

The Silicon Opportunity of the New Millenium – Digital Information Appliances

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Abstract

The century which is just ending saw the birth and growth of the computer industry, which has been the primary driver in growing semiconductor revenues from \$7 billion in 1977 to \$125 billion in 1998. Semiconductor technologists and executives often ask themselves what will drive next big silicon market. We believe that the next century will be that of ubiquitous computing, as the convergence between voice and data communications, consumer electronics and personal computers, Internet and Intranet commerce gives birth to a new class of hardware device: the information appliance. We project these devices will grow at an astounding CAGR of 50-75% versus the PC unit growth rate of 12-14% in the next five to ten years. We believe that the emergence of the appliance age will provide the single biggest growth opportunity for semiconductors in the coming decade and beyond.

Introduction

Information appliances will evolve naturally from the forces at work in the technology industry: 1) the evolution of the PC from a computing device to a communications tool, 2) the evolution of wireless devices from handling pure voice or data traffic to both, 3) the need for Internet access anywhere and at anytime, 4) the increasing desire for portability, 5) the need for an easier user interface, and 6) the desire for seamless connectivity.

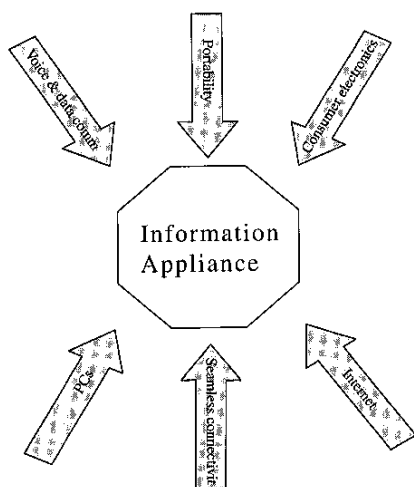


Figure 1: The Forces Creating a New Market

In general, these information appliances will evolve to fill the gap between the PC market and the wireless market. Looked at another way, these devices will bridge the gap between the need for computation and communication with the ease of use seen in consumer devices. The silicon needed to build these products will have a higher potential for failure and therefore more stringent requirements than most of today's devices. An eye towards systems expertise will be critical during design.

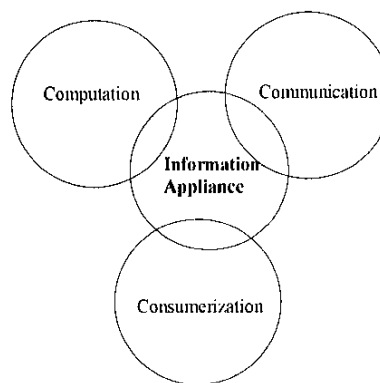


Figure 2: Information Appliances Bridge the Gap Between the 3Cs

Evolution of Two Markets Driving Semiconductor Growth

We believe that we are in the final stages in the evolution of computing from a niche, technical market to a mainstream business market, to finally a ubiquitous consumer market. As the computing market evolved from a closed, proprietary mainframe model in the 80s to the open standard PC model in the 90s, semiconductor consumption zoomed. For the past few decades, the growth of the PC market has driven semiconductor consumption, as can be seen in Figure 3.

However, the wireless pager and phone markets have also been gaining in importance as the need for mobile communication is increasing along with the need for computation. We estimate that today the PC market still commands about 40% of the semiconductor consumption worldwide with the communication markets commanding about 25%.

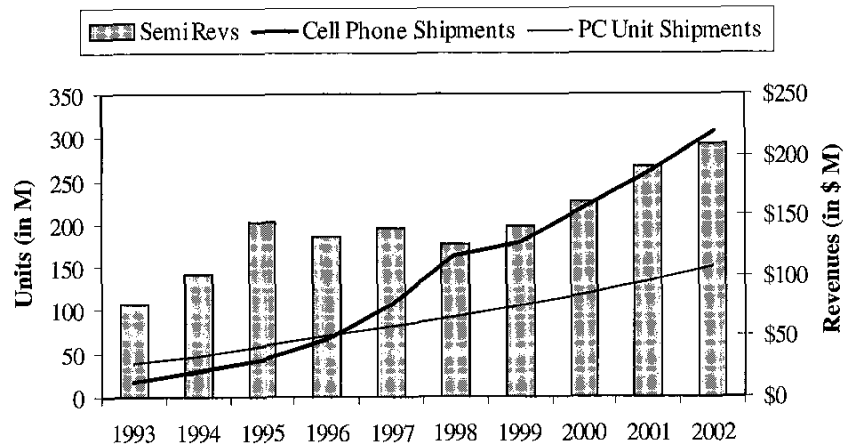


Figure 3: Semiconductor Revenues vs PC and Cellular Phone Shipments
Source: Dataquest, WSTS and BRS Estimates.

