DATABASE INDEXES HASH & COMPOSITE

باللغة العربية

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Hash Index

Buckets

Search key → **Hash Function f(x)** → [0... B-1]
(Bucket index)

(key, row id)

Buckets

0	
1	
2	(key, row id)
3	
.	.
.	.
.	.
B-1	
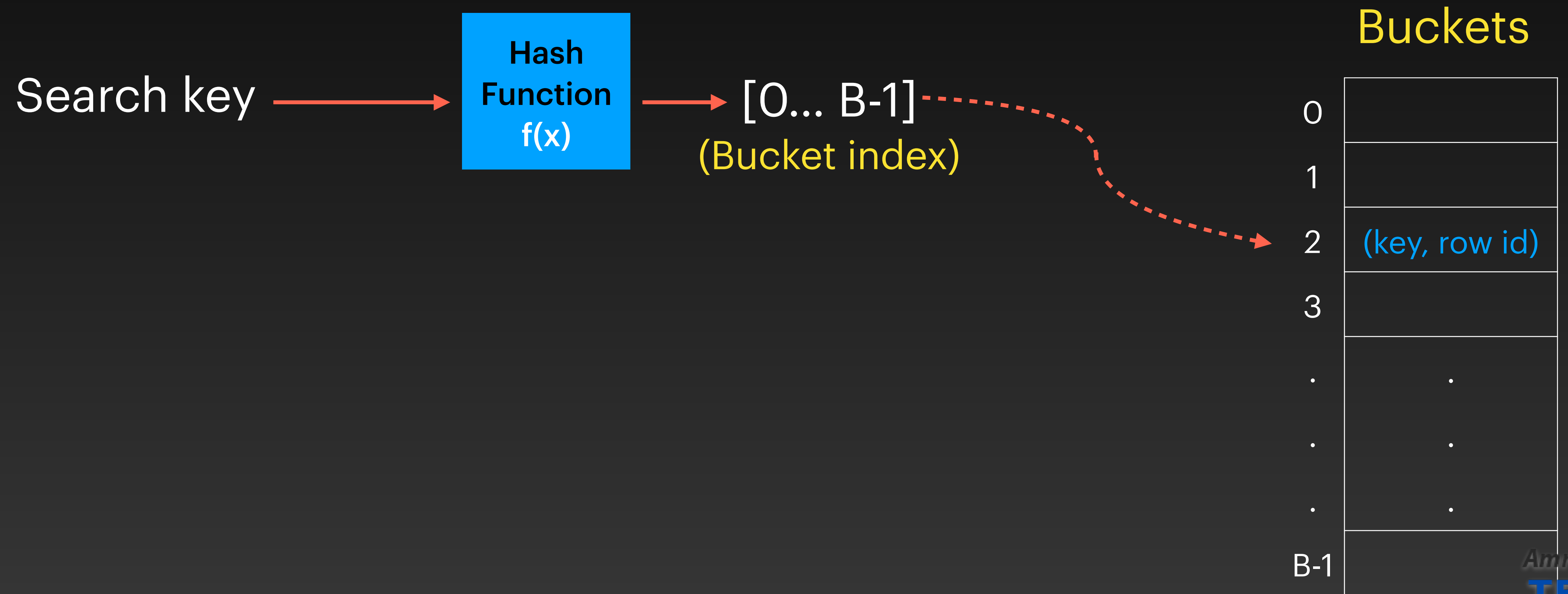
Hash Index (Build)

First Name

Alice

Bob

John

Hash
Function
f(x)

4

Buckets

0	
1	
2	('Bob', *<row id₂>*)
3	
4	('Alice', *<row id₁>*)
5	
6	
7	('John', *<row id₃>*)

Hash Index (search)

Search for: First Name = 'Sarah'

