NUCLEAR WASTE DISPOSAL

Network Modeling

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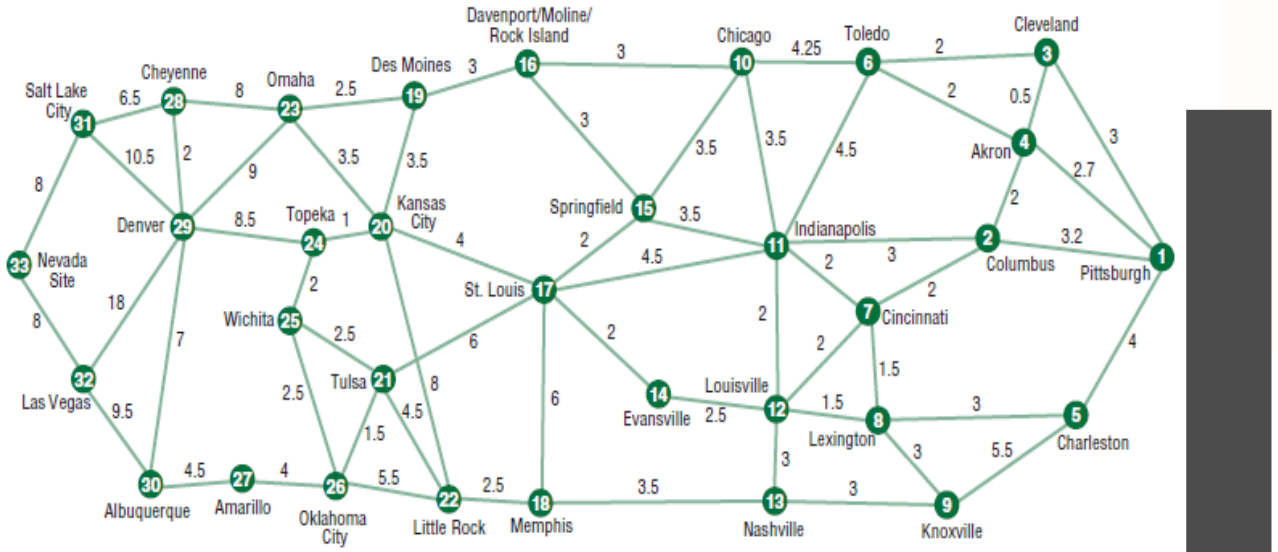
❑ OUTLINE

- Introduction and Motivation to Transportation of Nuclear Waste Disposal
- Model, Objective Function, Constraints and Programming
- Problem Solving Model and Solution
- Experimental Results
- Conclusion and Future Scope.
- References

❑ INTRODUCTION



Network Model

- PAWV power and light wants to dispose their waste from its nuclear power plants from Pennsylvania at a government operated nuclear waste disposal site in Nevada.
- The contracted waste disposal firm must dispose this nuclear waste in reinforced container trucks across the country, and all travel must be confined to interstate highway system.

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- The government insists that the transport of nuclear waste must be completed within 42 hours.

- The population affected should be least.

City	Population (1,000,000s)	City	Population (1,000,000s)
Akron	0.50	Las Vegas	1.60
Albuquerque	1.00	Lexington	0.50
Amarillo	0.30	Little Rock	0.60
Charleston	1.30	Louisville	0.93
Cheyenne	0.16	Memphis	1.47
Chicago	10.00	Nashville	1.00
Cincinnati	1.20	Oklahoma City	1.30
Cleveland	1.80	Omaha	1.40
Columbus	0.75	Salt Lake City	1.20
Davenport/Moline/ Rock Island	1.00	Springfield	0.36
Denver	2.20	St. Louis	2.00
Des Moines	0.56	Toledo	0.76
Evansville	0.30	Topeka	0.30
Indianapolis	1.60	Tulsa	1.00
Kansas City	2.10	Wichita	0.73
Knoxville	0.54		

❑ MOTIVATION

- Nuclear Waste is highly hazardous. Thus it is very crucial to dispose of it soon and safely.
- There are small number of government operated high level nuclear waste disposal sites.
- Government has proposed few regulations for transporting high level nuclear waste:
  - Travel of Disposal trucks should be within 42 hours
  - Nuclear waste should travel through least populated cities.

❑ MOTIVATION (CONT.)

- Node represents each *CITY*
- Arcs represents the *Highways connecting the cities*
- Quantitative Model - Network Model
- Objective Function – Optimal travelling route

❑ PROBLEM SOLVING

- Library used in R – lpSolveAPI and lprec() function.
- Application of the Integer Programming:
  - **Critical Path Method of Network Model.**

❑ INTEGER FORMULATION FOR FINDING CRITICAL PATH

- **Decision Variable:**
  - Xij defines the travel of Waste Disposal Truck from Source (i) to destination (j) Cities.
  - Cij defines the Population of the Cities.
  - Dij defines the time taken to travel between cities.

