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The MetaPad: A Disembodied Computer

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Stagnation of the PC

Personal Computers have changed very little in the last two decades in how they look and how we use them. A user approaches the computer and sits in front of it, viewing information on a display, and providing input via a keyboard and a navigation device, whether a mouse, trackball, pointing stick or touchpad. Much of the configuration and interface has remained constant for the last two decades. The biggest change in the life of the PC was in 1990 when Microsoft released version 3.0 of the Windows operating system with a Graphical User Interface and a mouse was included for navigation, modeled after the user interface of the Alto Computer developed by XEROX PARC in the 1970s. Since that addition, much of the way that a PC is used has stayed constant.

Notebook computers arose within the first five years of the PC, initially as luggables, seen first as the Osborne I, weighing 25 lbs. Notebook computers were mostly a form change from the desktop computer that allowed the PC to be brought to mobile work locations. As far as usability, notebook computers are essentially desktop computers that have been made small, retaining much of the same user interface as the desktop computer. Technological advances that enabled the success of notebook computers include thin and light LCD panels, improved battery technology and increased disk storage density. These technologies enabled notebook computers to be built with performance that was acceptably close to desktop technology.

Tablet computers have been available since 1989 when GRID introduced the first pen-based computer and have been mainly limited to the vertical markets. The new Windows XP PC Tablet operating system offers to add a new face to tablet computers, but the same impediments arise to inhibit their widespread adoption: 1) poor feel of writing on glass, 2) parallax of writing 3-4 mm above the display surface, 3) heavy weight, 4) awkward usability, balancing on one arm, and 5) fragility. It is expected that these deficiencies will diminish over time. Initial sales of the Microsoft XP PC Tablet operating system have been promising, with 72,000 sold in the fourth quarter of 2002, although many of the systems sold are convertibles that can be used as either notebook computers or tablet computers. Thus, it remains to be seen how broadly the tablet computer will impact the PC space.

Likewise, wearable computers have been limited to vertical markets and have not penetrated the mainstream personal computer user market. Wearable computers have been limited to specialized applications due to their poor ergonomics and cost premium compared to general purpose computers. The ruggedization and low volumes of wearable computers drive costs beyond the reach of anyone but large corporate or government customers.

The biggest change in personal computing in the last decade has been caused by the Personal Digital Assistant (PDA). The PDA provides a limited set of functionality and a view into a subset of the user's data through synchronization, often including calendar, address book, to do list, e-mail and small documents, spreadsheets and presentations. The PocketPC has enhanced that capability to provide limited viewing and editing of documents, but falls short of providing full Windows application compatibility.

The form and user interface of the PC have changed little in the last 20 years. This stagnation in the evolution of the PC has inhibited its penetration into other spaces and provides a motivation for exploring improvements that break the limitations of form.

PC Usage is Limited by Its Form

The form factor of a PC determines the places where and how the PC can be used. Thus, desktop computers are limited to work in a fixed place, laptop computers are constrained to places where there is a flat work surface or lap, and tablet computers are usable where there is a forearm or surface to rest the writing surface. A single user must either have several different personal computers, compromise in selecting a single system to meet all of the varied needs or give up the use of the computer in one or more of the settings.

The uses of a PC have also been limited by its form. As examples, try using your notebook computer to capture someone's voice while standing, typing on a notebook computer while standing, or using a tablet computer while performing a maintenance task occupying both hands. Likewise, a handheld computer can be used in more situations than a tablet computer that requires balancing the system on the forearm. Thus, the form of a computer is tied to how it can be used and in what spaces it can be used.

Considering that a PC is often limited in its use by its form, then a computer that could adapt to several different forms has a potential advantage. Conceivably such a computer could be used in a number of different ways and in more different spaces than a single computer with only one form and could be with an individual all the time, making it more useful.

New Technological Capabilities

New opportunities in advancing the PC form have arisen with progress in computer hardware technology. Moore's Law has driven processor performance to double every eighteen months. Memory chip capacity is doubling every 2 years and disk capacities are doubling every eighteen months.[1] These capabilities are growing faster than operating system or application requirements so that excess capabilities are now present.[2] With this excessive hardware capability comes the opportunity to tradeoff performance for lower power and smaller size.

As disk storage densities have increased faster than storage requirements, the size of disk needed to contain a user's data has decreased. Thus, while a 3.5" disk was needed to contain 7.5 GB of a user's data 6 years ago, a 2.5" disk would contain 15 GB of user data three years ago, and this year's 30 GB of user data can be contained on a 1.8" disk drive. Likewise, 8x12 mm FBGA memory packages and 512 Mbit memory parts allow 256 MB of memory to be assembled using 4 memory modules in 4 square cm of board area. Thus, the volumes needed for PC disks and memory are continuing to shrink at a rapid rate.

