Using software modems to enable low-cost, converged wireless

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Introduction

In recent years, the consumer electronics (CE) industry has experienced a proliferation of wireless standards. One key function of wireless connectivity in CE devices is to enable consumption of multi-media content of the user's choosing, at a time and place convenient to him or her. Internet protocol (IP), cellular and broadcast are three key technologies that can be used to deliver content to the user. With the relentless downward pressure on device form factor and prices, a multi-standard device must adhere to the consumer electronics mantra: low cost, small size, low cost, minimal power consumption and low cost. The recent emergence of the sub-$250 consumer-focused 'Netbook' personal computer (PC) is a wakeup call to the CE industry to rethink how wireless convergence can be delivered cost-effectively to the content-hungry, but cost averse, consumer masses.

The software-based modem concept has been mooted for many years as the solution to address the proliferation of wireless standards, and yet the architecture has not emerged as a widely deployed technology. There are some well known examples of software very successfully displacing hardware in *specific* applications, such dial-up modems and MPEG decoding, and these validate that concept's commercial viability. With the recent emergence of innovative reconfigurable RF silicon integrated circuits (ICs), and the rapid evolution of highly capable, portability-centric microprocessors in consumer electronics devices, software-based modems now have the opportunity to make an impact as a viable solution to low-cost wireless convergence.

This article will discuss one example of how the software modem architecture can be successfully leveraged to address the challenge of enabling broadcast TV and radio content reception on a personal computer (PC) platform - at a price the consumer is willing to pay and the manufacturer can afford to deliver.

Portable broadcast reception – historical barriers to uptake

The enduring importance of broadcast lies in the fact that is *the* most efficient way to deliver live media content such as sport and news to multiple users simultaneously and with infinite user scalability. Additionally, broadcast is well served today by free-to-air content globally. By offering broadcast reception - in conjunction with, and complementary to, cellular and IP-based technologies - CE device manufacturers can offer consumers the ability to enjoy content on-the-go.

Although broadcast radio has seen successful deployment in many portable devices, integration of TV reception has been less successful. This is due to four key reasons:

1. Legacy analog and digital TV services gave inadequate mobility performance and had high power consumption, necessitating the development of dedicated mobile digital TV (MDTV) standards such as DVB-H, CMMB, T-DMB and MediaFlo. These services typically required the deployment of dedicated transmission infrastructure.

2. Deploying a dedicated network to deliver MDTV services requires substantial levels of capital expenditure. This has lead service providers to attempt to levy significant subscription charges to potential customers, who in turn have proven to be reluctant to separately pay for content that they might already receive as part of their home TV package.

3. No single global standard or dedicated spectrum exists for the provision of broadcast TV services.

4. Cost

In the case of the first barrier listed above to successful TV deployment, silicon vendors have made significant improvements in lowering the power consumption and increasing mobility performance for terrestrial TV reception, and today, some notebook PCs and media players are now available with embedded *single-standard* TV.

Regarding the second listed barrier to TV uptake, cellular operator revenue models for MDTV are now being rationalised. Korea and Japan are two exceptions to the generally unsuccessful MDTV uptake experience, and in these countries, a *free-to-air* MDTV model quickly translated to a high MDTV attach-rate in handsets and other portable devices. To recoup MDTV deployment costs, the operators in these countries are now offering charged-for premium TV content and additional data services supported by the MDTV technologies such as traffic, weather, click-through merchandising and stock market updates. The Japanese and Korean MDTV experience suggests that with careful thought and collaboration, the infrastructure build-out cost dilemma for operators can be overcome.

The remaining barriers, therefore, to enabling portable broadcast reception, whether terrestrial or MDTV, lie in addressing the fragmentation caused by the multiplicity of worldwide standards, and by significantly reducing solution cost.

Broadcast standards – a global patchwork

Figure 1 shows the spectrum allocations for various broadcast radio and TV standards. In addition to the diverse spectral allocation, the channel bandwidths for these standards range greatly, from 5 kHz (AM radio) to 8 MHz (DVB-T TV). The fragmenting effect of multiple standards is readily apparent. Note also that the problem of multiple standards is further compounded by the fact that a particular broadcast standard such as DVB-T may be deployed with significant regional variances in terms of transmission power and modulation scheme.

