



Introducing LLDB for Linux on Arm and AArch64

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Agenda

- Brief introduction and history behind LLDB
- Status of LLDB on Linux and Android
- Linaro's contributions in LLDB
- An overview of LLDB Architecture
- More detail on working and architecture
- Overview of basic functionality and commands
- Overview of expressions and data formatters.

LLDB - Introduction

- Debugger component of LLVM project.
- A modular, high-performance source-level debugger written in C++
- Re-uses LLVM/Clang code JIT/IR for expression parsing, disassembly etc.
- Provides a C++ Debugger API which can be used by various clients
- Very permissive BSD-like license.



LLDB - Introduction (cont...)

- **Supported Host Platforms**

- OS X, Linux, FreeBSD, NetBSD, and Windows

- **Supported Target Architectures**

- i386/x86_64, Arm/AArch64, MIPS/MIPS64, IBM s390

- **Supported Languages**

- Fully support C, C++ and Objective-C while SWIFT and GoLang (under development)



LLDB - History

- Apple stopped shipping GDB after version 6.3.5
- Last GPLv2 based GDB release.
- Announced LLDB at WWDC2010.
- Extensively under development for various use-cases.
- Active code contributors are Apple and Google.
- Default debugger for OSX, Xcode IDE, Android Studio.
- Also adopted by FreeBSD as their default debugger.



LLDB - Linaro's contributions

- **LLDB port for ARMv7 architecture.**
 - Register Context and Basic Debugging support.
 - Support for SysV ARM/Linux ABI.
 - Support for Arm Hardware Watchpoints
 - Support for Arm Single Byte-Selection Watchpoints.
 - Various bug fixes and improvements.
 - Support for Arm Hardware Breakpoints **(NEW)**



LLDB - Linaro's contributions (cont...)

- **LLDB port for ARMv8 architecture.**
 - Support for SysV AArch64/Linux ABI.
 - Support for AArch64 Hardware Watchpoints
 - Various bug fixes and improvements.
 - Support for AArch64 Hardware Breakpoints **(NEW)**
- **Maintenance and Testing**
 - Buildbot development and maintenance
 - Tester bring up and validation
 - Buildbot Failure Triage



LLDB - Features Status ARM/AArch64

- LLDB features stable on ARM and AArch64
- For more details visit: <http://lldb.llvm.org/status.html>

	Process control -- attach -- continue -- exec -- fork -- launch -- status	Thread Control -- step-in -- step-out -- step-over -- inspection	-- Breakpoints -- HW Breakpoints -- HW Watchpoints -- DWARF Symbols -- ELF Obj File -- C++11 Support -- Backtracing	-- Register Inspection -- Memory Inspection -- Expression Evaluation -- JIT Expressions -- Disassembly -- Remote Debugging
ARM	OK	OK	OK	OK
AArch64	OK	OK	OK	OK



