HARVARD
School of Engineering
and Applied Sciences

CS165
Data Systems

Have fun learning to design and build modern data systems

class 19

updates

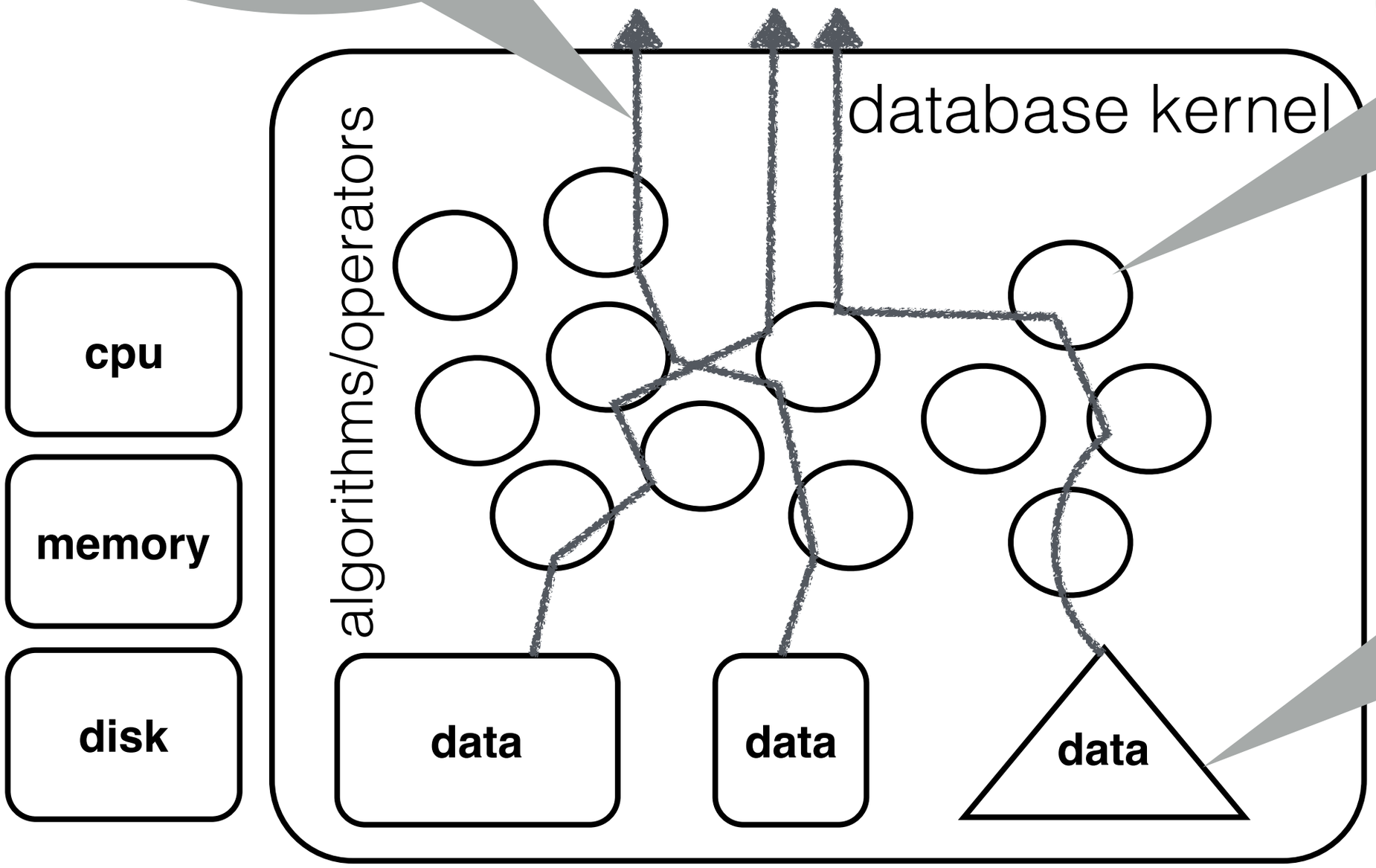
prof. Stratos Idreos

HTTP://DASLAB.SEAS.HARVARD.EDU/CLASSES/CS165/

so far

early/late tuple reconstruction, tuple-at-a-time, vectorized or bulk processing, intermediates format, pushing selects down, etc

scan, binary search, tuple reconstruction, min, max, search/update b-tree, join, etc.



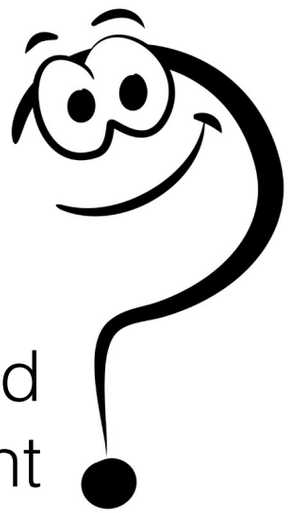
arrays, columns, matrixes, rows,trees

UPDATE table_name
SET column1=value1,column2=value2,...
WHERE some_column=some_value

INSERT INTO table_name
VALUES (value1,value2,value3,...)

updates

traditional applications
e.g., banking

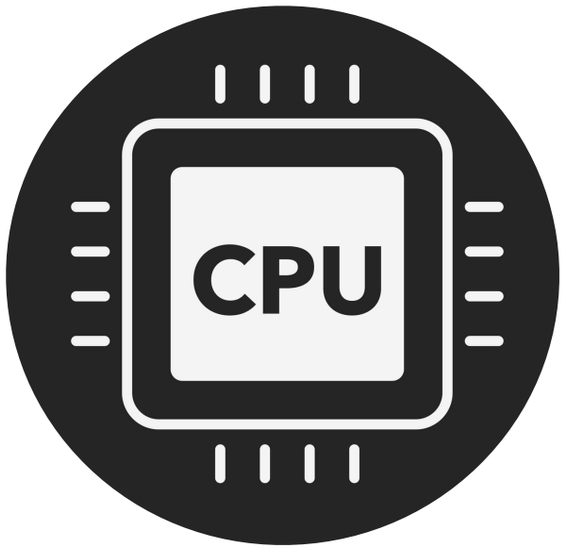


how many times per day do you send
update queries to your bank account

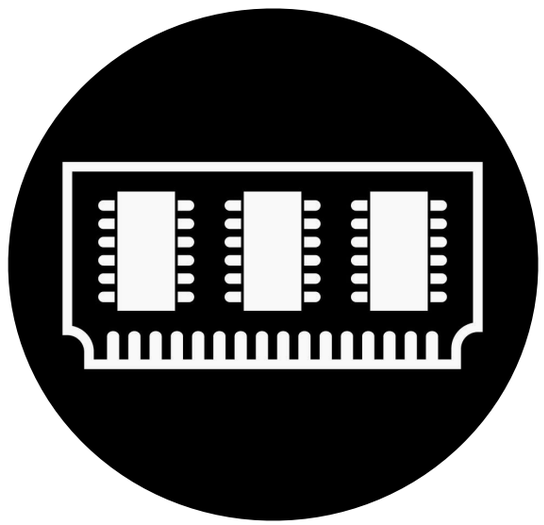
the world has changed
a little bit by now…

updates

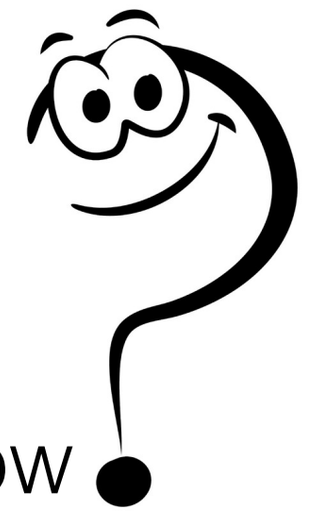
it is not just our data…
everything is data!



monitor CPU utilization



monitor memory
hierarchy utilization



what & how

monitor clicks
(frequency, locations,
specific links, sequences)

analyze data
as it arrives and react
(standing queries)

merge incoming
data with already
archived data

see the correct
up-to-date values

new data

data system

do not lose any updates
(software/hardware failures)

>>1 updates concurrently

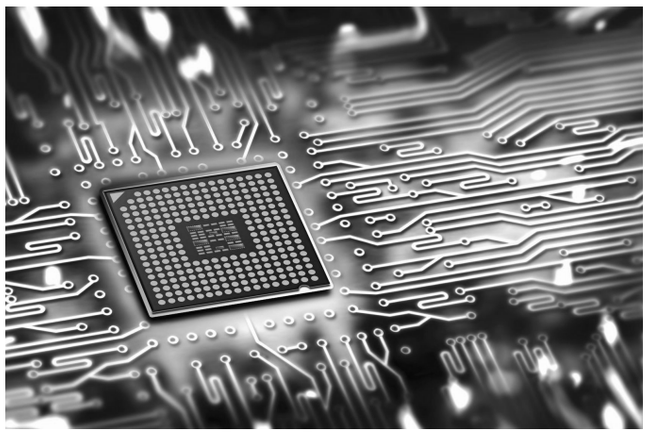
conflicting goals **moving target**

(hardware and requirements change continuously and rapidly)

application requirements

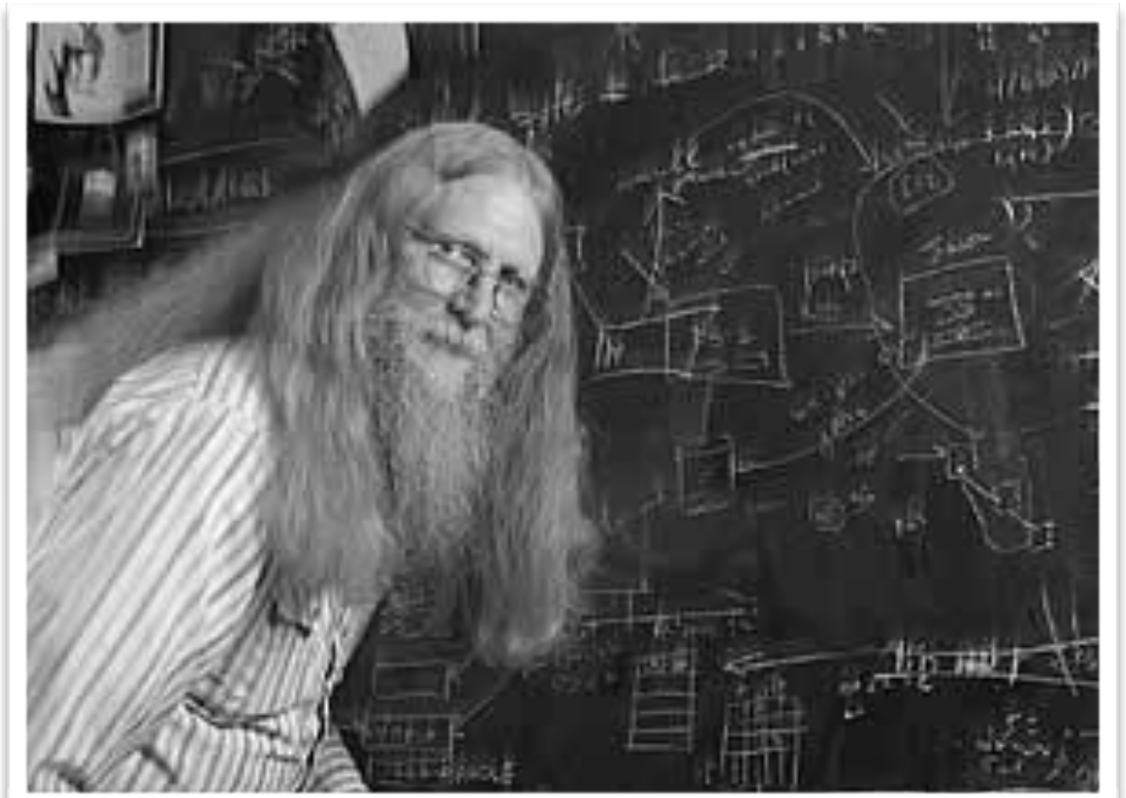
performance

budget



hardware

energy profile



"Three things are important in the database world: ***performance***, ***performance***, and ***performance***"

Bruce Lindsay, IBM
ACM SIGMOD Edgar F. Codd Innovations award 2012

true for both reads & writes

how to do fast (& correct) updates?

