Applying Line Graphs to Resource Allocation During Extreme Events

Leonard Lopez

Sergio Sandoval

Extreme Events

Year	Type	Fatalities	Damage	Article	Location
2012	Hurricane	147	$75 billion	Hurricane Sandy	Eastern United States
2011	Tornado	160	$3 billion	2011 Joplin Tornado	Joplin, Missouri
2011	Tornado	346	$11 billion	April 25-28, 2011 Tornado Outbreak	Southwest United States
2011	Flood	20	$4 billion	2011 Mississippi River Floods	Mississippi River Valley
2007	Fire	14	$5 billion	2007 California Wildfires	Southern California
2005	Cyclone	1,836	$84 billion	Hurricane Katrina	Florida, Louisiana, Mississippi, Alabama
2004	Cyclone	124	$19 billion	Hurricane Ivan	Texas, Florida, East Coast

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Statement of Purpose:

- Analyze connectivity patterns of network
- Optimize resource allocation distribution to strengthen sustainability
- Apply solution to strengthen sustainability

Bike Sharing

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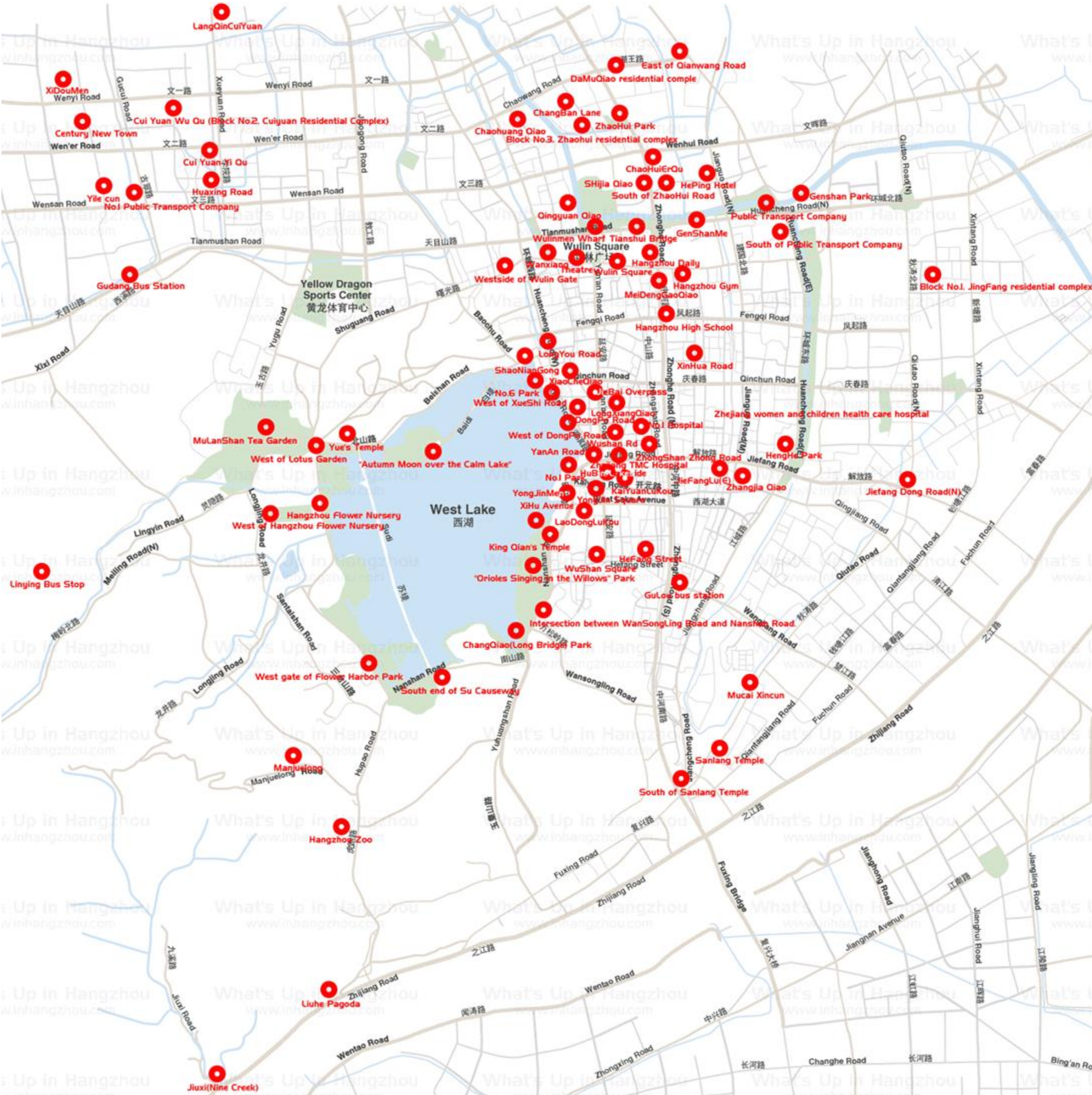
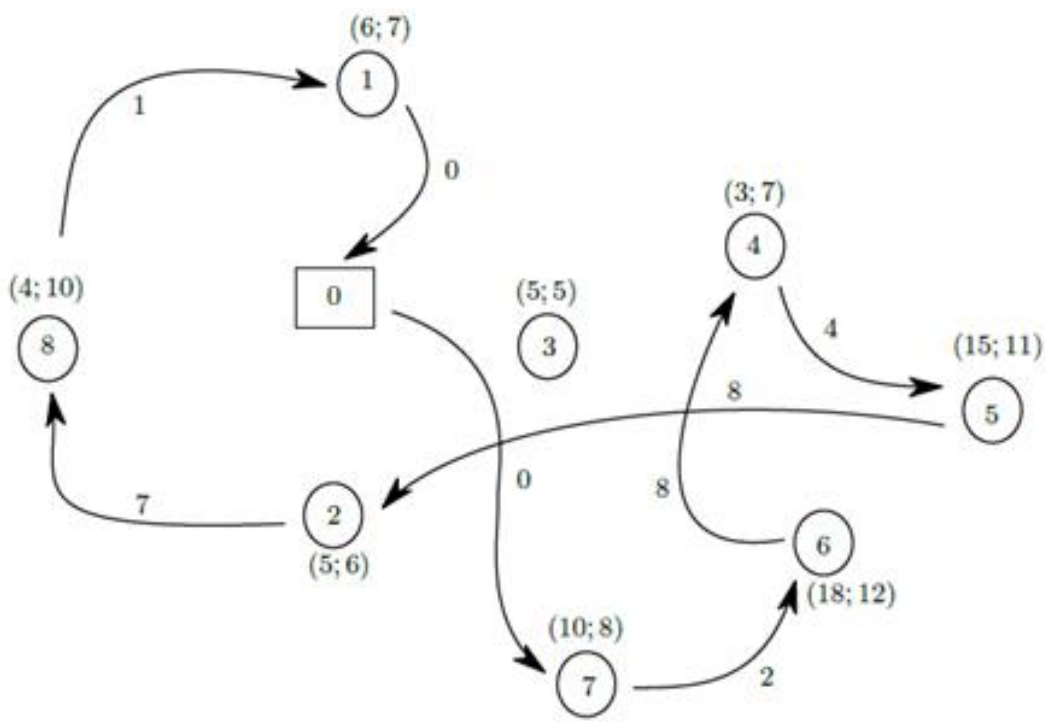
Bike Sharing, cont.



Xihú District

Using a Bike Sharing System as a model for the solution.



