Query Optimization

Exercise Session 5

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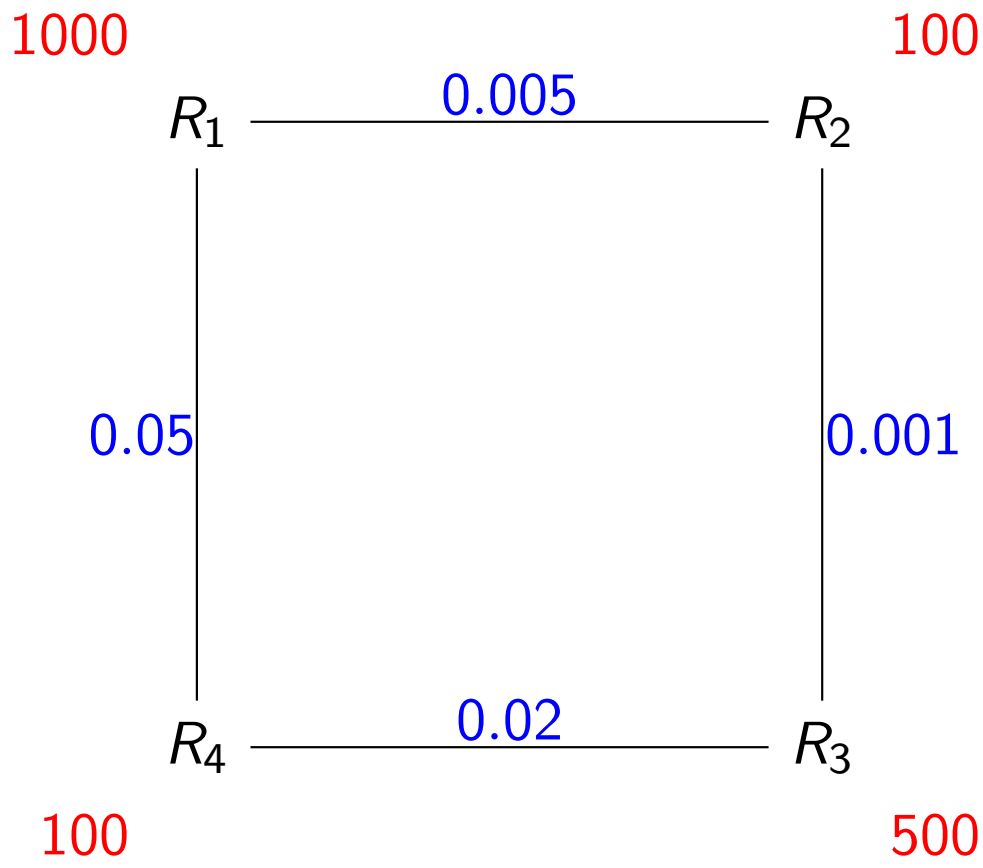
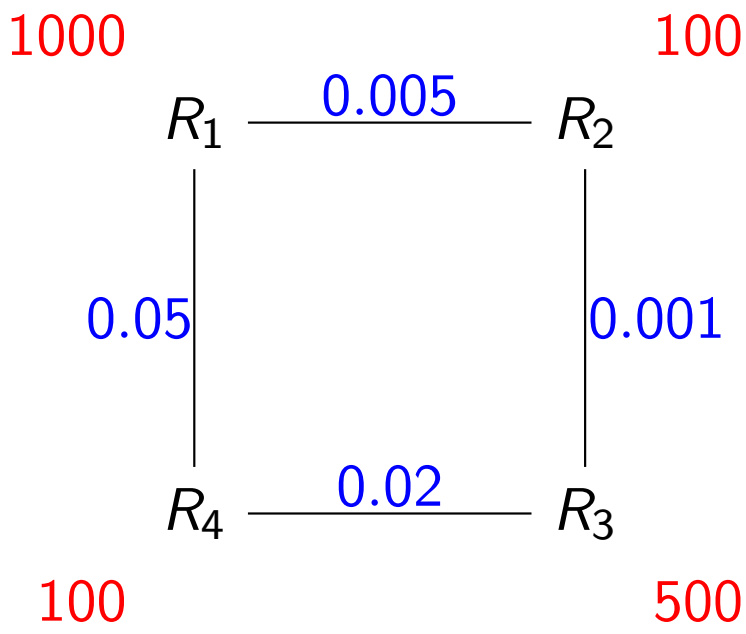
Homework: Task 1

- 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.
- For that example perform the IKKBZ-based heuristics

