



Support for mini-debuginfo in LLDB

How to read the .gnu_debugdata section

Konrad Kleine

February 2, 2020

Red Hat





Red Hat

- LLDB, C/C++, ELF, DWARF since 2019
- joined and worked on OpenShift in 2016



Reach out

-  <https://github.com/kwk/talks/>
-  <https://www.linkedin.com/in/konradkleine>

Improve LLDB for Fedora and RHEL *release* binaries¹

- when no debug symbols installed
 - not all function symbols available (only `.dynsym`)
 - backtraces mostly show addresses

Approach

- make LLDB understand mini-debuginfo
 - that's where runtime symbols are stored

¹Mini-debuginfo used since Fedora 18 (2013, Release Notes 4.2.4.1.) and RHEL 7.x

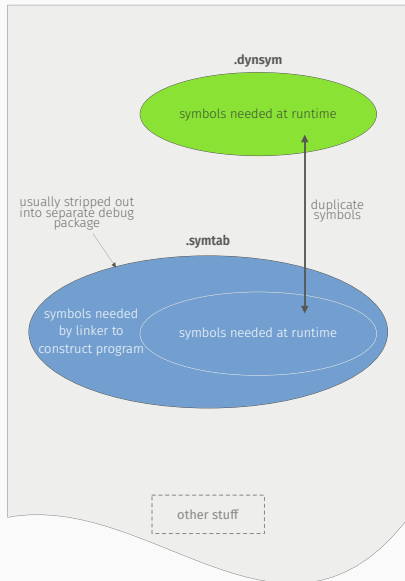
💡 Why was mini-debuginfo invented and how?

- Without installing debug infos
 - be able to generate a backtrace for crashes with ABRT²
 - ~~have symbol table (`.symtab`)~~
 - ~~have line information (`.debug_line`)~~
 - ➔ my guessed conclusion: *more than two sections make up an ELF file?!*
- Eventually only one relevant section
 - stripped `.symtab` (simplified: *just function symbols*)
 - rest was too big
 - ELF format remained
 - **no replacement** for separate full debug info
 - **not related** to DWARF
 - *just symbol tables*

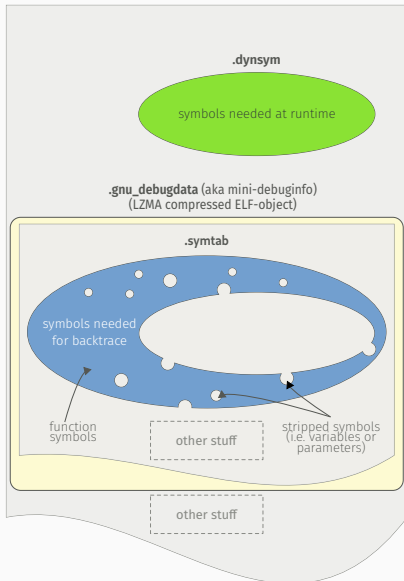
²Automatic Bug Reporting Tool

Symbol tables in an ELF file

regular ELF file



ELF file with mini-debuginfo



Not focus on backtraces

- but make LLDB see mini-debuginfo
 - set and hit breakpoint
 - `dump symbols ((lldb) image dump symtab)`

Take existing Fedora binary (/usr/bin/zip)

- identify a symbol/function
- shootout: GDB vs. LLDB
- hurdles:
 - not from `.dynsym`
 - from within `.gnu_debugdata`

Identify symbol in `zip.gdd` but not in main binary

```
1  # Show symbols
2  ~$ eu-readelf -s zip.gdd
3
4  Symbol table [28] '.symtab' contains 202 entries:
5      82 local symbols String table: [29] '.strtab'
6
7      Num:          Value      Size Type   Bind   Vis      Ndx Name
8      0: 0000000000000000      0 NOTYPE  LOCAL  DEFAULT  UNDEF
9      1: 0000000000408db0     494 FUNC    LOCAL  DEFAULT   15 freeup
10     2: 0000000000408fa0    1015 FUNC    LOCAL  DEFAULT   15 DisplayRunningStats
11     3: 00000000004093a0     128 FUNC    LOCAL  DEFAULT   15 help
12  [...]
```

help looks promising³.

```
11 ~$ eu-readelf --symbols /usr/bin/zip | grep help
12 ~$
```

³Promising as in: we may be able to trigger it with `/usr/bin/zip --help`.



