Linaro's Android Platform

LinuxCon Europe 2011

Zach Pfeffer
Linaro Android Platform Lead

Bernhard Rosenkränzer
Android Toolchain Engineer

Linaro

Mission Statement

Linaro's Android platform is

- Open
- Continuously Improving
- Validated
- Easy-to-Use
- Fully-Enabled
- Optimized
- Built from the **best open source components** for **all member boards**

Linaro

Achieving our Mission

Release Android builds for our member's boards

- TI

  Panda, Beagle, Beagle xM
- Freescale

  iMX53
- ST-Ericsson

  Snowball
- Samsung

  Origen

All Member Boards

Pictures and more details...

Linaro

Achieving our Mission

- Produce “Android-Next” with
  - Linaro GCC 4.6
  - Linux Kernel 3.1
  - Android Platform Source 2.3.5
  - Other components (libjpeg-turbo, libpng)
  - Busybox, ffmpeg, lrzsz
- Provide a CI loop
- Accept changes through Gerrit
- Provide pre-built images

Open

- All work is submitted to its upstream
  - AOSP, kernel, GCC, vendor patches
- Instructions for building and loading builds are open and easy to use
  - Build Linaro Android from Source
  - Try a Pre-Built Build
- All builds provided without “registering”
  - http://android-build.linaro.org

Open

- Source
  - git://android.git.linaro.org
  - git://git.linaro.org
- Vibrant community
  - IRC
    - #linaro, #linaro-android on Freenode
    - The Android team will answer your questions live!
  - Mumble
  - Lists

    linaro-dev

Linaro

Continuously Improving

- Monthly milestones
  - https://launchpad.net/linaro-android/+milestone/11.06

    14 blueprints, 18 bugs
  - https://launchpad.net/linaro-android/+milestone/11.07

    12 blueprints, 7 bugs
  - https://launchpad.net/linaro-android/+milestone/11.08

    14 blueprints, 5 bugs
  - https://launchpad.net/linaro-android/+milestone/11.09

    27 blueprints, 19 bugs
  - https://launchpad.net/linaro-android/+milestone/11.10

    31 blueprints, 33 bugs (in progress)

Continuously Improving

- New release the last Thursday of the month
- Release Candidate available the Monday before
- Next cycle planning begins during release week

Linaro

Continuously Improving

- Toolchain Benchmarking
  - Linaro performs monthly benchmarking tests to help gauge toolchain:

    Android Toolchain Benchmarks

    11.09, 11.08, 11.07
  - Comparisons are made between:
    - Current Android NDK
    - Current month's 4.5 and 4.6 toolchains
    - Previous month's 4.6 toolchain

