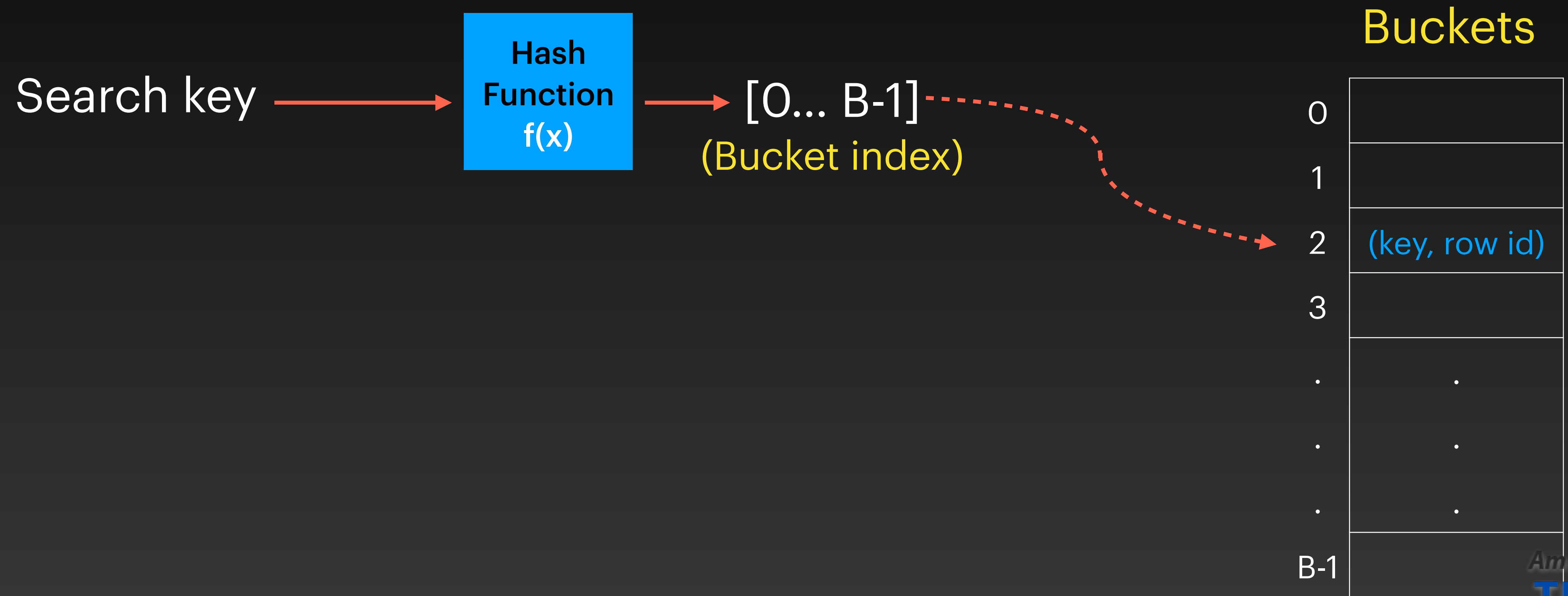


DATABASE INDEXES HASH & COMPOSITE



Hash Index



Hash Index (Build)

