Dynamic device management with Udev, HAL, and D-Bus

EASY ACCESS

Udev, HAL, and D-Bus provide automated hardware configuration, even if you plug in on the fly. We'll help you easily access new devices. **BY ERIC AMBERG**

In the old days, Linux pioneers were expected to install new hardware manually, but Linux now offers automatic hardware detection at system boot time, as well as on-the-fly configuration of pluggable devices – whether the device is a USB stick, a digital camera, or a Bluetooth phone.

The Udev subsystem takes the pain out of accessing new devices, and a pair of components known as the Hardware Abstraction Layer (HAL) and D-Bus provide an interface from the hardware to desktop applications.

Under the Hood

Udev [1], which runs in the background as the *udevd* daemon, creates dynamic device files under */dev* whenever it identifies a new device. The Udev daemon finds the devices at system boot time, and it also sets up new devices that are plugged in while the system is running – a feature that is commonly called *hot plugging*. The program might also create symbolic links for mass storage media such as disks or USB sticks under */dev/disk* to point to the physical device files under */dev*.

The Udev system makes sure device files are only created for existing devices. The kernel monitors the USB bus and detects the device you just plugged in. It generates a **Uevent** to report its findings to the Udev daemon. The Udev system processes the information by retrieving the data for the device from the kernel device database, **Sysfs**. The Udev rules specify what Udev does with the new device. The rules, which are located under */etc/udev/rules.d/*, comprise a number of individual files that define actions for various events.

As Listing 1 shows, rule file names start with numbers. The idea behind the numerical approach is to specify the processing order because some dependencies might need to be resolved to complete the configuration.

If you are interested in more detail on creating Udev rules, check out the article at kernel.org [1].

If you are interested, you can watch Udev working. The Udevmonitor tool gives you this option. Udevmonitor shows you the kernel Uevents that occur when you plug in a device (say, a USB stick) along with the matching Udev responses (Listing 2).

All the lines starting with *UEVENT* relate to kernel messages, whereas the lines that start with *UDEV* identify Udev actions. The new device is accessible via the */dev/sdb1* device file, as you can see from the last line in Listing 2. A quick glance at */dev/disk/by-label* reveals a link with the name the USB stick used to register with the system. The matching symbolic link for the stick in this example is *DISK_IMG*, which points to */dev/sdb1*, matching the Udevmonitor output. In this case, the system just used the name.

Many, but not all, devices register with their

James Steidl, Fotolia

model designations, or at least with their manufacturers' names. In this example, *DISK_IMG* is not very helpful.

In the case of USB devices, you can redefine the label for a device you plug in by issuing the *lsusb* command, as shown in Listing 3. The example here shows a Hewlett Packard keyboard and a digital camera, both of which are registered with their full device designations.

Abstract Art

After Udev has completed its chores, the Hardware Abstraction Layer (HAL) [2] makes its contribution. The idea behind HAL is that applications should be able to access hardware without the need to know anything about the details. HAL acts as an interface between the hardware and the applications.

To allow this to happen, HAL draws information from several sources. For one thing, it listens directly to system buses, for another, it retrieves information from Udev, the kernel, and certain other global and user-specific configuration files.

More information is stored in XML-formatted FDI files under */usr/share/hal/fdi/information/*. The FDI files contain long lists of information on devices by individual vendors, such as CD/DVD writers or digital cameras. HAL can draw on this resource to provide detailed information on the hardware.

If you want to view this information, you can either use *lshal* at the command line or launch a graphical front end, such as the HAL Device Manager (Figure 1), Gnome Device Manager, or KDE HAL Device Manager.

HAL, which is developed by the Freedesktop.org project [3], runs in the background in the form of the *hald* daemon. On top of this, it launches some

