🪂 Parachute: Single-Pass Bi-Directional Information Passing

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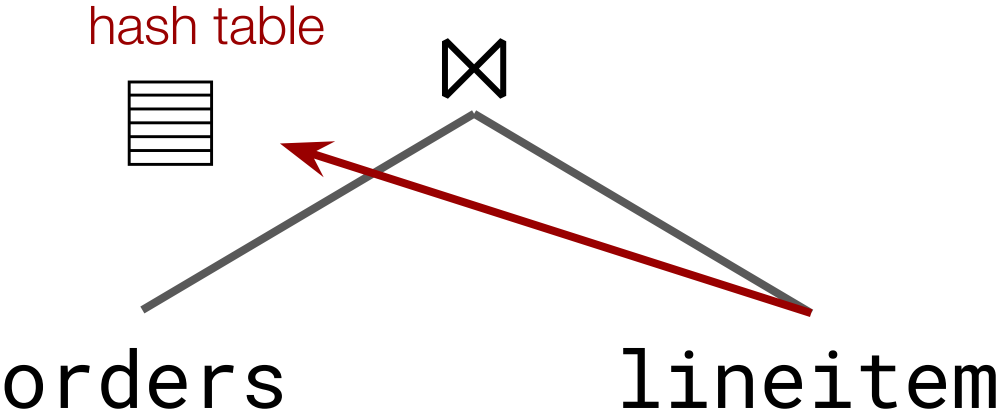
Databases for OLAP @VLDB’25

UTN Technische Universität Nürnberg

Massachusetts Institute of Technology

Semi-Join Filtering



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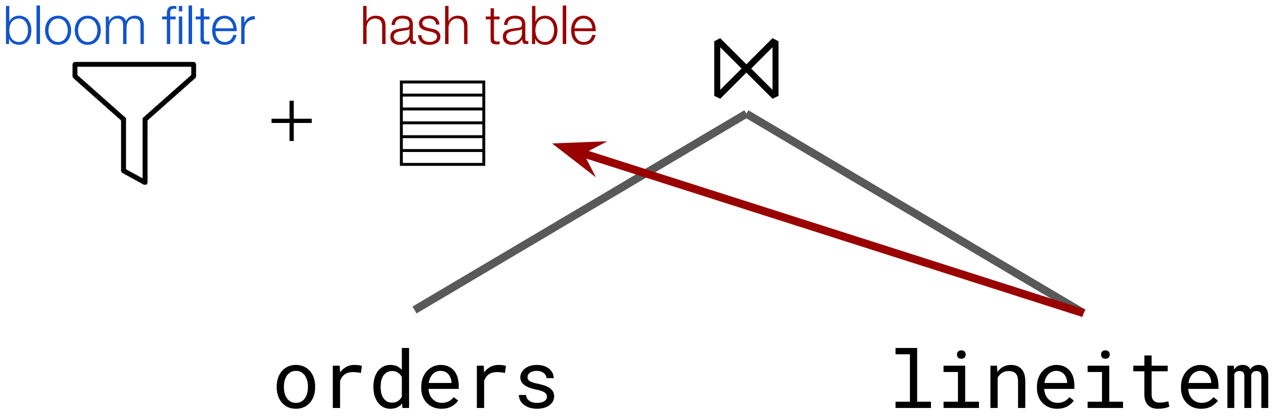

bloom filter + hash table

$\bowtie$

orders

lineitem

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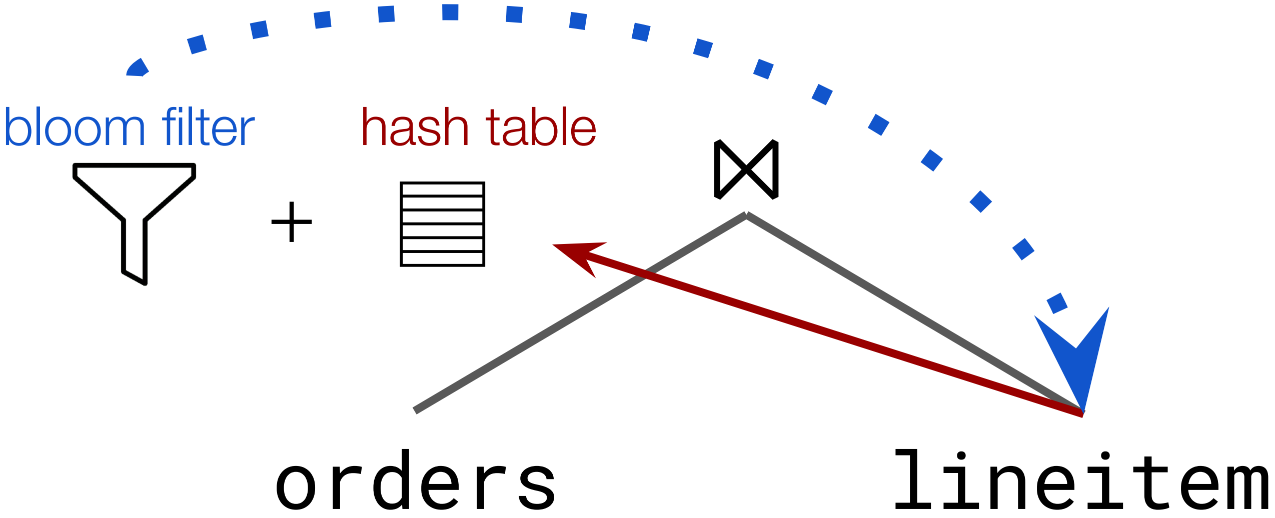

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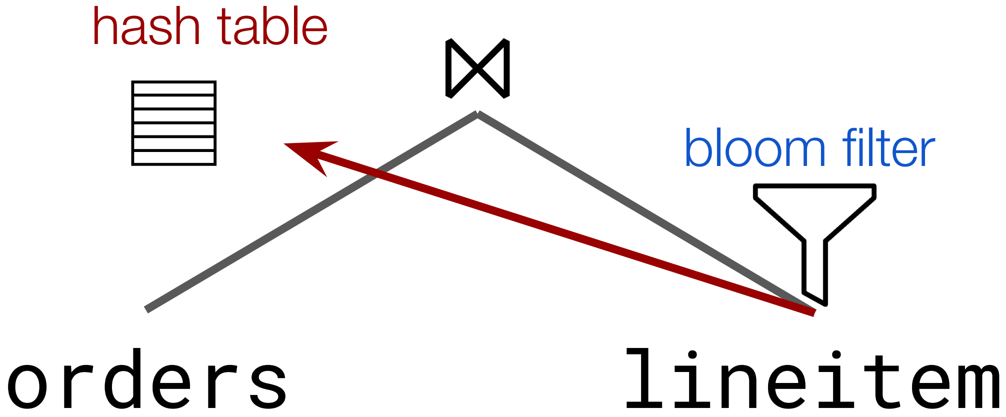

Semi-Join Filtering

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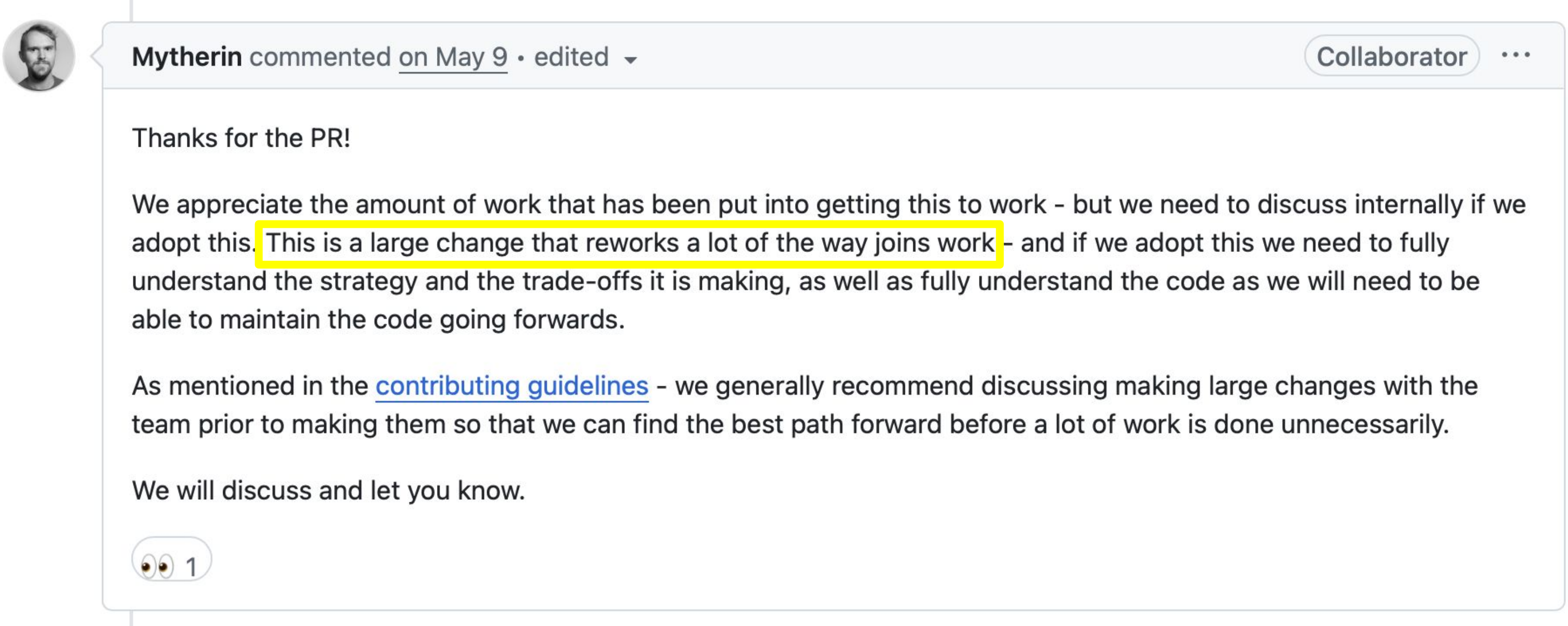

Mytherin commented on May 9 • edited ▾ Collaborator ···

Thanks for the PR!

We appreciate the amount of work that has been put into getting this to work - but we need to discuss internally if we adopt this. This is a large change that reworks a lot of the way joins work - and if we adopt this we need to fully understand the strategy and the trade-offs it is making, as well as fully understand the code as we will need to be able to maintain the code going forwards.

As mentioned in the contributing guidelines - we generally recommend discussing making large changes with the team prior to making them so that we can find the best path forward before a lot of work is done unnecessarily.

We will discuss and let you know.

