Smart Virtual Machine Backup
Incremental Backups Without Bitmap Indexes

- **mag. Sergej Rožman**; Abakus plus d.o.o.

- The latest version of this document is available at: http://www.abakus.si/

BACKUP PLAN

SMART INCREMENTAL BACKUPS

DO WE REALLY NEED ANOTHER FULL BACKUP?

WHY BACK UP THE SAME OLD STUFF? BE SMART! BACK UP ONLY WHAT CHANGED!

FULL?

BACKUP LIKE A BOSS

BACKUP HERO

TRUST BUT VERIFY

DATA NINJA

BACKUP WISDOM

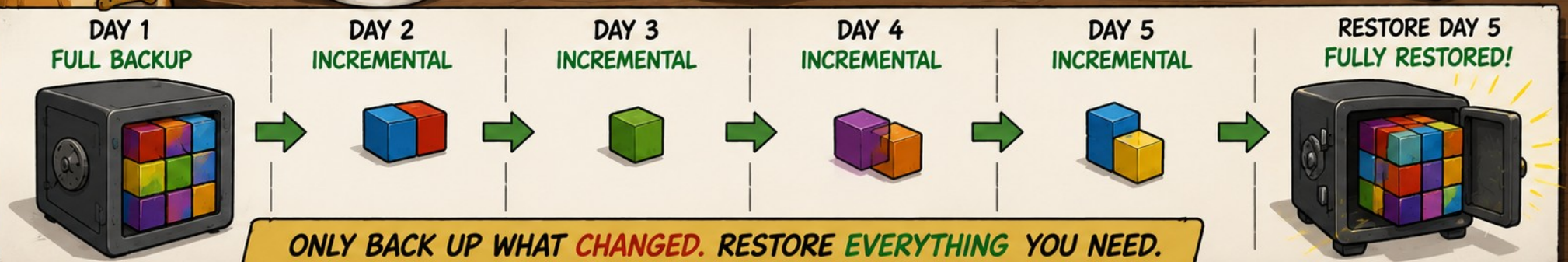
THE ART OF RESTORE

WORK SMARTER, NOT HARDER!

INCREMENTAL = INTELLIGENT

- FULL BACKUP: EVERYTHING.
- INCREMENTAL BACKUP: ONLY THE CHANGES SINCE THE LAST BACKUP.
- RESTORE: REBUILD THE FULL PICTURE FROM THE PIECES.

LESS DATA.
LESS TIME.
LESS STRESS.
MORE COFFEE.



ONLY BACK UP WHAT CHANGED. RESTORE EVERYTHING YOU NEED.

Abakus
As na disku.

Smart Virtual Machine Backup

(Incremental Backups Without Bitmap Indexes)

mag. Sergej Rožman

sergej.rozman@abakus.si

Make IT 2026

NOVA BANKA · MILENIJUM® OSIGURANJE · DRINA OSIGURANJE · PRVA · NLB Vita Življenjska zavarovalnica · SAVA INFOND

Gorenjska Banka · GENERALI Zavarovalnica · BANKA SLOVENIJE · Фонд здравственог осигурања Републике Српске · NLB Skladi

Abakus plus d.o.o.

Providing Mission-Critical IT Stability Since 1992

FLAGSHIP SOFTWARE

APPM – Advanced system performance monitoring.
ARBITER – Ultimate tool for enterprise audit trailing.

HARDWARE & SECURITY

Enterprise Servers & SAN Storage solutions.

MANAGED SERVICES

Oracle Database Administration (DBA).
GNU/Linux OS Administration.

TEAM PROFILE

~20 highly specialized senior engineers.
Dedicated to mission-critical availability.

PIONEERING EXPERIENCE

GNU/Linux Expertise
30 years of experience (since 1995).

Virtualization
Production KVM environments (since 2007).

Oracle Pioneers
Running Oracle on Linux since RDBMS 7.1.5 (before official support).

Customers

Gorenjska Banka

GENERALI Zavarovalnica

Ljubljana Airport

Iskra

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA OBRAMBO

NOVA BANKA

MILENIJUM® OSIGURANJE

NAŠABANKA

MM KARTON

KONTROLA ZRAČNEGA PROMETA SLOVENIJE

Hidria

Mestna občina Ljubljana

DRINA OSIGURANJE

PH

triglav

GOODYEAR

TRELLEBORG

UNIVERZITETNA PSIHIATRIČNA KLINIKA LJUBLJANA
University Psychiatric Clinic Ljubljana

BANKA SLOVENIJE

Blubit

SAVA INFOND

MAGNETIK

PRVA

ELES

Фонд здравственог осигурања Републике Српске

NLB Vita
Življenjska zavarovalnica

G96

EKDIS

CENTROSINERGIJA

SAVA HOTELS & RESORTS

terme čatež

NLB Skladi

Splošna bolnišnica Celje

Mercator

SPL d.d.

editel

INFOTRANS

LASERLINE

studio ritem

PRONET
CHOOSE THE FUTURE

hit alpinea
Kranjska Gora

ZAVOD ZA ŠPORT RS PLANICA

ORACLE

ROS d.o.o.

