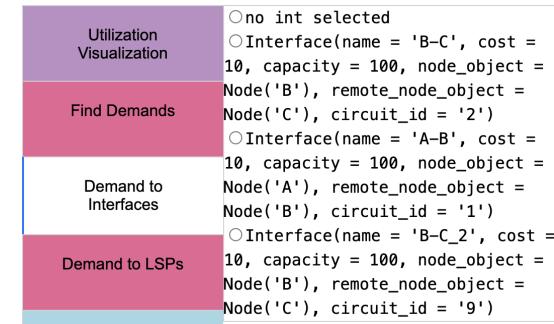
```
{"source": "F", "interface-name": "F-G_2", "dest": "G", "circuit_id": "8", "utilization %": 0, "cost": 25}
```

Find Interfaces by Node

Select an Interface directly on the map



The selected Interface appears thicker and with hatch lines on the map



Can also select Interfaces

Selecting an interface (continued)

The diagram illustrates the process of selecting an interface across several tabs in a software application:

- Selected Interface:** A box containing JSON data for a selected interface:

```
{"source": "F", "interface-name": "F-G_2", "dest": "G", "circuit_id": "8", "utilization %": 0, "cost": 25}
```

 with a "Clear Interface Selection" button.
- Utilization Visualization:** Shows a purple bar chart.
- Find Demands:** Shows a pink bar chart.
- Demand to Interfaces:** Shows a blue bar chart. This tab is highlighted with a red arrow pointing to it from the "Selected Interface" box.
- Demand to LSPs:** Shows a pink bar chart.
- Find LSPs:** A maroon panel containing the text "Find LSPs".
- LSP to Demands:** A maroon panel containing the text "LSP to Demands".
- LSP to Interfaces:** A white panel containing the text "LSP to Interfaces".
- Interface Selection Options:** A vertical list of radio buttons:
 - no int selected
 - Interface(name = 'B-C', cost = 10, capacity = 100, node_object = Node('B'), remote_node_object = Node('C'), circuit_id = '2')
 - Interface(name = 'A-B', cost = 10, capacity = 100, node_object = Node('A'), remote_node_object = Node('B'), circuit_id = '1')
 - Interface(name = 'B-C_2', cost = 10, capacity = 100, node_object = Node('B'), remote_node_object = Node('C'), circuit_id = '9')
 - Interface(name = 'C-D', cost = 10, capacity = 100, node_object = Node('C'), remote_node_object = Node('D'), circuit_id = '3')

Annotations:

- A red arrow points from the "Selected Interface" box to the "Demand to Interfaces" tab.
- A black arrow points from the "Selected Interface" box to the interface selection list.
- The text "Can also select Interfaces from Demand to Interfaces tab . . ." is positioned below the "Demand to Interfaces" tab.
- The text "... or from the LSP to Interfaces tab" is positioned below the "LSP to Interfaces" tab.
- The text "Clear the Interface selection by clicking on the **Clear Interface Selection** button or by clicking on one of the **no int selected** radio buttons in **Demands to Interfaces** or **LSP to Interfaces** tabs" is located on the right side of the interface selection list.

