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Db2 Symmetric Multiprocessing

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Db2 Symmetric Multiprocessing for IBM i

Database parallelism,
while inherently part of Db2 for i,
is enabled by installing the optional IBM i feature
"Db2 Symmetric Multiprocessing"

Symmetric Multiprocessing

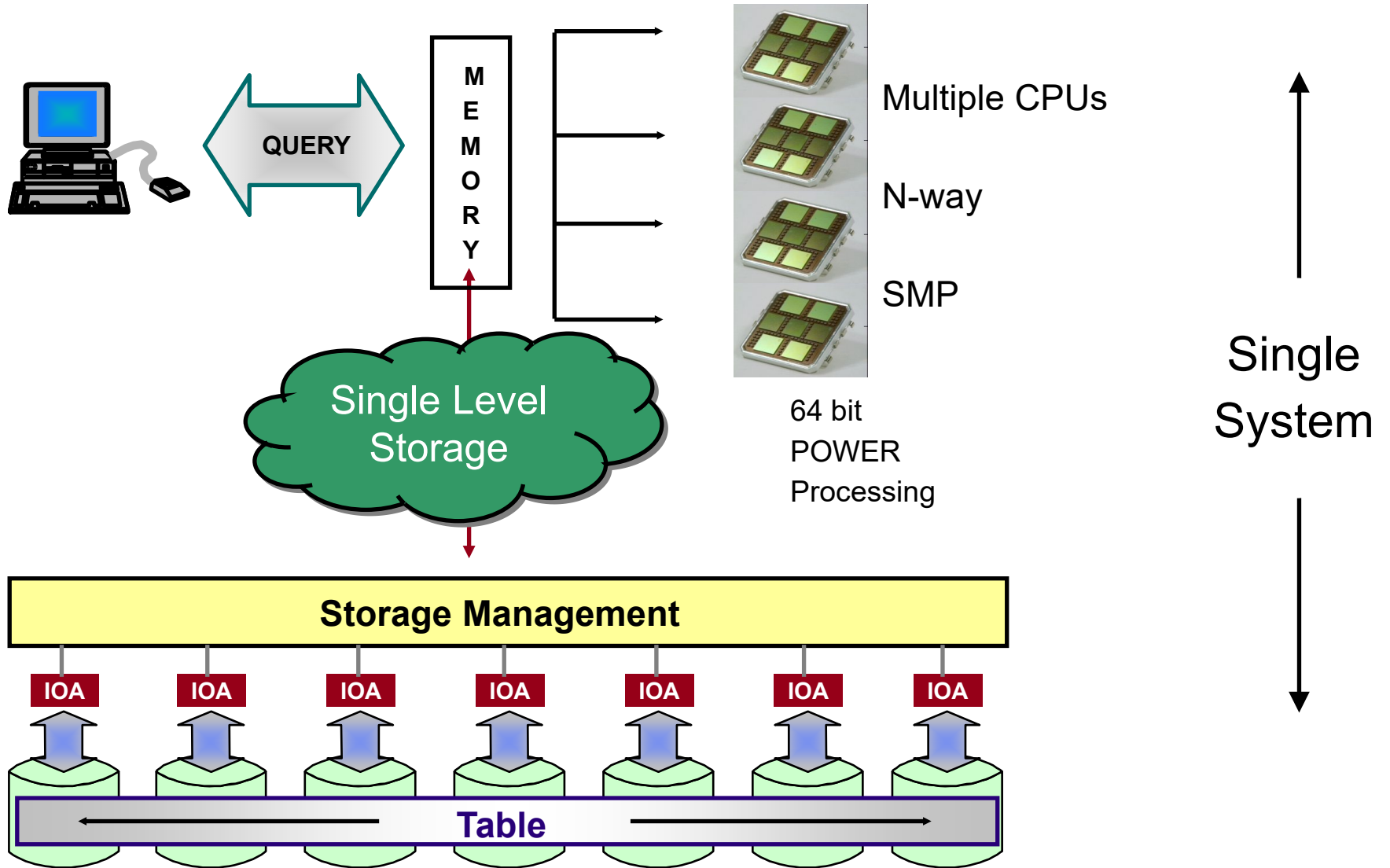
GO LICPGM, option 10 Display installed licensed programs

```
Display Installed Licensed Programs                                     System:  MCV7R1
Licensed  Product
Program   Option   Description
5770SS1   18       Media and Storage Extensions
5770SS1   21       Extended NLS Support
