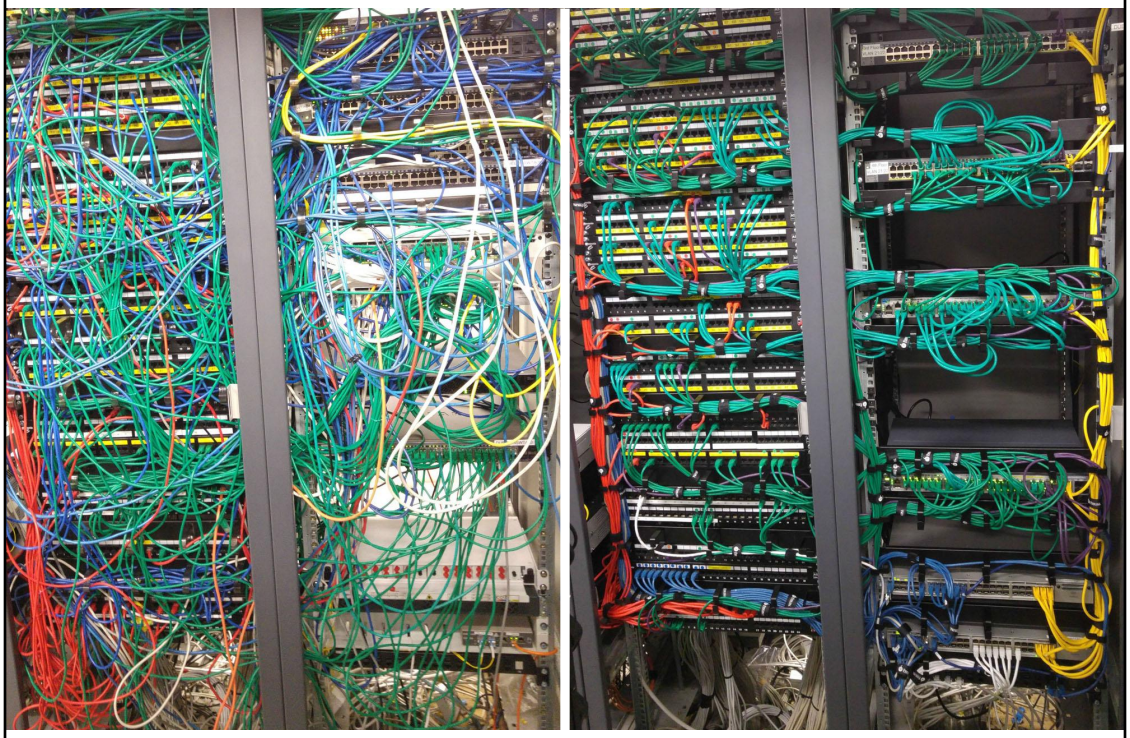
Graph Clarity, Simplification, & Interaction



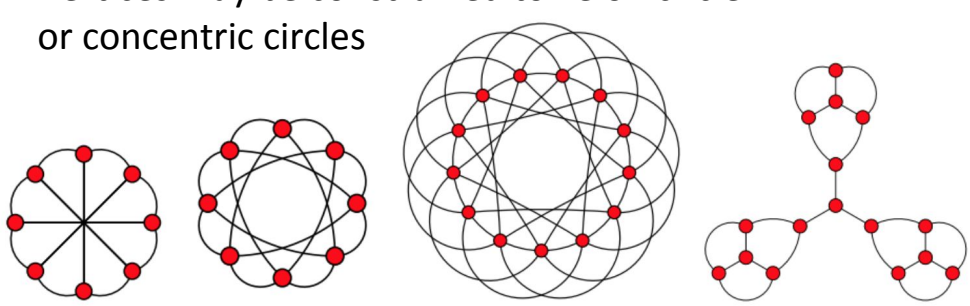
http://i.imgur.com/cW19IBR.jpg
https://www.reddit.com/r/CableManagement/

Today

- Today's Reading: Lombardi Graphs
  - Bezier Curves
- Today's Reading: Clustering/Hierarchical edge Bundling
  - Definition of Betweenness Centrality
- Emergency Management Graph Visualization
  - Sean Kim's masters project
- Reading for Tuesday & Homework 3
- Graph Interaction Brainstorming Exercise

"Lombardi drawings of graphs", Duncan, Eppstein, Goodrich, Kobourov, Nollenberg, Graph Drawing 2010

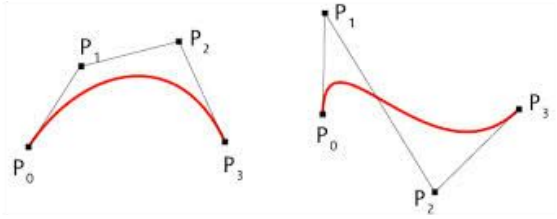
- Circular arcs
- Perfect angular resolution (edges for equal angles at vertices)
- Arcs only intersect 2 vertices (at endpoints)
- *(not required to be crossing free)*
- Vertices may be constrained to lie on circle or concentric circles



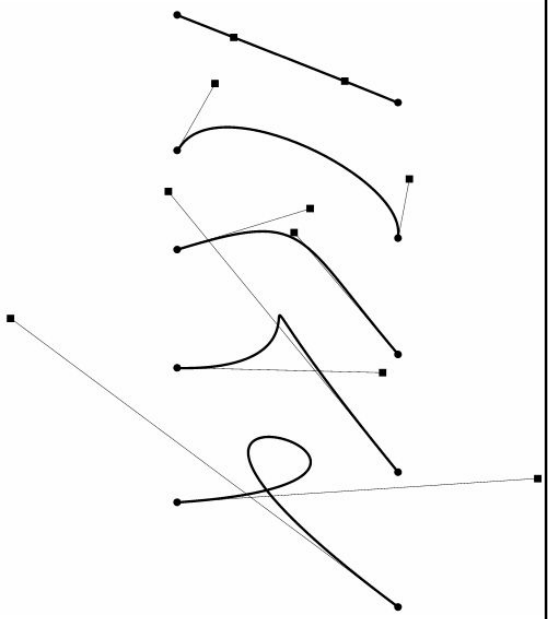
- People are more patient with aesthetically pleasing graphs (will spend longer studying to learn/draw conclusions)
- What about relaxing the circular arc requirement and allowing Bezier arcs?
- How does it scale to larger data?
- Long curved arcs can be much harder to follow
- Circular layout of nodes is often very good!
- Would like more pseudocode

Cubic Bézier Curve

- 4 control points
- Curve passes through first & last control point
- Curve is tangent at $\mathbf{P_0}$ to $(\mathbf{P_1}-\mathbf{P_0})$ and at $\mathbf{P_3}$ to $(\mathbf{P_3}-\mathbf{P_2})$



http://www.e-cartouche.ch/content_reg/cartouche/graphics/en/html/Curves_learningObject2.html



http://www.webreference.com/dlab/9902/bezier.html

“Force-directed Lombardi-style graph drawing”, Chernobelskiy et al., Graph Drawing 2011.

