Super Server in Firebird 3

Sponsors !


24-25 OCTOBER
PRAGUE
Firebird Conference 2014
Firebird Conference 2014

Introduction into Firebird3

- Firebird3 files
  - Root directory
    - network server (firebird.exe)
    - client library (fbclient.dll)
    - utilities (gbak, gfix, isql, etc)
    - configuration files (*.conf)
    - security database (security3.fdb)
    - support libraries (icu*.dll, ib_util.dll, MSVC CRT dll's)
    - support files (firebird.msg, icu*.ddat, license.txt)

Introduction into Firebird3

- Firebird3 files
  - ~~*bin sub-directory*~~
    - yes, no more bin sub-directory on Windows
  - intl sub-directory
    - internalization support library (fbintl.dll, fbintl.conf)
  - plugins sub-directory
    - engine itself (engine12.dll)
    - trace plugin (fbtrace.dll)
    - auth plugins (srp.dll, legacy_auth.dll, legacy_usermanager.dll)
    - UDR engine plugin
  - udf sub-directory
    - standard UDF libraries

Introduction into Firebird3

- Unified network listener
  - single network listener firebird.exe
    - no more fbserver.exe\fb_inet_server.exe
  - launch new process for incoming connection
    - process mode: by default
  - launch new thread for incoming connection
    - threading mode: add switch -m

Introduction into Firebird3

- Unified client library and unified engine library
  - No more fbclient.dll\fbembed.dll
    - single client: fbclient.dll
      - used for remote and embedded access
    - single engine: engine12.dll
      - used as Super Server and Classic Server
  - Super\Classic mode of engine defined by two new firebird.conf settings:
    - SharedDatabase
    - SharedCache

Introduction into Firebird3

- Classic Server
  - network server in process mode (firebird -a)
  - SharedDatabase = true
  - SharedCache = false
- Super Server
  - network server in threading mode (firebird -a -m)
  - SharedDatabase = false
  - SharedCache = true
- Super Classic (obsolete?)
  - network server in threading mode (firebird -a -m)
  - SharedDatabase = true
  - SharedCache = false

Introduction into Firebird3

- Embedded
  - need both fbclient.dll and plugins\engine12.dll
- Embedded in Classic mode
  - SharedDatabase = true
  - SharedCache = false
- Embedded in Super mode
  - SharedDatabase = false
  - SharedCache = true

Super Server

- Main difference from Classic
  - All attachments are handled by the single process
  - Shared common data
    - metadata cache
    - page cache
    - transaction inventory cache
  - Hand-made scheduler: cooperative multitasking
    - single scheduler, single active thread in process
    - threads voluntary switched control to each other
  - Metadata still synchronized by LM
  - Page cache not used LM
    - individual “latches” for page buffers

Super Server before Firebird3

- Pluses
  - shared caches - used much less memory than lot of Classic processes
  - single active thread - almost no need to synchronize concurrent access to in-memory structures
- Minuses
  - single active thread - no way to use more than one CPU\core
    - SMP is not possible
  - cooperative multitasking is very far from fair scheduling
    - “heavy” query in one attachment could get more CPU and slowdown queries in another attachments

Super Server in Firebird3

- On the way to the true Super Server
  - shared page cache
  - shared TIP cache
  - metadata cache is not shared (private per attachment)
  - no more custom scheduler, all threads works in parallel
    - SMP is supported now
  - new synchronization schema

Page Cache

- Page buffers
  - used to cache contents of database file pages
    - descriptor of page buffer, data buffer itself
- Control structures
  - Hash table
    - used to fast search for page buffer by given page number
  - LRU queue
    - defines page buffer eviction policy
  - Precedence graph
    - used to implement “careful write” policy
  - Dirty pages queue
    - what to write on commit

Page Cache

- Synchronization
  - individual latch for every page buffer
    - latch is a lightweight RW-lock
    - used always (despite of SharedCache setting)
  - individual Lock Manager's lock for every page buffer
    - used in SharedCache = false (Classic) mode only
  - separate RW-lock for every control structure
    - hash table
    - LRU queue
    - precedence graph
    - dirty queue

Page Cache

- Fine-grained synchronization is not free !
- Every page access consists of following steps
  - fetch page buffer
    - read contents from disk, if necessary
  - access (use) page buffer
    - read record data, for example
  - release page buffer

Page Cache

- Cost of page access in Super Server, before v3
  - fetch page
    - find buffer in hash table
    - if buffer is not used - increment use_count
    - else - voluntary switch to another thread and wait while current buffer owner granted us access
  - release page
    - decrement use_count
    - grant access to waiting tread(s)
- Minimal cost is two changes of use_count
    - very, very cheap

