Case Study

Gaming
Performance Optimization

Riot Games Performance Optimization Powers Elevated Gaming Experience for Players

Engineering collaboration with Intel helps new title *VALORANT* shatter gaming records

"When we started, we sat at 50 ms of compute per frame, so we had our work cut out for us. We often asked ourselves: 'Is this even possible?' Luckily, Intel's cloud computing team came in with a huge assist. We were able to dive deep, looking at how our software and Intel® hardware were interacting."

— Brent Randall, Staff Software Engineer, Riot Games

In a 2020 digital media trends survey Deloitte confirmed what many in the gaming industry already knew: the user base is still growing. The investigation revealed that fully one-third of consumers queried had recently—and for the first time—subscribed to a video gaming service, used a cloud gaming service, or watched an e-sports or a virtual sporting event.[1]

As explanation, industry watchers point to the importance of interactive entertainment among younger generations that have grown up online and playing video games as well as the growing popularity of online multi-player games. The proliferation of 5G, handheld consoles, and PC-based gaming are other emerging trends helping drive interest and new users.

Together, these and other developments are creating new opportunities for the gaming industry to innovate and create wonderful player experiences to win new players and convert casual players into devoted, long-term gamers. After over a decade of delivering unparalleled gameplay and record-breaking leadership, Riot Games looked to longtime partner Intel to help it raise the bar again for the release of its new first-person-shooter (FPS) title, *VALORANT*.

Riot Games leads with *League of Legends*

Riot Games was founded in 2006 to change the way video games are developed, published, and supported for players. In 2009, it released its debut title, *League of Legends*. With Riot Games' laser focus on players, the game has gone on to become one of the most-played PC games in the world. It boasts a thriving, engaged community and serves as a key driver of the explosive growth of e-sports globally.

In the last two years, Riot Games has added to its catalog, introducing three more games for its growing player base. The company also developed mobile play options that have allowed it to reach new fans and better serve existing ones. The annual *League of Legends* World Championship features qualified e-sports teams from 12 international leagues. Worlds is the most widely viewed and followed e-sports tournament and one of the largest and most popular gaming and sporting events in the world.

VALORANT pursues best-in-class experience

As Riot Games continued to evolve its popular *League of Legends* title, it also sought to develop a new game, *VALORANT*, which promised to be their most ambitious yet. A tactical 5v5 FPS game, *VALORANT* invites players to battle it out in an environment that rewards fast, meticulous play. Fates are decided by millisecond differences in reaction time.

Riot Games knew it had to offer a best-in-class player experience for its inaugural FPS game. Delivering on that goal would require an incredibly precise and up-to-date simulation on the company's dedicated game servers. The same servers would have to be optimized and tuned to meet strict performance requirements. Riot Games also realized it would need to make more investments in its infrastructure than any other game company had done for a first-person-shooter game.

Most importantly, the resulting play would have to meet the demands and expectations of a range of skills, from pro players to regular players to those who aspire to be pros. Riot Games focused its initial performance efforts on reducing the time it takes to process a single frame. The *VALORANT* workload running on Riot Games' game servers proved extremely latency sensitive. The team ran a number of experiments and determined that for *VALORANT* it would need to run at 128 frames per second, or 7.8 ms per frame. The problem was if Riot Games were to dedicate an entire core to each game session, it would simply become too costly for the company to host at scale.

After further evaluation, the determination was made that to be viable the optimal number would be three games per core (GPC). That means for each frame deadline of 7.8 ms Riot Games would need three processes to compute the frame. But the development team quickly ran into performance complications as it began to load the servers with multiple game instances. While the goal had been to achieve three GPC, the team struggled to reach even two GPC, while still meeting the strict performance requirements.

There were many variables that might need to be tuned to deliver an optimal configuration. Resolving the latency issue would be critical. Improvements in the player experience and a reduction in lag/hitches were necessary for Riot Games to increase play time and to grow their player base and player engagement.

