Digital Assistant for Resilient Operation of the Power Grid Using NLI

Jonah Davis

University of Rochester

Dr. Anurag Srivastava

SGDRIL

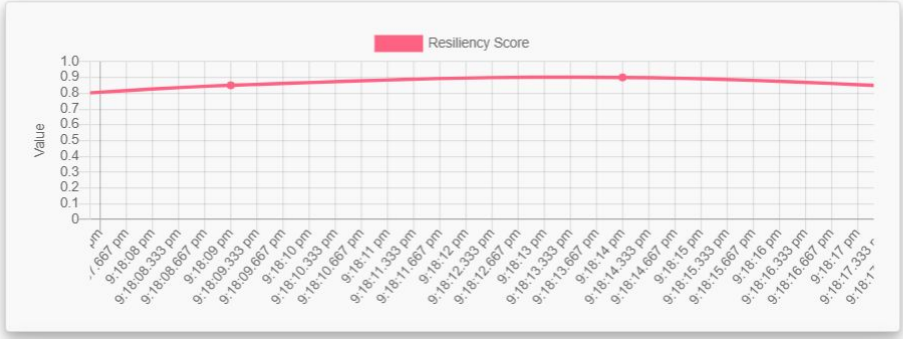
- Smart Grid Demonstration and Research Investigation Lab (SGDRIL)
- Headed by Dr. Anurag Srivastava
- Goal: develop and test algorithms for improving the performance of smart power grids
- Real-Time Resiliency Management System (RT-RMS)
  - Used by grid operators to make decisions during an adverse event (e.g. hurricane, tsunami, earthquake)

REAL-TIME RESILIENCY MANAGEMENT SYSTEM

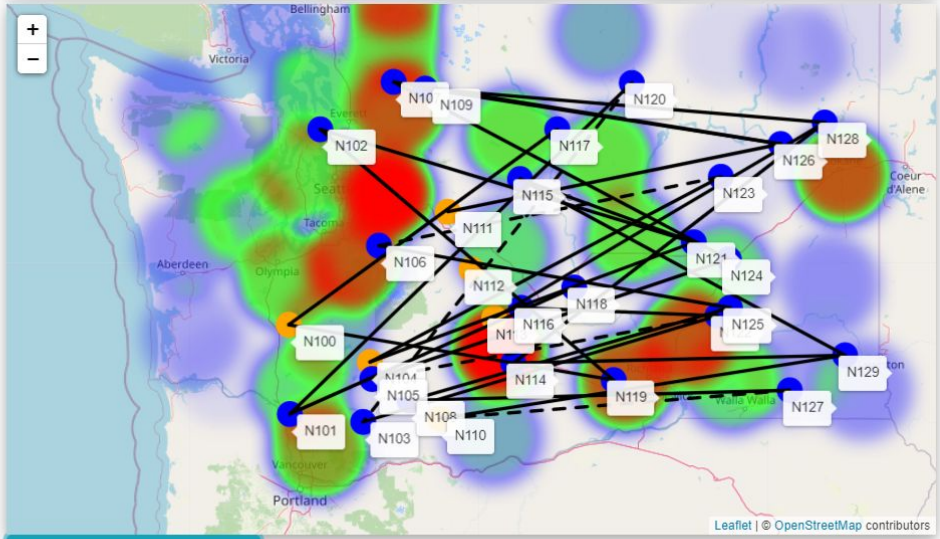
System Information | **Resiliency Monitoring** | Decision Support | Planning and Analysis

