Tutorial 3

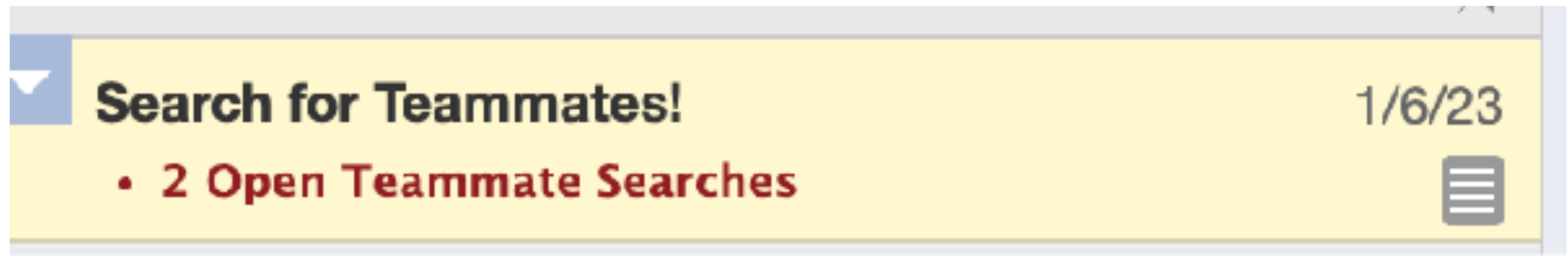
Database System Technology - Indexing

Niv Dayan - 25 Jan, 2023

Groups

Most of you are grouped up.

One new person in the course is looking for a team!



Agenda

More on SSD write-amplification

4 exercises on indexing

Introduce step 2 of the project

Modeling SSD Write-Amp More Precisely

There used to be some slides here, but they are not superseded by the following more thorough and correct explanation:

https://6c7de8b5-df3d-4a03-945a-9846af236553.usrfiles.com/ugd/6c7de8_a8d4def3b5d94b4f98c2238c064f28b2.pdf

Question 1

Consider a B-tree subject to uniformly randomly distributed updates. There are 100 entries per page. The b-tree occupies 70% of the SSD, while the rest is over-provisioned. What write-amplification would you expect?

Model: $$B \cdot (1 + \frac{1}{2} \cdot \frac{L/P}{1 - L/P})$$

Where L = logical data size

P = physical SSD capacity

Under what kind of workload would write-amplification for a B-tree be significantly lower?

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Model: $$B \cdot (1 + \frac{1}{2} \cdot \frac{L/P}{1 - L/P}) \;=\; 100 \cdot (1 + \frac{1}{2} \cdot \frac{0.7}{1 - 0.7}) \;=\; \mathbf{167}$$

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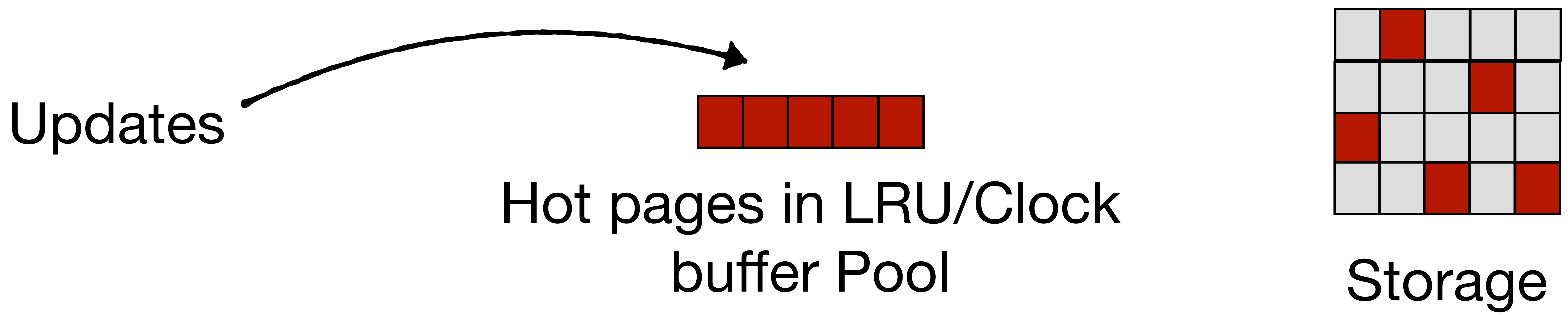
Under what kind of workload would write-amplification for a B-tree be significantly lower?

