

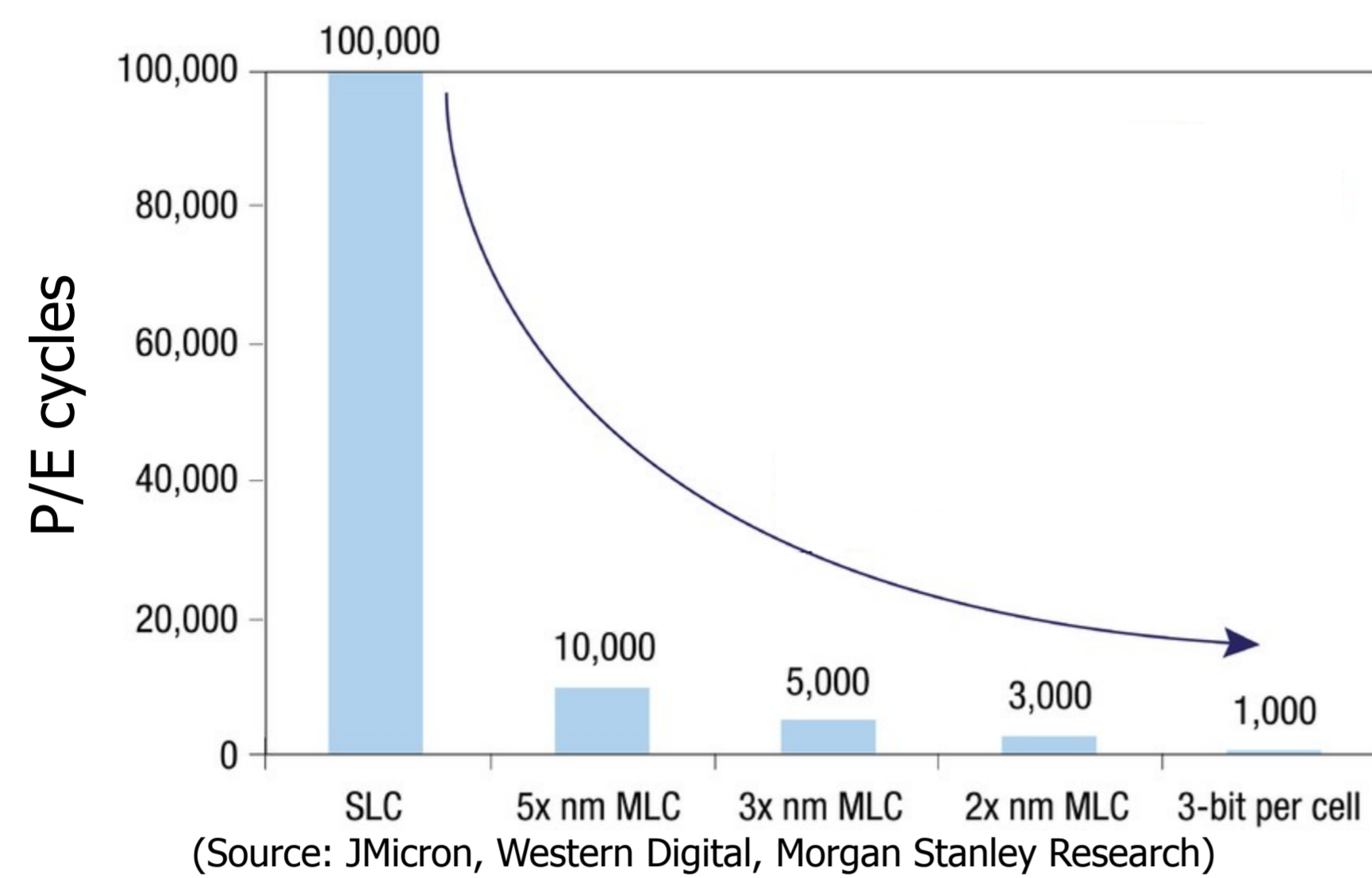


Lifetime Management of Flash-Based SSDs Using Recovery-Aware Dynamic Throttling

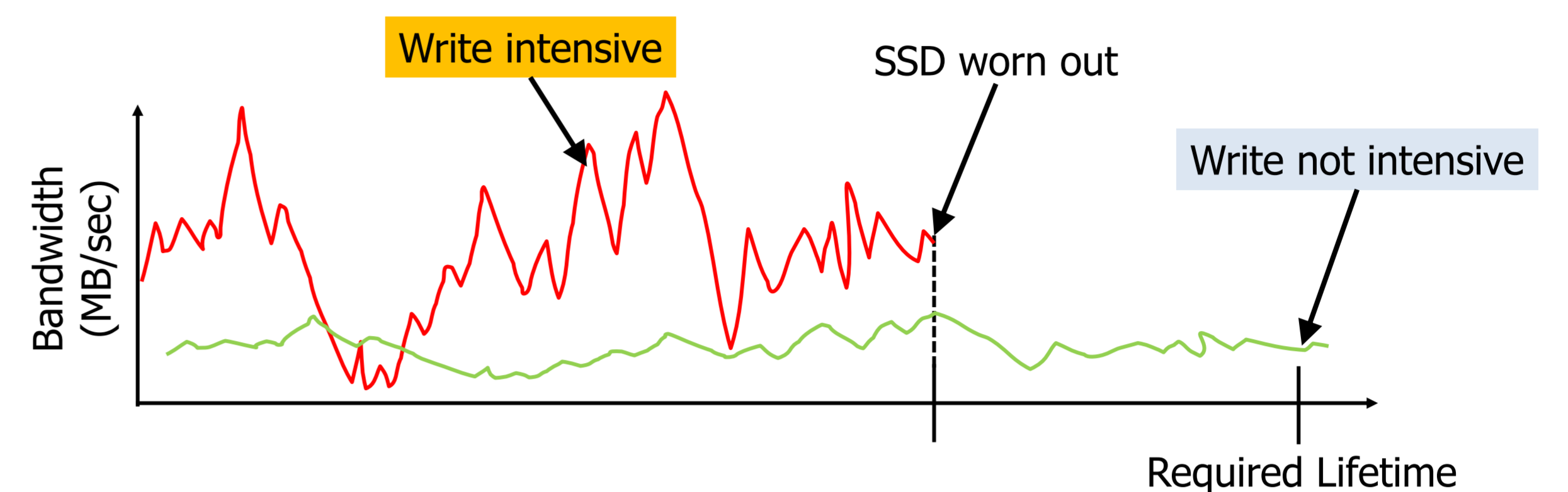
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Motivation

- The poor write endurance of SSDs is a main barrier for wider adoption of SSDs in the enterprise market.
- The endurance of SSDs is rapidly decreasing.
 - 100K P/E cycles (SLC) → 3K P/E cycles (2x nm MLC)



