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GIS-based Route Planning for HAZMAT Transportation

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Outline

1. The Route Planning Problem
2. GIS-based route planning
3. Algorithm: Distance Transform Path Planning (Zelenski et al.)
4. Case study: population layer
5. Case study: Class-1 HAZMAT and diffuse risk value layer
6. Case study: combined layers
7. Conclusion

1. The Route Planning Problem

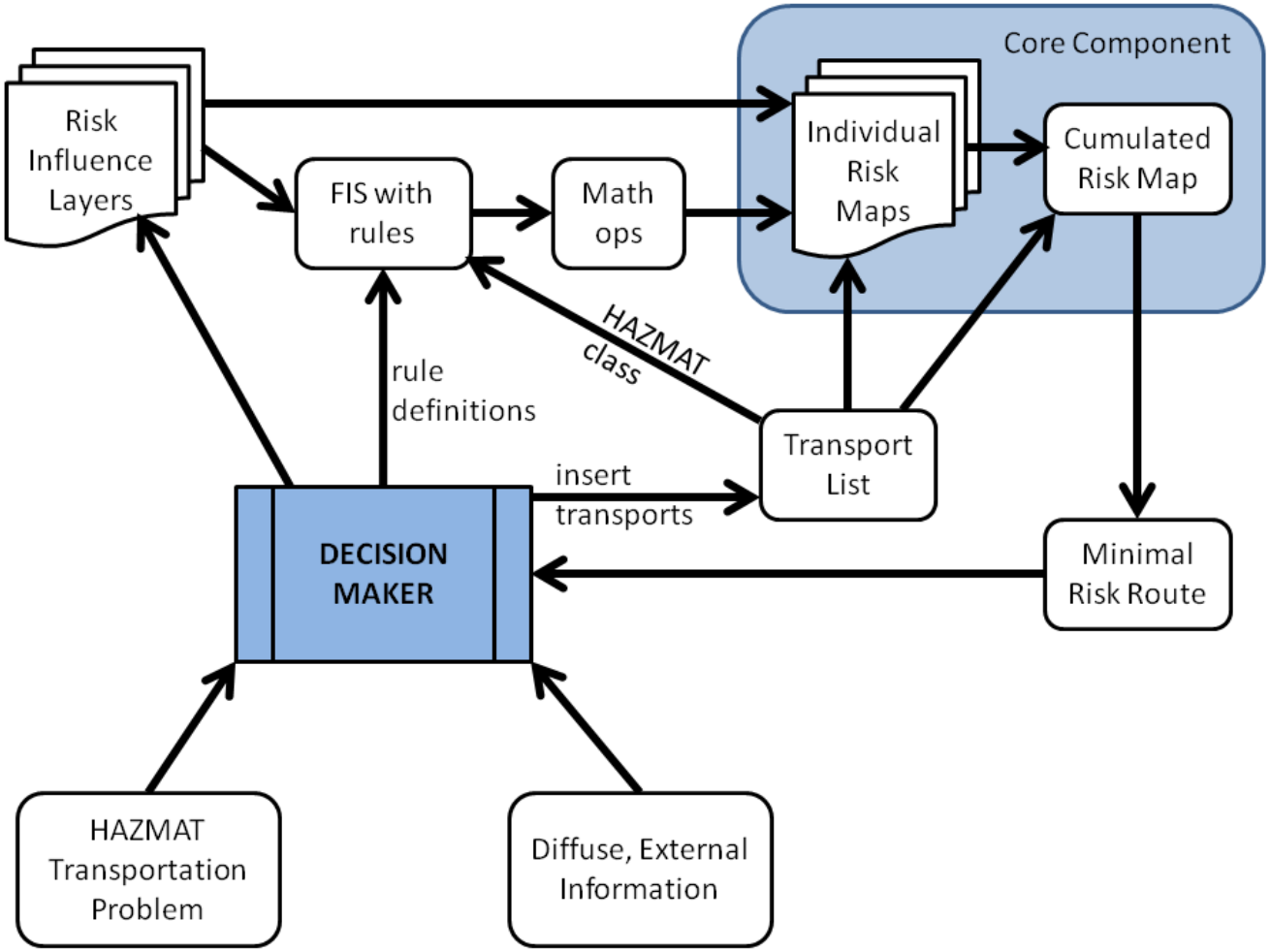
- Local Authority:
  - Minimize transportation risk
- Carrier:
  - Minimize costs
- Environment:
  - Spatio-temporal properties
  - Diffuse knowledge
  - Local (and political) valuation
- Problem:
  - NP hard
  - Typically solved using heuristics and graph-based methods