- **Objective Function:**
  - **Minimize $\sum_{\text{Truck Path}}$ Cij Xij**

❑ INTEGER FORMULATION FOR FINDING CRITICAL PATH

- **Constraints:**
  - Time Travel Constrain:
    - $\sum_{\text{Truck out}} \mathbf{Dij\ Xij <= 42}$
  - Starting node:
    - $\sum_{\text{Truck out}} \mathbf{Xij = 1}$
  - Intermediate nodes:
    - $\sum_{\text{Truck in}} \mathbf{Xij} - \sum_{\text{Truck out}} \mathbf{Xij = 0}$
  - Ending nodes:
    - $\sum_{\text{Truck in}} \mathbf{Xij = 1}$

    And Xij >= 0

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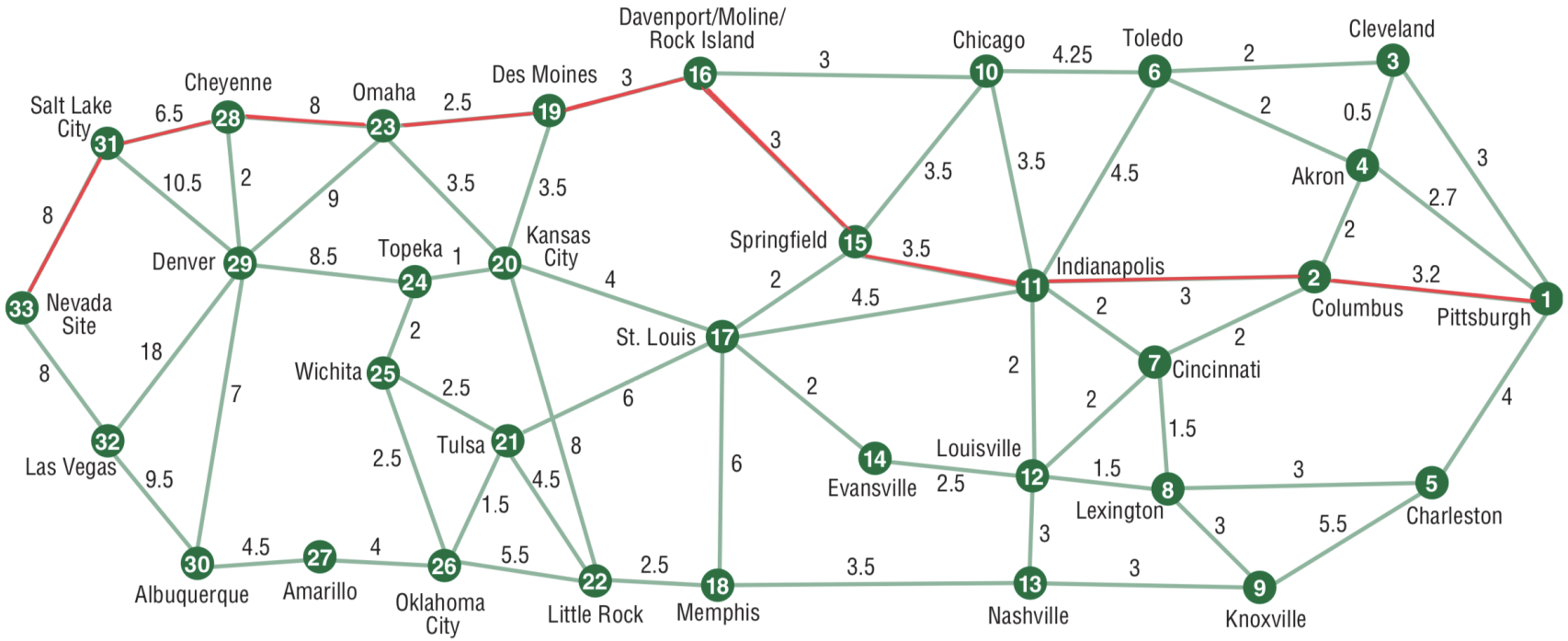
❑ SOLUTION

- **Objective Function: 7.03**
  - Minimum Population Affected during the Nuclear Waste Truck journey – 7.03 Million people.

- **Time Constraint: 40.7**
  - Time taken for the Truck to reach Nevada from Pittsburgh is 40.7 Hours

