Mini session
Setting up and using gdb for profiling

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This is the font size used for showing screen output. Be sure this is readable for you.
whoami

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Goals & prerequisites

• Goal: give a primer on using gdb for profiling C function sequences. This is by no means a comprehensive, full explanation.

• Prerequisites:
  – Understanding of (internal) execution of C programs.
  – Understanding of Oracle tracing mechanisms.
Use the correct tool!

• In order to troubleshoot performance problems or unexpected behaviour, sql_trace at level 8 is a decent starting point.

• sql_trace, level 8
• system calls: strace (combined with sql_trace)
• function calls: gdb

• This means using gdb is no “one size fits all” res.
Scope

• gdb is the GNU debugger.
• Installed by default on at least OL & RHEL.
• Not a dependency of the Oracle database.
• This means it’s installed on most systems!
Scope

• gdb is meant for debugging C programs.

• in order to do so, the ‘-g’ flag must be added when compiling the program (gcc).
  – The ‘-g’ flag adds debug info to the executable.

• The oracle database executables do **NOT** contain this info!
Scope

• Normal usage of gdb is to start gdb with the executable to be debugged:
  – gdb mycompiledprogram

• This can not be done with the oracle database.
Symbol table

• The Oracle executable is dynamically linked:

```bash
$ ldd oracle
linux-vdso.so.1 => (0x00007fff1dbff000)
libuuid.so => /u01/app/oracle/product/11.2.0.1/dbhome_1/lib/libuuid.so (0x00..
libcell11.so => /u01/app/oracle/product/11.2.0.1/dbhome_1/lib/libcell11.so (0x..
libskgx11.so => /u01/app/oracle/product/11.2.0.1/dbhome_1/lib/libskgx11.so (...
librt.so.1 => /lib64/librt.so.1 (0x0000003f39600000)
libbnz11.so => /u01/app/oracle/product/11.2.0.1/dbhome_1/lib/libbnz11.so (0x0..
libclsra11.so => /u01/app/oracle/product/11.2.0.1/dbhome_1/lib/libclsra11.so (.. ...
```
Symbol table

• A DL executable does not know the code location of a function in a library upfront. – Think new version of library, 3rd party, etc.

• In order to find these functions, there’s a table of function to code-location.
Symbol table

• The symbol table can be shown with the ‘nm’ command.

```bash
$ nm oracle | grep kcbgtcr
00000000082c8bca T kcbgtcr
0000000003ed68a2 T kcbgtcrf
```

• gdb can use the symbol table to understand in which function execution is taking place.
Using gdb on processes

• gdb can attach to (running) processes using:
  gdb -p <PID>

• This will suspend execution of that process (!!)

• Mind the absence of ‘oracle’; this is not oracle specific.
Warning

• gdb allows you to do specific things.
• If you want to know where oracle spend its time:
  – Use 10046/sql_trace at level 8.
• If you want to know what logical steps oracle executed:
  – Use an execution plan.
• If you want to look at system calls (I/O!):
  – Use strace (*although it can leave out information)
• If you want to look at C function call level:
  – Use gdb.
using gdb on oracle

• Attach to a running Oracle process (root!):

  
  # gdb -p 6615

  GNU gdb (GDB) Red Hat Enterprise Linux (7.2-56.el6)
  Copyright (C) 2010 Free Software Foundation, Inc.
  ...

  Attaching to process 6615
  Reading symbols from /u01/app/oracle/product/11.2.0.3/dbhome_1/bin/oracle...(no
debugging symbols found)...done.

  Reading symbols from /u01/app/oracle/product/11.2.0.3/dbhome_1/lib/
  libcell111.so...done.

  Loaded symbols for /u01/app/oracle/product/11.2.0.3/dbhome_1/lib/libcell111.so

  Loaded symbols for /u01/app/oracle/product/11.2.0.3/dbhome_1/lib/libnque11.so

  0x0000003f38a0e530 in __read_nocancel () from /lib64/libpthread.so.0

  Missing separate debuginfos, use: debuginfo-install glibc-2.12-1.80.el6_3.6.x86_64
  libaio-0.3.107-10.el6.x86_64 numactl-2.0.7-3.el6.x86_64

  (gdb)
using gdb on oracle

• The database session is stuck now:

  $ sqlplus ts/ts@v11203

  SQL*Plus: Release 11.2.0.3.0 Production on Mon Dec 9 15:51:05 2013

  Copyright (c) 1982, 2011, Oracle. All rights reserved.

