Volume 11 Issue 01 Published, February 15, 2007 ISSN 1535-864X DOI: 11.1535/itj.1101

Intel® Technology Journal

Designing Technology with People in Mind

Intel Technology Journal (Volume 11, Issue 1) focuses on "designing technology with people in mind" with insights on how we can build successful technologies by gaining a better understanding of people, their homes, their social and cultural practices, and the role technologies play in these contexts and spaces.

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Articles

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Preface

By Lin Chao
Editor and Publisher, *Intel Technology Journal*

This is an historic date for the *Intel Technology Journal* (ITJ). This Volume 11, Issue 1 marks our 10th anniversary as a Web-based publication. The ITJ was first published on the Web in 1997, but the journal has a 30-year history at Intel. For the first 20 years, it was an internal publication for Intel employees only. For the past 10 years though, it has appeared as an external and refereed journal featuring the most recent research and development by Intel Corporation aimed at an audience of medium-level technical expertise. Through the years, our publishing model has not changed; however, with this issue, we are adding an RSS Web feed for our readers. Congratulations to ITJ on its 10th anniversary as a Web-based journal. Also, a sincere thank-you to our readers.

Through the past decade, the papers in the ITJ have detailed a wide range of technologies from silicon to microprocessors, software, hardware, and platforms. In this issue, the focus takes a detour. We typically calibrate technology on metrics such as increased performance, functionality, and speed, often giving scant attention or even ignoring the connection between the technology and the people using it. In essence, we did not incorporate, or indeed fully understand, people's usage, point of view, roles and desires vis-à-vis our technology development.

This issue of the ITJ (Volume 11, Issue 1) focuses on "designing technology with people in mind." These eight papers and two short sidebars offer insights on how we can build successful platforms by gaining a better understanding of people, their homes, their social and cultural practices, and the role technologies play in these spaces. With knowledge about people, we can create technologies that will support meaningful and valued experiences for people. This new focus reflects a changing Intel Corporation: ten years ago this topic would not have been a likely focus for a technology journal.

The first two papers in this issue focus on ethnographic techniques. The first paper looks at how studying small or unique communities of people can lead to insights about a broader population. Recreational Vehicle (RV) and back-pack travelers were examined for their use of technology on the road. The role of television was also studied due to its placement in the home and its participation in the social fabric of families. The second paper examines how documentary videos can be used as a method in ethnographic and design research and how these videos can be used to communicate research results in a powerful way. There is a short sidebar paper that examines the use of "cognitive maps" for mapping a Brazilian household space.

The next four papers focus on the usage-driven design of technology. The third one looks at the "Usage-to-Platform Requirements" (U2PR) program at Intel. We reveal the U2PR process, describing the types of research necessary to inform the process, the methods we have evolved in developing use cases and usage requirements, and the importance of visual collateral to communicate the usage vision. The fourth paper describes the adoption of a usage model-driven platform definition process at Intel in three case studies: platform thermal design in mobile computers, cross-platform manageability, and enterprise information management. The fifth paper looks at the voice of the user in corporate IT's decisions. A consistent challenge for IT organizations is how to deploy and maintain a broad set of capabilities in a cost-effective manner. To address these challenges, Intel's IT organization is moving to an Off the Shelf (OTS) model. They are utilizing a variety of user research, which allows users' considerations to be balanced with technical and business factors. The sixth paper presents a methodology for PCs to remotely heal themselves. Intel® Active Management Technology is designed to provide a new level of IT management. With this technology, the computer can be accessed, diagnosed, and healed remotely. Then there is another short sidebar paper on decimal floating-point arithmetic. The primary motivation for this work is that decimal arithmetic makes numerical calculations more human-friendly. The results will be the same as using pencil and paper. Our work represents a reliable and efficient implementation of the IEEE 754R decimal floating-point arithmetic on Intel® Architecture platforms.

The final two papers look at how to assess the user's experience. The seventh paper looks at how to integrate health monitoring technology into everyday devices that can be translated into personalized feedback to support immediate wellness and long-term disease prevention. The eight paper exams User Experience Quality (UXQ) assessment and measurements using experimental psychology, experience research, and human factors techniques. Three examples of UXQ assessment methodologies are discussed: 1) a competitive benchmarking study, 2) a perceptual quality study, and 3) an in-home contextual study.

We can build better platforms by gaining a better understanding of ourselves as people. By studying our homes and our social and cultural practices, we can learn how technology enhances, shapes, or changes our families and communities. With this knowledge our technologies will better serve us as people in communities and will support meaningful and valued experiences for us all.

Foreword

By Herman D'Hooge
Senior Principal Engineer
Channel Platforms Group, Intel Corporation

PEOPLE-INSPIRED TECHNOLOGY DESIGN

People-oriented design is rapidly taking center stage in Intel's design strategies: it provides inspiration for new product ideas; and it informs strategies and technology roadmaps and guides their definition and development.

This outside-in approach to technology design, where technology is designed by first understanding how people will use the complete product or solution, starts with understanding people in their social and physical context. Understanding people is typically the role of *ethnography* and other social sciences. Although we often refer to people as *users*, in many instances we are also interested in discovering the needs of people who never used technology before. Envisioning and designing user experiences, products, and solutions is where *interaction design*, *industrial design,* and *human factors engineering* step into the driver's seat. These generate an understanding of what we imagine people will be using and how it should be implemented in order to be relevant to them. The user experience becomes the target of what we want to make possible for the user. This, in turn, drives constraints on the technology we design at Intel and those parts of the overall product solution provided by others in the industry. Setting early targets for user experience that are measurable in an unbiased way, and subsequent assessment of how our implementation measures up against those targets are the realm of *user experience assessment*, which adds the quality and validation aspect to people-oriented design.

So why does this ethnographic approach matter to a technology company? To put it simply, what's under the hood is only as relevant as the end user experience of the complete solution. Moreover, speed is no longer the *sole* measure of user satisfaction for our technology products: making the inners of computers faster, while still necessary, is no longer sufficient in today's marketplace.

The Early Beginnings

Individuals with a user-centered background first appeared in the employee ranks at Intel in 1993. They were psychologists hired as human factors engineers chartered with the design and usability of user interfaces for Intel's videoconferencing and communications products. Prior to that, the design of anything that was directly visible to human users of our products was typically assigned to the technical writer on the product. At that time, technical writers were the only people at Intel who produced parts of our technology products that people interacted with: written manuals. Since computer user interfaces involved text displayed to the user, much of which was also written about in the product's printed documentation, designing a user interface somehow didn't seem all that different. The first study to use ethnographic techniques at Intel was conducted in 1994. It was a small project, pretty much kept below the radar. In this study, communication between people in corporations was examined, and the study generated an application idea very similar to what we know today as *instant messaging*. The Intel videoconferencing product version that would include that feature was never released.

A year later, a second small ethnography study was conducted on US families with young children. The study revealed that the PC in the home didn't add much value to a family's daily routine. Often stuck in a home office or den, the PC was placed where people weren't for most of their daily activities. Although this was not what we really wanted to hear, presentations on the subject around the company became an instant hit and gradually started to change conversations. A little later, ethnography became a formal, but still tiny, team on the Intel organization chart. That team was later renamed *People And Practices Research,* and in many ways, it was ground zero for a lot of the people-oriented leadership in the company at the time.

Today

Today, people-oriented innovation teams exist across the company. They work closely with marketing, planning, and engineering in shaping not only future technology products but also our internal Information Technology (IT) direction to bring similar benefits to the Intel workforce worldwide. Designing technology with people in mind is key to Intel's platform strategy. We've come a long way from what used to be a small side act many years ago to what is now a lead role on the main stage with world-class actors. Yet, there's still a long road ahead before user-orientation is fully embedded in our company's DNA. That day will arrive when we stop talking about it as if it is something special.

Hope you enjoy this ITJ issue.

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Sideways Glances: Thinking Laterally and Holistically About Technology Placement in the Innovation Process

Alexandra Zafiroglu, Domestic Designs & Technologies Research, Intel Corporation

Index words: digital home, ethnographic research, methods, innovation process

ABSTRACT

Understanding how technologies are domesticated—how they find a place (physically, socially, symbolically) in homes—is a key goal of ethnographers in Intel Corporation's Domestic Designs & Technologies Research (DDTR) team. In this paper, I detail two ethnographic frameworks for placing technologies. Following from the basic premise that asking direct, head-on questions about how people use technology in their homes may lead us to be blinded by the light, to be dazzled and overcome by the primacy of the technology itself so to speak, that we fail to see how technologies are domesticated, I instead demonstrate, through two case studies, how DDTR ethnographers cast sideways glances at technologies to come up with direct insights into the types of experiences people have with and around technology. These insights inform the development of future technologies that will make sense in homes and add value to people's lives. Thinking laterally, we study small or extreme communities, practitioners, and domestic spaces with the aim of gaining deeper insight into larger populations. Thinking holistically, we study the entirety of the domestic lifecycle of a given consumer technology, avoiding blindness by diffusing our focus from people's direct interaction with, for example, a TV screen, to the entirety of the object's lifecycle in the home.

INTRODUCTION

Concomitant with its recent transformation into a platform company, Intel Corporation has recalibrated some of the metrics of success for its technology products. Rather than gauging success purely through increased processing power and speed, success for platforms is measured in (large) part by the quality and value of the experiences they enable for users. Does a platform afford people new opportunities to express themselves, manage their lives, better themselves and their families, feel the warmth of caring relationships, feel connected, respected, secure, empowered, content, enlightened, excited, transported, reflective, accomplished, and/or capable? Such questions cannot be answered by measuring transistors and resistors per chip or by what engineers know a platform is capable of supporting or what marketers or advertisers say it can do. Instead, the measure becomes how people experience technology. Building successful platforms involves taking seriously how people currently incorporate technology into their daily lives. Understanding people's feelings, point of view, and how they see the world becomes a necessary step in building successful platforms. Ethnographic research, with its goal of understanding the world through other people's eyes, allows Intel Corporation to incorporate our current and potential customers' perspectives on valued and valuable experiences into the platform planning process.

As an anthropologist in Intel Corporation's Domestic Designs & Technologies Research (DDTR) team, I study the complex relationships among people, spaces, and objects in domestic settings around the world, helping my colleagues in the Digital Home Group understand the experiences of technology that make sense in such spaces. An understanding of how people live, how they want to live, what matters to them, how technologies are used, understood, and imagined in homes around the world is the first step in the development of platforms that enable experiences people will, and do, value. In this paper, I explore the assumptions that inform my research, and through two case studies, I look at the types of research findings that are produced through ethnographic research and integrated into the design and planning processes to ensure that future platforms are user-centered.

PLATFORMS FOR THE DIVERSITY OF GLOBAL HOMES

Within Intel Corporation's Digital Home Group, DDTR members are charged with broadening and deepening the company's understanding of people, homes, social and cultural practices, and the role technologies play in these spaces, so that we can develop new technologies that will be easily and eagerly placed in people's lives. We broaden our understanding by moving beyond the homes and practices in the United States with which the majority of our colleagues are most familiar. We deepen our study by developing a clear and actionable understanding of how people live, how they want to live, what matters to them, how technologies come into their homes and how they fit physically, culturally, and socially with existing spaces and practices. We also look at how technologies are implicated in social interactions, how they are an expression of status, and how they affect the identity of their owners, caretakers, and users. These insights are combined with other data including market, business, and technology intelligence to define consumer experience and usage requirements for the platforms developed by the Digital Home Group.

With backgrounds in design research and design interaction, anthropology and documentary film, DDTR researchers have conducted ethnographic research in fourteen countries in the past 12 months. To paraphrase Malinowski, the American anthropologist famous in part as the father of fieldwork, our goal is to help our colleagues "see the world through other people's eyes" through our research, analysis, and presentations. What is it like to be a thirty-year-old accountant living in a 500-square-foot apartment in a 20-year-old building in Hangzhou, PRC with your daughter, husband, and your parents? What is it like to be the 80-year-old patriarch of a multi-generational family living in a 1200-square-foot house in Chennai, India? What is it like to be a 58-year-old retired fitter in Brittany, France, splitting your time between a condo in the city and a vacation home on the coast? If we understand how our customers see the world, what they want to accomplish, and how technology can play a role in their lives, we can build platforms that they will value.

As the popularity of claiming that one does ethnographic research has increased in recent years among the wide range of industry professionals interested in learning about consumers, users, and other business-defined populations, ethnographic research has regrettably become a catch-all for all qualitative research methods—from focus group discussions and standardized surveys administered in participants' homes to participant observation and *in-situ* open-ended interviews. While only the latter two methods qualify as ethnographic, the problem with such loose use of the term "ethnographic research" is larger than this. For DDTR researchers, ethnography is more than an assemblage of field research methods; it is a practice involving theory, methodology, and analysis. Literally "writing culture," ethnography is essentially interpretive, and thus analysis and presentation are key components. Ethnographic "research findings" are an unfortunate misnomer that imply a transparency of knowledge: in other words, "findings" are "found," ripe for the picking, accessible to anyone with a notebook, set of questions, or video camera. This is not the case. Making sense of what we experience and what people tell us while in the field hinges on a solid grounding in social and cultural theory. Our research frameworks are always theoretically informed. From a project's inception through to the presentation of findings, we make clear our assumptions about the nature of culture, social relations, the individual, networks, identity, and technology.

Before turning to two ways we frame our research projects, I want to examine in more detail three guiding principles that inform how I approach my work.

GUIDING PRINCIPLES

People, Rather than Users

The ethnographic and qualitative research I do for DDTR is based on three fundamental principles. The first principle is that I study people, rather than users. While the purpose of the research is, ultimately, to inform the design of technologies that will be deemed valuable by the people who will use them, the ethnographic insights that will inform such design can not be gleaned from simply studying how people use and interact with current technologies in their homes. If we tightly frame our research gaze around physical objects (PCs, TVs) or services (MySpace, YouTube, or text messaging) we end up with a very skewed view of the world, one in which a complex person becomes, as Ken Anderson, a fellow anthropologist at Intel Corporation has argued, "an appendage to the technology instead of a person with a need that can be met by technology" [1]. As Anderson goes on to argue, talking about an end user narrows our gaze to a set of behaviors around technology: "using" a keyboard or remote control, navigating an interface, setting up a home network. Users "don't have feelings, beliefs, values, emotions or contexts—in short, they have no life. People live lives" [1]. In all of DDTR's research projects, our focus always starts off-screen, by which I mean that while we are ultimately interested in how people use (or don't use) technology, our research is never narrowly framed as studies of how people interact with screens or interfaces, be they on computers, televisions, mobile phones, PDAs, MP3 players, home automation systems, motorized vehicles, audio/visual systems, GPS, or portable gaming devices. Instead, our studies are framed around activities, social practices, values, homes, and relationships.

Domesticated, Rather than Epiphytic Technologies

The second principle that informs my work is that technologies are fundamentally altered when they move from the realm of the imagination, from the domain of experts such as engineers, designers, marketers, and retailers, into homes, the domain of users, people, and customers. They change from fetishized objects of boundless promise capable of transforming their consumers, to domesticated ones that are interpreted and used in particular ways that fit with, and sometimes challenge, pre-existing familial, gender, social, cultural, and political contexts and practices. They cease to be unknown, flexible commodities and become known, defined and limited, domesticated, and embroiled in what anthropologists and sociologists often call the moral economy of the household. When this happens, a television is no longer simply an entertainment device, just another screen on which we can view analog or digital content; it becomes a "member of the family" as one mother in India explained to me. When this happens, a GPS in a recreational vehicle ceases to be simply a navigation device and takes on the role of "marriage saver" for an American couple living full-time in a 200-square-foot home on wheels. When this happens, a few black garbage bags, some chairs rescued from the sidewalk, a cardboard box, a white sheet and projection TV bought on an online auction site transform a damp unfinished basement in the north of England into a much-desired (albeit damp) home cinema for a houseful of cash-strapped university students.

The promise of the so-called technology revolution of the 1990s heralded by the widespread adoption of the Internet and mobile phones in some parts of the world was whenever, wherever communication and connectivity to data.[1] In the 1990s, these technologies, particularly mobile telephones, were imagined as epiphytic, capable of being sustained through the ether; they were seen as not tied to particular locations or contexts, similar to epiphytes or air plants that access all their moisture and nutrients from the air and rain. No matter where one was or what the time of day, new information and communication technologies could connect us like never before. Subsequently, place and space would lose their importance as containers of experience. The ability to communicate would become placeless and global, rather than rooted in specific locations, cultural, social, and political contexts. Even more so than other commodities, new information and communication technologies were imagined as capable of transforming people's lives.

While this language was seductive, placeless new information and communication technologies and the practices they support turned out to still be very much rooted in place-specific values, practices, and the inconvenient necessity of physical infrastructures such as electricity and telecommunications wiring. Placing new technologies entails understanding how they are interpreted through local lenses. In Sweden, fixed-line and mobile telephony are closely tied to ideas of citizenship and narratives of modernity and nation-state. In the late 1990s, the stock price of LM Ericsson Telefon AB was popularly described as driving the fortunes of the entire country [4]. Placing new technologies also entails understanding how they are used to support existing cultural patterns and practices. In the United States (and likely other countries) MySpace pages become mourning sites, places to leave messages and gifts for teens who have met untimely deaths, places for the living to publicly announce and display their grief, echoing similar offline memorial practices at the sites of automobile accidents, where white crosses, cards, teddy bears, and the like create highly public landscapes of grief along American roadways. Moreover, placing new technologies involves paying attention to the inconvenient necessity of physically tying technologies to infrastructures and the cost of services. In Ghana, "flashing," i.e., placing a mobile phone call only to get a ring, and then hanging up and waiting to be called back is a way of combating the high costs of mobile phone calls. The recipient of the "flash" may, in fact, choose to call back from a pay telephone in order to get a cheaper rate than calling on her mobile phone—a far cry from a utopian vision of whenever, wherever connectivity.

Life Off Screen, Rather than Blinded by the Light

The third principle informing my work is that the most expedient way to study how technologies are domesticated and find a place in people's lives is to avoid asking tightly framed, scripted, and direct questions about how people interact with technologies in their homes. These kinds of questions may lead us to be blinded by the light, to be so dazzled by the primacy of the technology itself that we are overcome and fail to see how technologies come to find a place—physically, socially, symbolically—in homes. Therefore, DDTR's research frameworks are explicitly ethnographic, and they focus on people, social interactions, cultural values, and practices of domesticity while only casting sideways glances at technologies in homes. The outcome of such a focus is a rich understanding of the texture of daily life in homes around the world that is fertile ground for insight that feeds into the innovation process.

CASTING SIDEWAYS GLANCES

Two such ways of casting sideways glances through ethnographic research are presented here. Thinking laterally, we study small or extreme communities, and practitioners and domestic spaces to come up with broader insights into larger populations. Thinking holistically, we study the entirety of the domestic lifecycle of a given consumer technology, avoiding blindness by diffusing our focus from people's direct interaction with, for example, a TV screen, to the entirety of the object's lifecycle in the home, to come up with focused insights into people's interactions with technology. These approaches are illustrated through descriptions of two

[1] Such discourses of shrinking worlds and anytime/anywhere communication are, of course, much older than the last few decades; similar prognoses about the effects of the telegraph and telephones systems abounded in the nineteenth century. [2; 3]

exploratory research projects and how they were presented and received within Intel. Each story explores the risks and rewards of this research. The research methods of the first research project were occasionally deemed suspect and misread as narrowly focused. The research insights of the second project currently inform our thinking about new home entertainment platforms.

Thinking Laterally: Extended Mobility Project

One way to learn about digital homes is to study a particular small and extreme group such as “early adopters,” a market segment that generally consists of people who are interested in new technologies and are among the first to buy. They care about brands and are interested in entertainment and gaming, and they are concerned with status and career success. Not surprisingly, early adopters skew towards the young, male, and well-educated, and the perspective of the early adopter is suspiciously close to the enthusiastic embrace of technology and understanding of hardware and software demonstrated by many of Intel’s employees. As DDTR’s goals are to help Intel see the world through “other people’s eyes,” to imagine other homes, other worlds, and other lives, in most of our research, we do not study early adopters.

Instead of early adopters, we sometimes study unexpected adopters, and find them in unexpected ways, when we set out to study people with particular social practices, rather than users or adopters of technology. During the summer of 2005, a design researcher, Michele Chang, and I completed a short and small-scale exploratory research project titled Extended Mobility. The project compared two types of travelers who are differently dependent on information networks and infrastructures with the aim of exploring how people who are traveling long distances (at least 200+ miles from their former home bases) over extended periods of time (6+ months) organized daily activities and needs without a geographically stable home base. We were interested in what people felt they “couldn’t live without” (whether it be something as abstract as privacy or as concrete as a Wi-Fi hotspot), how they handled personal and property security, how they managed social, financial, and professional obligations, and how they organized their travel, their daily movements, and managed their health and wellness. While previous ethnographic work had been done by Intel researchers on short-term and/or short-distance mobility practices, such as daily commutes and business travel, and on mobile professionals such as truck drivers [5, 6, 7], Extended Mobility was designed to do just that—extend our understanding of mobility practices, through a short, rock-turning study to see if there was anything interesting we could learn from people who are perpetually on the go.

The research was conducted in the United States and our two types of travellers included budget travellers and people travelling by recreational vehicle. The budget travellers consisted almost exclusively of backpackers, primarily younger adults travelling on a tight budget generally outside their home country, staying in hostels or other low-budget accommodation and carrying their belongings with them on their body in a large backpack. The recreational vehicle travellers, or “RVers,” consisted almost exclusively of older American adults (50+), many of whom were “full-time RVers,” meaning that their only home was an RV. They had cut all connections to a “stick-house,” their term for a conventional, non-mobile home.

Two things should immediately strike the reader about this project, both relating to the lack of a technology focus in the research framework. Following my first research assumption, we studied people and their mobility practices. The project could have been scoped as “how do RVers and backpackers use the Internet to plan their travels?” or “how do RVers and backpackers use mobile phones to keep in touch with friends and family?,” which would have given us very restricted research findings that provide us little understanding of the context of technology use. Following my third research assumption, the questions posed have to do with the management of obligations and daily activities, rather than how these activities are managed using technology. While our study participants did, in fact, use various technologies—as low-tech as pens, paper, and cork bulletin boards in RV parks and hostels, and as high-tech as $7,000 RV roof-mounted satellite dishes and $500 smart phones—we did not limit our focus only to silicon-based technologies. This would have reduced our RVers and backpackers to appendages to technology use, rather than people facing particular challenges when managing their personal, professional, and financial obligations.

Our research methods included interviewing backpackers in hostels, and RVers in their homes in camp grounds, RV parks, at RV rallies, and at an RV conference. Participant observation was a key component of our methodology; we learned about the challenges of extended mobility by living (albeit for short periods of time) like our research participants. For the backpacker part of the study, we travelled and stayed in hostels, experiencing first-hand the anxiety of finding a room for the night, securing our belongings from theft, and the lack of privacy and quiet in a room shared with 11 other travellers. For the RVer part of the study, we rented a 29-foot motor home and lived in it for one week. We drove east from Portland, Oregon to Moscow, Idaho and back again. Along the way, we camped at different types of RV parks, where we met and interviewed RVers in their homes. In Moscow, we attended a conference for “wannabe” and “newbie” RVers called “Life on Wheels” that featured over 100 classes.

The conference was attended by over 500 participants, the majority of whom were over the age of 55. We lived in our RV, attended classes, chatted with fellow conference attendees and instructors, toured homes during an evening open house, and did formal interviews in people's homes. We attended classes on everything from digital communications, weight restrictions, inverters, and chargers to healthy traveling, traveling with pets, and nurturing a happy marriage on the road. We also attended the Great North American RV rally in Redmond, Oregon where we conducted interviews, spoke with sales representatives about buying and maintaining an RV, and chatted with after-market retailers and fellow attendees. At both events, we collected and later read numerous sales brochures, magazines, pamphlets, and books about RVing, including books on how to cook in an RV, great routes, personal stories, how to plan a trip, and how to sell one's stick home and commit to full-time RVing.

Unexpected Digital Homes

Turning specifically to the RV half of the study, we found the mostly aged 55+ full-time RVers we met lived in highly digital homes. All of the RVs we visited housed assortments of new Information and Communication Technologies (ICTs) including laptops, mobile telephones, GPS units, video cameras connected to dashboard displays that showed the area behind the motor home, Pocketmail* (a product that allows one to send/receive email through a handheld device in conjunction with a telephone), and satellite dishes for digital television and broadband Internet connectivity. In the five RV parks we visited, a large percentage of RVs had a satellite dish for the TV, either built into the roof of the coach itself (costing about $1000) or as a free-standing unit placed outside the RV. Satellite TV, as we came to learn, is something that no RV is considered complete without. Each of our interviewed households had two TVs; a larger one in the front room of the motorhome, and a smaller one in the bedroom, closely approximating the average 2.24 televisions found in stationary American homes. Although not as popular as satellite TV, satellite Internet was present among almost half of the motorhomes we visited. These systems are very expensive, costing as much as $7,000 to install and incurring monthly fees of around $130. Seven of the eight households we interviewed were equipped with at least one laptop computer; three households had more than one computer.

In addition, RVs are replete with a variety of sensors and home automation technologies because resource management is an ever-present concern. Fresh water tanks have to be filled, and "grey" (shower and sink) and "black" (sewage) water tanks emptied; access to electricity, propane, and gasoline has to be procured at regular intervals. Tanks must be regularly checked, electrical hook-ups located, satellite systems aligned to avoid trees, tall buildings, steep hills, or other obstructions to the southern sky. These technologies make it possible for the RV to be used in a variety of settings, ranging from complete self-sufficiency (full fresh water and propane tanks; empty black and grey water) to complete dependence on infrastructures such as fixed location water, sewage, and electricity systems.

Expanding our Imagination—Sometimes Resisted

A key finding of our quick rock-turning project was that something remarkable and a bit unexpected was happening with people who are perpetually on the go. RVs turned out to be a noteworthy type of digital home that challenges and expands Intel's imagination about who and what we design for in a digital home. Much of the ubiquitous computing literature dealing with domestic spaces is based on a core set of assumptions about the physical size and infrastructure of the home, as well as the identity of household members, their life stages, values and lifestyles. In short, digital homes are assumed to be large (also glossed as American; a country where the average home is 1800-2400 sq. ft., the largest average in the world). They are imagined to be occupied by nuclear families containing children under the age of 18 and parents challenged by the frenetic pace of daily life and the need to get the kids to soccer practice on time. They are assumed to be blessed with robust and stable infrastructures and with owners who are willing to invest rather substantial amounts of money to automate, digitize, or otherwise boost their homes' IQs. Thinking about RVs as digital homes challenges us to design for a completely different physical footprint and infrastructure, and to design for household members in different life stages with diverse values, needs, and willingness to invest in their homes. What happens when you start designing technologies for the following: a small, unstable digital home; one where access to the Internet can change nightly, depending on shifting obstructions to the southern sky; one in which it may make sense to install a $7,000 satellite because it is, ultimately, portable (it can be removed when the home is sold), but installing complex calendaring and reminding systems to manage children's extracurricular activities and parents busy work schedules makes no sense?

When presenting the research findings from this study to internal audiences, we always carefully explain the value of learning about an extreme or small community as a case study that can give us insights into larger populations. The point of the project was to get us out of our preconceptions of what a digital home can look like; to give us insights that will help us when thinking about making homes in other parts of the world digital, i.e., *small homes*, homes with intermittent access to infrastructure, homes that need concerted effort and intent to keep taken-for-granted infrastructures and utilities like Internet access functioning, second or vacation homes, and/or homes occupied by relatively tech-savvy older adults.

After spending ten minutes explaining the project, complete with a poster outlining the research implications to attendees at a publicity event, I was asked by an Intel engineer, "Have you sized this market?" Given my framing of the project, the market that this research speaks to is potentially huge. Yet, what the engineer was asking me was "Have you sized the *RV market*?." While I knew there are approximately 30 million Americans who currently use the approximately 8.2 million RVs on US roads, and nearly 1 in 10 Americans over the age of 55 owns an RV, I was not arguing that Intel should design platforms for RVers [8]. The challenges they face in their domestic spaces are a fruitful starting point for thinking about much larger markets. For engineers who are accustomed to thinking about products, our work is sometimes misread as a study of products or market sizing for particular products. Instead we are thinking of expanding markets by recalibrating our expectations of the people for whom we are designing technologies. We are expanding our imaginations, not sizing markets.

Turning from some of the potential limitations of not focusing our research directly on technology use to some of its successes, my second example details a recently completed multi-country research project.

Thinking Holistically: The Social Lives of Televisions

In addition to making sure that our research frameworks are firmly focused on people, their values and practices, another way we avoid being blinded by technology is to extend our gaze at a technology beyond its screen to its entire lifecycle in a household. In the past year, I have led a four-country study of a truly ubiquitous technology in homes around the world, the television.[2] Television sets can be found in 1.1 billion households worldwide. In developed economies they are found consistently in between 96 and 100% of households, and in urban centers in some developing economies they are found in upwards of 85% of households [9]. In some areas of the world, they have been common in homes for over forty years. When thinking about digital entertainment in the home and what the future might hold, the television, as the well-loved and ubiquitous incumbent technology cannot, and should not, be overlooked.

In this project, entitled "The Social Lives of Television," we examined television as a social and cultural object and as a practice in urban middle class homes in China, India, the United Kingdom, and the United States. We were interested both in the physical object of the television and its attendant and dependent devices, and the experiences the content on a television enables. By broadening our focus from the television screen and the content available on it to the entire domestic lifecycle of the device and the experiences it provides household members, its relationships to people, other objects and practices in the home, we wondered what lessons we could learn to help us think about the future(s) of entertainment in homes. Moreover, we wanted to know what we could learn about building other potentially ubiquitous technologies for homes.

The research framework builds from the second and third guiding principles that inform my work, as outlined earlier in this paper; namely, that technologies are fundamentally altered when they move from the realm of the imagination—the market and advertising—into homes, and that the most expedient way of studying this alteration is to avoid tightly framed questions about how people interact with digital screens in their homes.

Our research methods for this project were similar to those for Extended Mobility, in the sense that we learned both by asking questions of our research participants, and by ourselves doing the same things they did. For the field site where we did not speak the local language, we partnered with a Ph.D.-trained qualitative researcher who was based close to our field site. She provided translation during interviews, and also provided guidance during other fieldwork activities. To understand how televisions are domesticated in middle-class homes, we twice visited for between two and four hours each 6-10 households in Hangzhou, Chennai, Leeds, and Kansas City. During these visits, we conducted semi-structured, opened-ended ethnographic interviews and home tours with research participants. Additionally, we had participants complete a photo diary between visits. Besides the home visits, we explored practices surrounding television outside the home in each of these four field sites. We visited retail locations selling television, attendant devices, and mediated content. These ranged from mega-stores to flea markets and street vendors to grey and black market outlets. We explored television consumption in public settings like mahjong parlors, pubs, coffee shops, restaurants, and public squares. Additionally, we investigated what it was like to buy a wide range of objects and services in these cities: we talked with realtors, went shopping for food, large and small household goods, visited significant sites (cultural, political, leisure) and absorbed as much as we could about the rhythms of daily lives in these cities.

Our research was informed by anthropological theories of consumption and domesticity [10, 11], as well as by methodologies for studying new information and communication technologies in domestic settings [12].

[2] Other researchers involved in this project included Ashwini Asokan, Susan Faulkner, and Barbara Barry.

From consumption studies, we took the perspective that objects express social status and identity of their owners and caretakers, and through their use and exchange give physical form to cultural categories and social structure. We drew on Kopytoff's concept of the cultural biography of things [11], to think about how the identity and meaning of objects, such as television, change over time, as they are exchanged, bought, sold, gifted, used, come into contact with other actors and objects, and age.

To structure our investigation of the domestication and life cycle of televisions in urban, middle-class homes, we used Silverstone, Hirsch, & Morley's tripartite model (appropriation, integration, conversion) for studying domestication of ICTs. Our research included such questions as these:

> *Appropriation*. How do televisions come into homes? What prompts acquiring televisions? How is content procured for the television (free to air analog or digital signals, cable, satellite, packaged media such as VHS, VCDs, DVDs, games, etc.)? Who is involved? Who is not involved? Why?
>
> *Integration*. How and where do televisions fit physically in homes? How do they fit socially? How do they move within the home? Where are they placed? Who controls how the television is used? What other activities happen when the television is in use, or not in use?
>
> *Conversion*. How does the television become a meaningful object? Is the object or the content it facilitates tied to individual, family, or household identity or social status? Are televisions or practices surrounding them tied to lifecycle transitions of individuals, families or households?

More Than Screens: The Most Powerful Object in Homes

Through our research, we learned that TVs are much more than screens for viewing content. They are companions, trusted advisors, time-killers, necessities, educators, informers, social-life enablers, child-minders, boredom-busters, stress-fighters, lullabies, and low-maintenance friends. Their use is often highly ritualized and affects the daily routine, use of time, and use of space in the home. They are considered so important that they are often afforded prime real-estate in the home, the objects around which all other furnishing and decorating decisions are made. Like family members, they provide emotional support and comfort, and their conspicuous placement and constant use lend structure to domestic time and space that facilitates and enables the seamless flow of daily responsibilities and activities.

For the households we visited, televisions were more numerous than any other ICT in the homes and were found in more locations in homes than any other, including living rooms, dining rooms, family rooms, kitchens, hallways, parents' bedrooms, grandparents' bedrooms, children's bedrooms, unfinished areas, garages, attics, children's play rooms, closets, and storage rooms. Most importantly, they were found in rooms where household members spent significant amounts of time during any given day. While the layout and size of homes differed dramatically (from >2400 sq. ft. for some homes in the US and UK to <600 sq. ft. for some homes in China), televisions were consistently in heavily occupied and high-traffic areas, unlike other ICTS like PCs or laptops, which were often ghettoized, when possible, to their own special-purpose rooms, or at the very least they were given marginal real estate, such as being tucked into the corners of rooms, their screens perpendicular to a wall.

