Qualcomm History and its GPU (R)evolution

Author: **Ryan Shrout**
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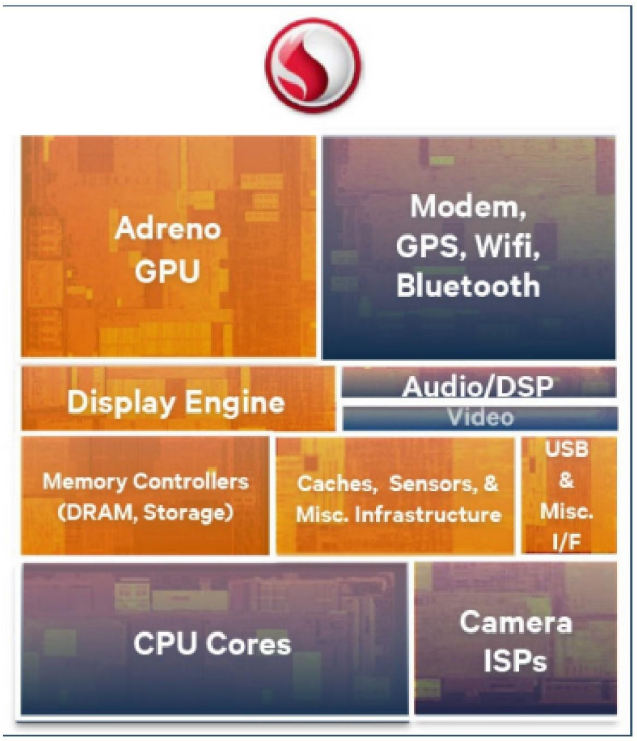
Qualcomm's GPU History

Despite its market dominance, Qualcomm may be one of the least known contenders in the battle for the mobile space. While players like Apple, Samsung, and even NVIDIA are often cited as the most exciting and most revolutionary, none come close to the sheer sales, breadth of technology, and market share that Qualcomm occupies. Brands like Krait and Snapdragon have helped push the company into the top 3 semiconductor companies in the world, following only Intel and Samsung.

Founded in July 1985, seven industry veterans came together in the den of Dr. Irwin Jacobs' San Diego home to discuss an idea. They wanted to build "Quality Communications" (thus the name Qualcomm) and outlined a plan that evolved into one of the telecommunications industry's great start-up success stories.

Though Qualcomm sold its own handset business to Kyocera in 1999, many of today's most popular mobile devices are powered by Qualcomm's Snapdragon mobile chipsets with integrated CPU, GPU, DSP, multimedia CODECs, power management, baseband logic and more. In fact the typical "chipset" from Qualcomm encompasses up to 20 different chips of different functions besides just the main application processor. If you are an owner of a Galaxy Note 4, Motorola Droid Turbo, Nexus 6, or Samsung Galaxy S5, then you are most likely a user of one of Qualcomm's Snapdragon chipsets.



Qualcomm's GPU History

Before 2006, the mobile GPU as we know it today was largely unnecessary. Feature phones and "dumb" phones were still the large majority of the market with smartphones and mobile tablets still in the early stages of development. At this point all the visual data being presented on the screen, whether on a small monochrome screen or with the color of a PDA, was being drawn through a software renderer running on traditional CPU cores.

But by 2007, the first fixed-function, OpenGL ES 1.0 class of GPUs started shipping in mobile devices. These dedicated graphics processors were originally focused on drawing and updating the user interface on smartphones and personal data devices. Eventually these graphics units were used for what would be considered the most basic gaming tasks.

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The mobile GPU market grew rapidly from 2006 into 2009. Qualcomm admits that these were the most difficult years of development, caused by the massive growth of the market. Though the company had talented engineers that were working on GPU technology, the speed of the market shift forced Qualcomm to look for help outside the company, to ATI (now AMD). Together they developed the Adreno 130 – an upgrade from Qualcomm's own in-house designed Adreno 120 GPU. The partnership expanded when Qualcomm licensed a GPU from ATI, called it Adreno 200, and later made some upgrades to create the Adreno 205. Eventually Qualcomm would purchase the handheld graphics division and its "Imageon" graphics technology. $65 million dollars later, the deal was complete in early 2009.

