SWPY006 – June 2002
White Paper

Multimedia Technologies on Terminals Based on the OMAP™ Platform

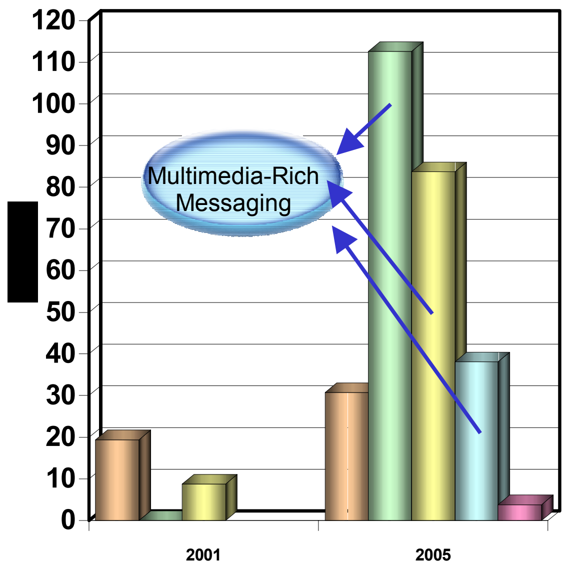
Shiv Ramamurthi, OMAP™ Applications Manager
Jay Srage, OMAP™ Strategic Partnerships Marketing Manager
Texas Instruments Wireless Terminals Business Unit

A New World of Wireless Opportunity

The growth of new wireless technologies is opening a world of opportunity to system developers. Third-generation (3G) wireless technology promises greater bandwidth for cellular and Personal Communication System (PCS) users, allowing service providers to offer a new level of wireless multimedia services, including data and audio/video, as well as voice. The market research firm Strategy Analytics predicts that by 2006, nearly 1 billion wireless instruments will be sold annually. More than 40 percent of the 1 billion will provide intermediate-generation (2.5G) data capabilities, and more than 20 percent full 3G multimedia capabilities. By that time, 3G instrument sales will be in a phase of accelerated growth, as wireless technology enables a new era of personal communications.

Wireless 3G instruments will combine the functionality of today's wireless phones, messengers and personal digital assistants (PDAs), along with streaming and interactive audio/video, imaging and graphics capabilities. New multimedia uses will include videoconferencing, video messaging, news clips, Web browsing, high-quality audio and other applications. Other new uses of wireless communications will include games, security, speech recognition, m-Commerce and location-based services. 2.5G and 3G applications will combine all or part of the above technologies. For example, a mapping display might present a map using graphics (SVG, Flash or other proprietary 2-D graphics technologies), with a small insert window showing a video of the traffic status at a specific intersection and an audio clip describing alternative routes. The different technologies (slide show, video, graphics, etc.) can be overlaid in separate windows or be part of a browser plug-in. Since growth is driven by consumer demand, applications will be provided based on the likeliness of the consumer to pay for these services.

One of the first emerging multimedia applications to be supported in next-generation networks will be Multimedia Messaging Services (MMS). Figure 1 shows the growth potential for this application.



Source: Cahners In-Stat Wireless Messaging Fusion, August 2001

Figure 1. Worldwide Wireless Messages Sent Per Month

Service providers and operators will be able to provide multimedia applications through their 3G networks, which include:

- Static content:
  - Downloadable audio/video and music
  - Pictures, books and documents
- Streaming media:
  - Real-time audio/video clips, news and financials
  - Audio/video on demand
  - Broadcast TV
- Interactive media:
  - Videoconferencing
  - Gaming and location-based services

To achieve the exciting potential of 3G multimedia communications, system developers need a new type of hardware and software technology. Hardware platforms must offer higher performance than ever, with low-level power consumption and a highly integrated solution. The solution must offer programming flexibility, since it will have to support a wide variety of evolving multimedia standards, mobile operating systems (OS) and end-user applications.

Texas Instruments, (TI), the industry's leading supplier of chipsets for digital wireless communications, offers the best solution for developers who want to take the next step into the future of wireless. TI's OMAP family of processors addresses the needs of each wireless terminal market segment. TI currently offers two OMAP platforms: the OMAP1510 and OMAP710 processors. The OMAP710 device, a highly integrated solution for 2.5G devices, is the first solution to combine a dedicated applications processor and a complete GSM/GPRS modem on a single piece of silicon. The OMAP1510 device integrates an ultra-low power TMS320C55x™ digital signal processor (DSP) for accelerating applications with a TI-enhanced ARM9 processor core for control and high-level OS, providing the highest processing performance without sacrificing battery life. The OMAP1510 device's open software architecture is designed to keep the dual-core hardware transparent to the user so it is easy to program and integrate into a multifunctional product. The OMAP platform offers the performance, low power consumption and programming flexibility needed for developing 3G multimedia wireless instruments.