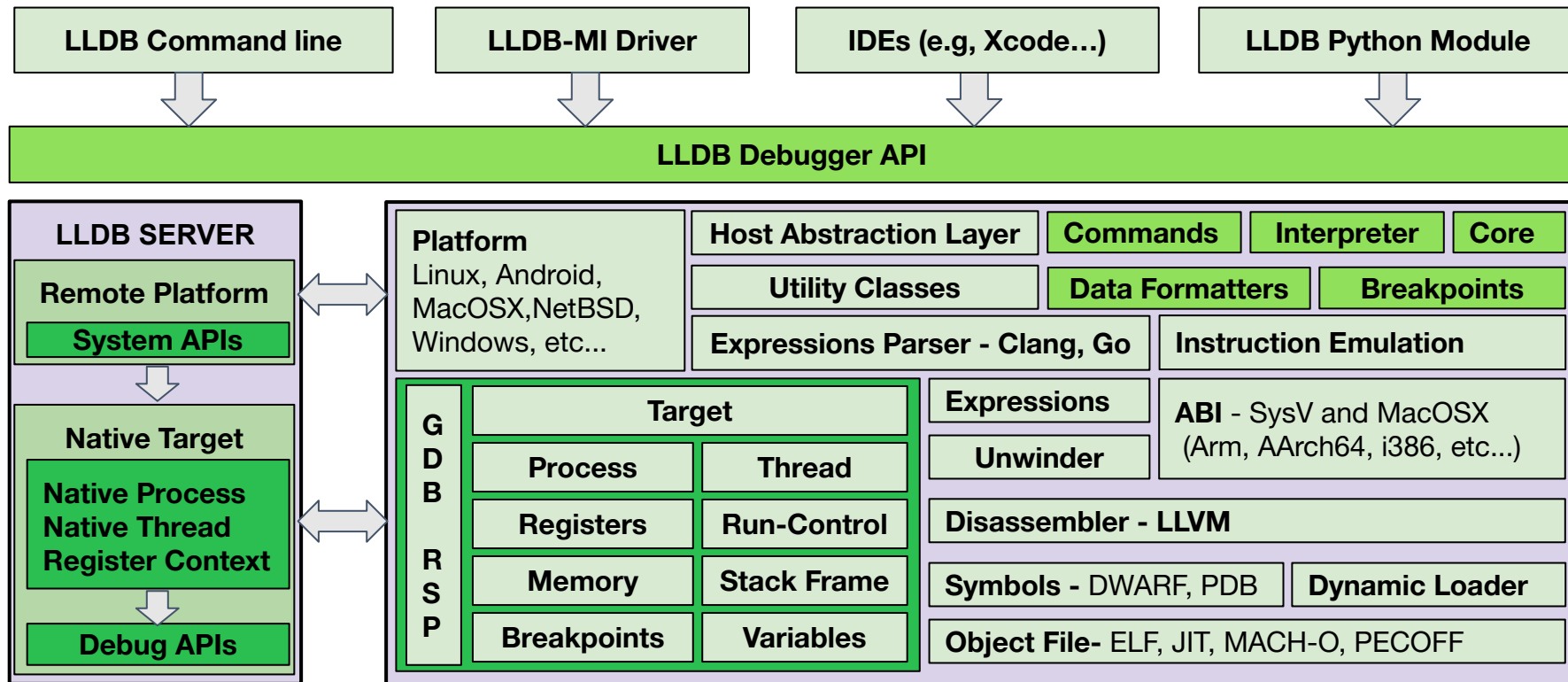
LLDB - Arm/AArch64 Test Devices

- Buildbots contributed by google test various Android devices
 - Link: lab.llvm.org:8011/builders/lldb-x86_64-ubuntu-14.04-android
- Linaro keeps track of LLDB on Linux platform for ARM and AArch64 targets.
 - Buildbot is still not public but we plan to do so.

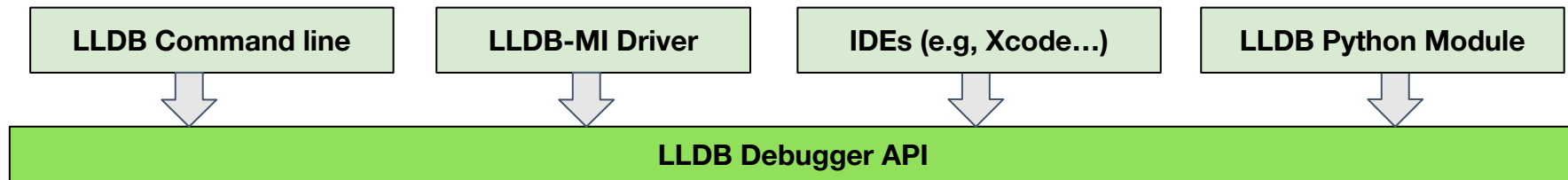
Platform/Architecture	ARMv7	ARMv8 - AArch64	ARMv8 - AArch32
Android M	Nexus 5	Nexus 5x	Nexus 5x
Ubuntu Linux - Xenial	Raspberry Pi2	Pine64	Pine64



LLDB Architecture



LLDB Debugger API

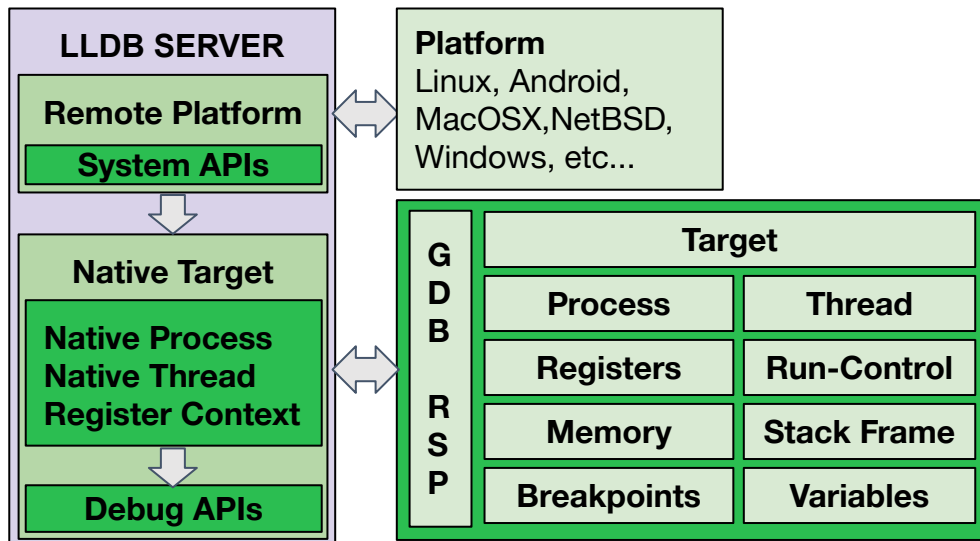


- A C++ shared library with object-oriented interface.
- **LLDB.framework** on MacOS X and **lldb.so** on linux.
- Used by
 - **lldb** - The LLDB Debugger command line
 - **lldb-mi** and **lldbmi2** - Machine Interface (MI) drivers
 - **XCode** and **Android Studio** - IDEs with graphical front-ends.
 - **lldb Python module** - LLDB API exposed through python script bindings using SWIG.



