

The World Leader in High Performance Signal Processing Solutions



uClinux on a \$5 Processor



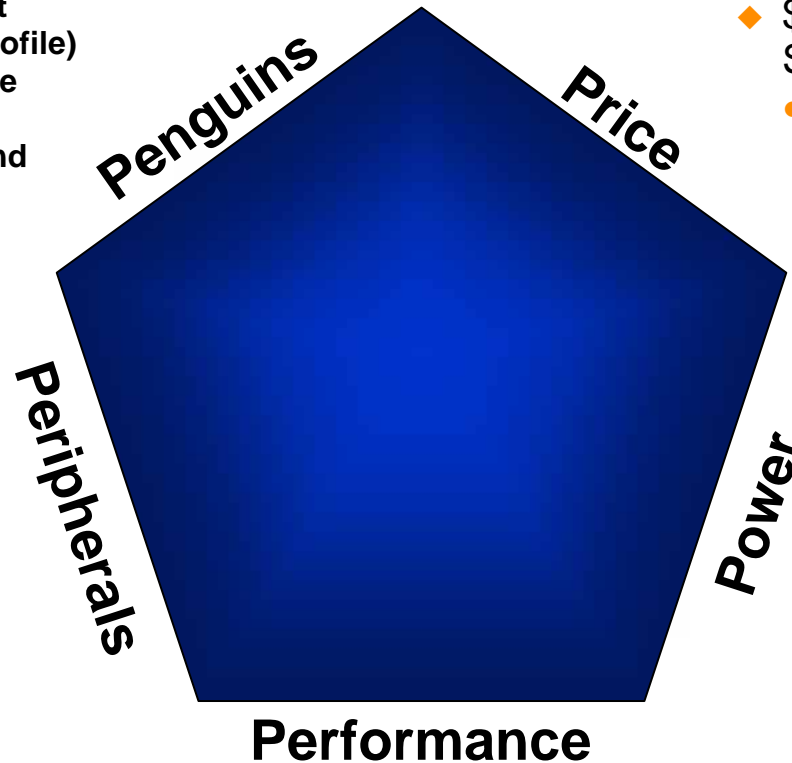
March 2008



5 Processor P's

- ◆ uClinux 2.6.22 kernel
- ◆ Open Source Development Tools (gcc, gdb, kgdb, oprofile)
- ◆ Thousands of Open Source Applications
- ◆ Linux Networking Stack and Protocols

- ◆ 10/100 Enet MAC
- ◆ CAN
- ◆ UART
- ◆ High Speed Serial Ports
- ◆ Drivers for External:
 - Various Codecs
 - ADC, DAC (SPI)
 - CMOS Imagers
 - Compact Flash (IDE, 802.11b)
 - IDE (Hard Drive, CD-ROM, DVD)
 - NOR, NAND Flash (YAFFS, JFFS2)



- ◆ Up to 600MHz:
- ◆ 992.87 BogoMIPS @ 500MHz
- ◆ Ethernet Performance : Line Rate

- ◆ \$4.95 @ 10k units for BF531
- ◆ \$200 for complete Open Source Development Suite
 - Target, Toolchain, and kernel

- ◆ 265mW Core, 600 MHz @ 1.2V (BF537)
- ◆ uClinux Power Management Drivers, for Dynamic voltage/clock control





What's so special about uClinux?

- ◆ **Source code freely available**
- ◆ **Robust and reliable**
- ◆ **Modular, configurable, scalable**
- ◆ **Superb support for networking and Internet**
- ◆ **Supports a large number of devices, file systems, and networking protocols**
- ◆ **Large pool of skilled developers and documentation**
- ◆ **Upgrades and new features are constantly being added, tested and refined by a large community of programmers and users**
- ◆ **Large number of applications and tools exist which require little to no porting effort**
- ◆ **Portable**

No runtime licenses

μClinux™



Downsides of using a kernel

- ◆ **Memory consumption**
- ◆ **Boot Time**
- ◆ **Interrupt Latency**



Embedded Linux

◆ Embedded Linux:

- Porting the Linux kernel to run on a particular CPU and board which to be used in an embedded device (cell phones, PDAs, other consumer electronics..)

◆ uClinux

- ◆ One type of Embedded Linux, “Microcontroller Linux”
- ◆ Derivative of the Linux kernel for processors without an MMU
- ◆ uClinux kernel tree maintained at: www.uclinux.org
- ◆ Blackfin port maintained at: <http://www.blackfin.uclinux.org>

◆ Considerations / Trade-offs:

- **The Blackfin Processor does not have a full-fledged MMU. (Virtual Memory Management)**
 - ◆ *Normally Unix uses the MMU to allocate different physical memory areas to identical virtual memory addresses.*
 - ◆ *uClinux removes the MMU requirement by implementing a flat memory model (a 1-to-1 virtual-to-physical mapping)*
 - ◆ *The key feature of uClinux is the ability to look and feel almost like a MMU-based system.*
- **No fork() system call – vfork instead()**





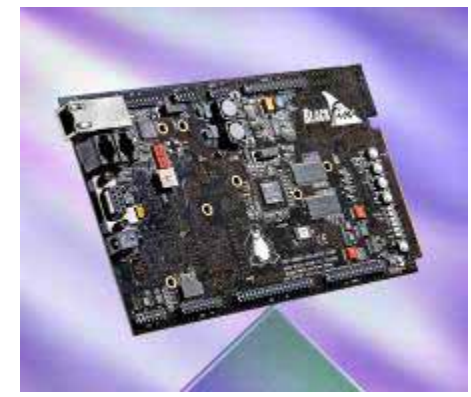
ADI's involvement in open source

- **Invest in the Open Source Infrastructure**
 - Porting uClinux kernel, GNU Toolchain, Das U-boot to:
 - ADSP-BF531/2/3
 - ADSP-BF534/6/7
 - ADSP-BF561
 - ADSP-BF548/7/4/2
 - ADSP-BF527/6/5/4/3/2
 - Tap into a large pool of embedded system developers

- **Provide Development boards via the distribution channel**
 - BF537 STAMP Board, BF561 EZ-Kit, BF533 EZ-Kit, BF548 EZ-Kit, BF527-EZ-Kit

- **Sponsor web site for support**
 - <http://blackfin.uclinux.org>
 - Forums and bug tracking for user support
 - Answers provided Analog Devices and Open source Developers

- **Host open source projects**
 - All projects posted on <http://blackfin.uclinux.org>
 - Example projects: Uboot for Blackfin, uClinux for Blackfin, GNU Toolchain Release 4.1.1
 - Schematics & documents for the STAMP board and all daughter cards
 - Board Support Packages (Linphone, Network Oscilloscope, etc – show proof of concept)





Forums for Support (same)

- ◆ Forums for uClinux, GCC, uboot, co-Linux, and hardware questions

The screenshot shows the uClinux forum website interface. The browser address bar displays the URL: http://blackfin.uclinux.org/gf/project/uclinux-dist/forum/?action=ForumBrowse&forum_id=39. The page has a navigation menu with options like HOME, MY STUFF, USERS, PROJECTS: UCLINUX-DIST, ADMIN, and SNIPPETS. Below the menu, there are tabs for SUMMARY, ADMIN, REPORTING, SEARCH, FORUMS, TRACKER, DOCS, NEWS, FILES, LISTS, and SVN. The main content area shows a list of forum threads with columns for Topic, Topic Starter, Messages, and Last post. The threads include various technical issues such as 'init_mm: initrd kernel panic', 'Microtechix linux booting problems', 'kernel hang after re-powered the board?', and 'Access System Registers'. The last post in the list is dated 2006-12-26 07:22:53.

Topic	Topic Starter	Messages	Last post
init_mm: initrd kernel panic	Douq Bailey	1	2007-01-08 12:45:34
Microtechix linux booting problems	Servans Jourd'heux	10	2007-01-08 11:20:17
corrupt filesystem	Servans Jourd'heux	9	2007-01-08 06:54:45
is the multimedia project available?	David Wang	2	2007-01-08 05:09:05
Blackfin architecture under fmpop	Taru Li	20	2007-01-08 05:02:23
kernel hang after re-powered the board? regarding SOBAM	Web Navi	2	2007-01-08 05:00:06
help to examine PFI driver codes	umamahesh velichury venkata	1	2007-01-08 04:58:14
init process hangs after bootup	Zhi Chen Lee	18	2007-01-08 04:49:58
Errors compiling bfinUlinux 2006R2	Marouardan Y	4	2007-01-08 03:37:41
No sound on bfinhome	Bill Fessler	7	2007-01-08 03:30:12
USB GadgetFS driver in R06R2	Acne Jan Dahl	3	2007-01-08 03:23:42
Kaoh server via Ethernet	Sven Kuster	9	2007-01-08 02:21:53
Why can't find fonts	karthiyan.e	3	2007-01-08 02:03:46
schematics for the BF537 STAMP ??	Wendino Heng	1	2007-01-08 00:54:17
kaoh kernel configuration issue	Bill Fessler	13	2007-01-07 21:32:54
no memory region specified for loadable section ".plt"	Phil Burkert	4	2007-01-07 19:05:54
error in compiling microwindows for BF537	Andy Wang	2	2007-01-07 11:30:42
kernel for BF537	SARAVANAN ANANDARAMAN	3	2007-01-07 00:33:09
Compiling kernel	SARAVANAN ANANDARAMAN	3	2007-01-06 05:34:09
Bootling uClinux over JTAG	Vladimir Parfilov	4	2007-01-06 05:29:40
Relationship between the Uclinux executables and file systems?	Nels Gram Jeppesen	8	2007-01-05 20:56:07
INCLUDE search path problems	Bill Fessler	2	2007-01-05 16:40:51
Dead pthread memory usage	Bill Fessler	2	2007-01-05 16:36:11
bfin_twi_ambus_xfer locks up	Douq Bailey	1	2007-01-05 13:02:16
outflash and flash fails on mtd0	John Ross	7	2007-01-05 11:08:47
A date issue in forum's mails	Peter Nielsen	7	2007-01-05 10:33:12
permission denied when downloading patch	Michele d'Amico	2	2007-01-05 10:20:22
Regarding BF538	Peter Nielsen	4	2007-01-05 06:46:06
Thread activity	muthu annamalai	3	2007-01-05 02:40:17
kernel frozen at Warning: unable to open an initial console	Vladimir Parfilov	10	2007-01-05 01:11:10
error: formation nond memory in linux/a-boot	Andy Wang	9	2007-01-04 13:50:18
AD73311 SPORT_IRQ	andrea.falasco	14	2007-01-04 10:14:32
STKport build error: stl/.config.h: No such file or directory	Acne Jan Dahl	5	2007-01-04 04:01:52
I need NFS support for my BF537 STAMP board	Andy Wang	4	2007-01-04 00:06:03
Access System Registers	Bill Fessler	9	2007-01-03 19:01:33
BF561 SPI ADC compilation errors.	Liu Huang	3	2007-01-03 13:22:05
alioscom execution error	Peter Anderson	9	2007-01-02 22:43:21
Permission Denied	Phillipe Le Gal	4	2007-01-02 14:02:13
Microwindows with no screen at all is it possible?	Vladimir Parfilov	4	2007-01-02 11:10:58
shoof: new problem on STAMP	Francis Castaldi	17	2006-12-29 16:15:28
adb application refuses problem	Phillipe Le Gal	4	2006-12-29 09:10:35
Partitioning the uClinux to the STAMP when it sets corrupted	Menkharan Kuopymäki	2	2006-12-28 04:42:55
outflash	Acne Chalokvanth	6	2006-12-27 17:14:21
how to use lan when nano-X runs...?	umamahesh velichury venkata	4	2006-12-27 12:56:03
	Wendino Heng	7	2006-12-26 07:22:53



