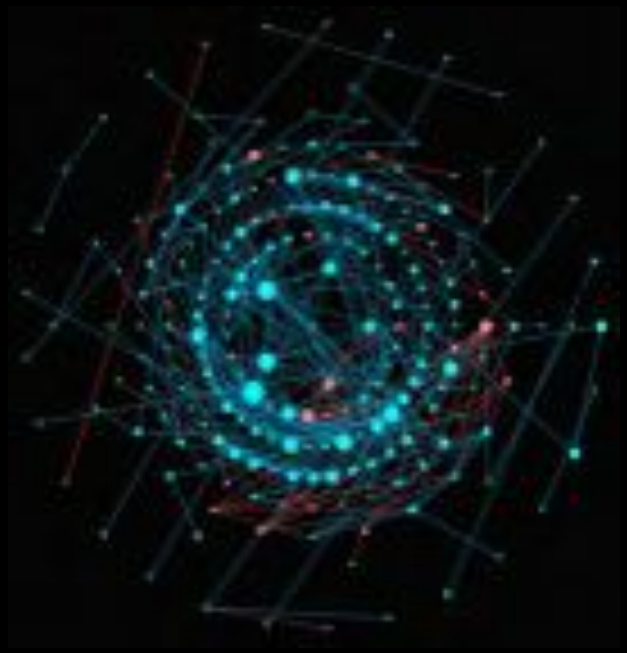
Leveraging Network Data to Support Women STEM Faculty



Recommendations from NJIT ADVANCE

More than the Sum of Its Parts:
Advancing Women at NJIT through Collaborative Research Networks

The NJIT ADVANCE Project

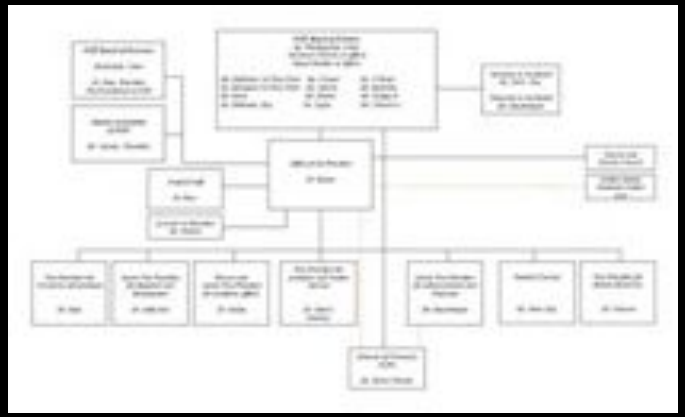
Overview
2006-2013

Funded by
The National Science Foundation

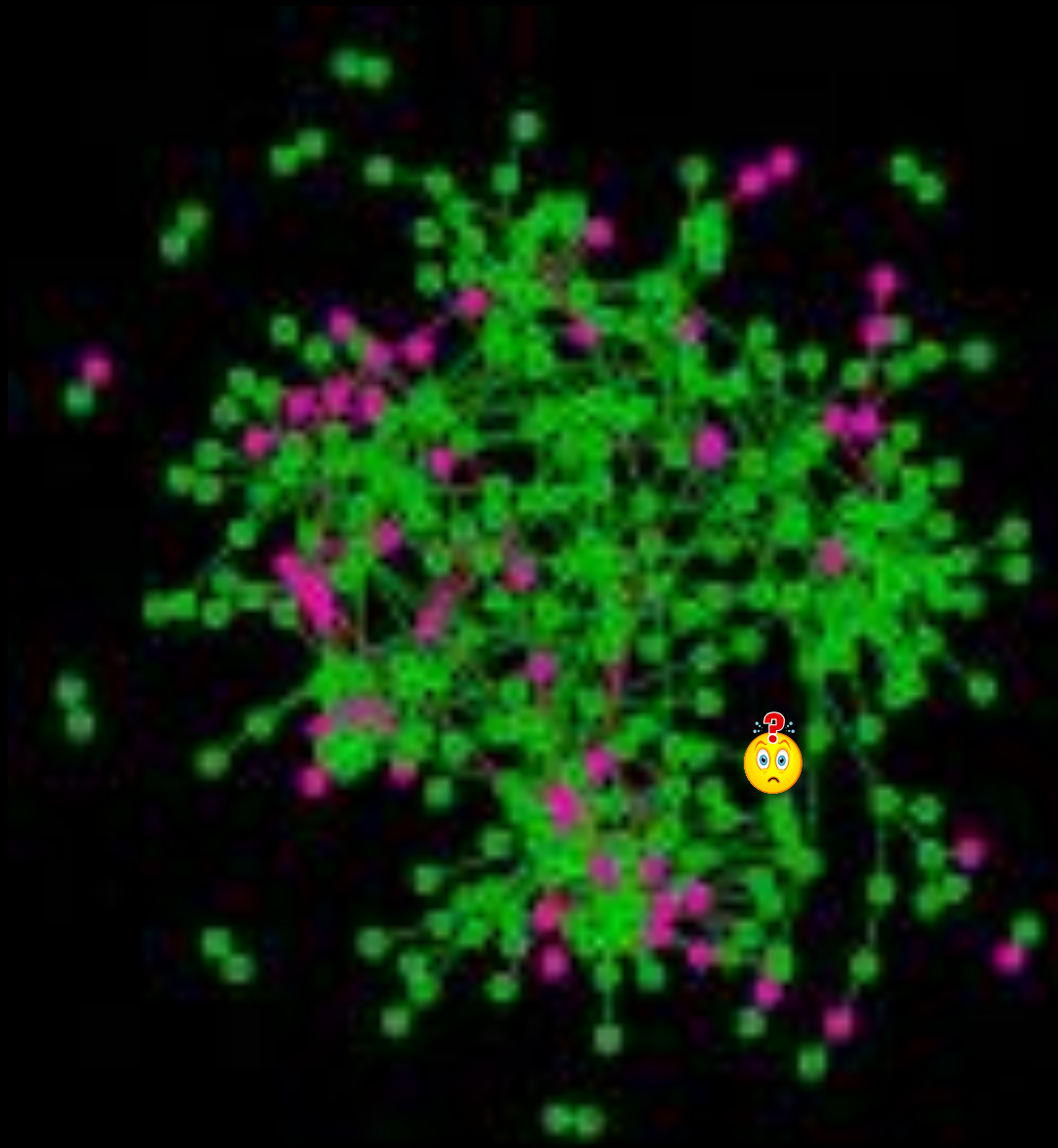
The NJIT ADVANCE Project pioneers the use of social network analysis to affect institutional change and ensure the full participation of women in academic science and engineering.

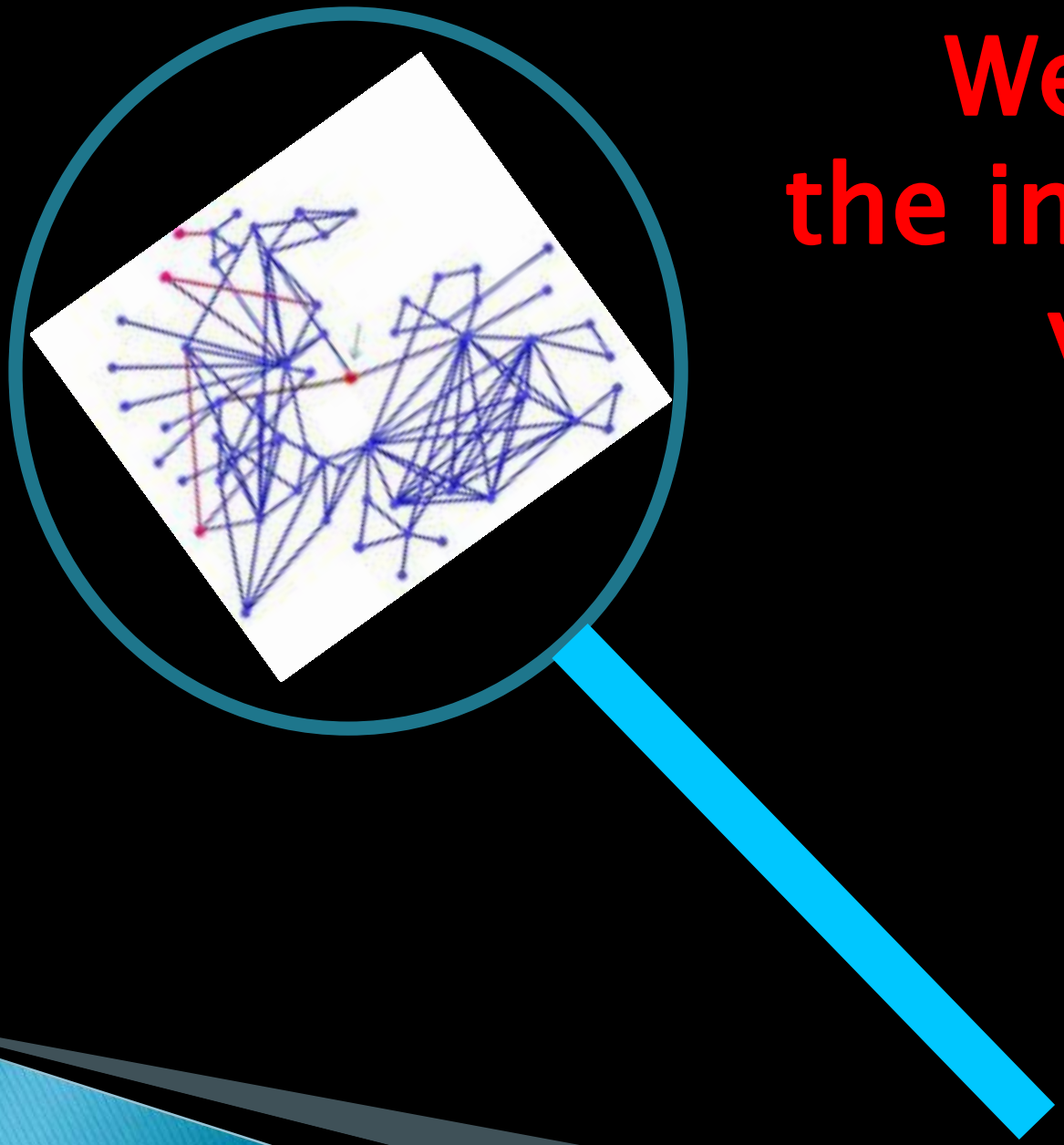
Universities are more than buildings….

and organization charts….



…They are **WEBS** of human interaction and perception whose complex structure is largely invisible to the people embedded in them.





We make the invisible visible.

THE IMPACT OF COLLABORATION ON STEM FACULTY CAREERS

A DECADE OF DATA

FROM THE NJIT ADVANCE PROJECT

Basic Research Question

What is the relationship among

collaboration

productivity

retention

advancement in rank

?