Finding demands that transit an interface

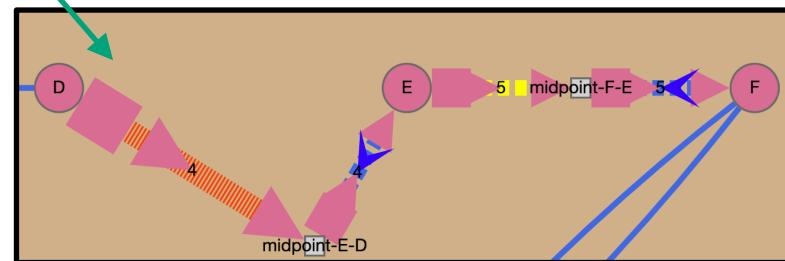
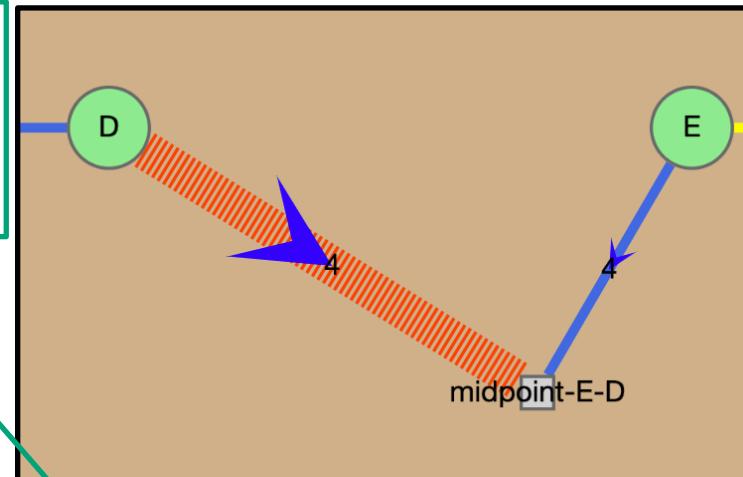
Find demands that transit the Selected Interface by clicking on the **Interface to Demands** tab

Utilization Visualization	<ul style="list-style-type: none"><input type="radio"/> no routed demand selected<input type="radio"/> Demand(source = D, dest = F, traffic = 20, name = 'dmd_d_f_1')<input type="radio"/> Demand(source = D, dest = E, traffic = 10, name = 'dmd_d_f_1')<input type="radio"/> Demand(source = A, dest = F, traffic = 100, name = 'dmd_a_f_1')
Find Demands	
Demand to Interfaces	
Demand to LSPs	
Find Interfaces on Node	
Interface to Demands	
Interface to LSPs	

Selecting a Demand here will set that as the **Selected Demand** and that Demand's path(s) will be shown on the map

Selected Interface: [Clear Interface Selection](#)

```
{"source": "D", "interface-name": "D-E", "dest": "E", "circuit_id": "4", "utilization %": 80, "cost": 10}
```



If the **Selected Interface** has traffic, the Demands that transit the interface will be listed

Finding LSPs that transit an interface

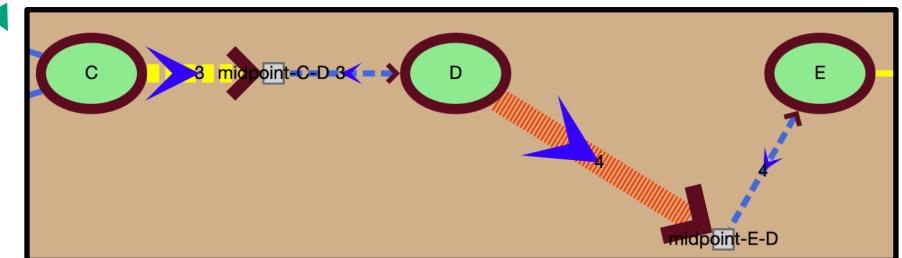
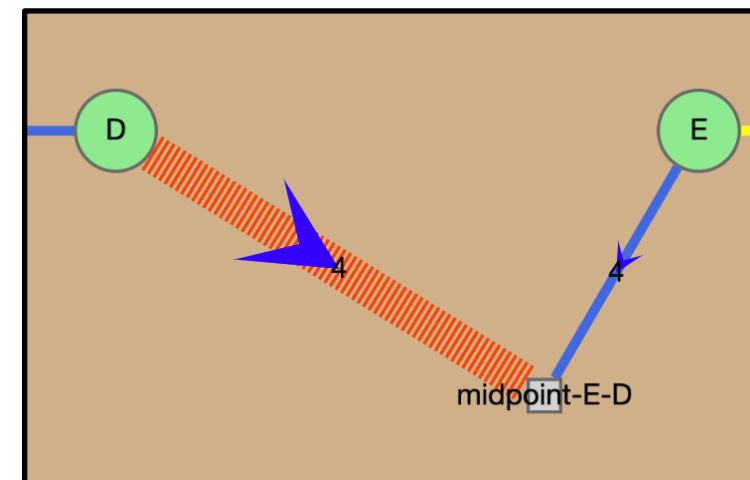
Find LSPs that transit the Selected Interface by clicking on the **Interface to LSPs** tab

