

Power, Energy and Thermal Considerations in SSD-Based I/O Acceleration

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Summary

Challenges: State-of-art SSD integrates much more internal resources compared to traditional ones. No one consider how growing internal resource impact **power, energy and thermal factor** on SSD.

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Goals: invokes the importance of power, energy, and temperature issues in high-end SSD and addresses the critical issues related with growing internal resources.

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Goals: invoke the importance of power, energy and temperature issues in high-end SSD and address the critical issues related with growing internal resource.

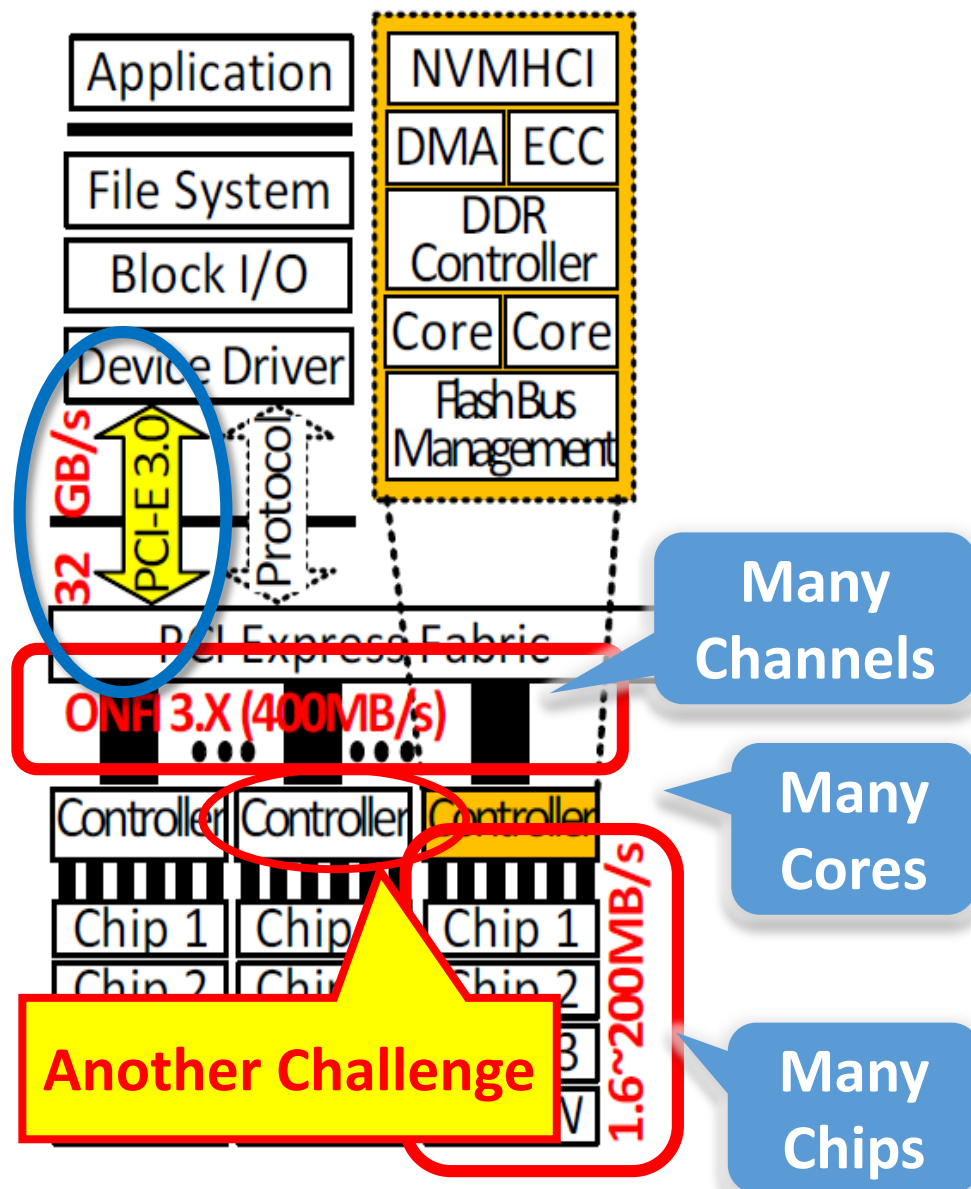
Contributions: we quantitatively analyze challenges of SSDs in integrating more resources:

- Operating temperature
- Dynamic power behaviors
- Energy consumption
- Overheating and power throttling issues

Outline

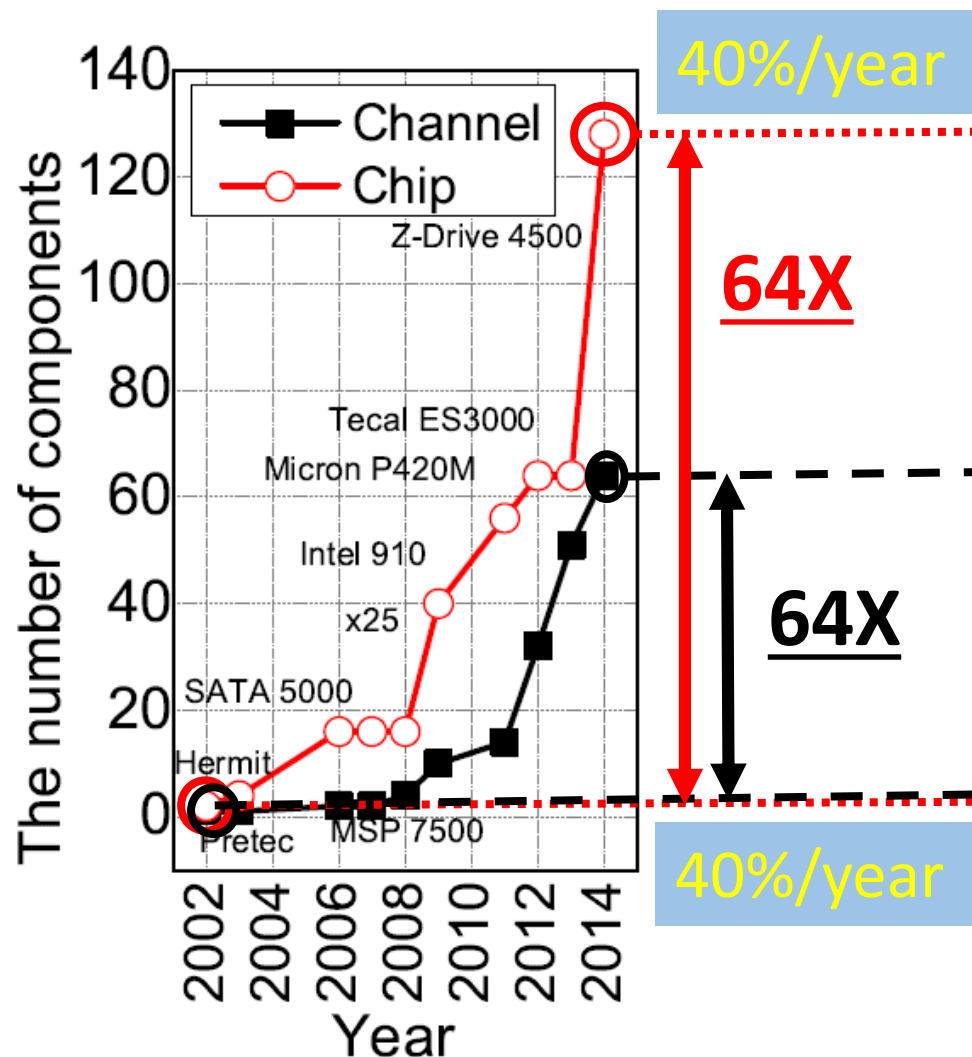
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Increased Resources in SSDs