The computation market is driven by the need for performance and flexibility of use. The communications market has been driven by the need for long battery life and a small form factor. As a result, the semiconductor devices developed for use in both of these markets is inherently different as can be seen in the evolution of the microprocessor for the PC market and the DSP for the wireless market. The microprocessor has evolved into a powerful and increasingly flexible device, yet with power consumption increasing every year. On the other hand, the DSP has evolved into a highly specialized data processing engine for the wireless market with power consumption of increasing importance. Both devices as a result have evolved into increasingly perfect engines for their own markets but increasingly unsuitable in the other's. In addition, the consumerization of both the computing and communications markets has driven the need for lower cost and easier to use devices.

Melding of The Two Markets Driven by Internet Connectivity

With the emergence of the Internet as a medium for communication and worldwide connectivity, the lines between the computation, communication and consumer markets will start to blur as phones add data traffic and computers add wireless connectivity. The focus must shift to a model for producing what the customer wants and not what the R&D department can produce as the market becomes increasingly consumer focused. The PC was originally a business computation device, and the initial "killer app" that drove its success was the electronic word processor and spreadsheet. In the emerging world of the information appliance, the "killer app" in contrast is constant connectivity and the ability to access information anywhere and at anytime. The Internet is the new enabler and the keys

are user interface and portability rather than just processing speed and functionality.

The introduction of the sub \$1,000 PC in 1997 and now the sub \$600 PC are examples of the computing market approaching a consumer electronics model. The PC is used mainly for email and Internet access, and very little else. These sub \$600 devices have already garnered about 20% of the US retail market, with sub \$300 PCs already being offered. The information appliance market evolution on the other hand will be fundamentally different from a sub \$300 PC, which is generally a lower speed, lower functionality version of a general purpose PC. What is required for success in the information appliance market is not a "stripped-down" version of a general purpose device, but a product built from the ground up to serve a specific need. We believe the new generation of Palm Pilots is an example of such a product: designed with a focus on personal information management with the addition of wireless connectivity in the next generation Palm appliances.

Types of Information Appliances

Information appliances (IAs) are a new generation of low-cost, web-access devices which include smart handheld devices (H/PC, Palm Companion, PDA), auto PCs, web TVs, digital set-top boxes, smart phones (or webphones), digital cameras, DVDs, smart cards, vertical application devices (which includes devices for the medical, industrial, financial, and communications markets), and a number of thin server appliances. IAs will deliver specific functionality to the user regardless of the underlying technology being utilized in a practical form factor without the cost and overhead typically associated with the PC market. We forecast that the Internet appliance market will grow at a much faster rate than the traditional PC market. The growth will probably be much

like the growth of the Internet. It will take longer to develop than initially expected but then later will grow more explosively than originally forecast. We project the information appliance market to grow at a compounded annual growth rate (CAGR) of 50-75% versus 12-14% for that of the PC industry in terms of unit shipments (see Exhibit 4), reaching over 30% of the total market by the year 2002.

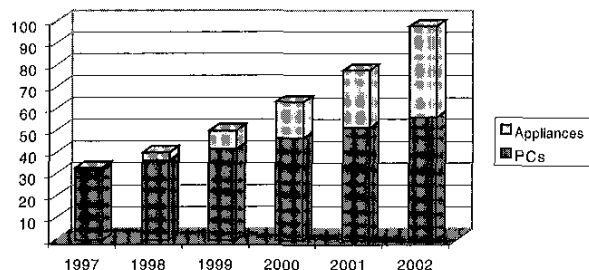


Figure 4: U.S. Information Appliances vs. PC Unit Shipments (Millions) CAGR: PC = 12-14%; Information Appliance = 50-75%
Source: International Data Corporation and RS&Co. estimates

Standardized Software Interface Will be Critical

Software infrastructure is extremely important as an enabler for hardware. Not only does it standardize a user interface, it also levels the field for semiconductor vendors who can more easily port to a standard software application. The advent of Microsoft's WindowsCE, as well as Sun's platform independent Java, promises to revolutionize the market with application software able to run on a wide variety of devices. Though the Palm Pilot is a good example of a standalone OS that has met with good success, we believe that such examples will be few and far between.