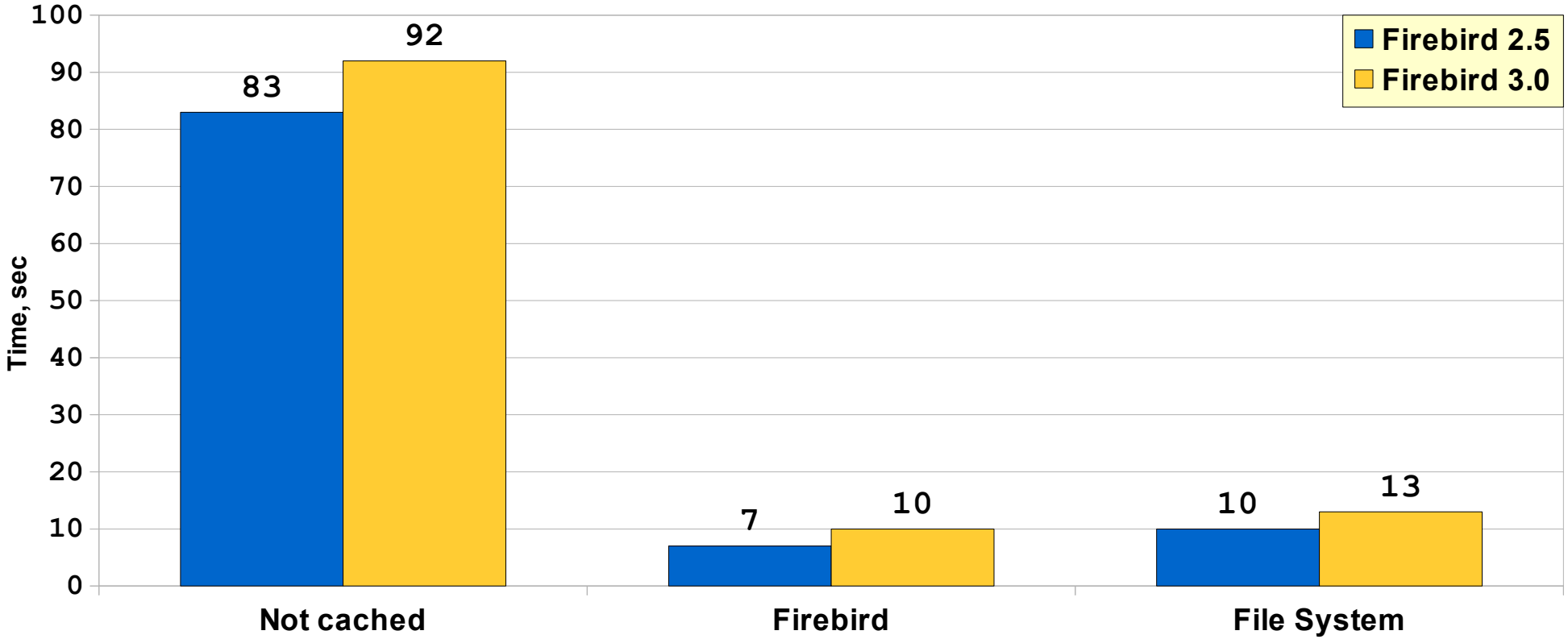
Page Cache

- Cost of page access in Super Server, in v3
  - fetch page
    - acquire lock for hash table
    - find buffer in hash table
    - release lock for hash table
    - acquire latch for page buffer
      - interlocked increment of latch state,
      - or wait while current latch owner granted us access
  - release page
    - release latch for page buffer
      - interlocked decrement of latch state
    - grant access to waiting tread(s)
- Minimal cost is four interlocked operations

Benchmark, single thread read

```
SELECT COUNT(*) FROM STOCK

10'000'000 rows
Memory buffers = 500'000
Reads from disk to cache = 418'604    ' not cached
Reads from disk to cache = 0          ' cached by Firebird
Reads from disk to cache = 418'822    ' cached by File System
Fetches from cache = 20'837'432
```



