Query Optimization

Exercise Session 4

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Homework: Selectivity estimations

The selectivity of $\sigma_{R1.x=c}$ is...

- if x is the key: $\frac{1}{|R1|}$
- if x is not the key: $\frac{1}{|R1.x|}$

The selectivity of $\bowtie_{R1.x=R2.y}$ is...

- if both x and y are the keys: $\frac{1}{max(|R1|,|R2|)}$
- if only x is the key: $\frac{1}{|R1|}$
- if both x and y are not the keys: $\frac{1}{max(|R1.x|,|R2.y|)}$

When our selectivity estimations are bad?

Example 1.1, due Bernhard Radke

```
select *
from title t, movie_companies mc,
    company_name n
where mc.movie_id = t.id
  and mc.company_id=n.id
  and n.country_code='[us]'
  and t.production_year=1880
```

Example 1.1, due Atanas Mirchev

```
select m2.movie_id
from movie_info m1, movie_link l, movie_info m2
where  m1.movie_id = l.movie_id
   and m2.movie_id = l.linked_movie_id
   m2.info = 'Comedy' and m1.info = 'Lifestyle'
```

Example 1.2, due André Kohn, Valentin Hauner

```
select * from title t,
    movie_info mi, kind_type kt
where t.id = mi.movie_id
  and t.kind_id = kt.id
  and t.title like '%from%'
```

Example 1.2, due Michele Bertoni

Movies with certain names, actors with certain names that acted as 'guests'

```
SELECT *
FROM role_type r
   join cast_info c1 on r.id = c1.role_id
   join name n1 on c1.person_id = n1.id
   join cast_info c2 on c2.movie_id = c1.movie_id
   join name n2 on n2.id = c2.person_id
WHERE n1.name like '%J%J%'
   and n2.name like '%J%J%'
   and r.role = 'guest';
```

Operator Optimality

When is the nested loops join optimal?

Operator Optimality

When is the nested loops join optimal?

```
select *
from R join S on R.str=S.str
where R.ID = 1
```

- R has the key ID

Operator Optimality

When is the blocked nested loops join optimal?

Operator Optimality

When is the blocked nested loops join optimal?

```
select R.b, S.b
from R, S
where R.b <> S.b * S.c
```

Operator Optimality

When is the merge join optimal?

Operator Optimality

When is the merge join optimal?

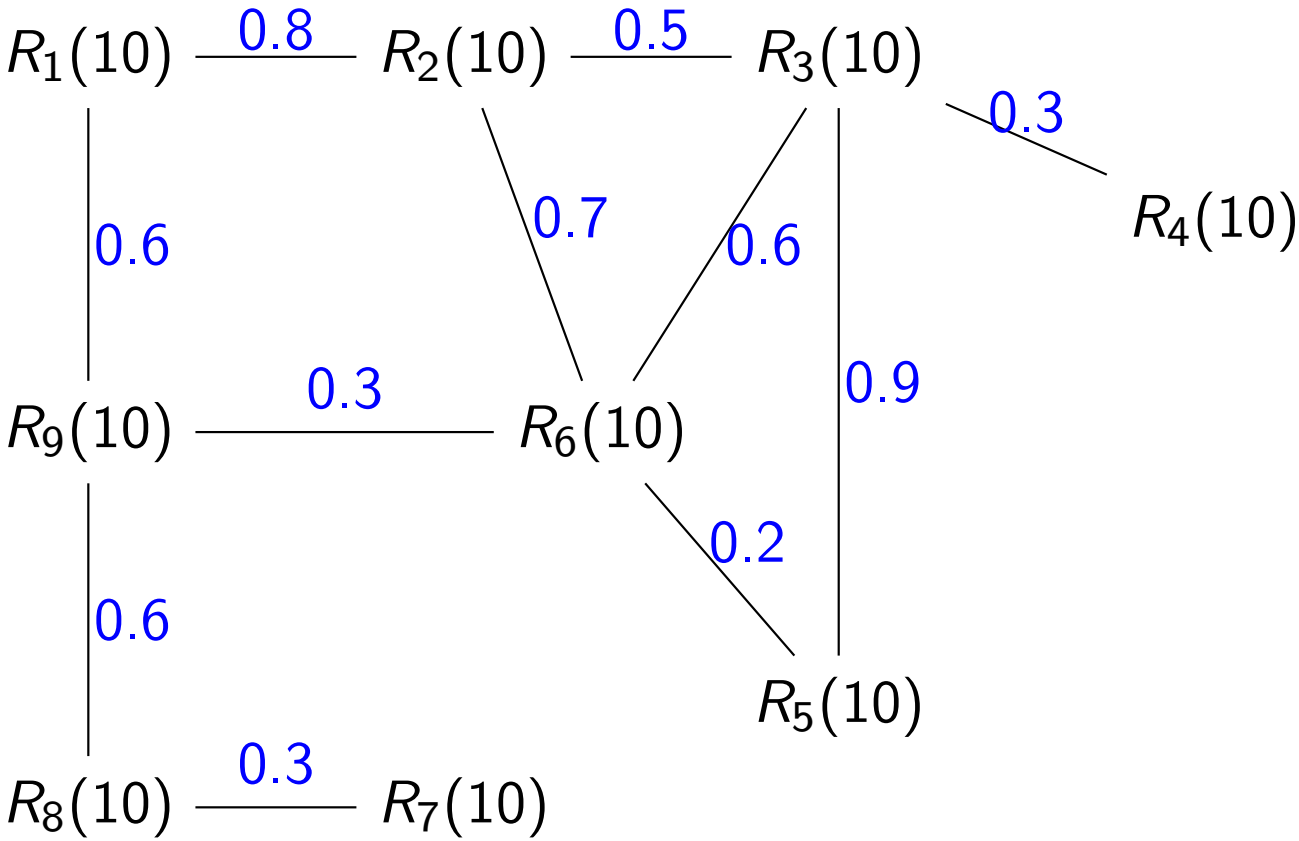
```
select *
from R, S
where R.a = S.b
order by R.a asc
```

Greedy operator ordering

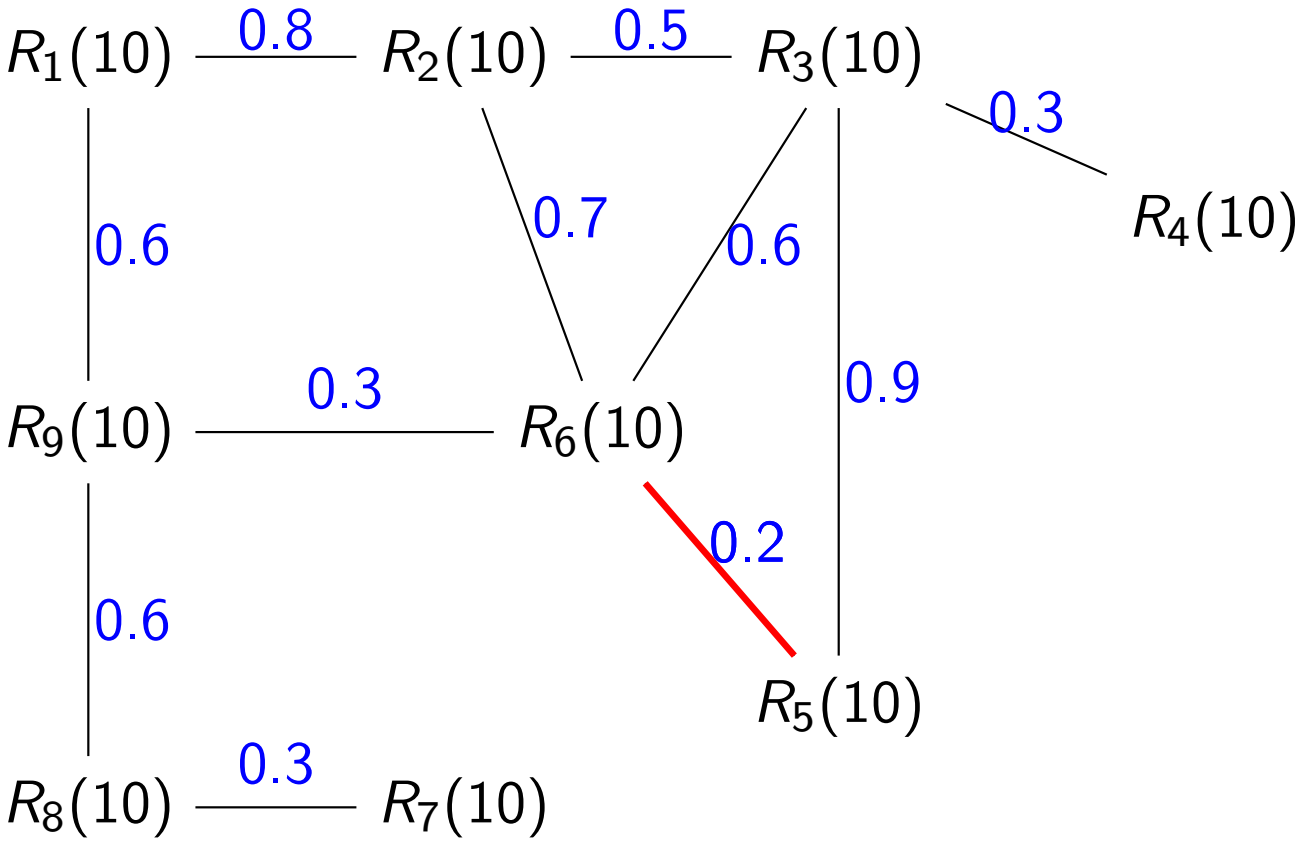
- take the query graph
- find relations R_1, R_2 such that $|R_1 \bowtie R_2|$ is minimal and merge them into one node
- repeat until the query graph has more than one node

