Advancing the AFF4 to the challenges of Volatile Memory & Single Hashes

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Agenda

- AFF4 background
- What can be improved with hashing in AFF4?
- Our refined single hashing proposal: the *Linear Chunk Hash*

Traditional forensic imaging introduces unnecessary delays

- Physical acquisition delays analysis by hours
  - Doesn't scale to multi-core/RAID/SSD/NVMe
  - Doesn't allow non-linear writes (concurrent imaging & analysis)

- Possible solution: logical imaging/triage
  - loses context and unallocated

Traditional forensic imaging doesn't scale

- ZIP/Deflate compression is really CPU expensive
  - (~ 40MB/s/core for high entropy)
- Hashing is CPU expensive
  - (~ 600MB/s/core for 2016 i7)
- ***Linear bitstream hashing isn't parallelizable***
  - ***Ceiling of around 600MB/s on current generation i7 CPU's***

The AFF4 removes the bottleneck from forensic imaging

- Snappy compression is CPU inexpensive
  - (> 1000 MB/s/core)
- Hashing is still CPU expensive
  - (~ 600MB/s/core for 2016 i7)
- AFF4 block hashing is parallelizable
  - Seeing > 1000 MB/s on current generation CPU's

The AFF4 removes enables acquisition to occur at the same time as analysis

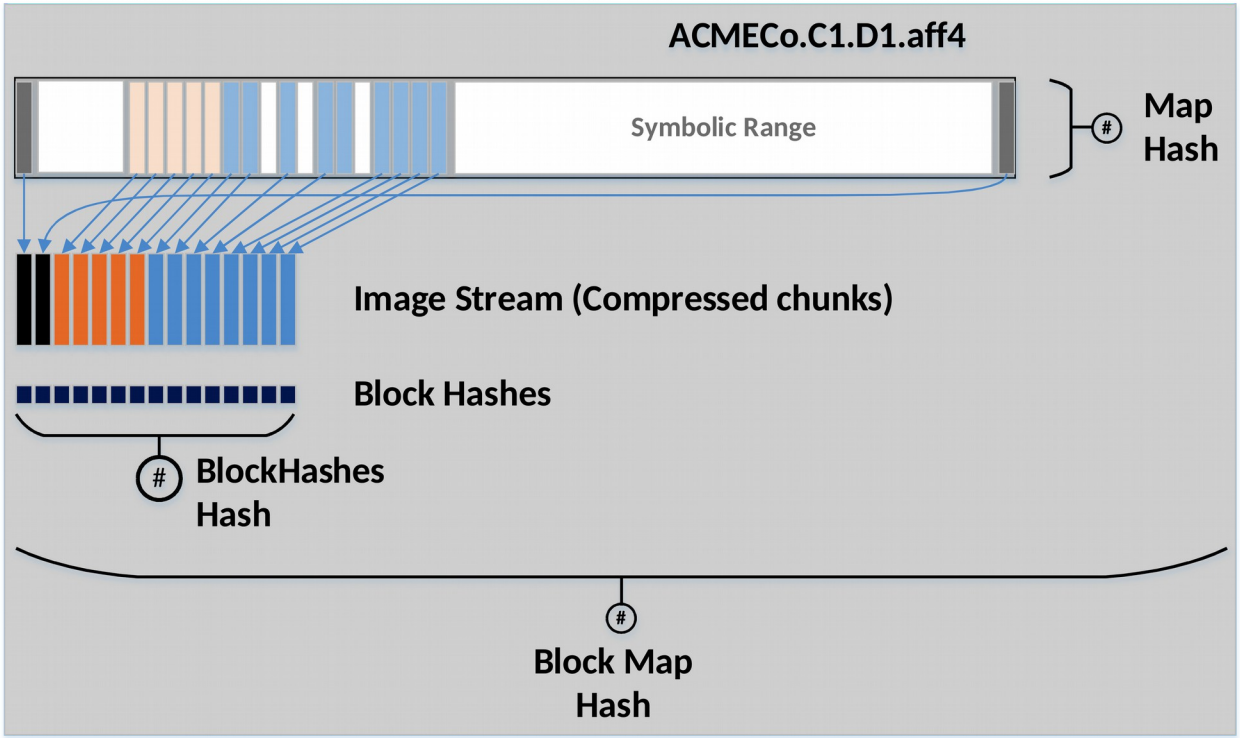
- Non-linear, potentially partial compressed block stream
- Hashing mechanism that enables incremental hash calculation

AFF4 Standard v1.0 Hashing

- Defines a hash construction called the **Block Map Hash**
  - Single hash for image