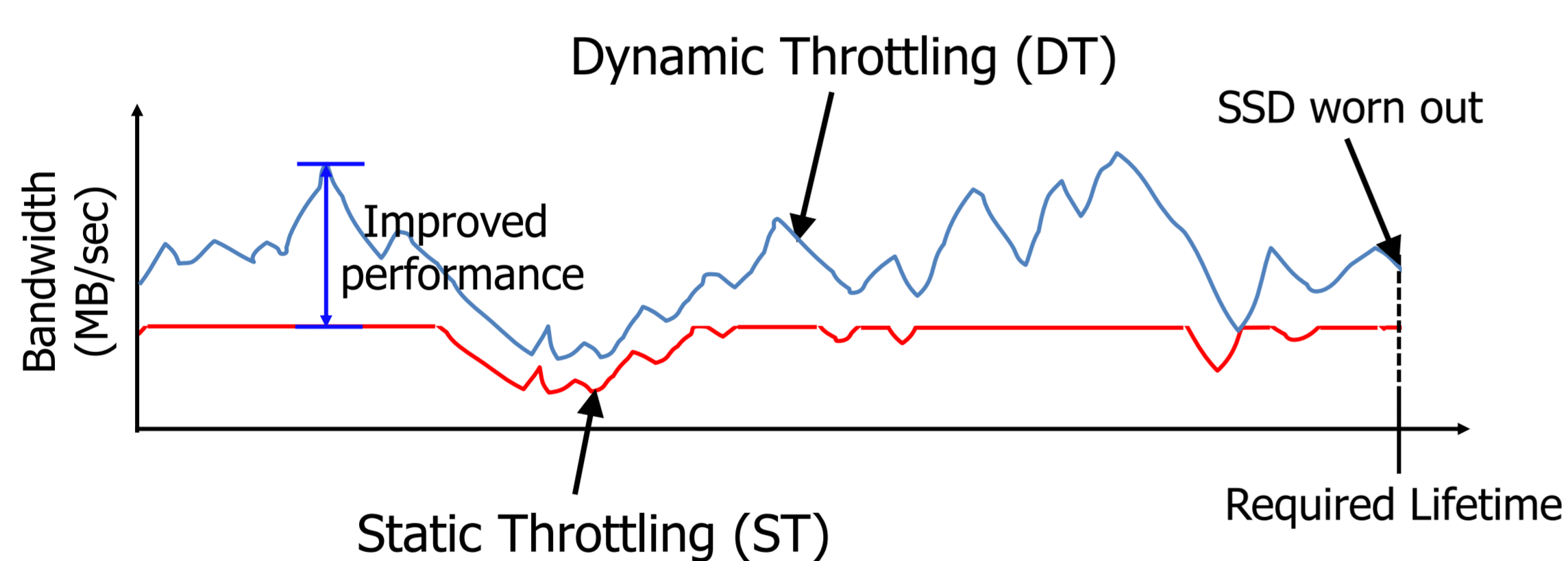
- The lifetime of SSDs is unpredictable.
 - The SSD lifetime is determined by write intensiveness of a workload (i.e., the amount of data written by a workload).



- It is a challenge to guarantee the required SSD lifetime, which is important for enterprise customers.