- Huge bandwidth gap between single chip/channel and host interface
- Many chips to utilize chip-level parallelism
- Many channels to utilize channel-level parallelism
- Many controllers/cores to handle multiple tasks
- Overall, more and more resources are integrated in state-of-art SSDs

Resource Integration Trend



- In past 12 years, the number of chips and channels has been increased by 64 times
- Following this trend, there are more internal resources in the future
- Massive integrated power contributors cause potential power concern
- Essential to study power, energy, and thermal factor of modern SSDs

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Evaluation Setup: SSD Testbeds

	Baseline SSD	Multi-core SSD	Multi-resource SSD
	SP-SSD	MC-SSD	MR-SSD
Feature	Multi-Channel	Multi-Core	Multi-Resource
Interface	SATA 6Gbps	PCIe 2.0	PCIe 2.0
Core	3	16	16
# of Channels	8	8	32
# of Chips	64	64	128
DRAM Sizes	256MB	2GB	2.25GB
Storage Cap.	512GB	400GB	512GB

- MC-SSD vs. SP-SSD: more cores, larger DRAM size
- MR-SSD vs. SP-SSD: more channels, more chips

Evaluation Setup: Workload & Dev. Status

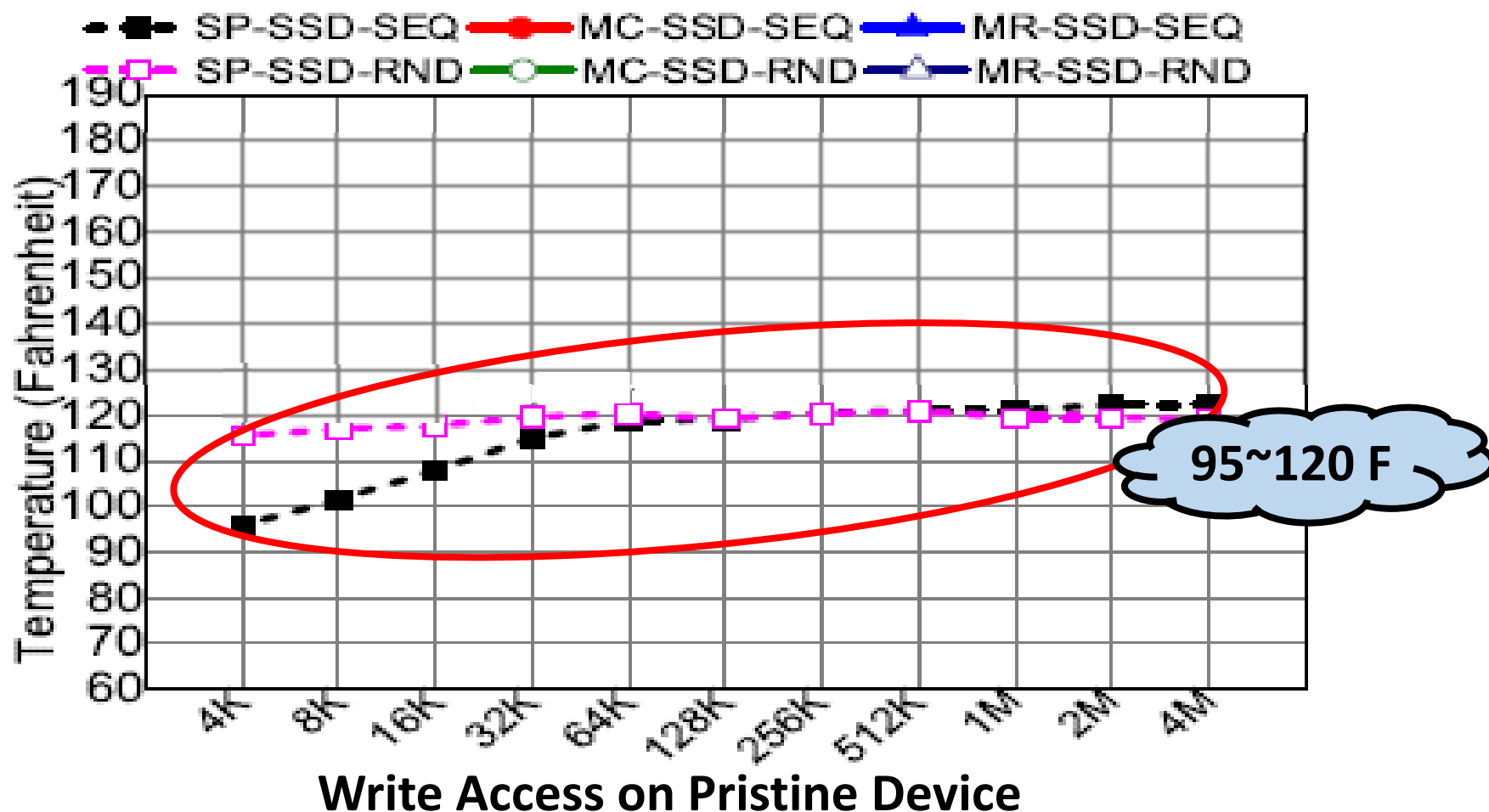
Data Type	SEQ			RND		
Data Size	4KB	8KB	16KB	32KB	64KB	128KB
	256KB	512KB	1MB	2MB	4MB	
Device Status	Pristine			Aged		

- **Data type:** sequential data and random data
- **Data size:** from **4KB** to **4MB**
- **Device status:**
 - Pristine device: SSD with default factory setting
 - Aged device: mimic actual aged SSD
- **Based on these, there are 192 different configurations**

