Social Networks & Network Structures

Paul H. Deitz, Ph.D., Director (A)
U.S. Army Research Laboratory
Human Research & Engineering Directorate
ATTN: AMSRD-ARL-HR
Aberdeen Proving Ground, MD 21005-5425

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# Social Networks & Network Structures

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See also ADM002075., The original document contains color images.
Social Network Analysis (SNA) is the collection, mapping and measurement of relationships and flows among persons, groups, organizations, technologies or other information processing entities.
What is a social network?

**Nodes** (●)
- People
- Units of action
- Coalition partners
- Departments
- Resources, assets
- Ideas, Skills, or Assertions
- Events
- Nation-states
- Computer Servers

**Relations Between Nodes** (→)
- Who do you like or respect?
- Transfer of resources, information, money
- Authority lines
- Association or affiliation
- Alliance
- Alternative resource
Sampling of Empirical Topics

- Workflow and hierarchy
- Network organizations (adaptable organizational designs)
- Actor (human node) similarity
- Physical and temporal proximity
- Personality
- Attitude similarity
- Job satisfaction and commitment
- Turnover
- Power, influence and leadership
- Job acquisition and promotion
- Social capital
- Individual and group performance
- Conflict and unethical behavior
- Creativity and innovation
- Diffusion of information and innovation
- Knowledge management
- Wealth distribution
- Epidemics
- Terrorist networks
- Scale-free networks/power laws
- Internet
## Individual network position

<table>
<thead>
<tr>
<th>Degree Centrality</th>
<th>High Betweenness</th>
<th>Cognitive Demand</th>
<th>Task exclusivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>in the know</td>
<td>connects groups</td>
<td>emergent leader</td>
<td>critical ability</td>
</tr>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
<td><img src="image4.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eigenvector</th>
<th>Closeness</th>
<th>Resource exclusivity</th>
<th>Knowledge exclusivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>central core</td>
<td>shortest paths</td>
<td>mobilize resources</td>
<td>Mobilize info</td>
</tr>
<tr>
<td><img src="image5.png" alt="Graph" /></td>
<td><img src="image6.png" alt="Graph" /></td>
<td><img src="image7.png" alt="Graph" /></td>
<td><img src="image8.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

- **Person with high measure value**
- **Task**
- **Resource**
- **Knowledge**
Who to target (vulnerabilities)

• **Centralities (Communication)**
  – Degree – most connected
  – Betweenness – most paths

• **Exclusivities (Expertise)**
  – Knowledge – special expertise
  – Task – special experience

• **Demands/Loads (Role)**
  – Cognitive demand – emergent leader
  – Workload
  – High Shared Situation Awareness
Recent Research in Command & Control

• Latent Semantic Analysis
  – Team communication
  – Emergent team dynamics
  – Shared situation awareness

• Dynamic Network Analysis
  – Organizational structure
  – Shared situation awareness
  – Organizational performance
Social Networks
Research Challenges

• Large-scale networks
  – Experiments
  – Measures
  – Modeling and analysis
    • Dynamics
    • Incomplete, incorrect data

• Topology
  – Relationship between architecture and function/behavior
  – Organizational design

• Process/Dynamics
  – Network formation and change
  – Information propagation/processing
  – Robustness and security

• Real-time Feedback
  – Dynamic decision-making
  – Self-adaptation

Network Structures
Chains versus Networks

Chain
Too brittle, simple pattern, simple control, scaled
“business end” most poorly connected, hard to reconfigure or change flow

Network
Very robust, complex pattern, complex control, scale free
“business end” best connected, natural to reconfigure or change flow
A Network Framework
The FCS BCT Integrates With Army Enterprise System Into the GIG
a-MIND™§ - Automated Mission Relevant Situational Awareness

Operational Architecture

Applications Layer

Services Layer

Transport Layer

a-MIND Technology automates dependency understanding enabling analysis of Mission Impact of Infostructure Disruptions

§ Mission Impact Management (MIM) Solution a Product of Northrop Grumman-Patent Pending
Missions and Means Framework

