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The hybridization of automatic identification techniques in mass market applications: towards a model of coexistence

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Abstract

The number and type of automatic identification technologies in the market have grown since the bar code was introduced in the retail sector in the late 1960s. This paper studies the selection environment of auto-ID and defines, describes and gives examples of three main patterns of innovation: migration, integration, and convergence. The findings indicate that technology adoption is not always about choosing the dominant design but about how to future-proof an auto-ID implementation. Enterprises wishing to adopt auto-ID techniques need to be aware that technology is not static, auto-ID techniques are not stand-alone, and consumers may have wide-ranging requirements for multipurpose auto-ID devices.

Keywords

Automatic identification, bar codes, magnetic-stripe cards, smart cards, biometrics, RFID, hybrid cards, migration, integration, convergence

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The Hybridization of Automatic Identification Techniques in Mass Market Applications: Towards a Model of Coexistence

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Abstract- **The number and type of automatic identification technologies in the market have grown since the bar code was introduced in the retail sector in the late 1960s. This paper studies the selection environment of auto-ID and defines, describes and gives examples of three main patterns of innovation: migration, integration, and convergence. The findings indicate that technology adoption is not always about choosing the dominant design but about how to future-proof an auto-ID implementation. Enterprises wishing to adopt auto-ID techniques need to be aware that technology is not static, auto-ID techniques are not stand-alone, and consumers may have wide-ranging requirements for multipurpose auto-ID devices.**

I. INTRODUCTION

The aim of this study is to describe the main patterns of change that have occurred in mass market automatic identification applications since the inception of the bar code. The automatic identification techniques that will be considered in this paper include: bar codes, magnetic-stripe card, smart card, biometrics and radio-frequency identification (RFID) tags and transponders. The central actor of this paper is the service provider of mass market applications who selects an auto-ID solution as a best-fit for a given case. New product launches may be required when an identification technology once selected as an optimal solution becomes obsolete, outdated, or incrementally improved- causing a company to seek new(er) technology options, or new combinations of existing technologies, to fulfill its obligations to its customers in order to remain competitive. For example, a financial institution may have opted for magnetic-stripe cards in the mid-1980s so that its account holders could make cash withdrawals at automatic teller machines (ATMs). However, due to a lack of security on the magnetic-stripe, and the rise in incidences of fraudulent activities, the bank is now forced to evolve its services by transitioning to smart card technology. It is this transition period which has received limited attention in the innovation literature, particularly in hi-tech devices like auto-ID. In mass market applications for instance, replacing all existing cards in circulation is cost prohibitive, and phased approaches are long and arduous projects which sometimes end in an unintended de-facto standard being established.

II. BACKGROUND

As opposed to manual identification, auto-ID is the act of identifying a living or nonliving thing without direct human intervention. Of course the process of auto-ID data capture and collection requires some degree of human intervention but the very act of authenticating or verifying an entity can now be done automatically. An entity can possess a unique code indicating personal identification or a group code indicating conformity to a common set of characteristics. Traditionally auto-ID has been synonymous with bar code labels on supermarket store items, financial transaction cards (FTCs) used to withdraw money from automatic teller machines (ATMs), and subscriber identity module (SIM) cards in mobile phones. Today auto-ID devices are being applied in very different ways to what they were originally intended. For instance, frequent air travelers can bypass immigration queues using their biometric trait, prisoners can serve their sentences from home by wearing electronic tags and animals can be identified by implanted transponders. While the nature of auto-ID is one that is innately compatible to mass market diffusion, it does also accommodate well for niche applications where for instance security is paramount and access is limited to only a few authorized persons.

III. LITERATURE REVIEW

It is surprising to note that from the hundreds of articles reviewed, that the term *automatic identification* has appeared in the titles of only a dozen publications including: Moran [1], Berge [2], Sharp [3], Schwind [4], Gold [5], Hewkin [6], Smith [7], Adams [8], Cohen [9], LaMoreaux [10], O'Gorman & Pavlidis [11], and Swartz [12]. This does not mean that the term is not popular for it is continually used in the main body of papers, irrespective of the type of technique being discussed. Rather what it may indicate is that the term *auto-ID* carries a loaded meaning when it is used in a paradigmatic fashion. Perhaps as a concept that has industry-wide applicability, admitting to the reality that numerous auto-ID solutions are co-existing and that there are common experiences that can be shared between stakeholders in the innovation process.

