SFU SIMON FRASER UNIVERSITY
THINKING OF THE WORLD

"Capturing the Outcomes and Impacts of Publicly Funded Research"

A Framework for Evaluating Formal Research Networks

DRAFT

Darryl Cressman, J. Adam Holbrook*, Brian S. Lewis, and Brian Wixted [1]

Centre for Policy Research on Science and Technology,
Simon Fraser University,
515 West Hastings Street,
Vancouver, BC
V6B 5K3

[1] In alphabetical order. * Corresponding author.

Abstract

Research granting agencies in Canada have increasingly turned to formal research networks (those with an organizational structure and mandate) such as NCEs and MCRIs as a mechanism to meet policy objectives such as collaboration, multi-disciplinarily and more importantly, the linking of researchers and perceived relevant stakeholder communities (industry and population groups).

The project by Lewis, Holbrook and Wixted, has developed an approach to evaluate the core policy objective of networks; that is, the networking. Our framework is to conceive of the different stakeholders in formal networks as clusters of actors, rather than as individuals connecting within social networks. From this starting point we have applied concepts from actor-network theory to develop quantitative and qualitative criteria to evaluate how well these formal networks connect researchers to stakeholder communities, and how these networks communicate among all of their stakeholders channels carry information (communications).

One important dimension of our work is to consider the effects of strong (established centres or associations) and weak (geographically diffuse or nascent in development) clusters of researchers or stakeholders on the performance of the network. Another implication of our actor-network theory approach shows that networks that include large capital facilites (such as health sciences or engineering sciences) is that those facilities (as objects), and their operators, become "obligatory passage points". On the other hand, social science networks, not (usually) having large capital facilities, are likely to have much more diffuse relationships among the major actors in the networks.

Comparisons of social science research networks with other forms of social networks, notably social activist non-governmental organizations, suggest they have much in common. This extends to NGOs that support research into specific health conditions.

A background paper has been prepared and is available at:
http://www.sfu.ca/cprost/docs/wixtedholbrook08-1.pdf. A revised version of this paper was submitted to the journal *Research Evaluation* in November 2008 and is currently under review. Two working papers related to the project are on the CPROST website.
http://www.sfu.ca/cprost/docs/A%20Brief%20Overview%20of%20ANT.pdf
http://www.sfu.ca/cprost/docs/GlossaryofTermsPhilosophyConstructivism.pdf

A Framework for Evaluating Formal Research Networks

Darryl Cressman, J. Adam Holbrook*, Brian S. Lewis, and Brian Wixted [2]
Centre for Policy Research on Science and Technology,
Simon Fraser University

Preface

This work was carried out under a grant (#421-2007-1002) from SSHRC as part of the President's Fund initiative to measure the impacts of publicaly-funded research .We initiated this project with what seemed to us a potentially useful insight into the structure of research networks which would be helpful with evaluation and what appeared as simple enough questions:

- Are there identifiable properties of formal research networks, a taxonomy, that merits a specific approach to their evaluation?
- (If so) does the taxonomy provide a meaningful starting point for network evaluation?
- (If so) what are the implications and key evaluation measures that flow from such a framework, and what could be suggested for future network evaluation methodologies?

We promised to deliver:

- A detailed literature review of current evaluation literature as it applies to networks and the challenges of evaluating formal knowledge networks (*see Wixted and Holbrook 2009, Cressman 2009, Cressman and Felczak 2009, and this report*);
- A workshop on network evaluation to be held at Simon Fraser University Harbour Centre campus during the week of May 30 – June 8, 2008 (see section X in this report); and
- A report on the development of our evaluation framework, the mid-project workshop and the results of limited case studies, including recommendations as to future research needs in this area.

Over the course of this project two things became obvious to us. First, the taxonomy of identifiable properties of formal research networks certainly does have intuitive appeal. Tools though in their infancy could be developed to analyze the information we need and

[2] In alphabetical order. * Corresponding author.

our partner networks remain interested in the project. Second, we have discerned that the challenges lie elsewhere. There is a noticeable lack of a vocabulary to describe networks. Network analysis in general (Barabasi 2002; Watts & Strogatz 1998) as well as social network analysis (Hawe et al. 2004; Borgatti et al. 1997) have a language for structure based in mathematics but make heroic assumptions about what it means. For example a 'bridge person' in such analysis is deemed significant but without analysis of the content of their communications and any influence they may have, it is only conjecture has to what their role in a network may be.

One possible solution to this problem can be derived from terms and concepts developed in Actor-Network Theory (ANT). Unlike other types of network evaluation that reduce networks to inputs and outputs or basic structure, ANT asks us to focus on content, context and the processes through which networks are constituted. To combine meaningfully the concepts of *research network* and *evaluation* it is necessary to consider content, context and structure together. As well, the ability to communicate and create and maintain connections is a basic element of potential evaluation criteria . Not only do researchers and stakeholders have to communicate and connect with each other, but both parties must be aware of "unidentified" parties to the network activities. External stakeholders can influence network activities for good or ill, and one of the criterion for success of a network are the dynamics of network connections created by stakeholders not identified at the inception of the network (for example, public interest groups, who may have a different point of view from the identified stakeholders).

This report on the activities of SSHRC grant includes a substantial quantity of material from Wixted and Holbrook (2007, 2008 and 2009). The first of these was a report to the Michael Smith Foundation for Health Research and the Health of Population Networks. Following this report a new version was written with additional analysis for the CPROST working paper series that has now been submitted to the journal Research Evaluation. This series of papers provide key reference material defining formal research networks, relevant evaluation literature and the initial taxonomy.

This work reflects on going efforts at CPROST to understand research networks (see Wixted 2006, Holbrook and Wolfe 2005 and Salazar and Holbrook 2007). It also suggests that there are significant differences between evaluating health and natural sciences research networks and social sciences and humanities research networks. It also suggests that there may be similarities between research networks and social activist non-governmental organization, and that similarities in their evaluation criteria should be explored.

Introduction to Research Networks

Research networks are a member of a class of organizations that are loosely called networks. They include networks of industrial activity (or clusters), social or human networks, and some types of non-governmental, non-profit organization as well as

research networks. Canada has led the way in the developed world in the development of research networks as a mechanism to manage research in general and support research that addresses specific public policy objectives, policies and programs in particular. Research networks cover a spectrum of activities from pre-research capability development, to structured research networks (such the MCRI program).

As Rogers *et al.* (2001) define them,

> *[networks] serve both as guiding metaphors for conceptualizing the relationships between actors and as techniques to measure structural properties of the ensemble. All network studies share the assumption that the ties between the actors, which connect them into a system, are more important than their individual attributes (p.161).*

It is understood by most Canadian researchers that the policy of creating research networks was initiated to meet two major objectives of the federal government:

- the encouragement of multidisciplinary and interdisciplinary research
- the encouragement of regional and cultural diversity in the Canadian research establishment

The utility of research networks is exemplified by the multiple goals for which they are established and against which they can be evaluated. Some of those goals include: encouraging research collaborations; encouraging the connection of researchers and users (and other stakeholders); building multidisciplinary research agendas; building critical masses in particular areas of research within small economies or those with relatively small populations in large geographic spaces. In Canada, networks address the needs of a population linearly spread across the northern US border, and meet the political needs within which most researchers operate (Salazar and Holbrook, 2007). Further, as Salter and Martin (2001) have argued, network formation is a core outcome of *publicly funded research*. By way of examples, knowledge network programmes that have been formally established in Canada include: MCRI (SSHRC), Strategic Knowledge Clusters (SSHRC), Strategic Networks (NSERC), Networks of Centres of Excellence, and the Michael Smith Foundation for Health Research (MSFHR) Health of Population Networks in BC.

While there has been much discussion around the importance of networks in innovation and knowledge development, there as been little research on how to evaluate networks[3]. Most evaluation of publicly funded R&D is conducted to assess the performance of individuals and/or specific institutions and, therefore, does not provide guidance on the value of networked R&D activities. Even in the case of evaluation of larger entities — such as research centres or programmes — they are treated as 'super-individuals', the

[3] It is worth making the observation here that along with other papers that note the absence of consideration of networks we can point to a recent edition of New Directions for Evaluation (118) which was devoted to research evaluation. The issue covered indicators at the micro meso and macro levels, research institutes, the research of university departments, large research initiatives and research centres (see Scriven and Coryn 2008), but not networks.

sum total of their members, for evaluation purposes. This tradition does not help in the specification of relevant boundaries for network analysis of R&D systems that may lead to evaluation based on their structural properties (Rogers et al. 2001).

As Rogers et al. (2001) and others (Mote et al. 2007) within the network evaluation community point out, translating what we know about networks into a framework for evaluation is quite difficult. The problem is that researchers rely almost exclusively on an evaluative model that reduces a network to its inputs and outputs. In practice there is nothing wrong with this. A thorough review of network inputs (individuals, money, infrastructure) and outputs (publications, patents) is essential for gauging the effectiveness of any given network. But, this particular approach disregards both the idea that a network is performed, that it is a process as well as a formal structure. It is assumed that successful networking is key to the success of a network as measured by outputs, but there are no tools on hand to evaluate what actually happens within a network. If we reduce evaluation to inputs and outputs both the form and the process of a network are, at best, loosely related to the primary evaluative concerns. In short, the evaluation of research networks emphasizes everything but the network itself.

