DIGITIMES

Standalone application processors are wining in mobility markets, says Petrov Group

Contributed by the Petrov Group -- 8 March 2011
http://www.digitimes.com/news/a20110308VL204.html

Several years ago there was a widely accepted expectation that application mobile processors would be fully integrated with baseband processors on a single chip. However, today we are witnessing a proliferation of standalone (S/A) application processors, and the integration of the baseband and the application processor is sporadic at best according to Ljubisa Ristic, managing director for mobile/wireless section at the Petrov Group.

We expect the strategy of S/A application processors will dominate the market for some time despite recent announcements by several companies of the integration of baseband and application processors on a single chip, said Ristic.

There are three processing blocks that are absolutely critical to the performance of products such as smartphones and tablets − baseband processor, application processor, and graphics processor. Each one of these has its distinct role, and there is often confusion when describing mobile processors whereby the term baseband is used to describe an application processor and vice versa.

The role of the baseband processor is to manage tasks related to a particular communication standard such as WCDMA, EDGE, CDMA, or LTE. The baseband processor manages radio communications and control functions (signal modulation, radio frequency shifting, encoding, etc.), and it runs the communication protocol stack. Baseband processors have been around basically from the inception of cellular phone technology, and its architecture has gone through several evolutions, following in lock-step the evolution of the cell phone industry, from analog to digital to 3G, and the latest development to LTE.

The application processor is a relatively new development driven by the proliferation of smart consumer products and smartphones that offer an enhanced user experience. The role of the application processor is to run the operating system and manage many applications such as multitasking, Internet browsing, e-mail, interfacing with peripheral devices, etc.

The underlining technology for both baseband and most application processor cores is ARM architecture. Almost everyone in the industry who is making baseband and application processors has a license from ARM Holdings, the company that designs and licenses low-power architectures. The only exception is Intel, which makes its Atom line of application processors based on x86 architecture, but Intel yet has to establish itself as a smartphone player.

The graphics processor (GPU) tailored for mobile applications is also a newer addition to the world of mobile processors, and it coincides with the rise of multimedia applications. The role of the GPU is to manage 2D and 3D graphics, video capture, playback, deliver mobile gaming, and provide a rich user interface. Here, as opposed to baseband and application processor cores where ARM architecture dominates the market, there is no single company holding the monopoly on technology. There are several competitors offering their graphic cores to others in the industry and a few that use internal solutions. The list of providers includes Imagination Technologies, Vivante Corporation, and ARM, while Nvidia, Qualcomm, and Broadcom use their own graphics. Nvidia, Imagination Technologies, and Vivante have developed their own graphics technology while ARM, Qualcomm, and Broadcom have gained technologies by acquisition. It should be

pointed out that Imagination Technology, one of the leaders, although independent, has both Apple and Intel holding significant equity positions in the company, commented Ristic. One should take note that mobile graphics is becoming an integral part of the application processor today, which means that graphics (one or multiple cores) are integrated on the same chip with the core of application processor.

Petrov Group: GPU platforms for mobility market	
Company	**GPU Platform**
Imagination Technologies	Power VR Platform (developed internally)
Arm Holdings	Mali VE Platform (originated from Logipard AB)
Vivante	ScalarMorphic Platform (developed internally)
Nvidia	GeForce/Cuda Platform (developed internally)
Qualcomm	Adreno Platform (originated from ATI)
Broadcom	VideoCore Platform (originated from Alphamosaic)

Source: Petrov Group, compiled by Digitimes, March 2011

To avoid any confusion in terminology we want to clarify the meaning of terms related to processors. When we say standalone (S/A) application processor it means an application processor together with a mobile graphics processor on the same chip. When we say baseband processor it means just a baseband processor. If a baseband processor and an application processor are integrated on a single chip we call it an integrated mobile processor (it contains a baseband core, application core, and mobile graphics core on a single chip). We use the expression mobile processor for all three, baseband, standalone application processor, and integrated mobile processor said Ristic.

It is important to point out that the mobile processor industry has gone through significant consolidation in the last couple of years and the dynamics of rapid change will most likely continue. Some of the dominant players a few years ago have decided to exit the baseband market: TI has focused on application processors and basically has exited the baseband segment, Freescale has divested the baseband business and has also focused only on application processors, while Analog Devices has exited (sold) the business completely; Intel has exited the baseband business by selling it to Marvell, only to turn around in 2010 and acquire it together with the RF business from Infineon.

Some of the established baseband businesses do not exist anymore as entities such as Agere and LSI (both now part of Intel). Others have stayed in it and have strengthened their teams with acquisitions. For example, Broadcom acquired Alphamosaic, Zyray, and Beceem, among others, and Qualcomm acquired Flarion, TeleCIS, and handheld graphics from AMD. ST Microelectronics and Ericsson have joined forces and operate as ST-Ericsson, as did Renesas and NEC in the new Renesas company. MediaTek became a player by acquiring technology from ADI, while newcomers Nvidia and Spreadtrum developed technology internally.