(more or less same way we do fast reads)

transactions

logging

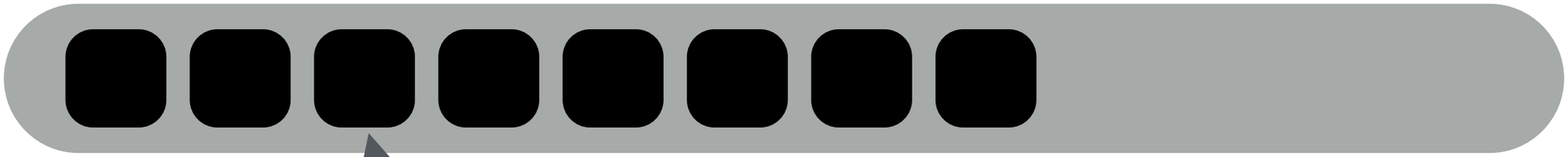
locking

lazy vs eager updates

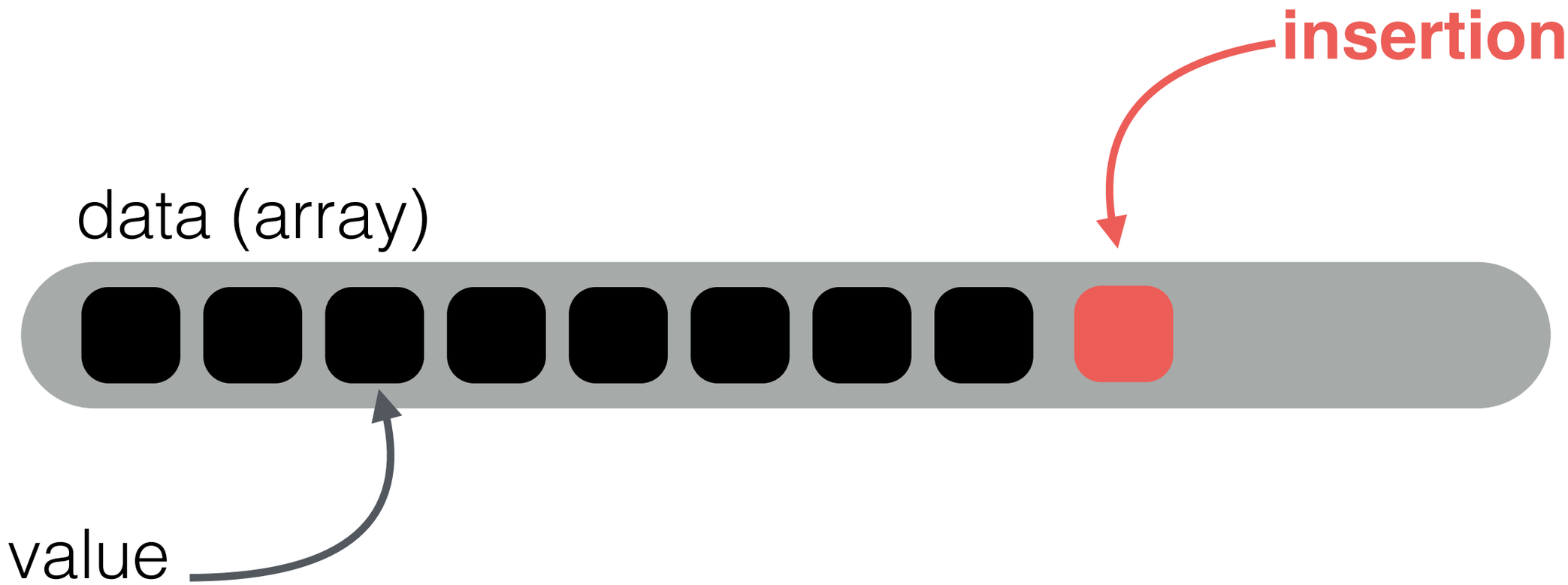
fractured mirrors

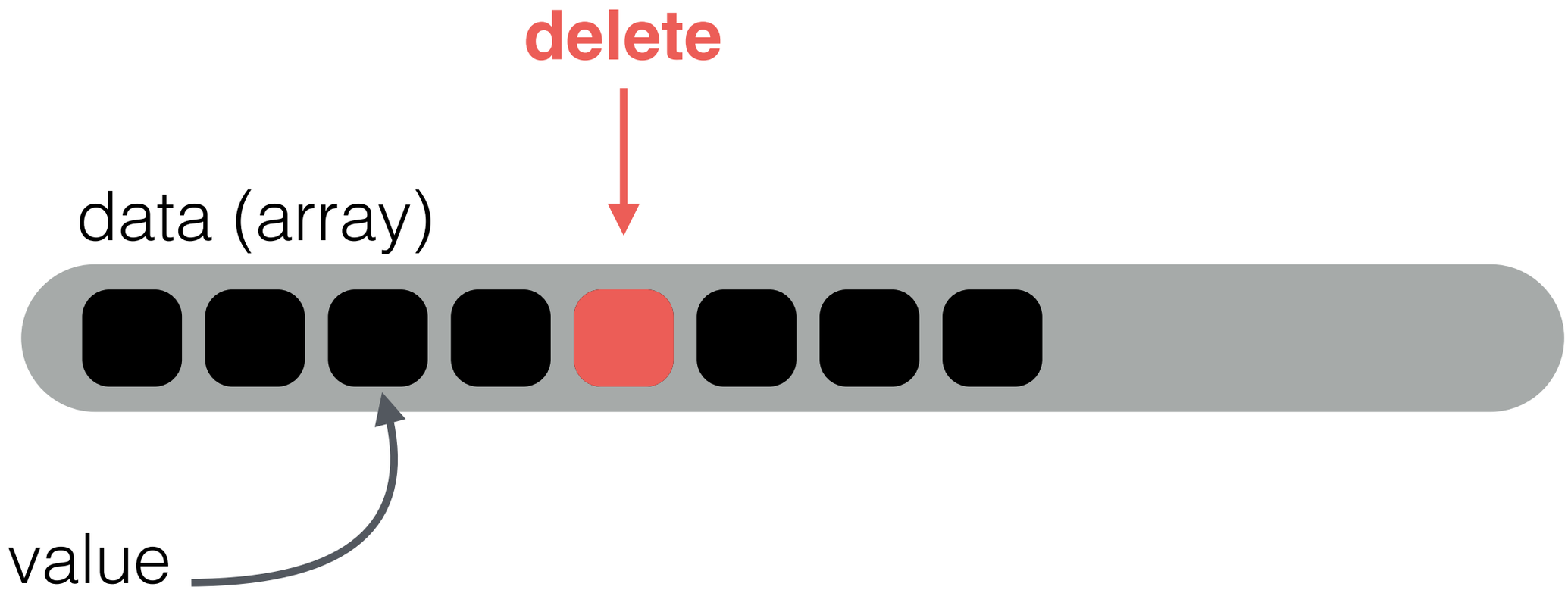
in-place or not

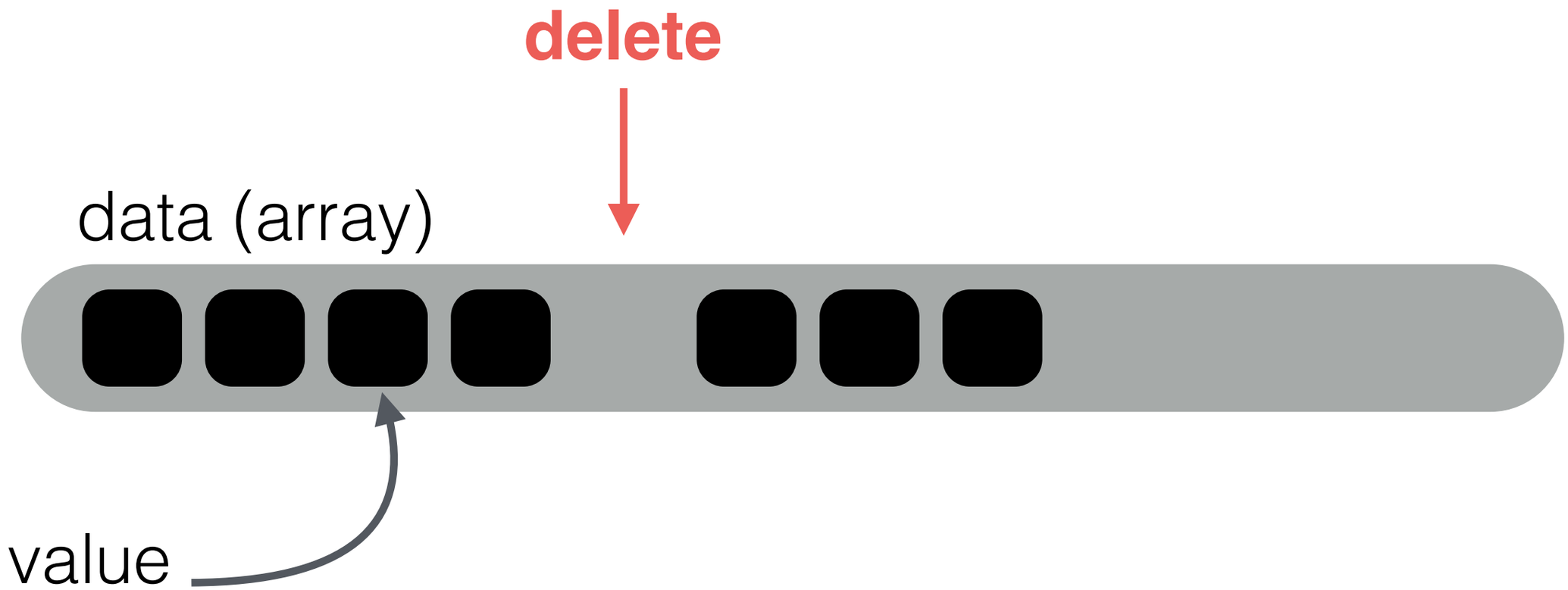
data (array)