For those households whose homes were large enough to allow for space or rooms that were not in constant use (mostly found in Leeds and Kansas City, where homes we visited were all at least 1200 sq. ft., and usually not as densely populated as the homes in Chennai and Hangzhou), the physical presence of a television or the availability of particular content on different televisions was often used to define the use of space in the home. For a single man in his early 40s in Kansas City, the absence of a television in his living room made the room unusable. As he explained, "I mean, I can't use my living room right now other than for chatting so it's—it would be a good place to have a TV in this house." Not only can't he use the room for anything other than chatting, he does not use it at all. For him, the room was uncomfortable, and it could not support social interactions with his friends, which he felt could not be properly done without the presence of the television. He felt stymied in his attempts to entertain in his home because, as he said, he needs "a reason to go in there like, 'oh, let's go watch TV'." For a family in Leeds with two lounges, conscious choices were made about what devices to attach to TVs in each room. For the "parents' lounge," the parents chose to have only a freeview box (digital aerial set top box) attached to the television, rather than a cable box, as they had in the "children's lounge." In effect, this means the children cannot watch their favorite cable cartoon channel in the parents' lounge, and by default, this room, with its white leather settee and custom-made furniture, becomes a place for peace, quiet, relaxation and escape from daily chores and responsibilities for their mother.

Televisions are placed in central locations in the home and valuable real estate afforded them because people see them as having broad value in their daily lives. While television certainly entertains, there are only so many hours in one day that can be devoted to entertainment. In many households we visited, at least one television was always turned on when people are present—or sometimes not present, up to 24 hours a day. What other experiences does the television support that makes it compelling enough to place everywhere and have on for long periods of time each day?

Very few people we interviewed used the word "entertainment" to describe what their TVs do. Instead, they talked about what the experience of using the television enabled, which was often only tangentially related to the television's role as an entertainment device. TVs "do" things besides entertain, and many of these things were described as activities that a caring family member or close friend would be entrusted with such as keeping one company and staving off loneliness, easing one's worries, acting as a trusted advisor, educating children, hosting social gatherings, lulling one to sleep, providing rewards for good behavior, to give but a few examples. And best of all, the television was seen as a low-maintenance technology; dependable, not in itself needy of attention or unstable, in essence, a giving but un-needy friend.

Because the television is viewed as capable of filling such roles, its presence and use play a key role in the flow of daily routines, and in many cases it comes to shape not only the use of space in the home, but the use of time. In several households with "always-on" televisions, the content on the television informed people when it was time to do certain tasks such as when to eat meals, put children to bed, take naps, do household chores like folding laundry, cooking, cleaning, and attending to educational tasks such as homework or to spiritual contemplation.

Thinking about Future Platforms

As the previous discussion indicates, televisions are more than just sources of entertainment; they are meaningful objects and sets of practices that are embedded in complicated domestic spaces and are part of relationships among household members. Our research findings have prompted us to reconceptualize how we define entertainment, and to look at the challenges inherent in providing compelling entertainment experiences in the home. By expanding our focus from people's interactions with the content on the screen—electronic program guides, ways of handling and using remote controls—to the contexts in which televisions as physical objects are found and the practices they support (watching, listening, multitasking, relaxing, learning, spending time with others, advising, de-stressing, babysitting, etc.), we can start to think of experiences of technology that make sense in domestic settings. Entertainment shifts from a small category of experience involving immersive escape from other activities, to a broad category, opening up many opportunities for us to think about platforms that can deliver value to our customers. The findings from The Social Lives of Television are currently helping to inform our thinking about entertainment platforms for the home.

CONCLUSION

The two case studies presented here illustrate that the value of ethnographic research lies in the fact that it provides a soft or diffused focus on technology use, combined with a sharp focus on people, looking at their homes, their daily lives, their relationships, and their values. Because such research always privileges people over technology, our research frameworks may initially seem to indicate that our attention is not focused on our "real" topic; gaining insight that will ensure that the technology platforms we develop will be used by and be useful to our customers. Because ethnography is not a prescriptive science, but an interpretive one, the deliverables produced are insights into people's daily lives and values that inspire innovation rather than dictate platform ingredients. Just as research findings are never "found" but are the result of data-gathering methods that are theoretically informed, and are in turn analyzed using social theory, so too are they in turn never taken, undigested, into the platform planning process.

DDTR researchers work closely with usage modelers, interaction designers, consumer experience architects, and human factors engineers from Experience Definition and Assessment (EDA), the sister group that forms the other half of the Digital Home Group's User Experience Group. As a whole, the User Experience Group defines consumer experience and value propositions for the platforms developed by the Digital Home Group. Subsequently, the User Experience Group has processes in place to move from ethnographic research findings to technology usage details that inform platform, subsystem, and ingredient planning and requirements related to user experience. It is at this tertiary level of translation of research data that our language shifts from people to users. Working with DDTR researchers, EDA members identify desired experiences which they combine with knowledge about technology to establish the usage scenarios needed to create those experiences. EDA members craft usage models that contain the detail necessary to translate usage information into a set of user requirements and to guide planners, architects, and engineers in generating platform and ingredient requirements, both hardware and software, that will meet the user requirements. Usage models include summaries of the usage, use cases (related interaction between uses and the system), scenarios that illustrate how users in a specific context actually use the system to accomplish their goals, task flows, and operational profiles. The tasks are translated to user experience requirements, allowing us to map directly to platform capabilities, the features and services that enable particular experience requirements to be met.

An analogy can be made between the relationship that Intel's products have to consumer goods and the relationship DDTR's ethnographic research has to the production of new platforms. In neither case is there a direct mapping: Intel Corporation does not make consumer products, but it makes the bits inside that make consumer products like PCs, mobile phones, PDAs, set top boxes, work. Similarly, the knowledge about diverse practices of domesticity that DDTR researchers produce does not directly inform new platforms but is combined with market research, technology, and business intelligence to inform and inspire innovation by enabling planners, engineers, and designers with knowledge about people rather than users (as complex actors with multifaceted agendas, loyalties, priorities, and values beyond their direct use of technology) so that they can create technologies that will support meaningful and valued experiences in and of the home.

ACKNOWLEDGMENTS

Intel Corporation sponsored the research projects on which this paper is based. In addition to the author, team members for the Social Lives of Television project included Ashwini Asokan, Susan Faulkner, and Barbara Barry. Additionally, Theresa Loo, Ph.D., worked with us in Hangzhou. Michele Chang was co-lead on the Extended Mobility project. I thank the research participants for their generosity in sharing their lives with us and Genevieve Bell, Françoise Bourdonnec, Susan Faulkner, Todd Harple, and Margaret Morris for their comments on earlier drafts of this paper.

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Real Reality TV: Using Documentary-Style Video to Place Real People at the Center of the Design Process

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Index words: ethnography, video, user-centered design

ABSTRACT

The creation of documentary video is a method used in ethnographic and design research to record study participants *in situ,* analyze interactions and observations after they have occurred, and ultimately to present insights and study findings to colleagues and key stakeholders in a form that brings the research to life. Ethnographically inspired research begins with observational and participatory field work, as researchers immerse themselves in the lives and cultures of study participants. These visits can last a few hours or take place over many days. Documentary-style video is a highly effective tool for capturing the essence of these encounters, and for putting real people and their values, habits, and lifestyles at the center of the design process.

This paper will show how video documentation, data analysis, well-crafted video editing, and strategic video presentations play an important role in a user-centered design process. Video can be used in all phases of user-centered design research—from documenting usability studies to minutely detailed analysis of behavioral patterns.

Using video clips from a study of PC usage and meaning conducted in Egypt, Germany, South Korea, and Brazil by Domestic Designs and Technologies Research in 2006, I demonstrate the power of documentary video in ethnographic research and its usefulness as a means for communicating research findings. I describe several types of ethnographic video clips, take a critical look at how video is best used, and consider whether video can stand alone as a source of design information.

INTRODUCTION

User-centered design is a term used to describe the process by which products and services are researched, tested, and developed while keeping the end-user's needs and desires constantly in mind. In this broad definition, "design" can refer to work in the fields of Human Computer Interaction (HCI), industrial design, engineering, and computer science. All of these disciplines are engaged on some level with creating products and services for people. In order to better understand people and their needs, practitioners in these fields started using social science techniques and methods in the 1980s (although there are examples of using social science to influence design going back to the 1920s and 30s) [1]. Increasingly, corporations are hiring social scientists to work with designers and technologists to inform and influence the design process. Instead of starting by creating a thing, a machine, a widget, and then hoping it will work when used by people, the idea behind user-centered design is to start with people, their needs, and the context in which a device, object, or service will be used. Ethnographic methods, including video documentation, are an extremely useful way of bringing "users," i.e., real people, into the early stages of the design process as examples of current practice, inspiration for future practice, and guides into the context in which a product or service might some day be applied.

This paper will not focus on *all* the numerous ways video can be used in a user-centered design process, but will concentrate on why video is an effective tool for communicating findings and research insights to colleagues during the early stages of that process.

While documentary footage is an effective tool for communicating insights and inspiring design ideas, it is usually one of several tools used and usually does not stand alone. Documentary-style video, in other words, video footage that is shot as an interview or observation unfolds, without a script or direction, needs interpretation to be most effective. Visual representations are particularly vulnerable to misinterpretation if the viewer is given no guidance or context for what he or she sees. It is up to the ethnographic researchers to interpret the footage, analyze the practices of the people being studied, synthesize that data, draw conclusions, and convey what they have learned to their corporate colleagues.

Field notes are another way of documenting field work. Researcher's written field notes comprise observations he or she felt were interesting or significant at the time. It is impractical to write down *everything* that happens during an ethnographic visit. Notes are jotted down in the moment, and a more complete account is written at a later time at the office or hotel. For that reason it could be erroneously argued that videotaping an ethnographic interview results in a more "truthful" or more "accurate" account than simply relying on the researcher's notes and recollections. While conducting an interview, researchers are often asked by study participants why the visit is being videotaped. A common reply is, "So I don't have to rely on my notes to remember you, and what we talk about today." The video serves as a record.

A videotape does provide a detailed record of an encounter. It can be transcribed, and if the audio recording of the visit was done well, the result will be a very thorough record of everything that was said (near the microphone) during the interview. The videotape and the transcript become a version of the truth.

What this notion of truth and reality doesn't take into account, however, are the numerous decisions that have to be made during, and the prevailing circumstances of, the filmmaking process. How a shot is framed, where the camera is placed, what questions are being asked, who is being heard, and who is not, and whose perspective is being shown: all of these can dramatically influence a videotaped account of field work. The researchers' impressions of a particular family, for instance, may be significantly altered by the presence of some family members, and absence of others, or the necessity to focus the camera on one part of a family while other members cook dinner, go to work, nurse a sick relation in another room, etc. From a practical standpoint, this is because research teams are generally small, and a videographer (or videographers) must choose where to be, where to point the camera, and whom to follow when the action changes. But no matter how many cameras, researchers, and willing participants are present, it is not possible to capture on videotape every aspect of a life, a home, a workplace or, of course, a culture. Additionally, how the final product is edited, scored, subtitled, and presented also play a large role in determining the impact the footage will have, and the insights it will impart. Even a film that is many-hours long is subject to interpretation by both the filmmaker and the audience. Frederck Wiseman, a documentary filmmaker known for creating long films devoid of narration, interviews or commentary, has said:

> I don't manipulate the events, but the editing is highly manipulative and the shooting is highly manipulative, not in the sense that people do things differently from what they will ordinarily do, but the way that people are shot. First of all what you choose to shoot, the way you shoot it, the way you edit it and the way you structure it [2].

In a user-centered design research setting, many hours of videotape are reduced to a few key minutes in the interest of saving colleagues' time, capturing short attention spans, and communicating that which is most compelling, insightful, and germane. Because of this brevity, video ethnographers are sometimes asked by colleagues, "How do we know what really happened when we only see footage after it has been edited?" It is a legitimate question. How does a fellow researcher know whether the video being presented accurately reflects reality? How does he or she know how to "read" the images? When does video need to be framed and contextualized for the viewer? Why can or can't it stand on its own? How does the specific use of video for ethnography and user-centered design research help determine how it should be viewed and by whom? Should different audiences be given different levels of contextualization and complexity? What is appropriate to present in an active, workshop setting, and what works in a relatively passive presentation?

Filmmaking and ethnography are both interpretive by nature. Both are framed and constructed by one person (or several people) to convey a particular point of view and both are interpretations of people and events. As Nafus and Anderson [3] have pointed out, a common pitfall of using visuals for ethnography in industry is that pictures (or videotape) are thought to "show the real," and are often considered by a corporate audience not to require interpretation or analysis.

While visuals can be problematic, they can also provide richness and depth to field data, and when properly framed and contextualized for an audience those pitfalls can, hopefully, be avoided or diminished. In this paper I do not address the need to move on from the "real period" that Nafus and Anderson assert, and will not cover the innovative applications of documentary filmmaking discussed by Raijmakers, et al., as new methods of using video in user research [4].

Rather, in this paper I demonstrate the power of using video for ethnographic research in an industry setting, and I examine some of the complex issues video representation can elicit. There is no single "reality," but through interpretation and analysis, researchers can create a version of what they witnessed in the field that speaks to a theme or gives insight that is relevant, inspirational, and useful. The result is a representation of reality that is both grounded in what the ethnographers experienced and instructive for colleagues who were not there. This version of "reality" can be powerful, meaningful, and highly effective in the design research process.

PLACING VIDEO ETHNOGRAPHY IN A HISTORICAL CONTEXT

Video has been used by anthropologists and ethnographers since the turn of the 20th century. Robert Flaherty famously filmed native Eskimos in the 1920s. Margaret Mead and Gregory Bateson started making films in Bali in the 1930s [5]. Because these films show tasks like bathing a baby or teaching a young boy to use a bow and arrow, they could be placed into a very broad definition of user-centered design research.

For the earliest examples of movies made with the express purpose of improving technology or designing new technology, the best example is the work of Lucy Suchman, an anthropologist, whose work at the Xerox Palo Alto Research Center (PARC) in the 80s and 90s focused on particular workplaces (an airport, a law firm, a state department of transportation) to combine the study of technologies-in-use with the design of new prototype systems. After conducting ethnographic fieldwork in a workplace, Suchman produced a film showing office workers struggling to use a Xerox copying machine. The film was shown to researchers and engineers at Xerox, and it led to significant changes in interface design, including the addition of the now ubiquitous large green button that allows users to quickly and easily make a copy [6].

Early ethnographic video at Intel Corporation includes footage shot in 1997 for the "Anywhere at Work" study conducted by John Sherry and Tony Salvador who were in the People and Practices Research Group at that time. The study focused on workers who spend their time away from the standard PC desktop or, in some cases, workers with no access to a desktop PC. The video showed how poorly suited the PC was to many different kinds of jobs and included a fisherman in Alaska who duct-taped a laptop to the side of his fishing shed so he could wirelessly transmit data about fish weight to the salmon cannery and the Alaska Fish and Game Commission.

Another People and Practices project to use video extensively was "Connected Consumer Applications" or "Con Con Apps." The study was conducted by Eric Dishman, Scott Mainwaring, and John Sherry in 2000. The researchers videotaped and interviewed approximately sixty families about their entertainment and communication habits and needs, and the footage was logged, digitized, and stored in a searchable online repository. The video was used in brainstorming sessions to develop concept prototypes, and during "informances" with live actors performing scenarios based on the footage of real people shot in the field. This video-based project had such a large impact at Intel that it influenced the decision to put people in Intel's ad campaigns—campaigns that up to that point were purely tech-centric. The project also was instrumental in the establishment of Intel's Proactive Health Strategic Research Project because so many of the study participants spoke about the challenges of caring for aging relatives. That project led to the formation of the Digital Health Group division [7].

Other uses of video at Intel Corporation for research or resulting from research have included "Visions of the Future" videos. Scenarios and experiences witnessed in the field are scripted and then dramatized by actors. The videos have a connection to ethnographic data because they are grounded in situations that were observed by researchers in the field. They are more highly produced, and the content is more tightly controlled than footage shot *in situ*. "Visions of the Future" videos are very effective communication tools, but they lack the spontaneity and nuance of documentary-style video footage of real people living, working, and playing in their own, unique surroundings.

CASE STUDY: VIDEO DOCUMENTATION IN DDTR'S PROJECT, "THE PC: DOES IT COMPUTE?"

The project, "The PC: Does it Compute?" is an ethnographically inspired research study I conducted with my colleague Jay Hasbrouck in 2006. The goal of the study is to gain deep knowledge of how the PC is understood in Egypt, Germany, South Korea, and Brazil. The emphasis was on how computers fit into people's homes both in terms of how they are placed and used, and how they are perceived. We focused on the everyday lives of our study participants—their daily habits and practices, their frustrations and joys, their fundamental values and aspirations—with an eye toward how technology is or is not playing a role in their daily life. By using ethnographic research methods, and looking at the breadth of experiences and behaviors of our participants, and the people around them, we gain a more profound sense of the context in which they live, and our insights and observations about their PC use are deeper and richer.

Research methods used in the study include in-home ethnographic interviews with as many family members as are present and available. Those initial interviews take about three hours, and include a tour of the home led by one of the participants. We also use a methodology referred to as participant observation in which we spend time with our research subjects in or outside the home. In many cases this is a shared meal: in one case we went on a long hiking excursion which was followed by a home-cooked meal.

We spend a significant amount of time in contextual investigation of the communities, towns, and cities where participants live by shopping in the stores where they buy electronics, interviewing the local PC shop sales people, and browsing in large stores and small “grey box” building establishments. We look at the high-end and low-end markets, and we try to get a feeling for how PCs are marketed, positioned, and sold in a given city or town. We visit Local Area Network (LAN) houses, Internet cafés, and other establishments where computers are used and enjoyed.

During the initial interview with a family we engage them in a cognitive mapping exercise. They draw a map of their own home and designate different areas of interest and paths of movement. We also give the family a Polaroid camera at the end of the first interview and ask them to complete a photo prompt questionnaire by taking photos to answer questions. Additionally, the home visits, much of the participant observation, and most of the contextual exploration are documented on digital audio recorders for easy transcription, and they are always videotaped.

I have chosen three examples of edited videos to demonstrate some of the ways in which video can be used to communicate research findings. There is no widely accepted terminology for describing ethnographic video clips: I use labels I have found useful and descriptive in my own work.

An Introductory Montage

Most corporate meetings, and certainly most Intel meetings, take place in conference rooms with long tables, numerous chairs, and no windows. These spaces are designed to be utilitarian, efficient, and neutral. Meeting attendees rush into the room consumed by thoughts of the last meeting, and their need to check e-mail or create a new to-do list. At the close of the meeting these attendees will rush off to the next meeting or some precious un-scheduled moments in their cubicle to tackle the tasks of the day. One of the jobs of the corporate ethnographer, and especially the video ethnographer, is to transport those meeting attendees to another world or worlds, and make an impact on how they see people (consumers) who are not like them. Taking colleagues out of the confines of their corporate culture, their regional culture, and often their national culture in order to help them better understand people in far flung parts of the world, for whom they are designing and marketing products and services, is the goal of the ethnographer, and video is the most effective tool to achieve those ends. Using a two-to-three minute video the ethnographer can capture the attendees’ attention and create an atmosphere of curiosity and openness.

The introductory video for “The PC: Does it Compute?” starts with quick cuts to grab viewers’ attention, gives a rapid overview of the places we visited, and conveys the pace and sounds of everyday life. Next, we see images of individuals involved in ordinary activities that evoke the country in which they live. The video segues into shots of people entering their apartments, and we have the sense of being invited into homes. The last part of the video comprises slightly longer clips featuring research participants showing and explaining intimate details of their lives. The purpose is to convey the wide variety of people, experiences, and activities we explored during our field research.

The first images are of brightly colored paper lanterns hanging in a courtyard in Seoul, then we see a sailboat in the bay of Rio de Janeiro at dusk, and then a helicopter above the famous statue of Jesus called “Corcovado” in Rio. Images of cars in traffic by the side of the Nile, Egyptian women in veils crossing a busy street, the outside of a church, a German boy eating a hot dog (Figure 1), a Brazilian woman texting on a cell phone while sitting on a beach, and a young man carrying a large CPU on the streets of Seoul (Figure 2) are interwoven.

Figure 1: Still image taken from Introductory Montage video: Bremen, Germany. A young boy eats a hot dog.

Figure 2: Still image taken from Introductory Montage video: Seoul, South Korea. Young man carries a CPU down the sidewalk.

The images transition and we see a Korean man unlock his door using a touch keypad (Figure 3), and are taken inside. A Korean boy holds his dog, a pair of white tennis shoes, and explains that if he doesn't remember to wear them at school it's "bad" (Figure 4). We see a German family with a TV prominently positioned next to a roaring fire in a living room, and then are introduced by them to their "little computer room," which looks like a tiny attic storage space. An Egyptian woman says she placed the family computer so that her kids "can be under my eyes" while they use it. We briefly meet a Brazilian family and the teenage daughter says she uses the computer "eight hours of the day." The montage ends with a young Brazilian boy whose father has helped him to play a song on the PC. The boy claps his hands, moves his feet, and pretends to play piano on the PC keyboard as the video fades to black.

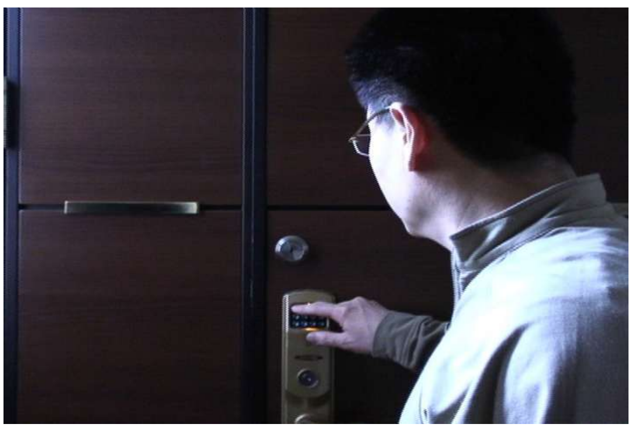

Figure 3: Still image taken from Introductory Montage video: Seoul, South Korea. Korean man uses touch keypad to unlock his front door.

Figure 4: Still image taken from Introductory Montage video: Seoul, South Korea. Teenage boy must remember to take white sneakers to school every day.

It is a powerful and compelling tool for capturing the attention of a busy and potentially distracted audience. It draws them in to the data, and it makes them curious to learn more.

Illustrative Clip

An illustrative clip is a clip that is edited with the goal of informing viewers of particular insights, and it is intended to guide viewers toward making specific conclusions. Researchers, who put this kind of clip together, have a pre-determined outcome in mind.

In our case study, one example of this kind of clip is a seven-minute video about the household of Sadia B.[1] in Cairo, Egypt. Sadia is a primary school principal who speaks excellent English. Her husband was not home for most of our interview because he was working at his jewelry shop in the Khan al Khalili market in the old part of Cairo. Joining their mother were Sadia's three children: Hatim, the eldest and only son, is 17; Bahar is the 14-year-old daughter; and Habiba, 7, is the youngest girl.

The clip was designed and edited to instruct the viewer in how Muslim homes are arranged in Egypt, how gender roles partly determine that arrangement, how birth order and gender affect technology use, and why the PC is unlikely to be placed in the public rooms of an Egyptian apartment. As you will see from the description of the clip, we didn't directly ask about any of those issues while interviewing Sadia and her family. As with all ethnographic interviews, we asked broad questions about daily life and habits, but since we were in Sadia's apartment, among her possessions, interacting with her and her family, and observing them interact with each other, those issues came up during our three-hour interview.

Our Clip from that Interview

The clip begins in the kitchen. Young Habiba is vying for attention from the visiting researchers, and after a brief conversation about how helpful Habiba is in the kitchen, and how much more helpful she is than her siblings, the following exchange takes place:

Researcher: "Some houses we've been to, the mother says, 'I don't let them (my children) in the kitchen.'"

Sadia: "*La, la, la* [no, no, no.]. We were four girls [growing up] and my mother used to let us help her a lot. But they [my daughters] are going to be, one of the days, a housewife and she has to cook for her husband and her children. She has to know, and helping me a little bit, to know what's responsibility. I can't let them sit and I'm bringing the drink to them…this is enough."

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[1] All names of research participants are fictitious.

(The scene changes to a small, interior room with a couch and a television that is on.)

Sadia: “This is our living room. This is where we live, all day long, and all day night.”

Researcher: “Do you have favorite spots? Who sits where?”

Sadia: “I always sit there.” (She points.)

Researcher: “Can you show me?”

Sadia: “Okay. I always sit here, stretching my legs together, taking my youngest daughter with me (Habiba is laughing and lying next to her mother). This is my special area.”

Researcher: “Where do you sit, Hatim?”

Hatim: “Here.” (He points.)

Researcher: “Can you show me?”

Sadia: “On both of them.”

Habiba: “And Bahar sits here.” (She points.)

Bahar: “I like to.” (Gesticulates.)

Sadia: “She’s wearing her eyeglasses; she wants to sit near the screen. I’m telling her all the time. ’Go back, please,’ but no way. My husband he prefers to sit here (points) and put his hand here, on my lap, and stretching all the way. He likes to prefer to sit on the floor.”

Habiba: “Like this.”

(Much laughter.)

Sadia: “And we never quarrel. When somebody sees me coming in the room and he is sitting here, he stands up, ‘Come Mama, this is your place.’”

(Sadia walks into the children’s room.)

Sadia: “This is their disaster. Not their room. I always try to prepare it, and clean it, but, ah, tomorrow’s Friday and it will be much more lovely. Here’s the computer. It is all the time here. Not giving much space for anybody, even Habiba, she doesn’t have the, when he goes out with his friends she quickly sits and opens it to play a little bit.”

Habiba: “I run, run, run, run, and sit like this.” (She sits at the computer.)

Hatim: (Pulls hard drive out of front of CPU) “I got this for my friend to come and put his work.” (He puts drive back in.)

Sadia: “This is what is destroying the computer. Every time he takes the hard (drive) and takes it to another friend, or bring, sometimes it has a virus. All the time there is something, there is a problem happening to the computer.”

(Scene changes to a new room).

Researcher: “Tell me a little bit about this room.”

Sadia: “This is the reception area. We always receive guests here.”

Researcher: “You were saying you spend a lot of time in the living room. Would you ever consider making this a living room?”

Sadia: “No. I would not feel comfort because I’m veiled. When I sit in the living room then I can wear whatever I want to wear, and keep my head not veiled, and sit without, ah, all the time waiting if someone will knock the door and, ‘Oh, bring me my veil.’ It will be inconvenient for me. But then I feel that I’m, ah, more comfort inside.”

Researcher: “This is more formal?”

Sadia: “Yes.”

Researcher: “Do you eat here?” (Dining room table is in same room.)

Sadia: “We always eat here only at Ramadan because my husband is here. At Ramadan we invite relatives and sometimes the neighbors. We must have space for that, although we are not using it because me and my children we are eating inside. This is the Egyptian style. My mother and my grandmother, and all of us, we can’t change this.”

End of clip.

What the Reader Can Learn

A reader can learn interesting information just from the above text that was transcribed from the edited video clip. This partial text is more instructive than a transcript of the full interview because scenes and conversations have been abbreviated, and there is less for a reader to sift through in pursuit of pertinent information. The reader could also be provided with a map or diagram of the home to gain valuable spatial knowledge and could be shown photos to create a more rich vision of Sadia’s family and their home. But, even after reading the dialogue, looking at a diagram, and seeing several photos, the reader is only reading about Sadia and her family and is missing most of the information, and all of the nuance provided by the video clip. Where does the family sit in the living room? What are the dynamics among family members? What does Sadia mean when she talks about eating “inside”? What mood is present in the different rooms? What are these people like? What is the tenor of their voices? What does their body language say? And what does all that tell us about where technology fits or doesn’t fit in Sadia’s home?

This clip provides a very detailed view into Sadia’s home—both the physical space and the dynamics of the family living there. At the beginning of the clip we see

Sadia's love for her youngest child in her body language and gaze. She calls Habiba "lovely" while stroking her hair and giving her a squeeze. When told by the researcher that some Egyptian mothers have said they don't let their children into the kitchen, Sadia's tone changes dramatically. She becomes serious, her voice lowers, and it is clear that her opinions about girls and their need to learn how to cook for their future husbands is of great importance to her.

The scene changes to the living room, and the mood is playful, fun, and even raucous. After being asked to show the researchers where they sit to watch TV, Sadia offers to explain where her absent husband sits. She sits in her regular position in the corner of the couch with her legs stretched out on one part of the "L" shape. She says he puts his hand "here, on my lap," as she smacks her hand down on her upper thigh. Habiba then plays the part of her father. She sits on the floor and opens her legs wide to take up space. She wears a mock-serious expression to mimic her father, and lays her arm across her mother's thigh while moving her head slightly from side to side.

Sadia tells the researchers that the family never argues about where they sit in the living room. If "someone" is in her spot, "he" moves and says, "Mama, this is your spot."

From watching this scene we learn a tremendous amount about the dynamics in Sadia's family. We know that Sadia is a strong matriarch with firm opinions about women's roles. In the living room we learn that she is respected by her children, and that they defer to her. We also sense some playfulness and affection between husband and wife even though he isn't present. Habiba's posture when playing the role of her father suggests that when he is present, Sadia defers to him. Additionally, we learn the importance of television in their lives. The spots from which they watch TV are well-established, and it is clear from watching the video that life in that room revolves around watching television. Sadia tells us, "This is where we live. All day long, and all day night."

After the comfort and good humor of the living room we are introduced to the "reception" room. What we see in the video, but cannot glean from just reading text, is that the room is very formal. Furniture is painted gold and upholstered in red or gold fabric. There are two seating areas, each with its own coffee table with decorative china on platters. This room is quite spacious, almost half the size of the entire apartment, and the researchers ask Sadia if she would consider making this room the living room. Sadia answers that question by talking about being veiled, and it is the first time veiling has been mentioned. Sadia's veil on this day is bright yellow, and she wears it with a grey tailored business suit. She explains she must have a living room "inside" so she can take off her veil and feel "comfort." On the video we can see the front door of the apartment behind her, and she turns and points to it as she explains that she needs to be veiled in this room because here, "all the time waiting if someone will knock the door." This is a public room to her; it is "outside," and not a place of comfort.

We learn the reception room and adjacent dining area are only used during Ramadan, and Sadia says, "This is the Egyptian style. My mother and my grandmother, and all of us, we can't change this."

Seeing these rooms on video, and hearing Sadia explain how they are used, tells us a lot about what they mean for the family. The room that to Americans looks like a "living room" is the reception room, and it is rarely used. That room contains no high-tech equipment, and it probably never will.

The room that looks like an American den is called the "living room" and it is where the family hangs out and watches TV. We see on the video that this room is small, cramped, and has one window covered by curtains. It is literally and figuratively "inside;" there is no chance of being seen unveiled.

The living room is where the family spends time together, and the technology reflects that. There is a TV, a satellite receiver, and a stereo system. As with almost all of the Egyptian homes we visited, the computer in this household is kept in the children's room. It is evident from the video that there isn't any space for a desk, chair, and CPU tower in the living room.

In the children's room are two large, queen-sized beds. We see the PC in a corner on a small desk, and suddenly Sadia's son grabs a plastic handle and forcefully yanks a plastic case containing the hard drive from the machine (Figure 5). Raising her voice to a level of frustration and anger heard nowhere else on the video, Sadia decries the activity of removing the "hard," as she calls it. This activity of taking the hard drive to a friend's house to give and receive content "is what is destroying the computer."

Figure 5: Still image taken from an Illustrative Clip video: Cairo, Egypt. Hatim pulls the hard drive out of the CPU so he can carry music files to his friend's house.

One of the most significant findings for Intel from this interview is about the placement of technology. Understanding that a desktop PC will never be placed in the formal reception room, and won't fit in most Egyptian living rooms, is useful information. Arguably, it is something that can be explained to a designer or engineer in a few short verbal or written sentences, but understanding the cultural context of why the PC is unlikely to be in those Egyptian rooms any time soon makes that information more rich, more meaningful, and more likely to strike a chord with the colleagues receiving it. The "sneaker-net" [8] practice in Cairo of removing an internal hard drive to walk music over to a friend's house is unfamiliar to Americans, and seeing how easily and forcefully Hatim yanks the drive out of the machine is a powerful demonstration of that practice. Intel colleagues who view this clip vividly remember the Egyptian woman with the strong, authoritarian voice wearing the striking yellow scarf. They are able to picture her relaxing on the couch in her living room, cuddling with her daughter, explaining the "Egyptian style" in her formal reception room, and stridently scolding her son about his unhealthy practice of sharing internal files, and thereby contracting and spreading viruses.

A Theme Video

A theme video is a compilation of video clips selected for their relevance to a key finding of a research study. The best example from "The PC: Does it Compute?" is a video entitled "Dead and Dying PCs." It is a three-minute edited video featuring frustrated study participants from three of the four countries we visited battling sick, slow, dying, and dead PCs. A college student named Adam in Rio has cranked open the lid on his CPU because it has been overheating and crashing a lot lately. He keeps a pink-haired troll on top of the computer to protect it "from viruses, bad influences" (Figure 6). A German woman explains that her computer has a "*troijaner"* (as in Trojan Horse) because her daughters use it to play games. Both girls have their own computers, but their PCs are older and slower, so they use their mother's, and now she has a virus. A teenage girl in Brazil is asked if having her computer out of commission is a very bad or not that bad state of affairs. In a tone of desperation and teenage angst she says the situation is very bad, and she explains in Portuguese that there is, "a problem with the main board, the memory, the keyboard, the mouse. Everything!"

Figure 6: Still image taken from a theme video about PC health: Rio de Janeiro, Brazil. Adam keeps a pink troll on his CPU to protect it "from viruses, bad influences."

In presentations the video is shown to audiences after several PowerPoint* slides on the same topic are presented. The video dramatically brings the PowerPoint data to life, but also benefits from having slides precede it. The two methods work together to make a strong point, i.e., that most of the PCs we encountered in our research were ailing, and their slow speeds and unpredictable behavior were a source of much frustration for their users. The country not included in this finding was Korea where the PCs we witnessed were invariably running smoothly. (The most likely explanation for the relatively healthy PCs in Korea has to do with strict governmental oversight of Internet service providers, and the near elimination of viruses from the Korean broadband system.)

DISCUSSION

Video is an extremely effective tool for communicating findings, bringing study participants virtually into the corporate setting, and making people, their habits, and their homes come to life. But it almost never stands alone. Video serves as an excellent record or document of people and events, but it needs interpretation. To get the minimum amount of information necessary from Sadia's clip, it is important to be told she is Egyptian and living in an apartment in Cairo, especially since her English is very good, and an observer might mistake her for an immigrant to the U.S. To get even more out of the clip it is helpful to know that Sadia's three children sleep in the same bedroom, and that Sadia considers this the worst problem in her life right now because it is inappropriate for a seventeen-year-old boy to live in the same room with his younger sisters. When armed with that background information the knowledge that Sadia will not consider turning her reception room into a living room has much more meaning. The living room would be a natural choice for a third bedroom if the family did not need a place for Sadia (and some day, her daughters) to relax unveiled.

