Building products with NetBSD - thin-clients

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Contents

- Who am I?
- What is a thin-client?
  - Client software
- Relevant experience and jobs
- Product history
  - The End?, A New Hope, Baggage, Brainwave
- Problems to address
- How NetBSD solves problems
- Problems hit against
- Problems not easily solved
- Exciting NetBSD developments
- Problems with NetBSD

Who am I?

- Live and work in Cambridge, UK
- PhD in psychoacoustics (not Computer Science!)
- NetBSD user since 1994
- NetBSD and pkgsrc developer/committer since Jan 2007
- Managing Director of Precedence Technologies Ltd
- Citrix Certified Administrator
- Citrix Certified Sales Professional

What is a thin-client?

- Small physical size
- No moving parts
- Low/medium performance
- No local storage (firmware only)
- Low power consumption
- Fast start time
- Centrally managed from network
- Contains network client software, but no general applications
  - c.f. a fat-client which has whole OS and applications locally (e.g. MacOS, Windows), plus complex local configuration

Usual client software in thin-clients

- Citrix ICA
- Microsoft RDP
- X11
- Terminal (ssh/telnet/tn3270)
- Web browser
- VNC

Relevant experience

- Used Masscomp Unix and Irix as part of PhD
- Avid Acorn (ARM) user (at time)
- Wanted a Unix-alike to use and learn on
- Acorn RISCiX was 4.3BSD-based, but expensive, old and not for new machines
- RiscBSD project launched in 1994. NetBSD for Acorn RiscPC
- RiscBSD became NetBSD/arm32 and then NetBSD/acorn32

Relevant jobs

- **Feb 1996**: started at Acorn Education in tech support (part time – still doing PhD)
- **Apr 1996**: Acorn and Apple UK formed Xemplar Education.
- Xemplar Education 2nd biggest supplier of IT to UK education. I transferred there full-time

Product history

- **Jan 1996**: Acorn launched Network Computer Reference Design with Oracle
- NC was 48MHz ARM7500FE, 16MB RAM, 10Mbit Ethernet, custom version of RISC OS, no local storage, boot from NFS, browser in ROM
- **Oct 1996**: Xemplar given 2 pre-release NCs by parent company Acorn. Sales/Marketing took one – I took other. I had a plan...

Product history

- Used NetBSD/arm32 on RiscPC to boot NC
- Apache for web-based UI
- Wrote web-based administration
- Wrote webmail package
- Wrote/designed application framework
- From summer 1997, solution sold to UK schools (NetBSD-based NCServer)
- Means Apple were selling BSD Unix in 1997!
  - Airport Extreme Base Station runs NetBSD/arm BTW

The End?

- **Summer 1998**: Became Network Computer Technical Manager
- **Summer 1998**: Large roll-out throughout UK
- **Jan 1999**: Acorn sell 50% share to Apple, i.e. Xemplar were now 100% Apple
- **Mar 1999**: Most staff made redundant (inc. me)
- Meant customers throughout UK with paid-up support contracts, but no support staff
- **Apr 1999**: Precedence starts trading. Buys NC stock. Contracted by Apple to provide support. Given all IPR and source code

A New Hope

- **Apr 1999**: Precedence sell CATS to replace aging RiscPCs (running NetBSD/cats)
- Re-position server as being a general purpose Internet/intranet/email/filtering server (NetManager)
- **Nov 1999**: Swap to NetManager running i386
- **Apr 2002**: Start complete modular re-write (NG on NetBSD/i386 1.6.1)
- **Today**: NetManager selling well (NetBSD/i386 3.1_STABLE)

Baggage

- Still selling 48MHz clients, very proprietary
- Very poor performance and old ICA client
- Evaluated netbooting NetBSD/acorn32 and running Linux/ARM ICA client – no benefit
- Refuse to sell WindowsCE clients
- Start to sell 233MHz+ Linux-based clients
  - Very poor support
  - Basic software
- Found alternative Linux-based clients
  - Slick UI
  - Pain to buy (have to import)
  - Expensive
  - No obvious future development plan

Brainwave

- Develop NetBSD-based solution to convert old PCs into thin-clients
- Chose name: ThinIT
- Started on 2nd May 2003. First release on 23rd May 2003 (v1.00)
- NetBSD 1.6 basic install
- Scripts to remotely manage
- Run read-only mount on HDD
- Citrix ICA/Microsoft RDP clients only
- Linux emulation for Citrix ICA client
- Extremely easy install (CDROM/floppy)

