Easy Geo-Redundancy with MARS + `systemd`

LCA2020 Sysadmin Miniconf Presentation

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Easy Geo-Redundant Handover+Failover: Agenda

- Short background: MARS for end-to-end SLA 99.98%
- Cluster management for long distances
- Using `systemd` as a clustermanager
- Current Status / Future Plans

Background: SLA + Growth at 1&1 Ionos ShaHoLin

= Shared Hosting Linux

1&1

- SLA: **99.98% end-to-end** measured from Frankfurt
  - Including WAN outages, PHP problems, HumanError™

    => MARS geo-redundancy must compensate much better!

- 4 datacenters at 2 continents, pair distance > 50 km
- ~ 9 millions of customer home directories
- ~ 10 billions of inodes + daily incremental backup
- > 4.7 petabytes *allocated* in ~ 3800 xfs instances

  LocalStorage LVM ~ 8 PB x 2 for geo-redundancy via **MARS**

  `https://github.com/schoebel/mars`

- Growth rate **~ 21 % / year**
- Solution: Container Football on top of MARS

  `https://github.com/schoebel/football`

Cluster Management for > 50 km

- Proprietary e.g. 1&1 `cm3` (no GPL)
- Pacemaker & co typically don‘t work as expected
  - original HeartBeat DSM model: *shared disk*

    cannot *really* handle Split Brain

    explainable by CAP theorem
- Using `systemd` as a Linux clustermanager
  - already in use almost everywhere e.g. startup of VMs
  - itself somewhat „monolithic“, but extensible via Unit Files
  - path watchers can monitor /mars/resource-$res/* remote updates from MARS cluster communication => generic remote control
- MARS dynamic resource creation / deletion

  `marsadm join-resource / leave-resource`
- Solution: `marsadm` internal macro processor

  creates / deletes systemd units „on the fly“

systemd Unit Example (Template)

```
bash> cat \^\{mntname\}-@\{res\}.mount
@eval{%let{mntpath}{%subst{%{mntname}}{-}{/}}}
[Unit]
Description=MARS local mount on /@{mntpath}/@{res}
Documentation=https://github.com/schoebel/mars/docu/mars-user-manual.pdf
Requires=mars.service
After=mars.service


ConditionPathIsSymbolicLink=/mars/resource-@{res}/systemd-want
ConditionPathExists=/mars/resource-@{res}/userspace/systemd-want-@{host}
ConditionPathExists=/dev/mars/@{res}
ConditionPathIsDirectory=/@{mntpath}/@{res}

[Mount]
What=/dev/mars/@{res}
Where=/@{mntpath}/@{res}

[Install]
WantedBy=mars.service
```

Use MARS' metadata symlink updates for remote control

Usage of systemd unit templates

- **Activation of template** (once after resource creation, for the whole cluster)

```
marsadm create-resource $resource /dev/$vg/$resource
mkfs.xfs /dev/mars/$resource
marsadm set-systemd-unit $resource $start_unit $stop_unit
    => automatic instantiation via macro processor
```

- **Usage at planned handover:**

  remote control:
  piggyback on distributed MARS symlinks

  `marsadm primary $resource` (or `marsadm primary all`)

  - **Automagically** (independently for each resource):
    - Old primary: `systemctl stop $stop_unit`
    - Old primary: MARS goes to secondary mode
    - New primary: MARS becomes primary /dev/mars/$resource will appear
    - New primary: `systemctl start $start_unit`

- **Usage at unplanned failover:**
  - `marsadm disconnect all ; marsadm primary --force all`

Current status of `systemd` interface

- **BETA feature!** not yet in production
  - example templates in `systemd/` subdir
- Currently works **sequentially**
  - observation: `systemctl` is non-reentrant, can **deadlock**
  - `marsadm` uses (breakable) locks for protection
- Planned improvements: all resources in parallel to each other
  - Needs heavy testing
  - Help from the community welcome!
  - e.g. contribute new systemd templates for KVM startup, or iSCSI / NFS exports, ...

MARS Current Status

- MARS source under GPL + docs:

  github.com/schoebel/mars

  docu/mars-user-manual.pdf

  docu/mars-architecture-guide.pdf

- mars0.1stable productive since 02/2014
- Backbone of the 1&1 Ionos geo-redundancy feature
- up to 14 LXC Containers on 1 Hypervisor
  - Efficiency project using Football:
  - TCO has **halved!**

MARS Future Plans

Kernel part almost done
mixed operations of old/new MARS versions

- Faster checksumming (CRC32c | CRC32 | SHA1 | MD5)
- Logfile compression (LZO | LZ4 | ZLIB)
- Optional network transport compression
  - may help for some very slow networks

IO data paths already scaling well

- TODO: better *metadata* scalability needed!
  - single `mars_main` control thread (non-blocking)
  - TODO: more resources per host (max. 24 in prod at 1&1)
  - TODO: more hosts per cluster
- TODO: Linux kernel upstream
  - requires a *lot* of work!
  - tomorrow‘s presentation at kernel miniconf
- TODO: more tooling, more systemd templates, integration into other OpenSource projects, ...

Collaboration sought

=> Opportunities for other OpenSource projects!

Sponsoring (MARS + Football)

- Best for > 1 PiB of enterprise-critical data
  - More Football plugins in future, e.g. for KVM, ...
- Future pool-optimizer will deliver similar functionality than **Kubernetes**
  - but on stateful storage + containers instead of stateless Docker containers
  - State is in the storage and in the machines, but not in orchestration
- Long-term perspective
  - MARS is largely complementary to DRBD
  - Geo-redundancy with OpenSource components
  - distances > 50km possible, tolerates flaky replication networks
  - **Price / performance** better than anything else (see mars-achitecture-guide.pdf)
  - Architectural **reliability** better than BigCluster with cheaper hw + network!
- ask me: decades of experience with enterprise-critical data and long-distance replication

Appendix

Why GEO-Redundancy

DR = Disaster Recovery
CDP = Continuous Data Protection

- Example: GALILEO incident (DR / CDP did not work)
  - Disaster = earthquake, flood, terrorist attack, power outage, ...
- BSI Paper 12/2018:

  Kriterien für die Standortwahl höchstverfügbarer und georedundanter Rechenzentren

  https://www.bsi.bund.de/SharedDocs/Downloads/DE/BSI/Sicherheitsberatung/Standort-Kriterien_HV-RZ/Standort-Kriterien_HV-RZ.pdf?__blob=publicationFile&v=5

