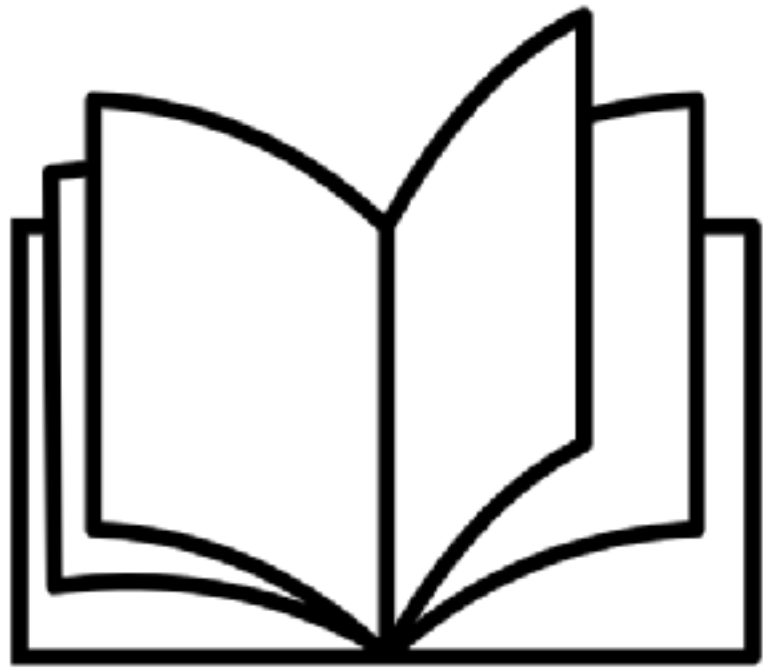
Tutorial on Sorting

Database System Technology

Niv Dayan

Midterm covers all
material so far
(Including this week)



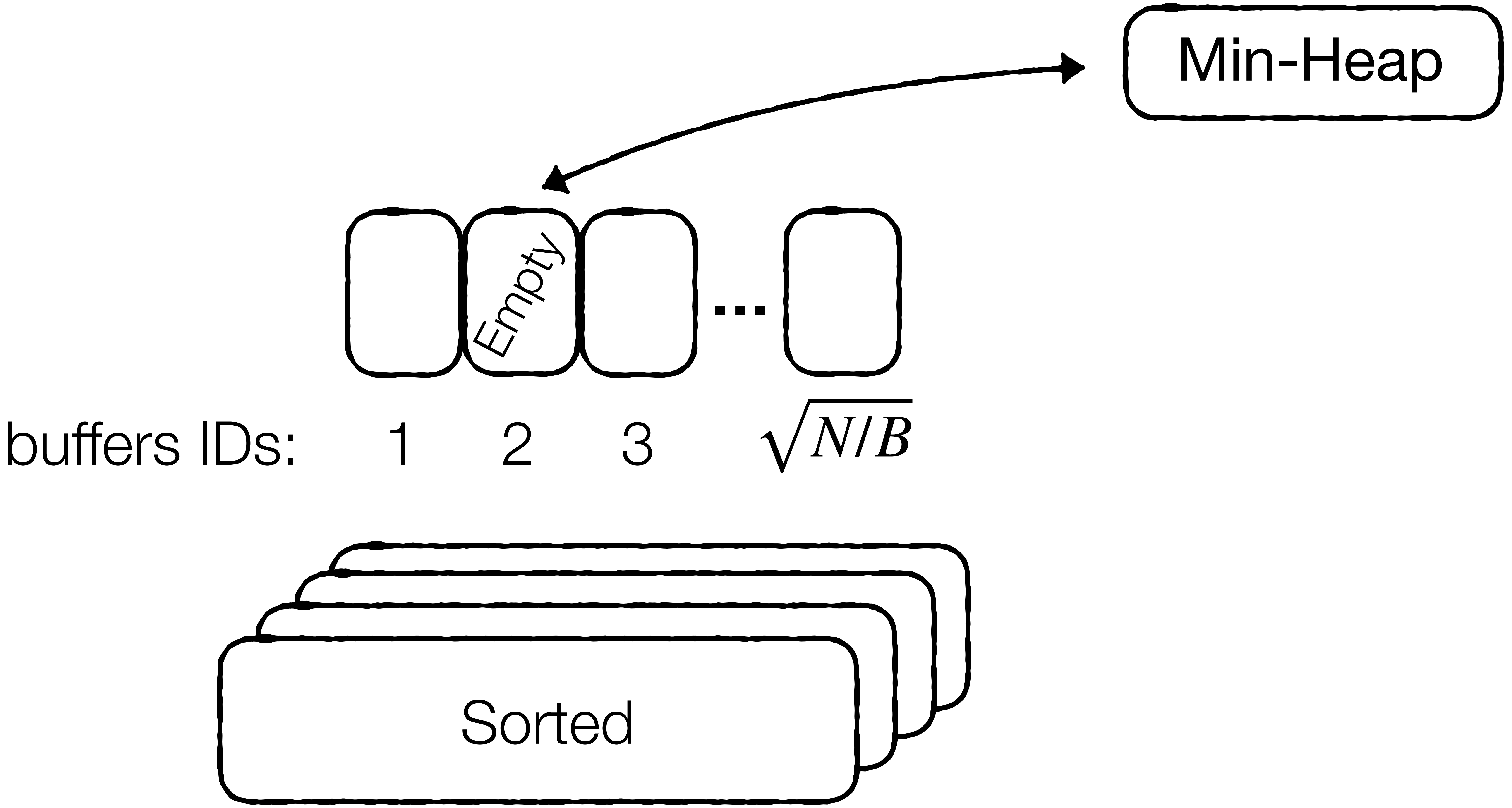
Open book

Office Hours

TA Office Hours
4-6 pm
(Project + content)

Instructor Office Hours
4-5 pm and 7-8 pm

Suppose we need next min entry from buffer 2 but it is empty.



