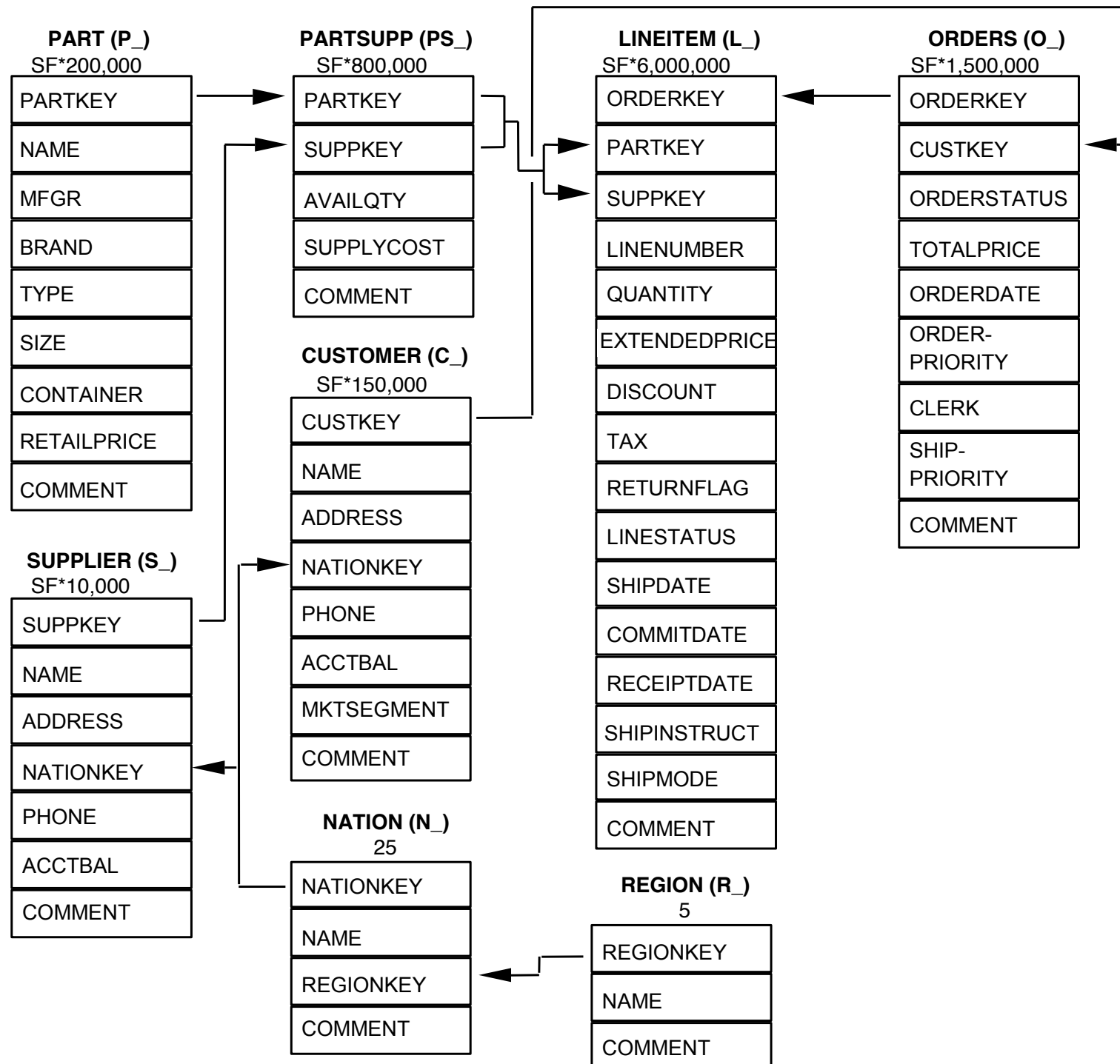# Project 3

Optimized Query Execution

1

Overview

1. Get your query processor to work with TPC-H.

2. Implement Hybrid Hash or Sort/Merge Join and a Relational Algebra Query Optimizer.

3. Implement Index Scan and Index-Nested Loop Join, and integrate them into your Optimizer.

Sunday, March 31, 13

TPC-H

- TPC - The Transaction Processing Council.

  - … defines database benchmarks.

- Benchmark H: Decision Support

  - http://www.tpc.org/tpch/

  - A major benchmark for database systems.

  - 22 query templates and a data generator.

