DB2® for z/OS™ and OS/390® Performance Update - Part 1

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Orlando, Florida October 1 - 5, 2001

M15a

NOTES

- **Abstract: The highlight of major performance enhancements in V7 of DB2 for OS/390 or z/OS, as well as recent performance enhancements made to V6, are covered in this presentation.**

- **Because of time constraints, only major performance enhancement highlights are covered. For more details, please see the redbook "DB2 for z/OS and OS/390 V7 Performance Topics" SG24-6129.**

Acknowledgment and Disclaimer

- **Measurement data included in this presentation are obtained by the members of the DB2 performance department at the IBM® Silicon Valley Laboratory.**
- **The materials in this presentation are subject to**
  - **enhancements at some future date,**
  - **a new release of DB2, or**
  - **a Programming Temporary Fix**
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Outline

- Transaction Performance
  - INSERT, UPDATE, DELETE SQL
- Utility Performance
- Dataspace Buffer Pool with zSeries™ processor and OS/390 2.10 or z/OS

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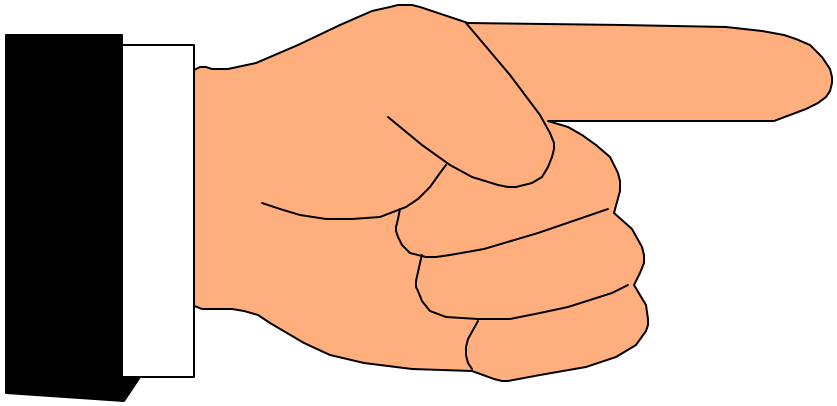
Transaction Performance

- Performance of
  - INSERT, UPDATE, DELETE SQL



NOTES

OUTLINE

- DB2 logging performance
- Asynchronous preformat
- Insert/Update performance enhancement
- Insert/Update performance tuning recommendation
- IRLM deadlock detection

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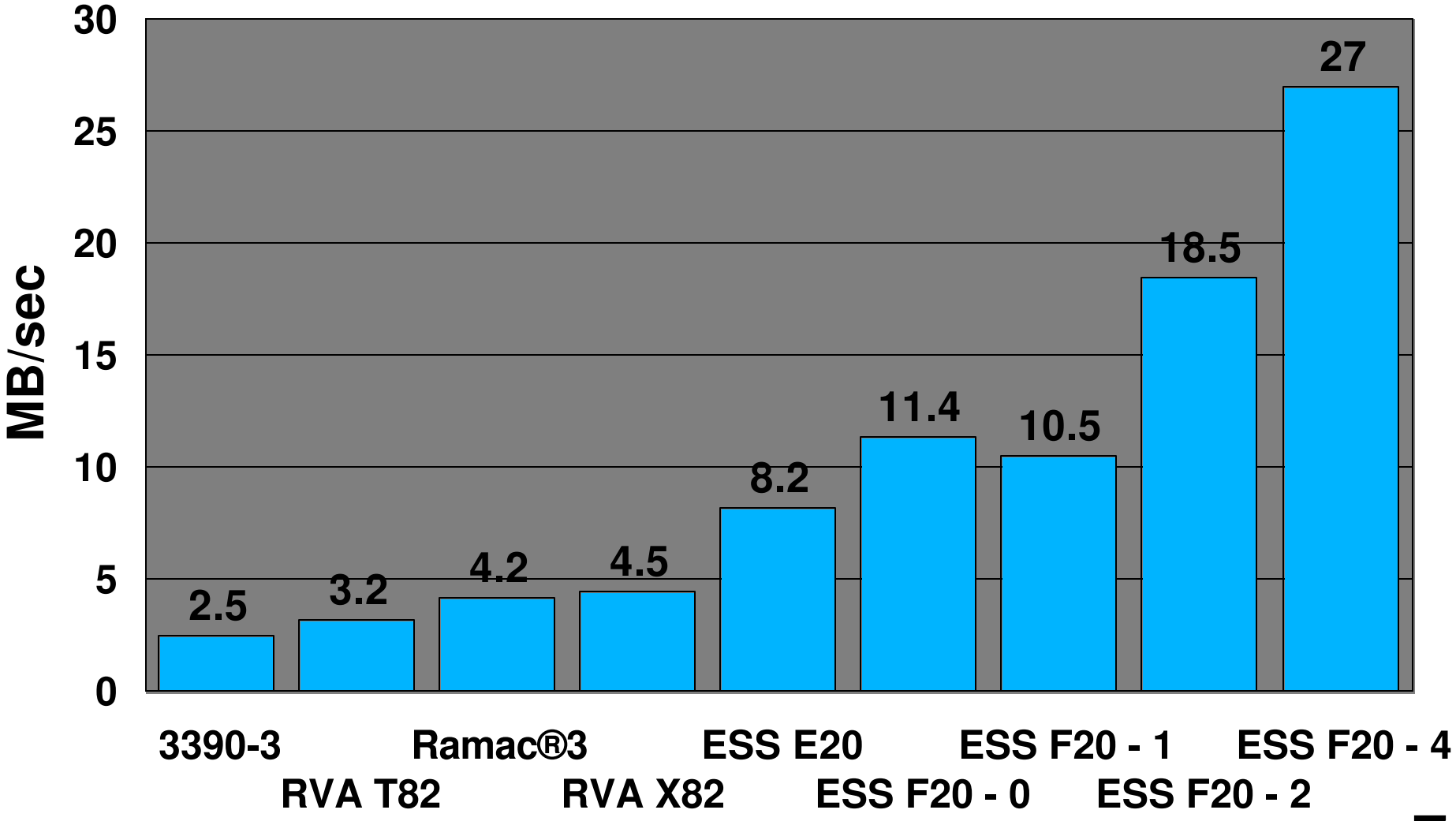
VSAM I/O Striping for DB2 Log

Max observed rate of writing to active log



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NOTES

- **Ramac1 and Ramac2 are similar to 3390-3.**
- **In "ESS F20-x", x indicates the number of stripes. This measurement from Ying Chang of IBM SSD, San Jose.**
- **For VSAM I/O striping, a data set must be SMS-managed, EF (Extended Format), and needs OS/390 2.10.**
- **8% less throughput from non EF log to a single striped EF log but no difference in CPU time.**
- **ESS F20 numbers include V6 PQ28857 8/99 for improved log write**

Log Statistics

Log activity/second

	OLTP	Batch
Log Records Created	3229	13600
Log CIs Created	70	1550
NEW Output Log Buffer Paged In	0	27.7
NEW Log Write I/O Request (Log 1 and 2)	417	35.6
NEW Log CIs Written (Log 1 and 2)	428	3172
NEW Log rate for 1 log in MB/sec	0.86	6.34

- 2 examples
  - OLTP (Online Transaction) insert with frequent commit
  - Batch insert with infrequent commit

NOTES

- **New Log statistics (V6 PQ28857 8/99 and DB2PM V7)**
  - **Average log record size = (log Control Intervals created * 4KB) / Log records created**
    - **So for OLTP, 70*4KB/3229 = 88 bytes average**
  - **Log Write I/O Request = Media Manager calls = sum of IFCID 38/39 pairs, should correspond to active log write I/O in RMF**

Log Statistics - continued

- LOG CIs (Control Intervals) Written represents a precise MB/sec log write rate as it counts each write of the same CI separately.
  - When more than 1MB/sec to one log, an attention should be paid on the log write performance.
  - Previously available Log CIs Created has been used to estimate the MINIMUM MB/sec log write rate as it does not account for the rewrite of the same CI.

NOTES

- Log CIs created vs Log CIs written
  - OLTP: 70 vs 428 or 214 per dataset
    - So each CI created is written 3 times per dataset
  - Batch: 1550 vs 3172 or 1586 per dataset
    - So each CI created is written once per dataset
  - In terms of active log dataset write performance, CIs written counter is a more meaningful measure than CIs created
- Log rate for 1 log = (Log CIs written * 4KB)/2 if dual log
  - So for OLTP, 428*4KB/2 = 0.86MB/sec

Log Statistics - continued

- Output Log Buffer Paged In
  - Can indicate insufficient real storage to back up log buffers (V6 PQ39000 6/00)
  - If class 19 log latch contention is also high (>200to1000/sec),
    - Reduce output log buffer size
    - Get more real storage if <2GB
    - Else use OS/390 2.10 or z/OS and zSeries processor with >2GB real storage

NOTES

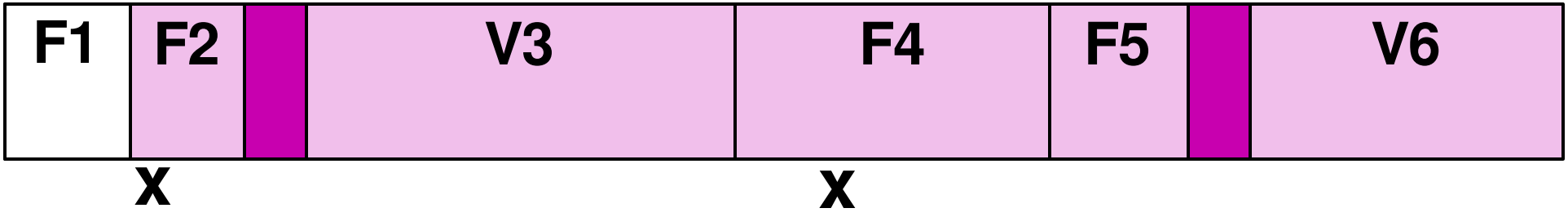
- **Maximum output log buffer size =**
  - **4MB in V5**
  - **400MB in V6**
  - **Watch out for real storage availability (Output Log Buffer Paged In counter) when increasing output log buffer size**
- **OS/390 2.10 or z/OS and zSeries processor enable exploitation of >2GB real storage**
- **Maximum active and archive log dataset size increased from 2GB to 4GB (V6 PQ48126 5/01)**

Reduction in the size of log data created

- Only log from the first changed byte to the last changed column in variable-length row update without length change, instead of from the first changed byte to the end of the row
  - -35% log CI created in one customer measurement
  - -8% log CI created in another
  - Greater improvement observed in less tuned environment

NOTES

- Let F1, F2, F4, and F5 be fixed length columns, and V3 and V6 variable length columns. F2 and F4 columns are updated as indicated by 'x'.