- Hybrid of:
  - Block (segment) hashing for concrete data chunks
  - Non concrete data chunks (eg. Sparse) protected by hash on map
  - Merkel tree like hash hierarchy

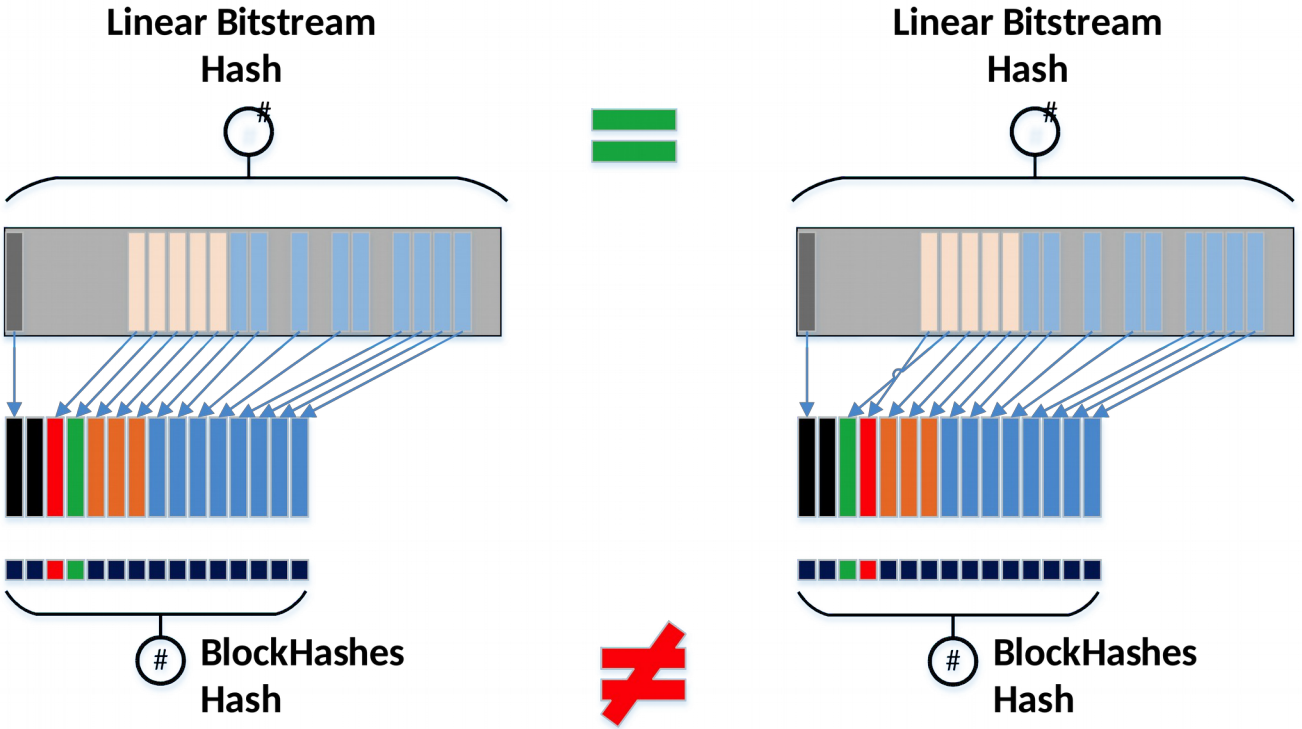
AFF4 Standard v1.0 Hashing



Desirable properties of hashing

	Linear Bitstream Hash	AFF4 Block Map Hash
Hash is concise	**Yes**	**Yes**
Hash of image matches hash calculated when imaging	**Yes**	**Yes**
Changed image results in failed hash match	**Yes**	**Yes**
Successive hashes of same source result in same hash	**Yes**	***Maybe***

Parallelism may lead to differing hashes



Can we generate a block based hash that is not subject to reordering ?

- Hypothesis 1: Reorder the lower Block Hashes based on their upper address
  - Works well for images of disks with no read errors.
  - Doesn't work so well for:
    - Disk images with read errors
    - *Memory images with chunk sizes > memory page size*

