Intel® Virtual RAID on CPU (Intel® VROC)

Jay Guilmart, Intel VROC Product Manager
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Intel® VROC Product Set

Intel® VROC consists of 3 functional sub-products within the same software product. All can be used at the same time:

- **Intel® VROC (VMD NVMe RAID):** For platforms with CPU(s) that have Intel® Volume Management Device (Intel® VMD) architecture. Requires additional licensing
- **Intel® VROC (SATA RAID):** For platforms with chipset that include this functionality. Included in the chipset purchase
- **Intel® VROC Integrated Caching:** For any platform that supports Intel VROC (NVM NVMe RAID). Can be used with SATA RAID. Requires additional licensing

This presentation will cover Intel VROC (VMD NVMe RAID) and Integrated Caching. For more details on Intel VROC (SATA RAID), please reference the Intel VROC User Guides
**Intel® Volume Management Device (Intel® VMD)**

- **Intel® VMD**: Intel® Xeon® Scalable CPU HW logic to manage NVMe SSDs
- Intel VMD acts like an integrated HBA to enumerate NVMe SSDs and own the communication up to the OS
- Each 1 VMD Domain is made up of x16 PCIe lanes
- # VMD Domains = # PCIe Lanes / 16
- Enables robust surprise hot-plug, status LED management and bootable RAID
Intel® VROC is Integrated RAID

Intel® VROC
Enterprise RAID Solution

- Integrated RAID on CPU/Chipset
  - NVMe and SATA RAID
  - Hybrid RAID with HW + SW
- Enterprise Quality with Compelling Feature Set
  - Supported and Validated by Intel
  - CPU attached Boot and Data RAID
  - Hot-plug/LED Management
  - SED and OOB Management on the Roadmap

Intel® VROC onboards RAID HBA functionality onto Intel® Xeon® CPUs
## Intel® VROC SKU

<table>
<thead>
<tr>
<th></th>
<th>Pass-thru (no license)</th>
<th>Standard SKU</th>
<th>Premium SKU</th>
<th>Intel® SSD SKU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intel® VMD</strong></td>
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<tr>
<td>CPU attached NVMe:</td>
<td>√</td>
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<td>√</td>
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<tr>
<td>• Hot-plug/Surprise Removal</td>
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<tr>
<td>• LED Management</td>
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<tr>
<td>• 3&lt;sup&gt;rd&lt;/sup&gt; Part SSD Support (non-RAID)</td>
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<tr>
<td><strong>Intel® VROC (VMD NVMe RAID)</strong></td>
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<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; party SSD support (RAID)</td>
<td>-</td>
<td>√</td>
<td>√</td>
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<tr>
<td>Bootable RAID</td>
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<td>√</td>
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<td>√</td>
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<tr>
<td>RAID 0/1/10</td>
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<td>√</td>
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<td>√</td>
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<tr>
<td>RAID 5</td>
<td>-</td>
<td>-</td>
<td>√</td>
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<tr>
<td><strong>Intel VROC (SATA RAID)</strong></td>
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<tr>
<td>SATA RAID on PCH</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>• Bootable RAID</td>
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<td></td>
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<tr>
<td>• RAID 0/1/5/10</td>
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<tr>
<td><strong>Integrated Caching</strong></td>
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<tr>
<td>RAID Acceleration</td>
<td>-</td>
<td>-</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>• Intel Optane SSD Cache</td>
<td></td>
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</tbody>
</table>
Windows and Linux: Supported Configurations

**Intel VROC Configuration Guidelines**

- **RAID Level Support:** 0, 1, 5, 10
- **RAID Spanning**
  - Data Volumes can span VMD Domains and CPUs
  - Boot Volumes must be within a single VMD Domain (e.g. PCH VMD)
- **Max. 48 NVMe SSDs/platform**
  - Up to 24 SSDs per RAID0/5 Array
  - Up to 4 SSDs per RAID10 Array
  - Up to 2 SSDs per RAID1 Array
VMware ESXi: Supported Configurations

Intel VROC Configuration Guidelines

- RAID Level Support: 1
  - Boot Volumes must be within a single VMD Domain (e.g. PCH VMD)
  - If vSAN is being used: Boot volumes must be on separate controller (VMD Domain) from data devices
  - If vSAN is NOT being used: Boot volumes and data devices can share a VMD domain
  - Max. 48 NVMe SSDs/platform
  - Up to 24 SSDs per Intel VMD Domain
Intel VROC Configuration Guidelines

- **RAID Level Support:** 1
  - Boot Volumes must be within a single VMD Domain (e.g. PCH VMD)
  - If vSAN is being used: Boot volumes must be on separate controller (VMD Domain) from data devices
  - If vSAN is NOT being used: Boot volumes and data devices can share a VMD domain
  - Max. 48 NVMe SSDs/platform
  - Up to 24 SSDs per Intel VMD Domain
New Intel VROC 7.5 Features