Continuously Improving

- Toolchain Benchmarking
  - Fully automated source available here

Linaro

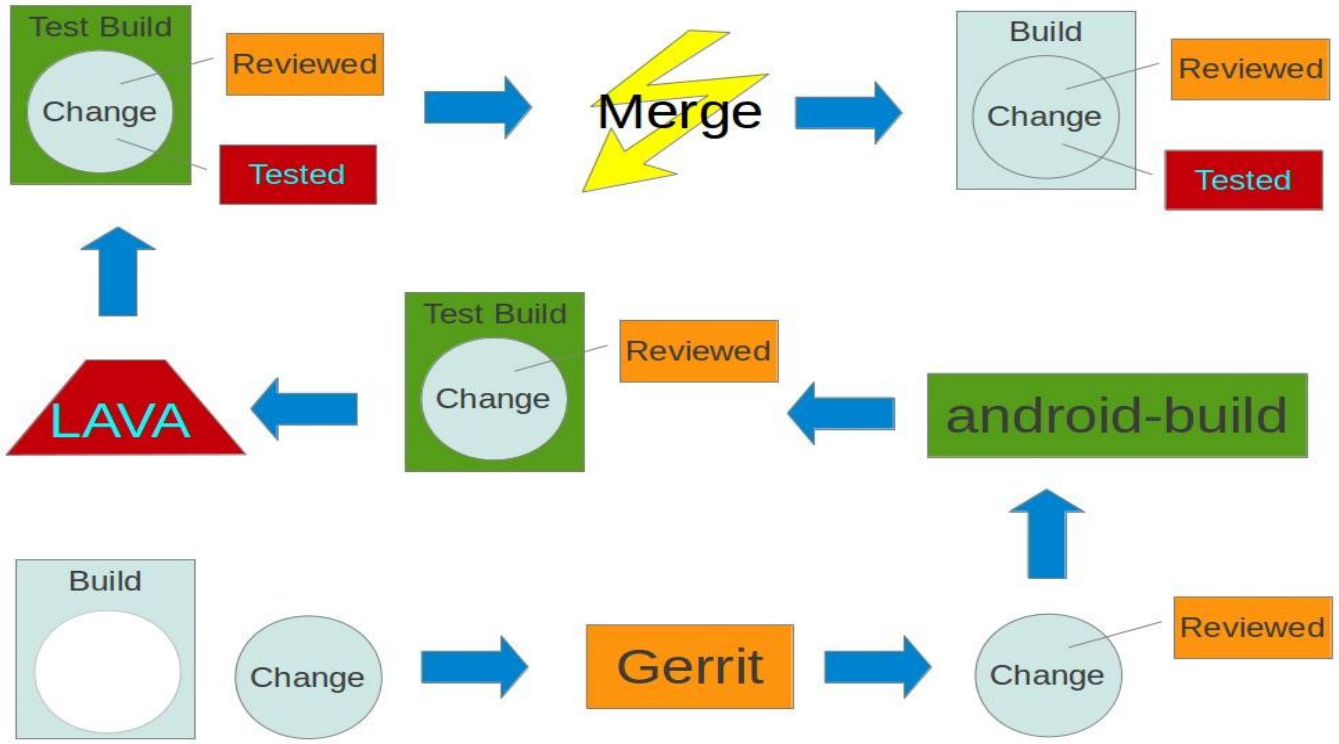
Validated

Continuous Integration

- Change Management
  - Gerrit
- Automated Regression Testing
  - LAVA (Linaro Automated Validation Architecture)
    - Monkey
    - 0xbench
    - busybox
    - mmtest
    - glmark
- Pre-merge Testing

Validated

The CI Loop



Linaro

Easy-to-Use

- Trying Android on a member board should be easy
- Building Android and programming it on a member board should be easy

Linaro

Try a Build
5 Commands and 1 minute

wget --no-check-certificate https://android-build.linaro.org/.../boot.tar.bz2

wget --no-check-certificate https://android-build.linaro.org/.../system.tar.bz2

wget --no-check-certificate https://android-build.linaro.org/.../userdata.tar.bz2

bzr branch lp:linaro-image-tools

./linaro-image-tools/linaro-android-media-create --mmc /dev/sdc
--dev panda
--system system.tar.bz2
--userdata userdata.tar.bz2
--boot boot.tar.bz2

Linaro

Make and Try a Build
7 Commands (and 1 hour)

wget –no-check-certificate
https://android-build.linaro.org/.../android-toolchain-eabi-linaro-4.6-...-linux-x86.tar.bz2

tar -jxvf android-toolchain-eabi-*.tar.bz2

repo init
-u git://android.git.linaro.org/platform/manifest.git
-b linaro_android_2.3.5
-m LEB-panda.xml

repo sync

make -j4 TARGET_PRODUCT=pandaboard
TARGET_TOOLS_PREFIX=/workspace/.../arm-eabi- boottarball systemtarball
userdatatarball

bzr branch lp:linaro-image-tools

./linaro-image-tools/linaro-android-media-create --mmc /dev/sdc
--dev panda
--system system.tar.bz2
--userdata userdata.tar.bz2
--boot boot.tar.bz2

Linaro

Validated

- QA
  - 3 build/test sets a cycle
  - Release Candidate (RC) builds enter week-long QA cycle before final builds
  - QA Tests

Linaro

Optimize

Let's make Android fast!!!

Linaro

Optimize

Switched compiler flags

- AOSP default

  -O2 -fno-strict-aliasing

- New

  -O3 -fmodulo-sched -fmodulo-sched-allow-regmoves -Wl,--hash-style=gnu -Werror=strict-aliasing

  Remove -fno-strict-aliasing

Linaro

Optimize

-O3

- Optimize for speed over code size
- Speed over compilation time
- Includes
  - -finline-functions
  - -funswitch-loops
  - -fpredictive-commoning
  - -fgcse-after-reload
  - -ftree-vectorize
  - -fipa-cp-clone

Linaro

Optimize

-fmodulo-sched -fmodulo-sched-allow-regmoves

- Improve loop scheduling
- More info

Linaro

Optimize

-Wl,--hash-style=gnu

- Improves program startup time via new hashing algorithm
- Needed to patch the AOSP dynamic linker

Linaro

Optimize

Remove -fno-strict-aliasing

- Enables better optimizations
- Requires a stricter coding style

  Example 1

  Example 2
- Most violations can be found with

  -Werror=strict-aliasing
- Cheat!