Sub chunk size data introduces further complication

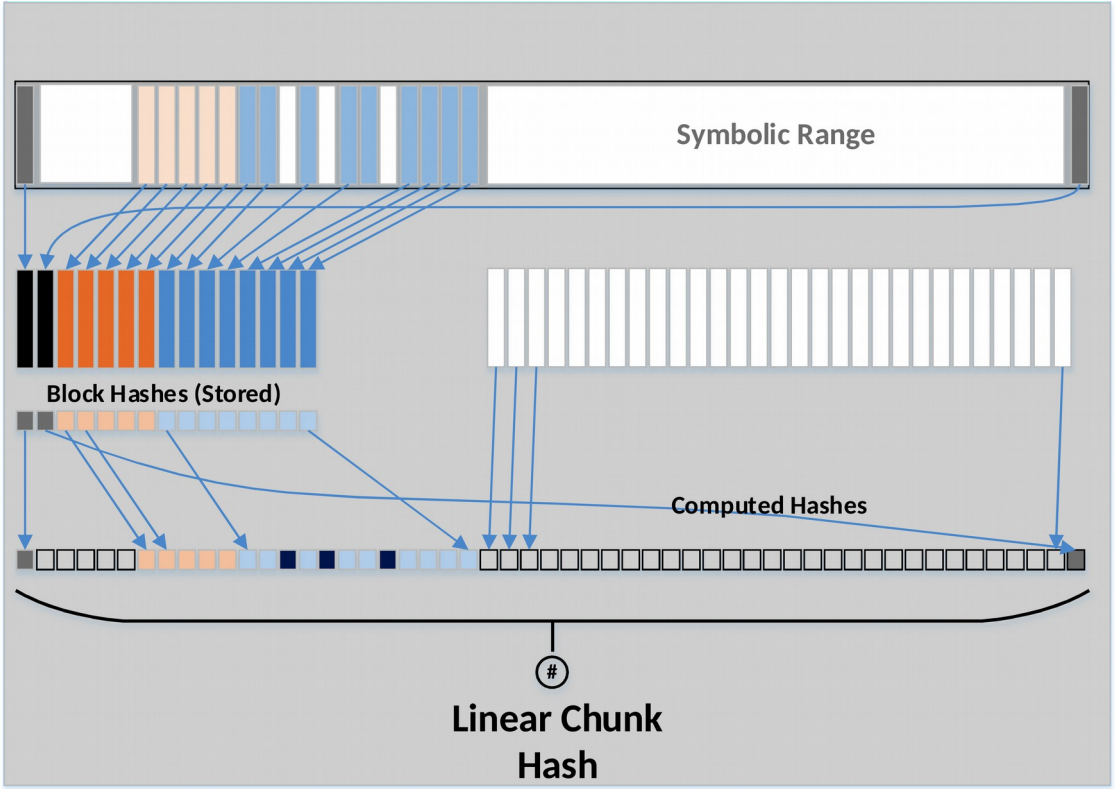
- High performance requires (chunk size > disk sector size)
  - IO Throughput - 1MB for disk IO
  - Memory consumption- Maps

- ddrescue bad sector imaging algorithm requires chunks of 512B or 4KB when the chunk size might be many multiples of this
- RAM physical address space holes lead to sub chunk sized data runs

Hypothesis 1a: introduce sub chunk encoding rules

- 4k sector gets written to first 4k of chunk, rest zero filled.
- -or-
- 4k sectors coalesced

Hypothesis 2: hash all chunks of the source



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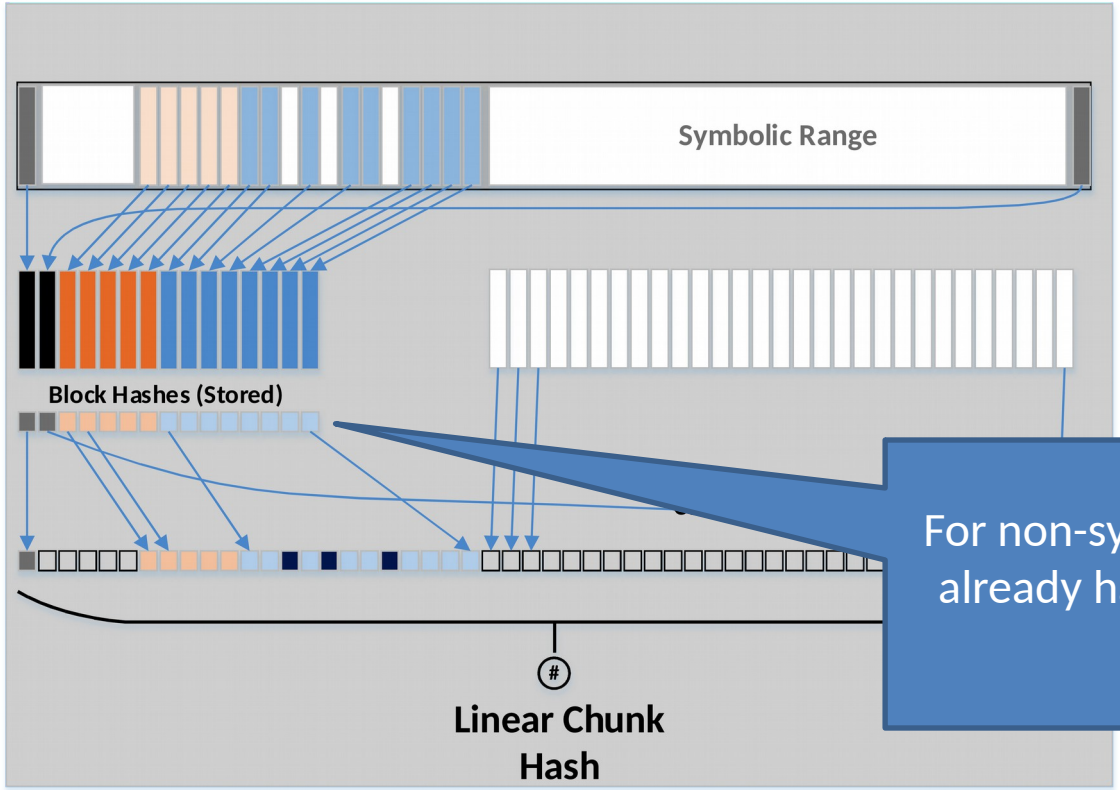

