



THE RISE OF MOBILE GAMING ON ANDROID: QUALCOMM[®] SNAPDRAGON[™] TECHNOLOGY LEADERSHIP

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1 Executive summary

Mobile gaming is the fastest growing segment in the game industry.¹ Today's consumers want immersive, connected gaming with all-day battery life that provides visually stunning graphics and high-fidelity audio. Android is helping fulfill that desire. With a large user base, Android devices provide a growing opportunity for game developers to generate revenue on a global scale.

The rapid iteration and fast innovation of Android have created a thriving ecosystem with numerous custom-designed form factors across device tiers. However, there are three challenges to taking Android gaming to the next level, including:

- How to create immersive gaming experiences within the power and thermal constraints of mobile devices?
- How to develop a game that addresses a sizeable portion of the mobile gaming segment with minimal code variations?
- How to take advantage of the hardware's capabilities without sacrificing time-to-market?

Qualcomm Technologies, Inc. (QTI) was the number one provider of Android smartphone application processor (AP) shipments in 2013.² Its Qualcomm® Snapdragon™ processors³ are fully integrated system on a chip (SoC) solutions designed with mobile in mind, handling everything from the most advanced, console-quality mobile games to the most popular casual games, all while delivering long battery life. This paper will describe the rise of mobile gaming on Android and how QTI is meeting the three challenges by:

- Creating low-power mobile processors by taking a heterogeneous computing (HC) approach and designing an efficient SoC architecture.
- Providing a consistent development platform across tiers due to its scalable architecture.
- Offering tools, support, and advanced technologies to easily unlock the full potential of Snapdragon processors for developers.

2 The rise of mobile gaming on Android

Mobile gaming is the fastest growing segment in the game industry, with a 30% compound annual revenue growth rate projected from 2013 to 2015.¹

Android burst onto the scene in 2008. The *open* nature and rapid iteration of the platform, combined with improving hardware, and a growing installed base of devices worldwide, has created excellent opportunities for the mobile gaming ecosystem.

¹ Source: Gartner, October 2013, "Forecast Video Game Ecosystem Worldwide"

² Source: Strategy Analytics, April 2014

³ [Snapdragon processors](#) extend across four product tiers: Snapdragon 800, Snapdragon 600, Snapdragon 400, and Snapdragon 200.

Through standard application program interfaces (APIs), Android exposes key platform capabilities to developers, such as connectivity, sensors, and graphics rendering. Android also has a history of quickly adopting the latest graphics standards, like OpenGL ES. The consistent release of new APIs helps limit fragmentation, improve ease of use, and decrease time-to market.

To take advantage of increasing consumer engagement on the Google Play app store, developers are now creating games that utilize the latest Android capabilities (e.g., 3D graphics). As a result, new game brands have been introduced (e.g., *Real Soccer*, *Asphalt*, *Real Racing*, and *Modern Combat*). Debuting in the smartphone, Android is now extending to other form factors, including tablets, handheld gaming devices, set-top-boxes, TVs, and more.

Total mobile gaming revenues (for all platforms) are projected to grow from \$13 billion in 2013 to \$22 billion in 2015⁴. Within this category, the Android platform provides a large and growing opportunity for developers. On the device side, 78.4% of smartphones shipped last year were Android, outselling devices based on the next leading smartphone mobile OS by almost 5x.⁵ Android device shipments (smartphones and tablets) are projected to exceed one billion units in 2014.⁶ On the apps side, 75% of Android users play games⁷, accounting for 90% of the app-generated revenue on Google Play⁸.

3 Immersive mobile gaming experiences at low power

Immersive gaming requires more than just console-quality graphics. Other elements include cinema-quality sound, realistic effects, instantaneous response times (low latency), and the ability to play anywhere. Figure 1 highlights the key components that contribute to the overall gaming experience.

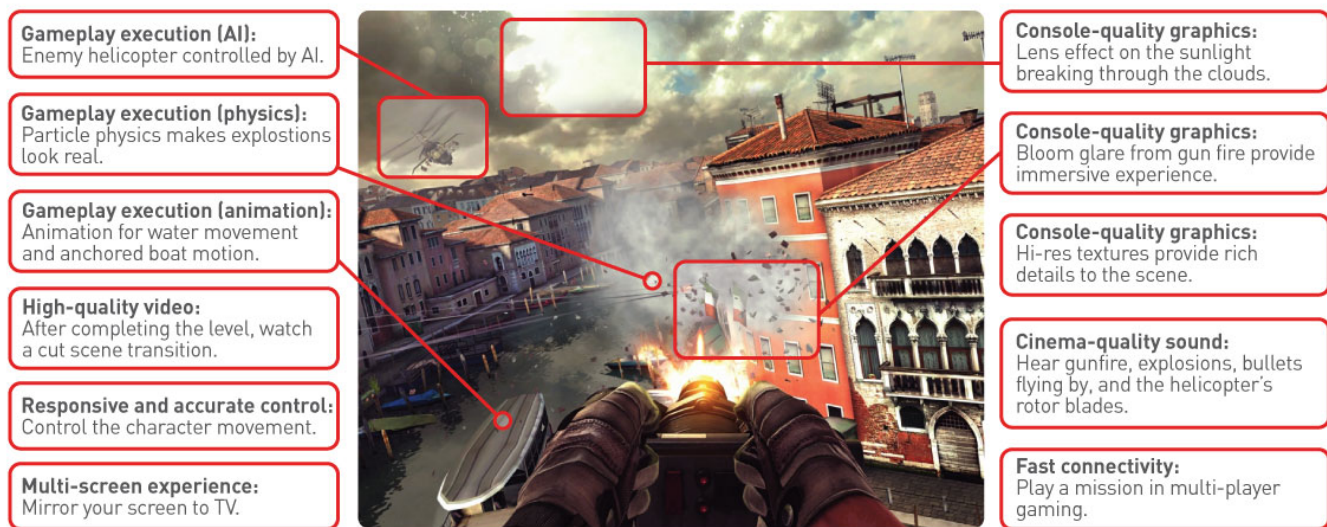


Figure 1: Example of key gaming components in Modern Combat 5: Blackout by Gameloft

⁴ Gartner, October 2013, "Forecast Video Game Ecosystem Worldwide"

⁵ Gartner, "[Gartner Says Annual Smartphone Sales Surpassed Sales of Feature Phones for the First Time in 2013](#)"

⁶ Gartner, "[Gartner Says Worldwide Traditional PC, Tablet, Ultramobile and Mobile Phone Shipments On Pace to Grow 7.6% in 2014](#)"

⁷ Kris Holt, "[Google Adds Some Serious Oomph to Play Games](#)"

⁸ eMarketer, "[Game Apps Are No. 1 for Amazon, Apple and Google](#)"

Today's mobile graphics are approaching the visual quality of consoles and PCs with high-end graphics cards.

