Linux on iPAQ

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Disclaimer

Whilst I work for Compaq, a Hewlett Packard Company this is a personal presentation and reflects my views and these may not necessarily coincide with those of Compaq, HP or anyone else!

Outline

- What is an iPAQ?
- Why Linux?
- Handhelds.org
- iPAQ Linux Distributions
- Mercury Project (BackPAQ)
- iPAQ Linux Nitty Gritty
- Installing Linux on iPAQ

What is an iPAQ?

•The iPAQ is a Compaq developed (now badged HP) PDA based on the StrongARM architecture running Windows CE

•There are many models

Model	RAM	ROM	CPU
3100	16Mb	16Mb	SA 206MHz
3600	32	16	SA 206MHz
3700	32	32	SA 206MHz
3800	32/64	32	SA 206MHz
3900	64	32/48	PXA250 400MHz
h1910	48	16	PXA250 200MHz
h5450	64	48	PXA250 400MHz

iPAQ expansion sleeve

- Allows iPAQ to be expanded
  - Single CF sleeve
  - Single PCcard sleeve
    - With battery
  - Dual PCcard sleeve
  - PCcard and CF sleeve
- Specifications are available to allow custom sleeves be be built
  - eg CRO sleeve
- Hot swappable

Why Linux?

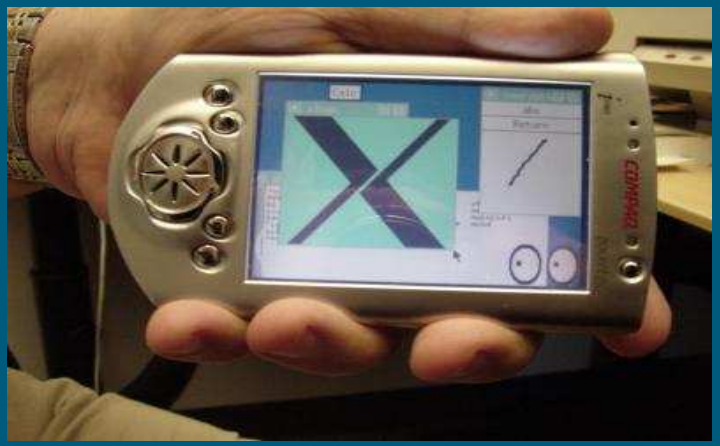
- Dumb Question!
- Ease of software development
- Good cross compiling tools
  - Free!
  - Just like a desktop
- Cool
- Interoperability
- Many others

Open Handhelds Project

- Program for stimulating development of innovative new applications on handhelds (e.g., iPAQ)
- Derived from OpenItsy Initiative
  - Joel Bartlett, Bill Hamburgen (WRL)
- Website (www.handhelds.org)
  - Hosts source code, binaries, discussion groups
  - Free technical support
  - Seed hardware for key developers
  - Community: > 1200 entries on email list, active IRC on openprojects.net
- Timeline
  - April 2000: Began Linux port to iPAQ H3600
  - June 2000: Posted first release of Linux for H3600 on www.handhelds.org

Linux Capabilities

- Linux 2.4.18 (this week)
- Complete GUI flexibility
- Filesystems
  - JFFS2: compressed journaling flash filesystem
  - ReiserFS, EXT3 on conventional drives
- Networking
  - WLAN, WWAN
  - IPSEC and other VPN
  - IPv6, Mobile IP
- Java 2 Micro and Standard Editions
- Not just a zippy PDA, but a pocket workstation



Hardware Support (November, 2002)

- H31xx, H36xx, H37xx, H38xx, H39xx (almost complete)
  - Power consumption now similar to WinCE
- Jornada 560/720 mostly working (John Ankcorn, HP Labs)
- Keyboards: Stowaway, MicroKeyboard, etc.
- CF, single/dual PCMCIA sleeves
  - Various ethernet CF/PCMCIA cards
  - 802.11b interfaces, BlueTooth (early days)
  - CF, Microdrive, ATA interface to larger drives
- Voyager VGA out
- Barcode scanner, various serial GPS's, etc.

