Linux as a handheld OS in Lenovo

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Abstract

In the near future, smartphone will become good enough for most PC users' usual purposes and any device can be connected to Internet. Finally PC and smartphone will converge as the next generation handheld device, which will be always best connected. Symbian, Windows Mobile, Linux, RIM, MacOS are the top 5 OSes, which compete in this fast-growing market segment. 20 million Linux-based mobile handsets have shipped over the last two years, and at least 2 groups including LiPS and LiMo began to standardize mobile Linux. One year ago, a software team in Lenovo began to use Linux as OS to build the prototype for the next generation handheld device, it is proved to be a difficult but valuable task. The team has learned a lot about how to build a complex product based on open source software and proprietary 3rd party software...

1 Introduction

What's on the desktop today is going to end up on your phone tomorrow. Ultimately, phones will turn into a box that you just wear, and it won't have any interface at all. It will be your connection to data and your authorization and you'll find the media that you need to visualize your data wherever you go. When you arrive at office, you'll get a big screen, and it'll talk to your data, and it'll be you. When you walk into the hotel room or sit at table, the display will be built in.

It is the future, and maybe not so far, phone industry will merge with PC industry finally, so Lenovo define it as the 3rd generation PC or handheld PC, its typical features including:

- Only one personal companion device

- All applications run in the device

- One small size computing/storage unit fit to different input/output

- Swiss knife, multi-function device, all personal asset stored in the device

- When the user is at his desk, this device with the help of a dock of some sort should give him the full desktop experience

2 Software Stack in handheld PC

Handheld PC/device, UMPC, smartphone, people uses all these techniques but may not know the difference between them clearly. In fact, the boundaries between them are not easy to be defined. Handheld PC is the device between UMPC and smartphone, but when we use PC as its subject, we categorize it as PC. Now screen size is the only physical limit, and you will find that Desktop CPU and Cellphone

CPU began to enter the territory of the counterpart when you read the technical spec of Intel MID platform (support 3G, WiMAX, hardware accelerated 3D) and 1G Arm Cortex A9. There is a rumor about Apple iPhone that Apple may be eyeing up Intel's recently announced Moorestown MID platform for use in an upcoming model of the iPhone. Finally, Docking fasten the convergence of desktop and mobile platform.

Desktop OS may win in handheld PC market, they are: Windows, MacOS, and Linux. Lenovo began to design a handheld PC prototype 1 year ago. Windows Mobile and Linux were the two candidates, finally we chose Linux. The main reasons are that we could have the complete control over the software in the phone, and have the unlimited freedom to innovate and create highly customized phone software and user interfaces, and at the same time we can get enough community support from:

- UMPC Linux
  https://wiki.ubuntu.com/MobileAndEmbedded

- Intel http://www.moblin.org/

- Nokia's Linux-powered "N-series" Internet Tablet line http://garage.maemo.org

- Google Gphone rumor: it run a Linux operating system

- OpenMoKo

- OpenEZX

- GPE Phone Edition

20 million Linux-based mobile handsets have shipped over the last two years, and at least 2 groups including LiPS and LiMo began to standardize mobile Linux.

We ever ask our customers in blog about Linux on a Mobile PC:
http://lenovoblogs.com/insidethebox/?p=97, nearly 90 replies received.
Informa forecasts that by 2012 Linux will ship annually in 128 million mobile phones, or 27 percent of all smartphones or about 8.8 percent of all handsets sold.
But, compared to MacOS, Windows or Windows Mobile, and Symbian, Linux world is fragment. Not a full distribution for handheld PC we can download from Internet, we need to DIY by ourselves by stacking all software component from 3rd parties ISV, community and we have to do lots of dirty coding and hacking, it is the Linux way.

We investigated desktop Linux distros in 2006; Ubuntu is very popular but no mature embedded version. RedFlag in China work with Intel on midlinux or Linux for Intel MID platform, it is cool but no voice phone functions. Because phone function is listed as required feature in Handheld PC, a Linux software stack in smartphone finally is chosen as the candidate for our handheld PC prototype: Qtopia 2, which is widely used in Motorola Linux phones.

3 Linux kernel at Lenovo smart phone

Our kernel is based on the stable Linux-2.6 version, while enabling some optimizations from open source community:

- Preemptive Kernel

- O(1) Scheduler

- Ingo Monlar RT-preemtion patches

- Small Footprint kernel from tiny

- POSIX High Resolution Timer

- Dynamic Tick

Besides the porting work on bootloader and driver, our engineers put effort on boot up time and system startup time optimization, file system, power management and quality test.

