Parallel Relational Database Systems

I. Introduction

II. Optimization-Parallelization Strategies (Inter-operation)

III. Efficiency of Parallelism

IV. Optimization of Data Communication

A. Hameurlain et al.

IRIT, Paul Sabatier University
Toulouse, France

I. Introduction to Parallel Rel. DB

1. Motivation [Dew 90, Val 93, Lu 94, ...]

☛ ***Relational Languages: Declaratives***

- ***Regular Data Structures : Static Annotation***
- ***Relational Language : Declarative***
  ➡ ***Automatic Parallelization***
- ***Decision Support Queries : Complex, Huge DB,***
  Join, Sort, Agregation

2. Objectives:

☛ ***Best Cost / Performance with respect to Mainframe***
DPS8 / GCOS, IBM 30390 / VMS, ...)

☛ ***High Performance:***

- ***Minimizes the Response Time***
- ***Maximizes the Parallel System Throughput***

☛ ***" Scalability " :***

- ***Adding New Resources (CPU, Disk, Memory)***
- ***Adding New Users***

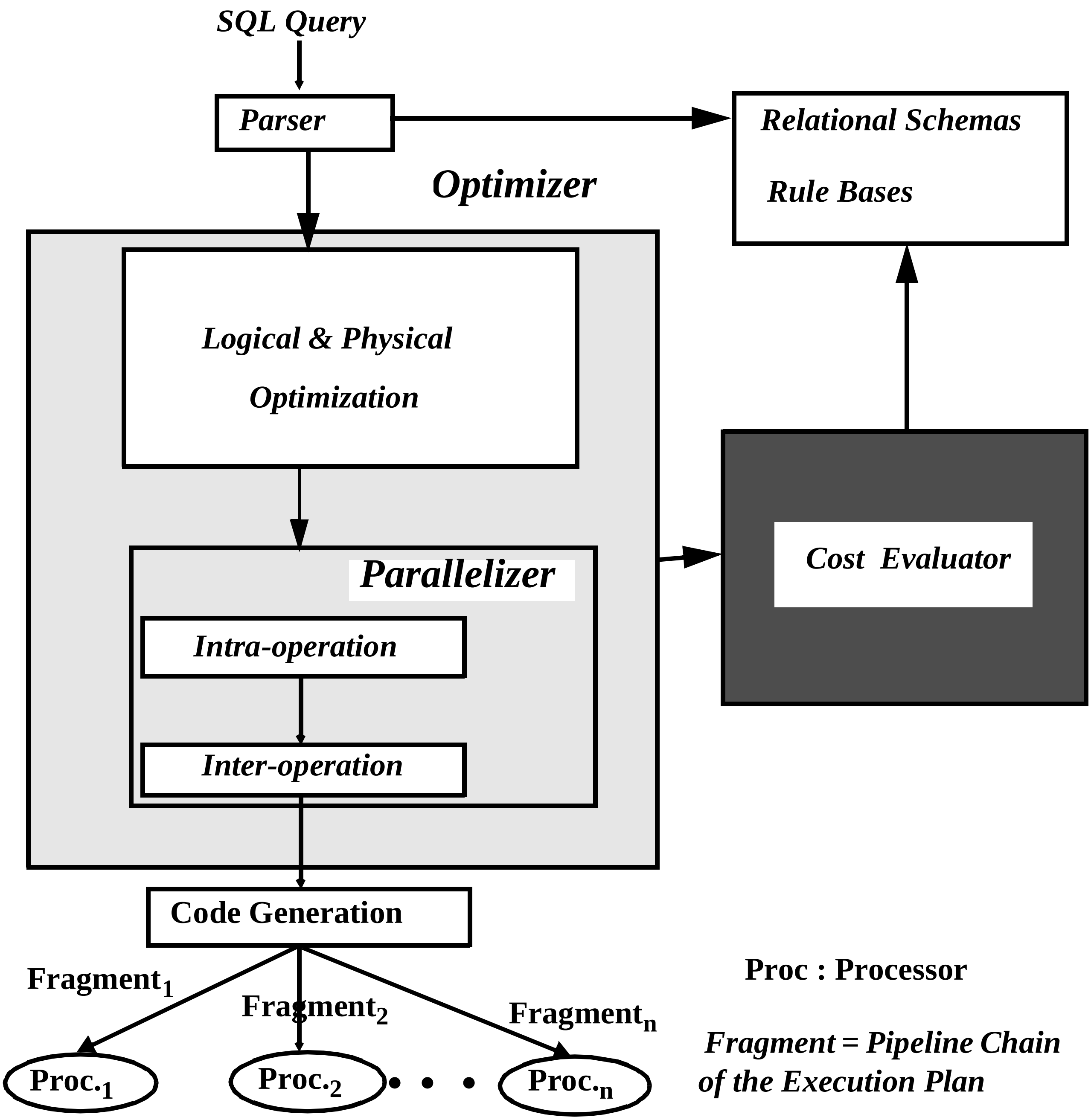
⇨ ***Holding the Same Performance***

☛ ***Availability***

II. Optimization-Parallelization Strategies (Inter-operation)

1. Introduction

☛ ***Query Compiler Architecture for Parallel Database Systems***



Proc : Processor

Fragment = Pipeline Chain of the Execution Plan

SPJ Query Parallelisation:

Parallelism Extraction & Resource Allocation

A. Parallelism Extraction

***1. Data Partitioning**: Approaches & Methods [Liv 87, Cop 88, Dew 92]*

- ***Partitioning Degree of each base relation?***

2. Parallelism degrees of Joins?

3. Parallelization Strategies (Inter-operator)

- ***Approaches***

⇨ ***Two- Phase Approach :*** Φ_1 ; Φ_2

◆ ***XPRS [Hon92, Sto 88], Papyrus [Gan 92, Has 94, Chek 95], Gamma Proj. [Kab 98], ...***

⇨ ***One-Phase Approach: packs*** Φ_1 & Φ_2 : ***into one process***
◆ ***[Sch90, Che92, Zia93, Lan93,...]***

Φ_1 : ***Physical Optimization (without considering the resources)***
Φ_2 : ***Parallelization: Parallelism Extraction & Resource Alloc.***

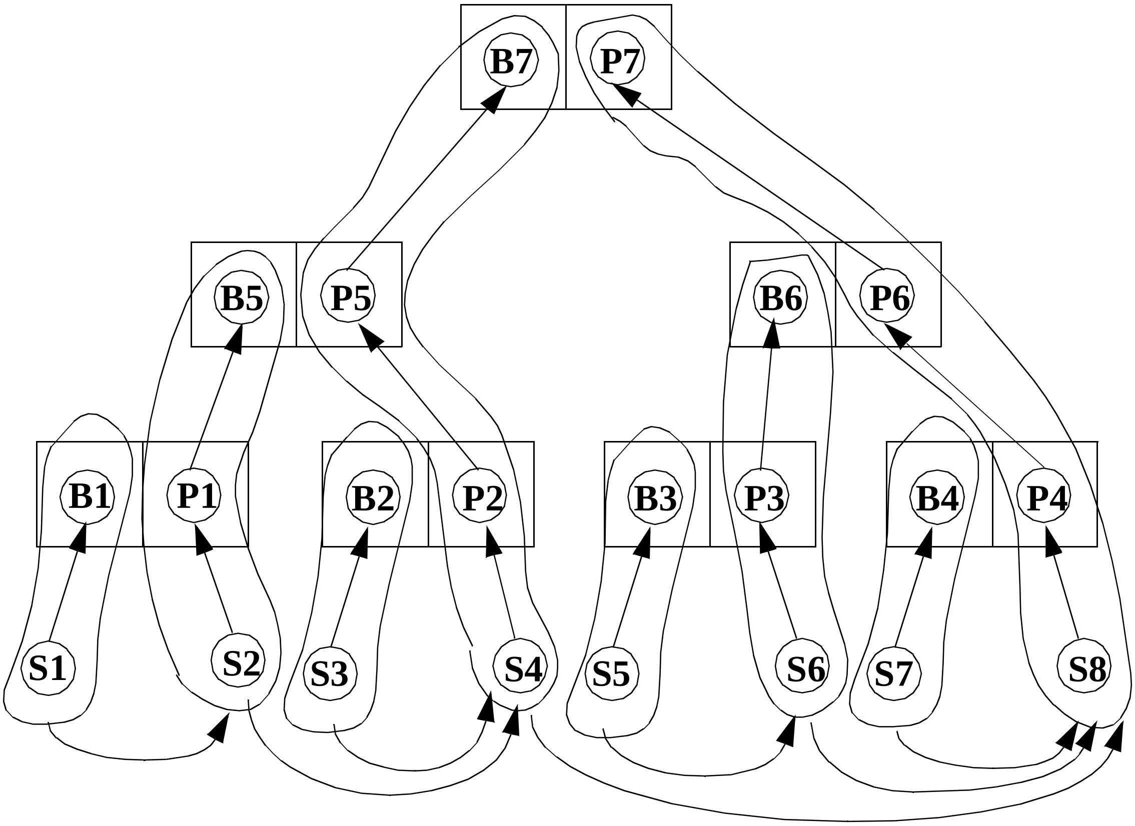
4. Generation of Parallel Programms :

