CSCI317 Database Performance Tuning

Performance Tuning of Relational Database Server

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Performance Tuning of Relational Database Server

Outline

Top 10 mistakes

(1) Bad management of database connections

- A database application always connects and disconnects to perform each operation on a database

(2) Bad use of cursors and Shared Pool

- Not using cursors and bind variables increases time spent on parsing and optimization, dynamic `SQL` has a negative impact on performance

(3) Bad `SQL`

- Processing of `SQL` statements (especially `SELECT`) takes more time than processing the same applications with algorithmic codes, relational tables are scanned too many times

(4) Use of nonstandard initialization parameters

- Setting the unusual values of initialization parameters, using undocumented initialization parameters

(5) Getting database I/O wrong

- Incorrectly distributing database files over available disk drives

Top 10 mistakes

(6) Redo log setup problems

- Setting too small redo log buffer, using to small number of too small redo log files

(7) Lack of freelists, shortage of rollback segments

- Typical for `INSERT`-heavy applications, too large number of users, no enough rollback segments

(8) Long full table scans

- Usually, caused by lack of indexing, poor transaction design, poor `SQL` optimization

(9) High amount of "recursive" `SQL`

- Too many accessed to data dictionary caused by too many space management activities, e.g. storage allocation

(10)Deployment and migration errors

- Usually caused by incomplete migration of relational tables from development environment or legacy systems, e.g. missing indexes, missing statistics from `ANALYZE` statement

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Outline

Tuning data buffer cache

How large data buffer cache supposed to be ?

Consistent gets

- Number of times a block was acquired in a consistent mode, that is with the correct timestamp to provide read consistency
- It is incremented by 1 for each block read during full table scans
- It is incremented by (index height + 2*index key entries) for indexed table lookups
- It is incremented by 1 for each block read during and index-only lookup

Db block gets

- Number of blocks read for update
- It includes updates to blocks in `UNDO` and temporary tablespaces
- It is also incremented during extent allocation and when update to high water mark takes place

Tuning data buffer cache

Logical Reads (`LR#`)

- `LR#` = consistent gets + db block gets

Physical Reads (`PR#`)

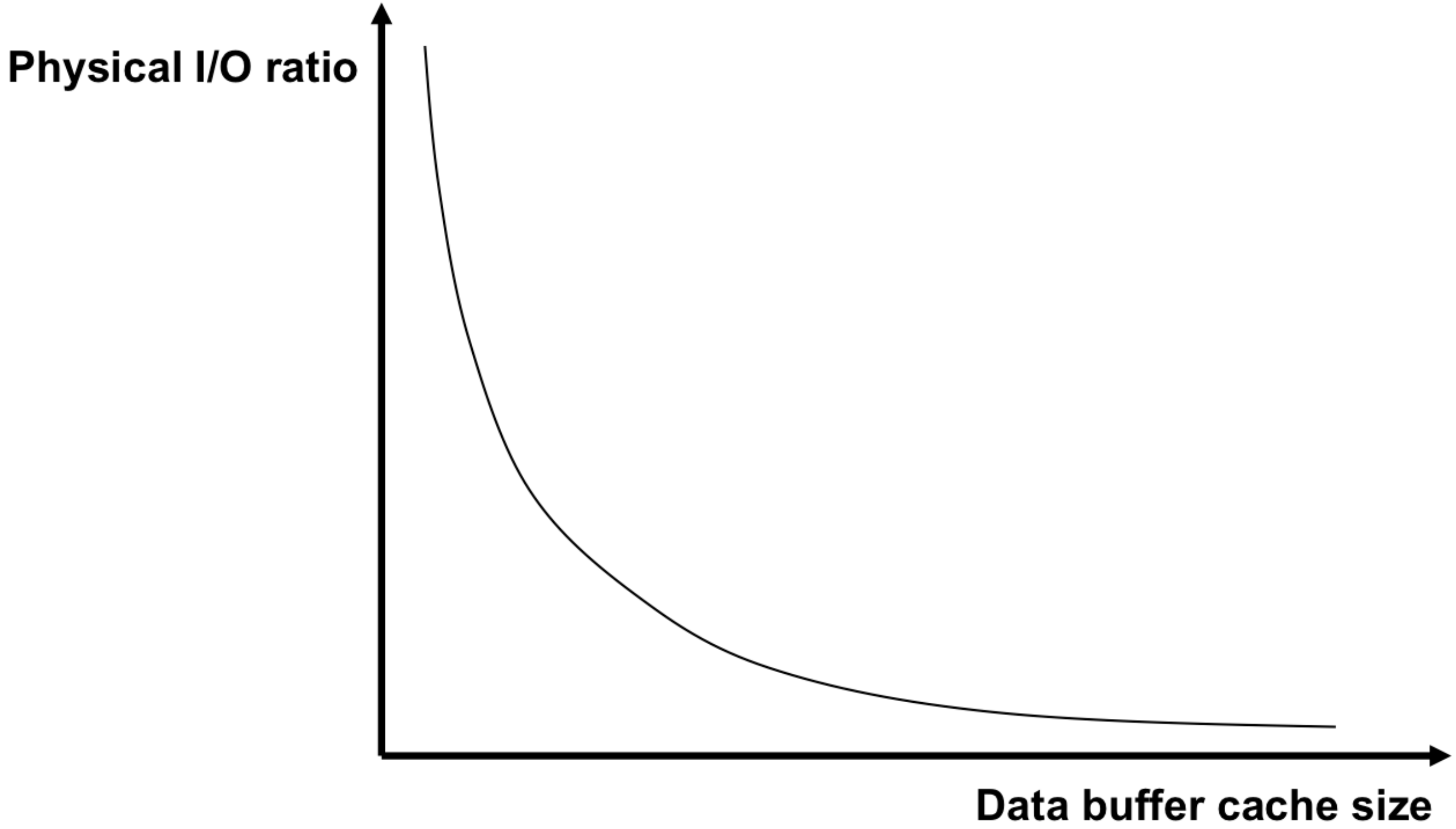
- Number of requests to an operating system to read a database block into data buffer cache
- If a parameter `DB_FILE_MULTBLOCK_READ_COUNT` is set to more than `1` then the physical reads number is incremented only by one
- Reading from temporary tablespace does not increment the number

