Rebuilding desktop distributions for small devices: Handhelds Mojo

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The problem...

Mobile device

- Maemo Linux, ~700 packages
- Scratchbox build environment

Development Laptop

- Ubuntu Gutsy Linux, ~12,000 packages
- Native build environment

The mobile device has a limited “off-the-shelf” environment

What we'd like

A distribution for mobile & embedded devices with:

- Large numbers of up-to-date binary packages
- Well-defined releases with security and bug fixes
- Code that takes full advantage of the processor
- Easily interoperates with the developer's desktop

We don't want to spend a lot of time
building and maintaining this…

Why existing solutions fall short...

Debian

- Pro: Large number of packages (>10,000)
- Con: Not optimized for hardware, infrequent stable releases

Open Embedded

- Pro: Good optimization for hardware, interesting GUI work
- Con: Small number of packages (~1680), doesn't match desktop

Maemo

- Pro: Good optimization for hardware, GUI
- Con: Small number of packages (~700), Scratchbox can be tricky, *really* doesn't match desktop

The Mojo approach

Strategy

1. Build standard desktop distributions for small devices
2. Modify the *minimum* number of packages necessary to compile
3. Compile each distribution once for each hardware architecture

Start with

- Ubuntu distributions and updates
- Latest ARM instructions set

Mojo distribution naming scheme

Ubuntu	Mojo
7.04 Feisty Fawn	Frisky Firedrake
7.10 Gutsy Gibbon	Grumpy Griffin
8.04 Hardy Heron	Hasty Hippogriff

In the future we'd like to extend this to Debian and other distributions

The rest of the talk...

