MEASURING 'HIGH TECH' SOCIAL CAPITAL IN THE BIOTECHNOLOGY CLUSTER LOCATED IN VANCOUVER, BRITISH COLUMBIA

by

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ABSTRACT

The health of a regional economic system can be measured many ways. One of the indicators is a high rate of innovative practice. The study of innovation has many different facets including the social aspects of innovations, the creative aspects of knowledge flows and the geographic and social capital characteristics of innovative locales. Despite our knowledge of innovation and communication of innovations, there is a lack of ways to measuring innovation in high tech knowledge based economies that focus on measuring social capital. This work examines the Greater Vancouver Biotechnology sector as a case study for measuring social capital within a cluster.

Initially, patent citations identify an active biotechnology cluster. Social capital networks were then identified as mattering to the cluster actors and were measured through the Internet. These web-based network measures of social capital show the health of a cluster and portray where current policy models are working.

DEDICATION

To my fellow travellers: The journey is the lesson. Pay Attention

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All errors within this document are my own.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION

In order to be effective, policy must be based on complete research - research beyond aggregate number crunching. This is because the best written policies can break down if not supported with facts.[1] Evidence based policy should reflect research that has a diversity of measures that accounts for a region's economic growth and specific concerns. The measure that I am focusing on is the measure of social capital. More specifically, diagrams of networks of firms and people involved in the biotechnology cluster in Vancouver, BC. "Networks constitute the new social morphology of our societies...the new information technology paradigm provides the material basis for its pervasive expansion..." (Castells, 1996, p. 469). These networks display the social capital flows and characteristics of a cluster, an important basis for policies affecting labour pools, tax regimes and other economic indicators.

Social capital is a way of measuring networks of people that work together in innovative industries. Social capital is cited as one of the factors needed in industrial clusters for them to be innovative, due the nature of industry. The right people need to be in the right job in order for an industry to grow to be productive and innovative. Therefore, "for social capital to become a serious indicator of regional and national well-being, measures of it need to be drawn from large representative samples, using indicators that have been pre-tested and refined for their suitability" (Woolcock, 2001, p.1). The web-based measurement of social capital networks adds an indicator to measure social capital that is tested in the biotechnology sector in Vancouver, BC.

[1] For more information about evidence based policy, see: www.evidencenetwork.org/bibliography.asp

One of my personal challenges in this process of studying innovation and regional economic systems is making the research relevant on a practical level, to explore the use of measures that point out the intricacies and particularities of different regions. I am originally from Southwestern Ontario and moved to British Columbia in 1996. Due to this, I have experienced first-hand the differences in attitudes, economic engines and social culture between these two economic regions. After attending conferences and other events 'back East', I realize that Western Alienation is not an abstract thing. This has emphasized that one size does not fit all in policy planning for innovation within regions. Regional differences are concretely expressed and must be accounted for in policy.

My interest in networks has been piqued through my identification by name as a member of an organization called The City Program at SFU in Montreal, Quebec. This identification was based on my marketing emails. The person who was expressing familiarity with me had been receiving my regular 'coming events' emails through a network of advertising linkages. I had not met this person in the flesh, but rather monthly emails had created a sense of familiarity between us and given me a place in her network. She had harnessed my social capital in establishing linkages at a conference. This 'small world' phenomenon has been documented in research (Milgram 1967; Pool & Kochen 1978).

After attending a presentation by ISRN researchers from the University of Toronto describing economic clusters within Waterloo Region, my hometown, it became apparently to me that certain measures may not reflect the intricacies of a region – its

'placeness'[2]. While many of the aspects measured reflected the economic realities of the region, a passing reference to "German work ethic" did not fully describe the deep roots and evolved networks within the Region. This was not a criticism of the individual work presented, but rather one of many examples of the limitations of the current regime of measures for innovation that do not account for social capital. This problem has begun to be addressed by Richard Florida and Robert Putnam, who are recognized as leading figures in bringing social capital out for the realm of Community Economic Development studies and into the study of innovation and innovation systems. Despite this, Florida and Putnam's measures are only part of the way towards measuring innovation systems in a comprehensive way. Putnam's tools are based on aggregate statistics, reflecting the human characteristics of regions. Florida's measures are difficult to concretely describe. Based on this, I have decided to tackle measurement of innovation to pursue further the truism that it's not 'what you know, but who you know'.

Studies have shown that a personal network brings in more job referrals to the job seeker, than newspaper ads do. The larger your network, i.e. filled with more weaker ties, the more successful you will be in your job search. This is attributed to the fact that people you are more strongly tied to hear about the same opportunities you do, while your weaker links hear about opportunities that you don't hear about (Granovetter, 1973, p. 1371). Nonetheless, it is ties that are important overall.

In his article entitled *The Growth of Voluntary Associations in America, 1840-1940*, Putnam asserts the historic importance of networks. He quotes Arthur Schlesinger (1944) saying: "[Americans] are a nation of joiners...in mastering the associative way they have mastered the democratic way" (2001, p.175). I recognize forming associations

[2] Place-ness is a function of place. "Places are imbued with the identity of those who live there," (Myers, in Casey, 1993, p. 304). "local origins" (Clark, 2003, p.47).

is not always democratic i.e. under Nazi rule, but Schlesinger is referring to associations in a Western democracy. This is not a new concept. In 1835, Alexis de Toqueville stated that "Americans of all ages, all stations in life, and all types of disposition are forever forming associations" (1969) that have strong and weak connections.

More recently, network diagrams have been used to determine funding allocations:

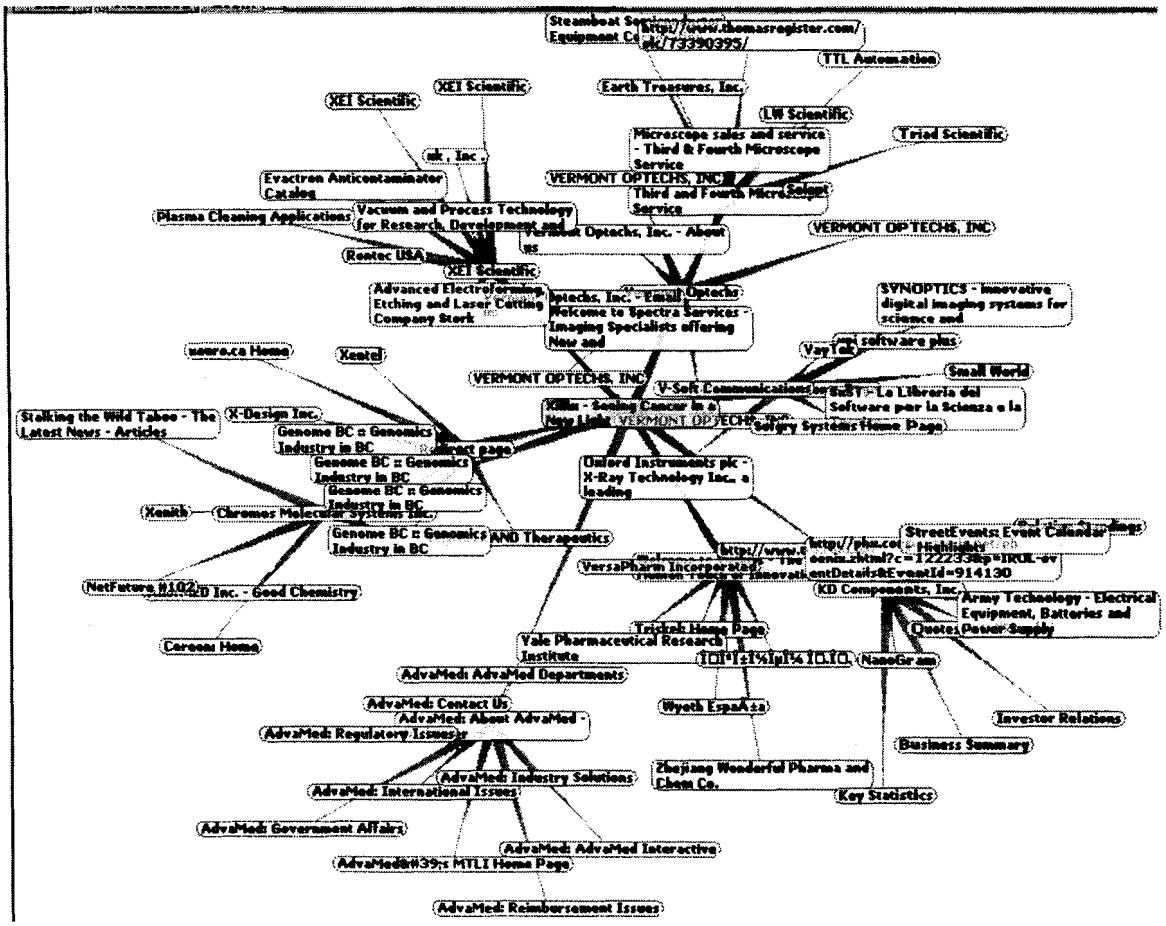
> "When it comes to scientific research, the most important gauges of success are peer review and citation. Who is citing whom, and how often? Mapping these relationships and distilling them into a single eyeful reveals which projects have the most impact." (Sterling, 2004).

Moving the allocation of funds from informal, and possible flawed personal network recognition to looking at a concrete measure of influence is a necessary step in measuring social capital and important in aiming money and resources at the point of greatest influence. Well-known persons may not have produced the greatest amount of influential work. An introverted, lacking in social skill scientist may be the most linked member of a research community, but not the most recognized name wise. Given the usefulness of these networks, what do they look like?

1.1 Depictions of Networks

The graphs of these networks depict the social structure that unites members of the network, referred to as actors. "Two people share a strong ties when the people they know, know each other; they share a weak tie when the people they know are not connected" (Hargadon, 2003, p.59). A modern depiction of associations of strong and weak ties can be illustrated comparing Figure 1 and Figure 2 networks from the biotechnology sector.

Figure 1: Xillix Network Diagram

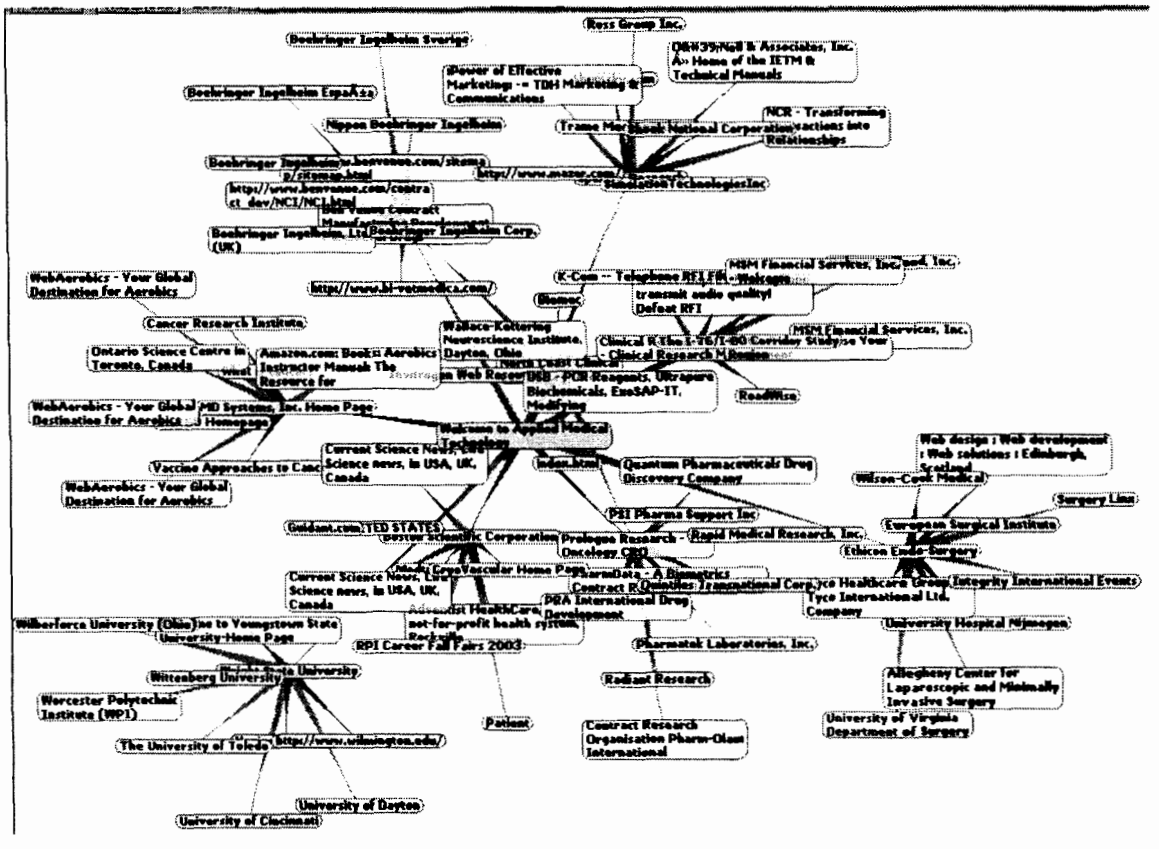


If an employee at Xillix Company wants to find work at another biotechnology firm they would use their social networks to enquire about the 'hidden job market'. This hidden job market is accessible through personal networks and word of mouth, rather

than through newspaper or other advertisements. In Figure 1, the links highlighted in beige show the stronger links (there are 10 unique links), while all the white companies are weak links. There are more weak links than strong links. This is an advantage for an employee looking for work.

If an employee from Applied Biomedical (Figure 2) used his/her network of loose and strong web linkages to secure employment elsewhere, their network would look different. Although they would have the same number of strong links, they would have many more weak links. Therefore, the second employee has a better chance of finding a position at another firm within the industry, due to a greater number of weak connections to leverage in their job search.

Figure 2: Applied Medical Network



The 'who you know' principle combined with 'place-ness', make large contributions to the economic engines of areas, and yet are not fully expressed in measurements of innovation.

The first person to depict social links as visual networks was Jacob L. Moreno in 1932. The describes the role of visualizations of networks as follows:

> "We have first to visualize . . . A process of charting has been devised by the sociometrists, the sociogram, which is more than merely a method of presentation. It is first of all a method of exploration. It makes possible the exploration of sociometric facts. The proper placement of every individual and of all interrelations of individuals can be shown on a sociogram. It is at present the only available scheme which makes structural analysis of a community possible" (Moreno, 1953, pp. 95-96).

This is the beginning of social network analysis, a field that was hard to study without the aid of computers to easily generate diagrams of networks. These diagrams became used in food web analysis, trade route mapping and other applications. needs to be a simple way to systematically account for associative networks in economic clusters, using these network diagram tools. The links between people need to be investigated beyond these fields and expanded from Putnam's specificity of studying voluntary associations. They need to be expanded to look at networks between firms and sectoral associations within a regional economic system. The health of a regional economic system can be measured many ways, some of the ways include number of patents filed, numbers of highly qualified personnel, value of exports, number and size of firms and now, through social network diagrams.

In this thesis I will examine a high tech knowledge based cluster - Greater Vancouver, British Columbia's Biotechnology sector. This sector is influenced by its social and economic geography, as well as its culture. It is also highly integrated with new digital and Internet technologies and has a rich ecology of virtual interactions. Given this highly integrated milleux, the question must be asked: Can Internet linkages be used to measure social capital and dynamics of the biotech cluster in BC? This question is important to the success of a cluster, as these linkages can show graphically the health of a cluster and be used to further illustrate the importance of both social and spatial geography to the study of innovative regions. Knowledge flows within an innovative region are neither used up nor destroyed. This flow through a network is important to innovative regions. It is similar to the linked flow properties of the World Wide Web. The trail left by these linkages makes Internet linkages and web presence a useful tool for measurement of knowledge flows.

The results of both interviewing and gathering indirect through automated means, concerning direct linkages on the web, shows that these linkages are important to attracting people to a region and also in keeping up connections within a cluster. There is considerable activity within the clusters' links, most especially to networking[3] agencies. These linkages can show hubs in the social milieux and naturally identify key champions and proper points of intervention within an economic cluster. These networks can be used to examine the diffusion of an innovation (Rogers, 1962; Gladwell, 2002;) as well as the players within an innovation system. First though, it is necessary to clarify the term innovation.

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[3] Networking is "the art of talking to as many people as you can without directly asking anyone for a job" (Flap & Boxman, 2001, p. 159).

For the purposes of this enquiry innovation will be limited to the high tech sector and innovations of product and process, as defined by the Organization for Economic Cooperation and Development : "...technologically new products and processes and significant technological improvements in products and processes... introduced on the market or used within a production process" (OECD, 1996, p.34). However, the traditional model of the lone inventor, creating disruptive changes in his garage will not be adhered to. Castells and Hall quote Josef Schumpeter: "It [innovation] needs not, and now commonly does not, consist in an individual inventor making a major advance..." (1993, p.226). The discarding of the 'lone inventor' theory, points towards examining networked factors and inputs into the innovation process. Peter Clark's book entitled *Organizational Innovations*, locates innovation within an economic agenda. "The old agenda focused upon the structure of technology innovation and the new agenda focuses upon the process of organizational innovation" (2003, p.2). Clark advocates for an examination within a "new agenda" – that of firms in clusters and webs and social capital as a determining feature of the firm. Not only does location matter, as Michael Porter states, but also location can be expanded to include place and context.

To borrow a biological metaphor - location has many elements. In a forest, not only must lichens find the right location in terms of sunlight, soil presence and space, but the organism needs a structural support to grow on and maintain the internal balance between their algae partner for photosynthesis and a fungal partner that provides physical structure. Just as a lichen is specialized to its environment, innovation is specialized to its environment. Innovation is not a form of 'cultural Darwinism', but rather innovation is a type of evolutionary force, influenced by variable elements in networks and selective pressures. But it is not as random as natural processes – "how much trial and error will be

needed in the creation of the next generation of designer pharmaceuticals?" (Ziman, 2000, p.12). Just as an ecosystem does, "innovation takes place via a system of economic actors" (Baldwin & Hanel, 2003, p.2) embedded in an 'ecology of knowledge' (Brown and Duguid, 2000). This cluster ecology brings to mind the tool of 'food webs' used by biologists to map interactions between species. They are similar to social network diagrams are an appropriate tool to map the networks of communication within the biotechnology cluster in BC.

1.2 Link to Communications

Networks of communications are all around us and effect us as never before due to the pervasiveness of networked communication devices in our lives. "It is about as unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located, as it is to study blood circulation without some knowledge of the structure of the veins and arteries" (Katz, 1961 as in Rogers, p.16). The increasing technological bias of our society and the drive towards the 'new economy' allows us to view the world in a more interdisciplinary way. This document draws upon the disciplines of economics, networks and social geography, with an underlying thread of communication running through it. The Science and Technology Studies field in Communication studies invites us to examine out attitudes and ways of explaining how technology works within our world. Providing a consistent framework for an exploration of the role of networks within our high tech world can be found in this area of study. Recent journals such as the Journal of Social Structure, embed this form of inquiry in a framework "focused on social structure-on the patterning of social linkages among actors" (www.cmu.edu/joss/content/mission.html). This journal provides a platform to debate issues of networks, most specifically social networks. Not only do we need to

recognise the truth of the social network platitude that "It's not what you know it's who you know", but it needs to be based in a theoretical framework.

Tracing from Rogers'1962 work on social networks for the diffusion of innovations within a population, to his revised definition of communication as "a convergence process in which the participants create and share information with one another in order to reach mutual understanding" (Mattelart & Mattelart, p.130). Social networks and social capital built from negotiated interactions based on trust are a fundamental notion of society and integral to our economic systems of innovation and prosperity.

According to Rogers, to analyze a communications structure, three steps must occur: "identifying cliques..., identifying certain specialized communication roles....and measuring communication structural indexes" (Mattelart & Mattelart, p.130). Theorists Bruno Latour and Michel Callon further explore this theme of 'network communication' called 'ANT' (Actor Network Theory). Latour and Callon "placed the notion of the network at the heart of their conceptual framework by rejecting the diffussionist model in favour of a model of 'translation' or socio-technical construction (Callon, 1986; Latour, 1987). The process of how these "heterogeneous agents[/actors] are enjoined into networks" (Clark, 2003, p.45) is translation. The formation of the network is directed, it is not random. The negotiation of network connections is a highly directed process. Given the high technology nature of such networks as the biotechnology cluster in the Lower Mainland of British Columbia, a web-based identification process is useful. Not only does the ANT approach place people, as actors in a network, but it places technology and other non-human actors into the network, allowing the 'new high technology economy' to be illustrated fully as a socially constructed network of actors.

This social construction of technology communication approach, which emphasizes flows of knowledge and the role of networks, is appropriate for examining the networks of social capital within the biotech sector.

1.3 A Multi Disciplinary Approach

Critiques of this model of networks of actors that includes non-human actors have said that these networks ignore the natural processes of weighing different relationships more heavily in a network and that not all actors are free to link with all other actors. Rogers' idea of 'cliques' and 'specialized social roles' refutes this critique and allows a more nuanced network to develop. The biotechnology sector and the realities of economics privileges certain links over others. Although it is necessary to account for technology due to its centrality in the biotechnology industry, it is still important to keep in mind "By rejecting the idea of an essence of technology, we also run the risk of excluding the very principle of the operational function of machines, which involves a succession of ordered rather than haphazard or arbitrary mediations" (Simondon, 1969 as in Mattalart & Mattalart).

Networks can be ordered or non-ordered and be linked in various ways, but their understanding is key to understanding an area. Upon touring a beautiful cathedral outside the town of Kutna Hora in the Czech Republic, I remarked on the wealth of the town as demonstrated by the lavish and technologically advanced church in the centre of town. With soaring rafters and expansive gothic arches it was a medieval technology tour de force. The tour guide explained that the town was actually quite poor, but the social relations and the network of money and labour flows all were directed into the church. The structure did not indicate the true order of power and resource allocation within the

network of townspeople, but demonstrated a) a key pointer of a place to look for money flows b) the hub of the community's social network.

In the town's network, the people chose to give their power and network resources to the church and to direct the town's wealth in the construction of the church. The town demonstrated "...a set of relations constituted and held in place: a set of relations that distinguished between this and that ...power, whatever form it may take, is recursively woven into the intricate dance that unites the social and the technical" (Law, 1991, p.18). The power of network linkages was highlighted in the roles of brokers and information technologies within networks. In this case the church brokered the network. Law's description of Actor Network Theory (ANT) is taken up in theme of the study of innovation within clusters. Not only must knowledge flow for innovation to occur, but "The ways in which knowledge is articulated by particular individuals or groups... may vary..." (Clark, p. 10-11). This set of relations within the biotechnology network in BC, make up the necessary and sufficient conditions for describing inter-firm and inner and outer cluster interactions. Social network research has been moving away from a dyadic approach examining ties between two people and branching outward. "Social network theories should not be tested using exclusively dyadic data because dyads are not good indicators of network characteristics" (Davern, p. 4). Once this networked approach is appropriately applied, the linkages between the actors in the network must be given value. This value measures social capital.

