POCKET PC TECHNOLOGY IN AN ADVANCED DISTRIBUTED LEARNING ENVIRONMENT

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ABSTRACT

A primary goal in an Advanced Distributed Learning system is to provide effective training anywhere and at anytime. One possible method of achieving this goal is to use Pocket PC technology in a stand-alone environment or integrated with PC-based and web-based training applications.

This paper will discuss the roles that Pocket PC technology may play in the military's future. These roles will be discussed further to show the current state of technology in achieving these goals. The key challenges in developing secure wireless applications in an Advanced Distributed Learning environment will be outlined and the advantages and disadvantages of various hardware architectures will be discussed in great detail.

This paper will look in detail at the special operating capabilities required to meet the mobile computing needs of the military. At a minimum, it will address the core needs of security, reliable data transactions, scalability, manageability, usability and synchronization of data through wireless connectivity options such as 802.11x, GSM and Bluetooth. Software development architectures will be profiled to include client/server-based applications, integration with ODBC applications and web-based applications. 3D rendering capabilities and software tools to create 3D content will be investigated also, as the potential role of 3D applications for distributed learning on the pocket PC is explored.

There are a host of third party development tools, middleware applications and new software products that will play critical roles in promoting the rapid development of next-generation wireless training applications and services for the military's ADL Program. These tools and applications will be surveyed to provide a quick roadmap to get information out of the classroom and into users' hands, while allowing developers to incorporate third-party products as part of the solution, when they wish to do so.

ABOUT THE AUTHORS

Since 1997, Brent has served as Chief Technology Officer, Vice-President, Director of Development and Project Manager for ECS, Inc. He has proven skills in building strategic affiliations to manage and solve complex training issues for a variety of clients. Mr. Smith is a frequent speaker on the topic of simulation training development and has helped design and teach a course on game engine design at the University of Central Florida. He has also spoken at the Architecture & Engineering Conference, the Advanced Technologies Forum at the Conference for Minority Transportation Officials, the National Research Council and the National Association of SIMMOD User's Conference. He has also written articles for various trade publications such as Airport Council International magazine.

Bill Pike serves as the Lead Principal Investigator for Advanced Distributed Learning (ADL) for the United States Army Simulation, Training and Instrumentation Command (STRICOM). In this role, he manages a Science and Technology Objective in partnership with the US Army Research Institute. Bill began his career with the US Air Force at Eglin Air Force Base as a co-operative education student in 1986. Upon graduation from the University of West Florida with a BS in Systems Science, he became a full-time employee of the 3246 Test Wing as a computer scientist. In 1989, he transferred to the Naval Training Systems Center (Naval Air Warfare Center Training Systems Division) in Orlando. Upon completing his Masters in Computer Engineering from the University of Central Florida, Bill received a Direct Commission as an Engineering Duty Officer in the Naval Reserves. Shortly thereafter, he received a promotion to move to STRICOM's Information Systems Division.

Bill transferred from the Information Systems Division to the Engineering Directorate in 2000. Since then, he has been instrumental in defining research and development topics for STRICOM's ADL efforts. Recent topics have included PC game engines for pre-live fire training, commercial game engines to simulate an actual C4I system and utilizing Personal Digital Assistants (PDAs) for true anytime, anywhere training.

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PROLOGUE

The vision of the Department of Defense's (DoD) Advanced Distributed Learning (ADL) initiative is to harness the power of the Internet and other virtual or private wide area networks (WANs) to deliver high quality learning. It brings together intelligent tutors, distributed subject matter experts, real time in-depth learning management and a diverse array of support tools to ensure a responsive, high quality "learner centric" system[1]. In the future, technology will continue to increase the features and functionality of these systems. These cutting-edge training programs allow for information to be randomly accessed and explored on many levels. Information will also be more relevant and up to date for the trainee to access at any time. Training programs may be tailored to each individual trainee. This allows the learning process to be centered on the student.[1]

INTRODUCTION

The potential of the handheld PC presents exciting opportunities as well as massive challenges. The convenience and flexibility of mobile services anytime and anyplace is matched by the complexities and risks associated with development for these platforms. As the power of these small, personal computers increase, more applications are being transferred to them. Software developers need to be aware of important issues regarding software development for these platforms such as media transmission rates, memory resources, user interface, power requirements, processing core architectures and development environments.

The introduction of new wireless technologies allows the industry an opportunity to offer new content. With the "coming of age" of wireless technology, Personal Digital Assistants (PDAs) are competing with another set of devices. At the same time PDAs are adding cellular connectivity and wireless data functions, cellular handsets are adding computing power and better graphics systems[2].

