



Immediate Impact Analysis

Tom Magelinski
tmagelin@andrew.cmu.edu



CarnegieMellon

Center for Computational Analysis of
Social and Organizational Systems
<http://www.casos.cs.cmu.edu/>



Presentation Goals

- Introduce **Immediate Impact** Report
- This is a Hands-On Lecture, we will be doing:
 - Replication Analyses (random node removal/entropic change)
 - Immediate Impact (specific node removal/targeted change)
 - Node Addition



June 2020

Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director

2



Carnegie Mellon
IST Institute for Software Research

What happens if...

- What if
 - You fire someone
 - A group of people retire
 - You arrest members of a cell
 - You use up a resource
- Some resilience researchers call this the “Truck Factor”
- There are two key questions
 - What happens immediately?
 - What will happen after the dust settles – near term?
- The **Immediate Impact** Report helps answer what happens immediately before the network restructures

CASOS
June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 3

Carnegie Mellon
IST Institute for Software Research

Purpose of Immediate Impact Report

- Supports what-if analysis of strategic interventions on organizational performance & individuals within
 - Interventions
 - Remove one or more nodes / links
 - Add one or more nodes / links
 - Two types of analyses
 - Impact of n specific node removals
 - Impact of n random node removals averaged over r replications
 - Report includes network- & node-level statistics for pre- & post-intervention organizations
 - Specific node removals yield Reports that include network- & node-level measures related to individual agents, tasks, resources
 - Random node removals yield Reports that include only network-level metrics.


CASOS
June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 4



Carnegie Mellon
IST Institute for Software Research

Basic Functionality


- Quick comparison metrics for impact of hypothetical change that involves removal of specific agents, tasks, resources, etc.
- Quick assessment of sensitivity to change based on random node removals
- Easy way to create new meta-networks by removing specific nodes
 - Iterative refinement of intervention strategy
 - Input to other types of analyses via other Reports
 - Once you've removed nodes save the meta-network
 - You can then run any Report comparing the old to the new

 June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 5

Carnegie Mellon
IST Institute for Software Research

General Process

- Random node removal analysis
 - Determine number of nodes to remove
 - Run **Immediate Impact** Report with r replications
- Specific node removal analysis
 - Determine nodes of interest
 - Qualitative analyses, hunches, intuition, etc.
 - Other ORA Reports...
 - **Key Entity** Report
 - **Intelligence** Report, etc.
 - Run **Immediate Impact** Report
 - Optional
 - Create new, post-intervention meta-network
 - Run other ORA Reports in comparison mode

 June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 6



Carnegie Mellon
 Institute for SOFTWARE RESEARCH
Report Output

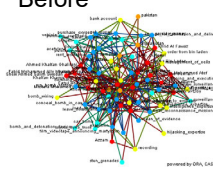
Both Analyses Before, After, %Change

- Number of Nodes
- Overall Complexity
- Performance as Accuracy
- Diffusion
- Clustering Coefficient
- Social Density
- Communication Congruence
- Average Communication Speed
- Number of Isolated Agents
- Fragmentation
- Overall Fragmentation

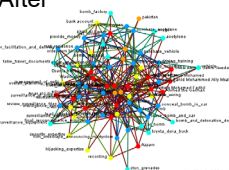
Specific Node Removal also includes Rank & Viz

- Emergent Leader
 - (Cognitive Demand)
- Potentially Influential
 - (Betweenness Centrality)
- Centrality
 - (Total Degree Centrality)

Before



After



powered by OPA, CASOS Core

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 7

Carnegie Mellon
 Institute for SOFTWARE RESEARCH
What do these things tell us

| Metric | Meaning |
|-----------------------------|---|
| Number of Nodes | Will go down – anchors how big is the change |
| Overall Complexity | Impact beyond that node – remember this is a meta-network |
| Performance as Accuracy | Likelihood the group will make mistakes |
| Diffusion | How fast does information flow through the group |
| Clustering Coefficient | Local density around nodes, “groupiness” |
| Social Density | Density in the social network |
| Communication Congruence | The higher the more effective the group |
| Average Communication Speed | Typical communication speed |
| Number of Isolated Agents | Who’s been entirely cut off from others |
| Fragmentation | Are there subgroups and level of subgroups |
| Overall Fragmentation | |