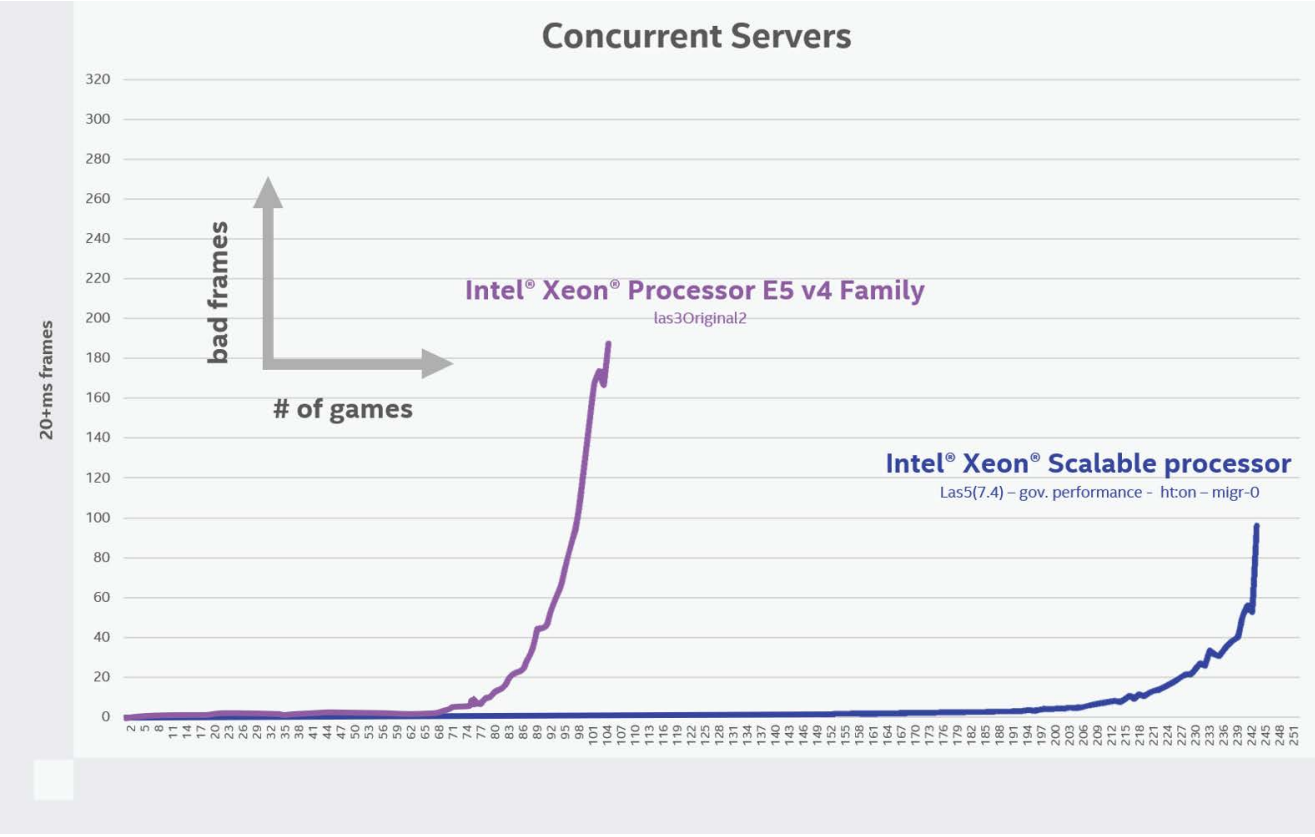
Riot Games collaborates with Intel on new title

As Riot Games sought to meet the demands of its newest title, *VALORANT*, it turned to Intel, a longtime partner and industry leader, for help. Riot Games and Intel engineering teams had worked together for years, including collaborating on defining a new standard game server configuration for the *League of Legends* game server refresh.

Intel brings a well-established commitment to gaming. The company is always seeking to inspire the development ecosystem to take advantage of Intel® architecture and hardware to bring the best possible gaming experience to players. In support of that mission, Intel has made an end-to-end investment, from client to server, in enabling the best possible gameplay.

Riot Games engaged Intel to help it optimize its game server performance on Intel® Xeon® Scalable processors. Intel and Riot Games engineers combined their deep expertise to address challenges related to the workload, power and performance tuning, optimal hardware and software configuration and settings, and, of course, to Riot Games' key project goal: games per core. At the same time, it remained critical that player experience metrics were met, including ensuring latency and frame drops stayed within acceptable limits.

The iterative process undertaken by the Intel and Riot Games teams was made possible by running the *VALORANT* workload on servers at Riot Games, in an Intel secure lab, and on the public cloud.



