Decision Support System for Winter Road Network Vulnerability Assessment

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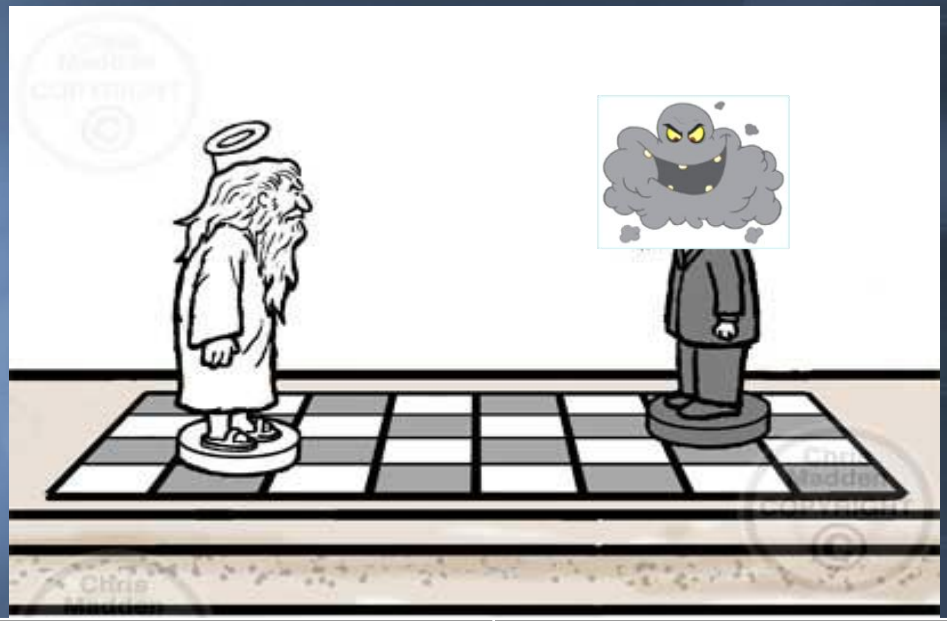
Introduction

- Quantifying winter road network vulnerability first step to proactive prevention.
- Obvious system vulnerabilities:
  - High-volume roads with limited alternative paths
  - Far from winter service stations
- May not be entire story…
- Game theoretic approach
  - Conceptually suitable
  - Practical

The Players



Role:	Traffic Management Authority	Worst Weather Scenario
Goal	Seeks safest, most efficient paths for all travelers	Disable road(s) to inflict greatest disruption
Tool	Route assignment strategy	Road failure strategy

Programing Solution Approach

Step 0: Initialize network

Step 1: Calculate the service station distance for each of link

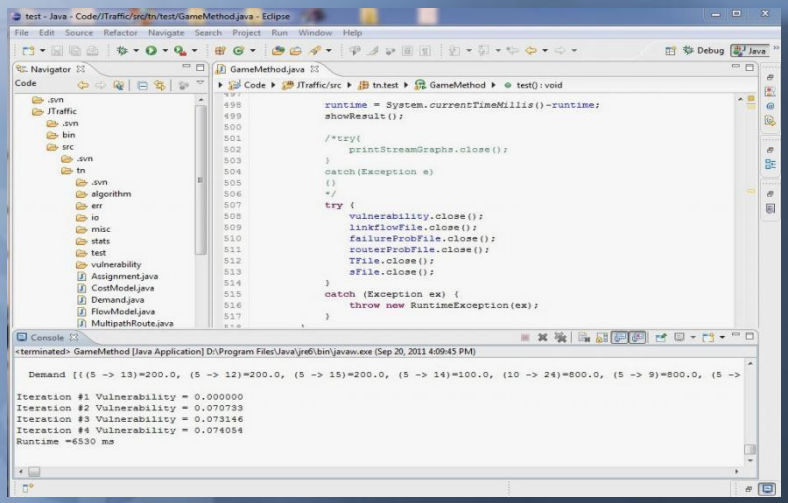
Step 2: Update link s-Expected costs S_e^n

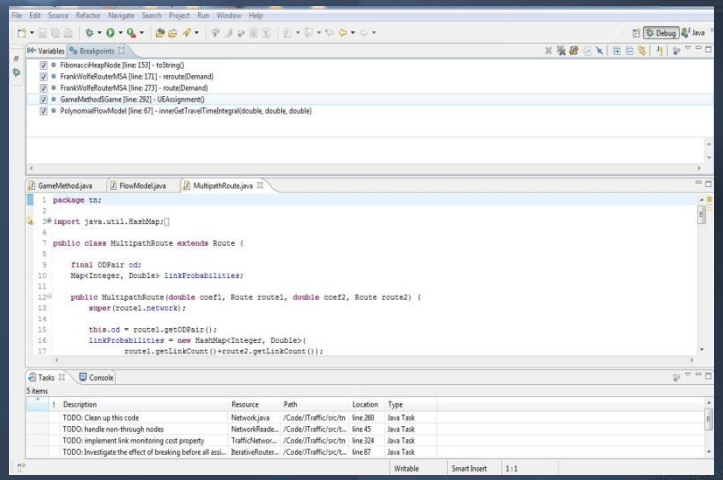
Step 3: Calculate Link heuristic cost T_e^n using MSA