Benchmark, single thread read

```
SELECT COUNT(DISTINCT S_W_ID), COUNT(DISTINCT S_I_ID) FROM STOCK

10'000'000 rows
Memory buffers = 500'000
Reads from disk to cache = 418'604    ' not cached
Reads from disk to cache = 0          ' cached by Firebird
Reads from disk to cache = 418'822    ' cached by File System
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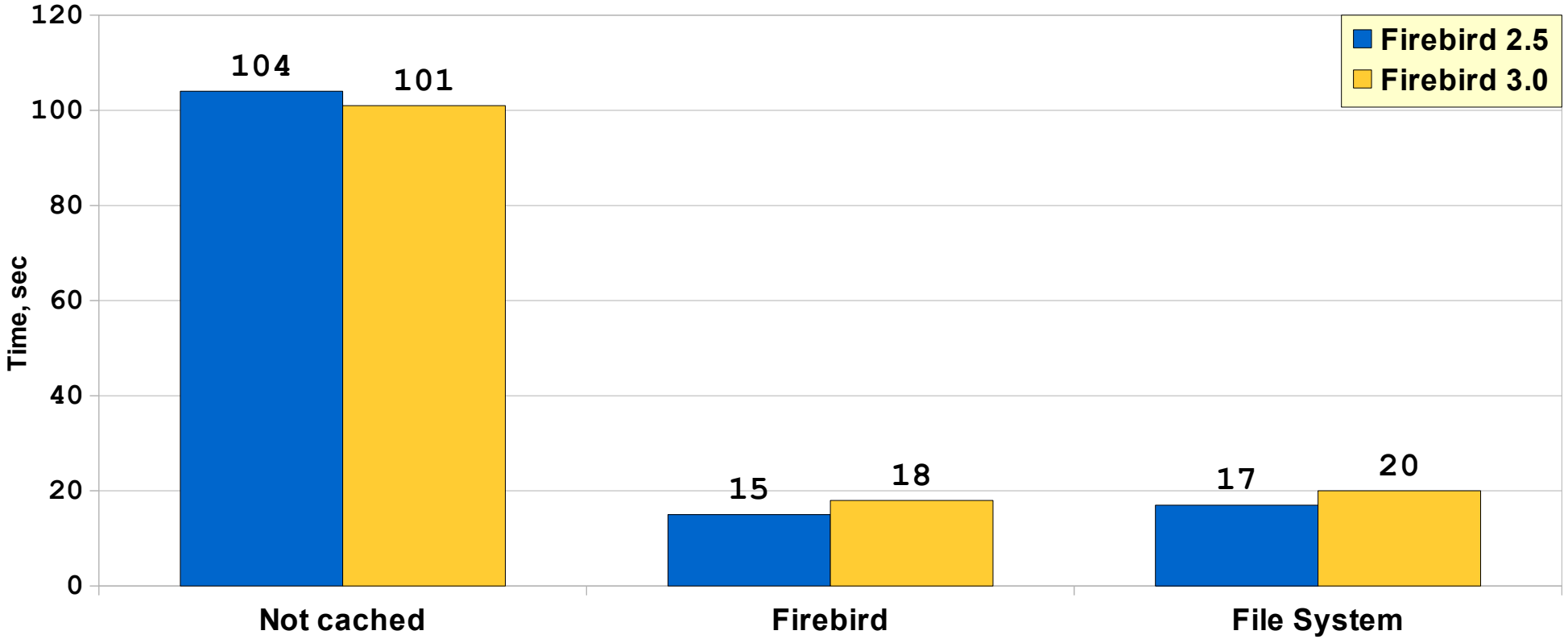
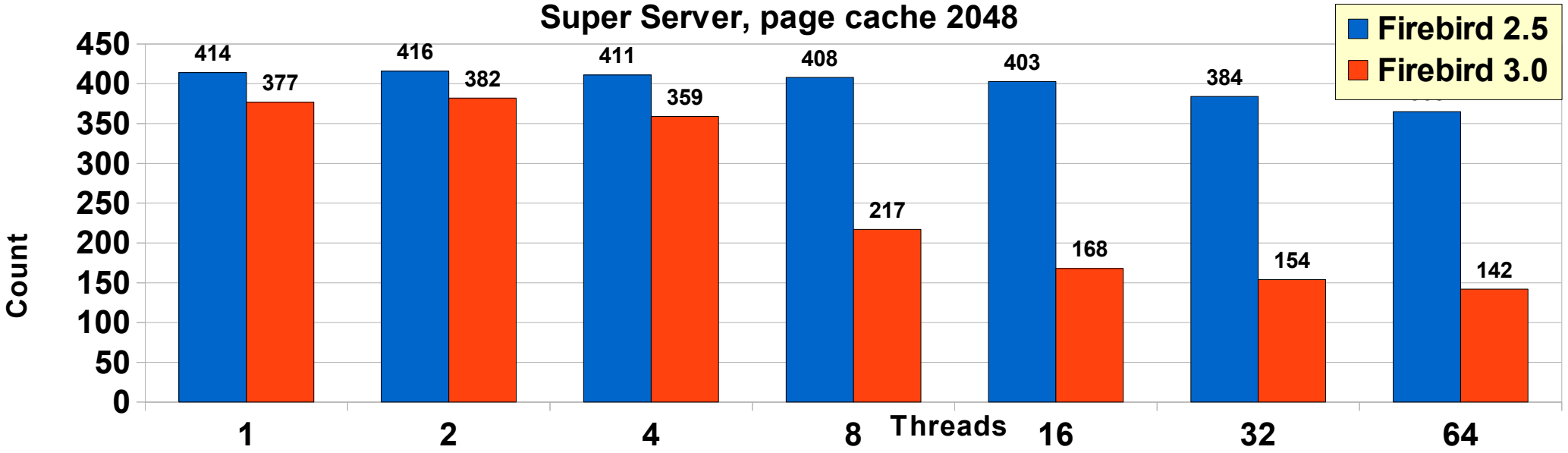
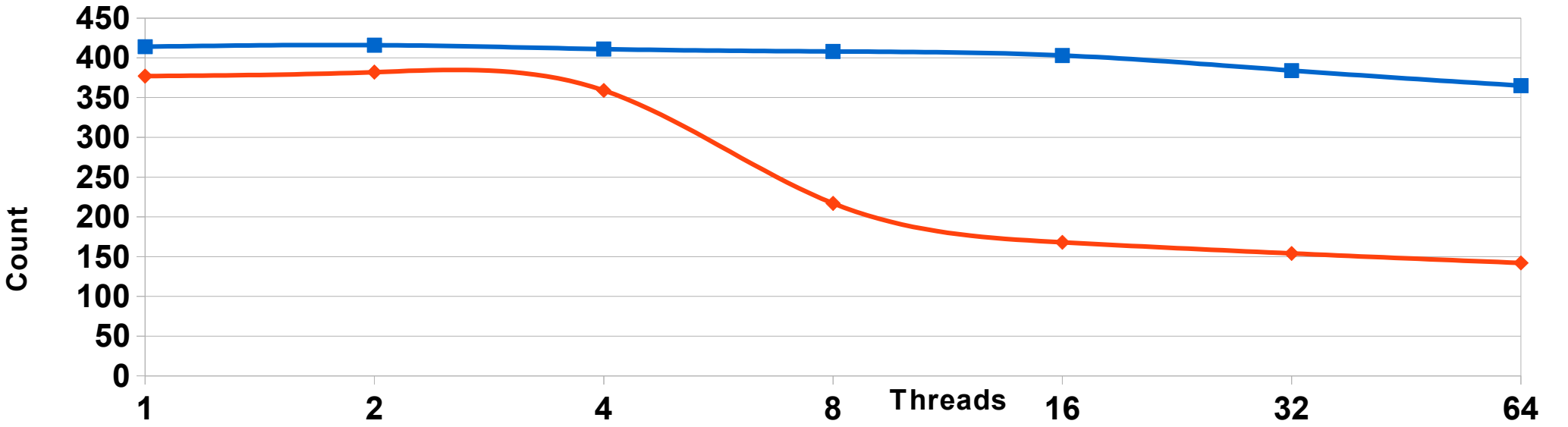


Benchmark, multithreaded read

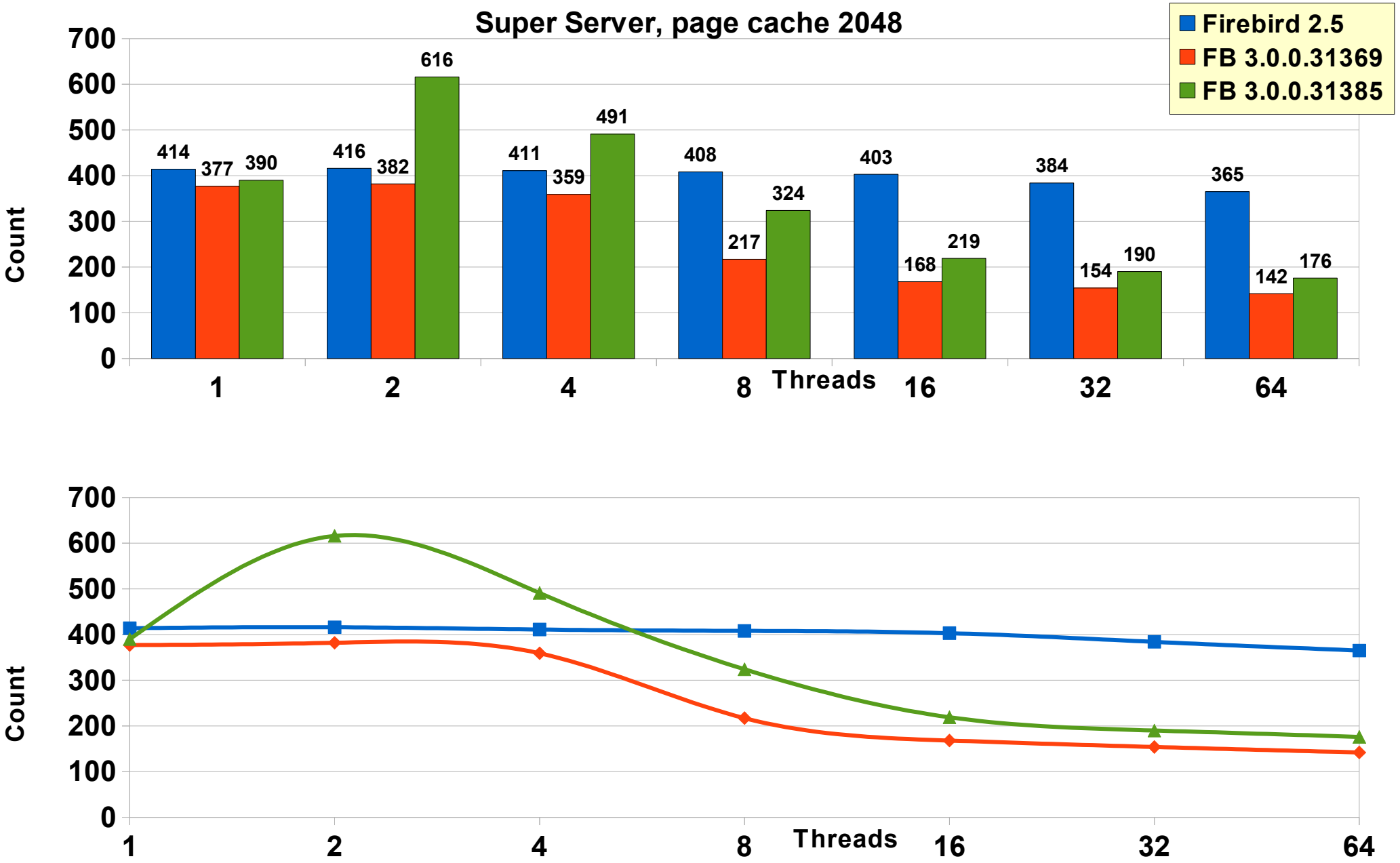
