

# Porting OpenBSD

Niall O'Higgins <niallo@openbsd.org>  
Uwe Stühler <uwe@openbsd.org>

OpenCON, 2005

# Outline

- 1 Porting OpenBSD
  - What It Takes
  - Preparation
  - Cross-Development
  - The Boot Loader
  - Building The Kernel
  - Adapting Startup Code
  - Writing Device Drivers
  - Going Native
  - Subsequent Work

- 2 OpenBSD/zaurus
  - History
  - What It Took
  - What Was Done
  - Tricky Parts
  - Current Status
  - Future Plans

# What It Takes

---

- motivation, some experience, time and persistence

# What It Takes

---

- motivation, some experience, time and persistence
- about 20 developers having the machines

# What It Takes

---

- motivation, some experience, time and persistence
- about 20 developers having the machines
- a user community

# What It Takes

---

- motivation, some experience, time and persistence
- about 20 developers having the machines
- a user community
- “full” support includes that:
  - release install media is known to work
  - architecture can compile itself
  - most of the basic tools exist on the architecture
  - snapshots are made available on a regular basis
  - packages exist

# Preparation

---

- get a hold of documentation

# Preparation

---

- get a hold of documentation
- familiarise yourself with the architecture



# Preparation

---

- get a hold of documentation
- familiarise yourself with the architecture
- start from an existing port that is very similar

# Preparation

- get a hold of documentation
- familiarise yourself with the architecture
- start from an existing port that is very similar
- copy and rename machine-dependent sources
  - `sys/arch/machine/...`
  - `share/man/mann/mann.machine/...`
  - `etc/etc.machine/...`
  - `distrib/...`

# Preparation

- get a hold of documentation
- familiarise yourself with the architecture
- start from an existing port that is very similar
- copy and rename machine-dependent sources
  - `sys/arch/machine/...`
  - `share/man/mann/mann.machine/...`
  - `etc/etc.machine/...`
  - `distrib/...`
- poke around in interesting places
  - opportunity to learn about things

# Preparation

- get a hold of documentation
- familiarise yourself with the architecture
- start from an existing port that is very similar
- copy and rename machine-dependent sources
  - `sys/arch/machine/...`
  - `share/man/man/mann/mann.machine/...`
  - `etc/etc.machine/...`
  - `distrib/...`
- poke around in interesting places and try to remember what you've changed
  - opportunity to learn about things
  - it's easy to make mistakes and some things can't be tested immediately

# Cross-Development

---

- to start the port, normally you have to cross-compile

# Cross-Development

---

- to start the port, normally you have to cross-compile
- we have to use the GNU compiler toolchain (binutils, gcc, gdb, ...)
  - makes it difficult to port OpenBSD to architectures not already supported by the toolchain

# Cross-Development

- to start the port, normally you have to cross-compile
- we have to use the GNU compiler toolchain (binutils, gcc, gdb, ...)
  - makes it difficult to port OpenBSD to architectures not already supported by the toolchain
- “make cross-tools” and “make cross-distrib” are there to aid the porter

# Cross-Development

- to start the port, normally you have to cross-compile
- we have to use the GNU compiler toolchain (binutils, gcc, gdb, ...)
  - makes it difficult to port OpenBSD to architectures not already supported by the toolchain
- “make cross-tools” and “make cross-distrib” are there to aid the porter
- cross-compiling is not used once the port can compile itself



# Cross-Development

- to start the port, normally you have to cross-compile
- we have to use the GNU compiler toolchain (binutils, gcc, gdb, ...)
  - makes it difficult to port OpenBSD to architectures not already supported by the toolchain
- “make cross-tools” and “make cross-distrib” are there to aid the porter
- cross-compiling is not used once the port can compile itself
- native builds are a good way to test the machine and a new port

# Cross-Development

- to start the port, normally you have to cross-compile
- we have to use the GNU compiler toolchain (binutils, gcc, gdb, ...)
  - makes it difficult to port OpenBSD to architectures not already supported by the toolchain
- “make cross-tools” and “make cross-distrib” are there to aid the porter
- cross-compiling is not used once the port can compile itself
- native builds are a good way to test the machine and a new port
- as a result, we switch to native builds as soon as possible

