Preface

WHY IS ANT A USEFUL FRAMEWORK FOR INVESTIGATING TECHNOLOGICAL INNOVATION?

ABSTRACT

This preface discusses Actor-Network Theory (ANT), and in particular Innovation Translation – its approach to innovation adoption and its value as an analytical framework for theorising technological innovation. It begins by noting the controversy with the name: actor-network theory (ANT), and whether this should be changed to something like "actant-rhyzome ontology" of "the sociology of translation." It then makes use of a number of early classic papers by Latour, Callon, and Law to show why ANT provides a useful framework for handling socio-technical situations without privileging the social over the technical or vice-versa. A process of technological innovation making use of an approach involving the four moments of Innovation Translation is illustrated and an argument made for its value in other socio-technical situations involving technological innovation.

WHAT'S IN A NAME?

Actor-network theory can be rather daunting for someone beginning to approach it: a superficial understanding of the idea of human and non-human actors is easy, but coming to a better idea of what this all means is not so straightforward. Actor-network theory (ANT) has been around since the mid-1980s and was developed by Bruno Latour, Michel Callon, and John Law in an attempt to give a significant voice to technological artefacts as they considered that both social and technical determinism are flawed. ANT was designed to instead give a socio-technical account in which neither social nor technical positions are privileged.

In 1999 Latour remarked that that there were four things wrong with actor-network theory: "*the word actor, the word network, the word 'theory' and the hyphen*" (Latour, 1999). Later he changed this view and notes that:

"I was ready to drop this label for more elaborate ones like 'sociology of translation', 'actant-rhyzome ontology', 'sociology of innovation', and so on, until someone pointed out to me that the acronym A.N.T. was perfectly fit for a blind, myopic, workaholic, trail-sniffing and collective traveller. An ant writing for other ants, this fits my project very well!" (Latour, 2005:9).

This preface will use discussion of some of the early classic ANT papers (and also some more recent ones) to investigate why actor-network theory provides a useful approach to theorising technological innovation, and one that provides insights that other approaches do not.

Electric Vehicles and Problematisation

In a classic ANT paper from the mid-1980s Michel Callon (1986a) tells the story of the attempted development by Electricité de France (EDF) of its electric vehicle (VEL – véhicule électrique) in the early 1970s. He notes that EDF's plan for the VEL *"not only determined the precise characteristics of the vehicle it wished to promote, but also the social universe in which the vehicle would function*." (Callon, 1986a:21). A group of engineers from EDF outlined their ideas for creating a new market for VEL in publications and funding applications. They went to great pains to make a case for an electric vehicle that would overcome the place in society of the traditional motorcar. The engineers believed that both the techno-scientific and the social issues that could lead to this change could be solved.

Callon describes how EDF drew a picture of the internal combustion engine car as 19th century industrial revolution technology, responsible for most of the noise and pollution in our cities. They suggested that their plan would turn the car into a simple useful object without these problems. The EDF identified the CGE (Compagnie Génèrale d'Electricité) as the company to develop the electric motor and the batteries, while Renault would manufacture the car body. Callon identifies the human entities responsible for all this, but also points out that these are not alone in exerting an influence, so setting the scene for ANT's treatment of human and non-human actors.

"Up to this point, the entities are ones familiar to the sociologist. There are consumers, social movements and ministries. But it would be wrong to limit the inventory. There are also accumulators, fuel cells, electrodes, electrons, catalysts and electrolytes. For, if the electrons do not play their part or the catalysts become contaminated, the result would be no less disastrous than if the users rejected the new vehicle, the new regulations were not enforced, or Renault stubbornly decided to develop the R5. In the world defined and built by the EDF, at least three new and essential entities must be added: zinc/air accumulators, lead accumulators, and fuel cells with their cohort of associated elements (catalysts, electrons etc.)." (Callon, 1986a:23).

HUMAN AND NON-HUMAN ACTORS: ACTOR-NETWORK THEORY

Actor-network theory considers both social and technical determinism to be flawed and proposes instead a socio-technical account (Callon & Latour, 1981; Latour, 1986; Law & Callon, 1988) in which neither social nor technical positions are privileged. In this socio-technical order nothing is purely social and nothing is purely technical (Law, 1991). What seems, on the surface, to be social is partly technical, and what may appear to be only technical is partly social. ANT deals with the social-technical divide by denying that purely technical or purely social relations are possible. It offers the notion of heterogeneity to describe projects such as the use of a programming language, database management system, barcode scanner, human programmer, and operator in the construction of a computer system for use in stock control in a supermarket. The utilisation of heterogeneous entities (Bijker, Hughes, & Pinch, 1987) then avoids questions of: "is it social?" or "is it technical?" as missing the point, which should be: "*is this*

association stronger or weaker than that one?" (Latour, 1988:27). This can be done after identification of both human and non-human actors – as was the case with the VEL.

