tBricks®

LET IT TRADE

TAKING OFF WITH SOLARIS

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COMPANY OVERVIEW

- Founded 2006, privately held
- Offices in Stockholm and St.Petersburg, ~25 employees
- Objective: Algorithmic Trading Solution
    - Ultra-low latency (under 1ms)
    - Highly scalable
    - Easy to setup, deploy and manage
    - Reliable, through fail-over capabilities
    - Zero configuration

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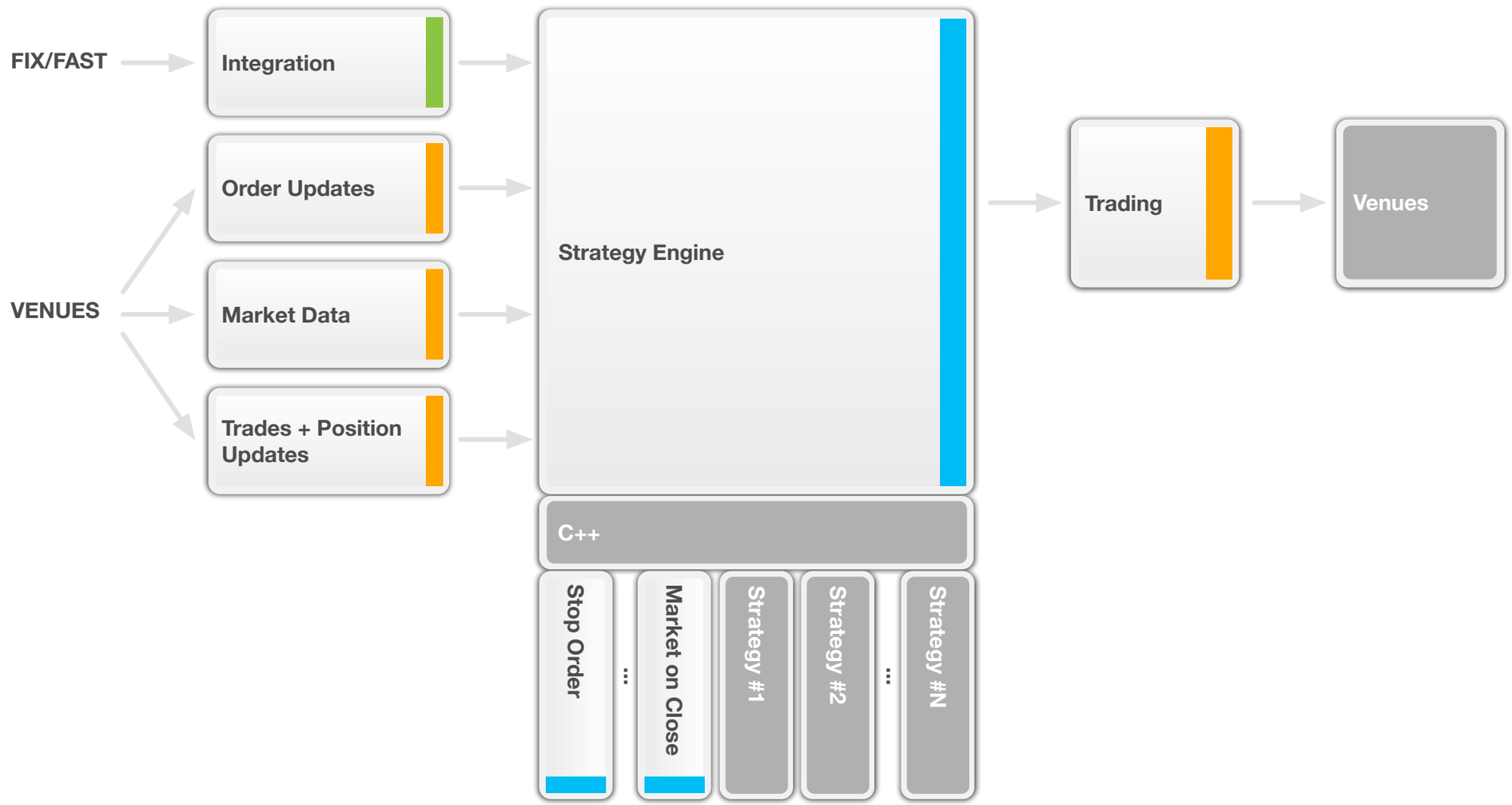
STRATEGY ENGINE OVERVIEW