lldb-server - Platform Mode

- File transfer to remote target.
- Spawns gdbserver on target.
- Runs shell commands on target.
- List remote processes.
- Allows single or multiple parallel debug sessions.



lldb-server - Platform Mode (Single Session)

- Spawn lldb-server on remote-android target in platform mode for single session.
- Select remote-android platform and connect.
- Try connecting another lldb remote-android platform session.

```
bullhead:/data/local/tmp/lldb/arm64 $  
./lldb-server platform --listen *:5432
```

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb  
(lldb) platform select remote-android  
Platform: remote-android  
Connected: no  
(lldb) platform connect connect://localhost:5432  
Platform: remote-android  
Triple: aarch64-*-linux-android  
OS Version: 25.0.0 (3.10.73-gfe160e5)  
Kernel: #1 SMP PREEMPT Wed Dec 7 20:26:32 UTC 2016  
Hostname: localhost  
Connected: yes  
WorkingDir: /data/local/tmp/lldb/arm64  
(lldb)
```

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb  
(lldb) platform select remote-android  
Platform: remote-android  
Connected: no  
(lldb) platform connect connect://localhost:5432  
error: failed to get reply to handshake packet  
(lldb)
```



lldb-server - Platform Mode (Multiple Sessions)

Select remote-android platform and connect.

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb
(lldb) platform select remote-android
Platform: remote-android
Connected: no
(lldb) platform connect connect://localhost:5432
Platform: remote-android
Triple: aarch64*-linux-android
OS Version: 25.0.0 (3.10.73-gfe160e5)
Kernel: #1 SMP PREEMPT Wed Dec 7 20:26:32 UTC 2016
Hostname: localhost
Connected: yes
WorkingDir: /data/local/tmp/lldb/arm64
(lldb) █
```

Connect another remote-android platform session.

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb
(lldb) platform select remote-android
Platform: remote-android
Connected: no
(lldb) platform connect connect://localhost:5432
Platform: remote-android
Triple: aarch64*-linux-android
OS Version: 25.0.0 (3.10.73-gfe160e5)
Kernel: #1 SMP PREEMPT Wed Dec 7 20:26:32 UTC 2016
Hostname: localhost
Connected: yes
WorkingDir: /data/local/tmp/lldb/arm64
(lldb) █
```

lldb-server platform -- server mode

```
bullhead:/data/local/tmp/lldb/arm64 $
/lldb-server platform --listen *:5432 --server
Connection established.
█
```

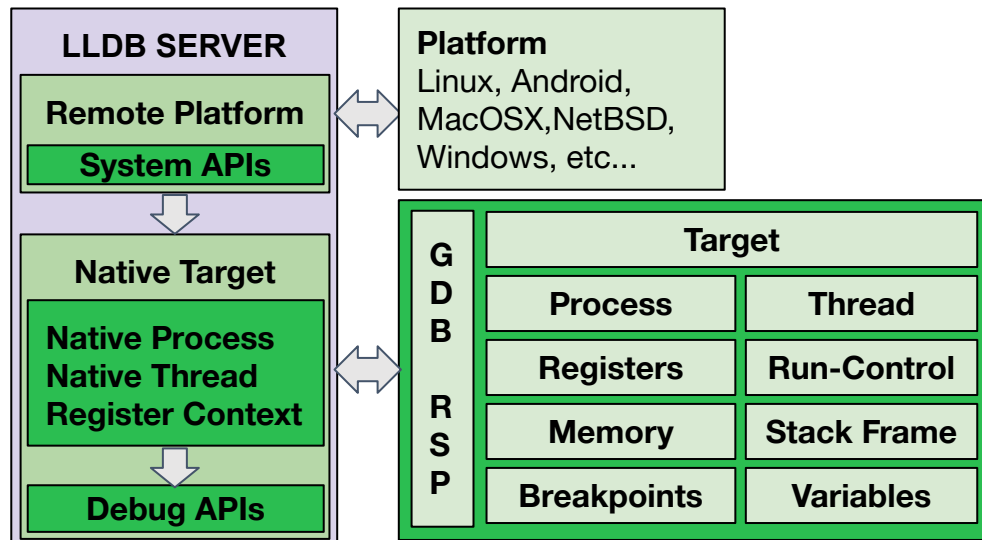
lldb-server multiple sessions connected

```
bullhead:/data/local/tmp/lldb/arm64 $
/lldb-server platform --listen *:5432 --server
Connection established.
Connection established.
█
```



lldb-server - GDB Server Mode

- Run as a gdb-remote-stub.
- Communicates with LLDB over RSP protocol.
- On Mac OSX and iOS, the remote-gdb functionality is in **debugserver** binary.



