ONLINE DISK REENCRYPTION
IN RHEL 8.1

ONDŘEJ KOZINA <OKOZINA@REDHAT.COM>
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WHY?

- Different data lifetime and algorithm lifetime
- Cut-off access to data with volume key backup (LUKS header backup)
  - LUKS keyslot passphrase (KEK) change does not affect volume key (MEK, data encryption key)
- Periodic volume key change may be enforced by policy
- Offline legacy cryptsetup-reencrypt utility misses few features
  - not online
  - not robust enough in case of failure
- Golden image reencryption (distributed with known passphrase and VK)
RESILIENT...?

- Reencryption writes device in segments (hotzones)
- Crash may produce torn write
- To detect and correct torn write we require:
  - Storage to keep additional information
  - Metadata format capable properly track reencryption progress
- LUKS2 format is flexible enough for it
BETTER TO BE SAFE...

- Checksums
  - 1 checksum per underlying logical sector size of underlying device
  - Stored in LUKS2 keyslots binary area

- Journal
- Data shift
- None
  - No syncs
  - No commit points
  - Only gracefully interrupted reencryption is safe
RECOVERY

- Checksums
  - Compare content of reencryption zone to stored checksums
  - Reencrypt only sectors with matching checksums
- Journal
  - Replay
- Data shift
  - Repeat
- None
  - :(
ONLINE REENCRYPTION

- Independent layer
- Filesystem/applications access the data via device-mapper stack
- Reencryption process controls access to reencryption zone
mounted filesystem

DM-CRYPT OLD KEY

LUKS2 HDR

OLD CIPHERTEXT
FOR EACH REENCRYPTION ZONE (CHECKSUMS):
1. Read old ciphertext
2. Calculate and store checkums in LUKS2 metadata (commit point)
3. Write new ciphertext
4. Update metadata (commit point)
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PERFORMANCE BASELINE:

- sequential **read**
- sequential **write**
- random reads and writes, **randrw** (70% reads, 30% writes)
- fio utility (iodepth=16, 4 threads, block size 32KiB, direct io)

**ROTATIONAL HDD (5400 RPMS, 512 GB)**

<table>
<thead>
<tr>
<th>storage</th>
<th>read</th>
<th>write</th>
<th>randrw</th>
</tr>
</thead>
<tbody>
<tr>
<td>raw</td>
<td>125 MiB/s</td>
<td>94 MiB/s</td>
<td>read 8,6 MiB/s, write 3,6 MiB/s</td>
</tr>
<tr>
<td>dm-crypt</td>
<td>125 MiB/s</td>
<td>65 MiB/s</td>
<td>read 9,3 MiB/s, write 4,0 MiB/s</td>
</tr>
</tbody>
</table>

**NVME (512 GB)**

<table>
<thead>
<tr>
<th>storage</th>
<th>read</th>
<th>write</th>
<th>randrw</th>
</tr>
</thead>
<tbody>
<tr>
<td>raw</td>
<td>2,2 GiB/s</td>
<td>875 MiB/s</td>
<td>862 MiB/s, 369 MiB/s</td>
</tr>
<tr>
<td>dm-crypt</td>
<td>2,2 GiB/s</td>
<td>875 MiB/s</td>
<td>833 MiB/s, 374 MiB/s</td>
</tr>
</tbody>
</table>
## REENCRYPTION PERFORMANCE:

### NVME

<table>
<thead>
<tr>
<th>reencryption zone size</th>
<th>resilience mode</th>
<th>idle</th>
<th>ETA</th>
<th>load</th>
<th>ETA</th>
</tr>
</thead>
<tbody>
<tr>
<td>95 MiB (3,7 MiB)</td>
<td>checksums</td>
<td>206 MiB/s</td>
<td>43m</td>
<td>156 MiB/s</td>
<td>56m</td>
</tr>
<tr>
<td>198 MiB (7,7 MiBs)</td>
<td>checksums</td>
<td>212 MiB/s</td>
<td>42m</td>
<td>175 MiB/s</td>
<td>50m</td>
</tr>
<tr>
<td>3,7 MiB</td>
<td>journal</td>
<td>116 MiB/s</td>
<td>1h49m</td>
<td>45 MiB/s</td>
<td>3h15m</td>
</tr>
<tr>
<td>7,7 MiB</td>
<td>journal</td>
<td>159 MiB/s</td>
<td>55m</td>
<td>67 MiB/s</td>
<td>2h11m</td>
</tr>
<tr>
<td>20 MiB</td>
<td>noop</td>
<td>400 MiB/s</td>
<td>22m</td>
<td>240 MiB/s</td>
<td>37m</td>
</tr>
<tr>
<td>95 MiB (detached hdr)</td>
<td>checksums</td>
<td>206 MiB/s</td>
<td>43m</td>
<td>156 MiB/s</td>
<td>56m</td>
</tr>
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<td>175 MiB/s</td>
<td>50m</td>
</tr>
<tr>
<td>8 MiB</td>
<td>data shift</td>
<td>235 MiB/s</td>
<td>38m</td>
<td>97 MiB/s</td>
<td>1h31m</td>
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</tbody>
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ETA: estimated time to reencrypt 512 GiB device
# REENCRYPTION PERFORMANCE:

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</tr>
</thead>
<tbody>
<tr>
<td>95 MiB (3.7 MiB)</td>
<td>checksums</td>
<td>37 MiB/s</td>
<td>4h</td>
<td>17 MiB/s</td>
<td>8h34m</td>
</tr>
<tr>
<td>198 MiB (7.7 MiB)</td>
<td>checksums</td>
<td>40 MiB/s</td>
<td>3h40m</td>
<td>29 MiB/s</td>
<td>5h2m</td>
</tr>
<tr>
<td>3.7 MiB</td>
<td>journal</td>
<td>11 MiB/s</td>
<td>13h15m</td>
<td>4 MiB/s</td>
<td>1d12h</td>
</tr>
<tr>
<td>7.7 MiB</td>
<td>journal</td>
<td>16 MiB/s</td>
<td>9h6m</td>
<td>6 MiB/s</td>
<td>1d</td>
</tr>
<tr>
<td>20 MiB</td>
<td>noop</td>
<td>50 MiB/s</td>
<td>2h55m</td>
<td>25 MiB/s</td>
<td>5h50m</td>
</tr>
<tr>
<td>95 MiB (detached hdr)</td>
<td>checksums</td>
<td>45 MiB/s</td>
<td>3h15m</td>
<td>33 MiB/s</td>
<td>4h25m</td>
</tr>
<tr>
<td>198 MiB (detached hdr)</td>
<td>checksums</td>
<td>45 MiB/s</td>
<td>3h15m</td>
<td>35 MiB/s</td>
<td>4h10m</td>
</tr>
<tr>
<td>8 MiB</td>
<td>data shift</td>
<td>15 MiB/s</td>
<td>9h43m</td>
<td>5 MiB/s</td>
<td>1d5h</td>
</tr>
</tbody>
</table>

ETA: estimated time to reencrypt 512 GiB device
RHEL 8.1

- Reencrytion
- Encryption (short offline period)
- Decryption (currently detached LUKS2 header only)
- Process may be interrupted, paused, resumed with different parameters
- Recovery performed automatically on device unlock
- Reencrypt/encrypt only initial part of device
- Available upstream since cryptsetup 2.2.0 (cryptsetup-2.2.0-2.el8)
DEMO
RHEL 8.2+

- Better support for encryption initialization in initramfs
- Service/daemon for automatic background resume of interrupted reencryption
- Find a viable solution to fully online in-place encryption
THANK YOU!

Q&A

- https://gitlab.com/cryptsetup/cryptsetup
- contacts: Ondřej Kozina <okozina@redhat.com>