Wireless devices are extremely constrained computing devices with limited CPU, memory and battery life with awkward screens and keypads. Wireless networks are strangled by low bandwidth and high latency, as well as unpredictable availability and stability[3]. Compounding the challenges of wireless development are the different technologies that may be used in carrier networks.

Handheld PCs should not be considered alternatives to PCs but rather a completely new means of interacting with an application. Certain tasks will be tailor-made for handheld PCs, while others will always require the power of a desktop or laptop PC. With the abundance of handheld devices available and the differences between them, developers must tailor applications to accommodate the specific devices that will access those applications. The most effective applications will be those that marry users' demands with the technology options available on a particular device.

CURRENT STATE OF TECHNOLOGY

Handheld PCs use embedded processors. The performance of embedded microprocessors rivals that of PCs of just a few years ago. With clock frequencies of up to 400MHz, these chips offer better performance than ever before. Their high performance levels, combined with low power requirements, are enabling a new generation of features and functionalities to be incorporated into handheld PC applications.

Advanced RISC Machines (ARM) is the industry's leading provider of 32-bit embedded Reduced Instruction Set Computing (RISC) microprocessors with almost 75% of the market[4]. ARM offers a range of processor cores based on a common architecture that deliver high performance together with low power consumption and system cost.

A microprocessor's "architecture" defines the instruction set and programming model for any processor based on that architecture. Examples would be the ARMv5TE and the ARMv6 architectures described below. The architecture describes the rules for how the microprocessor will behave without constraining or specifying how it will be built. The definition provides the specification for the interface with the outside world, which enables operating system, application and development support to be planned and implemented. The term "microarchitecture" refers to the implementations of those architectures, such as the ARM9™ and the ARM10™ families of cores.

The Embedded Feature Set

In February 2002, Intel announced the first of its new line of applications processors for handheld computers. The Intel PXA250 will have a performance range from 200MHz to 1GHz. At the core of the Intel PXA250 is an Intel Xscale microprocessor, a 32-bit RISC microarchitecture based on the ARMv5TE architecture. The PXA250 promises higher speeds and greater power than the current generation of StrongArm based processors developed around the ARMv4 instruction set architecture.

One major enhancement of the PXA250 is the addition of the ARM 16-bit Thumb® instruction set. Code density describes the space needed to store code in memory. RISC chips generally have significantly larger programs than Complex Instruction Set Computing (CISC) processors requiring more memory to store the same amount of code. Thumb technology improves this situation by compressing software density by about 30 percent over normal RISC code. This compression is handled automatically by the PXA250. Another improvement in the Intel Xscale core is the dual-multiply/accumulate (MAC) instruction. A MAC operation has been borrowed from the Digital Signal Processor (DSP) world. MAC operations are vital to many audio, video and wireless applications.[5]

The Intel PXA250 contains a number of peripheral features and functions. It includes an integrated Universal Serial Bus (USB) interface, an LCD controller capable of 800 x 600 resolution with 65,536 colors, integrated controllers for external memory, serial buses, parallel buses, wired and wireless communications links and expansion cards.[6]

Motorola has also had a lot of success with its DragonBall Microprocessor, which currently acts as the brains of Palm-based PDAs made by Handspring, Sony and Palm. The DragonBall has historically been based on the Motorola 68K architecture. Motorola has also migrated to the ARM architecture by incorporating the ARM920T™ microarchitecture (based on ARMv4T architecture) into its new DragonBall MX1 microprocessor. This microprocessor also includes the 16-bit Thumb instruction set and operates at 200MHz.

The needs of emerging products and evolving markets drive next generation architectures. The ARMv6 architecture has been developed by working closely with architectural licensees such as Intel, Motorola and Texas Instruments. The first implementations of ARMv6 are underway and should be rolled out in late 2002. The new ARM11 microarchitecture shares many common features with the Intel Xscale microarchitecture, but implements the ARMv6 instruction set architecture that includes the Thumb® extensions for code density, Jazelle™ technology for Java™ acceleration, ARM DSP extensions, and SIMD (Single Instruction Multiple Data) media processing extensions to enable more efficient software implementation of high-performance media applications such as audio, video and 3D graphics. The ARM11 forms the basis of a new family of ARM11 cores with a performance range from 500MHz to 1GHz.[7]

Multi-Processing

Application convergence is driving system implementations towards the need for multiprocessor systems. A single microprocessor typically provides the performance needed for applications normally found in today's PDAs, but it is inadequate by itself for handling streaming video and other multimedia applications. Second and a half generation (2.5G) and third generation (3G) wireless platforms typically demand integration between multiple applications processors, digital signal processors or other application accelerators.