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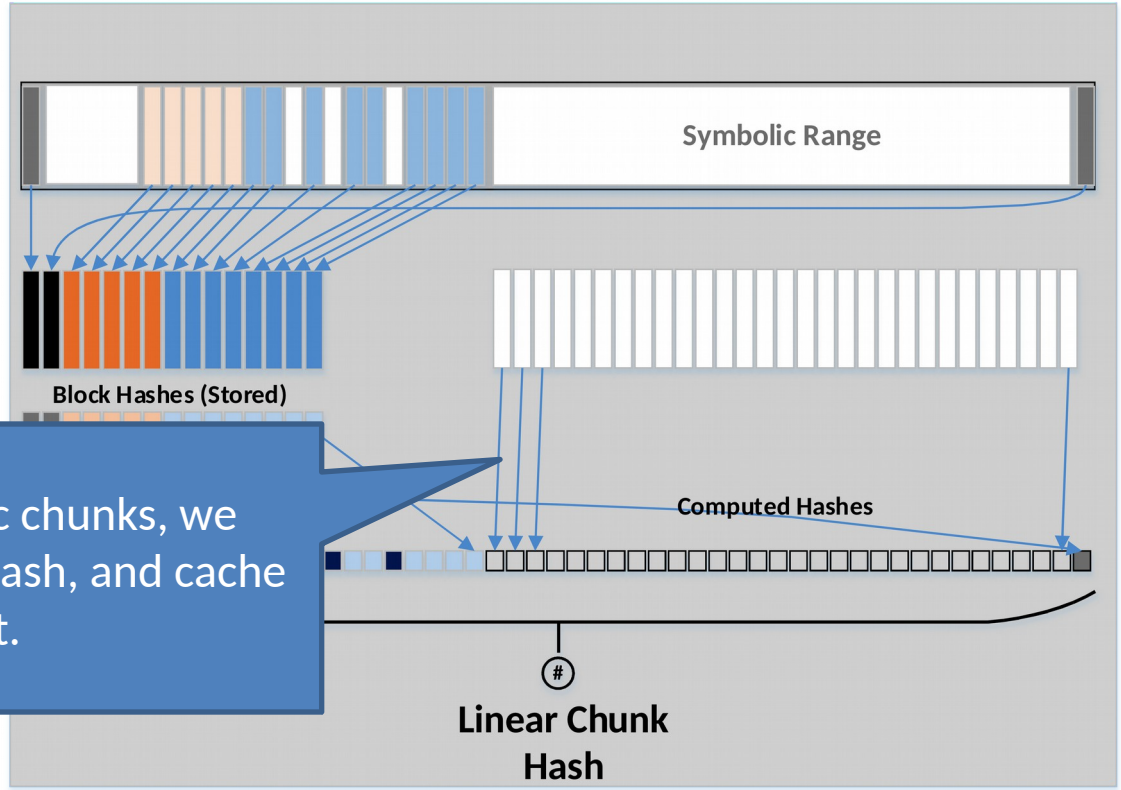
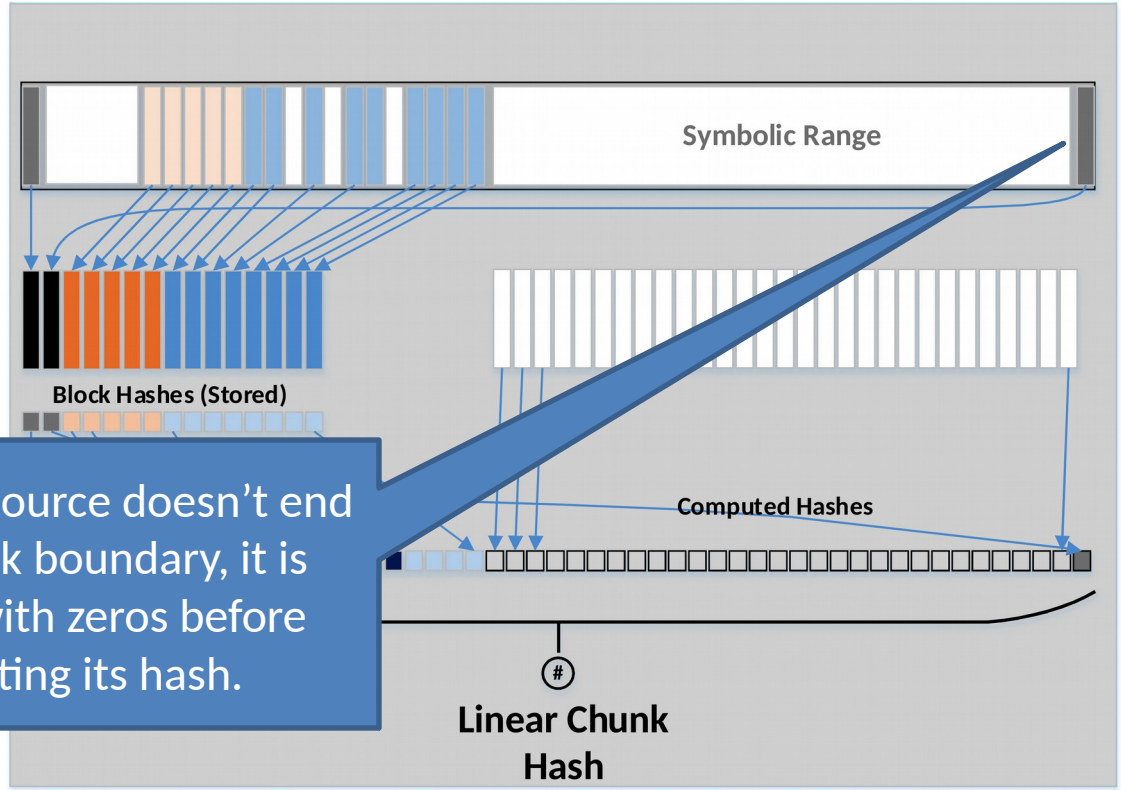


