

Applied Linux and Embedded Internet

Introduction

Linux is used by approximately 25.000.000 people around the world. It is run on many platforms, ranging from embedded devices PDA's to desktop and server Intel (x86, IA64), Alpha, PowerPC, IBM mainframes (S/360, S/390), Motorola, MIPS, Palm (Pilot), Amiga, PA-RISC, Strong Arm and many more. The Linux kernel is being developed and maintained by 10.000 people around the world. Even the tools are developed by volunteers around the world. Some even get payed.

In order to run Linux on a small device at least the kernel is needed. Added to that are all the tools needed to do something useful with it. Linux itself does not provide real-time (hard or soft) functionality. In the near future Linux will also provide real-time features. Starting with the EL/IX specification as proposed by a vast range of companies. To name a few: Alcatel, Arm Limited, 3Com, HP, IBM, Lineo, LinuxDevices, MetroLink, MetroWorks, Motorola Computer Group, PalmPalm Technology, QNX, RedHat, SuSe, Cygnus, WindRiver and many more (see <http://www.embedded-linux.org/roster.php3>).

Running Linux as low cost server for Internet sites is also a widely used appliance. For instance the Cobalt Cube. The hardware used for these web farms ranges from Intel to Sun Sparcs or even IBM mainframes S/390 or S360. All are capable of running Linux as their main operating system. The number one Internet server is Apache, an open source product. It even runs on Windows NT and also on other Unixes (Sun, Irix, OpenBSD).

Embedded and Internet

Linux is based on open standards. Just like the Internet. If nobody stuck to the agreed way of communication, then there would be no communication at all. Linux in embedded device is a rather new market, but not unexplored. Small and big businesses have been busy exploring the capabilities of Linux in an embedded environment. Look at yopi (Samsung), itsy (Compaq), webphone (Ericsson) or MP3 players.

Real time support is not available in the standard Linux kernel. The EL/IX

initiative proposed to include the Posix 1.b (real-time) and Posix 1.c extensions in the standard Linux kernel. Interesting solutions for using Linux in a hard or soft real-time environment are provided by RT-Linux, RTAI-Linux, Embeddix, Lineo and many more. See resources section at the end of this document. The big advantage of using Linux in an embedded device is the rich availability of tools. Using a Linux and Java together in an embedded device provides even more flexibility for your device.

Advantages of using Linux and Java in embedded devices are:

- Easy to find knowledgeable people
- Plenty and good tooling
- Standards
- Decoupling of hardware and software
- Lack of runtime licenses

Reason to choose Linux as your embedded OS are:

- High stability
- Broad range of availability (desktop, servers, embedded devices)
- Based on open standards (networking, graphics, threading, multi tasking)
- High performance compared to used hardware
- Supported by multiple vendors (IBM, HP, Compaq, SGI, QNX, LynxOS, WindRiver, RedHat, SuSe)
- Open Source nature (availability of source code)
- Easy to port to a new CPU
- No license model, so no license costs
- High innovative speed of development (follows technology curves)
- Certification RHCE
- User friendly interface
- Good technical support (even commercial if desired)
- Linux can be trimmed down to 8 MB Disk On Chip/Solid State Disk and support FTL
- Easy to write device drivers

Of course the sun does not always shine. There are also disadvantages on running Linux as your core embedded OS:

- Legal responsibility (This is not an issue if embedded Linux and support is bought from a distribution vendor.)

- Low visibility while it is still widely used.
- Low conscience of businesses
- Low confidence of management
- No marketing department and marketing budget
- Geek image
- Bigger footprint then custom-made or propriety real time kernels

One of the widely used arguments for not using Linux in an embedded device is its footprint. Although chips become smaller, faster, more powerful, memory gets cheaper every six months (Moore's law). This has also impact on embedded devices, they get more powerful, can support more memory, faster CPU with a low power consumption. A good example of innovation in the processor market is the Crusoe processor from Transmeta. The embedded market is changing, connectivity and remote maintenance is getting more important. Using standards will become a must to survive.

