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ISPadmin

EMBEDDED HARDWARE

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IN THIS EDITION OF ISPADMIN, I take a look at the use of embedded systems for ISPs and other networks. There are many embedded platforms and open source software applications available for those interested in deploying wireless access points and firewalls for an ISP or any network. It's not possible to cover all the hardware and software in the space available here, so I've provided overviews and pointers to other resources.

What Are Embedded Systems?

According to Wikipedia, an embedded system is "a special-purpose computer system, which is completely encapsulated by the device it controls" [1]. Embedded systems differ from general-purpose computers (such as PCs) by their programming to accomplish specific tasks. Many different types of embedded systems are in use on large networks, most notably switches and routers. Beyond their specific programming, embedded systems are usually characterized by:

- Low power utilization
- Small size and comparatively lower cost
- Limited use of active cooling devices (fans)
- Limited CPU and memory

To keep the devices in a small package, many design decisions must be made. First of all, the small size dictates a small power supply, which limits the number of components and the speed of the CPU (the faster the CPU, the more power and cooling is used). Less power also means that fewer memory chips can be used. All of these requirements lead to lower cost, which makes the platform attractive for all of the reasons larger devices (such as traditional PCs) are not.

Often, embedded systems are designed to use Compact Flash (CF) or similar types of non-volatile storage rather than hard disk drives. While reducing heat cost and increasing reliability by using fewer moving parts, the lack of a hard drive does make for some added complexity in design. It also requires "stripped down" versions of operating systems to run successfully and can limit log retention due to space and read/write cycles. CF memory is limited in the number of times the memory gates can be switched on or off, so the memory must be replaced after this threshold is exceeded.

Available Embedded Platforms

For the purposes of this discussion, platforms are broken down into two types, general-purpose and re-purposed. Rather than performing any specific function per se, general-purpose platforms are meant to accomplish different functions depending on the software loaded. Re-purposed platforms are commercial products that are loaded with alternate firmware and may or may not be used in the same applications that the original creators intended them for.

There are a number of general-purpose embedded platforms available on the market today. The more common, lower-cost platforms include:

- Soekris Engineering [2]
- PCEngines Wireless Router Application Platform [3]
- PC/104 [4]
- Mini-ITX [5]

The Soekris and PCEngines platforms are each particular to the vendors who created them and are not standards per se. The PC/104 and Mini-ITX platforms are standards in the sense that multiple companies manufacture boards in those formats.

Due to space constraints, only Soekris and Mini-ITX platforms will be covered in this article. However, many of the software packages mentioned run on the other platforms listed above. On the re-purposed platform side, the big target currently is Linksys hardware (and other hardware manufacturers who use similar chipsets). Only the Linksys WRT54G is covered in this article on the re-purposed hardware side.

Soekris Engineering

Soekris boards are one of the more widely used general-purpose embedded platforms available today. The Soekris platform consists of an AMD Geode [6] 100 to 266MHz processor and 16 to 256MB of memory (specifications depend on the model). Flash memory (long-term storage) is provided on board or through a CF socket. All Soekris models come with two or three Ethernet ports, which makes them ideal for firewalls or for aggregating multiple wireless access points/networks into one egress/firewall point. Soekris boards also support power over Ethernet, making them ideal for situations where no traditional 110V AC power is available.

All Soekris boards are available with at least one mini-PCI slot. Some models are available with regular PCI slots, which makes it easy to add functionality, assuming the add-in PCI board consumes little power and runs at 3.3V. However, be aware that the default Soekris case doesn't give external access to the slot, nor is it big enough for a full-size PCI card. These mini-PCI and regular PCI cards are often used for 802.11 wireless network cards.

Mini-ITX

Mini-ITX is a form-factor specification developed by VIA after the purchase of Cyrix from National Semiconductor and Centaur (WinChip) from IDT [7].

Most of the Mini-ITX products are meant to be low-cost PC desktop solutions, as most of the line includes faster processors and active cooling (fans). This is emphasized by the fact that most of the form factors for the Mini-ITX cases are desktop, set-top box, or other hobbyist type of enclosures. However, VIA clearly understands the potential for the embedded market, as it has several boards that do not require cooling fans and that do contain multiple Ethernet ports. These attributes make those VIA product lines ideal for the embedded market.

Embedded System Software

There are many choices when it comes to running software on your embedded device, and no possible way to cover them all here. If you need specialized ISP-type services (e.g., RADIUS, QoS), you must use an environment that allows packages to be added as desired and not a GUI environment such as m0n0wall (see next section). The available software platforms range from build your own from scratch, to flash images that can be loaded directly on flash and then onto the embedded box.

If you want the quickest start, the preprogrammed flash is the way to go. However, using a distribution such as Voyage Linux [8] is only a little more work, but you gain a lot of flexibility. One complication is that Voyage (and similar environments) requires an existing Linux machine to run the install script. If you want to build the Voyage kernel, environment, and/or additional packages, the machine must run a Debian Linux. Pebble [9] is another popular stripped-down Debian Linux environment for embedded/wireless applications.

