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Akemi T. Chatfield
University of Wollongong, akemi@uow.edu.au

Samuel F. Wamba
University of Wollongong, samuel.fosso.wamba@neoma-bs.fr

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A Sociomaterial Approach to Co-Creating RFID Value in a Multi-Firm Supply Chain Knowledge Sharing Environment: A Longitudinal Case Study

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Akemi Takeoka Chatfield
School of Information Systems & Technology
Faculty of Informatics
University of Wollongong
Wollongong NSW 2522 Australia
akemi@uow.edu.au

Samuel Fosso Wamba
School of Information Systems & Technology
Faculty of Informatics
University of Wollongong
Wollongong, NSW, 2522, Australia
Rouen Business School, Rouen, France
samuel@uow.edu.au

Abstract

Orlikowski and Lacono (2001, p. 132) aptly argue that IT artifacts, particularly distributed network technology applications, including RFID, "do not provide the same material and cultural properties in each local time or context of use." A sociomaterial theory suggests the importance of adopting an integrative approach to study the social and material effects when examining IT benefits realization. While much has been written about the high potential of RFID as a new class of strategic enterprise information systems, the early adopters of RFID and researchers still have to answer the question on how to co-create the business value of RFID in supply chain environments. In this longitudinal case study of six firms involved in the research, development, implementation and use of an innovative RFID system, several critical barriers to co-creating RFID-enabled business value were identified. Finally, a sociomaterial approach to study RFID provided new insights into these barriers.

Keywords: RFID, case study, co-creating of RFID value, sociomaterial approach, critical barriers, inter-firm knowledge transfer, inter-firm trust

Introduction

Strategic enterprise information systems (SEISs) are networked and integrated to enable new or improved corporate strategic decisions. Across the globe, radio frequency identification (RFID) information systems have been rapidly emerging as a new class of SEIS. RFID technology is defined as a wireless automatic identification and data capture (AIDC) (Fosso Wamba et al. 2008). A typical RFID infrastructure consists of three material components: (1) an RFID tag which may be active, passive or semi-passive, and acts as an electronic database attached to or embedded in a physical object to be identified, tracked and traced in real-time; (2) an RFID reader and its antennas which automatically communicate with the RFID tag without requiring a line of sight; and (3) an RFID middleware that manages the whole RFID information system. The latter is in charge of filtering all RFID data collected from RFID tags and routing them to the dedicated intra- or inter-organizational information systems, using the business rules configured within the middleware. RFID-based SEISs provide supply chain firms with the high potential: strategically, to enable new or improved corporate strategic decisions and, operationally, to improve inter-firm information sharing and coordination across a variety of supply chain stakeholders, and hence improving the supply chain management practices (Bensel et al. 2008). These claims have been made not only by academic researchers (Fosso Wamba et al. 2008; Fosso Wamba et al. 2006; Moon et al. 2008), but also by RFID vendors (IBM 2004; SAP 2004) and early RFID adopters such as Wal-Mart to improve supply chain management practices. Despite the high potential of RFID-based SEIS, however, both the early adopters of RFID and the academic researchers in this technology today face problems associated with business value co-creation from RFID-based strategic enterprise information systems in multi-firm supply chain environments.

Orlikowski and Lacono (2001, p. 132) aptly argue in their sociomaterial theory on new and innovative IT use in organizational practices that IT artifacts "do not provide the same material and cultural properties in each local time or context of use." Therefore, the sociomaterial theory postulates that a dynamic, tight coupling of the social and material dimensions underpinning each new, innovative IT use cannot be either separated or studied in a modular approach. It therefore advocates the need for a paradigmatic shift towards an integrative study of IT use in organizational practices. Moreover, in comparison to other enterprise systems such as enterprise resource planning (ERP) systems, RFID artifacts such as tags and readers – both of which are the material components of RFID-based SEIS – are often physically more tangible and visible. In consequence, organizations' users are more aware of and engage more actively with the physical forms of RFID-based strategic enterprise information systems in their daily organizational practices than they would with the traditional strategic enterprise information systems.

Unlike previous studies which have applied the sociomaterial theory to the sole use of ITs, the present research has applied the same theory to the entire systems development life cycle: organizational motivations for an RFID-based SEIS, design, development, implementation, and use. In this longitudinal case study, we have investigated the issue of co-creating business value from an RFID-based strategic enterprise information system within a Canadian vertical automotive supply chain environment. More specifically, the longitudinal case study focused on the following two guiding questions:

1) How business value is socially co-created and shared from an RFID-based strategic enterprise information system?

2) What are the critical barriers to co-creating business value?

Drawing on the sociomaterial theory, we have addressed these research questions by paying special attention to the study of the dynamic interplay between the social, material dimensions that are inherently intertwined in organizational practices and that might influence the benefits realization processes and outcomes among six Canadian vertical automotive stakeholder firms involved in the RFID-based SEIS project. An analysis of the longitudinal case study identified two critical barriers to co-creating the business value of RFID-based SEIS for yard management and after-sales service management in a multi-stakeholder knowledge sharing environment.

Following the introduction, the paper is organized as follows. In Section 2, we review previous studies on sociomaterial theories for the use of innovative ITs in organizational practices, and discuss the application of a sociomaterial perspective to study RFID-based SEISs. In Section 3, we describe the longitudinal case study research methodology that is being adopted to address the two research questions. Section 4 deals with our study, which describes how the dynamic interplay of the social, material factors, over a period of time, have exerted significant effects on the initial strategic vision, actual design, development, implementation and use, as well as the expected tangible benefits of an RFID-based strategic enterprise information system for automotive yard management and after-sales service management in a vertical, automotive industry supply chain of Canada. In Section 5, we discuss the two critical barriers to business value co-creation of the specific RFID-based SEIS concerned with our longitudinal case study. Section 6 presents the key lessons about the strategic, operational issues of business value co-creation. The main findings are then summarized, and a number of research limitations and future research directions end the paper.

