A Pervasive Computing Solution to Asset, Problem and Knowledge Management

by

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Abstract

In this dissertation we show that a pervasive computing approach to asset, problem, and knowledge management has a major positive impact on the cost-effectiveness and productivity of the Technical Support Function. Specifically, we show that it reduces time to complete all major tasks of the helpdesk functions and it leads to faster data availability, improved data quality, improved help desk effectiveness, improved help desk Return on Investment, lower overall Total Cost of Ownership, and increased user satisfaction. The research activities include the conceptualization, design, and construction of working wireless laptop and Pocket PC 2000 operating System PDA based asset, problem and knowledge management systems. These systems assist in the management of a divisional desktop support team across the U.S. The systems work on a Lotus Notes Domino based server supporting both wired desktops, wireless laptops, and wireless PDAs.

Acknowledgements

This project has been a long one, and many people have contributed significantly to its success. It began in late 2000, with the conception and initial design stage and proceeded through data collection in 2001 and 2002 with final analysis and reporting in 2002. Many people were involved in the development of the application for the desktops, laptops, and PDAs. Several people at multiple locations were involved in the analysis and network engineering of the supporting networks. Others took part in the evaluation of the pervasive computing equipment alternatives from which we made our final equipment selection. Many Field Support Engineers at multiple locations took part in the rollout of the actual application and in the collection of the data. Still others played a major part in the evaluation, documentation, and final assembly of the results.

In particular, I want to thank Michael Nguyen for working on Cadenza and Lotus Notes connectivity issues, Gary Eng and Ramon Diaz for helping with the development of the applications used for data collection and reporting, Bill Zack for assisting in the revision and preparation of the manuscript, and Carole Burstein for polishing the document and reformatting it into dissertation format.

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CHAPTER 1
INTRODUCTION

The following quote from IBM indicates the importance of pervasive computing in managing information: *"Information is the new currency of the global economy. We increasingly rely on the electronic creation, storage, and transmission of personal, financial, and other confidential information. We also demand the highest security for all these transactions. We require complete access to time-sensitive data, regardless of physical location. We expect devices -- personal digital assistants, mobile phones, office PCs, and home entertainment systems -- to access that information and work together in one seamless, integrated system; i.e., there has to be a migration from the PC-centric to a multi centric model. Pervasive computing can help us manage information quickly, efficiently, and effortlessly* [66]".

Pervasive computing aims to enable people to accomplish an increasing number of personal and professional transactions using a new class of intelligent and portable devices. It gives people convenient access to relevant information stored on powerful networks, allowing them to easily take action anywhere, anytime. These new intelligent appliances or "smart devices" are embedded with microprocessors that allow users to plug into intelligent networks and gain direct, simple, and secure access to both relevant

information and services. These devices are as simple to use as calculators, telephones, or kitchen toasters.

Pervasive computing simplifies life by combining open standards-based applications with everyday activities. It removes the complexity of new technologies, enables us to be more efficient in our work, and leaves us more leisure time. Computing is no longer a discrete activity bound to a desktop; pervasive computing is fast becoming a part of everyday life [66].

Computing technologies are being embedded into various information appliances or devices ranging from personal digital assistants to mobile phones and home entertainment systems. The emergence of wireless networking has allowed such information appliances to become network connected.

Pervasive computing enables enterprises, telephone service providers, Internet Service Providers (ISPs), and Application Service Providers (ASPs) to leverage all of their data assets regardless of disparate protocols, language, and formats. E-business content can now be delivered effectively, efficiently, and economically to anywhere, and to any device. Pervasive computing extends and enhances several layers of the Application Framework for e-business. It enables people to access Web-based applications using a new class of intelligent and portable devices. It provides convenient access to relevant information stored on one seamlessly integrated system providing access to information from disparate, unrelated sources. Pervasive computing

provides mobile professionals with the tools and services that allow them to access and interact with information (and services) and to work more efficiently with their customers, colleagues, and enterprises -- to leverage the value of e-business.

Pervasive computing services support the growing number of nomadic computer users. The main objective is to provide mobile users with access to the data and applications they require to be productive. To do this effectively, several unique characteristics of the mobile environment must be addressed. For example, most mobile links are high latency, low bandwidth, and unreliable connections, especially when compared to office networks. Disconnected operation is the rule, not the exception. Most roaming users use two or more devices to support their activities. The diversity of devices, networks, network connections, and operating systems negates a "one size fits all" solution, while remote and disconnected access makes mobile users more difficult to support and manage.