PART I: OS OF CHOICE

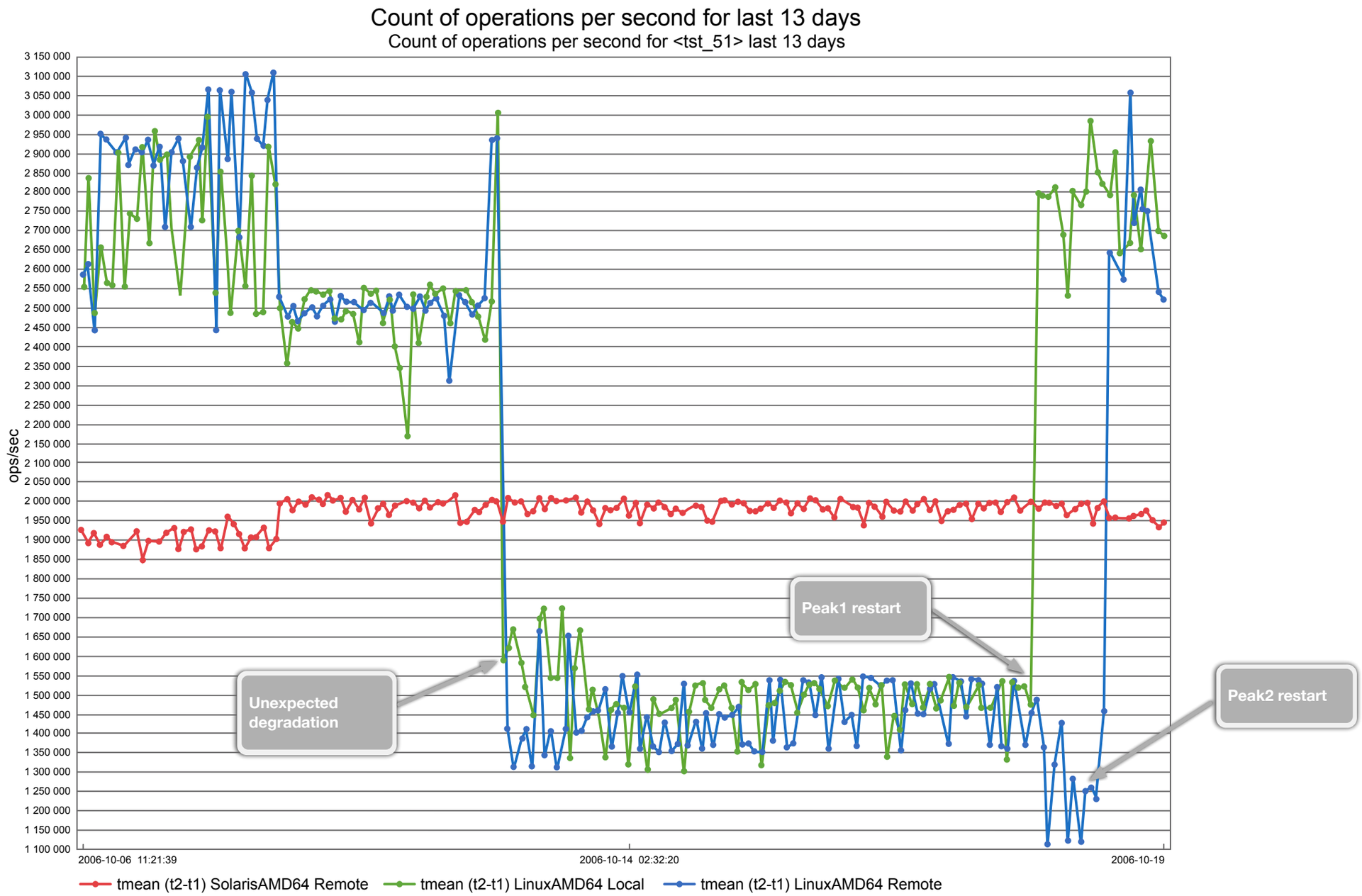
MAKING THE CHOICE

- Need highly scalable, tuned kernel
  - Solaris: > 20 years SMP development, known to perform well
  - Linux: Quickly gets up to speed
- Stable API, manageable upgrades
  - Solaris: Already there
  - Linux: OS version + GLIBC version + ...

MAKING THE CHOICE

- Good 64-bit development tools
  - Solaris: SUNWspro, DTrace, ProcUtils, ...
  - Linux: GCC/GDB (SystemTap to come)
- Reliable and fast file storage, preferably with backup solution
  - Solaris: ZFS
    - Fast
    - Easy built-in backup through snapshots
    - Easy to use, no more RAID nightmares
  - Linux: Traditional filesystems and tools
- Predictable scheduler performance and latency

MAKING THE CHOICE



REFERENCE PLATFORM

- Solaris 10/x86_64
- Sun Fire x4150 Server with 2 Quad-core Intel Xeons
- ZFS as an ultimate storage and backup

ALSO IN THE GAME

- Solaris/SPARC (T1000)
- Windows/x86
- MacOSX/x86_64 (Leopard 10.5.1)
- Linux/x86_64 (RHEL4 ES)

