

Extended Structures of Mediation: Re-examining Brokerage in Dynamic Networks

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Outline

- ▶ MURI themes and motivation
- ▶ Network features in a dynamic context
- ▶ Brokerage processes
- ▶ Implications of network dynamics
- ▶ Dynamic measure of brokerage

MURI Themes

- ▶ Theoretical foundation and substantive problems
- ▶ Statistical methods
- ▶ Fast algorithms and new data structures
- ▶ Rich models of large-scale, dynamic data with complex covariates

Motivation

- ▶ Substantive problems \Rightarrow statistical models
- ▶ Statistical models of networks build on basic network concepts: triangles, subgraphs, cliques, etc.
- ▶ These basic network concepts have been traditionally applied in small-scale, static contexts.

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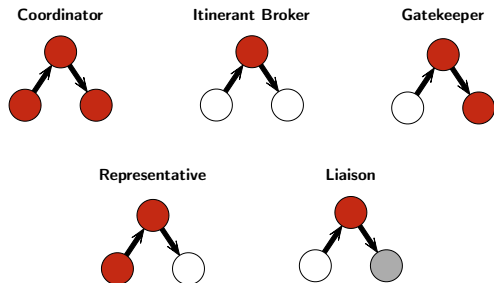
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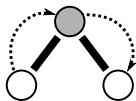
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- ▶ How to transition network ideas into large-scale, dynamic context where we may have a number of different covariates?
- ▶ Re-explore static network concepts and measures that were originally motivated by dynamic processes
- ▶ Today: brokerage

Structural Positions of Brokerage

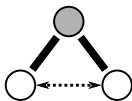
- ▶ Brokerage occurs when one actor serves as a bridge between two other actors who themselves lack a direct connection
- ▶ Gould and Fernandez (1989)



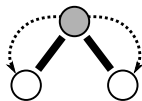
Process Perspective: Brokerage Mechanisms



Transfer



Matchmaking

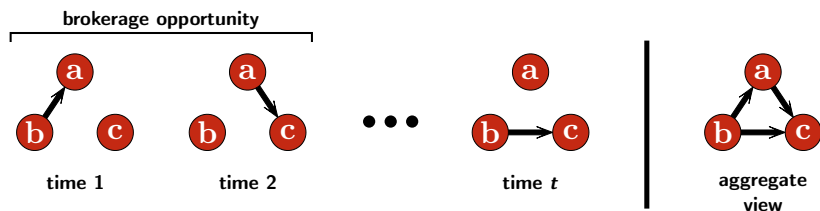


Coordination

Broker generates value by...	Conducting resources from one party to another	Facilitating tie formation between third parties	Allowing third parties to act without creating a direct relationship
Third-party tie is inherently...	Infeasible	Valuable	Costly
Mechanism of mediation	Resource held by first alter is transferred to second	First alter is introduced to or allowed to form tie with second	Dependencies from first alter used to guide second
Effect of brokerage on potential third-party tie	None (direct tie infeasible)	Increased chance of formation	Decreased chance of formation

Brokerage in a Dynamic Setting

- Basic temporal logic – B tied to A , followed by A tied to C , without an intervening tie from B to C – defines the critical necessary condition for performance of brokerage.



More Formally: Dynamic Brokerage

Definition:

In a graph representing a nonsymmetric binary relation R , j is said to be a *dynamic broker* for i and k if and only if

$$(iRj)_t, (jRk)_{t+i}, \text{ and } (i\bar{R}k)_{\forall t':t < t' < t+i}$$

where $(iRj)_t$ indicates that i sends a tie to j at time t by the relation R , and $(i\bar{R}k)_{\forall t':t < t' < t+i}$ is the negation of (iRk) for all t' such that $t < t' < t + i$.

Measure of Dynamic Brokerage

- ▶ Preserve fundamental structural characteristics – incomplete two-path
- ▶ Allow for temporal ordering of two-path edges – do not require simultaneity
- ▶ Repeat opportunities for brokerage within a given triad
- ▶ Avoid false positive errors
- ▶ Easy to compute and flexible to allow for various extensions or restrictions

Exploring Brokerage Behavior

- ▶ How does our measure of dynamic brokerage behave?
- ▶ Does it allow for additional insight into structural patterns in large-scale, dynamic data?
- ▶ Basic network statistics should reveal patterns of interest
- ▶ Case study: brokerage opportunity in disaster response

Case Study: Hurricane Katrina EMON

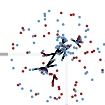
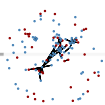
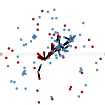
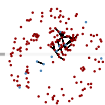
- ▶ EMON (emergent multiorganizational network) of collaboration
- ▶ Data was collected from archival documents produced by the organizations themselves
- ▶ Collaboration relationships are reported daily
- ▶ 13 daily network snapshots
- ▶ Aggregate EMON: 1,577 vertices, 857 edges (undirected), 997 isolates, 26 non-isolate components, and a mean degree around 1

August 23: Tropical Depression 12 forms

August 24:
Tropical Storm
Katrina named

Legend

- First appearance of organization
- Organization appeared previously

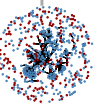
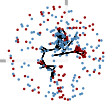
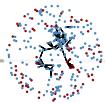
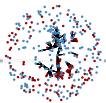
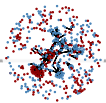