Updated GFORGE Web Site – Web site now faster

The screenshot shows the Blackfin/uClinux.org website. At the top, there are navigation tabs: HOME, MY STUFF, USERS, PROJECTS, ADMIN, and SNIPPETS. The main content area includes a welcome message, a list of main projects, support information, recent news, an activity graph, top downloads, and links. The GFORGE logo is visible at the bottom center of the page.

Welcome to the Blackfin/uClinux Project

This site is the central repository and workspace for [free](#) or [open](#) source software and open hardware [projects](#) targeted for use with certain members of the [Analog Devices Blackfin](#) processor family. In addition to a wide range of applications, this workspace also focuses on supporting [Open Source](#) hardware and software tools, including the [GNU GCC](#) toolchain and the [uClinux](#) distribution.

Here is a list of the main projects hosted on this wonderful site.

- [GNU Toolchain](#) ([Releases](#), [SVN](#), [Help](#), [Lists](#), [Bugs](#))
- [Linux Kernel for the Blackfin Processor](#) ([Releases](#), [SVN](#), [Help](#), [Lists](#), [Bugs](#))
- [uClinux Distribution for the Blackfin Processor](#) ([Releases](#), [SVN](#), [Help](#), [Lists](#), [Bugs](#))
- [Das U-boot for the Blackfin Processor](#) ([Releases](#), [SVN](#), [Help](#), [Lists](#), [Bugs](#))
- [ITAG for the Blackfin Processor](#) ([Releases](#), [SVN](#), [Parallel Port I/O](#), [Purchase](#))
- [CoLinux \(Run Linux on Windows\)](#) ([Releases](#), [Help](#))
- [Hardware Projects and schematics](#) ([Releases](#), [Purchase](#), [Help](#))
- [Online Documentation](#) ([Releases](#))

For the full list of projects hosted here, please use the [Projects link](#) at the top of the page.

Support

We do provide support (including user assistance and defect correction) for the above packages via this web site. If you have a question, or think you have found a defect, please ask in the [Help](#) or [Bugs](#) links above.

Recent News

System Upgrade and Status
Mike Frymoyer
2006-12-23

As many have noticed, we've mostly finished our transition to the new version of GForge. It was a rocky transition, but we think worth it. Anonymous CVS will be up and down as we test out the hardware and convert projects over to Subversion. Your downloads should also be much faster as we have offloaded them to a high speed mirror.

The Blackfin One documentation project has started!
Dimitar Penov
2006-12-17

The Blackfin One documentation project has started. The ultimate location for the BF1 documentation is still being determined however you can see the initial work at <http://bearoffire.org/wiki/bin/view/Projects/BlackfinOne>. If you are interested in contributing to the docs or have ideas about where/how it should be hosted please contact Christopher Pepe or see <http://blackfin.uclinux.org...>

Activity

Top Downloads

208,182	Stamps Development Platforms and Modules
134,819	uClinux for the Blackfin processor
93,867	GNU Toolchain for the Blackfin Processor
50,958	U-boot for the Blackfin processor
23,791	Blackfin Documentation Project
11,728	BlackStamp_BF-532
10,937	BlackfinOne_BF532
6,124	Uboot for the 532 Blackfin processor
5,929	uClinux for 532 Blackfin processor
4,079	Tools for ITAG on Blackfin Processors

Links:
[Blackfin.org](#)
[uClinux.org](#)
[Analog Devices Inc.](#)
[Archives Networks Inc.](#)
[uClint - Embedded Linux Developer Forum](#)
[Linux Devices - Embedded Linux News](#)

Most involvement by people is done on a volunteer basis, on their own time. Opinions expressed are personal opinions of individual contributors.

Professional Services:
The following 2nd Parties offer deterministic support or training for uClinux running on Blackfin:
[BlueTechnix](#)
[Openmedia](#)
[Rubicon](#)
[Section 5](#)
[Steamballion Inc.](#)
[System Design & Consulting Services, LLC](#)
Ask to be added to this list

Get Help
[GForge Help](#)
[Online Docs](#)

Contribute!
[Contribute to a project](#)



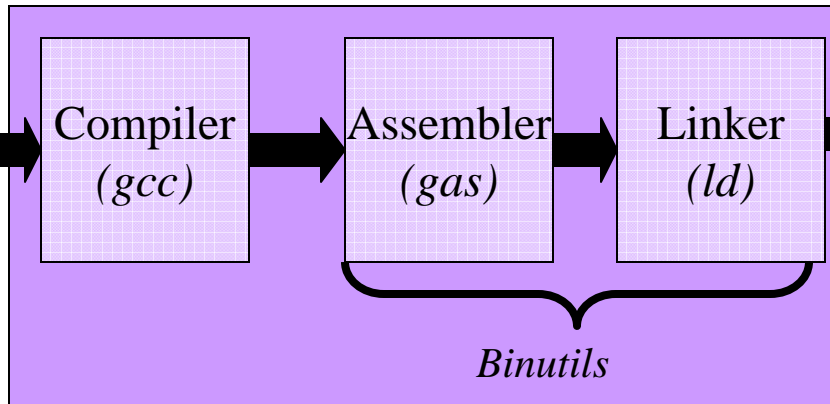
Components of an Open Source System

uClinux Kernel Release 2.6.24
gcc release 4.1.1
Binutils release 2.17

Source Code



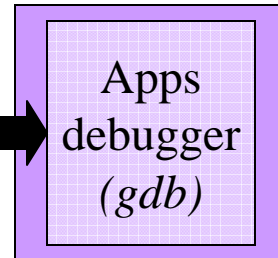
Code Generation Tool



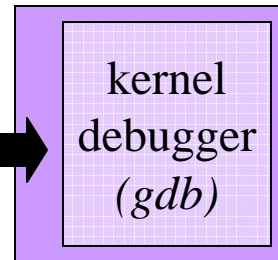
Linux
BLACKfin



Serial or Ethernet

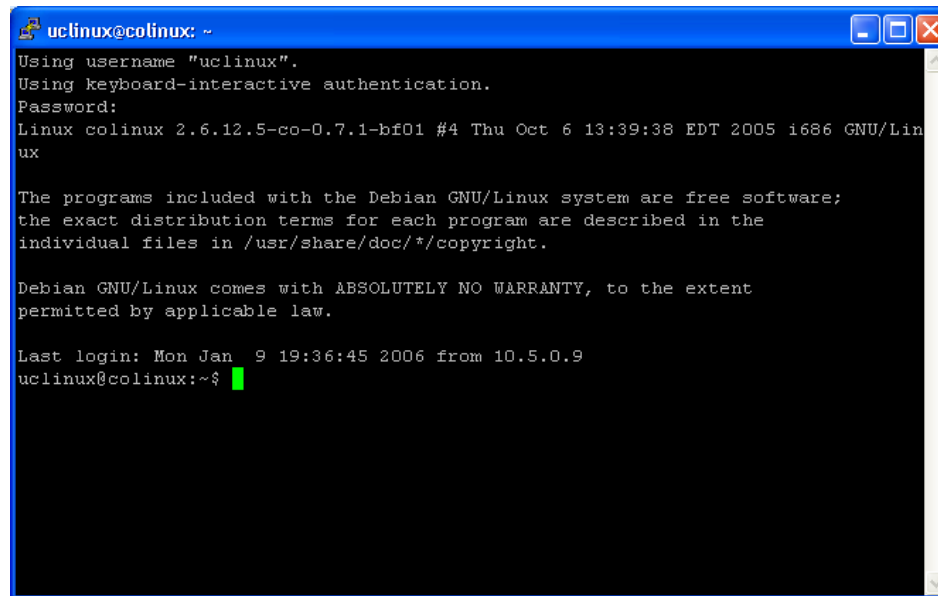


JTAG



Development Environment

Virtual Linux Host



```
uclinux@colinux: ~
Using username "uclinux".
Using keyboard-interactive authentication.
Password:
Linux colinux 2.6.12.5-co-0.7.1-bf01 #4 Thu Oct 6 13:39:38 EDT 2005 i686 GNU/Linux

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.

Last login: Mon Jan  9 19:36:45 2006 from 10.5.0.9
uclinux@colinux:~$
```

coLinux – allows you to run Linux alongside Windows

- ◆ **Most tools are supported**
- ◆ **Tends to be a little slower than native Linux**
- ◆ **Good where you wish to remain in a Windows environment**
- ◆ **Simple to install: <http://docs.blackfin.uclinux.org/doku.php?id=colinux>**