The vast majority of today's voice-only, second-generation (2G) wireless communications devices are based on a dual-processor architecture featuring a DSP and a general-purpose processor. In this architecture, the DSP handles many of the communications tasks, such as modulating and demodulating the bit stream, coding and decoding, encryption processes for security and compression/decompression algorithms. The second processor is assigned general-purpose tasks.

Texas Instruments developed a unique dual-core architecture that combines the command and control capabilities of a TI-enhanced ARM 925 processor with a high performance, low power DSP core. This OMAP 1510 application processor runs at 175 MHz and has been optimized for power efficient execution of key multimedia applications. It also includes MPEG–4 decoding and encoding, MP3 decoding and encoding and advanced speech recognition. The LCD controller on this solution will support monitor resolutions of up to 1024 x 1024.[8]

Multiprocessor systems need to share data efficiently through shared memory. The ARMv6 memory management unit (MMU) is important in ensuring that processors get predictable and consistent use of memory when it is shared between multiple processors. When memory is shared between multiple processors, the ARMv6's Memory Management Unit (MMU) ensures the processors get predictable and consistent use of that memory. Load and Store Exclusive Instructions have also been added in ARMv6 to support semaphores, which are used to synchronize tasks in a multiprocessor system.

One key concern in a multiprocessor system is optimizing the software to take advantage of the architecture. In a dual-core platform, the developer needs to decide which portions of the applications run better on the DSP and which run better on the microprocessor. Well-balanced software architecture enables the most efficient use of the system.

Embedded Graphics

The increased bandwidth available with new wireless technologies coupled with the increase in microprocessor speeds requires mobile systems and applications to deliver audio, video and graphics rich content. This digital convergence creates the demand for more advanced graphics capabilities to provide higher frame rates and crisper displays.

2D graphics accelerators, such as ATI's Imageon™ 100 media co-processor, replace existing LCD panel timing controllers and assist the CPU in optimally handling graphics functions and controlling the display. This solution uses embedded memory as a frame buffer for standard PDA resolutions. It also uses an integrated memory controller for support of external SDRAM for resolutions of 640 x 480 with 16-bit color. Additionally, it includes hardware acceleration for MPEG-4 decoding.[9]

Integrated 3D graphics cores are the next step in the evolution of handheld technology. 3D graphics refer to the systems used to create and display a modeled environment in a realistic way. The environment is typically constructed from objects made up from wireframe meshes of adjoining polygons, each defined by its vertices. Each vertex has a number of properties including position in 3D space (x, y, z) and color. To allow users to interact with the 3D environment, the entire model must be processed to display a new image on screen. This process is accomplished in three steps: transform and lighting, hidden surface removal and texturing and shading.

Transformation alters the world as objects move within it or as a users point of view changes. Lighting then performs the calculations necessary to simulate the effect of different lights on objects in the scene, ultimately affecting the color of each vertex as a result. Finally texturing and shading determines the color of each pixel in the scene by taking into account both the color of the polygons and their texture. Textures are stored in memory and the relevant pixel from the texture map is retrieved and used to texture each pixel before it is written into the display memory.

In February 2001, Imagination Technologies and ARM announced the PowerVR® MBX graphics core. This core is designed for integration alongside ARM microprocessor cores. A companion vertex geometry processor (VGP) is also available for transform and lighting (T&L) operations. This solution uses a screen-tiling technology to reduce the memory bandwidth and power consumption while delivering PC and console quality 3D graphics. Screen tiling can eliminate all redundant processing and memory bottlenecks by processing only what is necessary on the chip and minimizing accesses to off chip memory. This is accomplished by partitioning groups of polygons into small "tiles". Each tile is rendered independently. Because the "tile" is only a small subset of the whole scene, this solution implements hidden surface removal on the chip and uses an on-chip "frame buffer tile" as a local storage area. This means that the majority of external memory accesses are eliminated. Since hidden surface removal is completed in the first phase of the pipeline before texturing and shading, only the visible pixels to be finally drawn in the display memory are textured and shaded, eliminating both the redundant work performed and the redundant texture fetches from memory required by conventional 3D systems.[10]

WIRELESS CONVERGENCE

A number of wireless protocols have been developed and a variety of application vendors have begun to ship wireless products to the market. At a time when there are many wireless networking standards, including Bluetooth, 802.11x, infrared and other wireless interfaces, devices capable of supporting multiple protocols are a necessity. Central to all these wireless standards are serial controllers, called Universal Asynchronous Receiver/Transmitter (UARTs). These chips were one of the first successful integrated circuits and are included in the majority of today's handheld systems. Today's high speed UARTs can support bit rates of up to 1.84MHz, which is more than enough for Bluetooth and other high-end wireless standards. Full modem control capabilities are also present.