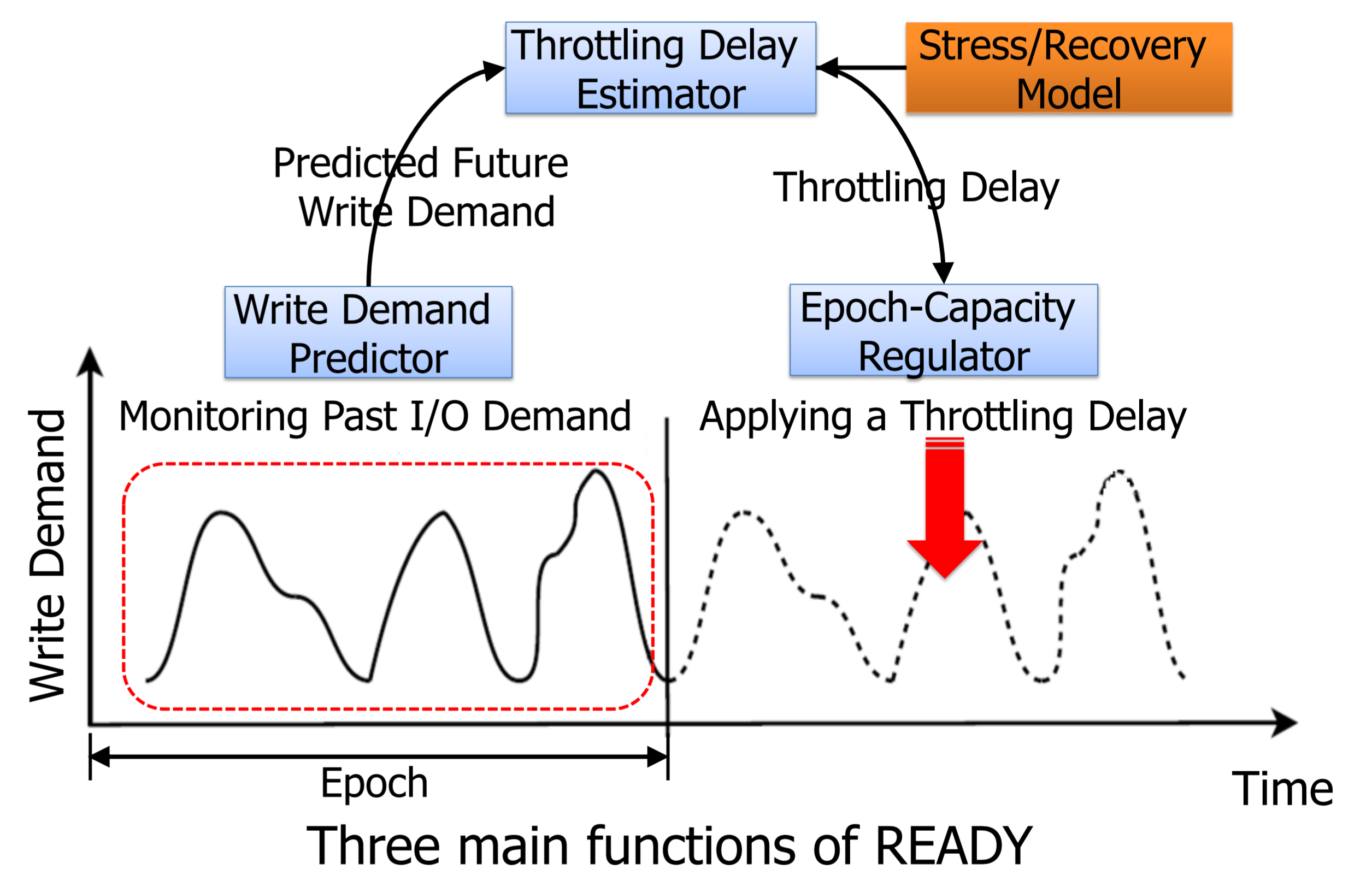
Our Approach

- Guarantee the required SSD lifetime by throttling (or reducing) the write performance of the SSD
- Static throttling (existing approach)
 - Limit the maximum SSD bandwidth to a certain fixed value
 - Underutilize the maximum endurance of the SSD
- Dynamic throttling (our approach)
 - Throttle the SSD performance adapting to a workload
 - Fully utilize the maximum endurance of the SSD, offering better performance than static throttling