Methodological Tactic

Using
COAUTHORSHIP DATA
as a proxy
for Faculty Research Networks

Collecting Coauthorship Data

NJIT ADVANCE researchers text-mined Scopus to capture publication data for the 512 tenure/tenure-track faculty at NJIT 2000-2010

- Built a web crawler to search Scopus
- Retrieved **8395 faculty publications**—including 3608 coauthored publications
- Also captured counts of publications of NJIT faculty with external faculty and grad students

STUDY POPULATION:
303 tenure/tenure-track STEM faculty

Faculty Attributes

department	number of publications	number of grants submitted
gender	number of co-authored publications: • With other NJIT faculty • With non-NJIT researchers • With NJIT graduate students	total $ amount of grants submitted
rank progression		number of grants funded
tenure status		total $ amount of grants funded
hire date		institute committee service
separation date	h-index	years at NJIT
retention status (left/stayed)	years in study (2000-2010)	number of patents submitted

Analytical Tools Used

For standard statistical tests:

SAS – Correlations, Wilcoxon tests
R – Survival Analysis
SPSS – Cluster Analysis

To analyze network structure:

Organizational Risk Analyzer (ORA) software from Carnegie Mellon

UCINET, a social network analysis program distributed by Analytic Technologies

PRODUCTIVITY
and
CAREER ADVANCEMENT

2000-2010

Analyzing the Relationship between PRODUCTIVITY and CAREER ADVANCEMENT 2000-2010

"Productivity" defined as rate of publication, grants funded, and patents applied for

"Career Advancement" defined as retention and promotion in rank.

FINDINGS
2000-2010

STEM faculty who published more were…

…more likely to be retained

…more successful in terms of rank increase

"When publishing productivity is measured by... a scientist's total number of publications, collaboration is a strong predictor of publishing productivity."

- Lee and Bozeman (2005)

"Collaboration" defined as coauthorship

"Productivity" defined as number of publications and rate of publication, grants funded, and patents applied for

"Career Advancement" defined as retention and promotion in rank

FINDINGS
2000-2010

For STEM faculty, co-authorship was positively correlated with productivity.

1. **Co-authoring with other NJIT faculty**
2. **Co-authoring with NJIT graduate students**
3. **Coauthoring with non-NJIT researchers**

FINDINGS
2000-2010

STEM Faculty who co-authored more were more successful in terms of rank increase.

1. **Co-authoring with other NJIT faculty**
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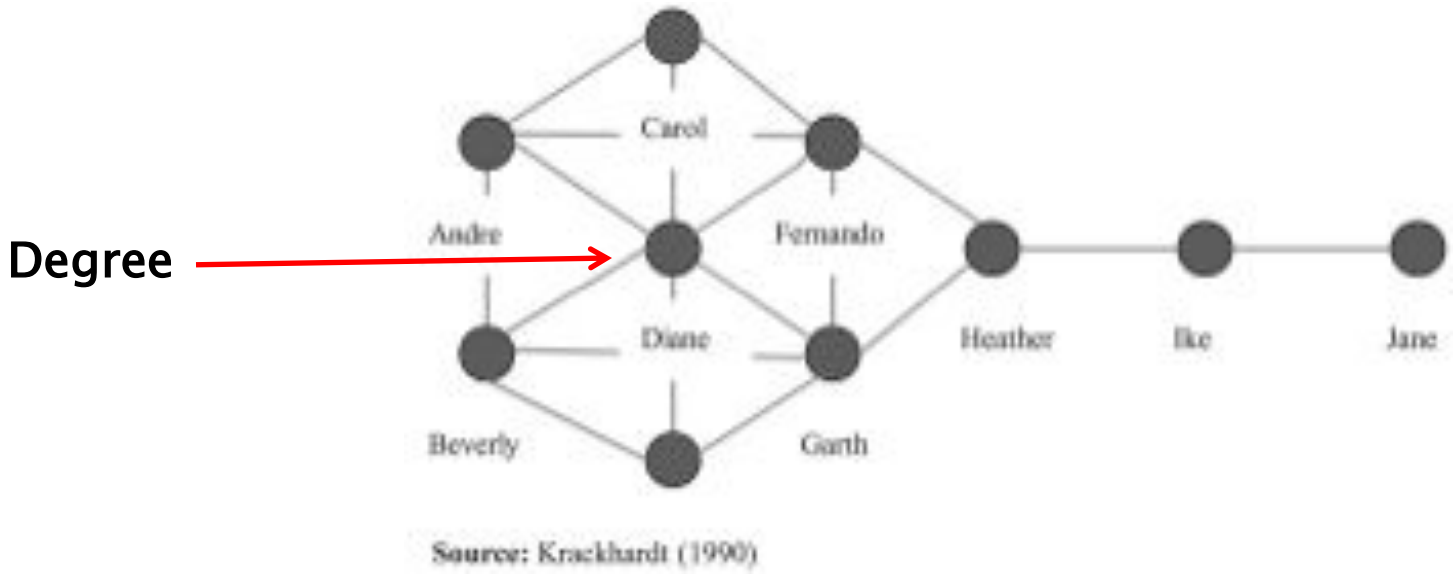
3. **Coauthoring with non-NJIT researchers**

NETWORK STRUCTURE, PRODUCTIVITY and CAREER ADVANCEMENT

2000-2010

NETWORK "CENTRALITY" MEASURES

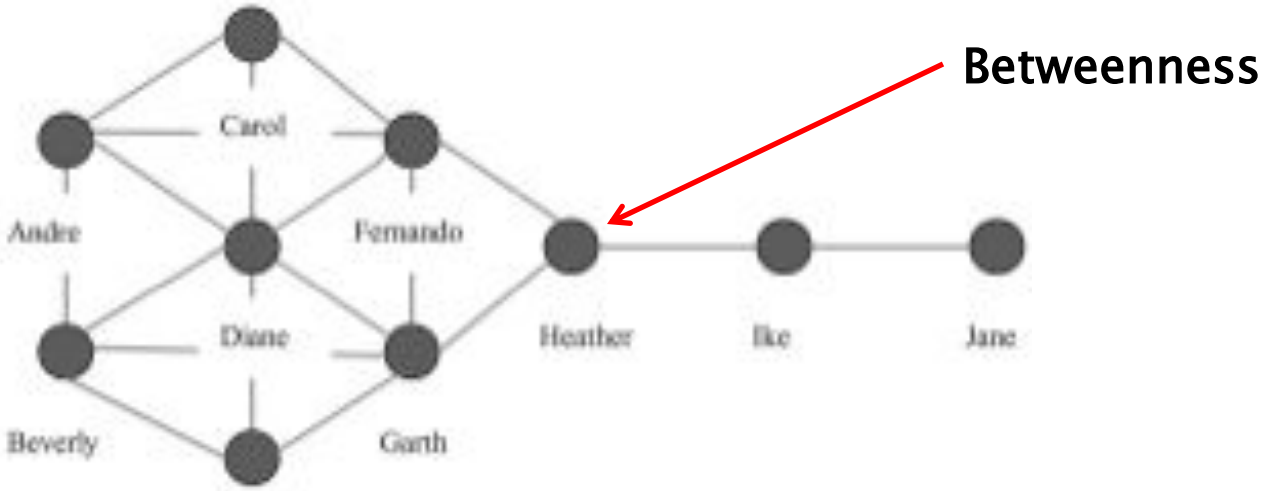
Degree Centrality— The number of connections ("ties") a person ("node") has. High degree centrality indicates well-connected people who can directly reach many people in the network.



Source: Krackhardt (1990)

NETWORK "CENTRALITY" MEASURES

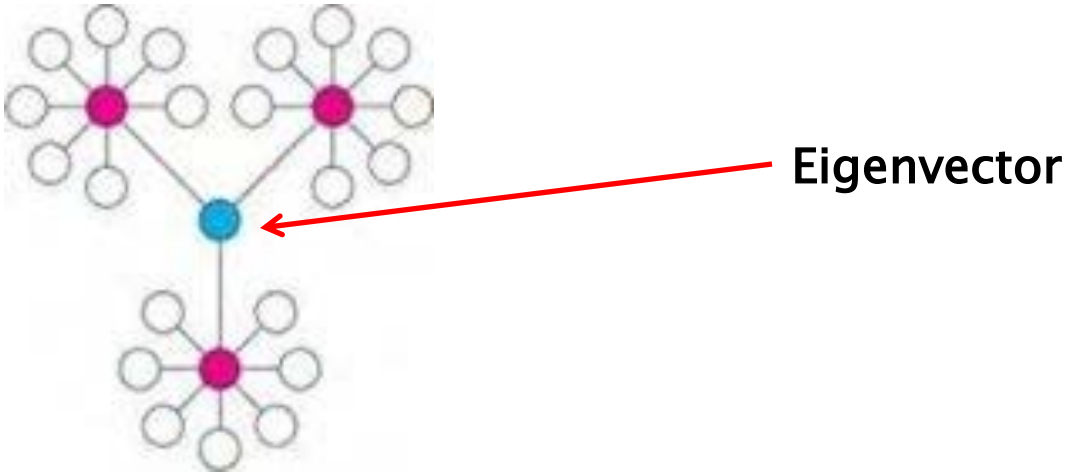
Betweenness Centrality— reflects the extent to which an individual has the ability to broker the flow of information in the network.



Source: Krackhardt (1990)

NETWORK "CENTRALITY" MEASURES

Eigenvector Centrality— reflects the extent to which an individual is connected to well-connected people in the network.



PRODUCTIVITY FINDINGS
2000-2010

For STEM faculty, network centrality measures were positively correlated with publication rate:

1. **Total degree centrality**
2. **Betweenness centrality**
3. **Eigenvector centrality**

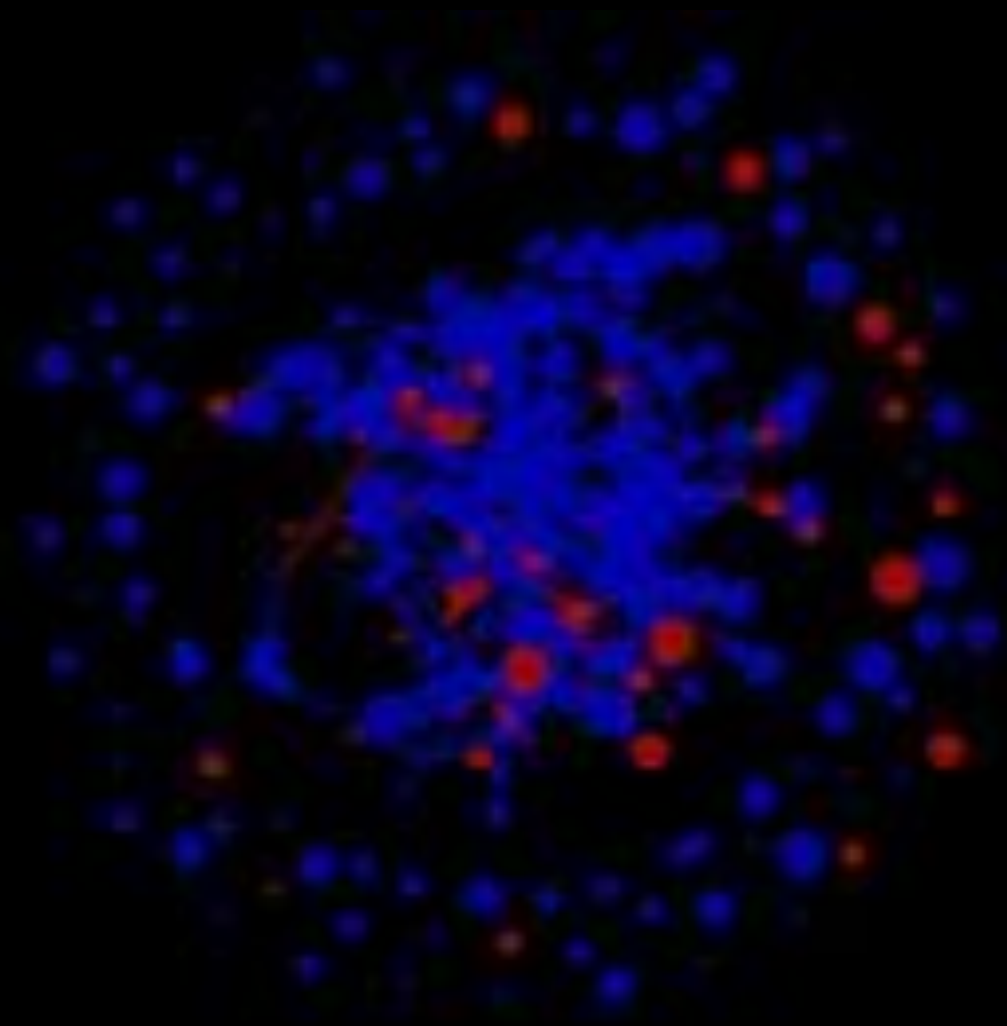
CAREER ADVANCEMENT FINDINGS

For STEM faculty, network centrality measures were positively correlated with promotion.