The introductory video benefits from the opposite treatment. It is shown to an audience without any preparation for the purpose of waking them up, taking them out of the conference room, and giving them something to think about that may be puzzling and a little confusing, but is hopefully compelling. It serves as a preamble to slides describing the study and helps demonstrate the methodologies used. Countries, cities, and neighborhoods were explored in context, and time was spent interviewing, observing, and interacting with families in their homes. The video does an excellent job of conveying the breadth and depth of the research in a few short minutes.

The themed video about dead and dying PCs is intended to drive home a point that has been introduced in several PowerPoint slides that precede it. The video is rendered more meaningful because it is shown after the slides give details and background on the subject. The slides alone cannot provide the punch and impact that the video delivers. The agitation, frustration, and misery of some of the participants cannot be fully appreciated without experiencing their stories, seeing the pain on their faces, and hearing the strain in their voices. The point is made much more forcefully through the use of both communication techniques.

What is clear to the audience viewing these videos is that they are representations of what the filmmaker thinks is interesting and important. They are not objective or neutral. In presenting the material, I, the filmmaker, explain that these edits represent themes that have emerged from the research. They represent a framing of my perspective, and are a very small sampling of the many hours of videotape recorded in the field. These clips are intended to grab the attention of the audience, to impart knowledge gained in the course of doing the research, and to suggest design ideas and areas of further investigation.

A videographer makes choices every moment he or she is filming. If the light is bad in one part of a room, a videographer might ask the study participants to move to different seats—seats they may seldom use in everyday life. If there is ongoing activity in more than one part of the home, the videographer must decide where to film. Time is limited. A corporate videographer cannot spend weeks or months with a subject. The videotaped account shows a particular day, in a particular season, with whomever is home and willing to participate. In Sadia's household, hers is almost the only point of view to which we were privy. How would our impressions of that family and their habits have changed if it had been Sadia, and not her husband who was away from home and at work that evening?

As an editor, weeks or months after the footage was recorded, I am still making choices about framing. In a corporate setting I consider the audience's availability and attention span. Short clips pack more of a punch and are easier to insert into a presentation. After determining what themes of the research are the most important to communicate, I narrow down the best examples of those themes. Who is easy to watch? Who is easy to understand? What is surprising? What is mundane, but of the utmost importance? Which clip goes where and in what order?

As I edit the material I am not looking for an overarching narrative as I might with a documentary film. The footage, which was shot in twenty-eight homes in four countries, becomes a loose collection of short narratives. My intention is to give colleagues enough context so they can understand a particular issue, habit, or practice portrayed in the video. I want to give them something to think about and interpret. As a social science researcher at Intel Corporation I work with engineers and other technologists who have a much more sophisticated understanding of silicon and micro-processors than I do. In using documentary-style video my goal is not to tell them what to think, but to inspire them to think about users, and what users need and desire, in new and different ways.

CONCLUSION

It is precisely because there is so much richness in video data, and often so many hours of raw footage, that editing and placing ethnographic video in context for viewers are important, especially in an industry setting. In a one-hour report of research findings to a roomful of busy, multi-tasking colleagues, video clips are necessarily brief and are carefully chosen for maximum relevance: they need to have as much of an impact as possible in a short period of time. In most technology companies, data are typically presented in text, graphs, and diagrams. The introduction of video clips into most meetings in this kind of setting results in a quiet, attentive, captivated audience that temporarily puts multi-tasking aside.

Another strength of using video is its power to keep research findings fresh. After weeks and months of analyzing field work data, distilling thoughts, synthesizing themes, creating documents, and sorting through images, the people who were visited and interviewed, and upon whose lives the data are based, can get lost. Video transports the researchers back to their weeks in the field, and it vividly portrays the heart and soul of the study, the participants, to colleagues.

It is ironic that I am using words to describe the rich depth of meaning and strong impact that visuals can provide. Clearly, it would be more effective to make these points visually, but ethical and legal considerations come into play when considering putting images of study participants on the Web.

The methods described in this paper are limited to the most common video presentation styles currently used at Intel Corporation. Since PowerPoint is both the industry and Intel standard for presenting findings, it is practical and efficient to embed video clips within a PowerPoint slide presentation. However, this is far from the only way to view ethnographic video.

While short clips work best in a typical one-hour corporate meeting, Domestic Designs and Technologies Research, and other multi-disciplinary research groups at Intel Corporation, engage our colleagues in half-day and all-day workshop and brainstorming sessions for which longer, more immersive video presentations are appropriate and provocative.

Filmmakers and researchers have been experimenting with new ways of using video to impart information for years. In 1998, Rachel Strickland's multi-station, interactive Portable Effects exhibit used video playback and video capture to teach visitors about their own "nomadic design" practices while being immersed in the practices of others [9].

Anthropologist Jay Hasbrouck's master's thesis about a collective of gay men ("radical faeries") living on a commune in a remote area of New Mexico was presented as a video installation with multiple screens and monitors presenting portraits of his research participants and their daily lives [10].

At Interval Research Corporation in the late 1990s I oversaw a project to log, code, and digitize over 250 hours of ethnographic research video, and 10,000 photos from multiple projects. The video was linked to an internal Web site and stored in a video "jukebox" that was searchable from any computer in the company [11].

What will come next for ethnographic video in industry? Will YouTube inspire EthnoTube? Will video podcasts push research findings to all interested colleagues anywhere in the world? Will the relative ease and affordability of video gear and production techniques lead to more participant-based video research in which the subjects themselves produce visuals about their own lives?

New and exciting uses of video are exploding on the Web, and in our homes. Intel and other innovative companies need to continue taking advantage of this powerful communication tool within the corporate setting.

ACKNOWLEDGMENTS

I thank Jay Hasbrouck, Jay Melican, Daria Loi, Alexandra Zafiroglu, Margaret Morris, and especially Maria Bezaitis for their editorial input during the writing of this paper. I also want to thank Scott Mainwaring and Eric Dishman for their contributions to the historical section of the paper, and their editorial suggestions. Additionally, I acknowledge the researchers with whom I conducted the study referenced in this paper: Jay Hasbrouck and Barbara Barry. Lastly, I thank the research participants who generously welcomed us into their homes, and who allowed us to document our visits on videotape.

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AUTHOR'S BIOGRAPHY

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Intel® Usage-to-Platform Requirements Process

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Index words: usage model, use case, requirements, task analysis, platform

ABSTRACT

Intel® strategic marketing groups conduct research that, when combined with other secondary sources and analysis, identifies promising usage models for Intel technology and products. Historically, usage model descriptions were handed off to "platform" architecture and planning teams, whose task was to identify the requirements necessary for the processor, chipset, software, and other components needed to enable the usage models. However, platform teams had difficulty gleaning actionable engineering requirements directly from the usage model descriptions, since the descriptions did not include all of the elements that make up fully defined usage models.

In 2004, Intel's User Centered Design (UCD) Group proposed and implemented the "Usage-to-Platform Requirements" (U2PR) program. The goal of this program is to discover usage requirements and to establish a foundation for the desired user experience inherent in the usage models. This is accomplished by analyzing and refining the usage models through a process consisting of user research, existing product evaluation, use case development, and usage requirements writing.

In 2006, other efforts have encouraged wider adoption of the U2PR process. First, the Intel Platform Product Life Cycle has incorporated the core process and deliverables from the U2PR program. Second, the UCD group and platform quality methods experts have widely disseminated the U2PR process through Intel training courses. Third, the U2PR deliverables and process have been formally adopted by multiple organizations across Intel consumer, business, and mobile product groups.

In this paper we discuss the U2PR process, describing the types of research necessary to inform the process, the methods we have evolved in developing use cases and usage requirements, and the importance of visual collateral to concretely communicate the usage vision. We also explain the wider context in which the U2PR process contributes to the development of an Intel platform, which involves challenges beyond the development of an individual product.

INTRODUCTION

Intel® Platforms

A platform, as understood within Intel, is a set of products that one or more companies deliver to the market as an integrated solution. One of the principal aspects of Intel's transformation from a microprocessor company into a platform company is the building of a comprehensive customer focus to complement technology excellence. Intel's customers range from the companies that purchase silicon all the way to end-users who interact with products and services that are based on our platforms.

Platforms based on Intel® architectures are built from a system of component ingredients, some of which Intel may not produce. Delivery of platform value depends on standardization as well as on an ecosystem of products and services that enables the platform. Because open, evolving platforms are not limited to a single product type, or even a product line, they are especially challenging to design. Adding to the challenge, the same platform may be delivered through a range of business models in multiple countries, may need to accommodate multiple types of users and uses, and may be required to adapt to accommodate changes in technology.

In order to manage complexity and make sense of these interdependent concerns, UCD established Intel's "Three-Circle Model" [1]. This model frames the relationships among business, usage, and technology perspectives, while integrating them as a coherent system (Figure 1).

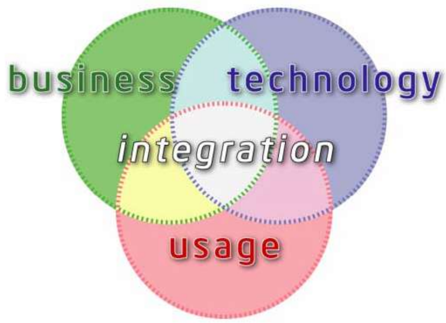

Figure 1: Three-Circle model

Usage Within the Three-Circle Model

The Usage circle encompasses all aspects of experience design and is centered upon usage models. Experience design is the process that relates the users' understanding, values, and experience of the system to usage models (Figure 2).

Figure 2: Usage circle

Usage models perform several functions. They describe the user-system interaction and demonstrate the benefit of the system to the user within a specific context. Usage models establish validation metrics and targets. Also, they connect quality of experience (perceptions, attitudes, emotions, etc.) back to the user goals, motivations, abilities, and context.

Where Usage and Business interact (Figure 3), we find value transactions—platform offerings that users and other stakeholders find compelling. "Value" relates the expectations and experience of usage to market concerns around an offering, such as value proposition, positioning, brand promise, and pricing.

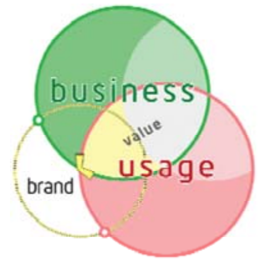

Figure 3: Usage and Business

Usage and Technology (Figure 4) are related through capabilities that describe what the system does for the user in pursuit of a goal. Capabilities most often map to the technologies or ingredients that embody or implement them. Sets of capabilities operate together to deliver the utility of the system, while utilization describes how technology satisfies usage and forms the basis of specification.

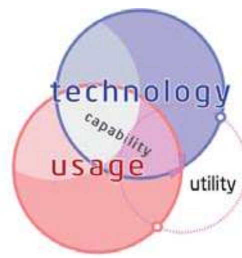

Figure 4: Usage and Technology

Business and Technology intersect to define platform ingredients, which represent those technologies that make business sense, in conjunction with their means of production and delivery.

The Three-Circle model forms the basis for decomposition, mapping, and traceability of requirements across these different and often distinct perspectives. It also facilitates establishment of achievable functional and quality targets. Within the Three-Circle model, the U2PR process relates business and technology concerns, informs the design and assessment of desired user experience, and articulates requirements for the platform.

Historical Need for a U2PR Process

Prior to the implementation of the U2PR process, platform planners and technology architects had difficulty interpreting the usage models identified by Intel marketing teams. In particular, the usage model descriptions did not include the detail necessary to generate actionable engineering requirements. A high-level usage model such as "consuming media anywhere and anytime within the home" had a good deal of thought and research behind it, and the planners also had anticipated what technologies would likely be employed to provide such an experience; however, handing off the concept to architects with only this level of detail had several problems.

First, the usage model could be interpreted in many ways. From an Intel point of view, having a PC in every room with a gigabit Ethernet network tying them together (in order to allow media to be transferred) is a highly desirable goal, but from a relatively normal home user's perspective, such an infrastructure could be expensive and difficult to install. Second, architects needed more tangible examples to help them better understand the end-user experience that marketing had in mind. For example, what kind of content is desirable for home entertainment needs? Third, a variety of devices needed to be considered for each usage model, especially across geographies and cultures. What kinds of TVs or stereos would users expect to use in conjunction with the PC? How would a notebook computer be used in such a scenario? Fourth, new usage models had implications for other PC-oriented tasks. For example, if the PC is being used to send media elsewhere in the home, would the PC still have bandwidth to do a file backup? And finally, usage models needed to be guided through the platform planning process. People who understand the usage models and the user impact must be available to discuss implications with architects. Often an architect is assigned to a particular technology, for example, wireless networking, and must interpret the relevance of the usage models for that technology.

The U2PR process was developed through a series of pilot exercises that showcased different aspects of the overall process, conducted with several different divisions and technology development teams at Intel Corporation. It found its first implementation in the work begun in 2004 aimed at the Digital Home and Digital Office platforms planned for 2007.

U2PR and the Platform Product Lifecycle

As with most disciplines involved, the focus of usage-oriented roles evolves over the course of the platform lifecycle as knowledge and decisions shape the platform. Work earlier in the process informs and constrains downstream efforts, adding more detail to specification and measurement of platform requirements.

The Intel Platform Product Lifecycle is a phase-based, iterative framework for managing pursuit of opportunity relative to risk and cost (Figure 5). For the purposes of this paper, the activities associated with major phases are roughly characterized as discover, design, develop, and deploy. Activities planned to occur during each of these phases assist in supporting product development with continued considerations of business, usage, and technology along the way. Although all of the following activities are not limited to these phases, the activities are the major foci within them.

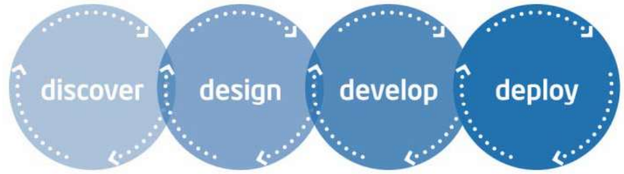

Figure 5: Product lifecycle phases

Discover
This earliest phase is focused on identifying opportunities and establishing strategy. Emerging usage trend-analysis and synthesis from research identify usage models and architectures. Observational work helps to articulate and validate these usage models, and to provide early indications of how potential requirements may be measured.

Design
The second phase concentrates on transforming strategy into actionable and effective plans. The bulk of U2PR efforts occurs during this phase, as key use cases determine specific platform requirements and feasibility. U2PR professionals refine and document conceptual models to guide downstream development, when user experience assessment of prototypes may occur. Definition of the "desired user experience" helps identify quality targets and metrics, used to scope test plans and other resources needed during development.

Develop
In this phase engineering consumes platform requirements while generating product specifications and implementation details. Development teams must also determine whether the products under development meet U2PR targets for experience quality and usability.

Deploy
The last phase deals with getting products built, delivered, and supported. Experience design can encompass the entire "usage lifecycle," ranging from the initial search for a product to the out-of-box experience to ongoing maintenance. U2PR is a key component of delivering on the user experience that was intended during early planning, and of realizing the value of the platform.

Figure 6 shows the role of U2PR in the platform product lifecycle.

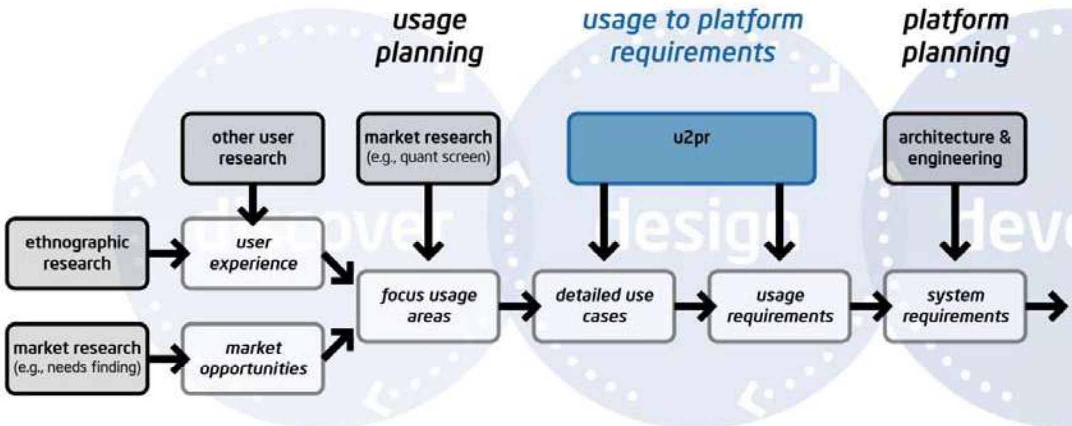

Figure 6: The role of U2PR in the platform product lifecycle

RESEARCH BEFORE U2PR

Identifying Usage Models

Before the U2PR process begins, usage models for Intel platforms begin their lives as a compilation of ideas resulting from research and careful planning. But in order for these ideas to be viable as innovative platform opportunities, those users who will ultimately be affected by the end product must perceive the ideas as useful, usable, and desirable. A process called usage modeling gives Intel strategists a tool for depicting how a particular technology will be perceived and adopted within the context of people's lives. Usage models enable a diverse group of technologists, strategists, and researchers within the company to begin to understand a product's impact on people before the product is actually built.

The development of usage models ensures a balance between business, technology, and user goals. As a result of achieving this balance, Intel is able to demonstrate how ideas can be implemented as technology that fulfills unmet needs while also ensuring Intel's business goals are achieved. The ideas may be potentially disruptive new uses that change how technology is consumed, or they may be existing uses that make sense to enable in Intel platforms.

To be successful at developing usage models, Intel researchers must understand the experience of their users. This is done through many of the research methods described in this paper—in-depth observational research, contextual interviews, prototyping of concepts, and learning what worked and what didn't from previously developed products. By talking with end-users, researchers gain insight into context, culture, and gaps in experiences with current technology.

Once a usage model has been identified as an opportunity for Intel, it is up to U2PR professionals to dig deeper by describing the user experience, ease-of-use, system interactions, and value propositions.

Comprehending Existing Research and Products

In preparation for U2PR work, U2PR professionals must have an adequate understanding of the potential business impact and current technology solutions and a thorough understanding of user needs. Such information is gathered in several ways. First, market research at Intel often provides a high-level understanding of usage model opportunities in various markets. Second, ethnographic studies, which collect user data from direct observation of the everyday life of a particular society or group, provide context for user needs. Third, a review of existing products helps identify the limitations of current solutions for existing usage models.

THE U2PR PROCESS

Identifying Use Cases

The core steps within the U2PR process are identifying the use cases, developing the use cases, conducting deep-dive research, and writing the requirements (Figure 7).

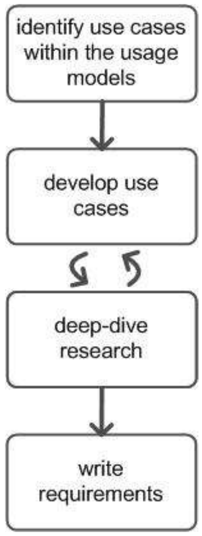

Figure 7: Core of the U2PR process

As stated earlier, a usage model describes the interaction between a user and a system and demonstrates the benefit of the system to the user within a specific context. A use case defines a more specific sequence of interactions between one or more actors and the system. More than one use case is usually needed to fully define a usage model.

In the example usage model cited earlier, "consuming media anywhere and anytime within the home," the U2PR professional would develop several key use cases to specify this usage model. For example:

> User selects and streams music from a PC to a device in the home.
>
> User adds music to a favorites playlist from any device on the home network.
>
> User manages playlists and streams to any device on the home network.

Many use cases could be developed, so it is important to identify a key set of use cases that cover the user types, device types, and media types to consider for this usage model. Having too many use cases will begin to offer diminishing returns, and not generate additional usage requirements. Usage requirements, as distinguished from requirements in general, are those that describe elements of the system that affect how people will experience it.

Figure 8 shows the relationships among usage model, use cases, and usage requirements. In practice at Intel use cases are typically contained within a usage model, and usage requirements enable one or more use cases. Depending on the approach adopted, however, use cases may cross usage models, and usage requirements may enable multiple usage models.

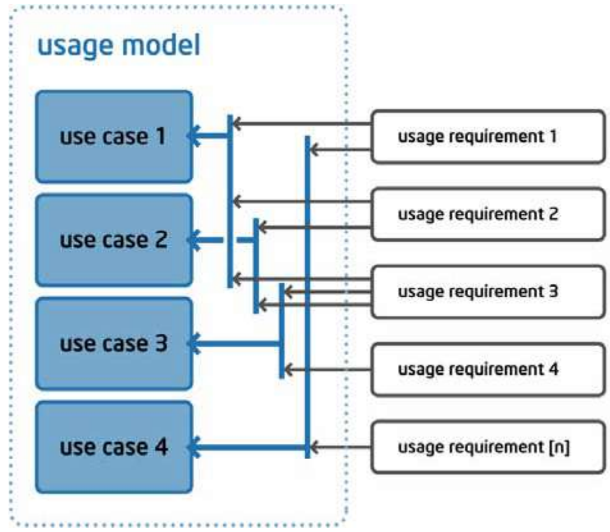

Figure 8: Typical relationship among usage elements

While Intel itself may not develop everything necessary to implement all of the use cases, it is still important to consider the usage model as a whole. This allows Intel to identify needs and potential gaps for non-Intel products. Products to fulfill those needs and gaps can usually be categorized as hardware, software, services, or standards.

In the development of use cases, usage requirements, which are needed for the system to satisfy user needs, are discovered. The ideal set of usage requirements may not be identified early in development, but a good set of use cases will lead to a good set of usage requirements.

Developing the Use Cases

In developing the details of use cases the main objective is to communicate the intended usage experience to others involved in developing a product. The primary vehicle for this communication is the use-case document. Use cases can take many different forms, which are intended for various purposes. Table 1 depicts the format and description of the elements that comprise Intel use cases as implemented by the User Centered Design Group.

Table 1: Use case elements

Identification
Use Case Title: Short name for reference purposes—the title should accurately represent its contents to avoid misinterpretation or confusion.
Use Case Tag: Unique identifier. Allows for traceability and common reference.
Summary: Brief description to highlight the main activity.

Context
Actors: People/systems who play a part in the use case. They may include formally defined personas (see discussion below).
Pre-conditions: Any pre-requisites or triggers for the use case.
Post-conditions: The end condition, the outcome of the use case.
Body
Sample Scenario(s): Narrative story, depicting a realistic situation, to demonstrate how the actors interact to satisfy the objective of the use case and the context in which the activity occurs. This is invaluable for communicating the intended user experience to architects and others.
Basic course of Events: Task flow visually representing the flow of information and interaction between the actors to help the audience visualize the flow of information.
Conceptualization: Screen shot, conceptual mockup, storyboard, or other graphical representation of the intended usage to help the audience visualize the intended user experience.
Simultaneous Usage: Listing of usages that may occur at the same time on the same system.
Alternate Paths: Narrative story depicting situations in which the normal interaction between the actors has deviated from the normal flow. It is important to capture the cause for deviation, and any distinctions and considerations from the normal situation.
Exceptions: Listing of the instances when the use case would NOT be triggered.
Requirements Management
Priority: Rating to indicate the importance this use case holds with respect to meeting the usage model objectives.
Author: Name of the individual who wrote/developed use case for tracking and reference purposes for any questions regarding the specifics of the use case.
Usage Owner/Originator: Name of the individual who conceptualized the usage for tracking and reference purposes for any questions regarding the origins of the use case.

In developing use cases, it may be valuable to take an approach that Cockburn terms "Black Box Use Cases" [2]. With this approach the use case does not address specific technologies but focuses instead on the user and the desired usage experience, leaving the implementation open for alternatives and design innovation. At other times a technology may be central to defining how a use case unfolds. In these cases, U2PR professionals may take a pragmatic approach that includes a particular technology, which may limit the user experience, as part of the use case.

"Deep-Dive" Research in U2PR

One approach that has been used to inform the U2PR work is referred to as "deep-dive" research. This approach is a combination of human factors and design research methodologies, which are commonly used in contextual inquiry and task analysis. The purpose of deep-dive research is to refine use cases and inform usage requirements. As Figure 7 indicates, findings from deep-dive research may require that the use cases be modified. Modifications may include adding use cases, deleting use cases, or changing the details within use cases.

U2PR professionals conduct deep-dive research via a series of face-to-face, semi-structured interviews with individuals who are identified as representative of users who are interested in a particular usage model. The interviews generally consist of two objectives. The first objective of the research is to understand participants' current user experience and pain points, to identify the gaps between the ideal user experience and the experience that current technology allows. The interviewer encourages the participants to describe their daily work, frustrations, and even to walk through typical tasks.

The second objective is to gather user feedback on details of proposed solutions that enable the usage models. This helps to determine what features are needed and how the platform should be designed to ensure the delivery of a desired user experience. The interviewer introduces the participants to a solution through conceptualizations (e.g., storyboards) and descriptions that demonstrate the concepts. The questions elicit responses that inform requirements, attempting to get a sense of what features and capabilities the system should have to satisfy the user need. The interviewer records the participant's responses to these questions and elicits ratings of the appeal and relevance of various attributes of the proposed solution.

The essential output of deep-dive research is detailed information that allows usage models to be developed into a set of use cases and usage requirements, as explained in the following section. This research approach also allows for the discovery of new usage models and product concepts.

The purpose of deep-dive research is not to test the usability or acceptance of a product user interface. Though low-fidelity prototypes and storyboards that show example user interfaces may be useful in this type of research, deep-dive research generally precedes product design.

Although both market research and deep-dive research are concerned with testing the potential of usage models before product development, there are basic differences. First, they have different purposes. Market research measures the overall market opportunities while deep-dive research examines key features and requirements needed for the implementation. In other words, the market research identifies the "what," and then the deep-dive research identifies the "how." Secondly, they are different in scope. Market research is often broad and based on a large sample of customers who are representative of an entire market. Deep-dive research is narrow and deep, focusing on a smaller sample of users who are likely interested in the usage model. Thirdly, they offer different outputs. Market research provides prioritized usage models, while deep-dive research offers detailed requirements within a particular usage model.

Writing Good Usage Requirements

Requirements are the foundation upon which products and platforms are created. They communicate what features and characteristics products must have. U2PR professionals at Intel develop usage requirements, those requirements that directly describe the human experience of the system. Other technical requirements for the platform apply, but they come from other sources, such as technical specifications and standards. In order to be effective, requirements must reliably communicate the desired characteristics for the product to be developed correctly. The main tenets of effective requirement include the following [4]:

Complete (sufficient detail and coverage)

Correct (valid and without errors)

Clear (unambiguous interpretation)

Concise (necessary; focus on pertinent/relevant details)

Consistent (no contradictions among requirements)

Coherent (requirements make sense as a whole system)

Connected (traceable; uniquely and consistently identified)

Feasible (can be met through at least one implementation)

Prioritized (documented for their importance to facilitate trade-off discussions)

Verifiable (testable as "met" or "unmet")

Going beyond these basic tenets, which are absolutely necessary for the product to be effective, the most important consideration when constructing usage requirements is to at all times develop them with the users in mind. What are the users' objectives? What interactions are reasonable to expect of them in the context of the activity that is taking place? Usage requirements must lay the necessary framework for the experience to satisfy the user.

Requirement writers should compose in a language that is easily interpreted by systems architects or software developers. The usage requirements communicate affirmative statements that clearly articulate what should be developed to improve the experience people have with the product. Each requirement also contains a rationale for why it needs to be considered when developing the technology to support the usage. The rationale points to primary and secondary research and data supporting the requirement. As with use cases, the focus is on the fundamental need to be met, not a specific technological implementation. An example of a usage requirement appears in Figure 9:

Name: Secondary Recording Status Display

Description: The PC shall present recording status when the PC is in the process of recording a TV show or capturing digital content, even if the main display is turned off.

Rationale: TV recording devices typically show a status light on the bezel to show recording in progress, allowing the user to see status without turning on a connected screen.

Priority: High – essential for competitive offering

Use case(s): Using PC to record cable TV show

Figure 9: Example usage requirement

Usage requirements can be categorized as functional and non-functional. The example above is a functional requirement, since it describes a particular function the system must perform. A non-functional requirement defines a quality of the system, such as how good the perceived video quality must be. Both types are outputs of the U2PR process.

Traceability of Requirements

A traceable or "connected" requirement, as described in the tenets above, is one that can be tracked to the objective that spawned it. At Intel, U2PR professionals enable traceability by tying a given requirement to both the marketing end of the process and the platform technology end of the process. The requirement ties to marketing by including a list of use cases, which are enabled by the requirement, in the full format of the requirement. The use case, in turn, is traceable to the usage model it describes. The usage model ties back to the original marketing and business plans.

A link between the requirements and the enabling platform technology must also be maintained. This is best accomplished by tracking the usage requirements through the development of a given platform component. If a requirement becomes unachievable at any point in the process, the impact can be traced back to the requirement and, therefore, the usage model.

Depending on how essential the requirement is to the usage model, and whether an alternative platform capability is available, the usage model may then be taken out of plan. Marketing and finance professionals must then adjust the business plan accordingly.

A Note on the Value of Ideation in U2PR

Brainstorm sessions and other ideation approaches are helpful in considering new usage models that may be opportunities in the future, and there are several steps in the U2PR process that benefit strongly from ideation. For example, when it is time to generate candidate use cases to develop usage models, a cross-functional team can brainstorm a list of use cases with just a few minutes per usage model. Detail within the use cases is also a good target for ideation. A small group, thinking critically about alternate paths and exceptions, can help build a strong use case. Generating usage requirements can also occur more completely and efficiently in a collaborative atmosphere than with a single, desk-bound individual. A wide variety of methodologies may be applied to ideation and are covered in depth in Kelley [5].

The ideation that occurs in the U2PR process should be captured and fed into other processes. Use case work, and the deep-dive research that feeds it, are fertile ground for identifying other usages and for building upon the original usage model. In the "consuming media anywhere and anytime within the home" example, this could be anything from an important way to automate setup to having the PC anticipate and do processing-intensive tasks during times of lighter usage.

COMMUNICATING THE DESIRED USER EXPERIENCE

Getting Requirements to the Right People

At a company such as Intel, a diverse team of engineers, architects, software developers, planners, and designers must design individual technology components that are to be integrated into a single, coherent platform. The challenge of the U2PR program is to ensure usage requirements and their implications are understood by all involved with product development across the platform. To achieve this, usage requirements are communicated both formally and informally to architects across various component teams.

Usage requirements are developed as the backbone for how a product will be experienced by customers, but when a difficult technology problem is facing a development team with a tight timeline, it is easy to lose sight of how the technology will actually be used. To ensure user-oriented concerns are considered along with technology-centric approaches to platform architecture, user requirements are communicated with the rationale for the requirement. Requirement developers derive rationales from research and human factors expertise and discuss them with architects whenever questions about a requirement arise. Mapping usage requirements to key technology capabilities allows architects to reference the end-user value that the technology enables.

U2PR professionals also communicate requirements in the form of compelling storyboards, videos, vignettes, and concept prototypes. These forms of visual storytelling put the focus on the user through tangible examples with people at center-stage living the experience.

Visual and Physical Collateral

It is often difficult for an architect to focus on hundreds of usage requirements and gain an understanding of how the user experience could be actualized. Illustrations, photos, and videos that depict or act out scenarios of use go a long way in helping architects think critically about the user experience, clarify requirements, and set the direction for design considerations.

Visual conceptualizations also provide a tool for eliciting feedback on future usages that do not have an existing frame of reference. For example, to complement requirements written to support the usage of accessing media anytime, anywhere in the home, the desired user experience could be conceptualized as shown in Figure 10. Such a conceptualization provides iterative input into the platform design process and ultimately helps architects focus on a few specific requirements that are important to the usage.

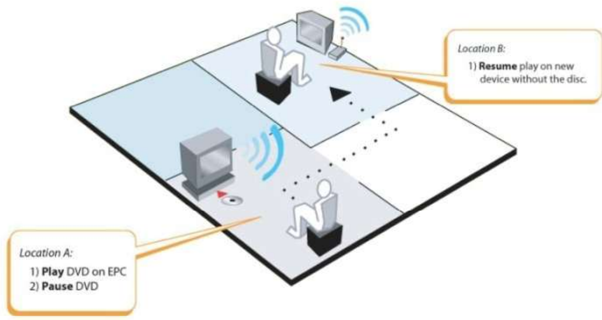

Figure 10: Example conceptualization

Value of Personas and User Profiles

Personas gained popularity after the book entitled *The Inmates Are Running the Asylum* by Alan Cooper [3] described their efficacy as a design tool and a way to improve an organization's drive towards a user-centric culture.

Personas allow anyone involved in designing a new product to identify their users. A persona gives product teams an opportunity to take a walk in target users' shoes and experience their goals and behaviors. U2PR professionals use personas in the context of a use case to show how a user's values and experience play a role in the user's interaction with a system. By understanding the attributes of a particular person, designers and developers can better understand how to build a product for a large group of individuals with similar goals and behaviors who will most likely be consumers of the product.

Personas communicate a fictitious individual's archetypical attributes from field research conducted with real people in their familiar environment. They are developed with the help of rich marketing data combined with ethnographic research to understand human values and characteristics. By developing an archetype for a product, we can humanize the technology. For example, in Figure 11 we see a photo and rich description of "Jeff" who lives in a European community with certain technology constraints, attitudes, and beliefs. Jeff represents a segment of individuals, and we can design technology to meet the needs of that particular person who may share similar characteristics with a much larger set of individuals worldwide. Note that full personas offer deeper and richer descriptions of users and their contexts.

Figure 11: Example user profile

U2PR IN THE REAL WORLD

Joining Programs Already in Flight

Like most new programs within an existing business with existing product cycles, U2PR professionals at Intel have had to apply the process to platform cycles already in progress. In some cases the deep-dive research that should inform use cases may not be available, and there may not be time to complete it on schedule. Small-scale, quick studies or informal interviews of co-workers can help inform first-draft use cases and usage requirements. Simply executing and documenting a use case with an existing product can also reveal basic usage requirements. Sufficient research can be planned to inform the next versions, while in the mean time the draft work can inform the current development cycle.

In situations when U2PR work must precede research, it is important to not overstate the validity of the use cases and usage requirements or to overreach the legitimate scope of the work that is done. A use case can be valuable in a draft form to help planners and architects recognize user needs and requirements categories, but the U2PR professional must position the draft use cases correctly and set the expectation that further research is needed. There is a danger that incorrect use cases may look credible and complete but may lead to the wrong requirements.