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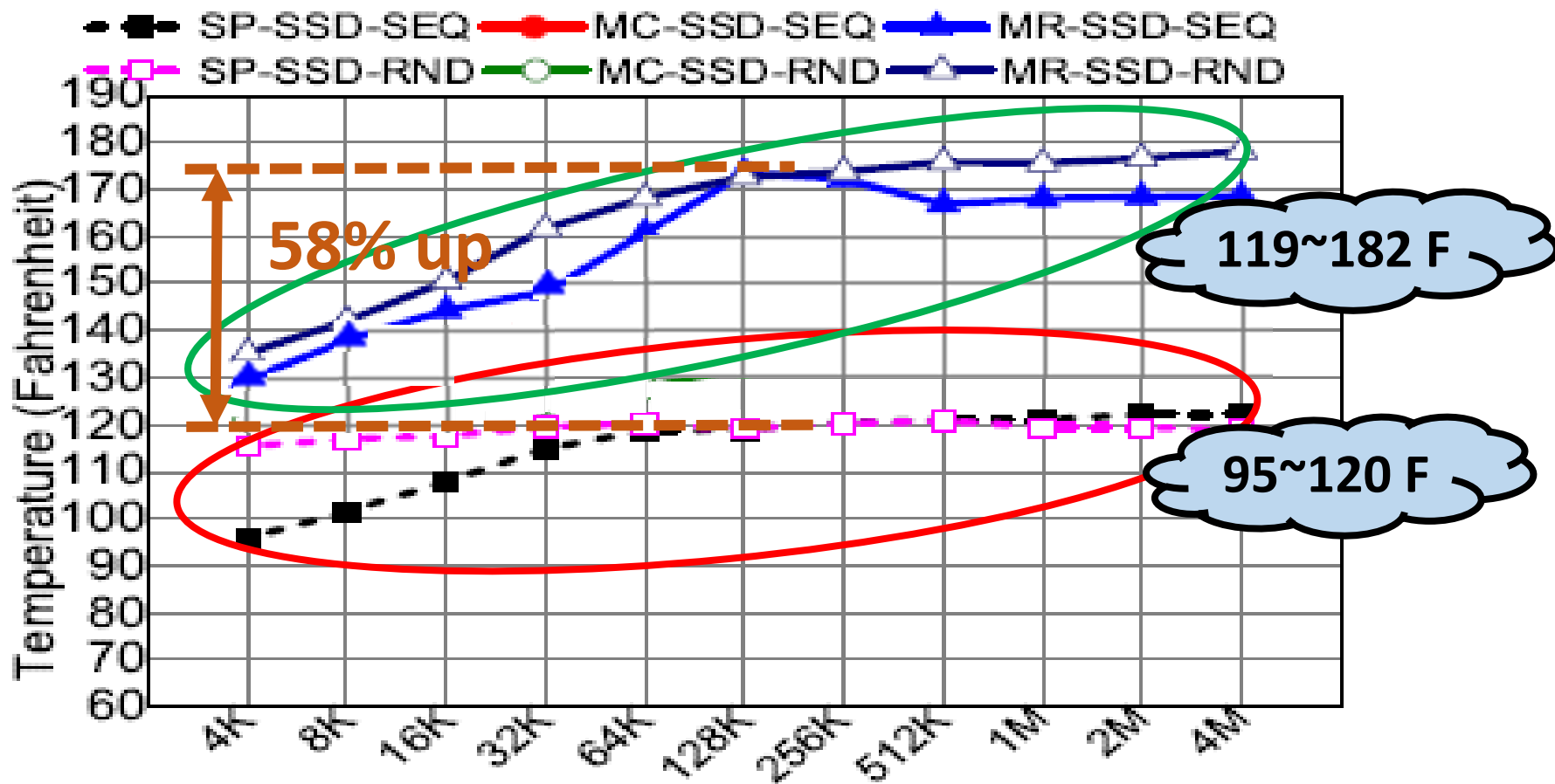
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Operating Temperature