Wireless Multimedia Requirements

Along with unmatched capabilities, 3G wireless multimedia systems have unique requirements that must be satisfied at every level of design, from the underlying hardware platform up to the highest level of application software. Mobility requires that the systems be light in weight and small in form factor. To provide the maximum usage time between battery charges, power consumption must be held to a minimum. Since wireless instruments are produced for the mass market, costs must be kept low, as well.

Tight space, low power consumption and cost sensitivity are all factors that constrain the computational performance and amount of memory that can be made available for wireless multimedia applications. Yet 3G systems are much more processing- and code-intensive than earlier generations of wireless instruments. Multimedia applications require a high level of system performance in to encode and decode vast amounts of pixel data. In addition, multimedia forces wireless systems to achieve an even higher level of signal quality than is needed for simple voice communications. Signal correction, already extensive in today's wireless transmissions, must include even more techniques to detect bit errors due to random channel noise and burst errors due to fading, multipath propagations and reflections.

Wireless multimedia systems also have to be highly flexible to support the wide range of applicable standards. Table 1 summarizes the major multimedia standards that exist today, relating them to their respective domains or areas of standardization. In addition, multimedia and other applications require different wireless service levels to govern signal quality and priority in delivery. Table 2 lists the traffic classes that govern delivery quality of service (QoS), along with representative application types.

Table 1. Overview of Multimedia Standards

Domain	ISO Standards	ITU Standards	IETF Standards	OTHER Standards
Media Codec	MPEG-4 Visual MPEG-4 Audio MP3 Audio JPEG2000 Image	H.263 Video H.26L Video H.323 Videoconf G.723.1 Speech		AMR Speech
Transport and Multiplex Control	MPEG-4 Systems Sync Layer and FlexMux	H.223	RTP/RTCP GeRM (Generic RTP Multiplexing)	HTTP WAP
Media Control Protocol	DMIF		RTSP	
File Format	MPEG-4 Multimedia			Microsoft ASF
Capability eExchange		H.245	SIP	
Metadata			SDP	
QOS			RSVP	WAP

Table 2. Traffic Classes and Characteristics

Traffic Class	Class Description	Example	Qos Requirements
Conventional	Preserve time relation Real time	Voice-over IP Video phone	Low jitter Low delay
Streaming	Preserve time relation Real time	Real-time audio/video content	Low jitter
Interactive	Bounded response time Preserve payload contents	Web browsing Database retrieval	Low-bit error rate Round trip delay time
Background	Preserve payload contents	E-mail File transfer	Low-bit error rate

In addition to those various standards, the terminal must support additional proprietary media codecs, such as Microsoft's® Windows Media Technologies (Player, WMV, WMA, WME), RealNetworks RealOne Player (RealAudio, RealVideo), Office NOA Nancy codec, and many others offered by companies that are part of TI's OMAP Developer Network.

The wide variability of standards, traffic classes and end applications demands that wireless multimedia systems be readily reprogrammable. Algorithms change as standards continue to evolve, requiring software updates to existing products. System developers need to be able to add or modify modules to spin new products using existing hardware and software. And mobile instruments must be programmable during operation to load new applications for temporary or long-term use.

The OMAP platform provides the performance, power savings and programmability needed for 3G wireless systems to support multimedia applications. Building software on top of hardware, OMAP devices offer a solution tailored to tomorrow's requirements for wireless multimedia systems. The OMAP platform makes the development of multimedia software engines and applications straightforward, saving time-to-market and more quickly opening the wireless multimedia market. Figure 2 shows the complete OMAP hardware and software architecture.