The integration of PC components required to lower the cost of desktop PCs have provided increased integration for mobile PCs, making smaller systems more feasible. Processors with integrated memory controllers and core chips with incorporating super I/O functions reduce the chip count and board area necessary to build a PC.

All of these technology improvements lead to the capability to build a standard PC architecture system with acceptable performance that is the same size as a PDA (16 x 80 x 120 mm) and will fit in a user's pocket. Is there any benefit from such characteristics for a PC? Once the size of a PC has been reduced to where it will fit in a pocket, are there new ways that the PC can be used or new applications that are enabled by this new level of portability?

Exploration of Critical Design Thresholds

Technological advances are enabling the PC to approach the size and battery life of a PDA. The success of the PDA can be attributed to the crossing of several thresholds by the Palm Pilot that made the device compelling, including pocketability and month-long battery life. Other attractive features of the Palm Pilot were the simple PC connection, the inexpensive price of $299, and simple ease of use.[3] These factors enabled the Palm Pilot to become the fastest-selling new consumer product in history, selling over a million units in its first year.

Likewise, notebook computers were not viable on a large scale until a number of technologies allowed the display resolution to approach that of a desktop, the battery life to be above 2 hours, the disk storage to be ½ of a typical desktop disk, the thickness to be below 2 inches, and the weight to go below the average baby birth weight. Before that laptops were designated as luggables and were a niche market.

Cell phones also were not large market devices until their size was reduced to where they would fit in a pocket and their battery life was increased to several days and talk times to over an hour. Additionally, cell phones were widely adopted only when there was a sufficient infrastructure so that coverage was prevalent in most densely populated areas.

The PDA, notebook computer and cell phone illustrate that there are certain thresholds in portability, battery life, communication and ease of use that enable new uses of computing and communications. Are there critical thresholds that still exist for the PC? Is there a connectivity infrastructure, wired or wireless, that would enable new usages? Is there a size of PC that will take it into new spaces and allow people to take it with them all the time? What are the critical thresholds that need to be crossed for the PC to fit into a new role? Besides size and battery life, what are the factors that will make the PC a desirable accessory? Or will the complexity of interacting with a PC limit its role to one where full attentiveness must be paid to the PC while interacting with it?

Enablement of New Usage Models

As we have observed, when devices reach certain critical sizes and convenience, they enable new usage models. Now that a PDA is small enough to carry in a pocket, it is useful for storing both work and personal information and becomes an indispensable personal device, much like the wristwatch, wallet or keys. As PDAs have become indispensable personal devices and the technology has advanced to where a PC can be a similar size to a PDA, the question arises as to whether a PC can become an indispensable personal device. And if a PC were to become an indispensable personal device, what would be the usage model?

A counter question arises: If communications is improving and I can always be connected, will I want to have my PC with me all the time? Can I instead access my PC across the network and reduce the amount of devices and weight I have to carry? Two answers address these concerns. The first is that continuous high-bandwidth connectivity is always one to two years in the future. As a practical matter, whatever bandwidth that is available when communications is present will be limited and a local computing device can serve as an information cache, providing rapid access to much of a user's information and providing continuous access even when communication is not present. Thus, even in the future when communications coverage improves, there will still be a need to access larger amounts of information faster than can be provided over remote communications networks.

METAPAD MOBILE MODULAR COMPUTER

The MetaPad was developed by IBM Research to explore new forms that the PC can take on as it moves into the future. The MetaPad embodies several new PC concepts that make it a unique design point and a vehicle for penetrating the PC into new spaces. As shown in Figure 1, the MetaPad is a modular PC. A modular core (3"x5"x3/4" and 9 oz) contains the processor, system memory, 3-D graphics, I/O support chips, hard disk drive and wireless adapters. This modular core can then be plugged into a number of different accessories to form a handheld, tablet, laptop, desktop, personal server or automotive computer as shown in Figure 1. The desirable attributes of the MetaPad include mobility, modularity, adaptability and decomposition.