- Various request sizes have little impact on SP-SSD's temperature

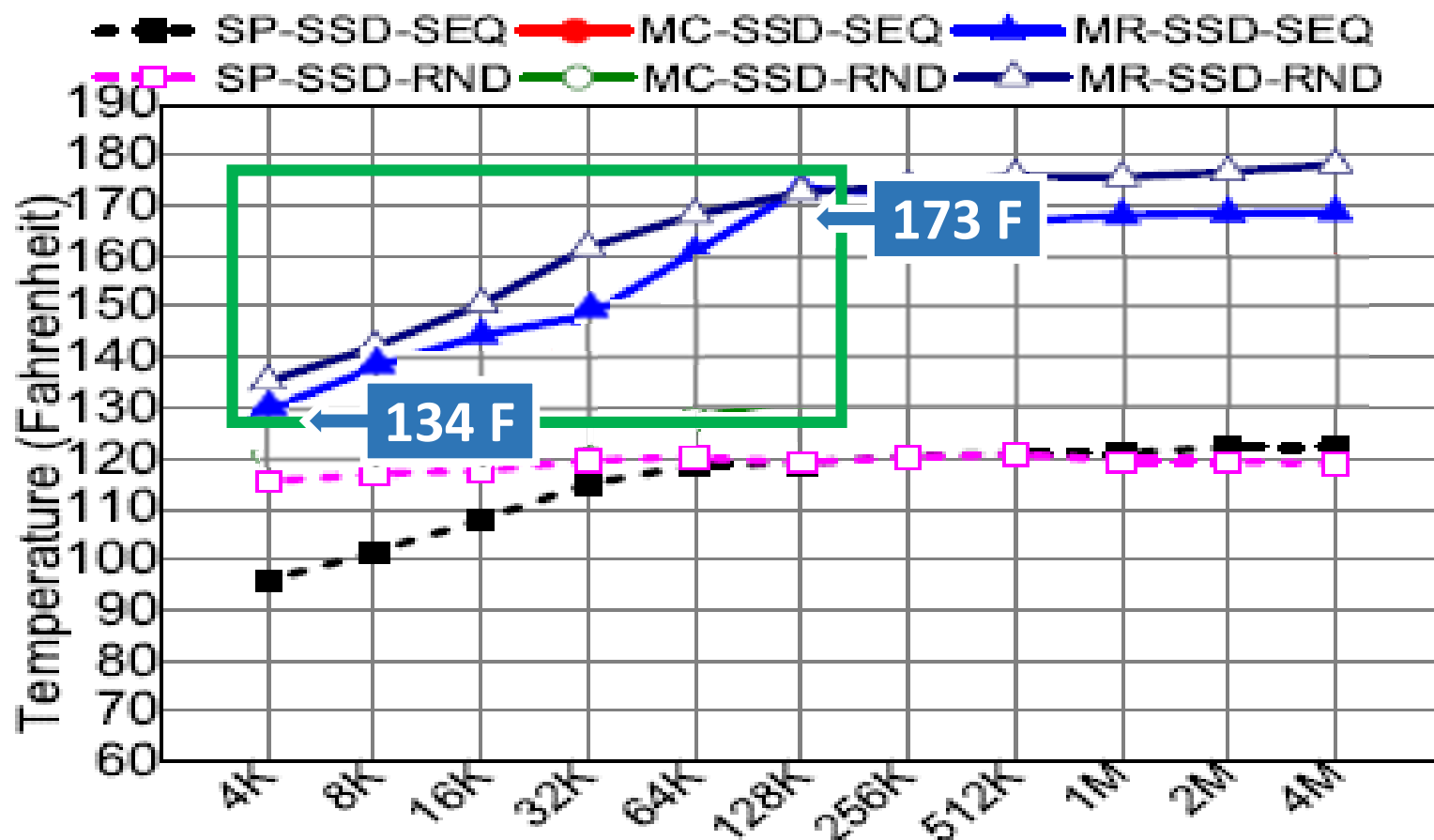
Operating Temperature



Write Access on Pristine Device

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- MR-SSD has higher temperature than SP-SSD

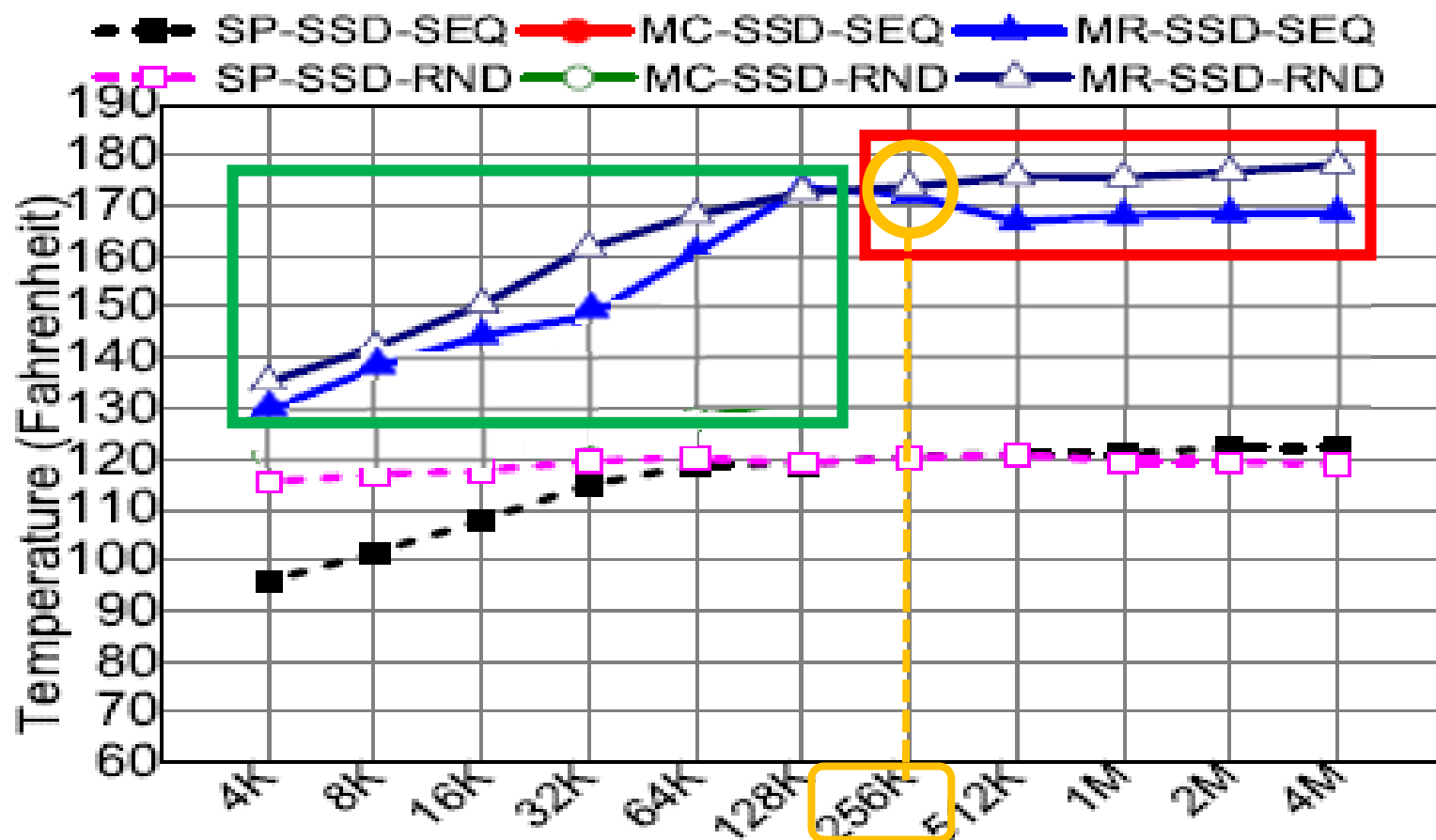
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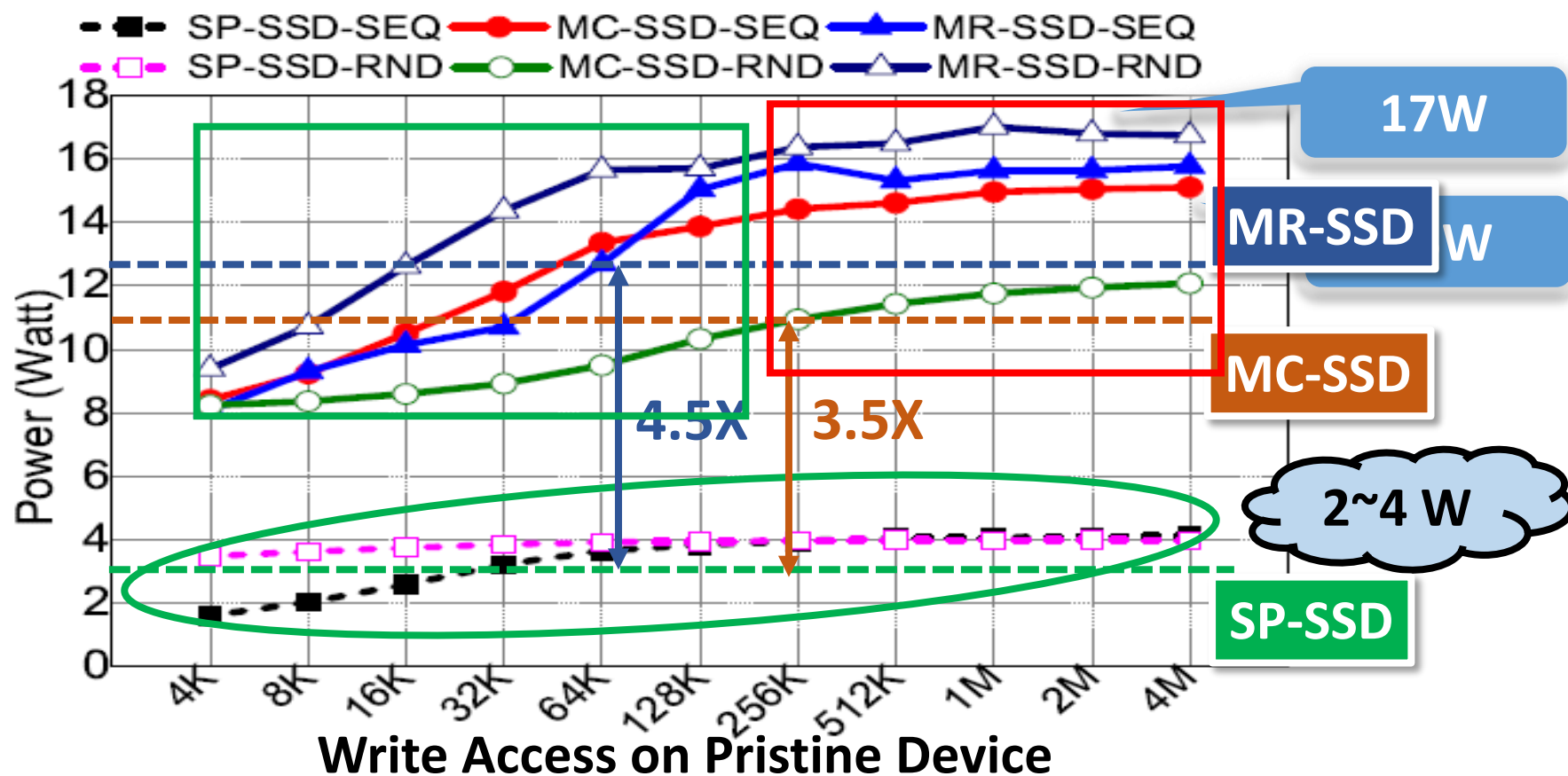
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Dynamic Power Behavior



