Tutorial 3

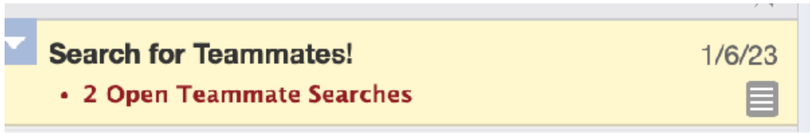
Database System Technology - Indexing

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

Consider an SSD for which the logical address space size is a fraction of x of the physical capacity.

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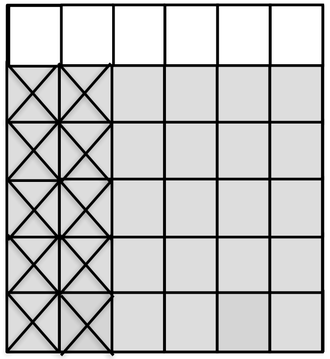
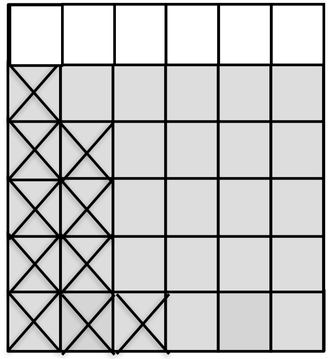


Non-Worst Case



← Best target

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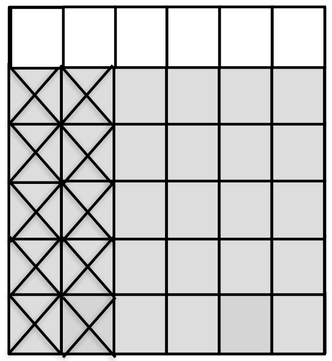

SSD WA Approx.
from last week

$$\frac{1}{1-x}$$

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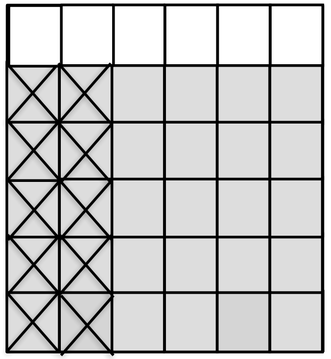

Tutorial 2 Question 1 Fri

Two questions regarding the garbage collection multiplicative factor:1. Can we get more intuition on how we arrived at t

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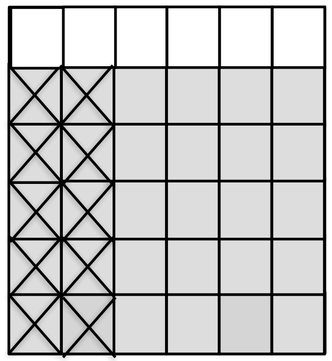

More precise model

$$1 + \frac{x}{1 - x}$$

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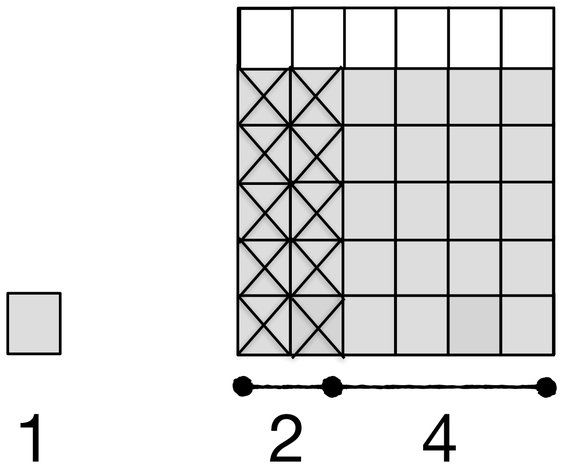

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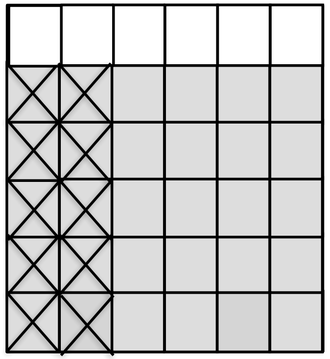


