The structure and construction of formal research networks: a policy oriented understanding of stakeholder engagement

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Abstract

Given the complexity of the modern research environment, funders (usually government agencies) are encouraging the formation of formal research networks (FRNs). FRNs have a predictable structure which includes primary and (whether acknowledged or not) secondary stakeholders as participants. Policy and program managers need to understand the larger structure, not just the internal operations, of the networks. We propose the use of actor-network theory to understand the strategy and construction of FRNs, and in particular to understand the specific problems surrounding FRNs for social science sand humanities research.

Introduction

In Canada, as elsewhere in the world, there has been an explosion in the role of research networks (cross sector collaborations, teams and in some cases 'groups'[1]) as a mechanism funded by granting councils to manage the research enterprise to address specific public policy objectives, policies and programs in particular. However, if we use the term 'networks' we run into the difficulty that it already has a different connotation. Rogers *et al.* (2001) defines them as,

> *[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).*

But this observation refers to network structures that emerge from observation and analysis and ignores the formally established, funded and mandated organisations that now populate the science systems of many countries. These funded research networks cover a spectrum of activities from pre-research capability development, to structured national research endeavours. By way of examples, knowledge network programmes that have been formally established in Canada include: Networks of Centres of Excellence; Major Collaborative Research Initiative – now replaced by Partnership Grants (SSHRC),

[1] We use the term networks to cover a multitude of terminology for simplicity.

Strategic Knowledge Clusters (SSHRC), Strategic Networks (NSERC), and the Michael Smith Foundation for Health Research (MSFHR) Health of Population Networks in British Columbia (now expired). There are many more (see Fisher *et.al.* 2001 for a discussion); these are seen in virtually every nation that has government funded R&D programs.

The utility of research networks (as we will call them) is shown 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 etc. In Canada, networks also address the research policy needs of a nation linearly spread across the northern US border, and meet the political requirements within which most Canadian researchers operate (Salazar and Holbrook, 2007).

Salter and Martin (2001) argued that (informal) network formation is a core outcome of publicly funded research. In this paper we restrict our discussion to formal research networks (FRNs) which we will define in the next section. From there we discuss the need for closer scrutiny of the strategy of FRNs, both *ex-ante* and *ex-post* as a guide to better evaluation

A primary concern in this paper is to pass beyond the more common social network analysis (Borgartti) and complex network analysis (Barabasi) and introduce 'policy network' concepts (Howells). We argue the need for policy analysts to understand the active role of actors in constructing networks, for which actor-network theory (ANT) has todate the most relevant concepts. Unlike other types of network evaluation that reduce networks to inputs and outputs or basic networks structure, ANT asks us to focus on the content, the context and the processes through which networks are constituted.

If a core reason for the establishment of an FRN is to connect researchers with stakeholders then we need concepts and analytical approaches that focus on and problematize the development of those connections. 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. Indeed, one criterion for success of a network is 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).

Formal Research Networks as policy instruments for cooperative research

Marshall McLuhan (1962, 1964) postulated that new technologies have a number of properties that transform the environment in which they exist. In this discourse, we

hypothesize that FRNs are a new "technology" that has been observed to substantially alter the environment in which they exists. It is no secret that public sector research funding in Canada in the past few years has tended to favour the formation of FRNs (see Salazar and Holbrook, 2007) – also known as (science) public private partnerships (see Atkinson-Grosjean 2006). This has markedly changed the research environment in the country.

In this light it is interesting to note that it would appear that national FRNs were developed as policy tool in Canada in the late 1980s. Although a number of 'networks' programs preceded it, the Networks of Centres of Excellence program established in 1988 appears to be the first significant nation-wide 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).

Networks, within the terms of this paper, 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-development' related activities; the multi-disciplinary nature of these knowledge activities can be key factor.

Table 2: Description of Formal Research Networks

Definition types	Description
Formal Condition 1	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.
Formal Condition 2	The network is required to establish a formal *administrative structure*.
Formal Condition 3	The network is established, in part, to meet a *policy agenda.* Examples include: encouragement of linkages between researchers and user communities, encouragement of communication across a geographically spread population.
Formal Condition 4	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/translation/mobilisation of new knowledge)
Formal Condition 5	An element of the network's mandate will be to train,

	encourage or mentor new researchers.
Probable Condition	The network will likely be formally evaluated at some point.
Interpretative Condition.	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[2] it is most relevant to situations where there is an expectation of formal network construction that reaches beyond researchers into the stakeholder communities.