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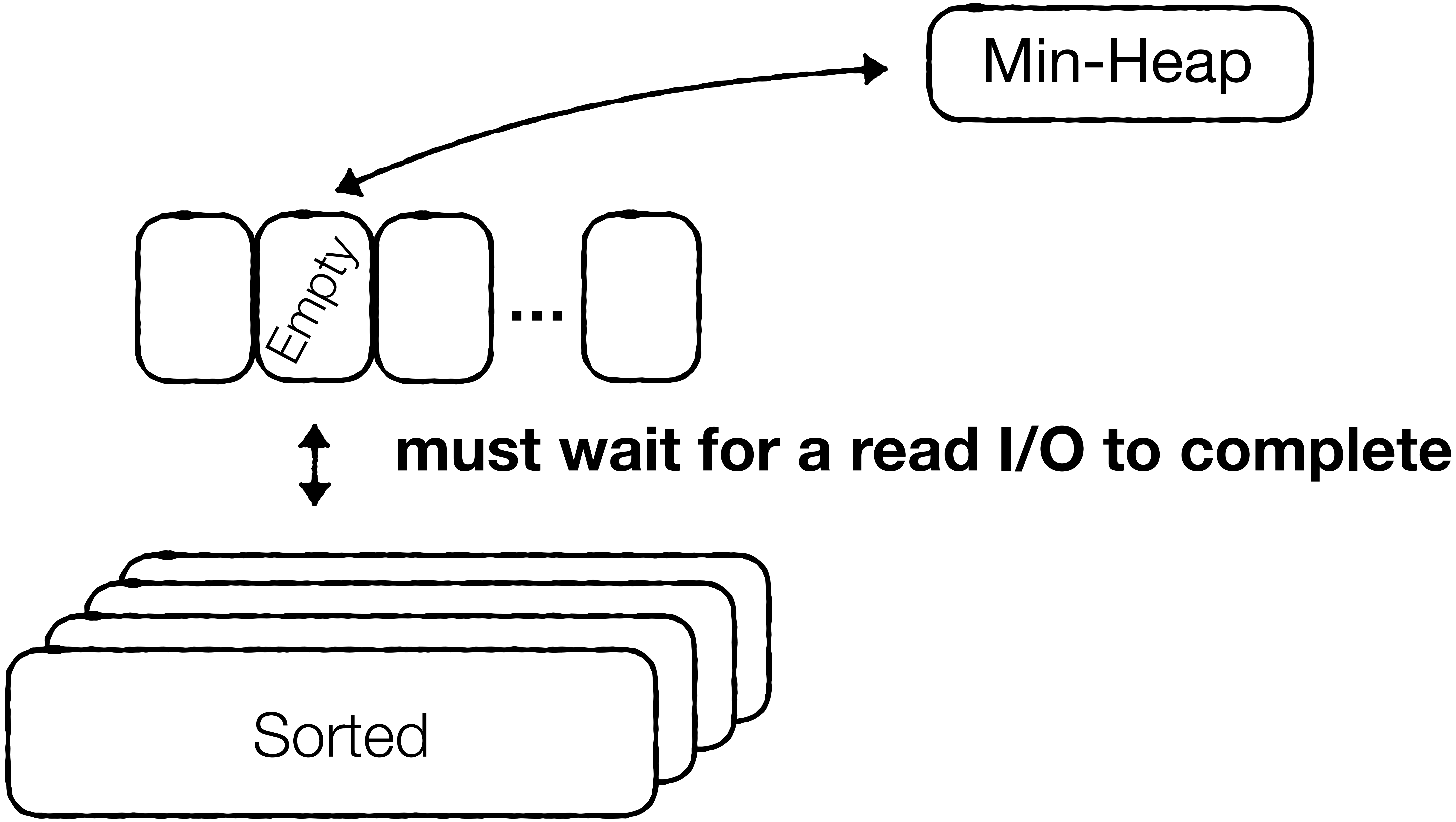
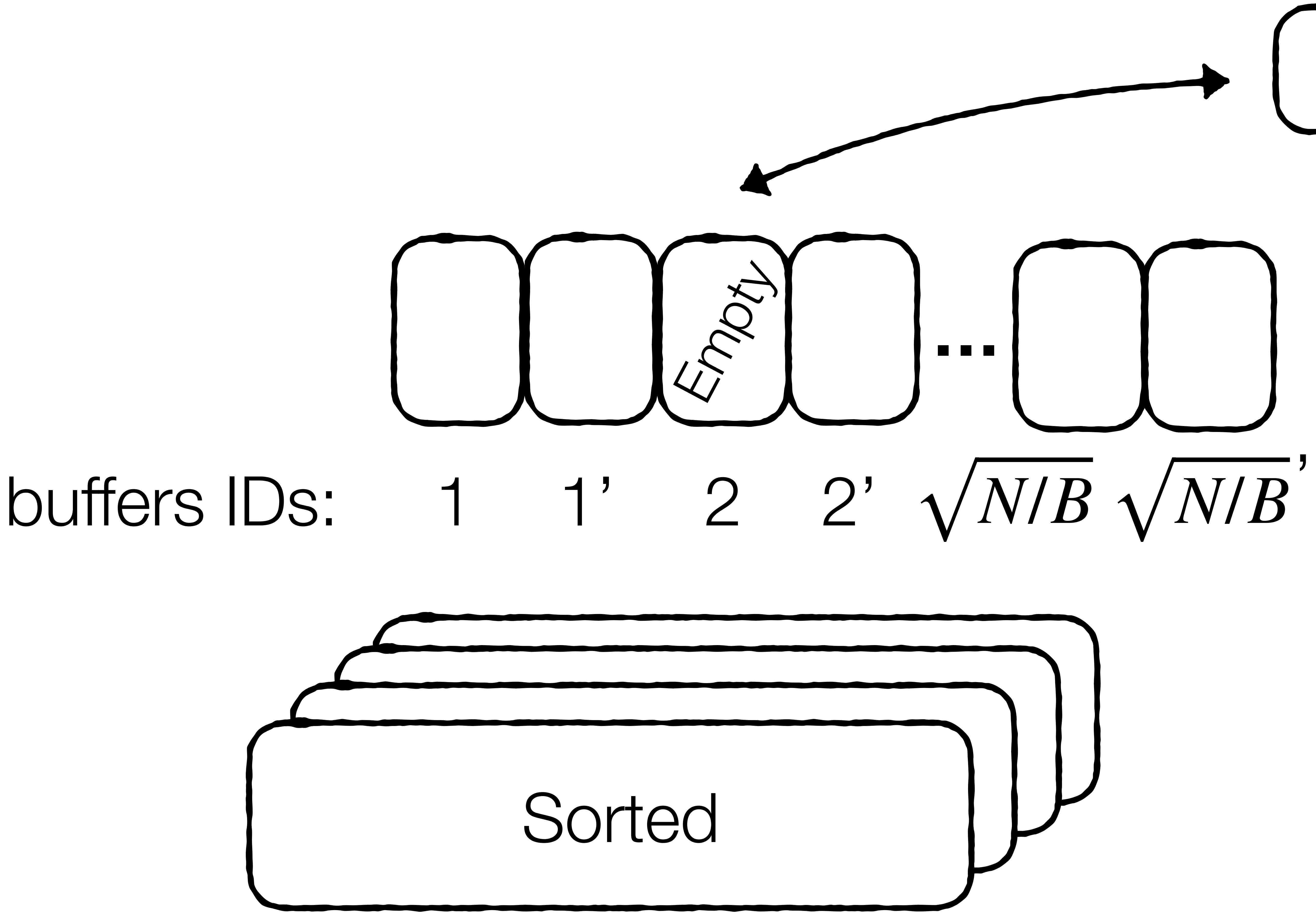