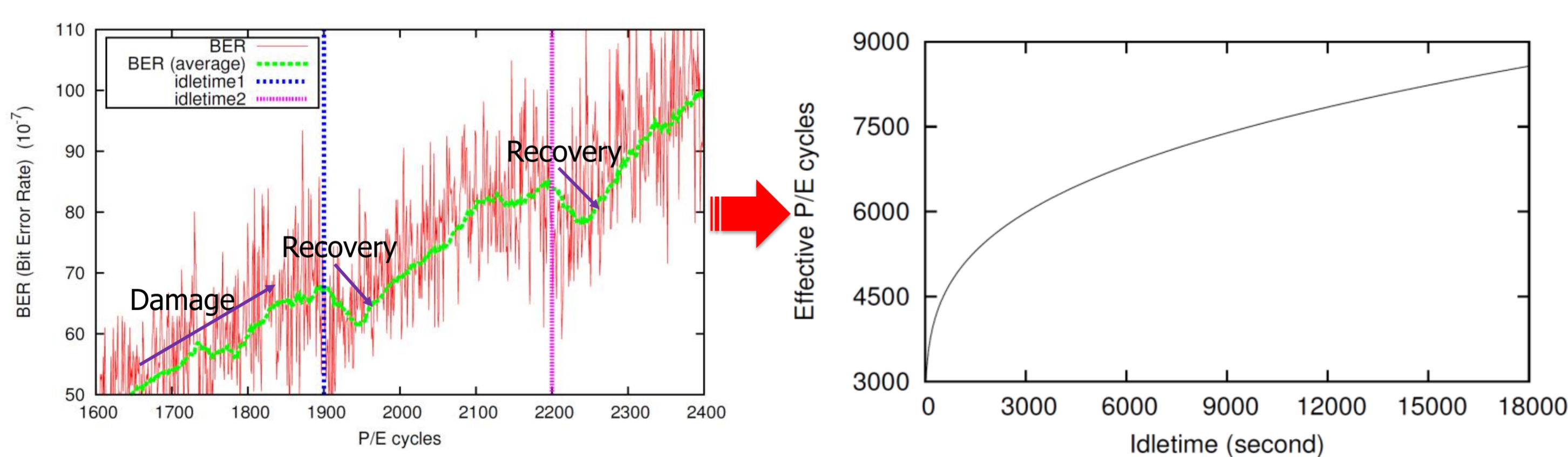
Dynamic Throttling

- Determine a throttling delay as low as possible
- Distribute a throttling delay over every write request as evenly as possible



Recovery-aware Dynamic Throttling (READY)

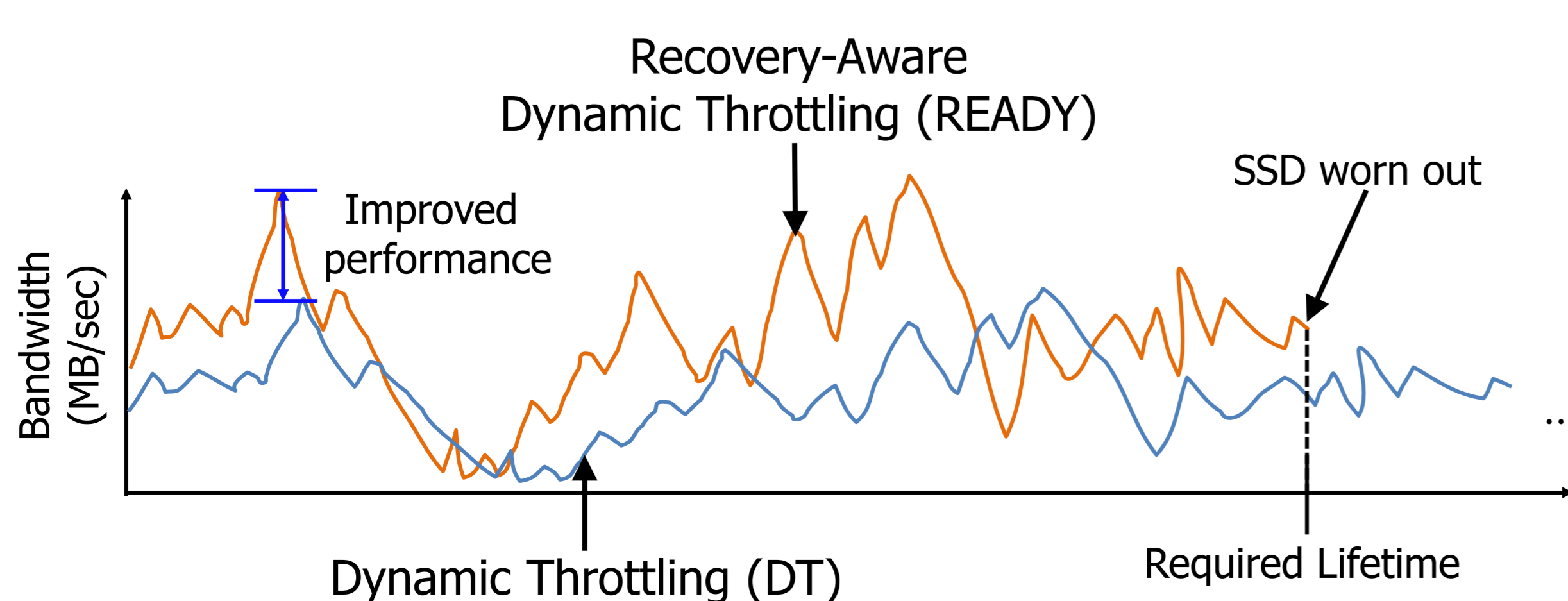
- Self-recovery effect: the number of effective P/E cycles is much larger than the number on datasheets.



