Highly Integrated, System-Level GPRS Solutions

GPRS solutions are taking center stage for worldwide mobile Internet access.

By Kassu Niiranen, Agere Systems

Cellular phones equipped with high-speed wireless Internet data capabilities are now available to consumers in all three major regions of the world: Asia/Pacific, Europe, and the United States. Nearly 70 percent of the world's cell phones use Global Systems for Mobile (GSM) Communications technology. While GSM predominates in Europe and Asia, it has not been the leading wireless technology in North America. But this may be changing. Recently, three of the top six wireless service providers in the United States announced plans to upgrade their networks with GSM-based services.

One of the major driving forces behind GSM adoption is General Packet Radio Service (GPRS) technology. GPRS is a key technology addition to GSM that enables the circuit-switched GSM voice network to handle packet-switched data at the same time. Industry experts predict that roughly 80 percent of GSM phones will be equipped with GPRS technology by the year 2005.

GPRS-enabled phones &#151 offering major steps forward in cell phone performance and Internet connectivity - enable consumers to perform higher-speed electronic commerce and mobile commerce transactions, browse the Web, play electronic games, receive video clips, and easily access many more services. These phones are expected to allow consumers to perform numerous higher-bandwidth, higher-speed services, such as receiving email attachments and downloading files such as contracts and price lists. However, for wireless service providers as well as handset and base station equipment manufacturers, moving from today's circuit-switched technology to a packet architecture compatible with IP-based services is fraught with technical and business challenges embedded in the rapidly changing underlying technologies; emerging, unproven enhanced services; and unknown customer acceptance rates.

What is GPRS?

In short, GPRS is a packet overlay for existing GSM networks. Dubbed 2.5 generation (or 2 1/2 G) technology, GPRS is a bridge technology expected to sustain the cellular phone industry for the next several years while third-generation (3G) cell phone technology continues to be developed.

Without GPRS, data moves over a GSM network by way of a 9.6 kilobits per second (Kbits/s) modem using a single timeslot in the GSM allocation scheme. GSM includes provisions for extending this performance to 14.4 Kbits/s. But even at this enhanced circuit-switched rate, the connections are too slow and far below what Internet users demand. And the cost of the cell phone call can be significant.

With GPRS, packet-switched technology is used instead for the data transmission, and different classes of GPRS service can use varying transmit and receive time

slots. The existing GSM system requires a base station upgrade to handle the packet overlay; the upgrade is typically done by a software download. Once this is done, the data rate for the users is much higher than 9.6 Kbits/s, and the incremental service costs to the carrier are very low.
Enabling GPRS on a GSM network requires the addition of two core modules, the Gateway GPRS Support Node (GGSN) and the Serving GPRS Support Node (SGSN). A GGSN acts as a gateway between the GPRS network and Public Data Networks such as IP and X.25. GGSNs also connect to other GPRS networks to facilitate GPRS roaming. The Serving GPRS Support Node (SGSN) provides packet routing to and from the SGSN service area for all users in that service area. In addition to adding multiple GPRS nodes and a GPRS backbone, some other technical changes need to be added to a GSM network to implement a GPRS service. These include 1) the addition of Packet Control Units often hosted in the base station subsystems, 2) section mobility management to locate the GPRS Mobile Station, 3) a new air interface for packet traffic, 4) new security features such as ciphering, and 5) new GPRS specific signaling.

GPRS Features

&#149GPRS promises data rates of 50 to 114 kbits/s, much faster than data rates possible on the existing circuit-switched GSM network
&#149GPRS is "always-on," thereby giving users the benefits of immediacy. The "always-on" connection or availability is convenient for sending/receiving messages, emails, notifications, and alerts, because there is no "dial up" waiting time to make a connection.
&#149GPRS was intentionally architected to make it easy for network operators to add packet technology to their existing infrastructure.
&#149GPRS lets network operators maximize the use of their network resources in a dynamic and flexible way. Packet-switching is spectrum-efficient because GPRS radio resources are used only when users are actually sending or receiving data. Rather than dedicating a radio channel to a mobile data user for a fixed period of time (as is the case with voice), the available radio resource can be concurrently shared between several users. This means large numbers of GPRS users can share the same bandwidth and be served from a single cell. From the service provider's point of view, GPRS improves the peak time capacity of a GSM network because it allocates scarce radio resources more efficiently by supporting virtual connectivity and also migrates traffic that was previously sent using circuit-switched-data to GPRS.
&#149Because of the spectrum efficiency of GPRS, there is less need for operators to build in idle capacity used only in peak hours. GPRS therefore lets network operators maximize the use of their network resources.
&#149GPRS also enables mobile Internet functionality by allowing interworking between the existing Internet and the new GPRS network. Any service that is used over the fixed Internet today will be as available over the mobile network because of GPRS. Because it uses the same protocols, the GPRS network can be viewed as a sub-network of the Internet with GPRS capable mobile phones being viewed as mobile hosts. This means that each GPRS terminal can potentially have its own IP address and will be addressable as such.