5770SS1   22       ObjectConnect
5770SS1   23       OptiConnect
5770SS1   26       DB2 Symmetric Multiprocessing
5770SS1   27       DB2 Multisystem
5770SS1   29       Integrated Server Support
5770SS1   30       Qshell
5770SS1   31       Domain Name System
5770SS1   33       Portable App Solutions Environment
5770SS1   34       Digital Certificate Manager
5770SS1   35       CCA Cryptographic Service Provider
5770SS1   36       PSF for IBM i 1-55 IPM Printer Support
5770SS1   37       PSF for IBM i 1-100 IPM Printer Support
More...

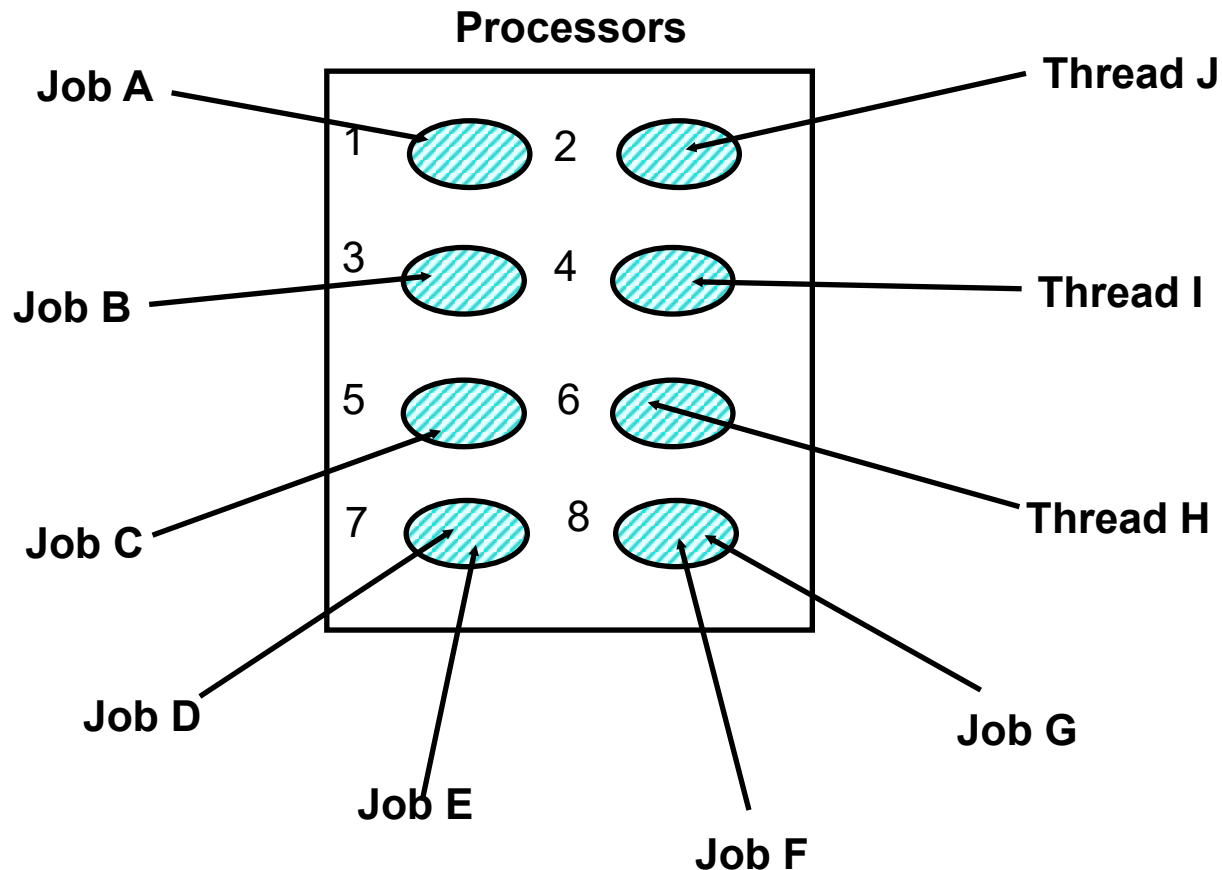
Press Enter to continue.

F3=Exit   F11=Display status   F12=Cancel   F19=Display trademarks
```