  Override with -fno-strict-aliasing

Linaro

Optimize

-ffast-math

- Dangerous
  - Breaks IEEE standards
- Useful in the skia 2D graphics and OpenGL libraries

Linaro

Optimize

Board specific optimizations

- Cortex-A9 for Panda, Origen, Snowball
- Cortex-A8 for iMX53, Beagle, Beagle xM

Linaro

Optimize

Graphite related optimizations

- -fgraphite-identity
- -floop-block
- -floop-interchage
- -floop-strip-mine
- -ftree-loop-distribution
- -ftree-loop-linear

Optimization effectiveness increases with better compiler SMP support

Linaro

Future Improvements

- OpenMP
  - API for easy multi-core parallelization
- -ftree-parallelize-loops for multi-core boards
  - requires android-eabi toolchain
- ARM vs Thumb2
- Locate detrimental -O3 code size
  - -fno-inline-functions may help
- Find more -ffast-math compatible code

Future Improvements

- binutils: -Bsymbolic-functions
  - Speed up the dynamic linker
- binutils/gcc: -flto, -fwhole-program
  - Link time optimization
- gcc: -fvisibility-inlines-hidden
  - Improve start-up time
- Move to GCC 4.7

Optimize

More info here!

Linaro

Thanks

Linaro

All Member Boards

- TI: PandaBoard
  - OMAP4430
    - Dual Core 1 Gz Cortex-A9
  - 1 GB LPDDR2
  - 1080p@30fps
    - Encode/Decode H.264, MPEG-4, H.263
    - Decode VP6, VP7
  - DSP, IVA-HD, 2 Cortex-M3 Ducati, Audio back-end (ABE), Imaging Subsystem (ISS), SGX, Image Signal Processor (ISP), still image co-processor (SIMCOP)
  - JTAG, UART, HDMI, DVI-D, Camera Connector, USB OTG/HOST, Microphone Jack, Headphone Jack, 10/100 Ethernet

All Member Boards

- TI: BeagleBoard
  - OMAP3530
    - 720 Mhz Cortex-A8
  - 110 MHz SGX
  - 256 MB NAND, 256MB DDR @ 166 MHz
  - JTAG, UART, DVI-D, USB OTG/HOST, Microphone Jack, Headphone Jack

http://beagleboard.org/static/BBSRM_latest.pdf

http://beagleboard.org/static/BBSRM_latest.pdf

All Member Boards

- TI: BeagleBoard xM
  - DM373
    - 1 GHz Cortex-A8
  - 200 MHz SGX
  - 512 MB DDR @ 166MHz
  - JTAG, UART, DVI-D, USB OTG/HOST, Microphone Jack, Headphone Jack, 10/100 Ethernet

http://beagleboard.org/static/BBSRM_latest.pdf

http://beagleboard.org/static/BBSRM_latest.pdf

All Member Boards

- Freescale: i.MX53 Quick Start
  - i.MX53
    - 1 GHz ARM Cortex™-A8
  - 1 GB DDR3
  - SGTL5000 Audio Codec
  - HDMI, camera connector SATA, 10/100 Ethernet, Microphone Jack, Headphone Jack
  - 3D Accelerometer
  - I2C, SSI, SPI

All Member Boards

- ST-Ericsson: Snowball
  - Nova A9500
    - Dual Cortex 1 GHz Cortex-A9 with Advanced SIMD (Neon) Extensions
  - Mali-400 GPU
  - 1080p
  - 1 GB of DDR2
  - HDMI, WLAN, Bluetooth, USB OTG, 10/100 Ethernet
  - 3D Accelerometer, 3D Magnetometer, 3D Gyroscope, Barometer

All Member Boards

- Samsung: ‘Origen’ low cost development board
  - Exynos4210
    - Dual Core 1 GHz Cortex-A9 with Advanced SIMD (Neon) Extensions
  - Mali400 MP4 GPU
  - 1080p@30fps Hardware Decode of
    - MPEG-4/H.263/H.264, MPEG-2/VC1/Xvi
  - 1GB of High Bandwidth DDR3
  - HDMI, WLAN, Bluetooth, Camera Connector, USB 2.0 OTG/HOST, SD/MMC
  - 8ch, I2C, SATA, PCI Express

http://www.linaro.org/assets/PDF/LinaroOrigenLowCostBoard.pdf

http://www.linaro.org/assets/PDF/LinaroOrigenLowCostBoard.pdf

Some Interesting Results

- 0xbench 3-D
  - Across all boards
  - Across all builds

Linaro

Panda 0xbench 3-D Test Result

Build	Toolchain	Kernel	Android
11.04	AOSP 4.4	2.6.38.3	2.3.3
11.05	AOSP 4.4	2.6.35.7	2.3.3
11.06	Linaro 4.5	2.6.38.7	2.3.4
11.07	Linaro 4.6	3.0.0	2.3.4
11.08	Linaro 4.6	3.0.0	2.3.5
11.09	Linaro 4.6	3.0.3	2.3.5
11.10	Linaro 4.6	3.0.4	2.3.5