MVP



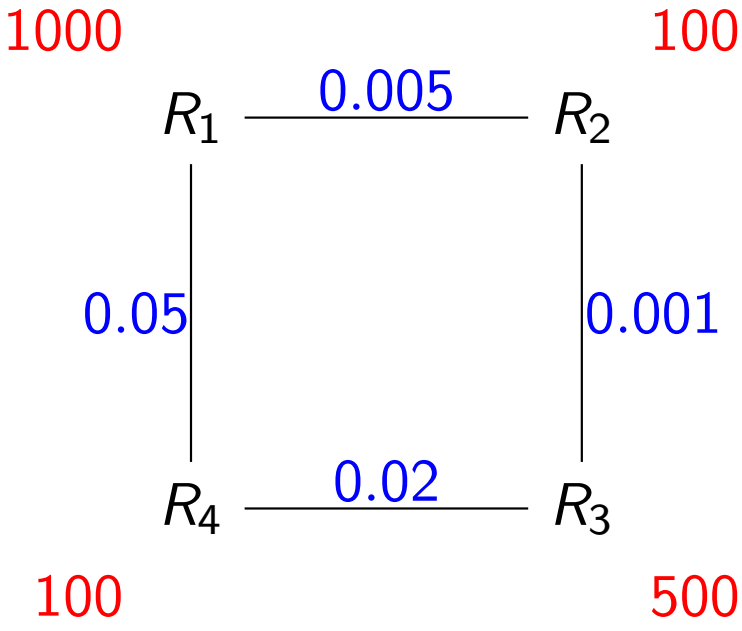
MVP

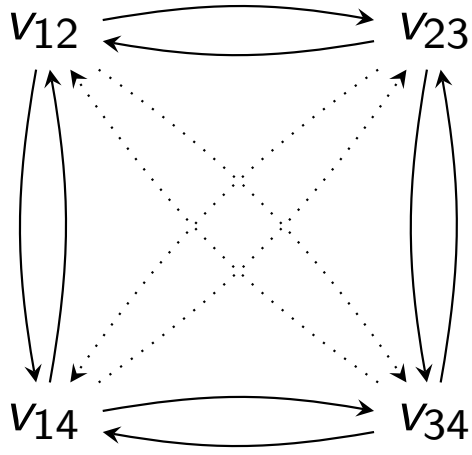


Query graph to Weighted Directed Join Graph:

- nodes = joins
- physical edges between "adjacent" joins (share one relation)
- virtual edges - everywhere else
- WDJG is a clique

MVP

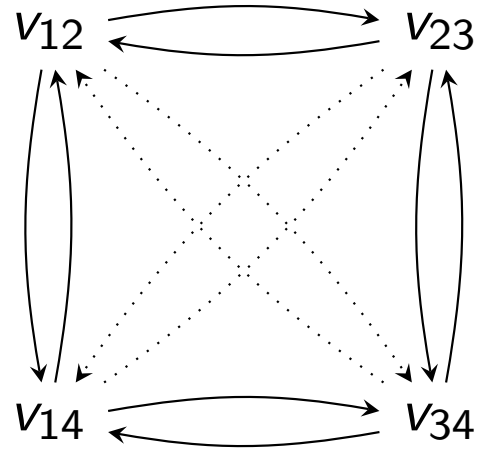




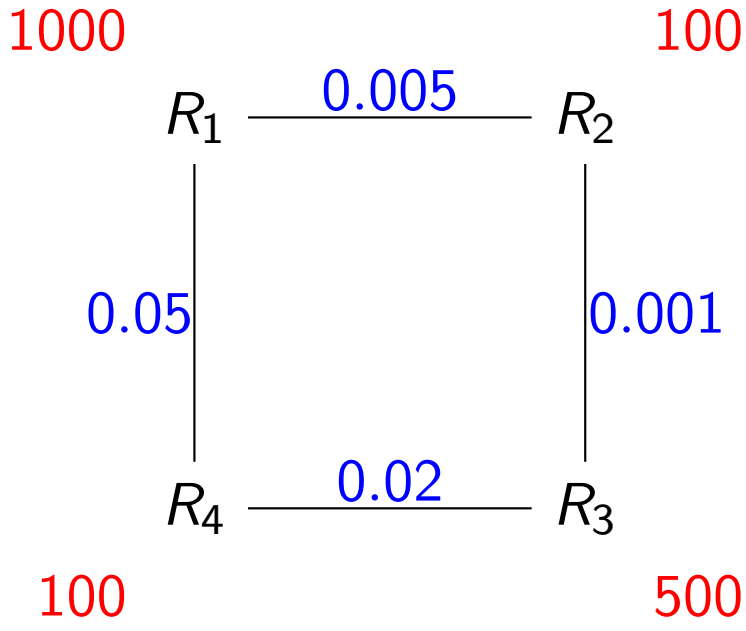
MVP

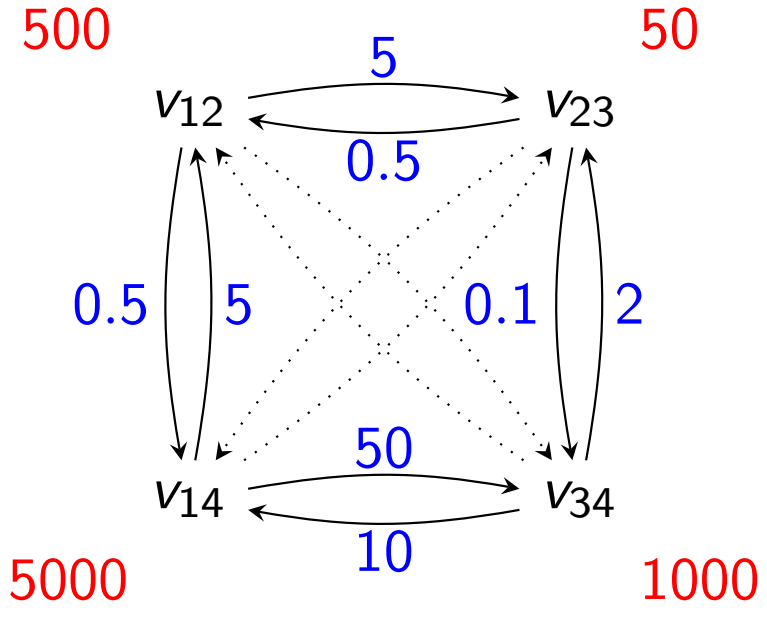
Annotations:

- edge weight $w_{u,v} = \frac{|\ltimes_u|}{|u \sqcap v|}$
- the cost of a node = the cost of the join C_{out}



MVP


1000
100
R_1
0.005
R_2
0.05
0.001
R_4
0.02
R_3
100
500


500
50
v_{12}
5
0.5
v_{23}
0.5
5
0.1
2
v_{14}
50
10
v_{34}
5000
1000

Effective spanning tree (informally)

ESP corresponds to an "effective" execution plan (no extra joins). Three conditions:

1. T is binary
2. For every non-leaf node v_i, for every edge $v_j \to v_i$ there is a common base relation between v_i and the subtree with the root v_j
3. For every node $v_i = R \bowtie S$ with two incoming edges $v_k \to v_i$ and $v_j \to v_i$
   - 3.1 R or S can be present at most in one of the subtrees v_k or v_j
   - 3.2 unless the subtree v_j (or v_k) contains both R and S

MVP (informally)

Construct an effective spanning tree in two steps:

Step 1 (**Choose an edge to reduce the cost of an expensive operation**)
Start with the most expensive node, find the incoming edge that can reduce the cost the most. Update the cost of the node. Add the edge to the ESP, check the conditions. Repeat until

- no more edges can reduce any cost
- no more join nodes to consider

MVP (informally)

Construct an effective spanning tree in two steps:

Step 1 (**Choose an edge to reduce the cost of an expensive operation**)
Start with the most expensive node, find the incoming edge that can reduce the cost the most. Update the cost of the node. Add the edge to the ESP, check the conditions. Repeat until

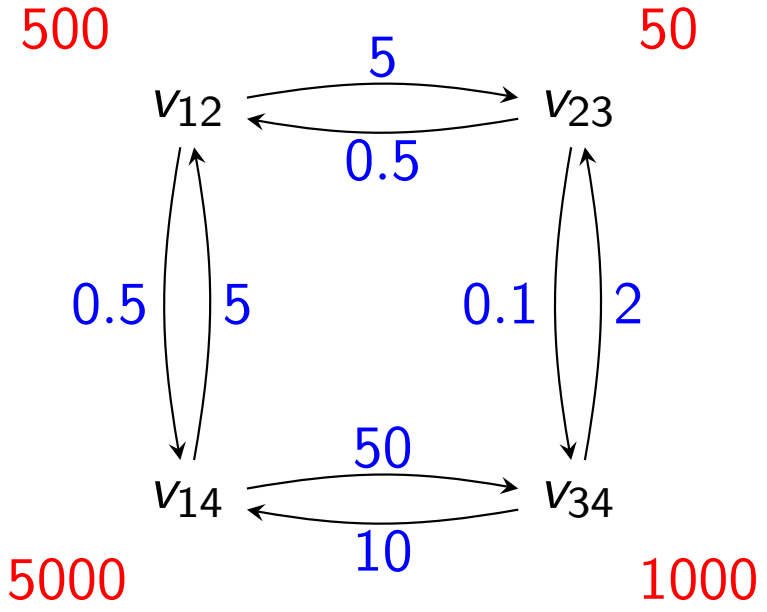
- no more edges can reduce any cost
- no more join nodes to consider

Step 2 (**Find edges causing minimum increase to the result of joins**)
Similar to Step 1, but start with the cheapest node.

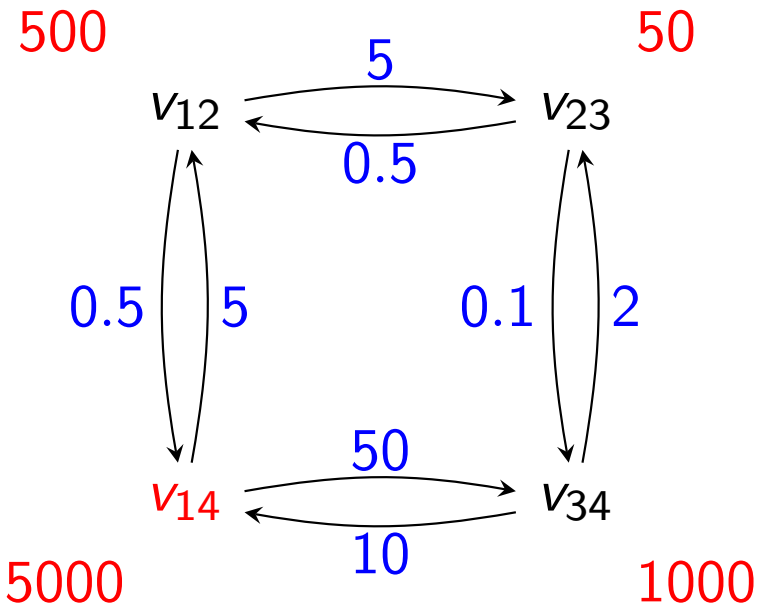
MVP - example

We start with a graph without virtual edges.
Two cost lists:

- for the Step 1:
  $Q_1 = v_{14}, v_{34}, v_{12}, v_{23}$
- for the Step 2: $Q_2 = \emptyset$