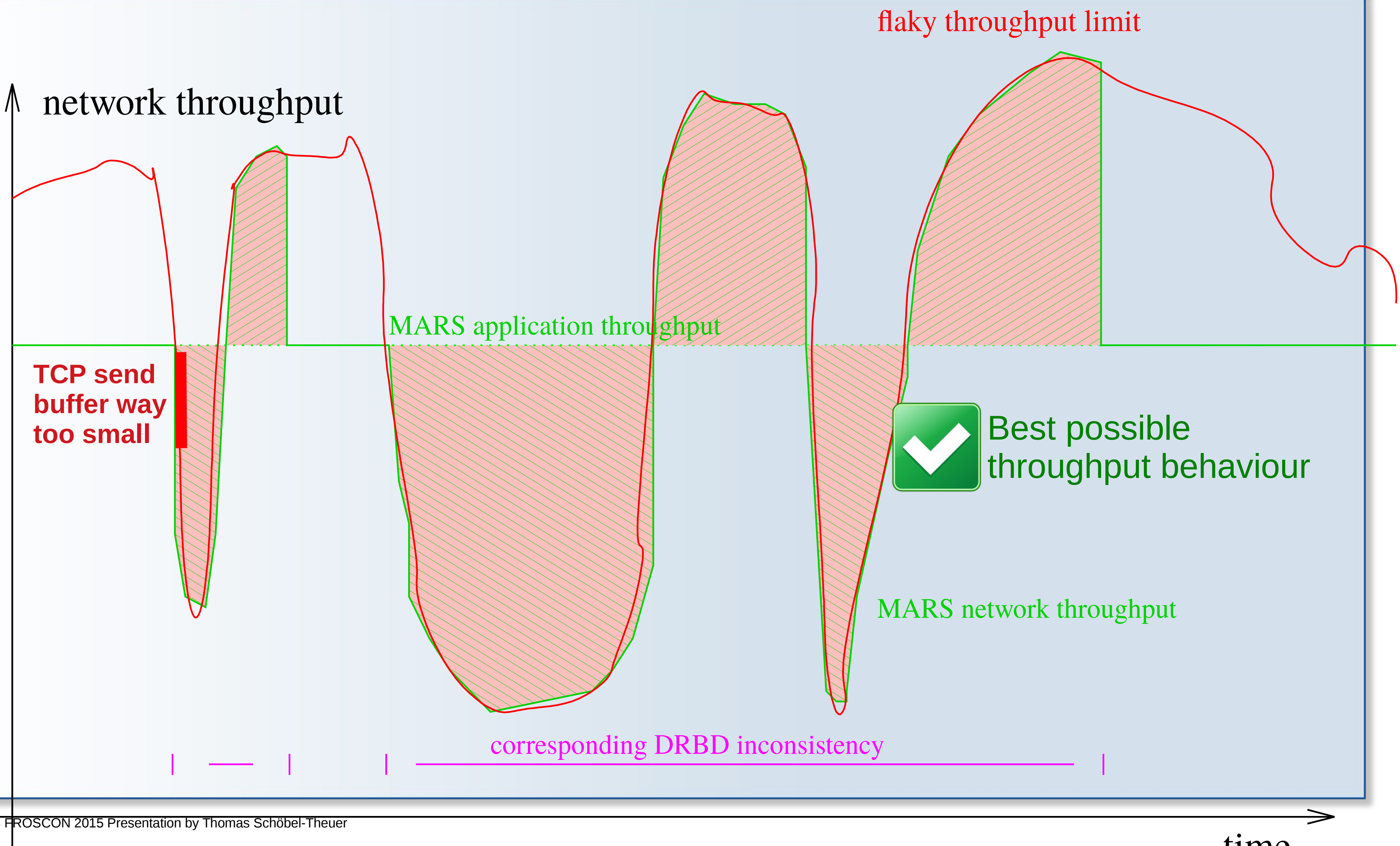
  in English: Criteria for Locations of Highly Available and Geo-Redundant Datacenters

  - Stimulated some controversial discussions, but see commentary https://www.it-finanzmagazin.de/bsi-rechenzentren-entfernung-bafin-84078/
- Conclusions: distances > 200 km „recommended“
- Might influence future legislation (EU / international)
- „Critical Infrastructures“ more important!

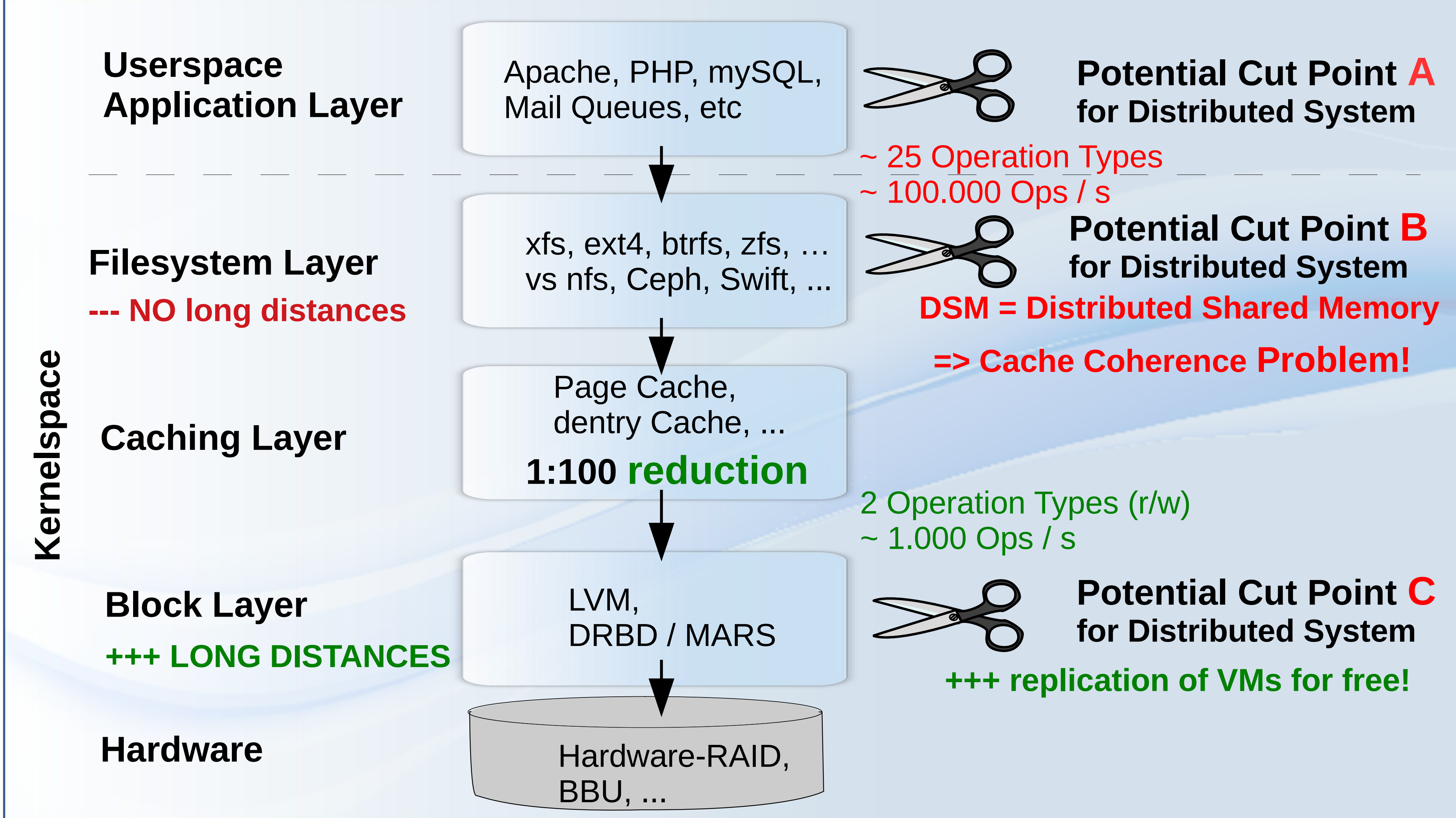
Long-Distance Asynchronous Replication

- **Synchronous** does not *generally* work over ≈50 km
  - like iSCSI over 50 km
- Need Asynchronous Replication
  - Application specific, e.g. mySQL replication ✔
  - Commercial appliances: $$$ €€€ ⊘
  - OpenSource ✔
    - plain DRBD is NOT asynchronous
      - commercial DRBD-Proxy: RAM buffering
    - MARS: truly asynchronous + persistent buffering + transaction logging + MD5 checksums + Anytime Consistency

