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Executive Summary

The purpose of this study is to analyze the emerging Information Appliance Industry, specifically the Personal Digital Assistant (PDA) segment and then to produce an industry forecast using competitive foresight scenarios. The importance of this study lies in the view that the emergence of this industry is a catalyst for disrupting the current PC centric computing model.



Donald Norman, Ph.D. and John Sculley have both envisioned the growing convergence of computing technologies with communications and consumer electronics that is rapidly shifting the computer industry's focus from multipurpose PC's to application specific devices. Information appliances are those devices. Information appliances are used for interactive information access and are characterized by their ease of use and affordability. Two characteristics demanded by the consumer and enterprise market are beginning to be offered by the emerging Information Appliance industry.

Some key market and technological trends are influencing the creation and direction of this industry. The dramatic growth of the Internet and its use by the general public has been coupled with the user's cry for convenience. These two trends have created a catalyst for change, a catalyst supported by technological innovations. Innovations such as embedded systems, intelligent user interfaces and an advancing universal communications network. These market and technological trends have created a new computing model, one of pervasive computing.

This new pervasive model, characterized by anytime and anywhere computing, has brought the computing industry to an inflection point for future strategy. This new

information technology has created the possibility of three scenarios. One described best by the words “The World Never Changes,” a scenario keeping the emergence of this new



industry at bay due to a lack of standards, network infrastructure and data security. The other is one where the PC remains key to all computing, with information appliances creating significant capability extensions to the PC. This scenario is best described as a “PC Plus Era” where the industry gains a share of the computer market, but relies on the PC for data, key processes and

multi-device coordination. The final scenario is one where the model of pervasive computing comes to fruition and the personal computer is relegated to network servicing and special computing tasks. This scenario is network centric, with information appliances thoroughly embedded into our everyday lives. The appliances are tied intimately to a universal network for data and security, but can also function with some independence for multi-device coordination.

From the technological innovation and user acceptance perspectives, the PC Plus Era scenario tends to hold up as a forecast for one product cycle. The unbridled growth of this technology is highly dependent on the successful emergence of embedded system and communication network technologies. But more importantly, the form factor has to be proven user friendly and corporate IT managers must be given an opportunity to migrate to this new technology. This new revolution is only equal to the shift from mainframes to PC a few decades ago and most current IT managers are not readily prepared for the transition.

Introduction

The growing convergence of computing technologies with communications and consumer electronics is rapidly shifting the computer industry's focus from multipurpose PC's to application specific devices designed for personal information access. These emerging devices -- known as information appliances (IA's) -- are making the age of information a reality - a time when people can get information anytime, anywhere.



Donald Norman, Ph.D., author of *The Invisible Computer*, says "IA's bring freedom into our lives. They allow us to do the tasks we care about, at the location we care about, when we care about it." (Norman) In this study we will describe and analyze the current Information Appliance Industry, specifically the Personal Digital Assistant (PDA) segment. The results of the analysis will then be used for constructing three competitive foresight

scenarios for the purpose of developing an industry forecast.

The goal of this industry analysis is to develop a picture of the future that is not only plausible, but also competitively relevant. To accomplish these goals the Six Forces model (Grove) will be used to describe and analyze the current industry, specifically the competitive nature of it. The model will be adapted to reflect an industry evaluation versus a single business in an industry. Applying the Six Forces model will allow for the description of the major forces that are shaping the industry and assist in identifying key factors and assumptions influencing the industry. The model most importantly, will illuminate key industry issues and prospective large-scale changes in the forces.

Additionally, an analysis of both market and technological trends is performed so that data extrapolation, curve matching and technological substitution can be done. The

primary data gathering methods used will include expert interviews, a review of pertinent business and technical literature and attendance of industry events. The data from the trend analysis is coupled with the findings from the Six Forces model to generate insight about industry strategy. The expert interviews were used to gather industry information and to develop strategic insight and to test possible scenarios. For managing the task of moving from analysis to industry scenario and forecast development, Liam Fahey's model for Constructing Industry Scenarios (Fahey and Randall) will be used.

