AN ANALYSIS OF THE RFID INDUSTRY:

WHY IS CAPTURING VALUE IN THIS INDUSTRY SO TRICKY?

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Introduction

Radio Frequency Identification (RFID) is a technology that allows firms to identify, track, and know real-time information about individual items. The ability to interact with individual items this way holds great economic promise for a number of industries. In the retail industry for example, RFID systems under development will soon be able to significantly reduce "shrinkage," the theft or loss of inventory, and "stock-out," running out of a product in stores. Within the consumer goods industry, there will be drastic improvements in "invoice deduction," which is the difference between the "good" inventory that suppliers, such as P&G, ship to Wal-Mart and the "good" inventory that retailers, like Wal-Mart, claim to receive. This difference can be driven by damage, spoilage, theft, and other factors. Wal-Mart has estimated that implementing RFID will cut supply chain costs by 6% and P&G estimates savings in its supply chain of around 10%[1]. These savings equate to about $6B annually for Wal-Mart[2]. Currently, RFID solutions are being implemented in over thirty applications across more than ten different industries.

Supporting this rapid innovation are approximately four hundred companies worldwide, 80% of which are focusing their efforts in the United States[3]. Many of these companies are pursuing opportunities within RFID using promising combinations of uniqueness and complementary assets. Several firms have made serious attempts to create and capture value by creating network externalities and the associated lock-in potential. Despite these efforts, these companies have yet to realize substantial economic success and many of these companies will likely never realize long term success. The RFID industry is a young industry, only in the ferment stage of its evolution. Only more recently have leaders begun to emerge from among the four hundred firms in the industry. In addition to basic evolutionary pressures like finding a dominant design, there are a number of other factors driving the difficult outlook for many RFID firms. These factors include the maturation of extra-RFID technologies, the role of standards, the fragmented mapping of RFID technologies to RFID applications, and the role of large scale solution providers.

In order to illustrate the trickiness of capturing value in the industry, these factors along with the efforts of the industry's leaders are discussed below and are the focus of this paper.

The ABC's of RFID

In every RFID system there are two primary components, a transponder known as a "tag" (or "label" if it is also integrated into adhesives for placement on boxes) and a device called a "reader". When a tag passes within a given proximity of a reader, data stored on the tag can be retrieved by the reader and the reader can write information to the tag. A tag is comprised of three major elements: the chip, the antenna, and the packaging (shown in Figure 1). The chip provides the tag with the ability to interact with the reader and also stores the data on the tag. The antenna allows the tag to communicate with the reader and the packaging binds the chip and antenna together to form the tag. About ten years ago, these components were made by separate companies and specialty manufacturers were then paid for tag assembly. Today, tag producers are typically fully integrated, except for a handful of "special form factor" tag producers that purchase chips and perform the remainder of tag production in house. There is no consistent pattern of reader development. Some reader producers outsource major portions of their design and manufacturing while other producers maintain these activities in house.

A simplified RFID value chain is shown in Figure 2 below. While many of the four hundred RFID firms employ strategies in various combinations of the activities in Figure 2, the emerging leaders in the industry focus on the three predominant strategies. The first of these strategies is to focus on the production of RFID tags and innovate by creating superior manufacturing technologies for high volume production. Alien Technologies is the leading "Tag Producer", and its proprietary Fluidic Self Assembly (FSA) manufacturing process allows the company to produce millions of tags per hour while many

