

# Survey: Embedded Linux Ahead of the Pack

**David Geer**

Linux appears to be approaching dominance in embedded systems—a trend that might make it easier for developers to choose a platform, speeding embedded systems' growth on the whole.

As of last quarter, Linux owned the highest percentage of new embedded-development projects of any operating system, according to a recent end-user survey by Venture Development Corporation ([www.vdc-corp.com](http://www.vdc-corp.com)), a technology market research and consulting firm. VDC conducted the survey as part of its 2004 Embedded Software Strategic Market Intelligence Program ([www.vdc-corp.com/embedded/reports/04/br04-21.html](http://www.vdc-corp.com/embedded/reports/04/br04-21.html)).

Driving this growth, at least in part, are developers who are migrating to Linux from Windows and the previous leader, Wind River Systems' VxWorks, says VDC analyst Stephen Balacco.

A dominant software platform such as Linux could boost embedded systems to rival PCs. Evidence from the mobile phone market alone puts potential embedded devices for Linux well above the number of PCs sold.

## The future looks bright

At 15.5 percent, commercial embedded Linux owns approximately 50 percent more of the new project market than either Microsoft or Wind River Systems ([www.windriver.com](http://www.windriver.com)), according to the survey. And, as telecom and consumer electronics each sell more units

worldwide than the PC market, Linux's success in those areas points to continued growth.

VDC's Balacco cites telecommunication and data communication requirements, which are consolidating around carrier-grade Linux, as a force driving Linux into the telecom space (and driving VxWorks out). Furthermore, Balacco says, in-house developers writing embedded systems for consumer electronics opt for Linux over Windows CE to blend "roll-your-own" and shrink-wrapped solutions by exploiting open source code, project control, and negligible licensing costs.

## **Market share means money**

Linux is expected to make up an ever-larger percentage of the world's embedded systems market, which grew to more than US\$760 million in 2003, according to VDC.

VDC estimates that worldwide shipments of embedded Linux operating systems, add-on components, and related services were at \$65.2 million in 2003. The same research predicts embedded Linux revenues will reach \$118.5 million by 2006.

One contributing factor is the GNU General Public License ([www.gnu.org/copyleft/gpl.html](http://www.gnu.org/copyleft/gpl.html)), which prevents the burgeoning aggregate of public Linux code from stealing away inside small, commercial systems. The license mandates that if you go commercial, you must go public with additions to the Linux code base.

Another driver is the plethora of new devices that developers can write to. Jim Ready, CEO of MontaVista ([www.mvista.com](http://www.mvista.com)), which controls the largest market share of embedded Linux, compares the situation to TV technology's expansion. When a TV was just a TV that you plugged into the wall, hooked up to your antenna, and accessed with a remote control, it was a metaphor for the whole universe of development, Ready says.

"Now you want to have a TiVo-like experience with a hard drive. The 4-Kbyte OS that was good enough for a TV doesn't scale into an environment in which you can do the kinds of things that you want to do with TVs today," he says. "Multiply that by virtually every kind of interesting device—cars, smart homes and appliances, instrumentation—it's a wide range, not to mention cell phones."

An additional hidden market boosts the Linux camp. "Our report measures the commercial market for Linux," Balacco says. "[But] there is an extremely large developer market out there that is not using commercial solutions. I would put it in the 40 to 50 percent range—those who are using noncommercial or public distributions of Linux."

## Competition responds

According to the VDC survey, embedded developers using Linux most frequently cited Windows CE/.NET, VxWorks, and proprietary in-house-developed or no formal OS as the systems they used in previous projects.

Linux's competitors hope to win back those customers. Some vendors are opening up their source code, and previous market leaders Wind River and Microsoft are pricing their offerings more competitively.

Wind River, the largest public company in the embedded software space, has a vested interest in protecting market share for its proprietary VxWorks solution. In the past year, the company has begun a transformation. "Through a partnership with Red Hat, Wind River will provide a platform that will incorporate Linux, specifically directed at the telecom space," Balacco says, referring to the new Red Hat Embedded Linux solution, announced in February 2004.

Inder Singh, CEO and chairman of LynuxWorks (creators of the Lynx OS), says the move confirms Linux's dominance. "I thought that was one of the strongest proofs—when the largest company that is fighting Linux decides it has to give in," he says. "That would be like Microsoft saying Linux is the future of desktops."

Microsoft also seems to be making some concessions to better compete with Linux. "Microsoft is releasing the majority of its CE source code," Balacco says. "They've reduced their runtime royalties significantly on the CE core license. They've set up developer Web meetings to talk with developers. They are creating a community of developers around the Microsoft products, in particular CE. They have taken steps to try to meet the challenges resulting from the perceived benefits of Linux."