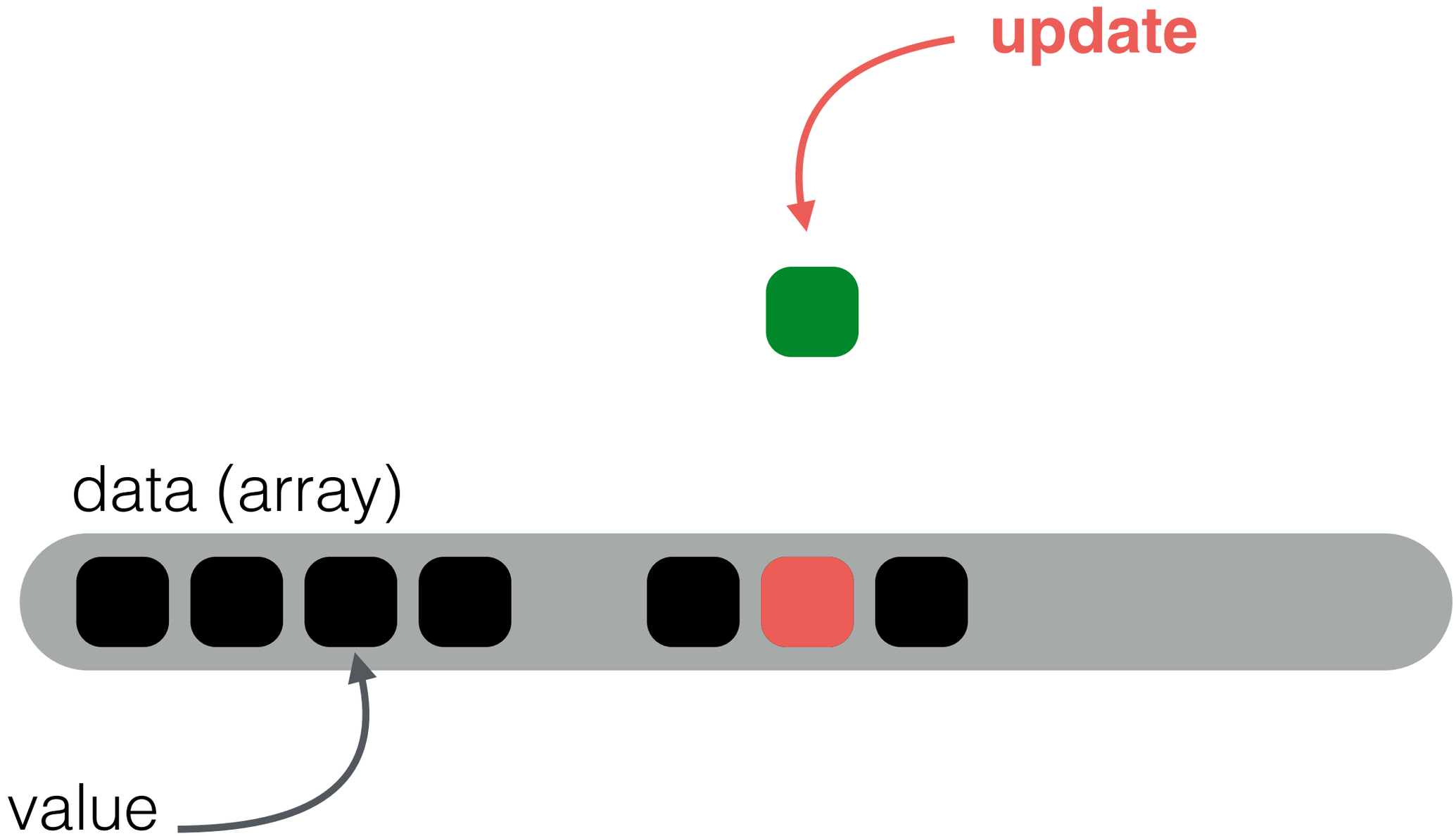


value

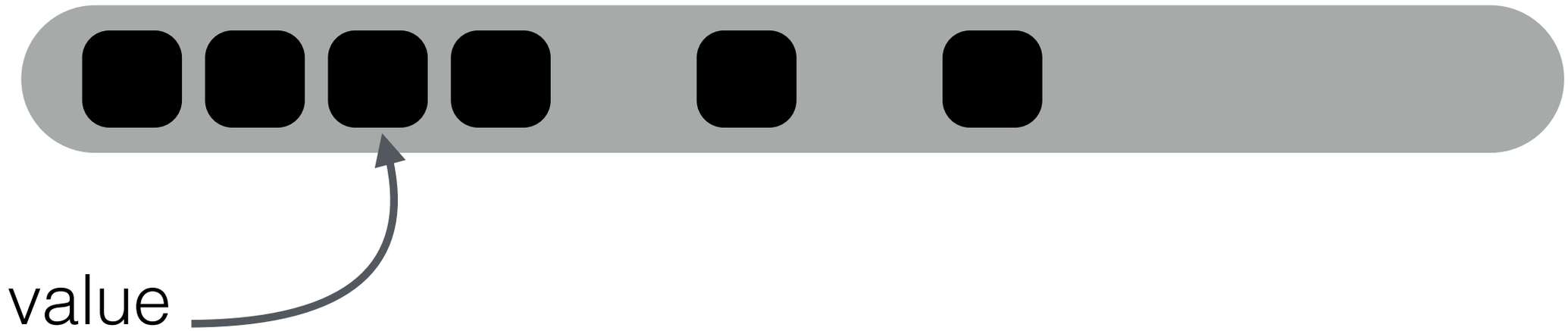

insertion
data (array)
value


delete
data (array)
value


delete
data (array)
value


update
data (array)
value

data (array)



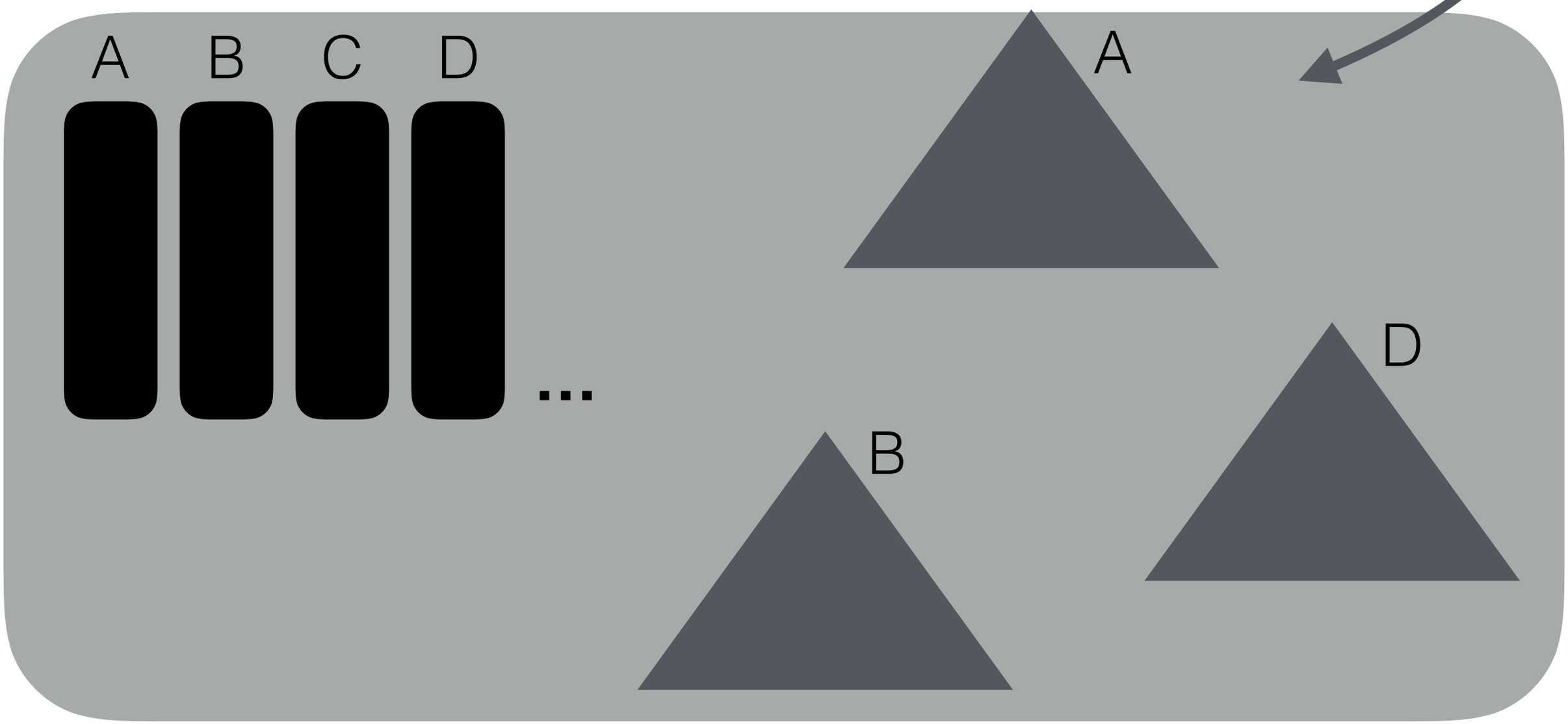
inserts, deletes, updates=deletes followed by inserts

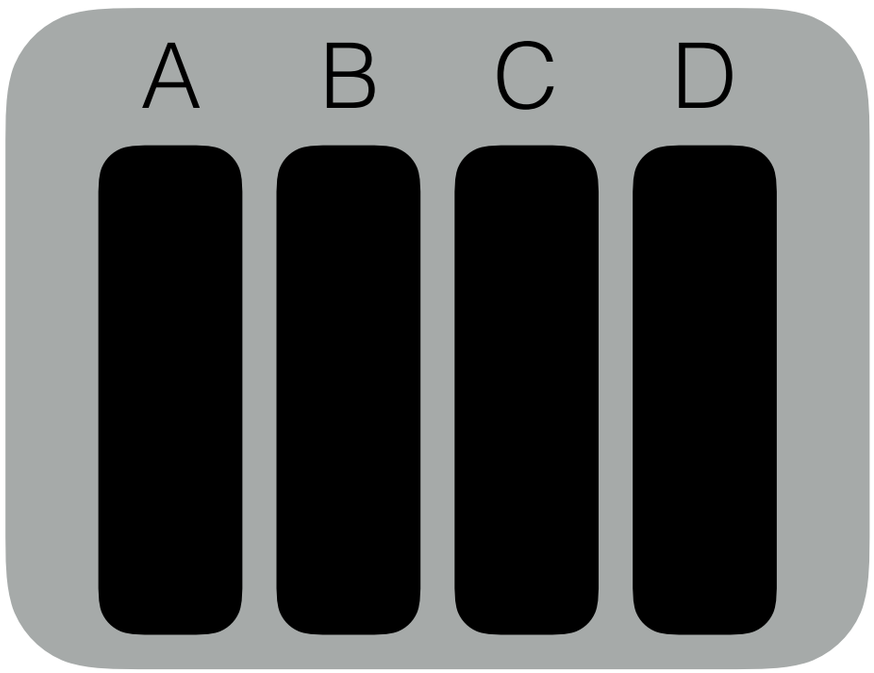
data structure vs application updates

student{name, age, address, telephone, GPA, …}

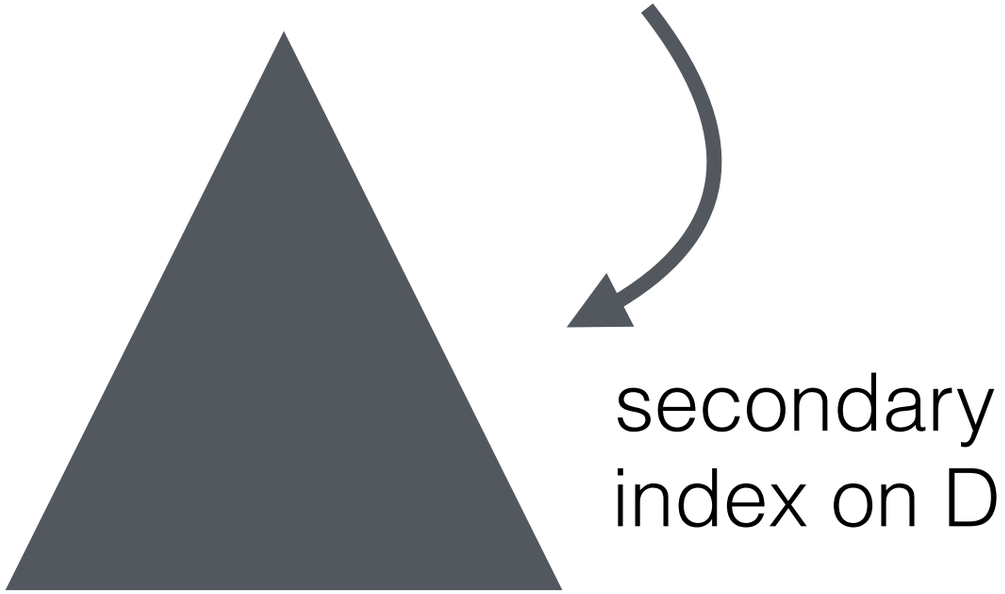
insert new entry (a,b,c,d,…) on table x

update N columns, K trees, statistics, …

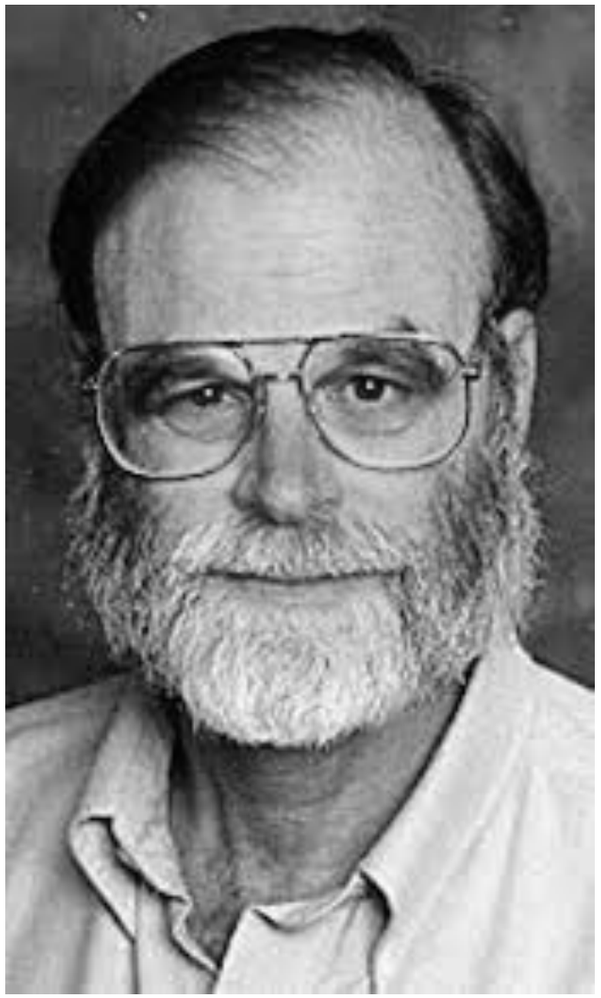




to index or not to index?