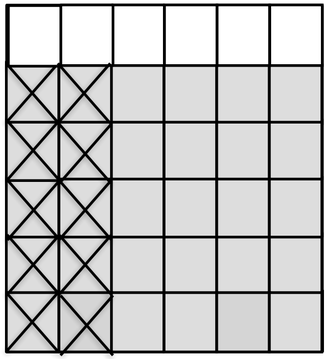
$$1 + \frac{4}{2} = 3$$

More precise model

$$1 + \frac{x}{1 - x}$$

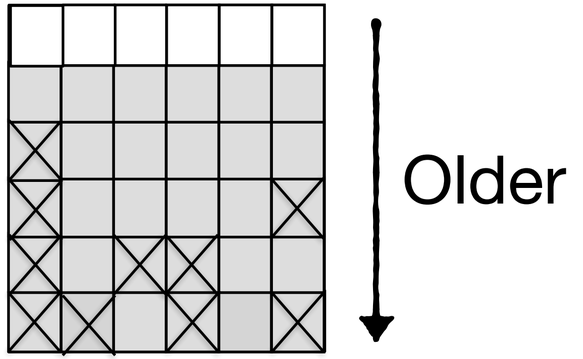
Modeling SSD Write-Amp More Precisely

But the worst-case hardly ever happens in practice



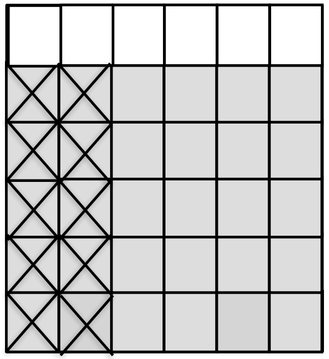
$$1 + \frac{x}{1 - x}$$

In practice, erase units written longer ago have more invalid pages, so GC is cheaper



Modeling SSD Write-Amp More Precisely

Cost model assuming uniformly randomly distributed writes?



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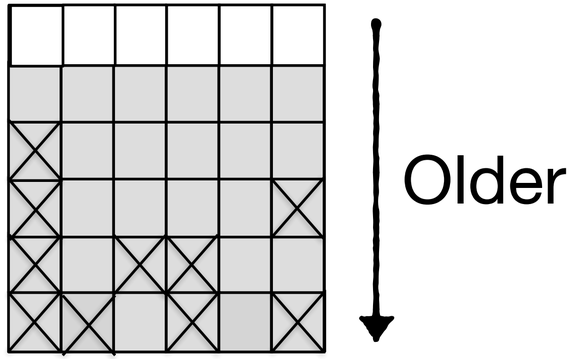

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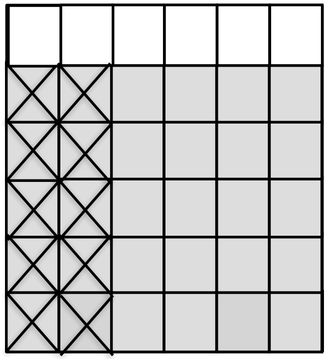
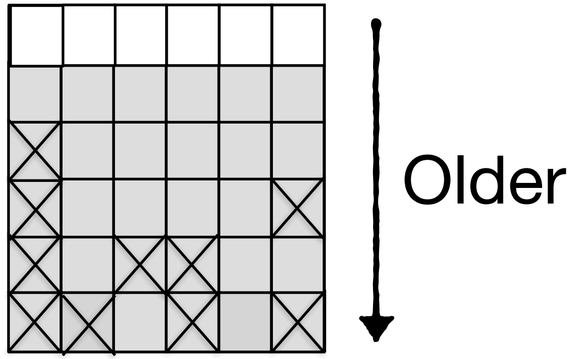


