Social Networks: New Paradigms for Modeling, Applications, Computations, and Visualization

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The support is acknowledged with gratefulness.

The Supernetworks Lab

The Supernetworks Lab

A Story About How Social Networks Evolve

- During the Spring/Summer of 2002 Professor Nagurney held the Distinguished Chaired Fulbright/University of Innsbruck Professorship at the Institute of Economic Theory at the Business School, SOWI, at the University of Innsbruck, Austria, where Tina was studying…

Outline of Presentation

- Introduction to social networks
  - History of social network theory
  - Applications
  - Dynamic social network theory
- The framework of supernetworks
- Supernetworks consisting of social networks and economic networks

Definition of Social Networks

- "A social network is a set of actors that may have relationships with one another. Networks can have few or many actors (nodes), and one or more kinds of relations (edges) between pairs of actors." (Hannemann, 2001)

History (based on Freeman, 2000)

- 17th century: Spinoza developed first model
- 1937: J.L. Moreno introduced sociometry; he also invented the sociogramm
- 1948: A. Bavelas founded the group networks laboratory at MIT; he also specified centrality

History (based on Freeman, 2000)

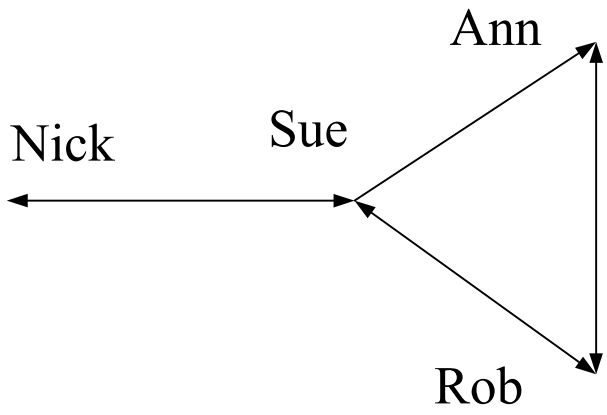
- 1949: A. Rapaport developed a probability based model of information flow.
- 50s and 60s: Distinct research by individual researchers
- 70s: Field of social network analysis emerged.
  - New features in graph theory – more general structural models
  - Better computer power – analysis of complex relational data sets

Representation of Social Networks

- Matrices

	Ann	Rob	Sue	Nick
Ann	---	1	0	0
Rob	1	---	1	0
Sue	1	1	---	1
Nick	0	0	1	---

- Graphs



Graphs - Sociogramms

(based on Hanneman, 2001)

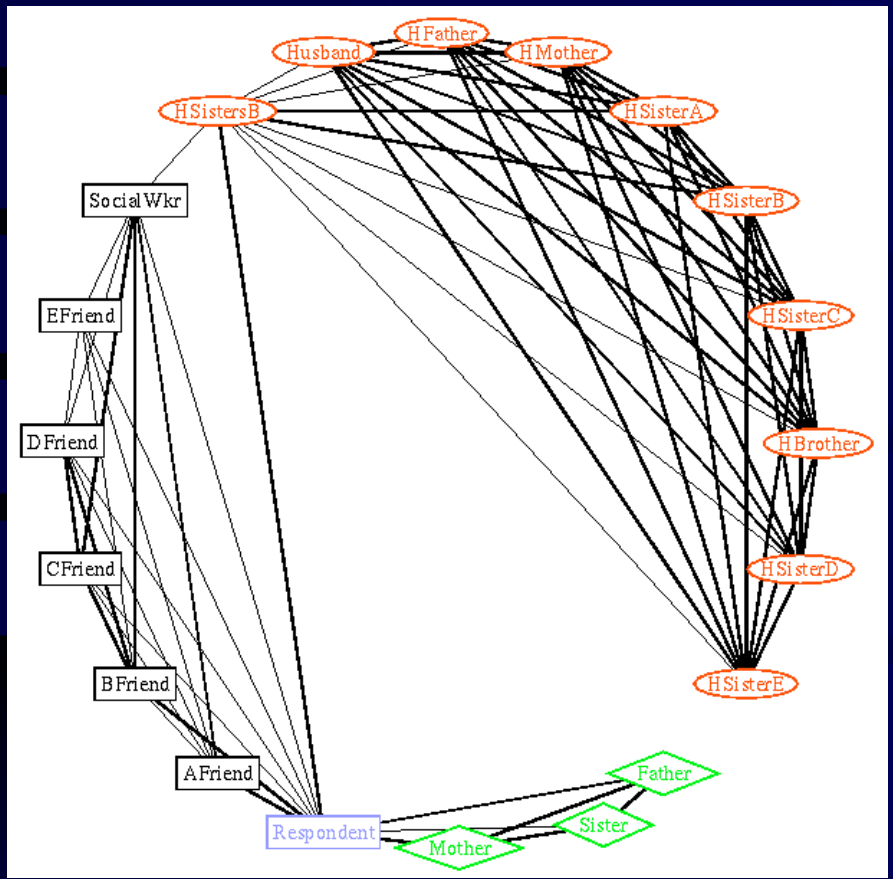
- Labeled circles represent actors
- Line segments represent ties
- Graph may represent one or more types of relations
- Each tie can be directed or show co-occurrence
  - Arrows represent directed ties