Today the list of key players in the mobile processor market includes Apple, Samsung, Qualcomm, Texas Instruments, ST-Ericsson, Broadcom, Renesas, Nvidia, Intel, Marvell, Freescale, Spreadtrum, MediaTek, Icera, and VIA Telecom. All of these companies are focusing on application processors or their integration with baseband with the exception of Icera and Via Telcom (both offer only basebands for the time being) summarized Ristic.

Domination of Standalone Application Processors

The wide acceptance of smartphones and our desire for instant information and connection with the world around us is constantly driving new applications and innovations. The development of new mobile application processors has become a part of that cycle whereby companies compete to deliver products with new features and better performance. The race is on and time is of essence. According to the Petrov Group, this is one of the major reasons why we see the proliferation of S/A application processors.

The S/A application processor provides independence from communication protocol software and baseband, reduces time to market, and allows for rapid development of multimedia applications. Operating systems that run on application processors are built as open source; thus they are inclusive and enable the independent development of hundreds of thousands of applications. The S/A application processor also gives smartphone manufacturers flexibility in choosing hardware from different vendors whereby they can plan for cost optimization. In addition, when one enters tablets into the picture, the S/A application processor is the preferred solution for tablet designers. They would rather have the option of creating a line of products with and without 3G connection − the S/A application processor allows just that. For many people the basic Wi-Fi connectivity on a tablet would be more than enough since one can always connect the tablet to a smartphone, thereby establishing a 3G connection. If you already have a smartphone plan, why would you pay for a second plan on your tablet? For all of these reasons S/A application processors make a lot of sense, and it should not come as surprise that they currently dominate the smartphone and tablet market. We believe this trend will continue in the near future, said Ristic.

Look at individual players

Apple is one of the biggest proponents of S/A application processor strategy. It designs internally, and optimizes the way it wants, and is in control. Currently Apple uses an A4 processor that includes a single core based on Cortex A-8 architecture and an integrated graphics core SGX 500 from Imagination Technologies. The next generation A5 application processor will be dual-core based on Cortex A-9 running at 1GHz and integrated with the PowerVR SGX 543 graphics core.

Samsung has an very similar strategy to Apple when it comes to S/A application processors, and we believe their partnership is much more than a simple supplier-customer relationship. Samsung's Hummingbird S5PC110 S/A application processor is almost identical to A4, and their next generation Exynos 4210 (S5PV310) is also based on the dual-core Cortex A-9 and ARM MALI-400 graphics core although one should not be surprised if it turns out to be PowerVR SGX 543 graphics core. Both Apple and Samsung are using their S/A application processors in smartphones and tablets.

Qualcomm, which is the leader in integrated mobile processors, has just announced two new S/A application processors, APQ8060 based on a dual-core Cortex A-9 and Adreno 220 graphics core, and APQ8064 that will have a quad-core based on a Cortex A-15 and Adreno 320 graphics core. The fact that Qualcomm has announced S/A application processors next to its powerful line of Snapdragon processors speaks for itself about the importance of offering S/A application processors.

Texas Instrument is one of the key suppliers of S/A application processors. For all practical purposes TI has abandoned baseband processors and has focused on application processors. The result is series of OMAP products. OMAP3 and OMAP4 have been very successful with customers, and now TI has announced its next generation of S/A application processors, OMAP5. The OMAP5430 is based on the dual-core Cortex A-15. It will have an integrated Power VR SGX544 graphics core. This will be a very powerful product running at 2GHz and manufactured in 28nm node.

ST-Ericsson is another key player formed by the joined forces of Ericsson and ST Microelectronics. Ericsson has a long tradition of designing baseband processors and is one of the most recognized names. ST-Ericsson has announced the next generation of S/A application processors, including Nova A9540, which is based on the dual-core Cortex A-9 and integrated graphics core SGX 600 Rogue, which is the newest generation of GPU from Imagination Technologies; the second product is Nova A9600, which will use dual-core Cortex A-15 running at 2.5GHz and the same integrated graphics core SGX 6000. These two S/A application processors will be manufactured in the 32nm and in 28nm node respectively.

Broadcom has also announced the next generation S/A application processor BCM 11311. This one also goes with dual-core Cortex A-9 and its own integrated graphics VideoCore IV. It will run at 1.1GHz and will use a 40nm CMOS process.

Renesas Mobile Corporation (now allied with NEC, which was a respectful processor player itself), has also announced the next generation of S/A application processor, dual-core, SH-Mobile APE5R, which is based on Cortex A-9 and an integrated graphics core based on PowerVR SGX MP. It runs at 1.2GHz and is in 45nm node.

Nvidia has been in the spotlight for several months now thanks to its Tegra 2 S/A application processor which gained wide acceptance in tablets and new smartphones. It is a dual-core processor based on Cortex A-8 and Nvidia's own GeForce integrated ultra low power GPU with eight cores. Tegra 2 runs at 1GHz. The dust has not yet settled around Tegra 2, and Nvidia has already announced a quad-core Tegra 3 that is based on Cortex A-9 and integrated 12 graphics cores. It runs at 1.5GHz and will most likely be made in 40nm although Nvidia would like to do it in 28nm node. With this line of products Nvidia has became the leader in the S/A application processor field.

