Cross-compiling Linux Kernels on x86_64: A tutorial on How to Get Started

Shuah Khan
Senior Linux Kernel Developer – Open Source Group
Samsung Research America (Silicon Valley)
shuah.kh@samsung.com

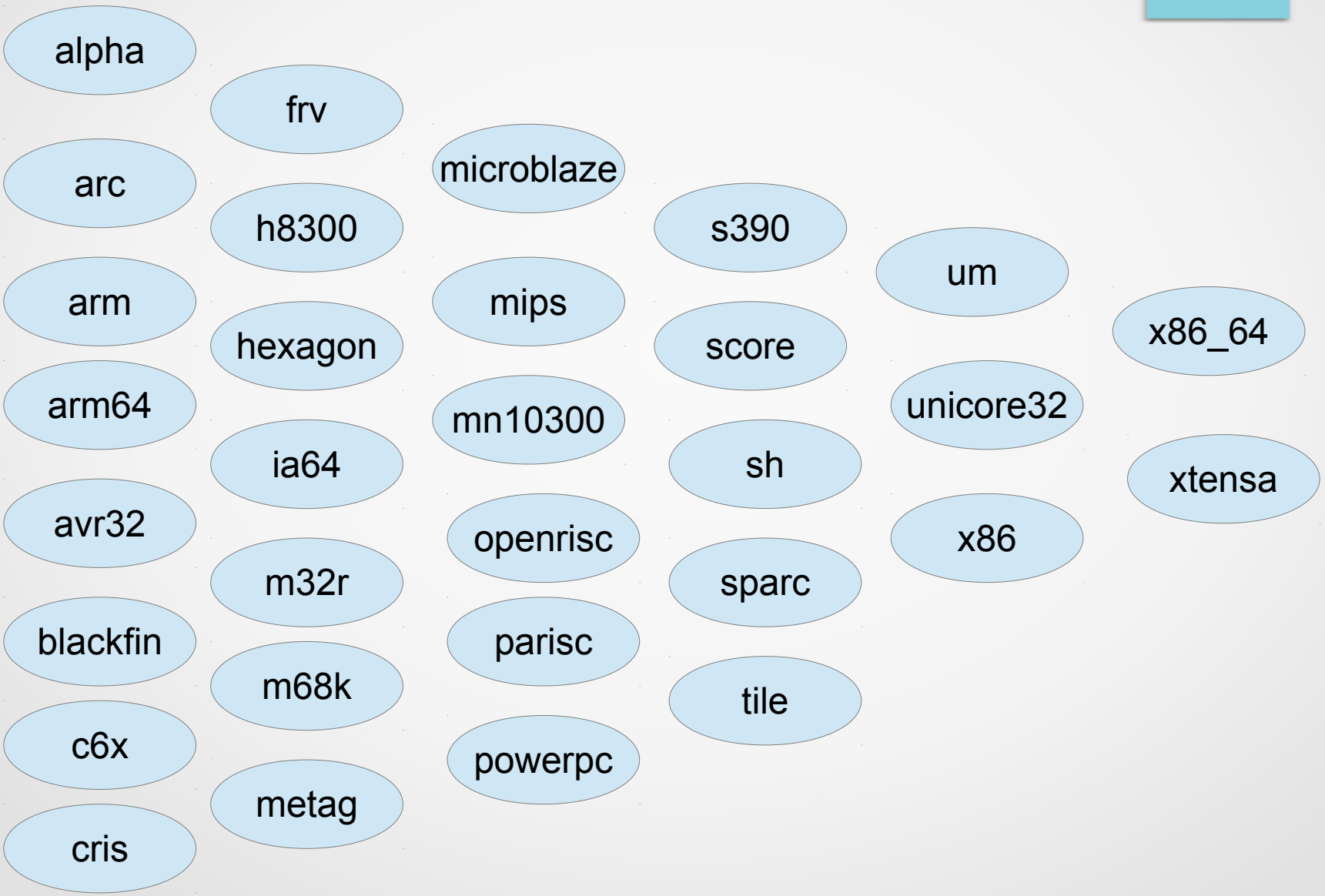
Agenda

- Cross-compile value proposition
- Preparing the system for cross-compiler installation
- Cross-compiler installation steps
- Demo – install arm and arm64
- Compiling on architectures
- Demo – compile arm and arm64
- Automating cross-compile testing
- Upstream cross-compile testing activity
- References and Package repositories
- Q&A