Four works must be especially highlighted in support of the emerging auto-ID paradigm. The first is "Automatic

Identification and Data Collection Systems", by Cohen [9]. Its contribution to the field is its attempt to give a thorough industry-wide perspective of auto-ID, though it falls short of its aim in terms of its unbalanced focus on bar code technology. It also does not compare auto-ID technologies and dedicates little space in the form of predictions about the future of the industry. The second work is by Hewkin [6], "Future Automatic Identification Technologies"; and the third by Swartz [12], "The Growing "MAGIC" of Automatic Identification". These works are both short articles focused on the need to understand auto-ID innovation. One will note a ten year interval between these publications. Neither goes into great depth but both offer insights worthy of future research effort. Hewkin understands the auto-ID market well and emphasizes the need for industry-wide communication flows between the different auto-ID players, independent of their major auto-ID product focus. Swartz, on the other hand, who has been able to witness the changes in the industry over the last decade, analyses the most prominent auto-ID technologies and describes the emerging auto-ID paradigm. His insights are integral to this paper, as they assist and garner support for the findings. Finally Smith [7] presents the AIM (automatic identification manufacturers) activity group in a brief article, stipulating that their focus is broader than just bar code, "[s]o the automatic identification industry has an almost unique global communication network… The members of AIM collectively cover all the established technologies as well as most of the emerging ones" (pp. 49, 52). In the small survey of organizations and their respective auto-ID product focus, what is apparent is that AIM is promoting the idea of one auto-ID industry sharing in common resources.

IV. Methodology

This study relies on the collection of data from a variety of industry trade sources. Trends and patterns are identified through the use of qualitative content analysis and the results are presented in a narrative description. The study defines and describes three major auto-ID patterns including:

- migration (e.g. the transition between magnetic-stripe cards and smart cards, and the transition between bar codes and RFID transponders);
- integration (e.g. the hybridization of several auto-ID techniques on the same device such as multi-technology cards, and the use of biometric minutiae on 2D bar codes); and
- convergence (e.g. radio-frequency capable smart cards).

V. Auto-ID Patterns

Patterns of migration and integration were prevalent in the examples found in the literature. Dependent on the application in question, some customers and service providers migrated from one auto-ID device to another, seeking better security, greater functionality, a reduction in fraud and counterfeit, even a smaller device that was more convenient for the end-user to carry. Convergence was also identified but predominantly at the application-level rather than at the device level. For instance, the ability to have more than one application on a smart card is quite different to 'true' technological convergence, where one device seamlessly coalesces with another. Integration is also all too often confused with convergence, although both can be considered forms of creative symbiosis (i.e. recombinations). Integration is the ability to use two or more auto-ID techniques on the same device. Integration has proven quite popular as legacy card technology systems have changed with the times- from embossed numbers, to bar codes, to magnetic-stripe and microprocessor functionality all on the same card device.

Many predictions have been made about particular auto-ID technologies becoming obsolete, however, one need only to look at the widespread diffusion of devices in the market today to consider this an unlikelihood (for the conceivable future anyway). Bar codes will for a long time yet serve their purpose, albeit in developing countries which cannot afford RF/ID devices; and magnetic-stripe cards will maintain their niche, perhaps not in banking but in other applications such as electronic ticketing. In addition, there are continual improvements being made to all auto-ID devices, of course in differing frequencies, but nevertheless the breakthroughs enable certain weaknesses in each technology to be overcome. The diversity in auto-ID techniques also allow for an end-to-end capability such as in the case of military applications.

A. *Migration from Magnetic-stripe to Smart Cards*

Joseph Sheppard [13] CEO of Xico Incorporated, a magnetic-stripe equipment manufacturing company, summed up the situation well: "[i]n short, the smart card industry assertion 10 years ago that magnetic stripes were dead was premature by at least half a century." This is graphically illustrated by the cover of the October 1997 issue of *Card Technology*, which tracks the trends in both magstrip and smartcard technologies and applications... "[w]hile smart card makers tout their benefits, mag-stripe card usage continues to proliferate. Don't expect that to change anytime soon." In 1997 "…less than 5% of smart cards worldwide [we]re issued by banks… Mass rollout of smart cards is years away because of the cost to convert magnetic-strip credit, debit and ATM card systems to chip technology" [14]. From this it can be seen that auto-ID migration is not as simple as choosing to invest in a new card technology, the decision also has implications for existing infrastructure and investment.