Sarah → Hash Function f(x) → 5

Buckets

0	Tom
1	Jill
2	Bob
3	Martha
4	Alice
5	Sarah
6	Mike
7	John
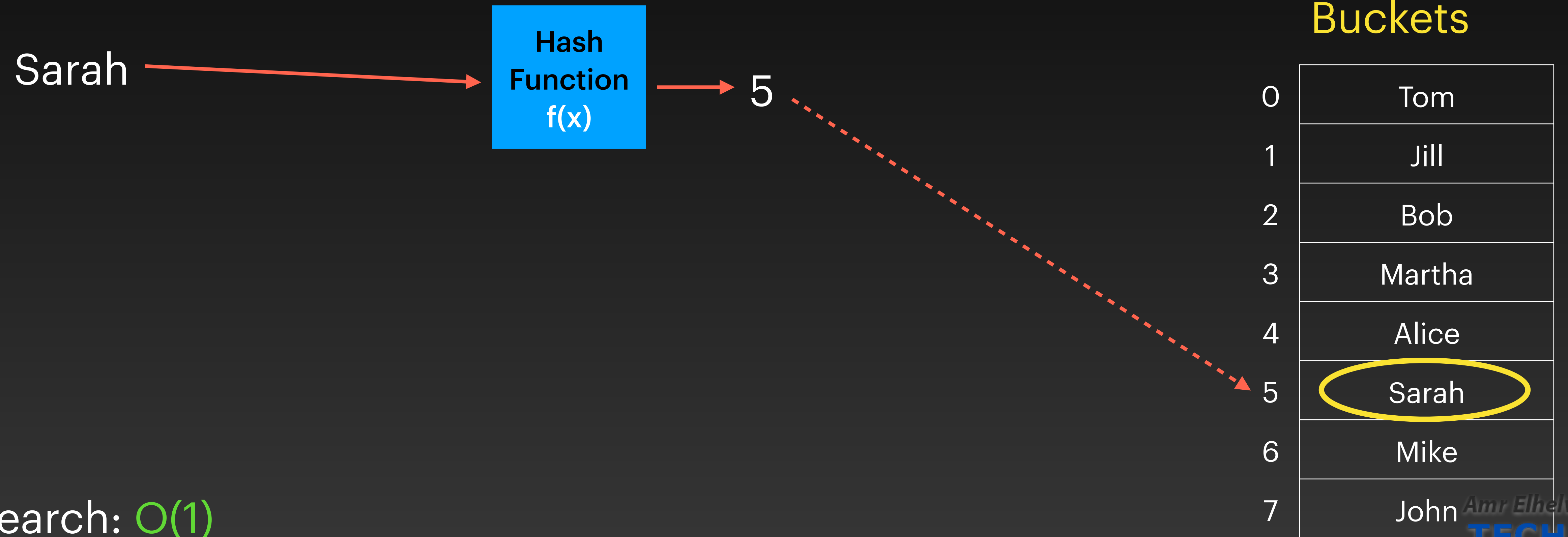
Search: O(1)

Hash Index (search)

Search for: First Name between 'Bob' and 'Mike'??

Buckets

0	Tom
1	Jill
2	Bob
3	Martha
4	Alice
5	Sarah
6	Mike
7	John

Bob → Hash Function f(x) → 2
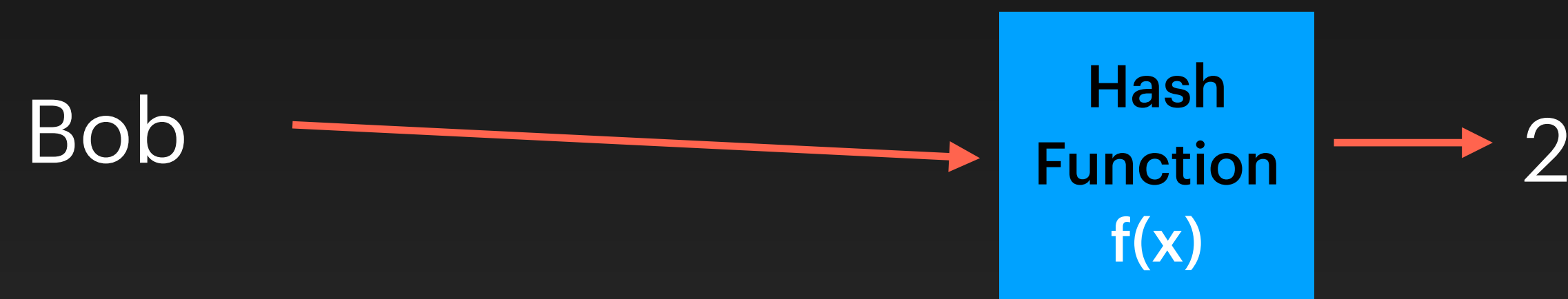
No relative order

No range queries!!

Hash Index

Search for: Name = 'Sarah' AND age = 30

Index on name

Sarah → [Hash Function f(x)] → 5

0	Tom
1	Jill
2	Bob
3	Martha
4	Alice
5	Sarah
6	Mike
7	John

age = 30?

❌

✔️

❌

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Composite Hash Index

Search keys
e.g. 'John', 10

Hash
Function
f(name, age)

[0... B-1]
(Bucket index)

Buckets

0

1

2 (keys, row id)

3

.   .

.   .

.   .