Cross-compile value proposition

- 30+ architectures supported (several sub-archs)
- Native compile testing requires wide range of test systems – not practical
- Ability to cross-compile non-natively on an widely available architecture helps detect compile errors
- Coupled with emulation environments (e.g: qemu) testing on non-native architectures becomes easier
- Setting up cross-compile environment is the first and necessary step

arch/


alpha
arc
arm
arm64
avr32
blackfin
c6x
cris
frv
h8300
hexagon
ia64
m32r
m68k
metag
microblaze
mips
mn10300
openrisc
parisc
powerpc
s390
score
sh
sparc
tile
um
unicore32
x86
x86_64
xtensa

Cross-compiler packages

- Ubuntu arm packages (12.10 or later)
  - gcc-arm-linux-gnueabi
  - gcc-arm-linux-gnueabihf
- Ubuntu arm64 packages (13.04 or later) – use arm64 repo for older Ubuntu releases.
  - gcc-4.7-aarch64-linux-gnu
- Ubuntu keeps adding support for compilers. Search Ubuntu repository for packages.

Cross-compiler packages

- Embedded Debian Project is a good resource for alpha, mips, mipsel, powerpc, sh, and sparc cross-compilers.
  - gcc-4.7-alpha-linux-gnu
  - gcc-4.7-mips-linux-gnu
  - gcc-4.7-mipsel-linux-gnu
  - gcc-4.7-powerpc-linux-gnu
  - gcc-4.7-sh4-linux-gnu
  - gcc-4.7-sparc-linux-gnu

Cross-compiler packages

- Fedora repo and Fedora Epel Repo are a good sources for several cross-compilers and binutils rpms
  - blackfin
    - binutils-bfin-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm
    - gcc-bfin-linux-gnu-4.7.1-0.1.20120606.fc17.x86_64.rpm
  - c6x
    - binutils-c6x-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm
    - gcc-c6x-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm
  - tile
    - binutils-tile-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm
    - gcc-tile-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm

Preparing the system for cross-compiler installation

- Choose an x86-64 system
- Install Ubuntu 12.10 or later.
  - Ubuntu 13.04 Install

Install common packages

sudo apt-get install build-essential

sudo apt-get install binutils-multiarch

sudo apt-get install ncurses-dev

sudo apt-get install alien

Note: ncurses-dev is required to run menuconfig and alien to generate .deb from .rpm

Configure apt for arm64 repo (Ubuntu 12.10)

```
wget -O - http://people.debian.org/~wookey/bootstrap/bootstrap-archive.key | sudo apt-key add
```

```
sudo apt-add-repository 'deb http://people.debian.org/~wookey/bootstrap/ubunturepo/ quantal-bootstrap main'
```

```
sudo apt-get update
```

Configure apt for emdebian repo

sudo apt-get install emdebian-archive-keyring

Create /etc/apt/sources.list.d/emdebian.list file with the following line:
deb http://www.emdebian.org/debian/ sid main

Download rpms from fedora repo

- blackfin rpms:
  - binutils-bfin-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm
  - gcc-bfin-linux-gnu-4.7.1-0.1.20120606.fc17.x86_64.rpm
- c6x rpms:
  - binutils-c6x-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm
  - gcc-c6x-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm
- tile rpms
  - binutils-tile-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm
  - gcc-tile-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm
  - Note: gcc-tile-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm is what you want. The older version is missing feedback.h, tilegx needs.