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 8



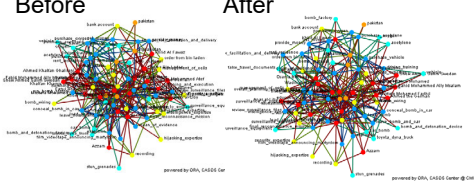
Carnegie Mellon
IST Institute for Software Research

What do these things tell us

Specific Node Removal Report also includes 3 node-level metrics, rankings & visualization

| Metric | Meaning |
|--|---------------------------------|
| Emergent Leader (Cognitive Demand) | Who will be calling the shots |
| Potentially Influential (Betweenness Centrality) | Who will work behind the scenes |
| Centrality (Total Degree Centrality) | Who will know what is going on |

Before After



CASOS
June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 9

Carnegie Mellon
IST Institute for Software Research

Hands On...

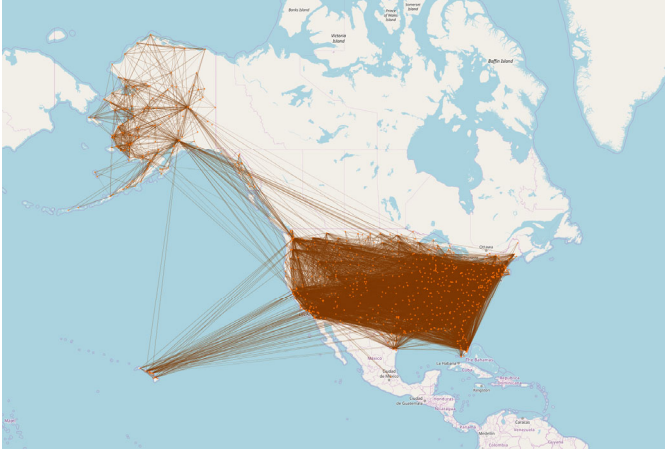
Replication Analysis

CASOS
June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 10



Carnegie Mellon
isi Institute for SOFTWARE RESEARCH

The Network of Interest

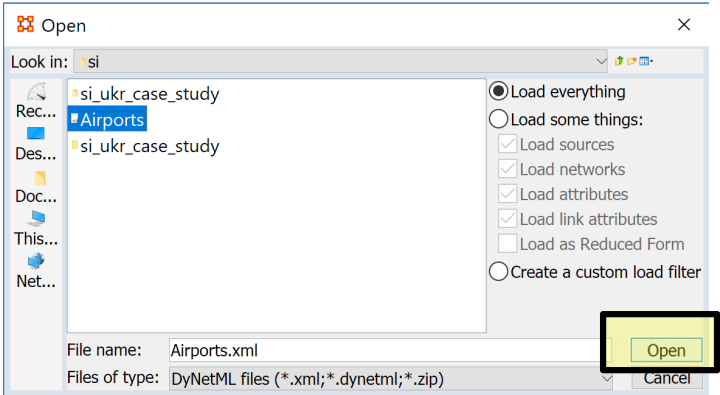


CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 11

Carnegie Mellon
isi Institute for SOFTWARE RESEARCH

Open Meta-Network



Open

Look in: si

- si_ukr_case_study
- Airports
- si_ukr_case_study

File name: Airports.xml

Files of type: DyNetML files (*.xml;*.dynetml;*.zip)

Open

Cancel

Load everything

Load some things:

- Load sources
- Load networks
- Load attributes
- Load link attributes
- Load as Reduced Form

Create a custom load filter

CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 12



Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

Select Immediate Impact Report

ORA-NetScenes 3.0.9.9.58
File Edit Preferences Data Management Generate Network Analysis Simulations Visualizations Help

Meta-Network Manager

- Generate Reports
- Measures Manager...
- Batch Mode Console
- Correspondence Analysis
- Socio-cultural Cognitive Mapping (SCM)
- Geary-C & Moran-I Analysis...