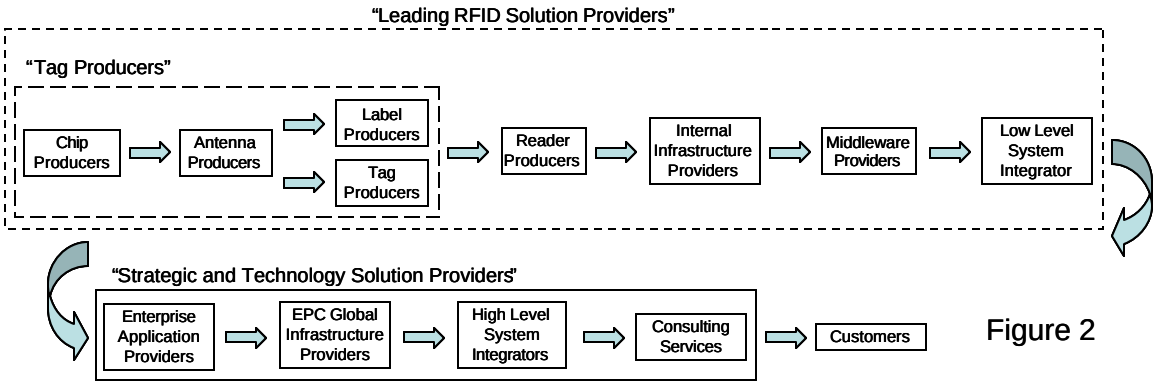

Figure 2

other tag producers can turn out only about ten thousand tags per hour[4]. More traditional chip-makers like Texas Instruments and Hitachi, however, have begun producing tags and are beginning to catch up to Alien. The second predominant industry strategy is to be a "Leading RFID Solution Provider" (LRSP) and design and provide end-to-end solutions that either stand alone or integrate into existing enterprise systems. The two leaders using this strategy, Intermec and Symbol Technologies, are fierce competitors and employ interestingly different approaches to this competition. The third major strategy within RFID is to act as a "Strategic and Technology Solution Provider" (STSP) and provide enterprise level design and implementation expertise. Industry leaders such as Accenture and IBM Global Services are aggressively pursuing opportunities in RFID, and other heavy weights like Oracle and SAP are also leveraging their services practices to extend their RFID activities beyond software sales.

One other important characteristic of the RFID industry today is that about half of the thirty applications being pursued are related to upgrading supply chain management practices. This focus on logistics optimization is being driven by the significant end-user improvements that can be obtained in supply chain throughput, accuracy of information, and "global" visibility of product flow among all participants in the chain. Leading the way in these efforts are Wal-Mart and the U.S. Department of Defense, both of which have issued mandates that require their suppliers to employ RFID solutions according to imposed deadlines. Other RFID applications, like personnel identification and animal tracking, are much smaller in comparison. For these smaller

applications, Figure 2 still accurately depicts the value creation process, except that customers can often make the tag, reader, and low-level integration decisions on their own or with the assistance of an application-specific low-level integration specialist.

The Role of Uniqueness and Complementary Assets

Many firms within RFID are attempting to create and capture value using combinations of uniqueness and complimentary assets. Within uniqueness, three firms standout: Alien Technologies, Symbol Technologies and Intermec. Alien Technologies carries multiple patents on its FSA tag production system. This system is noted not only for its incredible high volume capacity, but also for the convenience associated with tags being delivered in rolls that can easily be integrated into the distribution system machinery of customers. Protecting the FSA production system promises to provide a potentially powerful "control-point" based competitive advantage for Alien, since there will eventually be trillions of tags produced and used annually within global supply chains and perhaps only a few firms capable of supplying this demand[5].

Intermec and Symbol Technologies hold a combined 275 RFID patents[6]. These patents cover the designs of tags and readers, along with other products that are included in their end-to-end RFID solutions. Of particular note, are Symbol's fifteen patents on its PICA tag production system, the only other tag production system capable of building over one million tags per hour[7]. Even more impressive are Intermec's set of "core" RFID patents purchased from IBM in 1996, patents upon which all current RFID technology is based[8]. Symbol's patents create a potential competitive edge over Alien since they allow Symbol to effectively match Alien's tag production rates and provide more "high-touch", integrated and reliable end-to-end solutions to customers. Symbol also enjoys another potential advantage, since Intermec cannot match Symbol's tag production capabilities and is not attempting to do so. By pursuing a more vertically integrated strategy, Symbol is gaining insight into RF technology that Intermec can acquire only through strong relationships with tag producers. For

Intermec, setting appropriate rates for licensing its core patents should ensure at least modest economic success, since Intermec is receiving royalty payments from most firms in the RFID industry.

Complimentary assets are also vital to the success of Alien, Symbol, and Intermec. By working closely with Wal-Mart, Alien has created a strong relationship that will generate future business and also assist with building new partner, distribution, and customer relationships. Alien has also realized significant learning economies from this relationship, and has steadily improved upon an initial tag failure rate of 20%[9]. Symbol and Intermec both possess significant complementary assets including established customer bases, industry relationships, research and development competencies, existing sales and marketing channels and great reputations. Intermec possesses stronger and more extensive industry relationships, both by necessity and by it's inclusion on Microsoft's RFID Council. Of the members of this council, Intermec is the only major RFID hardware firm. The remaining members of the council include Accenture, the leading middleware providers, Provia Software and HighJump Software, and the leading low-level system integrators, Manhattan Associates and GlobeRanger Corporation[10]. In addition to these strong relationships, Intermec should also receive preferential access to Microsoft's general RFID solution partners which include HP, Infosys, Intel, Intellident and Regio[11]. These extensive industry relationships are the key for Intermec's strategy to compete against Symbol.

