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WHERE ENROLLMENT MEETS STRUCTURE: UNDERSTANDING PDA EVOLUTION THROUGH SOCIOTECHNOLOGICAL THEORY

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Abstract

Sociotechnological theory seeks to understand technology as both material and social artifacts. Actor-Network Theory (ANT) offers an approach to sociotechnological theory that emphasizes a micro-level analysis of political strategies, but has been criticized for not considering larger social and cultural processes. This paper presents an approach to sociotechnological theory that links the enrollment process of ANT with broader social practices, and social group memberships. Two case studies of Personal Digital Assistant (PDA) evolution (Psion, led by David Potter, and Palm, led by Jeff Hawkins) are used to illustrate this approach.

Introduction: Sociotechnological Theory in IT Research

Sociotechnological theory seeks to understand technology as both material and social artifacts. A long tradition of technological change research has identified the importance of theoretical concepts that do not distinguish *a priori* between the technological/scientific and the social/cultural/economic/political aspects of technological change (Bijker, 1995). In the world of information technology (IT) research, this tradition has influenced the use of ‘ensemble’ theories of IT change, which have been used to understand the dynamic interactions of people and technology during IT development and use (Orlikowski and Iacono, 2001).

No approach to sociotechnological theory has attracted more recent attention in IT research than Actor-Network Theory (ANT), developed by Latour and colleagues. A review of Actor-Network Theory in IT research cites examples of its application to IT development, IT-enabled organizational change, computer-mediated communication, and infrastructure standards (Walsham, 1997). The only other sociotechnological theory that could arguably be seen as having a similar impact is the extension of structuration theory developed by Orlikowski (2000), though it has not been used yet beyond her own research.

A major focus of Actor-Network Theory is to explain how stable networks of aligned interests are created and maintained by both human and non-human ‘actants’. “Successful networks of aligned interests are created through the enrollment of a sufficient body of allies, and the translation of their interests so that they are willing to participate in particular ways of thinking and acting which maintain the network.” (Walsham, 1997) The major attraction of ANT for IT research, and one of its most controversial elements, is its symmetric treatment of people and technologies as aligned interests. The concept of a non-human ‘actant’ (i.e., an information technology), influencing a network on the basis of the interests and assumptions inscribed within it, is one that has an undeniable appeal for understanding the IT world of today, where pre-packaged systems and global standards are routinely transplanted between very different use contexts.

One of the main critiques of ANT is its focus on local, contingent aspects of sociotechnical change, at the expense of broader social and cultural processes. The almost exclusive focus in ANT studies of the micro-politics of alliance-building has been described as Machiavellian, paying little attention to the influence of institutional or cultural routines (Layne, 1998). In his review, Walsham (1997) is unconvinced by the responses of the ANT advocates to this criticism, and suggests combining ANT with theories of social structure such as structuration theory. How exactly to combine the micro-politics of ANT with the broader

social and cultural context remains an important issue in sociotechnological theory, and therefore one for IT research as a whole (Orlikowski and Barley, 2001).

Enrollment in Context: Sociotechnical Configurations

Recent work by Bijker (1992, 1995) provides a means for linking enrollment activities with broader social and cultural processes. Three of Bijker's concepts are important for making this link: technological frames, inclusion, and configurations.

For Bijker, a technological frame structures interactions among the actors of a social group. A technological frame consists of "all the elements that influence interaction...and lead to the attribution of meanings to technical artifacts" (Bijker, 1995). Following Kuhn's (1970) concept of a disciplinary matrix (or, more informally, a paradigm) in the natural sciences, Bijker's technological frame provides for a social group:

- Goals for a technology
- Key problems to be solved by a technology
- Problem solving strategies
- Requirements to be met by solutions
- Exemplary artifacts

These elements of a technological frame both enable and constrain certain kinds of action, following Giddens' (1984) concept of structuration in social interaction. A technological frame "guides future practice, though without logical determination" (Bijker, 1995)—it offers a powerful way of both seeing the world with respect to a technology, and a set of strategies and examples for how to successfully develop and use a technology, but it does not dictate how interaction around a technology takes place.