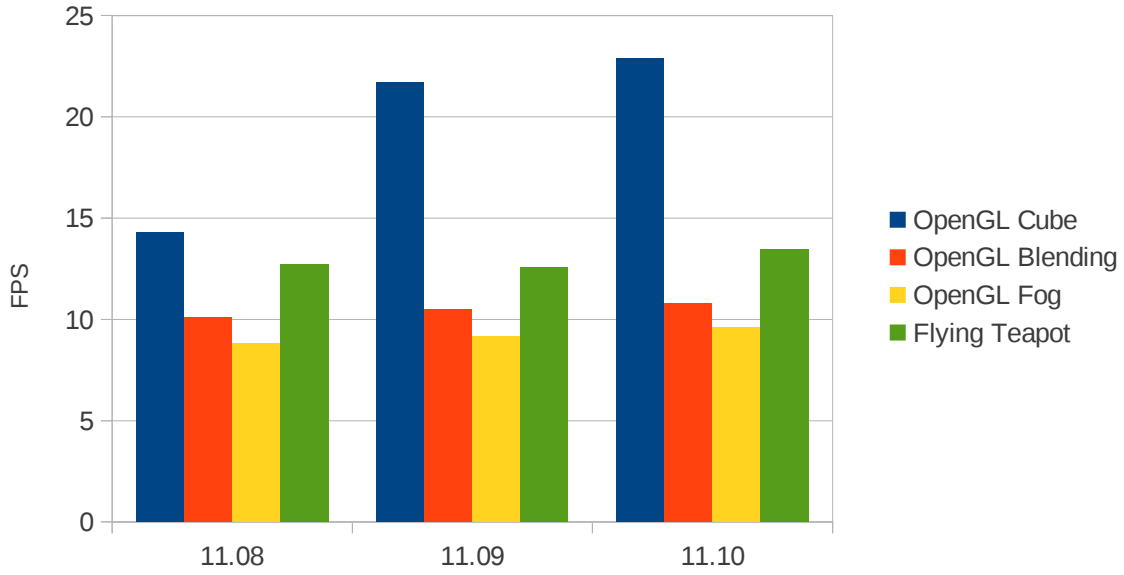
Linaro

Panda 0xbench 3-D Test Result

Build	Toolchain	Kernel	Android
11.04	AOSP 4.4	2.6.38.3	2.3.3
11.05	AOSP 4.4	2.6.35.7	2.3.3
11.06	Linaro 4.5	2.6.38.7	2.3.4
11.07	Linaro 4.6	3.0.0	2.3.4
11.08	Linaro 4.6	3.0.0	2.3.5
11.09	Linaro 4.6	3.0.3	2.3.5
11.10	Linaro 4.6	3.0.4	2.3.5

Linaro

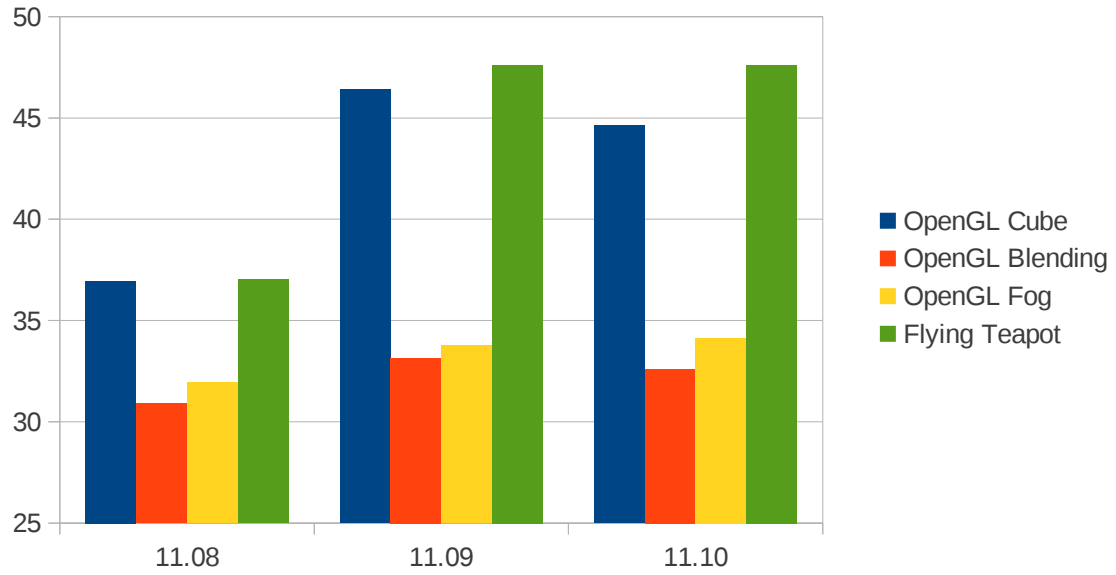
iMX53 0xbench 3-D Test Result



Build	Toolchain	Kernel	Android
11.08	Linaro 4.6	2.6.38.7	2.3.5
11.09	Linaro 4.6	2.6.38.7	2.3.5
11.10	Linaro 4.6	2.6.38.7	2.3.5

