

Embedded Linux Standards A Red Hat Perspective

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Internet Connectivity is Driving Post-PC Computing

- 1 in 5 Japanese (over 27 million) has an internet connection. More than 10 million use mobile connections to the Internet.
- By 2003, more than 50% of the people using the Internet will do so with handheld and/or portable (Post-PC) devices (IDC).
- By 2002, more than 55 million Post-PC devices will ship, and by 2005 shipments will exceed shipments of PCs (IDC).



Square Pegs/Round Holes

- Proprietary RTOSes have been successful in special-purpose devices that have limited application support
- IA-32 appearing in some designs
- Windows CE has been offered in sub-PC configurations
- The Post-PC market remains an open field



Many-to-Many Aspects of Open Source Software

- Open source compilers and debuggers run on many host platforms and support many target architectures
- Open source operating systems support many CPUs and embedded boards
- Open source simulators help embedded designers partition hardware and software functionality



Linux

- Linux supports target-as-host development model
- Linux supports many popular CPUs
 - IA-32
 - PowerPC
 - MIPS
 - ARM and StrongARM
 - Alpha
 - SH-3
- Linux is extensible



Embedded vs. Desktop

- It is rarely possible to create compelling applications only by stripping away functionality
- Reductions must result in improvements:
 - Size
 - Power
 - Speed
 - Cost
 - Operation environment



Embedded Linux

- Boot parameters
- Board parameters
 - Networking
 - Filesystems
 - Terminal/Graphics Support
 - Device Support
- Run-Time environment
- Configurations for multiple applications



Fragmentation

- Application-level
- Platform-level
- Development-level
- What's the difference between innovation and fragmentation?

Configurability

- Configurability can solve different kinds of fragmentation
- Configurability is not a magic bullet
 - Complex configuration tools can be more difficult to manage than fragmentation
- Is configurability a means or an end?

Standards

- Standards come in many flavors
 - De facto
 - Reference implementation
 - Specification
- Standards nail down things that cannot be changed (usually interfaces) so that other things (usually implementations) can be changed
- Good standards are hard to find
 - And harder to maintain



POSIX (ISO 9945)

- "Portable Operation System Interface"
 - Application-oriented
 - Interface, Not Implementation
 - Source, Not Object Portability
 - Minimal Interface, Minimally Defined
 - Broadly Implementable
- IEEE Std 1003.1, 1996 Edition
 - Part 1: System API
 - Part 2: Shells and utilities
 - Part 3: System Administration



POSIX.13

- September 1999
- POSIX.13 presents four real time system profiles
 - Minimal Realtime System Profile
 - Realtime Controller System Profile
 - Dedicated Realtime System Profile
 - Multi-Purpose Realtime System Profile
- EL/IX presents four "levels"



PE51 vs. Level 1

- Basic functionality for single-process deeply embedded system
- Signal and some memory management options enabled

EL/IX Level 1 is a flexible subset of PE51



PE52 vs. Level 2

- Extends PE51 with support for a filesystem and asynchronous I/O
- Signal, memory management, and filesystem options enabled

EL/IX Level 2 is a flexible subset of PE52



PE53 vs. Level 3

- Extends PE52 with support for multiple processes, richer filesystem capabilities
- Signal, some memory management options enabled

EL/IX Level 3 is a flexible subset of PE53



PE54 vs. Level 4

- Superset of other PEs, containing essentially POSIX.1, POSIX.1b, and POSIX.1c standards
- Remove GNU, BSD, and SYSV compatibility

EL/IX Level 4 is a strict superset of PE54

EL/IX Level 4 is exactly Linux



Real-Time Linux

- Much work going on
 - FSM Labs has working PSE 51 w/realtime performance (down to 5 microsecond response time)
 - TimeSys experimenting with Priority Inversion
- Realtime Linux market may be limited
 - Telephony (not exactly small...)
 - Multimedia (video, audio, etc.)



Memory Management

- Option for some, not others
 - Silicon and cost overheads
 - Security and Reliability
 - Real-time
- POSIX defines interfaces
- Red Hat is actively working to make hardware MMU an option in the "standard" 2.4 branch



Putting It All Together

- Many vendors combine Linux, configuration tools, libraries, board support, tools, and sample applications
- Customers are all asking for the same thing
 - Reference implementations
 - Tools
 - ISV and IHV support
 - Standards



Application 1: SAN

- Storage-attached networks depend on complex OS functionality
 - Cluster management
 - Filesystem management
 - Volume management
 - SMP performance
- Flexible client/server partitioning favor an OS strategy that is more common between client and server



Application 2: Web Phone

- Portability and battery life are key
- Must support wireless stacks
- DSP functionality
- Web browser
- Graphics
- Embedded storage devices
- Minimal memory footprint



Application 3: SOHO Router

- Must support complex broadband protocols
- Configurable to support new protocols
- Remote manageability
- Configure to support application partitioning (N-tier Post-PC architecture)
- Environmental concerns require low-power CPUs



Application 4: PDA

- Wireless support
- Graphics
- Browsers
- Data synchronization
- Remote manageability
- Security



Application 5: Servers!

- i-mode Phones in Japan sell over 5 million units in less than six months
- i-mode phone production nearly halted because *server capacity* is exceeded
 - Initial installation not powerful enough to judge fad from trend
 - IT staff not able to install machines fast enough
 - Server facility not large enough to handle low-density web serving solutions



Summary

- The Post-PC market is wide open
- Linux has the flexibility, configurability, and functionality to support a very wide range of applications and appliances
- Control standards by contributing to them
- Linux standards should be 100% open source software