(more about this in last two classes)

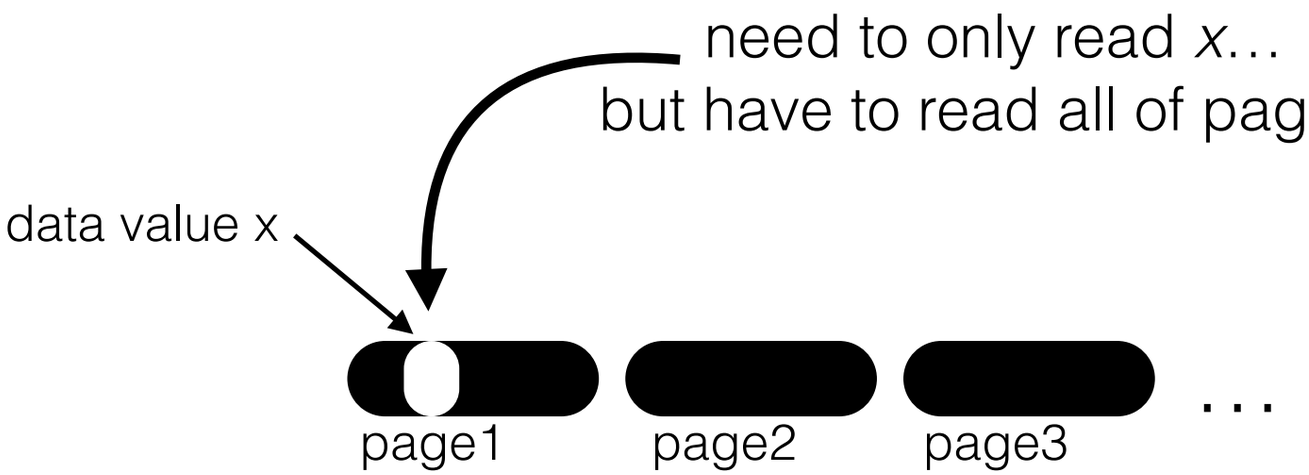


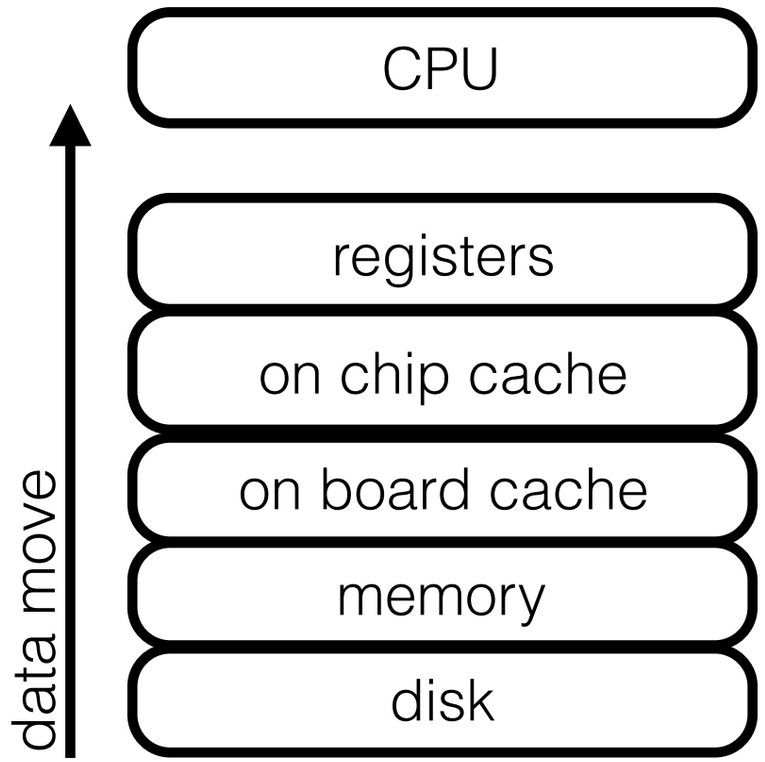
Jim Gray, IBM, Tandem, DEC, Microsoft
ACM Turing award
ACM SIGMOD Edgar F. Codd Innovations award

100Kx disk	**Pluto** 2 years
100x memory	**New York** 1.5 hours
10x on board cache	**this building** 10 min
2x on chip cache	**this room** 1 min
registers	**my head** ~0

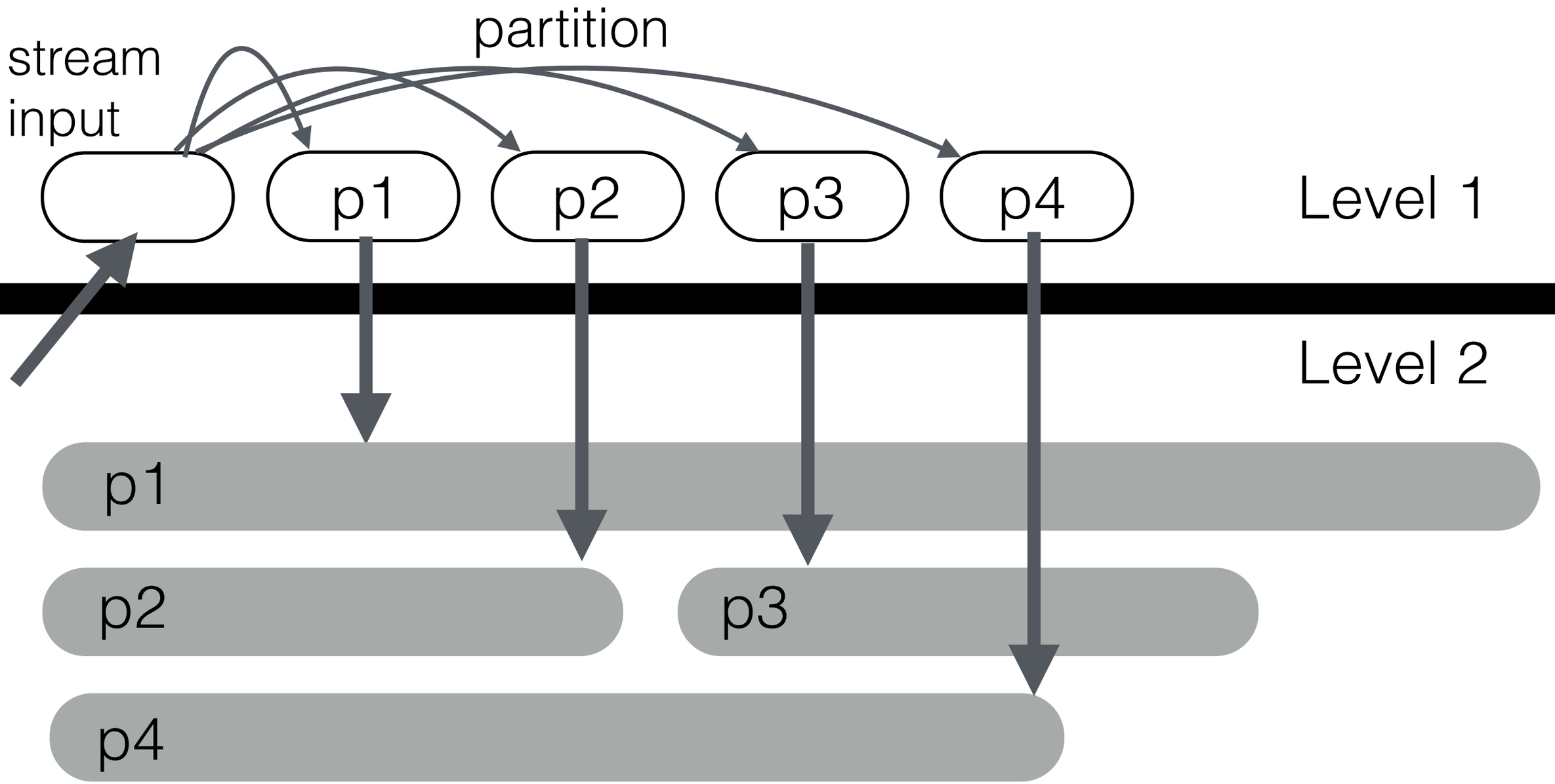
random access & page-based access

same for writes!