Double buffering: load one additional buffer preemptively for each partition before the first buffer empties



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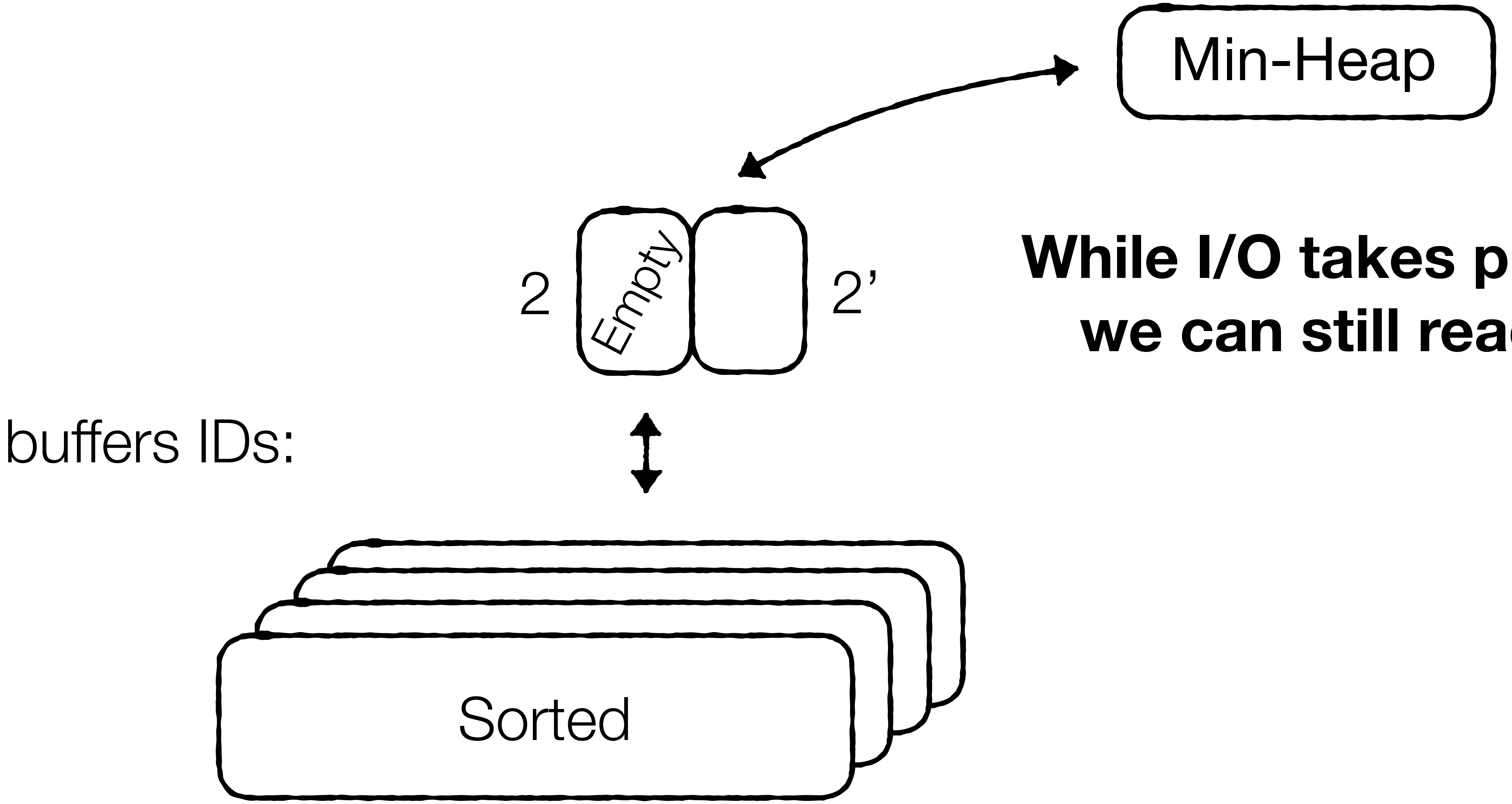
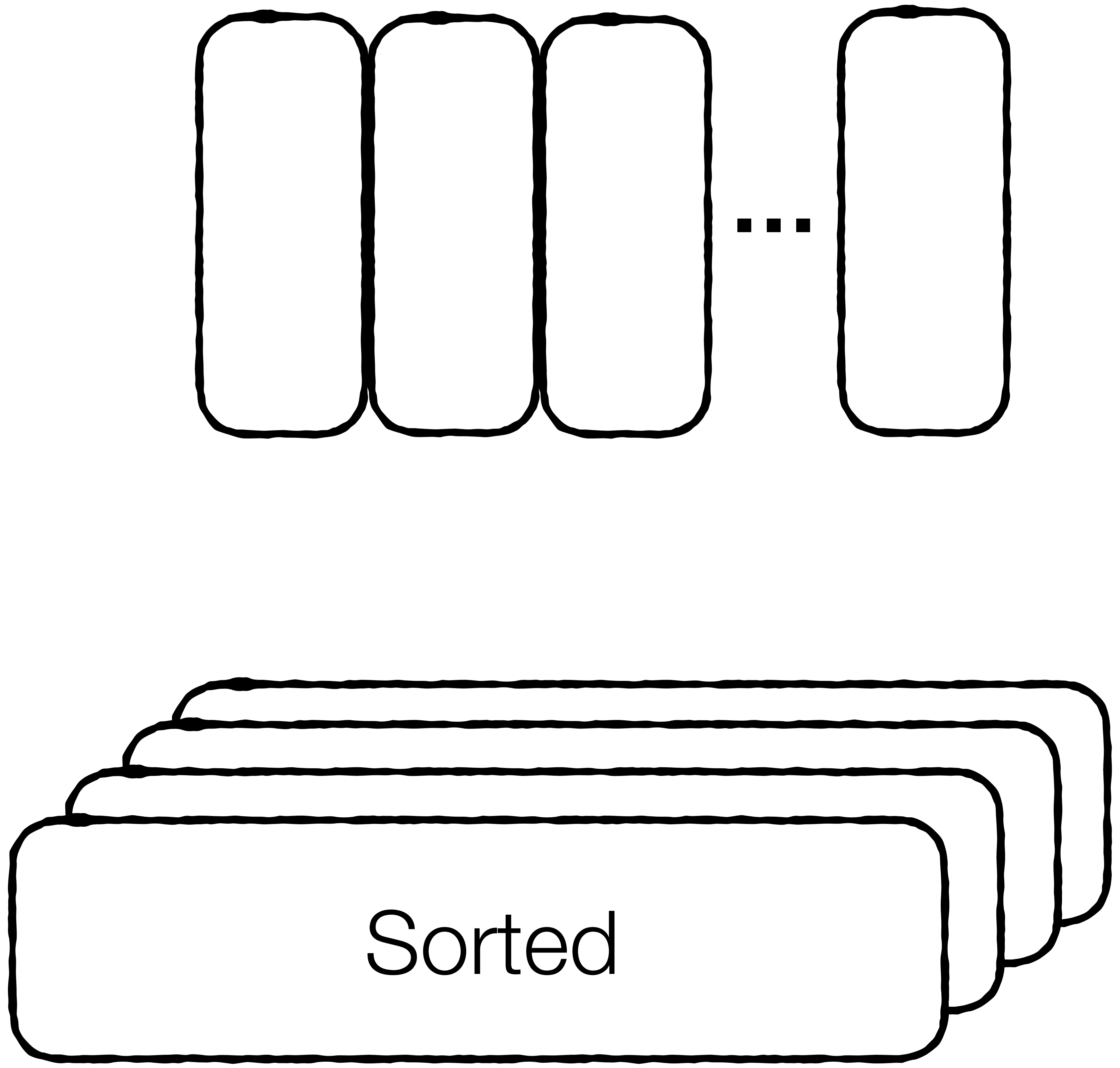


While I/O takes place into buffer 2, we can still read from buffer 2’

Larger though fewer buffers: more groups, so potentially more iterations, but each I/O reads more data



Question 1

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17 buffers

Table with 10,000 pages

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(A) How many partitions are created after the first pass?

(B) How many passes does it take to sort the file completely?

(C) How many I/Os are issued in total to sort the file?

(D) How many buffers would you need to sort the file in just 2 passes?