lldb-server - GDB Server Mode

Start lldb-server in gdbserver mode

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb-server gdbserver *:5432
lldb-server-local_buildConnection established.
Launched '/home/omair/work/lldb-dev/hwbreak/x86_64.out' as process 26892...
```

Connect to gdb remote stub and start a debugging session

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb /home/omair/work/lldb-dev/hwbreak/x86_64.out
(lldb) target create "/home/omair/work/lldb-dev/hwbreak/x86_64.out"
Current executable set to '/home/omair/work/lldb-dev/hwbreak/x86_64.out' (x86_64).
(lldb) process connect connect://localhost:5432
(lldb) b main
Breakpoint 1: where = x86_64.out`main + 8 at test.c:14, address = 0x00000000040054b
(lldb) run
Process 26892 launched: '/home/omair/work/lldb-dev/hwbreak/x86_64.out' (x86_64)
Process 26892 stopped
* thread #1, name = 'x86_64.out', stop reason = breakpoint 1.1
  frame #0: 0x00000000040054b x86_64.out`main at test.c:14
   11
   12     int main()
   13     {
-> 14         int temp = 0;
   15
   16         printf("Read Op: Value of temp is %i",temp);
   17
(lldb)
```



lldb - Debuggee (or inferior) context on host system

- **Platform**

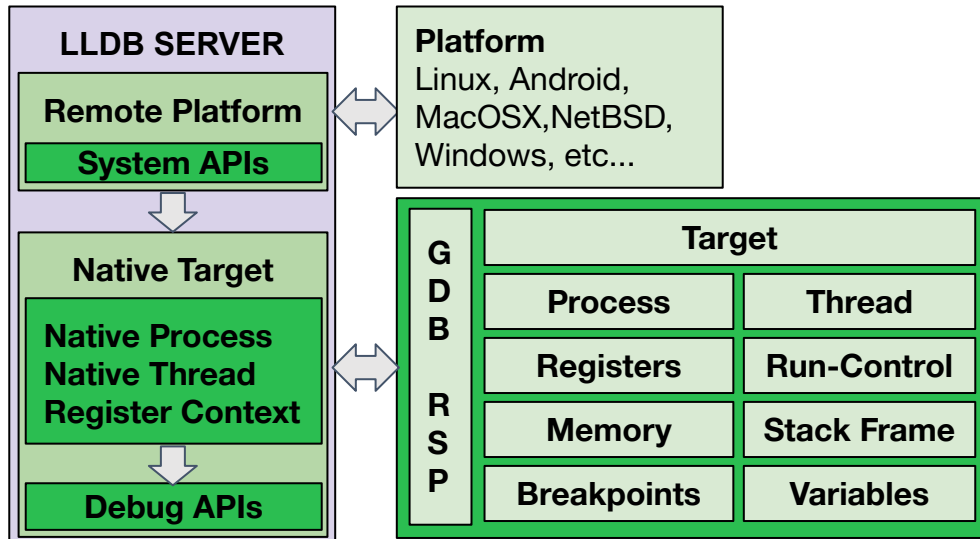
- Local or remote platform functions.

- **Process GDB Remote Client**

- Let lldb host talks to lldb-server running in gdb remote mode.
- Performs debug operations via GDB Remote Serial Protocol (RSP)

- **Target**

- Implements debugee (inferior) management functions like
 - Process Control
 - Thread Control
 - Registers and Memory
 - Stack Frames and Variables
 - Breakpoints and Watchpoints
 - Module loading