2. GIS-based route planning (1/3)

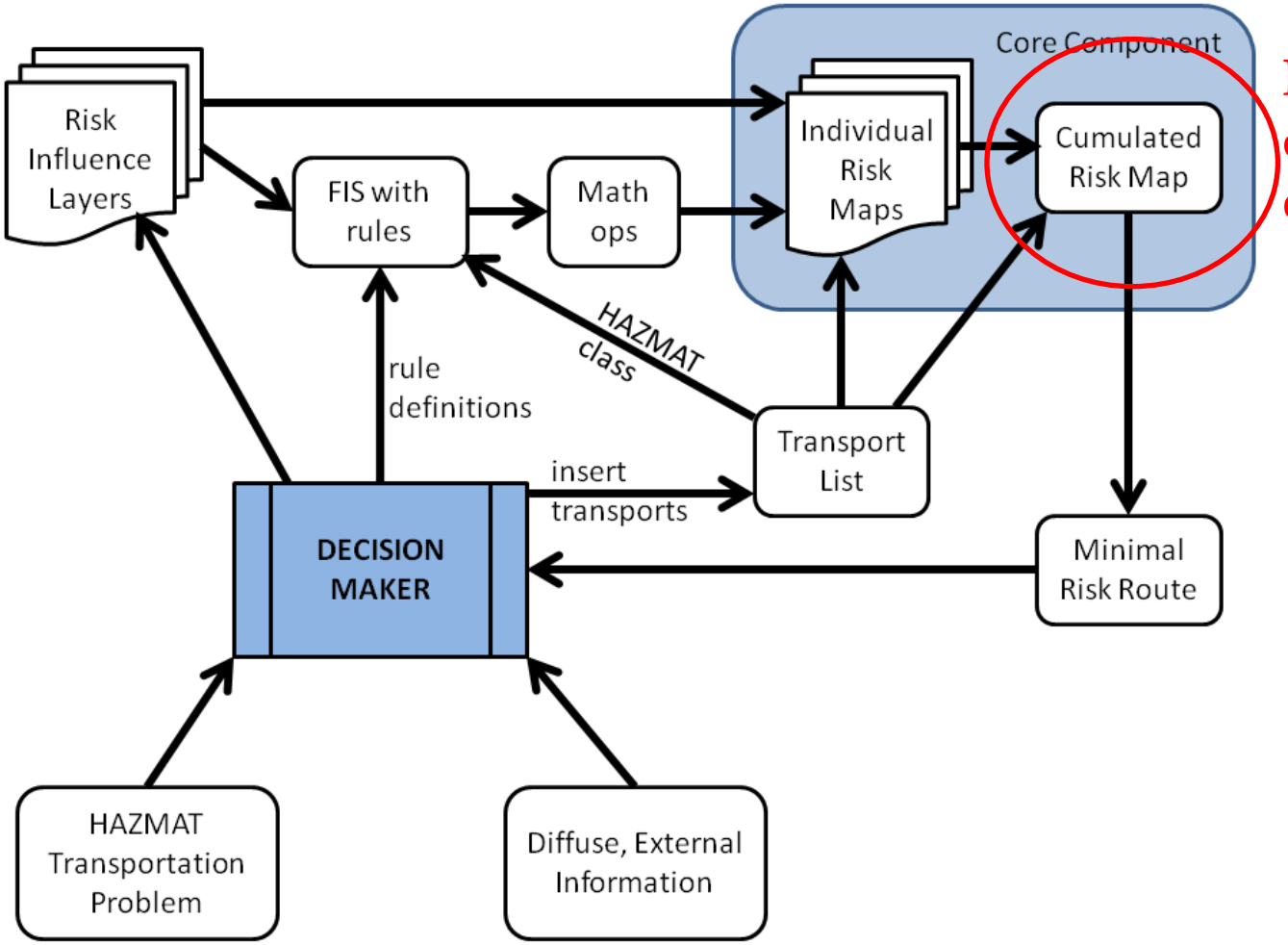
- Affecting factors represented as layers
- Each layer encodes risk values as a raster (matrix)
- Layers are disjoint and can be combined with operators
- Cumulated Risk Map is computed from combined layers
- Route analysis on Cumulated Risk Map