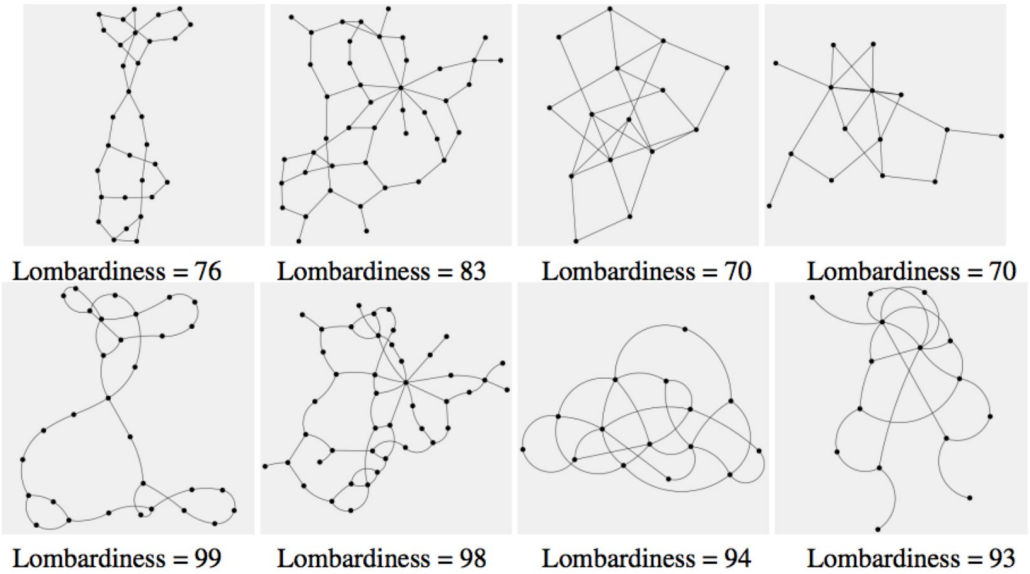
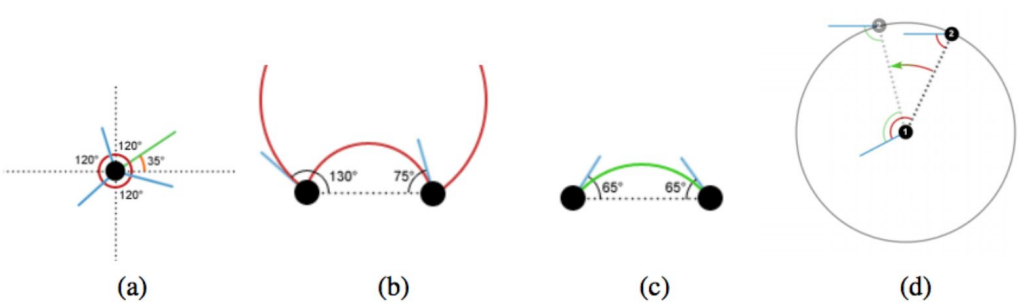


Fig. 5. Standard force-directed drawings (above) and near-Lombardi drawings (below).

- Relaxation of the Lombardi Graph requirements
- “straight-line segments rarely occur in nature ... it is not clear that humans prefer straight-line segments for the sake of graph readability”
- Forces on tangent angles as well as on vertex positions

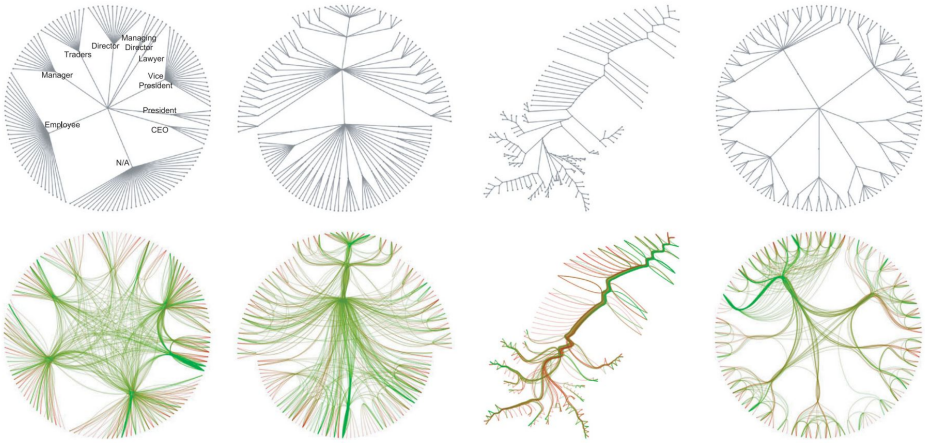


Today

- Today's Reading: Lombardi Graphs
  - Bezier Curves
- Today's Reading: Clustering/Hierarchical edge Bundling
  - Definition of Betweenness Centrality
- Emergency Management Graph Visualization
  - Sean Kim's masters project
- Reading for Tuesday & Homework 3
- Graph Interaction Brainstorming Exercise

Reading for Today

- "Social Network Clustering and Visualization using Hierarchical Edge Bundles", Jia, Garland, & Hart, Computer Graphics Forum, 2011.

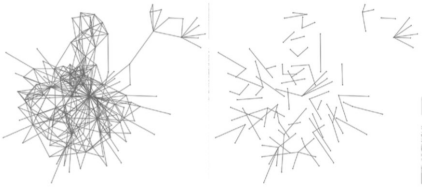


Manual (ideal) Strength clustering [ACJM03] BC communities [GN02] Our method

- Color is very helpful (be careful about colorblindness)
- Relation to '6 degrees of separation'
- Concern that small (but important) features or communities may be lost
- Concern about high cost of computing betweenness centrality (BC) metric
- Final graphs can still be confusing to interpret
- Diagrams very helpful in explaining steps algorithm
- Well written :)

"Social Network Clustering and Visualization using Hierarchical Edge Bundles", Jia, Garland, and Hart, Computer Graphics Forum 2011.

- Dense graphs, e.g., social networks
- Straight line drawings are cluttered by crossings
  - Curved edges
  - Bundled edges (similar pathways) reduce visual clutter, similar to clusters of electric wires
- Try to preserve tree balance
  - Merge equal height trees at the root
  - Differently heighted trees at levels to be balanced
- Clarifies communication, collaboration, and competition network structure



(a) Original graph (b) After edge removal

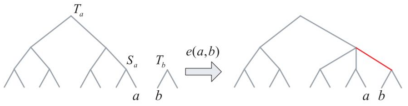
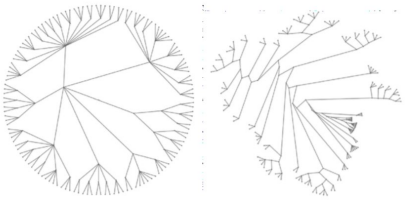


Figure 4: *Merging two communities. Here two communities are connected because node $a \in T_a$ and $b \in T_b$ are connected by an edge $e(a, b)$.*



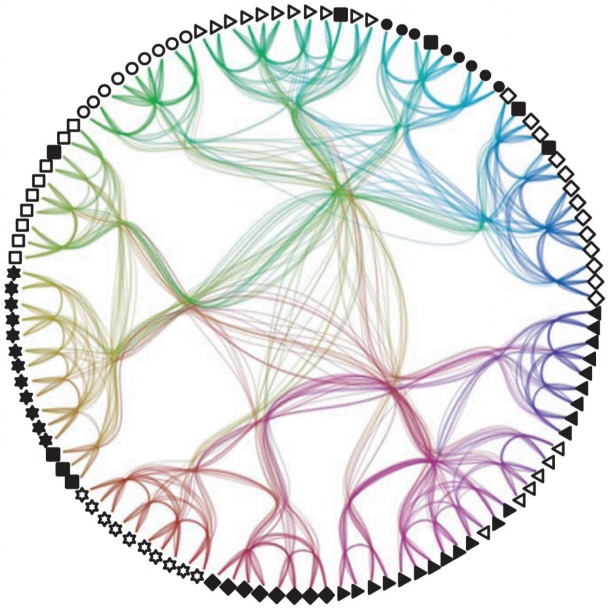
(a) With Definition 2 (b) Without Definition 2

"Social Network Clustering and Visualization using Hierarchical Edge Bundles", Jia, Garland, and Hart, Computer Graphics Forum 2011.

- Modularization Quality: average edge density within clusters vs. average edge density between clusters
  - Large MQ = better clustering
  - Unclear if this is actually a good metric? (degeneracies?)
- Their Contribution! Betweenness Centrality *Differential*
  - Inter-community vs intra-community edges
  - Was the decision to merge these trees obvious or arbitrary?
  - Used this value as the strength of an edge bundle
- Tradeoff: accuracy vs. running time
- Interactive: select or deselect nodes, text queries, change colors, edit numerical bundle strengths
- Uniform depth optimal for Radial Layout [Eades 92]

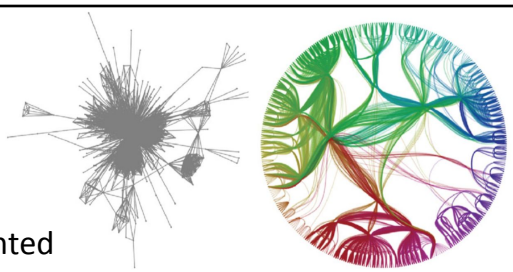
"Social Network Clustering and Visualization using Hierarchical Edge Bundles", Jia, Garland, and Hart, Computer Graphics Forum 2011.

- What are some anecdotal real-world examples of a "low BC edge" and a "high BC edge"?
  - Why does it make sense to preserve or simplify away these edges?
  - Why is a tree the best simplified representation of a big complex graph?
- Ground Truth Comparisons: Why is this the "best" simplification/rendering?
- Should this be a future Data Structures Homework?

