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The role of digital signal processors (DSP) for 3G mobile communication systems

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ABSTRACT : Digital Signal Processing is carried out by mathematical operations. Digital Signal Processors are microprocessors specifically designed to handle Digital Signal Processing tasks. These devices have seen tremendous growth in the last decade, finding use in everything from cellular telephones to advanced scientific instruments. In fact, hardware engineers use "DSP" to mean Digital Signal Processor, just as algorithm developers use "DSP" to mean Digital Signal Processing. DSP has become a key component in many consumers, communications, medical, and industrial products. This paper illustrated the role of Digital Signal Processors (DSP) for third generation mobile systems. The currently deployed wireless infrastructure supports the third generation of mobile communications comprised of many distinctly different standards. As a result, interoperability among these standards is nearly impossible with respect to the cellular base station. Many solutions for base station or mobile station have been implemented over the years, and each solution required a combination of two components, ASICs (Application Specific Integrated Circuits), and DSPs (Digital Signal Processors). This two-chip solution partitions the processing tasks between the ASIC and DSP, respectively. Although this solution is functionally acceptable, its system cost and flexibility are not completely optimized. Global objectives and attributes that include worldwide roaming, universal connectivity, high data transmission rates, location service capability, and support for high-quality multimedia services are now required.

Keywords : Digital Signal Processors, 3G Mobile Communications Systems

I. INTRODUCTION

The importance of digital signal processors (DSPs) for communications, and in particular mobile communications, has been ever increasing. Today DSPs present a key technology for executing base band modem and lower layer protocol functions. Historically DSPs were designed around one multiplieras stand-alone integrated circuits (ICs). In the light of VLSI technology the processing power and complexity of DSPs has been increasing to today's levels Hence, today embedded DSPs have been widely adopted and are becoming mainstream.In the future, however, the market can evolve even further. Large customers of embedded DSP ICs, as "tiers one" mobile terminal equipment manufacturers, today need to have ASIC design expertise to deûne the custom logic around the embedded DSP. This way they can ensure a proprietary solution with a competitive advantage. This paper shall provide a brief understanding of DSP technology.

II. MOTIVATION

A. Achieving a competitive advantage

The communications market is very dynamic and has a high growth rate. Hence DSPs [2] for communications must evolve to continue being a platform for achieving and sustaining a competitive standing. How can this be achieved?

The performance of DSPs is evolving further by advances in semiconductor technology. This leads *e.g.*, to higher clock frequencies as well as a reduced power consumption per MIPS. Additional performance improvements can be gained by the development of new DSP architectures, where performance is measurable by a reduced MIPS requirement per algorithm (improved efficiency), reduced power consumption, or allowable higher clock frequency. Riding on advances in semiconductor technology alone for achieving a competitive advantage can be extremely dangerous. Therefore, architecture technology is a key.

B. How to get a hold of DSP technology ?

Typical money maker ICs have gained a competitive advantage by sustaining a technical and/or marketing advantage. A technical advantage as :

(*i*) Power consumption
(*ii*) die size/cost
(*iii*) performance
(*iv*) package, I/O, chip-set integration

is achieved by combined architecture-application optimization.

C. What kind of DSPs are needed ?

There has been discussion on DSPs versus microprocessors. This was mainly based on general purpose floating-point DSPs. Actually, DSPs cover a very wide range of architectural customizing for applications. We can divide

DSPs into three general classes, *i.e.,*

(*i*) Application specific DSP (AS-DSP)

(*ii*) Domain specific DSP (DS-DSP)

(*iii*) General purpose DSP (GP-DSP).

Following, we refer to a circuit being a DSP only if it is software programmable by an assembly language. DSPs as defined *e.g.*, in [1] we call datapath processors AS-DSPs are typically customized to an application to serve high-end application performance requirements, or to minimize die size/ cost. Generally the market volume must allow for a custom solution to be developed, and customizing is carried out to gain market advantages However, time-to-market constraints must allow for a long design cycle. Examples of AS-DSPs can be found *e.g.*, for speech coding [2,3]. Application customizing can be found in the datapath, address generation, bus architecture, memory, and I/O.