Brainwave v2

- Linux-based thin-clients expensive and few upgrades. No control over software.
- Look for alternative clients
- Why not use ThinIT on OEM hardware?
- Search out low-cost, high performance clients
- TCX released Sep 05 (1GHz, 128MB flash, 256MB RAM)
- TCM release Jan 06 (1.5GHz laptop, 128MB flash, 256MB RAM)
- ThinIT v2 finally released for PC: Sep 07

Problems to address

- Needs to run from flash
- Easy build infrastructure
- Easy to test during development
- Should be able to boot from various sources (CDROM, USB, PXE, Flash, HDD)
- Should have slick user interface
  - No kernel text
  - No command line
  - GUI configuration
- Modular
- Many more session types
- Needs to have small footprint

Problems to address

- Needs to be difficult to rip off
- Centrally configured
- Remote management
- Wide hardware support, but excellent performance on known hardware

How NetBSD solves problems 1

- Run from flash
  - NetBSD installer has ffs image as root filesystem embedded in kernel with mdsetimage
  - Very easy to extend and build custom images
  - Requires small tweaks for multi-user
- Easy build infrastructure
  - build.sh
  - Single make can do a lot
- Easy to test during development
  - Auto-generate filesystem for Xen
  - Use Xnest

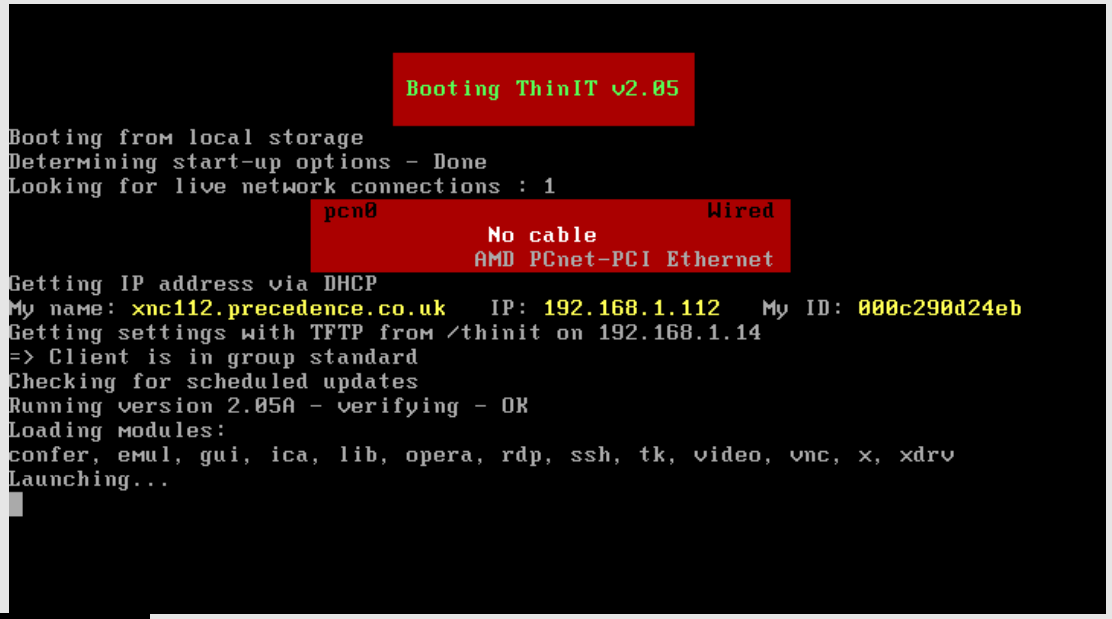
How NetBSD solves problems 2

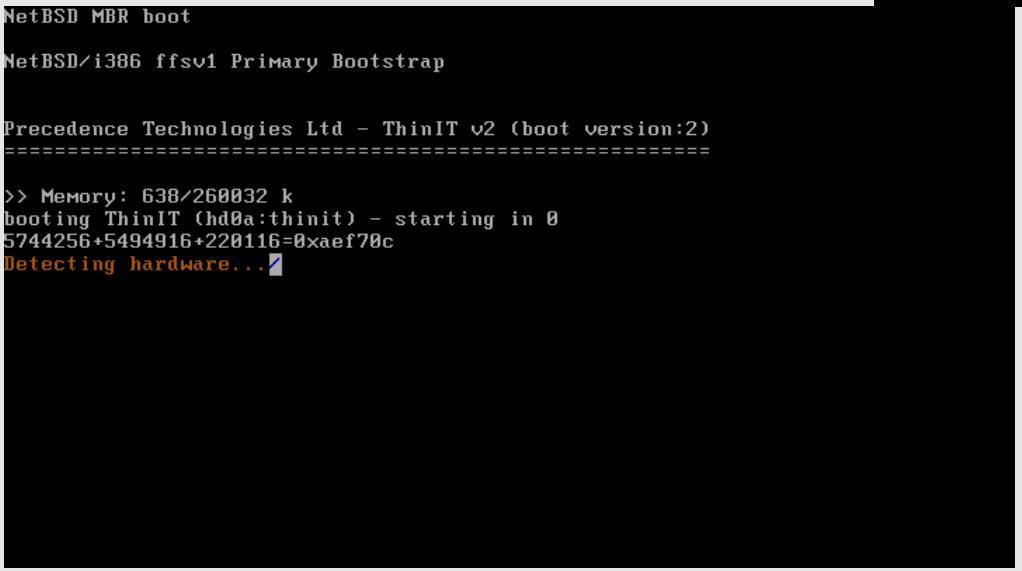
- Boot from various sources
  - Very easy – just one file + bootloaders
  - Tweak pxebooters to hardwire TFTP path
  - (NEW!) cdboot means no more floppy emulation and 2.88MB limit. Also allows a choice of kernels
  - Can still build floppies (removal of CD 2.88MB restriction means more floppies needed)
  - (NEW!) bootxx_fat16 allows easy boot from FAT USB pen drive without re-partitioning
  - Future? NTFS boot (drop files on PC and play!)

How NetBSD solves problems 3

- Slick user interface
  - Kernel boot messages must go
    - boot -z is NOT silent. Shows some autoconf text
    - aprint_* vs printf already there, but woefully underused (not mechanical conversion, needs human judgment)
    - Cheap hack – make printf do same as aprint_normal
  - Lock down boot loaders
    - Password protect, hardwire kernel path
  - Most of rc.d scripts rewritten
    - Differentiate between output to terminal (friendly text) and log to file (debugging)
  - Colour text, cursor positioning
  - (NEW!) vesafb/splashscreen (jmcneill@)
  - GUI configuration (GTK)
  - Lots of pretty screen savers (xlockmore)