General statistics:

- Source count: 0
- Nodeset count: 2
- Node count: 1714
- Network count: 4
- Total density: 0.013955

Link statistics:

- All links: 40972
- All link values: Min: 0, Max: 1489618, Mean: 29671.786, Stddev: 95309.979721, Sum: 1215712416, Mean + Stddev: 124981.765721
- Non self-loops: 40972
- Non self-loop values: Min: 1, Max: 1489618, Mean: 29671.786, Stddev: 95309.979721, Sum: 1215712416, Mean + Stddev: 124981.765721
- Self-loops: 0
- Self-loop values: Binary

Component statistics:

- Isolates: 0
- Dyads: 0

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 13

Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

Select Immediate Impact Report

Generate Reports - Immediate Impact

Select Report

- Filter Data
- Measures
- Negative Links
- Transform Data
- Remove Nodes

Reports: select a report to run from the list or by category.

Immediate Impact

Description Input Requirements Output Formats

Computes the key actors of the network, and then isolates them individually to determine the effect on measure values.

Meta-Networks: select one or more to analyze in the report.

- Airports

< Back Next > Cancel

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 14



Carnegie Mellon
ISI Institute for SOFTWARE RESEARCH

Replication Analysis lets us understand what?

Generate Reports - Immediate Impact

Parameters Choose a type of impact analysis: Remove Nodes Replication Analysis

Visualization Select the number of nodes to remove from each nodeset. Each replication consists of removing randomly selected nodes and computing measures. The impact is measured by the change in the measure values.

Ranked Tables

Number of replications: 100

Nodeset Location: 95

Nodeset region: 0

95 locations will be removed at random (10% of locations).

How robust our network is to entropic change!

< Back Next > Cancel

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 15

Carnegie Mellon
ISI Institute for SOFTWARE RESEARCH

Generate Reports - Immediate Impact

Save Options Reports can present their results in different formats. Each format produces one or more files that are saved to a specified location. When multiple files are created, each filename will be an extension of the one you give.

Preferences Select the report formats to create:

- Text
- HTML
- CSV
- JSON
- PowerPoint All slides
- PDF

Enter a directory in which to save the report:
C:\Users\vmagelin\Desktop\lsi Browse

Enter a filename without extension:
Immediate Impact

< Back Finish Cancel

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 16



Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

IMMEDIATE IMPACT REPORT

Input data: Airports
Start time: Tue May 26 14:11:35 2020
[Data Description](#)

Replication Analysis

The original input meta-network has the specified number of nodes from each class removed and the measures recomputed. This is repeated, and the average measure values across iterations computed.

| | Original Value | Avg Replicated Value | Percent Change |
|---|----------------|----------------------|----------------|
| Number of replications: | | 100 | |
| Nodeset | | Nodes removed | |
| Location | | 95 | |
| Potentially Influential (betweenness centrality) | 0.006 | 0.007 | +9.22% |
| Input network(s): Location x Location | | | |
| Potentially Influential (betweenness centrality, links inverted) [inverted=1] | 0.004 | 0.004 | +9.13% |
| Input network(s): Location x Location | | | |
| Parameter(s): inverted = 1 | | | |
| Potentially Influential (betweenness centrality) | 0 | 0 | N/A |
| Input network(s): region-region | | | |
| Potentially Influential (betweenness centrality, links inverted) [inverted=1] | 0 | 0 | N/A |
| Input network(s): region-region | | | |
| Parameter(s): inverted = 1 | | | |
| Overall Complexity | 0.008 | 0.008 | -6.84% |
| Input: entire meta-network considered as a single network | | | |
| Centrality (total degree centrality) | 4.519e-04 | 4.610e-04 | +2.02% |

CASOS
June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 17

Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

Hands On...