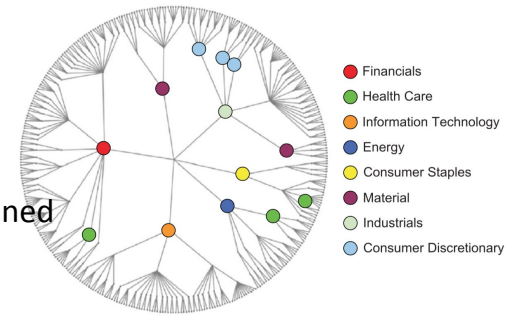


"Social Network Clustering and Visualization using Hierarchical Edge Bundles", Jia, Garland, and Hart, Computer Graphics Forum 2011.

- Writing:
  - Not all steps of prior work presented in full/intuitively
  - Difficult to read when referenced figure is on the next page
  - Each example graph/figure shows something specific, a contribution
  - Lengthy discussion comparing to previous methods
  - Limitations presented and explained
  - Would be nice to also have pseudocode. (or are the many diagrams a visual pseudocode?)



(a) Original graph (b) Edge Bundles



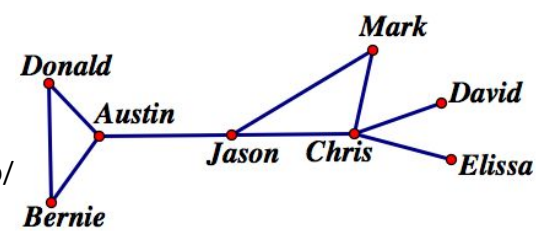
(c) Generated Hierarchy (with user supplied labels)

Figure 10: *Graph 'S&P500', including user supplied labels of stock sectors discovered by our community clustering method.*

Betweenness Centrality

http://mathforum.org/mathimages/index.php/Social_Networks#Betweenness_Centrality

Click on "A More Mathematical Explanation"



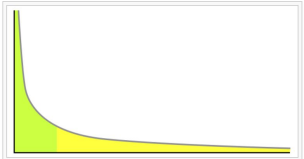
	Jason	Austin	Donald	Bernie	Chris	Mark	David	Elissa
Jason		*	A	A	*	*	C	C
Austin			*	*	J	J	J,C	J,C
Donald				*	A,J	A,J	C,J,A	C,J,A
Bernie					A,J	A,J	C,J,A	C,J,A
Chris						*	*	*
Mark							C	C
David								C
Elissa								

- For each pair of nodes "A" and "C" in the graph
- Compute the shortest path between A & C
- Is B on that path? A->B->C? How many of the paths?
- "Betweenness Centrality of node B" = # of times B appears in these shortest paths
- (Assuming?) Similar definition for "Betweenness Centrality of edge B_1->B_2"

Jason	12
Austin	10
Donald	0
Bernie	0
Chris	11
Mark	0
David	0
Elissa	0

"On the Visualization of Social and other Scale-Free Networks" Jia, Hoberock, Garland, and Hart, TVCG 2008.

- Scale free network ==(?) Power law graph
  - Degree distribution follows a power law
  - Few nodes with high degree (called "hubs"), many with low degree
  - Naturally occurring in many sciences



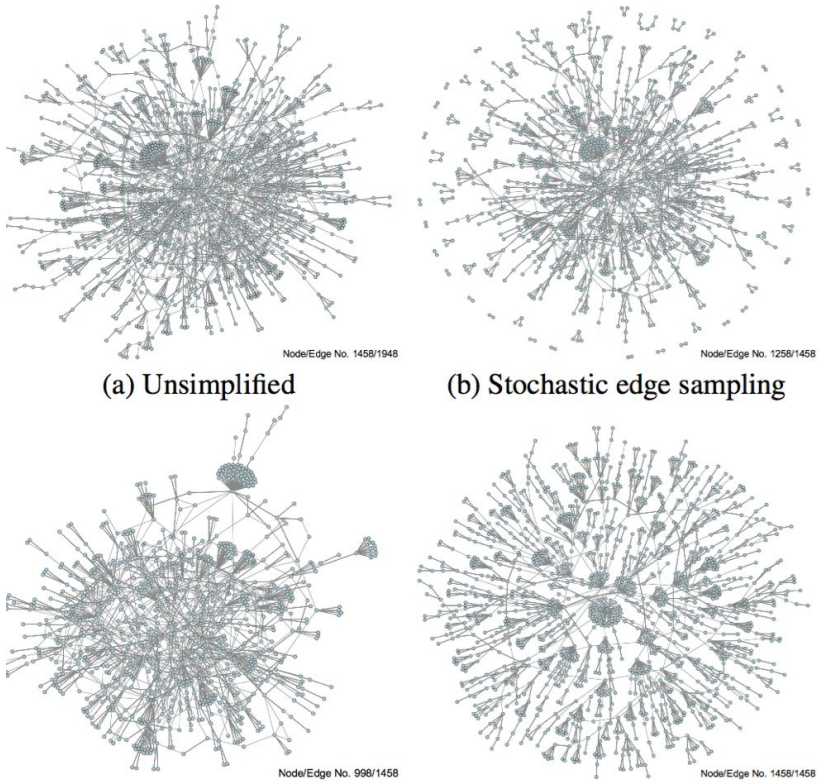
An example power-law graph, being used to demonstrate ranking of popularity. To the right is the long tail, and to the left are the few that dominate (also known as the 80–20 rule).

- Goal: Eliminate "less important" edges in the graph that are seldom used for communication
- Goal: Simplification will improve the convergence and quality of node layout algorithms
- Filtering vs. clustering?
- Automatically vs. interactively?

"On the Visualization of Social and other Scale-Free Networks" Jia, Hoberock, Garland, and Hart, TVCG 2008.

- Clustering works well for planar graphs, but can actually increase the edge density of non planar graphs. Also loses original semantics.
- Filtering retains edge & node semantics, simplified graph is a subset of the original.
  - Stochastic filtering (random edge deletion) can destroy connectivity & important features
  - Deterministic filtering choice:
    - preserve high betweenness centrality edges focus on communication pathways
    - preserve low betweenness centrality edges focus on clusters

"On the Visualization of Social and other Scale-Free Networks" Jia, Hoberock, Garland, and Hart, TVCG 2008.



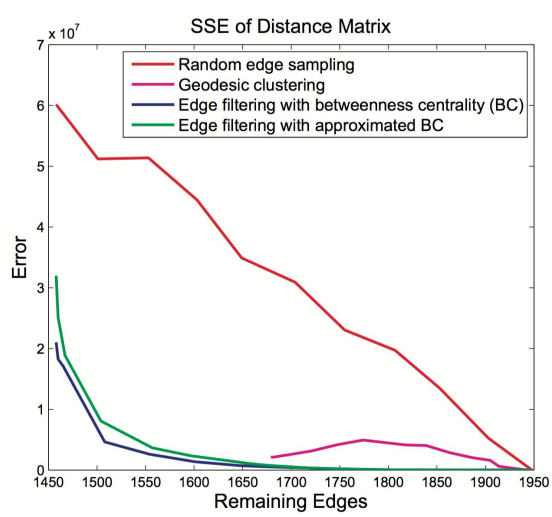
(a) Unsimplified (b) Stochastic edge sampling

(c) Geodesic clustering (d) Our method

"On the Visualization of Social and other Scale-Free Networks" Jia, Hoberock, Garland, and Hart, TVCG 2008.

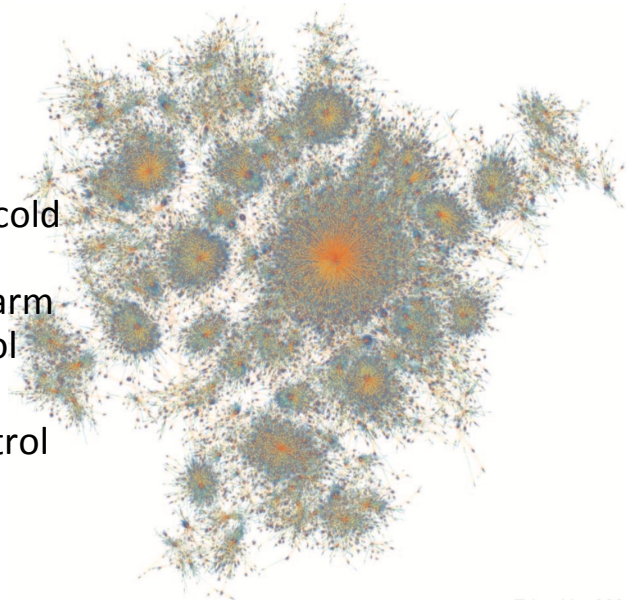
- Preprocess: mark feature edges (e.g., cliques or highly connected components)
- Priority queue
- Post-processing: catch errors in connectivity preservation approximation
- Estimate of betweenness centrality is much faster than exact computation
  - Focus on paths through 50+ hub nodes

Summed squared error in shortest paths of simplified vs original graph



"On the Visualization of Social and other Scale-Free Networks" Jia, Hoberock, Garland, and Hart, TVCG 2008.

