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RFID/INTERNET OF THINGS SYSTEMS ON THE BOUNDARY BETWEEN PUBLIC AND PRIVATE SECTORS: AN ANT STUDY OF MULTIPLICITY

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Research paper

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Abstract

Radio Frequency Identification (RFID) systems are becoming increasingly common in applications that are shared between the public and private sectors. These systems facilitate supply chain, traceability and sensor functions, not to mention the application of RFID technology in enabling the Internet of Things. Despite their increasing ubiquity, the management of public-private RFID systems is under-researched and little understood. This research addresses a gap in literature by using Actor-Network Theory (ANT) to uncover the public-private RFID network. It was found that the public-private sector relationship is initially characterised by stereotypical views which diminish as sectors work together. Further, the public sector in this context was seen to be a multiplicity with four different performances, public sector as a member of the public-private partnership; as legislator; as enforcer and as funding provider. This multiplicity is shown to lead to confusion within public-private partnerships as members of the partnership are not always clear about which performance of the public sector they are enacting, or interacting with. ANT provided a sound basis to explore such a complex networked system, its inclusion of technology within the construction of the social offers a way of understanding complexity within internet of things based applications.

Keywords: RFID, Actor-Network Theory, Internet of Things, Multiplicity, Private Sector, Public Sector, Public-Private Partnership

1 Introduction

From security card door access and passports, to tagging of cattle to ensure food safety, RFID technology is becoming increasingly common within organisations and throughout society (Ruiz-Garcia & Lunadei, 2011). RFID technology works through a simple RFID tag, reader and antennae combination. An RFID tag is placed on an item, and as the item passes through an RFID reader the number on the tag (and any other associated information) is read and transmitted to a database. As the tag number is usually unique to that particular item, this allows the movement of the item to be tracked. Currently the most common use of RFID technology is in the supply chain where items can be tracked from door to door. Other common uses for RFID technology include individual identification through door cards, passports and similar documents, and RFID based sensor systems (Dobkin, 2013).

Each organisation stores the data it gathers from the RFID tagged items that move through its readers. In order to derive maximum benefit from RFID systems (for example in terms of understanding the speed a particular item moves through a number of different organisations in the supply chain), organisations need to share the data they have gathered. This forces organisations into different types of collaborations where information is shared that might not have been previously (Conger, Pratt, & Loch, 2013). Where public and private sector organisations are working together, this requires inter-sector information sharing. The use of public-private sector information sharing has been investigated by Yang

and Pardo (2011), who discuss the importance of sharing data across government boundaries in order to increase the efficiency of government operations, while Gil-Garcia et al. (2010) note that governments are increasingly sharing information in various application types.

An extension of this widespread information sharing is the ability of RFID technology to form the basis of the Internet of Things (IoT). The IoT concept sees *everything* being equipped with digital devices allowing for item identification, transmission of sensor data or location information, and also for continuous interaction and communication between the tagged items and the internet, without necessitating the mediation of humans (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012). Such systems form complex socio-technical networks in which RFID tagged devices can be tracked and managed remotely by humans, or by machines. The internet of things is seen as being a "vast mostly unexplored territory, without clear borders, where all current technologies can play a role" (Zorzi, Gluhak, Lange, & Bassi, 2010, p. 44). The pace of implementation of IoT technologies is accelerating, and many questions remain unresolved around how such technologies will be managed, and how they fit within current management and governance structures (Whitmore, Agarwal, & Xu, 2014). In terms of partnerships between the public and private sector, the Internet of Things would theoretically see the government being able to identify and track the movements of every item that carries an RFID tag, wireless sensor or similar technology. This potential ability has led to a rise in concern about the ability of governments to track and trace items without the knowledge of those carrying the items (Gray, 2015).

