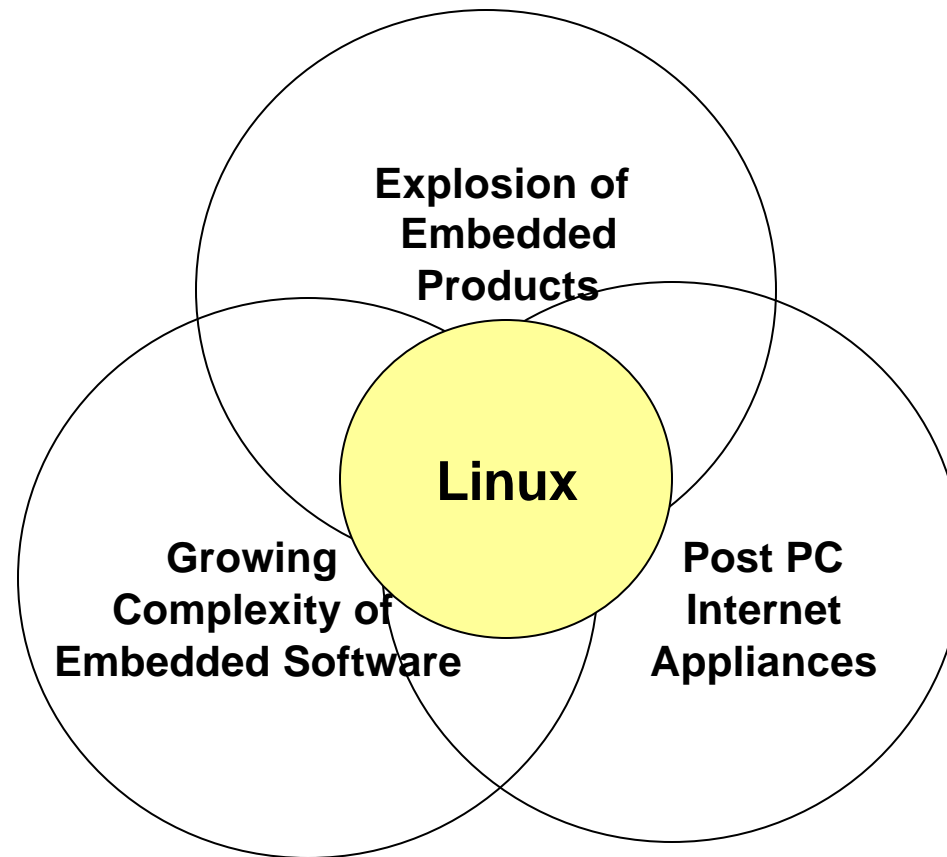


Trends in Embedded Linux



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Convergence of major market trends



Explosion of embedded products

- ❑ Moore's Law
 - ◆ Inexpensive 32-bit CPUs
 - ◆ MIPS & Mbytes dramatically cheaper
- ❑ Embedded intelligence everywhere
- ❑ Internet phenomenon
 - ◆ Host of new applications, connectivity requirements
- ❑ Pervasive computing
- ❑ Software complexity is mushrooming

Embedded developer seats will overtake desktop/server developer seats by 2005 - IDC (Feb. 2000)

Complexity of embedded apps

- ❑ Inexpensive silicon reducing memory constraints
- ❑ Internet phenomenon
 - ◆ Host of new applications
 - ◆ Connectivity requirements
- ❑ Ease of use requirements, GUIs
- ❑ Browser, PIM
- ❑ Embedded software performing more and more critical functions
- ❑ ***Linux is a better fit for today's embedded apps than traditional flat address space RTOSs.***

Post PC Emerging Consumer Markets

- ❑ Internet appliances
- ❑ Set-top boxes
- ❑ Web phones
- ❑ Connected PDAs
- ❑ Auto entertainment/navigation



Cahners In-Stat group: Internet appliances will grow by a factor of more than 15 by the end of 2004 to 37 million units, up from 2 million shipments in 1999

Potential for Embedded Linux

- ❑ “Embedded world will be the biggest market for Linux” - Gartner Group
- ❑ Embedded Linux Consortium (ELC) up to 125 members
- ❑ Embedded market fragmented - leading RTOS in only a fraction of designs
- ❑ Half of embedded designers still rolling their own OS
 - ◆ Strong trend towards outsourcing
- ❑ Limited traction for CE and embedded NT
- ❑ No clear leading “platform” like Windows on desktop
 - ◆ Embedded software is much harder and more expensive to develop
 - ◆ Limited off-the-shelf software and device support
 - ◆ Locked-in with a single vendor

Potential for Embedded Linux

- ❑ Linux is only multi-vendor platform candidate supporting open interfaces - POSIX and Unix
 - ◆ Linux is becoming what Unix was supposed to be
- ❑ Large and growing base of mainstream Linux applications and tools accessible for embedded apps
- ❑ Wide availability of Linux-literate programmers, consultants and service organizations
- ❑ POSIX was intended to provide open standard platform for embedded, but Linux will fulfil promise of POSIX
- ❑ *Emergence of Linux as an Open Standard Platform for embedded systems may be even more significant than open source aspect.*

Embedded Linux as “Platform”

- ❑ Growing Linux software base - reuse software instead of design from scratch
- ❑ Avoid lock-in to one supplier
- ❑ Internet appliances, distinction between embedded and non-embedded is blurred
 - ◆ Open alternative to CE, PalmOS
- ❑ OEM's customers want ability to obtain software from third parties

Linux as software enabler for new silicon

- ❑ Linux is becoming the OS of choice for out of box support for new silicon devices
- ❑ Proliferation of new System on Chip (SOC) devices
- ❑ many sources for Linux support
- ❑ control of own destiny
- ❑ open source - easy to distribute own extensions, drivers, etc.