DS-DSPs are targeted to a wider application domain, as cellular modems (TI C540, TCSI Lode). They can be applied to a variety of applications, however they were designed "with a target application in mind". Due to special instructions and additional hardware they can run domain specific algorithms efûciently

A DS-DSP is designed for a market with a volume high enough to allow specialized solutions. Its main advantage over an AS-DSP is its fast availability, and access to a small software library base. GP-DSPs have evolved from the classic FFT/filtering multiply-accumulate design paradigm. Examples are TI C50, Lucent 16xx, Motorola 563xx, ADI 21xxx, and DSP-Semi's Oak/Pine. GP-DSPs are readily available, are widely applicable, and have a large software base. However, they lack in performance when compared to more customized solutions for specific applications.

III. THE THIRD GENERATION OF MOBILE SYSTEMS REQUIREMENTS

As more and more applications require audio, video and communications processing capabilities, the requirements placed on processors used in base station and mobile stations (portable devices and edge-client devices) have become more computationally and bandwidth intensive. Both RISC microcontrollers (MCU) and DSPs have served these applications.

While RISC processors are traditionally architected to enable efficient asynchronous control flow, DSPs are architected to perform well for synchronous, constant-rate data flow (for example, audio or voice-band applications).

Because so many embedded applications have intense requirements for both control and media processing, engineers have typically used DSPs and MCUs together, either at the board level or in system-on-chip (SoC) integration. Together, the respective functional aspects of RISC processors and DSPs unite as the perfect processing engine for a wide variety of multimedia applications and products, such as cellular telephones, digital cameras, portable networked audio/video devices, and so on. Key base-station areas that require high-performance DSPs will include:

(*i*) Antenna Arrays with Adaptive Digital Beam-Forming (in BS- Base Station)

(*ii*) Power Control (in both BS and MS – Base and Mobile Stations)

(*iii*) Voice Processing (in BSC: Base-Station Control)

(*iv*) Base Band Modem (in BTS: Base Transceiver Station)

Digital signal processors are required both in BS and MS as we can observe in Fig. 1, 2. Nowadays, there are some emerging technologies such as :

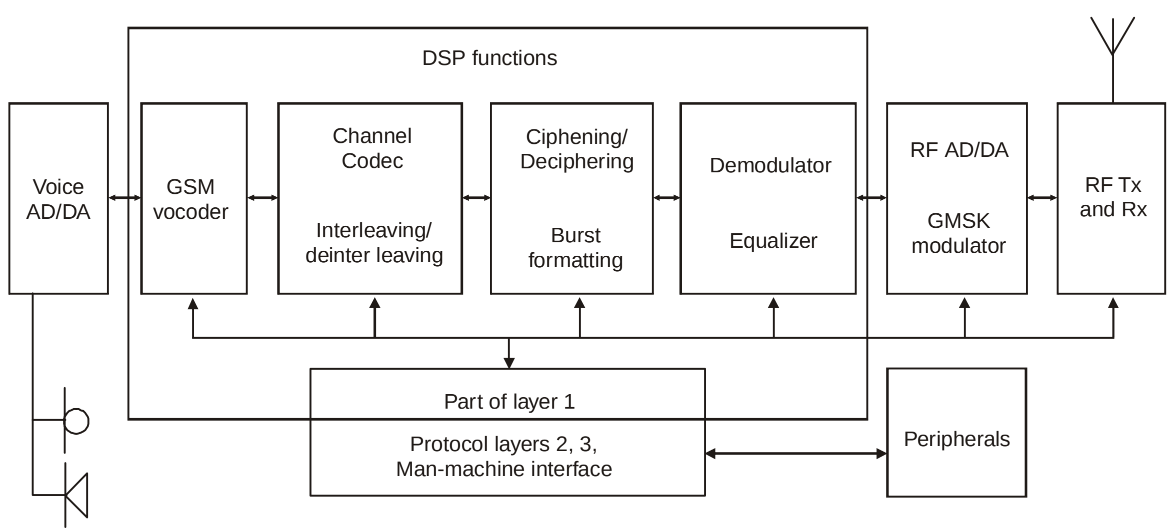

Fig.1. The GSM mobile station.

