Statistical Social Network Analysis of ELICIT Experiments

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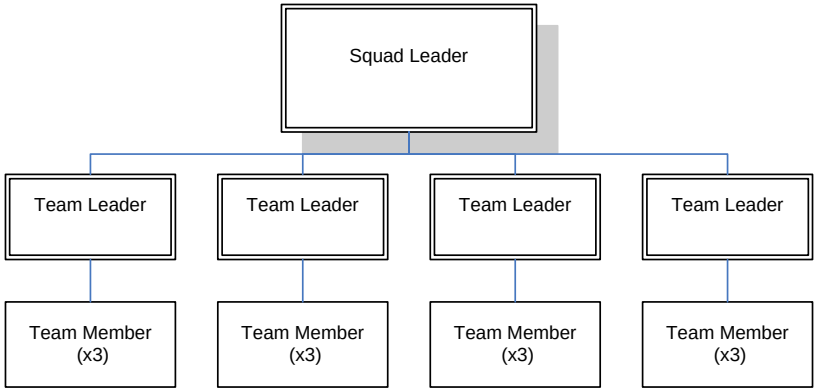
Background: ELICIT

- 34 cadets broken into two teams
- Edge (x17): No formal structure
- Hierarchical (x17): Formal structure imposed



- Information on a terrorist attack (Who What Where When) sprinkled around the networks
- Beliefs & communication data collected over a one hour period

Statistical SNA

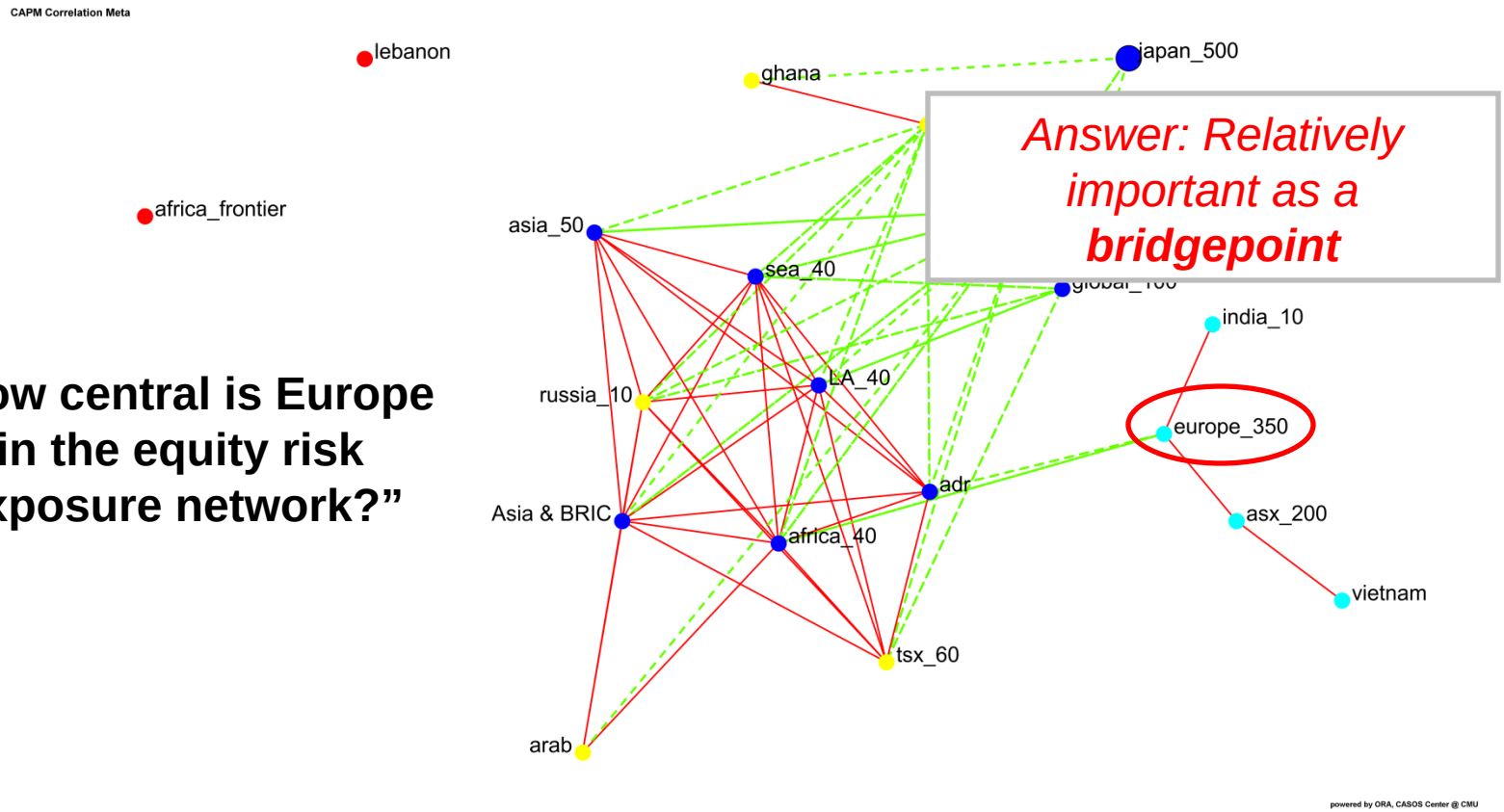
•Traditional SNA's determinism can be restrictive, particularly with longitudinal data