3.1 Bootloader and device driver

The application processor is Marvell Monahans, and the product supports both Edge and WiFi(802.11a/b/g) wireless network. China Mobile will build an 802.11a wireless network for Beijing 2008 Olympic Game and our device will support it.

3.2 Boot time and system startup time

Boot time in current Linux systems for desktop and server machines are in a few minutes, which is unacceptable for many CE devices. We use non-XIP and uncompressed kernel image for the advantage of no permanent runtime performance penalty and no kernel decompression. The non-compressed kernel has been reduced to less than 2MB, which is 1 MB larger than compressed one. However, the size of NAND flash in our product is 128MB, so 1MB loss is acceptable.

A general rule is followed, that is Only start what end customers need. Delay calibration, dynamic device probing and kernel console output, handheld PC do not know all these features.
The system startup time for end customer include

both boot time in bootloader and Linux kernel and startup time for Qtopia and Phone application, end customers care about the time they need to make the first phone call. To reduce application startup time, we use prelink technology, prelink is a program which modifies ELF shared libraries and ELF dynamically linked binaries, so that the time which dynamic linker needs for their relocation at startup significantly decreases and also due to fewer relocations the run-time memory consumption decreases too (especially number of unshared pages). We also add several printf into Qtopia to analysis the system startup time and do several dirty hacking by deleting unused code and postponing some code executed after loading the phone application.

3.3 Power Management

Our PM framework is based on DPM from open source and MSPM from Marvell, we integrate dynamic power management with Monahans scalable system frequency and voltage management, so that power policy management can automatically select appropriate power parameters based on system state.

3.4 QA of Linux Platforms

We adopt many patches from open source community, and we run a lot of benchmarks to test and validate all the patches. We built an automatically kernel validation test tool to benchmark the kernel patches we adopts. The basic verification and validation process include

- Linux Test Project (LTP)
- LSB test suite
- POSIX test suite

3.5 File System

JFFS2 and Cramfs is the most popular file systems used in handheld Linux OS for NAND Flash. JFFS2 is a log-structured file system designed for use on flash devices in embedded systems, while Cramfs is a compressed read-only file system.

We use both these 2 filesystems, and further optimize them based on file access mode and frequency, and discard some redundant property for handheld OS, such as atime (access time) of files.

4 Qtopia as software stack on Linux kernel

QPE (Qtopia Phone Edition) is a comprehensive application platform and user interface for Linux-based mobile phones. It is enhanced with pre-integrated applications allowing manufacturers and designers to build feature-packed phones. QPE is not only a GUI library, it includes more application and useful library. But compared to common GUI libraries, the quality and performance of phone library and man-machine interface is not so good, we need lots of dirty hacking.

There are 2 LCD screens in our product prototype, and screen size is not following industry standard which is not supported by any windows mobile version, this is also one important reason why we chose Linux and Qtopia, we have the freedom to customize any product. Our user interface design team designed a set of innovative fanny UI. More and more applications will be installed in handheld PC, not just text message and phonecall any more; end customers need cool UI such as iPhone and HTC TouchFLO.

5 Killer application in handheld PC

To make a success product, we should learn more from Apple iPhone:

- Not like PC, HHPC/Smartphone is fast-moving consumer goods, great user experience is most important

- HHPC is Always-Connected, so must work closely with MNO, AT&T is paying $3 dollars a month per every iPhone customer already with AT&T and $11 per month for every new subscriber

- Different from PC: It is natural for people to pay for mobile service, such as iTune and mobile music service, blackberry and push mail service.

And Google begin to try more aggressive business model by promoting mobile Ad on low cost Linux phone, the cost of those phones may be partly subsidized by the advertising that appears on their screens.

Web-based application and SaaS business model will also be very popular in handheld PC, device manufacturer will finally find new business opportunity by providing mobile service, not just competed on the device price.

Browser will be the key application as important as phone dialer, text message and Java in handheld PC, such as Sarifi in Apple iPhone. The Mozilla Foundation will ship a mobile version of the popular Firefox browser in 2008, according to a blog post from Mike Schroepfer, VP of engineering. Mobile

Firefox will be based on Gecko 1.9 with "significant changes" for improved performance and footprint, but before it is available, we use opera browser.

6 Conclusions

Currently, Lenovo just begin to learn more from open source community by integrating software components from the community, and we joined the community mainly by mailing group and indirectly via commercial Linux company, open source software development methodology is still unfamiliar to us, but open source has emerged as a software development methodology that is creating a welcome disruption to the mobile industry. Open Source is the trend that we need to follow, Linux will be one candidate OS for future Lenovo handheld PC business.