1. **Total degree centrality**
2. **Betweenness centrality**
3. **Eigenvector centrality**

STEM faculty who were retained had higher total degree centrality than those who left NJIT.

STEM Faculty Gender Trends 2000-2010



CAREER ADVANCEMENT TRENDS

Cohort: Assistant Professors Hired 1998-2006

Women were retained at the same rate as men

Women were promoted at the same rate as men

BUT…

Women did more institute committee service.

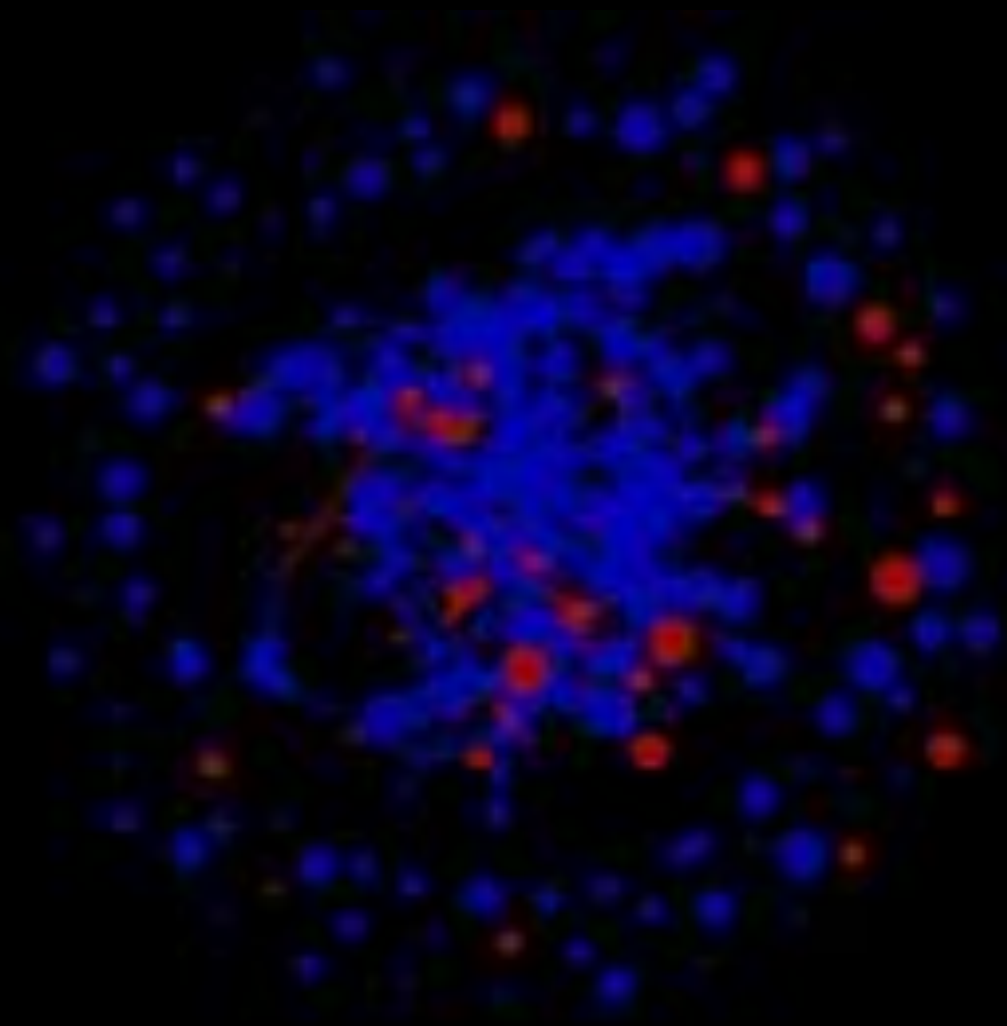
Women brought in more grants & more grant $.

And published just as much as their male peers.

In short…

Saying that men and women advance at the same rate is not necessarily the same as saying that men and women receive the same rewards for the same work.

STEM Faculty Gender Trends 2000-2010



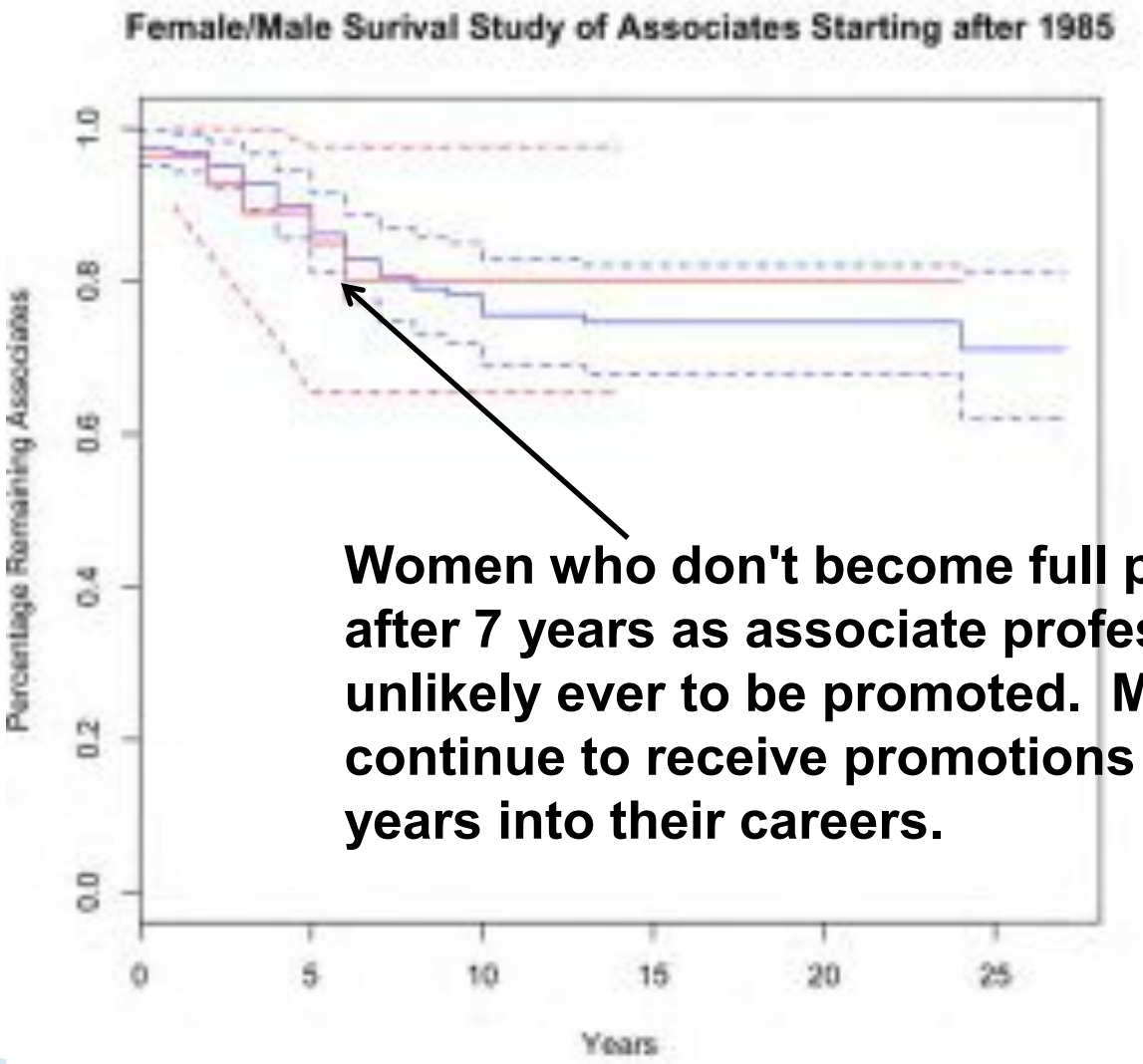
STEM FACULTY SURVIVAL STUDY

After 10 years, women drop off significantly.

Even the best case for women is worse than the worst case for men

Kaplan–Meier survival estimator

TIME TO PROMOTION FROM ASSOCIATE TO FULL

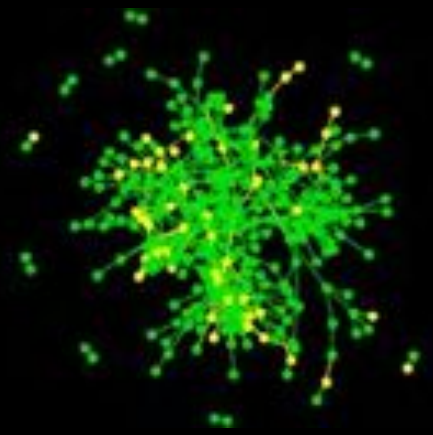


Women who don't become full professors after 7 years as associate professors are unlikely ever to be promoted. Men continue to receive promotions up to 23 years into their careers.

Kaplan–Meier survival estimator

MAPPING NETWORK GROWTH

In addition to mapping the whole NJIT STEM co-authorship network

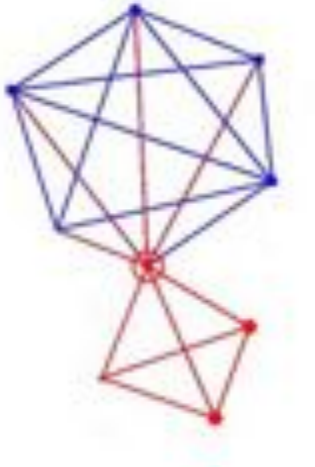


we can also use
DATA VISUALIZATIONS

to track individual faculty network development over time.