Market Dynamics

Wireless developers are wise to pay careful attention to the market and technology

dynamics when considering their technology and business strategies. For example, one of the driving forces behind GPRS is the broad range of new multimedia applications that the higher speed data transmissions, from 56 to 114 Kbits/s, can enable. Theoretical maximum speeds of up to 171.2 Kbits/s are achievable with GPRS by using all eight GSM timeslots. This is about three times as fast as the data transmission speeds possible over today's fixed telecommunications networks (56Kbits/s analog modems) and ten times as fast as current circuit switched data services on GSM networks (9.6 Kbits/s). By allowing information to be transmitted more quickly, immediately and efficiently across the mobile network, GPRS may well be a relatively lower cost mobile data service compared to SMS and Circuit Switched Data.

However, initial GPRS devices are likely to support only four slots downstream (50 Kbits/s) and one slot upstream (13 Kbits/s). Handset and base station designers as well as service providers need to plan on a stream of software and services upgrades as the infrastructure technology matures and higher bandwidths are enabled over time.

The GSM market in general and the GPRS market in specific are changing rapidly, as new technologies enable new services and drive the demand for ever more capable products. GPRS is slated for a series of performance improvements, while at the same time GSM is rolling out in more countries by multiple operators. Services are evolving to meet new demands of customers (data applications and multimedia content will stimulate latent demand of already existing customers), while the equipment evolves to take advantage of newer technologies.

Technical Challenges Created by Market Dynamics While some markets, such as Europe, are reaching mobile penetration rates of around 70 percent, new functionalities and applications and the supporting technologies are required to ensure continued strong growth in market size. OEMs need to increase their portfolio and introduce more products in parallel to meet specific customer expectations, while not missing the opportunity window. In the GSM/ GPRS handset market, this means having wireless phones available when the services roll out at the price, performance, and feature set combination that customers need. It also means having a technical team ready to roll the next-generation product as soon as the previous-generation design begins shipping.