PART II: BUILD FACTORY

CODE BASE

- ~500 000 lines of code backed by Subversion
  - Servers are in C++
  - Client is in C#
  - ~150 000 auto-generated C++ code
  - Some perl scripts
- Much larger code base is free software sources
  - ACE/QuickFIX/... (C++)
  - LibXML2/LibXSLT (C/C++)

COMPILER SUITES

- SUN Studio 12
  - Optimizes well for SPARC and x86_64
  - Sticks to the Standard
  - But provokes to use non-standard STL (libCstd.so.1)
  - And comes with STLport4 not optimized for x86_64

```
class Any
{
    ...
private:
    union {
        bool m_boolean;
        int64_t m_integer;
        double m_double;
    } m_value;
    std::string m_string;    // takes an allocator-wide lock bringing the system down
                             // Apache's stdcxx library optimizes this away using atomic ops
};
```

COMPILER SUITES

- GCC 3.x and 4.x
  - Most portable
  - Fairly strict
- MS Visual Studio 8
  - Fast
  - But has issues with portability (how about stdint.h?)

BUILD SYSTEM

- GNU Make 3.81
  - Feature rich
  - Supports parallel builds
  - Natively builds most of the platforms
- On Windows:
  - GNU Make 3.81
  - Custom build helper programs
  - MPC
  - MS VS msbuild and vcbuild as the engine

BUILD TIMES (NFS)

- Linux: 2xQuad-core Intel Xeon Harpertown 2.83 GHz 8Gb RAM

```
$ time tbmake -j
real    8m48.656s
user    20m38.300s
sys     17m53.620s
```

- Solaris: SunFire x4150 16Gb RAM

```
$ time tbmake -j
real    15m13.185s
user    38m45.659s
sys     9m59.379s
```

- Mac OS X: Apple Xserve Quad-core Xeon 2.66 GHz 4Gb RAM

```
$ time tbmake -j
real    54m36.624s
user    18m46.978s
sys     14m59.874s
```

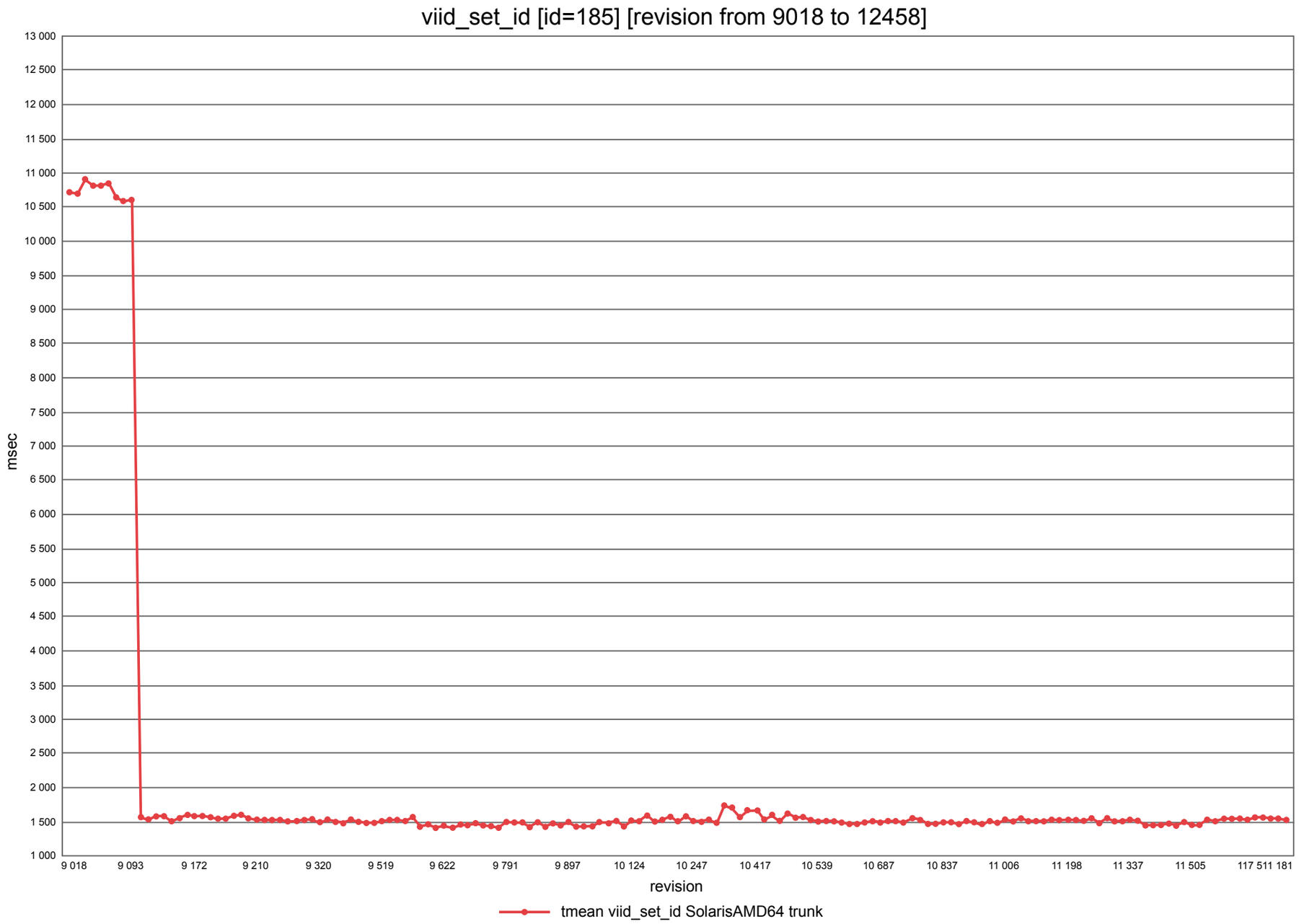
- Windows: VmWare i386 virtualization box

```
$ time tbmake -j
real    94m4.187s
user    0m0.015s
sys     0m0.093s
```