In the government sector several key RFID systems are driving adoption of RFID technology, particularly in the United States where the US Department of Defence (DoD) requires RFID tagging of many items shipped to, and through, DoD supply chains (Fries, Turri, Bello, & Smith, 2010). Due to increasing concerns regarding the safety of the food chain, requirements for monitoring of food supplies through the tracking of animals and animal products are also becoming common, with RFID technology leading the way in these applications (Vlad, Parvulet, Vlad, & Pivoda, 2012).

Within the public-private context, examples of RFID technology include various smart city initiatives. Caragliu, Del Bo, and Nijkamp (2011) define a smart city as a one which uses participatory governance to achieve a quality lifestyle for its citizens by combining social capital with traditional and modern ICT infrastructure, and sustainable resources management. RFID technologies play a large part in managing such smart cities through the use of RFID tags, distributed intelligent systems, and sensor networks to offer a wide range IoT style services. Komninos, Schaffers and Pallot (2011) outline the importance of combining the technological change with the social and policy changes required to create such smart cities. This type of collaborative public-private approach is being advocated by the European Commission through the European Innovation Partnership in order to speed the adoption of smart city technologies (European Commission, 2015).

Despite the increasing numbers of cross sector RFID systems, such technology implementations are under researched. Little research could be found addressing how such highly networked technology systems operated within the public-private context, with such research as there is tending to focus on individual cases, such as the DoD implementation or animal tracking applications. It is becoming important to study such technology in the context of public-private partnerships as the pace of adoption of RFID based technology is accelerating with RFID technology moving out of the boundaries of supply chain applications and into new smart city and internet of things type implementations (Whitmore et al., 2014). Thus, this research focuses on investigating how the public and private sectors act together when both are involved in an RFID system.

1.1 Actor-Network Theory

When the intent of a research study is to describe or explain, Bluhm et al. (2011) recommend the use of qualitative methods. Similarly, Creswell (2013) recommends the use of a qualitative method when the phenomenon being studied is a modern real life issue about which not much is known. Within the qualitative framework there are numerous theoretical and methodological approaches which could be

used to examine research questions. Given the highly networked nature of RFID technology, including both human and technological RFID actors, a theoretical foundation recognising the place of technology within the social was indicated. Actor-network theory (ANT) has its basis in the social study of technology. It examines how networks of technological and social actors form and become stable over time (if indeed they do). ANT allows for technological actants to influence the formation and stabilisation of these networks and thus is uniquely placed to address questions around how socio-technical networks operate (Latour, 2005).

Myers (2009) considers ANT to be a "grand theory" that can be used to understand complex socio-technical arrangements, whereas Gherardi and Nicolini (2005) consider that the social is constructed through the performances of its members, and that ANT can be used as a lens through which these performances can be understood. Because the objective of ANT is to describe how networks are formed and stabilised, it comes with its own ontology which is used as a framework to understand the network being studied.

ANT is agnostic to the status of a particular actant, be they macro or micro, human or technological, important or mundane ANT does not discriminate between them (Law, 1992). According to Latour (1991) it is the power relations between the actants that are interesting to the ANT researcher. Therefore an ANT study takes a symmetrical approach with the same neutral language describing both human and non-human interactions, powerful and not powerful. Law (1992) believes that this symmetry allows the powerful to be demystified, instead it is their performances that create the network, and the actants themselves. In order to understand and describe an ANT network Latour (2005) recommends that the observer "follow the actors" as they combine social skills to "things" thus forming a durable network.

The inclusion of non-humans as agents within ANT has been criticised by authors such as Alcadipani and Hassard (2010). However, this criticism is addressed by Law (1992) who draws a distinction between human and non-human actants, pointing out that while the non-human technology actants can act within the network, they do not act as humans would, and nor should we expect them to. Further criticism of ANT points towards the lack of a political dimension (Alcadipani & Hassard, 2010), and agnosticism (Walsham, 1997). Both of these criticisms are true in that ANT does not directly set out to critique the networks being studied but rather to describe them. However, as discussed by Law (2009) ANT examines each network and identifies both the good and the bad that arise from the networks. This study followed Klein and Myers (1999) in considering ANT to be a way of viewing socio-technical networks that allows for the recognition of new associations and perspectives.

