High-performance flash file system for
data-intensive workloads

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Problems with flash memory

Flash storage concerns #1

1. Flash memory wear-out

Flash memory lifetime limited by number of write cycles.

When max number write cycles (P/E cycles) reached = system failure.

Concerns for automotive, drones, and video:

- Automotive lifetime requirement is 10-20 years
- Automotive applications are becoming increasingly write-intensive
- Expensive to replace flash memory
- Potential damage to brand reputation due to system failure
- Used car market impact

Flash storage concerns #2

2. Storage latency

The time that an application has to wait before a storage operation completed.

Concerns for automotive, video, and phones:

- Can cause frame loss in high-quality video recording

Flash storage concerns #3

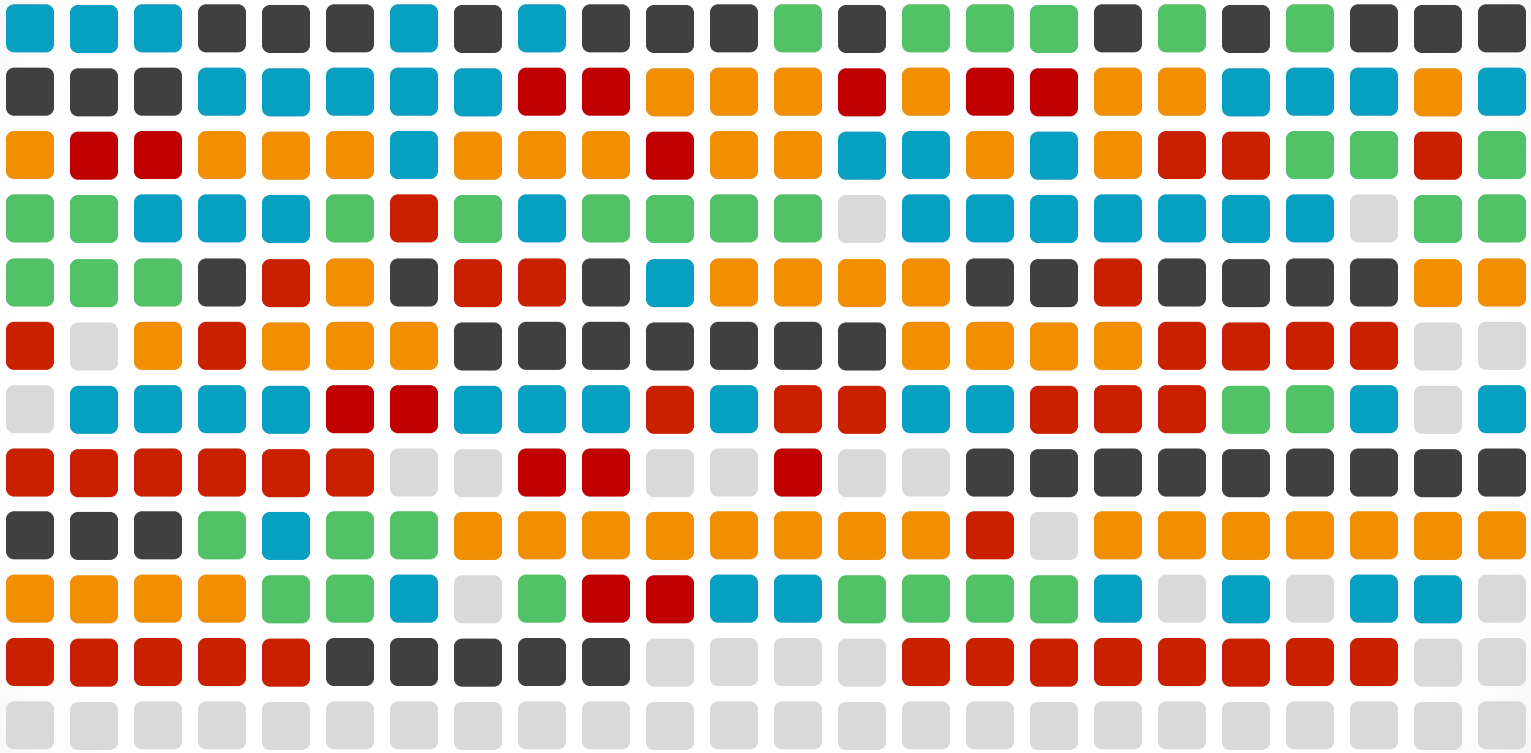
3. Fragmentation

Happens when a file system lays out files in non-contiguous parts, or fragments.