RFID-based SEIS: A Sociomaterial Theoretical Perspective

In her paper published in Organization Studies and dealing with sociomaterial theories, Orlikowski (2007, p. 1435) observes that contemporary organizational practices are increasingly intertwined with "multiple, emergent, shifting, and interdependent technologies." Within an organization, the stakeholders are expected to act and interact with the material forms of these information technologies. Yet, the author points out that previous organizational studies often distinguish between the social and the material, implying that the two constructs are distinct and largely operate in independent spheres of organizational practice. Against the extant research approaches, Orlikowski proposes the sociomaterial perspectives as a new integrative approach to address materiality—or the material forms of organizational technologies. She aptly argues that such a new integrative perspective is critically important for us to develop a richer understanding of contemporary organizational practices where "there is an inherent inseparability between the technical and the social" and "the fusion of technology and work in organizations" (Orlikowski et al. 2008).

In this paper we argue that a sociomaterial, theoretical perspective is relevant and useful for the theorization of organizational supply chain management practices. In the complex multi-firm supply chain management practices, a number of firms with different business strategies, different internal resources, different internal processes, different leadership styles, and different commercial interests need to interact socially and work collaboratively in order to continuously create and sustain strategic alignments and synergies, the ultimate gold being to co-create the business value of RFID-based SEIS in multi-stakeholder environments. This is obviously challenging because the materiality of RFID-based SEIS – the physical design (or selection) and testing of RFID tags, antennas, and readers – is highly specific to the local business needs, the local implementation site specifics, and the organizational practice spheres where the material forms are neither independent nor socially separated from the multiple stakeholders involved in a particular RFID project. As one may notice in our case study later hereinafter, the success of RFID-based SEIS, which is epitomized by a successful sharing of the business benefits co-created by the stakeholders from the implemented RFID-based SEIS, will require a high-level, tacit and technological knowledge transfer and exchange when achieving a good fit between the physical design, the local environment, and the local organizational practice. While the social and the material are very much intricately intertwined in RFID-based SEISs, in this section we discuss both the material and the social dimensions of RFID SEIS in two separate sub-sections.

Materiality of RFID-based SEIS

RFID tag can be defined using its size and its functional characteristics such as power source, operating frequency, reading range, data storage capacity and cost. For example, an active tag contains a tiny battery from which it draws its power, whereas the passive tag does not contain any power source, and a semi-passive tag functions as a passive tag, except that it has a power source that enables it to run an onboard sensor (Roberti 2006). Because the active RFID tag uses a battery for its power source, its operational life is shorter than that of the passive RFID tag, and it usually costs more than a passive RFID tag. With regard to the operating frequency, the low-frequency RFID tags use frequencies ranging from 125 to 134 kHz; as for the high-frequency RFID tags, they use the 13.56 MHz frequency, while the ultra-high-frequency RFID tags use a frequency varying from 866 to 960 MHz . In terms of data storage capacity and capability, RFID tags may either be read only or read/write (Asif et al. 2005).

With regard to the RFID readers, they may be a fixed or a mobile device, and the may have a read or read & write capability (Ngai et al. 2007). In addition, RFID readers can be configured to respond to messages from the RFID tags (the RFID tag talks first) or to control the timing communication with the RFID tags (the reader talks first) (Asif et al. 2005). However, the selection of the best RFID infrastructure depends heavily on the local business needs, the type of applications (e.g., smart-selves, dock doors, points of sale, conveyors, and forklifts), the implementation site environment, and the country of implementation. For example, a hostile environment (e.g., metal, extreme cold temperature) may affect the performance of the RFID system.

Strategically, the business value of RFID-enabled network of supply chain firms increases with the greater number of participating firms within the network, the higher level of organizational transformation, environmental upheaval, leadership, second-order organizational learning, and resources commitment (Fosso Wamba et al. 2009). Also, a commercial RFID frequency in the USA may be used as a military one in China; therefore, choosing a proper RFID frequency in an extended enterprise context is a key to the success of the implementation of the system. Furthermore, RFID infrastructure could be linked to feedback systems (e.g., light stack, audible devices, divert gates, cameras) to monitor the behaviour and the performance of the system. For example, a light stack may be used to validate a proper reading of an RFID tag on a product as it enters the RFID reader reading range.

Social dimensions of RFID-based SEIS

Social dimensions of RFID-based SEIS generally include multiple stakeholders with different "stakes" or commercial interests, executive project sponsors, organizational project management practices, change management practices, inter-firm project coordination mechanisms, and the type of inter-firm relationships – whether strategic partnerships or arms-length transactional relationships – in the context of design, development, and implementation projects in multi-firms environments (Fosso Wamba et al. 2009). However, in the particular context of multi-firm supply chain performance optimization, co-creating the business value from RFID technology design, implementation and use is very complex, because it involves dynamic, social and emotional interactions among multiple stakeholders, with a wide range of different economic, political, and personal stakes in the RFID-based SEIS project.

More importantly, these stakeholders also vary with respect to their technological knowledge and understanding of RFID technology and its implications for the need for organizational change and business scope redesign in order for them to leverage the technology and co-create the business value of IT (Fosso Wamba et al. 2009). Moreover, they may differ in terms of communication styles and knowledge sharing practices. For example, the design of the material, RFID-based and automotive yard management and automobile theft prevention system for a vertical automobile industry in Canada – a case study to be fully discussed in the next section of this paper – is intrinsically linked to the social: multi-stakeholder firms with different economic interests, inter-firm knowledge sharing practices, and different organizational cultures and communications. More specifically, during the design, development, and implementation phases of a RFID project, the design team leader communicated and interacted iteratively with many stakeholders from a telecommunication firm, the owner and CEO of an RFID solution provider firm, and supply chain firms in the vertical automobile industry. Interestingly, they responded to the materiality of RFID-based SEIS in radically different ways, showing conflicting interests, contradictory motivations and attitudes, divergent levels of technological knowledge with regard to RFID tags and antennas, other related hardware and computer technologies such as middleware.

Co-creation of the Business Value of RFID-based SEIS

The research question on whether and how multi-stakeholders can socially co-create the business value of IT in multi-firm IT project environments is new and emerging in the IS research community. The relevance and urgency of addressing this question is shown by the recent calls for papers, including that of the 2009 MIS Quarterly Special Issue on Co-creating the Business Value of IT.