CHAPTER 2 SOCIAL CAPITAL

Social capital can be generally defined as: "information, trust and norms of reciprocity inhering in one's social networks" (Woolcock, 1998). Social capital is a term that gives central importance to networks of strong personal relationships that develop over a period of time providing a basis for trust, cooperation, and collective action (Jacobs, 1965).

> ``Whereas physical capital refers to physical objects and human capital refers to the properties of individuals, social capital refers to connections among individuals, social networks and the norms of reciprocity and trustworthiness that arise from them. In that sense social capital is closely related to what some have called 'civic virtue'. The difference is that 'social capital' calls attention to the fact that civic virtue is most powerful when embedded in sense network of reciprocal social relations" **(Putnam, p.19).**

Social capital is a measurable element of modern socio-economic systems that contributes positive economic gains (Buerkle & Guseva, 2002; Rupasingha et al, 2000;). Although broad in nature, it can be broken down into two key areas: "the social relationship itself that allow individuals to claim access to resources possessed by their associates...and second, the amount and quality of those resources" (Hurlbert et al., 2001, p.209). This examination is most interested in the social relationship itself, rather than the quality of the resources, although the sheer concentration of relationship connects may indicate a relation of a great quality of resources. In his groundbreaking work *Bowling Alone*[4], Putnam examines the decline of associations and other voluntary organizations like bowling leagues. Putnam's concern about the decline in this form of social capital reflects the positive qualities he assigned to the presence of social capital. "Just as areas

[4] Robert Putnam's groundbreaking book concerning the decline of civic engagement in America.

of high social capital are good at maintaining livable spaces, they are also good at getting ahead" (Putnam, p. 319).

As stated in the Innovation Systems Research Network document of purpose: "the existence of social capital depends upon the ability of people to associate with each other and the extend to which their shared norms and values allow them to subordinate their individual interest to the larger interests of the community" (ISRN, Website). A lack of social capital, i.e. a lack of trust and reciprocity, can hinder the diffusion of innovations. "A mismatch between technological innovations proper and the supportive social and organizational environment can result in disruptive effects or in the blockage of innovation diffusion..." (Grubler, p.169). Rogers accounts for this through his examination of the social system, but does not supply an analysis of how trust can be built within a community. Rogers doesn't account for the social capital in the process of bringing an innovation from idea to product to market.

2.1 Why Does Social Capital Matter in Cluster?

Recently a new form of economics has been postulated. "...socio-economics – which might be termed a "Bourdieuconomics" – implies the usage of a capital theory that, methodologically, operates with material and non-material forms of capital at the same level" (Svendsend & Svendsend, 2003). This accounting of the social form of capital brought into the innovation process is integral to the development of an industrial cluster. This is especially true in the biotechnology sector, as specialized resources are needed to create a product and/or invention. Social capital matters in a cluster because it is the glue that holds the network ties together. Network analysis can deal with social capital in ego-centred networks i.e. the links of a specific Board of Director's member at

a particular firm. Or be concerned at a more general level. While ego-centric networks may provide more specific details and personal mechanisms for influence, non ego-centred network research can reveal dynamics not only in terms of valuing interpersonal features, but more convincingly account for such dynamics such as gender influences (Crowden, 2003) or the rapidly declining ethos of 'public good' (Atkinson-Grosjean, J., 2001).

Recently, the Federal Government agency Status of Women Canada put out a call to measure the effects of gender on the economy. This interest in uncovering the minute details of the mechanism of innovation is consistent with Canada's Innovation Strategy, both economically and socially. Allan Rock, Minister of Industry has committed Canada's innovation strategy to: "find ways to draw out the unique strengths of communities across Canada to bring the benefits of innovation to each and every part of this country, rural and urban, over the next decade"[5]. But how will this occur? And will it occur evenly in different industrial clusters and populations of workers? As Crowden states (2003), women in high tech professions are likely to adopt tactics to work with men, thus we can assume the organizational cultures are masculine in nature. This could result in the fragmentation of the workplace and a diminished innovative capability, but employees and corporations have overcome these and other difficulties,[6] in order to create an environment rich in knowledge flows and tacit knowledge exchange within networks.

[5] Canadian Chamber of Commerce: Canada's Innovation Strategy Achieving Excellence February 12, 2002 http://www.ic.gc.ca/cmb/Welcomeic.nsf/0/85256a220056c2a485256b5e005db42d?OpenDocument

[6] Some have been overcome more than others. See Crowden,2003 for a discussion of gendered innovation.

2.2 Development Theories

Given that knowledge flows within a cluster and actors act within a cluster to innovate and generate economic value, what model can be used to describe the activity of the cluster and its development and growth. There are many theories put forth. Some of these models include industrial districts, digital cities and learning regions (Komninos, 2002, p.7). Industrial districts include techno poles and industrial parks as inducements for innovation, while digital cities take a more virtual and technology oriented approach to solving the 'innovation gap'. Learning regions (Cooke and Morgan, 1997), include Regional Innovation Systems (Morgan, 1997; Simmie 1997) strategies.

The regional innovation system (RIS) "is a multilevel system of institutions supporting knowledge and learning processes" (Komninos, 2002, p.9). These processes "..occurring in a given geographical area...lead to the rapid diffusion of knowledge and best practices" (Nauwelaers & Reid, 1995, p.13). A regional system of innovation can be visualized as layers of supporting organizations. Labs, R&D institutes and companies make up a base, while institutions such as technology transfer agencies, etc make up a layer of supporting agencies. The strength and purpose of this system is to influence collective learning procedures and use it to foster innovative collaborations. Collective learning within the biotechnology sector involves an exchange of highly specialized knowledge. "Learning is necessarily an interactive and socially embedded process" (Lundvall, 1999, p. 20). As articulated by Thomas Kuhn, scientific knowledge is based

in its context and is the result of understanding the dominant paradigm of a community[7]. Therefore, science is created as a consensus of ideas within a particular community:

> "Normal science does and must continually strive to bring theory and fact into closer agreement, and that activity can easily be seen as testing or as a search for confirmation or falsification... But science students accept theories on the authority of teacher and text, not because of evidence" (Kuhn, 1970, p.80).

The socially constructed knowledge within the biotechnology sector[8], can be defined as "a consensus among the members of a community of knowledgeable peers- something people construct by talking together and reaching agreement" (Brufee, 1993). This means that the knowledge must be presented as an artefact or a set of beliefs to gain entrance into a specific group of peers – biotechnology professionals. The areas where this knowledge is communicated, negotiated and assimilated are 1) between two members of the community i.e. biotechnology scientist to scientist 2) between a member and a member-in-training i.e. biotechnology scientist to co-op student and 3) between community member and non-member i.e. biotechnology scientist and the person at the local coffee shop who consumes the (legal) drugs produced.

Theorist Kenneth Brufee outlines these areas of communication to underscore where communication takes place and that knowledge flows differently at each point. This is based on the different language and interaction between the interactants, who are either part of, want to join, or are not part of a specific "knowledge group" (Brufee, 1993). Innovation literature has picked up this theme in education research and has described tacit learning within a cluster as "learning-through-interacting" (Johnson 1992;

[7] In the late 1940s, Kuhn, then a doctoral student in physics at Harvard, was asked to teach a course introducing non-scientists to the practices of science. He wrote, "To my complete surprise, that exposure to out–of–date scientific theory and practice radically undermined some of my basic conceptions about the nature of science and the reasons for its special success." (firstthings.com/ftissues/ft0003/articles/kuhn.html)
[8] For a detailed discussion of the social construction of scientific knowledge and technology, see Bjiker and Pinch; Latour; et al.

Lundvall 1992 as in Wolfe, 2002) or as establishing a "community of practice" (Wenger, 1998). Storper (1997; 1993; 1994; Salais & Storper, 1993) highlights a primary trend in cluster economies: "the rise of the local...localized input-output relations in the agglomeration...and the role of untraded interdependencies" (Komninos, 2002, p.134). Brufee articulates and provides physical sites for knowledge flow of these untraded interdependencies within a learning region or regional innovation system and assigns value to personal relationships in clusters.

"Linkages between individual social networks and labour market outcomes command scholarly attention" (Marsden & Gorma, forthcoming). Not only do these linkage points need to be defined, as Brufee has indicated, but they need to be measured in such as way to illustrate the value of these social capital links. Connecting the measures of labour market outcomes, as per Michael Porter's Diamond model, to the more loosely defined individual social networks linkages measured by Richard Florida, becomes an easier task when the focus of these clusters becomes the learning and tacit knowledge building within a cluster as a contributor to the four forces that make up Porter's Diamond model. The balance of elements contained in the 'Firms, Related, Demand and Factors' criteria for a Porterian cluster are all influenced by the milleux of the learning region/cluster.

Richard Florida defines learning regions "as collectors and repositories of knowledge and ideas, that provide an underlying environment or infrastructure which facilitates the flow of knowledge, ideas and learning" (1995, p. 528 as in Wolfe, 2002). Florida operationalizes the measurement of a learning region through the Three Ts – talent, tolerance and technology to describe the ways knowledge flows and grows within a region.

2.3 Is there a biotechnology cluster?

Michael Porter defines a cluster as "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (1998, p. 199). This grouping has "untraded interdependencies" (Storper, 1997) due to their geographic proximity. "...The strength of the cluster and its supporting infrastructure of quasi-public goods and public institutions create a mutually reinforcing set of conditions that support its further growth and expansion" (ISRN report, p.5).

Michael Porter puts forth a Diamond model for the criteria that describes the dynamics in a cluster. The four elements that make up this model are: Firms, Related companies, Factors and Demand (Porter, 1998). 'Firms' refers to the companies providing services and products within an industry. These include Kirby Eades, a company that provides patenting services for companies in the biotechnology sector. 'Related companies' refers to the competitive and collaborative firms that provide interactions in the cluster. Examples in biotechnology include Cubist Pharmaceuticals and QLT. 'Factors' refers to things like universities and associations and in the case of biotechnology, facilities such as wet labs and companies to coordinate the medical trials process. 'Demand' refers to the demand from the market.

When determining the existence of a biotechnology cluster, necessary and sufficient conditions must be fulfilled to indicate a positive finding. Beyond Porter's measures, "[innovators] have shown their diversity, and therefore the diversity of the criteria by which they must be judged'" (Castells & Hall, p.222). This points research towards a regional innovation system approach and calls for diversity in criteria for

judging the effectiveness of clusters in creating centres for innovation. Contributing to this diversity is the measurement of social capital within a cluster.

2.4 Measuring Social Capital

"We argue that if the term 'social capital' is to mean anything more than "networks have value", then we need to demonstrate key features of the analogy to 'real capital'" (Fernandez & Castilla, 2001, p.85). Many measures have been used to measure social capital, in response to this criticism, including some effort by Michael Porter to account for the mechanics of social capital within his diamond model. Wolfe (2002) notes that "The strength of the cluster and its supporting infrastructure of quasi-public goods and public institutions create a mutually reinforcing positive feedback loop". Porter categorizes the positive implications of social capital trust as a quasi-public good. And overall social capital measures are collapsed into indicators for measuring competition, cooperation and size of barrier to entry in a particular market. For example, the high social capital present in Silicon Valley results in a low amount of competition as firms micro-specialize. The high levels of social capital present along Route 128 results in a lower barrier to entry as facilities are close together and shared between firms to make the best use of them. This low barrier to entry is also reflected in Vancouver's biotechnology industry as research within labs locations serves the needs of many parties.

Measures of innovation prominent in regional systems of innovation include:

- Expenditure on R&D
- Number of Highly Qualified Personnel (HQP)
- Patents
- Gross Expenditure for R&D (GERD)
- Business Expenditure for R&D (BERD)
- Amount of utilization of research tax credits, etc.

These measures are supplemented by social capital measures, including measuring the return on money invested in bonuses for employee referrals. "They [Employees] may be able to provide very good information about those in their work-related networks (both within and outside of the organization), especially if they are members of work-related groups such as unions or professional associations" (Marsden, 2001, p.119). One interviewee responded to a question about recruitment in the Summer 2004 interview saying: "Networking and internal relationships within industry are important, but also external relationships". Relationships reach social capital beyond the local cluster and leverage social capital across distances.

Cultural capital is the cumulative sum of human capital within the organization (Jones, 2001, p. 1). In short, cultural capital is an organization's human resources, which are valued as an important aspect of business in the emerging global economy (Bloom & Associates, 2000). This can also be a measure of social capital, in terms of human resources or HQP.

2.5 Knowledge Flows

The flow of knowledge is smoothed by these social capital links. In an environment of high investment in patents and ideas, due to the long production cycle of biotechnology products, high levels of trust indicative of strong social capital are necessary. "The appreciation of external knowledge...contributes to the articulation of the systems of innovation approach, where the production of knowledge is viewed as the result of the cooperative behaviour of agents undertaking complementary research activities" (Antonelli, 2001 as in Antonelli, 2003). The inputs of external knowledge that is shared through links, emphasizes networks as a unit. But how does this network

become a system of innovation? And where does innovation occur within this system? Innovation economics says that innovation is necessary to drive the growth of an economic system. It is necessary and sufficient to form an RIS. As in the time of the Pharaoh's when the Nile's flood plains bore a great and creative civilization, filled with technological innovations, knowledge flowed within a network and spills over between firms to create a fertile plain for innovation. Measuring this plain is a challenge to be pursued.

2.6 Measuring Linkages

Given that place-ness is important to clusters and cluster formation, linkages between firms and entities in a cluster are very important. Linkages can be measured through interviews with people that are involved in the sector as well as looking at indirect linkages, namely website links. But how do you measure these linkages? The next section will detail the methods used to measure linkages in the biotechnology sector through interviews and indirect methods. "Understanding the[se] networks and their underlying dynamics is critical to understanding the innovation process" (Hargadon, 2003, p.10).

CHAPTER 3 METHODS

How should social capital be measured in a cluster? Measures that have been classically used range from gathering statistical figures to focused guided questioning interviewing on a continuum: numerical statistics <----------> informal chats. Some theorists point to 'Triple Bottom Line' accounting indicators such as the Cascadia scorecard[9]and the Well-being Index[10] to measure social capital. While these indices measure 'Social GDP', they will not be discussed.

Identifying networks to be used is a measurement problem. Measuring the paths of an intangible resource, like a social network, is inherently non-trivial and requires innovative techniques. Measurement of networks began as an innovative experiment where random individuals mailed letters across the country to identify personal networks[11]. Today, hands on interviewing techniques are employed to have people identify their own personal networks.

The difference between these measurement techniques is the scale of the network and the direct vs. indirect measures employed. Stanley Milgram's mailed letters to targets from coast to coast was used to identify pathways (Milgram, 1967). This experiment

[9] Cascadia Scorecard: Seven Key Trends Shaping the Northwest: 2004 Edition.Northwest Environment Watch. ISBN 1-886093-14-8. This book measures indicators of the Northwest economic and social group using indicators categorized under seven areas: Health, Economy, Population, Energy, Sprawl, Forests and Pollution. The Economic indicators include the Economic Security Index, median incomes & unemployment rates.

[10] The Human Wellbeing Index (HWI) and Ecological Wellbeing Index (EWI) developed by Robert Prescott-Allen for the 2002 World Summit on Sustainable Development uses a combination of measures to plot the wellbeing of humans and the environment on a grid. The related book – The Wellbeing of Nations is available from Island Press and the author lives on Vancouver Island.

[11] Interesting note: Stanley Milgram was the experimenter who pioneered the shock treatment study to measure the impacts of actions undertaken through the permission of the authority of another.

revealed geographically large and diverse personal networks through an indirect task based measure. Instead of asking specific people who was part of their network, he identified a specific task and mapped the network paths followed by random individuals to complete it. This study identifies networks similar to the networks measured in studies concerning finding a job, rather than networks used to complete a task. It focuses on the networks people are part of, rather than a task oriented network. Another example of this personal network would be the game Six Degree of Monica[12] which examines the paths of Monica Lewinsky's social/professional network or the Oracle of Six Degrees of Kevin Bacon, which calculates the distance any actor in Hollywood is from Kevin Bacon.

3.1 Measuring Biotech

Measuring the biotechnology sector in terms of economic performance, including innovation and innovation measures has been occurring systematically in Canada since 1996. The European Innovation Monitoring System[13] uses patents, surveys and statistical data to measure innovation within the European Union. Canada uses Statistics Canada to measure innovation. The following studies have been catalogued in a recent OECD report on Canadian Biotechnology measures:

- Survey of Biotechnology Use in Canadian Industries 1996
- Biotechnology Firm Survey 1997
- Biotechnology Use and Development Survey 1999
- Survey of Biotechnology Use in Canadian Industries 2001
- Survey of Biotechnology Use in Canadian Industries 2003.
- Survey of Biotechnology Use in Canadian Industries 1996

[12] Kirby, D., and Sahre, S. "Six Degree of Monica" New York Times, February 21, 1998.
[13] To find out more about this program, please refer to www.cordis.lu/eims/home.html.

Some of the consistent measures used in these surveys include the following:

Table 1: Biotechnology Survey Measures

	Recruiting Process/Info.	Patents Existing	Patents Pending
1996 Survey			
1997 Survey	Yes		
1999 Survey	Yes	Yes	Yes
2001 Survey	Sources Used	Yes	Submitted in 2000/01
2003 Survey	Recruiting from Outside Canada Specifically	Yes	Submitted in 2002/03

Although this variation in measures is problematic for data comparisons, it is important to note that patents and recruitment are acknowledged as important and the categories for measuring them have become increasingly refined over time.

In a September 2004 report entitled *Assessing the Strength of the Toronto Biopharmaceutical Cluster* stated that: "We [Canada] produces a very small number of pharmaceutical and biotechnology inventions relative to the US; through 1998-2003 Canada produced...0.03 and 0.02 per thousand population vs...0.06 and 0.04 per thousand population" (CHI Country Patent as in Martin and Milway, 2004) .

3.2 Why Use Patents as an Indicator of Clusterfulness?

Patents can be used as one of the indicators of innovative work and/or relationships within a specific field in a specific geographic area. (Komninos, 2002; Baldwin & Hanel, 2003). Patents are a well-known method for measuring innovative activity within a biotechnology cluster. Therefore I am exploring patents to determine there is a cluster here before examining its' social capital in more detail. Even in our age of high

technology communication, "...the transmission of complex and non-codified knowledge still increases with distance" (Co, 2002, p. 394). Therefore, not only are patents important, but also the location is what anchors the knowledge. In the field of biotechnology, which is heavily dependent on intellectual property (IP) and patent protections it is especially important.[14] Patent filing statistics are available to be extracted from web-accessible databases at both the Canadian Patent Office (CPO) and the US Patent and Trademark Office (US PTO). The following methodology was used to gather data about biotechnology patents in British Columbia.

The Canadian Industrial Patent Office (CIPO) and the United States Patent and Trademark Office (US PTO) databases were both consulted, and it was found that US PTO record contains a greater number of patent filings. Both Canadian and US patents were consulted to determine if a significant number of Canadian inventions were not being patented in the US and vice versa. It was found that Canadian innovators more commonly register a US patent than a Canadian patent, therefore it was feasible to use *US patents filed by Canadian inventors* as an accurate measure of Canadian patenting activity and innovation. This also allowed a comparison of Canadian innovation in the field with American, with the knowledge that we were working with datasets that were derived under the same regulatory regime, if not the same market conditions. The date that patents were issued was used to contain the sample time period rather than the date filed, as patents are issued to fully verified unique inventions, rather than the possibly questionable uniqueness of patents filings. There is some delay (from 2-5 years on average) on granting of patents from date of filing to date of issue. This means that the search period from 1990 onwards for patents granted covers an R&D activity range from

[14] This is in contrast with other industries, like water technology, where custom made systems or process solutions are better protected through trade secrets than through patents.

1985-88 to 1999-2004. Interestingly the delay in patents granted is shorter in this field than in more process based technology areas such as wastewater treatment.[15] I am cautiously attributing this to the very defined nature of expertise involved in biotechnology processes, vs. the multi-disciplinary nature of many wastewater technologies may require more research to verify. Other studies have been unable to differentiate inventor city, multiple inventor cites and city of ownership. I have resolved this by counting inventors separately from owners and counting individuals involved in a patent, rather than just single city based patent citation.

Originally, the following search algorithm was used in the US PTO database to limit patents found to biotechnology patents:

- 1990 and post 1990,
- **Issued** Canadian Patent,
- Canadian firm or inventor.
- IPC code

These comprehensive search terms allow all post 1990 patents involving biotechnology IPC codes to be found. The International Patent Classification (IPC) coding system is used by the international community to classify inventions by type. Each patent application is assigned a main (primary) classification and can also be assigned multiple secondary classifications. These classifications were not as applicable as in other technology areas. Therefore a more specific search was carried out using the following criteria:

- 1990 and post 1990,
- **Issued** Canadian Patent,
- Canadian firm or inventor.

Once this search was completed a large, large dataset was gathered. This dataset was then made manageable through a narrowed search adding:

[15] My methodology and results in compiling water technology patents can be found in Volume Two of the Centre for Sustainable Communities Canada Study entitled: Measuring in the WREST Sector in Western Canada. Do I need to include it as an appendix?

- Keyword in abstract
  The keywords used to query the USPTO database of patents were generated out

of the following definition of biotechnology:

> "The provisional single definition of biotechnology is as follows: "The application of Science & Technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services".
>
> The (indicative, not exhaustive) list of biotechnologies as an interpretative guideline is:
>
> * DNA (the coding): genomics, pharmaco-genetics, gene probes, DNA sequencing/synthesis/amplification, genetic engineering.
> * Proteins and molecules (the functional blocks): protein/peptide sequencing/synthesis, lipid/protein glyco-engineering, proteomics, hormones, and growth factors, cell receptors/signalling/ pheromones.
> * Cell and tissue culture and engineering: cell/tissue culture, tissue engineering, hybridisation, cellular fusion, vaccine/immune stimulants, embryo manipulation.
> * Process biotechnologies: Bioreactors, fermentation, bioprocessing, bioleaching, bio-pulping, bio-bleaching, biodesulphurization, bioremediation, and biofiltration.
> * Sub-cellular organisms: gene therapy, viral vectors.
>
> (Source: OECD Website on biotechnology)

This methodology allowed patents that broadly relate to water from 1990 onwards as issued to Canadian Inventors, including International patents, that had the particular keywords indicated to be reviewed and analyzed. It is important to note that the differentiation between State and Country of inventor makes finding patents invented and/or owned by Americans a manual task, despite the use of a digital online database. As well, differentiating cellular phone technology "receptor" patents from biotechnology patents necessitated a manual filtering of results. Manual sorting of all results once compiled was then completed to the eliminate any patent that featured a keyword already searched, as it would be a multiple listing in the compiled search results. As well differentiating between 'CA' meaning Canada and 'CA' meaning California was filtered out through a manual search.