Technological frames are maintained by social interaction. They are also, of course, changed by social interaction, and an important source of dynamism in Bijker's theory comes from the concept of inclusion in a technological frame. Inclusion is "to what extent the actor's interactions are structured by that technological frame" (Bijker, 1995). Earlier versions of the social construction of technology (SCOT) approach, for which Bijker is probably most famous, described social groups as fairly monolithic, with basically fixed ideas about the appropriate problems and solution with regards to a technology. The concept of inclusion opens up new possibilities. Actors may have a high degree of inclusion in a technological frame, in which they are both heavily influenced and greatly skilled, or they may have a lower degree of inclusion, which perhaps makes them less skilled but more open to the influence of other technological frames. Actors can be participants in multiple technological frames, translating both problems and solutions across social boundaries.

A classic example of technological frames and inclusion comes from Bijker's study of Leo Baekeland, the inventor credited with developing the first synthetic plastic. According to Bijker, Baekeland participated in two different technological frames: the frame of Celluloid chemists, who were trying to develop a substitute for natural plastics to be used for fancy articles such as buttons and billiard balls; and the frame of photo chemists, who were trying to create better materials and processes for photography. For Celluloid chemists, the key problem solving strategy was to find new and better combinations of solvents that would produce an artificial plastic that was less flammable and cheaper. Progress, measured relative to the goals of the Celluloid chemists' frame, was slow. Baekeland shared the overall goal of the Celluloid chemists' technological frame, but also actively participated in the photo chemists' frame, where the main problem solving strategies included the careful variation and study of process parameters, such as the amount of heat and pressure applied to a reaction. This was not a common way of conceptualizing the problem in the Celluloid chemist frame. By drawing from his interactions within both technological frames, Baekeland was able to create a practical process for making Bakelite, the first widely-used synthetic plastic.

Bijker's third concept divides sociotechnological change into three distinct types, or configurations, depending on whether no clearly dominant technological frames shapes interactions, one technological frame is dominant, or two or more technological frames are important. According to Bijker (1995), each configuration is associated with a different sociotechnological change process. When no technological frame is dominant, innovations should be plentiful and radically different. The most important change process when no frame dominates is the enrollment process described by ANT, which tries to create a new constituency that can stabilize a sociotechnological innovation. In other configurations, different change processes become more important. When two or more technological frames dominate, Bijker's theory claims that rhetoric and compromise (his 'amalgamation of vested interests') are the most important change processes, while the search for improvements within the parameters of a given frame (his 'functional failure' and 'presumptive anomalies') are most critical when one technological frame dominates interaction.

Taken together, the three concepts of technological frame, inclusion, and configurations link together detailed enrollment activities and larger social and cultural processes. Enrollment is one important change process, but its importance depends on the configuration of technological frames guiding social interaction. Even within a single technological frame, varying degrees of inclusion open up the possibility of multiple technological frames, each with their own definitions of reasonable problems and solutions, having an influence on the enrollment process.

Case Study Objectives and Design

The two case studies discussed in this paper are part of a larger research project to understand the evolution of emerging information technologies (IT) from a sociotechnological point of view. In particular, the research project focuses on the question of how newly emerging IT stabilizes into an accepted form, and why new technologies take the form they do. In the handheld computer industry, also known as the Personal Digital Assistant (PDA) industry, the decade of 1987-1997 saw the introduction of many radically different designs, but by the end of that decade the first stable, generally accepted form emerged around the design of the original PalmPilot—a small, relatively simple ‘connected organizer’ with long battery life, a focus on personal information management (PIM) applications such as calendar and address book, pen-based character recognition, and easy synchronization with a personal computer (PC). Among the 34 companies that released handheld computer products during this period, and the many others who never got a product out the door, only two had sold more than one million units by 1997: Psion and Palm. The case studies analyze the process through which Palm and Psion were able to establish stable new technological forms, and why they took the form they did.