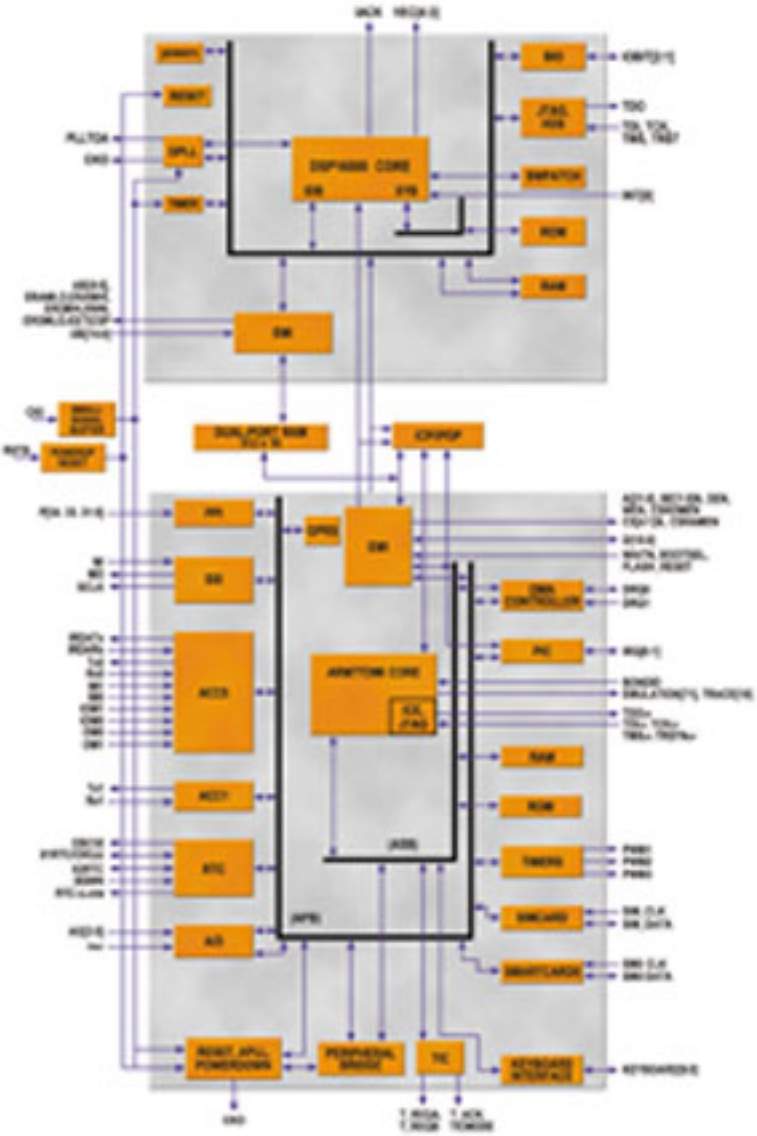
The technology management challenge here is often to understand your core expertise &#151 whether it is industrial design, software development and verification, hardware design and debugging, or customer relations. And then to farm out the rest to speed your time to market and to take advantage of the best-of-breed capabilities that accrue from using outsourced experts.

One piece of the equation in the GSM/GPRS formula is often working with a semiconductor manufacturer who can play a critical role in that part of a product's design. For example, for the advanced wireless services and applications described above to come to fruition, components such as processors, memories, and displays must increase in complexity while also improving in performance, price, and power consumption. Semiconductor manufacturers targeting the converged worlds of wireless Internet access and multimedia voice/data communications are focused on three key parameters to help handset (consumers) and base station (service providers) designers.

&#149*Focused Architecture and Processing Expertise.* The key to optimizing performance goes beyond higher clock rates and exaggerated MIPS (millions of