• Statistical SNA models networks as stochastic processes

•Allows us to create robust hypothesis tests

Example: Traditional SNA

“How central is Europe in the equity risk exposure network?”



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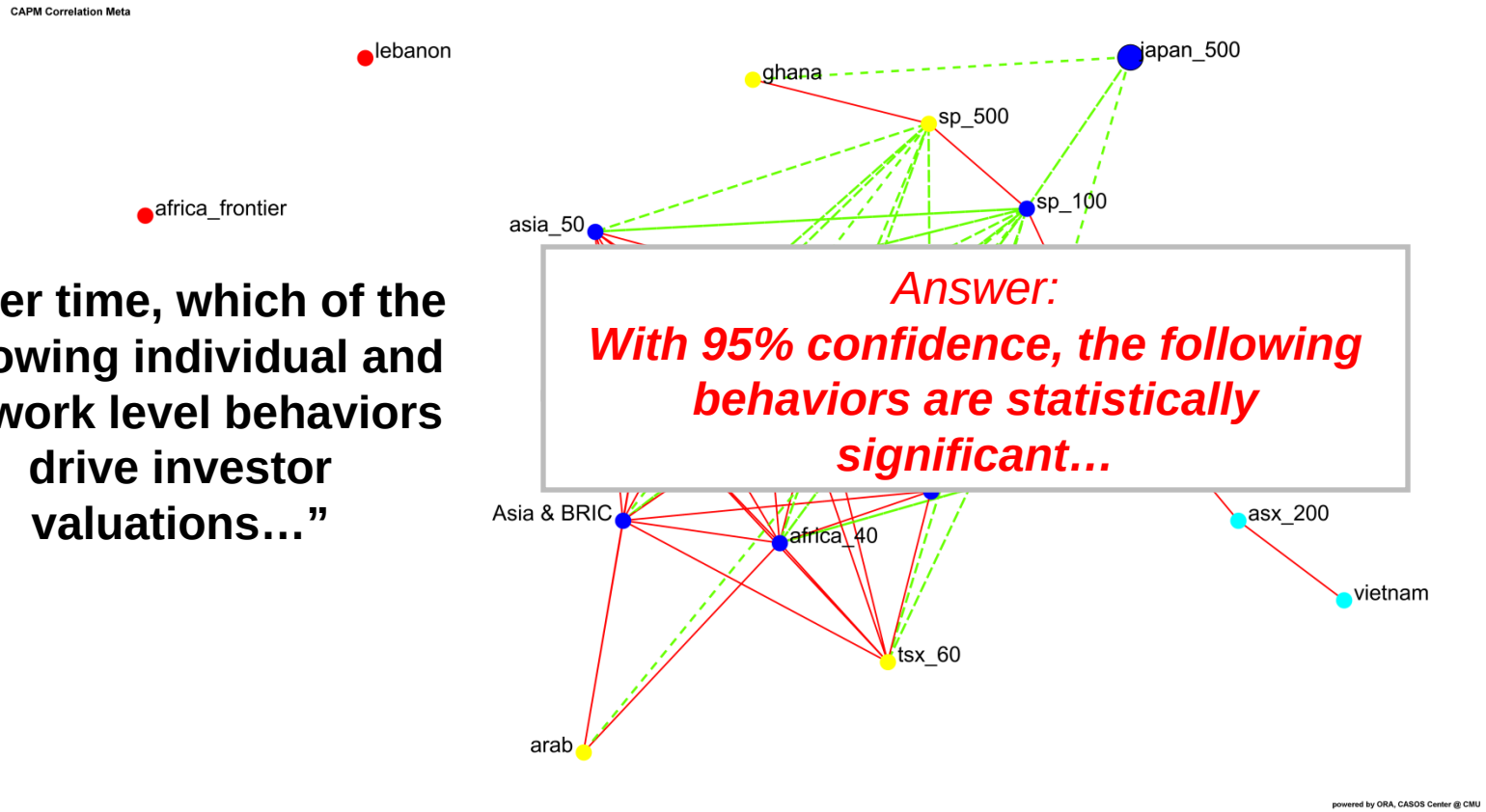
Example: Statistical SNA