B-1
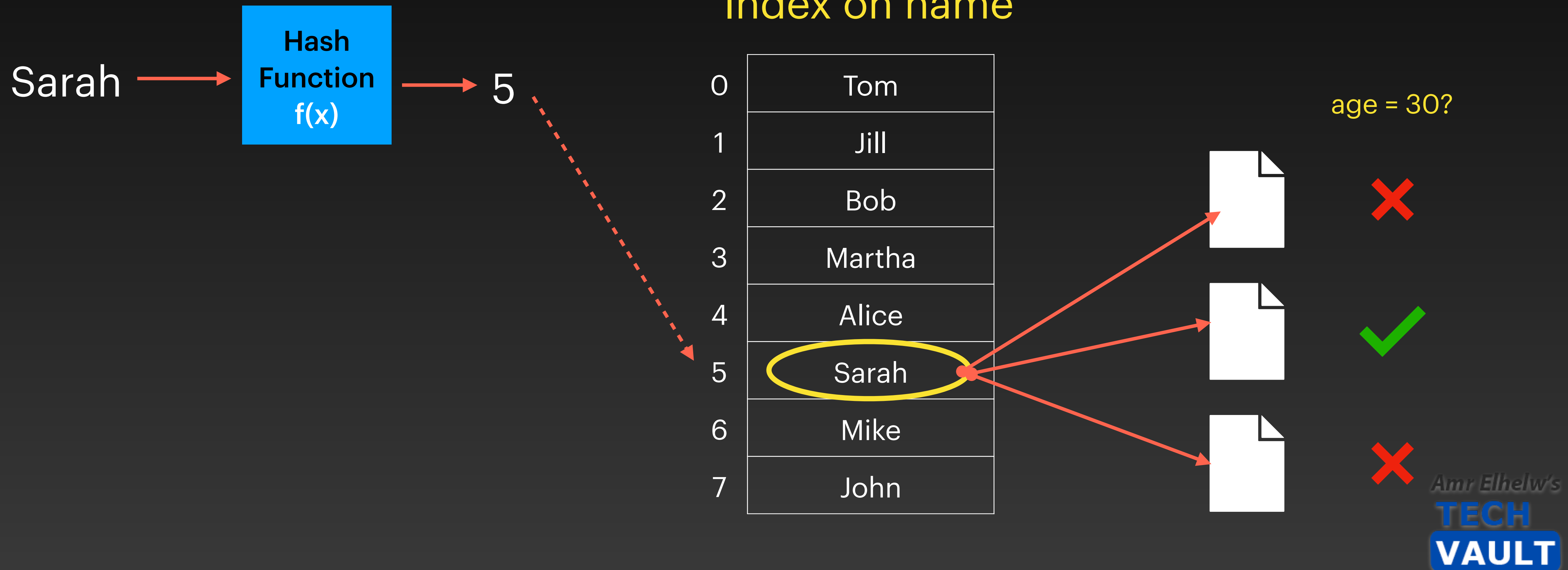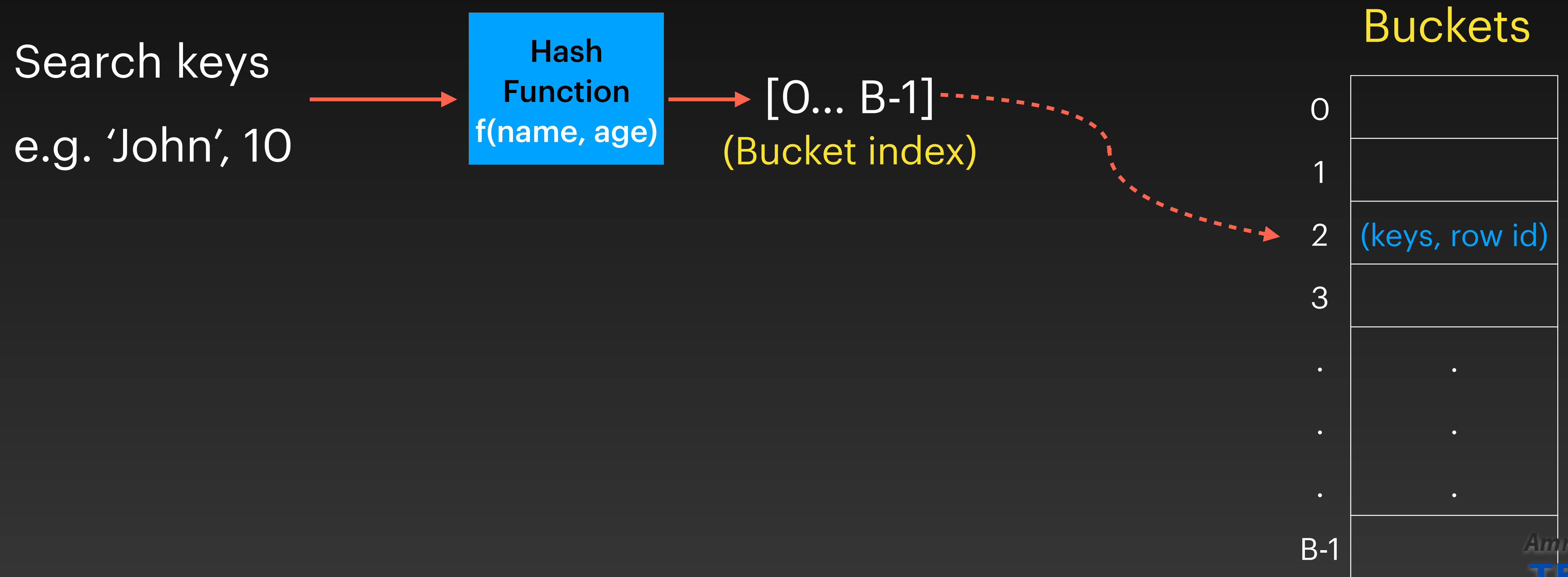
Composite B+ Tree Index