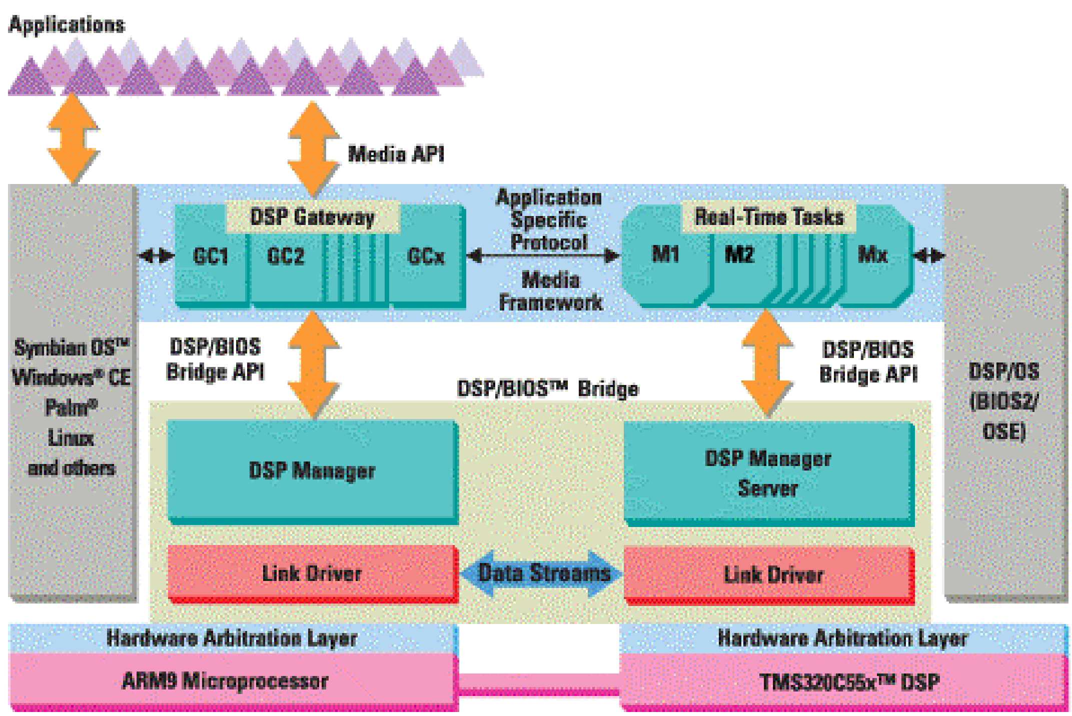


Figure 2. OMAP Hardware and Software Architecture

OMAP Hardware Architecture

The dual-core OMAP hardware architecture is designed to maximize system performance and minimize power consumption.

OMAP1510 device key features include:

- Up to 200 MHz (max freq.) C55x™ DSP core:
  - 192 KB Frame Buffer
  - Internal memory: 48-KW SARAM, 32-KW DARAM, 16-KW PDROM
  - 12-KB (24-KB) I-cache
- Up to 175 MHz (max freq.) TI-enhanced ARM9 processor core:
  - 16 KB I-cache
  - 8-KB D-cache
- DSP/BIOS™ bridge
- Shared memory interface
- DSP SmartCache™ plus memory management for optimal DSP core processing and protection
- Modem port targeted towards GPRS/EDGE, W-CDMA, UMTS/GSM, CDMA2000 and 1Xtreme Solutions
- 289-lead MicroStar BGA™ package (12 mm x 12 mm)

OMAP710 device key feature include:

- Up to 132 MHz (max freq.) ARM9 core
- Class 8 GSM/GPRS capability
- 192-kB SRAM frame buffer, 16 KB I-cache, 8-KB D-cache
- Compatible with OMAP1510 device for kernel and device drivers
- USB client, MMC, 9-channel DMA
- Enhanced audio codec interface
- 289-lead MicroStar BGA package (12 mm x 12 mm)

The OMAP1510 device, shown in Figure 3, is based on two integrated microprocessor cores: a C55x DSP and a high-performance ARM9 core. On-chip caches for both processors reduce average fetch times to external memory and eliminate the power consumption of unnecessary external accesses. Memory management units (MMU) for both cores provide virtual physical memory translation and task-to-task protection. Low-power operating modes are available to conserve power during periods when the OMAP device is used minimally or not in use.

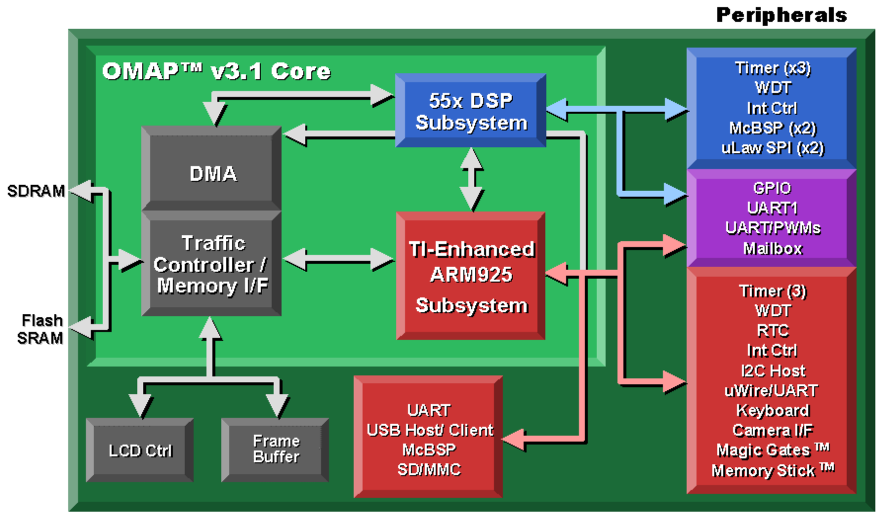


Figure 3. OMAP1510 Hardware Architecture

The OMAP platform also contains two external memory interfaces and a single internal memory port. One external interface supports a direct connection to synchronous DRAMs at up to 100 MHz. The second external interface supports standard asynchronous memories such as SRAM, Flash or burst Flash devices. This interface is typically used for program storage and can be configured as 16- or 32-bits wide. The internal memory port allows direct connection to on-chip SRAM or embedded Flash memory and can be used to save time and power for frequently accessed data, such as critical OS routines or the LCD frame buffer. All three interfaces are completely independent and allow concurrent access from either core or the DMA unit.

