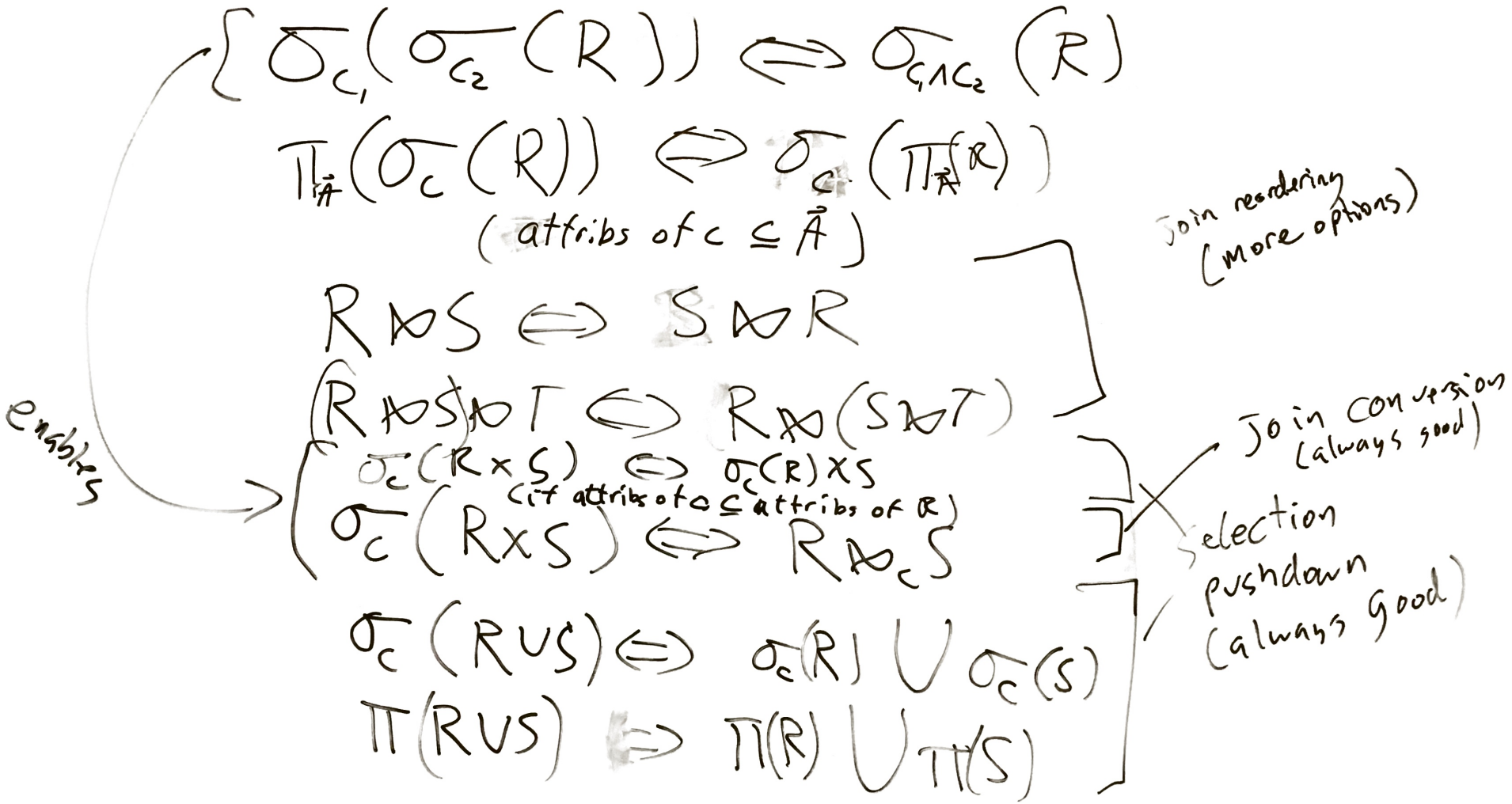

$\sigma_{c_1}(\sigma_{c_2}(R)) \Leftrightarrow \sigma_{c_1 \wedge c_2}(R)$
$\pi_{\vec{A}}(\sigma_c(R)) \Leftrightarrow \sigma_c(\pi_{\vec{A}}(R))$
(attribs of $c \subseteq \vec{A}$)
$R \bowtie S \Leftrightarrow S \bowtie R$
$(R \bowtie S) \bowtie T \Leftrightarrow R \bowtie (S \bowtie T)$
$\sigma_c(R \times S) \Leftrightarrow \sigma_c(R) \times S$
(if attribs of $c \subseteq$ attribs of R)
$\sigma_c(R \times S) \Leftrightarrow R \bowtie_c S$
$\sigma_c(R \cup S) \Leftrightarrow \sigma_c(R) \cup \sigma_c(S)$