Concerns for phones, video, and automotive

- Leads to flash memory wear-out
- Can cause critical system failure
- 2–5x storage performance slowdown
- 1.6–2x longer app launch time

Fragmentation illustration



Flash storage concerns #4

4. Write amplification factor

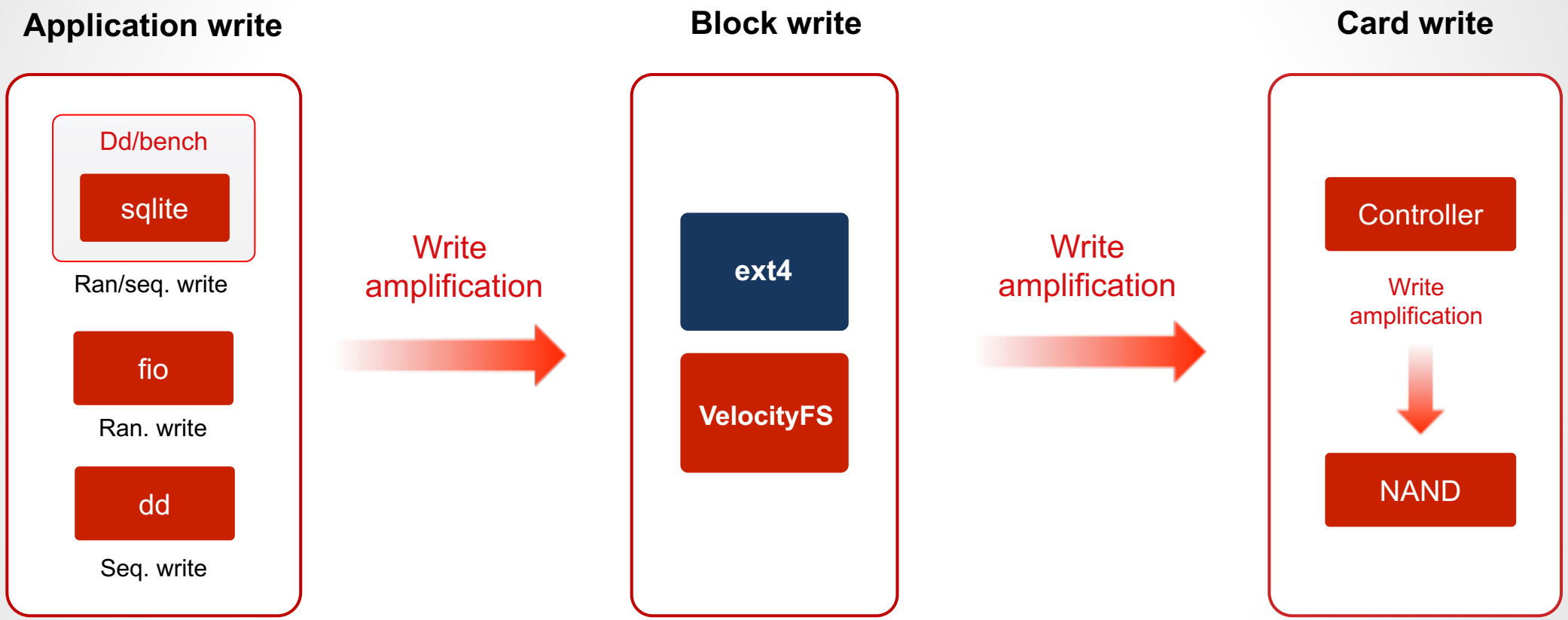
An undesirable phenomenon where the actual amount of physical information written is more than the logical amount intended.

$$\text{Write Amplification Factor} = \frac{\text{Card write}}{\text{Application write}}$$

Concerns:

- Leads to flash memory wear-out
- Can cause critical system failure
- Sluggish performance (phones, automotive)

How write amplification multiplies



Our customers often suspect open-source solutions cause problems such as:

- frame loss
- latency issues
- performance slowdowns
- write/erase wear

How VelocityFS by Tuxera can help

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FILE SYSTEMS AFFECT

READ/WRITE PERFORMANCE	DATA INTEGRITY	FLASH ENDURANCE	DATA/STORAGE INTEROPERABILITY

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An intelligently designed file system helps you get the maximum performance and lifetime from your flash memory hardware.

