

<FEATURES>

Six Degrees of Mohamed Atta

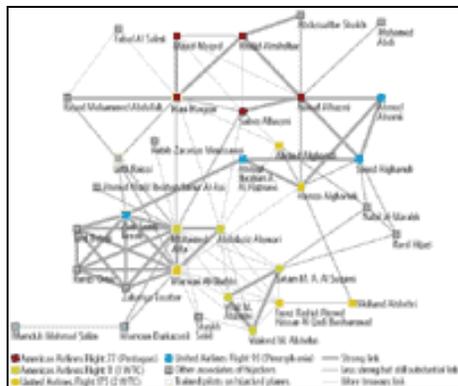
By: [Thomas A. Stewart](#)

Issue: December 2001

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Good maps are underappreciated in times of war, as the world was reminded by the inadvertent U.S. bombing of the Chinese embassy in Belgrade in 1999, the result of attack planners' reliance on an out-of-date street map. Maps play a particularly vital role in netwar: If you can accurately map a network, you can figure out how to break it apart.

The illustration here is based on social network theorist Valdis Krebs's [examination of the interrelationships](#) between the 19 hijackers aboard the planes used in the Sept. 11 attack and 15 people authorities say are connected with them. Employing proprietary software called InFlow, normally used to help companies improve communication, Krebs entered every publicly disclosed contact between people in the network. He then dated and weighted the contacts. Strong ties -- such as sharing a house or attending the same flight school -- got more weight than weak ones such as telephone calls. (Not everyone listed is necessarily a terrorist, of course; some of the contacts may have been innocent.)



[Click to see enlarged map.](#)

When all the data was entered, the software drew a picture. It shows every direct contact between network members: Mohamed Atta, for example, is known to have been in touch with 16 others, with strong links (the thicker lines) to 6. Mohamed Abdi, by contrast, has just one known link, of medium strength.

InFlow also analyzes and clusters the nodes in the network -- that is, the people -- according to three measures. One is "degrees," or activity, which measures the number of times someone contacts others in the network. A second is "betweenness." For example, there appears to have been no direct link between Abdulaziz Alomari and Ziad Jarrah; Atta and Marwan Al-Shehhi stood between them. The more often someone is in that "between" position, the more control he exercises in the network. The third attribute is "closeness," which measures the extent to which a person has direct contact with others, with no go-between; this is another clue to how important an individual is to the network.

The map is the software's attempt to make a picture that takes all three attributes into account. It is not a

complete picture; among other problems, it shows only those links that have been publicly disclosed. Still, it's possible to make some interesting inferences. First, the greatest number of lines lead to Atta, who scores highest on all three measures, with Al-Shehhi, who is second in both activity and closeness, close behind. However, Nawaf Alhazmi, one of the American Flight 77 hijackers, is an interesting figure. In Krebs's number crunching, Alhazmi comes in second in betweenness, suggesting that he exercised a lot of control, but fourth in activity and only seventh in closeness. But if you eliminate the thinnest links (which also tend to be the most recent -- phone calls and other connections made just before Sept. 11), Alhazmi becomes the most powerful node in the net. He is first in both control and access, and second only to Atta in activity. It would be worth exploring the hypothesis that Alhazmi played a large role in planning the attacks, and Atta came to the fore when it was time to carry them out.

It's also clear that this network would have been hard to dismantle. A hub-and-spoke network, where there is no contact between nodes except through a central figure, is an easy target: If just the central node is destroyed, the network disintegrates. Network analysts say a highly centralized network typically can be taken down by eliminating about 5 percent of the nodes. But the diffuseness of the hijacker network means that it won't suffer significant damage until the six nodes with the most numerous and important connections -- 21 percent of the group -- are removed. ♦

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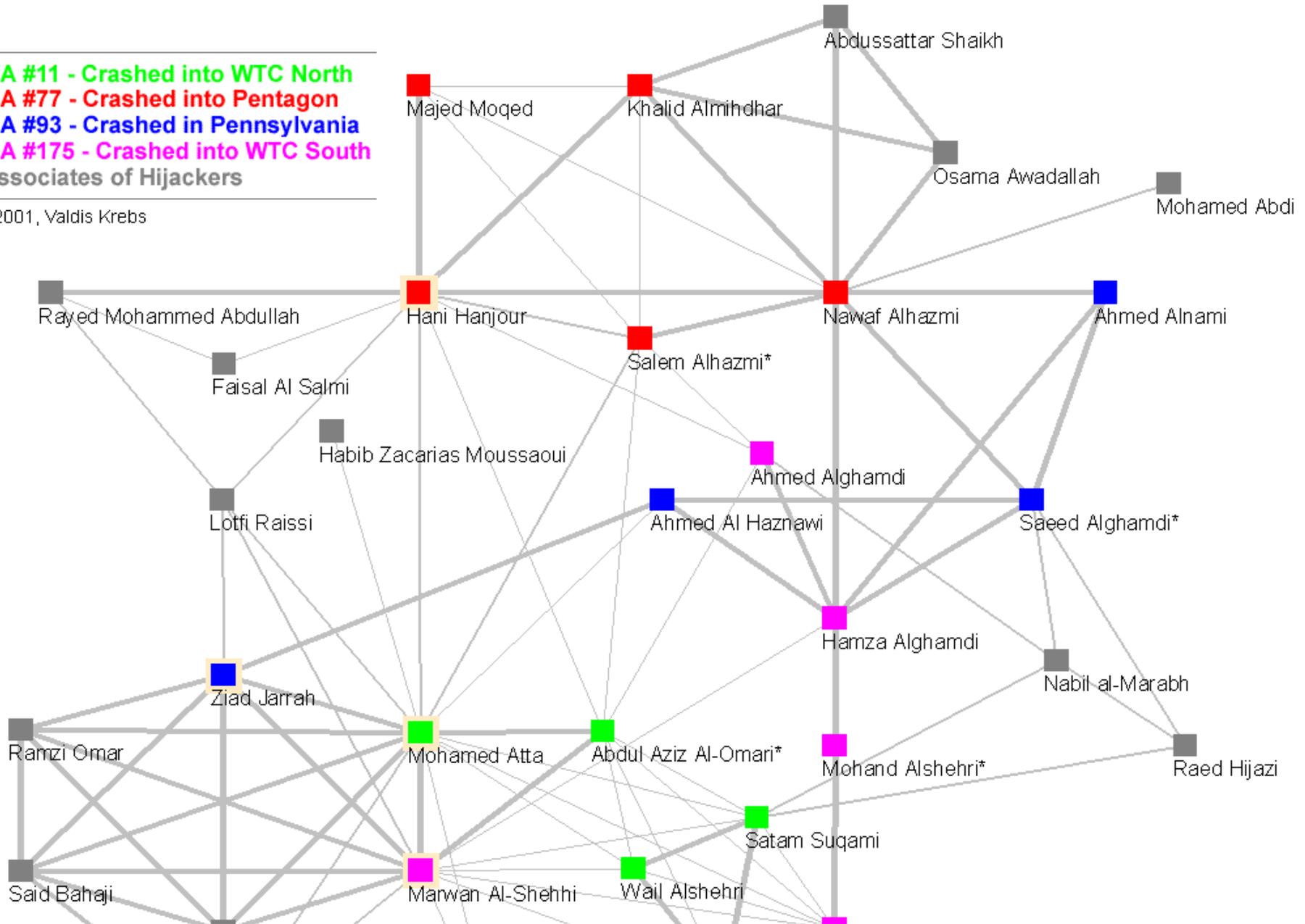
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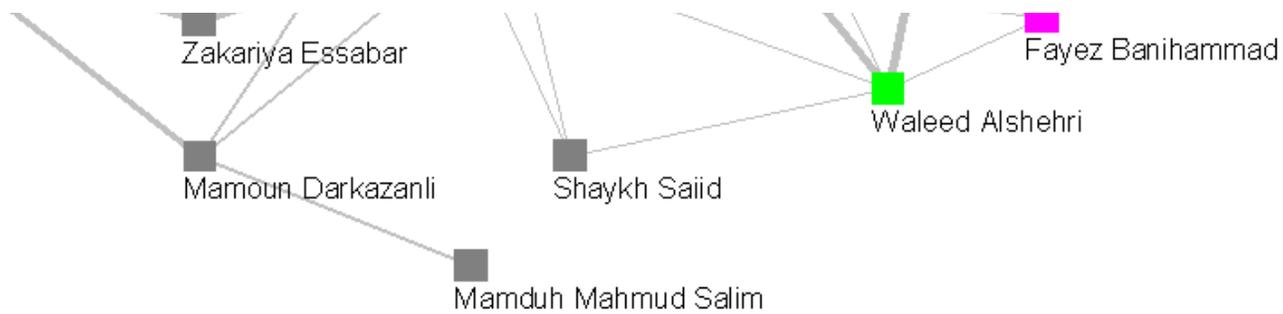
Terrorist Network of 19 Hijackers

Based on public data available from news sources on, or before, Oct 22, 2001

- Flight AA #11 - Crashed into WTC North
- Flight AA #77 - Crashed into Pentagon
- Flight UA #93 - Crashed in Pennsylvania
- Flight UA #175 - Crashed into WTC South
- Other Associates of Hijackers

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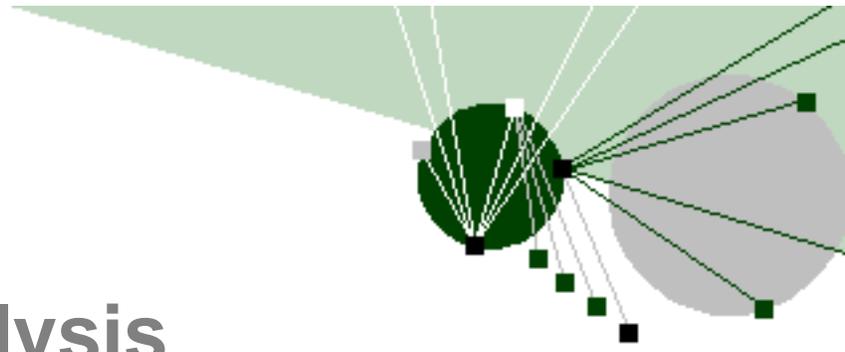




More information about terrorist networks...