Special issues for embedded Linux

- ❑ Development environment
- ❑ footprint
- ❑ hardware support
- ❑ power management
- ❑ real-time

Special issues for embedded Linux

- ❑ quality
- ❑ support

BlueCat Linux



- ❑ Support for leading processors
 - ◆ ARM (including Xscale, IXP), MIPS, Hitachi, PowerPC, Intel IA-32
 - ◆ Common code base
- ❑ Tools
 - ◆ Embedding tools
 - Kernel image + root file system -> ROMable image
 - Versatile boot loader
 - ◆ Cross Development Environments
 - ◆ VisualLinux -- Plug in to Microsoft Visual C++ on Windows
 - ◆ Kernel Trace Tool (SpyKer)
- ❑ Automated test system, extensive regression tests
- ❑ ISO 9001 certified
- ❑ Mature support infrastructure / programs including 7/24, long term support

A True Choice for Embedded Development

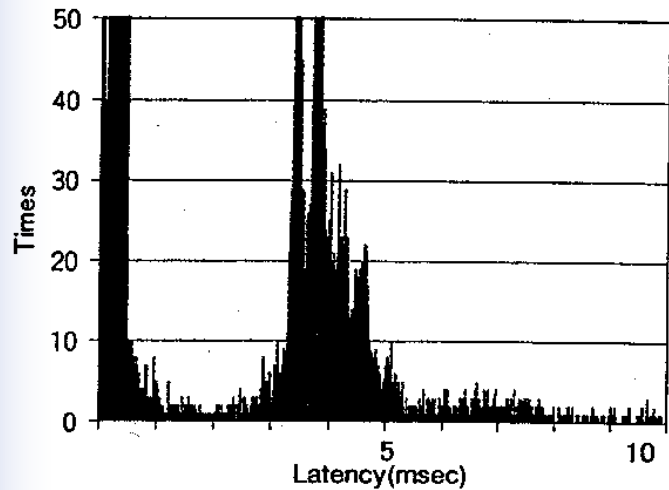
Linux Applications/Utilities

Open Source

Real-Time



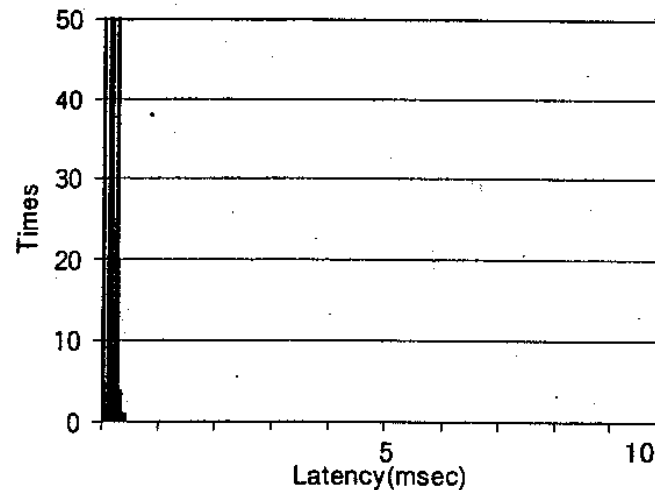
True Hard Real-Time Technology



❑ Linux kernel

- ◆ Worst case response of high priority task > 120 milliseconds for system under load
- ◆ Unpredictable

*source - actual customer application



❑ LynxOS kernel

- ◆ Worst case response of high priority task < 0.42 milliseconds for system under load
- ◆ Predictable

Real-Time

- ❑ Three main approaches to real-time Linux
 - ◆ Real-Time kernel + Linux
 - ◆ Real-Time improvements to Linux (preemption, scheduler..)
 - ◆ Linux compatible RTOS

2.4 kernel

- ❑ Expect quick adoption in embedded space
 - ◆ Support for more CPU architectures
 - ◆ USB and PCMCIA support
 - ◆ Support for Memory Technology Devices
 - Access ROM and Flash same way as disk
 - ◆ cramfs and ramfs
 - ◆ Improved structure and modularity of its source code

Challenges

- ❑ Fragmentation and lack of standards
 - ◆ real-time
 - ◆ embedded GUIs
 - Microwindows, Tiny-X, Qt/Embedded, Micro-X
- ❑ Concerns about open source
 - ◆ Overcome FUD from proprietary vendors
- ❑ Business Model

Business Model

- ❑ Days of “Dot.Com” capital markets are over
- ❑ Path to Profitability essential
- ❑ Consolidation in embedded Linux industry
- ❑ Customer needs assurance that embedded Linux vendor will be around to provide support

Summary

- ❑ Embedded Software is at a major inflection point
- ❑ Linux can provide the missing OS platform for the embedded industry, based on open standards and open source