- Rendering
  - Alpha (transparency)
  - Occlusion of less important lines
  - Interpolate warm to cold colors, highlight high-degree hubs (warm color foreground, cool color recedes)
- Interactive slider to control simplification



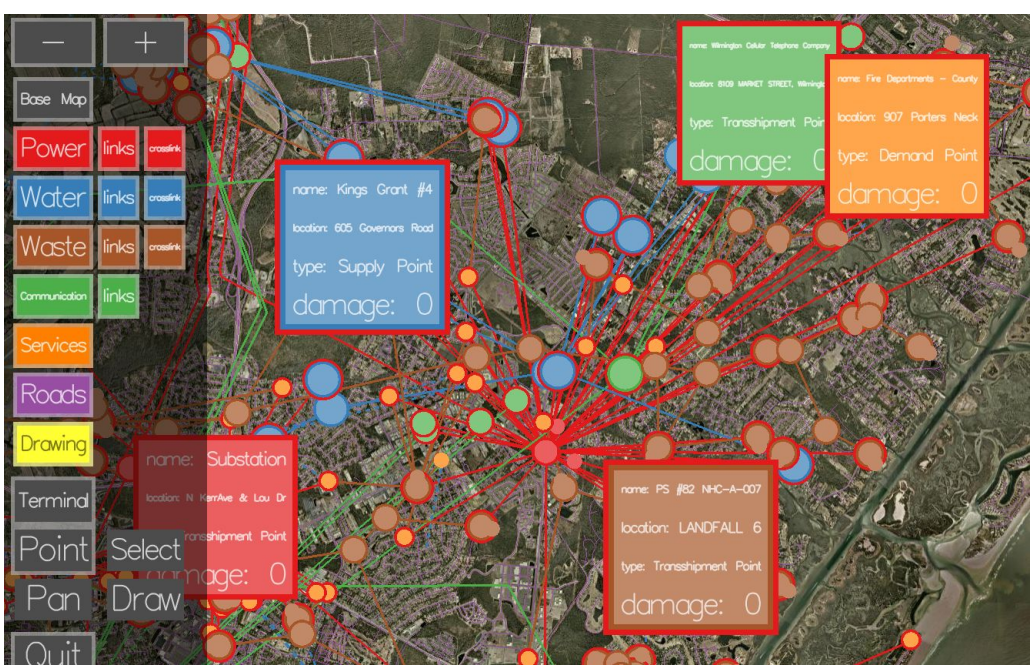
"On the Visualization of Social and other Scale-Free Networks" Jia, Hoberock, Garland, and Hart, TVCG 2008.

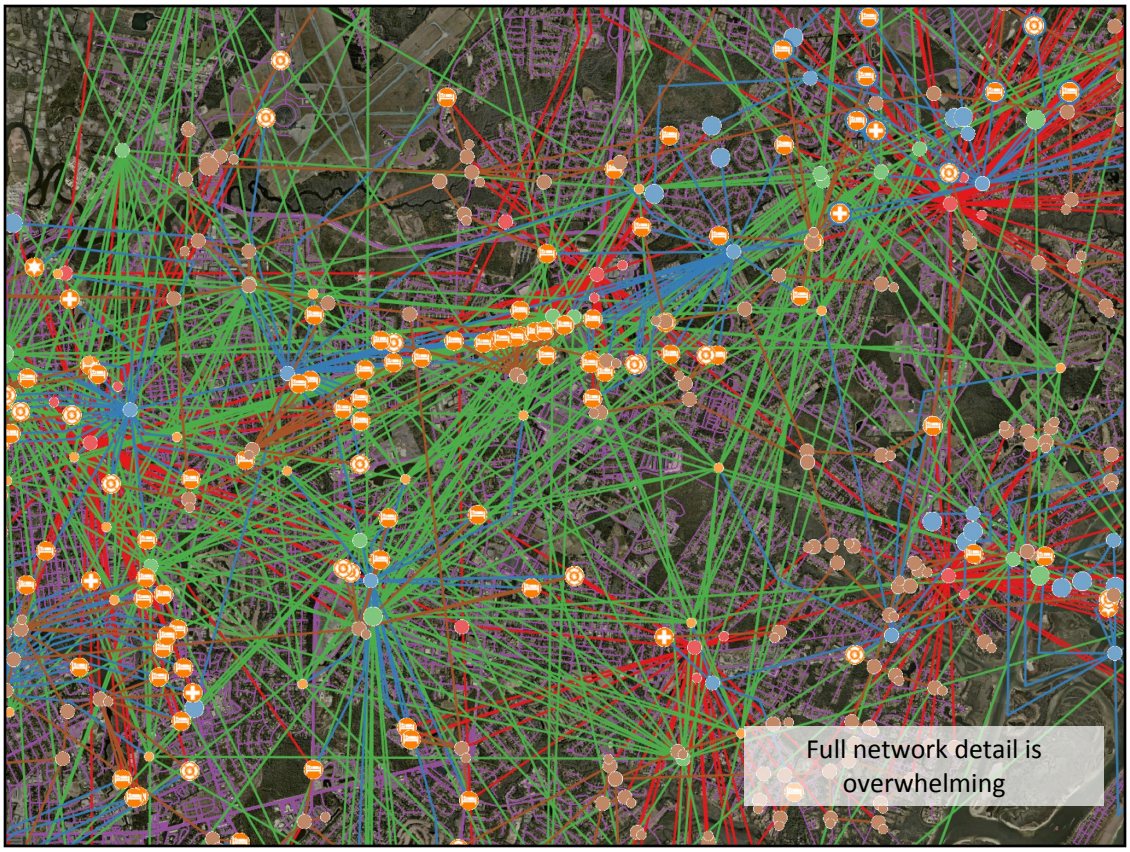
- How do we know these simplifications are correct/appropriate/*not misleading*?
  - Metrics may be application domain specific?
  - Study graph statistics
  - Perform tests of random node/edge selection & random walks
- Overclustering (problem with prior work) can imply that items directly interact when they did not in the original dataset