- [Social Network Analysis](#)
- [Business 2.0 - Six Degrees of Mohamed Atta](#)
- [Business 2.0 - Netwar: Network vs Network](#)

An Introduction to Social Network Analysis

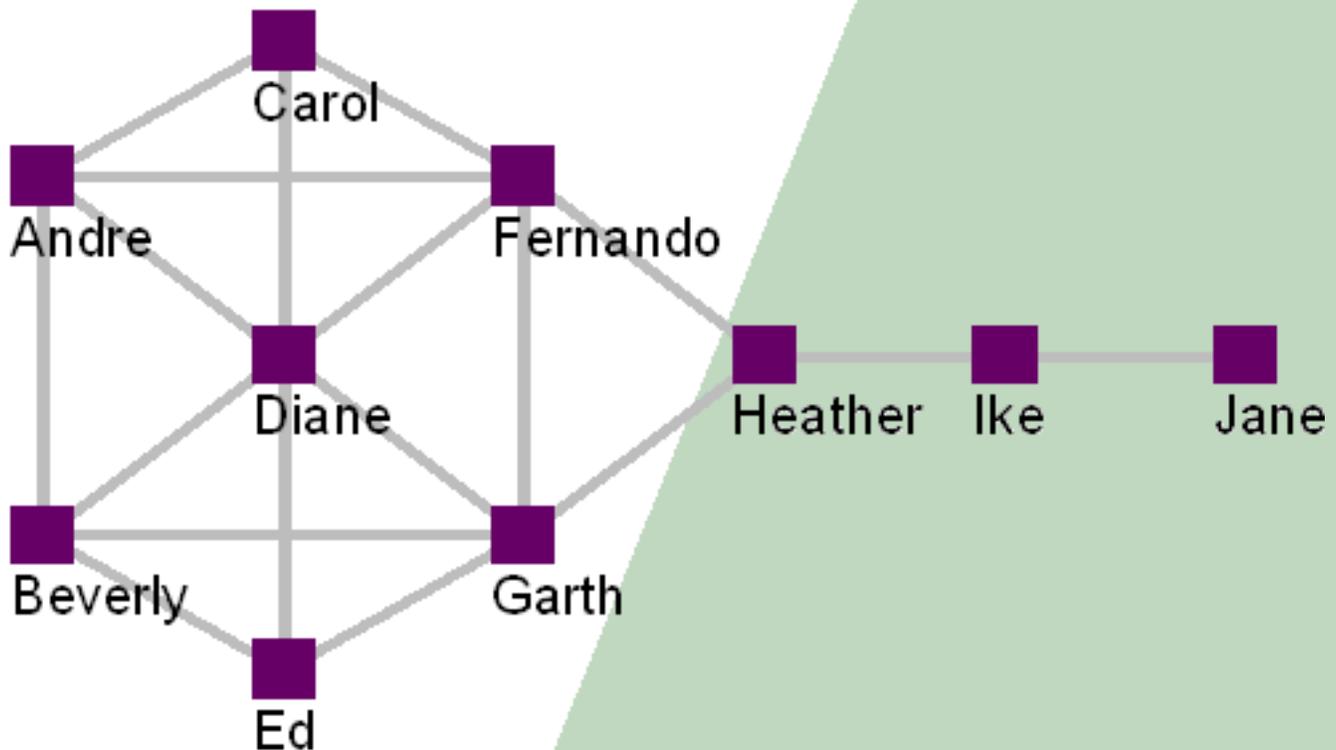


Social network analysis [SNA] is the mapping and measuring of relationships and flows between people, groups, organizations, computers or other information/knowledge processing entities. The nodes in the network are the people and groups while the links show relationships or flows between the nodes. SNA provides both a visual and a mathematical analysis of complex human systems.

One of the methods used to understand networks and their participants is to evaluate the location of actors in the network. Measuring the network location is finding the *centrality* of a node. These measures help determine the importance, or prominence, of a node in the network.

We will look at a social network, called the "Kite Network", first developed by David Krackhardt, a leading researcher in social networks. This network effectively shows the

distinction between the three most popular centrality measures: Degrees, Betweenness, and Closeness.



Degrees

Social network researchers measure network activity for a node by using the concept of degrees -- the number of direct connections a node has. In the kite network above, Diane has the most direct connections in the network, making hers the most active node in the network.

Common wisdom in personal networks is "the more connections, the better." This is not always so. What really matters is where those connections lead to -- and how they

connect the otherwise unconnected! Here Diane has connections only to others in her immediate cluster -- her clique. She connects only those who are already connected to each other.

Betweenness

While Diane has many direct ties, Heather has few direct connections -- fewer than the average in the network. Yet, in many ways, she has one of the best locations in the network -- she is a boundary spanner and plays the role of 'broker'. She is between two important constituencies.

The good news is that she plays a powerful role in the network, the bad news is that she is a single point of failure. Without her, Ike and Jane would be cut off from information and knowledge in Diane's cluster. A node with high betweenness has great influence over what flows in the network.

Closeness

Fernando and Garth have fewer connections than Diane, yet

the pattern of their direct and indirect ties allow them to access all the nodes in the network more quickly than anyone else. They have the shortest paths to all others -- they are close to everyone else.



They are in an excellent position to monitor the information flow in the network. They have the best visibility into what is happening in the network.

Network Centralization

Individual network centralities provide insight into the individual's location in the network. The relationship between the centralities of all nodes can reveal much about the overall network structure. A very centralized network is dominated by one or a few very central nodes. If these nodes are removed or damaged, the network quickly fragments into unconnected sub-networks.

Highly central nodes can become critical points of failure. A network with a low centralization score is not dominated by one or a few nodes. Such a network has no single points of failure. It is resilient in the face of many local and random failures -- many nodes or links can fail while allowing the

remaining nodes to still reach each other over new paths.

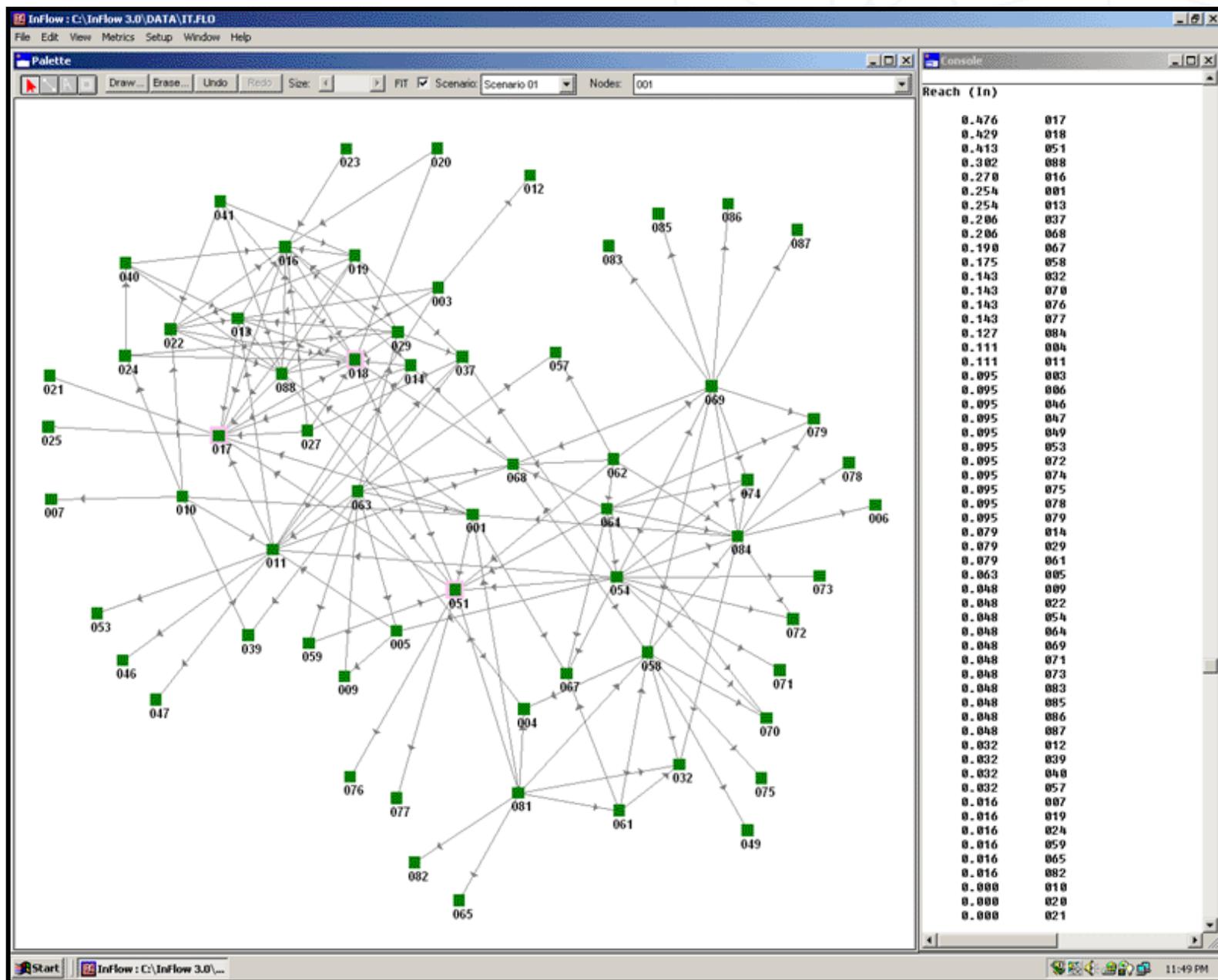
Other Network Metrics

1. **Structural Equivalence** - determine which nodes play similar roles in the network
2. **Cluster Analysis** - find cliques and other densely connected emergent clusters
3. **Structural Holes** - find areas of no connection between nodes that could be used for advantage or opportunity
4. **Network Structure** - find patterns of connectivity that reveal strengths, weaknesses and other insights into the behavior of the total network

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InFlow 3.0 - Network Mapping Software



InFlow is designed for consultants, by consultants. InFlow has been used to map and measure organizational networks since 1988! The InFlow screen above shows an I/T organization and how employees seek knowledge and assistance from each other. InFlow has been successfully applied in the following projects...

- Knowledge Management
- Post-Merger Integration
- Organization Design

- Workforce Diversity
- Team Building
- Internetwork Design
- Network Vulnerability Assessment
- Industry Ecosystem Mapping
- Diffusion of Innovation
- Community Development
- Building Productive Networks
- Mapping Terrorist Networks

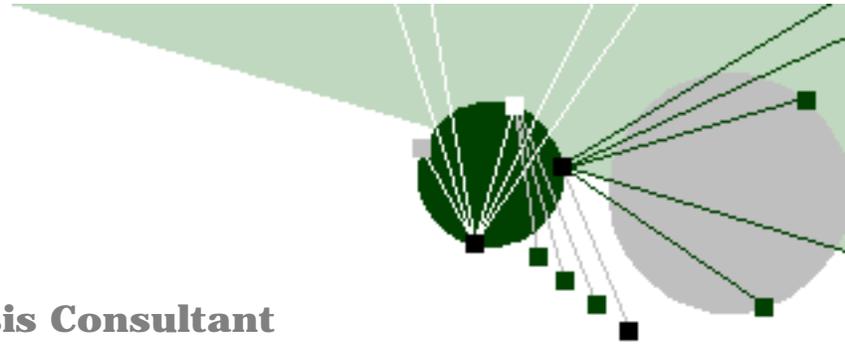
Version 3.0 provides new metrics, new network layouts, new what-if analysis, and is designed to work with Microsoft Office and the WWW.

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Valdis Krebs

Organizational Network Analysis Consultant



Valdis provides social network analysis software and services to organizations and their consultants.

Explore how these organizations have benefited from the value of network analysis: IBM, TRW, Raytheon, Boeing, Lucent, Chrysler, Rubbermaid, Hiram-Walker, Aventis, Cardinal Health, Ohio Department of Education, PricewaterhouseCoopers, Ernst & Young, ACEnet and others...

- [InFlow 3.0](#) - New version of network mapping software -- available soon!
- The Corporate Leadership Council describes Organizational Network Mapping -- *The most accurate, systematic means yet seen to identify key value creators and informal knowledge communities that drive corporate core competencies* [\[PDF\]](#)
- [Manage](#) connected assets -- make the right people connections to create an agile organization that thrives on innovation.