This is realized in a number of ways. First, most evaluations are conducted to assess the performance of individuals. Thus, translated to the evaluation of networks the result is a conceptualization of the nodes within a network as independent and autonomous entities. Of course this contradicts one of the essential characteristics of any network (quoted above), that the whole is more than a sum of their parts. Second, network evaluation need to move beyond simply noting connections and focus on describing the nature of these connections. Not all connections are equal, yet it is often the case that all connections are considered equal despite the range in strength and weakness that connections necessarily embody. Thus, it is important to "move beyond simple exercises of who is connected to whom" (Mote et al. 2007, p.192).

In this way, we can think of the network itself – that is, what actually happens in between the inputs and the outputs – as a "black box". This concept was originally used in information science and physics to make opaque the inner complexity of technologies in order to reduce this complexity to its inputs and outputs. Taken up by the sociology of science, the concept was used to refer to the unquestioned acceptance of the scientific method as objective truth. Reflecting the Mertonian tradition in the sociology of scientific knowledge, sociologists undertook investigations of the social relations and processes of science but left the cognitive basis of science unexamined (Whitley 1972; Mulkay 1979). Applied to our interpretation of network evaluation, we argue that the actual network itself, both as structure and as process, is black boxed within network evaluation literature. It is self-evident and apparent and as such taken to be unproblematic. Yet, as we have discovered, the many problems that plague network evaluation can be remedied by opening the black box and examining the networking of networks.

In an attempt to remedy this situation recently Mote et al. (2007) have identified the possibility of using social network analysis techniques for research evaluation as a tool for understanding how *real research happens*. However, neither comment on the growth

in funding and granting mechanisms for formal networks and their associated need for evaluation based on the full range of their activities. Thus, there is an urgent need to develop a literature base and a methodology for assessing formal networks.

Wixted & Holbrook (2009) have shown that while there is an extensive literature on the evaluation of publically funded scientific research, there is little on evaluating the properties of formal research networks. This appears to have resulted in evaluations that for the most part overlook the policy attributes of formal research networks. Further, they have shown that research networks driven by policy considerations (those that have identifiable clients) are special and need consideration on their own merits.

The challenge with such evaluations is that there are three crucial phenomena to assess:

- What were the actual and implied objectives of the funders?
- Did the network succeed in its primary objectives?, and
- Was it successful in developing and embedding connections and collaborations between mainstream and new members of the network?

To address these specific issues ongoing research on evaluation systems for formal research networks should address three different approaches:

- 'Network' analysis (based on the relations between the communities of participants), including:
    - Communication including the technical mediation of these activities
    - Interpersonal relations
    - Based on clusters of researchers and stakeholders
- Governance analysis, initially suggested by Creech and Ramji (2004), should be examined and adopted with modifications gained from experience of applying it in the science and technology community; and
- Continued development of indicators that capture the inputs and outputs of networks but with the caution that there are particular limitations to this approach.

This overall framework for the evaluation of networks, is just that a framework. We suggest that research networks in different fields (e.g. social sciences, natural sciences and engineering and medical) require different strategies and analytical tools. Each broad area of science has its own capital intensity, its own stakeholder community structures and the knowledge – problem frontier is different. In the natural sciences it is evolutionary whereas in the social sciences it is co-evolutionary (knowledge changes the actions of the researched subject – e.g. economic actors).

Evaluators interested in the mechanisms of research networks must incorporate more of the sociology of networking operations, structures and mechanisms. Social network analysis and Actor-Network Theory (ANT) were both developed as philosophical exercises arising from empirical observations. Neither were developed with evaluation in mind but both offer a rich set of concepts and terms with which to conduct more complete analyses of the sociology of formal research networks. Network mapping tools

may be better suited for within community collaborations analysis (see Mote et al. 2007: 199; Neurath & Katzmair 2004: Ryan 2008). However, we think ANT (Law 1992; Atkinson-Grosjean 2006), can provide particularly useful information on the challenges faced in network evaluation by addressing the much neglected area of networking between researchers and stakeholders. Crucially, it is not biased towards case studies of collaborations which already have strong internal ties. It may be possible to use the results for a framework for evaluation of changes over time (what level of change over the grant period was evident),

Application of ANT also leads directly into the analysis of network governance. Funding agencies and senior government officials are often as concerned about governance as they are about actual outputs. Focussing, at least partially, on governance can go a long way to providing them with the information on which they can base funding and policy decisions. Such a richer understanding will hopefully eventually feed back into research management practice within networks enabling them to be more effective.

In pursuing the current line of research we are interested in develop new concepts of what are deemed results from a management perspective. This is a conscious move away from the current prevailing paradigms in research organisation evaluations. Both a science production and an economic value perspective have come to dominate the field of research program evaluation (see Freeman 1968 & Godin 2007).

Media Theory & Network Evaluation

The value of employing concepts and terms from media theory can be seen if we think of networks as technologies, or techniques. Media theory posits that the introduction of any new media technology has tremendous consequences for the organization of any society. Printing, for example, is responsible for abstract thought, a fixed point of view, individualism, and factual certainty. The consequences of print, then, extend to all forms of knowledge and government that have emerged since the Gutenberg. This approach was first posited by Harold Innis (1950, 1951), taken up by Marshall McLuhan (1962, 1964) and later given a variety of names including “medium theory” and “media ecology” (Postman 1992).

> *Technological change is neither additive nor subtractive. It is ecological. I mean ecological in the same sense as it is used by environmental scientists. One significant change generates total change…This is how the ecology of media works as well. A new technology does not add or subtract something. It changes everything. In the year 1500, fifty years after the printing press was invented, we did not have old Europe plus the printing press. We had a different Europe. After television, the United States was not America plus television; television gave a new coloration to every political campaign, to every school, to every church, to every industry (Postman 1992, p.18).*

Marshall McLuhan postulated that new technologies have a number of properties that transform the environment in which they exist. In this discourse, we hypothesize that

research networks are a new technology that has been observed to substantially alter the environment in which it exists. It is no secret that public sector research funding in Canada in the past few years has tended to favour the formation of research networks (see Salazar and Holbrook, 2007). This has markedly changed the research environment in the country.

> "*Formally organised research networks (FRNs), in contrast to self-organising informal networks, (which are typically the professional and co-publishing networks of individual academics) are typically established to meet a range of policy goals. Some of those goals include: encouraging the connection of researchers and users (and other stakeholders) and building multidisciplinary research agendas. Although FRNs can be funded for these purposes in any jurisdiction, they are politically necessary in geographically large jurisdictions particularly where there are widely distributed (relatively small) populations. In this light it is interesting to note that it would appear that national FRNs are a Canadian invention. Although a number of 'networks' programs preceded it (see Atikinson-Grosjean), the Networks of Centres of Excellence program established in 1988 appears to be the first significant public-private research collaboration model. Other nations (such as Australia) may have looked at Canadian networks to see how they could be adapted to their situations (Salazar and Holbrook 2007).*"

Given these observations, think of networks as techniques or technologies. Arguably, in Canada, the formation and continued success of research networks has fundamentally changed to research environment. So, how to conceptualize this change? To do this one can draw upon McLuhan's (1988) media tetrad. McLuhan argued that there are only 4 testable questions that can be asked of all media to discover how they have changed the social world:

- What does it enhance or intensify?
- What does it render obsolete or replace?
- What does it retrieve that was previously obsolesced?
- What does it produce or become when pressed to an extreme? (p.7)

The telephone, for example, enhances communication, renders obsolete face to face communication, retrieves a sense of small community and when pushed to an extreme it tends to revert in on itself – in this case, too much telephone interaction bogs down productivity and action.

We can subject networks to the same framework: They enhance dialogue and cross-disciplinary research; they render obsolete autonomous and isolated research; they retrieve notions of collegiality and interdisciplinary research that seemed to be lost at Universities became organized disciplinary units as opposed to a whole; and, pushed to an extreme, they produce an emphasis on management and bureaucracy that can render the network ineffective. This type of conceptualization can be used to describe networks

in general, or they can be used to describe specific types of networks such as formal research networks.

Research plan and methodology

This project stems from work done by Wixted and Holbrook (2007) for the MSFHR Health of Population Networks on designing an appropriate evaluation framework. In developing a report for the Networks, some preliminary concepts began to emerge. A taxonomy was developed based on the most basic structure of many networks – the combination of a group of researchers and a community of stakeholders including the receptor population. We believe that the characteristics of the links between the multiple communities (conceived as broad *groups* of individuals in networks) of researchers, collaborators and stakeholders as a whole might begin to provide a practical methodological approach to evaluation. Therefore, we neither wish to map specific network structures nor the process of structure development. This differentiates us from authors such as Rogers et al. (2001) and others (*e.g*. Edler and Rigby 2005).

As a result of reviewing the results a workshop on evaluation for eight diverse health of population networks developed and funded by the MSFHR in British Columbia Wixted and Holbrook (2009) received valuable insights into how it might be possible to understand the internal structure of health research networks and their external relationships. These innovative and relatively unique networks are funded to promote the development of linkages between researchers and stakeholders with the goal that these linkages will foster new research questions, projects and teams. The eight networks cover the diverse population areas of: children and youth, environmental and occupational health, mental health, aging, rural and remote health, disabilities health, aboriginal health and women's health.