Utilization Visualization	<input type="radio"/> no routed lsp selected <input checked="" type="radio"/> RSVP_LSP(source = C, dest = E, lsp_name = 'lsp_c_e_1') <input type="radio"/> RSVP_LSP(source = D, dest = F, lsp_name = 'lsp_d_f_1')
Find Demands	
Demand to Interfaces	
Demand to LSPs	
Find Interfaces on Node	
Interface to Demands	
Interface to LSPs	

Selecting an LSP here will set that as the **Selected RSVP LSP** and that LSP's path will be shown on the map

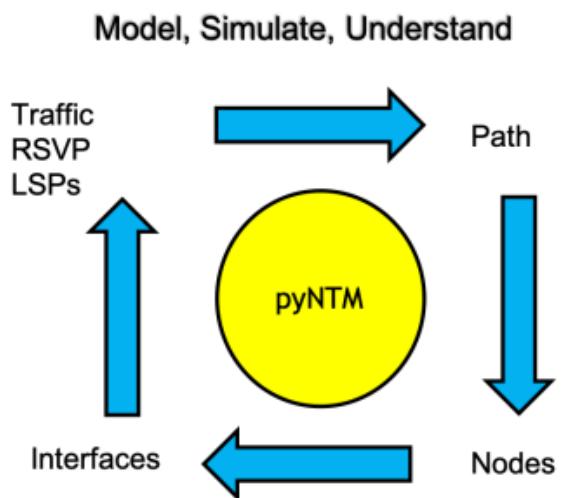
Selected Interface: [Clear Interface Selection](#)

```
{"source": "D", "interface-name": "D-E", "dest": "E", "circuit_id": "4", "utilization %": 80, "cost": 10}
```



If the **Selected Interface** has LSPs, the LSPs that transit the interface will be listed

Live Exercise 4: LSP operations



Selecting an LSP

Utilization Visualization	Clear the source or destination selection by selecting the 'X' on the right side of the selection menu
Find Demands	B Select a dest node
Demand to Interfaces	<input type="radio"/> no routed lsp selected <input checked="" type="radio"/> RSVP_LSP(source = B, dest = D, lsp_name = 'lsp_b_d_1') <input type="radio"/> RSVP_LSP(source = B, dest = D, lsp_name = 'lsp_b_d_2')
Demand to LSPs	
Find Interfaces on Node	
Interface to Demands	
Interface to LSPs	
Find LSPs	
LSP to Demands	
LSP to Interfaces	

LSPs can be searched for and selected from the **Find LSPs** tab, similar to the **Find Demands** tab

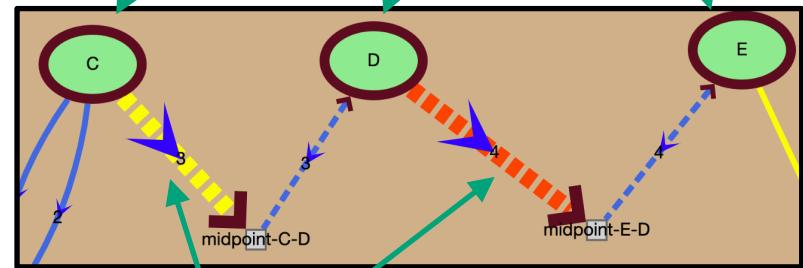
LSPs can also be selected from the **Interface to LSPs** and **Demand to LSPs** tabs