When a workload exhibits spatial and/or temporal locality: some areas of the logical address space are hot



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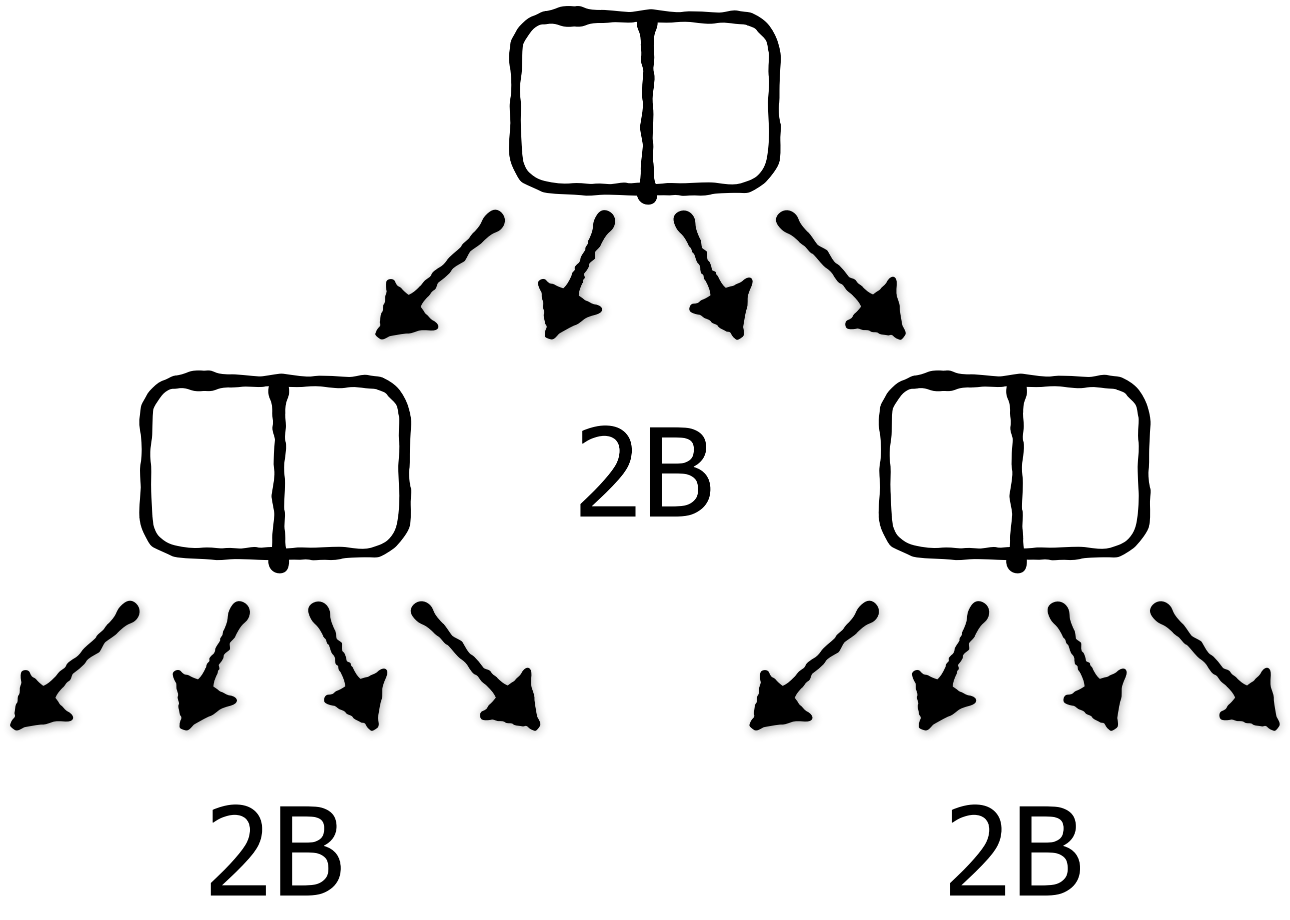
This argument does not hold for extendible hashing as entries that are adjacent logically are distributed randomly in the hash table! This is a disadvantage of hash vs tree indexes.

Question 2

Consider the possibility of making each B-tree node take up two rather than just one flash pages (i.e., 8KB rather than 4KB). This can make the tree shallower. Is this a good idea for flash? How about on Disk?



