Query Processing

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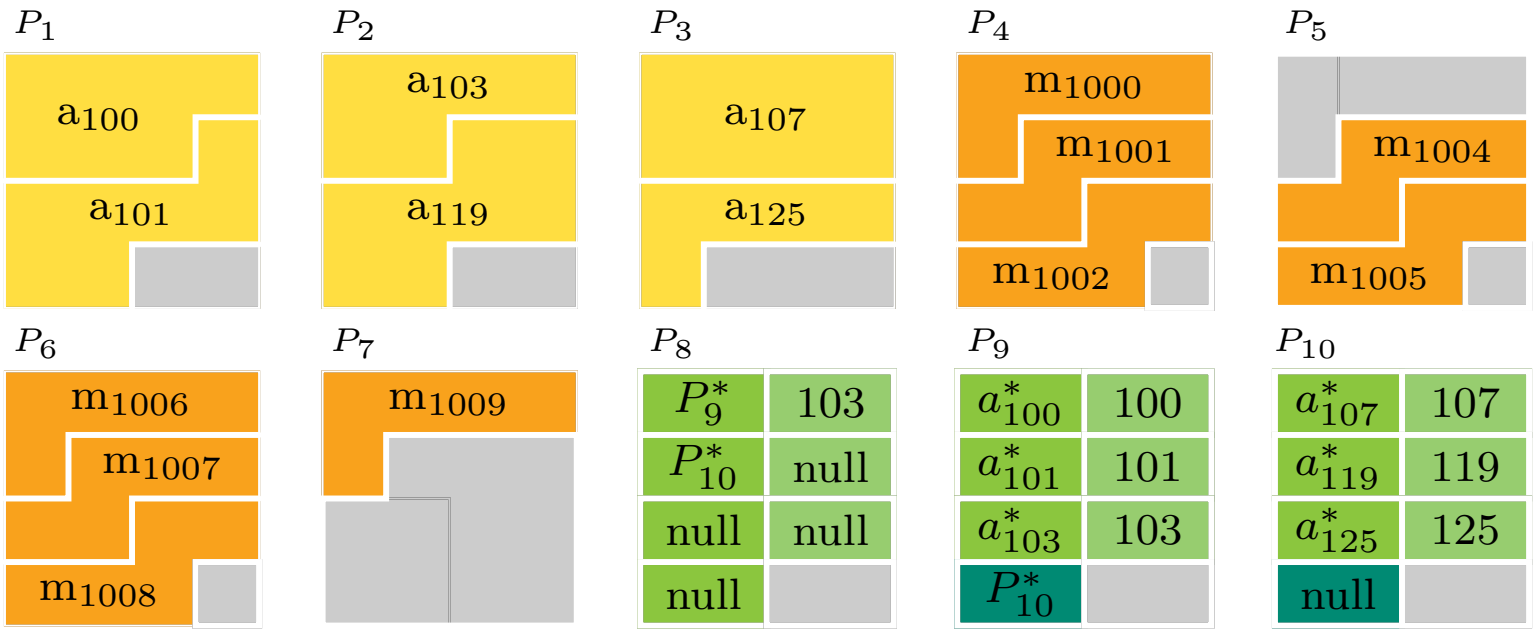
Rows and Pages

File metrics

$|\mathsf{account}| = 6$
$|\mathsf{movement}| = 9$
$|Pages(\mathsf{account})| = 3$
$|Pages(\mathsf{movement})| = 4$
$|Pages(\mathsf{index(account.no)})| = 3$

Page Layout on Disc



Quiz 1: Pages in a B^+-tree

A B^+-tree has fan out of 5, and the table it indexes has 80 rows.

What is the minimum number of pages occupied by the B^+-tree?