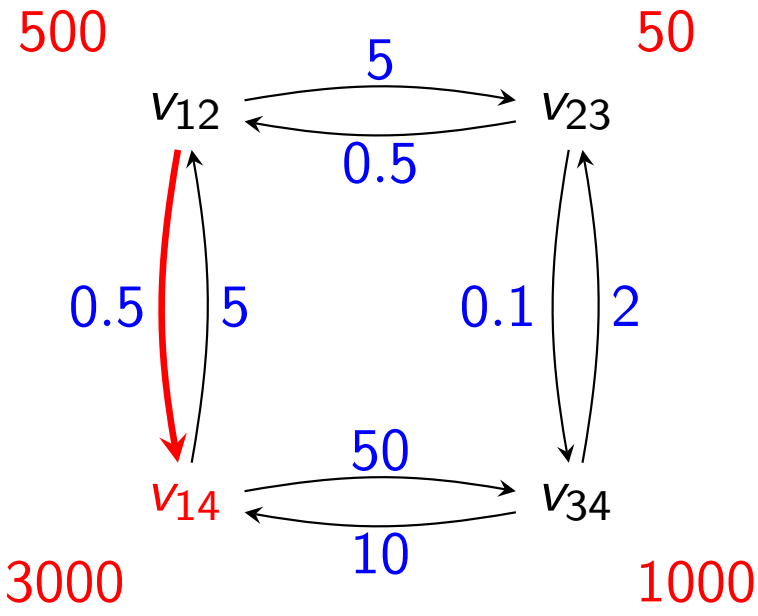


MVP - example



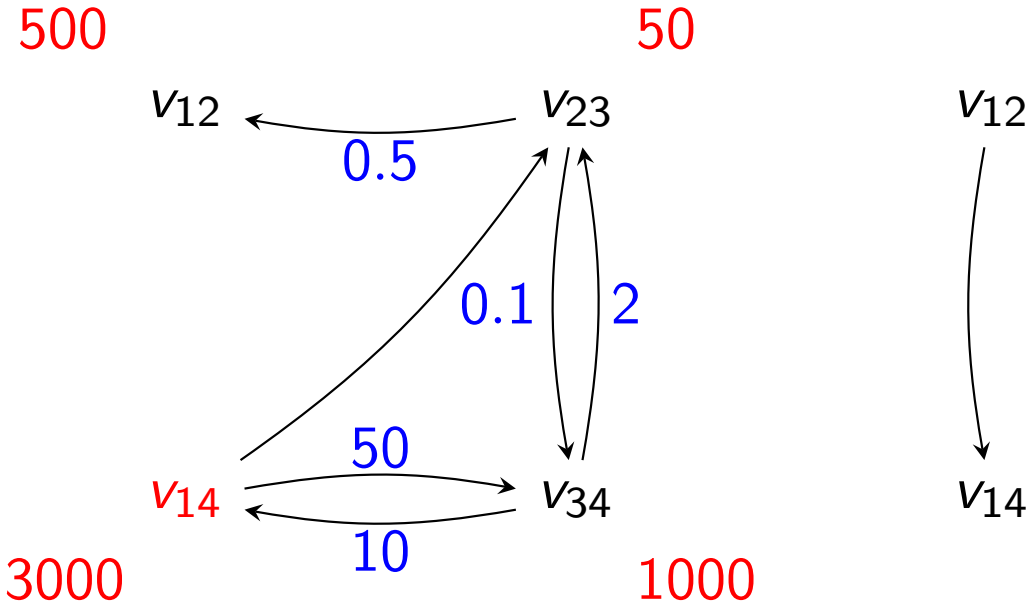
Start with v_{14},

MVP - example



Start with v_{14}, select the edge $v_{12} \rightarrow v_{14}$.
After v_{12} is executed, $|R_1 \bowtie R_2| = 500$
We replace R_1 by $R_1 \bowtie R_2$ in $v_{14} = R_1 \bowtie R_4$:
$v_{14} = (R_1 \bowtie R_2) \bowtie R_4$
$cost(v_{14}) = 500 * 100 * 0.05 + 500 = 3000$

MVP - example



Add edge to EST.

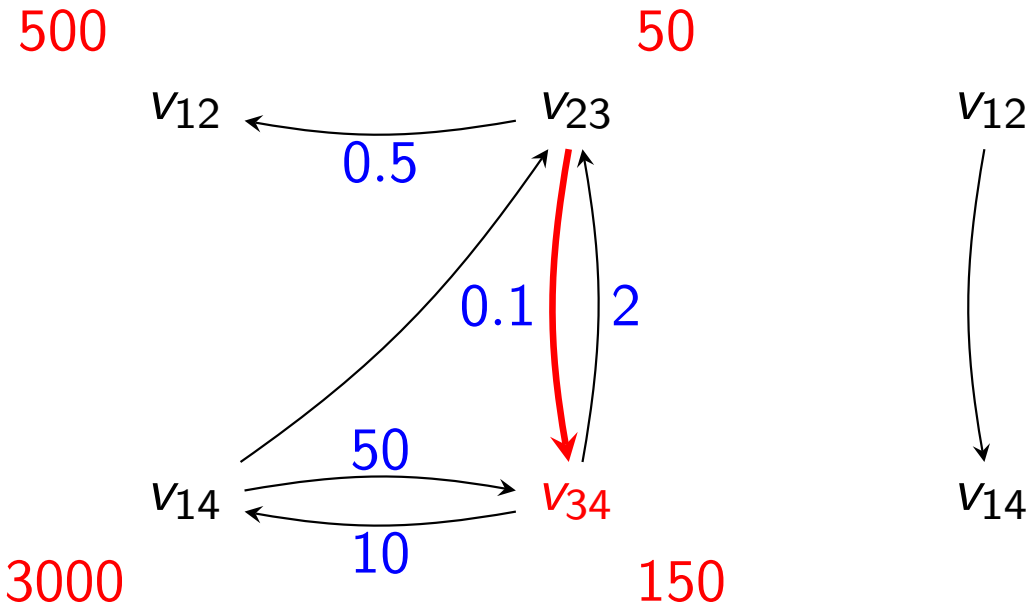
Add new edge $v_{14} \to v_{23}$.

Consider v_{14}, no incoming edge with weight < 1:

$Q_1 = v_{34}, v_{12}, v_{23}$.