lldb - target create and process launch

Select target platform

platform select <name>

Connect to platform

platform connect <url>

Load file and symbols

target create <file-name>

Set breakpoint at main

breakpoint set -b main

Start remote inferior

process launch

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb
(lldb) platform select remote-android
Platform: remote-android
Connected: no
(lldb) platform connect connect://localhost:5432
Platform: remote-android
Triple: aarch64*-linux-android
OS Version: 25.0.0 (3.10.73-gfe160e5)
Kernel: #1 SMP PREEMPT Wed Dec 7 20:26:32 UTC 2016
Hostname: localhost
Connected: yes
WorkingDir: /data/local/tmp/lldb/arm64
(lldb) target create /home/omair/work/lldb-dev/hwbreak/arm64.out
Current executable set to '/home/omair/work/lldb-dev/hwbreak/arm64.out' (aarch64).
(lldb) breakpoint set -b main
Breakpoint 1: where = arm64.out`main + 8 at test.c:14, address = 0x00000000000006dc
(lldb) process launch
Process 17232 launched: '/home/omair/work/lldb-dev/hwbreak/arm64.out' (aarch64)
Process 17232 stopped
* thread #1, name = 'arm64.out', stop reason = breakpoint 1.1
  frame #0: 0x000000558e4a06dc arm64.out`main at test.c:14
   11
   12   int main()
   13   {
-> 14     int temp = 0;
   15
   16     printf("Read Op: Value of temp is %i",temp);
   17
(lldb)
```



lldb - Target and Process commands

Target

- **Create / Delete**
- **List and Select**
- **Symbols**
- **Variables**

Process

- **Connect** - to remote debug.
- **Launch** - current target executable
- **Attach/Detach** - to a process
- **Continue/Interrupt/Kill** - current target process.
- **Load/Unload** - shared library



lldb - Thread, Frame, Memory & Registers commands

Thread

- **Stepping**
 - **Step-in**, **step-out** and **step-over**
 - **step-inst** and **step-inst-over**
- **Select** - Select current thread.
- **Backtrace** - Thread call stacks.
- **Continue** - Continue one or all threads.
- **info/list** - Information about threads in current process.

Frame, Memory and Registers

- **Frame**
 - **Variable**
 - **Select**
- **Memory**
 - **Read**
 - **Write**
- **Registers**
 - **register read** <reg-name>
 - **register write** <reg-name> <data>



lldb - Break/Watchpoints & Disassembly commands

breakpoint/watchpoint

- **set <options>**
 - Set a breakpoint based on options.
- **clear <line-no or filename>**
- **command <add, delete or list>**
 - Run command or script when breakpoint is hit.
- **delete**
 - All or specified breakpoint is deleted.
- **enable/disable**
 - All or specified breakpoint.
- **read/write**
 - Read from or write breakpoints to file.

disassemble

- **(-f) --frame**
 - from the start of the current frame
- **(-m) --mixed**
 - mixed source and assembly display.
- **(-n) --name <function-name>**
 - entire contents of the given function.
- **(-p) --pc**
 - around the current pc.
- **(-a) --address <address>**
 - function containing address.
- **--start-address / --end-address**



lldb - *command alias* <alias> <command> <args>

Some Built-in Aliases

File <file>

- target create <file>

b main

- breakpoint set -b main

run

- process launch

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb
(lldb) platform select remote-android
Platform: remote-android
Connected: no
(lldb) platform connect connect://localhost:5432
Platform: remote-android
Triple: aarch64-*-linux-android
OS Version: 25.0.0 (3.10.73-gfe160e5)
Kernel: #1 SMP PREEMPT Wed Dec 7 20:26:32 UTC 2016
Hostname: localhost
Connected: yes
WorkingDir: /data/local/tmp/lldb/arm64
(lldb) file /home/omair/work/lldb-dev/hwbreak/arm64.out
Current executable set to '/home/omair/work/lldb-dev/hwbreak/arm64.out' (aarch64).
(lldb) b main
Breakpoint 1: where = arm64.out`main + 8 at test.c:14, address = 0x000000000000006dc
(lldb) run
Process 17286 launched: '/home/omair/work/lldb-dev/hwbreak/arm64.out' (aarch64)
Process 17286 stopped
* thread #1, name = 'arm64.out', stop reason = breakpoint 1.1
  frame #0: 0x000000055863896dc arm64.out`main at test.c:14
   11
   12  int main()
   13  {
->  14      int temp = 0;
   15
   16      printf("Read Op: Value of temp is %i",temp);
   17
(lldb)
```



lldb - Using .lldbinit file

.lldbinit file on top right of this slide is running at startup:

- Platform select and connect
- Load object file and symbols
- Set breakpoint at main
- Start inferior process
- Run to main.