Data block buffer hit ratio (`H`)

- `H = ((LR# - PR#)/LR# ) * 100%`
- In a well tuned `OLTP` system `H ≥ 95%` and `H ≤ 85%` in `OLAP` system

Tuning data buffer cache

Physical I/O versus data buffer cache size



Tuning data buffer cache

What should be kept where ?

`KEEP` pool

- `KEEP` pool should contain the tables that are frequently referenced by the applications, like small tables with frequent full scans, lookup tables, and data objects that are normally more than 80% cached
- The contents of `KEEP` pool are not automatically removed or loaded
- `KEEP` pool should always have data block buffer ratio equal to 100%
- The size of `KEEP` pool should greater by 20% than the total size of data objects kept there

Tuning data buffer cache

What should be kept where ?

`RECYCLE` pool

- `RECYCLE` pool should contain the large relational tables which have rare full-table scans such that their data blocks are unlikely to be re-read
- Storing rarely and fully scanned relational tables in `RECYCLE` pool prevents more frequently used tables and indexes from being flushed out of the system
- The contents of `RECYCLE` pool are immediately removed after being used

Tuning data buffer cache

What should be kept where ?

`DEFAULT` pool

- `DEFAULT` pool contains all other data objects that are not assigned to either `KEEP` or `RECYCLE` pools

Tuning data buffer cache

What should be kept where ?

`nK` pools

- The significant performance gains can be achieved by switching to a longer data block size
- the tables with long rows have less chained rows
- full table scans and tables with large objects (`BLOB`, `CLOB`, ...) benefit from longer blocks because of less read block operations
- index range scans gather index node sequentially, temporary tablespaces used for sorting also need less I/O operations
- On the other hand the tables with smaller rows accessed randomly should be placed in smaller data blocks because they take to much space in data buffer cache
- B-tree indexes should use the largest supported size of data blocks (`32K`)
- A table should be stored in the data blocks longer than the average row size in the table to prevent row chaining
- `TEMP` tablespace benefits from the large blocks that allow to minimize disk I/O when sorting

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Outline

Tuning redo log buffer

Redo log space requests (`RLS#`)

- The total number of times a user process waits for space in a redo log buffer so that a redo entry can be written there

Redo entries (`RE#`)

- The total number of entries written to a redo log buffer due to modifications of data blocks

Redo log hit ratio (`RLH`)

- `RLH = RLS#/RE#`
- It is recommended to have `RLH ≤ 1/5000`
- In the large OnLine Transaction Processing (`OLTP`) systems the size of redo log buffer should be from `2M` to `4M`

Tuning redo log buffer

Redo log space wait time

- The total elapsed time of waiting for redo log space request; should be close to zero !

When the system waits for redo log space ?