Network Bottlenecks: MARS



Replication at Block Level vs FS Level



CAP Theorem

C = Strict Consistency

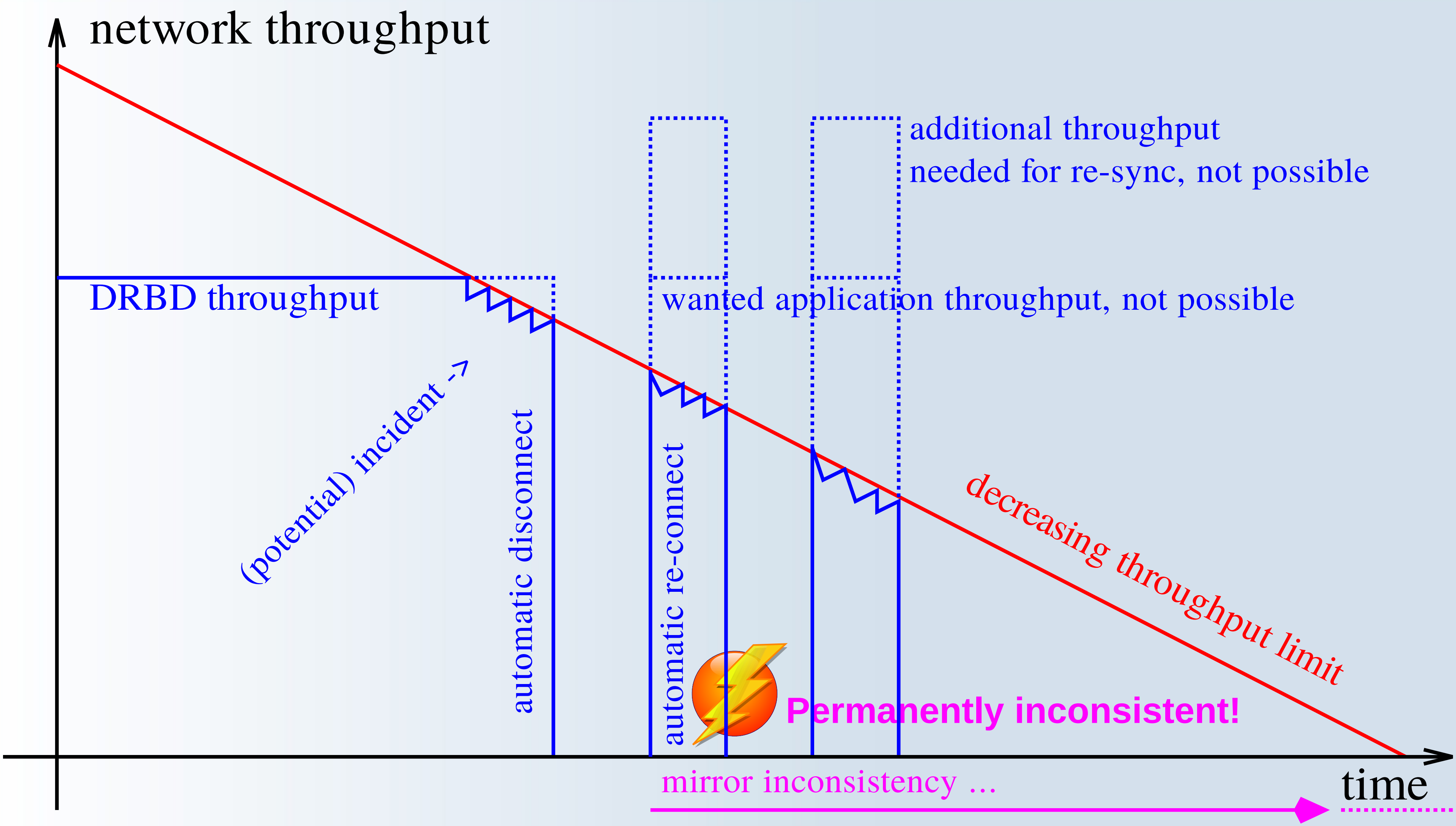
violated at
- disasters
- LONG distances