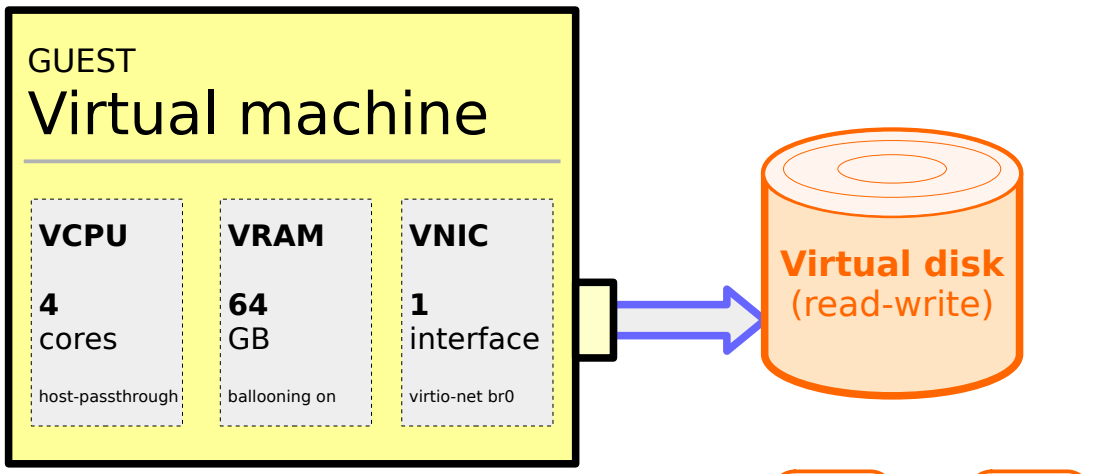
sij acroni

ANDRITZ

jata emona
LJUBLJANA

ADRIA ANKARAN
HOTEL & RESORT

Subject of Interest

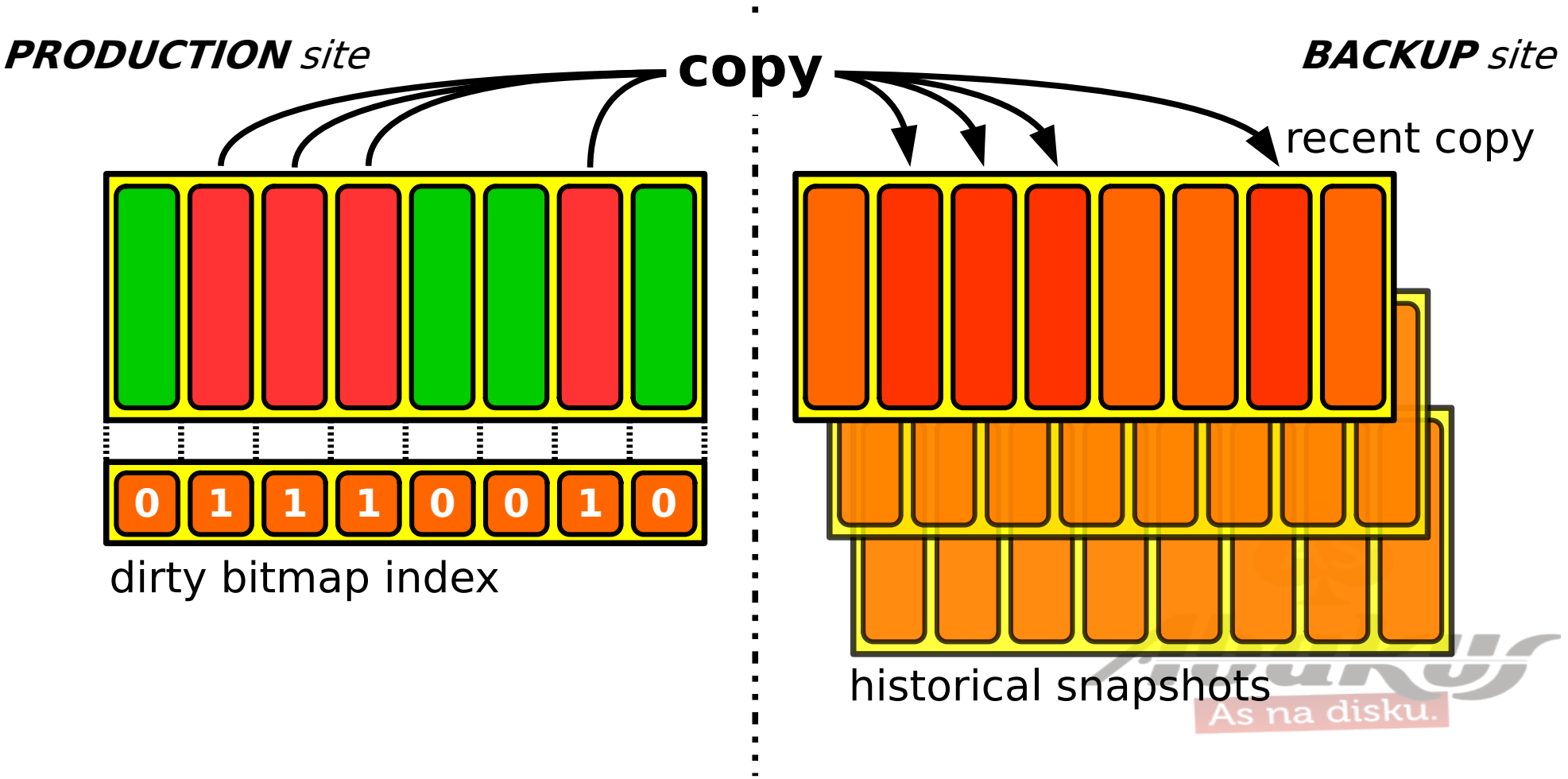


TYPE image or device

FORMAT raw or qcow2

Abakus
As na disku.

