MesosCon Asia (Hangzhou) 2016

Mesos on ARM

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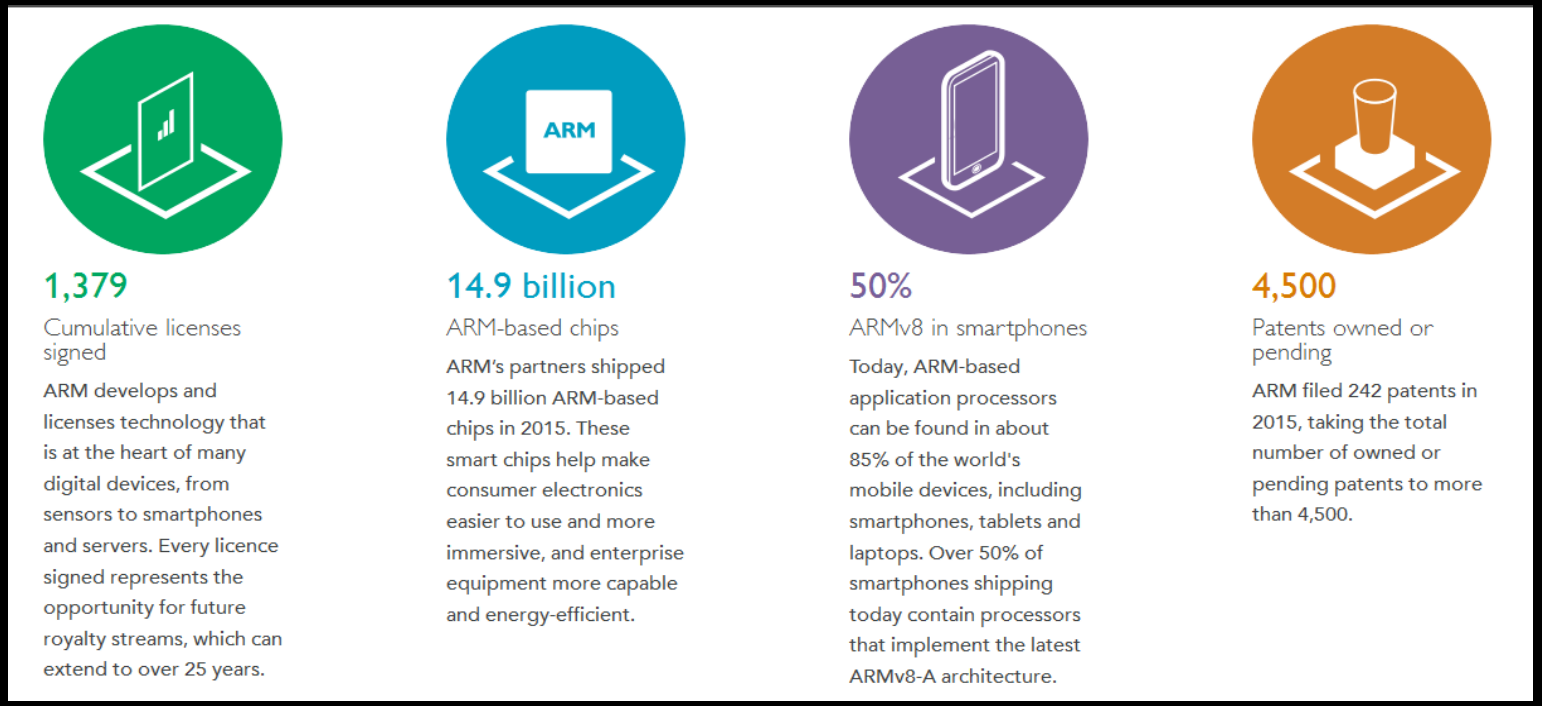
I. Background Information

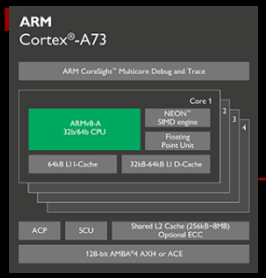
1) ARM Ecosystem Today

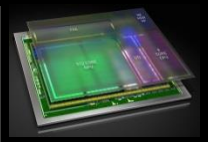
- https://en.wikipedia.org/wiki/ARM_architecture
- https://www.arm.com/