Following analysis of the responses to a worksheet aimed at assisting the workshop participants build an indicator set representing multiple possible outputs of their activities some interesting differences between the networks became apparent. Some networks clearly had a strong sense of the research possibilities, while others saw strong stakeholder interest in the network activities. These responses suggested a possible taxonomy of network attributes which focuses not on the individuals but upon the communities of actors inside them.

In the most simple modelling of this approach we have two stakeholder communities researchers and others (industry or populations) and we have two starting positions for each community (strong and weak). This gives a two by two matrix of combinations (Table 1). The examples given do not reflect actual positions of the networks represented at the workshop but characterise the reflection of the authors on the *risks* in terms of a network's ability to network, examples are from the field of health and medical research.

Table 1: Identification of Researcher/Community combinations

	Weak stakeholders	**Strong stakeholders**

Strong Researcher Community	'researchers' are relatively easy to define, but the population communities are more diffuse on a comprehensive basis (e.g. gerontology, rural etc)	formal networks where there are two strong poles.(e.g. AIDs researchers and AIDs support organizations)
Weak Research Community	there is both a disparate researcher community and a diffuse stakeholder community (e.g. women's health)	the research community is more disparate but there is a strong emphasis on community engagement and support. (e.g. First Nations)

Networks within the terms of this proposal are limited to *formal knowledge networks*. We are interested in the organization of research projects which are funded by granting councils as networks, and thus 'formal', as opposed to the myriad of self-forming networks that emerge and disappear around particular individuals or projects (see Bozeman et al. 2001). We will further restrict our target population to 'knowledge' related activities. These can be either pre-research or research-related, but we are explicitly excluding what we might call action networks which are attempting to achieve a particular change in the behaviours of a particular group (e.g. some health networks). The disciplinary or multi-disciplinary nature of the knowledge activities is a key factor.

Research networks as policy instruments for cooperative research

In this paper we aim to both map the complexities of evaluating formal research networks and to suggest a path for future research to pursue. There are a number of necessary and sufficient conditions that describe research networks:

Necessary conditions:

- The network will be established to generate new knowledge, using the OECD Frascati Manual definition of R&D (and will likely have as a policy objective, the diffusion of new knowledge)
- An element of the network's mandate will be to train, encourage or mentor new researchers.

Sufficient conditions:

- The network is *funded* for a set purpose for a set period of time. Most often they are a creation of a government research grants organisation, although they could, for example, be funded by large non-profit foundations.

- The network is required to establish a formal *administrative structure*.
- The network is established, in part, to meet a *policy objective.*
- The network will likely be formally evaluated at some point

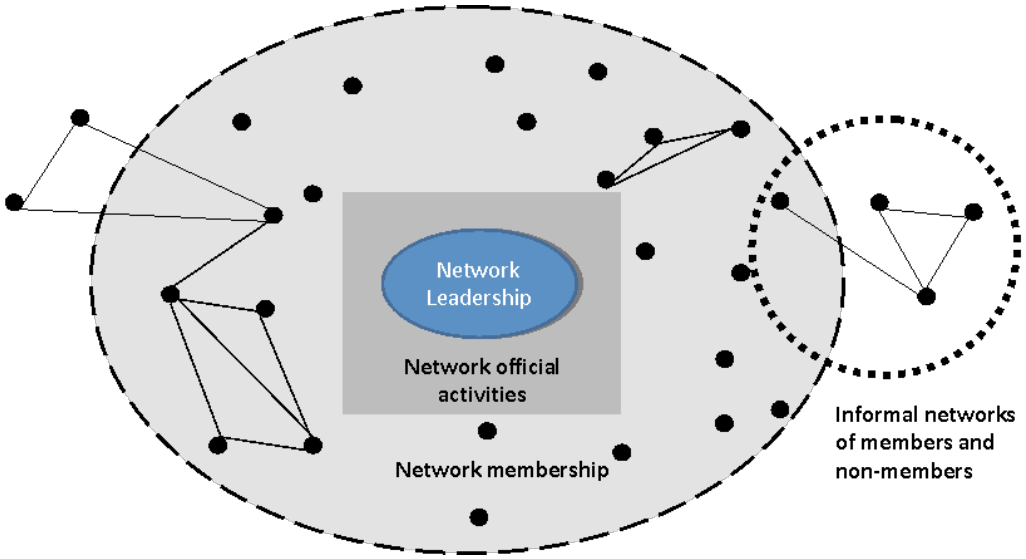
Even if all these conditions are met there will be a need to distinguish between *collaborations* across organisations, space or discipline and networking. Although, the analysis presented in this paper is of relevance to large collaborations[4] it is most relevant to situations where there is an expectation of formal network construction that reaches beyond researchers into the stakeholder communities.

The nature of networks being what they are, there are scale and boundary effects to be understood, which we address specifically in section Y. For evaluation purposes it is worth noting that within the formal organisational entities of networks there are many informal networks of the kind Bozeman and others describe, but our interest here is at the level of the organisation.

There are two particular features that separate formal from informal research networks. The first is that the former is often established with the purpose of improving the embedding of players and of increasing the numbers of players. The second is that FRNs are established with an explicit management structure. Taking this second issue, we can build a model of the formal knowledge network organisation; although at the edges they have loosely defined and porous boundaries

Figure 1: The structure of research networks

[4] We are thinking here of 'team science' type projects of the kind funded by agencies such as the Canadian Institutes of Health Research – in these situations the network (collaborative partners) for the most part need to be in place before the grant is offered. Our observation is that in many network grants there is some expectation that during the course of the research project there will be attempts to reach out to new partners and expand the network.

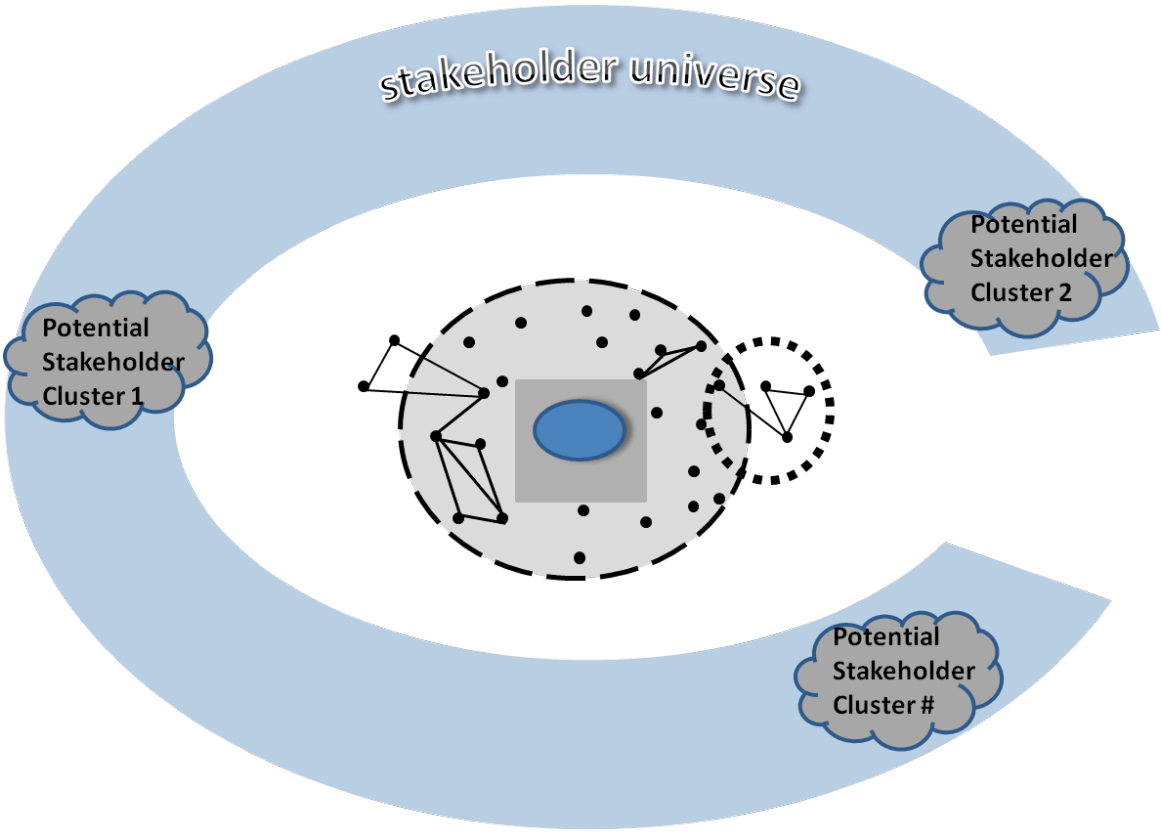


Source Wixted and Holbrook (2009)

At the core of a formal network is the leadership team consisting of principal investigators and administrative staff. Beyond this team is the 'stuff' of *the* network. These are the members of the network engaged in network supported and endorsed *activities* (researchers and stakeholders). However, beyond perhaps a few core fully paid researchers and doctoral students, network *membership* typically includes many individuals who devote only a small percentage of their time to official network work. Thus while they exist within the network, their work is often a grey zone of semi-related activities (often unfunded but often attributed to the network). Lastly, these members will often have their own formal /informal connections to research beyond the walls of the network (other paid research grants etc). Understanding this complex structure of relevant, irrelevant and ambiguous activities is critical for developing an evaluation structure. It is also why we focus our attention on network attributes rather than the more typical focus of evaluation studies, that of project attribution which in the case of networks is complex and secondary to important policy objectives noted above.