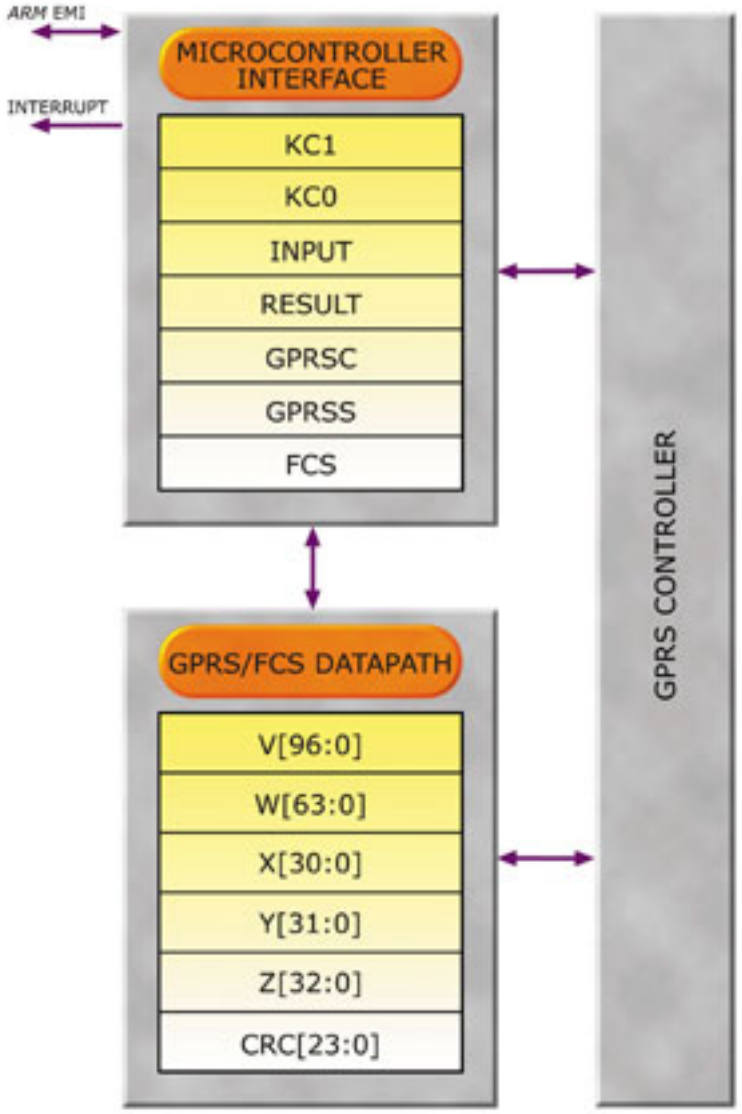
instructions per second) ratings to a process of ensuring the architecture and the instruction set are matched to the needs of the applications, ranging from voice coding to control functions to web-page display. Besides the issues of matching the instruction set to the application, other architectural considerations include the possibility of multiple processing cores, fast memory access, and mixed-signal capabilities. In short, even the semiconductor technology should come from a vendor focused on GSM/GPRS needs.
&#149*Decreased Size and Power Consumption.* In portable and handheld devices, lower power consumption translates to longer battery life and longer operating times. For consumers, this has proven to be a key satisfaction parameter. In base stations, lower power consumption allows more dense packing of devices, eliminates cooling systems, reduces power supply requirements, and improves overall system reliability. As semiconductor manufacturers evolve towards smaller geometries in their fabrication processes, chip sizes decrease, enabling higher clock rates and hence higher performance. Smaller chips also mean more chips per wafer, which helps drive down costs.
&#149*Improved Cost.* In any mass market or consumer application, cost is one of the primary determining factors of commercial acceptance. In the converged communications and computing hardware universe, semiconductor costs are a prime determinant of overall system costs. One way to decrease costs is to reduce a chip's die size. Another way to decrease costs is to reduce the amount of memory needed in the final system. Hence efficient processor architectures enable programs for wireless applications to be implemented with minimal memory requirements.

Meeting the Technical Challenges
If the new technology dynamics make vertical integration a disadvantage, then one successful strategy is to master a horizontal slice of the technology stack and outsource the rest. Many cell phone manufacturers now outsource most of their design work, and concentrate on sales, marketing, and brand awareness. This trend has created a whole new breed of electronics companies known as Original Design Manufacturers (ODMs). And many OEM designers focus on the industrial design and outsource much of the basic hardware and software development for GSM handsets to specialists in that area.
One of the key developments that makes such outsourcing successful is the availability of reference designs that provide a complete circuit board-level hardware and software integrated design for a tri-band 900/1800/1900 GPRS up to Class-12-capable mobile handset. One example is Agere's SVL12 platform, which is built on the foundation of a highly integrated digital signal processor (DSP) and microcontroller system with protocol stack software that has passed stringent interoperability tests and has received operator approval for GPRS Class 8 (50 kbps). In some cases, Agere's wireless platform can enable cell phone manufacturers to deliver their GPRS cell phones to market up to one year faster than if they build such cell phones from the beginning. This is doubly true because the underlying technologies in digital cell phones are becoming more difficult to develop and increasingly are being integrated into fewer integrated circuits.



The Agere Systems Highly Integrated GPRS System-Level Chipset

OEMs in the cellular market need to understand the silicon strategy of their vendor to understand the capability of today's products as well as their ability to adapt for the future. The SLV12 uses an Agere chipset consisting of the DSP16000 and ARM7 microcontroller and the CSP1093 mixed signal system that provides a seamless interface between the DSP and the tri-band RF system. A power management chip integrates power/battery management and SIM interface functions to complete a highly integrated baseband with virtually no discrete components, saving cost and manufacturing complexity. Agere believes that such reference designs play a key role in meeting the technology and business challenges of the GSM road ahead.



The microcontroller interface used with the Agere chipset

The rapid changes occurring at multiple levels of wireless technology make it crucial for OEMs to modify their approach to product design and technology investments. The market has redefined the cell phone business; the products, technology, and business strategies must align to meet the new market conditions.
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