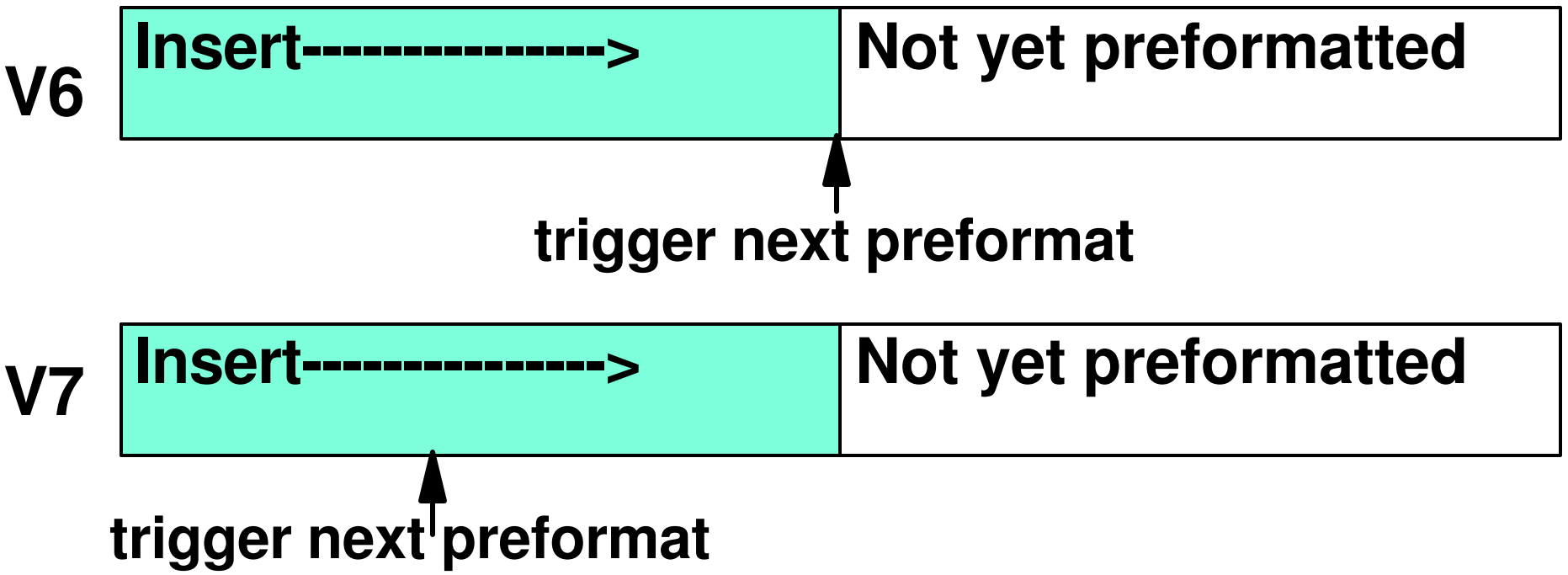


  - 2 dark areas indicate 2 byte length field preceding variable length columns.

- If fixed-length row update, then from first changed column to last changed column is logged.
- Log CI = 4KB log Control Interval

Asynchronous Preformat

- Preformat engine scheduled ahead to reduce wait time for preformat



  - Maximum possible reduction in elapsed time with one inserter can be estimated from Dataset Extend wait time in class 3 accounting

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NOTES

- The concept of asynchronous preformat is similar to that of asynchronous prefetch by triggering preformat by anticipating the near-future need.
- In an Insert-heavy workload to one or small number of data sets and I/O-bound, asynchronous preformat may not result in the net elapsed time reduction equal to the dataset extend wait time, as other wait times may increase.
  - The net elapsed time reduction ranges from 0 to Dataset Extend wait time in accounting class 3.
- With multiple inserters to the same dataset, both Dataset Extend wait and Lock wait time can go down.

Insert/Update Performance Enhancement

- OS/390 2.10
  - VSAM I/O striping to remove log I/O bottleneck
  - Dataspace buffer pool for index, at least to avoid nonleaf page read I/O (with zSeries processor)
- DB2 V7
  - Less log data created in Update
  - Asynchronous preformat to reduce elapsed time
  - Avoid unnecessary dynamic prefetch and read I/O in non-segmented tablespace insert by multiple agents
- ESS PAV to reduce I/O contention, especially for non partitioning indexes

NOTES

- Rule-of-Thumb to keep nonleaf pages in buffer pool
  - Buffer pool size > 2*(number of nonleaf pages)
- V7 change in sequential detection algorithm in Insert to track read I/O instead of pages accessed without read I/O can reduce unnecessary scheduling of dynamic prefetch and read I/O
  - Also for insert to end of non-segmented tablespace or segmented mass deleted pages (V6 PQ42372 12/00)
- ESS PAV = Parallel Access Volume feature of ESS to enable concurrent I/O's to the same volume at the same time

Insert/Update Performance Tuning Recommendation

- For a large table with non partitioning indexes, I/O typically becomes the most critical performance bottleneck.
- If index I/O-bound,
  - ESS with PAV
  - Non partitioning index piece
  - Hiperpool, or Dataspace buffer pool on zSeries processor
  - Default freespace

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NOTES

- PAV = Parallel Access Volume to allow multiple concurrent I/O's to the same volume

- If data I/O-bound,
  - ESS, with PAV if possible
  - V7 asynchronous preformat or Load/Reorg with preformat option
  - 0 freespace

- If log or non DB2 data I/O-bound,
  - ESS, with PAV if possible
  - I/O striping (VSAM, BSAM)

Insert/Update Performance Tuning Recommendation - continued

- Deferred write threshold tuning for update-intensive data or index
- Segmented tablespace for variable-length record insert or update, and mass delete
- V7 Online Load Resume to reduce CPU time while minimizing concurrency impact
- Data sharing
  - MEMBER CLUSTER tablespace to minimize spacemap and data page P-lock contention
  - V7 CURRENT MEMBER special register to enable insert by tablespace or partition by member to reduce data sharing overhead

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NOTES

- **For recommendations on deferred write threshold tuning, please see Insert Performance Considerations in DB2 for OS/390 in 2000 DB2 Tech Conference**

Deadlock detection interval

- Deadlock detection interval reduction (IRLM PQ44791 5/01)
  - Before Apar: 1 to 5sec interval
  - After Apar: 0.1 to 5sec interval
  - To keep pace with ever-faster processors
  - Negligible performance impact

NOTES

- 0.1sec versus 1sec deadlock detection interval
  - +0.44% IRWW (IBM Relational Warehouse Workload) transaction CPU time because of IRLM CPU time increase
- New MODIFY irlmproc,SET,DEADLOK= command to dynamically change deadlock frequency
- Dynamic change of timeout value without shutting down and restarting DB2 subsystem
  MODIFY irlmproc,SET,TIMEOUT=1to3600sec
  via IRLM PQ38455 6/00

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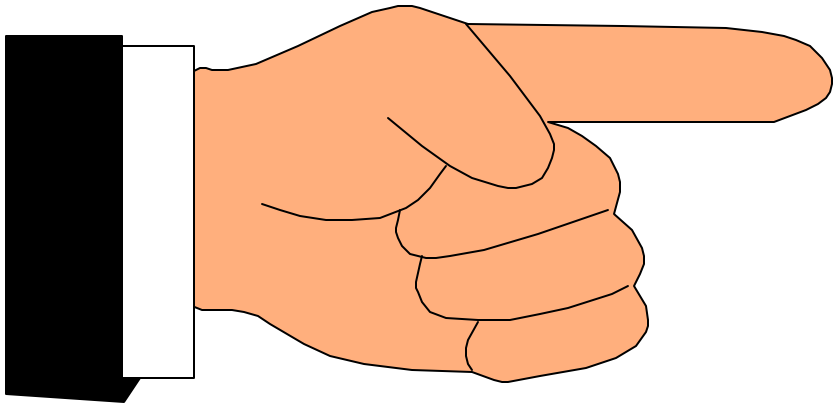
Utility Performance



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NOTES

OUTLINE

- Faster and more available Online Reorg
- Online Load Resume
- Parallel Partition Load from multiple input data sets in one job
- Load performance tuning recommendations
- Fast Unload
- Modify Recovery

Faster and more available Online Reorg

- Data Availability during Online Reorg

Online Reorg Phase	Data Access Allowed
Unload	Read/Write
Reload	Read/Write
Sort and Build Index	Read/Write
Log processing iterations	Read/Write
Last log iteration	Read Only (1)
Switch	None (2)
Build2	None to affected area (3)

V7

V7

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NOTES

- **3 phases in Online Reorg do not allow full Read/Write access of data.**

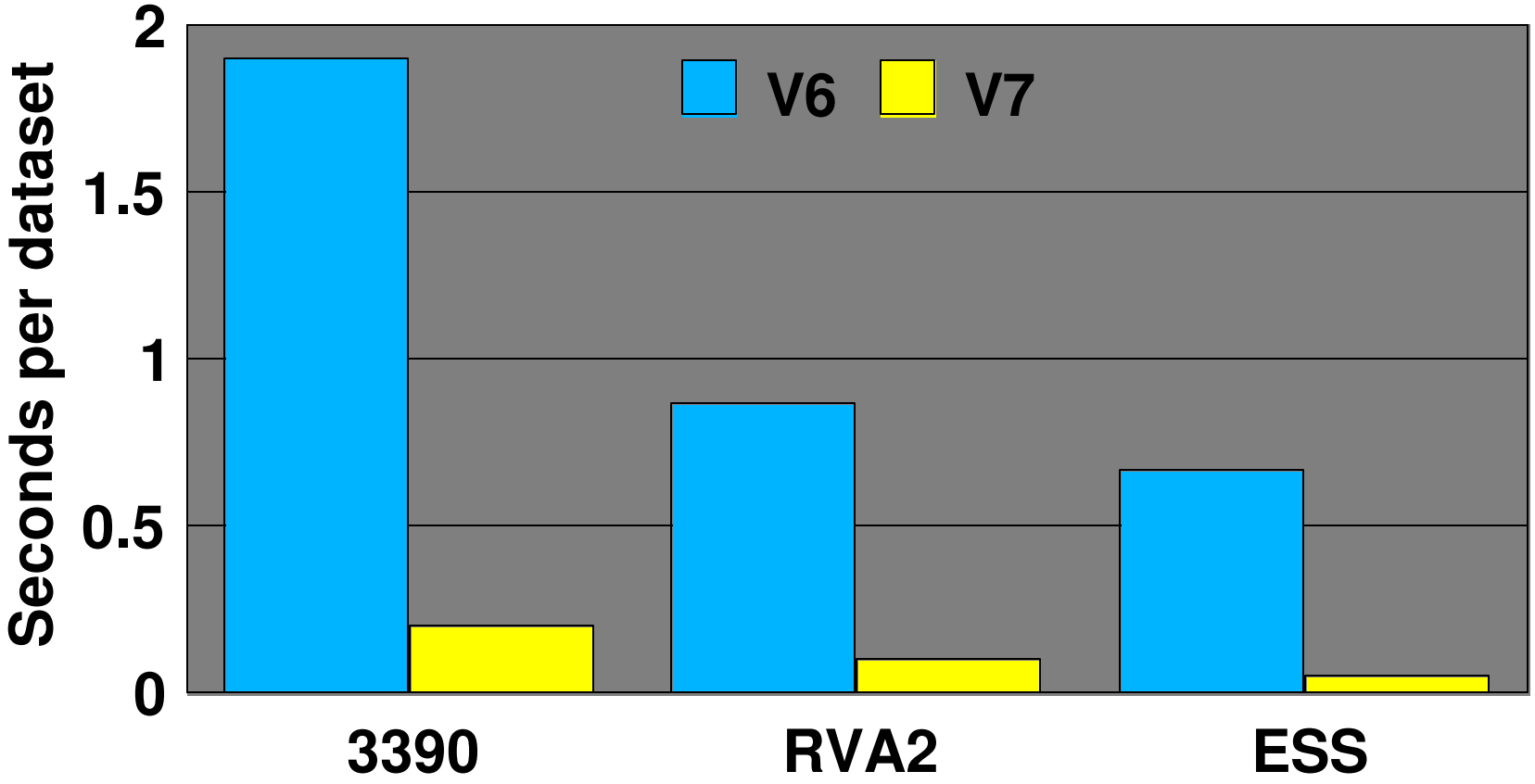
1. **Last Log Iteration phase supports read only access. However, this phase is typically very short and also the duration can be user-controlled by REORG MAXRO parameter.**