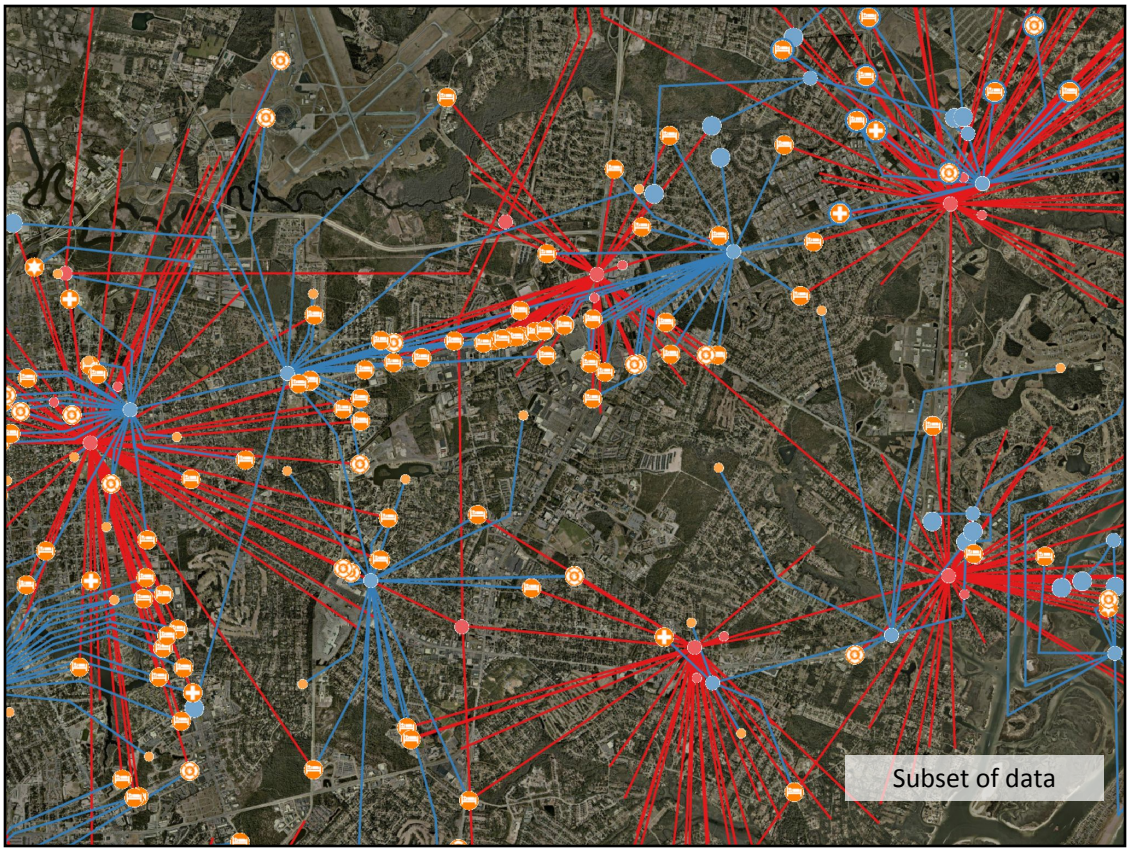
Today

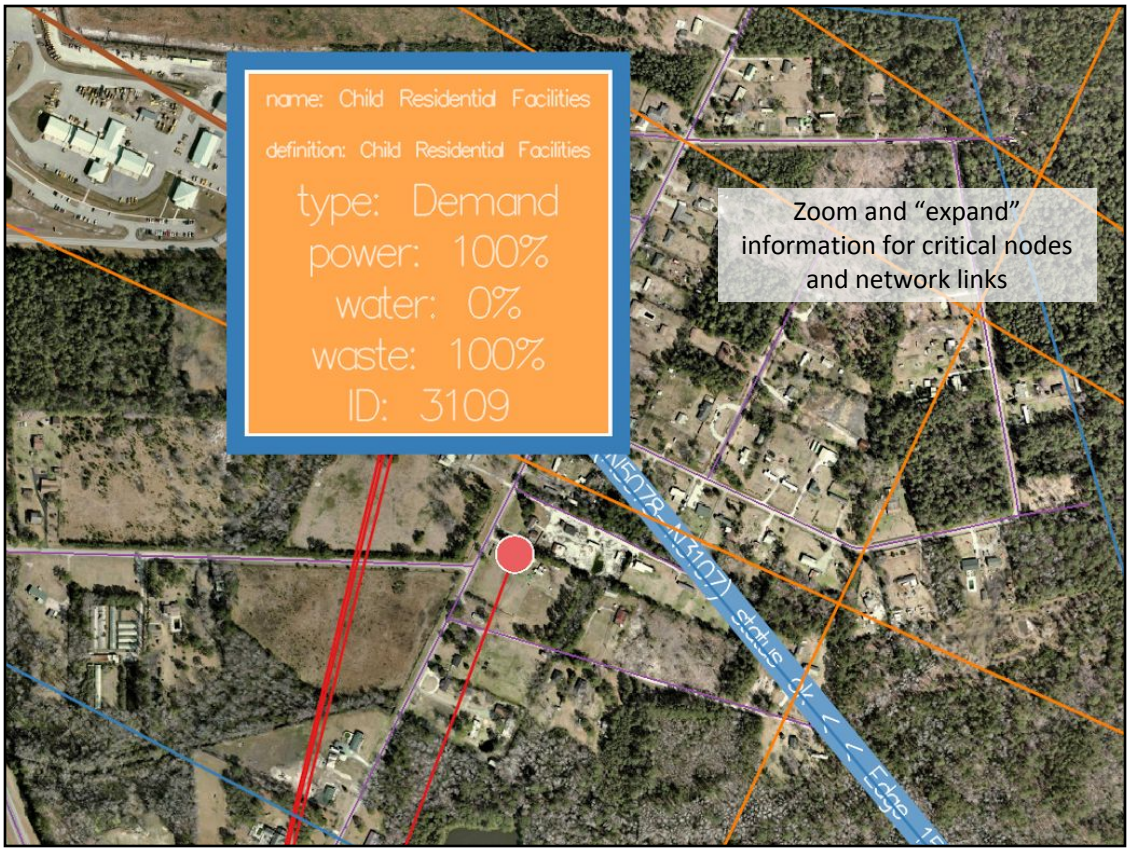
- Today's Reading: Lombardi Graphs
  - Bezier Curves
- Today's Reading: Clustering/Hierarchical edge Bundling
  - Definition of Betweenness Centrality
- Emergency Management Graph Visualization
  - Sean Kim's masters project
- Reading for Tuesday & Homework 3
- Graph Interaction Brainstorming Exercise