Immediate Impact Analysis (Targeted Node Removal)

CASOS
June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 18



Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

Typical Process

- Run a Report to find nodes to remove
 - Must 1st identify nodes to target with strategic intervention
 - Good candidates for removal depend on your goal
 - Several Reports identify nodes of interest
 - Popular Reports for finding nodes whose removal will degrade organizational performance
 - **Key Entities**
 - **Management**
 - **Intelligence**
- Run **Immediate Impact** Report
 - Remove 1 or more entities identified as notable by prior analyses
 - save the modified meta-network for additional analyses if desired

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 19

Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

Where should we target?

Betweenness Centrality

The Betweenness Centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v , the percentage that pass through v . When the data is weighted, the higher the weight the more value the link has. Individuals or organizations that are potentially influential are positioned to broker connections between groups and to bring to bear the influence of one group on another or serve as a gatekeeper between groups. This agent occurs on many of the shortest paths between other agents. The scientific name of this measure is betweenness centrality and it is calculated on agent by agent matrices.

If the node of interest has a higher than normal value (greater than 1 standard deviation(s) above the mean) the row is colored red. The row is green if the node is within 1 standard deviation of the mean. Finally, the row is colored blue if the node has a lower than normal value (less than one standard deviation(s) below the mean).

Input network: Location x Location (size: 951, density: 0.0228513)

Show 10 entries Search:

| Rank | Location | Value | Unscaled | Context* |
|------|----------|-------|-------------|----------|
| 1 | 88 | 0.390 | 351,216.563 | 19,994 |
| 2 | 240 | 0.147 | 137,737.563 | 7,493 |

ANK (88), Anchorage Alaska is by far the highest in betweenness

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 20



Carnegie Mellon
IST Institute for Software Research

Select Immediate Impact Report

ORA-NetScenes 3.0.9.9.58
File Edit Preferences Data Management Generate Network Analysis Simulations Visualizations Help

Meta-Network Manager

Generate Reports

- Measures Manager...
- Batch Mode Console
- Correspondence Analysis
- Socio-cultural Cognitive Mapping (SCM)
- Geary-C & Moran-I Analysis...

Knowledge Networks & Network Text Analysis

- Statistical Procedures and Diagnostics
- Geospatial
- Characterize Groups and Networks
- Dynamics
- Locate Key Entities
- Locate Key Relations
- Show me everything (All Measures)

Belief Propagation

Change in Key Entities

Immediate Impact

Influence Net

GAP/MROAP Analysis

Statistical Change Detection

Tactical Insight

General statistics:

- Source count: 0
- Nodeset count: 2
- Node count: 1714
- Network count: 4
- Total density: 0.013955

Link statistics:

- All links: 40972
- All link values: Min: 0, Max: 1489618, Mean: 29671.786, Stddev: 95309.979721, Sum: 1215712416
Mean + Stddev: 124981.765721
- Non self-loops: 40972
- Non self-loop values: Min: 1, Max: 1489618, Mean: 29671.786, Stddev: 95309.979721, Sum: 1215712416
Mean + Stddev: 124981.765721
- Self-loops: 0
- Self-loop values: Binary

Component statistics:

- Isolates: 0
- Dyads: 0

CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 21

Carnegie Mellon
IST Institute for Software Research

Select Immediate Impact Report

Generate Reports - Immediate Impact

Select Report: Reports: select a report to run from the list or by category.

Filter Data

Measures

Negative Links

Transform Data

Remove Nodes

Immediate Impact

Categories

Description Input Requirements Output Formats

Computes the key actors of the network, and then isolates them individually to determine the effect on measure values.