Generates bushy trees!

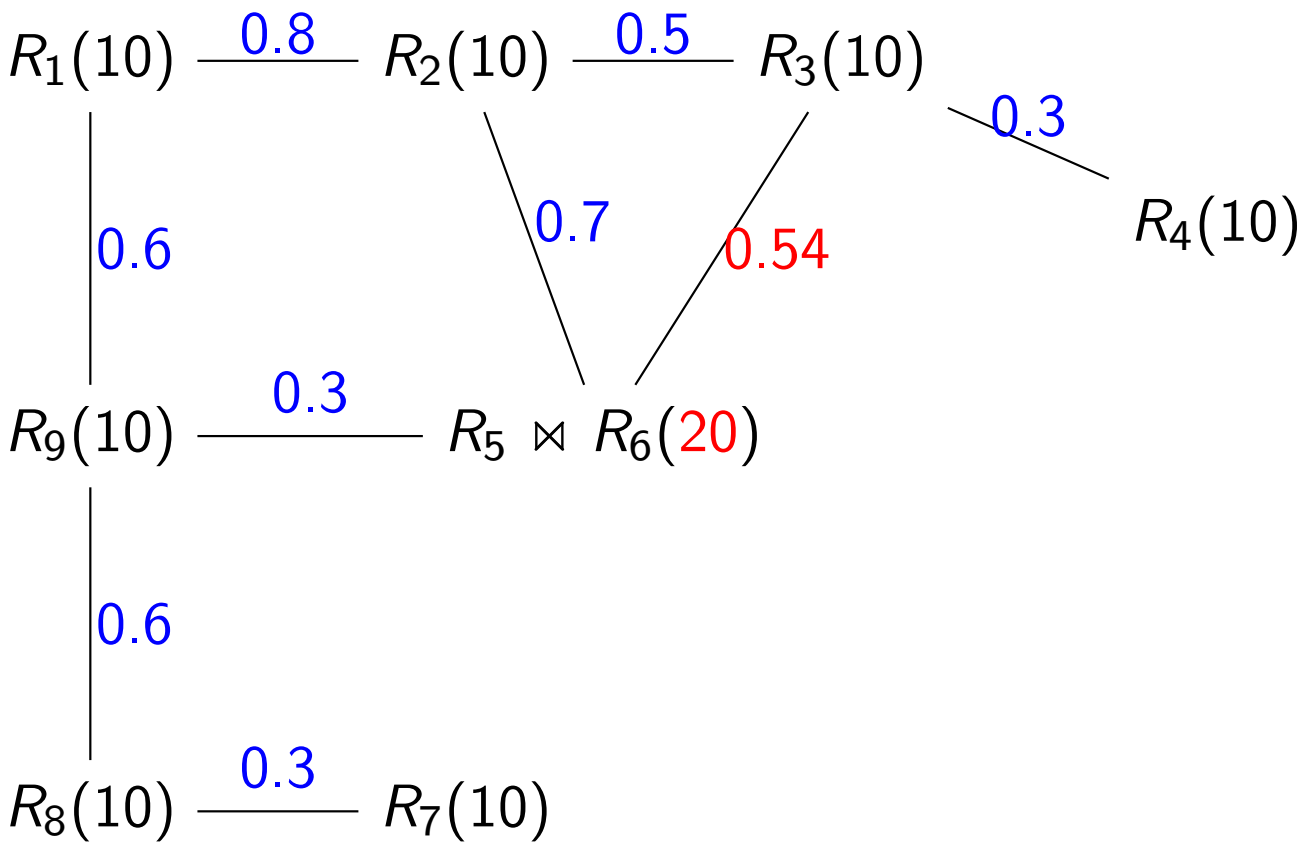
Example


$R_1(10)$
0.8
$R_2(10)$
0.5
$R_3(10)$
0.3
$R_4(10)$
0.6
0.7
0.6
0.9
$R_9(10)$
0.3
$R_6(10)$
0.2
0.6
$R_5(10)$
$R_8(10)$
0.3
$R_7(10)$

