

DSP: Driving Convergence in Digital Communications

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Abstract

Until recently, the four major sectors of the digital communications market - telecommunications, data communications, utility communications and enterprise communications – had little in common. Each sector developed relatively independent of the others, using different (and often isolated) networks and data types to transmit information. This paradigm is changing rapidly – with profound implications for the hardcopy industry, not only in terms of product functionality and printer controller architectures, but also in terms of the acquisition and use of hardcopy data.

Advances in semiconductor technology such as the programmable DSP are making digital convergence a reality. As a result, hardcopy, softcopy, voice, audio, video, and enterprise data soon all will be traveling over the same airwaves and wires at extremely high data rates. This DSP-driven digital convergence will give rise to a new generation of networked communication or information appliances that capture, create, and display data types in useful and intriguing new ways. Technologies from Texas Instruments are at the heart of this revolution, and our insights may help product engineers understand the business opportunities and market dynamics created by the powerful new connections now taking shape in the digital communications marketplace.

Introduction

Texas Instruments recognized – early on – the potential for semiconductor technologies such as the digital signal processor (DSP) and analog chips to transform the way we interact with our world. In these two technologies, we saw the opportunity to take the information revolution beyond the desktop. Just as the microprocessor fundamentally changed the way data is computed and shared, we believed the combination of DSP and analog chips could bring the inherent speed and flexibility of a digital language to real-world signals such as sound, light, heat and pressure. In addition to recognizing the potential in "digitizing" the real-world, we also understood that software – programmability – would play an increasingly important role in this new digital age. Through acquisition and internal development, TI developed a chip-and-software infrastructure that successfully delivered breakthroughs in the design of embedded systems focused on wired and wireless networked digital communication protocols. Just as our technologies helped to usher in the digital age in communications, we now expect the programmable DSP to transform hardcopy devices and other appliances linked over digital networks.

Digital Age and the DSP

The digital wireless telephone is one concrete manifestation of the new digital age in communications. The wireless phone represents a class of new digital products often referred to as information appliances – a term used to describe digital devices that operate without the aid of a PC and are pervasive and user friendly. The wireless phone also illustrates the classic dilemma facing those envision a digitally-connected future: We live in an analog world. Therefore, in order for our voices – analog sound waves – to be transformed into a digital domain, each syllable first must be transduced into an electrical analog signal and then sampled into digital impulses. Once in a digital format, we can start to do some useful things: The voice data can be filtered to remove noise; it can be selectively or adaptively amplified; it can put into packets and compressed, and then sent over wires or the airwaves. At the receiving end the data can be reassembled in the right packet order, decompressed, and then transformed back into an analog signal.

Of course, it all has to happen in real-time, in order for a digital wireless phone to work. And that's why it's become the domain of the DSP, supported by analog parts. This conversion of analog to digital signals, filtering or transforming the signals, sending the signals, and then converting the signals back to analog is the process that drives the digital communications age (Figure 1).