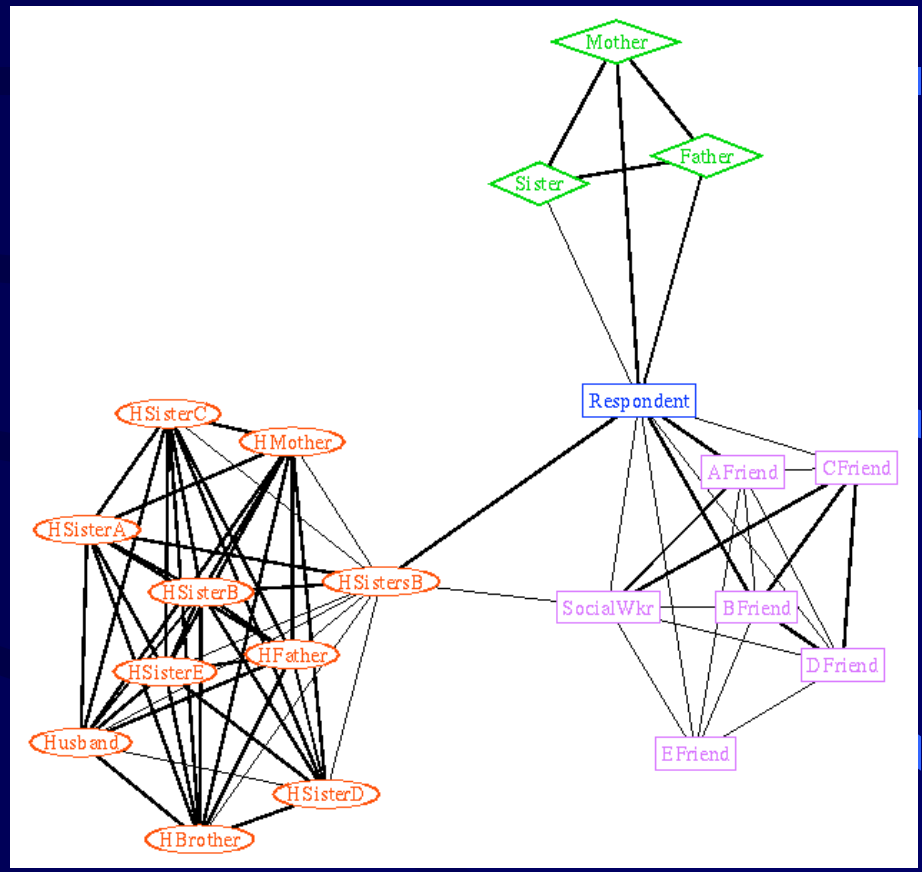
Graphs – Sociogramms 2

(based on Hanneman, 2001)

- Strength of ties:
  - Nominal
  - Signed
  - Ordinal
  - Valued

Visualization Software: Krackplot





Sources: http://www.andrew.cmu.edu/user/krack/krackplot/mitch-circle.html
http://www.andrew.cmu.edu/user/krack/krackplot/mitch-anneal.html

Connections (based on Hanneman, 2001)

- Size
  - Number of nodes
- Density
  - Number of ties that are present/ the amount of ties that could be present
- Out-degree
  - Sum of connections from an actor to others
- In-degree
  - Sum of connections to an actor

Distance (based on Hanneman, 2001)

- Walk
  - A sequence of actors and relations that begins and ends with actors
- Geodesic distance
  - The number of relations in the shortest possible walk from one actor to another
- Maximum flow
  - The amount of different actors in the neighborhood of a source that lead to pathways to a target

Some Measures of Power

(based on Hanneman, 2001)

- Degree
  - Sum of connections from or to an actor
- Closeness centrality
  - Distance of one actor to all others in the network
- Betweenness centrality
  - Number that represents how frequently an actor is between other actors' geodesic paths

Cliques and Social Roles

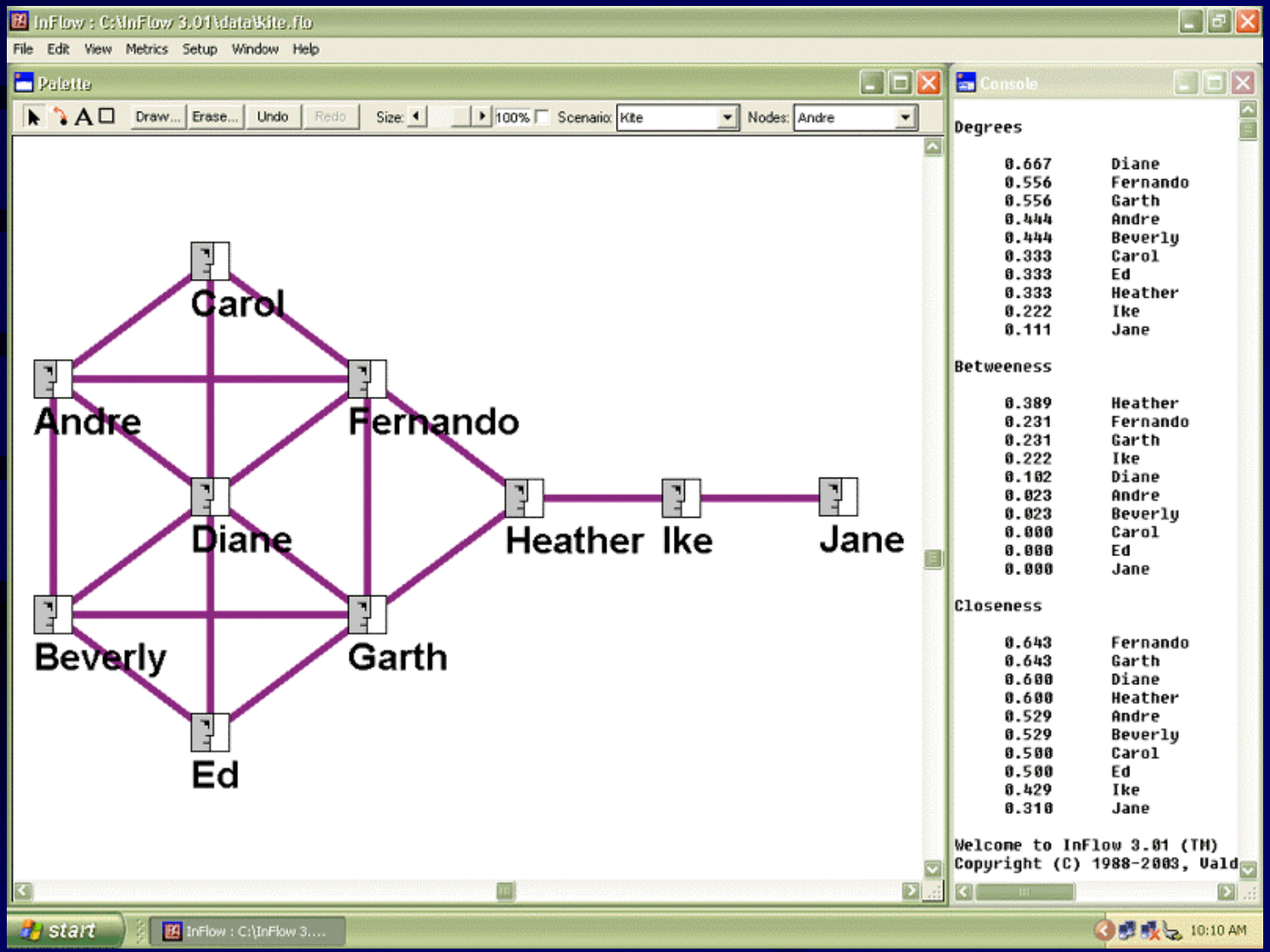
(based on Hanneman, 2001)