The OMAP platform also contains numerous interfaces for connecting to peripherals or external devices. Each processor has its own external peripheral interface, which supports both direct connection to peripherals and DMA from the processor's DMA unit. The local bus interface is a high-speed, bi-directional, multimaster bus that can be used to connect to external peripherals or additional OMAP devices in a multicore product. Additionally, a high-speed access bus is available to allow an external device to share the main OMAP system memory, both external and internal. The interface provides an efficient mechanism for data communication, as well as allowing the designer to reduce the number of external memories.

To support common OS requirements, the OMAP platform includes on-chip peripherals such as timers, general-purpose I/O, a UART and watchdog timers. A color LCD controller is also included to support a direct connection to the LCD panel. The ARM DMA unit contains a dedicated channel used to transfer data to the LCD controller from the frame buffer, which can be allocated in either the SDRAM or internal SRAM.

Dual-Core Advantages

The OMAP1510 device, with its combination of DSP and RISC cores, offers unique advantages in performance and power consumption for wireless multimedia instruments. The ARM RISC is well suited for handling control code, such as user interface, OS and OS applications. The DSP, on the other hand, is better suited for the real-time signal-processing applications used in multimedia.

Results of comparative benchmarking by Pace Soft Silicon are shown in Table 3. These benchmarks demonstrate multimedia tasks require 3x as many cycles and 2x more power to execute on a latest-generation RISC processor as they do on a C55x DSP. Battery life between charges, a factor that is critical for mobile applications, is much longer for a dual-processor device than a single-processor device performing the same multimedia applications. And the system performs tasks faster, since it has available two processors adapted to different types of code.

Table 3. C55x DSP vs ARM9E for Typical Multimedia Tasks (source: Pace Soft Silicon).

	ARM9E	C5510	Units
AMR Decode	7	2.2	Mcycles/s
AMR Encode	34	16.5	Mcycles/s
WB-AMR Encode	65	32	Mcycles/s
WB-AMR Decode	17	7.2	Mcycles/s
MPEG-4/H.263 decoding QCIF at 15 fps	16	9.6	Mcycles/s
MPEG-4/H.263 encoding QCIF at 15 fps	90	33	Mcycles/s

As an example of the improved task execution, say that the system is handling an H.263 videoconference consisting of QCIF video at 15 frames per second (fps) with audio. In this situation, a RISC alone would struggle to perform the application. But a single C55x DSP uses only 40-percent computation capability and half the power as the RISC to process the application in real time. Sixty percent of the DSP's performance capacity and all of the RISC's remain for performing other tasks. The mobile user can still have access to a word processor, spreadsheet, date book, etc., while engaged in a full-motion videoconference.

The C55x and Multimedia Extensions

The C55x DSP architecture was designed for fast execution, reduced code size and ultra-low power consumption in wireless modem and vocoder applications. In addition, the flexible C55x DSP core architecture allows extension of the core functions for multimedia-specific operations. Facilitating the demands of the multimedia market for real-time, low-power processing of streaming video and audio, C55x devices are the first family of DSPs with such core-level multimedia extensions.

Motion estimation, discrete cosine transform (DCT) and its inverse (iDCT), and pixel interpolation are tasks common to all industry video-imaging standards. They are also among the tasks that consume the greatest number of cycles in a pure software implementation on the C55x DSP. As a result, they are the first multimedia extensions that the C55x DSP supports. Software developers have access to the multimedia extensions through coprocessor-specific instructions that have been added to the general C5500 instruction set. Combining the coprocessor and general arithmetic instructions yields a variety of data flow modes that can be used to efficiently extend the application domain of the system.

With the multimedia hardware extensions, the videoconferencing application used as an earlier example is doubled in speed over a classic software implementation. By reducing the cycle counts necessary to perform tasks, the DSP's operating frequency can be reduced as well, resulting in power savings. Table 4 summarizes cycles and current consumption at the maximum and minimum supply voltages of a C55x using multimedia extensions to perform an MPEG-4 video codec for various image rates and formats.

Table 4. AAC Decoder Performance and Power on C5510 DSP

Rate	Mcycles/s	mA at 1.5 V	mA at 1.2 V
64 K	22.1	8.0	6.4
48 K	16.2	5.8	4.7
32 K	11.4	4.1	3.3

OMAP Software Architecture

The OMAP platform includes an open software architecture that is needed to support application development and provide a dynamic upgrade capability for a heterogeneous multiprocessor system design. This architecture includes a framework for developing software, which targets system design and application programmer interfaces (API) for executing software on the target system.