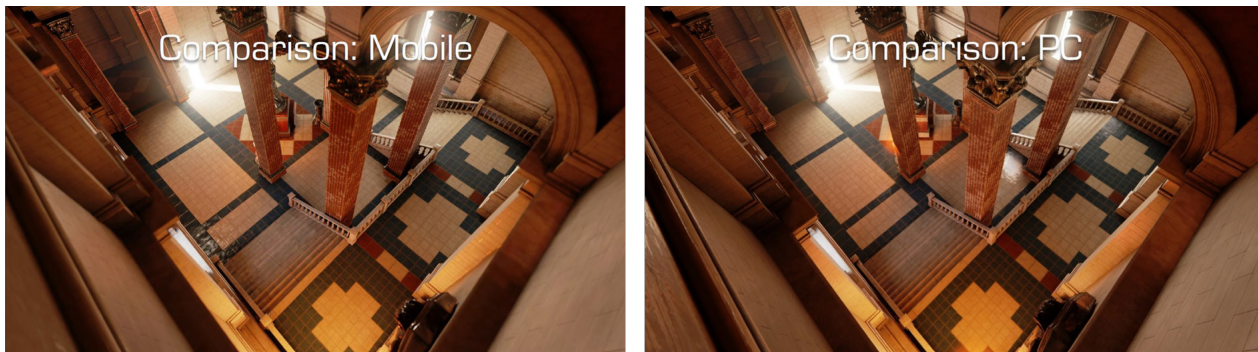


Figure 2: Mobile (left) vs. PC (right) rendering for Epic Unreal Engine 4

Consumers expect console-quality graphics and long battery life when playing any mobile game, from simple casual games like *Candy Crush* to more immersive games like *Modern Combat 5: Blackout*. However, enabling advanced mobile gaming experiences for sustained periods is challenging. Consoles and PCs have the luxury of being able to use fans (and large heat sinks) while drawing triple-digit wattages from an external power outlet. Mobile devices, on the other hand, are *passively* cooled, powered by a battery, and limited to single-digit wattages in order to meet the power and thermal constraints of the thin form factor.

Through its Snapdragon processors, QTI is addressing the performance and power challenge by:

- Taking a power-optimized, *heterogeneous approach to mobile computing*.
- Analyzing performance bottlenecks and designing an *efficient SoC architecture* that improves each generation.



"Qualcomm® Snapdragon™ processors really help enable us to create an immersive experience for the gamer..."

Sylvain Baudry
Business Development Director
Gameloft

Figure 3: Asphalt 8: Airborne by Gameloft

3.1 Heterogeneous computing: specialized engines designed for efficient processing

QTI has a long history of taking a heterogeneous computing approach. This approach intelligently utilizes specialized engines, such as the GPU, DSP, and display engine, to support new immersive experiences, while helping to maximize battery life and thermal efficiency.

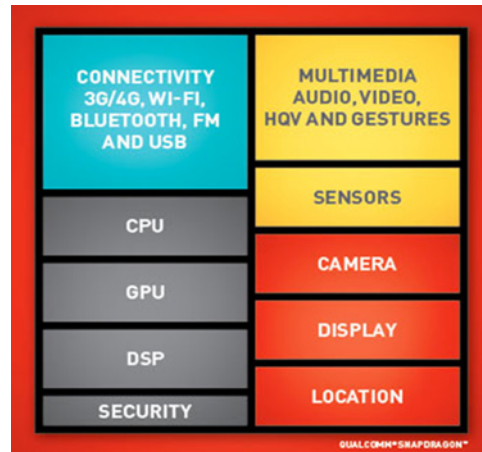


Figure 4: Snapdragon processing engines

As mentioned in Section 3, games are comprised of multiple components. These components may be implemented as one or more tasks. To support the optimal gaming experience at the lowest power and thermal levels, each task should be designed to run on the most appropriate engine. Figure 5 is an example of this.