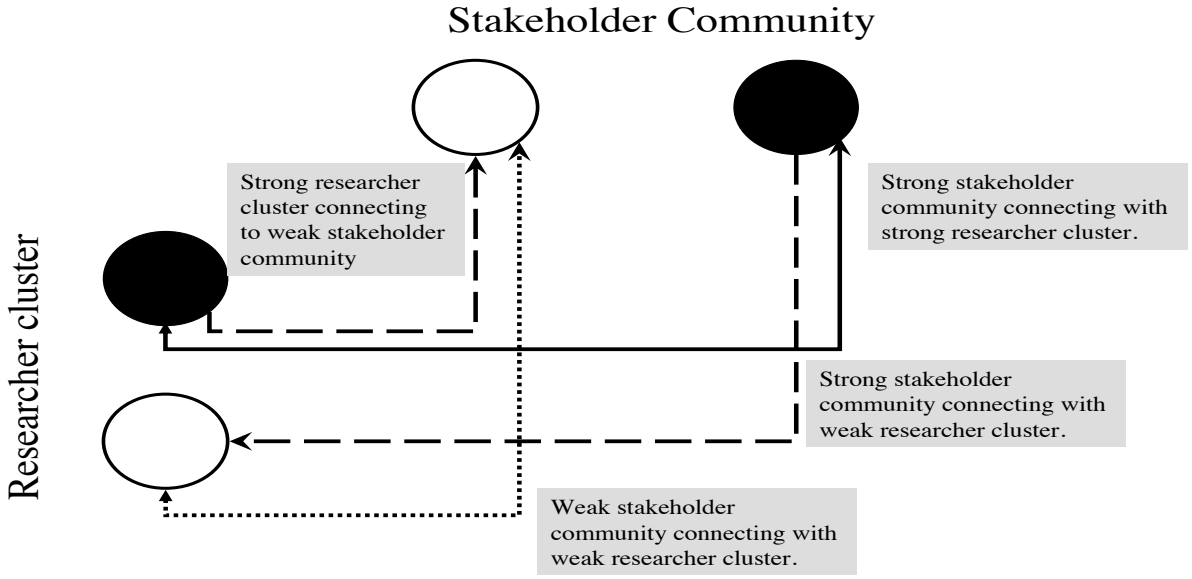
But this model has to take into account the existence of the stakeholders of a research network (as per table 1). In figure 1 the existence of actors external to the research network is hypothesized. Indeed the stakeholders are usually a larger group than the research network with the result that the research network sits inside the stakeholder universe (figure 3)

Figure 2



But what are the relations between the researchers and the stakeholders, for that we must understand issues of connectedness and relatedness. Figure 3 illustrates our thinking that networks emerge in a range of situations precisely because of the particular strengths of the communities of researchers and stakeholders respectively. This view arose from our studies of the MSHRF Health of Populations networks.

Figure 3: Research Network Collaboration Taxonomy



(see Wixted and Holbrook, 2009)

What is Actor-Network Theory, in Theory and in Practice?

At this point we note that there are two discussions which are possible: One based on techniques for identifying the researchers and stakeholders and mapping the relations between them; or another which digs for deeper understandings of the ways in which network connections are made and performed .

In the first instance, there are methodological tools such as social networking analysis that can be employed, and have been, to understand research networks (Elder & Rigby 2004; Ryan 2008) or stakeholder groups (Prell et al. 2007). However, social network analysis is still little more than methodologies looking for meaning (Rogers 2001; Durland & Fredericks 2005; Mote et al. 2007). The structures look impressive, but it is hard to discern what they mean. Instead, as Durland and Fredicks (2005) note, theory and understanding of the importance of relationships and relationship structures must precede the use of relationship mapping tools.

Thus, while noting that relationship mapping methodologies are relevant to our needs and will be required at some point, we as a team have instead focused our attention on the more pressing need – that of *meaning before maps*. We have paid considerable attention to developing a tool-box of concepts that derives from Actor-Network Theory (ANT). Although primarily a sociological tool, we feel that ANT can be valuable for evaluation purposes.

While a separate paper (Cressman 2009) that explores ANT on its own terms, in this report we are interested in the need to adapt, modify and deploy relevant ANT concepts for our need of evaluation constructs while remaining as true as possible to their original meaning. As Law and Callon (1988) said :

"we are not primarily concerned with mapping interactions between individuals…we are concerned to map the way in which they (actors) *define and distribute roles, and mobilize or invent others to play these roles".*

In this section of the report we use our work with ANT literature and language to understand its implications in three different scenarios. First we use ANT to critique our own taxonomy. Second we use some key concepts from ANT to understand how pre-funding decisions of networks might be affected by the Wixted-Holbrook (W/H) taxonomy and also key ANT concepts. Lastly we examine how ex-post evaluation of network performance may be conducted with the aid of the W/H taxonomy and ANT.

But first we need to explain some of the key ANT terminology we are interested in.

- *Problematization:* To problematize is to define a specific problem and a potential solution, enroll and define the actors within the network in which this problem will be undertaken, and co-relate the interests of actors so that they match the interests of the system builder. See Callon, Law, & Rip 1986; Callon 1981; Callon 1986.

- *Enrollment*. A strategy by which actors, their roles, and their interests are defined by network builders. Enrollment is never permanent and success is never guaranteed, rather it should be understood as a contingent process consisting of a variety of techniques and materials (Callon 1986)

- *Generalized symmetry*. Within ANT both human and non-human actors (technologies, other materials) are to be evaluated equally. We are not interested here in the philosophical implications of this move. Rather, we recognize the importance of both the social and the technical within any given network.

- *Local/Global Network:* In some instances it is possible to identify the existence of global and local networks. Global networks are usually large funding agencies who seek to create local networks to solve problems that they have identified. Of note for our purposes is the spaces created for local networks to act and the relationship between the local and the global network (Law 1988; Law & Callon 1988; Law & Callon 1992).

- *Obligatory Passage Point:*To make oneself indispensable within the network. More specifically, this term refers to particular locations, technologies or people through which all of the actors interests must pass (Callon 1986; Latour 1987).

- *System Builder:* Although not an ANT term per se, the idea of a system builder permeates much work in ANT. In order to account for the heterogeneous activities of the people behind technological systems this term is used to account for the management and interconnectedness of the entrepreneurial, financial, promotional, inventive, and lobbying efforts needed to build networks. Like all other actors, system builders are constituted in the course of technology construction and the interaction with other actors. See Hughes 1979, 1983; Law 1988.

ANT, funding decisions, ex-post analysis and the W/H Network Taxonomy

From the perspective of ANT there are a number of steps required to interpret the network taxonomy that was the starting point for this paper.

First, any given relationship between a research network and a stakeholder community must be considered an "Actor-Network",

> The actor-network is reducible neither to an actor alone nor to a network. Like networks it is composed of a series of heterogeneous elements, animate and inanimate, that have been linked to one another for a certain period of time. The actor-network can thus be distinguished from the traditional actors of sociology, a category generally excluding any nonhuman component and whose internal structure is rarely assimilated to that of a network. But the actor-network should not, on the other hand, be confused with a network linking in some predictable fashion elements that are perfectly well defined and stable, for the entities it is composed of, whether natural or social, could at any moment redefine their identity and mutual relationships in some new way and bring new elements into the network. *An actor-network is simultaneously an actor whose activity is networking heterogeneous elements and a network that is able to redefine and transform what it is made of*" (Callon 1987, p. 93, our italics)

Next, we need to work backwards, starting from the point where researchers, stakeholders and connections are not yet in the form described in the figure 3 (where a network exists). By working backwards we problematize the above taxonomy. Instead of assuming that there are research clusters, stakeholders and connections which vary from strong to weak we need to first ask how it is that these actors and processes came into being (Latour 1987, chapt.1).

This requires, first, identifying the network builder. Using the above model we can assume that the network builder is either the stakeholder community or the research cluster. For the sake of clarity and continuity X will be the research cluster and Y will be the stakeholder community. In this scenario X is the network builder.

X begins the construction of an actor-network by asking an apparently simple question: Why is the unemployment rate so high in one particular area of British Columbia and what can we do to encourage long-term sustainable employment?

This question comes to be the basis of documents (funding applications, reports) produced by X. These documents, however, do not simply ask this question – they also "*determine a set of actors and define their identities in such a way as to establish themselves as an obligatory passage point in the network of relationships they are building*" (Callon 1986, p.204). The network builder is defining a world in which particular actors, their goals, and their interests, have a definite history and trajectory. The totality of context is defined within and specific to this particular actor-network. (Callon 1987).

Building this context and defining actors is accomplished by mustering enough allies (rhetoric, documents, similar studies) to convince the actors that your proposed actor-network (that is, the definition of actors and their interests) actually corresponds with their interests. Once this is accomplished, the initial connections are created that will come to constitute the actor-network.

In relation to the W/H Network Taxonomy and the X/Y actor-network identified earlier we would be primarily interested in how the stakeholder community – Y – is defined by X.

Enrollment and Network Connections

At this stage, though, these initial connections are tenuous. To correct this it is important to turn to more durable means than rhetoric or documents. Technologies, buildings, lines of communication and other materials become intertwined with social elements to ensure that enrollment is both successful and can be consistently maintained without being completely dependent on autonomous actors left to their own devices.