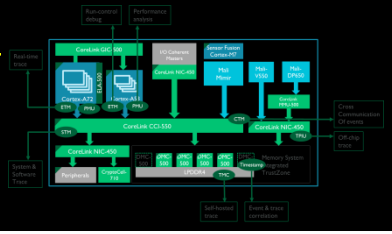
ARM at a Glance

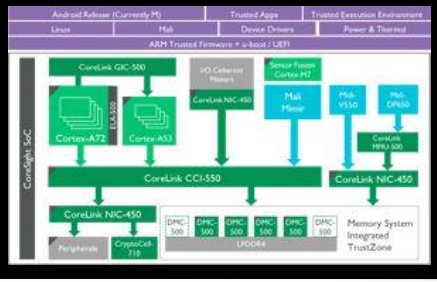


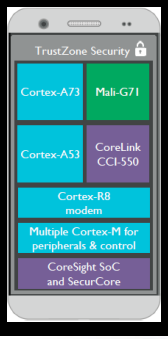
Leading HW/SW Technoglogies

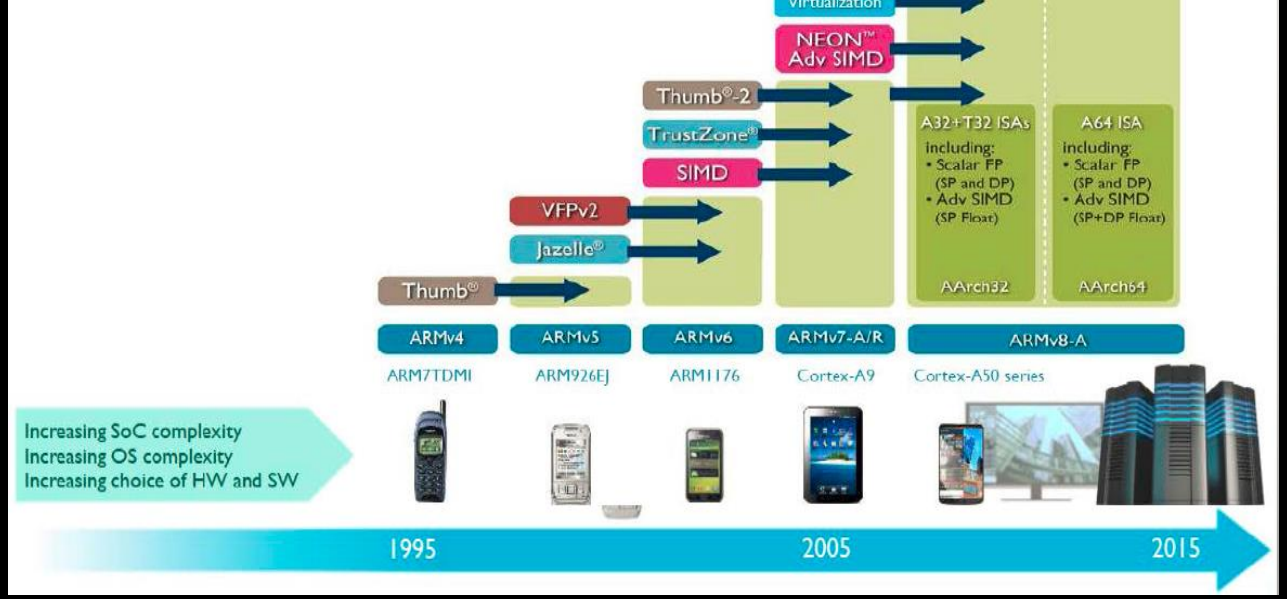


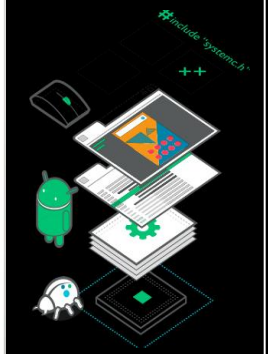


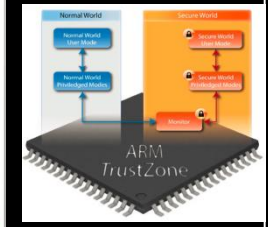


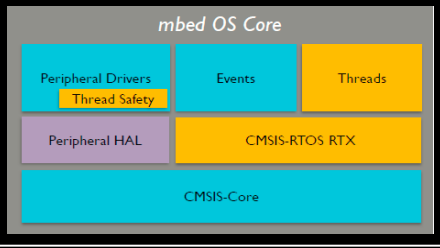


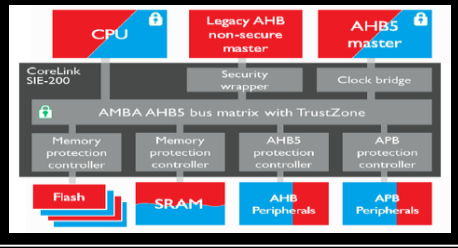






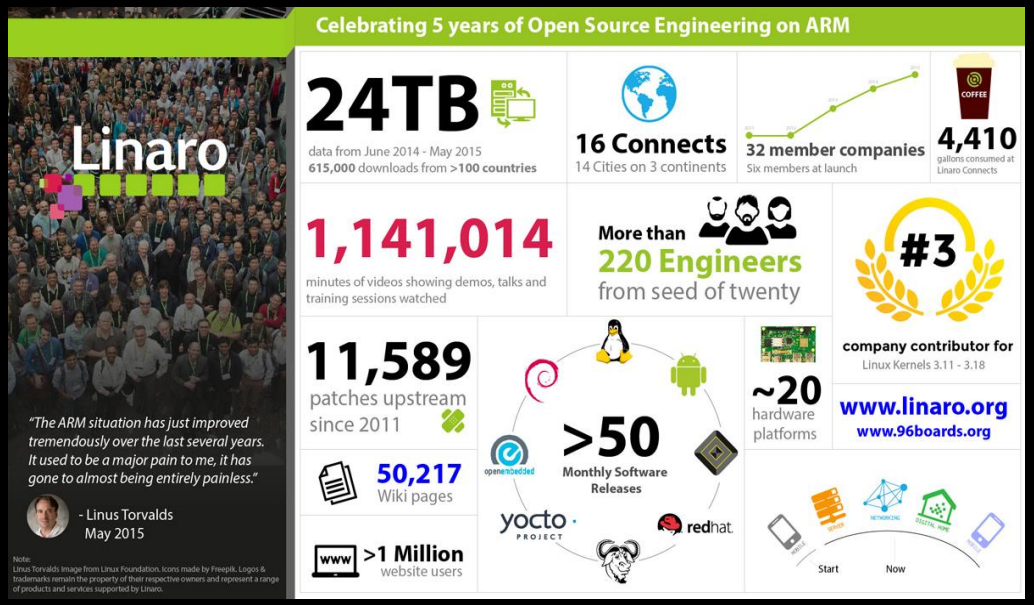




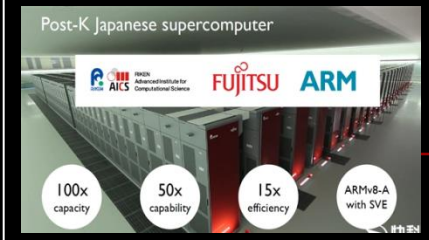


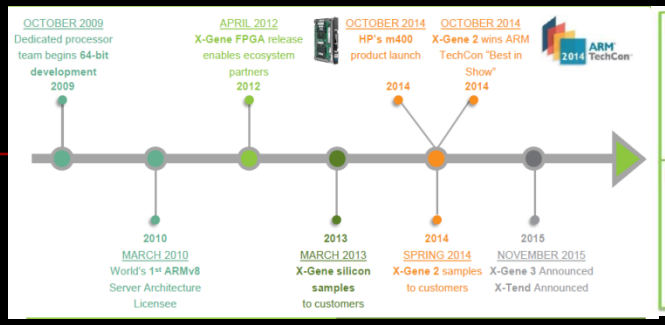
Linaro

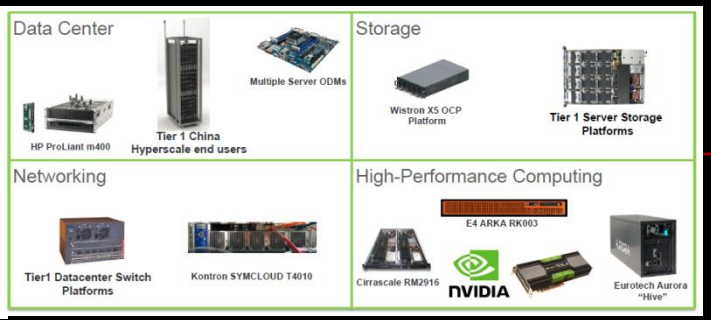
- http://www.linaro.org/

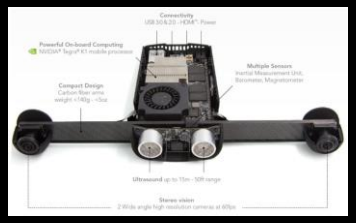


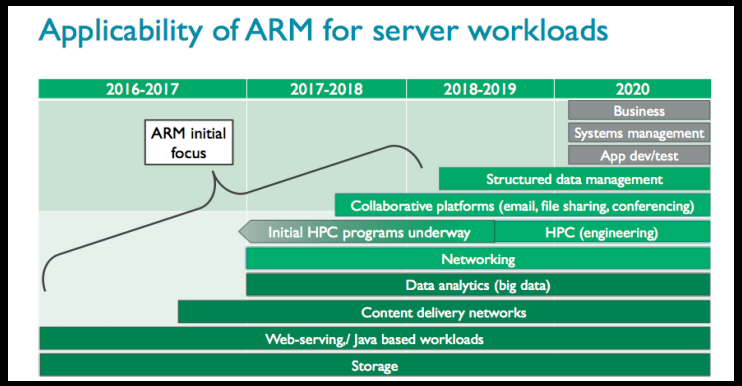
ARM-based Solutions

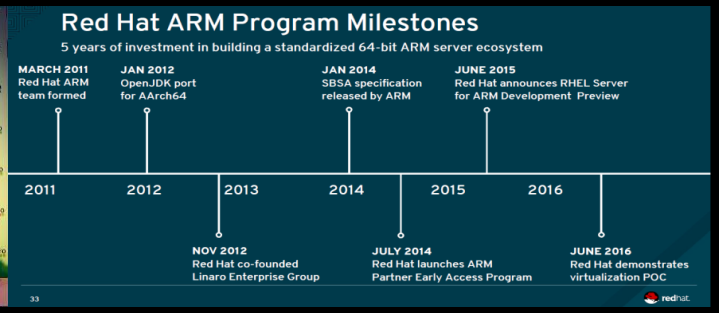












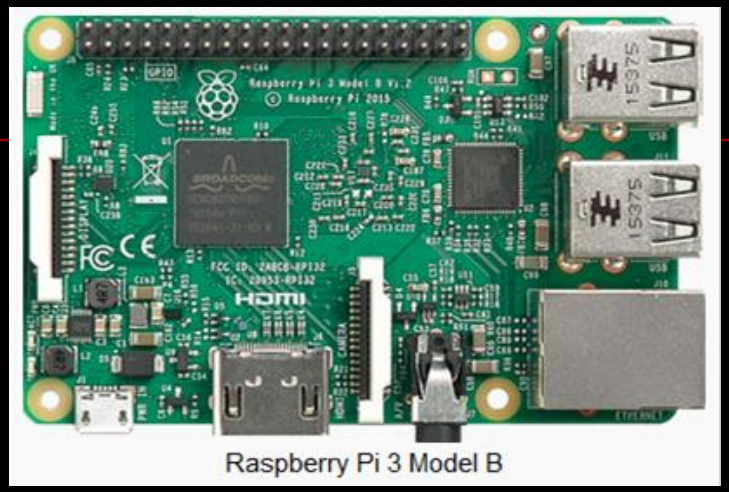
2) Raspberry Pi

- https://en.wikipedia.org/wiki/Raspberry_Pi
- https://www.raspberrypi.org/

HW Spec

Variant	Raspberry Pi 1				Raspberry Pi 2	Raspberry Pi 3	Compute Module*	Raspberry Pi Zero	
Model	Model A	Model A+	Model B	Model B+	Model B	Model B	N/A	PCB v1.2	PCB v1.3
Release date	February 2012	November 2014[39]	April–June 2012	July 2014[40]	February 2015[13]	February 2016[14]	April 2014[41]	November 2015[42]	May 2016
Target price	US$25	US$20[43]	US$35[44]	US$25[45]	US$35	US$35	US$30 (in batches of 100)[41]	US$5[42]	US$5
Architecture	ARMv6 (32-bit)				ARMv7 (32-bit)	ARMv8 (64/32-bit)	ARMv6 (32-bit)		
SoC	Broadcom BCM2835[11]				Broadcom BCM2836	Broadcom BCM2837	Broadcom BCM2835[41]		
CPU	700 MHz single-core ARM1176JZF-S[11]				900 MHz 32-bit quad-core ARM Cortex-A7	1.2 GHz 64-bit quad-core ARM Cortex-A53	700 MHz single-core ARM1176JZF-S	1 GHz ARM1176JZF-S single-core[42]	
GPU	Broadcom VideoCore IV @ 250 MHz (BCM2837: 3D part of GPU @ 300 MHz, video part of GPU @ 400 MHz)[46][47] OpenGL ES 2.0 (BCM2835, BCM2836: 24 GFLOPS / BCM2837: 28.8 GFLOPS) MPEG-2 and VC-1 (with license),[48] 1080p30 H.264/MPEG-4 AVC high-profile decoder and encoder[11] (BCM2837: 1080p60)								
Memory (SDRAM)	256 MB (shared with GPU)	512 MB (shared with GPU) as of 4 May 2016. Older boards had 256 MB (shared with GPU)[49]			1 GB (shared with GPU)		512 MB (shared with GPU)		
USB 2.0 ports[30]	1 (direct from BCM2835 chip)		2 (via the on-board 3-port USB hub)[50]	4 (via the on-board 5-port USB hub)[29][40]			1 (direct from BCM2835 chip)	1 Micro-USB (direct from BCM2835 chip)	

RPi3 Model B



Limitations

1) 1GB LPDDR2 RAM @900MHz

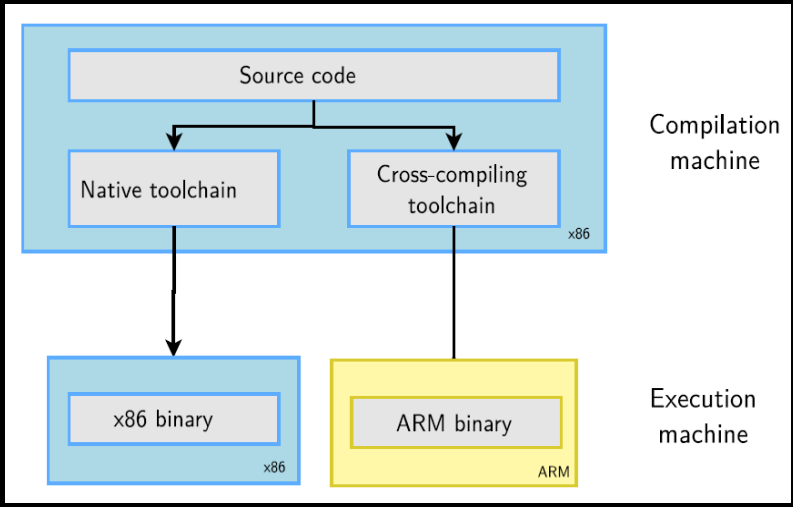
2) Official release (Raspbian with Linux Kernel 4.4 currently) does not support AArch64

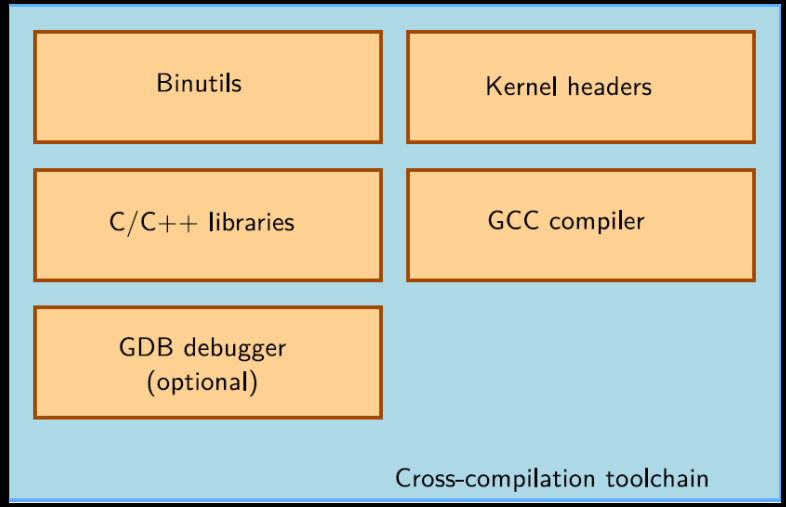
```
pi@raspberrypi:/opt/MyWorkSpace/Mesos/mesos $ cat /proc/cpuinfo
processor       : 0
model name      : ARMv7 Processor rev 4 (v7l)
BogoMIPS        : 76.80
Features        : half thumb fastmult vfp edsp neon vfpv3 tls vfpv4 idiva idivt vfpd32 lpae evtstrm crc32
CPU implementer : 0x41
CPU architecture: 7
CPU variant     : 0x0
CPU part        : 0xd03
CPU revision    : 4
```

