A proposal for the analysis of disaster-related network data

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- The purpose of this project is twofold:
 - To revisit datasets difficult to analyze with traditional ERGMs
 - To provide a framework for testing novel modeling ideas proposed by MURI team members
- The datasets provide a diverse array of network sizes and structures
- The networks can be aggregated or disaggregated depending on the needs or constraints of the model
- Some of the datasets are dynamic in nature

WTC Intraorganizational Networks WTC Emergent Multiorganizational Networks Hurricane Katrina Emergent Multiorganizational Networks



- WTC Intraorganizational Networks
- WTC Emergent Multiorganizational Networks (EMONs)
- Hurricane Katrina Emergent Multiorganizational Networks (EMONs)

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Radio Transcripts

- 17 radio transcripts from WTC, Port Authority, Newark responders
 - Divided into partitions
 - Partitions contain transcribed transmissions
 - Transmissions contain identifiers, text
- Used to construct multigraphs of interpersonal communication during WTC event: (i,j) edge corresponds to a transmission from i to j
- Divided into two groups: Specialist and Non-specialist responders
- Vertex attributes: institutionalized coordinator, sex

Modeling Frameworks Initial Application Ideas Contribution

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Police Reports

- 161 police reports filed by Port Authority PD officers participating in WTC response
- For all pairs of individuals named in each report, coded "worked with" and "communicated with" relations
- Data can be treated separately as ego networks or jointly as an aggregate network

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Overview

- Materials on interorganizational interaction were collected from nearly 1,000 newspapers, magazines, electronic publications, field documents, and interviews beginning on September 11, 2001 and completed in March of 2002.
- Coding: attributes of the participant organizations and the types of tasks in which they were involved
- Organizational attributes: type of organization (e.g., non-profit, governmental, etc.) and scale of the organization (e.g., local, state, etc.)
- Functional tasks: 42 functional tasks were identified, such as Building Inspection and Repair, Debris Management, Emergency Coordination, Telecommunications, and Transportation Infrastructure

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- Result: 42 emergent multiorganizational networks (EMONs), in which an (i,j) edge corresponds to an interaction between organization i and organization j
- The 42 EMONs can be aggregated into 12 bigger EMONs according to the 12 emergency support functions in the National Response Plan, or into an aggregate EMON, which comprises 717 organizations.

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Emergency Support Function 4 - Fire - EMON

ESF 4 - Firefighting



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Emergency Support Function 5 - Information and Planning - EMON





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Emergency Support Function 6 - Mass Care - EMON



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World Trade Center Aggregate EMON



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A set of 188 networks, each consisting of the organizations and associated relationships reported in a specific source document, as well as secondary information on the organizations involved.

- Attributes: organizational scale and type (same categories as for the WTC interorganizational data), lineage
- Can be used to study dynamics because one EMON can be constructed for each day covered by the reports
- Can be aggregated into one EMON: highest number of organizations involved at one time = 777; approximately 64% isolates

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Hurricane Katrina Aggregate EMON Evolution



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Hurricane Katrina Aggregate EMON



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Disaster network datasets

Relational Event Framework (Butts, 2008) Relational Event Model Applied to WTC Radio Transcripts New ERG models and estimation methods

Relational Event Framework (Butts, 2008)

- Model for "relational events" = discrete events generated by a social actor ("sender") and directed toward one target ("receiver").
- Assumes that past history creates the context for present action, leading to differential propensities for relational events to occur, as well as affecting which actions are possible
- The likelihood of the set of realized events is a function of the likelihoods of the events that did occur and the likelihoods of the events that could have happened in each instant but did not

Relational Event Framework (Butts, 2008) Relational Event Model Applied to WTC Radio Transcripts New ERG models and estimation methods

Relational Event Framework (cont.)

- Assumes that each potential event has a constant hazard of occurrence given a particular prior event history (piecewise constant latent hazard model)
- Given this, we can posit a rate function λ such that $h(t) = \lambda$ and $S(t) = exp(-\lambda(t t'))$ for an event transpiring at time t following a prior event at time t' < t
- λ is a function of sender, receiver, action type, and exogeneous covariates, and a set of unknown parameters, θ

Relational Event Framework (Butts, 2008) Relational Event Model Applied to WTC Radio Transcripts New ERG models and estimation methods

Relational Event Framework - Rate Function

 $\lambda(s(a), r(a), c(a), X_a, A_t, \theta) = exp[\lambda_0 + \theta^T u(s(a), r(a), c(a), X_a, A_t)]$ where *a* is hypothetical event, *s*, *r*, and *c* are the source, receiver, and event type functions, *X* is a covariate set, and A_t is the past history associated with some time point, *t*

Relational Event Framework (Butts, 2008) Relational Event Model Applied to WTC Radio Transcripts New ERG models and estimation methods

- Only order of events is known
- Effects included: Individual-level heterogeneity, preferential attachment, triadic effects, persistence, recency, conversational norms (participation shifts)
- Cognitive/behavioral effects and local rules are key drivers to dynamic behavior of WTC radio communication networks

Relational Event Framework (Butts, 2008) Relational Event Model Applied to WTC Radio Transcripts New ERG models and estimation methods

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- Hierarchical ERGM (Schweinberger, 2009)
- Dynamic ERGMs (Krivitsky, 2009)
- Bias reduced MPLE (Van Duijn, Gile, and Handcock, 2007)

- Use WTC EMON data, because it can be disaggregated into smaller networks
- Much of the structure in EMONs remains unexplained because ERGMs do not converge in most cases. One possible culprit is the structural heterogeneity of these networks; a hierarchical ERGM that models local, rather than global, dependency may be a good avenue for further analysis

- Extend the analyses of Butts (2007) to the complete set of 17 transcripts from the WTC Radio dataset (initial paper covered only 6)
- Possible computational challenges, since the largest network has 240 nodes
- May have to fit without fixed effects, or condition on the degree of the nodes

- The goal is to identify the mechanisms through which networks are formed, whether they be intraorganizational radio communication networks or interorganizational collaboration networks
- Butts (2007) has shown initial results in terms of relational event evolution, but studying the bigger networks would provide a better understanding of the communicative behavior of respondents during September 11, with clear implications for further planning and allocation of resources