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10,000 * 4 = 40,000

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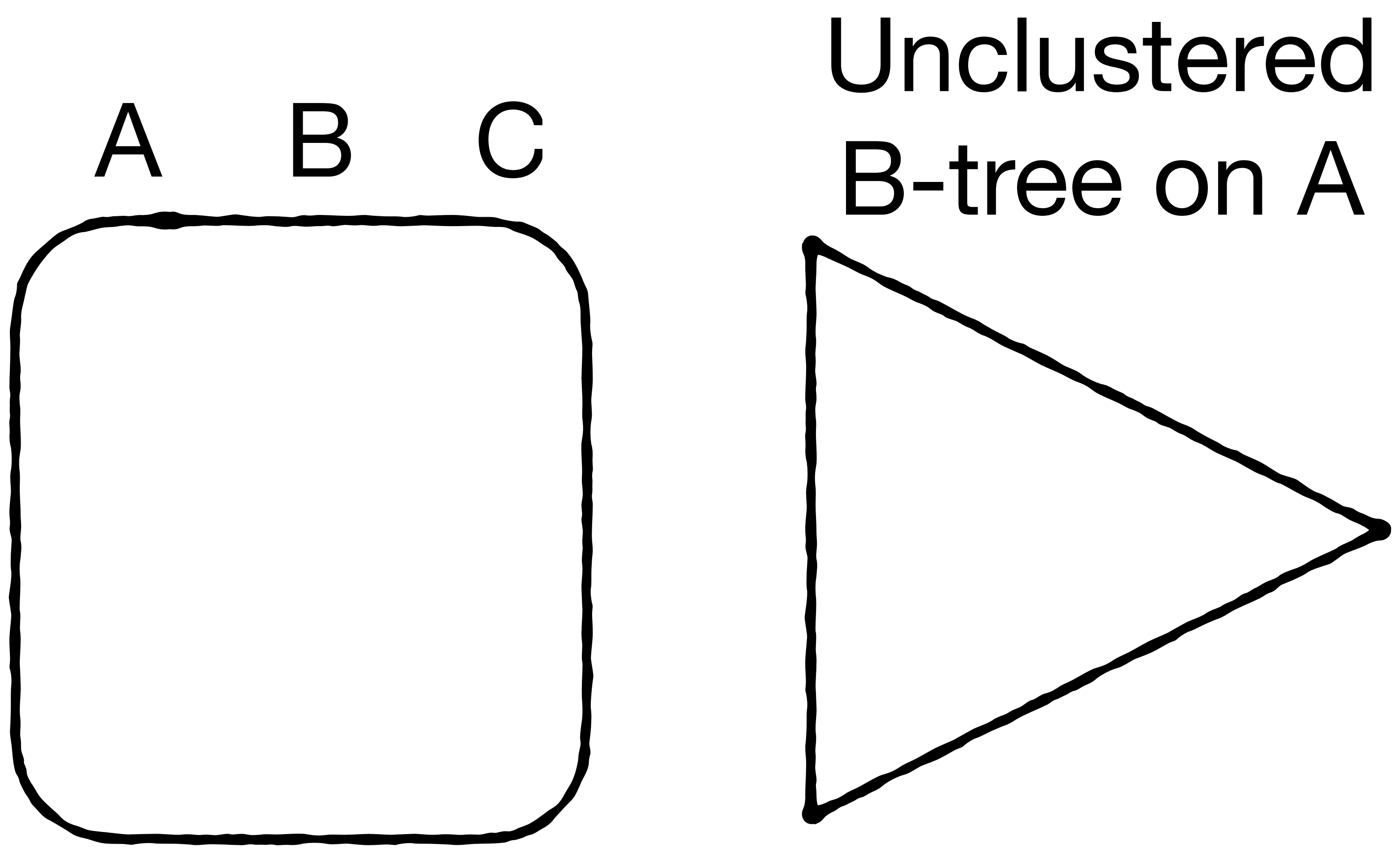
The total number of passes generally is $\log_{M/B}(N/B)$ where M/B is the number of buffers. We know that N/B = 10,000. So we can equate $\log_{M/B}(N/B)$ to 2 and solve for M/B

$\log_{M/B}(10{,}000) = 2$ -> M/B = 100

Question 2

Consider a table that is too large to fit in memory. We have an unclustered B-tree index over column A. We get the following query: “Select * from table order by A”. There are two options to process this query: (1) scan the index, or (2) externally sort the file based on column A. What are the costs of these methods, and under which circumstances would you choose each one?



Select * from table sort by A

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Method (2) is generally better, but if we have large entry sizes (small B), little memory, and/or astronomical data, approach (1) may be better.

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Follow up: how would your answer change if we have a clustered index on column A?

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Follow up: how would your answer change if we have a clustered index on column A?

Scanning the clustered index to return sorted data now costs N/B I/Os, which is cheaper than even even a two-pass external sort, which costs 2(N/B) I/Os.

Question 3

You are given M memory and N entries where N >> M >> 3B. Why is it a bad idea to use the available memory as virtual memory (e.g., to allocate using 'new' space for M entries, and to use in-memory Quicksort? Use cost models to justify your answer.