While the number of RFID applications and adopters in various fields are rapidly increasing, some critical barriers such as high investment cost and inadequate technological knowledge and capability (Fosso Wamba et al. 2009), and the lack of motivation for organizational change and business process redesign

(Fosso Wamba et al. 2009) still remain as challenges for multiple stakeholders in leveraging RFID technology and co-creating business value from RFID-based SEIS. These prior studies suggest the role of technological knowledge or the knowledge transfer capability. However, very little is being written, especially in the form of a longitudinal case study, about how multi-stakeholders socially co-create or fail to co-create the business value of RFID-based SEIS in the course of the RFID project life cycle. Therefore, this paper relies on a sociomaterial approach (Orlikowski 2007; Orlikowski et al. 2008) to study the critical barriers to co-creating the value of RFID-based SEIS. Because co-creating business value from designing, developing, implementing, and using RFID-based SEIS cannot be fully studied by separately treating the technology, the people and the work practices, it is important to present and analyze a case study of RFID projects in a Canadian vertical automobile industry. Let's remind that "[t]he challenge for organization scholars is to figure out how to take seriously the recursive intertwining of humans and technology in practice." (Orlikowski 2007) (p. 1437).

Methodology: A Longitudinal Case Study

The overarching aim of this research study is to extend the extant sociomaterial theory towards the development of a better understanding of sociomaterial effects on business value co-creation. More specifically, the longitudinal case study was undertaken under the two guiding questions:

1) How business value is socially co-created and shared from an RFID-based strategic enterprise information system?
2) What are the critical barriers to co-creating business value?

This research adopts a research design: the case study research for theory development (Eisenhardt 1989). This research design is appropriate to address our research questions, since it allows researchers to explore and capture the dynamic key stakeholders within the supply chain (Eisenhardt 1989), and therefore focus on emerging and complex phenomena, and ultimately induce theories (Benbasat et al. 1987). Furthermore, the case study strategy is well indicated when answering research questions such as "why" and "how" things are done (Yin 1994). In addition, case study is appropriate to explore the sociomaterial effects on business value co-creation dynamics and synergies among the firms operating in a multi-firm supply chain knowledge sharing environment, where theory and research are at their early and formative stages (Benbasat et al. 1987). Increasingly, the case study is being used in the logistics and operation management fields (Barratt 2004). Moreover, in the IS research field, early studies have already successfully applied the case study to study RFID technology (Fosso Wamba et al. 2008; Loebbecke et al. 2008).

More precisely, an in-depth longitudinal case study of an innovative RFID research, development, implementation, and use in a Canadian vertical automotive industry was conducted to explore the dynamic sociomaterial interplay effects and identify the critical barriers to co-creating the business value of RFID-based SEIS. Six firms were involved in this RFID development project: a Telecommunication provider firm, a Start-up RFID Solution Provider firm, a RFID Research and Development firm, a Knowledge Management and Transfer firm, a Car Dealer, and a Software Developer firm. Table 1 below summarizes these stakeholder firms involved in the project. Data collection involved multiple sources of evidence including: on-site observations, semi-structured interviews, industrial reports, technical (e.g., RFID specifications and network) or non-technical documents, all of which allowed us to increase the validity of our constructs (Yin 1994).

The Telecommunication provider firm is a major Canadian public company with around 45,000 employees. The company provides firms of various sizes (e.g., large businesses, government organizations, small and medium businesses) with telecommunications solutions including telephone services, wireless communications, high-speed Internet, digital television and voice over IP. In 2005, the firm started exploring the possibilities of entering the RFID solutions market. Later, it acquired a small RFID-based company in order to access in-depth knowledge and expertise in supply chain optimization, manufacturing and logistics. The final objective was to improve its current wireless data capabilities in RFID technology, inventory management, field force automation, fleet management and wireless local area networks (WLAN) (Bell-Canada-Media 2005). To consolidate and secure this new acquisition, several managers from various divisions of the firm were requested to attend training and certification sessions on RFID technology.

Table 1. Six Stakeholder Firms

Reference	Case Study Site	Key Informant Position Title	Main Motivation
1	Telecommunication provider firm	Business development manager	• Add to their portfolio of RFID solutions a new tool for RFID-based SEIS for automotive yard management and after-sales service management • Use insight from the project as a marketing strategy for gaining potential adopters
2	Start-up RFID solution provider firm	CEO and Owner	• Design, develop, and test in a real-life environment cost-effective RFID-based SEIS for automotive yard management and after-sales service management • Leverage the knowledge gained from this project to launch a mass customization of RFID-based SEIS for yard management and after-sales service management in the Canadian vertical automotive industry
3	RFID research and development firm	CEO and Owner	• Apply and test current RFID expertise to a real case study • Participate for the commercialization of the final RFID solution
4	Knowledge management and transfer firm	Senior consultant	• Provide consulting services in codifying and transferring knowledge from the RFID research and development firm to the Start-up RFID solution provider firm
5	Car dealer firm	President	• Use RFID system to prevent the theft of auto parts (e.g., catalytic converter) from the automotive yard • Project an innovative firm image to customers and competitors in Canada, as the first automotive firm to use RFID-based SEIS for yard management and after-sales service management
6	Software developer firm	CEO	• Apply and test current RFID expertise to a real case study

The owner and CEO of the Start-up RFID solution provider was one of the managers at the Telecommunication provider firm. He has worked as a business development manager for the mid-market division of mobile solutions, telecommunications and IS/IT solutions. He has solid, diversified international experience in various business development positions within the ICT sphere. Moreover, he has a strong technical sales management and product development background in various land and wireless communication systems (e.g., ATM, WLAN, ZigBee, and Bluetooth). One of the researchers gave CompTIA's RFID+ certification training and had the first contact with the owner and CEO of the Start-up RFID solution provider firm. Early, the owner and CEO of this Start-up RFID solution provider firm left the Telecommunication provider firm to launch his own firm with his personal savings. Then, he established a joint-venture partnership with his long-term friend, owner of the RFID Research and development firm. Also, he established a partnership between his firm and the Telecommunication provider firm to act as an RFID subcontractor for all services related to RFID technology for small- and medium-sized enterprises. The current RFID case study is a materialization of that partnership. Indeed, the Telecommunication provider firm referred to the President of the Car dealer firm as well as to the owner and CEO of the Start-up RFID solution provider firm.

