Fedora Silverblue With Disk Encryption:

How I Almost Lost Everything But Gained Much Wisdom (Side Story: Bmaptool And Ddrescue: Why One Should Never Ever Use Dd)

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Speaking today

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ROLE

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Contents

Disaster Struck Timeline

What happened?

- Testing different RADXA ROCK 5B board boot options
  - Booting from eMMC, NVMe, SPI, USB, uSD
- Inadvertently typed `sudo dd of=/dev/nvme0n1` on my notebook!
- Unfortunately the image was around 8 GB in size!
  - Doesn't sound that big given my 2 TB NVMe SSD
- Overwrote entire boot chain plus several GB well into the encrypted system partition
  - no backup of the LUKS header

lsblk (abbreviated)

```
nvme0n1         1.8T  0 disk
├─nvme0n1p1     600M  0 part
/boot/efi
├─nvme0n1p2       1G  0 part
/boot
└─nvme0n1p3     1.8T  0 part
└─luks-24d7de45-bb6d-49f7-914a-9
17810617f8f
```

Gosh, what happened

Disaster Struck – Timeline

```
Oct 02 09:32:41 fedora kernel: hub 8-1.2.4.4.4:1.0: 4 ports detected
=> docked in

Oct 02 09:57:27 fedora sudo[73444]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64/tmp ; USER=root ; COMMAND=/usr/sbin/losetup -P -f --show
disk.img
…
Oct 02 09:58:06 fedora sudo[73490]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64/tmp ; USER=root ; COMMAND=/usr/bin/mount /dev/loop0p1
/mnt
=> poked the disk image

Oct 02 09:59:23 fedora kernel: usb 2-1: new SuperSpeed USB device number 7 using xhci_hcd
Oct 02 09:59:23 fedora kernel: usb 2-1: New USB device found, idVendor=0781, idProduct=5591,
bcdDevice= 1.00
Oct 02 09:59:23 fedora kernel: usb 2-1: New USB device strings: Mfr=1, Product=2,
SerialNumber=3
Oct 02 09:59:23 fedora kernel: usb 2-1: Product:  SanDisk 3.2Gen1
=> plugged in USB stick which should have been written instead
```

Disaster Struck – Timeline

```
Oct 02 10:00:53 fedora sudo[73877]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64 ; USER=root ; COMMAND=/usr/bin/ls
=> dirty trick doing a sudo ls to prime shell for disaster?

Oct 02 10:00:59 fedora sudo[73889]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64 ; USER=root ; COMMAND=/usr/bin/dd conv=fsync
of=/dev/nvme0n1 bs=4M status=progress
=> here you go, disaster struck!

Oct 02 10:01:22 fedora udisksd[1379]: Error getting '/dev/nvme0n1p3' metadata_size:
Failed to initialize device: No such device (g-bd-crypto-error-quark, 1)
=> yep, udisksd kinda noticed it pretty quick

Oct 02 10:01:51 fedora sudo[73926]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64 ; USER=root ; COMMAND=/usr/sbin/blockdev
--flushbufs /dev/sda
=> yes, I flushed the USB stick :)
```

Disaster Struck – Timeline

```
Oct 02 10:02:13 fedora kernel: usb 2-1: USB disconnect, device number 7
Oct 02 10:02:13 fedora systemd-homed[1376]: block device
/sys/devices/pci0000:00/0000:00:08.1/0000:c1:00.3/usb2/2-1/2-1:1.0/host0/target0:0:0/0:0:0:0
/block/sda/sda1 has been removed.
=> removed it and tried on my embedded system without much luck :(

Oct 02 10:06:35 fedora sudo[74347]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64 ; USER=root ; COMMAND=/usr/bin/dd conv=fsync
of=/dev/nvme0n1 bs=4M status=progress
=> so I actually re-tried it again a few minutes later (from command history)

Oct 02 10:06:58 fedora udisksd[1379]: Error getting '/dev/nvme0n1p3' metadata_size: Failed
to initialize device: No such device (g-bd-crypto-error-quark, 1)
=> yep, udisksd is still not happy

Oct 02 10:07:08 fedora sudo[74363]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64 ; USER=root ; COMMAND=/usr/sbin/blockdev --flushbufs
/dev/sda
=> :)
```

