Super Server
in Firebird 3
Sponsors!
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 thread(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
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**

```sql
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
Fetches from cache = 20'837'432
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 filesystem
Benchmark, multithreaded read

Super Server, page cache 2048

- Firebird 2.5
- Firebird 3.0

Threads

Count

Threads

Count

Prague 2014

Firebird 3
Benchmark, multithreaded read

Super Server, page cache 2048

- Firebird 2.5
- FB 3.0.0.31369
- FB3 hash table patch

Count

Threads

1 2 4 8 16 32 64

414 416 411 408 403 384 365
377 382 359 217 168 323 142
371 382 359 217 168 323 142

Count

Threads

1 2 4 8 16 32 64

414 416 411 408 403 384 365
377 382 359 217 168 323 142
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Benchmark, multithreaded read

Super Classic, page cache 256

Count

Threads

Firebird 2.5
Firebird 3.0
Benchmark, TPCC

- 2.5 Super Server
- 2.5 Super Classic
- 3.0 Super Server

### Terminals

- 1 Terminal: 2571, 6745, 18390
- 2 Terminals: 11437, 6745, 12732
- 4 Terminals: 10660, 6745, 25631
- 8 Terminals: 11091, 6745, 15519
- 16 Terminals: 10452, 6745, 15786
- 32 Terminals: 10429, 6745, 19203
- 64 Terminals: 10469, 6745, 15660

### Performance

- Benchmark, TPCC
THANK YOU FOR ATTENTION

Questions ?

Firebird official web site

Firebird tracker

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