Figure 3 shows how various types of RFID firms might fare in their ability to capture value using uniqueness and complimentary assets. Overall, the prospects for successful value capture look relatively promising. With "easy to maintain" uniqueness and "tightly held" complementary assets, the future looks bright for Intermec, Symbol and Alien. The prospects for

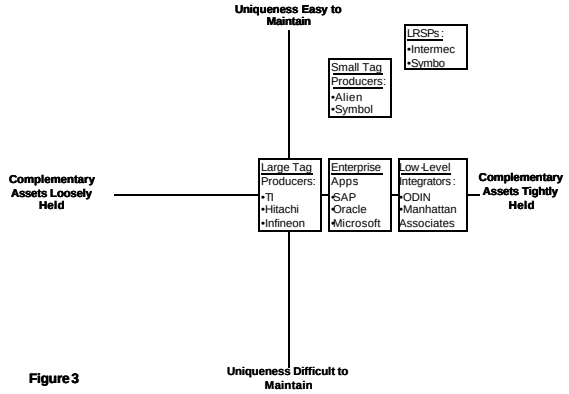

Figure 3

low-level integrators and enterprise application providers are not as good, because the solutions that they develop are expected to spillover into general industry best-practices within a short period of time. The outlook for large tag producers is less clear, since they are focusing their efforts on producing tags and are behind Alien and Symbol in learning. It is also unclear as to whether the extensive complementary assets that they possess in other industries and applications areas will yield substantial benefits within RFID.

The Role of Standards

Standards play a crucial role in the development of the RFID industry and significantly affect the value capture possibilities for firms in the industry. This critical role has its roots in the barcode industry, the industry that RFID is replacing. The first commercially successful barcode effort was started in 1969, when the National Association of Food Chains hired McKinsey & Company to help study and establish a "product marking standard" for the grocery industry. From this work a non-profit group was formed in 1970, known today as the Uniform Code Council (UCC). The UCC's first action was to request product marking proposals from IBM, RCA, and NCR. In 1973, a standard based on a proposal from IBM was published as the industry standard and IBM and NCR brought the first barcode products to market in 1974[12]. Since 1974, these "public/open" standards have been maintained by the UCC and the European Article Numbering Association (EAN). The EAN is a governing body similar to the UCC and was founded in Europe in 1977.

In the mid-1990's the first firms in RFID developed their products and solutions using solely proprietary standards since no alternatives were yet in existence. These firms guarded their standards closely since they were the source of early competitive advantage. In 1999, the Auto-ID Center was established at MIT in order to create a set of hardware, information and communication network standards so that a global network for tracking product flows could be created. The Auto-ID Center established basic standards in each of these areas. In 2003, the Auto-ID Center and was closed when the UCC

and EAN formed a joint venture called EPCglobal, which licensed these standards from MIT. Since 2003, EPCglobal has managed a set of public/open standards that now dominate much of the RFID industry. In fact, proprietary standards today can only be found in smaller applications like animal tracking.

In December 2004, EPCglobal standards were strengthened even further when Generation 2 RFID standards were implemented[13]. Generation 2 standards achieved this strengthening by consolidating and streamlining three previously incompatible public/open standards: (1) EPCglobal high-frequency (HF), EPCglobal ultra-high frequency (UHF) and (3) ISO 18000-6 UHF[14,15]. The adoption of Generation 2 was spurred on by end-users and governments seeking to pay less for RFID systems in the coming years. Generation 2 public/open standards have effectively combined three artificially separated markets so that greater economies of scale and lower average total production costs on RFID equipment can be realized. While this development is potentially great news for end-users and consumers, it is not so promising for many of the firms in the RFID industry. Figure 4 shows the progression of standards within the industry over the last decade. Within the broad application of supply chain management (SCM), these standards have migrated toward a strong set of public/open standards that are leveling market segments making value capture increasingly difficult for firms in the RFID industry.