👀 1

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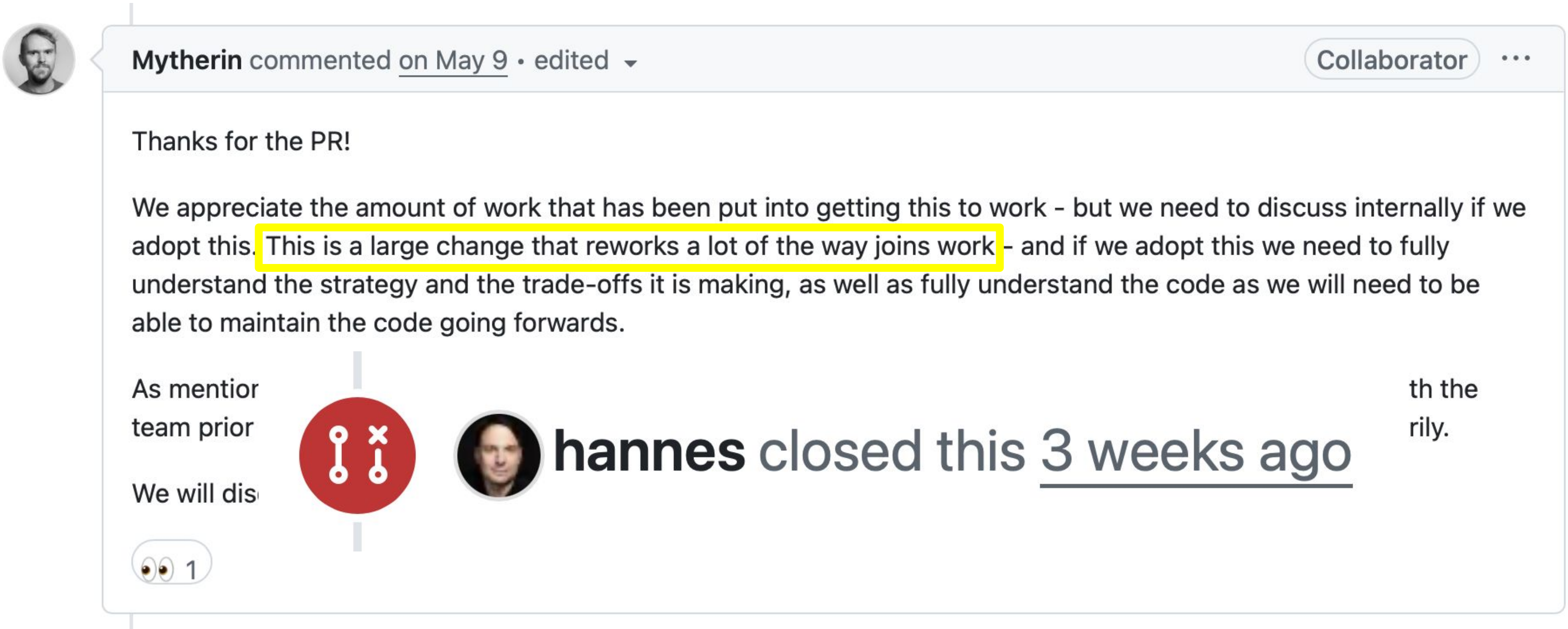

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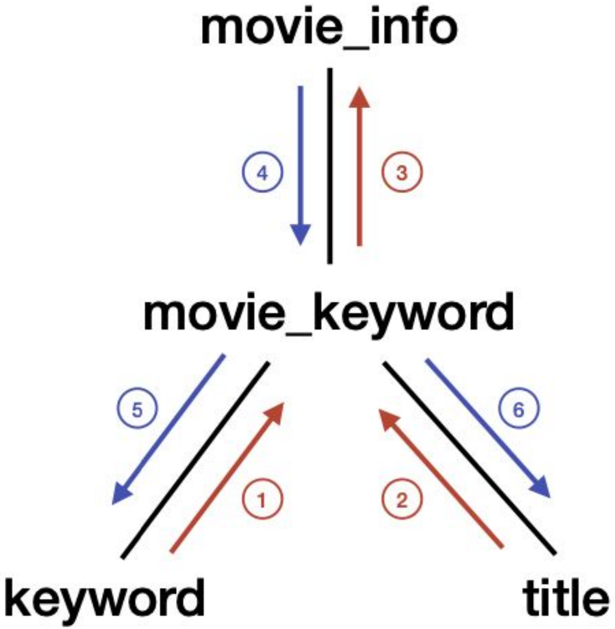
hannes closed this 3 weeks ago

But Why?



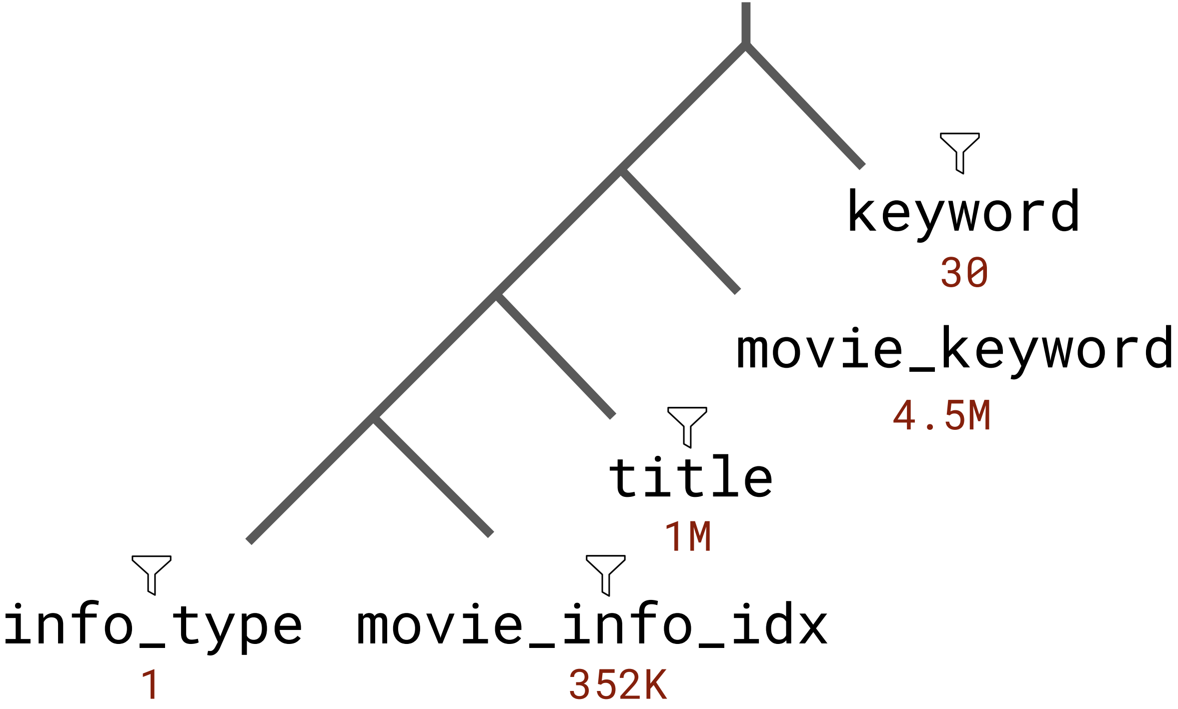
Forward Pass

1. movie_keyword $\ltimes$ keyword
2. movie_keyword $\ltimes$ title
3. movie_info $\ltimes$ movie_keyword

Backward Pass

4. movie_keyword $\ltimes$ movie_info
5. keyword $\ltimes$ movie_keyword
6. title $\ltimes$ movie_keyword