A

21

B

25

C

26

D

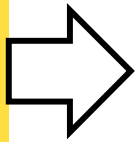
31

Example Query

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

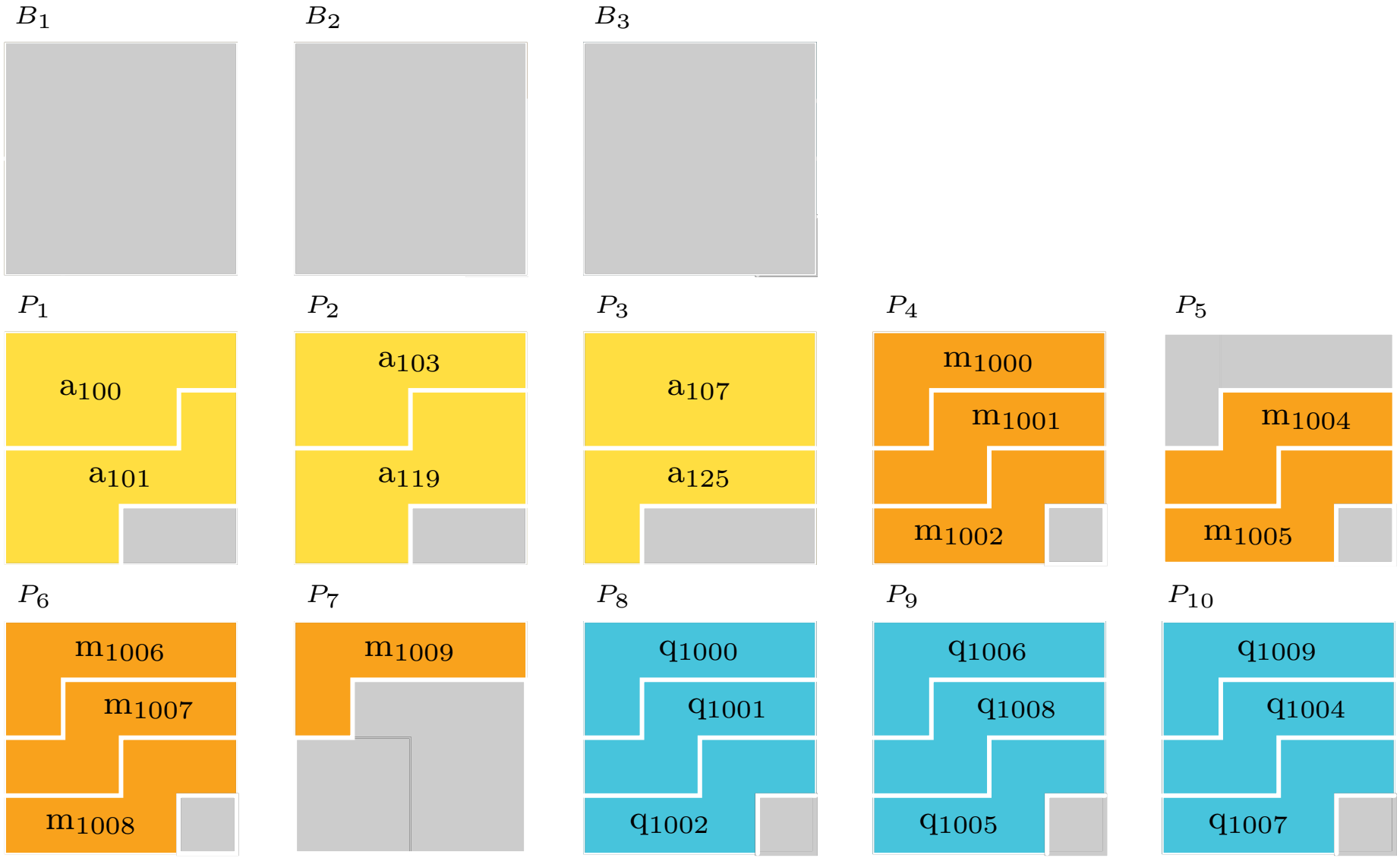
movement			
mid	no	amount	tdate
1000	100	2300.00	5/1/1999
1001	101	4000.00	5/1/1999
1002	100	-223.45	8/1/1999
1004	107	-100.00	11/1/1999
1005	103	145.50	12/1/1999
1006	100	10.23	15/1/1999
1007	107	345.56	15/1/1999
1008	101	1230.00	15/1/1999
1009	119	5600.00	18/1/1999

```
SELECT   movement.mid
         account.no,
         account.cname,
FROM     account JOIN movement
         ON account.no=movement.no
```