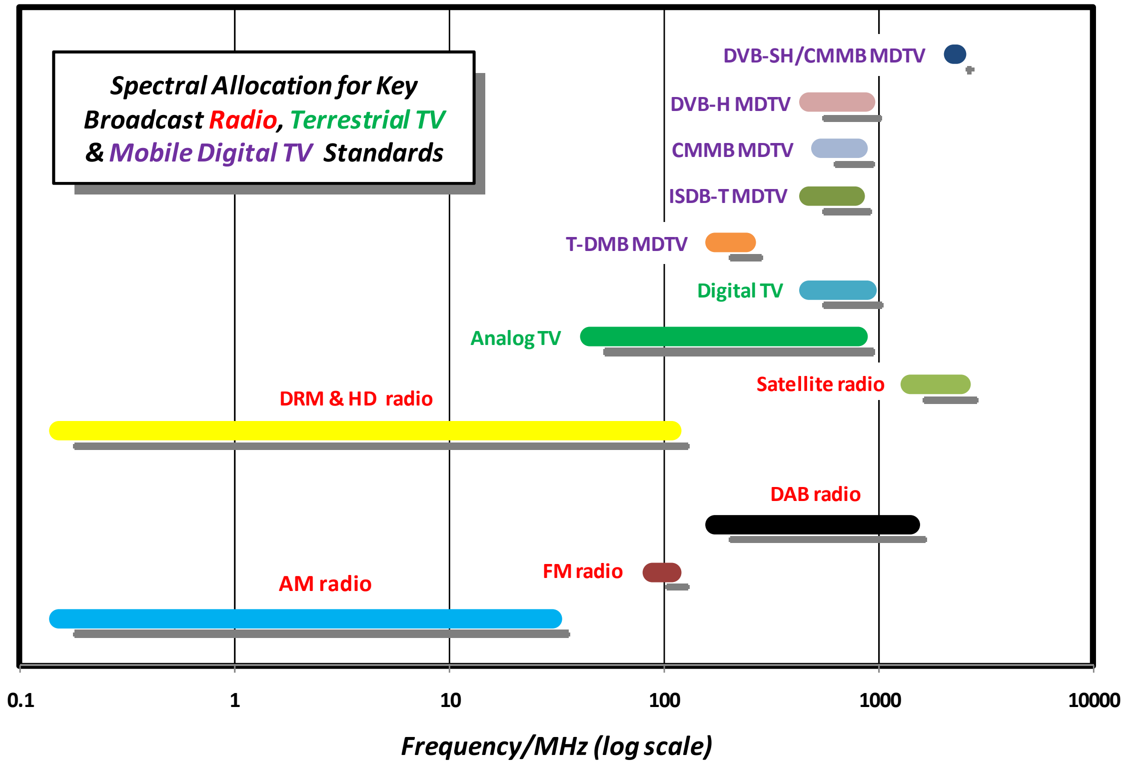

Figure 1: Spectrum allocation for various broadcast TV and radio standards showing a large degree of fragmentation

Broadcast receivers: cracking the multi-standard nut with reconfigurability

A typical broadcast receiver comprises RF tuner and demodulator silicon blocks. These silicon functions may be separate ICs or both integrated into a system-on-chip (SoC). This generic approach is shown in **Figure 2**. This receiver architecture is well proven and deployed, but it has been limited to single-standard broadcast reception. To enable multi-standard TV and radio reception, OEMs currently must integrate multiple receiver ICs, leading to an unacceptable increase in cost, battery power dissipation and device size for consumers.