= Origin

= Locations (Vertices)

$(p_i, q_i) = (\text{initial state}, \text{target state})$

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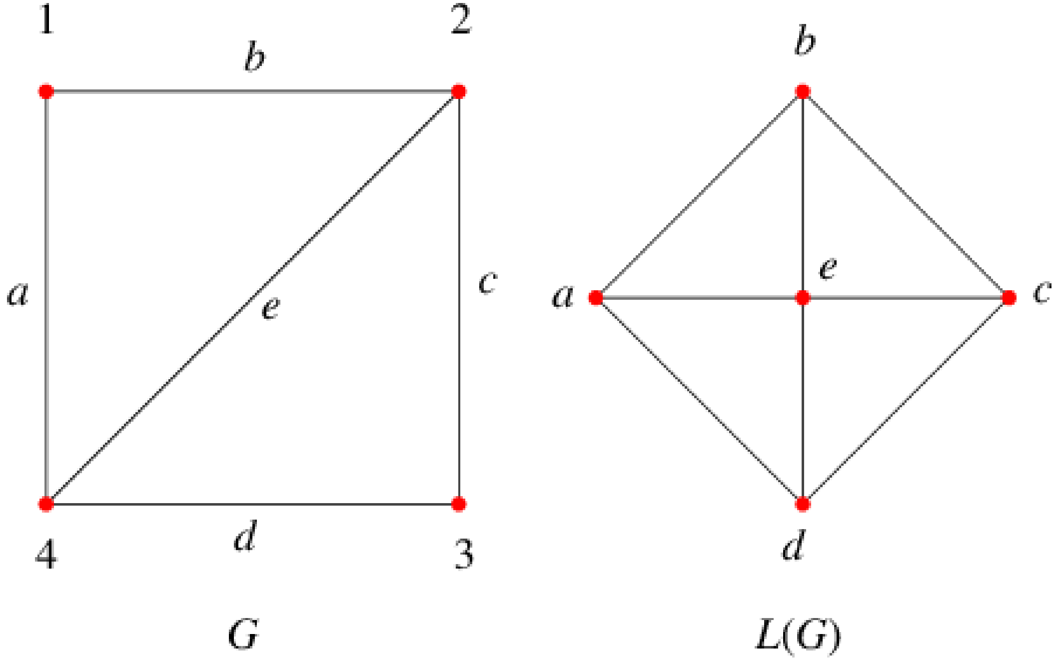
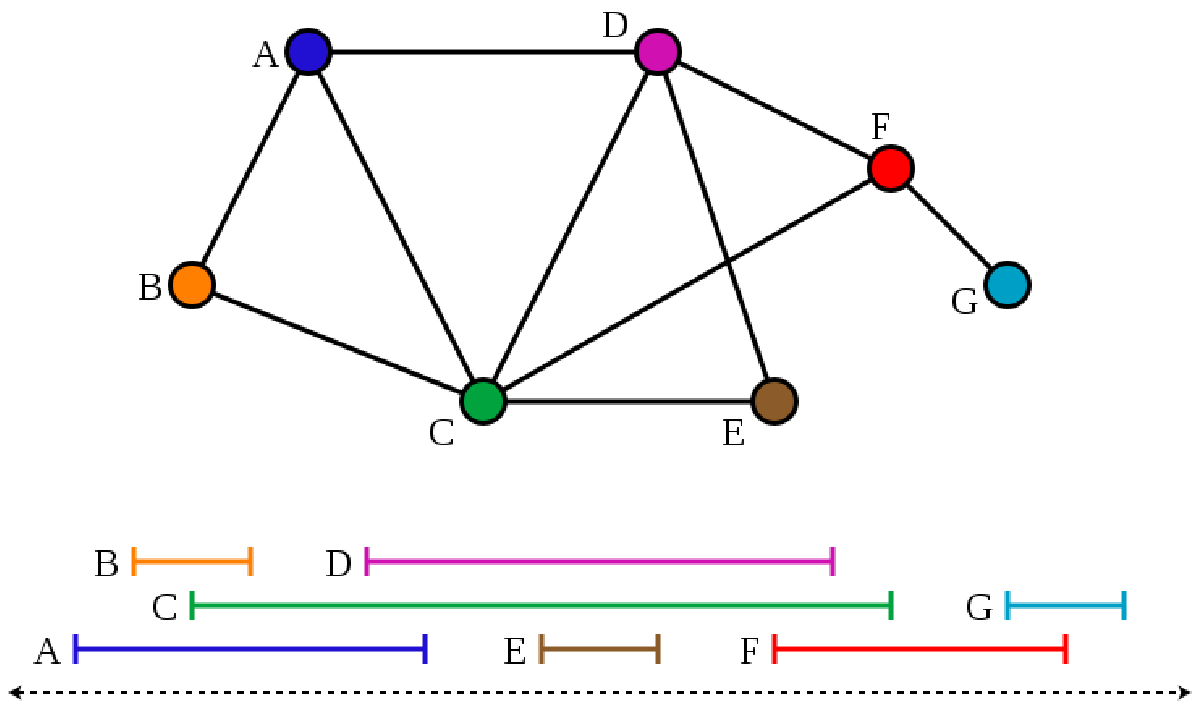
Definition of a Line Graph