The two case studies use the theory of sociotechnological change developed by Bijker (1995), as described in the previous section. The cases use technological frames, inclusion, and configurations as sensitizing concepts to guide the selection and interpretation of the data. The data used in the cases came from three sources: a database of the 71 consumer-oriented handheld computers released by North American and European companies between 1987 and 1997; a collection of 425 trade press articles over the same period, taken from the ABI/Inform Global database; and 25 in-depth interviews producer company employees, user representatives, and industry analysts. Within the broad parameters specified by the theoretical perspective, standard qualitative data analysis techniques such as constant comparison, theoretical saturation, and the search for negative cases were used (Strauss, 1987).

The presentation of the case studies is outlined in Table 1. In each case, the company was able to establish a stable new technological form, enrolling the sustained interest of a set of producers, investors, and consumers. For each form, an exemplary artifact served as part of an organizing definition in an emerging technological frame. The new technological form is then discussed from the standpoint of how the problem of handheld computing was redefined, in an attempt to enroll groups that had not yet been successfully drawn into the handheld computing world up to that point. The inclusion of key players at Psion and Palm in different technological frames is used to account for the source of their ‘counterintuitive’ problem definitions that resulted in successful enrollment. Their inclusion in technological frames is also used to account for examples of ‘successful resistance’: how they were able to avoid redefinitions that led to many unsuccessful enrollment attempts in the emerging handheld computer industry.

Table 1. Case Study Elements

Sociotechnological Concept	Psion	Palm
<i>New Technological Form</i>	Palmtop Organiser <i>Exemplary artifact:</i> Series 3 (1991-)	Connected Organizer <i>Exemplary artifact:</i> PalmPilot (1996-)
<i>Problem Redefinitions</i>	- Low power/Battery life - PIM applications	- Pen input (Graffiti) - Synchronization with PC
<i>Technological Frames</i>	- PC industry - UK computer industry - Industrial (vertical) applications	- PC industry - Pattern recognition research - Consumer electronics industry
<i>‘Successful Resistance’</i>	- Palmtop - Pen-based computer/PDA - Personal communicator	- Palmtop - Pen-based computer/PDA - Personal communicator

Case Study: Psion

Psion PLC was founded as a PC software company in 1980 by David Potter, a professor of mathematical physics at UCLA and Imperial College. Concerned about the increasing level of competition, and the growing capital requirements of PC software, Psion changed in the early 1980s from a software company to a handheld computer company, releasing their first handheld computer (the “Organiser”) in 1984. Psion introduced a modestly successful industrial handheld (the “HC”), and a commercially disastrous notebook-sized computer with solid-state storage and long battery life (the “MC”), before releasing the first Series 3 handheld in 1991.

The Series 3 adopted the same ‘clamshell’ form factor as the existing palmtop computers of the day (for example, the Atari Portfolio and Fujitsu Poqet PC), using a small keyboard as the only input device. It differed from existing palmtops in two important ways. First, it was designed from the ground up to be a low power device, using solid-state storage to achieve long battery life. This meant designing a new operating system from scratch (the 16-bit ‘SIBO’ platform), rather than assuming that using a PC compatible operating system such as DOS was a prerequisite for successfully establishing a new technological form. Second, the Series 3 was designed to have very easy to use personal information management (PIM) applications, such as scheduling and contacts information, available at the touch of a button. With these redefinitions of the handheld computer concept came shifts in the enrollment strategy of Psion, in contrast with other handheld producers. The consumers were redefined as executives and professionals, rather than existing PC users who wanted mobility, resulting in design, marketing, and distribution decisions focused on busy executives rather than technophiles. Instead of the traditional PC industry emphasis on enrolling strategic partners and independent software vendors, Psion focused much more attention on enrolling suppliers and subcontractors to control the entire ‘user experience’ of the Palmtop Organiser. Using these enrollment strategies, Psion was able to establish the Series 3 as the exemplary artifact in a sustainable new technological community.