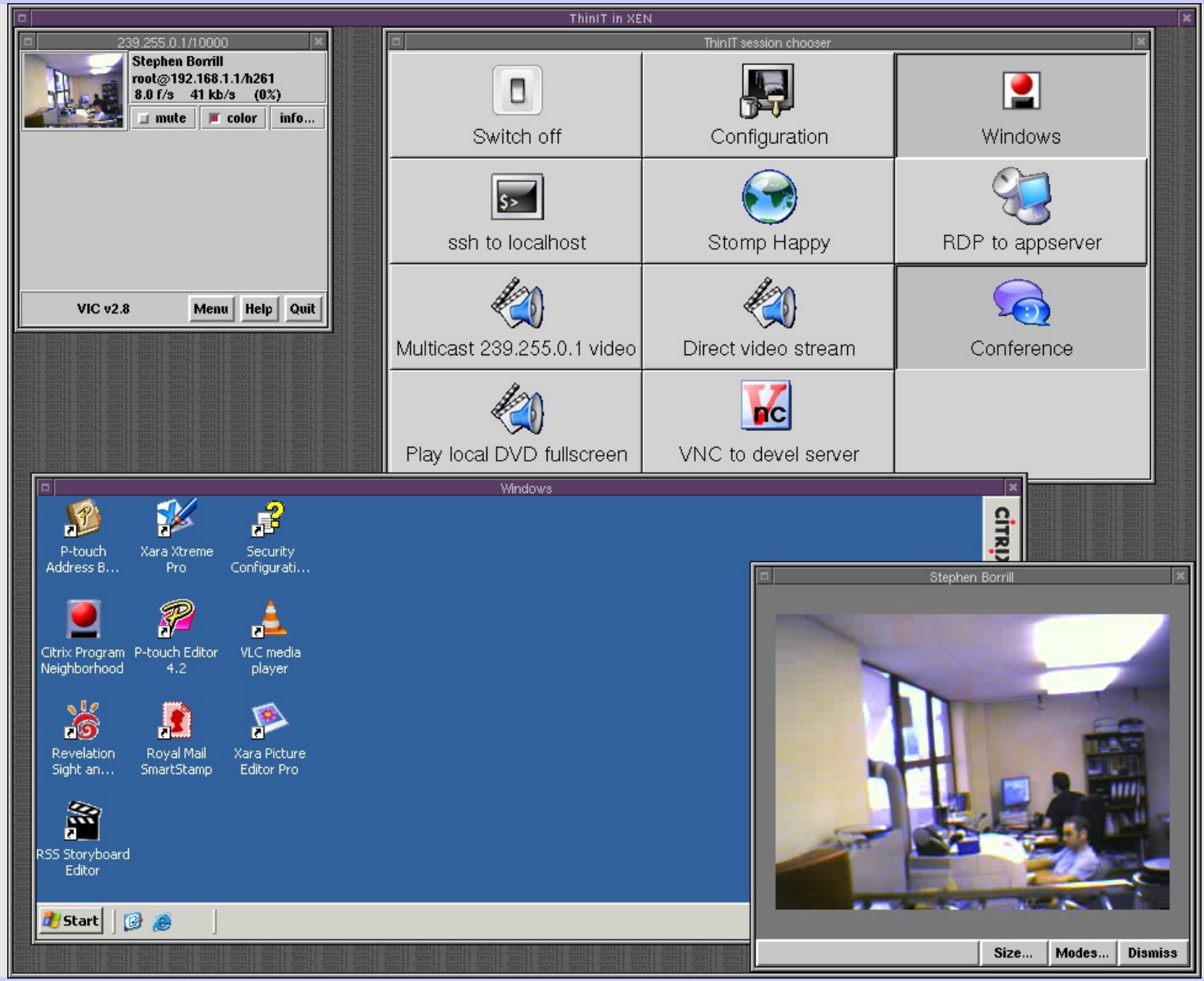
User interface at boot time





- vesafb splashscreen (top left)
- non-vesafb version (bottom left)
- boot sequence (top right)

User interface when running



How NetBSD solves problems 3

- Modular
  - ThinIT kernel is standalone. Knows how to upgrade itself, get settings, speak to various networks and find files on various filesystems
  - Supported by a number of modules which it loads either into RAM (over http/tftp/ftp or from CD) or from local filesystem (ffs, FAT, NTFS)
  - Modules are disk images created with makefs and configured as vnds
  - Some required (e.g. libs, X)
  - Some useful, but could be removed (e.g. gui)
  - Session modules optional (e.g. ica, rdp, vnc)
  - Some required by others (e.g. emul)

How NetBSD solves problems 4

- More session types
  - Configuration file format extended
  - Adding a new type as easy as adding a new module (based on pkgsrc binary packages)
    - Streamed video and DVD playback (vlc)
    - Web browser (opera)
    - Conferencing (mbone tools: vic, rat, wb)
    - ssh
    - vnc
    - Citrix ICA
    - Microsoft RDP
    - SIP
    - Datalogging
  - This variety of session types is unique in market

How NetBSD solves problems 5

- Small footprint
  - Crunchgen monolithic binary very memory efficient (similar to busybox on Linux)
  - Kernel with embedded ramdisk gzip -9
  - Less than 2.5MB (for TCX)
  - (NEW!) cloop2 compressed vnd (Cliff Wright, Florian Stoehr) used for modules. Came along just at right time!