One issue in the development of applications for the next generation of handheld PCs is the narrow transmission bandwidth available in the wireless medium today. It is important to differentiate between wireless local area network (WLAN) and wireless wide area network (WWAN) communications technology.

Wireless LAN

A wireless LAN is a grouping of network components connected by radio waves instead of wires. There are two types of wireless LANs. An ad-hoc, or peer-to-peer wireless network consists of a number of computers each equipped with a wireless networking interface. Each communicates directly with all of the other wireless enabled computers. A wireless network can also use an access point, or base station. In this type of network the access point acts like a hub, providing connectivity for the wireless computers.

Most WLANs today are based on the IEEE 802.11 standards for wireless communication. 802.11 refers to a family of specifications developed by the IEEE for wireless LAN technology. 802.11 specifies an over-the-air interface between a wireless client and a base station or between two wireless clients. 802.11b is an extension to 802.11 that provides 11Mbps transmission in the 2.4GHz band.

The 802.11a standard, also an extension of 802.11, represents the next generation of wireless LAN technology. Among the advantages it has over current technologies are greater scalability, better interference immunity, and significantly higher speed. At speeds of 54Mbps and greater, it is faster than any other unlicensed solution. 802.11a and 802.11b both have a similar range, but 802.11a provides higher speed throughout the entire coverage area. 802.11a uses Orthogonal Frequency Division Multiplexing (OFDM), a new encoding scheme that offers benefits over spread spectrum in channel availability and data rate. Channel availability is significant because the more independent channels that are available, the more scalable the wireless network becomes.

With the increase in information being transmitted with 802.11a, it became necessary to guard against data loss. Forward Error Correction (FEC) was added to the 802.11a specification for this purpose. At its simplest, FEC consists of encoding a secondary copy along with the primary information. If part of the primary information is lost, insurance then exists to help the receiving device recover the lost data.[11]

Bluetooth is another technology that is being included with many handheld devices. Last year, over 9 million Bluetooth devices were sold. Market analysts predict an increase to 40 million devices in 2002[12]. Bluetooth was conceived both as a personal area network (PAN) cable replacement technology and as a universal low cost wireless connection into both voice and data networks. The IEEE 802.15 working group for personal area networks has announced that they will be adopting Bluetooth as the IEEE 802.15 standard. However, Bluetooth is not primarily intended for use in networking, and its low data rate and other limitations will probably prohibit its use for most networking purposes except for small, ad-hoc wireless networks.

Bluetooth is specifically designed for low power operation. Radios that comply with the Bluetooth wireless specification operate in the unlicensed, 2.4 GHz radio spectrum ensuring communication compatibility worldwide. These radios use a spread spectrum, frequency hopping, full-duplex signal. The signal hops among 79 frequencies at 1MHz intervals to give a high degree of interference immunity. Up to seven simultaneous connections can be established and maintained within a range of approximately 30 feet. Bluetooth supports an asymmetric data rate (one way) of 721kbps while permitting 57.6kbps in the return direction. A symmetric rate of 432.6kbps is possible according to Bluetooth spec.

Wireless WAN

The digital wireless networks that are in place today, which were designed for voice services, offer about 15 to 20 kbps per channel. Newer 2.5G schemes multiply this rate a few times, so that the end result is comparable to an analog modem or slightly faster. When 3G wireless networks are eventually deployed, transmission speeds under optimum conditions will be comparable to broadband.[13]

The world's first cellular networks were introduced in the early 1980s, using analog radio transmission technologies. To accommodate more traffic within a limited amount of radio spectrum, the industry developed a new set of digital wireless technologies called TDMA (Time Division Multiple Access) and GSM (Global System for Mobile). TDMA and GSM used a time-sharing protocol to provide three to four times more capacity than analog systems. TDMA is a very successful mobile standard in the Americas. However, GSM has become the most popular mobile standard in the world with more than 565 million subscribers in 400 networks in 171 countries. These second-generation (2G) wireless networks carry voice, limited data and short messaging services. Just as the second generation of wireless technology improved upon earlier systems, the industry looked to a third generation of technology for more advances.

