

When Is RFID Perceived as a Radical Technology?

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Abstract. RFID Technology has been in existence since the 1940's when it was used to differentiate between friendly and enemy aircraft in World War II. Its application in the business world is however relatively new. RFID has the potential to revolutionize supply chains and take product tracking to a new level. However, its adoption has been slow not only because of the higher cost of tags compared to barcodes but also because many companies have not been able to figure out how to effectively use it. In this study we focus on one of the key issues companies face when they try to evaluate RFID i.e. its radical and disruptive nature. Using data from semi-structured interviews we build a case for why organizations may perceive RFID as a disruptive and radical technology. Perceived radicalness of a technology is presented as a second order formative with five critical dimensions. Testable hypotheses are proposed for each dimension and its contribution towards the "radicalness of RFID".

Keywords: Radical Technologies, Perceived Radicalness, Adoption, RFID, Emerging Technologies.

1 Background and Introduction

"RFID will have a pervasive impact on every aspect of civilization, much the same way the printing press, the industrial revolution and the Internet and personal computers have transformed society.... RFID is a big deal. Its impact will be pervasive, personal and profound. It will be the biggest deal since Edison gave us the light bulb."

-Rick Duris, Frontline Solutions Magazine, December 2003

The "digital wallet," "the personal data warehouse," "unison," "ubiquity," and "universal:" these terms characterize current discussions of cutting-edge information technologies. Information technologies (ITs) pervade modern daily life and continue to move into previously analog spaces, such as our money management (smart phones with digital cash chips built in), basic information in our lives (PDAs, smart phones, etc.), and any communications we conduct (email, SMS, cellular communications, MySpace and blogs, etc.). Radio Frequency Identification (RFID) technology provides the necessary cornerstone for identifying almost any item uniquely and digitally from a distance enabling new efforts with "blink" debit and credit cards, mass transit ticket systems, and a variety of industrial applications beyond the well-known application of replacing bar codes (i.e. Walmart's initial RFID efforts). Many of RFID applications in business promise to extend far beyond simple logistics. They can include smart sensor units that track and report their status and self-reporting receipts and warranties built into items and controlled by their owners. A breakthrough

application of this fundamental change in identification technology (from prior analog or barcode systems) could disrupt the way businesses compete. RFID hence may be perceived as a radical technology offering great opportunity. Businesses know that there is great risk to attempting to apply such a radical technology. It will cost a lot and it will require substantial business process change to leverage its true potential. At the same time, businesses are also aware that great risk is present in failing to address RFID: it could displace the rules of business which lead to their current profitability.

The developer and the adopter of a new technology innovation represent two sides of the same coin. While one side helps create new and better technologies the other helps determine its impact and eventual success. Most characterizations of an emerging technology innovation such as radical, breakthrough, revolutionary and discontinuous are from the *creator/developer perspective* where these labels are used interchangeably to suggest technologies that are new and distinct and that provide significantly large rewards. The innovations are also characterized as disruptive because they have the potential to alter competitive position of innovating firms [16]. This research began with a broad, qualitative inquiry into the current efforts in business to apply RFID. A substantial literature review showed that research has yet to address the issue of RFID's radicalness and its implications from the adopter's perspective. Thus, we conducted intensive 1-2 hour interviews with 12 senior managers in 10 large or medium organizations (6 Fortune 500, 1 Major IT consulting firm) to better understand what are the special risks and opportunities present in a radical platform IT innovation such as RFID and how organizations deal with them. We report the findings of this research here. We show how research must clarify the meaning of radicalness as it applies to adoption of new IT in order to make it useful for academic and practice purposes.

It is often assumed that term radicalness of an innovation is clearly understood and means the same for all researchers and managers. This however is far from truth. Different people characterize the same innovation as radical for very different underlying reasons. This lack of definitional clarity belies understanding the inherent attributes of radicalness for effectively understanding radical technologies and innovations. Researchers often face ambiguity in understanding and explaining the effects of radicalness on adoption and implementation decisions and outcome due to this lack of clarity.