iPAQ Linux Distributions

- Familiar Linux (familiar.handhelds.org)
  - jffs2 root, python scripting, ipkg, X & window manager
- Intimate Linux (intimate.handhelds.org)
  - ARM Debian with disk or net, boot via WinCE or Familiar
- QPE now called Qtopia (www.trolltech.com)
  - We're helping get this running on top of X
- Opie distribution
  - Open source version of Qtopia
- Original handhelds.org distribution (defunct)
  - characterized by cramfs, twm, motley apps
- PocketLinux (www.pocketlinux.com) (defunct)
  - kaffe jvm, xml app def'n

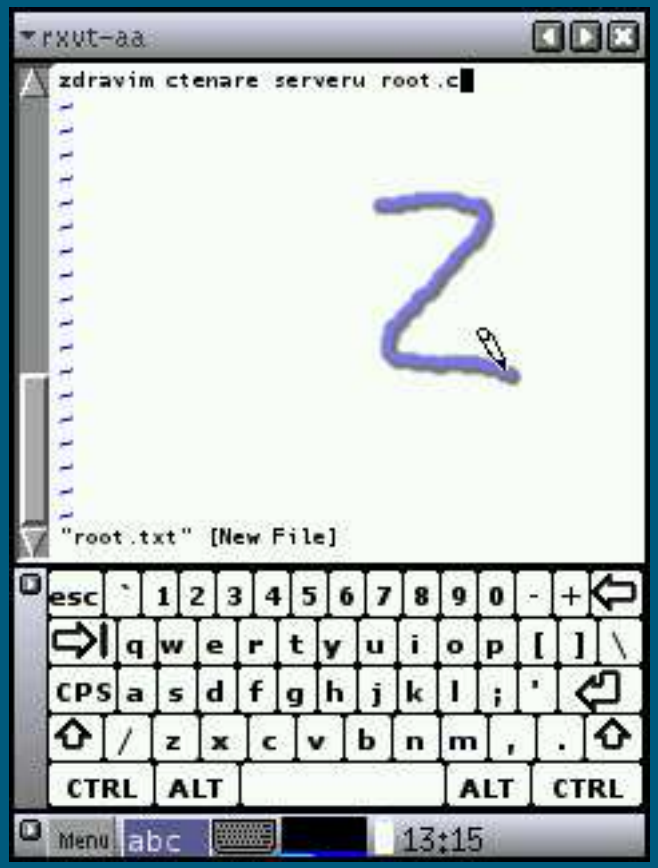
Linux on the iPAQ: Familiar distribution

- Python scripting
- JFFS2 root
- X Window System
  - GTK 1.4 toolkit
  - Full screen handwriting input
  - Anti-aliased fonts
  - Landscape or Portrait mode
- Full networking
- Distributed as ipkgs

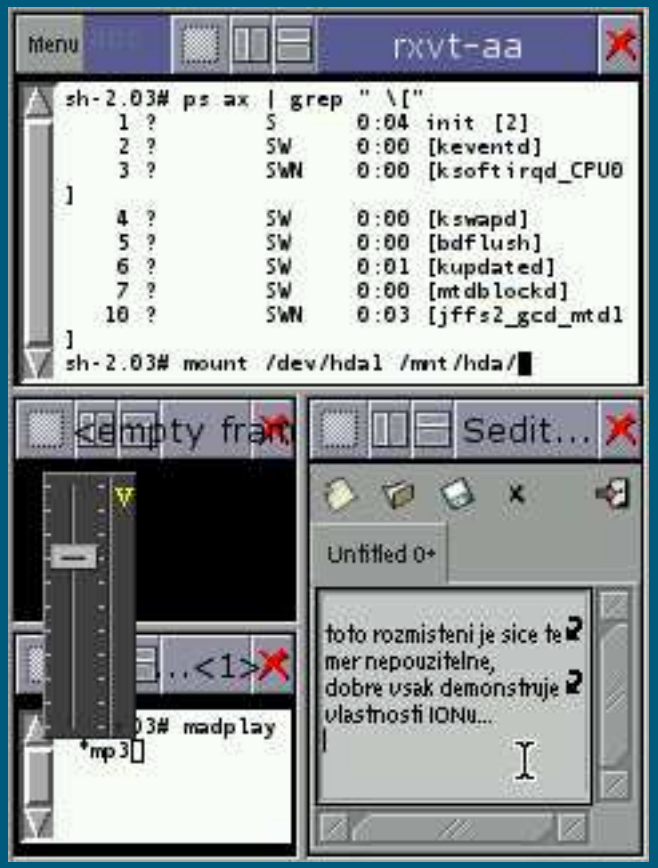
[Dbutter@wireless.net]