- Multithreaded read only benchmark
  - Table STOCK have 10'000'000 records
    - 100 warehouses, 100'000 items in each
  - Each reader reads random items in own warehouse
  - We don't test network subsystem
    - client application executes procedure, which selects a number of random items (100 by default)
  - We don't test IO subsystem
    - before each test series we ensure whole table STOCK is fully cached by filesysem

Benchmark, multithreaded read





Benchmark, multithreaded read



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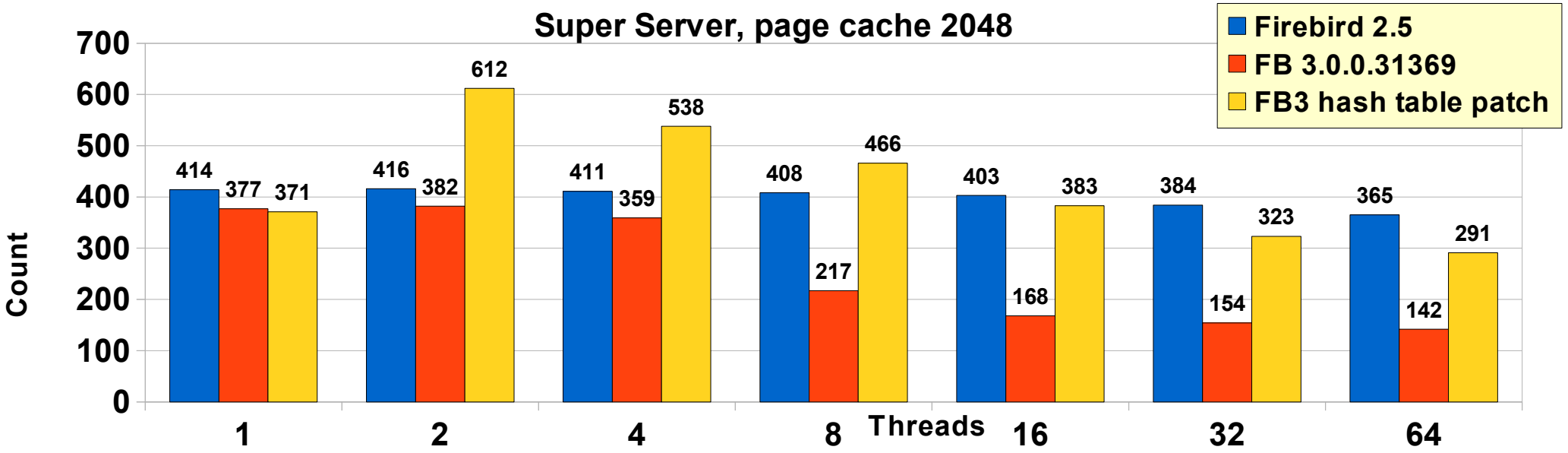
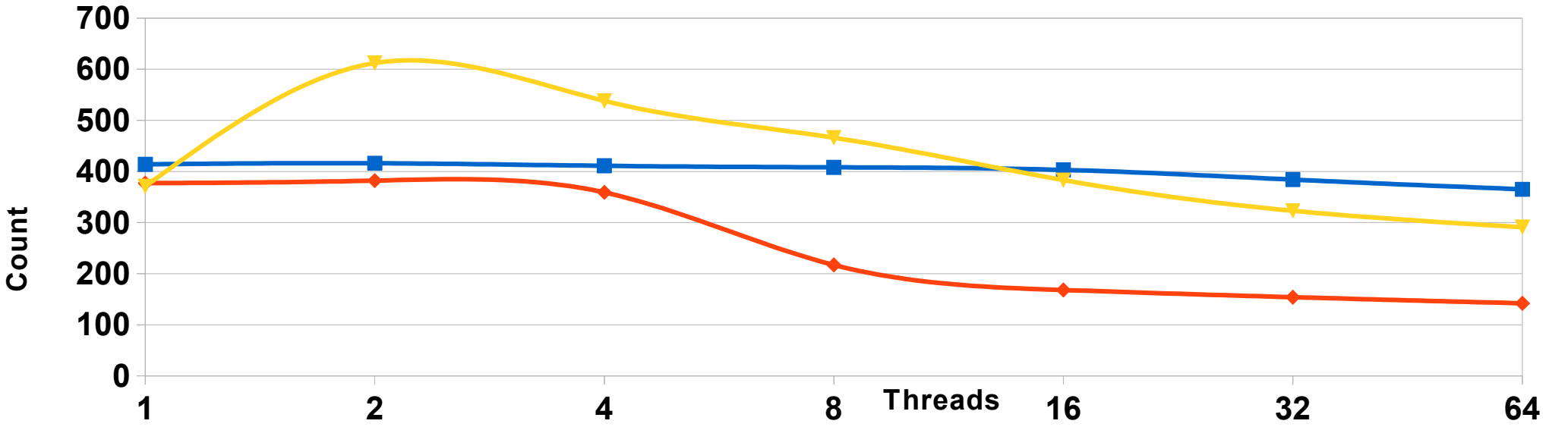
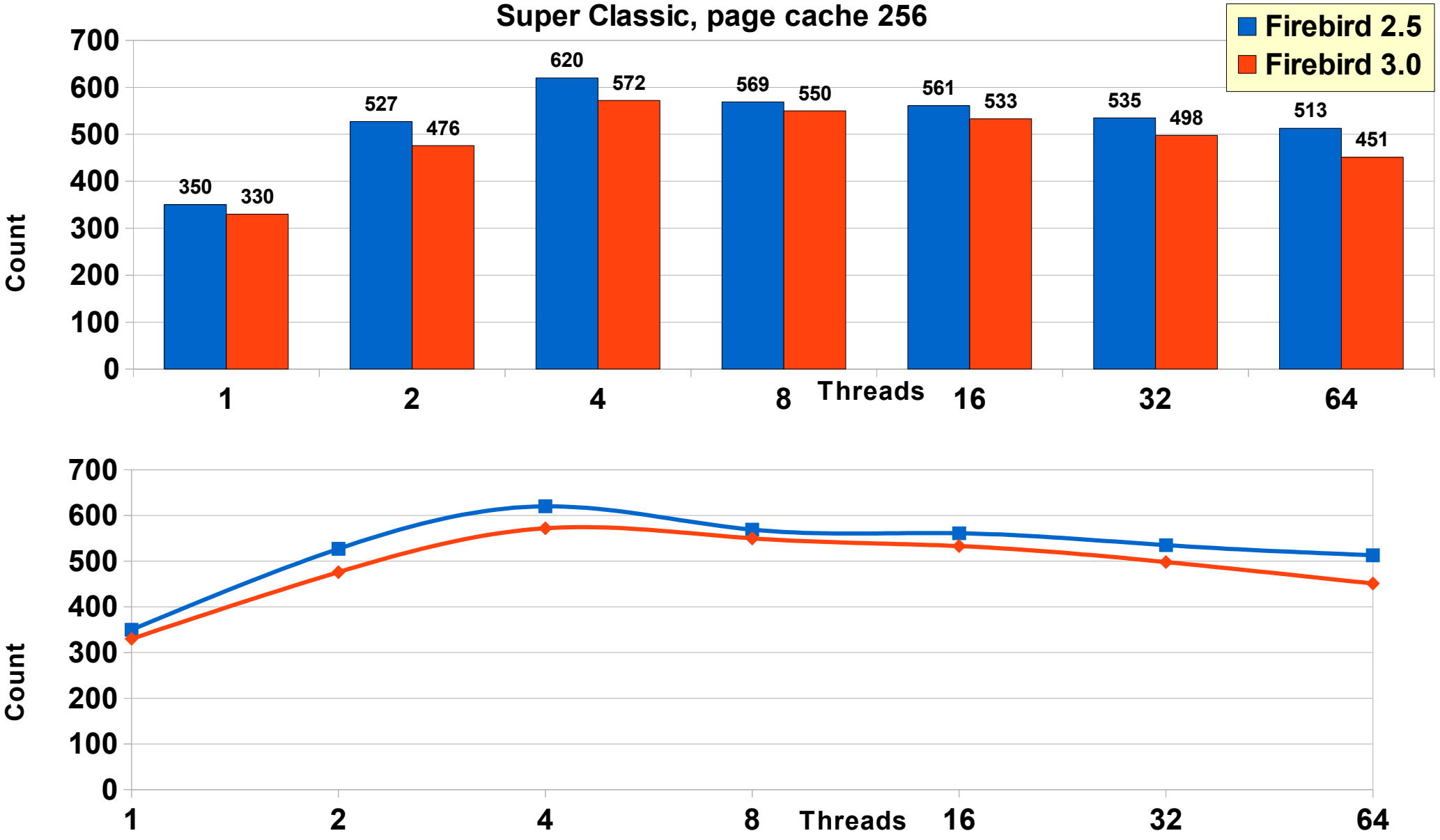
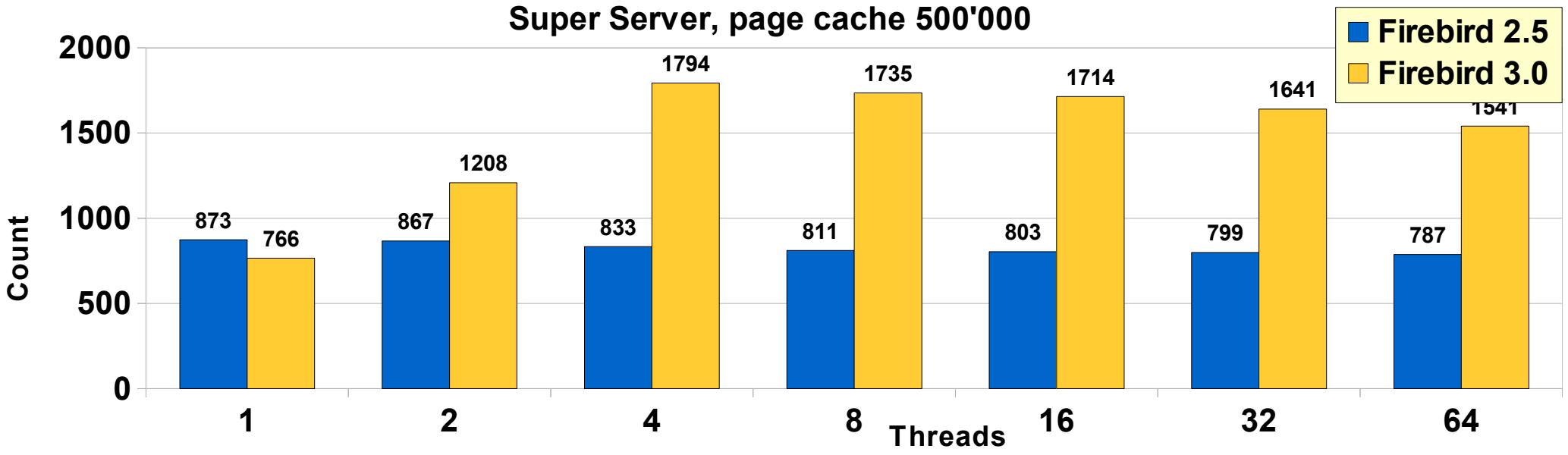


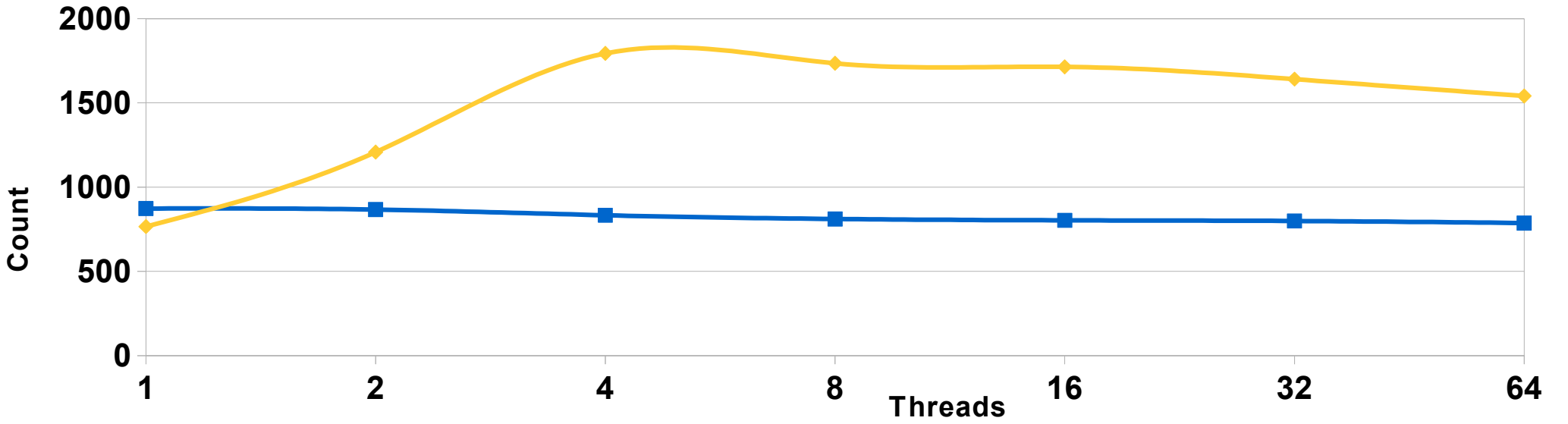


Benchmark, multithreaded read