We address this literature gap and argue that the radicalness of a technology innovation is inherently related to technology adoption. To be understood more completely the IS research community needs to conceptualize radicalness as a multi-dimensional construct including user perceptions and their application context along with the inherent technology attributes. The conceptualization of radicalness in technology adoption we present herein extends work by Sood and Tellis [17]; Chandy and Tellis [2]; Henderson and Clark [10] on innovation attributes by incorporating technology-organization-context focused dimensions which, we argue, will enable radicalness to better explain when and why a technology will experience adoption resistance or success.

We begin by discussing the role of technology radicalness in new technology adoption and making a case for its relevance in adoption studies. We follow with a discussion on prior conceptualizations of technology radicalness in the innovation literature. We define perceived radicalness of a technology as a second order formative construct and present its five critical dimensions while discussing their contribution towards RFID's radicalness. Testable hypotheses are proposed for each dimension and

its effect on perceptions of RFID's radicalness. We support our conceptualization through the data collected from semi-structured interviews in an emerging technology adoption context and more specifically in our current empirical study of the adoption of Radio-Frequency Identification (RFID) technology.

2 Literature Review

As technology relates to innovations, configurations of business process can be implied by and built into the structure of technologies, directing specific usage behaviors that, if faithfully followed, will yield the intended benefits of the technology [4]. Radical technologies are very different from incremental technologies. They are likely to require specific usage behaviors that vary greatly from the existing behaviors within the affected organizational business processes for their implementation. As a result, radical technologies are less frequently adopted than incremental innovations [3], appear more complex to adopters and generate uncertainty about the resources required to use them effectively [8]. It has been suggested that perceptions of a technology's radicalness may influence its adoption and need to be better understood [1].

To address differences in adoption patterns, we focus on radical technology-enabled business process innovations, as this is an area where consultants and practitioners focus their efforts to improve business. These innovations require a higher perspective than that of the individual user. At a minimum, we must look at multiple users to isolate steps and sequences in adoption. Business process innovations involve group level convergence of technology, people, and process producing some non-incremental change in the status quo – a “radical” innovation. It follows that any conceptualization of radicalness to understand business innovation will need to address at least a group or in some cases a business unit or an organization.

2.1 Radicalness in RFID

RFID is an infrastructure technology [11] associated with platform innovation [17]. As such it requires substantial initial investment and future follow on investments with significant changes in the routines and practices of organizations to realize benefits. This degree of change coupled with the newness of RFID to commercial endeavors indicates that decision-makers would likely perceive it as highly radical. RFID technology has a potential to become a disruptive technology [13] with a profound impact on business and society. RFID adoption in a firm poses the issue of modifying and altering the business processes to leverage the benefits from it, and it has yet to be widely applied in practice, indicating substantial newness. In this sense, adoption of RFID may be characterized as risky and disruptive as it brings about changes in structure and functioning of organizations. To realize supply chain benefits from RFID adoption, synergies need to be built propagated through multiple organizations, as is happening with Wal-Mart and its suppliers. Such inter-organizational systems changes are complex and involved heightened uncertainty and potential for gain [12]. Though some technologies exhibit one or two of the characteristics of radicalness, few exhibit them all. RFID presents a context ideal for studying radicalness because it involves high expense and risk as well as great potential for gain.

2.2 Prior Conceptualizations of Innovation Radicalness

Most of the prior literature views innovations dichotomously (i.e. product or process, administrative or technological and incremental or radical) [9]. An innovation is defined as radical if it is both new and introduces a magnitude of change [6]. Radical innovations are characterized as competence destroying [18] often making existing skills and knowledge redundant. Dewar and Dutton [5] recognize radical innovations with high degree of new knowledge embedded in them. These categorizations while useful are incomplete as they leave out perceptions of radicalness within an application context. The fact that existing technologies may display a characteristic of radicalness directly contradicts the notion that radicalness must be new-to-the-world or inherent in a technology. Indeed, taken as a whole, existing literature argues that radicalness is in the eye of the beholder but that beholder may be a group or organization when it comes to understanding radicalness of platform technologies such as RFID. A conceptualization of technology radicalness that includes perceptions of its radicalness within its application context has yet to be well formulated.