Future wireless systems will see a classic voice phone merger with PDA functionality and non-voice multimedia applications. As a result, these systems will have to accommodate wireless standards, a variety of popular handheld OSes for PDA-type applications, and real-time OSes for dynamic multimedia applications multitasking. The OMAP platform; therefore, provides a software architecture that is open and generic, allowing easy adaptation and expansion for future technology. Standardization and reuse of existing APIs and application software are the main goals for the open platform architecture. Standardization will permit extensive reuse of previously developed software, accelerating time-to-market for new software products.

To simplify software development, the DSP software architecture must be abstracted from the general-purpose programming (GPP) environment, as shown in Figure 4. In the OMAP platform, this abstraction is accomplished by defining an architectural interface that allows the GPP to be the system master. This interface, the *DSPBridge*, consists of a set of APIs that include device driver interfaces. The DSPBridge provides communication that enables GPP applications and device drivers to:

- Initiate and control DSP tasks
- Exchange messages with the DSP
- Stream data to and from the DSP
- Perform status inquiries.

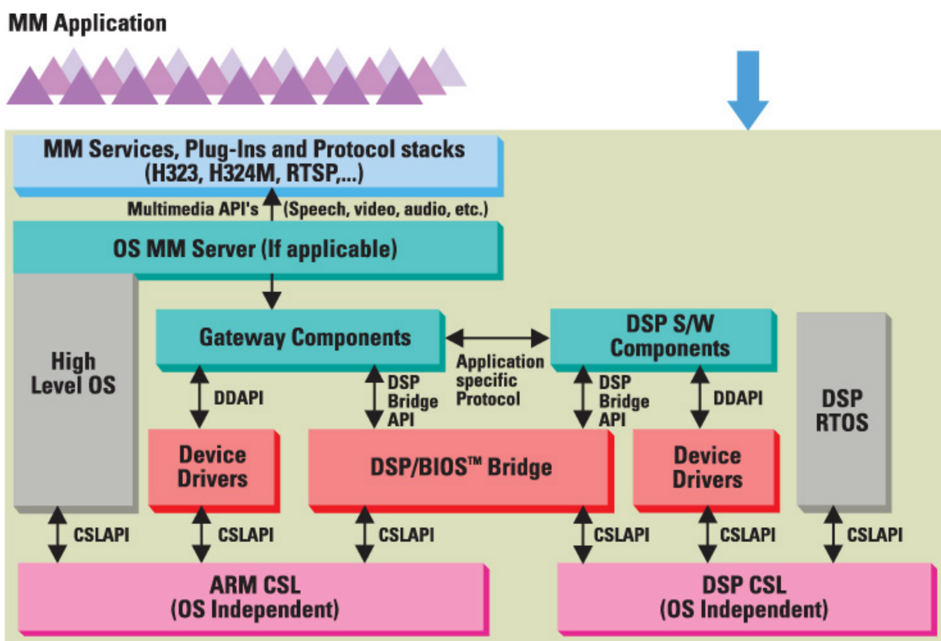


Figure 4. OMAP Software Architecture

On the GPP side, the API that interfaces to the DSP is the *resource manager*, the single path through which DSP applications are loaded, initiated and controlled. The resource manager keeps track of DSP resources such as MIPS, memory pool saturation, task load, and so forth. It also controls starting and stopping tasks, controlling data streams between the DSP and GPP, reserving and releasing memory and other shared system resources, as well as other tasks. Through the resource manager, the DSP is projected into the GPP programming space, so that GPP applications can address the DSP functions as if they were local to the application.

OMAP Platform Advantages in Video Applications

Video entertainment, messaging, surveillance and other applications are communicated bidirectionally and either encoded or decoded unidirectionally. Voice communications in 2G wireless networks require 8 to 13 kbps of transmission bandwidth. By comparison, video requires a minimum of 20 kbps for low-motion content on a small display, and the requirements for video rise rapidly as frame rates, display size, resolution and the motion of frame content increase. Although 3G technology will increase the bit rates available for video transmission, there will always be a need for intense compression and decompression in wireless video coding.

Compressed video is particularly sensitive to errors that can occur with wireless transmission. To achieve high compression ratios, variable-length code words are used and motion is modeled by copying blocks from one frame to the next. When errors occur, the decoder loses synchronization, and errors propagate from frame to frame. Encoding typically requires about 3x as much processing as decoding. Since the main bottlenecks in many video standards are motion estimation, DCT and iDCT, the OMAP hardware accelerators serve to double video encoding by tight coupling of hardware and software. In addition, the OMAP platform provides the high rate of data transfer needed for video applications. Frame rates of 10 to 15 fps need to be supported for wireless applications. Higher resolutions, frame rates and content motion require more processing; nevertheless, the OMAP platform is clearly designed to offer plenty of performance for the most demanding mobile multimedia applications.

Multimedia Messaging Services

MMS offers another example of the OMAP platform in use for 2.5G and 3G multimedia applications. TI, through its internal development and partnerships with OMAP developers, provides the basic components needed to build a rich MMS application based on audio, text, graphics and video.