- A way to reason about forces, materiel, and other resources in context of operational missions, their purposes, and desired end states
- Builds on standard best practices (e.g., MDMP, METL Development)
- Explicitly links requirements and solutions
End
Missions and Means Framework vice DoD

Architecture Framework Products:

**MMF Levels**

- **Level 7:** Purpose Mission OV-1 AV-1
  The **Why** and **Wherefore** An assignment with a purpose that indicates the action to be taken. **What** the required outcomes are and “who” has been assigned them

- **Level 6:** Environment Context AV-1
  Under what **Circumstances** a mission is to be accomplished

- **Level 5:** Index Location/Time OV-1 AV-1
  Where (geo-spatial) and **When** with what TPFDD execution matrix

- **Level 4:** Tasks Operations OV-5
  Task-based, outcome-centric specification of Operations that provide the Means to accomplish the Mission. **Objective:** Organize Task outcomes, Evaluate Mission Effectiveness

- **Level 3:** Functions Capabilities OV-5 SV-11
  Function-based, performance-centric **How Well** specifications of Capabilities.

- **Level 2:** Components Forces OV-2 OV-3 OV-4 All SV
  Component-based, state-centric specifications of the Forces that provide the Means. Network of Units, Personnel, and Equipment. Physical and Logical networking

- **Level 1:** Interactions Effects OV-6a,OV-6b,OV-6c,OV-7 SV-10a,SV-10b,SV-10c
  Interaction-based, Phenomena-centric Specification of Effects of Operations on Forces
Missions and Means Framework vice DoD Architecture Framework Products: MMF Operators

- **Level 7:** **Purpose** Mission OV-1 AV-1
  The *Why* and *Wherefore*. An assignment with a purpose that indicates the action to be taken. *What* the required outcomes are and *Who* has been assigned them

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  Under what *Circumstances* a mission is to be accomplished.

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Developed by Jim Watkins, Applied Research Laboratories, The University of Texas
Social Networks
Some Common Network Properties

• Individual Network Position
  – Centrality
  – Structural hole
  – Strong vs. Weak ties

• Topology
  – Experimental
    • Circle, Star, Chain, Y
  – Real Organization
    • Hierarchy, Network organization
Human Dimension: Connections to the Broader Community

- Collaboration with Army Partners
- Stress Effects
- High Speed Computing
- University & Industry Partners
- In-house Acceleration
- Customer Transition
- Business Link
- Basic Science Transition
- International
- Scientific Forum

- Strategic Research Objective (SRO): Enhancing Soldier Performance
- MURI: Optimizing Cognitive Readiness under Combat
- Cooperative R&D Agreements
  - MINDSS program & University of Maryland
- Collaborative Technology Alliances
  - Advanced Decision Architectures & Robotics – New ITA
- Director’s Research Initiative (DRI)
- Customer Funding
  - Survivability, Lethality, and Analysis Directorate, Recognition-Primed Decision Making Modeling
- Small Business Innovative Research (SBIR) contracts
- Advanced Technology Objectives
- NATO panel on Human Beh Rep; DEAs; TTCPs
- Conference on Behavior Rep in M&S (BRIMS)
Dynamic Network Analysis: Interacting Dynamic Networks

Multi-mode

Multi-plex

People

Resources

Knowledge

Teams

Organizations

Locations

Tasks
DyNetML
Extensible Meta-Matrix Ontology (multi-mode, multi-plex, multi-timeperiod)

Multi-level Analysis
Battle Command Group
CPOF Analysis of the Network-Centric Organization

1st Cavalry Division (Field)

UEx (Laboratory)
Exposing Network-Centric Social Structure

Communication Network

Central Personnel

Low Contributors

Boundary Spanners
Shared Situational Awareness

• Important to maintain a common understanding of the situation
  – Rapidly changing environment; uncertainty
  – Decentralized, distributed and interdependent units
  – Joint and coalition operations
  – Combat and non-combat responsibilities

• Shared SA was measured by similarity in perceived risk to the operation.
Unit Level - High Shared SA
Takeaway

• Social Context matters
  – Networks enable and constrain behavior/decisions
    • Who you talk to
    • What tasks you perform
  – SA and SSA are dynamic
    • Environmental/Organizational stress

• Integrating SA research (cellular and social)
  – How is SA developed for a variety contexts?
    • Multi-tasking
    • Operational requirements
  – How does SA develop dynamically?