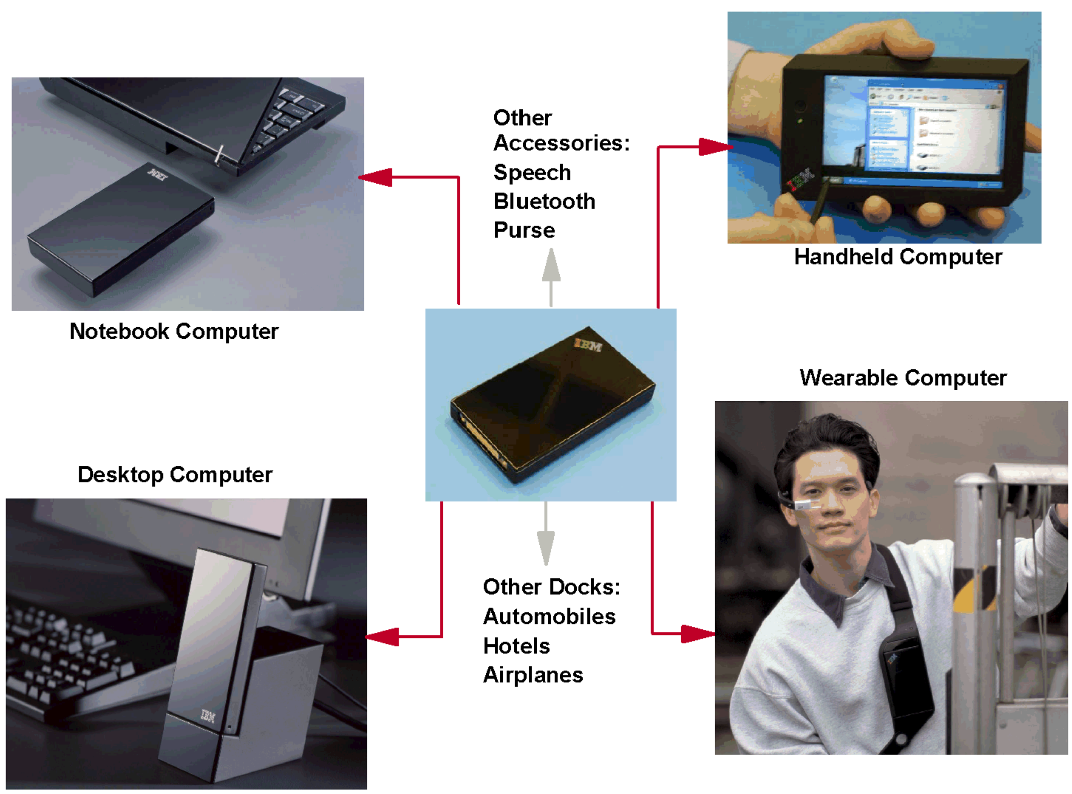

Figure 1. MetaPad Mobile Modular Computer

Mobility

The first design attribute of the MetaPad is mobility. As we have noted before, the success of the Palm Pilot can be attributed to its crossing of the pocketability threshold. The MetaPad modular core is approximately the same volume as the original PalmPilot and at 9 ounces is approximately the same weight. The MetaPad was designed to minimally cross the mobility threshold in fitting in a pocket, but as mobile PCs based on the MetaPad mature, they can be expected to become smaller and lighter, as we have seen in the evolution of the PalmPilot and PocketPC.

Modularity

The MetaPad was designed for modularity. Modularity means that the MetaPad core is a standardized unit allows a variety of use, through pairing of the core with a variety of separate interface accessories. This allows the computer to not to be constrained by a particular shape and form, breaking the existing shape and form limitations. The modularity also allows the interface accessories and core unit to be upgraded or replaced separately. The separation of the modular core from the interface accessory allows the modular core to be designed for the minimum size and the form of the interface accessory to be shaped to meet the specific need.

The specific design of the MetaPad is that the modular core will provide all of the capabilites that typically are always needed and do not change for different uses of the computer module. Thus, the first MetaPad design included the processor, system memory, hard disk drive, graphics, other support logic, and means for coupling the system generated heat to the accessory. After receiving customer feedback on the need for embedded wireless capabilities, WiFi was included in the second version of the MetaPad modular core.

The accessory provides power from either AC or a battery, a user interface and cooling. The handheld MetaPad accessory includes a small display, touch screen and battery. Feedback from the initial MetaPad design led to the inclusion of a built-in microphone in the handheld accessory to support voice recognition software.

One major design objective of the MetaPad was to create a modular PC system where accessories are inexpensive and can become pervasive. Putting more of the cost in the modular core supports two opportunities in the vision of modular computers: 1) the use of multiple accessories with a single modular computer core and 2) the pervasive spread of docking adapters in stationary locations including hotels, airports, automobiles, airplanes, hotel offices and libraries. The components included in the core were chosen so that a diverse set of accessories would not all have to include the same components and a stationary docking station could be realized by passive wiring to display, keyboard and power connectors. Further, the minimization of cost and complexity of the accessory allows for short design time of customized accessories, such as ruggedized systems for the military or transportation industry, or tablets with keypads and bar-code readers for the retail industry.