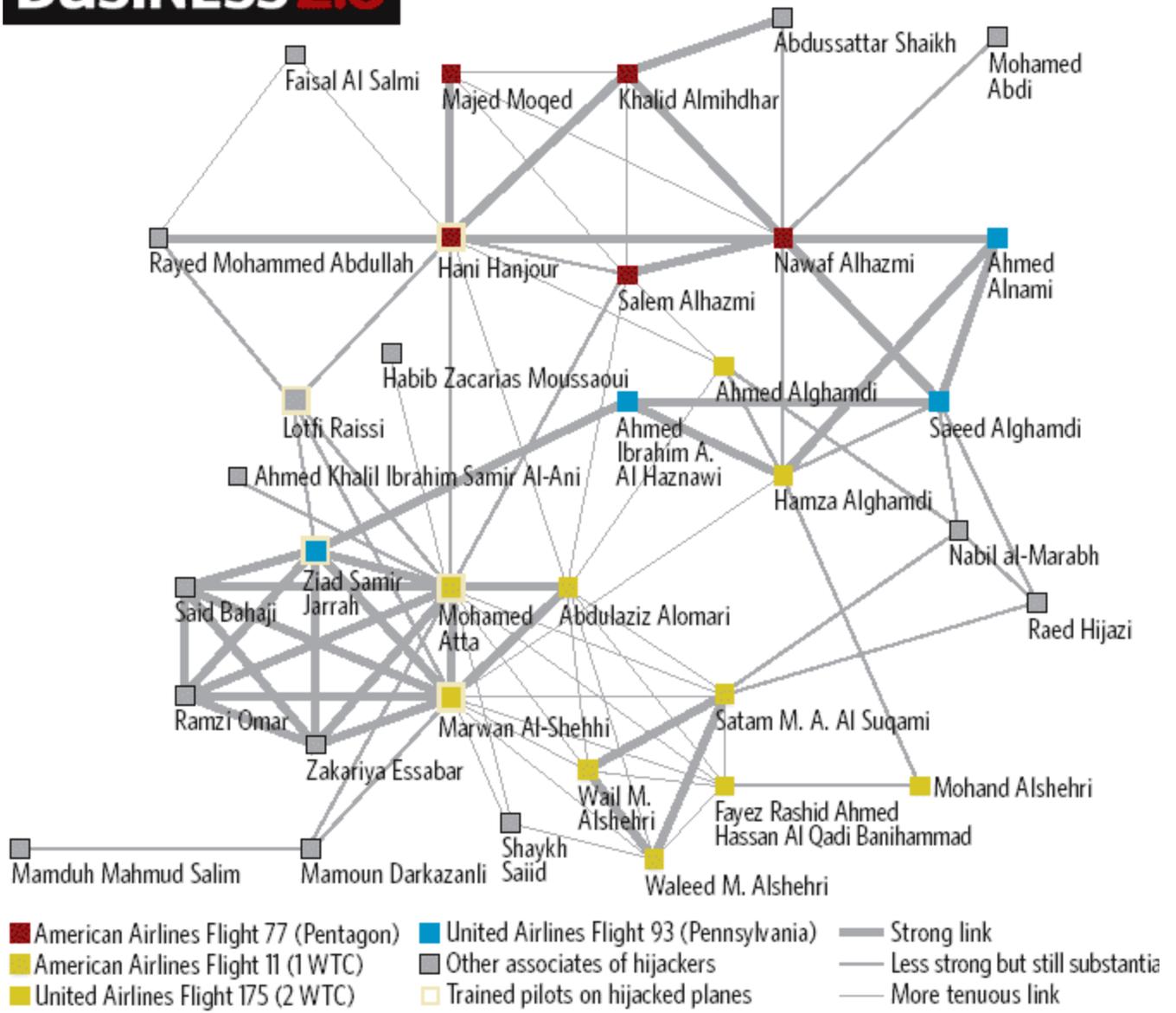
- [Expose](#) the structure of terrorist networks; view [network](#) of 19 hijackers.
- [Map and Measure](#) knowledge sharing and exchange in your organization.
- [Build](#) resilient computer networks using network analysis. [\[PDF\]](#)
- [Locate](#) expertise and knowledge communities in your organization.
- [Examine](#) emergent purchasing patterns on the WWW.
- [Discover](#) the *real* structure of the Internet industry.
- [Introduce](#) yourself to Social Network Analysis.
- [See](#) knowledge networking in your company.

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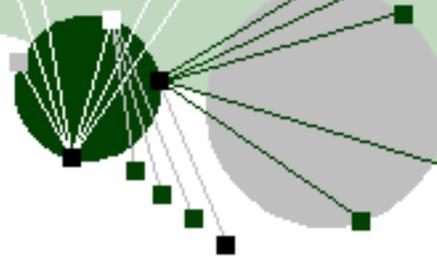
BUSINESS 2.0



Working in the Connected World

Managing Connected Assets

by *Valdis E. Krebs*



If knowledge is power, what is connected knowledge?

The new economy operates on the complexities of connections. Human resource (HR) professionals in the past focused solely on the individual and recently on collections of individuals called teams. The economics of networks has no place for independent (i.e., unconnected) objects whether they are individuals, teams or computer systems. All individuals, communities, systems, and other business assets are massively interconnected in an evolving economic web. No man, woman, team, or organization is an island. In the connected economy, each network actor (individual, team, or organization) is embedded in a larger economic system that affects each participant and, in return, is influenced by each participant. In such an interdependent system we can no longer focus on individual or single team performance. If they are to be effective in improving the effectiveness of their organizations, HR professionals must see that they are helping to manage connected assets, not unconnected individuals.

Efforts at making sense of this new world are beginning to reveal some basic principles at work in the complex adaptive systems we call our organizations, work groups, and economic webs.

*"There is a central difference
between the old and new
economies: the old industrial
economy was driven by
economies of scale; the new
information economy is driven by
the economics of networks..."*

Information Rules by Carl Shapiro,

Hal R. Varian

Recent research on productivity and effectiveness in the knowledge economy provides insight into what works in the connected workplace.

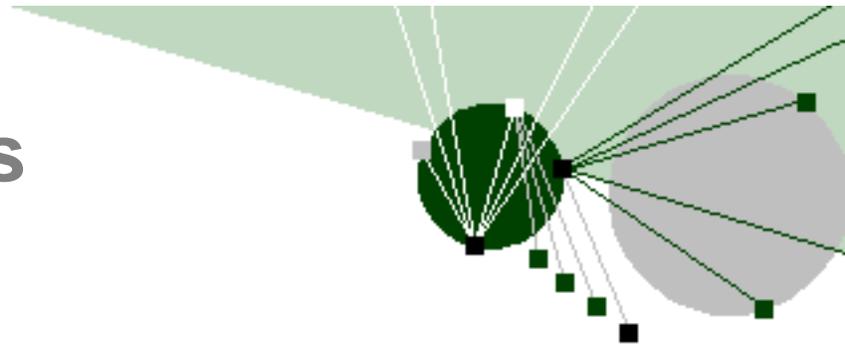
Certain patterns of connections appear around both effective individuals and successful teams when performing knowledge work. Other research shows us how to provide the 'missing links' that change a poor economic network into a better conduit for information, influence, and knowledge.

- **Introduction**
- **[Social Capital - Improving Individual Effectiveness](#)**

- [Improving Team Effectiveness](#)
- [Improving Information Flow](#)
- [Leading Edge HR](#)

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Disrupting Networks of Terrorist Cells



Know Your Enemy

What do terrorist networks look like? How do they operate? How do they communicate? How can we analyze them? What are their weaknesses? How can we build counter-measures and ultimately how can we disrupt and dismantle them?

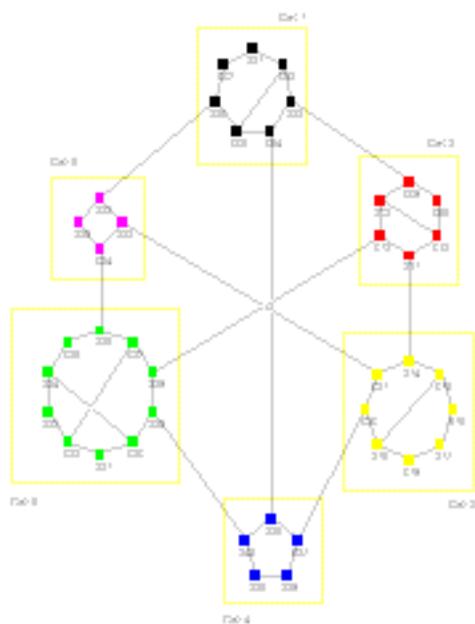
A covert network must meet three competing goals...

1. Establish efficient communication and information flow within and between many cooperating cells by minimizing path length throughout the network.
2. Limit discovery and monitoring of the network from outsiders by minimizing the number of communication links in the network.
3. Limit damage when a node is discovered or removed from the network by minimizing the number of direct ties each node has.

Because of these constraints, covert networks have a different topology than normal social networks. *Illegal networks tend to exchange efficiency for secrecy.*

Map the Network

In the example below each node represents a terrorist. The node color can represent a terrorist's geographic location, nationality, blood relations, or group affiliation. In this example a grey line between two nodes represents a task-related communication link -- who interacts with whom to plan and carry out terrorist acts. For simplicity, links to outside resources and the leadership network are not shown.



[Click to Enlarge](#)

This network meets the 3 competing goals...

- The average path length in the network is kept low through the judicious use of 'short-cuts' between cells. Shorter path lengths between all nodes usually support faster and less distorted communication.
- No extraneous links exist. There is redundancy in the network to compensate for links that are

damaged or removed -- but it is kept to a minimum.

- Each node has a maximum of 3 network neighbors, new nodes in the network have only two. This limits exposure if a terrorist is captured.
- Examine the [network metrics](#)...

Monitor the Network

If the goal is not to destroy the network immediately, the network can be used to gather intelligence on the enemy -- using an enemy's own assets against them! Nodes 028, 021, 029, 004, 014, and 020 have the quickest access to the rest of the network. They can reach the most nodes in a minimum number of steps. They are listening posts... but also access points for injecting misinformation. Monitoring multiple nodes will improve knowledge of what is happening in the network. Multiple monitoring points may also reveal potential conflicts in the network that can be used to advantage.

Disrupt the Network

Disrupting a network requires removing the best-connected nodes. We measure the network and see that node 036 is

the 'best-connected'-- removing it, we re-measure the network and find node 023 is now the best-connected. We iteratively remove 5 nodes, [036, 023, 012, 020, 006] and the network splits in two. We remove 4 more nodes [029, 014, 033, 026] and the network is now completely fragmented -- no cell can reach any other cell. We have to remove 9 nodes, 22.5%, to accomplish this. This is a resilient network. A more centralized network would have fragmented with about 5% of its best-connected nodes removed. *A network's topology determines how easy it is to disrupt and dismantle!*



Complex Dynamic Organization

We have examined one facet of a terrorist organization -- the communication links that plan and perform terrorist acts. To get a more complete picture we need to map other links such as financial flows, kinship ties, work/school/event ties, and trusted prior contacts.