3

TPC-H Schema

PART (P_)
SF*200,000

| PARTKEY |
| NAME |
| MFGR |
| BRAND |
| TYPE |
| SIZE |
| CONTAINER |
| RETAILPRICE |
| COMMENT |

PARTSUPP (PS_)
SF*800,000

| PARTKEY |
| SUPPKEY |
| AVAILQTY |
| SUPPLYCOST |
| COMMENT |

LINEITEM (L_)
SF*6,000,000

| ORDERKEY |
| PARTKEY |
| SUPPKEY |
| LINENUMBER |
| QUANTITY |
| EXTENDEDPRICE |
| DISCOUNT |
| TAX |
| RETURNFLAG |
| LINESTATUS |
| SHIPDATE |
| COMMITDATE |
| RECEIPTDATE |
| SHIPINSTRUCT |
| SHIPMODE |
| COMMENT |

ORDERS (O_)
SF*1,500,000

| ORDERKEY |
| CUSTKEY |
| ORDERSTATUS |
| TOTALPRICE |
| ORDERDATE |
| ORDER-PRIORITY |
| CLERK |
| SHIP-PRIORITY |
| COMMENT |

CUSTOMER (C_)
SF*150,000

| CUSTKEY |
| NAME |
| ADDRESS |
| NATIONKEY |
| PHONE |
| ACCTBAL |
| MKTSEGMENT |
| COMMENT |

SUPPLIER (S_)
SF*10,000

| SUPPKEY |
| NAME |
| ADDRESS |
| NATIONKEY |
| PHONE |
| ACCTBAL |
| COMMENT |

NATION (N_)
25

| NATIONKEY |
| NAME |
| REGIONKEY |
| COMMENT |

REGION (R_)
5

| REGIONKEY |
| NAME |
| COMMENT |

4

Part 1: DBGen

- Compiling DBGen: See instructions in project writeup.

  - Copy makefile.suite and modify it

  - Special instructions for OSX

- `dbgen -s [size in GB]`

  - Creates one .tbl file for each table.

5

DBGen Data File

```
1|3691|O|194029.55|1996-01-02|5-LOW|Clerk#000000951|0|nstructions sleep furiously among |
2|7801|O|60951.63|1996-12-01|1-URGENT|Clerk#000000880|0| foxes. pending accounts at the pending, silent asymptot|
3|12332|F|247296.05|1993-10-14|5-LOW|Clerk#000000955|0|sly final accounts boost. carefully regular ideas cajole carefully. depos|
4|13678|O|53829.87|1995-10-11|5-LOW|Clerk#000000124|0|sits. slyly regular warthogs cajole. regular, regular theodolites acro|
5|4450|F|139660.54|1994-07-30|5-LOW|Clerk#000000925|0|quickly. bold deposits sleep slyly. packages use slyly|
6|5563|F|65843.52|1992-02-21|4-NOT SPECIFIED|Clerk#000000058|0|ggle. special, final requests are against the furiously specia|
7|3914|O|231037.28|1996-01-10|2-HIGH|Clerk#000000470|0|ly special requests |
32|13006|O|166802.63|1995-07-16|2-HIGH|Clerk#000000616|0|ise blithely bold, regular requests. quickly unusual dep|
33|6697|F|118518.56|1993-10-27|3-MEDIUM|Clerk#000000409|0|uriously. furiously final request|
34|6101|O|75662.77|1998-07-21|3-MEDIUM|Clerk#000000223|0|ly final packages. fluffily final deposits wake blithely ideas. spe|
35|12760|O|192885.43|1995-10-23|4-NOT SPECIFIED|Clerk#000000259|0|zzle. carefully enticing deposits nag furio|
36|11527|O|72196.43|1995-11-03|1-URGENT|Clerk#000000358|0| quick packages are blithely. slyly silent accounts wake qu|
37|8612|F|156440.15|1992-06-03|3-MEDIUM|Clerk#000000456|0|kly regular pinto beans. carefully unusual waters cajole never|
38|12484|O|64695.26|1996-08-21|4-NOT SPECIFIED|Clerk#000000604|0|haggle blithely. furiously express ideas haggle blithely furiously regular re|
39|8177|O|307811.89|1996-09-20|3-MEDIUM|Clerk#000000659|0|ole express, ironic requests: ir|
64|3212|F|30616.90|1994-07-16|3-MEDIUM|Clerk#000000661|0|wake fluffily. sometimes ironic pinto beans about the dolphin|
65|1627|P|99763.79|1995-03-18|1-URGENT|Clerk#000000632|0|ular requests are blithely pending orbits-- even requests against the deposit|
66|12920|F|100991.26|1994-01-20|5-LOW|Clerk#000000743|0|y pending requests integrate|
67|5662|O|167270.36|1996-12-19|4-NOT SPECIFIED|Clerk#000000547|0|symptotes haggle slyly around the furiously iron|
68|2855|O|305815.83|1998-04-18|3-MEDIUM|Clerk#000000440|0| pinto beans sleep carefully. blithely ironic deposits haggle furiously acro|
69|8449|F|228015.94|1994-06-04|4-NOT SPECIFIED|Clerk#000000330|0| depths atop the slyly thin deposits detect among the furiously silent accou|
70|6434|F|133507.10|1993-12-18|5-LOW|Clerk#000000322|0| carefully ironic request|
71|338|O|244449.86|1998-01-24|4-NOT SPECIFIED|Clerk#000000271|0| express deposits along the blithely regul|
96|10778|F|72504.36|1994-04-17|2-HIGH|Clerk#000000395|0|oost furiously. pinto|
97|2107|F|128590.11|1993-01-29|3-MEDIUM|Clerk#000000547|0|hang blithely along the regular accounts. furiously even ideas after the|
98|10448|F|62956.90|1994-09-25|1-URGENT|Clerk#000000448|0|c asymptotes. quickly regular packages should have to nag re|
99|8891|F|136624.34|1994-03-13|4-NOT SPECIFIED|Clerk#000000973|0|e carefully ironic packages. pending|
100|14701|O|204408.59|1998-02-28|4-NOT SPECIFIED|Clerk#000000577|0|heodolites detect slyly alongside of the ent|
101|2800|O|142434.13|1996-03-17|3-MEDIUM|Clerk#000000419|0|ding accounts above the slyly final asymptote|
102|73|O|172239.95|1997-05-09|2-HIGH|Clerk#000000596|0| slyly according to the asymptotes. carefully final packages integrate furious|
103|2911|O|147675.81|1996-06-20|4-NOT SPECIFIED|Clerk#000000090|0|ges. carefully unusual instructions haggle quickly regular f|
128|7396|F|57495.50|1992-06-15|1-URGENT|Clerk#000000385|0|ns integrate fluffily. ironic asymptotes after the regular excuses nag around |
129|7114|F|273469.52|1992-11-19|5-LOW|Clerk#000000859|0|ing tithes. carefully pending deposits boost about the silently express |
130|3697|F|169065.69|1992-05-08|2-HIGH|Clerk#000000036|0|le slyly unusual, regular packages? express deposits det|
131|9275|F|143898.91|1994-06-08|3-MEDIUM|Clerk#000000625|0|after the fluffily special foxes integrate s|
132|2641|F|180897.80|1993-06-11|3-MEDIUM|Clerk#000000488|0|sits are daringly accounts. carefully regular foxes sleep slyly about the|
133|4400|O|120535.39|1997-11-29|1-URGENT|Clerk#000000738|0|usly final asymptotes |
134|620|F|203218.79|1992-05-01|4-NOT SPECIFIED|Clerk#000000711|0|lar theodolites boos|
135|6049|O|280793.15|1995-10-21|4-NOT SPECIFIED|Clerk#000000804|0|l platelets use according t|
```