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VELOCITY FS

By Tuxera

High-performance data storage support for internal flash memory.

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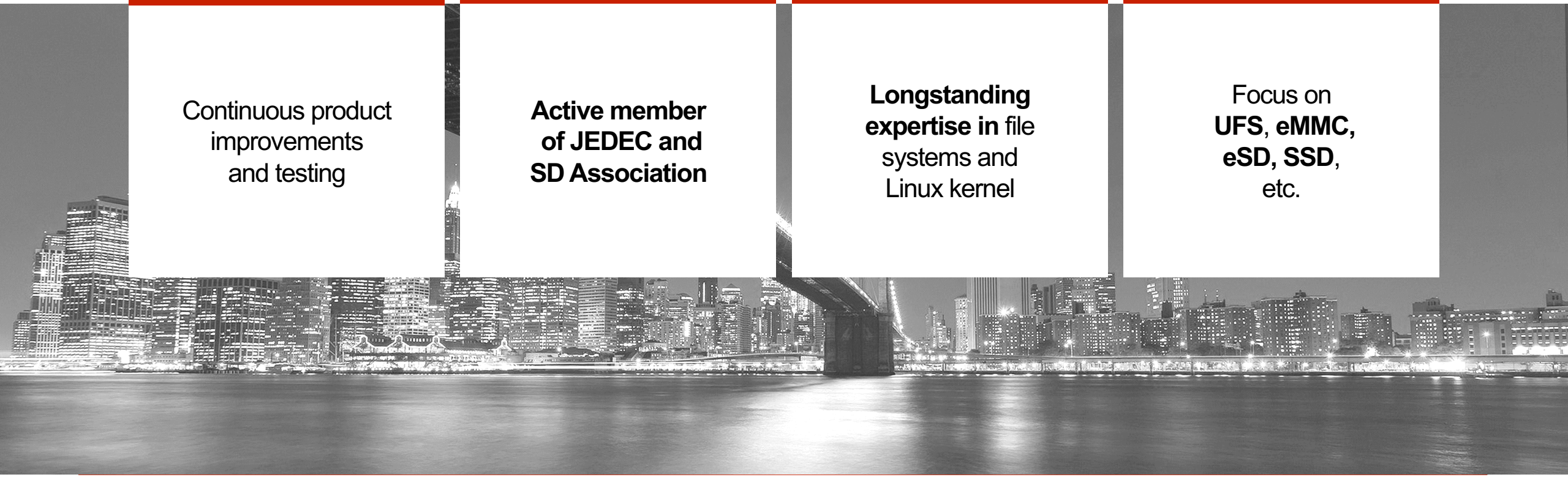
Our expertise in the flash industry

Trusted work with hardware vendors	Contributions to industry standards	Technical competence	Understanding market trends
Continuous product improvements and testing	**Active member of JEDEC and SD Association**	**Longstanding expertise in** file systems and Linux kernel	Focus on **UFS**, **eMMC, eSD, SSD**, etc.



