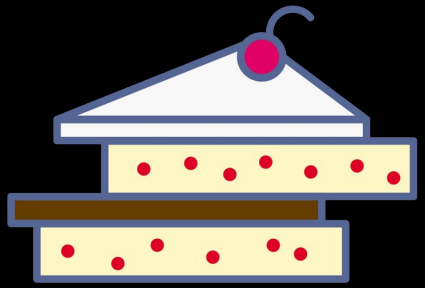
Shufflecake, AKA VeraCrypt on Steroids

Improvements, Updates, and 2026 Status



Tommaso Gagliardoni

From a joint work with Elia Anzuoni

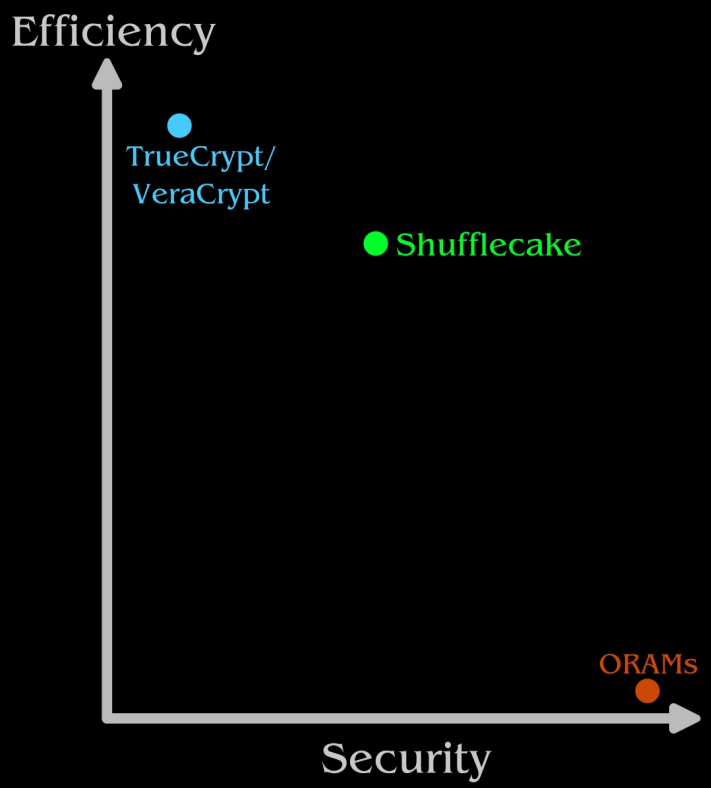
and The Shufflecake Project Contributors

Cryptographic Applications Workshop (CAW) @EUROCRYPT'26

2026-05-10, Rome, Italy

Shufflecake: TL;DR

- Encrypts, hides existence of disk partitions
- Plausible deniability like TrueCrypt/VeraCrypt
- Security and usability improvements
- Cryptographic proof of security
- Faster than ORAM-based solutions
- Potential to improve security even further
- FLOSS (“free” as in “freedom”)



Shufflecake: TL;DR

Shufflecake

AKA TrueCrypt on Steroids for Linux

DEF CON 31 Demo Labs

2023-08-11, Las Vegas (NV), USA

Introducing Shufflecake: Plausible Deniability For Multiple Hidden Filesystems on Linux (kudelskisecurity.com) 90

Posted by EditorDavid on Saturday November 12, 2022 @02:34PM from the magic-mounting dept.

Thursday the Kudelski Group's cybersecurity division released "a tool for Linux that allows creation of multiple hidden volumes on a storage device in such a way that it is very difficult, even under forensic inspection, to prove the existence of such volumes."

"Each volume is encrypted with a different secret key, scrambled across the empty space of an underlying existing storage medium, and indistinguishable from random noise when not decrypted."

Hacker News new | past | comments | ask | show | jobs | submit

16. Shufflecake: Plausible deniability for hidden filesystems on Linux (2023) (iacr.org)
66 points by simonpure 9 hours ago | hide | 22 comments

Shufflecake: Plausible Deniability For Multiple Hidden Filesystems On Linux

Elia Anzuoni
ETHZ and EPFL and Kudelski Security
Switzerland

Tommaso Gagliardoni
Kudelski Security
Switzerland

ABSTRACT

We present Shufflecake, a new plausible deniability design to hide the existence of encrypted data on a storage medium making it very difficult for an adversary to prove the existence of such data. Shufflecake can be considered a "spiritual successor" of tools such

by means of (physical, legal, psychological) coercion, they can obtain the encryption keys to any encrypted content identifiable on the user's device. The security goal in this scenario, then, becomes to still retain secrecy of some selected, "crucial" data on the disk, by making the presence of such data not even identifiable, thus allow-

30th Anniversary 2023 acm SIGSAC

ACM CCS 2023

26-30 NOV., 2023

Who am I

Tommaso “Tomgag” Gagliardoni

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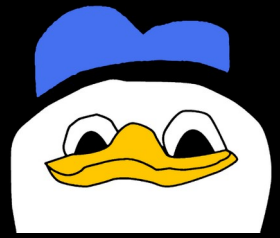

More business

Less business

Overview

- TL;DR
- Bio
- Introduction
- TrueCrypt (and VeraCrypt)
- Shufflecake
- Implementation
- Hidden OS
- Future directions
- How to contribute

Introduction

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- FileVault 2 (MacOS)
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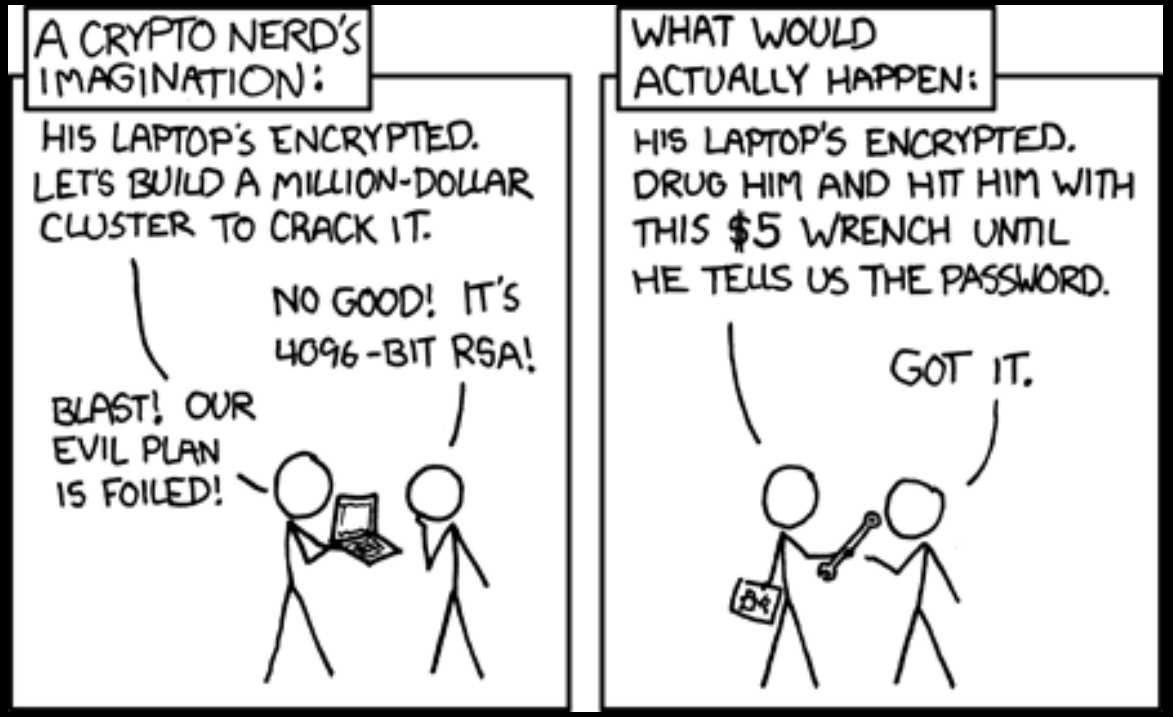

Source: https://xkcd.com/538/

Plausible Deniability (idea)

Must hide sensitive information in undetectable way

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But at the same time must be "plausible"

- You have PD software installed – can't deny existence of encryption
- "I forgot the password" – nope
- Must "give in" some decoy data and hide the rest

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Example:

- Disk is obviously encrypted
- Password 1 unlocks cat pictures
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Note: different from Steganography

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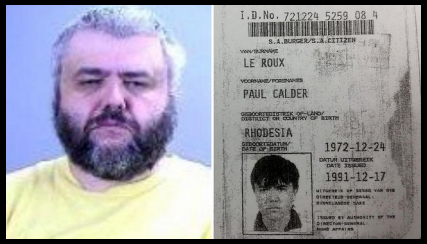