To address the need to treat both human and non-human actors fairly and in the same way, actor-network theory is based upon three principles: agnosticism, generalised symmetry, and free association (Callon, 1986b). In summary, under these principles, actor-network theory attempts impartiality towards all actors in consideration, whether human or non-human, and makes no distinction in approach between the social, the natural and the technological. As Callon puts it:

"The rule which we must respect is not to change registers when we move from the technical to the social aspects of the problem studied." (Callon, 1986b:200).

"It makes sense to treat natural and social adversaries in terms of the same analytical vocabulary. Rather than treating, for instance, the social in one way and the scientific in another, one seeks instead to follow the fortunes of the network in question and consider its problems, the obduracy of the elements involved in those problems, and the response of the network as it seeks to solve them." (Law, 1987:4).

In actor-network theory an actor is any human or non-human entity that is able to make its presence *individually felt* (Law, 1987) by the other actors. An actor is made up *only* of its interactions with these other actors (de Vries, 1995; Law, 1992), and Law (1992) notes that an actor thus consists of an association of heterogeneous elements constituting a network. Callon (1986a) argues that an actor can also be considered, at times, as a black box, as we do not always need to see the details of the network of interactions that is inside it. The concept of a network is an important one in actor-network theory.

ANT also attempts to do away with binaries like far/close, macro/micro, and inside/outside (Latour, 1997) as it claims that it is not whether or not the various elements of a network are in close physical proximity that matters. What does matter is their interconnectedness. In considering macro/micro distinctions, Latour (1997) maintains that one network is never "bigger" than another, but simply "longer" or more intensely connected and that concepts like outside or inside make no sense as a network is made up only of interconnections. What is important is whether or not a connection has been established between elements. In ANT the passage of time also loses much of its importance and becomes just a consequence of the formation of alliances between actors rather than a fixed explanatory framework (Latour, 1991).

Latour argues that for every "socio-technical imbroglio" (Latour, 1988) two things are necessarily involved in the formation of its definition. Firstly, we need to determine the number of people who are convinced that it can be considered as a simple single entity (a black box), and secondly, what sorts of changes it must undergo to convince still more people of this. But the formation of a network is not the end of the story as networks are always unreliable and can become unstable. Callon (1987) further proposes that entities become strong and stable by gathering a "mass of silent others" to give them greater strength and credibility. A network becomes durable partly due to the durability of the bonds that hold it together, but also because it is itself composed of a number of durable and simplified networks.

"The solidity of the whole results from an architecture in which every point is at the intersection of two networks: one that it simplifies and another that simplifies it." (Callon, 1987:97).

Actor-network theory, or the "sociology of translations" (Callon, 1986b; Law, 1992), is concerned with studying the mechanics of power as this occurs through the construction and maintenance of networks

made up of both human and non-human actors. It is concerned with tracing the transformation of these heterogeneous networks (Law, 1991) that are made up of people, organisations, agents, machines, and many other objects. It explores the ways that the networks of relations are composed, how they emerge and come into being, how they are constructed and maintained, how they compete with other networks, and how they are made more durable over time. It examines how actors enlist other actors into their world and how they bestow qualities, desires, visions, and motivations on these actors (Latour, 1996). Law and Callon put it this way:

"Our object, then, is to trace the interconnections built up by technologists as they propose projects and then seek the resources required to bring these projects to fruition." (Law & Callon, 1988:285).

ARAMIS: A COMPLEX INNOVATION

Latour's book (1996) tells the story of a revolutionary "guided-transportation" system intended to be part of the Parisian public transportation system in the 1970s. It was intended for the Petite Ceinture district in Paris. Work on the system commenced in 1969 and was abandoned in 1987. Apart from its allusion to The Three Musketeers, **Aramis** is an acronym for *Agencement en Rames Automatisées de Modules Indépendants dans les Stations* (Arrangement in Automated Trains of Independent Modules in Stations). The idea was to produce a system that combined the flexibility of a car with the efficiency of a railway. The book tells of Aramis' conception, development, and ultimate failure in the form of a detective story, and tells it simultaneously from several different perspectives using a number of different voices. A young engineer and the sociologist, Norbert, conducting the investigation carry the storyline. The engineers and administrators who worked on Aramis speak through both interviews and documents. The "author" interjects from time to time to provide a sociological commentary, and later, Aramis speaks on its own behalf, bewailing its fate. In the book, each voice, or reality (Wertheim, 1997) is identified by the use of a different typography. This style of writing provides an interesting and novel approach. The young engineer describes the technique used by Norbert to organise "*meetings and confrontations*" (Latour, 1996:6) in the evenings after the interviews to discuss the events of the day and to determine which actor to follow next. The sources of data used in Aramis are principally interviews and documents.