- The system waits for redo log space when the log writer process (`LGWR`) is waiting for a disk space
- Disk space is available when a log file switch occurs
- log file switch forces a checkpoint
- Check point means that all "dirty blocks" in data buffer cache must be written to persistent storage (disk drive)

Consequence of too small redo log buffer

- Smaller redo log buffer forces the log writer process (`LGWR`) to write to a log file more frequently

Tuning redo log buffer

How to detect log buffer contention ?

- A simple way to detect redo buffer contention is to analyze the latch usage statistics and in particular find a ratio of `gets` to `misses` or a ratio of `immediate_gets` to `immediate_misses`
- the ration should not exceed 1%

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Outline

Tuning library cache

Pin (`P#`)

- Pin indicates that parse tree of SQL statement to be processed is included in library cache

Reload (`R#`)

- Reload indicates a cache miss; a parse tree is not in library cache or it has been removed from a library cache

Library cache hit ratio (`LCH`)

- `LCH = ( P#/(P# + R# ) ) * 100%`
- It is recommended to have LCH ≥ 99%

Tuning library cache

Principles

- Use as much generic code as possible
- Use bind variables (`:v`) instead of constants in SQL statements

```sql
SELECT *
FROM EMPLOYEE
WHERE E# = 25;
```

```sql
VARIABLE EMPNUM NUMBER
BEGIN
 :EMPNUM := 25;
END;
SELECT *
FROM EMPLOYEE
WHERE E# = :EMPNUM;
```

- Increase size of library cache when necessary
- Prevent invalidations (a data object used in SQL statement is modified with `ALTER`, `DROP`, or `ANALYZE` statement

Performance Tuning of Relational Database Server

Outline

Tuning dictionary cache

Get (`G#`)

- Get indicates that relevant data from data dictionary are found in dictionary cache

Getmiss (`M#`)

- Getmiss indicates that relevant data from data dictionary are not found in dictionary cache

Dictionary cache hit ratio (`DCH`)

- `DCH = ( G#/(G# + M# ) ) * 100%`
- It is recommended to have `DCH ≥ 90%`

Performance Tuning of Relational Database Server

Outline

Tuning Process Global Area

PGA memory management is controlled by system initialization parameter WORKAREA_SIZE_POLICY

In manual PGA memory management mode the values of system initialization parameters SORT_AREA_SIZE, SORT_AREA_RETAINED_SIZE, and HASH_AREA_SIZE have the largest impact on PGA size

In manual PGA memory management mode the optimal size of PGA is equal to

((1M (Unix) or 2M Win) + sort area size + hash area size) * number of connected users through dedicated connections + 2M

In automatic PGA memory management PGA size is determined by system initialization parameter PGA_AGGREGATE_TARGET

It controls how much memory a server can allocated for all work areas used to sort and hash data

Tuning Process Global Area

Then, `PGA` size = total transient memory available to the system - the maximum size of System Global Area (`SGA`)

In multithreaded configuration `PGA` consumes less memory even it consumes more shared memory as sort and hash areas are kept in shared memory)

Automatic `PGA` memory management is recommended in a system where a large number of users needs medium amounts of memory for sorting and hashing

Manual `PGA` memory management is recommended in a system where a small number of users needs large amounts of memory for sorting and hashing

Automatic `PGA` memory management is recommended for end-user sessions while manual `PGA` memory management is recommended for large batch jobs running when there is no other activities

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Outline

Tuning I/O

Tuning I/O is effective when an application is I/O- bound, for example it spends majority of time on waiting until I/O operations are completed

Tuning I/O must take under the consideration physical parameters of persistent storage devices, number of persistent storage devices, and controllers

Tuning I/O includes application of software or hardware disk stripping feature of operating system

Parameters to be determined: stripe depth (size of a single stripe, 256K .. 1M) and stripe width (number of disk drives)

Important system initialization parameters that have impact on I/O tuning

```
DB_BLOCK_SIZE                  Determines size of database blocks
DB_FILE_MULTIBLOCK_READ_COUNT  Determines the maximum I/O size
HASH_AREA_SIZE                 Determines I/O size for hash operations
SORT_AREA_SIZE                 Determines I/O size for sort operations
OS block size                  Determines an operating system block size
```