Convert rpms to .deb

sudo alien -d binutils-bfin-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm

sudo alien -d gcc-bfin-linux-gnu-4.7.1-0.1.20120606.fc17.x86_64.rpm

sudo alien -d binutils-c6x-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm

sudo alien -d gcc-c6x-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm

sudo alien -d binutils-tile-linux-gnu-2.23.51.0.3-1.fc17.x86_64.rpm

sudo alien -d gcc-tile-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm

You will see warnings about missing keys e.g: below which you can safely ignore.

warning: gcc-tile-linux-gnu-4.7.2-2.aa.20121114svn.fc17.x86_64.rpm:
Header V3 RSA/SHA256 Signature, key ID 1aca3465: NOKEY

Resulting .debs

- binutils-bfin-linux-gnu_2.23.51.0.3-2_amd64.deb
- binutils-c6x-linux-gnu_2.23.51.0.3-2_amd64.deb
- binutils-tile-linux-gnu_2.23.51.0.3-2_amd64.deb
- gcc-bfin-linux-gnu_4.7.1-1.1_amd64.deb
- gcc-c6x-linux-gnu_4.7.2-3_amd64.deb
- gcc-tile-linux-gnu_4.7.2-3_amd64.deb

Install cross-compilers

alpha
sudo apt-get install --install-recommends gcc-4.7-alpha-linux-gnu
sudo ln -s /usr/bin/alpha-linux-gnu-gcc-4.7 /usr/bin/alpha-linux-gnu-gcc

arm
sudo apt-get install gcc-arm-linux-gnueabi

arm64
sudo apt-get install --install-recommends gcc-4.7-aarch64-linux-gnu
sudo ln -s /usr/bin/aarch64-linux-gnu-gcc-4.7 /usr/bin/aarch64-linux-gnu-gcc

mips
sudo apt-get install --install-recommends gcc-4.7-mips-linux-gnu
sudo ln -s /usr/bin/mips-linux-gnu-gcc-4.7 /usr/bin/mips-linux-gnu-gcc

mipsel
sudo apt-get install --install-recommends gcc-4.7-mipsel-linux-gnu
sudo ln -s /usr/bin/mipsel-linux-gnu-gcc-4.7 /usr/bin/mipsel-linux-gnu-gcc

Install cross-compilers

powerpc
sudo apt-get install --install-recommends gcc-4.7-powerpc-linux-gnu
sudo ln -s /usr/bin/powerpc-linux-gnu-gcc-4.7 /usr/bin/powerpc-linux-gnu-gcc

sh
sudo apt-get install --install-recommends gcc-4.7-sh4-linux-gnu
sudo ln -s /usr/bin/sh4-linux-gnu-gcc-4.7 /usr/bin/sh4-linux-gnu-gcc

arm64
sudo apt-get install --install-recommends gcc-4.7-aarch64-linux-gnu
sudo ln -s /usr/bin/aarch64-linux-gnu-gcc-4.7 /usr/bin/aarch64-linux-gnu-gcc

sparc
sudo apt-get install --install-recommends gcc-4.7-sparc-linux-gnu
sudo ln -s /usr/bin/sparc-linux-gnu-gcc-4.7 /usr/bin/sparc-linux-gnu-gcc

Note: Creating link to *arch*-linux-gnu-gcc is necessary as the CROSS_COMPILE directive to find the compilers.

Install cross-compilers from .debs

blackfin

```
sudo dpkg -i binutils-bfin-linux-gnu_2.23.51.0.3-2_amd64.deb
sudo dpkg -i gcc-bfin-linux-gnu_4.7.1-1.1_amd64.deb
```