# The Boot Loader

---

- need a way to load the kernel (JTAG is nice, but not always available)

# The Boot Loader

---

- need a way to load the kernel (JTAG is nice, but not always available)
- loader can be 50 lines of assembly or a big C program

# The Boot Loader

- need a way to load the kernel (JTAG is nice, but not always available)
- loader can be 50 lines of assembly or a big C program
- in the long run you want to port **boot(8)** - the *stand-alone* kernel
  - easier to port than the BSD kernel: does not use the full build infrastructure
  - harder if you have no BIOS, Open Firmware-compliant or similarly sophisticated firmware to call out to (for console and disk access, device tree traversal, etc.)
  - but **boot(8)** can run on and replace another operating system in memory - e.g. Linux : )

# The Boot Loader

- need a way to load the kernel (JTAG is nice, but not always available)
- loader can be 50 lines of assembly or a big C program
- in the long run you want to port **boot(8)** - the *stand-alone* kernel
  - easier to port than the BSD kernel: does not use the full build infrastructure
  - harder if you have no BIOS, Open Firmware-compliant or similarly sophisticated firmware to call out to (for console and disk access, device tree traversal, etc.)
  - but **boot(8)** can run on and replace another operating system in memory - e.g. Linux : )
- good firmware can be used to simplify things at runtime
  - like OpenBoot callouts on “sparc” to traverse the device tree or print characters on the console

# Building The Kernel

---

- get familiar with *config(8)* and *files.conf(5)*

# Building The Kernel

- get familiar with ***config(8)*** and ***files.conf(5)***
- “multi-arch” platforms (e.g. cats, macppc, sgi, solbourne, zaurus) vs. “single-arch” platforms (amd64, i386, hppa, sparc, sparc64)



# Building The Kernel

- get familiar with *config(8)* and *files.conf(5)*
- “multi-arch” platforms (e.g. cats, macppc, sgi, solbourne, zaurus) vs. “single-arch” platforms (amd64, i386, hppa, sparc, sparc64)
- work on RAMDISK first, then on GENERIC
  - with `bsd.rd` you can interactively test and debug the kernel and drivers

# Building The Kernel

- get familiar with *config(8)* and *files.conf(5)*
- “multi-arch” platforms (e.g. cats, macppc, sgi, solbourne, zaurus) vs. “single-arch” platforms (amd64, i386, hppa, sparc, sparc64)
- work on RAMDISK first, then on GENERIC
  - with `bsd.rd` you can interactively test and debug the kernel and drivers
- building `bsd.rd` is only slightly more complicated
  - install *crunch tools* from `distrib/crunch`
  - run `make` in `distrib/machine/ramdisk`
  - `rdsetroot` may give you problems during cross-development

# Adapting Startup Code

- begin with *start()* (locore.S)
  - disable interrupts
  - bring the processor into a known state
  - initialise or disable MMU and caching
  - relocate the kernel image
  - initialise interrupt controller
  - pick up boot arguments
  - initialise early console (serial)
  - find memory and initialise *pmap(9)* backend
    - map the kernel
    - set up stack(s)
    - trap/vector tables
  - call *main()*

# Adapting Startup Code

- begin with *start()* (locore.S)
  - disable interrupts
  - bring the processor into a known state
  - initialise or disable MMU and caching
  - relocate the kernel image
  - initialise interrupt controller
  - pick up boot arguments
  - initialise early console (serial)
  - find memory and initialise *pmap(9)* backend
    - map the kernel
    - set up stack(s)
    - trap/vector tables
  - call *main()*

# Adapting Startup Code

- begin with *start()* (locore.S)
  - disable interrupts
  - bring the processor into a known state
  - initialise or disable MMU and caching
  - relocate the kernel image
  - initialise interrupt controller
  - pick up boot arguments
  - initialise early console (serial)
  - find memory and initialise *pmap(9)* backend
    - map the kernel
    - set up stack(s)
    - trap/vector tables
  - call *main()*
- use reliable, *unbuffered* indicators for debugging (LED)

