Soft Modems Take Cheap Shot at DSPs

"Host Signal Processing" May Supplant DSPs in PCs and Consumer Devices

by Peter N. Glaskowsky

Hoping to take over a market segment now dominated by dedicated DSP chips from Rockwell, AT&T, and others, Motorola and General Magic have independently announced soft-modem initiatives. By combining simple analog I/O circuitry with host-based real-time signal processing, both companies claim significant reductions in cost and time to market compared with DSP-based fax/modem solutions.

Motorola's initiative, developed by the company's hardware modem group, intends to eliminate the modem as a separate peripheral in both desktop and mobile PCs, a goal that may not be attainable until the end of the decade. General Magic is focusing on embedded applications and consumer devices; its first design win is Philips' Velo, a Windows CE handheld PC (HPC). The company had developed modem software for its Magic Cap operating system and now, aching for revenue, is licensing the technology to others.

Processors Get Faster, Phone Lines Don't

Both companies have a similar view of their markets. Processor power increases with time, but the complexity of modem algorithms has hit a wall: conventional phone lines have a limited frequency response and signal-to-noise (SNR) ratio, fixing the available bandwidth at about 33.6 kbps. Even the 56-kbps modem algorithms under development are only slightly more complex, due to asymmetric operation: they operate at the higher speed only in the downlink direction. Although a significant percentage of typical host processor performance is required to implement a software modem today, this percentage will rapidly decline with time.

Implementing a hardware modem also becomes easier with time, however. Modem designs that once required a DSP, a microcontroller, and several support chips have been superseded by today's two- and three-chip designs. This is usually achieved by combining the DSP and microcontroller into a single programmable device and integrating all analog ICs into one or two more chips.

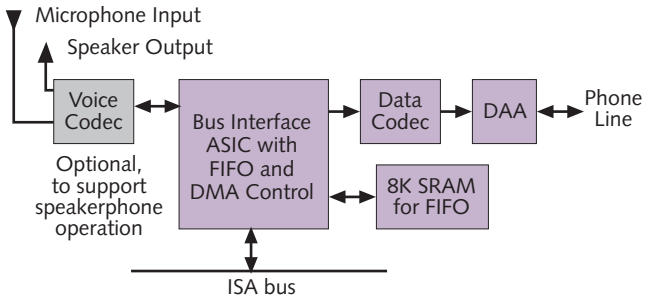

Figure 1. The analog circuitry for soft modems can be simple and inexpensive. A typical configuration will include 14-bit A/D and D/A converters, FIFOs, a DMA engine, and a commodity data access arrangement (DAA) for the telephone line interface.

With modems down to just a few chips, it becomes reasonable to think about performing the digital operations on the system's existing host processor. The same analog interface components can be used in this configuration, with the same data-access arrangement to provide isolation from the telephone line, as Figure 1 shows.

This solution is feasible but not yet ideal for PC applications. Because Intel's Pentium processor was not designed for signal-processing tasks, such algorithms require a substantial fraction of the chip. Motorola's measurements show that 43% of a Pentium-150 is required to implement the 28.8-kbps V.34 modem standard.

General Magic's results are similar. Its unoptimized (pure ANSI C) V.34 code consumes 50% of a P-166. By comparison, General Magic's measurements show that utilization of a 36-MHz MIPS R3000 core can be as low as 38%. This improvement results in part from including 3K of hand-coded assembly language for critical sections of the code, but the use of a hardware multiply-accumulate (MAC) unit, which Pentium lacks, makes the greatest difference in modem code, which depends heavily on finite impulse response (FIR) filtering.

Past Efforts Have Been Inadequate

These utilization figures illustrate the "pain threshold" for host-based signal processing. Modem functions must be thought of as background tasks—users are more interested in applications like e-mail and Web access. If modem algorithms consume most of the available processing power, users will notice the degraded performance of their applications and become dissatisfied with the solution.

Apple has been shipping host-based modem products for a number of years. All PowerMacs introduced since 1994 support the Geoport Express Modem, a host-based solution. Excessive CPU utilization and problems accommodating real-time signal processing tasks within MacOS have prevented the Geoport Express Modem from becoming a popular product, especially compared with hardware modems that typically cost only slightly more.

Apple's experiences illustrate the risk in Motorola's strategy, one that Motorola seems to appreciate. Motorola is introducing its SM34DVF soft-modem product now but does not expect it to become a mainstream solution immediately. The company understands that the benefits of host-based signal processing will become more significant with time. For example, the same code that requires 43% of a Pen-

tium-150 needs only 23% of a P55C-200 with MMX. With future P6-class processors at 300 MHz and above, CPU utilization will drop to less than 10%.