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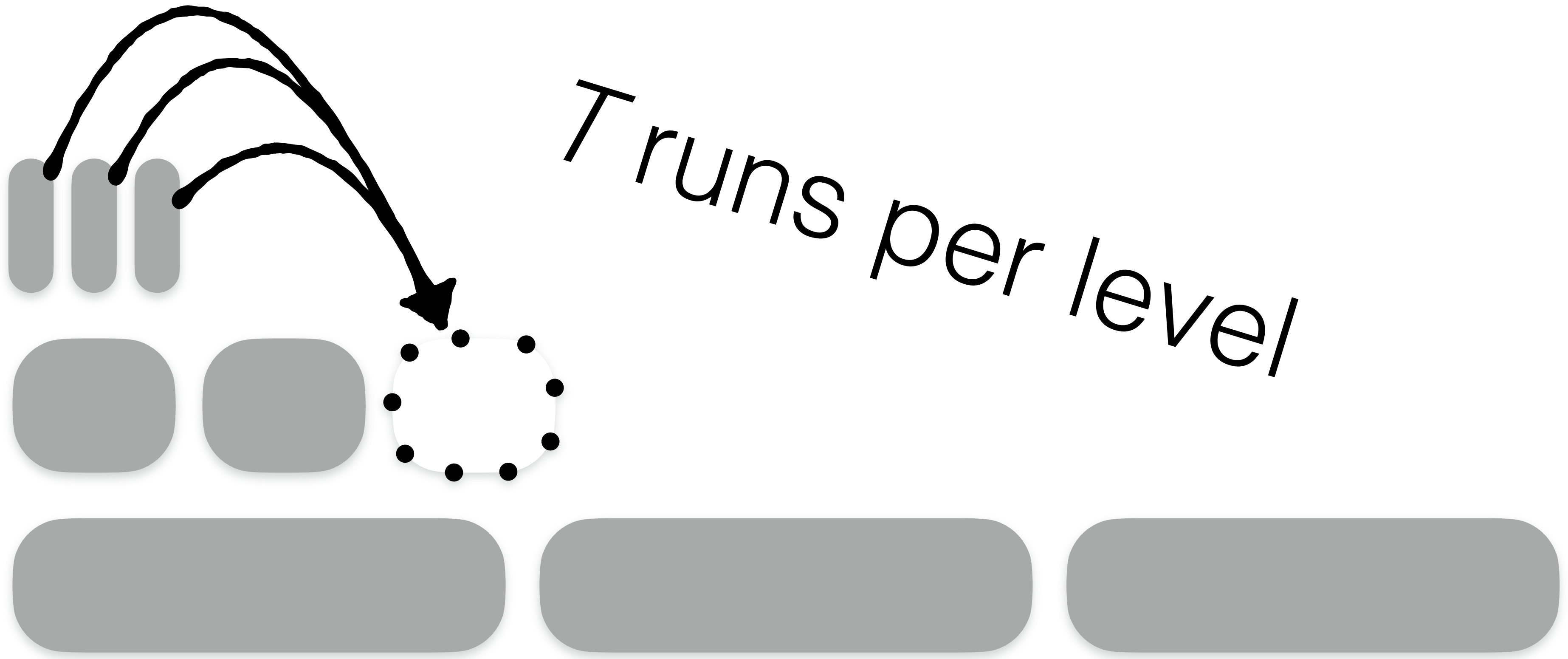
With virtual memory, swapping would kick in. Quicksort scans the data sequentially, so we would expect $O(N/B \cdot \log_2 N)$ I/Os as it performs $\log_2 N$ iterations.

In contrast, external sort provides $O(N/B \cdot \log_{M/B}(N/B))$, which dominates.

Question 4

Suppose we have a tiered LSM-tree with a size ratio of T. Analyze the CPU costs of compaction assuming we check all buffers each time to find the minimum key. Then propose a technique to improve CPU costs.



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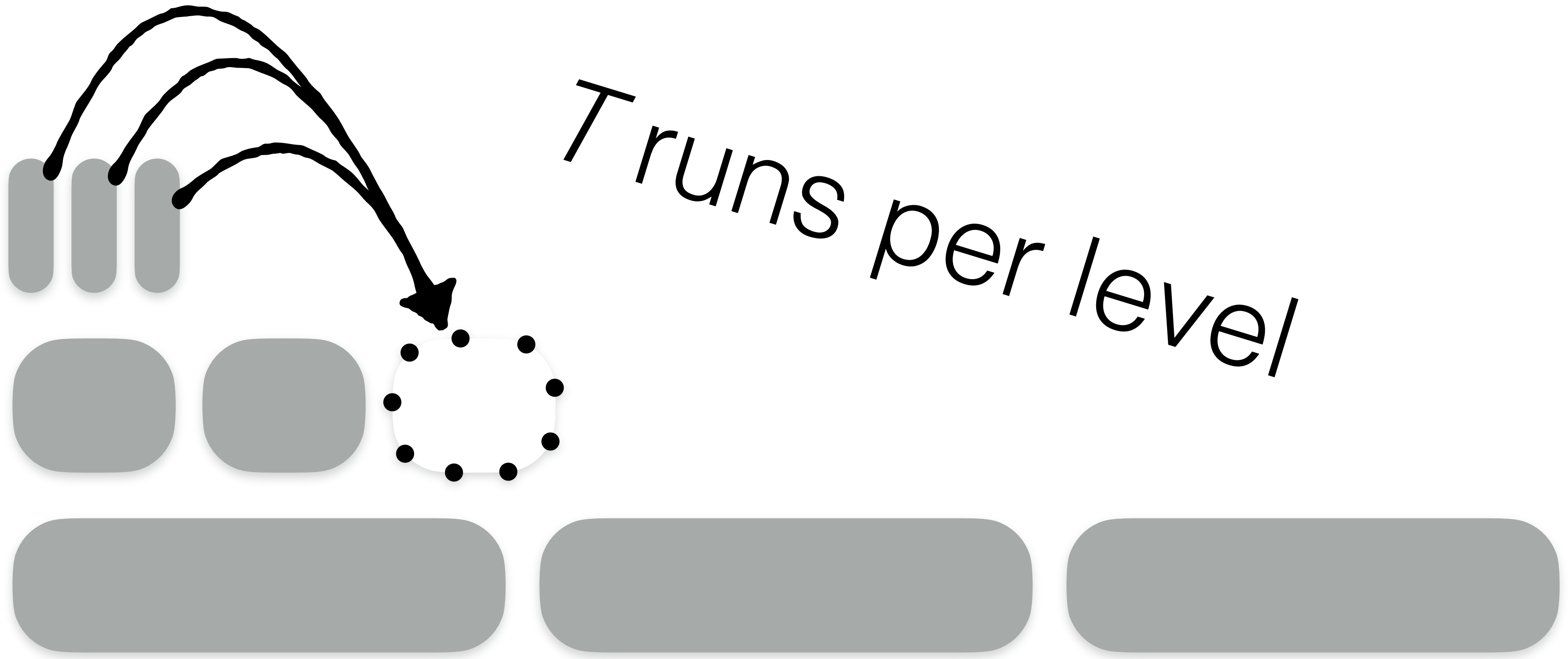