A Cross-Organization Process

Since U2PR deals with usage models, often the details that are not directly visible to the user allow for a range of implementations that satisfy the same requirements. In many cases, a usage area (telephony, for instance) may span many devices or platforms, and even involve cross-platform interactions.

Because of this, U2PR can form a bridge between business groups, product lines, and technology research and development. Usage models can provide a connecting perspective and expose new opportunities, reduce risk, improve consistency, and increase the value of platforms and products.

Working Across Multiple Platform Generations

Because the development cycles for processors and chipsets at Intel can be relatively long, compared to software development cycles, multiple platform plans are in development simultaneously. This aspect of overlapping years can challenge U2PR resources, but it also has potential advantages. The typical user's ideal experience of a given usage model usually does not change radically year to year, while the ability of technology to meet the ideal experience is more subject to change. If the user wants to stream a video from a PC to a TV somewhere else in the house, the user will always desire certain traits, such as the video being ready to play immediately after selection, to be part of the experience. The technology may trail that desire, needing some extra time to access and adjust the video for the target TV. The U2PR process can define requirements that improve the experience from one product release to another.

Another characteristic of multiyear planning is that usage models may shift from one year to another. A given usage model and corresponding technologies may move up sooner if planners see it at an earlier opportunity, or a usage model may slip a year if planners anticipate that the market will not be ready. In either case, if U2PR professionals work across years, they can work more efficiently since they can transfer their knowledge about the usage models across platform years. They can also bring an understanding to a marketing or platform team that may not fully understand a usage model that was defined by another team.

Where Does U2PR Stop?

Thus far at Intel the U2PR process fills the gap between marketing plans and platform plans. As discussed earlier, a variety of marketing research and ethnographic research may take place before the U2PR process. After the U2PR process, after a platform plan is complete, a product must be created, and the user experience of that product must be measured to ensure the product has met the business and user goals. U2PR at Intel ends with a set of usage requirements that feed an architectural analysis process. Subsequent development of the user experience requires iterative prototyping and evaluation. In some organizations, the same group that does a U2PR-like process may do this work as well, but for the scope of this paper, U2PR ends with the communication of the usage requirements. As another paper in this volume of the *Intel Technology Journal*, "Assessing the Quality of User Experience" [6] explains, the user experience torch should be carried through prototype evaluation and post-shipment, through a "user experience quality" measurement program.

Other Challenges

The nature of developing a platform, instead of a product, brings other challenges. Coordinating the usage requirements with multiple products in multiple organizations is difficult. Individual product teams are already coordinating hardware, firmware, software, service, and ecosystem aspects of their products. Those product teams are already creating their own platforms and managing a high degree of complexity. The arrival of additional requirements for the overall platform requires a great deal of organization. This creates key roles for U2PR professionals who can communicate across these product groups and organizations, and it requires Intel to invest resources to enable the creation of a coherent platform.

Another challenge is getting U2PR professionals in the correct mindset to define a platform, instead of only one product that will present the user interface. While it is important to comprehend the user interface to some degree to anticipate the usage requirements, an over-focus on designing the end product will direct resources away from defining the other facets of a platform that must support the user interface. While good user interface design is essential for the company that delivers the final user experience, Intel may have limited impact on that design and, therefore, limited benefit in designing it. For each usage area, the degree of user interface design will be somewhat different. U2PR professionals must constantly monitor whether they have an adequate understanding of the final user experience in order to judge how far they must go in defining the user interface.

The nature of U2PR challenges the application of traditional requirements-based planning. Sometimes a requirement can be a limited, "clean," line item that can be addressed by Intel products. For example, in the "consuming media anywhere and anytime within the home" usage model, requiring media to begin playing at a TV within a certain period of time after the user clicks "play" is fairly direct. However, having a movie download service with the equivalent of DVD special features meeting various requirements is not as straightforward. First, there is a requirement that such a service with those "special features" should exist. Second, there are requirements about how the user should be able to experience the special features. The U2PR professional is now writing platform requirements for the existence of a product Intel will not create. Delivering the correct level of requirements for such a topic is challenging and requires close work with ecosystem partners to ensure success in the final product.

OPPORTUNITIES FOR U2PR EVOLUTION

In almost any vision of U2PR evolution, reliance on more tangible implementations of the user experience is important. As another paper in this volume of the *Intel Technology Journal*, "Usage Model Driven Platform Innovation—Case Studies" [7] demonstrates, steps have already been taken in this direction. The U2PR process is moving toward tighter integration with prototyping and early product evaluation efforts.

At a higher level, U2PR progress could take at least two routes. In one vision for the U2PR process to meet its potential, the program must have support at multiple levels across multiple organizations. Intel has adopted the process as part of its product life cycle, but to really allow a platform that is designed to deliver a specific experience, many people beyond the U2PR professional need to adopt the goals. The architects who own the roadmaps for various platform components must carry through the requirements. Those who own the interfaces to the ecosystem must deliver the requirements to other companies, who must have their own incentives to deliver the experience. This vision is challenging to achieve, since dependencies across multiple products and companies are complex. The payoff, however, is great, since usage models are delivered to the market on a larger scale with a more standardized, predictable experience.

In the second vision the U2PR process could be more focused on delivering a more limited set of usages that affect fewer product roadmaps. The number of products could be minimized, and ecosystem influence could be limited to perhaps one partner company. This approach would increase the likelihood of success, but wider adoption of the usage would take longer, and standardization of products that deliver the experience would take much longer.

CONCLUSION

Companies that develop platforms composed of multiple products face special challenges in filling the gap between marketing plans and platform architecture. Those challenges go beyond those inherent in individual product development. Intel has developed and implemented a process that fills the gap using a combination of research, human factors methodologies, use case and requirements processes, and visual conceptualization.

ACKNOWLEDGMENTS

The authors thank Paul Sorenson for recognizing the need for a U2PR process at Intel, for establishing the program, and for ongoing leadership and guidance. We thank Erik Simmons for helping to define the process and for teaching Intel how to go about usage model development. Thanks also to Herman D'Hooge for fostering a corporate culture that recognizes the need to bring the user perspective into technology development.

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Usage-Based Platform Design: Case Studies in Thermal Design, Enterprise Manageability, and Information Access

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Keywords: usage, architecture, workload, thermal, manageability, information management, platform capability

ABSTRACT

This paper describes the adoption of a usage model-driven platform definition process at Intel in three case studies: mobile platform thermal design, cross-platform manageability, and enterprise information management. It illustrates how usage models are defined and used to characterize platform workload, identify performance bottlenecks, optimize thermal design, and identify new platform capabilities. In the first case study, we focus on how usage models help us predict workloads on mobile platforms and how they help us define the right thermal design to address the diverse user needs for mobile platforms. In the second and third case studies, we analyze enterprise user needs for more agile IT and business processes. Based on the top usage models developed to address these needs, a set of cross-platform capabilities is defined to guide our platform definition.

INTRODUCTION

As Intel moves to becoming a platform company, more emphasis has been put on understanding end-users needs and integrating user requirements into the process of platform design. As described in [1], Intel has been using a usage model-driven process to define platform capabilities and ingredients. There are four major milestones in this process: 1) researching user needs, 2) usage models and use case development, 3) platform capabilities and ingredient mapping, and 4) platform verification and refinement through Proof of Concept (PoC) projects.

User needs. We typically use ethnographic or qualitative research to understand top user challenges, barriers, and needs for technology adoption. These research methods often involve in-depth interviews with end users in business settings or at their homes, direct observation of user activities and environments, or job shadowing and participant observation. In a business setting, we try to understand three tiers of needs to identify the best technology solutions, which lie at the intersection of business needs, IT needs, and end-user needs. Other sources of information on user needs include feedback from sales teams in the field, direct engagement with customers, ecosystem players (key software and hardware vendors, service providers, etc.) and independent market analysts (Gartner, IDC, etc.).

Usage models. A usage model is a representation of desired user experiences and user interactions with a computing system. Key components of a usage model include user personas, use conditions, storyboards, use cases, usage scenarios, and user task flows [2]. The creation of usage models is a structured process that requires expertise from different disciplines, including user research or human factors engineering, platform architecture design and business development, or product marketing.

Platform and ingredient capabilities. For high-priority use cases and usage scenarios, we focus on two areas of analysis: platform capabilities and platform ingredient requirements. For platform capabilities, we perform gap analysis on new platform capabilities and ingredients that are needed to enable the usage models or user experience; for platform ingredient requirements, we conduct workload analysis or predictions to identity performance bottlenecks and desired architecture. In order to prioritize different platform features, we typically conduct quantitative market research to understand market potential for different features.

Platform verification and refinement—Proof of Concept (PoC). After the platform features are defined and a prototype is developed, we engage selected customers or end users in different regions and industries to conduct PoC evaluations of targeted platforms, which consist of engagement with real end users, pilot solution deployment with the new platform features, and analysis of the pilot result against expected business outcome. The same use cases and usage scenarios used for platform definition are used to guide PoC projects. Through this type of deep customer verification processes, we gather further feedback for our platform designs and further refine our platforms before offering them to the general market. In this way, we develop end-to-end integration stories with end user buy-in before a platform is launched, so that the platform is better suited for adoption by both end users and the entire supply chain.

We use three cases studies in this paper to illustrate the usage model-driven platform design process. We discuss how usage models are defined and used to create new platform capabilities or to optimize platform performance.

CASE 1: APPLICATION OF USAGE MODELS FOR MOBILE SYSTEM THERMAL DESIGN

Intel® Centrino® mobile technology is designed to meet user needs that are focused on the four vectors of mobility: performance, battery life, form-factor, and wireless connectivity. There is a highly correlated interdependency between each of these vectors that must be properly balanced in order to produce a system that is capable of providing the best user experience possible. A system that is designed with only performance as the key design point must compromise form factor and possibly battery life. Likewise, a system intending to maximize the form-factor vector may be very compact but sacrifice performance if not properly designed. Each individual user may weigh the importance of each vector uniquely and make an educated purchasing decision based on how well a system meets those needs. Therefore, each mobile system design must consider the intended usage models of the target user profile for an optimal solution. While each of these vectors may be shifted around to produce different systems, the overall design constraint is determined by the thermo-mechanical characteristics of the system. Without knowing how much power will be consumed by a system and its components it is impossible to create a well designed system to handle the computing needs of a user.

In this section we describe a process by which these problems on mobile platforms may be addressed. First a user profile and representative usage models are defined. Worst-case realistic workload scenarios are then generated to represent the usage models. Such scenarios correspond to a probable mix of applications and activities corresponding to a high-intensity usage model (and thus high platform power), but still correspond to a typical usage model for the targeted user and form factor. Power consumption for these scenarios is then measured and analyzed to form the basis of projecting power consumption for the target systems. Because actual components for a design are often not available for some time prior to launch, existing hardware is used for this analysis. Changes in platform and component and software architecture are then considered and used to tune the resulting forecast. This approach yields unique results for each usage model and helps us to design systems that are tuned to achieve the optimal capability for each vector of mobility aligned with the needs of users.

The Need for Thermal Mechanical Design Requirement Forecasting

Designing a mobile system with little or no understanding of the forecasted power consumption will expose the thermal and mechanical system design to many negative consequences. The Platform Thermal Forecasting Process (PTFP) is a usage model-based approach to address this problem. This process enables early engagement with notebook system engineers to define the necessary form-factor, component placement, layout, and cooling technologies required to design a system that is sufficiently engineered to meet the needs of their customers. Without this process Original Equipment Manufacturers (OEMs) are at risk of either over- or under-designing some or all of these elements for a system.

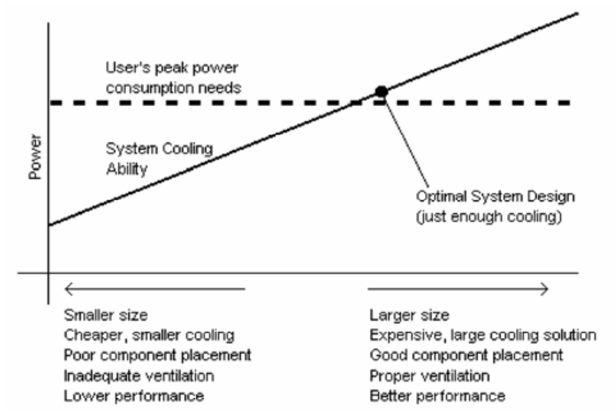

Figure 1: Balancing system thermal mechanical design with user needs

A system that is over-designed may be physically larger than necessary or may have cooling systems capable of handling workloads that are far more active (greater power consumption) than the intended usage models for the system. This results in a system that is compromised in mobility due to increased size and weight as it is designed for actions that are rarely or never initiated by a user. Over-design thus increases the total cost of materials and manufacturing.

A system that is under-designed has many desirable properties on the surface. The system may be thin, light weight, quiet, and less expensive to produce. However, such a system is prone to a range of negative consequences. One outcome may be skin or exhaust temperatures that are too great for a user to tolerate. Frequently entering low-performance thermal throttling states is another consequence that results from insufficient thermal mechanical design. In either case the design is not capable of handling the power consumed during use that is consistent with the intended usage models for the system. These consequences may result in systems that are not competitive in performance, may have long-term reliability issues, and may produce a significant support call volume at OEM call centers. The severity of consequences resulting from over- or under-designing the thermal solution illustrates the necessity of creating a process that can be applied to accurately produce forecasted power consumption to enable appropriate thermal and mechanical designs in mobile systems.

Defining the Usage Models

The first step in defining an optimal thermal mechanical solution is to define the user profile and usage models that represent the work being done by the system. This is a necessary step in determining how much thermal power must be cooled to meet the needs of the user profile. This user profile and usage model will form the basis of a workload model that is used to represent the worst-case platform power consumption for this group. Defining the user profile and usage models requires detailed market segment analysis, primary research on targeted user-profiles and proposed capabilities, and analysis steps to translate general usage model descriptions into detailed user experience requirements–with targets, metrics, and methods for measurement. It is also useful to obtain customer feedback on these requirements and capabilities prior to doing the workload modeling. Details of this process are not defined within this paper. The approach adopted widely at Intel (Usage to Platform Requirements, or U2PR) is described in detail in another paper in this issue of the *Intel Technology Journal* [1]. Once the user profile and usage models have been defined, work may begin to create representative workloads for each usage model.

Characterizing a Usage-Based Workload

The goal of this stage of the process is to produce a multi-tasking workload that represents the worst-case system power consumption resulting from a user's activities that are defined in the usage models and use cases of interest. The process is divided into multiple stages that include application selection, application profiling, multi-tasking workload generation, multi-tasking workload characterization, and selection of the workload that represents worst-case platform power consumption for the target usage models.

Once the user profile and representative usage models and use cases are defined, applications that may be used to represent the activities within the usage models must be identified. Each high platform power usage scenario should be represented by multiple applications if possible. These applications should be modern applications as forecasting may be less accurate with older software. (The impact of changes in software architecture is discussed further in the Forecasting Power Consumption section of this paper.) Applications are individually profiled, and the peak measured power consumption is identified as the characteristic Peak Power Consumption (PPC). The characteristic PPC is determined for each major platform component (processor, memory, memory controller hub, I/O controller hub, graphics processor, etc.) and the collection of PPC for all components for a specific application, known as application PPC or APPC, is generated.

Once the APPC had been measured for all applications, combinations of these applications may be created to form a multi-tasking workload. The selection of applications to create a multi-tasking workload is based on the distribution of power in the APPC. An application that consumes substantial power on the CPU but little power in memory and the graphics processor would be paired with an application that consumes little CPU power but consumes a significant amount of power at the graphics controller and memory. This balancing approach is required to eliminate bottlenecks in the system that can reduce the power density for platform components. For example, if two applications heavily consume CPU resources and are run concurrently on the same system, code segments that exercise another device such as graphics will be accessed less frequently. This is because both applications depend on a resource that is being shared providing less total CPU time to both threads and creating more time between calls to the graphics device.

Multiple workloads are defined to represent possible multi-tasking scenarios within the usage model. This list is then paired down to remove workloads that are unrealistic or too extreme, so the final mix of applications corresponds to the actual usage profile targeted (and described in use cases and task flows associated with particular usage models). An example of an unrealistic usage profile would be running multiple 3D games concurrently on the same notebook. The criterion for determining unrealistic scenarios is unique for each system, depending on the user profile or intended use of the system.

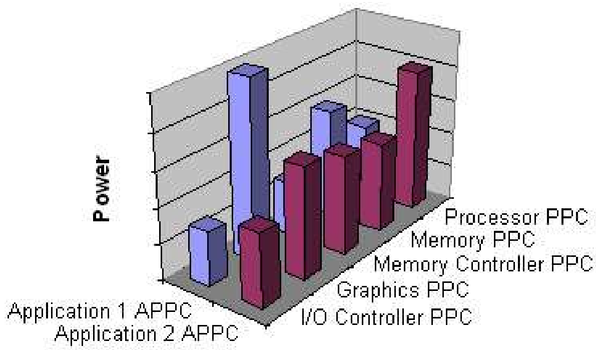

Figure 2: Comparing the APPC across applications

Once a final list of multi-tasking workloads is defined, the activity is scripted and profiled using the same process described for individual applications. A Multi-tasking PPC (MPPC) is generated for each scenario to determine power consumption for all components across each workload. The MPPC for each multi-tasking workload is compared across all other multi-tasking workloads to determine the best scenario for use in forecasting the worst-case system power consumption. This workload is known as the Worst-Case Platform Power Scenario (WCPPS.) Factors considered in selecting this workload include total system power consumed and individual component power consumption.

Forecasting Power Consumption

Forecasting platform and component power consumption may begin once the WCPPS is selected. The PPC for each component is compared to the measured Thermal Design Power (TDP) for each component on the same platform to produce a Scenario Ratio (SR).

$$SR_{device} = MPPC_{device}/TDP_{device}$$

This SR is then applied to the forecasted TDP (FTDP) of that device to produce a Forecasted Power Consumption (FPC) of that device on the future platform.

$$FPC_{device} = SR_{device} * FTDP_{device}$$

This process is applied to all devices on the system to generate a distribution of power across the system. The total platform power is then considered to be the sum of these forecasted powers.

This simplified process works as a first approximation of forecasted platform power but ignores the impact that changes in components, and platform and software architecture will have on the distribution of power on future systems. Individual steps are taken to address the impact that each one of these factors may have on the power forecast. Ratios that represent shifts in distribution of power consumption for each component are produced for each of these classes and then applied to the component SR. Updated component power forecasts are then produced to generate the final PPC forecast.

Impacting the Thermal Mechanical Design

The resulting power forecast for the mobile platform and components has a significant impact on form-factor, component placement and layout, cooling technology, and system temperatures and will help determine system performance. This usage model-based approach enables optimal system design by mapping the user needs for a specific system to the critical factors that impact the four vectors of mobility. Component placement and layout can be optimized to enable better cooling for more critical devices as determined by the forecasting process. Optimal cooling technology can be clearly defined for the target systems. The form factor of the system may be tuned specifically for the user needs enabling more compact system designs. These designs will also provide sufficient cooling that can handle the activities for which the system will be used. Furthermore, this process enables optimal performance from system components to address the mobile computing needs of the user profile.

CASE 2: DRIVING EXCELLENCE FOR PLATFORM MANAGEMENT EXPERIENCE

Platform manageability is about how to monitor, track, protect, and fine-tune computing platforms (clients and servers) in the IT environment to maximize the business benefits of the IT infrastructure investment. There has been continuous effort to improve new platform manageability, and the industry has made great progress over the years in developing tools and automating platform management processes [3]. The key to any company's success is the ability to manage and adapt to a changing and competitive environment while containing costs. This includes managing and adapting to changing infrastructures and increased demands for IT services. As computer networks grow increasingly large and complex, the challenge of managing IT also increases tremendously. As indicated in Table 1, 89% of an IT budget is used to manage the IT environment and support the business operation. At the same time, IT infrastructure administrators typically feel their time and effort are tied to daily tasks to ensure the availability and health of the computing environment. These burdens of managing the environment greatly reduce IT organizations' ability to innovate and build more value-added solutions for the business bottom-line.

In this section, we show how a cross-platform (client, server, storage, and network infrastructure) innovation process has been used at Intel to improve manageability solutions for servers in large enterprises. We describe the work conducted by the Digital Enterprise Group over the last year to influence the designs of server platforms.

Table 1: Typical management resource allocations (Source: IDC and Intel IT Studies)

Description	Resource
Length of time to provision a server	15 days
Number of man-hours required to audit computing assets each year	10,000 man-hours
Percent of IT budget allocated for day-to-day activities (operational costs)	89%

Understanding User Needs

Intel is fully aware of the importance of platform management for its customers. Structured user research and customer engagements are routinely used to understand user needs and market trends. For ecosystem analysis and enabling, we work with Independent Software Vendors (ISVs), Original Equipment Manufacturers (OEMs), and service providers, as well as the entire value chain of the computing infrastructure to develop standards and solutions to better serve our customers.

From ethnographic research (structured interviews and on-site observation) we conducted with data-center managers, IT professionals, and CIOs, we found that fundamental IT objectives in the platform manageability include the following:

> *Cheaper*. Operational and capital cost reduction, as well as reduction of Total Cost of Ownership (TCO) of the IT infrastructure life cycle.
>
> *Faster*. More agile and nimble IT services that respond to business changes quickly and effectively.
>
> *Better*. Turning IT into a competitive advantage that contributes to the business' bottom line, rather than being a simple "cost center."

Table 2 summarizes the top manageability challenges faced by large enterprises (defined as companies with 1000 or more employees). These findings are derived from primary research and various customer engagements our group has conducted over the past year.

Table 2: Top five manageability challenges for large enterprises in the U.S market

1	Power control (thermal limits, etc.), optimized performance within a data center for a given power budget.
2	Security and regulatory compliance: protection from malware, security policy enforcement, prevention of virus outbreaks.
3	Automatically add, remove, build, and rebuild systems, especially in dynamic virtualized environment.
4	Patch Management: remotely identify a system and its configuration; update BIOS and new patch regardless of system state.
5	Data protection for data encryption and to meet privacy and financial requirements.

With an understanding of IT end users' needs and desires, we need to determine business priorities and hurdles along the entire supply chain in order for Intel to best position our platforms and related enabling programs to deliver the desired end-user experience. As part of the usage model development process, we have discussions with OEMs, ISVs, Managed Service Providers (MSPs), and Value-added Retailers (VARs) to understand the entire supply chain of the enterprise computing ecosystem

Table 3 summarizes the objectives and needs for different players in the ecosystem. In this landscape of the computing industry, we position Intel as one of the ecosystem players to fulfill end users' business computing needs, and we strive to understand how we could effectively drive the ecosystem to embrace the new usage models and platform capabilities/features we introduce to a new platform.

Table 3: Manageability trends in the IT and Data Center ecosystem

IT End Users	Moving from static to dynamic management to increase agility and reduce cost. Sensitive to power, security, automation TOTAL solutions. Legacy support and backward compatible, preserve existing investment.
OEM/ System Vendors	SUN, HP, IBM and Intel platform vying for prime position. Networking vendors pushing their network solution view. Power efficiency is currently number one concern; operational complexity, the second.
ISVs/ Service Providers	Virtualization is driving force; abstracts out hardware differences. Few ISVs control virtualization and management console market, and drive vertical data center solutions. SPs want to evolve remote manageability experience. ISV's use Web services capability to expand Total Available Market (TAM).
Value Chains	Margin pressures forcing platform providers to explore innovative business models focused on recurring revenue (e.g., Dell/Google bundle). Large ISVs with Web services enabling third-party solutions, grow service portfolios. Channel seeking creative solutions for small- and medium-sized businesses (SMB).

Defining the Usage Models

With a prioritized list of end-user needs and a good understanding of supply-chain landscape, a cross-functional team composed of usage modelers, architects, platform planners, and market/business analysts worked together to create usage models to address user needs. We first took a look at the top-end user needs as outlined in Table 2, and then we defined what it takes to satisfy these needs from an end-to-end perspective in order to come up with an overall storyboard of how a particular end-user need could be met by a combination of hardware, software, and services provided by the entire supply chain. A usage model with associated use conditions, use cases, and usage scenarios is created following the storyboard. With such a structured analytical process, we defined which part of the usage model is enabled by hardware features, and which part needs to be enabled by software and service providers.

Taking power management of servers in a data center at a large enterprise as an example, we identified two usage models:

> *Define and optimize a power profile using a manageability system*. IT operators define power budget and monitor power consumption in servers through sensors, power supply monitors, and CPU/chipset registers. The goal is to optimize power utilization through autonomics at the platform, chip, feature, and server group level. Server operators do this by defining operational parameters at the node, chassis/rack, and domain level. In an automated data center environment, IT operators achieve power and thermal optimization through a set of Service-Level Agreements (SLAs), which translate into a set of actionable policies that could be automatically followed by the software and hardware systems in the data center.
>
> *Rebalance workloads using thermal policies*. Following the policies set by the IT operators, data center software and hardware work together to consistently monitor the power consumption at all levels as described by the policies. When a "hotspot" is detected, the workload scheduling and rebalancing procedure will be initiated based on the correlation between thermals, capacity availability, and utilization. Applications will be moved based on the rebalancing plan. As a result, power and thermal distribution are kept under control, and application performance is maintained at an optimal level.

Defining Platform Capabilities

With the on-going effort to transform usage models into platform capabilities, we develop a list of platform capabilities needed to enable these usages. Based on the dependency and progression of services over time, the capability requirements are divided into three phases we called "Crawl," "Walk," and "Run." Such delineation is important, because not all the new capabilities could be built into a platform at the same time, as we have to take into consideration technology readiness, cost to build the capabilities, ecosystem readiness, and many other factors. It usually takes several iterations to deliver the capabilities and bring them to maturity over time. We also identified software dependency and enabling challenges along the way as we identify these platform capabilities.

It is also important for the IT end users (IT managers, data center managers, and knowledge workers) to understand such a progression so that they can validate our usage model, usage assumptions, and details of use-case interaction. Getting the end users to agree with us on the usage model definition and the sequencing of the platform capability progression is part of the feedback loop: we take usage models back to selected end users for verification and refinement. Table 4 is a summary of power management capability requirements following this process.

Table 4: Platform requirements of power management

Usage Model	Platform Capability Requirements		
	Crawl	Walk	Run
Power Management by a management system	Discovery of all system components and their power management features. Interact with the management system IB & OOB. Heuristic engine to inference power management actions. Instrumentation to monitor power profile components.	Crawl + Heuristic engine to analyze power and thermal info in real time. Group manager that makes tradeoff power/thermal/performance decision to load balancing. Application migration service that seamlessly migrate apps from one execution environment to the other w/o date or performance loss.	Walk + Dynamic update of policies and thresholds on managed device. Self-learning mechanism that improves "hotspot" mediation strategy overall. Advanced analysis and alerting before "hotspot" appears and advise IT user to add capacity.

Prioritized platform capability requirements are normally used in the platform planning process, together with other factors such as technology readiness, business values, and platform Bill of Materials (BOM) cost. That is a set of processes that is beyond the scope of this paper. Nevertheless, these platform planning teams are the direct consumers of the above user-centric analyses.

CASE 3: INFORMATION ON DEMAND IN REAL-TIME

Organizations constantly search for ways to innovate and improve business processes and performance. To be competitive, many enterprises try to effectively leverage information within their disparate electronic and manual systems. Without the right information at the right time and place, companies cannot manage their businesses effectively and proactively**.** The premise is that abundant information—about customers, products, finances, business processes, partners, and employees—provided on-demand, becomes a competitive differentiator. It can significantly improve customer orientation, reduce costs, improve the product roadmap, mitigate risks, and enable compliance with regulatory policies.

In this section, we describe the top challenges in information management faced by both end users and IT in enterprises. We also provide a synopsis of the top three usage models and the associated capabilities and platform technologies.

Understanding User Needs

End-user challenges in the information management domain are best summarized by Figure 3.

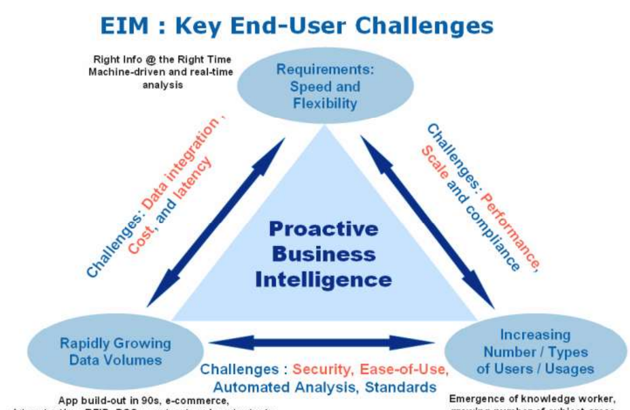

Figure 3: Information management challenges

They are broadly classified into three categories, namely, time-to-decision, time-to-information, and broad support of users and new usages. Data volumes (both structured data and un-structured content) have grown significantly and are projected to continue growing significantly. IDC projects structured enterprise data to grow 50% CAGR (Capital Annual Growth Rate) and unstructured content to grow 300% CAGR. Decision times are shrinking from weeks to hours and even to minutes.

From in-depth interviews we conducted with business decision makers, IT, and end users, we found both the number of users and their needs for business intelligence are growing significantly. Knowledge workers and business decision makers are demanding instantaneous access to real-time information, and they have high expectations for machine automation of high-density and low-value tasks and activities. Along each of these vectors, technical challenges abound. Among these, data integration, performance, latency, TCO, scalability, compliance, and data and content security are the critical ones.

In conjunction with research on end-user needs/challenges, the market trend analysis gives us a basis for developing a set of usage models for compelling platform solutions. The key market trends we have observed include 1) the drive towards information appliances (special computing devices with dedicated functionalities); 2) a balanced computing model with the client (desktop, laptops, smart devices) as an integral part of the computing chain; 3) Rich-Internet Applications (RIA) (web2.0) delivered using Software as a Service (SaaS) model; and 4) the notion of virtual appliances (a complete software solution stack that can be distributed as a unit of work) that executes in its own "dedicated environment" on a device. Analyses of these trends clearly show the strategies and tactics that businesses and ISVs are implementing to address/alleviate the end-user needs and challenges articulated in the previous section. For example, dedicated information appliances are exploding because of the need to provide high-performing data integration and analytical engines that scale linearly with users, and are extremely easy to use and manage. The RIA and SaaS architectures are addressing the need for rich visualization and analytical applications on the client that can work in an online and offline setting, with very low TCO and high security. Virtual appliances are emerging as a solution to provide security and isolation, in addition to the benefits of flexibility and ability to balance/optimize data center infrastructure.

Defining the Usage Models

These end-user needs and market trends lead us to a set of core usage models and usage scenarios to influence the definition of future Intel platforms, including both clients and servers. These are listed below.

Client Analytics and Unified Search

This enables a knowledge analyst to innovate through client-side analytics via fast access, modeling, simulation and data visualization. As a result, a business analyst can achieve secured data mining and decision making on desktop or mobile platforms that normally happened on servers.

On-Demand, and Real-Time Analytics

This usage allows users of different roles in an organization to access, analyze, and visualize data from different sources in real time. With reduced latency and time to information, business analysts can make decisions where they need it, when they need it.

Mobilized Analytics

Mobilized analytics allow rich, interactive, and continuous analysis of data on a mobile computer (laptop, tablet, or handheld). In addition to the time to information advantages described in the previous usage model, this usage model focuses on delivery of real-time analytical functions with complete mobile experience for business analysts.

Defining Platform Capabilities

We have developed a simplistic framework, referred to as the usage-platform hypothesis matrix. Table 5 shows a sample version for the "on-demand and real-time analytics" usage model. At a high level, the columns in the matrix represent the functional capabilities of the domain, and the rows are the platform attributes. Through a preliminary analysis of the workloads and the data flows for each of these usages, we identify the potential bottlenecks across each of the platform attributes (marked with an "X"). Ideally, the size of "X" would show various intensities and weight of bottlenecks. From this matrix, you can identify clusters of bottlenecks, which then drive the discussion on platform capabilities that are needed to address these bottlenecks.

For example, in the on-demand analytics usages, data integration, data acquisition and transformation, and end-user query response are the dominant use cases. Operating from the freshest data possible for business decisions requires pulling data that are scattered across various data sources in the company. The various data integration and transformation technologies that have emerged still don't address the on-demand and real-time needs for decision making, because these functions are highly memory, compute, and disk intensive. Being able to characterize these functions for certain workloads would provide insights for platform architects to develop technologies/features to improve performance. This framework gives a first order orientation to frame up the criteria and scope of the workload characterization efforts.

Table 5: Use cases to platform capabilities matrix

Platform capabilities attributes	Use cases			
	Data acquisition	Data transformation	Data integration	Data persistence
Network I/O	x		x	
Storage I/O	x		x	x
Local disk I/O				x
Memory: capacity, BW and latency			x	
CPU cache performance & size		x	x	
CPU/Cores		x	x	
XML acceleration		x	x	
WSvc/XML security	x	x	x	
Virtualization			x	x
NVM	x	x	x	
Many-/multi-core		x	x	
In-memory processing	x		x	

Characterizing the Workload

The next challenge is to identify and define a realistic set of workloads that best reflect the criteria and scope identified from the hypothesis matrix. These workloads are carefully crafted to simulate real-world use scenarios (and in some cases production applications are used in a lab environment), and they are instrumented to collect the data. As part of the characterization effort, we selected the data-acquisition use-case referred to in Table 5. Briefly, this is the functionality where high amounts of data are extracted, transformed, and loaded into a data warehouse or a data mart. To simulate the workloads, we have taken a data mart used in a business group that supports ten analytical applications, and we have instrumented it so we could profile the application and various degrees of detail. The workloads are executed in the lab environment multiple times with tools like MS PerfMon*, EMon* and in some cases the Intel® VTune™ Performance Analyzer, each time capturing the CPU utilization, disk, memory, network, cache-misses, time spent in Windows* API, blocked-times, etc. In order to understand the next-level detail on the disk activity, tools like iPeak*, which is a disk tracing tool, are used to characterize the disk access behavior. The analysis of the data from the workload characterization is fed to the platform architects as a specific set of platform requirements. These requirements are then mapped to capabilities that are either in-flight, or will drive a new set of capabilities and features in the platform. The details of the platform requirements and the ensuing features for these usages are beyond the scope of this paper.

SUMMARY

As we can clearly see from these three cases studies, the usage-driven innovation process has a clear focus on end-user needs and user-oriented solutions. Some of these solutions have been built into Intel platforms and have yielded positive end-user feedback, while others are still evolving. Our initial success in Intel® Centrino® mobile technology and Intel® vPro™ technology-based platforms in developing compelling customer values makes us believe that this is the right approach to best meet our customer needs and build competitive advantages.