DBGen Data File

- ' | '-Separated Fields

- Datatypes

  - Integers

  - Decimals (Floats)

  - Strings (Varchar, Char)

  - Dates (YYYY-MM-DD)
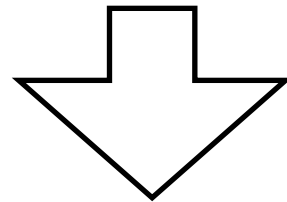
    - Represent as Integer: YYYYMMDD

7

Todo?

- Add a main function

  - ./sql [filename]

- Generate a 0.1 GB Database with DBGen

- Add support for parsing DBGen files.

  - Add support for parsing date types

- Test TPC-H Queries 1, 3, 5, 6, 10 and 19

8

Part 2: Optimization
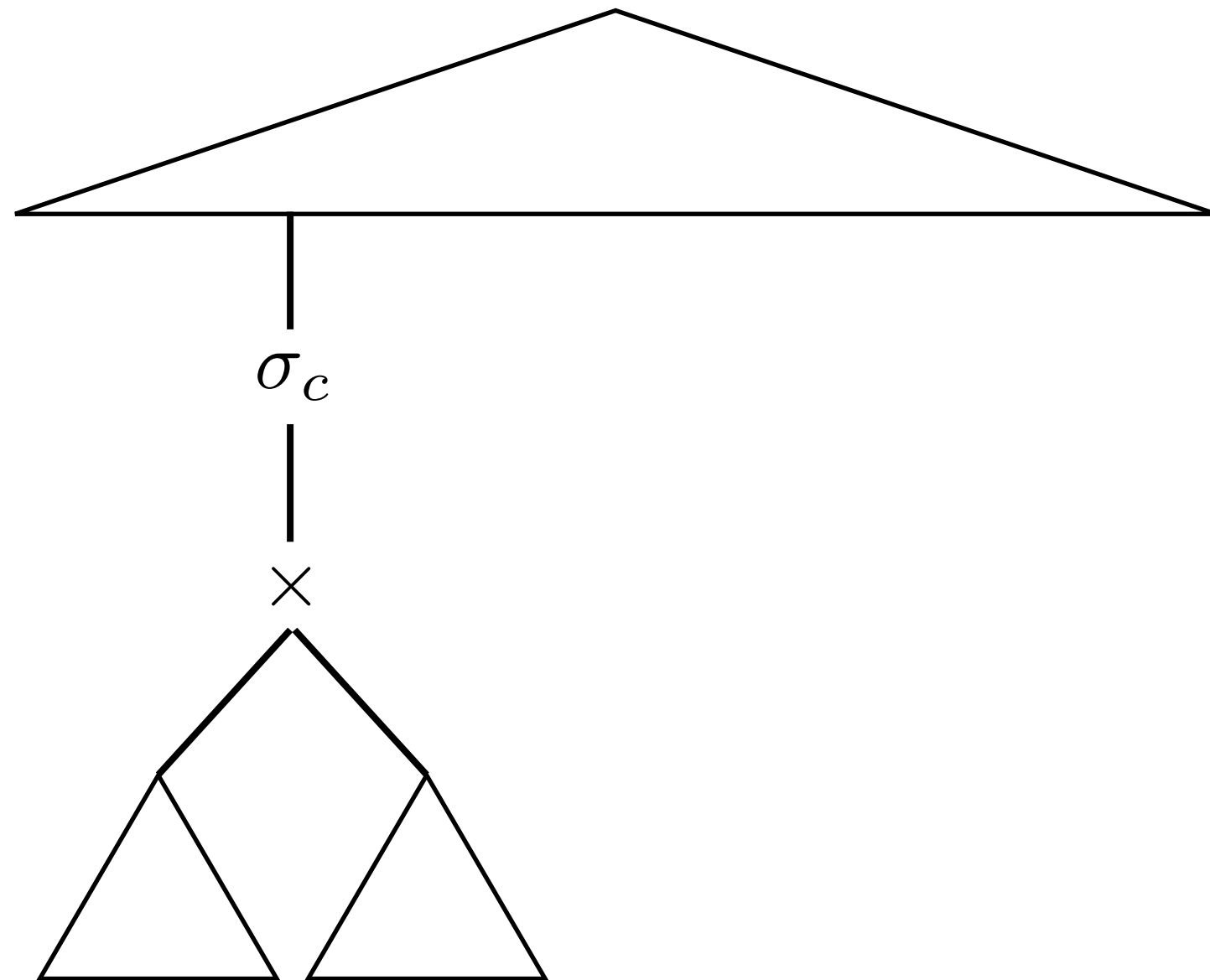
$$\pi_{\vec{a}}(\sigma_{c \wedge c'}(\pi_{\vec{a}'}(R) \times (S \times T))))$$

Part 2: Optimization

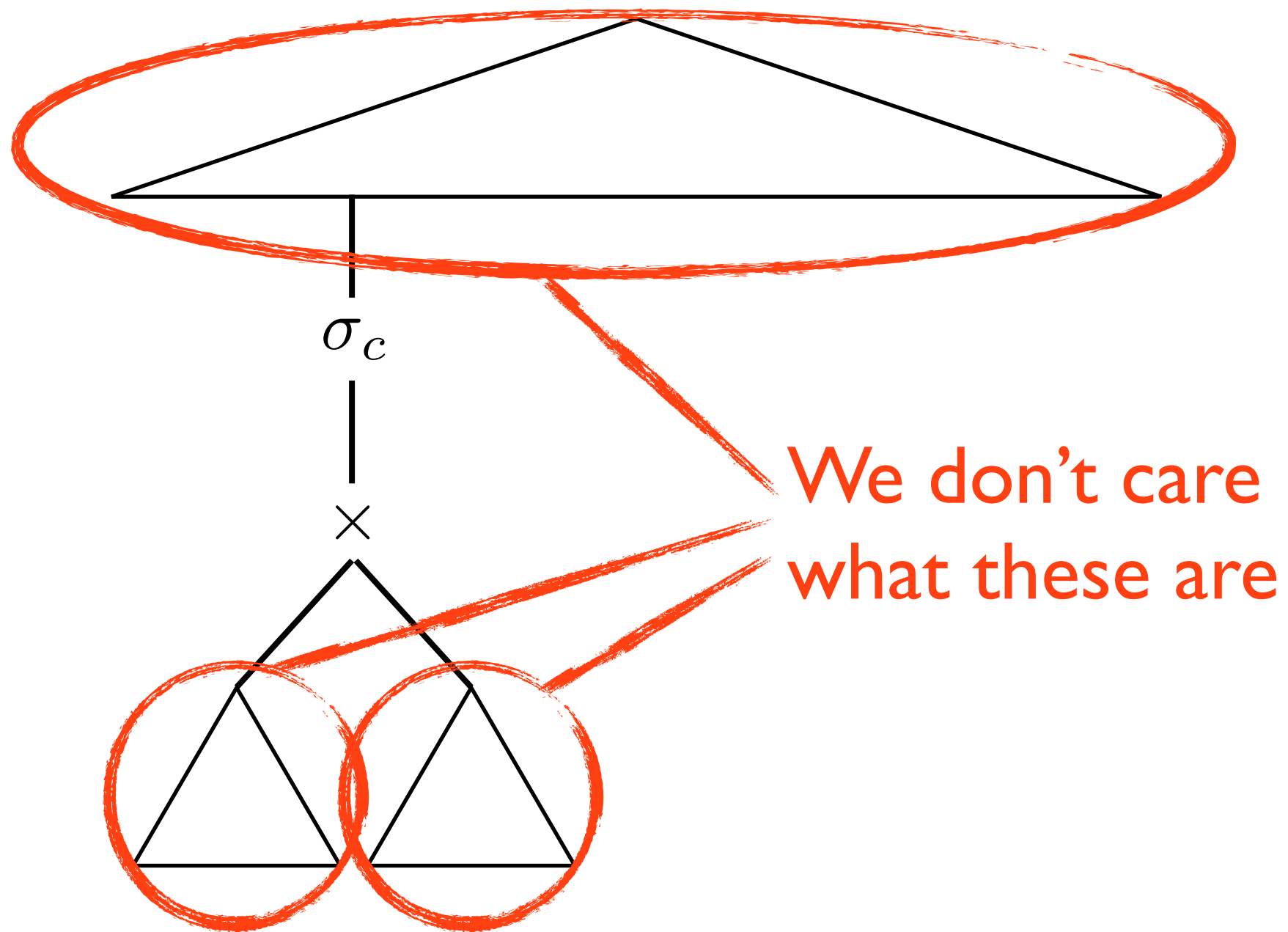$$\pi_{\vec{a}}(\sigma_{c \wedge c'}(\pi_{\vec{a}'}(R) \times (S \times T))))$$