Query = R1xR2xR3xR4xR5xR6xR7xR8

B. Resource Allocation (Mapping)

1. Data (relations) Placement : Alloc_R

2. Tasks (Operator) Placement : Alloc_T

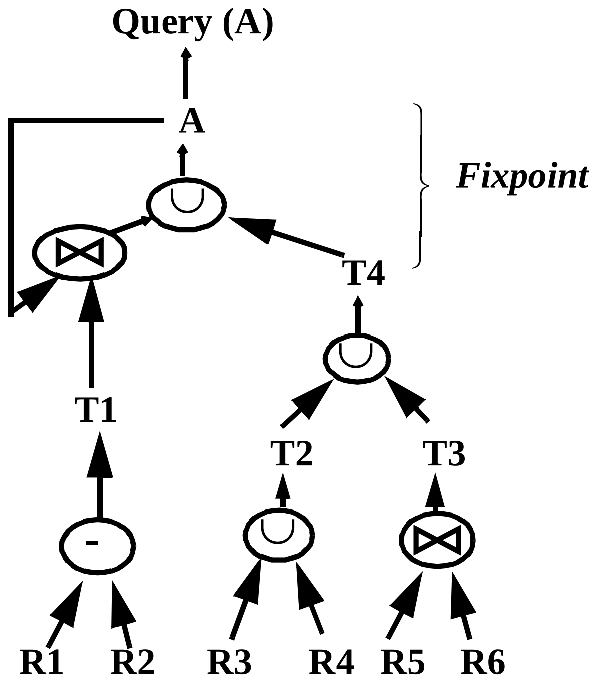


```
SEQ
    PAR
        PIPE Scan S1 - Build J1 ENDPIPE
        PIPE Scan S3 - Build J2 ENDPIPE
        PIPE Scan S5 - Build J3 ENDPIPE
        PIPE Scan S7 - Build J4 ENDPIPE
    ENPAR;
    PAR
        PIPE Scan S2 - Probe J1- Build J5 ENDPIPE
        PIPE Scan S6 - Probe J3 - Build J6 ENDPIPE
    ENDPAR;
    PIPE Scan S4 - Probe J2 - Probe J5 -Build J7 ENDPIPE
    PIPE Scan S8 - Probe J4 - Probe J6 - Probe J7 ENDPIPE
ENSEQ
```

Bushy Tree

III. Efficiency of Parallelism

- ***Shared-Nothing Architecture***
- ***Rel. Size [Bit 83], & Parameters [Sch 90], [Val 88]***



- **Simple Hash-Join Algorithm (Build + Probe)**
  Build (R) holds in memory

LRT $(T \leftarrow R \bowtie S) = T_{ef} + T_{d} + T_{com}$ where

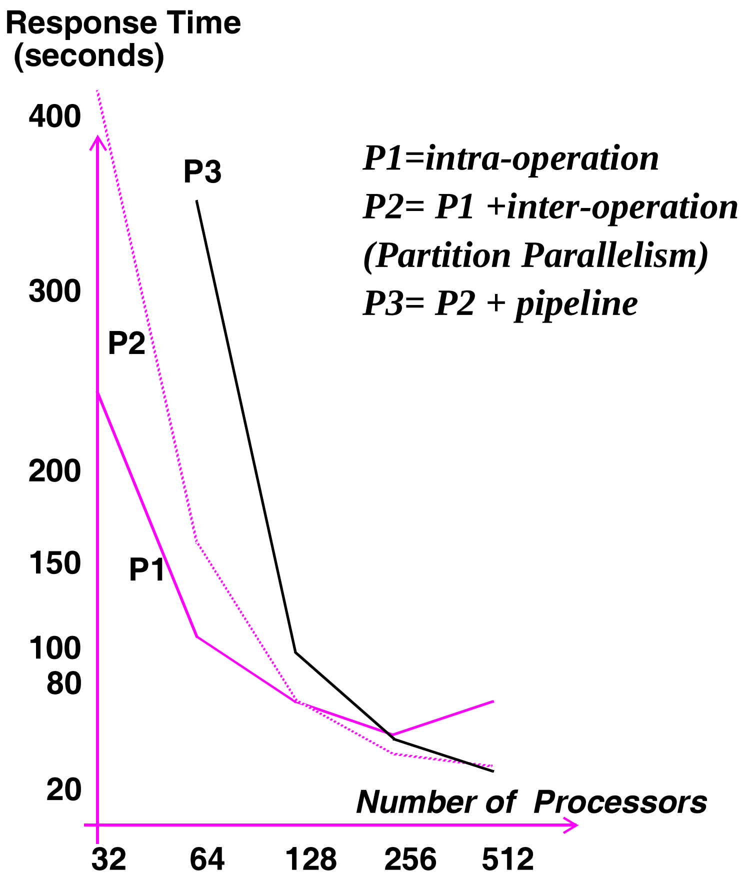
$T_{ef} = (|R|/d).th + ((||R||/d) + (||S||/d)).CR + (||R||/d/q).(||S||/d).CJO + |T|.I + ||T||/d.CW$