Because of the symmetrical view that ANT adopts, with the acknowledgement of a vast range of actants, and because the way these actants are viewed depends on their circumstances, ANT accommodates numerous possible views of reality – or multiplicities. These multiplicities, according to Cresswell, Worth and Sheikh(2010), assist in interpretation of the ANT network as the different roles, forms, and performances of each actant can be accommodated within the explanation. Mol (1999) agrees with this perspective taking the view that reality is "done and enacted" (p77) as an alternative to being observed. Her example focuses on three different multiples (or performances) of anaemia. It is understanding these performances which allows Mol (1999) to describe how things happen, and how the different performances might come into conflict. Similarly, Latour (2002) recognises 21 multiples of the Aramis transportation system, from the fully operational to the completely non-functional. Even the ANT approach itself is described as being multiple by Gad and Jensen (2010) who argue that the flexibility of the ANT approach allows different applications of ANT in practice. In fact, even the research being reported here is one perspective, or multiple, of a larger piece of research conducted by Vos (2014).

2 Methods

As discussed above ANT by itself is not a methodology it is more of a way of illuminating or describing a particular network or context, in this case the RFID systems that cross the boundary between public

and private RFID systems. ANT resists telling the researcher how a study must be done, beyond offering the advice to "follow the actors" (Latour, 2002). Instead, according to Gad and Jensen (2010) researchers must use their training in the examination of the network being studied. In these circumstances, Thomas (2006) recommends adopting an inductive approach to data gathering and analysis whereby data in the form of text is analysed in order to identify themes and categories. The organisation of these themes allows the researcher to derive new understanding of the phenomenon being studied, and to develop frameworks from the raw data.

The research reported here is part of a larger ANT based study by Vos (2014). Because this paper considers the nature of the relationships between public and private sectors when working together using RFID based systems, the technology itself does not appear to be as central here as it does in other parts of the research. However, the technology is still important, and represents part of the context in which the relationships between the two sectors are discussed. ANT itself remains the theoretical basis of the study, and the ANT terminology is used to describe the data observed.

2.1 Locating the Actant

The context of this research is RFID systems shared between public and private sector organisations. From the initial human actants identified as being involved in a public-private RFID system, other actants were located by "following the actors" as recommended by Latour (2002). This study commenced with two human actants who were experienced within the context of cross sector RFID systems. These actants referred the researcher to other human and non-human actants, thus the tracing of the network began. The need to include both technical and human actants within a network leads to the requirement to find a way to follow them, and their interactions. Human actants can be interviewed, however, this is more difficult with technical actants. Vidgen and McMaster (1996) recommend identifying representatives for non-human actants that can "speak" on behalf of the actant. This might involve finding technical documentation to describe how an RFID tag or reader operates, or it might involve locating a human actant to describe how a particular RFID system operates. A similar approach was adopted by Bryson, Crosby and Bryson (2009) in a study of strategic planning. They treated concepts such as strategic visions and plans as non-human actants in order to understand how they affected organisational performance. This allowed documents to speak for themselves, while concepts were studied through a human or documentary representative.

Theoretically, an ANT study could continue following actants with no boundaries of any type as each network is made up of actants, while being an actant itself (Callon, 1987). However, such a boundless network could not be studied so a decision as to when to stop following actants needs to be made. In the case of this study the advice of Bonner and Chiasson (2005) was taken to follow the network until no new actants emerged. This led the researcher to 40 human actants with at least two years' experience in cross sector RFID implementations across four countries, some speaking as representatives for non-human actants. 24 documentary actants were also reviewed: these included business cases, legislation, standards, reports and technical documentation. Interviews were in-depth and open ended with each interview recorded and transcribed. The transcripts were checked by the interviewees who were able to make clarifications and corrections. Following Stake (2005), further member checks occurred with human participants as each reviewed any quote placed within the text of the study. Documentary actants were treated as if they were human actants – and coded accordingly.