Like most new technology, this innovative Parisian transport project was not seen as being *real* at the beginning of its development (Tatnall, 2005). In common with other technological projects it could not possibly be real at the beginning as it did not then exist for people to see and to evaluate whether it might be something they could use. The problem was that Aramis never did succeed in becoming real and hence eventually died. Latour describes Aramis as "*merely realizable*" and "*not yet real*" (Latour, 1996:85) and notes that Aramis should have taken on reality by degrees.

The story of Aramis shows how an innovative project like this can involve a great deal of complexity that can easily be overlooked. Aramis made use of non-material couplings between carriages to facilitate fast coupling and uncoupling of the independent modules. Technical issue with these couplings presented a good deal of trouble, and a simplistic investigation of the story of Aramis could easily conclude that this was the reason for its failure. The real story is, however, much more complex!

ANT and Complexity

A major issue in any research dealing with technological innovation is how to understand and handle the complexities of this technology. A common method of handling complexity in all subject areas lies in simplification, but in this case, the danger with simplification is that it runs the risk of removing just those things that constitute the description wanted by concealing the parts played by many actors (Suchman, 1987). It can be argued that without this detail, any understanding of technological innovation tends to be superficial and lacks the necessary detail that would allow a more holistic account. Of course some simplification is necessary in order to represent the infinite possibilities of any complex situation and all research methodologies offer ways of simplifying complex social phenomena. The question here is which details to include and which to leave out, and who is to decide. ANT attempts to resist any attempt at the process of explanation by labelling, and Law notes that any attempt at naming does analytical work and "*strains to perform simplicity*" (1997). In this respect, an appropriate research approach needs to ensure that complexities are not lost "*in the process of labelling*" (Law, 1999:9).

An actor is not just a point object but an association of heterogeneous elements themselves constituting a network, so each actor is also a simplified network (Law, 1992). An actor can, however, in many ways also be considered as a black box, and when we open the lid of the box to look inside it will be seen to constitute a whole network of other, perhaps complex, associations (Callon, 1986a). In many cases, details of what constitutes an actor – details of its network – are a complication we can avoid having to deal with all the time. We can usually consider the entity just as an actor, but when doing this though it must be remembered that behind each actor there hide other actors that it has, more of less effectively, drawn together (Callon, 1987). This means that any changes affect not just this actor, but also the networks it simplifies (Callon, 1987). It is, likewise, often also possible to "punctualise" (Law, 1992) a stable network and so consider it in the form of a single actor. Whenever possible, it is useful to simplify, to an actor, a network that acts as a single block or a black box to make it easier to deal with. An actor then:

"... can be compared to a black-box that contains a network of black-boxes that depend on one another both for their proper functioning and for the proper functioning of the network." (Callon, 1987:95)

The important thing to note about the use of black-boxing for simplification is that the complexity is not just put into the black box and lost as it is always possible, and indeed necessary, to periodically reopen the black box to investigate its contents. The complexity is punctualised (Law, 1992:385), but not lost, and the *messy reality* (Hughes, 1983) is retained.

It is a feature of actor-network theory that the extent of a network is determined by actors that are able to make their presence individually felt (Law, 1987) by other actors. The definition of an actor requires this and means that, in practice, actors limit their associations to affect only a relatively small number of entities whose attributes are well defined within the network (Callon, 1987). This simplification is only possible if no new entities appear to complicate things, as the actor-network is the context in which the significance and limitations of each simplified entity is defined (Callon, 1986a). If a new element is added, or if one is removed, then some of the other associations may be changed as it is the juxtaposition of actors within the network that is all-important.

"The simplifications are only possible if elements are juxtaposed in a network of relations, but the juxtaposition of elements conversely requires that they be simplified" (Callon, 1987:95).