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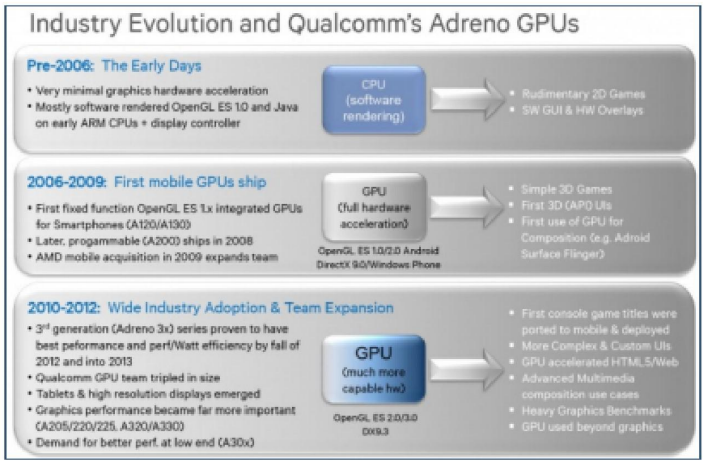
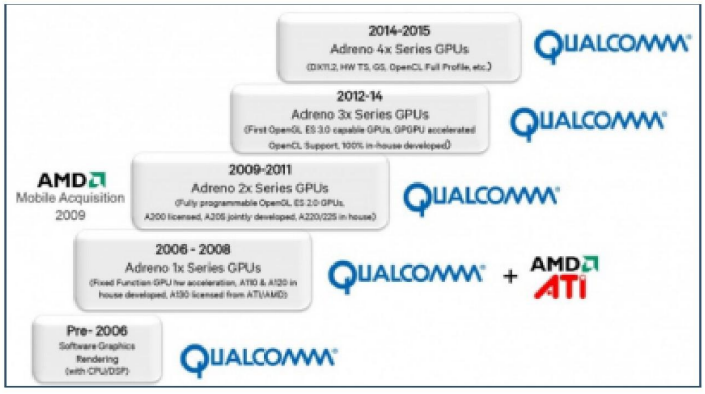


During this complex but vitally important business division transition, the world of GPU technology was not standing still. In 2006 fixed function hardware and a new OpenGL ES mobile-specific API was being built. By 2008, fixed hardware had moved to the side in favor of programmable shaders, allowing for a more flexible environment. User interface was still the primary usage model for GPUs including the first GPU-accelerated composition in the form of the "Android Surface Flinger" but simple 3D games were starting to pop up too.

NVIDIA, a company built on GPU technology, has marketed and promoted its own Tegra processors on the stance that mobile GPU horsepower is critical and the company's expertise from the desktop markets will trickle down into the ultra-low-power fields. Only recently though has the GPU really been able to take advantage of the compute tasks that are executed on smartphones. The world of the mobile GPU is now starting to come into its own, proving and showcasing the importance of this particular portion of a typical SoC.

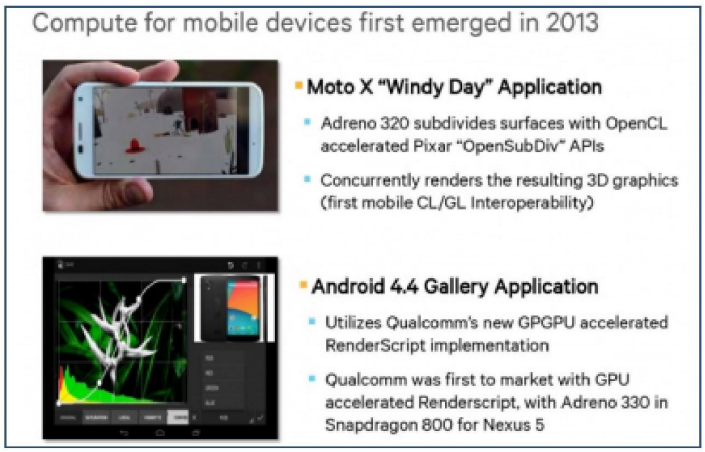
Bringing Modern Designs to Mobile

The next era of GPUs started in roughly 2010 and ran through 2012 and was even more disruptive than the previous. The use cases for GPUs on mobile devices was snowballing, starting with some major game engine developers outwardly discussing bringing console level gaming to mobile platforms and devices. GPU acceleration in the world of HTML5 and more advanced multimedia compositions required more processing power to support multi-camera configurations, overlays, windows, and visual effects. Everything in smartphones was happening *concurrently*, invoking engineering challenges that were greater in some ways than those that were faced in desktop PCs, particularly when considering the far more stringent battery and thermal constraints of mobile devices. Meanwhile, GPGPU (general purpose GPU) workloads were realizing their potential in the consumer desktop computing space; users, software developers and OEMs saw the potential benefits of highly parallel computing in a low power form factor like phones and tablets.



Interestingly, Qualcomm and others stated that during this time that the importance of graphics heavy benchmarks should not be overlooked. While very often OEMs and SoC designers will lament the unfair or unreasonable impact that benchmarks can have on sales, mobile processor companies generally believed that the improved benchmarks from professional graphics benchmark publishers like Kishonti, Rightware and others forced mobile OEMs to focus on application performance when selecting processors for mobile devices, rather than just making decisions based on theoretical hardware specifications. All benchmarks should be used and interpreted with care, since no single

benchmark can approximate the relative device performance for every conceivable workload. But it is likely that without these applications pushing hardware vendors to improve their frame rates for heavier game workloads, mobile devices would be much less capable today.