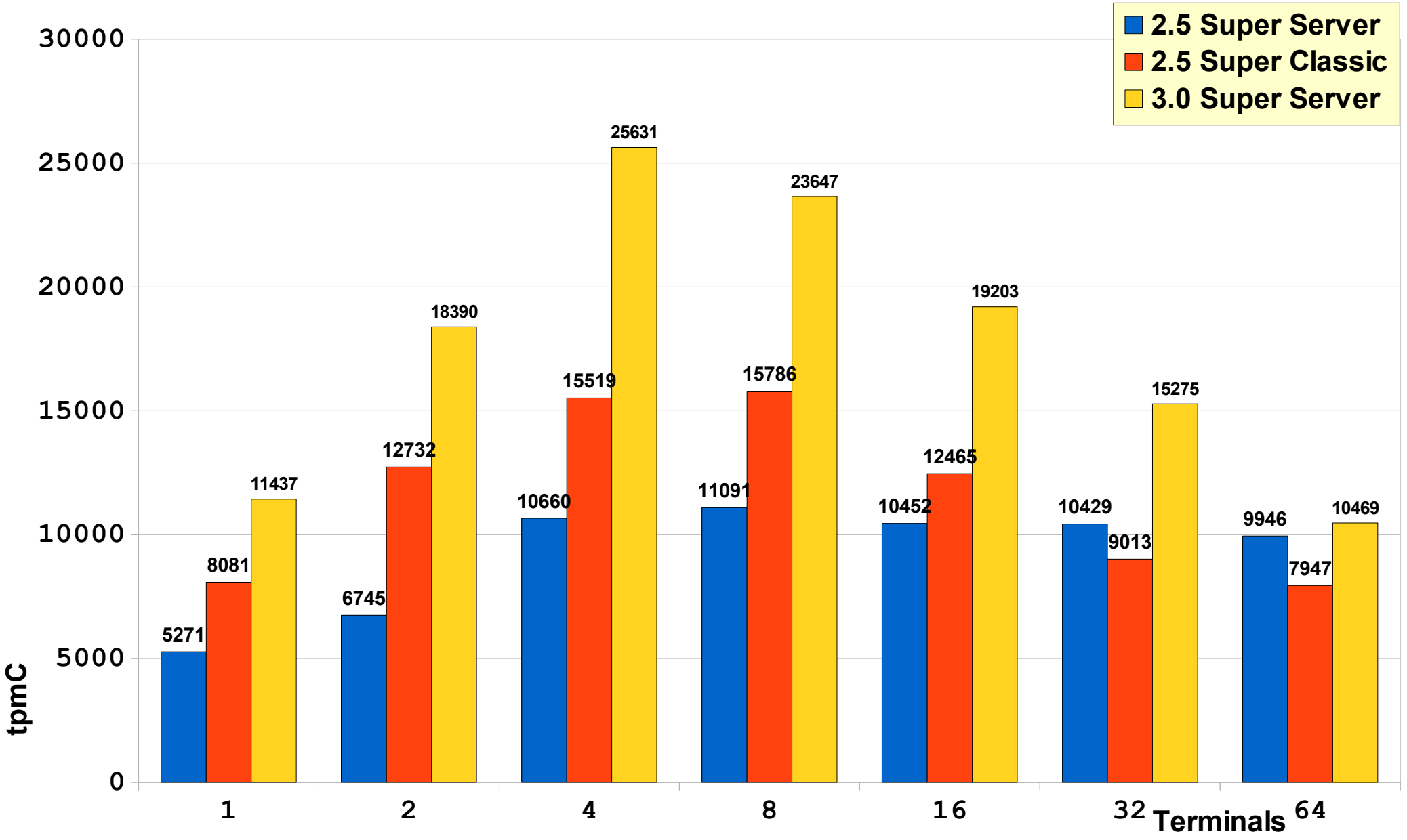


Benchmark, multithreaded read

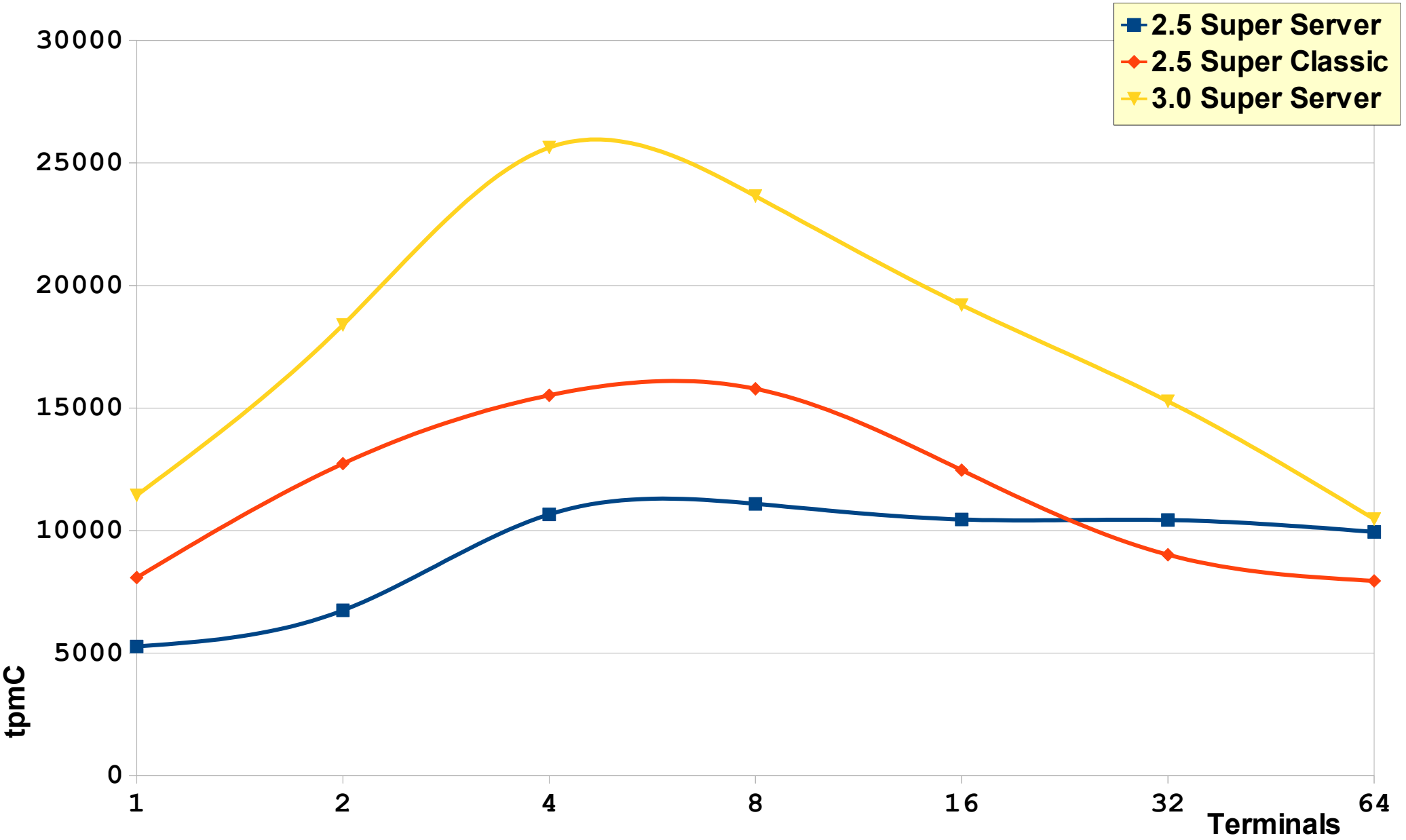




Benchmark, TPCC



Benchmark, TPCC



THANK YOU FOR ATTENTION

Questions ?

Firebird official web site

Firebird tracker

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