$$\Downarrow$$

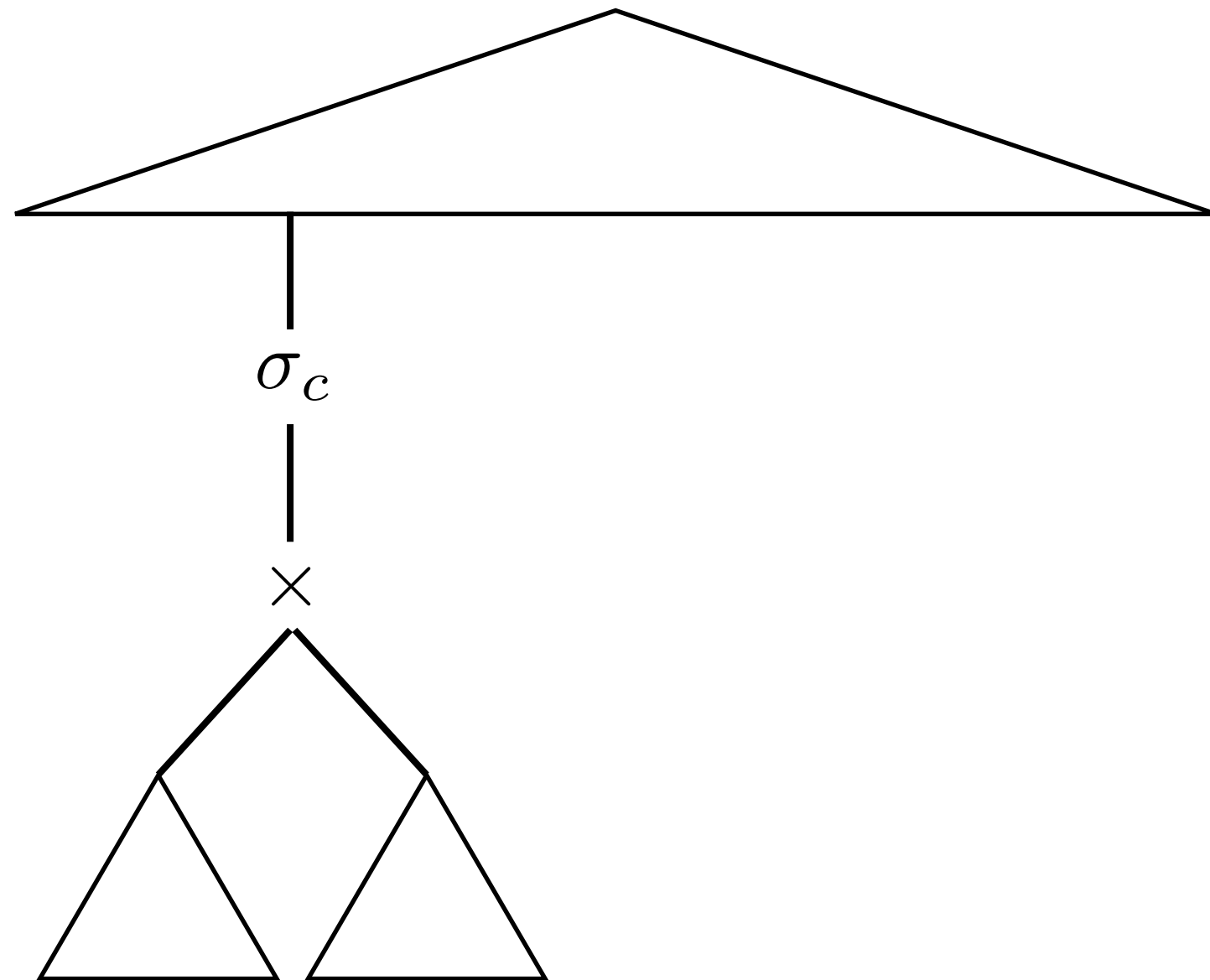$$\pi_{\vec{a}}(\sigma_{c}(\pi_{\vec{a}'}(R) \bowtie_{c'} (S \times T))))$$