3 Conceptualization and Hypotheses: Perceived Radicalness a Multidimensional Construct

A five item scale for perceived radicalness was proposed [7] that tried to capture the radicalness inherent in a technology innovation. The scale was later extended and used [15]. However, we believe that radicalness as a concept needs to be looked at from the adopter's perspective where attributes inherent to the technology interact with its application context. Henderson and Clark [10] provide three factors that capture radicalness in terms of the changes in a product innovation. We extend their conceptualization into a technology adoption context by including the new knowledge and changes an innovation mandates for successful adoption. Hence we propose a multi dimensional construct of "Perceived Radicalness". Consistent with this prior work we have defined the perceived radicalness to include the following five dimensions: 1) embedded knowledge in the technology or product knowledge; 2) knowledge and prior experience in the application of technology or business application knowledge; 3) changes in fundamental concepts of the business activities to which it is applied or business concept change; 4) changes in the resources needed for the business activities to which it is applied or business component change and 5) changes in the business processes of the business activities to which it is applied or business linkage change.

The following sub-section delineates each dimension along with its role in RFID being perceived as radical:

- 1) Product knowledge: Encompasses the knowledge about a specific technology, particularly its features and capabilities, resources required to operate it and its limitations. In the RFID context, the knowledge about RFID (How does it work? What are its limitations?) would constitute the knowledge about the technology or product knowledge. Organizations that are unaware of RFID's unique features and capabilities are likely to perceive it as radical due to high knowledge barriers. Hence,

H1: Lower level of product knowledge will contribute towards higher perception of radicalness of RFID

- 2) **Business application knowledge:** Encompasses knowledge about the settings and contexts in which a technology could be applied in a given business. The knowledge about how RFID could be utilized in a current business setting (for example inventory tracking, theft prevention etc) to leverage benefits would constitute business application knowledge. This knowledge can be thought of as an intersection of technology with business and may be very context specific. Greater application knowledge will allow businesses to visualize and use RFID in unique and unexpected ways contributing towards its radicalness.

H2: Higher level of business application knowledge will contribute towards higher perception of radicalness of RFID

- 3) **Business Concept Change:** Encompasses changes in underlying ideas of what a business does and can do including how it makes money and what its products or services are. RFID tag and reader enable the unique item-level identification, non-line of sight, real time and parallel processing of identification data. All of these scientific concepts are embedded in the technology. However, the use of RFID in business activities such as asset management would lead to a change in the concepts of how that activity is and can be conducted. Fundamental and conceptual changes in the way the business is conducted will contribute towards RFID's radicalness.

H3: Higher level of changes at the conceptual level of the business activity will contribute towards higher perception of radicalness of RFID

- 4) **Business Component Change:** Encompasses changes in assets and resources that are available to a firm including employee skills, IT, systems and equipment for doing its business. In the context of RFID use, the readers and tags, other hardware, software, systems and sub-systems and people would be components associated with the RFID innovation required to execute a business activity. Any improvements, replacements, additions or removals of existing components would mean a change in components for the business activities. The level of change in components will be high when RFID technology is to be used to accomplish business tasks that were manually performed in the past, because the innovation adoption may involve all of the above-mentioned changes. Greater need for change in resources will cause greater disruption in the current activities of the business contributing towards RFID's radicalness.

H4: Higher level of changes at the component level of the business activity will contribute towards higher perception of radicalness of RFID

- 5) **Business Linkage Change:** Encompasses changes in the processes including tasks and routines by which a firm links its business components to execute its business model. In context of RFID, linkage change applies to how the tags, readers, other hardware, software, middle-ware, other systems and people are inter-connected to accomplish the business activity. Any change in the way components are connected through tasks and processes for

accomplishing a business activity would mean a change in linkages. Greater linkage change will contribute towards RFID's radicalness.