$$1 + \frac{x}{1 - x}$$

$$1 + \frac{1}{2} \cdot \frac{x}{1 - x}$$



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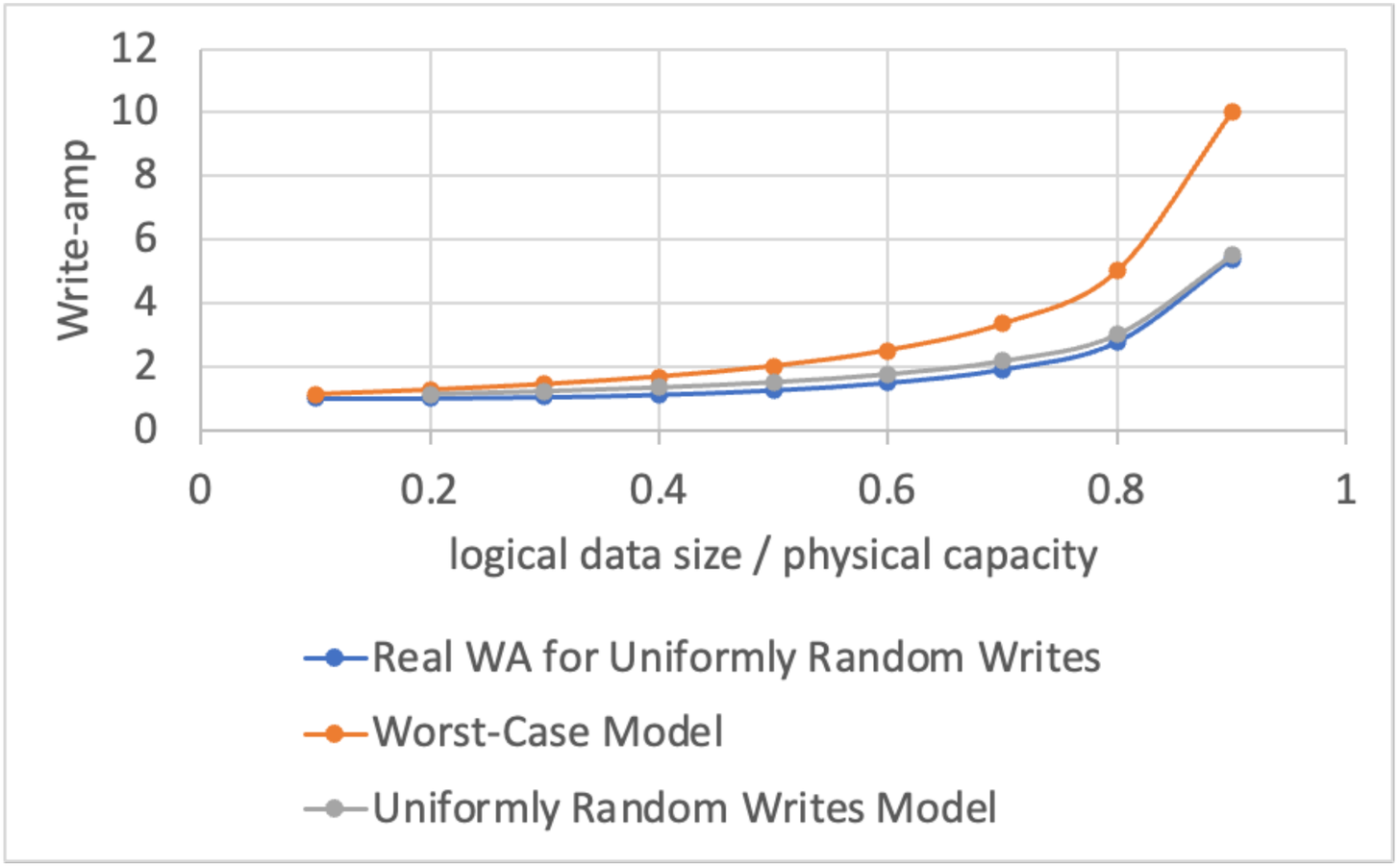

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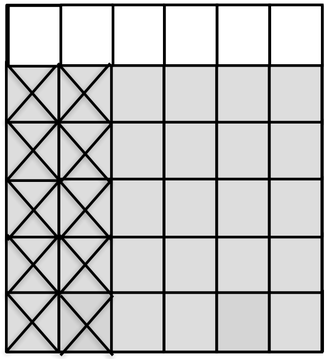
How does this model change assuming there are B entries per page, and each update modifies B entries?

Worst-case



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Uniformly Random Case

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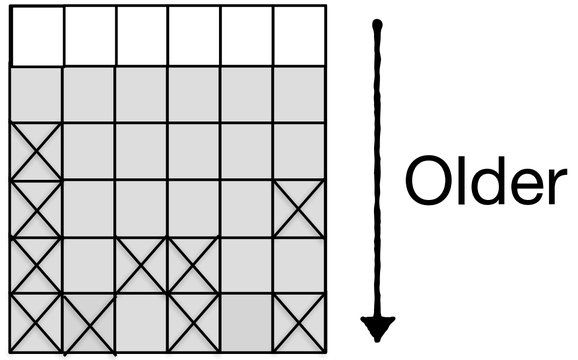