The President of the Car dealer firm was exploring the use of RFID technology to solve a recurring problem of theft of auto parts (e.g., catalytic converter) in his automotive yard. Indeed, the firm has a large 600ft x 200 ft automotive yard and has been suffering on average three catalysts thefts every two weeks, which cost between $ 500 and $ 1,500 to the firm to replace each of the component parts, as well as additional theft-related administration and labor costs. Although the company is insured against such thefts, the President is reluctant to report the thefts, fearing that that its premium may be increased or that the existing policies may be even cancelled. He was also concerned about the potential damage to the company's reputation – an intangible asset, which is strategically important for the automotive dealership's sustainable business growth. Therefore, solving the recurring problem by using RFID technology appears to be the preferred solution. In line with this objective, he was looking to an RFID solution that can be integrated to the existing IT infrastructure (Figure 2) and that can detect in real time any "suspicious movement" underneath any car in his yard and generate a voice alert. He was willing to invest CAN$ 25,000 in such a system. The average stock capacity of the automotive dealer yard is about 150 vehicles (new and used), with estimated total sales of 500 to 600 vehicles annually. The firm has 12 full-time and 4 part-time employees.

Project Questions

This case study examines the benefits of designing, developing, implementing, and using an RFID-based SEIS for yard management and after-sales service management. More specifically, the study wants to examine the following project questions:

1. Is it possible to use RFID technology to prevent auto parts thefts (e.g., catalytic converter) in an automotive yard, and to offer better after-sales services?
2. What is the optimal RFID architecture that enables the attainment of these goals?
3. What are the key stakeholders involved in the design, development and implementation of an RFID-enabled theft prevention of auto parts (e.g., catalytic converter) in an automotive yard, and that can allow better after-sales services?
4. Whether and how can the business value be socially co-created and shared from RFID-based SEIS for yard management and after-sales service management across the key project stakeholders?

RFID Project Objectives

In the RFID-based SEIS for yard management and after-sales service management project, each key stakeholder has its own agenda.

1. From the perspective of the owner and CEO of the Start-up RFID solution provider firm, the main objective was to design, develop, and test in a real-life environment cost-effective RFID-based SEIS for yard management and after-sales service management. Then, leveraging the knowledge gained from this project, he would pursue a strategy to launch a mass customization of the said system for other firms in the Canadian vertical automotive industry.
2. From the Car dealer firm President's perspective, the initial main objective was to use the new RFID system to prevent the theft of auto parts (e.g., catalytic converter) from the automotive yard. However, his strategic vision included sending its innovative firm image to customers and competitors in Canada, as the first automotive firm to use RFID-based SEIS for yard management and after-sales service management.
3. From the Telecommunication provider firm perspective, the main objectives were to add to their portfolio of RFID solutions a new tool for RFID-based SEIS for yard management and after-sales service management, and to use insight from the project as a marketing tool among potential adopters of the said solution.

4. From the RFID Research and development firm perspective, the main objective was to exploit the existing capabilities of the company's RFID technology so as to develop a set of RFID products to sell.

Case Analysis

The current RFID project started in November 2008, when through many phases that shall be discussed in detail below, and went live at the end of June 2009 (Figure 1).