IBM i Architecture



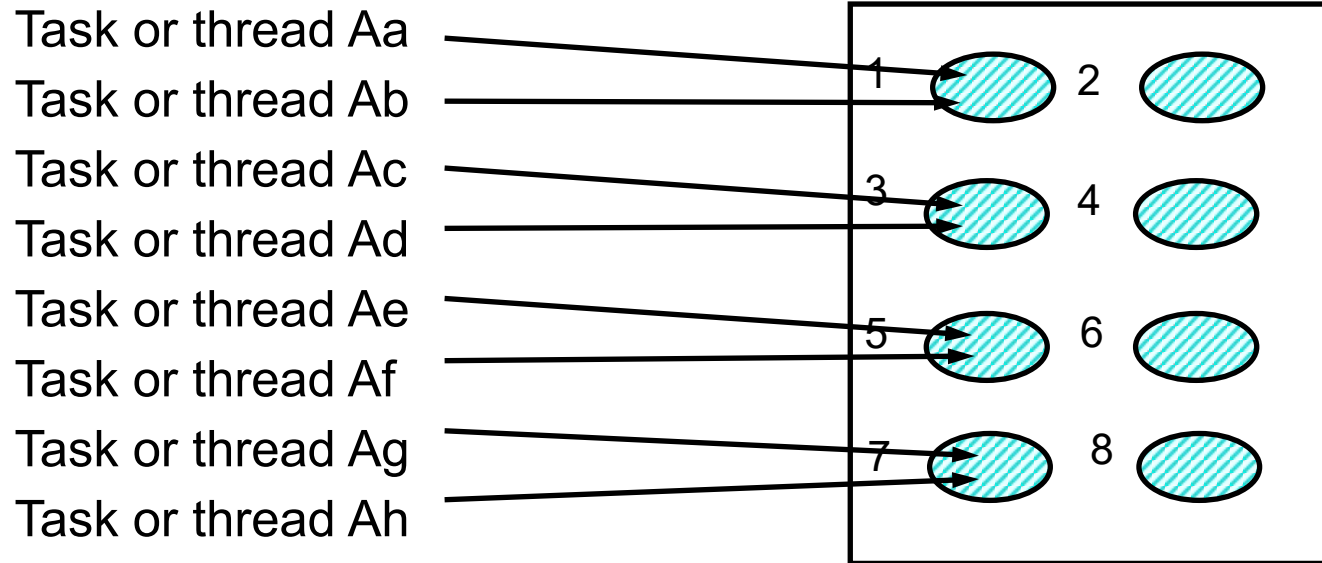
N-way processing



- ✓ n Processors can work on several jobs or threads at one time without any special programming
- ✓ Memory is shared across all processors
- ✓ Database is shared across all jobs and all processors
- ✓ No one job is running on more than one processor

Symmetric Multiprocessing

Job A



- ✓ The system automatically divides the query work into multiple tasks or threads
- ✓ Multiple processors can work on one job's tasks or threads
- ✓ Process the individual SMP tasks or threads simultaneously (N-way)

- ✓ Db2 for i parallelism does not require table space partitioning

Symmetric Multiprocessing

- SQL Query Engine (SQE) uses threads
 - Small number of threads needed to drive parallel I/O and data processing
 - Normally 1 or 2 threads per CPU
- Classic Query Engine (CQE) uses DB Level 3 tasks
 - Large number of tasks needed to drive parallel I/O and data processing
 - Normally 1 task per disk unit (up to 255 per request or 1024 per system)

Symmetric Multiprocessing

Features and functions that take advantage of SMP...

- Requests processed by the Db2 Optimizer
 - SQL, OPNQRYF, QUERY, QUERY Manager
 - High-Level-Language native I/O is not SMP enabled
 - RPG, COBOL, C, C++, Java programs must use SQL to take advantage of SMP
- Index Creation
 - CREATE INDEX
 - CREATE ENCODED VECTOR INDEX
 - CRTLF
 - CHGLF
 - Recreation of index (keyed access path) at restore or recovery
- Index Maintenance
 - Blocked INSERTs and writes
- Copy from import file (CPYFRMIMPF)
- Reorganize physical file member (RGZPFM)