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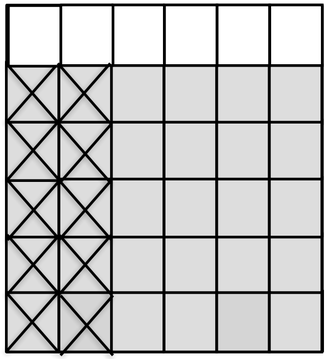

$$B \cdot (1 + \frac{x}{1-x})$$

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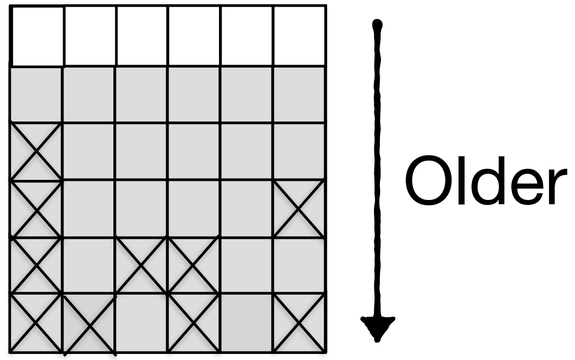

Question 1

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 empty. What write-amplification would you expect?

Model: $$B \cdot (1 + \frac{1}{2} \cdot \frac{x}{1-x})$$

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

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Model: $B \cdot (1 + \frac{1}{2} \cdot \frac{x}{1-x})$ **= 216**

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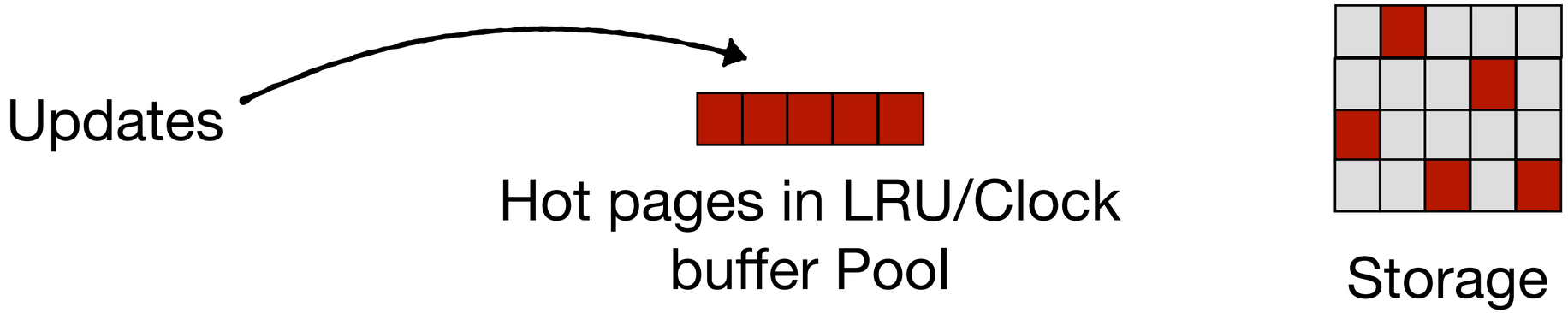
When a workload exhibits spatial locality: some areas of the logical address space are hot



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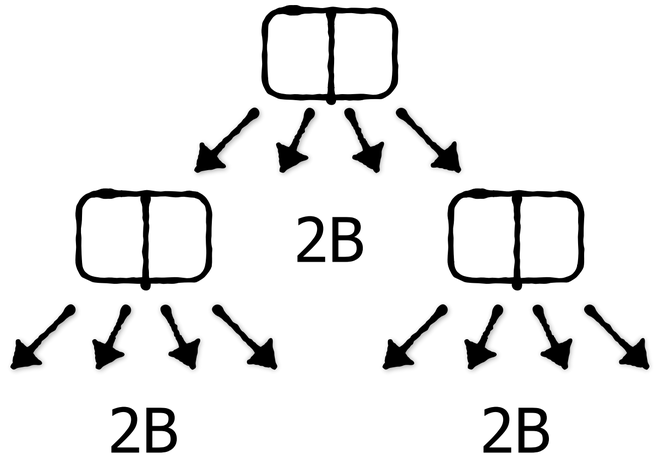
When a workload exhibits spatial locality: some areas of the logical address space are hot