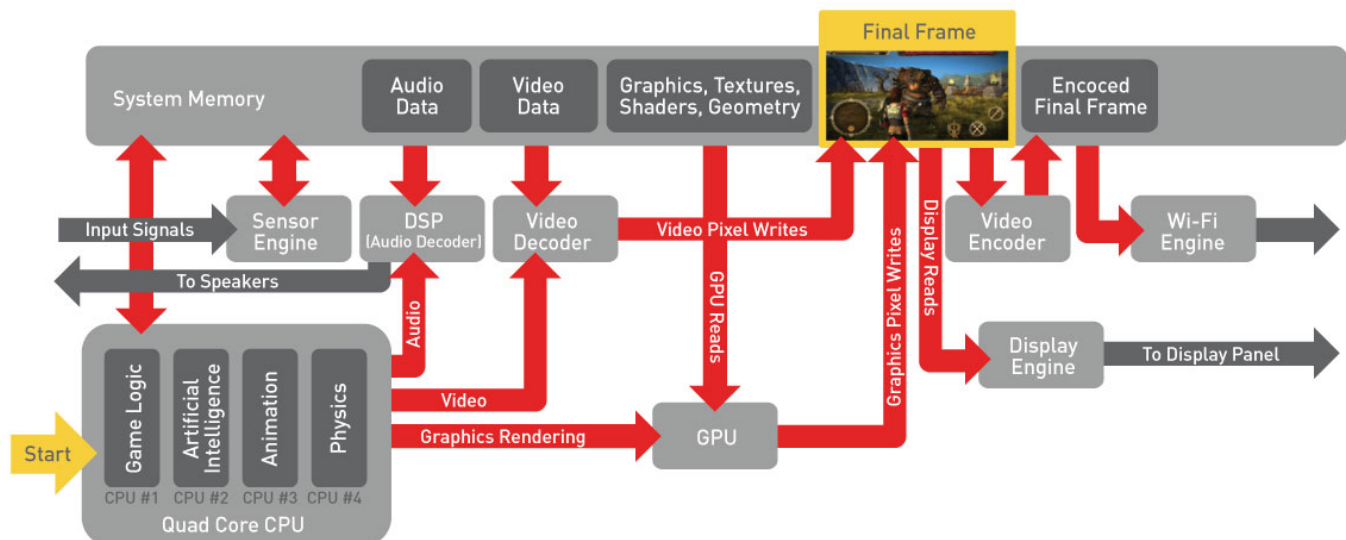


Figure 5: High-level view of gaming tasks being appropriately distributed to specialized engines

The rest of this section provides examples of how Snapdragon processors are designed to run key gaming tasks on the most appropriate processing engines.

Controlling gameplay execution — keeping everything in sync: The CPU dispatches work to the appropriate specialized engine and processes individual functions within the game as separate tasks. For example AI, animation, physics, and gameplay are processed on the CPU.

Functions like physics and AI require high-precision math, which can be efficiently processed on the VeNum floating point units of QTI's custom-designed Krait™ CPU. In addition, because the tasks are independent, they can be written as separate threads and run on separate CPUs for optimal performance and latency.

QTI has been innovating its power management and scheduling software for years to provide the different amounts of processing that various tasks require. For example, Krait CPUs have long employed asynchronous symmetric multi-processing (aSMP) so that optimized performance is delivered per CPU core, thus saving power.

Console-quality graphics — advanced features and graphics rendering (at low power): When most people think of modern mobile gaming, it is the console-quality graphics that immediately come to mind. Rendering graphics at low power and at high frame rates requires a specialized engine, the GPU. QTI's custom-designed Qualcomm® Adreno™ GPUs are a family of low power, fully programmable GPUs that are designed for optimal mobile gaming performance.

Adreno GPUs provide comprehensive support for the latest graphics APIs. The Khronos OpenGL ES specifications define the primary graphics APIs for Android gaming. QTI works closely with the Khronos group to help define the standards, and the Adreno GPU is optimized to support OpenGL ES (from the silicon to the drivers and software stack).

Adreno GPUs have a long history of graphics technology leadership. They support many design innovations for efficient graphics processing, including a flexible, power-efficient unified shader architecture, which is designed to support dynamic resource allocation (for optimal shader processing).

“Epic now has brought Unreal Engine 4 to Android with the Snapdragon 800 and 805 chipsets from Qualcomm Technologies. Recently we worked with Qualcomm [Technologies] to elevate graphics to the next level on the ... Adreno GPU hardware, which delivers some of the most power-efficient unified shader capabilities we've seen yet for Android smartphones and tablets.”
— Niklas “Smedis” Smedberg, Epic Games

The Adreno GPU also supports dynamic [FlexRender™](#) technology, which is designed to intelligently choose between immediate/direct mode and deferred/tile-based rendering, to render various tasks (such as user interface and gameplay) in a more efficient manner.

Custom designing the Adreno GPUs allows QTI to evolve the architecture in a timely manner for emerging mobile use cases, such as new gaming features and APIs. For example, the newest Adreno 4x series GPUs are designed to the DirectX11FL_11_2 specification, the same graphics specification as today's high-end desktop graphics cards and the latest gaming consoles.

To support next-gen features (beyond the newly announced Khronos OpenGL ES 3.1 APIs), Adreno 4x series GPUs extended their unified shader architecture by adding several completely new shaders (e.g., geometry and tessellation).

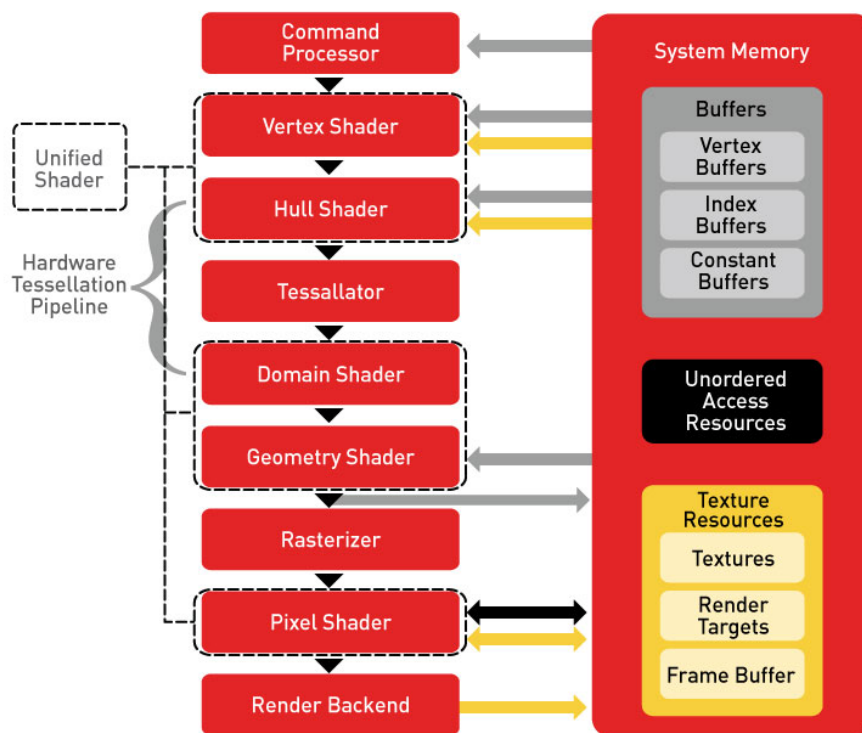


Figure 6: Adreno 4x series GPU's Direct3D 11 FL_12 based 3D hardware pipeline

The Adreno 420 GPU is one of the first commercial mobile GPUs to support dynamic hardware tessellation. Dynamic hardware tessellation is designed to help developers to provide greater detail for more visually realistic scenes in a manner that requires less memory bandwidth, lower power consumption, and lower overall memory footprint for the application.