2. **Switch phase time which is a function of the number of data sets to be renamed can take in the range of 0.7 to 2 seconds per dataset. So, for a tablespace with 100 partitions, no access is allowed for up to 400 seconds. (100 datasets for data and 100 datasets for partition index)**

3. **Build2 phase which takes place in Online Reorg of selected partitions with non partitioning indexes (NPI) stops access to Reorg'd partitions as well as entire NPIs.**

Online Reorg - continued

- Fast switch phase by avoiding dataset RENAME
  - About 10 times faster switch phase
    - ➡ 10 times availability improvement



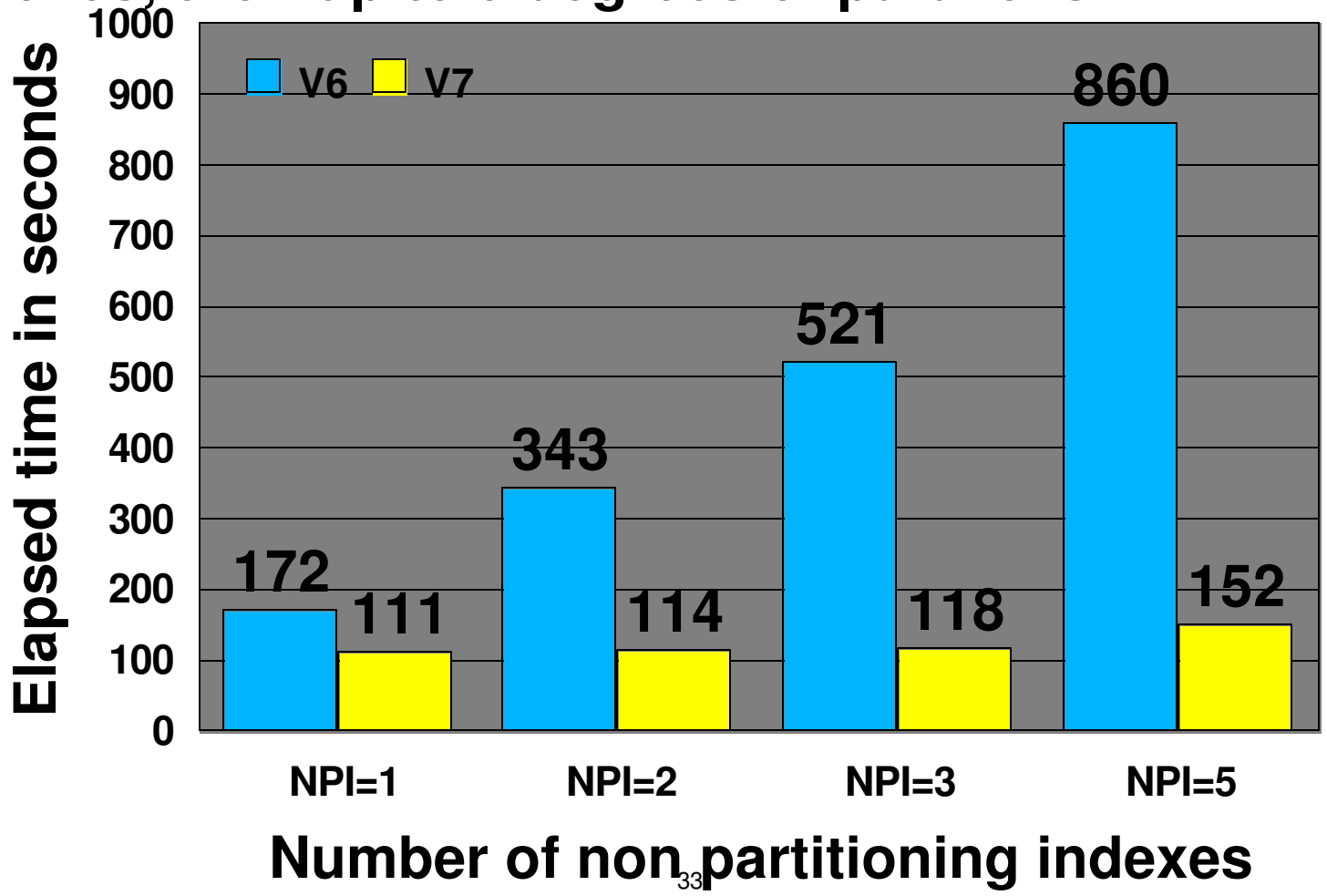
NOTES

- **Switch phase time of**
  - **0.7 to 2 seconds per dataset in V6**
  - **0.05 to 0.2 seconds per dataset with V7 Fast Switch**

depending on the device type

Online Reorg - continued

- **Parallel Build2 phase**
  - **If Partition Reorg of partition(s) with 5 non partitioning indexes, then up to 5 degrees of parallelism**



NOTES

- **Measurement of Reorg of 3 out of 10 partitions in 20 million row tablespace**

Number of non partitioning index	Elapsed time reduction
1	1.55 times (35%)
2	3 times (67%)
3	4.4 times (77%)
5	5.66 times (82%)

  - **Improvement even for one NPI because of elimination of unnecessary logging for each index entry**

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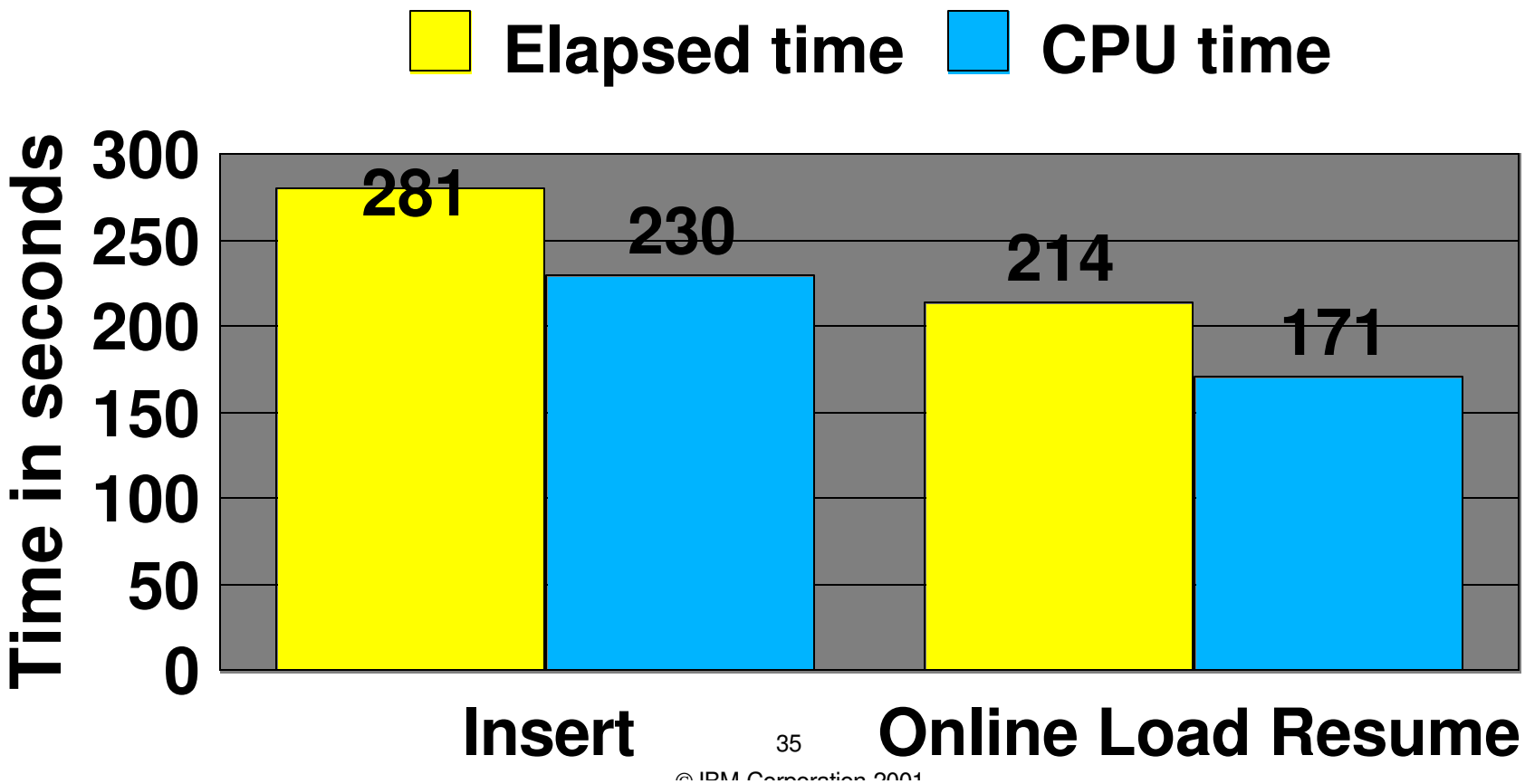
Online Load Resume