The paper begins with a definition and brief history of information appliances and PDAs. Next, an in-depth description of the industry is presented along with key market and technology trends. In the final sections an industry analysis will generate three scenarios and a forecast.

PDA's - Definition and History

To talk about personal digital assistants we must also talk about the computing concept of information appliances. The industry has not quite settled on a standard definition for information appliances, but both Donald Norman and John Sculley have created some early and industry accepted thinking about these devices. Common to both definitions we find the following:

1. Information appliances are affordable; easy-to-use devices designed for specific and interactive information access functions.
2. Key features for IA products will be functionality, quality, reliability and ease of use.
3. Actual computing done by IA's will be transparent to the users.

4. IA products will be differentiated by use and not by technical specifications such as, MHz, Kbs, or MB.

What Norman and Sculley have envisioned is a market demanding simpler, easy-to-use, information based devices that are optimized for one or two tasks. Both Norman and Sculley's foresight envisioned IA's revolutionizing our current world of computing. A current world that is mostly based on multiple purpose machines (PC's) assisting with many tasks.

This current world of computing is dominated by the PC platform. Sculley and Apple recognized the challenges that this PC dominated world brought to the user as they set about trying to do everyday tasks. In 1988 Apple Computer set out on developing a new generation of "intimate computing devices". By 1991, Apple introduced the Newton MessagePad. The MessagePad was described as a highly portable smart device that would capture, organize and communicate information to and from anywhere in the world. Technology buffs mainly purchased the Newton, based on its "cool" factor. Apple sold 120,000 of the devices by 1993. 80,000 were sold in the first year. Sales didn't come close to the millions Apple expected and the Newton was finally pulled from the market in 1998.

But from today's perspective, the Newton is a landmark product for the PDA market. "It brought the concept of PDA's and handhelds into the computer vernacular, and it actually helped define what would and would not work," says Tim Bajarin, President of Creative Strategies in San Jose. A major assumption that led to the failure of the Newton was that Apple believed microprocessor power, at the chip level, was strong

enough to handle handwriting recognition. This was not the case and users were disappointed with the performance of the handwriting recognition interface.

Between 1993 and 1996 many companies placed new handhelds computers into the market with varying degrees of success. The company that seems to have gotten it right is Palm Computing, Inc. now owned by 3Com Corp. Sculley and Apple wanted the Newton to be all things to all people. On the other hand, Palm Computing believes “Let’s do one or two things absolutely brilliantly.” The device is mostly utilitarian, but highly productive. Today 5.5 million Palm devices have been sold. Today’s market is lead by Palm Computing, but both Psion and Microsoft are chasing the lead with their product entries. International Data Corporation expects the total number of handheld devices sold to reach 13 million by 2001. (www.palm.com)

Industry Description and Analysis

Key Technology Trends

As the market for handheld devices increases the involvement of many companies has speed up the development of handheld technologies. Also the cross pollination of technologies from other markets has helped to breed new and more efficient technologies for PDA devices.

Key and Bleeding Edge Technologies

With this shift in technological evolution many new technologies have become key to the handheld form factor. Internal systems such as embedded systems that integrate components into small chipsets are helping to make the PDA a more powerful tool for today's users.

The development of lightweight operating systems has also enabled the increased flexibility of handhelds. Light O/S such as Palm O/S TM and Epoch TM as well as lighter versions of full O/S such as Windows CE TM are bringing increased function to the once limited hands of users. Firms are also looking at adapting the popular desktop and server operating system Linux to the handheld arena.



Bleeding edge technologies such as Bluetooth TM and Jini TM are enabling greater device-to-device communications. This object technology will help the PDA device to add new functions without the drawbacks of higher power consumption by utilizing the functions of surrounding devices. This communication also extends to the outside world

as users seek to have devices that can access the Internet for email and content delivery. This results in the need for the device to communicate with a system of wireless towers for the mobile user to connect.