When there is a Selected RSVP LSP, its path will be visualized on the map

Selected RSVP LSP: Clear LSP Selection

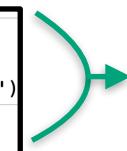
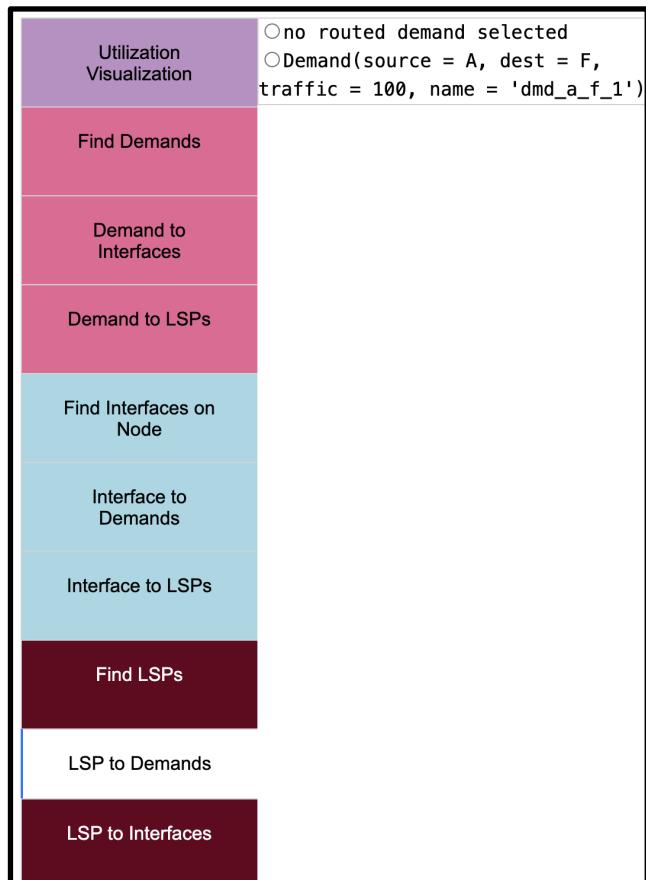
```
{"source": "C", "dest": "E", "name": "lsp_c_e_1",  
"routed": true}
```

An LSP's path will be denoted via a brick red border around the Nodes, which will also turn from circular to oval in shape...



... and the transited Interfaces will have a brick red arrow denoting the LSP's direction, a wider Interface line, and the line will be segmented

Finding Demands that transit the LSP



Any Demands that transit the LSP are found on the LSP to Demands tab

Selected RSVP LSP: [Clear LSP Selection](#)

```
{"source": "B", "dest": "D", "name": "lsp_b_d_1",  
"routed": true}
```

Selecting a Demand from the list will make that Demand the **Selected Demand** and visualize the Demand's path on the map

Selected Demand: [Clear Demand Selection](#)

```
{"source": "A", "dest": "F", "name": "dmd_a_f_1",  
"routed": true}
```

Finding Interfaces that the LSP transits

Utilization Visualization	<pre>no int selected Interface(name = 'C-D', cost = 10, capacity = 100, node_object = Node('C'), remote_node_object = Node('D'), circuit_id = '3') Interface(name = 'D-E', cost = 10, capacity = 100, node_object = Node('D'), remote_node_object = Node('E'), circuit_id = '4')</pre>
Find Demands	
Demand to Interfaces	
Demand to LSPs	
Find Interfaces on Node	
Interface to Demands	
Interface to LSPs	
Find LSPs	
LSP to Demands	
LSP to Interfaces	

Interfaces that the LSP transits (egresses) are found on the LSP to Interfaces tab

Selecting an Interface from the LSP to Interfaces tab will make that Interface the **Selected Interface** and highlight that Interface on the map

Selected RSVP LSP: [Clear LSP Selection](#)

```
{"source": "C", "dest": "E", "name": "lsp_c_e_1", "routed": true}
```

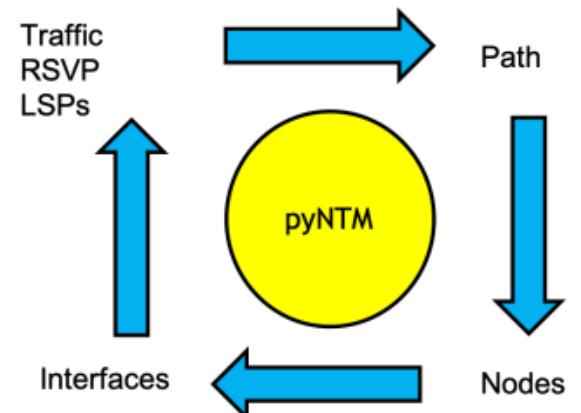
Selected Interface: [Clear Interface Selection](#)

```
{"source": "C", "interface-name": "C-D", "dest": "D", "circuit_id": "3", "utilization %": 50.0, "cost": 10}
```