Traditionally, in order for most 3D games to be visually immersive, the programmer must include a substantial amount of geometry detail per object. The denser the geometric mesh used to create an object in the scene (human or monster for example) of a game, the smoother and more realistic its surfaces will look. In traditional mobile GPUs, these additional geometry assets (required for improved visual realism) need to be stored in memory as part of the game binary package. These assets have to be copied or written by the CPU to the system memory and eventually have to be read into the GPU for further processing. These additional read and write operations could increase the memory bandwidth usage and power consumption to unsustainable levels (for console-quality games) on mobile devices.

Dynamic hardware tessellation helps solve this problem by allowing the GPU to generate additional geometry on-chip, without requiring additional data transfers from off-chip, system memory. Dynamic hardware tessellation can help significantly reduce bandwidth and power consumption. Another advantage is that the developer doesn't have to author and store these additional geometry details into their game package, which significantly reduces the memory footprint and the overall binary size of the game.

The image below shows the additional detail that tessellation provides to both the wireframe and the final image rendered. For this simple “Hornet” graphics scene, hardware tessellation delivers a bandwidth savings of ~360MB/s, and a memory footprint savings of ~20MB⁹. For larger games, the savings on memory footprint could be in GBs.

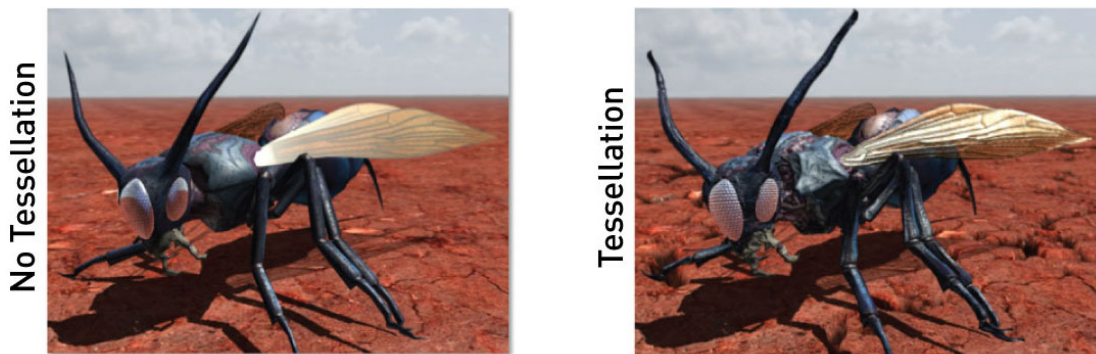


Figure 7: Tessellation (OFF: left, ON: right) provides more realistic and detailed graphics

By providing more detail, tessellation is designed to help significantly improve the gaming experience, not only for high resolution content, but also for low resolution content that needs to be upscaled.

The Adreno 4x series GPUs are a great example of QTI’s commitment to bringing console-quality gaming up to 4K Ultra HD (4K) resolution to mobile devices.

“[Adreno 420 is] the most aggressive move in mobile graphics by any company, to add all the shader types, and HW tessellation, on top of what they did in Subdiv for Motorola, shows Qualcomm [Technologies] as the most committed mobile graphics supplier today. It really is bringing console-class graphics to mobile devices.”¹⁰ — Jon Peddie, Jon Peddie Research.

Multi-screen experiences — high fidelity on your screens: Playing a game on a high-quality, high-resolution screen significantly enhances the gaming experience. The display engine enhances images, composites multiple images, and supports high resolution (both on-device and on external displays) of up to 4K.

For image enhancement, the display engine utilizes QTI’s Qualcomm® TruPalette™ and Qualcomm® EcoPix™ feature sets, which include high quality post-processing algorithms for superior picture quality, including picture adjustment, color enhancement, contrast enhancement, scaling, sharpening, and power efficiency. For example, using the ecoPix sunlight visibility improvement technology, the display engine can use information from the device’s light sensor to enhance the rendered game content to make it much more visible in bright conditions (e.g., outdoors on a sunny day) through tone correction.

⁹ Numbers based on QTI internal testing

¹⁰ Jon Peddie, “[Qualcomm Moves to 4K with Snapdragon 805](#)”

TruPalette

- Gamut mapping
- Color enhancement
- Memory color
- Six color zone
- HSV adjust



EcoPix

- Content adaptive backlight
- Frame buffer compression
- Variable refresh
- Sunlight visibility improvement

Figure 8: Snapdragon display engine TruPalette and EcoPix feature sets

Device-to-device connectivity further elevates the mobile gaming experience. External displays, such as a TV, are driven by either a wired (e.g., HDMI) or wireless connection (e.g., Miracast). It is the task of the display engine to efficiently process both types of connections. With the wireless display feature, you can send the contents of your mobile device screen to your smart TV screen. QTI supports wireless display standards, like Miracast, and is adding wireless display support to an increasing number of Android devices.

Cinema-quality sound — efficient audio processing in sync with the graphics: Just as sound is a huge part of the movie-going experience, it is also important in the world of immersive mobile gaming. Accordingly, QTI provides a comprehensive audio solution, including hardware and software, which offers high-fidelity audio and advanced features like 24-bit/96kHz play back and cinema-quality 7.1 surround sound audio.

The processing required to efficiently support these computationally complex audio features is primarily handled by QTI's Hexagon™ DSP, which is custom designed for heavy signal processing tasks, like audio. The real-time processing capabilities of QTI's Hexagon DSP are designed to keep the audio in sync with the graphics rendering. QTI has also worked with industry leaders, such as DTS and Dolby, to provide an optimal audio experience on Snapdragon processors, including support for headphone surround virtualization.

High-quality video — specialized video engine: Some games incorporate pre-rendered cut scenes to enhance the overall gaming experience. To save memory, these scenes are compressed into encoded video. To playback video, Snapdragon processors are designed to use a specialized video engine to decompress encoded videos at low power. For higher resolutions and more complex codecs, a specialized engine becomes even more important.