Disaster Struck – Timeline

```
Oct 02 10:07:15 fedora kernel: usb 2-1: USB disconnect, device number 9
…
Oct 02 10:07:15 fedora systemd-homed[1376]: block device
/sys/devices/pci0000:00/0000:00:08.1/0000:c1:00.3/usb2/2-1/2-1:1.0/host0/target0:0:0/0:0:0:0
/block/sda has been removed.
=> removed it again

Oct 02 10:07:21 fedora kernel: usb 2-1: new SuperSpeed USB device number 10 using xhci_hcd
Oct 02 10:07:21 fedora kernel: usb 2-1: New USB device found, idVendor=0951, idProduct=1666,
bcdDevice= 1.00
Oct 02 10:07:21 fedora kernel: usb 2-1: New USB device strings: Mfr=1, Product=2,
SerialNumber=3
Oct 02 10:07:21 fedora kernel: usb 2-1: Product: DataTraveler 3.0
Oct 02 10:07:21 fedora kernel: usb 2-1: Manufacturer: Kingston
=> trying another brand USB stick?

Oct 02 10:21:19 fedora sudo[74954]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64 ; USER=root ; COMMAND=/usr/bin/dmesg
=> wait a minute, …
```

Disaster Struck – Timeline

```
Oct 02 10:21:36 fedora sudo[74966]:      zim : TTY=pts/9 ;
PWD=/var/home/zim/Downloads/aarch64 ; USER=root ; COMMAND=/usr/bin/dmesg
=> something doesn't feel right

Oct 02 10:26:59 fedora kernel: usb 1-4: reset full-speed USB device number 2 using
xhci_hcd
=> undocked

Oct 02 10:27:04 fedora sudo[75226]:      zim : TTY=pts/2 ; PWD=/tmp ; USER=root ;
COMMAND=/usr/bin/ls -l /boot/efi/
…
Oct 02 10:27:51 fedora sudo[75284]:      zim : TTY=pts/2 ; PWD=/tmp ; USER=root ;
COMMAND=/usr/bin/tar cfj boot-efi.tar.bz /boot/efi
…
Oct 02 10:28:13 fedora sudo[75295]:      zim : TTY=pts/2 ; PWD=/tmp ; USER=root ;
COMMAND=/usr/bin/tar cfj boot.tar.bz /boot
=> poked and backed-up my boot chain
```

Disaster Struck – Timeline

```
Oct 02 10:28:13 fedora kernel: EXT4-fs warning (device nvme0n1p2):
ext4_dirblock_csum_verify:406: inode #23: comm tar: No space for
directory leaf checksum. Please run e2fsck -D.
Oct 02 10:28:13 fedora kernel: EXT4-fs error (device nvme0n1p2):
htree_dirblock_to_tree:1083: inode #23: comm tar: Directory block failed
checksum
=> /boot partition starts going bad

Oct 02 10:29:45 fedora flatpak[75414]: libostree pull from 'flathub' for
app/com.slack.Slack/x86_64/stable complete
=> updates running in the background don't help
```

Disaster Struck – Timeline

```
Oct 02 10:30:01 fedora kernel: BTRFS error (device dm-0): bad tree block start, mirror
1 want 762494976 have 11287069813007085624
Oct 02 10:30:01 fedora kernel: BTRFS error (device dm-0): bad tree block start, mirror
2 want 762494976 have 16203133442273220086
Oct 02 10:30:01 fedora kernel: BTRFS error (device dm-0 state A): Transaction aborted
(error -5)
Oct 02 10:30:01 fedora kernel: BTRFS: error (device dm-0 state A) in
__btrfs_free_extent:3235: errno=-5 IO failure
=> now system partition went bad

Oct 02 10:30:01 fedora kernel: BTRFS info (device dm-0 state EA): forced readonly
Oct 02 10:30:01 fedora kernel: BTRFS error (device dm-0 state EA): failed to run
delayed ref for logical 34041208832 num_bytes 12288 type 178 action 2 ref_mod 1: -5
Oct 02 10:30:01 fedora kernel: BTRFS: error (device dm-0 state EA) in
btrfs_run_delayed_refs:2223: errno=-5 IO failure
=> the end of the journal as we know it
```

Disk Encryption

Block Device Encryption

- Encrypts/decrypts data transparently
- Underlying block device sees only encrypted data
- Passphrase required to mount
- Additional security beyond existing OS security mechanisms
- Protects device contents even if physically removed from system