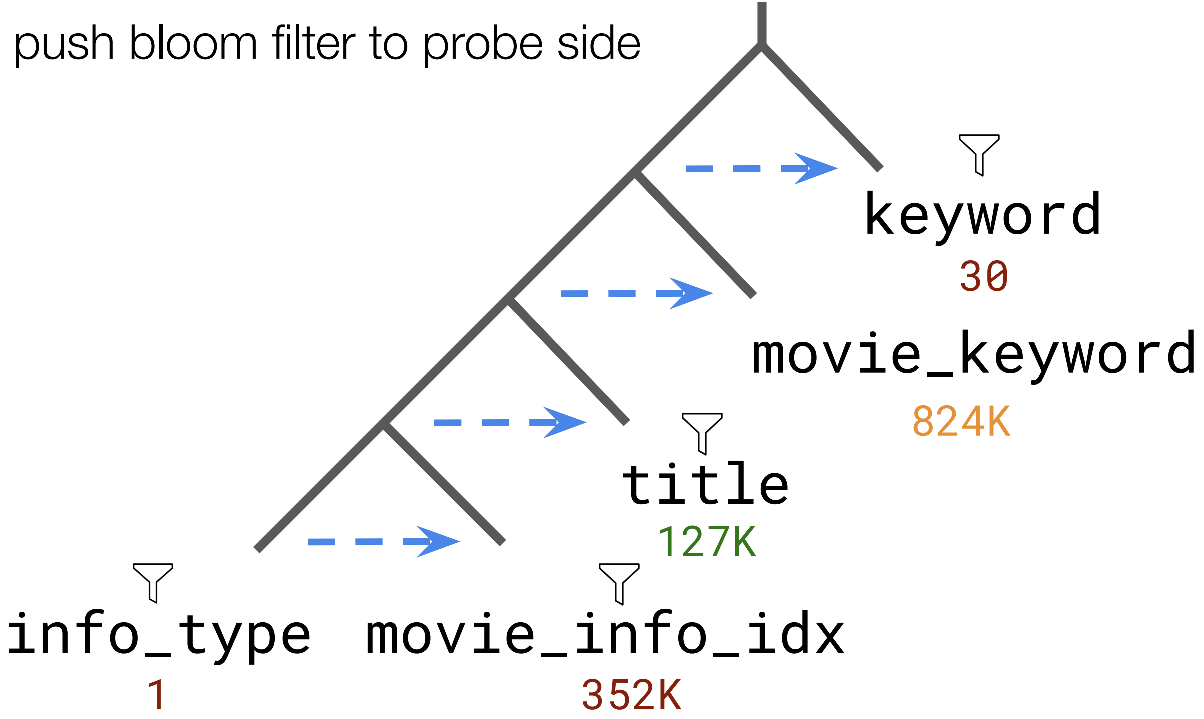
Semi-Join Filtering: Why We Love It



duckdb: 0.32s

Semi-Join Filtering: Why We Love It

⇢ = push bloom filter to probe side



keyword
30

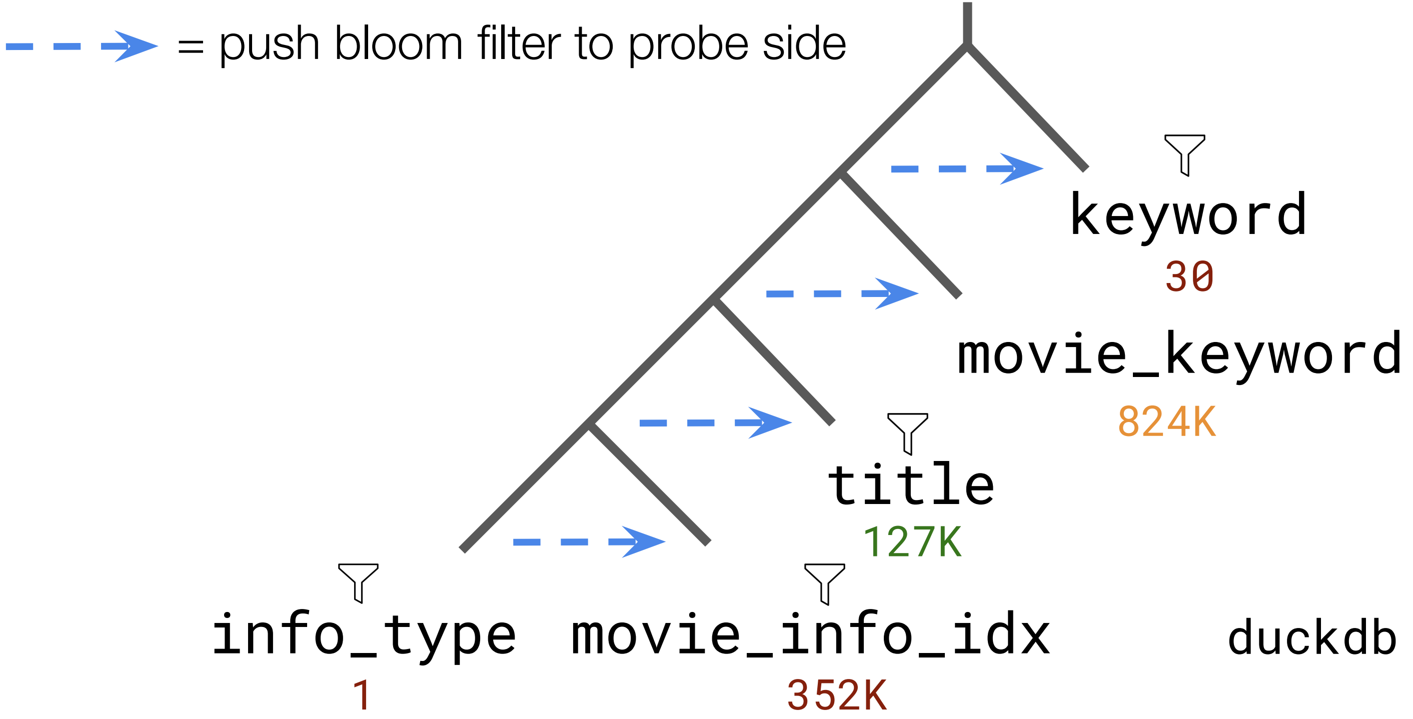
movie_keyword
824K

title
127K

info_type
1

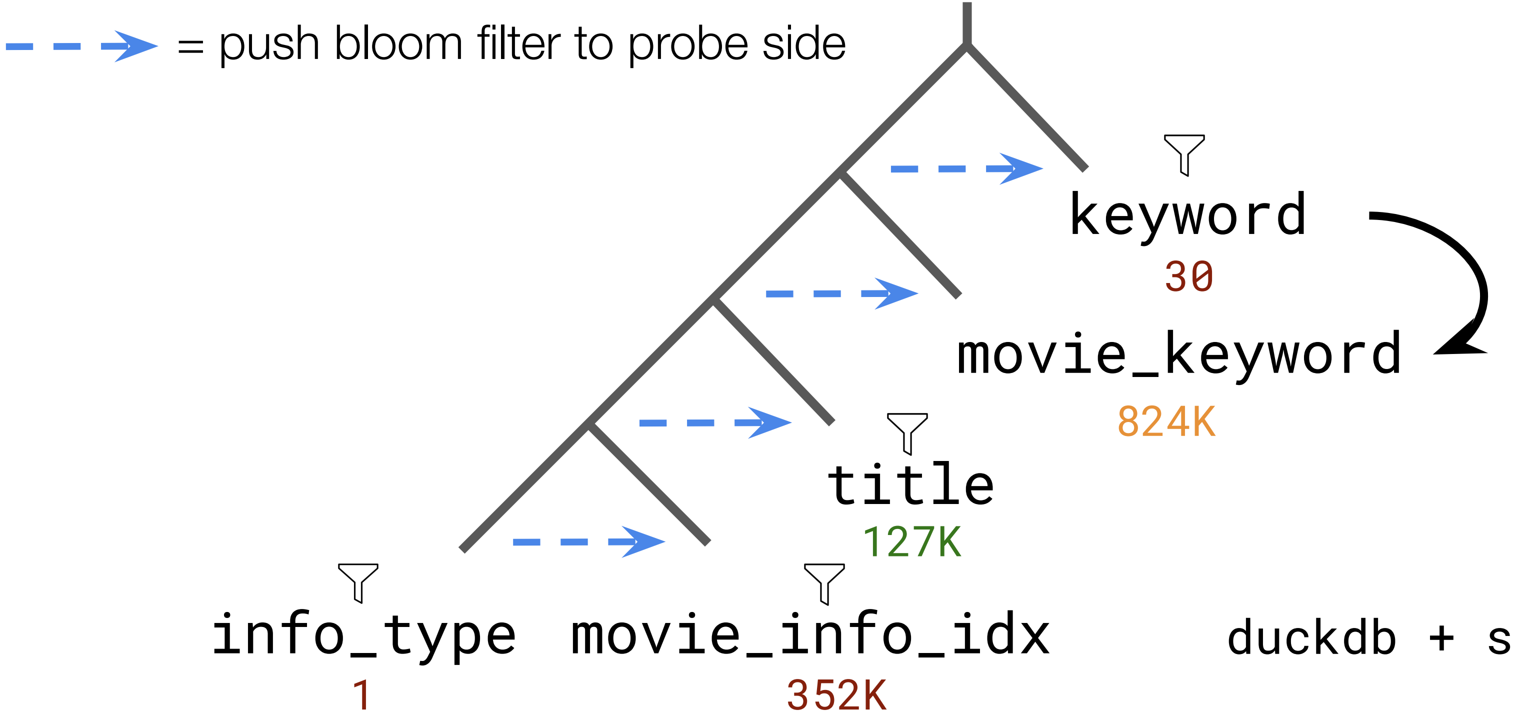
movie_info_idx
352K

Semi-Join Filtering: Why We Love It



duckdb + sjf: 0.27s

Semi-Join Filtering: *The Missing Bit*



duckdb + sjf: 0.27s

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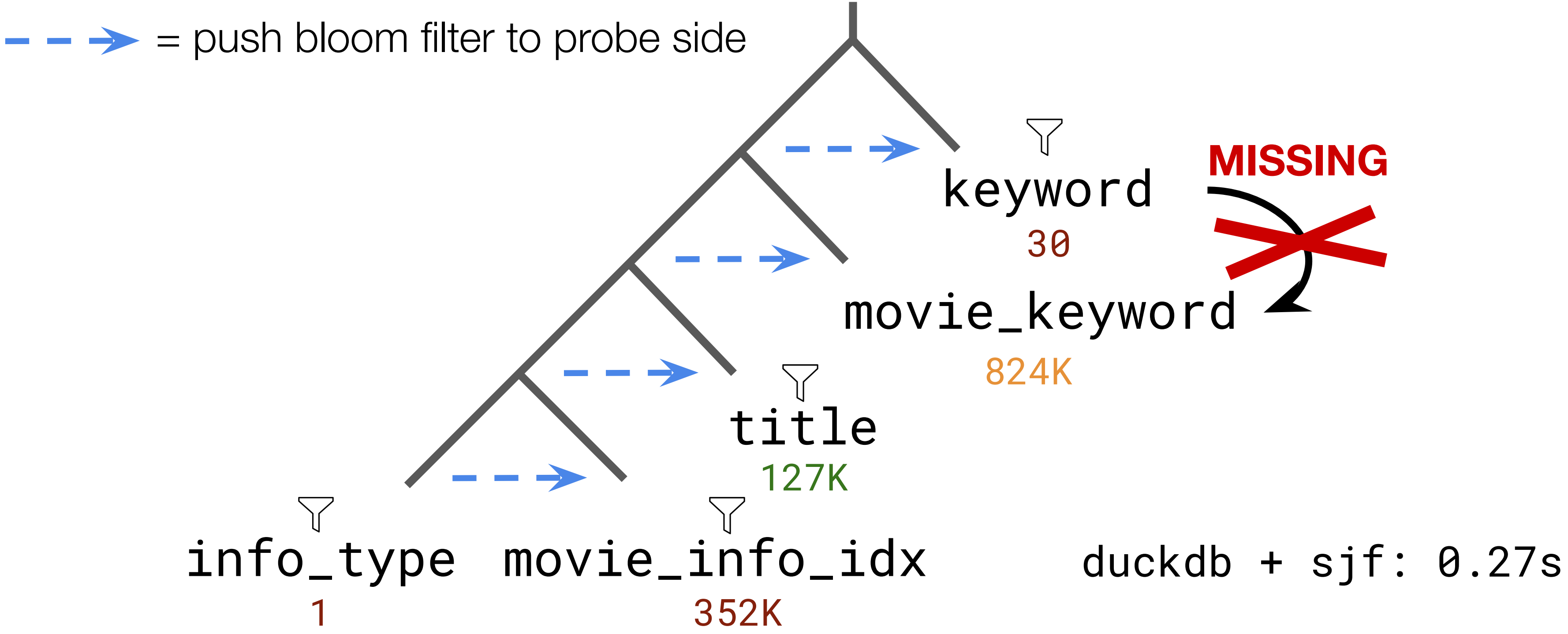
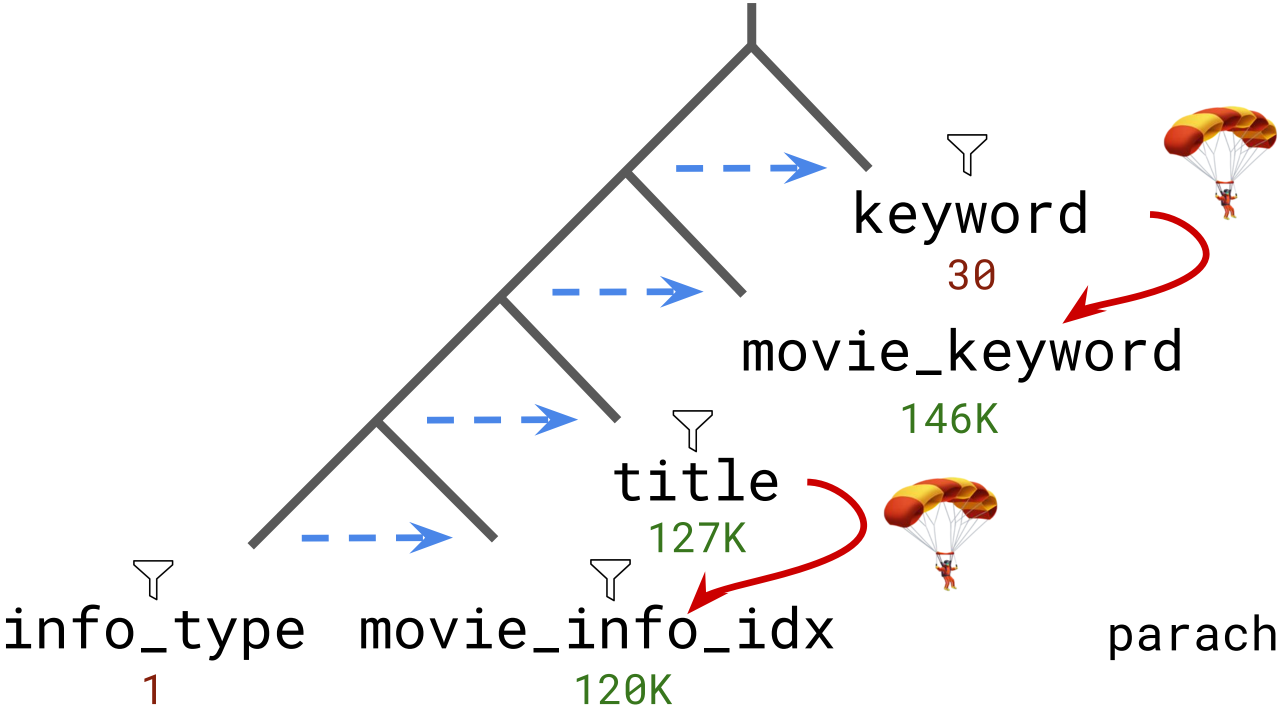