II. Build Mesos for ARM

1) Cross Compiling

- when memory or storage on the target system is too restricted or target system is much slower than host system
- While set up the right cross-compiling environment for target system is not an easy thing



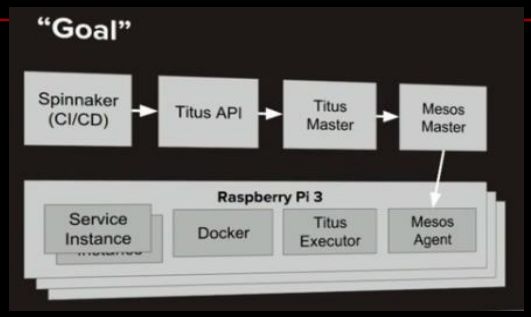


Source: http://free-electrons.com/doc/training/embedded-linux

2) Native Compilation

Successful Cases

- https://github.com/Netflix-Skunkworks/mesos-on-pi
  Built Mesos 0.24.1 natively based on older guides

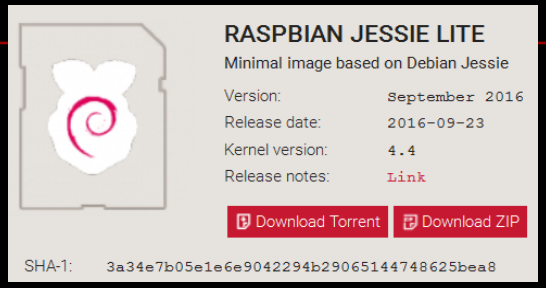


- http:///likemagicappears.com/projects/raspberry-pi-cluster/mesos-on-raspbian/
- http:///blog.haosdent.me/2016/04/24/mesos-on-arm/
- http:///a.frtzlr.com/running-apache-mesos-on-a-raspberry-pi-2/
  Limitations: use low GCC version (< 6) and Mesos version (< 1.0), disable Java/Python for some cases

- https://www.tapatalk.com/topic/63351-odroid-forum-hardkernel/22544-guide-how-to-build-a-mesos-cluster-on-odroid-c2 (Mesos 1.0.0-rc2)
  meveric's debian jessie (ARM64) image, ODROID-C2 has Amlogic S905 2Ghz 4 core CPU and 2GB 32bit DDR3 912MHz

My Attempt

- Step 1. install Raspbian Lite distribution(no GUI) and upgrade it to “Stretch” with GCC(arm-linux-gnueabihf) 6.2.0




```
pi@raspberrypi:~ $ free -h
              total        used        free      shared  buff/cache   available
Mem:           925M         39M        746M         12M        139M        830M
Swap:           12G          0B         12G
```

```
deb http://archive.raspbian.org/raspbian/ stretch main contrib non-free rpi
# Uncomment line below then 'apt-get update' to enable 'apt-get source'
#deb-src http://archive.raspbian.org/raspbian/ stretch main contrib non-free rpi
~
configure: error: GCC 4.8 or higher required (found 4.7.3)
```

```
if test "x$is_ge_gxx48" != "xyes"; then
  # GCC < 4.8 is not supported.
  as_fn_error $? "GCC 4.8 or higher required (found $ax_cv_cxx_compiler_version)" "$LINENO" 5
fi
```

https://github.com/apache/mesos/archive/mesos-1.1.0.tar.gz (with cmake)

http://www.apache.org/dist/mesos/1.1.0/mesos-1.1.0.tar.gz (no cmake)

- **Step 2. install prerequisite libraries and utilities**

  zlib1g-dev libcurl4-nss-dev libsasl2-dev libsasl2-modules
  libapr1-dev libaprutil1-dev libsvn-dev…
  cmake ninja-build autoconf automake libtool…

- **Step 3. Set up the build environment**
  switching linker

If you are building LLVM/Clang on an ARM board with 1G of memory or less, please use `gold` rather then GNU `ld`. In any case it is probably a good idea to set up a swap partition, too.

sudo ln -sf /usr/bin/ld.gold /usr/bin/ld

```
pi@raspberrypi:/usr/bin $ ll |grep ld
lrwxrwxrwx  1 root root          6 Oct 17 11:12 arm-linux-gnueabihf-ld -> ld.bfd*
-rwxr-xr-x  1 root root     506916 Oct 17 11:12 arm-linux-gnueabihf-ld.bfd*
-rwxr-xr-x  1 root root    4269876 Oct 17 11:12 arm-linux-gnueabihf-ld.gold*
-rwxr-xr-x  1 root root       6275 Jul 31 10:57 dpkg-buildflags*
-rwxr-xr-x  1 root root      24177 Jul 31 10:57 dpkg-buildpackage*
-rwxr-xr-x  1 root root       7503 Jul 31 10:57 dpkg-checkbuilddeps*
-rwxr-xr-x  1 root root      26384 Feb 27  2016 fold*
lrwxrwxrwx  1 root root          7 Oct 17 11:12 gold -> ld.gold*
-rwxr-xr-x  1 root root      22352 Oct  1 11:41 gtk-builder-tool*
lrwxrwxrwx  1 root root          7 Nov 11 20:35 ld -> ld.gold*
lrwxrwxrwx  1 root root         26 Oct 17 11:12 ld.bfd -> arm-linux-gnueabihf-ld.bfd*
-rwxr-xr-x  1 root root       5312 Oct 26 00:35 ldd*
lrwxrwxrwx  1 root root         27 Nov 11 20:34 ld.gold -> arm-linux-gnueabihf-ld.gold*
-rwxr-xr-x  1 root root        125 Sep 25 20:22 perldoc*
-rwxr-xr-x  1 root root      14008 Oct 26 00:35 pldd*
lrwxrwxrwx  1 root root         26 Aug 17 22:27 pybuild -> ../share/dh-python/pybuild*
```

Make a Big SWAP File (6~16G)

https://www.cyberciti.biz/faq/linux-add-a-swap-file-howto/

```
pi@raspberrypi:~ $ free -h
              total        used        free      shared  buff/cache   available
Mem:           925M         39M        746M         12M        139M        830M
Swap:           12G          0B         12G
```

- **Step 4. build**

  cd $MESOS-1.1-0_HOME/build
  cmake ..
  make

  Note: you can speed up the compiling process by using “make –jN” with 1 < N <= 4 but you might run into an out of memory situation that way.

- **Unfortunately, it always got failed after building 7~9 hours for lack of memory -- either use cmake or autoconf/automake, no matter use ld or gold linker, and though Java/Python is disabled…**

```
                 from /opt/MyWorkSpace/Mesos/mesos-1.1.0/include/mesos/type_utils.hpp:24,
                 from /opt/MyWorkSpace/Mesos/mesos-1.1.0/src/cli/execute.cpp:21:
/usr/include/c++/6/bits/unique_ptr.h:49:28: note: declared here
   template<typename> class auto_ptr;
                            ^~~~~~~~
/usr/bin/ld: fatal error: ../mesos-execute: mmap: failed to allocate 393159524 bytes for output file: Cannot
 allocate memory
collect2: error: ld returned 1 exit status
make[2]: *** [src/mesos-execute] Error 1
make[1]: *** [src/cli/CMakeFiles/mesos-execute.dir/all] Error 2
make: *** [all] Error 2
icojson-1.3.0 -I/opt/MyWorkSpace/Mesos/mesos-1.1.0/build/3rdparty/protobuf-2.6.1/src/protobuf-2.6.1-lib/lib/
include -I/usr/include/subversion-1 -I/opt/MyWorkSpace/Mesos/mesos-1.1.0/src/src -I/opt/MyWorkSpace/Mesos/me
sos-1.1.0/3rdparty/libprocess/include -I/opt/MyWorkSpace/Mesos/mesos-1.1.0/build/3rdparty/http_parser-2.6.2/
src/http_parser-2.6.2 -I/opt/MyWorkSpace/Mesos/mesos-1.1.0/build/3rdparty/libev-4.22/src/libev-4.22 -I/opt/M
yWorkSpace/Mesos/mesos-1.1.0/build/3rdparty/zookeeper-3.4.8/src/zookeeper-3.4.8/src/c/include -I/opt/MyWorkS
pace/Mesos/mesos-1.1.0/build/3rdparty/zookeeper-3.4.8/src/zookeeper-3.4.8/src/c/generated -I/opt/MyWorkSpace
/Mesos/mesos-1.1.0/build/3rdparty/leveldb-1.4/src/leveldb-1.4/include  -std=c++11 -g   -o CMakeFiles/mesos-e
xecute.dir/execute.cpp.o -c /opt/MyWorkSpace/Mesos/mesos-1.1.0/src/cli/execute.cpp
2016-11-12 12:29:22 [ 92%] Linking CXX executable ../mesos-execute
2016-11-12 12:29:22 cd /opt/MyWorkSpace/Mesos/mesos-1.1.0/build/src/cli && /usr/bin/cmake -E cmake_link_scri
pt CMakeFiles/mesos-execute.dir/link.txt --verbose=1
2016-11-12 12:29:22 /usr/bin/c++    -std=c++11 -g   CMakeFiles/mesos-execute.dir/execute.cpp.o  -o ../mesos-
execute  -L/usr/lib/arm-linux-gnueabihf/libapr-1.so  -L/opt/MyWorkSpace/Mesos/mesos-1.1.0/build/3rdparty/glo
g-0.3.3/src/glog-0.3.3-lib/lib/lib  -L/opt/MyWorkSpace/Mesos/mesos-1.1.0/build/3rdparty/protobuf-2.6.1/src/p
rotobuf-2.6.1-lib/lib/lib  -L/usr/lib/arm-linux-gnueabihf/libsvn_delta-1.so  -L/usr/lib/arm-linux-gnueabihf/
```

or

```
/usr/bin/ld: failed to set dynamic section sizes: Memory exhausted
collect2: error: ld returned 1 exit status
make[2]: *** [libmesos.la] Error 1
make[1]: *** [all] Error 2
make: *** [all-recursive] Error 1
```