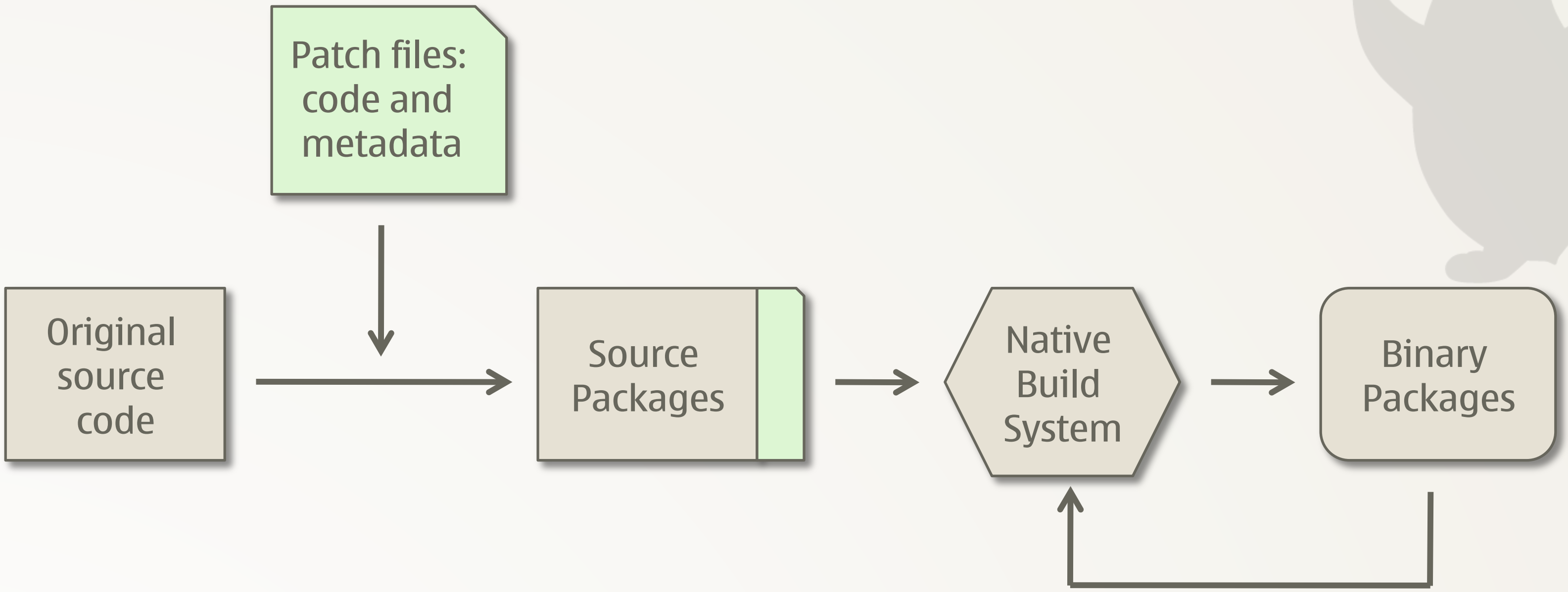
Critical choices and challenges

- The build process – getting a stable place to stand
- Matching the toolchain
- Build machines – handling the "native" problem
- Naming of names – Debian architecture

Current status

- State of the distributions
- Using the distributions

Desktop distribution build process



Key points

1. The build system is running its own packages. Iteration required!
2. The build system runs on *native* hardware
3. The toolchain is intrinsic to the distribution and gets compiled along with all of the other packages

Challenge #1: A stable place to stand

A Debian-style build system is a moving target

- The build system relies on having a large number of installed binary packages
- The binary packages have to be (mostly) compatible with what you are building
- The system is inherently incremental: you build packages, install them, build the next set, install them, ...

Where can we start? (A classic "chicken-and-egg" problem)

The first challenge: EABI

EABI vs. OABI

Changes in the ARM Application Binary Interface

- Floating point handling
- Structure alignment
- New Linux syscall interface (can co-exist with old)

Supported by:

- ARMv4T and higher (ARMv4 with some hacks)
- gcc 4.1.0 (4.1.1 for ARMv4T), binutils 2.16.92, glibc 2.4
- Linux kernel 2.6.16+

EABI and OABI do not interoperate

Building a distribution on EABI

First, you need an EABI distribution!

- Debian “ARM” = OABI
- Debian “ARMEL” & “ARMEB” = EABI

Early in 2007 ADS released a version of Debian compiled with EABI

- Generated from an Open Embedded EABI distribution

First pass on Debian ARM machine
with ADS-based chroot image

Challenge #2: Matching the toolchain

A toolchain is the combination of:

- C compiler (gcc)
- Linking and object tools (binutils)
- Standard C libraries (glibc)

A “good” toolchain is one that passes a most of its test suites.

- ARM is not the most popular architecture: building a “good” ARM toolchain requires a fair bit of testing and patching
- Toolchains depend in surprising ways on all sorts of other packages (e.g. Perl, bash, ...)
- Number of errors from test suite decreases as you iterate; for example, for gcc 4.1.2, we went from 11 to 5 to 0 with each iteration.