For an undirected graph G, a line graph L(G) represents the adjacencies between the edges of G.



Definition of an Interval Graph

Interval Graph: the graph of a multiset of intervals on the real line. It has one vertex for each interval in the set, and an edge between every pair of vertices corresponding to intervals that intersect.



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Additional Concepts of Graph Theory

Directed Line Graph:

Line graph whose edges have direction. The directed edges are commonly called arcs.

Weighted Graph:

With each edge e of G let there be associated a real number $W(e)$, called its weight.

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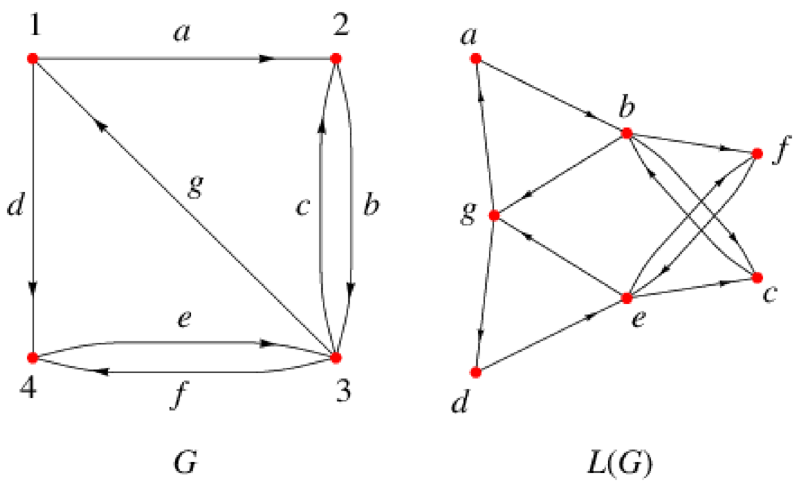
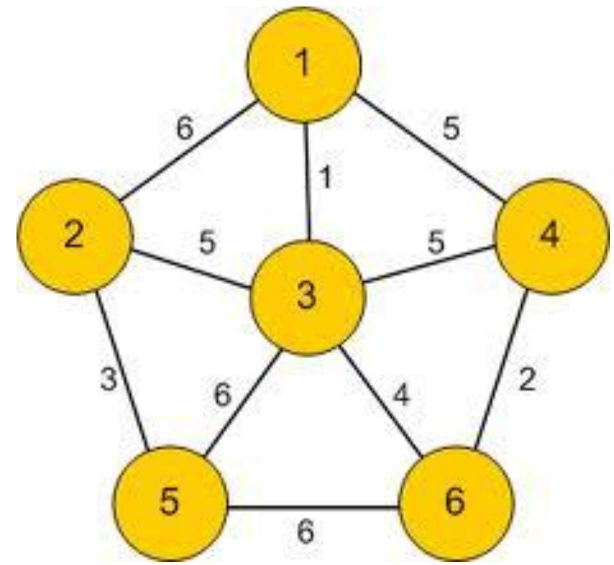
Concepts of Graph Theory, cont.