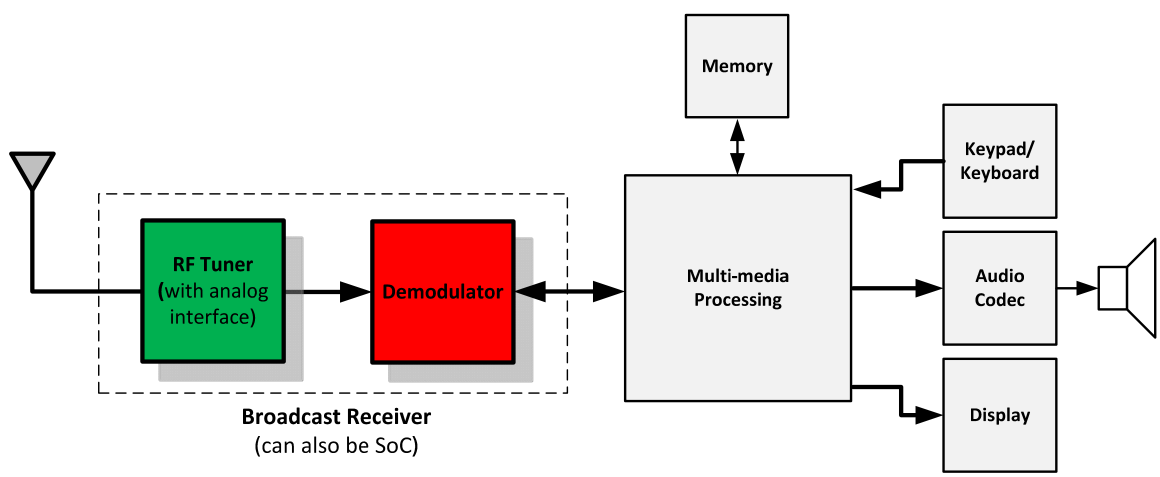

Figure 2: A typical broadcast receiver

If *reconfigurable* circuit techniques in the tuner and demodulator can be leveraged, it is in theory be possible to develop a multi-standard broadcast receiver. Reconfigurability ensures efficient use of IC die area since flexibility is achieved without recourse to multiple instantiations of similarly circuitry. Reconfigurability therefore mitigates a potential multi-standard cost ‘penalty’.

The technical challenges that must be overcome to deliver an RF tuner that can cover almost five decades in frequency, co-exist with multiple external interfering signals, accommodate diverse channel bandwidths and frequency step sizes, exceed industry receiver specifications *and* still be cost effective, appear insurmountable. However, a number of multi-standard broadcast RF tuners are now becoming commercially available, and shown in **Figure 3** is one example from Mirics. Mirics’ FlexiRF tuner can receive all of the commercially launched TV and radio standards detailed in **Figure 1**.

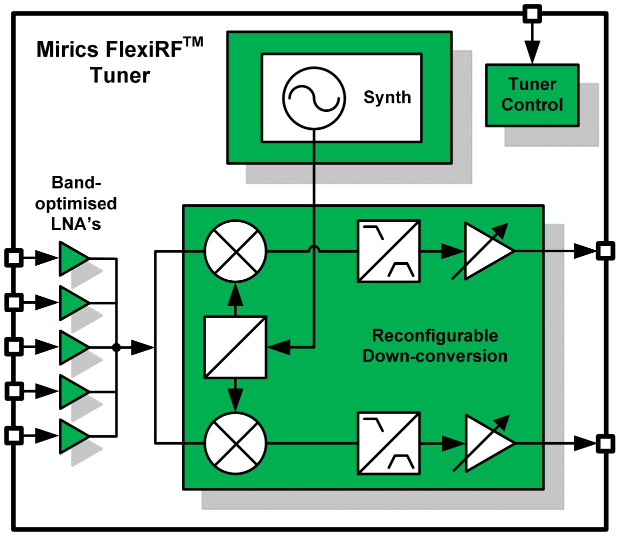

Figure 3: An example multi-standard tuner that can receive all the commercially launched TV and radio standards

The multi-standard tuner is of course only one half of the multi-standard receiver equation – the demodulator must also be considered. The main challenge for implementing a cost-effective multi-standard demodulator in silicon hardware is the fact that the circuit architecture required for the demodulation of the differing broadcast signals - unlike in the case for an RF tuner - can be vastly dissimilar, leading to significant die size, and hence cost, increase. Some newer demodulator enable multi-standard functionality by embedding digital signal processing (DSP) blocks to deliver functional reconfigurability.

While pairing reconfigurable RF tuners with DSP-based demodulators may resolve many of the technical aspects of multi-standard broadcast reception, ultimately, this hardware approach will not deliver the *lowest cost* solution. For portable devices such as netbook PCs and mobile internet devices (MIDs) in which multiple wireless modems must be accommodated, a rethinking of the integration model is required.

Redefining the hardware-software boundary

The PC has evolved from a business tool to a device supporting multi-media entertainment functionality. Some notebook platforms are beginning to feature embedded broadcast terrestrial TV reception, but the uptake so far has been slow for the reasons already cited.

As discussed, some silicon broadcast demodulators deliver multi-standard flexibility through the use of on-chip DSP. If the utilization of DSP is extended to its logical extreme, the *entire* demodulator function can be implemented in *software* running on a host processor. By combining such a software demodulator with a multi-standard RF tuner, it is possible to implement a universal broadcast receiver, with ultimate standards flexibility and future-proofing due to the inherent reconfigurability of software. Software demodulation enables manufacturers to implement a platform strategy, and delivers a *step-change* in solution cost due to the complete elimination of the silicon demodulator, which typically accounts for close to three quarters of today's conventional silicon-based receiver cost.

Today's portable PC provides the ideal platform to leverage software modems, featuring multi-core CPUs and abundant system memory. A generic software-based broadcast receiver for PC platforms is depicted in **Figure 4**. A multi-standard RF tuner interface directly to the host processor via a digital interface, such as USB2.0, PCIe or SDIO, and the demodulator runs in software on the host CPU.

