SOLID STATE STORAGE TECHNOLOGY CORPORATION

Head in the Clouds: Gaming in a New Direction

The advent of cloud services has been a boom for the entertainment-consuming user. Video on demand, from a datacenter server to a client device of any type, is convenient and affordable. Add interaction and you have gaming on demand through the cloud – streaming from a library of titles, whether owned or as part of a subscription. This of course puts demands on the network and the devices involved. Even with compression technology the need for bandwidth is high, and particularly with cloud gaming you want the

lowest latency possible for smooth action. Although home-oriented options like Parsec exist, the majority of streaming takes place over wired and wireless ISPs which must balance quality while maintaining rapid deployment of services.

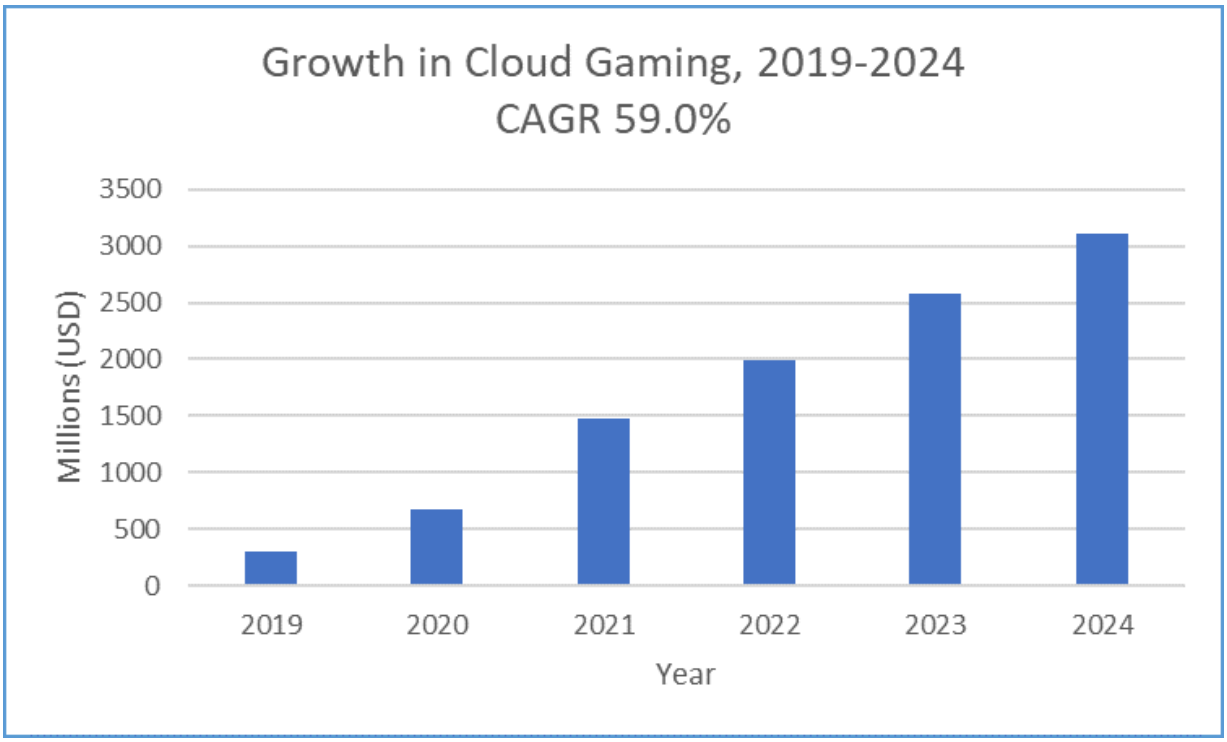
What is Cloud Gaming and How is it Growing?

Historically, cloud gaming – also known as gaming on demand and including Gaming as a Service (GaaS) – has faced many hurdles. OnLive, Gaikai, GameFly, and similar earlier services, most of which attempted to work on the NetFlix model, failed to be revolutionary. This was due to many challenges including the lack of consumer bandwidth and no real standard between streaming devices. The market was also small, but growing. Over time these ideas gained traction with many modern renditions that have been more successful – Google's Stadia, Microsoft's xCloud, Amazon's Luna, and NVIDIA's GeForce Now, to name a few. All of these companies have experience with hosting cloud services but also with artificial intelligence (AI) which helped them exploit the lessons learned.