H5: Higher level of changes at the linkage level of the business activity will contribute towards higher perception of radicalness of RFID

4 Data and Methodology

We wished to explore the meaning of radicalness of an innovation for the adopting organizations, why organizations perceive some innovations as more radical than others, and how radicalness may impact their decision to adopt and integrate a technology-based innovation. Prior literature showed inconsistent definitions and incoherence across fields in understanding radicalness in innovation adoption. In such a case, interpretive research focusing on exploring the unknown phenomenon best serves to initiate a valid and accurate line of inquiry [19], [14] precisely our underlying research goal. To accomplish the above-mentioned goals and to develop a better understanding of the adoption process, we conducted in-depth, semi-structured interviews using a convenience sample. The interviewees were executives and RFID program managers and supply chain managers across 10 organizations (12 interviews) involved in RFID initiatives at some level. We sampled from three perspectives in order to triangulate and, thereby, strengthen our understanding of radicalness of RFID adoptions. These perspectives were the adopter perspective (7 firms and 8 interviews in three industries: manufacturing, retailing, and logistics), the implementer perspective (1 top IT consulting firms and 2 interviews), and the vendor perspective (2 firms and 2 interviews).

The interviews were conducted over a period of three months (May-July, 2005) and were either face to face or over the phone, lasting between one and two hours. The questions for the interviews were a mix of open-ended questions and closed questions to allow both the flexibility of exploring new contexts but also to help maintain focus on some of the previously identified relevant themes. At the time of the interviews, we were not exploring radicalness as perceived or context dependent. These themes emerged from the data and were later developed conceptually, because of what we found from practice.

The interviews were recorded and later transcribed. The authors coded the interview data in an effort to extract key ideas underlying the concept of innovation radicalness for managers evaluating emerging technologies such as RFID. This coding process involved the first author identifying patterns and underlying themes that emerged from quotations in the raw text, excerpting them and bringing them to the other two authors for joint discussion and refinement over a period of 7 months and more than 20 hours of discussion.

5 Discussion

We became aware that all three perspectives were unified in seeing RFID adoption radicalness as a continuous, context-dependent phenomenon with multiple dimensions. Prior conceptualization of radicalness as dyadic or non-perceptual does not fit these data from practice. The context dependency fits well if we expect radicalness would be perceptual for innovation adoptions.

Some of the key quotes of managers that were interviewed are presented in Table 1 (Appendix) as a representative sample that supports our multi-dimensional conceptualization of radicalness as perceived and depending upon prior experience and application context. Table 1 also shows the major patterns and underlying themes found as a result of the coding and analysis process.

Repeated mentions of “need for learning” and “need for high level of changes in business processes and infrastructure that could prove disruptive” by the interviewees suggest support for multiple dimensions of product knowledge, business application knowledge, change in business linkages and business components. Another important theme that emerged from the interviews was about paradigm shift in the way a particular business activity is conducted. This idea is also reflected in our proposed dimension of change in business activity concepts.

6 Implications for Practice and Theory

This study addresses an important question i.e., why RFID might be perceived as radical by its adopters? In doing so it also discusses what radicalness means and how perceptions of radicalness may influence adoption decisions.

The conceptualization of radicalness as a multi-dimensional construct has implications for both theory and practice. For the practitioners our conceptualization addresses the issue of “lack of definitional clarity” and enables managers to understand the inherent attributes of innovation radicalness. This will allow managers to effectively develop or respond to radical innovations. From the theoretical and academic perspective, our conceptualization opens the “black box” of radicalness by proposing a multi-dimensional construct. This will enable researchers to reconcile seemingly disparate results and aggregate their understanding of role of radicalness in innovation adoption.

7 Conclusion

Overall the data from interviews supports our conceptualization of radicalness as a perceptual and formative multidimensional construct with the five proposed dimensions. We expect to test our proposed hypotheses as an extension of our current work. We believe that our conceptualization of radicalness will further the understanding of the role of “Perceived Radicalness” construct on RFID adoption and implementation decisions.