LLDB command-line output on bottom right shows lldb state after we start it with .lldbinit file in user's home directory.

```
1 # Select platform
2 platform select remote-android
3
4 # Connect to platform
5 platform connect connect://localhost:5432
6
7 # Create debuggee target with executable
8 file /home/omair/work/lldb-dev/hwbreak/arm64.out
9
10 # Set breakpoint at main function
11 b main
12
13 # Launch debuggee process
14 run
```

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb
Process 17782 stopped
* thread #1, name = 'arm64.out', stop reason = breakpoint 1.1
  frame #0: 0x0000000558151d6dc arm64.out`main at test.c:14
   11
   12   int main()
   13   {
->  14       int temp = 0;
   15
   16       printf("Read Op: Value of temp is %i",temp);
   17
(lldb) █
```



LLDB - Brief description of components

- **ABI**

- Executes JITted function calls in process being debugged.
- Call frame calculation based on target calling convention.

- **Unwinder**

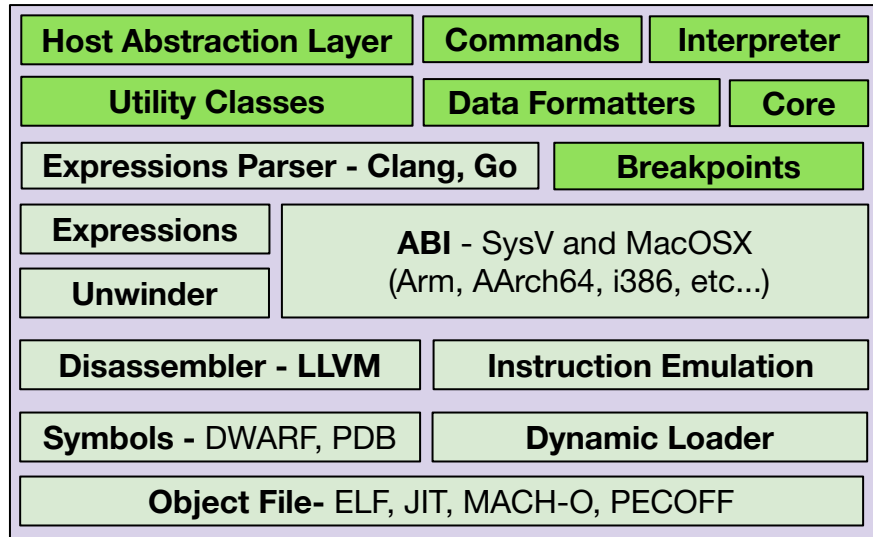
- Implements stack unwinding features.

- **Instruction Emulation**

- Helps with stack frame constructions.
- Helps single step by emulating execution paths.

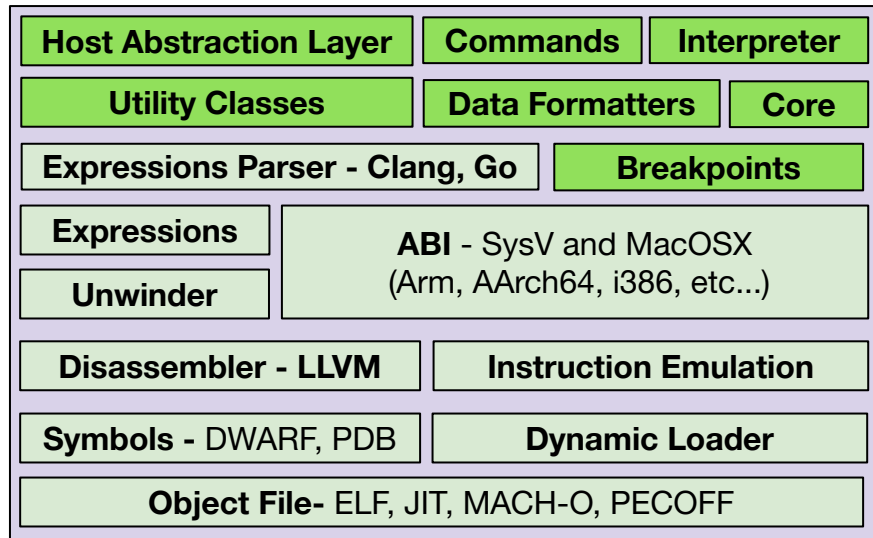
- **Expression Parser**

- A modified DWARF expression parser
- Clang front-end latest c++ support



LLDB - Brief description of components

- **Disassembler**
 - LLVM disassembler
- **Dynamic Loader**
 - Helps detect dynamically loaded modules
- **Object File**
 - Handles object files management.
- **Symbols**
 - Handles debug symbols mangement
- **Host Abstraction Layer**
- **Core and Utility Classes**
- **Interpreter and Commands**
- **Data Formatters**
- **Breakpoint Utilities**



LLDB - `unique_ptr` variables with data formatters

Without deleter

- frame variable `nup`
- frame variable `iup`
- frame variable `sup`

With deleter

- frame variable `ndp`
- frame variable `idp`
- frame variable `sdp`