Index on attributes: x, y   ≠   Index on attributes: y, x

x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'
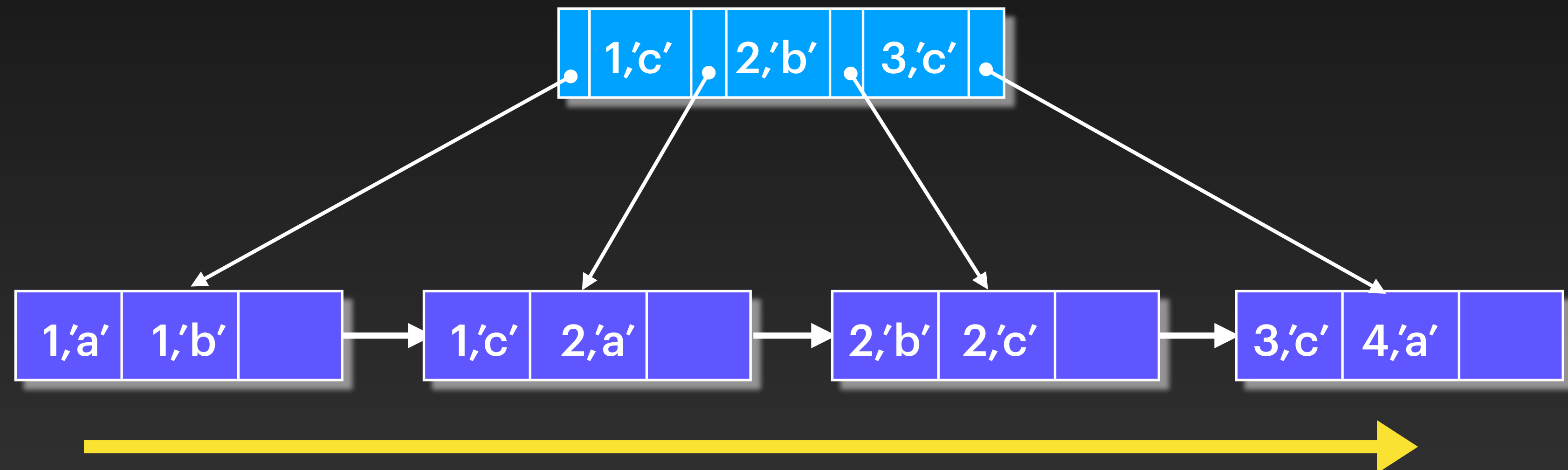
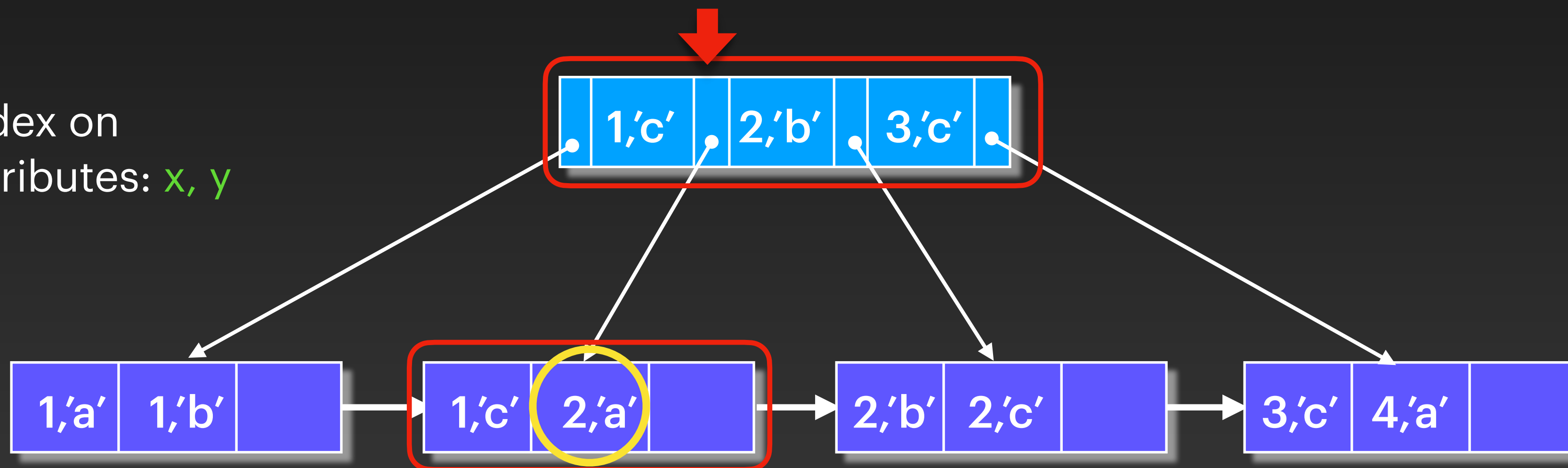# Query