The following is a list of key words to be used in Patent Searches, as generated from the OECD definition and interpretive guideline of biotechnology, modified:

Table 2: Keywords used for Patent Database Generation

Keyword	USPTO Hits
gene	162
Transgenic (added)	102
receptor	66
DNA	53
Hormone	53
Genomic	43
Hybridization	35 (chemical assays excluded)
embryo	22 (excluding assemblies)
Bioreactor	18 (only 3 if systems and tanks are excluded)
genetic	16
Stem cell	16
PDT	10
Bioremediation	3 (systems i.e. arrangements of containers excluded)
peptide synthesis	3
pheromone	3
tissue engineering	3
cell culture	3 (2 found under bioreactor)
Bioprocessing	2 (both excluded as apparatus, not biotechnology)
Gene sequencing	2
proteomics	1
viral vector	1
cellular fusion	0
glyco-engineering	0
peptide sequencing	0
pharmaco-genetics	0

3.3 Data Collection Methods - ISRN

At Simon Fraser University's Centre for Policy Research on Science and Technology, innovation is being studied as part of a national research initiative called the Innovation Systems Research Network. The focus of the network is to investigate the development of cluster in regions across Canada in different industries. This will result in policy recommendation for the Federal government, in terms of innovation policies for different regions and clusters. The Innovation Systems Research Network is studying

clusters and innovation in over 23 different sites/industries spanning across Canada from Vancouver to New Brunswick. In Vancouver the industries that are under study include the following: water, wood, wine, multimedia, wireless and biotechnology. These industrial clusters are being examined for their characteristics, best practices and 'fit' with current theories about innovation and clusters. Part of the mandate for the network is as follows:

> "Recent studies of the *innovation process* point towards the interdependence of economic, political, social and cultural factors in determining the relative degree of success enjoyed by individual nations and regions in the global and knowledge-based economy. These studies point the way towards a better understanding of the complex interdependencies between internal firm dynamics around the innovation process and the broader institutional setting within which the firms operate"[16]

16 Excerpt from ISRN network mandate found at: [at] www.utoronto.ca/isrn/ Italics added.

There is a relationship between clusters and innovation, but it is also important to note that innovation occurs within clusters, but that not all clusters are innovative. This is why the question of innovation is so important. The regional focus of this study uses the definition of clusters to categorically limit the members of a region engaged in a particular industry and to properly reflect the mechanisms of innovation occurring within a region and an industry. A specific definition of each industry further focuses each inquiry. The definition used for biotechnology was consistent with my use of the OECD definition. An comprehensive interview guide was then used to gather information about the cluster, including relationship and contact information. These interviews were then transcribed and the relationships indicated in the interviews were entered into the RISC[17] database. It appears in the following format in Figure 5:

Figure 3: Relationship Listing from RISC Database

Relationship Listing

Entity 1	Entity 2	Relationship	Direction
Forbes Medi-Tech Inc.	BC Biotech	Member Of	Entity 1 to Entity 2

Finally, I took this data and entered it into the visualization program called Agna[18] to generate graph visualizations of the relationships. Agna is a program which "is a platform-independent application designed for social network analysis, sociometry & sequential analysis" (geocities.com/imbenta/agna/what_is_agna.htm). This allowed me to

[17] The RISC database http://arago.cprost.sfu.ca/~smith/risc/home.php depicts: "... strong national, regional, or local components that influence the opportunities for science-based innovation and competitiveness of firms...It moves from a simple description of the entrepreneur in an isolated firm to a consideration of how all the elements of society contribute to technological change. It encourages the examination of interactions and synergies which would not be visible in an analysis of individual firms or competition among firms."

[18] More information on Agna (Applied Graph & Network Analysis) can be found at: www.geocities.com/imbenta/agna/what_is_agna.htm

produce images of the links expressed in the ISRN interviews. A screen capture program was then used to capture the image of the network at high resolution.

3.4 Data Collection Methods – CMNS 362

The ISRN project generated a list of firms in the biotech sector that was taken as the initial list of firms for this enquiry. This list is cited in Holbrook et al., 2004 and is "taken from a snapshot in early 2002 based on information from the Nation Research Council and BC Biotech" (Holbrook et al., p.100 as in Wolfe & Lucas, 2004). In April of 2004, this list was taken and double-checked for accuracy, looking for firm takeovers, mergers and business shutdowns. The list of firms and organizations was then cross referenced with the current list of members of the BC Biotech Association, the BC TIA membership and was reviewed by this researcher for any missing companies or companies that were present, but were obviously from other jurisdictions. Firms from other jurisdictions were eliminated as although they may network and look for networking opportunities within this Lower Mainland, their IP and other knowledge flows would occur outbound from the cluster and not necessarily back into the area. The firm that was included despite being located outside the cluster was an organization that dealt specifically with HR issues in the biotechnology industry in Canada. This organization was interviewed by telephone.

This list was the first step to provide material for data collection through interviews, but also for use as an accurate listing of firms and organizations to gather a large amount of data about in a short period of time, for later analysis. The selection of interviewers from CMNS362 (Introduction to Qualitative Methods) was done by self-selection. All the student interviewers had completed a previous course in quantitative

data analysis. As noted in previous work, prospective interviewees would be more receptive to interviews conducted by students, rather than duplicate visits from ISRN interviewers. During the course, data was collected on both biotechnology and new media companies. This thesis deals with the biotechnology data specifically, but the author coordinated assignment of companies for both the new media and biotechnology companies. This process is documented in the next section.

3.4.1 Indirect Data Collection

On June 1st, 2004 this list of 145 biotechnology companies was circulated to members of the Communications 362 class for the first step of the research process. The goal of the class was to teach students the steps necessary in completing research[19], while allowing the data to be used for analysis outside the course. This meant that a greater amount of data could be gathered for research and students were able to conduct real-life research. Many students commented in their reflections on the process that they were pleased to engage in real research and that they learned more from actually completing indirect and direct interview research, than reading any book on research methods would have taught them. In fact, completing interviews and gathering more tombstone data proved so popular that when given a choice in assignment fourteen students chose to complete more interviews and tombstone data gathering tasks.

[19] This thesis used a new case of data clearances for the ethics office – clearance for both initial data collection through course work and clearance for use of the secondary data by the researcher. As well as requiring SFU ethics approval for use of secondary data, students received approval to collect data under the course approval for CMNS362. Students signed release forms to authorise the release of their biotechnology sector data gathered to Shawna Reibling, stating the following: I, student name, student number, hereby agree to contribute the data I collected as part of my assignments in CMNS362, Summer 2004 to research projects being carried out by Michelle Petrusevich and Shawna Reibling, under the direction of their supervisors, Richard Smith and Adam Holbrook. Date signed. Student Signature.

Using this list of 145 companies, students were directed to do 'systematic background research' in order to develop a picture of the company. This step is required before interviewing a company for many reasons. These reasons include:

1. To create a perception that the interviewer is prepared, and therefore the interview is not 'wasting' the interviewees' time.
2. To be prepared for the interview to gather as much information as possible from the interviewees that is not available elsewhere.
3. To know who to speak with at the firm being interviewed and the location and phone number of the company to set up the interview.
4. To have more tools to create rapport with the interviewee – more information allows the interviewer and interviewee to create a 'common bond'.

The 'Indirect Research Assignment: Company Profile" form can be found in Appendix B and includes the basic tombstone data for the company, as well as questions pertaining to the use of the company's website in recruitment, memberships held and a place to record any information found on the internet about the company. The students collected this information between June 1st and June 8th, 2004.

This assignment was a success in terms of illustrating the information that is and is not available on the web and allowed students to know information about companies, but also to gather observations about the state of the website and its design, as well as see if the company is mentioned in other places on the web and how much information is available through the website. Each student was assigned eight companies to look up and fill in the "indirect sheet" with the available information.

After this step, the researchers marked the assignments based on the following criteria: "Is the profile sufficient to proceed to the interview or does it require the reader to go back to the website?" Students were not penalized if the companies website did not

have any information or did not exist. Students were also assigned one mark for following the format and using proper grammar and English[20].

While marking the assignments I assigned a mark and grade to each company profile and put comments relating to features of the companies and/or comments on marks lost to the student. I then indicated in the margins beside each company comments for choosing a list of companies to be interviewed. These marks included "*" and "←" for companies I wanted interviewed, as well as notating any geographical constraints such as "Victoria" or "Ontario". This was a double check to filter out any companies who were not located in the Lower Mainland and not eliminated earlier.[21]

3.4.2 Direct Data Collection

After the previous step was completed, the assignments were photocopied and the names of students completing the assignment were blacked out so that they could not be read and they were added into a locked filing cabinet to be stored for analysis. The process of photocopying assignments for research and for course records was tedious, but simple. After the administrative copies were made, the profiles were separated into forms for distribution to students when interviews with companies were assigned. This required a lot of time to shuffle paper and to separate biotechnology and new media companies. Notating the companies that were most promising in terms of information available and notable in the community on the cover pages of each assignment during

[20] If a research piece does not have understandable English and grammar, it is useless to a researcher and/or interviewer. In the world of research, this means the data is unusable. In the world of students, marks are lost.

[21] In the interviews, two companies that were not located in the Lower Mainland were interviewed. One was located in Victoria, and it gave the students a chance to go away for the weekend. The Biotechnology Human Resources Council spoke directly to the issue of employer/ employee networks and therefore was included.

marking was helpful and allowed me to photocopy and create a ranked list of companies to be contacted to arrange an interview.

On June 15th, 2004 students were grouped into pairs, and in one case a group of three, to go and conduct interviews. There were 37 groups of students to complete interviews. Therefore 75 (74 plus one for a group of three) interviews were required between the biotechnology and new media companies for the students to complete. As well, fourteen groups also selected to complete additional interviews in lieu of a poster assignment. More than fourteen groups selected this option, but they did not request it by the deadline of June 29th and therefore they were denied this option, as each group was to submit the dates of their interviews to the research by this date[22].

In order to assign the companies to the groups, each group was instructed to sign up together on a list, this list assigned them a group number. Their group number was then assigned to (and written on) the indirect assignment sheet that corresponded to the company they were assigned to interview. Each group of two was initially assigned two companies - one for each student to interview, while the other student took notes. This ensured that each student would have experience in being the interviewer and the note taker and could fairly be marked based on each experience. It would also keep data collection consistent in terms of the experience of interviewers. The students were split so that some were assigned new media companies and others were assigned biotech companies. Each group of students then received an indirect assignment sheet about the company they were to interview.

[22] Pedagogical Note: The Week 9 deadline (out of a 13 week semester), for scheduling an interview with a company was done to prevent students from rushing in week 12 to complete an interview. Given the busy nature and 'time is money' orientation of the biotechnology industry, it was important to give interviewees a wide time frame to book any interviews. However this technique was not successful as it caused many students to panic.

After the assignment of companies to be interviewed, the students were then taught in lecture by Professor Holbrook how to engage in the interview process and conduct the three steps of interviewing. The three steps are as follows:

1. Setting up the interview
2. Conducting the interview
3. Writing up the interview data gathered.

This demarcation of steps was based on the lessons learned through the ISRN biotechnology cluster interviews. After Professor Holbrook's lesson, the students were given some coaching by Michelle Petrusevich and myself. My experience in this area was based on conducting and observing biotechnology and new media cluster interviews, during the first phase of their collection for the ISRN project.

3.4.2.1 Step 1, Setting up the interview

The first step in the process of interviewing is setting up the interview. This process involves contacting the companies. I decided to allow the students to contact companies instead of pre-screening them in order to allow them the full 'research experience'. The selection of the companies was based on the amount of information available on their website. This is because I am interested in whether or not their interviews would confirm my hypothesis that the sector would yield high social capital as evidenced by their website richness. Also, the fewer number of 'cooks in the kitchen' would result in less confusion and suspicion on the part of the interviewees.

Students were advised to make phone calls rather than sending emails to contact people in the company and to "ask the secretary" whom they should speak with about the human resources issues at the company. The reason for this is that the secretary knows all about the schedules and suitability of most personnel for not only giving interviews,

but if they would know the requisite information. Setting up interviews with companies quickly became a very labour intensive task, despite my not being directly involved in speaking with companies. In hindsight, I regret my decision to allow the students to book the interviews and contact companies. I may have had better response if I would have contacted them myself. As an experienced researcher, especially with my background in cold calling, I have a larger palette of skills to use to secure an interview. This finding also confirms the utility of Dr. Richard Smith's snowball sampling technique for securing interviews in the multimedia sector of the ISRN research project.

After the initial assignment of companies, students began receiving rejections. This meant that I had to move beyond my initially selected list of companies to assign companies that had had less than complete indirect company profiles generated through indirect research on the web. To facilitate this task I developed a detailed Excel spreadsheet to co-ordinate the assignment of companies, as the task was now to be done over email. Also, instead of receiving an indirect assignment sheet, students were instructed to complete their own indirect assignment sheets on the company before conducting an interview. If students gathered the data on their own they would not be crippled by some of their fellow students inability to fulfil the requirements for a successful indirect assignment. Further along in the process, as I searched once again for more companies to add to the list, indirect assignment sheets were not available for the companies.

The excel spreadsheet used to assign the companies involved assigning one row to each group of students and then adding companies that were assigned to them to contact. The assignment of companies was kept track by writing "assg" beside the name of a company as it was assigned. If the company said no, it was highlighted in the groups'

row and another company was assigned. Companies who had confirmed an interview were highlighted in green and companies who had not gotten back to the group yet or who had said maybe were coded in either light yellow for "call back another day" or dark yellow "for no contact at all, but will try again". This was because a light yellow company had contact established and was tentative, whereas a dark yellow company had more of a chance to say no.

Groups who had designated additional interviews, i.e. who needed to complete four, instead of two interviews, has their names highlighted in orange. When receiving the name of another company to pursue for an interview, one or both of the students in a pair received the following email message:

> "Here are more companies, please let me know if you do or do not get interviews from the companies or if you do not need any of the companies so that I can assign them to someone else. If the company is a small or one-person operation, then ask them why they are located here - they are their own HR department. Thank you, Shawna"

This allowed the procedure of co-ordinating assignment of the interviews assigned over the web to proceed more smoothly, with the communication between the students and the researcher being of utmost importance. Initially, when the methodology was being designed, I decided not to have students tap into their own personal networks for possible interviewees. This was because it gave some students an unfair advantage over others in terms of knowledge of a company and did not reflect the cold-call nature of research. However, as assignment deadlines approached for the Direct Interview assignment, some students asked if they could interview someone they knew. I granted

permission to these students in consultation with the course supervisor Professor Holbrook, as it lessened student stress and my own stress in assigning interviews to all students. This only occurred in two cases, both being in the new media sector. I also assigned one company, Linnaeus Plant Science, based not on its position on any list, but as I had heard of it through my work in the water technology sector and had observed that the owner had worked in the biotechnology area before his company was bought out.

His current company Linnaeus Plant Science Inc. was in a start up stage too small to be found on the BC Biotech or other industry association lists. The mining of my own personal/profession network led to this interview. In terms of response for the biotechnology companies contacted, 115 companies were contacted and 46 companies agreed to be interviewed. That is a response rate of 40%.

3.4.2.2 Step 2, Conducting the interview.

Conducting the interviews, interviewers were instructed to follow the procedure outlined in Appendix C.

3.4.2.3 Step 3, Writing up the data gathered

Step three in the process of interviewing is writing up the interview data gathered. Students were directed to arrange time directly following their actual interviews to write up their observations and answers to the interview questions. The official write-ups for the direct assignment were due on July 27th, 2004. At this time the following data was collected, as per the guidelines outlined in Appendix D. The final assignment was marked

to include the following elements: An Introduction, The Indirect Assignment, The Interview Guide and a Methods Reflection[23].

3.4.2.3.1 Write up Elements - The Introduction

The introduction was a place to record the process of securing the interview and also for recording any observations made in the field as well as documenting data such as interview location and length.

3.4.2.3.2 Write up Elements - The Indirect Assignment

This area was for an updating of the information found in the indirect assignment sheet. This was to flesh out the data gathered earlier.

3.4.2.3.3 Write up Elements - The Interview Guide

This section recorded the responses of the interviewee to the interview questions as well as a space for noting any questions paraphrased or not answered. It was important and stressed with the interviewers and note takers, to record the interviewee's phrases and words, and not to "put words in their mouths" or to record impressions. Systematic data gathering not interpretation is the goal of this section.

3.4.2.3.4 Write up Elements - The Methods Reflection

This section revealed many of the limitations of the method as outlined in the above sections outlining the process of data gathering over all. It also revealed the learning done by the students through the process. Questions explored in this section were as follows:

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[23] There were also 'marks' assigned for submitting a soft copy of the assignment and for grammar and form. In the real world a mark is analogous to a something creating a problem in the analysis of the data. If the data gathered is not grammatically understandable or spelled incorrectly, issues are created. This was pointed out to me in the ISRN transcribing process as specific, non-common words to the industry were often transcribed in correctly. In the process of research, creating a digital record of the information is becoming more and more important as researchers are spread out geographically and the sheer volume of paper to be handled in larger studies is often overwhelming.

a) What interview procedures would you use again and why?
b) What interview procedures would you not use again and why?
c) What did you learn from the process that you would apply to further interviews?
d) What things does the note taker need to do? What things does the interviewer need to do?

Identify and explain each partner's different experiences as a note taker vs. an interviewer. You will not loose marks in this section for commenting on deviations from how you conducted your interviews, rather, reflect on the research method of interviewing and what you learned from the process – from initial contact to writing up the final copy.

These assignments formed the Summer 2004 body of interview and background data.

3.5 Data Collection Methods – Web based

Collection data through a web-based method began with a search for software that addressed the problem. A process and software package that was easy to use and inexpensive was key. One of my personal philosophies is that open source and other freeware packages are preferred, especially given the academic use of said software and my limited finances.[24] The use of email or web-based material was also considered as a web-based measure. Other studies have pointed out problems with using email to account for information networks, they may not be the networks that carry the most information (Cross and Parker, 2004). After consulting with some computing science students to determine the correct name for the realm of software I wanted to search in, I

[24] Open source is a term that refers to software that has a license that conforms to the open source definition found at: http://www.opensource.org/docs/definition_plain.php. These elements include: free redistribution, source code availability, allowing of derivative works and distribute the original source code with author attributations and license attached. As well no discrimination between persons, platforms or fields of study is allowed. Essentially, open source software is software that has a free license and the source code for the program is available to all. This should not be confused with freeware or shareware or GNU Public License (GPL) software. Freeware software is no cost software, but the copyright and code is controlled and owned by the owner. Shareware software is limited use software, with the same restrictions as freeware, but the additional feature of only being useable for a limited amount of time without charge. I.e. 30 days. GPL is a type of software license that conforms to the criteria of open source. A list of licenses can be found at: http://www.opensource.org/licenses/.

discovered what I wanted was data mining software and then visualization software to graphically display the result of the data mining software.

Data mining is part of a process of "knowledge discovery from data" (KDD). KDD is more than sorting through a database, it involves grouping and classifying data within a data set to find patterns... to extract the data hidden in large data set. (paraphrased from Data Mining Seminar at http://vu.cs.sfu.ca/vu/tlnce/PublicReg). KDD asks "understanding" questions rather than "counting questions". I.e. What is a company's website linked to? vs. How many hits does a website receive? This meant that I was unable to use data gathering tools designed for website statistics such as web logs.

My experience with computers and software has been more broad than most. I have worked with Windows, DOS, Unix, Macintosh and Linux platforms, therefore my software choices were quite broad. I consulted many resources during my search for the proper website. Sites listing various software included: www.graphviz.org/, kdnuggets.com/software/visualization.html, www.sfu.ca/~insna/INSNA/soft_inf.html and www.manageability.org/blog/stuff/. These sites, as well as conversations yielded up one good option that would allow me to maximize the use of my computing resources and allow me to gather as much data as possible, while still keeping the problem trivial. One of the limitations pointed out early on in the project was limiting the information I wanted gathered from the Internet. Did I want website linkages between pages? Or content mentions of relationships within pages? i.e. contents of press releases. Given the scope of my research question and technical limitations, website linkages were determined to be the area of interest. The method for data collection using web-based tools was designed to have two steps:

Step 1: collection of linked websites

Step 2: Drawing of the links between websites.

Step one was designed to collect links through a web crawling program known as "htdig" or "htt:/dig"[25]. This program is designed to create an index of a particular site to be searched through a search engine, specific to a site or group of sites. It is configured to run on many platforms, but most specifically on a Linux platform. This is ideal for installation on web servers that already have the website to be indexed installed on it.

The details of htdig can be broken down into three steps – "digging...merging ...and searching" (The ht://Dig Group, 2002, accessed at: htdig.org/howitworks.html). The advantage of this system is that it can meet the needs not only of creating a record of website links, but also provide a built in interface for querying more detail out of the database of linked information. Some additional features include automated indexing of multiple sites and an option to either include or exclude additional links such as Adobe Acrobat software downloads. Eliminating certain document types such as Word documents or .pdf files is possible. This program fulfilled the needs of step one – it efficiently and completely gathered data.

But finding proper software to complete the task of Step Two – visualizing the data gathered was proving to be more difficult. "The apparent 'ease' offered by these technologies hides much of the extra work they involve...it's [computers] still a young person's medium, calling for intense concentration and few distractions" (Brown and Duguid, p.81). This is what I found this process to be like when finding not only a program to visualize the data gathered but also one that had an easy to understand interface to enter the relationships.

[25] The website for this product can be found at www.htdig.org.

As I proceeded with installing ht://dig, I was met with problems and limitation of my ability to install software. I attempted to install the program using an automated install tool known as "apt-get" on a Debian Linux system. This procedure proved to be ultimately unworkable, so I proceeded onto "Plan B" – installing the program on another computer and platform.

I proceeded to install the program on a Mac OSX system. This proved impossible to install due to configuration limitations of the platform, namely a lack of libraries to run the system. I contacted numerous users who had previously successfully installed the program on an OS X platform, but my repeated inquiries were not met with replies.

After much frustration I decided to revisit the installation on the Debian Linux system, using a manual installation instead of the automated "apt-get" installation. This was unsuccessful due to library dependencies that frustrated me to no end. Finally the "apt-get" installation was re-attempted to a successful conclusion. The apparent problem during the previous install was based in the code of the software, which was recently corrected, rather than in my installation.

Once the program was operational and ready to go, I entered the websites to be indexed into the configuration file, setting the 'step count' to 5 and excluding all .pdf and .doc files from the index. This meant that websites up to 5 links away would be indexed. Running the program did not work as the default configuration was indexed, not the configuration indicated in the configuration file I had modified.

After manually indicating and forcing the program on the command line to use the revised configuration file, this too failed and I was unable to figure out why the

alternate configuration file was not being used. Some reasons that were double-checked included: IP Tables, file permissions, capitalization and spelling, command preferences and operator tiredness. I tried rerunning the alternatively configured program to gather the appropriate data several times over a week long period. All to no avail. This resulted in substantial frustration and I decided to move onto another phase of the project and to try again later. While doing this, I uncovered the limitations of the web indexing system.

The limitations of search engines can be found described in detail by Brown and Duguid on pages 42-44 of *The Social Life of Information.* Their search, using six major search engines, for relevant documents that held the word "knobot" yielded 51 useless or not existing links. It looked like the automated search option was inconclusive and therefore I would need to look elsewhere.