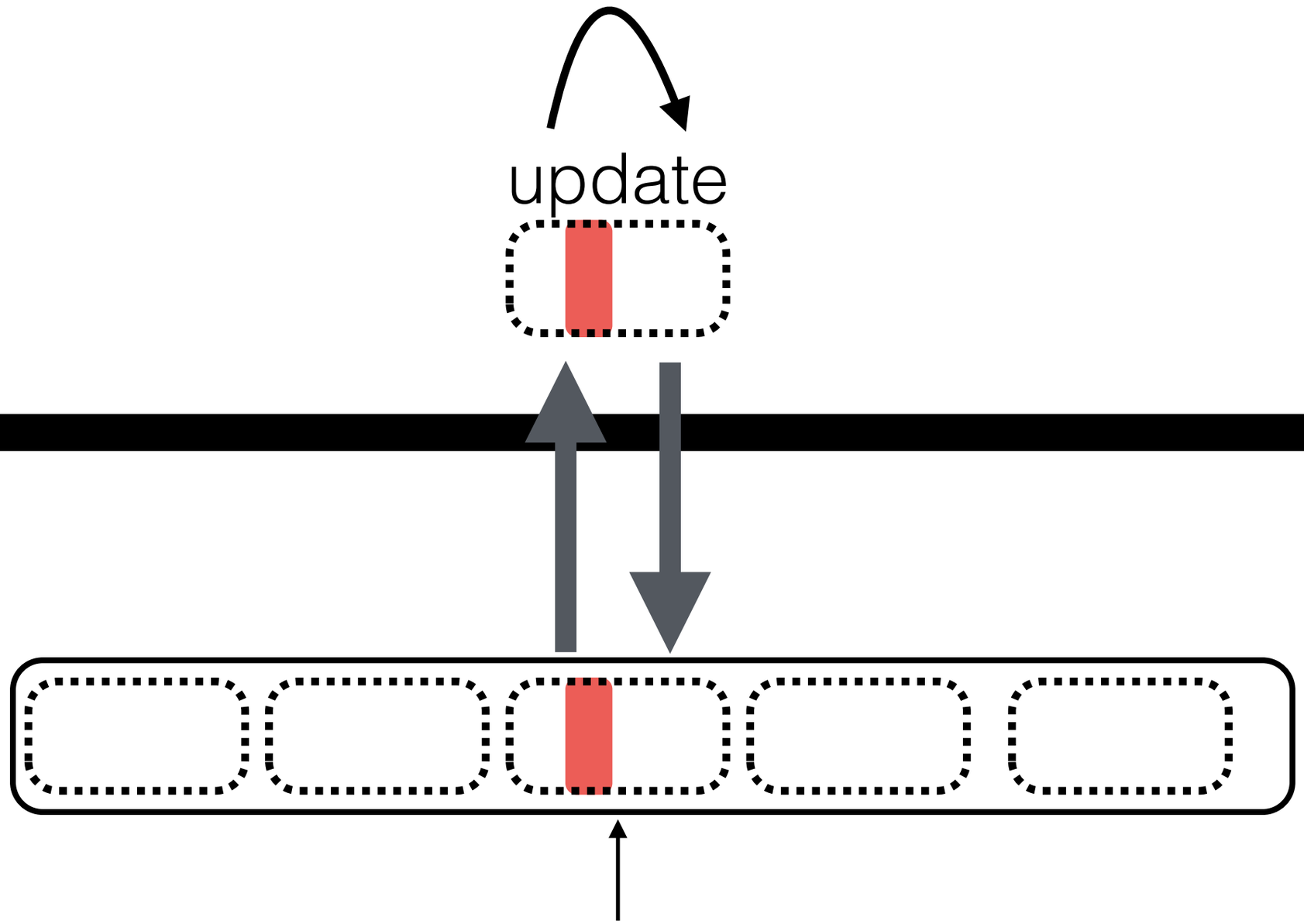




1. read input into stream buffer, hash and write to respective partition buffer
2. when input buffer is consumed, bring the next one
3. when a partition buffer is full, write to L2



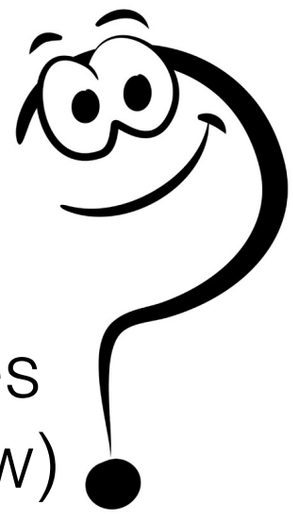
update value x to y in page p of array z



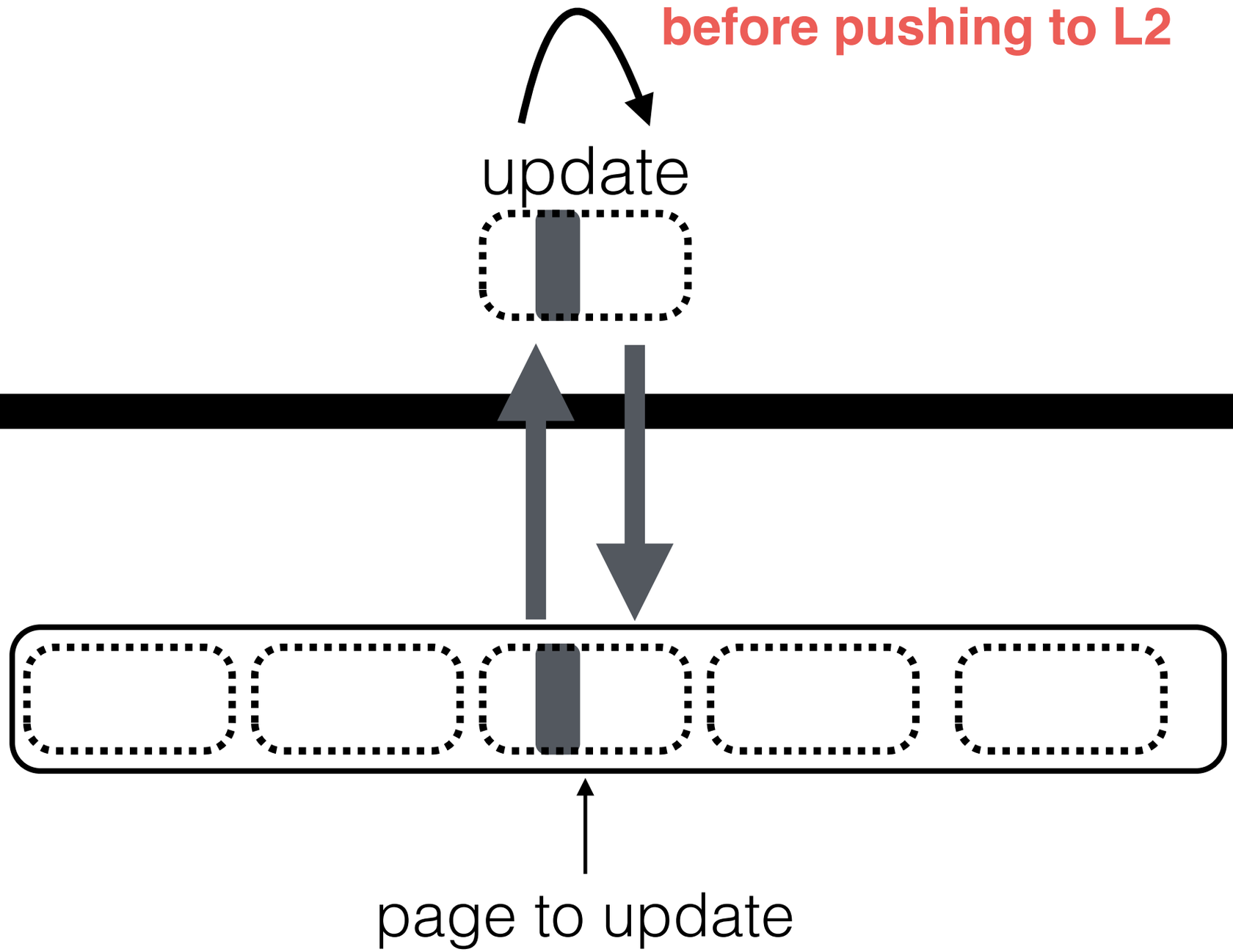
Level 1

Level 2

cost
what if >1 updates
(no locking for now)



buffer >>1 updates to this page before pushing to L2



to structure or not to structure

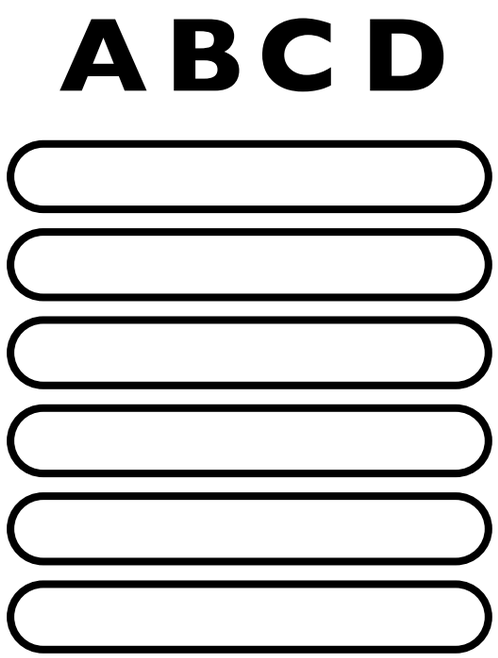
insert v, delete v, update v to v’