  - Severely pruned file list in modules (see later)
  - (NEW!) tmpfs efficient memory file system (jmmv@)

File sizes in ThinIT v2.05

rdp-3.enz	101,376	lib-4.enz	2,016,256
vnc-4.enz	124,928	xdrv-1.enz	2,048,000
xvia-3.enz	135,680	tcx-7.krn	2,426,211
xi810-2.enz	207,872	tcm-7.krn	2,587,539
xsis-2.enz	225,792	video-3.enz	3,930,624
ssh-3.enz	261,632	thinit-7.krn	4,196,849
confer-3.enz	418,304	emul-3.enz	4,336,640
tk-2.enz	1,227,776	x-3.enz	5,730,303
gui-6.enz	1,301,504	opera-3.enz	8,435,712
ica-6.enz	1,886,720	**TOTAL (TCX)**	**34,815,330**

.krn files are kernels for different machines
Total includes only TCX kernel

How NetBSD solves problems 6

- Difficult to rip off
  - Compressed modules encrypted
    - cgd tricky to use because must encrypt AFTER compression (ffs on vndz, vndz on ffs, ffs on cgd, cgd on vnd).
    - Extended vnd(4) to support encryption
  - Check hardware we're running on
  - Encrypt embedded filesystem (future)
  - Signed modules (future)
  - Licence management (future)

How NetBSD solves problems 7

- Centrally configured
  - Fetches config file with http, ftp or tftp
  - Path configured with DHCP option
  - Supports groups and per-machine files
  - Plain text format
    - session.1.type=ica
    - session.1.name=Run Windows
    - session.1.server=icaserver
    - ica.usb=b
- Remote management
  - Shutdown, reboot, probe, configure, view logs, play music(!)
  - Shadow screen (x11vnc)

