Query Optimization: Exercise

Q & A Session 2

Bernhard Radke

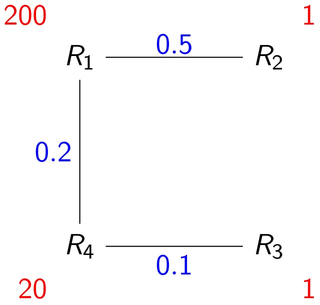
January 14, 2019

- Uniformly-Distributed Random Generation of Join Orders [1]

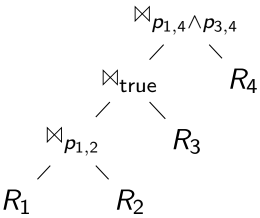
Order-Preserving Joins

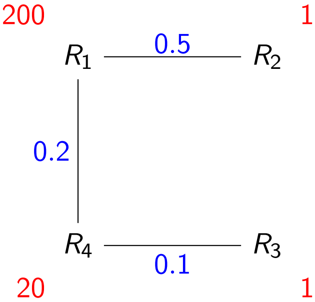
Consider the following *sequence* of relations R_1, R_2, R_3, R_4 with cardinalities $|R_1| = 200$, $|R_2| = 1$, $|R_3| = 1$, $|R_4| = 20$ and join selectivities $f_{1,2} = 0.5$, $f_{1,4} = 0.2$, $f_{3,4} = 0.1$.

Give the fully-parenthesized, optimal join-expression that abides by this order. Use C_{out} as a cost function.



Let's start off with a cost analysis of the left-deep tree:





$$C_{out} = 100 + 100 + 40 = 240$$

OrderPreservingJoins($R = \{R_1, \ldots, R_n\}$,P)

Input: a set of relations to be joined and a set of predicates

Output: fills p, s, c, t

for each $1 \leq i \leq n$ {

$p[i,i]$ =predicates from P applicable to R_i

$P = P \setminus p[i,i]$

$s[i,i]$ =statistics for $\sigma_{p[i,i]}(R_i)$

$c[i,i]$ =costs for $\sigma_{p[i,i]}(R_i)$

}

predicates p

∅			
	∅		
		∅	
			∅

statistics s

200			
	1		
		1	
			20

costs c

0			
	0		
		0	
			0

split points t

for each $2 \leq l \leq 4$ **ascending** (in text: $2 \leq l \leq n$)
  for each $1 \leq i \leq 5 - l$ (in text: $1 \leq i \leq n - l + 1$)
    $j = i + l - 1$
    $p[i, j]$=predicates from P applicable to $R_i, \dots, R_j$
    $P = P \setminus p[i, j]$
    $s[i, j]$=statistics derived from $s[i, j-1]$ and $s[j, j]$ including $p[i, j]$
    $c[i, j]$=∞
    for each $i \leq k < j$
      $q = c[i, k] + c[k+1, j]$+costs for $s[i, k]$ and $s[k+1, j]$ and $p[i, j]$
      if $q < c[i, j]$
        c[i,j]=q
        t[i,j]=k

predicates p

$\emptyset$			
	$\emptyset$		
		$\emptyset$	
			$\emptyset$

statistics s

200			
	1		
		1	
			20

costs c

0			
	0		
		0	
			0

split points t

for each $2 \leq l \leq 4$ **ascending** (in text: $2 \leq l \leq n$)
  for each $1 \leq i \leq 5 - l$ (in text: $1 \leq i \leq n - l + 1$)
    $j = i + l - 1$
    $p[i,j]$=predicates from P applicable to $R_i, \ldots, R_j$
    $P = P \setminus p[i,j]$
    $s[i,j]$=statistics derived from $s[i,j-1]$ and $s[j,j]$ including $p[i,j]$
    $c[i,j]$=∞
    for each $i \leq k < j$
      $q = c[i,k] + c[k+1,j]$+costs for $s[i,k]$ and $s[k+1,j]$ and $p[i,j]$
      if $q < c[i,j]$
        c[i,j]=q
        t[i,j]=k

predicates p

$\emptyset$	$p_{1,2}$		
	$\emptyset$		
		$\emptyset$	
			$\emptyset$

statistics s

200	100		
	1		
		1	
			20

costs c

0	100		
	0		
		0	
			0

split points t

	1		

for each $2 \leq l \leq 4$ **ascending** (in text: $2 \leq l \leq n$)
  for each $1 \leq i \leq 5 - l$ (in text: $1 \leq i \leq n - l + 1$)
    $j = i + l - 1$
    $p[i,j]$=predicates from P applicable to $R_i, \ldots, R_j$
    $P = P \setminus p[i,j]$
    $s[i,j]$=statistics derived from $s[i, j-1]$ and $s[j,j]$ including $p[i,j]$
    $c[i,j]$=∞
    for each $i \leq k < j$
      $q = c[i,k] + c[k+1,j]$+costs for $s[i,k]$ and $s[k+1,j]$ and $p[i,j]$
      if $q < c[i,j]$
        c[i,j]=q
        t[i,j]=k