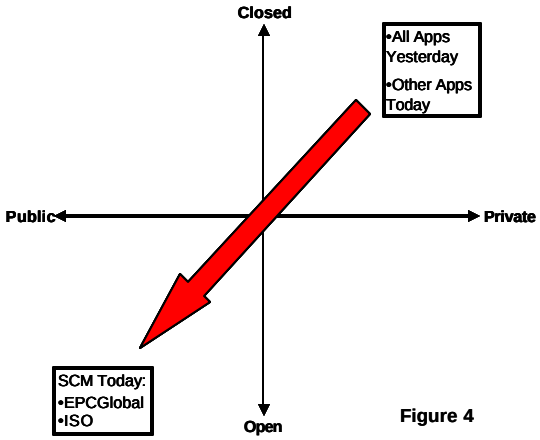

Figure 4

The Role of Network Externalities and Lock-in

Using network externalities and lock-in to capture value has so far been very difficult for RFID firms. The elusiveness of success with this approach is driven by limitations of RF technology, regulatory issues, and a general unwillingness among industry participants to allow any firm before them in the value chain to create substantial lock-in. Figure 5 shows a simplified mapping of RF technology to current uses and highlights some of the key enablers and barriers to in these applications. One of the key ideas to understand from it is that based on the physical behavior of RF waveforms, only certain specific implementations of RF technology can adequately serve certain applications well. Even within UHF, the predominant frequency band for use within supply chain management applications, the combinations of tags and readers, their relative orientations, and their spacing are critical and unique elements in correctly engineering RFID systems. Not correctly accounting for any one of these concerns will cause an RFID implementation to be unsuccessful. This idea manifests itself very powerfully since across the globe and within many individual end-users, there are no standard designs of loading docks, warehouse layouts, and IT infrastructure. Even if all of these elements were standardized and replicated using an Intel-like "copy-exactly" technique, the weather and simple changes in humidity would be the next issue to require more individualized solutions. It is important to note, then, that while EPCglobal's public/open standards are critical for coordinating and facilitating global supply chain integration, they cannot magically level all factors that create market segments.

Figure 5

Radio Frequency	Benefits	Limitations	Common Uses
Low Frequency (LF) 125 kHz – 134 kHz	•Frequency accepted worldwide •Works well near metal •In wide use today	•Limited read range, making it unsuitable for warehouse and many other supply chain related applications	•Animal ID •Beer keg tracking •Automobile ID and anti-theft systems
High Frequency (HF) 13.56 MHz	•Frequency accepted worldwide •Works well in moist environments •In wide use today	•Does not work well near metal •Limited read range, making it less useful for warehouse and many other supply chain related applications than UHF	•Library book tracking •Pallet and container tracking •Building access control •Airline baggage tracking •Apparel item tracking
Ultra High Frequency (UHF) 868 MHz – 928 MHz	•Read ranges longer than 6 feet •Rapidly growing commercial use (especially with supply chain applications)	•Frequency not licensed for worldwide use •Does not work well in moist environments	•Pallet and container tracking •Truck and trailer tracking (within shipping yards) •Tracking of individual items within pallets and containers
Microwave 2.45 GHz	Read ranges longer than 6 feet	•Frequency not licensed for worldwide use •Complex systems development required •Not in wide use today	Access control for vehicles

Derived from: Forrester 2003

Figure 5 outlines another key regulatory barrier to creating network externalities within UHF. Currently, UHF bandwidth is not uniformly allocated for RFID use throughout the world, and hence, it is currently impossible to fully integrate global supply chains using the RF technology that is best suited for the application. There is an integration plan for UHF currently under discussion among a number of governments. This plan divides the world into three major UHF regions and provides for compatibility among regulatory policies so that common bandwidth allocations enable UHF RFID devices to communicate on common frequencies worldwide[16].

Finally, even if there were no technologic or regulatory hurdles to creating network externalities and lock-in, RFID firms higher up in the value chain are simply not going to allow themselves to get locked-in to proprietary standards or certain suppliers. An interesting example of this dynamic played out last summer with Alien Technologies and their ALR-9780 reader. In February 2004, Alien introduced the ALR-9780, which along with their tags was fully EPCglobal compliant. However, one of the features of ALR-9780 was an operating mode that used a proprietary transmission protocol to effectively double the throughput and increase the accuracy of the distribution system in which it was installed. Despite this promising performance boost, few firms jumped at the opportunity to use this proprietary standard, and by September 2004, Alien completed and EPCglobal hardware interoperability test that further standardized this reader into the mainstream of available devices[17].