The Effect of self-recovery on bit error rate (BER)

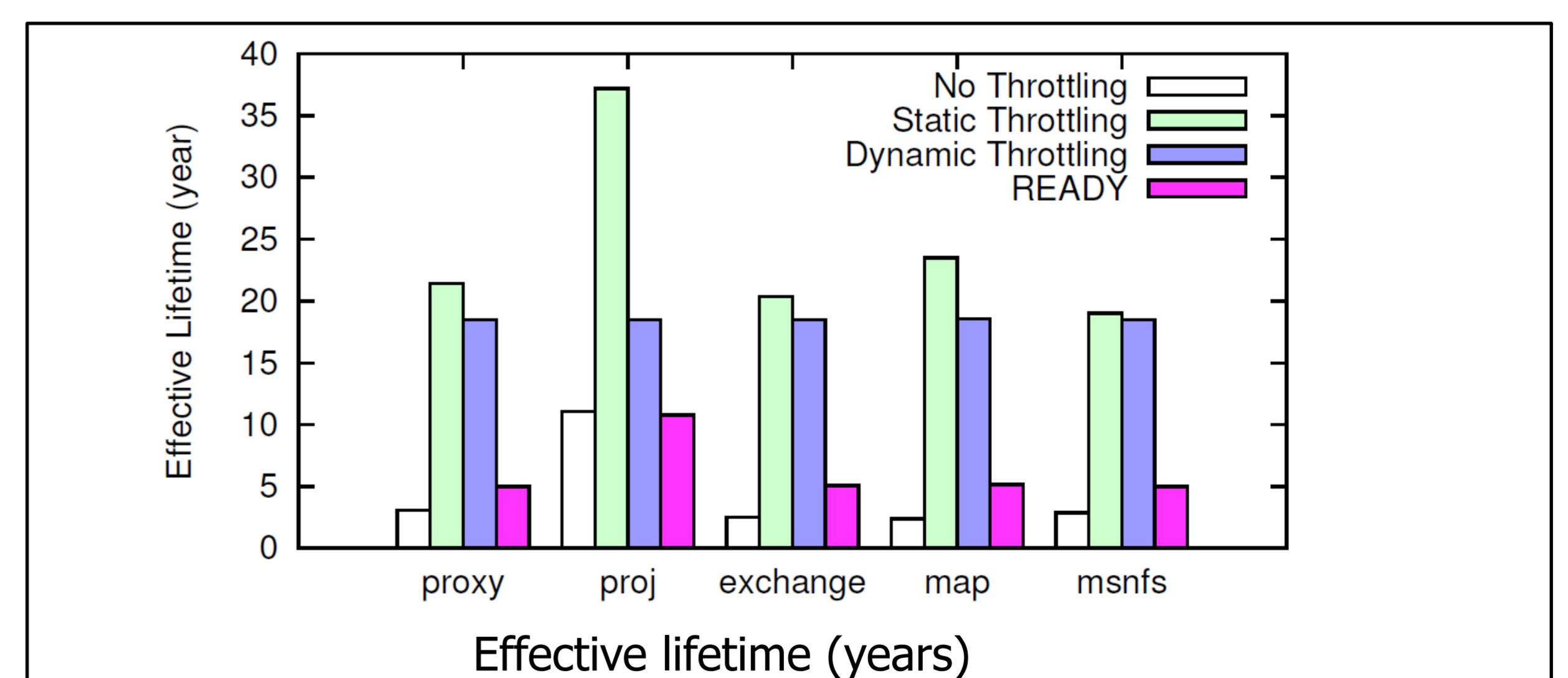
The effective number of P/E cycles

- Recovery-aware dynamic throttling (READY): exploit the self-recovery effect to guarantee the SSD lifetime with less throttling overheads

