MTML Models to Study theEmergence of Networks

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Graduate School of Library & Information Science
Director, Age of Networks Initiative, Center for Advanced Study
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WHY DO WE CREATE, MAINTAIN, DISSOLVE, AND RECONSTITUTE OUR COMMUNICATION AND KNOWLEDGE NETWORKS?
Social Drivers: Why do we create and sustain networks?

- Theories of self-interest
- Theories of social and resource exchange
- Theories of mutual interest and collective action
- Theories of contagion
- Theories of balance
- Theories of homophily
- Theories of proximity
- Theories of co-evolution

Sources:
“Structural signatures” of MTML

Theories of Self interest
Theories of Exchange
Theories of Balance

Theories of Collective Action
Theories of Homophily
Theories of Cognition
What Have We Learned These Network Mechanisms?

- Research typically looks at only one of these mechanisms, but when they look at multiple mechanisms ....

- ... there is variation in the set of theoretical mechanisms that explain network emergence in different contexts.
A contextual “meta-theory” of social drivers for creating and sustaining communities

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<th>Mobilizing</th>
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**Core Research**

Social Drivers for Creating & Sustaining Communities
## Contextualizing Goals of Communities

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Challenges of empirically testing, extending, and exploring theories about networks … until now
Enter: Cyberinfrastructure & Web 2.0

The Atkins Report

Revolutionizing Science and Engineering through Cyberinfrastructure:

Report of the National Science Foundation Advisory Panel on Cyberinfrastructure

February 3, 2003

Daniel E. Atkins, Chair, University of Michigan
Kelvin K. Droegemeier, University of Oklahoma
Stuart I. Feldman, IBM
Hector Garcia-Molina, Stanford University
Michael L. Klein, University of Pennsylvania
David G. Messerschmitt, University of California at Berkeley
Paul Messina, California Institute of Technology
Jeremiah P. Ostriker, Princeton University
Margaret H. Wright, New York University

http://www.communitytechnology.org/nsf_ci_report/
Science and Engineering Cyberinfrastructures
Multidimensional Networks in CI (Cyberinfrastructure)
Multiple Types of Nodes and Multiple Types of Relationships
CLEANER Community: A multidimensional network

David Streamflow Analyst

CHATS WITH

Annie

Mary

EXPERT IN

AFFILIATED WITH

NCSA

watersheds

C-U County Hydrologic Dataset

Searches for Keyword

Contains as Keyword

Hydrologic Information System Status Report

AUTHOR OF

DOWNLOADS

Streamflow Analyst

USES

HUDSON RIVER Hydro DATA

Contains as Keyword

Hydrologic Information System Status Report
It's all about “Relational Metadata”

- Technologies that “capture” communities’ relational meta-data (Pingback and trackback in interblog networks, blogrolls, data provenance)

- Technologies to “tag” communities’ relational metadata (from Dublin Core taxonomies to folksonomies (‘wisdom of crowds’) like
  - Tagging pictures (Flickr)
  - Social bookmarking (del.icio.us, LookupThis, BlinkList)
  - Social citations (CiteULike.org)
  - Social libraries (discogs.com, LibraryThing.com)
  - Social shopping (SwagRoll, Kaboodle, thethingsiwant.com)
  - Social networks (FOAF, XFN, MySpace, Facebook)

- Technologies to “manifest” communities’ relational metadata (Tagclouds, Recommender systems, Rating/Reputation systems, ISI’s HistCite, Network Visualization systems)
MTML meets Web 2.0 (XML?)

- Theorizing the creation, maintenance, dissolution and reconstitution (CMDR) of network linkages between not just people ….. but also sensors, data sets(streams), documents, and visual-analytic tools

- Testing theoretical propositions about existing network configurations using unprecedented digital trace data

- Developing network recommender systems to assist members’ navigation of multidimensional networks

- Testing theoretical propositions about potential network reconfigurations by assessing members’ use (or non-use) of network recommendations.
1. Develop a meta-theory for the dynamics of networks (MTML)

2. Develop agent-based computational models to assess and evaluate alternative trajectories of network dynamics (Repast/Blanche)

3. Collect/capture longitudinal empirical network data (Crawdad/D2K/Automap)

4. Deploying Web 2.0 and Cyberinfrastructure to enable and investigate networks (CI-IKNOW)

5. Statistical methods to empirically validate networks dynamics predicted by agent based models based on MTML theories (p*/ERGM techniques using MCMC methods)

Generative mechanisms

Design of Web 2.0/Cyberinfrastructure

Model predictions of networks

Multi-level hypotheses and concepts to be measured

Web-based surveys, usage logs, text-mining, and web-crawling tools to capture network dynamics