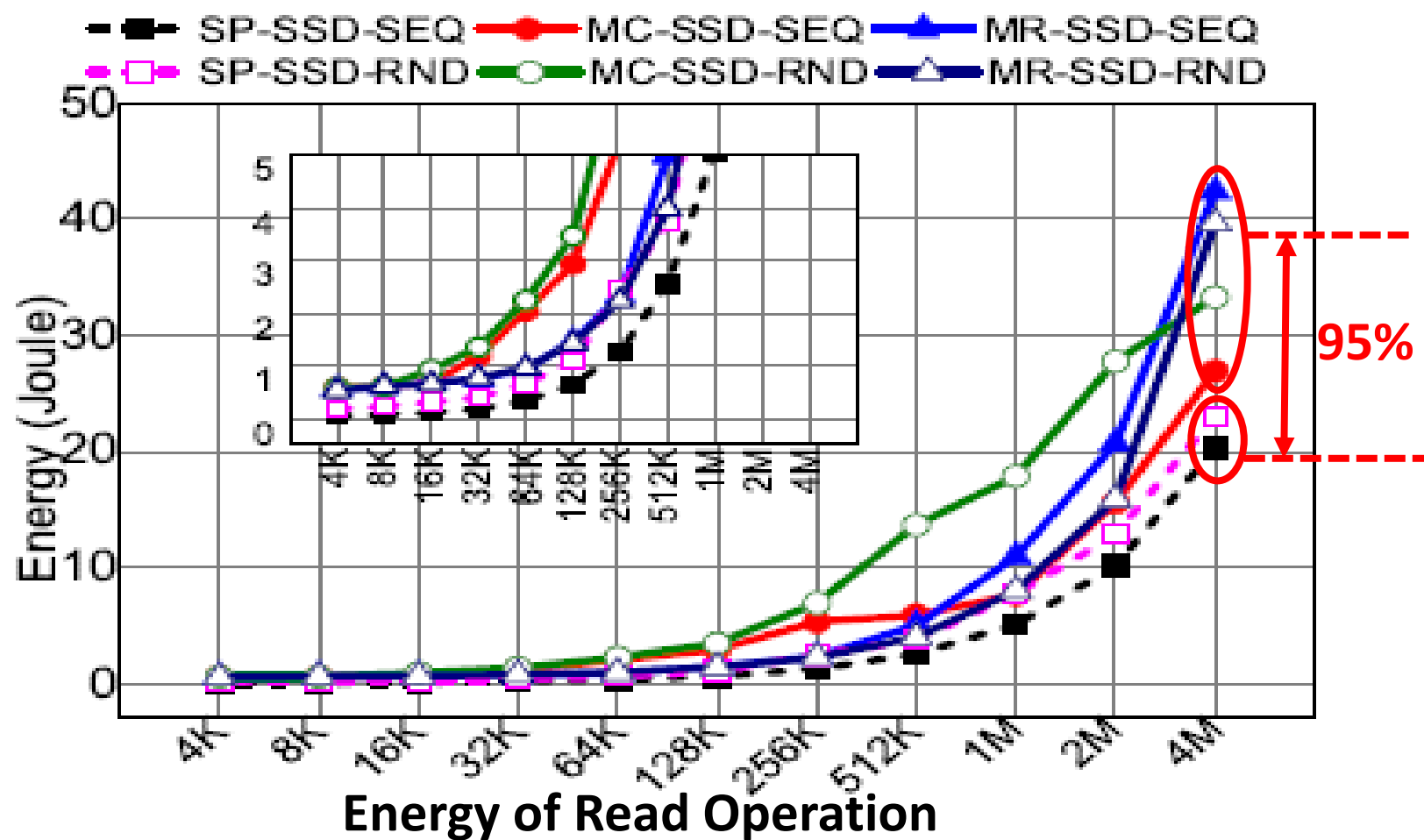
- Various request sizes have little impact on power of SP-SSD
- MC/MR-SSD consume 3.5X and 4.5X more power than SP-SSD
- As for MC/MR-SSD, power increases when data size increases
- Power saturates when data size increases to a certain level