3) Build Mesos with Ninja

- https://ninja-build.org/

MESOS-5656

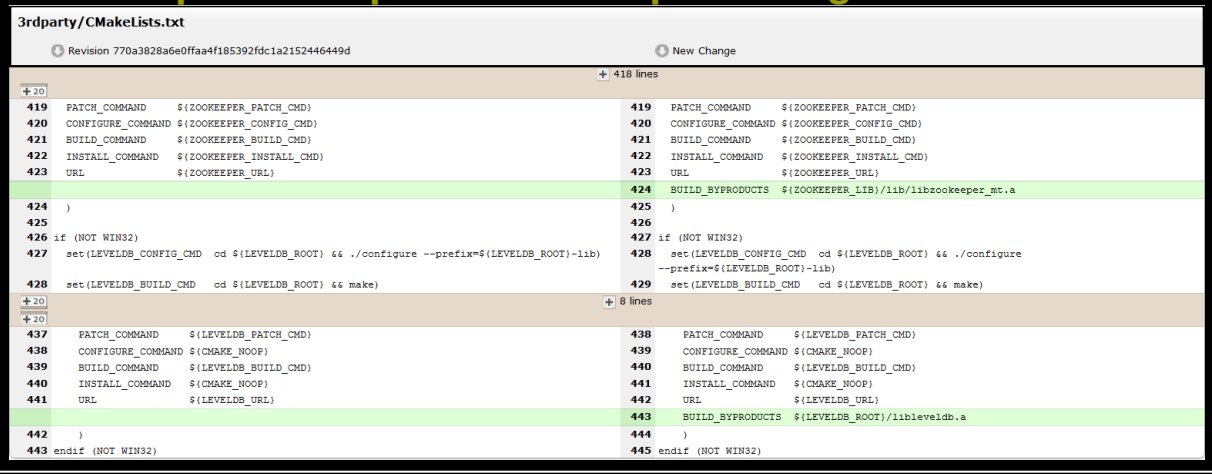
cd $MESOS_HOME/build

cmake -G Ninja ../

```
3rdparty/
build.ninja
CMakeCache.txt
CMakeFiles/
cmake_install.cmake
CTestTestfile.cmake
include/
rules.ninja
src/
```

```
pi@raspberrypi:/opt/MyWorkSpace/Mesos/mesos-master/build $ ninja
ninja: error: '3rdparty/zookeeper-3.4.8/src/zookeeper-3.4.8/src/c/lib/libzookeeper_mt.a', needed by 'src/mesos-execute', missing and no known rule to make it
```

#official patch: https://reviews.apache.org/r/52690/diff/1#index_header



3rdparty/CMakeLists.txt

Revision 770a3828a6e0ffaa4f185392fdc1a2152446449d — New Change

418 lines

```
419  PATCH_COMMAND      ${ZOOKEEPER_PATCH_CMD}
420  CONFIGURE_COMMAND  ${ZOOKEEPER_CONFIG_CMD}
421  BUILD_COMMAND      ${ZOOKEEPER_BUILD_CMD}
422  INSTALL_COMMAND    ${ZOOKEEPER_INSTALL_CMD}
423  URL                ${ZOOKEEPER_URL}
                                                  |  424  BUILD_BYPRODUCTS  ${ZOOKEEPER_LIB}/lib/libzookeeper_mt.a
424  )                                            |  425  )
425
426 if (NOT WIN32)                                |  427 if (NOT WIN32)
427   set(LEVELDB_CONFIG_CMD  cd ${LEVELDB_ROOT} && ./configure --prefix=${LEVELDB_ROOT}-lib)
                                                  |  428   set(LEVELDB_CONFIG_CMD  cd ${LEVELDB_ROOT} && ./configure
                                                  |      --prefix=${LEVELDB_ROOT}-lib)
428   set(LEVELDB_BUILD_CMD   cd ${LEVELDB_ROOT} && make)
                                                  |  429   set(LEVELDB_BUILD_CMD   cd ${LEVELDB_ROOT} && make)
```

8 lines

```
437    PATCH_COMMAND      ${LEVELDB_PATCH_CMD}
438    CONFIGURE_COMMAND  ${CMAKE_NOOP}
439    BUILD_COMMAND      ${LEVELDB_BUILD_CMD}
440    INSTALL_COMMAND    ${CMAKE_NOOP}
441    URL                ${LEVELDB_URL}
                                                  |  443    BUILD_BYPRODUCTS  ${LEVELDB_ROOT}/libleveldb.a
442    )                                          |  444    )
443 endif (NOT WIN32)                             |  445 endif (NOT WIN32)
```

```
#my workaround:  do not change current Mesos code
git clone https://github.com/google/kati $KATI_HOME
cd $KATI_HOME; make
cd $MESOS_HOME/build
cmake ../
$KATI_HOME/m2n --kati_stats
./ninja.sh
```

- **Use Ninja to build Mesos 1.1.0 ~10 hours (without error) and stop it, cannot wait for build to end…**

```
pi@raspberrypi:/opt/MyWorkSpace/Mesos/mesos-1.1.0/build/src $ ll
total 1254564
drwxr-xr-x 13 pi pi       4096 Nov 13 21:11 ./
drwxr-xr-x  7 pi pi       4096 Nov 13 11:59 ../
drwxr-xr-x  3 pi pi       4096 Nov 13 11:59 cli/
drwxr-xr-x  4 pi pi       4096 Nov 13 11:59 CMakeFiles/
-rw-r--r--  1 pi pi       1994 Nov 13 11:59 cmake_install.cmake
-rw-r--r--  1 pi pi        466 Nov 13 11:59 CTestTestfile.cmake
drwxr-xr-x  3 pi pi       4096 Nov 13 11:59 docker/
drwxr-xr-x  3 pi pi       4096 Nov 13 11:59 launcher/
-rw-r--r--  1 pi pi 1164509022 Nov 13 21:04 libmesos-1.1.0.a
-rw-r--r--  1 pi pi   48385064 Nov 13 13:30 libmesos-protobufs.a
drwxr-xr-x  3 pi pi       4096 Nov 13 11:59 local/
drwxr-xr-x  3 pi pi       4096 Nov 13 11:59 log/
-rw-r--r--  1 pi pi     281490 Nov 13 11:59 Makefile
drwxr-xr-x  3 pi pi       4096 Nov 13 13:15 master/
-rwxr-xr-x  1 pi pi   71427560 Nov 13 21:12 mesos-docker-executor*
drwxr-xr-x  2 pi pi       4096 Nov 13 13:15 messages/
drwxr-xr-x  6 pi pi       4096 Nov 13 11:59 slave/
drwxr-xr-x  3 pi pi       4096 Nov 13 11:59 tests/
drwxr-xr-x  3 pi pi       4096 Nov 13 11:59 usage/
```

4) Summary

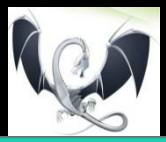
- **Memory** is the most important thing to natively build big software project like Mesos on resource constrained ARM devices
- A lot of performance hidden in linker
- A better C++ template compiler is needed?
- Modern build systems like **Ninja**, **Shake**, **Buck**, **FASTBuild**, **Meson**, and **llbuild** is worth trying

III. Clang/LLVM-based Optimization

1) Introduction

- https://en.wikipedia.org/wiki/LLVM
- http://clang.llvm.org/

GCC vs LLVM



GPL v3	UIUC, MIT
Front-end: CC1 / CPP	Front-end: Clang
ld.bfd / ld.gold	lld / mclinker
gdb	lldb
as / objdump	MC layer
libstdc++	libc++
libsupc++	libc++abi
libgcc	libcompiler-rt
libgccjit	libLLVMMCJIT

How is LLVM being used today?

XCode, Swift
FreeBSD, OpenMandriva Lx
Android
Debian experimenting with Clang as an additional compiler
...

Clang Goals

- GCC compatibility
- Fast compilation and low memory footprints
- Can reduce the linking time
- User friendly diagnostics
- Tooling
  - static analyzers
  - sanitizers

2) LLD & MCLinker

- **http://lld.llvm.org/**

- Key design choices
  - Do not abstract file formats (c.f. BFD)
  - Emphasis on performance at the high-level, do minimal amount as late as possible.
  - Have a similar interface to existing system linkers but simplify where possible

ELF Linker a drop in replacement for GNU ld

- Support for AArch64, amd64, ARM (sort of), Mips, Power, X86 targets
- Focused on Linux and BSD like ELF files suitable for demand paging
- FreeBSD team aiming at using it for AARCH64 lld
- Many ld command line options supported
- Linker script support in active development
- Not ready for being a callable library yet

Source: http://connect.linaro.org/resource/las16/las16-414

- **https://github.com/mclinker/mclinker**

- A system linker
- GNU ld options compatibility
- Support cross linking
- Can be used as a library or a stand-alone tool
- Support multiple targets
- Fast, small with low memory footprint

Design for on-device linking
A candidate linker of Android and BSD standard systems

3) Build Clang/LLVM on RPi3 with LLD enabled

Build Mesos with Clang/LLVM for x64

//configure.ac

```
# Default to gcc toolchain (we rely on some atomic builtins for now,
# that are also present with clang).
AC_PROG_CXX([clang++-3.9])
AC_PROG_CC([clang-3.9])
```

or

```
CC='clang-3.9' CXX='clang++-3.9' cmake -G Ninja -DCMAKE_INSTALL_PREFIX=./Install ..
```

or

```
cmake -G Ninja -DCMAKE_TOOLCHAIN_FILE=./Toolchain_Clang-LLVM-X64_For_Mesos.cmake ..
```

- Clang for x86_64 Ubuntu 14.04 (.sig)
- Clang for x86_64 Ubuntu 16.04 (.sig)
- Clang for x86_64 Debian 8 (.sig)

//Toolchain_Clang-LLVM-X64_For_Mesos.cmake

```
set(CMAKE_SYSTEM_NAME Linux)
set(CMAKE_SYSTEM_PROCESSOR amd64)

set(tools /opt/DevSW/Toolchain/LLVM/clang-llvm-3.9.0-x86_64-linux-gnu-ubuntu-16.04)
set(CMAKE_C_COMPILER ${tools}/bin/clang)
set(CMAKE_CXX_COMPILER ${tools}/bin/clang++)
```