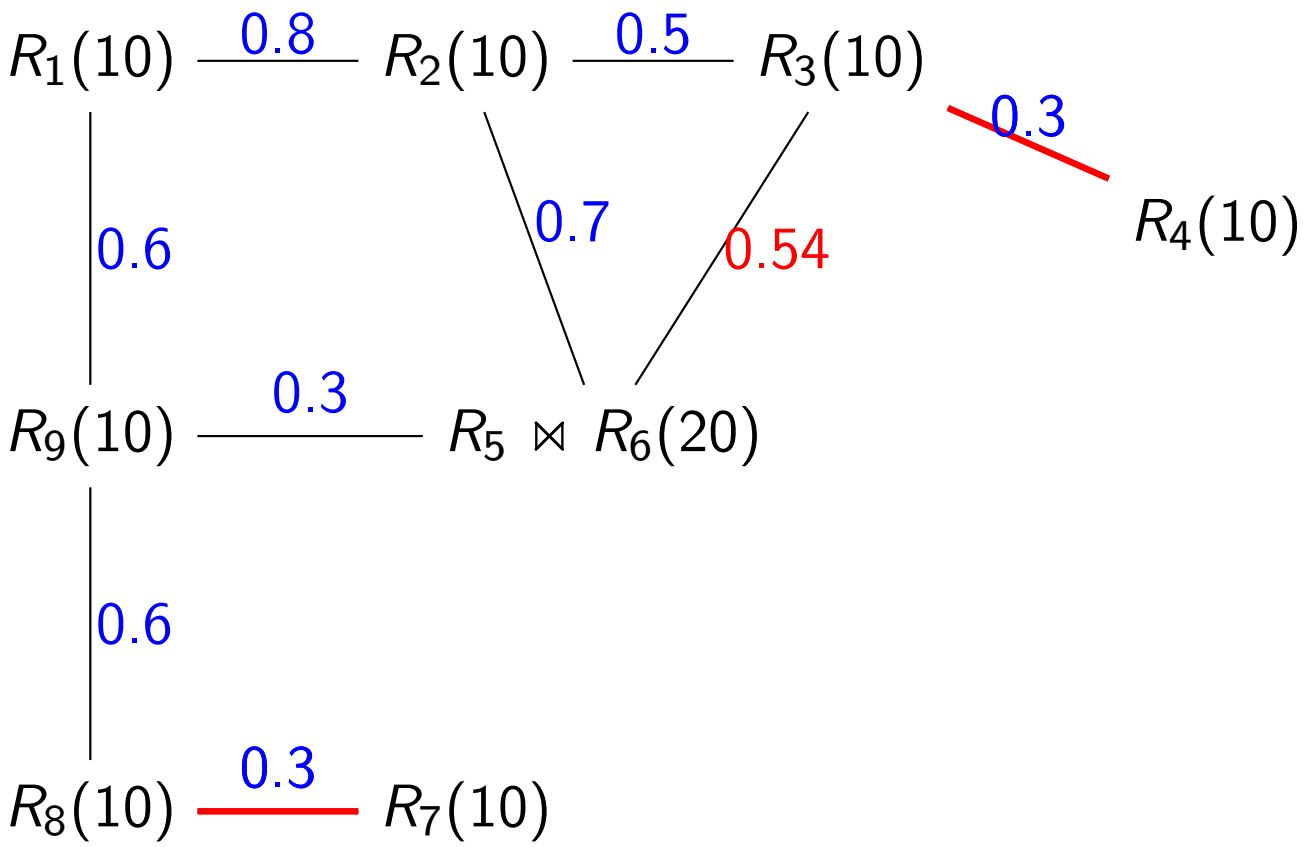
Example - step 1



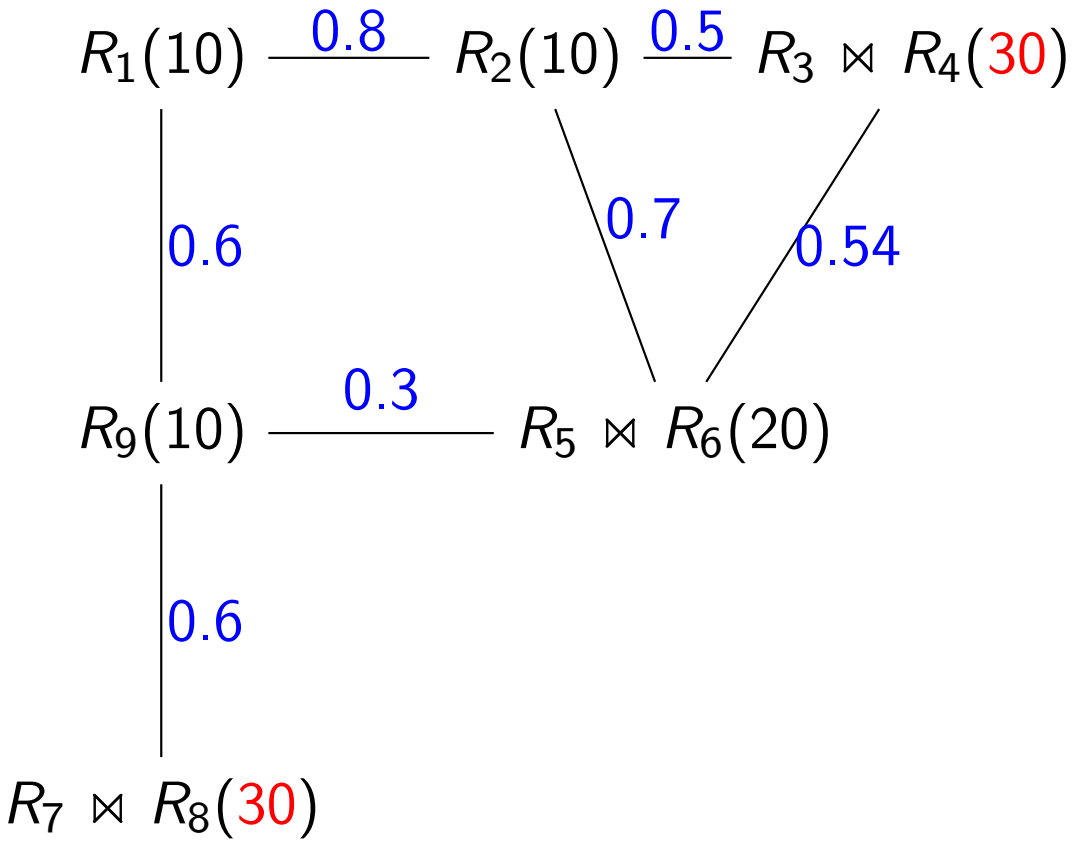
Example - after step 1



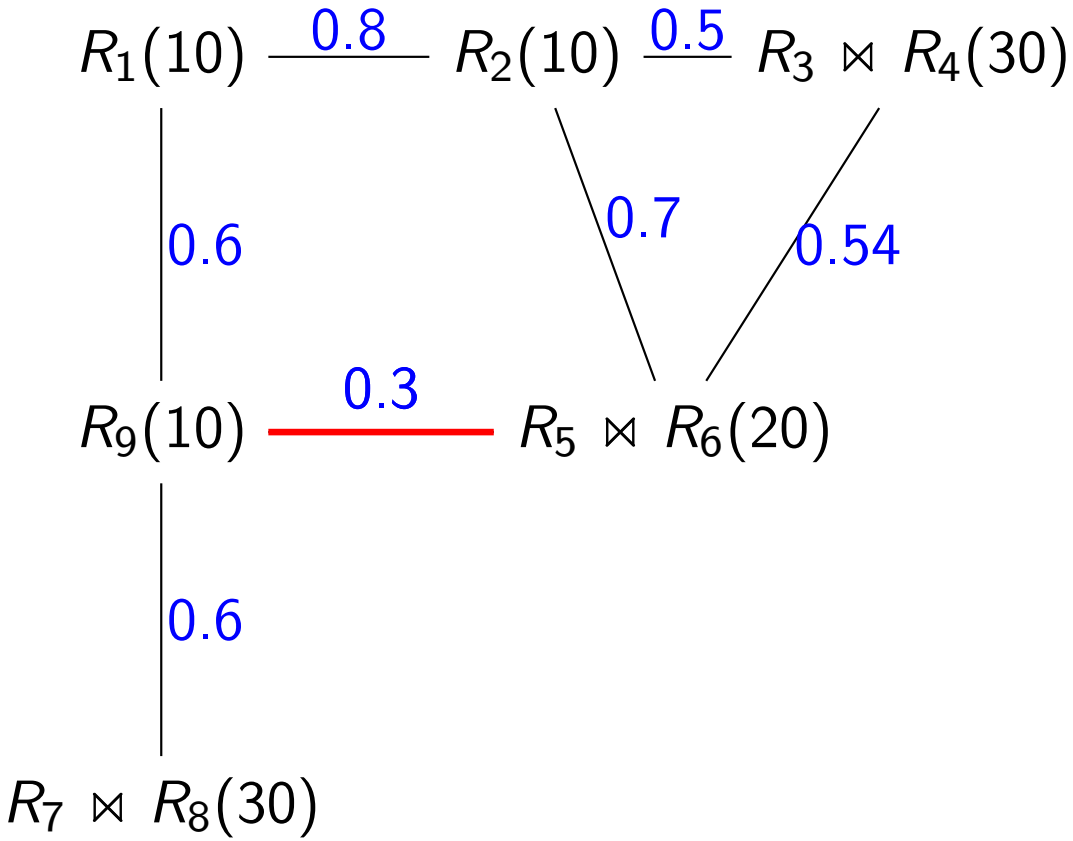
Example - step 2



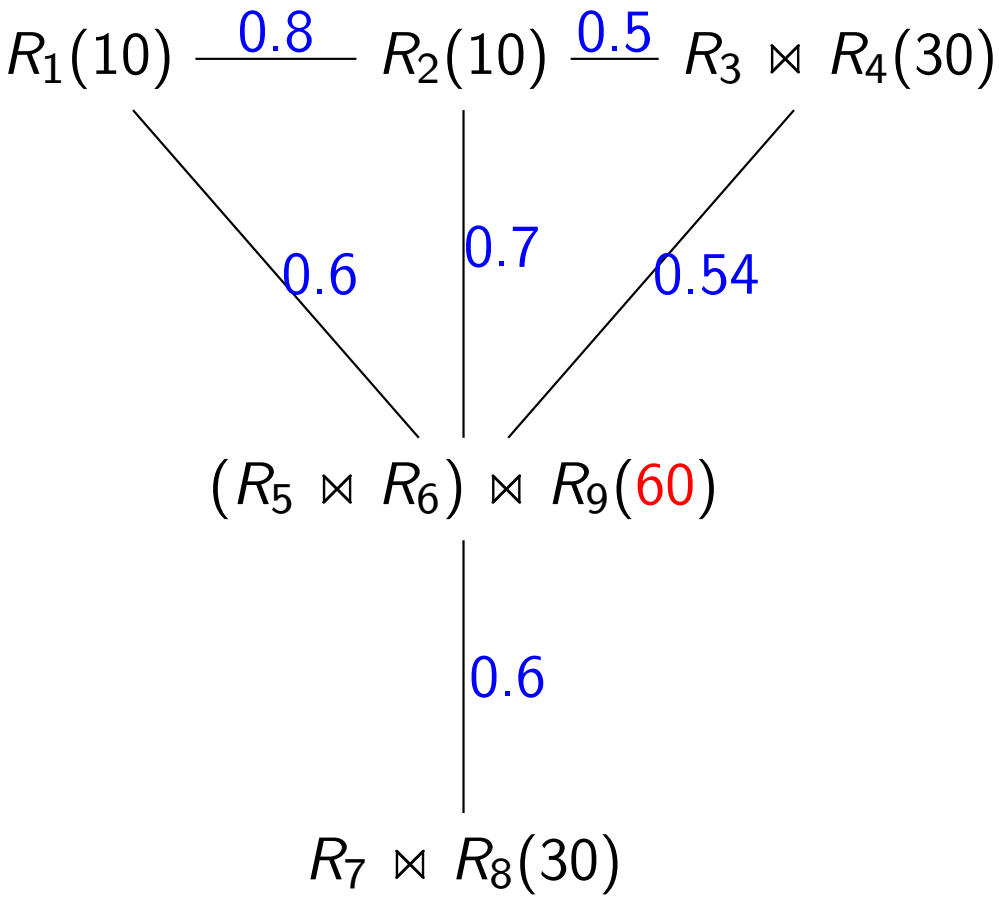
Example- after step 2



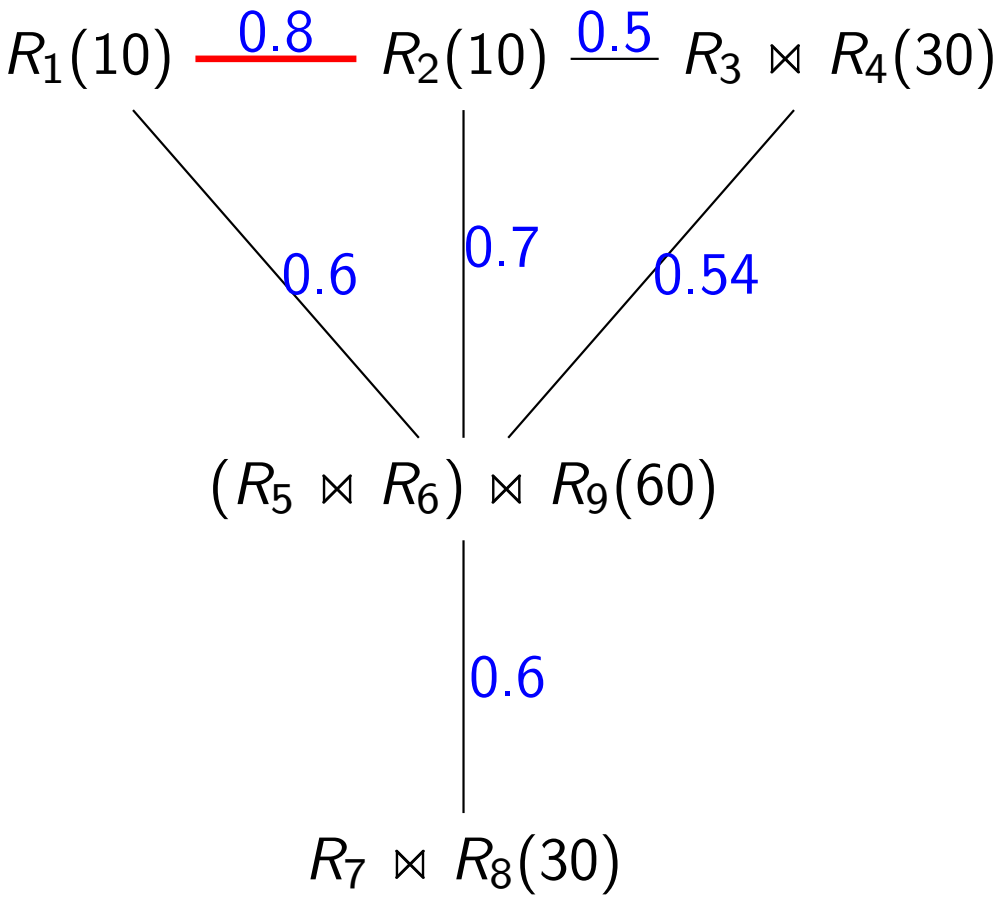
Example - step 3



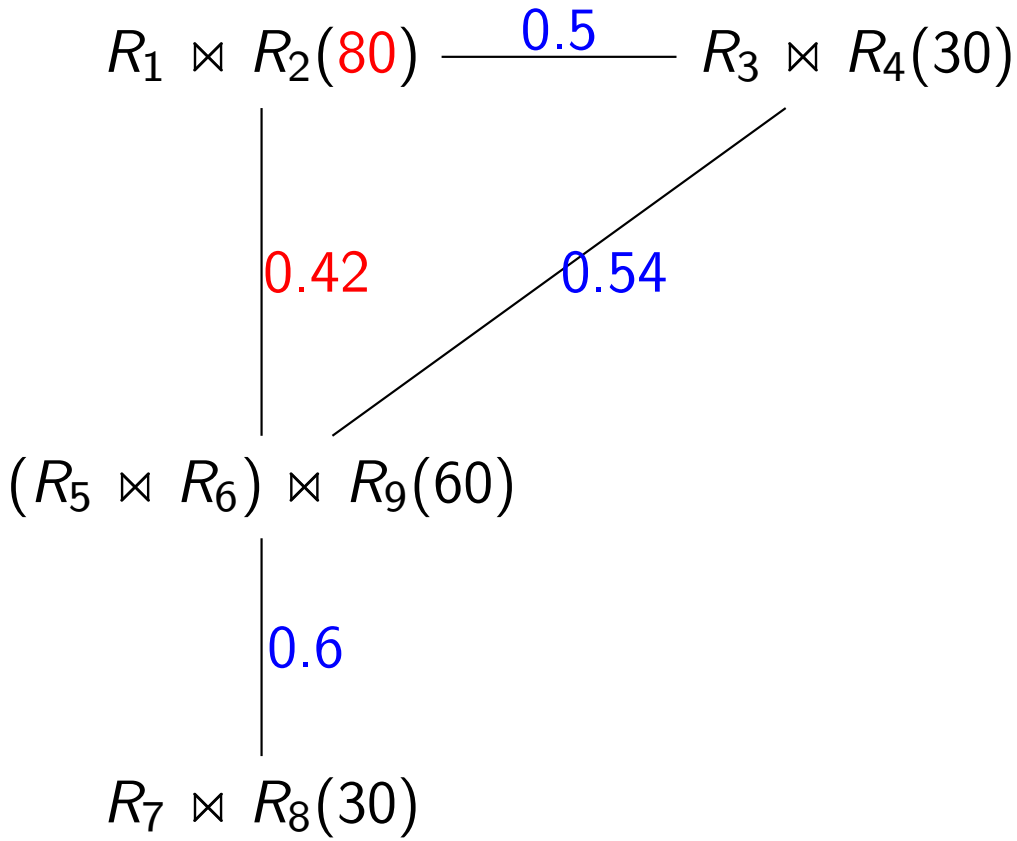
Example - after step 3



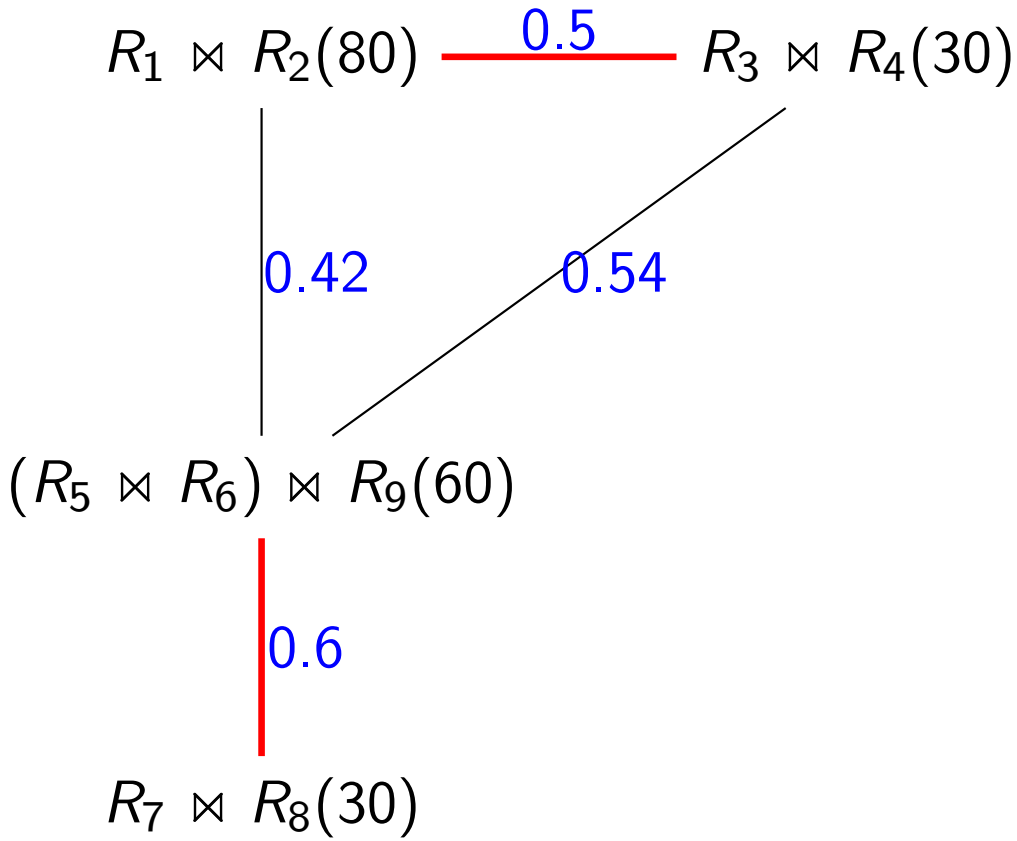
Example - step 4



Example - after step 4