## Embedded systems gaining clout?

If Linux's growth does skyrocket, as VDC predicts, it could spur a significant shift in the global computer market, including both traditional computers and embedded systems.

"Embedded systems have always been the stepchild of computing," Ready says. Although most microprocessors and microcontrollers go into embedded systems rather than servers, desktops, and laptops, the embedded market has never come together as a single driving force.

Without Linux, myriad runtime systems would litter the development landscape, fragmenting the embedded-software plane among multiple OSs and stunting the embedded-systems market's growth. "Imagine what desktop computing would be if there were 40 different OSs, all of them incompatible with each other, and you were trying to find a word processor. The economics get lousy for everybody," Ready says. "If you're an application developer, which of the 40 do you target to develop to?"

With a single, dominant software platform such as Linux, the target would be clear. "As Linux becomes pervasive in the nondesktop, nonserverspace, embedded devices become an enormously powerful and influential platform, rivaling that of the PC," Ready says.

## **Rivaling PCs in real numbers**

Handset sales for 2004 are expected to be triple the number of PC sales. More than 309.4 million handsets were sold in the first half of 2004, according to the Gartner analyst group ([www.gartner.com](http://www.gartner.com)). Total 2004 PC shipments aren't expected to be much over 175 million units, according to the IDC analyst group ([www.idc.com](http://www.idc.com)).

"Today's average cell phone has as much compute power as your desktop did five years ago. There are those that argue that the next platform of significance in computing will be the phone," Ready says. "That is not a Microsoft monopoly; in fact, it's just the opposite, and it's a very attractive home for Linux."

And that's just phones. Consumer electronics and other embedded markets only enhance the picture.

## **Why Linux?**

Linux is compatible and interoperable from distribution to distribution and with other Linux- and Unix-based systems and software. MontaVista built its Linux distribution without concern for compatibility with Oracle, and it runs fine as a platform under Oracle 9i.

Linux is also attractive for networked devices, which are becoming ubiquitous and a broadening portion of the embedded market (smart homes, smart appliances, networked consumer electronics, and so on). "Once you sit on the network, you are likely to want to run multiple applications," Ready says. "For example, you are likely to want to have remote management and security capabilities."

"In the [real-time OS] world, most of that was either missing, done ad hoc, or ported over from Unix." If you examine the kinds of environments you have on networks, you'll find that Linux supplies the vast majority of applications for these off the shelf, Ready adds.

One of Linux's chief applications is security. Developers generously apply Linux to secure systems, commercial and homespun firewalls, and other network devices such as smart firewalls and routers. This is a natural progression from Linux's predominance as a network development platform.

There is some question, however, as to whether Linux is secure enough, because so many people develop for it. "One of the trends that we are seeing [to address that] is an architecture called Mill's architecture, which creates multiple virtual environments on a given processor," Singh says. "You can run Linux inside one of those secure partitions. That is something we are actively working on with the [National Security Agency] for some major customers."

## The real-time question

Real-time requirements are still an issue with Linux. Some applications require response times in microseconds and nanoseconds. "For example, antilock brakes. If you're moving in a car at 70 mph on the freeway, when you step on that brake pedal, you want response time in a modern car to be on the order of a few hundred nanoseconds," says Murry Shohat, executive director of the Embedded Linux Consortium ([www.embedded-linux.org](http://www.embedded-linux.org)). Fortunately, most applications are comfortable running in the millisecond range.

Linux has the millisecond range covered. MontaVista and other developers helped close the gap between Linux and the real-time operating systems by adding modifications, which became part of the Linux 2.6 kernel ([www.kernel.org](http://www.kernel.org)) in December 2003.

According to Ready, one such modification, which MontaVista had in its Linux product, decreased the real-time scheduling latency to about one millisecond in a computing environment with a midrange, approximately 500-MHz Pentium processor. "There are certain applications where that is still way too slow, where you need to get to process levels at least a factor of 10 better than that," he says. "Achieving that is part of an effort that we currently have under way."

Linux has been improving its real-time capabilities while also addressing internal design issues for multiprocessor systems. "You have multiprocessors that are sharing common data structures, and you have to avoid lockouts of any kind—you have to make things very preemptible," Singh says. "That's what you have to do to make things good for real-time, too."

## Conclusion

As Linux addresses demands for a smaller footprint and more real-time capabilities, it will continue to expand its presence within the embedded market. Some say the platform is the best bet for success.

"The number of applications that cannot technically use Linux is shrinking to where those won't necessarily be a very fast-growing business. They will be marginal applications," Ready says. "For the vast majority of interesting applications, where all the volume is, Linux is technically capable today. And it's provable—we're in phones."