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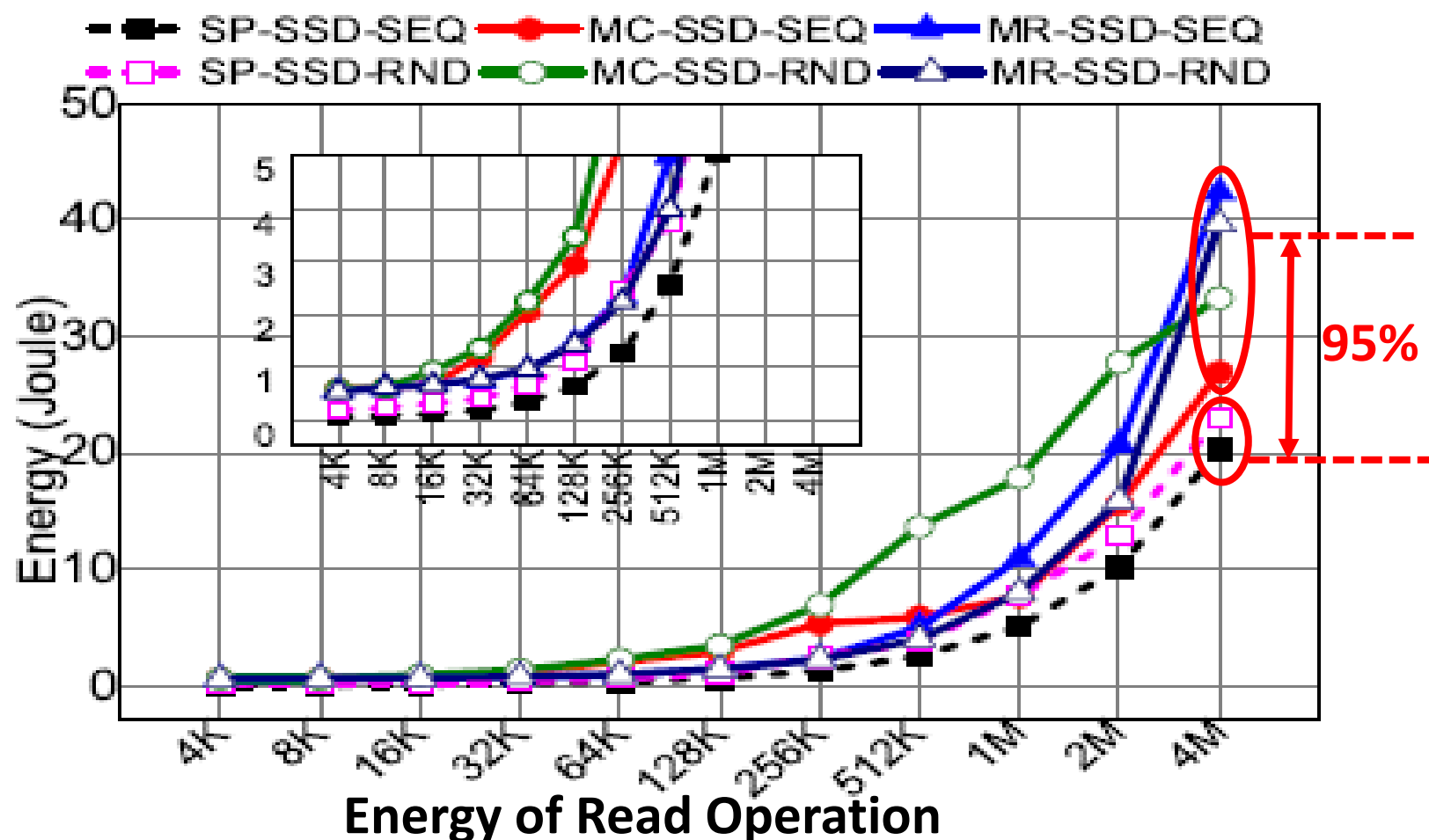
Energy Consumption

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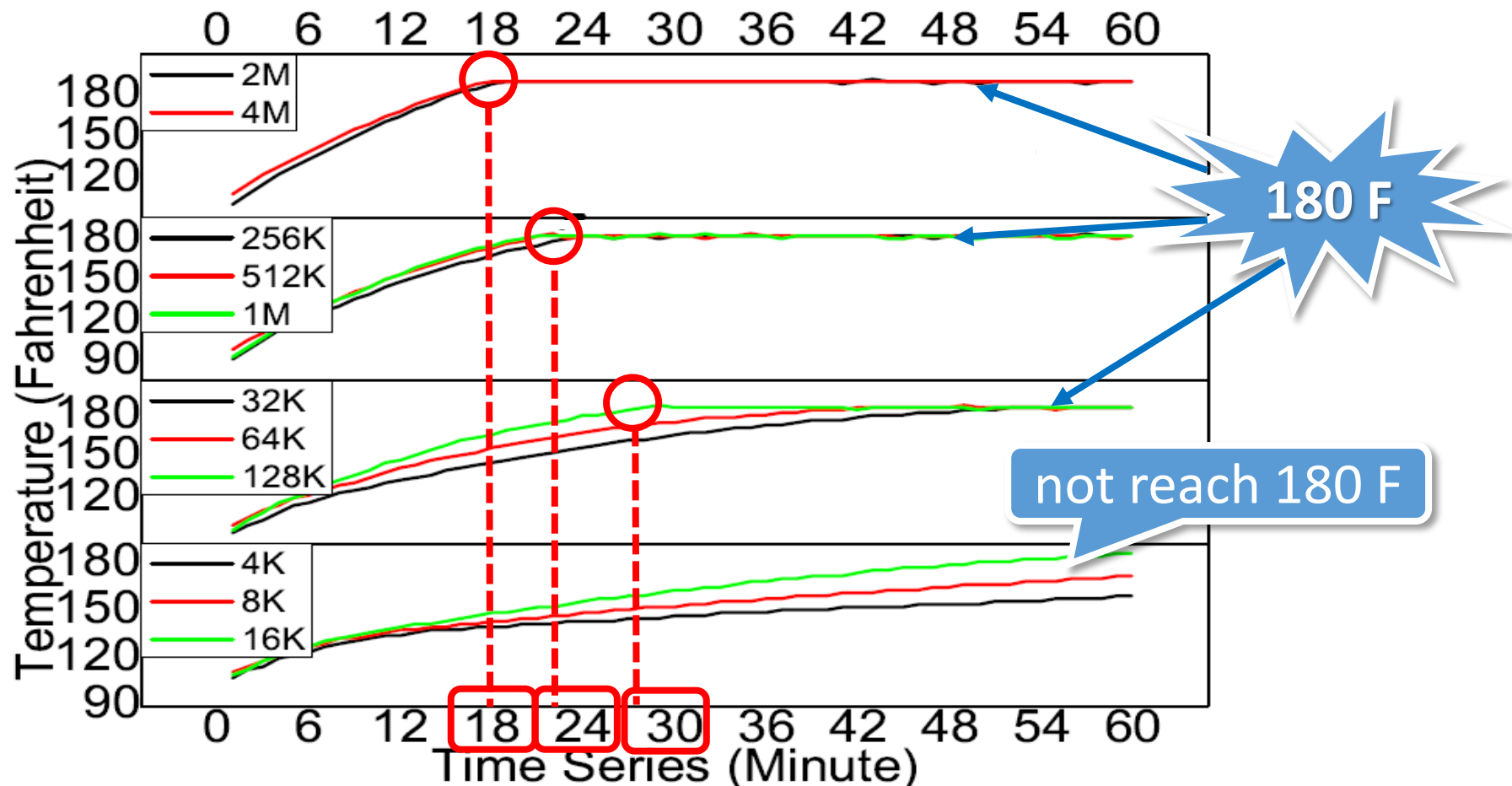