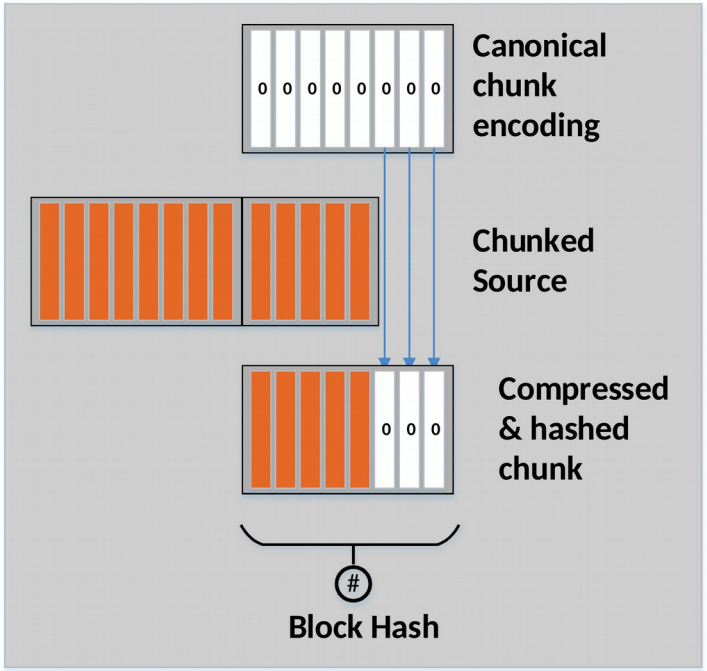
For symbolic chunks, we calculate the hash, and cache it.

Hypothesis 2: hash all chunks of the source



Where the source doesn't end on a chunk boundary, it is padded with zeros before generating its hash.