9
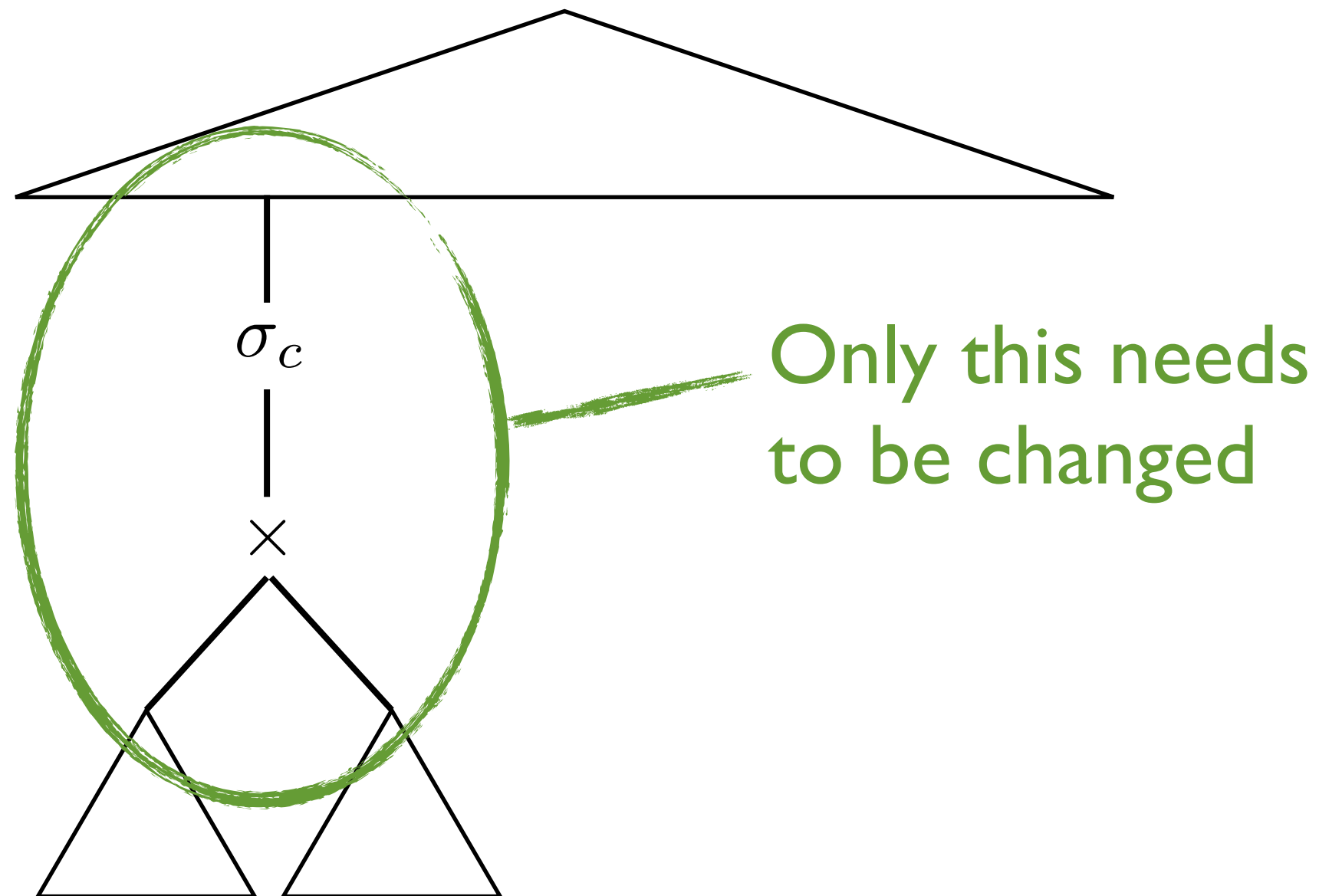
Part 2: Optimization

The figure shows a tree diagram with a large triangle at top connected by a vertical edge labeled σ_c to a node marked $\times$, which branches into two smaller triangles below.