```
* thread #1, name = 'unique.out', stop reason = breakpoint 1.1
  frame #0: 0x0000000000400baf unique.out`main at main.cpp:21
  18     std::unique_ptr<std::string, Deleter> sdp(new std::string("baz"),
  19                                           Deleter{3, 4});
  20
-> 21     return 0; // Set break point at this line.
  22 }
```

(lldb) frame variable nup
(std::unique_ptr<char, std::default_delete<char> >) nup = nullptr {}

(lldb) frame variable iup
(std::unique_ptr<int, std::default_delete<int> >) iup = 0x616c20 {
 object = 123
}

(lldb) frame variable sup
(std::unique_ptr<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::def
sup = 0x616c40 {
 object = "foobar"
}

(lldb) frame variable ndp
(std::unique_ptr<char, Deleter>) ndp = nullptr {
 object = <parent is NULL>

deleter = (a = 0, b = 0)

}

(lldb) frame variable idp
(std::unique_ptr<int, Deleter>) idp = 0x616c70 {
 object = 456
 deleter = (a = 1, b = 2)

}

(lldb) frame variable sdp
(std::unique_ptr<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, Deleter>
 object = "baz"
 deleter = (a = 3, b = 4)

}



LLDB - **shared_ptr** & **weak_ptr** with data formatters

--ptr-depth 1

- Dereference pointer once

std::shared_ptr

- frame variable **nsp**
- frame variable **isp**
- frame variable **ssp**

std::weak_ptr

- frame variable **nwp**
- frame variable **iwp**
- frame variable **swp**

```
Process 13041 launched: '/home/omair/work/bud17/formatters/smart.out' (x86_64)
Process 13041 stopped
* thread #1, name = 'smart.out', stop reason = breakpoint 1.1
  frame #0: 0x000000000400cc7 smart.out`main at main.cpp:15
  12      std::weak_ptr<int> iwp = isp;
  13      std::weak_ptr<std::string> swp = ssp;
  14
-> 15      nsp.reset(); // Set break point at this line.
  16      isp.reset();
  17      ssp.reset();
  18
(lldb) frame variable --ptr-depth 1 nsp
(std::shared_ptr<char>) nsp = nullptr {
  _M_ptr = 0x0000000000000000
}
(lldb) frame variable --ptr-depth 1 isp
(std::shared_ptr<int>) isp = 123 {
  _M_ptr = 0x00000000000617c20 {
    *_M_ptr = 123
  }
}
(lldb) frame variable --ptr-depth 1 ssp
(std::shared_ptr<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > > >)
_M_ptr = "\x80|a"... {}
}
(lldb) frame variable --ptr-depth 1 iwp
(std::weak_ptr<int>) iwp = 123 {
  _M_ptr = 0x00000000000617c20 {
    *_M_ptr = 123
  }
}
(lldb) frame variable --ptr-depth 1 swp
(std::weak_ptr<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> > > >) s
_M_ptr = "\x80|a"... {}
}
```



LLDB - **std::map** variables with data formatters

std::map<std::string, int>

- frame variable **si**

std::map<int, std::string>

- **frame variable is**

```
std::map<std::string,
std::string>
```

- frame variable **ss**

```

Process 13892 launched: '/home/omair/work/bud17/formatters/map.out' (x86_64)
Process 13892 stopped
* thread #1, name = 'map.out', stop reason = breakpoint 1.1
  frame #0: 0x0000000000401363 map.out`main at main.cpp:29
    26         ss["gatto"] = "cat";
    27         ss["a Mac.."] = "..is always a Mac!";
    28
-> 29         return 0; // Set breakpoint at this line.
    30     }
(lldb) frame variable si
(std::map<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::pair<const std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::allocator<char> > > > >) is = size=4 {
    [0] = (first = "one", second = 1)
    [1] = (first = "three", second = 3)
    [2] = (first = "two", second = 2)
    [3] = (first = "zero", second = 0)
}
(lldb) frame variable is
(std::map<int, std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::allocator<char> > > > >) is = size=4 {
    [0] = (first = 1, second = "is")
    [1] = (first = 2, second = "smart")
    [2] = (first = 3, second = "!!!")
    [3] = (first = 85, second = "goofy")
}
(lldb) frame variable ss
(std::map<std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::pair<const std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >, std::allocator<char> > > > >) ss = size=4 {
    [0] = (first = "a Mac..", second = "..is always a Mac!")
    [1] = (first = "casa", second = "house")
    [2] = (first = "ciao", second = "hello")
    [3] = (first = "gatto", second = "cat")
}
(lldb)

```

LLDB - Evaluate **expressions** using clang parser

- Compile “hello world” code
- Launch it using LLDB.
- Stop in main before return.
- Now our expressions will have a context to work with.
- Let's try some example expressions.