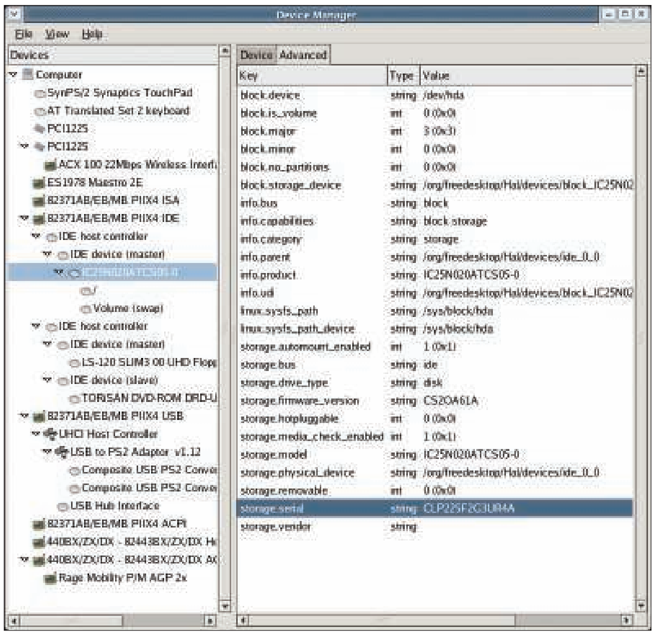
Listing 1: The Rules File

```
# ls /etc/udev/rules.d/
05-udev-early.rules       50-udev-default.rules               60-cdrom_id.rules
64-md-raid.rules          70-persistent-net.rules             79-yast2-drivers.rules
40-alsa.rules             55-hpmud.rules                      60-persistent-input.rules
70-kpartx.rules           75-cd-aliases-generator.rules       80-drivers.rules
40-bluetooth.rules        55-libsane.rules                    60-persistent-storage.rules
70-persistent-cd.rules    75-persistent-net-generator.rules   90-hal.rules
                          56-idedma.rules                     64-device-mapper.rules
                          77-network.rules                    95-udev-late.rules
```

Listing 2: Udevmonitor Output

```
# udevmonitor
udevmonitor will print the received events for:
UDEV the event which udev sends out after rule processing
UEVENT the kernel uevent

UDEV  [1212504262.814732] add      /devices/pci0000:00/0000:00:1d.7/usb3/3-1 (usb)
UDEV  [1212504262.814934] add      /devices/pci0000:00/0000:00:1d.7/usb3/3-1/usb_endpoint/usbdev3.7_ep00
(usb_endpoint)
UDEV  [1212504262.815017] add      /devices/pci0000:00/0000:00:1d.7/usb3/3-1/3-1:1.0 (usb)
UDEV  [1212504262.815086] add      /class/scsi_host/host5 (scsi_host)
UDEV  [1212504262.815146] add      /devices/pci0000:00/0000:00:1d.7/usb3/3-1/3-1:1.0/usb_endpoint/usbdev3.7_
ep01 (usb_endpoint)
UDEV  [1212504262.815193] add      /devices/pci0000:00/0000:00:1d.7/usb3/3-1/3-1:1.0/usb_endpoint/usbdev3.7_
ep81 (usb_endpoint)
UEVENT[1212504263.666057] add      /devices/pci0000:00/0000:00:1d.7/usb3/3-1/3-1:1.0/host5/
target5:0:0/5:0:0:0 (scsi)
UEVENT[1212504263.666112] add      /class/scsi_disk/5:0:0:0 (scsi_disk)
UEVENT[1212504263.673463] add      /block/sdb (block)
UEVENT[1212504263.673511] add      /block/sdb/sdb1 (block)
UEVENT[1212504263.673538] add      /class/scsi_device/5:0:0:0 (scsi_device)
UEVENT[1212504263.673565] add      /class/scsi_generic/sg2 (scsi_generic)
UDEV  [1212504263.716085] add      /devices/pci0000:00/0000:00:1d.7/usb3/3-1/3-1:1.0/host5/
target5:0:0/5:0:0:0 (scsi)
UDEV  [1212504263.733094] add      /class/scsi_disk/5:0:0:0 (scsi_disk)
UDEV  [1212504263.793736] add      /class/scsi_device/5:0:0:0 (scsi_device)
UDEV  [1212504263.823559] add      /class/scsi_generic/sg2 (scsi_generic)
UDEV  [1212504263.831015] add      /block/sdb (block)
UDEV  [1212504263.900340] add      /block/sdb/sdb1 (block)
```



