MARVELL

White Paper

Marvell Android Cloud Gaming

A High-Performance Scalable Solution on Marvell ThunderX

August 2020

Executive Summary

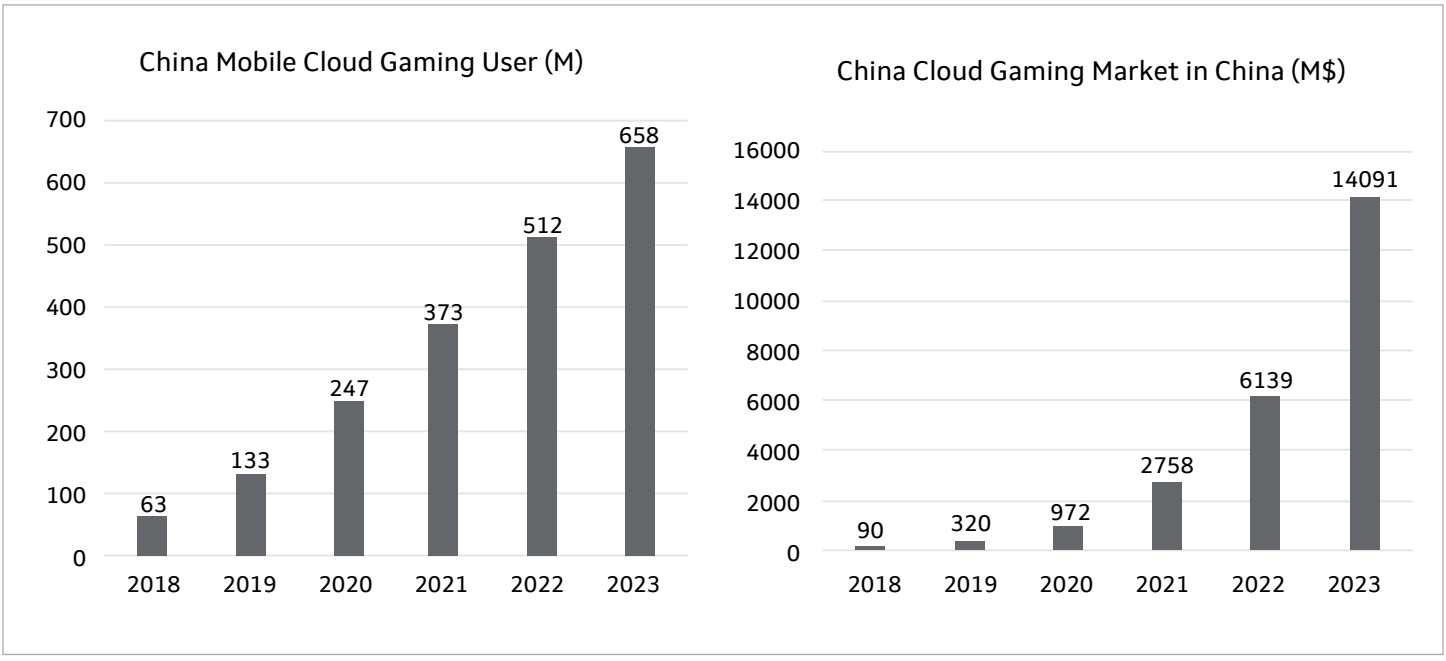
5G is coming, and with it, efficient data transmission and low latency for cloud services. Along with advances within the data center, the quality and performance required for high-end cloud gaming on mobile devices is now a reality. Cloud gaming offers a richer gaming experience and enhanced social interaction and the potential for business growth. By eliminating the need for players to buy high-end mobile devices and removing the content installation barrier, cloud gaming enables an expansion of user base as well as higher engagement. As of May 2020, Android is the leading mobile device operating system with over 72 percent worldwide market share[1]. And newly available Arm-based servers are uniquely suited to run these Arm-based platforms.

This whitepaper introduces Marvell's Android Cloud Gaming solution, a high-performance scalable reference implementation built on the Arm 64-bit ThunderX family of server SoCs. The current Marvell ThunderX2 solution scales from 720p30[2] to 1080p60[3] modes. With Marvell's 3rd generation ThunderX3 SoC, we expect to increase the performance in the same server form-factor. Android cloud gaming providers can integrate Marvell's full reference solution to effectively deliver Android cloud gaming instances at scale, beginning with ThunderX2 today.