For the GSM community, the migration to 3G technologies is filled with interim, 2.5G solutions. Many carriers are beginning to launch General Packet Radio Service (GPRS). GPRS is an enhancement to existing GSM networks that introduces packet data transmissions. Today's cellular telephone systems are mainly circuit-switched, with connections always dependent on circuit availability. Packet-switched connections mean that a virtual connection is always available to any other end point. This means that users can choose to be permanently "logged on" to e-mail, Internet access and other services. GPRS will be implemented by adding new packet data nodes and upgrading existing nodes to provide a routing path for packet data between the mobile terminal and a gateway node. The gateway node will provide inter-working with external packet data networks for access to the Internet and intranets.

Once GPRS has been implemented, some carriers will introduce Enhanced Data Rates for Global Evolution (EDGE) technology. EDGE uses existing frequencies to provide higher data speeds by making changes and additions to the standards and protocols of the air interface and the backbone networks. Some carriers have chosen to bypass EDGE as an unnecessary step. Carriers are expected to finally enter 3G in 2004 with the implementation of UMTS

Code Division Multiple Access (CDMA) is a radically new concept in wireless communications. It has gained widespread international acceptance by cellular radio system operators and has over 100 million subscribers. The first CDMA networks were commercially launched in 1995, and provided roughly 10 times more capacity than analog networks. CDMA is a "spread spectrum" technology, which means that it spreads the information contained in a particular signal of interest over a much grater bandwidth than the original signal. A CDMA call starts with a standard rate of 9600 bits per second. This is then spread to a transmitted rate of about 1.23 megabits per second. Spreading means that digital codes are applied to the data bits associated with users in a cell. These data bits are transmitted along with the signals of all the other users in that cell. When the signal is received, the codes are removed from the desired signal, separating the users and returning the call to a rate of 9600bits per second. Traditional uses of spread spectrum are in military operations. Because of the wide bandwidth of a spread spectrum signal, it is very difficult to jam, difficult to interfere with, and difficult to identify.[14]

In 1999, the International Telecommunication Union (ITU) adopted an industry standard for 3G wireless systems that can offer high burst rate packet communications and deliver high-speed data and voice communications. The 3G standard includes three operating modes, all based on CDMA technology. Of these standards, the two main standards that will arise will be CDMA2000 and the Universal Mobile Telecommunications System (UMTS). Multi-mode chipsets are being developed so that one handheld device will work with both systems.

CDMA2000 is a decidedly efficient 3G standard for the delivery of high bandwidth data and high capacity voice services. Voice and data share the same resources in CDMA, so voice capacity does not suffer during periods of higher data consumption. The evolution of the CDMA2000 standard will enable mobile systems to offer data throughputs of over 2 Mbps. Wireless providers are now offering CDMA2000 1X, which is the first phase in the evolution. The initial service runs on existing CDMA infrastructure and offers data speeds in excess of 144kbps. CDMA2000 will be implemented in the existing frequency bands of CDMA and TDMA at 800 and 1900 MHz.

Although CDMA2000 is gaining an early stronghold in the US, Korea and China, it is apparent that UMTS will also become a widely accepted world standard for 3G mobile communications. UMTS, also known as Wideband-CDMA (W-CDMA), is a wideband radio technique that operates on the same GPRS backbone for packet data services, but operates in a newly purchased spectrum in the 2GHz bandwidth. In theory, UMTS enhances the advantages of CDMA by expanding the spread in its “spread spectrum”. While CDMA and CDMA2000 spread the signal to 1.23 megabits per second, UMTS spreads the signal to 3.8 megabits per second.

These high-speed wireless networks will certainly permit new types of content and operational activities. However, the fragmentation of service platforms provides for potential inter-operability issues. The Open Mobile Alliance (OMA) was formed in June 2002 to implement global standards and specifications to permit applications and services to be built, deployed and managed across markets, operators and mobile terminals. The architectural framework is based on global standards, protocols and interfaces and is not locked to proprietary technologies, operating systems or backbone technologies. The goal is to provide seamless geographic and inter-generational roaming.

POWER MANAGEMENT

The real advantage of many high-end embedded microprocessors like the Intel PXA250, the DragonBall MX1, and the ARM11 core is not strictly their performance, but the fact that they extract this performance while consuming minute amounts of power. One power management technique used is automatic clock gating. A chip has several million transistors but not all of them are used all the time. The chip temporarily shuts down elements that aren’t being used by disabling their input signals.

Programmers can also reduce power consumption through software. Wireless operating systems typically provide power management features that allow for the partial shutdown of the system when there are idle cycles. Therefore, it is important for the application to return control to the OS when it is waiting for a system resource. An example of this would be the user input on a keyboard.