Run-time Resiliency Score | Threat and Impact | Resiliency History

Resiliency Readings



Live Map and Weather



Ask Virtual Assistance

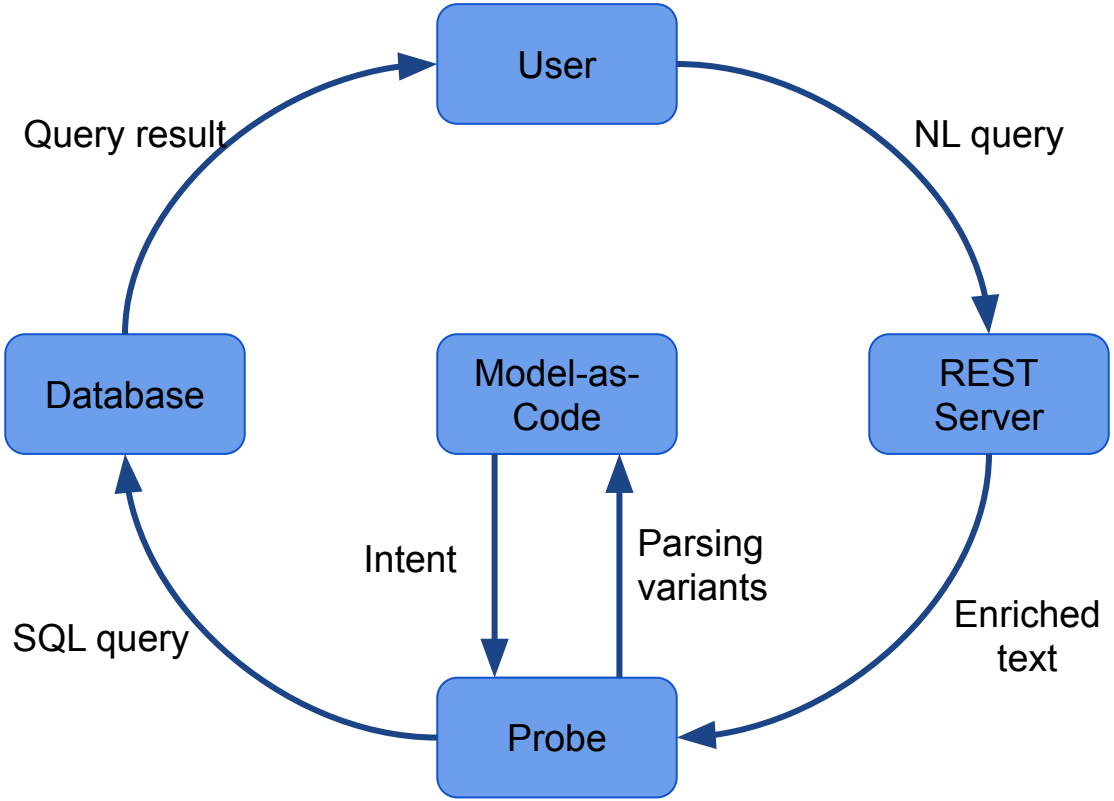
Problem

- Overwhelming amount of data, especially for an operator under stress
- Existing UI for decision support may result in not accessing all useful information to enable resiliency
- Need an alternative way to access the database

Approach

- Current: UI-based interaction
  - Tables with fixed columns
  - Data split between tabs
- Proposed: natural language interface
  - Tailored to operator’s request
  - Built around NLPCraft
  - Uses intent matching to generate and send SQL queries

Step by step

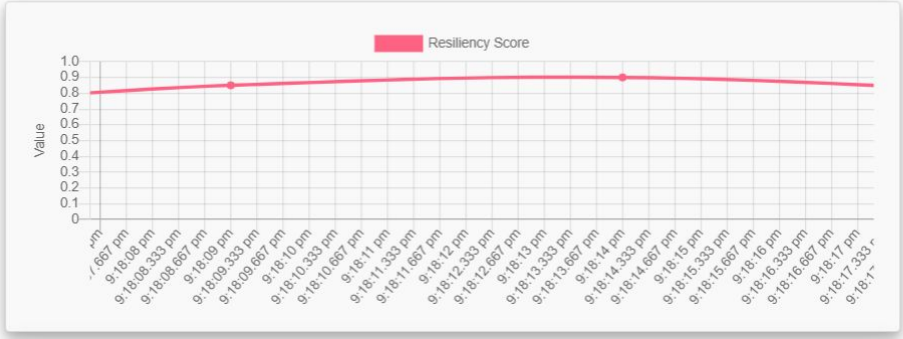

User
NL query
REST Server
Enriched text
Probe
Parsing variants
Intent
Model-as-Code
SQL query
Database
Query result