> *The resources of the body…are altogether inadequate to generate the kinds of social effects that we witness round about us. For orderings spread, or (sometimes) seek to spread, across time and space. But, and this is the problem, left to their own devices human actions and words do not spread very far at all. For me the conclusion is inescapable. Other materials, such as texts and technologies, surely form a crucial part of any ordering* (Law 1994, p.24).

The addition of new actors (technologies, materials, techniques) changes the actor-network. Each time we add another actor to the network it changes. Let's say that X attempts to enroll Y within their network through the addition of communications technologies. For X it is imperative for all of the actors that make up Y to communicate with each other and with X. This addition, in turn, shapes both X and Y by forcing them into a more complex system of communication that may or may not work as predicted.

For example, if Y is a tight-knit stakeholder group whose communicative practices are localized in one particular area the addition of technologies used for long distance communication may not create the results X requires simply because Y does not use the technologies provided. Similarly, if Y is a disparate group spread over a large

geographical area the building of permanent infrastructure may not work. In short, the imperative of building connections undertaken by X requires the addition of durable materials. These materials, though, are not neutral and presuppose a context and goals that may contradict the interests and goals of either X or Y.

This example highlights both how connections are built and how they are performed. An actor-network is constituted by and defined by its connections. In this sense we need to recognize that connections are performed through the interactivity between humans and technology. Connections are not static and unchanging, they are dynamic – a process, not a form. In the first instance, one may assume that weak connections mean a weak network, one that will likely fail. Similarly strong connections imply a strong network that will likely grow. But Granovetter (XXX) suggests that multiple weak connections may be more important than a few strong ones.

More to the point, any given network is an effect of the interactions between the actors that constitute it. If we add new actors (humans or non-humans) to the network we are fundamentally altering the network itself. When network connections are performed consistently actor-networks become punctualized – they become black boxed. This happens because all of the actors within the network have been successfully enrolled/translated and as such disappear behind the façade of a smoothly operating network.

Symmetry

One of the critiques of ANT is that it is overly managerial – it is inherently a top down approach, negatively defining interests that are not those of the network builder. However, In the proposed network typology it is important to identify ways in which the researchers or stakeholders reflexively shape the interests – and hence processes of enrollment and translation – of each other.

For example, if Y refuses to be enrolled into X's network, a conventional ANT analysis would see this as a failure on the part of X. However, for our purposes, it may be handy to understand why X failed by adopting the perspective of Y. In this way, we could remedy the failures of X by encouraging them to change how they have defined Y that better corresponds with how Y defines both themselves and X.

Although writers on ANT claim that it is not a theory and cannot be used for evaluation, this is not absolute. ANT concepts are helpful in interpreting and understanding the operations and evolution of a research network. We use the concepts in this section to suggest what meaning may be attached to particular findings of how a formal research network performed in retrospect.

Basically, ANT provides a conceptualization and a terminology that enables the following questions:

- How did X initially define Y? Which documents/texts established this definition?
- How was enrollment attempted? What was done to ensure that the proposed actor-world came into being?
- Did the Network builder establish themselves as an obligatory passage point? If not, how did proposed actors fail to fall in line with their proposed identities?
- How are connections performed? What materials are used to ensure performativity and durability?
- How it the actor-network transformed by the addition of new actors & techniques?

ANT and ex-post analysis of network performance

Although the principal writers on actor-network theory believe that it does not provide a basis for project or program evaluation, this statement is not always true. ANT concepts provide a useful language for describing the activities of networks and from there it is a short jump in logic to go beyond mere descriptions to ask questions with evaluative meaning. For example, were network activities effective in meeting the goals of the network.

The key concepts in using ANT for ex-post analysis are:

Translation and Problematisation

In the Wixted and Holbrook (W/H) taxonomy (2009 forthcoming) a key question revolves around whether the network was able to recruit enough of the right people. In turn this involves two key questions of ANT 'translation'.

- How was the research question defined – who (researchers and stakeholders) was included and excluded by the research proposal;

- In hindsight was the research question the important question?

We can summarise this as, at the time of funding, a group of researchers made a strong case that an important research topic was question X. However, did the evolution of the research and subsequent stakeholder involvement reveal this to be true? Was it *the* issue, or even if it was not the primary issue in the field was it at least significant? In the absence of either, what was the response of the research management team?

Enrollment

If the research question / research field is thought in hindsight to have been appropriate and further that the research management team took appropriate steps to evolve the research topic, then:

- How did the network perform in enrolling research members and stakeholders?
- Where in the taxonomy did the network fall?
- What does this tell us about the management of the network?

Within in the initial framing of the W/H taxonomy enrolment was the key focus and improved understanding, however as later analysis presented here reveals it is only one of a series of key constructs.

Obligatory Passage Points

An essential part of building a network is the creation of obligatory passage points (OPP), often key people through which key information passes. Too many OPPs and the network will be dysfunctional – there will be too much information leaking from the organization with a probable lack of focus on major stakeholder communities. Alternatively, with too few OPPs the opportunity for network construction will be limited. Valuable serendipitous meetings and flows of tacit knowledge will be restricted, reducing the opportunity for creativity.

Thus, if a network builder is to become an obligatory passage point it will have to become indispensable to the goals of the actors which are to be enrolled in the proposed network. As well, using a variety of techniques (rhetoric, research findings, studies) actors feel obligated to pass through the translations that the network builders propose.

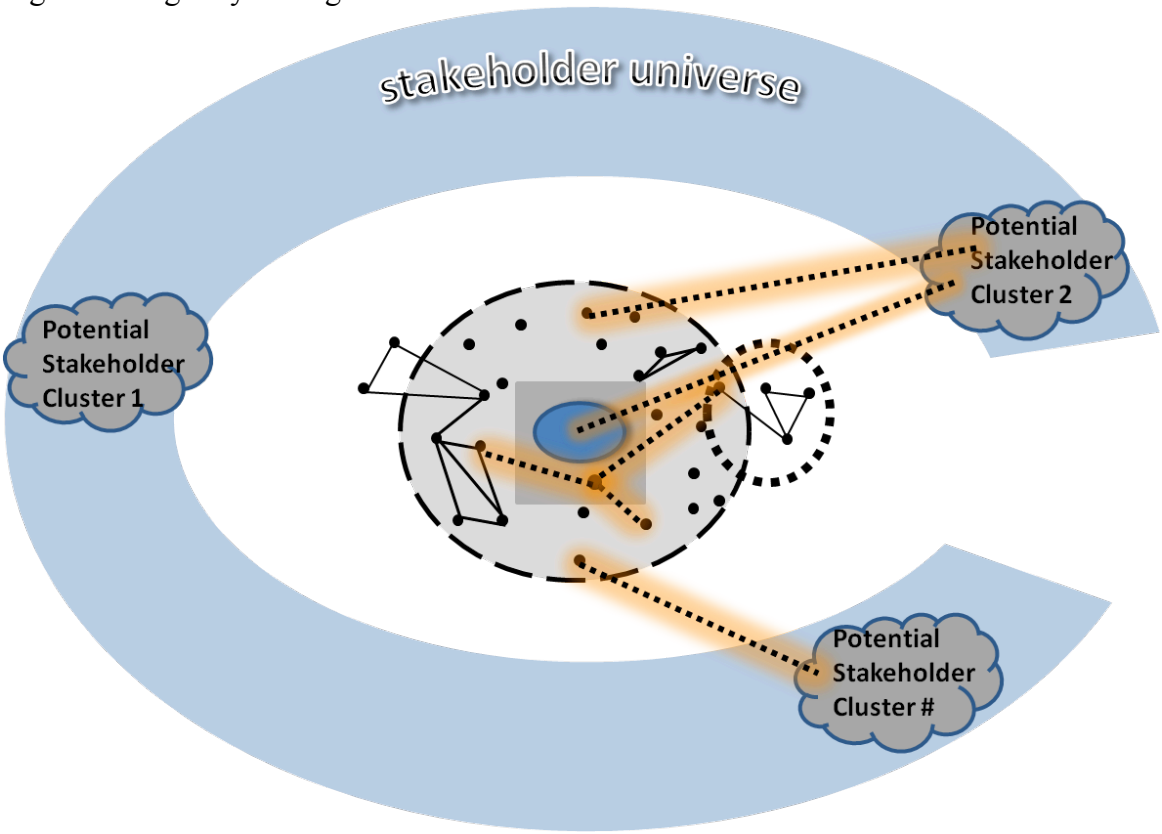
If we limit our definition of 'obligatory passage points' (OPPs) for the purpose at hand to either institutional or human actors we can think in terms of the nexus people – those through whom knowledge (etc) *must* flow. The role of individuals or organisations as OPPs are important and we can describe a number of situations.

- Even if the network is somewhat decentralised – who are the key people in the network – co-investigators or others (perhaps keepers of databases);
- Did the internal gatekeepers (say of data) act as a 'switchboard' or match maker – matching information with the interests of members or did they 'protect' the data from other users – how did this affect performance?
- Centralised versus decentralised communications between the researchers in the network and the outside world;
- OPPs can sit at the interface between the network and particular organisations – perhaps government ministries, in such cases did the people prove to be the right people?

Looking backwards, in conducting an evaluation of a network we can ask; were there too many (diluted) obligatory passage points, not enough, the wrong people / organisations and other related questions.