DEVELOPMENT WORKFLOW

- Design/Code/Build/Debug
- Commit reviews (untested commits prohibited)
- Automated per-commit, per-component tests
- Full system tests few times a day
    - Leaks detection
    - Performance inspection
    - Memory consumption analysis
    - Run-time checks (with Rational tools)
    - Test coverage computation
- Static code analysis

TRACKING PERFORMANCE



DEVELOPER'S DESKTOP

- 15% Native Windows development
- 55% Windows as a terminal to Solaris/Linux
- 25% MacOSX
- 5% Linux

DEVELOPER'S DESKTOP

- 50% : ViM
- 30% : MS Visual Studio
- 20% : Other (Emacs/Xcode/Joe)

NO SOLARIS???

- Not promoted as a desktop system
- Lacks support from software vendors
  - VmWare is of high importance to us
  - I want my Firefox 3 RC with Flash plug-in!
  - Even configure is not always adopted for Solaris/x86
- Windows is de-facto standard
  - Means: You must be better by far to make people move

PART III: TOOLS

DTRACE

- Non-intrusive
- Very limited performance impact to the traced processes
- Does not require change/build/run cycle
- Provides for process sampling
- Incredible for troubleshooting: Even customers can use it!

BBO LATENCY

```
#include "make_uuid.d"
string strategy_id;
string parent_id;
BEGIN
{
    printf( "\nTracing SE for 'order latency' strategy checking.\n\n");
    start_time = timestamp;
}

#define LATENCY_ENTRY(name, display_name, direction)                                                                    \
    se_latency$target:::name                                                                                            \
    {                                                                                                                   \
        MAKE_UUID( strategy_id, arg1, arg2);                                                                            \
        MAKE_UUID( parent_id, arg3, arg4);                                                                              \
        nsec = timestamp - start_time;                                                                                  \
        sec = nsec / 1000000000;                                                                                        \
        nsec -= sec * 1000000000;                                                                                       \
        msec = nsec / 1000000;                                                                                          \
        nsec -= msec * 1000000;                                                                                         \
        usec = nsec / 1000;                                                                                             \
        nsec -= usec * 1000;                                                                                            \
        printf( "[%03d.%03d.%03d.%03d] %04d display_name %s direction %s\n", sec, msec, usec, nsec, arg0, strategy_id, parent_id);  \
    }

LATENCY_ENTRY(Engine_create_strategy,create_strategy,<-)
LATENCY_ENTRY(Engine_handle_strategy,handle_strategy,->)
LATENCY_ENTRY(SH_HSI_execute,call_h_strategy,->)
```