The diagram shows a network topology with three nodes: C, D, and E. There are two LSPs: one from C to D (via interface C-D) and another from D to E (via interface D-E). The interface C-D is highlighted with a yellow arrow, and the interface D-E is highlighted with an orange arrow. The LSPs are represented by dashed lines connecting the nodes.

Live Exercise 5: Failed Objects and Interpreting Concurrent Visualizations

Model, Simulate, Understand



Failed Object Visualization

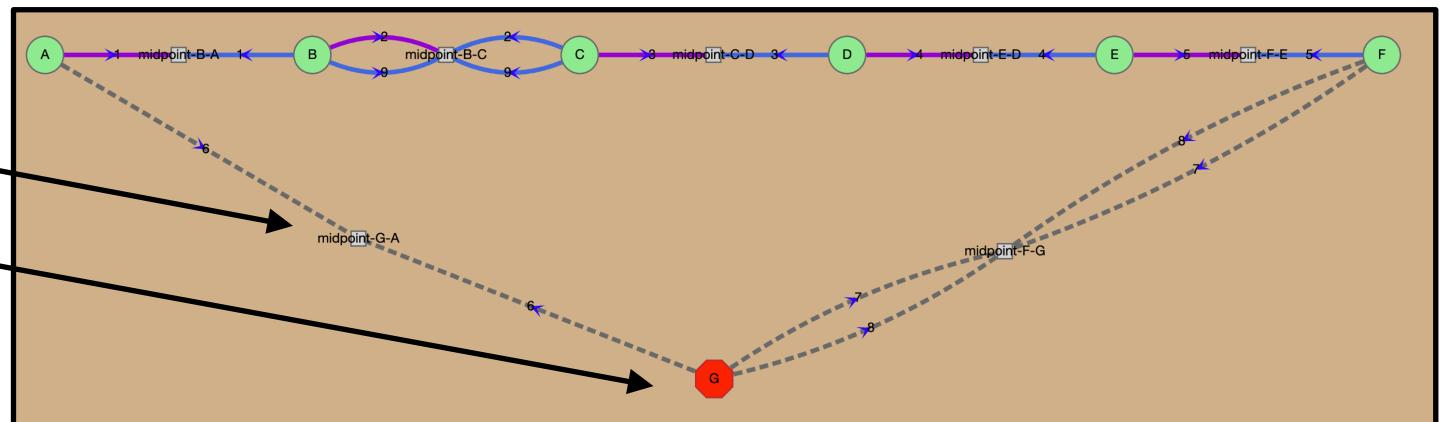
Create a model and fail a Node as shown

Create a WeatherMap for the model with the failed node and visualize it

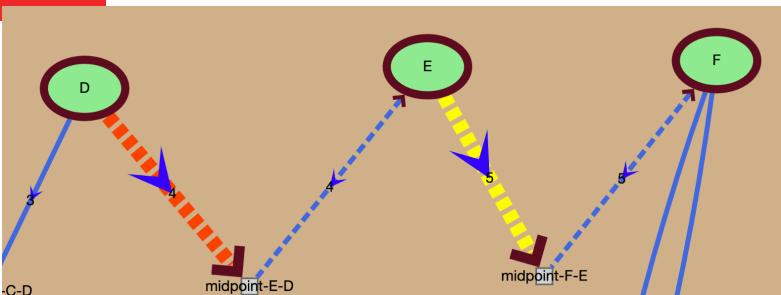
```
>>> model = FlexModel.load_model_file('igp_shortcuts_model_mult_lsps_in_path_parallel_links_2.csv')
>>> model
FlexModel(Interfaces: 18, Nodes: 7, Demands: 4, RSVP_LSPs: 4)
>>>
>>> model.node_objects
{Node('D'), Node('G'), Node('E'), Node('A'), Node('C'), Node('B'), Node('F')}
>>>
>>> model.fail_node('G')
>>>
>>> model.update_simulation()
Routing the LSPs . .
Routing 1 LSPs in parallel LSP group D-F; 1/3
Routing 1 LSPs in parallel LSP group C-E; 2/3
Routing 2 LSPs in parallel LSP group B-D; 3/3
LSPs routed (if present) in 0:00:00.024036; routing demands now . .
Demands routed in 0:00:00.005829; validating model . .
>>>
>>> wm = WeatherMap(model)
>>>
>>> wm.create_weathermap()
```