Don't mess up with this guy lol

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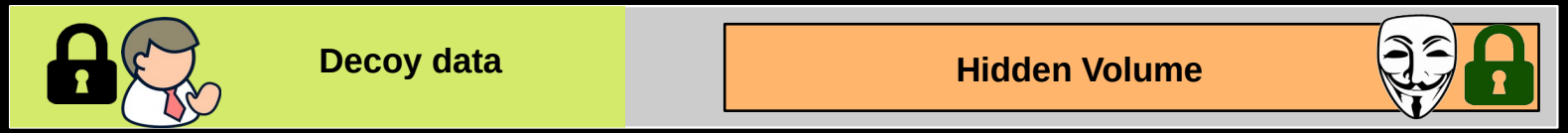

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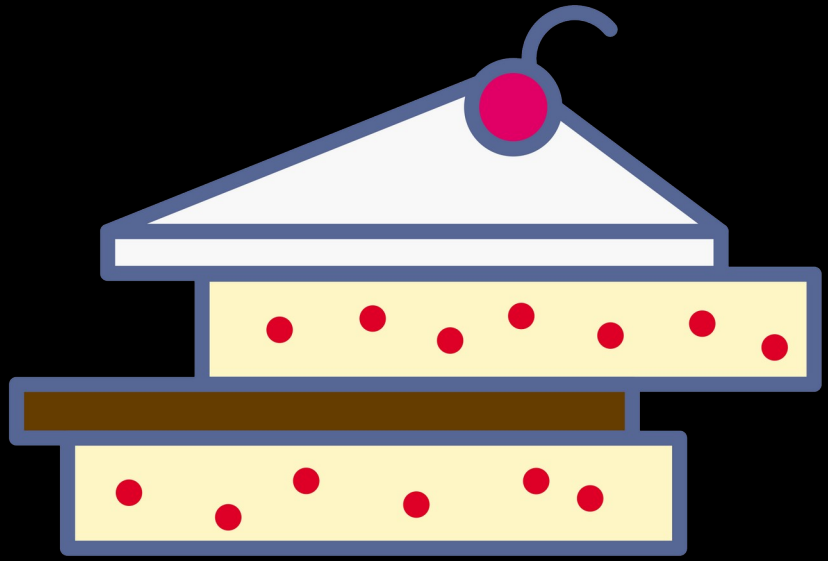
Shufflecake

- Native for Linux
- File-System agnostic
- Many nested layers
- Concurrent volume use
- One password to open
- GPLv2



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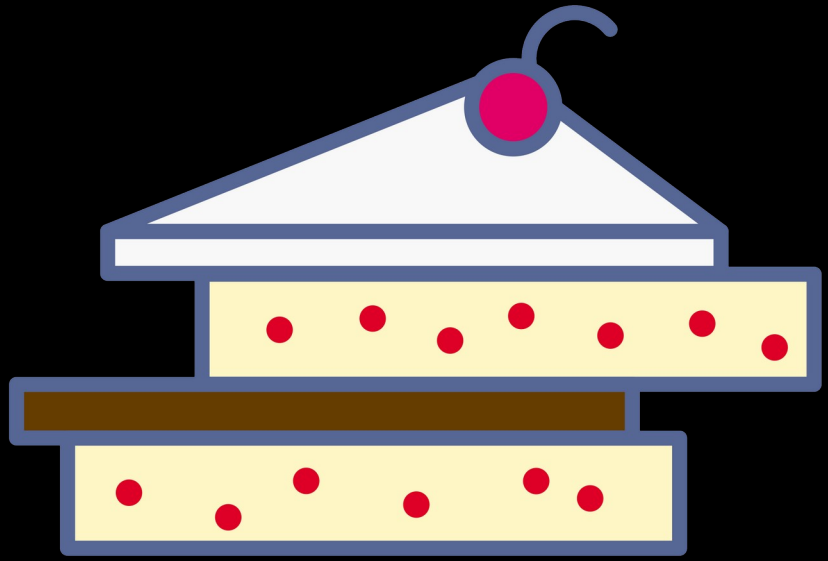

Operating Principles

- One device = multiple volumes (with concurrency)
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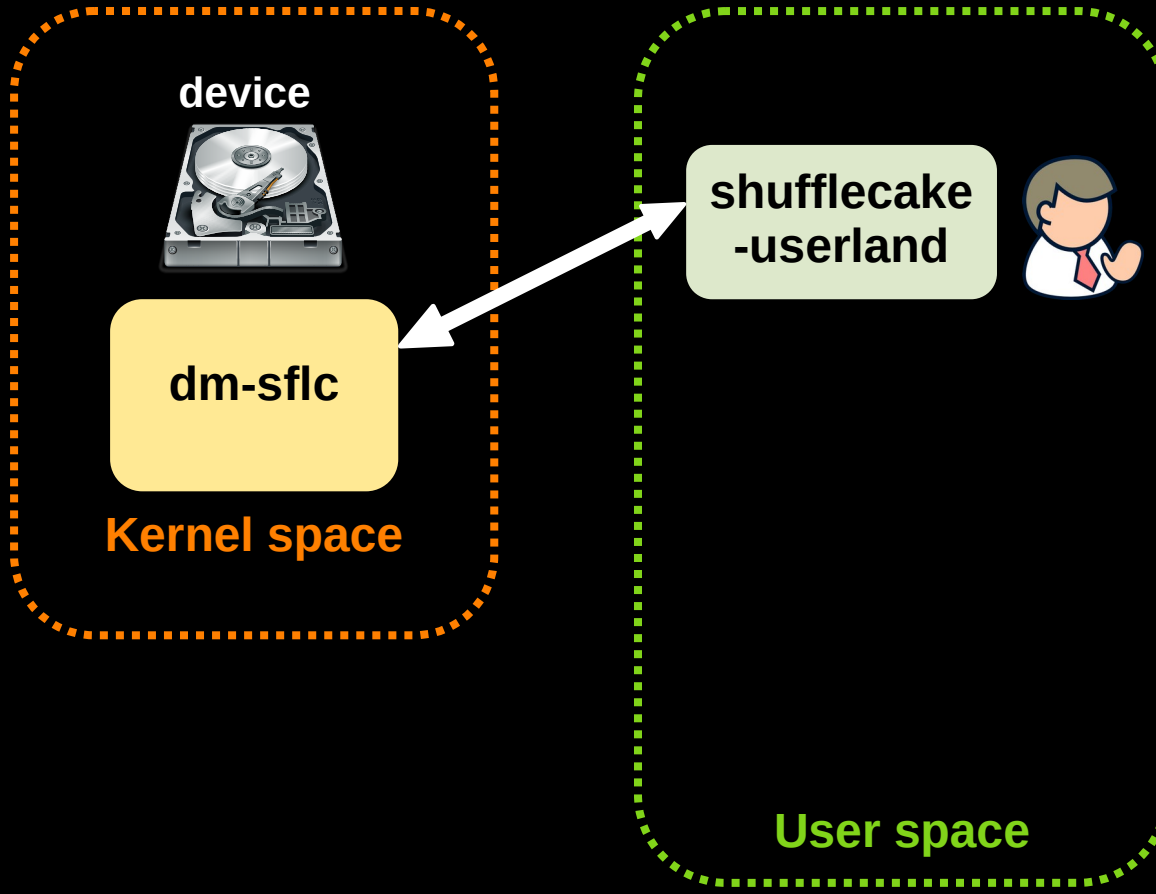
Cryptography

- Well-established schemes (AES, Argon2)
- Cryptographic security proof (single-snapshot)

Shufflecake: implementation



- Userspace can leverage more advanced crypto
- Also better for error handling, interfacing, etc