- Functionally operate like SQL Insert
  - But up to 37% less CPU time by avoiding Insert API overhead
  - Corresponding elapsed time reduction also possible



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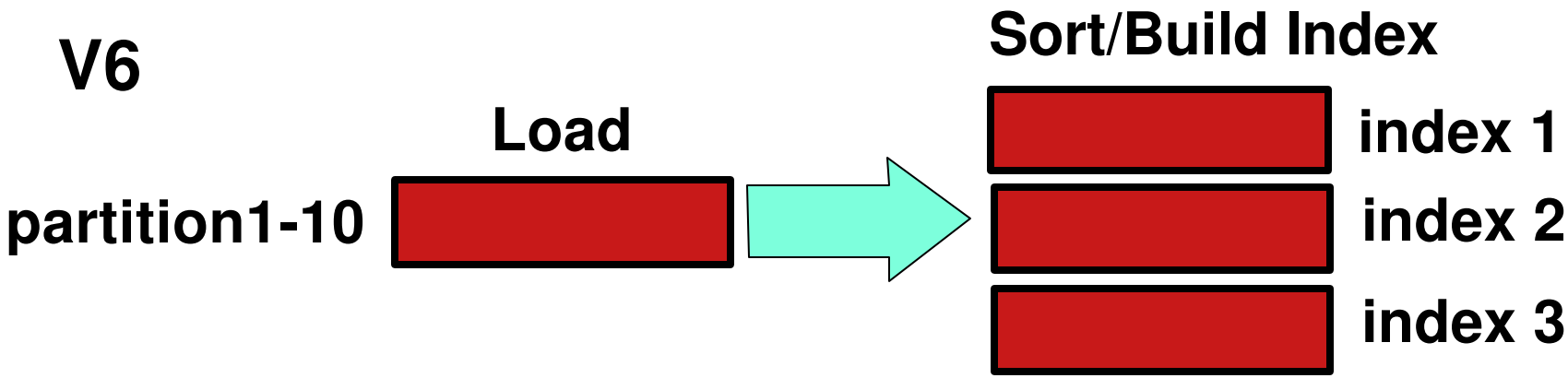
NOTES

- Unlike normal Load Resume, Online Load Resume provides the same level of concurrency as Insert
- API = Application Program Interface. There is a fixed overhead of invoking an SQL call such as Select, Open, Fetch, Close, Insert, Update, Delete, etc.
- Online Load Resume vs Insert measurement example
  - 2 million rows added to 8 million row table with 2 indexes, resulting in 10 million row table
  - 24% reduction in elapsed time
  - 26% reduction in CPU time
- 15 to 37% elapsed time and CPU time reduction for 1 to 3 indexes, with 1 index getting the best improvement.

Parallel Partition Load in one job

- By up to N tasks for N partitions with N input datasets (used to be sequential here in V6)
  - followed by parallel sort and build for M indexes



- About 30% faster compared to one Load job for the whole table

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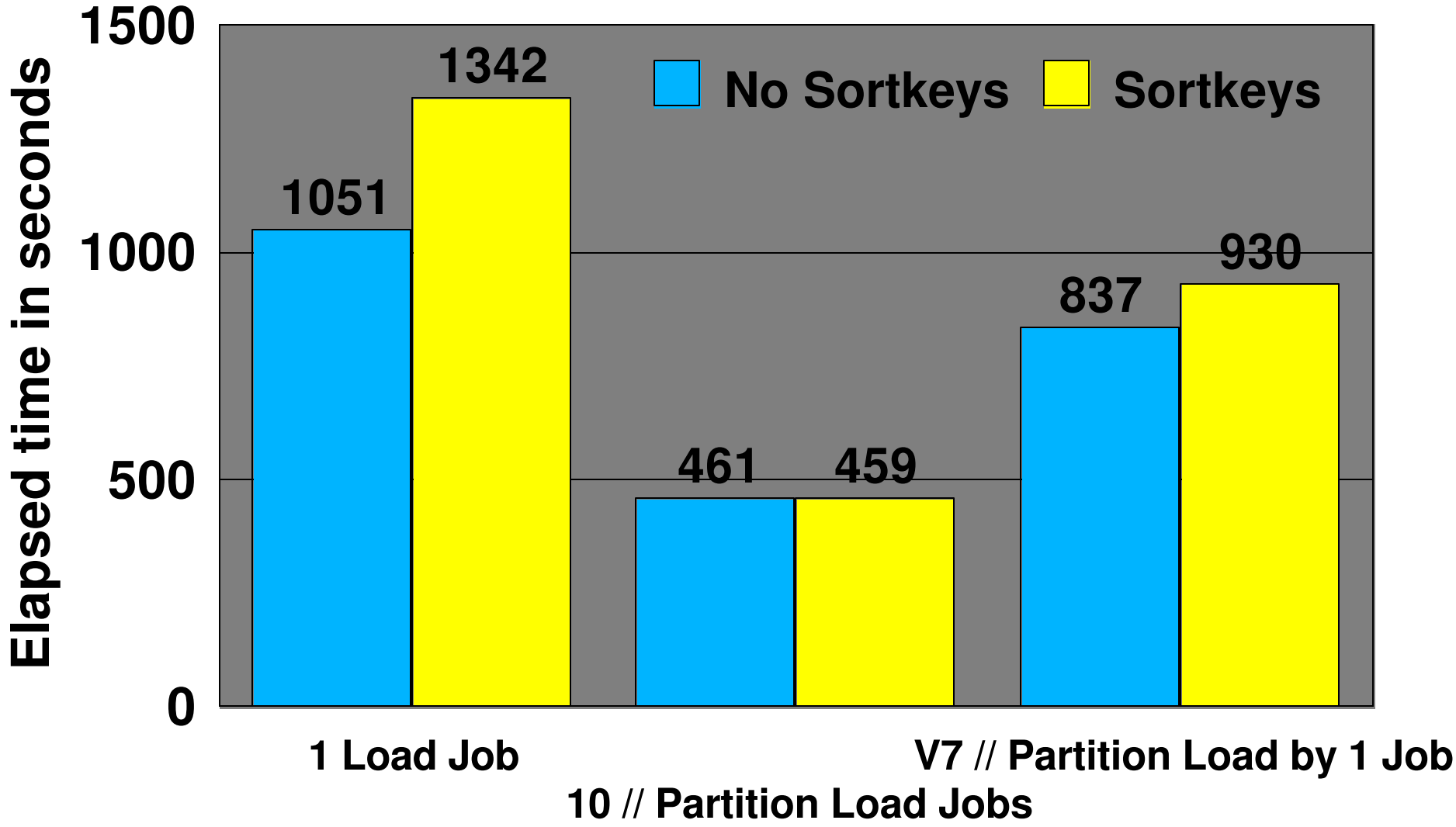
NOTES

- In the following pages, 50 million row Load into a 10 partition tablespace was measured using 12way G6 turbo and ESS.
- A bigger elapsed time reduction possible for parallel processing if well-tuned I/O configuration, also BSAM i/o striping
- A similar result was obtained for 20 partition tablespace containing 50 million rows

Parallel Partition Load - continued

- Load into table with 1 index



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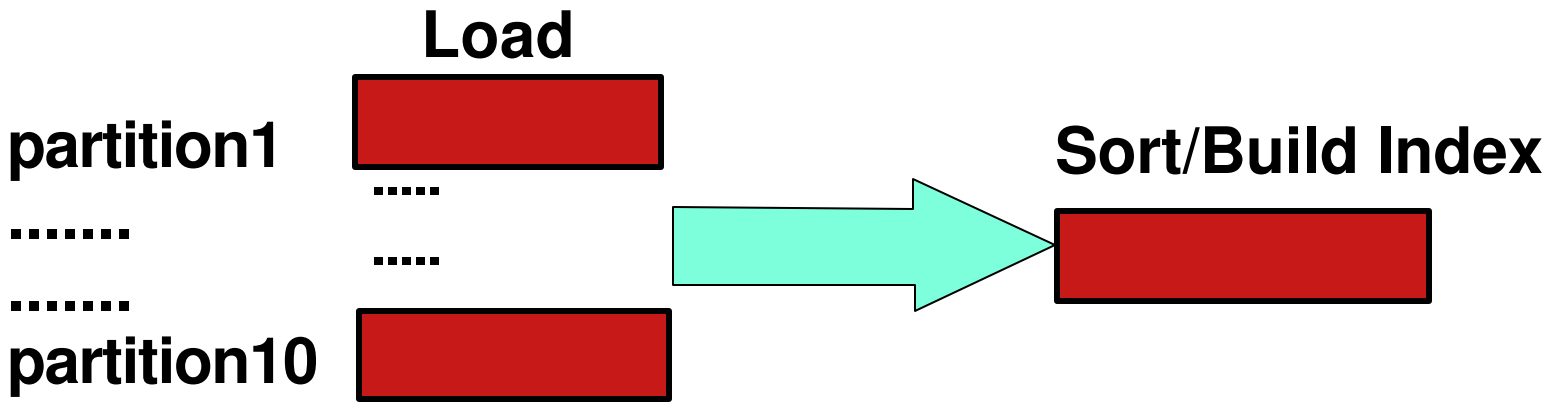
NOTES

- When there is only one index on a table to be loaded,
  - 10 // (Parallel) Partition Load Jobs the fastest.
  - V7 // Partition Load by 1 Job is faster than V6 1 Load Job, but slower than 10 // Partition Load Jobs because of sequential index build.



  - SORTKEYS option, which always calls DFSORT, tends to be slower if input data is already in key sequence.