2.2 Data Analysis

Thomas (2006) recommends taking a general inductive approach to qualitative data. This approach identifies themes which allow understanding to emerge from the collected data. In ANT terms such an analysis would allow the network to be identified from the data. Miles, Huberman and Saldana (2013) outline a general approach to data analysis which has three phases, data condensation, data display and conclusion drawing. These phases were followed in this study, along with the advice of Thomas (2006)

who recommended multiple passes through raw data in order to develop categories and understanding of the network being studied.

All interview transcripts and documentary actants were coded using the HyperResearch programme. Two cycles of coding were used as recommended by Miles et al. (2013). Portions of coded manuscript were discussed between authors in order to ensure coding consistency and rigour (Thomas, 2006). This process of coding allowed the researchers to understand the "story" of the RFID network, and to unpick how it comes together and is managed.

In the first cycle codes were assigned through an inductive process, with codes being derived from the words of the interviewees (*in vivo* codes), descriptive codes and process codes. The *in vivo* codes placed emphasis on the words of the actants themselves, as is indicated in an ANT approach, and included such codes as "trust", "benefit" and "negative data". Descriptive codes were used to locate the technology actors within the transcripts, thus providing a source for indexing. These codes included technology terms such as "RFID", "tag", "internet of things" and other RFID technology related codes. Codes related to the ontology of ANT were also used including those indicating the various phases of the ANT process of translation, "performance", "multiple", "black box" and similar.

Process codes focus on actions, and were used especially where actants invoked changes, or were involved in actions. These codes highlighted the nature of the relationship between the sectors and included codes identifying the various sector interactions and mediators of the relationships between the two sectors such as "finance", "standards", data sharing" and "privacy".

The second cycle of coding, pattern or axial coding, involved summarising the process and in vivo codes into summary groups to assist with identifying concepts within the data. According to Miles et al. (2013) this grouping helps the researcher to understand the scope of the data, and highlights associations and data constructs.

It is recognised in studies such as those undertaken by ANT researchers that the researcher inevitably becomes part of the research process. Callon (1986) recommends three guidelines for the ANT researcher, based on the principles of ANT, which assist in allowing the researcher to focus on the actants. The first is the principle of agnosticism, where the researcher listens to the actants but does not judge what they say. The second is symmetry where the researcher does not distinguish between the social and the "natural" in describing them. Thirdly, the researcher does not distinguish between the social and the natural (or technological), following actants wherever they lead. These principles were followed as closely as possible within this study.

3 Findings

This research was specifically focused on how RFID systems operated where they were shared between public and private sector organisations. In order to focus on this network, the researcher remained agnostic to the particular organisation in which the RFID system was found, as it was the interaction between the public and private sector actants that was important. It was found that actants located throughout the study shared similar characteristics. All were involved in RFID systems in a public-private sector context. All were within industries identified by literature as being involved in such RFID systems (Health, Defence, and Food/Animal Traceability), or were RFID experts who represented technical parts of the network. Because of the need to ensure that the actants could speak accurately for public-private RFID systems, all human actants had at least two years' experience with this context. The participants, human, documentary or technological, spanned four countries (New Zealand, Australia, USA and Hong Kong) and six RFID implementations.

In this findings section, quotes from the actants themselves have been used as much as possible in order to preserve their voices. This follows the recommendation of Latour (2005), who believes that the voice of the actant should be stronger than that of the researcher wherever possible.

3.1 Sector Attitudes

Relationships between the sectors seemed to be framed by what could be considered stereotypical views. Some private sector actants viewed the government as being "less flexible" and "slow", lacking in responsiveness. For example, one actant commented that "they [the government] don't have the funds, and they don't have someone with a cohesive vision across the enterprise". Another actant highlighted this view stating "government has its proper way that government tends to like it".