August 25:
Hurricane Katrina
named, FL landfall

August 26

August 27

August 28



September 1

August 31

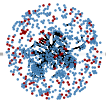
August 30

August 29:
LA landfall



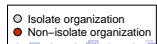
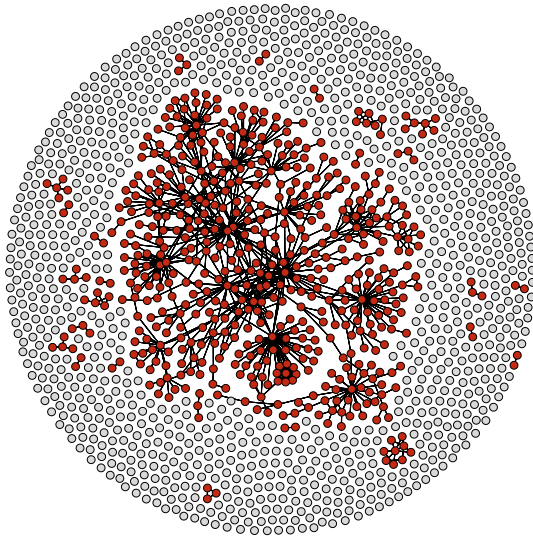
September 3

September 4



September 5





Top Five Brokers - Measure Comparison

Static Brokerage Measure

Organization	Coord.	Itinerant	Gate.	Rep.	Liaison	Total
Colorado DEM	322 ***	240 **	474 ***	474 ***	392 **	1902 **
American Red Cross	20 *	522 ***	168 **	168 **	656 ***	1534 **
Texas SOC	980 ***	4 *	125 **	125 **	6 *	1240 **
U.S. FEMA	146 ***	112 **	214 **	214 **	146 **	832 **
EMA Compact	0	308 **	24 *	24 *	310 **	666 **

Significantly high: *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

Dynamic Brokerage Measure

Organization	Coord.	Itinerant	Gate.	Rep.	Liaison	Total
Texas SOC	2100 ***	279 **	1491 ***	1470 ***	636 **	5976 **
Colorado DEM	496 ***	315 **	713 ***	776 ***	702 **	3002 ***
American Red Cross	99 **	604 **	276 **	321 **	338 **	1638 **
Georgia SOC	523 ***	90 **	422 **	366 **	170 *	1571 **
Alabama EMA, ESF 9	65 **	315 **	265 **	268 **	506 **	1419 **

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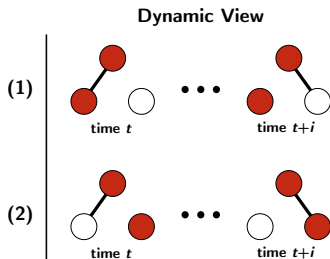
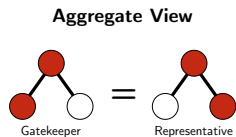
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Gatekeeper/Representative Clarification



Brokerage Consistent Patterns

- ▶ Transfer – time-ordered two-path connecting two alters who previously could not reach each other via a direct tie
- ▶ Matchmaking – a time-ordered two-path followed by a third party tie
- ▶ Coordination – a third party tie may precede the brokerage opportunity, but the added value of the broker permits any subsequent third party tie from existing after the time-ordered two path

Brokerage Consistent Patterns

Organization	Brokerage Consistent Pattern		
	Transfer	Matchmaking	Coordination
Federal	2066	18	3
State	16596*	97	31
Local	30	56*	29*
NGO	2255	154*	30
International	38	8	0
Unknown	102	1	0

Implication of Network Dynamics for Brokerage Processes

- ▶ We can now identify matchmaking mechanisms of brokerage - two-path followed by triadic closure
- ▶ Brokerage scores reflect repeat opportunities for brokerage - each time window is distinct
- ▶ In an undirected network we can now distinguish between gatekeeper and representative brokerage
- ▶ Eliminate falsely identified brokerage opportunities

Insights and Applications

- ▶ Potentially inappropriate to use static network concepts in a dynamic setting
- ▶ New measure of dynamic brokerage with important properties
- ▶ Detecting differences in these statistics is vital for statistical models
- ▶ Incorporating network dynamics allows a distinction between patterns of opportunity or behavior
- ▶ Potential to relate activity patterns to complex covariates

Data produced by MURI team

- ▶ **Improvisation** This dataset consists of human action microevents coded from emergency responder reports from two major disasters in the United States.
- ▶ **Katrina Collaboration Network** This data represents an emergent multi-organizational network (EMON) of collaboration activity among organizations involved in the initial response to Hurricane Katrina in 2005.
- ▶ **WTC Radio Communications** Using archival materials obtained from the Port Authority of New York and New Jersey, this data captures the networks of communication and interaction among responders to the World Trade Center disaster.
- ▶ **Twitter** This dataset consists of a sample of tweets pertaining to hazards and events. It also contains a longitudinal sample of personal networks. It is a large-scale, dynamic social network that involves text, spatial data, and an extensive set of covariates.
- ▶ **Political Blogs** This dynamic network consists of inter- and intra-group blog citations. It captures interactions among all blogs credentialed by the DNC or RNC for their respective 2004 conventions.

Network Data Archives

- ▶ UCI Network Data Repository