REAL-TIME RESILIENCY MANAGEMENT SYSTEM

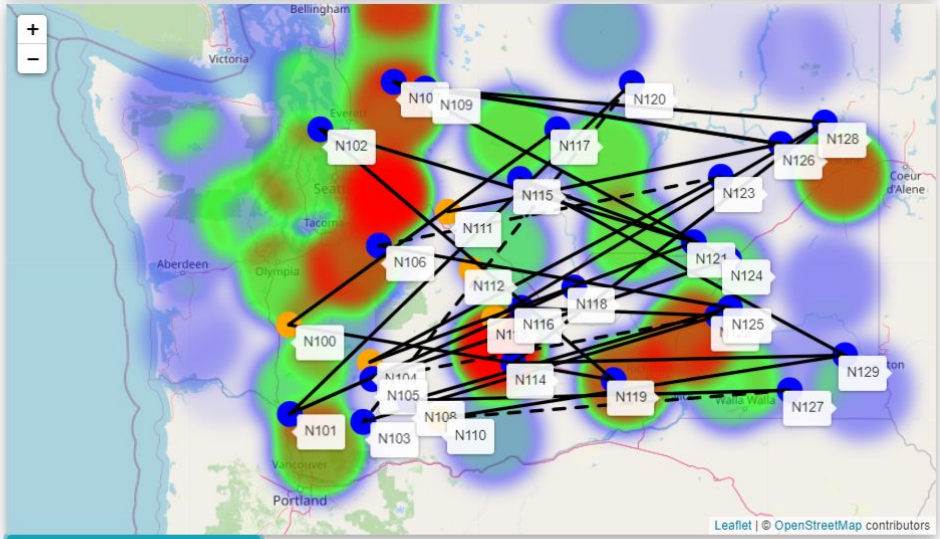
System Information | **Resiliency Monitoring** | Decision Support | Planning and Analysis