Riot Games harnessed Intel® technology and optimization to help achieve 3.25 games per core (GPC) for VALORANT—and did so without sacrificing the game's best-in-class player experience.[2]

Intel® technology powers *VALORANT* development

Intel contributed an array of technologies as part of its efforts to help Riot Games achieve the vision it had for its first FPS game, *VALORANT*. Principal among them were Intel® Xeon® Scalable processors.

Intel Xeon Scalable processors

Riot Games had been relying on Intel® Xeon® E5 processors but built its game server solution on Intel Xeon Scalable processors. The company worked with Intel power and performance engineers and used Intel® tools to identify, evaluate, and deploy the optimized configuration. Using the powerful Intel Xeon Scalable processor family, the game developer achieved major performance gains for its server application.

The system was able to meet the high bar for performance that the *VALORANT* experience and *VALORANT* players were sure to demand. Systems like Riot Games' that are built on the Intel® Xeon® Scalable platform are designed to deliver agile services.

See other Intel® technologies used in the development of the popular FPS title in the technology spotlight, Technical Components of *VALORANT*.

VALORANT wins fans and breaks records

Benefits for the game

The collaboration between Riot Games and Intel delivered significant benefits spanning performance, latency, user experience, and GPC. *VALORANT* servers proved to be memory and cache hungry. By upgrading its CPUs to the latest Intel® Xeon® Scalable processors, Riot Games not only improved cache utilization but also helped the cores to improve utilization. The result was an up to 30 percent boost in system-wide performance—even at the same clock rates.[2]

Latency commanded Riot Games' attention from the beginning of the development process. As part of that focus, the team looked at the non-uniform memory access (NUMA), evaluating how to maximize performance of the multisocket architectures. By using a Linux command-line tool called numactl, developed by an Intel engineer, the company saw memory latencies improve and helped it meet the SLA for its extremely latency-sensitive workload. The move also increased performance by 5 percent system-wide.[2]

Intel helped improve performance in yet another way as well: hyper-threading. Despite early tests that showed hyper-threading diminished frame rates, Riot Games turned that around by upgrading to the latest Intel® processor family, employing numactl, and getting help from Intel to tune Linux Scheduler and Power management settings. By the end, hyper-threading had increased performance by more than 42 percent,[2] marking an important turning point for the project in its efforts to reach the project's exacting performance targets.

The work with Intel also delivered benefits with regard to the all-important GPC goal. Overcoming early failures to even reach two GPC, Riot Games harnessed Intel technology and optimization help to achieve a 3.25 GPC—and did so without sacrificing *VALORANT's* best-in-class player experience. Reaching that milestone also gave Riot Games welcome breathing room in its data centers around the world, all of which now run Intel hardware.

Finally, and no less importantly, the shared mission of Riot Games and Intel not only helped the gaming leader overcome a range of technical hurdles, it also enabled it to unveil its much-anticipated new title months ahead of schedule.

Benefits for the players

VALORANT launched smoothly in spring 2020, with millions playing daily and zero live service instances due to game server load. But the game had already built up considerable attention among eager fans. During its earlier closed beta introduction, *VALORANT* set a new Twitch record for single-day hours watched, attracting 1.7 million concurrent viewers. Fully 34 million hours of viewing of the game had been logged.[3]

The weekly numbers were similarly jaw dropping. In their busiest week, fans spent 148.7 million hours watching *VALORANT* be played, dramatically eclipsing the previous benchmark of 30 to 40 million hours of viewership on the platform.[3] In the past two years, only one game has managed to post more hours watched in a *full month* than *VALORANT* amassed in a single week.[4]

The primary benefit for players revolves around the technology's ability to minimize a competitive integrity challenge that commonly plagues networked shooter games. Called peeker's advantage, the issue gives attackers in a game more time to spot an opponent and line up a shot. This scenario stood in direct conflict with Riot Games' goal to protect holder's advantage, the idea that a player holding territory should, on average, have an advantage over a player looking to take territory.

A second advantage being enjoyed by players is a reduction in total input latency. This refers to the time it takes from the moment when a user clicks to when that input is realized in the game. The higher tick rates achieved in *VALORANT* makes the game and experience more resilient when it comes to lags and hitches and other problems seen in networked games.

"Working with Intel on your critical workloads can deliver big performance returns. Many of the returns can be realized without massive changes to your software's architecture. Intel can help you best understand how your software is interacting with a variety of Intel® technologies, so reach out."