Public sector actants also shared stereotypical views, with one commenting that the private sector was focused on "competitive advantage", while another commented that private sector organisations were more "bullish". This observation was reflected in the way the two sectors handled the issue of privacy and security within public-private RFID systems. The public sector was seen to be more sensitive to privacy and security issues as "governments need to more carefully understand the privacy implications than private sector companies". The reason for this was seen as relating to the presence of privacy legislation, because of guidelines in place within public sector organisations, and to the voluntariness of provision of information to government. As one actant observed, "if the government muck up how they handle your information, you've still got to keep handing them information". Politicians were also included within these stereotyped views with one actant commenting, "it's just another project [for the politicians] and they always think they have bigger problems… like where to put a new softball field".

The term "government" was often used in place of either naming the department involved, or using "public sector". A count of the number of times the word "government" was used by actants within this study showed it was used 835 times, whereas "public" or "public sector" were only used 208 times.

3.2 Sectors Working Together

Beyond these stereotypes, public and private sector organisations were seen to work together with "joint [sector] owners, and subject matter experts working side by side to develop… requirements". Where legislation was required, in one example the private sector approached the public sector and "convinced government that it will create and maintain jobs and profit that can be funnelled back into the nation's economy". The public sector in this example agreed, further believing that the project being proposed would "achieve value for money, collaboration and co-ordinated agencies". Commenting on the way public and private agencies worked together, one private sector actant observed "we are an equal player with the other parties". This example, and others, were framed by legislation which was put in place as industry had approached government and argued, "you've got to do this, or you've got to help us do it, and there's no way it's going to happen unless its mandatory…". Legislative actants were extremely strong, providing "legislative authority" for the different implementations and in this example requiring "cattle and deer to be tagged". These actants required RFID technology to fulfil "assessment processes", and mandated how the public and private sectors were to function together. There were examples observed where legislation had not been enacted and in order to avoid legislation private sector actants had "attempted to demonstrate to government that they are able to [manage traceability] so that there isn't a necessary regulation passed". However, the desire to avoid legislation did not prevent the private sector from approaching government to secure funding, as noted by one actant who had been "in the odd position of having to talk the government out of being involved in it in terms of it being an industry based scheme, and then having to talk them back in to being involved in it for the funding…".

3.3 Tensions Between Sectors

The public-private RFID systems, relationships between the sectors also displayed tensions. In one example the private sector had to work hard to persuade the government to get involved with the traceability system they wanted to implement, as government officials were concerned that "[they] would be left trying to administer a scheme which was a disaster area because we would all walk away". There were also tensions about ownership in this example, with one actant commenting that the different organisations involved "all want to own it, and run it, and share it, and be in charge". In the examples

where legislative authority was used to mandate involvement in the RFID system cost was a "highly relevant" consideration, with one actant arguing that "the system was a biosecurity insurance policy for the good of [our country]. Therefore, in [our] view, [our country] should pay for it, not just those implementing it". In another example the private sector partners had started to argue with each other over costing, as one actant observed "who has to pay and how much? That's where things started to fracture a bit in the sector being entirely unified".

At times confusion was apparent within the various examples about what exact role the members of the partnership were supposed to take, and this confusion caused conflict as one actant observed "…the policy wonks get involved and [the network] grows a life of its own. So then you got to go and grab them all and bring them all back...". In another example private sector users of a legislated RFID system had found instructions difficult to follow as they had heard "about the policy part of it at the same time as the fact that they had to do it, and it wasn't well explained".

Many of the actants considered that the relationships between the sectors were centred on the people involved rather than the particular organisations. As one actant observed when discussing how sectors worked together over RFID systems, "it is really how educated a person is, and how much research they've done" that determines the success of the system. Another actant involved in a difficult exchange observed that "it's actually [about] one individual, and that individual has a view within the context of the industry". On actant in particular saw "the challenges for government to private sector interactions are the same as government to government, and private sector company to private sector company interactions".