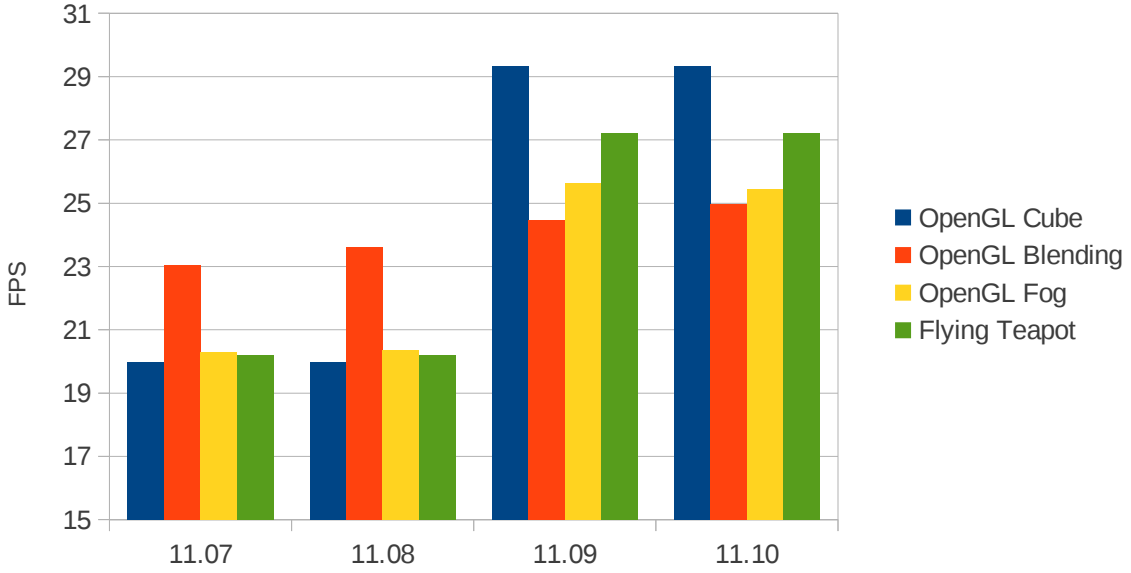
Linaro

Origen 0xbench 3-D Test Result



Build	Toolchain	Kernel	Android
11.08	Linaro 4.6	3.0.3	2.3.5
11.09	Linaro 4.6	3.0.3	2.3.5
11.10	Linaro 4.6	3.0.4	2.3.5

Snowball 0xbench 3-D Test Result



Build	Toolchain	Kernel	Android
11.07	Linaro 4.6	3.0.0-rc7	2.3.4
11.08	Linaro 4.6	3.0.0-rc7	2.3.5
11.09	Linaro 4.6	3.0.0-rc7	2.3.5
11.10	Linaro 4.6	3.0.0-rc7	2.3.5

Linaro

Results

- Slowdowns
  - TARGET_CPU_SMP increases locking overhead
  - GCC 4.6 performance regressions
  - Using Linaro Android build parameterization to track down regressions

Linaro's Android Platform

LinuxCon Europe 2011

Zach Pfeffer
Linaro Android Platform Lead

Bernhard Rosenkränzer
Android Toolchain Engineer

Linaro

Mission Statement

Linaro's Android platform is

- Open
- Continuously Improving
- Validated
- Easy-to-Use
- Fully-Enabled
- Optimized
- Built from the **best open source components** for **all member boards**

Linaro

Achieving our Mission

Release Android builds for our member's boards

- TI
  - Panda, Beagle, Beagle xM
- Freescale
  - iMX53
- ST-Ericsson
  - Snowball
- Samsung
  - Origen

Linaro

All Member Boards

Pictures and more details...