During installation in Anaconda

Checking "Encrypt System" checkbox on "Automatic Partitioning" screen

Better safe than sorry

Using dm-crypt/LUKS

LUKS (Linux Unified Key Setup)

- specification for block device encryption
- on-disk format for the data
- passphrase/key management policy

LUKS uses kernel device mapper subsystem via dm-crypt module

- low-level mapping handling encryption and decryption
- user-level operations (creating/ accessing encrypted devices) using cryptsetup utility

system startup

– presented with passphrase prompt

– enter correct passphrase

– system will continue to boot normally

Seamless.

LUKS Overview

- Encrypts entire block devices
- Protecting contents of mobile devices
  - Removable storage media
  - Laptop disk drives
- Underlying contents of encrypted block device are arbitrary
- Useful for encrypting swap devices
- Can be useful with certain databases using specially formatted block devices for data storage
- Uses existing device mapper kernel subsystem (like LVM, so well tested)
- Provides passphrase strengthening
- Protects against dictionary attacks
- LUKS devices contain multiple key slots
- Allows users to add backup keys/passphrases

LUKS not well-suited

- for applications requiring many (>8) users to have distinct access keys to same device
- for applications requiring file-level encryption

Tooling

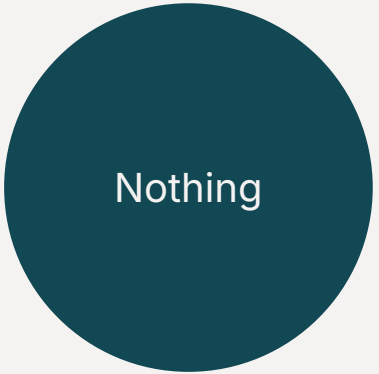
cryptsetup

Command-line tool for managing LUKS-encrypted disks

systemd-cryptsetup

Automatically unlocking encrypted disks at boot (e.g. using a keyfile)

ToDO



So far so good.

Fedora Silverblue Lessons Learned

During/After Installation

/boot partition is way too small (1 GB)

– limits (pinned) deployments

– disaster case overwrote important data way beyond

– suggest using at least 16 GB

Backup LUKS header

```
sudo cryptsetup luksHeaderBackup
/dev/nvme0n1p3 --header-backup-file
luks-header.img
```

– in case it ever gets corrupted

– typically only 16 MB

and

– backup your keys

Don't wait for disaster to strike.

Fedora Silverblue as a Daily Driver

- Use flatpak and toolbox aka toolbx :)
  - just relax - it works
  - if not flatseal might help
  - okay, worst case just copy your favourite/important tool from a toolbx to ~/.local/bin (;-p)
  - see below under bmaptool usage
- python
  - just use venv
- Blindness?
  - `gsettings set org.gnome.mutter experimental-features "['scale-monitor-framebuffer']"`

use upstream flathub

```
flatpak remove --all
flatpak remote-delete fedora
flatpak remote-add --if-not-exists
flathub
https://flathub.org/repo/flathub.
flatpakrepo
```

So far so good.

Libostree (previously OSTree)

- `sudo rpm-ostree status`
- `sudo ostree log fedora:fedora/41/x86_64/silverblue`
- `sudo rpm-ostree deploy 41.20250129.0`
- `sudo ostree remote refs fedora`
- `sudo rpm-ostree rebase fedora:fedora/41/x86_64/silverblue`
- ostree pinning
  - `sudo ostree admin pin 0`
  - `sudo ostree admin pin --unpin 3`

what is it?

– system for versioning updates of Linux-based operating systems

– "git for operating system binaries"

Atomic.

More Advanced Tricks

how about wireshark?

– gosh, did you seriously miss my USB talk (see references below)?

```
- sudo ~/.local/bin/tcpdump -i wlp1s0
  -U -w - | flatpak run
  --filesystem=host --file-forwarding=
  host --share=network
  org.wireshark.Wireshark -k -i -
```

and meld?

```
- alias meld='flatpak run
  org.gnome.meld'
```

ToDO

Watch my other talks :)

Anything can be made to work.