Newer Window Managers

- Matchbox



- Ion



Screenshots: http://www.root.cz/clanek.phtml?id=1127

QPE/Qtopia: Qt Pocket Environment

- Uses Familiar as base
- without X
  - (soon with X too…)
- distributed as ipkg's
- very polished look
- PDA-oriented

Open Palm Integrated Environment (OPIE)

- Open source project based on Qtopia source base
- Uses Familiar base
- http://opie.handhelds.org

Intimate Linux

•Marked by close acquaintance, association, or familiarity. See Synonyms at familiar.

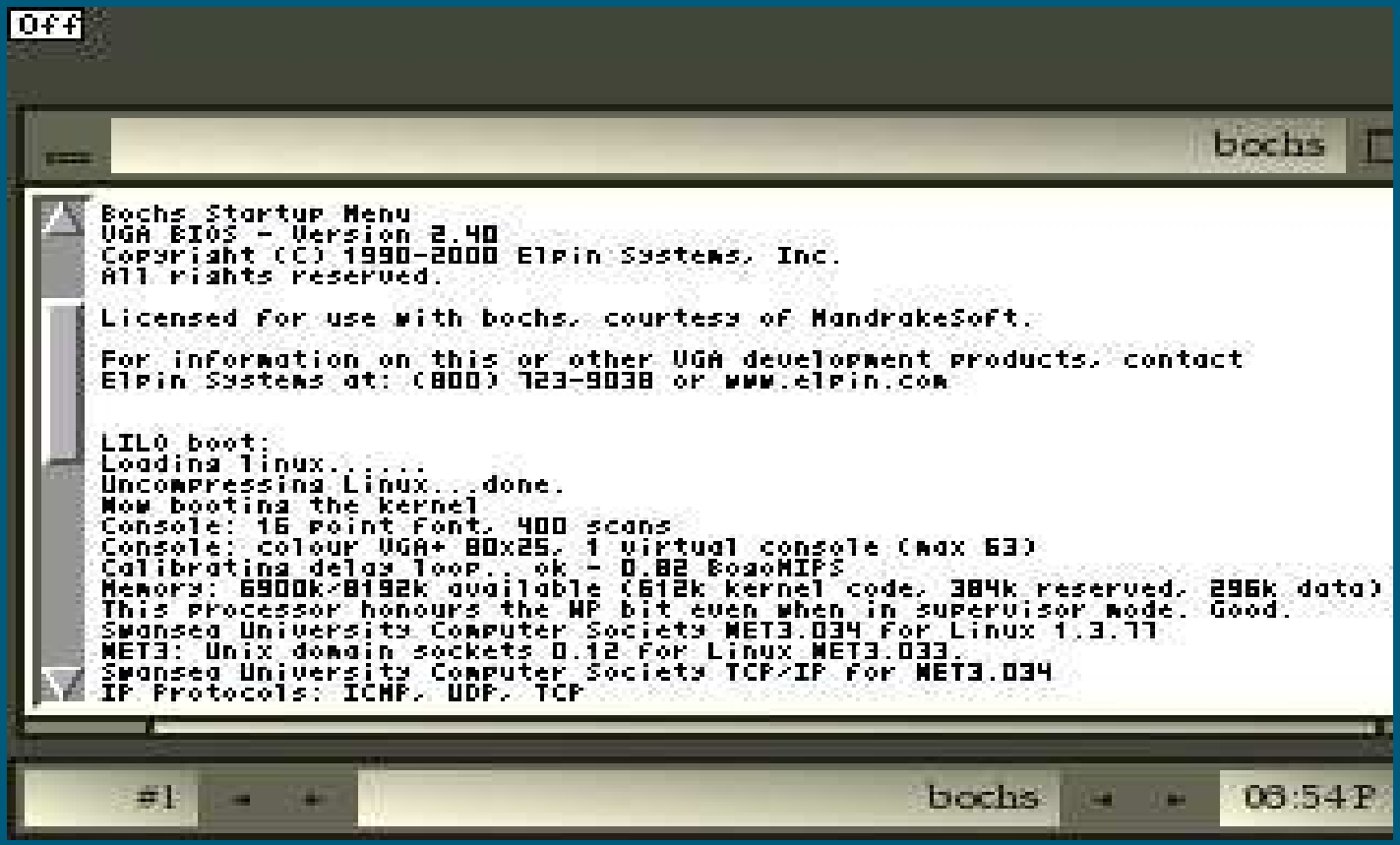
•Full blown Linux on the Compaq iPAQ!