Meta-Networks: select one or more to analyze in the report.

- Airports

< Back Next > Cancel

CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 22



Carnegie Mellon
ISR Institute for SOFTWARE RESEARCH

Change Analysis lets us understand what?

Generate Reports - Immediate Impact

Parameters
Visualization
Ranked Tables

Choose a type of impact analysis: **Change Analysis**

Choose nodes to add or remove, and choose links to add, remove, or modify in value. The changes in measure values are then reported.

Remove Nodes Add Nodes Change Links

All Nodes: **Location** region

88 **Equals**

| Node Name | AirportCode | City | Lat | Long |
|-----------------------------|-------------|-----------------------------|----------|------------|
| <input type="checkbox"/> 88 | ANC | Ted Stevens Anchorage Int'l | 61.17... | -149.99... |

How robust our network is to targeted change!

Select/Clear All Select/Clear Visible 0 / 951 Selected, 1 / 951 Visible

< Back Next > Cancel

CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 23

Carnegie Mellon
ISR Institute for SOFTWARE RESEARCH

Generate Reports - Immediate Impact

Save Options
Preferences

Reports can present their results in different formats. Each format produces one or more files that are saved to a specified location. When multiple files are created, each filename will be an extension of the one you give.

Select the report formats to create:

- Text
- HTML
- CSV
- JSON
- PowerPoint All slides
- PDF

Enter a directory in which to save the report:
C:\Users\vmagelin\Desktop\lsi Browse

Enter a filename without extension:
Immediate Impact

< Back **Finish** Cancel

CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 24



Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

IMMEDIATE IMPACT REPORT

Input data: Airports
Start time: Tue May 26 14:18:00 2020
[Data Description](#)

What is the impact of the removal of selected key entities from the network?

The selected entities are removed from the network and the effects are measured by comparing the values of key metrics before and after their removal. The results are shown graphically in terms of the portion of the network "near" the entities that are removed and statistically based on the entire meta-network. The portion of the network that is "near" the entities that are removed is defined as all known entities of the user selected entity classes within a path length of 2 from the target entities.

For example, if the entity class is agent, and the target is Alexander Bell then the displayed network contains all other agents that are directly connected to Bell or are directly connected to someone who is directly connected to Bell.

The following nodes were removed:

| Nodeset | Node |
|----------|------|
| Location | 88 |

Before Changes
After Changes

Network Level Measures

| | Before | After | Percent Change |
|--------------------|--------|-------|----------------|
| Overall Complexity | 0.008 | 0.008 | -0.97% |

Input: entire meta-network considered as a single network

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 25

Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

Hands On...

Node Addition

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 26



Carnegie Mellon
IST Institute for Software Research

Select Immediate Impact Report

NetScenes 3.0.9.9.58
File Edit Preferences Data Management Generate Network Analysis Simulations Visualizations Help

Meta-Network Manager

- Generate Reports
- Measures Manager...
- Batch Mode Console
- Correspondence Analysis
- Socio-cultural Cognitive Mapping (SCM)
- Geary-C & Moran-I Analysis...

General statistics:

- Source count: 0
- Nodeset count: 2
- Node count: 1714
- Network count: 4
- Total density: 0.013955

Link statistics:

- All links: 40972
- All link values: Min: 0, Max: 1489618, Mean: 29671.786, Stddev: 95309.979721, Sum: 1215712416, Mean + Stddev: 124981.765721
- Non self-loops: 40972
- Non self-loop values: Min: 1, Max: 1489618, Mean: 29671.786, Stddev: 95309.979721, Sum: 1215712416, Mean + Stddev: 124981.765721
- Self-loops: 0
- Self-loop values: Binary

Component statistics:

- Isolates: 0
- Dyads: 0

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 27

Carnegie Mellon
IST Institute for Software Research

Generate Reports - Immediate Impact

Select Report

Filter Data

Measures

Negative Links

Transform Data

Remove Nodes

Reports: select a report to run from the list or by category.