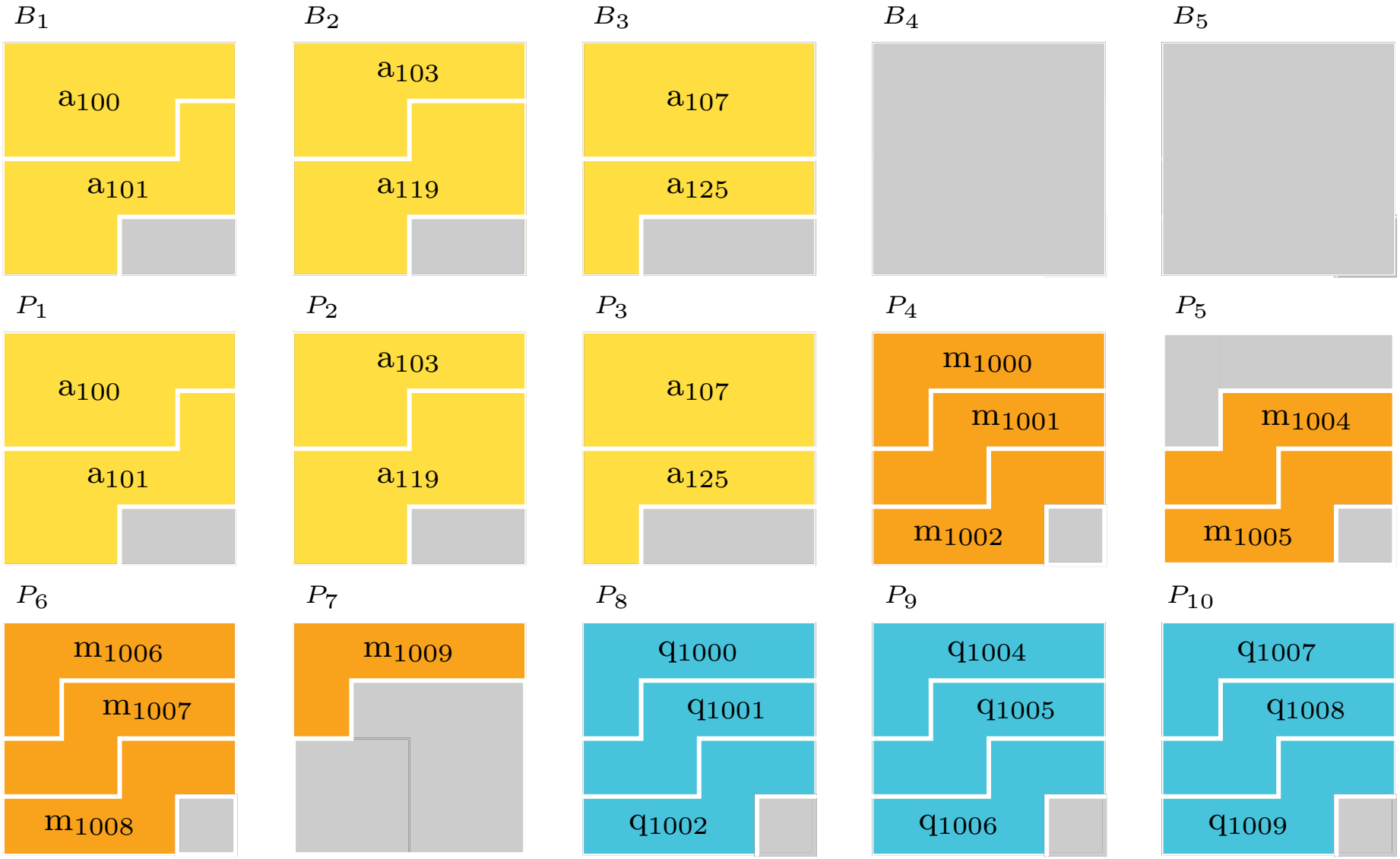


query1		
mid	no	cname
1000	100	'McBrien, P.'
1001	101	'McBrien, P.'
1002	100	'McBrien, P.'
1006	100	'McBrien, P.'
1008	101	'McBrien, P.'
1005	103	'Boyd, M.'
1009	119	'Poulovassilis, A.'
1004	107	'Poulovassilis, A.'
1007	107	'Poulovassilis, A.'

Block Nested Loop Join: Minimum Buffer Space



Block Nested Loop Join: Buffer Space for Smallest Relation



Block Nested Loop Join: Analysis

$R \overset{BNL}{\bowtie} S$

- If $|B| = 3$ then for each page in R, must read all the pages in S
  Number of disc page reads is

$$|Pages(R)| + |Pages(R)|.|Pages(S)|$$

- If $|B| = |Pages(R)| + 2$ then read in all pages of R, and then read in each page of S once to join with all pages of R
  Number of disc page reads is

$$|Pages(R)| + |Pages(S)|$$

- In general, number of page reads is

$$|Pages(R)| + \lceil \frac{|Pages(R)|}{|B| - 2} \rceil .|Pages(S)|$$

Quiz 2: Performance of BNLJ

If we compare $R \overset{BNL}{\bowtie} S$ with $S \overset{BNL}{\bowtie} R$, where $|Pages(R)| < |Pages(S)|$

Which will have the lower $NDPR$?