A = Availability

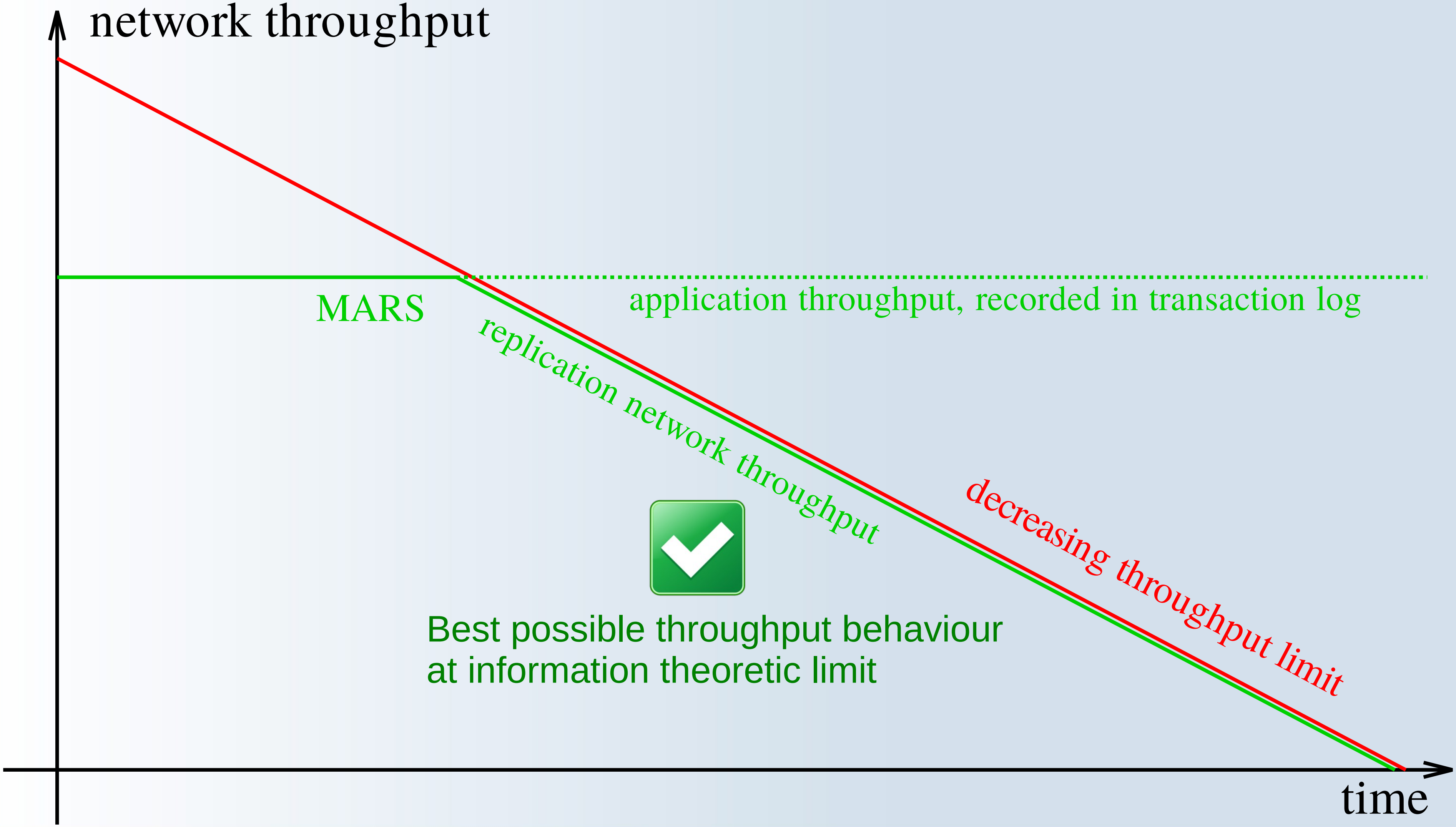
P = Partitioning Tolerance

= the network can have its own outages

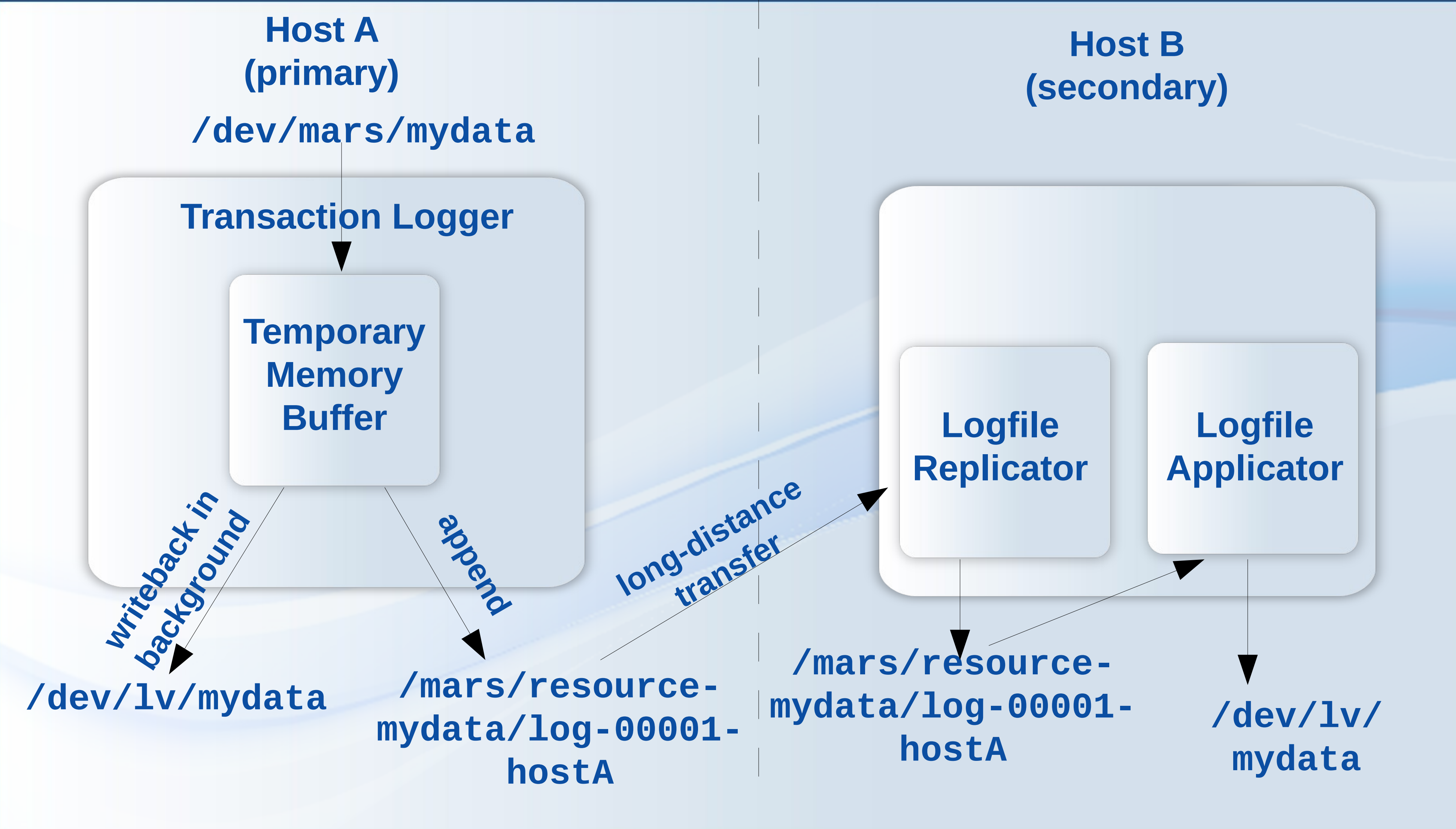
Network Bottlenecks (1) DRBD



Network Bottlenecks (2) MARS



MARS Data Flow Principle



Use Cases DRBD+proxy vs MARS

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DRBD+proxy
(proprietary)

Application area:

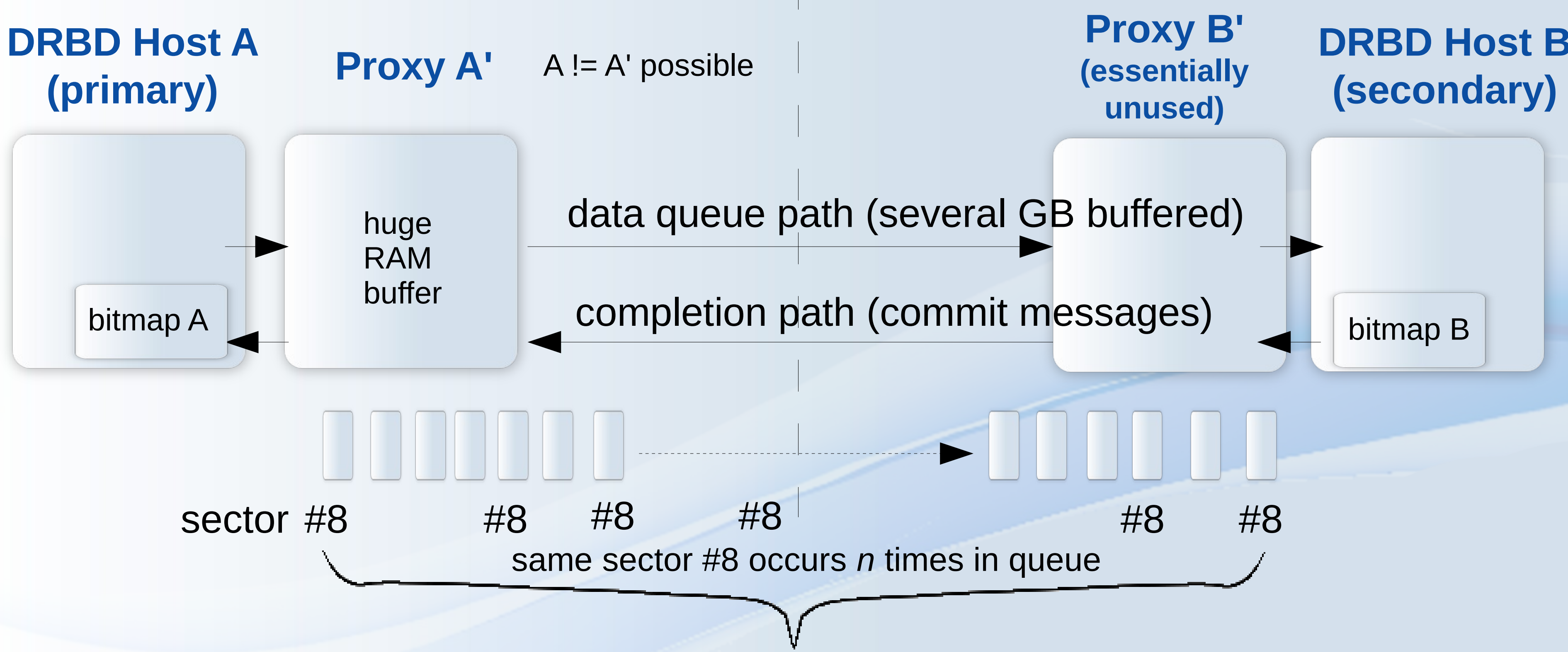
- Distances: any
- Aynchronously
  - **Buffering in RAM**
- Unreliable network leads to **frequent re-syncs**
  - RAM buffer gets lost
  - at cost of actuality
- **Long** inconsistencies during re-sync
- Under pressure: **permanent** inconsistency possible
- High memory overhead
- Difficult scaling to k>2 nodes

MARS
(GPL)

Application area:

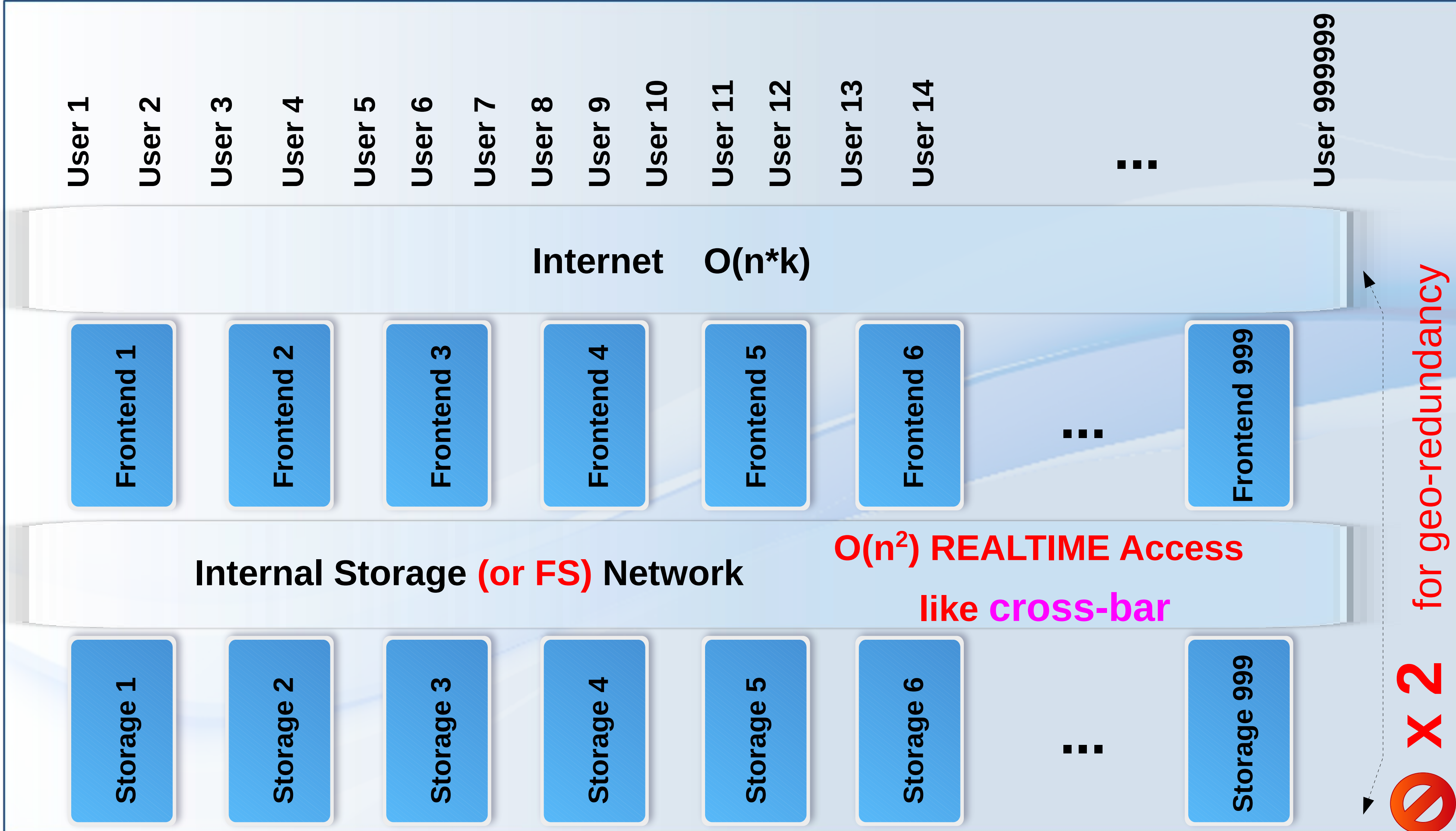
- Distances: **any** (>>50 km)
- Asynchronously
  - near-synchronous modes in preparation
- Tolerates **unreliable network**
- Anytime consistency
  - no re-sync
- Under pressure: no inconsistency
  - possibly at cost of actuality
- Needs >= 100GB in `/mars/` for transaction logfiles
  - dedicated spindle(s) recommended
  - RAID with BBU recommended
- Easy scaling to k>2 nodes