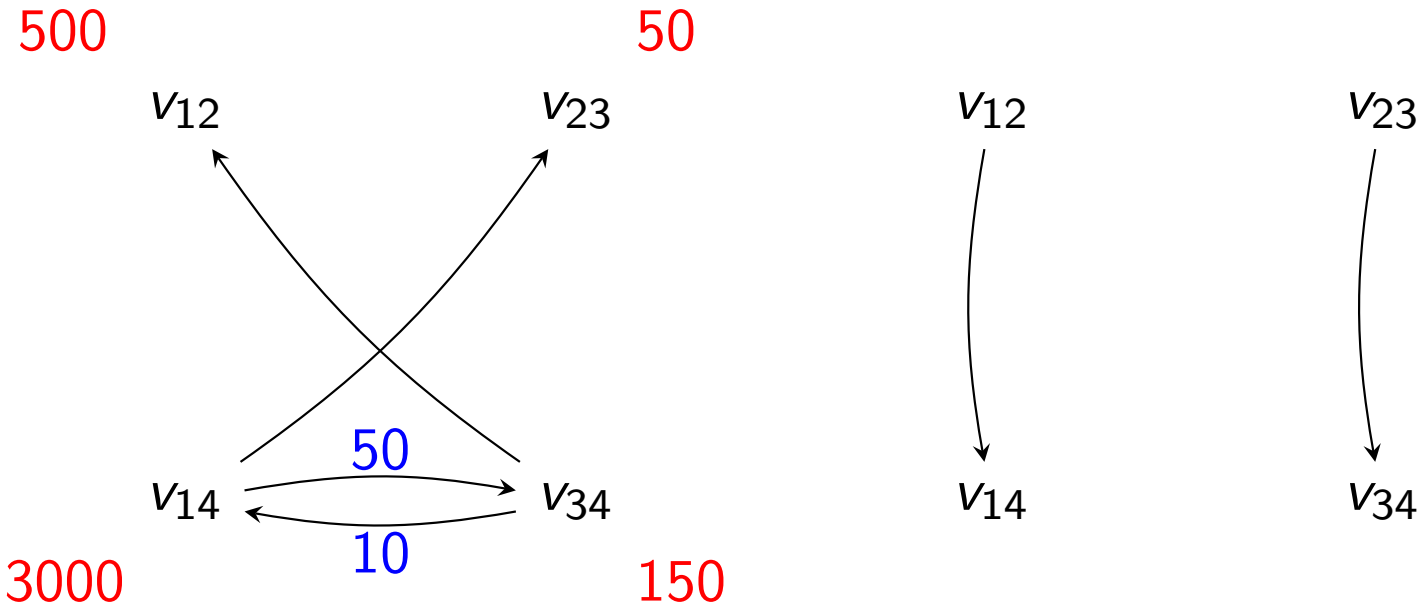
$Q_2 = v_{14}$

MVP - example



Consider v_{34}, one incoming edge with weight < 1:
Recompute cost: $cost(v_{34}) = 50 * 100 * 0.02 + 50 = 150$
$Q_1 = v_{12}, v_{34}, v_{23}$.
$Q_2 = v_{14}$

MVP - example

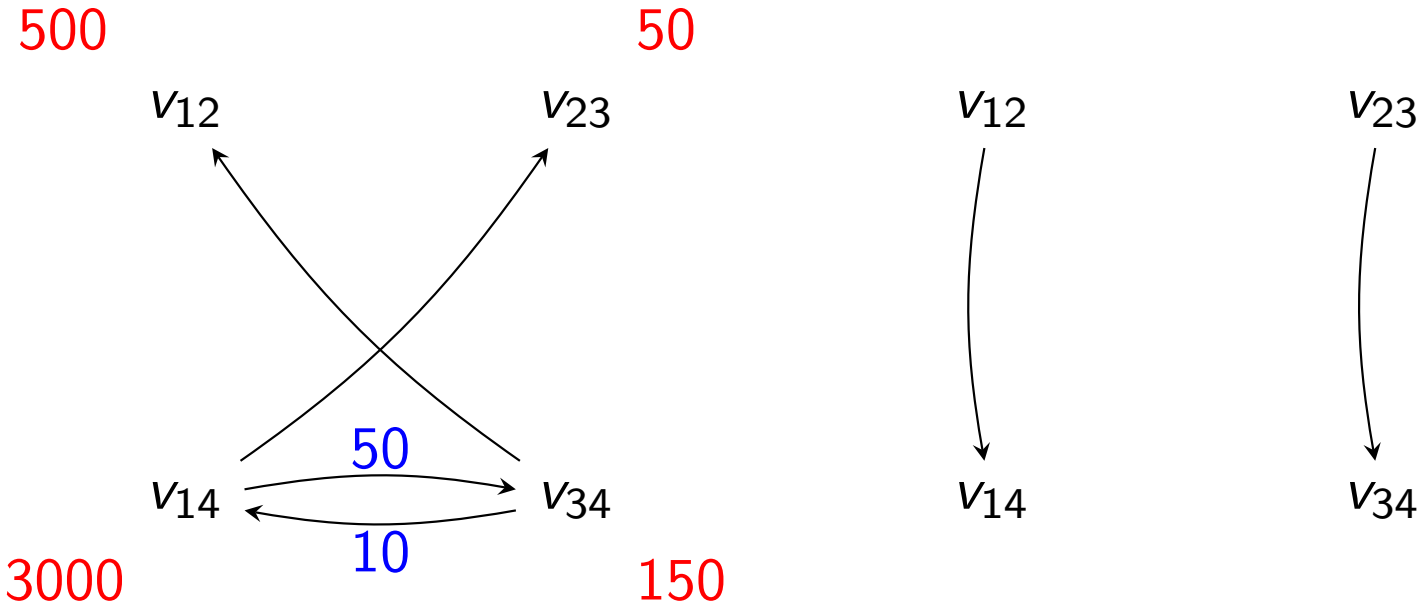


Remove edges, add to EST.

$Q_1 = v_{12}, v_{34}, v_{23}$.