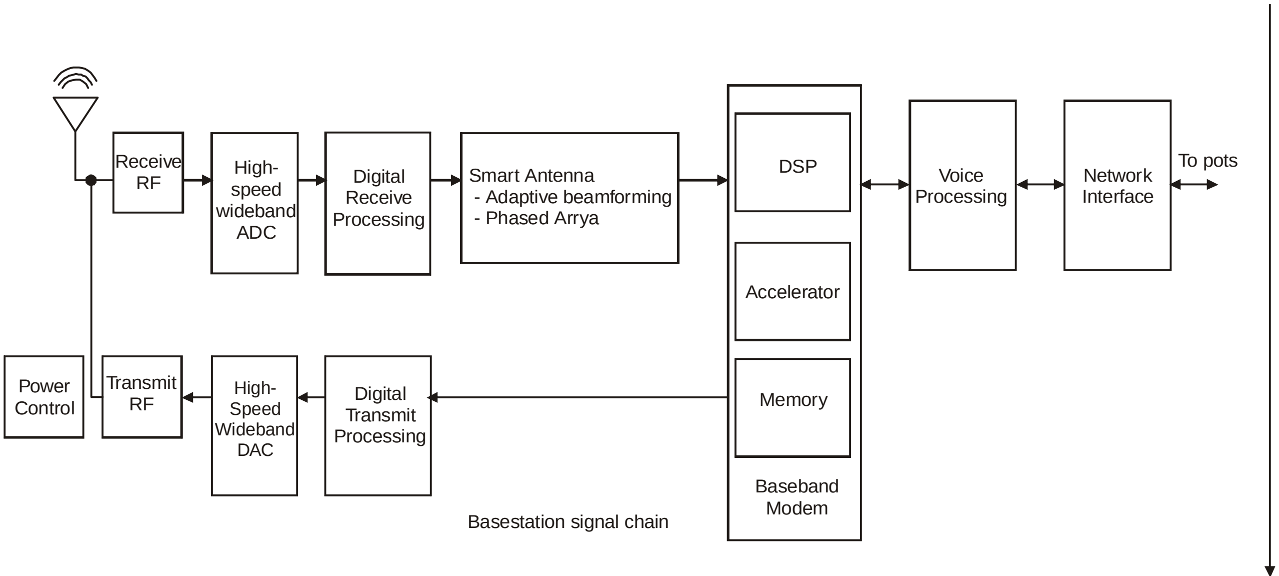

Fig.2. The base station.

(*i*) DSP – based Internet telephony which bridge between PSTN and packet network (VoIP gateway); the DSP advancements in processing power, smaller footprint, and reductions in power dissipation have expanded number of channels carried on VoIP gateways.

(*ii*) ADSL market

(*iii*) Software radio

(*iv*) Space-time processing

A. Smart antennas

Digital beam-forming algorithms are designed to target source locations in a noisy environment. They rapidly compare responses of several spatially deployed antennas; the result of the computation is a signal that is believed to have originated from the target direction. Basically, they compute a correlation function that compares the signals and gives a measure of how close the desired and received signals are. Due to the many factors involved in the algorithm, and their wide dynamic range, floating point multiply accumulate operations are used almost exclusively to minimize roundoff errors. The target is mobile, and could be moving at a significant speed, this adds another dimension of complexity to the computation.

B. Power control

In the code-division multiple-access (CDMA) systems proposed for 3G, base-station-initiated power control of remote-unit transmitters (uplink) is critical to compensate for fast fading, peaks in transmission power, and to avoid near-far problems. This is necessary to reduce inter-cell interference. The computations required for power control are multiply-accumulate intensive, requiring high performance digital signal processing to meet delay time requirement in 3G systems.

C. Voice processing

DSPs [3] are the traditional choice for speech processing within the cellular system. The phone user's opinion of the quality of the system is directly dependent on the performance of the speech coder, and this has a strong influence on the channel density. Several speech coders are in use today in current 2G systems and must be supported in 3G systems. Although lower codec bit rates increase equipment capacity, they worsen the speech quality. The critical DSP characteristics for high-quality voice processing combine large on-chip RAM and high processing capacity to support fast context switching and high channel density.