- Notes:
  - Problem is still NP hard
  - GIS-based approach is complementary to graph-based approaches
  - Use of layers simplifies computation and supports what-if-analysis
  - GIS-based approach supports parallel computation

2. GIS-based route planning (2/3)



2. GIS-based route planning (3/3)



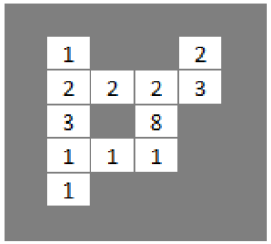
How to compute efficiently?

3. Algorithm: Distance Transform Path Planning (Zelenski et al.) (1/2)

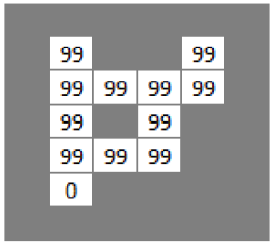
prepare r as the risk map
prepare c as the initial cumulated risk map
repeat
    compute m, such that for each cell
        $m_{i,j} = \min(c_{i-1,j}, c_{i+1,j}, c_{i,j-1}, c_{j,j+1})$
    recompute $c_{i,j}$ as $\min(r_{i,j}+m_{i,j}, c_{i,j})$
until c does not change

Zelinsky, A., Jarvis, R., A., Byrne, J., C., Yuta, S.: Planning paths of complete coverage of an un structured environment by a mobile robot. In the Proceedings of International Conference on Advanced Robotics, 533 - 538 (1993).

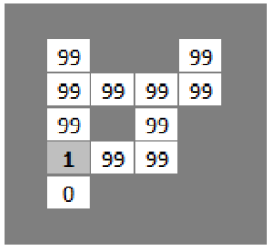
3. Algorithm: Distance Transform Path Planning (Zelenski et al.) (2/2)