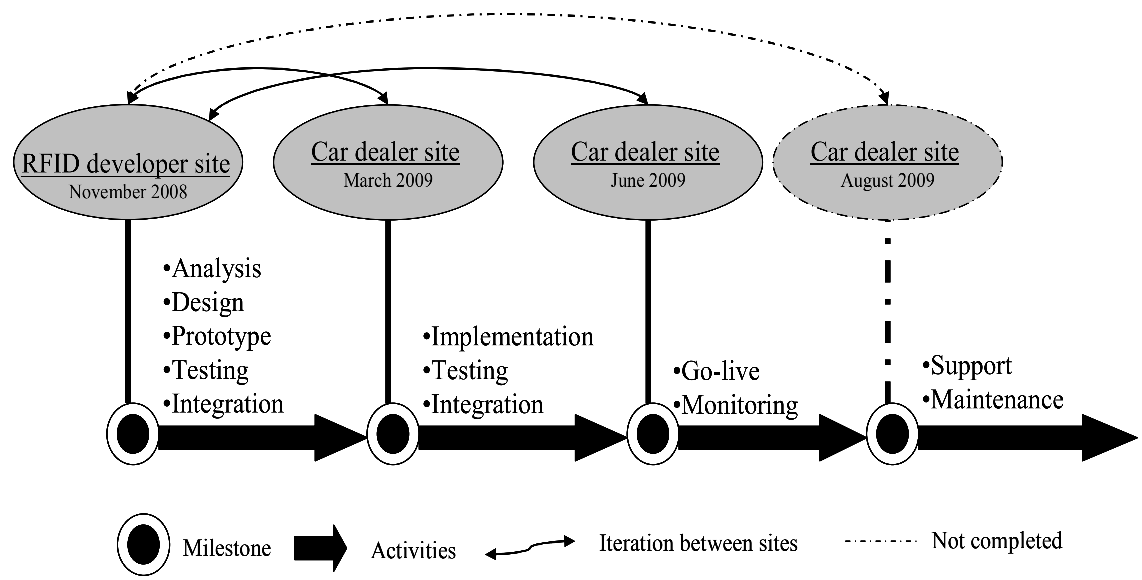

Figure 1. RFID development phases involved in the project

RFID developer site: starting November 2008

Activities in the RFID developer site involve the design, analysis and prototype of all RFID components as well as their integration to assess the behaviour of the resulting RFID system. The analysis phase encompasses three onsite visits to the car dealer's site in order to conduct the physical site survey with the aim to assess the potential environmental challengers that may affect the system, analyse the current car dealer IT infrastructure, identify the potential physical locations of RFID equipment, and measure the expected reading area to be covered by the system. In the early stage of the design phase, a preliminary RFID architecture emerges and involves the use of 30 of the RFID Research and development firm in-house RFID readers antennas to cover the entire yard. Very quickly, this idea was abandoned by the project team mainly because of technical considerations such as security issues related to the physical wiring and installation of RFID antennas, and the challenges regarding the integration of that architecture with the current IT architecture (Figure 2), as well as business issues related to the costs of the architecture, since it required about 30 readers antennas to cover the 600ft x 200 ft automotive yard. The laboratory testing of this infrastructure within the RFID Research and development firm's facilities also demonstrates a very low-power transmission between the RFID readers antennas and RFID tags. Moreover, the selection and testing of the appropriate, active RFID tags fitting with the requirements of the RFID Research and development firm's RFID readers antennas took about two months, which was considered "too long" by the CEO of the Start-up RFID solution provider. Indeed, a range of RFID tags were tested in the RFID Research and development firm's facilities in order to assess their capabilities in relation to the project specifications and to the requirements for the firm's in-house RFID readers antennas. Finally, an active tag working at 433MHz was selected as the best fit for the RFID solution. Thereafter, a total of 150 of the said RFID tags were purchased for the entire project at about CAN$100 each. Afterwards, the owner of the RFID Research and development firm together with the owner of the Start-up RFID solution provider decided to develop a new helical high-gain antenna which is at the core of the implemented RFID infrastructure. The said helical, high-gain antenna went through 8 rounds of prototyping to obtain a final product. The resulting helical, high-gain antenna is new, more efficient, and provides greater bandwidth, longer range gain and improved flexibility in wireless communications. More importantly, this helical, high-gain antenna is capable of distributing signal multi-dimensionally, which is very useful for RFID deployment in large areas such as an automotive yard (See table 2 for more details).

Table 2. The Helical High Gain Antenna Description

Characteristic	Capabilities
RF frequency range	433.92 MHz
Bandwidth (antenna)	600KHz
Antenna gain	14 decibel isotropic (dBi) (on axis)
Polarization	Circular
Wind loading	Horizontal thrust at 200km/h
Operating temperature	-400C to +800C
Net weight	1.8 kg

Furthermore, an RFID middleware called coordinator was developed in-house by the RFID Research and development firm in collaboration with the Start-up RFID solution provider. This middleware is built on an “open platform” and is capable of achieving 10,000 transactions per second; without moving parts, it is programmed in C and in the assembler, and provides a software layer equipped with algorithms that can manage alarms (actual alarms vs. false alarms). In addition, the coordinator offers many setting options to connect and manage the RFID tags, readers/antennas and the helical antenna, to create a link between the RFID physical infrastructure and part of the Car dealer current IT infrastructure, mainly the cameras, the modem, the server, and the digital video recorder (DVR) through Ethernet. In addition, the RFID Research and development designed, in collaboration with the Start-up RFID solution provider, an interface, that is, a general purpose input/output device called Pro-GPIO to connect the coordinator to the alarm panel for areas management to which pertain the managing and monitoring all Car dealer cameras. The final characteristic of the proposed RFID solution is an intelligent panel for car keys management called ProkeyTrace, which is designed to assist the car dealer during after-sales services (e.g., car maintenance), including the monitoring of the customers’ arrival, the real-time validation of all activities on the car, beginning from the current one up to the following activities (see Figure 2 for more details).

By the end of March 2009, all the testing process — including all units testing, the system integration testing and the operation testing — was completed, and the proposed RFID solution was ready to be installed on the Car dealer site.

Car dealer site: part 1-starting end of March 2009

The actual implementation of the proposed RFID solution started at the end of March 2009, followed by the testing of all units, the system integration testing and the operation testing, and finally the integration of the RFID solution with the current Car dealer firm IT infrastructure in real-life conditions. During these phases, three consultants were hired by the Start-up RFID solution provider and RFID Research and development firm: two external consultants for assistance during the integration of the RFID solution with the alarm panel for areas management, and another one for the physical installation of the components of RFID solution and their testing. These phases lasted until the end of June 2009. These phases were executed under extreme weather conditions (e.g., hail, rain and violent winds), allowing the project team to test the system in such extreme conditions, and to adjust all system parameters. For example, during that period, there were an increased number of false alarms from the system.

Car dealer site: part 2-starting end of June 2009

The proposed RFID solution went live at the end of June 2009, and issues related to the system behaviour were being monitored to identify any abnormality.

Car dealer site: August 2009

Under the agreement between the Start-up RFID solution provider and the Car dealer, the various phases involved the monitoring, support and maintenance of the system without additional cost from the Car dealer. However, the vast majority of activities within these phases were not executed because of discrepancies in the understanding of "what is a final project", mainly between the RFID Research and development firm and the owner and CEO of the Start-up RFID solution provider. The owner of the RFID Research and development firm believed that he should be paid for any additional work related to the project, while the owner and CEO of the Start-up RFID solution provider considered support and maintenance as part of the package. Despite this disagreement, the system continued to properly function after six weeks of its installation and the president of Car dealer firm could already see the tangible benefits associated with the implementation of the RFID system. In fact, no theft of auto parts had been noticed since the installation of the system. If the system continues to work perfectly, the President of the Car dealer firm forecasts tangible savings to the tune of CAN$ 11,000 to CAN$ 83,000 per year (Table 3).

Table 3. Expected Tangible Annual Savings by Firm Car Dealer

Costs related to the theft of 72 auto parts per year		Implementation costs	Minimum savings per year	Maximum savings per year
At minimum cost of $500 per part	At maximum cost of $1500 per part			
$36,000	$108,000	$25,000	$11,000	$83,000

During all phases executed in this project, a knowledge management and transfer firm was hired by the owner and CEO of the Start-up RFID solution provider in order to closely collaborate with the development team, codify all knowledge gained during the project, and store them into a knowledge management system in order to facilitate the mass production of the final RFID-based SEIS for yard management and after-sales service management product.