• Application
  – Training requirements
  – Information technology requirements
LSA

Essentials of Latent Semantic Analysis
Communication Analysis

• Goal: Automatically monitor and analyze communication streams to better understand team performance and process

• Improve collaboration within and between organizations and cultures

• Approach
  – Provide tools to monitor communication content and patterns of interaction
  – Automatically relate communication analysis measures to:
    • Performance
    • Situation Awareness
    • Consensus
    • Shared Interest
    • etc.
Coalition Metrics

• Contributions
  – Participation
  – Amount of content

• Communication network
  – Social network analysis: Who’s talking to whom
  – Changes over time in communication patterns

• Shared interest
  – Similarity between team members’ comments
  – Are members of other groups discussing the same things as your group

• Topical consensus
  – Is everyone discussing the same or different things
  – Evidence of “groupthink”
Participation Analysis: Email, Chat & VOIP

<table>
<thead>
<tr>
<th></th>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Messages</td>
<td>3187</td>
<td>4499</td>
</tr>
</tbody>
</table>

More communication in collaborative technology assisted Run 2.

<table>
<thead>
<tr>
<th></th>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTF Comd</td>
<td>80%</td>
<td>66%</td>
</tr>
<tr>
<td>CTF Deputy Comd</td>
<td>20%</td>
<td>34%</td>
</tr>
</tbody>
</table>

CTF commander did not delegate to his deputy in Run 1, but in Run 2 the CTF commander used his deputy to help coordinate planning.

<table>
<thead>
<tr>
<th></th>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bde 1 Comd</td>
<td>62%</td>
<td>78%</td>
</tr>
<tr>
<td>Bde 2 Comd</td>
<td>38%</td>
<td>22%</td>
</tr>
</tbody>
</table>

Bde 1 Commander was more active than Bde 2 Commander in both runs.
Team Viz: Contributions

Click Week to view by week, Day to view by day or Hour to view by hour.

Hovering the mouse over a message will display a summary of the message.

The length of the message line indicates how much content is in the message with longer lines indicating more content.

Each player has a vertical line. Each message is shown as a horizontal line.

Bde2: ART 5.3.1.2.2 Construct Crew-Served Weapon Fighting Positions 5-21.
Bde 1 commander is an active participant in CTF planning.

TeamViz makes it clear that Bde 2 commander is not participating, and fails to respond to the CTF commander’s requests.
Immediately following the CTF commander's briefing communication traffic increases showing that players are busy executing orders.
How to Influence

- For the target
  - Who are they connected to
  - What groups are they in
  - What do they know
  - What resources do they control
  - What activities are they involved in

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Score</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacts with</td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>Knowledge areas</td>
<td>10</td>
<td>High</td>
</tr>
<tr>
<td>Resource areas</td>
<td>7</td>
<td>High</td>
</tr>
<tr>
<td>Organizations associated with</td>
<td>17</td>
<td>High</td>
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<tr>
<td>Density of ego net</td>
<td>.097</td>
<td>High</td>
</tr>
<tr>
<td>Task exclusivity</td>
<td>.0226</td>
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<tr>
<td>Resource exclusivity</td>
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<td>Knowledge exclusivity</td>
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<td>Degree Centrality</td>
<td>.017</td>
<td>Norm</td>
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<tr>
<td>Betweenness</td>
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</tr>
<tr>
<td>Cognitive Demand</td>
<td>.033</td>
<td>High</td>
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<tr>
<td>Eigenvector Centrality</td>
<td>.001</td>
<td>Low</td>
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