We also learned from the 9.11 attacks that the network becomes very active right before a planned event. As activity increases, new links emerge and existing links carry more volume. The covert network now takes on the structure of a

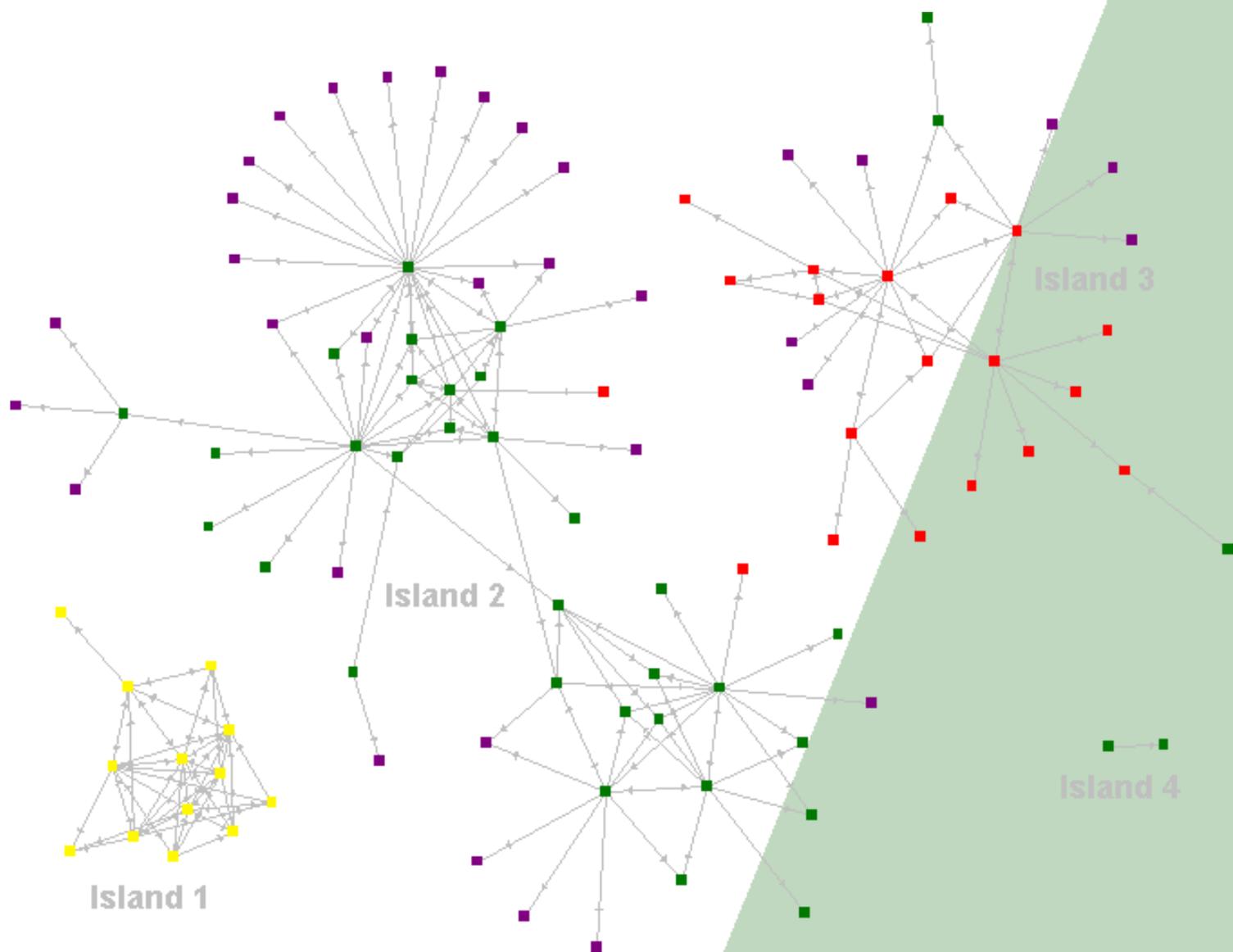
more common social network. This is when the network is most vulnerable and open to discovery. Unfortunately this phase of increased activity does not last long and ends tragically.

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Mapping Knowledge Networks

Knowledge Sharing Among High Tech Workers



Each node in the network represents an employee in this organization. Employee names are hidden for privacy. A gray line is drawn between two employees if they share specific knowledge and information. Node colors designate departmental membership -- some departments interact [green and purple], others remain isolated [yellow].

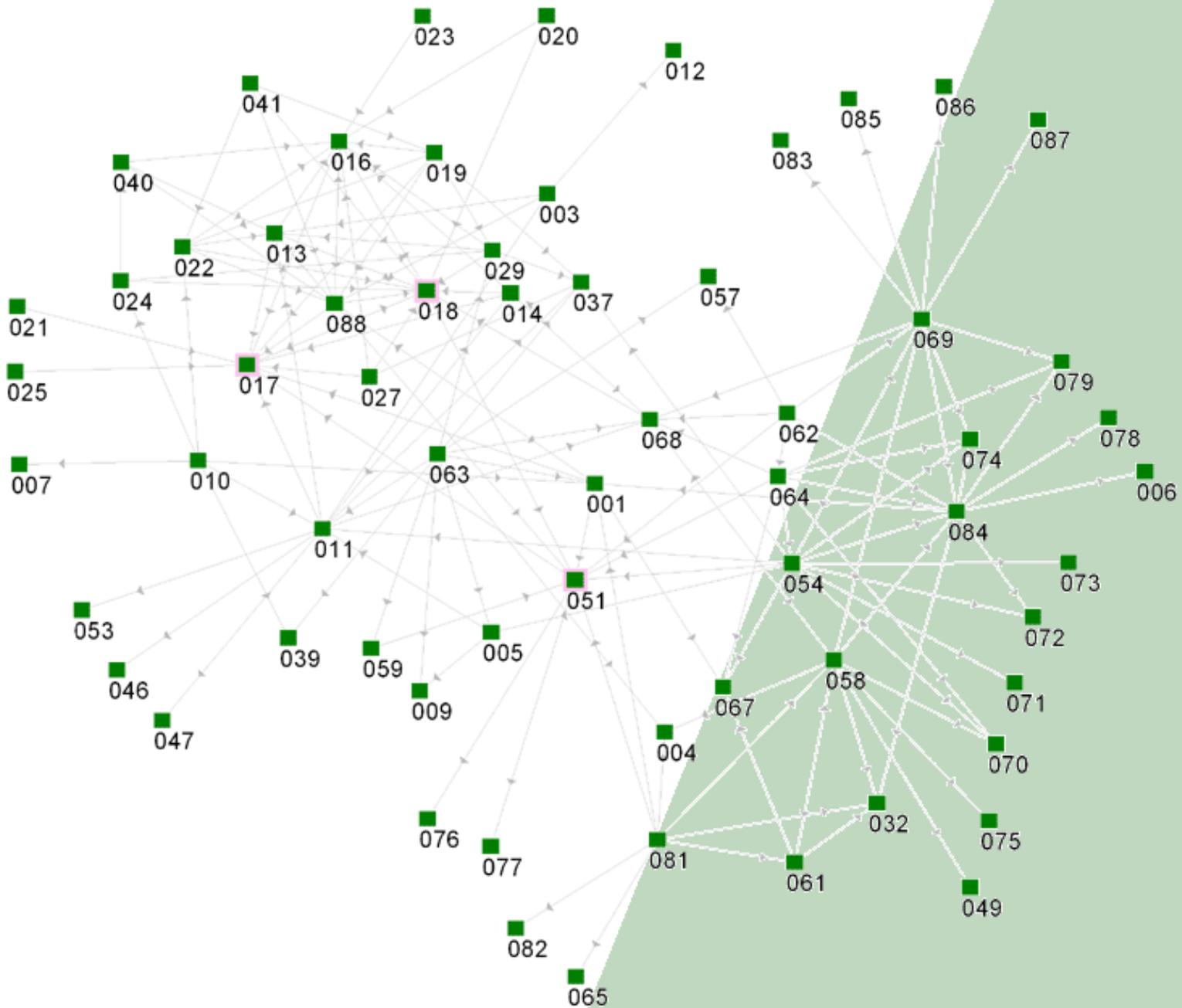
Notice the fragmentation -- there were four islands of knowledge in this organization. After seeing this *organizational x-ray*, management started to connect key individuals who acted as bridges between the islands. Soon there were exchanges between the clusters and the cross-pollination of knowledge and ideas ignited innovation.

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[Home](#) | [Contact](#) | [Organizational X-Ray](#)

Locating Expertise in Your Company

Who does everyone go to for... ?



Each node in this knowledge network represents an employee in this I/T organization. Employee names are hidden for privacy. A gray, directed line is drawn from the seeker of knowledge to the source of expertise. Those with many arrows pointing to them are sought out often for assistance and advice. Yet, they

may not be the deep experts in the organization.

Three key experts in this I/T organization's knowledge network are highlighted in pink [nodes 017, 018, 051]. They were discovered by calculating network metrics that look at both direct *and* indirect links in the network. The algorithm is similar to how the Google search engine ranks web pages.

This knowledge network was easily and quickly created by querying the organization using Knetmap™ -- developed in partnership with Know Inc. Employees of an organization answer simple email-delivered questions about their work -- Question of the Week™. This data is visualized in a Knetmap web page to show *who goes to whom* for knowledge in the organization. Knetmap also tracks the knowledge artifacts that are created, combined, and re-combined in knowledge work. In-depth network analysis is performed using [InFlow](#), with data directly from Knetmap.

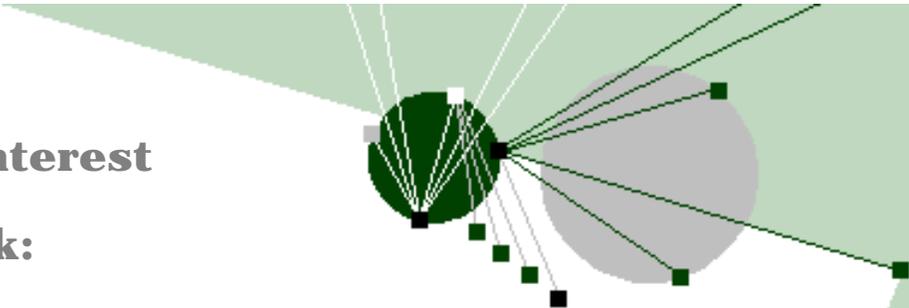
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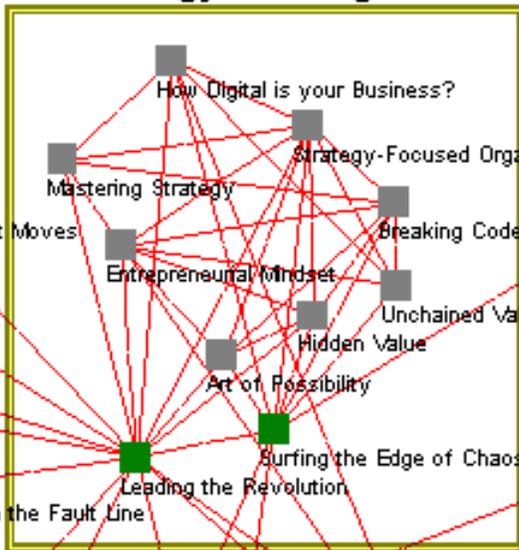
Emergent Communities of Interest

Around the Best-selling Book:

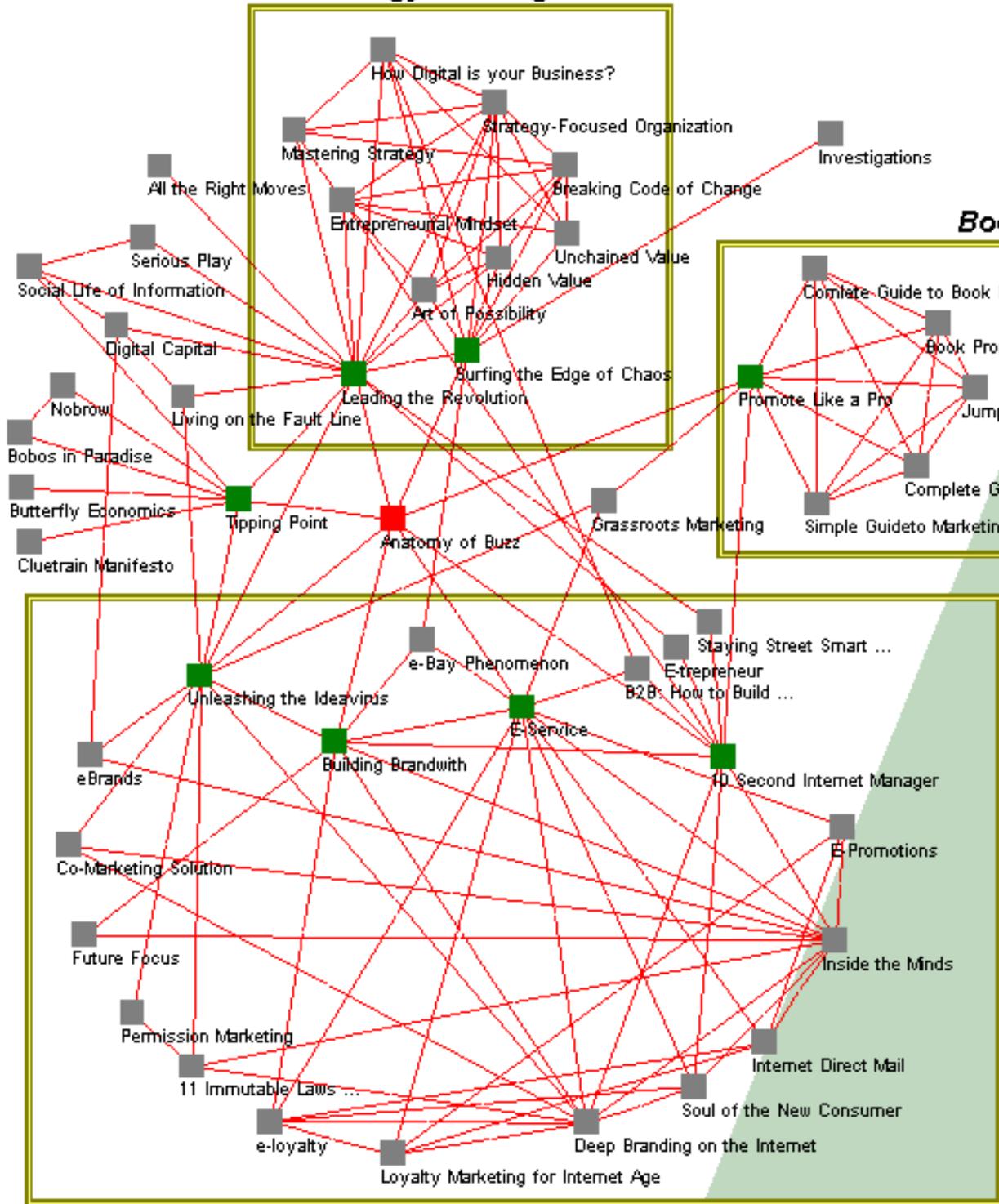
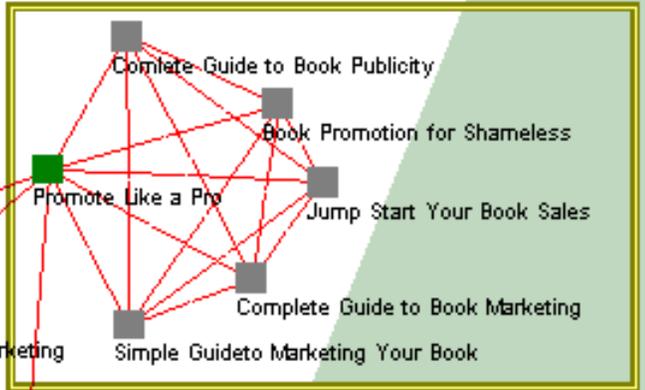
The Anatomy of Buzz



Strategy & Change Cluster



Book Promo Cluster



Internet Marketing Cluster

A red line is drawn between two nodes[books] if they were bought together at a major web bookseller -- these relationships are derived from buying behavior. The red node is our focus book, the green nodes are tied directly[1 step] to our focus book, while the grey nodes have an indirect relationship[2 steps] to *Buzz*. All these books are considered within the network neighborhood[community of interest] of *Buzz*.

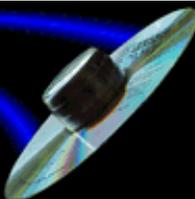
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...Thinking Software

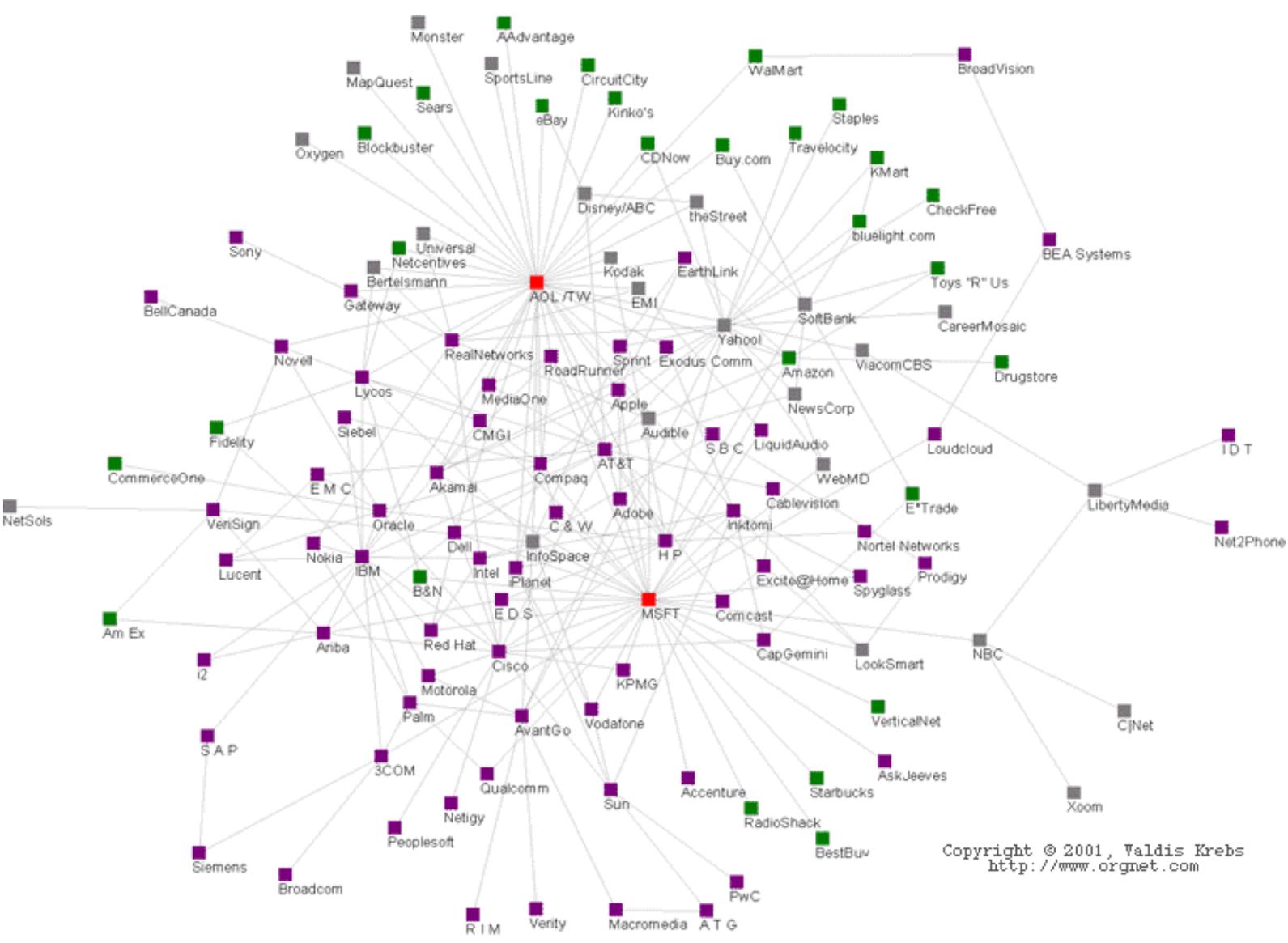


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Internet Industry Partnerships

Strategic Alliances & Joint Ventures

Last Updated: June 21, 2001



Each node in the network represents a company that competes in the Internet industry. Two companies are connected with a grey line if they have announced a joint venture, strategic alliance or other partnership.

Two firms, AOL-TW and Microsoft are colored red -- they are in *positions of power* in this network. Positions of power are calculated from the overall pattern of connections in this network.