While most banks and financial institutions still utilize magnetic-stripe on their customer FTCs, particularly in the U.S., all of the banks in France are reaping the benefits of smart card. "All bankcards in France have a chip imbedded in them... When a French cardholder makes a purchase, the transaction is processed at the point of service using the chip and not the magnetic stripe" [15]. Each of the French chip cards carry a payment application known as B0'. Smart cards have always been a dormant threat to magnetic-stripe but in most countries it has taken until the year 2000 for

noticeable migration from the magnetic-stripe card to the smart card to happen. It took almost 40 years to distribute plastic payment cards widely; it will probably take another 10 years before consumers worldwide are comfortable with the multiapplication smart card.

Many banks have conducted feasibility studies on smart cards, either by doing secondary research or conducting pilot studies. It is not an uncommon practice today for banks to issue customers with hybrid technology cards until the migration from magnetic-stripe to smart cards is complete. Major banks across the world have begun marketing the smart card concept to consumers. In Australia for instance in 1997, the ANZ bank advertised the change from magnetic-stripe to smart card in full-page advertisements. One of these announcements is worth noting in full- a magnetic-stripe bankcard appears on the left page and a VISA card (with IC) on the right: "October 1974. There it was in your letterbox. Whether you wanted it or not. A Bankcard. They all looked the same and their new owners likewise, were all treated the same. You were told where to use it and how much you could spend. All that changed. At ANZ it changed faster than most. To the point where you can now enjoy ANZ cards that not only provide credit… Cards that are aligned to your telecommunications company, your airline, and many other major companies you do business with on a daily basis. What next? Well, we're currently at the forefront of smart card technology. Cards that use a microchip to record details of transactions and the balance on the card. Now won't that be a nice change?" [16]

In France there are even migrations occurring from smart bank cards developed in the 1980s to newer smart cards that adhere to the EMV standard and are based on the MULTOS operating system. Clearly this has been an unsettling period for banks and merchants as the costs to upgrade or replace existing ATM, EFTPOS, electronic cash registers, self-service fuel dispensers and other such terminals to make them smart card-ready are very high.

Murphy [17] also asserts that, "smart cards are the talk of the card manufacturing industry, but the magnetic stripe will be the bread and butter of card makers for the near term." Yet, one cannot ignore the gravitational pull that is obviously occurring from magnetic-stripe to the chip card. "Visa, MasterCard and other players in the smart card business contend that an 'evolution' or a 'migration' to smart card technology is under way. The pace of that evolution, though, is anybody's guess" [16]. The magnetic-stripe card was more of an enabler, a convenience card; something that would accustom people to a particular behavioral style. The smart card is being heralded as the grand solution to personalization, tailored to the specific needs of the individual. Hybrid cards may well end up facilitating the evolution and be phased out gradually as they are not required. Already the widespread use of magnetic-stripe has ensured that the size of smart cards must maintain the same ISO standard dimensions. Hybrid cards now have a physical location for microchips, magnetic-stripes, bar codes, embossed characters, holograms and photographs. Read/write equipment is even starting to become multi-technology capable [18].

In 1987 Svigals [19] was undecided whether the pattern taking place was "magnetic stripe evolution or smart card migration". Perhaps what can be said, in the case of magnetic stripe and smart card, is that the "migration" phase is part of a larger evolutionary process. What Svigals observed in the card technologies was equally applicable to tag technology over a decade later. Many ATM machines have already been upgraded to accept both magnetic-stripe and smart cards. Some smart cards have even been developed to emulate magnetic-stripe or bar code cards so that very costly card readers do not have to be entirely replaced, at least in the short term. This has posed a special challenge to card issuers who are attempting a seamless migration. McCrindle [20] stated: "[e]xisting equipment, such as ATMs, are not going to be discarded overnight. A smart card must, therefore, be capable of being used in the current generation of machines as well as in smart card based equipment… the two types of technology must coexist."