$\pi(R \cup S) \Leftrightarrow \pi(R) \cup \pi(S)$
enables
Join reordering (more options)
Join conversion (always good)
selection pushdown (always good)

SQL → RA → Optimized RA → Set of possible plans → one plan

RA: apply always good opts whenever possible (pattern + replace)

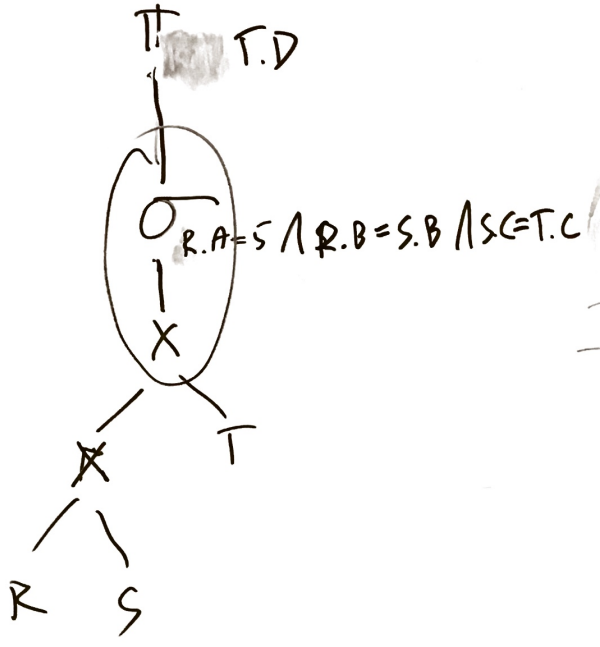
Optimized RA: plan compiler

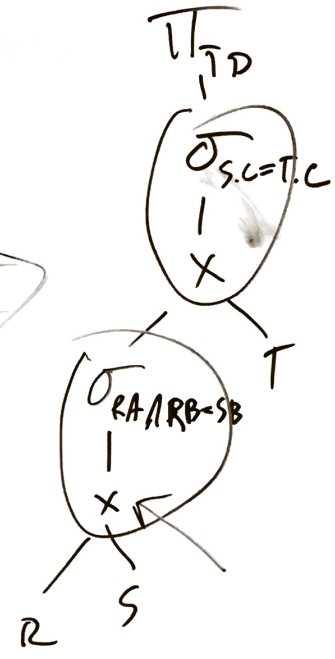
Set of possible plans: cost based optimizer

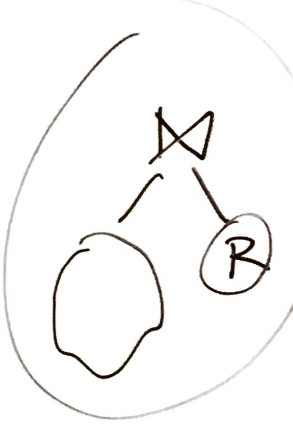
FB user $\bowtie_{\text{friend of}}$ FB user