$Q_2 = v_{14}$

MVP - example

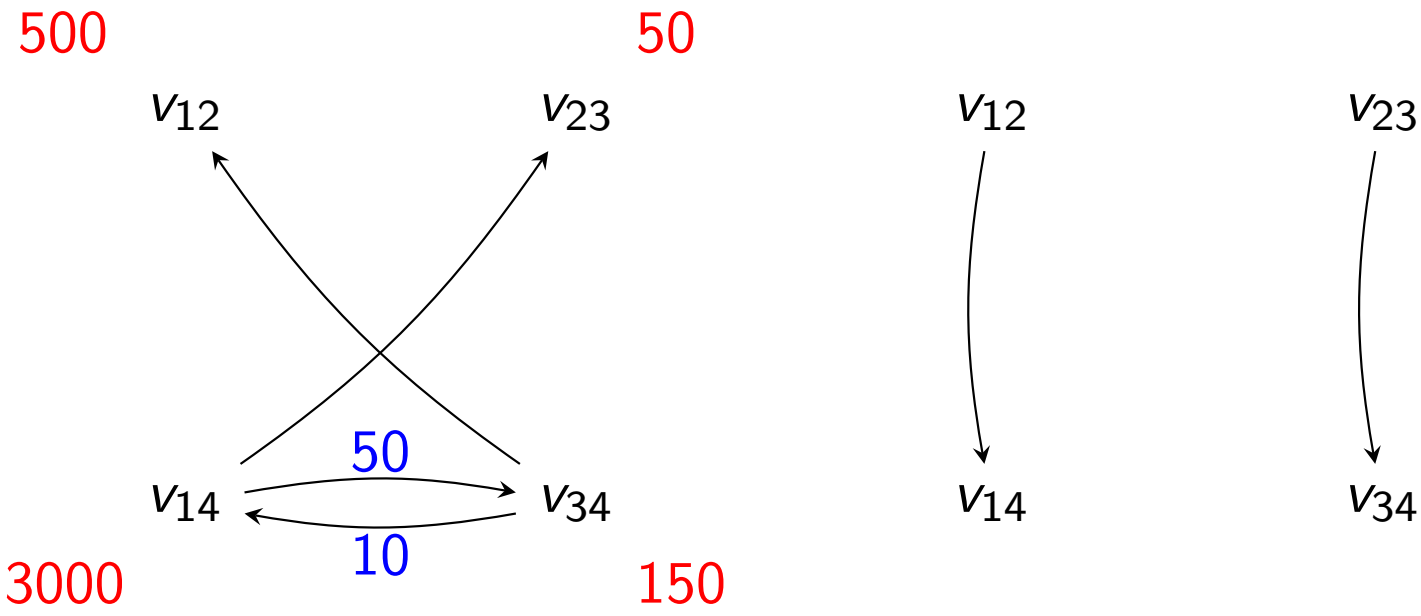


v_{12}: no incoming edge with the weight < 1

$Q_1 = v_{34}, v_{23}.$

$Q_2 = v_{12}, v_{14}$

MVP - example



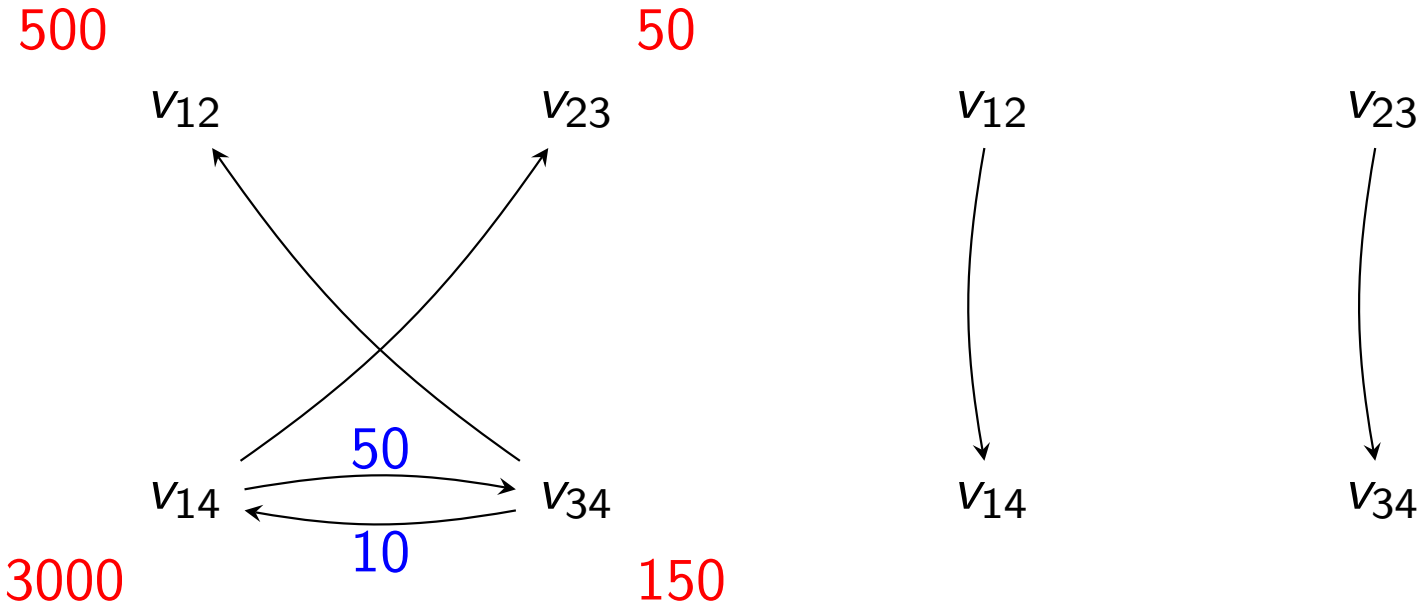
v_{34},v_{23}: no incoming edges with the weights > 1

$Q_1 = \emptyset$.