Figure 9 shows that running H.265 HEVC decode on a specialized video engine versus a CPU reduces power consumption, while still meeting the frame rate requirements¹¹.

¹¹ Estimated numbers based on QTI internal testing

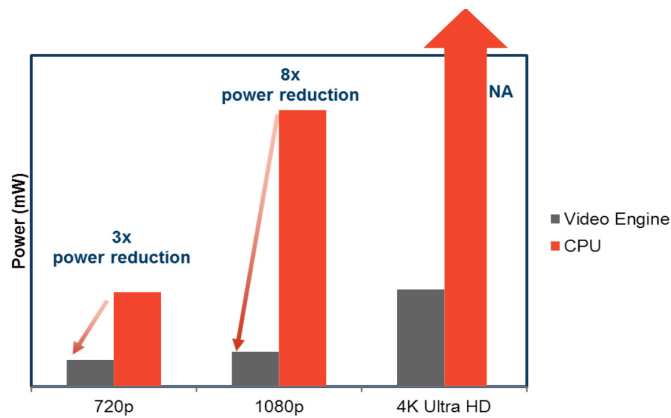


Figure 9: Power reduction by running HEVC decode on specialized video engine versus the CPU

Fast connectivity — multi-player gaming: Connected gaming experiences, like massively multiplayer online (MMO) games, require fast and reliable connectivity solutions with low latency where the difference between winning and losing often comes down to milliseconds. To achieve that, Snapdragon processors include connectivity technologies, such as 802.11ac Wi-Fi and 3G/4G LTE.

QTI has a long history of being an industry leader in advanced connectivity solutions. Its latest Snapdragon 810 processor continues the tradition, integrating a Cat 6 LTE Advanced multimode modem that is designed to support reliable communication at speeds of up to 300 Mbps. QTI optimizes the software stack for connectivity to achieve low client-server ping times on Snapdragon processors, so gamers can worry less about a slow connection and focus more on enjoying the game.

Responsive and accurate control — supporting multiple input methods: A good gaming experience requires an input method that gives precise control at low latency. There are multiple ways to control and interface to games, such as through a touch screen, device movement, a game controller, and gestures. Snapdragon processors have been designed to reduce latency and provide accurate control for these methods. For example, device movement generally is determined by processing data from motion sensors, such as the accelerometer or gyroscope. Sensor processing requires intensive signal processing, control processing, and real-time processing. QTI's specialized sensor engine, which excels at handling these tasks, is integrated in Snapdragon processors. As a result, the response time for device movement is faster — and at low power.

3.2 Efficient SoC architecture: smart management of system resources

An efficient SoC architecture is required in order to sustain console-quality gaming at high frame rates within the thermal and power constraints of mobile devices. As noted above, the majority of the processing engines within the SoC are running concurrently in a heterogeneous manner to efficiently process gaming tasks. Beyond heterogeneous computing, smartly managing the shared system resources, such as memory bandwidth, power budget, and thermal budget, is necessary to support sustained gameplay of a visually complex game.

Efficient memory bandwidth: While playing a game, the processing engines need to be fed data (starving a processing engine of data can lead to lower frame rates). To prevent bottlenecks, Snapdragon processors use advanced memory management techniques. The memory controller is designed to deliver high quality of service (QoS) for different throughput and latency requirements of different processing engines, while still maximizing the memory utilization. By minimizing the overhead associated with memory transactions, the memory controller helps increase memory utilization and minimizes power consumption.

Snapdragon processors are also designed to deploy smart caching mechanisms in many processing engines to help minimize the need for frequent DRAM access. For example, the Adreno GPU's tile-based architecture, which subdivides the graphics image into smaller tiles and renders them to the tile-buffer cache, helps minimize DRAM bandwidth and saves power.

Advanced power and thermal management technology: Drawing high power not only reduces battery life, it also releases excess heat. This will raise the skin temperature of the device, making it uncomfortable to hold. To reduce the system power, Snapdragon processors are designed to deploy sophisticated algorithms that manage power based on workload requirements. They support a wide range Dynamic Clock and Voltage Scaling (DCVS). DCVS dynamically varies the clock frequencies and voltages of the processing engines. For example, the Adreno 420 GPU now has more granular DCVS power control levels, so it can run most use cases at a nominal voltage state, thus saving power.

Several of the specialized engines have innovative, power-saving techniques. For example, the display engine also uses a proprietary compression scheme called Frame Buffer Compression (FBC), which compresses display data by up to 66% in a visually lossless manner—before transmission to the display panel.¹²

The Adreno 420 GPU also has an increased Z-reject rate for graphics rendering so that pixels that are not going to be visible (because they are blocked by a pixel on top) are not processed. An increased Z-reject rate means lower power per pixel—and improved performance.

4 Providing a consistent development platform at scale

To attract game developers, devices with Snapdragon processors provide an excellent opportunity with a consistent development environment.

4.1 Android gaming on Snapdragon: an excellent opportunity

As of January 2014, over 1,350 devices with Snapdragon processors had been announced or were commercially shipping. In addition, more than 525 new device designs are in development, and QTI is currently working with over 85 manufacturers worldwide. QTI was the #1 provider of Android smartphone AP shipments in 2013.¹³

¹² QTI internal metrics

¹³ Strategy Analytics, April 2014

By optimizing their games on Snapdragon processors, developers have the opportunity to reach this very large and growing installed base of Android devices with Snapdragon processors that span across various price tiers and regions.



Figure 10: Devices with Snapdragon processors

Examples include iconic flagship Android-based devices like the Nexus 5 by Google, LG G Pro2, and Samsung Galaxy Note 3. Recently launched devices, including the HTC One (M8), One+ One, LG G3, Samsung Galaxy S5, and the Sony Xperia Z2, are powered by the Snapdragon 801 processor. Amazon Kindle Fire HDX 8.9 and Fire TV, based on Fire OS, are also powered by Snapdragon processors.

Refer to the [smartphones](#) and [tablets](#) websites for the latest devices powered by Snapdragon processors. With Adreno 4x series GPUs on the verge of being launched in commercial devices, Snapdragon processors continue to provide graphics and gaming technology leadership.