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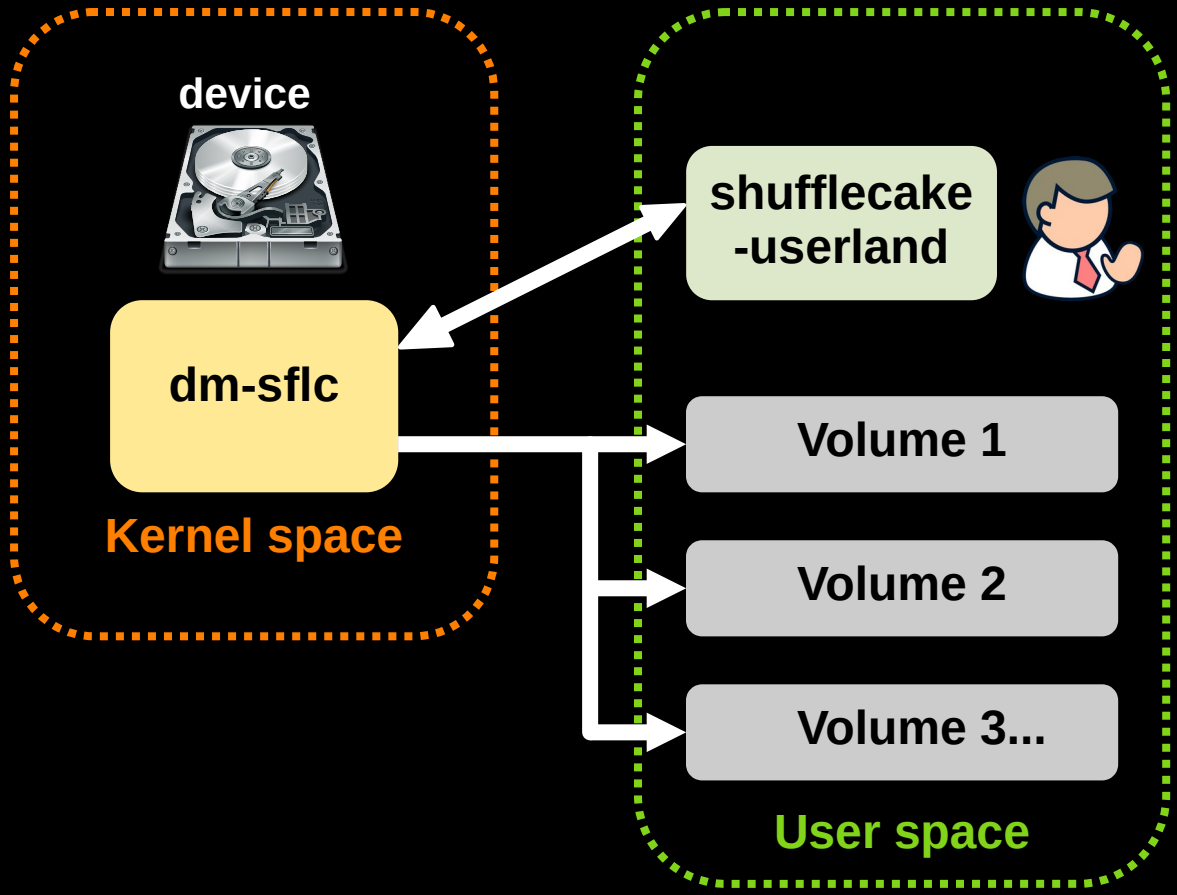

- Userspace can leverage more advanced crypto
- Also better for error handling, interfacing, etc
- Hidden volumes appear as `/dev/mapper/sflc_X_Y`
- They can be used as any other block device (formatted at wish, mounted, etc)

Let's talk about multi-snapshot

Physical volume (hard disk/partition)

Decoy data (FAT filesystem)	Empty space (?)

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"modern" solid-state drives: caching / layering / TRIM

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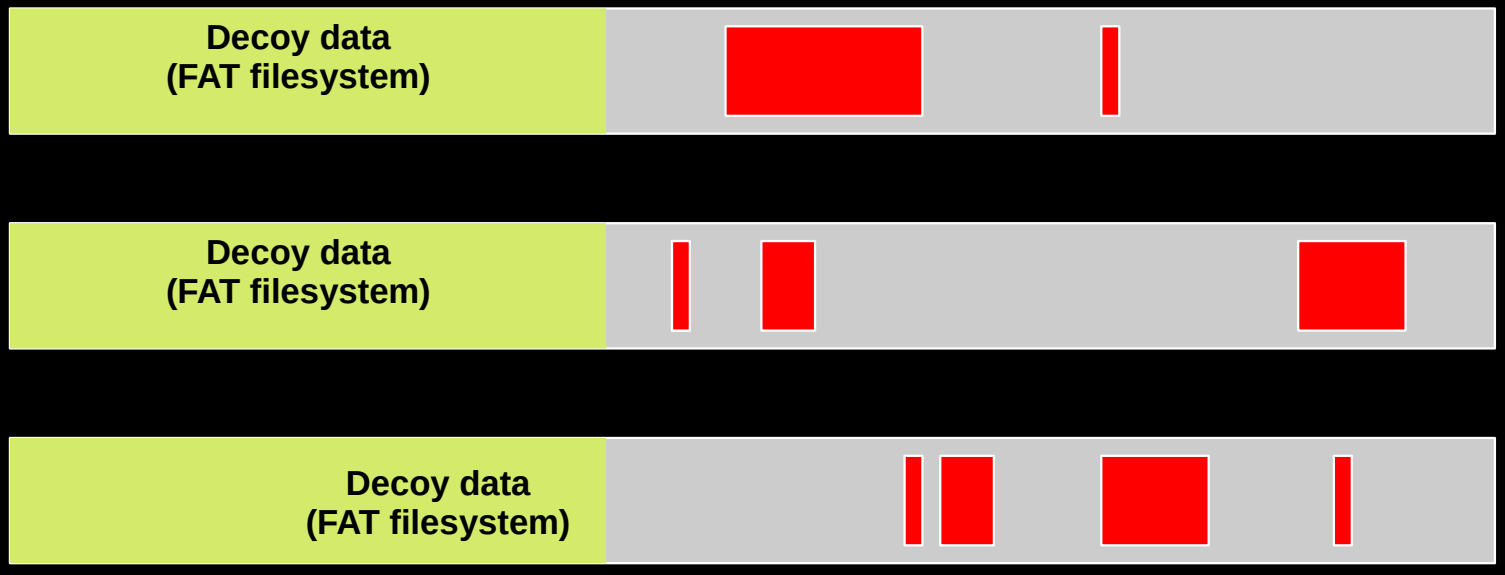

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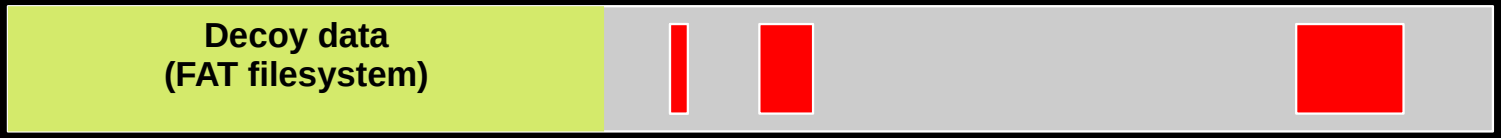

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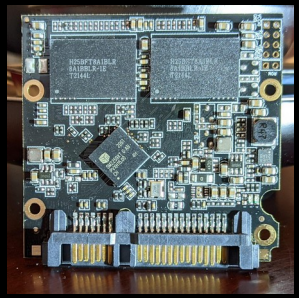

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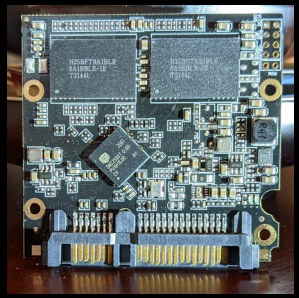

- How about practical / legal security?
- What if secure “with high enough” probability?
- What if I’m proved guilty with 2/3 probability?

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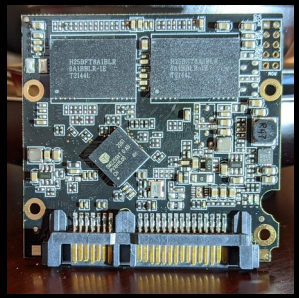

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- How about operational security?
- Are multi-snapshot attacks realistic at all? Should we care?

Shufflecake "Legacy"

- Initial design of Shufflecake scheme
- Uses AES-CTR to achieve ciphertext re-randomization
- The goal is to exploit re-randomization for multi-snapshot resistance in the future (kind of a "lightweight ORAM")
- But needs to write IVs on disk: cumbersome, corruption-prone
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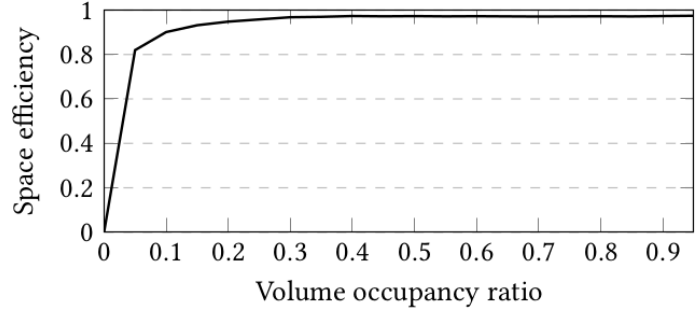
	Shufflecake	dm-crypt/LUKS	VeraCrypt
random write	26.77	38.43	39.07
random read	26.78	38.44	39.09
sequential write	176.87	247.14	247.75
sequential read	177.10	247.43	248.04

Table 1: I/O performance (in MB/s) of Shufflecake, dm-crypt/LUKS, and VeraCrypt.