Introduction

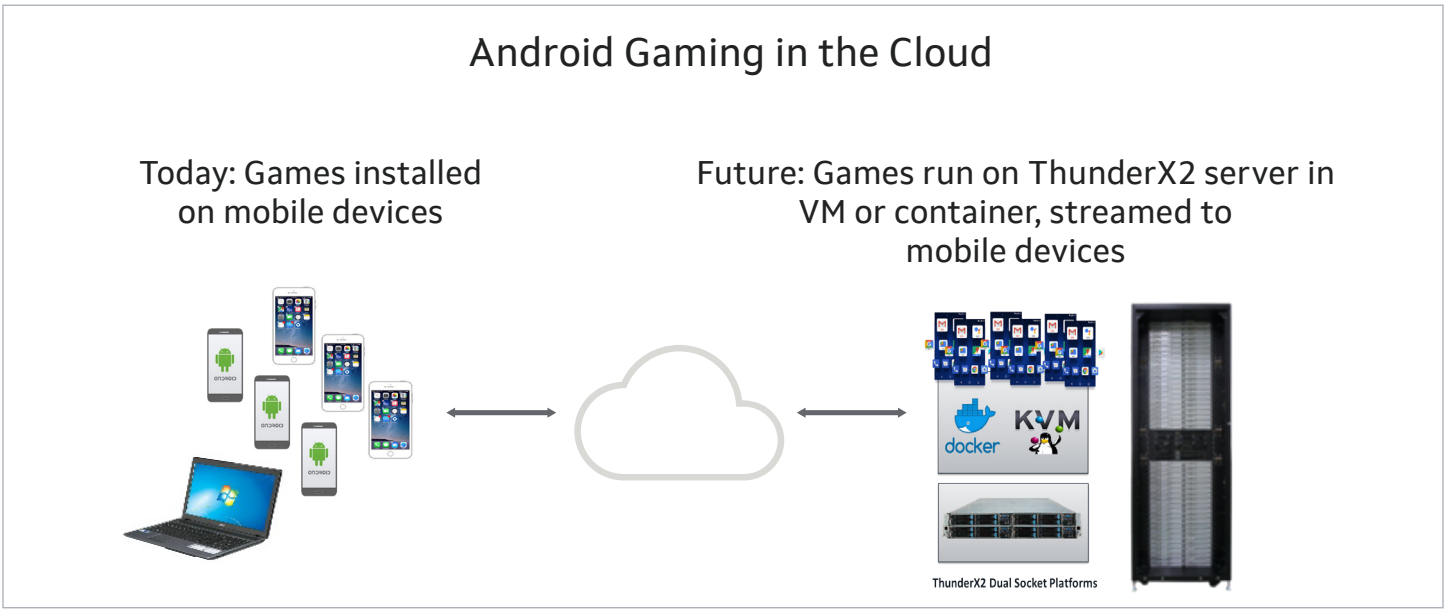
Mobile is now increasingly becoming the world's preferred platform for gaming, generating nearly 70% of combined iOS and Google Play app spending in 2019. Four of the top five grossing mobile games in 2020 provide real-time multiplayer gameplay[4]. These types of games are extremely compute & data intensive and sensitive to network latency, and thus place a lot of demand on mobile device power consumption, data usage, and connection requirements. However, by leveraging the cloud, both compute and power demands on the local device can be lowered, which extends battery life and the overall number of mobile phones these high-end games can run on. Combining this with the increased network speeds, lower latency, and improved coverage brought about by 5G networks, gaming providers can serve data reliably and fast from the cloud to their end-user's device.

Tencent Games in China launched their cloud gaming service in March of 2019 and one year later has serviced the highest-grossing mobile game worldwide, PlayerUnknown's Battlegrounds (PUBG) Mobile[5]. Within China alone, the cloud gaming user growth is expected to almost triple to over 650 million users by 2023, creating a $14B dollar market[6] .