Critical Barriers to Co-creating the Value of RFID

The project was initiated both by the Owner and CEO of the RFID solution provider firm, and the President of the car dealer firm. Their motivations for initiating the project were different. On the one hand, the Owner and CEO of the RFID solution provider firm thought that the perceived business value of the project was the creation of new capabilities for the firm to leverage an innovative RFID-based SEIS developed for the car dealer, and to generate further sales opportunity for others in the vertical automotive industry. On the other hand, the perceived business value of the project, according to the President of the car dealer firm, referred to a strategic use of the new RFID-based SEIS to solve the recurring business problem concerning the theft prevention of fairly expensive to very expensive auto parts (e.g., catalytic converter) in the inventory stock of cars at the automotive yard, and the tracing and tracking of these parts. Although the two executives were divided on their motivations for the RFID development project, they shared some mutual interest in co-creating business value for the innovative RFID applications. An in-depth analysis of the case study disclosed two critical barriers to co-creating business value for the RFID-based SEIS designed, developed, and implemented for the car dealership in Canada. They are important hurdles to the inter-firm transfer of RFID technological knowledge and to the integrity of inter-firm trust.

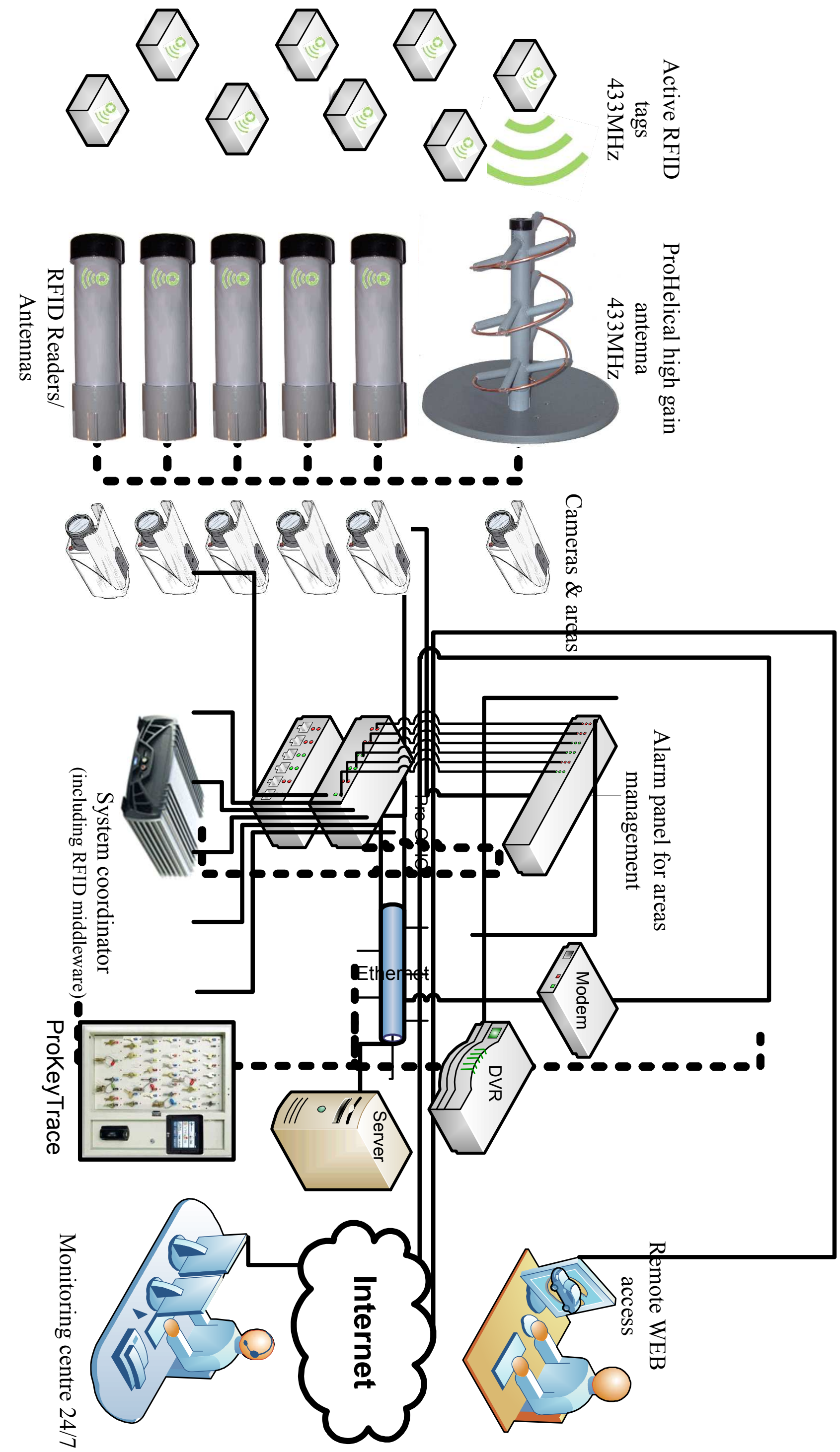

Figure 2. Positioning the RFID infrastructure deployed into the firm IT landscape

The difficulty in interfirm transfer of RFID knowledge

Davenport (Davenport, 1995, p. 5) asserts that "Information sharing is a voluntary act of making information available to others." Knowledge sharing is also a voluntary act requiring the motivation of the holder of technological knowledge to make it available to other stakeholders involved in the project.

In our case, the difficulty in inter-firm transfer of RFID technological knowledge appears to be a critical barrier to co-creating the business value of RFID SEIS implemented in the Canadian automotive dealership firm. There are two plausible explanations for the difficulty observed in the case: (1) the 'stickiness' of RFID knowledge, and (2) the self-interest of the holder of sticky knowledge.

First, the concept of sticky information and its implications for technical problem solving and innovation (Von Hippel 1994) explains that it is often costly to acquire, transfer, and use technical information or knowledge needed by innovators or new product developers in the course of their problem-solving practices. In our case study, this was true with the RFID technological knowledge – both explicit and tacit knowledge – held by the development team leader involved in the project. The reason is that his RFID knowledge has been acquired from deliberate learning through his private research, design, and development practices. His RFID development practices involved a wide range of different product items to be traced and tracked to support dynamically diverse local organizational practices in uniquely and often radically different physical environments. He has acquired his RFID tacit knowledge by designing and developing the best RFID tags, readers, and antennas for each of these different projects. So his tacit RFID knowledge is very sticky, and therefore it is very costly to transfer them to other stakeholders, particularly the members of the knowledge management and transfer firm involved in the project for the explicit purpose of facilitating the mass customization of the RFID-based yard management system.

