The Reality of SDR in User Equipment (UE)

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1. Introduction

Software Defined Radio (SDR) platforms and solutions are being actively pursued by both the industry and the academia. The purpose of SDR is to enable a programmable solution based on Digital Signal Processing (DSP).

The importance of wireless communication systems can be seen easily by the rapid increase in the number of its subscribers. With the ever increasing user demands and resource consuming applications, pressure has been built up for developing new standards for communication. 2G (such as GSM and IS-95) systems opened the door for digital communication systems. Later on these systems were replaced by 3G (WCDMA, TD-SCDMA and CDMA-2000) technology, deployed in many parts of the world, which is being evolved as 3GPP LTE with higher data rate, ultimately going to be updating to LTE-Advanced.

New standard, as well as the demands for upgrading the algorithm to achieve better performance, push manufacturers to announce new products. Meanwhile, operators and the subscribers need user equipments (UEs) supporting several kinds of standard to utilize legacy network and provide seamless global coverage. These have posed major challenges to keep the radio hardware and software from becoming obsolete. UE chipset vendors must respond to the changes and come up with new innovations in technology to provide cost-effective multi-mode chipset, to upgrade or to fix any bugs discovered later.

To answer these big challenges of rapidly growing communication industry we need a piece of reusable hardware that can work with different standards and protocols at different times to provide service providers and users most effective solution in terms of low cost, adaptability and future needs. We need so much flexibility because with ever growing standards always changing the hardware causes huge costs and huge delays for time-to-market as well. This is the motivation behind the "Software Defined Radio".

2. DIGITAL BASEBAND TECHNOLOGIES

Most of the very high data rate broadcast applications today are based on multi-carrier techniques. The basic principle relies on the fact that high data rate stream is divided into multiple low rate data sub-streams. Each of these sub-streams is modulated on different sub-carriers which are all orthogonal to each other. Orthogonal Frequency Division Multiplexing (OFDM) proposed has been widely adopted as a very efficient multi-carrier digital modulation scheme to realize such systems.

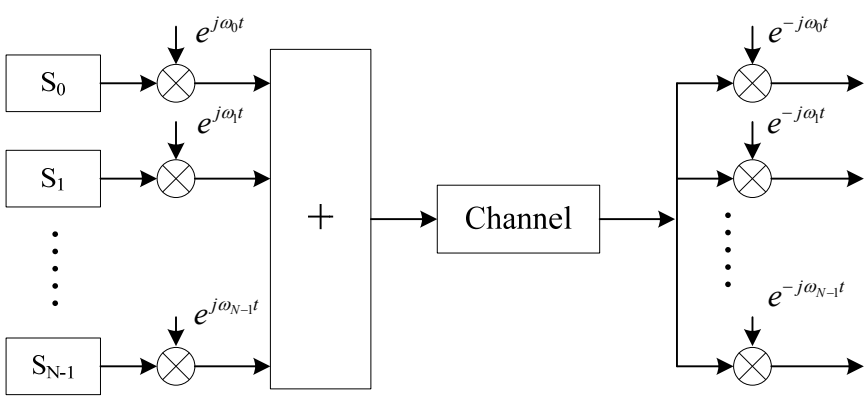

Figure 1 Multi-Carrier System

The major algorithms in an OFDM receiver chain to be processed by the baseband processor are related to channel estimation, equalization, demodulation, channel decoding and synchronization. Generally, current algorithm is designed properly to provide the possibility to employ parallel processing. It is convenient to arrange the data to be "vectors", which is popular used by most of SDR solution. Technology such as single instruction multi data (SIMD) and very long instruction word (VLIW) enable the DSP to process data vectors, which involved several vectors of data, according to a same algorithm or flow.

Theoretically, almost all kinds of algorithm can be deployed by software, which is totally programmable, in vector DSP. But in UE side, considering about the efficiency and power consumption, algorithm which is stable and with high computation complexity, such as Turbo/LDPC decoding, FFT/IFFT, is more suitable to be deployed by hardware accelerators. Furthermore, to keep the hardware and software from becoming obsolete, flexible or configurable hardware accelerators

978-1-4673-5225-3/14/$31.00 ©2014 IEEE

should be designed, i.e. FFT/IFFT with hybrid-radix supporting, Turbo decoder compatible for both WCDMA and LTE. Fortunately, flexible hardware does not consume much die-size or power consumption than traditional fixed hardware, UE pays little for the flexible hardware in UE SDR solution.

Looking at the other part of UE SDR solution, it is developed totally by software with vector processing. Algorithm with the most motivation to be evolved, are appropriate to be realized by software. For example, the algorithm of channel estimation and measurement of the spatial channel, may need to be adjusted according with field test after tapping-out. Inner-receiver algorithm with large differences may also be needed for different standards. If these kinds of algorithm are still deployed by hardware, it is impossible to reuse the resources of each other. So it is an advisable ideal to choose UE SDR solution instead.

The architecture of a typical UE SDR solution supporting GSM/TD-SCDMA/WCDMA/LTE FDD/LTE TDD, which is to be shipped by Leadcore, INNOPOWER® LC186x, is showed below.

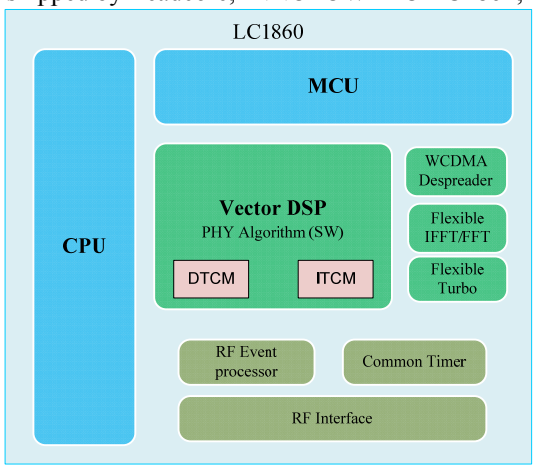

Figure 2 Architecture of LC186x SDR solution

In LC1860, hardware processes stable algorithm, such as de-spreader, IFFT/FFT and Turbo Decoder, but remain flexibilities for Turbo and IFFT/FFT. Software in "Vector DSP" processes other algorithm with the requirements to be evolved and re-use the computing resources with each other. This solution achieves good balance between flexibility and efficiency by SDR technology.

3. SDR: LEADING TREND FOR UE

NVIDIA acquired Icera for $367 million in cash on May/9/2011 and MTK acquired Coresonic on April/4/2012. MTK said SDR is "With its smaller footprint and higher degree of scalability, it facilitates very effective high-performance baseband designs". It is expected SDR will inspire a significant evolution in the design of UE in the coming 4G era.