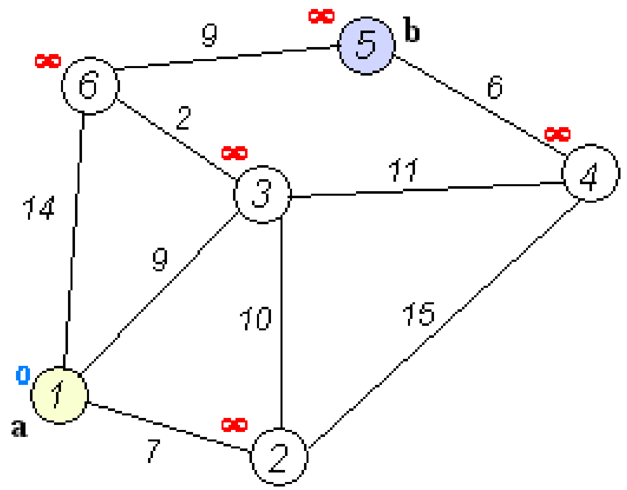
Directed Line Graph



Weighted Graph

Dijkstra’s Algorithm

Picks the unvisited vertex with the lowest-distance, calculates the distance through it to each unvisited neighbor, and updates the neighbor's distance if smaller.



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Shortest Path

Given digraph (V,A) with source node *s*, target node *t*, and cost w_{ij} for each arc *(i,j)* in A with variable x_{ij}

minimize $\sum_{ij \in A} w_{ij} x_{ij}$ subject to $x \geq 0$ and for all *i*, $\sum_j x_{ij} - \sum_j x_{ji} = \begin{cases} 1, & \text{if } i = s; \\ -1, & \text{if } i = t; \\ 0, & \text{otherwise.} \end{cases}$

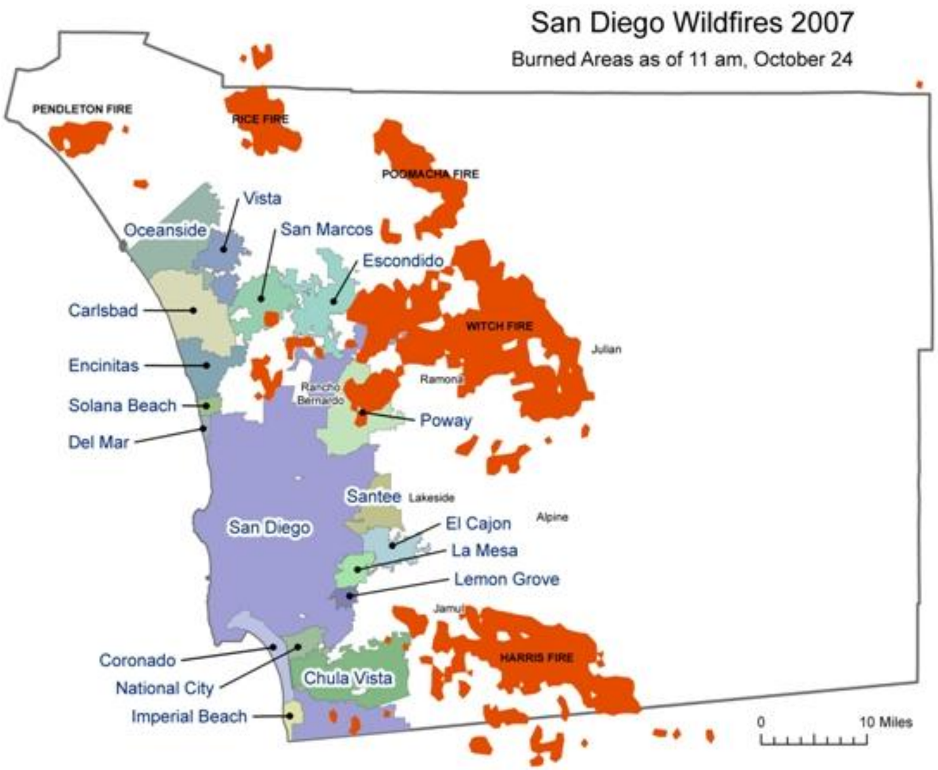
Example: Fires in San Diego

In October 2007 , Southern California experienced a series of wildfires that destroyed over 1,500 homes and burned over 500,000 acres of land.

Example: Fires in San Diego

In this example, a line graph with weighted edges could be used to model the fire. The weight of the edges would be dependent on the factors affecting the transmission of the fire.

The bike model would be used to find an optimal path available for firefighting resources. This path would take into considerations obstacles that arise such as blocked paths, which could be modeled as cut-vertices.