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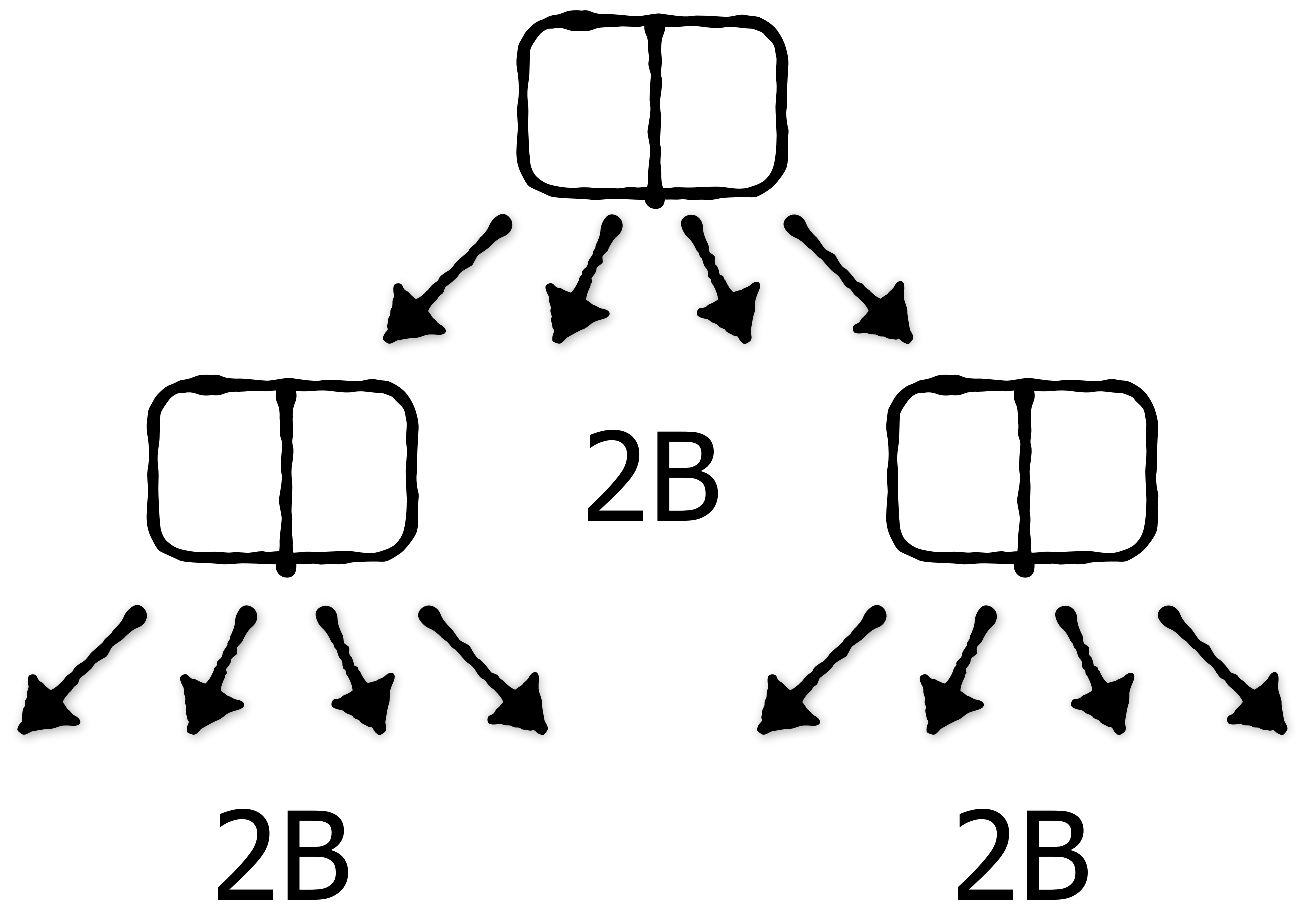
Consider the possibility of making each B-tree node take up two rather than just one flash pages. This can make the tree shallower. Is this a good idea? How about on Disk?

On SSD, cost is measured as # pages accessed

$$= 2*\log_{2B}(N)$$



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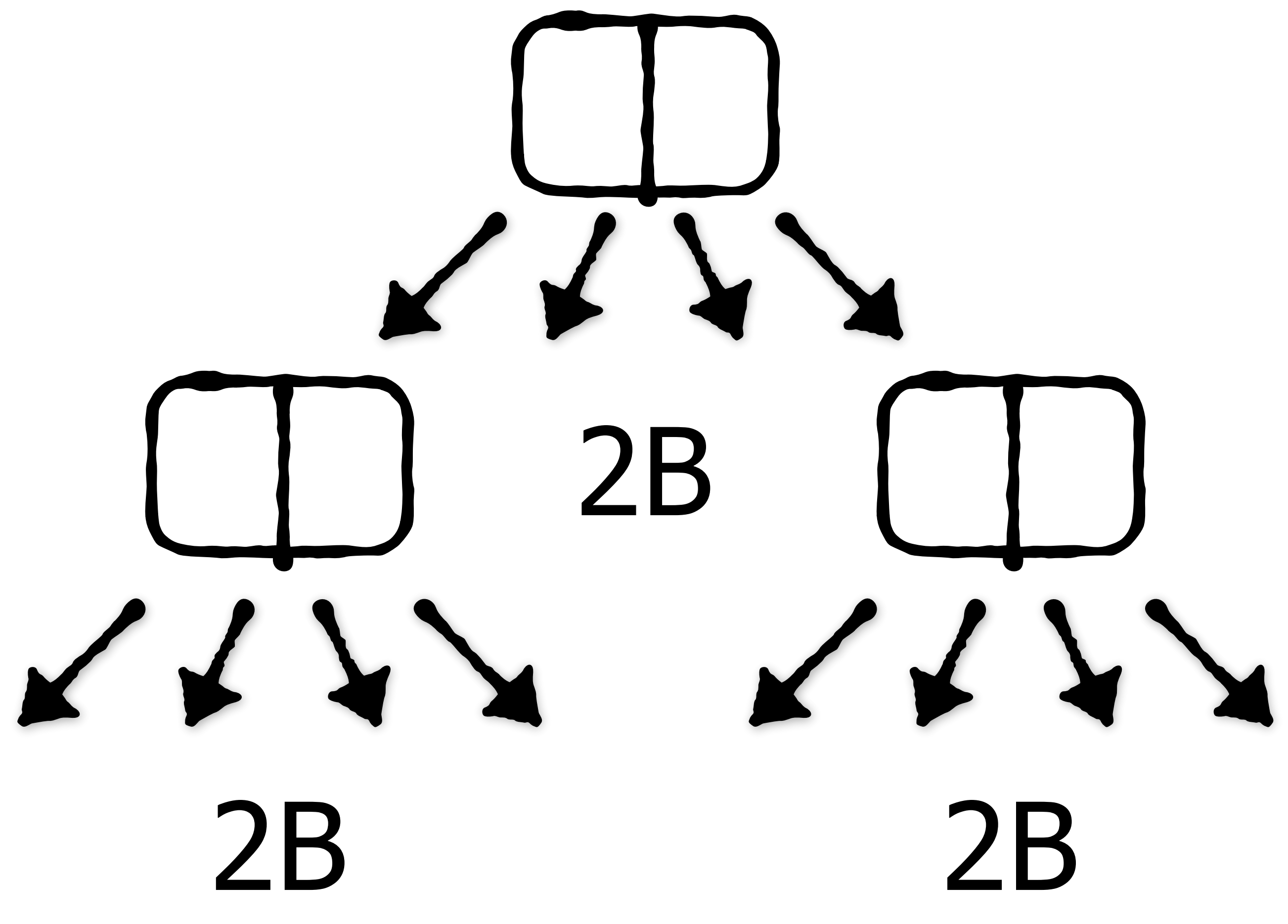
↑