Step 4: Router assign traffic based on User Equilibrium Assignment

Step 5: Tester choses link to fail, get link failure probability ρ_e^n

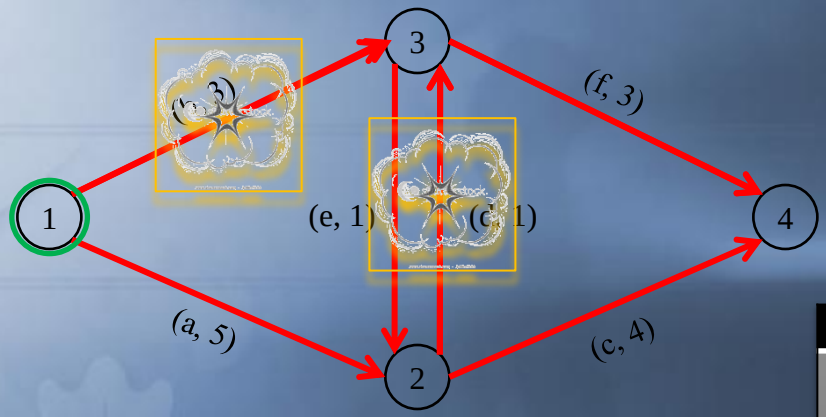
Step 6: If $\Sigma\,|\rho_e^n - \rho_e^{n-1}| < \varepsilon$, stop. Otherwise, goto Step 2





Simple Illustration

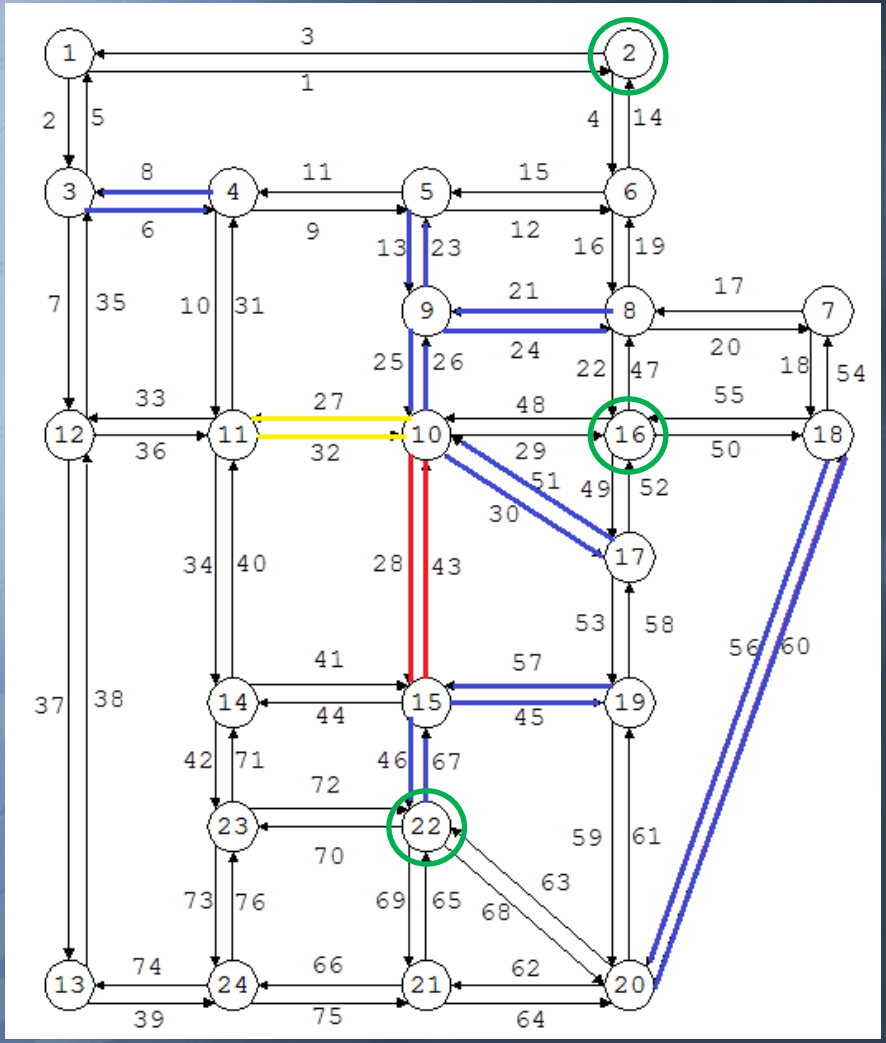
- 4 Towns
- 6 Roads
- Unique edge costs



O-D Pair	Demand
(1, 2)	1
(1, 3)	1
(1, 4)	1
(2, 3)	1
(2, 4)	2
(3, 4)	1

		1st Iteration			2nd Iteration		
e	C_e^-	S_e^n	γ_e^n	ρ_e^{n+1}	S_e^n	γ_e^n	ρ_e^{n+1}
a	5	12.5	0	0	8.75	0.233	0.309
b	3	7.5	0.333	0.470	11.59	0.023	0.012
c	4	10.1	0.222	0.209	10.86	0	0
d	1	2.6	0.111	0.078	2.20	0.403	0.412
e	1	2.6	0.111	0.075	2.19	0	0
f	3	7.6	0.222	0.167	7.61	0.341	0.266

Sioux Falls Criticality Assessment



- 24 Nodes
- 76 Edges
- 552 O-D pairs

High

Medium

Low

Service Station

Conclusion

- Transportation demand model includes road characteristics:
  - Distance, capacity, connections, and origin/destination trip table, etc…
- "Villain"/weather attacks most vulnerable roads:
  - High traffic volumes
  - Few alternative routes
  - Far from the snow plow deployment site
- Most critical roads/links identified after many rounds of play:
  - Frequently attacked links given highest priority
  - Identifies roads to be plowed first to keep road network in best condition

Thank you.

Question?