Sub chunk sized end of stream is zero filled



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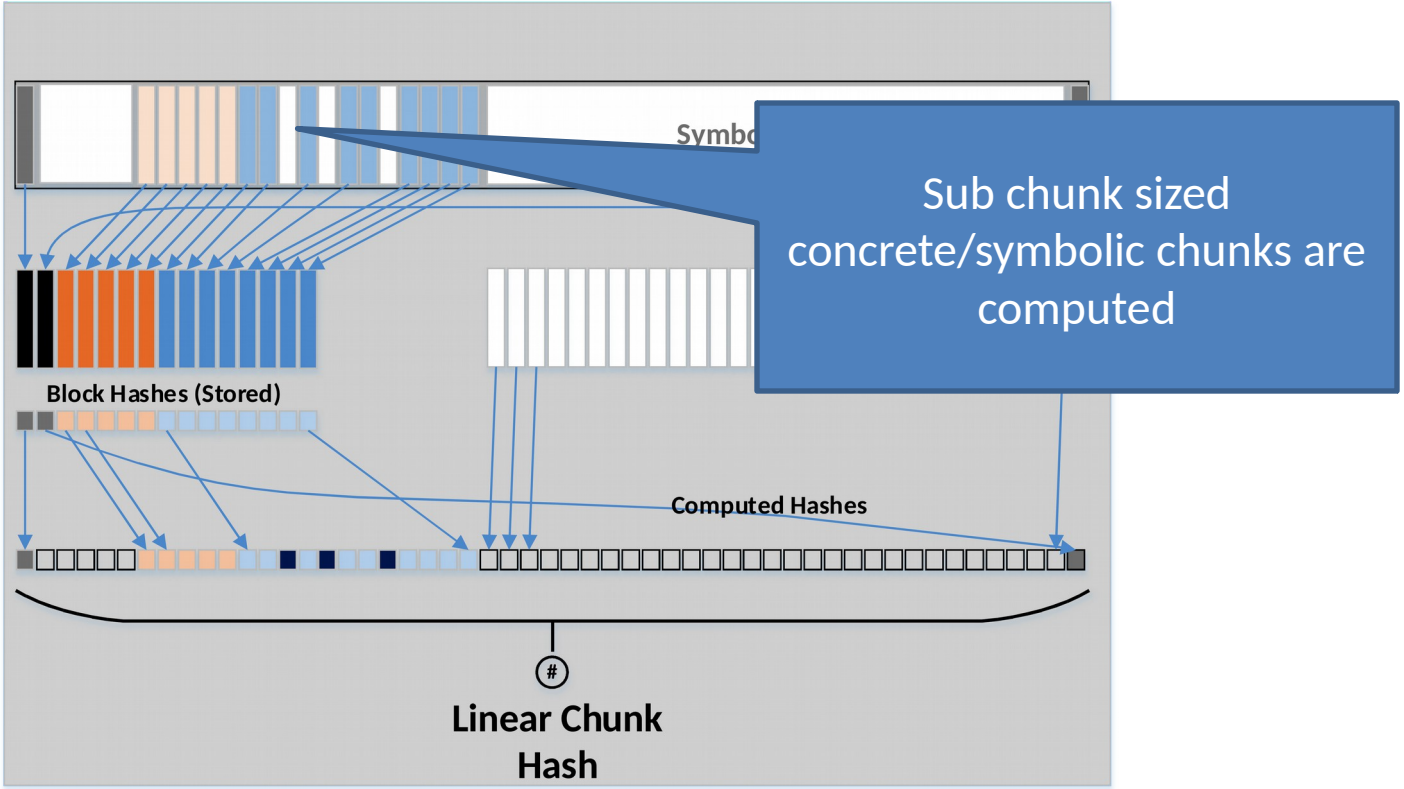
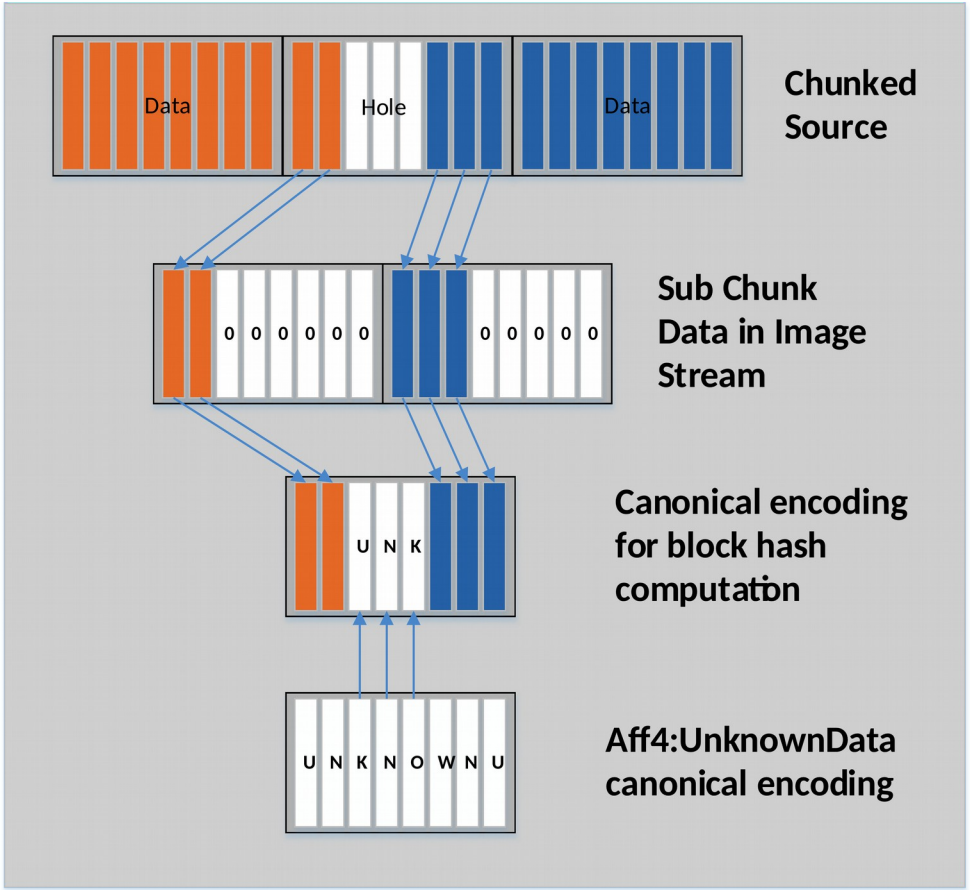
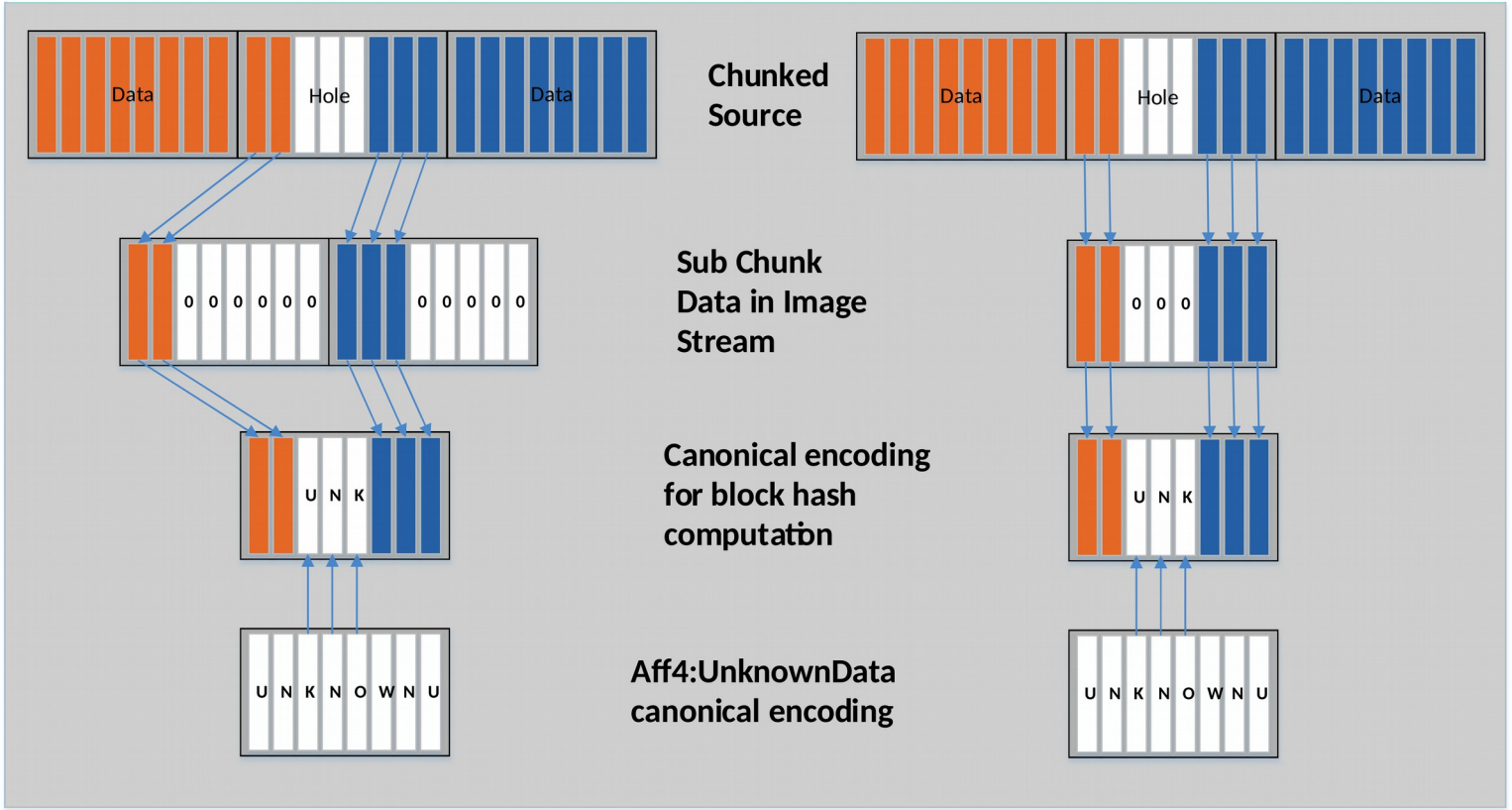