# Writing Device Drivers

---

- some drivers have to be done first:
  - serial port (or another console device)
  - interrupt controller
  - crucial machine-dependent bus drivers such as *mainbus(4)* or *pxaip(4)*

# Writing Device Drivers

- some drivers have to be done first:
  - serial port (or another console device)
  - interrupt controller
  - crucial machine-dependent bus drivers such as *mainbus(4)* or *pxaip(4)*
- BSD has the *autoconf(9)* framework
  - basically, there is direct and indirect configuration

# Writing Device Drivers

- some drivers have to be done first:
  - serial port (or another console device)
  - interrupt controller
  - crucial machine-dependent bus drivers such as *mainbus(4)* or *pxaip(4)*
- BSD has the *autoconf(9)* framework
  - basically, there is direct and indirect configuration
  - direct configuration is used where enumeration is possible (PCI, PCMCIA, ...) - drivers can easily be matched with hardware by device class, vendor ID and product ID



# Writing Device Drivers

- some drivers have to be done first:
  - serial port (or another console device)
  - interrupt controller
  - crucial machine-dependent bus drivers such as *mainbus(4)* or *pxaip(4)*
- BSD has the *autoconf(9)* framework
  - basically, there is direct and indirect configuration
  - direct configuration is used where enumeration is possible (PCI, PCMCIA, ...) - drivers can easily be matched with hardware by device class, vendor ID and product ID
  - indirect configuration is used where busses have to way to see what devices are attached and how (ISA, I<sup>2</sup>C, ...) - drivers have to probe for the hardware

# Writing Device Drivers

- some drivers have to be done first:
  - serial port (or another console device)
  - interrupt controller
  - crucial machine-dependent bus drivers such as *mainbus(4)* or *pxaip(4)*
- BSD has the *autoconf(9)* framework
  - basically, there is direct and indirect configuration
  - direct configuration is used where enumeration is possible (PCI, PCMCIA, ...) - drivers can easily be matched with hardware by device class, vendor ID and product ID
  - indirect configuration is used where busses have to way to see what devices are attached and how (ISA, I<sup>2</sup>C, ...) - drivers have to probe for the hardware
- layered drivers and *attachment drivers*
  - *apm(4)*, *lcd(4)*, *ohci(4)*, *pcmcia(4)*, more?
  - because of some obscure chips (*scoop(4)*, backlight control, ...)

# Writing Device Drivers

- some drivers have to be done first:
  - serial port (or another console device)
  - interrupt controller
  - crucial machine-dependent bus drivers such as *mainbus(4)* or *pxaip(4)*
- BSD has the *autoconf(9)* framework
  - basically, there is direct and indirect configuration
  - direct configuration is used where enumeration is possible (PCI, PCMCIA, ...) - drivers can easily be matched with hardware by device class, vendor ID and product ID
  - indirect configuration is used where busses have to way to see what devices are attached and how (ISA, I<sup>2</sup>C, ...) - drivers have to probe for the hardware
- layered drivers and *attachment drivers*
  - *apm(4)*, *lcd(4)*, *ohci(4)*, *pcmcia(4)*, more?
  - because of some obscure chips (*scoop(4)*, backlight control, ...)
- you can use drivers from other BSDs

# Going Native

---

- you can mount an NFS root until the disk driver works  
(“make cross-distrib” can build a minimal distribution)

# Going Native

- you can mount an NFS root until the disk driver works (“make cross-distrib” can build a minimal distribution)
- you have to cheat, but it’s done only once:
  - use the natively-built distribution from another port with the same CPU architecture (cats for zaurus)
  - worst case: cross-compile the native compiler

# Subsequent Work

---

- fix most annoying bugs

# Subsequent Work

---

- fix most annoying bugs
- port *boot(8)*

# Subsequent Work

---

- fix most annoying bugs
- port *boot(8)*
- document the boot process (*boot\_zaurus(8)*, ...)