Murphy [17] also agrees that "...cards will be issued for many years with both mag stripes and computer chips." Jerome Svigals attributed this trend to a global evolution from cash to electronic currency but admitted he could not predict how long the evolution would take to complete [18]. What is of interest to note however, is that the longer the migration phase continues, the more it will become ingrained into applications as a de-facto standard.

B. Migration from Bar Codes to RF/ID Transponders

RF/ID manufacturers are starting to make inroads into the bar code market. While some predict RF/ID will replace bar codes, it is more realistic to say (as has Phil Calderbank, general manager of Sensormatic's RF/ID group) that RF/ID will have a market for high-cost items rather than low-cost items [21]. The trend is towards combining RF with EAS (electronic article surveillance), as have Sensormatic Electronics and Checkpoint Systems. Bar codes have poor readability rates in applications that are exposed to harsh environments whether it is indoors or outdoors. RF/ID can capitalize on this and other weaknesses, particularly where material handling and tracking of components is of the utmost importance. RF tags have many advantages over bar code. First, they can be placed anywhere and can store a lot of information, whereas the bar code is limited by its own label size. Second, RF/ID does not require LoS (line-of-sight) and cannot be erased by strong magnetic fields. Third, the systems have almost 100 per cent accuracy. Fourth, the tag is not affected by substances such as dirt or paint which may cover the tag from time to time. Fifth, tagged objects can be mobile, without the need to stop to be identified which speeds up the process significantly. And finally, non-metallic objects can come between the tag and the reader without interfering with the system [22]. Marsh [23] believes that bar codes have played an incredible role in reaching widespread productivity benefits in industry but that there

time is now coming to an end: "[t]he RF/ID tag to replace barcodes is about to arrive from a number of different suppliers who are all working towards this goal." There are however, numerous counter arguments for why bar code will not be replaced altogether by RF/ID. For the time being at least, it seems impossible that every single bar coded item in existence today will have a RF/ID tag or transponder attached to it. Well-known proponents of RF/ID such as Wal-Mart, Gillette, and Proctor & Gamble have already conducted trials for item-level tracking using the EPCglobal standard.

C. *Integration- the Rise of Multi-Technology Cards*

It is difficult to say whether "integration" was a consequence of an attempt at "migration" in some applications areas or an independent phenomenon. Initially integration of auto-ID techniques on the same device was born from the idea that each technique could serve its own function for different applications (this was particularly true of closed systems). In addition, as a consequence of migration patterns, multi-technology cards served as a way to transition from auto-ID legacy systems to future modes of operation. The requirement to include more than one technique on the card was a result of roll-out phases of the new technologies (i.e. different geographic regions transitioning at different times). New cardholders receive the latest cards while existing cardholders are transitioned prior to card expiration. This interim period usually requires hybrid cards to be used. Hodgson [24] described this incidence of multi-technology cards as an evolutionary process. "When multi-technology cards first came on the scene, many saw them as a potential solution to a sticky problem- how to eliminate the need for numerous cards or keys without going to a lot of expense to integrate whole systems. Beginning with dual technology, the cards then evolved to true multi-tech capabilities, incorporating functions such as lending items (bar code), time and attendance (magstrip) and photo ID. Now they are much more than just a temporary solution to a non-integrated system. Their evolution is just beginning, and will include not only new applications, but also new technology-specifically the smart card." Multi-technology cards form a strong argument and present us with a compelling reason of why individual auto-ID techniques will continue to co-exist independent of a declining adoption rate. In Portugal for instance, the SIBS (Sociedade Interbancaria de Servicos) have introduced the Multibanco electronic purse, yet another hybrid card incorporating a microprocessor for purse applications and magnetic-stripe for credit facilities. Close to 7000 smart card terminals have been introduced, the majority are off-line and about one-third can read both magnetic-stripe and smart card technology.

D. *Converging Auto-ID Technologies*

The convergence of auto-ID technologies is now starting to become evident at different levels such as standards, regulations, infrastructure and applications. True convergence however at the auto-ID device level is not as common as it is often portrayed. It all depends on the definition one uses to describe what they mean by convergence. Greenstein and Khanna [25] identify two types of industry convergence: convergence in substitutes and convergence in complements. "Two products converge in substitutes when users consider either product interchangeable with the other. Convergence in substitutes occurs when different firms develop products with features that become increasingly similar to the features of certain other products… Two products converge in complements when the products work better together than separately or when they work better together now than they worked together formerly. Convergence in complements occurs when different firms develop products or subsystems within a standard bundle that can increasingly work together to form a larger system…" Depending on the perspective taken, the selection environment of automatic identification can be considered to fit into either classification.