Added Size and Weight

The major disadvantages of a modular design are added size, weight and compromised design. To make a modular system requires that additional connectors and intermediate layers of system covers be added, increasing size and weight over a single integrated design. Actually, any time an individual carries multiple devices, such as pagers, PDAs and phones, there are additional covers and weight beyond what a single unit would require. Additionally, multiple communicating devices are present, additional battery capacity is necessary for supporting the communication between devices. As long as a modular system fits within the pocketability threshold, the additional size due to modularity is an inconsequential disadvantage.

Compromised Design

One additional potential disadvantage of a mobile modular computer is that it is a compromised desktop design, i.e., a full performance graphics adapter cannot be included, nor can 2 GB of system memory. With personal computing capabilities increasing faster than our ability to exploit them, this issue will be decreasing in importance. Thus, a top-end full PC is not required by the typical user using word processor, spreadsheet and web applications. Every good system design is a compromise, with its attributes optimized to the user's needs, providing the highest performance for a given cost, weight and size. The MetaPad is no different than any other system design in that a set of system components was chosen to best support the desired modes of operation: supporting full Windows and Linux applications in a mobile environment.

Single System Image

The biggest advantage of modularity is that it allows a single system image to be used in a number of computer forms, alleviating synchronization. Thus, the same mobile modular computer can be configured as a handheld, a tablet, a laptop or a desktop allowing the same data to be accessed in all these forms without requiring any synchronization. Having a single system saves support costs as only one system must be maintained and the communications between multiple systems can be eliminated. This single system image has major advantages in software costs as only one copy of the operating system and applications are required.

Business Model Change

While there are certain advantages and disadvantages of a mobile modular computer, the biggest potential change would be the impact on the personal computer business model. Today, PCs are purchased as integrated units and other accessories may be added to complete the system. When a mobile modular computer is purchased, the modular core is purchased and several different accessories are purchased to allow it be used in different forms. The difference in the business model is that desktop, laptop or tablet computers are no longer purchased separately, but become accessories that are bought for use with the modular core. The PC market transforms from system unit sales to accessory sales.

Another change in the business model is that when it is time to upgrade the computer, a whole new desktop or laptop system would not be purchased as is currently done, but the modular core could be upgraded if a faster processor or more memory is needed and the interface accessory would be upgraded if a higher resolution display or different I/O were required. Thus, between the changes in system purchases and the changes in system upgrades, the mobile modular computer could radically upend the PC business model.

Adaptability

A key required characteristic of a modular computer is adaptability. For a modular design to be useful, the modular core must sense the accessory interface and system environment and adapt its behavior to provide the proper connectivity, software interface, performance, battery life and cooling. For example, when a speech accessory is attached to the MetaPad modular core, the modular core recognizes the attached accessory, disables graphics and launches the speech recognition software. Likewise, when the modular core is inserted into the dashboard of an automobile, it launches GPS, voice recognition, dialog management, and MP3 playback software and connects to the automobile's GPS and sound systems. Thus, the MetaPad can provide core functionality for navigation, trip planning and digital audio.

The MetaPad provides adaptation of the system performance to match the performance required in a given accessory. For example, a handheld accessory will typically be used for viewing information and does not require the full performance that a desktop or laptop configuration used for content creation would require. This allows the thermal solution and battery capacity in the handheld accessory to be scaled back, enabling a smaller, lighter handheld accessory. Additional software can be launched for this accessory, such as a touch screen keyboard. Thus, for handheld and notebook accessories, the performance, display resolution, user interface, battery life and thermal solution are all adapted to suit the accessory.

Disembodiment and Decomposition

The MetaPad and the variants of computers described above fit into a newly emerging class of computers that is variously called disaggregated,[4] decomposed or disembodied.[5] Each of these terms emphasizes slightly different aspects of what is accomplished, disaggregated and decomposition communicating the concept of separating the system into component or constituent parts. The less specific term, disembodied, means to divest of a body, an apt analogy for a computer where the heart has been removed and the notebook or desktop body that normally gives it its characteristic form is no longer present. Thus, while concepts that break the computer into many parts may primarily be called disaggregated or decomposed, the MetaPad, which removes the computer from its form might most appropriately be called a disembodied computer.

