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

<table>
<thead>
<tr>
<th>Model</th>
<th>RAM</th>
<th>ROM</th>
<th>CPU</th>
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<tbody>
<tr>
<td>3100</td>
<td>16Mb</td>
<td>16Mb</td>
<td>SA 206MHz</td>
</tr>
<tr>
<td>3600</td>
<td>32</td>
<td>16</td>
<td>SA 206MHz</td>
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<td>3700</td>
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<td>3800</td>
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<td>3900</td>
<td>64</td>
<td>32/48</td>
<td>PXA250 400MHz</td>
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<td>h1910</td>
<td>48</td>
<td>16</td>
<td>PXA250 200MHz</td>
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<td>h5450</td>
<td>64</td>
<td>48</td>
<td>PXA250 400MHz</td>
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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](http://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](http://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

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: xkb, 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
• 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
  • 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
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

boot>

>> Compaq OHI 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 the terms of the GNU General Public License.
>> See http://www.handhelds.org/bootsdr/ for full license and sources
Press Return 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 PMCIA 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 LOGIN
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
  • PC card Expansion sleeves are expensive
    – I’d like a dual PC card 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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