•Native development

•Via local disk, NFS over ethernet, or via USB networking

Stunts

bochs x86 emulator



PocketLinux (Defunct!)

- XML application framework
- Implemented in Java
- Runtime: kaffe JVM
- Linux OS underneath
- Full support for “theming”

- Do not follow the 1.0 installation instructions – they can be hazardous to iPAQs

Java 2 Standard Edition

- Full JDK 1.2.2 and JDK1.3 ported by CRL and Blackdown.org
- available from www.blackdown.org
  - ftp://ftp.tux.org/pub/java/JDK-1.3.1/arm/rc1/
- Requires NFS, microdrive, CF card, or lots of pruning to install
- Available as ipkgs

CRL's Mercury Project

- A research project to extend the boundaries of pervasive wireless computing
  - Hardware:
    - A handheld research platform
  - Software:
    - Networking, middleware and applications
    - Based on Linux OS and Applications

Exploring the future of handheld computing

Mercury Hardware

- Pushing the envelope of integration
- BackPAQ: prototyping platform
  - Extension pack with VGA CMOS camera, 32MB Flash, FPGA, external expansion connector, 2 PC Card slots, accelerometer, audio codec and headset connector
  - WLAN and WWAN via PC Cards
  - Last known bug fixed, boards in rework

iPAQ H3600/BackPAQ

iPAQ H3600/BackPAQ

BackPAQ Modules and Interfaces

- FPGA (camera, accel, audio)
  - Module: h3600_backpaq_fpga, h3600-sleeve
  - status: cat /proc/backpaq/fpga
  - programming: cat foo.bin > /dev/backpaq/fpga
- Camera: 640x480x8 CMOS imager
  - Video4Linux interface: /dev/v4l/video0
  - Required modules:
    - h3600_backpaq_camera
    - h3600_backpaq_fpga
  - Required ipkgs: backpaq-firmware-6abc, hotplug
  - hotplug normally programs FPGA on BackPAQ attach or unsuspend

BackPAQ Modules and Interfaces

- Accelerometer
  - /dev/backpaq/accel?
  - Required modules:
    - h3600_backpaq_accel
    - h3600_backpaq_fpga
  - Required ipkgs: backpaq-firmware-6abc, hotplug
  - hotplug normally programs FPGA on BackPAQ attach or unsuspend
- Audio
  - /dev/sound/????
  - Required modules: You could contribute by writing this module!!
  - Required ipkgs: backpaq-firmware-6abc, hotplug
  - hotplug normally programs FPGA on BackPAQ attach or unsuspend

BackPAQ3

- BackPAQ1 was eval board
- BackPAQ2 you've seen
- BackPAQ3 is update of BackPAQ2
- Looks similar, but more manufacturable
- Increased size of FPGA from Virtex 100 to 300E
  - Enables more image processing in fpga
  - Interfaces to both PCMCIA sockets
  - Enables cardbus (good student project)
  - Enables direct imager to ethernet connection (good student project)
- Switched to Philips imager and optics

The Nitty Gritty Linux Details

iPAQ Linux Resources

- Handhelds.org website (www.handhelds.org)
- Handhelds wiki (www.handhelds.org/z/wiki)
  - Includes search interface
  - World writable – please use and contribute
- Chat (IRC on irc.openprojects.net)
  - #handhelds.org mostly ipaq linux discussion
  - #familiar Familiar distribution discussion
  - #ipaq lightly populated, installation support
  - #opie Opie developers
- Email: (www.handhelds.org/email_lists.html)
  - ipaq@handhelds.org, linux@handhelds.org, familiar@handhelds.org, bootldr@handhelds.org