# Subsequent Work

---

- fix most annoying bugs
- port *boot(8)*
- document the boot process (*boot\_zaurus(8)*, ...)
- document already supported devices (*intro(4)*, ...)

# Subsequent Work

- fix most annoying bugs
- port *boot(8)*
- document the boot process (*boot\_zaurus(8)*, ...)
- document already supported devices (*intro(4)*, ...)
- build snapshots, announce the port and make it available
  - update web pages
  - set up a mailing list
  - make other people do these things : )

# Subsequent Work

- fix most annoying bugs
- port *boot(8)*
- document the boot process (*boot\_zaurus(8)*, ...)
- document already supported devices (*intro(4)*, ...)
- build snapshots, announce the port and make it available
  - update web pages
  - set up a mailing list
  - make other people do these things : )
- write and document new device drivers

# Subsequent Work

- fix most annoying bugs
- port *boot(8)*
- document the boot process (*boot\_zaurus(8)*, ...)
- document already supported devices (*intro(4)*, ...)
- build snapshots, announce the port and make it available
  - update web pages
  - set up a mailing list
  - make other people do these things : )
- write and document new device drivers
- fix more bugs

# Subsequent Work

- fix most annoying bugs
- port *boot(8)*
- document the boot process (*boot\_zaurus(8)*, ...)
- document already supported devices (*intro(4)*, ...)
- build snapshots, announce the port and make it available
  - update web pages
  - set up a mailing list
  - make other people do these things : )
- write and document new device drivers
- fix more bugs
- make the ports tree aware of the new platform, eg create plists

# Outline

- 1 Porting OpenBSD
  - What It Takes
  - Preparation
  - Cross-Development
  - The Boot Loader
  - Building The Kernel
  - Adapting Startup Code
  - Writing Device Drivers
  - Going Native
  - Subsequent Work

- 2 OpenBSD/zaurus
  - History
  - What It Took
  - What Was Done
  - Tricky Parts
  - Current Status
  - Future Plans

# History

- “cats” and “zaurus” are “multi-arch” ports
- NetBSD/cats ported to OpenBSD by Dale Rahn (drahn@) to support ARM processors
- Dale started in December 2004 based on OpenBSD/cats (but worked on some stuff before, like *lcd(4)*)
- kind-of usable for Theo in January 2005
- first release was 3.7 (released in May 2005)
  - only a few things missing, like audio support
- work is ongoing

# What It Took

---

- ball really started rolling at OpenCON 2004



# What It Took

- ball really started rolling at OpenCON 2004
- more than 10 developers who contributed Zaurus-specific code in different areas (some of them didn't even have one)
  - eg pascoe@ worked on **zaudio(4)** without even having a zaurus, all remotely

# What It Took

- ball really started rolling at OpenCON 2004
- more than 10 developers who contributed Zaurus-specific code in different areas (some of them didn't even have one)
  - eg pascoe@ worked on **zaudio(4)** without even having a zaurus, all remotely
- good documentation

# What It Took

- ball really started rolling at OpenCON 2004
- more than 10 developers who contributed Zaurus-specific code in different areas (some of them didn't even have one)
  - eg pascoe@ worked on *zaudio(4)* without even having a zaurus, all remotely
- good documentation
  - processor documentation was extremely useful, even for writing device drivers - it is a System-on-Chip design

# What It Took

- ball really started rolling at OpenCON 2004
- more than 10 developers who contributed Zaurus-specific code in different areas (some of them didn't even have one)
  - eg pascoe@ worked on *zaudio(4)* without even having a zaurus, all remotely
- good documentation
  - processor documentation was extremely useful, even for writing device drivers - it is a System-on-Chip design
  - touch-screen controller, audio controller and the microdrive were also documented