Example - step 5



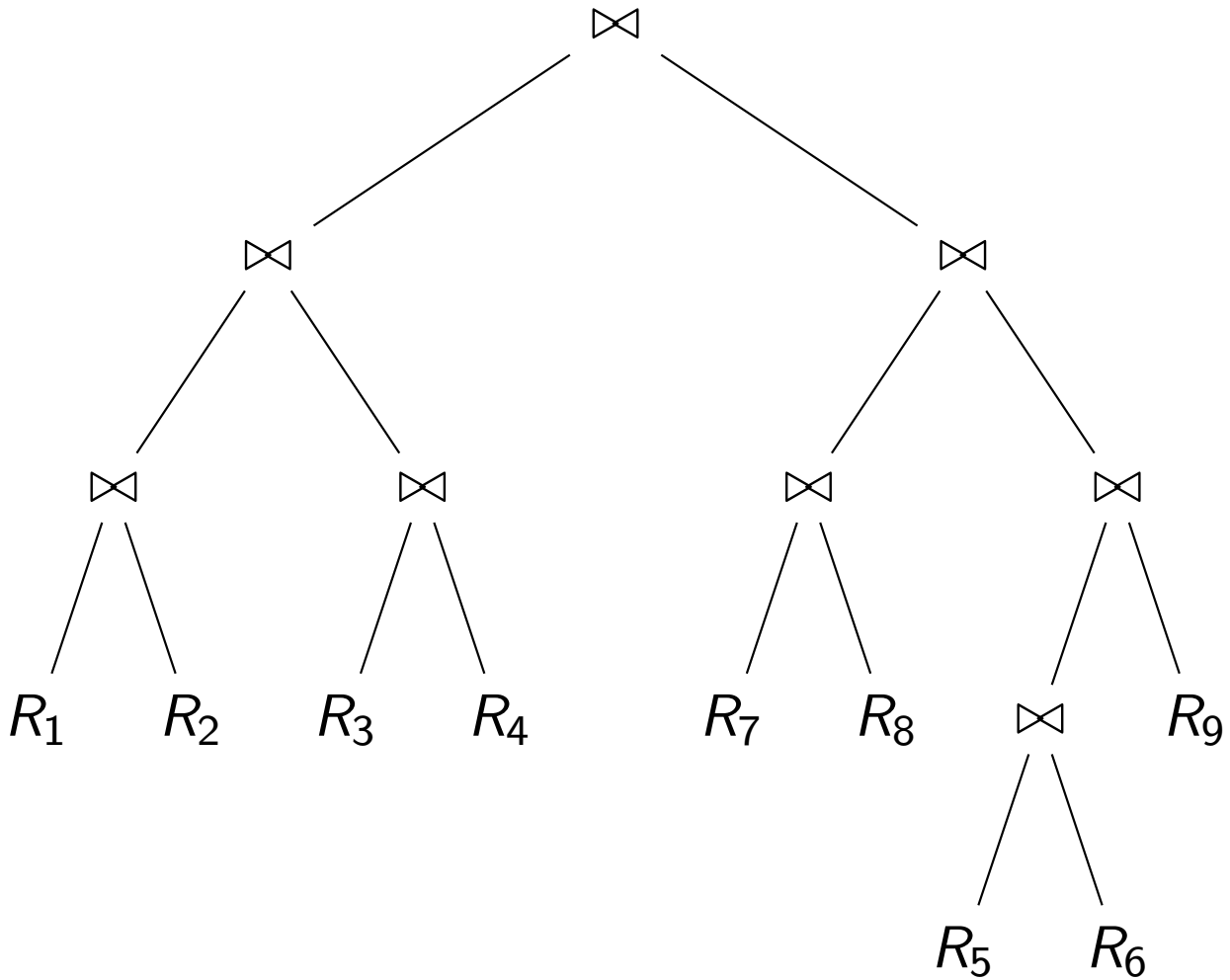
Example - after step 5

$$(R_1 \bowtie R_2) \bowtie (R_3 \bowtie R_4)(1200)$$

$$\Big| \; 0.2268$$

$$(R_7 \bowtie R_8) \bowtie ((R_5 \bowtie R_6) \bowtie R_9)(1080)$$

Example - result



IKKBZ (informally)

Query graph Q is acyclic. Pick a root node, turn it into a tree. Run the following procedure for every root node, select the cheapest plan

Input: rooted tree Q

1. if the tree is a single chain, stop
2. find the subtree (rooted at r) all of whose children are chains
3. normalize, if $c_1 \to c_2$, but $rank(c_1) > rank(c_2)$ in the subtree rooted at r
4. merge chains in the subtree rooted at r, rank is ascending
5. repeat 1

IKKBZ (informally)

For every relation R_i we keep

- cardinality n_i
- selectivity s_i — the selectivity of the incoming edge from the parent of R_i
- cost $C(R_i) = n_i s_i$ (or 0, if R_i is the root)
- rank $r_i = \frac{n_i s_i - 1}{n_i s_i}$