NETWORK GROWTH OF A SUCCESSFUL WOMAN FACULTY RESEARCHER OVER TIME

2010



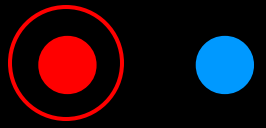
GROWTH OF THE WOMEN'S NETWORK

COAUTHORSHIP TIES AMONG WOMEN STEM FACULTY AND THEIR MALE PEERS

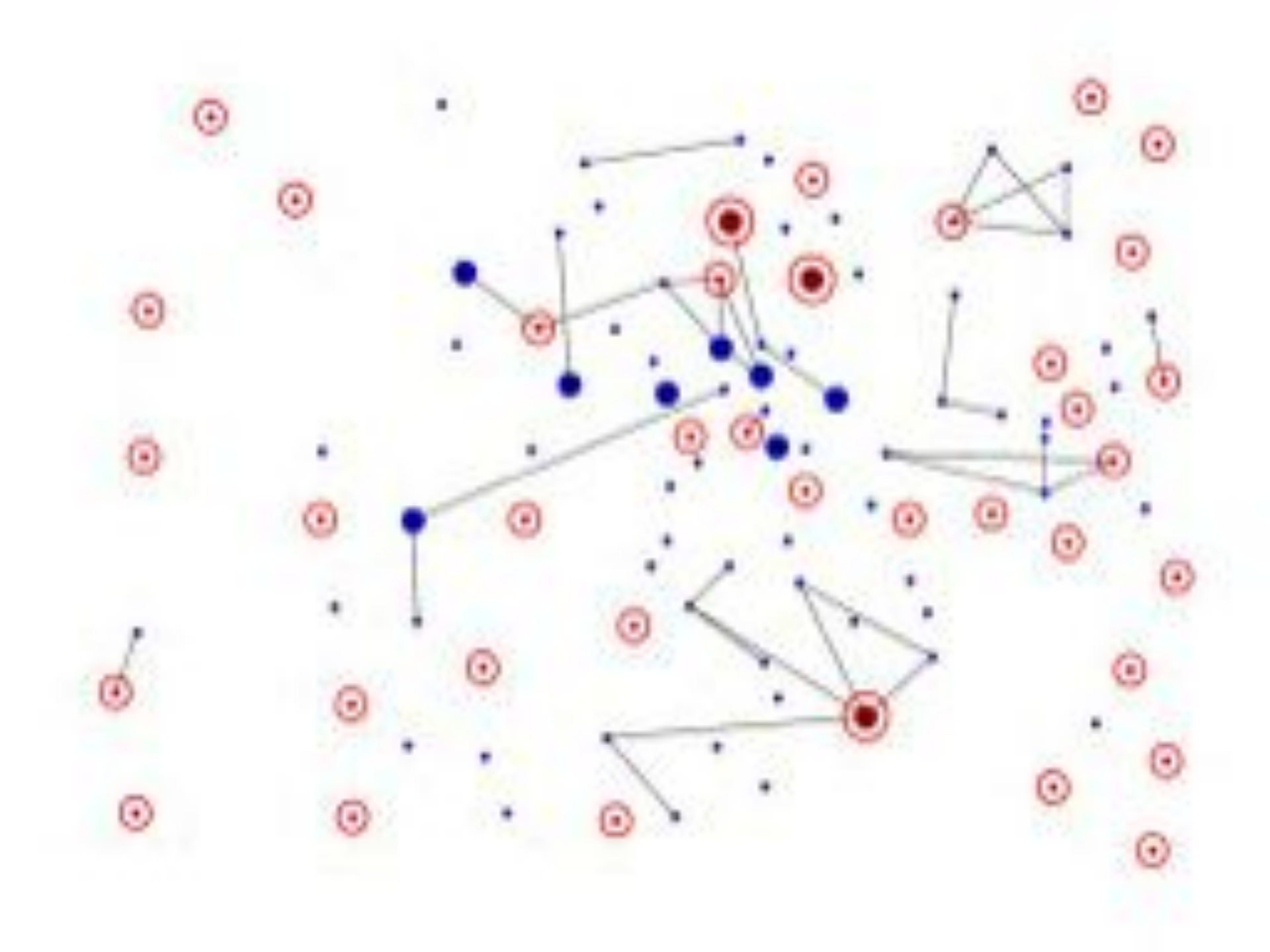
2000–2010