The source of Psion’s different (and relatively successful) enrollment strategies can be seen in terms of technological frames and inclusion. Though Potter and his initial management team were mathematical physicists, they were all heavily involved in computer technology, and saw the industry largely in terms of computing. Successful handhelds for them would basically be computers, with a computer CPU and hardware architecture, an operating system, and separate applications software. As late as 1996, Psion was still announcing their new products with the slogan “A Computer For Every Pocket”. In contrast to other palmtop computer companies, however, Psion participated in two other very different social worlds. One was the unique world of the British PC industry, which in the early 1980s had a 24% share of global PC sales, almost entirely on the strength of Sinclair products (Langlois, 1992). The early Sinclair computers, such as the ZX81, were influential for Psion in showing that very small, relatively low power devices could be successful—moving from a ZX81 to a small handheld was a small conceptual leap in the UK. In the US, the IBM PC was the exemplary artifact, and the ZX81 was a ‘side show’. Second, Psion was unique in the early handheld industry because it designed computers for both mass-market consumers and niche ‘vertical’ industry applications. Psion entered the world of industrial applications by accident, after some early industrial successes with the original Organiser product, but became heavily involved with the introduction of the HC range. Psion was able to draw upon industrial experience with more expensive, cutting edge technologies, such as new screens and wireless communications, before they ever became practical for a mass-market audience.

Psion, with its Series 3, was not only able to establish a new technological form that differed from its palmtop predecessors, it was also able to ‘successfully resist’ many of the trendy, ‘obvious’ ideas about the future of handhelds in the industry’s early chaotic phases. The first case of ‘successful resistance’ already mentioned above was to modify the palmtop form, which argued that successful handhelds should be smaller versions of existing PCs. Psion was also able to resist the pen-based computer craze that swept through the industry in the early 1990’s by drawing upon its inclusion in other technological frames besides the traditional PC industry. Every major PC company of the day (including Apple, IBM, Microsoft, Tandy, and Compaq) pursued the dream of a small tablet device with intelligent freeform handwriting recognition, a product intended to serve a mass market of ‘technophobes’ who were intimidated by keyboards and other PC complexities. While PC companies busily enrolled venture capital and software partners for a mass-market assault, Psion drew upon its experience with mobile professionals to argue that reliable data input through a keyboard was crucial for enrolling their defined set of customers. Though Psion’s management team thought the ‘death of the keyboard’ idea was evidence that ‘the industry went mad’, Psion management organized a US study tour in late 1993. The director of Psion Computing assessed their findings as follows:

“We visited the USA to see the pen platform, Microsoft, everyone. We asked them why they did this? Why leave out the keyboard? It was a management axiom that they should start with a pen...they had bought Sculley’s concept [of a pen-based PDA like the Apple Newton] and we’d better do that just in case he’s right. It was a given.

For us, it was an example of West Coast groupthink. If we'd been in California, would we have been sucked into that? But we weren't immersed in it. We asked ourselves: did we know more about the market, or were we on a different planet?" (Interview, December 1997)

Following the commercial failure of the Apple Newton in 1994, the pen-based computer concept fell out of fashion. Another proposed technological form for a handheld computer arose: the personal communicator. During this phase, many of the major telecommunications companies (including AT&T and Motorola) proposed handhelds based on the assumption that wireless communications was the key to success. Producers tried to enroll large telecommunications companies as resource and infrastructure providers, and 'content providers' to create the content that would drive network traffic. Psion drew upon its interactions with the industrial applications frame to reason that wireless communications was still too difficult and expensive for mass-market use. By drawing upon its inclusion within the industrial applications frame, with its different problems and solutions already at play, Psion was once again able to 'successfully resist' what in retrospect was an unsustainable technological fad.