Latour (1997) notes that actor-network theory is not about *traced* networks, but about the activity of network *tracing*. He maintains that a network cannot exist independently of the act of tracing it, and that it should be thought of not so much as a thing, but as the recorded movement of a thing. He contends that there is no difference between the explanation of some project, and telling the story of how a heterogeneous engineer (Law, 1987) mobilises actors, and a network subsequently surrounds itself with new resources. Of networks, he notes that: "... by their very growth they become more and more of an explanation of themselves" (Latour, 1997:8).

Portuguese Navigation, Jet Planes, Scallops, and Fishermen

Looking at the expansion of Portuguese sea trade routes to India, Law (1986b, 1987) suggests that the process that led to the Portuguese domination of the Indian Ocean can be explained through system building or heterogeneous engineering. Law suggests that Portuguese king Henry the Navigator was the heterogeneous engineer who made this happen. The actors he identifies include: the boats used, need for a large crew to row and hence need to stop often to replenish supplies, masters of the vessels, Cape Bojador (point of no return), ocean currents, et cetera. (A shift in focus from Henry to the master of the vessel would bring a further network of sailors, spars, and stores into focus.) The galleys initially used were essentially war vessels needing to undergo several translations to become suitable for their new task. Law suggests three necessary technological innovations needed to be engineered: the improved sailing ship, the magnetic compass, and better knowledge of the Atlantic currents.

"... the stability and form of artifacts should be seen as a function of the interaction of heterogeneous elements as these are shaped and assimilated into a network." (Law, 1987:3)

An early paper on technological innovation by Law and Callon outlines the TSR2 military aircraft project in the UK in the late 1950s and early 1960s (Law & Callon, 1988, 1992). It describes how it was conceived, designed, and developed. It also looks at the various technical, political, and bureaucratic difficulties that led to its demise. The prototype aircraft flew well and were well liked by their pilots, but cost overruns and various political decisions following a general election led to its cancellation. This is seen as another example of a situation where an examination of either the technical or the social alone would not have revealed the true picture.

Innovations are of no value unless they are adopted and used, and in another classic ANT paper, Callon tells of domestication of the scallops and fishermen in St Brieuc Bay in France (Callon, 1986b). The population of scallops in St Brieuc bay was in decline and the story describes the attempts of three marine biologists to develop a conservation strategy to halt this decline. Actors are soon determines to be the scallops, the fishermen and the marine biologists. It was clear that changes would need to be made to the way the scallops developed and to the methods used by the fishermen. Callon explains how this was achieved in terms of the four moments of translation which are discussed in the next section.

Innovation Translation

The model of translation as proposed in actor-network theory thus proceeds from a quite different set of assumptions to those used in Innovation Diffusion (Rogers, 1995, 2003) or the Technology Acceptance Model (Davis, 1989). Latour (1986) argues that the mere possession of power by an actor does not automatically confer the ability to cause change unless other actors can be *persuaded* to perform the appropriate actions for this to occur. The notion that power is an attribute that can be *possessed* by an actor is an essentialist one, and Latour contends that rather than this it is the number of other people who enter into the situation that indicate the amount of power that has been exercised (Latour, 1986). He maintains that in an Innovation Translation model, informed by actor-network theory, the movement of an innovation through time and space is in the hands of people, each of whom may react to it in different ways. They may accept it, modify it, deflect it, betray it, add to it, appropriate it, or let it drop (Latour, 1986). He adds that this is true for the spread of anything from goods and artefacts to claims and ideas. In this case the adoption of an innovation comes as a consequence of the actions of everyone in the chain of actors who has anything to do with it. Furthermore, each of these actors shapes the innovation to their own ends, but if no one takes up the innovation then its movement simply stops; inertia cannot account for its spread. Instead of a process of transmission we have a process of continuous transformation (Latour, 1996) where faithful acceptance involving no changes is a rarity requiring explanation.

"Instead of the transmission of the same token – simply deflected or slowed down by friction – you get ... the continuous transformation of the token." (Latour, 1986:286)

McMaster *et al*. (1997) add that innovations do not wait passively to be invented or discovered, but are instead created:

"... from chains of weaker to stronger associations of human and non-human alliances. ... Each actant translates and contributes its own resources to the shape and ultimate form of the emerging black box." (McMaster, et al., 1997:4).

The key to innovation is the creation of a powerful enough consortium of actors to carry it through, and when an innovation fails to be taken up, this can be considered to reflect on the inability of those involved to construct the necessary network of alliances amongst the other actors (McMaster, et al., 1997). Getting an innovation accepted calls for strategies aimed at the enrolment of others in order to ensure the creation of the black box. Latour (1986) maintains that this is done by interesting others and then getting them to follow our interests, so becoming indispensable to them. This process is facilitated if other possibilities are first blocked off.