MetaPad Technical Description

The technical specifications of the MetaPad were driven by the desire for a modular PC with performance comparable to a current generation notebook computer, while minimizing volume and power. This translates to maximizing Mhz/watt/cc/Kg. With a design decision to minimize the complexity and redundancy of components in accessories, the accessories become nearly passive devices, mainly providing standardized I/O connectors and human interface functions.

The MetaPad core contains an x86 compatible, variable frequency (300-800Mhz) Transmeta 5800 processor that utilizes a 0.9-1.3v variable core voltage, supporting both Windows XP and Linux operating systems. The single system board also contains 128MB SDRAM, 3D graphics subsystem with 8MB of video memory, PC Card controller, and audio amplifier. Circuitry to support external devices via the docking connector include 3 USB ports, analog and DVI digital video, PS/2 mouse and keyboard, audio in/out, and docking control signals. The modular core power supply provides power to the system board and external interface accessories. A NiMH battery is present in the modular core to provide 1.6 hours of standby to RAM (suspend) capability to enable warm swapping in less than 30 seconds between accessories. The core assembly also includes an 802.11b wireless card and a mechanically isolated 1.8" 10GB HDD.

The MetaPad modular core is housed in a machined aluminum alloy case with dimensions of 18.5 x 72 x 126 mm. The partially slotted back surface comprises part of the thermal solution providing passive cooling and heat spreading for the components on the system board and enabling active fan cooling by accessories. The single docking connector and mechanical guide receptacles are located on one of the small ends, and LED status indicators and wireless antenna are located on the opposite end. The weight of the assembled MetaPad core is 257g.

The MetaPad modular core docking connector provides the I/O signals and power necessary to implement various interface accessories. The docking connector also includes signals for power control, docking verification, and accessory identification. The core has the capability to query and identify the attached accessory and modify its behavior and operation accordingly. For example, when warm swapping the core between the handheld shell and the desktop dock accessories, the user interface changes from touch screen input and a 800x480 screen resolution, to an external mouse and keyboard and the desktop display that was detected by the desktop dock.

Accessories

To enable a compact computer form factor, a handheld shell interface accessory was developed with a 5.8” 800x480 backlit active matrix LCD display, a resistive touch screen, and a removable 15.1Wh lithium ion rechargeable battery. The shell accessory also contains a battery charger and USB, audio, and power connectors. The combined size of the handheld configuration is 30.5 x 170 x 102 mm weighing 647g.

For desktop usage, a dock accessory was developed to provide a mechanical stand for the core, active fan cooling, and fanout to standard I/O connectors for USB, PC Card, PS/2 ports, audio, and analog (VGA) and digital (DVI-I) video connectors. A similarly capable dock could also be built in the back of a display to provide an ultra-small footprint PC.

The handheld and desktop dock accessories, shown in Figure 2, were the two examples of accessories that were actually built to demonstrate the broad range of accessories possible for a modular computer. Other potential accessories could have different LCD sizes, varying from PDA size to tablet size. For a wearable computer application, the accessory would consist of a small battery pack and a connector to attach an audio enabled head mounted display. Laptop, dashboard and airplane seat accessories are other examples of potential accessories.

Power and Thermal

While the MetaPad system uses both active and passive cooling, the thermal management within the MetaPad core is accomplished solely via passive cooling. Components on the system board and the HDD are thermally coupled to the aluminum case with the use of boron nitride filled silicone elastomers. Data from temperature sensors located on the CPU die and the system board is used to limit the MetaPad's thermal output if the operating conditions cause the temperatures to rise above a programmable value.

In addition to passive cooling and heat spreading provided by the aluminum case, additional cooling is provided by conduction to the accessory, via direct contact with adjacent mating surfaces, as well as through the docking connector guide pins. When the MetaPad is docked to a larger accessory, such as a notebook or desktop, active fan cooling can be provided to enable continuous operation at maximum performance, without thermal limitation. The fan is also actively controlled with the core's internal temperature sensors, which enables low speed (quiet) operation under most usage scenarios, with higher cooling capability as necessary.

USAGE MODELS AND USER SCENARIOS

There are four prospective usage models that can be imaged for a future pocketable personal computer: 1) the micro-PC, 2) the PC Phone, 3) the Personal Server, and 4) the Modular Computer. The potential evolution of these devices is shown in Figure 3. The major differences in these usage models is the interface that is used to access the information on the personal computer.