"Over time, which of the following individual and network level behaviors drive investor valuations…"

Answer:

With 95% confidence, the following behaviors are statistically significant…

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The Actor Oriented Model

- A statistical Social Network Analysis method that distills networks over time into defined behaviors
- Each actor has an objective function (which we hypothesize) that tells us how he maintains his position in the network
- An estimation procedure produces coefficients for these defined behaviors in the objective function
- **More positive coefficients mean faster rates of transition from one network to the next, indicating which behaviors are statistically and practically important**

Cadets as ELICIT Actors

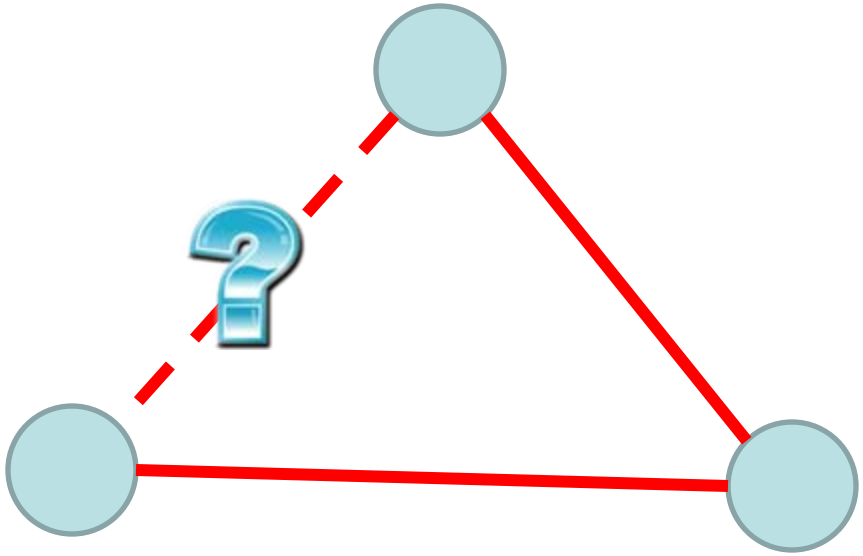
- We **define six behaviors** and test their relevance
- Comparing hierarchical and edge networks through these behaviors tells us how different C2 environments affect actors and organizations
- *Preliminary research questions:*
  - Do leaders communicate with their peers differently than with their subordinates?
  - How does knowledge affect communication choices?
  - Do hierarchies cause anomalous social behavior?

Density: Constraints

How does an additional tie affect an actor's decision to form a tie?

Reciprocity: Back-talk?

Transitivity: Friends of Friends



Location-link effect

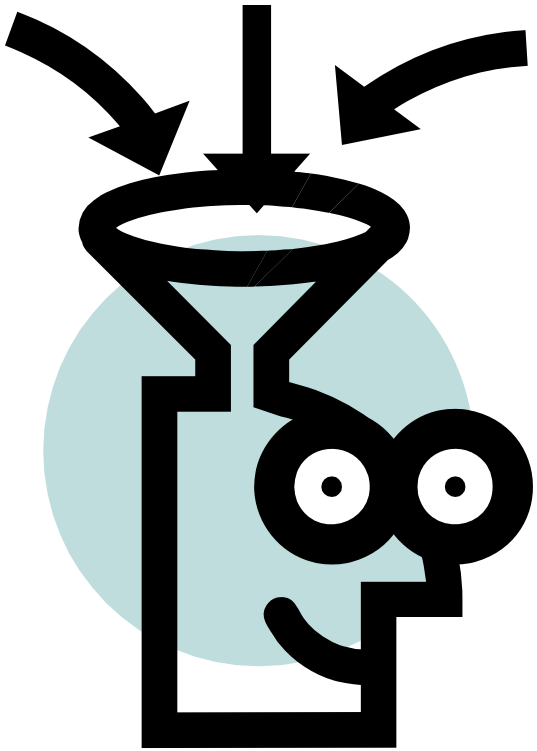
Do people tend to communicate more with those within their own "country" (a proxy for teams within the hierarchy).