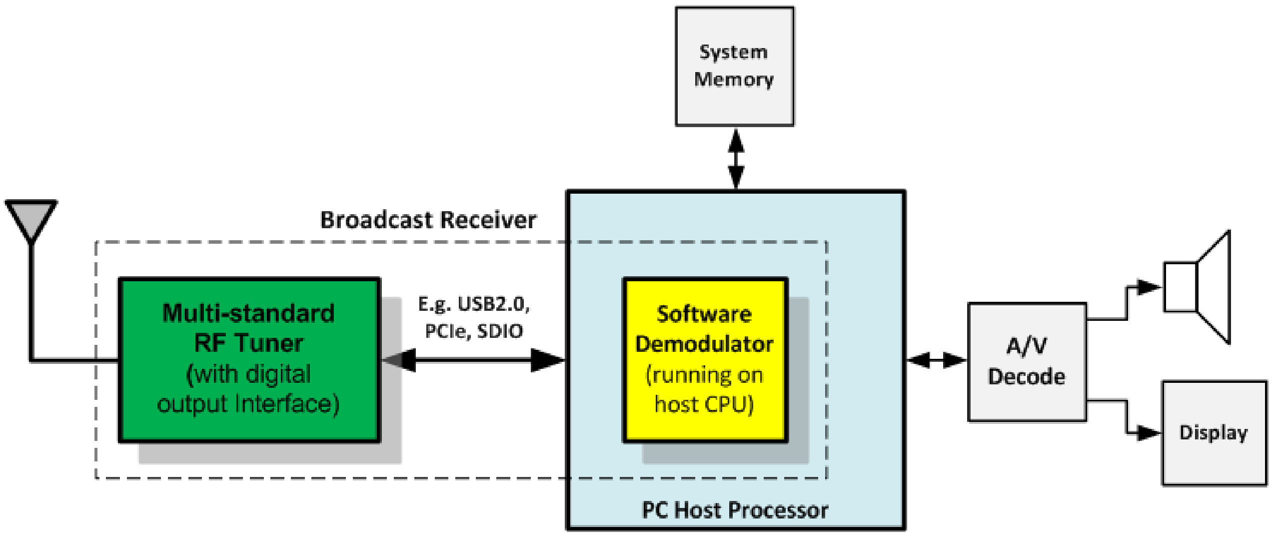

Figure 4: A multi-standard broadcast receiver based upon software demodulation

The Mirics FlexiTV broadcast receiver solution shown in **Figure 5** is a commercial implementation of software demodulation targeting PC platforms. By combining the FlexiRF multi-standard tuner with efficient software-based demodulation algorithms, a global PCTV solution is made possible for *less than* the cost of conventional hardware-based single-standard solutions. Note that the digital interfacing between the FlexiRF tuner and the PC host processor is implemented by a 'bridge' interface IC, which digitizes the quadrature baseband analog output of the tuner via on-chip ADCs, and then translates this sampled signal to USB2.0 for host interfacing. The MSi3101 RF tuner and interface IC chipset can also be implemented as a SoC as a future step in cost and size reduction.