$Q_2 = v_{23}, v_{34}, v_{12}, v_{14}$

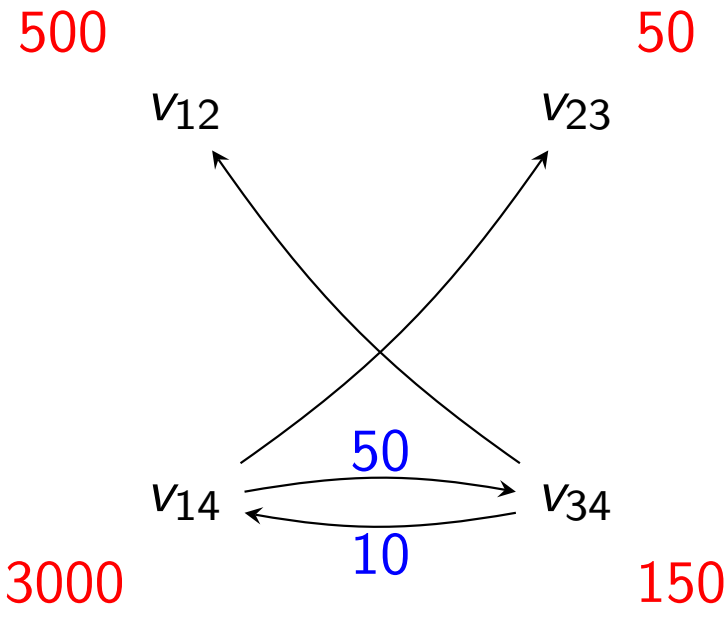
End of Step 1.

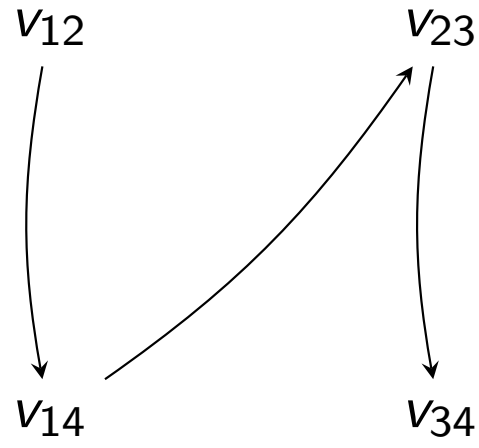
MVP - example



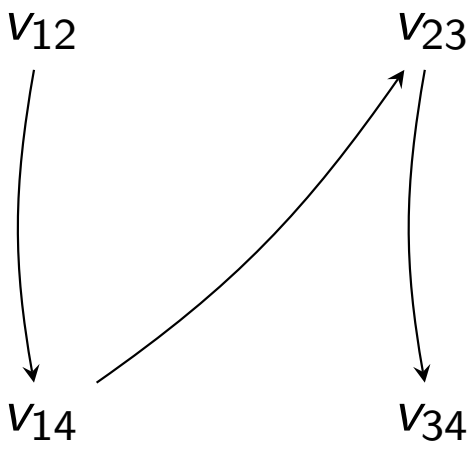
Step 2: try to increase the cost of the EST as little as possible.
v_{23}: one incoming edge, does not violate the EST conditions. Add it and stop.

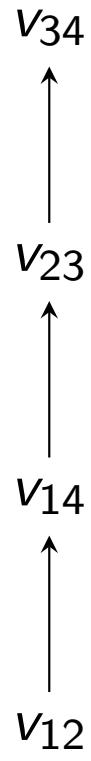
MVP - example





MVP - example





See also

C.Lee, C.Shih and Y.Chen. *Optimizing large join queries using a graph-based approach*. In *IEEE Transactions on Knowledge and Data Engineering*, 2001.

Overview Dynamic Programming Strategy

- generate optimal join trees bottom up
- start from optimal join trees of size one (relations)
- build larger join trees by (re-)using those of smaller sizes