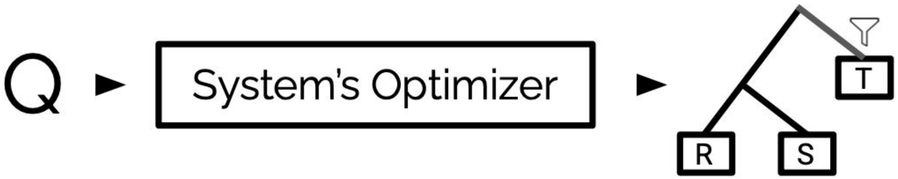
duckdb + sjf: 0.27s

🪂 Parachute: *Bi-Directional* Information Passing



parachute: 0.21s

🪂 Parachute @Runtime



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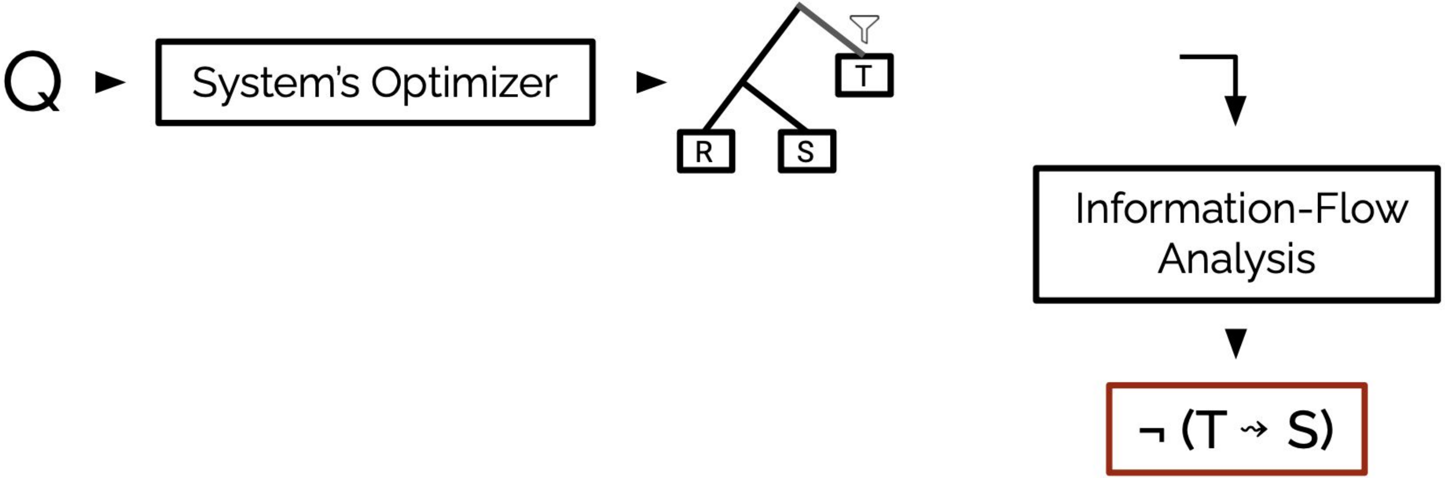

i.e., not covered in PSF

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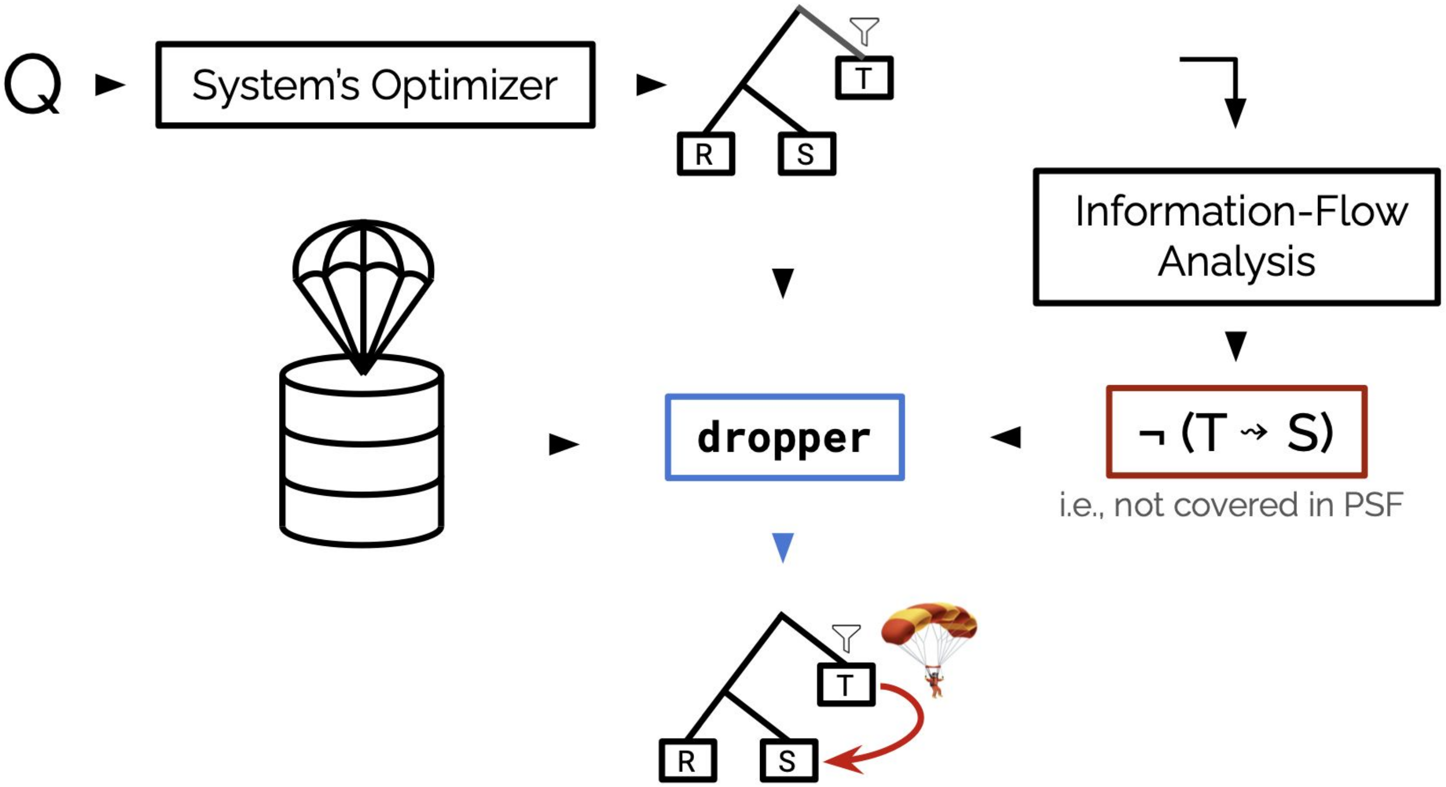

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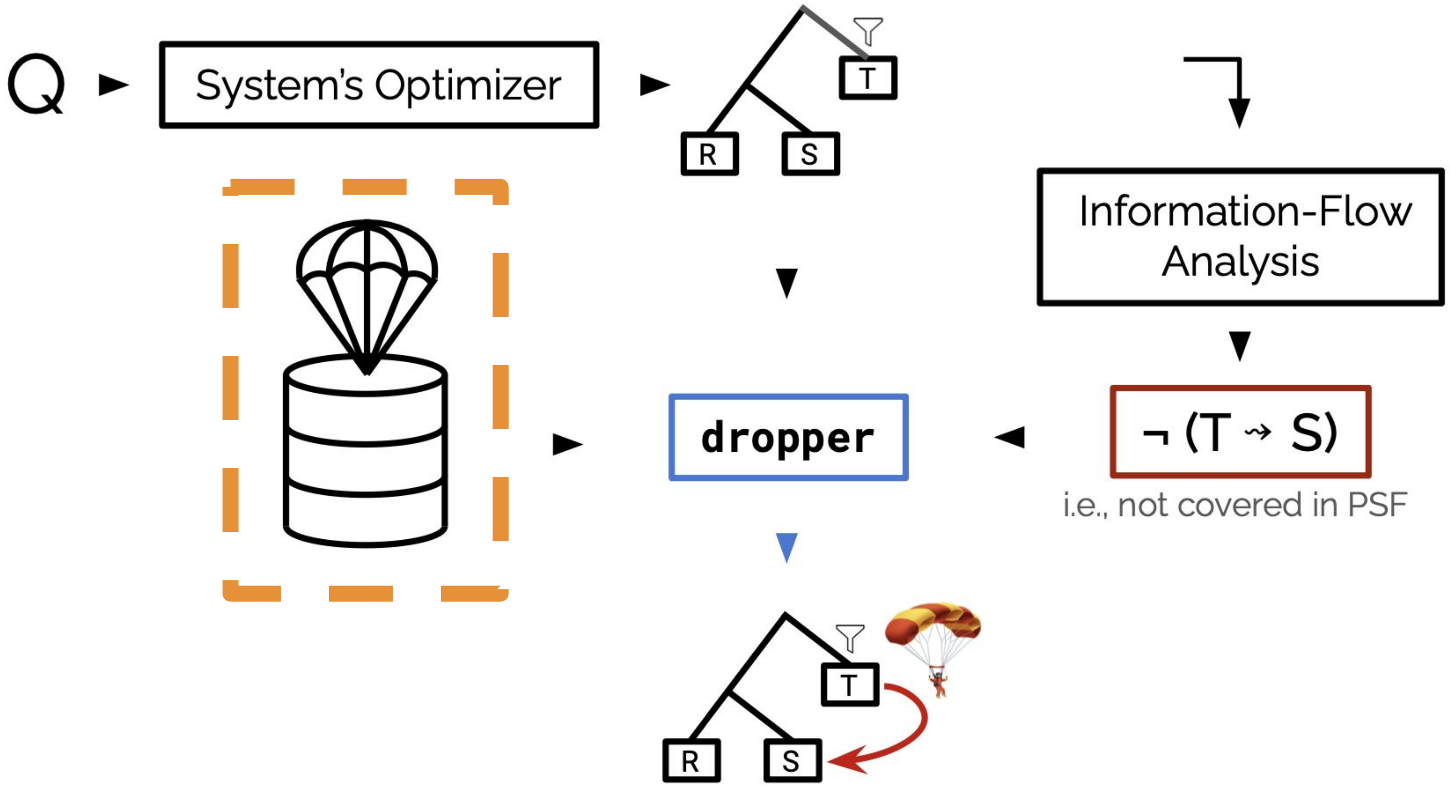
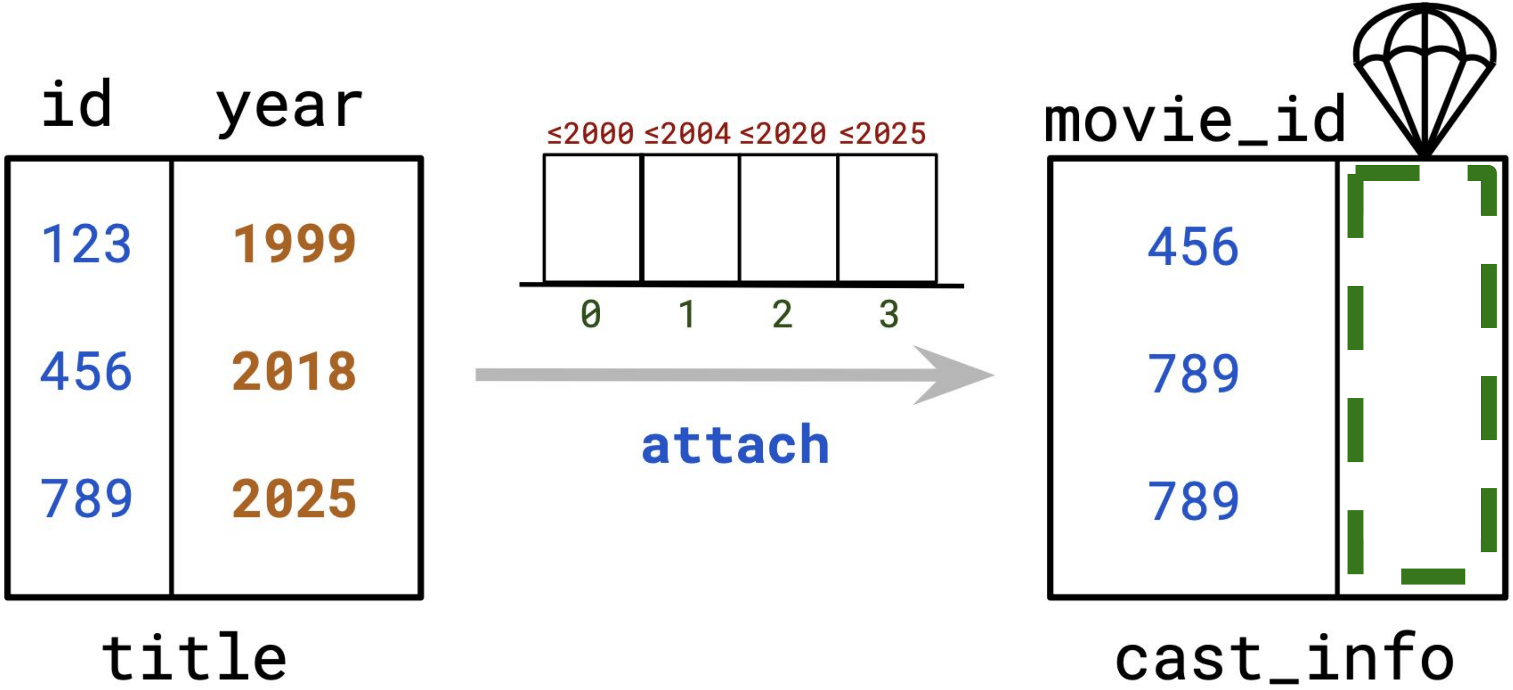