First Name

Alice

Bob

John

Hash
Function
 $f(x)$

4

Buckets

0

1

2

3

4

5

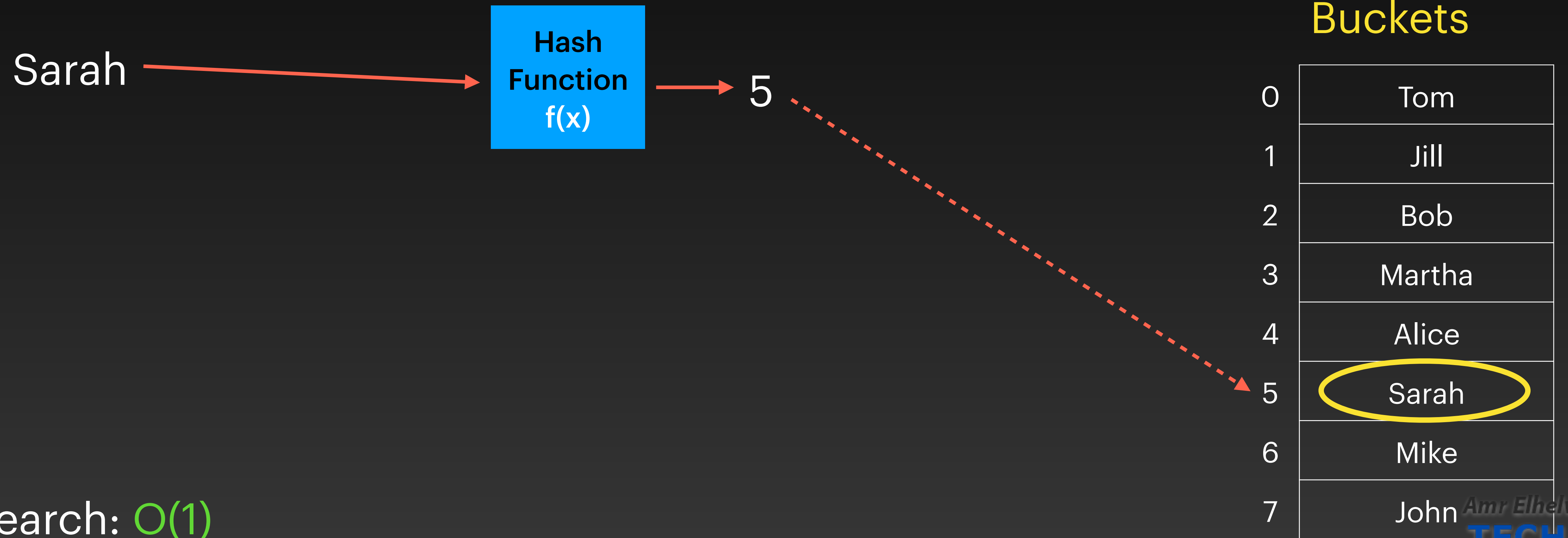
6

7

	(<i>'Bob'</i>, <row id₂>)
	(<i>'Alice'</i>, <row id₁>)
	(<i>'John'</i>, <row id₃>)

Hash Index (search)

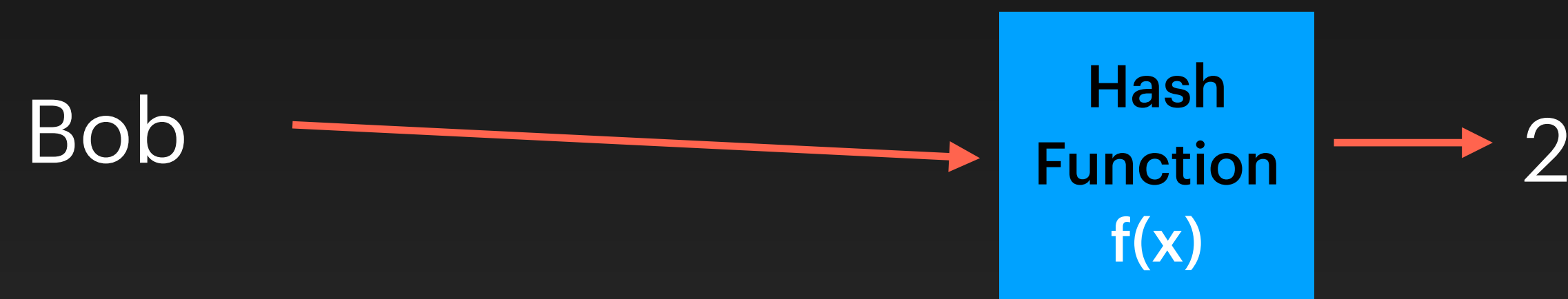
Search for: First Name = 'Sarah'



Search: $O(1)$

Hash Index (search)