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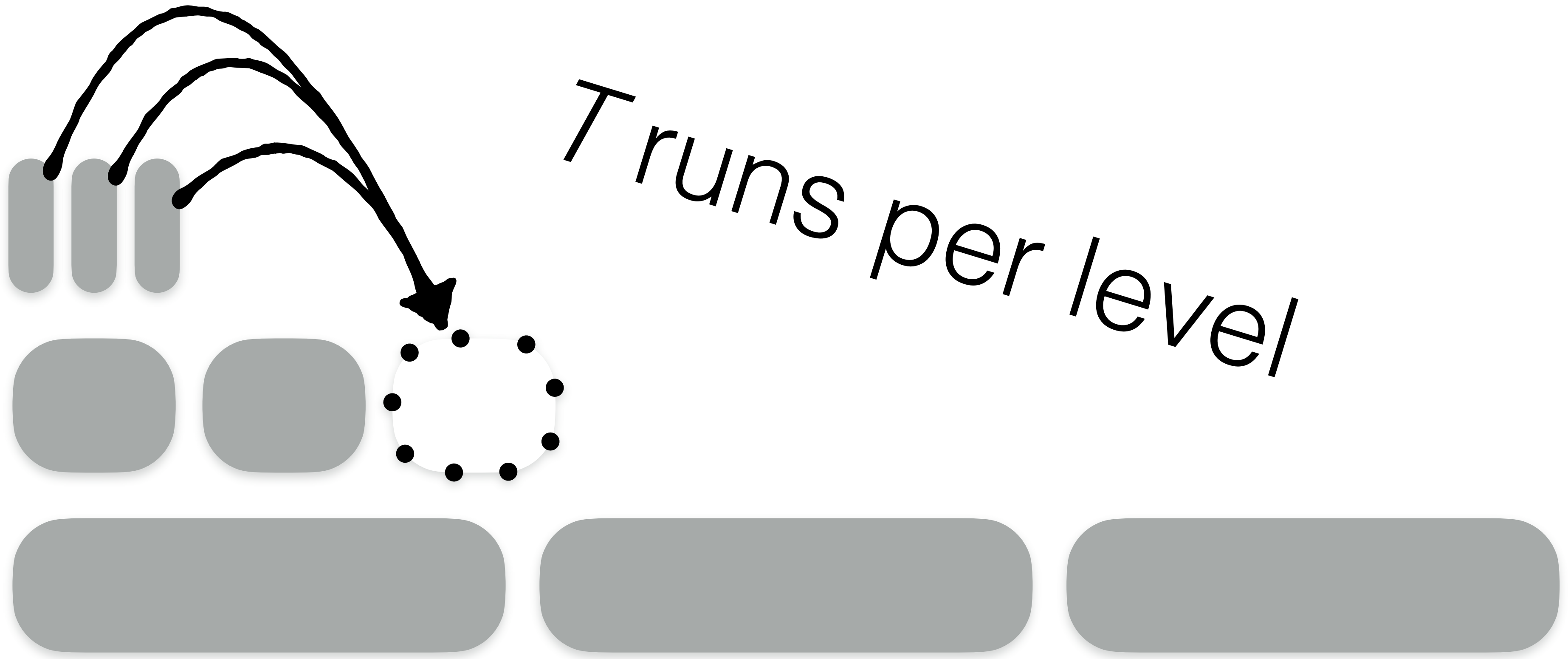