Immediate Impact

Categories

Description Input Requirements Output Formats

Computes the key actors of the network, and then isolates them individually to determine the effect on measure values.

Meta-Networks: select one or more to analyze in the report.

Airports

< Back Next > Cancel

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 28



Carnegie Mellon
ISI Institute for SOFTWARE RESEARCH

Generate Reports

Parameters
Visualization
Ranked Tables

Choose a type of impact analysis: **Change Analysis**

Choose nodes to add or remove, and choose links to add, remove, or modify in value. The changes in measure values are then reported.

Remove Nodes | Add Nodes | Change Links

Select a nodeset to add nodes to:
Location

List the Node IDs to create, and the number of nodes to create for each:
New_Airport 1

space delimited comma delimited semi-colon delimited

Choose how to create links for the new nodes:

| | | | |
|---------------------|--------------------|----|---------|
| Location x Location | High degree alters | 10 | Percent |
| Location--region | Random alters | 1 | Count |
| region--Location | Random alters | 1 | Count |

What if we open an airport?

Connect new Airport to 10% of other important airports, and assign to a region

CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 29

Carnegie Mellon
ISI Institute for SOFTWARE RESEARCH

Generate Reports - Immediate Impact

Save Options
Preferences

Reports can present their results in different formats. Each format produces one or more files that are saved to a specified location. When multiple files are created, each filename will be an extension of the one you give.

Select the report formats to create:

Text
 HTML
 CSV
 JSON
 PowerPoint All slides
 PDF

Enter a directory in which to save the report:
C:\Users\vmagelin\Desktop\lsi Browse

Enter a filename without extension:
Immediate Impact

< Back Finish Cancel

CASOS

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 30



Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

IMMEDIATE IMPACT REPORT

Input data: Airports
Start time: Tue May 26 14:23:20 2020

[Data Description](#)

What is the impact of the removal of selected key entities from the network?

The selected entities are removed from the network and the effects are measured by comparing the values of key metrics before and after their removal. The results are shown graphically in terms of the portion of the network "near" the entities that are removed and statistically based on the entire meta-network. The portion of the network that is "near" the entities that are removed is defined as all known entities of the user selected entity classes within a path length of 2 from the target entities.

For example, if the entry class is agent, and the target is Alexander Bell then the displayed network contains all other agents that are directly connected to Bell or are directly connected to someone who is directly connected to Bell.

Nodes were added to nodeset: Location
Node IDs: New_Airport

The following link creation rules were used:

| Network | Link Creation Method | Link Quantity |
|---------------------|-----------------------------------|---------------|
| Location x Location | Linked to nodes of highest degree | 10% |
| Location-region | Randomly created to other nodes | 1 |
| region-Location | Randomly created to other nodes | 1 |

Network Level Measures

| | Before | After | Percent Change |
|--------------------|--------|-------|----------------|
| Overall Complexity | 0.008 | 0.008 | +0.74% |

Input: entire meta-network considered as a single network

CASOS June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 31

Carnegie Mellon
IST Institute for SOFTWARE RESEARCH

What have we learned?

- Compare change when we remove 10% at random, to when target the airport with highest betweenness
- Complexity = number of alternate paths
 - Implications for traveler options (trip cost)
 - Implications for network sensitivity
- In random removal, complexity *increases*
- In targeted removal, complexity *decreases*
- In node addition, complexity *increases*
- **The airport network is robust to random shutdowns, but somewhat vulnerable to targeted outages**

CASOS – Classic problem with "hub-spoke" network structures

June 2020 Copyright © 2020 CASOS, ISR, CMU -- Kathleen M. Carley - Director 32



4 General Isolation Strategies

- Random isolation (removal from network) of 1 or more people, resources, tasks
- Centrality-based isolation
- Betweenness-based isolation
- Scenario-based isolation