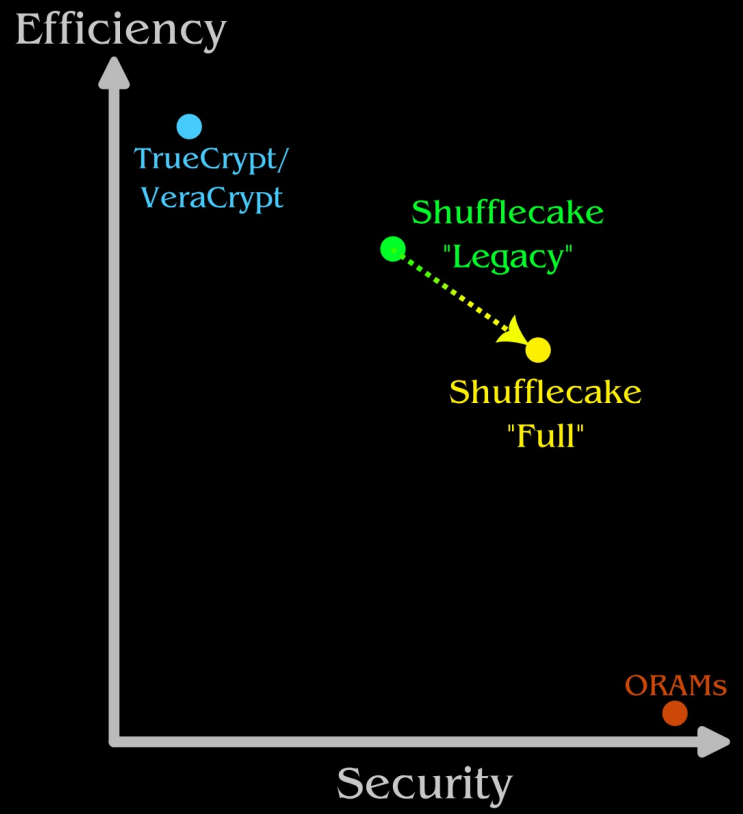


- ~30% slower than LUKS/VeraCrypt
- Negligible waste of space

[PLANNED] Shufflecake "Full"

Like Shufflecake "Legacy" (use of AES-CTR for ciphertext rerandomization) but with added features

- Crash consistency
- (Partial) multi-snapshot security
- "lightweight ORAM" in spirit
- Will not achieve "full" multisnapshot security (that requires full ORAM)
- But goal is to reach "operational" security (= "stands in court")



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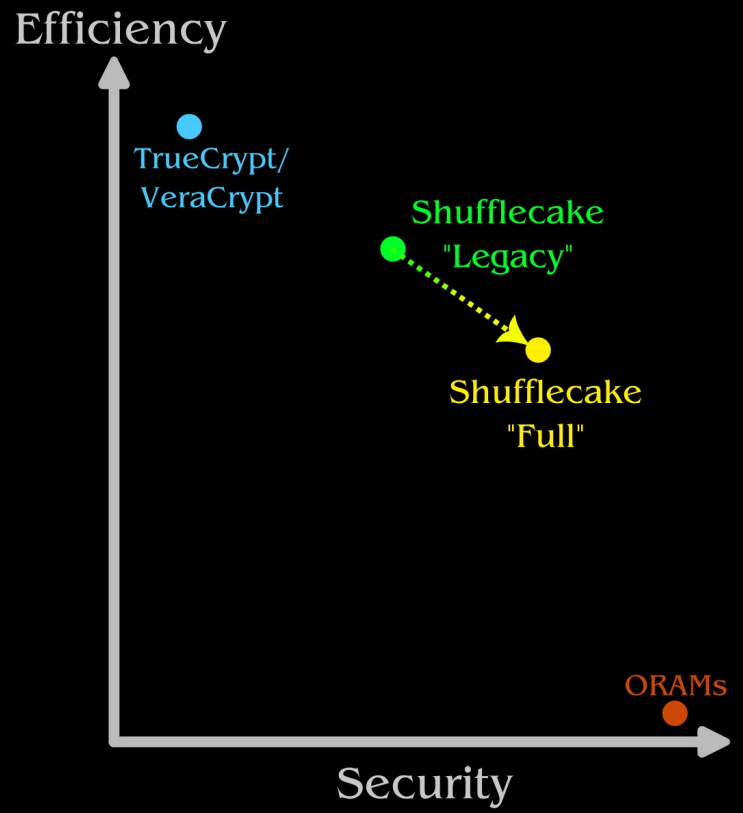

Open questions:

1) should we bother?

2) what security model/limits on nr. of snapshots?

Shufflecake “Lite”

Shufflecake v0.5.0 introduces “Lite” scheme

- Uses AES-XTS instead of AES-CTR (like most disk encryption tools)
- As secure as Legacy (single-snapshot)
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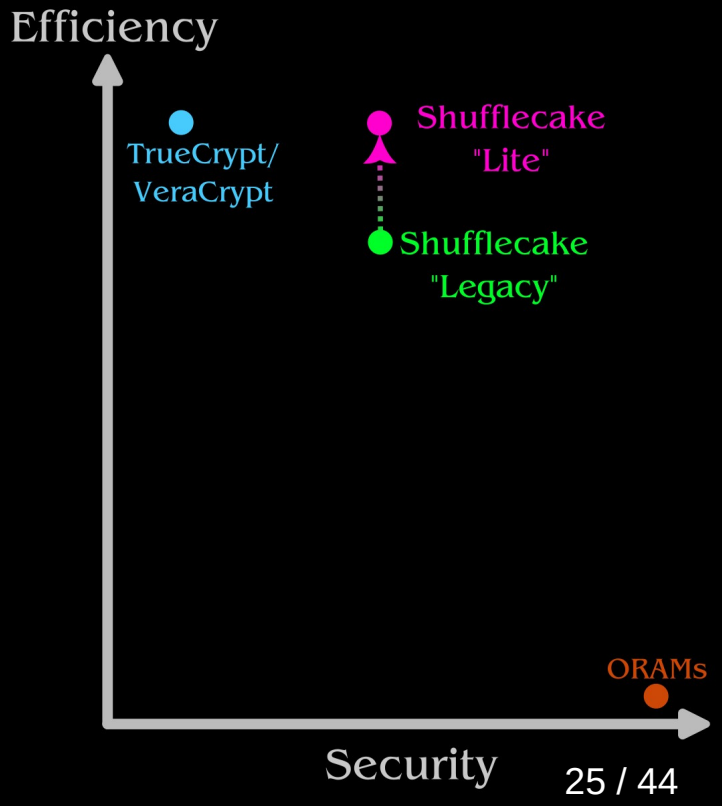

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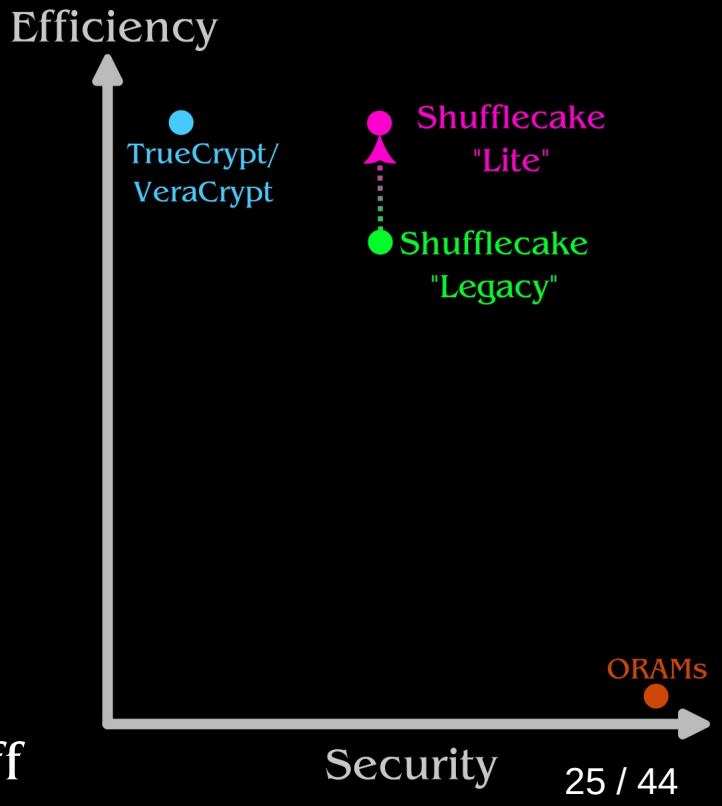
Lite as default mode, but
Legacy supported for
backward compatibility

Rationale: very good
security/performance tradeoff



Shufflecake “Lite”: Performance

I/O performance (MB/s) using `fio` with 1 job, 32 requests, 4 KiB

	dm-crypt	dm-sflc
read_rnd	650	622
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This is MADNESS! Shufflecake Lite's performances are more or less on par with *the standard Linux disk encryption engine*!!!

