The Linley Group

MOBILE CHIP report

Insightful Analysis of Mobile System Design

Ceva Targets Wearables

IP Platform Provides Main Elements for Always-On Devices

By Linley Gwennap (May 5, 2014)

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Today's wearable devices get by with smartphone processors or microcontrollers, but more-successful devices will require processors custom-designed for this application. To jumpstart that design process, Ceva announced a collection of useful IP at last week's Linley Tech Mobile Conference. This integrated platform supports always-on functions and low-power connectivity, two capabilities that are critical in wearable devices.

The platform includes a low-power TeakLite-4 DSP to handle voice functions and sensor management, as Figure 1 shows. It can even run a simple user interface, eliminating the need for a host CPU. The second hardware piece is Ceva's Bluetooth core, which includes the MAC and baseband for Bluetooth 4.1. Most importantly, the platform comprises a set of pretested software modules that implement these functions, enabling customers to focus on their own value-add software.

Wearable designers are even more constrained in power and cost than their smartphone brethren. A smartwatch may have only a 300mAh battery; a fitness band perhaps a 100mAh battery. These batteries are 80% to 90% smaller than those in a smartphone. When using a standard application processor, even one that is downclocked and constrained to about 40mA, the life for such a small battery is only a few hours. To get a full week per charge, which many wearable designers are targeting, the power budget for the always-on processor is about 1mA. Ceva rates its DSP at 0.15mA, leaving plenty of power for the rest of the system.

Using a DSP to handle always-on functions is becoming a common theme. Audience employs a custom DSP in its processors (see *MCR 4/7/14,* "Audience Is Always On"), and Qualcomm implements similar functions in its Hexagon DSP. A DSP consumes less power than a Cortex-A CPU, and it can perform voice functions (such as wake-on-voice and voice authentication) that a low-power Cortex-M CPU cannot. Ceva differentiates by licensing the always-on software stack and the Bluetooth core in addition to its DSP. The new platform also includes face activation in its bag of tricks.

TeakLite-4 Revised and Improved

TeakLite-4 is the newest core from the leading DSP-IP vendor. It's a powerful design that can issue three instructions per clock cycle and perform up to four 16x16 multiply-accumulate operations per cycle (see *MPR 4/16/12,* "Ceva TeakLite-4 Illuminates Roadmap"). The wearables platform uses the TL410, which is the lowest-power member of the TeakLite-4 family. An implementation of this DSP requires

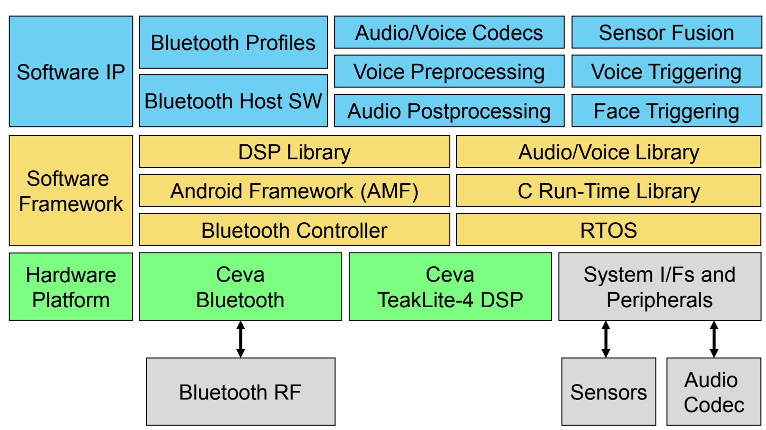

Figure 1. Ceva's platform for wearable devices. The company licenses this combination of its DSP IP, Bluetooth core, and software stack, enabling SoC designers to more easily develop custom solutions for wearables.

only 90,000 gates, minimizing cost. Although it is limited to two 16x16 multiply-accumulates per cycle, the TL410 can perform all the functions described in this article. If they desire, however, chip designers can upgrade to a higher-end family member to get more headroom for their own code.

Ceva has improved the TeakLite-4 microarchitecture since its original release. The new Version 2 adds 50 custom instructions that accelerate audio and voice processing. These instructions include some 64-bit arithmetic operations and 128-bit memory operations, boosting performance. The new design also implements a completely revised instruction-set encoding that reduces code size by an average of 30%, according to the company. This reduction improves the efficiency of the program memory, cuts the power required to fetch instructions, and decreases the cost of external code storage (e.g., flash memory).

Additional power savings come from improvements in the power manager (Ceva calls it the PSU), which turns off unused portions of the core on a cycle-by-cycle basis. For example, once an instruction is decoded, the DSP clocks only the function units needed by that instruction (a technique that other mobile CPUs employ). The new PSU also manages three voltage domains: the DSP core, the data and program memories, and the debug modules. In the field, the debug functions are always powered off. The core can be shut down while the memories retain state, enabling a fast wakeup. Whereas clock gating eliminates active power, turning off the voltage also cuts out leakage power.

Don't Forget the Connectivity

Ceva's Bluetooth IP includes two parts, as Figure 2 shows. The Bluetooth MAC layer is implemented in software on the TeakLite-4 DSP, whereas the baseband is in a separate hardware block. The baseband connects to a third-party RF transceiver. The TL410 DSP and the baseband total to about 150,000 gates. The company provides a complete set of firmware that runs on the DSP and implements Bluetooth LE 4.0 and 4.1.