Build Time + Read Time + ComparisonTime +
Time for Moving a Tuple + WriteTime

$T_{d} = (|T|/d).th$ **and** $T_{com} = ((|T|/d).trf + p.msg).\lceil d/p \rceil$

|R| : Number of Tuples in R=10^6
||R|| : Numbre of Pages in R
th : Time to hash a tuple (200 B)
CR : Time to read 1 page (18KB)= 8 ms
CW : Time to write 1 page= 16 ms
CJO : Time for joining 2 unsorted pages
d : Number of proc. of source operation
p : Number of proc. of destination operation

Trf : Time to transfer a tuple
msg : Time to process a message
CPU = 4 MIPS



P1=intra-operation
P2= P1 +inter-operation
(Partition Parallelism)
P3= P2 + pipeline

◆ ***Efficiency of Parallelism :***

- ***Intra-Operation with Lower NB of Processors***

- ***Pipeline with Large NB of Processors***

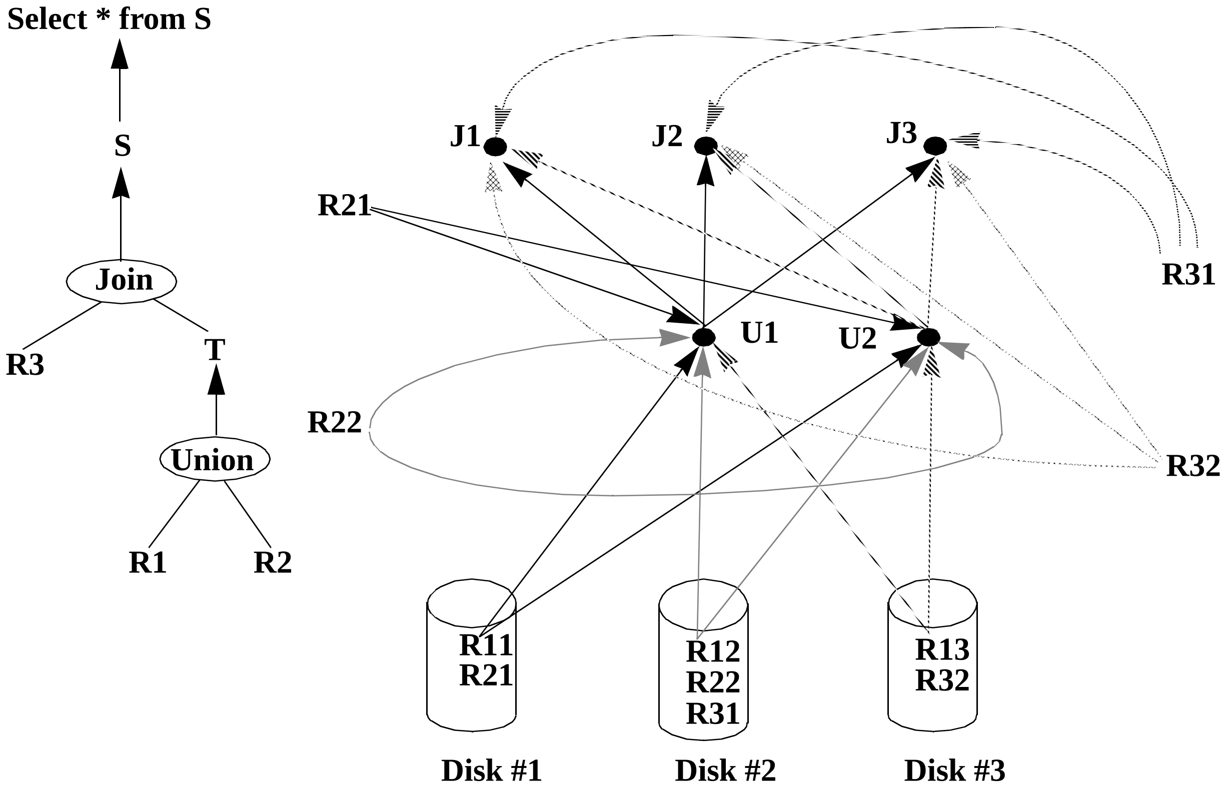
➥ ***The Plague of Parallelism : Cost of Data Communication***

IV. Optimization of Data Communication

1. Logical Optimization : JSP -->PSJ (Reducing the Vol. of Data)

2. Physical Optimization : the order in which the joins are executed

3. Parallelization Phase :
Cost of Tuple Redistributing



A Simple SQL Query and Associated Data Flow Graph

Methods : Tree Coloring [HAS 95] Propagation Method[Ham 93]

- *Partitioning Attributes &*
  /Same Partitioning Function
- *Number of Processors*

Propagation Method : Partition Attribute & Number of Processors