References

1. Ciganek, A., Zahedi, F.M.: Radical! The Influence of Perceived Radicalness on Technology Acceptance. In: Proceedings of the Tenth Americas Conference on Information Systems, New York, NY (August 2004)
2. Chandy, R.K., Tellis, G.J.: The Incumbents Curse? Incumbency, Size, and Radical Product Innovation. *Journal of Marketing* 64, 1–17 (2000)

3. Damanpour, F.: Organizational Complexity and Innovation: Developing and Testing Multiple Contingency Models. *Management Science* 42(5), 693–716 (1996)
4. DeSanctis, G., Poole, M.S.: Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization Science* 5, 121–147 (1994)
5. Dewar, R.D., Dutton, J.E.: The adoption of radical and incremental innovations: an empirical analysis. *Management Science* 32(11), 1422–1433 (1986)
6. Ettlie, J.E., Bridges, W.P., O’Keefe, R.D.: Organization Strategy and Structural Differences for Radical Versus Incremental Innovation. *Management Science* 30(6), 682–695 (1984)
7. Gatignon, H., Tushman, M.L., Smith, W., Anderson, P.: A Structural Approach to assessing Innovation. *Management Science* 48(9) (September 2002)
8. Gopalakrishnan, S., Damanpour, F.: Patterns of Generation and Adoption of Innovations in Organizations: Contingency Models of Innovation Attributes. *Journal of Engineering and Technology Management* 11, 95–116 (1994)
9. Hage, J.: *Theories of Organizations*. John Wiley and Sons, New York (1980)
10. Henderson, Clark: Architectural Innovations, The reconfiguration of existing product technologies and failure of the firms. *Administrative Science quarterly* 35 (1990)
11. Kauffman, R.J., Riggins, F.J., Curtin, J.: Working paper. University of Minnesota, Minneapolis (2004/2005)
12. Karimi, J., Konsynski, B.R.: Globalization and information management strategies. *Journal of Management Information Systems* 7, 7–26 (1991)
13. Krotov, V., Junglas, I.: RFID as a disruptive innovation. *Journal of Theoretical and Applied Electronic Commerce Research* 3(2), 44–59 (2008)
14. Lee, A.S.: Integrating positivist and interpretive approaches to organizational research. *Organization Science* 2, 342–365 (1991)
15. Lyytinen, K., Rose, G.M.: The Disruptive Nature of Information Technology Innovations: the Case of Internet Computing in Systems Development Organizations. *MIS Quarterly* 27(4), 557–595 (2003)
16. O’Connor, G.C., McDermott, C.M.: The Human Side of Radical Innovation. *Journal of Engineering Technology Management* 21, 11–30 (2004)
17. Sood, A., Tellis, G.J.: Technological Evolution and Radical Innovation. *Journal of Marketing* (69), 152–168 (July 2005)
18. Tushman, Anderson: Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly* (31) (1986)
19. Yin, R.K.: The Information Systems Research Challenge: Qualitative Research Methods. In: Cash Jr., J.I., Lawrence, P. (eds.), vol. 1, pp. 1–6. Harvard Business School, Boston (1989)

Appendix

Table 1. Key Quotes from Managers

#	Key Quotes	Organization	Underlying Themes
1	We find benefits but RFID is not on our priority list and we don't think we are ready as we <i>don't have the infrastructure and expertise to process huge amount of data</i> that would be generated by it and make sense out of it. Lack of standards and cost of tags and readers is prohibitive. Also RFID will be <i>a major change for our company in overhauling our business processes.</i>	A	Business Application Knowledge, Business Component Change, Business Linkage change
2	For RFID we could easily identify which tag would work and what device would work for our products, that didn't take very long, less than six months but now we are facing a <i>major issue as far as its application. How much changes you have to do to all the existing ERP systems and front end business applications required in its application, we are not clear as there may be a lot.</i>	G	Business Application Knowledge
3	Smaller organizations see RFID as an opportunity to make two leaps at once and hence displace some of the existing organizations. Also I believe that it is <i>more perceptual and determined by the business context</i> in which it is applied. For us, in terms of retail checkout at this point it is not a major change, as it does not fundamentally change the business process. But going into the future, when there is item level tagging, and automated checkouts. It may be a paradigm shift because it <i>Eliminates the basis of our business. We may have to kiss our scanning and retail business goodbye.</i>	J	Business Concept Change, Business Component, Business Linkage Change
4	RFID would require <i>altering our existing optical scanners infrastructure and processes currently in place. A lot of learning, major changes in infrastructure may be required.</i> This would be <i>disruptive</i> for the organization.	C	Product Knowledge, Business Application Knowledge, Business Component Change, Business Linkage Change