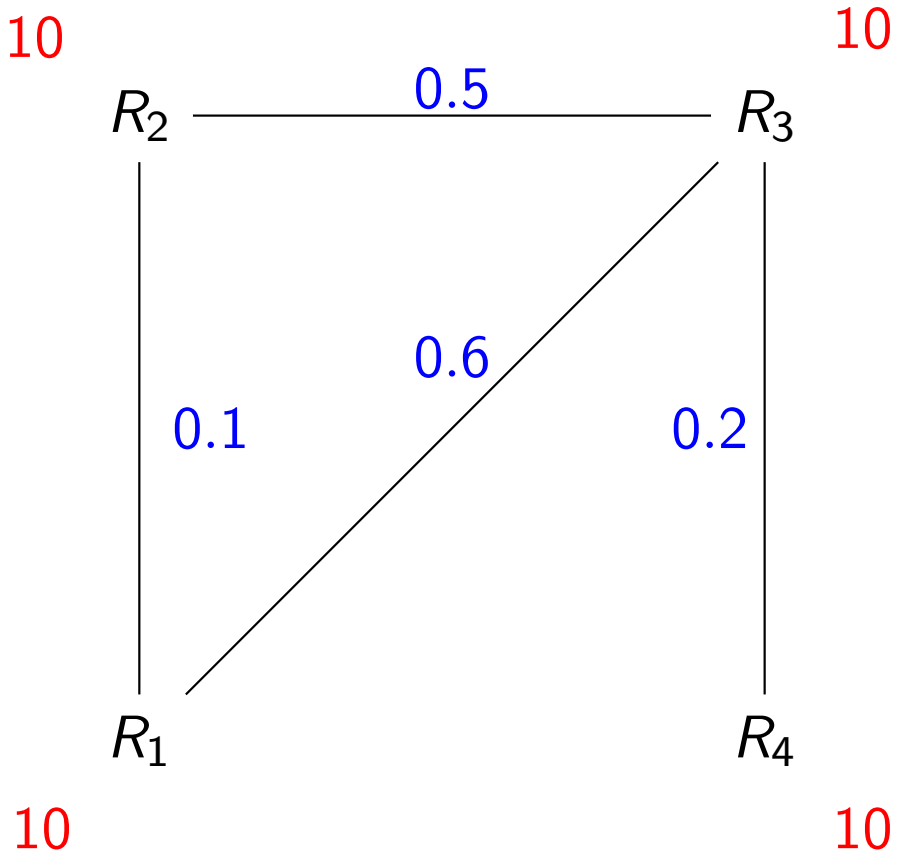
DP: Generating Linear Trees

DPsizeLinear(R)
Input: a set of relations $R = \{R_1, \ldots, R_n\}$ to be joined
Output: an optimal left-deep (right-deep, zig-zag) join tree
$B =$ an empty DP table $2^R \rightarrow$ join tree
for each $R_i \in R$
  $B[\{R_i\}] = R_i$
for each $1 < s \leq n$ **ascending** $\{$
  for each $S \subset R, R_i \in R : |S| = s - 1 \wedge R_i \notin S$ $\{$
    if $\neg$cross products $\wedge \neg S$ connected to R_i **continue**
    $p_1 = B[S], p_2 = B[\{R_i\}]$
    if $p_1 = \epsilon$ **continue**
    $P =$ CreateJoinTree(p_1, p_2);
    if $B[S \cup \{R_i\}] = \epsilon \vee C(B[S \cup \{R_i\}]) > C(P)$
      $B[S \cup \{R_i\}] = P$
  $\}$
$\}$
return $B[\{R_1, \ldots, R_n\}]$

DPsize

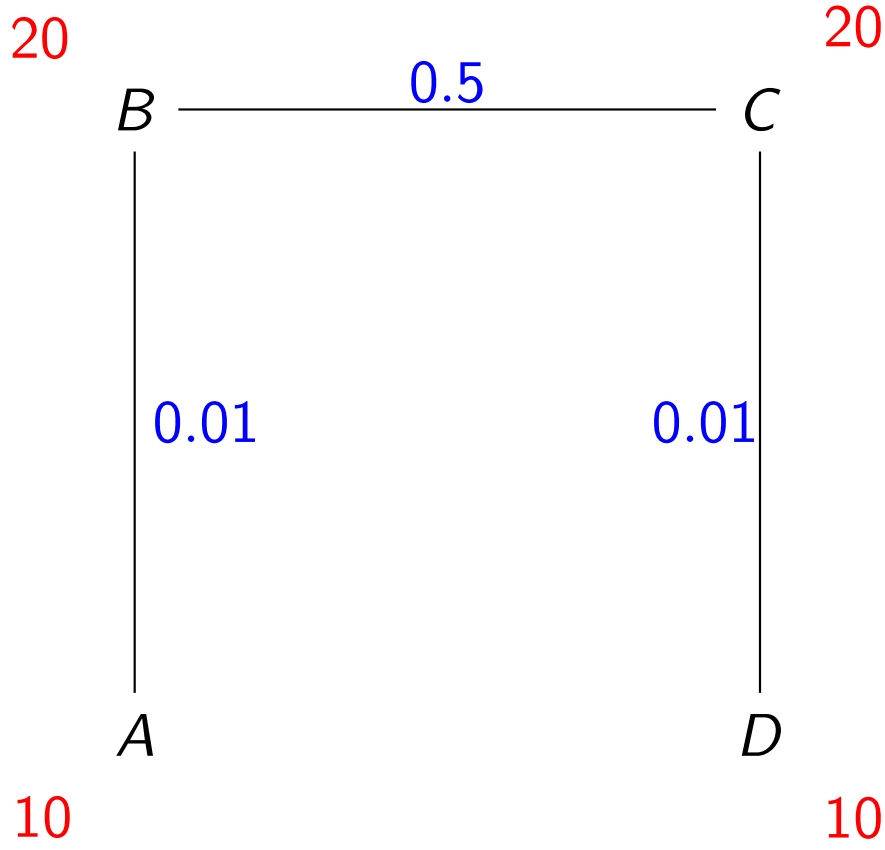
- iterate over subsets of the set of relations, the size is increasing
- S_1, S_2: $S_1 \cap S_2 = \emptyset$, S_1 is connected to S_2

DPsize - example



Bushy vs. Linear trees

- Linear: add one more relation every time, i.e. add R to optimal T_1 to get optimal $T = T_1 \bowtie R$
- Bushy: consider all pairs of optimal T_1 and T_2 to find optimal $T = T_1 \bowtie T_2$



DPsub

- Iterate over subsets in the integer order
- Before a join tree for S is generated, all the relevant subsets of S must be available

DPsub: Integer Enumeration

Enumerate $\{R_1, R_2, R_3, R_4\}$ in Integer order.

NB

The ability to build the DP table is crucial for passing the exam!

Homework: Task 1 (10 points)

Create the DP table (manually) for the relations A, B, C with cardinalities $|A| = 10$, $|B| = 20$, $|C| = 100$ and selectivities $f_{AB} = 0.5$, $f_{BC} = 0.1$ (cost function C_{out}). Mark the final table entries. Enumerate subsets in the integer order. Consider cross products.

Homework: Task 2 (20 points)

- Using the program from the last exercise as basis, implement Greedy Operator Ordering. Print the partial steps together with their costs (e.g., $P = R_1 \bowtie R_2 200, Q = P \bowtie R_3 400$), as well as the final join tree.
- Load the TPC H data set. (You can use our snapshot of the data set, the loadtpch-* script loads the data). Then, execute the following SQL query using the program implemented above:
  select *
  from lineitem l, orders o, customers c
  where l.l_orderkey=o.o_orderkey and o.o_custkey=c.c_custkey and c.c_name='Customer#000014993'.

Info

- Slides and exercises: www3.in.tum.de/teaching/ss13/qo
- Send any comments, questions, solutions for the exercises etc. to Andrey.Gubichev@in.tum.de
- Exercises due: 9 AM, May 26, 2014