Leadership-link effect

Do people tend to communicate more with their leaders (hierarchy only)?

Information effect

Do people tend to communicate with others who have the right information?



The Model

- Each state of the network is **a state** in a continuous time Markov chain
- Each behavior enters into a rate function that determines the *infinitesimal generator*
- Bayesian estimation (MCMC) returns these parameters
- **Parameters tell us what drives actor behavior!**

Results

Effect Parameter	Heirarchical	Edge
Density	-.9976 (.035)	-.3693 (.028)
Transitivity	.2007 (.044)	.2054 (.031)
Reciprocity	.0640 (.36)	.1502 (.070)
Location-link	.2632 (.017)	.0513 (.471)
Leadership-link	.1507 (.023)	
Information	-.1647 (.019)	.2146 (.009)

•Positive numbers make communications increasing that quantity more likely: *i.e.* replacing a non-transitive link with one that involves a transitive triplet increases the rate by +.2 (all else equal)

•Numbers in parentheses are *standard errors* that tell us statistical significance: **rule of thumb: if the coefficient is at least twice the magnitude of the standard error, it is statistically significant**

Future Work

- We have found which sociological theories are applicable to a given empirical network
- We can use the results from SIENA to tune multi-agent simulations like CONSTRUCT so that we can test various scenarios on a given social group
- These various scenarios give us insight into agility, efficiency, and effectiveness of our organizations

Questions?

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Agenda

- Network Science at West Point
- Survey of faculty & cadet research
- Intro to Statistical Social Network Analysis (SSNA)
- Modeling ELICIT under an Actor Oriented Model
- Model estimation and results

Network Science at the United States Military Academy

“A ***network*** may be described as the interaction between two or more entities regardless of domain, or level of abstraction.”

“***Network Science*** is based on the fundamental knowledge derived from diverse network domains, their behavior, and relationships.”

*“*From a Network Science perspective*,* ***the entire universe*** is interwoven in a vast array of network domains.”

“Network Science facilitates the design and development of mechanisms to describe, categorize, and relate seemingly random data into coherent and useful information by way of the ***scientific method***.”

- Dr. Frederick I. Moxley

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Network Science at the
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Timeline

Curricula and center initiated in 2004
First undergraduate course developed in 2005
Network Science Center established in 2007
Proposed interdisciplinary Minor in 2009

Network Science is truly an interdisciplinary field involving several departments at the United States Military Academy

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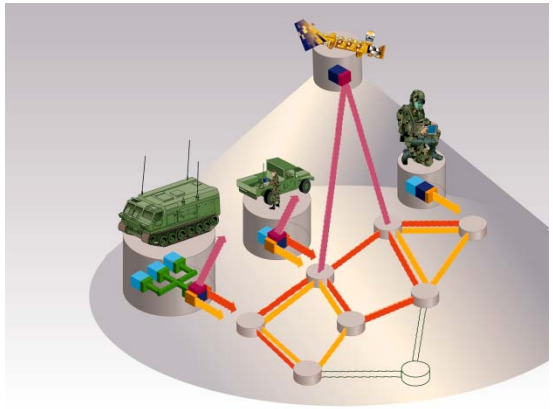
West Point Approach towards Network Science

- Design and develop the tools necessary to discover, assess, integrate, link, interpolate, dynamically compose, assimilate and construct both technical and social relationships across, between and within diverse domain network configurations
- Stimulate cadet interest through new & innovative curricula and research projects
- Verify research via testbed emulation and (limited) field tests



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Results to date

Scores of network oriented Cadet and Faculty research efforts involving a multitude of domain areas that will ultimately benefit the DoD Warfighter!

We are just beginning to reap the rewards
of this new and burgeoning field!