- **Virtual Machine with 16 vCPU, 128G RAM, Ubuntu Desktop64 16.10**

ninja -j 16 (GCC 6.2.0)
(with MESOS-5656 patch)

```
      4096 Nov 14 00:50 ./
      4096 Nov 14 00:31 ../
      4096 Nov 14 00:31 cli/
      4096 Nov 14 00:31 CMakeFiles/
      2906 Nov 14 00:31 cmake_install.cmake
       618 Nov 14 00:31 CTestTestfile.cmake
      4096 Nov 14 00:31 docker/
      4096 Nov 14 00:31 launcher/
1202872966 Nov 14 00:49 libmesos-1.1.0.a
  53459766 Nov 14 00:42 libmesos-protobufs.a
      4096 Nov 14 00:31 local/
      4096 Nov 14 00:31 log/
      4096 Nov 14 00:42 master/
 281947616 Nov 14 00:51 mesos-agent*
  58756112 Nov 14 00:49 mesos-containerizer*
  72164976 Nov 14 00:50 mesos-docker-executor*
 400246560 Nov 14 00:51 mesos-execute*
  85058408 Nov 14 00:50 mesos-executor*
  55263624 Nov 14 00:50 mesos-fetcher*
 391281832 Nov 14 00:51 mesos-local*
  73010432 Nov 14 00:49 mesos-log*
  32512080 Nov 14 00:49 mesos-logrotate-logger*
 207835304 Nov 14 00:50 mesos-master*
  37167040 Nov 14 00:49 mesos-usage*
      4096 Nov 14 00:42 messages/
      4096 Nov 14 00:31 slave/
  48454064 Nov 14 00:50 test-helper*
      4096 Nov 14 00:31 tests/
      4096 Nov 14 00:31 usage/
```

~20 minutes

ninja -j 16 (Clang/LLVM 3.9.0)
(with MESOS-5656 patch)

```
      4096 Nov 14 20:16 ./
      4096 Nov 14 20:01 ../
      4096 Nov 14 20:01 cli/
      4096 Nov 14 20:01 CMakeFiles/
      2642 Nov 14 20:01 cmake_install.cmake
       574 Nov 14 20:01 CTestTestfile.cmake
      4096 Nov 14 20:01 docker/
      4096 Nov 14 20:01 launcher/
 995962070 Nov 14 20:15 libmesos-1.1.0.a
  50271156 Nov 14 20:11 libmesos-protobufs.a
      4096 Nov 14 20:01 local/
      4096 Nov 14 20:01 log/
      4096 Nov 14 20:10 master/
 303861872 Nov 14 20:17 mesos-agent*
  60223488 Nov 14 20:16 mesos-containerizer*
  74539888 Nov 14 20:16 mesos-docker-executor*
 430519200 Nov 14 20:17 mesos-execute*
  90062528 Nov 14 20:16 mesos-executor*
  56606224 Nov 14 20:16 mesos-fetcher*
 420589456 Nov 14 20:17 mesos-local*
  72441688 Nov 14 20:16 mesos-log*
  32318288 Nov 14 20:15 mesos-logrotate-logger*
 217117512 Nov 14 20:16 mesos-master*
  37749648 Nov 14 20:15 mesos-usage*
      4096 Nov 14 20:10 messages/
      4096 Nov 14 20:01 slave/
  50091536 Nov 14 20:16 test-helper*
      4096 Nov 14 20:01 tests/
      4096 Nov 14 20:01 usage/
```

~17.5 minutes

Getting started

- http://llvm.org/docs/GettingStarted.html
- http://lld.llvm.org/getting_started.html
- http://lldb.llvm.org/build.html
- https://github.com/mclinker/mclinker/wiki/Getting-Started

$LLVM_HOME/llvm
$LLVM_HOME/llvm/tools/clang
$LLVM_HOME/llvm/tools/clang/tools/clang-tools-extra
$LLVM_HOME/llvm/tools/lld
$LLVM_HOME/llvm/projects/compiler-rt
$LLVM_HOME/llvm/projects/libcxx
$LLVM_HOME/llvm/projects/libcxxabi
$LLVM_HOME/llvm/projects/libunwind
$LLVM_HOME/llvm/projects/openmp
$LLVM_HOME/llvm/projects/test-suite

Natively compile upstream Clang/LLVM for RPi3

- **http://llvm.org/docs/HowToBuildOnARM.html**
- **Use Ninja to build ~22 hours on RPi3 and finally got failed**

```
cmake -G Ninja -DCMAKE_INSTALL_PREFIX=./Install -DCMAKE_BUILD_TYPE=Release -DLLVM_ENABLE_LLD=True
-DLLVM_BUILD_DOCS=False -DLLVM_TARGETS_TO_BUILD=ARM ..
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h: In instantiation of 'struct llvm::cast_retty<clang::ObjCAtFinallyStmt, const clang::Stmt*
const>':
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:248:5:   required by substitution of 'template<class X, class Y> typename std::enable_if<(!
 llvm::is_simple_type<Y>::value), typename llvm::cast_retty<X, const Y>::ret_type>::type llvm::cast_or_null(const Y&) [with X = clang::ObjCAtFina
llyStmt; Y = const clang::Stmt*]'
2016-11-13 13:20:51 ../tools/clang/include/clang/AST/StmtObjC.h:228:73:   required from here
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:182:72: warning: ignoring attributes on template argument 'llvm::simplify_type<const clang:
:Stmt* const>::SimpleType {aka const clang::Stmt*}' [-Wignored-attributes]
2016-11-13 13:20:51                     typename simplify_type<From>::SimpleType>::ret_type ret_type;
2016-11-13 13:20:51                                                                        ^~~~~~~
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h: In instantiation of 'struct llvm::cast_retty<clang::Expr, const clang::Stmt* const>':
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:248:5:   required by substitution of 'template<class X, class Y> typename std::enable_if<(!
 llvm::is_simple_type<Y>::value), typename llvm::cast_retty<X, const Y>::ret_type>::type llvm::cast_or_null(const Y&) [with X = clang::Expr; Y =
const clang::Stmt*]'
2016-11-13 13:20:51 ../tools/clang/include/clang/AST/StmtOpenMP.h:1977:56:   required from here
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:182:72: warning: ignoring attributes on template argument 'llvm::simplify_type<const clang:
:Stmt* const>::SimpleType {aka const clang::Stmt*}' [-Wignored-attributes]
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h: In instantiation of 'bool llvm::isa(const Y&) [with X = clang::CaseStmt; Y = const clang::
Stmt*]':
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:298:16:   required from 'typename llvm::cast_retty<X, Y*>::ret_type llvm::dyn_cast(Y*) [wit
h X = clang::CaseStmt; Y = const clang::Stmt; typename llvm::cast_retty<X, Y*>::ret_type = const clang::CaseStmt*]'
2016-11-13 13:20:51 ../tools/clang/include/clang/AST/Stmt.h:737:69:   required from here
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:133:74: warning: ignoring attributes on template argument 'llvm::simplify_type<const clang:
:Stmt* const>::SimpleType {aka const clang::Stmt*}' [-Wignored-attributes]
2016-11-13 13:20:51    return isa_impl_wrap<X, const Y,
2016-11-13 13:20:51           ~~~~~~~~~~~~~~~~~~~~~~~~~
2016-11-13 13:20:51                       typename simplify_type<const Y>::SimpleType>::doit(Val);
2016-11-13 13:20:51                       ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~^~~~
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h: In instantiation of 'bool llvm::isa(const Y&) [with X = clang::Expr; Y = const clang::Stmt
*]':
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:298:16:   required from 'typename llvm::cast_retty<X, Y*>::ret_type llvm::dyn_cast(Y*) [wit
h X = clang::Expr; Y = const clang::Stmt; typename llvm::cast_retty<X, Y*>::ret_type = const clang::Expr*]'
2016-11-13 13:20:51 ../tools/clang/include/clang/StaticAnalyzer/Core/PathSensitive/ProgramState.h:736:40:   required from here
2016-11-13 13:20:51 ../include/llvm/Support/Casting.h:133:74: warning: ignoring attributes on template argument 'llvm::simplify_type<const clang:
:Stmt* const>::SimpleType {aka const clang::Stmt*}' [-Wignored-attributes]
2016-11-13 13:20:51 ninja: build stopped: subcommand failed.
```