D. Base band modem

The 3G standard is expected to be an essential factor that enables applications involving the transmission of wideband signals. Accordingly, the base band modem (BTS) must be designed and implemented with the ability to intermix high bandwidth applications and low bandwidth voice and paging. In the downlink, the base transceiver station packages parallel transport-block streams into physical channels; and in the uplink, it recreates the transport blocks from the base band signal. Fig.3 shows a typical base band modem section of the 3G base station for both uplink and downlink configurations. During downlink, error-coding schemes are first applied to the transport block. Then the blocks are reordered and recombined with other channels before being sent off to the radio. For the uplink, the rake receiver is first used to sort out multipath effects and possibly to combine the data from several antennas. The blocks are then restored to their original order and channels before forward error correction is applied. In the next section, the partitioning of the base band modem provides insight as to where a designer might choose to use a DSP. An optimum must be sought between minimizing the performance cost and maximizing the flexibility of the system to handle future design iterations. Rake, Channel-Encoding/Decoding Hardware-Software Tradeoffs: An overview of the functions depicted in the Fig.3 is needed in order to see exactly where DSP is more appropriate than other alternatives. The interleaving, channel segmenting, and rate matching are I/O intensive operations, which combine data from several sources and reorganize data to minimize the effects of errors. Because of the variability of the parameters, data-rates, and memory-referencing, these functions are ideally suited to DSP for manipulation; they would be difficult to implement cost-effectively in an ASIC. The error-coding and -correction algorithms involve significant bit manipulations that-properly implemented - can be implemented in the DSP. The error-correction algorithms also represent an area of the modem that can provide equipment manufacturer differentiation.

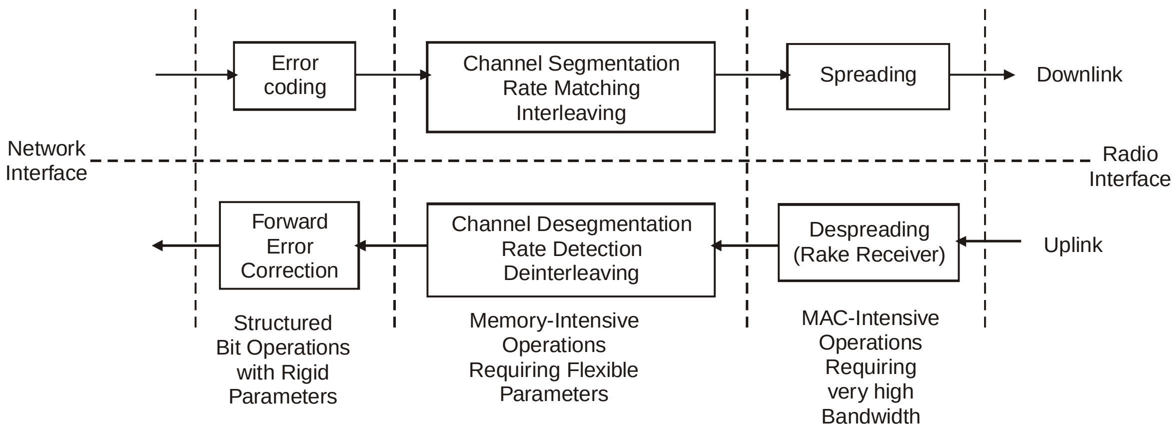

Fig.3. Block diagram showing the baseband processor's signal chain.

E. Advanced technologies

The advanced technologies take into consideration the enhancements provided by multiple antenna (MIMO) processing in physical layer. Traditionally, the speed of a wireless link is limited by the radio resource (power, bandwidth). When the transmitter has antennas and the receiver has antennas, the link speed increases linearly with given the same power and bandwidth budget. Multiple antenna introduces Spatial Dimension into the radio resource set. Some technologies are briefly illustrated below. These technologies are suitable for using of DSP.- BLAST (Bell-Labs Layered Space-Time Architecture): At the transmitter, n independent data streams are transmitted out of the n-antennas on the same bandwidth. At the receiver, each receive antenna "sees" all of the transmitted sub-streams superimposed, not separately. If multipath scattering is sufficient, these n data streams have different spatial signatures to each of the n receive antennas are separable.

IV. CONCLUSION

Designers of 3G base stations will make use of the DSPs in order to achieve the high performance and flexibility needed for tomorrow's voice and data applications. Speech coding is an essential application of digital signal processing in modern day telephony and mobile communications, which employ high data compression ratios. Effective embodiment of these design principles will fulfill the promise of 3G to provide the foundations of the kind of wireless infrastructure necessary for tomorrow's applications.

REFERENCES

[1] G. Fettweis, S. Wang, "Strategies in a cost-effective implementation of the PDC half-ratecodec for wireless communications," IEEE 46th

[2] Gerhard Fettweis, "DSP Cores for Mobile Communications: Where are we going?"

[3] Gatherer, E. Auslander, editors, "The application of programmable DSPs in Mobile Communication", Ed.Wiley, (2002),

[4] Y. Okumura, T. Ohya, Y. Miki, T. Miki, "A study of DSP circuits applied to speech codec for digital mobile communications," Proc. of the Fall Meeting of the IEICE, B-294, p.2-294(1993).