- Cliques
  - Sub-set of actors
    - More closely tied to each other than to actors who are not part of the sub-set
- Social roles
  - Defined by regularities in the patterns of relations among actors

Examples of Applications
(based on Freeman, 2000)

- Visualizing networks
- Studying differences of cultures and how they can be changed
- Intra- and interorganizational studies
- Spread of illness, especially HIV

Commercial Application



Source: http://www.orgnet.com/sna.html

Dynamic Networks (based on Carley, 2003)

- Limitations to traditional social network analysis
  - Focused on small bounded networks
    - With 2-3 types of links among one type of nodes
  - At one point of time
  - Close to perfect information

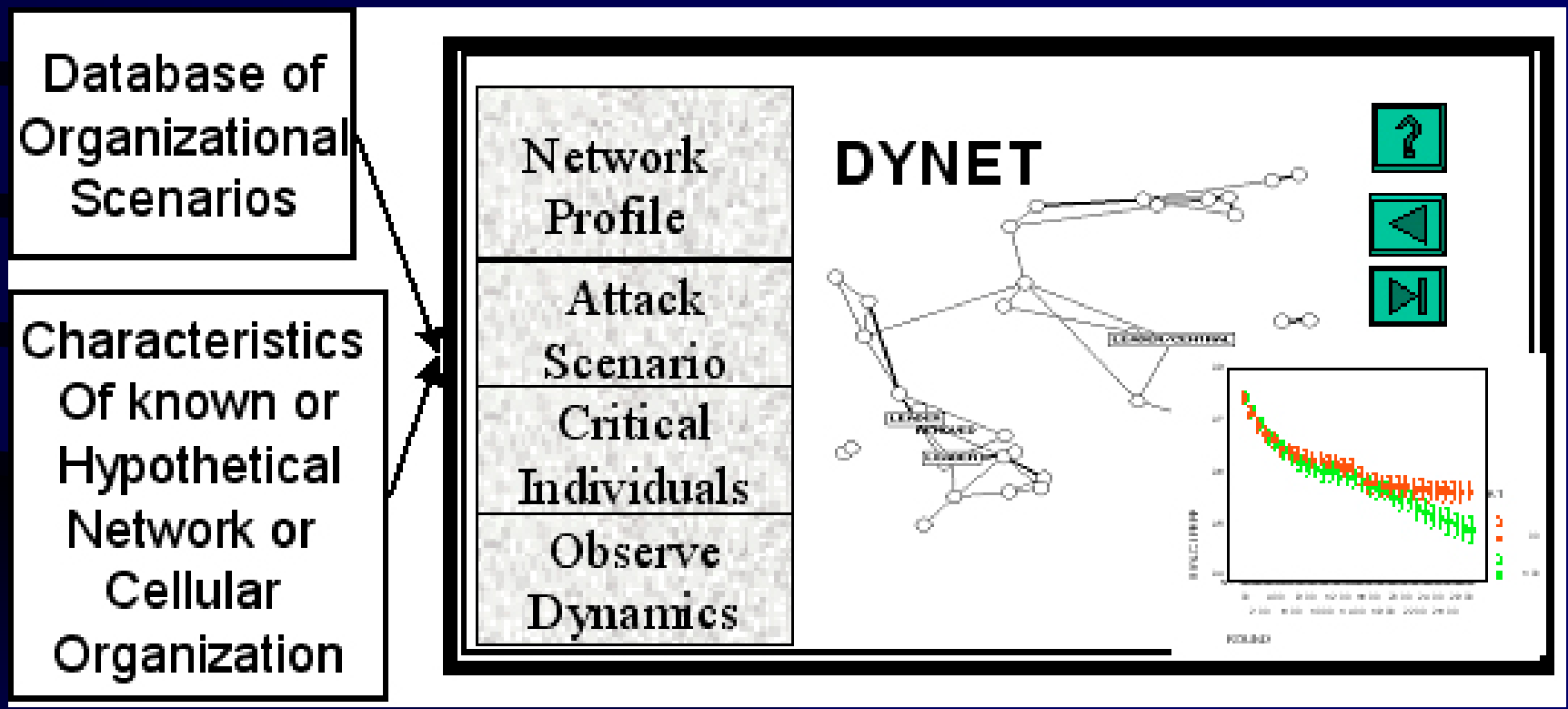
Dynamic Networks (based on Carley, 2003)