Condition for being cheaper than standard B-tree



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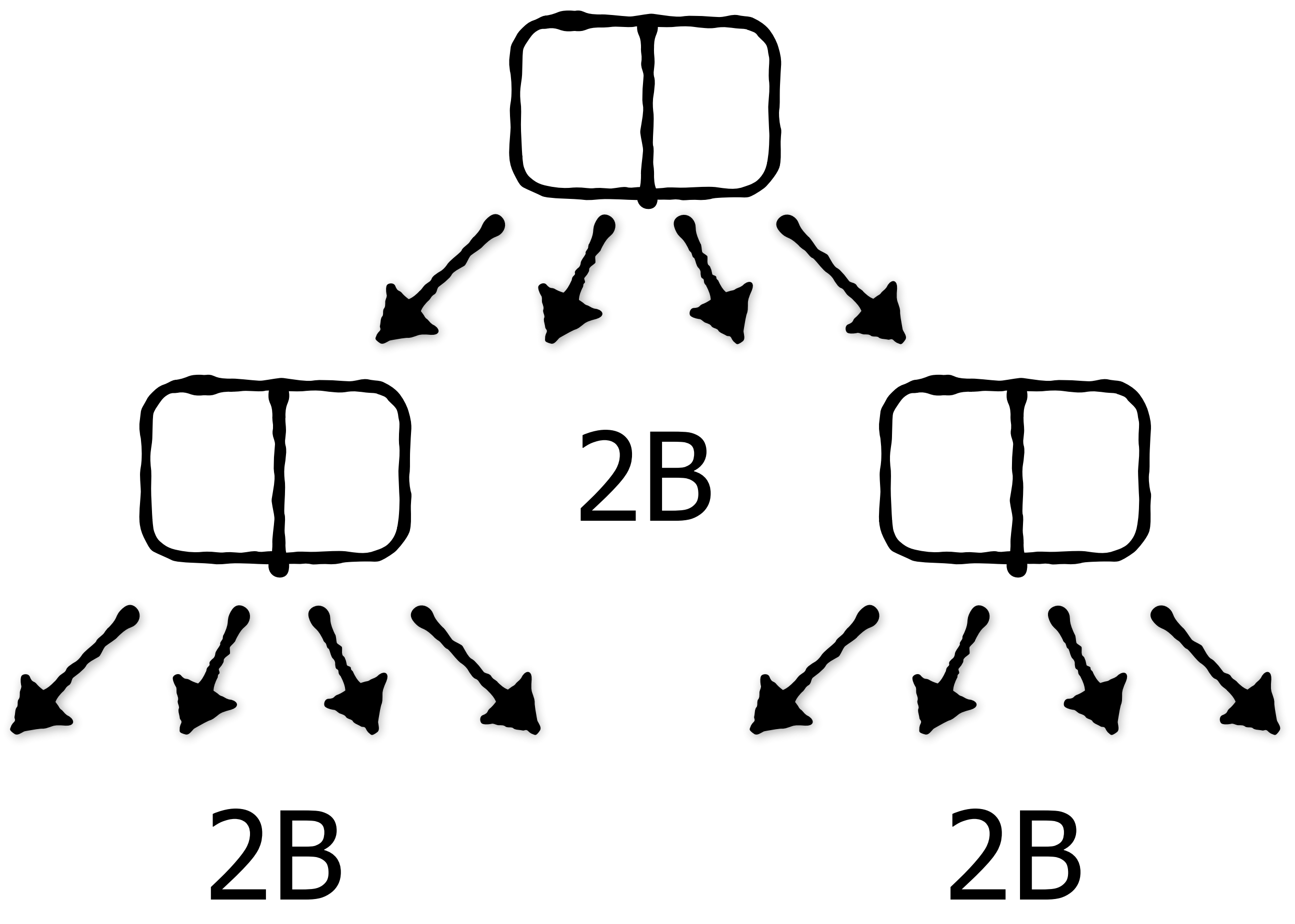
Simplifies to: $\mathbf{B \leq 2}$