User interfaces are also seeing research time. As users demand better handwriting recognition, the current input method, as well as new input interfaces such as voice recognition. LCD screens are a bottleneck for many PDA innovations, as current technologies tend to consume power, have low screen resolutions, and are fragile.

Emergence of the information appliance prototypes

As innovations occur new devices are released to probe the market for acceptance and in many cases beta testing. Smart phones, two-way messaging pagers and other discrete task devices accompany new PDA devices into the market. These new devices are helping to provide the connection and tools for the increasingly mobile work force.

Some of these devices are entering the market at relatively low cost while others are at much higher costs. This probing of the market to see what price certain levels of technology has given managers in organizations lots of questions as to how profitable these new devices will be if left as discrete tools.

Innovation of new technologies is occurring

When looking at the PDA as a new innovation it seems to become reminiscent of the PC revolution. Making the comparison of the Palm to the IBM PCs leads to an interesting view of the current market. Soon after the roll out of the PC came the clones. Palm Computing's Connected Organizer has recently been cloned with the 100% compatible Visor™ from Handspring. At Fall Comdex 1999 Sony and Palm Computing

announced an alliance as Sony enters in as a consumer electronics company to utilize the Palm O/S in new ways.

The Palm O/S currently has approximately 15,000 applications that have been written (www.palm.com). Developers are in the form of individuals and firms specializing in handheld applications. Other complementary devices such as the Minstrel modem from Omnisky and AT&T Wireless Services (www.omnisky.com) extend the functions of the unit as well. These killer apps and others being developed for other handheld devices are becoming the spreadsheet of the PC revolution.

Embedded Systems

Companies are making the most of a tiny space. A hand-held computer's overall throughput depends on memory handling, how the display is cached and the efficiency of the CPU. The handhelds performance can also be greatly enhanced by building core system elements right onto the chip. This embedding of key system processes onto the chip gives many benefits such as smaller form factor and faster processing speeds to information appliance devices.

Semiconductor vendors are producing chip sets that allow OEM's to perform a variety of tweaks and optimizations on the basic processor core to obtain better power consumption, better performance, or lower cost. For example, to keep costs down, a



vendor might leave out fast infrared, high-speed data buses or digital protocols for wireless LAN even though the chip set may have those capabilities. The focus is on getting such peripheral features down to a manageable group and then porting them to small-geometry chips.

Typical peripheral chip sets now include 56K modems, universal serial bus (USB) and smartcards. Chipmakers are trying to leverage processor volume by allowing appliance OEMs to take out features they don't think their target market will want or need.

Examples of Programmable Chip Sets:

Motorola DigitalDNA™ (RF) technology is an open system that enables developers to add more function to the chip for better use of the system.

National Semiconductor SOAC (System On A Chip) technology allows for the key system functions to be built directly onto the chip allowing for smaller form factors and increased system performance.

Bluetooth technology. (Please see Appendix 2.)

Proliferation of simple and light operating systems

Despite Palm O/S dominance of the market so far it has not discouraged other competing operating systems. The other major player, Microsoft's Windows CE is in the process of a major overhaul. The extent of

the overhaul is not fully known. Psion's



Epoch has proven to be very popular in Europe and increasing in popularity in the North American markets. Linux is also in the process of being scaled down for use in handheld devices.

With the platform-independent Java technologies, Sun is extending the net all the way to consumer devices. Sun has plans for many devices ranging from smart cards to wireless phones to touch-screen kiosks. To build this new generation of network-ready information appliances, many device manufacturers are turning to Sun for fast, low-cost

Java processors, the lightweight JavaOSTM operating system, and other enabling technologies.

Enhanced user interface technology enters the market

The devices that run on the new operating systems will take off only if they are equipped with radically different, intuitive interfaces that make technology transparent to users. Researchers have been designing new interfaces to make both desktop computers and consumer devices more useful, efficient, and friendly. In 2000 these interfaces, which include voice-recognition and gesture-analysis technology, will become viable alternatives to the dominant Windows model.