  Connected to:
Oracle Database 11g Enterprise Edition Release 11.2.0.3.0 - 64bit Production
With the Partitioning, Automatic Storage Management, OLAP, Data Mining
and Real Application Testing options

  TS@v11203 > select * from dual;
using gdb on oracle

• Now let the oracle process continue:

  (gdb) c
Continuing.

• ‘select * from dual’ continues.
  — Please mind performance is much lower with gdb attached to a process!

• A process can be suspended at any time by pressing CTRL+c in gdb.
• The functionality that is useful for profiling, is using the ‘break’ functionality.

• The function of break is to ‘break’ execution when a certain function is entered.

• Granularity of breaking is function call level.
Let’s break on a well known function: io_submit()

^C
Program received signal SIGINT, Interrupt.
(gdb) break io_submit
Breakpoint 1 at 0x3f38200660
(gdb) c
Continuing.
• Issue a full scan (to make oracle use of AIO):

```
TS@v11203 > select count(*) from t2;
```

• This will trigger AIO, and gdb breaks execution:

```
(gdb) c
Continuing.

Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/ libaio.so.1
(gdb)
```
• So we now we know the Oracle process called ‘io_submit()’.

• If we press ‘c’ (continue), the process continues.

  (gdb) c
Continuing.

  Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1
  (gdb)

• Another encounter of ‘io_submit()’, etc.
• The continue command can be automated:

    (gdb) commands 1
    Type commands for breakpoint(s) 1, one per line.
    End with a line saying just "end".
    >c
    >end
    (gdb) c
    Continuing.

    Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1

    Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1

    ...
Let’s add breaking on `io_getevents()` too:

```
^C
Program received signal SIGINT, Interrupt.
0x00000003f38a0e530 in __read_nocancel () from /lib64/libpthread.so.0
(gdb) break 'io_getevents@plt'
Breakpoint 2 at 0x3f382006a0
(gdb) commands
Type commands for breakpoint(s) 2, one per line.
End with a line saying just "end".
>c
>end
(gdb) c
Continuing.
```
• Issue another full scan:

```
TS@v11203 > select count(*) from t2;
```

• Now we see the AIO calls in gdb:

```
(gdb) c
Continuing.
Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1
Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1
Breakpoint 2, 0x000000000000a09030 in io_getevents@plt ()
Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1
Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1
Breakpoint 2, 0x000000000000a09030 in io_getevents@plt ()
```
• Wait! Don’t we now have exactly the same as strace, but in a very difficult way?

```sh
# strace -e trace=io_submit,io_getevents -p 10430
Process 10430 attached - interrupt to quit
io_submit(140441218691072, 1, {{0x7fbb03109450, 0, 0, 0, 257}}) = 1
io_submit(140441218691072, 1, {{0x7fbb031091f8, 0, 0, 0, 257}}) = 1
io_getevents(140441218691072, 2, 128, {{0x7fbb03109450, 0x7fbb03109450, 106496, 0}}, {0, 0}) = 1
io_getevents(140441218691072, 1, 128, {{0x7fbb031091f8, 0x7fbb031091f8, 122880, 0}}, {0, 0}) = 1
io_submit(140441218691072, 1, {{0x7fbb03109450, 0, 0, 0, 257}}) = 1
io_getevents(140441218691072, 1, 128, {{0x7fbb03109450, 0x7fbb03109450, 122880, 0}}, {0, 0}) = 1
```
• Yes.
• But once you add in (oracle) user land functions, the advantage becomes clear:

• kslwrbctx () : start a wait event*
• kslwtectx () : end a wait event*

*Oracle 11 and up
• Add these functions to the breaks:

  (gdb) break io_submit
  Breakpoint 1 at 0x3f38200660
  (gdb) break 'io_getevents@plt'
  Breakpoint 2 at 0xa09030
  (gdb) rbread ^kslwt[be]ctx
  Breakpoint 3 at 0x8f9a652
  <function, no debug info> kslwtbctx;
  Breakpoint 4 at 0x8fa1334
  <function, no debug info> kslwtctx;
  (gdb) commands 1-4
  Type commands for breakpoint(s) 1-4, one per line.
  End with a line saying just "end".
  >c
  >end
  (gdb) c
  Continuing.
• And issue the scan again, gdb now shows:

Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1

Breakpoint 1, 0x0000003f38200660 in io_submit () from /lib64/libaio.so.1

Breakpoint 2, 0x0000000000000a09030 in io_getevents@plt ()

Breakpoint 2, 0x0000000000000a09030 in io_getevents@plt ()

Breakpoint 2, 0x0000000000000a09030 in io_getevents@plt ()

Breakpoint 2, 0x0000000000000a09030 in io_getevents@plt ()

Breakpoint 2, 0x0000000000000a09030 in io_getevents@plt ()

Breakpoint 3, 0x0000000000008f9a652 in kslwtbctx ()

Breakpoint 2, 0x0000000000000a09030 in io_getevents@plt ()
• Wait! There’s more!

