Augmented Resource Allocation in Disaster Scenarios

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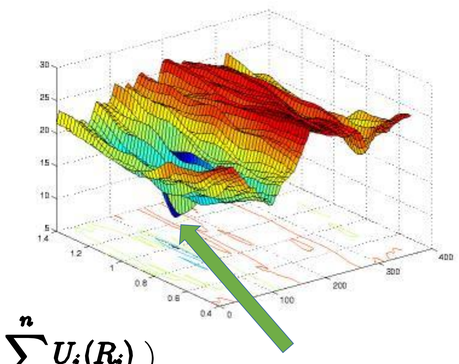
Overview of Dynamic Emergency Routing

- Responders need to know the most efficient way to address a disaster
- No **internet access** and little situational awareness make this highly difficult
- How can we capture intuitive awareness of the scene and leverage optimized algorithms?

Defining the Problem

- Metrics and Quality Dimensions:
  - Timeliness $(\Delta T = \frac{anticipated\ time}{actual\ time})$
  - Quality of Care
  - Responder Leverage



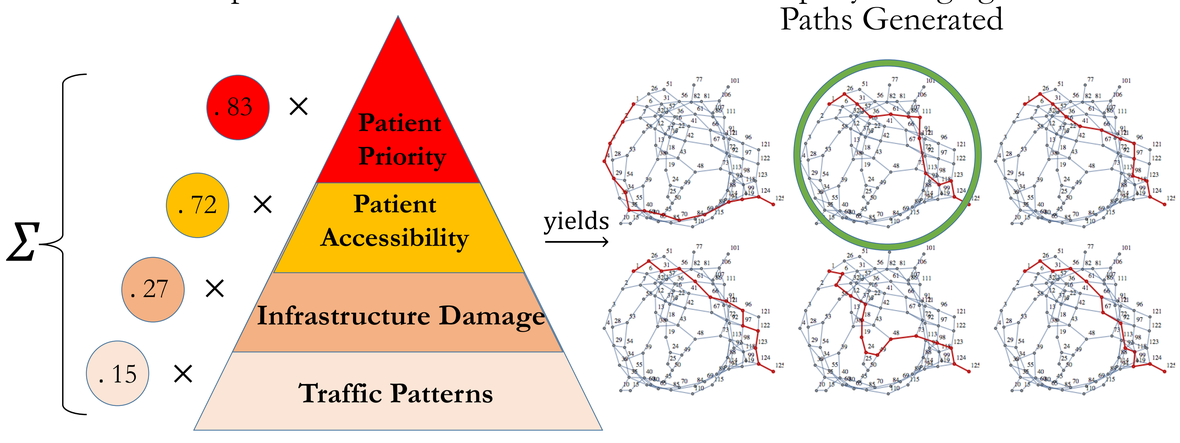
Incident Utility = Min$\left(U(Q^1R^1, Q^2R^2, \ldots, Q^nR^n) = \sum_{i=1}^{n} U_i(R_i)\right)$

Disaster Utility = Min$\left(U(I^1, I^2, \ldots, I^k) = \sum_{j=1}^{k} U_j(I_j)\right)$

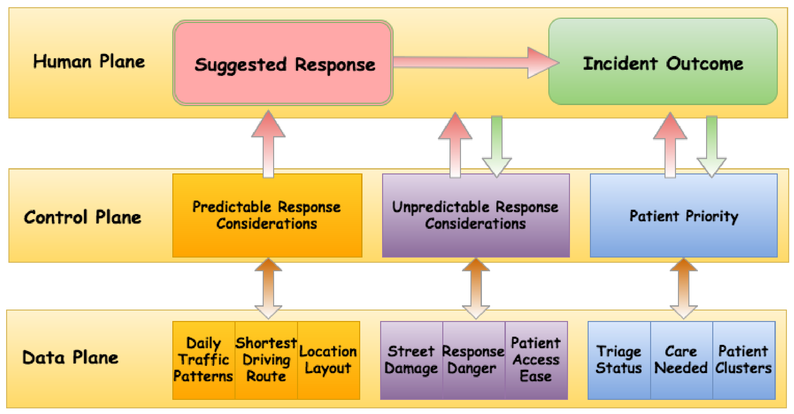
- Maximize each quality metric while matching the largest number of responders and respondees each incident-response cycle