DRBD+proxy Architectural Challenge

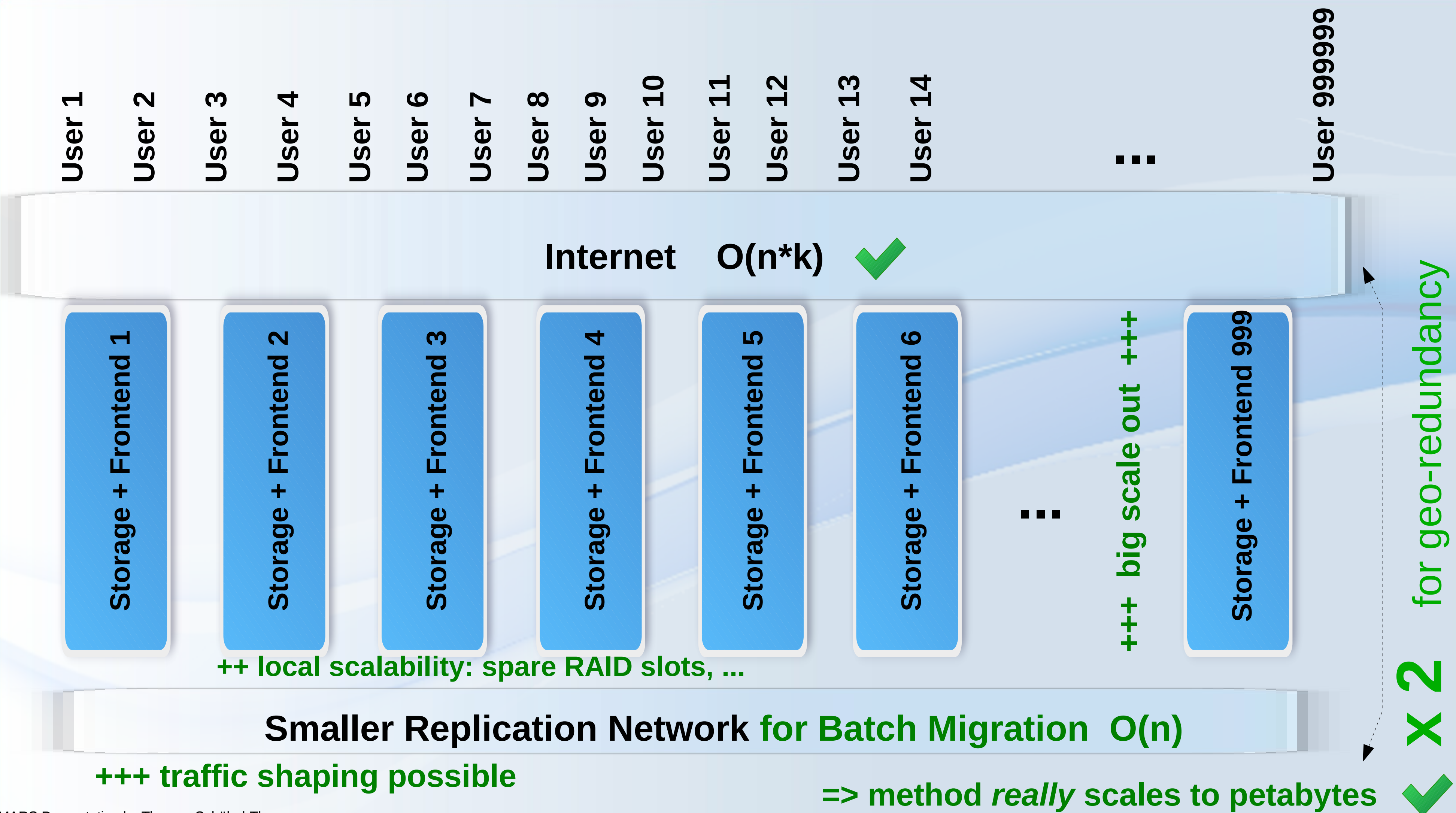


n times
=> need *log*(n) bits for counter
=> but DRBD bitmap has only 1 bit/sector
=> workarounds exist, but complicated
(e.g. additional dynamic memory)

Badly Scaling Architecture: Big Cluster



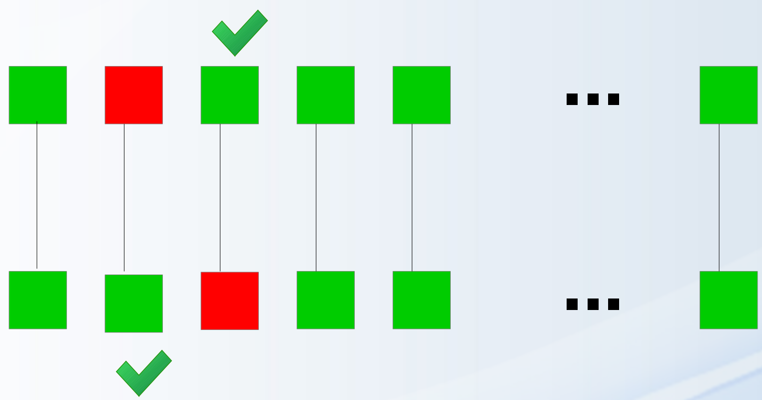
Well-Scaling Architecture: Sharding



Reliability of Architectures: NODE failures

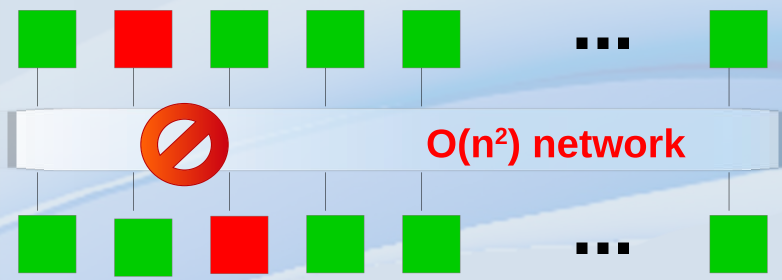
2 Node failure => ALL their disks are unreachable

DRBD or MARS simple pairs



same n

Big Storage Cluster e.g. Ceph, Swift, ...