A

$R \overset{BNL}{\bowtie} S$

B

$S \overset{BNL}{\bowtie} R$

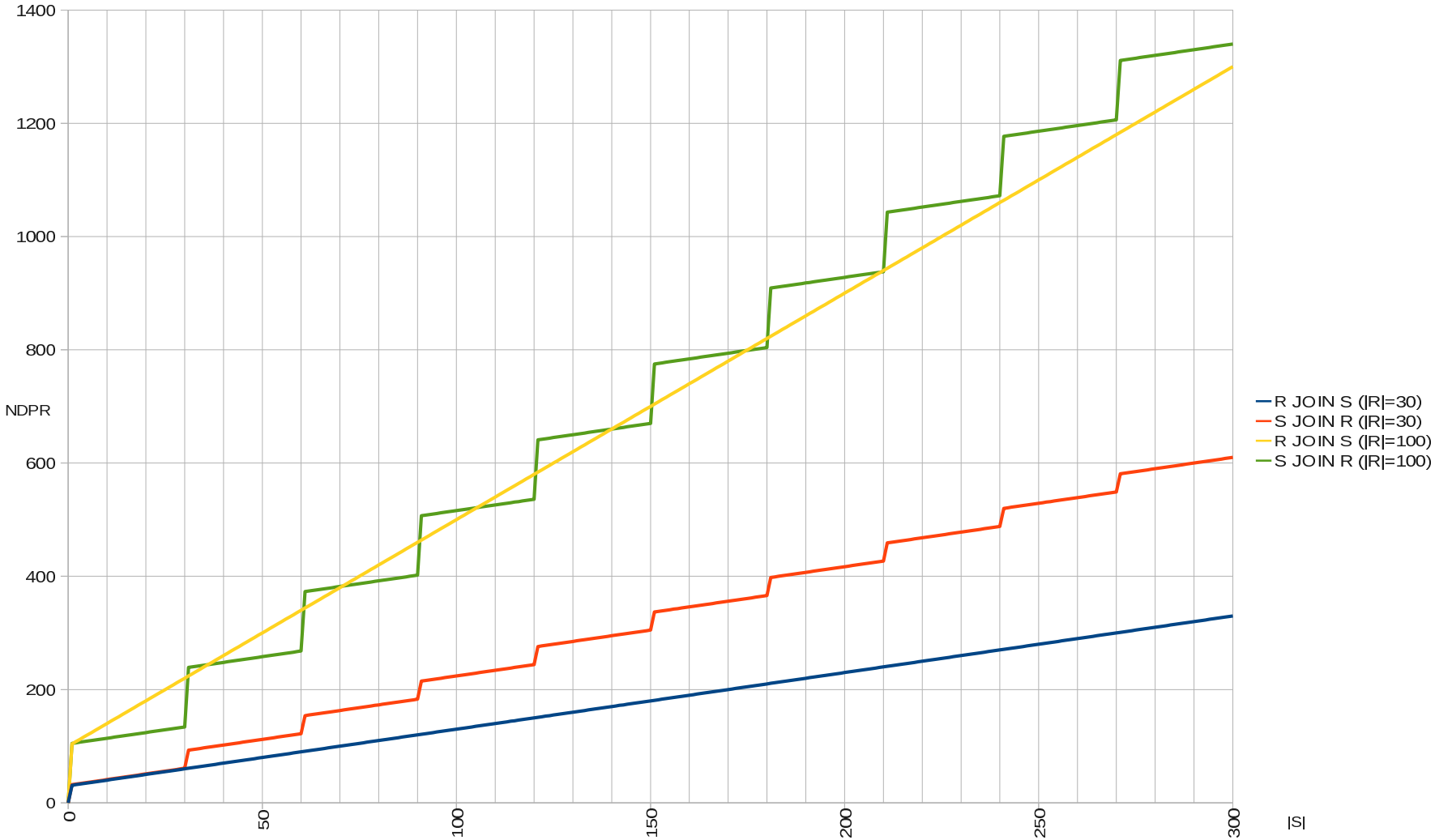
C

Neither, the two are equal

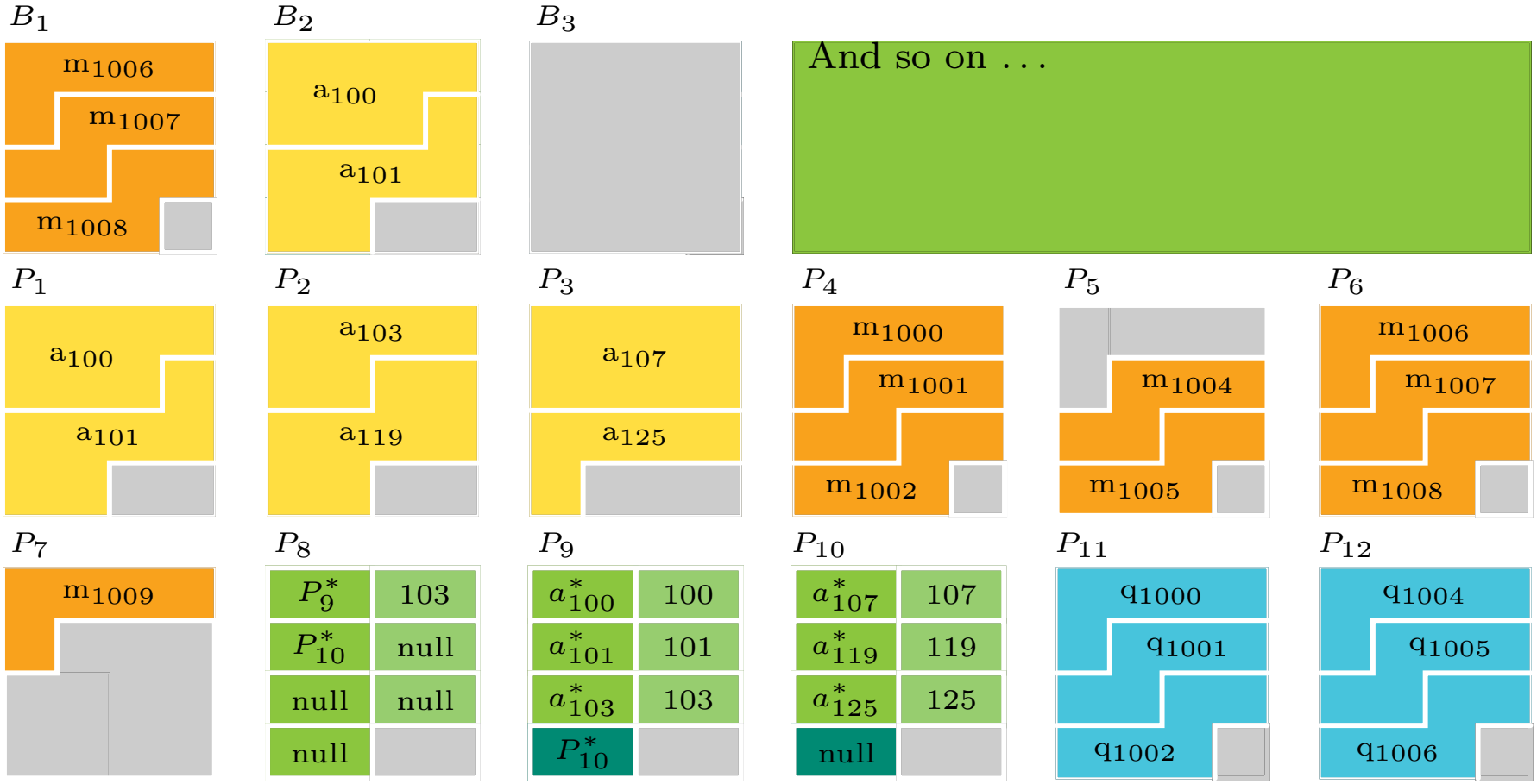
D

Sometimes $R \overset{BNL}{\bowtie} S$, sometimes $S \overset{BNL}{\bowtie} R$

Performance of BNLJ, with $|B| = 32$



Index Nested Loop Join: Minimum Buffer Space



Quiz 3: Choosing a Query Plan

branch		
sortcode	bname	cash
56	'Wimbledon'	94340.45
34	'Goodge St'	8900.67
67	'Strand'	34005.00

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

If we execute the following query on the above schema

```
SELECT bname, cname
FROM   branch NATURAL JOIN account
```

Which Query Plan is not available?

A

$\text{account} \overset{\text{BNL}}{\bowtie} \text{branch}$

B

$\text{branch} \overset{\text{BNL}}{\bowtie} \text{account}$

C

$\text{account} \overset{\text{INL}}{\bowtie} \text{branch}$

D

$\text{branch} \overset{\text{INL}}{\bowtie} \text{account}$

Index Nested Loop Join: Analysis

$R \overset{INLJ}{\bowtie} S$, and I_S is a B$^+$-tree index over the join attribute of S

- If $|B| = 3$

$$NDPR = |Pages(R)| + |R|.Depth(I_S) + |R \bowtie S|$$

- If $|B| = |Pages(I_S)| + 3$

$$NDPR = |Pages(R)| + |Pages(I_S)| + |R \bowtie S|$$

Worksheet: Nested Loop Joins and Index Loop Joins

account				
no	type	cname	rate	sortcode

movement			
mid	no	amount	tdate

movement.no $\rightarrow$ account.no

column_size	
column	bytes
no	4
type	10
cname	20
rate	4
sortcode	6
mid	4
amount	8
tdate	8