Taken together the issues of technology limitations, regulatory hurdles, and industry resistance to lock-in suggest that there is little chance for any RFID firm to develop a successful strategy that relies heavily on network externalities. These factors combine to really limit lock-in and tipping to local markets that are specific mappings of RF technology to certain applications--at least for the time being. Perhaps the best prospect for larger scale tipping in the future lays with Intermec and Symbol. Such a scenario would require a carefully crafted platform and product development strategy where Intermec and Symbol leverage their uniqueness and complementary assets to “pack-in”

enough disparate EPCglobal compliant RF technology into a single device. In creating such a device, Intermec and Symbol might be able to effectively combine current RFID supply chain markets into a single supply chain market and tip this market to their favor using superior solutions design or aggressive penetration pricing.

Challenges to Capturing Value for Tag Producers and LRSPs

The sections above outline the basic tensions contained within building a successful value capture strategy in RFID. You might even imagine a strategic planning meeting at Intermec that starts with uniqueness and complementary asset employment and concludes with the notion things will go really well. Then someone at the table says, "Not so fast, these public/open standards are going to kill us." The discussion then turns to how EPCglobal standards are pushing for homogeneous, commodity-like markets where economies of scale and scope are critical and competing on cost suddenly seems really important. This scenario represents a big departure from capturing significant value using easy-to-maintain uniqueness and tightly-held complementary assets. So someone else at the table then says, "Fine, if the RFID market is going to homogenize, how can we capture value by tipping this homogeneous market to us? Is there a way to use network externalities and lock-in here?" After some further discussion, it becomes apparent that EPCglobal's public/open standards are perhaps not as strong as everyone first thought. This is good news since the original strategy will now work better, but it is also bad news since alternative tipping strategies will not really work too well if they are needed.

Unfortunately for tag producers and LRSPs, the trickiness in capturing value does not end with these basic tensions. Other forces are at work as well, and these forces will significantly impact any value capture strategy under consideration. These forces can categorized as follows: (1) avoiding the past, (2) the effect of Wal-Mart leading the way, and (3) the lack of dominant designs and the threat of emerging technologies.

Avoiding the past

Firms higher in the RFID value chain are insistent about not allowing the history of the barcode industry or the electronic article surveillance (EAS) industry to play out again within RFID. For two decades, Symbol dominated the barcode industry by using a patent portfolio of over 800 patents to extract lucrative licensing fees from its competitors, prevent market entry by foreign firms and drive several competitors out of business through aggressive litigation[18]. Through its dominance, Symbol controlled the basic evolution of the barcode industry. Symbol could get away with its aggressive practices since a mass of adoption of barcode technology had already taken place within the grocery industry during the 1970's.

The EAS industry is another predecessor industry to RFID. EAS tags are very much like RFID tags except that they only store 1-bit of data (i.e. one true or false condition). When you buy a book at Borders and the cashier rubs your book across the magnetic plate for example, the cashier is changing the 1-bit tag in your book to tell the detector at the door that you have actually purchased the book. Without this action from the cashier, the sensors at the door will alarm since the EAS tag will report that the book has not been purchased. Within the EAS industry, Tyco Sensormatic and Checkpoint Meto enjoy an 80% combined market share. These two firms have also each separately introduced three incompatible types of EAS systems[19]. This practice benefits both Tyco and Checkpoint and clearly is more costly to every other participant in the EAS industry.

The Effect of Wal-Mart Leading the Way

In order to promote the rapid adoption of RFID, Wal-Mart will not allow scenarios like those above to either increase the cost of adoption or slow the rate of adoption through intellectual property related litigation. As a result of its efforts, Wal-Mart has produced some interesting effects on the rest of the industry. Wal-Mart has used its favorable bargaining power to curb Intermec's ability to profit from its core RFID patents. During the final adoption testing of

Generation 2 standards, Wal-Mart "convinced" Intermec to suspend all RFID royalty requirements for sixty days so that the adoption testing could be completed by more firms more quickly[20]. Even more detrimental to Intermec's long-run prospects is the pressure exerted by Wal-Mart and others to maintain low licensing fee rates. Currently, Intermec is charging royalty rates of 6% of the wholesale value of products sold. This compares to the 10% of wholesale value that Symbol charged firms in the barcode industry[21].