Summarised from Wixted and Holbrook (submitted).

Networks language: particles and waves, structure and construction

From quantum mechanics we have learned that light and other particles behave as both particles and waves. It is possible to measure the structure (particles) or the flow (waves) but not both simultaneously.

In network analysis we believe a similar point can be made. Almost all the research effort to date has been expended on developing an understanding the mathematical properties of networks and network change in terms of their structural identity but very little on the actor strategies (see Kilduff and Brass 2010) to construct or configure networks. We do not believe this is an either or situation. Structure and construction can and in many cases exist simultaneously. Progress on understanding network dynamics is obviously important but it is naive to assume that is all situations actors are powerless to construct or configure networks. A prime example of this might be the research networks programs themselves. When a policy decision is made to fund research networks, the networks solidify the informal groupings (colleagues who know one another in a particular field) into formal structures while they call into being research that was not being conducted before. Therefore the actors in Government (whether ministers, public servants or the peer assessment panels) are all actors that influence the trajectory of the structure and content of research and they participate in the network structuring. Likewise, policy makers when establishing programmes to encourage networking should be aware of the strategies and characteristics of fields that underlie their development to better understand the performance of research networks.

Briefly, it is worth revisiting the existing networks literature so that our latter points become more apparent. There are two dominant streams of network analysis, one

[2] 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.

emerged from graph theory and is being pushed along by higher mathematics and physicists (Barabasi 2002; Watts & Strogatz 1998 etc). This group is primarily interested in very large datasets and comparing reality with notions of randomness etc (see Barabassi 2002 and Borgatti etal 2009). The second group is that of the social network analysts. who are also interested in structure but in situations with fewer nodes and more focussed on the implications. Borgatti *et.al.* provide a very succinct summary of the underlying assumption of SNA thus;

> *"*The importance of structure. As in the study of isomers in chemistry, *a fundamental axiom of social network analysis is the concept that structure matters. For example, teams with the same composition of member skills can perform very differently depending on the patterns of relationships among the members. Similarly, at the level of the individual node, a node's outcomes and future characteristics depend in part on its position in the network structure. Whereas traditional social research explained an individual's outcomes or characteristics as a function of other characteristics of the same individual (e.g., income as a function of education and gender), social network researchers look to the individual's social environment for explanations" (2009: 893-4).*

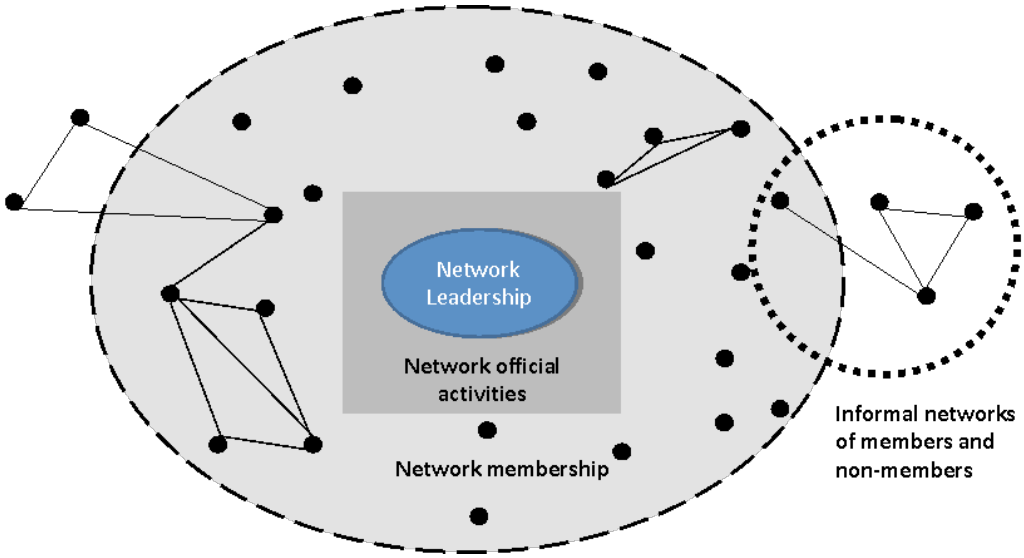
So network structure conditions the outcome for individuals. Reflexively, we should ask how individuals strategise within networks and from there we can begin to develop evaluation criteria. Wixted & Holbrook (submitted) have shown there is a growing literature on evaluating research networks and a strong element within that analysis is to use SNA. Wixted and Holbrook argue that this approach overlooks the possible characteristics of individual science fields – i.e. whether they are coherent or fragmented and how these factors impact on the ability of researchers to construct networks.