Build Mesos with prebuilt LLVM toolchian on RPi3

- clang-llvm-3.9.0-armv7a-linux-gnueabihf

- Clang for AArch64 Linux (.sig)
- Clang for armv7a Linux (.sig)
- Clang for Fedora23 i686 Linux (.sig)

```
3rdparty/stout/tests/proc_tests.cpp
[ 28%] Linking CXX executable stout_tests
cd /opt/MyWorkSpace/Mesos/mesos/build/3rdparty/stout/tests && /usr/bin/cmake -E cmake_link_script CMakeFiles/stout_tests.dir/link.txt --verbose=1
/opt/MyWorkSpace/DevSW/Toolchain/LLVM/clang-llvm-3.9.0-armv7a-linux-gnueabihf/bin/clang-3.9    -stdmc++11 -g   CMakeFiles/stout_tests.dir/base64_tests.cpp.o CM
akeFiles/stout_tests.dir/bits_tests.cpp.o CMakeFiles/stout_tests.dir/bytes_tests.cpp.o CMakeFiles/stout_tests.dir/cache_tests.cpp.o CMakeFiles/stout_tests.dir/
duration_tests.cpp.o CMakeFiles/stout_tests.dir/dynamiclibrary_tests.cpp.o CMakeFiles/stout_tests.dir/error_tests.cpp.o CMakeFiles/stout_tests.dir/flags_tests.
cpp.o CMakeFiles/stout_tests.dir/gzip_tests.cpp.o CMakeFiles/stout_tests.dir/hashmap_tests.cpp.o CMakeFiles/stout_tests.dir/hashset_tests.cpp.o CMakeFiles/stou
t_tests.dir/interval_tests.cpp.o CMakeFiles/stout_tests.dir/ip_tests.cpp.o CMakeFiles/stout_tests.dir/json_tests.cpp.o CMakeFiles/stout_tests.dir/jsonify_tests
.cpp.o CMakeFiles/stout_tests.dir/linkedhashmap_tests.cpp.o CMakeFiles/stout_tests.dir/mac_tests.cpp.o CMakeFiles/stout_tests.dir/main.cpp.o CMakeFiles/stout_t
ests.dir/multimap_tests.cpp.o CMakeFiles/stout_tests.dir/none_tests.cpp.o CMakeFiles/stout_tests.dir/numify_tests.cpp.o CMakeFiles/stout_tests.dir/option_tests
.cpp.o CMakeFiles/stout_tests.dir/os_tests.cpp.o CMakeFiles/stout_tests.dir/os/env_tests.cpp.o CMakeFiles/stout_tests.dir/os/filesystem_tests.cpp.o CMakeFiles/
stout_tests.dir/os/process_tests.cpp.o CMakeFiles/stout_tests.dir/os/rmdir_tests.cpp.o CMakeFiles/stout_tests.dir/os/socket_tests.cpp.o CMakeFiles/stout_tests.
dir/os/strerror_tests.cpp.o CMakeFiles/stout_tests.dir/os/systems_tests.cpp.o CMakeFiles/stout_tests.dir/recordio_tests.cpp.o CMakeFiles/stout_tests.dir/result
_tests.cpp.o CMakeFiles/stout_tests.dir/some_tests.cpp.o CMakeFiles/stout_tests.dir/strings_tests.cpp.o CMakeFiles/stout_tests.dir/subcommand_tests.cpp.o CMake
Files/stout_tests.dir/try_tests.cpp.o CMakeFiles/stout_tests.dir/uuid_tests.cpp.o CMakeFiles/stout_tests.dir/version_tests.cpp.o CMakeFiles/stout_tests.dir/pat
h_tests.cpp.o CMakeFiles/stout_tests.dir/protobuf_tests.cpp.o CMakeFiles/stout_tests.dir/protobuf_tests.pb.cc.o CMakeFiles/stout_tests.dir/svn_tests.cpp.o CMak
eFiles/stout_tests.dir/os/sendfile_tests.cpp.o CMakeFiles/stout_tests.dir/os/signals_tests.cpp.o CMakeFiles/stout_tests.dir/proc_tests.cpp.o  -o stout_tests  -
L/usr/lib/arm-linux-gnueabihf/libapr-1.so  -L/opt/MyWorkSpace/Mesos/mesos/build/3rdparty/glog-0.3.3/src/glog-0.3.3-lib/lib/lib  -L/opt/MyWorkSpace/Mesos/mesos/
build/3rdparty/protobuf-2.6.1/src/protobuf-2.6.1-lib/lib/lib  -L/usr/lib/arm-linux-gnueabihf/libsvn_delta-1.so  -L/usr/lib/arm-linux-gnueabihf/libsvn_diff-1.so
  -L/usr/lib/arm-linux-gnueabihf/libsvn_subr-1.so  -L/opt/MyWorkSpace/Mesos/mesos/build/3rdparty/gmock-1.7.0/src/gmock-1.7.0-lib/lib  -L/opt/MyWorkSpace/Mesos/
mesos/build/3rdparty/gmock-1.7.0/src/gmock-1.7.0-build/gtest/lib/.libs -rdynamic -lcurl -lglog -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lprotobuf -ldl -lapr-1
-lrt -lpthread -lcurl -lglog -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lprotobuf -ldl -lapr-1 -lrt -lpthread -lcurl -lgl
og -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_sub
r-1 -lprotobuf -ldl -lapr-1 -lrt -lpthread -lcurl -lglog -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_di
ff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lsvn_delta-1 -lsvn_diff-1 -lsvn_subr-1 -lprotobuf -ldl -lapr
-1 -lrt -lgmock -lgtest -lpthread -lgmock -lgtest -Wl,-rpath,/usr/lib/arm-linux-gnueabihf/libapr-1.so:/opt/MyWorkSpace/Mesos/mesos/build/3rdparty/glog-0.3.3/sr
c/glog-0.3.3-lib/lib/lib:/opt/MyWorkSpace/Mesos/mesos/build/3rdparty/protobuf-2.6.1/src/protobuf-2.6.1-lib/lib/lib:/usr/lib/arm-linux-gnueabihf/libsvn_delta-1.
so:/usr/lib/arm-linux-gnueabihf/libsvn_diff-1.so:/usr/lib/arm-linux-gnueabihf/libsvn_subr-1.so:/opt/MyWorkSpace/Mesos/mesos/build/3rdparty/gmock-1.7.0/src/gmoc
k-1.7.0-lib/lib:/opt/MyWorkSpace/Mesos/mesos/build/3rdparty/gmock-1.7.0/src/gmock-1.7.0-build/gtest/lib/.libs
/usr/bin/ld: CMakeFiles/stout_tests.dir/flags_tests.cpp.o: undefined reference to symbol '_ZNSt7__cxx1112basic_stringIcSt11char_traitsIcESaIcEE11_M_capacityEj@
@GLIBCXX_3.4.21'
//usr/lib/arm-linux-gnueabihf/libstdc++.so.6: error adding symbols: DSO missing from command line
clang-3.9: error: linker command failed with exit code 1 (use -v to see invocation)
3rdparty/stout/tests/CMakeFiles/stout_tests.dir/build.make:1200: recipe for target '3rdparty/stout/tests/stout_tests' failed
make[2]: *** [3rdparty/stout/tests/stout_tests] Error 1
make[2]: Leaving directory '/opt/MyWorkSpace/Mesos/mesos/build'
CMakeFiles/Makefile2:651: recipe for target '3rdparty/stout/tests/CMakeFiles/stout_tests.dir/all' failed
make[1]: *** [3rdparty/stout/tests/CMakeFiles/stout_tests.dir/all] Error 2
make[1]: Leaving directory '/opt/MyWorkSpace/Mesos/mesos/build'
Makefile:97: recipe for target 'all' failed
make: *** [all] Error 2
```

4) Upcoming LLVM/Clang 4.x for Mesos

- https://llvmdevelopersmeetingbay2016.sched.org/

ORC – LLVM's Next Generation of JIT API

A good news for Java, Python Frameworks on Mesos

LLVM Coroutines – Bringing resumable functions to LLVM

Actor Model based libprocess may benefit from it

llbuild – A New Architecture for Building Software

The build system of Mesos may need some update

Performance improvements in libcxx

Fix some regressions on LLVM/Clang 3.9.0

And many other optimizations…

5) Summary

- LLVM/Clang is a great innovation for software projects and programmers
- Clang/LLVM can directly running on ARM devices like RPi now
- LLVM based next generation linkers and linking technologies is important to build Mesos on ARM device
- It'll be better tomorrow

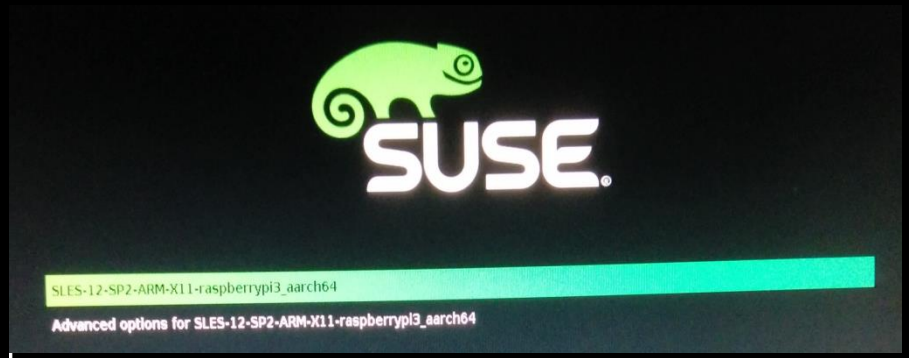
IV. Virtualization-assisted Development

AARCH64 distribution for RPi3

- https://www.suse.com/newsroom/post/2016/new-suse-linux-enterprise-12-service-pack-2-speeds-innovation-with-reliability/

  - Support for ARMv8-A, including enablement for the Raspberry Pi3, making SUSE Linux Enterprise Server 12 SP2 one of the first commercially available enterprise Linux platforms for this architecture.

Take a try




```
linux:/ # uname -a
Linux linux 4.4.21-69-default #1 SMP Tue Oct 25 10:58:20 UTC 2016 (9464f67) aarc
h64 aarch64 aarch64 GNU/Linux
linux:~ # free -h
             total       used       free     shared    buffers     cached
Mem:          785M       316M       468M       5.8M       2.3M       193M
-/+ buffers/cache:       120M       664M
Swap:         494M         0B       494M
```

1) Ubuntu/Fedora ARM64

Ubuntu Cloud

- http://www.cnx-software.com/2016/05/10/how-to-run-ubuntu-16-04-aarch64-64-bit-arm-cloud-images-on-your-intelamd-linux-computer/

https://releases.linaro.org/components/kernel/uefi-linaro/16.02/release/qemu64/

Name	Last modified	Size	License
Parent Directory			
QEMU_EFI.fd	25-Feb-2016 12:00	2.0M	open
QEMU_EFI.img.gz	25-Feb-2016 12:00	723.4K	open

https://cloud-images.ubuntu.com/yakkety/current/

yakkety-server-cloudimg-arm64-lxd.tar.xz	10-Nov-2016 17:41	840	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-arm64.img	10-Nov-2016 17:36	292M	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-arm64.manifest	10-Nov-2016 17:40	13K	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-arm64.squashfs	10-Nov-2016 17:41	138M	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-arm64.squashfs.manifest	10-Nov-2016 17:41	13K	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-arm64.tar.gz	10-Nov-2016 17:43	221M	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-armhf-lxd.tar.xz	10-Nov-2016 17:37	840	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-armhf.img	10-Nov-2016 17:33	387M	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-armhf.manifest	10-Nov-2016 17:36	13K	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-armhf.squashfs	10-Nov-2016 17:37	138M	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-armhf.squashfs.manifest	10-Nov-2016 17:37	13K	Ubuntu Server 16.10 (Yakkety Yak) daily builds
yakkety-server-cloudimg-armhf.tar.gz	10-Nov-2016 17:39	356M	Ubuntu Server 16.10 (Yakkety Yak) daily builds

apt-get install qemu qemu-utils cloud-utils

//generate a ssh key pair to ~/.ssh

```
mydev2@mydev2-virtual-machine:~/.ssh$ ssh-keygen -t ecdsa
Generating public/private ecdsa key pair.
Enter file in which to save the key (/home/mydev2/.ssh/id_ecdsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/mydev2/.ssh/id_ecdsa.
Your public key has been saved in /home/mydev2/.ssh/id_ecdsa.pub.
The key fingerprint is:
SHA256:dXncuQyHuu3E7bj1k7X5VZaGxJ99isEw2n4kSS0k0Fc mydev2@mydev2-virtual-machine
The key's randomart image is:
+---[ECDSA 256]---+
|     ..  ..E     |
|     ..o.   .o...|
|      ... * o=oo.|
|         * Bo.* =|
|        S +.+. B=|
|         . o+ooo+|
|          ..o+.o*|
|           .o +=o|
|             +..=|
+----[SHA256]-----+
```