Another is the issue of legal responsibility. Who to sue when things go seriously wrong? The common believe (and marketing talk of that famous Redmond company) is that you are out on your own if Linux is used as core OS for a product. But what does the disclaimer and license from Redmond tell as much as: "We cannot behold responsible for ill behaving software according to US law. Even if we are hold responsible by law or court in another country, then it will not be more then 5 US dollar per license." (Free translated). Read that license agreement very carefully they will not take any responsibility.

In the near future the market for Personal Digital Assistance, Voice over IP, Wireless LAN, BlueTooth and Web devices is going to explode. New frequencies UMTS are being auctioned. Every device is will become net enabled. Look at the current mobile market it is a booming business. In such a market it is essential that your time to market will be less then that of the competition. Open Source Software can help, because when a lot of people share basic technology like operating system, tools, compilers and knowledge, then companies can focus on their core business. This gives companies a greater edge than their competition. In any new market the early adopters make a lot of money. Of course early adopters also have the biggest risk.

Business and Linux

In the Netherlands 23 companies make money with Linux and 1600 companies are interested. The vast majority of those and other companies are waiting. They are not sure how to deal with the changing world of Open Source Software and Linux, because it is new and uses another business model. The time for propriety operating systems has gone. Standards, communication and openness are needed to bring professional software engineering to a new level.

The idea of Open Source Software however is not new. It existed already back in the seventies, when computers were developed by people sharing their ideas and knowledge. Today the computing industry still taps into the ideas of that time.

In a business strategy the combination of embedded and Internet is an important factor. Linux is suited for both worlds and thus fits nicely in the overall strategy. Making money in the OSS world is all about providing services. The Linux distributors sell support and knowledge. Creating yet another tailored distribution is not wise, instead tapping into existing efforts will leverage the most out of Open Source Development in business.

Flexibility:

Linux strengths are its flexibility to run on small and mid range systems. Also the high-end systems are not far away with the upcoming kernel version 2.4.

Networking

Another strength is connectivity and protocol support (ATM, IPX, TCP/IP, NetBeui, etc.). Linux can blend in with any network being WAN, LAN or wireless.

Compatibility with Windows is no problem with Samba. Running Windows binaries is even no problem anymore with Wine. Another method is using a commercial product VMWare. It runs a virtual machine directly on the computers hardware from within the hosting OS. For the OS under VMWare's control it just looks like it runs on the hardware.

Internet

The Apache Internet Server is used by 10.000.000 websites around the world (source: IDC). In Linux kernel version 2.4 serving static pages will become faster (see next chapter for more details). Together with a suite of tools like Professional

Home Page (PHP 3/4), Perl, Zope (Application Servers and E-commerce), Java (swing library and JBuilder), Squid (proxy cache) and the OpenSSL for encryption of connections and transactions Linux is able to provide secure and dynamic websites needed for E-commerce and other business solutions.

Linux and Java

An interesting combination is Linux and Java on embedded devices. That is if you can spare the computing power and memory. For the smallest devices (e.g. wrist watch) this is still to far fetched, but for the medium sized to larger sized devices (e.g. handhelds and PDA) it might become a winning combination.

Security

Also on the security front Linux provides tools, like: OpenSSH, OpenSSL, nessus, saint, psionic, logcheck, portsentry, hostsentry, xinetd and ipchains. Secure distributions for building firewalls are: Trustix Secure Linux, ImmuniX. If you look for a very secure firewall, then look at OpenBSD the other not so well known Open Source Software.

Linux kernel version 2.4

New features in kernel version 2.4 will offer more support and performance for the mid and high range servers systems. Important new features are:

- Journaling file system (ReiserFS, JFS, ext3)
- Internal memory support goes up from 24 GB to 64 GB
- Devfs smarter device support in /dev directory
- Symmetric multiprocessing (SMP) goes up from 16 to 64 processors
- Networking and especially the TCP/IP stack will become parallel
- Maximum number of processes will go up and can be tuned in runtime
- Support for Universal Serial Bus (USB)
- Kernel HTTP server for faster serving of static web pages

Resources

• **Articles** "Open source business models in the embedded/devices space."