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



No relative order

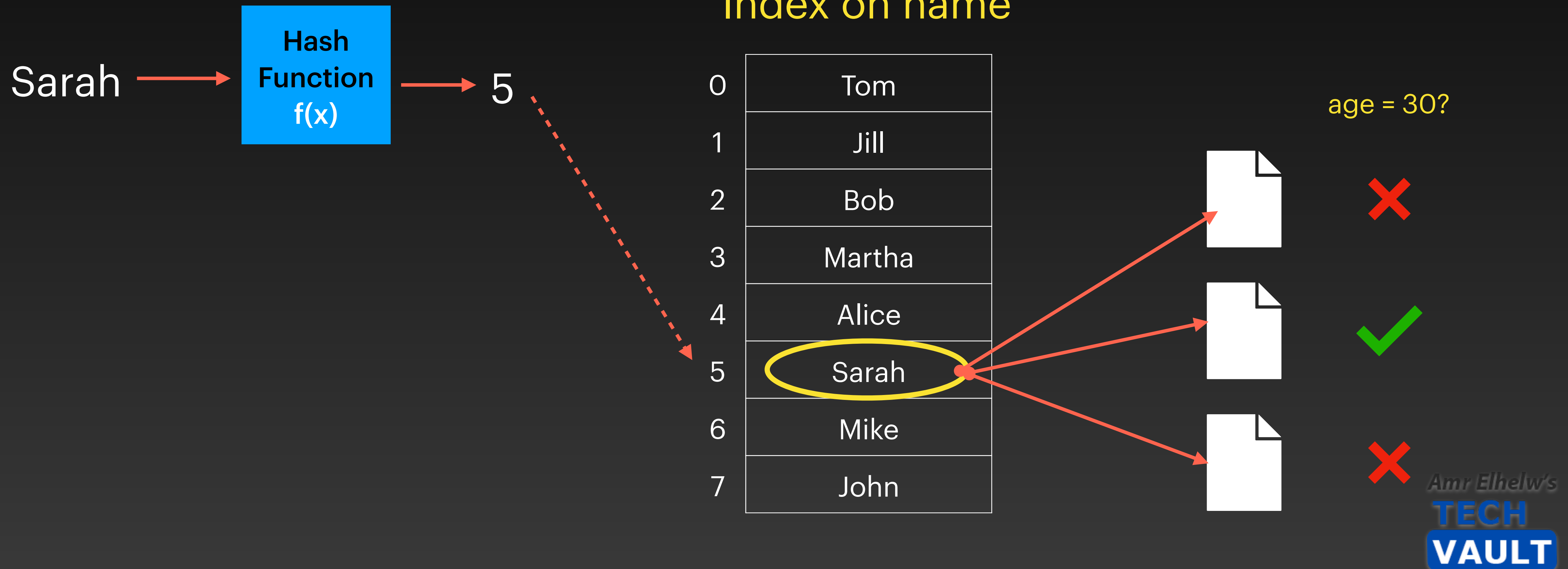
No range queries!!

Buckets

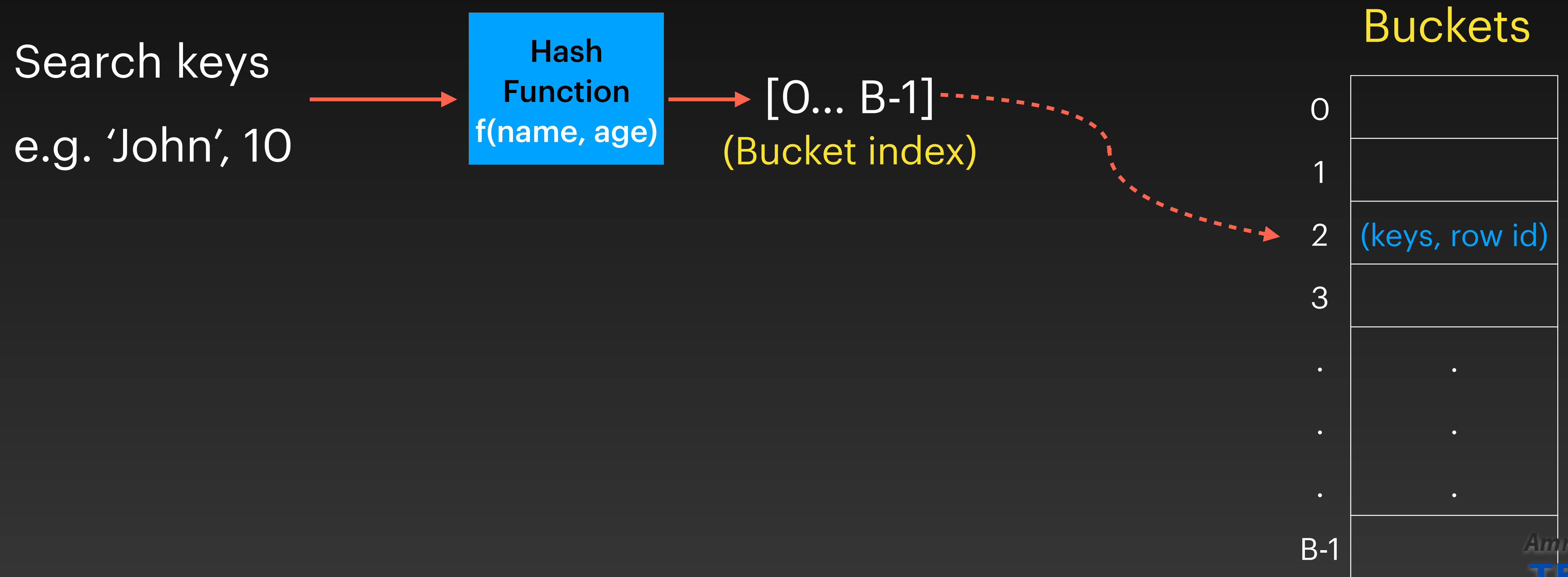
0	Tom
1	Jill
2	Bob
3	Martha
4	Alice
5	Sarah
6	Mike
7	John