Case Study: Palm

Palm Computing was founded in 1992 by Jeff Hawkins as an application software company for handheld computers. Palm supplied the PIM applications, handwriting recognition, and the PC connectivity software for the Casio/Tandy Zoomer handheld, introduced soon after the Apple Newton in 1993. Palm supplied handwriting recognition and PC connectivity software for other handhelds, until a frustration with existing products led them to develop their own handheld computer. Their first handheld, the PalmPilot, was released in 1996, and quickly became one of the fastest selling consumer products of all time.

Given the state of the handheld computer industry in the mid 1990s, when widespread disillusionment had set in after the disappointing performance of pen-based computing and personal communicators, the original PalmPilot was a radical departure from conventional wisdom. The PalmPilot was small enough to fit in a shirt pocket, used a pen rather than a keyboard, and had relatively little computing power and memory. Two redefinitions were particularly important. First, the PalmPilot used pen input at a time when pen-based computing was blamed for the high-profile failure of the Apple Newton and similar handhelds. Instead of recognizing freeform handwriting, however, the PalmPilot used a technology called Graffiti invented by Hawkins. Graffiti forced the end user to write one character at a time, requiring users to learn a simplified new alphabet. The second major redefinition is reflected in the name that Palm gave to their new products: Connected Organizers. The PalmPilot was designed around the assumption that the handheld computer user would also have a PC. The design of the PalmPilot made it extremely easy to connect to a PC and synchronize PIM data.

As in the Psion case, these redefinitions called for different enrollment strategies from what was then the industry norm. Using a simplified handwriting recognition technology, developed in-house, radically decreased the hardware and software requirements of the PalmPilot. This redefinition allowed Palm to develop the PalmPilot using their existing resources, rather than having to sell outside investors and potential partners on a new and unproven technology concept. For end consumers, the enrollment message shifted from accurate handwriting recognition to the simplicity and ease-of-use of the PalmPilot's PIM applications. Redefining the handheld as a PC companion also shifted Palm's enrollment tactics away from technophobes with no previous computing experience—the message of pen-based computing—and towards technophile early adopters who were already comfortable with PCs. By connecting through PCs to outside networks, rather than relying on wireless communications, Palm removed the need to enroll wireless infrastructure providers, a major stumbling block even today because of the expense and coverage of wireless networks.

The source of Palm's unique problem redefinitions, resulting in different enrollment strategies, can be seen as the inclusion of Palm's founders in different technological frames. As in the Psion case, the successful handheld for Palm would basically be a computer, with a typical computer hardware architecture, an operating system platform for developing new applications, and separate application software. Palm's founders all had years of experience in the California PC industry, at companies such as Intel and Apple. Palm also absorbed existing features of the Palmtop Organizer technological frame, such as low power requirements and easy access to PIM applications. Probably the most surprising redefinition was the use of Graffiti handwriting recognition. Though difficult to appreciate in retrospect, this was a technology so counterintuitive that no independent analyst, and even few within Palm itself, could see it as a viable handheld computer technology. Making end users 'learn a new way of writing' went completely against the founding assumptions of the handheld industry. Jeff Hawkins, however, did graduate work in biophysics at Berkeley, and was peripherally involved in the pattern recognition and neural network research community. From this unique experience base, Hawkins was able to see the potential of Graffiti. Through their experience with the Casio/Tandy

Zoomer product, Palm was exposed to the very different world of consumer electronics, where ‘out of the box’ experience and low price points take on much more importance than in the PC world. Even though it was a commercial failure, it was primarily through their surveys of Zoomer users that the key performance criteria of PC connectivity became a major focus.