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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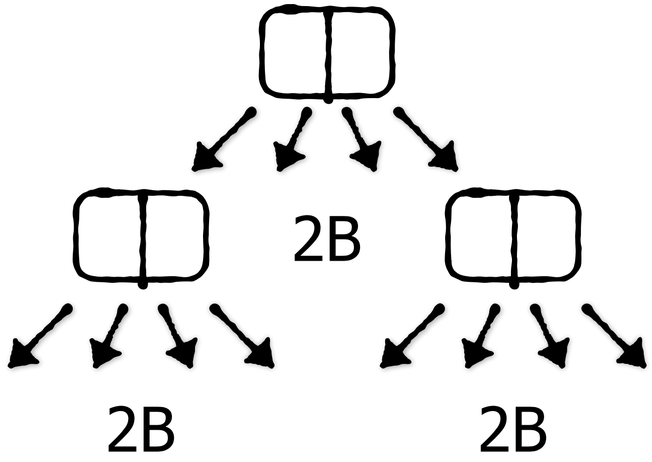
On SSD, cost is measured as # pages accessed

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



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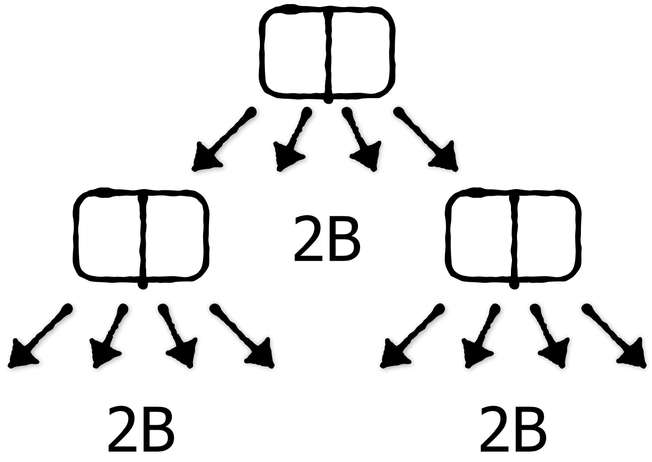
Condition for being cheaper than standard B-tree



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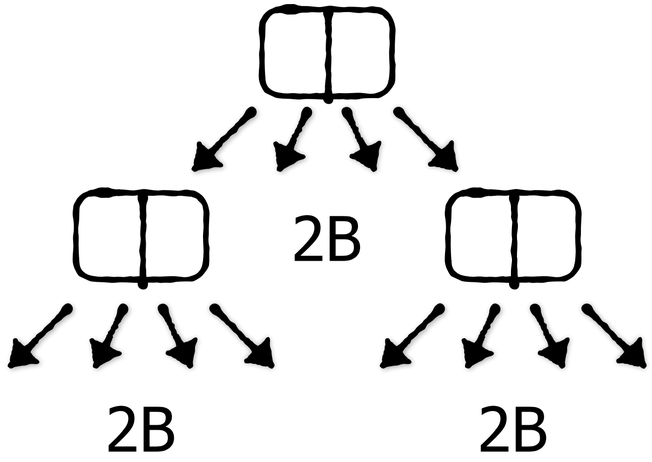

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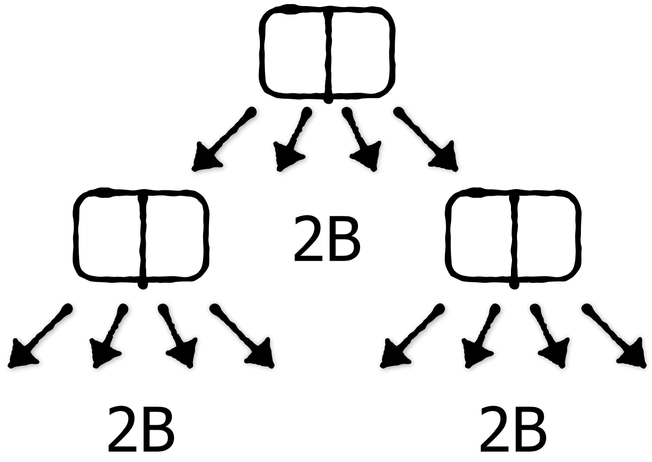
But B is typically larger. So it's not generally a good idea.