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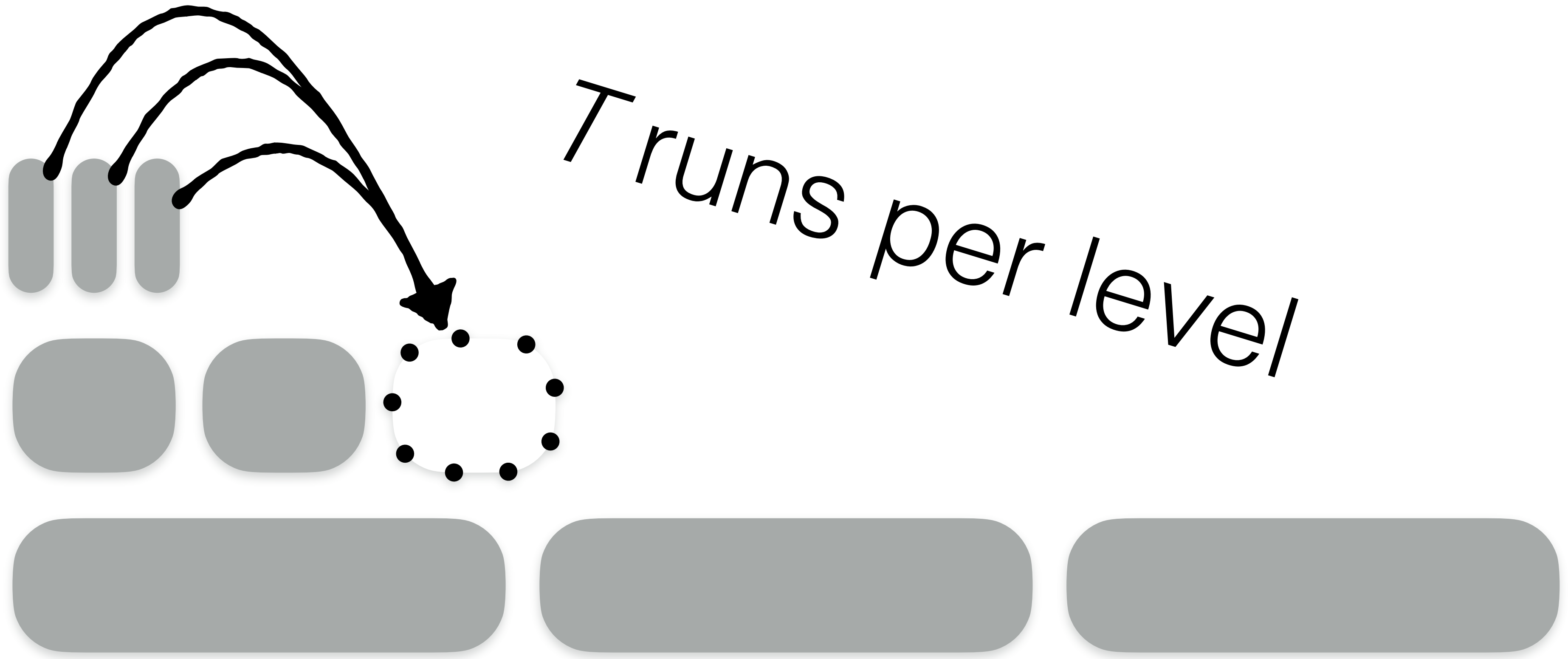

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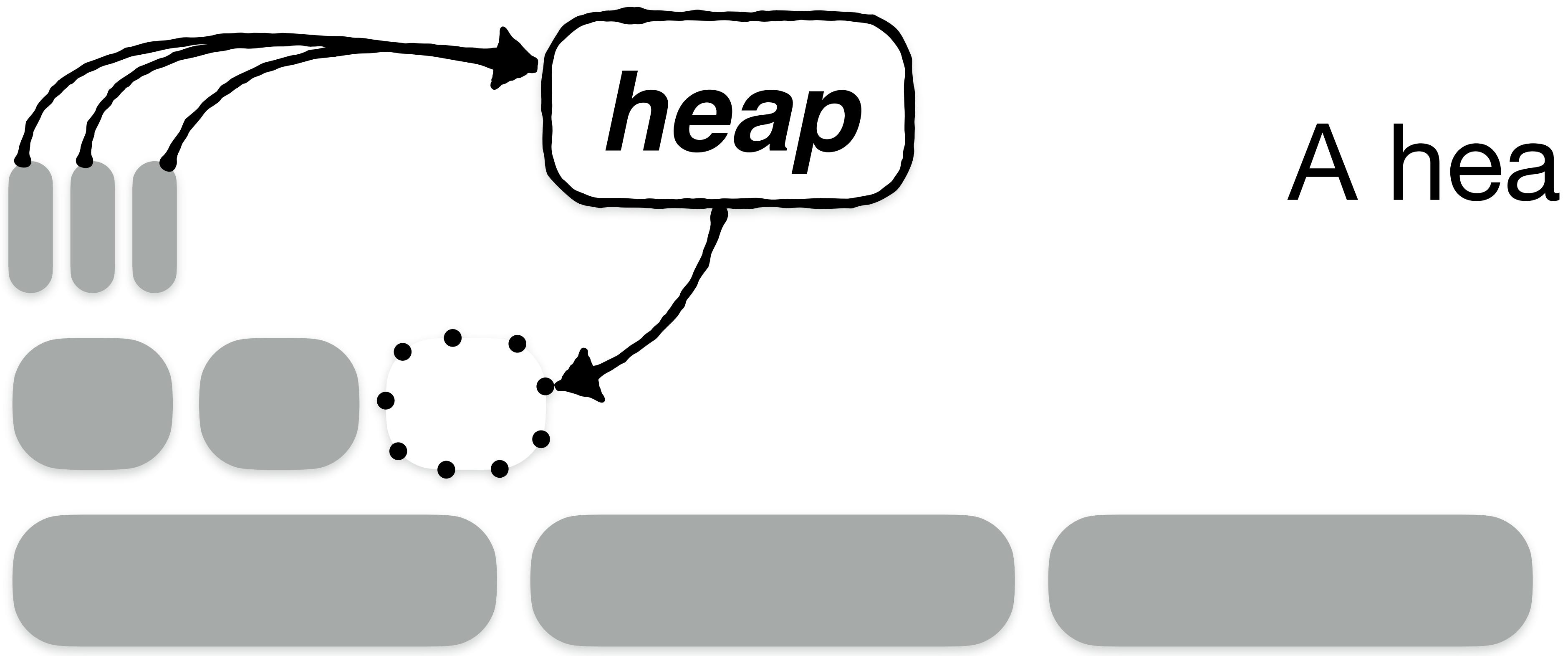

A heap brings this down to $O(N \cdot \log_T(N/P) \cdot \log_2(T))$