Failed Interfaces are shown as dashed, gray lines

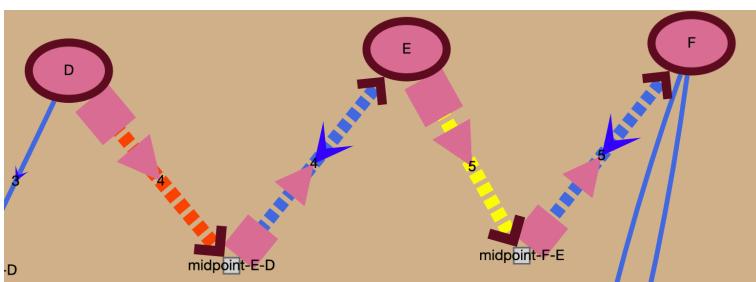
Failed Nodes are shown as red octagons



Concurrent Visualizations

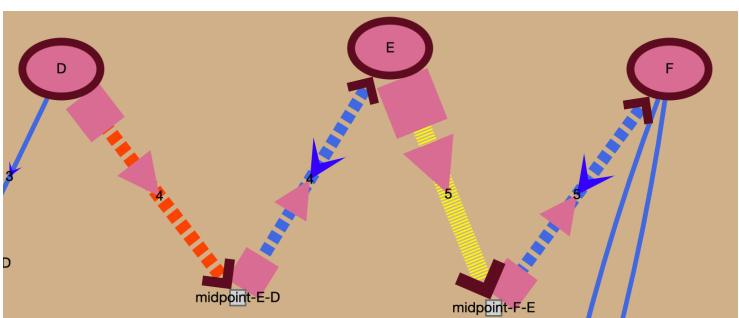


Selected RSVP LSP: [Clear LSP Selection]
 {"source": "D", "dest": "F", "name": "lsp_d_f_1",
 "routed": true}



Selected RSVP LSP: [Clear LSP Selection]
 {"source": "D", "dest": "F", "name": "lsp_d_f_1",
 "routed": true}

 Selected Demand: [Clear Demand Selection]
 {"source": "D", "dest": "F", "name": "dmd_d_f_1",
 "routed": true}



Selected RSVP LSP: [Clear LSP Selection]
 {"source": "D", "dest": "F", "name": "lsp_d_f_1",
 "routed": true}

 Selected Demand: [Clear Demand Selection]
 {"source": "D", "dest": "F", "name": "dmd_d_f_1",
 "routed": true}

 Selected Interface: [Clear Interface Selection]
 {"source": "E", "interface-name": "E-F", "dest": "F",
 "circuit_id": "5", "utilization %": 70, "cost": 10}

Selected RSVP LSP path

- Dark-red arrows
- Wider Interface lines with thick dashes
- Dark-red Node borders

Add a Selected Demand on the LSP

- Add the pinkish squares and arrows on the Circuit of the transited Interfaces
- Wider Interface lines for entire Circuits that contains Interfaces that Demand transits
- Pinkish arrows in LSP direction of travel
- Pinkish filling for the Nodes in the Demand path

Add Selected Interface in LSP and Demand path

- Wider Interface line with finer dashes
- Wider arrows on Selected Interface

FIN

Model, Simulate, Understand