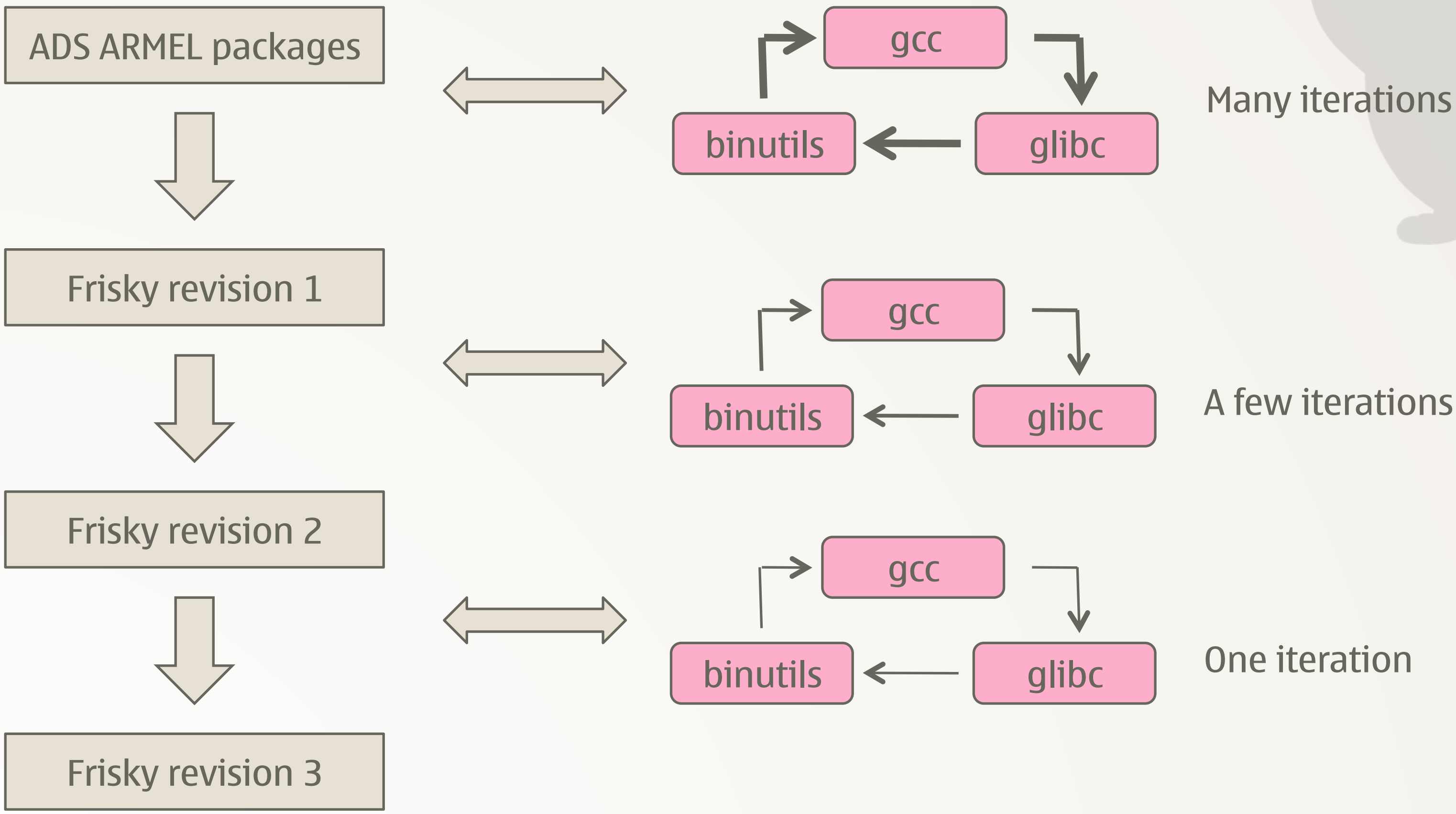
The toolchain in Ubuntu

	gcc	binutils	libc6
Dapper	4.0.3-1	2.16.1.cvs2006...	2.3.6-0ubuntu20
Edgy	4.1.1-6ubuntu3	2.17-1ubuntu1	2.4-1ubuntu12
Feisty	4.1.2-1ubuntu1	2.17.20070103...	2.5-0ubuntu4
Gutsy	4.1.2-9ubuntu2	2.18-0ubuntu3	2.6.1-1ubuntu9
Hardy	4.2.3-1ubuntu3	2.18.1~cvs2008...	2.7-10ubuntu3

Native ARM toolchains can be a bit of a problem...

- glibc <= 2.5 and binutils <= 2.17 had ARM C++ errors
- A surprisingly large number of packages affect the toolchain
- EABI supported by: gcc 4.1.0 (4.1.1 for ARMv4T), binutils 2.16.92, glibc 2.4

Bootstrapping from ADS Debian Etch



Challenge #3: Handling the “native” problem

Desktop distributions are not cross-built: you need an ARM-based machine to build an ARM-based distribution

- Option #1: Fundamentally change the build system using something like Scratchbox. We couldn’t find a good way to do this without a lot of source package modifications
- Option #2: Create a build cluster of ARM-based machines.

Remember: One goal is the absolute minimal number of modifications to existing source packages

Options for “native” build machines

Pure ARM	QEMU-ARM Chroot	QEMU-SYSTEM-ARM
ARM Distribution	ARM Distribution	ARM Distribution
ARM Kernel	ARM Chroot	ARM Kernel
ARM Hardware	QEMU-ARM	Virtual ARM Hardware
	x86 Distribution	QEMU-SYSTEM-ARM
	x86 Kernel + binfmt	x86 Distribution
	x86 Hardware	x86 Kernel
		x86 Hardware

In early 2007 we looked at the time and cost to build a sufficiently fast cluster