Moreover,

- $C(S_1 S_2) = C(S_1) + T(S_1) C(S_2)$
- $T(S) = \prod_{R_i \in S} (s_i n_i)$
- rank of a sequence $r(S) = \frac{T(S) - 1}{C(S)}$

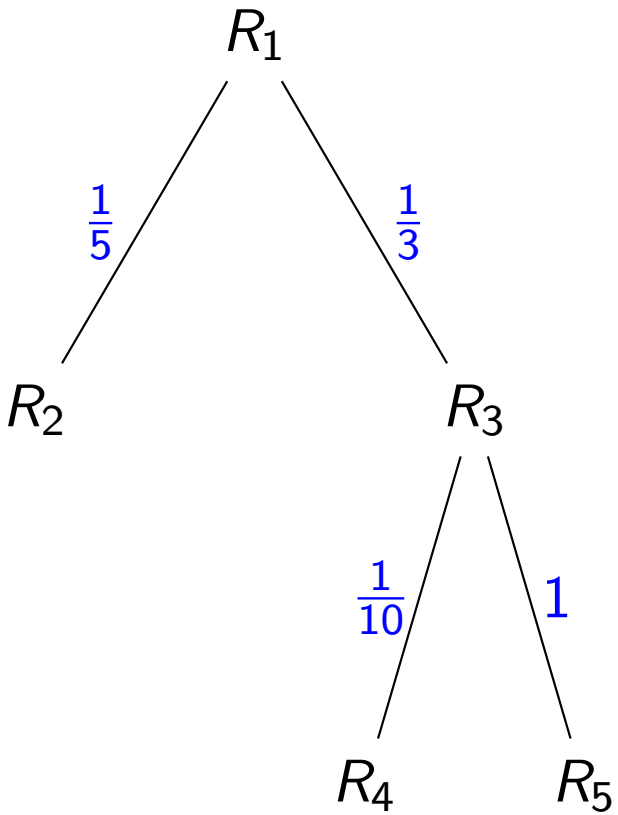
Understanding IKKBZ

- what is the rank?
- when is $(R_1 \bowtie R_2) \bowtie R_3$ cheaper than $(R_1 \bowtie R_3) \bowtie R_2$?

Understanding IKKBZ

- what is the rank?
- when is $(R_1 \bowtie R_2) \bowtie R_3$ cheaper than $(R_1 \bowtie R_3) \bowtie R_2$?
- if $r(R_2) < r(R_3)$!

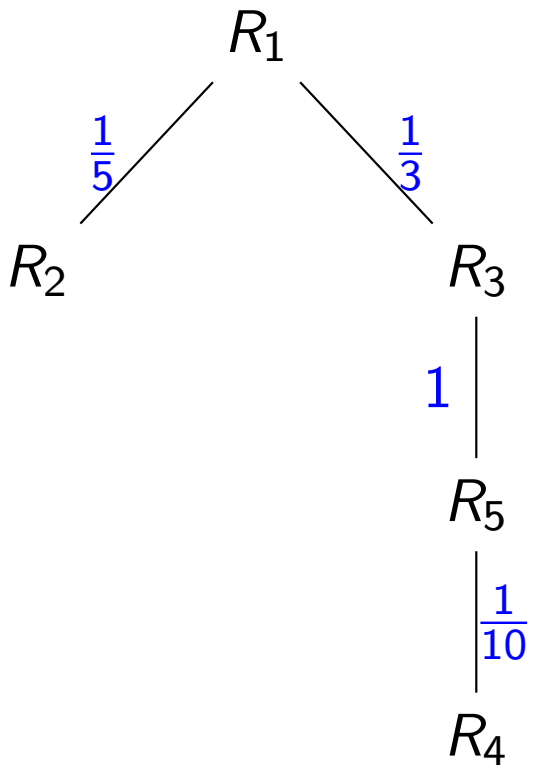
IKKBZ - example



Relation	n	s	C	T	*rank*
2	20	$\frac{1}{5}$	4	4	$\frac{3}{4}$
3	30	$\frac{1}{3}$	10	10	$\frac{9}{10}$
4	50	$\frac{1}{10}$	5	5	$\frac{4}{5}$
5	2	1	2	2	$\frac{1}{2}$

IKKBZ - example

Subtree R_3: merging, $rank(R_5) < rank(R_4)$



Relation	n	s	C	T	*rank*
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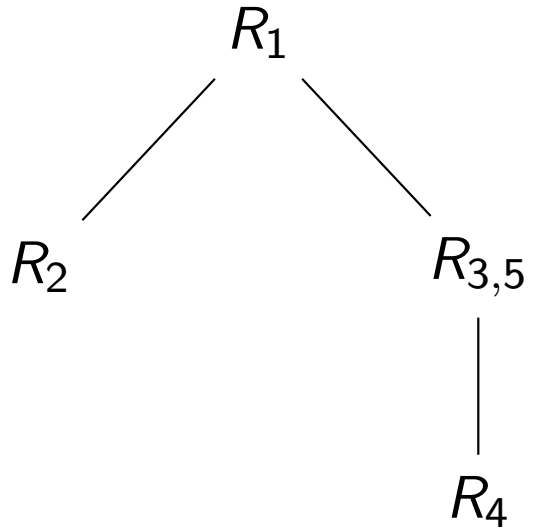
4	50	$\frac{1}{10}$	5	5	$\frac{4}{5}$
5	2	1	2	2	$\frac{1}{2}$

IKKBZ - example

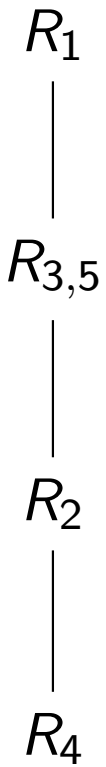
Subtree R_1:
$rank(R_3) > rank(R_5)$,
normalizing



Relation	n	s	C	T	*rank*
2	20	$\frac{1}{5}$	4	4	$\frac{3}{4}$
3	30	$\frac{1}{3}$	10	10	$\frac{9}{10}$
4	50	$\frac{1}{10}$	5	5	$\frac{4}{5}$
5	2	1	2	2	$\frac{1}{2}$
3,5	60	$\frac{1}{3}$	30	20	$\frac{19}{30}$

IKKBZ - example

Subtree R_1: merging



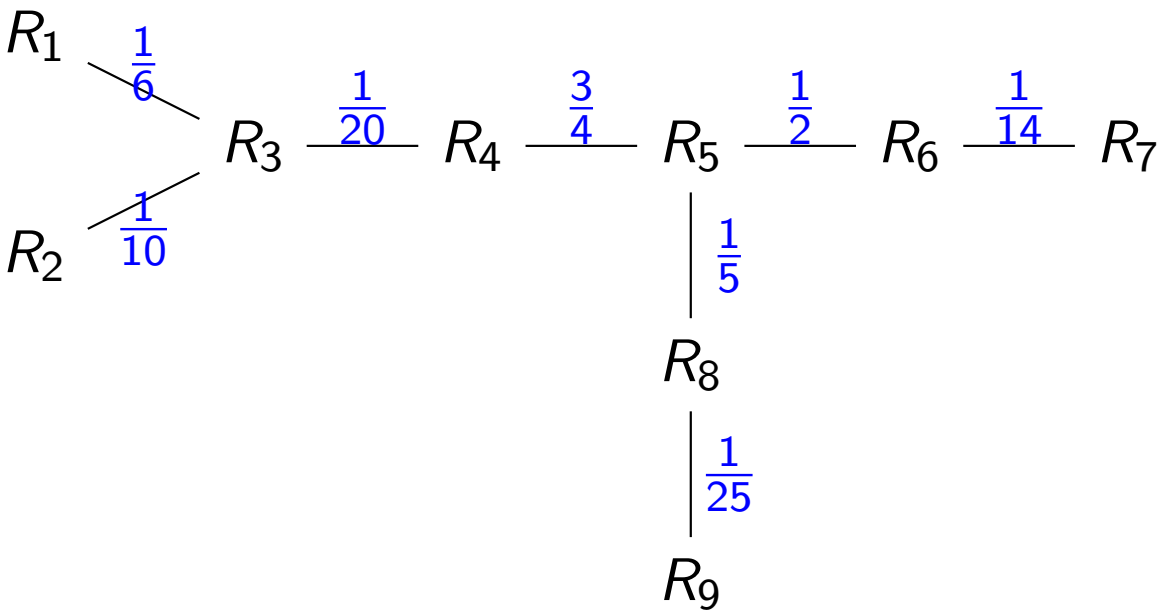
Relation	n	s	C	T	*rank*
2	20	$\frac{1}{5}$	4	4	$\frac{3}{4}$
3	30	$\frac{1}{15}$	10	10	$\frac{9}{10}$
4	50	$\frac{1}{10}$	5	5	$\frac{4}{5}$
5	2	1	2	2	$\frac{1}{2}$
3,5	60	$\frac{1}{15}$	30	20	$\frac{19}{30}$