In wireless technology, power use increases in proportion to the frequency and by the square of the voltage. As vendors move to higher frequencies, power budgets tend to explode. High bandwidth is commonly advertised as up to 384kbps. Regardless of RF technology, such transmissions require greater power budgets, and therefore produce more battery drain. The transmission power required for all CDMA technologies, including CDMA2000 and UMTS, is continuously adjusted to the bits being transmitted. If, at a particular moment, few bits are being transmitted, as in a short message, less power is used. If more bits are being transmitted, as in a video clip, more power is used. This is commonly called a variable data rate. Thus, CDMA2000 and UMTS are more efficient, in that they allocate only the RF power needed to deliver the bits being transmitted. Battery drain will vary accordingly.

GSM technologies, including GPRS and EDGE, also vary their power output to match the number of bits being transmitted. However, they are less adaptive in how they match power output to bits rates. Because of this less refined matching of power output, the battery drain will generally be higher than CDMA-based technologies that transmit the same content.[15]

APPLICATIONS DEVELOPMENT

Operating Systems

When PDAs first came into market, the Palm Operating System (OS) powered them. Palm's success spawned a host of competitive offspring from Microsoft, Symbian, Research in Motion and a host of others, all of whom found their own successes. From an end-user's and a software developer's point of view, PDAs have offered few new capabilities over the past two or three years. The Palm OS has stagnated by offering older architecture, slow processor choices and limited memory options. Palm is no longer synonymous with "PDA" as it was a few years ago. In addition, developers have begun shifting to alternative operating systems that are multi-threaded. With the next-generation of PDAs being release, it appears that all of the leading OS vendors have announced or released major upgrades to their operating systems.

The Palm OS 5.0 is offering a new security model that supports full authentication, authorization and 128-bit encryption. Palm is also including support for ARM compliant processors, which opens the door to processor choices such as the Intel StrongARM and XScale, Motorola DragonBall MX1 and the Texas Instruments OMAP. With the move to ARM, handhelds running Palm OS 5 will be equipped with the same types of chips that have powered devices running Microsoft's rival Pocket PC. However, Palm applications that completely harness the power of the new chips may not be available until the end of 2002.[16]

Microsoft's mobile solutions have long supported many of the features that are being introduced by Palm's 5.0 release including support for ARM processors, security, multimedia and wireless networking. Microsoft's current PDA operating system, Pocket PC 2002, is based on a Windows CE 3.0 kernel, which is optimized for a class of processors which includes StrongARM, but not Xscale. However, to receive the full benefit of speed and power-saving features, the Xscale processors need to run specially optimized programs, which are not yet available. Since the Xscale is a successor to StrongARM chip architecture. It can run StrongARM code while being several times faster. This operating system also includes many enabling technologies that support special operating requirements needed for the mission-critical operating environment of the military. It also supports a wide variety of connectivity options with reliable and secure data transactions through the Microsoft Transaction Service, which is included in the Pocket PC SDK.

The Symbian OS is a multi-threaded OS with advanced capabilities through support for GSM, GPRS, infrared, serial and dial-up communications. It is particularly strong when it comes to hybrid devices that feature integrated voice/data communications and keyboard inputs. Symbian's strong Java/C++ development framework also puts it on a level with Windows CE in terms of available developer tools and skill sets. Intel is working with embedded Linux company MontaVista on a version of Linux for XScale based PDAs, although there is no date for a launch.

Three application architectures are commonly used when building mobile applications today: client/server or multi-tier, thin client, and Web-based. All three architectural approaches are available when targeting Windows Powered devices.

Thick or Thin Client computing

Wireless bandwidths must be considered together with system resources in making decisions about client-server applications. With all networks, developers must determine where the processing will take place. Factors that enter into this determination include not only the transfer rate, but also the amount of performance available in the local system. In the case of mobile, battery-operated systems, the power consumption required by a program is an issue, as is the available memory.

Pocket PC 2002 includes a full TCP/IP stack and Web browser, and full Internet connectivity can be achieved either by placing the Pocket PC in a cradle attached to a PC that is connected to the Internet or by using Ethernet, modem, or cell phone connections. TCP/IP also provides the connectivity for synchronizing data with a user's PC or servers over a network without having to be physically connected to a PC. In addition, the multitasking, multithreaded design of Windows CE enables more than one application to connect over

TCP/IP at a time, allowing users to interact with each other in realistic 3D environments.