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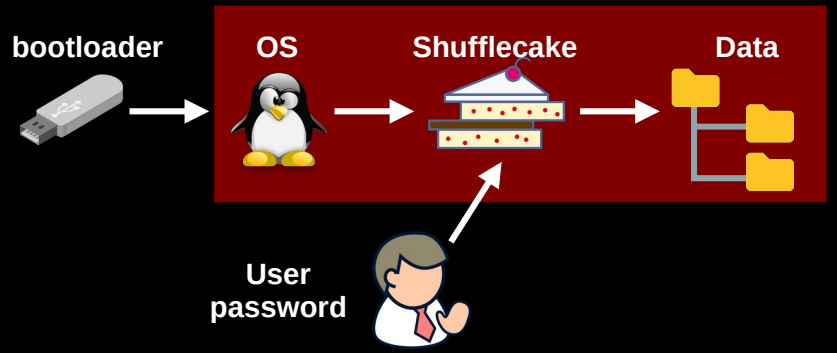

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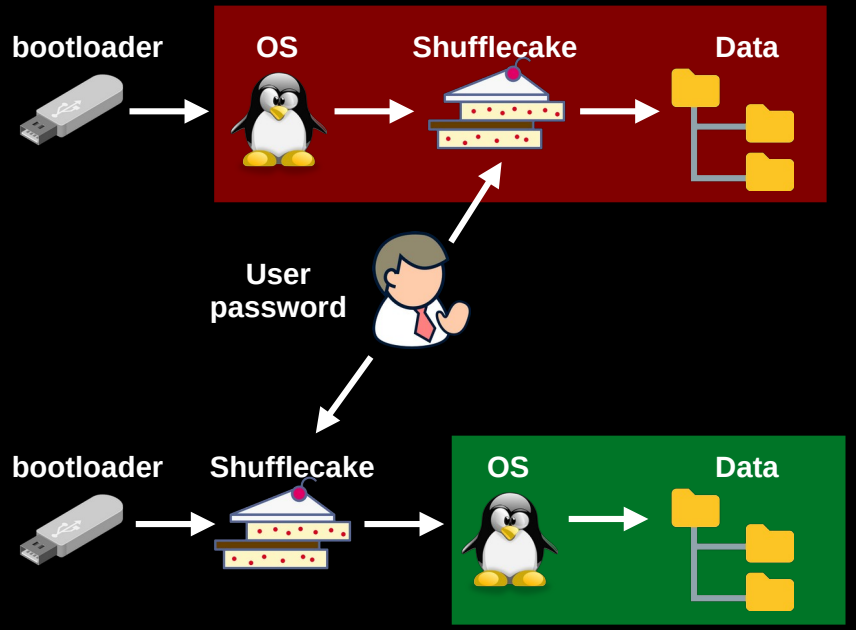

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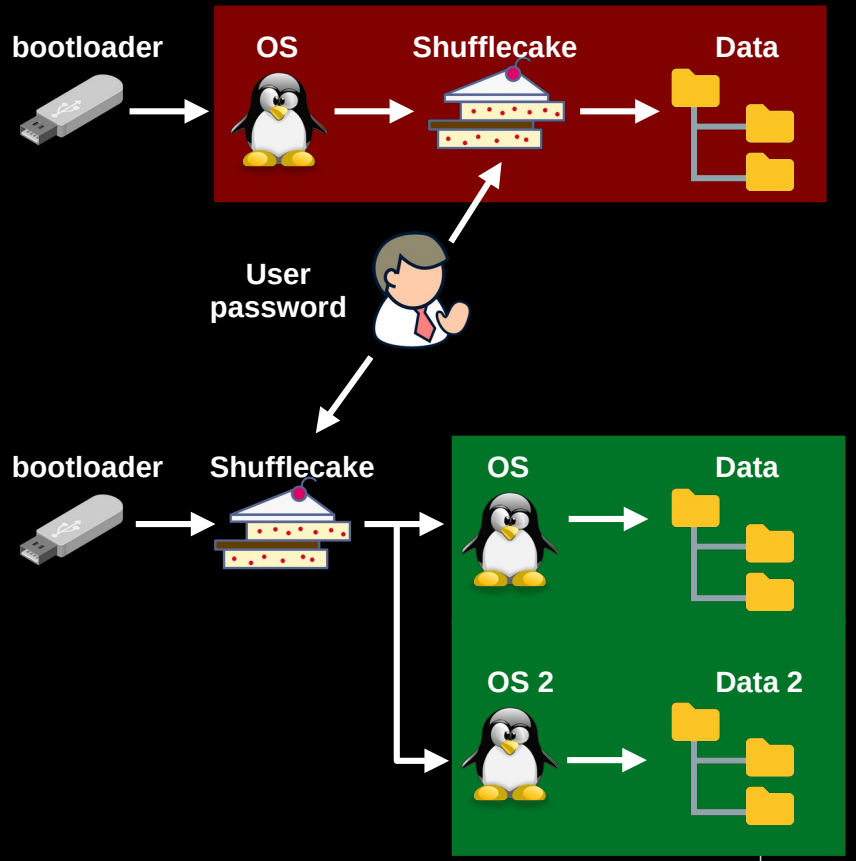

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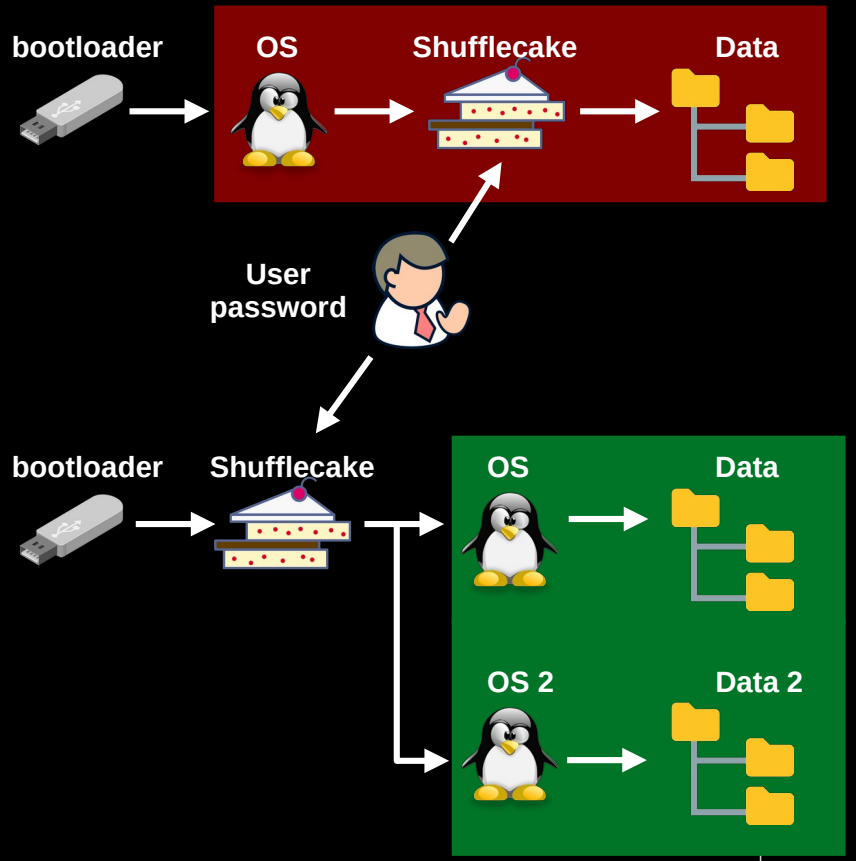