Logical Query Optimisation

Push project inside joins

$\pi_{R.A,S.B,\ldots}(R \overset{\theta}{\bowtie} S) \equiv ((\pi_{A,\ldots} R) \overset{\theta}{\bowtie} (\pi_{B,\ldots} S))$
if $R.A, S.B, \ldots$ includes attributes used in θ
Reduces memory required to hold R, S pairs

Push select inside joins

$\sigma_P(R \overset{\theta}{\bowtie} S) \equiv ((\sigma_P R) \overset{\theta}{\bowtie} S))$
if P only contains attributes from R and not S
Reduces number of R, S pairs to be considered in join

Quiz 4: Choosing an Efficient Query Plan

branch		
sortcode	bname	cash
56	'Wimbledon'	94340.45
34	'Goodge St'	8900.67
67	'Strand'	34005.00

account				
no	type	cname	rate	sortcode
100	'current'	'McBrien, P.'	NULL	67
101	'deposit'	'McBrien, P.'	5.25	67
103	'current'	'Boyd, M.'	NULL	34
107	'current'	'Poulovassilis, A.'	NULL	56
119	'deposit'	'Poulovassilis, A.'	5.50	56
125	'current'	'Bailey, J.'	NULL	56

Assume that there are 100 rows in branch, and 10000 rows in account, and we execute the following query on the above schema

```
SELECT bname, cname
FROM   branch NATURAL JOIN account
WHERE  account=100
```

Which Query Plan has the lowest NDPR?

A

$\text{account} \overset{\text{BNL}}{\bowtie} \text{branch}$

B

$\text{branch} \overset{\text{BNL}}{\bowtie} \text{account}$

C

$\text{account} \overset{\text{INL}}{\bowtie} \text{branch}$

D

$\text{branch} \overset{\text{INL}}{\bowtie} \text{account}$

Index Sort-Merge Join: Analysis

$R \overset{ISMJ}{\bowtie} S$, I_R and I_S are B$^+$-tree indexes over the join attributes of R and S