- Dynamic networks
  - Meta matrix
  - Treating ties as probabilistic
  - Combining social networks with cognitive science and multi-agent systems
  - Networks and agents co-evolve

Applications of Dynamic Network Analysis (DNA) (based on Carley, 2003)

- The possible effects of biological attacks on cities (BioWar, Carley et al, 2002)
- Evaluation of information security within organizations (ThreatFinder, Carley, 2001)
- Evaluation of how to build stable adaptive networks with high performance and how to destabilize networks (DyNet, Carley et al, 2002)

Dynet



Source: http://www.casos.cs.cmu.edu/projects/DyNet/dynet_info.html

Roles of Social Networks in Economic Transactions

- Examples from Sociology
  - Embeddedness theory
    - Granovetter (1985)
    - Uzzi (1996)
- Examples from Economics
  - Williamson (1983)
  - Joskow (1988)
  - Crawford (1990)
  - Vickers and Waterson (1991)
  - Muthoo (1998)

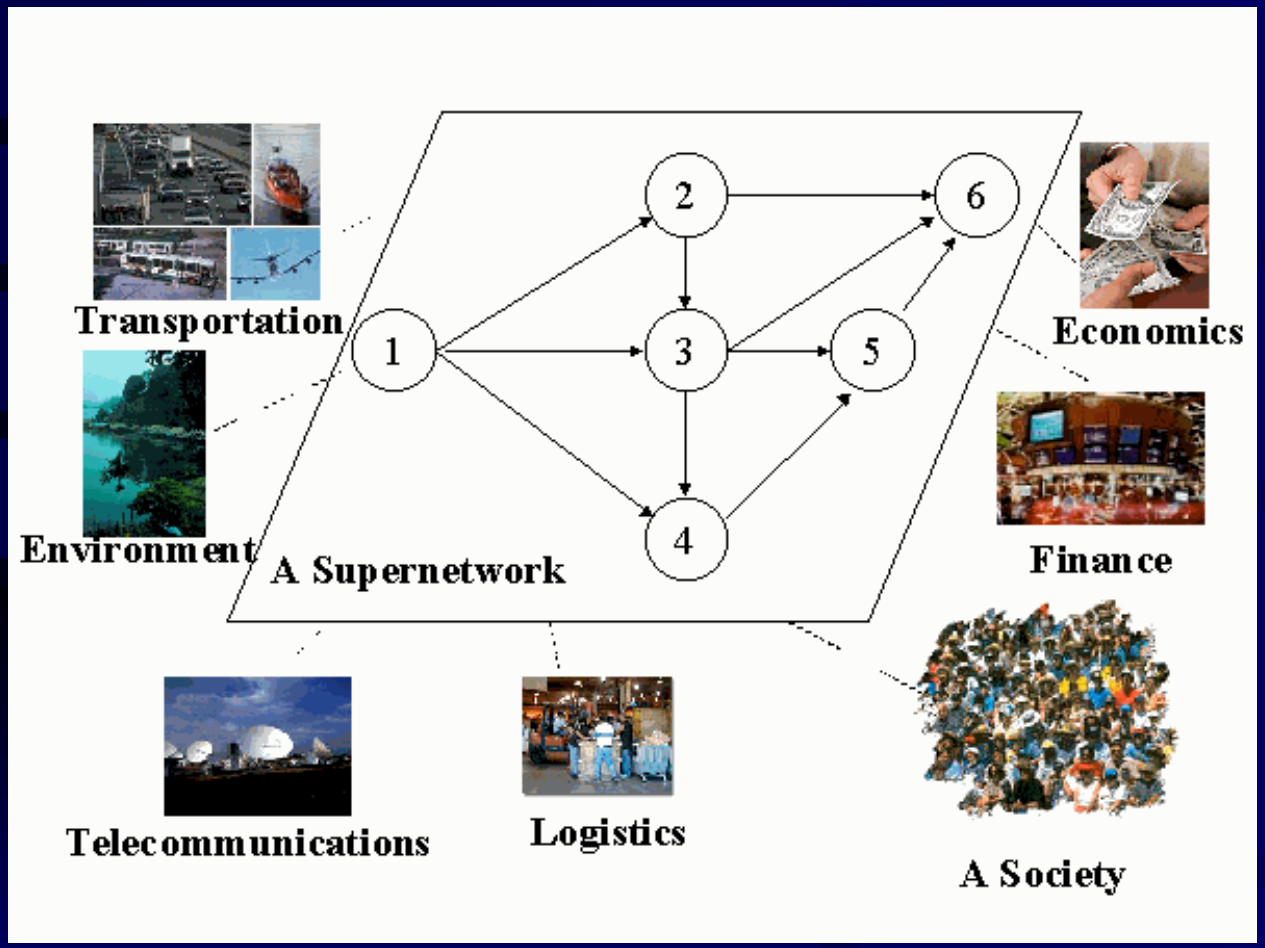
Roles of Social Networks in Economic Transactions

- Examples from Marketing
  - Relationship marketing
    - Ganesan (1994)
    - Bagozzi (1995)