FRNs 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 a different level of capital investment, its own stakeholder community structures and its unique knowledge – problem frontier. 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).

The conceptual structure of Formal Research Networks (FRNs)

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 researchers and stakeholders and of increasing the numbers of researchers and stakeholders. The second is that FRNs are established with an explicit management structure. Starting with the second feature, 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



Source Wixted and Holbrook (2009)

At the core of a formal network is the leadership team consisting of principal investigators and administrative staff. But beyond this team is the 'stuff' of the network; 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 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). 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 policy objectives.

This can be taken further to illustrate the difference in macro-conditions of networks. The following is summarised from arguments in Wixted and Holbrook (submitted). This analysis stems from work done by Wixted and Holbrook (2007) for the MSFHR Health of Population Networks on designing an appropriate evaluation framework

A taxonomy was developed based on reviewing the results a workshop on evaluation for eight diverse health of population networks developed and funded by the MSFHR in British Columbia. These innovative and relatively unique networks were 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.

The most basic structure of many networks is 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, in the submitted paper we neither wished to map specific network structures nor the process of structuration, differentiating this analysis from authors such as Rogers et al. (2001) and others (*e.g*. Edler and Rigby 2005).

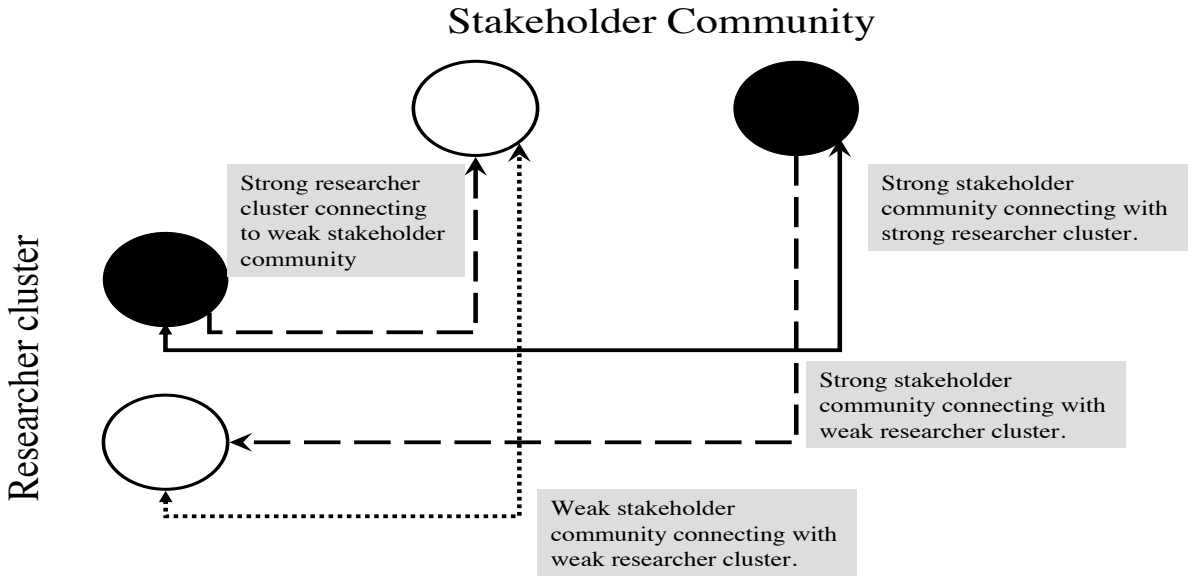
Following analysis of the responses to a worksheet aimed at assisting the workshop participants build an indicator set representing multiple possible outputs of their activities some interesting differences between the networks became apparent. Some networks clearly had a strong sense of the research possibilities, while others saw strong stakeholder interest in their 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 there are two stakeholder communities (researchers and others (industry or populations) and there are two starting positions for each community (strong and weak). This gives a two-by-two matrix of combinations (Table 1 and figure 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 conditions that affect a network's ability to develop as a network.