- MC/MR-SSDs cost more energy than SP-SSDs
- MC/MR-SSDs require more power to feed its internal resources

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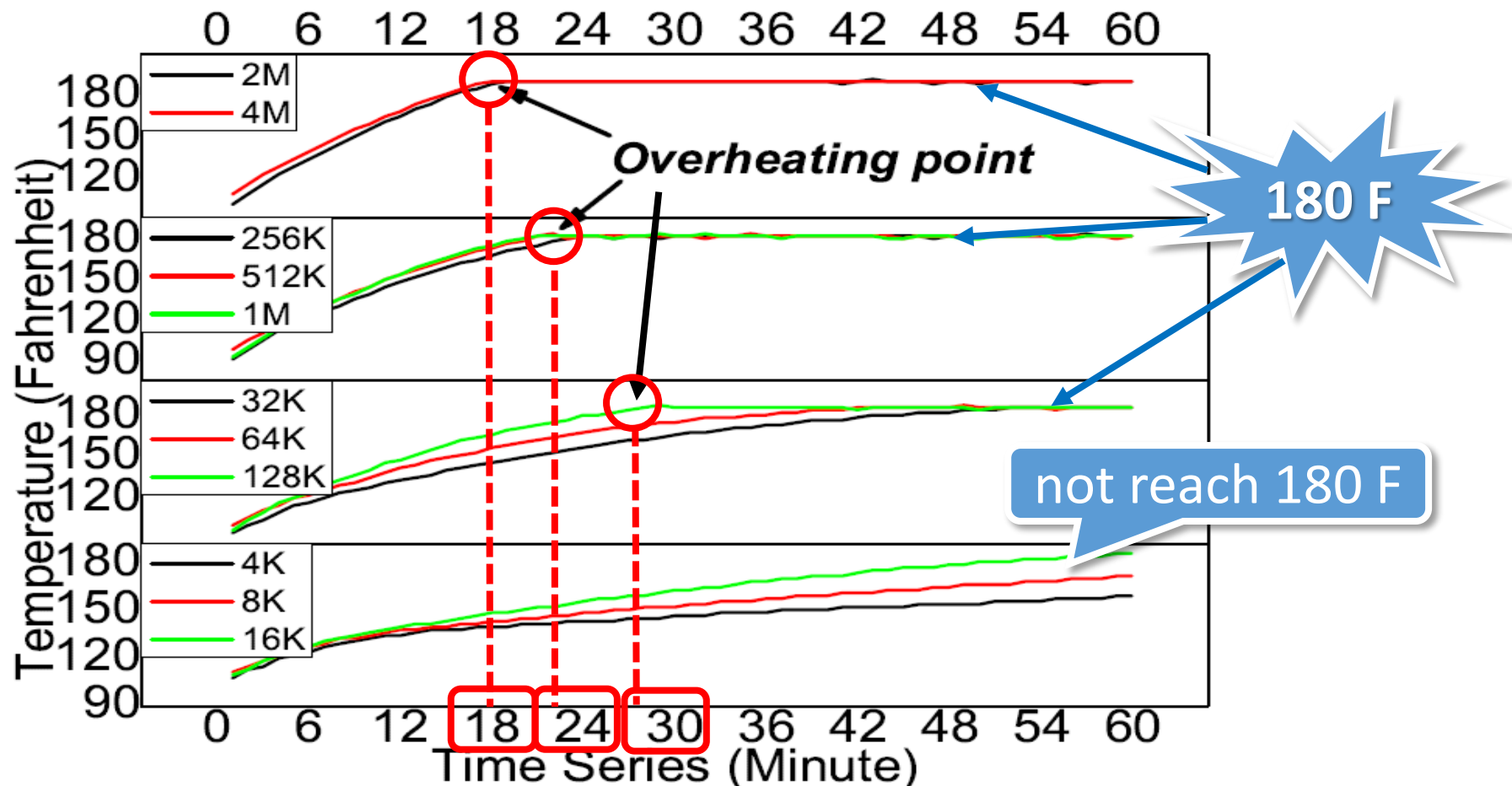
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Overheating Problem



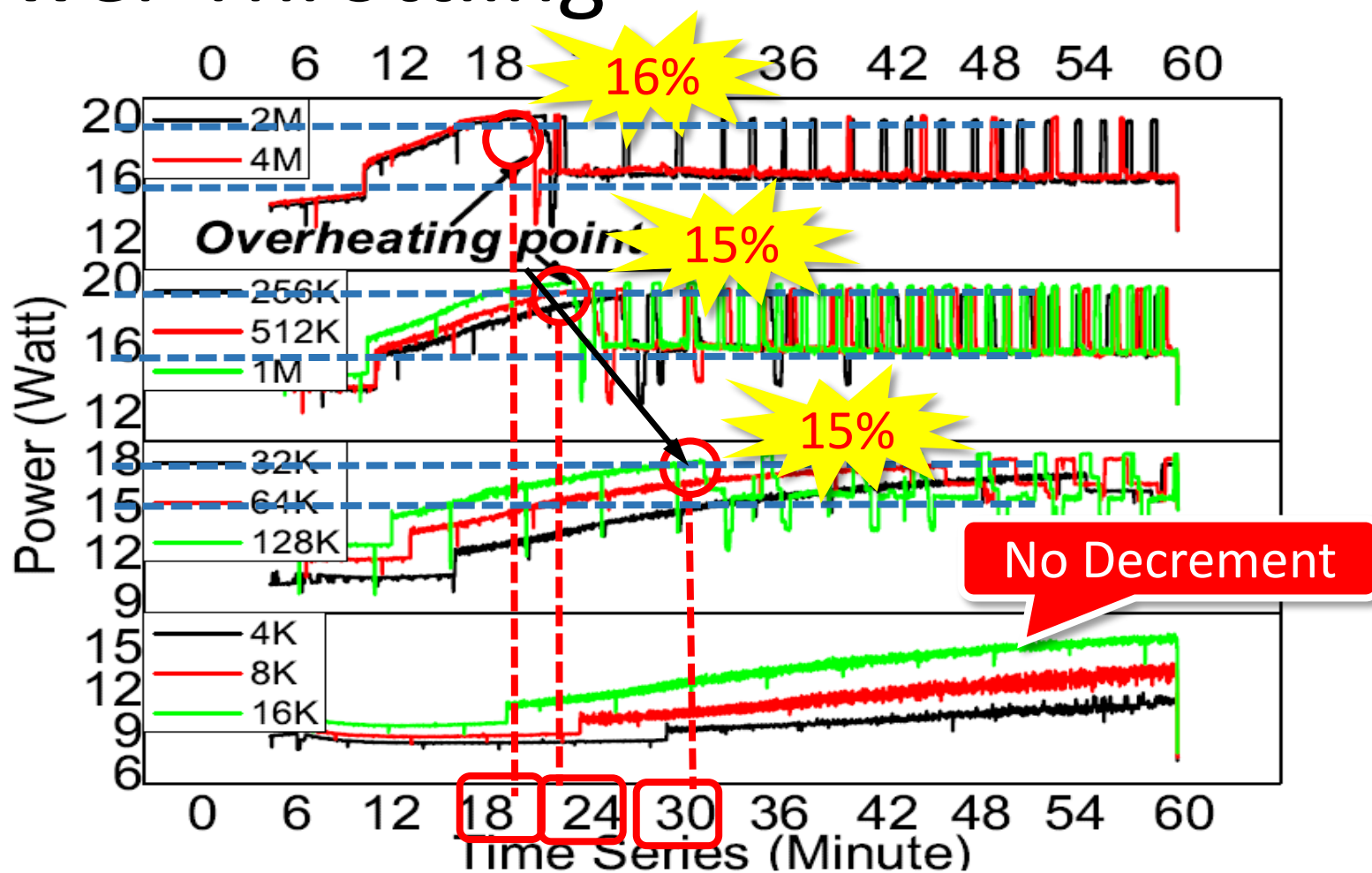
- Overheating problem: heat output exceeds certain level which may lead to malfunction of SSDs
- Device-level protection mechanism dynamically reduces heat output