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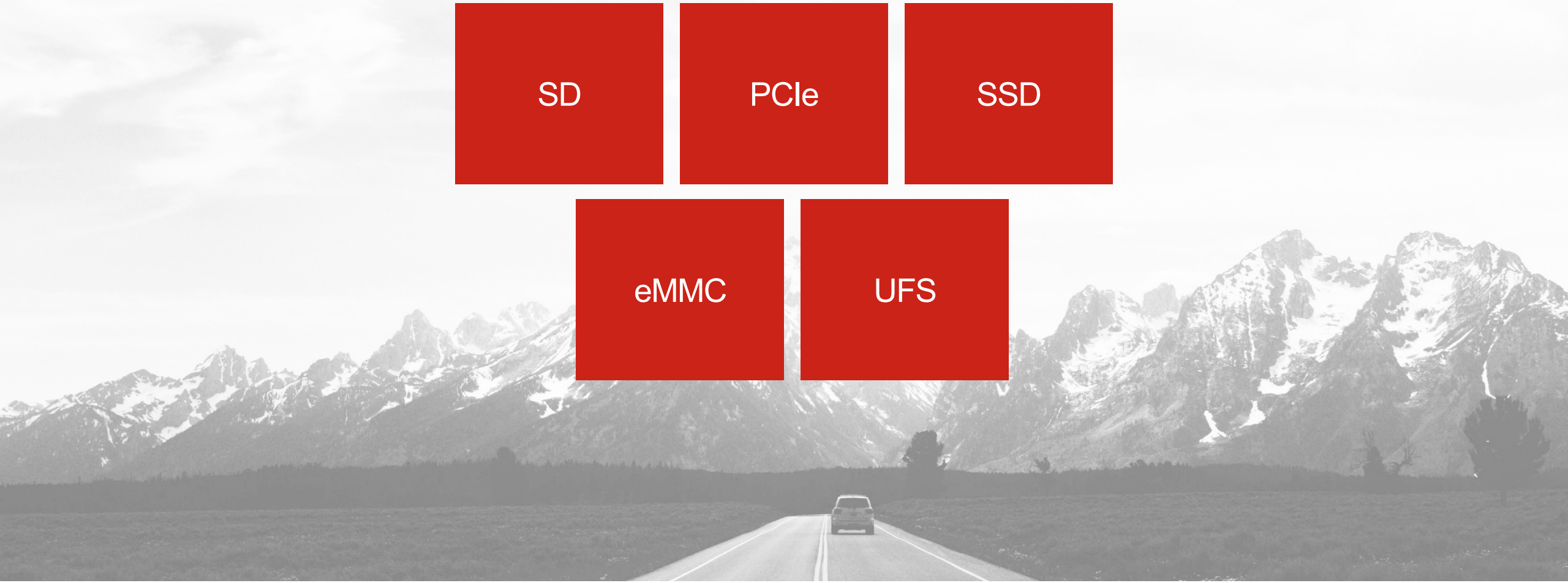
We optimize for all flash memory technologies



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Multi-platform integration support for all automotive operating systems, hypervisors, and complex combinations.

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Superior performance benefits

Low latency,
no frame loss

Sustained,
high-speed data
recording

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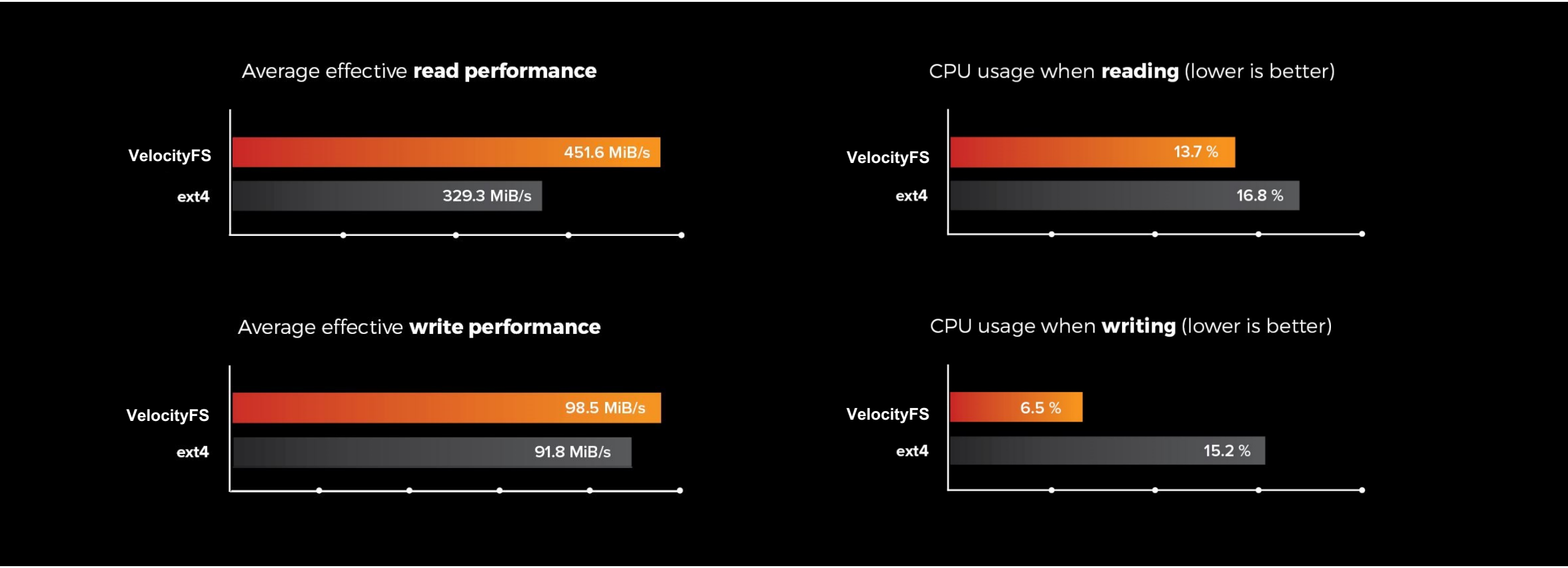
Superior performance benefits