The most authentic example in auto-ID of convergence in complements at the present is that between the contact smart card and RF/ID card capabilities (i.e. contactless). Smart cards once required to make contact with a reader, today a RF smart card can either be utilized by inserting it in a reader or by presenting it close to a RF field. Companies like AT&T and GEC have demonstrated smart cards which communicate using radio frequency signals [25]. The ability to store biometric templates on a bar code or magnetic-stripe is another example of convergence in complements. In the case of the bar code, the biometric replaces the need for a unique ID number to be stored, with an ID derived from a fingerprint or other unique human characteristic. Biometric techniques can be used seamlessly in just about any type of card or transponder-based technology making it highly versatile. Multimodal biometrics also encourages the use of more than one type of biometric match for authentication. Biometrics has been responsible for revitalizing the prospects of stand-alone magnetic-stripe cards given the additional security embedded in the technique itself.

VI. Towards a Model of Coexistence

While recombinations and mutations of auto-ID technology are occurring in the form of integrated devices and those that have converged, it does not mean that existing markets for technologies suddenly disappear. Rather the integration and convergence should be seen as one more step in the evolution of the technology, not rendering all other devices obsolete, but simply meeting the requirements of a new problem. Examples of coexistence can be found especially in peripheral devices like readers and printers. Some readers are able to read both magnetic-stripe cards and smart cards, and some printers can print dual-mode bar codes and RF/ID labels. "Today, many of us see Auto ID technologies as "complementary," with each filling a space in the market defined by the fit between its strengths and weaknesses, and the requirements of target applications. And looking forward, I believe we'll evolve from a "coexistence"

model to one that leverages the many converging opportunities around the intersections and in the gaps between those technologies" [12].

In open systems especially, it is highly unlikely that a single auto-ID device could ever cater for the needs of a complete end-to-end application, rather auto-ID technologies usually work in concert to fulfill large-scale initiatives. And while some have a vision that every single non-living thing will eventually be 'smart' or 'intelligent', as put forward by the development of the Electronic Product Code (EPC), consumers will probably insist that certain items remain 'dumb'. In understanding the auto-ID selection environment, the paradigm has shifted from an economy that seeks the domination of one auto-ID device, towards an economy that accepts (if not welcomes) the coexistence of numerous auto-ID devices. While the relative shares of production for each auto-ID device may vary over time, and some devices will address particular market needs better than others, overall several technologies will continue to coexist.

A. *Future Research*

Using the preliminary findings of this study, future research should focus on whether particular patterns of auto-ID innovation are more prevalent in specific types of devices that may perhaps lend themselves more easily to hybridization. A quantitative study of global auto-ID manufacturers and system integrators would also provide more evidence towards a conceptual model of coexistence. For instance, are the technology companies themselves investing in the research and development (R&D) of multiple auto-ID techniques, and presenting the combined benefits of these to their customers. And if so, is the auto-ID industry on a common trajectory such that the success of one technique will inevitably influence the success of another. Adoption curves for single auto-ID techniques, dual techniques and hybrid techniques could be compared over time to ascertain whether stakeholders in the industry have undergone a process of cross-pollenization.

VII. CONCLUSION

The auto-ID industry is a technology system that is bringing diverse stakeholders together to innovate by enabling interaction and the sharing of resources. Whether it is in the establishment of new research centers that embrace multiple auto-ID techniques, the use of common network infrastructure, system integrators that are increasingly conversant with generic auto-ID topologies or the formation of associations that encourage joint collaboration, the notion of an auto-ID industry is beginning to prevail. Previous studies have mainly focused on one auto-ID technology and to this end it has been difficult to identify patterns or trends common to all techniques. Rather than seeing auto-ID as one larger system embodying numerous technologies, usually one auto-ID device was highlighted by authors at the neglect of others. But auto-ID is more than just bar code or RFID.

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