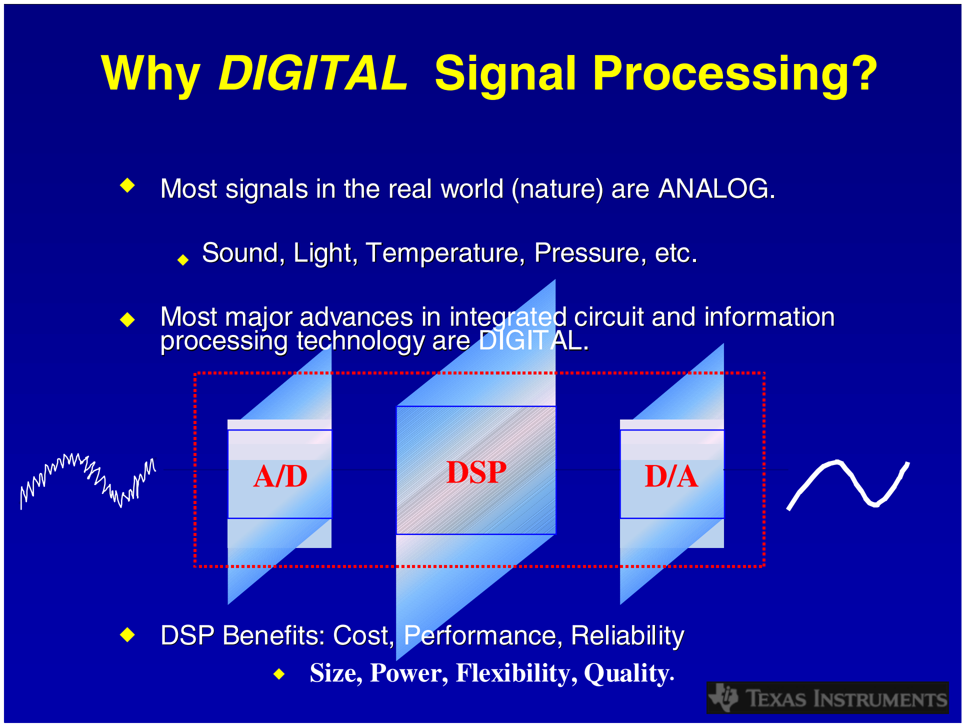

Figure 1

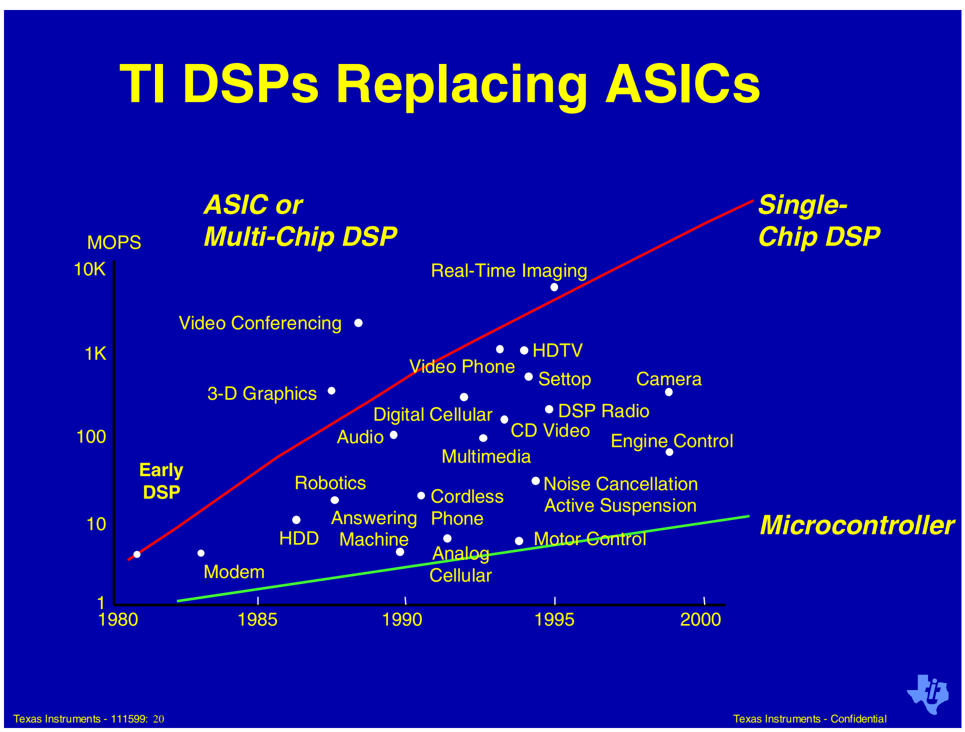

Figure 2.

The digital wireless phone is not an isolated success story: More and more information appliance applications are moving to DSP today (Figure 2). As the performance of the DSP has improved and chip prices have steadily dropped, applications that once were ASIC-, or RISC-and-ASIC-based are now reaping new performance or programmability benefits by using a single DSP or a RISC and DSP system-on-a-chip solution.

This migration is being driven by more than the price-per-chip. The programmability of the DSP has played an equally important role in reducing "total systems" cost and in speeding the pace of innovation. Simply put, it's extremely valuable to be able to add or change functions within a digital information appliance through a code-load. In contrast, with an ASIC solution, valuable time-to-market and development resources are consumed by the need to design, fabricate, and then test a hardwired solution.

To further enhance the advantages of the DSP, TI has developed C and C++ compilers for this versatile chip. In addition, we have developed VLIW instructions and architectures so that the DSP can operate in an interrupt-driven, real-time operating systems environment – much like the traditional RISC processor. In some special sessions at this IS&T conference, TI presentations will show how these features and design rules can be used to process page description languages and scan to print data.

But the opportunities don't end with hardcopy devices. Now that standards for communication are set and inter-operability issues are being resolved, we can expect to see information appliances that will bring a whole new level of connectedness and functionality to our lives.