Arm provides for the best mobile cloud computing platform for running compute-intensive mobile workloads at scale, such as secure enterprise application hosting and application CI/CD. By lowering latency, maintaining video quality, and achieving scalability, Arm-based deployments are also perfectly positioned to overcome the scalability and performance challenges of profitably delivering cloud gaming services to end-users. Due to the history of being widely deployed on the Arm platform, many Android applications are optimized and available only for the Arm architecture. Thus, leveraging an Arm-based cloud infrastructure for Android in the Cloud solutions allows for both the best performing solution and the largest addressable Android user base available.

Android cloud gaming uses servers to run the Android applications, encodes the rendered graphics and streams the game over network to a mobile device (Android or iOS). Cloud mobile gaming offers service providers new opportunities to deliver instant-on experience, uniform across different clients, with improved server-side interactions for massively multiplayer games. The server infrastructure at cloud datacenters or edge sites enables compute density and manageability necessary to deliver the gaming service at scale.



Value Proposition

- Seamless migration of all Android apps to Cloud
- Multiplayer gaming between handsets of any type
- Centralized 24/7 deployment and upgrades
- Reduction in CI/CD time
- No need to install/update apps locally on the client
- Significant reduction in storage and memory usage on client
- Compute intensive operations and graphics rendering are done in the cloud
- Enables low cost and long battery life on the client devices
- Centralized game life cycle manage ment, policy enforcement, high scalability, security, high availability and reliability in the cloud.

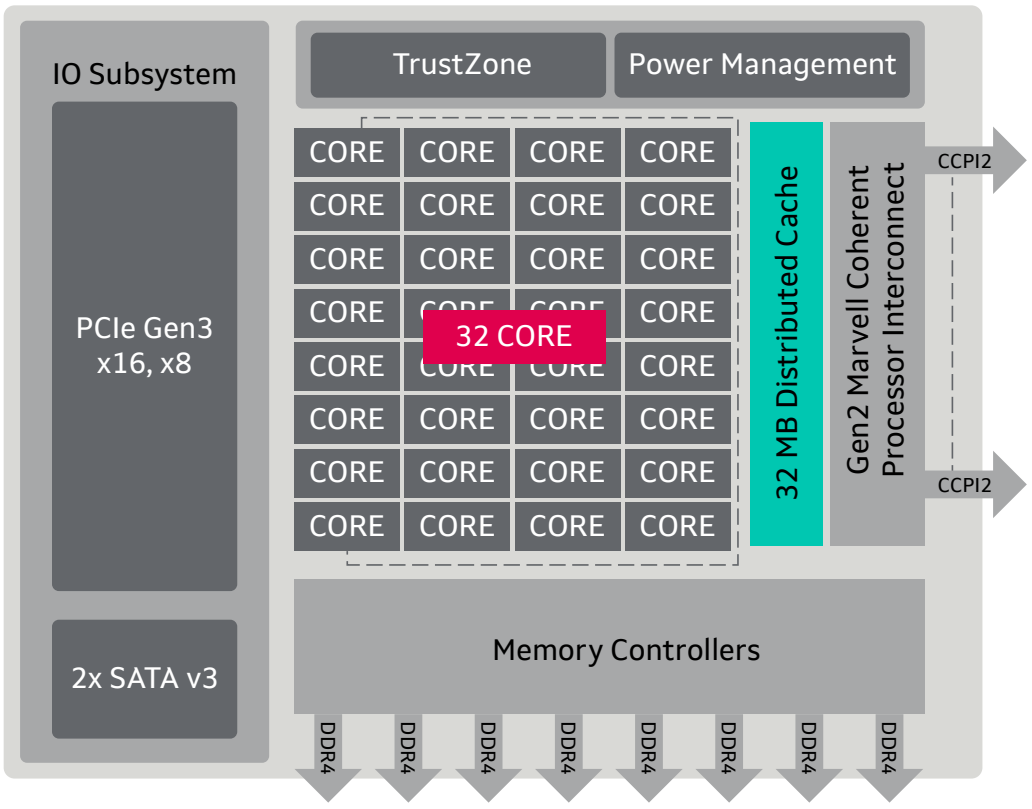
Marvell Android Cloud Gaming Solution Overview

Marvell's Android Cloud Gaming solution provides a reference implementation to achieve the following key requirements for an Android cloud gaming platform:

- Native (Arm-based) support for 32-bit and 64-bit Android games
- Support of Android 9 Pie and newer
- Rendering at high resolution (up to 1080p) and frame rates (up to 60fps)
- H.264[7] encoding for streaming
- Configurable encoding bit rate and video streaming options
- Scalable user instances in virtualized environment
- Deployable and operable at scale

About ThunderX2

At the heart of this solution is a compute platform based on ThunderX processors. ThunderX2 is Marvell's second generation of Arm based server processors targeted for the HPC, Cloud/Hyperscale and Enterprise market segments. Based on the 64-bit Armv8-A architecture, the ThunderX2 processor includes a custom core built using the Arm architectural license. Fully out-of-order, it supports simultaneous multithreading, providing ample compute for data center workloads. In addition, the ThunderX2 processors support dual socket configurations essential for scaling out applications. The processors are manufactured using a power efficient TSMC 16nm process technology and are fully compliant with Arm's Server Base System Architecture (SBSA) standard.



Key Features that support Gaming:

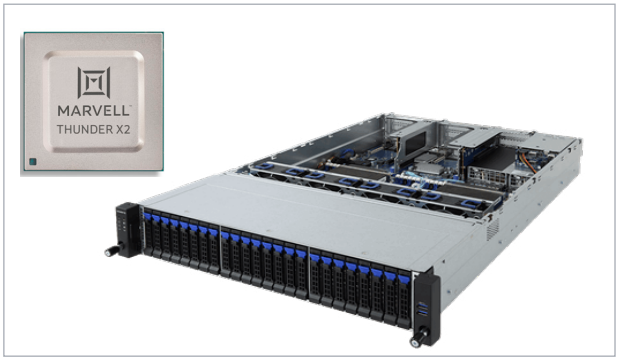
- Up to 32 cores with quad-thread support, 128-threads per socket
- 8 x DDR4-2666 72-bit memory controllers
- 56 lanes of PCIe and 14 PCIe controllers – supporting 2 or more x16 GPUs
- Server class virtualization & RAS features – run each gaming instance within VM for security and isolation
- Extensive power management
- Dual socket support for up to 256-threads – run higher number of gaming instances with more compute per VM.

Production Server Platform

Gigabyte R281-T94 is a ThunderX2-based server platform, commercially available from Gigabyte and channel partners.

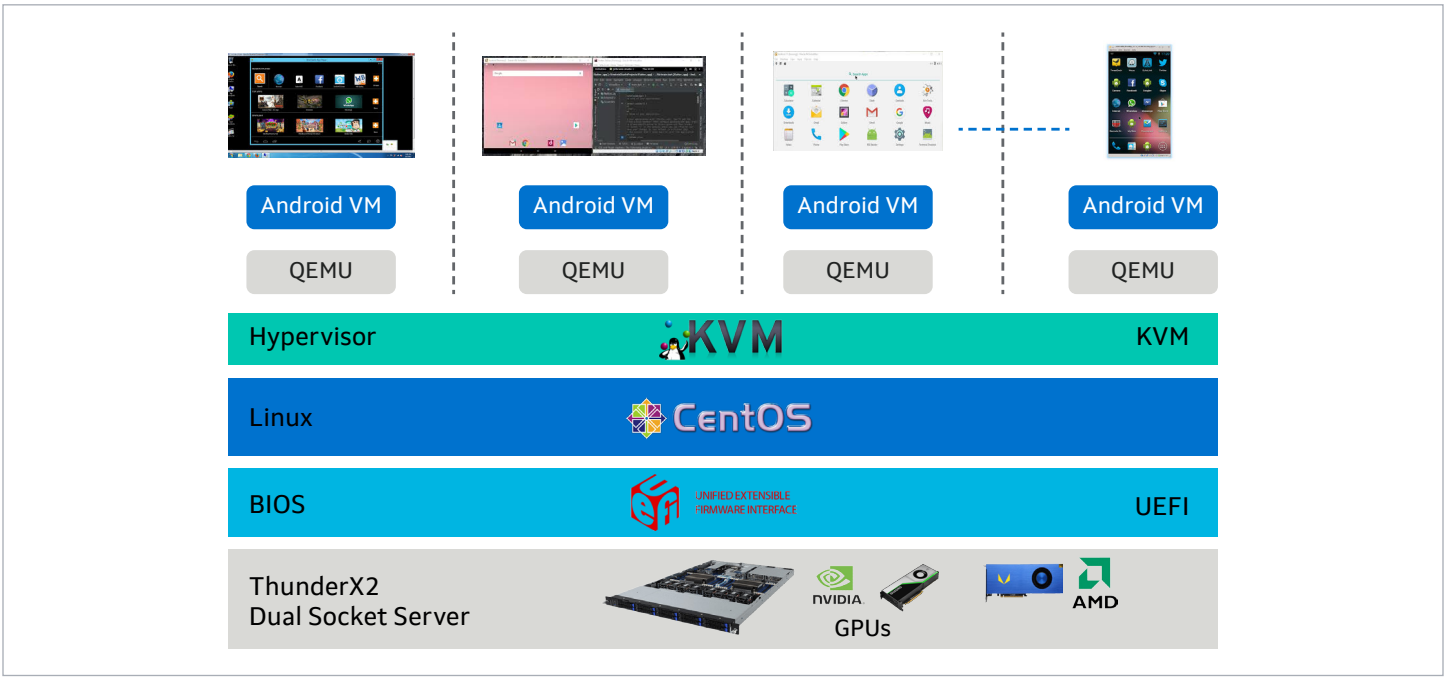
Key features include:

- 2x Marvell ThunderX2 CN9980 (32C/128T, 2.2GHz/2.5GHz Turbo)
- 16-channel DDR4-2666
- 24x 32GB DIMMs
- 2x SSD, 24x hot-swappable drive bays
- 8x PCIe Gen3 expansion slots
- UEFI firmware and BMC remote management



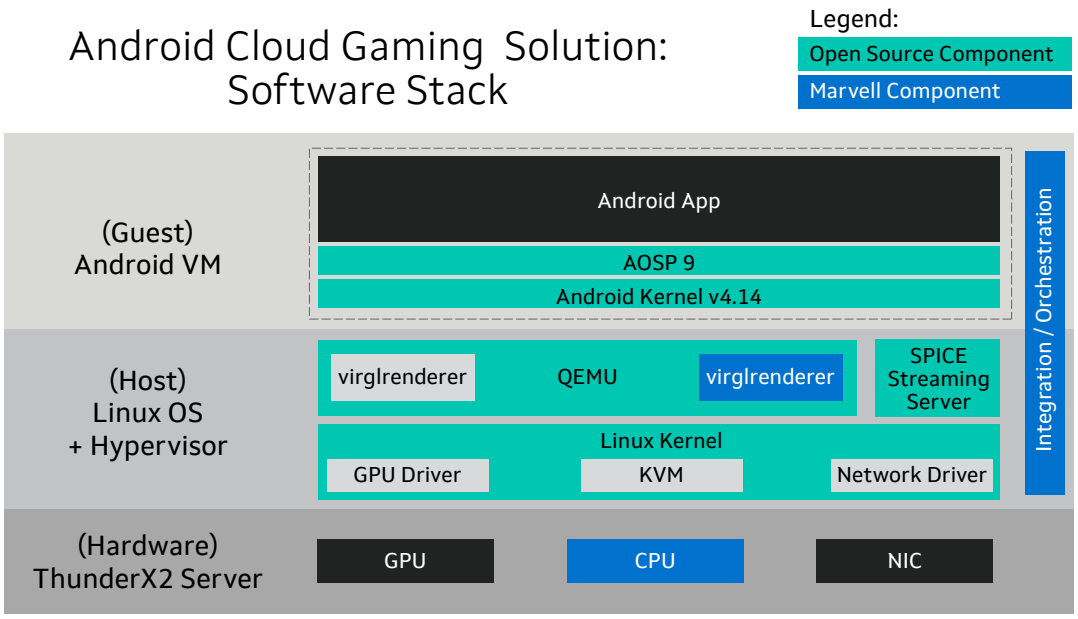
Android cloud gaming providers can deploy and operate server-class platforms based on ThunderX processors within their existing datacenter infrastructure, without having to build custom clusters based on consumer-grade hardware.