=> no customer-visible incident

k=2 replicas not enough
=> INCIDENT because objects are randomly distributed across whole cluster

Low probability for hitting the *same* pair, even then: only 1 shard affected
=> low total downtime

Higher probability for hitting *any* 2 nodes, then O(n) clients affected
=> much higher total downtime

need k >= 3 replicas here

Cost (1) non-georedundant, n>100 nodes

- **Big Cluster:**
  Typically ≈RAID-10 with k=3 replicas for failure compensation
- **Disks: > 300%**
- **Additional CPU and RAM for storage nodes**
- **Additional power**
- **Additional HU**

- **Simple Sharding:**
  Often local RAID-6 sufficient (plus external backup, no further redundancy)
- **Disks: < 120%**
- **Client == Server**
  no storage network
  MARS for LV background migration
- **Hardware RAID controllers with BBU cache** on 1 card
- **Less power, less HU**

Cost (2) geo-redundant => LONG Distances

- **Big Cluster:**
  - 2X ≈ RAID-10 for failure compensation (k=6 replicas needed, smaller does not work in long-lasting DC failure scenarios)
- **Disks: > 600%**
- **Additional CPU and RAM for storage nodes**
- **Additional power**
- **Additional HU**

- **Geo-redundant Sharding:**
  - 2 x local RAID-6
  - MARS for long distances

    or DRBD for room redundancy
- **Disks: < 240%**
- **Hardware RAID controllers with BBU**
- **Less power**
- **Less HU**

Cost (1+2): Geo-Redundancy Cheaper than Big Cluster

- **Single Big Cluster:**
  - ≈RAID-10 with k=3 replicas for failure compensation
- O(n) Clients

  \+ 3 • O(n) storage servers

  \+ O(n^2) storage network
- Disks: > 300%
- Additional power
- Additional HU

- **Geo-redundant sharding:**
  - 2 x local RAID-6
  - MARS for long distances

    or DRBD for room redundancy
- 2 • O(n) clients = storage servers

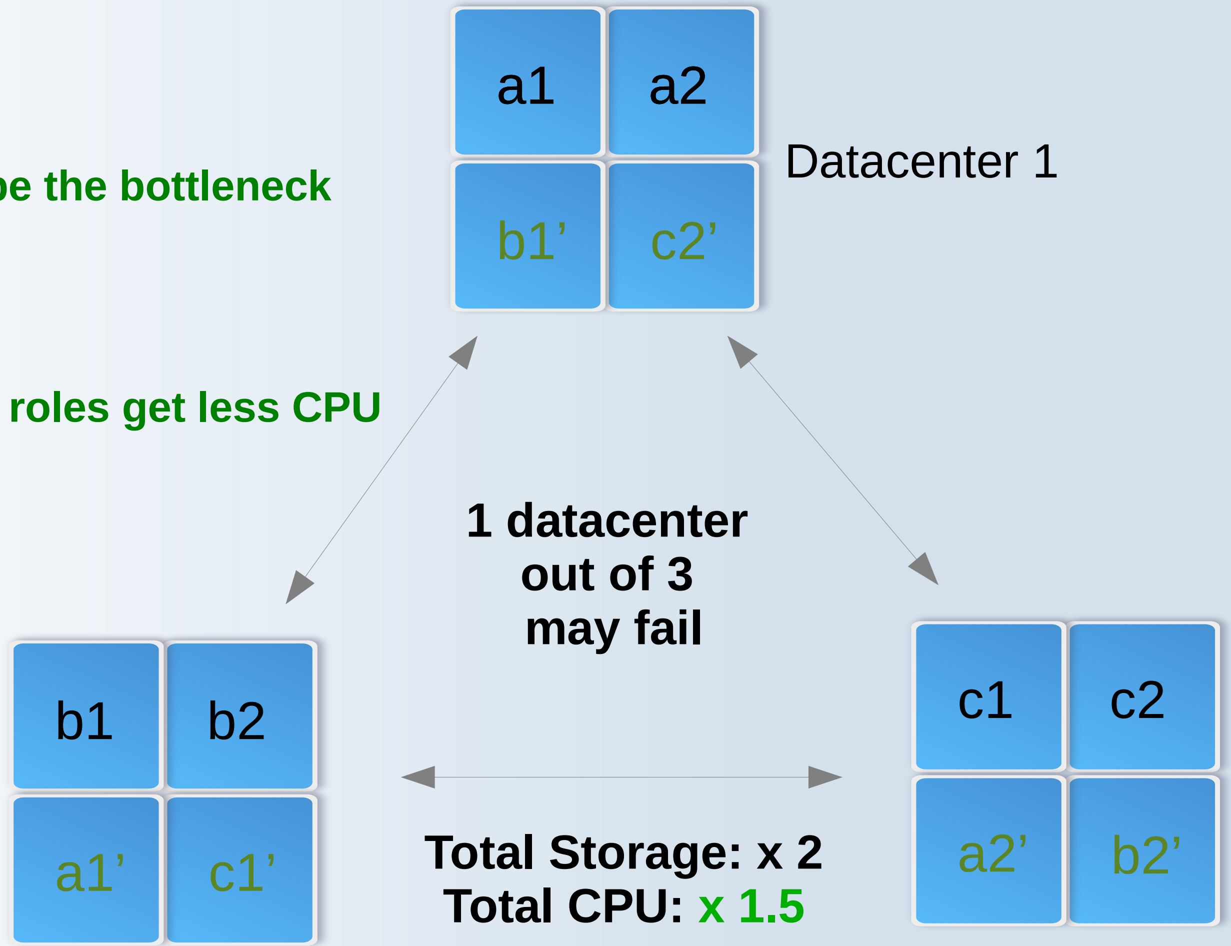
  \+ O(n) replication network
- Disks: < 240%
- Less total power
- Less total HU