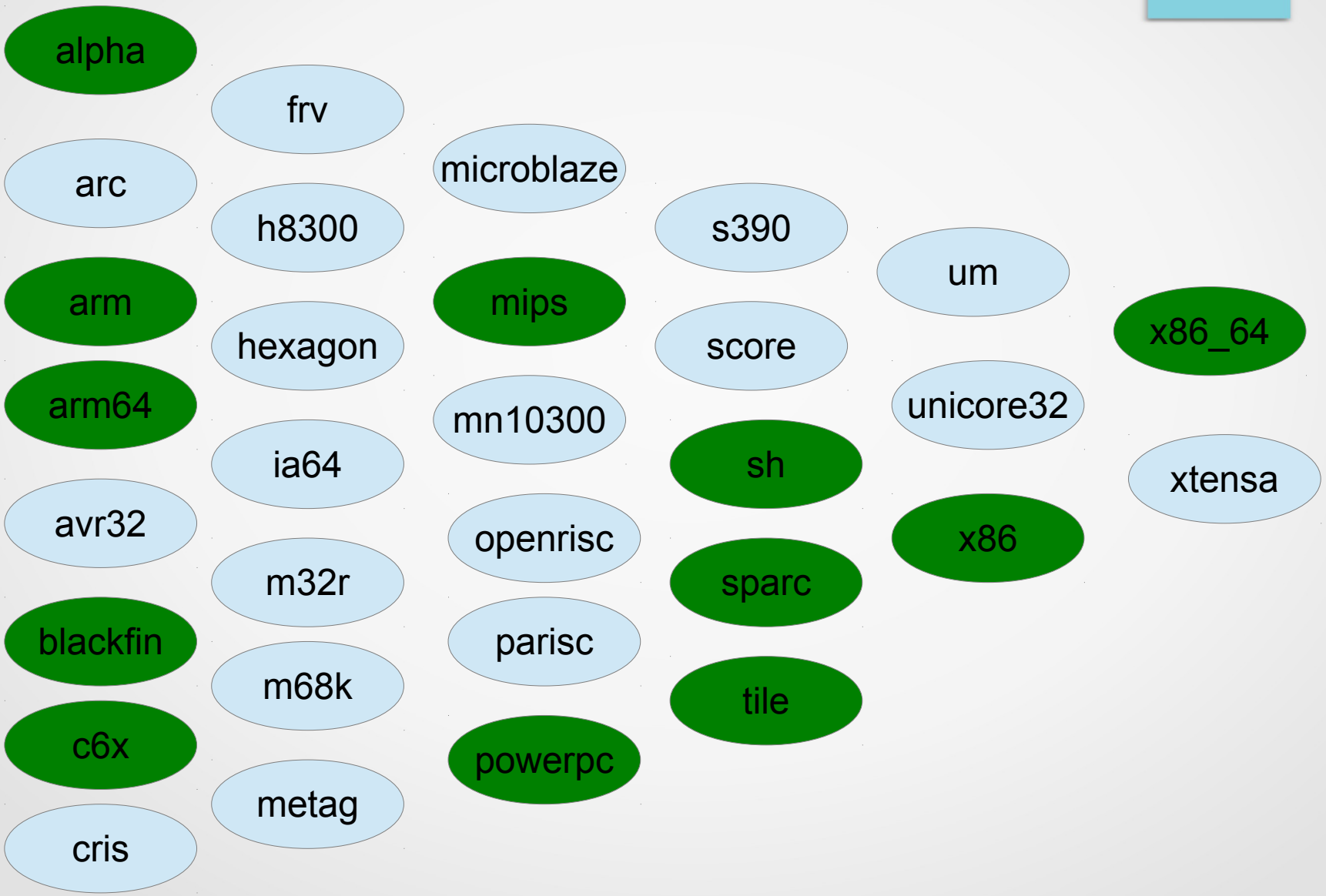
c6x

```
sudo dpkg -i binutils-c6x-linux-gnu_2.23.51.0.3-2_amd64.deb
sudo dpkg -i gcc-c6x-linux-gnu_4.7.2-3_amd64.deb
```

tile

```
sudo dpkg -i binutils-tile-linux-gnu_2.23.51.0.3-2_amd64.deb
sudo dpkg -i gcc-tile-linux-gnu_4.7.2-3_amd64.deb
```

arch/compile



Building from sources

- Mauro Chehab's build_cross script
  - downloads compiler sources for a specified arch from gnu repo, builds and installs.
  - Usage: build_cross arm
  - Runs on fedora

Demo arm and arm64 install

Compilation Tips

- If make ARCH=arch defconfig fails on an arch, pick a config to test from arch/*/configs
- Some architectures don't support defconfig in cross-compile mode. e.g: powerpc.
- In some cases, you might see errors in LD phase, and please keep in mind these are just compile tests.