• The Oracle database doesn’t have/distribute debug symbols.
• But Oracle Linux has!
  – These are called the ‘debuginfo’ packages!
  – As yum repo (!)
• Add the debuginfo repository to your yum config:

```bash
# vi /etc/yum.repos.d/debuginfo.repo
[ol6_debuginfo]
name=Oracle Linux 6 debuginfo
baseurl=http://oss.oracle.com/ol6/debuginfo
gpgkey=https://oss.oracle.com/ol6/RPM-GPG-KEY-oracle
gpgcheck=1
enabled=1
```
• Watch what gdb tells you when you attach to an oracle process:

Reading symbols from /u01/app/oracle/product/11.2.0.3/dbhome_1/lib/libnque11.so... (no debugging symbols found)...done.
Loaded symbols for /u01/app/oracle/product/11.2.0.3/dbhome_1/lib/libnque11.so
0x0000003f38a0e530 in __read_nocancel () from /lib64/libpthread.so.0

Missing separate debuginfos, use: debuginfo-install glibc-2.12-1.80.el6_3.6.x86_64
libaio-0.3.107-10.el6.x86_64 numaclt-2.0.7-3.el6.x86_64

(gdb)

• This leaves the impression that you should execute ‘debuginfo-install’...
• No! That actually is RH specific (AFAIK)
• Use:
  
  # yum install glibc-debuginfo libaio-debuginfo numactl-debuginfo

• Sadly, this *might* not work...
  – Personal experience is the metadata of oss repo is not kept up to date very much...
  – It will install the latest version in the metadata.
• If it doesn’t work, use rpm directly:
  
  # rpm -Uvh https://oss.oracle.com/ol6/debuginfo/glibc-debuginfo-
  common-2.12-1.80.el6_3.6.x86_64.rpm
• Now attach to an Oracle session again:

```
0x0000003f38a0e530 in __read_nocancel () at ../sysdeps/unix/syscall-template.S:82
82 T_PSEUDO (SYSCALL_SYMBOL, SYSCALL_NAME, SYSCALL_NARGS)
(gdb)
```

• Look what io_submit ()/io_getevents () shows:

```
(gdb) break io_submit
Breakpoint 1 at 0x3f38200660: file io_submit.c, line 23.
(gdb) break io_getevents_0_4
Breakpoint 2 at 0x3f38200620: file io_getevents.c, line 46.
(gdb) commands 1-2
Type commands for breakpoint(s) 1-2, one per line.
End with a line saying just "end".
>c
>end
(gdb) c
Continuing.
```
debuginfo: function call args

Breakpoint 1, io_submit (ctx=0x7fbb04f3a000, nr=1, iocbs=0x7fffcffce7a0) at io_submit.c:23
23 io_syscall3(int, io_submit, io_submit, io_context_t, ctx, long, nr, struct iocb **, iocbs)

Breakpoint 1, io_submit (ctx=0x7fbb04f3a000, nr=1, iocbs=0x7fffcffce7a0) at io_submit.c:23
23 io_syscall3(int, io_submit, io_submit, io_context_t, ctx, long, nr, struct iocb **, iocbs)

Breakpoint 2, io_getevents_0_4 (ctx=0x7fbb04f3a000, min_nr=2, nr=128, events=0x7fffcfffd6e08, timeout=0x7fffcffdaef0) at io_getevents.c:46
46 if (ring==NULL || ring->magic != AIO_RING_MAGIC)

Breakpoint 2, io_getevents_0_4 (ctx=0x7fbb04f3a000, min_nr=2, nr=128, events=0x7fffcfffd9ee8, timeout=0x7fffcffdaef0) at io_getevents.c:46
46 if (ring==NULL || ring->magic != AIO_RING_MAGIC)

Breakpoint 2, io_getevents_0_4 (ctx=0x7fbb04f3a000, min_nr=2, nr=128, events=0x7fffcfffd6c08, timeout=0x7fffcffdaef0) at io_getevents.c:46
46 if (ring==NULL || ring->magic != AIO_RING_MAGIC)
• Other useful gdb commands:
  – info break
  – save breakpoints <yourfilename>
  – source <yourfilename>
  – disable <breaknr>
  – enable <breaknr>
  – set pagination off
  – q
  – ~/.gdbinit
  – bt
Questions?