Bitmap Incremental Backup



Pros & Cons Bitmap Indexes

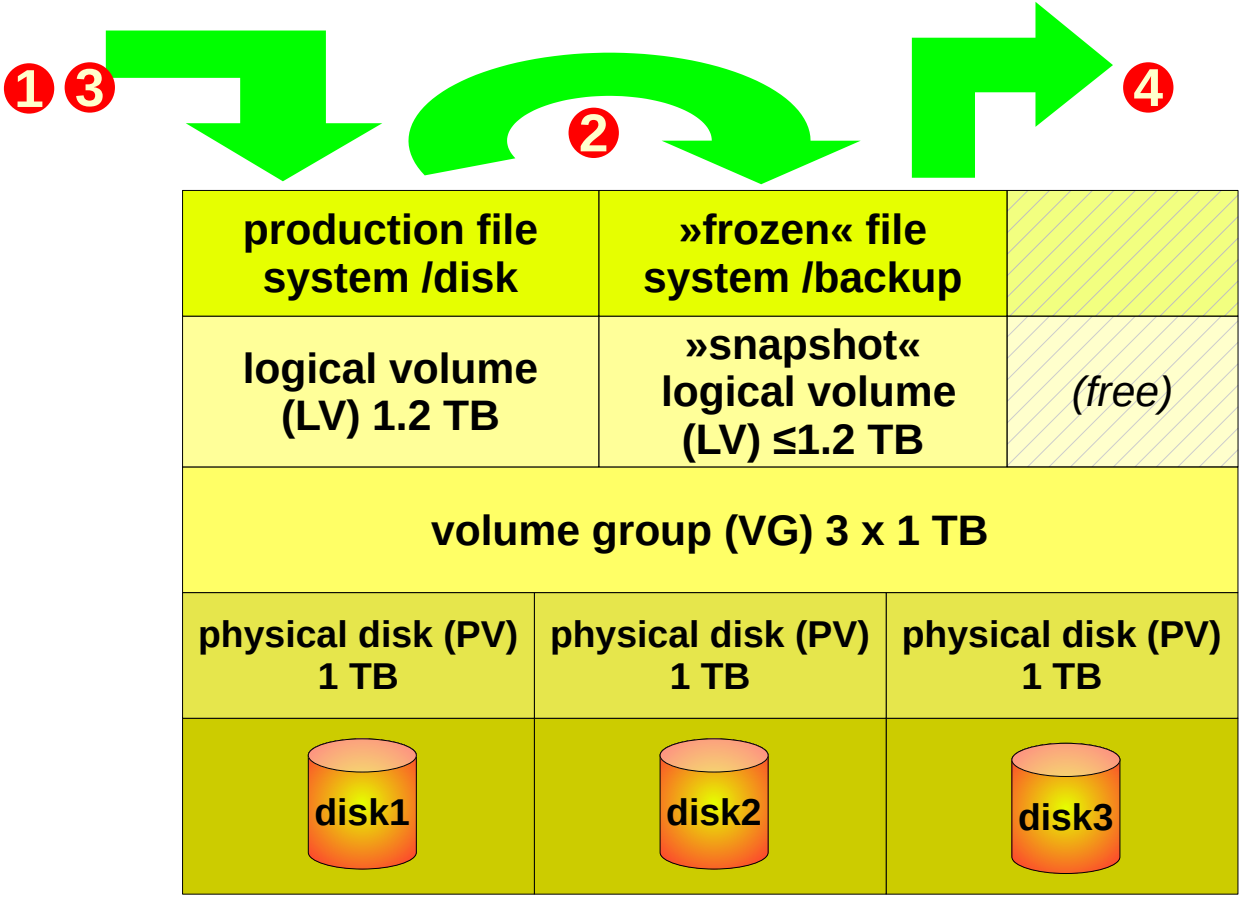
- ✔ Industry-Standard and Proven Methodology
- ✔ Highly Efficient and Purpose-Built
- ✔ Deep Native Hypervisor Integration

- ✖ Storage Format Constraints (Lack of RAW Support)
- ✖ Vulnerability to Bitmap Invalidation (Crashes & Maintenance)
- ✖ Inherent Limitations in Backup Validation
- ✖ RAM and Performance Overhead during High I/O

Urh Srečnik: OLVM Incremental Backups (2022)
https://www.abakus.si/download/events/2022_urh_srecnik_olvm_backup.pdf

AS Abakus As na disku.

LVM snapshots (COW Copy-On-Write)



Operations / Step-by-Step Execution:

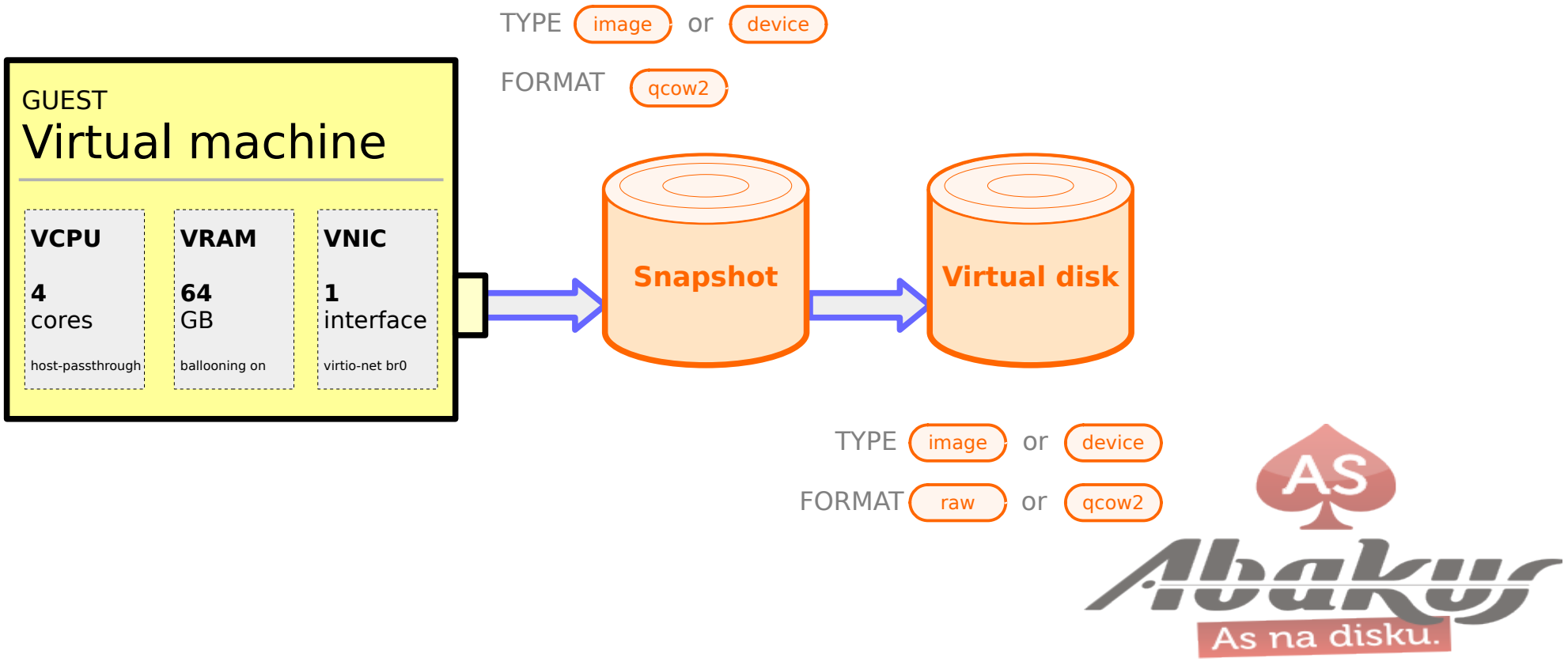
1. Intercepting the Write Intent
2. Relocating the Original Block (Copy-on-Write)
3. Commiting the New Write
4. Reading/Extracting the Frozen State (Consistent Backup)

