Why We Are the Power Rangers

- Network interest in social media and causation
- Exposure to computational network analysis
- Ecological networks
August 14, 2003
Power Grid Failure

This event contributed to at least 11 deaths and cost an estimated $6 billion.

**Cause of Failure:**
- Natural events
- Human error
- Hardware malfunction

**Affected States and Province:**
- OH, MI, PA, NY, VT, MA, CT, NJ
- Ontario

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1. "The anatomy of a power grid blackout" (Pourbeik, P. et al. 2006)
General Grid Structure
Figure: Data collected July 18, 2016
- Open source
- Extra-high voltage transmission system (220kV+)
- Minimum: two substations and one transmission lines
- *Abstracted transmission network*: transmission lines are *not* actual paths
Types of Networks

- **Random Graphs (Erdös-Rényi)**
  - Degree homogeneity
  - Low clustering
  - Short average paths
  - Mathematically constructed

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1 “On random graphs, 1” (Erdös, P., & Rényi, A., 1959)
Types of Networks

- **Small-world Graphs (Watts-Strogatz)**
  - Short average paths
  - High clustering
  - High modularity

- **Small-World Networks**
  - Social Networks
  - Cortical maps

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Types of Networks

- **Scale-free Graphs** (Barabási-Albert)
  - Degree heterogeneity
  - Low clustering
  - Fault tolerance

- **Scale-free Networks**
  - Protein-protein interactions
  - Semantic maps

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## Comparing Measures of Network Models

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1. “The Topological and Electrical Structure of Power Grids” (Hines, P. et al., 2010)
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Collaborative Abstraction

- Modeling as a group
- Identify Goals
  - Generate and compare network models
  - Contrast targeted and random failure
Final Network

- Maximize generality
- Unweighted, undirected
- Focus on topology
Results

- Secondary topological failure
  - Sequentially remove nodes
  - Record secondary failures

- R, Igraph, Nexcade

- Degree matters
  - Red - highest to lowest
  - Black - random
  - Green - lowest to highest

![Graph showing the number of secondary failures against the percentage of removed nodes, with three lines representing different node removal strategies: highest to lowest (red), random (black), lowest to highest (green).]
What We Learned

- The nuances of working in an interdisciplinary team
- R and bash scripting (iGraph, Nexcdae)
- Network modeling
Thank You

Industry Advisor

Dr. Mihai Anitescu
Faculty Advisors

Professor Paul “Find the Data” Maglio

Professor Ashlie “Evaluate” Martini

Professor Michael “It’s About Learning” Spivey
Questions?
Open Street Map (OSM)

- Open source
- Local Knowledge
- Community Driven
Types of Power Grid Data

- Test Cases
- Simulated
- Proprietary
- Natural
Where We Could Go From Here

- Electrical detail
- Applications in our domains