Internet Information Appliances, and Printers

The programmable DSP is playing a central role in this next stage of the revolution, as well – the bandwidth revolution. Broadband modems, built around powerful programmable DSP technology, are beginning to unlock the full potential of the Internet, by creating economical data gateways that can accommodate streaming video, audio, and interactive communications. Soon, these broadband connections will be pervasive: Nearly every appliance and device will be able to communicate at very high speeds over wired and wireless networks (Figure 3).

In short, internet information appliances, IIAs, are taking the digital revolution beyond the desktop – communicating directly over the Internet, without a PC in between. This capability opens up a whole new world of distributed computing. Among other things, it makes shared functionality a reality. For example, printing functionality can be distributed to achieve additional features, or to make a low-end printer perform in many respects as a high-end printer (Figure 4).

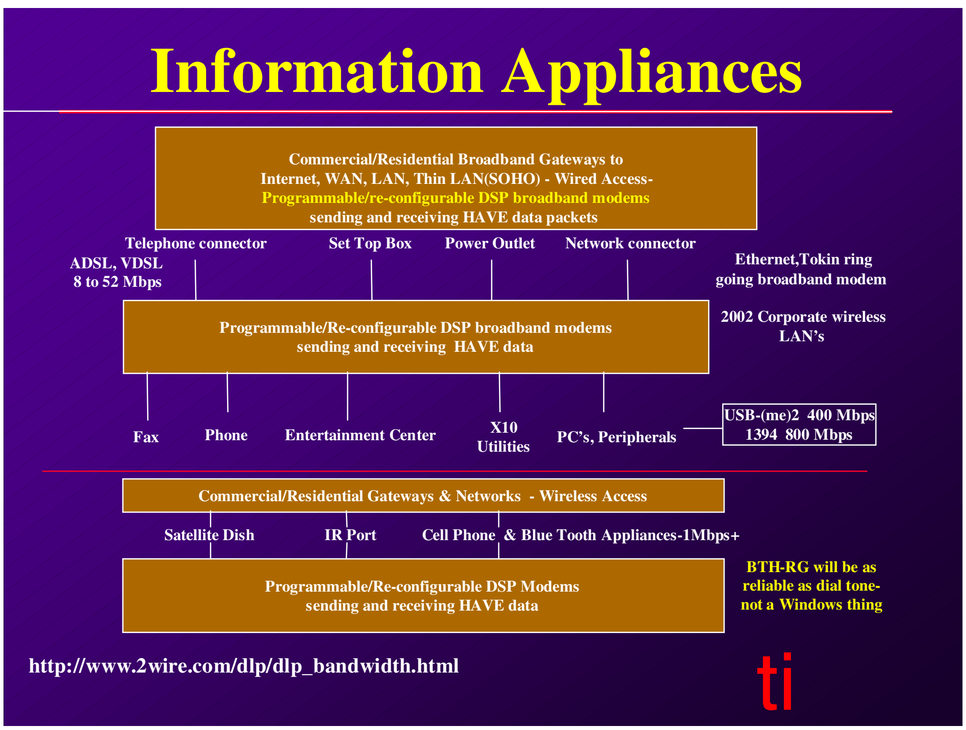

Figure 3

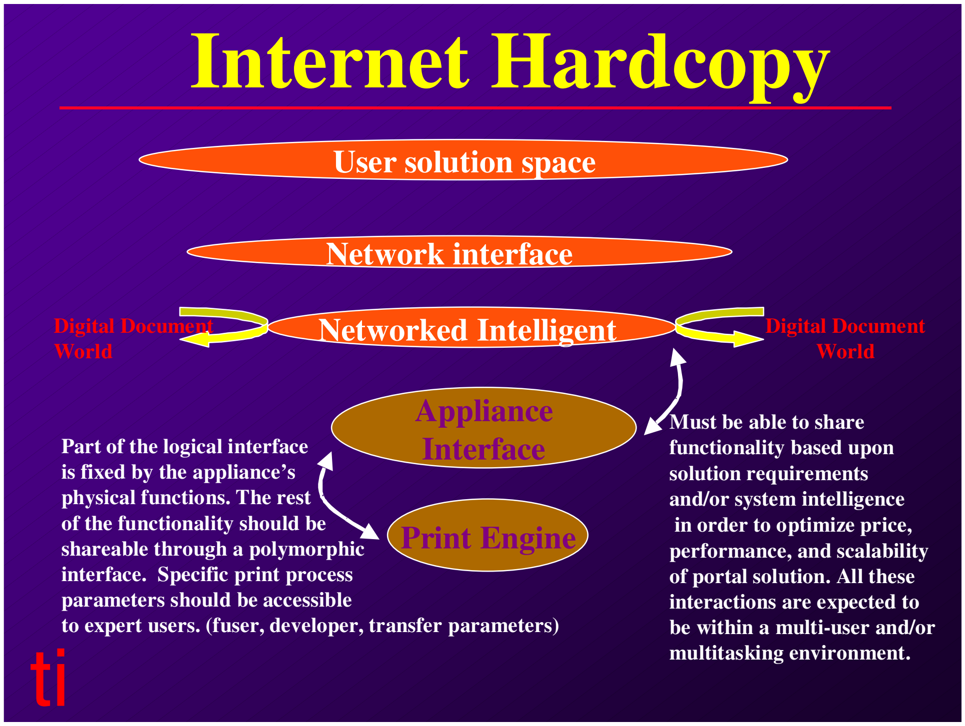

Figure 4

As several technologies mature – namely, dual core processors, ubiquitous connectivity and distributed software component management – they will combine to enable the framework for such a distributed computing environment. We know, for example, that a high performance DSP core with a general-purpose processor can support a wide range of analog/digital interfaces – and manage the digital-to-digital interactions – with a single hardware architecture. Meanwhile, ubiquitous TCP/IP connectivity will enable device-to-device communication, and maturing software component technologies will allow devices to interface at a very high level of cooperation.

How will hardcopy printers fit into this new environment? Let's consider one possible scenario – an option built around a model that provides both basic functionality, and the ability to scale quality of service with cost and convenience.

Let's say I want to print a number of documents stored in various places on the web. In a broadband world, all I'd need to do is tell an Internet-enabled printer that I want the documents. The printer will find the documents, determine what it takes to print them, construct the processing pipeline, and produce them. It won't matter to me where the documents are stored or whether they were all created using different authoring programs. The printer will use the network to access the documents, determine their formats, find a service that can convert the document to a format the printer can use and produce the hardcopies.

Let's say that this scenario involves a very low-cost printing device. The print job coordination can be accomplished by an off-board service, much like it is today when a printer is connected to a PC. But instead of the limited functionality of the desktop printer, an Internet enabled printer – even a very low-cost model – could handle much more complex tasks, such as finding a print coordination service and acting as a proxy for it. With my wireless phone in hand, all I have to do is interact with the printer (the device I view as the service provider). It doesn't matter to me that the printer might really be farming out most of the work to other servers somewhere on the web, because in the end I get the printed documents I want.