2007 cluster: Native ARM build machines

20 home-built 1U ARM boxes

- 600 MHz Intel 80219 (ARMv5)
- 256 MB DRAM / 160 GB disk
- Ethernet, USB
- 593 BogoMIPS
- gcc-4.1 compile and test suite: 32 hours

4 days to build
Frisky Main

2008 cluster: QEMU virtual ARM build machines

5 Dell PWS 390 (10 virtual machines)

- 2.66 GHz Intel Core2
- 2 GB DRAM / 80 GB disk
- QEMU 0.9.1, Versatile PB
- 650 BogoMIPS
- gcc-4.1 compile test: 25 hours

25% faster machines
than original cluster

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Challenge #4: Debian architecture names

Debian ARM architecture schemes

• arm	ARMv3 + hard float	*package.arm.deb*
• armel	ARMv4T, EABI, little-endian	*package.armel.deb*
• armeb	ARMv4T, EABI, big-endian	*package.armeb.deb*

The "arm/armel/armeb" architecture information appears in the *Architecture* field of the Debian control file. Changing means changing every source file....

We'd like to optimize our code for the *exact* processor type, not a generic one

Solutions to the naming problem

Option #1: Add new architectures

armv5el	ARMv5, EABI, little-endian (soft float)
armv5teb-hard	ARMv5, thumb, EABI, big-endian, hard float
armv6elvfp	ARMv6, EABI, little-endian, vector floating point

This requires modifying *each* source package once for *every* architecture we compile

Option #2: Don’t follow Debian model...

Our solution: Differentiate by *feed*

CLASSIC / ubuntu / dists / feisty / main / binary-i386, binary-arm, binary-sparc, source ...
/ universe / binary-i386, ...
/ feisty-updates / main / binary-i386...
/ gutsy...
/ pool...

MOJO / frisky-armv5el / dists / frisky / main / binary-arm, source
/ universe...
/ frisky-updates...
/ pool...
/ frisky-armv6el-vfp / dists / frisky / main / binary-arm, source
/ universe...
/ frisky-source / dists / frisky / main / source

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The implications of differentiating by feed

- No source packages need to be changed – we just use the “arm” architecture
- Debian systems use the default settings of the toolchain – so we need to modify the toolchain once for each architecture target
- The source packages end up in three different directories:
  1. Replicated copy from original distribution
  2. Common directory of modified source packages (“frisky-source”)
  3. Architecture-specific directory (“frisky-armv5el”)
- We’re acting against explicit Debian policy. This is a subject for discussion with Debian. Is there a better solution?

Where are we?

Critical choices and challenges

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Current state

frisky-armv5el

- Main, Universe "largely" complete and stable
- Updates and security in progress