Cross-compiling

alpha
make distclean
make ARCH=alpha defconfig
ARCH=alpha CROSS_COMPILE=alpha-linux-gnu- make all

arm
make distclean
make ARCH=arm defconfig
ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- make all

arm64 (3.7 and later)
make distclean
make ARCH=arm64 defconfig
ARCH=arm64 CROSS_COMPILE=aarch64-linux-gnu- make all

blackfin
make distclean
make ARCH=blackfin defconfig
ARCH=blackfin CROSS_COMPILE=bfin-linux-gnu- make all

Cross-compiling

c6x (3.4 and later)
make distclean
make ARCH=c6x defconfig
ARCH=arm64 CROSS_COMPILE=aarch64-linux-gnu- make all

mips
make distclean
make ARCH=mips defconfig
ARCH=mips CROSS_COMPILE=mips-linux-gnu- make all

mipsel
make distclean
make ARCH=mips defconfig
ARCH=mips CROSS_COMPILE=mipsel-linux-gnu- make all

powerpc
make distclean
cp arch/powerpc/configs/wii_defconfig .config
ARCH=powerpc CROSS_COMPILE=powerpc-linux-gnu- make all

Cross-compiling

sh
make distclean
make ARCH=sh defconfig
ARCH=sh CROSS_COMPILE=sh4-linux-gnu- make all

sparc
make distclean
make ARCH=sparc defconfig
ARCH=sparc CROSS_COMPILE=sparc-linux-gnu- make all

tile
make distclean
make ARCH=tile defconfig
ARCH=tile CROSS_COMPILE=tile-linux-gnu- make all

Demo arm and arm64 compilation

Automating cross-compile testing

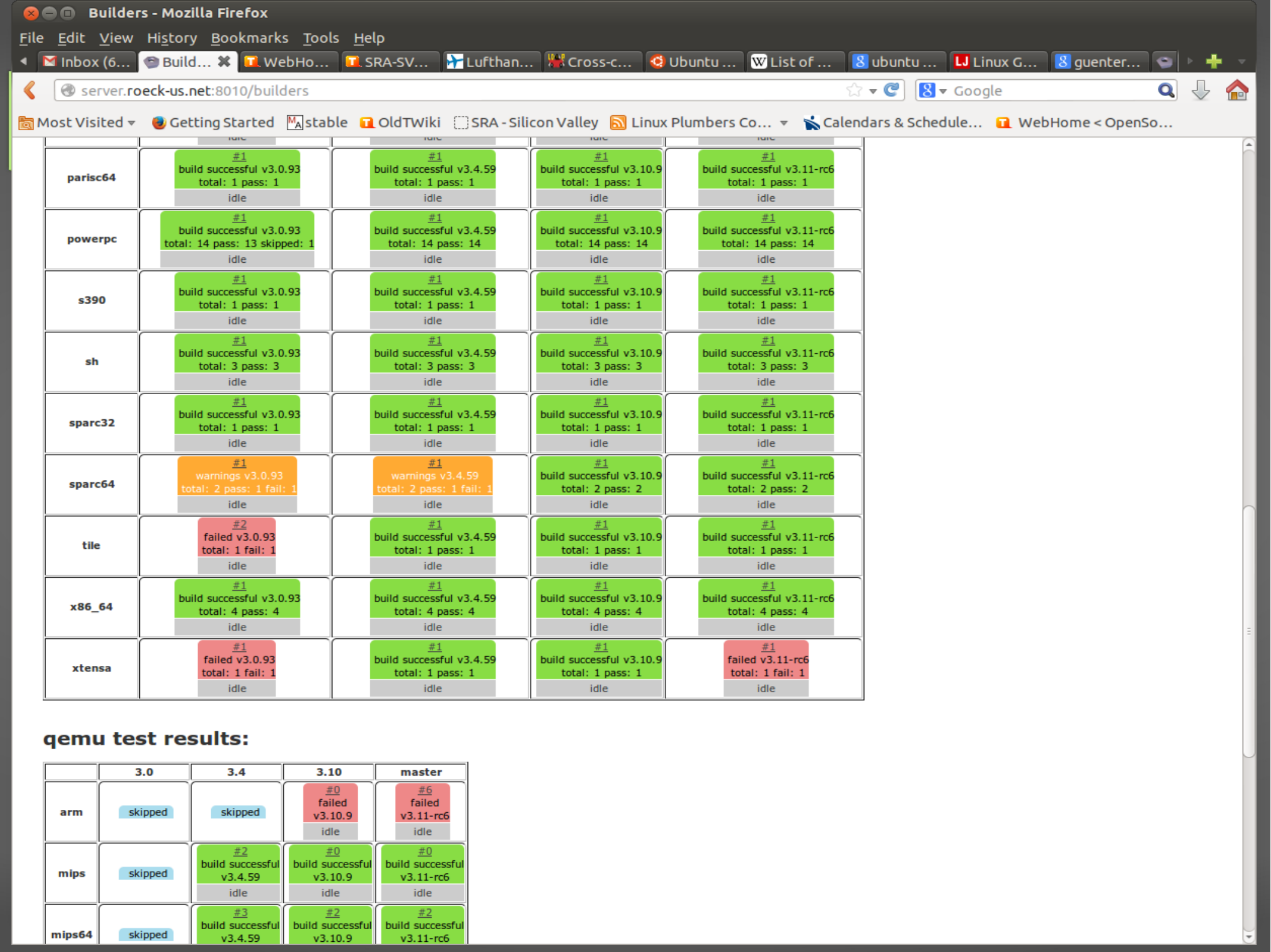
- Script – cross_compile.sh automates builds for the compilers mentioned in this talk
- ktest – crosstests.conf
- Buildbot – tool for automating software builds. It can be configured to checkout Linux kernel sources from git repos and build.

