EXECUTIVE SUMMARY

Oracle Database is known for its exceptional performance, scalability, availability, and security. With Oracle Database 21c release, this converged database offers customers best of breed support for data types including relational, JSON, XML, spatial, graph, OLAP, etc. This means that customers can efficiently handle different data formats within a single database. It simplifies database consolidation, allowing organizations to bring together diverse workloads while maintaining isolation and helping to ensure that each workload receives the necessary resources and performance. Oracle Database 21c aims to provide a comprehensive and efficient solution as multi-model, multi-tenant, multi-workload database platform.

Pliops–Oracle Solution Benefits

- Increase the consolidation density of Pluggable Databases by 50%.
- Easy to provision and move the Oracle Database 12c,18c workloads to a new Oracle database 21c solution.
- 66% higher aggregate performance with PDBs
- Increased redundancy with external storage array benefits at significantly lower costs
- Close to 3X additional database capacity gains with Oracle ASM plus XDP external redundancy for ASM.
- Faster database backup and recovery benefits to meet service level objectives using HW offload benefits.
- Higher reliability and resiliency of Oracle database to tolerate multiple SSD failures.
- Enables to reduce the SSD $/TB cost with capacity and Endurance benefits.

Performance Scaling with Pliops

As shown in Figure 2, HammerDB4.7 was employed to evaluate the combined benefits of Pliops setup with Oracle Database 21c for multi-tenant deployment. Oracle Database 21c with container and four pluggable database testing environment is configured on Dell PowerEdge R750 server using the Oracle Linux 8.6 operating system with the Unbreakable Enterprise Kernel (UEK) 5.4.17-2136.307.3.1.el8uek.x86_64 version. The servers are set up with Intel 8368 38-Core processor and 1Tera Byte of Memory and storage is configured with 4 Gen4 3.84TB NVMe SSDs (Samsung PM9A3) that are directly managed by Pliops XDP.
Oracle Database 21c: HammerDB Performance

To identify multi-tenant database capacity and performance of Pliops XDP, Oracle Automatic Storage Management (ASM) is initially configured with internal redundancy with NVMe SSDs. Later, Oracle ASM is configured with external redundancy with Pliops providing the data protection for NVMe SSDs. Pliops XDP exposes a high-performance, highly reliable data storage volumes with built-in data protection to tolerate SSD failures. To execute an OLTP workload, each PDB is loaded with 1TB of dataset that is HammerDB TPROC-C benchmark-configured with 10,000 warehouses. Our benchmark testing included both Use All-Warehouses option enabled and disabled to evaluate benefits in both customer scenarios. Enabling the Use All-Warehouses option will increase the I/O load on the storage system significantly by accessing all 10K warehouses and simulating highly random access to the dataset.

Oracle Database Capacity Savings:

![Database Capacity Savings Table]

<table>
<thead>
<tr>
<th>NAME</th>
<th>TOTAL_MB</th>
<th>Usable_TOTAL_MB</th>
<th>FREE_MB</th>
<th>FREE_PCT</th>
<th>USED_MB</th>
<th>USED_PCT</th>
<th>USED (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ASM_DISGROUP</td>
<td>14651312</td>
<td>5494242</td>
<td>615400</td>
<td>11</td>
<td>4878835</td>
<td>99</td>
<td>99%</td>
</tr>
<tr>
<td>2 ASM_PLIOPSXDP</td>
<td>14656820</td>
<td>14656820</td>
<td>9778180</td>
<td>67</td>
<td>4878640</td>
<td>33</td>
<td>33%</td>
</tr>
</tbody>
</table>
As shown in Figure 3, during Oracle ASM with internal redundancy setup, the total usable capacity was 5.4TB. However, after provisioning 4 Pluggable Databases (PDBs) with 1TB each (index files and log files total size increases to 1.35TB), the free capacity reduces to 650MB. When utilizing a Pliops-accelerated and protected volume with the same SSD setup, it exposed 14TB of space. Provisioning 4 PDBs with 1TB each resulted in 9.8TB of free space. This significant increase of close to 10TB of additional space provides a notable benefit for Oracle customers. It allows them to provision additional PDBs or accommodate database growth without incurring additional storage costs. Growing enterprise data continues to drive the need for higher capacity, higher performance, and easier manageability. Oracle Database 21c multi-tenancy simplifies the management of pluggable databases to greater extent and when combined with Pliops XDP, it enables higher capacity to provision additional databases or extend the database capacity, providing further flexibility and scalability to Oracle customers.

50% Higher PDB Consolidation with Pliops

With the database capacity expansion benefits realized using Pliops XDP, the next objective was to assess the performance benefits. The Transactions per Minute (TPM) metric was captured after executing HammerDB TPROC benchmark for a 60-minute duration with four pluggable databases initially without Pliops XDP and compared with Pliops XDP setup. Subsequently, two pluggable databases were added to evaluate the aggregate performance gains with Pliops XDP. The automatic workload repository and active session history reports were also captured to assess the read and write latency and CPU, IO information. In addition to this, write amplification was also captured to assess SSD durability and performance challenges.