In addition, we have learned that building end-user focused solutions takes end-to-end efforts. It is not something that Intel can deliver alone. In order to deliver desired end-user experiences, we carefully evaluate and plan our ecosystem engagement and build win-win stories for the entire supply chain including OEMs, ISVs, and service providers. The usage-driven innovation process applies to products and services beyond Intel platforms.

ACKNOWLEDGMENTS

Special thanks to Jose Ramirez, Brian Kluge, Eric DiStefano, Marc Hobler, Jim Midkiff, Luke Koons, and Claude Cruz for contributing to the usage model-based mobile system thermal mechanical definition process.

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Bringing the Voice of Employees into IT Decision Making

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Index words: IT, user experience, usability, third party, vendor, user research, ethnography

ABSTRACT

One of the main purposes of Information Technology (IT) is to empower the most important resources a corporation has—its people. However, a consistent challenge for IT organizations is how to deploy and maintain valuable capabilities in a cost-effective manner. To address these challenges, Intel IT is moving to an Off the Shelf (OTS) model where third-party applications are purchased to minimize or eliminate custom design and development. This approach is designed to shorten implementation time, allow an iterative implementation approach, and ultimately position IT to respond more quickly and effectively to its business partners.

The risk of this approach is that decisions regarding which capabilities to deploy and how to deploy them will be heavily based on technical considerations and high-level business need without fully understanding the resulting impact to end users. Traditionally, IT departments have under emphasized the importance of User Experience (UX) considerations when deploying third-party systems. By not understanding the implications of a poor UX, potential Total Cost of Ownership (TCO) benefits associated with the OTS method risk being offset through lost productivity, additional training, low adoption rates, and post-deployment design changes. In other words, IT departments can technically deliver an OTS capability flawlessly, but if the user's experience with the solution is poor, TCO benefits will at best be reduced and in the worst case, offset entirely.

Intel IT is beginning to utilize a variety of user research activities, allowing end user considerations to be balanced with technical and business factors. A comprehensive understanding of the context within which employees use technology is valuable across purchase, configuration, and deployment activities, enhancing usability, training effectiveness, user adoption, and the overall efficiency of the business transformation. Therefore, by systematically gathering and employing user research data, IT organizations are better positioned to provide capabilities that enable employees to more efficiently meet business objectives.

After reviewing a case study where UX factors were overlooked on an OTS deployment, we review user research techniques and how the resulting data can be used to reduce the risk of IT deployments. In addition, we examine specific instances that have begun to emerge within Intel IT where user research techniques have been successfully applied to improve UX with OTS capabilities.

INTRODUCTION

When designing and developing products, companies consider a wide variety of factors and tradeoffs, and these factors may differ from those that end users value. In the conceptual stage, two critical factors that product teams first consider are whether a product is technically feasible and the business case for how it can be marketed. A third category that consumers value (but that product design teams may overlook) is that products are useful, usable, effective, and aesthetically pleasing. As products become more technically complex, the differentiating factor for consumers has increasingly become ease of use. Quite simply, people prefer using products that are easy to use and that allow them to complete activities efficiently [1, 2].

In the consumer market, if end users cannot utilize a product to accomplish a desired goal with relative ease, they are not likely to adopt a product, or if they do, they are likely to abandon it. However, for many individuals, the most complicated products they interact with are those provided by the IT departments where they work, where use may not be optional. In these cases, the desire for easy to use tools is still present, but the ability to choose between different options is limited or nonexistent. While it is generally believed that the use of IT-provided applications is not voluntary, these mandates are not always effective at forcing employees to utilize capabilities that do not meet their needs.

If IT capabilities do not allow employees to complete activities quickly and meet their work goals effectively, a wide array of negative effects can result. At the most rudimentary level, users will simply not be able to work as effectively as possible, reducing corporate productivity. In cases where applications are truly not valuable, users may take active steps to increase their productivity through developing local solutions or alternative procedures that bypass the capability entirely. These situations breed a host of potential issues ranging from poor data quality to compromised corporate security. On the positive side, by providing capabilities that give employees more time to problem solve and meet objectives in innovative ways, the employees' potential to contribute to the company's success can be fully realized. For example, by providing capabilities that minimize manual data entry and automate analytics, sales personnel will have more time to establish and foster positive relationships with customers.

As IT departments are increasingly responsible for providing and maintaining the capabilities that enable employees to compete in rapidly changing business environments, many are concurrently faced with the reality of flat or shrinking budgets. In addition to budget constraints, many other factors, such as changes to business strategy or increasing complexity in the business environment continue to accelerate the need for new IT capabilities. Given the number of competing factors, it is easy for management to overlook or downplay user considerations in the decision-making process. User research practitioners within Intel IT have increasingly utilized Intel's "Three-Circle" model [3] to convey the importance of evenly balancing user considerations with business and technical factors. As shown in Figure 1, the model indicates that successful products balance business, usage, and technology. Although originally designed to enhance Intel's customer focus throughout the shift to a platform company, the model has proved to be a powerful way to represent the importance of the end user in the traditionally tech-centric world of Intel IT.

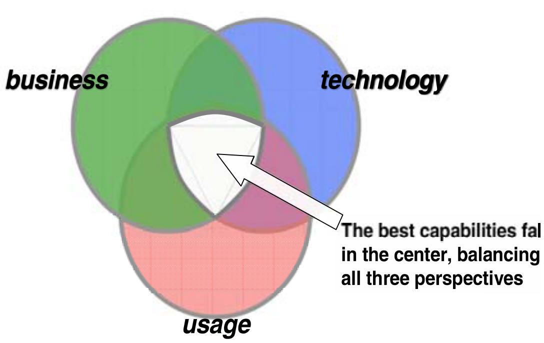

Figure 1: The Three-Circle model

At a more applied level, Human Factors Engineers (HFE) have traditionally employed User-Centered Design (UCD) techniques, which place user needs at the center of technology development and deployment [4]. Typical UCD activities consist of working with end users throughout the design lifecycle to evaluate and test the User Interface (UI) of a capability prior to deployment. While these activities have been successful in improving tool usability, it has become more and more apparent that many factors beyond usability are important to ensure the successful introduction of new business solutions. For example, if installing a capability requires the user to perform several manual steps, the probability of an unsuccessful install increases, potentially hindering employee productivity and resulting in technical support calls. In addition, without adequate self-help functionality, users may experience ongoing difficulties with completing activities despite interacting with a UI that meets accepted design principles. Therefore, although direct interaction with the capability may be efficient, other activities associated with the product, such as the initial install and ongoing help mechanisms, can lead to an overall negative impression of the solution.

To address these challenges, Intel IT user research practitioners have begun utilizing a more comprehensive User Experience Design (UED) perspective. As shown in Figure 2, this comprehensive approach incorporates the entire User Experience (UX) with IT products, including product awareness, acquisition, use, support, and end of life [5]. By understanding and optimizing each of the components of UX, Intel IT is better enabled to deploy capabilities that immediately and continually provide business value.

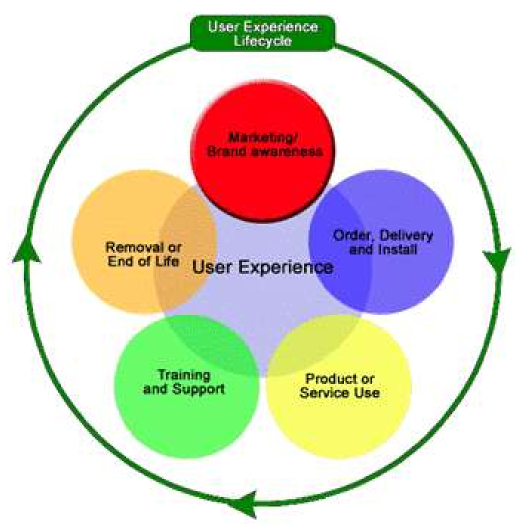

Figure 2: The IT User Experience lifecycle

Outside the context of a specific capability, Intel IT has also begun utilizing ethnography and other qualitative research techniques, facilitating a broader understanding of the context in which IT products are deployed. Ethnography offers a window into the employees' world by providing a holistic understanding of how and why employees work the way they do. Ethnography provides a deeper analysis of context, such as user's values and motivations (the "why" behind what they do) than other techniques. Whereas UCD and UED are useful to optimize design and deployment decisions, ethnographic and other qualitative techniques can be used to understand the social and organizational factors that may hinder the effective deployment and adoption of IT products.

THE CHALLENGES OF DELIVERING END-USER VALUE

Despite the number of user-centric methods available, most IT departments are still overwhelmingly technology focused. If UX considerations are so critical, why are they so often overlooked? Some IT investment decisions will always be technology driven: some maintenance investments will always be necessary that are not directly visible to end users (upgrading network capacity or improving the stability of e-mail servers, for example). After all, when the e-mail server goes down, everyone notices, and the effect is visible and immediate. For most IT departments, measures such as "percentage of down time" are the most critical and perhaps only indicators of success. Solely relying on these measures leads to a disproportionate focus on simply making technology available rather than providing technology that is easy to learn or that delivers the most value to end users.

Furthermore, the effects of deploying unusable business solutions, such as lost end-user productivity or high volume of tech support calls, more easily go unnoticed. Few enterprises have the type of metrics and measurement systems in place to capture these impacts and accurately convert them into financial terms. Although there are loose references to training and customer support costs within most Total Cost of Ownership (TCO) equations, the estimates typically used do not come close to truly accounting for the productivity loss and frustration that occurs as a result of deploying solutions that do not match user's needs. Even more difficult to detect and quantify is the result of deploying a capability that doesn't provide anticipated value and as a result is underutilized, leading to non-approved tools and procedures. In essence, productivity loss and other negative consequences of unusable or under utilized applications do not have the same "voice" as technical or business concerns. However, the undeniable truth is that the value (and potential return) of investing in a new capability can only be realized if end users adopt and utilize a new capability to more effectively complete business objectives [6].

Even when the driving force behind IT investment is to directly deliver end-user value, often times an IT solution is mistakenly selected to address a non-IT problem. For example, a common scenario driving investment in a new capability is the goal of improving overall business (and hence individual employee) performance. Attributing existing performance inefficiencies to technology (or a lack thereof), management believes that productivity will improve if employees are provided with state-of-the-art software. However, in many cases, the root causes of existing inefficiencies are not tool related but instead can be attributed to the culture or structure of the organization, or to business process issues. In these scenarios, the expected improvements to overall business performance by deploying a new capability will never materialize.

A slightly different scenario often is the deployment of the next release of a software package simply because it is available; the assumption typically being that new functionality equals increased productivity. However, if the new functionality is not providing additional value to the end user, not only does it go unutilized (wasting development time and money), it also increases overall product complexity, and can require additional training to learn how to use it. In the end, applying a technology solution to a non-technology problem will result in few, if any, improvements in business performance. In fact, sometimes these types of deployments can result in a net financial loss, with resources being spent to deploy them and users taking time to learn functionality that does not deliver its intended value.

In the past, many corporate IT groups, including Intel IT, have worked to meet employee needs by building highly customized applications for different user populations. Although this method allows users the ability to input exactly the needs and features they felt were most important, the overall development process is costly and time consuming. In addition, although optimization occurred for certain job roles and business units, the result is typically overall sub-optimization because of the complexity associated with integration across end-to-end business processes. To offset the cost and complexity of customized development, Intel IT began purchasing and deploying more industry-standard IT solutions. However, even in these scenarios, development teams found themselves coding additional functionality to facilitate infrequent exception steps and processes. In fact, recent usage data from Intel IT indicates that employees had never used over 40% of post-purchase modifications on a large third-party solution. These data highlight the fact that a significant amount of development and support effort can be wasted on functionality that is not delivering value to end users. In addition, since end users directly requested these modifications, it shows that even end users themselves may not have the proper insight and visibility into their work to determine their most critical needs.

THE UX RISK OF OFF THE SHELF

To address these issues, Intel IT has recently begun adopting an "Off the Shelf" (OTS) model that minimizes or eliminates custom development. The initial adoption of this methodology has resulted in shorter implementation times, easier system upgrades, and an overall reduction in TCO. Although these initial benefits are promising, aspects of the OTS approach further increase the risk of downplaying UX as a critical component of successful deployments. For example, cost and schedule goals are two of the most critical success criteria for project teams and this will be especially true as adoption of the OTS model increases. After all, lower TCO and improved deployment velocity are some of the expected benefits that prompted the shift away from heavily customized development. However, one potential risk associated with focusing too heavily on hitting schedule and cost goals is the minimization of activities perceived to slow velocity or increase spending. On OTS deployments, activities such as usability testing and quality assurance are often overshadowed by the pressure to quickly deploy. Project teams also assume that the vendor has completed these testing activities during the original development and further testing would therefore be redundant. In reality, many third-party capabilities have a significant amount of configuration and deployment flexibility and thus require the same types of testing (usability, system performance, etc.) traditionally performed on more customized applications to ensure end-user effectiveness.

Within the OTS framework, end users can no longer provide "blue sky" requirements, a process where all functionality requests are captured and later prioritized for development. As mentioned earlier, although this method has its own detriments it can provide end users a sense of involvement in the development process, improving adoption rates. Because third-party vendors develop OTS solutions, they will likely be significantly different from the customized applications that end users may be familiar with. In addition, because OTS benefits result from avoiding or minimizing customized development, IT has a limited ability to subsequently design in enhancements if an OTS capability does not meet users' expectations. Due to the increased difficulty of making mid-course development corrections, UX considerations become more critical to the success of OTS deployments than they were with the more flexible customization approach.

The desire to deploy OTS solutions means that organizations and end users must be more willing to adapt to the capability vs. developing or customizing the capability to match user wishes. In many cases, adapting to OTS system functionality can require a significant amount of business transformation. Most often this means changing existing business processes (who does what and when, how communications happen, how decisions are made, etc.) to match how a given capability architecture is designed or can be configured. Companies routinely underestimate the difficulty of managing these business transformations and their impact on individual workers. Even a well-planned change in a business process can disrupt the work routines of experienced employees, and it can have a significant short-term impact on effectiveness and productivity. Poorly planned changes can lead to the overall failure of the business transformation efforts, resulting in significant financial loss [7].

When deploying a new capability, focusing too heavily on one set of considerations while overlooking others is simply not an optimal approach, and this is true on OTS deployments as well. Although a new capability can be technically delivered flawlessly, if it does not deliver end-user value, significant resources will be invested, but the intended return will at best be reduced and in the worst case, offset entirely. Missing or not comprehending the factors that will optimize employee effectiveness places IT management in a situation to make multi-million dollar decisions without all the available data. The long-term success of the OTS approach will be contingent on evenly balancing technical, business, and user considerations.

The Consequences of Overlooking UX

There are various cases from the IT world where UX implications were not considered, degrading the full benefits of deploying an OTS capability. One such Intel IT experience involved an enterprise-wide deployment of an OTS capability where a "zero configurations" approach was utilized. In other words, when deploying the capability into production, all available functionality in the purchased system was activated. It quickly became apparent to end users that certain functionality in the new solution was redundant with other applications they had traditionally used to complete the overall business process. This redundant functionality forced end users to alter the steps they were accustomed to performing, resulting in frustration and significant increases in the time it took to complete tasks. In addition, users found that online help resources were not useful in addressing questions, resulting in a considerable number of technical support calls. Lastly, subsequent survey results and end-user feedback pointed out that pre-deployment communications about what was changing and where to get training on these changes were not clear. In summary, by not accounting for how the new capability differed from existing work practices and the resulting impacts of these differences, a host of UX issues ensued, impacting employees ability to complete activities across the corporation. The time and effort to address these issues were significant, eroding the intended benefits of deploying an industry-standard solution.

ADDRESSING ISSUES WITH USER RESEARCH

The project team, working with a user research practitioner, conducted user research to identify root causes and solutions to the variety of UX problems that end users were facing. Subsequent activities included iterative rounds of usability tests and configuration changes to build an optimized business process that better matched end users' natural workflow. With some very simple configuration changes, average task completion times dropped from 45 min. to 23.5 min. In addition, several modifications were implemented to address critical usability issues, and those that were not addressed through modification were channeled back to the vendor to improve future releases. On future deployments, the training team shifted their focus from "quantity" (e.g., percentage of users trained) to "quality" (effectiveness) to verify that end users were adequately prepared for upcoming changes. Lastly and most importantly, multiple parties were involved in improving the overall UX, including stakeholders, end users, technical support personnel, training personnel, and user readiness representatives. Although the initial deployment provided some hard lessons, the result across Intel IT has been positive as it has increased focus on the importance of UX considerations when purchasing, configuring, and deploying OTS capabilities.

Qualitative Research Methods and Outputs

To avoid similar scenarios, Intel IT is increasingly utilizing user research techniques to proactively understand UX considerations. Using these techniques optimizes the effectiveness of technology deployment projects and allows organizations to incorporate user concerns in longer-term technology roadmap planning.

User research practitioners utilize both quantitative and qualitative methods drawn from various fields. Traditional quantitative methods tell you what people are doing and can provide some detail around user's attitudinal and behavioral patterns. However, qualitative research techniques, such as ethnography or contextual inquiry, provide the insight and rich context needed to understand the why behind users' actions. "Although traditional market research techniques such as surveys and focus groups can identify trends and tell us what computer users are doing, they cannot necessarily describe why. And yet the answer to "why" is a key to defining products that will be readily adopted" [8].

Primarily, qualitative research techniques are exploratory and are often most useful to examine areas about which little is known. These techniques can also provide a detailed understanding of existing contextual work practices and workflows. They are useful in exploring the user environment and can help identify factors that might increase resistance to adopting new systems (organizational structure, cultural, values, attitudes, perceptions, beliefs, etc.). There are various methods used within the field of qualitative research, but we primarily use the ethnographic methods of direct observation and unstructured or semi-unstructured interviews to gain the highest quality contextual data we can about our users (Intel employees).

Ethnography is the study of people in their natural environment. The ethnographic method was initially developed within the discipline of anthropology but it has been used and extended throughout various social science disciplines, including sociology, psychology, information science, and human-computer interaction, among others. Interviews and direct observation (observing people while they work) are the primary methods used. Other methods include group interviews, video documentaries, or photo, audio and written journals or diaries. The ethnographic method essentially involves a researcher immersing him or herself within a specific context and establishing relationships and rapport with people within that context. The rapport the researchers develop allows them to interact with people through actual participation in that environment and through observation and dialogue to uncover people's attitudes, beliefs, cultural constructs, and values that shape their behavior.

Contextual inquiry is a method from the overall Contextual Design methodology [9] utilized by UCD and Human Computer Interaction (HCI) practitioners. It borrows much of its technique from ethnography but differs because the researcher actively seeks understanding while actions are happening. Regardless of the specific qualitative research method used, its main advantage is that it solves one of the major challenges of design—understanding users' real needs and the way users work. Work processes often become so automatic that end users find it difficult to articulate specifically what they are doing and why. In these cases, outside observations of work practices often lead to key questions and insights that result in improvement opportunities.

The benefits of qualitative research include the following:

- Gain holistic understanding of employees and how and why they work the way they do.
- Identify unarticulated needs or behaviors.
- Allow natural patterns to emerge to guide understanding as opposed to starting with a narrow research question.

- Learn intricate details about difficult-to-study phenomena.
- Understand differences in cultural responses to technologies or workflow processes.
- Identify problems with systems or technologies that users attribute to their own failings, and thus do not report.
- Add richness to and support for quantitative data.
- Gain a rich understanding of the context within which employees work (social, cultural, physical).

User researchers generally summarize the major themes and patterns in the data for decision makers and then use these to develop various kinds of visualizations of the data that help describe the users and their needs and goals in vivid ways. These visualizations include user profiles that describe key characteristics of user groups or "Day in the Life" narratives. They may also include scenarios that represent one particular activity observed during the field research. Various types of flow diagrams that show workflow, information flow, and relationships between different job roles or processes are also effective ways to demonstrate the user's current experiences during their workday. Typologies or classifications based on certain factors are another common type of output. Researchers often collect various kinds of artifacts from users that may include work products/outputs, documents, photos, or images. All of the outputs or deliverables generated by user research describe the user and his/her current experiences.

Applying User Research to an OTS Deployoment

In the case of OTS deployments, user research can provide key insights about users and usage that will help guide purchase decisions, application configuration, and necessary business process engineering efforts. Ideally, conducting user research occurs prior to the initial OTS selection with the resulting data continually influencing the configuration and deployment processes. However, user research is still beneficial to programs where the purchase decision has already been made but configuration and deployment have yet to occur. One example of how user research has been used to enhance the UX of OTS products is a study conducted earlier this year on Intel's Platform Product Life Cycle (PPLC). Study results identified organizational structure and cultural issues that the selected tool would not have addressed directly. For example, the PPLC data showed that about 50% of the issues discovered were in fact related to organizational culture and structure, areas that are critical to understand when deploying any major new capability, but that are often overshadowed by business or technical considerations.

Many of the organizational issues discovered were directly related to efforts undertaken at a corporate level to transition Intel to a platform company. Developing the new OTS product has primarily focused on business processes and new tool capabilities for management of the platform product life cycle. The study was able to highlight the importance of understanding the context within which an OTS product is deployed as well as validate some of the design choices that had already been made.

By proactively understanding issues prior to deployment, user research practitioners were able to work directly with the transition change management team to address gaps and mitigate risks to increase adoption rates. It has also allowed the team and other decision makers to understand more about any possible organizational roadblocks that may make adoption of the new tool difficult. Findings like these highlight the value that user research brings to an IT organization. Through understanding and addressing all aspects of user experience before making initial OTS purchase decisions, decision makers and deployment teams are better able to effectively configure and deploy valuable capabilities, increasing adoption rates of end users.

See Appendix A at the end of this article for an overview of how to utilize user research to optimize OTS deployments.

A PROCESS FOR INTEGRATING USER RESEARCH INTO IT DECISION MAKING

Based on our learnings in 2006, we feel that the following considerations are important when implementing a systematic user research effort.

Step 1: Influence the IT organization to accept usage as a key decision driver.

The Three-Circle model in Figure 1 outlines the balance of business, usage, and technology needs. Without a good understanding of each area, decisions may not have the desired impact. This balanced Three-Circle approach weighs the various components of decision making and comes up with a compromise that will represent a positive outcome for the company. Generally, acceptance of usage as a key component of decision making can often be driven by doing a few pilot research studies that demonstrate the richness of the data gathered from utilizing a full complement of quantitative and qualitative research methods.

This step establishes the basic acceptance for the value of the research and ensures that the research will be used throughout the organization.

Step 2: Develop a research team focused on internal users (employees).

We propose a mix of qualitative and quantitative researchers. Many corporations have groups with related skills: business or market research, human factors engineers, social scientists, business process engineers, etc. A small research group aligned with these organizations can share skill sets and data in synergistic ways to ensure that decision makers get a full understanding of their users and usage through a comprehensive research analysis.

Step 3: Conduct research on two levels: foundational and directed.

Ideally, there are simultaneous layers of user research underway in an internally focused user research effort (e.g., ethnography of the company itself). The first layer is a broad or foundational layer of research that explores large themes or topic areas to start identifying the large picture of how and why people work the way they do. This research may cross job roles and organizational unit boundaries and focus instead on large thematic areas such as how people use and need mobility to complete their job tasks or how employees in different areas of the world collaborate across time zones. This layer can help an organization gain an overall understanding of the biggest issues that users have, to direct spending of limited IT dollars. The second level of research is directed or project-specific research that addresses specific research needs for a given project. This research may have been identified as a need through the foundational research or be requested by a specific project, based on findings from other kinds of research such as usability testing on a current capability.

Conducting research on these two levels allows projects to be provided with immediate support and results while slowly building a broad set of data on users over time. Both layers of research are important for building momentum around the user research effort. These layers are also important to the continuous augmentation of the user data set with both quantitative and qualitative research results. The results of all studies should be cross-analyzed to fully identify the top IT user priorities that can be addressed through improved processes, tools, and services, or organizational structure adjustments.

Step 4: Fully disseminate user research data.

The benefit of the two levels of research is that they provide both a basic and specific understanding of users in a given work process. Once the results are in, it is important to disseminate the results to the appropriate places.

Making the data visible in various outputs such as user profiles, scenarios, and flow diagrams that clarify and make the user come alive is one way that we have been ensuring the research data are utilized. These visualizations can then be used during the product life cycle for any capability. They can also be used during roadmap or long-term strategic planning efforts to identify the direction an organization needs to take, and they can be fully considered alongside technology and overall business needs.

Step 5: Determine the business value for the user research.

Once the top priorities are identified from this broad view of usage, business, and technology needs and fed into strategic, long-range planning and the development or the next release of capabilities, the user research effort needs to start determining the business value of the research. Business value is defined as the benefits for the business unit and the enterprise as a whole, represented in dollar terms, that is a result of IT solutions or services [5]. A clear understanding of where the research is disseminated and used as well as its impact on actual capability deployments will help an organization continue to conduct research that has the most impact.

USER RESEARCH KEY LEARNINGS

We are currently implementing this kind of systematic approach in Intel IT. Our pilot studies this year have determined some best practices and recommendations around how to most effectively utilize user research data for internal IT improvements. We have found that user research must be conducted in a broad, strategic space where it can be fed into the overall direction for a company's IT organization (Figure 3). This is especially effective in IT organizations that are heavily utilizing OTS applications. It is the best place for a company to ensure that user concerns are considered in long-term planning processes, and it ensures that the research will not be constrained by strict project timelines or be limited by project scope. It also allows more directed research to be conducted on actual projects and to be used by program managers, business process engineers, human factors engineers, transition change management, or other usage and process experts to guide their strategy and design of specific tools or applications.

As new applications are purchased, configured, and deployed, user data can then be used to optimize OTS deployment at the capability level. For example, examining business and usage considerations together can help project teams determine when modifications to OTS solutions are needed. As the previously mentioned data on modification usage highlights, employees may not have the broad or longer-term perspective to accurately determine which system functionality is critical and which functionality can be adapted through procedure or process changes. Broad and systematic research that looks at usage patterns across time and the entire job context of multiple roles can be used to succinctly identify the most value-added modifications. Additional directed research that is specific to a given capability can then fill in the more specific usage details needed to move forward in development.

Many different corporations are increasingly using ethnography and other types of user research during their product design cycles but they have not been used as frequently to look internally at a company's own employees. While our efforts are somewhat innovative, they borrow heavily from the work that other groups have done at Intel to bring field research into product design. Numerous new Intel products such as the Community PC designed to meet specific user needs in rural India and the China Home Learning PC designed to address specific computer needs in Chinese households are two of the more recent examples of this new focus on people-centric product development.

As such, there are not a lot of case studies yet that detail some of the possible missteps or difficulties one may encounter during efforts to implement a user research effort. We provide some of our key learnings from the past year as a starting point to this topic.

The first thing we learned is that it takes at least two researchers. The best research analysis comes from having at least two researchers involved in any given effort. This reduces bias and improves the quality of the analysis. In addition, if the research is being undertaken at a project level, the researchers need to lead and own the research results and process so that they can structure things to ensure the highest quality of data and research outputs.

Another key lesson we learned from this past year is that it is important to get management buy-in and agreement before starting. The research process and outputs to both participants and management should be clearly articulated before beginning any research effort to establish a shared understanding and vision of the research goals and outputs. This helps to gain access to the users that need to be talked to and ensures the data will reach the right people to be fully utilized to improve decision making. Conducting a few key pilot projects showing the kinds of research results they can expect will be beneficial in highlighting the unique benefits of understanding the contextual nature of how people work.

A third lesson we learned is to talk to a wide variety of people. The users targeted as participants should include both the actual employees as well as managers of groups of employees in the study. This allows a full picture of the organization and its culture and processes. It is also crucial to communicate the results back to both groups for two main reasons: to validate any findings and to enhance understanding of the value and process of user research.

Another lesson we learned is that quality field research and data analysis take time. We have found that it takes approximately 12-16 weeks to run an ethnographic study, longer if including multiple geographic locations or large number of participants. The scheduling and actual field research generally take at least 4-6 weeks and the data analysis and final outputs take another 4-6 weeks or longer depending on the outputs to be created.

A major lesson we learned was to utilize a variety of techniques to make users come alive for decision makers. Providing research results with detailed quantitative numbers as well as a summary analysis will create a clear path from the field research to creating visualizations. Making users come alive for decision makers is important for gaining support and understanding of research findings. The use of user profiles, "Day in the Life," and other narrative techniques help communicate work in an easily digestible format that can be used across an organization.

One final lesson we learned is that the researcher can often provide an overall "research coordinator" perspective to decision makers. By working with market researchers and other people who have conducted research on a particular area, an overall analysis can be provided that builds on previous research and provides one research summary to decision makers. This type of strategy helps them avoid dealing with fragmented pieces of user data and enables them to make better, faster decisions.

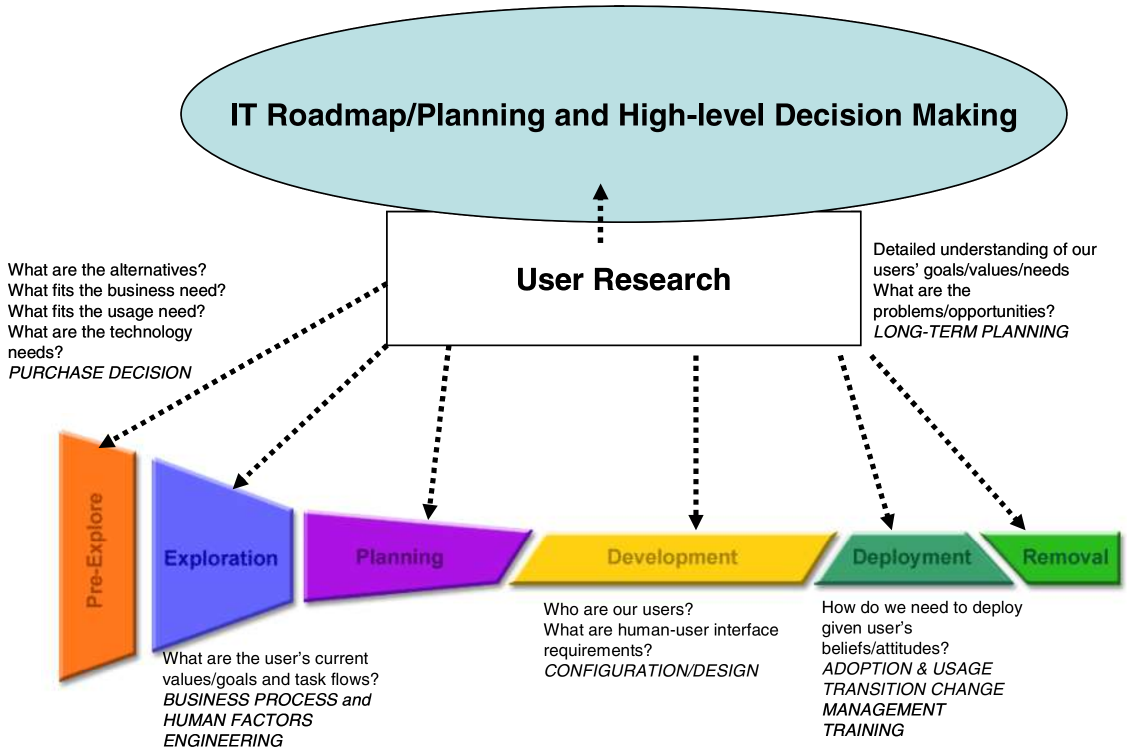

Figure 3: User research approach

CONCLUSION

In sum, user research provides an understanding of employees: it highlights what is important to them, what incentives motivate them, what their goals and work behaviors are, so that an IT organization can deploy OTS capabilities that better match user's needs. However, the benefits that contextual user research provides to a corporation go beyond the realm of IT. A typical qualitative research study identifies a wide range of potential areas for further study and/or highlights areas for improvement in business processes, services or tools, and organizational structure. User research often identifies overall organizational and cultural issues that might limit employee effectiveness or efficiency or affect user adoption and acceptance of new systems and processes. In essence, user research data helps a company understand the effectiveness of internal processes and practices to better identify improvement opportunities.

Companies may also find that their employees have needs that are similar to their customers. Because of this similarity, qualitative data gathered from employees can also directly contribute to product design decision making. For example, Intel IT has been involved in a pilot of several new phone technologies in an effort to increase job effectiveness through increased mobility. The pilots and eventual implementation of any new capabilities will also highlight the products that Intel sells. The user research data will thus have an impact on our overall understanding of people that use our mobility products, improving the technology that Intel sells to the consumer market.

Beyond benefits to the corporation, a more significant focus on delivering end-user value has major implications for the IT industry as a whole. Just as functionality alone is no longer adequate in driving product sales [10], simply providing technology to employees will not provide optimal return on IT expenditures. Ten years ago, many employees were provided with more powerful technology in the workplace (laptop computers, T1 lines, etc.) than could be easily accessed in their personal lives. As technology has become pervasive in all aspects of day-to-day life, more companies have incorporated UX principles into the development of consumer products. In many cases, the technology now available to consumers meets or exceeds the capabilities provided by IT departments, both in terms of functionality and UX. As people become more accustomed to products and services that deliver a good UX, the greater will be the desire for IT departments to do the same. Disheartening to employees is how they can search the entire Internet and find relevant results but that they cannot find customer information on the company Intranet.

A competitive advantage that IT organizations can deliver is greater business value through positive UX. Moving forward, it will be increasingly insufficient to simply deploy cheaper technology, focusing primarily on driving down TCO. IT organizations will maximize the business value they deliver by directly addressing and solving the issues their end users and business organization have in achieving their goals and objectives. Focusing on getting the optimal UX designed into the IT solution will help drive a greater overall return on investment than can be achieved by focusing primarily on TCO.

As companies realize that greater business value is a result of optimizing the UX delivered by IT, they will increasingly look to IT vendors that excel in this area. One of the underlying justifications for maintaining an internal IT organization is that it has a more in-depth understanding of and can provide solutions that meet employees' needs by working within a given corporate environment. Internal IT organizations that continue to focus primarily on TCO put themselves at risk for outsourcing as it becomes more difficult for them to demonstrate the value they add to the company compared to that offered by outside vendors. For vendors of IT services, delivering solutions that provide a superior UX will give them a competitive advantage over their peers. Internal IT departments that embrace the relationship between UX and business value position themselves to become a strategic partner within the company as opposed to simply being viewed as an additional expense.