Marvell-Optimized Software Stack

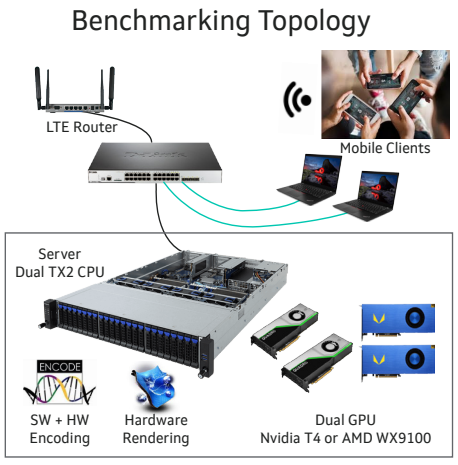


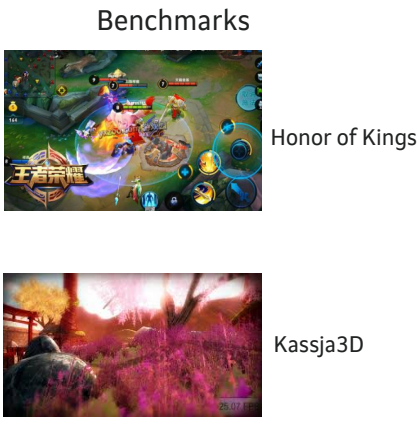
The Marvell Android gaming solution uses a Virtual Machine (VM) based architecture. The solution as shown above runs on a dual-socket ThunderX2 server with dual AMD or NVIDIA GPUs. The software stack includes a UEFI BIOS with the CentOS host operating system. Virtualization is provided by the KVM hypervisor with the individual guest instances being launched by QEMU. Each Android guest VM consists of AOSP and the Android kernel that runs within the context of a QEMU process on the host CentOS operating system.

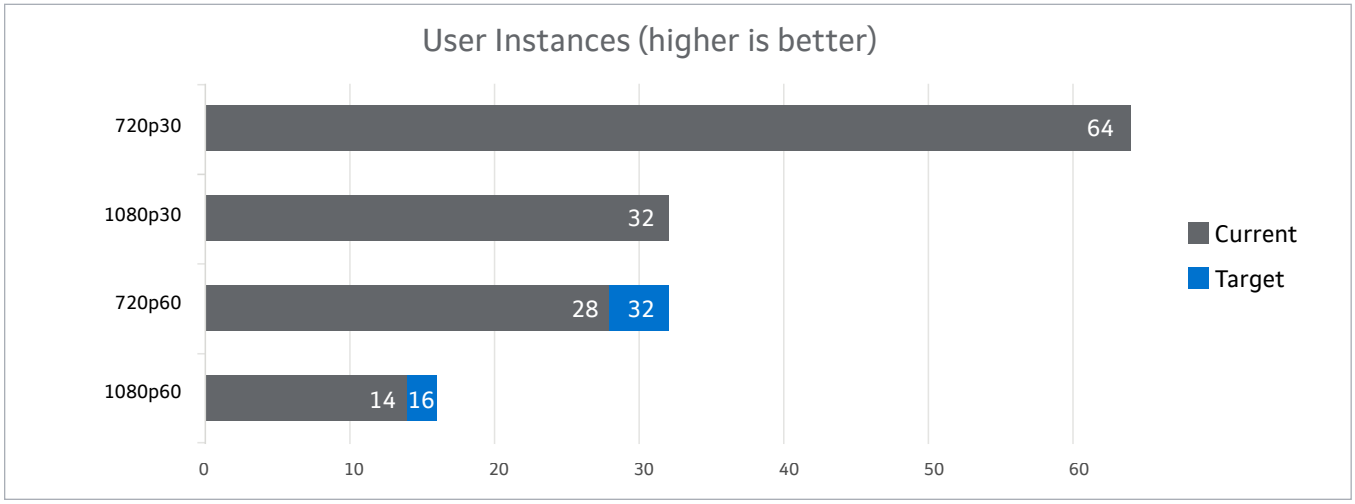
The modular architecture of the solution enables Android cloud gaming providers to customize the reference software stack depending on product deployment model and customer requirements.