Developing for ARM Linux

- Standard Linux API’s
- Adjust for storage space (32MB)
- Adjust for screen size (320x240 12-bit color)
- Adjust for lack of keyboard

- Input methods: xkbd, xstroke, serial cable, remote input via X, ssh

iPKG Software Packages

- iPKG (Carl Worth)
  - Structure derived from Debian packages
  - Provides apt-get style network installation
  - Small ipkg implementation
  - http://www.handhelds.org/z/wiki/iPKG
- Usage
  - ipkg update — downloads list of avail packages
  - ipkg install foo — (re)installs package foo, its deps
  - ipkg upgrade foo — upgrades to latest version of foo
  - ipkg remove foo — removes foo
  - Ipkg info foo — describes foo package

iPKG Feeds

- A feed is a collection of ipkgs
- Packages file
  - summarizes control files for latest version of each ipkg
  - Created by "`ipkg-make-index . > Packages`"
- Feeds accessible via
  - Local filesystem
  - HTTP
  - FTP
  - NFS

iPKG and Debian

- Easy to convert one to the other
  - ipkg-deb-unbuild foo.deb
  - remove docs, etc.
  - edit DEBIAN/control
  - ipkg-build <pkgdir> <ipkg-dest-dir>
  - Ipkg will now also install .deb files
    - Still working to improve ipkg further
- Finding ARM Linux .deb files
  - http://www.debian.org/distrib/packages
    - " Search the Contents of the Latest Release"

Finding Packages

- http://ipkgfind.48ers.dk/ has a search interface

Compiling for ARM Linux

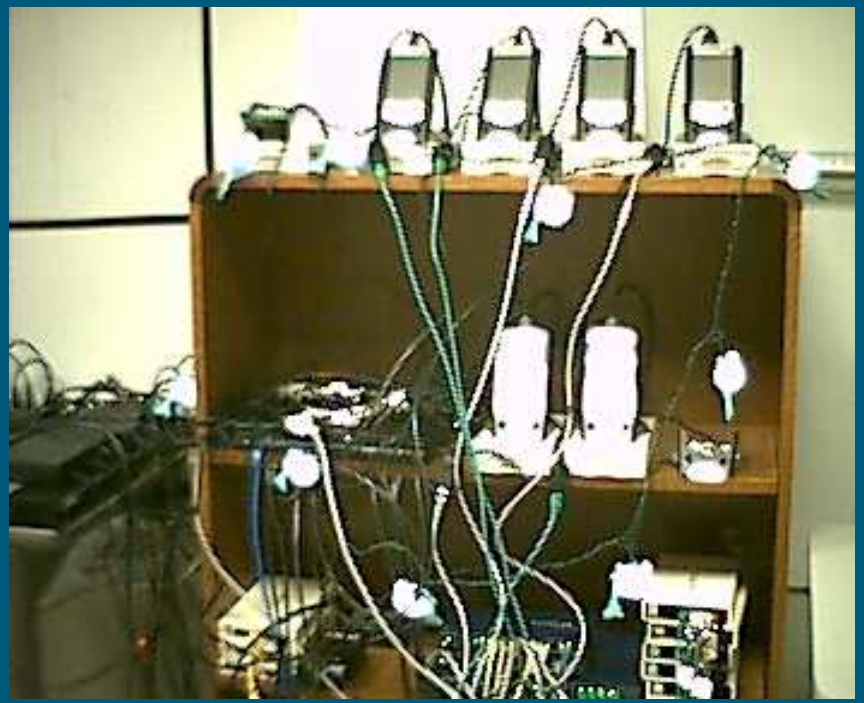
- Cross compilation
  - E.g., x86 linux host -> ARM linux target
  - Faster than native compilation
  - Often requires Makefile modification
- Cross-toolchain
  - ftp://ftp.handhelds.org/pub/linux/arm/toolchain/arm-linux-toolchain-current.tar.gz
  - Unpack in root directory
  - Add /skiff/local/bin to PATH
  - Prepend “arm-linux-” to gcc, g++, ld, strip, nm, ranlib, ar
  - Generally: make CC=arm-linux-gcc all
- To watch out for:
  - Segv from ld usually indicates attempt to link x86 object file into arm binary
  - “ Capture” of headers from /usr/include and libs from /usr/lib