Users must be able to access applications and data in a consistent and natural manner from multiple devices through various network connections. For example, calendar information must be consistent whether it is accessed from a LAN-attached laptop or a wireless smart phone. [1].

Even when users are not connected to the network, they must be able to browse Web pages, read, and respond to e-mail, and access calendar information and other groupware and desktop productivity applications.

When roaming users do connect to the network, they must be able to access enterprise applications, synchronize their local data with the server, and receive updates from the network in an efficient manner.

Pervasive computing is the next natural evolution of network computing, which in turn evolved from client-server computing. In [9], Jerry Cole asserts that, ”It is not technology that will shape the next decade, but the way that we use it to drive improved business models”.

1.1 Background

Miller and Pascoe said “*Technology has never been so in vogue. It is transforming the way we live, work and communicate, and creating untold wealth for nations, entrepreneurs and investors. As we enter a new millennium, we find ourselves living in a wired and wireless world that is shrinking distances, saving time, and, vastly changing our expectations as consumers. What lies ahead? Smaller, faster and better computing appliances - called pervasive computing devices - will become increasingly commonplace, making network access ubiquitous. At the same time, advances in computing technology will make it possible to improve nearly every business process. And, just as they did in the l990s, information technology specialists in businesses all over the world will be clamoring for increased budgets to pay for the new technologies* [31]”.

Today, professionals are conducting an increasing number of business activities outside traditional office settings, and the pervasive computing environment is large and growing rapidly:

- According to the McKenna Group, the pervasive computing market could be worth $120 billion in the next 3-5 years.
- According to a Forester Research interview, the Global 2,500 network managers report that about 23% of their user populations don't currently connect to the corporate network from a fixed location. They further expect that the number of mobile users will rise to 35% within two years -- an increase of 57%.
- International Data Corp. (IDC) expects 18.9 million handheld PC companions to be shipped worldwide in 2003, which will contribute to the 34.6% CAGR in the handheld market over the 1999 to 2003 period.

Pervasive computing is all about access to your information, anytime, anywhere, from any device.

1.2 Data-centric computing

Closely tied to the concept of pervasive computing is the concept of Data-Centric Computing. The basic tenet of Data-Centric Computing is that infrastructure and computing components need to become more invisible and ubiquitous in order to support the pervasive computing model.

Esler [16] compares today's multi-purpose desktops and palmtops to Swiss Army knives. A Swiss Army knife has it place, on a camping trip for instance, but how many of us would use a Swiss Army knife to carve a turkey at home? There, of course, we would use a more specialized tool instead of choosing one that attempts to be all things to all people. Likewise, the current crop of desktops and palmtops are too complex precisely because they are so versatile. Although we may encounter them everywhere, we cannot easily use them for our purposes. They often operate in an unfamiliar way, attempt to do too much, or use services that we may not (or should not) access. Esler argues that consumer computing devices should be just as easy and flexible to use as kitchen utensils. The focus needs to shift from the innards of devices to the uses and services that make sense in our daily lives [16]. He also argues that such a conceptual shift will become possible as the cost of technology becomes less of a limiting factor. They hypothesize that, in the very near future, we can expect to pay $10 for a gigabyte of RAM, a gigaflop per second of computation, a mega pixel of display area, one megabyte per second of wireless communication, or 100 gigabytes of disk space. This will enable us to take computing capability for granted in everyday devices and define new modes of interacting with computers; methods such as user movement, proximity of devices, and embodied information presentation will augment the keyboard, audio and video interfaces that we see today. The challenge is to maintain task-oriented consistency across physical devices while managing

these interfaces in a consistent manner. This will allow the focus to shift away from the user interface and explicit command modes to the data and the tasks necessary to perform the desired functions. In effect the computer becomes invisible and we can focus on the nature of the data and the processes that are necessary to provide the non machine-centric user interfaces required by pervasive computing. Esler's conclusions published in 1999 are more relevant today. In fact the whole purpose of the current Web Services movement can be viewed as attempt to provide ubiquitous access to services across platforms and from devices with dissimilar user interfaces.