# What It Took

- ball really started rolling at OpenCON 2004
- more than 10 developers who contributed Zaurus-specific code in different areas (some of them didn't even have one)
  - eg pascoe@ worked on *zaudio(4)* without even having a zaurus, all remotely
- good documentation
  - processor documentation was extremely useful, even for writing device drivers - it is a System-on-Chip design
  - touch-screen controller, audio controller and the microdrive were also documented
  - but some Sharp-made chips are not, and depending on Linux source code as documentation is horrifying

# What It Took

- ball really started rolling at OpenCON 2004
- more than 10 developers who contributed Zaurus-specific code in different areas (some of them didn't even have one)
  - eg pascoe@ worked on *zaudio(4)* without even having a zaurus, all remotely
- good documentation
  - processor documentation was extremely useful, even for writing device drivers - it is a System-on-Chip design
  - touch-screen controller, audio controller and the microdrive were also documented
  - but some Sharp-made chips are not, and depending on Linux source code as documentation is horrifying
- money for machines for developers

# What It Took

- ball really started rolling at OpenCON 2004
- more than 10 developers who contributed Zaurus-specific code in different areas (some of them didn't even have one)
  - eg pascoe@ worked on *zaudio(4)* without even having a zaurus, all remotely
- good documentation
  - processor documentation was extremely useful, even for writing device drivers - it is a System-on-Chip design
  - touch-screen controller, audio controller and the microdrive were also documented
  - but some Sharp-made chips are not, and depending on Linux source code as documentation is horrifying
- money for machines for developers
- an unknown amount of beer : ) to start things

# What Was Done

---

- processor startup code adapted for the Zaurus  
(`arm/arm/locore.S` is shared between different machines)



# What Was Done

---

- processor startup code adapted for the Zaurus  
(`arm/arm/locore.S` is shared between different machines)
- ***boot(8)*** ported to Linux

# What Was Done

- processor startup code adapted for the Zaurus  
(`arm/arm/locore.S` is shared between different machines)
- ***boot(8)*** ported to Linux
- hacked up ***com(4)*** driver for PXA27x
  - integrated ***pcic(4)*** driver for PXA27x from NetBSD
  - integrated ***lcd(4)*** for PXA27x

# What Was Done

- processor startup code adapted for the Zaurus  
(`arm/arm/locore.S` is shared between different machines)
- ***boot(8)*** ported to Linux
- hacked up ***com(4)*** driver for PXA27x
  - integrated ***pcic(4)*** driver for PXA27x from NetBSD
  - integrated ***lcd(4)*** for PXA27x
- fake ***apm(4)*** backend to use the existing framework

# What Was Done

- processor startup code adapted for the Zaurus  
(`arm/arm/locore.S` is shared between different machines)
- ***boot(8)*** ported to Linux
- hacked up ***com(4)*** driver for PXA27x
  - integrated ***pcic(4)*** driver for PXA27x from NetBSD
  - integrated ***lcd(4)*** for PXA27x
- fake ***apm(4)*** backend to use the existing framework
- and many little things...

# Tricky Parts

---

- in general, porting went on fairly quickly and straightforward

# Tricky Parts

---

- in general, porting went on fairly quickly and straightforward
- *nlist()* on non-native objects - a cross-development (non-)issue in elfrdsetroot

# Tricky Parts

- in general, porting went on fairly quickly and straightforward
- *nlist()* on non-native objects - a cross-development (non-)issue in elfrdsetroot
- undocumented chips and circuitry (**scoop(4)**, backlight controller, power circuit)

# Tricky Parts

- in general, porting went on fairly quickly and straightforward
- *nlist()* on non-native objects - a cross-development (non-)issue in elfrdsetroot
- undocumented chips and circuitry (**scoop(4)**, backlight controller, power circuit)
- we couldn't support C860 machines
  - no disk drive; just raw flash
  - too many differences between models
  - more developers have the C3x00



# Tricky Parts

- in general, porting went on fairly quickly and straightforward
- *nlist()* on non-native objects - a cross-development (non-)issue in *elfrdsetroot*
- undocumented chips and circuitry (***scoop(4)***, backlight controller, power circuit)
- we couldn't support C860 machines
  - no disk drive; just raw flash
  - too many differences between models
  - more developers have the C3x00
- ***zkbd(4)*** is just a bunch of GPIO inputs