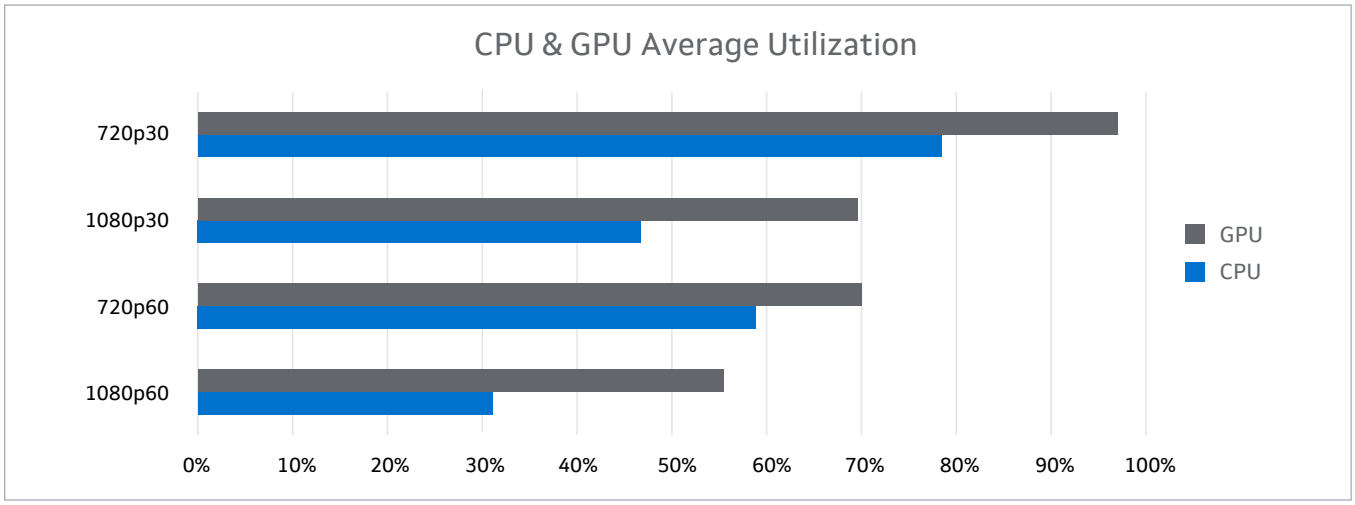
Performance







Using a single ThunderX2 server, with two GPUs for hardware rendering, Marvell's Android Cloud Gaming solution enables 64 user instances running High-Definition games at 720p30. The same solution scales with higher resolution and framerates as well, achieving 32 user instances at 1080p30, 28 user instances at 720p60, or 14 user instances at 1080p60.[8]



In the case of 32 user instances streaming at 1080p30, about 70% of GPU is consumed, while around 50% of CPU in a user instance is utilized. The compute resource utilization shows that there is headroom available for the game within each user instance. It also indicates opportunities for cloud gaming providers to leverage available compute resources to add platform features or to optimize for higher density of user instances.

Next Steps and Future

While the reference solution provides a high-performance implementation that Android cloud gaming providers can integrate and deploy today on ThunderX2-based servers, we continue to make further tuning and performance optimizations as shown below:

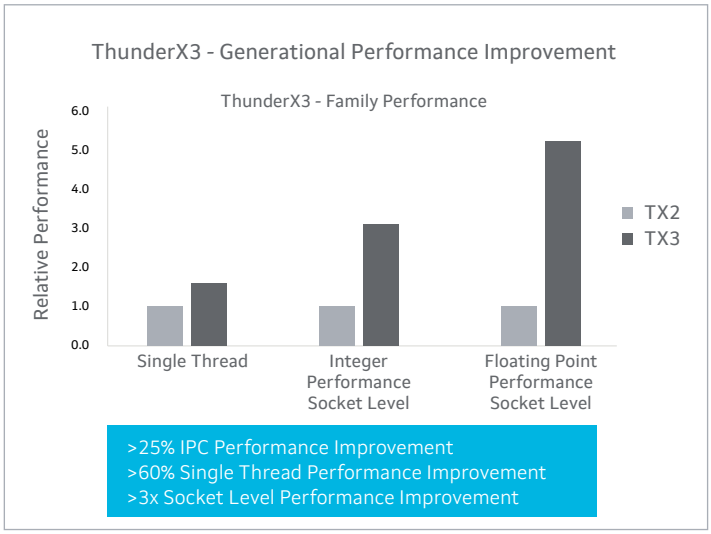
- Achieve performance targets for 720p60 (32 user instances) and 1080p60 (16 user instances)
- Android 10 Q support
- Integrate solution to ThunderX3 and improve performance

About ThunderX3

ThunderX3 is Marvell's third generation of Arm-based server processors targeted for Cloud/Hyperscale, HPC, and Arm-native Edge market segments.