Hash Index

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



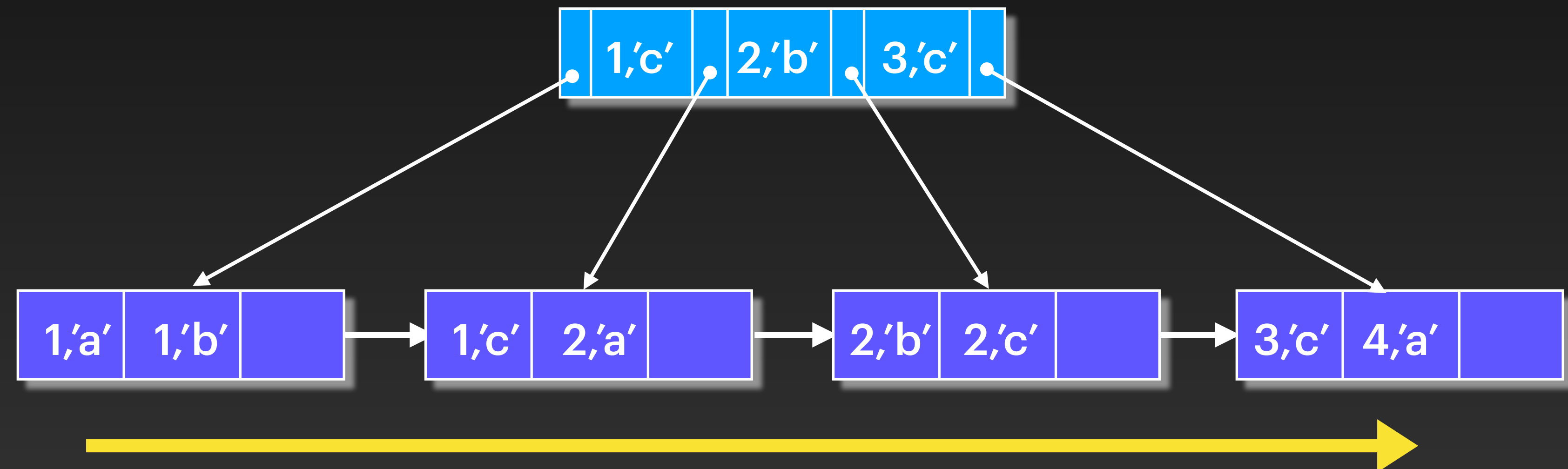
Composite Hash Index



Composite B+ Tree Index

Index on attributes: $x, y \neq$ Index on attributes: y, x

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



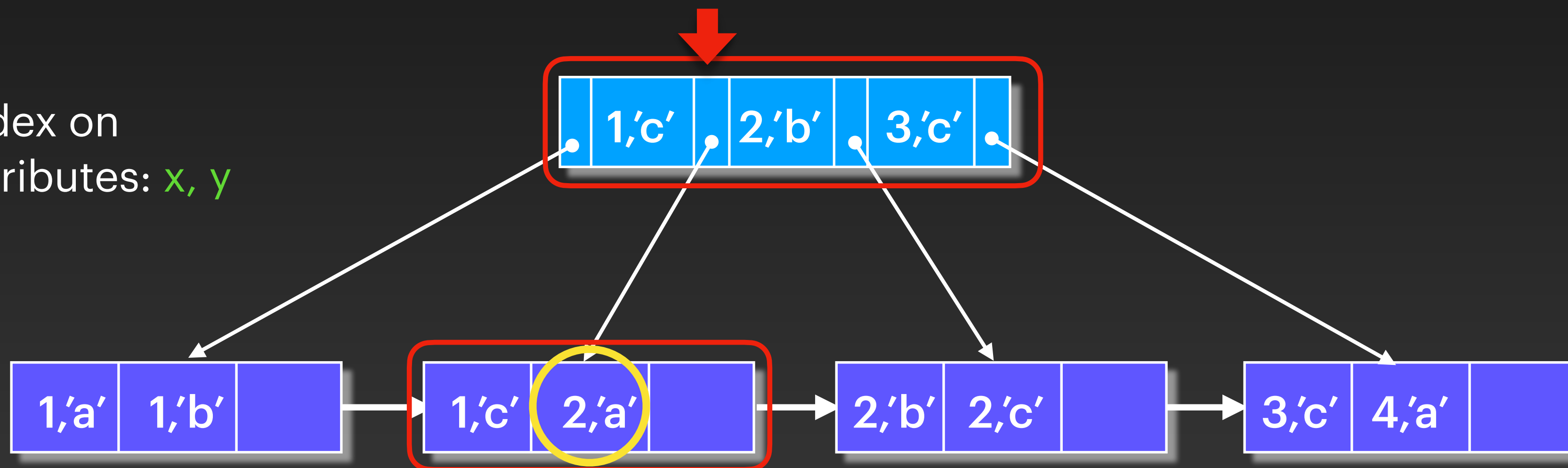
Query

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