🪂 Parachute Columns



title

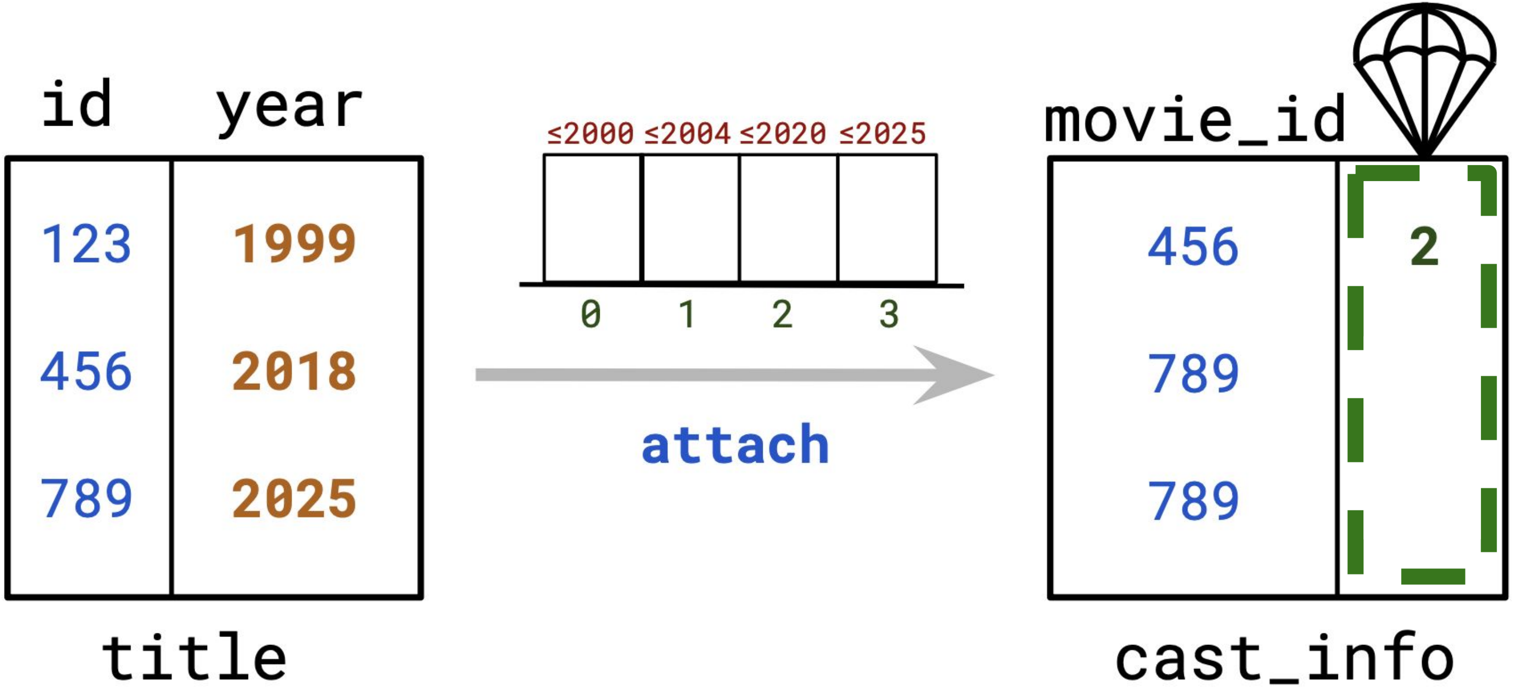
id	year
123	1999
456	2018
789	2025

≤2000	≤2004	≤2020	≤2025
0	1	2	3

cast_info

movie_id	
456	
789	
789	

🪂 Parachute Columns



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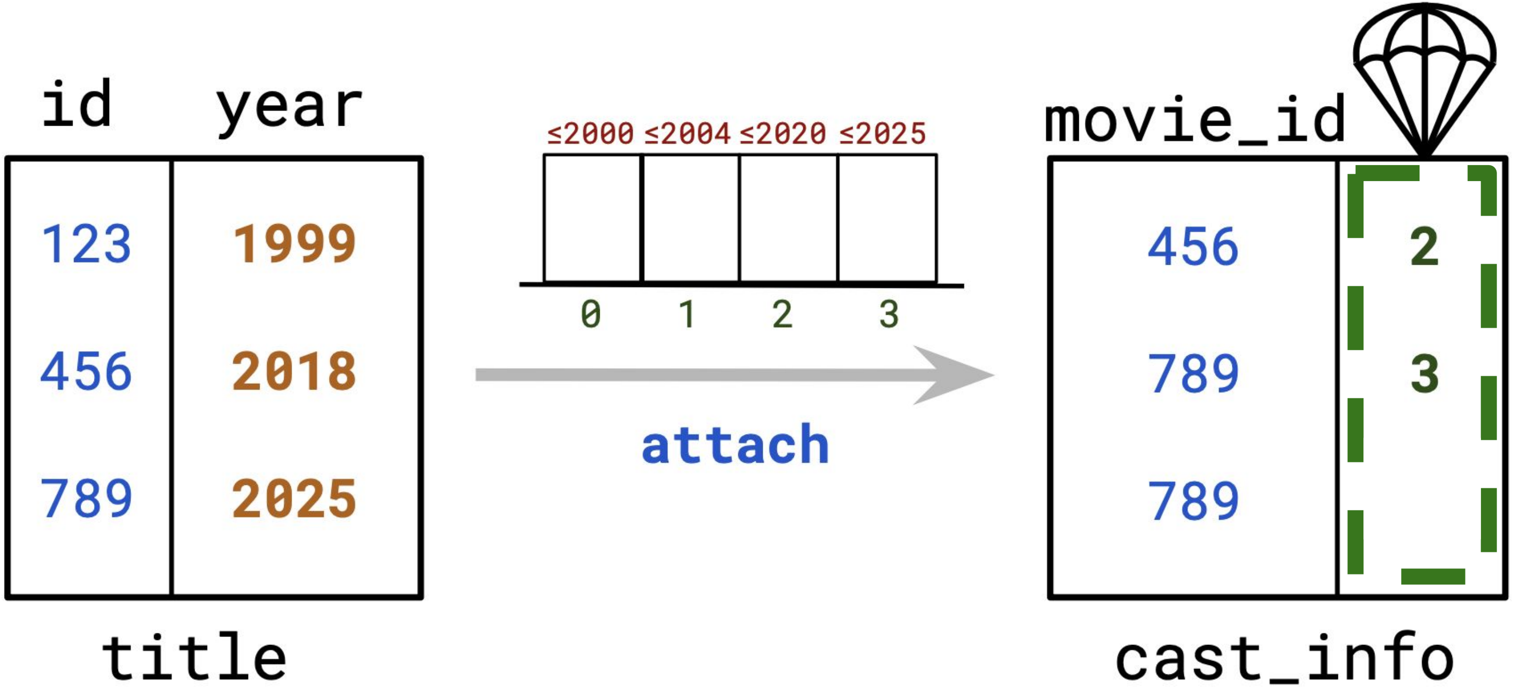

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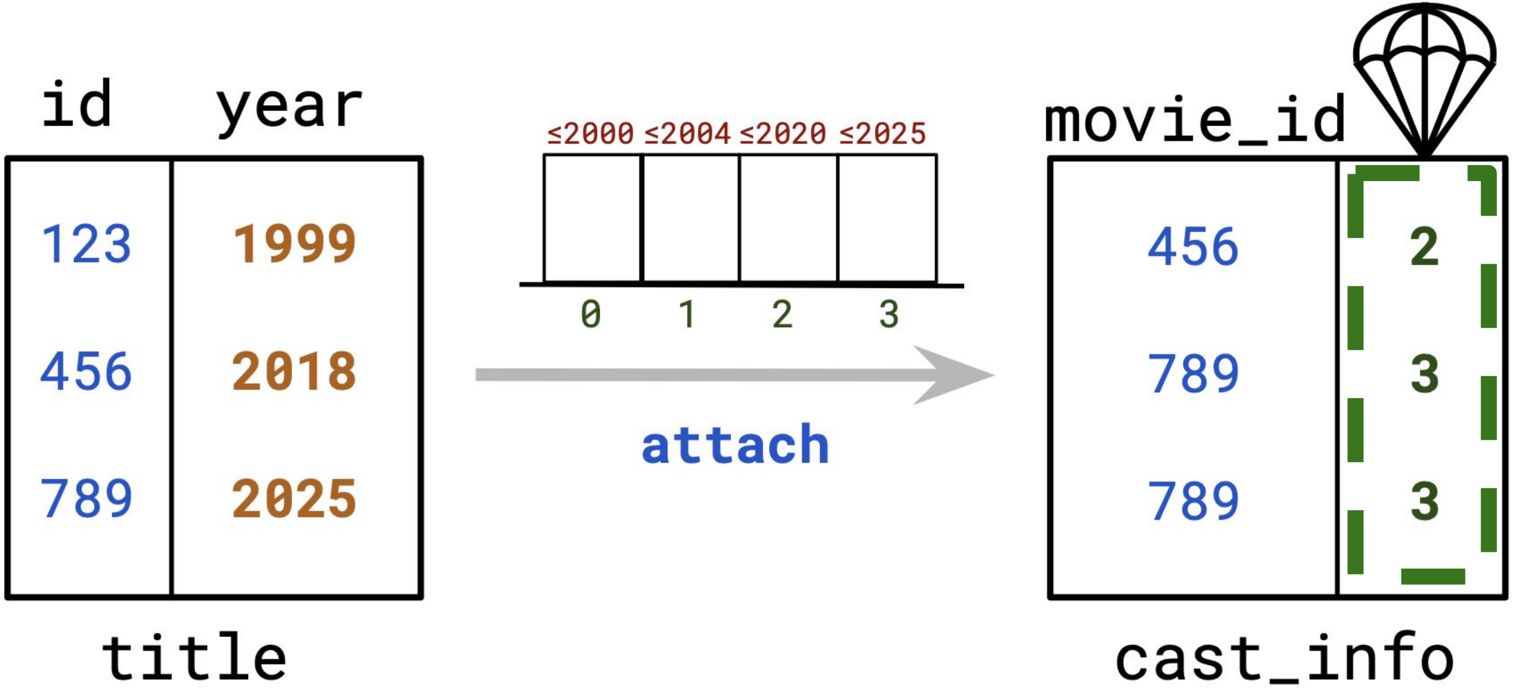