How NetBSD solves problems 8

- Excellent performance on known hardware
  - Very cut down kernel configs for TCX and TCM clients and optimisations
  - Very quick boot times as no probing for devices
  - Tweaked X drivers
- Wide hardware support
  - GENERIC-type kernel for everything else
  - Minimise kernel configs (acpi vs non-acpi?)
  - (NEW!) Bootprops (jmcneill@)
    - proplib-based (XML).
    - Configure autoconf (boot -c) from config file
    - Configure boot loader
    - Akin to OpenBSD's config -e with FreeBSD's boot.conf
    - Not yet used or committed (due to bike-shedding)

Problems hit against

- NetBSD 3.1 didn't support WEP with iwi(4) which was in new OEM laptops
  - Forced a switch to 4.0_BETA2.
  - Meant lot of work in short time against tight deadlines
  - Compressed vnds broken at switch – bad timing!
- All packages rebuilt for 4.0
  - Another round of working out what can be removed
- Meant new Linux emulation (SuSE 10 vs 9)
  - More to chop out!
- New Citrix ICA client
  - Required more Linux libraries

Problems hit against

- Forced to switch to modular X.org (widescreen modes, new Intel chipset)
  - Actually very painless (joerg@)
  - Made module generation much easier as provides a clear list of components and their dependencies
  - Constantly moving target
  - Module size increased (5.7MB vs 3.7MB) – mainly due to including more fonts and including more libraries

Problems not easily solved

- Lack of hardware support
  - Standard problems familiar to us all
    - Lack of device drivers
    - Blobs
    - Licencing (e.g. Intel uCode)
  - FreeBSD's Linux driver project (Luigi Rizzo) very exciting, no takers for GSoC :-(
  - Linux kernel->userland driver project worth watching. rump (pooka@) allows NetBSD filesystems to be run in userspace.

Problems not easily solved

- pkgsrc not designed for embedded system
  - Large dependency lists (e.g. gtk2+ is 33+ MB, got this down to 3.5MB ThinIT module)
  - Options framework not widely used enough
  - Packages include everything needed for development (e.g. header files, static libraries)
  - ThinIT Makefile removes *.h, *.a, *.la & man. Plus supports extracting against a fixed list
- Dependence on Linux emulation
  - Precedence is a Citrix Global Alliance Partner – perhaps we'll get source ($20k last time we asked)
  - Opera do not not want to pursue a native version of their browser at this point in time

Exciting NetBSD developments

- PUFFS/refuse
  - Thanks to pooka@, agc@
  - API not yet fixed and widespread FS change mean little chance of 4.0 backport :-(
  - ntfs-3g (r/w NTFS) useful for ThinIT booting
  - Lots of filesystems that could be exported to ICA and RDP sessions
    - gphotofs (most cameras that are not mass-storage)
    - ntfs-3g (access local data)
  - Could be used as basis for amd replacement
    - Would allow NFS to be removed from ThinIT kernel
    - amd is overkill for mounting USB pen drives on demand
    - amd uses symlinks which are disabled in Citrix ICA client. Prefer them disabled to stop access to root filesystem

Exciting NetBSD developments

- DRM/DRI coming soon
  - Thanks for jmcneill@, blair@
  - Higher performance video streaming
- Power management framework (jmcneill@, joerg@).
  - About to be merged into -current
  - Proper suspend/resume ACPI support
- envsys2 (xtraeme@) for environment monitoring
  - In conjunction with power management, means excellent for laptops
- Revamped vnd(4) to support more image types
  - Includes compression, encryption
  - e.g. MacOS .dmg support

Problems with NetBSD

- Slow releases
  - NetBSD 4.0 far too slow to arrive. When 5.0?
- Too many developers working at the cutting edge without backporting
  - Without a faster release process (pouncing?) real world products like ThinIT can't use new features
- Difficult to fund development
  - TNF funding ad@ for SMP development
  - But not many developers for hire
- BSD licence clearly better than GPL
  - Advertising clause is difficult to support

Conclusion

- NetBSD is excellent for embedded work
  - Quick to develop on
  - Clean code
  - Powerful bulk and cross-building tools
- BSD as whole ideal for product development
  - Commercially friendly licence
  - Integrated kernel/userland
- Has familiar problems seen throughout OSS
  - Lack of device drivers
- Not just a research OS
  - **Striving for perfection can slow progress**
  - **Encouraging commercial use can fund development. Bear such needs in mind**