<http://www.linuxdevices.com/news/NS6317242594>

• "Handheld makers are grasping for Linux"

<http://www.zdnet.com/eweek/stories/general/0,11011,2593078,00.html>

• "Streaming media picture on Linux coming into focus"

http://opensourceit.earthweb.com/news/000621_streaming.html

• "Can we marry the open source and commercial worlds?" Look at:

http://www.upside.com/Open_Season/3958dd960.html

• "Informix Announces Availability Of Foundation.2000 9.21 And Cloudscape 3.5 On Linux "

<http://www.newsalert.com/bin/story?StoryId=Cova9WdCbmdyXtG>

• Why Open-Source Software Matters to End Users: Countering Locked-Up Data and Locked-In Obsolescence

<http://www.linux.com/news/articles.phtml?sid=93&aid=8664>

• An Interview With Eric S. Raymond

<http://www.wirelessdevnet.com/articles/may2000/esr.html>

• The Gartner Group is gung-ho for open source now: "We recommend that IS organizations that currently exclude all OSS from their acquisition plans should reexamine this policy." From gartnerweb.com.

<http://gartner3.gartnerweb.com/public/static/hotc/hc00088469.html>

• Mission Critical Linux Expands Secure Linux Systems Monitoring to

Include Palm VII Handheld Computer <http://linuxpr.com/releases/1860.html>.

More information on using Linux in a mission critical environment can be found at: <http://www.missioncriticallinux.com/>

• "Why Open-Source Software Matters to End Users: Countering Locked-Up Data and Locked-In Obsolescence"

<http://www.linux.com/news/articles.phtml?sid=93&aid=8664>

• "Embedded Linux basics - Where it's used, what it's good at, and what it isn't suitable for." <http://www.linuxworld.com/linuxworld/lw-2000-05/lw-05-embedded.html>

• Real-time Linux developers unite on API

<http://www.planetit.com/techcenters/docs/linux/technology/PIT20000313S0012>

• "Why Embedded Linux?"

<http://www.ddj.com/articles/2000/0075/0075g/0075g.htm>

• "Is Linux right for your small biz?"

<http://www.msnbc.com/news/373134.asp?cp1=1>

• "The mainstreaming of Linux - Comprehensive update on what the big computer makers -- IBM, Sun, Compaq, HP, Dell, and SGI -- are doing with Linux now. http://www.linuxstocknews.com/vol1_26_5.html

Embedded

• Embedded Linux organization. We are a dynamic new trade association and vendor neutral non-profit dedicated to promotion and implementation of the Linux operating system throughout embedded computing. Our web site is brought to you by proactive members and many volunteers. Funding is derived from the general membership.

• Vision: <http://www.embedded-linux.org/vision.php3>

• Benefits: <http://www.embedded-linux.org/benefits.php3>

• Axis ETRAX 100 contains the functionality of an entire thin server system, including a 32-bit RISC processor and a full set of I/O controllers -- and is supported by a ready-to-use embedded Linux OS. Just add RAM, ROM, a few cheap components, Linux, . . . and stir! http://www.linuxdevices.com/cgi-bin/news_view.cgi?newsid=NS6712273111

• LinuxDevices.com home page: <http://www.linuxdevices.com/> Other interesting links on this site are

<http://www.linuxdevices.com/articles/AT3611822672.html>,

<http://www.linuxdevices.com/news/NS2253476419.html>

• Realtime Linux organization: <http://www.realtimelinux.org/>

• The EL/IX embedded API standard for Linux can be found at:

<http://sourceware.cygnum.com/elix/>

• Running Linux+RTOS instead of Linux as RTOS. Read more at:

<http://www.newsalert.com/bin/story?StoryId=CoqKmWbKbyteYnJq&FQ=Linux&Nav=na->

[search- &StoryTitle=Linux](#)

•Euro startup unveils credit-card sized Linux system Swiss startup Smartdata unveiled a credit-card sized embedded Linux computer called |-computer Chipslice. The tiny device, which runs uClinux, is intended to be used in a wide range of mobile, portable, and wearable computing applications. Read more about it here " I can already dream of several possibilities of one of these combined with wireless internet access.