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Knowledge Networks

Mapping and Measuring Knowledge Creation and Re-Use

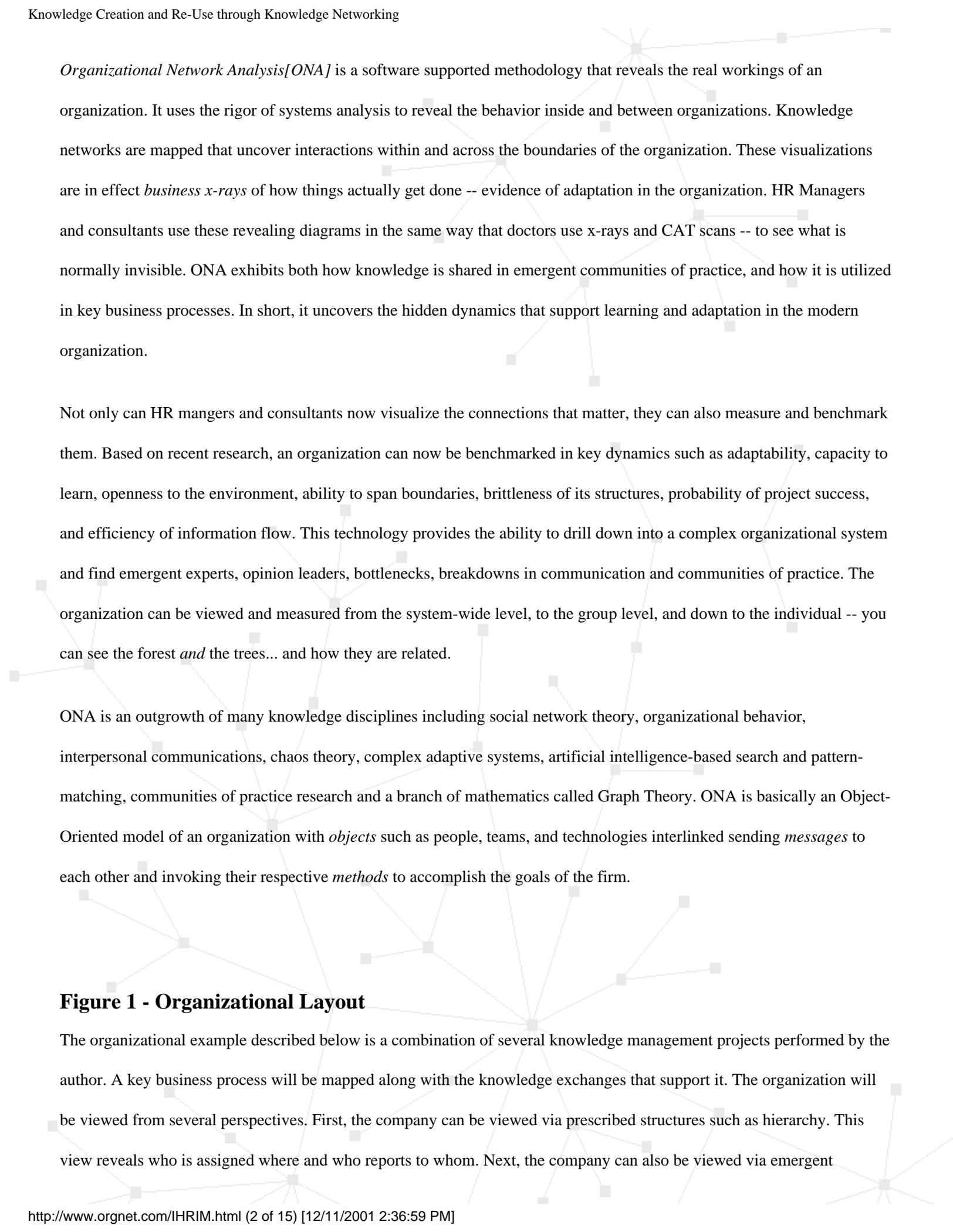
by Valdis Krebs

No one doubts that better management of knowledge within the firm will lead to improved innovation and competitive advantage. Everyone agrees on the goal -- better utilization of internal and external knowledge. It is the approach to this goal that is hotly debated. Many vendors and consultants push a technology-driven approach. "Buy our state-of-art knowledge storage system and you will never again lose knowledge that is vital to the company!", they exclaim. Other consultants emphasize the soft-side of Knowledge Management. "Create a learning culture, that rewards sharing, and knowledge management will take care of itself!", they postulate. There are no silver bullets. Not from the technologists. Not from the culture prophets.

The effective utilization of knowledge and learning requires *both* culture and technology. Explicit information and data can be easily codified, written down, and stored in a data base. For this type of business information we have the necessary skills and more than adequate tools. Yet, simple data is frequently *not* where competitive advantage is found. An organization's real edge in the marketplace is often found in complex, context-sensitive, knowledge which is difficult, if not often impossible to codify and store in ones and zeroes. This core knowledge is found in individuals, communities of interest and their connections. An organization's *data* is found in its computer systems, but a company's *intelligence* is found in its biological and social systems. Computer networks must support the people networks in today's fluid and adaptive organizations -- not the other way around.

Visualizing Knowledge Networks

The organization chart has been a staple in the Human Resource[HR] department. It displays *who works where* and *who reports to whom*. This was sufficient knowledge in a time when organizations faced gradual change. These charts were tools for *control* and *planning*. Today's fluid business environment does not allow only static structures and does not reward those that follow prescribed configurations in the face of rapid change. The fast economy requires flexible, adaptive structures that self-organize internally in response to changes externally. In this knowledge-critical economy we need charts to show us *who knows what* and as a complement *who knows who*. In addition to pictures of hierarchy we need visualizations of the massive interconnectivity that occurs in the learning systems that are our organizations.



Organizational Network Analysis[ONA] is a software supported methodology that reveals the real workings of an organization. It uses the rigor of systems analysis to reveal the behavior inside and between organizations. Knowledge networks are mapped that uncover interactions within and across the boundaries of the organization. These visualizations are in effect *business x-rays* of how things actually get done -- evidence of adaptation in the organization. HR Managers and consultants use these revealing diagrams in the same way that doctors use x-rays and CAT scans -- to see what is normally invisible. ONA exhibits both how knowledge is shared in emergent communities of practice, and how it is utilized in key business processes. In short, it uncovers the hidden dynamics that support learning and adaptation in the modern organization.

Not only can HR managers and consultants now visualize the connections that matter, they can also measure and benchmark them. Based on recent research, an organization can now be benchmarked in key dynamics such as adaptability, capacity to learn, openness to the environment, ability to span boundaries, brittleness of its structures, probability of project success, and efficiency of information flow. This technology provides the ability to drill down into a complex organizational system and find emergent experts, opinion leaders, bottlenecks, breakdowns in communication and communities of practice. The organization can be viewed and measured from the system-wide level, to the group level, and down to the individual -- you can see the forest *and* the trees... and how they are related.

ONA is an outgrowth of many knowledge disciplines including social network theory, organizational behavior, interpersonal communications, chaos theory, complex adaptive systems, artificial intelligence-based search and pattern-matching, communities of practice research and a branch of mathematics called Graph Theory. ONA is basically an Object-Oriented model of an organization with *objects* such as people, teams, and technologies interlinked sending *messages* to each other and invoking their respective *methods* to accomplish the goals of the firm.

Figure 1 - Organizational Layout

The organizational example described below is a combination of several knowledge management projects performed by the author. A key business process will be mapped along with the knowledge exchanges that support it. The organization will be viewed from several perspectives. First, the company can be viewed via prescribed structures such as hierarchy. This view reveals who is assigned where and who reports to whom. Next, the company can also be viewed via emergent

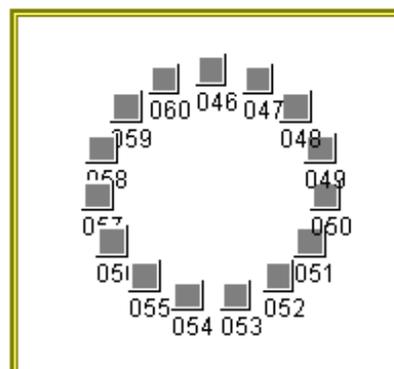
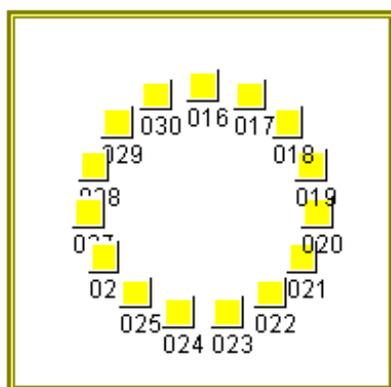
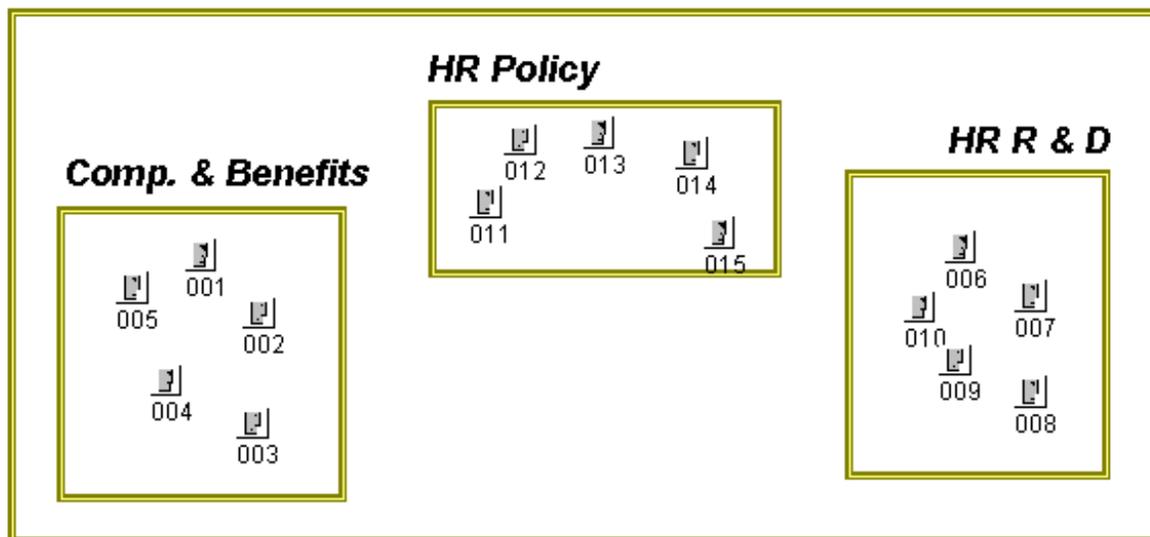
structures. These views reveal what happens in the white space [between the boxes] on the organization chart. The emergent views also show where certain knowledge is clustered in the organization.

The model organization in Figure 1 below is divided into four components:

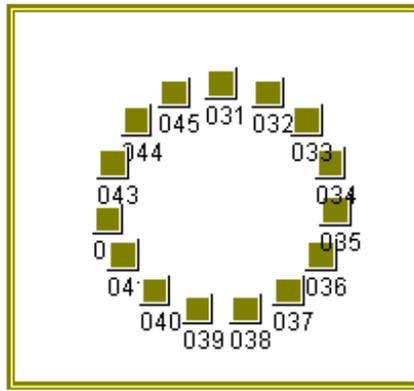
1. Corporate HR Office
 - o Compensation & Benefits
 - o HR Policy & Practice
 - o HR Research
2. Strategic Business Unit[SBU] 1 HR Office
3. SBU 2 HR Office
4. SBU 3 HR Office

The Corporate HR office is divided into the 3 departments that participate in a critical HR process. Five key knowledge areas that contribute to this process were uncovered from interviews with the client's employees. Employees names are replaced by numbers to maintain privacy of the study participants.

Corporate HR Office



SBU 1 HR Office



SBU 3 HR Office

SBU 2 HR Office

Figure 1 - Organization Layout

The first question that employees were asked was: "With whom do you exchange information, documents, and other resources in order to perform your role in HR business process X?" Below is a map of the work exchanges to execute this critical HR business process. These are all confirmed two-way [give and receive] interactions. The line thickness denotes intensity of relationship.