Symmetric Multiprocessing

■ SELECTING

- Index scan or probe
- Table scan or probe via bitmap or RRN list
- Table scan

■ JOINING

- Index scan or probe
- Hash

■ GROUPING

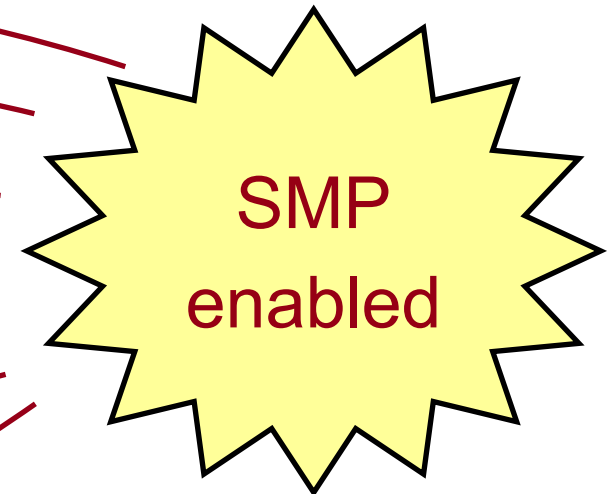
- Index scan or probe
- Hash

■ ORDERING

- Index scan or probe
- Sort

- Creating temporary indexes for joining, grouping or ordering is SMP enabled

- INSERT, UPDATE, DELETE are not SMP enabled



Parallel Processing

- Allows a user to specify that queries should be able to use either I/O or CPU parallel processing as determined by the optimizer
- Parallel processing is set on a per-job basis:
 - The parameter DEGREE on the CHGQRYA CL command
 - The parameter PARALLEL_DEGREE in the QQQINI file
 - The system value QRYDEGREE
 - The SQL statement SET CURRENT DEGREE
 - Each job will default to the system value (*NONE is the default)
- I/O parallelism utilizes shared memory and disk resources by pre-fetching or pre-loading the data, in parallel, into memory
- CPU parallelism utilizes one (or all) of the system processors in conjunction with the shared memory and disk resources in order to reduce the overall elapsed time of a query
 - CPU parallelism is only available when Db2 Symmetric Multiprocessing is installed
 - CPU parallelism does not necessarily require multiple processors, but limited benefits with a single processor system

Degree Parameter Values: *NONE and *IO

- ***NONE**
 - No parallel processing is allowed for database query processing
 - Default setting
- ***IO**
 - Any number of tasks may be used when the database query optimizer chooses to use I/O parallel processing for queries
 - CPU parallel processing is not allowed
 - SQE always considers IO parallelism

Degree Parameter Values: *OPTIMIZE and *MAX

- *OPTIMIZE

- The query optimizer can choose to use any number of tasks or threads for either I/O or CPU parallel processing to process the query
- Use of parallel processing and the number of tasks or threads used will be determined with respect to the number of processors available in the system, this job's share of the amount of active memory available in the pool which the job is run, and whether the expected elapsed time for the query is limited by CPU processing or I/O resources
- Optional **n%** allows decrease or increase in degree (only available via QAQQINI)
 - *OPTIMIZE 50%

- *MAX

- The query optimizer can choose to use either I/O or CPU parallel processing to process the query
- The choices made by the query optimizer will be similar to those made for parameter value *OPTIMIZE except the optimizer will assume that all active memory in the pool can be used to process the query
- Optional **n%** allows decrease or increase in degree (only available via QAQQINI)
 - *MAX 50%