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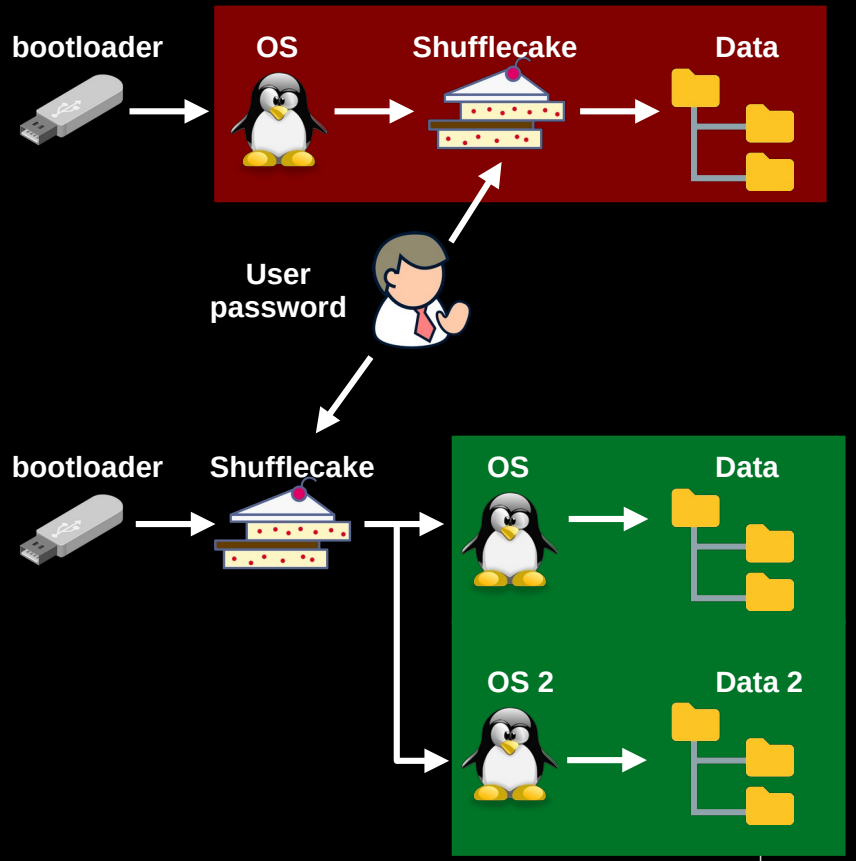
  - We were wrong…



Shufflecake OS

Thanks to the community we now have not only one, but TWO different prototypes for a fully hidden Shufflecake OS!

1) `sflc-boot` by Sidharth Sankar
   - Insert Shufflecake logic at boot time via Dracut module, allowing to boot different OSes on different volumes
   - Versatile: allows e.g. to modify an existing OS or have different kernels or distros

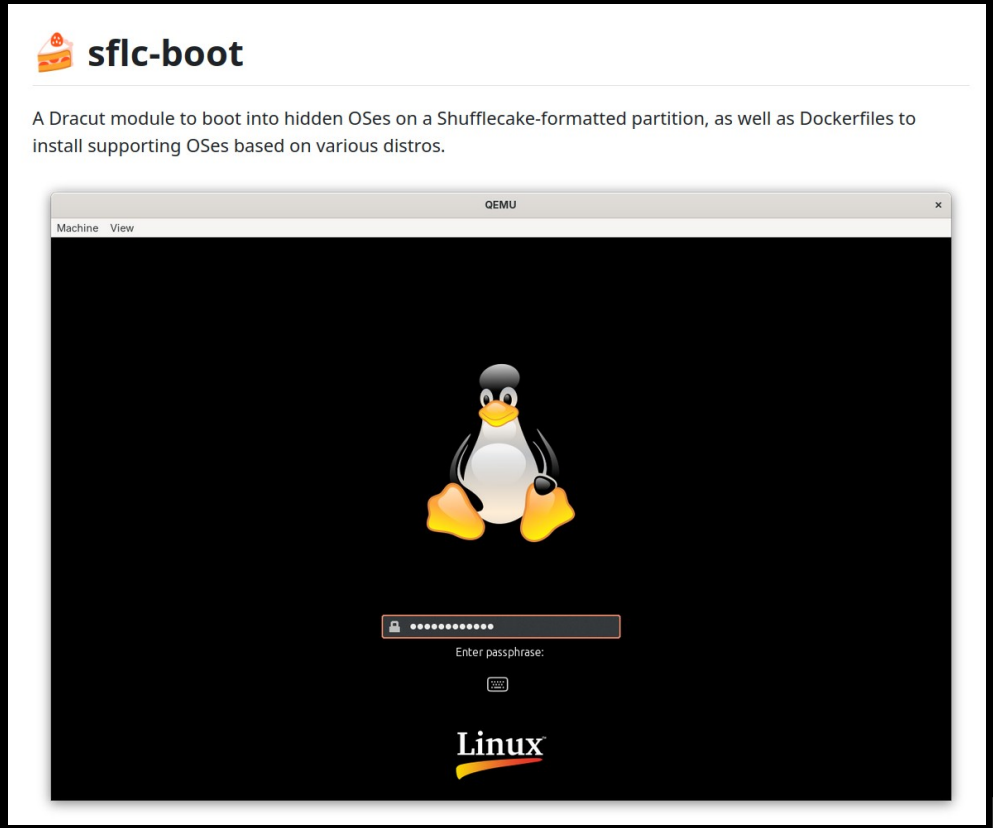
2) `Reliant` by Anderson Rosenberg
   - Modifies QubesOS to load qubes from different Shufflecake volumes
   - Secure: maximum isolation, leverage QubesOS security

sflc-boot

- Specialized Dracut module to boot into hidden OSes on a Shufflecake-formatted partition

1) Install base (decoy) OS
2) Create Shufflecake volumes
3) Clone other OSes in those volumes
4) Install sflc-boot to handle boot time

https://github.com/sidstuff/sflc-boot



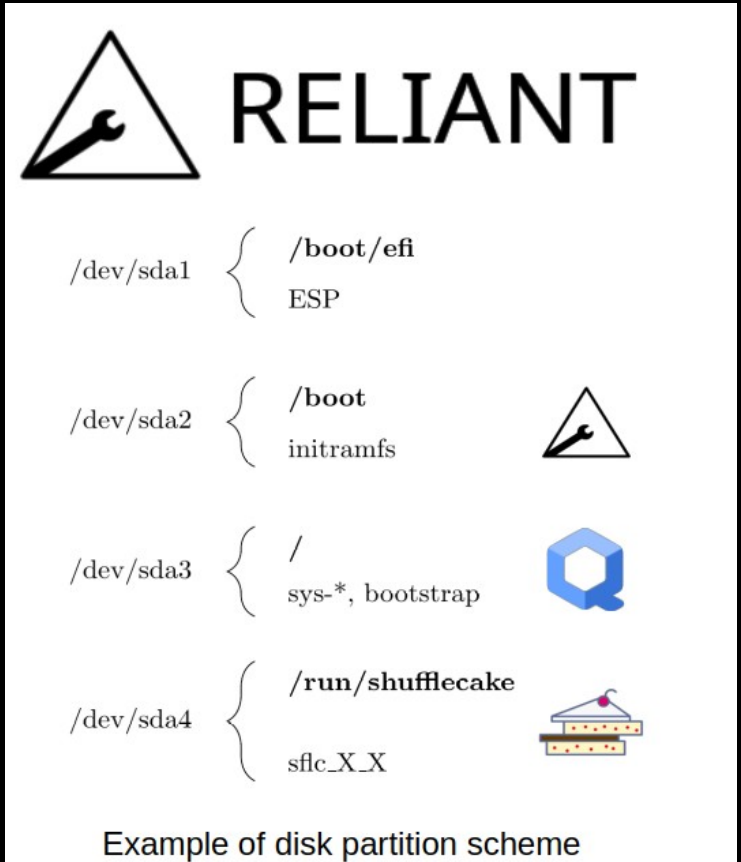
Reliant

An advanced plausible deniability system combining Shufflecake and Qubes OS.

- Eliminates the ‘stale decoy’ problem: hidden and decoy volumes can be used simultaneously
- Qubes OS provides runtime isolation
- Live dom0 prevents metadata leakage
- Memorization daemon included

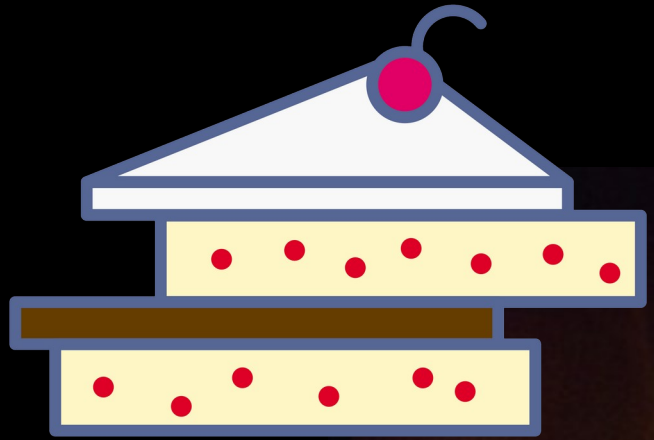
https://codeberg.org/andersonarc/reliant-system

Contact:
anderson.rosenberg@arcscience.org



Example of disk partition scheme

Future Directions



2025 In Review

2025 was a very good year!