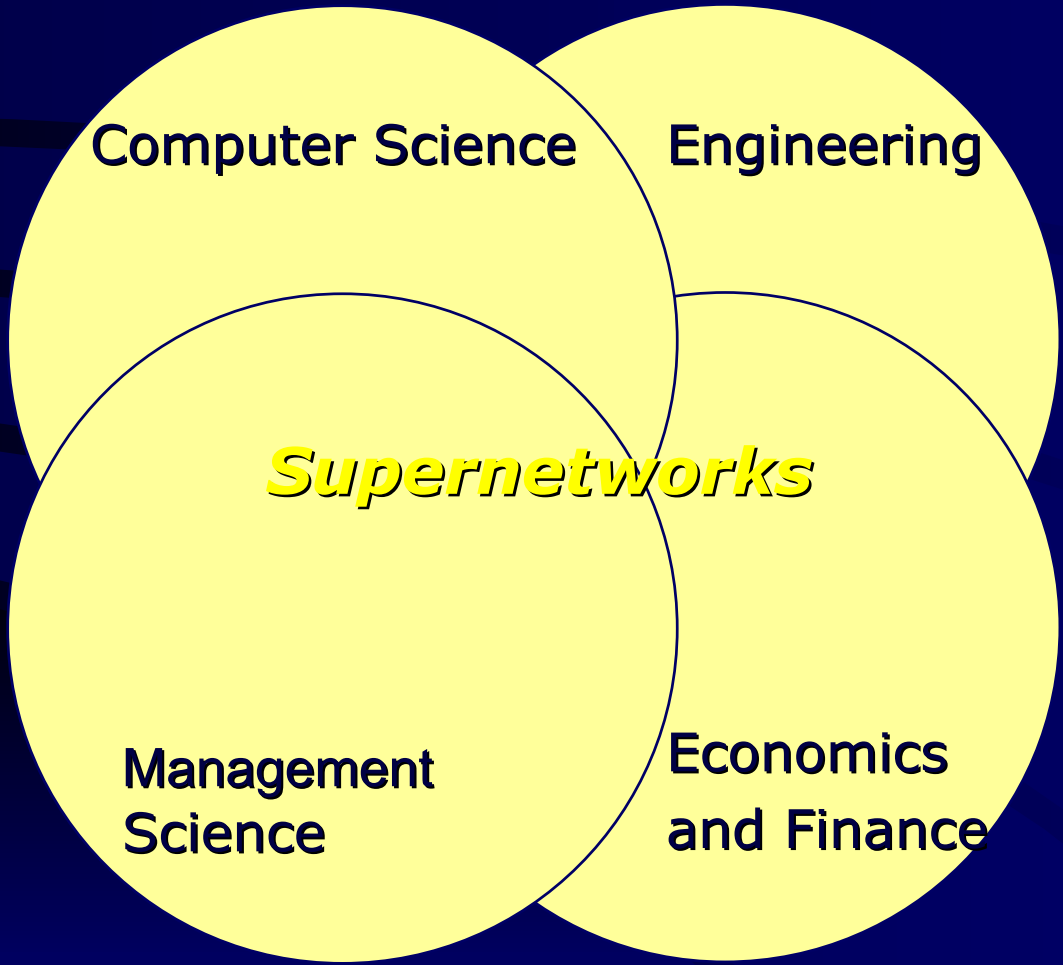
Novelty of Our Research

- Supernetworks show the dynamic co-evolution of economic (product, price and even informational) flows and the social network structure
- Economic flows and social network structure are interrelated
- Network of relations has a measurable economic value

Supernetworks



A Multidisciplinary Approach



Tools That We Have Been Using

- Network theory
- Optimization theory
- Game theory
- Variational inequality theory
- Projected dynamical systems theory (which we have been instrumental in developing)
- Network visualization tools

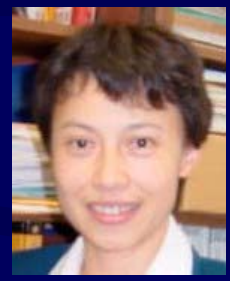
Applications of Supernetworks

- Telecommuting/Commuting Decision-Making
- Teleshopping/Shopping Decision-Making
- Supply Chain Networks with Electronic Commerce
- Financial Networks with Electronic Transactions
- Reverse Supply Chains with E-Cycling
- Energy Networks/Power Grids
- Knowledge Networks

The Supernetwork Team















Supernetworks Integrating Social Networks with Other Networks

- We have formulated and analyzed supernetworks consisting of:
  - Supply chain and social networks
  - Financial and social networks
  - International supply chain and social networks
  - International financial and social networks