# Tricky Parts

- in general, porting went on fairly quickly and straightforward
- *nlist()* on non-native objects - a cross-development (non-)issue in elfrdsetroot
- undocumented chips and circuitry (**scoop(4)**, backlight controller, power circuit)
- we couldn't support C860 machines
  - no disk drive; just raw flash
  - too many differences between models
  - more developers have the C3x00
- **zkbd(4)** is just a bunch of GPIO inputs
- UART was not completely compatible to a standard 16550A or 16750

# Tricky Parts

- in general, porting went on fairly quickly and straightforward
- *nlist()* on non-native objects - a cross-development (non-)issue in elfrdsetroot
- undocumented chips and circuitry (**scoop(4)**, backlight controller, power circuit)
- we couldn't support C860 machines
  - no disk drive; just raw flash
  - too many differences between models
  - more developers have the C3x00
- **zkbd(4)** is just a bunch of GPIO inputs
- UART was not completely compatible to a standard 16550A or 16750
- screen rotation on framebuffer console - not in 3.7

# Tricky Parts

- in general, porting went on fairly quickly and straightforward
- *nlist()* on non-native objects - a cross-development (non-)issue in elfrdsetroot
- undocumented chips and circuitry (**scoop(4)**, backlight controller, power circuit)
- we couldn't support C860 machines
  - no disk drive; just raw flash
  - too many differences between models
  - more developers have the C3x00
- **zkbd(4)** is just a bunch of GPIO inputs
- UART was not completely compatible to a standard 16550A or 16750
- screen rotation on framebuffer console - not in 3.7
- no hardware floating-point unit - creates performance problems with some software (e.g. xmms, mplayer; on zaurus we use integer math decoders for these kinds programs where possible)

# Current Status

---

- mostly feature-complete

# Current Status

---

- mostly feature-complete
- we support wired and infrared serial ports

# Current Status

---

- mostly feature-complete
- we support wired and infrared serial ports
- all existing USB and PCMCIA cards should just work

# Current Status

---

- mostly feature-complete
- we support wired and infrared serial ports
- all existing USB and PCMCIA cards should just work
- LCD works in portrait and landscape mode (under X)
  - but you have to restart X
  - on-the-fly rotation is hard - no API in X to do that



# Current Status

---

- mostly feature-complete
- we support wired and infrared serial ports
- all existing USB and PCMCIA cards should just work
- LCD works in portrait and landscape mode (under X)
  - but you have to restart X
  - on-the-fly rotation is hard - no API in X to do that
- audio playback works well, with occasional glitches

# Current Status

---

- mostly feature-complete
- we support wired and infrared serial ports
- all existing USB and PCMCIA cards should just work
- LCD works in portrait and landscape mode (under X)
  - but you have to restart X
  - on-the-fly rotation is hard - no API in X to do that
- audio playback works well, with occasional glitches
- even Java works

# Future Plans

---

- of course, continue to fix and improve stuff
  - better keyboard support (***zkbd(4)***)
  - “xdm=YES” should work out of the box
  - PCMCIA bugfixes (some detection problems, voltage switching)
  - anything else?

# Future Plans

- of course, continue to fix and improve stuff
  - better keyboard support (***zkbd(4)***)
  - “xdm=YES” should work out of the box
  - PCMCIA bugfixes (some detection problems, voltage switching)
  - anything else?
- add “sysctl hw.cpuspeed” support for running at 91 Mhz, 208 Mhz or 416 Mhz

# Future Plans

- of course, continue to fix and improve stuff
  - better keyboard support (***zkbd(4)***)
  - “xdm=YES” should work out of the box
  - PCMCIA bugfixes (some detection problems, voltage switching)
  - anything else?
- add “sysctl hw.cpuspeed” support for running at 91 Mhz, 208 Mhz or 416 Mhz
- ***wdisplay(4)*** is improving thanks to miod@