By drawing upon their (peripheral) inclusion in other technological frames, Palm was able to ‘successfully resist’ many of the industry’s key beliefs. Following the lead of Psion and others, it was relatively easy to grasp that the ‘palmtop’ notion of handheld as shrunken PC was not a sustainable new form. Much more difficult to resist was the idea that, because of the failure of products like the Apple Newton and the Casio/Tandy Zoomer, that ‘the pen was dead’. Jeff Hawkins was able to draw upon his experience in the world of pattern recognition research to see that a new and different kind of pen input could ultimately be a stable new technological form for a substantial audience of end consumers. With their redefinition of handhelds as a connected organizer, drawn from their experience in the consumer electronics world, the key problem of the proposed ‘personal communicator’ form became much less significant. Rather than having to wait for cheap, ubiquitous wireless communications to become a reality, Palm was able to draw upon the strengths of the PC while still creating a relatively easy to use consumer device.

Discussion: Enrollment as Problem Redefinition

In Bijker’s (1995) theory, the enrollment process described by ANT is the most important sociotechnological change mechanism within a particular configuration: no dominant technological frame. The early evolution of PDAs, as presented in this study, supports Bijker’s claim that enrollment, rather political negotiation or the search for solutions within a shared problem space, is the major sociotechnological change mechanism. Bijker went further, however, in claiming that problem redefinition is a particularly important type of enrollment. In both the Psion and Palm cases, redefining a technological problem to enroll a different set of social groups played a crucial role.

Given ANT’s usual focus on micro-politics and negotiation tactics, the example of PDA evolution is useful for reminding us that enrollment is not only a matter of negotiation and power plays. It is perhaps obvious to conclude at the end of an ANT-type study that the secret to establishing a new technological form is to “create [a] network of aligned interests” and that technologists should “enroll stakeholder groups to align their interests with the technology” (Walsham and Sahay, 1999). Many actors in the handheld computer world made what, in retrospect, appears to be the mistake of spending too much time and energy enrolling the ‘wrong’ social groups, forming ‘grand alliances’ with other producers and investors. The challenge of establishing a new technological form is to include or exclude a non-obvious set of social groups in a new technology definition, as well as to bring these social groups on-board.

Discussion: Linking Enrollment and Social Group Practices

This paper began with the critique of Actor-Network Theory (ANT) as too focused on the micro-politics of enrollment, at the expense of broader social and cultural processes. How can an ANT approach to IT research maintain a balance between actor-oriented and structure-oriented aspects of sociotechnological change? Where, in other words, does the enrollment process meet structure?

Bijker’s concepts of technological frames, inclusion, and configurations provide one way of making this link. As the Psion and Palm cases illustrate, these concepts allow an analyst to trace the influence of a larger structural background—to group practices around a technology which are relatively stable—while still creating a detailed account of how enrollment took place in a specific case. In these cases, our understanding of the details of the enrollment process is aided by an account of existing community practices around a technology (the technological frames), and the participation of key actors in those communities (inclusion).

In both the Psion and Palm cases, the sources of their unique problem definitions and enrollment strategies have their roots in larger social group practices. Their view of the PDA world, and their ability to skillfully act in the PDA world, was most shaped by their participation in the technological frame of the PC industry, from which they adopted many of their established problem definitions and solution strategies. Their successful establishment of new technological forms, however, requires reference to places outside normal PC industry practice. How was it that these companies, and not others with much more resources, were able to establish new forms, and do it in such a unique way? The intended contribution of the cases was to identify exactly how each of these companies redefined the problem of the PDA, and the sources of these redefinitions in community practices outside the PC industry.

Conclusion

Using the concepts of technological frames, configurations, and inclusion, it is possible to create a link between the details of enrollment activities, and larger social and cultural processes. This approach addresses one of the central problems of sociotechnological theory identified by Bijker (1995): maintaining the balance between actor-oriented and structure-oriented explanations of technological change. More specifically, however, this approach allows us to extend and deepen our understanding of enrollment. Enrollment through mechanisms such as problem redefinition can be just as, if not more, important than obvious political tactics such as negotiation and rhetoric. And the sources of ideas for enrollment can be found in the inclusion of key individuals and organizations in different social groups, such as the pattern recognition social world in the Palm case, and the peculiarities of the British personal computer industry in the Psion case.

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