LVM snapshots (COW)

- ✔ Proven and Enterprise-Ready Solution
- ✔ Consistent Backups (Online Backups)
- ✔ Flexible Storage Footprint

- ✖ Write Performance Degradation (CoW Overhead); single read + double write
- ✖ Cascading Performance Drop with Multiple Snapshots
- ✖ Lack of Native Cascading (Nested) Snapshots
- ✖ Risk of Snapshot Overflow (Dropping)

Snapshots (ROW - Redirect-On-Write)

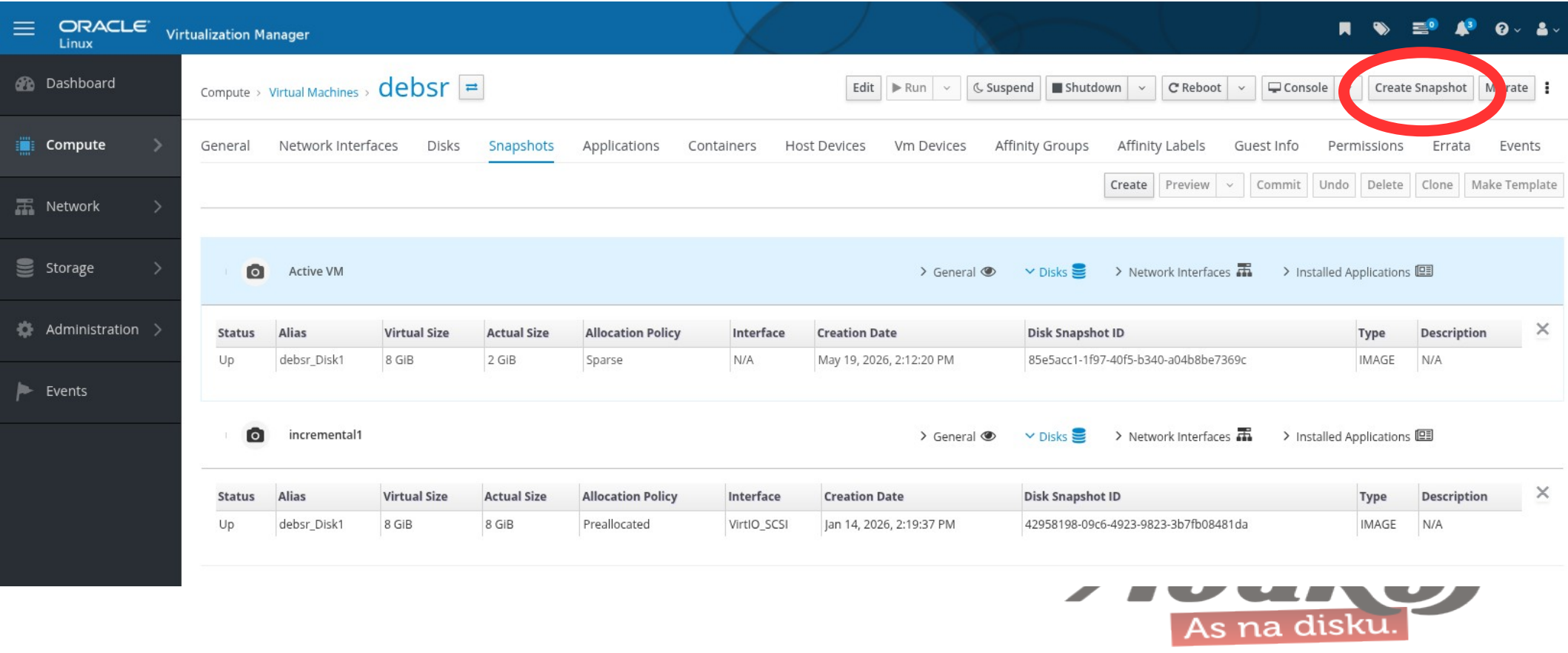


Comparison: COW vs. ROW

Feature / Criteria	Copy-on-Write (COW)	Redirect-on-Write (ROW)
Primary Use Cases	LVM, certain hardware RAID controllers	QEMU (qcow2), VMware, NetApp
Write Operation	Writes to the original space (after copying old data)	Writes to a new location (frontend allocation)
Write Speed	Slower (Write Penalty due to I/O overhead)	Fast (no additional background I/O operations)
Read Speed (Old Data)	Fast (direct read from the original unfragmented block)	Can be slower (requires searching through the snapshot chain)
Complexity / Overhead	Simple management and tracking	File chaining (Chain fragmentation and lookup overhead)

As na disku.

Snapshots – OLVM (Oracle Linux Virtualization Manager)



As na disku.

Snapshots – OLVM

storage

- /rhev/data-center/mnt/blockSD/<Storage-Domain-UUID>/images/<Image-UUID>/**<Volume-UUID>**

example

- **base image:**
  /rhev/data-center/mnt/blockSD/4c852b95-399d-4df8-8427-88e876c7db95/images/b5cbb7af-19cd-465b-8d2a-b7f3be54042e/**42958198-09c6-4923-9823-3b7fb08481da**
- **snapshot:**
  /rhev/data-center/mnt/blockSD/4c852b95-399d-4df8-8427-88e876c7db95/images/b5cbb7af-19cd-465b-8d2a-b7f3be54042e/**85e5acc1-1f97-40f5-b340-a04b8be7369c**

Abakus
As na disku.