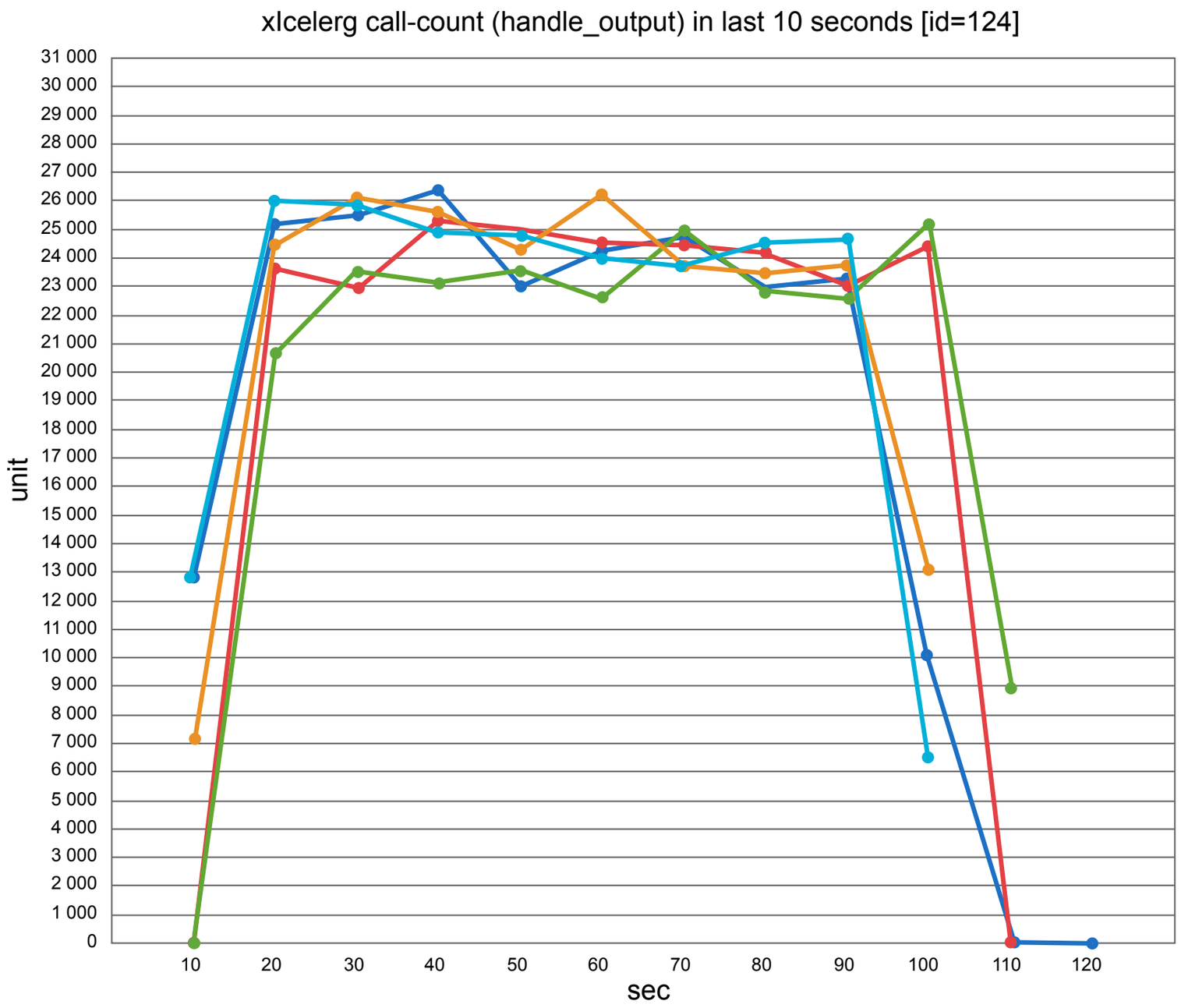
BBO LATENCY

```
[cdi@k2(pts/3) ~/src/tb/trunk/src/scripts/dtrace]$ dtrace -Cql /home/german/trunk/src/scripts/dtrace -s /home/german/trunk/src/scripts/
dtrace/se_order_latency.d -P se_latency\* -p 3289

Tracing SE for 'order latency' strategy checking.

[052.569.044.552] 0000 handle_strategy 2950c08a-36f8-11dd-97a5-09d0a6796c37 -> 8ddd9ac6-5003-4e42-bff9-0c499a4fadc5
[052.511.740.421] 0000 create_strategy 2950c08a-36f8-11dd-97a5-09d0a6796c37 <- 8ddd9ac6-5003-4e42-bff9-0c499a4fadc5
[052.569.270.343] 0000 call_h_strategy 2950c08a-36f8-11dd-97a5-09d0a6796c37 -> 8ddd9ac6-5003-4e42-bff9-0c499a4fadc5
```

DTRACE: I/O SAMPLING

```
[cdi@k2(pts/3) ~/src/tb/trunk/src/scripts/dtrace]$ dtrace -Cqs ./storage.d 3289
Tracing BDB database calls every 10 seconds.

Call count during last 10 seconds:

  StorageBDBBackend::put()                                  1
  StorageBDBBackend::BDBCursor::get()                       3
  StorageBDBBackend::BDBCursor::BDBCursor()                 6
  StorageBDBBackend::BDBCursor::~BDBCursor()                6

 <...>

Total summary:

Total number of calls (count):
================================================================================

  total                                StorageBDBBackend::modify()                    2
  total                                StorageBDBBackend::BDBCursor::get()            3
  total                                StorageBDBBackend::put()                       5
  total                                StorageBDBBackend::BDBCursor::BDBCursor()      6
  total                                StorageBDBBackend::BDBCursor::~BDBCursor()     6

Average time spent in each call (microseconds):
================================================================================

  StorageBDBBackend::BDBCursor::get()                     4
  BDBCursor open <-> close                               69
  StorageBDBBackend::put()                              319
  StorageBDBBackend::modify()                           351
```