In summary, all technology design and deployment efforts face constraints. Whether deploying an IT solution or marketing a new consumer product, project teams face the competing pressures of providing useful technology while balancing time, cost, and other limitations. Regardless of the context, however, the importance of delivering end-user value to ensure adoption (and sales) remains consistent. Delivering end-user value is best enabled by understanding end users through rich, contextual user research. From a UX standpoint, the OTS approach will at best lead to an approximation of the ideal solution. User research allows decision makers to find and deploy from available sources the standardized solution that most closely meets employees' needs.

To be most successful, decision makers need to understand the interplay and trade-offs between optimizing one area to the potential detriment of another. For example, on the one hand, customizing a solution to improve UX will add cost and can potentially impact other systems, increasing ongoing support costs. On the other hand, staunchly avoiding all customization at the expense of UX can increase training time, decrease productivity, and lead to poor user adoption. Adequately comprehending user considerations allows decision makers to identify the optimal balance with technical and business factors to ensure overall success.

APPENDIX A: A USER RESEARCH PROCESS TO OPTIMIZE OTS DEPLOYMENT

1. Conduct strategic contextual user research at a broad level to have a baseline understanding of employees' needs and goals.
2. Use the contextual data to feed into various research outputs: qualitative research analysis, narratives such as user profiles and "Day in the Life," usage model components (e.g., personas/scenarios), and develop user requirements.
3. Compare user's goals, business process, etc. with the functional capabilities of different OTS systems.
4. Determine appropriate trade-offs between user requirements and technology and business needs (e.g., system requirements, TCO, overall business directions, etc.).
5. Determine a course of action (purchase decision, development path, etc.).
6. Utilize the strategic research to guide the program or project-specific UCD strategy and determine additional research needed to help create defined user requirements.

ACKNOWLEDGMENTS

A big "thank you" is in order for the individuals who took the time to review and provide feedback on article ideas and content. A very special thanks goes out to Linda Wooding, Randy Sieffert, and David Sward for not only providing feedback multiple times but for their ongoing mentorship and overall efforts to ensure user experience receives the focus it deserves within Intel IT and beyond. We would also like to thank Olivia Williamson for her original abstract submission.

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Home PC Maintenance with Intel® AMT

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Index words: Intel® AMT, home PC, remotely diagnose, remotely heal, security

ABSTRACT

At present, home PCs are maintained in a very costly and inefficient way. When problems arise, the user has to call a support center to try to get the problem resolved. The user hangs on the line to talk to a technician. The technician will often try to hone in on the problem by going through a script of possible problems related to what the user is talking about. The process can be time consuming and frustrating, as often times, users, especially inexperienced ones, cannot explain adequately what the problem is and technicians are tied to a script of "possible" solutions that may or may not resolve that user's particular problem. In this paper we propose a new usage model that uses Intel® Active Management Technology‡ (Intel® AMT) to maintain home PCs remotely.

In this usage model the home PC is connected and managed with Intel AMT remotely. To ensure a secure connection between the remote management service and the home PC, a Transport Layer Security (TLS) protocol is used. Additionally, home PC users have full control over when their PC is accessed and by whom. And finally, users with very little computer knowledge can use this model as the operations are simple and easy to use.

In this paper we describe the architecture of this usage model and discuss the problems of connection security and ease of use. We also present a typical scenario of our usage model to illustrate the convenience and efficiency that is available to PC users and IT technicians when using Intel AMT.

INTRODUCTION

Home PCs are ubiquitous in today's world, but their maintenance is costly and inefficient. For hardware or software problems, users have to call support centers to try to fix their problems under the guidance of a technician. This process is time consuming and frustrating for users. When the problem cannot be fixed by a phone call, sometimes it is necessary to take the computer to a repair center or have a technician make a house call, a very expensive proposition. With the advent of Intel Active Management Technology (Intel AMT), the barriers to greater efficiency of home PC maintenance are removed, and it becomes possible to maintain home PCs remotely without too much imposition on the user.

Intel AMT is designed to provide a new level of IT management. With this technology, the computer can be accessed, diagnosed, and healed remotely. The following key features are supported by Intel AMT:

- Out-Of-Band (OOB) System Management allows remote management of platforms independent of the Operating System (OS) and regardless of the power state and OS state. Essentially, the only requirements are that the platform has a network connection and standby power.
- Non Volatile Memory (NVM) holds asset ID and inventory information so that the IT technician can access this information remotely.
- The remote diagnosis and healing function enables the IT technician to reboot the machine, diagnose hardware or software problems, fix software problems, and install an OS remotely.

Intel AMT implements these features as new hardware and firmware capabilities on the platform's motherboard. Additionally, Intel AMT uses the platforms' auxiliary power to keep the features active even when the platform is turned off. Therefore, even with a crashed hard drive or locked OS, an IT technician can still access the platform for remote asset, inventory, and software management or remote diagnoses.

Up to now, Intel AMT has mostly been used in the enterprise environment to improve a corporation's IT management. In this paper we propose a new usage model in which Intel AMT is used to remotely maintain home PCs and small business PCs (such as those in hotels, Internet cafés, etc.). This usage model provides remote diagnosis, healing, OS installation, and other features.

This paper is organized as follows. We first introduce the concept of remote maintenance. Then we discuss the architecture of the usage model and describe in detail the work process. We go on to discuss the challenges inherent in this usage model and propose solutions. Finally, we present a typical usage scenario.

APPLICATION OF INTEL AMT FOR HOME PC MAINTENANCE

Key Capabilities of Intel AMT in the Enterprise Environment

Intel AMT provides three key capabilities for the enterprise's IT managers to simplify their daily workload and significantly reduce IT operating costs.

Remotely Discover Computing Assets in Any State

Accurate platform, software, and hardware inventories are necessary for regulatory compliance as well as for accurately managing maintenance contracts and software licenses. There are some in-band tools available today for remote inventory, but they miss platforms that are powered down, have been tampered with, or have an OS problem. As a result, IT enterprise departments often have to maintain lengthy and expensive manual inventory to ensure accuracy. By contrast, Intel AMT eliminates manual inventory costs by using OOB management tools and tamper-resistant agents in NVM to discover all network-connected computing assets.

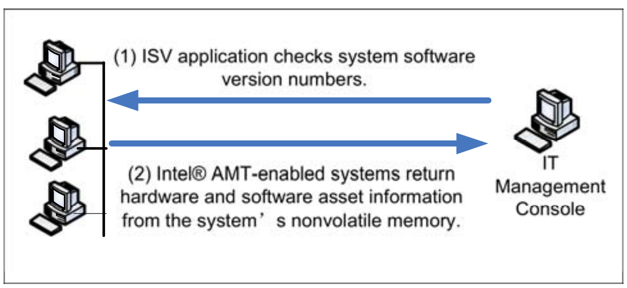

Figure 1: Remotely discovering

Figure 1 illustrates the Intel AMT discover process. Here a third-party or Independent Software Vendor's (ISV) management application polls network-connected PCs to discover inventory. Because polling occurs through OOB communication, even powered-down and OS-disabled platforms are discovered. Additionally, because of the tamper-resistant agents and NVM features, a full and accurate inventory of the platform's hardware and software is always available through Intel AMT.

Remotely Diagnose and Heal Computing Assets

In the past, an inoperable OS, corrupted application, or crashed hard drive invariably required at least one or two desk-side visits to fix the problem. The proactive alerting and remote-boot capabilities of Intel AMT can reduce the number of desk-side visits and even eliminate them in some cases by remotely healing the platform problem. Figure 2 illustrates the process of remotely healing computing assets.

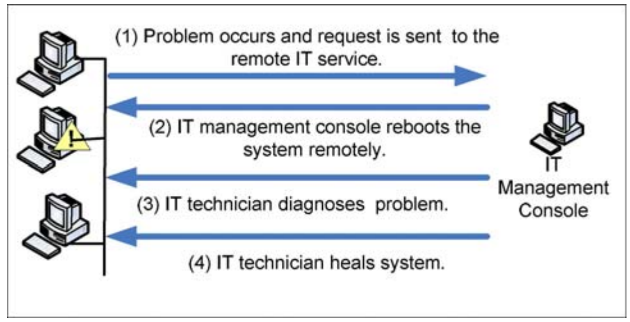

Figure 2: Remotely diagnosing and healing

In the first step shown in Figure 2, a problem occurs in one of the platforms and the Intel AMT proactive alerting feature notifies the IT management console. Depending on the type of problem alert, IT can remotely reboot the platform to an IT diagnostics platform if necessary (step 2 in Figure 2). Remote reboot would be necessary, for example, when the platform's OS becomes unstable or locks up, or if there is a hard-drive failure. Even with the OS down or a drive failure, Intel AMT's proactive alerts and remote reboot still function because they occur using OOB communication. Once IT has control of the platform using remote reboot, third-party diagnostics can be used to diagnose the problem and define a repair solution to heal the system (step 3, 4 in Figure 2).

Remotely healing assets using Intel AMT provides faster time-to-repair and significantly reduces desk-side visits, thus increasing IT efficiency and reducing maintenance costs.

Remotely Protect Computing Assets

For an enterprise, it is important to protect computing assets and maintain corporate productivity by ensuring that each platform has the latest IT-approved software versions installed. This minimizes file and operating incompatibilities that can occur when different departments or groups use differing application software versions. In particular, it is vital to protect against virus attacks by ensuring that anti-virus software and virus-definition files are kept up to date on all platforms.

While in-band tools are available for identifying and updating anti-virus software, their OS-level agents can be accidentally removed or overwritten. Additionally, in-band tools cannot work if the platform is powered down or its OS is not available.

The OOB capability of Intel AMT allows remote maintenance of anti-virus software, regardless of platform state. This is shown in Figure 3, where an ISV application operating through Intel AMT checks platform software version numbers. Upon finding an out-of-date version number, IT can wake the platform for off-hours version updates or patches.

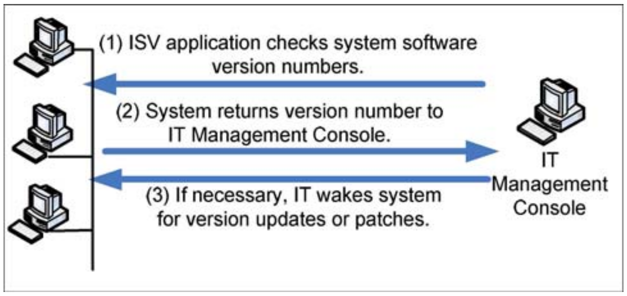

Figure 3: Remotely protecting

Complete software update and patching is done remotely through Intel AMT, eliminating desk-side visits and ensuring that enterprise protection is current across all Intel AMT-enabled platforms.

Home PC Maintenance Through Intel AMT

The most common issues with home PCs are virus infection, software installation or configuration problems, and hardware problems. These issues often result in OS errors or even OS crashes. Once these problems occur, home PC users, with little knowledge about computer technology, are forced to call support centers and spend time on the phone, or sometimes they even have to request a site visit from a technician. The remote-diagnose and remote-heal capabilities of Intel AMT can eliminate these kinds of costly and frustrating tasks. The process used for remotely healing in the enterprise environment (Figure 2) also can be used to remotely heal a home PC with Intel AMT.

When a problem occurs in a home PC that is enabled with Intel AMT, the user can inform the IT technician about the problem. The IT technician remotely connects to the home PC and reboots the system to control the remote machine. The serial and Integrated Device Electronics (IDE) communications are redirected from the home PC client to the management console. The only requirement is that the home PC be connected to the network and have standby power.

Once the IT technician has control of the platform, third-party diagnostic tools can be used to diagnose the problem. If it is a virus infection, the IT technician can eliminate it with anti-virus software. If the virus cannot be deleted, the IT technician can re-install the OS. During this period of time, users need not be at home: all of these operations can be done by the IT technician remotely without the intervention of the user.

If the failure is diagnosed as a hardware problem, such as a problem with a hard disk drive, Intel AMT can access the platforms' NVM, in which inventory information is stored, to determine the disk drive make, model, and warranty status. The technician can then check if this disk drive is available at a certain location and convey this information to the user; alternatively, the technician can arrange for this hard drive to be sent to the user's home or place of business.

Remotely healing home PCs using Intel AMT is significantly easier for users. Furthermore, AMT can provide faster time-to-repair with home PC users and decrease the cost of maintenance. Due to the difference in the network environment of an enterprise versus a home PC, a special usage model is needed in order for Intel AMT to remotely fix a home PC. We now discuss this usage model.

USAGE MODEL

In this usage model, the management service for the home PC is provided by the companies that offer maintenance services for the PCs. These may be the call centers of Original Equipment Manufacturers (OEMs). Also they can be independent companies that only provide maintenance services for PCs manufactured by different OEMs. In this paper, we use the term Management Service Provider (MSP).

The OOB remote management in Intel AMT is implemented as a Web service. The remote boot, redirection, and hardware inventory functions are supported over a Transmission Control Protocol (TCP), and the IT management service can access these functions through designated ports. For example, to access NVM the management service should connect to the port 16992 or 16993, and for Serial Over LAN (SOL), the management service should connect to the port 16994 or 16995. The AMT management console, running as the client that requests the AMT services, will initialize the connection.

There are, however, two issues that block the application of Intel AMT for home PC maintenance.

Firstly, the Network Address Translation (NAT, which is a method of connecting multiple computers to the Internet (or any other IP network) using one IP address) firewall deployed by the Internet Service Provider (ISP) blocks the above communication between a home PC and management services. Generally, the NAT firewall sits between the home PC and the management service, provided by the MSP, to protect the local network and translate the IP address. The home PC is configured to use the local IP address that is not visible outside of the NAT firewall, so the active connection from outside the Internet, the MSP service in this scenario, will be refused access to the PC by the NAT firewall.

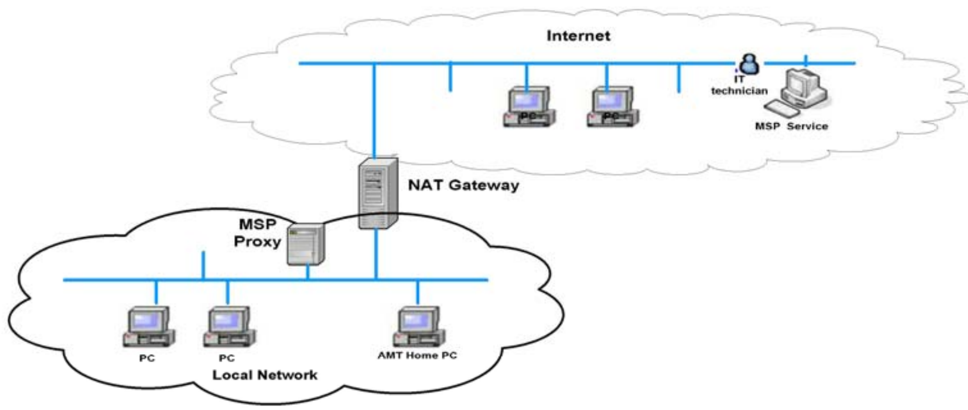

Figure 4: Intel® AMT usage model for home PC

Secondly, ISPs always require users to input the account name and password before allowing them to access the outside network. But when the OS is seriously corrupted by a virus or even when it has crashed, the user may not have a chance to input the account name and password. Therefore, the machine cannot access the outside network at all.

To adapt to this special environment of the home PC network, a new usage model of Intel AMT is proposed in this paper, which introduces an MSP proxy to bridge the home PC and MSP management console. The network deployment is shown in Figure 4. The MSP proxy sits behind the NAT firewall and is capable of performing direct communication with a group of home PCs from the same local network. Also, the proxy serves as a communication device for the MSP service that is located outside of the NAT firewall. The process of communication between the MSP proxy and the MSP service is as follows:

1) The active connection initiated by the MSP proxy is accepted by the NAT equipment.
2) Receiving the initial packet from the MSP proxy, the NAT will translate the local IP address and port of the proxy to the NAT equipment's address and port pair and record the mapping relationship for future use. Also the NAT will forward the packet to the MSP service.
3) After the MSP service receives the packet, it will record the proxy's IP address and port. Then the messages will be sent back from the MSP service to the proxy with this IP address and port.

After the connection between the MSP proxy and the MSP service is set up, all the control messages will be sent through the single TCP connection to penetrate the NAT firewall. The proxy provides interfaces (e.g., Simple Object Access Protocol (SOAP) [1] APIs) which can be invoked by the outside MSP services. Moreover, the MSP proxy can call the AMT services provided by the AMT device directly. In this way, the ISV proxy eliminates the necessity of introducing a separate NAT propagation module into the AMT platform.

The second issue mentioned above, that of home PC users not being able to authenticate the ISP to access the outside network can also be solved by introducing a proxy. The AMT device can obtain the IP address by using a Dynamic Host Configuration Protocol (DHCP) as long as the machine is connected to a power source and the network. Authentication is only required when the home PC needs to connect to the outside network. Since the proxy is deployed in the same local network as the home PC, the AMT device can visit the proxy directly without any authentication problem.

Therefore, the proxy can successfully remove the two barriers that block the use of Intel AMT to remotely manage home PCs.

Furthermore, in this usage model, the proxy does not store any client information, such as the home PC's local IP address and port; thus, it can be a very simple service that only provides a message transfer function. The detailed working process is described in Figure 5.

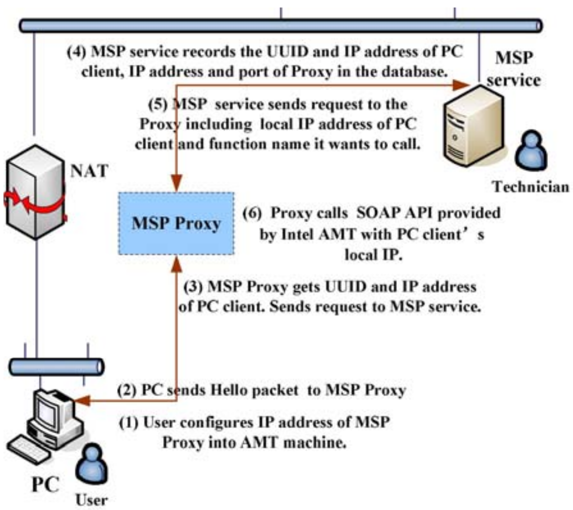

Figure 5: Working process

Working Process

These are the steps involved in this process.

1) The home PC user gets the IP address of the MSP proxy from the IT technician and configures it into the AMT device.

2) When the home PC is enabled to be connected remotely with Intel AMT, the PC client will send a Hello packet to the MSP proxy. The Hello packet contains the Universally Unique Identifier (UUID) of the PC client that is burned into the platform's NVM during manufacturing.

3) After receiving the Hello packet, the MSP proxy will send a request to the MSP service that contains the IP address and UUID of the PC client.

4) The MSP service can get the UUID from the request packet and record the UUID and IP address of the PC client and the IP address and port of the proxy in the database. The UUID will be used as the key to identify the PC client.

5) When the IT technician manages the AMT device remotely, the MSP service finds the corresponding PC client record to get its information as well as the address of the MSP proxy. Then the MSP service sends a request to the proxy that contains the local IP address of the PC client and the function name it wants to call.

6) After parsing the request from the MSP service, the proxy calls the corresponding SOAP API provided by Intel AMT with the PC client's local IP. The proxy also forwards the response from the AMT machine to inform the MSP service if the request is executed successfully.

In the above solution, the MSP proxy is deployed as a separate piece of equipment located in the same local network as the PC clients. There is another solution that deploys the proxy together with the gateway. In this solution, the proxy is installed on the gateway running as a service module. The process to set up a connection between the MSP service and the PC client is the same as the process for the first solution.

Both these solutions have advantages and disadvantages. In the second solution, the MSP does not have to deploy separate proxy machines for each local network. However, the MSP requires the support of the ISP. If the ISP supports the proxy, this solution can decrease the cost. Compared with the second solution, the benefit of the first solution is its flexibility, since it does not depend on the support of the ISP. Although deploying separate proxy machines for the home PC local network is costly, it is advantageous to implement it in hotels, Internet cafés, schools, and other small businesses. If a small business wants to outsource the maintenance of PCs to an MSP, it can buy a proxy device from the MSP and deploy it on its local network. The business is free to choose any MSP according to its preference without having to be concerned whether this MSP is supported by the ISP.

CHALLENGES

Security

When using Intel AMT to maintain home PCs remotely, there are some security issues that must be considered.

The first security problem is that home PC users should have full authority to control who is permitted access to their machine and when. To control when the home PC can be connected remotely, this usage model proposes a switch scheme. When the problem occurs on the computer, the user can enable Intel AMT to enable the machine to be connected remotely. After the problem is fixed, the user can disable the remote connection. With such a switch, the user controls the period of remote connection and limits the security risks.

To control who is allowed to access the AMT device, Intel AMT supports the HTTP Digest [2] and Kerberos [3] schemes for the purpose of authentication before allowing access to the system. In the enterprise environment, the Kerberos authentication is used to provide more secure mutual authentication as compared with the HTTP Digest scheme. To make the Kerberos scheme work, the Key Distribution Center (KDC) and domain controller are required to be deployed in the enterprise Intranet, and AMT devices must be configured with Kerberos options such as Service Principle Name (SPN), Service Key, and other data. Furthermore, clock synchronization is required for proper working of the Kerberos protocol. The Kerberos scheme is too complicated to be implemented and deployed for home PC maintenance. In the home PC maintenance scenario, such a powerful authentication scheme is not necessary, since the home PC is only controlled remotely by the MSP technician for a period of time.

Therefore, this usage model uses the HTTP Digest scheme to implement authentication. Intel AMT provides an admin account for the management of the AMT device. Users can configure the admin password. Only the individual who knows this password can access the computer. The process of HTTP Digest authentication in home PC maintenance is as follows:

1) The home PC user configures the password for the admin user account and tells the password to the MSP IT technician.

2) When the IT technician remotely connects to the AMT device through the HTTP protocol, he/she will be required to input the username and password for accessing the AMT device.

3) After inputting the password and username correctly, the IT technician can access the AMT device and manage it.

Another security problem is that the connection between the AMT device and the MSP service should be secure during the remote management period. To solve this problem, Intel AMT uses Transport Layer Security (TLS) [4, 5] to secure the communication over the network. The TLS protocol establishes a secure channel of communication between the client and server and provides authentication and message privacy services. In the AMT management usage scenario, the AMT management service on the PC client is running as a TLS server, while the remote IT management service is running as a TLS client. Moreover, AMT supports a server authentication scheme that enables a remote management service to check the certificate presented by the AMT device. To make TLS authentication work, the AMT device must apply for the certificate from a third-party Certificate Authentication (CA) and generate a <private, public> key pair. However, Intel AMT has no function to process these security operations. There is a provisioning service that applies the certificate, generates keys for the AMT device, and configures them into the AMT device through the Web interface. In the enterprise environment, it is feasible to provision every AMT device before it is deployed on the network. But in the home PC usage scenario this is too complicated to implement.

Therefore, this usage model uses a TLS-PSK (Pre-Shared Key) scheme to ensure the security of the transmission between home PCs and the MSP proxy, and the MSP can choose other more powerful security schemes to ensure a secure connection between the MSP service and proxy (this is not discussed in this paper). In Intel AMT, PSK is referred to as the Provisioning Pass-Phrase (PPS). We, therefore, use the term PPS instead of PSK in the following discussion.

Home PCs and MSP proxies share a symmetric key that is used to encrypt communication data. A PSK must be generated and configured into the AMT device before the remote maintenance process. The PPS should be unique to each home PC to ensure that even if one PPS is stolen, it won't work for other machines. Therefore, in this usage model, the PPS is generated by an algorithm using the password of the admin user account as the seed. This algorithm is then shared between the home PC and the MSP service.

The detailed process to set up a secure connection is as follows:

1) The home PC user configures the admin password and relays it to the IT technician via phone. A PPS is generated based on this password and is configured into the AMT machine.

2) The MSP service uses this password to generate the PPS and store it in the database.

3) The PPS will be included in every management message sent to the MSP proxy, so that the MSP proxy does not have to store the PPS for PC clients.

4) The MSP proxy can get this PPS and use it to encrypt communication with the home PC.

Easy to Use

As the above description indicates, there are some tasks that must be done by users to configure the AMT device, including configuring the admin password, the IP address, the TCP port of the MSP proxy, and the UUID of the AMT device. To make this process easy for a home PC user, this usage model provides users with a very friendly and simplified User Interface (UI) to complete these configurations. A sample UI is shown in Figure 6.

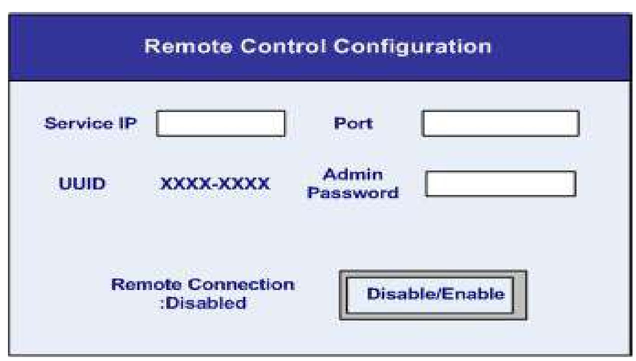

Figure 6: Sample UI

With this UI, the home PC user can easily complete the above steps by doing the following:

1) Reading the UUID of the AMT device.

2) Configuring the password of the admin user.

3) Configuring the IP and TCP port of the MSP proxy.

4) Disabling or enabling remote connection.

There are two means to implement the UI. One is to embed the UI into the BIOS. Using this method, the BIOS need to be modified, and OEMs are required to implement a simplified UI for configuring AMT in the BIOS. For example, the OEM can use the Intel® Platform Innovation Framework for Extensible Firmware Interface to develop BIOS that provide a simplified UI. However, this method is not flexible, since it depends on the OEM's support. Therefore, in this usage model, another method is presented. A simple application is built in a bootable OS image. MSPs are free to design the unique UI and choose their own encryption methods to generate the PPS.

Intel AMT provides a Host Embedded Controller Interface (HECI) for the local OS to set and change the AMT configuration (refer to Figure 7).

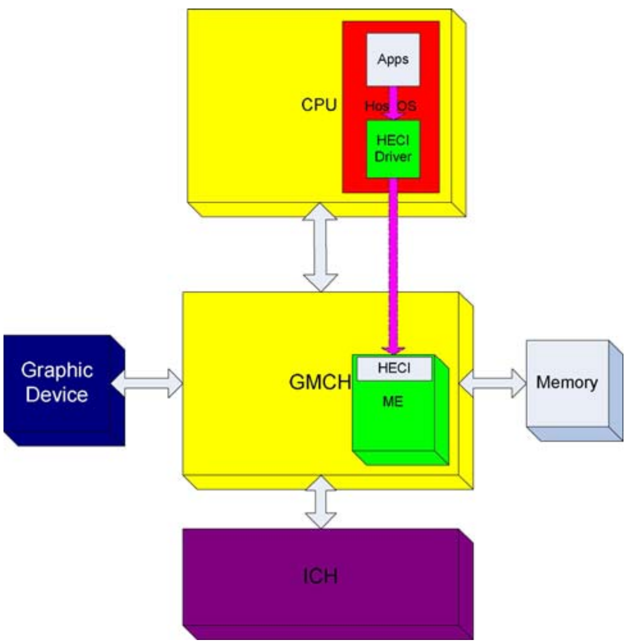

Figure 7: AMT HECI interface

In the AMT machine, the host OS sees the AMT device as a PCI device. The application can configure AMT settings through the HECI driver provided by Intel. In this usage model, the application program implements a user-friendly interface with the APIs provided by the HECI driver. This application program can be stored in a memory disk (maybe a USB bootable disk or a bootable Linux*/Windows* CD) that is provided together with the PC or is provided by MSPs. After the home PC user inserts this disk into the computer, the application program will be started automatically. This application will read the UUID of the AMT device and display it on the UI for the user to read. It will also allow the user to modify the admin password from the UI.

Protection of Personal Data

When establishing the secure connection between the management console and the home PC, security technologies, such as TLS and HTTP Digest are used. However, these technologies only ensure the security of data transfer and that the PC can only be accessed by the MSP. These technologies cannot keep users' personal data private. Home PC users may be concerned that the MSP attendant can access some of their personal data in their hard drive. This has the potential to cause breach of privacy issues and possibly lost or stolen data.

To avoid these risks, Intel® Virtualization Technology (VT) and LaGrande Technology (LT) can be adopted in the future. Intel VT supplies the capability to virtualize the I/O devices and memory. Before the Virtual Machine (VM), (the OSs will run on the VMs), is started, the Virtual Machine Monitor (VMM) will partition and virtualize the devices. The VM will only see the virtualized devices. Therefore we can design one piece of software for home users to enable Intel VT to partition the disk and hide the part that contains users' private data. When the MSP uses the SOL/Integrated Drive Electronics Redirection (IDER) and accesses the user's machine from a remote console, it will only be able to see the virtualized disk after the partition and will not be able to see private data.

Furthermore, Intel LT also can be used to protect users' private data. Users can use the sealed storage capability of Intel LT to encrypt their data. Intel LT provides the ability to encrypt and store keys, data, or other secrets within hardware on the platform. It does this in such a way that these private data can only be released (decrypted) to an executing environment that is the same as the environment in which these data were encrypted. Therefore, after users have encrypted all their personal data by using the sealed storage of Intel LT, even if the MSP technician could steal a user's private data, he/she could not decrypt that data.

A TYPICAL USE SCENARIO

In this section, we present a typical scenario for using this usage model to fix a home PC remotely.

With the popularity of the Internet, more and more people access it to download software, chat, and search for information. As a result viruses are common and prolific and they cause operating problems for home PC users. With the usage model proposed in this paper, the MSP technician is able to remotely fix viruses, and the only thing the user has to do is call the technician and complete several simple configurations under the guidance of the technician. Figure 8 describes the whole work flow of this usage model from the time the user calls the technician to the time the problem is fixed and the remote connection is disabled.

The PC user only needs to take the following actions to get his/her PC problem fixed:

1) Call the IT technician.
2) Enter the configuration UI under the guidance of the IT technician.
3) Configure the IP address and TCP port of the service. Configure the password for the admin user account.
4) Read the UUID in the configuration UI and convey this information to the IT technician.
5) Enable the remote connection of his/her machine and wait for the IT technician to fix the machine.
6) Disable the remote connection after the IT technician fixes the problem.

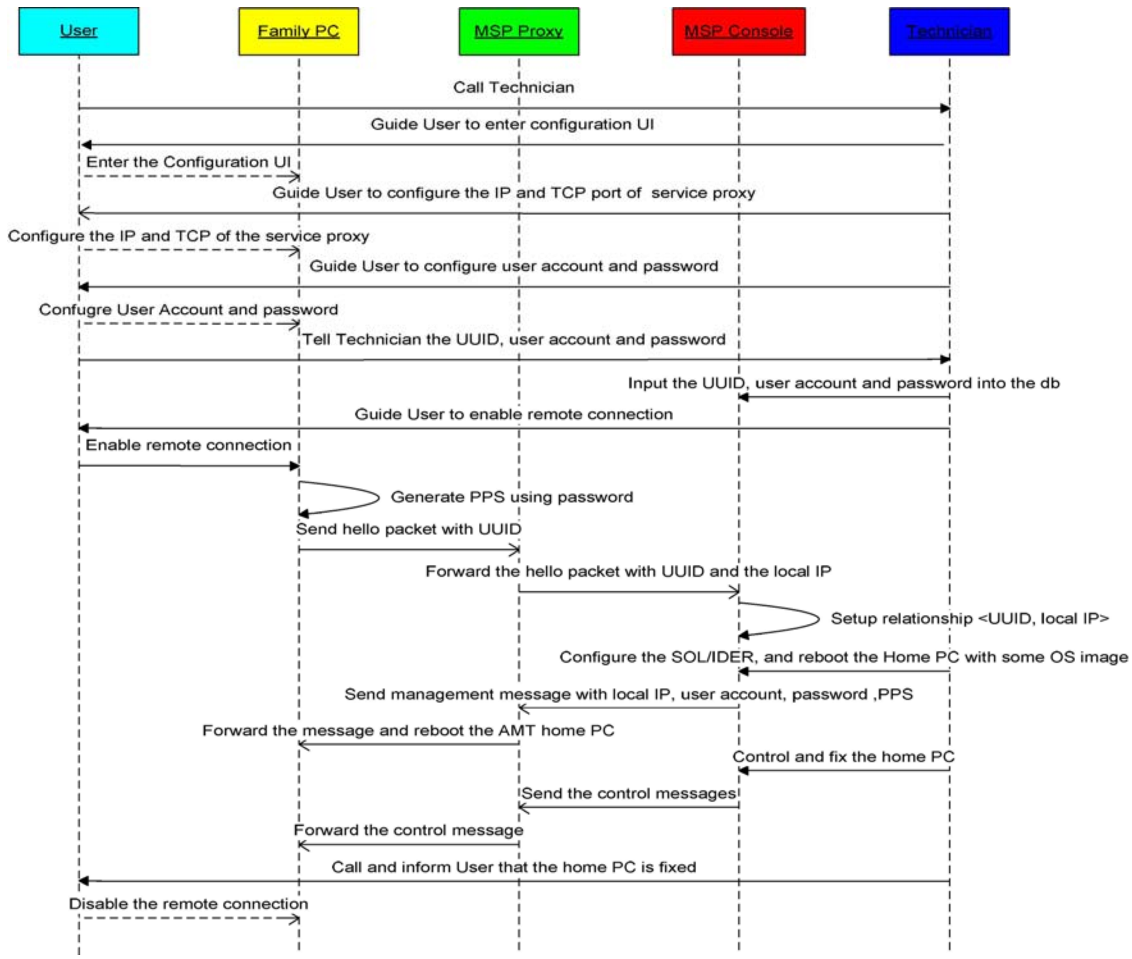

Figure 8: Workflow of a typical usage scenario

Not only does this usage model require minimal work on the part of the home PC user, but it also simplifies the process for IT technicians of fixing PC problems remotely. The IT technician only needs to complete the following steps to control and fix a PC after receiving a phone call from the home PC user:

1) Guide the home PC user to enter the configuration UI.

2) Tell the IP address and TCP Port of Proxy to the home PC user and guide him/her to start the configuration UI.

3) Get the UUID and admin password from the home PC user and enter them on the management console.

4) Check if the service receives the Hello packet from this PC on the management console. If so, access the home PC with the admin user account.

5) Configure the SOL/IDER setting of the home PC and boot the home PC through the local OS image.

6) Use the scan and antivirus software on the local OS image to repair the host OS on the disk of the home PC.

7) Close the connection and inform the home PC user that the problem is fixed (or not) and that the connection is closed.