no order
fixed-width & dense

sorted
fixed-width & dense

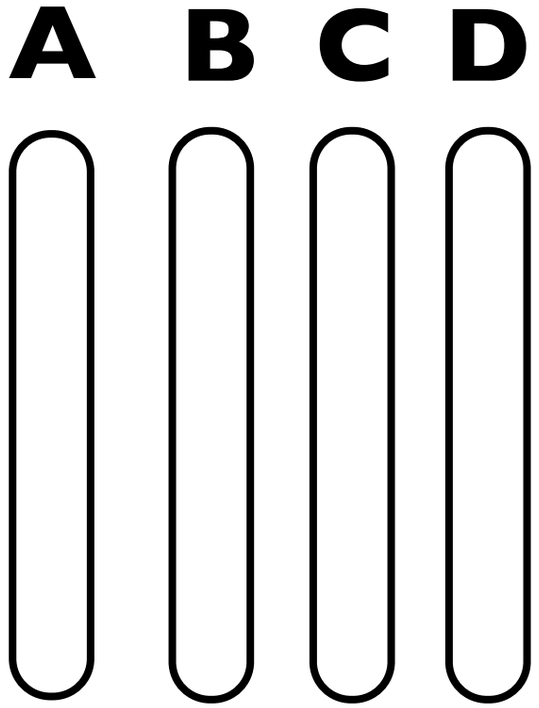
sorted
fixed-width with holes

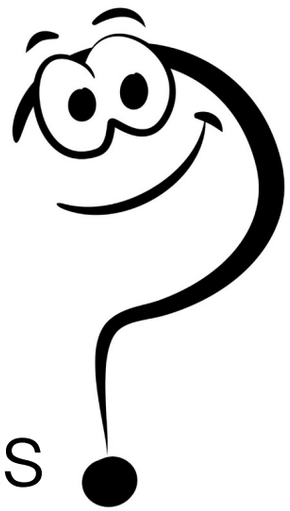
row-store



vs

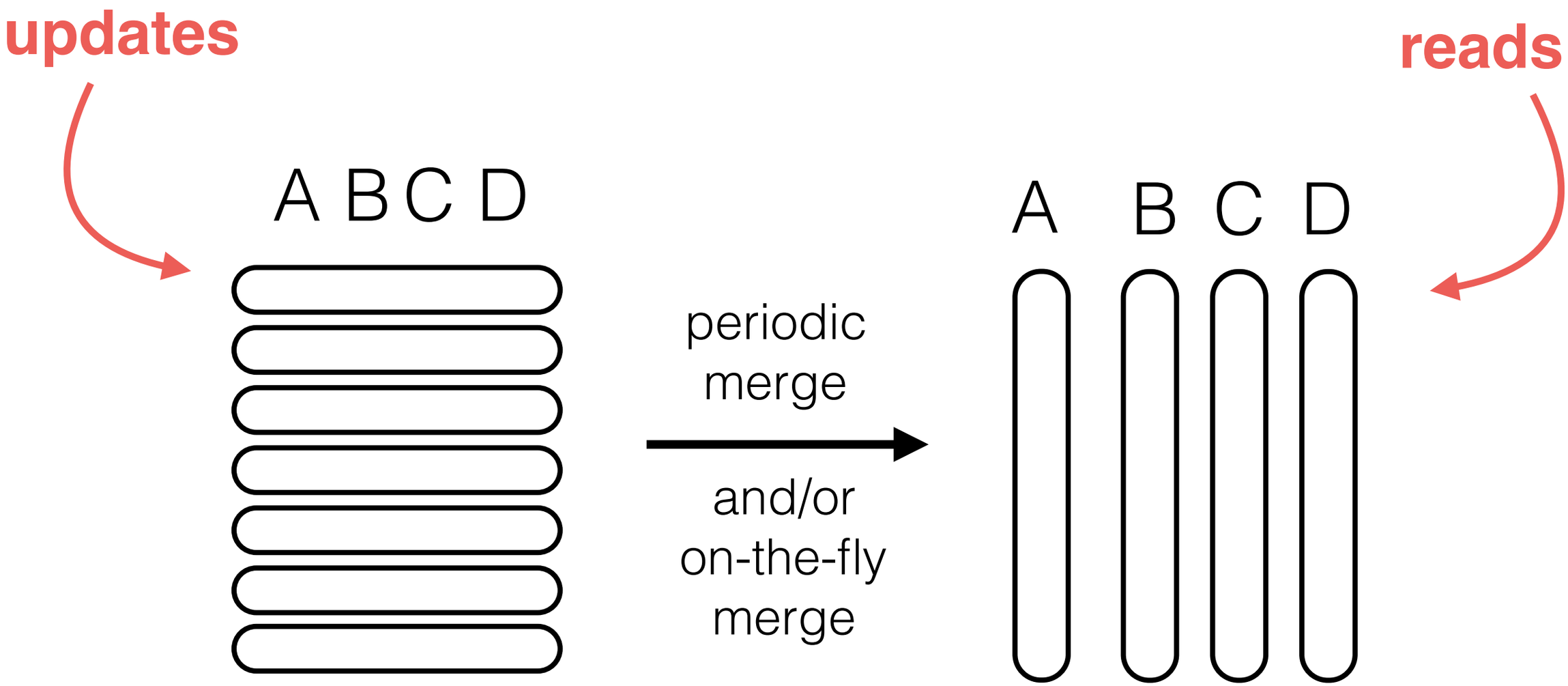
column-store



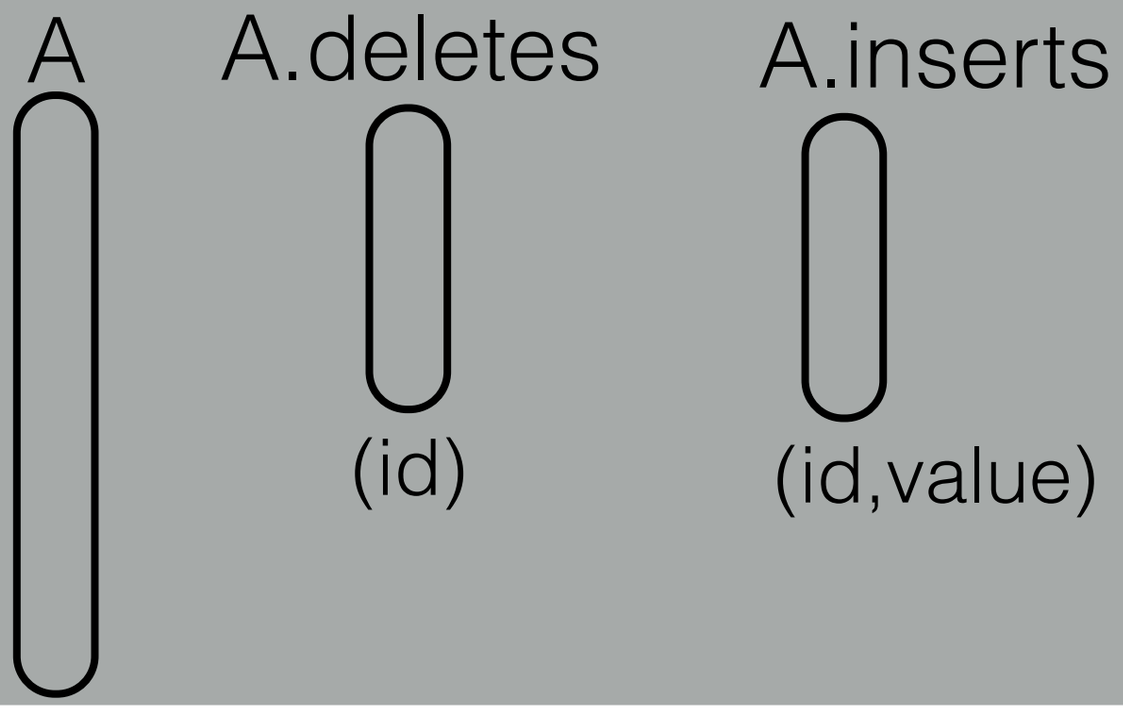


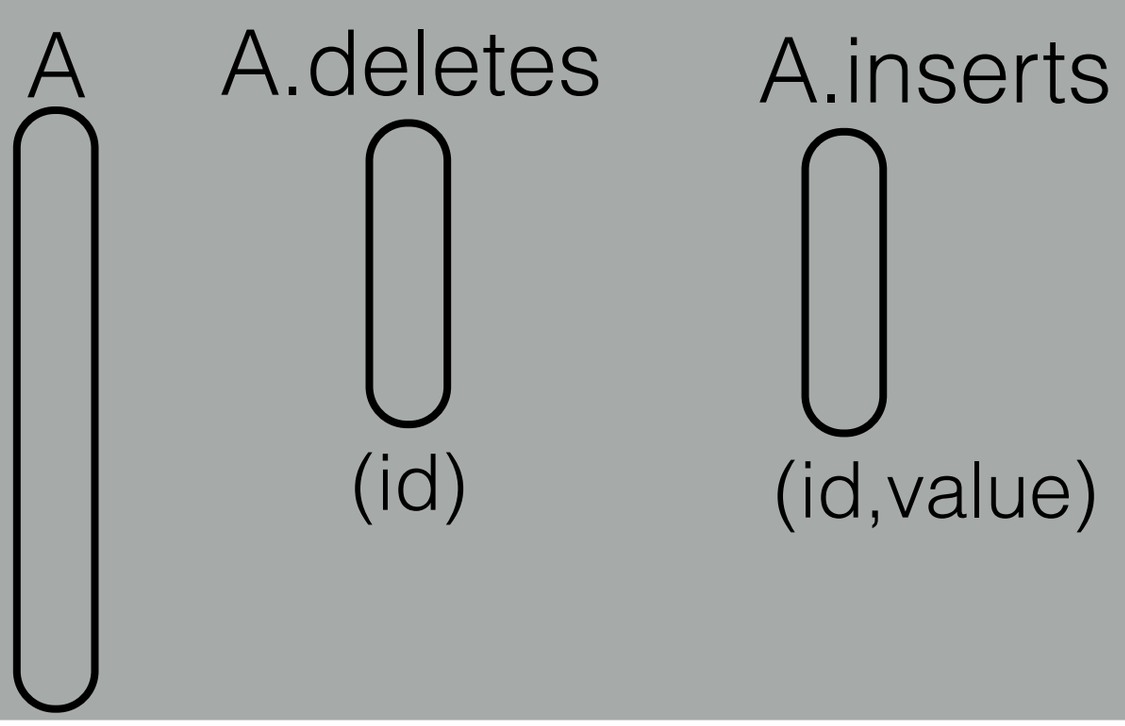
costs

update row7=(A=a,B=b,C=c,D=d)

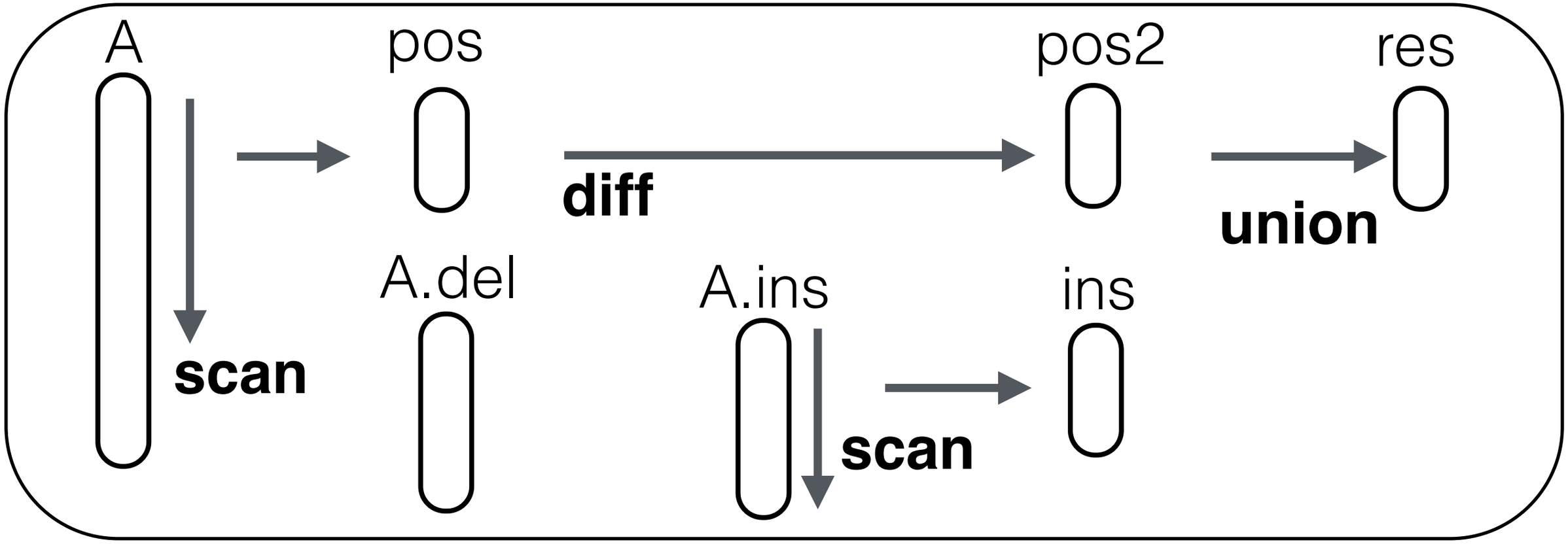


A case for fractured mirrors
Ravishankar Ramamurthy, David J. DeWitt, Qi Su
Very Large Databases Journal (**VLDBJ**), 2003


A
A.deletes
A.inserts
(id)
(id,value)

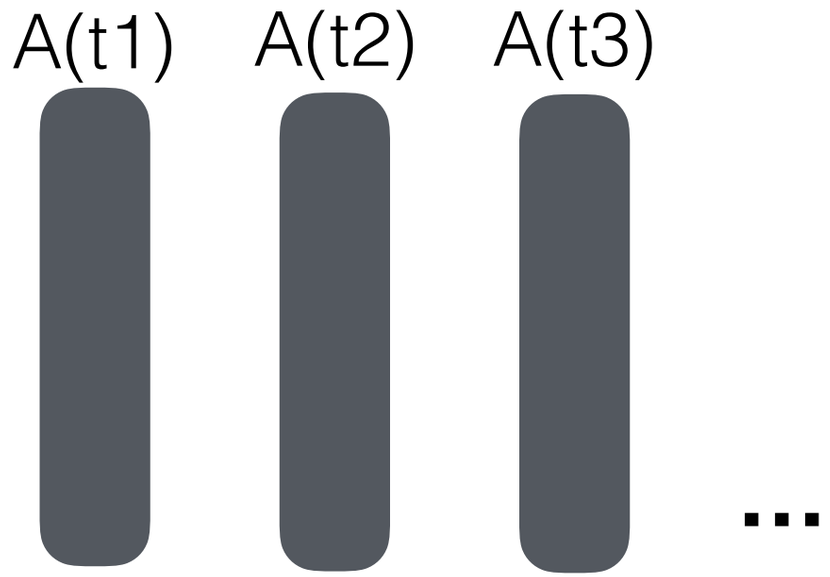


select(A,v1,v2)