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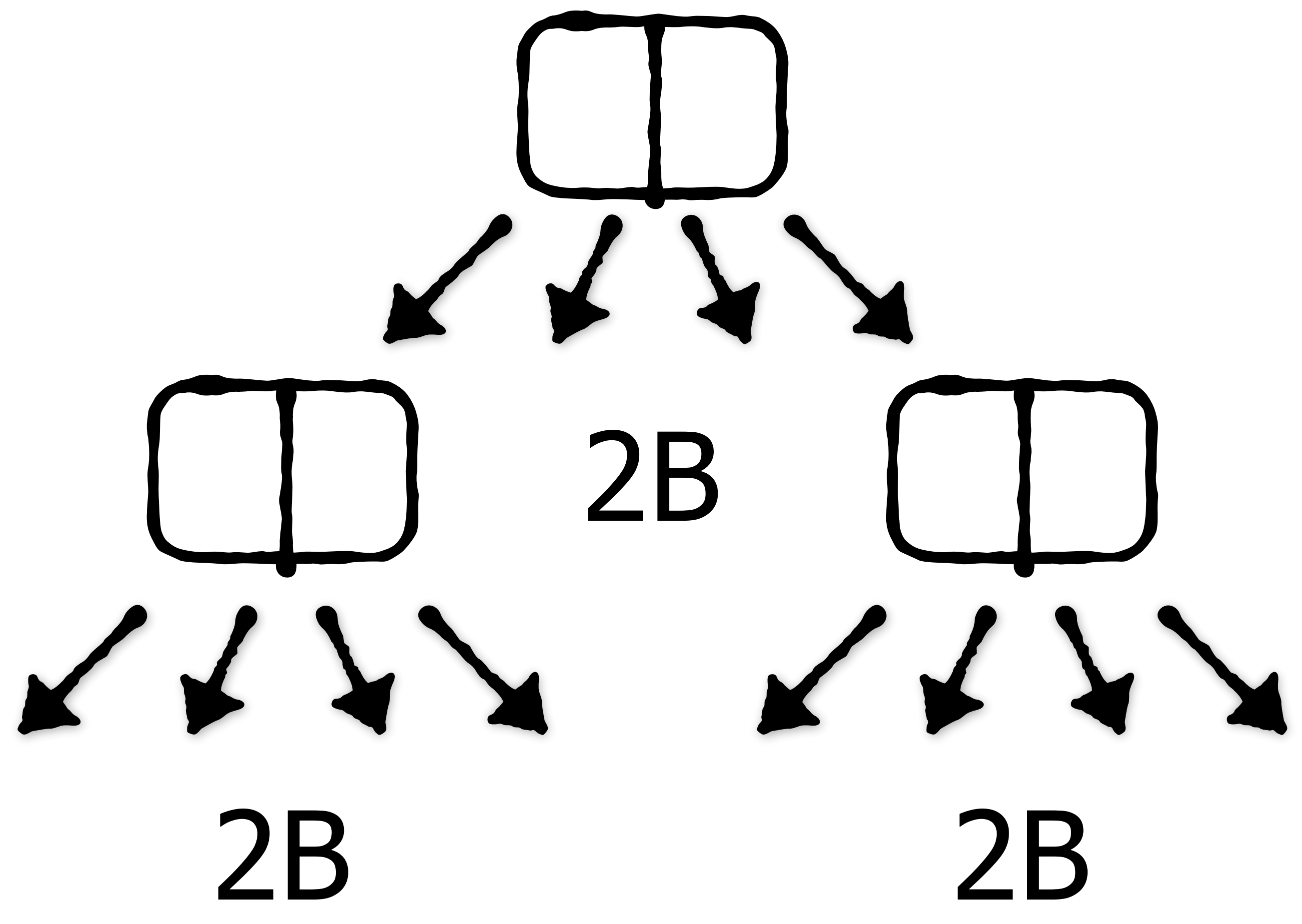

But B is typically larger. So it's not generally a good idea.