Part 2: Optimization

σ_c

$\times$

We don't care
what these are

Part 2: Optimization

$$\sigma_c$$

$$\times$$

Part 2: Optimization

σ_c

Only this needs
to be changed

Part 2: Optimization

$$\bowtie_c$$

Part 2: Optimization

$$\bowtie_c$$
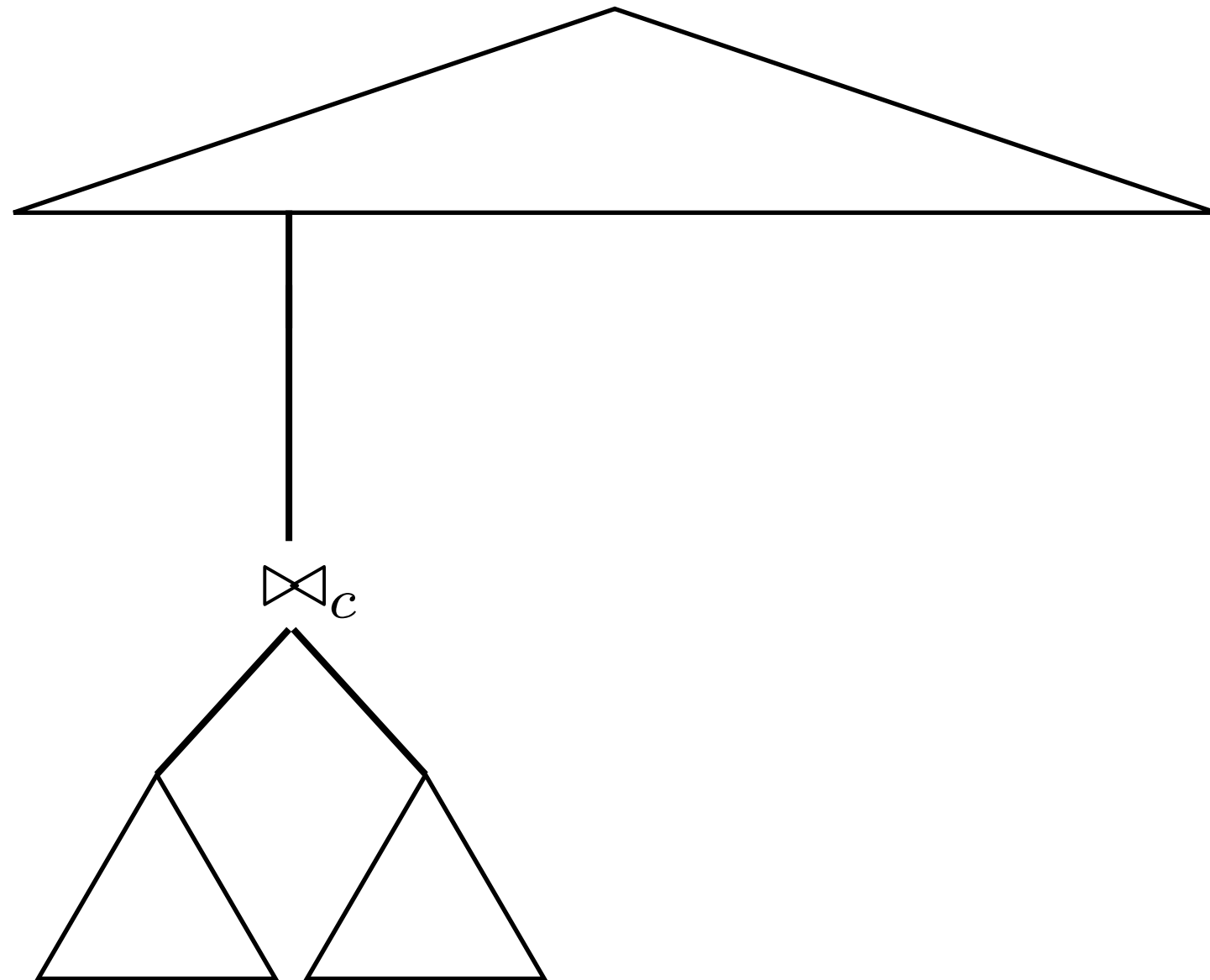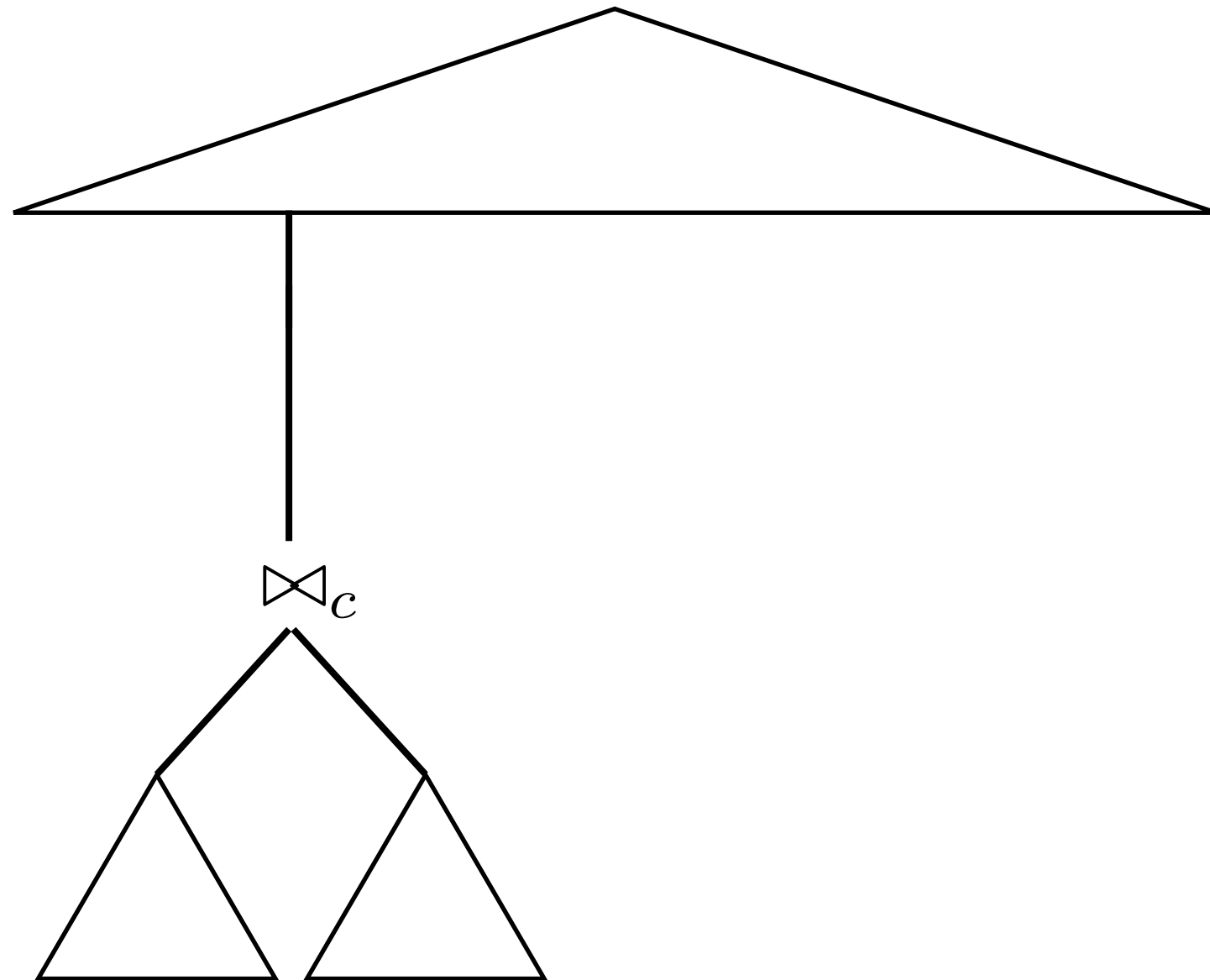
Part 2: Optimization