Degree Parameter Values: *SYSVAL and *NBRTASKS

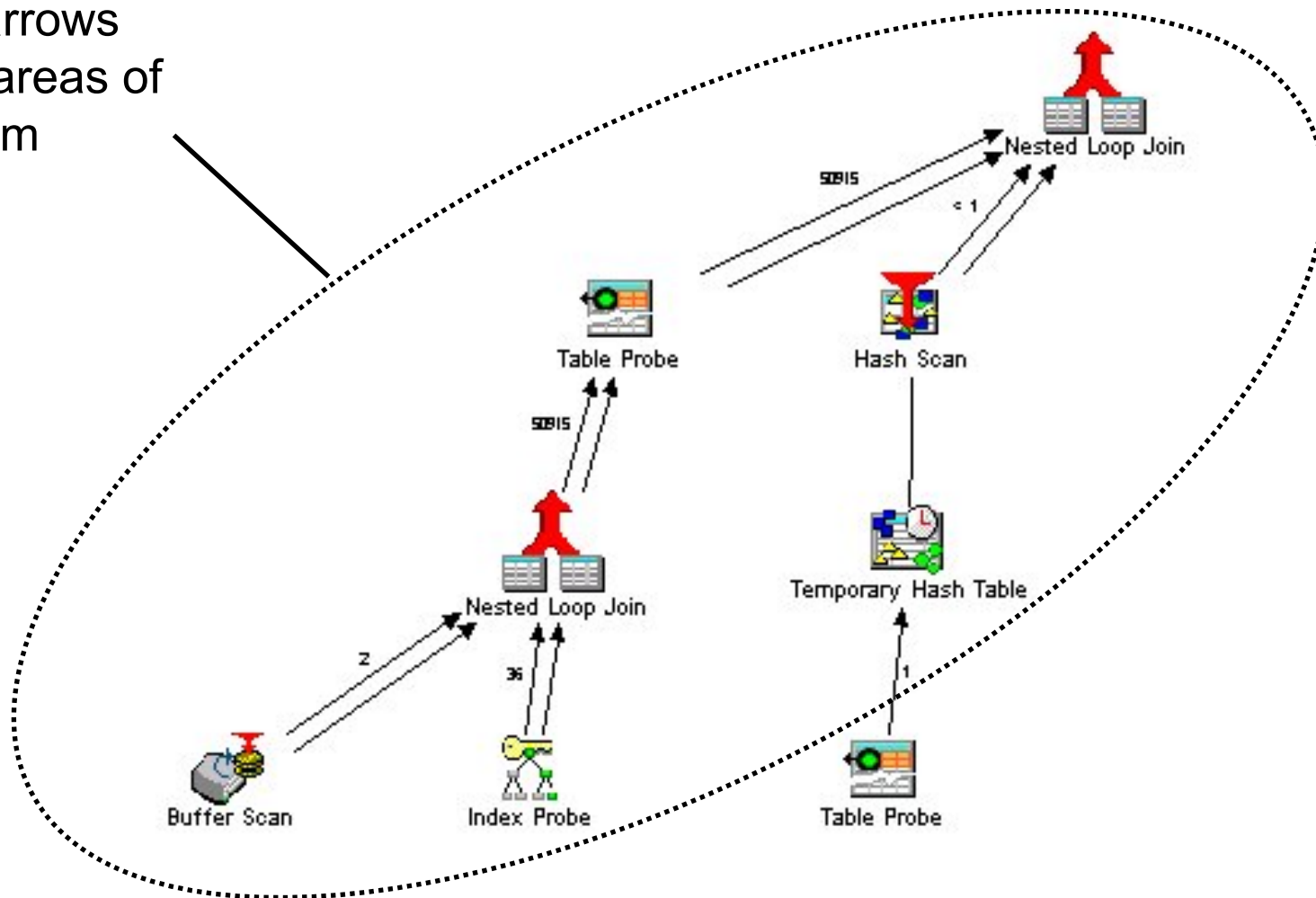
- *SYSVAL
 - Specifies that the processing option used should be set to the current value of the system value, QQRVDEGREE
 - Used with CHGQRYA command to “reset” the degree value
- *NBRTASKS nn
 - Specifies the number of tasks or threads to be used when the query optimizer chooses to use CPU parallel processing to process a query
 - I/O parallelism will also be allowed
 - Not available via the system value
 - Used to manually control the degree value
 - The value is used whether or not parallelism provides a faster elapsed time
 - Primarily for research and testing
 - Use with care and caution

Background Database Server Jobs

- QDBSRVxx jobs handle asynchronous requests such as rebuilding or refreshing indexes after restore or alter operations
 - 2 jobs per CPU + 1
 - Jobs are started at IPL
- QDBSRVxx jobs get assigned their parallel degree prior to handling each request
- To change the degree, issue a CHGQRYA DEGREE(...) using the QDBSRVxx job's name
- Given multiple QDBSRVxx jobs running simultaneously, you may have to lower or restrict the amount of parallelism for these jobs
 - Example: ALTER TABLE and multiple indexes are recreated

Feedback - SQE

Double arrows indicate areas of parallelism



Feedback - CQE

The screenshot shows the Visual Explain interface for a query. The execution plan on the left includes a 'Table Scan, Parallel' node with a parallelism icon (a small grid with a red and green pattern) and an arrow pointing to a 'Final Select' node. The right pane displays optimizer statistics:

Attribute	Value
Number of Primary Key Columns	0
List of Key Columns for Advised ...	ORDERKEY, LINENUM
Type of Index Created	Binary Radix
Number of Unique Index Values	Not Available
ACS Table Name	*HEX
ACS Table Library	*N
Columns for table selection, key...	
Columns for Data Space Selection	ORDERKEY, LINENUM
SMP parallel information	
Parallel Pre-Fetch	No
Parallel Pre-Load	No
Parallel Degree Requested	255
Columns used to join monitor 10...	
System Name	TERAPLXB
Job Name	QZDASOINIT
Job User	QUSER
Job Number	065960
Unique Query Count	104
Subselect Number of the Query	1
Information common to most m...	