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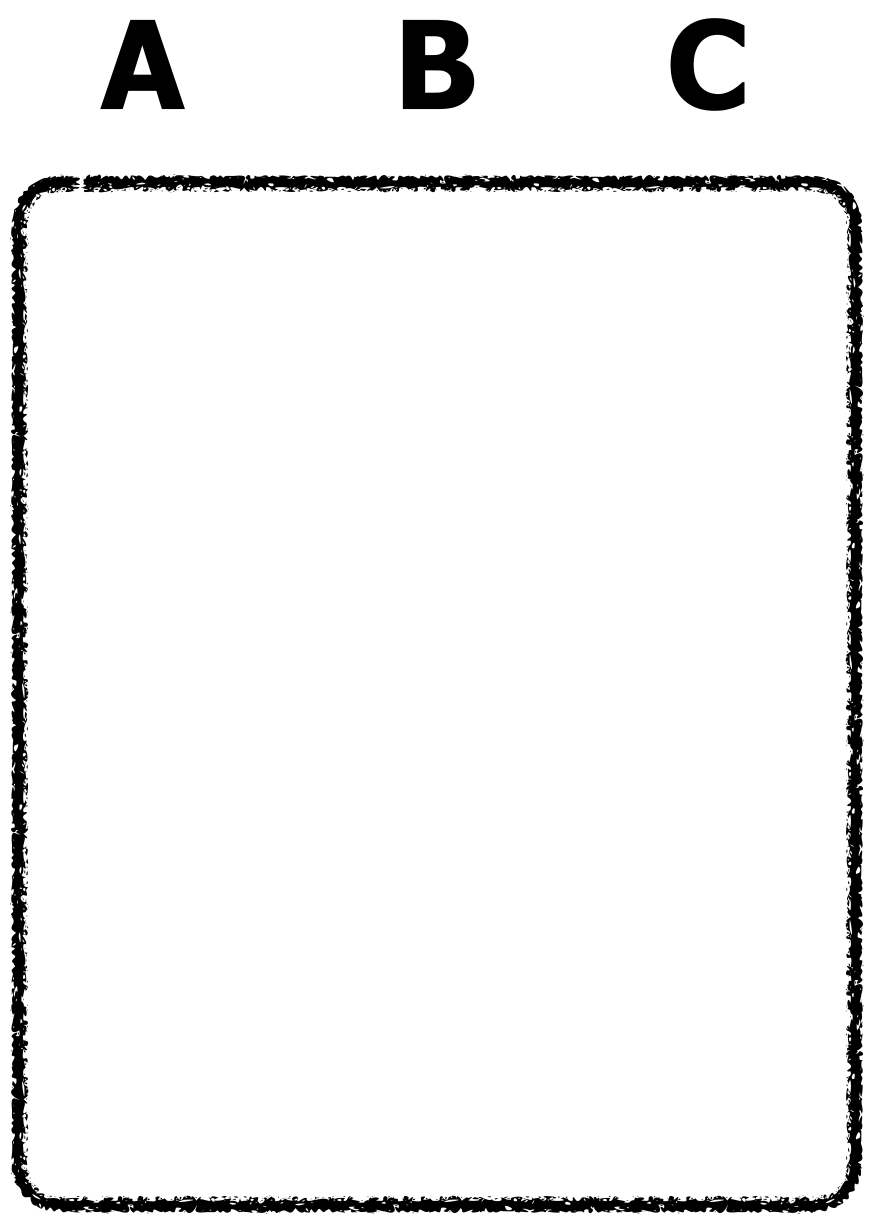
On disk, seek & rotational delay dominate, while data transfer is negligible. So this is a good idea (enlarging the node size by a multiplicative factor of B will approx. halve the depth). Likely incur diminishing returns beyond that.

Question 3

Consider a table with columns A, B and C. Suppose we employ buffered inserts at a cost of O(1/B) each.



The workload consists of:

50%	Select * from table where A = "…"	Return 1 row each
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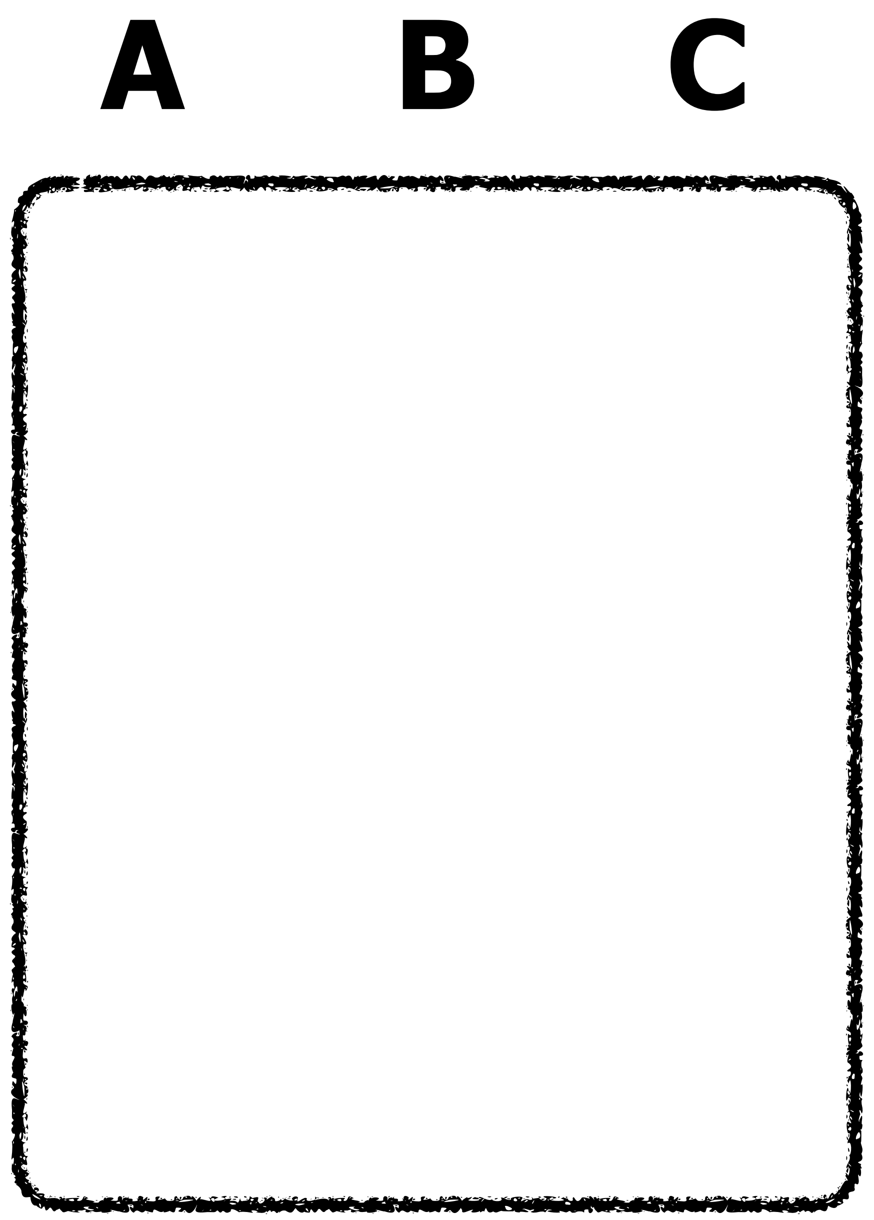