Search for: x = 2 AND y = 'a'

Look for: (2, 'a') —> Point query

Between (1, 'c') and (2, 'b')

Index on attributes: x, y

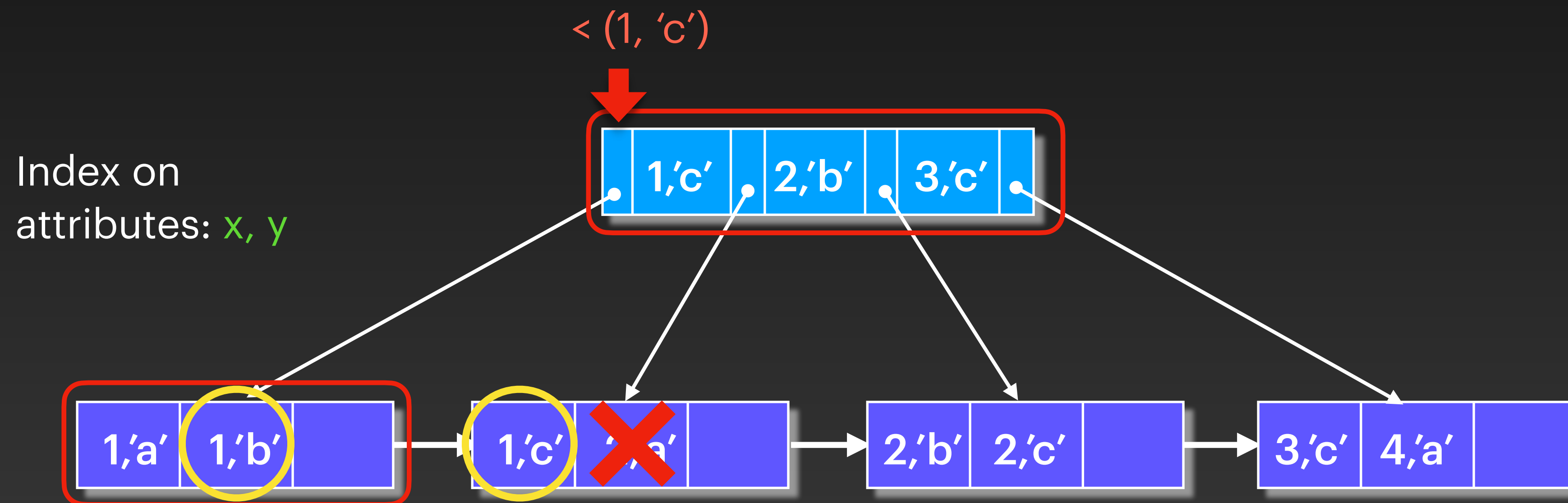| 1,'c' | 2,'b' | 3,'c' |

| 1,'a' | 1,'b' | | 1,'c' | 2,'a' | | 2,'b' | 2,'c' | | 3,'c' | 4,'a' |

x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

Query

Search for: x = 1 AND y >= 'b'