Computer
SynPS/2 Synaptics TouchPad
AT Translated Set 2 keyboard
PCI1225
PCI1225
ACX 100 22Mbps Wireless Interf
ES1978 Maestro 2E
82371AB/EB/MB PIIX4 ISA
82371AB/EB/MB PIIX4 IDE
IDE host controller
IDE device (master)
IC25N020ATCS05-0
/
Volume (swap)
IDE host controller
IDE device (master)
LS-120 SLIM3 00 UHD Flop
IDE device (slave)
TORISAN DVD-ROM DRD-U
82371AB/EB/MB PIIX4 USB
UHCI Host Controller
USB to PS2 Adaptor v1.12
Composite USB PS2 Conve
Composite USB PS2 Conve
USB Hub Interface
82371AB/EB/MB PIIX4 ACPI
440BX/ZX/DX - 82443BX/ZX/DX Ho
440BX/ZX/DX - 82443BX/ZX/DX AG
Rage Mobility P/M AGP 2x

Key	Type	Value
block.device	string	/dev/hda
block.is_volume	int	0 (0x0)
block.major	int	3 (0x3)
block.minor	int	0 (0x0)
block.no_partitions	int	0 (0x0)
block.storage_device	string	/org/freedesktop/Hal/devices/block_IC25N02
info.bus	string	block
info.capabilities	string	block storage
info.category	string	storage
info.parent	string	/org/freedesktop/Hal/devices/ide_0_0
info.product	string	IC25N020ATCS05-0
info.udi	string	/org/freedesktop/Hal/devices/block_IC25N02
linux.sysfs_path	string	/sys/block/hda
linux.sysfs_path_device	string	/sys/block/hda
storage.automount_enabled	int	1 (0x1)
storage.bus	string	ide
storage.drive_type	string	disk
storage.firmware_version	string	CS2OA61A
storage.hotpluggable	int	0 (0x0)
storage.media_check_enabled	int	1 (0x1)
storage.model	string	IC25N020ATCS05-0
storage.physical_device	string	/org/freedesktop/Hal/devices/ide_0_0
storage.removable	int	0 (0x0)
storage.serial	string	CLP225F2G3UR4A
storage.vendor	string	

Figure 1: The HAL Device Manager displaying HAL information.

auxiliary services when necessary. The services typically appear as entries starting with *hald-addon-* in the process list. A service typically monitors the status of a device.

If you find an entry for *hald-addon-storage: polling /dev/hda*, this means the device that follows */dev/hda* is currently being polled; it is a CD/DVD drive in this example.

Taking the Bus to Work

Although HAL provides device information for applications, it does not communicate directly with them. This is the domain of D-Bus [4], which is also maintained by the Freedesktop.org project and interacts very closely with HAL.

GLOSSARY

Uevent: Short form of *User Event*. This means a notification event from the kernel to programs in userspace. This memory area, which is separate from the kernel space, is populated by normal programs and non-kernel subsystems. The Udev subsystem runs in userspace.

Sysfs: A virtual filesystem that was introduced with kernel version 2.6. It is normally accessible under */sys* and makes device and driver information defined in the Kernel Device Model, the kernel's internal device database, available to programs in userspace.

IPC: Short for Interprocess Communication, a method of communication and data exchange between processes on the same computer.

D-Bus is an IPC framework geared to the needs of desktop applications, and it is part of nearly any Linux distribution today.

D-Bus is used for communication between desktop applications within the same desktop session, as well as communication between the operating system and its components.

The idea behind the IPC framework has been around for some time. Both major desktops – Gnome and KDE – made heavy use of completely different approaches in the past, with Gnome mainly relying on Corba [5] and KDE using DCOP [6]. Windows, which also has IPC services, relies on the proprietary DCOM [7]. Other IPC mechanisms also exist on Linux, however, they are restricted to specific tasks.

D-Bus also runs as a daemon and provides two communications channels or buses. The system bus is launched at boot time and is available whether the user logs on to the GUI system or not; that is, it runs all the time.

If a user logs on to the graphical interface, a second bus is launched: the session bus. The daemon process, *dbus-daemon*, has two options for this: *--system* and *--session*.

Whereas the daemon process for the system bus reads its configuration parameters from the */etc/dbus-1/system.conf* file, the session bus parses */etc/dbus-1/session.conf*. Incidentally, the dbus-launch program is used to launch the daemon.

Dbus-launch runs permanently as a daemon during a graphical user session, just in case it needs to launch further session bus processes.

After the user logs off, dbus-launch and the corresponding session bus terminate, leaving the system bus running. Figures 2 and 3 show the interrelationships.