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)

Figure 1: Research Network Collaboration Taxonomy



(see Wixted and Holbrook, 2008)

This is an interesting insight into the nature of research environments, and one that we have tested in a number of researcher and policy forums but how do such structures come into being and evolve? How are then enacted and what are the challenges in the human process of connecting with people, collaborating and cementing those relationships into a funded formal research structure?

Network strategising: Actor-Network Theory, in Theory and in Practice

In searching across literatures for a body of work that provides a coherent set of concepts that gives the basis for discussing the strategy of players within or building networks, it quickly becomes apparent that there is very little. Actor Network Theory is not necessarily perfect in this respect but for the moment gives the basis for powerful analysis.

Social network analysis and Actor-Network Theory (ANT) were both developed as fields of study 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 FRNs. While, one has taken a direction towards mathematical and structural analysis the other (ANT) has stayed rather philosophical and conceptual though this need not have been the case as there are ideas within in that could indeed be 'mapped' out. Current 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 can provide particularly useful information on the challenges faced in network evaluation (Law 1992; Atkinson-Grosjean 2006) by addressing the much neglected area of networking between researchers and stakeholders. ANT is not biased towards case studies of collaborations which already have strong

internal ties. It is possible to use ANT for a framework for assessment 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 (see discussion in Wixted and Holbrook submission). 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 developing new concepts of what are deemed outcomes or impacts from a management perspective. This is a conscious move away from the current prevailing paradigms in research organisation evaluation; both science production and economic value perspective have come to dominate the field of research program evaluation (see Freeman 1968 & Godin, 2007).

To understand these human processes we want to suggest that the insights provided by an actor centric approach are needed alongside the structural perspective. The rest of the paper will present the rational for returning to ANT not to replace other network languages but to be used in conjunction with them – perhaps even providing a richer language of concepts that can be used with data on network structures.

Many view ANT as obscure, heavy in philosophy and of little relevance to the 'hard' problems of science policy today. However, the work that led to ANT started out as two years observation of researchers in a large biology research centre (the Salk Institute) with Latour and Woolgar (1986) examining what scientists do in much the same way Henry Mintzberg studied what managers do (1971).

We are by necessity here reducing a complex literature down to its simplest form (purists might argue over-simplified). We are also deliberately and without apology pick out those concepts most useful to our arguments, revealing that that it has some powerful concepts for describing the strategy and evolution of organisations like FRNs.
Some key actor-network theory (ANT) terminology[3]:

- *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.

[3] For a slightly more detailed, but user friendly, discussion see Cressman (2009) and Cressman and Felczak (2009)

- *Problematization:* To problematize is to define a specific problem and a potential solution, enrol 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.

- *Enrolment*. A strategy by which actors, their roles, and their interests are defined by network builders. Enrolment 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 evaluated equally. While there are philosophical implications of this move, the importance lies in both the social and the technical within any given network.

- *Margin of Manoeuvre*: An ambiguous potential inherent in the implementation of a dominant technical code. Corresponds to the potential actions and tactics of those charged with this implementation, that is, the actions and tactics unaccounted for by the system builders symmetry. See Callon 1986b; Feenberg 1999, 2002.

- *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 are 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:* Specifically, this term refers to particular locations, technologies or people through which all of the actors interests must pass (Callon 1986; Latour 1987).

ANT, funding decisions, and ex-post analysis of network performance

ANT concepts provide a useful basis for describing the activities of networks. 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? From the perspective of ANT there are a number of steps required to interpret the network taxonomy (Fig 2.). First, any given relationship between a research cluster 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,)*

Working backwards, let us start from the point where researchers, stakeholders and connections are not yet in the form described as an FRN. Instead of assuming that there are research clusters, stakeholders and connections which vary from strong to weak; one asks first ask how it is that these actors and processes came into being (Latour 1987, chapt.1). This requires, first, identifying the network builder. We assume for simplicity (overlooking the policy networks here) that the network builder is either the stakeholder community or the research cluster (primarily PIs, although clearly one can visualize a situation where a researcher is also a stakeholder, or a stakeholder can be part of more than one stakeholder community). For the sake of clarity, community 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 research question. This question comes to be the basis of documents (research grant applications, reports, papers) 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.