Fast mount time

Improved system responsiveness

Read-write performance and CPU usage



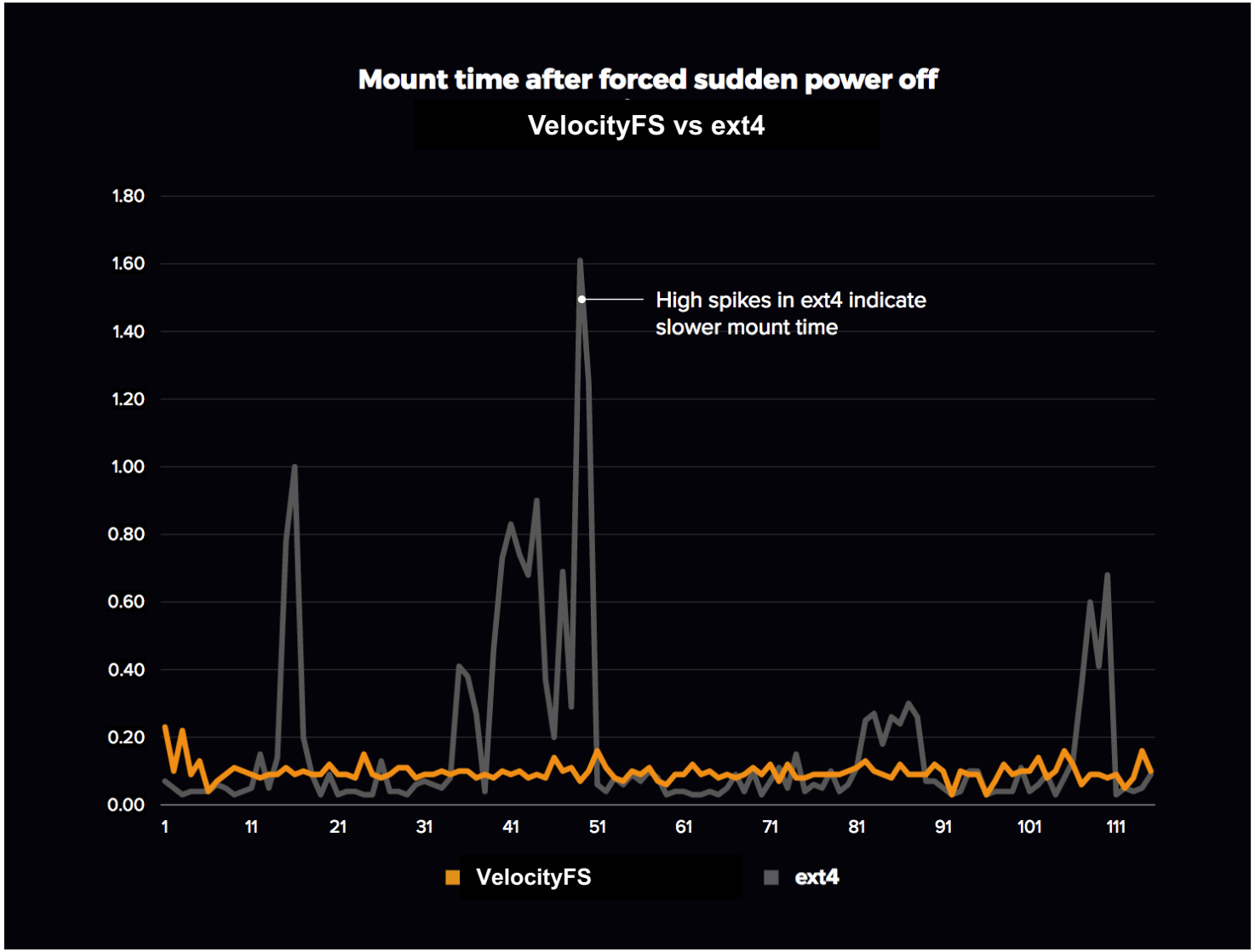
Tests performed on ARMv8-A Cortex-A53 Automotive SoC, 32 GB UFS storage.

