KNOW THE NETWORK, KNIT THE NETWORK:

APPLYING SNA TO N2C2 MATURITY MODEL EXPERIMENTS

by Bárbara Manso and Marco Manso

15th ICCRTS
June 23rd 2010
The Value of SNA
Mapping SNA to ELICIT
SNA Findings in the N2C2M2 ELICIT Experiments:
- Node Centrality
- Node Embeddedness
- Network Activity
- Network Path Length & Diameter
- Network Inclusiveness
- Network Clustering Coefficient
- Network Connectedness
- Network Structural Cohesion
Evolving From Less Mature to More Mature C2 Approaches
Knowing the Network, Knitting the Network
Social Network Analysis (SNA) is a scientific methodology that assists in the explanation of networking and personal interactions.

SNA focuses on individuals or nodes and on degrees or links.

SNA enables to determine how the network’s structure, location and connection properties affect organisational performance and effectiveness.
ELICIT is an experimentation platform that instruments the actions of a group of seventeen participants engaged in a situational awareness problem, with the goal to identify the who, what, when and where of a pending attack.

ELICIT participants build situational awareness by gathering and analyzing factoids and interacting with one another through factoids' sharing directly with each other or factoids' posting to websites.
# SNA Findings in the N2C2M2 ELICIT Experiments

<table>
<thead>
<tr>
<th>SNA Variable</th>
<th>SNA Variable Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node Centrality</td>
<td>- Compound variable, measured by:</td>
</tr>
<tr>
<td></td>
<td>- Node Degree — number of nodes to which a node is directly related to;</td>
</tr>
<tr>
<td></td>
<td>- Closeness — degree to which a node is close to all other nodes;</td>
</tr>
<tr>
<td></td>
<td>- Betweenness — frequency by which the node is located between pairs of other nodes.</td>
</tr>
<tr>
<td>Node Embeddedness</td>
<td>- Node Embeddedness — a compound variable, measured by:</td>
</tr>
<tr>
<td></td>
<td>- Link Density — the relation between the node’s links and the total number of links;</td>
</tr>
<tr>
<td></td>
<td>- Link Strength — number of times a link has been used;</td>
</tr>
<tr>
<td></td>
<td>- Link Flow — number of in-degrees and out-degrees of a node.</td>
</tr>
<tr>
<td>Network Activity</td>
<td>Number of times each link has been used</td>
</tr>
<tr>
<td>Network Mode Path Length</td>
<td>Mode of all nodes’ path lengths</td>
</tr>
<tr>
<td>Network Diameter</td>
<td>Maximum path within the network</td>
</tr>
<tr>
<td>Network Inclusiveness</td>
<td>Relation between the number of isolated nodes and the total number of nodes</td>
</tr>
<tr>
<td>Network Clustering Coefficient</td>
<td>Likelihood that two associates of a node are associates themselves</td>
</tr>
<tr>
<td>Network Connectedness</td>
<td>Capability of each node to reach all other nodes in the network</td>
</tr>
<tr>
<td>Network Structural Cohesion</td>
<td>Minimum number of nodes that, if removed, causes the network to collapse</td>
</tr>
</tbody>
</table>
SNA Findings in the N2C2M2 ELICIT Experiments

Node Centrality

L1 01 Sociogram

L3 03 Sociogram

L5 02 Sociogram
Node Centrality

<table>
<thead>
<tr>
<th>Node Centrality</th>
<th>Betweenness</th>
<th>Degree</th>
<th>Closeness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average L1</td>
<td>0.196</td>
<td>2.529</td>
<td>2.627</td>
</tr>
<tr>
<td>Average L2</td>
<td>16.059</td>
<td>2.735</td>
<td>6.946</td>
</tr>
<tr>
<td>Average L3</td>
<td>15.857</td>
<td>2.912</td>
<td>7.081</td>
</tr>
<tr>
<td>Average L4</td>
<td>3.154</td>
<td>2.132</td>
<td>7.223</td>
</tr>
<tr>
<td>Average L5</td>
<td>5.059</td>
<td>2.745</td>
<td>6.363</td>
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SNA Findings in the N2C2M2 ELICIT Experiments

Node Centrality

<table>
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<tr>
<th>SNA Variable</th>
<th>Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches</th>
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</thead>
<tbody>
<tr>
<td>Node Centrality</td>
<td>From VERY LOW (isolated node) to HIGH (central node sets) and to MEDIUM (decentralised network)</td>
</tr>
</tbody>
</table>
SNA Findings in the N2C2M2 ELICIT Experiments