Supernetworks Integrating Social Networks with Other Networks

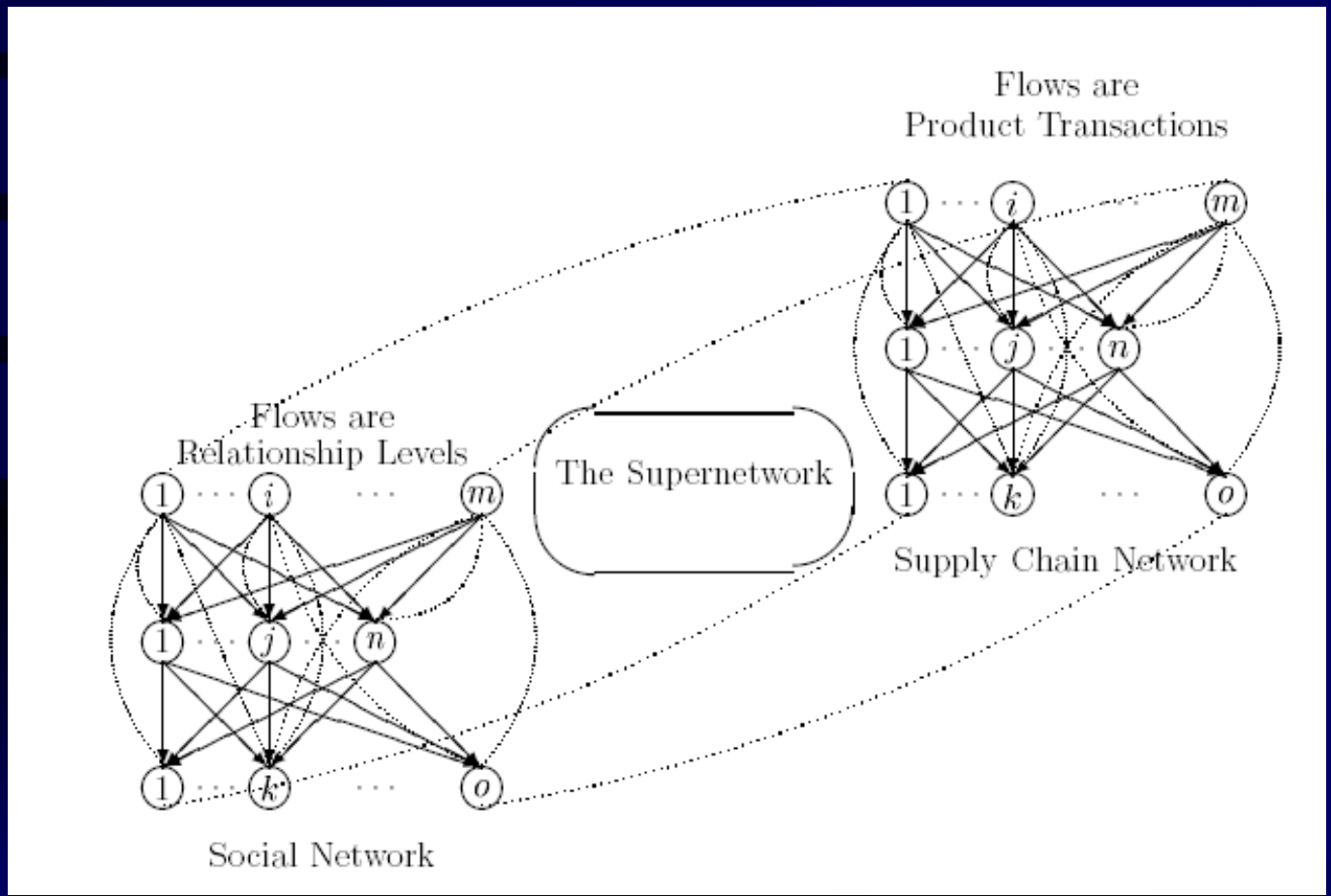
- Decision-makers in the network can decide about the relationship levels [0,1] that they want to establish.
- Establishing relationship levels incurs some costs.
- Higher relationship levels
  - Reduce transaction costs
  - Reduce risk
  - Have some additional value ("relationship value")

Supernetworks Integrating Social Networks with Other Networks

Dynamic evolution of

- Product transactions/financial flows and associated prices on the supply chain network/financial network with intermediation
- Relationship levels on the social network

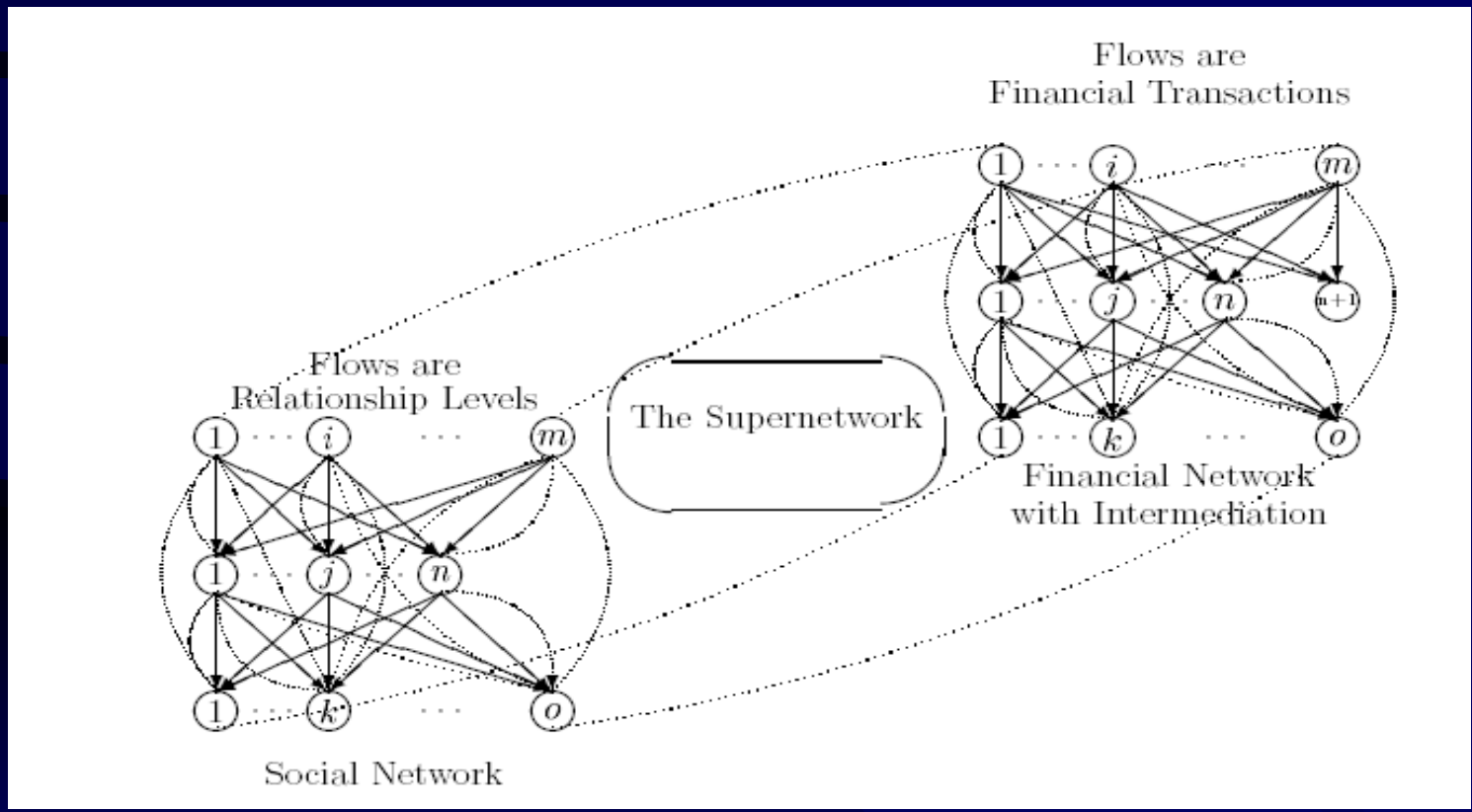
Supernetwork Structure: Integrated Supply Chain/Social Network System