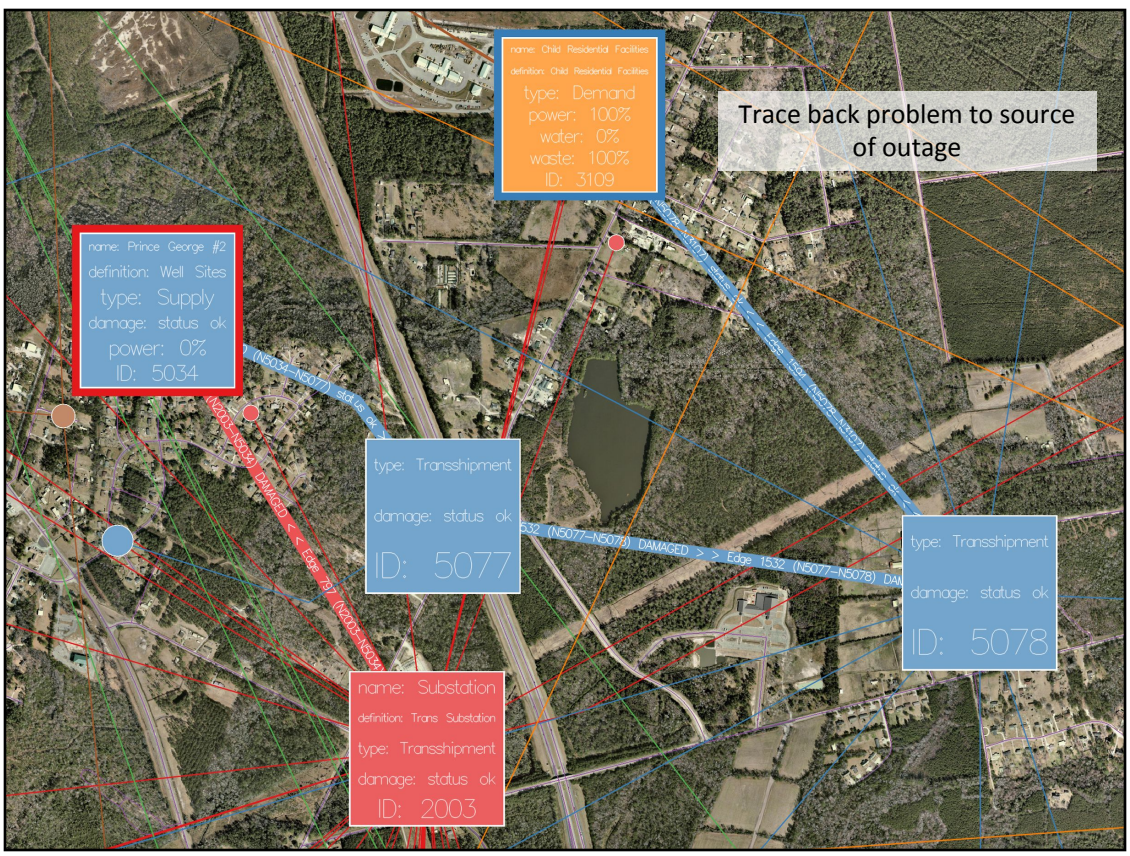
Emergency Response Decision Making

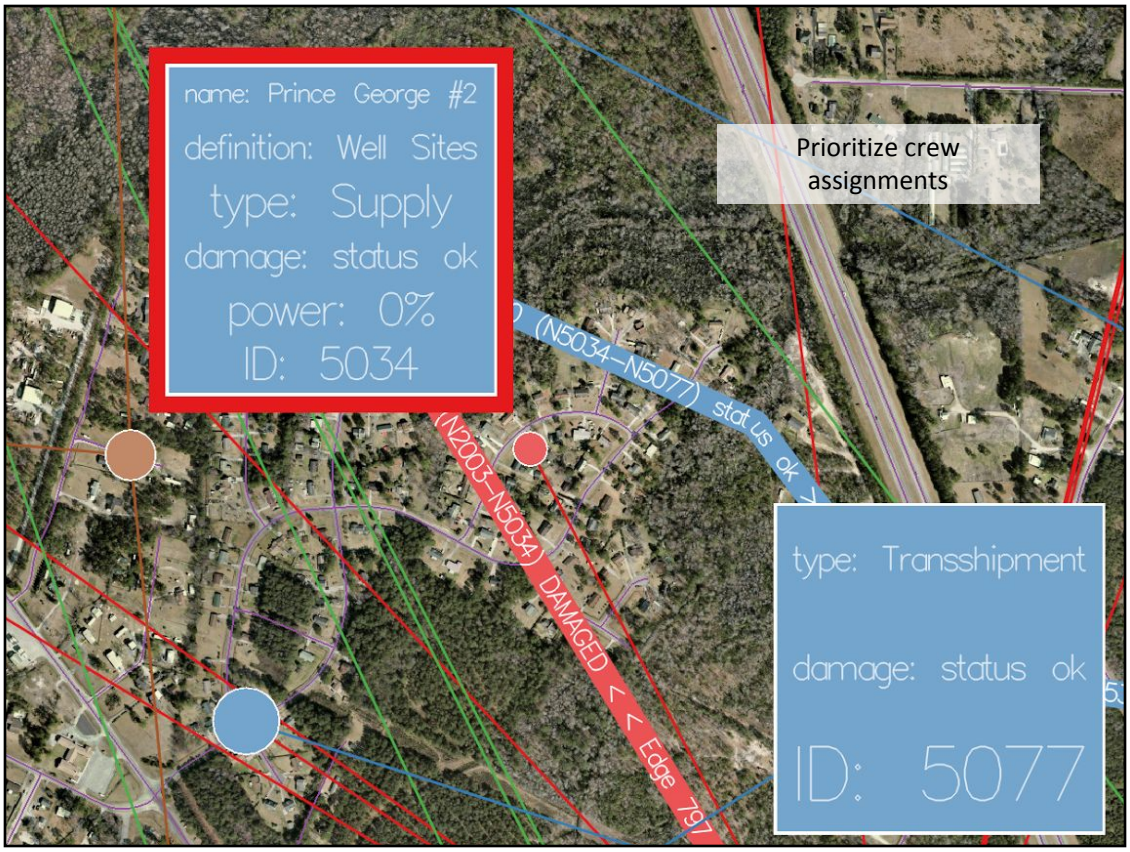


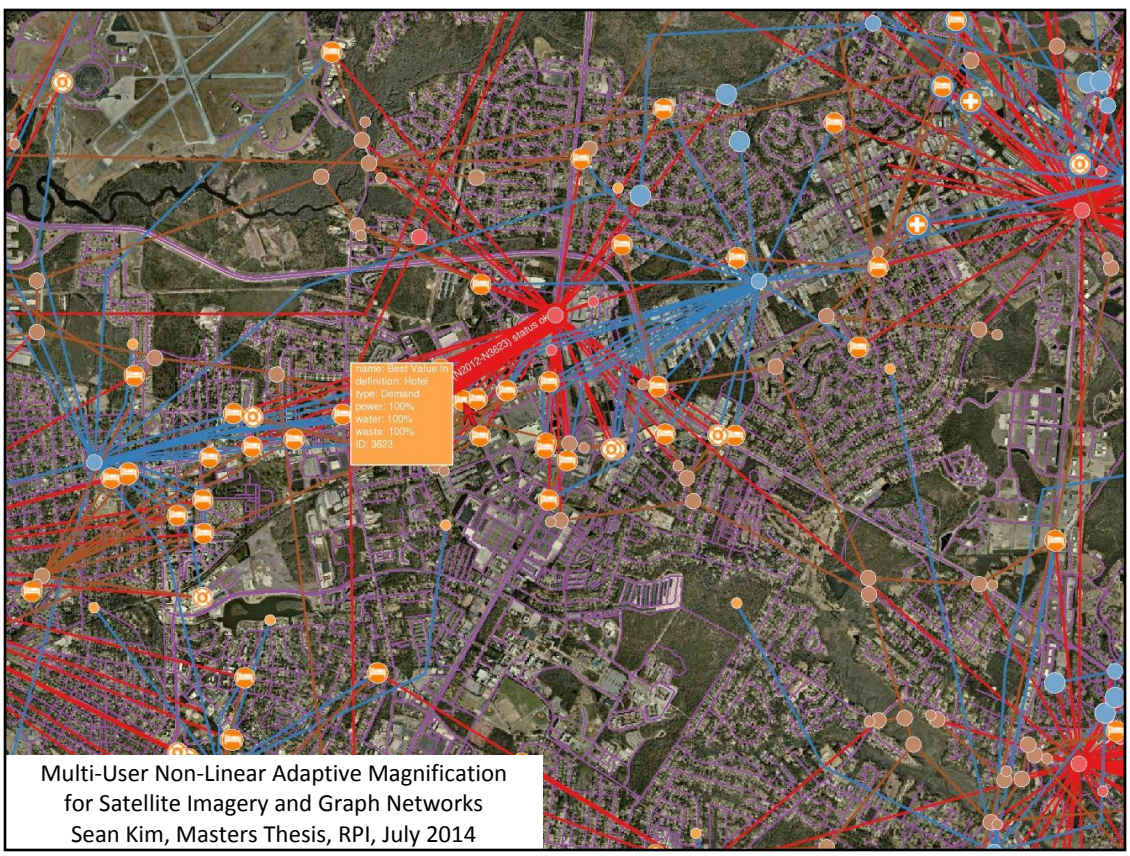

Full network detail is overwhelming


Subset of data

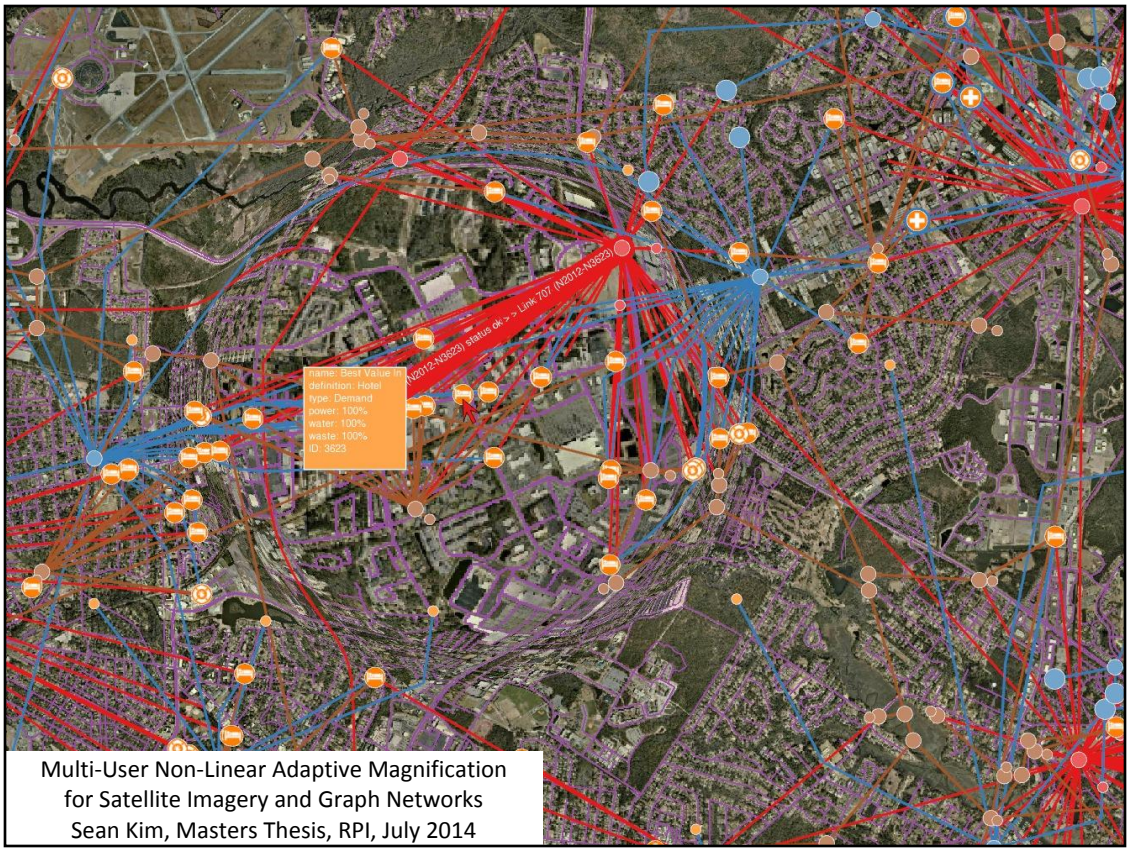

name: Child Residential Facilities
definition: Child Residential Facilities
type: Demand
power: 100%
water: 0%
waste: 100%
ID: 3109
Zoom and "expand" information for critical nodes and network links