Look for: $(2, 'a')$ \rightarrow Point query

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

Index on
attributes: x, y

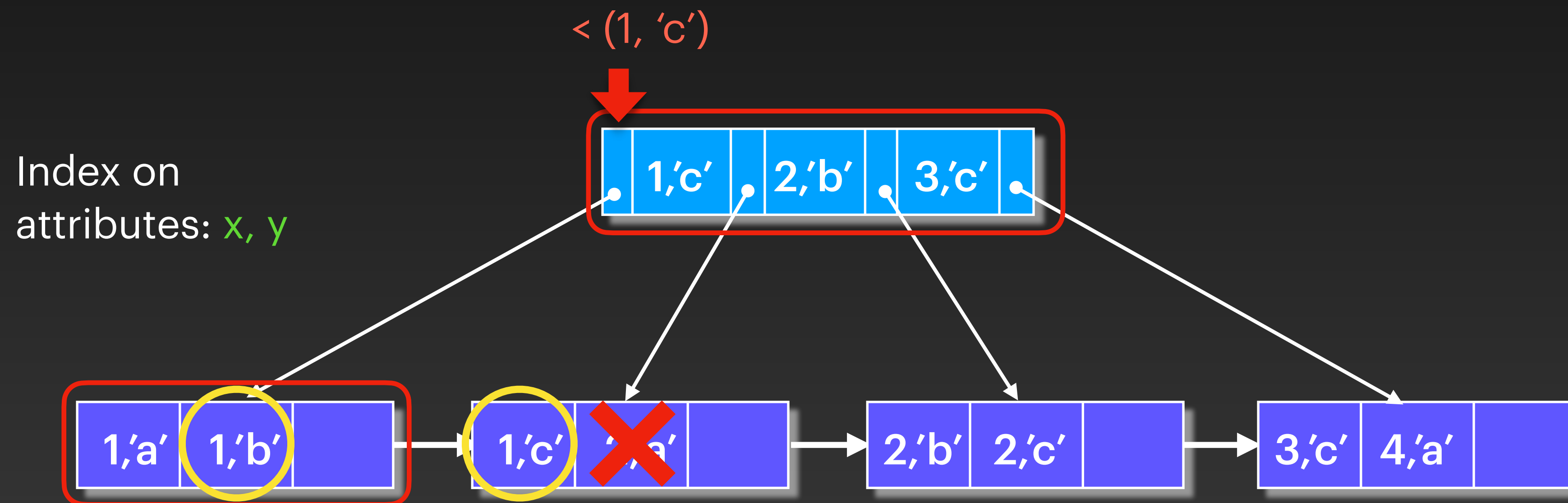


x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

Query

Search for: $x = 1$ AND $y \geq 'b'$

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



x	y
1	'a'
1	'b'
1	'c'