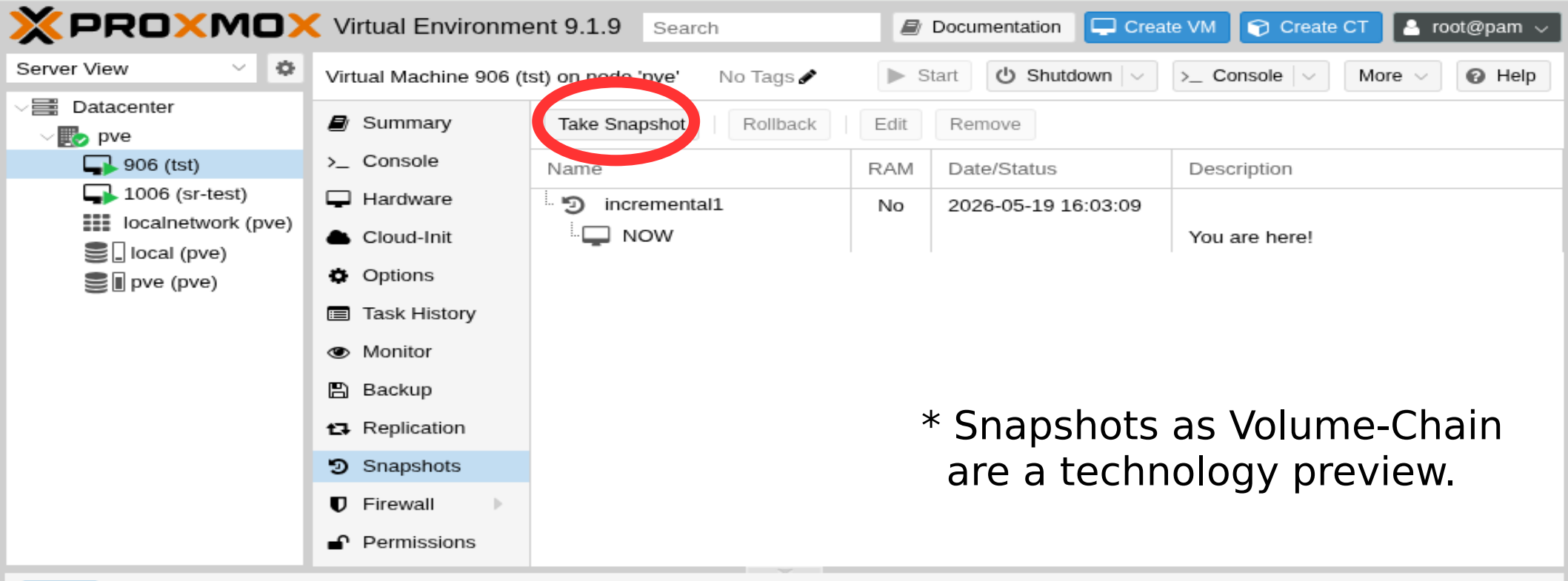
Snapshots – OLVM

Layout:

```
# file -sL *
42958198-09c6-4923-9823-3b7fb08481da:
  DOS/MBR boot sector; partition 1 : ID=0xee, start-CHS (0x0,0,2),
  end-CHS (0x3ff,255,63), startsector 1,
  16777215 sectors, extended partition table (last)

85e5acc1-1f97-40f5-b340-a04b8be7369c:
  QEMU QCOW Image (v3),
  has backing file (path 42958198-09c6-4923-9823-3b7fb08481da),
  8589934592 bytes
```

Snapshots – Proxmox VE (since 9.0*)



* Snapshots as Volume-Chain are a technology preview.

Snapshots – Proxmox VE

Layout:

```
# lvs
LV                                          VG   Attr        LSize
snap_vm-906-disk-1_incremental1.qcow2 pve  -wi-ao----  <32,02g
vm-906-disk-1.qcow2                         pve  -wi-ao----  <32,02g


# file -sL /dev/pve/vm-906-disk-1.qcow2

/dev/pve/vm-906-disk-1.qcow2: QEMU QCOW Image (v3),
  has backing file (path snap_vm-906-disk-1_incremental1.qcow2,
  mtime Thu Jan  1 00:00:17 1970), 34368126976 bytes (v3),
  has backing file (path snap_vm-906-disk-1_incremental1.qcow2), 34368126976 bytes
```

Snapshots – libvirt

libvirt virtualization API – https://libvirt.org/index.html

```
virsh snapshot-create-as debsr \
  --name "snap-$(date +%Y%m%d-%H%M)" \
  --disk-only \
  --diskspec sda,snapshot=external,file=/backups/incremental1.qcow2 \
  --atomic
```