Intel VROC 7.5 will add the below new features:

- Intel VROC Integrated Caching
  - Accelerate RAID volumes with Intel® Optane SSDs
- Intel VMD 2.0 Technology
  - 4 Intel® VMD Domains per CPU (16 PCIe Lanes per domain)
  - 1 Intel® VMD Domain on the Chipset for NVMe RAID1 Boot volumes
  - Intel® VMD Direct-Assignment to VM
- Self Encrypting Drive (SED) OPAL Key Management via UEFI driver
- NVMe RAID BMC OOB management via OS
  - UEFI OOB management coming with Intel VROC 8.0
- Add support RAID1 Boot for ESXi

1-Intel VROC feature support is platform specific. Please consult platform provider for details
2-Requires Generation 3 Intel Xeon Scalable Processor
3-Requires additional driver integration at platform level. May not be available on all Intel VROC enabled platforms
Integrated Caching Explained

**Intel® VROC adds RAID + Caching architecture:**

- **Intel® VROC Integrated Caching (Intel® VROC IC)**
- **Optimized for Intel® Optane™ SSDs:**
  - Allows a persistent cache with more capacity than DRAM WB
- **Enterprise Supported and Validated Caching**
  - Part of the Intel® VROC supported feature set
- **Platform Integrated**
  - Easy for end-users to pull in as a platform upgrade
- **Flexible Usage Models:**
  - Caching for SATA and NVMe devices
  - RAID0/1/10 for cache layer to provide performance and capacity cache scaling
- **Eliminate Singled Points of Failure:**
  - Use Intel® VROC RAID1 for a redundant cache

![Diagram showing Intel® Xeon® Scalable Processor with Intel® VROC NVMe RAID array and Intel® VROC SATA RAID array](image-url)
Intel® VROC for Boot

Simple, flexible, integrated RAID1 for boot

- Redundant OS and High Availability
- Pre-OS RAID configuration (UEFI/HII)
- CPU or PCH Intel VMD domains for boot attach points
- Broad OS Support:
  - Linux, Windows, VMware
- FF Flexibility: M.2, U.2, E1.S
- RAID0/10 configurations for larger boot volumes
Intel® VROC SED Key Management

- UEFI utility with HII interface for SED setup
- Automatic drive provisioning and unlock on system boot
- Boot from a secured RAID volume or secured single drive into any Intel VROC supported OS
- Secure sensitive data volumes with SED
- Support for multiple key managers:
  - OASIS based KMIP – industry standard KMS
  - Local Security Chip/TPM
- Intel VROC SED itself does no encryption, just key management

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1-Requires additional driver integration at platform level. May not be available on all Intel VROC enabled platforms. Specific functionality depends on platform provider integration into their preferred KMS
## Major RAID Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>HW RAID</th>
<th>VROC</th>
<th>SW RAID</th>
<th>Intel® VROC Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error Handling Isolation</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>Intel® VMD isolates SSD error/event handling from OS to reduce system crash or reboot due to error</td>
</tr>
<tr>
<td>Reliable data storage</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>Enterprise data protection, even when power loss occurs</td>
</tr>
<tr>
<td>Boot support</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>Redundant system volume = less down-time/crashes</td>
</tr>
<tr>
<td>Complete Management Tools</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>UEFI, GUI, CLI, RESTful API, remote web, OOB (full solution coming with Intel VROC8.0)</td>
</tr>
<tr>
<td>Dedicated I/O processor for RAID</td>
<td>✓</td>
<td>1</td>
<td>x</td>
<td>1. Uses powerful Intel® Xeon® CPU to RAID the fast NVMe* SSDs. Long term option for dedicated storage cores</td>
</tr>
<tr>
<td>Protected write back cache</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>Replace DRAM WB Cache + BBU with persistent Optane media (VROC IC)</td>
</tr>
<tr>
<td>SED Key Management</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>Xeon-based Platform integrated Key Management solution</td>
</tr>
<tr>
<td>Easily upgraded</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>Software update vs new HW purchase</td>
</tr>
<tr>
<td>Less hardware required</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>No need for HBA, BBU. Save power and PCIe* lanes</td>
</tr>
</tbody>
</table>

## Biggest Advantages of Intel VROC over RAID HBA

Intel® Xeon Integrated for great performance, less HW

Industry Proof Point:
NVMe Integrated RAID SNIA Presentation
https://www.youtube.com/watch?v=586EcdZEipg
Intel® VROC Resources and Support Docs

- **Intel.com/VROC for:**
  - Product Brief
  - FAQ
  - Supported OS/HW Information
  - Related Links

- **Intel® VROC Support Page for:**
  - User Guides
  - Tech Briefs
  - Performance Documentation
  - Technical Docs on RDC