Look for (1, 'b')   Then follow leaf level while x = 1

< (1, 'c')

Index on
attributes: x, y

| 1,'c' | 2,'b' | 3,'c' |

| 1,'a' | 1,'b' | | 1,'c' | a' | | 2,'b' | 2,'c' | | 3,'c' | 4,'a' | |

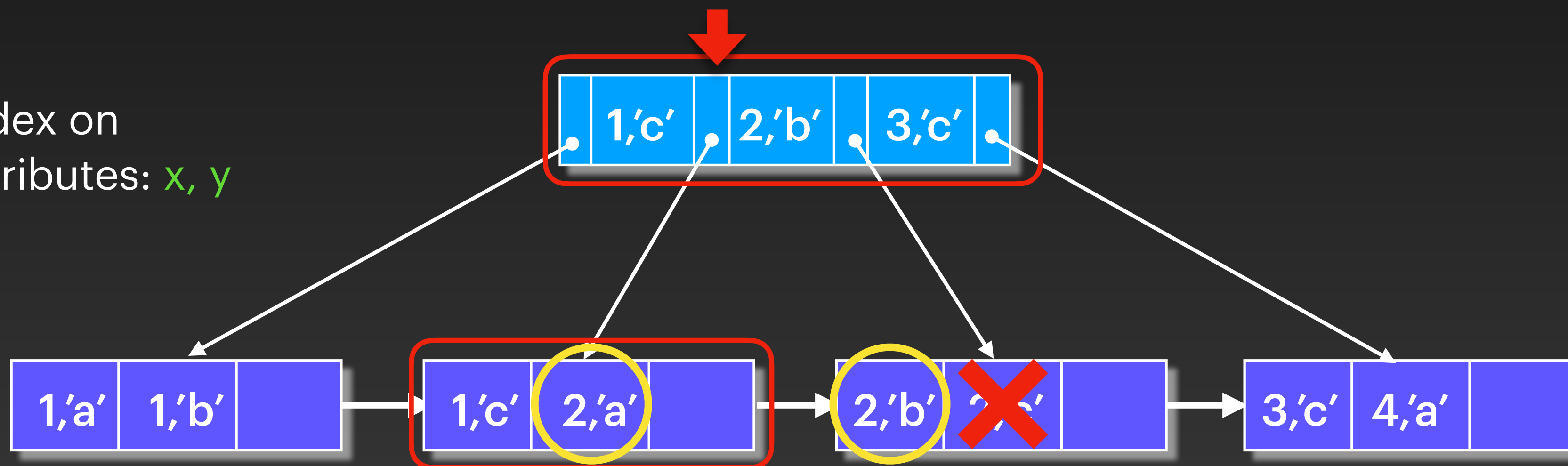| x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

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Query

Search for: x = 2 AND y < 'c'

Look for first key that has x = 2   Then follow leaf level while x=2 and y < 'c'

Index on attributes: x, y

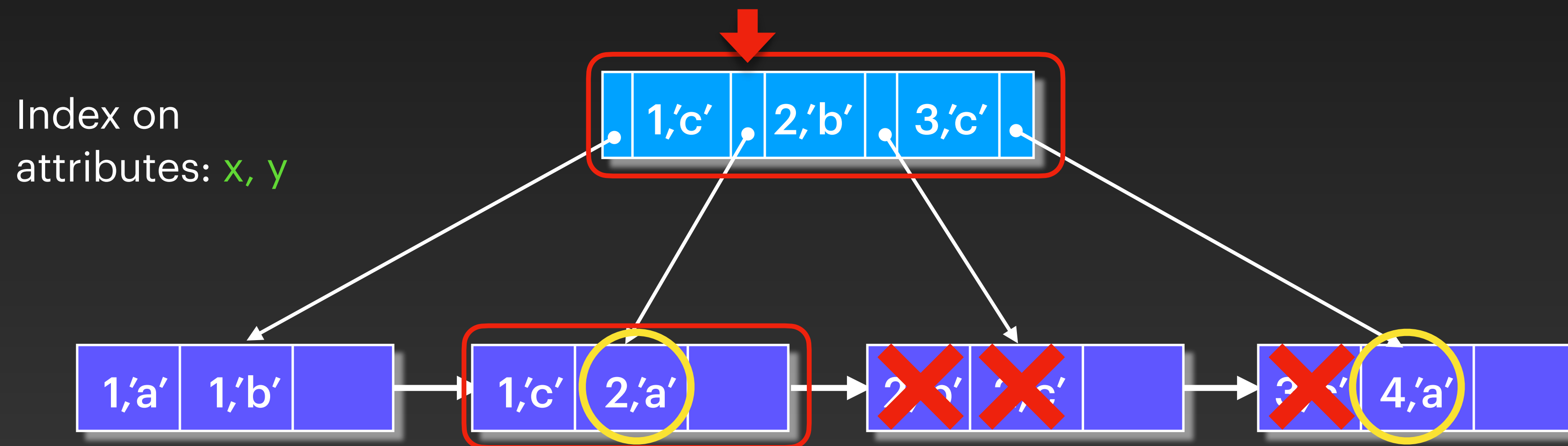| x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