Conventional business wisdom states that a website is an important marketing tool. The interview response data from Summer 2004, indicated the importance of websites as a place where people can find out more about a company – a virtual employee, to field questions about the firm and to act as a public relations representative as well as a way to manage inquiry traffic and workload on employees. Many firms indicated that their websites received hundreds of resumes a week through website inquiries.

Beyond the basic marketing concern of increasing a specific website's page ranking on Goggle, focus on finding the number of connections for a website is what most interests me. The high rank of a website on a search result is not the concern, but the digging each search engine performed is important. A greater number of links found indicates a richer and more complete picture of the networks of the website. Therefore, the best way to find out if a website is an indicator of relationships is to use a search

engine accessible to the general public, that indexes the most number of linkages and relationships between firms. This is completed to find a website that is very connected in a network– a hub. A December 2003 study by the website searchengineshowdown.com/ indicated that Google indexes the most number of webpages[26]:

Table 3: Listing of Amount of Pages Indexed by Various Search Engines.

Search Engine	Showdown Estimate (in millions) Dec 03	Claim (in millions) December 2003
Google	3 033	3 083
Alltheweb	2 106	2 112
AltaVista	1 689	1 000
Wisenut	1 453	1 500
Hotbot	1 148	3 000
MSN Search	1 018	3 000
Teoma	1 015	500
NLResearch	733	125
Gigablast	275	150

Data compiled from: www.searchengineshowdown.com/stats/sizeest.shtml and searchenginewatch.com

This indication of Google's role as the indexer of the most websites makes it an ideal tool to use to determine web-based relationships. Therefore using Google to find linkages to and between specific firm websites would be an ideal solution to the problem of finding links on the web. It is a hub of interconnectivity. As well, Google uses PageRank technology[27] to index its pages. The most important pages identified by Google are likely to be the more important links to the firm's webpage due to its comprehensive and weighted ranking system. Once these links are found, they will need to be indexed and visualized. Enter "TouchGraph LLC: Java coding for TGGoogle

[26] The invisible web is not indexed by Google. I am more concerned with linkages between sites, firms and documents than links to specific information. i.e. the information embedded in dynamically generated database webpages, a common member of the invisible web, therefore this is not an issue.

[27] "PageRank relies on the uniquely democratic nature of the web by using its vast link structure as an indicator of an individual page's value. In essence, Google interprets a link from page A to page B as a vote, by page A, for page B. But, Google looks at more than the sheer volume of votes, or links a page receives; it also analyzes the page that casts the vote. Votes cast by pages that are themselves "important" weigh more heavily and help to make other pages "important." " (www.google.com/technology/)

Browser Applet! This program can be found at:

touchgraph.com/TGGoogleBrowser.html. It allows the user to enter a specific URL and then displays either as a list or as a graph all the sites found related to the starting URL. There are options for viewing the graphic results in Table 4:

Table 4: Options for Display of TGGoogleBrowser Network Visualization

Label	Description	Setting
Show Single	shows links with only a single incoming edge[28]. "A lack of outgoing edges implies that related links have not yet been fetched...Nodes which have outgoing edges have already had the first 10 search results retrieved automatically." This check box allows you to eliminate from view any single path links. I.e. non-reciprocal links.	1st: yes 2nd: no
Radius	show nodes reachable by following radius number edges[29] "...if you select a radius of 1, only pages which appear directly on the "similar-to" list for that page from Google... will be shown. A radius of 10 is pretty much equivalent to a radius of infinity... Setting the radius to all will show all the nodes queried so far, even if there is not a path from one to the other, as will happen if you use the Add URL field to add two completely unrelated nodes." This is another way of specifying the minimum distance of nodes you want to see from the main URL. Possible Values: (0,1,2,3,4,10,all)	10
Show First	first N search results. "Used to narrow down the connections displayed to only the first N results in a "similar to" query...Setting the value of the show first drop down to All, will show the rest of the connections in an even lighter grey." The number of links shown can be restricted. This relates to the link rankings found by Goggle. Possible Values: (2,3,4,5,6,7,8,9,10, All)	All
Min Inbound	Only show nodes with a min. of N inbound edges. "...The idea is that nodes with a high number of inbound edges...are likely to be more important then those with a low inbound count. Thus, setting the minimum inbound drop down to a large value will show only the most important nodes." Filter out nodes with less then the specified number of inbound edges. Possible Values: (0,2,3,4,5,6,8,10,12)	0

Source: Adapted from: http://www.touchgraph.com/TGGB_FullInstructions.html

[28] Definition: a graph is a finite set of dots called nodes connected by links called edges.
[29] "The radius of the graph G, rad(G), is the minimum value of e(u), for any vertex u, and the diameter, diam(G), is the corresponding maximum value." http://www.math.fau.edu/locke/graphthe.htm

For example:

Table 5: Listing of Treatments for Network Visualization in TGGoogleBrowser

	Show Single	Radius	Show First	Min Inbound
Default	Yes	10	ALL	0
#1	No	10	ALL	0
#2	yes	ALL	ALL	0
#3	yes	10	5	0
#4	yes	10	ALL	12
#5	Yes	1	ALL	0

Using Angiotech.com, the 5 treatments are displayed in Figure 4. Treatment 'Default' and '#2' are the same – they list the maximum number of links. '#1' lists all the direct connections only. '#3' shows the 5 most important links. '#4' results in no graph at all. '#5' shows only the directly similar pages. Notice that all links are only one step away from the site searched. Using the default settings of the Touchgraph program I generated two different graphs for each website - "Default" and #1 as indicated in the chart above and used for analysis. This shows both the most direct and the most diffuse networks related to each company. Or in the terms of describing graphs – the minimum and maximum ranges of the networks (Hargadon, 2003).

The Touchgoogle programmer provided more detail concerning what determined the positioning of the links in the graph, especially given such unusually shaped graphs as Cantox and ARC Pharmaceuticals in Figure 5. The algorithm for placing links graphically is as follows:

> "The distance between the links is dependent on two factors. The first factor is the order a site appears when one does a "related: www.targetsite.com" search for the target site on Google. The second factor is that two websites in a cluster of related sites all of which appear of each other's "related:" lists will be placed close together." (Personal communication with Author).

Figure 4: Angiotech: All Treatments

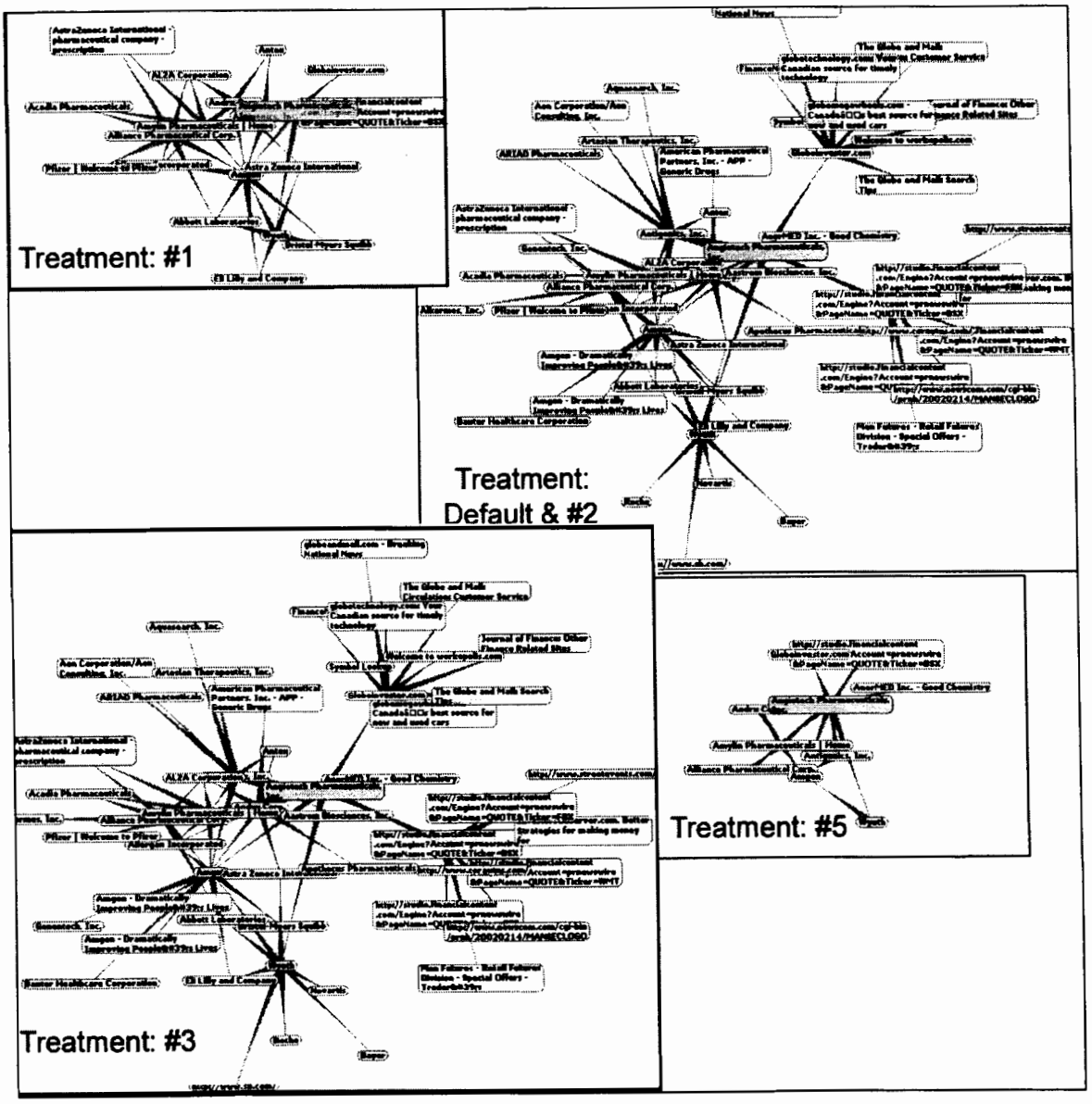
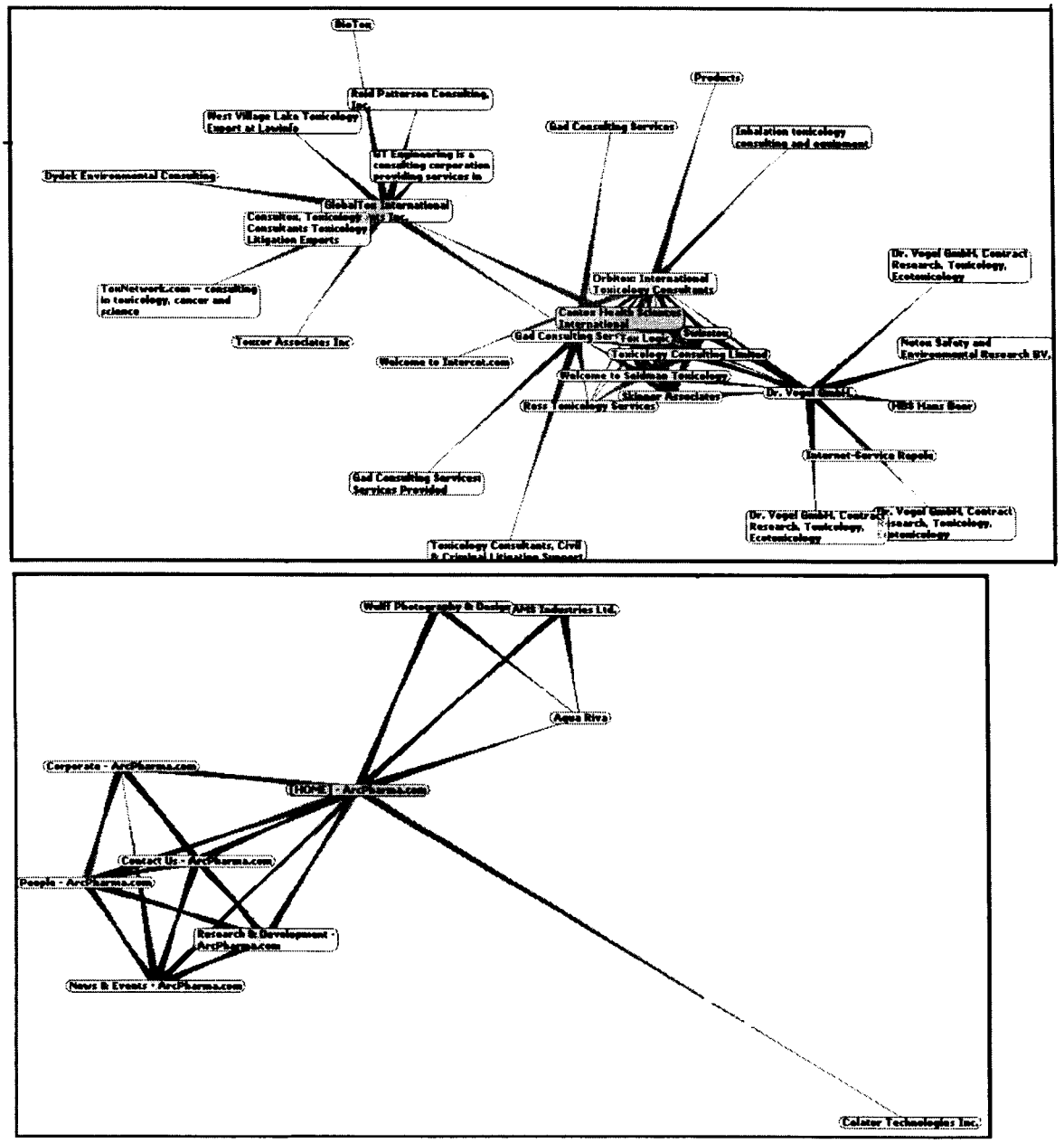


Figure 5: Unusually Shaped Graphs



CHAPTER 4 FINDINGS AND DISCUSSION

The results of both the indirect and direct research questions were achieved to determine if **Internet linkages could be used to measure social capital and dynamics of the biotech cluster in BC?** This question is important to the success of a cluster, as these linkages can illustrate the importance of both social and spatial geography to the study of innovative regions.

Once it is determined that there is a web linked biotech cluster in BC, a way of showing linkages within the cluster is needed. In order to answer the question of the role the usefulness of Internet sources in finding relationships, finding a method and tool for accounting for linkages between actors in the network is necessary. The interviews conducted with companies by the ISRN team, provides one picture of linkages. Interviews conducted over the summer semester of 2004 added to this picture. Once the importance of the website linkages is determined, using the internet to collect linkages between companies and using a program to automatically gather internet linkages will all be used to triangulate an answer to the question: Can internet linkages be used to measure social capital and dynamics of the biotech cluster in BC? "By having a cumulative view of data drawn from different contexts, we may, be able to triangulate the true state of affairs" (Silverman, 2000, p.98). The elements of this triangulation include a) determining linkages present from ISRN interviews and in Summer 2004 and b) determine linkages present through an automated web link searching process. These steps have been discussed in the previous 'Methods' sections.

The guiding question examined in this study is: Can Internet linkages be used to measure social capital and dynamics of the biotech cluster in BC? The hypotheses generated to answer that question are as follows:

1. There is an active biotech cluster in BC, as demonstrated by patent citations.
2. Social capital networks are present in this cluster and can be measured through interviews and through the Internet.
3. A web presence matters to the members of the social network in the biotech sector.
4. Automated Internet searches of web present biotechnology cluster networks reveals complex relationships.
5. Web links can show the health of a cluster and portray points where intervention may be useful and possibly places where current models are working.

Each result will be discussed in more detail in the following sections.

4.1 Hypothesis One: There is an active biotech cluster in BC, as demonstrated by patent citations.

"Patent statistics are recognized to be the best indicator of innovation" (Griliches, 1990, p. 1669; Co, 2002, p.396). Therefore I have used them as an indicator of innovation. Feldman and Florida (1994) determined that there is a .93 correlations between geographical distribution of innovation and patents. A correlation of 1.0 is statistically perfect strong correlation and effect relationship.

In a 2000 study, Niosi and Bass reported 21 patents granted to private firms in Vancouver between 1989 and 1999. This was 7 percent of patents in the biotechnology industry, compared to 17 percent filed by Montreal inventors and 61 percent filed by Toronto inventors. This places Vancouver as the third largest geographic cluster to generate patents. Unfortunately the study does not indicate whether this is the owner or inventor or patent office location of the US PTO patent granted.

Based on this study's compilation of US PTO database, there are clusters of patents filed by Inventors in Quebec (15%) and British Columbia (13%) (See Table 6). More specifically, the cities of Toronto (18%), Vancouver (11%) and Montreal (8%) have a high number of patents. According to one study in the UK, most firms used external patent agents to file their patent applications (Thomas, 2003). This may explain the high number of patents registered in Toronto.

Table 6:Biotechnology Patents Granted to Canadian Inventors And Groups Including Canadian Inventors Since 1990 By Canadian City

Location	Total Patents		Tot. %	
British Columbia	**190**		**13**	
Vancouver (Lower Mainland)		163		11
All Other		27		2
Alberta	**117**		**8**	
Calgary		54		4
All Other		63		4
Saskatchewan	**42**		**3**	
Manitoba (Winnipeg)	**19**		**1**	
Ontario	**527**		**35**	
Ottawa		85		6
Toronto/GTA		277		18
Waterloo		18		1
All Other		147		10
Quebec	**227**		**15**	
Montreal		127		8
All Other		100		7
Other Canadian	**11**		**1**	
United States	**320**		**21**	
Foreign	**67**		**4**	

n=469 patents; 1520 inventors engaged in research Source= US PTO Data

Looking more specifically at the findings, they are consistent with the results of Niosi and Bas - "...one major biotechnology firm dominates the invention capability landscape in Montreal (BioChem Pharma), ...Vancouver (QLT)" (as in Holbrook, 2000, p. 51). The patent by owner shows a similar break down, with the only notable outlier

being Saskatchewan, patent ownership has been transferred elsewhere. This is explored further in Table 7.

Table 7: Biotechnology Patents Granted to Canadian Owners And Groups Including Canadian Owners Since 1990 By Canadian City

Location	Total Patents		% Patents	
British Columbia	**54**		**10**	
Vancouver (Lower Mainland)		43		8
Other		11		2
Alberta	**36**		**7**	
Calgary		19		4
Other		17		3
Saskatchewan	**8**		**1**	
Manitoba (Winnipeg)	**10**		**2**	
Ontario	**189**		**35**	
Ottawa		45		8
Toronto/GTA		101		19
Waterloo		2		<1
Other		41		8
Quebec	**73**		**13**	
Montreal		44		8
Other		29		5
Other Canadian	**6**		**1**	
United States	**119**		**22**	
Foreign	**21**		**4**	
N/A Inventors(s) are the owner (s).	**30**		**6**	

n=546 patents Source=Data generated from statistics found in US PTO

The results of the chart above reflect the ranking of regional concentration of US patents to Canadians as illustrated by Niosi and Bas. This is interesting as their 2000 study included only companies. But this could be explained as it is not uncommon for research groups to assign the patent to a non-local external entity and the USTPO database contained many entries filed by foreign firms, as both owners (assignees) and inventors. Therefore it is necessary to examine not only the inventors, but the owners of the patents. The foreign countries (other than Canada) that occurred the most in the records examined were Great Britain, Japan and Korea.

The break down of these patents by institution is listed in Table 8. The further break down of each category of institution is broken down by country.

Table 8: Biotechnology Cluster Patent Ownership (Percentages)

	Research Inst./ Hospitals	Gov't	Universities	Companies	Total
Canada	**21**	**9**	**22**	**27**	79%
USA	**3**	**0.4**	**6**	**11**	20.4%
Foreign	**2**	**0**	**0**	**2**	4%
Total	**26**	**9**	**28**	**40**	

N= 548; 30 patents - no specified owners. Does not equal 100% due to rounding.

In Canada there is a large amount of patent ownership to universities and research institutes/research hospitals. "Universities and R&D laboratories affect patent output only in.... metropolitan areas in the non-manufacturing belt" (Anselin et all 2000a, 2000b; Co, 2002). While working with the database generated it was surprising to notice that University of Calgary has many patents licensed to it. This could be due to the IP regime at University of Calgary (and UBC). These two institutions have formed specific mechanisms and structures to spin off IP into firms creating marketable products. The knowledge generated through the work of Canadians (and Canadians and Americans and Others) working together is mostly embodied in companies, universities and research institutes/research hospitals. But where does the IP flow outside of this institutional context? Can we see where it flows – either locally or into other places? Table 9 shows the flow of Canadian and jointly generated IP into US and other sources, as well as staying in Canada. This demonstrates the global nature of the biotechnology sector and therefore highlights the importance of electronic connections. Being related electronically and geographically dispersed who know a flow of knowledge, but patents confirms that people are here and are working in knowledge intensive ways.

Table 9: Break down of IP flow between Countries and Inventors vs. Owners

	Patent Inventors	Patent Owners	Total
Canadian Only	35	34	69
US Only	--	7	7
Canadian/US Joint	11	3	14
Canadian/ Int'l Joint	0	<1	<1
Cdn./US/Int'l	1	<1	1
Cdn./Int'l	3	<1	3
Int'l Only or Int'l/Int'l	0	1	1

N= 930; 30 patents - no specified owners (3.23%). May be >100% due to rounding.