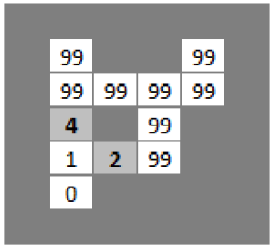
r: summed risk per cell



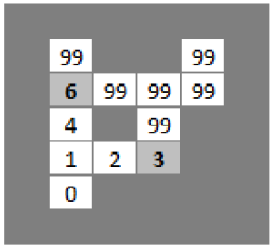
c: initial cumulated risk



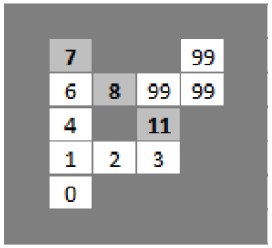
c after teration: 1



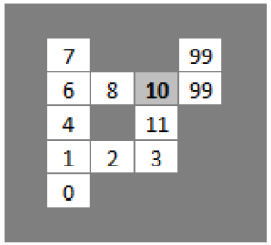
c after teration: 2



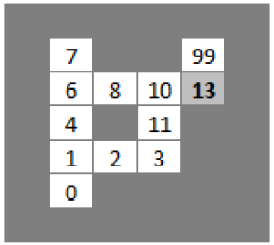
c after teration: 3



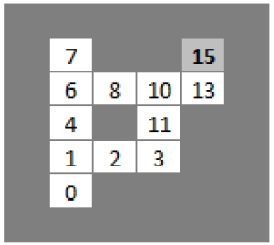
c after teration: 4



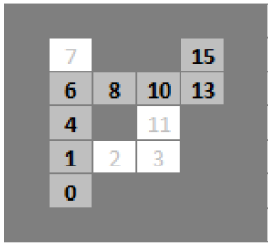