Development Environment

Kernel, Bootloader and Toolchain

Next Release:

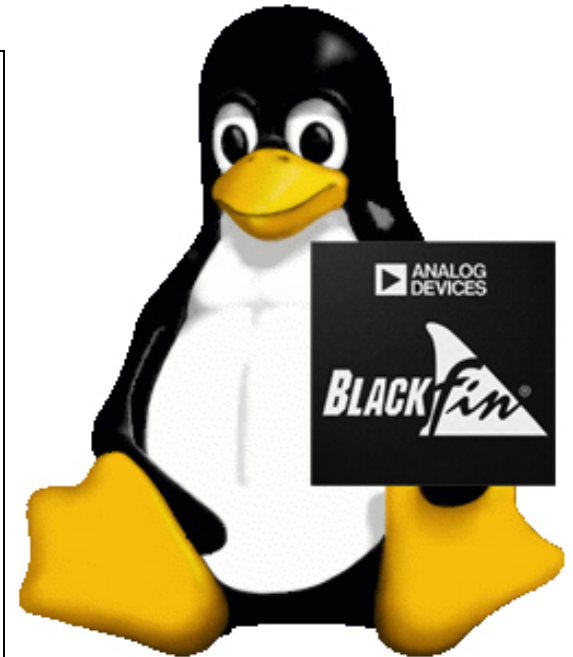
- 2008_R1
- March 2008

Processors supported:

- ADSP-BF531/2/3 (rev 0.3 or higher)
- ADSP-BF534/6/7 (rev 0.2 or higher)
- ADSP-BF561 (rev 0.2 or higher)
- ADSP-BF548/4/2 (rev 0.1 or higher)
- ADSP-BF527/5/2 (rev 0.1 or higher)

Latest versions:

- Linux Kernel: 2.6.24.1
- Toolchain: gcc 4.1.1
- Binutils: 2.17
- Das U-boot: 1.1.6



What's new in the release?

<u>Feature</u>	<u>Benefit</u>
2.6 uClinux Kernel (2.6.24.1): <i>Improved Scheduler, more filesystems, more USB drivers supported, expanding XIP support (execute in place)</i>	Kernel is more suited for Embedded Sytems <i>(Faster real-time response, better connectivity to windows and flash file systems, smaller RAM footprint for embedded devices)</i>
L1 Memory Allocator	L1 can be used in a Linux system <i>(Applications are capable of 5-10x improvement in execution)</i>
GPIO Abstraction Layer / Driver	Allows for proper management of GPIOs <i>(Resolving conflicts, portability between different architectures and other platforms)</i>
Eclipse	Graphical debugging environment <i>(customers can use Windows PC to build and debug gcc programs)</i>
Better support for shared objects and dynamic libraries	Allows users to reduce memory footprint when running multiple applications, easier to move existing linux source code to Blackfin <i>(Higher degree of portability)</i>
U-boot restructured	Easier for customers to port U-Boot to their own platform
Improved toolchain performance	Dhrystone and Whetstone benchmarks Whetstone: 176.5 MIPS Dhrystone:





Automated Testing

uClinux for Blackfin

◆ Toolchain testing:

- Use DeJagnu to ease/automate 40,000+ Toolchain tests on hardware
- All features of the toolchain (C, C++, gdb, gas, binutils, etc.) are 'exercised'

◆ Kernel testing

- All tests run on different targets: BF533-STAMP, BF537-STAMP, BF561-EZKIT
- Run Linux Test Project (LTP), which is a collection of test suites to validate the reliability, robustness, and stability of Linux.
- Blackfin/uClinux is the first architecture to run LTP on uClinux/uClibc/nommu architecture.
- Automated stress tests on kernel and device drivers using expect scripts.

All tests are Well documented on docs.blackfin.uclinux.org and can be reproduced

◆ BootLoader

- Tested on all targets (STAMP, EZ-kit)

◆ Add Tests (Based on customer input)

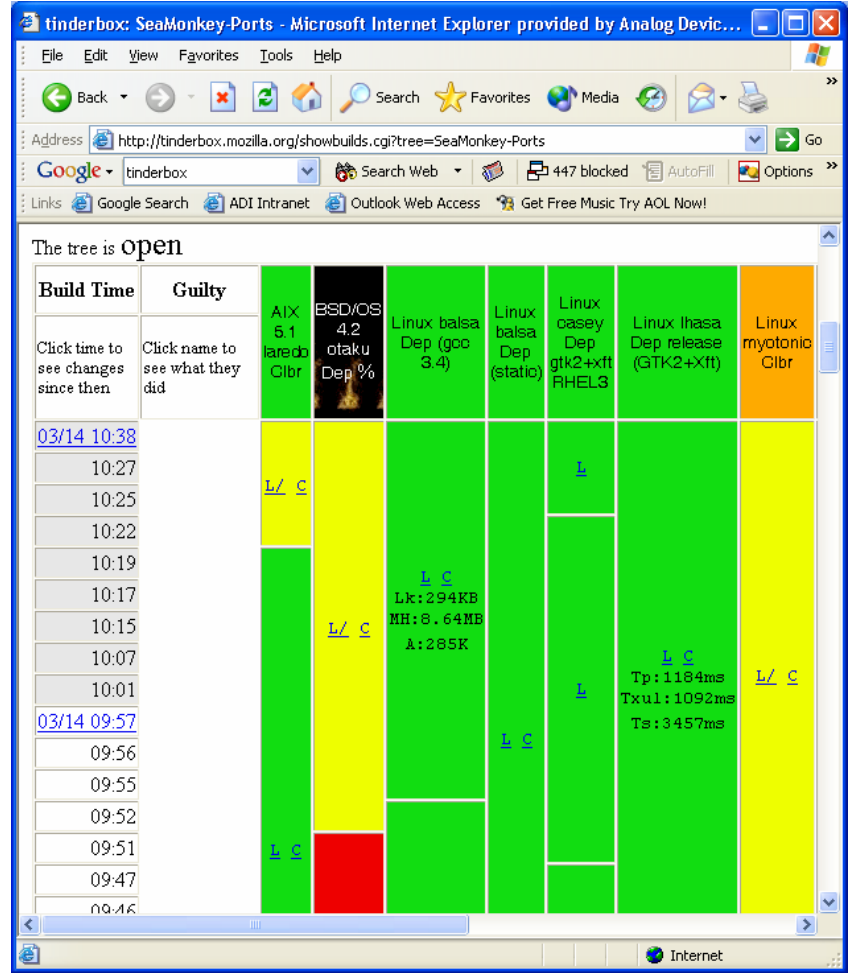
- Continually reboot a JFFS2 filesystem for 30 days (over 40,000 reboots and still going)
- Test on custom hardware





Testing During Development - Tinderbox

- ◆ **Tinderbox finds bugs during development process, not at the last stage of testing.**
- ◆ **Allows you to see what is happening in the source tree. It shows you:**
 - who checked in what (by asking cvs);
 - what platforms have built successfully;
 - what platforms are broken and exactly how they are broken (the build logs);
 - the state of the files that made up the build (cvsblame)
- ◆ **With this - the system can automatically determine who broke the build, so fixes can occur quickly**



Recent additions

◆ Kernel

- Release 2.6.24
- Drivers
 - ◆ NAND Flash,
 - ◆ Frame buffer driver for TFT QVGA and WQVGA LCD (and VGA)
- LCD driver and Keypad interface
- Touchscreen interface
- Bluetooth
- USB OTG
- OPIE and QT Embedded, Graphical Browser

◆ Toolchain

- Hardware loop support in gcc
- Dynamic object loading
- Enable GCJ
- Optimize floating point libraries
- Port Intrinsic/Builtin functions

◆ U-boot

- NAND Flash Driver
- IDE and CF Card Driver

◆ “Tasks” in each project page will provide a list of upcoming features

- Kernel:
http://blackfin.uclinux.org/pm/task.php?group_project_id=50&group_id=17&func=browse

◆ Complete List of Current features:

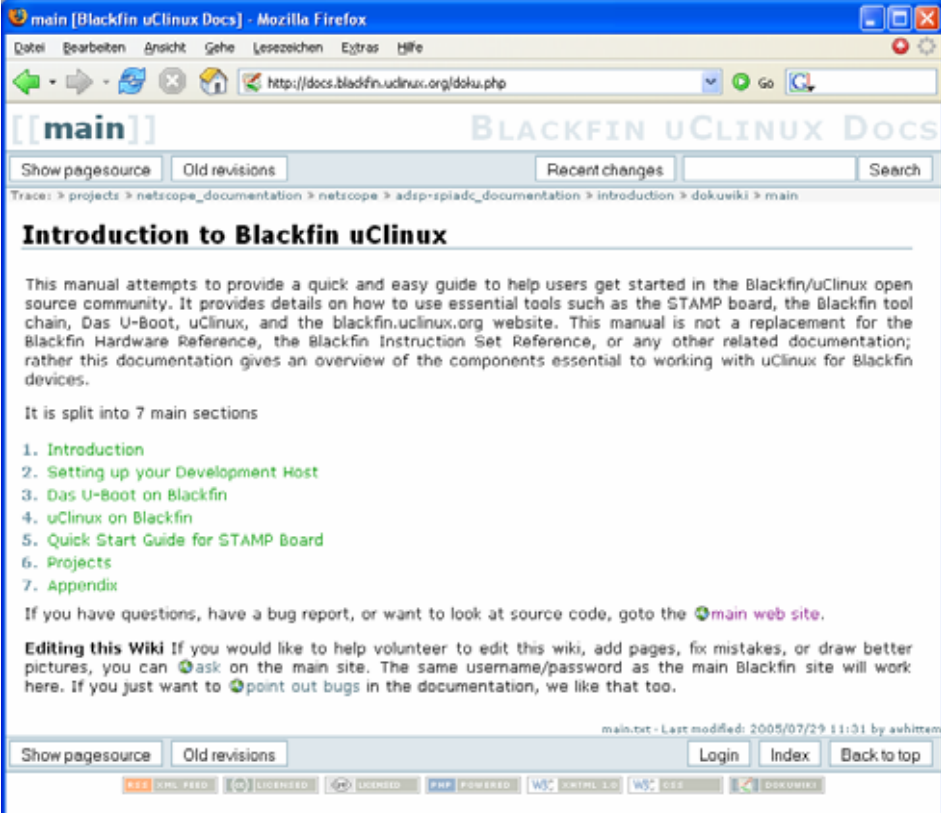
- http://docs.blackfin.uclinux.org/doku.php?id=uclinux_features