Microsoft is positioning Windows CE as a platform for a line of horizontal information appliances such as HPCs, Palm PCs, PDAs, Auto PCs, digital set-tops, smart phones etc. Windows CE possess three core strengths, in our view, that include an advanced and familiar graphic user interface, user friendly portable applications, and extensive developer tools available in multiple programming languages.

Sun's Java strategy is also tailored to the embedded and Internet appliances market. Designed for Intranet, Internet, and embedded devices, Java OS provides all sizes with a small and efficient standalone Java application platform and substantially reduces client system administration while enabling users to log-in anywhere on the network and still use their familiar workspaces. Jini, a new software product from Sun, seeks to make connecting any computing device to a computer network as easy as "plug and play" with use in everything from printers to television set-top boxes to dishwashers. Though the battle between Microsoft and Sun to proliferate their interface will prove to be confusing, it

ultimately will lead to one if not two highly universal standards such as Windows and Mac in the PC world.

The Silicon Opportunity

In the computing marketplace, Microsoft and Intel have set the standards and therefore have an extremely high degree of control over the overall system design. As a result, in the computing market, both system and silicon vendors have a decreasing ability to technologically differentiate their products and gather high margins.

In the emerging information appliance market there will be a variety of form factors and vertical applications. This inherently leads to numerous silicon opportunities and the ability to differentiate, thereby garnering higher margins. There is a dark cloud in this silver lining. Given the lack of standards, the risk of spending years to design an ASIC for a proprietary device that does not succeed is much greater. Given the early phase of development for the IA market, except for those based on early leadership in strategic IP, it will be a while before standard products appear in this market. Several silicon competencies will determine success in this market. First, programmability will be a key differentiator. Second, standard product vendors must be able to offer integration using IP cores. Finally these same vendors must be able to use their system knowledge to differentiate their products.

We believe that the two main drivers for silicon development in the PC market have historically been performance and flexibility while in the wireless market it has been power consumption and form factor. The IA market will have characteristics of both markets leading to an increasingly complex set of design decisions between performance and power consumption, flexibility and die package size.

Processors DSPs

We believe the processor will take center stage in the IA market with either a MIPS or ARM based engine at the heart of most systems. Without the need to support a large legacy code base, these processors can use their die areas much more efficiently than an x86 based design. In embedded appliances, performance will become increasingly important causing microcontrollers to be replaced by 32-bit and 64-bit embedded microprocessors. Digital signal processors are a key enabling technology in this market as the need for wireless connectivity continues to grow. Smart phones should be a tremendous driver for DSPs as standard cellular phones were in the past. In addition, DSPs have been designed with the power to performance tradeoffs in mind. We will see integration of MCU-DSP functionality in the future, as well as application specific programmable signal processors as alternatives to stand-alone DSPs in this market.

Texas Instruments seems to have an increasing lock in this market as competitors scramble to catch up. Other than the vendors of standalone processors, ASIC vendors will also try to integrate microprocessor/DSP functionality by embedding cores into their designs. Vendors of processors as well as processor cores will increasingly gain importance as they become central to system performance and system design.

ASIC's and IP

Application-specific ICs should also benefit from IA growth. We believe, however, that it is increasingly likely that "programmable standard products" will start to replace the hardwired ASSPs that have until now dominated the market. The design of consumer products such as digital cameras, cellular phones and set-top boxes will need a silicon platform solution that includes software design tools in order to enable differentiation of the OEM product. In addition, the proliferation of embedded system products such as PDAs, digital TVs etc. will drive silicon markets that improve display technology. We believe that the most successful ASIC vendors will not only have a high degree of proprietary technology in-house, but access to strategic IP such as processor cores (MIPS) and memory architecture (Rambus). The ability to design systems on a chip will be crucial for these vendors

Memory

Semiconductor memory technology, often overlooked, will be crucial in this market. This market will be principally dominated by Flash memory due to the need for non-volatile removable storage. We are likely to see defensible memory franchises emerge along vertical markets with form factor being crucial. Embedded DRAM could also be a key technology for systems on a chip where the power and performance enhancements offset the lower die yield.

Conclusion

In summary, we believe the emergence of the information appliance as the computer communications and consumer markets converge will provide one of the greatest silicon opportunities for the next century. Although there are silicon vendors that have taken early leads in market niches, we believe that the market still is in its infancy. A customer driven, not R&D driven product approach will determine the future winners. System knowledge, programmability and functional integration will all be needed for success in this market, but should offer ample rewards for those that are successful.