The 'SMP parallel information' section is circled in black. The bottom of the window shows the SQL statement and optimizer messages:

```
select * from star10g.item_fact where orderkey < 1000 and linenum <= 0 optimize for all rows
```

Statement text Optimizer messages

Icon indicates areas of parallelism

Feedback

SQL Performance
Monitor and
Plan Cache
Snapshot data
contains
information on
parallelism

	Value	Summary Available	Statements Available
8/22/07 3:49:19 PM to 8/22/07 3:49:40 PM			
Overview			
How much work was requested?			
What options were provided to the optimizer?			
What implementations did the optimizer use?			
● Average Runtime	0.569355		
● Runtime	8.540328		
● Full Indexes Created	0		
● Sparse Indexes Created	0		
● Index From Index Created	0		
● Index Creates Advised	1	✓	✓
● Advised Statistics	0		
● Average MQTs Used	0		
● Average Indexes Used	2	✓	✓
● Temporary Tables	0		
● Sorts	0		
● Bitmap Creates	1	✓	✓
● Bitmap Merges	0		
● Skip Sequential Scans	1	✓	✓
● Table Scans	0		
● Nested Loop Join	0		
● Hash Join	1	✓	✓
● Index Group By	0		
● Hash Group By	1	✓	✓
● Index Order By	0		
● Sort Order By	0		
● Average Parallel Degree Used	1.28		
● Maximum Parallel Degree	2		
● Parallelism Restricted	10	✓	✓
● Parallel Table Scan	0		
● Parallel Index Scan	0		
● Parallel Hash Join	1	✓	✓
● Parallel Hash Group By	0		
● Parallel Bitmap Create	1	✓	✓
● Parallel Bitmap Merge	0		
● Parallel Index Create	0		
● Parallel Prefetch	10	✓	✓
● Parallel Preload	1	✓	✓
● Maximum Estimated Rows	169949		

	Parallel Prefetch	Parallel Preload	Parallel Degree Used	Parallel Degree Requested	Parallelism Restricted	R
	Yes	No	2	2	4	

Work Management Feedback - WRKSYSACT

Session C - [24 x 80]

File Edit Transfer Appearance Communication Assist Window Help

PrintScreen Copy Paste Send Recv Display Color Map Record Stop Play Quit Clipbrd Support Index

Work with System Activity TERAPLXD
07/30/01 14:24:53

Automatic refresh in seconds 5

Elapsed time : 00:00:03 Average CPU util . . . : 99.9

Number of CPUs : 23 Maximum CPU util . . . : 99.9

Overall DB CPU util : 99.1 Minimum CPU util . . . : 99.8

Type options, press Enter.

1=Monitor job 5=Work with job

Opt	Job or Task	User	Number	Thread	Pty	CPU Util	Total Sync I/O	Total Async I/O	DB CPU Util
—	DBL3Base05				20	2.5	0	0	1.9
—	DBL3Base04				20	2.5	4	0	2.2
—	DBL3Base00				20	2.4	8	0	3.8
—	DBL3Base00				20	2.4	8	0	2.8
—	DBL3Base01				20	2.4	8	0	2.4
—	DBL3Base04				20	2.4	0	0	2.8
—	DBL3Base03				20	2.3	0	0	3.0
—	DBL3Base04				20	2.3	4	0	2.5

More...