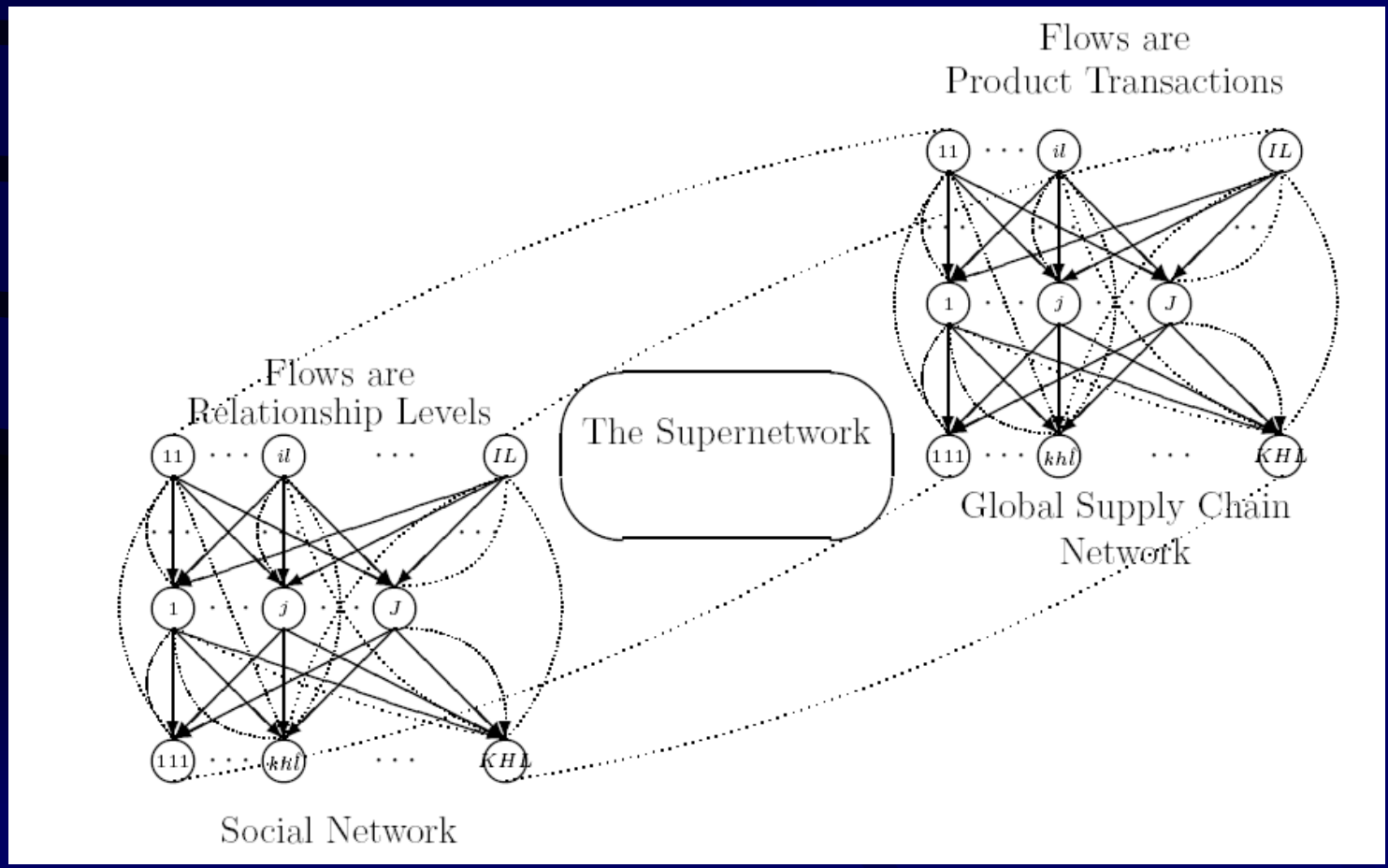
Multicriteria Decision-Makers

- Manufacturers and Retailers try to
  - Maximize profit
  - Minimize risk
  - Maximize relationship value
  - Individual weights assigned to the different criteria