Run-time Resiliency Score | Threat and Impact | Resiliency History

Resiliency Readings



Live Map and Weather



Ask Virtual Assistance

REAL-TIME RESILIENCY MANAGEMENT SYSTEM

System Information | Planning and Analysis

Run-time Resiliency Score | Threat and Impact | Resiliency History

Resiliency Readings

Virtual Assistant

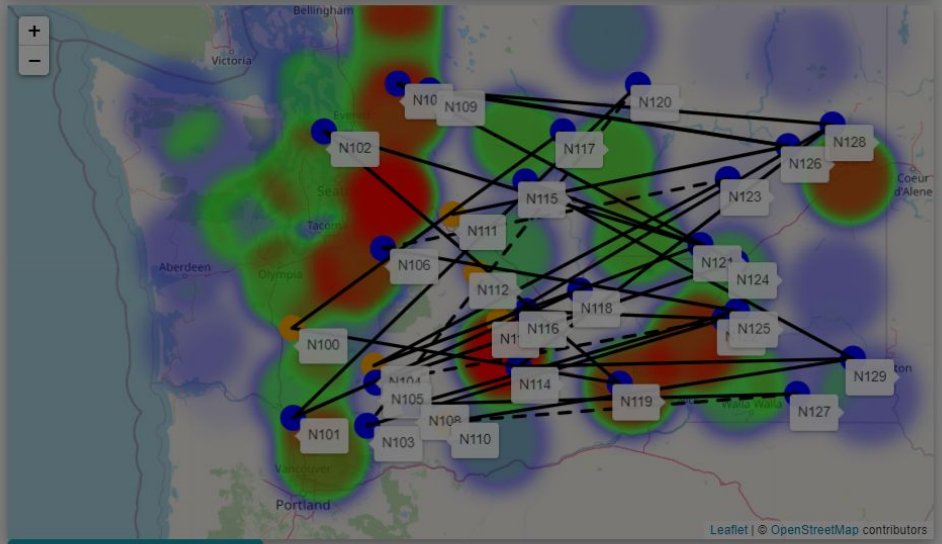
Enter your query here

Cancel | Submit

Live Map and Weather

73°F
Drizzle

Wednesday	Thursday	Friday
75°F 57°F	75°F 52°F	73°F 55°F



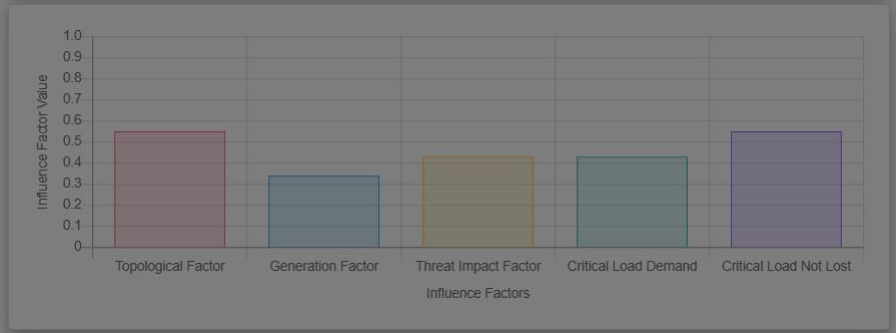
Ask Virtual Assistance

REAL-TIME RESILIENCY MANAGEMENT SYSTEM

System Information | Planning and Analysis

Run-time Resiliency Score | Threat and Impact | Resiliency History

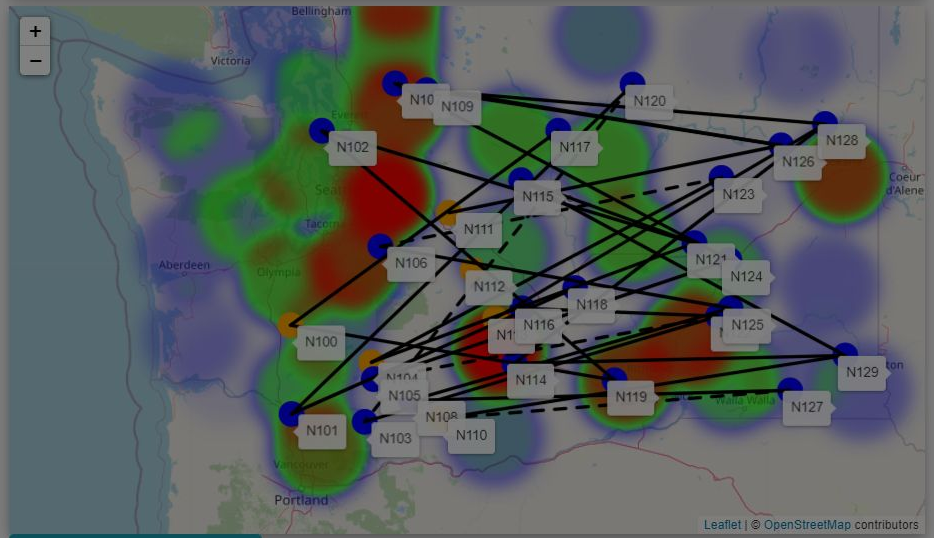
Resiliency Readings



Live Map and Weather

73°F
Drizzle

Wednesday	Thursday	Friday
75°F 57°F	75°F 52°F	73°F 55°F

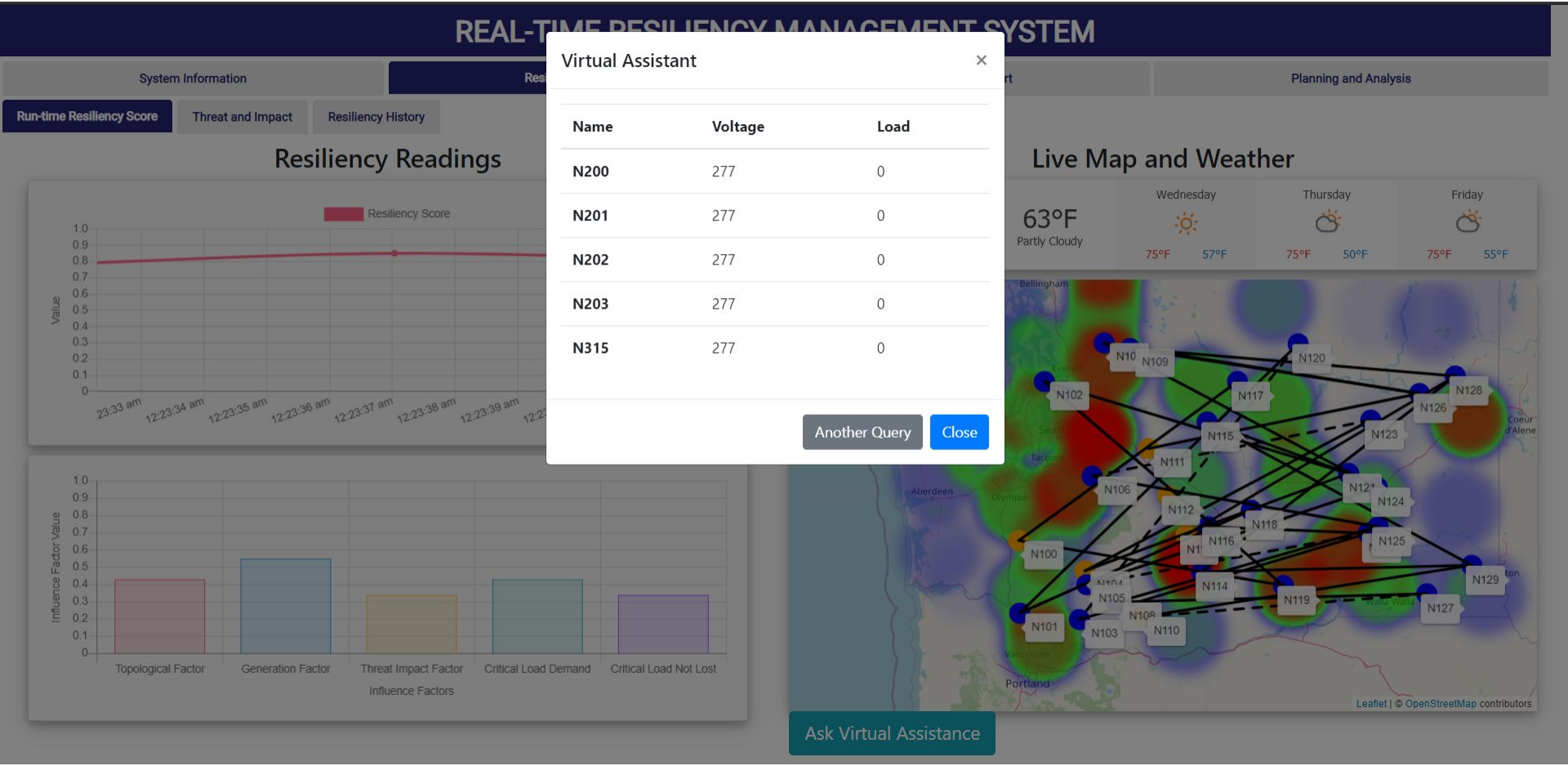


Ask Virtual Assistance

Virtual Assistant