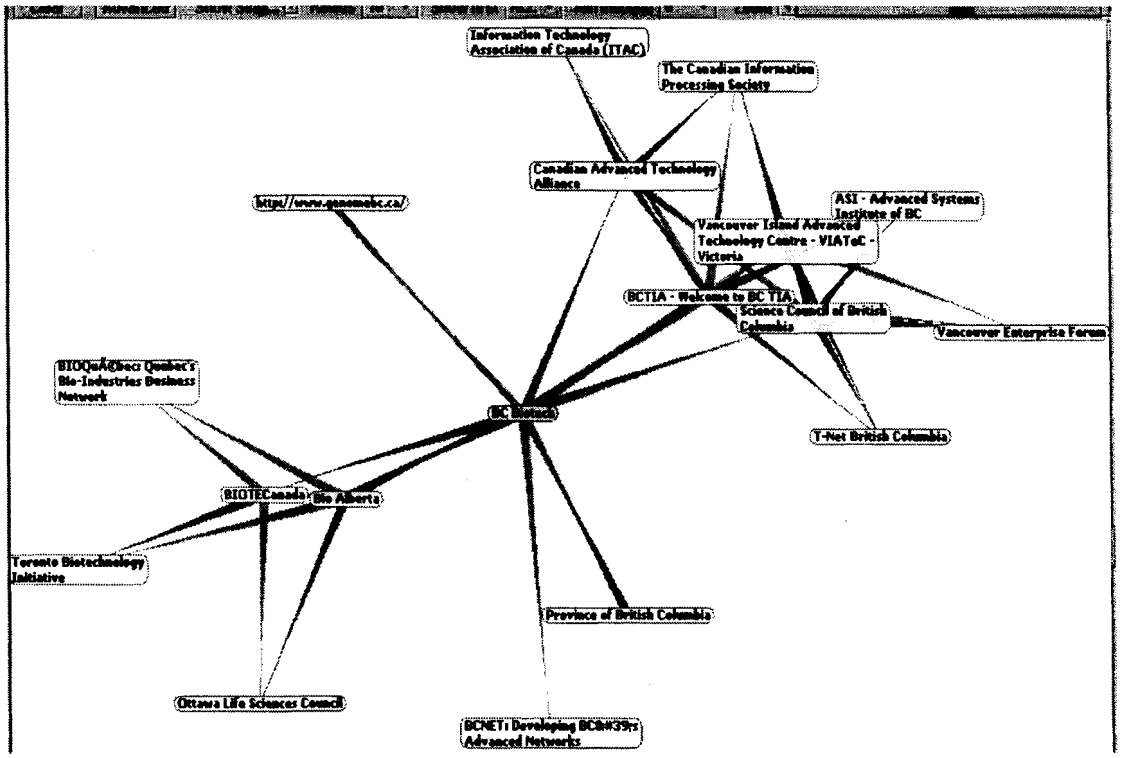
The patents database has shown that there are a lot more multi-geographical working groups than in the water industry. This maybe due to the more global nature of the industry or as Thomas (2003) notes, "research collaboration has become almost de rigueur for much of biotechnological research in both the public and private sectors" (p.75) in the UK. Also, the reputation of those located in the Lower Mainland and therefore other individuals and institutions seek them out globally. Intellectual property is the lifeblood of industries such as biotechnology.

4.2 Hypothesis Two: Social capital networks are present in this cluster and can be measured through interviews and through the Internet.

Once it is determined that social capital is present in the cluster, the question of how to measure it becomes important. Networks encapsulate the untraded capacities value of the social capital. "Not only are networks generating social capital and wealth, they have also been closely associated with...a higher degree of innovativeness and of

capacity to transform..." (Acs, 2002, p.173) and create wealth (Fukayama, 1995). Social capital is present in the cluster – there are abundant linkages throughout the cluster. "BC Biotech appears to be the glue that keeps these companies together" (Holbrook et al., p.103). BC Biotech's immediate google-generated network is shown in Figure 8.

Figure 6: BC Biotech Immediate Network



This network of linkages was also demonstrated in ISRN interviews and in the Summer 2004 interviews. The linkages between firms and BC Biotech matters. Not only does the reputation of your fellow network members confirm the same attributes to your firm, but "density of firms, practices and practitioners also promotes reliable risk- and trust-assessment...a knowable community" (Brown and Dugiud, 2000, p.169).

In the biotechnology sector, some firms were shown to have smaller, but dense networks. "...Strong links do not exist in isolation; rather, they tend to fall within triangles. Strong ties between people should almost always appear this way" (Buchanan,

p.41). This also means that these strong links are also hard to break, given their triangular nature. The best examples of these tight triangular networks were found in linkages between different webpages either internal to a firm's website or within different branches of the same company. See these networks as examples of strong internal links in Figure 7 and Figure 8.

Figure 7: Strong internal network: Geographic Branches

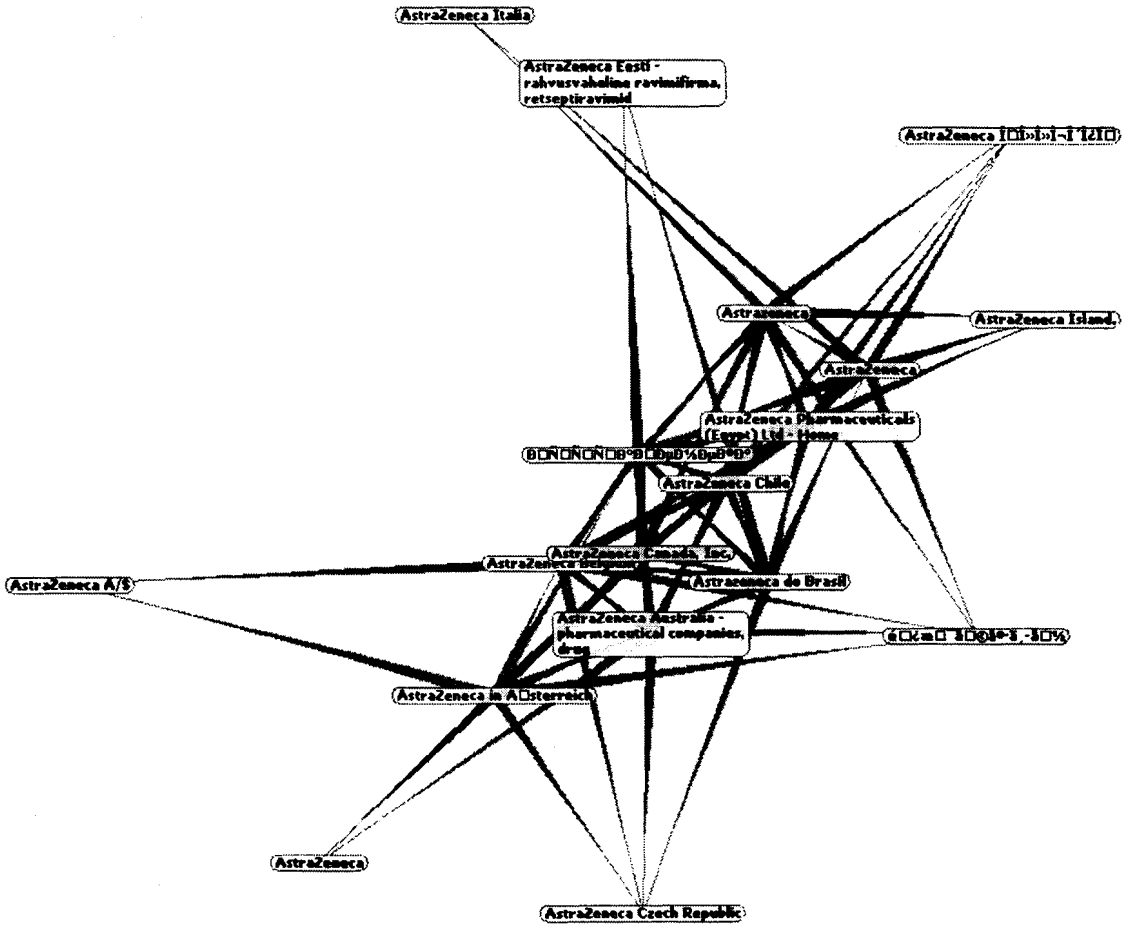
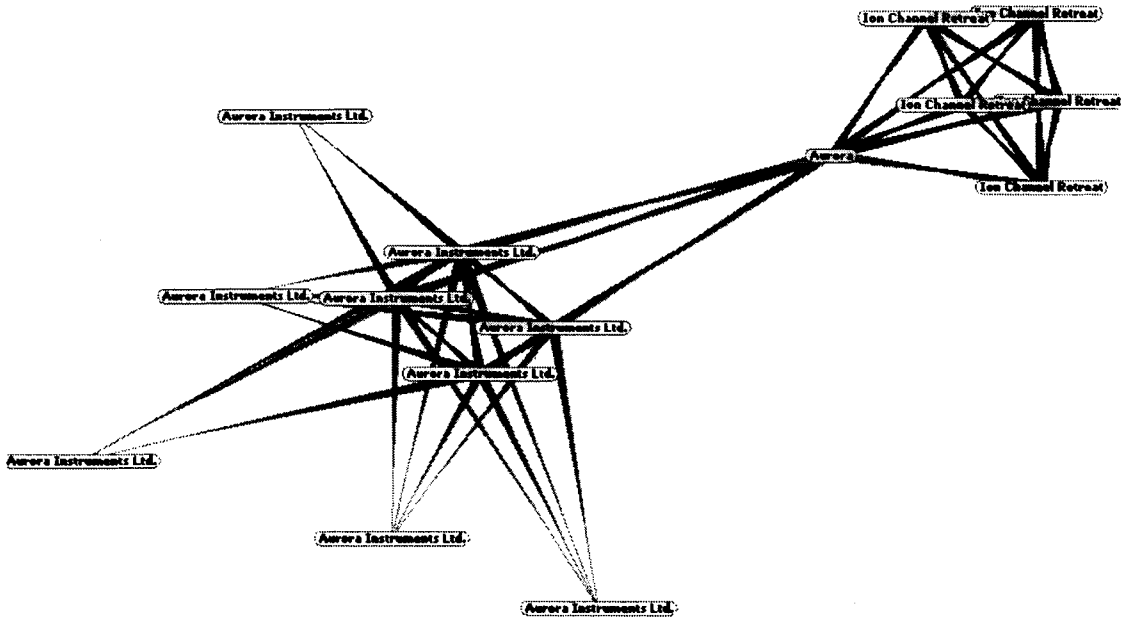


Figure 7 shows the network linkages between the different branches of a single company. These linkages are diverse in their geography, but intra-firm in nature. These sorts of companies, pictured in Figure 7 and Figure 8, have an internal focus - their links

are consistently within the company so that they are presenting a consistent "key message". But they do not have strong initial linkages to others in the network. The implication of this is that unless someone is searching specifically for the name of the company, they will not find the company in an Internet search. This is a limitation.

Figure 8: Example of Strong internal links: Non-branch based

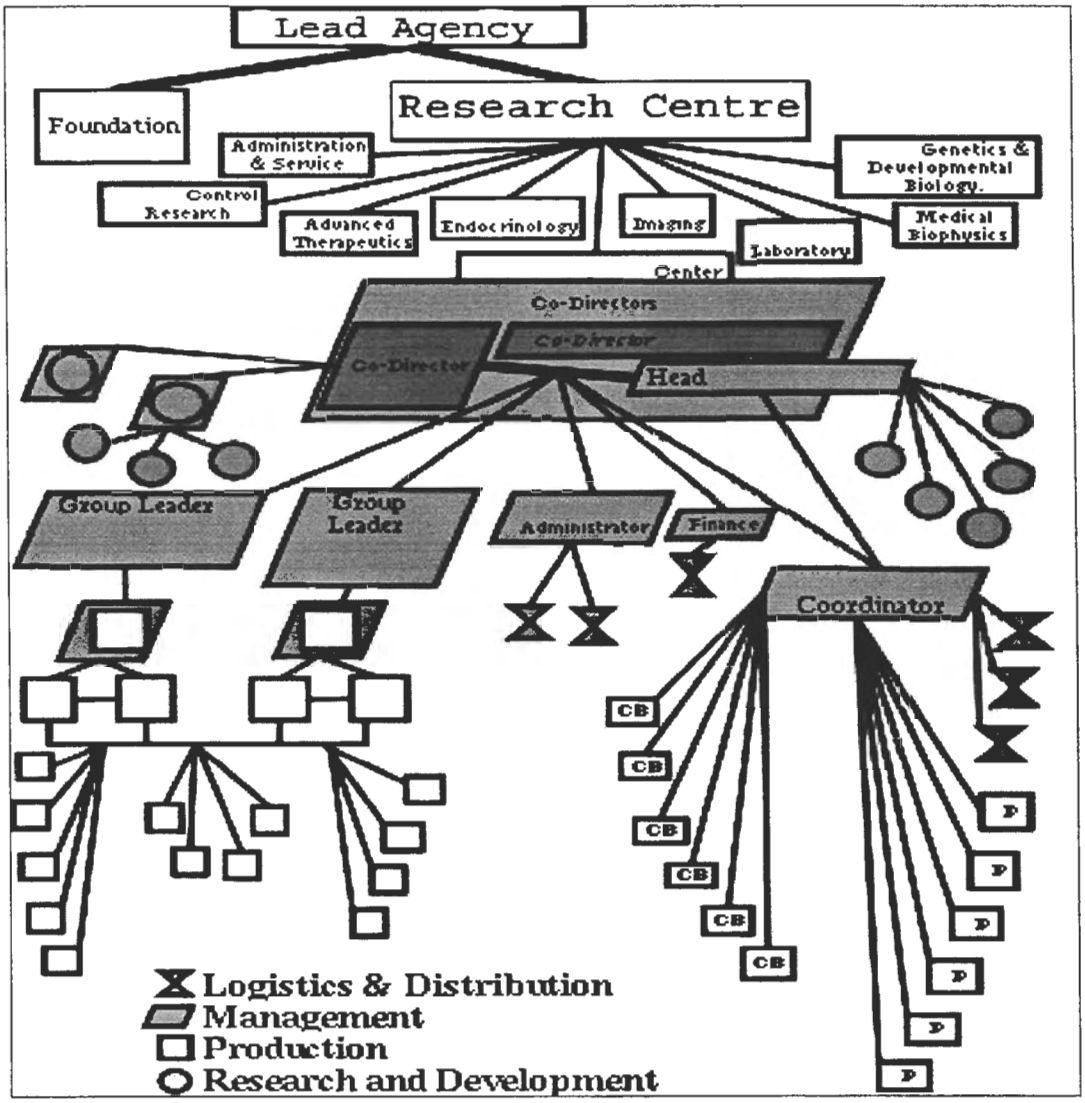


Conversely, the positive result of this situation is that no matter what webpage of a company, a potential customer/employee lands on, they can be quickly directed towards to home page of the company. Figure 8 shows a company that not only has strong internal links, but strong internal links to a different branch of the company. The company's strong direct links are all with itself. The network belonging to Aurora shows strong triangulation within its internal sites. But it also shows a single triangular link between its instrumentation and therapeutic company areas of research. Similarly to Astrazeneca, its larger network including singular links is almost the same as this smaller network. Inwardly focused companies might be more suitable for internal network analysis rather than network analysis or have a centralized marketing plan out of another

branch. This would mean that all linkages would lead to a central site with a resounding key message.

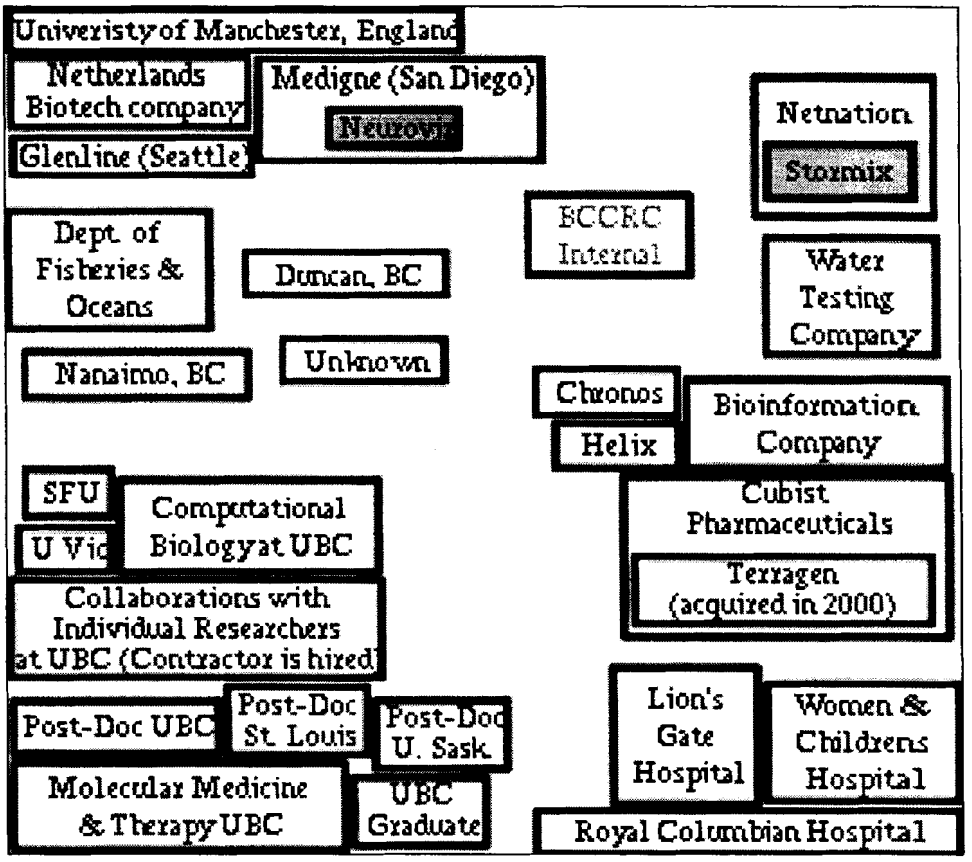
In terms of network visualization, organizations that are more inwardly focused would benefit from depictions of internal network to view their internal social capital. An example of this can be found in the depiction of the organizational structure, Figure 9, and HQP, Figure 10, in a Lower Mainland research organization.

Figure 9: Internal Company Organizational Network.



Source: ISRN Interview Data.

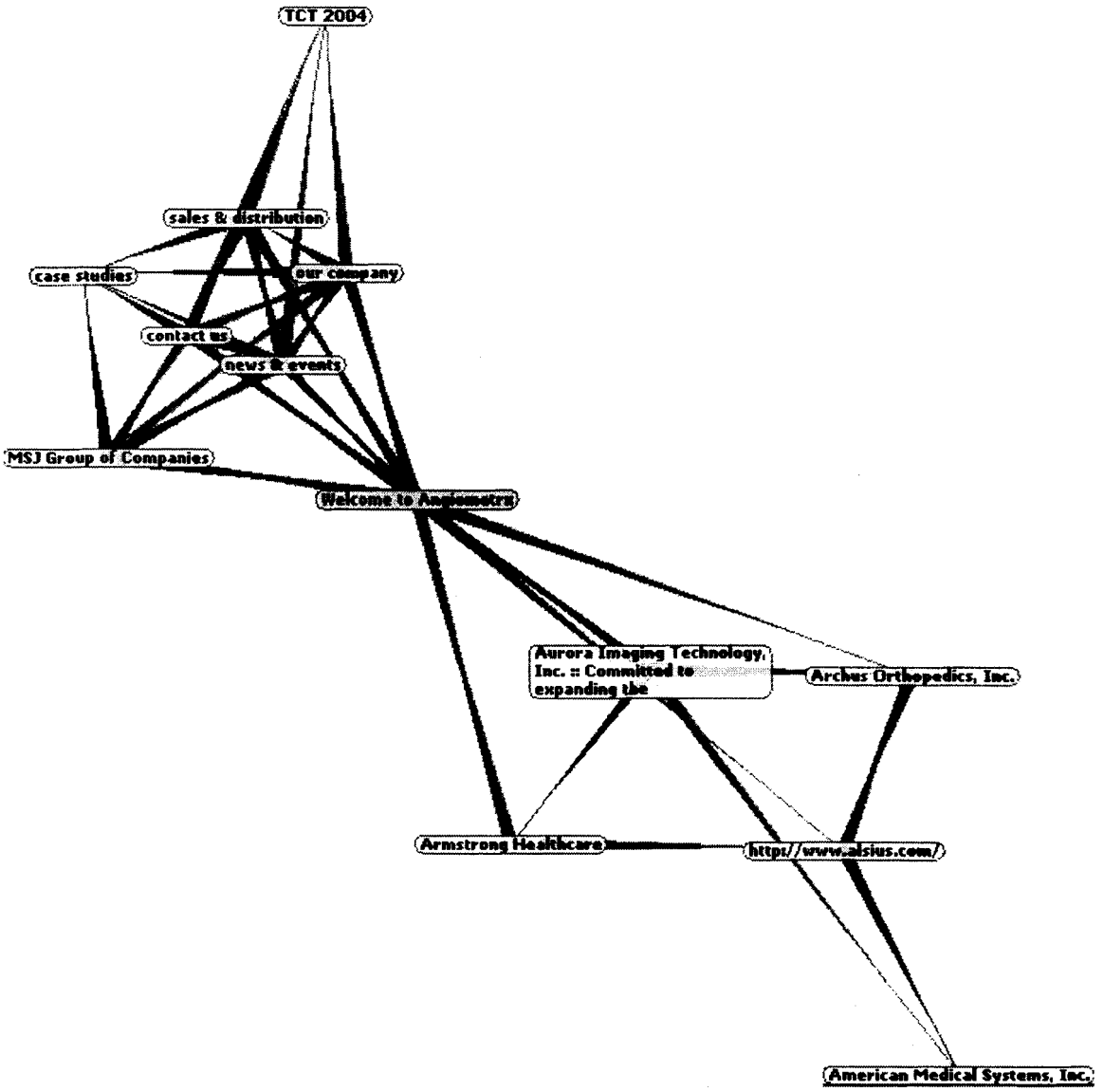
Figure 10: Sources of HQP for a Lower Mainland Research Org.



Source: ISRN Data.

In contrast to the internally linked firm, Figure 11 shows a company that not only has strong internal links, but external links as well.

Figure 11: Strong internal network with external network



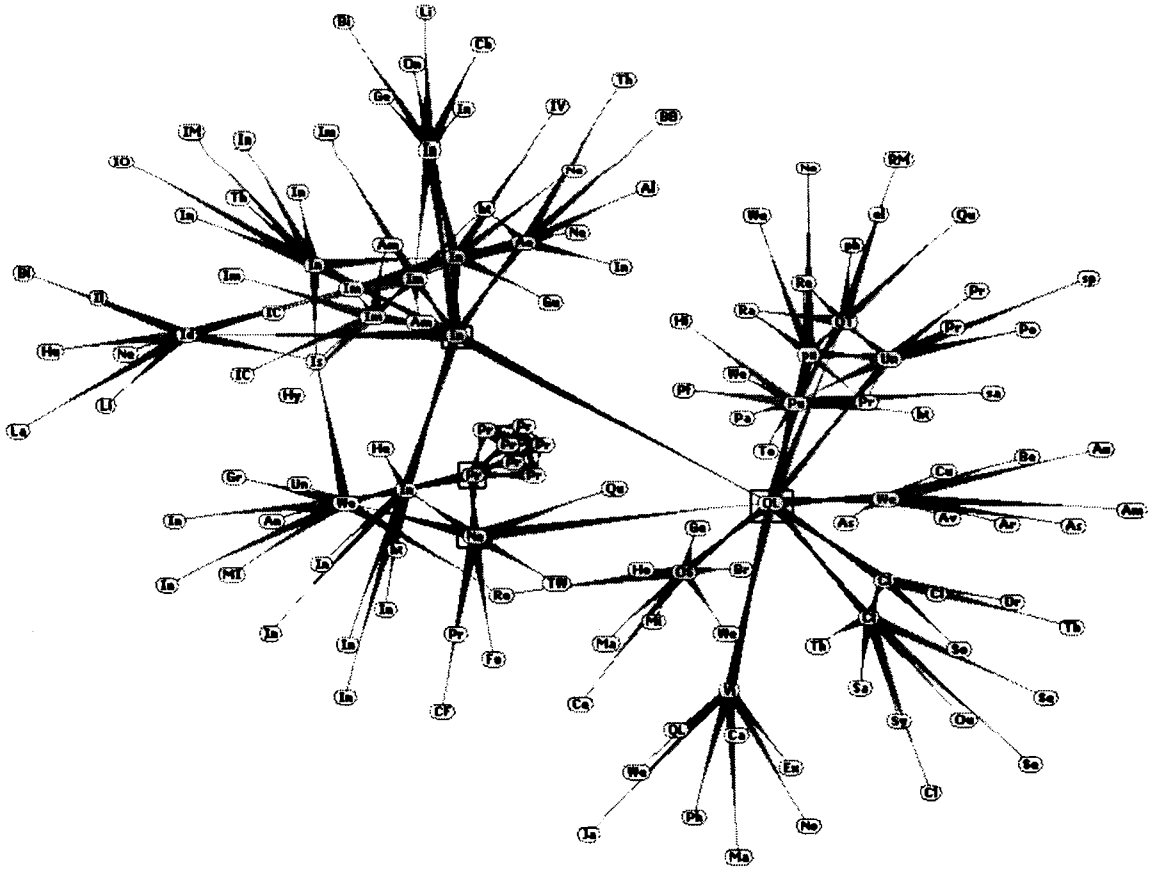
A larger network means that each of the resources available to each member of a network has a lower cost to acquire. "Technology brokers attempt to maximize their range of connections because by doing so they are in a better position to be the first to see how people, ideas and objects of one world may provide valuable solutions in another" (Hargadon, 2003, p. 25). These technology brokers include VC firms, entrepreneurs and associations.

