Firebird and disk I/O

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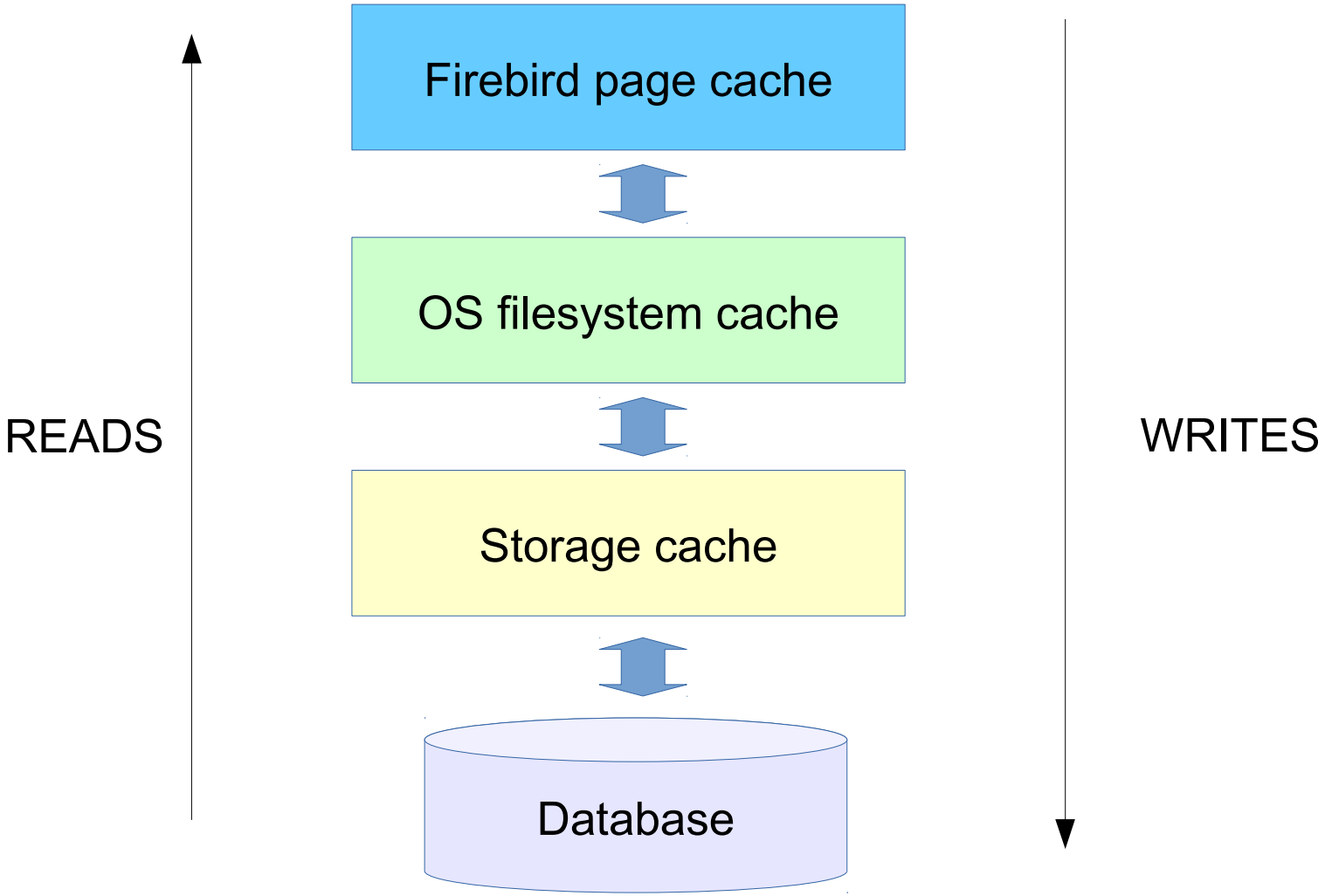
Page I/O operations

- Page reads
  - Single page is read from disk and copied to the page cache
  - Attempted to be sequential / uni-directional
  - Random under load
- When happens
  - Cache miss (all architectures)
  - Page was modified by other process (CS / SC)

Page I/O operations

- Page writes
  - Single page is written from the page cache to disk
  - Attempted to be uni-directional (partially)
  - Random under the load
- When happens
  - Transaction commit or rollback (all architectures)
  - Cache full of dirty pages (all architectures)
  - Other processes need modified pages (CS / SC)

I/O and caching



I/O optimization

- Tuning for faster I/O
  - DefaultDbCachePages / gfix -buffers (bigger might be better or worse!)
  - TempCacheLimit / RAM disk
  - Reserve RAM for the OS filesystem cache (up to 50%)
  - Fast storage, SSD preferred
  - RAID is a good idea

Durability

- Careful Writes
  - Page relationships (inter-page pointers)
  - Page dependency graph
  - Related pages are written one before another
    - record before index
    - backversion before record
    - fragment before record
    - data page before pointer page
    - etc
  - Disk image is consistent at any point of time
  - Orphan pages

Durability

- Careful Writes
  - Page relationships (inter-page pointers)
  - Page dependency graph
  - Related pages are written one before another
  - Disk image is consistent at any point of time
  - Orphan pages
- Recovery
  - Immediate, nothing special should be done
  - GFIX allows reuse of orphan pages

Durability

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  - Writes must reach the disk