- The 3GPP spec that standardizes MMS requires the minimum: JPEG, MIME text with SMS interoperability, GSM AMR, H.263 and SVG for graphics

- Optional features: AAC, MP3, MIDI, MP4 and GIF

- The MMS user agent needs to provide the following application layer function:
  - MM presentation
  - Notification of the user
  - Retrieval of MM messages

- Additional functions that can be provided are:
  - MM composition
  - MM submission
  - Encryption and decryption
  - Storing MM messages
  - User profile management and other functions.

So, the MMS user agent should be able to send a message through SMTP/HTTP to the MMS server/relay. The server will forward the message to the recipient. The recipient would send an acknowledgment to the server that relays it back to the sender. The user agent needs to recognize and provide notification to the user.

The application and communication layers handle all those functions.

The mandatory use of GSM-AMR, SVG, H.263 and JPEG, with the optional use of AAC, MPEG-4 and other Multimedia algorithms only makes the use of OMAP1510 more compelling. With the compounded effect on performance (40 percent average cycle saving and 50 percent power savings), handset manufacturers can afford to integrate many, if not all, optional features in MMS without compromise to battery life at extremely high performance. Then carriers and service providers can please consumers with a variety of rich applications provided by the handset manufacturers.

Another Example Application: SIP

Session Initiation Protocol (SIP) is the 3GPP standard for two-way videoconferencing over packet-switched wireless networks. SIP specifies only the control signaling between end-points. So, in addition to SIP there are many other standards and components that are required to build a complete videoconferencing application.

The various components in a videoconferencing system can be classified into the following categories:

1. Media codec (encoder and decoder). This component compresses the speech, audio and video information before transmission and also decompresses what is received. The information has to be compressed before transmission to conserve bandwidth.

2. Media transport protocol. This protocol is responsible for adding sequence numbers and time stamps to packets transmitted over wireless channels. The sequence numbers detect packet loss, and time stamps are required to control media playback.

3. Control signaling protocol. This protocol is responsible for call set-up and teardown.

4. Session description protocol. This protocol describes the content going to be used in the videoconferencing session.

In a SIP-based videoconferencing system, typical media types supported include MPEG-4 and H.263 for video coding and AMR, GSM FR, G.723.1 and G.711 for speech coding. For two-way communication, we need both the decoder and encoder. Compression is a signal-processing intensive task that is best suited for DSP execution.

The media transport protocol used is the real-time transport protocol (RTP). RTP headers are typically 12-bytes long and include information on sequence numbers, time stamps and payload type. RTP also supports mechanisms for speech and video synchronization and QoS feedback.

SIP carries out control signaling. It uses the session description protocol (SDP) to negotiate the media types to use in a session. On the OMAP platform, protocols can be run on the ARM.

OMAP Products and Support

The OMAP1510 device is the first high-performance TI product based on the dual-core architecture. Figure 5 shows the block diagram of a typical 3G wireless system based on the OMAP1510 device. The OMAP1510 device is designed to offer the highest performance for gaming, security and encryption, m-Commerce, audio/video streaming, video calls, multimedia messaging and other real-time tasks. The optimized dual-core architecture enables application multitasking, preventing the system from being overloaded by computation tasks.