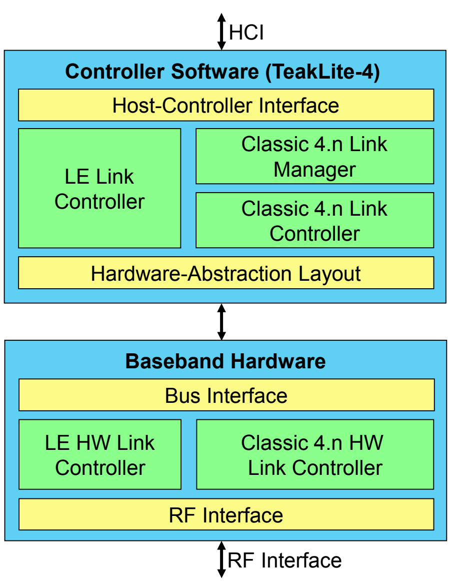

Figure 2. Ceva Bluetooth implementation. The MAC layer runs on the TeakLite-4 DSP, leaving only a small amount of hardware for the baseband.

As its name implies, Bluetooth Low Energy (BLE) reduces the power required to implement local connectivity. A wearable device will typically use BLE to connect to a smartphone that the user is carrying in a pocket or purse; therefore, the required range is only a few feet (although the technology must also tolerate situations in which the user's body is between the two devices, blocking direct transmission).

BLE operates in short bursts at 1Mbps; fast transfers allow the client to quickly receive data and then power down. To keep transmissions to a minimum, the protocol enables simple device discovery as well as fast setup and teardown of connections. Dedicated frequency channels, which also can be used as IPv6-based connections, help prevent interference. These changes make BLE more like Wi-Fi, with a router hub. Bluetooth Smart is the new branding for BLE.

The Ceva IP can also be configured for dual-mode operation, adding support for all Bluetooth modes including Bluetooth 2.1+EDR and 3.0. These modes provide greater compatibility with host devices, but they use more power than BLE. They are required when carrying higher-bandwidth traffic such as music or voice. Ceva does not provide its own firmware for these older Bluetooth modes, but it works with third-party vendors that support classic Bluetooth on the TeakLite-4 DSP.

The Bluetooth baseband provides a digital interface to the Bluetooth RF circuitry, which is typically integrated on the SoC. The digital interface supports the BlueRF standard but can be customized. Because customers usually provide or design their own RF, connecting these two blocks through an on-chip bus is straightforward.

Software Completes the Solution

Ceva provides several software modules for wearable-system design. These modules interface with the newest Android builds (e.g., KitKat) through a Ceva API called the Android Multimedia Framework (AMF), which runs on the host processor. For systems that instead use a real-time operating system (RTOS), the company provides its API for Enea, Quadros, ThreadX, and others. These APIs allow customers to develop applications using standard programming tools while accessing the optimized firmware on the DSP.

The firmware functions include a voice and audio processing suite that Ceva and its partners have developed over several years. This suite enables designers to implement a broad range of functions in their wearable devices, from simple voice capture and automatic gain control (AGC) to multi-microphone noise suppression and acoustic echo cancellation (AEC). For wearable devices that play music or voice, it includes sound-enhancement and bass-boost functions that improve the output of small speakers. Partners develop many of these functions, but Ceva can offer them to its licensees as part of the platform. Licensees can also choose to work directly with the many ISVs in the Ceva ecosystem.

Other software partners have developed modules for wearable-specific functions such as voice triggering, which allows the user to wake the device with a spoken phrase. Once the DSP detects voice activity, it checks whether the speech matches the trigger phrase and optionally determines whether the speaker matches the registered user (voice authentication). Ceva has also implemented face triggering, which watches through the device's camera and wakes the main CPU when it detects a face. Sensor-hub firmware enables the DSP to analyze the input from various motion sensors to recognize specific gestures, detect the user's status (such as sitting or walking), or count steps.

Enabling Market Innovation

With all this software, a little bit of hardware goes a long way. Ceva gave an example of a smartwatch with a microphone, camera, and motion sensors. The DSP can continuously listen for a voice trigger, continuously watch for a face, continuously monitor the sensors, and control the BLE link with the remote device (smartphone). It can also perform simple updates to the display, such as maintaining the correct time. While performing all these functions, the DSP will consume an average of 0.15mW, according to Ceva. To achieve this feat, it spends much of its time in sleep mode, waking only to take a sample and occasionally analyze the result.

If the watch has a speakerphone mode, the DSP can switch to classic Bluetooth mode to receive and send voice traffic while encoding and decoding voice (e.g., mSBC vocoder at 16kHz, mono) with postprocessing functions such as noise reduction, AEC, and AGC. These functions require the DSP to operate at 60MHz and use 1.6mW. Similarly, if the watch plays music, the DSP handles classic Bluetooth and MP3 decoding (44kHz, stereo) at 70MHz and 1.9mW. These power figures all assume a 28nm HPM implementation.

Although much of Ceva's work has focused on wearables, the same technology applies to other applications. For example, a wireless speaker is similar in function to a smartwatch playing MP3 audio. In this case, the speaker can use Bluetooth instead of Wi-Fi to reduce power, enabling long play time without the speaker being plugged in. This technology also applies to Internet of Things (IoT) devices that have a user interface, such as home-management and home-security controllers.

The wearables market is in an early stage, with many small and large companies creating innovative products. These companies may innovate in function, form factor, and services, but they don't want to reinvent the wheel. Ceva's new platform is a starter kit of hardware and software blocks that a company can use to build a processor for its wearable product. This level of customization will enable the long battery life and low cost that consumers want from their wearable devices. All the designer has to add is a compelling user experience. ♦

For More Information

For additional information on Ceva's new wearables platform, access the company's web site at *http://ceva-dsp.mediaroom.com/white-papers.*