Outside of indicators such as patents for the presence of minimal research linkages and a knowable community, Pricewaterhouse Cooper's 2003 Techmap graphically revealed the biotechnology cluster. The manual drawing and layout of a genealogy of firms in high technology sectors in BC was groundbreaking and impressively illustrated the linkages of money and people within the province. This manual graphic depiction of the networks set the groundwork for the positive reception of a next step – a web-based graphic depiction of specific clusters in BC. While this map has not as of yet appeared, the appetite for such a resource is indicated by the limited availability of printed copies of the 2003 BC Techmap. The compiled network of locally found strong links for QLT Inc. (incl. Neuromed, Inex and Protiva) is as follows in Figure 12[30].

The demonstrated presence of linkages between individuals and companies indicated through the interviews and web-based inquiries conducted in this work has shown that Social capital networks are present in this cluster and can be measured through interviews and through the Internet. "Networking casts much more of a local shadow than is usually presumed: space becomes ever more variegated, heterogeneous and finely textured in part because the processes of spatial reorganization...have the power to exploit relatively minute spatial differences to good effect (Harvey, 1988). The concentration of linkages to specific people is an indicator of dense interconnectivity through 'hubs'. A hub of a network can be virtual or spatial in nature. Measures of 'hub ness' or 'clusterfulness' can show an industrial agglomeration; therefore it is important to show that biotechnology workers working in the Lower Mainland of BC are connected.

[30] This diagram was compiled by looking at the #1 touchgoogle diagram and finding links in the cluster to QLT.

Figure 12: A Network of Local Networks



The existence of hubs in these networks, demonstrated over multiple measures, triangulates their existence. In the ISRN interview based diagram, BC Biotech, QLT Inc. and Donald Rix illustrate a density of connections in the cluster. This is indicated in the network diagram of the ISRN interviews, Figure 13. The presence of these same QLT and BC Biotech hubs can also be shown in the interview networks generated from the Summer 2004 interviews, as seen in Figure 14. It is interesting to note that Donald Rix does not appear in this diagram. This could be due to many factors, include a different questionnaire being used, the larger sample size and a change over time of prominent players in the field.

Hubs can also be an indicator of the history of the cluster, the story that the industry tells itself about its origin. Donald Rix's absence may just be an artefact of a sampling of industry professional who do not include him in their story they tell themselves about the industry. Wolfe points out that "The folklore purporting to explain the basis for unique conditions of trust masks the negotiated compromise..." (Sabel 1992 as in Wolfe, 2002).

Figure 13: ISRN Interviews Network Diagram

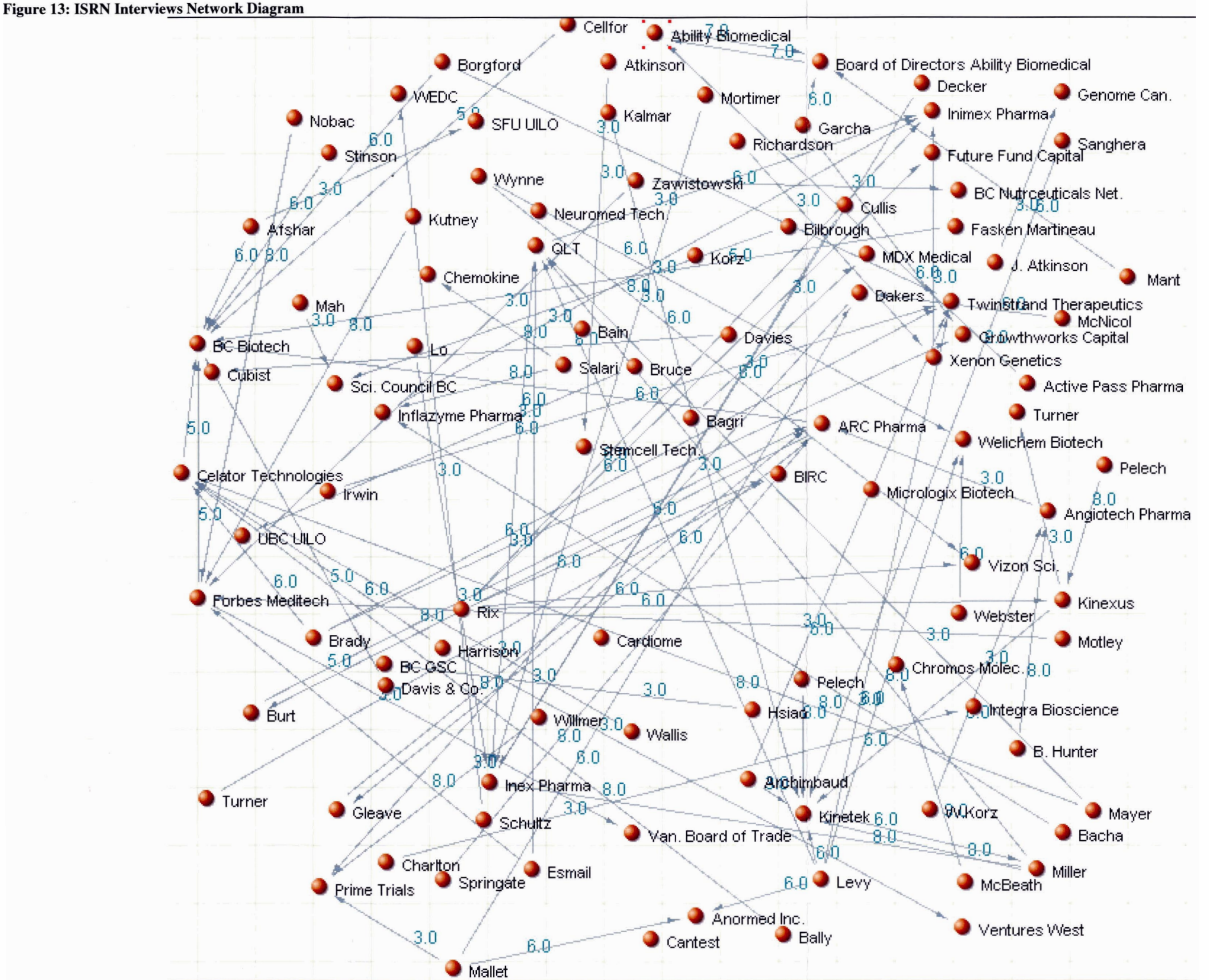
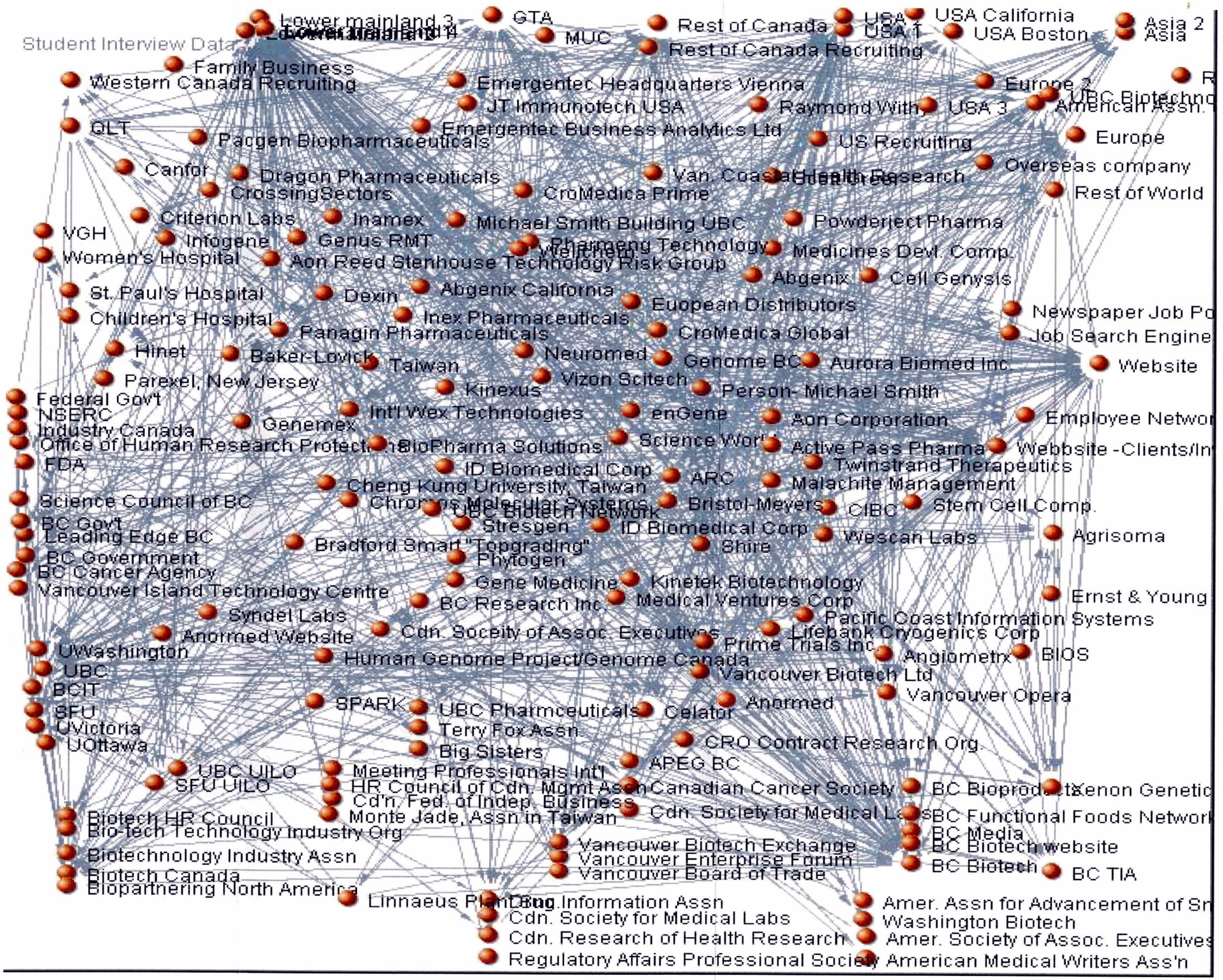


Figure 2 14: Summer 2004 Interview Network



Both the manual and the Googletouch generated diagrams indicate the presence of social capital in the biotech industry. Could it be that the social capital collecting around UBC be the outcome of negotiated compromise for space and resources masks the compromise over royalties and patent rights under the UBC patent regime?[31] The linkages of firms, not just individuals names, indicates that the links are not between vacation properties of adjacent biotechnology inventors. Rather, there is active work between and within firms occurring. The diagram generated from the indirect links manually found is too large to show, but many web based links and mentions of companies were reported. The biotechnology social capital network has a web presence.

4.3 Hypothesis Three: A web presence matters to the members of the social network in the biotech sector.

Of the 46 biotech firms interviewed, 59 percent stated that their firm's website is either 'very important' or 'important' to part of their recruitment strategy and 87 percent of firms stated that their firm's website is either 'very important' or 'important' to the firms' strategy for contacting potential customers and investors, it can be said that a web presence matters to the members of the biotechnology sector in BC. One interviewee noted: "Wow. Important. Very important. Compared to five or six years ago, it is definitely indispensable to us". Some of the reasons stated for the importance of the website included the following:

- It saves time in explaining our company to clients.
- There is no time zone issues with a website
- It gives people time to digest the complicated nature of our product.
- It allows us to spread the word about our product.
- It's industry standard to have a website. (Summer 2004 Interviewees)

[31] Any discovery made at UBC by a faculty member or research, must sign over or share IP with UBC. Therefore UBC collects royalties on its researchers' patents. This is different than SFU, where individual researchers own their won IP discovered at the university.

The BC Biotech Association was even more frank – "It's our whole package". The use of the website to coordinate all it's activities and to bring value to their members in a cost effective way makes the website very important to them specifically. Some interviewees mentioned BC Biotech as the place where they posted their job vacancies and made contacts with employees. Web linkages are important to attracting people to a region and also in keeping up connections within a cluster. In the ISRN interviews conducted, 80 percent of interviewees mentioned the importance of the BC Biotech Association (Holbrook et al, 2004). As the Summer 2004 interviews revealed, the package of services delivered by BC Biotech are mainly virtual in nature or are coordinated through their website, the web is the resource of importance to creating linkages. More specifically, the web coordinates and aligns network actors into the same room for specific events and announcement events. And on a virtual level circulates information about the industry and local job openings.

The lower percentage given for the use of the website in recruiting indicated that word of mouth networks, rather than websites are used by employers to obtain information regarding potential employees (Granovetter 1994; Montgomery 1991, 1992). In fact, one interviewee expressed distain for unsolicited resumes received through their website from out –of –province job seekers:

> "I had an urge to tell them that they had an interview at 8 o'clock the next morning, just to see if they would come"! 23.53 percent said that the website was 'not important' to their recruitment strategy at all".

If this is so, where to employers find employees? Especially specialized technical staff and experienced upper level management personnel? Networks are a valuable resource to firms; the importance of websites to these networks

highlights this. In the Community Innovation Survey (CIS) performed by the European Union, 36,000 Innovative European firms found the barriers of Lack of cooperation opportunities (10%), lack of external services (10%), lack of finance (34%) and lack of skilled staff (18%) to be problems (Smith, 1997 as found in Komninos, 2002, p.37). Each of these problems can be overcome through network linkages that would provide access to network member's mutual resources. Further analysis of the data gathered by the CIS indicated, "...internal sources [of information] are more important than external" (EIMS Publication No. 36, 1996). This was reflected to be true when firms recruited for a technical position and for management positions. Internal sources of information allowed firms to overcome the barriers of either finding local people easily or overcoming the inertia of relocating personnel to the region.

One of the features of a high-technology clusters that contributes to the formation of a cluster is " 1) labour market pooling...2) intermediary and non-traded inputs and 3) technological spillovers and knowledge flows between nearby firms and between the firms and nearby universities or research institutions (Krugman 1997; Komninos, 2002, p. 45). Knowledge spillovers within a cluster have been historically documented as important. In 1920 Marshall indicates that 'if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus becomes the source of further new ideas (as in Komninos, 2002).

In this study, 48% of interviewees indicated that they would take advantage of this technical skill knowledge spill over and recruit personnel from educational institutions in the Lower Mainland. Some even used the website to attract co-op

education students form local universities and colleges. "The strength of this interface [technologically mediated] rests in the multiplicity of the tools for technology transfer...which do not rely on heavy and costly infrastructure, nor on the size of the cluster of innovative firms" (Komninos, 2002, p.101).

The scale of the firm was most affected by the use of their website for recruiting. Smaller firms tended not to use it, while larger firms tended to use it as part of a larger strategy for recruitment and raising the profile of the firm to potential job seekers.

Holbrook et al., 2004 conducted a survey of web accessible Board of Directors biographies for 30 companies in biotechnology sector in BC. The presence of these biographies online demonstrates the importance of a web-based interface in accessing the HQP of the company. It also could be that by highlighting their links into the local education/research infrastructure? So that other similarly web-accessing professionals could see their network linkages into the BC biotechnology sector? Further, they found that, "45% of these key personnel had degrees from Canada, with 27 percent coming from BC. About 30 percent has their highest degree from a US institution" (p.104).

The results of this study explores the same phenomenon from a different perspective. When interviewees were asked where there management personnel came from the results were as follows:

	From Another Company	Directly from Educ. Institution
Lower Mainland	**35%**	
USA	**19%**	
Rest of Canada	**11%**	
GTA	**9%**	
UBC	**7%**	
Europe	**4%**	
Asia	**4%**	
BCIT	3%	

It's very clear that experience is important to serving in a management capacity. Interviewees also mentioned that the strength that management candidates would bring to any position was their own personal networks and contacts. This meant that companies tended to look south, rather than east for suitable candidates. Networks in the same time zone are valuable indeed. A California venture capital executive highlights the importance of accessing the local network – "For something to explode entrepreneurially, you have to have a community, a geographically compact entity. It's not going to happen unless you have the tom-tom network...the tribe gathers at conferences, shows and parties". (Rosenberg, 2002, p.7).

In their book entitled *The Hidden Power of Social Networks,* Cross and Parker show the network diagrams of a group of fifty-four executives. They compare the network size and density with and without the top nine executives. The network missing the top nine executives shows a network without an identifiable leader – a body without a brain (Cross and Parker, 2004). Despite the weakness of a network when it is lacking

leadership, the configuration of weak ties, with a low density of connections is a strength in leveraging networks.

"Structural holes" (Burt, 1992a, 1992b) are the names for the spaces where there are gaps in the network. Structural holes are positions where a single individual could be the gatekeeper between the networks. The use of this position as a force for bringing world together, instead of using it as a leverage point, has been articulated by Paul DiMaggio (Hargadon, 2003). "...brokers can use their connections to distant networks to recognize and bring combinations of people, ideas and objects from these different worlds together to create something of value that did not exist before" (p.62). Brokers are important on the world wide web, as Barabasi and Albert took generated pictures of web linkages and proved that it is a small world. "Each time they doubled the number of links, the number of elements having that many fell off by a factor of about eight" (Barabasi and Albert, 2001). The 'small world-ness of these networks magnifies the importance of brokers and bridge makers. Further evidence to support this small world theory can be found in the work of Gerald Davis who studied Boards of Directors and found "...any two of the 6724 Fortune 1000 directors can be connected by 4.6 links, and any two of the 813 boards are 3.7 degrees distant" (Davis, 2001 as in Buchanan, 2002).

4.4 Hypothesis Four: Automated Internet searches of web present biotechnology cluster networks reveals complex relationships.

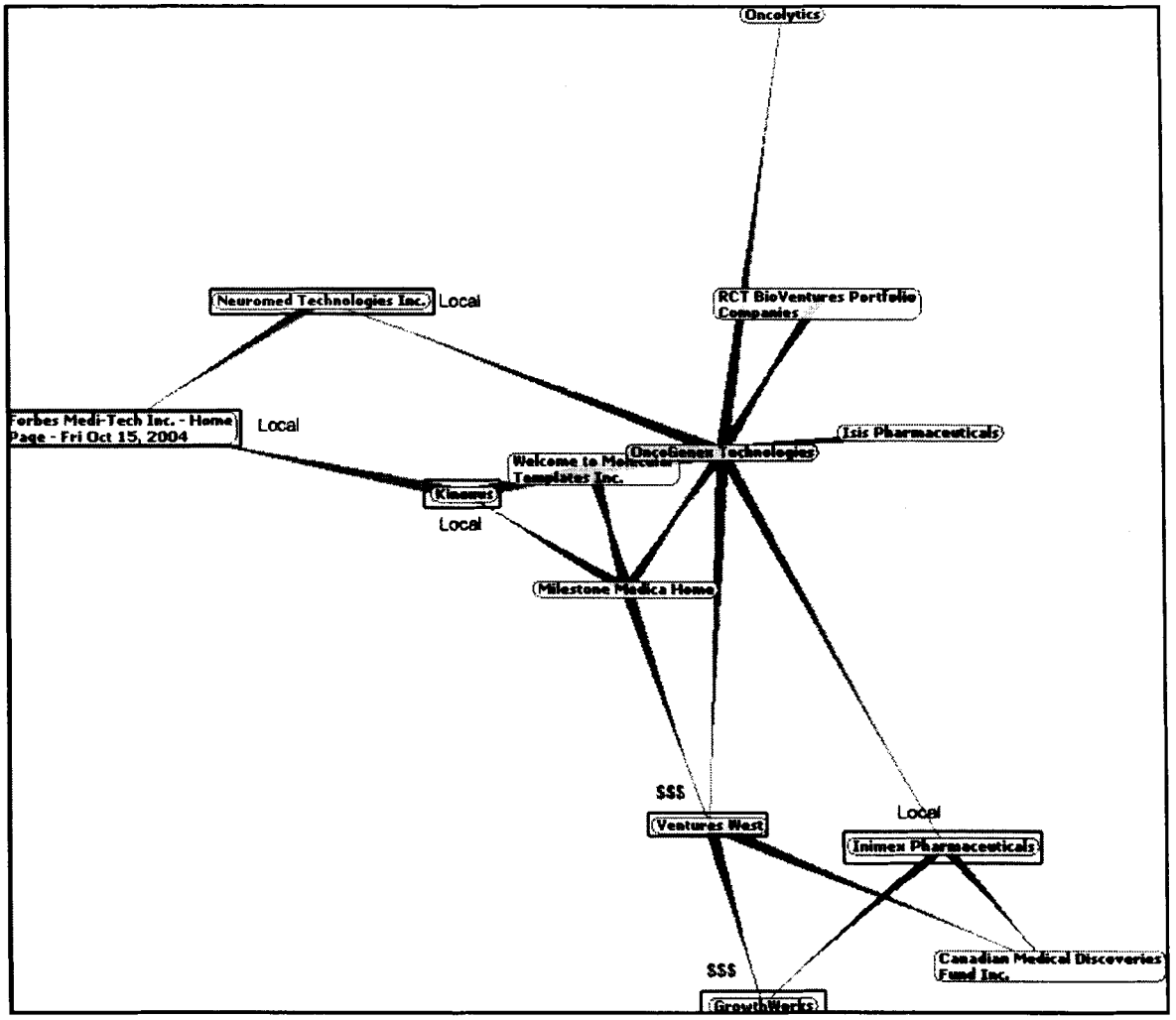
The quality of relationships revealed by automated tools is unclear, although the complexity and quick availability of them make then a handy tool for determining basic trends in networks. The larger network diagrams filled with single links, while

impressive were difficult to analyze. Also, the importance of stronger, triangular shaped links is more important that links that are weaker father away and end in unidirectional connections.