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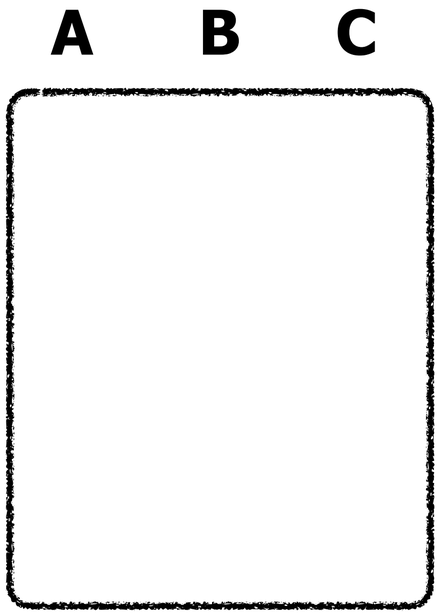
On disk, seek & rotational delay dominate, while data transfer is negligible. So this is a good idea. Enlarging the node size by a factor of B will reduce depth by one. Likely incur diminishing returns beyond that.

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

50% Insert (, ,)

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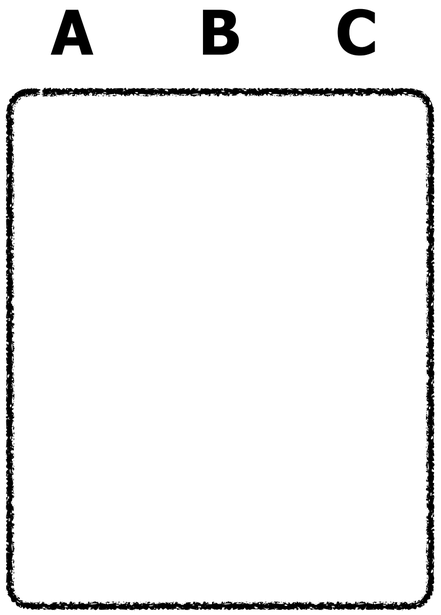

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Should we employ a B-tree index on any of the columns? Estimate the overall I/O cost of both queries with and without out it.

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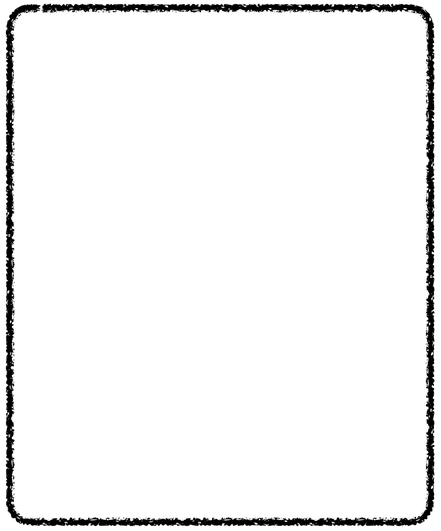
A B C



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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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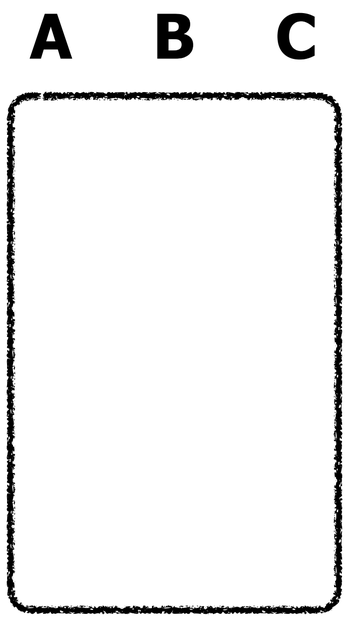

50% Select A from table where A = "…" Returns 1 row each

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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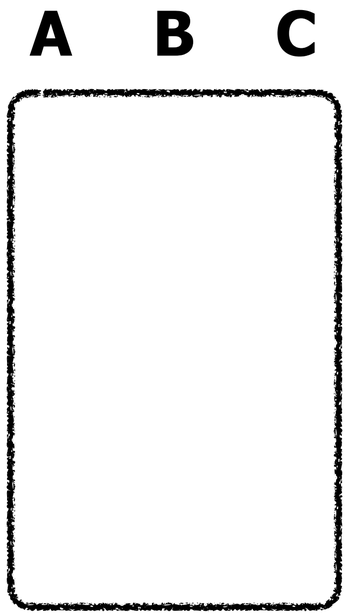

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Clustered B-tree on B

log_(N) + S/B

4 + 1

Extendible Hash table on A

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