Query

Search for: x > 1 AND y = 'a'

Find the first key that has x > 1 Then follow all remaining leaf nodes and check y='a'

Index on attributes: x, y
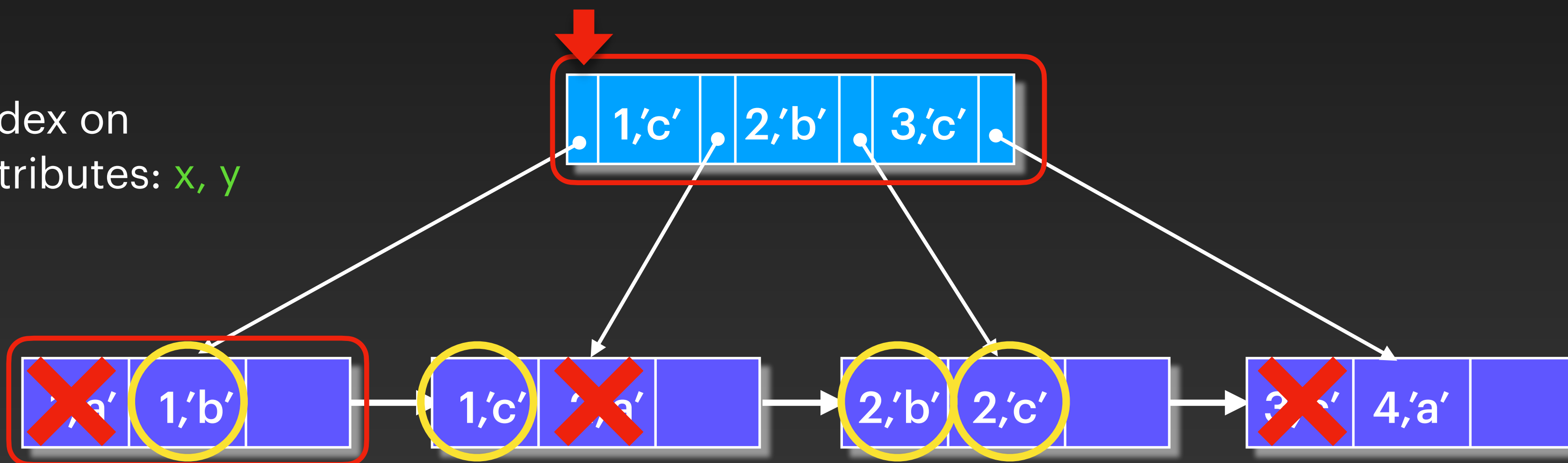
x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

Query

Search for: x < 3 AND y > 'a'

Find the first key Then follow leaf nodes while x<3 and check y>'a'