Bonus Track: DHCP/TFTP Servers (e.g. for Embedded use)?

```
sudo nmcli con add type vlan ifname devnet dev eth0 id 91 ip4 192.168.10.1/24 gw4
192.168.10.1
sudo nmcli con up vlan-devnet
sudo firewall-cmd --add-masquerade --permanent
sudo firewall-cmd --add-service=dhcp --permanent
sudo firewall-cmd --add-service=dns --permanent
sudo firewall-cmd --add-service=tftp --permanent
sudo firewall-cmd --zone=FedoraWorkstation --add-interface=devnet --permanent
sudo firewall-cmd --reload
sudo nmcli connection modify vlan-devnet ipv4.method shared
sudo nmcli connection modify vlan-devnet ipv6.method shared
sudo systemctl restart NetworkManager
sudo chmod -R 777 /var/lib/tftpboot
sudo chcon -Rt tftpdir_t /var/lib/tftpboot
[zim@fedora ~]$ cat /etc/NetworkManager/dnsmasq-shared.d/dhcp-tftp.conf
enable-tftp
tftp-root=/var/lib/tftpboot
dhcp-boot=flash.bin
dhcp-host=00:14:2d:67:28:6a,192.168.10.2
dhcp-range=192.168.10.2,static
```

Bmaptool

Generic Tool

- creating block map (bmap) for a file
- copying files using block map

faster and more reliable

- large files
  - raw system image files

- originally created for "Tizen IVI" project
- written in Python

faster depends on various factors

- write speed
- image size
- how full an image aka sparseness
- proves 5-7 times faster

Got it.

Integrity/Usability

Integrity

– verifies data integrity while flashing

– possible data corruptions noticed immediately

Usability

– read images directly from remote server

– no need to download images and save them locally

protects user's data

– mistake like specifying wrong block device name

– less likely destroy your data

– protection mechanisms: prevent writing to mounted block device

Aha!

Usage

```
zim@fedora:~$ sudo PYTHONPATH=~/.local/lib/python3.12/site-packages/ ~/.local/bin/bmaptool
--help
Place your finger on the fingerprint reader
^C[sudo] password for zim:
usage: bmaptool [-h] [--version] [-q] [-d] {create,copy} ...

A tool for creating block maps (bmap) and copying disk images using bmap files.
Documentation can be found here:
source.tizen.org/documentation/reference/bmaptool

options:
  -h, --help      show this help message and exit
  --version       show program's version number and exit
  -q, --quiet     be quiet
  -d, --debug     print debugging information

commands:
  {create,copy}
    create        generate bmap for an image file (which should be a sparse file)
    copy          write an image to a block device using bmap
```

Concepts

Sparse files

– filesystem maps blocks of file data to disk sectors
– disk index points to mapped blocks
– "free" area not mapped yet
– unmapped, contain "holes"

Block map

– xml file contains list of mapped areas

Raw images

– system images for target block devices
e.g. for embedded systems

okay

– mapping none-holes basically

Interesting.

Sparse files

- help save disk space as holes do not occupy any disk space
- reading data from a hole returns zeroes
- writing data to a hole destroys it by forcing file system to map corresponding file areas to disk sectors
- filesystems usually block based so mapping adheres to block boundary

not all tooling can handle sparse files (e.g. scp)

– some tooling requires a parameter (e.g. --sparse for tar and rsync)

Sweet.

Sparse Files – Multiple Implementations in Linux

- 2 ioctls to find mapped and unmapped areas
  - FIBMAP: old, widely supported, rather limited, requires root privileges
  - FIEMAP: more advanced, does not require root privileges
- lseek() system call with whence argument of SEEK_HOLE and SEEK_DATA
  - Allows positioning to next hole and next mapped area of a file
- fallocate() system call with FALLOC_FL_PUNCH_HOLE mode
  - punching holes: unmap aligned area, turn it into a hole

but

not all file systems support all or even one such mechanism

Welcome to the "real" world.

Ddrescue

GNU ddrescue

`ddrescue`

– data recovery tool

– copies data from one file or block device to another

– trying to rescue good parts first in case of read errors

`ddrescuelog`

– auxiliary tool

– manipulate ddrescue mapfiles

– basic operation fully automatic

and

No need to wait for an error, stop/restart, etc

Sounds promising.