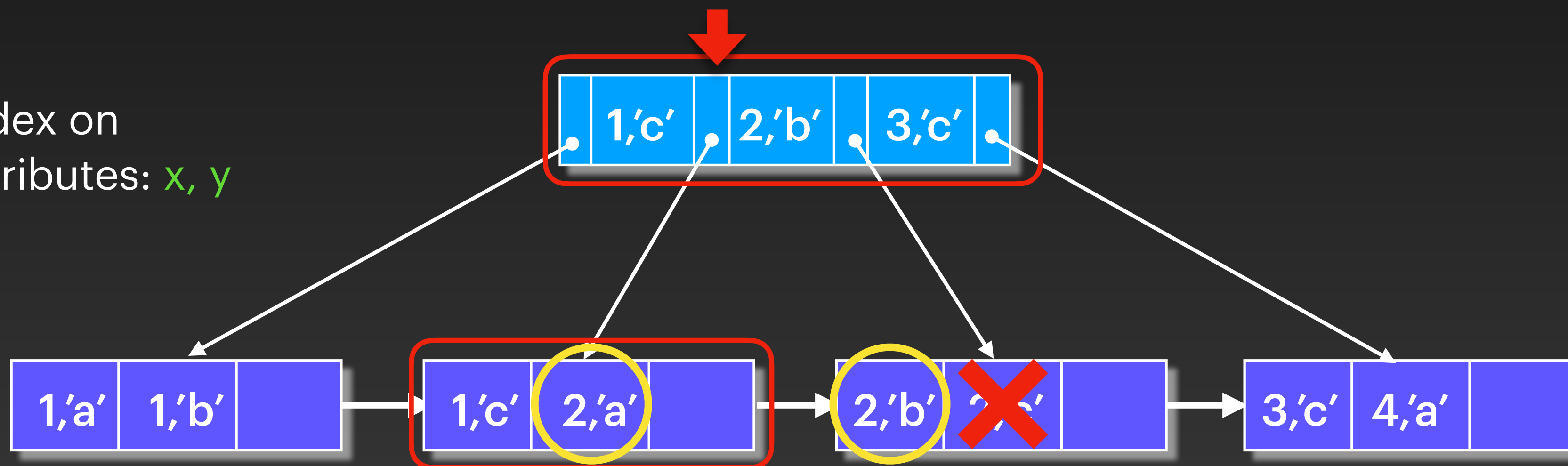
2 'a'
2 'b'
2 'c'
3 'c'
4 'a'

Query

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

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'