<http://www.linuxdevices.com/news/NS4033319254.html>

•Information about RT-Linux and Java can be found on <http://www.RTJ.org> and at Java Consortium.

Consumer Products

Video/Screenphone

•TiVo personal TV service from Philips

<http://www.avsforum.com/ubb/Forum6/HTML/003200.html>

•Ericsson's Screen Phone Runs Linux

<http://www2.linuxjournal.com/articles/briefs/061.html/>

Personal Digital Assistant

•Compaq PDA running Linux (Itsy) <http://www.linuxworld.com/linuxworld/lw-2000-06/lw-06-h3600.html>. Itsy: PDA with ARM/Linux from Flash memory (Flash Translation Layer) Download the Information Needed to Build an Itsy Prototype <http://www.research.compaq.com/wrl/itsy/>

•Gnome on PDA's <http://henzai.com/en/product.html>

•GNU/Linux Wristwatch Videophone <http://www2.linuxjournal.com/lj-issues/issue75/3993.html>

Voice recognition

•IBM's ViaVoice for Linux - voice recognition for Linux

<http://news.cnet.com/news/0-1006-200-2125025.html?tag=st.ne.1002.bgif.ni>

Network administration

•Network server management made easy (Trustix)

<http://www.linuxworld.com/linuxworld/lw-2000-06/lw-06-trustix.html>

Database

•Sybase Adaptive Server Enterprise <http://www.sybase.com/>For Linux

<http://www.sybase.com/products/download.html>

• Oracle 8i for Linux <http://www.oracle.com/http://platforms.oracle.com/linux/>

• Informix Internet Foundation.2000 for Linux

<http://www.informix.com/linux/>

• Interbase the Open Source Database <http://www.interbase.com/>

• MySQL for Linux <http://www.mysql.com/>

• IBM DB2 Universal Database for Linux <http://www-4.ibm.com/software/data/db2/linux/>

Office Suites

• Sun's StarOffice <http://www.staroffice.com/>, StarOffice downloads can be found at <http://www.sun.com/products/staroffice/>

• Applixware Office <http://www.vistasource.com/products/axware>

• Corel's WordPerfect office 2000 for Linux

http://www.corel.com/linux/http://linux.corel.com/products/wpo2000_linux/index.htm

• GNOME Office <http://www.gnome.org/>

Distributions

• RedHat Linux is targeted at the server platforms. More information can be found at: <http://www.redhat.com/>

• SuSe Linux <http://www.suse.com/>

• Debian Linux is an Open Source effort for providing the best distribution. More information can be found at: <http://www.debian.org/>

• Corel Linux is targeted at the desktop user. More information can be found at: <http://linux.corel.com/>

• Mandrake Linux is targeted at the desktop user. More information can be found at: <http://www.mandrake.com/>

• Slackware Linux <http://www.slackware.com/>

• Trustix Secure Linux is targeted at providing a secure Linux server for business. More information can be found at: <http://www.trustix.com/>

• Lunar Penguin Linux is a distribution targeted at ISP and includes only Open Source tools and standards like File Hierarchy Standard (FHS). More information can be found at: <http://www.lunar-penguin.com/> The Linux standard organization home page can be found at: <http://www.linuxbase.org/>

• Nexus is a free, portable and secure Linux distribution. It's target audience is the enterprise application, the paranoid system administrator and other

areas where security is not a "nice-to-have" additional feature, but an essential requirement. More information can be found at:

<http://www.lemuria.org/Nexus/>

- uLinux (micro-linux)
- BlueCat Linux from the makers of LynxOS.