Iterative refinements to theories about network dynamics

FRAMEWORK FOR MODELING SOCIAL NETWORK DYNAMICS
Examples

- Santa Barbara Digital Transitions Forum
- Inter-organizational Network in response to Katrina
- Tobacco Informatics Grid – TobIG: The case for smokeless tobacco
- CI-Scope: Mapping Science of Cyberinfrastructure
Digital Harvesting of Relational Metadata

- Bios, titles & descriptions
- Personal Web sites
- Google search results
- Web of Science Citation

CATPAC
UBERLINK

CI-KNOW Analyses and Visualizations

Text-mining Tools I

CRAWDAD

Steve Corman
Arizona State University, Crawdad Technologies

http://www.crawdadtech.com

CATPAC

http://www.galileoco.com/

Joseph Woelfel
University at Buffalo
Text-mining Tools II

Kathleen Carley
CASOS at Carnegie Mellon University

http://casos.isri.cmu.edu

Jana Diesner

D2K

Loretta Auvil
NCSA at University of Illinois at Urbana-Champaign

http://alg.ncsa.uiuc.edu/do/tools/d2k
Web-crawling tools

Richard Rogers
Govcom.org Foundation

http://www.issuecrawler.net/

Robert Ackland
VOSON at Australian National University

http://voson.anu.edu.au/
Data-sources for 29 forum panelist and speakers

- Speaker short bios
- Speaker article titles and/or full text of company descriptions
- Speaker personal website URLs
- Top-10 pages from Google for each of the speakers
- ISI-Web of Science citation data for speakers who are cited (N=14)
Santa Barbara Digital Transitions Demo
CRAWDAD Speakers by Keywords multidimensional network

- Policy & Pol. Sci.
- Sociology
- Core keywords
- Business
- Open Source
- Computer science
- Organizational
- Academia
- Business & Gurus
- CS
- Keyword
### CRAWDAD: Speakers sharing the same keywords

Common choices are highlighted in grey.

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<th>J.D. Lasica</th>
<th>Howard Rheingold</th>
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<th>Lance Bennett</th>
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Projects Investigating Social Drivers for Communities

Science Applications
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Hurricane Katrina 2005

Formed: Aug 23, 2005
Dissipated: Aug 31, 2005
Highest wind: 175 mph
Lowest press: 902 mbar
Damages: $81.2 Billion
Fatalities: >1,836
Areas affected: Bahamas, South Florida, Cuba, Louisiana (especially Greater New Orleans), Mississippi, Alabama, Florida Panhandle, most of eastern North America

Map source: http://hurricane.csc.noaa.gov/
Data and picture source: http://en.wikipedia.org/wiki/Hurricane_Katrina/
SITREP Content

- Basic Format / Information
  1. Situation (What, Where, and When)
  2. Action in Progress
  3. Action Planned
  4. Probable Support Requirements and/or Support Available
  5. Other items
*Colorado Division of Emergency Management  
SITUATION REPORT 2005-6  
(Hurricane Katrina)  
August 30, 2005*

*Event Type:* Hurricane Response

*Situation:* On August 29, Hurricane Katrina hit the gulf coast east of New Orleans. It was considered a Category 5 Hurricane, which brings winds of over 155mph and storm surge of 18 feet above normal. Massive property damage has occurred and undetermined number of deaths and injuries.

Colorado response to date include two deployments:
- Two members from the Division of Emergency Management to the Louisiana EOC, departed on August 29.

*Weather Report:* Katrina is moving toward the north-northeast near 18 mph. A turn toward the northeast and a faster forward speed is expected during the next 24 hours. This motion should bring the cent

*Agencies Involved:* Colorado Department of Military and Veteran Affairs, Department of Local Affairs, Division of Emergency Management, Governor's Office.*

*Additional Assistance Requested:* Type III teams, consisting of Operations, Plans, and Logistics personnel (two individuals for each area). These teams could deploy to Alabama, Louisiana, and/or Mississippi. Teams will be at either working the State or Parish/County EOCs.
Human Coding Procedure

- Using an HTML editor to mark entities (people, organizations, locations, concepts)
  - as bold and include a unique HTML tag
  - `<b><a name="F10005505a00003">FEMA</a></b>`
Automatic Coding

- D2K – The Data to Knowledge application environment is a rapid, flexible data mining and machine learning system
- Automated processing is done through creating itineraries that combine processing modules into a workflow
- Developed by the Automated Learning Group at NCSA
Compare Human & Automated coding

SITREPS

D2K
- People List
- Location List
- Organization List

Human
- Organization List

Compare
- Organizations D2K Only
- Organizations Common
- Organizations Human Only
Emergency Multi-Organizational Networks (EMONs)