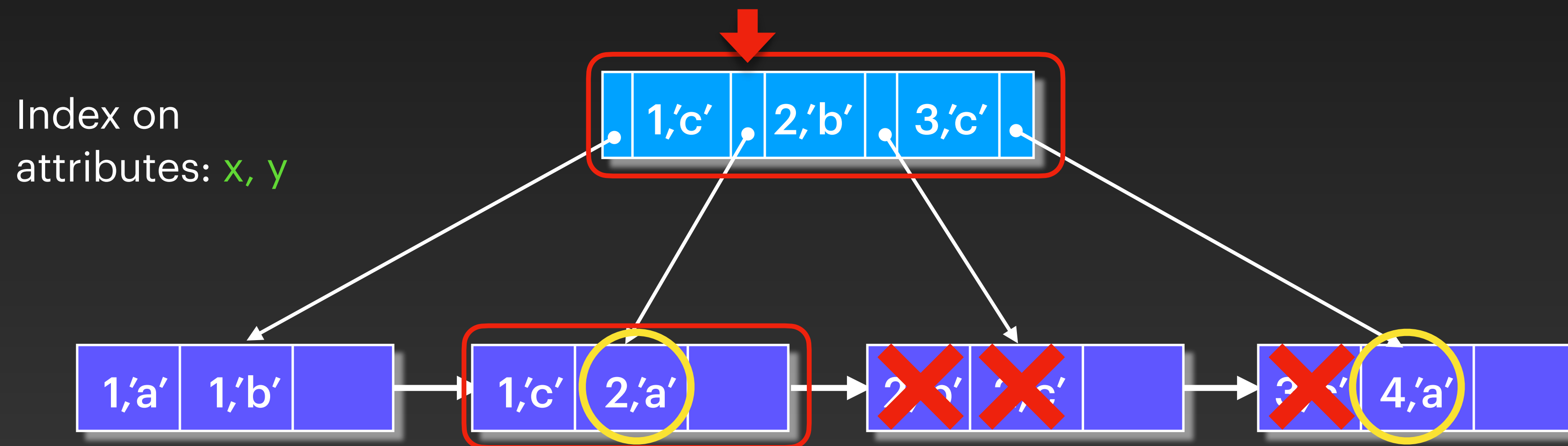
Amr Elhelw's

TECH
VAULT

Query

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

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



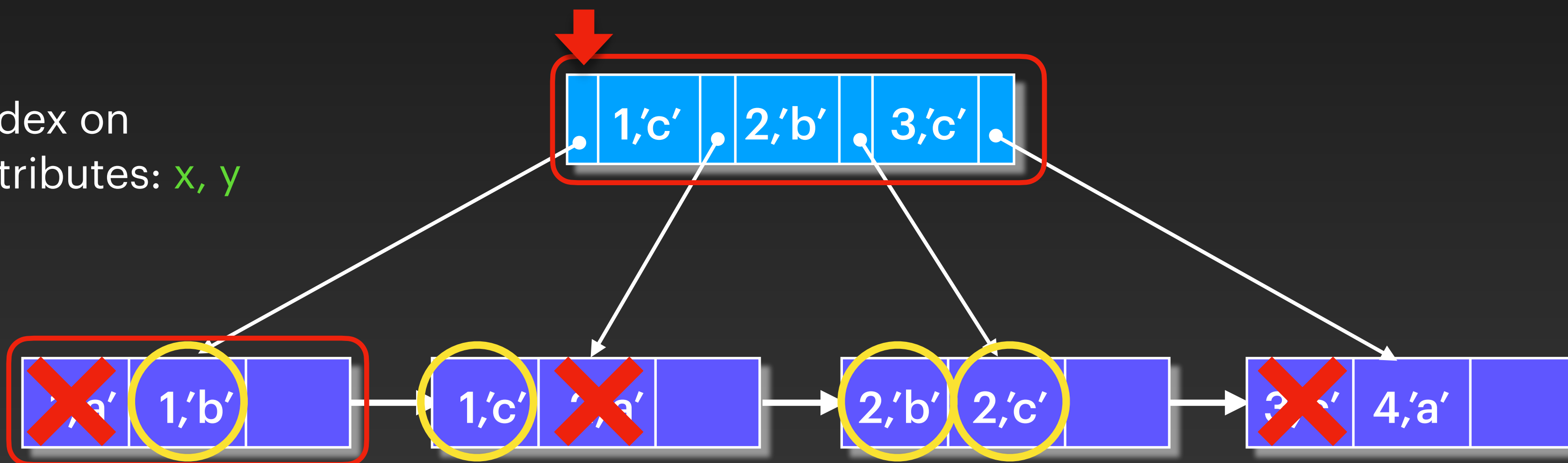
x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

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'

4 'a'

4 'a'