The network diagrams generated for the BC biotechnology cluster by touchgoogle were classified into the following categories: QLT, Events, Small & Dense, Universities/External Research Institutes (non–BC), Media, Association or Directory, Money, Regulatory/Foundation, Human Genome Project/ BC Biotech/Genome BC/ BC Cancer Agency, External to cluster, well connected locally, SFU, UBC, Other BC Educational Institution and not significant. These categories were generated after it was determined that there is a biotechnology cluster in the Lower Mainland, with social capital networks present in the cluster and that a web presence matters to the members. The categories shifted during classification, as it became clear early that media links and event links were not an anomaly, bur rather a regular occurrence.

Classification was done to point out the interesting features of each graph, with many graphs falling into multiple categories. For example, Oncogenex has links to 'Money' and "Well connected Local" as illustrated in Figure 15.

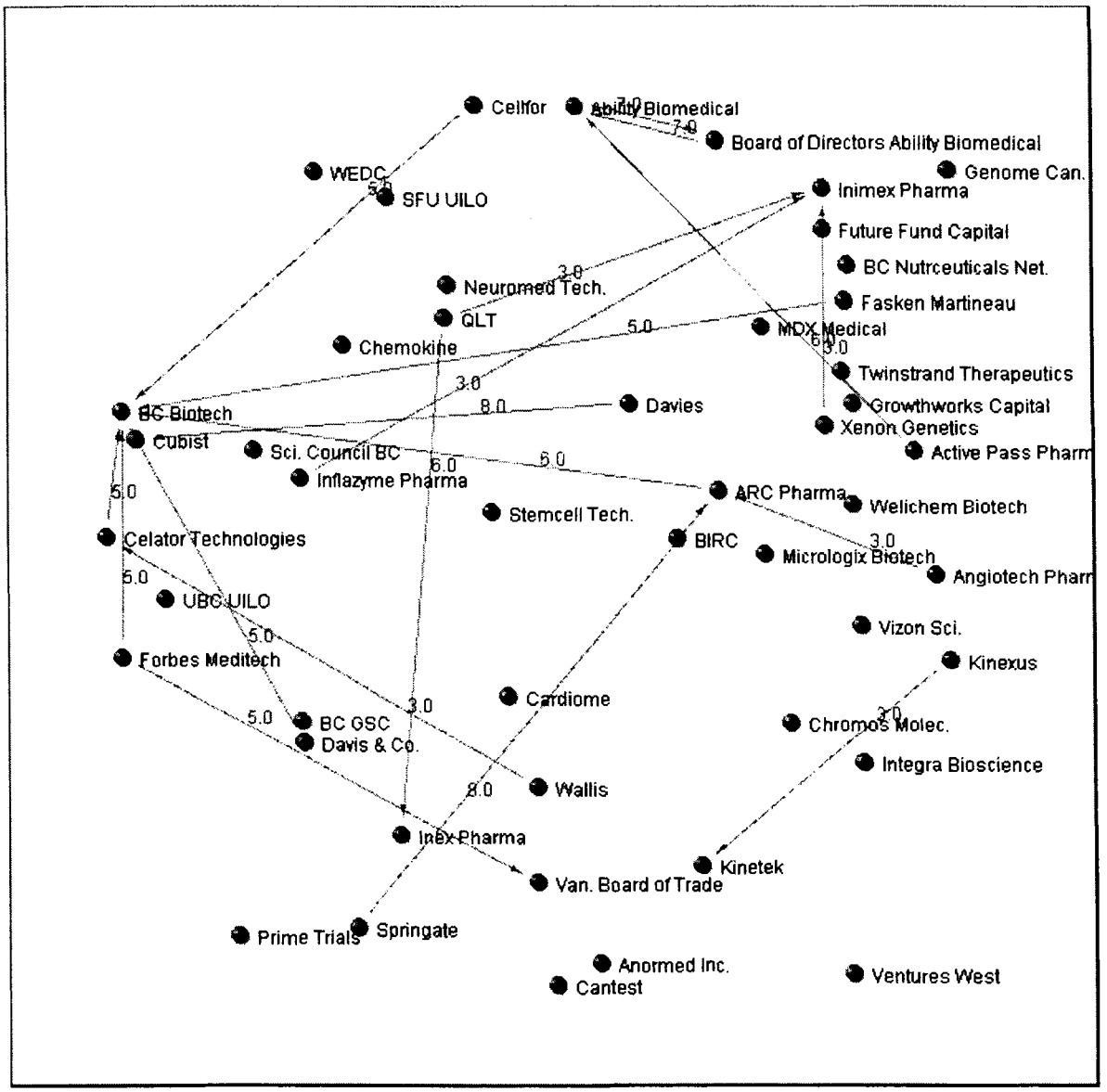
Figure 15: A "money" and "well connected locally" network



There is a scale difference between relationships shown through interviews and web based means. By scale difference, I am referring not only to the size of a relationship found, but also the players involved in the relationship. Web based methods account for formalized links through website linkages. As stated earlier, these web-based relationships are public and important to the perception of the firm to future employees, customers and investors, where as relationships mentioned in interviews are often based in personal awareness and networks. Although a smaller number of more individually important relationships can be shown through interviews, it must be noted that without

firm linkages, many of these relationships would cease to exist, as shown below in Figure 17, except for the indicated link through Board of Directors.

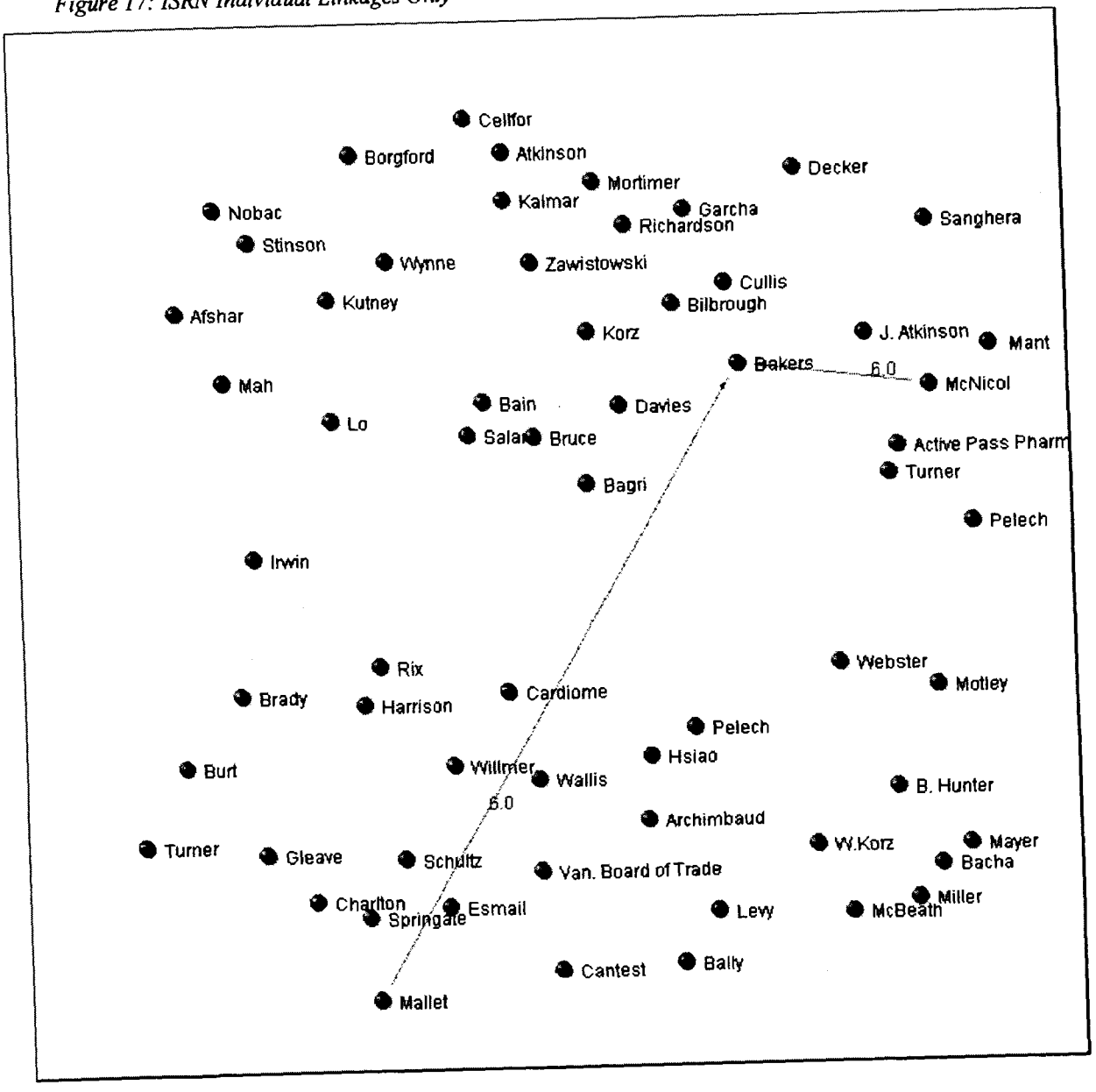
Figure 16:ISRN Firm Linkages Only



This would follow from the simple fact that companies are the nature of the networks, as they are business networks, but the linkage shown through links on a Board of Directors transcends firm level link. Conversely, Figure 16 shows that linkages

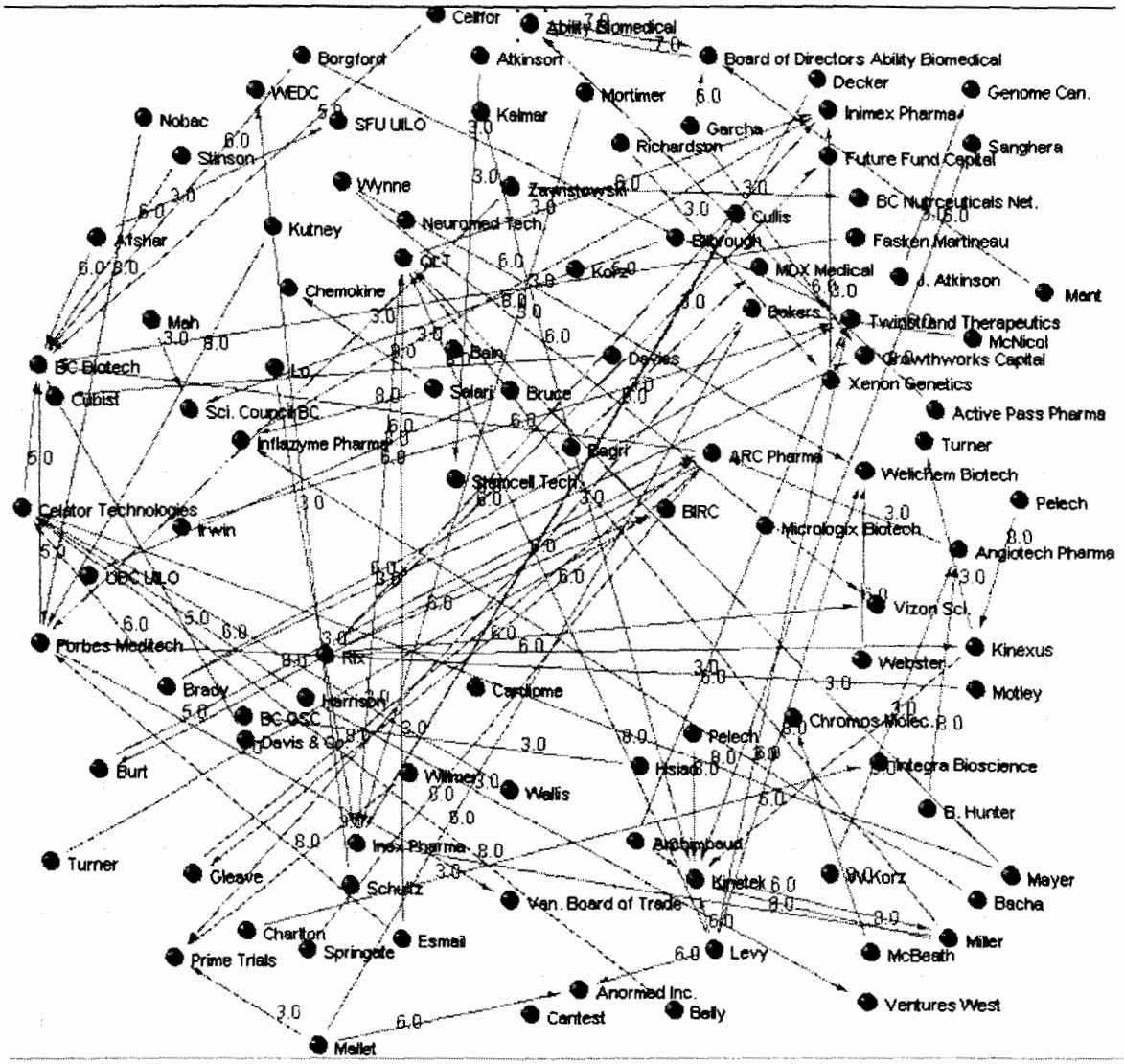
between Firms would be fewer, if links that explicitly mention people were eliminated and only firm level links were displayed.

Figure 17: ISRN Individual Linkages Only



In Figure 18, the sum total of the relationships revealed through the ISRN interviews are given for comparison.

Figure 18: ISRN Interview Links - All



4.4.1 Firm level links

Granovetter defined the strength of a tie as: "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (1973, p. 1361). The reciprocity of this

link means that not only is the sender sending a message, but the receiver is also sending a reply message. Relationships in the ties are two-way and are possibly multi-levelled.

Although it may be counter intuitive, "weak links can save the day" (Buchanan, p. 148). Sixteen companies in the cluster had a web presence that did not fall into any particular special categories. They were not well connected locally, or were linked to specific events or media or were connected to SFU or UBC. These firms are more resilient in case of collapse of the local network. But this strength is balanced with the inability to leverage the benefits of being part of the local network.

It's also important to note that due to the nature of biotechnology – a product that affects human health, actors such as regulatory agencies, hospitals and regulatory associations and advocacy groups i.e. Lupus Foundation, play a role in the industrial process of bringing a drug for idea to market.

Many have pointed out that the biotechnology cluster in BC is immature due to the lack of a large pharmaceutical manufacturing firm within the boundaries of the Lower Mainland. The small number of large firms, like a pharma manufacturer could be the result of network features and is a natural result of how the industry clusters. "...Social capital appears to be intimately connected with the mathematical property of clustering..." (Buchanan, p.201). This means that conforming to Pareto's Law[32] may be natural. The small concentrated nature of the biotechnology industry maybe a natural phenomenon.

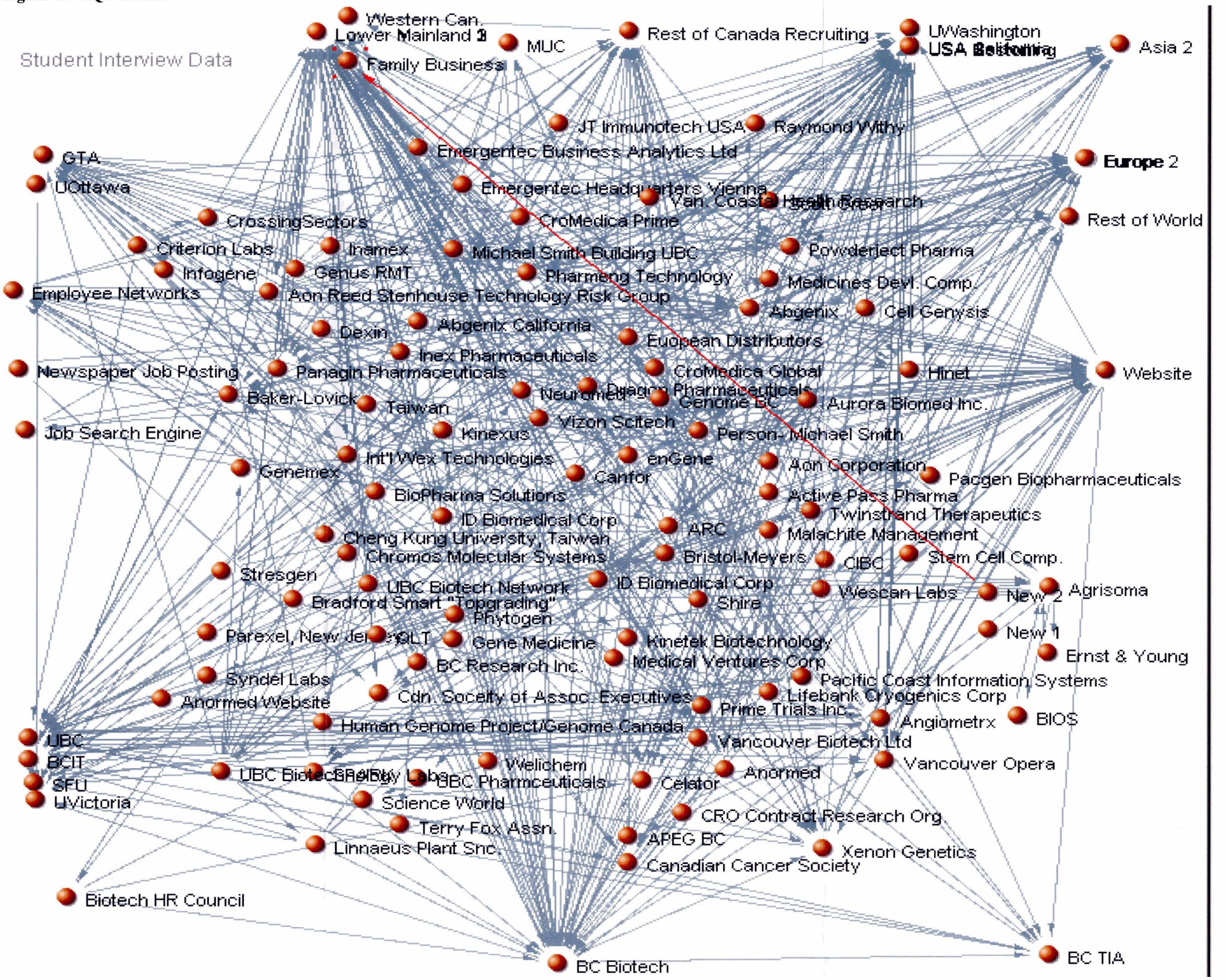
[32] Pareto's Law: In studies of concentration of wealth, it has been found that as wealth doubles, the number of people who have access to this wealth falls off at the same rate.

4.5 Hypothesis 5: Web links can show the health of a cluster and portray points where intervention may be useful and places where current models are working.

Stanley and Smeltzer point out "If abundant natural resources, law wages and benefits, and low taxes were the only factors that contribute to high levels of investment and economic growth, then the current economic status of Japan and Argentina would be quite reversed" (p.231 as in Osberg, 2003). Innovation is one of the factors that contribute to the status of Japan, as well as a stable social structure high in social capital (Osberg, 1992). Therefore demonstrating the presence of and encouraging innovation is key to the health of a cluster. To encouraging innovation, other studies have called for the fostering f social capital within a cluster. "Develop the social capital of the region through increased networking between firms... between large and small firms and between firms and "interveners" (government and associations") (Nimijean & Landry, 2000 p. 135). This social capital has been measured through networks that visually show areas of concentration of linkages and documents them. Answers to such questions as the relative connectivity and dependences of individual firms and associations can be demonstrated.

The relative importance of different regions for HQP recruitment can be demonstrated as in Figure 19, where the density of links to USA and the Lower Mainland, greatly outweigh those connected to other parts of Canada and Europe. It is interesting to note that the connections to Europe are stronger than the connections to Asia, in terms of management personnel and recruitment of future management personnel. As well, newspaper ads, employee networks and job search engines together are as important as the website as a mechanism for recruitment.

Figure 19: HQP Trends



"...The connectedness and the physical proximity that promotes innovation are important lessons for public policymakers" (Holbrook and Wolfe, 2000, p.13). This diagram is a telling illustration of that recommendation. Additionally, when asked about hiring upper management, there is a lack of these personnel in the biotechnology industry in Lower Mainland and many firms look for management personnel from outside of the biotechnology industry. The recruitment patterns as indicated by interviewees are listed in Table 10 and are graphically illustrated in Figure 20.

Table 10: Recruitment Patterns Management Positions within Lower Mainland Firms.

	From Other Company	Straight from Educ. Institution
Lower Mainland	19.11%	
GTA	10.29%	1.47%
MUC	5.88%	1.47%
Rest of Canada	11.59%	1.47%
US	30.88%	
Europe	11.59%	
Asia	5.88%	
Rest of World		

Figure 20 shows the flow of the present HQP management individuals into Lower Mainland biotech firms. Hargadon advocates for this practice of hiring from outside a firm, as it bridges local networks between industries and may "actively inject new perspectives and innovative ideas" (2003, p.84). It is the network, not the particular skill set that allows an industry to flourish, keeping in mind that the communities must conform to Brufee's rules of common language and collaboration. "Without a minimum of social cohesion the ability to learn and master new technologies...will be weak" (Lundvall, 1999). The importance of web links as a strengthening agent of a cluster is important in such high tech industries as biotechnology and in such a high technology city as Vancouver, BC. The dynamic, non-linear depiction of networks opens up the

field of measurement to include a wider range of measures than Porter's prescriptive model and more able to be instituted, different from Florida's bohemian index.

A mechanism for the creation of social capital is formed through providing a place to form collaborative networks between the actors of the business and civic communities (Henton et al; Gertler & Wolfe 2002; Wolfe 2002). Business theorists recommend rotating staff across network boundaries, once inter-firm boundaries are discovered. This process establishes a shared point of view, common context and joins up previously unconnected networks (Cross & Parker, 2004).

Figure 21 depicts the flows of knowledge between government agencies, institutions and organizations in the biotechnology sector. Knowledge can be sticky within an organization or flow, depending on the situation and the support or lack of supportive networks. Knowledge freely flows within the sector.

"The knowledge that stuck within Xerox leaked readily through its front door" (Brown and Duguid, p. 151) and out into another part of the network. Regional Innovation Systems take advantage of this feature of networks through their "bottom-up regional strategy based on consensus of regional actors belonging to the private, university, and technology sectors" (Komninos, 2000, p. 141). Further leveraging the strategy, actors in the network of a regional innovation system:

> "give emphasis to local clustering and networking, spin-offs of innovative companies, local matching of technology demand and supply, the local innovation environment. Their implementation is primarily based on regional programmes, incentives and funds" (Komninos, p.141, 2002).

Not only do web linkages give a picture of the health of an industry, but they can also be used to help overcome innovation barriers.