IKKBZ - example

Denormalizing

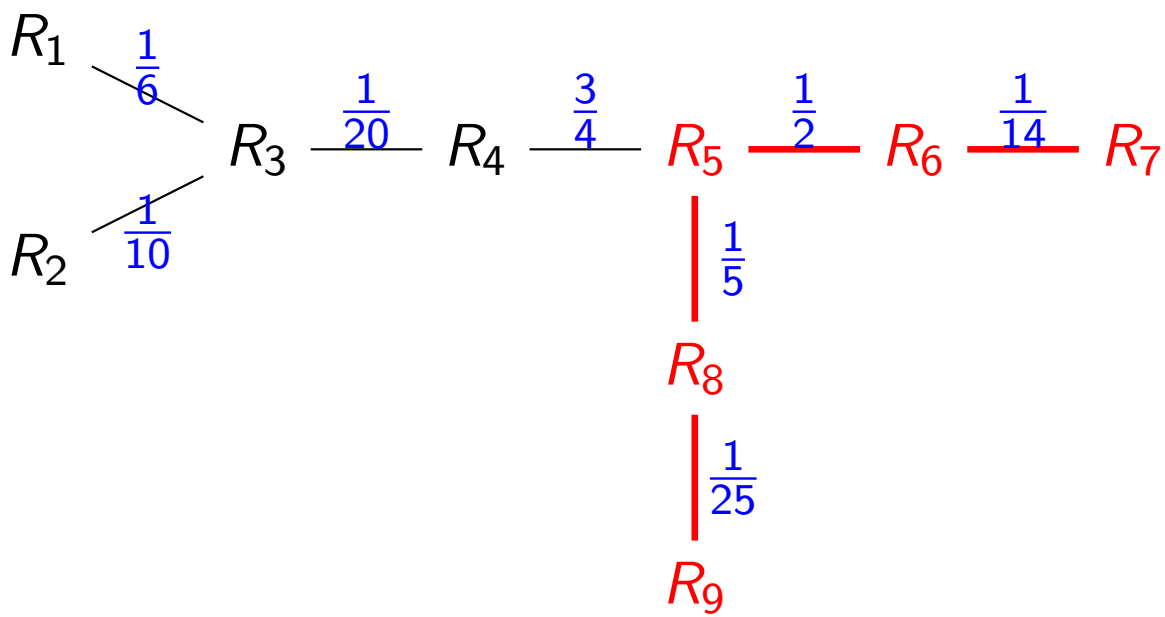
Relation	n	s	C	T	*rank*
2	20	$\frac{1}{5}$	4	4	$\frac{3}{4}$
3	30	$\frac{1}{15}$	10	10	$\frac{9}{10}$
4	50	$\frac{1}{10}$	5	5	$\frac{4}{5}$
5	2	1	2	2	$\frac{1}{2}$
3,5	60	$\frac{1}{3}$	30	20	$\frac{3}{30}$

IKKBZ - another example



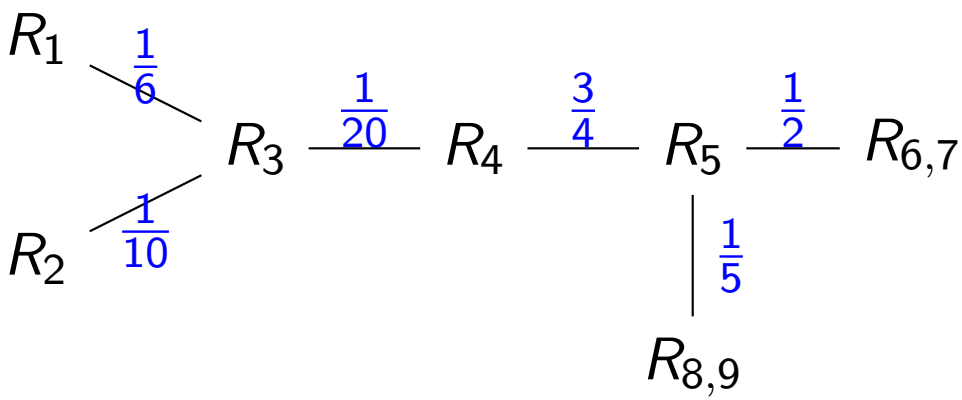
- $|R_1| = 30$
- $|R_2| = 100$
- $|R_3| = 30$
- $|R_4| = 20$
- $|R_5| = 10$
- $|R_6| = 20$
- $|R_7| = 70$
- $|R_8| = 100$
- $|R_9| = 100$

IKKBZ



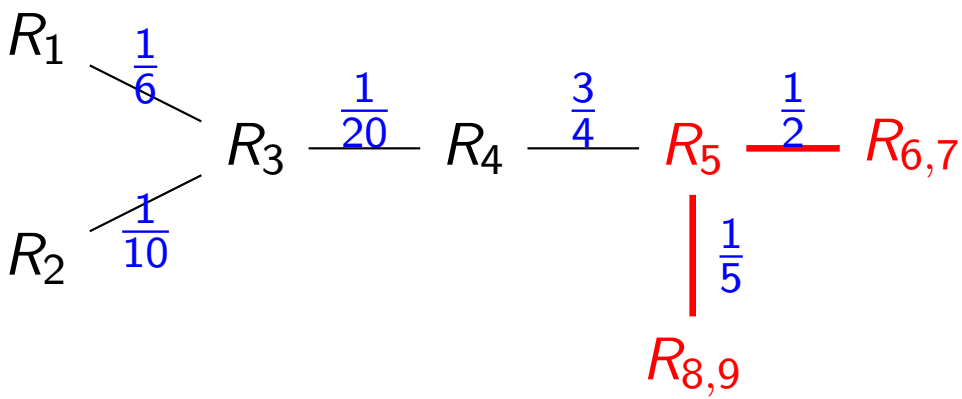
- $r(R_2) = \frac{9}{10}$
- $r(R_3) = \frac{4}{5}$
- $r(R_4) = 0$
- $r(R_5) = \frac{13}{15}$
- $r(R_6) = \frac{9}{10}$
- $r(R_7) = \frac{4}{5}$
- $r(R_8) = \frac{19}{20}$
- $r(R_9) = \frac{3}{4}$

IKKBZ



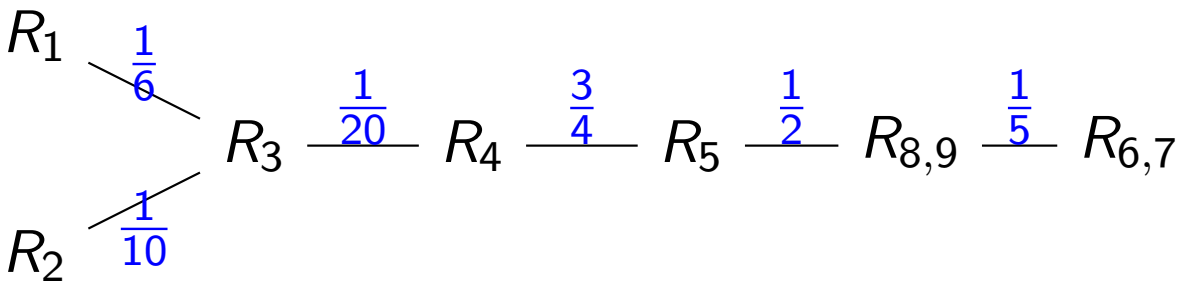
- $C(R_{8,9}) = 100$
- $T(R_{8,9}) = 80$
- $r(R_{8,9}) = \frac{79}{100} = \frac{237}{300}$
- $C(R_{6,7}) = 60$
- $T(R_{6,7}) = 50$
- $r(R_{6,7}) = \frac{49}{60} = \frac{245}{300}$