Enrolment 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 enrolment 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 enrol a stakeholder group (Y). For X it is imperative for all of the actors that make up Y to communicate with each other and with X.

An actor-network is constituted by and defined by its connections. Weak connections mean a weak network that will likely fail. Strong connections mean a strong network that will likely grow. In this sense we need to recognize that connections are performed through the interactivity between humans and technology as the chosen technologies aid or get in the way of communications. Connections are not static and unchanging, they are dynamic – a process, not a form.

More to the point, any given network is a product of the interactions between the actors that constitute it. If we add new actors (humans or institutional) to the network we are fundamentally altering the network itself. 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 additional research members and stakeholders?
- Where in the taxonomy did the network fall?

Symmetry

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

For example, if Y refuses to be enrolled into X's network, a conventional analysis would see this as a failure on the part of X. However, for evaluative purposes, it may be useful to understand why X failed by adopting the perspective of Y. In this way, one can 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.

Translation and Problematisation

A key question revolves around whether the network can 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 question;
- In hindsight was the research question the important question?

One can presume that at the time of funding, a group of researchers made a strong case for their research question. However, did the evolution of the research and subsequent stakeholder involvement reveal this to be true? Did the FRN meet the expectations of the funder? Was this *the* issue, or even if it was not the primary issue, was it significant? In the absence of either, what was the response of the research management team?

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?

Summary

ANT concepts are helpful in interpreting and understanding the operations and evolution of a research network. Basically, ANT provides a conceptualization and a terminology that enables the following questions:

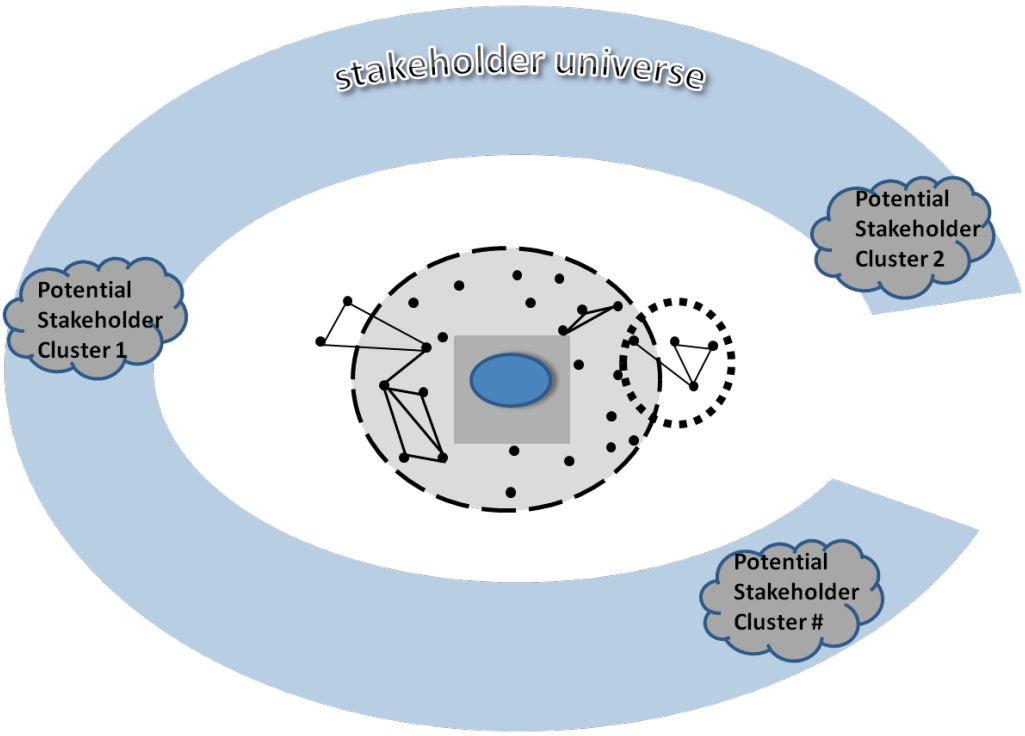
- How did X initially define Y? Which documents/texts established this definition?
- How was enrolment attempted? What was done to ensure that the proposed actor-world came into being?
- Did the network builder establish themselves as an obligatory passage point? If not, how did proposed actors fail 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?