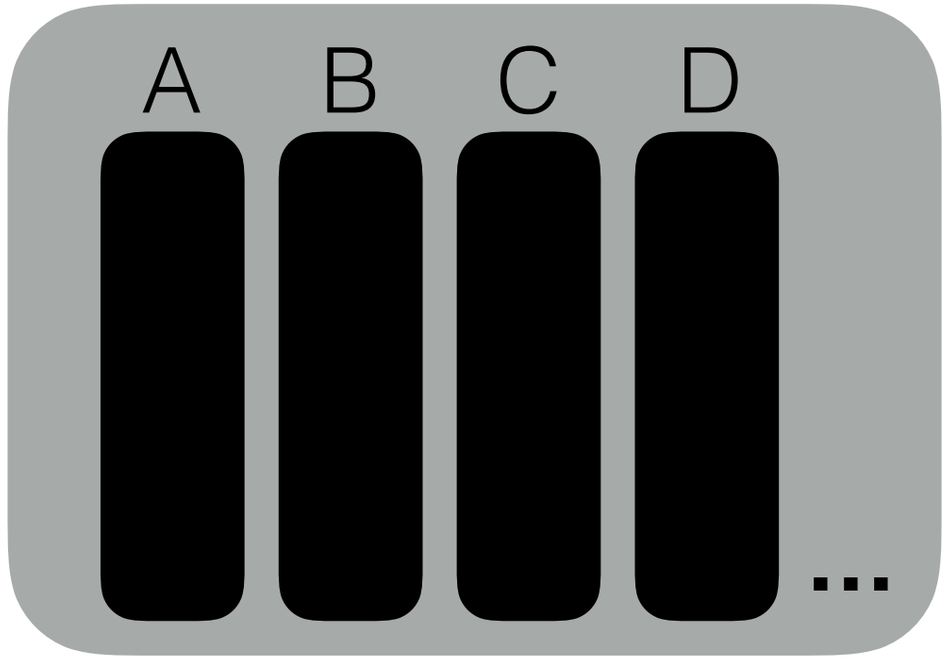


in-place updates: the cardinal sin

The Transaction Concept: Virtues and Limitations
Jim Gray, Tandem TR 81.3, 1981



update all rows
where A=v1 & B=v2
to (a=a/2,b=b/4,c=c-3,d=d+2)



CPU

level 1

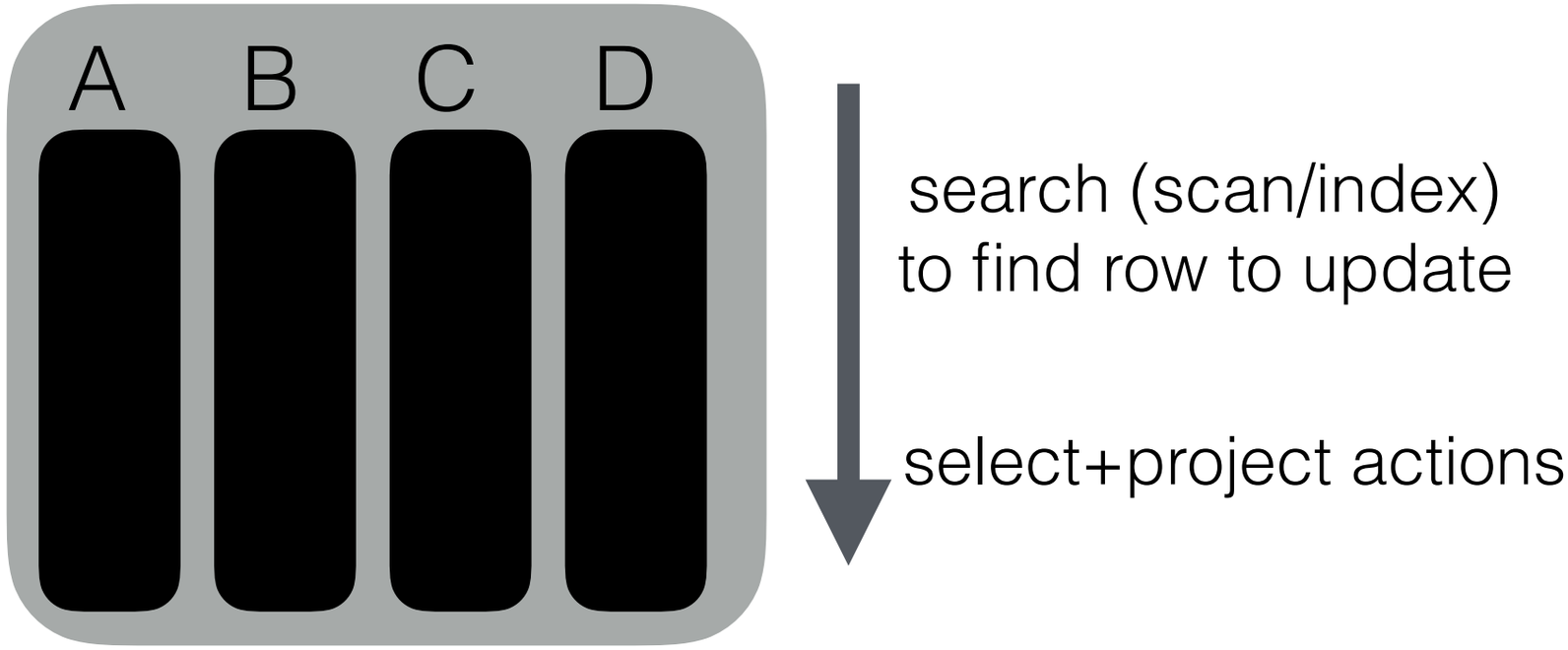
level 2

how to perform updates efficiently and correctly?
correctly=all or nothing

problems to worry about (?):
what if user/applications aborts?
what if power goes down?
what if there is an earthquake in our city?
what if aliens come to earth?

(assume simplified memory hierarchy)
all data fit in L2, not all data fit in L1
L2 is non-volatile, L1 is volatile

update all rows
where A=v1 & B=v2
to (a=a/2,b=b/4,c=c-3,d=d+2)



update all rows
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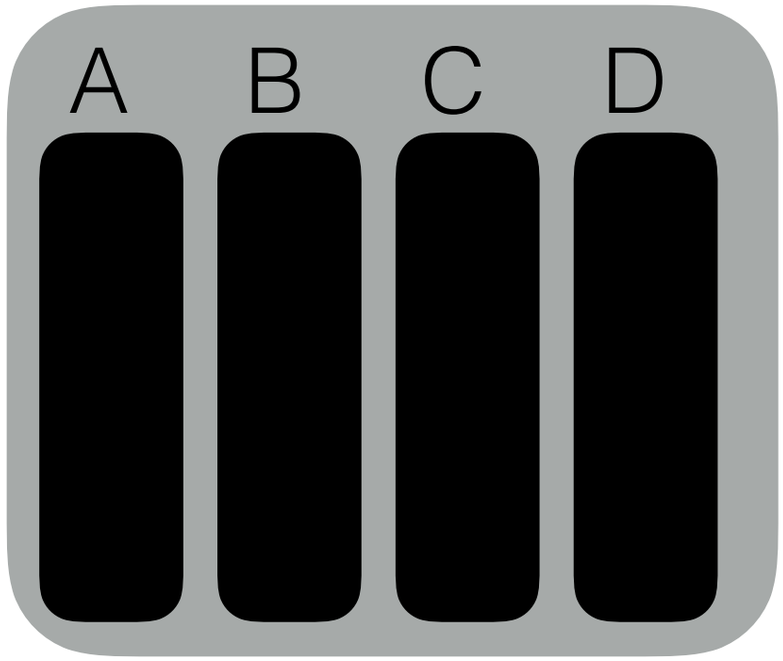
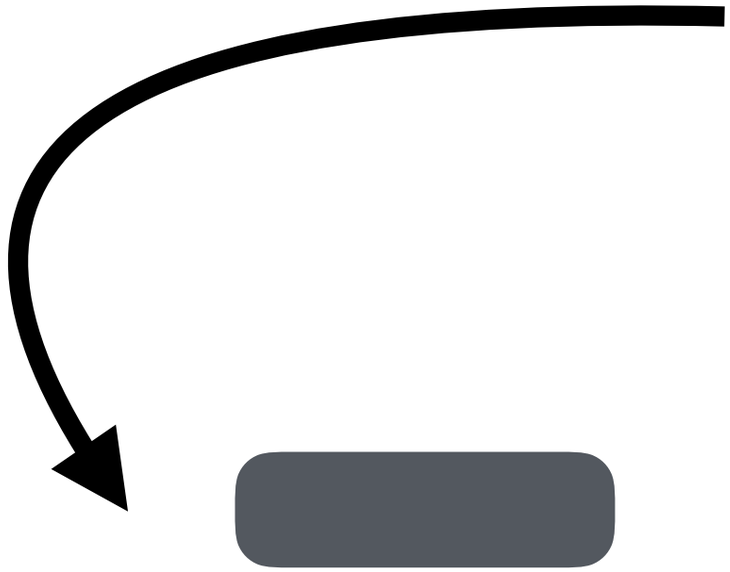
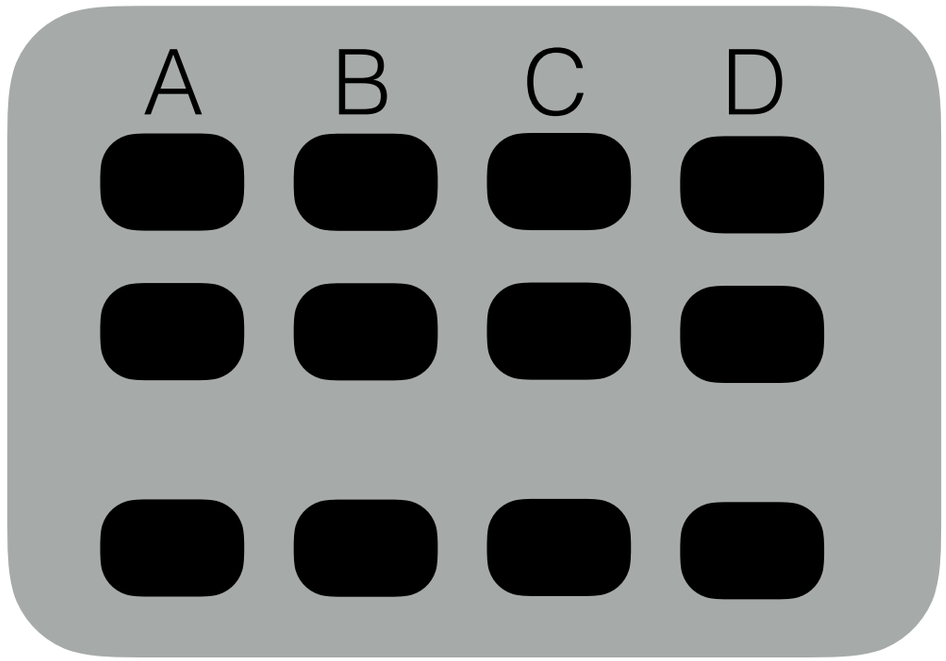


search (scan/index)
to find row to update

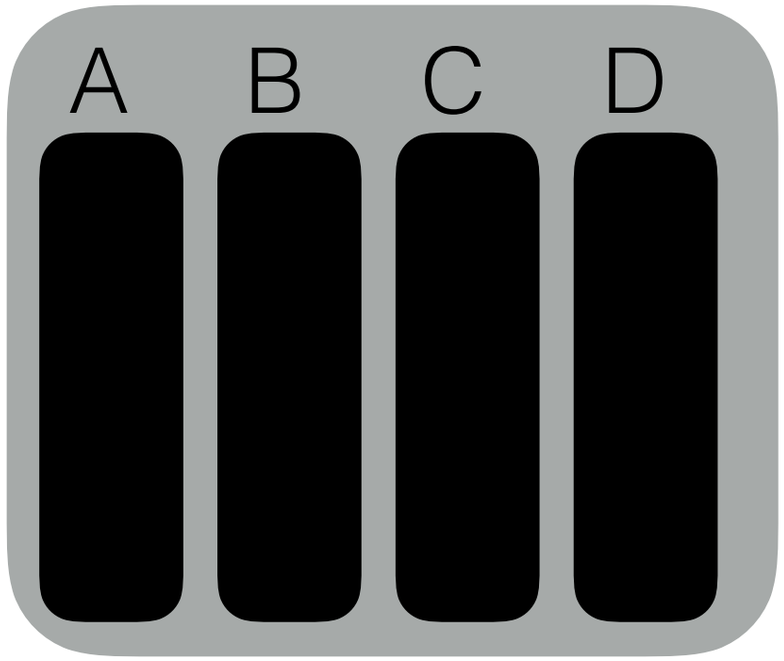
select+project actions



list of rowIDs (positions)



update all rows
where A=v1 & B=v2
to (a=a/2,b=b/4,c=c-3,d=d+2)