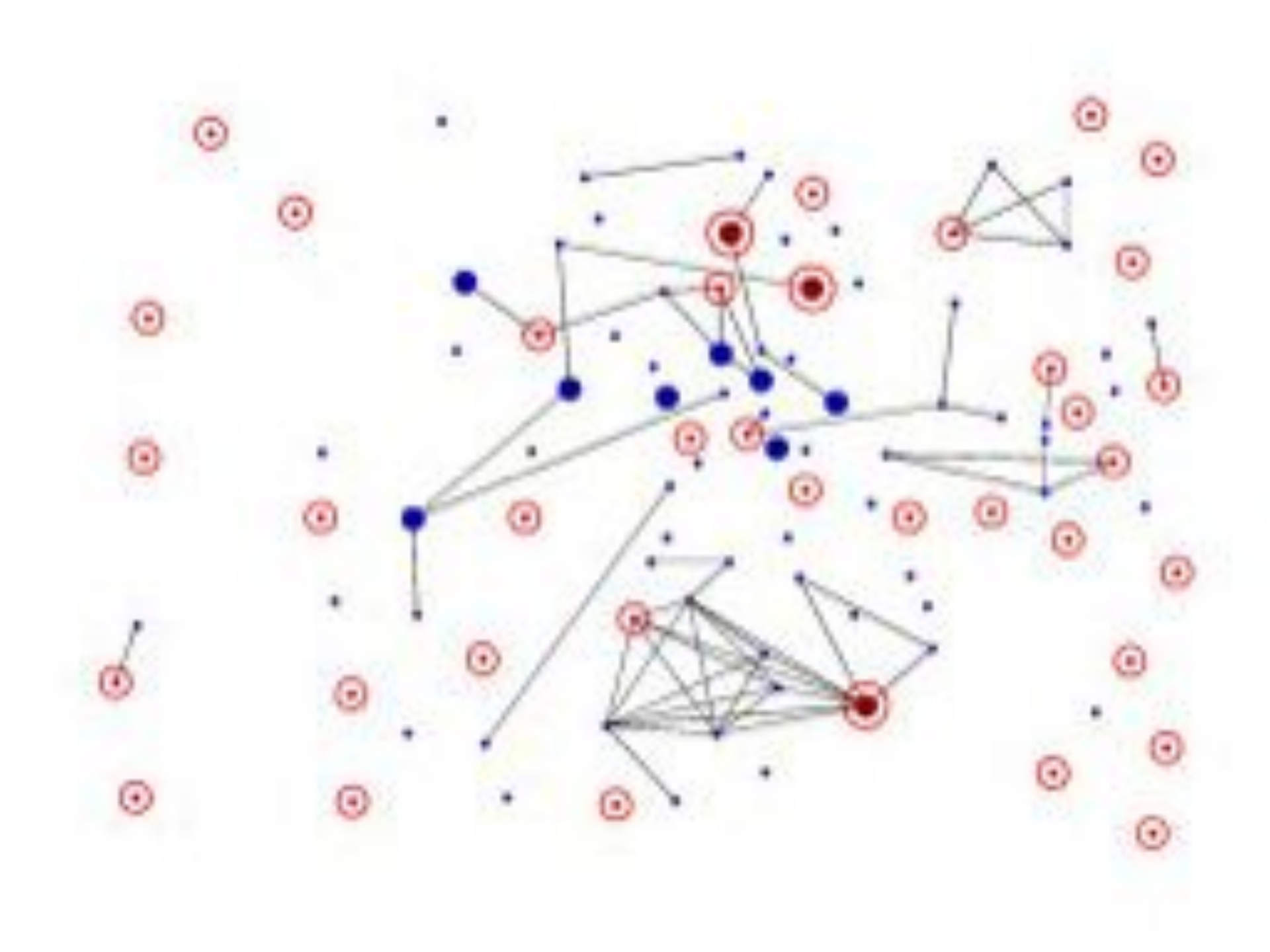
Red Node = Female Faculty Member

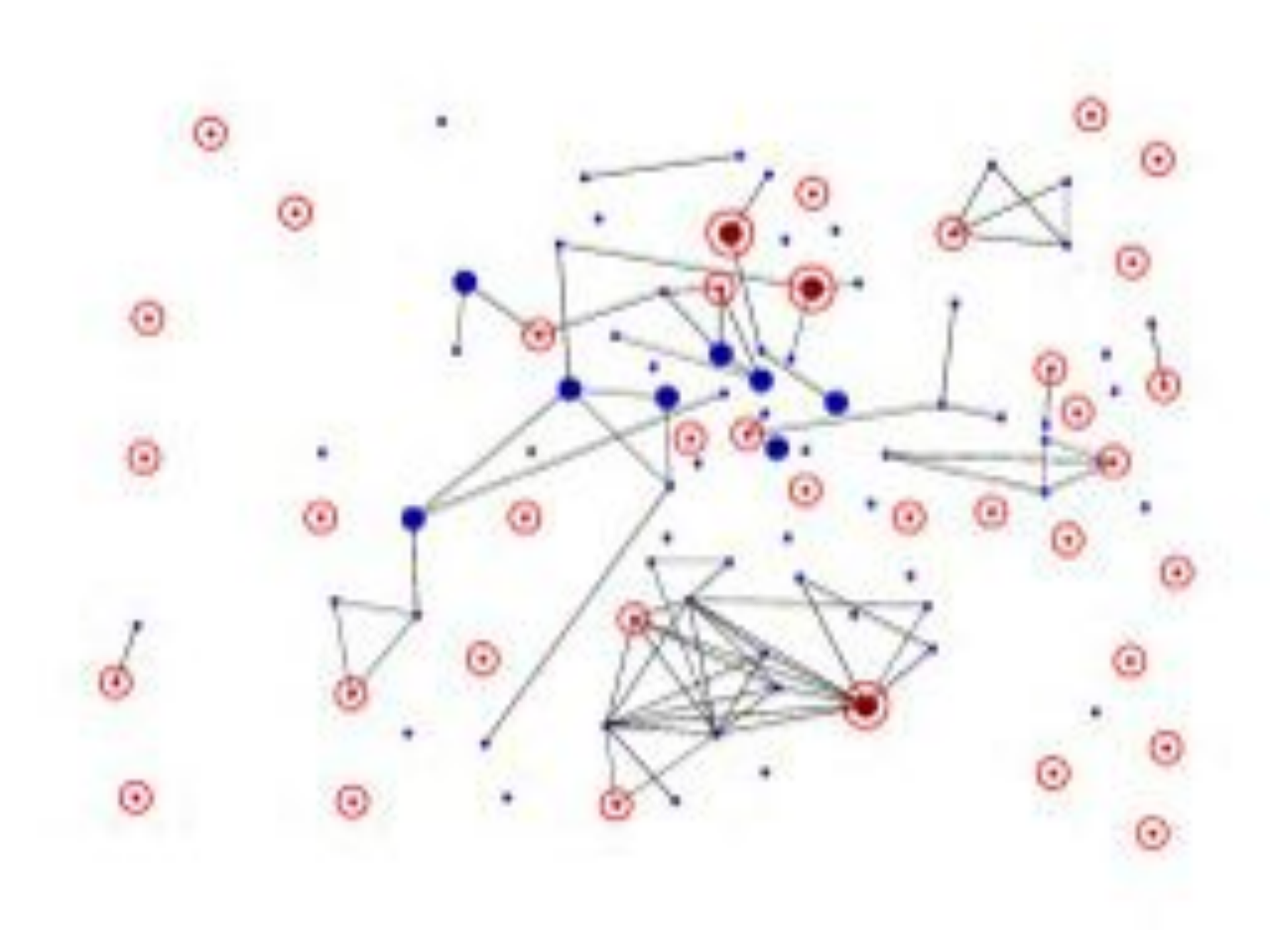
Blue Node = Male Faculty Member

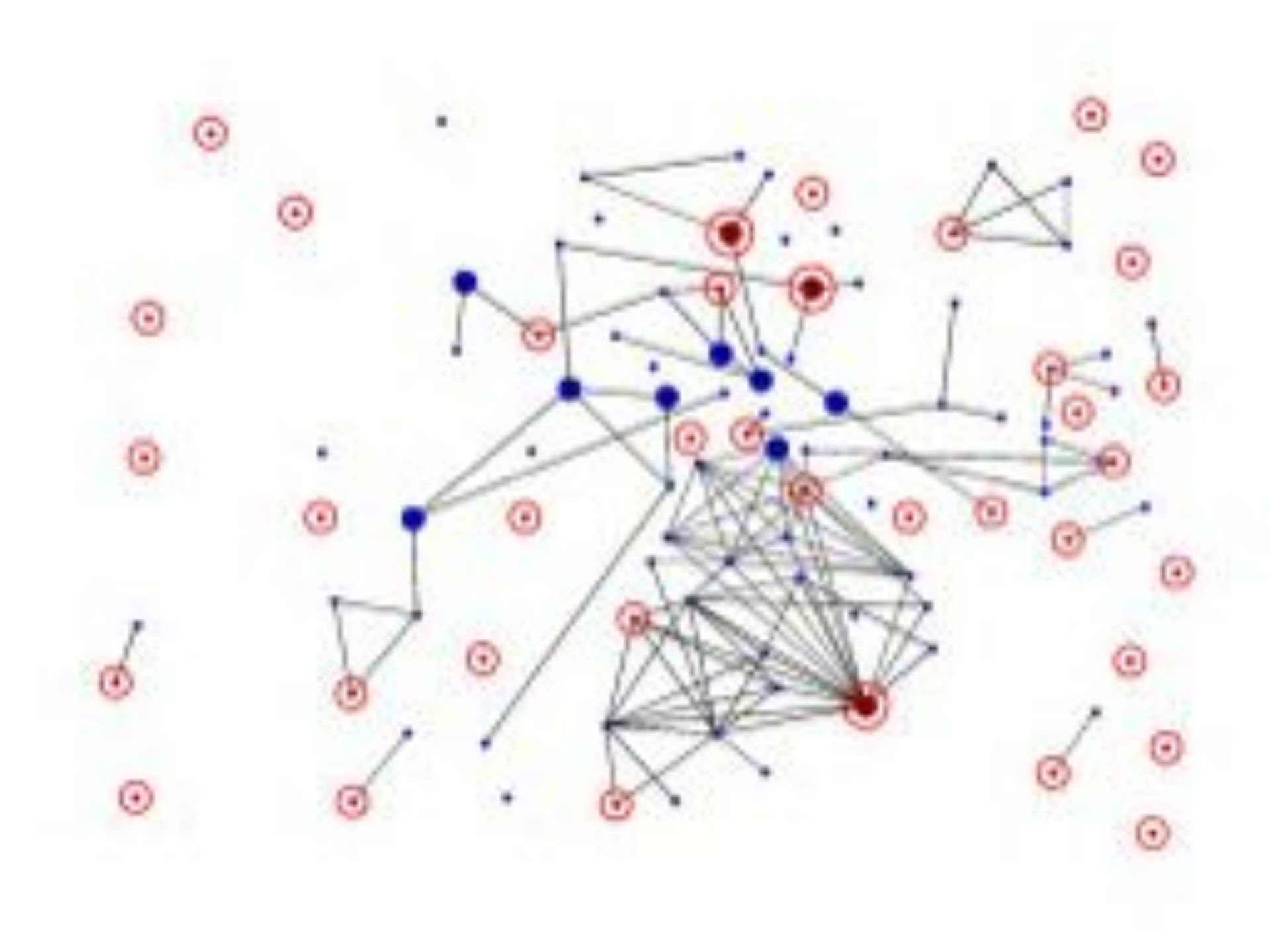


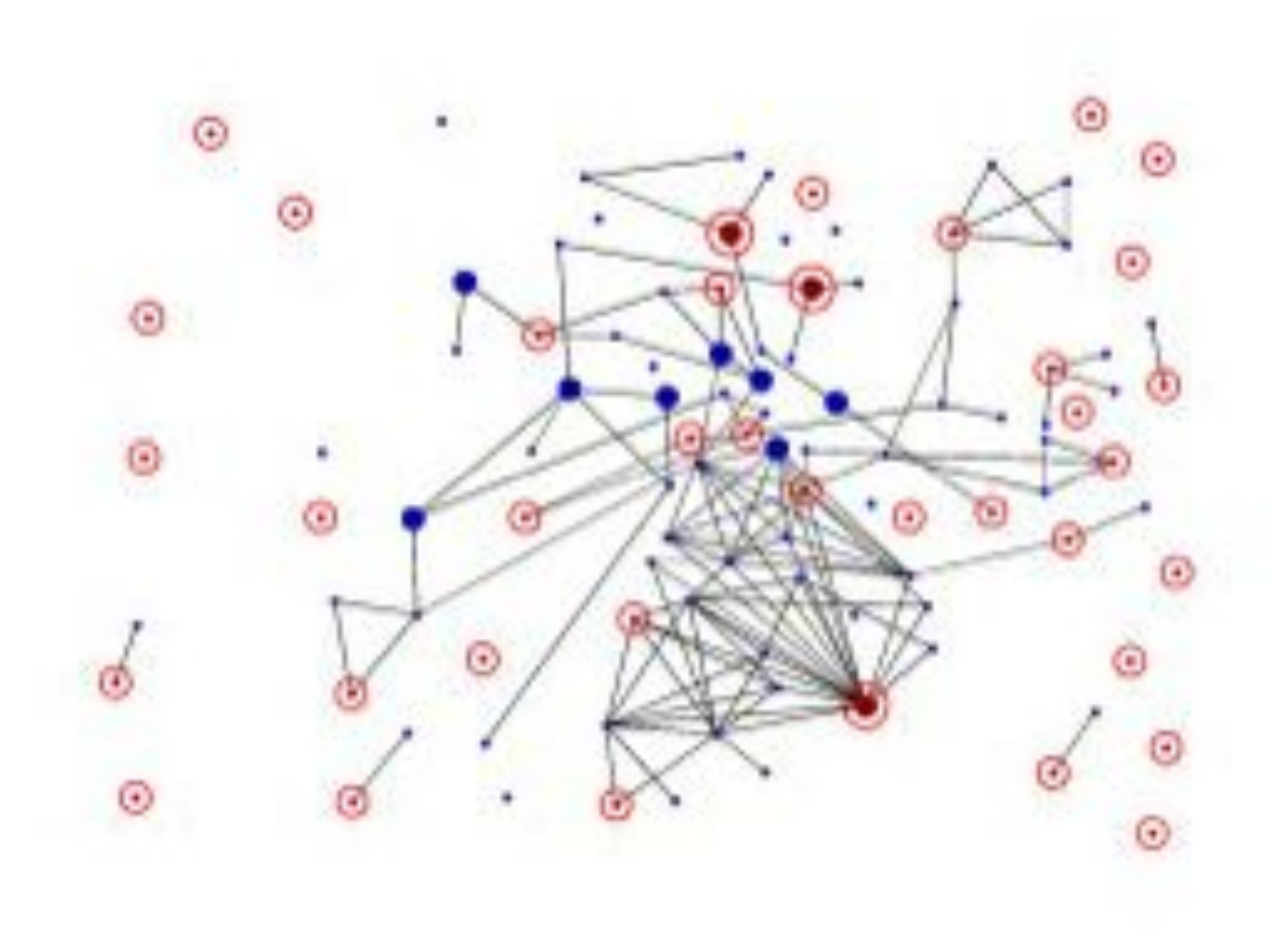
Large nodes = Most productive, most successful faculty members