Strategy and Stakeholders

Any model of an FRN has to take into account the existence of the stakeholders. (see table 1). In figure 1 the existence of actors external to the research network was 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[4] (figure 3).

[4] There is a rich literature in the field of policy networks on the concepts related to the stakeholder universe see Howells ().

Figure 3: Stakeholder Universe



But what are the relations between the researchers and the stakeholders? For that we must understand issues of connectedness and relatedness. Figure 1 introduced into our thinking that networks emerge in a range of situations precisely because of the particular strengths of the communities of researchers and stakeholders respectively. But there are many "secondary" stakeholders – stakeholders who may not interact frequently with the FRN, but who nevertheless influence the activities of the FRN. Ministries of Health often interact only rarely with medical researchers, but nevertheless influence the activies of health researchers.

Beyond 'secondary" stakeholders are "unintended stakeholders" These are often activist groups who may resist the direction of the research by the FRN. In Canada there has been significant controversy over genetically modified (GM) seed research, particularly as it relates to grains and oilseeds. In a recent case (decided in favour of the anti-GM) lobby, Monsanto was denied any control over their GM seeds that had migrated from their test plots to the lands of adjacent farmers (Hall???). The role of unintended stakeholders is a major concern in any research project involving human or animal health or the environment. Network planners should use foresight techniques to test what sensitivities their project may have to either favourable or unfavourable public reaction.

The public as a whole does play a major role as a stakeholder in virtually every FRN. As taxpayers, the public have a right to know how their money is being spent and whether or not the FRN is in the public interest. But there is a subset of the "public stakeholder" group which is becoming increasingly important. Charities and foundations are

increasingly active in raising money directly from the public for research. Often the success of the charity and its influence on a particular issue can be measured by the amount of money that it raises for its specific cause. Thus public events such as "Runs for the Cure" (in this case breast cancer) serve to direct public attention on a specific research problems. The charities and their interest in research is not restricted to health: environmental and conservation charities are also important stakeholders (as with the Monsanto case). In Canada charities and private foundations contribute about 3% of total GERD, but almost certainly influence a far greater proportion of GERD through matching grants and "moral suasion" of the granting agencies. Recruitment of these stakeholders by the FRNs (or conceivably the recruitment by the charities of FRNs) is a major policy issue, for it is through the contributions to these charities and foundations by individual members of the public that the individual gets to make a direct decision as to where they would like to see their research money spent.

Impact and Assessment Criteria for Formal Research Networks

FRNs 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
- 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 criteria that also emerge from ANT. ANT suggests some important over-arching tests for the potential 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:

- Enrolment: 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?

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

- Problematization: Was the research question the important question?;

- System Builders: Who are/were the system builders?

Social Science and Humanities Research Networks – a special case?

The Humanities, Arts and Social Sciences (HASS) FRNs are, by definition, different from natural sciences, technology, engineering and medical research networks. The most obvious difference is that HASS networks generally do not have large capital investments in equipment or other physical assets. Where there are large 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.An analysis using ANT can be used to show how HASS research networks differ from NSE and health networks. The HASS 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 HASS 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 enrol 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?

- Does the proposal 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 enter the research network from the stakeholders, as well as flow outwards, and these flows should move with equal facility

Conclusions

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. Analysts 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 FRNs, particularly ex-ante analyses.

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, 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.

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 of FRNs. 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.

We would therefore emphasize that there is a need to pursue three 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. As always, more and better indicators are desirable. 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.

Thirdly, as useful as ANT is, it carries with it particular baggage that does not completely suit it for the task of explaining strategizing behaviour within networks. It would be useful to have concepts and methods that are native to that task.
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 various R&D tax credit programs, 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.

Furthermore, as noted above, the role of charities and foundations in funding research and FRNs, is an area that is completely ignored. It is not just that they make direct investments in R&D (usually through FRNs) but that they influence a much larger group of expenditures. Public granting agencies are sensitive to public opinion, and if they see that the general public is supporting a specific cause (whether health or environment related) they will respond to that interest. The level of this influence is uncharted and deserves further research. Similarly the role of unintended stakeholders can influence the management of an FRN. The influence of these unintended stakeholders may, or may not, be negative, but they certainly can influence how the FRN is managed and how its final outcomes may be received. This is an area that requires further work in many jurisdictions and over many areas of research including SSH research..

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