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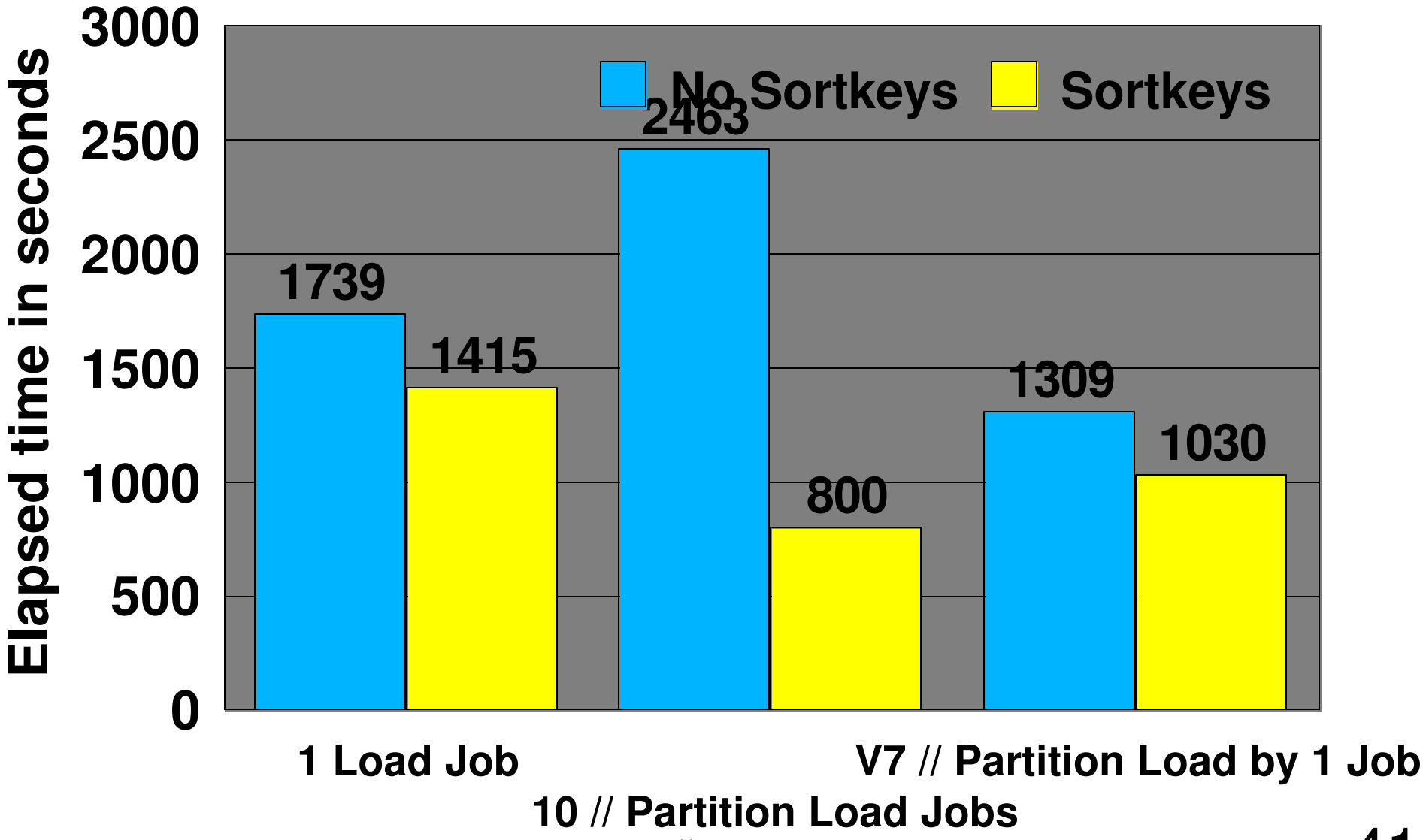
Parallel Partition Load - continued

- Load into table with 2 indexes



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NOTES

- When there are 2 indexes on a table to be loaded,
  - SORTKEYS option is clearly better.
    - No DASD Read/Write for SYSUT1 and SORTOUT work files for indexes (V5)
    - Parallel sort and build of indexes (V6)
    - SORTKEYS option always recommended if more than 1 index
  - 10 // (Parallel) Partition Load Jobs is the fastest, followed by V7 // Partition Load by 1 Job. However, since the latter uses about 20% less CPU time, it is considered to be a toss up.

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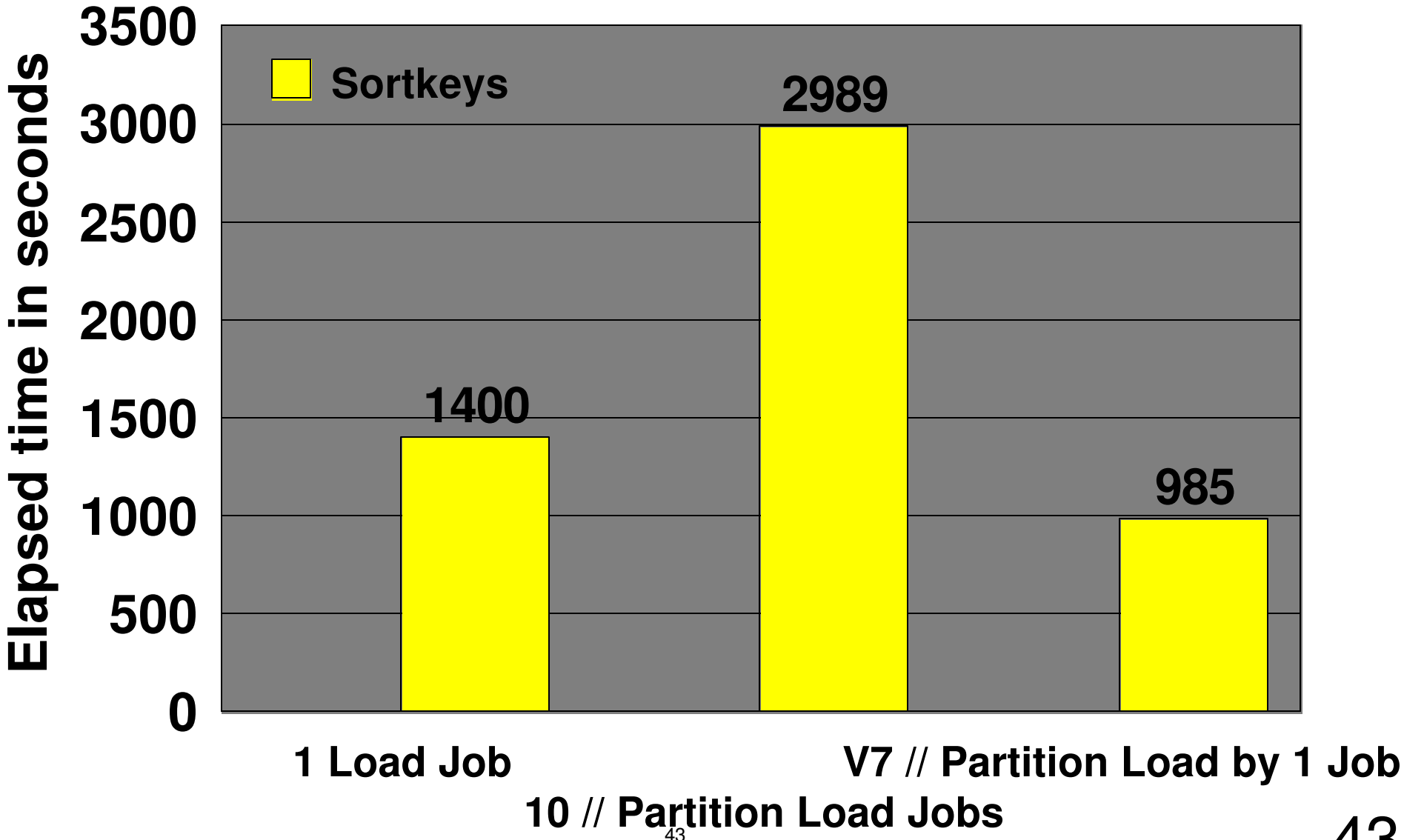
Parallel Partition Load - continued

- Load into table with 3 indexes



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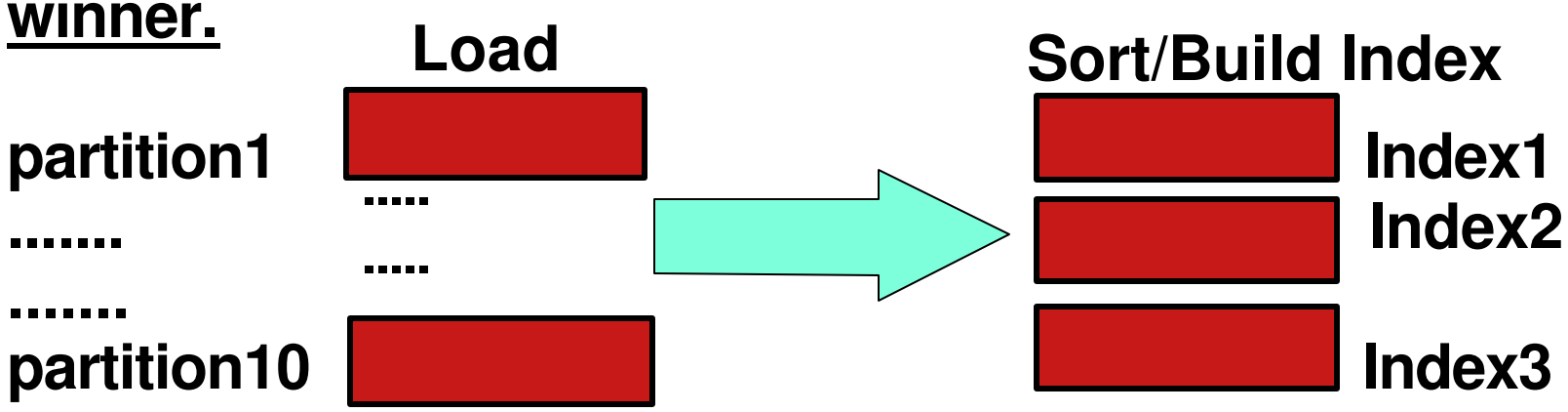
NOTES

- When there are 3 indexes on a table to be loaded,
  - As a result of multiple jobs contending for non partitioning index pages, // Partition Load Jobs deteriorate rapidly as the number of indexes increases because of much higher CPU time for non-partitioning index processing.
  - V7 // Partition Load by 1 job with SORTKEYS option is a clear winner.