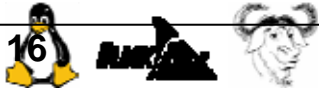
Online documentation

<http://docs.blackfin.uclinux.org>

- ◆ Doc database for Blackfin uClinux
 - **drivers, kernel, getting started, applications, introductions, How to use**
- ◆ Projects
 - **Linphone**
 - **Network Oscilloscope**
 - **U-Boot**
 - ...
- ◆ Examples
 - **Using the Distribution**
 - **Adding New Targets**
 - **Adding a Hello Program**
 - **Using Drivers**
 - **Living Without Forks**
 - **Cache Management**
 - **Example Applications**
 - **Example Projects**
 - ...
- ◆ Online or PDF availability
- ◆ Download the White Paper
 - www.analog.com/uclinuxwhitepaper.pdf
 - **“uClinux as an Embedded OS on an Embedded Processor”**

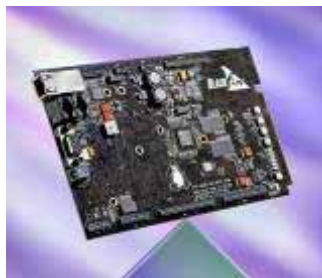


The screenshot shows a Mozilla Firefox browser window displaying the Blackfin uClinux Docs website. The browser title is "main [Blackfin uClinux Docs] - Mozilla Firefox". The address bar shows the URL "http://docs.blackfin.uclinux.org/doku.php". The page content includes a navigation bar with "Show pagesource" and "Old revisions" buttons, and a search box. The main heading is "Introduction to Blackfin uClinux". The text explains that the manual provides a quick and easy guide to help users get started in the Blackfin/uClinux open source community. It lists seven main sections: 1. Introduction, 2. Setting up your Development Host, 3. Das U-Boot on Blackfin, 4. uClinux on Blackfin, 5. Quick Start Guide for STAMP Board, 6. Projects, and 7. Appendix. At the bottom, there are links for "Login", "Index", and "Back to top", along with a footer containing "main.txt - Last modified: 2005/07/29 11:31 by awhitten" and various icons for RSS, XML, and other services.



Available NOW

BF537 STAMP Board



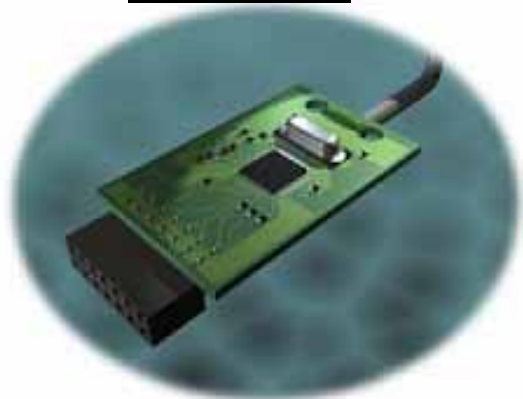
Part Number: **ADDS-BF537-STAMP**
Cost: **\$225 (distribution only)**

IGLOO ICE



Available from Excelpoint
<http://www.excelpoint.com>
Cost: **\$50**

ICE Bear



Available from Section 5
<http://www.section5.ch/icebear>
Cost: **\$300 US**

Add-On Card 1/3

◆ AD7476A SPI ADC Card

- This daughter card implements an A/D converter with a 2MHz anti-aliasing filter and an option for AC or DC coupling.
- connector on the STAMP board and receives its input from a BNC connector.
- This card connects to the Serial Peripheral Interface (SPI)
- Networked Oscilloscope application:
http://blackfin.uclinux.org/frs/?group_id=17&release_id=172



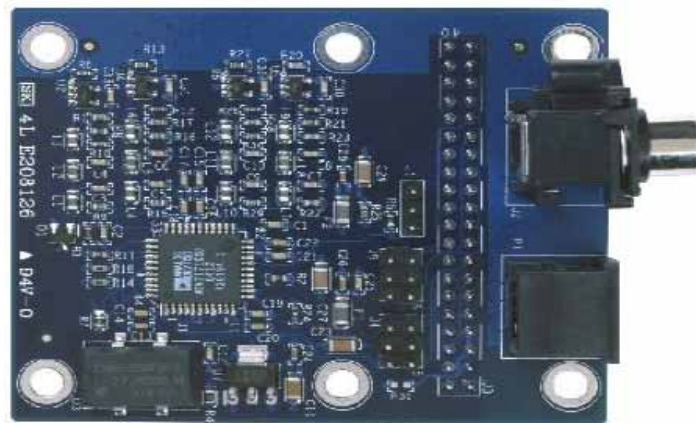
Add-On Card 2/3

- ◆ **AD1836A Audio Codec Card**
 - This daughter card implements both digital and analog audio input and output.
 - It is based on the AD1836A chipset .
 - Two stereo inputs and three stereo outputs are provided with support for both mic and line level input.
 - S/P-DIF interface with transmit and receive capabilities.
 - Connects via the Serial Port Controller Interface (SPORT0 or SPORT1) connector.



Add-On Card 3/3

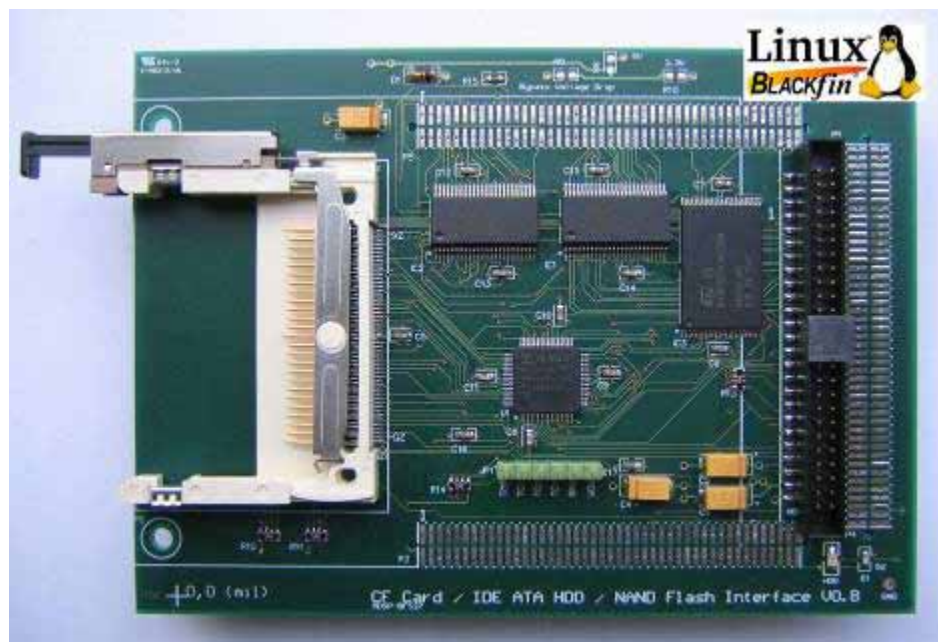
- ◆ **ADV7171 Video Encoder Card**
 - **The ADV7171 Encoder board supports video output applications.**
 - **converts a digital ITU-R 601/656 compatible signal to an analog NTSC or PAL signal.**
 - **connect to the Parallel Peripheral Interface (PPI)**



Add-On Card 4

◆ Multi-function card

- CF Card Interface
- TRUE IDE PIO Mode Hard Disk Drive Interface
- NAND Flash Memory Interface