Figure 120: Locations of Management HQP Flow

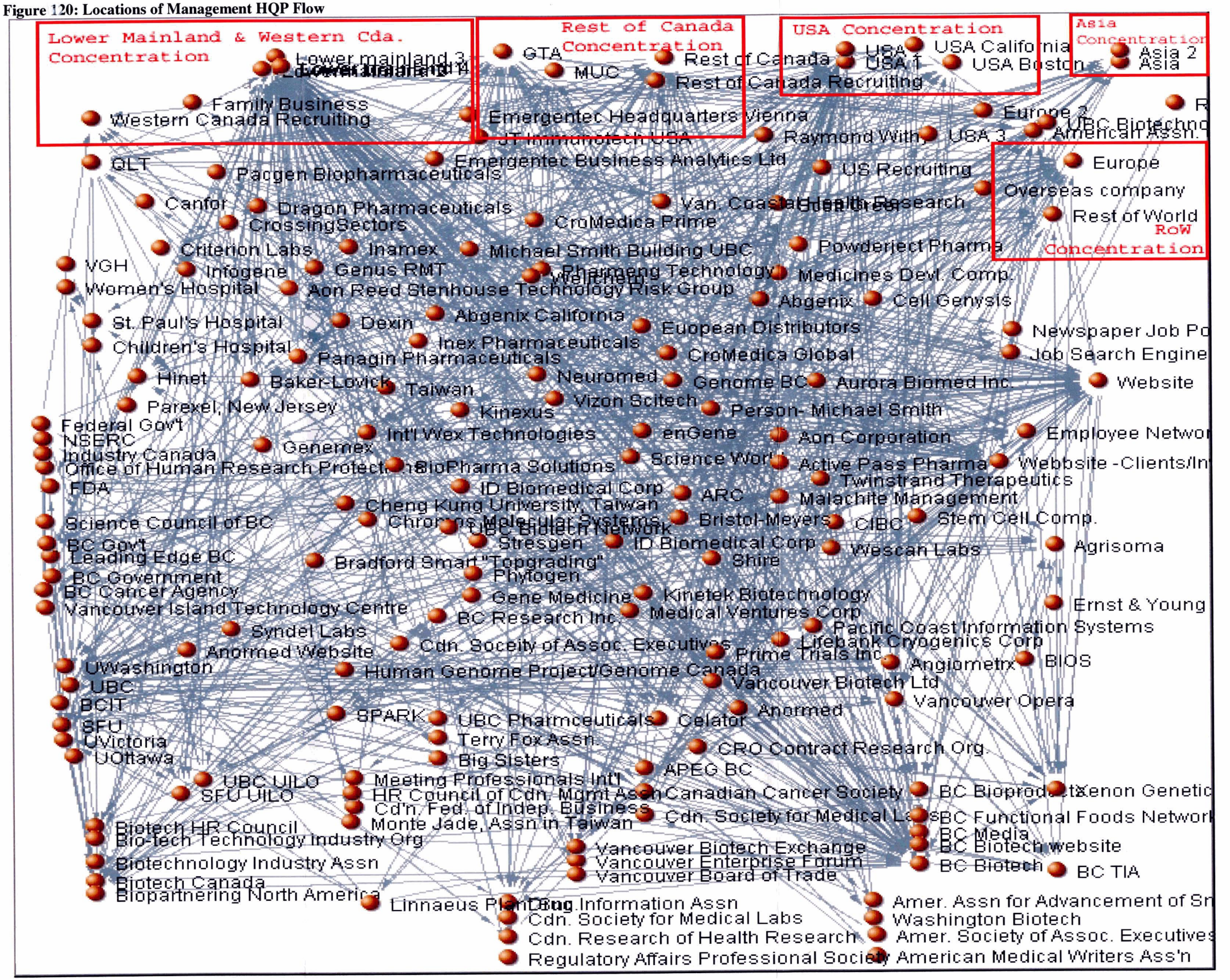
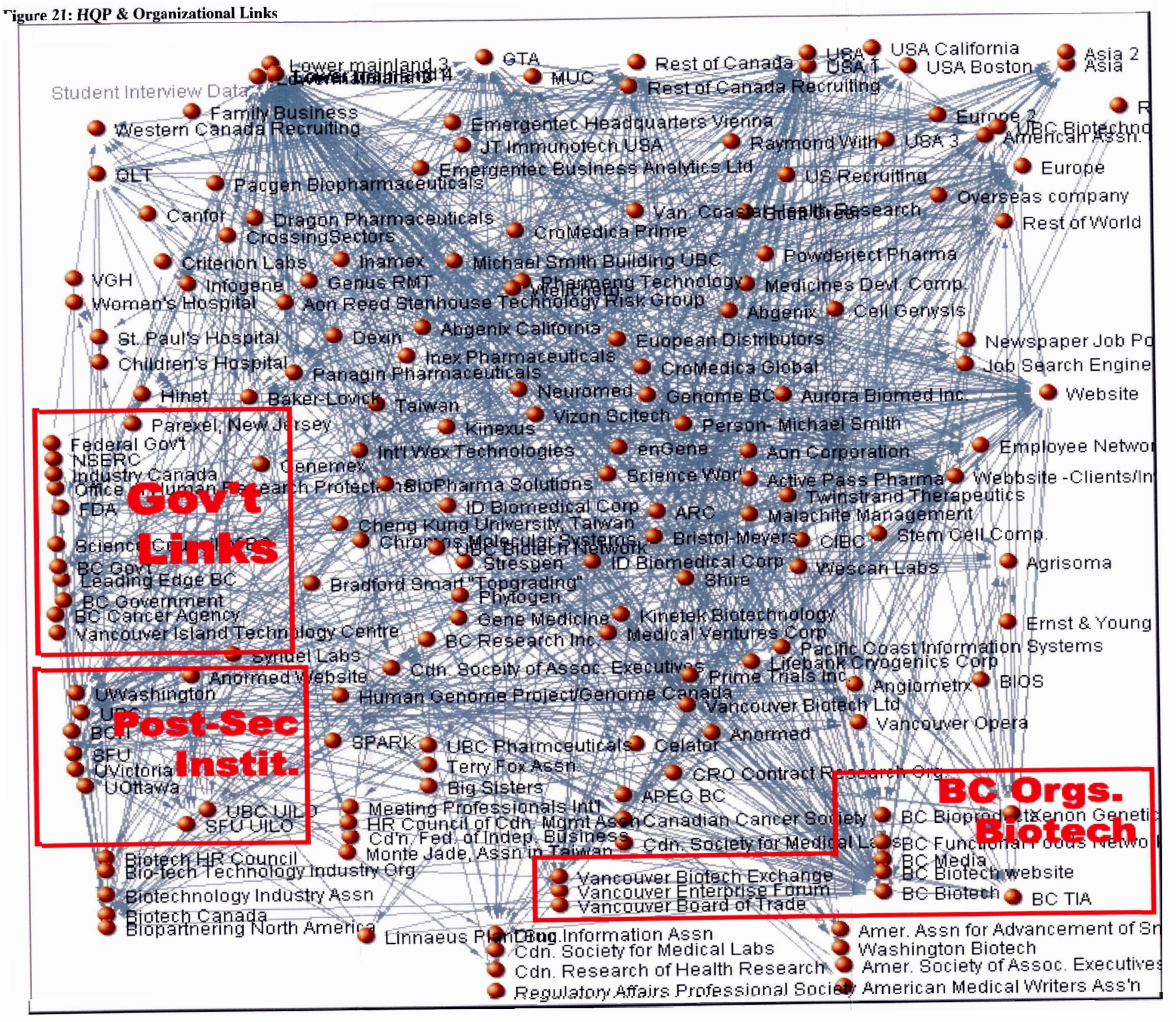


Figure 21: *HQP & Organizational Links*



"In the new innovation environment, composed of many players and multiple initiatives, the real issue is the establishment of networks and 'command centres'" (Komninos, 2002, p.101). What do the 'command centres' i.e. networks look like? The recent establishment of the Leading Edge BC Technology Centre brings together the networks of the following associations:

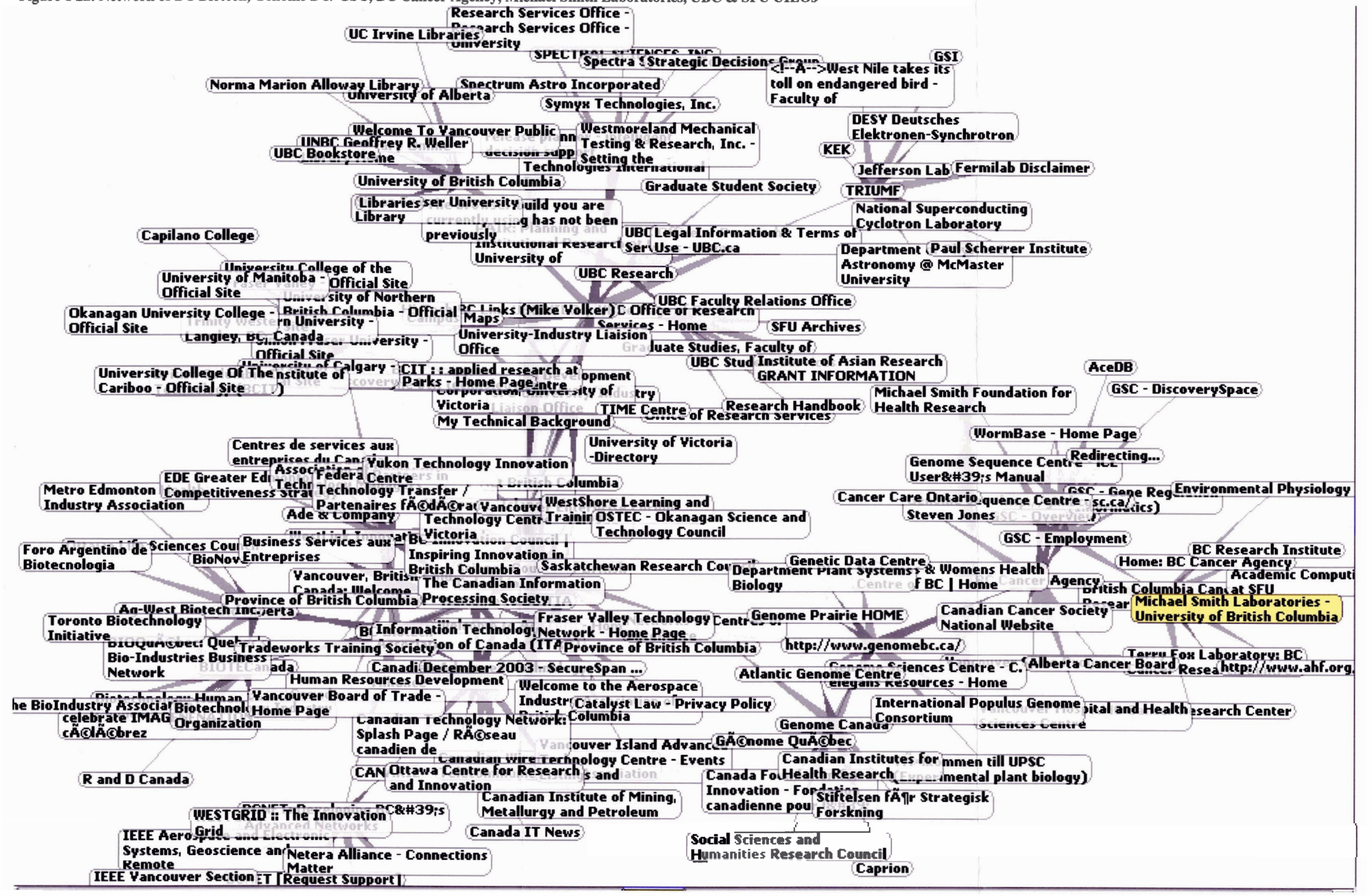
- Acetech Academy for Tech CEOs
- BC Biotech
- BC Innovation Council
- BC Technology Industries Assn.
- BC Technology Social Venture Partners
- Wireless Innovation Network of BC
- And others.

Time will tell what the bringing together of these organizations could bring, but the cross-sectoral bridging of networks has been shown to be successful. The networks of the BC Biotechnology industry have already been forming around associations/initiatives in the industry. These entities include the following:

- BC Biotech
- BC Cancer Agency
- GSC/Genome BC
- Michael Smith Laboratories
- UBC UILO
- SFU UILO

The combined networks of these associations appear in Figure 22. As shown, the possibilities for intervention in this network are limitless. As the biotechnology industry bridges its networks and grows, its web presence will grow with it and researchers will be able to document the change in these networks and their contribution to innovative practice in the Lower Mainland.

Figure 1 22: Network of BC Biotech, Genome BC/ GSC, BC Cancer Agency, Michael Smith Laboratories, UBC & SFU UILOs



CHAPTER 5 FURTHER RESEARCH

Further research linking social networks, social capital and innovation is ongoing and growing. Recent publications by Mark Buchanan (2002) and Albert-Laszlo Barabasi's (2002) retroactively titled "Linked: The *New* Science of Networks" (italics Added) have added excitement to the field. The second edition of this book included an alternate subtitle: How Everything is Connected to Everything Else and What it Means. In light of the increased focus on the importance of networks and the tracking of distributed networks such as the 9/11 Terrorists[33], networks and mapping their weak and strong links has become important and has entered mainstream discourse. This field is growing and becoming more exciting. I would like to suggest some areas for further research.

5.1 Further Research In Patent Citations

The evolution of patent citations as a measure for innovation continues. Some questions to consider include looking at the density of patents filed over time – does this indicate any change in a cluster? Perhaps the movement of a cluster from a type I (knowledge creation) to a type II (knowledge application)[34] cluster? Are the people who file and who are named in patents the same? Could patents be shown to be a network of knowledge flow either into or out of an area? Moving beyond a tabulation of change in

[33] For a discussion of Terrorist networks, see Valdis Krebs at orgnet.com/hijackers.html and "Uncloaking Terrorist Networks" First Monday Vol.7, No.4, Apr/02 firstmonday.org/issues/issue7_4/krebs/index.html.
[34] For a discussion of Type I and Type II clusters in the biotechnology area please see Phillips, Wolfe and Gertler as cited in Holbrook et al., 2004.

ownership of a patent from inventor to named owner to charting the flow of this IP ownership on a map of the world may identify visually brain drain/gain flows.

5.2 Further Research In Modelling Networks

Modelling networks comes from a branch of physics/mathematics known as graph theory. The entry of graph theory into the domain of social science research is a recent phenomenon, although it is in its infancy. "When it comes to the social world, our understanding of complex webs of cause and effect is again sadly lacking" (Buchanan, 2002, p.18). Taking a micro set of data from a cluster, say e-mails sent out by networking agencies may reveal hidden networks of influence that maintain themselves person-to-person, and be an accurate tracker of information flow through networks. Is the information presented in association emails sticky? Does it get 'forwarded' through networking bridging actors? Could 'email forwarding' be the tool of the high – technology networker? This research question could be addressed through the use of an enhanced and automated web spider that was capable of perusing documents and selecting relationship based on 'reading' the data. This automated 'smart too' could then draw clusters where they may not exist and suggest incoming and outgoing, inter connected and outside links.

5.3 Further Research in Building Social Networks

Networks have dimension and connection density, but what about direction? Could vertical networks in value chains depict different information than horizontal networks? What about a hybrid depiction of a value chain and a social capital network? This would allow questions around untapped resources to expand to include all elements of the value chain within a cluster and more fully map the dynamics of a cluster.

The Human Wellbeing Index (HWI) and Ecological Wellbeing Index (EWI) developed by Robert Prescott-Allen for the 2002 World Summit on Sustainable Development uses a combination of measures to plot the wellbeing of humans and the environment on a grid. The interactions of his measures and the interactions between the networks of humans and ecological bits present an exciting opportunity to extend economic actors in innovation to non-human vertebrates and non-animate ecosystem elements. AS well, linking the networks that make up the cultural fabric of a society and pointing out places where an particular industry's node interact with the cultural fabric of a society may bring about point where compromise and negotiation concerning sociocultural/industrial issues can be undertaken.

5.4 Further Research In Points Of Intervention

As of September 2004, a new initiative entitled the Integrated Technology Initiative (ITI) is taking place in British Columbia. This initiative is looking at clusters including the biotechnology sector and its mandate is to "create an integrated strategy for supporting highly competitive, functional technology clusters in British Columbia" (http://techinit.ca/about.htm). This mandate has taken work completed through the ISRN project, as well as other projects and pooled it together in order to operationalize the recommendations of these projects. This process is interesting to watch as it takes the various clusters of industries in BC and is creating synergy around them, to address mutual barriers and to leverage the overlaps in their networks.

During this process one of the emerging things out of the process is that industry associations are playing a large role in cluster interventions. As well, the identification of champions, through the pooling of networking resources is an exciting application of social capital networks.

5.5 Further Futuristic Research

The future of social networks as a tool for business and research is bright. Imagine opening your email box at some point in the future and ranking your 'In Box' by the size of network of the people who sent you mail. Or extending the principles of such technologies of Friendster into a hand held device that holds your networked rolodex of contacts. From a marketing perspective, the ability to beam a person your contact information and receive the social networks of even ten of their contacts would be revolutionary. A portable hand held device would be needed to take advantage of the transient nature of social networks and their applicability to the situation. i.e. your Ultimate team mate network vs. your business network. Being able to measure social networks this way would result in the ability to quantify advertising to a particular market share in a whole new way. "...these momentary networks can be of tremendous value because, for relatively little time and energy, they can bring together distant people" (Hargadon, 2003, p.113).

The ability to visualize and describe social networks would allow more creative interactions and spur possible new collaboration to bring heightened innovation to industry. Knowing in which network to embed policy incentives for innovation would allow for a dynamic leveraging of social capital networks to allow the biotechnology cluster in BC to grow and maintain its reputation for innovativeness and talent.

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APPENDIX A: NETWORK VALUES

Student Interview Data
11 = very important link
10= company A becomes or part of company B (merge)
9= research partner/working with
8= founding relationship/spin off
7= management link
6= former employer or BoD link
5= medium link
4= member of
3= recruitment link
2= money link
1= weak link

This is based on the web interviews
10= company A becomes company B (merge)
9= research partner
8= founding relationship
7= spin off
6= former employer or BoD link
5= member of
4= education link
3= People link
2= money link
1= general link

APPENDIX B: INDIRECT INTERVIEW GUIDE

Indirect Research Assignment: Company Profile

Student Name: _____ Student #:_____Tutorial #:_____
Company Name: _____Sector: _____
Address: _____Tele: _____
Fax: _____ Website: _____Key Contact: _____

1. Overview of website and Description of the Company:
2. Is the company currently recruiting through their website or the Internet? _Yes _No
3. Does the website use it's geographic location (i.e. Vancouver/Lower Mainland) as a draw for prospective employees? If so, how? (You might find this info. in the Careers Section or About Us, etc)
4. Firm ownership (please check all that apply): _Public _Private _Foreign _Domestic
5. Year founded: _____
6. Type of business: _Service _Manufacturing Pls. specify: _____
7. What is the number of employees

	Permanent	Contract	Total
At this location:	_____	_____	_____
In your company:	_____	_____	_____

8. How many employees of your establishment are in:

Management:	_____	_____	_____
Marketing/Sales:	_____	_____	_____
Production:	_____	_____	_____
Research & Development	_____	_____	_____

9. Are there any other internet sites or local publications that list information about the company? Please list below:

Internet Link	Brief Summary of Information

10. Key Personnel/ Profiles of Management Team

Title	Name	Work Experience	Education

11. Does the company hold memberships in Industry/ Associations? __Yes __No
Please list them:_____

APPENDIX C: SUMMER 2004 INTERVIEW GUIDE

CMNS 362 Survey Project

Note: DO NOT give the survey to the respondent to fill out. Ask the questions as they are written and record the responses yourself. Have a clipboard or other hard surface to write on (and a pen or two!).

Survey procedure, at the interview:
1.Identify yourself: " Good morning/afternoon/evening. Thank you for taking the time to meet with me today. I am a student in the School of Communication at Simon Fraser University. Would you be willing to answer a few questions about the origins of the human capital of your senior management for my SFU university course on research methods? This survey will take approximately 20 minutes"

2.If the response is yes, "Thank-you. The results from this survey will be used for a study on origins of the human capital of your senior management. You may stop the survey at anytime. No individual data will be released and will only be added to aggregate results. The university's ethics committee has granted ethical approval for this survey."

3. If the answer is no: "Thank you. May I ask why?" (Write down answer).

4. Commence survey. (If the participant discontinues the survey at any time, please ask and record the reason why the respondent has stopped).

5. At the end of the survey, thank the respondent for participating and let them know that they can find out more about the results of the survey by contacting Adam Holbrook at jholbroo@sfu.ca or 604.291.5192.

Interview Guide

Interview Date/Location: _____
Name of Interviewer: _____
Name of Note Taker: _____

Name of the Interviewee:_____
Company Name: _____ Company Sector: _____
Company Address: _____
Telephone: _____ Website: _____

Company Profile** (confirm or gather information from the indirect assignment sheet)

Overview of Management Team

1.What events/people stimulated the founding of the company?
2.How many people make up your management team (i.e. people who make decisions) ?
3.Has the team changed in the last few years? (i.e. has it grown? Change of personnel? Why?)

4.Where do the people on your management team come from?

	Other Company (Please specify)	**Straight from Post Secondary Institution (Please specify)**
Lower Mainland (GVRD, Fraser Valley, Sunshine Coast but not the Vancouver Island)		
GTA (Greater Toronto Area)		
MUC (Montreal Urban Community)		
Rest of Canada		
United States		
Europe		
Asia		
Rest of World		

Recruiting

1.How have you found the recruitment process for senior personnel? What were some of the difficulties you encountered?

2.What facilitated the process? (Draws to Vancouver? The company, etc?) What made the process challenging?

3.If you had to recruit for a management position, would you be able to fill it from a local talent? If yes, from where? If not, where would you likely go to look?

4.If you had to recruit for a technical position, would you be able to fill it from local talent? If yes, from where? If not, where would you likely go to look?

5.If you were to recruit from outside of the Lower Mainland, would it be a smooth or a challenging process? Why?

6.Do you belong to any industry/professional association(s)? If yes, which ones (check all that apply):

New Media Industry	**BioTech Industry**
New Media BC	BC Biotech
TechVibes	TechVibes
The Wired Woman Society	Biotechnology Human Resource Council Science Council of BC
International Game Developers Association (IGDA Vancouver Chapter)	Bioinformatics.ca
E-Learning BC	Vancouver Bioinformatics Users Group
Association of British Columbia Animation Producers (ABCAP)	BC Functional Foods and Nutraceuticals Network
British Columbia Film	
BC Technology Industries Association (BCTIA)	
Other (please specify)	Other (please specify)

7.If not, why not? (please check all that apply)
a.Cost of the membership
b.Services they offer are not relevant to your company's business activities
c.Lack of time/time conflicts
d.Lack of human resources.
g. other:_____

8.What are the benefits that you derive from the membership in this association(s), (Please check all that apply):
a.Assist with recruitment process
b.Networking opportunities
c.Educational purposes
d.Knowledge transfer/sharing
e.Community involvement
f. Other (specify, prompt if necessary)
g. other: _____

9. How important is the company website as a tool for the company to raise its profile and recruit employees? Why?

10. What type of employees are attracted to working in your sector? Your company?

11. What amenities do you use specifically in your company to attract personnel?

12. Do you use any specific interview process to select a specific type of person to your firm?