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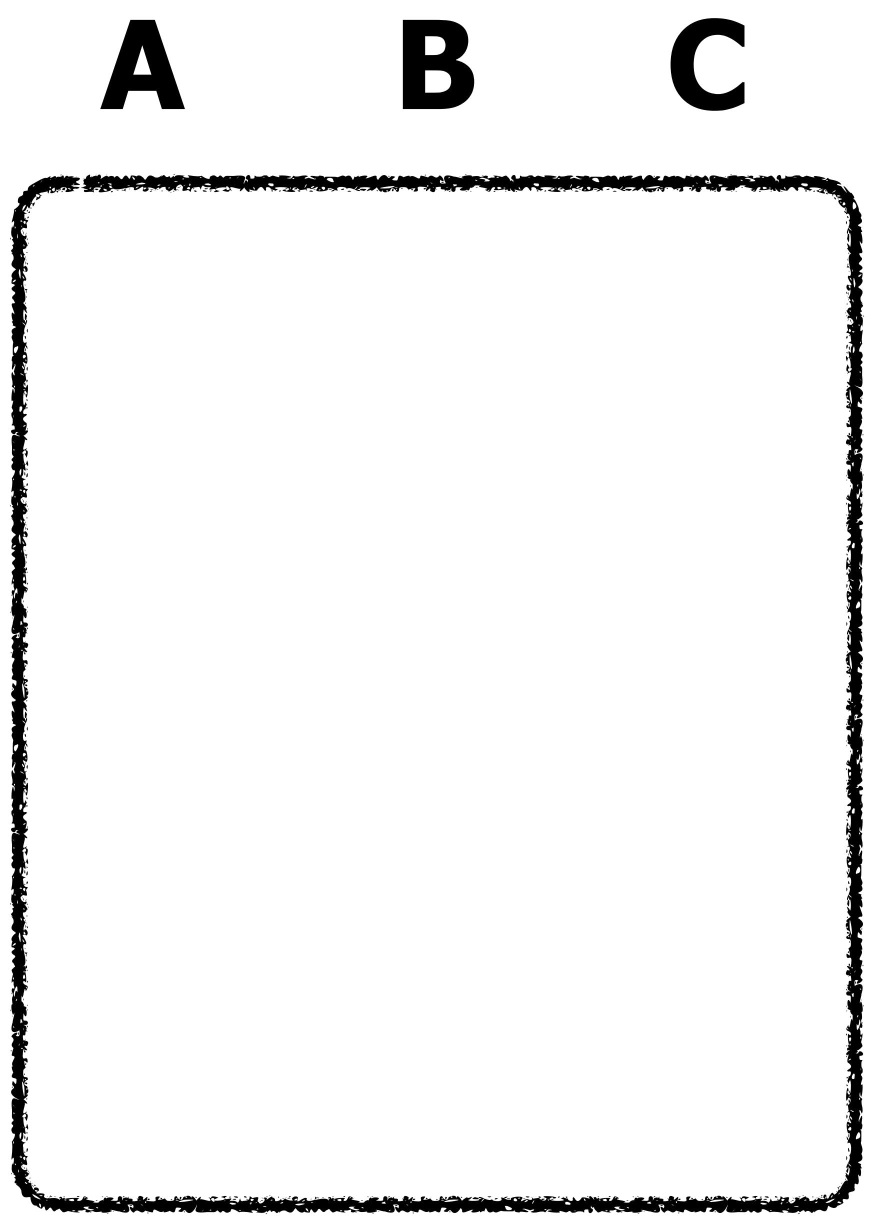

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Indexing A significantly reduces overall costs.