So if we return to our diagram we can introduce ‘key people’ into the illustration of a network.

Fig 4: Obiligatory Passage Points



In this diagram we can see a number of features.

- nobody in the network has a connection to stakeholder cluster 1 – this is not *a priori* bad – it just depends on the significance of that cluster.
- there are two connections (OPPs) to stakeholder cluster 2 and 1 OPP to Cluster #.
- Simultaneously, within the network there is a key individual who perhaps is the keeper of a database.

Once we know that these key people exist we can evaluate their role in the performance of the network.

Generalised Symmetry & Materiality

Simply, did the network use appropriate means of networking (conferences, websites, databases etc)? Were there enough meetings either face-to-face and online to build a sense of unity and joint interest both in the outcomes of the network and in the interesting research questions confronting both the academics and stakeholders.

Impact and Evaluation Criteria for Formal Research Networks

Formal research networks are part of the system of innovation at the level of geography in which they operate. Thus a nation-wide research network is part of the national system of innovation, while a local research network is both a part of the local system of innovation and the mosaic of policies and structures which forms the national innovation system. But at whatever level they operate, they are part of the infrastructure of that system of innovation, just as research councils, research organisations and key laboratories can be understood as infrastructure that supports innovation. Thus research networks need to be analyzed within their respective system of innovation and tested as to the contribution they, as infrastructure, make to those systems of innovation.

The literature on the benefits of research has largely firmed up around a list that is typified by Salter and Martin (2001), which includes impacts and outputs, but also includes much more in other social and economic benefits. They argue that there are six principal outcomes of research, namely:

- Increasing the stock of useful knowledge
- Training skilled graduates
- Creating new scientific instrumentation and methodologies
- Forming networks and stimulating social interaction;
- Increasing the capacity for scientific and technological problem-solving; and
- Creating new firms.

Of this list, some of the sub-elements are the subject of long standing research interest. In particular, the stock of new knowledge (especially its quality and commercial knowledge, as measured by patents and licences) and the creation of new firms (spin-offs) have received considerable attention. Likewise, some aspects of problem solving have received widespread attention in the business literature.

The issue of network formation, has received less attention, but is a growing area, particularly stemming from the work of Bozeman on informal scientific and research networks and the so called 'research value mapping' methodology[5].

A completely different model for evaluation rests on an assessment of the governance of networks. Creech and Ramji, (2004), in analyzing networks for the development and dissemination of information for international development have suggested that network evaluation be based upon:

- Effectiveness: changes in knowledge base, communication practices, relationships; strategic plan
- Structure and governance: network formation, relationships, governance

[5] http://www.rvm.gatech.edu/index.htm

- Efficiency: interaction among members, institutional support, systems and procedures
- Resources and sustainability: human and financial resources, timelines, sustainability
- Lifecycle: life-cycle analysis

Although, these are valuable criteria, applying them to research networks is challenging due to a lack of detailed criteria against which they could be tested. However, researchers who have worked in research networks would agree that governance is an importance aspect of network success (see e.g. Atkinson-Grosjean 2006). It is all the more important given that so many networks appear to be relatively short lived.

But on top of these "conventional" criteria there are, as we have shown the criteria that emerge from a study of ANT and McLuhan/Postman. The W/H taxonomy in conjunction with ANT suggests some important over-arching tests for the performance of a research network, that moves beyond mere research collaboration or research output. These characteristics are valid for all types of research networks.

Typically they include:

- Enrollment: How well did the network manage the process of enrolling stakeholders to its network?
- Environment: How did the network integrate into the research environment? Did it modify the environment?
- Global local linkages: How well was the process of moving information between researchers and stakeholders managed?
- New technologies; Did the network move the 'technology' of research networks forward?
- Obligatory Passage Points; Who, or what are the obligatory passage points?
- Problematization: Was the research question the important question?;
- System Builders: Who are/were the system builders?

Research Networks as Complex Systems

There have been a lot of studies on the general characteristics of networks and systems. These range from studies on the performance of complex control systems, through to social networks. In general social systems are complex: while for analytical purposes these systems are often treated as having a finite number of variables, interconnections or nodes, in practice, they are far more difficult to model.

Given the prevalence of information technologies, it is possible to have a greater number of nodes, a greater density of connections among the nodes and a faster movement of information along the connections (see the work of A-L Barabasi). Thus what was once a simple research endeavour consisting of, at most three or four individuals, research networks of considerable complexity can be formed. Indeed, as we have seen, this formation is encouraged by policy makers, in the name of increased efficiency, in a manner similar to the increase in efficiency of social units described by Holling et.al (2002).

One can observe that complex systems:

- are more than the sum of their part (they have emergent properties)
- can move from one state of equilibrium to another
- have disproportionate cause and effect (they are non-linear)
- cannot be easily managed because their behavior is unpredictable (at least by simple models)

These characteristics too, can be part of a suite of evaluation processes. In evaluating a research network, one can ask:

- is the network greater than the sum of its parts?
- is the system non-linear, in that minor perturbations have major outcomes?
- Is the network stable (i.e. in equilibrium)

These are not simple questions for conventional evaluation practices. Being aware that networks are more akin to complex systems than individual research projects suggest that evaluators need to be more eclectic in assessing the strengths and weaknesses of them. Indeed, it is possible that networks which proceed along typical project lines and produce a given end-product may have reached their end point through being extremely controlled and thus may have less impact than another more complex network influenced by the wider environment, but which did not achieve what was originally intended.

Such thoughts lead us back again to emphasise that it is essential for networks to be assessed on the core criteria of how they are managed and how the components (individuals) interact before assessing what the networks produce.

Social Science and Humanities Research Networks

Social science and humanities (SSH) research networks are almost, by definition, different from health sciences, natural sciences and engineering research networks. Indeed, an analysis of the ANT – W/H tests can be used to show how SSH research networks differ from NSE and health networks.

The most obvious difference is that SSH networks generally do not have large capital investments in equipment or other physical assets. Where there are large in capital investments (as in the natural sciences) there is a clear tendency for the network to coalesce around the capital equipment. The network leaders are usually very closely associated with the operation and maintenance of the equipment, and thus the structure of the network is defined by access to the equipment and who controls that access. Stakeholders outside the network are often marginalized, in terms of access to the equipment: this often hampers transfer of the research findings out of the network.

SSH is different. Indeed, the SSH network is often very much smaller than the group of stakeholders, so that the linkages, the *obligatory passage points* may (or should) be defined by the stakeholders, not the research leaders. This suggests some SSH – specific tests that can be applied in a **pre- project evaluation**, such as the peer-evaluation process used by SSHRC for network research proposals:

- Is the proposed network entirely contained within the universe of stakeholders?
- Does the network proposal clearly define the stakeholders, or how the members of the network will reach out to enroll all stakeholders?
- Does the proposal address not only the composition of the direct stakeholder universe, but also discuss the possible composition of the universe of non-direct, or secondary, stakeholders?
- The proposal must identify the "*obligatory transition points"* between the researchers and the stakeholders
- The proposal must address the translation of information of information through the transition points. More importantly it must demonstrate the symmetry of this translation of information. Information must entre the research network from the stakeholders, as well as flow outwards, and these flows should move with equal facility

Analysis of SSH research networks

We have had the opportunity to present our thinking on the evaluation of formal research networks at least twice during this past academic year. The first was to a key group of Canada's research council evaluators and academics with an interest in evaluation. SSHRC, CIHR and BC's MSFHR were represented at the meeting along with the Ministry for Advanced Education in British Columbia (please see Appendix "A" for details). Our second presentation was to the InnoCom research network, which is a part of the SSHRC MCRI Innovation Systems Research Network. The Innovation Systems Research Network (ISRN) is an excellent example of a successful SSH research network (see Holbrook and Wolfe, 2005). We can test the performance of the ISRN 1 network (2001 – 2005) against the criteria outlined above and compare the efficacy of each approach.

Table 4: ISRN 1 Performance

Criteria	Outcomes
Salter and Martin	
- increasing the stock of useful knowledge	Yes: see the publications record in the ISRN website : <www.utoronto.ca/isrn>
- training skilled graduates	Yes: see the ISRN website
- creating new scientific instruments and methodologies	Yes: the research methodology was developed and refined: it is now being used in ISRN 2
- forming networks and stimulating social interactions	A strong network and several subnetworks were formed that have persisted past the end of the ISRN 1 project
- increasing capacity for S&T problem solving	Yes: the whole practice of innovation analysis in Canada was advanced
- creating new firms	While no new firms were created, the network enhanced the capabilities of several consulting firms, such as HAL Associates of Ottawa
Creech and Ramji	
- effectiveness	Yes: see publications, student training etc. on the website
- efficiency	Yes: SSHRC funding was heavily leveraged with funds from provinces and regional economic development agencies
- resources and sustainability	Yes; ISRN 1 created a stable network environment with a relatively modest outlay of resources
- lifecycle	ISRN 1 lasted (and expanded throughout its defined lifespan, and then morphed into ISRN 2
ANT analysis	
- enrollment	The managers of ISRN 1 were able to recruit a number of researchers who otherwise would never have worked together
- environment	ISRN1 showed how SSH research can be performed within the overall network-based research environment in Canada
- global/local linkages	ISRN developed strong individual-regional linkages, and equally strong regional – national linkages

- new technology	ISRN 1 was one of the first SSH networks to operate successfully in Canada
- obligatory passage points	The network manager and the sub-network managers were able to facilitate the transfer of information and knowledge among participants
- problematization	The network started with a general problem – how to understand innovation in Canada – and refined it to specific research tasks that examined innovation in each region
- system builders	The network/sub-network structure clearly identified the system builders and assisted them in developing the network and sub0-networks

Summary[6]

It is not surprising that some general understanding of what a network is has become part of the shared knowledge of contemporary culture. Networks are largely understood to be self-evident, unproblematic and largely unquestioned conceptual frameworks. As such, it would not be an exaggeration to say that networks have attained paradigmatic status across large sections of popular and academic culture.