  - The same story for more than 3 indexes

Load Performance Tuning Recommendations

- If one index, parallel partition Load jobs
- If multiple indexes, V7 parallel partition Load in 1 job with SORTKEYS option

- If I/O-bound,
  - ESS with PAV
  - I/O striping (BSAM, VSAM)

- If Load Resume Yes, similar to Insert recommendation

- If DB2 data compression, zSeries processor

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NOTES

- Use SORTKEYS option unless there is only one index and data is in index key sequence
- PAV = Parallel Access Volume to allow multiple concurrent I/O's to the same volume
- Other possibilities
  - V7 Online Load Resume for high concurrency
  - V7 Union Everywhere and Parallel Load of small tables

Fast Unload

- More function and 15 to 18% less CPU time compared to Reorg Unload External
  - Reorg Unload External, which was made available in V6 and V5 apar PQ19897 11/98, uses up to 4 to 9 times less CPU time compared to DSNTIAUL.
- 2 times faster with partition parallelism in one measurement (similar to user-controlled parallelism in V6)

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NOTES

- **V7 Unload utility, which is independent of Reorg utility, is an enhanced version of Reorg Unload External**

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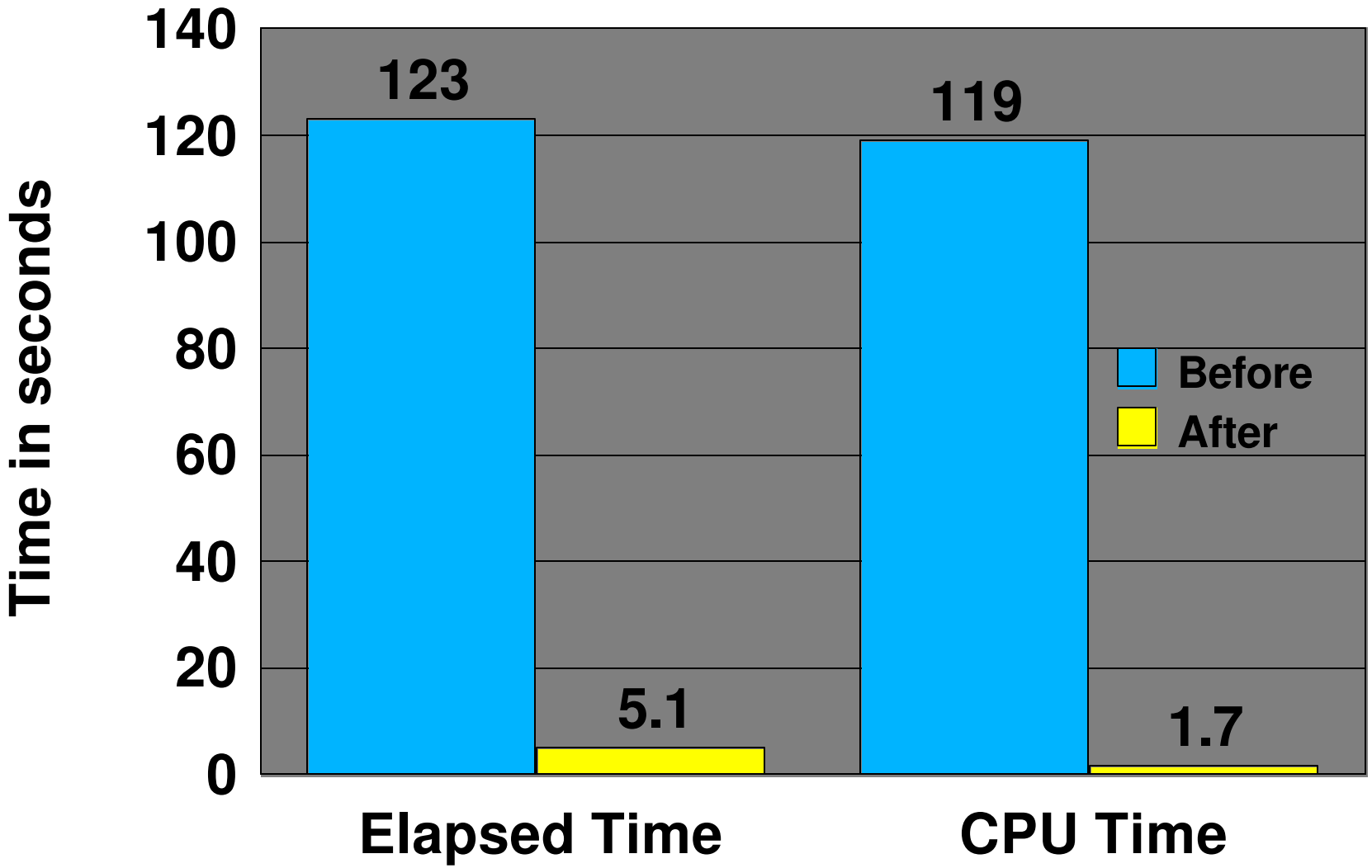
Modify Recovery Performance



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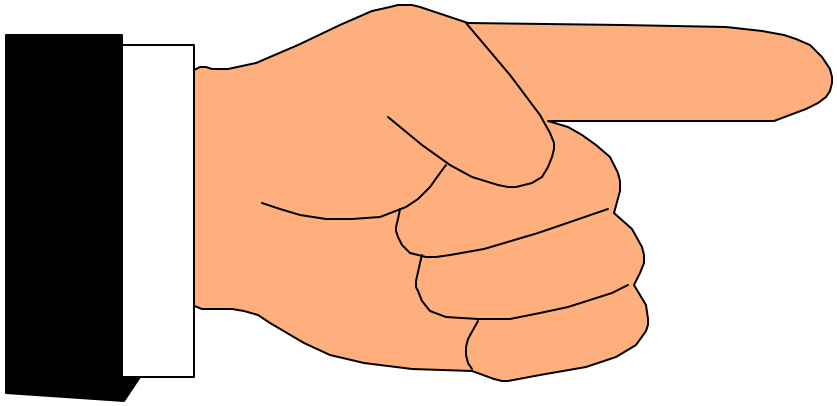
NOTES

- MODIFY to delete from SYSCOPY, SYSLGRNX, and DBD
- Example of MODIFY DELETE AGE(*) for one tablespace
  - Deleting 7500 rows out of 1 million SYSCOPY rows
  - 24 times less Elapsed Time and 70 times less CPU time
  - V5/V6/V7 PQ45184 5/01

	Before Apar	After Apar
Lock Request	7,400,000	8,000
Unlock Request	7,400,000	37
Catalog Getpage	400,000	100,000
Catalog Update	42,000	42,000

Dataspace Buffer Pool with zSeries Processor and OS/390 2.10 or z/OS



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NOTES

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Dataspace Buffer Pool

- With zSeries processor and OS/390 2.10 or z/OS enabling exploitation of >2GB real storage, Dataspace Buffer Pool becomes a powerful force in
  - DBM1 virtual storage constraint relief
  - Bigger buffer pool to reduce DASD I/O rate, promoting performance scalability for bigger and faster processors
    - Doubling the throughput when the processor power doubles

NOTES

- **zSeries processor became available 12/00**
- **Dataspace buffer pool was introduced in V6 DB2, but its full exploitation was not possible until >2GB real storage is supported.**

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Dataspace Buffer Pool - continued

- **Dataspace buffer pool with sufficient real storage**

1. **Typically 0 to 10% additional CPU time compared to virtual pool. However, CPU and elapsed time reduction possible compared to storage constrained virtual pool.**
2. **Up to 8 million buffers total (32GB with 4K pages)**
3. **Direct I/O support - more concurrent parallel prefetch I/O's can be supported**
4. **Can contain updated pages not yet written to DASD - better for update-intensive data**
5. **Reduced class14 latch contention because no VP-HP page movement**

NOTES

- For sufficient storage, make sure PAGE IN FOR READ or WRITE is less than 5% of pages read or written in steady state
- Higher %CPU overhead for page-processing intensive application, such as a query simply scanning a large amount of data
- Relevant apars
  - OS/390 R10 preconditioning 64bit support to allow dataspace BP and global dynamic statement cache to be fixed above 2GB real storage (V6 PQ25914 4/99)
  - Same as above for virtual pool and log buffers (V6 PQ36933 4/00)
  - Both apars remove the need to move the page to be fixed below 2GB
- VP = Virtual Pool, HP = Hiper Pool

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Dataspace Buffer Pool - continued

- **Hiperpool comparison**

1. **More overhead compared to dataspace buffer pool with sufficient real storage**
2. **Up to 8GB total**
3. **No direct I/O to/from HP - less concurrent I/O's can be supported**
4. **Can not contain updated pages not yet written to DASD**
5. **High class14 latch contention possible even with FIFO buffer steal option**

NOTES

- Support of HP (Hiperpool) via Fast Synchronous Data Mover Facility without ADMF on G5 and up (V4/V5/V6 PQ38174 6/00)
  - ADMF = Asynchronous Data Mover Facility, which has been a prerequisite since DB2 V3 for HP support.
- FIFO = First In First Out buffer steal option, recommended for data or index which are entirely resident in buffer pool (100% hit) or practically never resident (nearly 100% miss)
- IFCID 198 indicates where buffer is found
  - VP (Virtual Pool)
  - HP (Hiper Pool)
  - GBP (Group Buffer Pool)
  - Dataspace Buffer Pool

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Dataspace Buffer Pool - continued

- **Conclusion: With zSeries processor and OS/390 2.10 or z/OS, dataspace buffer pool is recommended over hiperpool.**

NOTES

- **Prior to zSeries processor and OS/390 2.10, hiperpool recommended over dataspace buffer pool**

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Dataspace Buffer Pool - continued

- Other performance benefits of zSeries for DB2
  - 15 to 30% faster on single engine and 30 to 75% more throughput than G6 turbo
    - on non-compressed data
  - 3 to 4 times more efficient hardware compression than G6 turbo
    - So 30 to 60% faster on compressed data
- Therefore, more than doubling of throughput possible with zSeries compared to G6 turbo

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NOTES

- **Maximum of 12 engines in G6 turbo, 16 in zSeries processor**

References

- Redbooks at www.redbooks.ibm.com
  - DB2 for z/OS and OS/390 V7 Performance Topics SG24-6129
  - DB2 UDB Server for OS/390 V6 Technical Update SG24-6108
  - DB2 UDB for OS/390 V6 Performance Topics SG24-5351
- DB2 UDB for OS/390 Administration Guide, Performance Monitoring and Tuning Section, SC26-9003 for V6, SC26-9931 for V7
- More information on DB2 UDB for OS/390 at www.ibm.com/db2

DB2® for z/OS™ and OS/390® Performance Update - Part 2

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NOTES

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Outline

- Query Performance
  - More efficient access path
  - Query parallelism
  - More efficient bind of many-table join
- V5 to V6 Performance Regression
- Fetch First N Rows
- Backward Dynamic Prefetch
- Catalog Migration Performance

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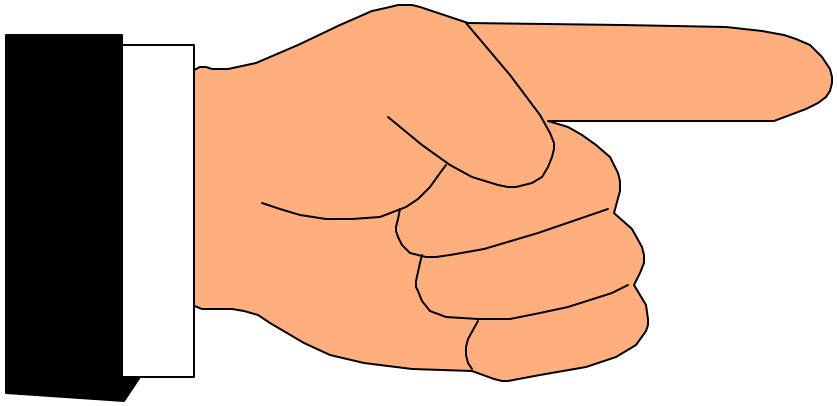
Query Performance

- **Performance of SELECT SQL scanning many rows**



NOTES

OUTLINE

- More efficient access path
- Query parallelism
- More efficient bind of many-table-join

More Efficient Access Path

- Matching index access in "column comparison-operator column expression" in join

```
Select from A,B where a1=SUBSTR(b1,1,8) ...
```

```
Select from A,B where a1=b1+x ...
```

  - Use index on a1 if table A accessed after table B
  - Particularly useful for large table A

NOTES

- **Exploitation of available index(es) has always been one of the top performance requirements in DB2 since V1.**

  V7 continues to further exploit available indexes for performance advantage.