Until recently, the needs of most desktop computer users were satisfied by what is referred to as the WIMP model -- a graphical user interface based on windows, icons, menus, and a pointer. Because the WIMP interface layers open documents directly on top of one other, navigating through them requires constant opening and closing of the windows. In an effort to solve this problem, Inxight, a subsidiary of Xerox's Palo Alto Research Center (PARC), has designed a next-generation desktop alternative to WIMP called Hyperbolic Tree. This component allows users to move quickly through large amounts of data by bringing documents in use to the center of the screen while branching related information to the periphery.

Voice-recognition and gesture-analysis technologies go even further by un-tethering users from their mouse and keyboard. Commuters could use voice-recognition interfaces, for example, to work while they drive. And Reality Fusion's FreeAction lets users interact with video-camera-enabled PCs by motioning with their hands. Gesture-

analysis technology is being touted as the perfect interface for interactive advertising and games.

And for the swelling ranks of people who rely on devices like personal digital assistants (PDAs) and mobile phones, developers are creating Spartan, easy-to-use interfaces inspired by the PalmPilot. Because they are often operated with one hand while driving or walking, these consumer devices increasingly will take advantage of scroll wheels, application buttons, and touch screens. Beverly Harrison, a research scientist with Xerox PARC, is developing interfaces that respond to the position in which a user holds the device -- for example, letting a user of a PDA address book flip through virtual pages by tilting the unit backward.

The traditional WIMP interface remains useful for standard word processing and number crunching, but these newer technologies prove that there's more than one way to interact with a computer. All these new interface technologies will change the landscape of what today is called a mini-browser.

Key Market Trends

The PDA market was created to fill the needs of an increasingly mobile society. These trends and market requirements will drive innovation and other important factors that will affect the future of the PDA.

The Cry for Convenience

Lower and lower prices have made personal computers more affordable than ever, but no easier for the average person to use. People want to access the Internet as easily as

they make a phone call or change the channel on their TV. Most users will continue to demand simpler, easy to use information devices that are optimized for one task.

Ease-of-use and affordability are key drivers needed to bring IAs to the masses. Only half of US homes currently own personal computers (Odyssey). Market research indicates that nearly 30% of US households that do not plan to purchase a PC this year cite affordability as a major deterrent. Another top concern when considering replacement of a current computer or buying a new system is that PCs are "too difficult or complicated to use."

Growth of the Internet

People are sending email and browsing the Web at a rapidly increasing rate. Home Internet use is up from 9 to 33 percent since 1995 - less than 5 years. (Odyssey) Market watcher Jupiter Communications predicts that 56 percent of US homes will have some kind of net connection by 2002. The Internet lifestyle is becoming a reality.

Content and services moving onto the Internet

The Internet has become a primary information source providing immediate access to hundreds of innovative services - ranging from checking local movie listings to purchasing a car to online investing. This is evidenced by the strong and continuing growth of web sites and domain names. Web sites have grown from 1 million in June of 1996 to over 7 million in June of 1999. This trend of migrating information content to the web will continue over the next several years, as businesses, individuals and organizations of all types realize the benefits of the Internet. This will lead to more

people turning to the Internet for information and entertainment. The PDA will be the device that will provide that access on the run.

Saturation of Markets for IT Investments

Many investment firms are finding themselves without prospective investments with strong market potential. They are again turning to the information appliance market, even though they were burned by it in early 1990's. As cellular phones and PDAs merge this will create a new excitement in the technology markets.

Flarion Partners has announced five investments in a \$50 million fund dedicated to moving computing away from the traditional desktop. Their investment fund is labeled the "Pervasive Computing Initiative" and is devoted to the idea that a great number of people will want to be connected to the Internet for short periods of time using specialized devices.

The business model for this type of investment plan is not new. Wireless service operators, for example, have been giving away mobile phones for years with the expectation that revenues on monthly service plans will more than make up for the fixed cost of the phones themselves. This concept has already spread to companies giving away PCs. It is believed that WEB portal companies will also have to adopt this business model and give away hardware to build loyalty, raise the cost of switching portals and increase user retention (Red Herring, October 1999). Additionally, many companies are being forced to consider the new non-standard information appliances as new platforms for their interactive messages. Interactive advertising will eventually have to move to these new platforms as user migrate their attention time to these devices.