- Community expanded, new contributions
- Shufflecake Hidden OS prototypes
- Crazy performance boost
- Full crash consistency
- Garbage collection of unused slices
- Lot of bugfixes

Todos, Chores and contributions

Shufflecake is still an experimental, very low-level tool

- Expand testing to other Linux distros (now: Debian/Ubuntu)
- `make install`
- Distribute through DKMS
- Packetization (.deb, .rpm etc)
- Expand Developer documentation

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- Porting to Rust?
- GUI?
- Port to Windows/iOS/BSD?

Work in progress and plans

- Solidify Shufflecake OS
- Shufflecake “Full”
- Corruption resistance
- Use of volume metadata
- Virtual quotas
- Reclaiming unused slices
- Anti-safeword: unbounded number of volumes

We are founding a Swiss No-Profit for managing the project’s governance!
Are you interested? Come talk to us!

How to contribute

- Code https://codeberg.org/shufflecake
- Mastodon @shufflecake@fosstodon.org
- Website https://shufflecake.net
- E-mail website@shufflecake.net
- XMPP xmpp:shufflecake@conference.draugr.de

Thank you for your attention!

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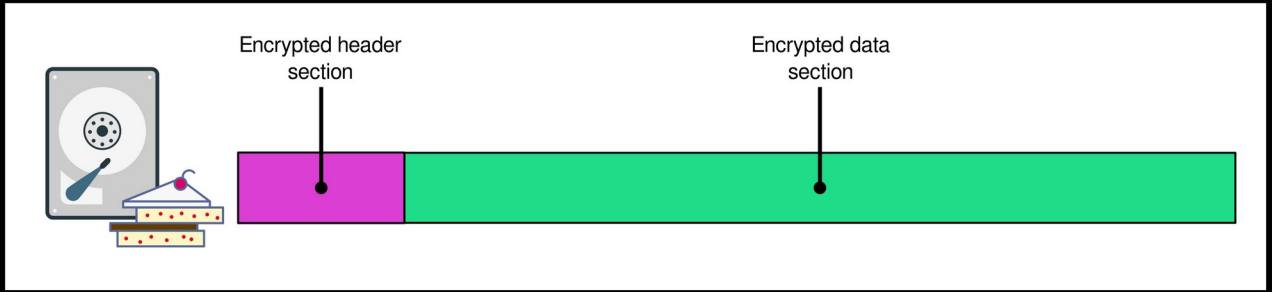
* : with certain restrictions, depending on the “flavor” of PD

Shufflecake: disk layout



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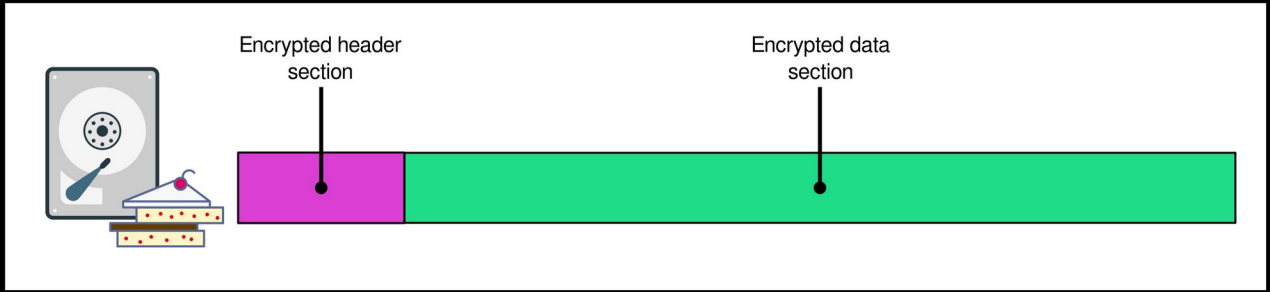

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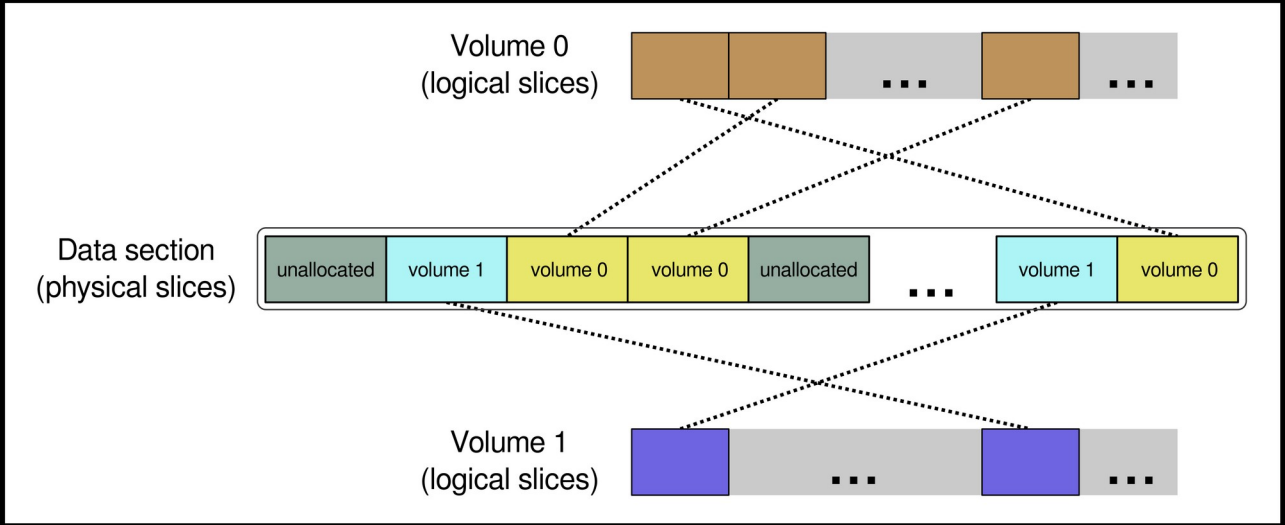
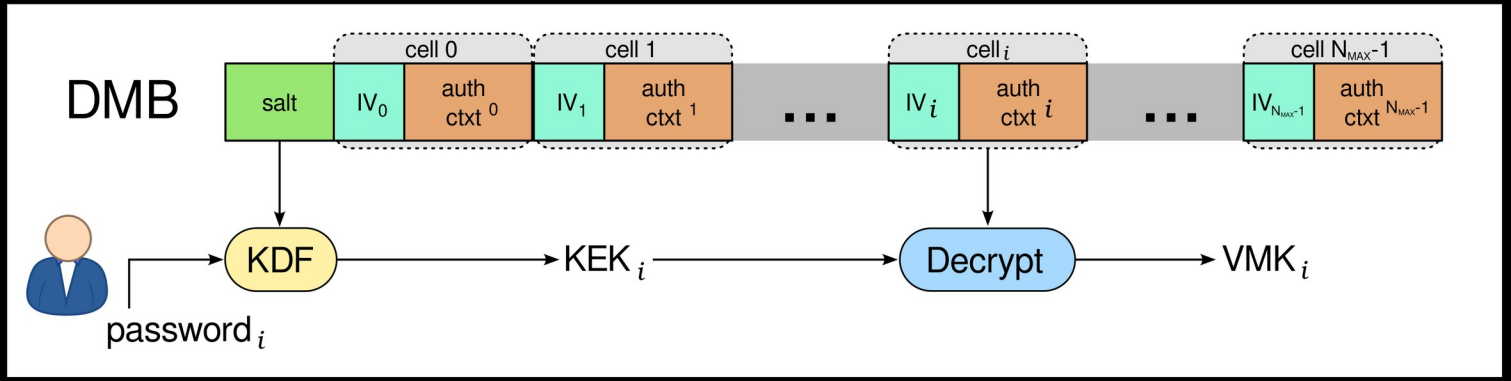