Durability

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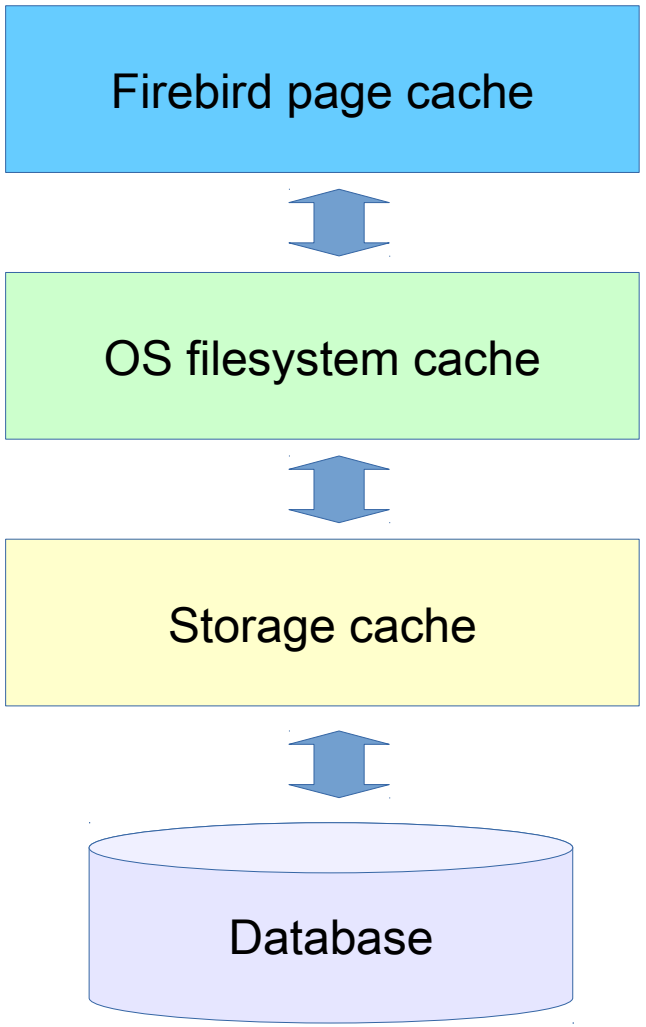
  - Order of writes is absolutely important
  - Writes must reach the disk
- Any problems?
  - Yes, caching may play against durability!
  - Write-through cache is OK
  - Write-back cache is BAD

Durability and caching



Firebird crash

OS crash

Hardware crash or power loss

Storage crash

Filesystem cache

- OS filesystem cache
  - Often useful for reads (cold cache)
  - Extremely important for Classic
  - May dramatically affect performance for writes
  - Can be write-through or write-back
  - Flushed in background (async) or by request (sync)

Filesystem cache

- How to control?
  - Forced writes = ON → write-through
  - Forced writes = OFF → write-back
  - MaxUnflushedWrites: how many transactions can be lost
  - MaxUnflushedWriteTime: how much time of work can be lost

Filesystem cache

- Sample configurations
  - MaxUnflushedWrites = -1, MaxUnflushedWriteTime = -1
  - MaxUnflushedWrites = 100, MaxUnflushedWriteTime = 5
  - MaxUnflushedWrites = -1, MaxUnflushedWriteTime = 1
  - MaxUnflushedWrites = 1, MaxUnflushedWriteTime = -1

Filesystem cache

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  - MaxUnflushedWrites = 100, MaxUnflushedWriteTime = 5
  - MaxUnflushedWrites = -1, MaxUnflushedWriteTime = 1
  - MaxUnflushedWrites = 1, MaxUnflushedWriteTime = -1
- Any problems?
  - Yes, OS can reorder writes!
  - Careful Writes idea is violated, data corruption is possible
  - UPS and storage w/BBU somewhat help, but…
  - OS crash may cause a disaster

Filesystem cache

- Durability again
  - Either FW=ON (write-through cache, synchronous writes)
  - Or FW=OFF with explicit cache flushes (MaxUnflushed*)

Filesystem cache

- Durability again
  - Either FW=ON (write-through cache, synchronous writes)
  - Or FW=OFF with explicit cache flushes (MaxUnflushed*)
- Any problems?
  - Yes, sync/flush requests can be ignored by lower levels!
  - Some storage interfaces do not support sync'ing
  - Smart storage caches play against durability

Filesystem barriers

- Barriers
  - Split sets of writes into ordered groups, down to page level granularity
  - Play in favor of the Careful Writes idea

Filesystem barriers

- Barriers
  - Split sets of writes into ordered groups, down to page level granularity
  - Play in favor of the Careful Writes idea
- Any problems?
  - Yes, the cost is very high!
  - Performance vs durability: choose only one

Performance vs durability

- Cached writes (FW=OFF)

Performance vs durability

- Cached writes (FW=OFF)

- Cached writes with forced flushes (FW=OFF + MaxUnflushed*)

Performance vs durability

- Cached writes (FW=OFF)

- Cached writes with forced flushes (FW=OFF + MaxUnflushed*)

- Uncached writes (FW=ON or mount=sync)

Performance vs durability

- Summary
  - FW=ON w/barriers provides absolute durability, but terribly slow
  - FW=ON w/o barriers is faster, but not 100% reliable
  - FW=OFF w/flushes with/without barriers is even faster, but allows some data loss and may violate Careful Writes during soft crashes
  - FW=OFF w/o flushes is the fastest, but absolutely unreliable

Performance vs durability

- Recommendations
  - Barriers may be avoided if BBU storage is used
  - Software RAID → better use barriers
  - SSD with/without Power Loss Protection
  - FW=ON is generally safe (see above)
  - FW=OFF may be used if
    some predicted data loss is acceptable
    or
    some kind of redundancy is enforced
  - Using Windows w/o BBU or redundancy is questionable
  - Firebird on Windows PDC is a bad idea

Questions?