Corporate HR Office

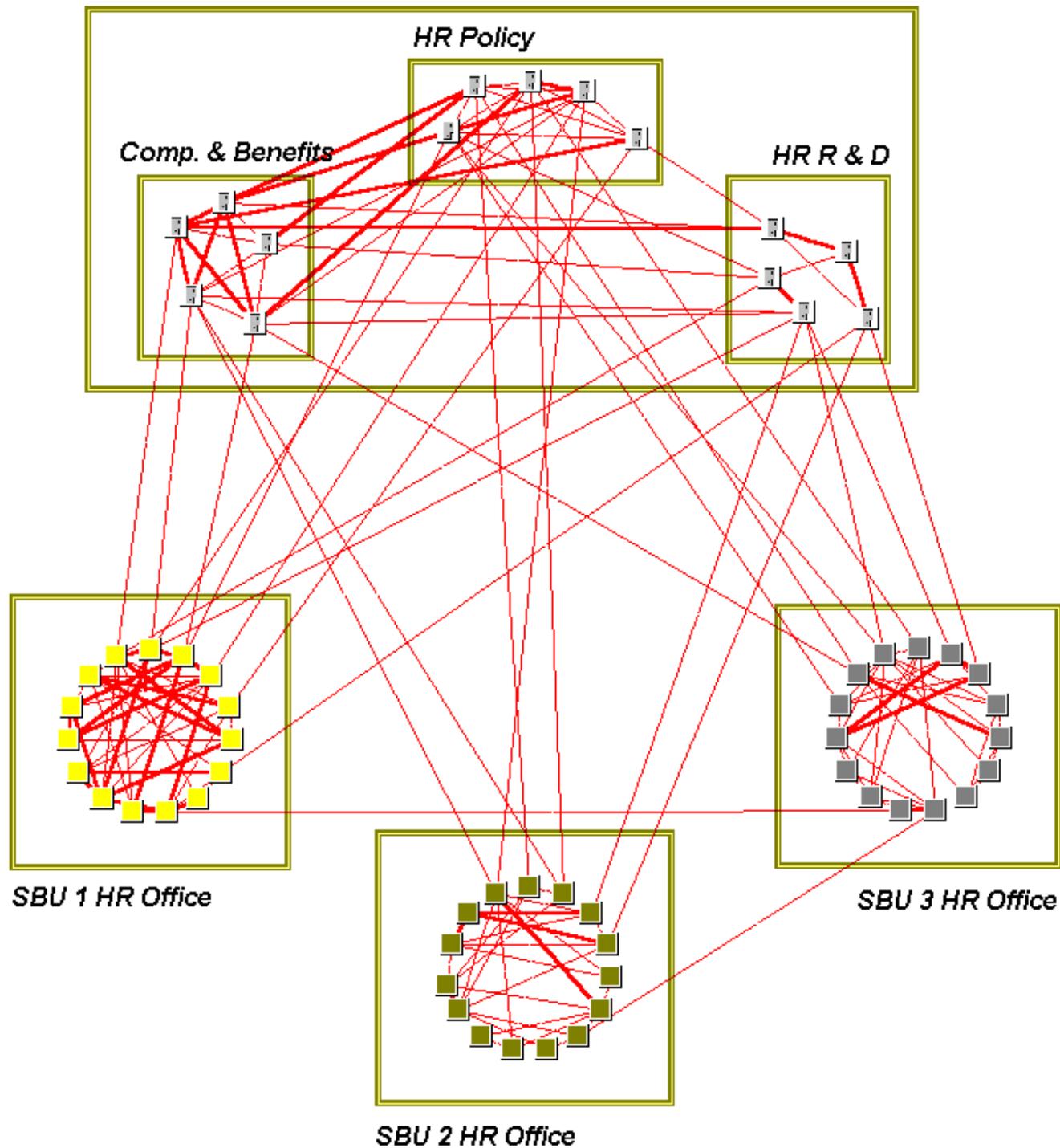


Figure 2 - Work Flow Network

Figure 2 - Work Flow Network

The formal organization structure supports the work flow for this business process -- most of the strong work relationships are within the functional walls of the prescribed organization. Compensation & Benefits and HR Policy are strongly interconnected and appear to be working as one unit in this process. The SBU's HR offices do not work with each other directly. Most of their interaction is with the corporate HR office. This revelation alarmed the Executive VP of Human Resources. All SBUs have similar missions and very similar employee populations -- they should be talking to each other about the changes in this key HR program. As a result of this finding the most central node in each SBU was invited to process change meetings together with the other SBUs so that knowledge and experience sharing relationships would start to develop.

The knowledge exchanges around this business process are mapped next. These links reveal who helps who learn and *make sense* of what is happening in this business process. This is a map of how expertise is shared. Nodes that are central in this network are the experts that are sought out for critical information and knowledge to complete this business process. Which nodes appear to be *'in the thick of things'* in the knowledge network in Figure 3 below?[See Table 1 for the answers] How does the work flow network compare with the knowledge exchange network?

Corporate HR Office

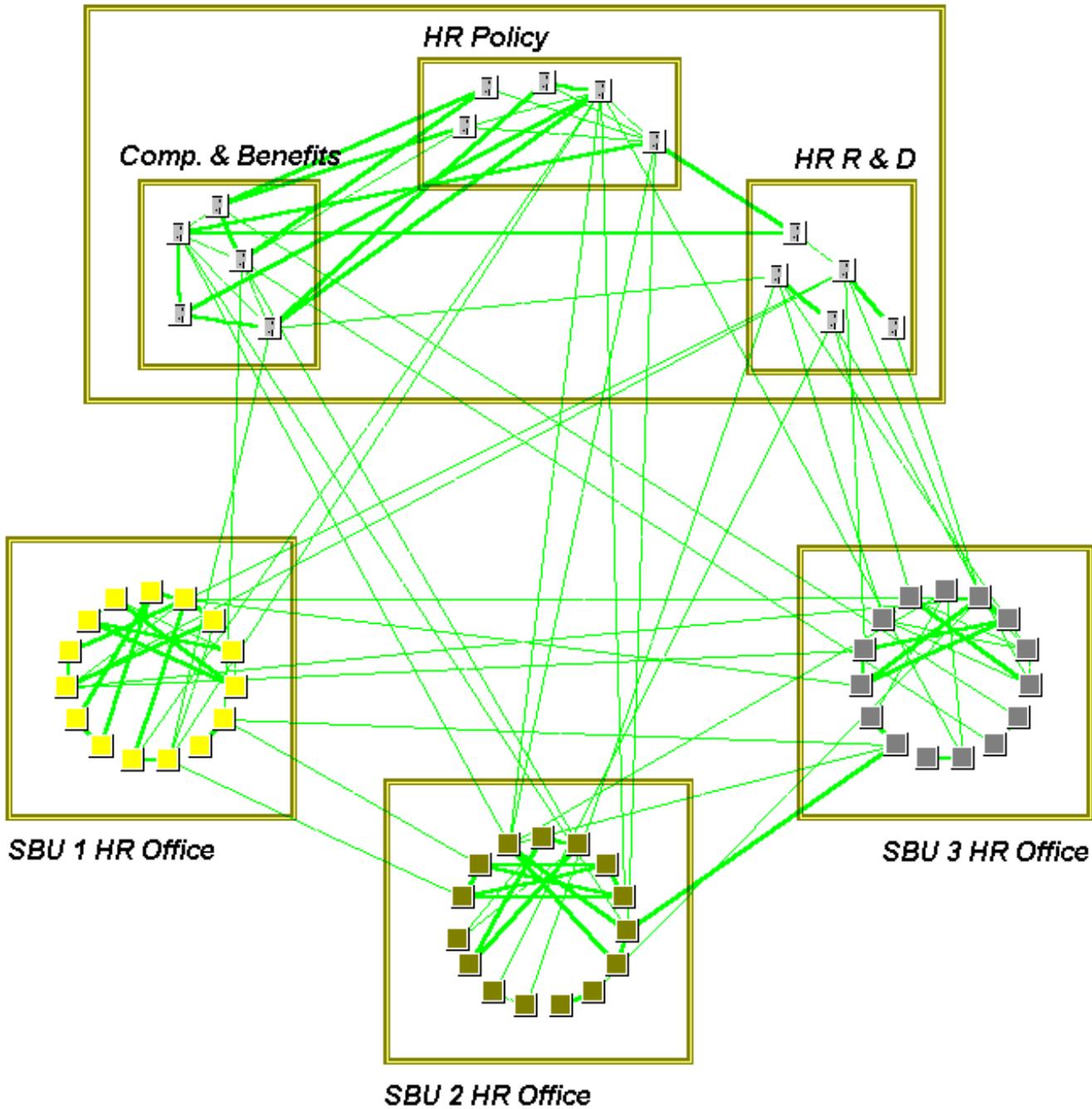


Figure 3 - Knowledge Exchange Network

Figure 3 reveals more inter-group connections -- knowledge necessary for this process is distributed

throughout the organization. A greater number of links between the SBUs are discovered. Yet, corporate seems to hold most of the knowledge to execute this process. R&D has fewer connections within the corporate office and is now well connected to SBU 3 whose HR programs are holdovers from its former parent company before it was acquired. They apparently need more interaction to adapt to this new program.

A cluster discovery algorithm is applied to the network data to see if this knowledge resides in emergent communities of knowledge [aka *communities of practice*]. Communities naturally self-organize naturally in companies around common problems, interests, customers, and complex knowledge areas. It is within these communities where core competencies of organizations are stored, shared, nurtured and enhanced. Individual learning is enhanced by being a member of one or more communities of practice.

Emergent communities have formed around the 5 knowledge areas. They are mapped in Figure 4 below. To identify who is from which organization the reader can refer back to Figure 3 to see which node color corresponds to which business unit. Employees from SBU 1 are connected to each other in Knowledge Community C and E but are not tied to community members from other organizations. Community fragmentation like this is found in both forming, and dissolving, communities. The communities in this organization were just forming in response to a changed environment and new direction from the HR VP.

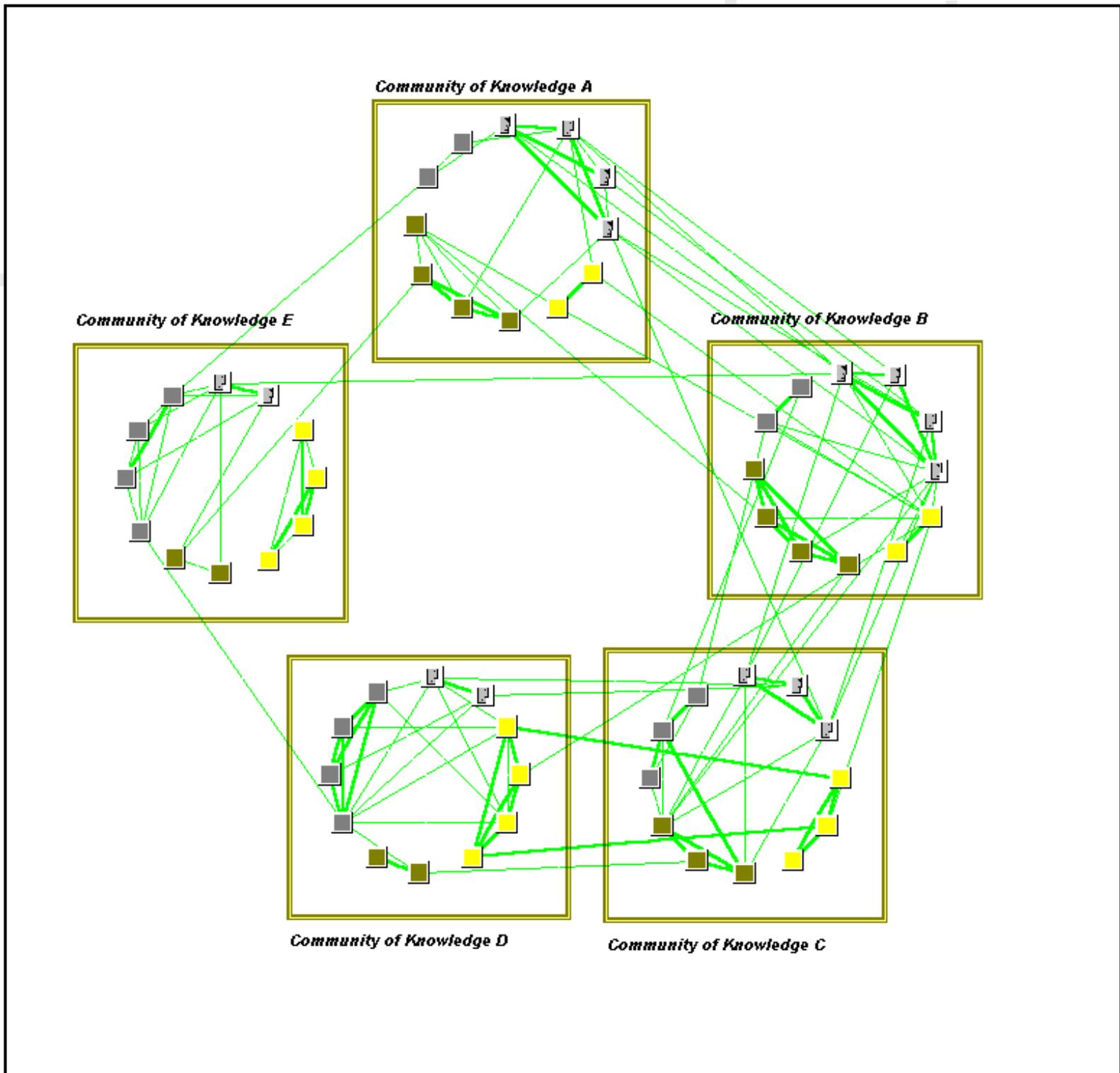


Figure 4 - Emergent Communities of Knowledge

Visualizations, like in Figures 1, 2, 3 and 4 above, give insight into complex human systems not readily available by other means. Even deeper insights can be gained from measuring these complex human structures. Networks can be measured on the individual, group, and system-wide basis. The focus here will be

on individual *network centrality*. This measure reveals which employees are key in the flow of information and exchange of knowledge. A central node is *in the thick of things* and has access to diverse network resources such as knowledge, support, and other hidden assets in the organization. Employees with high network centrality scores have a greater capacity to get things done.