name: Child Residential Facilities
definition: Child Residential Facilities
type: Demand
power: 100%
water: 0%
waste: 100%
ID: 3109
Trace back problem to source of outage
name: Prince George #2
definition: Well Sites
type: Supply
damage: status ok
power: 0%
ID: 5034
type: Transshipment
damage: status ok
ID: 5077
type: Transshipment
damage: status ok
ID: 5078
name: Substation
definition: Trans Substation
type: Transshipment
damage: status ok
ID: 2003

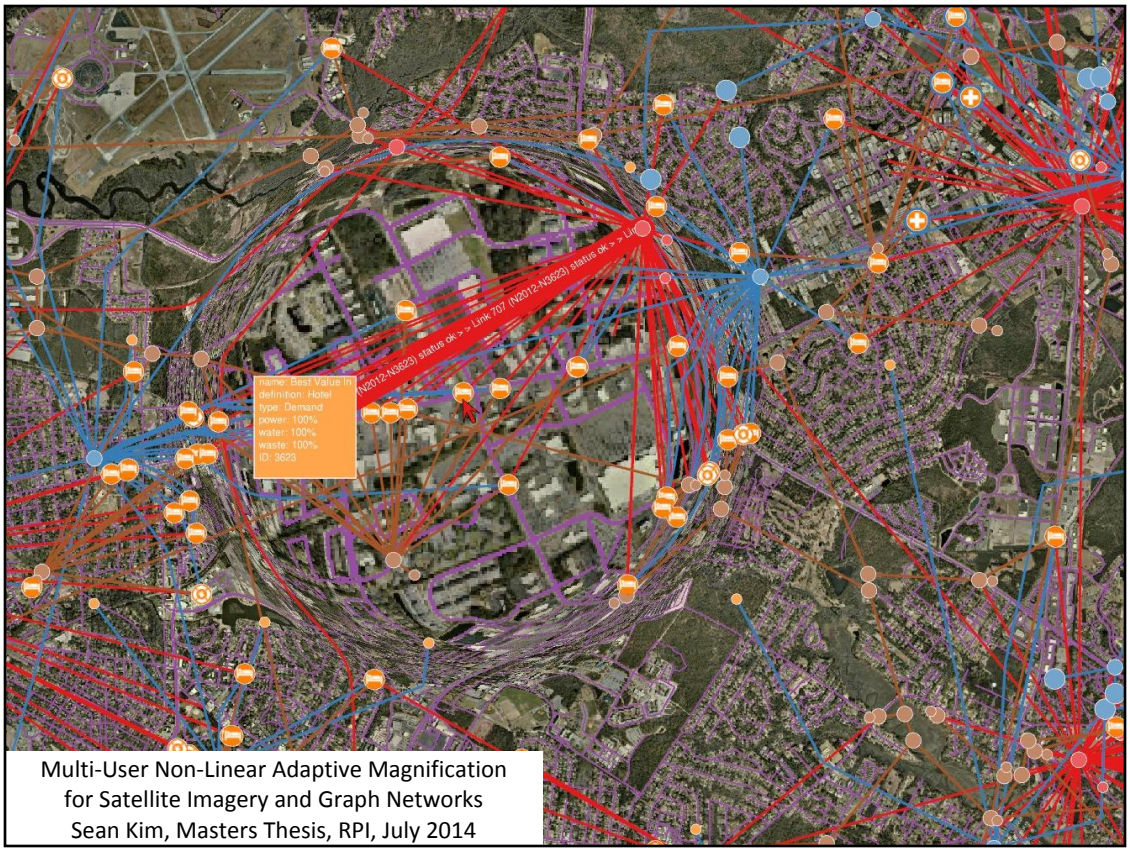




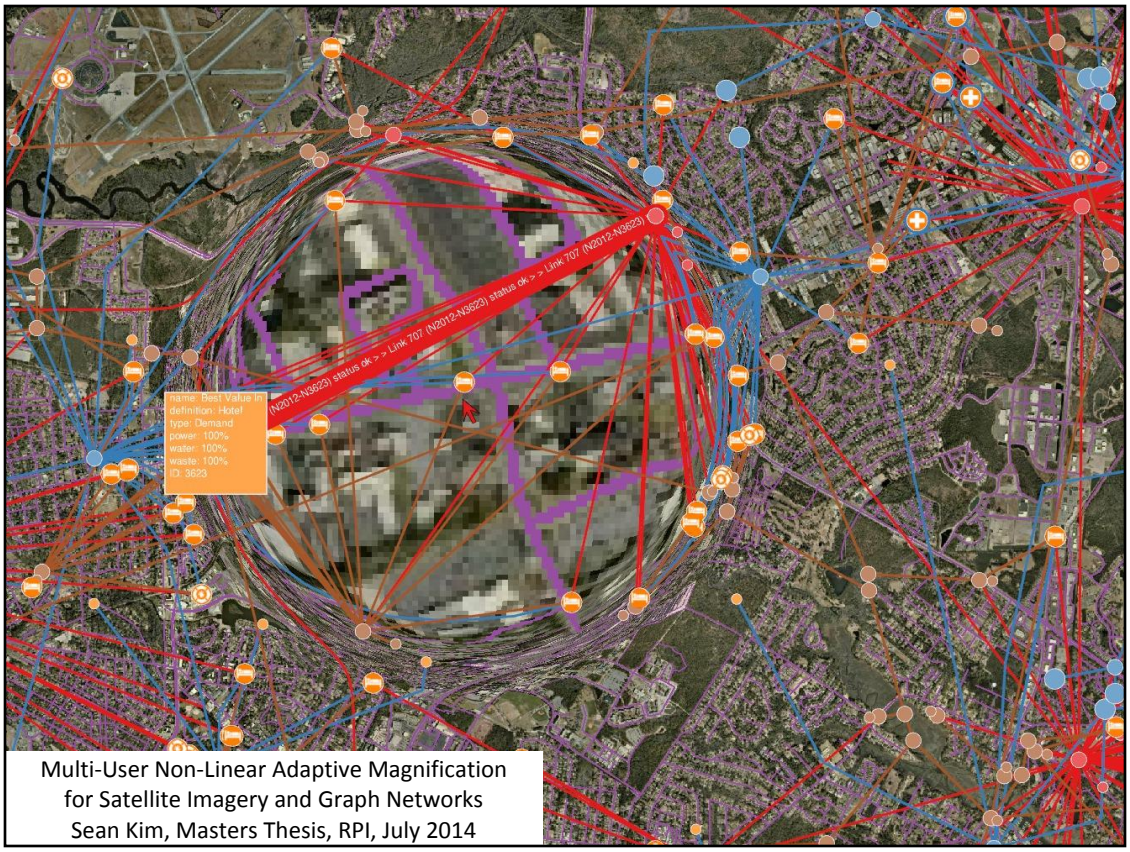
Multi-User Non-Linear Adaptive Magnification for Satellite Imagery and Graph Networks
Sean Kim, Masters Thesis, RPI, July 2014