Second, the concept of self-interest might be useful in explaining the difficulty in inter-firm knowledge transfer that was observed in our case study. For effective inter-firm knowledge transfer or knowledge sharing to occur, a development team leader with sticky knowledge must be willing to share his knowledge with other stakeholders involved in the project. Effective knowledge sharing requires at least two factors on the part of the sticky knowledge holder: (1) motivation (Jarvenpaa et al. 2000), and (2) communication (Gilbert et al. 1996). The sticky knowledge holder must be motivated to "be open and get involved" in knowledge transfer. In the act of communicating, he must be willing to codify his tacit knowledge embedded in his past work practices into explicit knowledge that can be transferrable to other stakeholders involved in the project.

This process of changing from "personal knowledge as an individual's attribute" to "personal knowledge as organizational "public good"" (p. 195)(Dulipovici et al. 2007) is often very difficult largely because of self-interest. The concept of self--interest in the context of personal knowledge transfer is articulated by many scholars as having a negative impact on professional and personal value. For example, "as an attribute of an individual, personal knowledge, either tacit or articulated, may be a source of income because individuals are generally employed on the basis of their skills and expertise. Personal knowledge may also bring respect and prestige in communities, especially if this knowledge is unique and relevant to the community. Transfer of personal knowledge diminishes the individual's value, because it may have a negative impact on his or her professional value (Wasko et al. 2000) or on the unique character of that knowledge" (p. 196).

This conflicting self-interest existing across different stakeholders induces a knowledge paradox because its transfer can be both beneficial and detrimental, depending on a particular perspective of the stakeholders concerned by our study (Wasko et al. 2000). Sharing technological knowledge may be detrimental, because it could be used by the firm to create, for example, a knowledge-based expert system, which may diminish the personal value of the knowledge expert.

The erosion of interfirm trust

The second critical barrier to co-creating the business value of RFID is the erosion of interfirm trust, particularly between the RFID solution provider firm and the developer firm. While it is difficult to ascertain a causal relationship between the difficulty in interfirm knowledge transfer and the erosion of interfirm trust observed in our case, we argue that these barriers are somewhat intricately inter-related and dynamically inter-played in the course of their technological problem-solving work practices.

There are many antecedent factors that contributed to the erosion of interfirm trust between the RFID solution provider firm and the developer firm, as well as between the developer firm and the automotive car dealership firm. At the surface level, we cannot ignore the economic impacts of the project that, over time and over budget, was on the erosion of interfirm trust. However, at a deeper level, we argue that the critical impact of the sociomaterial aspects of RFID technology was ignored by all the stakeholders, including the RFID solution provider firm, and that this factor contributed to much longer RFID research and development times, and consequently, to a substantial delay in meeting project milestones and to a significant project cost overrun. About the much higher development cost, the Owner and CEO of the RFID solution provider firm remarked:

"*Selecting the right RFID tag took too long: it would be interesting to monitor the solution end-to-end…We have lost financially, but at least we have a functional solution that can be sold. We anticipate a return on our investment in a year*".

Even the developer firm could not accurately estimate the time it would take to select the right RFID tags for the application. Initially, the solution developer team leader decided to design and develop new tags according to their functional specifications. However, none of these tags were satisfactory to the particular automotive yard inventory management practices and the local physical environment that required RFID tags to be integrated with the extant monitoring cameras and information systems. After a series of failures in research, development and testing, the development team leader decided to select active tags from RFID tag vendors. This iterative process was very time-consuming because though the locus of innovation was at the developer firm, the multiple testing had been rather done in the physical environment of the automotive yard (materiality), which involved the numerous interactions with the management team members, sales staff, after-sales services mechanics, and the automotive yard workers who handled the inventories. The solution developer team leader himself did not anticipate this lengthy time requirement. Although he initially agreed to share all the costs and profits with the RFID solution provider firm, he changed his mind in the middle of the project to demand compensation for the over-time; he was required to spend on the project. This new financial demand created personal conflict with the owner and CEO of the Start-up RFID solution provider firm, who stated: "*The owner of the RFID research and development firm is a great person, very intelligent and hard working person, but I had a very bad experience with him during this project. At the beginning of the project, we agreed that we were partners and that we would therefore share all the costs related to the development of the solution and the benefits generated by the sales of the solution. However, as the project was going, he wanted to get paid for the time he spent on the solution development and prototype*." The owner and CEO continued: "*Also, he did not meet the deadlines, and more importantly, he refused to transfer the knowledge gained during the whole development process to the knowledge management firm for knowledge codification prior to building RFID solutions in a large scale at low cost. This was a big financial risk for me: I can not rely only on one person to sell the solution. I have a big trust issue with him. He does not share his knowledge and the core of the firm lies in his hands. He changes his mind according to their needs: one day, he is an associate, and another day he becomes a developer consultant*".

Key Lessons Learned

The lack of attention to the sociomaterial dimensions of this RFID SEIS project that is discussed in the case study appears to be affecting a number of strategic and operational issues that are important to researchers and practitioners. We will discuss two key strategic issues for the RFID solution provider firm: (1) the difficulty in co-creating the business value of RFID SEIS, and (2) the necessary shift in the firm-level business strategy. We will also present two major operational issues from a perspective of the automotive dealership firm: (1) physical integration, and (2) inter-firm communication.

Strategic issues

Difficulty in co-creating the business value of RFID-based SEIS

One of key strategic issues of importance from the perspectives of the RFID solution provider firm and the development firm was the difficulty in co-creating the business value of RFID-based SEIS developed and implemented for the Canadian car dealership. As discussed in the case analysis section, these firms formed a strategic joint venture partnership with a shared vision of leveraging their RFID technological knowledge and RFID solutions to grow their RFID businesses. The strategic joint venture partnership had a formal agreement on shared costs and profits. Moreover, the Presidents of these firms initially shared high-level mutual trust at the onset of establishing the new partnership—prior to launching the RFID-based SEIS development project discussed in the case study. However, as discussed in the previous section on the critical barriers to co-creating the value, these firms experienced the frustrating difficulty in inter-firm technological knowledge transfer and the accelerated erosion of inter-firm trust. As discussed in the case analysis section, the RFID developer firm experienced unexpected longer lead time to complete the iterative process of research, design and testing of the RFID material components at the developer firm's facilities from November 2008 to March 2009. The main reason for the unexpected longer lead time was that the RFID material components had to perfectly fit with the existing IT infrastructure, local practice, and external environment (e.g. large outdoor yard) of the car dealership.