"The work of generating interest consists in constructing these long chains of reasons that are irresistible, even though their logical forms may be debatable" (Latour, 1996:33).

An actor-network is configured (Grint & Woolgar, 1997) by the enrolment of both human and non-human allies, and this is done by means of a series of negotiations in a process of re-definition in which one set of actors seeks to impose definitions and roles on others (Callon, 1986b). Translation can be regarded as a means of obliging some entity to consent to a detour (Callon, 1986a) that takes it along a

path determined by some other entity. Law (1987) uses the term *heterogeneous engineer* to describe the entity that designs and creates these detours. A heterogeneous engineer is then able to speak on behalf of other actors enrolled in the network. The process of translation has four aspects or moments (Callon, 1986b):

a. In **Problematisation** a group of one or more key actors attempts to define the nature of the problem and the roles of other actors so that these key actors are seen as having the answer, and being indispensable to the solution of the problem (McMaster, et al., 1997).

In the case of VEL, problematisation of the petrol driven motorcar as noisy and polluting set the scene for the need for an electric vehicle. For the scallops in St Brieuc Bay:

"... the problematization describes a system of alliances, or associations, between entities, thereby defining the identity and what they want" (Callon, 1986b:206).

"They also show that the interests of these actors lie in admitting the proposed research programme. The argument which they develop in their paper is constantly repeated: if the scallops want to survive (no matter what mechanisms explain this impulse), if their scientific colleagues hope to advance knowledge on this subject (whatever their motivations be), if the fishermen hope to preserve their long term economic interests (whatever their reasons) they must: 1) know the answer to the question: how do scallops anchor?, and 2) recognize that their alliance around this question can benefit each of them." (Callon, 1986b:205)

b. **Interessement** is a series of processes which attempt to impose the identities and roles defined in the problematisation on the other actors. It means interesting and attracting an entity by coming between it and some other entity (Law, 1986a). "To be interested is to be in between (inter-esse), to be interposed." (Callon, 1986b :208). In the case of the scallops of St Brieuc Bay, Callon suggests that each entity can submit to being integrated into the plan or refuse by defining its identity and interests in another manner:

"Interessement is the group of actions by which an entity (here the three researchers) attempts to impose and stabilize the identity of the other actors it defines through its problematization." (Callon, 1986b:207).

c. **Enrolment** then follows through a process of coercion, seduction, or consent (Grint & Woolgar, 1997), leading to the establishment of a solid, stable network of alliances.
d. **Mobilisation** occurs as the solution gains wider acceptance (McMaster, et al., 1997) and an even larger network of absent entities is created (Grint & Woolgar, 1997) through some actors acting as spokespersons for others.

To define the relationship between themselves, many actors make use of intermediaries such as texts, technical artefacts, humans with specific skills, and money (Callon, 1991). These intermediaries then constitute the form and substance (Callon, 1992) of the interactions. A network becomes durable when actors feel no need to spend time opening and looking inside black boxes, but just accept these as given.

CONCLUSION

Many other situations involving technological innovation have resulted in ANT papers, including a number in the *International Journal of Actor-Network Theory and Technological Innovation*. Apart from these, however, there have been many ANT papers covering diverse topics including: the UK Cervical Screening Programme, the 19th century Luddite rebellion, the introduction and use of computers in schools, how university students build expert systems, medical school curricula, hospitals and other things medical, projects in museums, car parking systems, the achievements of Louis Pasteur, and the simultaneous invention of the Kodak camera and the mass market for amateur photography. Topics of other papers include: how changes occur in regional economies, the formation of attitudes by farmers and "field-level bureaucrats" on issues of farm pollution, the globalisation of coffee marketing, and a description of the failure of the IT Department in a UK City Council to adopt a structured systems design methodology.

Technological innovations are adopted for a variety of reasons, but these are often not the reasons proposed by the instigators and promoters of these technologies. The processes by which they are adopted are also often not entirely rational. Most of the various approaches to theorising the processes involved in innovation describe reasons for adoption based on a potential user's interpretation of the characteristics or usefulness of the technology, but do not really offer any good explanation for partial adoptions. In this respect Innovation Translation provides useful in allowing for people and organisations often not just accepting technological artefacts in their entirety in the form offered, but translating then into a form that contains just those aspects or applications of the technology that fill their real needs.

Arthur Tatnall
Victoria University, Australia

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