As MMX and P6 enter the mainstream in 1997 and 1998, Motorola's solution becomes more reasonable. Indeed, Motorola believes that 1997 will be the last year of sales growth for hardware modem manufacturers, followed by a rapid decline to about 20% of their current business by the year 2000.

Other factors stand in the way of this success, however. Windows 95 wasn't designed to accommodate real-time tasks like host-based signal processing. Intel's 1994 fling with native signal processing (NSP) ended abruptly when Microsoft refused to cooperate with Intel's planned real-time extensions to Windows 3.1—but little has changed since.

Hardware components in today's PCs are even less accommodating. For example, Motorola's reference implementation uses an ISA-bus expansion card to provide the analog interfaces, FIFOs, and DMA support logic. The FIFOs must be periodically filled from or emptied to main memory, but other system operations can block such transfers for long periods. Some graphics chips have been known to tie up the PCI bus for several milliseconds during graphics acceleration functions. To ensure sufficient tolerance for these delays, Motorola uses an external 8K SRAM to hold FIFOs managed by a state machine in its ASIC.

Real-time tasks within Windows may lead to other undesirable side effects like jerky cursor movements and brief pauses in the playback of digital audio and video clips. Microsoft is currently developing the Win32 Driver Model (WDM) in an effort to control as many of these problems as possible. WDM, planned for an early 1997 release, brings some real-time capabilities to Windows 95 and Windows NT. The goal is to reduce maximum OS interrupt latency from several milliseconds to less than one millisecond. WDM cannot solve the problem of hardware latency, however.

Laptops Offer Near-Term Opportunity

Motorola believes that laptop computers are one of the best markets for its software modem technology. OEMs have more control over the peripherals used in laptops, eliminating some potential conflicts. Laptops are used for a narrower range of applications than desktop PCs, involving less multitasking; laptop users are also more willing to accept compromises in performance to achieve reductions in cost and power consumption. All these factors make laptops a more hospitable environment for soft-modem implementations.

Even so, laptops in 1997 will have barely enough processing power to handle the extra load imposed by V.34. Mobile P55C processors will debut at 166 MHz, and low-power P6 parts are unlikely to arrive before 1998. Here again, Motorola is facing a problem previously encountered by Apple; the PowerBook Duo line uses a hybrid of host-based and hardware-based processing for its internal modems, but its processor power has never been fully adequate for this task.

For More Information

Motorola's SM34DVF will be available for OEM licensing in January. Ordering and pricing information can be obtained by calling Motorola (Mansfield, Mass.) at 508.261.4323. Additional information may be found on Motorola's Web site at *www.mot.com/isg*.

Inquiries for General Magic (Sunnyvale, Calif.) may be directed to Rainer Kunz at 408.774.4211, or to the company's Web site at *www.genmagic.com*.

General Magic Aims at Easier—But Smaller—Target

General Magic plans to avoid these problems by positioning its soft-modem product as a solution for the embedded space. Office-automation products like fax machines and consumer devices like HPCs provide an even more controlled environment than laptop PCs. This both reduces contention for limited processor resources and makes it easier to predict the actual performance of the modem software.

General Magic's first design win is with Philips' TwoChipPIC chip set, consisting of the PR31500 MIPS processor and UCB1100 support chip. This win is no surprise, since the UCB1100 was designed by a former General Magic engineer. Philips includes the soft-modem code in the TwoChipPIC product as if it were another hardware component and even gives it a part number: SMF1100. Philips uses the TwoChipPIC in its Velo HPC and is actively pursuing other markets, including Web boxes and smart phones.

General Magic's code is written in C and is highly portable. The company estimates only a few days' effort is required to port the code to a new platform and get it running; a few weeks may be needed to hand-code the critical sections in native assembly language.

Future Plans Provide for Enhancements

Both companies plan updates to support additional modem capabilities like digital simultaneous voice and data (DSVD) and 56-kbps modem standards. This potential for inexpensive field upgrades is perhaps the most significant advantage of soft-modem implementations. More demanding standards—including ISDN, ADSL, and cable modems—will also become opportunities for software implementations, and both companies plan to support them when host CPUs become fast enough.

Both companies also envision overlaps in their market coverage: Motorola is interested in embedded applications, and General Magic is willing to discuss PC-based products. They both face competition from other companies, including PCtel *(www.pctel.com)* and HostModems *(www.hostmodems.com)*.

It may be a few more years before soft modems become a sensible choice for mainstream PCs, but embedded and mobile systems can benefit from this technology today. M