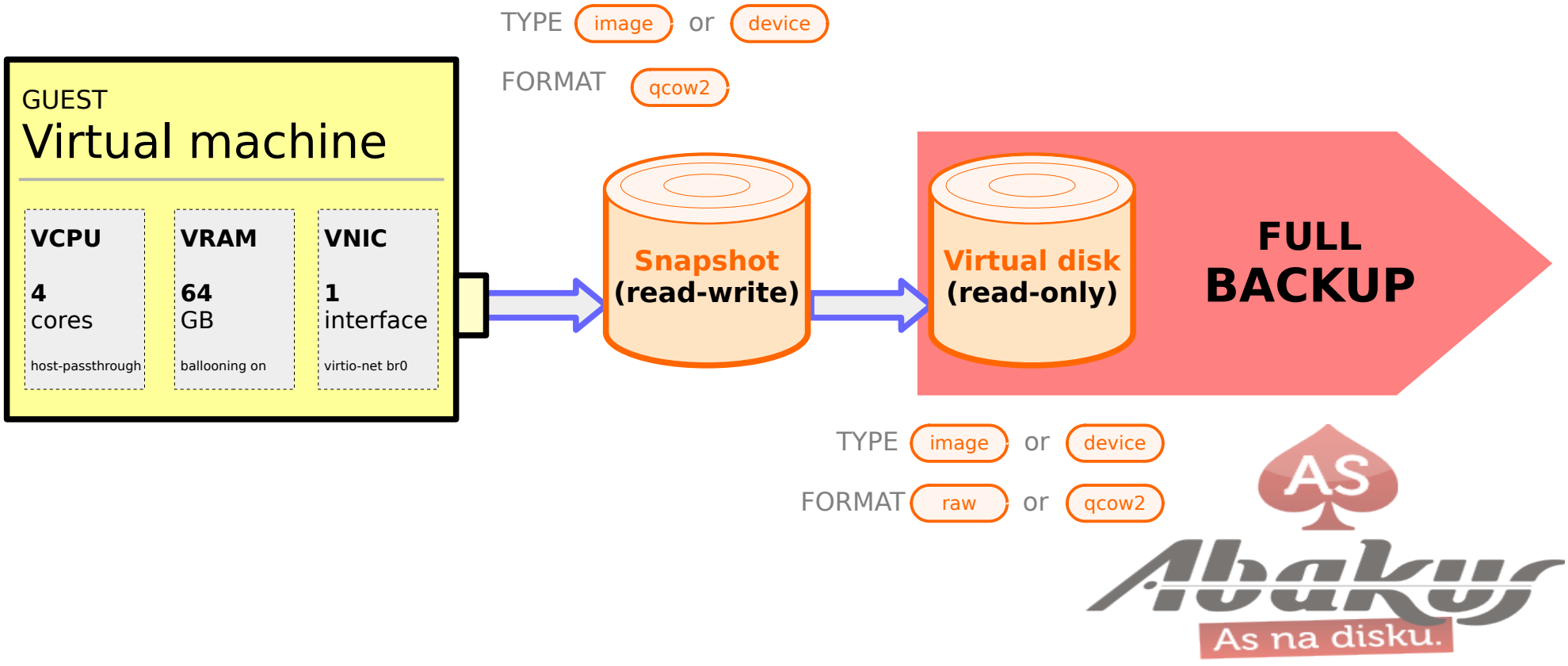
Snapshots – QMP

QEMU Machine Protocol – https://qemu-project.gitlab.io/qemu/interop/qemu-qmp-ref.html

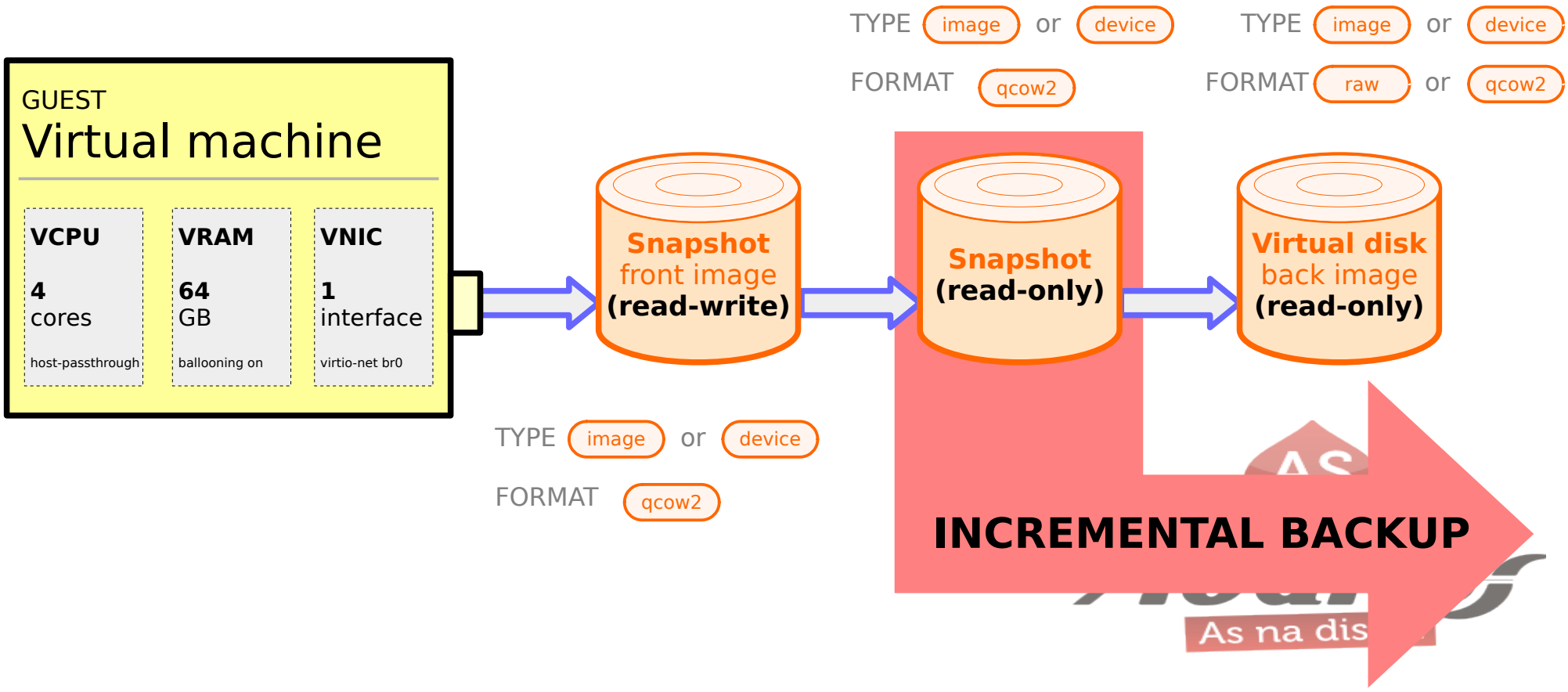
```
SOCKET="/var/run/qemu-server/99006.qmp"

echo '
{"execute": "qmp_capabilities"}
{
  "execute": "blockdev-snapshot-sync",
  "arguments":
    {"device": "drive-scsi0",
      "snapshot-file": "/backups/incremental1.qcow2"}
}
' | socat - UNIX-CONNECT:${SOCKET}
```