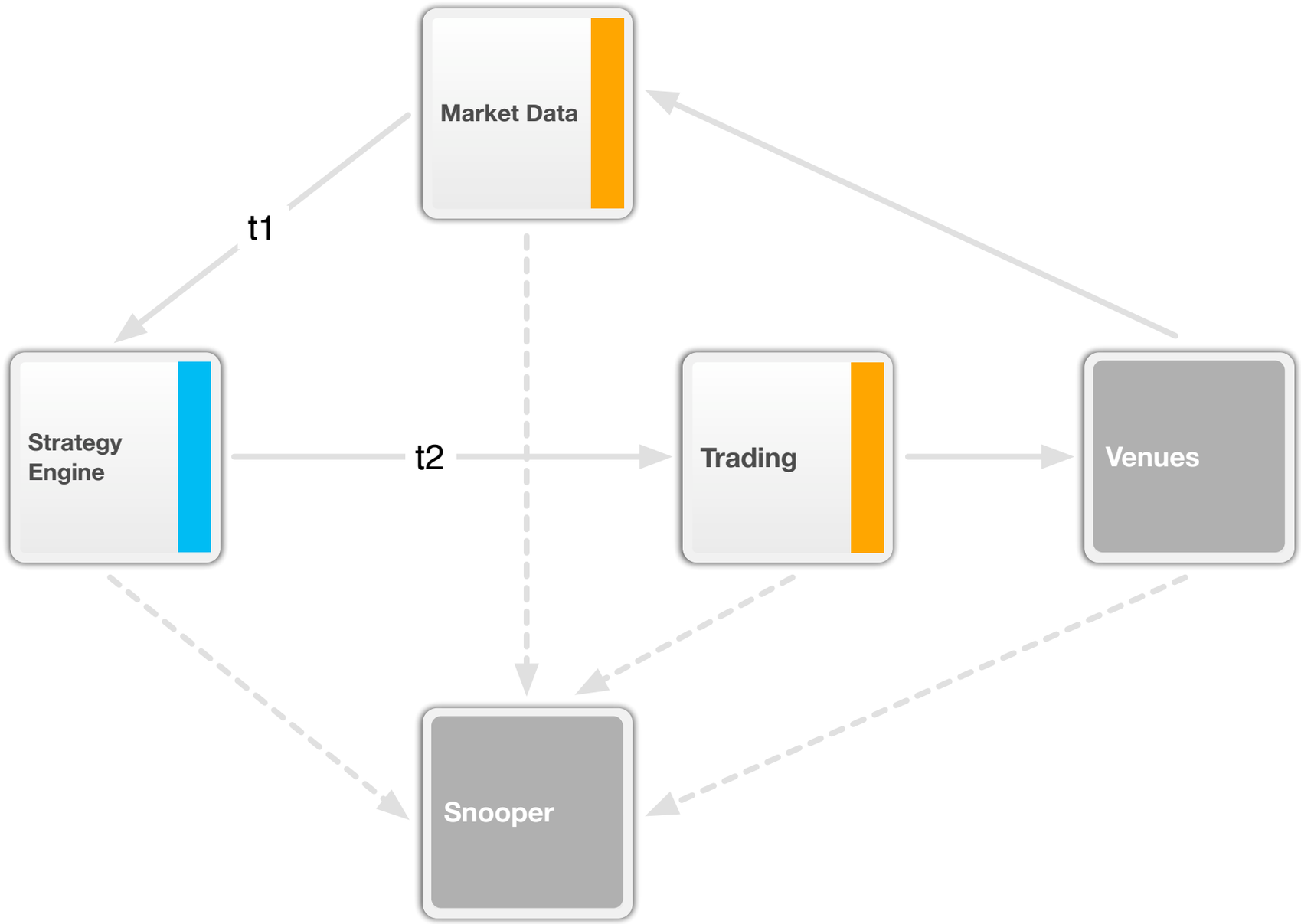
DTRACE: I/O SAMPLING



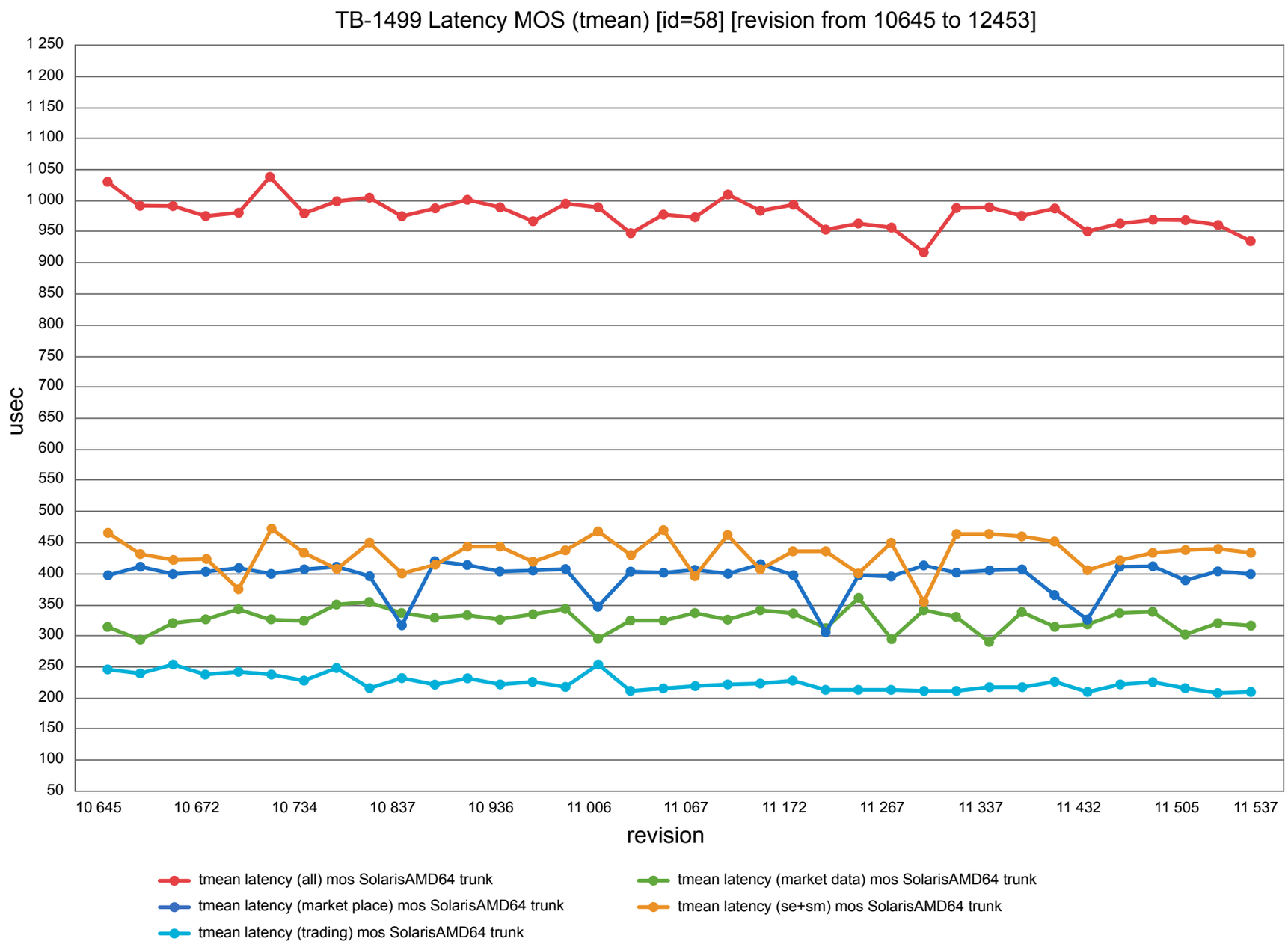
WHAT'S MISSING?

- Documentation
  - *"No inter-process tracing (or at least gettimeofday() call)"*
- TCP/IP checkpoints [tcpsnoop not integrated for ~2 years]
- Static checkpoint signature length limited to 128 characters
- Limited D syntax (only integral types for local variables)
- No distributed measurements

TBSNOOPER SAMPLING



LATENCY TRACKING



RIVALS: SYSTEMTAP (LINUX)

- Script syntax close to C (ifs, cycles, and more)
- TCP/IP checkpoints built-in
- No user-level checkpoints yet

LIBUMEM

- Provides object-caching memory allocator
- Fast (SE developer has no more fear for operator new)
- Designed for use in multi-threaded applications
- Built-in leaks detection
- Built-in memory corruption detection

ANYTHING ELSE OUT THERE?