Sub chunk symbolic encoding rules

- Partial chunks stored padded
- Block hash computed from canonical block encoding

Alternate part chunk storage schemes result in the same hash



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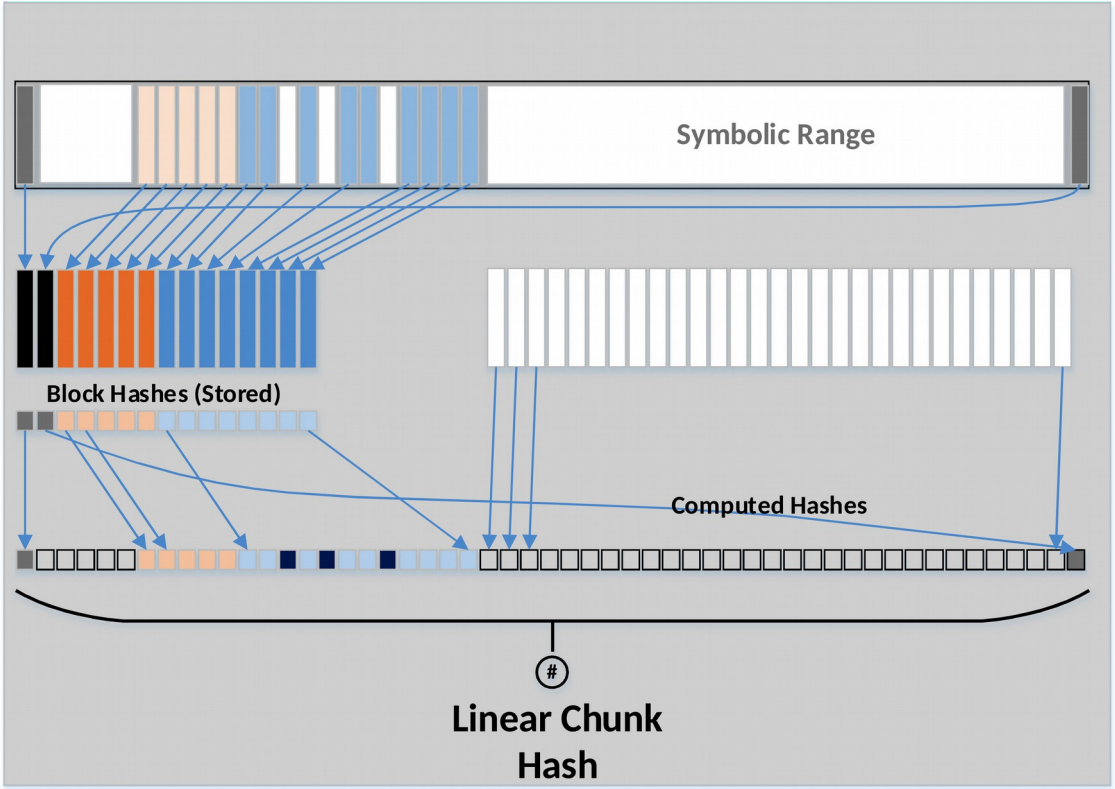

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Contact

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'Hard Disk Drive X-Ray'
image by Jeff Kubina