The role of digital signal processors (DSP) for 4G mobile Communication systems

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Abstract: **Digital Signal Processing is the mathematical handling of an information signal to modify or improve it. Digital Signal Processors are microprocessors specially 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 fourth generation mobile systems. The currently deployed wireless infrastructure supports the fourth generation of 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, 4G 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 multipliers 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 define 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 use 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) Type 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 data path 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 data path, 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 efficiently.

III. THE FOURTH 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:

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

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

(c) Voice Processing (in BSC: Base-Station Control)

(d) 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:

(a) 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.

(b) ADSL market

(c) Software radio

(d) Space-time processing
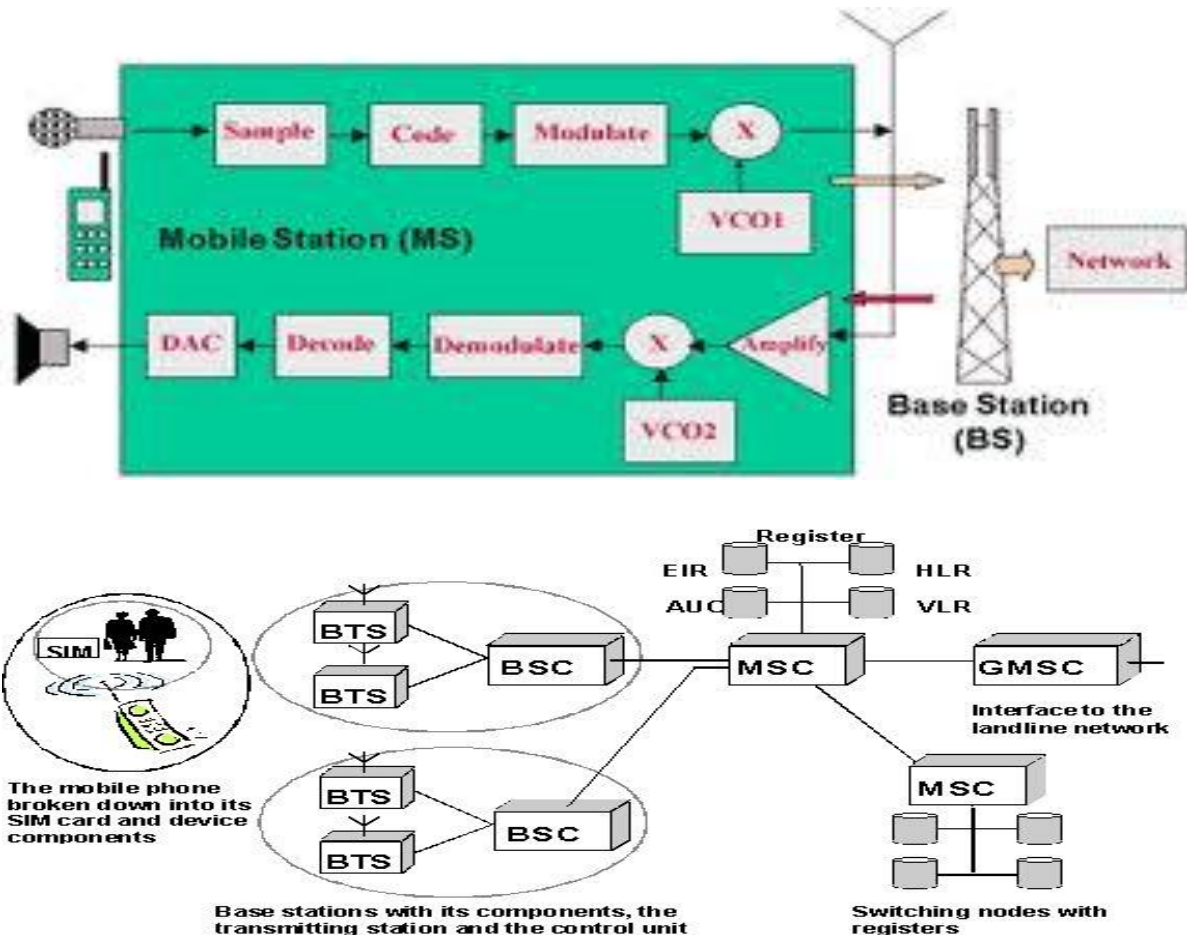
A. Smart antennas

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 round off 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

As CDMA is not expected to be used in 4G system, and is also not used in pre-4G system such as LTE and WIMAY, but it about to be supplemented by more spectral efficient frequency-domain equalization (FDE) techniques such as OFDMA. For a two user cooperative orthogonal frequency division multiple access (OFDMA) system with full channel state information (CSI), we obtain the optimal power allocation (PA) policies which maximize the rate region achievable by a channel adaptive implementation of inter-sub-channel block Markov superposition encoding (BMSE), used in conjunction with backwards decoding. We provide the optimality conditions that need to be satisfied by the powers associated with the user's code words and derive the closed form expressions forth optimal powers.
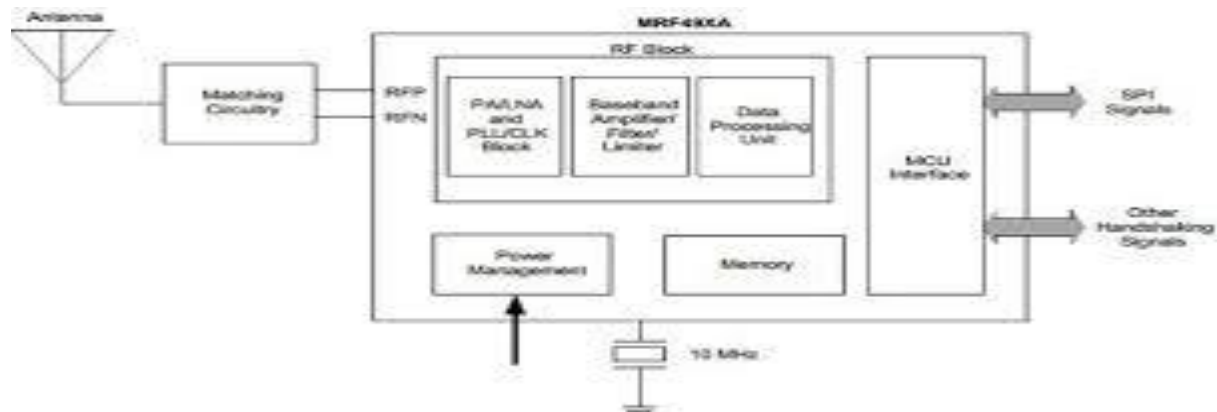
C. Voice processing

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 and 3G systems and must be supported in 4G 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. 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, 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 4G base stations will make use of the DSPs in order to achieve the high performance and lower transmission cost per bit for network operators. potential savings start at the Radio access Network (RAN) ,where higher spectral efficiency with 4G orthogonal Frequency Division multiple access (OFDMA) download link and single carrier Frequency Division Multiple Access (SC-FDMA) uplink modulation schemes ,enabling operator to push more data through available bandwidth. 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 4G better than 3G to provide the foundations of the kind of wireless infrastructure necessary for future applications.

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