c after teration: 5



c after teration: 6

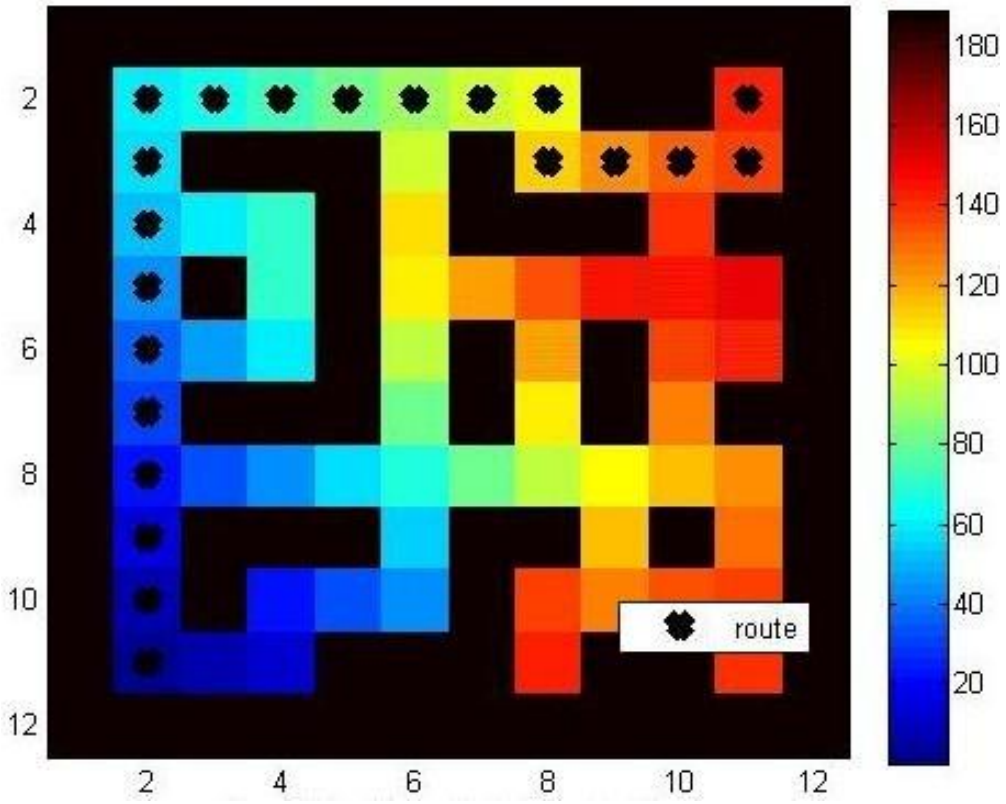


c after teration: 7

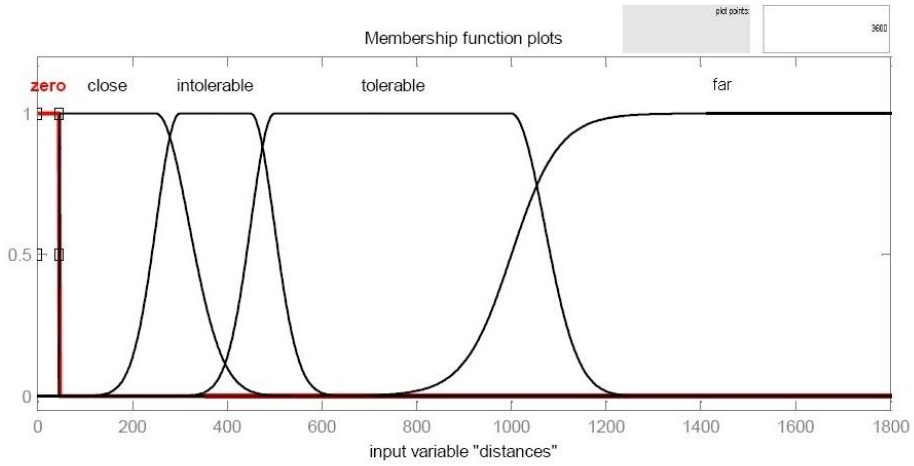


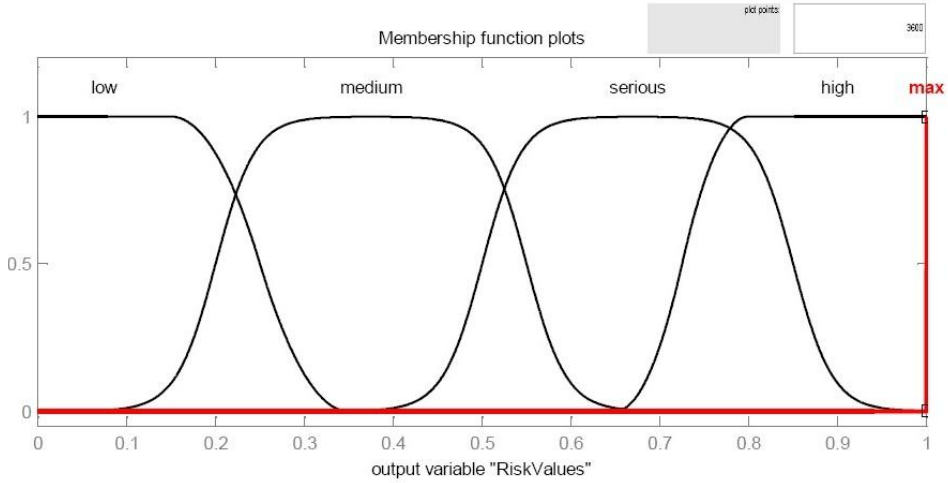
Route with minimal risk

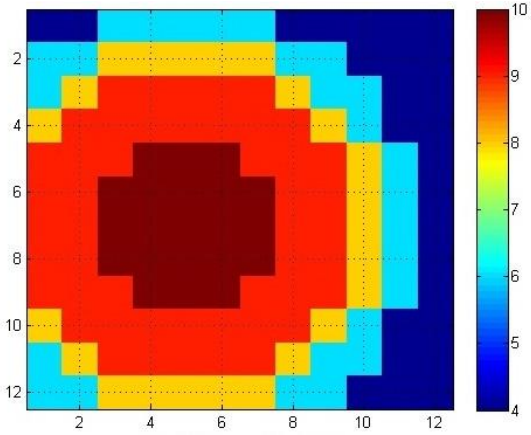
4. Case study: population layer



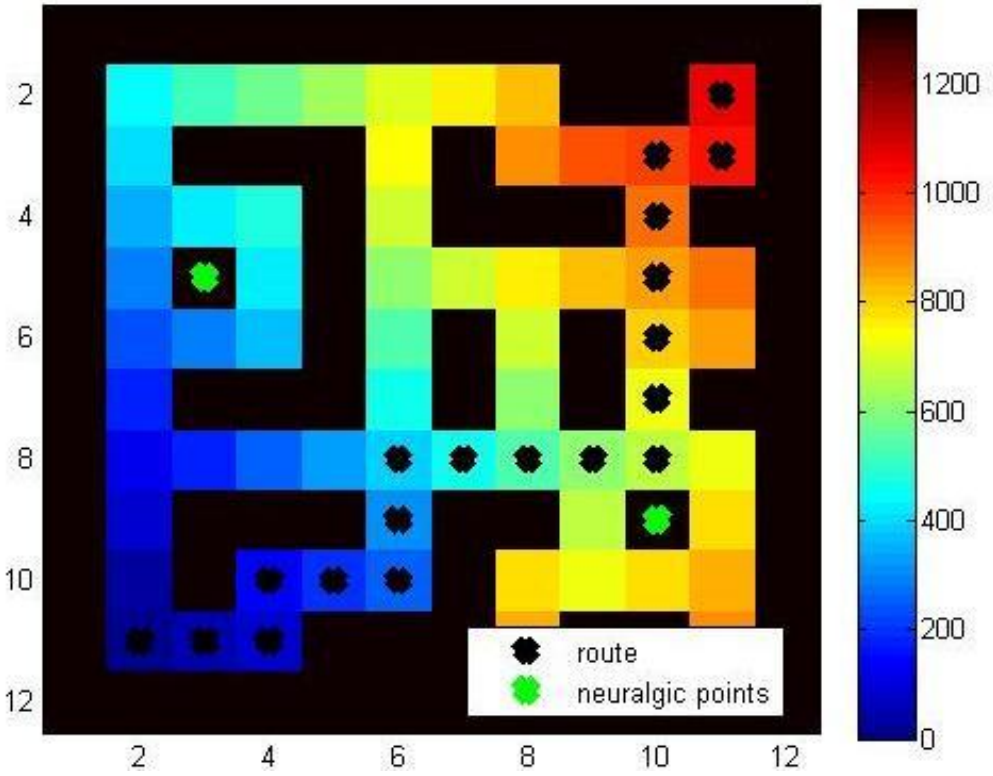
5. Case study: Class-1 HAZMAT and diffuse risk value layer (1/2)