SUMMARY

Intel AMT is a key Digital Office feature for IT departments in the enterprise. It can solve many of the top problems in current corporate IT management areas such as virus containment, asset management, client diagnostics, and health management. However, for the home PC user, there is not enough specialist support when problems arise. Intel AMT provides a general platform on which software companies can develop diverse applications to support any users working from home. By introducing this home PC maintenance usage model, the door is open to bring Intel advanced active management technology into each home. As for small- and medium-sized businesses such as hotels, cafés, and schools, they will also be able to benefit from this low-cost service from MSP, since these kinds of businesses use PCs in the same way as home users.

The Intel platform strategy is to continue to add valuable features to products by a timely capture of all kinds of PC users' needs. This home PC maintenance usage model will provide a new way to essentially help home and small business PC users solve daily hardware and software technical problems.

ACKNOWLEDGMENTS

Thanks to Brian He for providing technical support on Intel AMT. Thanks to Tony Chen for helping us organize the paper and modify its content. We also thank Jackie Wu and Rossey Liu for reviewing the paper and giving us many valuable suggestions.

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‡ Intel Active Management Technology: Intel® Active Management Technology (Intel® AMT) requires the platform to have an Intel® AMT-enabled chipset, network hardware and software. The platform must also be connected to a power source and an active LAN port.

Intel Virtualization Technology: Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

Technologies for Heart and Mind: New Directions in Embedded Assessment

Margaret E. Morris, Digital Health Group, Intel Corporation

ABSTRACT

Embedded assessment is a technology design strategy to drive preventive health care and early disease detection. This approach addresses barriers to early detection observed through ethnographic research. Health monitoring is integrated into everyday devices and then translated into personalized feedback that supports immediate wellness and long-term disease prevention. Three embedded assessment projects are described that involve close collaboration between the author (a clinical psychologist) and engineers in Intel's Digital Health Group. First is a mobile oximetry and feedback tool designed to facilitate safe exercise and thereby prevent escalation of heart failure. Second is a system of sensors and ambient displays to support social interaction and prevent cognitive impairment among older adults. Third is a mobile coaching system, responsive to physiological sensors, for people whose emotional reactivity poses risk for coronary artery disease. In these projects and ongoing work, granular biological and behavioral metrics are translated into psychologically meaningful feedback in order to motivate change.

INTRODUCTION

The vast majority of medical care remains focused on late stage illness, a bias that perpetuates the health care crisis in the U.S. and internationally. It is estimated that seventy-five percent of national health care costs in the U.S relate to the treatment of chronic diseases [1, 2]. Heart failure, for example, affects 5 million people and costs approximately $21 billion annually in the U.S. [3]. Although not classified as a chronic condition, Alzheimer's disease takes a similar toll: it now affects 4.5 million Americans, and is estimated to cost the U.S. $100 billion annually [4, 5]. To a large extent, the diseases that we treat almost exclusively in their late stages progress predictably, as do the costs of treatment. Symptoms that are difficult and costly to treat in late stages can be stabilized and sometimes reversed if addressed early. A growing body of literature suggests common vulnerabilities for heart failure, dementia, and a range of other diseases. These shared risk factors—negative affectivity, isolation, and weight gain—are ideal targets for preventive medicine.

Shifting more attention and resources to preventive care could certainly increase return on medical investment. But there are significant barriers: the close monitoring of risk factors required for preventive medicine is difficult for both clinicians and individuals. Clinicians lack sensitive tools to determine individual baselines of premorbid functioning and early signs of decline. Among individuals facing the prospect of a daunting disease, psychological dynamics such as denial and adaptive optimism delay acknowledgement of symptoms. People frequently overlook early signs and avoid clinical assessment, but at the same time eagerly adopt strategies to prevent future disease and compensate for their current limitations [6].

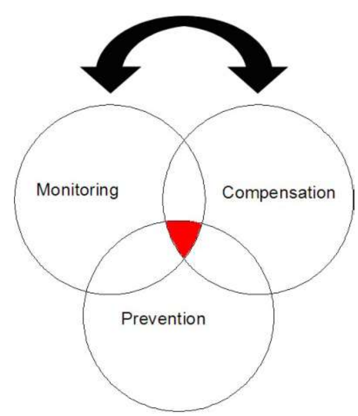


Figure 1: Embedded Assessment: Closing the loop

This approach links health monitoring with tailored feedback to help individuals compensate for current limitations and prevent disease.

Embedded assessment emerged as a design resolution to the conflict between the need for early detection and significant obstacles to health monitoring. In this approach, continuous assessment is integrated into an individual's routines and translated into supportive, tailored feedback. The feedback helps the person compensate for current limitations and prevent future disease. The closed loop between monitoring and compensation ensures that individuals receive the appropriate level of support. Conversely, trending of users' responses to graduated cues reveals variability in how much help is required at different times—data that can help with early detection. If embedded assessment technologies are adopted in midlife for performance optimization and disease prevention, they can identify individual baselines and early indicators of health decline (see Figures 1 and 2 and [6]).

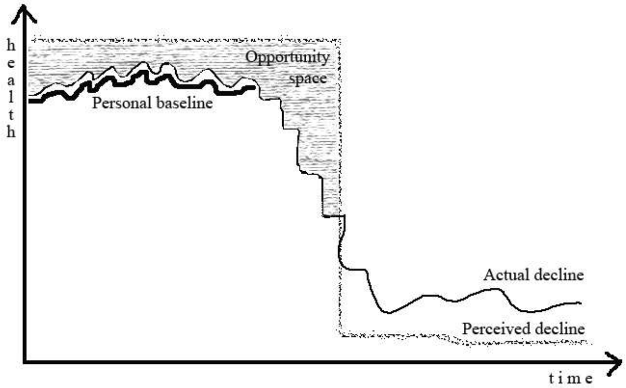


Figure 2: Opportunities for early detection

Diagnosis and treatment are delayed by limitations in clinical assessment and psychological dynamics such as denial. Embedded assessment determines personal baselines and early disease indicators.

In this paper I examine three means for embedded assessment to assist with management and prevention of disease. I review three research prototypes that vary in preventive reach (from acute symptom management to risk reduction far in advance of illness), the time intervals for monitoring, and the degree to which monitored data are translated into feedback. The first, a mobile oximetry device, is intended to reduce acute risks associated with exercise in heart-failure patients. It monitors cardiovascular exertion levels over short time intervals and reflects them in a relatively straightforward manner. The second, a social health platform for older adults, monitors and facilitates behaviors with preventive value over slightly longer intervals (from days to months versus minutes). The feedback is translated from a quantitative index of social interactions into metaphorical visualizations of interpersonal engagement. The last, a mobile feedback system for emotional self-regulation and preventive cardiology, is the most far reaching of these projects. It is intended to be used far in advance of disease onset, and it translates physiological data into psychological interventions.

PROJECT 1: MOBILE OXIMETRY

Motivation in Ethnography

This innovation was inspired by struggles of patients with heart failure. Heart failure is one of the leading causes of death in the U.S and is very costly and difficult to treat in its late stages. Life is seriously restricted for these patients, who must follow a strict plan of diet, exercise, and medications. Even small deviations, for example, in salt intake or exertion, can result in a sudden inability to breathe. Heart-failure patients are known to fill emergency rooms for this reason: these visits are frightening, extremely costly, and largely avoidable.

Ethnographic interviews with patients and clinicians revealed barriers to this critical regime of medication, diet, and exercise. Here I focus on the theme of maladaptive risk aversion as a barrier to exercise. This risk aversion involves a fear-driven collusion between clinicians and patients that contradicts explicit guidelines. Patients are formally advised to exercise, but informally discouraged from doing so. The implicit message they receive from clinicians, especially when a condition worsens, is to tread very carefully once outside the safety of the clinician's office. Patients commonly receive an "exercise prescription" for a physical rehabilitation clinic, but this setting is impractical and undesirable for most patients. As a result, patients frequently become tethered to their homes and restricted from the physical and social stimulation that is critical to their long-term health.

Fear of overexertion and other barriers to exercise among heart-failure patients are illustrated in the case examples below:

> A woman in her early 90s calculated that she can typically walk 50 steps. Her trip to get the mail is just within this range, and so she often hesitates to venture out: "I might not be able to make it back from the mailbox."
>
> A woman in her 50s dislikes gym exercise but enjoys catering for her church. This volunteer work is physically, socially, and spiritually invigorating. But after helping out with the last church dinner she ended up in the emergency room. Over the years, she's had many frightening hospital visits. She wants to feel productive and remain engaged with her community, but doesn't know how to avoid over-extending herself.
>
> I overhear a nurse encourage her patient, a 38-year-old woman who moved to the U.S. from Jamaica, to enroll in the hospital's physical rehabilitation clinic, "It's there for you … and it's free... why don't you try it?" The patient responds that she didn't know about the clinic; according to the nurse they've had this conversation several times. Later, the patient tells me, "I'd like to dance or do yoga… not be wired up to a treadmill. … And that clinic is really far – a $40 taxi ride from here."

These patients want supportive reassurance for their exercise and other activities, in the context of their daily environments. They need to know, at the moment of activity, whether or not they are within safe parameters of exertion. Over longer time periods, they need motivational coaching to illustrate progress towards long-term goals. Patients expressed helplessness about exercising and losing weight, even if refusal to do so eliminated chances of a heart transplant or significantly worsened prognosis in a more general way. These observations inspired the prototype below which provides immediate feedback to help people modulate exertion; and a longitudinal view to reinforce progress towards health goals. The mobile wireless form factor allows people to move free of wires, in places that are convenient.

Figure 3: Oximeter earpiece and mobile feedback

Continuous, untethered monitoring, coupled with mobile feedback helps cardiovascular patients modulate exertion and benefit from exercise.

The Research Prototype

The prototype (shown in Figure 3) allows continuous, untethered monitoring of cardiovascular exertion and real-time feedback on a mobile device. Oximetry, a measure of blood oxygenation, is unplugged from a normally cumbersome system and embedded into the wireless earpiece. These data are plotted against accelerometry data to indicate the relationship between activity and cardiovascular distress. The screen displays a short-term view of current exertion levels and a longitudinal view to reinforce the patient's progress towards exercising and fitness goals.

Components of Embedded Assessment

Monitoring. Oximetry and accelerometry are embedded into a wireless earpiece of a mobile phone to allow for continuously monitoring of cardiovascular stress and trending of exertion relative to activity levels.

Compensation. The phone displays real-time feedback to help the patient monitor cardiovascular stress. The feedback compensates for an impaired regulatory system. The snapshot view is most useful for modulating exertion (e.g., resting); the longitudinal view visualizes progress towards fitness goals that might not be immediately apparent, and thereby motivates continued exercise.

Prevention. This system is intended to prevent the progression of heart failure and other forms of cardiovascular illness by helping patients to stay safely physically active. Real-time alerts about over-exertion may reduce dangerous incidents.

Future development will concentrate on the feedback displays for this system. One challenge is to encourage self-awareness of both exertion and positive feelings from increased exercise. The feedback should foster, not replace, autonomous motivation and self-regulation. Other critical questions concern the representation of cardiovascular health in ways that are psychologically compelling and culturally resonant.

PROJECT 2: SOLAR DISPLAYS FOR SOCIAL HEALTH

Motivation in Ethnography and Previous Research

Social engagement has profound health benefits, protecting against illnesses from the common cold to dementia [7, 8]. Our ethnographic inquiry highlighted barriers to social engagement in later life [10]. With retirement, many people lose opportunities for spontaneous contact as well as visibility of others' availability. Concerned about imposing on others or being rejected, many drift into isolation. These situational shifts, along with cognitive changes, such as difficulty recalling names or following rapid conversation, make many feel helpless about loneliness. As one formerly very social man put it "loneliness is a part of old age and there ain't a damn thing you can do about it."

We also noted significant variability in the way older adults described their experiences of loneliness. Current measures and interventions underestimate this variability and rely on characterological rather than situational explanations for differences in social engagement. But our interviews suggest that, like blood pressure or glucose levels, loneliness varies by the moment and therefore requires adaptive solutions.

These themes of helplessness and variability are illustrated in examples below:

> After the death of her husband, an 82-year-old woman moved across country to be near her daughter. She left behind a network of friends. She is socially gracious and very charming but uncomfortable initiating contact. She loves seeing family, especially her grandchildren, but feared imposing. A history of depression makes isolation a particularly serious risk.
>
> A 77-year-old divorced woman enjoys casual interaction with neighbors, choir practice, and creative writing during the week but dreads the

> weekends: "I just wish I could make them disappear." She retained an expectation that weekends should be spent with family and suffered chronic disappointment because her children were typically unavailable on weekends.
>
> An extremely bright and extroverted 91-year-old woman relocated to live near her son following an injury. She now struggles with quiet evenings in a retirement community. She fills her days with group activities and enjoys the weekends she spends with her son's family, but complained that, in the evenings "It's like a morgue around here."

Psychological research has demonstrated the benefits of mindfulness, or awareness of change. When people recognize fluctuations in negative circumstances, particularly their own ability to bring about positive change, they feel less helpless [9]. In this research, we tried to foster elders' social self-efficacy and empowerment by highlighting the dynamic qualities of social interaction.

The Research Prototype

We developed a platform of sensors and feedback displays to measure and encourage social engagement, for the prevention of cognitive decline. In the primary feedback display (Figure 4), friends and family rotate around the elder—planets which can be pulled in by a phone call or visit. This use of social networks as health feedback displays is described in [10].

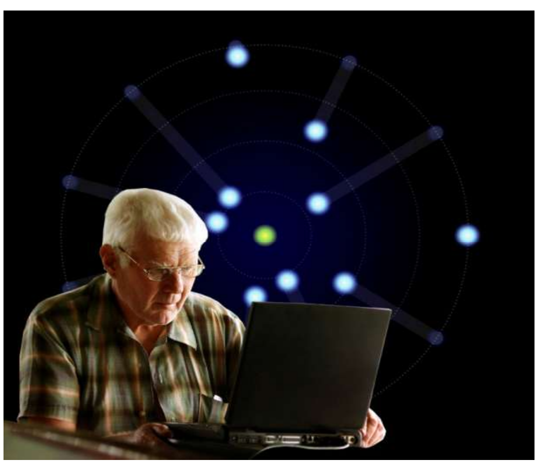


Figure 4: Solar display of social activity

The elder, depicted as the sun in the center of the display, is surrounded by planetary representations of friends and family. Social interaction, measured by sensors, draws planets closer to the center.

The Components of Embedded Assessment

Monitoring. A sensor network and online journal allowed continuous measurement of phone activity and other social interaction over several months. We first determined a baseline of social interaction (by monitoring only) and then measured changes in social interaction associated with the introduction of feedback displays.

Compensation. To encourage and reinforce social efforts, the displays provided real-time feedback of interactions with friends and family. It was important that the displays be intuitive and nonstigmatizing. They included the solar view shown in Figure 4, longitudinal graphs, visual cues of callers' names and faces, and a lamp that signaled the availability of a family member. Feedback was intended to help people compensate for isolated lifestyles and for cognitive changes in recall and processing of social information.

Prevention. This system was intended to protect against onset and progression of cognitive decline, by motivating social outreach and mitigating feelings of loneliness.

Responses to Solar Displays

A three-month-long in-home pilot study indicated that the feedback displays were valued by elders and their caregivers (see [10] for fuller description). We observed subtle and overt increases in social engagement. These behavioral changes not only improved the quality of life for elders and families, but they also set in motion a style of interacting that may protect against a range of illnesses in later life.

Revisiting case examples above:

> The 82-year-old woman who didn't want to burden her family started initiating plans, especially with her grandchildren. She also began volunteering as a teacher's aid for first-grade students. This activity was very gratifying for her, in part because of the positive impact she had on others. Her daughter exclaimed, "The kids love her … she's in the yearbook and they've asked her to continue helping the same class next year."
>
> The 77-year-old woman who dreaded the weekends became more involved with friends. For example, she started seeing some members of her choir group outside formal practice sessions. These outings and those with other friends shifted her attention away from the unavailability of her children.
>
> The 91-year-old woman who spends weekends with her son remains very close with her family. But she also started reaching out to peers in the retirement community with a new level of interest. She even invited some neighbors into her apartment.

Observations from this study have implications for the model of embedded assessment. First, the feedback displays raised participants' enthusiasm for monitoring technologies that they initially experienced as intrusive and burdensome. Their enjoyment of the displays appeared to generalize to the monitoring: several participants even started to speak of the online journaling as a hobby. This observation provides support for the premise in embedded assessment that feedback will motivate monitoring. Second, elders and caregivers recognized opportunities in the feedback displays to catch early trends of isolation. This eagerness to catch early indicators, central to embedded assessment, most likely occurred because the visual displays invited people to objectively examine and discuss topics that were previously avoided or overlooked. Finally, we observed that the adult children who participated in the study as caregivers used the displays as an opportunity to reflect upon their own lives and set priorities pertaining to their health, professional pursuits, hobbies, and relationships. This finding supports the idea that embedded assessment technologies should be adopted in midlife to support early detection: tools used to help an elderly parent can simultaneously offer services to help a caregiver manage his or her own life. Baseline data can be gathered from implicit variables, such as the caregiver's typing speed or voice quality, as well as explicit entries in care-giving and self-health applications.

PROJECT 3: MOBILE HEART HEALTH

Motivation in Ethnography and Previous Research

This project is grounded in preventive cardiology and ethnographic research on interpersonal conflict. Cardiovascular health is increasingly understood as the accumulation of behaviors, perceptions, and emotional reactions throughout life. This lifestyle view is reflected in etiological metaphors for cardiovascular disease; even the explanation of heart failure is shifting from the dichotomous model of a "broken pump" to the process of "progressive remodeling." Cardiovascular disease progression is influenced by an array of stressors, including hostility or proneness to interpersonal conflict (reviewed in [11]). The cumulative stress of repeated interpersonal conflicts, like the damage incurred by insufficient sleep, poor nutrition, and inactivity, leads to a prolonged deregulation of the autonomic nervous system and what is termed "allostatic load" [12].

Psychological interventions can help people modulate interpersonal stress and its consequences. Cognitive behavioral therapy can have dramatic effects by training people in "emotional regulation" or what mindfulness practitioners call "catching the flicker before the flame." Patients learn to critically evaluate the automatic thoughts and maladaptive interpretations that generate negative emotions and reactions. To address a highly conflictual style, this therapy emphasizes the tendency to perceive irritating situations as intolerable and unjust. Through self-awareness, patients learn to modulate their emotional and physical reactions to stress. The therapy also emphasizes alignment of behaviors with goals, assertive problem solving, and relaxation exercises [13].

The biggest limitations in behavioral medicine and psychotherapy are scalability: few people have access to good mental health care. The continued stigma associated with psychotherapy adds another barrier to those who could benefit. Furthermore, interventions are generally not available in the moments of greatest need. Therapy appointments are scheduled, stressful interactions are not.

Ethnographic interviews illuminated contexts for interpersonal stress, physical symptoms associated with conflict, and personally tailored coping strategies. Below are several examples that inspired concept development.

> Irritated by loud fellow travelers on the subway, a woman sheltered herself with mobile tools "I shifted my iPod* to something more soothing, opened my book and locked myself in a little cocoon."

> "Sometimes I'll lock myself in the bathroom (just to take a breath)… my kids are pounding on the door." This self-described "married single mom" sets her phone display to read "calm now." (Figure 5).

Figure 5: A woman reprograms her mobile phone display "I look at it, I breathe and I get calm."

> A man invents reasons to leave irritating work meetings, "I'll say I have to go get something at my desk…just to get out of a meeting for a bit... sometimes I half convince myself that this is true… it's a really internalized strategy I've developed to step away."

As an ethnographer and a clinician, I was impressed by the immediate effectiveness of these strategies. In contrast to common therapeutic techniques, they are highly contextualized, personalized, and almost instantaneous. They point to exciting opportunities for mobile therapies to enhance and expedite clinical medicine.

The Research Prototype

Continuous monitoring of stress is coupled with timely mobile feedback (see Figure 6). Mobile interventions are prompted by cardiovascular, contextual, and subjective stress indicators. The interventions are inspired by cognitive behavioral therapy and mindfulness practices and they are translated to mobile interfaces. The intent is to provide support, when and where it is most needed, to help alleviate emotional distress and limit cumulative risk of cardiovascular disease.

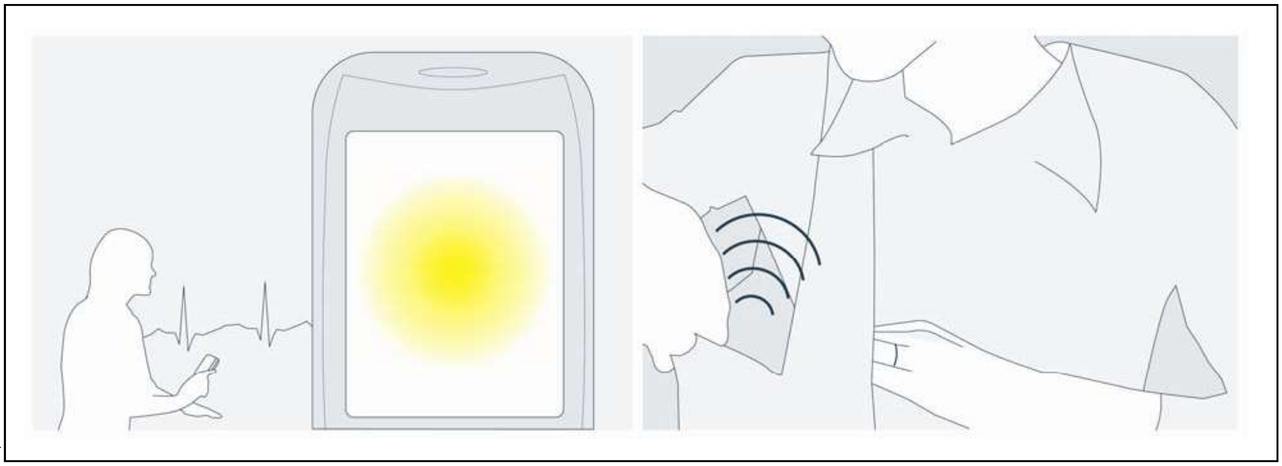


Figure 6: Mobile heart health

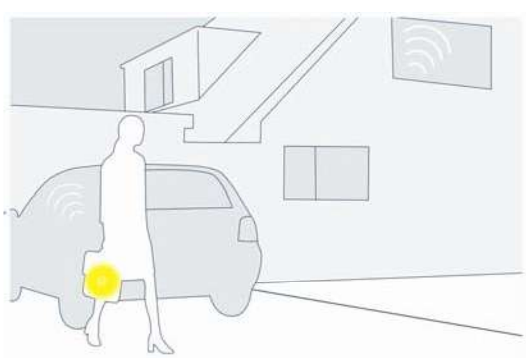
Mobile therapy is triggered by physiological, contextual and self-reported stress indicators. This woman's phone provides an "exit strategy"–a call away from a conflict–after detection of cardiovascular stress. The goal is to improve emotional regulation and reduce the risk of cardiovascular disease.

Components of Embedded Assessment

Monitoring. Wireless monitoring of physiological, contextual, and self-reported stress occurs via worn and environmental sensors and phone applications. Physiological sensing occurs via a chest-worn sensor that tracks heart rate characteristics, temperature, and movement. Contextual indicators are measured with location beacons and a calendar system. Self monitoring occurs via a touch-screen translation of a mood questionnaire [14], and a "panic button."

Below Figures: In addition to physiological sensors, location beacons, "mood mapping," and a "panic button" also monitor stress indicators.

7b: Mood Mapping allows touch-screen indication of emotional valence and intensity



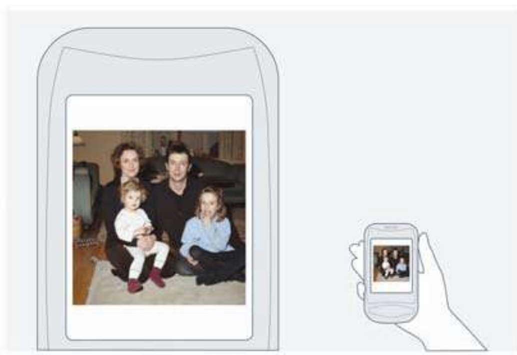
7a: Bluetooth* and iMote* detect stressful transitions between home and work, and prompt contextually appropriate therapies

7c. Pressing the "panic button" expresses fiery rage and initiates the "exit strategy" intervention

Compensation. Feedback based on cognitive therapy protocols [13] to encourage reinterpretation of negative thoughts, physiological relaxation and behavioral change is triggered by the stress indicators above. The feedback is adapted to the mobile form factor and personalized. Examples include animated breathing exercises, provocative questions, music and imagery.

Below Figures: References to cognitive therapy [13].

8a. Breathing exercises offer guided relaxation



8b. Positive images are beamed before stressful encounters to inoculate against conflict

8c. Invitation to reappraise automatic thoughts

Prevention. This system is intended to reduce the risk of cardiovascular disease by improving emotional regulation and limiting the cumulative toll of interpersonal stress.

The mobile heart health system illustrates some of the value propositions and capabilities of embedded assessment that could inform future products. In upcoming field studies, we will examine how people relate to this feedback system over time, how they integrate it with their other healing and communication practices, and most importantly, how it affects their emotional and physical health.

CONCLUSION

Embedded assessment offers a basic strategy for addressing a broad range of health issues, across stages of illness and at different points in the lifespan. The prototypes shared in this paper illustrate key capabilities of this approach: continuous sensing of objective and subjective health indicators, intuitive feedback offered when and where it is most needed, and facilitation of activities with preventive value. Future products using this approach will most likely include a more comprehensive set of sensing and feedback applications to address a range of health concerns. For example, the cardiovascular sensing and mood reporting in mobile heart health project would be logically combined with the interpersonal measures from the social health platform. The addition of other noninvasive measures (e.g., of glucose and hormonal levels) would allow such systems to adapt to the changing health needs that individuals experience at different points in their lives.

Significant design advances are necessary to develop compelling products from the exploratory prototypes discussed in this paper. Hardware configurations must of course extend from the standalone PC to a range of mobile and wearable interfaces. These systems will require more sensitivity to both geographic and social contexts. Computing-intensive solutions will be required to interpret continuous streams of behavioral and biological data gathered by peripherals.

Perhaps even greater challenges lie in interaction design. We need to display health information in ways that mirror the mental schemas that people use to make sense of health concerns and the rest of their lives. That is, they need to reflect not isolated biological metrics but complex interplays of emotion, cognition, social interaction, and physiology. In addition, far more intuitive interfaces are required for collecting and reflecting health data. Input modalities, ranging from passive physiological sensing to gesturing, will depend on individual preference and contexts. Similar differences apply for feedback: a succinct text message might be ideal in some situations, but in others, musical feedback or a physical nudge will be more effective. Research is needed to develop these basic interaction modalities and to determine their adaptation to individuals, context, and moment-to-moment variability in health status. Advances in data visualization and interaction design will increase the odds that technologies will stick. Ultimately, we want to develop objects that people not only use, but love – ones that invite close attachment as individuals initiate and maintain the often difficult changes required to improve their health.

ACKNOWLEDGMENTS

The projects described in this paper involved extensive collaboration with Intel colleagues. Special appreciation is owed to designers Stefanie Danhope-Smith, Jason Cassezza and Daria Loi; to social scientists Jay Lundell, and Eric Dishman; and to engineers Farzin Guilak, Terry Dishongh, Brad Needham, Bill Deleeuw, Michael Labhard, Mick Flannigan, and JM Vanthong. Thoughtful reviews were provided by John Sherry, Gina Grumke, Sue Faulkner, and Alex Zafiroglu. In addition, I thank collaborators Richard Sloan and Ethan Gorenstein of Columbia University and Larry Jamner from the University of California at Irvine. The research was supported by the Health Research and Innovation division of Intel's Digital Health Group.

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Assessing the Quality of User Experience

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Index words: user experience assessment, UX, platform quality, consumer experience, perceptual quality

ABSTRACT

User Experience (UX) has become an increasingly important consideration in the design of technology. As part of a corporate wide strategic initiative focusing on creation of platforms, Intel has been steadily shifting toward a more holistic and user-centered approach to the design and development of technology. In essence, Intel's platform approach is about integration of technology ingredients, infrastructure, and service or content to ensure the creation of new end-user value [1].

The capability to deliver end-user value propositions requires the ability to set goals and measure the quality of end-user experience during the development process. Since perceived user experience and end-user value is psychological in nature, behavioral sciences researchers at Intel have made substantial inroads toward driving the creation and measurement of platform user experiences.

In this paper we describe the rationale behind setting User Experience Quality (UXQ) goals and measuring against these goals using experimental psychology, experience research, and human factors techniques. The assessment described here goes beyond traditional out-of-box or usability testing methodologies and toward a broader conception of user experience as is emerging in professional practice. Setting UXQ goals explicitly targets aspects of UX beyond usability that may be emotional, attitudinal, behavioral, and perceptual. Assessment of UX requires measurement at milestones placed throughout the development lifecycle and may be targeted at specific points of use or "moments of truth" in the users experience. In turn, the data about how the UXQ changes over time and compares to other products allows organizations to better target and control the quality of the UX.

Working definitions are proposed and three diverse examples of UXQ assessment methodologies are described: 1) a competitive benchmarking study, 2) a perceptual quality study, and 3) an in-home contextual study. Although these are only a few examples of user experience assessment methodologies used at Intel, the examples illustrate the diversity of the UXQ assessment approach. Implications of developing a user experience assessment capability beyond traditional usability testing are discussed.

Note: Intel works with other companies in delivering platform solutions. To maintain the confidentially of specific product data, the data in this paper have been modified and are deliberately not linked to specific Intel or partner products.

INTRODUCTION

As a semiconductor manufacturer, Intel's competitive edge has been based on technology design leadership combined with industry-leading manufacturing technology. Both the rapid evolution of technology and delivering high-quality products in large volumes are among Intel's primary strengths. Recently, the strategy for staying ahead of the competition has been evolving to become more closely tied to the creation of noticeable end-user value. Our traditional technology optimization goals of rapidly improving performance and power are necessary but not sufficient in the context of competitive pressures. A user-centered approach allows new growth opportunities through creation of platforms that support new consumer usages and ensure noticeable differences in the quality of User Experience (UX) for Intel® platforms. In this way, establishing platform credibility has extended beyond technology-based development processes to include planning and assessment of the UX itself.

The platform approach recognizes the importance of the end-user experience resulting from the combination of hardware, software, and services. These elements are often inextricable from a UX perspective and work in concert to enable end-user value propositions. For this reason, the platform approach emphasizes holistic solutions in Intel's product line planning strategies. These solutions involve hardware and software development, ecosystem enabling, and influencing industry standards.

Explicitly targeting UX and associated end-user value propositions requires a holistic understanding of how people interact with technology. This has presented new challenges and opportunities in setting User Experience Quality (UXQ) goals and ensuring proper validation against these goals.

Across the technology industry, assessing and improving the UX of products has become an increasingly sought-after objective. This is reflected in a greater number of conference topics on UX, and to a lesser extent, an increasing number of books and journal articles [2, 3] over the past ten years. This increase in attention reflects the fact that consumers have now come to expect products to be easy to use. As ease-of-use becomes more and more of a basic expectation, it is becoming more important for companies to differentiate on other aspects of UX [4].

Despite good intentions, there are often many barriers to designing and delivering good user experiences [5, 6]. Reasons include lack of understanding of users, poor usage model definitions, too many constraints on the technology, and inconsistency and/or inability to integrate the technology with other parts of the ecosystem. One of the overarching issues is a lack of a top-down approach to UX and an inability to systematically measure and communicate UX. Although UX is increasingly valued as an outcome tied to business objectives, in the past, it has often been thought of by decision makers as intangible or immeasurable. Traditional human factors engineering approaches have tended to focus on task-based efficiency and effectiveness at the moment of use [3] rather than emotional, attitudinal, and perceptual aspects; and across the stages of the usage lifecycle (including the "moments of truth" before, during, and after initial use of the product).

Over the past decade, a wider approach to UX has been taking hold in the fields of psychology, Human Computer Interaction (HCI), and the human factors disciplines [3, 4, 7]. As technology develops to the point where PCs have become more usable, people increasingly seek to satisfy higher-level needs including emotional needs. Recent examples highlighting the importance of emotion and attitudes in product design include *Emotional Design* [8], *Designing Pleasurable Products* [4], and *Funology: From Usability to Enjoyment* [9]. The trend in the literature toward recognizing the importance of a wider conception of UX reflects progress that has been made within private industry. Although these trends create new opportunities to educate and motivate stakeholders, there is still a need to better define these concepts and to explicitly distinguish them from related concepts and metrologies.

DEFINING TERMS

Although the term "user experience" (UX) has been used extensively in recent years, it has been associated with a wide range of meanings [10]. Commonly, however, the definition of UX goes beyond the traditional instrumental conception of usability common in the HCI literature [2, 3]. Unlike usability, UX tends to include wider human experience dimensions (such as pleasure, fun, and other emotions) and also may have a temporal or longitudinal component. While usability tends to be focused on task efficiency and effectiveness measures, UX includes emotional and perceptual components across time. UX involves a constant feedback loop repeated throughout the usage lifecycle including from initial discovery through purchase, out-of-box, usage, maintenance, upgrades, and disposal.

At a minimum, there are at least four components of UX. The components and a simplified relationship between these components are shown in Figure 1. The UX consists of perceptions that shape emotions, thoughts, and attitudes. The UX directly influences behavior that then continues the loop.

Components of UX

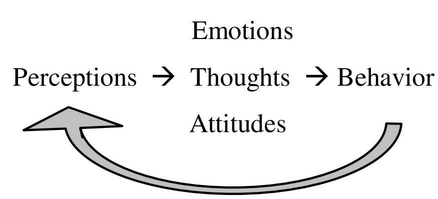

Figure 1: Components of User Experience

The following definitions are based on a literature review within psychology and HCI and have been developed to be relevant across different perspectives. The goal is to provide distinctions between key terms associated with UX. These distinctions are also relevant to potential UX goal setting and measurement.

User Experience (UX): Emotions, attitudes, thoughts, and perceptions felt by users across the usage lifecycle.

User Experience Quality (UXQ): (1) degree to which a system meets the target user's tacit and explicit expectations for experience or (2) the measured level of quality of a particular UX when compared to a specific target, using a specified metric and method or tool.

Perceptions: The process of acquiring and interpreting sensory information. Focus is on the intake of information. Psycho-visual and psycho-acoustics studies assess human perceptual variables that can provide data to drive requirements and assess human perceptual aspects of interaction with technology such as video quality, audio quality, acoustical, and thermal performance.