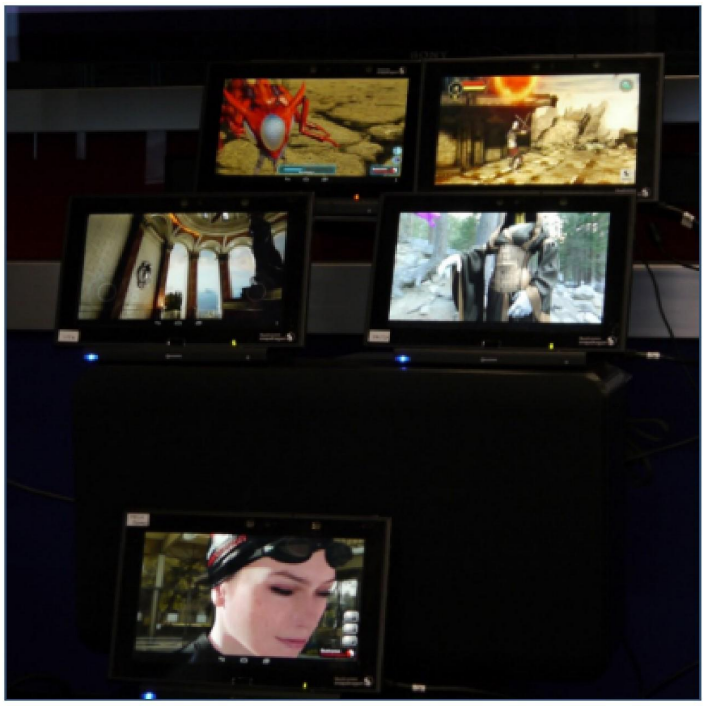
Other outside factors continued to push the importance on the GPU forward. Screen resolutions were increasing to HD and beyond, increasing the pixel processing power necessary for smooth and fluid motion dramatically. Feature phones were slowly fading away during the 2012 timeframe, forcing SoC developers like Qualcomm to integrate GPUs not just in high end processors, but into the lower-end markets as well. For this to be successful, improved power efficiency was not just desired, it was necessary for basic functionality.

Qualcomm started developing new programmable OpenGL ES 2.0 capable GPUs and its development team tripled in size in the span of only a couple of years. The Adreno A225 was perhaps the best example of a GPU built to address this rapidly changing market. It added support for the latest API specifications including DirectX 9 and OpenGL ES 2.0 and was one of the most power efficient GPUs in the mobile space. Built into the Snapdragon S4 and S4 Plus SoCs, A225 powered some of the world's most popular devices including the Nokia Lumia 1020, the HTC One X, Droid Razr M and the Galaxy S3 to name just a few. Qualcomm's dominance in a market that only six years ago hadn't existed was taking shape.

The next-generation of Adreno architecture, the Adreno 3x series (abbreviated A3x), actually has its beginnings in development prior to the acquisition of AMD/ATI Imageon, but was also heavily influenced by a new GPU architecture codenamed "QShader". The result was an OpenGL ES 3.0 capable GPU that transitioned away from A2x's VLIW shader architecture, to a much more flexible scalar-based one. It was also designed with GPGPU computing purposes in mind, and was another success for Qualcomm, since it was a GPU architecture that scaled particularly well from low to high tier, finding a home in various Snapdragon 200, 400 and 800 parts.

Despite the dominance that Qualcomm held on the mobile processor and mobile GPU market as late as 2012, there were outside forces that began to put pressure on the company to increase its development resources once again. Newcomer to the mobile processor space, but marketing master NVIDIA, announced the Tegra processor - a mobile SoC with a focus on the GPU. Though the company had very little market share and experience with anything other than large, power hungry graphics chips used in laptops, desktops and workstations; the promise of a mobile chip and GPU built by a company with such a pedigree was exciting with the media and some OEMs taking note.

Another company would also throw its hat into the ring, one with significantly more potential impact, though equally little mobile experience. By 2010, Intel was beginning to see the writing on the wall, which was that the mobile space, including smartphones and low power tablets, were the next frontier of computing. Taking a completely different approach than every other company competing for these segments, Intel bought Infineon's wireless unit and subsequently would attempt to bring x86 (rather than ARM) into the fold as well as a unique GPU implementation. Intel still has yet to truly deliver on its claims to enter and make an impact on the mobile market, but a computing giant this size should not be overlooked. Qualcomm needs to continue to push innovation forward if they are to maintain the lead from this new player.



A collection of GPU technology demos running

Work on GPU hardware continued, but Qualcomm also took note of some of the advantages that this new competition had over its current support system. Software development teams were ramped up and an outreach program for gaming developers implemented, including specifically the developers working on game engines like Unity and Unreal Engine. The sales pitch from this new group was easy – game developers want their games to work on the widest array of devices to increase sales potential and Qualcomm's Adreno graphics was the most popular GPU in the mobile space by a wide margin. Work with them, optimize their engine for Adreno and Snapdragon, and enjoy the instant benefits where it matters most – the wallet. So far it has worked and partnerships with UE and Unity were forged, among others. Qualcomm also brought in its own team of game developers to effectively start an in-house engine aimed at offering support to other teams, and to work on new visual effects libraries to share with the community.

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