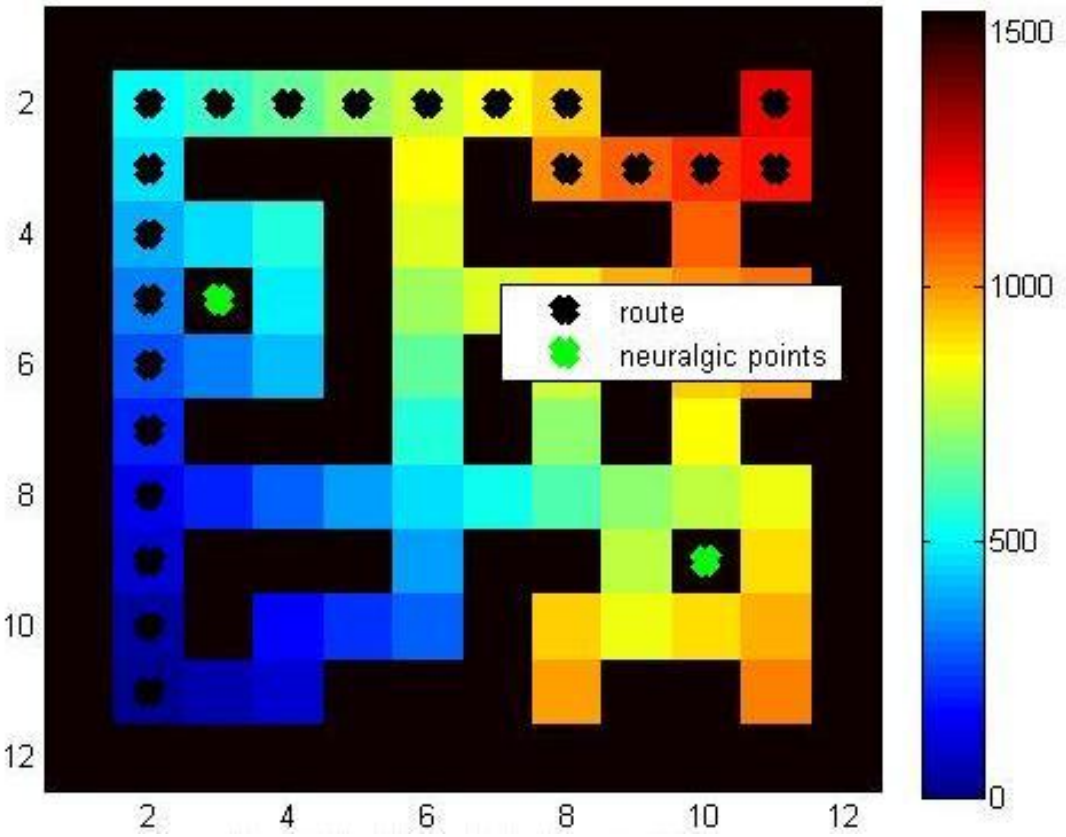




5. Case study: Class-1 HAZMAT and diffuse risk value layer (2/2)



6. Case study: combined layers



7. Conclusion

- GIS-based route planning method
- Risk factors represented as individual layers
- Combined risk computed from selected layers
- Cumulated Risk Map computed from combined risk map
- Uses Distance Transform Path Planning (Zelenski et al.)
- Complementary approach to graph-based approaches
- Supports what-if analysis
- Supports parallel computation

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