# Future Plans

- of course, continue to fix and improve stuff
  - better keyboard support (***zkbd(4)***)
  - “xdm=YES” should work out of the box
  - PCMCIA bugfixes (some detection problems, voltage switching)
  - anything else?
- add “sysctl hw.cpuspeed” support for running at 91 Mhz, 208 Mhz or 416 Mhz
- ***wdisplay(4)*** is improving thanks to miod@
- support CF XGA cards (miod@ and matthieu@ are working on this)

# Future Plans

- of course, continue to fix and improve stuff
  - better keyboard support (***zkbd(4)***)
  - “xdm=YES” should work out of the box
  - PCMCIA bugfixes (some detection problems, voltage switching)
  - anything else?
- add “sysctl hw.cpuspeed” support for running at 91 Mhz, 208 Mhz or 416 Mhz
- ***wdisplay(4)*** is improving thanks to miod@
- support CF XGA cards (miod@ and matthieu@ are working on this)
- ***apm(4)*** improvements
  - turn off some more chips when suspended
  - extended power-saving measures, perhaps

# Future Plans

- of course, continue to fix and improve stuff
  - better keyboard support (***zkbd(4)***)
  - “xdm=YES” should work out of the box
  - PCMCIA bugfixes (some detection problems, voltage switching)
  - anything else?
- add “sysctl hw.cpuspeed” support for running at 91 Mhz, 208 Mhz or 416 Mhz
- ***wdisplay(4)*** is improving thanks to miod@
- support CF XGA cards (miod@ and matthieu@ are working on this)
- ***apm(4)*** improvements
  - turn off some more chips when suspended
  - extended power-saving measures, perhaps
- ***gpioc(8)*** support (LED, hinge state?)



# Future Plans

- of course, continue to fix and improve stuff
  - better keyboard support (***zkbd(4)***)
  - “xdm=YES” should work out of the box
  - PCMCIA bugfixes (some detection problems, voltage switching)
  - anything else?
- add “sysctl hw.cpuspeed” support for running at 91 Mhz, 208 Mhz or 416 Mhz
- ***wdisplay(4)*** is improving thanks to miod@
- support CF XGA cards (miod@ and matthieu@ are working on this)
- ***apm(4)*** improvements
  - turn off some more chips when suspended
  - extended power-saving measures, perhaps
- ***gpioctl(8)*** support (LED, hinge state?)
- Fix the ARM pmap issue with write-back caching

## Future Plans (cont'd)

---

- audio recording

## Future Plans (cont'd)

---

- audio recording
- BlueTooth support via USB dongles - grange@ already ported ***ubt(4)*** from FreeBSD and created `net/bluetooth-tools`

## Future Plans (cont'd)

---

- audio recording
- BlueTooth support via USB dongles - grange@ already ported ***ubt(4)*** from FreeBSD and created net/bluetooth-tools
- support more Zaurus models (C860, probably even StrongARM-based SL-5500)

## Future Plans (cont'd)

---

- audio recording
- BlueTooth support via USB dongles - grange@ already ported **ubt(4)** from FreeBSD and created net/bluetooth-tools
- support more Zaurus models (C860, probably even StrongARM-based SL-5500)
- SDIO support - new framework

# Future Plans (cont'd)

- audio recording
- BlueTooth support via USB dongles - grange@ already ported **ubt(4)** from FreeBSD and created net/bluetooth-tools
- support more Zaurus models (C860, probably even StrongARM-based SL-5500)
- SDIO support - new framework
- USB device framework
  - client-side **cdce(4)**
  - storage class device support needs to be thought through. is it useful after all?

# Future Plans (cont'd)

- audio recording
- BlueTooth support via USB dongles - grange@ already ported **ubt(4)** from FreeBSD and created net/bluetooth-tools
- support more Zaurus models (C860, probably even StrongARM-based SL-5500)
- SDIO support - new framework
- USB device framework
  - client-side **cdce(4)**
  - storage class device support needs to be thought through. is it useful after all?
- what can you think of?

- need donations (time, money, bugfixes, beer)
- thanks