→ one plan

ost
ased
optimizer



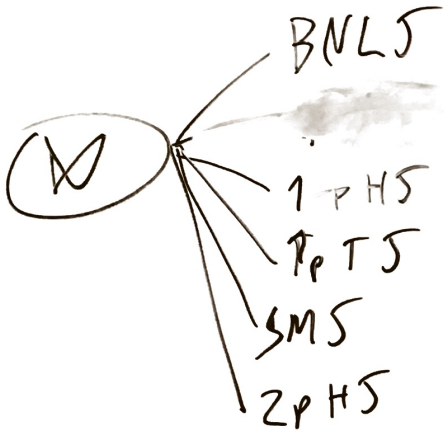


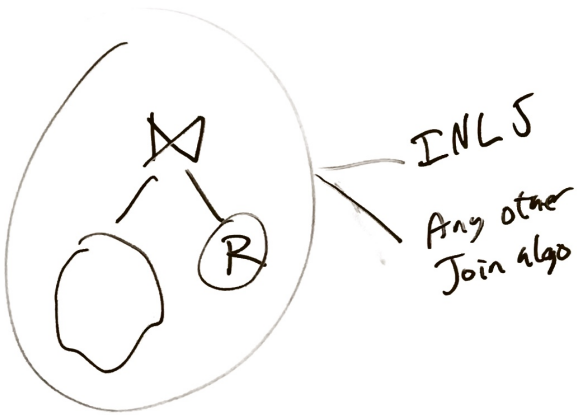


er $\bowtie_{\text{friend of}}$ FB user

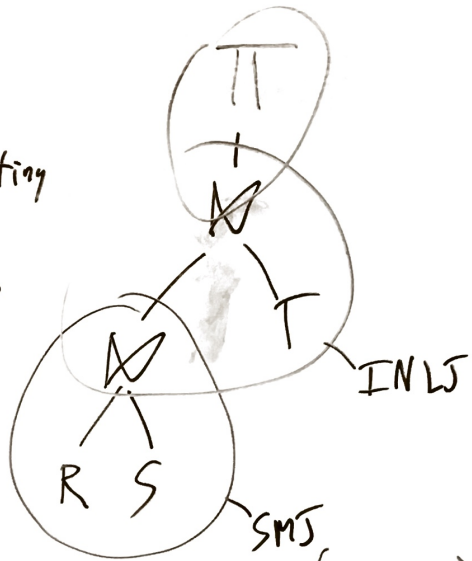
$(R \bowtie T) \bowtie S$

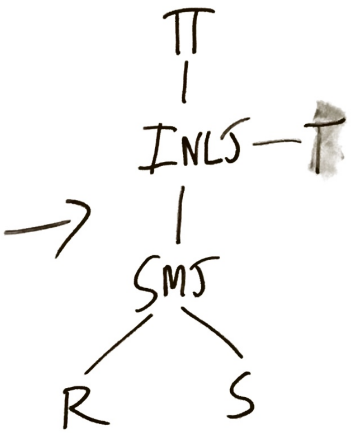
$(S \bowtie T) \bowtie R$

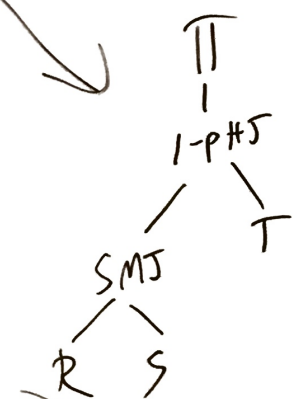




Constructing One possible plan







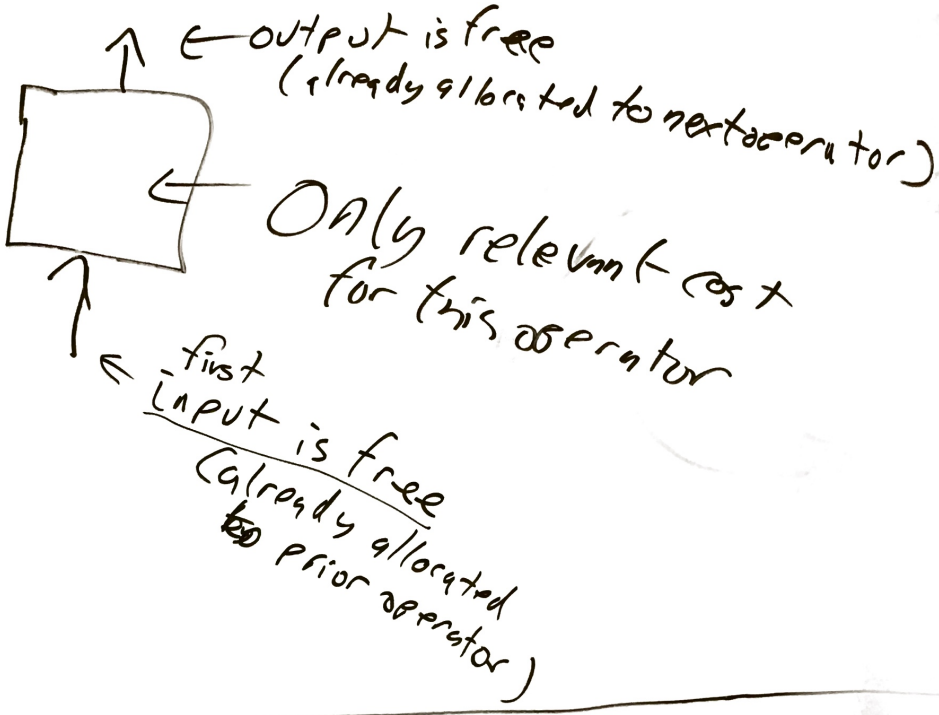
Time Taken – minimize

↳ #IOs

↳ CPU Time

Memory Required – upper bound

Measuring IO



Statistics of interest

- Pages of data in a table |R|
- Index Stats → depth of tree
- how many records returned |OR|

Algorithms

Access paths
- File Scan
- Index Scan

- projection (map)
- selection (filter)
- Union

(no IO cost)

- Sort <- InMem / External
- BNLJ
- 1-pHJ
- 1-pTJ
- 2-pHJ
- SMJ
- INLJ