More Efficient Access Path - continued

- For compatible column types such as numeric to numeric and target column having equal or bigger size and/or precision
  - float a1 = cast(decimal b1)
  - integer a1 > smallint b1 + x
  - date a1 between date(b1) and date(b1) + 10 days
  - char a1 = char b1||char b2

NOTES

- Join examples here show an index on a1 can be used if the table A is access after the table B
- Related enhancements in review
  - Scalar and noncolumn expression indexable in V5
    - a1 = date(host-variable)
    - a1 = x+y
  - Char/Varchar of different size indexable in equi-join with V5 PQ22046 and PQ24933 3/99
    - 10byte char a1 = 20byte varchar b1

More Efficient Access Path - continued

- Indexable non-correlated IN subquery in Select/Update/Delete
  - Introduced by V5 PQ23243 3/99 and V6

```
where a1 IN (Select b1 from ...)
```

  - Extended in V7 to
    - =ANY, =SOME
    - Multi-column (row expression)

```
where a1 =ANY (Select b1 from ...)

where (a1,a2) IN (Select b1,b2 from ...)
```

NOTES

- **AccessType = N**
  - **i.e. no join in Plan Table**
  - **Index on a1 or a1,a2 can be used**

More Efficient Access Path - continued

- Correlated subquery transformation to join

```
Select a1 from A where a1 in
                    (Select b1 from B where b2=a2) ...
```

transformed into

```
Select a1 from A,B where a1=b1 and b2=a2 ...
```

  - IN, =ANY, =SOME, EXISTS correlated subquery can be processed as stage 1 and transformed to join in Select, Update, Delete
  - Typical 2 to 10 times faster and less CPU time possible if large outer and small subquery results

NOTES

- Both correlated and non correlated subquery transformed to join prior to V7 if single table and single column guaranteed by unique index to have unique values. In V7 correlated subquery,
  - searched Update and Delete supported
  - subquery result does not have to be unique
  - EXISTS subquery supported

- In general, join can be more efficient than subquery because Optimizer can choose the best table join sequence (A to B, or B to A).
  - In subquery, sequence of table processing is fixed (A to B).

- Explain shows join if applicable

More Efficient Access Path - continued

- Avoid unnecessary sort when equal predicate on Order By key

```
Select from A where a1=x and a3=y order by a1,a2,a3
```

equivalent to

```
Select from A where a1=x and a3=y order by a2
```

➡ Thus, index on a2 could avoid sort in V7.

NOTES

- **Optimizer still relies on cost estimate to determine the best access path**
  - **Therefore, sort avoidance occurs only if that results in the lowest cost estimate.**
  - **For example, if an index on a1 and another on a2,**
    - **a2 index can avoid sort**
    - **but a1 index may be preferable, depending on what % of rows satisfy a1=x, how many rows are to be fetched (Optimize for N Rows), cluster ratio, etc.**

More Efficient Access Path - continued

- Avoid unnecessary sort when equal predicate on Order By key - join example

```
Select from A,B where a1=x and ... order by
a1,b2
```

equivalent to

```
Select from A,B where a1=x and ... order by b2
```

➡ Index on b2 could avoid sort in V7

NOTES

- **Prior to V7, it was not possible to avoid sort by creating an index, when a sort key consists of columns from different tables.**
  - **In V7, it is now possible to avoid sort even when sort key columns come from multiple tables.**

More Efficient Access Path - continued

- Immediately go to end of file for predicate "not null column is null" (V6 PQ39261 8/00)

```
Create Table A
        a1 INTEGER NOT NULL
             ....
Select from A where a1 is null
```

  - Previously, all rows in table A scanned to find no qualifying rows.

NOTES

- **If V6 apar number is specified in parentheses, an enhancement is retrofitted to V6. An apar closing date is also shown if already closed.**

More Efficient Access Path - continued

- Direct access for both MAX and MIN can now be supported with only one index

```
Select MAX(a1) from A where a1<X

Select MIN(a1) from A where a1>X
```

  - In V6, descending index on a1 and ascending index on a1 are required for MAX and MIN, respectively, to avoid a possibly long index sequential scan
  - In V7, only one index, either ascending or descending, is needed to avoid a scan

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NOTES

- **AccessType of I1 instead of I indicates an efficient one-fetch index access**

	V6	V7
MAX(a1) with ascending index on a1	I	I1
MAX(a1) with descending index on a1	I1	I1
MIN(a1) with ascending index on a1	I1	I1
MIN(a1) with descending index on a1	I	I1

More Efficient Access Path - continued

- Index-only access for VARCHAR when results won't change, e.g.
  - VARCHAR in where clause
  - No VARCHAR in scalar function, LIKE, Group By, Select list
  - Example: Select a1,a2 from A where a3=x with index on a1,a2,a3
    - Index only in V7 but not V6 if a1 and a2 CHAR and a3 VARCHAR
    - No index only if a1 or a2 VARCHAR

NOTES

- **Less restrictive but more error-prone index-only VARCHAR zparm option in V5 not recommended in general**
- **Index-only access can benefit transaction performance also.**

More Efficient Access Path - continued

- Minimize premature elimination of multi-index access path, ie index ANDing/ORing (V5 PQ39587 8/00)
- Optimizer cost formula change to account for index I/O cost reduction for prefetch to enable optimal access path selection (V5/V6 PQ38106 7/00)
  - Enabled via OPTPREF zparm in V5/V6, no zparm in V7

NOTES

- **A RID pool threshold will be applied AFTER considering more index matching predicates**

  Example: SELECT FROM A WHERE a1=? AND (a2=? OR a3=?), with one index on a1,a2 and another on a1,a3

  - **If 100M(million) row table with filter factors FFa1=10%, FFa2=6%, FFa3=4%,**
    then estimated number of rids to be processed =

    - **Before: 100M*10% = 10M rids**
    - **After: 100M*(10%*6% + 10%*4%) = 1M rids**

  - **So if 20MB RID pool, RID processing disabled before apar, enabled after apar.**

Query Parallelism

- **IN-list index access in parallel**

  Select from A where a1 IN (-, -, -, -)

  - **V6 supports parallel IN-list index access for inner table in join**
  - **V7 support for both outer table and single table access**
  - **Typical 2 to 5 times faster possible for IN-list index access**

NOTES

- **IN-list index access is indicated by AccessType 'N' in Plan table**
- **Number of degrees determined by smaller of**
  - **Number of values in IN-list or number of partitions if I/O-bound query**
  - **Number of values in IN-list or number of processors if CPU-bound query**

Query Parallelism - continued

- Disable unnecessary dynamic and list prefetch in a query parallelism when VPSEQT=0 (V6 PQ41128 11/00)
  - Just like in sequential execution
  - Can reduce DBM1 SRB time and class 24 latch contention, especially in many concurrent prefetch
  - V6 eliminated unnecessary prefetch scheduling for sequential, but not dynamic or list, prefetch, independent of VPSEQT value.

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NOTES

- **VPSEQT = Maximum percentage of Virtual Pool buffers that can be used for sequential, dynamic, and list prefetch (default = 80%)**
  - **When VPSEQT is set to 0, prefetch is usually disabled. This can result in up to 10% reduction in query CPU time when the requested pages are all in buffer pool and possibly even bigger improvement when high class 24 latch contention due to many concurrent prefetch.**
  - **Under query parallelism, prefetch was scheduled even when VPSEQT set to 0 prior to this enhancement.**

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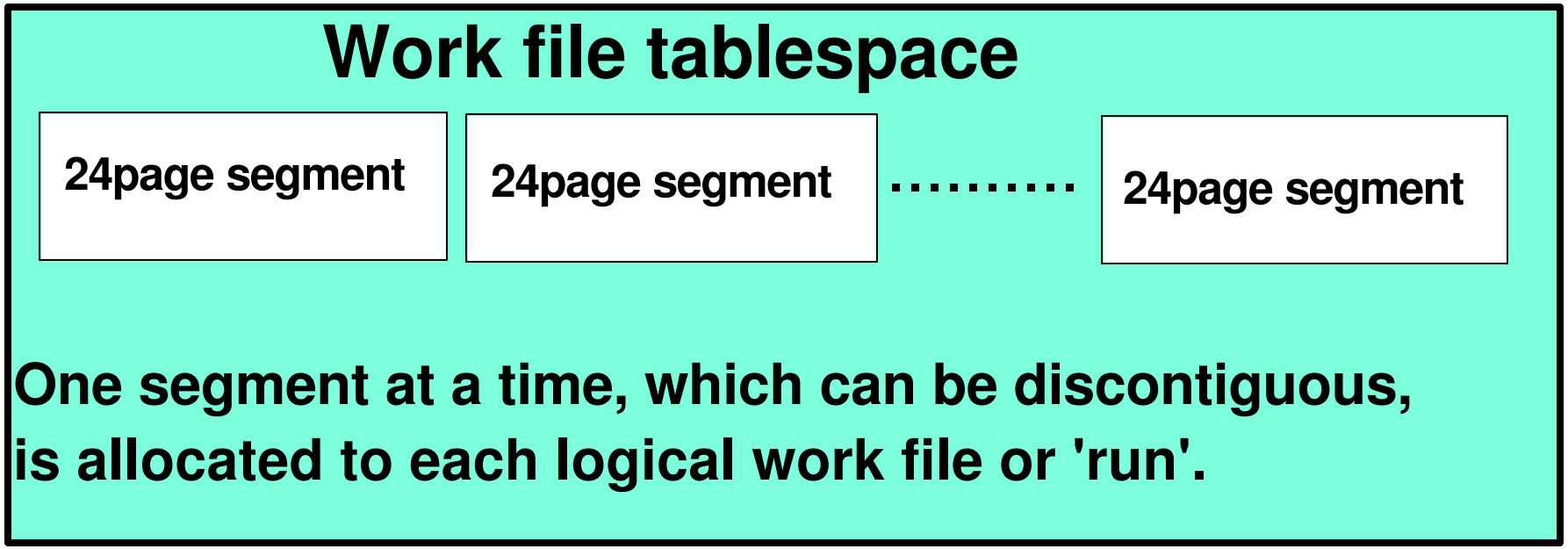
Query Parallelism - continued

- Work file prefetch quantity of 32 in parallel query brought down to 8, just like sequential query
  - Can reduce unnecessary page reads, especially when many concurrent work file activities, such as concurrent sort and Star Join
  - 10 to 20% reduction in the number of pages read for a single query in one measurement
  - Bigger reduction expected for multiple concurrent work file activities

NOTES

- A work file consists of a set of segments, each containing 24 pages. So reading 32 pages can cause pages belonging to a segment in a different logical work file to be read unnecessarily.