F3=Exit F10=Update list F11=View 2 F12=Cancel F19=Automatic refresh

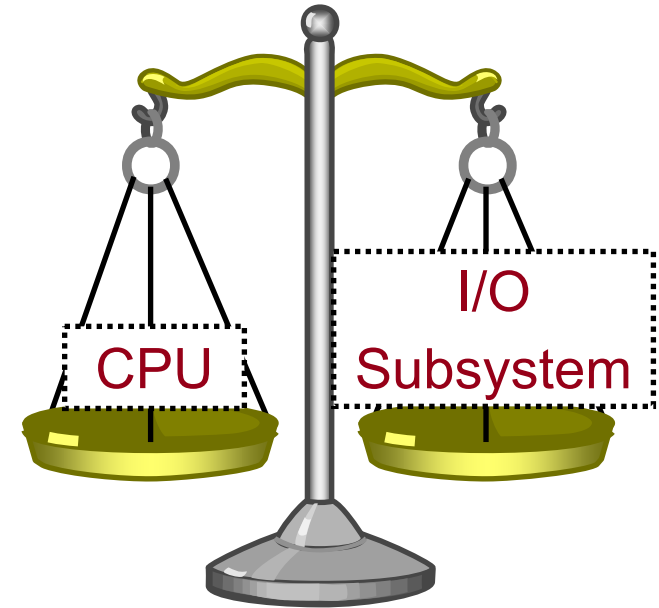
F24=More keys

MA c 13/003

Connected to remote server/host dadt using port 23

Symmetric Multiprocessing

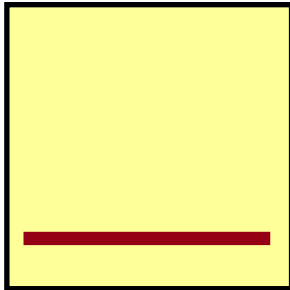
To make use of SMP,
resources must be:
Available and Balanced



- Trade resources for time
 - More resources used to decrease overall time spent running the request
- SMP = multiple tasks or threads used to perform the work
- Multiple tasks or threads = more resources used to perform the work
- N-way = ability to use multiple CPUs concurrently

Symmetric Multiprocessing

Job / Query
without
SMP



1x

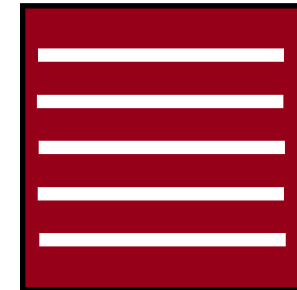
Running 10 jobs
results in

$10 * 1x$

or

10 units of demand

Job / Query
with
SMP



5x

Running 10 jobs
results in

$10 * 5x$

or

50 units of demand

Symmetric Multiprocessing

- Work Management is the same, and different
 - DB tasks or threads used to perform work on your job's behalf
 - Fair share of memory considered
 - Automatic preload, prefetch, prebring
 - Optimization affects use of resources
 - Available resources affects optimization
- With IBM i 7.5, `PARALLEL_MAX_SYSTEM_CPU` QAQQINI option can be used to prevent SMP queries from over-committing system CPU resources

SMP Considerations

Parallel access methods may not be used for queries that require any of the following:

- Sensitive cursor or ALWCPYDTA(*NO)
- Invocation of UDF or UDTF created with DISALLOW PARALLEL
 - If an external UDF or UDTF specifies ALLOW PARALLEL, then user responsible for ensuring high-level language program is thread safe
- Use of the *ALL or *RS commitment control level, or Repeatable Read isolation level
- Restoration of the cursor position on rollback
- Scrollable cursor

Parallel methods can be used on any intermediate temporary result regardless of the interface used to define the query

Note: SQL does not guarantee order of results, use the ORDER BY clause to ensure a specific order.

SMP Considerations

- When and where to consider using database parallelism and SMP?
- Application environments that can use and benefit from parallelism
 - Longer running or complex SQL queries, PARALLEL_MIN_TIME QAQQINI option can be used in IBM i 7.5 release to limit parallelism to longer running queries
 - Longer running database operations like index creation
 - Few or no concurrent users running in the same memory pool
 - Willing to dedicate most or all the resources to the specific SQL request(s)
- Computing resources
 - ≥ 1 (physical) CPU / core (limited benefit with single CPU)
 - 16GB memory per CPU / core, possibly more
 - Properly sized and configured I/O subsystem to support the requests
 - 60% or less average CPU utilization during the time interval of the request

SMP Considerations

- When and where to consider using database parallelism and SMP?
 - Start with *OPTIMIZE on longer running queries
 - For single running jobs try *OPTIMIZE first, then try *MAX
 - Run jobs in memory pools with paging option set to *CALC
 - The optimization goal "ALL I/O" tends to allow SMP, while "FIRST I/O" does not
 - Use n% to adjust degree for maximum throughput and resource use

SMP Considerations

Reminders:

- ✓ Db2 SMP is a no charge feature as of June 1, 2022
([Announcement letter](#))
- ✓ Db2 SMP must be installed and enabled to get the benefits