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456	2
789	3
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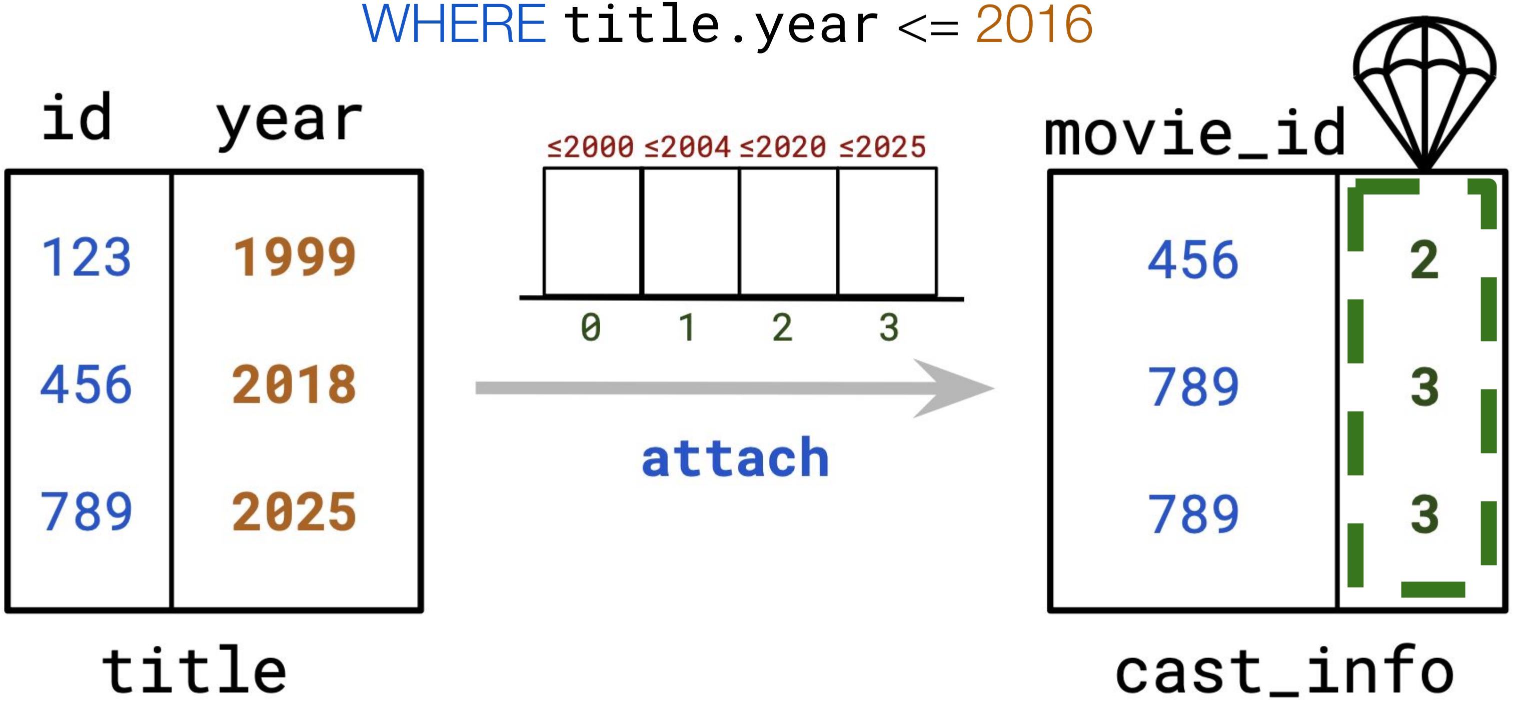
🪂 Parachute Predicates