3.4 Public Sector as a Multiplicity

When considering the nature of the interactions between public and private sectors it became apparent there were multiple different performances being enacted by the public sector actants. This was most clear when considering the role that documents play in public-private sector interactions. For example, within legislated RFID systems there were a number of different documentary actants being used. Legislation was used to frame the requirements of participation in the RFID system, with roles being mandated for particular actants in part because "it would never work voluntary". Private sector actants enrolled in the system because "there was a mandate", and because of concern that they would be prosecuted if they did not. But the public sector actants also shared membership in the RFID systems, some being involved in development, others as supply chain partners, and still others received large amounts of data in respect of food and animal health traceability. Initially these systems were framed by business case and proposal documents, which led to the legislative and policy frameworks.

To a certain extent the private sector saw the public sector as a funding source with one actant noting "in countries where there is government funding… it's much easier to move industry forward". It was also hoped that public sector organisations would bear a burden of funding, especially where RFID systems were mandated. Where public-sector organisations were involved in the RFID system as part of everyday business the public sector and private sector actants worked together over time. It was "more about how educated a person is [about RFID]" rather than the sector they were involved in.

Confusion was observed in some of the public-private RFID networks, and it became apparent that this was caused by different human actants not being certain about the role they were enacting. If the findings above are reconsidered with the actants taking different perspectives or performances within the network, four multiples or performances of the public sector emerge:

- Public sector as a member of the RFID network
- Public sector as a policy/legislation provider
- Public sector as an enforcer
- Public sector as a funding/service provider.

Table 1, illustrates how the actants, human and documentary, displayed these different roles or performances.

Public Sector Role/ Performance	Human Actants	Documentary Actants
Public sector as a member of the RFID network.	"…joint [sector] owners, and subject matter experts working side by side to develop… requirements".	Business case
Public sector as enforcer	"… we had to tell vendors to do it… let there be no doubt that there was a mandate."	Case law
Public sector as legislator/ regulator	"…. The way government acts with industry is regulation…"	Legislation
Public sector as a funding provider	"… in [our] view, [our country] should pay for it."	Government grants and funding
Confusion between performances	"…the policy wonks get involved and [the network] grows a life of its own. So then you got to go and grab them all and bring them all back...".	Newspaper reporting

Table 1: Role multiplicity of the public sector in public sector-private sector RFID networks.

4 Discussion

In the findings it is deomonstrated that public-private sector RFID systems are complex with the public sector taking a number of different roles in such systems. As is the nature of ANT, this observation is mundane, but describes something that many consider to be implicit within public-private interactions. The public sector (or government as many actants within this study tended to say) in this context, can be seen to be a multiple. As a member of the network the public sector receives goods and services, or participates in administration of the RFID network. In this context the public and private sectors are partners, and the relationship between the entities is not based on a sectoral division. As the partners worked together longer, they became more familiar with each other, and differences between the sectors become less relevant.

As a provider of legislation, the public sector was approached in order to legislate or mandate involvement in particular RFID systems. This was seen to occur at the request of industry in one example within this study. This provision of legislation was based on the premise that the legislation was for the public good. The public sector can also be seen to be driving RFID implementations in other instances where legislation requires traceability within food supply chains (although some of these examples are outside the scope of this study as they are not always within the public-private context). This provision of legislation leads to the third performance of public sector, that of the enforcer. With legislation requiring certain behaviours, actants within the RFID network had to comply, even though the public sector was also a partner with the private sector in that network. These two performances are within the stereotypical view of government, that of the legislator or enforcer.

The fourth performance is that of the public sector as a funding or service provider. Again this is more of a stereotypical view with private sector actants approaching government for funding – at times after persuading the public sector not to become involved in legislation. The arguments supporting these bids for funds centre on economic benefit and increased efficiency of public sector processes, as might be expected.

So, if the observation of multiplicity within the public sector is mundane, why does it matter? In the public-private RFID network these multiple performances caused considerable confusion. At times private sector actants would be trying to persuade the public sector to provide funding, while the public sector was emphasising the legislative performance. In other instances the public sector as a provider of policy would need to be brought back to think in terms of themselves as a member of the network. In some instances the private sector was unsure about which performance of the public sector they were interacting with, and public sector actants could be seen to be unsure about which role they should be taking. The different performances also gave rise to different approaches within the public-private network, as the public sector preferred the legislative approach, while private sector was more orientated towards partnership, especially if this led to the provision of public sector funding.