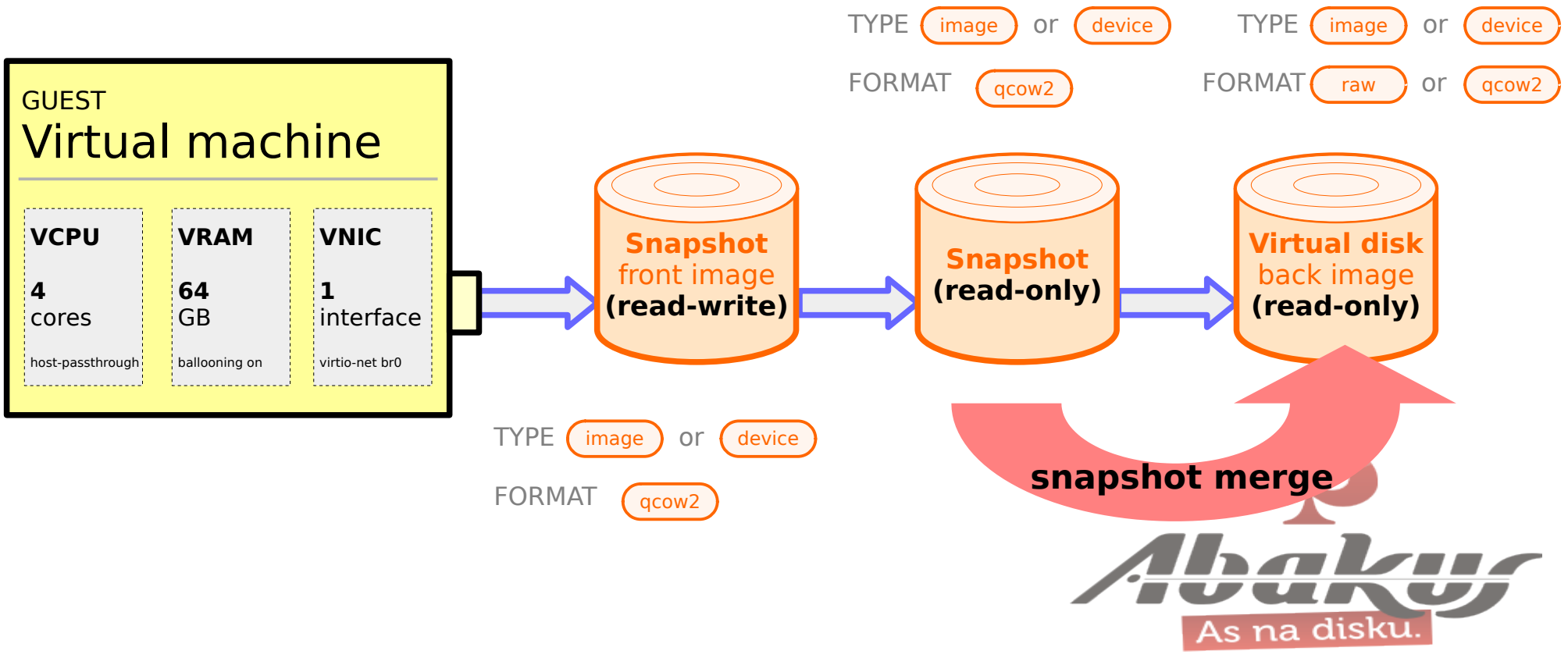
Full Backup – Just Once!



Next step


TYPE image or device
FORMAT qcow2
TYPE image or device
FORMAT raw or qcow2
GUEST
Virtual machine
VCPU
4
cores
host-passthrough
VRAM
64
GB
ballooning on
VNIC
1
interface
virtio-net br0
Snapshot
front image
(read-write)
Snapshot
(read-only)
Virtual disk
back image
(read-only)
TYPE image or device
FORMAT qcow2
INCREMENTAL BACKUP

Last step


TYPE image or device
FORMAT qcow2
TYPE image or device
FORMAT raw or qcow2
GUEST
Virtual machine
VCPU
4
cores
host-passthrough
VRAM
64
GB
ballooning on
VNIC
1
interface
virtio-net br0
Snapshot
front image
(read-write)
Snapshot
(read-only)
Virtual disk
back image
(read-only)
TYPE image or device
FORMAT qcow2
snapshot merge
Abakus
As na disku.

Snapshot Merge – OLVM, Proxmox VE

Deleting a snapshot triggers the hypervisor to merge all delta changes back into the base volume.

- **OLVM:** Click Delete to initiate the snapshot merge.
- **Proxmox VE:** Click Remove to consolidate the disk chain.

Snapshot Merge – libvirt

libvirt virtualization API – https://libvirt.org/index.html

```
virsh blockcommit debsr sda \
    --base <base-image> \
    --top <middle-snapshot> \
    --active \
    --wait \
    --verbose
```

Abakus
As na disku.