Tuning I/O

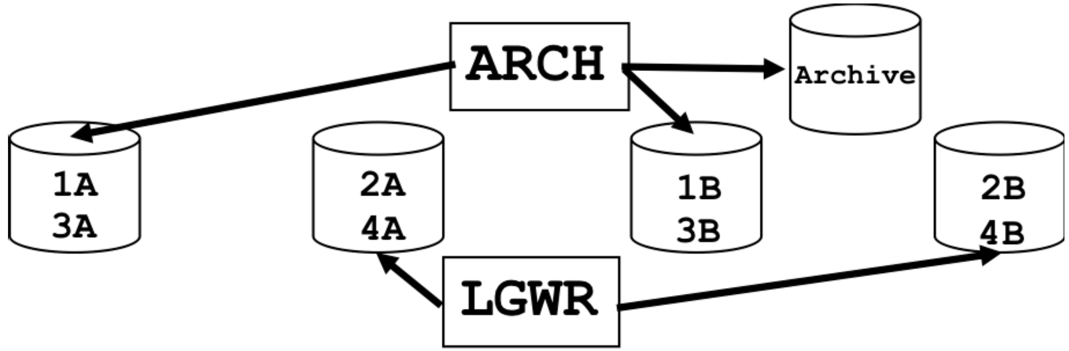
Tuning `I/O` over tables indexes and temporary tablespaces

- Spread the database files across multiple persistent storage devices
- Separate the files with a high `I/O` rates from the remaining files
- If the files with high `I/O` activities contain tables and indexes then try to tune SQL or application code
- If the files with high `I/O` activities implement a temporary tablespace (`TEMP`) then tune the applications performing sorting

Tuning `I/O` over redo log and archived redo log files

- Place all redo log files on one disk without any other database files
- Members of the same redo log group should be located on different persistent storage devices without any other database files
- Perform stripping of redo log files across many persistent storage devices
- If a persistent storage device contains archived redo logs then no other process should compete with archiver process for the access to the device

Tuning I/O



Sizing redo log files

- Larger redo log size provide better performance
- Smaller redo log size increases checkpoint activity and decreases performance
- Checkpoint frequency depends on redo log file size and on parameter `FAST_START_MTTR_TARGET` which restricts instance recovery time
- Oracle tries to automatically perform checkpoint to limit amount of recovery time determined by the parameter
- Optimal size of redo log files is suggested in `OPTIMAL_LOGFILE_SIZE` column of `V$INSTANCE_RECOVERY` view

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Choosing data block size

To minimize a number of read operations

- A block size of `8K` is considered to be the most universal solution
- If rows are small and access is random then choose a smaller block size
- If rows are small and access is sequential then choose a larger block size
- If rows are small and access is both random and sequential then choose a larger block size
- If rows are large and contain `LOB`s then choose a larger block size

To minimize a number of write operations

- A block size of `8K` is considered to be the most universal solution for OnLine Transaction Processing (`OLTP`) systems
- OnLine Analytical processing (`OLAP`) systems (Data Warehouses) benefit from large block size

Performance Tuning of Relational Database Server

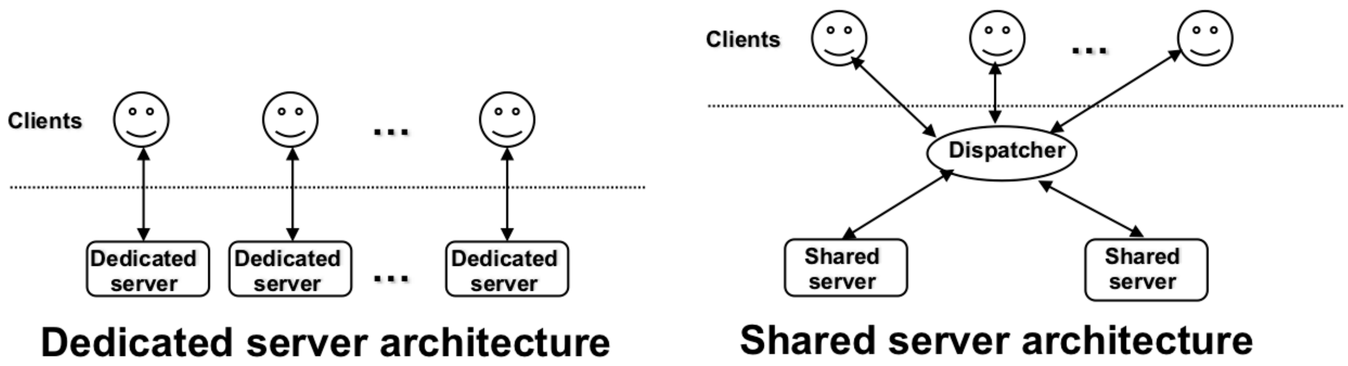
Outline

Tuning operating system scheduling

Principles

Minimize amount of time spent on switching context (activating of a different thread of control)

Choose operating system that has a lightweight thread switching facility



Minimize a number of times context switching occurs (minimize `I/O` requests, time-slice driven interrupts)

References

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