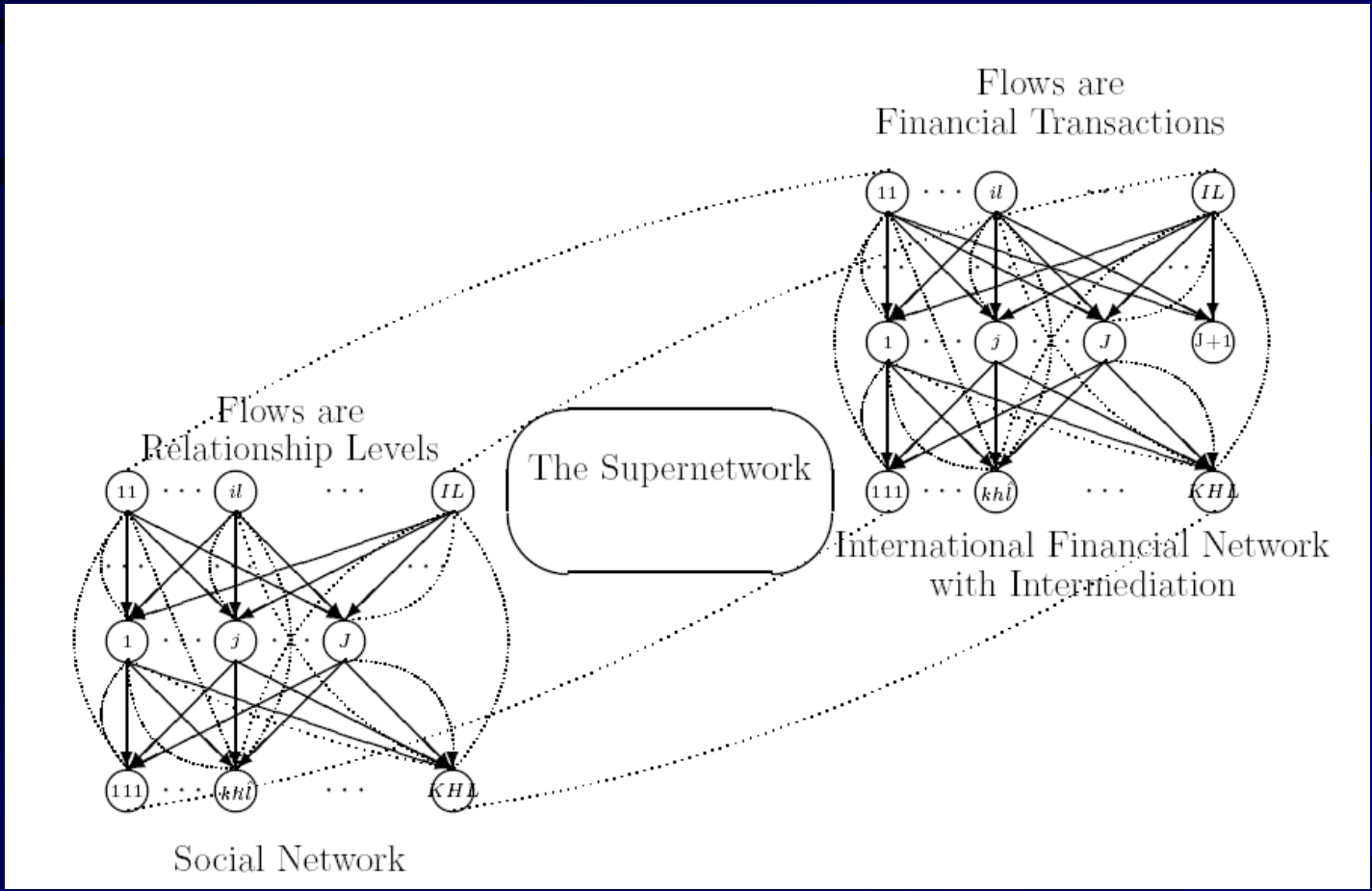
Supernetwork Structure: Integrated Financial/Social Network System



Supernetwork Structure: Integrated Global Supply Chain/ Social Network System



Supernetwork Structure: Integrated Global Financial/ Social Network System



Types of Simulations

- We can simulate
  - Changes in production, transaction, handling, and relationship production cost functions
  - Changes in demand and risk functions
  - Changes in weights for relationship value and risk
  - Addition and removal of actors
  - Addition and removal of multiple transaction modes
  - Addition and removal of countries and currencies

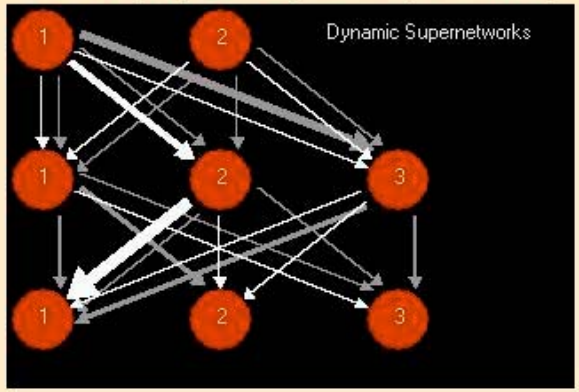
The Virtual Center for Supernetworks Webpage

The Virtual Center for Supernetworks

Supernetworks for Optimal Decision-Making and Improving the Global Quality of Life

The Virtual Center for Supernetworks at the Isenberg School of Management, under the directorship of Anna Nagurney, the John F. Smith Memorial Professor, is an interdisciplinary center.

NEW! The Supernetwork Sentinel Fall 2004 Issue
NEW! Isenberg School of Management Website
NEW! Papers on Dynamic Supernetworks



NEW! INFORMS Student Chapter
NEW! Fall 2004 Seminar Series!!!

Top site users during the past month were from UMass, Cornell, Columbia, and Purdue University. Top foreign users were from China, Russia, Australia, Italy, France, and Morocco.

Friends of the Virtual Center for Supernetworks

Mission: The mission of the Virtual Center for Supernetworks is to foster the study and application of supernetworks and to serve as a resource to academia, industry, and government on networks ranging from transportation, logistical, telecommunication, and power networks to economic, environmental, financial, knowledge and social networks.

The applications of Supernetworks include: transportation, logistics, critical infrastructure, telecommunications, power and energy, electronic commerce, supply chain management, environment, economics, finance, knowledge and social networks, and decision-making.

Funding for the Center has been provided by:
The National Science Foundation
The AT&T Foundation
The Rockefeller Foundation
The John F. Smith Memorial Fund of the University of Massachusetts
The Isenberg School of Management - University of Massachusetts.

Summary

- We model the behavior of the decision-makers, their interactions, and the dynamic evolution of the associated variables.
- We study the problems qualitatively as well as computationally.
- We develop algorithms, implement them, and establish conditions for convergence.
- We have studied to-date "good behavior." Fascinating questions arise when there may be situations of instability, multiple equilibria, chaos, cycles, etc.

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The full text of the papers can be found under Downloadable Articles at:

http://supernet.som.umass.edu

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