search (scan/index)
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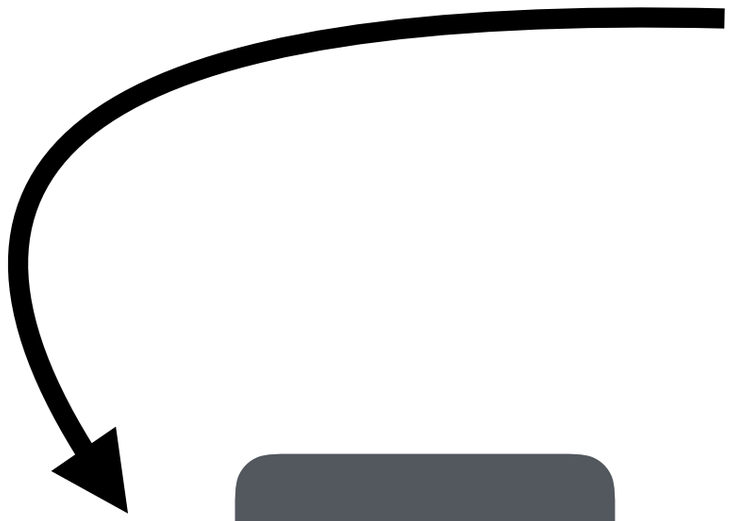
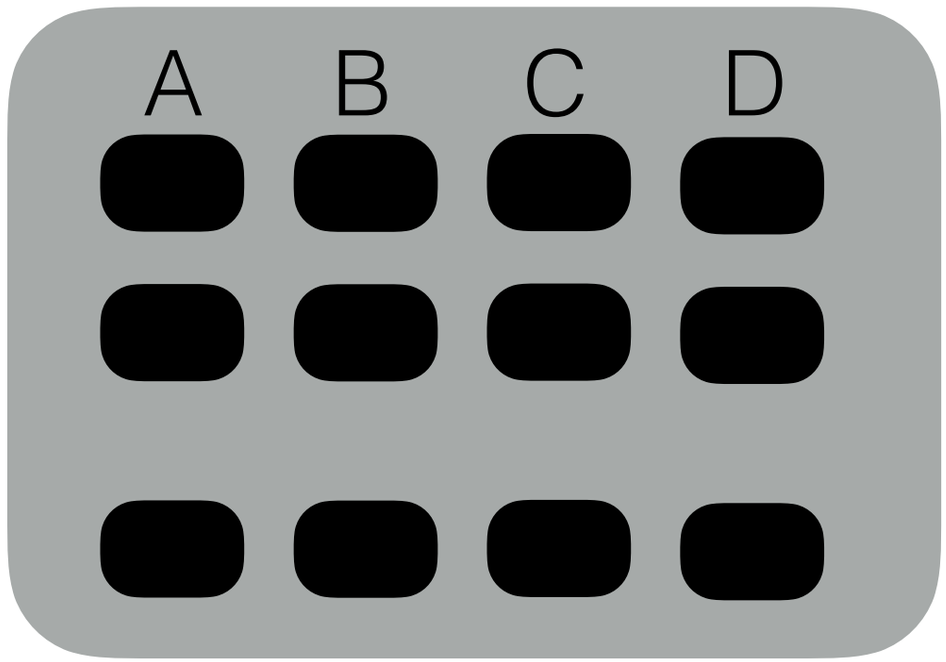
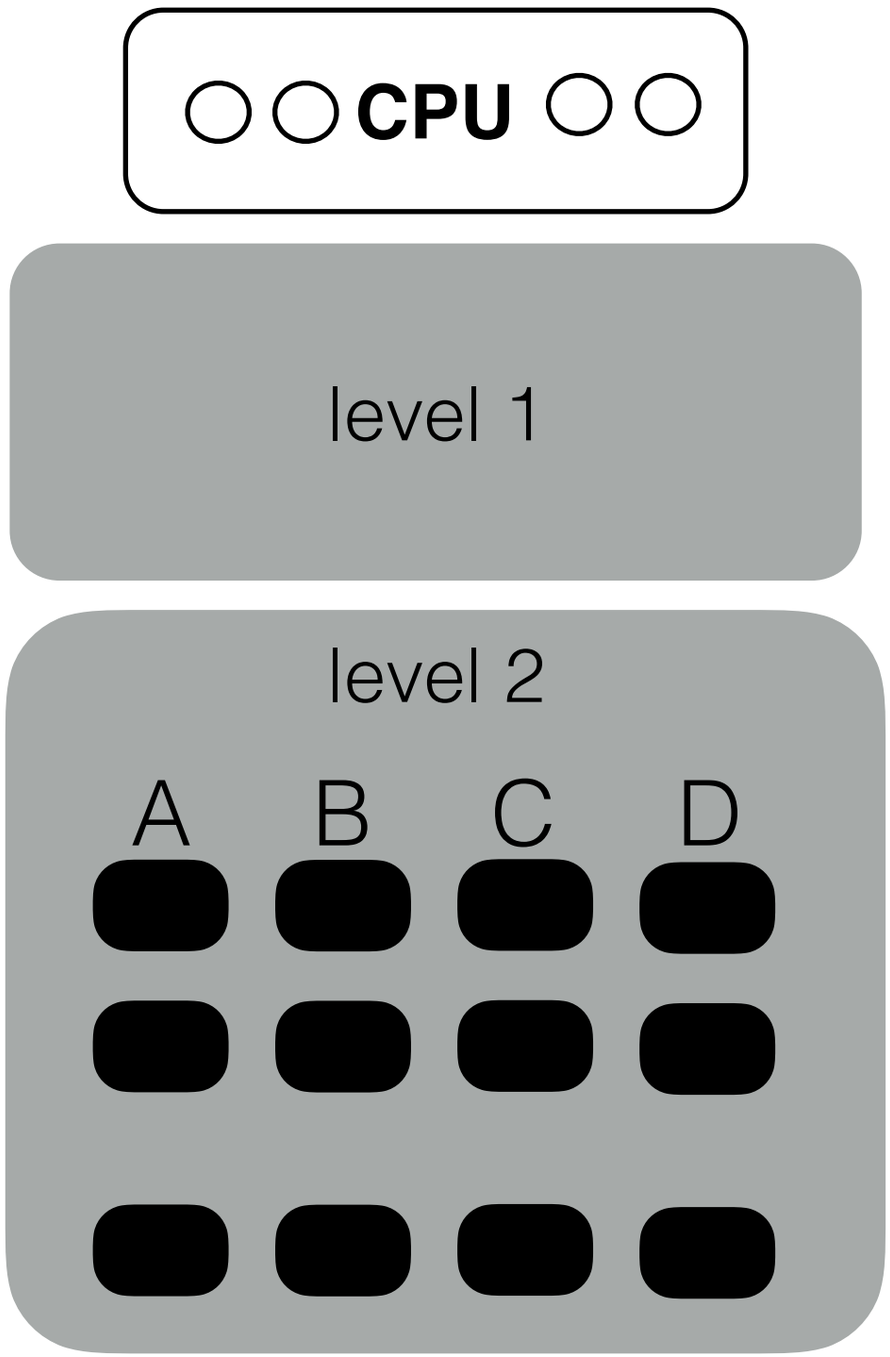


list of rowIDs (positions)



we know what to update but nothing happened yet



read page in L1
update
persist to L2

if problem (power/abort)
before we write all pages
we are left with an inconsistent state

WAL: keep persistent notes as we go so we can resume or undo

when is our the log or an update persistent?

disk

persistent memory, e.g., disk?

when is our the log or an update persistent?

disk

persistent memory, e.g., disk?

machine 1 **machine 2** **machine 3**

replicate to multiple machines?

when is our the log or an update persistent?

persistent memory, e.g., disk?

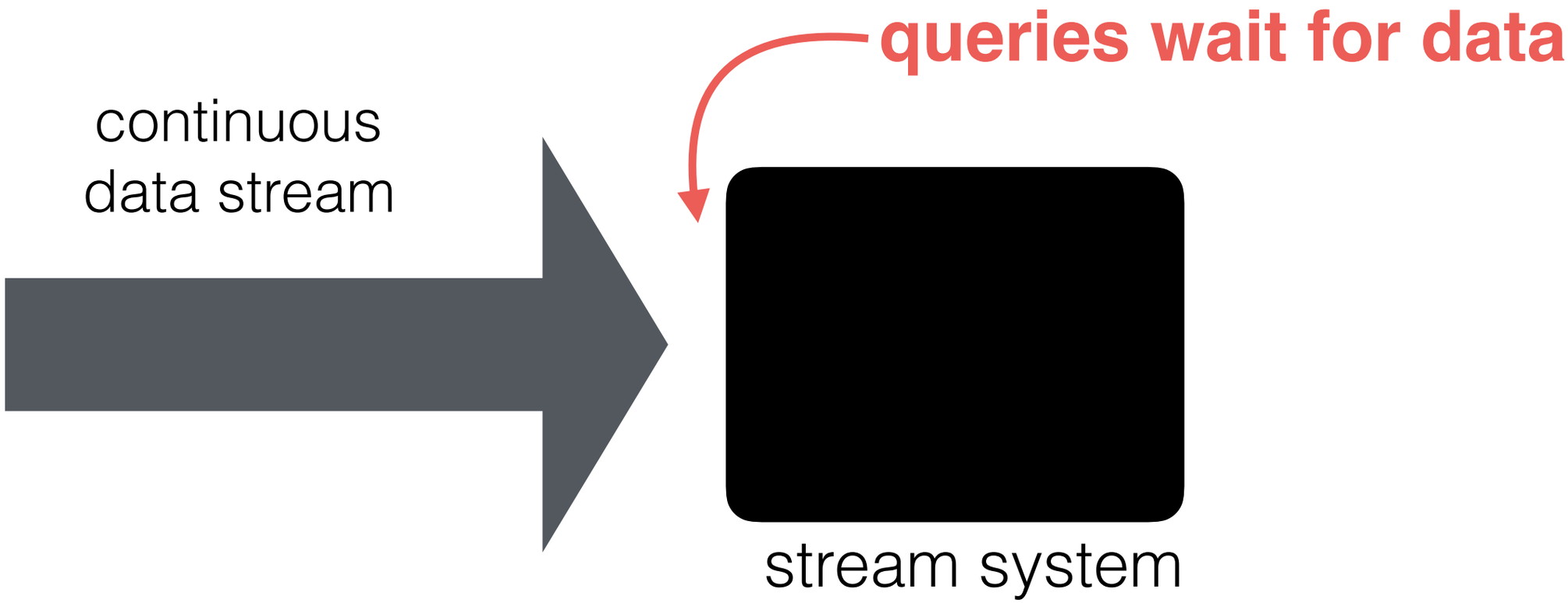
replicate to multiple machines?

replicate to multiple machines
>1 clusters in >1 cities?

next class: transactions, ACID

what if >>1 update queries
at the same time

WAL & replication



Aurora: a new model and architecture for data stream management
Daniel J. Abadi, Donald Carney, Ugur Çetintemel, Mitch Cherniack, Christian Convey, Sangdon Lee, Michael Stonebraker, Nesime Tatbul, Stanley B. Zdonik
Very Large Databases Journal (**VLDBJ**), 2003

Enhanced stream processing in a DBMS kernel
Erietta Liarou, Stratos Idreos, Stefan Manegold, Martin Kersten
In Proc. of the International Conf. on Extending Database Technology (**EDBT**), 2013

(also for next class)

textbook: chapters 16, 17, 18

Positional update handling in column stores
Sándor Héman, Marcin Zukowski, Niels J. Nes, Lefteris Sidirourgos, Peter A. Boncz
In Proc. of the ACM **SIGMOD** Inter. Conference on Management of Data, 2010

Updating a cracked database
Stratos Idreos, Martin Kersten, Stefan Manegold
In Proc. of the ACM **SIGMOD** Inter. Conference on Management of Data, 2007

updates

DATA SYSTEMS

prof. Stratos Idreos