Full Native Development and Compilation

- No Makefile issues, but slower
- Use Debian on iPAQ, netwinder, skiff, shark
- iPAQ/skiff Cluster
  - 8 iPAQ's (40Gig local disks), 2 iPAQs (9 Gig local disks), 6 skiffs, 2 sharks
  - iPAQ 1-10, skiff[1-6].handhelds.org, reefshark, tigershark
  - rlogin, telnet, ssh -l guest, no password
  - Use ftp, scp, etc. from the machines to transfer files to them
  - Create a directory in /home2/guest/<emailaddress>
  - Or get your own accounts
  - Maintained by Nick Duffek, George France

Picture of skiff cluster

- The Skiff cluster can be viewed at
  - http://www.handhelds.org/cam.html



iPAQ Linux Kernel Source

- E.g., 2.4.18 (Linus Torvalds)
  - http://www.us.kernel.org/pub/linux/kernel/v2.4/linux-2.4.18.tar.gz
- ARM Linux Port (Russell M. King)
  - E.g. 2.4.18-rmk3
  - ftp://ftp.arm.linux.org.uk/pub/armlinux/source/kernel-patches/v2.4/patch-2.4.18-rmk3.gz
- Handhelds Kernel (Jamey Hicks, Andy Christian)
  - E.g., 2.4.18-rmk3-hh3
  - Cvs.handhelds.org or ftp.handhelds.org
- We feed our changes upstream periodically

Running Linux on iPAQ

Linux Configurations

- Using handhelds.org bootldr (firmware)
  - First 256KB of flash
- Native install
  - JFFS2 root filesystem in flash partition
  - /tmp, /var etc using tmpfs or ramfs
- CF install
  - Ext3 root filesystem in /dev/hda2
  - VFAT filesystem in /dev/hda1 -- share with Windows
  - Either PocketPC or Linux in flash

Flash Memory

- NOR Flash
  - SRAM/ROM-like interface
  - Fast reads, slow writes
  - Must erase large sectors before rewriting
    - 256KB on iPAQ
  - 100K erase lifetime per sector, requires wear-leveling
- NAND Flash
  - Much denser than NOR Flash
  - Slow reads, slow write, fairly large erase blocks
  - requires wear-leveling and error-correction
  - Used in CF cards
- CompactFlash
  - Misnomer, actually PCMCIA PC Card in small formfactor

Flash Filesystems

- Block Remapping Strategy
  - Present disk-like block interface
  - Map disk blocks to parts of sectors
  - Spread writes across flash for leveling
  - CF flash cards, which present IDE interface
- Journaling Flash Filesystem (1,2)
  - Filesystem directly on NAND/NOR Flash
  - Log structured:
    - all data and meta data only in the log
  - JFFS2 also does compression

Removable Filesystems

- Not so great for removable media:
  - VFAT: Windows filesystem
  - Ext2: Linux standard filesystem
- Journaling filesystems
  - Ext3
    - Ext2 disk format
    - + journal of recent data/metadata updates
  - Reiserfs
    - Reiser's disk format with journaling
    - Wants to include database interface
  - JFFS2 not a good match for disks

Installing Linux on the iPAQ

Installing handhelds.org bootldr on iPAQ

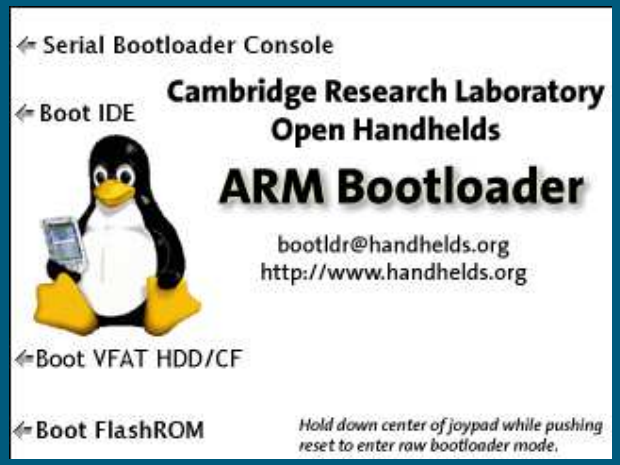
- Transfer bootblaster.exe and bootldr-2.18.39.bin to iPAQ
- Run bootblaster
- Use bootblaster to backup old firmware, pocketpc
- Use bootblaster to install bootldr