- `PlanRewrite:` Apply a transformation to every node in a relational algebra tree.

- Find every node where a rewrite is applicable and apply it.

  - E.g., a Select node with a NL join as its child.

  - Also push-down selects, push-down projects.

- Implement Hybrid Hash or Sort/Merge Join.

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Part 2: Optimization

- Implement an -explain flag in your project's main function. Should print out:

  - Before: The original RA query.

  - After: The optimized RA query.

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Part 3: Indexing

- Look at the query workload:

  - TPC-H Queries 1, 3, 5, 6, 10 and 19

- Determine what indexes can/will help you.

  - Use -examine!

- Add an -index flag to build these indexes.

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Part 3: Indexing

- Implement Index Scan.

- Implement Index-Nested Loop Join.

- Modify your optimizer to create these where appropriate.

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Extra Credit

- Implement Sort/Limit

  - Can combine sort with merge-sort

- Track which subtrees are sorted, and on what attribute.

  - Avoid re-sorting an already sorted dataset.

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Racing Implementations

- Bi-Weekly (Wednesday night, Sunday night)

- All submitted projects will be timed and measured for memory use.

  - Your score is based on how well your implementation does relative to the median performance of all groups.

- Top 5 teams each run win 15 bonus pts (up to 30)

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Project 4

- Optional Project

- List of project ideas in project 3 writeup.

  - … or pick your own!

- Add a feature to your query processor.

- Evaluate your added feature.

- Document your findings.

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Project 4

- Step 1: Determine which project you want to do.

- Step 2: Decide on implementation and evaluation strategies.

- Step 3: Discuss the project with me.

- Step 4: Go!

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