Using FreeBSD in an Embedded Environment

A Work in Progress

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The FreeBSD Project

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Outline

Differences with Other Worlds

- Space is not free
- There is never any time
- Electricity costs money too

Intellectual Property

- Legal uncertainty is not an option
- Some things really should not be GNU-"free"
  - You do not want to hack a payment terminal
  - ...or an ATM
  - ...or an X-ray detector
- Repeat after me: GNU is **not** (always) "free"

Traditional Embedded Systems

- Proprietary
  - . . . and often expensive
- Tiny code-size (10s–100s of Kbytes)
- More or less “hard” real-time
- Task-switching or multithreaded
- Single-application optimized

Features of FreeBSD

- Friendly BSD-style licence
  - Contrast with GNU licence
- Integrated build-system
  - Easy to build complete systems
  - Easy to modify to requirements
- Support for some popular embedded platforms
  - x86
  - ARM
  - PowerPC
  - MIPS

Problems with FreeBSD

- Somewhat larger than perhaps desirable
  - On the order of 10s–100s of Mbytes
  - Easy to strip down up to a point
  - Slightly trickier to strip down further
- Chunks of infrastructure still lacking
  - Support for more embedded architectures
  - NAND/NOR flash device abstraction
- Hard to compete with Linux
  - Linux has a lot of mindshare
  - Not as bad as it used to be. . .
  - Tougher to compete purely on features

Outline

What is a Console Server Anyway?

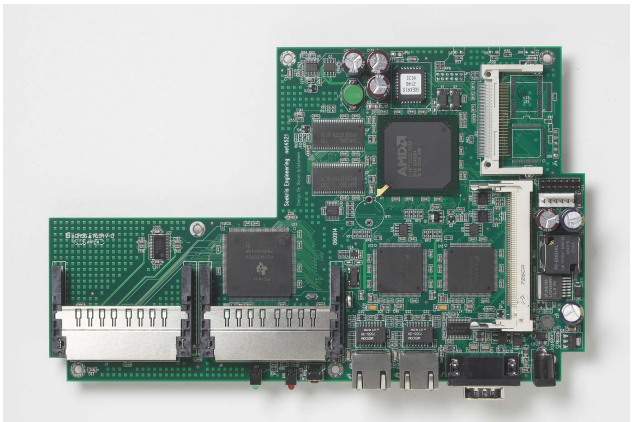
- Central component of any hacker lab
- Talk to consoles without keyboards and monitors
- Debug kernels using DDB or even GDB from a comfy chair
- Similar uses in large datacentres
  - . . . for many of the same reasons

Why Build This Yourself

- Commercial units often very expensive
  - Blame the datacentres!
- Retired ones on eBay loud, clunky and powerhungry
- It's fun, of course!

Outline

Soekris Net4521



- 100/133 Mhz AMD ElanSC520
- 32 Mbyte RAM
- Compact flash storage
- 8 GPIOs
- 1 UART
- No USB on-board
- MiniPCI and some other stuff
- Max 14W power consumption

Artila M-501

- 180MHz Atmel AT91RM9200
- 64 Mbyte RAM
- 16 Mbyte on-board NOR
- 32 GPIOs
- 4 UARTs
- USB on-board
- The usual complement of busses (I^2C, I^2S, SPI, SD, ...)
- Max 2.5W power consumption

Feature Comparisson

Soekris net4521:

- PRO: Standard PC architecture
- PRO: Easy to flash CF cards
- CON: High power requirement
- CON: Few UARTs
- CON: Largish hardware
- CON: Fairly expensive

Artila M-501:

- PRO: Lots and lots of UARTs
- PRO: Tiny power requirements
- PRO: Cheap(ish) to manufacture
- PRO: Very small hardware
- CON: Higher porting effort
- CON: Less convenient development

Getting Software on the Boards

Development phase:

- Netbooting with BOOTP/TFTP
- Software runs from root on NFS
- FreeBSD makes this *very* easy

Production system:

- Soekris runs from easy CF cards
- Artila has NOR flash on board
- Flashing NOR is a bit tricky

FreeBSD as a Development Workstation

- Base system contains most required tools
- Other bits can easily be installed from ports/packages
- Netbooting FreeBSD is fairly trivial(ish)
  - Once it works, it tends to keep working

Documentation

- Interfaces are (often) extensively documented
- Even the kernel!

Integrated Build Environment

- Build a cross-toolchain in one command
- Build the “world” in one command
- Yes! You can do partial builds
- No need to reinvent yet another wheel

Features of NanoBSD

- NanoBSD is a script to drive the "normal" build system
- Primarily optimized for producing disk images for CF
- Chops the FreeBSD world down to 10s of Mbyte easily
  - That is still quite large though

Remember `crunchgen`?

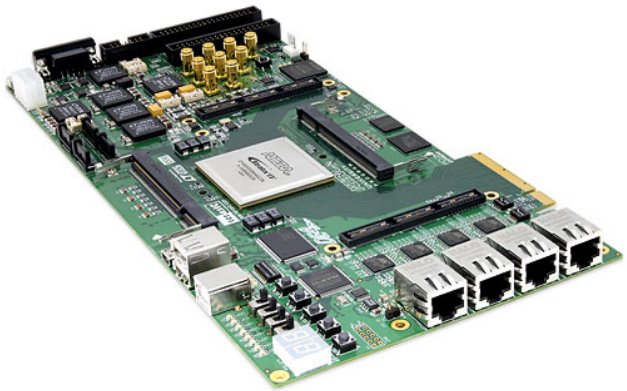
- A bit like "busybox" from the Linux/GNU world
- . . . but not really
- Originally from PicoBSD
- Now mainly used in `/rescue`
- Can chop FreeBSD down to $<$ 10 Mbyte

Outline

Make FreeBSD Better

- Bootloader improvements for development
- Generic flash layer in the kernel
- Cross-platform pkg_add
- Better integration of crunchgen with the build
  - Perhaps with NanoBSD
  - Call it FemtoBSD?
- . . . your wishlist here . . .

Porting FreeBSD to CHERI



- My current “big” project
- 64bit-only MIPS on an FPGA
- Security research with University of Cambridge
- FreeBSD target operating system

Questions? Comments?