Performance under typical automotive workloads

Tests performed on ARMv8-A Cortex-A53 Automotive SoC, 32 GB UFS storage

Fast and consistent mount time

2X faster average mount time than ext4



Tests performed on ARMv8-A Cortex-A53 Automotive SoC, 32 GB UFS storage.

Longest flash memory lifetime

Low write and erase wear

Reduced fragmentation

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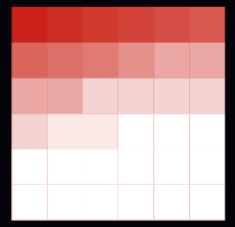
During random write

2.5 times
longer lifetime than **ext4**

3.2 times
longer lifetime than **VFAT**

During sequential write



9%
longer lifetime than **ext4**

35%
longer lifetime than **VFAT**

Write amplification with SQLite workload // Renesas R-Car H2 with SD card

Costs saved over VFAT
per 100 000 units*

1.3 M €

Replacement costs reduced up to **2** times

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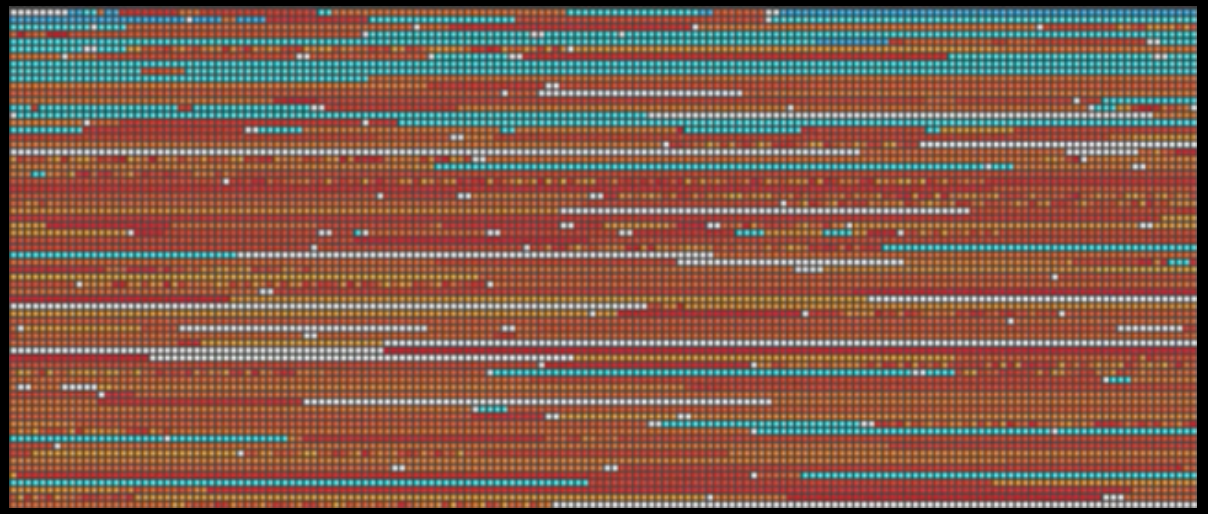
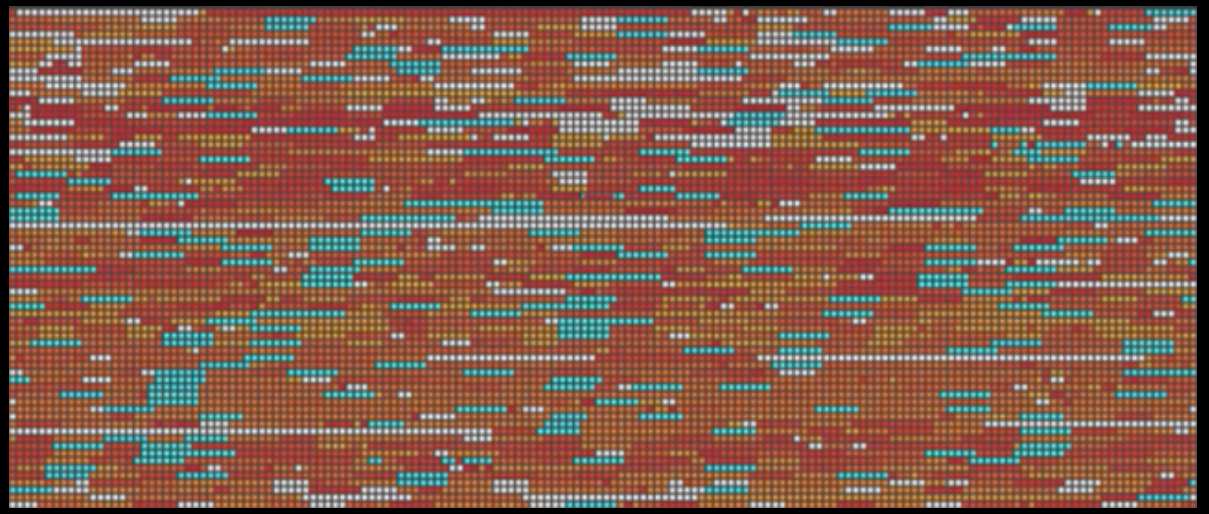
Low fragmentation under long-term workloads