Even with the developer firm's extensive knowledge and experience of RFID development projects, the complex socio-technological processes of research, design, and testing were intricately intertwined with the material dimensions of RFID technology that were implemented and used at the physical outdoor spheres. In consequence, both the RFID developer firm and the RFID solution provider firm continued to miss the critical project milestones and the agreed delivery dates. These project delays largely contributed to the project budget overrun, suffering significant financial losses to the RFID solution provider firm, a start-up firm without abundant capital and cash flows. Similarly, the developer firm also incurred much higher development costs. This led the President to demand the new financial compensation for his development work, a shift away from the initial agreement on the shared costs and profits.

Their shared strategic vision for the growth of their firms required a reasonable positive return on investment from the RFID-based SEIS development project and the future development projects that would leverage the initial project. As discussed earlier in the paper, the initial strategic vision to leverage knowledge learned from the completed initial project and to mass customize the initial RFID-based SEIS for other firms in the vertical automotive industry in Canada had to be abandoned by the President of RFID solution provider firm largely because his firm encountered the critical barriers: the difficulty in inter-firm knowledge transfer and the erosion of inter-firm trust, which precluded the partnership firms to co-creating the business value from the initial RFID development project.

Necessary strategic shift from a RFID solution provider to a RFID solution integrator

From a perspective of the President of the RFID solution provider firm, his firm's core strategy was to provide an end-to-end RFID solution that meets a client's business needs. He tried to achieve this by forming the strategic joint venture partnership with the President of RFID development firm. However, as discussed earlier in the paper, it was very costly for the partnership to design and develop the initial RFID-based SEIS for the automotive dealership largely due to the intertwined state of the social and the material dimensions that impacted the RFID development process. Furthermore, the RFID solution provider firm pursued a mass customization strategy for the partnership to leverage new knowledge created through the actual experience of the initial project and to mass customize the initial "RFID solution" for further sales in the vertical automotive industry. A mass customization strategy aims at "producing goods and services to meet individual customer's needs with near mass production efficiency" (Tseng et al. 2001) (p. 685). In order for him to realize a positive return on investment from the initial "RFID solution" development, he needed to acquire, transfer, and use RFID technological knowledge from the developer firm to a third-party knowledge management firm. However, the critical barriers experienced by the partnership firms made the President of the RFID solution provider firm to reflect on the future value of the strategic partnership and its likely success in leveraging the initial "RFID solution" to mass customizing and co-creating the future value from the investment in the initial RFID development. Over time, the President of the RFID solution provider firm made a significant strategic shift on his firm's core competence and capability, away from a RFID end-to-end solution provider toward a RFID solution integrator. As a RFID solution integrator firm, he does not need to lock in a single trusted RFID solution developer firm; instead, he can pick and choose any combination of developers and RFID hardware vendors to meet the client's varying needs in a timely manner.

Operational issues

Physical integration issues

This case study identifies two types of physical integration issues, namely: (i) the lower level of integration, which encompasses the selection and/or design and the integration of all material components (e.g., RFID tags, readers-antennas, middleware and RFID auxiliary devices) required to obtain an optimal RFID architecture for a given RFID-based SEIS, and (ii) a higher level of integration, which involves the integration of RFID architecture with all material components of the existing firm SEIS and material components of the physical environments of RFID implementation. In the case study, the successful lower-level integration was based on the development of a new helical high-gain antenna to allow better power transmission between the RFID readers/antennas and RFID tags. Regarding the higher level of integration, two new materials were developed, namely the coordinator to connect and manage the RFID tags, readers/antennas and the helical antenna, to create a link between the RFID physical infrastructure and part of the car dealer's current IT infrastructure. Also, a new interface general-purpose input/output device called Pro-GPIO was developed to connect the coordinator to the alarm panel for areas management to which pertain the management and monitoring of all Firm CD cameras.

Interfirm communication issues

As discussed, the RFID project involved a total of six firms with different interests and different expectations. In consequence, interfirm mutual understanding and communication practices were challenged. There were different perceptions about the level of completeness of the RFID solution among the different stakeholders. On the one hand, the developer firm saw 100% completion. On the other hand, the car dealership firm was dissatisfied with the level of the solution completeness. The car dealership firm wanted the RFID solution provider to assure the proper running of the RFID system implemented at the client's site, which the President of the RFID solution provider agreed, both assessing the implementation as a 95% success. However, the designer viewed the client's request as an added-on support and maintenance work which would incur an additional service cost. The existing different perceptions about the level of RFID-based SEIS implementation - commonly used by multi-stakeholders in IT project environments, were not articulated by interfirm communications. The lack of effective interfirm communication created costly misunderstanding among the different stakeholders, and contributed to the erosion of interfirm trust.

Conclusions

Orlikowski (2007, p. 1437) argued that "there is no social that is not also material, and no material that is not also social." Iedema (2007) also called for a paradigmatic shift in organizational research by viewing the social and the material as co-emerging in organizational practices. In our paper, we have adapted a sociomaterial perspective to address the four research questions, including the question on whether and how we can co-create business value for RFID-based SEIS development in multiple-stakeholders environments. We have conducted a longitudinal case study of an innovative RFID-based SEIS for automotive yard and after-sales services in a vertical automobile industry in Canada. The analysis of this longitudinal case study has identified interfirm knowledge transfer and the erosion of interfirm trust as critical barriers to co-creating the business value from innovative RFID-based SEIS in a car dealership firm. Moreover, the analysis of the longitudinal case study allowed us to address all our four research questions. Indeed, using a phase-by-phase approach, key stakeholders in this project have successfully designed, implemented and used an RFID-based SEIS for automotive yard, which allowed the car dealer firm to solve a recurring problem of theft of auto parts (e.g., catalytic converter) from its automotive yard. Our future research directions include the need to validate our key findings in other industry settings.

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