Linaro

Achieving our Mission

- Produce “Android-Next” with
  - Linaro GCC 4.6
  - Linux Kernel 3.1
  - Android Platform Source 2.3.5
  - Other components (libjpeg-turbo, libpng)
  - Busybox, ffmpeg, lrzsz
- Provide a CI loop
- Accept changes through Gerrit
- Provide pre-built images

Linaro

Open

- All work is submitted to its upstream
  - AOSP, kernel, GCC, vendor patches
- Instructions for building and loading builds are open and easy to use
  - Build Linaro Android from Source
  - Try a Pre-Built Build
- All builds provided without “registering”
  - http://android-build.linaro.org

Linaro

Open

- Source
  - git://android.git.linaro.org
  - git://git.linaro.org
- Vibrant community
  - IRC
    - #linaro, #linaro-android on Freenode
    - The Android team will answer your questions live!
  - Mumble
  - Lists

    linaro-dev

Linaro

Continuously Improving

- Monthly milestones
  - https://launchpad.net/linaro-android/+milestone/11.06
    14 blueprints, 18 bugs
  - https://launchpad.net/linaro-android/+milestone/11.07
    12 blueprints, 7 bugs
  - https://launchpad.net/linaro-android/+milestone/11.08
    14 blueprints, 5 bugs
  - https://launchpad.net/linaro-android/+milestone/11.09
    27 blueprints, 19 bugs
  - https://launchpad.net/linaro-android/+milestone/11.10
    31 blueprints, 33 bugs (in progress)

Continuously Improving

- New release the last Thursday of the month
- Release Candidate available the Monday before
- Next cycle planning begins during release week

Continuously Improving

- Toolchain Benchmarking
  - Linaro performs monthly benchmarking tests to help gauge toolchain:

    Android Toolchain Benchmarks

    11.09, 11.08, 11.07
  - Comparisons are made between:
    - Current Android NDK
    - Current month's 4.5 and 4.6 toolchains
    - Previous month's 4.6 toolchain

Linaro

Continuously Improving

- Toolchain Benchmarking
  - Fully automated source available here

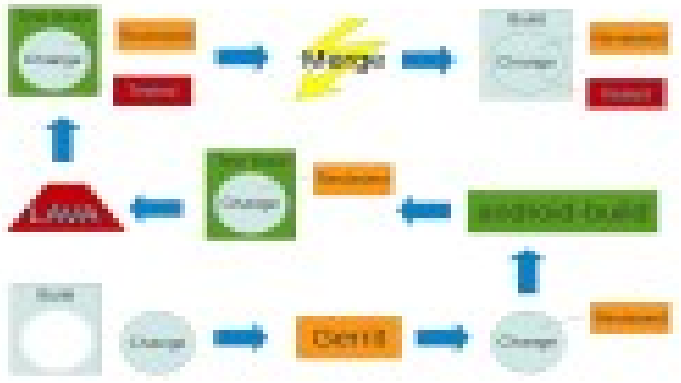
Validated

Continuous Integration

- Change Management
  - Gerrit
- Automated Regression Testing
  - LAVA (Linaro Automated Validation Architecture)
    - Monkey
    - 0xbench
    - busybox
    - mmtest
    - glmark
- Pre-merge Testing

Validated

The CI Loop



Linaro

Easy-to-Use

- Trying Android on a member board should be easy
- Building Android and programming it on a member board should be easy

Linaro

Try a Build
5 Commands and 1 minute

wget --no-check-certificate https://android-build.linaro.org/.../boot.tar.bz2

wget --no-check-certificate https://android-build.linaro.org/.../system.tar.bz2

wget --no-check-certificate https://android-build.linaro.org/.../userdata.tar.bz2

bzr branch lp:linaro-image-tools

./linaro-image-tools/linaro-android-media-create --mmc /dev/sdc
--dev panda
--system system.tar.bz2
--userdata userdata.tar.bz2
--boot boot.tar.bz2

Linaro

Make and Try a Build
7 Commands (and 1 hour)

wget –no-check-certificate
https://android-build.linaro.org/.../android-toolchain-eabi-linaro-4.6-...-linux-x86.tar.bz2

tar -jxvf android-toolchain-eabi-*.tar.bz2

repo init
-u git://android.git.linaro.org/platform/manifest.git
-b linaro_android_2.3.5
-m LEB-panda.xml

repo sync

make -j4 TARGET_PRODUCT=pandaboard
TARGET_TOOLS_PREFIX=/workspace/.../arm-eabi- boottarball systemtarball
userdatatarball

bzr branch lp:linaro-image-tools

./linaro-image-tools/linaro-android-media-create --mmc /dev/sdc
--dev panda
--system system.tar.bz2
--userdata userdata.tar.bz2
--boot boot.tar.bz2

Linaro

Validated

- QA
  - 3 build/test sets a cycle
  - Release Candidate (RC) builds enter week-long QA cycle before final builds
  - QA Tests

Linaro

Optimize

Let's make Android fast!!!