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Example: Hurricane Sandy

- October 2012
- 285 fatalities
- $53 billion dollars in damage

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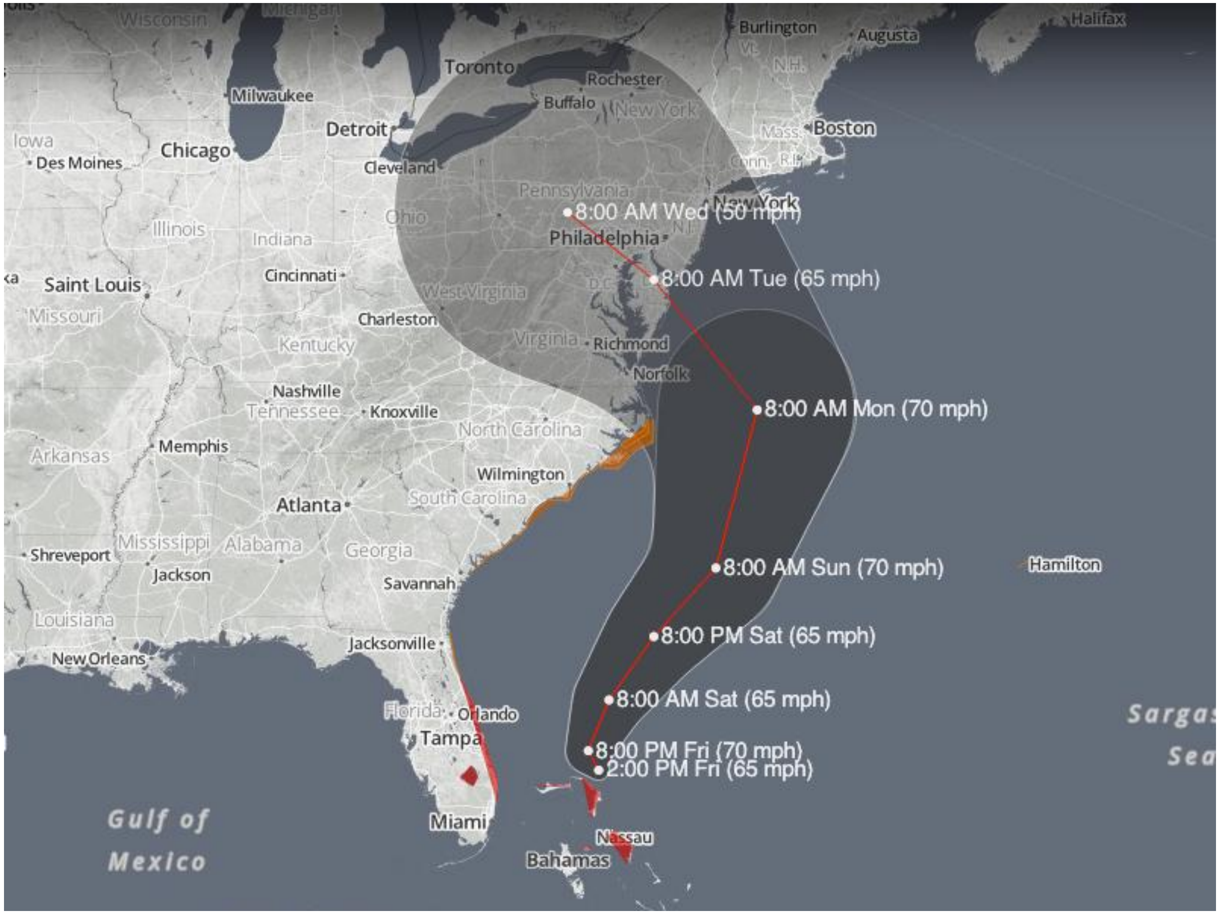
Example: Hurricane Sandy

- Applications of Line Graphs
- Reallocating Resources



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Research Questions

- Which type of resource will we be working with?
- For each resource what are some possible limiting factors and exceptions?
- What defines the shortest path in certain situations?
- How should obstacles be defined in specific situations?

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