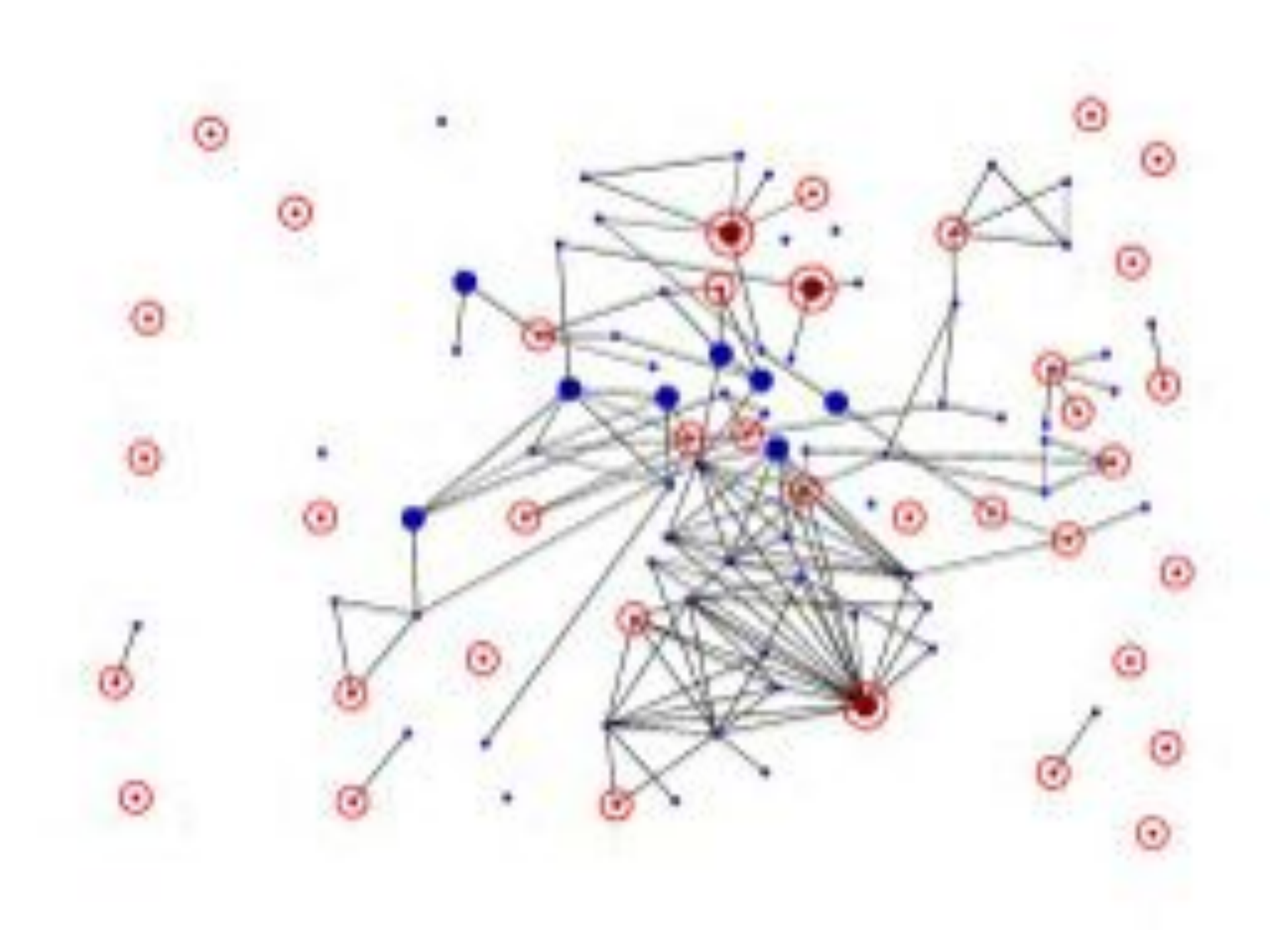


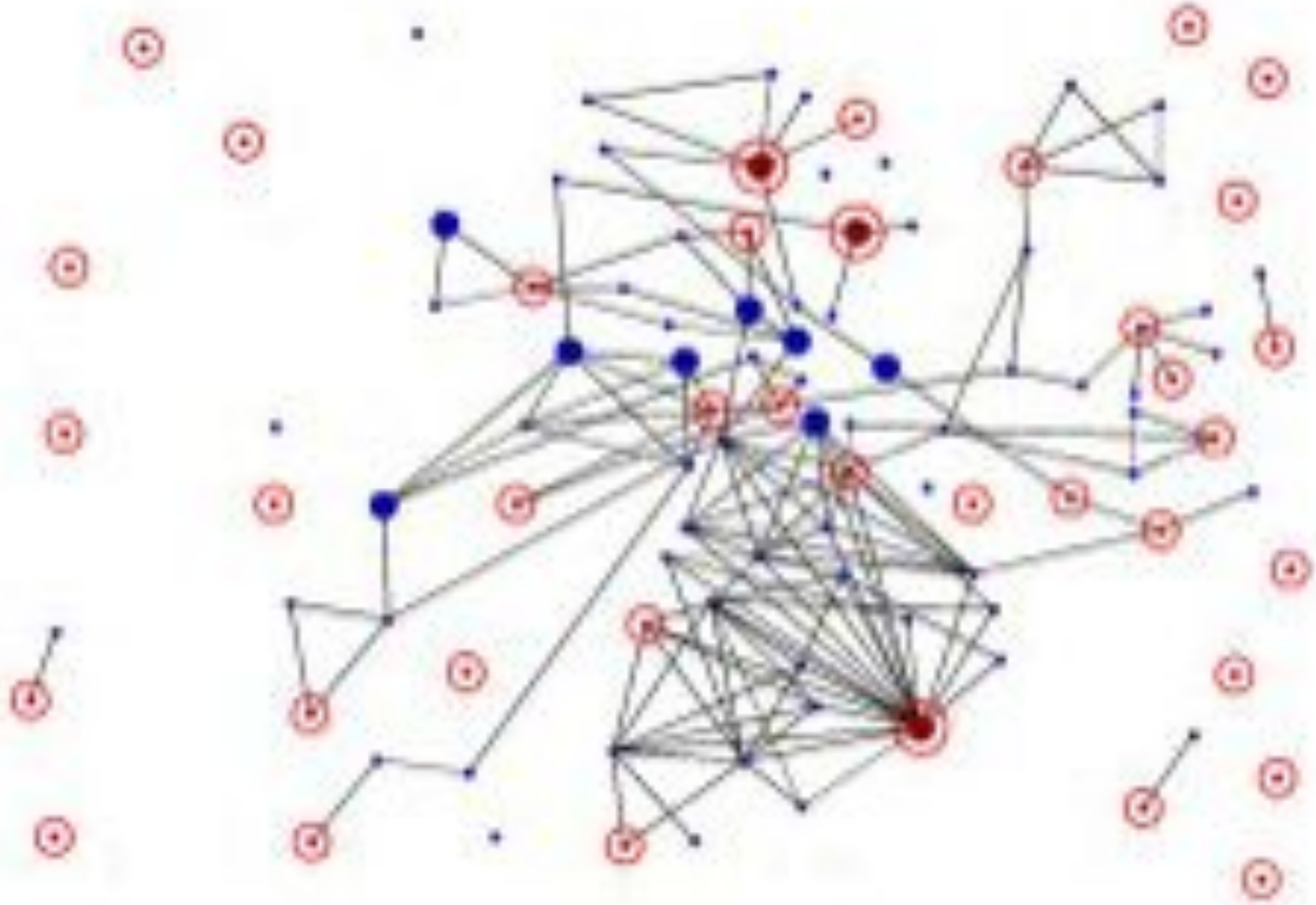


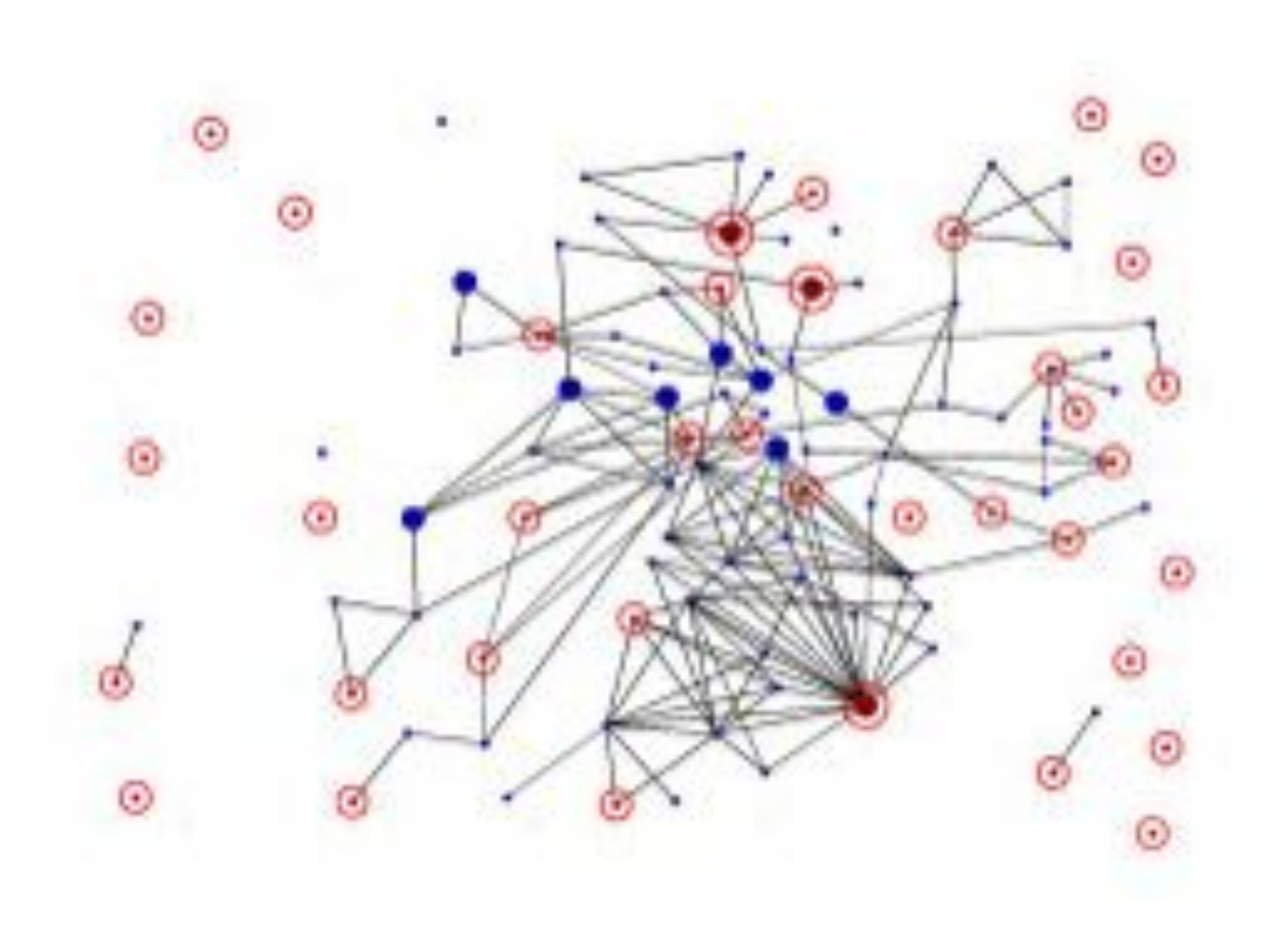


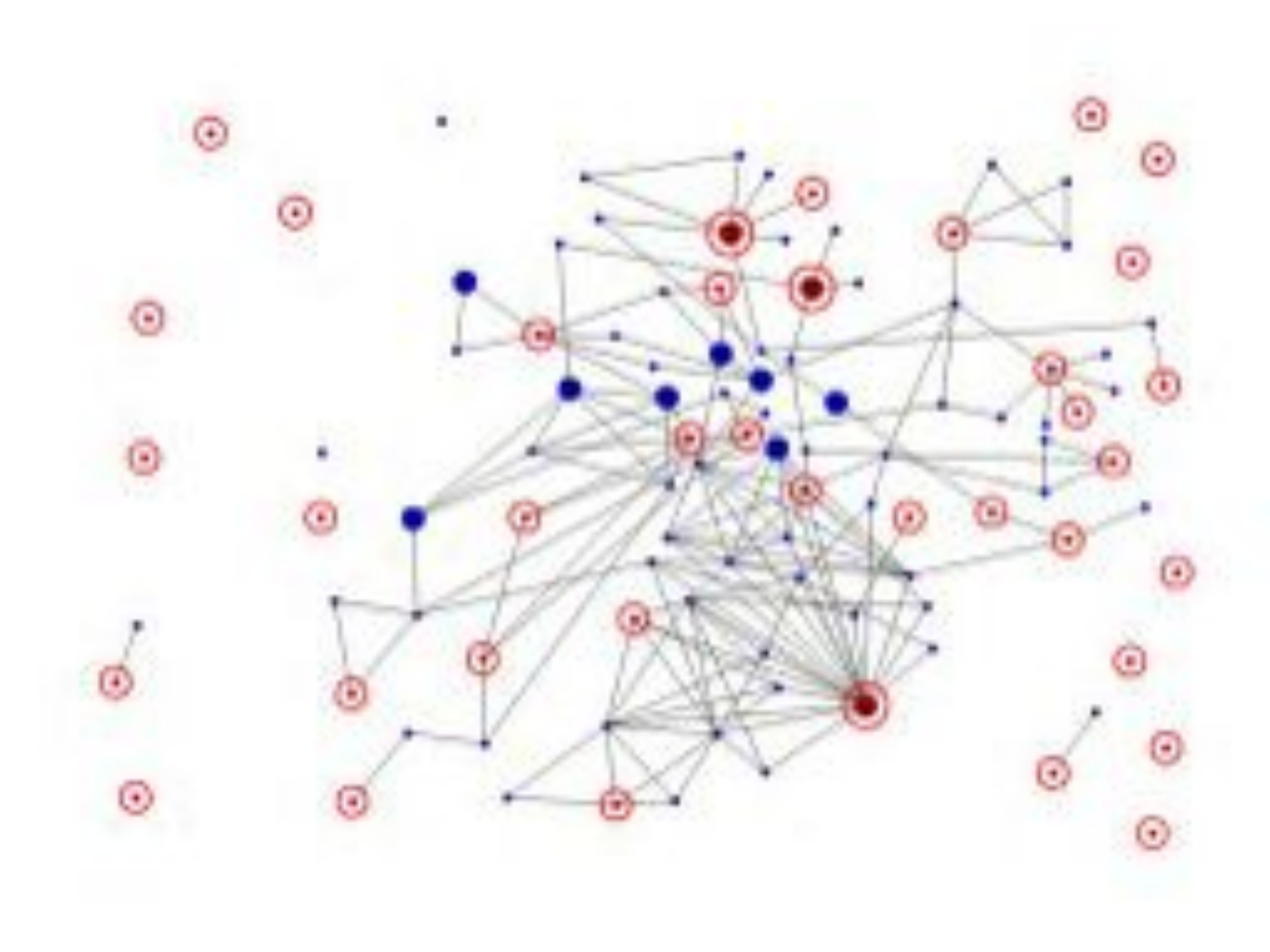


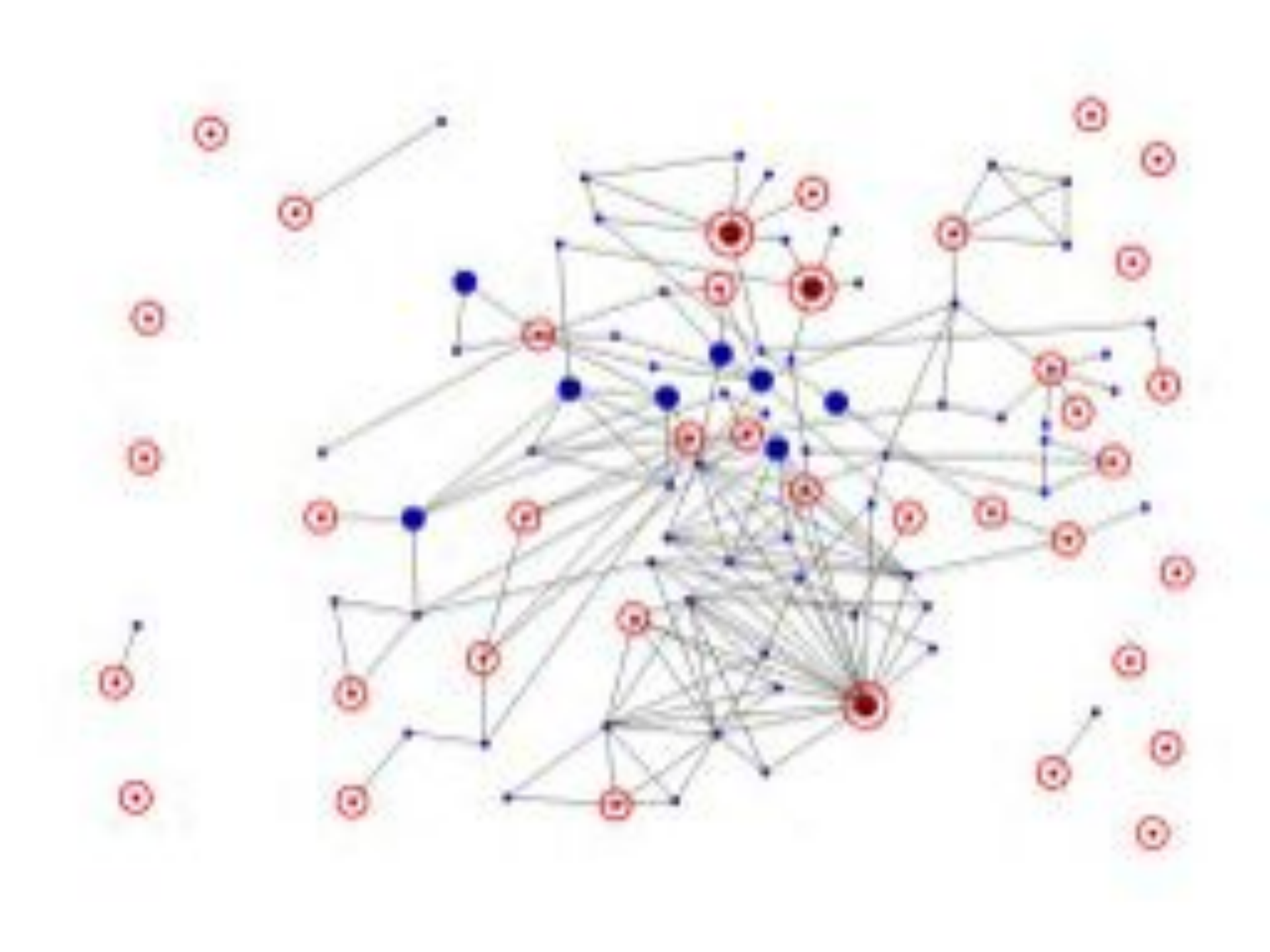






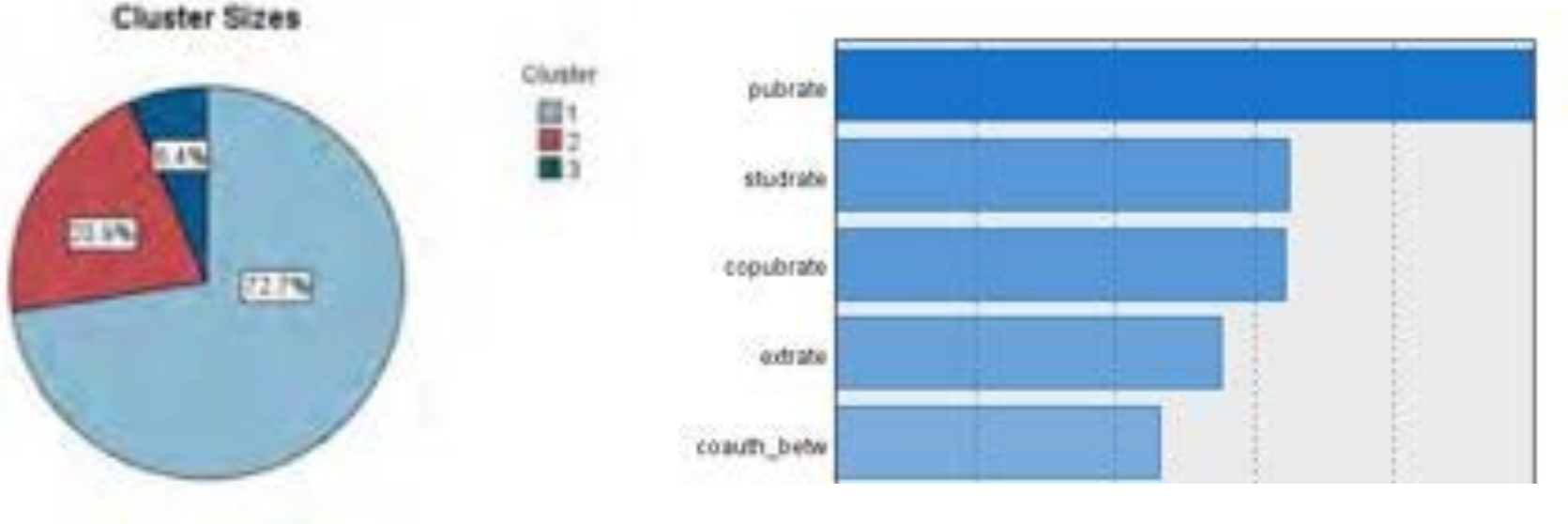