//edit ubuntucloud.config

```
users:
  - name: ubuntucloud
    ssh-authorized-keys:
      - ssh-ecdsa AAAAE2VjZHNhLXNoYTItbmlzdHAyNTYAAAAIbmlzdHAyNTYAAABBBG3neetMc4QArUwCkpqoLpR5NLDzwxVrdw4p
Ajp2kXM6ZMY2ttVmWnjW1jxhrDgKRjCsHMuLNwkGzZ7Cbyp8bG4= mydev2@mydev2-virtual-machine
    sudo: ['ALL=(ALL) NOPASSWD:ALL']
    groups: sudo
    shell: /bin/bash
```

cloud-localds ubuntucloud-yakkety.img ubuntucloud.config

//edit start-ubuntu-yakkety-cloud-arm64.sh

```
#### Ubuntu Cloud
## yakkety
qemu-system-aarch64 -smp 2 -m 16384 -M virt -bios QEMU_EFI.fd -nographic \
        -device virtio-blk-device,drive=image \
        -drive if=none,id=image,file=yakkety-server-cloudimg-arm64.img \
        -device virtio-blk-device,drive=cloud \
        -drive if=none,id=cloud,file=ubuntucloud-yakkety.img \
        -netdev user,id=user0 -device virtio-net-device,netdev=user0 -redir tcp:2222::22 \
        -cpu cortex-a53
```

./start-ubuntu-yakkety-cloud-arm64.sh

```
error: no suitable video mode found.
EFI stub: Booting Linux Kernel...
EFI stub: EFI_RNG_PROTOCOL unavailable, no randomness supplied
EFI stub: Using DTB from configuration table
EFI stub: Exiting boot services and installing virtual address map...
[    0.000000] Booting Linux on physical CPU 0x0
[    0.000000] Linux version 4.8.0-27-generic (buildd@bos01-arm64-047) (gcc version 6.2.0 20161005 (Ul
 6.2.0-5ubuntu12) ) #29-Ubuntu SMP Thu Oct 20 21:02:10 UTC 2016 (Ubuntu 4.8.0-27.29-generic 4.8.1)
[    0.000000] Boot CPU: AArch64 Processor [410fd034]
[    0.000000] efi: Getting EFI parameters from FDT:
[    0.000000] efi: EFI v2.60 by EDK II
[    0.000000] efi:  SMBIOS 3.0=0x43c030000  ACPI=0xffff0000  ACPI 2.0=0xffff0014  MEMATTR=0x43ec5e01
[    0.000000] No NUMA configuration found
[    0.000000] NUMA: Faking a node at [mem 0x0000000000000000-0x000000043fffffff]
[    0.000000] NUMA: Adding memblock [0x40000000 - 0xfff4ffff] on node 0
[    0.000000] NUMA: Adding memblock [0xfff50000 - 0xfffaffff] on node 0
```

...

```
[  OK  ] Started Login Service.
[FAILED] Failed to start LXD - container startup/shutdown.
See 'systemctl status lxd-containers.service' for details.
[  OK  ] Started LSB: Record successful boot for GRUB.
[  OK  ] Started iSCSI initiator daemon (iscsid).
         Starting Login to default iSCSI targets...
         Starting Authenticate and Authorize Users to Run Privileged Tasks...
[  OK  ] Started Login to default iSCSI targets.
[  OK  ] Reached target Remote File Systems (Pre).
[  OK  ] Reached target Remote File Systems.
         Starting LSB: automatic crash report generation...
         Starting Permit User Sessions...
         Starting LSB: daemon to balance interrupts for SMP systems...
[  OK  ] Started Authenticate and Authorize Users to Run Privileged Tasks.
[  OK  ] Started Accounts Service.
[  OK  ] Started Permit User Sessions.
         Starting Hold until boot process finishes up...
         Starting Terminate Plymouth Boot Screen...
[  OK  ] Started Hold until boot process finishes up.
[  OK  ] Started Terminate Plymouth Boot Screen.
```

...

//SSH fail !

```
mydev2@mydev2-virtual-machine:~/.ssh$ ssh -p 2222 ubuntucloud@localhost
The authenticity of host '[localhost]:2222 ([127.0.0.1]:2222)' can't be established.
ECDSA key fingerprint is SHA256:jTSER1EtfWboTboSzZvHY4KK6IUvaisnHi/M9SKXhW8.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[localhost]:2222' (ECDSA) to the list of known hosts.
Permission denied (publickey).
```

Fedora

- https://fedoraproject.org/wiki/Architectures/AArch64/F24/Installation
- https://fedoraproject.org/wiki/Architectures/AArch64/Install_with_QEMU

Installing Fedora aarch64 with QEMU and libvirt

These steps will work on both x86 and aarch64 hardware. If running on actual aarch64 hardware, the virt-install commands should automatically request KVM for maximum performance.

Get the necessary bits

- Fedora 22 host or later is required
- Grab the latest qemu-system-aarch64, libvirt, and virt-manager
- Grab UEFI builds for QEMU and AARCH64: `sudo dnf install edk2-aarch64` (fedora 23 & newer)
  - Note: These bits are not part of fedora 22 and older due to licensing issues. See Using_UEFI_with_QEMU#EDK2_Licensing_Issues for more info.
  - Install Gerd's nightly firmware repo, as described here: https://www.kraxel.org/repos/
  - Install the relevant bits: `sudo dnf install edk2.git-aarch64`

Installing F23 aarch64 from URL

- This example uses the F23 aarch64 install tree. The virt-install command is:

```
sudo ./virt-install \
  --name f23-aarch64-urlinst --ram 2048 --arch aarch64 \
  --boot uefi --disk size=8 \
  --location https://dl.fedoraproject.org/pub/fedora-secondary/releases/23/Server/aarch64/iso/
```

Installing F23 aarch64 from CDROM

- Grab the ISO:
  - This example uses the F23 aarch64 install DVD: https://dl.fedoraproject.org/pub/fedora-secondary/releases/23/Server/aarch64/iso/Fedora-Server-DVD-aarch64-23.iso
  - Move it to /var/lib/libvirt/images
  - From the virt-manager.git checkout, run:

```
sudo ./virt-install \
  --name f23-aarch64-cdrom --ram 2048 --arch aarch64 \
  --boot uefi --disk size=8 --os-variant fedora22 \
  --cdrom /var/lib/libvirt/images/Fedora-Server-DVD-aarch64-23.iso
```

2) CoreOS ARM64

- https://coreos.com/blog/coreos-on-arm64/
- https://github.com/glevand/hikey-coreos
- https://github.com/coreos/docs/blob/master/os/booting-with-qemu.md

Startup

#download a alpha/beta/stable image according to https://coreos.com/releases/

#e.g., https://alpha.release.core-os.net/amd64-usr/current/


[file] coreos_production_qemu.DIGESTS
[file] coreos_production_qemu.DIGESTS.asc
[file] coreos_production_qemu.DIGESTS.sig
[file] coreos_production_qemu.README
[file] coreos_production_qemu.README.sig
[file] coreos_production_qemu.sh
[file] coreos_production_qemu.sh.sig
[file] coreos_production_qemu_image.img.bz2
[file] coreos_production_qemu_image.img.bz2.DIGESTS
[file] coreos_production_qemu_image.img.bz2.DIGESTS.asc
[file] coreos_production_qemu_image.img.bz2.sig
[file] coreos_production_qemu_uefi.DIGESTS
[file] coreos_production_qemu_uefi.DIGESTS.asc
[file] coreos_production_qemu_uefi.DIGESTS.sig
[file] coreos_production_qemu_uefi.README
[file] coreos_production_qemu_uefi.README.sig
[file] coreos_production_qemu_uefi.sh
[file] coreos_production_qemu_uefi.sh.sig
[file] coreos_production_qemu_uefi_efi_code.fd
[file] coreos_production_qemu_uefi_efi_code.fd.sig
[file] coreos_production_qemu_uefi_efi_vars.fd
[file] coreos_production_qemu_uefi_efi_vars.fd.sig
[file] coreos_production_qemu_uefi_image.img.bz2
[file] coreos_production_qemu_uefi_image.img.bz2.DIGESTS
[file] coreos_production_qemu_uefi_image.img.bz2.DIGESTS.asc
[file] coreos_production_qemu_uefi_image.img.bz2.sig

#generate a ssh key pair to ~/.ssh

ssh-keygen

#vim ~/.ssh/config

```
Host coreos
HostName localhost
Port 2222
User core
StrictHostKeyChecking no
UserKnownHostsFile /dev/null
```

---

bzip2 -d coreos_production_qemu_uefi_image.img.bz2

#modify settings: ./coreos_production_qemu_uefi.sh

```
#!/bin/sh

SCRIPT_DIR="`dirname "$0"`"
VM_BOARD='arm64-usr'
VM_NAME='coreos_production_qemu_uefi-1221-0-0'
VM_UUID=
VM_IMAGE='coreos_production_qemu_uefi_image.img'
VM_KERNEL=
VM_INITRD=
VM_MEMORY='16384'
VM_CDROM=
VM_PFLASH_RO='coreos_production_qemu_uefi_efi_code.fd'
VM_PFLASH_RW='coreos_production_qemu_uefi_efi_vars.fd'
VM_NCPUS="`grep -c ^processor /proc/cpuinfo`"
SSH_PORT=2222
SSH_KEYS=""
CONFIG_FILE=""
CONFIG_IMAGE=""
SAFE_ARGS=0
USAGE="Usage: $0 [-a authorized_keys] [--] [qemu options...]
```