— Brent Randall, Staff Software Engineer, Riot Games

Technical Components of *VALORANT*

Intel® SSD D3-S4610 Series
The SSD series helps reduce storage operating costs, accelerate read-intensive workloads with power-efficient performance, and improve overall system reliability and flexibility. These SSDs also meet demanding service-level requirements while increasing server efficiency.

Intel® Ethernet 700 Series Network Adapters
The network adapter series helps users address the demanding needs of the next-generation agile data center. It does so by providing unmatched features for both server and network virtualization and ensuring flexibility for LAN and SAN networks with proven, reliable performance.

Intel® VTune™ Profiler/EMON
The profiler helps to improve software performance and makes the most-effective improvements for greater optimization. The profiler collects key profiling data and presents it with a powerful interface that simplifies its analysis and interpretation.

Intel engineers also helped Riot Games run and interpret data using EMON, a low-level command-line tool that provides the ability to profile system performance. The EMON profiling helped the engineers identify opportunities for latency optimization and maximize the use of hardware.

Day 0 drivers for client-side play
Intel and Riot Games incorporated Day 0 Graphics Drivers—verified by Intel Labs—to enable *VALORANT* to run as designed on players' PCs and without functional issues. The drivers also help ensure that the exciting new game title is playable on 10th Gen Intel® Core™ processors with Intel® Iris® Plus Graphics.

A high-performance partnership

In its pursuit to continue to elevate gameplay for its devoted fan base, Riot Games tapped Intel to help it raise the bar on its newest title, *VALORANT*. The two companies worked together to optimize the data center infrastructure to meet its ambitious player experience targets and host the desired number of games on its infrastructure—all in an economically viable way. In the end, the partnership succeeded on all counts, exceeding expectations by producing a stunningly original gaming experience that managed to win fans and break records before it was even released.

Learn more about Riot Games and its popular titles ›

Read more about how Riot Games accomplished 128-tick servers for *VALORANT* ›

1. Chris Arkenberg, "Will gaming keep growing when the lockdowns end?" Deloitte, July 8, 2020: deloitte.com/us/en/insights/industry/technology/video-game-industry-trends.html.
2. Testing by Riot Games on May 2020 as measured on VALORANT game server LoadTest. Up to 30 percent boost in system-wide performance based on previous deployment of Intel® Xeon® Processor E5-2695 v4 compared to Intel® Xeon® Gold 6150 Processor at same clock speed. 3.25 games per core (GPC) and 42% increase in perforamnce: Baseline configuration: 2x Intel® Xeon® Gold 6150 with 256GB (8X32GB 2666 MT/s) total memory, 2x 1 GB/s Intel® Ethernet Server Adapter I350, 2x 10 GB/s Intel® Ethernet Converged Network Adapter X710-DA2/DA4, ucode: 0x200004d on CentOS 7.4 (Core), 3.10.0-327.10.1.el7.x86_64, HT off, Turbo on: Software: Software: Docker version 18.09.6, build 481bc77156. New configuration: 2x Intel® Xeon® Gold 6150 with 384GB (24X16GB @ 2666 MT/s) total memory, 2x 1 GB/s Intel® Ethernet Server Adapter I350, 2x 10 GB/s Intel® Ethernet Converged Network Adapter X710-DA2/DA4, ucode: 0x200004d on CentOS 7.4 (Core), 3.10.0-327.10.1.el7.x86_64, HT on, Turbo on, Power & Perf Policy: Performance, CPU Freq Driver: intel_pstate, CPU Fre Governor: performance, Software: Docker version 18.09.6, build 481bc77156.
3. Jack Webb, "*VALORANT* breaks Twitch viewing record with a whopping 1.7 million concurrents," Evening Standard: standard.co.uk/tech/gaming/*VALORANT*-twitch-record-riot-games-a4411066.html.
4. Max Miceli, "*VALORANT* shatters viewership records for one week on Twitch," Dote Sports, April 14, 2020: dotesports.com/*VALORANT*/news/*VALORANT*-shatters-viewership-records-for-one-week-on-twitch.

Software and workloads used in performance tests may have been optimized for performance only on Intel® microprocessors.

Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations, and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more complete information, visit www.intel.com/benchmarks.

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See configuration disclosure for details. No product or component can be absolutely secure.

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