Query Parallelism - continued

- **Default maximum parallel degree reduction from 254 to [10*number of CPUs] (V6 PQ47914 6/01)**
  - **To minimize excessive use of DBM1 virtual storage, buffers, CPU time, etc. from over-parallelism**
  - **Overriding the default may be beneficial for very I/O-bound long-running query**

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NOTES

- **Recommendation to have number of physical work files at least equal to the maximum parallel degree**

More Efficient Bind of Many-Table-Join

- Bind CPU and DBM1 storage reduction
  - A new algorithm enabled for 9 or more tables in join
  - Up to 6 times reduction in DBM1 storage and CPU time observed for complex queries with 15 to 20 tables joined

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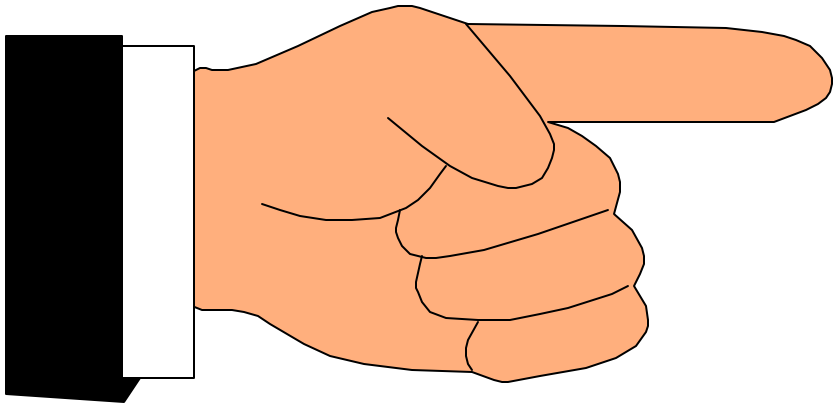
NOTES

- **Bind storage reduction extended to Outer Join queries via V7 PQ48306 5/01**
  - **Up to 25 times reduction in virtual storage usage for outer join queries**
  - **Up to 2 times further reduction in virtual storage usage for inner join queries**

Miscellaneous Topics



NOTES

OUTLINE

- V5 to V6 performance regression
- Fetch First N Rows
- Scrollable Cursor Performance Considerations
- Catalog migration (CATMAINT)

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V5 to V6 performance regression

- Stored procedure call with stored procedure name in host variable results in incremental bind at runtime
- Short-running SQL with degree any
  - especially those repeatedly executed in a loop

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NOTES

- **Stored Procedure regression fix**
  - **Reduce incremental bind overhead by saving the executable form of the bound CALL statement (V6 PQ35329 3/00)**
  - **Reduce excessive class28 (stored procedure) and class32 (storage pool) latch contention when many active threads are issuing frequent stored procedure calls, also minimize storage get/free in incremental bind (V6 PQ38744 10/00)**

Performance regression - continued

- Query parallelism threshold SPRMPTH zparm with nonzero default to avoid parallelism overhead for short-running queries (V6 PQ45820 3/01)
  - More important in each new release/version in trying to avoid performance regression as more queries become enabled for parallelism
  - Can dramatically reduce high 'Other service task wait' in class 3 accounting when degree any

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NOTES

- **Some examples of V5 to V6 parallelism enablement**
  - **Non partitioned tablespace**
  - **Outer join**
  - **Non partitioning index**
- **Service task wait breakdown in V6 accounting class 3**
  - **To quickly identify those with significant wait time**
  - **'Other service task wait' is supposed to be small**

Fetch First N Rows

- Limits the number of rows fetched to avoid fetching unwanted rows
- Singleton Select (or SELECT INTO) can be used with Fetch First 1 Row even if multiple rows qualify
  - Avoids -811 SQLCODE
  - Up to 30% CPU time saving compared to Open Cursor/Fetch/Close
  - Bigger improvement possible for CICS attach

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NOTES

- Can result in a significant elapsed time reduction in a distributed environment by reducing the message traffic
- Existence check without the use of EXISTS subquery
  - SELECT FROM T WHERE COLUMN = ...
    - Fetches all qualifying rows
    - Adding FETCH FIRST 1 ROW ONLY terminates a query execution as soon as the first qualifying row is returned

Fetch First N Rows - continued

- Access path selection (V7 PQ49458)
  - Use M in OPTIMIZE FOR M ROWS if specified
  - Else use N in FETCH FIRST N ROWS if specified
  - Example of M=1, N=50, and 100 qualifying rows
    - Optimizer picks the best access path for 1 row fetch. 50 rows are fetched
  - Example of N=10 and 5 qualifying rows
    - Optimizer picks the best access path for 10 row fetch. 5 rows are fetched

NOTES

- **Example of 25 (estimated) qualifying rows with no N or M specified**
  - **Optimizer picks the best access path for 25 row fetch. All qualifying rows are fetched.**

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Backward Dynamic Prefetch

- Introduced with scrollable cursor support but applies to all tables and indexes
- Sequential detection enabled for both forward and backward direction
  - Forward only in V6
  - With or without scrollable cursor

NOTES

- **Example**
  - **Do loop of Select * from T where c1=host-variable resulting in 1 million data pages accessed backward.**

V6	**1 million synchronous read I/O's**
V7	**31250 dynamic prefetch I/O's reading 1 million pages asynchronously**

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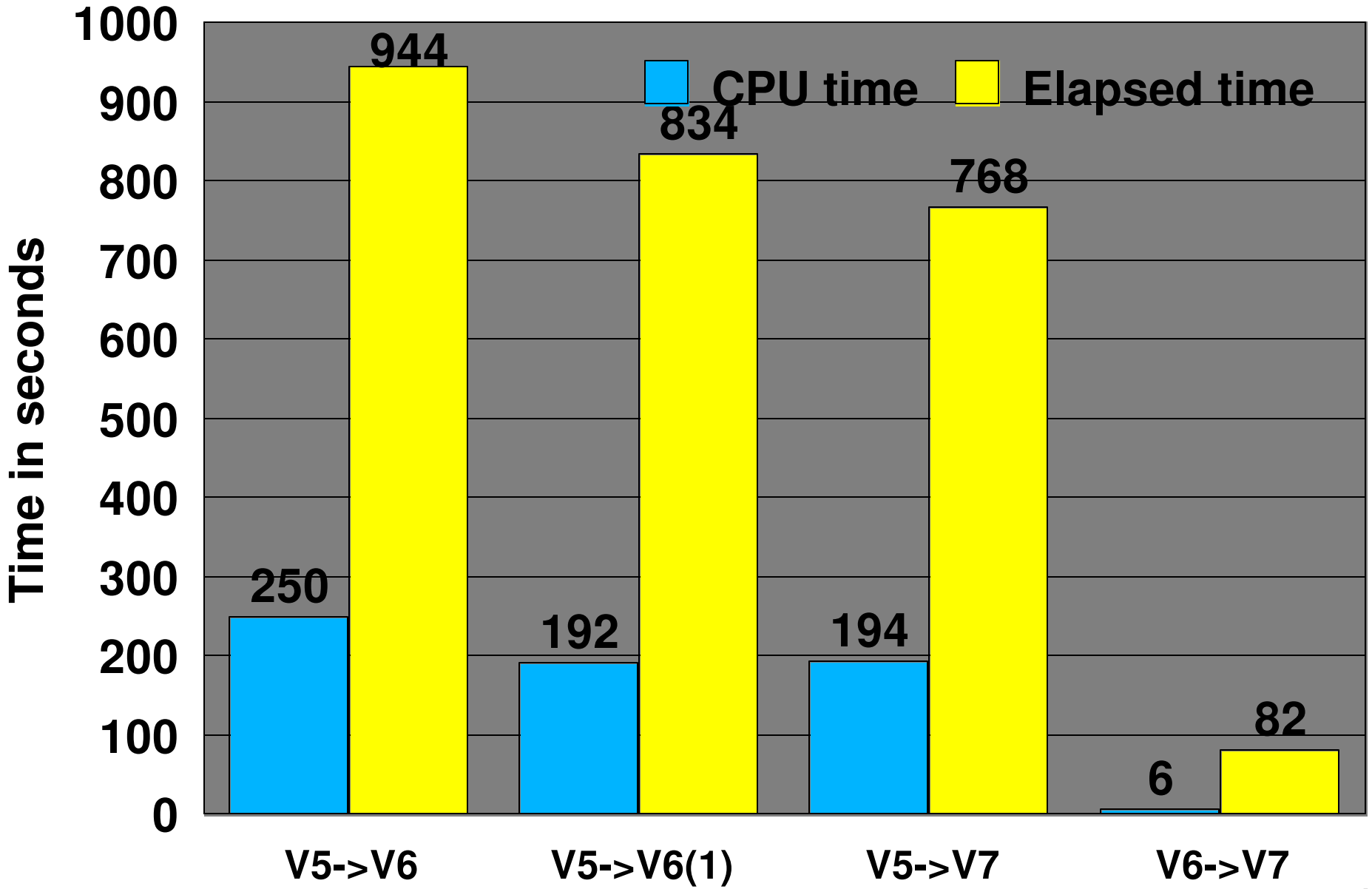
Catalog Migration Utility (CATMAINT)



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NOTES

- (1) With V6 PQ38035 2/01 and PQ44985 4/01
- For 5GB catalog with 7million rows
- Recommended buffer pool size for high performance catalog migration
  - Catalog buffer pool = 10000 buffers
  - Workfile buffer pool = 10000 in V5->V6, 1000 in V6->V7
- More than 10x elapsed time and 40x CPU time reduction in V6->V7 compared to V5->V6
  - 7x reduction in catalog Getpage
  - 21000x reduction in workfile Getpage as DB2 sort practically eliminated

References

- Redbooks at www.redbooks.ibm.com
  - DB2 for z/OS and OS/390 V7 Performance Topics SG24-6129
  - DB2 UDB Server for OS/390 V6 Technical Update SG24-6108
  - DB2 UDB for OS/390 V6 Performance Topics SG24-5351
- DB2 UDB for OS/390 Administration Guide, Performance Monitoring and Tuning Section, SC26-9003 for V6, SC26-9931 for V7
- More information on DB2 UDB for OS/390 at www.ibm.com/db2

NOTES

- **A comprehensive set of performance tuning recommendations for JDBC/SQLJ in V7 Performance Redbook**

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