Configuring the Serial Port

- Hyperterminal (COM1) or minicom (/dev/ttyS0)
- 115200 baud
- No parity, 1 stop
- ***No flow control***

Getting to the boot> prompt

- Press and hold center of joypad
- Push reset
- Wait for splash screen, release joypad




```
>> Compaq OHH BootLoader, Rev 2-18-39 [BIG_KERNEL] [MD5] [MONO]
>> 02-04-18_12:05
>> Last link date: Thu Apr 18 12:05:25 EDT 2002
>> Contact: bootldr@handhelds.org

>> StrongARM SA-1110 revision B4
>> (c) 2000-2001 Compaq Computer Corporation, provided with NO WARRANTY under th
e terms of the GNU General Public License.
>> See http://www.handhelds.org/bootldr/ for full license and sourcesPress Retur
n to start the OS now, any other key for monitor menu
DEBUG BOOT: not evaluating params
DEBUG BOOT: use `params eval' to evaluate parameters.
boot>
```

Installing task-bootstrap

- Multiple choices
  - Installing task-bootstrap.jffs2 via serial port (xmodem)
    - http://familiar.handhelds.org/familiar/releases/v0.6.1/install/H3600/install.html
    - –boot> load root
    - –Then xmodem send task-bootstrap.jffs2
    - –Verifying … done
    - –boot> boot
  - Installing task-bootstrap.jffs2 from CF
    - –Transfer task-bootstrap.jffs2 to CF card (via laptop or iPAQ)
    - –Copy it to images/task-bootstrap.jffs2
    - –Insert CF card into sleeve
    - –boot> vfat read 0xc0000000 images/task-bootstrap.jffs2
    - –Bytes read=0x6c0000
    - –boot> program root 0xc0000000 0x6c0000
    - –Verifying … done
    - –boot> boot

Logging in

- The bootstrap will boot to login prompt
- Login as `root`, password `rootme`

```
Starting PCMCIA services: cardmgr.
cardmgr[132]: starting, version is 3.1.22
cardmgr[132]: watching 2 sockets
cardmgr[132]: socket 0: Compaq WL110 PC Card
cardmgr[132]: 'wvlan_cs' already bound to socket 0
cardmgr[132]: executing: './network start eth0'
Starting OpenBSD Secure Shell server: sshd.
cardmgr[132]: start cmd exited with status 1

familiar login: root
Password:
PAM_unix[146]: (login) session opened for user root by LOGI
login[146]: ROOT LOGIN on `ttySA0'

sh-2.03#
```

Finishing install in flash

- Install rest of packages
  - ipkg update
  - ipkg upgrade
  - ipkg install task-complete
- Install fonts, set time:
  - /root/postinst

Networking

- Serial connection to the console
- ppp over serial link
- ppp over USB
- Ethernet via PCcard or CF
- Wireless via PCcard or CF
- Bluetooth
  - Built-in on 387x, 397x or via PCcard or CF

All that glitters isn’t necessarily gold

- Problems
  - Not quite enough ROM in a 3600
    - Upgrades can fail as “disk space” runs out
      - Current fix is to remove Konqueror before doing any upgrades
  - Can’t sync automatically with Outlook
  - PCcard Expansion sleeves are expensive
    - I’d like a dual PCcard expansion
      - Wireless plus hard drive/CF

Demonstration

- Using VNC server running on iPAQ and VNC viewer on laptop
- Wireless network between the two
- Serial connection to the iPAQ as well
- My iPAQ is running OPIE
  - Basic home use is as a portable web browser and terminal
    - Wireless connection to Internet and other systems
  - New project in the wings
    - More details at another presentation?

Questions?

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