Certainly one of the reasons for this paradigmatic status is the conceptual duality of networks. A network, in this sense, can be considered both form and process. On one hand, a network refers to a particular architectural form, or organizational structure, wherein people and institutions (amongst other entities) interact. On the other hand, the term network can also be considered a verb, a process that occurs within the networks. However, we should not be so quick to delineate between process and form. In some instances, networking precedes and shapes form and in other instances form shapes process. In short, networking and network should be understood as co-constitutive, inseparable dimensions of the same phenomenon.

Yet, despite this holistic view of networks, it has become increasingly evident that for the purposes of analysis and evaluation an analytical distinction between form and process is required. Across a number of countries public funds are increasingly being used to fund scientific and technical networks as a means to spur innovation, economic prosperity and an increased quality of life. These networks are subject to routine evaluations that gauge their efficacy and relevance. Although this may appear to be rather straight forward, network evaluation presents many obstacles for traditional evaluative frameworks. As Rogers et. al (2001) and others (Mote et. al. 2007) within the evaluation community point out, translating what we know about networks into a framework for evaluation is quite difficult. Very generally, the problem is that researchers do not know how to

[6] This section is taken in its entirety from Cressman (2009)

differentiate networks from other frameworks and as such rely on an evaluative model that is dependent on inputs and outputs. In practice there is nothing wrong with this. A thorough review of network inputs (individuals, money, infrastructure) and outputs (publications, patents) is essential for gauging the effectiveness of any given network. But, this particular approach disregards both the idea of network as process and the formal structure of networks. It is assumed that successful networking is key to the success of a network as measured by outputs, but there are no tools on hand to evaluate what actually happens within a network. If we reduce evaluation to inputs and outputs both the form and the process of a network are, at best, loosely related to the primary evaluative concerns. In short, the evaluation of research networks emphasizes everything but the network itself.

This is realized in a number of ways. First, most evaluations are conducted to assess the performance of individuals. Thus, translated to the evaluation of networks this results in conceptualizing the nodes as independent and autonomous entities. Of course this contradicts one of the essential characteristics of any network – the whole is more than a sum of its parts (Rogers et. al. 2001, p. 167). Second, network evaluation needs to move beyond simply noting connections and focus on describing the nature of these connections. Not all connections are equal, yet it is often the case that all connections are considered equal despite the range in strength and weakness that connections necessarily embody. Thus, it is important to "move beyond simple descriptive exercises of who is connected to whom" (Mote et. al. 2007, p.192).

The problem is clear – how to create an evaluative framework for networks that can account for the unique characteristics of networks. This means leaving behind lists of inputs and outputs and attempting to explore what happens in between the inputs and outputs. In other words, how do we evaluate both the "network" and "networking".

To some this may appear to be counter-intuitive; after all, it does not matter what the structure is as long as the results are consistent. However, it is becoming more evident that there is a link between the processes of networking and the forms that it takes and the overall efficacy of the network itself. Following up on Rogers et. al. (2001) point that while there has been an abundance of empirical contributions to network studies there has been "insufficient theoretical development of network analysis in general" (p.162) I believe that ANT can potentially open up new avenues of network evaluation by examining, first, the heterogeneous associations that constitute networks. And second, by paying closer attention to how networks are performed instead of attempting to provide a snapshot of a network based on inputs and outputs.

Further Research

Evaluators interested in the mechanisms of research networks must incorporate more of the sociology of networking operations, structures and mechanisms. Social network analysis and Actor Network Theory (ANT) were both developed as philosophical exercises arising from empirical observations. Neither were developed with evaluation in

mind but both offer a rich set of concepts with which conduct more compete analyses of the sociology of formal research networks. Network mapping tools may be better suited for within community collaborations analysis (see Mote et al. 2007: 199, Neurath and Katzmair 2004, or Ryan 2008). However, we think ANT (Law 1992; Atkinson-Grosjean 2006), can provide particularly useful information on the challenges faced in network evaluation, by addressing the much neglected area of networking between researchers and stakeholders. Crucially, it is not biased towards case studies of collaborations which already have strong internal ties. It may be possible to use the results for a framework for evaluation of changes over time (what level of change over the grant period was evident),

Application of ANT leads also directly into the analysis of governance. Funding agencies and senior government officials are often as concerned about governance as they are about actual outputs. Focussing, at least partially, on governance can go a long way to providing them with the information on which they can base funding and policy decisions. Such a richer understanding more hopefully eventually feed back into a research management practice within networks that makes them more effective.

As always, more and better indicators are desirable. This area has been investigated by many authors over the past couple decades. At the same time public sector managers have both asked for more and better indicators (while being less inclined to fund additional indicator research and data collection!). Arguably a fresh approach to an understanding of the internal operations of research networks might rekindle their appetite for such management information.

We would therefore emphasize that there is a need to pursue two lines of research in the future. The first is to continue to develop practical concepts and tools for evaluating networks. The second, just as importantly (or more so) is to develop our *understanding* of how research networks actually *operate*. Beyond the assumptions of networking, we know surprisingly little about whether the rhetoric and reality align.

There is a rich literature in several fields that are pertinent to the study of research systems. As we have seen ANT provides many possibilities for additional evaluative measures for research networks. Similarly the concept of research networks as complex systems, and the consequential development of evaluation criteria, offers another area for the development of this material.

Research networks need not be just academic research networks. In this study we have looked at research networks that were funded by granting councils and were clearly academic, and at health research networks, which while funded and operating in the public sector, have (or should have) a more focused view of their interactions with their clients. The same could be said of research networks operating in other quasi-non-governmental areas such as researchers working on problems of international development (as was described by Creech and Ramji). But these criteria also apply to research networks operating in the commercial world. After all, this is where Bruno Latour started his studies that led to the development of ANT. The evaluation criteria described above should also apply to the evaluation of research networks that are either public/private (such as NCEs) or entirely privately funded. In many case where there is private sector involvement, the public sector does support some of the work through the

Scientific Research and Experimental Development tax credit program, so that analyses of their performance are as important to the federal government as are analyses of public sector research networks. We believe that further research in this area is entirely in the public interest.

Similarly, stimulated by the work of Creech and Ramji (2004), there is a strong suggestion that socially–oriented, non- profit, non-governmental organizations may also be evaluable using concepts from ANT. Examples of such organizations could include medical charities, international NGOs, civic improvement associations, and perhaps even some industrial associations. These types of organizations need to be examined through the evaluation lens described above.

Acknowledgements

The authors gratefully acknowledge the support of the Social Sciences and Humanities Research Council of Canada through a Presidential Fund grant for the evaluation of Research Programs. We would also like to acknowledge that the thinking behind the concepts presented here benefited greatly from the opportunity to make presentations made to a Michael Smith Foundation for Health Research funded Health of Population Networks (HoPNs) workshop called *Navigating Network Evaluation*. The workshop was coordinated by Dr. Gloria Gutman (BC Network for Aging Research) and Dr. Bonita Sawatzky (Disabilities Health Research Network).

References

Barabasi , A-L, (2003) *Linked: How Everything is Attached to Everything Else,* New York, Plume

Bozeman, B., Dietz, J., Gaughan, M., (2001). Scientific and technical human capital: an alternative model for research evaluation. *International Journal of Technology Management* 22 (7/8), 636–655.

Callon, Michel (1981). "Struggles and Negotiations to Define what is Problematic and what is not: The Socio-logic of Translation." In K. Knorr, R. Krohn & R. Whitley (eds.) *The Social Process of Scientific Investigation*. Dordecht, Holland: D. Reidel Publishing Co.

Callon, Michel. (1987). "Society in the Making: The Study of Technology as a Tool For Sociological Analysis." In Bijker, W., Hughes, T., & Pinch, T. (eds.) *The Social Construction of Technological Systems*. Cambridge: MIT Press.

Callon, Michel. (1986) "Some Elements of a Sociology of Translation: The Domestication of the Scallops and the Fishermen of St.Brieuc Bay." in Law, J. (ed.) *Power, Action & Belief: A New Sociology of Knowledge?* London: Routledge & Kegan Paul.

Callon, M., Law, J., & Rip, A. (1986). *Mapping the Dynamics of Science and Technology: Sociology of Science in the Real World*. London: MacMillan Press.