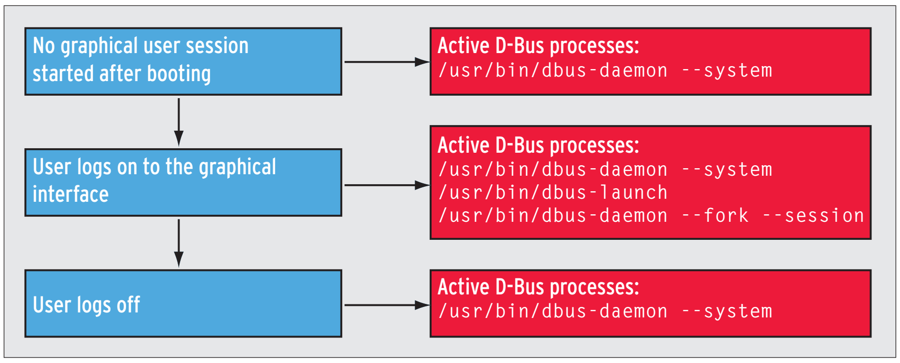

No graphical user session started after booting
Active D-Bus processes:
/usr/bin/dbus-daemon --system
User logs on to the graphical interface
Active D-Bus processes:
/usr/bin/dbus-daemon --system
/usr/bin/dbus-launch
/usr/bin/dbus-daemon --fork --session
User logs off
Active D-Bus processes:
/usr/bin/dbus-daemon --system

Figure 2: Although the D-Bus system bus runs permanently, the D-Bus launcher and the session bus only run during the user session.

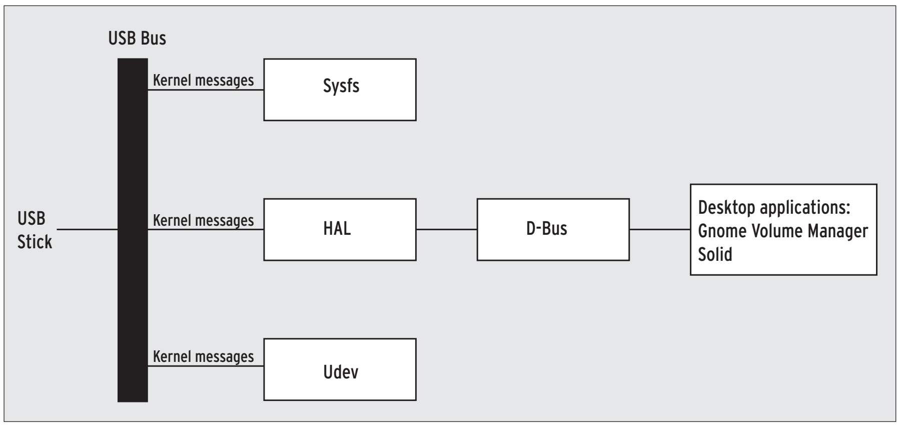
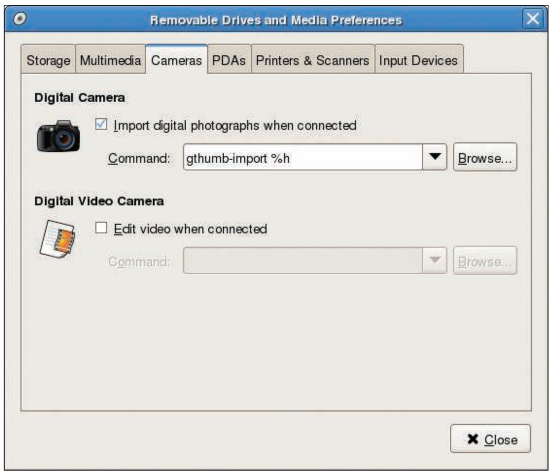


Figure 3: HAL organizes information on attached hardware and uses D-Bus to make the information available to applications.



Digital Camera

☑ Import digital photographs when connected

Command: gthumb-import %h

Digital Video Camera

☐ Edit video when connected

Command:

Figure 4: The Gnome Volume Properties tool helps you launch Gthumb-import when you connect your digital camera.

If an application requests a specific device class (such as *camera*, or *storage*) HAL uses D-Bus to notify the program as soon as the status of a device in this class changes. For example, the Gnome Volume Manager launches the gthumb-import import tool when you connect a camera (Figure 4).