The Lack of Dominant Designs and the Threat of Emerging Technologies

Like many of other industries in the ferment stage of evolution, a dominant design is still under development and the firm(s) that establish the dominant design become the firm(s) that survive ferment and prosper as the industry moves through "takeoff." Within RFID, there are two key areas where no dominant design has been established. These areas are network infrastructure and tag and antenna production technology. Like Digital's mini-computers of the 1980's that never displaced mainframes and were subsequently replaced by PCs, today's RFID firms at the LRSP level and below are being threatened by challenges from two emerging technologies. Within network infrastructure, mobile phone makers like Nokia are pursuing product development strategies that integrate RFID functionality directly into mobile phones for use over existing 3G networks. While the exact impact of this development is unclear, this move represents a significant change in RFID solution design, where more traditional, off-the-shelf IT infrastructure is used. If Nokia were to become successful, firms like Symbol and Intermec might be forced to partner under unfavorable terms in order to develop their next generation products.

Within tag and antenna design, the emerging technology of "printed electronics" threatens to render many of today's RFID products obsolete. Instead of using silicon and copper based chip construction, printed electronic takes conductive materials like silver and prints them directly onto surfaces like labels. Currently this technology is being pioneered largely by firms in

electroluminescence and other applications that have little relation to RFID. One of the major promises of printed electronics is that tag design changes would be much easier and cheaper to effect. Instead of designing new production machines (and perhaps new production processes as well) to change tag designs, simply redesigning and changing the printer head on the label printer will permit the production of new tags and labels. There are additional potential technical benefits including greater flexibility in antenna designs[22].

It's Good to be a Strategic and Technology Solutions Provider

An analysis of the issues discussed above demonstrates that capturing value for tag producers and LRSPs is tricky and difficult. This same analysis, however, also demonstrates that the prospects for STSPs in RFID are much brighter. Driving this conclusion are several key factors. First, there are very few firms like Wal-Mart that have the technical capabilities and financial incentives to develop an RFID solution in-house. In fact, only a few firms like Proctor & Gamble, Gillette and Target are attempting such a strategy. This insight means that the vast majority of firms will seek assistance from some outside source—the question then is from whom? A survey conducted by the Aberdeen Group in March 2004 shows that 47% of all firms considering RFID implementations are planning on using STSPs or are unclear as to who they will use, meaning that STSPs are the likely choice[23]. This result should be expected since it is the STSP's that possess the human and knowledge capital required to reliably and efficiently design and implement RFID solutions.

Second, since STSPs create and capture value by heavily relying on human and knowledge capital, they are relatively insulated from the adverse effects that industry evolution and potential disruptions bring to tag producers and LRSPs. In fact, leading STSPs might even welcome these events as they could drive future client business as the cost of RFID systems continues to decline. Third, based on strong relationships within the industry and among their customers, STSPs are among the best positioned firms to identify and sell new innovative uses for RFID. Finally, there is currently a shortage of RFID-

related talent in the United States[24]. It is the STSPs that possess the majority of this talent, further strengthening the arguments above.

These dynamics can be seen by firms like Accenture continually operating at the forefront of RFID developments. In addition to its numerous partnerships and membership on Microsoft's RFID council, Accenture is actively positioning itself as one of the key thought leaders of the industry. By hosting major conferences and also piloting projects for the pharmaceutical industry, where the hardware is provided free of charge, Accenture is clearly strengthening its existing relationships and learning more about its client needs[25]. This strategy will permit STSPs like Accenture to effectively create and capture value within the RFID industry in the future.

Conclusion

RFID is a technology that promises to save billions of dollars annually for many companies that successfully take advantage of its abilities. Given the large amount of savings being generated by RFID, it is almost natural to assume that firms within the industry will do well. However, such an assumption would be too hasty as capturing value for vast majority of RFID firms is tricky at best. Large-scale system integrators like Accenture should prosper in RFID as they do in other industries. Many of the Accenture's potential industry partners will not be so lucky. Despite clever strategies employing uniqueness, complementary assets, network externalities and lock-in, many firms in RFID will not actually realize long term success, and many will not survive the industry's ascension into "takeoff." Pressures revolving around public/open standards, technology limitations, the current implementation leaders, and a desire among many end-users to not relive the past are driving this weeding out process. Analyzing the RFID industry, then, provides an excellent opportunity to gain insight into how tricky developing an effective value capture strategy can be.

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