According to Jon Peddie Research, “Qualcomm [Technologies] is clearly the largest SoC supplier”.¹⁴ For Q2 2013 and as indicated in Figure 11, QTI was the single largest GPU supplier for personal devices, which includes smartphones, tablets, and dedicated handheld game consoles.¹⁴

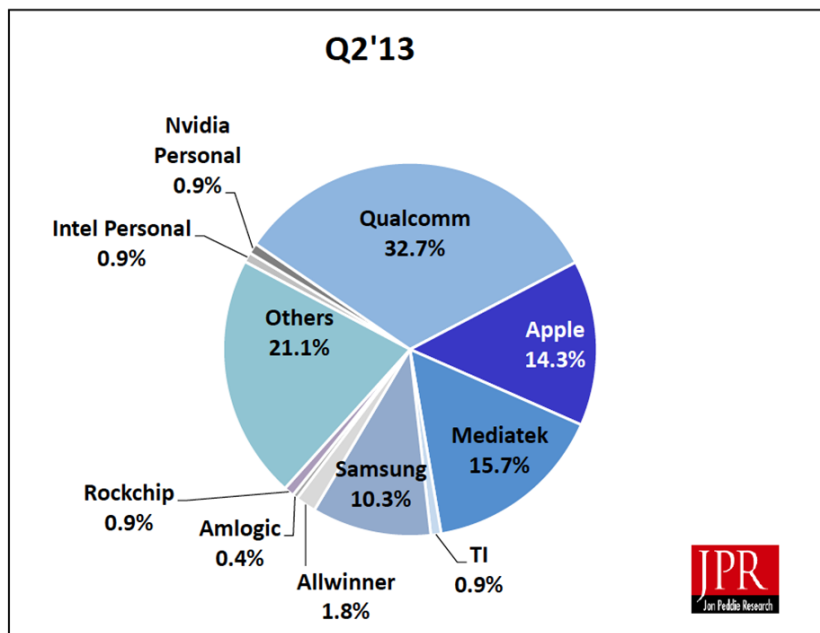


Figure 11: Share of personal systems SoC suppliers for Q2 2013

¹⁴ Jon Peddie Research, Oct. 2013, “Mobile Devices and the GPUs inside”

4.2 Scalable architecture: consistent gaming experiences across various tiers

Consumers expect immersive gaming experiences whether they own a premium or an entry-level mobile device. Snapdragon processors are designed to support great gaming experiences across the spectrum of device tiers. Apart from offering backwards-compatible software between different tiers, Snapdragon processors with the scalable Adreno GPU are designed to provide consistent features and APIs across tiers. Using APIs as an example, Adreno 3x series GPUs (and above) support OpenGL ES 3.0. Having common support of APIs and features ranging from entry-level to premium devices helps make it easier for developers to introduce next-generation features to mass audiences, without having to custom design for each tier.

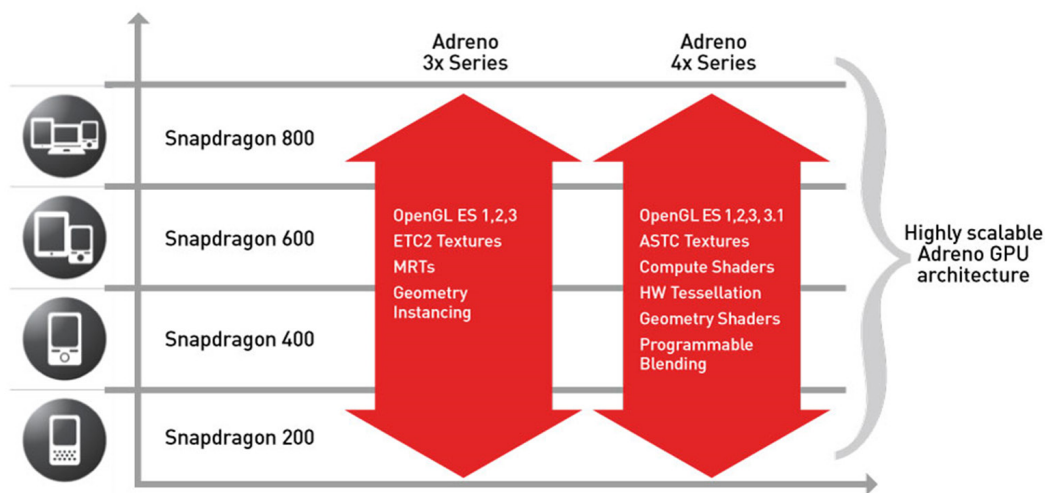


Figure 12: Snapdragon processors with the scalable Adreno GPU are designed to provide consistent features across tiers

Snapdragon processors are software compatible, helping both OEMs and developers to efficiently invest and develop across multiple device types and tiers. With a consistent software stack, including graphics drivers, devices with Snapdragon processors are designed to provide a consistent and optimized gaming platform across various tiers.

5 Unlocking the potential of Snapdragon processors for developers

QTI and its affiliates have a long history of technology leadership in supporting the mobile gaming ecosystem, dating back to 2001 with the Brew™ platform. This breakthrough development platform allowed native C/C++ games to be written “closer to the metal,” supporting higher-quality and higher-performance games, and helped usher in some of the world’s first 3D games in mobile. Brew was also one of the earliest monetization platforms for mobile applications, paying out more than \$3 billion to developers¹⁵.