- Links are created by nodes being named within 50 words of each other in a SITREP
- Human coders in our project have not yet coded links between nodes
- Visualizations are of initial analysis
Time Slice 1: 8/23 to 8/25/2005

Florida is the Topic of the Conversation

Petroleum Network formed Early
Time Slice 1 to 2
Time Slice 2: 8/26 to 8/27/2005
Time Slice 2 to 3

- Gov Bush
- ARC
- SAL
- FEMA
- TX
- MS
- LA
- NO
- FL
- GA
- Power
- Shelter
- Military
Time Slice 3: 8/28 to 8/29/2005
Time Slice 3 to 4

- TX
- AL Power
- National Guard
- GA
- FEMA
- FL
- NO
- NC
- Army
- S & R
- Power
- Shelter
- ARC
- Military
- FP&L
- Gov Bush
- AL
- MS
- LA
- NC
Time Slice 4: 8/30 to 8/31/2005
Time Slice 5: 9/1 to 9/2/2005
Time Slice 5 to 6
Time Slice 6: 9/3 to 9/4/2005
Change in Network Centrality Rankings

• “American Red Cross” starts in the 200s and moves to the teens
• “FEMA” starts in the 20s, moves to the teens, and ends in the 60s

Crossover where American Red Cross becomes relatively more central than FEMA (Sep 1, 2005)

FEMA drops rank and American Red Cross moves up
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Tobacco Surveillance, Epidemiology, and Evaluation Network (TSEEN)

- National Cancer Institute
- Center for Disease Control’s National Center for Health Statistics (NCHS),
- Center for Disease Control’s Office of Smoking and Health (OSH),
- Agency for Healthcare Research and Quality (AHRQ),
- National Library of Medicine (NLM) and
- Non-government agencies such as the American Legacy Foundation.
Low-tar cigarettes cause more cancer than regular cigarettes …

A pressing need for systems that will help the TSEEN members effectively connect with other individuals, data sets, analytic tools, instruments, sensors, documents, related to key concepts and issues
CI-KNOW: Harvesting the online community’s relational meta-data

**INPUTS**
- Cybercommunity Resources
- Cyberinfrastructure

**PROCESSES**
- Generating a Multi-Dimensional network
- Network Analysis
- Network Maps
- Network Referrals
- Network Diagnostics

**OUTPUTS**
- User activity logs related to cyberinfrastructure
- Users’ Profiles
- Documents
- Collaboration Tools
- Datasets
- Analysis Tools
- Bibliographic DBs
- Personal Websites
- Organizational Websites
- Project Websites
- Patent Databases

**Linking all data together**

1. Algorithms to generate Network Referrals
2. Algorithms to create Network Maps
3. Algorithms to compute Network Diagnostics

**Using Tools to Analyze Datasets**

**Using Chats, Forum**

**Downloading Presentations**

**Organizational Websites**
- Project Websites
- Patent Databases
CI-KNOW: Harvesting the online community’s relational meta-data

**Inputs**
- Cybercommunity Resources
- Cyberinfrastructure Use
- External Resources

**Processes**
- Generating a Multi-dimensional Network

**Outputs**
- Network Maps
- Network Referrals
- Network Diagnostics

**Outputs**
1. What nodes are important for what relations
2. The amount of scanning, absorption, diffusion, robustness, vulnerability in a network

**Inputs**
1. Who to contact for what topic
2. What tools to use for what data
3. What dataset to analyze for what concepts
4. What papers to read for what keywords
TOBIG Demo

MTML based modifications to recommender algorithms

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<tr>
<td>Contagion</td>
<td>Rate of Access Degree Prestige</td>
<td>Rate of Access Degree Prestige</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homophily</td>
<td>Scanning Different on Attribute</td>
<td>Scanning Different on Attribute</td>
<td>Similar on Attribute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity</td>
<td>Geographically Topologically Distant</td>
<td>Geographically Topologically Near</td>
<td>Geographically Topologically Near</td>
<td>Geographically Topologically Near</td>
<td>Geographically Topologically Near</td>
<td>Geographically Topologically Near</td>
</tr>
</tbody>
</table>
CI-Scope:
Mapping the science of cyberinfrastructure

… or are we out of time?
Summary

Research on the dynamics of networks is well poised to make a quantum intellectual leap by leveraging recent advances in:

- Theories about the social motivations for creating, maintaining, dissolving and re-creating social network ties

- Development of cyberinfrastructure/Web 2.0 provide the technological capability to capture relational metadata needed to more effectively understand (and enable) communities.

- Exponential random graph modeling techniques to empirically validate the local structural signatures that explain emergent global network properties
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