WHERE title.year <= 2016



title

id	year
123	1999
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789	2025

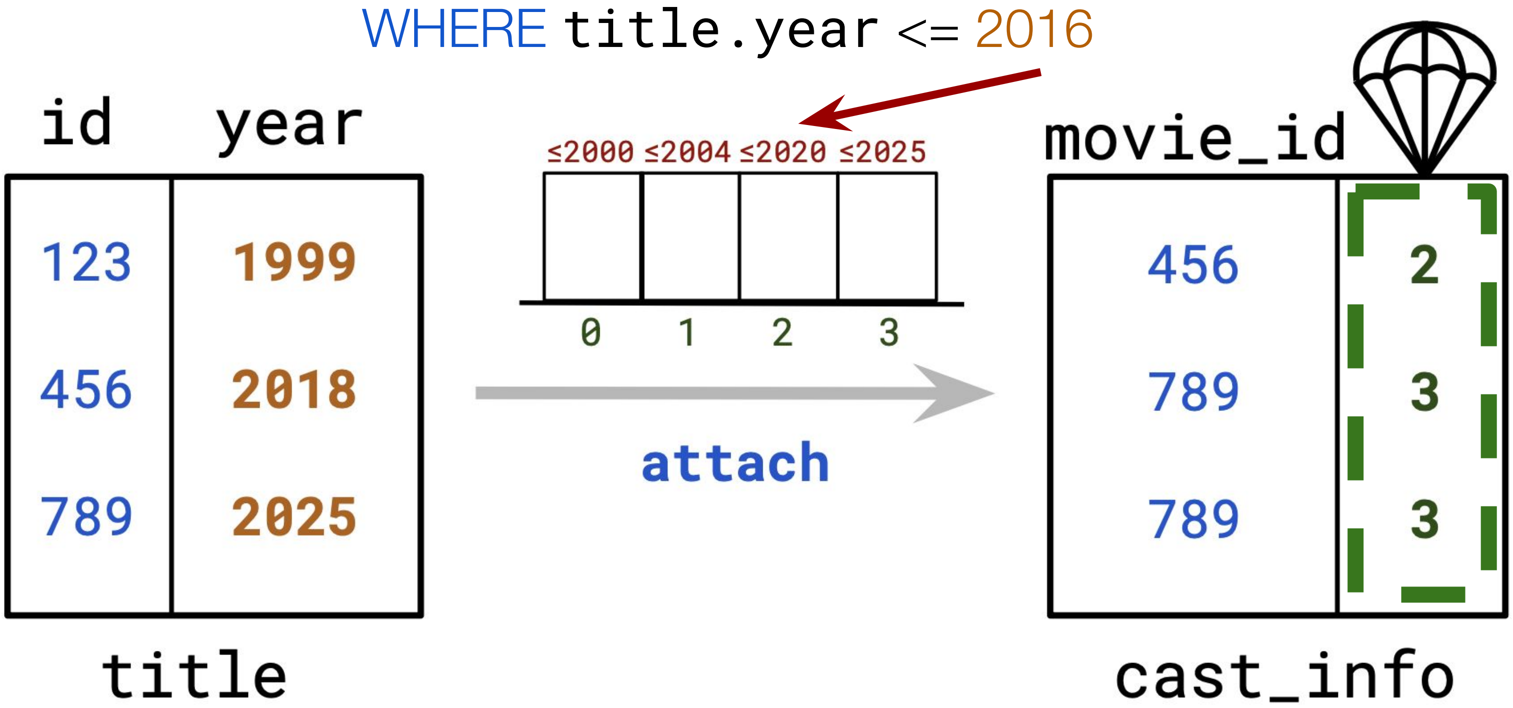
≤2000	≤2004	≤2020	≤2025
0	1	2	3

attach

cast_info

movie_id	
456	2
789	3
789	3

🪂 Parachute Predicates



WHERE `title.year <= 2016`

id	year
123	1999
456	2018
789	2025

title

≤2000	≤2004	≤2020	≤2025
0	1	2	3

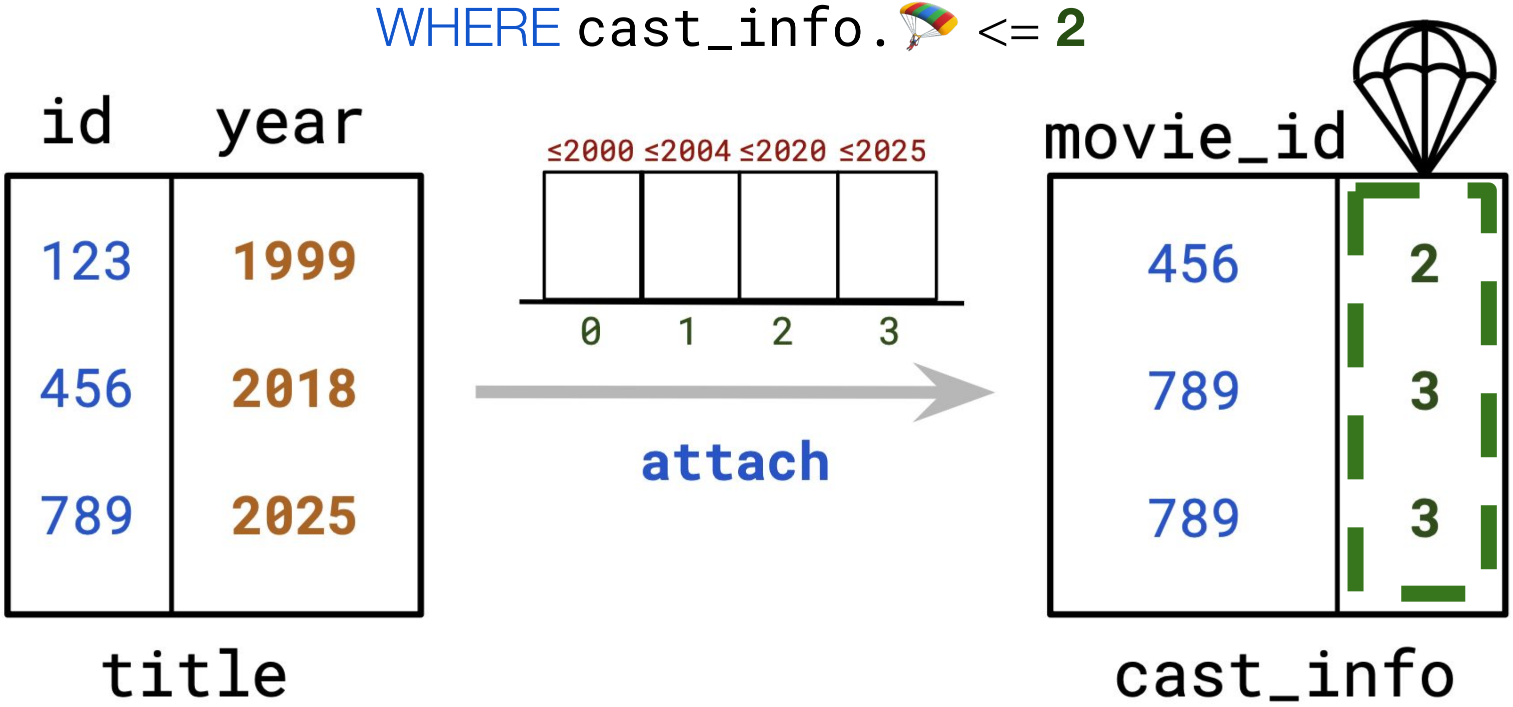
attach

movie_id	
456	2
789	3
789	3

cast_info

🪂 Parachute Predicates

WHERE `cast_info.🪂 <= 2`



title

id	year
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456	2018
789	2025

cast_info

movie_id	🪂
456	2
789	3
789	3

🪂 Parachute Predicates

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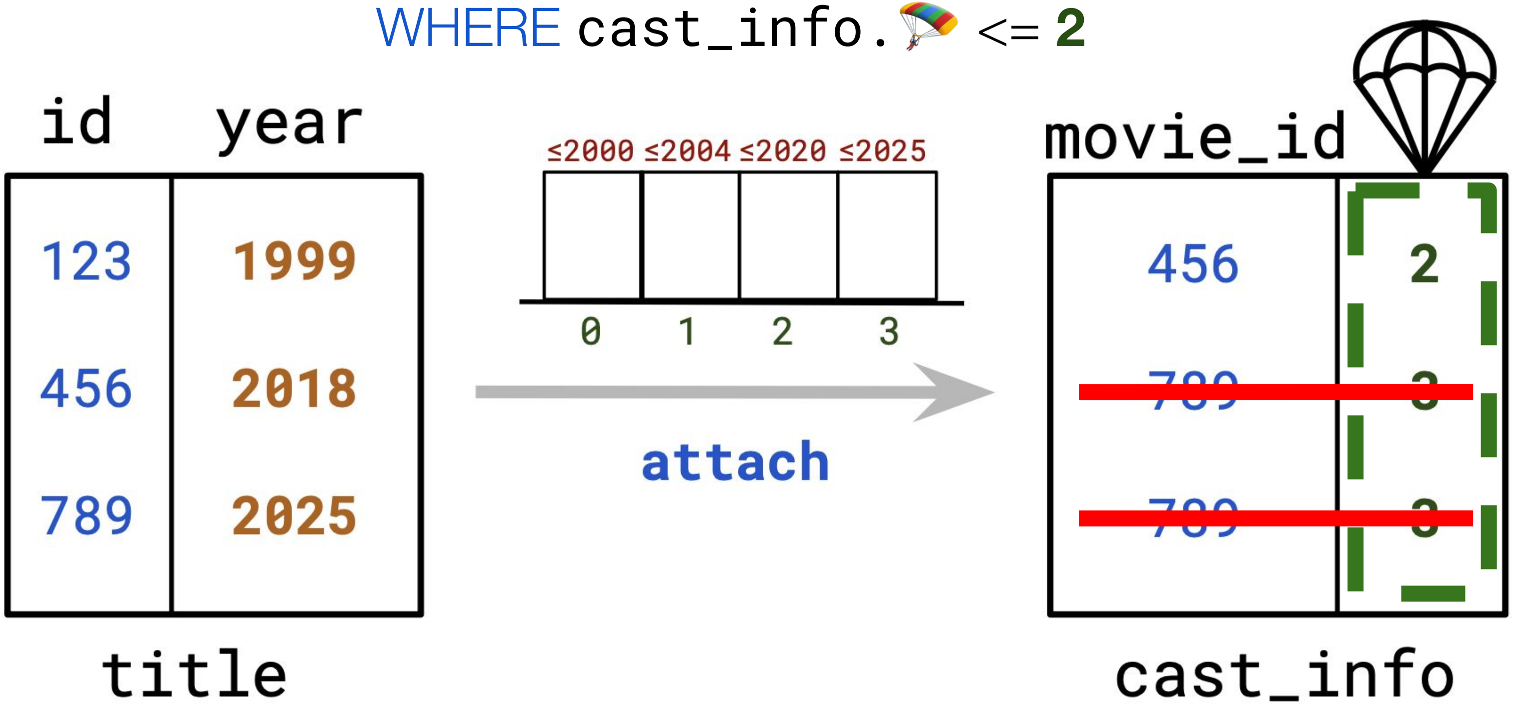

id	year
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789	2025

title

movie_id	
456	2
~~789~~	~~3~~
~~789~~	~~3~~

cast_info

Evaluation

- **Benchmarks**:
  - JOB: 113 queries.
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  - *Bonus*: RPT as @SIGMOD’25: **`duckdb v0.9 + rpt`**.

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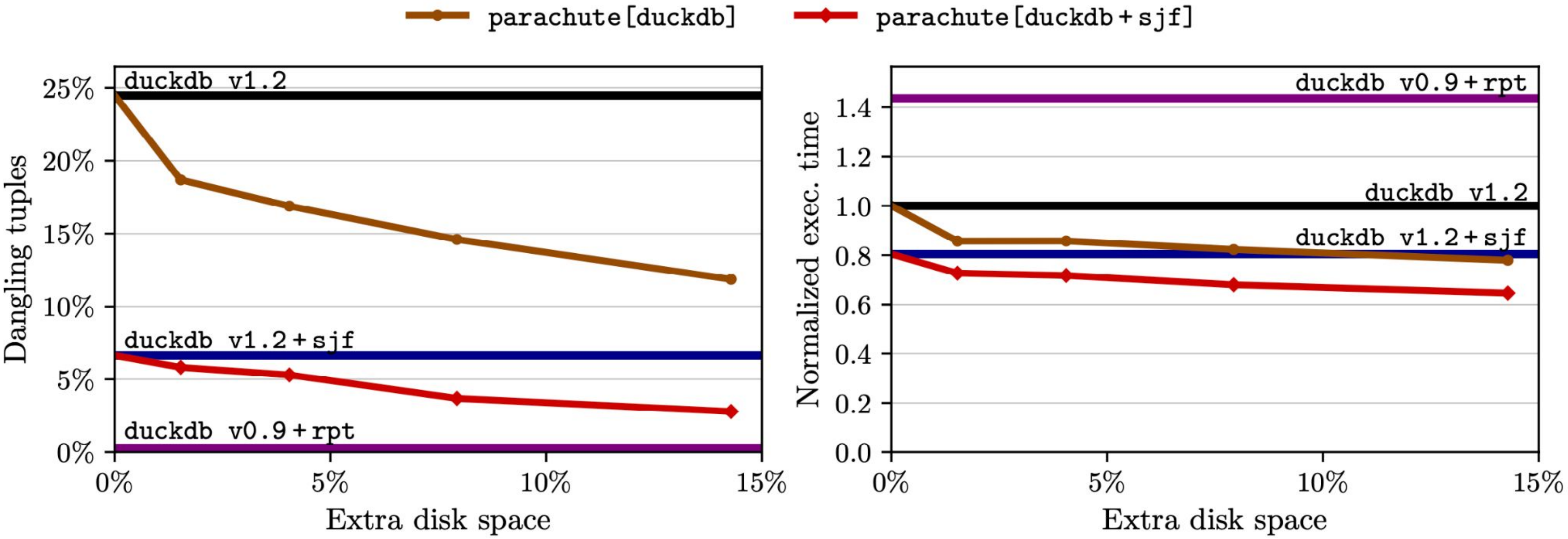
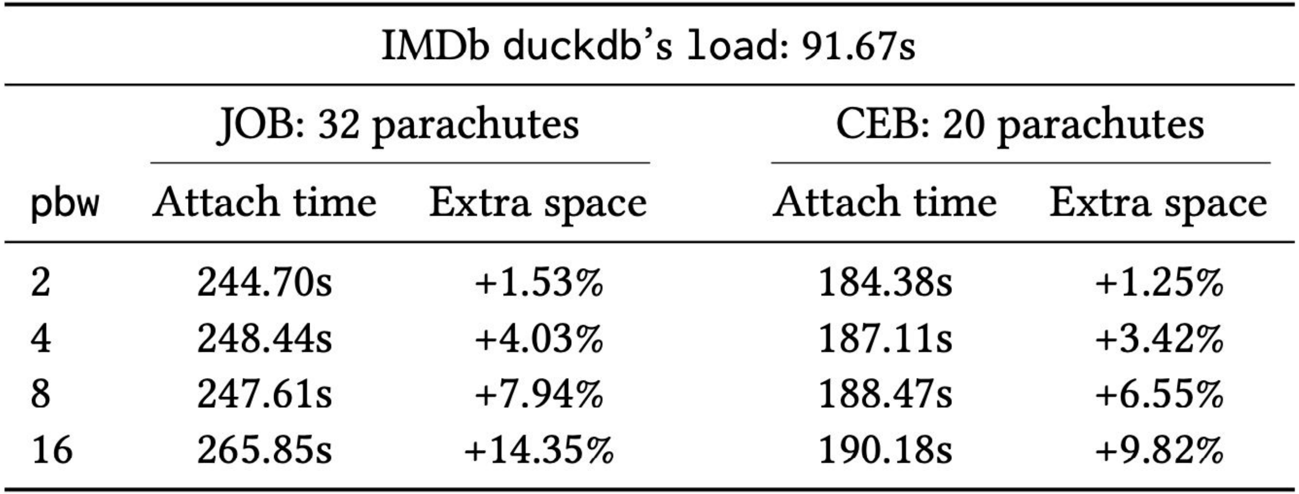
  - *Bonus*: RPT as @SIGMOD'25: **`duckdb v0.9 + rpt`**.
- Parachute column bit-widths ∈ {2, 4, 8, 16}.

JOB: #DanglingTuples & Exec. Time



Build Overhead

- JOB: Parachute’s build amortizes in the 4th run.
- CEB: The overhead is amortized already in the 1st run.



IMDb duckdb’s load: 91.67s				
	JOB: 32 parachutes		CEB: 20 parachutes	
pbw	Attach time	Extra space	Attach time	Extra space
2	244.70s	+1.53%	184.38s	+1.25%
4	248.44s	+4.03%	187.11s	+3.42%
8	247.61s	+7.94%	188.47s	+6.55%
16	265.85s	+14.35%	190.18s	+9.82%

Future Work

- Parachute columns ~ “cached bloom filters”:

  ⇒ Parachute columns can be used for partition pruning — think zonemaps.