¹⁵ <https://www.brewmp.com/about>

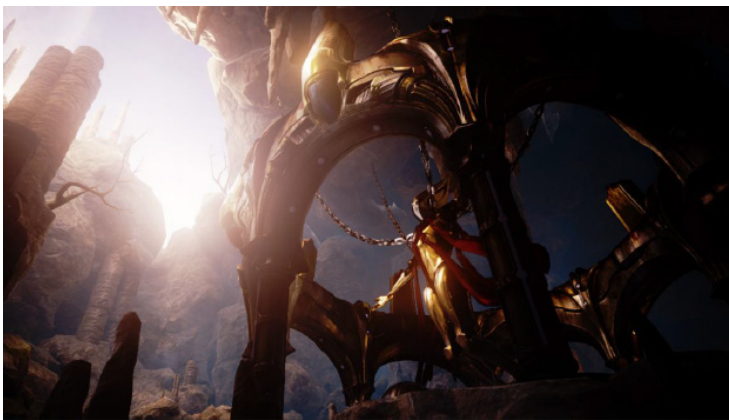
The introduction of 3G in the early 2000s enabled faster downloads of larger games, multi-player gaming, and more robust client-server-based game designs. In addition, Qualcomm Ventures also helped fund mobile gaming pioneers such as JAMDAT Mobile and more recently invested in companies such as Bluestacks, Gaiikai, Grand Cru, Playdek, Playnery, and TabTale.

It takes more than just great hardware to advance the mobile gaming industry. To support game developers in producing immersive games, QTI provides comprehensive tools, extensive support, and advanced technologies.

5.1 Supporting developers with comprehensive tools

QTI supports developers in unlocking the performance and advanced features of Snapdragon processors by not only offering comprehensive development tools, but by also working closely with the gaming ecosystem.

Game engine optimization — access to the latest features and reduced time-to-market: QTI works closely with the world's leading third-party game engine providers, such as Unity Technologies and Epic Games, to optimize their engines for Snapdragon processors. Additionally, QTI helps expose the latest graphics APIs and advanced features of Adreno GPUs to developers through these engines. For example, QTI worked closely with Epic Games to optimize Unreal Engine's advanced lighting and post processing pipeline for Snapdragon processors.



"Bringing Unreal Engine 4 PC AAA graphics to mobile has enabled us to do content that we've never been able to do before. A big advantage has been our close relationship with Qualcomm [Technologies]. Without that close relationship we wouldn't have been able to reach this point."

Niklas "Smedis" Smedberg
Senior Engine Programmer – Mobile Graphics
Epic Games

Figure 13: Unreal Engine 4 demo showcasing optimized post-processing on Adreno GPU

QTI also worked with Unity Technologies to help accelerate the support of new features, making the Unity Engine one of the first gaming engines to support important OpenGL ES 3.0 features like ETC2 textures, multiple render targets (MRT), and transform feedback in Unity 4.x. Unity and QTI continue this work by helping bring new Unity 5.0 innovative features like physically based shading to Snapdragon processors.



“We’re excited to work with an innovative global mobile technology provider such as Qualcomm Technologies and support their incredible Snapdragon processors, which are at the heart of many Android and Windows mobile devices across the globe.”

David Hegalson
CEO
Unity Technologies

Figure 14: Unity 5 demo showcasing physically based shading technique on Adreno GPU

By using these popular game engines, which have been optimized for Snapdragon processors, developers can focus their time on content creation.

In addition, QTI also works closely with developers to help optimize their proprietary in-house game engines so that they run well on Snapdragon processors. In turn, these developers can then utilize their optimized engines across their internal studios when developing mobile games.

Game development tools — developing, debugging, and optimizing games: For those who are programming directly to the hardware and not using a third-party game engine, QTI has created (and made available) powerful game development tools, which are designed to help debug and optimize games, while reducing time-to-market. These tools include the [Adreno SDK](#), [Adreno Profiler](#), and [Trepn™ Profiler](#).

The Adreno SDK includes tools, emulators, libraries, documentation, samples, and tutorials. The desktop OpenGL ES emulator is designed to eliminate the need to have a device early in the development process. Adreno SDK supports the most common APIs such as OpenGL ES, DirectX, and OpenCL. In addition, the Adreno SDK contains several time-saving utilities and over 100 samples and tutorials, including 50 advanced shader effects.

The Adreno Profiler provides developers with detailed GPU utilization analysis to help them optimize their games for faster frame rates, smoother rendering, and longer battery life. It works on commercial devices without making changes within a game, device drivers, or builds, which helps further save development time and reduce setup complexity.

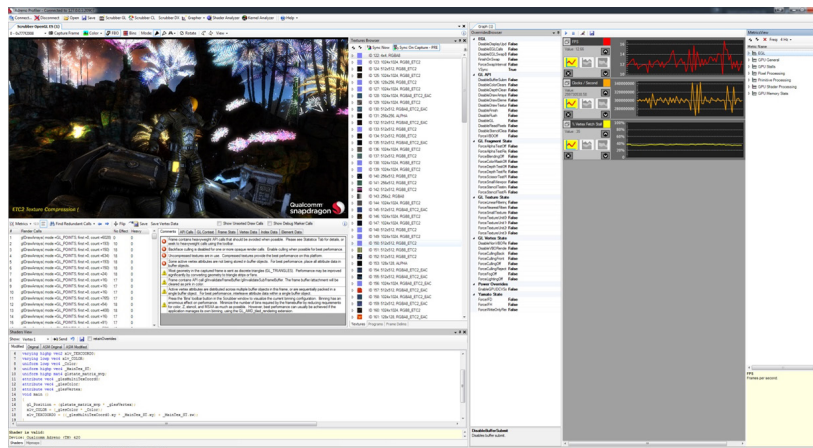


Figure 15: Adreno Profiler helps optimize games

The Trepp Profiler is designed to integrate directly into a developer's workflow, which helps him or her see how much power a game is consuming, pinpoint issues and quickly resolve them. Consumers expect all day battery life, consistent performance, and a device that stays cool. In fact, battery life has become an extremely important decision factor for consumers when buying smartphones. Managing power consumption and remaining within the thermal envelope of mobile devices are key development considerations. Exceeding the thermal envelope will not only heat up the device, but also throttle the game's frame rate, which negatively affects gameplay.