Form Factor

Information appliances are driven by a friendly human interface including multiple form factors such as intuitive touch screens, pen/stylus, speech and handwriting recognition and graphical user interfaces. These lightweights, palm size personal access devices are designed to be handheld. They offer user-centered features like instant on/off Internet access, minimal start-up and no system crashes. They are providing a very simple interface to access the Internet as well as traditional PDA functions of calendar and phone book.

A personal access device features wireless connectivity, enabling unique portability that lets users surf the Internet, send and receive messages and view information from the comfort of their personal area. They offer quick, convenient access to real time information and allow interaction in multiple settings.

Growth of the universal network infrastructure

The convergence of voice and data on the Internet is one of the most prominent and disrupting technologies since the personal computer and networking was introduced. As communications hardware and software vendors keep introducing technologies that unify voice, video, and data networks, lower usage costs are emerging for all forms of communications, along with greater access to a wider array of services. As next-generation communications companies build new fiber networks and as cable operators upgrade their infrastructures, bandwidth capacity will continue its explosive growth rate.

Broadband multimedia services are on the horizon, as will a host of new communications devices capable of receiving these services. Enormous bandwidth at low

cost is becoming available through the emergence of broadband communications technology. The telecommunications industry is now focused on moving data, video and other objects in addition to the standard voice traffic.

Over the past year, communications providers began offering services that suggest that the Universal Network (Internet) is emerging. In June the long-distance carrier Sprint introduced Ion, a new network that provides vastly increased bandwidth over a single standard telephone line for simultaneous voice, video, and data transmission. Sprint joins newer service providers like Qwest Communications International and Level 3, which were both founded on the premise of providing integrated voice and data services. Also, Internet telephony companies continue to enter the long distance calling market (Pontin, 1998).

Underlying the Universal Network is Internet Protocol (IP), the packet-switching network layer that has proven to be very robust. The volume of voice communications across IP-based networks to continue growing in 1999, and look for data-networking equipment companies like Cisco Systems to propel the integration trend.

It is important to note, however, communications networks are not transformed overnight. Elements of the public telephone networks and private corporate networks, for instance, will remain largely unchanged for years to come. Existing investments must be protected, and not every type of communications will require full integration of data and voice. There will be times when a simple phone call will suffice (Red Herring, Dec. 1998).

Pervasive computing emerges

Pervasive computing is defined loosely as a computing architecture that allows for anytime, anywhere computing. A key component of this computing architecture is a large, sophisticated and available communications network that surrounds the daily activities in our physical world. Clustered within this network will be vast databases of information and user services. The network will be accessed through intelligent and network connected devices that are everywhere and available at anytime. These intelligent devices will be distributed into everyday objects available for completing some specific task. Computing for anytime, anywhere. Any type of information will have the ability to flow over any device.

Analysis of Key Market and Technology Trends

The personal computer has had a transfiguring effect upon business, society and economics. The PC was the first broadly distributed computer. Compared with the huge number of consumer electronics devices, there were never that many PCs and their uses were limited. Key market and technology trends point to a change in the state of computing, a state where intelligent networked devices will be everywhere, distributed into the ordinary objects of life.

In analyzing the market and technology trends, three broad trends are transforming computing and bringing in the era of information appliances:

1. The proliferation of cheap, powerful microprocessors running simple operating systems

2. The growth of the Internet into a Universal Network whose bandwidth is enormous and whose carrying costs are consequently free or nearly so, and
3. The saturation of existing markets for IT, which is forcing traditional computing companies and investors to look to new markets to grow.

The PC and the WEB do not seem to be the summit of digital technology. There is a new era of computing on the rise, the era of pervasive computing. This new era will follow the mainframe, the PC and the network in its evolution. Following the path of previous technologies, the pervasive computing technology points in the direction of not replacing existing ones, only making them less important.