Index on
attributes: x, y

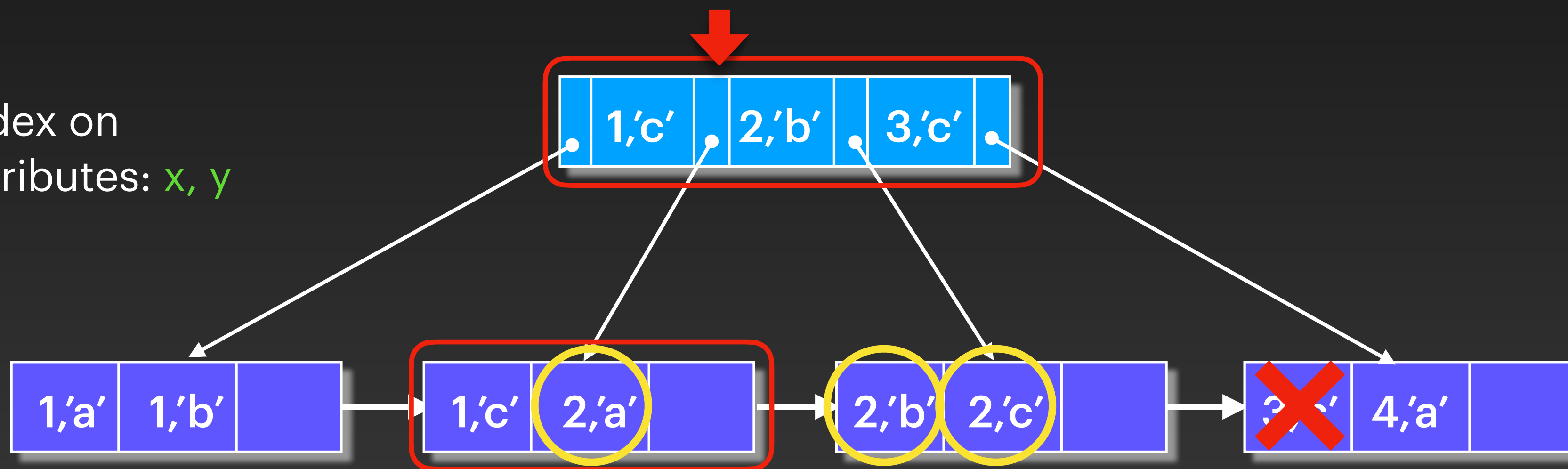| x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

Query

Search for: x = 2

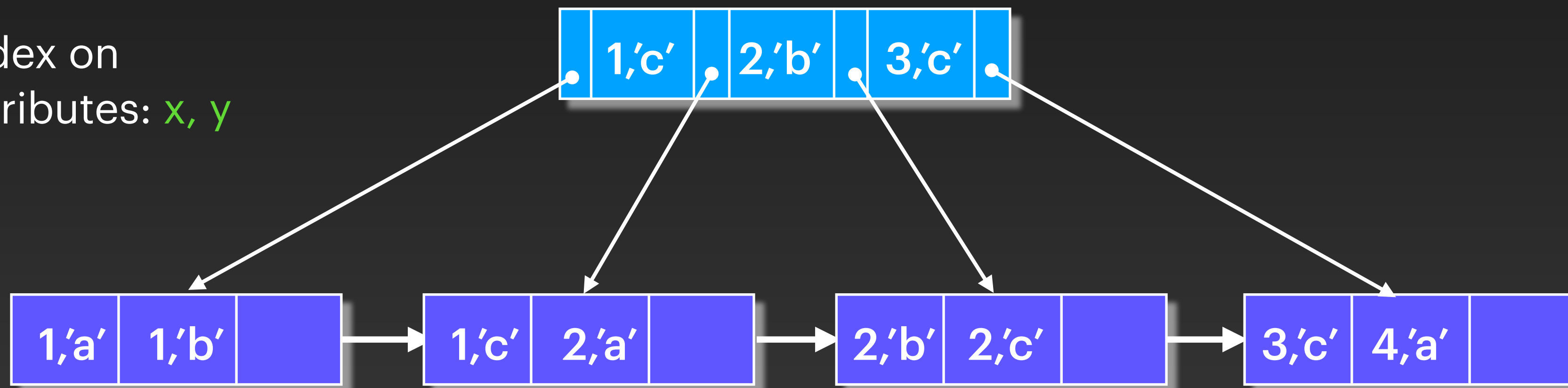Find first key with x=2 Then follow leaf level while x = 2

Index on
attributes: x, y

| 1,'c' | 2,'b' | 3,'c' |

| 1,'a' | 1,'b' | | 1,'c' | 2,'a' | | 2,'b' | 2,'c' | | ✗ | 4,'a' |

x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

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Query

Search for: y = 'a'

We have to scan <u>ALL</u> the leaf nodes!

Index on
attributes: x, y

x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

Internal node: 1,'c' | 2,'b' | 3,'c'

Leaf nodes: 1,'a' | 1,'b' → 1,'c' | 2,'a' → 2,'b' | 2,'c' → 3,'c' | 4,'a'

Composite Indexes

- Index on attributes ($a_1, a_2, ..., a_n$)

- Can be used to answer any prefix search

  - Any search involving a <u>conjunction</u> of $a_1, a_2, ..., a_k$; k <= n

Composite Indexes

Indexes

Searches	(x)	(y)	(x, y)	(y, x)	(z, y, x)
x > 1	✅		✅		
y = 3		✅		✅	
x = 7 AND y < 4	✅	✅	✅	✅	
x = 7 OR y < 4					❌
x = 7 AND y < 4 AND z = 1	✅	✅	✅	✅	✅

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