LCD



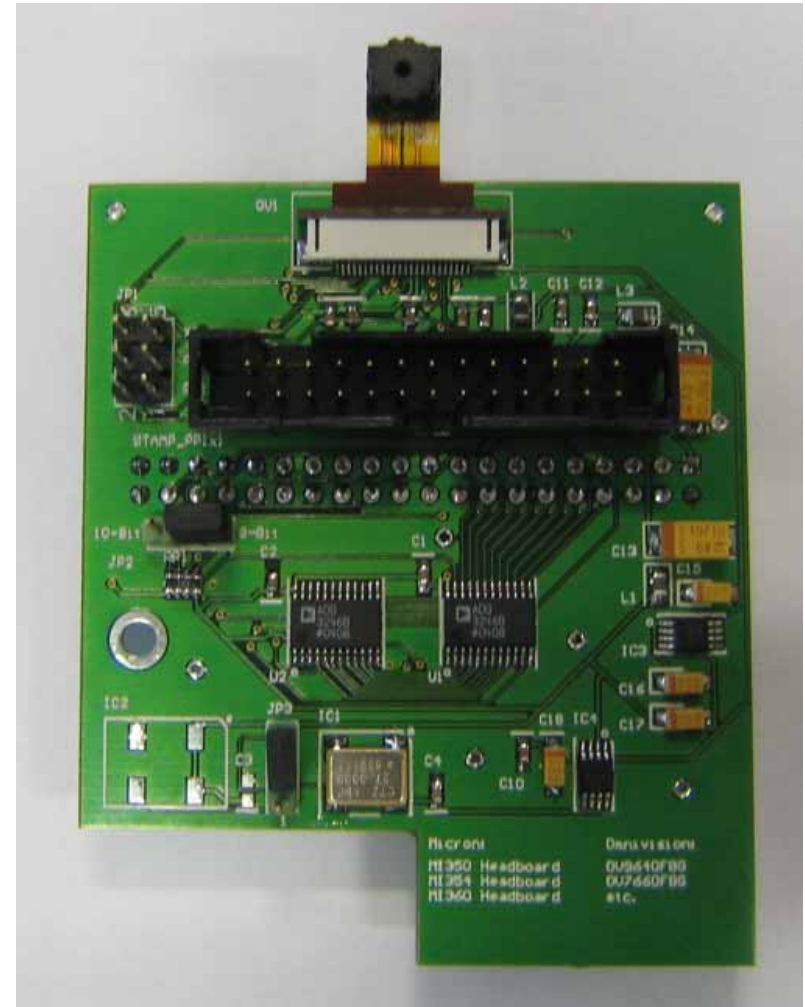
New Daughter Cards

- ◆ **USB Host Daughter Card (Buy from Schmartboard)**
http://www.schmartboard.com/index.asp?page=products_analog&id=111
- ◆ **Blackfin® Compact Flash / NAND / IDE EZ-Extender™ Daughter Board**
http://www.schmartboard.com/index.asp?page=products_analog&id=99
- ◆ **AD7393-DBRD**
 - Will be available from ADI
- ◆ **PBX**
 - Contact us for samples
- ◆ **For information on purchasing daughter cards and STAMP boards, go to:**
 - http://docs.blackfin.uclinux.org/doku.php?id=buy_stuff

CMOS Camera Daughter Card (coming soon)

Supported CMOS camera modules can be:

- All Micron Head Boards with the 26 Pin 100mil connectors (many different Sensors supported)
- Omnivision sensor on-board camera and lens modules using the 24 Pin Flex Cable To Molex 52437-2491 (different Sensors supported)



PBX board

- ◆ 2FXS+2FXO daughter card
- ◆ Can run uCasterisk
- ◆ The Asterisk is an open source, converged telephony platform, which is designed primarily to run on Linux.
- ◆ Features:
 - Voice mail, hosted conferencing, call queuing and agents, music on hold, and call parking are all standard features built right into the software.
- ◆ Contact us for samples of this board
- ◆ Information on the wiki:
http://docs.blackfin.uclinux.org/doku.php?id=enable_asterisk_for_uclinux





uClinux – Board Support Packages

- ◆ **Documentation on BSPs exist at:**
 - <http://docs.blackfin.uclinux.org/doku.php?id=projects>
- ◆ **Networked Camera**
 - Capture still images across the network
- ◆ **Spinning Media (ATA Hard Drive)**
Access files on hard drive
- ◆ **Compact Flash Card**
 - Accessing a 802.11b CF card
- ◆ **Arbitrary Wave Form Generator**
 - Using the AD5443
- ◆ **Open Source VoIP SIP Phone**
 - Uses AD1836A, Linphone, oSIP, oRTP
- ◆ **Flash File System**
 - Uses the ST parallel and Serial Flash that is on the STAMP Board

- ◆ **Integrated Development Environment (alpha)**
 - Uses Eclipse, and GDB via JTAG with the IGLOO (\$50 Parallel Port Emulator)
- ◆ **Hard Real Time Linux Adaptive Domain Environment for Operating Systems (ADEOS)**
- ◆ **Documentation**
 - <http://docs.blackfin.uclinux.org>
- ◆ **System Level Simulator (Skyeye)**
– Boot the kernel without hardware
 - <http://www.skyeye.org/index.shtml>
- ◆ **Networked Audio Player**
 - <http://www.linuxdevices.com/articles/AT9272421886.html>
- ◆ **CoLinux**
 - Linux for Windows





Demos available



Mplayer Demo

- **The demonstration consists of a media player application (mplayer) that plays video files (MPEG4, DivX) stored in a network directory in a remote PC (mounted using SAMBA).**
- **Mplayer is an open source movie player that is known to support more multimedia formats than any other player.**
- **This application runs on a BF537 EZ-Kit Lite board with a daughter card featuring the ADV7393 Low Power, Chip Scale 10-Bit SD/HD Video Encoder.**

Networked Camera demo

- ◆ **The demonstration consists of a media player application (mplayer) that plays video files (MPEG4, DivX) stored in a network directory in a remote PC (mounted using SAMBA)**
 - Uses VLC (video lan client)
 - Uses FFMPEG for H.264 and MPEG4 encoding
 - Outputs an RTP compatible bitstream
 - Can be decoded by QuickTime
 - Documentation –
 - For more information:
<http://docs.blackfin.uclinux.org/doku.php?id=ffmpeg>

XMAME Arcade Gaming

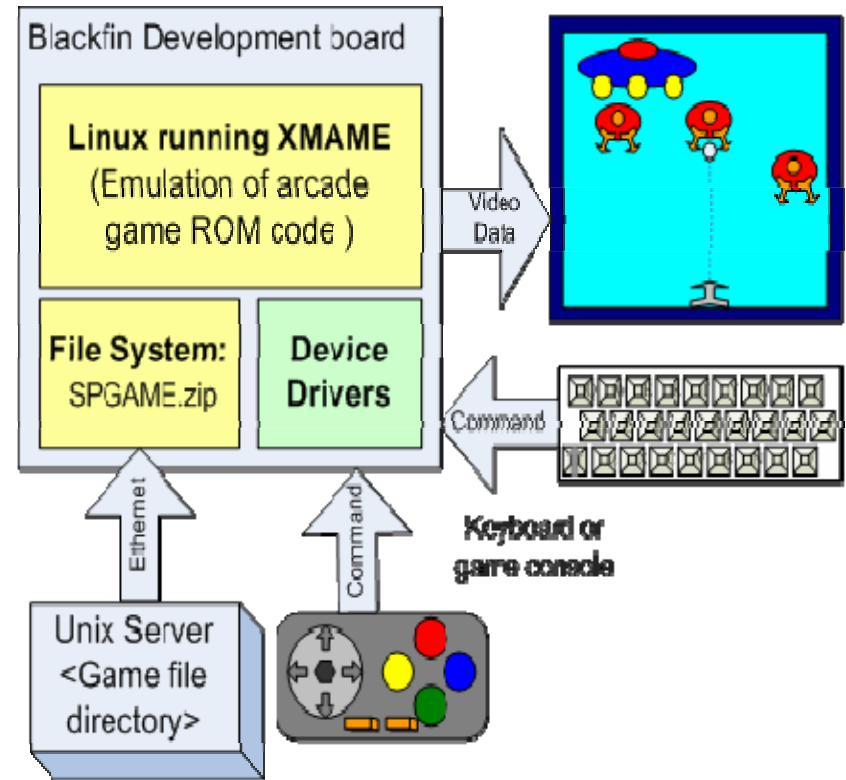
BF537 STAMP + LCD Daughter Card + Kernel + Drivers + Application

XMAME Features

- ◆ 1000's of arcade games available
- ◆ AV outputs for TV monitor
- ◆ Multiple input options
 - Keyboard, joystick, XArcade, push buttons.
- ◆ Download of games from a server

Concept Benefits

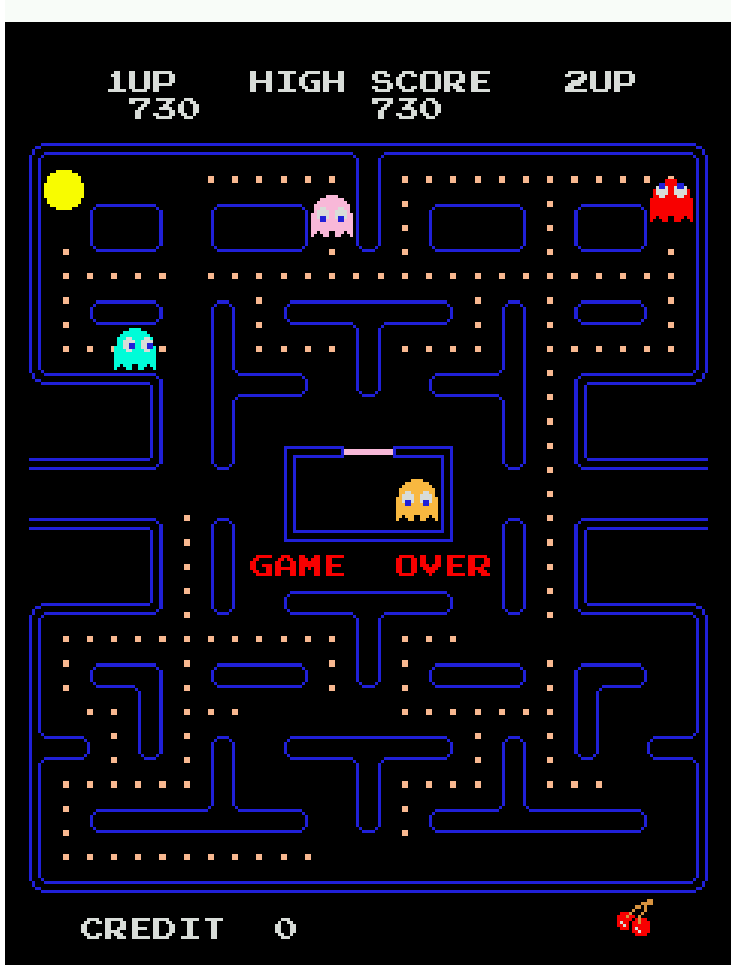
- ◆ Audio and video codec drivers
- ◆ SDL Graphics drivers
- ◆ Hardware simulation in SW
- ◆ Needed for catching open source developers
- ◆ Keeps boards on top of Desks



XMAME System

Emulation of arcade game machines on a Linux platform
Existing open source project [license free]
Gaming ROM's sourced by end user