The conflating of the terms "public sector" and "government" only added to the confusion, with private sector actants using the term "government" with all the stereotypes attached to that term. This made it more difficult for private sector actants to focus on the role they wanted the public sector to play.

There is no denying that public-private RFID systems will become more common. With smart city initiatives, and the increasing use of RFID in supply chain and other applications including the internet of things, organisations will have to learn to manage complex cross sector relationships involving networked technology. The nature of the technology itself forces organisations to work together as data must be shared between organisations in order to gain maximum benefit from RFID systems. This requires collaboration and understanding between public and private sectors.

5 Conclusion

This study highlights an often overlooked area of interaction between sectors in RFID systems, that of the relationship between the sectors themselves. A possible explanation of why such relationships can be difficult is offered – that the public sector is a multiple, and that public and private sector actants are at times confused about which performance they are enacting. Further, the two sectors were somewhat influenced by stereotypical views of each other. However, the longer the two sectors worked together the more the stereotypes diminished, with the two sectors coming to see each other as partners.

The use of the ontology of ANT allowed for these observations to come to light, with its emphasis on reality being constructed through the performance of its actants. The ability to see different perspectives within the same network illuminated the different performances present within the public sector and allowed for a further understanding of how these performances affected the construction of the public-private RFID network.

As technology systems become more distributed and complex through the formation of internet of things enabled networks, it is necessary to find a way to study such systems. This research demonstrates the use of ANT in studying public-private RFID systems, noting that RFID systems are the building blocks of the internet of things. ANT's inclusion of technology within its construction of the social allows the highly networked technology actants that form internet of things systems to be uncovered,and included within the explanation of these systems.

5.1 Contributions to Research

This research addresses a gap in literature by contributing to understanding how RFID networks operate within a public-private context. Such socio-technical networks are becoming increasingly common and researchers need to begin understanding how these networks are formed, and function. The use of ANT in this research offers a way to study networked systems in detail through recognising the agency of technology within the construction of the social.

5.2 Contributions to Practice

This research contributes to practice by assisting public and private sector actants to understand how to interact together. The uncovering of the public sector as a multiple assists organisations in understanding the necessity to be clear about which performance of the public sector practitioners are interacting with. This should reduce confusion and improve efficiency of public-private interactions. Further, RFID technology is becoming increasingly common, and early understanding of how to work with such systems will assist practitioners in developing public private partnerships involving RFID technology.

5.3 Limitations

As with all qualitative research, this research is not generalizable outside the context in which it was undertaken (Bryman, 2012). However, complex socio-technical systems are becoming more common, and this research does point towards a possible explanation for difficulties encountered within the management of such systems. Further research and consideration of the multiplicity of the public sector should assist in understanding public-private technology systems.

The nature of ANT itself also presents difficulties as ANT is a descriptive approach which does not allow for the prediction of outcomes. Theoretically, an ANT approach would require the following of actants *ad infinitum* but this is clearly not practical or possible, so the network has to be closed in an arbitrary way when the point of saturation appeared to be reached (Corbin & Strauss, 2008).

5.4 Future Research

There are a number of questions that remain un-answered within this research. Primarily, although the public sector has been identified as a multiple insufficient information was gathered to indicate whether the private sector is also multiple. The possibility of multiplicity with the private sector suggests a further level of complication in regards to inter-sector relationships in the public-private context. Also, the stereotyped view of government adopted by some private sector actants could be further explored, as this appears to present a barrier to understanding and inter-sector collaboration.

Further, a quantitative study could be undertaken specifically focused on the nature of multiplicity within the public-private RFID network, in order to confirm the findings of this research, and to increase understanding of how the multiplicity of the public sector influences relationships in complex socio-technical networks.

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