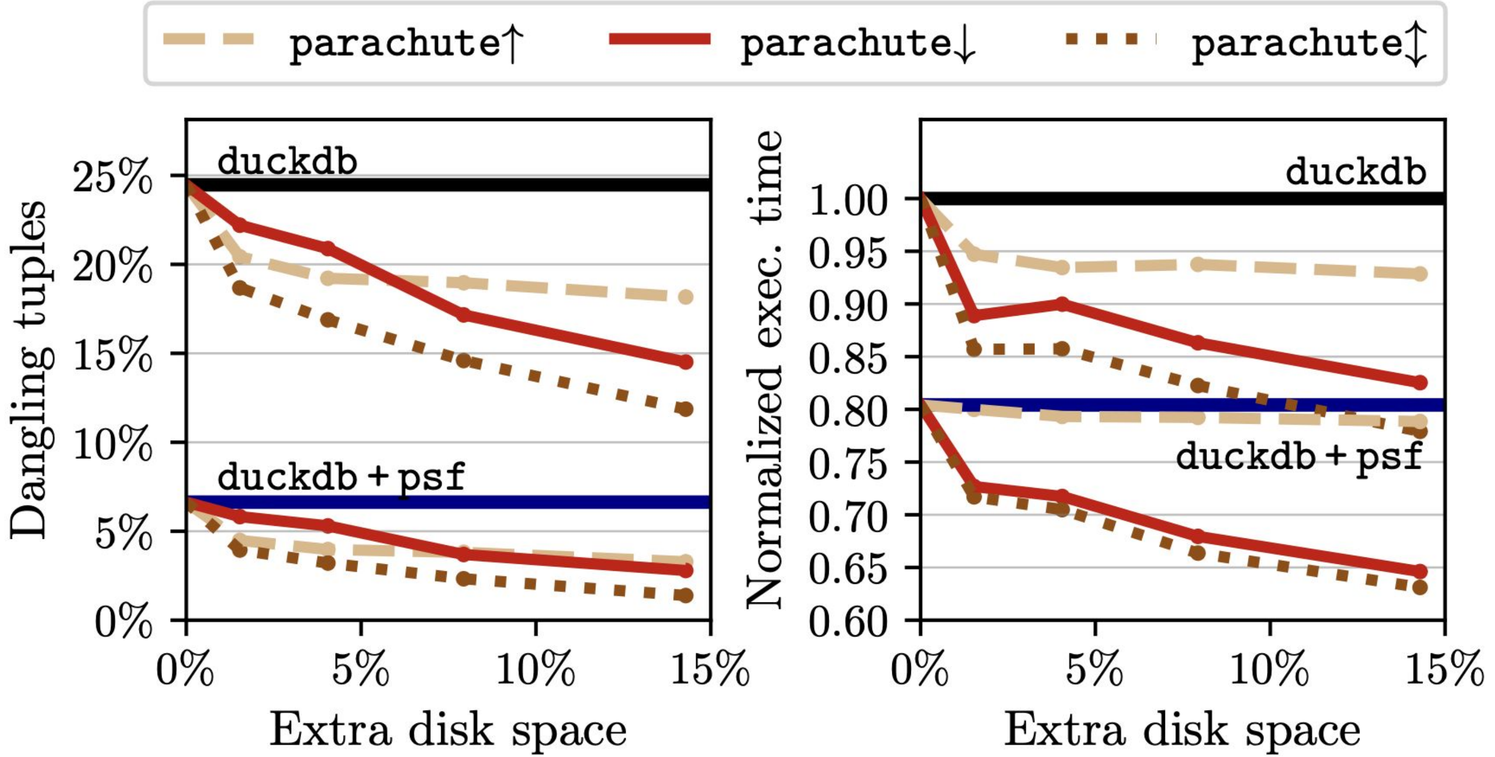
- Instance-optimized parachute columns.

  ⇒ Check out *string fingerprints* in AIDB’25 ⇒ 🚀 1.36x faster `LIKE` scans.

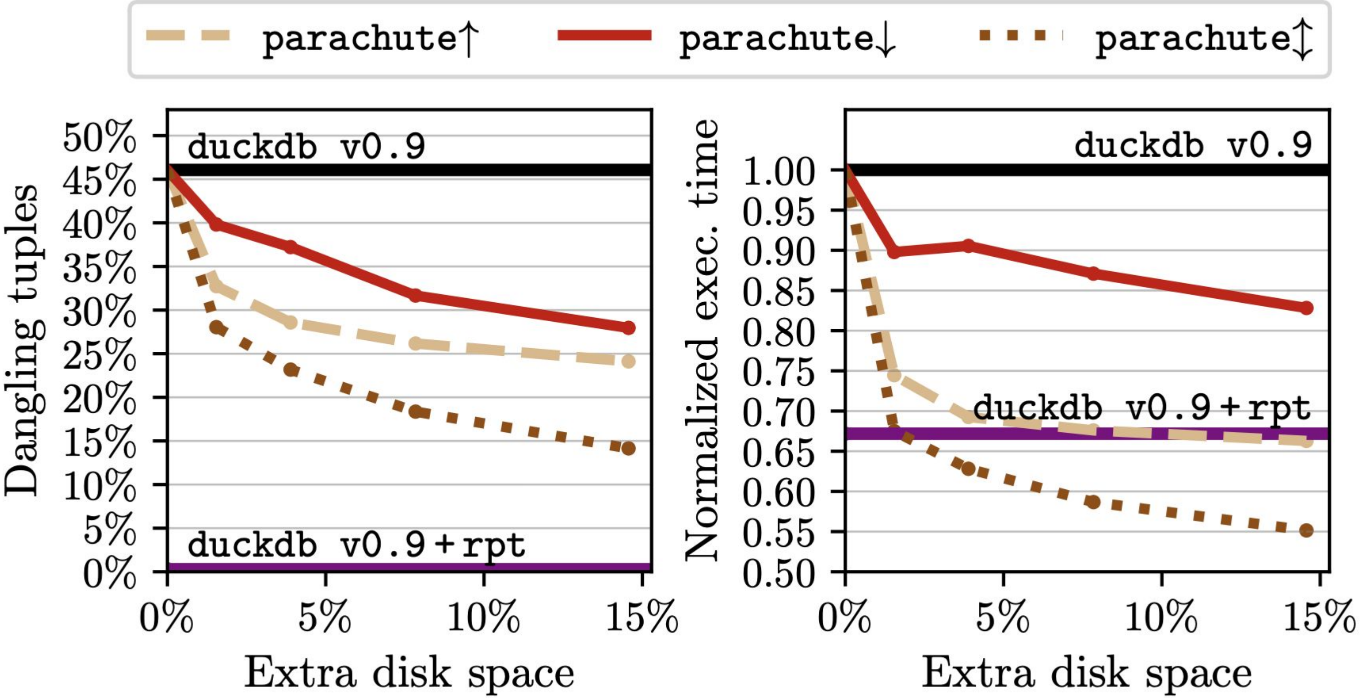
📖 `@utndatasystems/parachute`

Back-up Slides

🪂 Parachute Modes



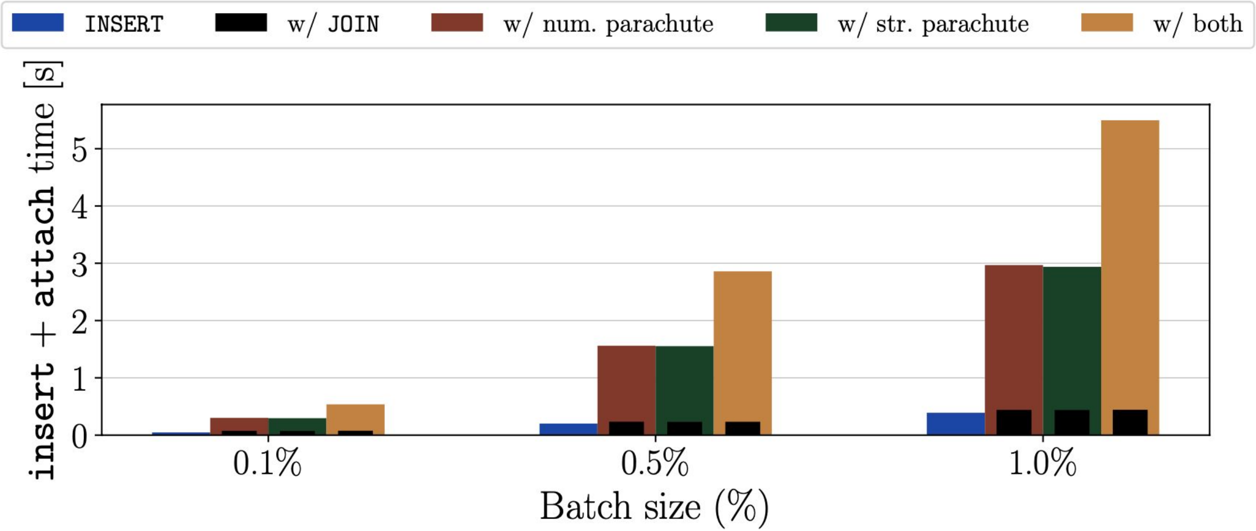
JOB on DuckDB v0.9: 🪂 Parachute vs. RPT



Update Overhead

- DuckDB v1.2 runs `UPDATE` single-threaded.

  ⇒ `JOIN` is *not* the main bottleneck.



Information Flow

- **Formalization:**

$$R \rightsquigarrow S :\Longleftrightarrow (R \prec S) \land (R \leftrightarrow S) \land \mathtt{is\_probe}(S),$$

$$R \rightsquigarrow^{n+1} S :\Longleftrightarrow \exists T.\, R \rightsquigarrow^{n} T \rightsquigarrow S,$$

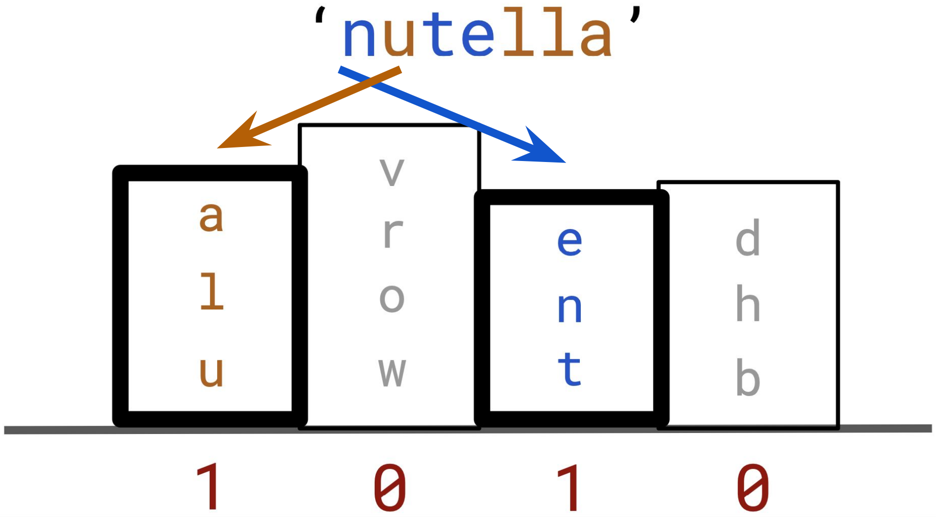
$$R \rightsquigarrow^{*} S :\Longleftrightarrow \exists n > 0.\, R \rightsquigarrow^{n} S.$$

- **Precedence Relation:**

$$R \prec S :\Longleftrightarrow \begin{array}{l} (\mathtt{pipeline}(R) < \mathtt{pipeline}(S)) \\ \lor\ (\mathtt{pipeline}(R) = \mathtt{pipeline}(S) \land \mathtt{is\_probe}(S)). \end{array}$$

🪂 Parachute’s String Fingerprints

1. **Partition** the letter space in a fixed number of bins.
2. Compute a **bitmask** of bin indices



‘nutella’
a
l
u
v
r
o
w
e
n
t
d
h
b
1
0
1
0