Why One Should Never Ever Use Dd

Why One Should Never Ever Use Dd

Doesn't do any sanity checks

– overwrite mounted partition
– writing beyond partition boundary

Just stops encountering any error

– left with corrupt/partial data
– no easy way to continue

Worst-case

– forgot what happened?

and best-case

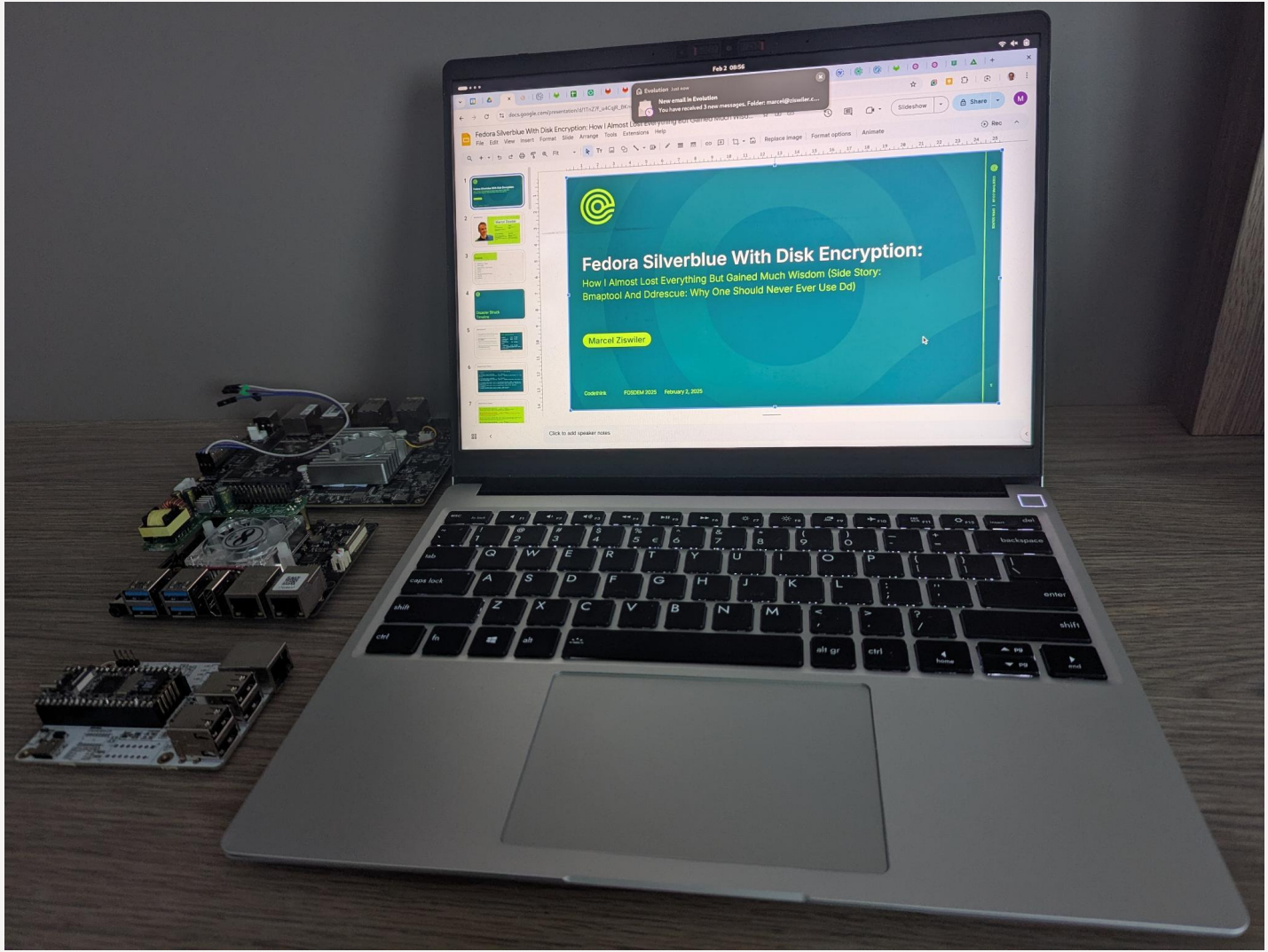
– it's just slow

– dirt slow

Let the matter rest!

Live Demo

Live Demo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References

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- Bmaptool
  https://github.com/yoctoproject/bmaptool
- Ddrescue
  https://www.gnu.org/software/ddrescue

Thank You.

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