LLDB Kernel Module Improvement

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Who am I?

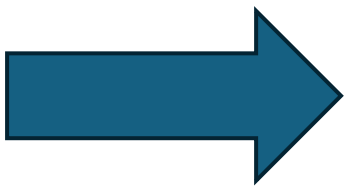
- Student in NTNU CS
- Interest in Kernel and Toolchain
- Bhyve Raw TCP console
- LLDB Kernel Module

aokblast

Outline

- Introduction
- What we already have?
- What I have done?
- Demo
- Ongoing work
- Conclusion

Introduction



LLVM Review

Old	New
gcc	clang
Libstdc++	Libc++
libgcc	compiler-rt
libgcc_s	libunwind
GNU ld	lld
gdb	lldb

LLVM Review

Unchanged	Not shipped
libc	llvm-lto
elf-toolchain	bolt
	libclc

LLDB Architecture

1. Target - Builtin
2. ObjectFile
3. Process
4. ABI
5. DynamicLoader

What we already have?

1. Target - Builtin
2. ObjectFile - ✓
3. Process - ✓
4. ABI - ✓
5. DynamicLoader

Dynamic Loader Plugin

Kernel Module is like shared library

- Shared same address space
- Load when needed
- Load by dynamic loader

Goals of this Plugin:

- Parse all loaded Kernel Module
- Make symbols load address
- Run in tier-1 platform

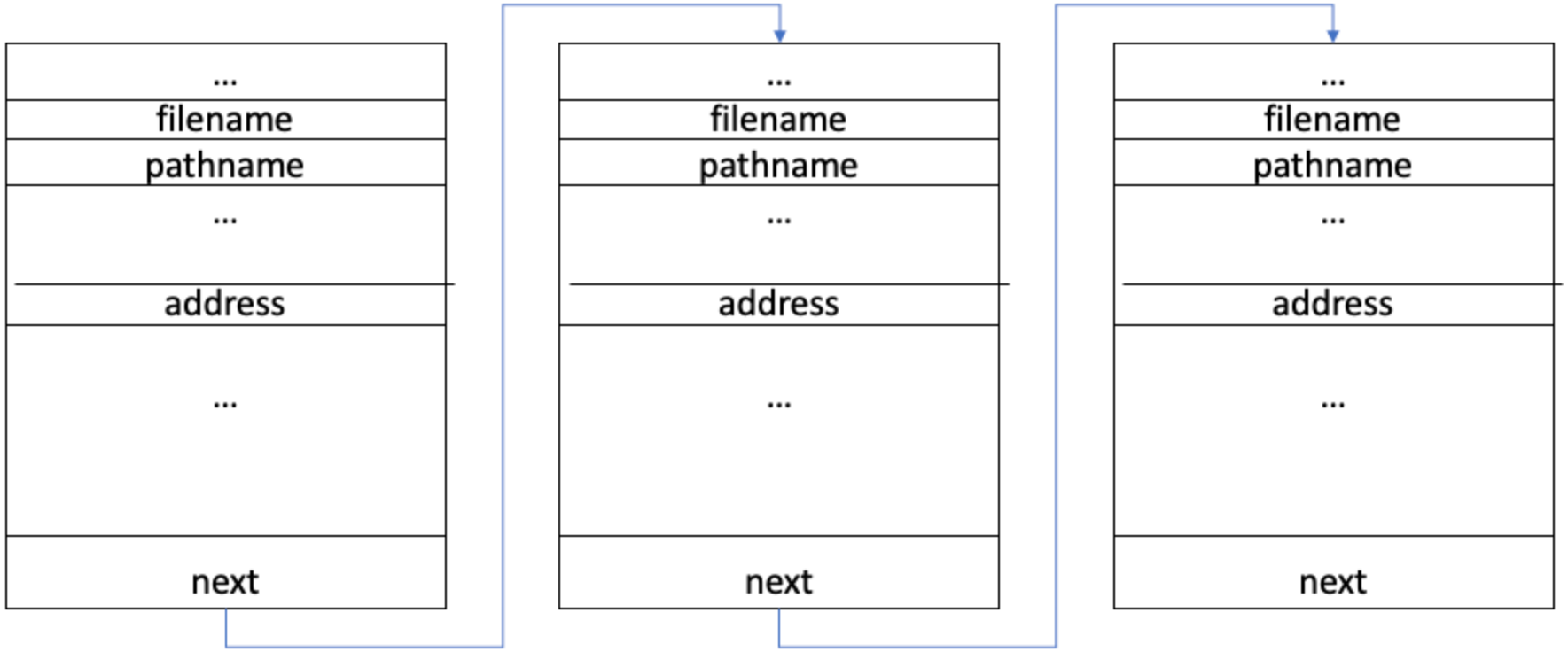
Design

1. Called by ProcessFreeBSDKernel
2. Find and Verify coredump information
3. Parsing Kernel Loaded Module Address
4. Handle Relocatable file and Shared Object

Find and Verify Coredump

- Currently, according to the load address in kernel binary
- Problem
  - When we have kASLR in the future
- Some other method available:
  - Search near PC