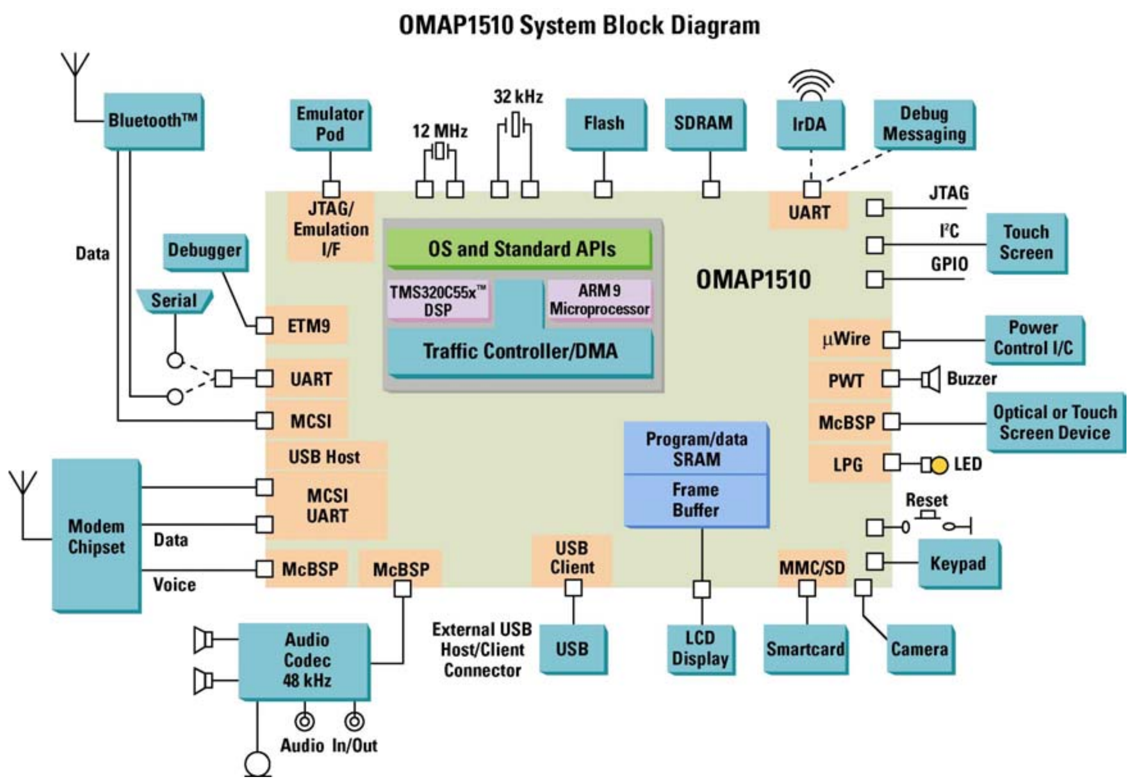


Figure 5. OMAP1510 System Block Diagram for a Typical 3G Device

Besides doing away with the dreaded "blue screen" for system overloads, the dual-core architecture saves power and prolongs battery life between charges. Tests have shown that for digital video streaming and still image downloads, the OMAP1510 device uses only half the power of a standalone RISC processor. The more advanced the task, the greater the savings: for real-time videoconferencing and 3D-image rendering, the OMAP1510 device consumes only one-fourth the power of a RISC-only solution.

Some systems, especially among 2.5G handsets, may not need the full performance provided by the dual-core architecture. For these systems, TI offers the OMAP710 device, an economical single-core OMAP processor designed for enhanced voice and data support and the industry's first solution to combine the GPRS modem and a dedicated applications processor on a single chip. The OMAP710 device is well suited for mid-range applications that will not need to multitask, such as mixed multimedia messaging, Internet audio downloads, low-definition video clip playbacks, and over-the-air synchronization with address book and calendar. Figure 6 shows an OMAP710 system block diagram.

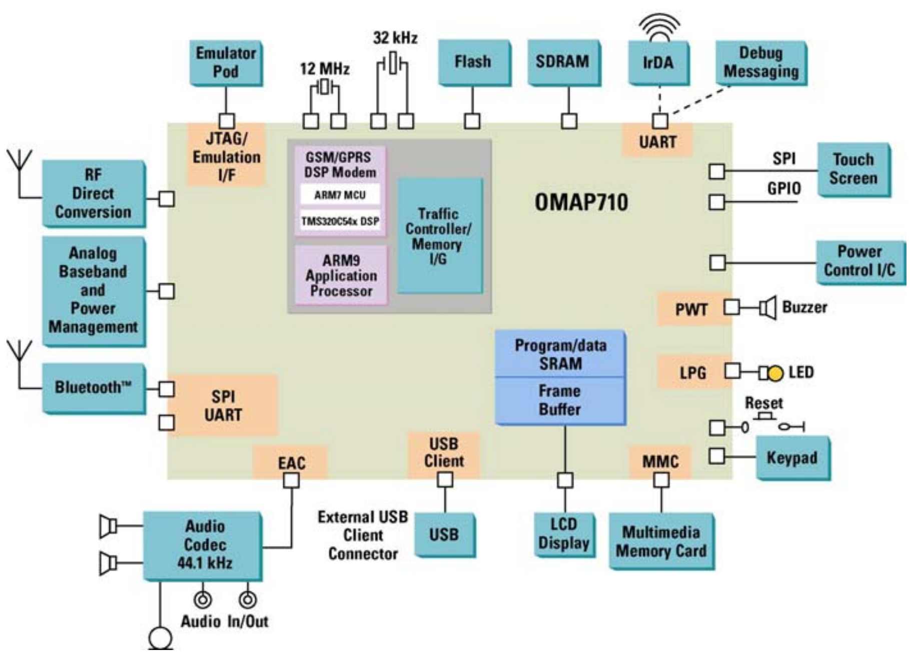


Figure 6. OMAP710 System Block Diagram

Both OMAP710 and OMAP1510 devices complement other TI wireless solutions, including chipsets for leading transmission standards worldwide, as well as Bluetooth™, Ethernet and Global Positioning Services (GPS).

The software development process for both the dual- and single-core OMAP processors is identical, providing an upward migration path and allowing wireless OEMs to target various markets with a single development flow. The software architecture and APIs give easy access to DSP algorithms, allowing programmers to create products using familiar C code, with no direct manipulation of the underlying hardware. Developers have access via one open platform to all world-leading standards, including GSM, GPRS, W-CDMA, UMTS and so forth. All leading mobile OSes are supported, including Microsoft®, Symbian™, Palm®, Linux®, Nucleus, and others, and development environments like Java™. Figure 7 shows the OMAP platform software development flow.