Marvell has announced the triple-core S/A processor Armada 628 based on Cortex A-9 that runs at 1.5GHz and has an integrated graphics core based on Vivante GC2000. This one is made in 40nm node and has a unique architecture where the third core runs at lower frequency.

Freescale has announced an iMAX6 S/A application processor with four cores based on Cortex A-9 and integrated Mali graphics from ARM. The processor is scalable (there is a single, dual, and quad-core version) and it runs at 1.2GHz.

Intel is currently offering Atom Z670 as an application processor for the mobility market. The architecture of this processor is based on x86 as opposed to the rest of the vendors that use ARM's architecture. This processor runs at 1.5GHz and is made in 32nm node − the most advanced node among current S/A application processors on the market. Intel has a chance to become a player in the smartphone market if it manages to reduce power, which is one of the most critical features of the S/A application processor. Intel has two possible paths.

The first one is further optimization of the Atom architecture and features that are already part of the Atom such as thermal power envelope, clock frequency scaling, and hyper-threading. The Petrov Group predicts that Atom's performance will eventually become "good enough" for its targeted segments − OEMs will accept and use it when weighing all other numerous benefits.

But if all of this does not work, there is a second option for Intel according to Ristic − to adopt ARM architecture and pursue it in parallel. After all, Intel already has a line of baseband processors based on ARM architecture (which came with the Infineon acquisition), and nothing is preventing it from extending the license to mobile application processors. The situation is interesting, and it remains to be seen how Intel will execute. Certainly Intel will continue to be a significant player with its line of baseband processors and customers such as Apple's iPhone and iPad.

There are several things to be drawn from this overview, according to Ristic. One can see a clear

Petrov Group: Current state of standalone application processors					
Company	**Processor Name**	**Core Architecture**	**Clock Frequency**	**GPU Core**	**Node**
Apple current	A4	Single, Cortex-A8	1GHz	PowerVR SGX 500	45nm
Apple Next Gen	A5	Dual, Cortex-A9	1GHz	PowerVR SGX 543	45nm
Samsung	Hummingbird S5PC110	Single, Cortex-A8	1GHz	PowerVR SGX 500	45nm
Samsung Next Gen	Exynos 4210 (S5PV310)	Dual, Cortex-A9	1GHz	ARM MALI-400 or PowerVR SGX 543	45nm
TI Cuurent	OMAP4430	Dual, Cortex A-9	1GHz	PowerVR SGX540	45nm
TI Next Gen	OMAP5430	Dual, Cortex A-15	2GHz	PowerVR SGX544	28nm
Nvidia Current	Tegra 2	Dual, Cortex A-9	1GHz	ULP GeForce, 8 cores	45nm
Nvidia Next Gen	Tegra 3	Quad, Cortex A-9	1.5GHz	ULP GeForce, 12 cores	28/40nm
QCOM Next Gen	APQ 8060	Dual, Cortex A-9		Adreno 220	45nm
QCOM Next Gen	APQ8064	Quad, Cortex A-15	2.5GHz	Adreno 320	28nm
Marvell Current	Armada 610	Single, Cortex A-8	1GHz	Vivante GPU	45nm
Marvel Next Gen	Armada 628	Triple, Cortex A-9	1.5GHz	Vivante GC2000	40nm
Intel Current	Atom Z670	Single, x86	1.5GHz	PowerVR GPU	32nm
Intel Next Gen	Atom or ARM?	x86 (or ARM?)			
Freescale Current	iMX535	Single, Cortex A-8	1GHz	ARM MBX R-S	45nm
Freescale Next Gen	iMX6	Quad, Cortex A-9	1.2GHz	Arm Mali T-604	40nm
Broadcom Current	BCM2763	Single, ARM11	1GHz	VideoCore IV	40nm
Broadcom Next Gen	BCM11311	Dual, Cortex A-9	1.1GHz	VideoCore IV	40nm
Renesas Current	SHE-Mobile APE4	Single, Cortex A-8	1GHz	PowerVR SGX2	45nm
Renesas Next Gen	SHE-Mobile APE5R	Dual, Cortex A-9	1.2GHz	PowerVR SGX MP	45nm
ST-Ericsson Next Gen	Nova A9540	Dual, Cortex A-9	1.8GHz	PowerVR SGX 600	32nm

ST-Ericsson Next Gen	Nova A9600	Dual, Cortex A-15	2.5GHz	PowerVR SGX 600	28nm

Source: Petrov Group, compiled by Digitimes, March 2011

transitional trend from single-core to multiple-core processors. The performance of S/A application processors improves by a minimum of one order of magnitude and at the same time power is reduced. The S/A application processors are among the most advanced products in semiconductor industry and at this point their manufacturing is clustered at the 45/40 nm node with the exception of Intel that is already at 32nm node. Furthermore, there is a clear indication that the next generation application processors will migrate to the 28nm node. The pace of change is very dramatic and development cycles are shorter.

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