VelocityFS by Tuxera



ext4



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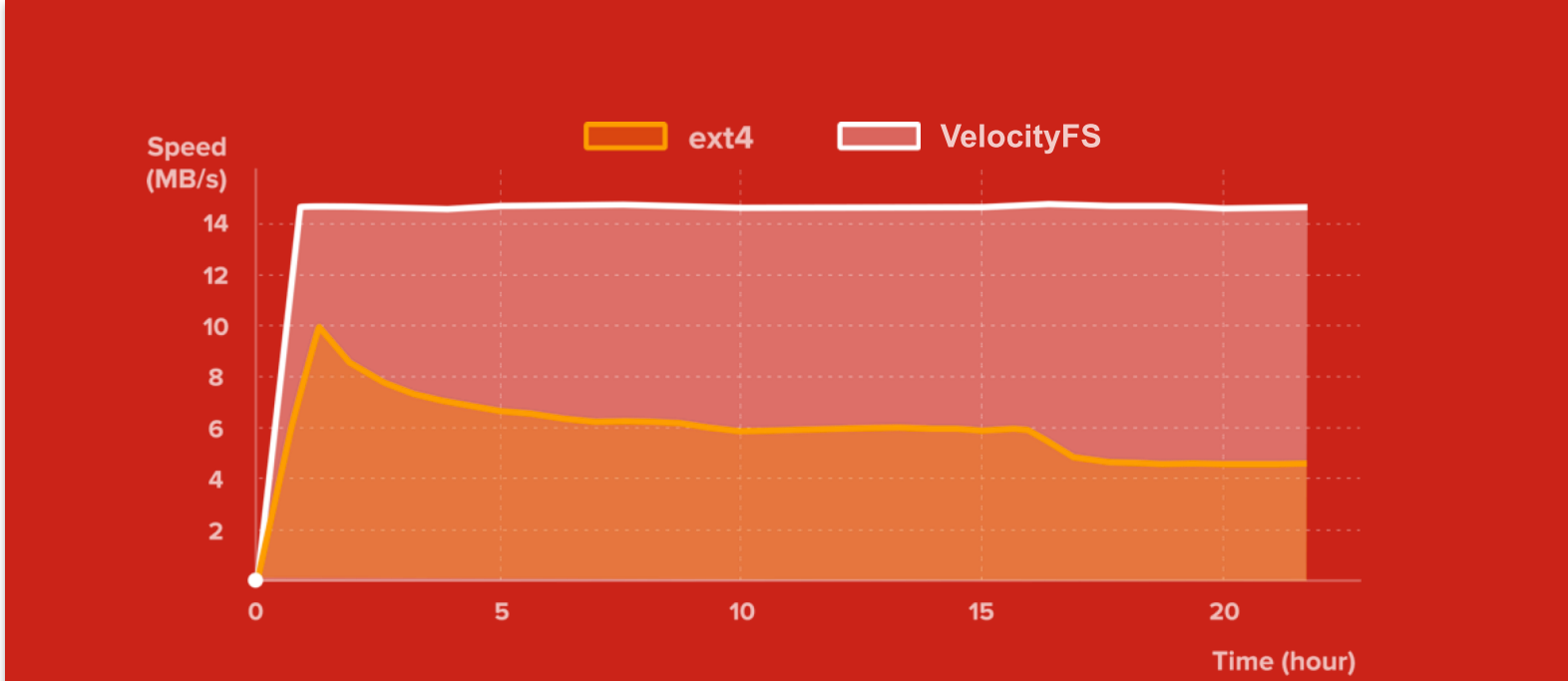
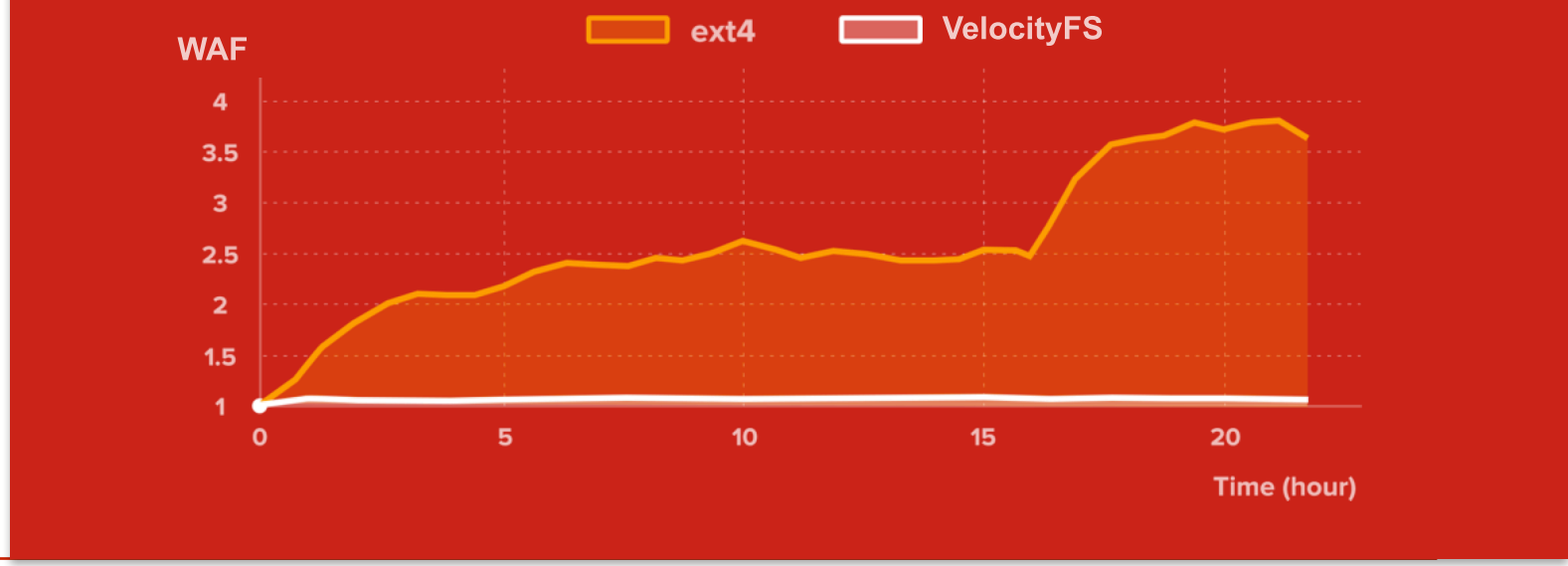
VelocityFS by Tuxera has consistently low WAF

Over the long term:

- ext4 performance drops
- erase amplification increases
- ext4 fragmentation gets worse





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Unsurpassed reliability and security

Fail-safe,
power safe

Encryption,
quotas, metadata
check-summing

Verified boot and
secure delete

What's in it for you

- ✓ Best/most cost-efficient storage stack for use case
- ✓ Ensure storage performance for safety
- ✓ Extend system lifetime by up to 3.2 times
- ✓ No lost data or frame loss
- ✓ 100% fail-safe and power-safe
- ✓ Reduce BOM costs
- ✓ Improved user experience and satisfaction

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Data-driven cars of tomorrow need intelligent storage software design today.

QUESTIONS AND ANSWERS

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