Creech, H. and Ramji,A. (2004) *Knowledge networks; Guidelines for assessment* International Institute for Sustainable Development see:www.iisd.org/pdf/2004/networks_guidleines_for_assessment.pdf

Cressman, D. (2009) "A User's Guide to Actor-Network Theory", *CPROST report 09-01*

Cressman, D and Felczak, M., (2009) "A Glossary of Terms for Philosophical & Sociological Approaches to Technology" *CPROST report 09-02*

Durland, M. and Fredericks, K., (2005), *"Next Steps for Nodes, Nets, and SNA Analysis in Evaluation",* in Maryann M. Durland and Kimberly A. Fredericks *Social Network Analysis in Program Evaluation : New Directions for Evaluation, 107: 99-101*

Edler, Jacob and John Rigby (2004). "Research Network Programmes Evaluation for the Austrian Science Fund (FWF)" PREST, in the Institute of Innovation Research at the University of Manchester and Fraunhofer Institute for Systems and Innovation Research,Karlsruhe see: www.fwf.ac.at/de/downloads/pdf/networks_evaluation.pdf

Holbrook, J.A.D., & Wolfe, D.A. (2005). "The Innovation Systems Research Network (ISRN): A Canadian Experiment in Knowledge Management". *Science and Public Policy*, 32 (2), 109-118.

Holling, C.S., Gunderson, L.H., and Ludwig, D., (2002) "In Search of a Theory of Adaptive Change" Chapter 1 in Gunderson, L.H., and C.S. Holling (Eds.). *Panarchy: Understanding Transformations in Human and Natural Systems.* Island Press, Washington D.C.

Hughes, Thomas P. (1979). "The Electrification of America: The System Builders." *Technology and Culture*, Vol.20 (1), pp.124-162.

Hughes, Thomas P. (1983). *Networks of Power: Electrification in Western Society 1880-1930*. Baltimore: Johns Hopkins University Press.

Innis, H. (1950). *Empire & Communication*. Toronto: University of Toronto Press.

Innis, H. (1951). *The Bias of Communication*. Toronto: University of Toronto Press.

Latour, Bruno. (1987). *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge: Harvard University Press.

Law, John (1992). "Notes on the Theory of the Actor-Network: Ordering, Strategy, and Heterogeneity." *Systems Practice* 5(4): 379-393.

Law, John. (1994). *Organizing Modernity*. Oxford: Blackwell Publishers.

Law, John. (1988). "The Anatomy of a Socio-Technical Struggle: The Design of the TSR 2." In Elliott, B. (ed.) *Technology and Social Process*. Edinburgh: Edinburgh University Press.

Law, John & Callon, Michel. (1992). "The Life and Death of an Aircraft: A Network Analysis of Technical Change." In Bijker & Law (eds.) *Shaping Technology/ Building Society: Studies in Sociotechnical Change*. Cambridge: MIT Press.

Law, John & Callon, Michel. (1988). "Engineering and Sociology in a Military Aircraft Project: A Network Analysis of Technological Change." *Social Problems*. Vol.35, No.3 pp.284-297.

McLuhan, M. (1964). *Understanding Media: The Extensions of Man*. New York: McGraw-Hill.

McLuhan, M. (1962). *The Gutenberg Galaxy: The Making of Typographic Man*. Toronto: University of Toronto Press.

McLuhan, M. & McLuhan, E. (1988). *Laws of Media: The New Science*. Toronto:

University of Toronto Press.

Mote, Jonathon, Gretchen Jordan, Jerald Hage and Yuko Whitestone (2007). "New Directions in the Use of Network Analysis in Research and Product Development Evaluation" *Research Evaluation*, 16(3): 191–203.

Postman, N. (1992). *Technopoly: The Surrender of Culture to Technology*. New York: Knopf

Prell, C. ,Hubacek, K., and Reed, M. (2007) "Stakeholder Analysis and Social Network Analysis in Natural Resource Management" *SRI Papers 2007-06*. Sustainability Research Institute, School of Earth and Environment, University of Leeds.

Rogers, J.D., Bozeman, B., and Chompalov, I. (2001) "Obstacles and opportunities in the application of network analysis to the evaluation of R&D", *Research Evaluation*, Vol. 10 (3), 161–172,

Rigby, J. and Edler, J. (2005) "Peering inside research networks: Some observations on the effect of the intensity of collaboration on the variability of research quality" *Research Policy* 34: 784–794

Salazar, M. And Holbrook, A. (2007) "Canadian Science, Technology and Innovation Policy: The Product of Regional Networking?" *Regional Studies*, 41 (8): 1–13.

Salter, A., and Martin, B. (2001) "The economic benefits of publicly funded basic research: a critical review". *Research Policy*, 30, 509 – 532.

Scriven, M., & Coryn, C. L. S. (2008). "The logic of research evaluation" in C. L. S. Coryn & M. Scriven (Eds.), *Reforming the evaluation of research. New Directions for Evaluation, 118,* 89–105.

Whitely, Richard D. (1972). "Black Boxism and the Sociology of Science: A Discussion of the Major Developments in the Field." In Eric Ashby (ed.) *The Sociological* Review Monograph: The Sociology of Science, No. 18, pp.61-93

Wixted, B. (2006) "The Structures, Purpose and Funding of Academic Research Networks" *CPROST Report* 06-08.

Wixted B. and Holbrook, J.A. (2007) "*Navigating Network Evaluation".* A Report to the Michael Smith Foundation for Health Research Health of Population Networks. Vancouver, British Columbia.

Wixted B. and Holbrook, J.A. (2008) "Conceptual Issues in the Evaluation of Formal Research Networks"*, CPROST Report* 08-01.

Wixted B. and Holbrook, J.A. (2009) "Conceptual Issues in the Evaluation of Formal Research Network"*, Research Evaluation (in press)* See also CPROST report 08-01

Appendix "A"

SSHRC Research Evaluation Workshop – 4 June 2008.

Comments by a director of evaluation and analysis for a granting agency.

She raised the question whether what first came to mind about the institute structure of CIHR (for example the Institute of Nutrition, Metabolism and Diabetes led by Diane Finegood of SFU) was that they were 'networks'? However, she went on to note that CIHR itself was a network organisation.

The granting agency official identified three main purposes of evaluation:

- support decision making including program design;
- support learning; and
- enabling accountability.

She supported our research agenda noting that hopefully the framework we have begun to construct will help networks perform better and may indicate changes in program design.

One of the outcomes of the June workshop, was that the team took more seriously the diversity of types of networks funded by CIHR, NSERC and SSHRC. This is reflected in this report with consideration that beyond a broad science neutral framework there are key differences that need to be accounted for in the more detailed development of evaluation tools.

Is networking a policy objective, an end in itself or a means to an ends?

We would continue to argue that it is a policy objective because the 'ends' is to require a transfer of ideas which in turn requires networking.

The director of evaluation suggested that the current focus of evaluation teams within the major science agencies (referencing her own experience at CIHR) has been on 'results' based management and evaluation, noting for example the recent review of the NCE program.

This was an interesting observation by the official. Part of the agenda behind the current project has been to begin to develop new concepts for how 'results' should be understood for research networks, changing the emphasis from publications or economic knowledge translation to the results of the networking.

Comments by a former granting agency vice-president

Her key emphasis was what difference does research investment make?

She wanted a greater parsing of the project, one part focusing on structure and dynamics of networks and a second focusing upon the characteristics of successful networks.

She also wondered whether networking was an objective or a means to various ends, emphasising higher level policy agendas such as Canada furthering its international connectedness and influence.

What are the outcomes of networks:

- Capacity to do research;
- Capacity to use research; and
- Capacity to interact with researchers.

What benefits have accrued to researchers and stakeholders from interacting within networks? Can networks facilitate research which asks questions that could not be done without a network? When are networks an appropriate form of funding model?

The asking of different questions and focusing on the benefits of the networking is at the heart of our model. Our application of ANT concepts heavily emphasizes the central ideas of research problematisation and stakeholder enrolment. What indeed did change from being a part of a network?

Data collection is an important issue for measurement and performance evaluation .

Our view is that the framework should lead the data collection. We need to know which data collect before we develop the guidelines and requests for data.

Comments by a director of performance, evaluation and audit for a granting agency

Program considerations – not all research networks are the same. Some focus on research some on the interactions. Networks facilitate inter-disciplinarily and some are inter-sectoral. Differentiation is important.

The 3Rs

Resources (generation and use information, availability of time – commitment etc);
Reach (who the constituents are);
Results (differing definitions of what constitutes a result – needs analysis).

Theory

Evaluations need to be based in theory with some predictive power of the performance of networks.

Evaluation So what?

Many of these considerations are part of our reasoning for mining further the ANT literature. See our section on the ex-ante and ex-post analysis.

Comments by a former university vice-president, research.

- We deal with a multi-stakeholder universe, so it is hard to define what stakeholders want.
- We need further information on the processes of knowledge exchange (as opposed to translation or other such terms)
- Social networking analysis can be a useful tool.

We agree that we need to know more and we also agree that social networking analysis can be a useful measurement tool but our analysis indicates that it is challenging to move beyond individual ties and this fragmented perspective makes evaluation extremely difficult and this reasoning is the basis of the W/H taxonomy.

Response to the tone of the comments

Broadly, at the June 4 workshop there was support for the direction of the research project and the particular focus on networks as an important question of policy interest.

It is clear that the questions raised at this meeting have formed an important basis for our work on this project. We have focused our efforts on the language of network construction and pre and post evaluation ideas.

We acknowledge that there is more to do in developing a detailed understanding of the purpose, structure and dynamics of different network programs or even how we would form groups of network programs with similar characteristics. At the macro level there are three underlying architectures to *formal research* networks - teams (constricted networks), platforms (networks of researchers that use common infrastructure – e.g. Neptune etc) and open research networks, which has been our focus to date.