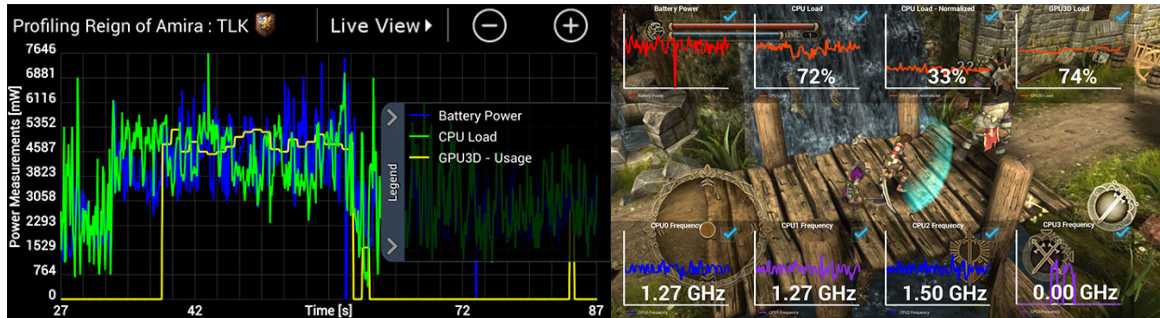


Figure 16: Trepp Profiler provides diagnostic views, such as battery power, CPU load, and GPU usage



Figure 17: BombSquad by Eric Froemling

"I would definitely recommend developers work with Qualcomm [Technologies] and use the Snapdragon tools. I know they've been a big go-to for me."

Eric Froemling

Development devices — optimizing games for real hardware:

[Mobile development platforms](#) (MDP) powered by certain Snapdragon processors in the form of tablets and smartphones are currently available to game developers prior to the launch of commercial OEM devices. These MDPs provide early access to new features of Snapdragon processors and are designed to allow developers to optimize their games in advance of the commercial launch of devices with Snapdragon processors. Devices with Snapdragon processors are available across tiers, and developers can select from a wide range of existing commercial devices to complete final testing and validation of their games.



Figure 18: Snapdragon Mobile Development Platform



“Developing on the kits is a great help for us as a development team because it allows us to address a wide installed base since many devices use the same Snapdragon chipset.”

Francois Bodson
Studio Manager
Ubisoft Paris / Mobile

Figure 19: Assassin's Creed Pirates by Ubisoft Entertainment

5.2 Supporting the developer community

QTI can provide game developers with technical support to shorten time-to-market and improve game quality. QTI also can provide business and marketing support to help developers promote their games and facilitate potential business opportunities.

Technical support for developers — providing expert game optimization: Such technical support is provided via QTI's internal game studio, which is comprised of developers with comprehensive prior work experience in console, PC, and mobile gaming. Support activities range from tools, training, technical feedback on optimizations and builds (from alpha to beta to release candidates), and new feature support.

To take advantage of the capabilities of Snapdragon processors and to extend, enhance, and differentiate their games, QTI can help developers add full screen post-processing effects, OpenGL ES 3.0/3.1 features, and more. There is also a [developer forum](#) where developers can ask questions and engage with the QTI team and others in the Snapdragon developer community.



“The Qualcomm® Snapdragon™ processor has allowed us to create a better experience in our game Gates of Osiris because it's allowed us to develop faster, push our graphics, and understand how to optimize our game to be the best it can possibly be.”

Brian McRae
CEO
Fenix Fire

Figure 20: QTI worked closely with Fenix Fire to optimize Gates of Osiris on Snapdragon

Business and marketing support for developers — facilitating business opportunities: QTI is engaged with some of the world’s leading publishers and developers, from traditional console and PC to indies. The list includes companies such as EA, Gameloft, Activision Blizzard, Ubisoft, Square Enix, Mojang, and Take-Two Interactive. QTI also facilitates introductions for engagements with OEMs and carriers across the global gaming ecosystem.

Throughout the year, QTI has a presence at several key mobile and gaming tradeshows, where it helps developers obtain exposure to show attendees, press, and OEMs. In the past year, QTI participated in shows such as CES, MWC, GDC, E3, SIGGRAPH, Unite, and many more, reaching hundreds of thousands of attendees. In addition, QTI often features games on the latest Snapdragon development platforms and commercial devices with Snapdragon processors.



Figure 21: Showcasing games at the QTI booth during CES 2014 (left); GDC 2013 (right)

5.3 Next-generation gaming experiences

QTI continues to push the mobile gaming industry forward by developing new and innovative technologies.

QTI actively develops tech demos to showcase the latest Snapdragon features and advanced capabilities. The “Swimmer” demo is a recent example of how developers can utilize OpenGL ES 3.0 APIs for advanced rendering techniques. The demo shows advanced skin rendering using subsurface scattering techniques running optimally at 60 frames per second, at 2K resolutions.



Figure 22: QTI “Swimmer” technology demo

To help further advance the evolution of gaming, QTI and its affiliates have developed (and continue to develop) innovative technologies that support ever-more advanced capabilities and features including vision-based augmented reality ([Qualcomm® Vuforia™](#)), proximal peer-to-peer networking ([AllJoyn™](#)), biometrics, and more. For example, Vuforia supports the Smart Terrain™ feature, which is designed to provide real-time 3D mapping of a physical play area, including intelligent interaction with objects and surfaces. With this technology, gamers can create user-generated, playable content from physical objects by using their mobile device as a level editor. Another example of a promising new technology that can be utilized by game designers is biometrics data from a wearable. By capturing measurements from pulse and blood pressure sensors, gameplay can be adjusted accordingly to either reward or penalize a player.

6 Conclusion

Consumer demand for gaming on mobile devices is growing rapidly, generating strong momentum and opportunity. The Android platform is thriving and offers game developers a growing opportunity to generate revenue on a global scale. QTI is helping the mobile gaming industry to take advantage of this opportunity by solving three key challenges for developers:

- To support immersive gaming experiences within the power and thermal constraints of mobile devices, QTI creates low-power SoCs by taking a heterogeneous computing approach and designing an efficient SoC architecture.
- To efficiently address a sizeable portion of the Android gaming segment with minimal code variations, QTI's scalable architecture is designed to provide a consistent development platform across tiers.
- To take advantage of Snapdragon processors' capabilities and to help reduce development time and costs, QTI offers developers a comprehensive set of tools, support, and advanced technologies.

Snapdragon processors are purpose-built and custom designed with mobile in mind, supporting gaming experiences from simple casual games to console-quality games, so consumers can play longer and recharge less. This is yet another example of how QTI is once again re-inventing the mobile world we live in.

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