K-Shortest Path with Analytic Hierarchy Process

- Determining shortest path can be done using Dijkstra's algorithm
  - Uses cost function and distance to find shortest path
  - **K-shortest Path** returns multiple "short" options
  - Cost function can be modified to consider additional info
- The **Analytic Hierarchy Process** (AHP)
  - Considers relative weights of each factor while determining cost
  - Involves manual configuration by an expert, meaning it is **slow**
- Using AHP, we calculate weights for K-shortest path based on fixed weight
- This is not optimal for disaster scenarios because of rapidly changing conditions



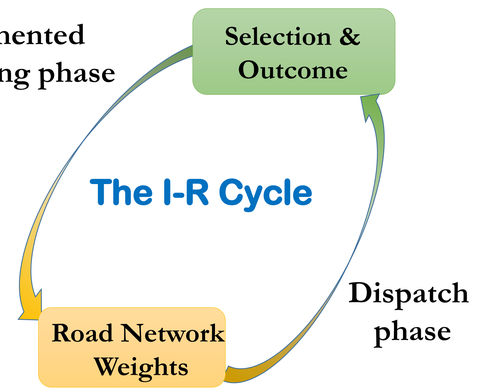
Augmented Resource Allocation (ARA) Framework



The incident-response (I-R) model classifies a disaster scenario as a series of geotemporally distinct incidents and has

- Responders
- Victims
- Start-end times
- Location data

- The **dispatch phase** optimizes response to single incident given predictable considerations and current road network weights
- The **augmented annealing phase** optimizes response to future incidents given previous ones

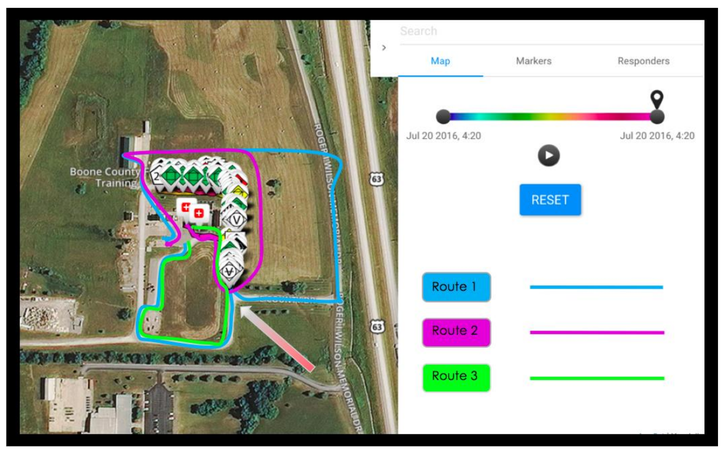


Case Study: Panacea's Cloud

- **Panacea's Cloud** is a mobile, internet-free disaster management platform. Using a retrofitted tracking platform, we tested responder effectiveness *with* real-time connectivity, but *without* intelligent routing recommendations
  - Total **response time** decreased
  - Total **response accuracy** decreased
  - After discovery phase, incident commander would have to manually route responders to respondees
  - At this stage, augmented resource allocation could **enhance future responses**

ARA Simulation Procedure

1. Initialize road network weights from discovery phase
2. Present multiple routing options to Incident Commander
3. Update weights based on selection
4. Update weights based on outcome



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[1] David Carraher of Mathematica Stack Exchange under **cc by-sa 3.0** : *"Finding Not Shortest Path Under Two Vertices"*
[2] Tor Vision Group of University of Oxford **:** *"Combined Tracking and Object Recognition: Tracking Hands"*