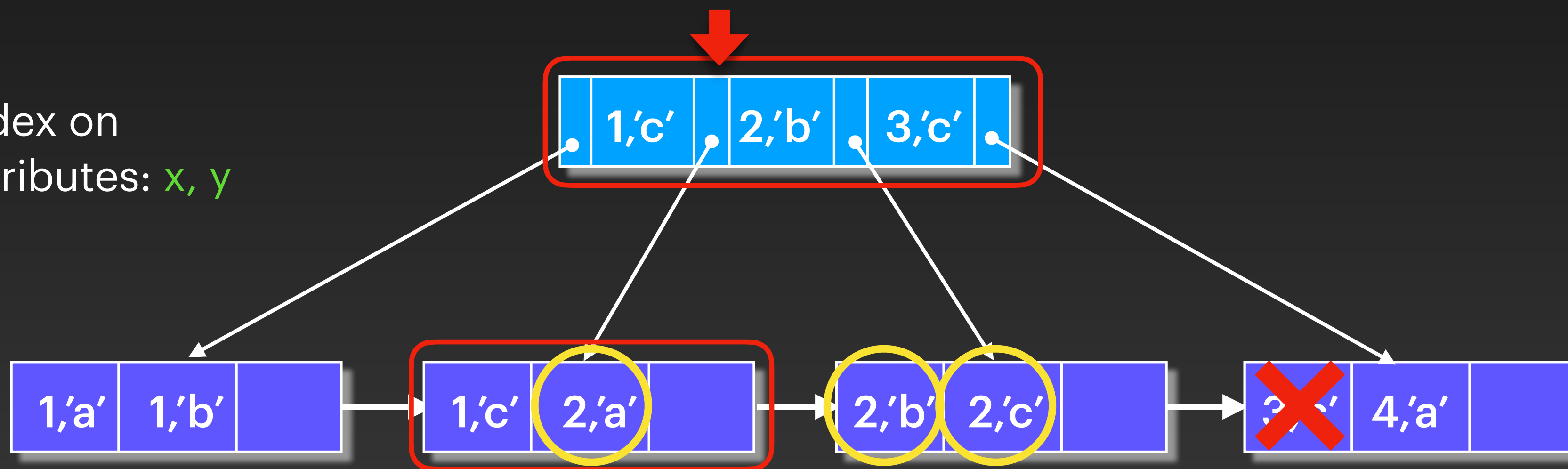
4 'a'

Query

Search for: $x = 2$

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

Index on
attributes: x, y



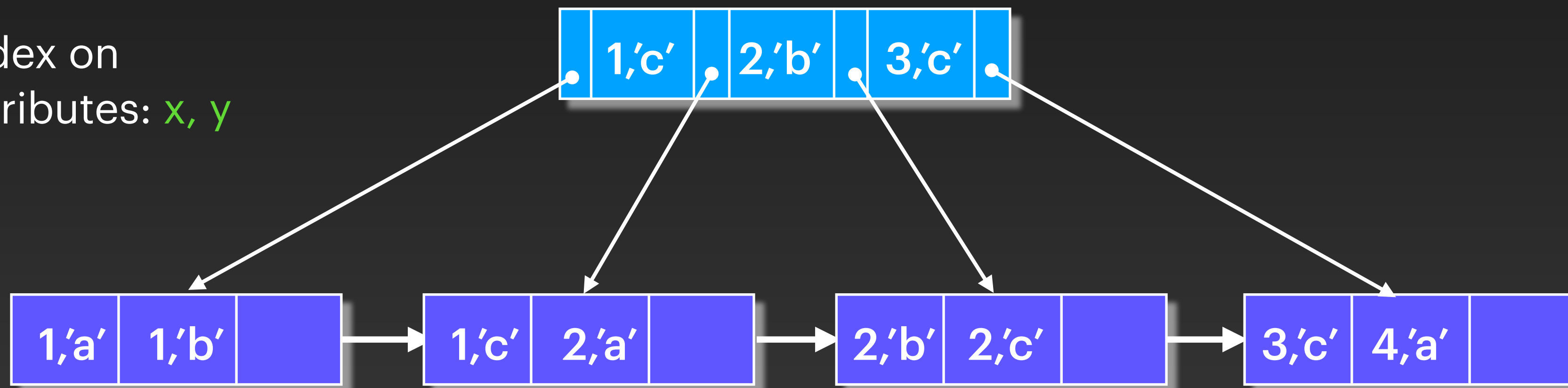
x	y
1	'a'
1	'b'
1	'c'
2	'a'
2	'b'
2	'c'
3	'c'
4	'a'

Query

Search for: $y = 'a'$

We have to scan ALL 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'

Composite Indexes

- Index on attributes (a_1, a_2, \dots, a_n)
- Can be used to answer any **prefix search**
 - Any search involving a conjunction of a_1, a_2, \dots, a_k ; $k \leq n$

Composite Indexes

Searches	Indexes					
	(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	✓	✓	✓	✓	