Upstream Cross-compile testing activity

- Linux Kernel stable queue builds project
  - Guenter Rock keeps adding new compilers each week.
  - Configs: allmodconfig, defconfig, configs with mmu and without (nommu) where applicable.
  - qemu test results on selected architectures.

stable queue:

	3.0	3.4	3.10	master
alpha	#12 build successful v3.0.93 total: 1 pass: 1 idle	#9 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
arm	#1 warnings v3.0.93 total: 16 pass: 9 skipped: 6 fail: 1 idle	#1 warnings v3.4.59 total: 16 pass: 11 skipped: 4 fail: 1 idle	#1 build successful v3.10.9 total: 16 pass: 16 idle	#1 warnings v3.11-rc6 total: 16 pass: 13 skipped: 2 fail: 1 idle
blackfin	#1 build successful v3.0.93 total: 1 pass: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
cris	#1 build successful v3.0.93 total: 3 pass: 3 idle	#1 build successful v3.4.59 total: 3 pass: 3 idle	#1 build successful v3.10.9 total: 3 pass: 3 idle	#1 build successful v3.11-rc6 total: 3 pass: 3 idle
frv	#18 failed v3.0.93 total: 1 fail: 1 idle	#2 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
i386	#1 build successful v3.0.93 total: 4 pass: 4 idle	#1 build successful v3.4.59 total: 4 pass: 4 idle	#1 build successful v3.10.9 total: 4 pass: 4 idle	#1 build successful v3.11-rc6 total: 4 pass: 4 idle
ia64	#1 build successful v3.0.93 total: 1 pass: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
m68k	#1 build successful v3.0.93 total: 3 pass: 3 idle	#1 build successful v3.4.59 total: 3 pass: 3 idle	#1 build successful v3.10.9 total: 3 pass: 3 idle	#1 build successful v3.11-rc6 total: 3 pass: 3 idle
m68k_nommu	#1 build successful v3.0.93 total: 5 pass: 4 skipped: 1 idle	#1 build successful v3.4.59 total: 5 pass: 4 skipped: 1 idle	#1 build successful v3.10.9 total: 5 pass: 5 idle	#1 build successful v3.11-rc6 total: 5 pass: 5 idle
microblaze	#1 failed v3.0.93 total: 2 fail: 2 idle	#1 build successful v3.4.59 total: 2 pass: 2 idle	#1 build successful v3.10.9 total: 2 pass: 2 idle	#1 build successful v3.11-rc6 total: 2 pass: 2 idle
mips	#1 warnings v3.0.93 total: 12 pass: 8 skipped: 3 fail: 1 idle	#1 build successful v3.4.59 total: 12 pass: 10 skipped: 2 idle	#1 build successful v3.10.9 total: 12 pass: 12 idle	#1 build successful v3.11-rc6 total: 12 pass: 12 idle
parisc	#1 failed v3.0.93 total: 1 fail: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle



parisc64	#1 build successful v3.0.93 total: 1 pass: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
powerpc	#1 build successful v3.0.93 total: 14 pass: 13 skipped: 1 idle	#1 build successful v3.4.59 total: 14 pass: 14 idle	#1 build successful v3.10.9 total: 14 pass: 14 idle	#1 build successful v3.11-rc6 total: 14 pass: 14 idle
s390	#1 build successful v3.0.93 total: 1 pass: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
sh	#1 build successful v3.0.93 total: 3 pass: 3 idle	#1 build successful v3.4.59 total: 3 pass: 3 idle	#1 build successful v3.10.9 total: 3 pass: 3 idle	#1 build successful v3.11-rc6 total: 3 pass: 3 idle
sparc32	#1 build successful v3.0.93 total: 1 pass: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
sparc64	#1 warnings v3.0.93 total: 2 pass: 1 fail: 1 idle	#1 warnings v3.4.59 total: 2 pass: 1 fail: 1 idle	#1 build successful v3.10.9 total: 2 pass: 2 idle	#1 build successful v3.11-rc6 total: 2 pass: 2 idle
tile	#2 failed v3.0.93 total: 1 fail: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 build successful v3.11-rc6 total: 1 pass: 1 idle
x86_64	#1 build successful v3.0.93 total: 4 pass: 4 idle	#1 build successful v3.4.59 total: 4 pass: 4 idle	#1 build successful v3.10.9 total: 4 pass: 4 idle	#1 build successful v3.11-rc6 total: 4 pass: 4 idle
xtensa	#1 failed v3.0.93 total: 1 fail: 1 idle	#1 build successful v3.4.59 total: 1 pass: 1 idle	#1 build successful v3.10.9 total: 1 pass: 1 idle	#1 failed v3.11-rc6 total: 1 fail: 1 idle

qemu test results:

	3.0	3.4	3.10	master
arm	skipped	skipped	#0 failed v3.10.9 idle	#6 failed v3.11-rc6 idle
mips	skipped	#2 build successful v3.4.59 idle	#0 build successful v3.10.9 idle	#0 build successful v3.11-rc6 idle
mips64	skipped	#3 build successful v3.4.59	#2 build successful v3.10.9	#2 build successful v3.11-rc6

xtensa	failed v3.0.93 total: 1 fail: 1 idle	build successful v3.4.59 total: 1 pass: 1 idle	build successful v3.10.9 total: 1 pass: 1 idle	failed v3.11-rc6 total: 1 fail: 1 idle

qemu test results:

	3.0	3.4	3.10	master
arm	skipped	skipped	#0 failed v3.10.9 idle	#6 failed v3.11-rc6 idle
mips	skipped	#2 build successful v3.4.59 idle	#0 build successful v3.10.9 idle	#0 build successful v3.11-rc6 idle
mips64	skipped	#3 build successful v3.4.59 idle	#2 build successful v3.10.9 idle	#2 build successful v3.11-rc6 idle
ppc	#0 build successful v3.0.93 idle	#0 build successful v3.4.59 idle	#0 build successful v3.10.9 idle	#0 build successful v3.11-rc6 idle
x86	#0 build successful v3.0.93 idle	#0 build successful v3.4.59 idle	#0 build successful v3.10.9 idle	#0 build successful v3.11-rc6 idle
x86_64	#0 build successful v3.0.93 idle	#0 build successful v3.4.59 idle	#0 build successful v3.10.9 idle	#0 build successful v3.11-rc6 idle

stable repository import:

#14
build successful
idle

stable queue import:

#6
build successful
idle

References and Package repositories

- ARMv8 Debian and Ubuntu bootstrap repositories
- Embedded Debian Project
- Fedora Repo
- Fedora Epel Repo
- Kernel.org - crosstool
- Ubuntu 13.04 Install
- Buildbot
- Linux Kernel stable queue builds project
- Ktest

Q&A

Thank you.

Shuah Khan
Senior Open Source Developer – Open Source Group
Samsung Research America (Silicon Valley)
shuah.kh@samsung.com

Summary