Network Connectivity

Table 1 below contains measures of network centrality and activity in the network. Only the nodes with measures in the top tier are listed. The nodes are sorted in decreasing order. The nodes designated by **bold type** are effective networkers. They have attained network centrality without being overwhelmed by network activity. Their networks can be used as benchmarks when training other employees in building productive networks.

Work Flow Network		Knowledge Exchange Network	
<i>Network Centrality</i>	<i>Network Activity</i>	<i>Network Centrality</i>	<i>Network Activity</i>
009	017	001	023
003	023	003	003
014	018	013	014
013	025	014	015
012	028	002	045
016	003	055	012
004	012	012	009
015	013	004	047

045	016	031	005
002	027	032	002

Table 1 - Individual Network Measures

A common belief is that high network *activity* brings increased network benefits. This is not necessarily true. High network centrality *does* bring network benefits. Research has shown that employees who are central in key networks learn faster, perform better, and are more committed to the organization. These employees are also less likely to turn over. On the other hand employees with low centrality, those who are on the periphery, are much more likely to leave the organization. Project teams also benefit from being central in advice and expertise networks. Teams that are central in the organization's knowledge networks complete their tasks quicker than project teams who struggle to access the knowledge they need to perform their work.

The secret to network benefits is in the pattern of direct and indirect connections surrounding a node. It is the pattern of relationships, that a node is embedded in, that either constrain or enhance the ability to get things done in the organization. The goal is to obtain wide network reach without having too many direct ties. It is the indirect ties that provide network benefits. Research has shown that both individuals and groups who are central in organizational networks, *yet are not overwhelmed by direct ties*, are very effective in getting things done. Those burdened with too many direct ties are not as effective.

From Table 1 it is apparent that activity does not lead to network benefits. Node # 023 is very active in both networks but *not* central in either. Is he/she just spinning their wheels?

Opportunities in Networks

Innovation happens, within and between organizations, at the intersection of diverse information flows and knowledge exchanges. The network in Figure 4 above shows many opportunities to cross-fertilize knowledge -- connect knowledge communities that are not yet connected. These potential connections in networks are called *structural holes*. It is across these holes in the network that the opportunity-seeking player [individual,

team, or organization] can establish a superior position where diverse knowledge and ideas intersect. This position is superior because it is unique -- these flows do not intersect anywhere else in the network. The node that spans the right structural holes receives a diverse combination of information and knowledge available to no one else in the network. From this advantageous position innovative products and services can be created. An organization whose employees effectively span these internal holes of opportunity creates a competitive advantage that can *not* be easily duplicated by competitors. Even if competitors hire away a few employees in the network they still cannot easily duplicate the knowledge community [the unique pattern of interconnections] that is in place in the other organization.

Figure 5 - Possible New Knowledge Exchanges

How should these knowledge communities be connected? Use ties that already exist between groups -- the work ties that currently exchange task resources but not knowledge and learning. Find nodes that are not overloaded in the work network and assign them the additional duty of knowledge exchange. The links in Figure 5 below reveal who has a work tie, but *not* a knowledge exchange. It is these single purpose ties that can be expanded for multiple duty. Use Figure 5 and the network activity measures in Table 1 to find the best candidates for knowledge exchange.

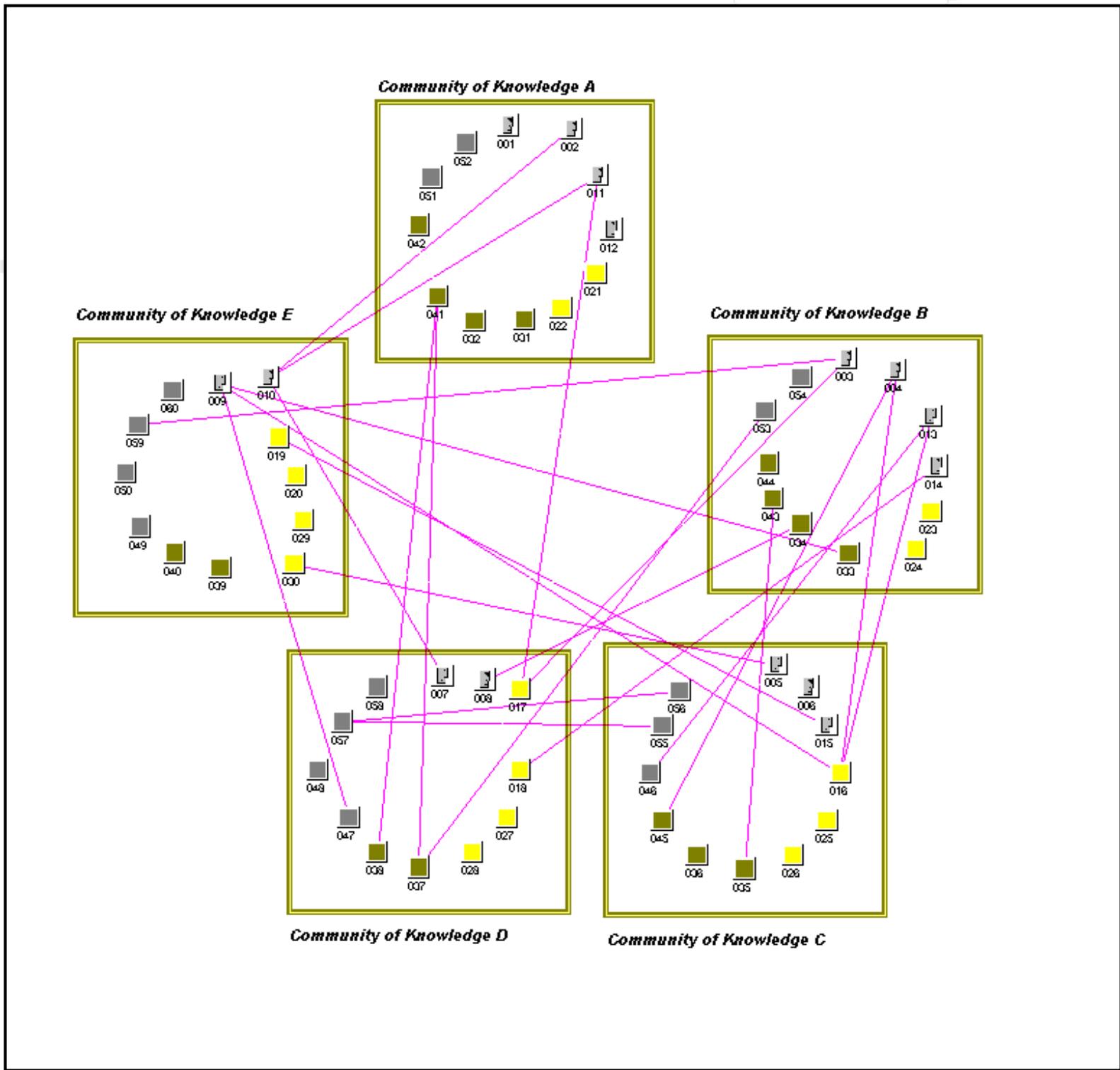


Figure 5 - Possible New Knowledge Exchanges

- Why did the HR VP look for possible connections in the emergent organization? Why didn't she just assign various employees to these boundary-spanning roles? She knew how emergent communities work -- trying to *formalize* the informal, or trying to steer an emergent process, just leads to resistance and then disappointment. Knowledge-based organizations, through the people in them, attempt to adapt to their

environments. Exerting too much control over this process hinders effective outcomes. Building emergent communities and informal networks is a lot like gardening. The manager/gardener must provide resources and remove obstacles/weeds so that the employees/plants can follow goals/sunlight to self-organize and grow. Trying to exert too much control over this emergent process will usually result in a poor harvest.

Network Management

Once the people networks are understood, the right technology can be implemented to support these evolving entities. Computer technology needs to be as flexible as the adaptive, self-organizing human networks it supports. To meet this demand for adaptive technology many organizations are utilizing the flexible technology and protocols of the Internet inside the organization.

Tools to manage computer networks have been in existence for a few years and are becoming more sophisticated. Tools for human networks are just starting to emerge into general business use. ONA tools such as *InFlow* [used in this article] are aimed at HR experts and management consultants. ONA software has been utilized by *early adopter* firms since the late 1980s and is now gaining interest in many industries.

Network Models: Tools for the Connected Economy

Today's fast and fluid business environment requires HR managers and consultants to understand the constantly changing economic webs within and between organizations. Static, hierarchical structures are no longer sufficient to function in the connected economy. Adaptation and Learning are joining Control and Planning in the executive suite of today's innovative corporations.

ONA has been used in many progressive firms including Rubbermaid, TRW, IBM, and Lucent Technologies. These firms have applied ONA to improving knowledge exchange, workforce diversity analysis, post-merger integration, process improvement, and organizational redesign. Consulting firms such as Ernst & Young LLP and the IBM Consulting Group have, between them, utilized this technology with hundreds of clients to support various projects such as product development, computer system implementation, organizational design, business transformation, retention analysis, business process reengineering, knowledge management, strategic planning and other organization effectiveness efforts. ONA has also been applied to understanding the emergent dynamics in the network of alliances between firms in the Internet industry.

A network view of the world is necessary to adapt to the chaos and complexity of continuous change. In the past, HR departments focused on the nodes[employees] in the network which were often modeled as boxes on a hierarchical chart. In times of reorganization the boxes and their formal connections were moved around by management prescription.

In today's fluid economy, HR must also focus on the ties[flows, relationships] in the network, and their ever-changing patterns. Many adaptations to the rapidly changing environment today are *soft* reorganizations -- knowledge exchanges and information flows are created/strengthened/weakened, but the formal hierarchy remains in place. This allows for more frequent and rapid adaptation. Obviously technology must be adaptable with these frequent soft reorganizations. Network models of how organizations get things done are as necessary in the new economy as organizational charts were in the industrial era.

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