Red Hat
Platform
Tools Team

Support for mini-debuginfo in LLDB

How to read the .gnu_debugdata section

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About me

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

Overall goal

Improve LLDB for Fedora and RHEL *release* binaries[1]

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

Approach

- Make LLDB understand mini-debuginfo
  - that's where more function symbols are

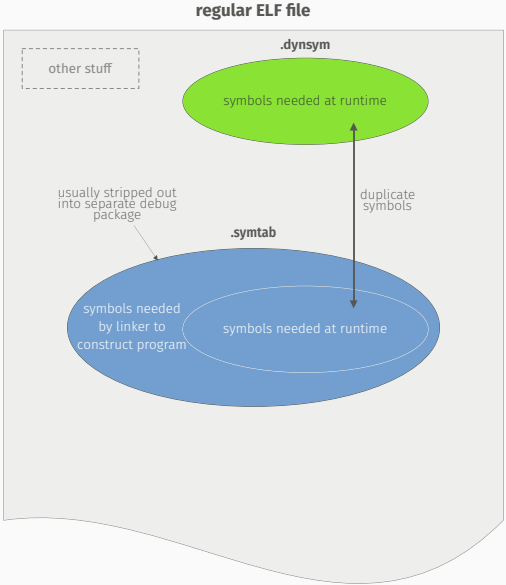
[1] Mini-debuginfo used since Fedora 18 (2013, Release Notes 4.2.4.1.) and RHEL 7.x

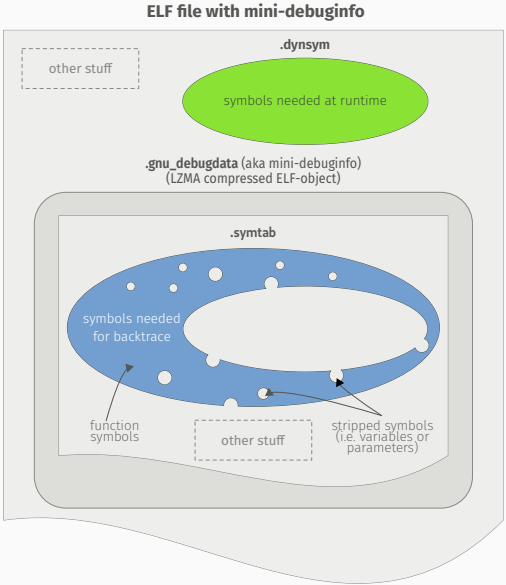
Why was mini-debuginfo invented and how?

- Without installing debug infos
  - be able to generate a backtrace for crashes with ABRT[2]
  - ~~have full symbol table (`.symtab`)~~
  - ~~have line information (`.debug_line`)~~
  - *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*

[2] Automatic Bug Reporting Tool

Symbol tables in an ELF file





Approach

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
  - not from `.dynsym`
  - from within `.gnu_debugdata`
- shootout: GDB vs. LLDB

Identify symbol not directly accessible

```
# Show symbols
~$ eu-readelf -s zip.gdd

Symbol table [28] '.symtab' contains 202 entries:
 82 local symbols  String table: [29] '.strtab'
  Num:            Value   Size Type    Bind   Vis          Ndx Name
    0: 0000000000000000      0 NOTYPE  LOCAL  DEFAULT    UNDEF
    1: 0000000000408db0    494 FUNC    LOCAL  DEFAULT       15 freeup
    2: 0000000000408fa0   1015 FUNC    LOCAL  DEFAULT       15 DisplayRunningStats
    3: 00000000004093a0    128 FUNC    LOCAL  DEFAULT       15 help
[...]
```

`help` looks promising[3].

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

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

...and do a demo!

Didn’t work?

Symtab (reminder)

- normally, `.dynsym` is a subset
- **but** for mini-debuginfo `.dynsym` symbols are stripped[4] from symtab

Implications for LLDB (and other tools)

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

[4] https://sourceware.org/gdb/current/onlinedocs/gdb/MiniDebugInfo.html

…and do *yet another* demo!

Didn’t work?

Ready to ship?

What tests exist 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 analogue to gdb's documentation

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`[5] always produced `.symtab`
    - made my tests go nuts

Community aspects

- ⚖ polishing for upstream
- repo migration to github, review in phabricator

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

Thank you!

Please, share your feedback ★★★★½

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

Appendix

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

```
// REQUIRES: system-linux, lzma, xz
// RUN: gcc -g -o %t %s
// RUN: %t 1 2 3 4 | FileCheck %s

#include <stdio.h>
int main(int argc, char* argv[]) {
  // CHECK: Number of {{.*}}: 5
  printf("Number of arguments: %d\n", argc);
  return 0;
}
```

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

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

Real example of sparse ELF test file

Check to find symbol `multiplyByFour` in mini-debuginfo

```
1  # REQUIRES: lzma
2  # RUN: yaml2obj %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 `yaml2obj` was fixed

Extract + decompress `.gnu_debugdata` from `/usr/bin/zip`

```
# Dump section
~$ objcopy --dump-section .gnu_debugdata=zip.gdd.xz zip

# Determine file type of section
~$ file zip.gdd.xz
zip.gdd.xz: XZ compressed data

# Decompress section
~$ xz --decompress --keep zip.gdd.xz

# Determine file type of decompressed section
~$ file zip.gdd
zip.gdd: ELF 64-bit LSB executable, x86-64, version 1 [...]
```

Set and hit breakpoint on `help` with GDB 8.3[6]

```
~$ gdb --nx --args /usr/bin/zip --help

Reading symbols from /usr/bin/zip...
Reading symbols from .gnu_debugdata for /usr/bin/zip...
(No debugging symbols found in .gnu_debugdata for /usr/bin/zip)
Missing separate debuginfos, use: dnf debuginfo-install zip-3.0-25.fc31.x86_64

(gdb) b help
Breakpoint 1 at 0x4093a0

(gdb) r
Starting program: /usr/bin/zip --help

Breakpoint 1, 0x00000000004093a0 in help ()
(gdb)
```

Success and two things to note:

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

[6] GDB 8.3 is what ships with Fedora 31

Set and hit breakpoint on `help` with LLDB 9.0.0[7]

```
~$ lldb -x /usr/bin/zip -- --help

(lldb) target create "/usr/bin/zip"
Current executable set to '/usr/bin/zip' (x86_64).
(lldb) settings set -- target.run-args  "--help"

(lldb) b help
Breakpoint 1: no locations (pending).
WARNING:  Unable to resolve breakpoint to any actual locations.

(lldb)
```

Back to demo 1.

[7] LLDB 9.0.0 is what ships with Fedora 31

☑ Show that LLDB can now find `help` symbol

```
$ lldb -x /usr/bin/zip -- --help
...

(lldb) b help
Breakpoint 1: where = zip`help, address = 0x00000000004093a0

(lldb) r
Process 277525 launched: '/usr/bin/zip' (x86_64)
Process 277525 stopped
* thread #1, name = 'zip', stop reason = breakpoint 1.1
    frame #0: 0x00000000004093a0 zip`help
zip`help:
->  0x4093a0 <+0>:  pushq  %r12
    0x4093a2 <+2>:  movq   0x2af6f(%rip), %rsi       ;  + 4056
    0x4093a9 <+9>:  movl   $0x1, %edi
    0x4093ae <+14>: xorl   %eax, %eax
(lldb)
```

♡ shipping with LLVM 10 (Back to demo 1.)