Set and hit breakpoint on help with GDB 8.3⁴

```
1 ~$ gdb --nx --args /usr/bin/zip --help
2
3 Reading symbols from /usr/bin/zip...
4 Reading symbols from .gnu_debugdata for /usr/bin/zip...
5 (No debugging symbols found in .gnu_debugdata for /usr/bin/zip)
6 Missing separate debuginfos, use: dnf debuginfo-install zip-3.0-25.fc31.x86_64
7
8 (gdb) b help
9 Breakpoint 1 at 0x4093a0
10
11 (gdb) r
12 Starting program: /usr/bin/zip --help
13
14 Breakpoint 1, 0x00000000004093a0 in help ()
15 (gdb)
```

Success and two things to note:

1. Symbols read from `.gnu_debugdata`
2. No debug symbols installed for zip

⁴GDB 8.3 is what ships with Fedora 31


```
1 ~$ lldb -x /usr/bin/zip -- --help
2
3 (lldb) target create "/usr/bin/zip"
4 Current executable set to '/usr/bin/zip' (x86_64).
5 (lldb) settings set -- target.run-args "--help"
6
7 (lldb) b help
8 Breakpoint 1: no locations (pending).
9 WARNING: Unable to resolve breakpoint to any actual locations.
10
11 (lldb)
```

⁵LLDB 9.0.0 is what ships with Fedora 31



Symtab

- normally, `.dynsym` is subset
- **but** for mini-debuginfo `.dynsym` symbols are stripped⁶

Implications for LLDB (and other tools)

- parse `.dynsym` when
 - no `.symtab` found **or**
 - mini-debuginfo present and smuggled in

⁶<https://sourceware.org/gdb/current/onlinedocs/gdb/MiniDebugInfo.html>

Show that LLDB can now find help symbol

```
1 $ lldb -x /usr/bin/zip -- --help
2
3 (lldb) target create "/usr/bin/zip"
4 Current executable set to '/usr/bin/zip' (x86_64).
5 (lldb) settings set -- target.run-args "--help"
6
7 (lldb) b help
8 Breakpoint 1: where = zip`help, address = 0x0000000004093a0
9
10 (lldb) r
11 Process 277525 launched: '/usr/bin/zip' (x86_64)
12 Process 277525 stopped
13 * thread #1, name = 'zip', stop reason = breakpoint 1.1
14   frame #0: 0x0000000004093a0 zip`help
15 zip`help:
16 -> 0x4093a0 <+0>: pushq  %r12
17       0x4093a2 <+2>: movq   0x2af6f(%rip), %rsi      ; + 4056
18       0x4093a9 <+9>: movl   $0x1, %edi
19       0x4093ae <+14>: xorl   %eax, %eax
20 (lldb)
```

 shipping with LLVM 10



READY TO SHIP?

② What tests exists for mini-debuginfo?

- 🔍 find symbol from `.gnu_debugdata`
- ⚠ warning when mini-debuginfo w/o LZMA support
- ❗ error when decompressing corrupted xz
- ⚙ full example with compiled and modified code in accordance to gdb's documentation

 FELL ASLEEP YET?

</> Example test file in Shell test suite

lldb/test/Shell/Breakpoint/example.c:

```
1 // REQUIRES: system-linux, lzma, xz
2 // RUN: gcc -g -o %t %s
3 // RUN: %t 1 2 3 4 | FileCheck %s
4
5 #include <stdio.h>
6 int main(int argc, char* argv[]) {
7
8     // CHECK: Number of {{.*}}: 5
9     printf("Number of arguments: %d\n", argc);
10
11     return 0;
12 }
```

- features added: lzma, xz
 - just some CMake canonisation and Python config

```
1 if config.lldb_enable_lzma:
2     config.available_features.add('lzma')
3 if find_executable('xz') != None:
4     config.available_features.add('xz')
```

You might wonder...

What was the hardest part?

- 😊 setting a breakpoint worked
- 😞 hitting a breakpoint didn't work
 - non-runnable/sparse ELF files in YAML form didn't cut it
- 📖 dealing with tests
 - `yaml2obj`⁷ always produced `.symtab`
 - made my tests go nuts

Community aspects

- ⚖️ polishing for upstream
- 🔄 repo migration to github, review in phabricator
 - strong opinions add unconstructive noise on LLVM mailing lists

⁷*"yaml2obj takes a YAML description of an object file and converts it to a binary file."*
(<https://llvm.org/docs/yaml2obj.html>)

Real example of sparse ELF test file

🔍 Check to find symbol `multiplyByFour` in mini-debuginfo

```
1  # REQUIRES: lzma
2  # RUN: yamll2obj %s > %t.obj
3  # RUN: llvm-objcopy --remove-section=.symtab %t.obj
4  # RUN: %lldb -b -o 'image dump symtab' %t.obj | FileCheck %s
5  # CHECK: [ 0] 1 X Code 0x00000000004005b0 0x000000000000000f 0x00000012 multiplyByFour
6
7  --- !ELF
8  FileHeader:
9    Class:      ELFCLASS64
10   Data:       ELFDATA2LSB
11   Type:       ET_EXEC
12   Machine:    EM_X86_64
13   Entry:      0x00000000004004C0
14 Sections:
15   - Name:     .gnu_debugdata
16     Type:     SHT_PROGBITS
17     AddressAlign: 0x0000000000000001
18     Content:   FD377A585A000004E6 # ...
19   ...
```

- notice line 3 manually removes `.symtab`
- meanwhile `yamll2obj` was fixed



Thank you!

Please, share your feedback ★★★★★

<https://submission.fosdem.org/feedback/10393>