Emotions: Subjective states of consciousness that evoke positive or negative feelings. Emotions, both positive and negative, are critical to learning, trust, and assessment of what's desirable [7, 8, 11]. These, in turn, affect purchasing behavior, how much the technology is used, and what consumers say about their experiences. Despite the widely held impression that people make decisions logically, in fact, research shows that decisions are highly dependent on the emotional states of end users [12, 13].

Attitudes: Judgments about a target, usually expressed as good or bad, helpful or harmful. Attitudes are a function of experience or anticipated experience with the target and include value judgments.

Thoughts: Mental and cognitive processes that allow humans to model what they experience and plan behavior.

Behaviors: Observable overt movement that includes verbal behavior as well as physical. Actions in response to our environment or experience.

Measurement of UX can be explicitly targeted to measure certain aspects of these constructs depending upon the product goals.

UXQ GOALS: SETTING MINIMUM REQUIREMENTS

Setting measurable UXQ goals is particularly relevant in companies undergoing transitions toward establishing user-centered processes. It increases emphasis and visibility of the key usage model being developed and sets targets for high-level UX outcomes to facilitate user-centered processes and accountability. UXQ goal-setting complements and may come well before detailed usability requirements and use-case development. The purpose of UXQ goal-setting is to set the level of UXQ that the final product should deliver with respect to perceptions, emotions, and thoughts, as well as attitudes that the product should elicit from the target market segments. These convey to stakeholders in management and the development process clear targets regarding how good the product must be.

We describe three broad steps in setting UXQ goals. Here is a brief outline. The first step in setting UXQ goals involves identification and prioritization of the relevant UX dimensions. For the purposes of this paper, it is assumed that market research and needs-finding processes (such as market segmentation, ethnographic research, and usage model definition) have already defined the nature of the product opportunity [14]. The first step in setting UXQ goals then is to rank order the high-level key features and usages that have already been defined. Particular attention should be given to the features and usages that are end-user noticeable, will be included in the marketing messaging, and differentiate the system from others that will be on the market. In addition, any usages involving perceptual quality (such as acoustics, video, or audio quality) can be called out as relevant according to the end-user value propositions being targeted.

The second step is targeting specific, measurable UX dimensions for each of the key usages and features. This involves assessing what emotions, attitudes, perceptions, and thoughts are being targeted for the planned end-user value propositions. Selecting the proper dimensions to target and how to best measure them is where a background in psychology and psychometrics is essential. The measures selected should be based on branding/marketing strategies as well as practical and experimental design considerations.

The third step is working with the UX owners to assign specific cutoffs for each of the key features with respect to the variables being measured. To do this, competitive analysis benchmarking data or prior baseline data can be used. If no prior UX data are available, then judgment based on experience with similar types of systems can be used to start with. The main objective is to set explicit goals for UXQ well in advance of product development so that these goals can serve as clear targets and bring appropriate attention to the UX throughout the development cycle. By highlighting what should be the UX outcomes to development teams and the accountable stakeholders, strategies and resources can be channeled to ensure user-centered design processes are prioritized appropriately with other business demands.

After goals have been set, measurements to assess the state of the UX can be planned for explicit milestones in the program. At these milestones, decision makers can now better weigh tradeoffs that may affect both the UX and other business outcomes.

Common questions that UXQ assessment can help answer include: How good is the UX for the target market? What levels of perceptual qualities will consumers notice and value? How does the end-user value proposition change when ecosystem partnerships or key functionality changes? How will the product be perceived if key features are implemented differently, delayed, or eliminated altogether? How do we know if a system is good enough to be released? These types of questions can be answered with UXQ studies.

UXQ Assessment Within Industry

Leading companies that consider UX to be a core part of their business have been using UXQ measures as checkpoints and quality gates in their development processes. Based on a series of informal benchmarking interviews, companies including IBM, Microsoft, British Telecom, Google, and Yahoo use some form of UXQ assessment data as part of ongoing assessments and go/no go decisions regarding product releases. These and other companies, including Philips, Ford Motor, and Proctor & Gamble have indicated that they routinely assess the UX of products during the development process. The methods used for assessing UX in these companies tend to be part of a larger user-centered innovation effort.

Integration into Organizational Processes

UXQ assessment can be geared to provide critical data about whether key aspects of the planned end-user value are being achieved. Since the complete UX is not typically under the exclusive control of any one project team (or even a single company), UXQ assessment provides a means to see, from the end-user perspective, how the value propositions are manifesting themselves in realistic usage scenarios.

When aggregated across targeted user segments, UXQ data indicate the extent to which the quality goals are being met. Results intersect at multiple points in the product lifecycle. Results can be quantifiable, such as in a classic summary dashboard format, or focus on richer description and story-photo-based reports. As such, study results can be tailored for executive reviews and become part of existing or new feedback processes that help UX stakeholders make good decisions affecting the UX. This type of information is particularly useful when tuning product requirements, refining marketing messages, negotiating with the ecosystem co-travelers, addressing existing issues, and helping to drive innovation for future systems.

The following sections describe three examples of UXQ studies illustrating some of the many distinct methodologies used in these assessments. Each was applied in assessing aspects of a digital home platform. The studies are real but the data shown are examples only and are not the actual data from the studies conducted to protect the proprietary interests of the parties involved.

Example 1: UXQ Benchmark Dashboard Study

A competitive benchmarking study was run to assess how the UXQ of a platform, based on Intel® technology, compared to similar usages on competitive platforms. This study was conducted during platform development to assess the current state of UX and set goals for the next version of the platform. Since a number of formative usability studies were conducted at earlier stages of planning and development, micro-level usability issues were known and not the focus of this study. This UX study was designed to answer the following research questions:

1) What delighted and frustrated consumers about the UX of the Intel platform?
2) How did the Intel platform compare to a prior version of the platform?
3) How did the Intel platform compare against non-Intel platform solutions?
4) To what extent did the Intel platform meet predefined UXQ goals?
5) How could product messaging be refined to reflect the actual UX?

There were 32 participants in this study carefully selected based on target market segments and additional demographic selection criteria. Each participant received $200 in exchange for about four hours of their time.

The study setting was a furnished apartment located in downtown Portland, Oregon. The apartment was divided into two similar sections with each section containing different platform solutions. The platform solutions each involved components that would be found in the den (PC, modem, wireless router) and living room (digital media, adapter, and a TV). On one side, a platform based on Intel technology was placed in boxes ready to be set up in the den and living room. On the other side was a similar configuration but with competitive solutions.

Before arrival, participants were randomly assigned an order in which they would be exposed to the platforms (Intel vs. competitor). Each condition started with participants learning about the technology according to the platform messaging provided by marketing. Participants were not aware that Intel was involved in the study until the debriefing at the end. As they learned about the platform value propositions through the marketing messaging, positive and negative comments showing participants reactions to the messaging were collected. Participants were encouraged to discuss their initial reactions to the purpose and value of the technology.

Next, participants were asked to set up and use the technology as they would normally do in their home if they had purchased the technology. High-level task guides were given to the participants that provided a minimal level of structure. The activities contained in the task guide were based on prior research so that it would reflect how people tend to go about the activities in actual home settings. The main goal from the participants' perspective was to be able to get media content (picture, music, and videos) stored on the PC to be viewed on the TV using new technology solutions. This involved unpacking the equipment, setting up a wireless network, connecting a digital media adapter to the TV, and finally building a media library on their PC. Exactly how participants did this and the order in which they did it was up to them.

Data collection involved structured interviews at natural breaking points in the set-up process. Rather than focusing on documenting micro-level usability issues (most of these were known from prior usability studies), the point of the UXQ assessment was to understand how the complete platform made people feel during set-up and initial use. To this end, three main types of data were collected. First, rating scales were developed to assess 1) level of satisfaction, 2) perceptions of being in control of the technology, 3) comparison with other similar experiences, and 4) value of the feature. Ratings consisted of Likert-type scales and semantic differentials embedded within a semi structured interview by a trained psychologist. Each of the rating scales was given at breaking points in the set-up process. The interviews were used to bring out more details of how participants were responding during their experience and to set an appropriate tone for participant introspection.

The second aspect of data collection was termed "user experience success." This was based on a professional assessment during participant observation. A pre-defined set of criteria included task times, number of user errors, and required assists. This and professional assessment was used to classify whether the participant had a positive (successful UX) or negative (failed UX) interaction with the platform. The UX success indicator is different than traditional usability-style success/failure rates in that, although participants may be able to complete the task, the main variable of interest in a UXQ study is maintaining a pleasurable experience during interaction with the platform. As a follow-up, exploratory semi-structured interviews were conducted by the psychologist to get an understanding of additional attitudes and emotions that were being experienced and which features participants were responding to.

The quantitative results were aggregated into a dashboard style UX summary. This summary highlighted differences between goals that were set early in development and the measured UX quality of the platform (see Figure 2). As this example illustrates, each of the key features and usages were assigned colors (green, yellow, or red) based on the degree to which they met criteria for the targeted UX dimensions. The particular UXQ dimensions assessed will vary depending upon the UXQ goals targeted (e.g., may include specific targeted emotions or perceptions). In this example the focus was on UX success, attitudes (composite of several attitudinal variables), comparisons to past experience, and the value the user indicated for the key feature.

	Sample Key Feature or Usage	Success	Attitude	Compare	Value
1	Easy set up Wireless Network	75%	5.0	5.3	6.4
2	Easy set up Add a Device	79%	5.7	5.6	6.6
3	Access Media Content	86%	5.2	4.7	6.4

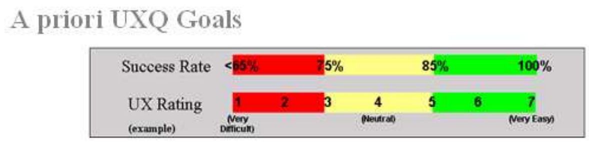

Figure 2: Sample UXQ dashboard against goals

Additional comparisons were made between the Intel platform and competitive usages (see Figure 3 for an example). Figure 3 shows how key features were compared with two competitive usages, C1 and C2. In order to facilitate future goal setting, an overall bar or individual UXQ goals can be set to explicitly consider comparative usages. In this example, the primary uses of these data was for immediate feedback to product developers, for helping to shape marketing messaging, and for setting clear goals (including targeting the right UX dimensions) for the next version of the platform.

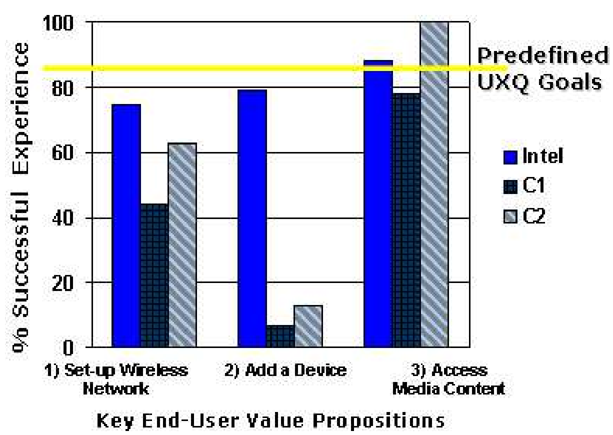

Figure 3: Sample comparison benchmarking data

Example 2: Streaming Video Quality Study

As previously mentioned, end-user perceptual experience is another vector of UX assessment. Perceptual quality is a key aspect of UX that lends itself to setting targets and measuring against these targets. Perceptual targets can be dynamic: the expectations of end-users change over time as technology delivers different levels of quality, and comparison points alter in response to those changes. For example, as the media community shifts from standard-definition to high-definition resolutions, the consumer anticipation of high picture quality increases and this must be reflected in perceptual requirements. There are many elements of human perception in the technology field; including areas of vision, hearing, and touch that can influence an end-user's experience of a given product. For the purposes of this case study the area of vision with respect to streaming video quality is discussed.

Streaming video is the process of sending video files from a server computer to a client computer so that they can be viewed in real time. Traditionally, streaming video has not been designed for use by the average consumer. However, recent advances in computer networking, combined with powerful computers and video technologies, have introduced the use of streaming video into the digital home infrastructure. Unfortunately, there are still limitations due to bandwidth constraints, which typically means that during a streaming session, video files are forced to be transcoded (format conversion) or transrated (bit rate conversion) to a more manageable size. The compression of the video leads to visual artifacts that are commonly displayed as blocking or loss of detail. These transformations tend to result in degraded video quality and overall degraded UX. Delivering excellent quality is a necessity in the highly competitive consumer electronics and PC market.

The following perceptual quality case study was conducted to find the lowest operational transrating level for streaming media associated with an acceptable UX. In addition, this work was intended to provide validation engineers with a calibrated objective tool to estimate the UX in a testing environment quickly, repeatedly, and reliably. In order to achieve these goals two questions were addressed.

1. What is the failure characteristic associated with reducing the bit rate used for MPEG-2 and the corresponding subjective assessments?
2. At what point on the failure characteristic curve do the results have no more return on investment or lowest operational point (what are the platform's video quality targets)?

The experimental design employed three measurement methods to determine the relationship between video quality and UX scores: 1) an expert assessment, 2) a non-expert assessment, and 3) an objective tool output. Video experts have prior knowledge of image compression, familiarity with video, and possess extensive training, practice, and experience in evaluating different technologies. Contrary to experts, non-expert participants are not directly concerned with video quality as part of their typical vocation [15]. The final method used was the Video Quality Metric (VQM), a tool that produces a numerical result that correlates to a set of non-experts' average perception known as a Mean Opinion Score (MOS) [16]. Since the VQM is a non-adaptive "black box" algorithm, the results need to be calibrated with every new format or platform under test.

For these three methods the independent variable was bit rate, defined by the amount of data transferred per second. In general, the higher the bit rate, the better the quality; DVD quality for a standard definition video has an average bit rate of 7Mb/s with a peak of around 10Mb/s. The dependant variable was the MOS value. The subjective assessments used a double stimulus impairment method in which participants were instructed to score their perception of a processed video clip (i.e., reduced bit rate) when shown a reference video clip (10Mb/s).

The study was designed using a standardized methodology verified by the International Telecommunications Union (ITU). A critical part of the experimental design was to properly choose the visual stimuli to be used for testing. For this experiment a standardized sequence of six clips was chosen that encompassed a wide range of video content created to stress the transrating stack for different video conditions. Source video was encoded using the transrating stack and written to the hard drive for playback. A controlled playback system called Video Clarity was attached to a calibrated (color temperature, brightness, and contrast) display [17]. Video Clarity was required for consistent evaluations, because it captures and outputs exactly what it records [18].

All evaluations took place in a semi-anechoic chamber with 50% grey walls, lighting measured to 10 lux, and participants were seated at a predetermined viewing distance to control viewing conditions.

All participants went through a vision acuity (Snellen Eye Chart) and color deficiency (Ishihara Testing Plates) screening [19, 20]. Participants were instructed on the double stimulus impairment method and the five point ordinal impairment rating scale that is typically used to determine failure characteristics [21]. A practice session was also given to familiarize the participants with the testing set-up. Once the evaluation began, the first five trials were discarded to address any learning issues and to stabilize the viewer's opinion [22]. Each session had a unique randomized order of presentation, so that opinions were balanced out.

The significant result is that we were able to differentiate between expert and non-expert when relevant, enabling validation and comparison of subjective results to an objective measure. Thus, we were better able to focus development efforts where they need to be focused, rather than over- or under-designing our platforms and missing the return on investment point.

There are many touch points in a product lifecycle at which performing video quality evaluations can benefit the design teams. One such place is during validation. At this phase, it is most efficient for the engineers involved to have an objective tool to accurately evaluate the video performance during the platform testing phase. This is crucial, since performing subjective assessments would be time consuming, expensive, and probably too late to impact product design prior to release. Using the VQM, validation engineers can get an estimated MOS value that is mapped back to end-users' perceptions.

However, as the subjective assessments have shown, this tool needs to be calibrated for every new video test because it only provides measurements for typical artifacts. If the engineers were to use the tool without calibration, the inflated results would indicate that transrating could go as low as 2Mb/s and be above the true target threshold. This would have created an unacceptable experience for the end consumer. As we've shown here, employing a holistic approach to assessments and drawing on the results of the expert and non-expert assessment, we were able to calibrate the video quality metric tool so that it would work for setting the appropriate performance threshold of the transrating stack. If we hadn't performed the two assessments, we may have passed (with the tool) video that was, in fact, unacceptable. Psychological assessment techniques thus play an important role throughout the development cycle.

This study not only determined the lowest operational level for a specific digital home platform, it also set target levels and changed the validation process by adding correction factors to an objective tool. Implications are clear for setting UXQ perceptual goals as part of larger UXQ assessment to drive end-user noticeable value propositions of platforms. The eventual goal is to roll-up relevant human perceptual data including areas of vision, hearing, and touch that can influence an end-user's experience of a product.

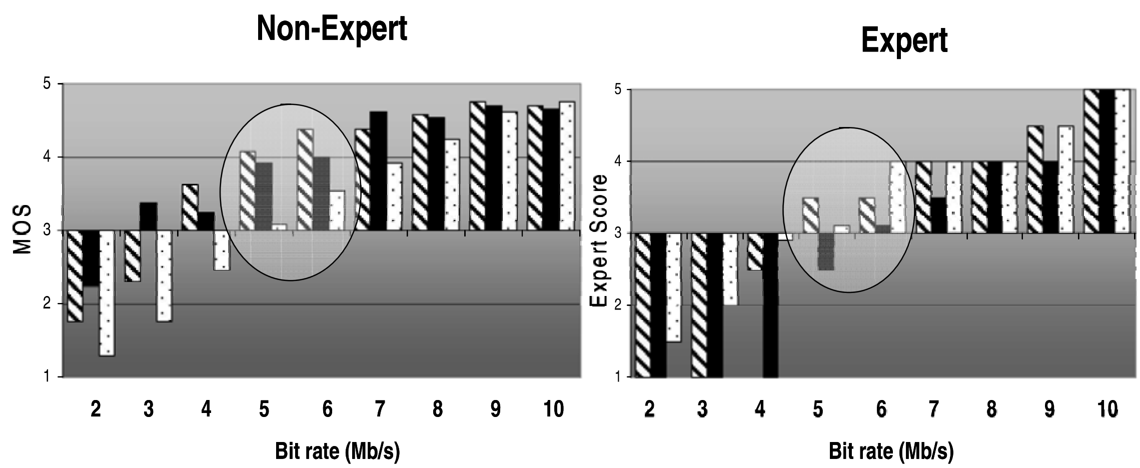

Figure 4: Non-expert versus expert ratings of visibility of impairment introduced with decreasing bit rate

Example 3: In-home Contextual Study

The final case study, a series of contextual in-home data gathering exercises provides an example of an exploratory and qualitative approach to UXQ assessment. Contextual studies provide useful data about how the platform integrates into real home settings. In this example, the main goal was to understand how the digital home platform and connected devices would be integrated into three home settings given the richness and complexity of target market households. We set out to gather anecdotes, photos, and rich information providing insight into the attitudes and emotional responses people have to the technology. The main research questions were these:

1) What are initial expectations and questions people have when they plan to set up the technology in their homes?
2) What are their attitudes and behaviors during set-up?
3) What are their reactions after the first several weeks of use, and how do they change from the initial and set-up reactions?

Three households were selected for participation in the study. Selection criteria were used so that each family would match at least one of the target market segments. Given only three families were used in this study, the results were not meant to be predictive or representative of the target consumer population but rather help identify integration issues with existing technology and other family members. Some characteristics of the three families are described in Figure 5.

Each family was asked to set up and use Intel platforms complete with all parts of the technology that made up the platform value propositions. Families were compensated approximately $300 for integrating the technology into their homes and participating in the study activities. The platform solution provided to participants allowed them to aggregate digital media (pictures, music, and videos) stored on PCs throughout their home for viewing on their TV, using a remote control. The equipment included a PC, monitor, input devices, a surround-sound speaker system, a digital media adapter, and a wireless router.

The procedure involved four main parts. The first was a home technology tour. Photos and notes were taken regarding the type of digital entertainment technology the families had, aesthetics themes, and how media were stored (pictures, music, videos) before introducing the new technology.

Second, in-person observations of the participants while they set up the equipment in their homes were conducted. Key areas of interest included the locations they thought made sense and evidence of the mental models participants had regarding how the technology could be integrated into their other PC and media-related technology. Observations of interaction with the technology in context started with the full "out-of-box-experience" assessment for each component of the equipment. The initial observations lasted about four hours for each household. Data were collected on any trouble the participants experienced, especially focusing on how good/bad the experience was for the participants. Semi-structured interviews, photographs, voice recordings and follow-up probes were used to collect data to understand attitudes and emotions associated with initial expectations and how these were resolved during this early phase of the usage lifecycle.

Figure 5: Participant profiles

UX data were collected across time as participants became more familiar with the platforms. This part of the in-home data collection involved email questions and follow-up telephone calls. Participants were left a series of activities to carry out at their own discretion, and they reported their success (or failure) and reactions via e-mail and telephone calls. The activities prompted participants to use certain aspects of the system and provide feedback. Participants were encouraged to explore all the key features of the platform and provide feedback as if they owned the system.

The final part of the data collection involved follow-up home visits. These were conducted after families had a chance to use the technology for several weeks. During these sessions, participants were asked to demonstrate how they used the systems and asked questions about the impact of the technology on their entertainment choices, daily routines, and social interactions. They discussed issues and what they saw as opportunities that came up along the way. The follow-up interview lasted approximately two hours for each household. As in the first home visits, semi-structured interviews, photographs, voice recordings and follow-up probes were used to collect data to understand attitudes and emotions associated with use of the platform.

Given these were case studies, the results of the home visits were presented to UX owners in the form of anecdotes of experience, photos, and selected clips from the voice recordings. Based on these results, two compelling potential drivers of attitudes to the brand were identified in addition to three potential liabilities. These converged with evidence from prior studies. Several examples of known areas where the user mental model did not match the conceptual design model were identified, and specific examples were described. Finally, evidence of clear gaps in features was used to help prioritize feature requests.

The findings were triangulated with the results of the other user studies to better understand and help "make real" to stakeholders some of the key UX issues with the technologies. Examples regarding key assets and liabilities to the brand messaging were presented, and as a result, changes were made to the platform messaging. Contradictions or gaps related to the users' mental models of the system were also addressed through modification of the messaging. Combined with quantitative dashboard data, the in-depth illustrations of problem areas helped to drive what would have been low-priority recommendations for future basic product functionality.

In-depth illustrations of problem areas, combined with quantitative dashboard data, created new directions for future basic product functionality out of what would otherwise have been low priority recommendations.

DISCUSSION

As consumers are faced with an increasing number of choices in the marketplace, UX has become a key differentiator. In this paper we described the UX assessment program at Intel that moves beyond the traditional technical validation and assessments of usability toward a multi-method approach to better understanding and managing key differentiators involving end-user value propositions.

Over the past five years, Intel has been developing internal expertise in the areas of social science including human factors, experimental psychology, and ethnography. One of the key results is an increased focus on the end-user value produced by a platform approach and a focus on understanding and advancing the user experience.

In this paper, one of Intel's approaches to UX assessment was outlined that highlights the roll of emotions, attitudes, thoughts, and perceptions across the usage lifecycle as well as product development lifecycle. A process was outlined to set measurable UX goals beyond technical validation or usability goals early. Setting explicit UX milestones at key gates in the development lifecycle allows the bigger picture UX to be assessed and checked against set goals, and provides useful visibility of the UX to key stakeholders. The data, both quantitative and qualitative in nature, are used to inform the development of platforms, guide future platforms, create demand, and provide answers to co-travelers regarding unique end-user benefits associated with the platform vision.

By increasing visibility through explicit UX goal setting and measurement across stages of development, not only is UX emphasized as an important organizational objective, but strategies and resources can be better channeled to ensure user-centered design processes are prioritized appropriately relative to other business demands.

ACKNOWLEDGMENTS

Thanks for the many contributions of our colleagues that made this effort possible. Specifically, we thank Paul Sorenson for the ongoing support and development of the UXQ program, Mike Payne, Genevieve Bell, and David Sward for insightful conversations and input that helped determine the direction of the research, and Amy Briggs for long hours and dedication in study execution. Additional thanks go to Anne McClard, Cory Booth, Colin Bay, and Delbert Marsh for their expertise in data collection. We are also grateful to Brian Bramlett, Paul Osterlund, and Erik Simmons who have helped to drive UXQ across Intel. Finally, we thank Herman D'Hooge and Genevieve Bell who continue to successfully sponsor and champion these concepts at an executive level.

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Mapping the Digital Home: Making Cultural Sense of Domestic Space and Place

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Index words: cognitive mapping, ethnography of domestic space

The structures in which people reside, and their interpretations of them, are embedded with a great deal of cultural knowledge. As part of our charter to understand practices of domesticity around the globe—and the ways in which technologies are integrated within them—Intel's Domestic Designs and Technologies Research (DDTR) team uses a range of ethnographic methods to grasp how people shape, and are shaped by, their domestic environments. A method that has proven particularly effective for our group is a form of mapping inspired by developments in environmental psychology and related social sciences. At the source of this method is a process known as "cognitive mapping," generally defined as

> *a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls, and decodes information about the relative locations and attributes of phenomena in their everyday spatial environment* [1].

Kitchin condenses this as a "marriage between spatial and environmental cognition," where spatial cognition can be understood as the "cognitive representations of the structure, entities, and relations of space," and environmental cognition as "the awareness, impressions, information, images, and beliefs that people have about environments" [2].

Although there has been some debate about the various manifestations cognitive mapping might assume (biological/literal, analogous, metaphoric, or hypothetical [2]), we advocate the position that cognitive maps are essentially hypothesized—that they reside in the "mind's eye." However, since understanding cognitive maps is critical to gaining insight into domestic place as the locus of human intentions [3], there is a great deal to be gained from generating graphic representations of our participants' spatial and environmental processes and organizations of knowledge, however "sketchy, incomplete, distorted, and otherwise simplified and idiosyncratic" they may be [4].

Our methods for producing spatial schemata that represent specific components of our participants' cognitive maps typically begin with their perspective of the boundaries and proportions of the home. First, we ask participants to sketch a floor plan of their residence as they see it (without regard for cartographic accuracy or proportion). We then ask them to add domestic objects that are significant to their daily lives (i.e., furniture, technologies, appliances, etc.). From this basic rendering, participants are asked to respond to a series of prompts by using various colors to represent their interpretations, including their path of typical daily routine, best places to be together, best places to entertain, best places to relax, best places to learn, places of limited access, and areas of conflict. In addition to eliciting a dialog about their interpretation of the space, the exercise results in a set of representations that serve as visual artifacts from which we can develop comparative analyses (from home to home and across cultures). Figure 1 shows a typical map.

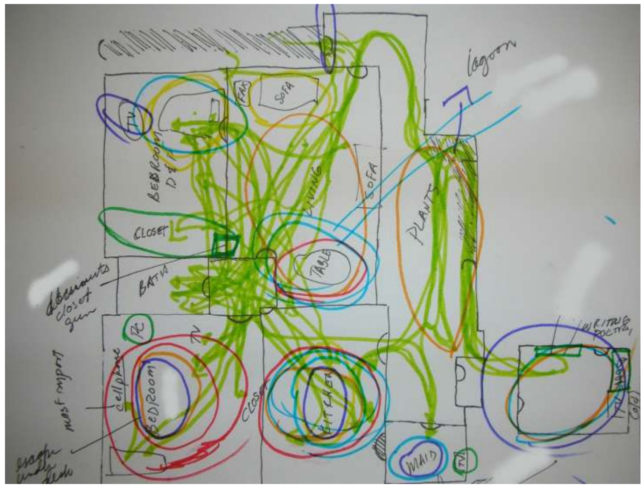

Figure 1: A map from a Brazilian household

Collectively, the maps also form an archive that helps us understand how layers of cultural values, priorities, and world views are infused within domestic space, as well as how those layers intersect with technologies. From this, we begin to understand where technologies belong (and where they don't), how they may or may not fit into the fabric of everyday life, the sets of associations people have with various domestic experiences, and how "ecosystems" of domestic practice relate to "ecosystems" of technology.

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IEEE 754R Decimal Floating-Point Arithmetic: Reliable and Efficient Implementation for Intel® Architecture Platforms

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The IEEE Standard 754-1985 for Binary Floating-Point Arithmetic [1] is being revised. An important addition in the current draft [2] is the definition of decimal floating-point arithmetic. The primary motivation is that decimal arithmetic makes numerical calculations more human-friendly. Results will be as people expect them, identical to what would be obtained using pencil and paper. Decimal arithmetic also provides a robust, reliable framework for financial applications that are often subject to legal requirements concerning rounding and precision of the results in the areas of banking, telephone billing, tax calculation, currency conversion, insurance, or accounting in general. The binary floating-point arithmetic that computers use does not always satisfy the existing accuracy requirements. For example, (7.00 / 10000.0) * 10000.0 calculated in single precision is 6.9999997504, and not 7.00. The underlying cause is that most decimal fractions, such as 0.1, cannot be represented exactly in binary floating-point format. The IEEE 754R standard proposal attempts to resolve such issues by defining all the rules for decimal floating-point arithmetic in a way that can be adopted and implemented on all computing systems in software, hardware, or a combination of the two.

In the past, the lack of a good standard for decimal computations has led to the existence of numerous proprietary software packages for this purpose, each with its own characteristics and capabilities. In planning to improve on this and make Intel one of the early adopters of the proposed Standard 754R for decimal floating-point arithmetic, we have developed new algorithms along with correctness proofs and we have used them to implement in software a decimal floating-point library [3, 4, 5]. Standardization committees for high-level languages such as C and C++ are already developing plans to add decimal floating-point support to these languages. Once this happens, our new software package for decimal floating-point arithmetic will be available to be used as a computation engine by compilers, and it should constitute an attractive option for various financial computations. A logical question is whether a software implementation of the decimal arithmetic will be fast enough for financial applications, or whether a hardware implementation is needed. A close look at decimal-intensive applications today reveals that most spend between 1% and 5% of their execution time performing decimal operations while the rest is spent in integer, binary floating-point, memory, I/O, or other operations. A software implementation of the IEEE 754R decimal floating-point arithmetic should therefore be sufficient for the foreseeable future, compliance with the standard being far more important than raw performance in this case.

A decimal floating-point number n defined by the IEEE 754R standard proposal can be represented as $n = \pm C \cdot 10^e$ where C is a positive significand with at most p decimal digits, and e is an integer exponent. The basic decimal floating-point formats with their precision and exponent range are shown in the following table:

Table 1: Decimal floating-point formats with their precision and exponent range

	decimal32	decimal64	decimal128
Precision p	7	16	34
Exponent range $[e_{min}, e_{max}]$	[–95, +96]	[–383, +384]	[–6143, +6144]

Two equivalent encoding methods are described in the IEEE 754R proposal: the decimal encoding method [2] and the binary encoding method [2, 6]. The main characteristic of the decimal encoding is that it uses the Densely Packed Decimal (DPD) method, which compresses three consecutive decimal digits in 10 bits. The binary method encodes the entire decimal significand as a binary integer, and hence it is also referred to as Binary Integer Decimal, or BID.

The new algorithms for decimal floating-point arithmetic implemented in the Intel IEEE 754R Decimal Floating-Point Library are equally applicable to both encodings, although they are more efficient with the binary (BID) encoding.

Selected performance results expressed in numbers of clock cycles for the Intel® BID Decimal Floating-Point Library are shown in the figure below, where average and median values are given after subtracting the call overhead. Clock cycle counts are shown for decimal64 and decimal128 format addition, multiplication, division, square root, conversion to string, conversion from string, and quantize operations. An Intel® Xeon® processor 5100‡ series 3.0 GHz was used for these measurements. The library is currently being tested in Windows*, Linux*, OS X*, and HP-UX* on IA-32, Intel® 64 , and IPF platforms.

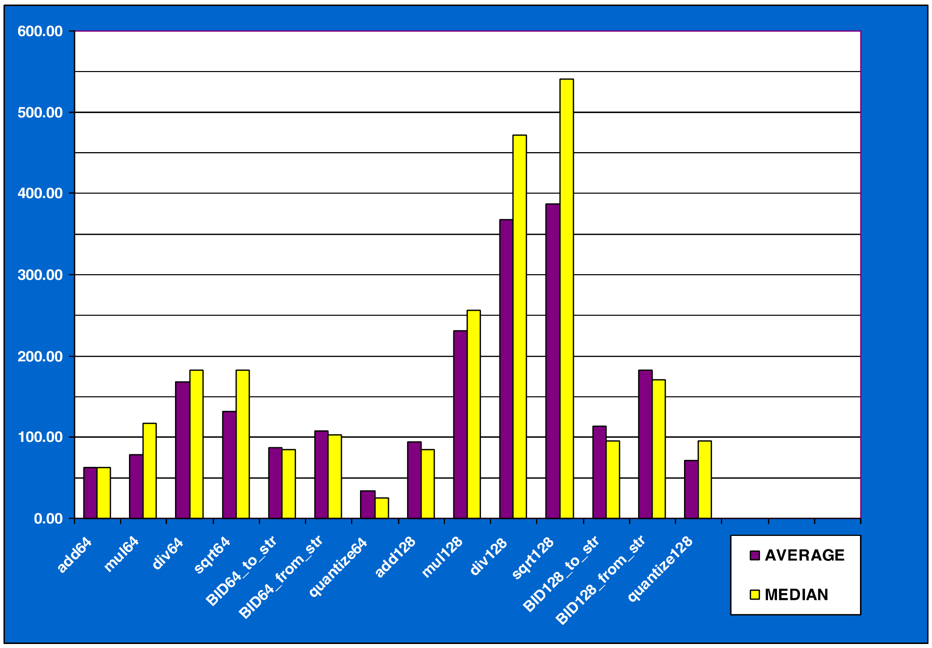

Figure 1: Performance Results: Clock cycle counts for a subset of functions from the Intel® IEEE 754R BID Decimal Floating-Point Library, measured on an Intel® Xeon® processor 5100 series 3.0 GHz

We expect that properties and algorithms used in the new library for decimal floating-point arithmetic can be applied as well for a hardware implementation, with re-use of existing circuitry for binary operations. We believe that our library work represents an important step toward reliable and efficient implementations of the IEEE 754R decimal floating-point arithmetic on Intel® Architecture platforms.

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‡ Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. See http://www.intel.com/products/processor_number for details.

† 64-bit computing on Intel architecture requires a computer system with a processor, chipset, BIOS, operating system, device drivers and applications enabled for Intel® 64 architecture. Processors will not operate (including 32-bit operation) without an Intel® 64 architecture-enabled BIOS. Performance will vary depending on your hardware and software configurations. Consult with your system vendor for more information.

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