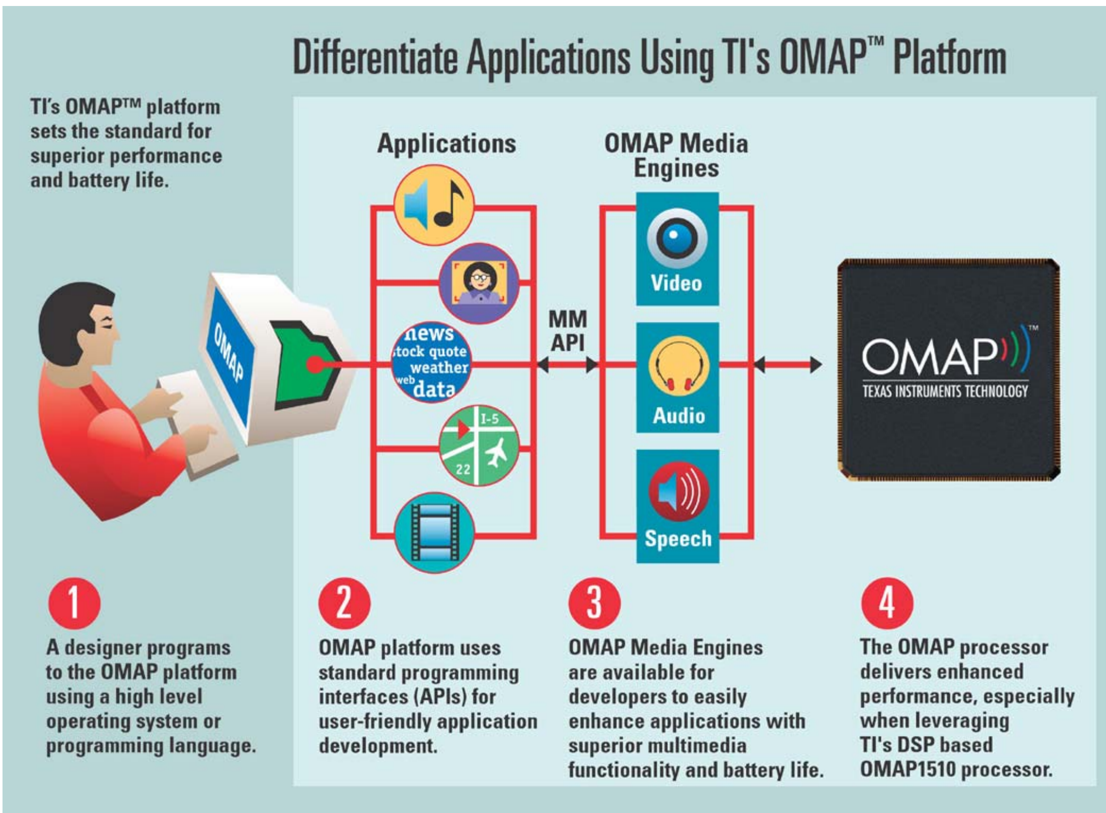


Figure 7. OMAP Platform Programming Flow

OMAP software support is based on TI's eXpressDSP™ Real-Time Software Technology, the industry's most advanced system for DSP code development. eXpressDSP Technology includes the Code Composer Studio integrated development environment (IDE), the DSP/BIOS real-time kernel, the TMS320 DSP Algorithm Standard for interoperability and reuse, and the industry's largest base of third-party software modules. In addition, an optimized library of video and imaging tasks is available to aid in development of multimedia modules.

TI's OMAP Developer Network provides the support needed to help media engine and application developers bring OMAP products to market quickly and enlarge the market space for advanced wireless applications. Besides optimized tools, the OMAP Developer Network offers training and technical support for creating differentiated wireless applications. The network also provides access to leading system manufacturers, shown in Figure 8, who have selected the OMAP platform for their wireless instruments. The OMAP developers' community of is driving wireless innovation, not only in multimedia, but also in areas such as games, speech recognition, security, m-Commerce and location services.

Figure 8. OMAP Multimedia Developers

A Revolution in Communications

As 3G wireless becomes a reality, multimedia will be among the most important applications that take full advantage of the new technology. Wireless instruments will have to be designed for much greater performance with a minimal increase in power consumption to provide multimedia audio/video, imaging and graphics. With its DSP/RISC dual-core hardware and open software architecture, the OMAP platform offers the industry's highest performance in a solution designed for ultra-low power consumption. OMAP platforms also provide outstanding support, which helps developers extend their products' functionality, lower overall system costs and reduce development time to take faster advantage of market opportunities.

Multimedia and other new services enabled by 3G wireless technology represent a revolution in the way we communicate. With its leadership in integrating hardware, software and support, TI's OMAP architecture is playing a leading role in bringing about the 3G revolution.