- GBAgg <- InMem / Hash / Sort
- Distinct

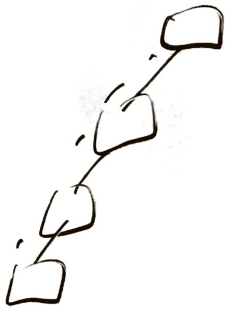
File Scan (R)

of IOs: $|R|$

Index Scan (σ_c I R)

↳ Tree

# of IOs: depth of tree + $|\sigma_c R|$



Sort($\tilde{R}$) (with B pages of buffer)

$\#\text{of IOs}: \log_B(|R|/2) \cdot 2 \cdot |R|$

BNLJ $\binom{x}{R\ S}$ (with B pages of buffer for each R, S)

```
for block_R in R:
    for block_S in S:
        for r in block_R:
            for s in block_S:
                emit r x s
```

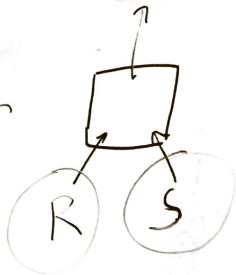
no IOs

if first pass:
write out block_S

$\#\text{of IOs}: |R| + \frac{|R|}{B} \cdot |S| + |S|$

comes from input

- $|R|$: IOs in outer loop
- $\frac{|R|}{B}$: # of blocks of R
- $|S|$: IOs in inner loop



$$\left(\frac{|R|}{B} - 1\right) \cdot |S| + |S|$$

$$= \frac{|R|}{B} \cdot |S|$$