Most applications are, for the most part, not stand-alone. This means that the application is designed from the outset to collect information and seamlessly transfer that information from the handheld to the desktop/database/server. The means of synchronous data transfer will allow for an uninterrupted and seamless transfer of data without requiring the end user to manually sync to the network. The application software should automate processes. It should turn the emerging wireless technologies into innovative solutions that will increase awareness and knowledge.

The new Terminal Server client in Pocket PC 2002 enables users to remotely operate full desktop applications running on a Windows Server. Some organizations prefer this thin client computing approach since it avoids the need to push application software to remote mobile devices. The end user has little concern for how the processing is done, as long as it is accomplished quickly. With thin client computing, the bulk of the processing is performed not at the mobile client level, but at the faster, more powerful controller. Centralized or controller based architecture is often faulted for having a single point of failure that effects the entire system. Modern systems, however, employ controller redundancy to reduce the risk of failure.

SHARABLE CONTENT OBJECT REFERENCE MODEL (SCORM) CONFORMANCE

The Sharable Content Object Reference Model (SCORM™) was released in January 2000. Although still in its infancy, the SCORM applies current technology developments from groups such as the IMS Global Learning Consortium, Inc.[17], the Aviation Industry CBT Committee (AICC)[18], the Alliance of Remote Instructional Authoring & Distribution Networks for Europe (ARIADNE)[19], and the Institute of Electrical and Electronics Engineers (IEEE) Learning Technology Standards Committee (LTSC)[20] – to a specific content model to produce recommendations for consistent implementations of web based distributed learning. A goal of the SCORM is the reusability and interoperability of learning resources across multiple Learning Management Systems (LMS). At its simplest, it is a model that references a set of interrelated technical specifications and guidelines designed to meet DOD's high-level requirements for Web-based learning content.

The SCORM focuses on key interface points between content and LMS environments and is silent about the capabilities provided within a particular LMS. Within the SCORM context, the term LMS implies a server-based environment in which the intelligence resides for controlling the delivery of learning content to students. This involves gathering student profile information, delivering content to the learner, monitoring key interactions and performance within the content and then determining what the student should next experience. In other words, in the SCO reference model, the LMS has the "smarts" about what to deliver and when, and tracks the student progress through the learning content.

The SCORM is divided into two primary areas of focus:

1. The Content Aggregation Model - describes the SCORM components used to build a learning experience from reusable learning resources. . It also defines how these lower-level sharable, reusable learning resources are combined to compose higher-level units of instruction.

2. The Run-Time Environment – provides a means for interoperability between Sharable Content Object-based learning content and Learning Management Systems. The Launch mechanism, API and data model are all software components that provide communication between the LMS, which would reside on a server and its SCOs, which would reside on the client. They also provide a standardized way for SCOs to communicate with the LMS, yet shields the particular communication implementation from the content developer.[21]

SECURITY

Because a wireless signal is not limited to the physical confines of a building, the potential exists for unauthorized access to the network. Three possible security concerns arise from this aspect of wireless. The first is unauthorized access to network resources via the wireless media. The second would be eavesdropping of the wireless signal. The third would corruption or discovery of local data stored on the PDA.

This security is not limited to wireless technologies. Data transmission technologies that rely on cables are not any more secure, although they are easier to protect with physical barriers. Should the physical barriers be broken, then the actual security of the network can easily be compromised.[22]

In addition to device password protection, mobile device security includes a documented security policy, authentication, encryption, public key infrastructure (PKI), Virtual Private Networking (VPN), and protection against viruses. In this context, the approach to security changes from trying to encrypt the radio transmissions to creating secure end-to-end connections between stations. Currently, the most flexible method for doing this is through VPN technology. This technology provides the means to securely transmit data between multiple devices over an unsecure data transport medium. Pocket PC 2002 now includes support for the Point-to-Point Tunneling VPN Protocol. It is commonly used to link remote computers or networks to a server via the Internet. However, it is also the ideal solution for protecting data on a wireless network. VPN works by creating a tunnel on top of a protocol such as IP. Traffic inside the tunnel is encrypted and totally isolated.[23]

VPN technology provides three levels of security. Authentication ensures that only authorized users are able to connect, send and receive data over the wireless network. Encryption offers additional protection as it ensures that even if transmissions are intercepted, they cannot be decoded without significant time and effort. To encrypt data for protection from unauthorized access, a device must support industry-standard 40-bit or 128-bit encryption or be able to use a standard encryption technique. Data authentication ensures the integrity of data on the wireless network, guaranteeing that all traffic is from authenticated devices only. The benefits of VPN technology can be enhanced by combining it with other security features such as biometric or SecurID card authentication.