PACMAN



Resources and additional information

- **Web sites**
 - <http://www.blackfin.uclinux.org> (Blackfin uClinux User's Site)
 - <http://blackfin.org> (Forum for developers using ADI Blackfin processors)
- **Documentation:**
 - <http://docs.blackfin.uclinux.org>
- **uClinux for BF533 Webcast (archived)**
 - http://seminar2.techonline.com/s/analogdevices_sep3004
- **Digikey Presentation**
 - <http://dkc1.digikey.com/us/mkt/vendors/505.html>
- **Whitepaper – “uClinux as an Embedded OS on an Embedded Processor”**
 - <http://www.linuxjournal.com/article/7814>
- **Several Articles (a few listed here):**
 - *“Embedded Linux steals design wins”*, EDN Europe
<http://www.edn.com/article/CA605681.html>
 - *Embedded's New Star*, Design News
<http://www.designnews.com/article/CA603743.html>





Introduction Backup Slides

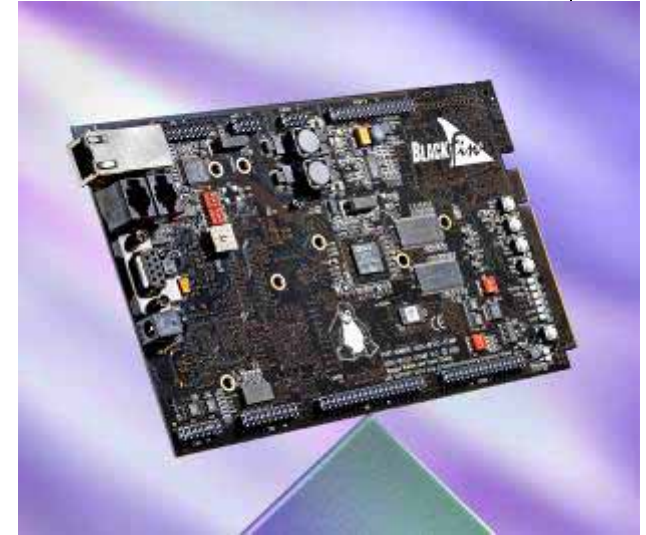


Part Number: ADDS-BF537-STAMP

FEATURES

- ◆ **ADSP-BF537 500 MHz Blackfin® Processor**
 - IEEE 802.3-Compliant 10/100 Ethernet MAC
 - Controller Area Network (CAN) 2.0B Interface
- ◆ **64 Mbytes SDRAM**
- ◆ **4 Mbytes Flash Memory**
- ◆ **RS232 Serial Interface**
- ◆ **JTAG interface for debug and FLASH programming**
- ◆ **On-Board Power**
- ◆ **I/O Connectors for Blackfin peripherals**
 - SPI, two-wire interface, IrDA™
 - SPORT0 and SPORT1
 - Timers
 - PPI (general purpose parallel high speed interface, glueless TFT flat panel)

- ◆ **LED's (6) and push buttons (4)**
- ◆ **Power supply**
- ◆ **Price: \$200**
- ◆ **Availability: Mid October**



STAMP Board Support Package

◆ Hardware

- ◆ BF537 STAMP Board
- ◆ Power Supply

◆ CD

- ◆ Uboot Bootloader 1.1.6
- ◆ GCC Tool Chain (Release 4.1.1)
- ◆ uClinux Kernel (Release 2.6.24)
- ◆ JTAG tools
- ◆ STAMP board schematics etc.
- ◆ coLinux (Linux on Windows)
- ◆ Documentation

◆ Documentation

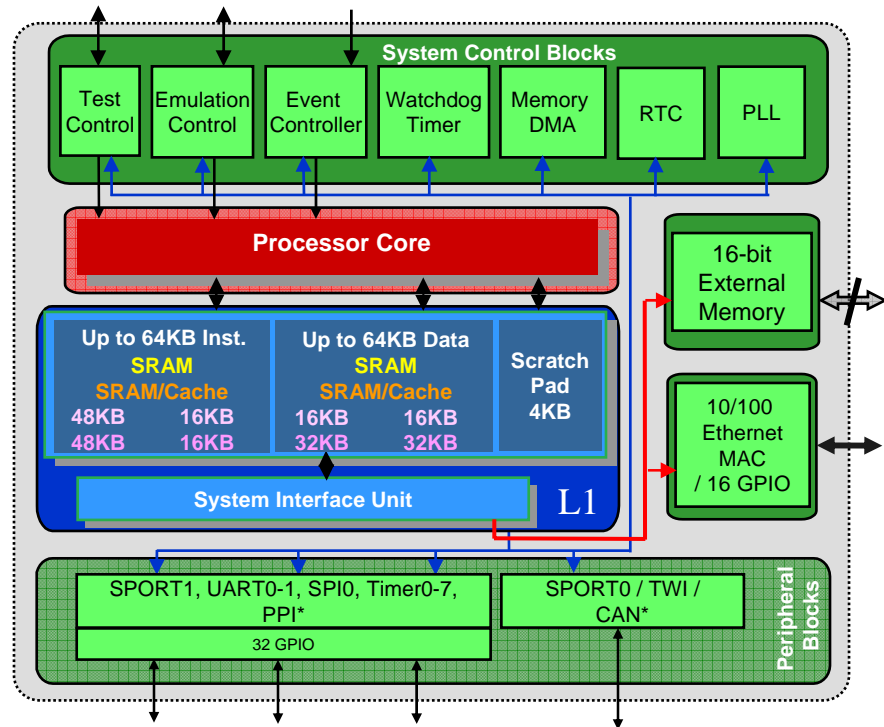
- ◆ Quick Start Document (hardcopy)
- ◆ Users guide (CD/Web)
- ◆ <http://docs.blackfin.uclinux.org>

ADSP-BF536/537 -- Embedded Network Connectivity

Performance	300 MHz to 600 MHz 16/32-bit Core (2.4Gb/s Bandwidth)
Power @ 1.2V @ 1.0V	265mW, 600 MHz <100mW, 300 MHz
Address Range	132 MBytes
On-Chip RAM	100K to 132K Bytes
Peripherals	<ul style="list-style-type: none"> ◆ 10/100 Ethernet MAC ◆ CAN 2.0B ◆ TWI (I²C) ◆ 2 SPORTS ◆ 2 UARTS ◆ SPI ◆ 8 Timers ◆ Parallel Peripheral Interface/GPIO
Bandwidth	<ul style="list-style-type: none"> ◆ 266Mbps I/O ◆ 266Mbps DMA ◆ 266Mbps Memory DMA
Voltage	0.8V to 1.2V (INT) 2.25 to 3.6V (EXT)
Product Differences	<p>ADSP-BF536 Offers:</p> <ul style="list-style-type: none"> 100KB L1 300MHz, 400MHz (-40C to +85C Ambient) <p>ADSP-BF537 Offers:</p> <ul style="list-style-type: none"> 132KB L1 500MHz (-40C to +85C Ambient) 600MHz (0C to +70C Ambient)
Package	<ul style="list-style-type: none"> ◆ 182 MBGA ◆ 208 Sparse MBGA

Key Features

- Embedded 10/100 Ethernet MAC
- Embedded CAN
- 8 timers & 48 GPIOs
- Dynamic Power Management varies frequency and voltage
- Interfaces to External FLASH and SDRAM



uClinux - Networking

◆ Network Platforms

- BF533 + SMSC 91C111
- BF537

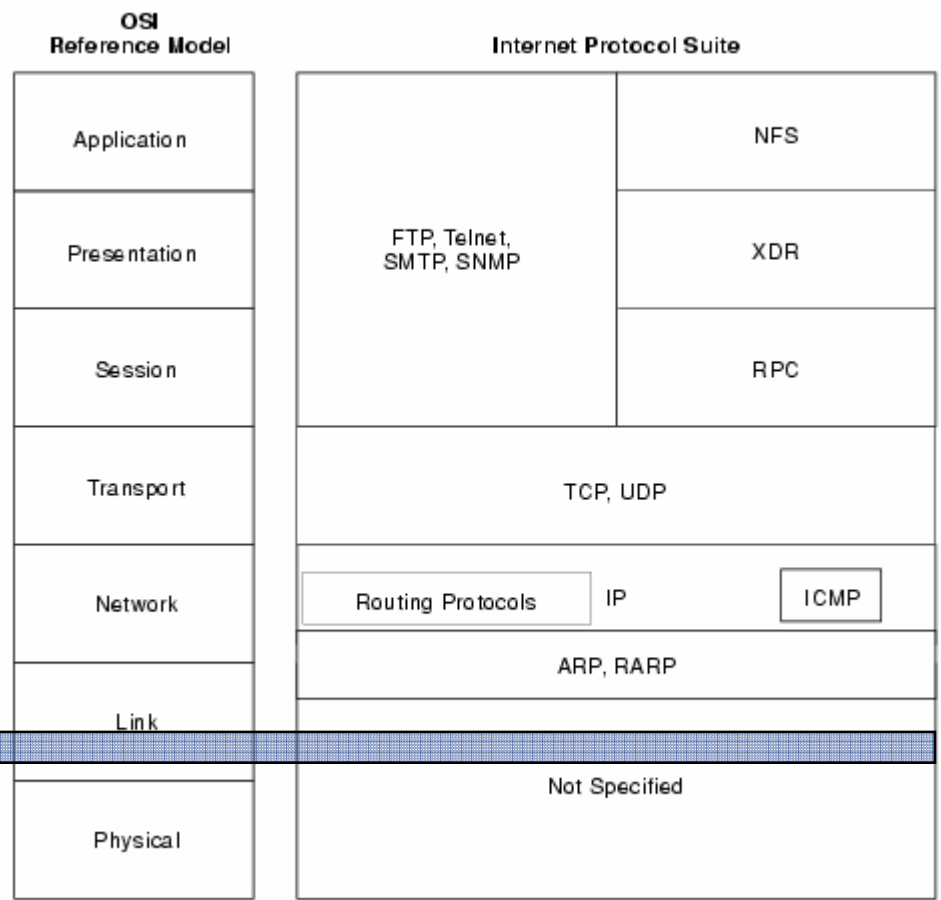
◆ Performance metrics:

- Netperf is a standard Linux benchmark that can be used to measure the performance of many different types of networking. It provides tests for both unidirectional throughput, and end-to-end latency.
- To determine CPU Performance, the uClinux CPU_IDLE Loop is measured – this includes application, kernel and TCP/IP overheads, and is a raw benchmark of CPU idle time.



uClinux - Networking

- ◆ **Uses Linux Networking Stack.**
- ◆ **1/3 of PCs today (over 100M) use 100% the same code as runs on Blackfin, at the network and above levels.**
- ◆ **Most robust, and full featured TCP/IP stack available on the Blackfin.**



Blackfin Specific Code



ith2301



uClinux - Networking

- ◆ **A 2003 study by Reasoning found that the Linux kernel's implementation of the TCP/IP Internet protocol stack had fewer defects than the equivalent stacks of several proprietary general-purpose operating systems, and equaled the best of the embedded operating systems.**
- ◆ **The company used automated tools to look five kinds of defects in code:**
 - **Memory leaks,**
 - **null pointer dereferences,**
 - **bad deallocations,**
 - **out of bounds array access**
 - **uninitialized variables**

◆ http://www.businesswire.com/cgi-bin/f_headline.cgi?bw.021103/230420300





uClinux – Networking Features

- ◆ IPX/SPX
- ◆ AppleTalk
- ◆ IPv4 and IPv6 support
- ◆ Core Net Stack
 - TCP/UDP/IGMP
 - DHCP Client & Server
 - DNS Resolver & Server
 - FTP Client & Server
 - HTTP & HTTPS Server
 - NAT / Firewall
 - Telnet Client and Server
 - SSH Client and Server
 - PPP, PPPoE, SLIP, PLIP, Diald
 - SNMP V2 & V3

- SNTP & NTP
- NFS Client and Server
- SMTP Client and Server
- LDAP
- VPN pass through support for L2TP, PPTP, and IPSEC VPN
- TFTP Client & Server
- NNTP
- SMB/NMB Client, Server and printing
- RTP & SRTP
- And more





JFFS2 – Flash Based File System

◆ Journaling Flash File System, Version 2

- <http://sourceware.org/jffs2/>
- <http://www.linux-mtd.infradead.org/>
- JFFS2 is a log-structured file system designed for use on flash devices in embedded systems, developed by Red Hat, that takes care of:
 - ◆ Bad Blocks
 - ◆ Wear Leveling
 - ◆ Error correction
 - ◆ Power Fail during file write
- Documentation exists at:
http://docs.blackfin.uclinux.org/doku.php?id=enabling_jffs2





Differences between uClinux and Linux



uClinux for Linux Programmers

- ◆ **Much of this is documented at (or borrowed from):**
 - <http://www.linuxjournal.com/article/7221> - uClinux for Linux Programmers, by David McCullough
 - http://docs.blackfin.uclinux.org/doku.php?id=living_without_forks
 - http://docs.blackfin.uclinux.org/doku.php?id=operating_systems#introduction_to_uclinux

- ◆ **Blackfin/uClinux and m68k/uClinux are not the same. We offer more protection.**
- ◆ **Blackfin/uClinux and x86/Linux are not the same. We offer less protection.**

- ◆ **So, what does a person who is familiar with x86/Linux or m68k/uClinux need to be aware of?**



uClinux for Linux Programmers

No Memory Management

- ◆ **Under x86/Linux, memory management is achieved through the use of virtual memory (VM).**
- ◆ **All processes run at the same address (virtual zero), and the VM system takes care physical <-> virtual mapping.**
 - the virtual memory the process sees is contiguous, the physical memory it occupies can be scattered around
 - arbitrary physical memory can be mapped to anywhere in the process' address space, it is possible to add memory to an already running process.
 - Application A can not read or write into Application's B or the kernel's memory space, because everything is translated from the virtual application address.
- ◆ **uClinux was created for systems do not support VM**



uClinux for Linux Programmers

No Memory Management

- ◆ **Under m68/uClinux – there is no memory management / protection.**
 - each process must be located at a place in memory where it can be run, this area of memory must be contiguous.
 - It cannot be expanded as there may be other processes above and below it.
 - **Memory is not protected:**
 - ◆ application stack grows down into the code space of the application
 - ◆ application A can read or write into application B, or kernel's memory space.
- ◆ **Random crashes as application stack runs into application data.**
- ◆ **Random crashes as null pointers write into kernel space (kernel is usually at the bottom of physical memory)**



uClinux for Linux Programmers

No Memory Management

- ◆ **Under Blackfin/uClinux – there is no memory management, but there is limited protection – stopping random crashes.**
 - each process must be located at a place in memory where it can be run, this area of memory must be contiguous.
 - It cannot be expanded as there may be other processes above and below it.
 - **Memory is protected:**
 - ◆ application stack grows down into the code space of the application, optional run time checks halt application if the stack is exceeded.
 - ◆ application A can read or write into application B memory space, but not the kernel. Applications crash – kernel does not.

- ◆ **Random crashes due to stack overflows or null pointers will not happen on Blackfin/uClinux**





uClinux for Linux Programmers

Kernel Differences

- ◆ **To a kernel developer, uClinux is not very different from Linux.**
- ◆ **The only 'real' issue:**
 - **Cannot take advantage of the paging support provided by an MMU.**
 - **This doesn't affect much of the kernel.**

- ◆ **Standard executable formats (ELF) are unsupported, because they make use of VM features that do not exist under uClinux.**
 - **Instead, a new format is required, the flat format. Flat format is a condensed executable format that stores only executable code and data, along with the relocations needed to load the executable into any location in memory**



uClinux for Linux Programmers

Memory Allocation

- ◆ **The kernel memory allocator under Linux uses a power-of-two allocation method.**
- ◆ **This helps it operate faster and quickly find memory areas of the correct size to satisfy allocation requests.**
- ◆ **Unfortunately, under uClinux, applications must be loaded into memory that is set aside by this allocator.**
- ◆ **To understand the ramifications of this, especially for large allocations,**
 - **Consider that an application requiring a 33KB allocation in order to be loaded actually allocates to the next power of two, which is 64KB. The 31KB of extra space allocated cannot be utilized effectively.**
- ◆ **This memory wastage is unacceptable on most embedded uClinux systems -**

uClinux for Linux Programmers

Applications

- ◆ **On VM Linux, whenever an application tries to write off the top of the stack, an exception is flagged and some more memory is mapped in at the top of the stack to allow the stack to grow.**
- ◆ **Under uClinux, no such luxury is available as the stack must be allocated before run time. This means that the developer, who previously was oblivious to stack usage within the application, must now be aware of the stack requirements.**
 - **On Blackfin/uClinux, optional checks can take place to halt the application before things go really bad if stack overflow takes place.**
 - **On m68k/uClinux, application, or kernel can crash.**
- ◆ **By default, the uClinux toolchains allocate 4KB for the stack**
- ◆ **Run “`bfin-uclinux-flthdr -s <stacksize> executable`” after the application has been built.**

uClinux for Linux Programmers

Applications

- ◆ **On Linux with VM, an application can increase its process size, allowing it to have a dynamic heap. This is the area used to satisfy memory allocations with malloc and related functions in C.**
- ◆ **Because uClinux cannot implement the functionality of a dynamic heap, it instead implements a global memory pool that basically is the kernel's free memory pool.**
- ◆ **global memory pool pitfalls:**
 - **a runaway process can use all of the system's available memory.**
- ◆ **global pool advantages:**
 - **only the amount of memory actually required is used, unlike the pre-allocated heap system that some embedded systems use.**
 - **memory can be returned to the global pool as soon as it is finished being used,**
 - **the implementation can take advantage of the existing in-kernel allocator for managing this memory, reducing the size of application code.**

uClinux for Linux Programmers

Applications

- ◆ **One of the common problems new users encounter is the missing memory problem.**
 - The system is showing a large amount of free memory, but an application cannot allocate a buffer of size X (where X is less than free memory)
- ◆ **The problem here is memory fragmentation, all of the uClinux solutions available at this time suffer from it (including Blackfin)**
- ◆ **Because of the lack of VM in the uClinux environment, it is nearly impossible to utilize memory fully due to fragmentation.**
- ◆ **Example: a system has 500KB of free memory**
 - Applications attempts to to allocate 100KB.
 - It is important to remember that one must have a contiguous 100KB block of memory in order to satisfy the allocation.
 - Suppose the memory map looks like this:

```

0      100    200    300    400    500    600    700    800    900    1000
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|xxxxxx|xxxxxx|---xx|--x--|-x---|xx---|-x---|-xx--|-x---|xxxxxx|
    
```

uClinux for Linux Programmers

Applications

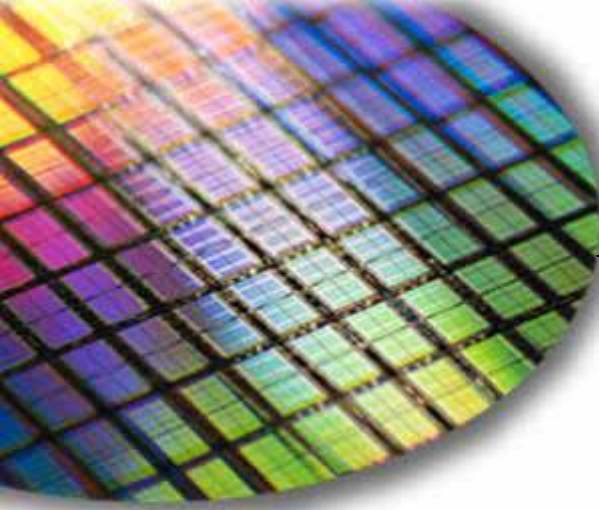
- ◆ **In this case, 500KB are free, but the largest contiguous block is only 80KB.**
- ◆ **There are many ways to arrive at such a situation. A program that allocates some memory and then frees most of it, leaving a small allocation in the middle of a larger free block, often is the cause.**
- ◆ **Transient programs under uClinux also can affect where and how memory is allocated.**



uClinux for Linux Programmers

Applications and Processes

- ◆ **No fork() system call in uClinux**
- ◆ **Use vfork() under uClinux – There are some differences**
- ◆ **fork() and vfork(), allow a process to split into two processes, a parent and a child.**
 - **When a process calls fork(), the child is a duplicate of the parent in all ways, but it shares nothing with the parent and can operate independently, as can the parent.**
 - **With vfork() this is not the case.**
 - ◆ The parent is suspended and cannot continue executing until the child exits or calls exec(), the system call used to start a new application.
 - ◆ The child, directly after returning from vfork(), is running on the parent's stack and is using the parent's memory and data. This means the child can corrupt the data structures or the stack in the parent, resulting in failure. This is avoided by ensuring that the child never returns from the current stack frame once vfork() has been called and that it calls `_exit` when finishing-exit cannot be called as it changes data structures in the parent.
 - ◆ The child also must avoid changing any information in global data structures or variables, as such changes may break the execution of the parent.
- ◆ **Making an application use vfork instead of fork usually falls into the absolutely simple or incredibly difficult category.**