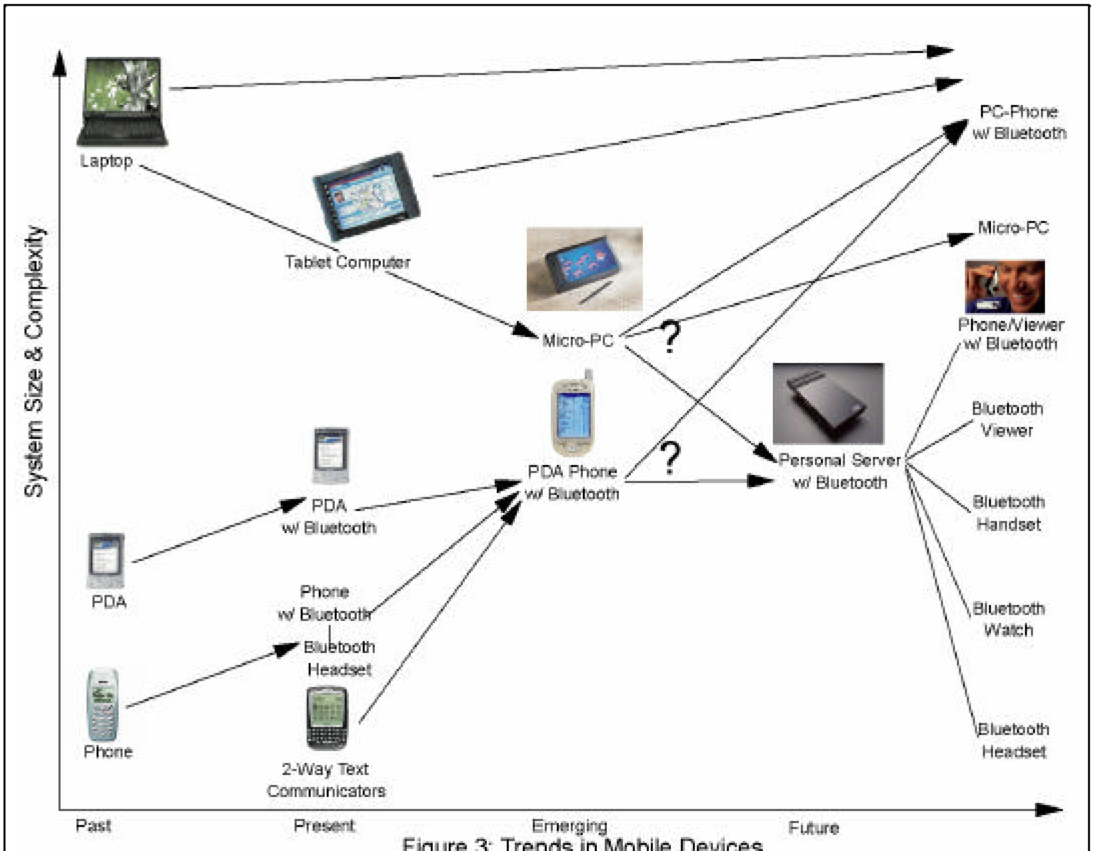

Figure 3: Trends in Mobile Devices

Micro-PC

The micro-PC usage model is an extension of the PDA. The micro-PC would have one user interface built-in that is typically used for all interactions. This could be a built-in display with a touch screen or a miniature keyboard and potentially quick access buttons for frequently performed functions. The micro-PC model would use the PC as an all in one unit as seen in Figure 3, most frequently used independently of other devices.

The PocketPC is a PDA that is approaching the micro-PC in functionality. The PocketPC, since it does not provide full Windows 32 application support or an architecture with permanent storage cannot be regarded or used as a full computer, so falls short of the micro-PC concept. Early micro-PCs have been announced as the Tiqit[6] and OQO[7] computers. Both have four inch diagonal displays and the Tiqit has a small keyboard for data entry. The usability of both systems is limited due to difficulty of using a Windows on such a limited display area device.

PC-Phone

The full integration of the Personal Server with communications and the display and I/O interface produces a single device capable of acting a phone, PDA, MP3 device or personal computer. The PC-Phone will look like a large PDA, but provide all of the functionality of a full PC, running a full Windows or Linux operating system. An example of such a device is shown in Figure 3. This device will be the most challenging to design to reduce the volume and weight to the point where it will fit in a pocket and be comfortable for making phone calls, yet will have a display large enough to provide the full Windows PC interface.

Personal Server

The third potential usage model is a Personal Server. In the Personal Server model, the computer system is configured with a battery and a wireless network connection such as 802.11b or Bluetooth and no direct I/O interface. The Personal Server can then be placed in a location that is close to the user so that it can be accessed wirelessly, such as in a purse, briefcase, pocket or belt-holster. The information on the Personal Server can then be accessed by a number of different accessory devices including cell phones, PDAs, Bluetooth enabled watches, MP3 players, or a wireless personal viewer.