predicates p

$\emptyset$	$p_{1,2}$		
	$\emptyset$	$\emptyset$	
		$\emptyset$	
			$\emptyset$

statistics s

200	100		
	1	1	
		1	
			20

costs c

0	100		
	0	1	
		0	
			0

split points t

	1		
		2	

```
for each 2 ≤ l ≤ 4 ascending (in text: 2 ≤ l ≤ n )
  for each 1 ≤ i ≤ 5 − l (in text: 1 ≤ i ≤ n − l + 1)
    j = i + l − 1
    p[i, j]=predicates from P applicable to R_i, . . . , R_j
    P = P \ p[i, j]
    s[i, j]=statistics derived from s[i, j − 1] and s[j, j] including p[i, j]
    c[i, j]=∞
    for each i ≤ k < j
      q = c[i, k] + c[k + 1, j]+costs for s[i, k] and s[k + 1, j] and p[i, j]
      if q < c[i, j]
        c[i,j]=q
        t[i,j]=k
```

predicates p

$\emptyset$	$p_{1,2}$		
	$\emptyset$	$\emptyset$	
		$\emptyset$	$p_{3,4}$
			$\emptyset$

statistics s

200	100		
	1	1	
		1	2
			20

costs c

0	100		
	0	1	
		0	2
			0

split points t

	1		
		2	
			3

The values of t are:

i/j	1	2	3	4
1		1	1	1
2			2	3
3				3
4				

ExtractPlan($R = \{R_1, \ldots, R_n\}$,t,p)
Input: a set of relations, arrays t and p
Output: a bushy join tree
return ExtractPlanRec(R,t,p,1,n)

ExtractPlanRec($R = \{R_1, \ldots, R_n\}$,t,p,i,j)
if $i < j$
  T_1 =ExtractPlanRec(R,t,p,i,$t[i,j]$)
  T_2 =ExtractPlanRec(R,t,p,$t[i,j]+1$,j)
  return $T_1 \bowtie^L_{p[i,j]} T_2$
else
  return $\sigma_{p[i,j]} R_i$

The values of t are:

i/j	1	2	3	4
1		1	1	1
2			2	3
3				3
4				

extract-subplan(. . . , i=1, j=4)
    extract-subplan(. . . , i=1, j=1)
    extract-subplan(. . . , i=2, j=4)
        extract-subplan(. . . , i=2, j=3)
            extract-subplan(. . . , i=2, j=2)
            extract-subplan(. . . , i=3, j=3)
        return $(R_2 \bowtie_{\text{true}} R_3)$
        extract-subplan(. . . , i=4, j=4)
    return $((R_2 \bowtie_{\text{true}} R_3) \bowtie_{p_{3,4}} R_4)$
return $(R_1 \bowtie_{p_{1,2} \wedge p_{1,4}} ((R_2 \bowtie_{\text{true}} R_3) \bowtie_{p_{3,4}} R_4))$

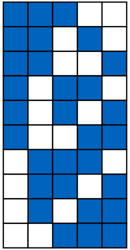
The total cost of this plan is $c[1,4] = 43$.

Combinatorics 101

Given a set of n elements, how many distinct k-element subsets can be formed?

$$\binom{n}{k} = \frac{n!}{(n-k)! \cdot k!}$$

Example: Choose 3 out of 5: $\binom{5}{3} = \frac{5!}{2! \cdot 3!} = \frac{120}{2 \cdot 6} = 10$

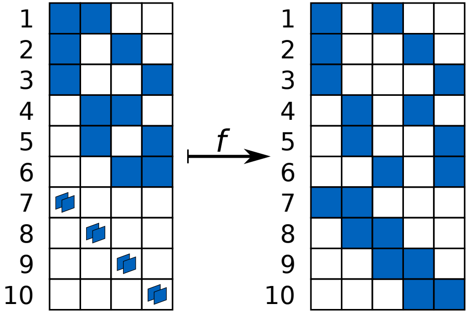


Homework

$$\binom{n}{k} = \binom{n}{n-k}$$

$$\binom{n}{k} = \binom{n-1}{k} + \binom{n-1}{k-1}$$

- Now *with replacement*: How many distinct *multisets* exist chosing k from n? As many as there are distinct sets chosing k from $n + k - 1$!
- Bijection between multisets and sets. From multiset to set: $f : (x_1, x_2, \ldots, x_k) \mapsto (x_1 + 0, x_2 + 1, \ldots, x_k + (k-1))$
- Example: Choose 2 from 4
  - # sets: $\binom{4}{2}$
  - # multisets: $\binom{4+2-1}{2}$



- Slides: db.in.tum.de/teaching/ws1819/queryopt
- Exercise task: gitlab
- Questions, Comments, etc:
  mattermost @ mattermost.db.in.tum.de/qo18
- Exercise due: 9 AM next monday

[1] C. A. Galindo-Legaria, A. Pellenkoft, and M. L. Kersten.
Uniformly-distributed random generation of join orders.
In G. Gottlob and M. Y. Vardi, editors, *Database Theory - ICDT'95, 5th International Conference, Prague, Czech Republic, January 11-13, 1995, Proceedings*, volume 893 of *Lecture Notes in Computer Science*, pages 280–293. Springer, 1995.