Overheating Problem



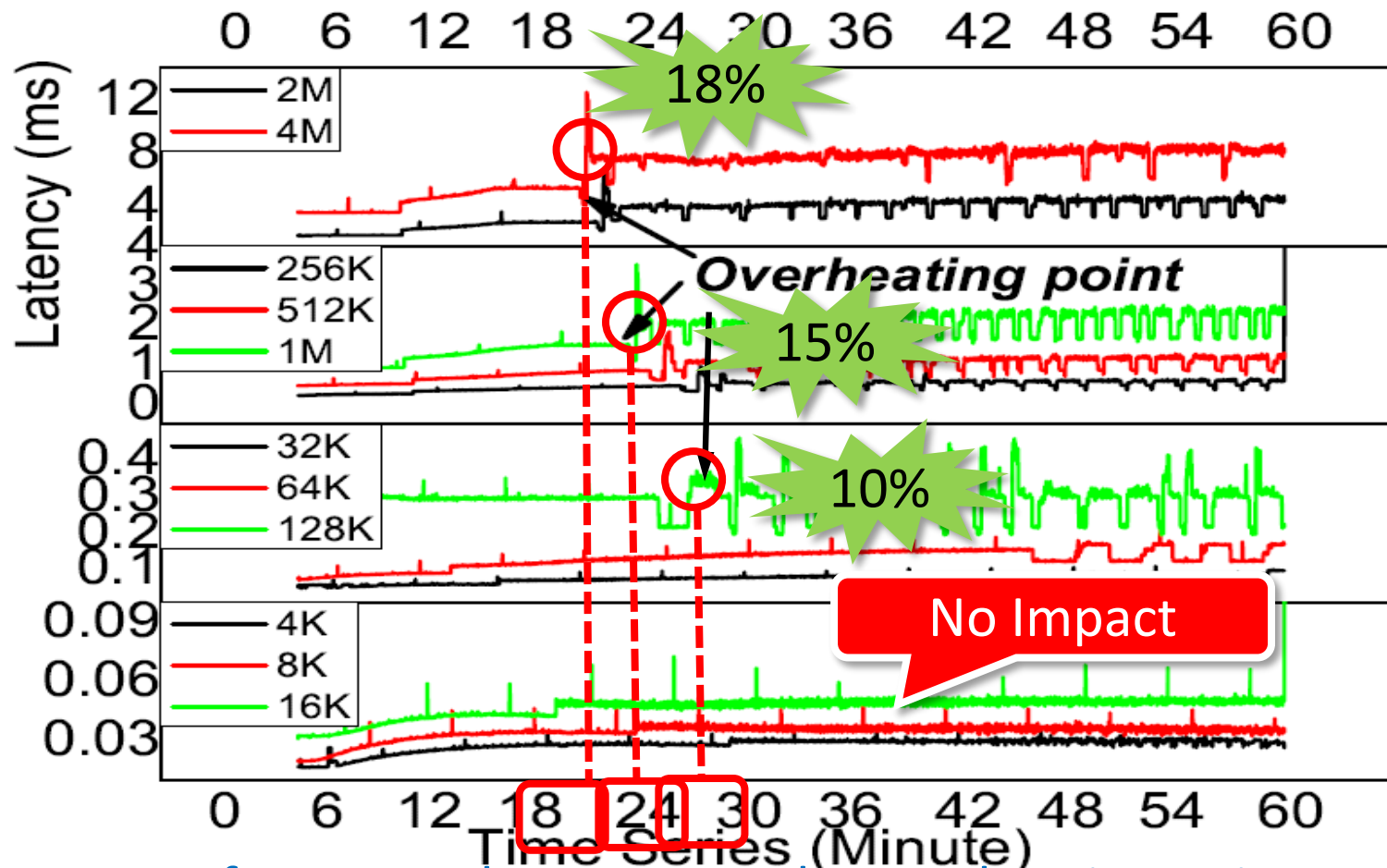
- Overheating problem: heat output exceeds certain level which may lead to malfunction of SSDs
- Device-level protection mechanism dynamically reduces heat output
- Devices with larger data sizes reach overheating points earlier
- How is the temperature controlled?

Power Throttling



- Power throttling : power is automatically decreased at overheating point to control heat output
 - This decrement is carried out by device-level mechanism
- Is simply decreasing power good enough?

Power Throttling's Drawback



- Huge performance decreases at the overheating point
- protection mechanism throttles power by turning off active resources
- Less power reduces temperature, but also limit active resources
- Overheating problem and power throttling issue hinders SSDs from integrating more resources

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Critical Findings:

- MC/MR-SSDs generate higher temperature, consume larger power and energy than conventional SSDs-not acceptable for many work conditions
- Overheating problem and power throttling issues are holding back state-of-the-art SSDs from achieving potential performance gains

Future Work:

- HW/SW optimization studies are required to improve power and energy efficiency of SSDs

Thank you!