What node has the lowest voltage?

Cancel | Submit

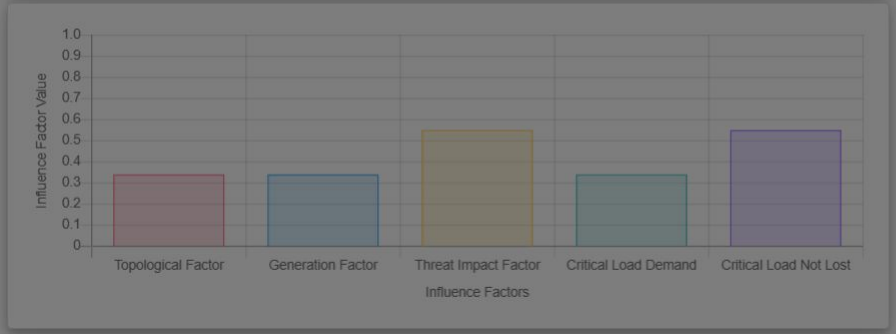

REAL-TIME RESILIENCY MANAGEMENT SYSTEM
System Information
Planning and Analysis
Run-time Resiliency Score
Threat and Impact
Resiliency History
Resiliency Readings
Resiliency Score
Value
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
23:33 am
12:23:34 am
12:23:35 am
12:23:36 am
12:23:37 am
12:23:38 am
12:23:39 am
Influence Factor Value
Topological Factor
Generation Factor
Threat Impact Factor
Critical Load Demand
Critical Load Not Lost
Influence Factors
Live Map and Weather
63°F
Partly Cloudy
Wednesday
75°F
57°F
Thursday
75°F
50°F
Friday
75°F
55°F
Bellingham
Aberdeen
Olympia
Portland
N102
N109
N120
N117
N128
N126
N115
N123
N111
N106
N112
N118
N116
N100
N114
N105
N119
N125
N129
N127
N101
N103
N110
Leaflet | © OpenStreetMap contributors
Ask Virtual Assistance
Virtual Assistant
Name
Voltage
Load
N200
277
0
N201
277
0
N202
277
0
N203
277
0
N315
277
0
Another Query
Close

