

# B+ Trees & Operator Costs CSE 444 - Section 3



## B+ Trees

## N-ary tree with variable children per node d = degree of the tree Each node has d <= m <= 2d keys (except root)</p> Each node has m+1 pointers



![](_page_1_Picture_3.jpeg)

![](_page_1_Picture_4.jpeg)

## B+ Node Setup

![](_page_2_Figure_1.jpeg)

![](_page_2_Figure_2.jpeg)

![](_page_2_Figure_3.jpeg)

#### Internal node: Left pointer from key = k points to keys < k • Right pointer from key = k points to keys >= k

## Left pointer from key = k points to block containing the

 Last remaining right pointer points to the next leaf on right

![](_page_2_Picture_7.jpeg)

## Insert 42

![](_page_3_Figure_1.jpeg)

![](_page_3_Figure_2.jpeg)

![](_page_3_Picture_3.jpeg)

![](_page_4_Figure_1.jpeg)

![](_page_4_Figure_2.jpeg)

![](_page_4_Picture_3.jpeg)

## **Operator Cost Notations**

# B(R) = blocks in relation R T(R) = tuples in relation R V(R, a) = distinct values of attribute a in relation R M = memory size in blocks

![](_page_5_Picture_2.jpeg)

![](_page_6_Figure_1.jpeg)

# Nested Loop Join

#### Block Size # Tuples 50 tuples 10020025 tuples

### Using tuple-at-a-time nested loop join

#### Better to use R or S as the outer relation?

R as outer relation: Cost = 802

S as outer relation: Cost = 408

### Using page-at-a-time nested loop join

#### Better to use R or S as the outer relation?

#### R as outer relation: Cost = 18

#### S as outer relation: Cost = 24

![](_page_6_Picture_20.jpeg)

![](_page_6_Picture_23.jpeg)

# Index Loop Join

![](_page_7_Figure_1.jpeg)

## We now have a clustered index on the join attribute of S There are 100 unique values of this attribute in S Idea: iterate over R, probe into S Cost = B(R) + T(R)\*B(S)/V(S, B) = 2 + 100\*8/100 = 10

Block Size	# Tuple
50 tuples	100
25 tuples	200

- Note: may or may not be better than a nested-loop join

![](_page_7_Picture_9.jpeg)

![](_page_7_Picture_10.jpeg)

## Preview of Optimization... Cardinality Estimation

T(R) = ...  $B(R) = \dots$ 

![](_page_8_Figure_2.jpeg)

![](_page_8_Picture_3.jpeg)

![](_page_8_Picture_4.jpeg)