Node Embeddedness

L1 02 More than 5
Link Strength Connection

L3 01 More than 5
Link Strength Connection

L5 03 More than 5
Link Strength Connection
Node Embeddedness

<table>
<thead>
<tr>
<th>Node Embeddedness</th>
<th>Link Density</th>
<th>Link Strength</th>
<th>Link Flow</th>
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<tbody>
<tr>
<td>Average L1</td>
<td>0.196</td>
<td>2.529</td>
<td>2.627</td>
</tr>
<tr>
<td>Average L2</td>
<td>0.549</td>
<td>7.397</td>
<td>25.750</td>
</tr>
<tr>
<td>Average L3</td>
<td>0.659</td>
<td>5.647</td>
<td>17.176</td>
</tr>
<tr>
<td>Average L4</td>
<td>0.143</td>
<td>2.029</td>
<td>7.529</td>
</tr>
<tr>
<td>Average L5</td>
<td>0.208</td>
<td>1.352</td>
<td>7.176</td>
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SNA Findings in the N2C2M2 ELICIT Experiments

Node Embeddedness

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<tr>
<td>Node Embeddedness</td>
<td>From LOW (low density) to HIGH (high density) and to MEDIUM (distributed density)</td>
</tr>
</tbody>
</table>
Network Activity

L1 03 Sociogram with websites  L3 04 Sociogram with websites  L5 03 Sociogram with websites
Network Activity

<table>
<thead>
<tr>
<th>SNA Variable</th>
<th>Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches</th>
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<tbody>
<tr>
<td>Network Activity</td>
<td>From LOW (minimal degrees) to MEDIUM (limited degrees) and to HIGH (multiple degrees)</td>
</tr>
</tbody>
</table>
SNA Findings in the N2C2M2 ELICIT Experiments

Network Path Length

L1 02 Dale’s Egonet

L3 02 Francis’ Egonet

L5 02 Robin’s Egonet
Network Path Length

**Network Average Path Length**

<table>
<thead>
<tr>
<th>SNA Variable</th>
<th>Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Mode Path Length</td>
<td>From HIGH (first order zone) to LOW (hierarchical rules) and to LOW (geodesics)</td>
</tr>
</tbody>
</table>
SNA Findings in the N2C2M2 ELICIT Experiments

Network Diameter

L1 01 Dale’s Egonet

L3 04 Dale’s Egonet

L5 01 Kim’s Egonet
SNA Findings in the N2C2M2 ELICIT Experiments

Network Diameter

<table>
<thead>
<tr>
<th>SNA Variable</th>
<th>Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Diameter</td>
<td>From LOW (adjacency) to MEDIUM (hierarchical setting) and to LOW (wider neighbourhood of geodesics)</td>
</tr>
</tbody>
</table>
Network Inclusiveness

L1 02 Isolates  
L3 02 Component  
L5 02 Isolates
SNA Findings in the N2C2M2 ELICIT Experiments

Network Inclusiveness

<table>
<thead>
<tr>
<th>A Variable</th>
<th>Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusiveness</td>
<td>From LOW (one isolate) to NOT APPLICABLE (no isolates) and to MEDIUM (isolated node behaviour)</td>
</tr>
</tbody>
</table>
SNA Findings in the N2C2M2 ELICIT Experiments

Network Clustering Coefficient

2 Reciprocal Ties  L3 04 Reciprocal Ties  L5 01 Reciprocal Ties
SNA Findings in the N2C2M2 ELICIT Experiments

Network Clustering Coefficient

<table>
<thead>
<tr>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
</tr>
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<tbody>
<tr>
<td>Average</td>
<td>Average</td>
<td>Average</td>
<td>Average</td>
<td>Average</td>
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</table>

*Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches*

- Clustering Coefficient: From HIGH (small node sets) to LOW (rigid node association) and to VERY LOW (free node association)
SNA Findings in the N2C2M2 ELICIT Experiments

Network Connectedness

L3 03 Harlan’s Egonet

L5 03 Jesse’s Egonet

03 Kim’s Egonet
SNA Findings in the N2C2M2 ELICIT Experiments

Network Connectedness

<table>
<thead>
<tr>
<th>Variable</th>
<th>Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connectedness</td>
<td>From LOW (minimum node reach) to MEDIUM (limited node reach) and to HIGH (full node reach)</td>
</tr>
</tbody>
</table>
SNA Findings in the N2C2M2 ELICIT Experiments

Network Structural Cohesion

Blocks and Cutpoints  L3 01 Blocks and Cutpoints  L5 02 Blocks and Cutpoints
SNA Findings in the N2C2M2 ELICIT Experiments