The Personal Server model provides the opportunity for a number of accessories that work together with the Personal Server. The personal viewer would be a device that is specifically designed for accessing and displaying information from the Personal Server. Another accessory possible for the Personal Server configuration is a personal mobile gateway, such as envisioned by IXI[8]. This device would reside close to the Personal Server and would provide routing to a cellular network so that Internet and voice communication can be maintained. With such a gateway providing a voice communication channel, a phone now becomes a Bluetooth connected handset or headset accessory.

The effectiveness of the Personal Server is dependent on low power communication with low overhead and the proliferation of inexpensive accessory devices. The cost of accessory devices is driven low because the accessory devices become general purpose, useful for viewing data from other Bluetooth accessible devices. IBM has previously explored a Personal Server in the miniaturization of the PC in a wearable computer prototype, the IBM VisionPad, which was a standard IBM ThinkPad 560 design shrunk to the size of a paperback book. The Personal Server concept has also been explored by IBM, Intel, Motorola and other computer companies, most frequently in the form of an IBM Microdrive disk, a low power processor and Bluetooth communications.

The Personal Server model can be extended with further functional integration to directly incorporate a cellular modem into the server. Typical accessory devices would be audio accessories for phone and MP3 functions and display accessories for accessing information from the Personal Computer and Communications Server. An example of such a device is shown in Figure 3.

Mobile Modular Computer

The Mobile Modular Computer enables several of these mobile usage concepts while retaining access to the data that is used in other configurations. The Mobile Modular Computer usage model would have a modular core to which a number of different user interface accessories are attached to provide different user interface capabilities. The MetaPad in its current form is an example of a Mobile Modular Computer. To form a Micro-PC configuration, a handheld display accessory is added to the MetaPad, the PC-Phone is formed by adding a display with embedded phone capability and a Personal Server can be formed by adding an accessory with a battery and Bluetooth communications.

Some other potential interfaces for the MetaPad are shown in Figure 1. Thus, a user of the Mobile Modular Computer could choose whether they wanted to use a handheld, laptop, tablet device, wearable, car mounted or desktop mounted device. The Mobile Modular Computer configuration as a handheld is slightly larger than the dedicated Personal Computer Assistant model. To explore the Mobile Modular Computer usage model, the modular core should be pocketable and should enable computers that are wearable and handholdable.

User Scenarios

The new mobility and freedom of access provided by the modularity of MetaPad breaks through the form factor limitations that have constrained the use of desktop and notebook PCs. MetaPad bridges the gap between large, enterprise IT infrastructures and previously distributed, disconnected mobile professionals, manufacturing environments, equipment maintenance and repair facilities, retail sales and medical services, putting sophisticated computing resources right at the finger tips of the workers or professionals directly engaged in conducting business. For mobile workers, MetaPad's modularity also provides a smooth, natural link between the home, office and mobile environments. Consider the following MetaPad user scenarios:

Manufacturing and Equipment Maintenance

While computing technology is widely used in today's large manufacturing facilitates or equipment maintenance depots, it is typically partitioned into two separate environments. One that controls the manufacturing equipment and processes, or is built into the equipment being manufactured (such as a commercial aircraft), and another for administrative, scheduling and other conventional IT data processing services. The separate environments coupled with the access and usage limitations of traditional PCs inhibit the value of computing in these situations. As an example, consider a typical manufacturing scenario encountered by an aircraft assembly worker named "Liz". Upon arriving at her desk on the manufacturing floor, Liz inserts her MetaPad core into a docking station connected to the IT network and brings up the schedule for today's airframe assembly, and the status of work on airframes during the overnight shift. Liz sees that a problem was detected overnight with the onboard computing and control system on the widebody plane being outfitted for Hula Airlines. Since Liz's expertise is trouble shooting computer problems, the defective program and information describing the "bug" are copied to Liz's MetaPad for her review. However, before she is able to look it over, an instant message comes through to her from the floor supervisor, inviting her to attend a staff meeting. On her way to the meeting, Liz inserts the modular core into a handheld accessory, and brings up the defective program. Reviewing it she quickly sees the problem, corrects it and recompiles the program. At the conclusion of her meeting, Liz walks back to the manufacturing floor, and over to the Hula Airlines plane. She removes her modular core from the handheld accessory and inserts it into the docking slot in the airplane cockpit, and loads the corrected program into the flight control computer for in-situ testing. Following the test, the onboard aircraft manufacturing log information is updated, and copied to Liz's MetaPad. Finished with the repair, Liz removes the modular core from the dock and returns to her desk where she reinserts the core into her desktop dock. Information on the Hula Airlines correction is transferred to the IT network, and Liz receives directions and data on her next trouble shooting task.