Parsing Kernel Module



Structure of linker_files

Parsing Kernel Module

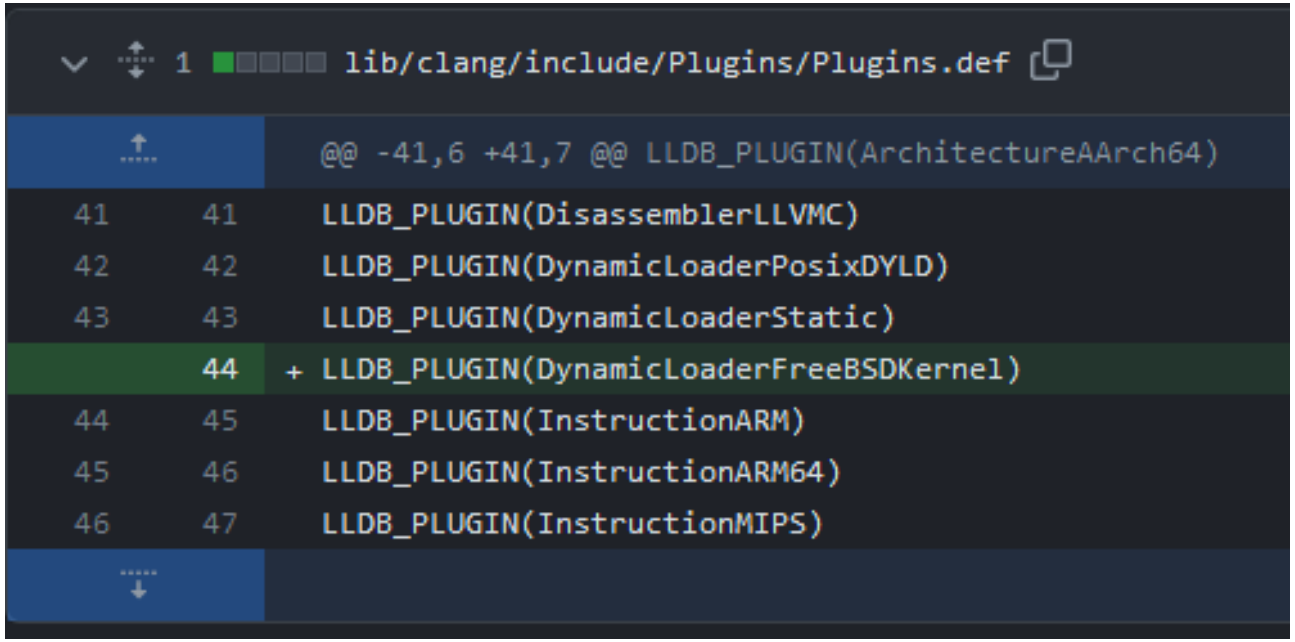
```
// DynamicLoaderFreeBSDKernel.cpp

while (current_kld != 0) {
    // Read kld_filename, load_addr, pathname
    kmods_list.emplace_back();
    KModImageInfo &kmod_info = kmods_list.back();
    kmod_info.SetName(kld_filename);
    kmod_info.SetLoadAddress(kld_load_addr);
    kmod_info.SetPath(kld_pathname);

    current_kld =
        m_process->ReadPointerFromMemory(current_kld
+ kld_off_next, error);
    if (kmod_info.GetName() == "kernel")
      kmods_list.pop_back();
    if (error.Fail())
      return false;
  }
```

Append Kernel Module into LLDB Module list

- Attach the symbol file
- For Dynamic Library
  - Verify ELF file and adjust section addr
- For relocatable kernel module
  - SetLoadAddress
- Put it into loaded module list

Single line cost me 2 weeks.

- Without this, the plugin will not work
  - Don’t find any ref on network
  - No compile err or link err
  - In a path I seldom think about



Modification beyond the Dyld Plugin

- LoadAddress of Kernel Module

```
// ObjectFileELF.cpp

+  if (GetType() == ObjectFile::eTypeObjectFile)
{
+   for (I : m_section_headers) {
+     const ELFSectionHeaderInfo &header = *I;
+     if (header.sh_flags & SHF_ALLOC)
+       return Address(GetSectionList()-
>FindSectionByID(SectionIndex(I)), 0);
+   }
+   return LLDB_INVALID_ADDRESS;
+ }
```

Modification beyond the Dyld Plugin

- DebugInfo for Relocatable file

```
// ObjectFileELF.cpp

if ((ObjectType == eTypeObjectFile … ) {

  NextVMAddress =
  llvm::alignTo(NextVMAddress,
       std::max<addr_t>(H.sh_addralign, 1));
  Address = NextVMAddress;
  NextVMAddress += Size;
}
```

Modification beyond the Dyld Plugin

- DebugInfo for Relocatable file

```
// ObjectFileELF.cpp

if ((ObjectType == eTypeObjectFile) ||
     (ObjectType == eTypeDebugInfo && H.sh_addr == 0)) {

  NextVMAddress =
  llvm::alignTo(NextVMAddress,
       std::max<addr_t>(H.sh_addralign, 1));
  Address = NextVMAddress;
  NextVMAddress += Size;
}
```

Modification beyond the Dyld Plugin

- Check if the binary is kernel
  - No way way to detect it directly in ELF
  - special ".interp" in FreeBSD (/red/herring")

```
  case llvm::ELF::ET_EXEC:
-    // 2 - Executable file
-    // TODO: is there any way to detect that
an executable is a kernel
-    // related executable by inspecting the
program headers, section headers,
-    // symbols, or any other flag bits???
```

You can find the code in llvm-project

Quick Demo

https://reurl.cc/OGOLk9

Ongoing work

- Programmer may load incompatible kernel coredump with kernel binary
- Use .note.gnu.build-id section
- ID in binary should be same as kernel coredump, if not, refused to load the DynamicLoader
- Extended to the kernel module

Thank you