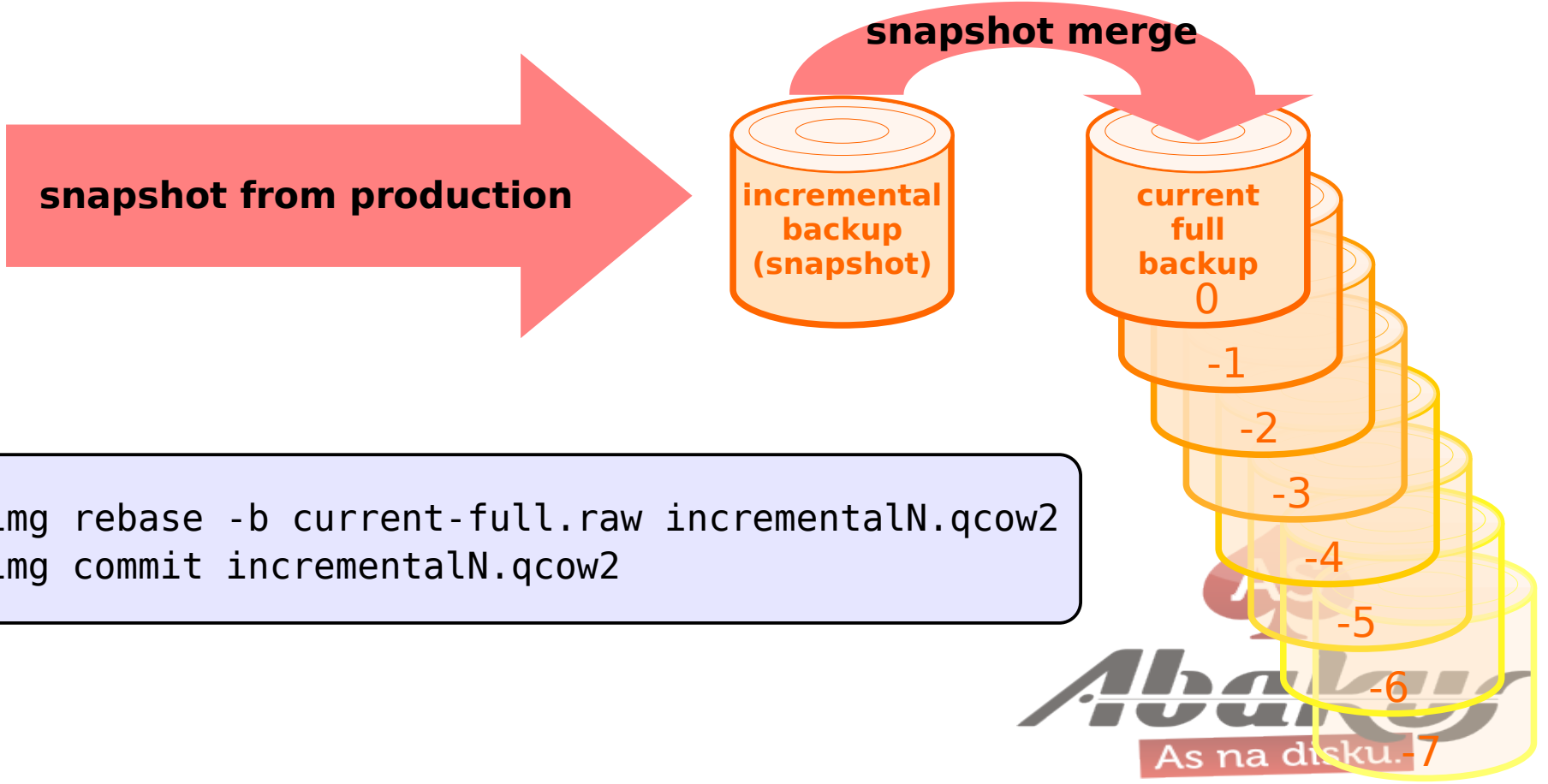
Snapshots Merge – QMP

QEMU Machine Protocol – https://qemu-project.gitlab.io/qemu/interop/qemu-qmp-ref.html

```
SOCKET="/var/run/qemu-server/99006.qmp"

echo '
{"execute": "qmp_capabilities"}
{
"execute": "block-commit", "arguments":
   {"device": ""drive-scsi0",
   "base": "<base-image>",
   "top": "<middle-snapshot>"}
}
' | socat - UNIX-CONNECT:${SOCKET}
```

On the backup site



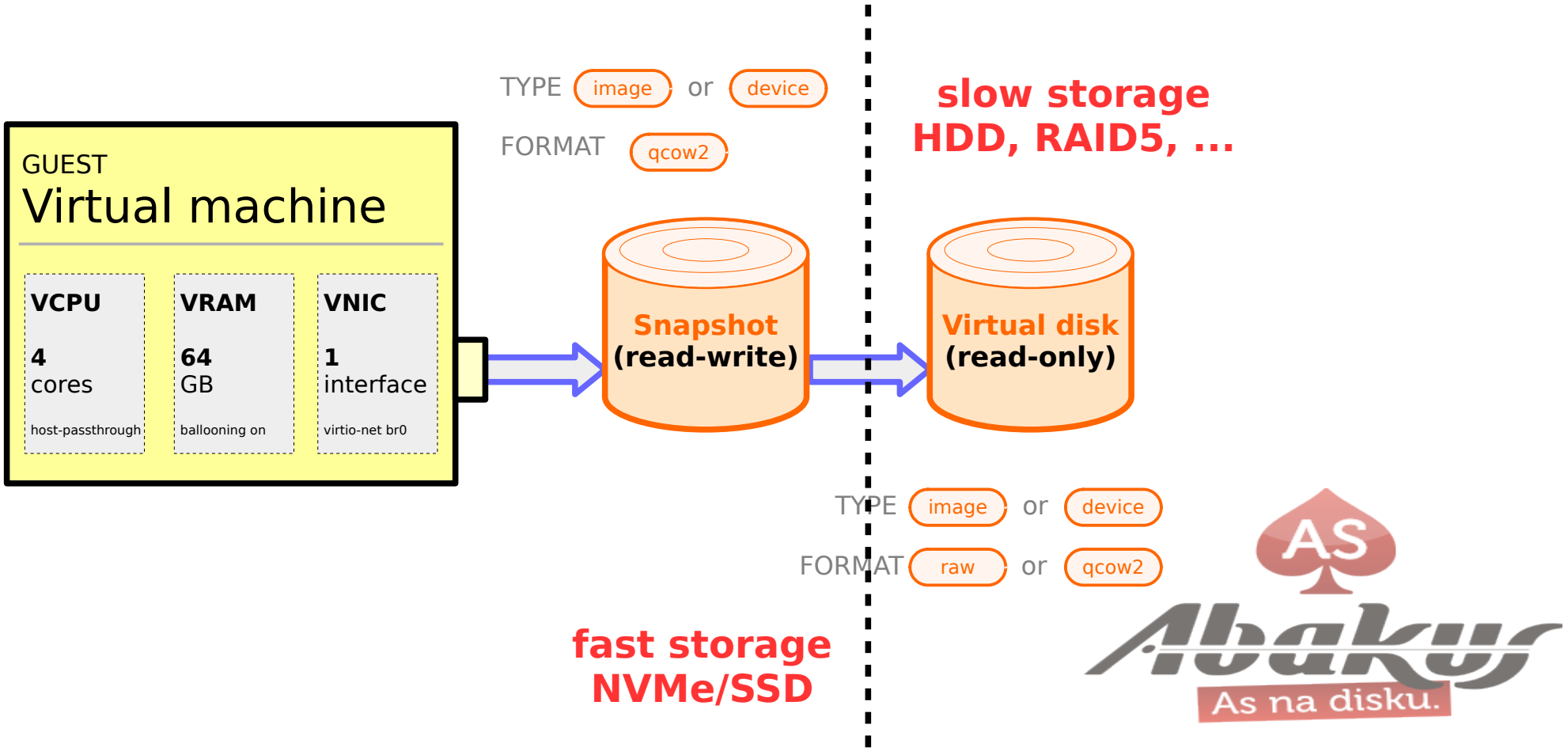

```
qemu-img rebase -b current-full.raw incrementalN.qcow2
qemu-img commit incrementalN.qcow2
```

Benefits and Pitfalls

- ✔ Direct Backup Validation
- ✔ Unbreakable Incremental Backups
- ✔ Storage Agnostic & Universal Architecture
- ✔ **and more** ... (next slide)

- ✖ Accidental Snapshot Deletion Before Merge
- ✖ Commit/Merge Failures
- ✖ Mismatched Rebase (Target Corruption)
- ✖ Storage Exhaustion (Runaway Snapshots)
- ✖ Complicated VM Migration

Snapshot-Based I/O Acceleration



Smart Virtual Machine Backup

Thank You

mag. Sergej Rožman
ABAKUS plus d.o.o.
Ljubljanska c. 24a, Kranj, Slovenija

e-mail: sergej.rozman@abakus.si

phone: +386 4 287 11 14

Brihtno backupiranje virtualk

ANDRITZ MM KARTON Hidria TRELLEBORG Iskra GOODYEAR sij acroni