  +++ geo failure scenarios

Costs (3): Geo-Redundancy even Cheaper

Precondition:
CPU must not be the bottleneck

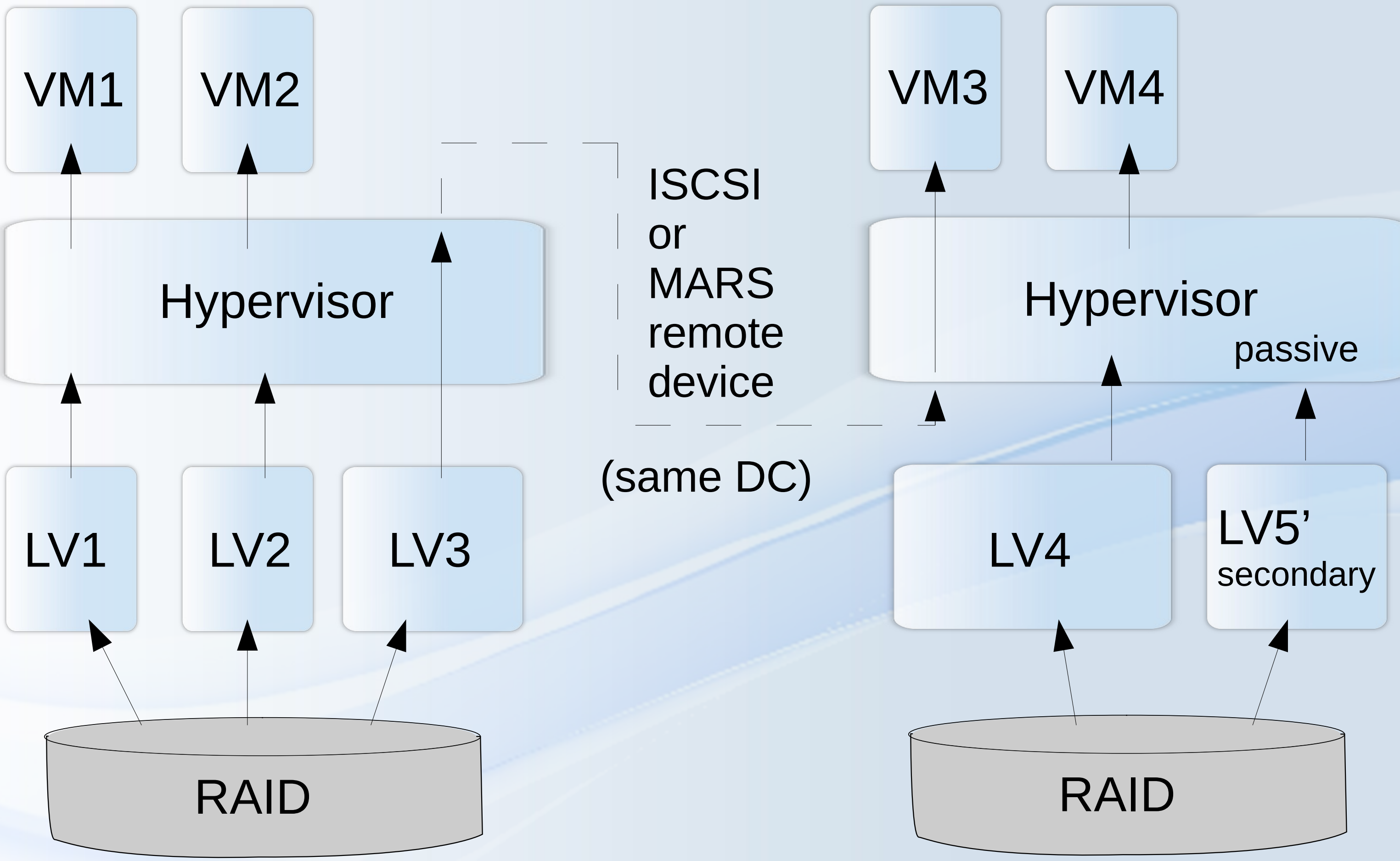
Idea: passive LV roles get less CPU



Total Storage: x 2
Total CPU: x 1.5
=> 1.5 • O(n)

HOWTO flexible CPU assignment => next slide

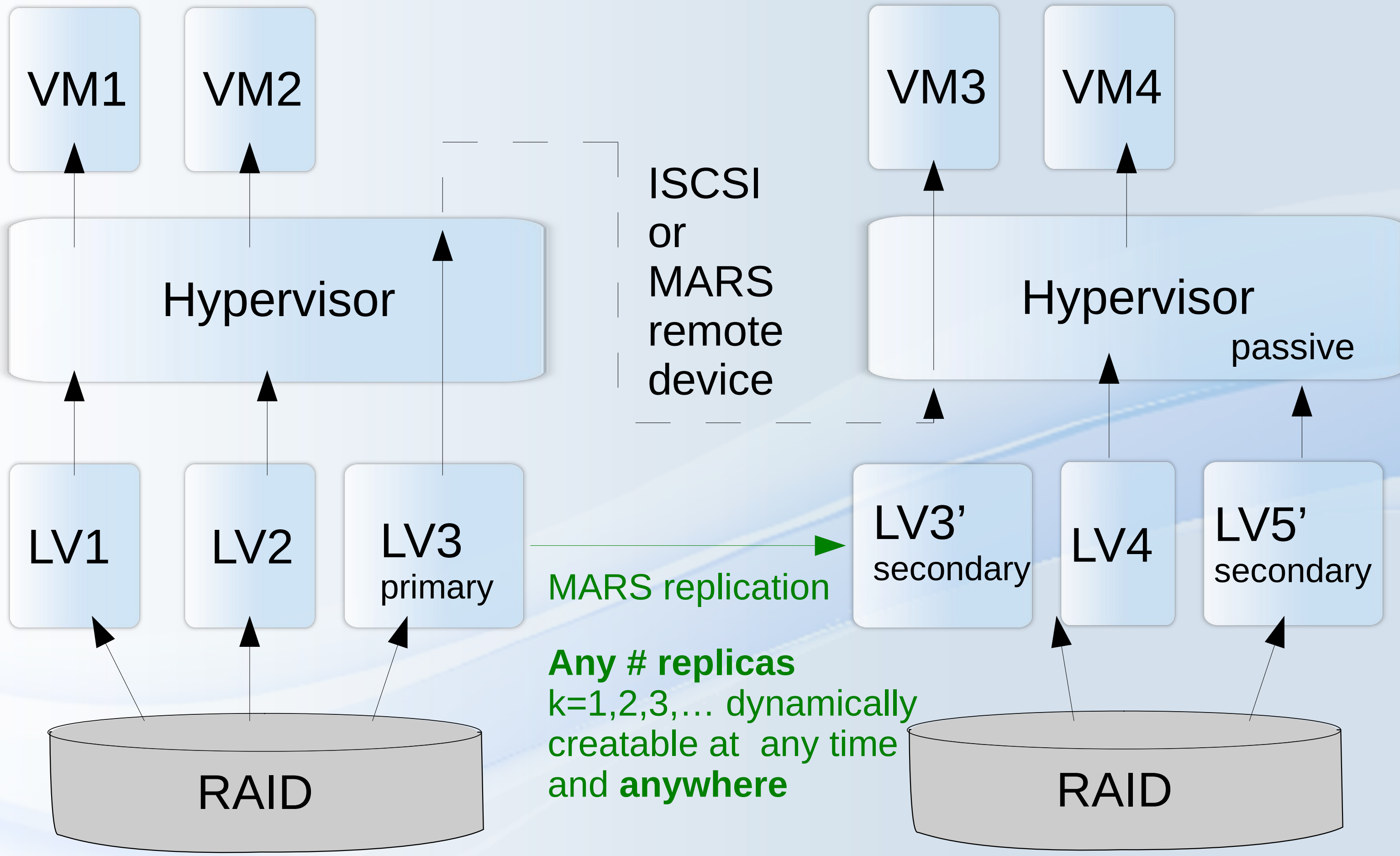
Flexible MARS Sharding + Cluster-on-Demand



any hypervisor works in client and/or server role

and preferably **locally** at the same time

Flexible MARS Background Data Migration



=> any hypervisor may be source or destination of some LV replicas at the same time

Football Current Status

- GPL with lots of plugins, some generic, some 1&1-specific
  - about 2/3 of code is generic
  - `plugins/football-basic.sh` uses `systemd` as cluster manager
  - https://github.com/schoebel/football
  - https://github.com/schoebel/mars
- Multiple operations:
  - **migrate** $vm $target_cluster
    - low downtime (seconds to few minutes)
  - **shrink** $vm $target_percent
    - uses local incremental rsync, more downtime
  - **expand** $vm $target_percent
    - online, no downtime
- In production at 1&1 Ionos
  - get rid of old hardware (project successfully finished)
  - load balancing
  - >50 „kicks“ per week
    - limited by hardware deployment speed
    - Proprietary Planner (for HW lifecycle)