1.3 Relevance of research in the context of other work

It is important to note that, although the term pervasive computing has been coined only recently, the concept for which it stands has plenty of historical precedent. In particular companies such as IBM [45] and United Parcel Service [6] have implemented pervasive computing infrastructures going as far back as 1982. Although the UPS implementation was for tracking package shipments the IBM implementation was actually for a purpose more similar to our own, i.e., improving the effectiveness of Field Technical Support personnel.

1.3.1 IBM's Data Communications System

The IBM Data Communications System (DCS) was implemented in the 1982-1984 time frame (See Appendix 1, email from one of the original developers, Edward Keating, also see [45].)

It featured small beige-colored house brick sized wireless terminal devices with an LCD screen capable of displaying a few lines of text and a small keyboard. This device also incorporated an integrated packet radio modem capable of communicating messages across a specially built private packet radio network. This terminal, affectionately known as "the brick" for its appearance, was deployed widely by IBM.

To support these terminals, IBM contracted with Motorola to build a nationwide private packet-radio network operating at a speed of 4.8KBPS on a carrier frequency of 800MHz. This private network eventually covered most of the major cities in the United States. This combination made it possible for IBM Customer Engineers to communicate with their Dispatchers by sending and receiving short text messages. These messages were used to dispatch technicians to customer sites and report call status back to the Dispatchers.

Based on this work, Motorola also built a public-access version of the network using the same technology. In 1990 the IBM and Motorola networks were joined to create a public-access network called: Advanced Radio Data Information System (ARDIS). This new network also increased the available transmission speed to 19.2KBPS.

Swedish Telcom also developed a similar packet radio network in Sweden. It was called Mobitex. The Mobitex system used equipment supplied by Erickson Mobile Communications AB. It began operation in 1986. This system has now become the de-facto standard in most of Europe. Today both of these systems are available in other parts of the world such as Southeast Asia and the Pacific Rim [45].

Limitations of Data Communications System (DCS)

In effect, the IBM DCS system was little more than a private wireless email service, since the disconnected nature of the packet radio network, the relatively slow data transfer speed, and the dumb-terminal nature of the end user devices made running any kind of real application on the end user devices impossible.

This should be contrasted with the architecture we used in this study. The IBM/Motorola network implementation had to provide coverage on a citywide basis in major cities across the United States for IBM Customer Engineers who could be located at, or en-route to, any of IBM’s client installations.

Our architecture, on the other hand, is designed to provide coverage only in specific buildings in specific cities where the company has business offices. All networking is done using Wireless Access Points (WAPs) connected to local area networks on a campus-wide basis. Where business offices in different cities must be connected, these LANs are in turn bridged with wide

area network circuits. This provides a much higher usable bandwidth than the IBM system provided.

In place of dumb terminals we use more intelligent programmable devices such as laptop computers and PDAs. This makes it possible to run client-side application code directly on the end-user device. This allows us to transcend the email-like nature of the IBM system and enables us to provide a much richer user experience at the client site. Whereas only IBM customer engineers and dispatchers used IBM system, our solution allows end users to be direct participants in the process.

Also, the use of components that are widely available and off-the-shelf such as laptops and PDAs coupled with standard local area networks and wide area network bridges allowed us to implement our solution at a fraction of the cost of a proprietary solution.

Despite the limitations of IBM's DCS it is important to give them credit as one of the earliest implementations of the pervasive computing metaphor that we have carried on to a further conclusion.

1.3.2 Making better business use of emerging technology

In a real-world project it is important to make use of the most modern technology that can be successfully applied to solve a business problem. In this project we were careful to use leading-edge wireless and server platform pervasive technology that was both robust and tested in the market to ensure

the integrity of the research while avoiding the use of any “bleeding-edge” unproven technologies. Bringing data closer to relevant parties

In the pervasive computing environment where users and support personnel are frequently mobile and not tied to a fixed location it is important to bring data concerning problem status to the users and engineers and not vice-versa. It is likewise important to bring the ability to report problems to them wherever they are located.

CHAPTER 2
HELP DESK TECHNOLOGY ENVIRONMENT

2.1 Statement of justification

A company, hereafter referred to as ABC Company, spends more than three billion dollars a year to procure technology. A major portion of it is used to procure new desktops computers, client/server systems, and associated peripherals. In-spite of such a huge investment year after year, there is no system in place to consolidate the technology procurement and to track the assets throughout their life. It is a tedious task to compute the total cost of the ownership, since there is currently no system in place that will track an asset through its life cycle, along with its maintenance work and the software tools deployed on it.