As the capabilities of the device increase, the quality of service also increases. For example, I might select a networked device that has its own mass storage, its own rasterizing hardware, a large set of format converters, and so forth. This device will likely print the documents faster and at a lower cost per page. However, such a device probably won't be as readily available as the low cost ones. Therefore, I can choose to pay for the level of quality and service I need – whether that means rapid output, high image resolution, or simply the chance to save a little money.

That's one of the real benefits digital communications can bring to the hardcopy marketplace. This new networked paradigm lets me, as the user, focus on things that really matter to me – such as cost, quality, convenience. I don't have to worry about distractions such as which driver to install, what application originally created the documents, or what operating system my printer of choice was running on. I don't have to concern myself with anything that's not directly related to the service I want performed.

Conclusions

Most would agree that we're just scratching the surface when it comes to unlocking the potential of Internet-enabled digital appliances. With programmable DSPs creating common ground among the next generation of networked appliances, we can look for incredible new services and applications to emerge. Hardcopy devices will certainly command a significant segment of that connected marketplace – and their opportunities will grow in direct relationship to their ability to link with and enhance the way we use all the digital equipment in our lives.

Biography

John Scarisbrick is senior vice president of Texas Instruments Semiconductor Group and worldwide manager of the Applications Specific Products business. He is responsible for such product families as digital signal processors, microscontrollers, ASIC products, microprocessors and networking.

Mr. Scrisbrick, 47, was named to this position in August, 1996. Prior to this assignment he was president of TI Europe, responsible for all of TI's business operations in the European region, including its business units, maufacturing services and sales and marketing offices in 16 countries.

Mr. Scrisbrick joined the company in 1976 as a field engineer in the UK and has since held a variety of positions in TI's Semiconductor Group. From 1984 through 1989 he was responsible for TI's Digital Singal Processing activities, based in Houston, Texas. Between 1989 and 1994, as vice president of Texas Instruments Europe, he was responsible for TI's European Linear business, based in Bedford, England. From February 1994 through February 1995, Scrisbrick managed TI's worldwide Computer Component organization, responsible for TI's SPARC and x86 microprocessor and networking business, based in Dallas, Texas.