As depicted in Figure 4, setting up Pliops XDP enables the provisioning of two additional Pluggable Databases (PDBs), and accomplish 66% higher aggregate performance gain. It enables oracle customers to increase pluggable database consolidation (PDB) density and increased performance gains.
The AWR report (Automatic Workload Repository) as shown in figure 5 provides insights into the reasons behind the higher performance achieved using Pliops XDP with six PDBs compared to the setup without Pliops XDP with four PDBs. Firstly, the average latency associated with redo log write events, specifically the logfile sync, is reduced from 1.56 milliseconds to 1.07 milliseconds. This indicates improved efficiency in writing transaction log data. Secondly, the CPU utilization for executing transactions increases from 29.6% to 46.4%. This demonstrates that the system can handle a higher workload and process transactions more efficiently. Additionally, the logfile checkpoint incomplete event, which had an average wait time of 2937 milliseconds, is eliminated with the Pliops XDP setup. This suggests improved checkpointing operations, leading to better database performance. Finally, due to a higher number of pluggable databases and higher number of concurrent user requests with Pliops XDP setup, the database file sequential read that is associated with single block read events is at 1.53 milliseconds compared to 497 microseconds without Pliops XDP setup.

Database Backup Offloading with Pliops

Database backup and restore is one of the main responsibilities of Oracle Database administrators to help ensure the databases are protected against storage media corruption or accidental drop of business-critical tables. We wanted to explore how Pliops XDP can be utilized not only as a database accelerator but also serve as database backup acceleration and offloading as shown in figure 6.

The additional 9TB of disk space exposed by Pliops XDP is leveraged to carve out ASM backup disks, and an ACFS file system is mounted to serve as the backup location for these pluggable databases.
The test metrics of duration, storage IO, capacity and CPU utilization were captured during full database backup, differential backup, and restore operations. As shown in the table below 5 pluggable databases with around 5.5TB database is backed up with compression in 1 hour and 7 minutes with just 6% CPU utilization.

<table>
<thead>
<tr>
<th>Backup Operation</th>
<th>Database Size (GB)</th>
<th>Duration (Minutes)</th>
<th>Backup Size (GB)</th>
<th>CPU Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Database Backup for 5 PDBs</td>
<td>5500</td>
<td>1.07:51</td>
<td>4100</td>
<td>6%</td>
</tr>
<tr>
<td>Validate Backup Set</td>
<td>2500</td>
<td>0.12:35</td>
<td></td>
<td>7.5%</td>
</tr>
<tr>
<td>Restore Backup for PDBs</td>
<td>5500</td>
<td>0.23:47</td>
<td>4100</td>
<td>7.3%</td>
</tr>
</tbody>
</table>

Table 1: Database Backup & Recovery Testing

The database restoration for these 5 pluggable databases is under 25 minutes with 7% CPU utilization. Based on additional experiments, the backup duration can be considerably reduced with Oracle Recovery Manager’s (RMAN) parallel operations and multi-channel implementation. The goal of the testing is to validate and obtain the out-of-the-box Oracle Database backup and recovery operations metrics and this can be further improved with additional optimization.

SSD Write Amplification Challenges

The primary challenges with traditional NVMe SSD storage configurations with RAID10 or RAID 5 are the write and read amplification overhead that not only limits the database performance but also reduces the longevity of SSD usage. Write amplification increases the amount of data that’s written to SSDs compared to database application workloads. Since SSDs have a limited number of write cycles, write amplification results in shortening SSDs’ durability. Pliops XDP mitigates the SSDs durability issue significantly by providing the in-line compression of Oracle Database data and then data shaping activities that include packing and merging the variable length data and finally converting random writes to sequential writes. This process minimizes the write amplification to a significant level and thereby increasing database performance and SSD durability. Chart 1 demonstrates that during Oracle pluggable database workload testing IO throughput, the Pliops XDP delivers a robust write throughput of 4.7 GB/s to the Oracle Database. Yet, the per-SSD write rate is just 620 MB/s a 7.5X reduction.
Collectively, all four SSDs incur a 2.4 GB/s total disk write of, nearly halved. In contrast, without the Pliops XDP setup, each SSD experiences 2.3 GB/s high amount of disk writes—equivalent to the combined write for all SSDs within the XDP configuration. Based on these test results we can draw on conclusion that with Pliops enabled setup drives higher performance and improves the longevity (useful life) of the SSDs by minimizing the disk writes from database applications.

Oracle Linux

Oracle Linux is a robust, secure, and optimized operating system for application development and deployment. It supports X86 and Arm for on-premises, MultiCloud and Edge environments. based applications. It’s tuned for business-critical demanding workloads like Oracle database at cloud scale and on-premises deployments. It Increase scalability, security, and productivity by automating manual processes in DevOps with open source, Ansible-based automation tools.

Conclusion

The combination of Oracle Database 21c on Oracle Linux with Pliops XDP offers several benefits to enterprises. Oracle Database 21c with Pliops XDP provides higher pluggable database density, higher aggregate transaction performance, database capacity expansion, and backup offload benefits to consolidate databases and simplify overall IT operations. The built-in performance acceleration, capacity expansion, and data protection features enable enterprises to efficiently manage data growth challenges without performance and reliability impacts. The built-in data protection enables enterprises to increase database uptime and resiliency. This solution also significantly improves the system and storage utilization by offloading database backups and provides a faster recovery to meet or enhance availability service level objectives for critical applications.

Pliops multiplies the effectiveness of organizations’ infrastructure investments by exponentially increasing data center performance, reliability, capacity, and efficiency. Founded in 2017 and named as one of the 10 hottest semiconductor startups by CRN in 2020 and 2021. Pliops global investors include NVIDIA, Intel Capital, SoftBank, Western Digital, KDT, and Xilinx. Learn more at www.pliops.com.