KDE 4 has an applet in the form of a laptop icon labeled *Device Monitor*. The applet collaborates with D-Bus to display new hardware you plug in.

At the same time, it lets you launch a specific action depending on the device. For example, you could launch the Dolphin file manager to display the content of any USB sticks you plug in.

KDE's Solid framework is configured via the system preferences. So far, hardware detection has only been implemented for HAL management, the network, and Bluetooth.

Conclusions

Just a couple of years ago, configuring new hardware on Linux was a daunting task and just one more reason for newcomers to keep clear. Now, Linux offers convenient device management that provides trouble-free, dynamic handling of devices plugged in at run time – including WLAN sticks, digital cameras, and even camcorders. Linux can listen on interfaces such as Bluetooth and Firewire and, if necessary, not only integrate a device you plug in, but launch the matching application as well.

Fortunately, the trend in recent months has been toward standardizing the underlying technologies. Udev has already clearly ousted its predecessor, Devfs, and found its way into the Linux kernel. Now the Freedesktop.org-sponsored team of HAL and D-Bus is establishing itself in the face of competition from the previous Gnome and KDE favorites, Corba and DCOP.

This merge has greatly improved communications between the two desktop environments. Gnome already has a mature front end for dynamic device management with Gnome Volume Manager and related tools. KDE is following suit after considerable restructuring of its libraries in version 4.

The KDE Solid hardware library adds a new and powerful framework to make hardware management on KDE easier than ever. In the months to come, you can look forward to more dynamic device management fireworks. ■

Listing 3: lsusb

```
# lsusb
Bus 001 Device 005: ID 03f0:0024
Hewlett-Packard
Bus 001 Device 001: ID 0000:0000
Bus 005 Device 001: ID 0000:0000
Bus 004 Device 001: ID 0000:0000
Bus 002 Device 002: ID 04a9:3073
Canon, Inc. PowerShot A70 (ptp)
Bus 002 Device 001: ID 0000:0000
Bus 003 Device 001: ID 0000:0000
```

Hot-Wired

In the past, users had to manually mount devices such as CDs or DVDs, but Gnome systems now handle this task through the Gnome Volume Manager. The manager dynamically creates an icon on your desktop, which you can then click to access the CD or DVD. Other external mass memory devices, such as USB sticks, are also mounted automatically by the software. The Gnome Volume Manager creates a matching subdirectory under */media*, where it mounts the device. The directory is named after the name the device uses to register with the system.

Depending on your configuration, the manager might also launch a matching application. In the case of mass storage devices such as CD/DVDs, USB sticks, or USB hard disks, you can launch the file browser to display the contents below the mount point for the dynamically mounted device (Figure 5).

If you connect a digital camera, the Gnome Volume Manager will launch an image viewer or the import routine associated with an image viewer.

The Gnome volume manager has a number of configuration options. Gnome Volume Properties dialog, which you can launch by popping up a terminal window in Gnome, handles the options (Figure 6).

For each device class, such as digital cameras, mass storage, printers, and scanners, you can define a specific response. This means that you can configure the system to, say, auto-detect and set up new printers.

KDE has a similar framework. Whereas KDE formerly experimented with home-cooked solutions like Corba or DCOP, the developers moved to Udev/HAL/D-Bus some time ago. Both major desktop environments now use the same underpinnings for device management. KDE version 4 and later relies on the Solid program package to offer functionality similar to Gnome Volume Manager.

INFO

[1] Udev: *http://www.kernel.org/pub/linux/utils/kernel/hotplug/udev.html*

[2] HAL: *http://www.freedesktop.org/wiki/Software/hal*

[3] Freedesktop.org: *http://www.freedesktop.org/wiki*

[4] D-Bus: *http://www.freedesktop.org/wiki/Software/dbus*

[5] Corba: *http://de.wikipedia.org/wiki/CORBA*

[6] DCOP: *http://developer.kde.org/documentation/other/dcop.html*

[7] DCOM for programmers: *http://msdn.microsoft.com/en-us/library/ms809311.aspx*

THE AUTHOR

Eric Amberg has worked for many years as a System Engineer for IT networks, specializing in Linux and network security for large corporations. On top of this, he has published books and articles on Linux. His latest book, *Linux Servers with Debian GNU/Linux* (German) was published in June 2007.