REAL-TIME RESILIENCY MANAGEMENT SYSTEM

System Information | Planning and Analysis

Run-time Resiliency Score | Threat and Impact | Resiliency History

Resiliency Readings



Virtual Assistant

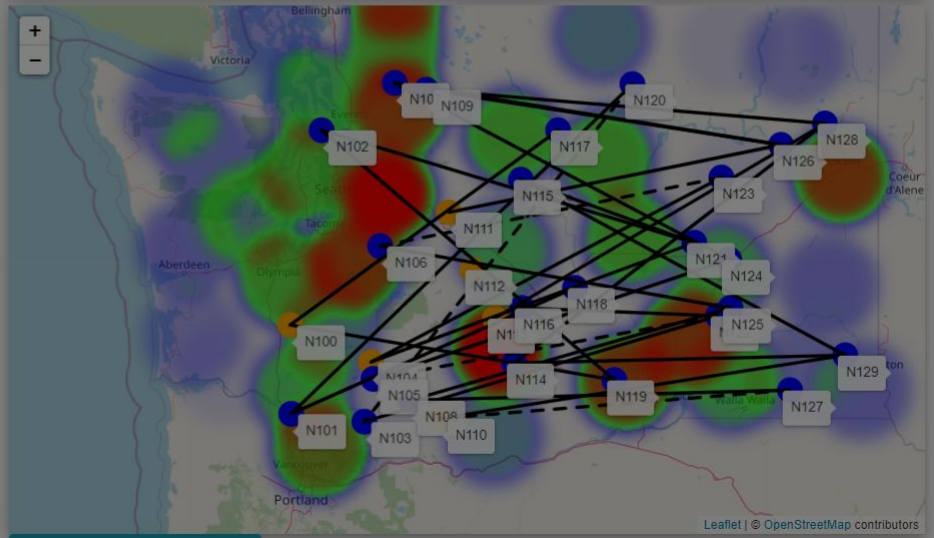
What plants are not working?

Cancel | Submit

Live Map and Weather

73°F
Drizzle

Wednesday	Thursday	Friday
75°F 57°F	75°F 52°F	73°F 55°F



Ask Virtual Assistance

REAL-TIME RESILIENCY MANAGEMENT SYSTEM

System Information | Planning and Analysis

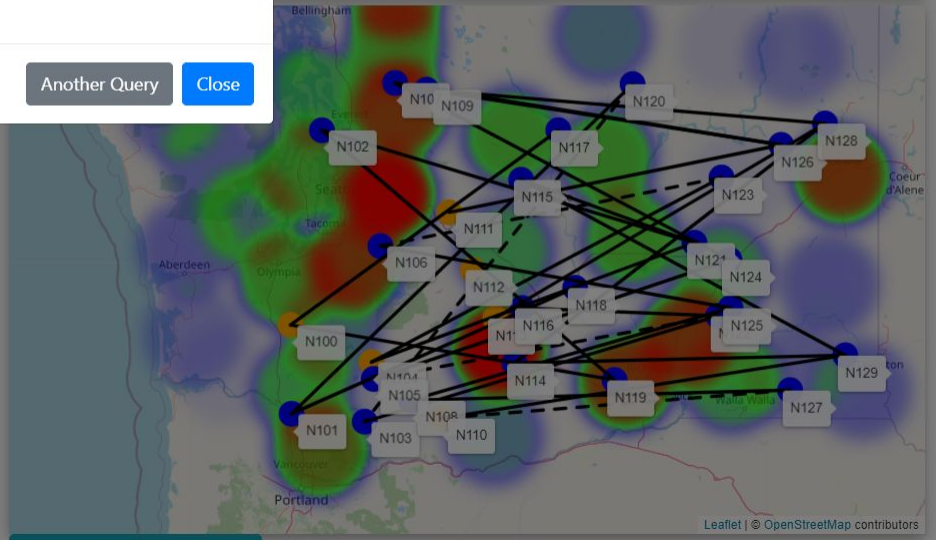
Run-time Resiliency Score | Threat and Impact | Resiliency History

Resiliency Readings

Live Map and Weather

63°F
Partly Cloudy

Wednesday	Thursday	Friday
75°F 57°F	75°F 50°F	75°F 55°F



Ask Virtual Assistance

Virtual Assistant

Generator ID	Status	KV
DG1	Off	4.16
DG4	Off	1.54
DG5	Off	3.22

Another Query | Close

Evaluation

- Metrics:
  - Percent of questions answered correctly
  - Speed
- 53 questions across all tables and columns in the model
- Includes multiple ways of phrasing questions

Results

- Average time: 568 ms
- Questions answered correctly: 92%
- Incorrect answers are usually caused by
  - the phrasing of a question not being accounted for by the model
  - the probe choosing the wrong parsing variant

Conclusions

- Based on the speed and accuracy already shown, this is a viable solution to the problem
- Next steps:
  - increase the model's scope to handle more complex questions
  - integrate with RT-RMS visualization tool

Acknowledgements

- Dr. Anurag Srivastava
- Dr. Sanjeev Pannala
- Anshuman Lnu
- National Science Foundation Research Experiences for Undergraduates Program under Grant No. 1757632