I/O cost without index: $0.5 * N/B + 0.5 * 1/B \approx N/B$

I/O cost with index: $0.5 * \log_B N + 0.5 * \log_B N \approx \log_B N$

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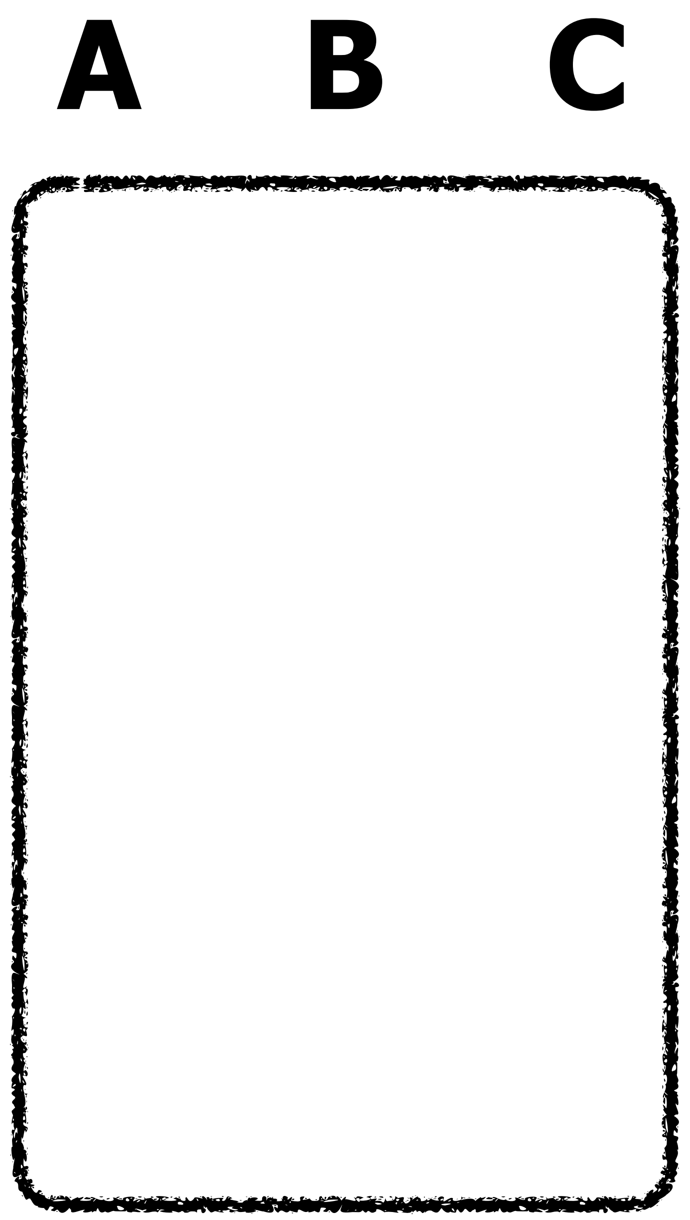

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50% Select * from table where B > x and B < y Returns avg. S=10 rows

How should we index this table? B-tree or extendible hashing? Clustered vs. unclustered? Estimate worst-case I/O cost with your plan for each query with these indexes assuming $N=2^{40}$ and $B=2^{10}$

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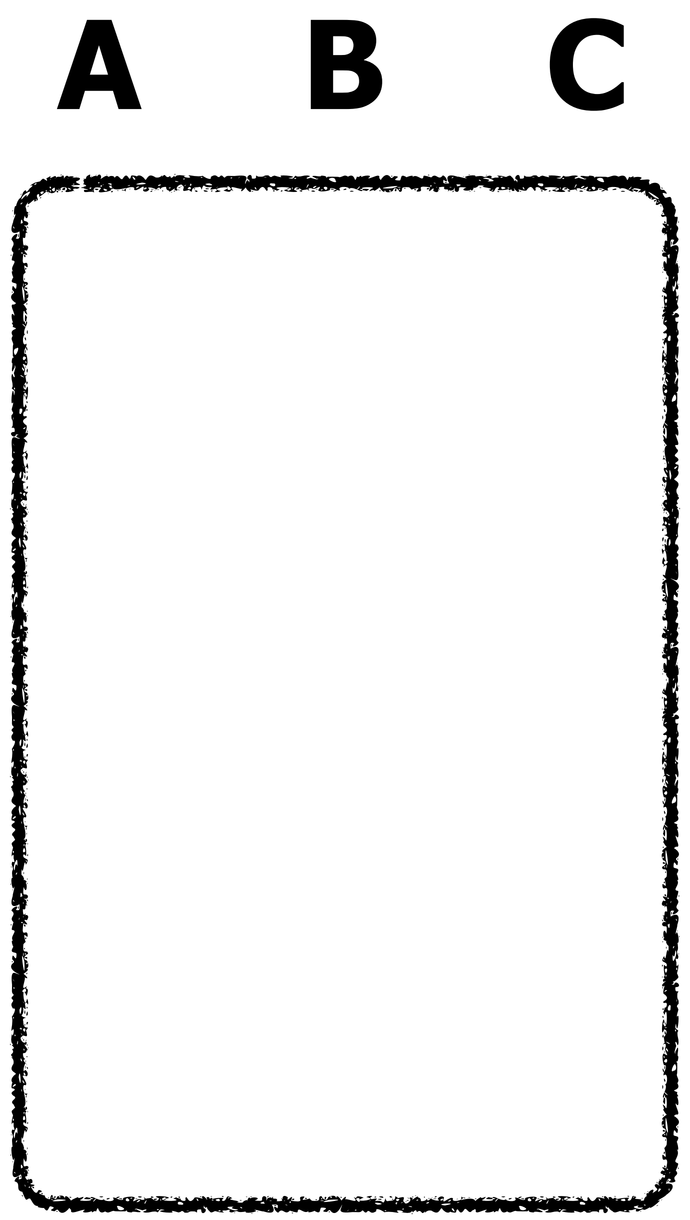

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Clustered B-tree on B

log_(N) + S/B

4 + 1

Extendible Hash table on A

1-2, assuming directory is in memory and data is evenly distributed