Shufflecake “Legacy”: headers

DMB = Device Master Block VMB = Volume Master Block



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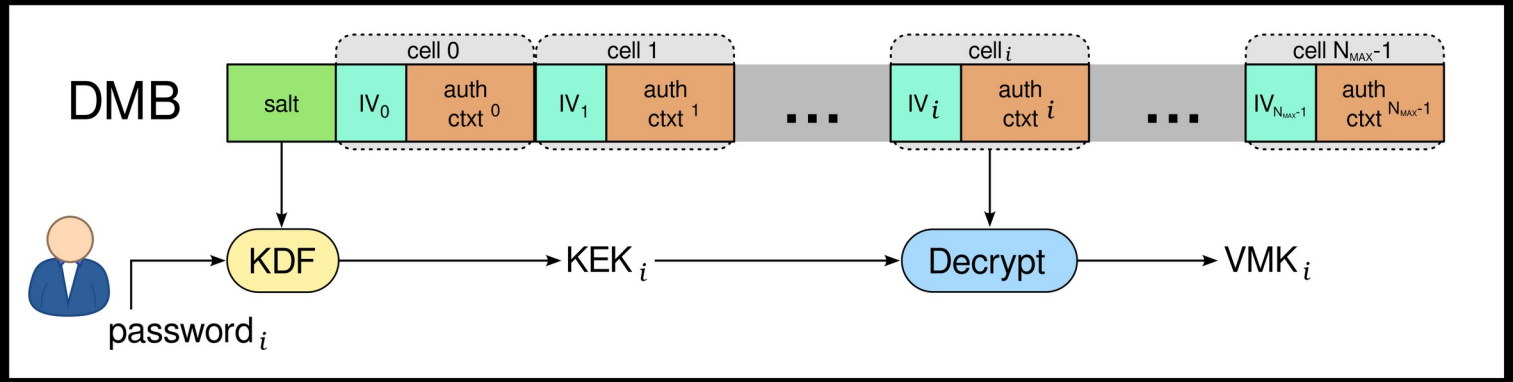

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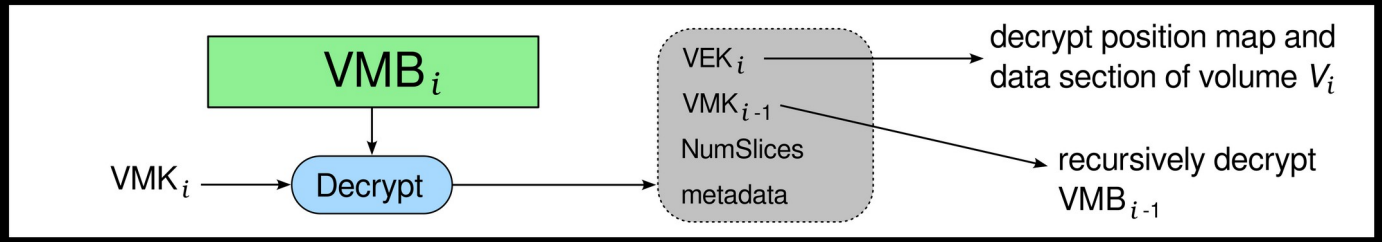

VMK_(i-1) allows to decrypt all VMBs recursively

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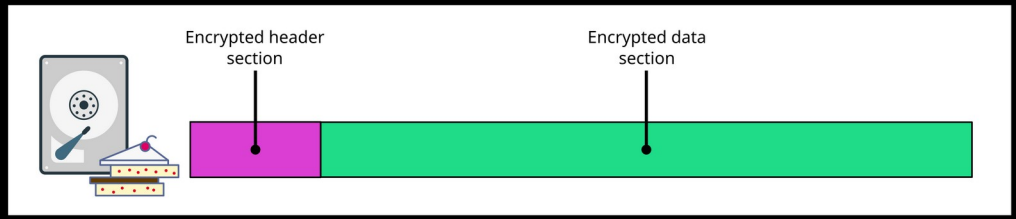
    - Problem understudied: it exists in all PD solutions we are aware of.
    - Only fix: have an unbounded number of nested volumes.

Unbounded number of volumes

- Remember Shufflecake disk layout:
- This clearly cannot work.



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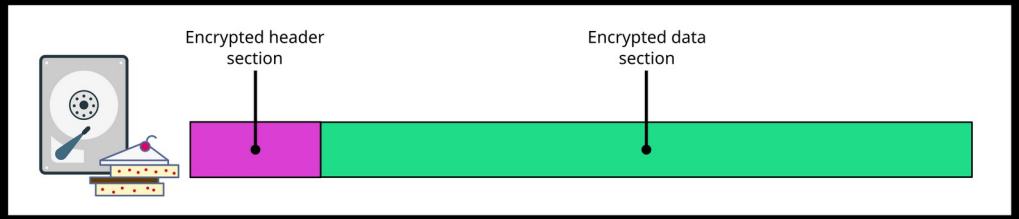

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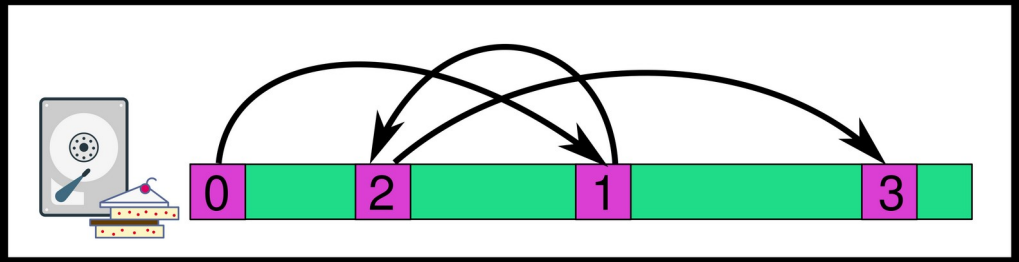

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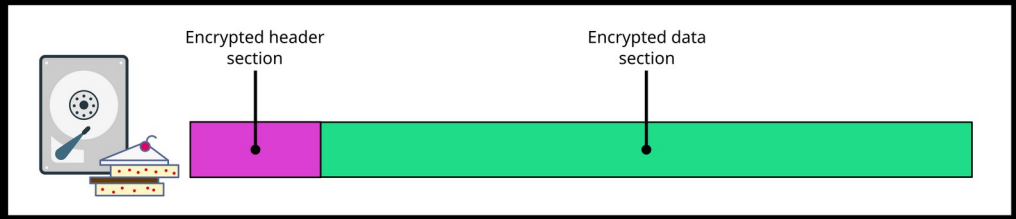

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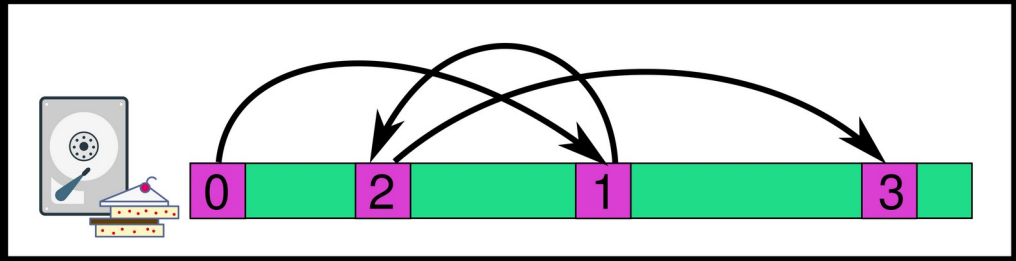

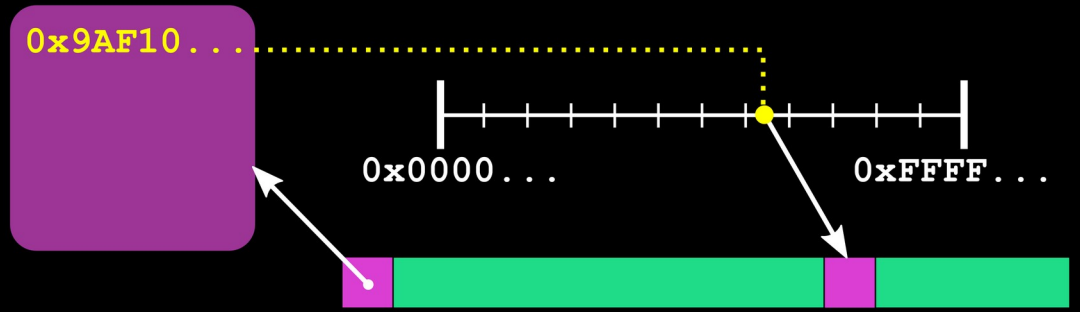

- Linked list, navigation through cleartext randomness
- Position maps split into more list nodes if too large

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Option 2

- Store IV along data block and make write of block atomic
- Minimum addressable block size (on Linux): 512 bytes
- Use 9-block writes (4096 bytes data + 512 bytes IV block)
- Wastes ~11% space but faster, extra space in IV block to be used

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- Obfuscation can be delegated to a daemon (additional component)
- "Poor man's ORAM" in spirit

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- Shufflecake reallocates corrupted slices, but recovery left to external tools
- We are implementing API to help external tools
- Open problem: how to protect not only data blocks, but also position map?

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- Example: mountpoint (and allow Shufflecake to automount)
- Example: corruption status flag
- Example: virtual quotas
  - To limit overcommitment and avoid corruption
  - Every volume's VMB has a virtual quota not for itself, but for the volume below
  - Topmost volume is assigned total space minus sum of virtual quotas