frisky-armv6el-vfp

- Compiling Main

grumpy-armv5el

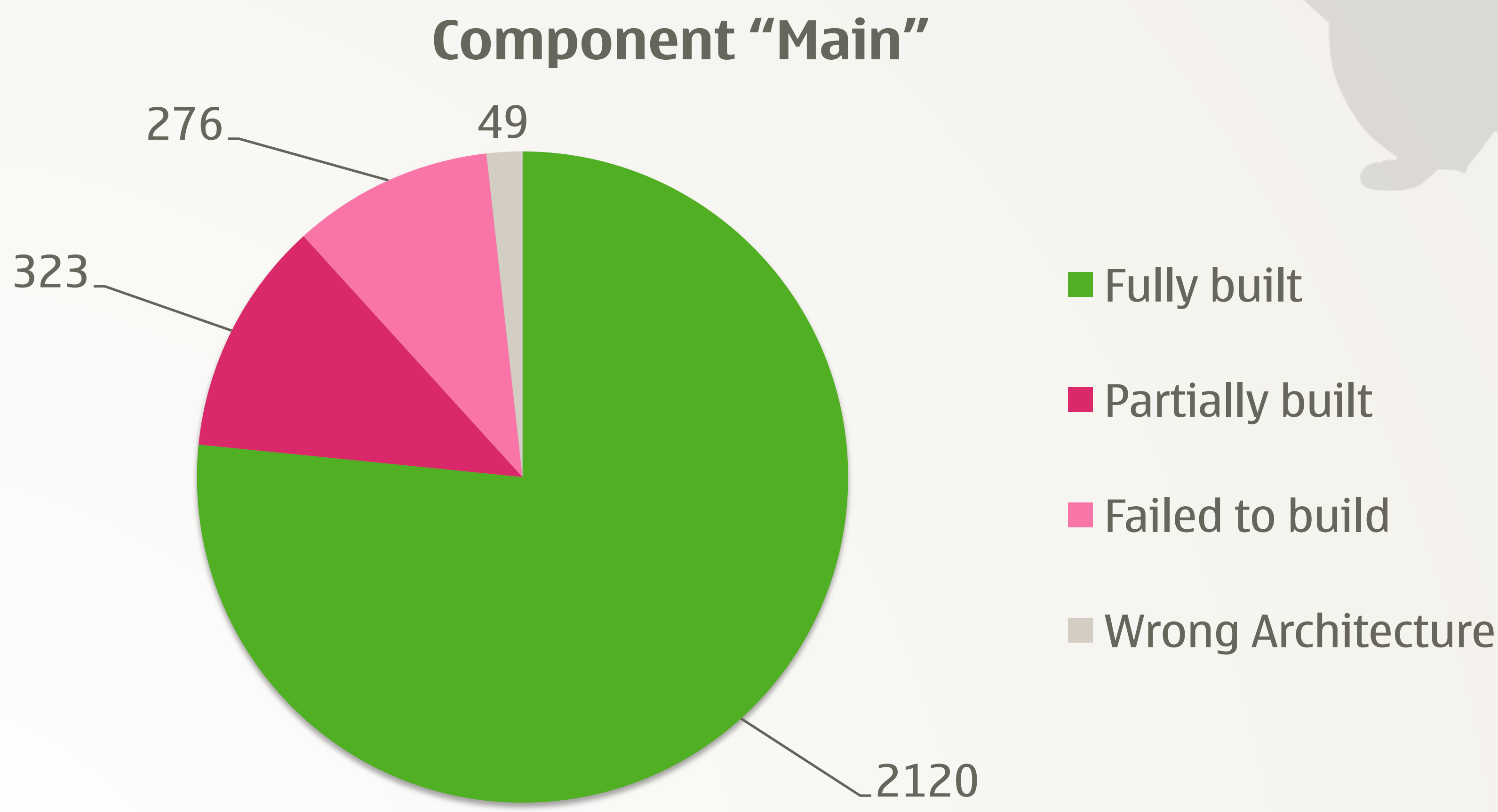
- Main (first round) complete

Frisky: What is "largely" complete?

	Feisty source packages	Modified source packages	Feisty binary-i386 packages	Frisky binary-arm packages
main	2768	61	5099	4265 (85%)
restricted	5	0	33	0
universe	9596	1	15642	12081 (77%)
multiverse	399	0	595	0

Build time is ~4 days on native ARM cluster for Main, ~10 days for Universe

What happened to the source packages?



What have we modified?

Added one package

- handhelds-keyring: For package signatures

Modified 61 packages:

- Most are just a few lines of code fixing dependencies or ARM-specific bugs
- Five packages (tar, tzdata, gzip, coreutils, docbook2x) pulled from later distributions to match glibc2.6
- A few larger patches to work around ARM issues. E.g., qt-x11-free XML parsing bug needed removal of '\n\r' at end of .ui files.

What packages haven't built?

- The ARM machines have trouble with large C++ libraries. GCC can crash on the linking stage with an out-of-memory error (KDE is a particular challenge)
- We don't have a Java or Mono for ARM
- A number of math libraries depend on the g77 Fortran compiler
- Documentation packages (they have remarkable dependencies)

It's a bit of a hobby to continue to patch and fix packages to fill out the distribution

How can you try this out?

Option #1: Put it on your desktop in a virtual machine

- A pre-built file system is available and works with the QEMU VersatilePB emulator
- The netboot installer “mostly” works and will allow a remote installation of Frisky onto a clean filesystem.

Option #2: Use it on an existing device

- N800 demonstration

Final thoughts: What we're doing now

- Automating the security and bug-fix feeds
- Patching source packages that failed to build
- Submitting patches back to Debian and Ubuntu
- Starting up new distributions
- Filling out the architecture
- Fixing up the installers
- ...and *using* these distributions, of course...

http://mojo.handhelds.org

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