Optimize

Switched compiler flags

- AOSP default

  -O2 -fno-strict-aliasing

- New

  -O3 -fmodulo-sched -fmodulo-sched-allow-regmoves -Wl,--hash-style=gnu -Werror=strict-aliasing

  Remove -fno-strict-aliasing

Linaro

Optimize

-O3

- Optimize for speed over code size
- Speed over compilation time
- Includes
  - -finline-functions
  - -funswitch-loops
  - -fpredictive-commoning
  - -fgcse-after-reload
  - -ftree-vectorize
  - -fipa-cp-clone

Optimize

-fmodulo-sched -fmodulo-sched-allow-regmoves

- Improve loop scheduling
- More info

Optimize

-Wl,--hash-style=gnu

- Improves program startup time via new hashing algorithm
- Needed to patch the AOSP dynamic linker

Optimize

Remove -fno-strict-aliasing

- Enables better optimizations
- Requires a stricter coding style
  - Example 1
  - Example 2
- Most violations can be found with
  - -Werror=strict-aliasing
- Cheat!
  - Override with -fno-strict-aliasing

Optimize

-ffast-math

- Dangerous
  - Breaks IEEE standards
- Useful in the skia 2D graphics and OpenGL libraries

Optimize

Board specific optimizations

- Cortex-A9 for Panda, Origen, Snowball
- Cortex-A8 for iMX53, Beagle, Beagle xM

Optimize

Graphite related optimizations

- -fgraphite-identity
- -floop-block
- -floop-interchage
- -floop-strip-mine
- -ftree-loop-distribution
- -ftree-loop-linear

Optimization effectiveness increases with better compiler SMP support

Future Improvements

- OpenMP
  - API for easy multi-core parallelization
- -ftree-parallelize-loops for multi-core boards
  - requires android-eabi toolchain
- ARM vs Thumb2
- Locate detrimental -O3 code size
  - -fno-inline-functions may help
- Find more -ffast-math compatible code

Future Improvements

- binutils: -Bsymbolic-functions
  - Speed up the dynamic linker
- binutils/gcc: -flto, -fwhole-program
  - Link time optimization
- gcc: -fvisibility-inlines-hidden
  - Improve start-up time
- Move to GCC 4.7

Optimize

More info here!

Thanks

Linaro

All Member Boards

- TI: PandaBoard
  - OMAP4430
    - Dual Core 1 Gz Cortex-A9
  - 1 GB LPDDR2
  - 1080p@30fps
    - Encode/Decode H.264, MPEG-4, H.263
    - Decode VP6, VP7
  - DSP, IVA-HD, 2 Cortex-M3 Ducati, Audio back-end (ABE), Imaging Subsystem (ISS), SGX, Image Signal Processor (ISP), still image co-processor (SIMCOP)
  - JTAG, UART, HDMI, DVI-D, Camera Connector, USB OTG/HOST, Microphone Jack, Headphone Jack, 10/100 Ethernet

All Member Boards

- TI: BeagleBoard
  - OMAP3530
    - 720 Mhz Cortex-A8
  - 110 MHz SGX
  - 256 MB NAND, 256MB DDR @ 166 MHz
  - JTAG, UART, DVI-D, USB OTG/HOST, Microphone Jack, Headphone Jack

http://beagleboard.org/static/BBSRM_latest.pdf

http://beagleboard.org/static/BBSRM_latest.pdf

All Member Boards

- TI: BeagleBoard xM
  - DM373
    - 1 GHz Cortex-A8
  - 200 MHz SGX
  - 512 MB DDR @ 166MHz
  - JTAG, UART, DVI-D, USB OTG/HOST, Microphone Jack, Headphone Jack, 10/100 Ethernet

http://beagleboard.org/static/BBSRM_latest.pdf

http://beagleboard.org/static/BBSRM_latest.pdf

Linaro

All Member Boards

- Freescale: i.MX53 Quick Start
  - i.MX53
    - 1 GHz ARM Cortex™-A8
  - 1 GB DDR3
  - SGTL5000 Audio Codec
  - HDMI, camera connector SATA, 10/100 Ethernet, Microphone Jack, Headphone Jack
  - 3D Accelerometer
  - I2C, SSI, SPI

Linaro

All Member Boards

- ST-Ericsson: Snowball
  - Nova A9500
    - Dual Cortex 1 GHz Cortex-A9 with Advanced SIMD (Neon) Extensions
  - Mali-400 GPU
  - 1080p
  - 1 GB of DDR2
  - HDMI, WLAN, Bluetooth, USB OTG, 10/100 Ethernet
  - 3D Accelerometer, 3D Magnetometer, 3D Gyroscope, Barometer