- MacOSX Leaks: Much easier to use
- Valgrind
  - Memory error detection
  - Memory consumption analysis (even if reference is kept)
  - Heap profiler
  - Very good documentation
  - Easy to use

WHY LEAKS AND VALGRIND?

```
  $ export UMEM_DEBUG=default
  $ export UMEM_LOGGING=transaction
  $ export LD_PRELOAD=libumem.so.1
  <start program>
  $ echo "::findleaks" | mdb -p <pid>
BYTES            LEAKED        VMEM_SEG CALLER
4096                  1 fffffd7ffbca9000 MMAP
------------------------------------------------------------------------
          Total       1 oversized leak, 4096 bytes

CACHE            LEAKED           BUFCTL CALLER
00000000008e6668      12 0000000003961d20 libCrun.so.1`__1c2n6FL_pv_+0x29
00000000008f1028       2 000000000273b7e0 libdb_cxx-4.6.so`__os_malloc+0x9a
<...>
00000000008d4028     260 00000000025f02a0 libtypes.so`__1cHtbricksFtypesKDictionaryJget_value6Fr2Lpkv_i_+0x2a
  $ echo "0000000003961d20$<bufctl_audit" | mdb -p <pid>
          ADDR          BUFADDR        TIMESTAMP           THREAD
                         CACHE          LASTLOG         CONTENTS
        3961d20          395b740    5810d3912710d               18
                         8e6668          8b1300                0
              libumem.so.1`umem_cache_alloc_debug+0x12b
              libumem.so.1`umem_cache_alloc+0xc8
              libumem.so.1`umem_alloc+0xaf
              libumem.so.1`malloc+0x2e
              libCrun.so.1`__1c2n6FL_pv_+0x29
              libstrategy.so`__1cHtbricksGEngine<...>SrategyContext_rkn0AUInstrumentIdentifier__n0AKInstrument__ +0x111
              strategy.bin`__1cFOrderVHandleValidateRequest6MrknHtbricksSStrategyParameters_rn0BLEditContext__v_+0x89c
              libstrategy.so`__1cHtbricksIStrategyVHandleValidateRequest6Mrn0ARValidationContext__v_+0xa6
              __1cQValidateStrategyHexecute6M_v_+0x77
```

WHY LEAKS AND VALGRIND?

```
$ export MallocStackLogging=1
<start program>
$ leaks <pid>

Leak: 0x1030b9600  size=4608
        0x00001050 0x00000000 0x00000000 0x00000000  P...............
        0x0000002d 0x00000000 0xffffffff 0xffffffff  -...............
        0x01682048 0x00000000 0x00000001 0x00000000  H h.............
        0x0498db78 0x00000001 0x00000000 0x00000000  x...............
        0xffffffff 0xffffffff 0xffffffff 0xffffffff  ................
        0x00000000 0x00000001 0x00000001 0x00000000  ................
        0x00000000 0x10000000 0x00000501 0x00000000  ................
        0x00000001 0x00000000 0x00000000 0x00000000  ................
        ...
        Call stack: [thread 0x1050a5000]: | thread_start | _pthread_start | ace_thread_adapter | ACE_Thread_Adapter::invoke() |
ACE_Thread_Adapter::invoke_i() | ACE_Task_Base::svc_run(void*) | Task::svc() | strategy_storage::GetSnapshot::execute() |
strategy_storage::StorageTask::get_snapshot(tbricks::types::UUID const&, tbricks::filter::Filter const&) |
tbricks::storage::MessageStorageT<tbricks::types::UUID, tbricks::protocol::StrategyInstance,
<...>

Leak: 0x1049c2550  size=400        instance of 'tbricks::types::Instrument', type C++, implemented in libprotocol.dylib
        0x0089f338 0x00000001 0x00000000 0x00000000  8...............
        0x00000000 0xc0000000 0x00000001 0xc0000000  ................
        ...
        Call stack: [thread 0x104f1c000]: | thread_start | _pthread_start | ace_thread_adapter | ACE_Thread_Adapter::invoke() |
ACE_Thread_Adapter::invoke_i() | ThreadPool::svc_run(void*) | ThreadPool::svc() | ValidationPool::execute_event(SH*) |
SH::execute_validation_event() | SH::execute_n_check_delete(StrategyEvent*) | ValidateStrategy::execute() |
tbricks::Strategy::HandleValidateRequest(tbricks::ValidationContext&) | Order::HandleValidateRequest(tbricks::StrategyParameters const&,
tbricks::EditContext&) | tbricks::Engine::ResolveInstrument(tbricks::StrategyContext const&, tbricks::InstrumentIdentifier const&) const |
operator new(unsigned long) | malloc | malloc_zone_malloc
```

SO, WE DELIVER ON SOLARIS

- For its scalable and tuned kernel
- Stable API and manageable upgrades
- Reliable scheduler
- Compilers that are so standard compliant
- ZFS
- Runtime analysis tools

BUT WE RUN LINUX

- For its faster builds
- And it's just faster (at least when not overused)
- Because it has better support from software vendors

AND MAC OS X

- As it has extremely easy to use analysis tools
- Quite easy to setup an use
- Of course, religion issues

AND WINDOWS

- Because C# makes GUI development blazingly fast
- De-facto standard for desktop computing

WHAT CAN WE ASK FOR?

- Documentation
- Performance
- Faster feature turnaround times
- User friendliness
- More interaction with software vendors (e.g. market API)
- More hypes about the platform

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