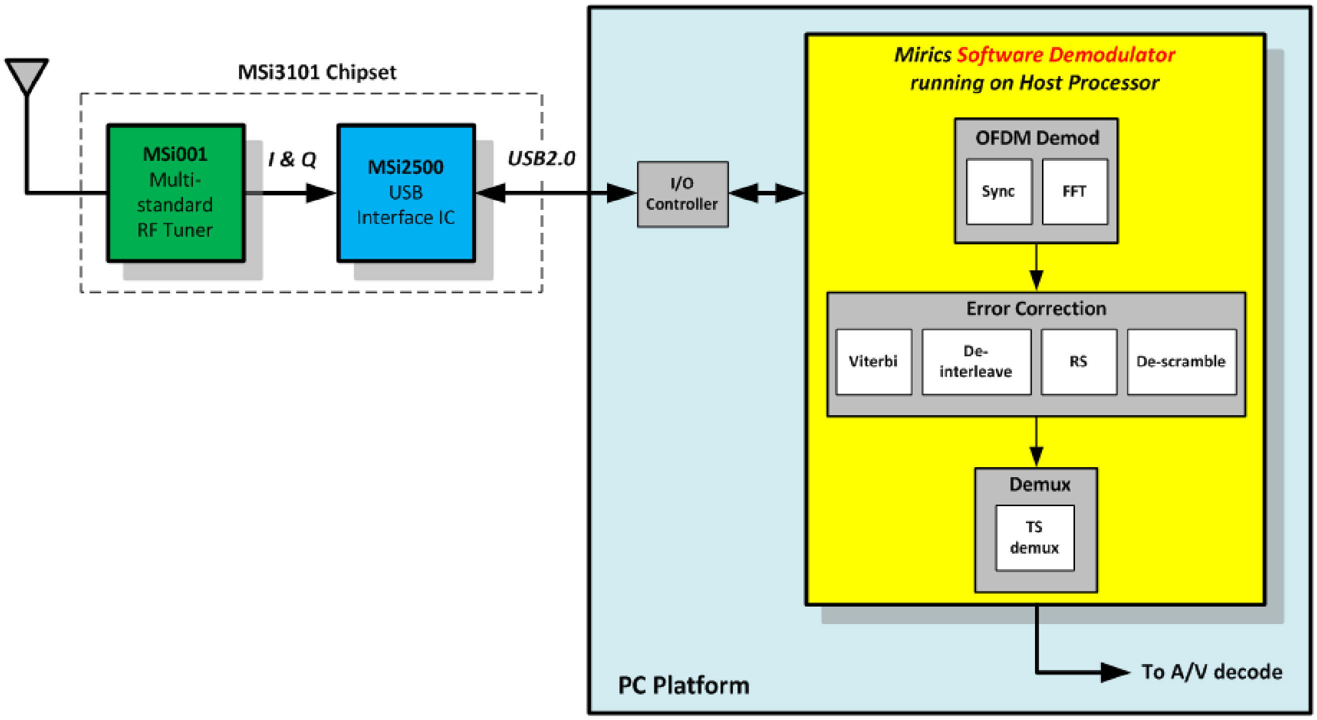

Figure 5: Mirics' FlexiTV global broadcast solution based upon software demodulation

Won't software demodulation max out the CPU?
A concern that may be raised about a software-based demodulation is the percentage CPU load consumed by the demodulation algorithms. What makes software-based demodulation so compelling is the fact that the processing power of modern processors is constantly increasing over time, and, for example, where a dual-core PC processor architecture may have been state-of-the-art 12 months ago, today it is mainstream. Software-based demodulation therefore expends a smaller proportion of total processor load as processors evolve.

To illustrate what has already been achieved today, consider the example of notebook featuring a dual core x86-based 2.6GHz processor, utilizing Mirics' FlexiTV to receive a standard-definition (SD) commercial DVB-T terrestrial TV broadcast. This is platform has been field-tested to require just 25% total CPU load. In fact, the PC's media player controlled SD video *decoding* (performed in software running on the host processor) itself requires 5% CPU load. It is clear, therefore, that the demodulation load – *if efficiently implemented* – is very modest.

High-Definition video: an inconvenient truth
Of much greater concern than the CPU load or battery life impact of software demodulation, is the growing consumer demand to playback high-definition (HD) video content or enjoy 3D gaming and other similar decoding intensive applications on portable PCs. On the same dual core 2.6 GHz x86 platform noted above, software HD video decoding running on the host CPU alone consumes greater than 100% of the available CPU power i.e. it is simply not possible, and this is before addition of software demodulation is even considered. In this context, therefore, software demodulation is a secondary concern.

Fortunately, the HD CPU bottleneck has a white knight in the form of media co-processors. Also known as graphics processing units (GPUs), these devices have today evolved as highly parallel multi-core processors which complement the host PC processor. HD decode can be offloaded to these media co-processors, releasing the majority of the CPU bandwidth to enable other tasks such as software modems. It is the evolution of these powerful media co-processors and the employment of distributed processing, that will also ensure that netbooks, MIDs and smartphones

– which today feature more modest host processors - will also benefit from the cost advances delivered by software demodulation.

Conclusion

The software modem is the *only* viable architecture to deliver consumer cost goals for converged wireless content delivery on portable CE devices. While this article has focused upon the example of a software-enabled broadcast receiver for PC platforms, it is clear that by leveraging the power of distributed processing, CE devices such as MID's and smartphones will also be able to benefit from the new cost and flexibility paradigm delivered by software modems.

Chet Babla is product line director at Mirics Semiconductor. Babla has over 16 years semiconductor marketing and IC development experience in RF and mixed-signal ICs. Prior to Mirics, Babla has held product marketing positions at Frontier Silicon and Phyworks, and IC development roles at Conexant, Nortel Networks and GEC-Plessey Semiconductors. Babla's professional experience has covered the fields of mobile TV, digital radio, optical communications and digital telephony. Babla graduated in Electrical and Electronic Engineering in 1992.