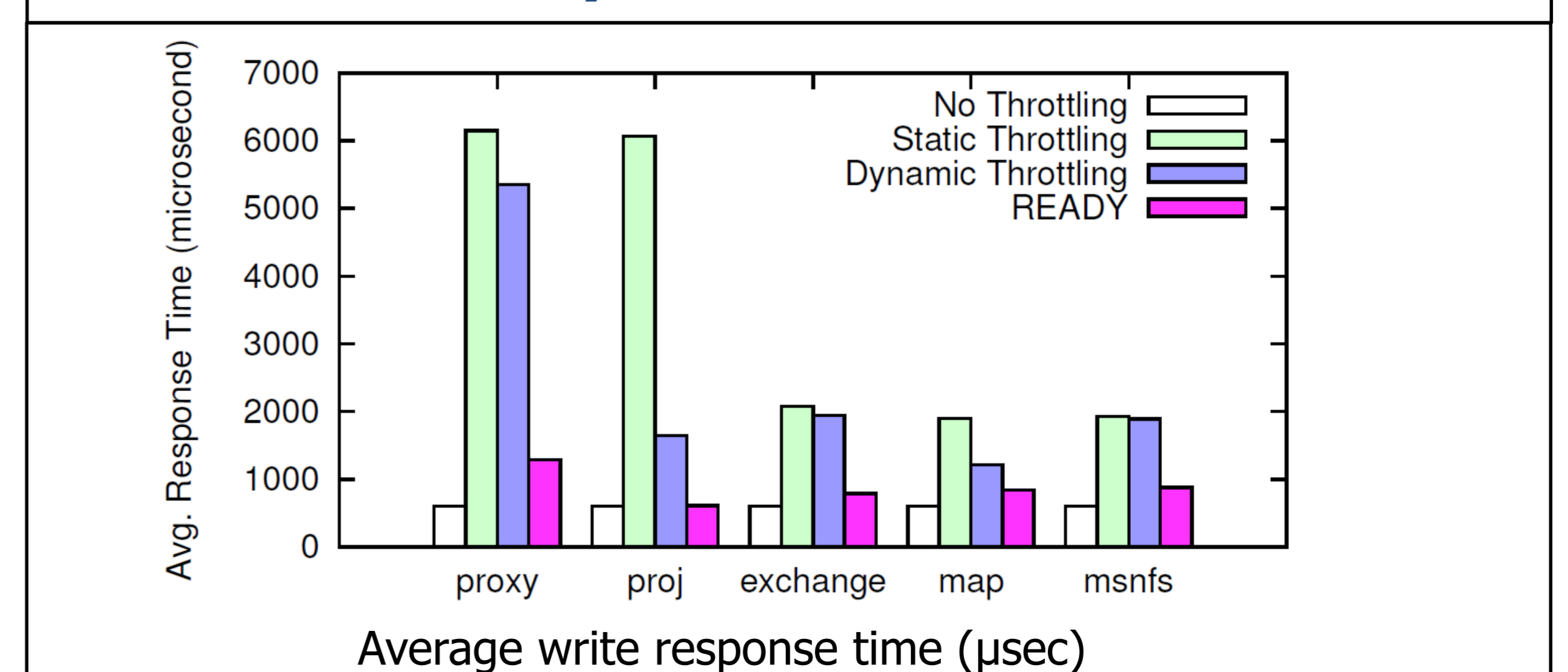


Results

- Evaluate the lifetime and performance using enterprise traces from MSR-Cambridge and MS-Production



- Guarantee the **5-year lifetime** for all the traces



- Improve the write speed by **4x** over static throttling