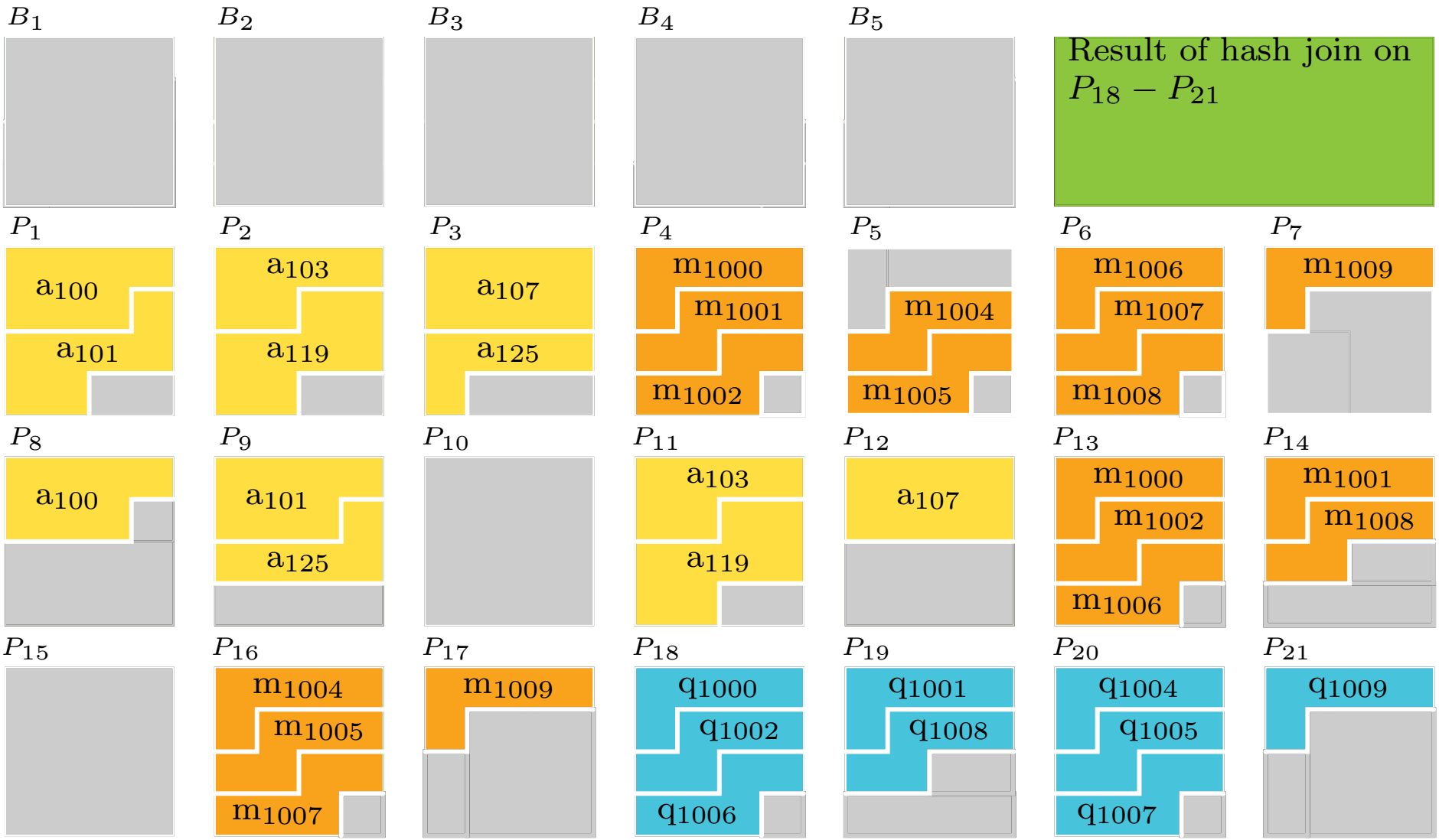
- If $|B| = 3$

$$NDPR = (Depth(I_R) + 1).|R| + (Depth(I_S) + 1).|S|$$

- If $|B| = 5$

$$NDPR = |Pages(I_R)| + |R \ltimes S| + |Pages(I_S)| + |S \ltimes R|$$

Hash Join


B_1
B_2
B_3
B_4
B_5
Result of hash join on $P_{18} - P_{21}$
P_1
a_{100}
a_{101}
P_2
a_{103}
a_{119}
P_3
a_{107}
a_{125}
P_4
m_{1000}
m_{1001}
m_{1002}
P_5
m_{1004}
m_{1005}
P_6
m_{1006}
m_{1007}
m_{1008}
P_7
m_{1009}
P_8
a_{100}
P_9
a_{101}
a_{125}
P_{10}
P_{11}
a_{103}
a_{119}
P_{12}
a_{107}
P_{13}
m_{1000}
m_{1002}
m_{1006}
P_{14}
m_{1001}
m_{1008}
P_{15}
P_{16}
m_{1004}
m_{1005}
m_{1007}
P_{17}
m_{1009}
P_{18}
q_{1000}
q_{1002}
q_{1006}
P_{19}
q_{1001}
q_{1008}
P_{20}
q_{1004}
q_{1005}
q_{1007}
P_{21}
q_{1009}

Hash Join: Analysis

$R \overset{HJ}{\bowtie} S$

- Cost of reading in pages to generate hash buckets

$$|Pages(R)| + |Pages(S)|$$

- Cost of writing out hash buckets

$$|Pages(R)| + |Pages(S)|$$

- Cost of reading in hash buckets

$$|Pages(R)| + |Pages(S)|$$

- Total cost

$$3(|Pages(R)| + |Pages(S)|)$$