./coreos_production_qemu_uefi.sh -a ~/.ssh/id_rsa.pub -- -nographic

```
...
[   94.686589] systemd[1]: Started Cleanup udevd DB.
[  OK  ] Started Cleanup udevd DB.
[  OK  ] Reached target Switch Root.
[   94.748990] systemd[1]: Reached target Switch Root.
[   94.875395] systemd[1]: Starting Switch Root...
         Starting Switch Root...
[   95.456545] systemd[1]: Switching root.
[   96.159314] systemd-journald[157]: Received SIGTERM from PID 1 (systemd).
[   98.243453] systemd: 14 output lines suppressed due to ratelimiting
[   98.691957] ip_tables: (C) 2000-2006 Netfilter Core Team

Welcome to CoreOS 1221.0.0 (MoreOS)!

[  OK  ] Stopped Switch Root.
[  OK  ] Stopped Journal Service.
         Starting Journal Service...
[  OK  ] Created slice system-addon\x2drun.slice.
[  OK  ] Listening on /dev/initctl Compatibility Named Pipe.
[  OK  ] Started Forward Password Requests to Wall Directory Watch.
[  OK  ] Reached target Remote File Systems.
[  OK  ] Set up automount Arbitrary Executab...ats File System Automount Point.
[  OK  ] Created slice User and Session Slice.
[  OK  ] Created slice system-addon\x2dconfig.slice.
[  109.117588] audit: type=1305 audit(1479119644.993:2): audit_enabled=1 old=1 auid=4294967295 ses=4294967
295 subj=kernel res=1
         Starting Apply Kernel Variables...
         Mounting Debug File System...
[  OK  ] Reached target Slices.
[  OK  ] Started Dispatch Password Requests to Console Directory Watch.
[  OK  ] Stopped target Switch Root.
[  OK  ] Stopped target Initrd File Systems.
...
[  245.756722] x9 : 0000000000000000 x8 : 0000ffff98ecdbe0
[  245.824506] x7 : 0000000000000004 x6 : 0000000000000004
[  245.923328] x5 : 0000000000000002 x4 : 0000000000000000
[  246.033085] x3 : 0000000000000002 x2 : 0000000000000004
[  246.108227] x1 : 0000ffff96911180 x0 : 0000ffff969111a0
[  246.192201]
[  246.319095] audit: type=1701 audit(1479121626.494:3): auid=4294967295 uid=235 gid=235 ses=4294967295 su
bj=kernel pid=600 comm="polkitd" exe="/usr/lib/polkit-1/polkitd" sig=11


This is localhost (Linux aarch64 4.8.6-coreos) 11:07:11
SSH host key: SHA256:H61NZsE4ljBfXC5DhnVBYN9lUUlDNL45rwN1SPyBUpw (RSA)
SSH host key: SHA256:6Tm/pXyqI8hjfR9AAn6OjjXw1UrK5tPb1YX5iK791/U (DSA)
SSH host key: SHA256:r5poVlFFDxG232jwpW10Mc12H2UK8u4HPC3WkdtHKOo (ED25519)
SSH host key: SHA256:8MMKSafzuoy1T/GosPg2Ly1JTVpJHhp9XKPKZ5CVays (ECDSA)
eth0: 10.0.2.15 fec0::5054:ff:fe12:3456

localhost login:
```

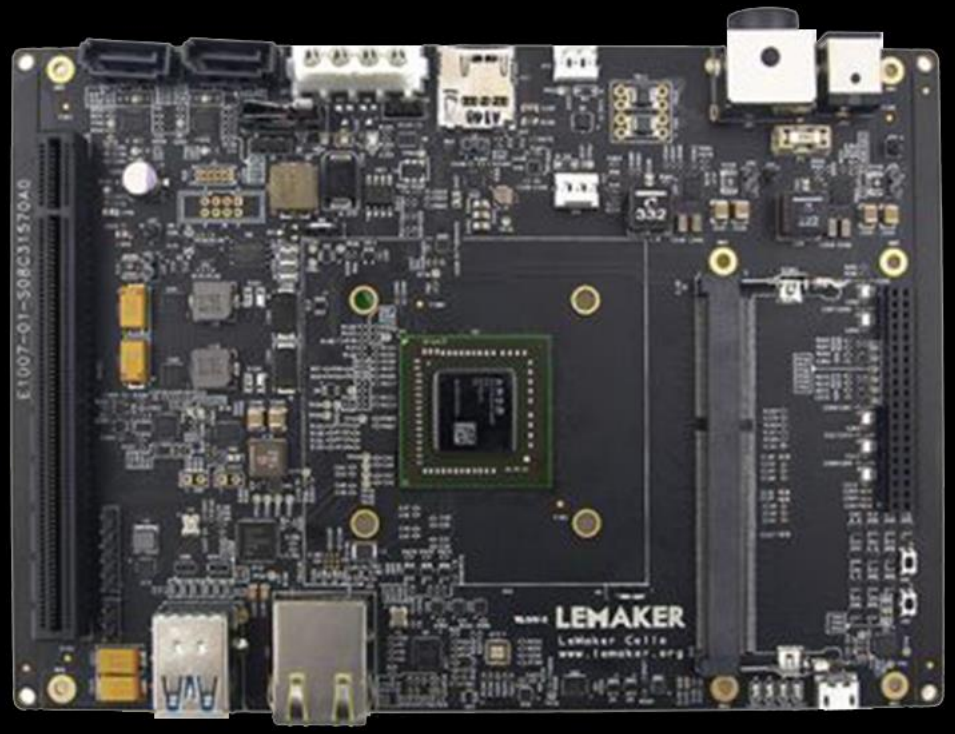
ssh coreos

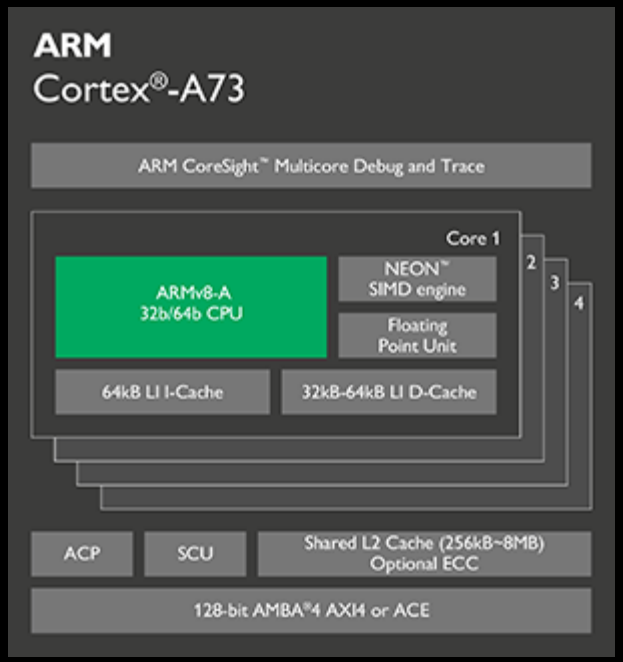
```
Warning: Permanently added '[localhost]:2222' (ECDSA) to the list of known hosts.
Enter passphrase for key '/home/mydev2/.ssh/id_rsa':
CoreOS alpha (1221.0.0)
Failed Units: 1
  polkit.service
core@localhost ~ $
```

```
core@localhost ~ $ uname -a
Linux localhost 4.8.6-coreos #1 SMP PREEMPT Thu Nov 3 04:31:31 UTC 2016 aarch64 GNU/Linux
```

V. Wrap-Up

- **Moving to new experiment platform in 2017:**
  - **Upcoming Raspberry Pi 4**
  - **96boards**
  - **Cortex-A73 development board**





- A fully customized Linux distribution:
  - Upstreaming Kernel
  - Full support for AARCH64
  - LLVM/Clang 4.x as the unique toolchain
  - Development related packages preinstalled
  - Debian-based
  - …

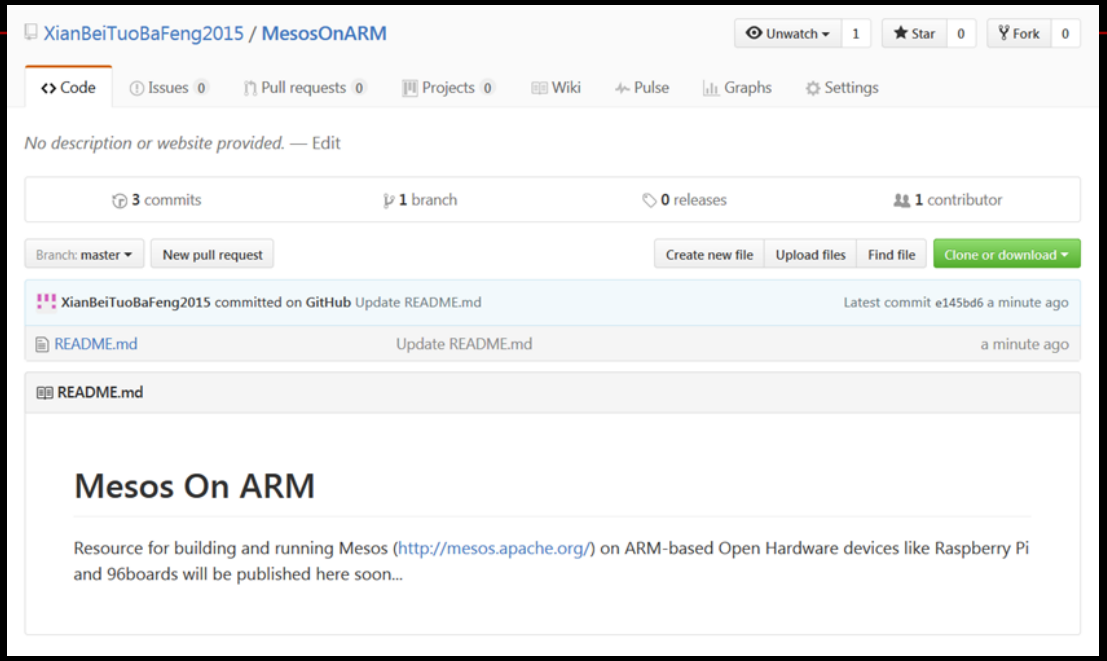
Rank	Distribution	H.P.D*
1	Mint	2880▼
2	Debian	1668▬
3	Ubuntu	1347▬
4	openSUSE	1234▲
5	elementary	1085▬
6	Manjaro	1039▼
7	Fedora	982▼
8	Zorin	914▬
9	CentOS	773▬
10	deepin	736▲

- Clang/LLVM is the system compiler on several platforms in FreeBSD 10.0 and later, and GCC is not installed by default. FreeBSD is still pursuing the use of the LLVM Linker (LLD) on its base system, and its ARM64 support continues getting better.

- **Build Mesos (version >= 1.0) on single RPi3 board seems to be "Mission Impossible"**

But why I still insist on trying to build Mesos on single RPi3 board? Because I believe that there is still much room left for further optimization, and I am aware that the success is depend on whole system optimization.

- **My github:**
  https://github.com/XianBeiTuoBaFeng2015/MesosOnARM/
  XianBei2011@gmail.com



- **ARM-based Solution will certainly play a key role in next generation Data Center & Cloud Infrastructure, so make Mesos running stably, fastly, and smoonthly on ARM is very important!**

Q & A

THANK YOU!

Reference

Slides/materials from many and varied sources:

- http://en.wikipedia.org/wiki/
- http://www.slideshare.net/
- https://www.kernel.org/
- http://elinux.org/Main_Page
- http://free-electrons.com/
- http://llvm.org
- http://llvm.linuxfoundation.org/index.php/Main_Page
- https://www.freebsd.org/
- http://mesos.apache.org/
- https://github.com/apache/mesos
- https://cmake.org/
- http://wiki.qemu.org/Main_Page
- …