The World Leader in High Performance Signal Processing Solutions



ADEOS Hard Real Time

Real Time Scheduling in Linux - ADEOS

◆ ADEOS is an open source project:

- <http://home.gna.org/adeos/>
- Runs a kernel module in a higher priority interrupt task than the kernel.
- Is able to “hold” off kernel interrupts so the hard real time task can be completed
- We have an ADEOS patch for our kernel, and are looking at performance measurements now.
- Also looking for customers who have this requirement (Hard Real Time application under uClinux) so we can develop examples

Real Time Layer

Hypothesis: Embedded Processing users expect to have a host applications Processor and a real time processor in their system (ARM + DSP).

ADEOS FEATURES

- Flexible environment for sharing hardware resources among multiple operating systems,
- Allows multiple instances of a single OS for SMP

BENEFIT

- Enables deterministic event processing
- Virtual partitioning of RT and Application processes
- Customer acceptance of partition

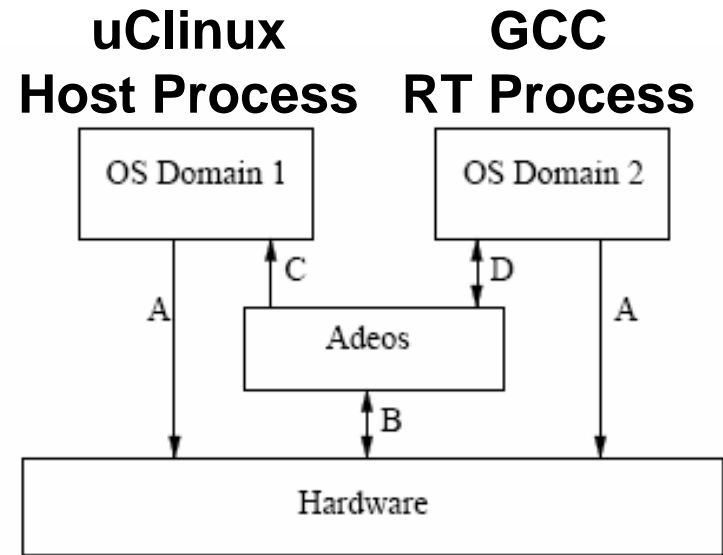
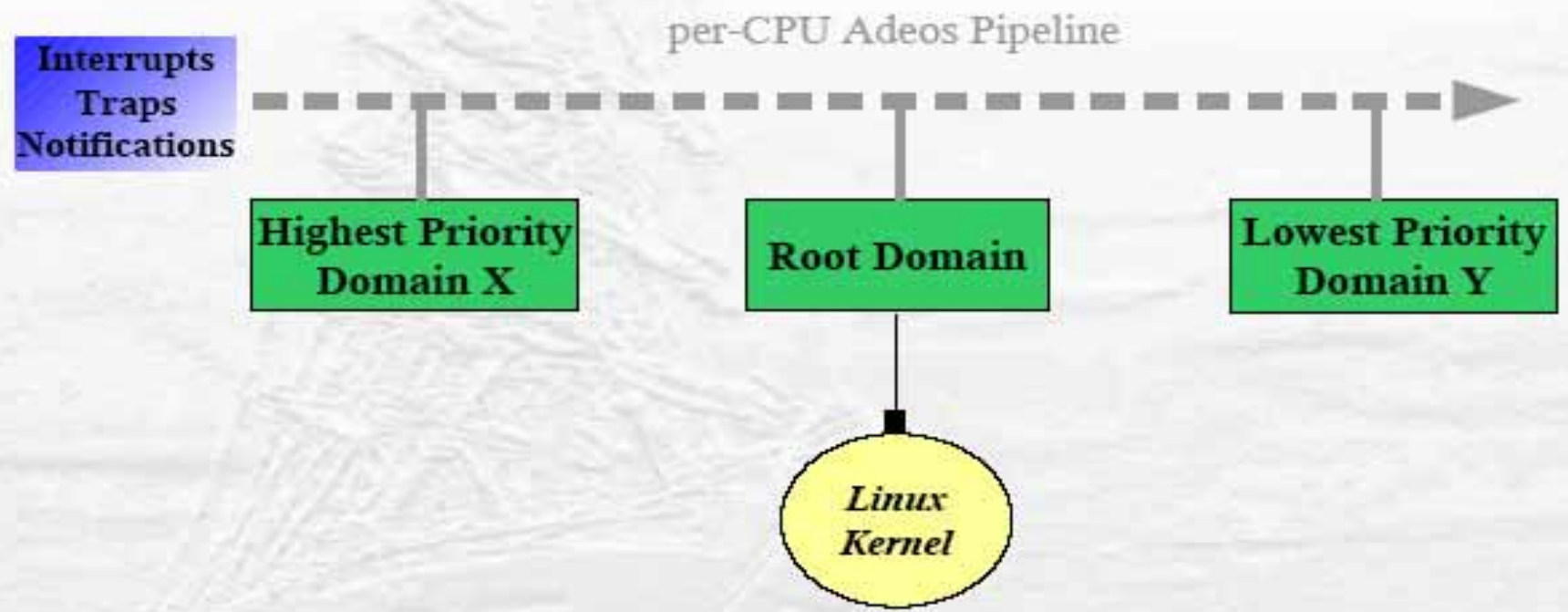
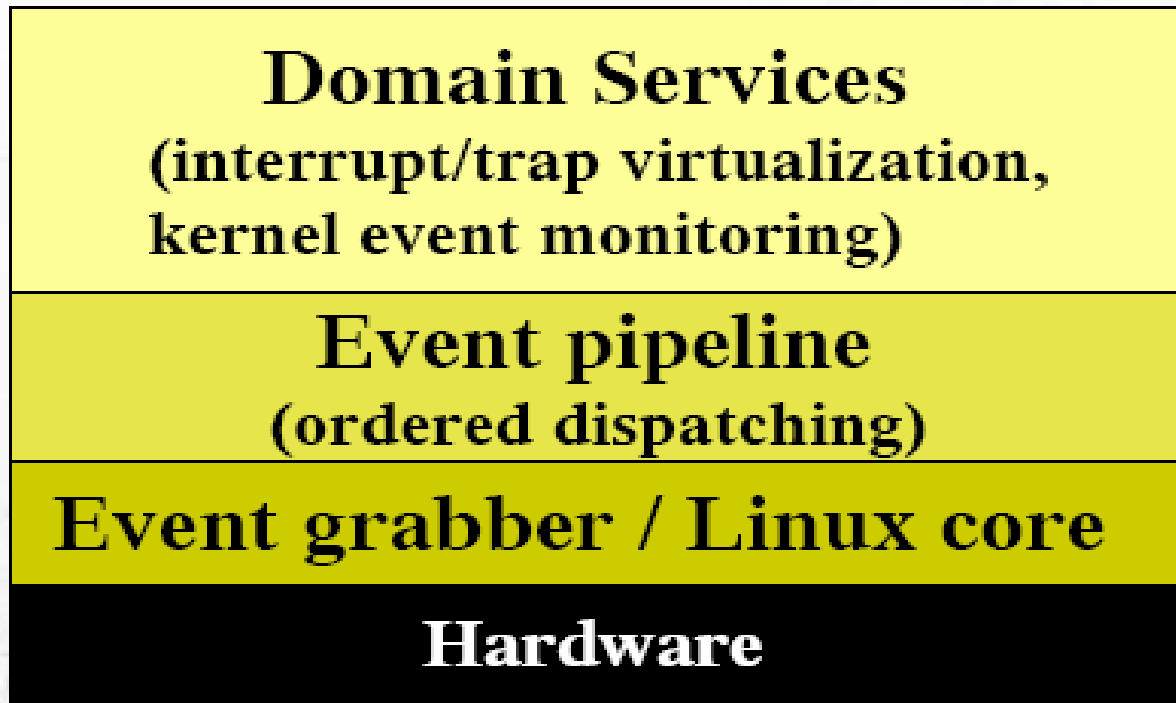


Figure 1: Adeos architecture.

ADEOS nanokernel scheme



ADEOS Internals



- ▶ Domain programming API
- ▶ Event ordering and dispatching
- ▶ Low-level interposition



ADEOS Services

- ◆ **Per-domain event virtualization**
 - Hardware interrupts
 - Processor traps
 - Linux kernel notifications

- ◆ **Pipeline control**
 - Domain registration
 - Event propagation (accept, pass, terminate, discard)
 - Stage stalling / unstalling (Stodolsky-based)

- ◆ **Inter-domain mutexes (w/priority inheritance)**