Every desktop computer is assumed to have a three-year life span. Within a three-year period it will be replaced with newer technology. Laptop computers are assumed to have an even shorter life span.

While the cost of the new technology is dropping, the cost of maintenance of the existing technology is going up. Increasing manpower cost to support and maintain the deployed technology coupled with lack of appropriate knowledge of the hardware assets is making the task of technology maintenance cumbersome and expensive. In this study we demonstrate that the cost of maintenance of the technology can be reduced and controlled by employing a pervasive computing solution. Additionally, there is no knowledge transfer of

the kind of problems encountered and procedures followed by different support groups on such hardware/software procured through the different parts of the organization. This is not only ABC Company's problem, but also one that is much broader and requires the attention of the industry.

In this research-based solution, we develop a suite of applications and a wireless infrastructure. This research integrates the three issues of technology asset tracking, problem management, and building a knowledge base. It also demonstrates that it is possible to contain costs through the use of pervasive computing.

2.2 Purpose of the study

The purpose of this study is to determine the effects of pervasive computing on the management of technology in a Help Desk environment. The research activities include the conceptualization, design, and construction of working wireless laptop and Pocket PC 2000 Operating System PDA based asset, problem and knowledge management systems. These systems assist in the management of a divisional desktop support team across the U.S. The systems work with a Lotus Notes Domino based server supporting both wired desktops, wireless laptops, and wireless PDAs.

2.3 Hypotheses

We believe that pervasive computing should bring improvements in Help Desk functionality and throughput. Keeping this in mind we create a baseline from our mature pre-pervasive computing Help Desk environment. Then we apply pervasive computing techniques and measure the results. We demonstrate that pervasive computing proves our main hypothesis and supports our auxiliary hypotheses.

2.3.1 Main hypothesis – Pervasive computing reduces time to complete defined help desk functions

Help desk functions may be broken down into many task categories ranging from password resets to deploying and configuring complex software applications. Each task requires a range of time to completion. We believe that pervasive computing reduces the time to complete tasks of a helpdesk function. Once we determine the time to complete various tasks in the help desk environment in the baseline phase, we compare the results obtained from the pervasive phase. We will prove that time to complete help desk functions during the pervasive phase is less than that during the baseline phase for the similar task. We will prove the results with significance testing using the Chi Square mathematical model.

2.3.2 Auxiliary Hypotheses

In addition to our main hypothesis, we claim that the deployment of pervasive computing will also support the following auxiliary hypothesis as well.

2.3.2.1. Speeds data availability and improves data quality

We believe that problems get resolved faster and at a lower cost by bringing the problem reporting mechanism closer to its point of origin and by bringing the relevant problem solution information closer to the point where it is needed, i.e., placing it directly in the hands of the field service engineers.

With a pervasive knowledge base, the field service engineers have access to the relevant knowledge for a reported problem. This reduces the call resolution time. As the pervasive computing motivates more problem recording, it provides more data for analysis. It also brings us to justify our service level agreements and bring in more revenue in cases where we get paid on a per-call basis. In addition, we also believe that more calls will be recorded, since the engineers have the recording tools handy.

2.3.2.2. Improves the effectiveness of the Help Desk

We believe that paper-based and semi-technology based help desk systems are not very effective. If the help desk agents and engineers are brought closer to the source of reported problems and the possible solutions to these problems, then resolution costs decrease substantially with a corresponding increase in user satisfaction. We also believe that, through pervasive computing, help desk management is facilitated, and that this results in substantial savings.

2.3.2.3. Improves Help Desk Return on Investment and Lowers overall Total Cost of Ownership

There are two measures generally used in evaluating the impact of any change on the enterprise. They are Return on Investment (ROI) and Total Cost of Ownership (TCO).

Return on Investment

In keeping with commonly accepted definition of ROI (see *Glossary for definition*), we compare the relative merits of the non-pervasive and pervasive computing approaches to technical support. It is our contention that deploying pervasive computing in a help desk environment increases our ROI substantially. In other words, given a fixed investment, the "payback" of the fixed investment will be greater.

For our purposes we consider such ROI factors as:

- **Investment protection:** Given a fixed initial investment, how is that investment preserved?
- **Rate of return:** How much benefit do we get from a given investment?
- **Period of return:** How do we extend and prolong the benefit period over which we make this investment and obtain the payback?