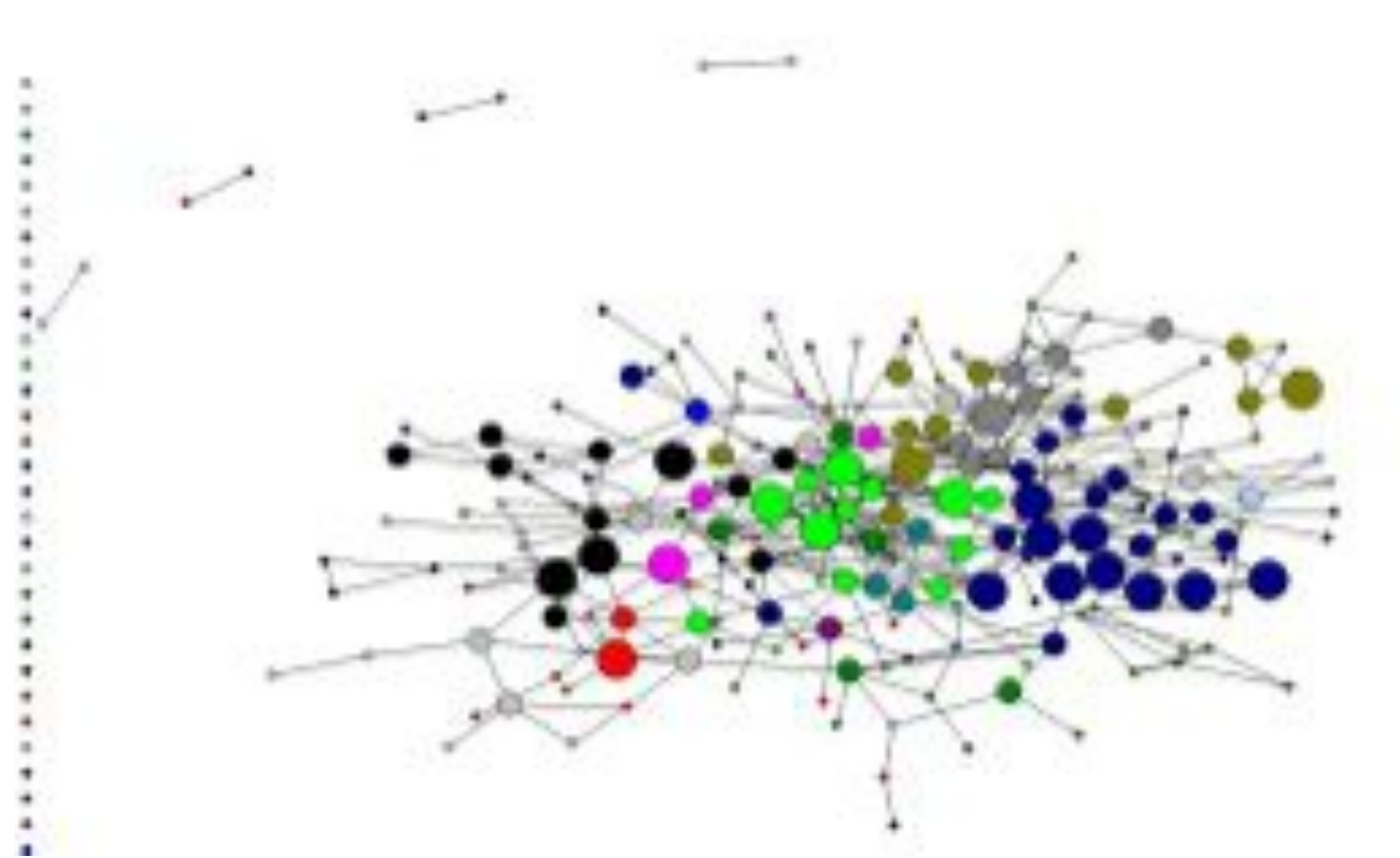




USING DATA MAPS TO INVESTIGATE HIDDEN PATTERNS

SPSS CLUSTER ANALYSIS





NETWORK MAPPING

Can Help Us
Leverage the Benefits of

COLLABORATION

The Benefits of Collaboration

Increased productivity and advancement!