IKKBZ



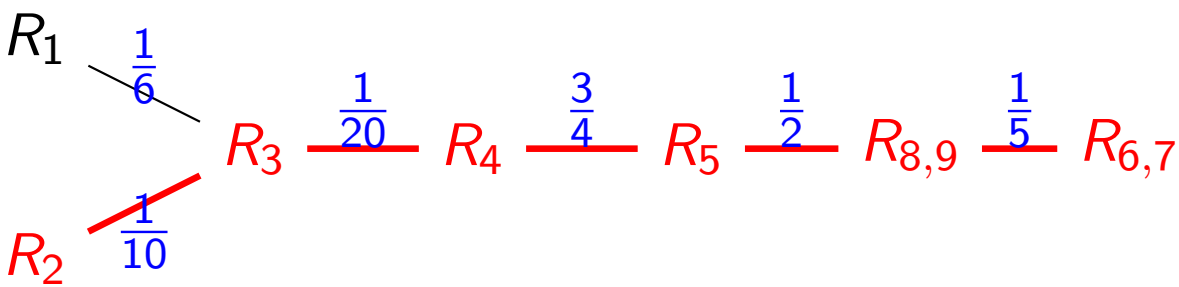
- $C(R_{8,9}) = 100$
- $T(R_{8,9}) = 80$
- $r(R_{8,9}) = \frac{79}{100} = \frac{237}{300}$
- $C(R_{6,7}) = 60$
- $T(R_{6,7}) = 50$
- $r(R_{6,7}) = \frac{49}{60} = \frac{245}{300}$

IKKBZ



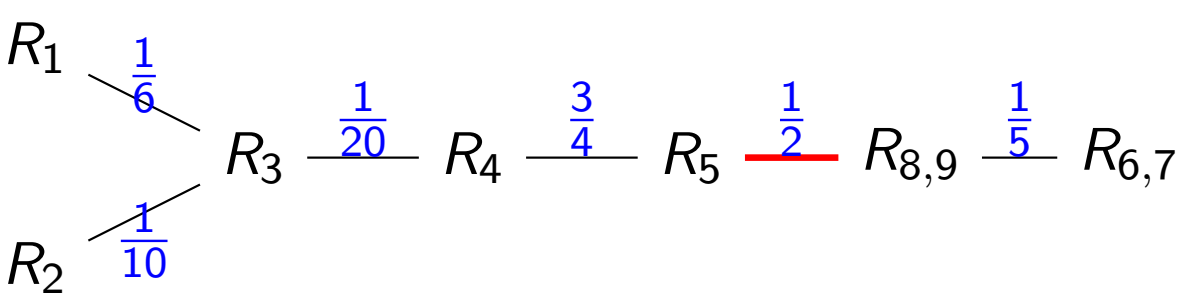
- $r(R_{8,9}) < r(R_{6,7})$

IKKBZ



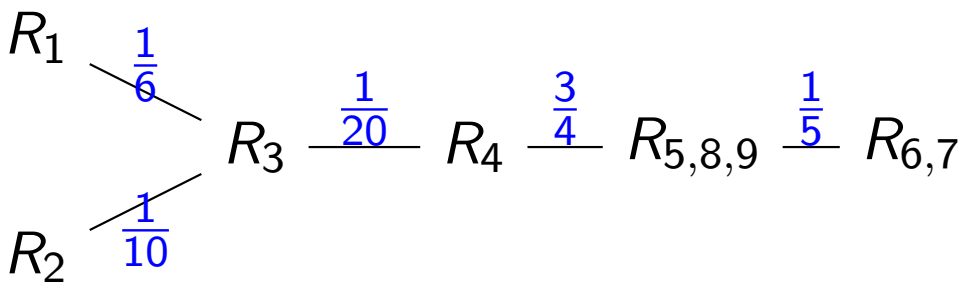
- $r(R_2) = \frac{9}{10}$
- $r(R_3) = \frac{4}{5}$
- $r(R_4) = 0$
- $r(R_6) = \frac{9}{10}$
- $r(R_7) = \frac{4}{5}$
- $r(R_5) = \frac{13}{15} = 0.86..$
- $r(R_{8,9}) = 0.79$

IKKBZ



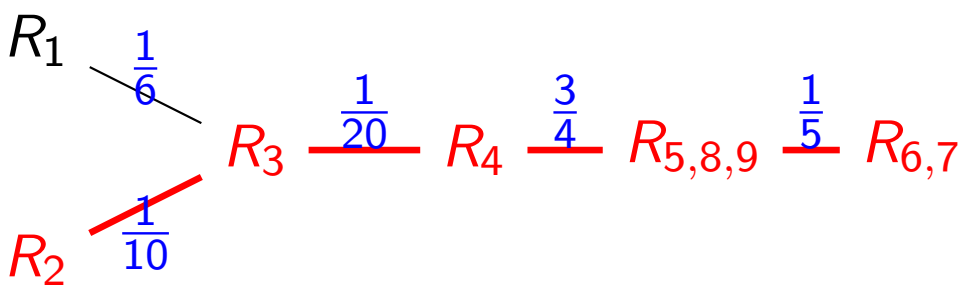
- $r(R_5) = \frac{13}{15} = 0.86..$
- $r(R_{8,9}) = 0.79$

IKKBZ



- $n_{5,8,9} = 800$
- $C_{5,8,9} = \frac{1515}{2}$
- $T_{5,8,9} = 600$
- $r(R_{5,8,9}) = \frac{1198}{1515} = 0.79..$
- $r(R_{6,7}) = 0.816..$

IKKBZ

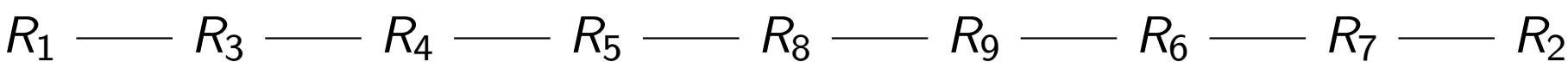


- $r(R_2) = \frac{9}{10}$
- $r(R_{5,8,9}) = \frac{1198}{1515} = 0.79..$
- $r(R_3) = 0.8$
- $r(R_4) = 0$
- $r(R_{6,7}) = 0.816..$

IKKBZ

$$R_1 \text{ —— } R_3 \text{ —— } R_4 \text{ — } R_{5,8,9} \text{ — } R_{6,7} \text{ —— } R_2$$

IKKBZ



IKKBZ-based heuristics

What if Q has cycles?

- Observation 1: the answer of the query, corresponding to any subgraph of the query graph, is a superset of the answer to the original query
- Observation 2: a very selective join is more likely to be influential in choosing the order than a non-selective join

IKKBZ-based heuristics

What if Q has cycles?

- Observation 1: the answer of the query, corresponding to any subgraph of the query graph, is a superset of the answer to the original query
- Observation 2: a very selective join is more likely to be influential in choosing the order than a non-selective join

Choose the minimum spanning tree (minimize the product of the edge weights), compute the total order, compute the original query.

Homework: Task 1 (15 points)

- Give an example query qraph with join selectivities for which the greedy operator ordering (GOO) algorithm does not give the optimal (with regards to C_{out}) join tree. Specify the optimal join tree. No cross products
- For that example perform the IKKBZ-based heuristics

Homework: Task 2 (15 points)

- Using the program from the the last exercise as basis, construct the query graph for each connected component.

Info

- Exercises due: 9 AM, November 17, 2014