All Member Boards

- Samsung: ‘Origen’ low cost development board
  - Exynos4210
    - Dual Core 1 GHz Cortex-A9 with Advanced SIMD (Neon) Extensions
  - Mali400 MP4 GPU
  - 1080p@30fps Hardware Decode of
    - MPEG-4/H.263/H.264, MPEG-2/VC1/Xvi
  - 1GB of High Bandwidth DDR3
  - HDMI, WLAN, Bluetooth, Camera Connector, USB 2.0 OTG/HOST, SD/MMC
  - 8ch, I2C, SATA, PCI Express

http://www.linaro.org/assets/PDF/LinaroOrigenLowCostBoard.pdf

http://www.linaro.org/assets/PDF/LinaroOrigenLowCostBoard.pdf

Linaro

Some Interesting Results

- 0xbench 3-D
  - Across all boards
  - Across all builds

Linaro

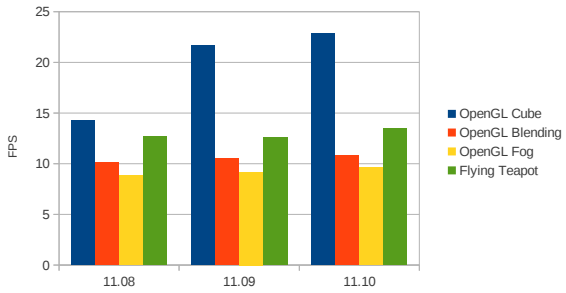
Panda 0xbench 3-D Test Result

Build	Toolchain	Kernel	Android
11.04	AOSP 4.4	2.6.38.3	2.3.3
11.05	AOSP 4.4	2.6.35.7	2.3.3
11.06	Linaro 4.5	2.6.38.7	2.3.4
11.07	Linaro 4.6	3.0.0	2.3.4
11.08	Linaro 4.6	3.0.0	2.3.5
11.09	Linaro 4.6	3.0.3	2.3.5
11.10	Linaro 4.6	3.0.4	2.3.5

Panda 0xbench 3-D Test Result

Build	Toolchain	Kernel	Android
11.04	AOSP 4.4	2.6.38.3	2.3.3
11.05	AOSP 4.4	2.6.35.7	2.3.3
11.06	Linaro 4.5	2.6.38.7	2.3.4
11.07	Linaro 4.6	3.0.0	2.3.4
11.08	Linaro 4.6	3.0.0	2.3.5
11.09	Linaro 4.6	3.0.3	2.3.5
11.10	Linaro 4.6	3.0.4	2.3.5

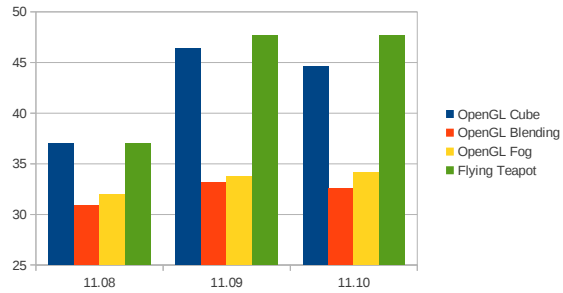
iMX53 0xbench 3-D Test Result



Build	Toolchain	Kernel	Android
11.08	Linaro 4.6	2.6.38.7	2.3.5
11.09	Linaro 4.6	2.6.38.7	2.3.5
11.10	Linaro 4.6	2.6.38.7	2.3.5

Linaro

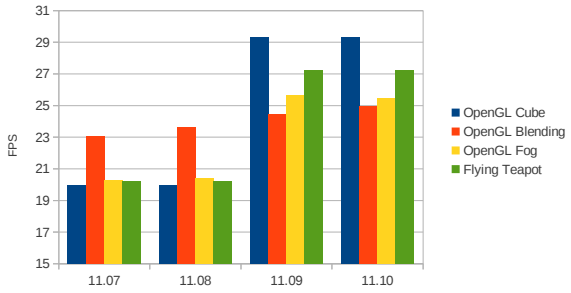
Origen 0xbench 3-D Test Result



Build	Toolchain	Kernel	Android
11.08	Linaro 4.6	3.0.3	2.3.5
11.09	Linaro 4.6	3.0.3	2.3.5
11.10	Linaro 4.6	3.0.4	2.3.5

Linaro

Snowball 0xbench 3-D Test Result



Build	Toolchain	Kernel	Android
11.07	Linaro 4.6	3.0.0-rc7	2.3.4
11.08	Linaro 4.6	3.0.0-rc7	2.3.5
11.09	Linaro 4.6	3.0.0-rc7	2.3.5
11.10	Linaro 4.6	3.0.0-rc7	2.3.5

Linaro

Results

- Slowdowns
  - TARGET_CPU_SMP increases locking overhead
  - GCC 4.6 performance regressions
  - Using Linaro Android build parameterization to track down regressions