❑ SOLUTION- CRITICAL PATH



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❑ EXPERIMENTAL RESULTS

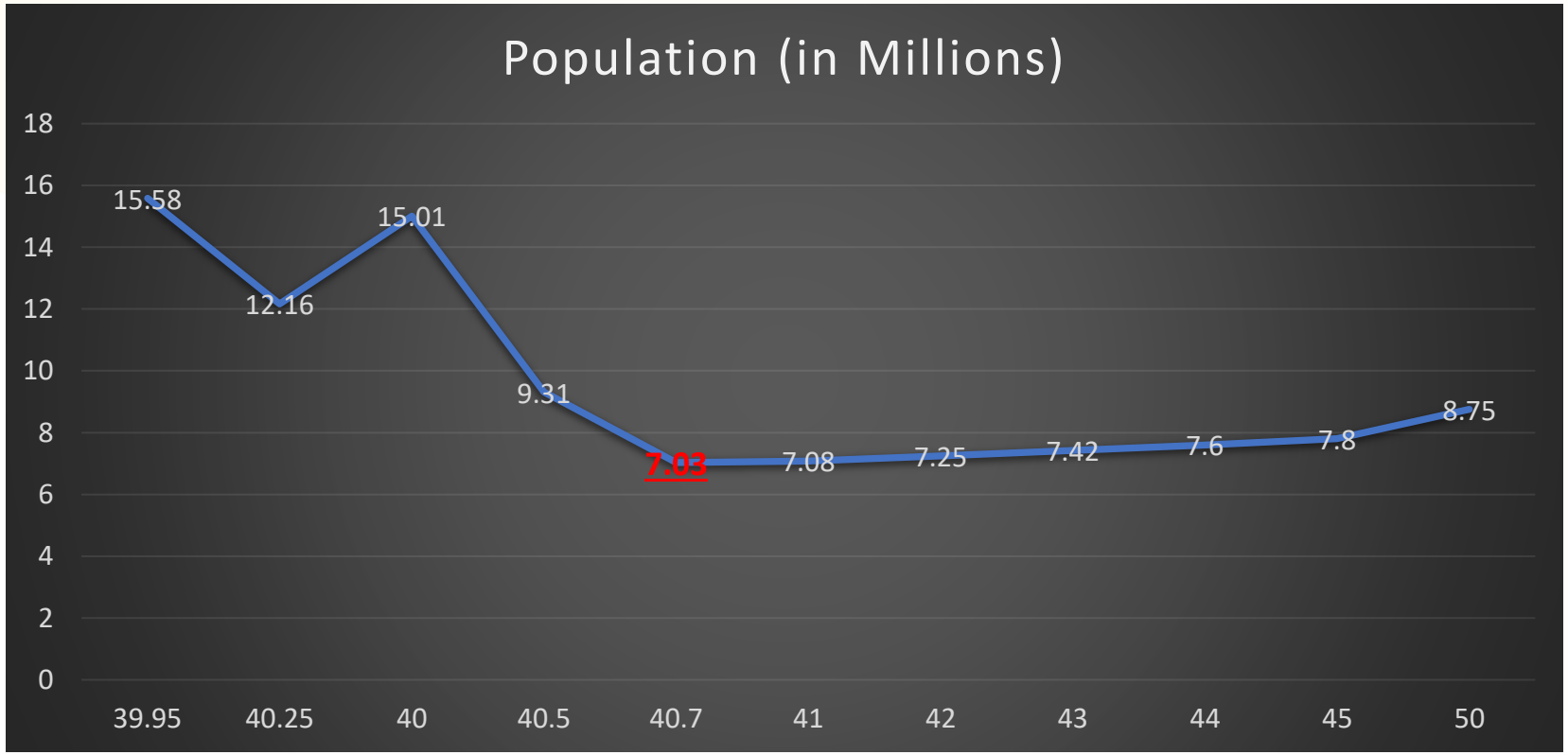
- We tried to find the variation on the Objective function with a change in the time constraint value.

- **Result:**

  - There is a steady rise in the affected number of Population with gradual increase in the time taken for the journey.

  - Whereas, after a certain decrease in the time constraint we get an infeasible solution.

❑ EXPERIMENTAL RESULTS (CONT.)



Travel Time (Hours)

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❑ CONCLUSION

- The critical path for the journey of Nuclear Waste from **Pittsburgh to Nevada Site**
  - will take about **40 hours and 42 mins**,
  - while affecting minimum population of **7.03 million population**.

```
Minimum_Path <- Followed_Path[Followed_Path$Path == 1,

Minimum_Path
```

```
##                                          City Path
## 1                          Pittsburgh - Columbus    1
## 7                        Columbus - Indianapolis    1
## 25                     Indianapolis - Springfield    1
## 31 Springfield - Davenport/Moline/Rock Island    1
## 33  Davenport/Moline/Rock Island - Des Monies    1
## 39                             Des Moines - Omaha    1
## 47                               Omaha - Cheyenne    1
## 53                     Cheyenne - Salt Lake City    1
## 58                  Salt Lake City - Nevada Site    1
```


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❑ FUTURE SCOPE

- The construction of new Highway routes.
- Building of new disposal sites around Nuclear power plants.

❑ REFERENCES

- Introduction to Management Science, (11th edition) by Anderson, Sweeney and Williams. Page 337.
- https://www.dep.pa.gov/Business/RadiationProtection/NuclearSafety/Pages/Pennsylvania's-Nuclear-Power-Plants.aspx
- http://home.ubalt.edu/ntsbarsh/Business-stat/opre/PartIII.htm

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Thank You.