Numerous BSD-flavored environments are available because the Soekris line of boards seems to have a bias toward this UNIX variant. BSD variants that run on Soekris include m0n0BSD [10] and wifiBSD [11], and there's a nice write-up on installing embedded FreeBSD on Soekris net4801 hardware [12]. Many people seem to roll their own BSD variant for use on embedded hardware [13]. As with Linux, if you want to build your own embedded BSD-based environment, you must first have a BSD-based development system from which to work.

Pre-Packaged Firewalls

If all you require is a firewall, then specialized GUI environments are for you. One of the nicest ones available that runs on Soekris and other PC hardware is m0n0wall [14]. It is a FreeBSD-based system, stripped down, with a very nice GUI; another one is IPcop [15]. However, ease of installation and management comes at the price of flexibility, as you cannot easily add functionality to these firewalls.

Price/Performance Comparison

From a cost/performance standpoint, VIA is clearly the leader—500MHz VIA boards for embedded applications can be purchased for approximately US$100 as of this writing. Add a case, power supply, CF-to-IDE adapter, RAM, and a 128MB CF card and the cost of an embedded Mini-ITX system is comparable to the low-end Soekris models. Obviously, the performance is much greater for the Mini-ITX system; the Soekris boards run at only 100 to 266MHz and have smaller amounts of memory, but they also require very little power (10 watts for a 266MHz net4801 system including a pair of wireless cards).

The inclusion of the typical PC devices on the Mini-ITX platform (VGA adapter, mouse, keyboard, parallel, sound, etc.) does factor in, however. The "wasted" space on the printed circuit board, at least for the embedded application, means that the package for the Mini-ITX form factor can never be as small as the Soekris. The added components will increase power requirements for Mini-ITX as well. The small size of the Soekris (as well as PC/104 and WRAP) form factor is certainly useful in applications where space and power are at an absolute premium.

Re-Purposing Hardware

First, a warning: Re-flashing firmware on Linksys (and similar devices) is going to void your warranty and support agreements, so be sure you know what you are doing before embarking on any project that involves such activity!

On the low-cost embedded hardware side, devices such as the Linksys NSLU2 [16] and Linksys and WRT54G [17] can be re-purposed. The NSLU2 is designed to be a network storage device that allows a USB hard drive to be accessed across the network. It runs proprietary firmware, but this can be changed by installing one of the NSLU2-Linux project software images [18]. One of the firmware releases allows the user to add other hardware devices, turning your NSLU2 into a firewall or otherwise increasing its usefulness.

Most commonly in the ISP market, the WRT54G device is used for enabling wireless access points at low cost. As shipped by Linksys, built-in functions of the WRT54G include:

- Wireless radio
- Five-port Ethernet switch
- Consumer-grade router
- Firewall

Similar chipsets are used by products offered by a number of manufacturers, including Asus, Buffalo, Motorola, and Siemens, among others, according to the OpenWRT Table of Hardware site [19]. The OpenWRT software will run with varying degrees of support on most of these other platforms. The hardware specifications for the Linksys WRT54G version 3.0 device, according to [19], are the following:

- Broadcom 4712 chipset running at 200MHz
- 4MB flash/16MB RAM

At a current street price of US$50 for the WRT54G, that's an excellent price/performance ratio! Products marketed specifically to the service provider with similar functionality start around US$100.

Software for Re-Purposing Devices

ISPs don't use consumer-grade products such as the Linksys WRT54G because the firmware as shipped from Linksys doesn't include authentication methods (such as RADIUS) and other functionality needed for working with their networks. These features are often found in higher-priced devices aimed specifically at the service-provider market, but are lacking in consumer-grade devices.

To rectify this, several people have put out replacement firmware for the WRT54G (and similar) devices. Two of the more widely used ones are:

- Sveasoft Talisman [20]
- OpenWRT [21]

For someone wanting an easy, drop-in network solution, Sveasoft is probably better. It is open source, but a small fee is charged for the latest versions of firmware/support. While OpenWRT is more flexible due to its modular framework for adding packages, more time must be invested to configure the exact image you want. If the package you need isn't available, you may be able to port it to the OpenWRT environment and load it into your custom image.

Conclusion

Embedded hardware is in use at many ISPs and other larger networks. The application for such hardware is usually wireless access points and/or firewalls. There are many embedded hardware solutions available to the ISP or hobbyist today. These include general-purpose platforms such as Soekris Engineering and Mini-ITX, as well as re-purposed hardware such as Linksys WRT54G.

On the software side for general-purpose embedded hardware, stripped-down versions of Linux and BSD variants are in wide use. Images can be readily obtained and loaded via CF and similar media. GUI front ends
are available for firewall applications as well. For re-purposed hardware such as WRT54G, several Linux distributions are available that enable additional functionality for ISPs, including RADIUS and other service provider requirements.

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