TRAINING REQUIREMENTS

The fall of the Soviet Union has caused massive changes to the role of today's military. During the Cold War, the assumed threat was a land-based invasion of Western Europe through the Fulda Gap, resulting in an armor and mechanized infantry battle on the plains of West Germany. Post-Cold War, the American warfighter was more apt to find himself or herself engaged in Operations Other Than War (OOTW), limited Military Operations in Urbanized Terrain (MOUT), or peacekeeping operations in any one of numerous locations around the globe. One can see the military responding in kind to these changes through documents such as the Navy's …From the Sea and Forward…From the Sea, as well as the Army's Transformation effort. The events of September 11th have likewise caused our military's role to be re-evaluated in light of new homeland security missions and the increased need for counter-insurgency, force protection and anti- and counter-terrorism assets. Obviously, as the military's missions change, so too do training requirements. Additionally, advances in technology have fueled a desire to change training tactics.

In general, training can be divided into four categories:

- Accession, or entry, training
- Specialty training
- Leadership training
- Next duty assignment training

Accession, or entry, training is basically "boot camp", the first training a new recruit receives. It tends to be oriented toward increasing teamwork and is usually physically demanding. It can also involve such programs as Direct Commission Officer's Indoctrination as well as Chief Warrant Officer's schools. Specialty training, as the name implies, will vary in requirements, intensity and length, depending on the particular specialty being trained. It spans the spectrum from pilot training to the Navy's "A Schools" for recent boot camp graduates. Specialty training should be considered "life-long learning" as there are always areas in which personnel require refresher training or doctrine and missions change requiring training to change as well. Leadership training is likewise life-long in nature, as military members lead different groups as they progress in their careers. Finally next duty assignment training differs from specialty training in that it is very specific to the particular position a member holds. For example, a sniper may have received the best marksmanship training the Marine Corps has to offer, but until he arrives in Afghanistan, he won't be made aware of the particular Rules of Engagement particular to his new assignment.

MILITARY ROLES FOR POCKET PC TECHNOLOGY

Handheld PCs have come a long way from their original roles as mere electronic organizers and calendars. The military is increasingly looking to handheld PC technology to provide the warfighter a quality computing device on the battlefield. One prime example of the need for handheld PCs is the Army Land Warrior program. Land Warrior's Mission Needs Statement stipulates that "Land Warrior must have secure voice communications; create, send, receive, and store information; display visual images to include digital maps and graphics; and transmit and receive position location information…The system must provide the soldier with situational awareness and combat identification."[11] Needless to say, as the system is intended for the dismounted soldier, another requirement is for a highly mobile – i.e., lightweight – system. Objective Force Warrior looks to build upon Land Warrior by continuing to reduce weight while making the overall equipment more sustainable and survivable.

Clearly there will be a need for PCs at a smaller-than-laptop level for tomorrow's warfighter. Handheld PCs fill this need. They are lightweight, secure and inexpensive. With embedded wireless and Global

Positioning System (GPS) technology, a soldier can instantly identify his/her location, or the location of an enemy, and relay that back to his unit commander. Super-lightweight memory packs, about the size and weight of a quarter, can be pre-programmed with terrain maps, 3D building models, or practically any other information needed about the locale into which the unit is being deployed.

CONCLUSION

The key factors affecting the reliability and performance of Internet applications are bandwidth limitations, latency and server response times. By leveraging the strengths of centralized computing with the advantages of Handheld computing, we can effectively provide training anytime and anywhere, thus fulfilling one major goal of the military's ADL initiative. Increased processing speeds and integrated graphics processors can provide a realistic 3D environment that may be manipulated in different ways from a variety of perspectives. The user's input information can be transmitted at high speed to a Windows based Learning Management System (LMS) and can easily be tied to an Intelligent Tutoring System and Discrete Event Simulations engine to process real-time behavioral models that can power fully interactive graphics in a wireless LAN/WAN environment.

The list of potential uses for wireless communications in the future is as endless as we dare to dream. Soldiers may incorporate a Mobile Mission Planning system to review the layout of the terrain, streets and buildings that they are about to attack while they are on the way. Small groups of soldiers may train in the field with wireless LANs to practice tactics or for identification of enemy vehicles and weapons. Service manuals can be fully interactive to allow technicians to fully understand the complexity of how different parts fit together.

The fantastic range of possibilities will require far reaching technological innovation to make them a reality: innovation that is already well underway. The task now at hand is to start developing scalable applications that will utilize this technology in order to hit the ground running. The most effective applications will be those that marry users' demands with the technology options available on a particular device.

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