```
1 #include <iostream>
2
3 int main()
4 {
5     std::cout << "Hello World!" << std::endl;
6
7     return 0;
8 }
```



LLDB - Evaluate **expressions** using clang parser

- Let's try evaluating a few simple expressions.
- Create **integer type** local variables **i** and **j**
- Let see if we can call **getpid**
- Evaluate **getpid() + i + j**
- Evaluate **getpid() + i & j**
- Evaluate **getpid() + i ^ j**
- Evaluate **getpid() + i << j**

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb ~/work/bud17/jit/hello
(lldb) target create "/home/omair/work/bud17/jit/hello"
Current executable set to '/home/omair/work/bud17/jit/hello' (x86_64).
(lldb) breakpoint set -l 7
Breakpoint 1: where = hello`main + 32 at hello.cpp:7, address = 0x0000000000004000
(lldb) run
Process 15744 launched: '/home/omair/work/bud17/jit/hello' (x86_64)
Hello World!
Process 15744 stopped
* thread #1, name = 'hello', stop reason = breakpoint 1.1
   frame #0: 0x0000000000004000 hello`main at hello.cpp:7
       4      {
       5          std::cout << "Hello World!" << std::endl;
       6
->      7          return 0;
       8      }
(lldb) expression int $i = 9
(lldb) expression int $j = 3
(lldb) expression (int)getpid()
(int) $0 = 15744
(lldb) expression (int)getpid() + $i + $j
(int) $1 = 15756
(lldb) expression (int)getpid() + $i & $j
(int) $2 = 1
(lldb) expression (int)getpid() + $i ^ $j
(int) $3 = 15754
(lldb) expression (int)getpid() + $i << $j
(int) $4 = 126024
(lldb) █
```



LLDB - Evaluate expressions using clang parser

- Create context as we did in previous slide.
- Try evaluating a **for** loop expression.

```
omair@omAlien:~/work/bud17$ ../lldb-test/build/host/bin/lldb ./jit/hello
(lldb) target create "./jit/hello"
Current executable set to './jit/hello' (x86_64).
(lldb) breakpoint set -l 7
Breakpoint 1: where = hello`main + 32 at hello.cpp:7, address = 0x0000000000400866
(lldb) run
Process 13579 launched: './jit/hello' (x86_64)
Hello World!
Process 13579 stopped
* thread #1, name = 'hello', stop reason = breakpoint 1.1
  frame #0: 0x0000000000400866 hello`main at hello.cpp:7
    4      {
    5          std::cout << "Hello World!" << std::endl;
    6
-> 7          return 0;
    8      }
(lldb) expression for (int i = 0; i < 10; i++) printf("%d x %d = %d\n",i,i, i * i);
0 x 0 = 0
1 x 1 = 1
2 x 2 = 4
3 x 3 = 9
4 x 4 = 16
5 x 5 = 25
6 x 6 = 36
7 x 7 = 49
8 x 8 = 64
9 x 9 = 81
(lldb) █
```



LLDB - Evaluate **expressions** using clang parser

- Create a c++ lambda expression named **add**.
- Specify return value **auto**
- Evaluate lambda expression on our dummy context.
- Cool we have them working.
- Lets try a more complex lambda with **auto** arguments

```
omair@omAlien:~/work/lldb-test/build/host/bin$ ./lldb ~/work/bud17/jit/hello
(lldb) target create "/home/omair/work/bud17/jit/hello"
Current executable set to '/home/omair/work/bud17/jit/hello' (x86_64).
(lldb) breakpoint set -l 7
Breakpoint 1: where = hello`main + 32 at hello.cpp:7, address = 0x0000000000400406
(lldb) run
Process 16036 launched: '/home/omair/work/bud17/jit/hello' (x86_64)
Hello World!
Process 16036 stopped
* thread #1, name = 'hello', stop reason = breakpoint 1.1
  frame #0: 0x0000000000400866 hello`main at hello.cpp:7
    4      {
    5          std::cout << "Hello World!" << std::endl;
    6
-> 7          return 0;
    8      }
(lldb) expression auto $add = [](int a, int b) { return a + b; }
(lldb) expression $add(2,3)
(int) $0 = 5
(lldb) expression $add(33,66)
(int) $1 = 99
(lldb) expression auto $add = [](auto a, auto b) { return a + b; }
error: 'auto' not allowed in lambda parameter
error: 'auto' not allowed in lambda parameter
(lldb)
```



Conclusion

- Start using LLDB.
- Its more stable than ever before.
- Wanna go an extra mile? Feel free to contribute.
- Topics for future
 - Using LLDB Python API and built-in Python interpreter
 - How-To on more advanced expressions
 - How to use more advanced and Python based data formatters



Questions

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ENGINEERS
AND DEVICES
WORKING
TOGETHER

References

- LLDB (Architecture, GDB to LLDB commands, Doxygen)
- LLVM LAB - [LLDB Android Buildbot](#)
- Linaro LAB - [LLDB Linux Buildbot](#) (Under Development)
- LLDB on [FreeBSD](#)





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