Key features include:

- Up to 96 high performance custom-designed Arm v8.3+ cores
- 4-threads/core deliver up to 384 threads/socket
- 8 DDR4-3200 memory controllers
- 64 lanes of PCIe 4.0, 16 PCIe controllers per socket. 128 lanes, 32 controllers in dual-socket configuration
- 4 128-bit SIMD (Neon) Units
- Single and Dual socket Support
- Enterprise class RAS and virtualization capabilities
- TSMC 7nm
- 24x 32GB DIMMs
- 2x SSD, 24x hot-swappable drive bays
- 8x PCIe Gen3 expansion slots
- UEFI firmware and BMC remote management



Conclusion

Android cloud gaming enables new lucrative opportunities for service providers streaming existing Android games and offering enhanced gamer experiences.

Marvell's Android Cloud Gaming solution provides a reference implementation achieving all the key feature and performance requirements for Android cloud gaming compute platform.

Cloud gaming providers can leverage Marvell's solution to deliver high performance Android instances to their users and customers today – starting with production ThunderX2-based servers, and scale further with ThunderX3.

Learn More

Arm Developer Resources: https://developer.arm.com/solutions/infrastructure/developer-resources/development-platforms/marvell

Gigabyte R281-T94 ThunderX2-based Server: https://www.gigabyte.com/us/ARM-Server/R281-T94-rev-100

Marvell Server Processors: https://www.marvell.com/products/server-processors.html

Marvell ThunderX2 Processor: https://www.marvell.com/products/server-processors/thunderx2-arm-processors.html

Marvell ThunderX3 Processor: https://blogs.marvell.com/2020/03/the-next-generation-of-thunderx-delivers-performance-and-power-advantages-to-cloud-and-hpc-server-markets/

[1] Mobile Operating System Market Share Worldwide: https://gs.statcounter.com/os-market-share/mobile/worldwide

[2] 720p: Display resolution of 1280x720 pixel. Also known as "HD" (High-Definition) or "Standard HD". See https://en.wikipedia.org/wiki/720p for more information. / 720p30: 720p at 30 FPS (Frame per second).

[3] 1080p: Display resolution of 1920x1080 pixel. Also known as "Full HD". See https://en.wikipedia.org/wiki/1080p for more information. / 1080p60: 1080p at 60 FPS.

[4] "Gaming Spotlight: 2020 Review" by App Annie & IDC: https://www.appannie.com/en/insights/market-data/gaming-spotlight-2020-review/

[5] "Tencent's PUBG Mobile was the world's highest-grossing game in March amid coronavirus crisis" by the South China Morning Post: https://www.scmp.com/tech/big-tech/article/3079839/tencents-pubg-mobile-was-worlds-highest-grossing-game-march-amid

[6] Data Source: Analysys 易口; iimedia Research https://www.iimedia.cn/c1020/68163.html; Estimated

[7] H.264: A video compression standard, commonly used in video streaming. See https://en.wikipedia.org/wiki/Advanced_Video_Coding for more information.

[8] Benchmark Configuration: User Instances = Configured up to 64 user instances, per desired resolution and framerate. / Benchmark Application = 王者荣耀 (Honor of Kings), Kassja3D. Unmodified APK. Sources: https://pvp.qq.com/zlkdatasys/mct/d/play.shtml?device=android, https://play.google.com/store/apps/details?id=com.mkdesignmobile.KassjaBenchmark&hl=en_US. Application is run on each user instance. / Software Package = Marvell Android Gaming Solution release version 3.3. (Android OS = AOSP 9; Android Kernel = 4.14) / Operating System = CentOS 8; Host Kernel = 5.6 stable kernel / Hardware Platform = Gigabyte R281-T94, ThunderX2 CN9980 (32 cores @ Base 2.2GHz/Turbo 2.5GHz), 512GB (16x32GB) DDR4-2666. Add-ons = 2 x (Nvidia T4 or AMD WX9100) GPU cards.