Telematics and the Mobile Professional

The telematics, or automotive, usage scenarios for the MetaPad modular computer span both the personal consumer and enterprise commercial market segments. In the personal segment, the growing need for computing mobility in personal lives, such as long daily commutes or weekend pleasure trips, has positioned the automobile as a natural extension of the home and working environment. As such the automobile has adopted many of the high technology and personal comfort features found in today's home or office: comfortable surroundings, automatic controls, communication or phone connection, audio and video entertainment systems, and others. The movement of individuals between their home, office and car (or even multiple, different cars), presents a significant technological discontinuity and ease-of-use barrier from computing, communication or entertainment systems used in the home and office. The MetaPad's modularity can remove this discontinuity, making the transition from home to office to automobile nearly transparent to the individual. Consider for example, the scenario of a mobile business professional named "Bob". At home in the morning, Bob uses his MetaPad modular core in a desktop configuration connected to a large display, a broadband network Internet connection and his corporate e-mail and collaboration software environments, and to a home entertainment system to read and respond to his e-mail, while selecting digital audio selections and sipping his morning coffee. Before leaving for work he selects music to listen to while commuting to work, and the next chapter of the electronic "books-on-tape" he has been reading, automatically transferring them to the MetaPad modular core. Removing the MetaPad core from the docking station and walking to the car, he simply inserts the core into a small slot in the dashboard of his car. Upon starting the car, the MetaPad resumes running, and is connected to the car's dashboard LCD display, audio/stereo system, built-in cell phone, Global Positioning System and even the car's own internal control and maintenance computer system. Sensing the environment it is now operating in, it configures its application and user interface for the automotive surroundings and accessing Bob's calendar information on the MetaPad, and knowing the exact time and location of the car, MetaPad can then launch a control program to converse with Bob:

MetaPad: "Good Morning, Bob! It's 7:30 AM, Tuesday, May 13th. Your first appointment today is at the office. I've checked the road and traffic conditions and have found your normal route is blocked due to an accident. I've plotted a new route for you and am displaying it on the screen."

Bob: " Thank you MetaPad, I'll use that route. Please play the music I brought with me. Also, I'd like to download and browse the presentation material for my meeting. "

MetaPad: "All done, Bob. The presentation material is on the screen for you"

Bob: " Please change the order of the first two charts and save this."

MetaPad: "Bob, the car computer is indicating that it will be needing brake system maintenance in the next week. I'll mark your calendar with a reminder to make an appointment at the dealer."

Upon arriving at his work location, Bob removes the MetaPad core from the dashboard and carries it into his office, where he inserts it into a notebook shell with wireless network connectivity. Appearing on the notebook desktop, ready for use in his first meeting is a link to the presentation material he revised in the car.

This scenario for the mobile professional can be extended beyond the horizon of the personal automobile, home and office to encompass many other aspects. For example, while traveling on an airplane to attend a remote business meeting, Bob can utilize the MetaPad core in a small, mini-tablet format to read and respond to e-mail and create or edit presentation materials, and at his destination, Bob can use desktop docking and networking environment in the hotel to view his personal DVD and home digital movies taken over the weekend or at a docking station in the office of the company he is visiting.

CONCLUSIONS

Technological advances are making pocket-sized PCs possible and are opening up new opportunities for using the PC, potentially breaking the stagnation of the Personal Computer. The PC does not have to be consigned to commoditization, but can be revitalized by pushing its form into new spaces and enabling new usage and business models. The commoditazation of the PC market threatens to deaden innovation and further stagnate the PCs advancement.

The MetaPad is a new PC concept developed by IBM Research with new attributes designed to enable new PC applications and to exploit new technological capabilities. Through the MetaPad, we hope to explore new usage models of the PC and push technologies that allow further advancement of the PC into the mobile device space. Between the MetaPad and emerging new micro-PCs, the PC faces a new future that's smaller, but grander. In this future, new and different challenges await, reconciling the small device size for portability with the need for a usable interface. This user interface requirement will open up new opportunities for advancements in user interfaces and multimodality, spurring the growth of pen and speech interfaces, potentially revolutionizing the personal computer and making it more "personal" than computer, providing a computer that we can use when and where we need it.

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