- **Division of labor;**
- **Partnership with colleagues who have *complimentary* expertise;**
- **Access to expensive equipment;**
- **Access to graduate student RAs;**
- **Intellectual stimulation;**
  Collaboration among people with different intellectual tool kits drives knowledge creation and innovation;
- **Access to new and novel information;**
- **Access to tacit knowledge;**
- **Devil's advocacy;**
  Internal referring weeds out unfruitful approaches;
- **Safe reality checking;**
- **Diminished social isolation;**
- **Increased social capital.**

When it works well, **strategic collaboration** offers the very advantages that faculty need most in order to thrive:

the ability to do more high quality work in less time

and

the ability to signal the value of their work to the research community as a whole.

BUT…

1) Collaborations have ***costs*** as well as benefits;
2) Not all collaborators are equal.

   In social networks, as in real estate, it is often “location, location, location” that creates value.

"TRANSACTION COSTS" OF COLLABORATION

International collaboration involves:

time and money for travel

transaction costs resulting from differences in language and cultural expectations

Internal collaboration across lines of ethnicity and gender involves:

cross-cultural communication issues;

Reaping the "assembly effect" (1+1=5) requires:

a sophisticated understanding of small group process;

expertise in effective project management;

experience in conflict resolution;

(and skill in psychiatric counseling?)

"Teamwork" can mean losing credit for your work;

Pro-rating papers by number of authors;

The "Matilda Effect" (Rossiter, 1993);

"Teamwork" can mean loss of the "alone time" needed for creativity.

Most of all, collaboration involves the "transaction cost" of locating and assessing potential research partners.

RESEARCH MAP

A new Data Visualization tool from NJIT ADVANCE reduces the transaction costs associated with professional collaboration.

RESEARCH MAP

Allows faculty to identify…

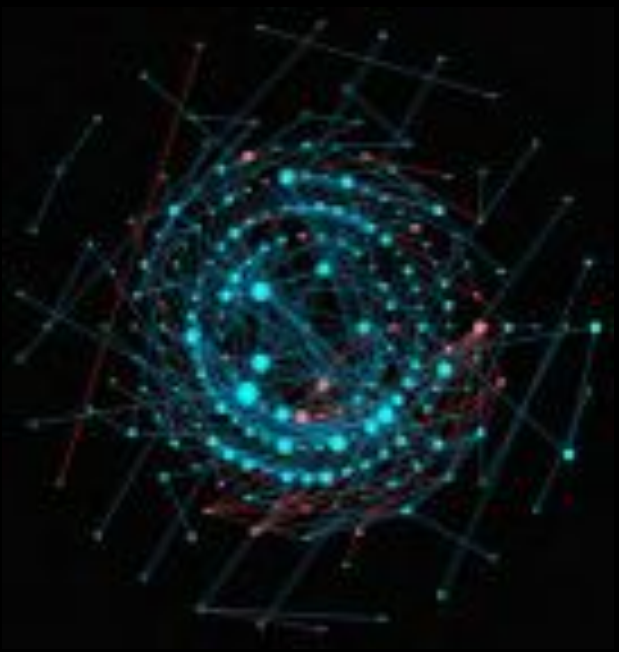
- **potential collaborators who have similar or complimentary research interests & methods**
- **colleagues who can broker introductions to potential collaborators**

Allows academic administrators to identify….

- **problematic characteristics of the units they manage**

RESEARCH MAP DEMO

Rethinking the NSF 12…



Strengths
of NSF 12 Indicators Approach

Collects data on resources as well outcomes

Some attempt to track careers over time (cohorts)

Looks at institutional trajectory (e.g. leadership)

Limitations of NSF 12 Indicator Approach

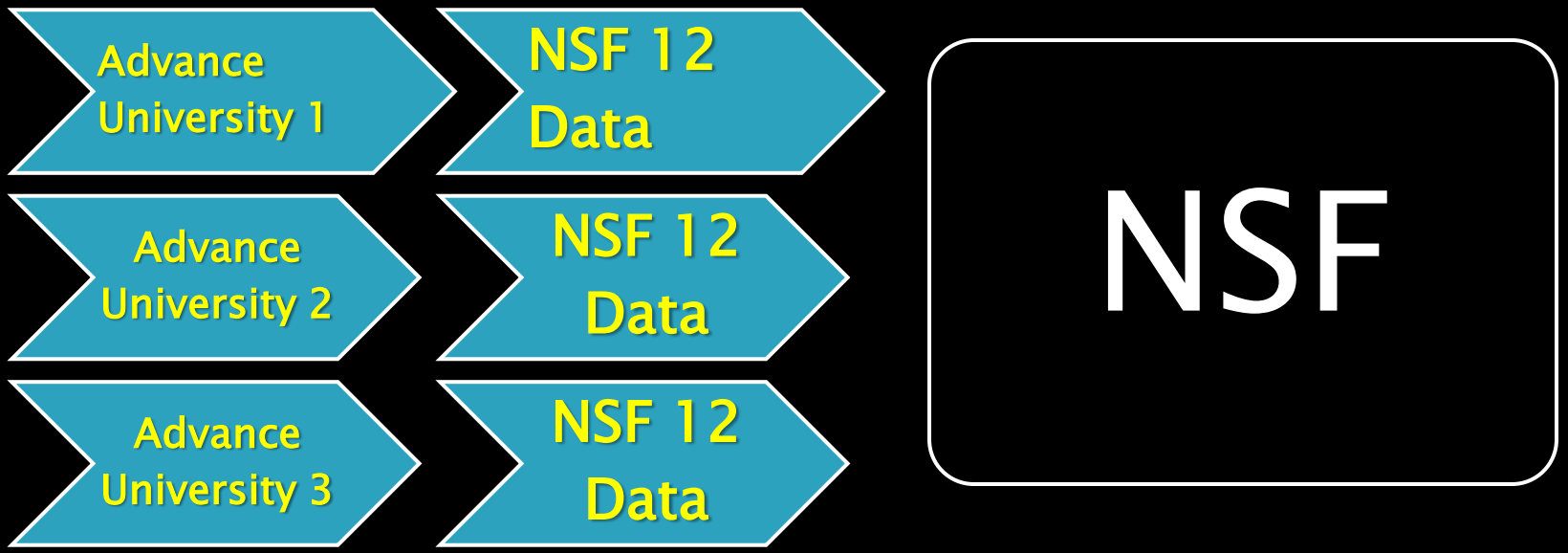
Promotion & tenure data needs to be integrated with productivity data to be meaningful.

Absence of contextual network data can conceal tokenism.

Meaningful statistical analysis is difficult at the local level because of skewed male/ female population sizes and small female n.

Limitations of NSF 12 Indicator Approach

The "Roach Motel" Problem…
Data goes in, but it doesn't come out.



NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES

"Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty" (2010)

2004 survey

492 STEM departments. Research I universities

Focus: P&T decisions

2005 survey

1,800 faculty from the 492 departments

Included self-reported productivity data

FINDING:

Female and male STEM faculty "have enjoyed comparable opportunities within the university, and gender does not appear to have been a factor in a number of important career transitions and outcomes."

Limitations of the "Critical Transitions" Study

Only tenure-track faculty in Research I institutions

Only 6 STEM disciplines represented

Study is a 2-year snapshot, not longitudinal

No attrition data collected

Productivity data is not connected to P&T outcomes

No network centrality data collected

NJIT Faculty Data Collection

Scopus / Digital Measures

Faculty Network DB

Research Map Interface

Research Network Map: INTERESTS

Research Network Map: COLLABORATIONS

FACULTY MENTORING
DEPARTMENTAL MANAGEMENT

NSF Data Collection: A Modest Proposal

NSF/ISI Web of Science: Publications Data

Advance Projects: Indicator Data

NSF

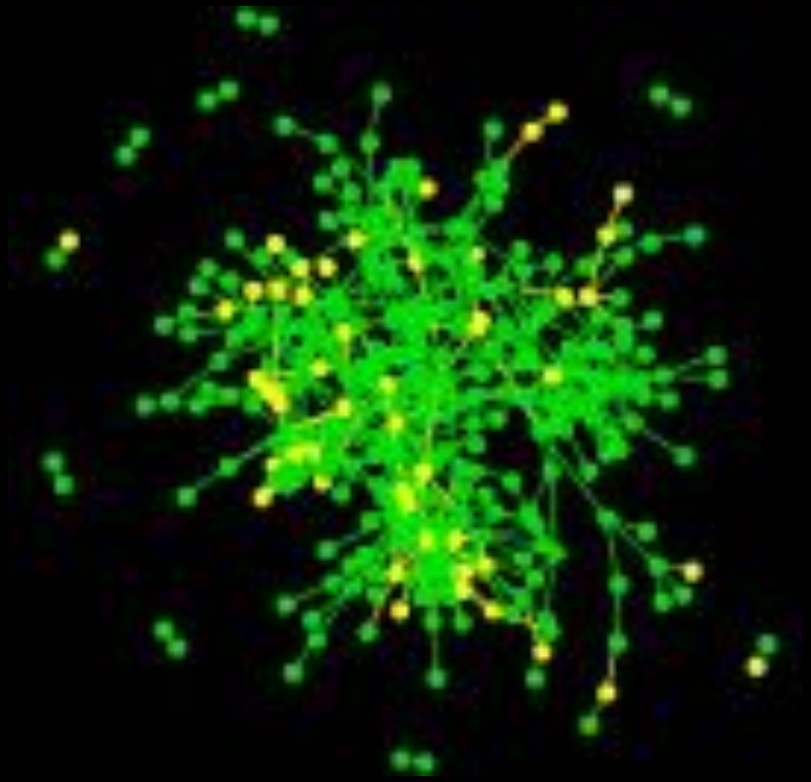
Faculty Analytics DB

Research Map Interface

Research Map: INTERESTS

Research Map: COLLABORATIONS

FACULTY MENTORING
DEPARTMENTAL MANAGEMENT
PROJECT ASSESSMENT



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NJIT New Jersey's Science & Technology University

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