Network Structural Cohesion

<table>
<thead>
<tr>
<th>Variable</th>
<th>Expected SNA Variable Behaviour From Less Mature To More Mature C2 Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Cohesion</td>
<td>From LOW (small network cohesion) to VERY LOW (minimum network cohesion) and to HIGH (high network cohesion)</td>
</tr>
</tbody>
</table>
### SNA Findings in the N2C2M2 ELICIT Experiments

<table>
<thead>
<tr>
<th>Node Centrality</th>
<th>Node Embeddedness</th>
<th>Network Activity</th>
<th>Network Average Path Length</th>
<th>Network Inclusiveness</th>
<th>Network Clustering Coefficient</th>
<th>Network Connectedness</th>
<th>Network Structural Cohesion</th>
</tr>
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<tbody>
<tr>
<td>Betweenness</td>
<td>Degree</td>
<td>Closeness</td>
<td>Link Density</td>
<td>Link Strength</td>
<td>Link Flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.196</td>
<td>2.529</td>
<td>2.627</td>
<td>0.198</td>
<td>2.529</td>
<td>2.627</td>
<td>291</td>
<td>0.138</td>
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<tr>
<td>16.157</td>
<td>2.667</td>
<td>6.903</td>
<td>0.536</td>
<td>6.941</td>
<td>22.725</td>
<td>490</td>
<td>0.950</td>
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<tr>
<td>16.182</td>
<td>2.824</td>
<td>7.010</td>
<td>0.614</td>
<td>5.863</td>
<td>17.373</td>
<td>400</td>
<td>0.616</td>
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<tr>
<td>2.852</td>
<td>2.038</td>
<td>8.098</td>
<td>0.154</td>
<td>1.627</td>
<td>6.314</td>
<td>704</td>
<td>0.471</td>
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<tr>
<td>5.059</td>
<td>2.745</td>
<td>6.363</td>
<td>0.208</td>
<td>1.392</td>
<td>7.176</td>
<td>981</td>
<td>0.561</td>
</tr>
</tbody>
</table>
Evolving From Less Mature to More Mature C2 Approaches

**L1 Conflicted C2 Approach**

- **Low node centrality**
- **Low node embeddedness**
- Constrained/Low **network activity**
- Geodesic **path lengths**
- Lowest **network diameter**
- **Low inclusiveness**
- High **clustering coefficient**
- Reduced **connectedness**
- Poor **network structural cohesion**

In 2 out of 3 runs, **one team solves its own problem space**

**Very Low** organisational success (mean value = 31%)
Evolving From Less Mature to More Mature C2 Approaches

L2 Deconflicted C2 Approach

High node centrality
Highest node embeddedness
Enlarged/Medium network activity
Largest path lengths
Widest network diameter
No inclusiveness
Reduced clustering coefficient
High connectedness
High network structural cohesion

In 3 out of 4 runs, two teams solve their own problem spaces
Low organisational success (mean value = 44%)
Evolving From Less Mature to More Mature C2 Approaches

**L3 Coordinated C2 Approach**

- Highest **node centrality**
- High **node embeddedness**
- Medium **network activity**
- Large **path lengths**
- Wide **network diameter**
- No **inclusiveness**
- Highest **clustering coefficient**
- High **connectedness**
- Medium **network structural cohesion**

In 3 out of 4 runs, the Coordinator solved at most one problem face.

**Very Low** organisational success (mean value = 34%)
Evolving From Less Mature to More Mature C2 Approaches

L4 Collaborative C2 Approach

- Low node centrality
- Low node embeddedness
- High network activity
- Smallest path lengths
- Small network diameter
- Highest inclusiveness
- Lowest clustering coefficient
- Highest connectedness
- Low network structural cohesion

In 3 out of 4 runs, three teams solve their own problem spaces or the Facilitator solves three problem spaces. 

High organisational success (mean value = 80%)
Evolving From Less Mature to More Mature C2 Approaches

L5 Edge C2 Approach

Medium **node centrality**
Medium **node embeddedness**
Highest **network activity**
Small **path lengths**
Large **network diameter**
Medium **inclusiveness**
Low **clustering coefficient**
High **connectedness**
Highest **network structural cohesion**

Ds plurality in 3 out of 4 problem spaces are correct
**Moderate** organisational success (mean value = 61%)
SNA is successful in displaying organisational networking.

The power of knowing the network enables the opportunity to actively manage it or knit it.

SNA is a tool to build creative organisations, based upon interaction dynamics and collaboration facilities, so as to deliver enhanced performance and achieve success.
Thank You for Your Attention :::

Questions?