This knowledge makes an extension into the cloud gaming business sensible, but what does it offer to the user? If gaming is primarily a social endeavor, the ease of multiplayer with cloud gaming is a huge selling point. This is especially true as cloud gaming is cross-platform and it's even possible for games to be designed specifically for the cloud. This also means less cheating, all while being convenient and inexpensive with no strict hardware requirements. The know-how these companies have also brings other relevant advances including the improvement of experience through machine learning, cloud-specialized gaming engines, and predictive input as with Stadia's "negative latency." For those who want to game without worry, and that includes seamless updates, this is extremely convenient.

With technology finally catching up to demand and plenty of investment in the cloud, gaming on demand has become a reality with a bright future. According to MarketsandMarkets, cloud gaming will see an increase in market value from 306 million (0.3bn) USD to 3107 million (3.1bn) USD between 2019 and 2024. This high level of growth matches and in fact exceeds that seen in other cloud-based areas such as edge computing. As in that case growth is expected to be greatest in the Asia-Pacific (APAC) region. The

primary reasons for this are the eventual adoption of 5G for mobile devices as well as the fact that such gaming has a significantly lower cost of entry.



Cloud Datacenter Storage Challenges

While cloud gaming makes it easier for the user, the companies hosting these platforms must be careful in designing and managing their data centers. The NVM Express™ organization highlights five challenges for non-volatile solid state storage: form factor plus interface, graceful degradation, debugging, telemetry, and security. This translates to the need for high storage density and efficiency, redundancy, monitoring, and of course the security of user data. These challenges are in addition to those of performance which again include the need for high bandwidth coupled with low latency.

This last bit is also known as quality of experience (QoE) as contrasted to the traditional concept quality of service (QoS). In essence, it is necessary to meet a certain threshold of performance on the client end while maintaining a specific level of efficacy on the server side. This includes weighing different options such as utilizing dedicated GPUs, GPU scheduling, and GPU virtualization. On top of these demands is the

reality that geography plays a real role – the location of the server, client routing, and mitigation strategies for latency and distributed computing. The choice of storage therefore plays an additive role in that performance overhead should be as small as possible.

Choosing the Right SSD

With these outlined challenges datacenters must be particularly mindful of storage requirements. Certainly, solid state is the best option with regard to both the bandwidth and latency needs, especially as raw capacity is not as high a priority with so much redundant game data. In fact, this combination makes SATA/SAS also untenable, as you need the high bandwidth of NVMe™, the maximization of IOPS with low latency that comes with that protocol, plus the flexibility of NVMe™ over Fabrics (NVMe-oF™). This includes the use of Remote Direct Memory Access (RDMA) in Converged Ethernet (RoCE) or similar (e.g. InfiniBand). It is of no surprise that NVIDIA has recently purchased Mellanox and revealed GPUDirect Storage (GDS), or that Google's Stadia is using "SSD over network" as a method of sharing fast storage with multiple machines and instances. This way, individual gaming instances can be created quickly on-the-fly with virtual machines pulling static data directly from storage without CPU intervention.

There are many inherent benefits to utilizing SSDs in this type of configuration, including: reliability, low latency, high performance density, PCIe™access to direct memory regions, linear scaling, disaggregation, speed to deploy, distributed hybrid processing, and RAID 6. This means a reduced physical footprint, agility in the datacenter, scalable infrastructure, and general flexibility. Of particular importance is power loss protection and redundancy for the SSDs – as you get with the presence of capacitors and a dual-port configuration; UPS alone is not sufficient in this distributed model. SSDs with these features with the appropriate interface and protocol support must also include data encryption capability and full data path protection. Lastly, game streaming is read-heavy which reduces the need for high-endurance drives which allows for some cost savings.

When coupled with a reliable, fast internet connection and streamlined game development, such storage minimizes downtime and allows the service to become transparent to the user – all while being efficient in

the server space.

Our SSD Solution

Our ED1 Series is a powerful, high performance SSD made for edge storage applications. It comes in M.2 and U.2 form factors. Contact us today to find out why Tier 1 cloud providers and Fortune 500 Enterprise companies adopted our SSDs.

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