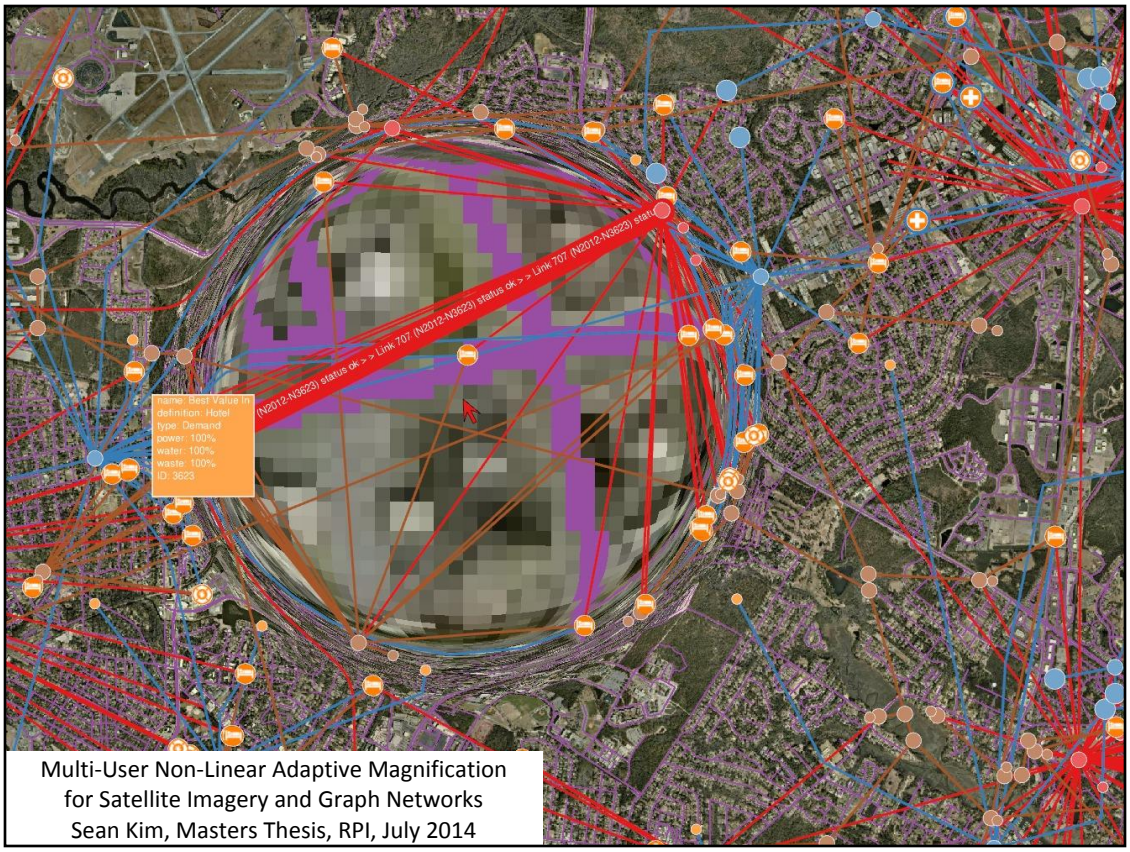
Multi-User Non-Linear Adaptive Magnification
for Satellite Imagery and Graph Networks
Sean Kim, Masters Thesis, RPI, July 2014



Multi-User Non-Linear Adaptive Magnification
for Satellite Imagery and Graph Networks
Sean Kim, Masters Thesis, RPI, July 2014



Multi-User Non-Linear Adaptive Magnification
for Satellite Imagery and Graph Networks
Sean Kim, Masters Thesis, RPI, July 2014



Multi-User Non-Linear Adaptive Magnification
for Satellite Imagery and Graph Networks
Sean Kim, Masters Thesis, RPI, July 2014

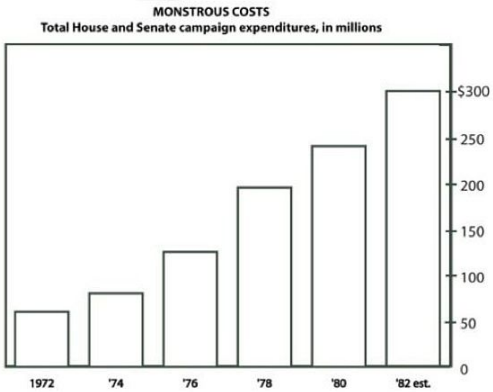
Today

- Today's Reading: Lombardi Graphs
  - Bezier Curves
- Today's Reading: Clustering/Hierarchical edge Bundling
  - Definition of Betweenness Centrality
- Emergency Management Graph Visualization
  - Sean Kim's masters project
- Reading for Tuesday & Homework 3
- Graph Interaction Brainstorming Exercise

Reading for Tuesday

Post a comment/question on LMS by Tuesday @10am

- "Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts" Bateman et al., CHI 2010.



- Article discussed here: http://eagereyes.org/criticism/chart-junk-considered-useful-after-all

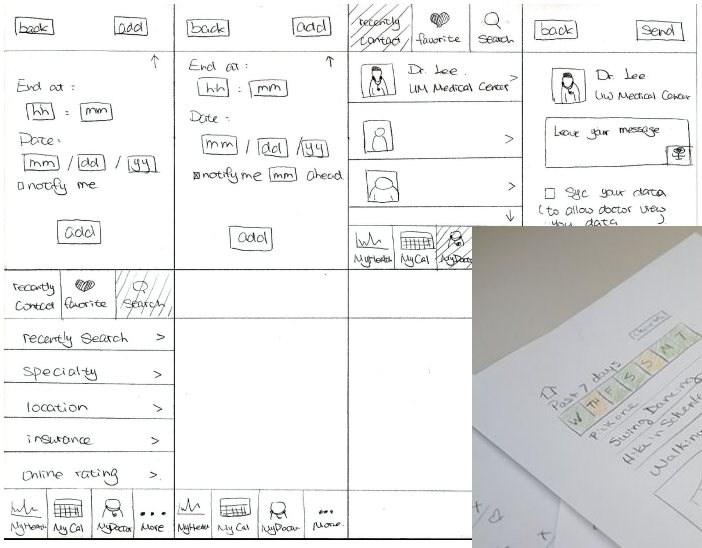
Homework Assignment 3: due Thursday @ 11:59pm
Intro to (Web-Based) Interaction

- Explore the examples on the D3: Data-Driven Documents
- http://d3js.org/ website (download the examples, modify them, start to read the documentation)
- Make an interactive (visualization) artifact:
  - Depends on your level of prior experience with Web Development tools (if you're already a D3 expert, you can choose another new-to-you tool)
  - Purpose: Can be silly & possibly exemplify our "bad visualization" traits (pie charts, chart junk, etc.)
  - Types of "interaction" may include:
    - pop up text messages
    - data hide/reveal/emphasize/restructure
    - font/size/color/transparency change

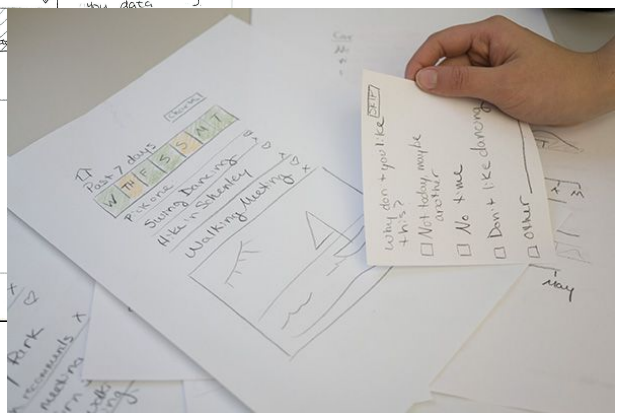
"Story-boarding"

http://pixar-animation.weebly.com/storyboard.html

“Wizard-of-Oz” for Interface Design



http://courses.cs.washington.edu/courses/cse440/12wi/projects/pocketdoctor/medfi.html



http://kate-vogt.com/bond.html

Today’s Worksheet

- *Teams of 2. Someone you did not work with last time. Hopefully someone you just met in this course :)*

- Enhance the course, prerequisite, and degree requirements graph from last lecture to include interaction.
- Story board/“Wizard of Oz” interaction use case for a sophomore planning courses and/or about adding a dual or switching majors
- Initial Visualization (showing completed courses vs. requirements)
- Sketch/label a simple UI (checkboxes, radio buttons, drop down menus, visual object interaction via click/drag, etc.)
- Clearly label a specific action the user might make…
- Post-Action Visualization (show course selection or impact of add dual or change-of-major)