Chapter

7

Securing and Monitoring Kali Linux

Contents

As you begin to use Kali Linux for increasingly sensitive and higher-profile work, you will likely need to take the security of your installation more seriously. In this chapter, we will first discuss security policies, highlighting various points to consider when defining such a policy, and outlining some of the threats to your system and to you as a security professional. We will also discuss security measures for laptop and desktop systems and focus on firewalls and packet filtering. Finally, we will discuss monitoring tools and strategies and show you how to best implement them to detect potential threats to your system.

7.1. Defining a Security Policy

It is impractical to discuss security in broad strokes since the idea represents a vast range of concepts, tools, and procedures, none of which apply universally. Choosing among them requires a precise idea of what your goals are. Securing a system starts with answering a few questions. Rushing headlong into implementing an arbitrary set of tools runs the risk of focusing on the wrong aspects of security.

It is usually best to determine a specific goal. A good approach to help with that determination starts with the following questions:

- *What* are you trying to protect? The security policy will be different depending on whether you want to protect computers or data. In the latter case, you also need to know which data.
- What are you trying to protect *against*? Is it leakage of confidential data? Accidental data loss? Revenue loss caused by disruption of service?
- Also, *who* are you trying to protect against? Security measures will be quite different for guarding against a typo by a regular user of the system versus protecting against a determined external attacker group.

The term ”risk” is customarily used to refer collectively to these three factors: what to protect, what should be prevented, and who might make this happen. Modeling the risk requires answers to these three questions. From this risk model, a security policy can be constructed and the policy can be implemented with concrete actions.

Permanent Questioning Bruce Schneier, a world expert in security matters (not only computer security), tries to counter one of security's most important myths with a motto: “Security is a process, not a product.” Assets to be protected change over time and so do threats and the means available to potential attackers. Even if a security policy has initially been perfectly designed and implemented, you should never rest on your laurels. The risk components evolve and the response to that risk must evolve accordingly.

Extra constraints are also worth taking into account as they can restrict the range of available policies. How far are you willing to go to secure a system? This question has a major impact on which policy to implement. Too often, the answer is only defined in terms of monetary costs,

but other elements should also be considered, such as the amount of inconvenience imposed on system users or performance degradation.

Once the risk has been modeled, you can start thinking about designing an actual security policy.

There are extremes that can come into play when deciding the level of security protections to adopt. On one hand, it can be extremely simple to provide basic system security.

For instance, if the system to be protected only comprises a second-hand computer, the sole use of which is to add a few numbers at the end of the day, deciding not to do anything special to protect it would be quite reasonable. The intrinsic value of the system is low and the value of the data are zero since they are not stored on the computer. A potential attacker infiltrating this system would only gain a calculator. The cost of securing such a system would probably be greater than the cost of a breach.

At the other end of the spectrum, you might want to protect the confidentiality of secret data in the most comprehensive way possible, trumping any other consideration. In this case, an appropriate response would be the total destruction of the data (securely erasing the files, shredding of the hard disks to bits, then dissolving these bits in acid, and so on). If there is an additional requirement that data must be kept in store for future use (although not necessarily readily available), and if cost still isn't a factor, then a starting point would be storing the data on iridium–platinum alloy plates stored in bomb-proof bunkers under various mountains in the world, each of which being (of course) both entirely secret and guarded by entire armies.

Extreme though these examples may seem, they would nevertheless be an adequate response to certain defined risks, insofar as they are the outcome of a thought process that takes into account the goals to reach and the constraints to fulfill. When coming from a reasoned decision, no security policy is more, or less, respectable than any other.

Coming back to a more typical case, an information system can be segmented into consistent and mostly independent subsystems. Each subsystem will have its own requirements and constraints, and so the risk assessment and the design of the security policy should be undertaken separately for each. A good principle to keep in mind is that a small attack surface is easier to defend than a large one. The network organization should also be designed accordingly: the sensitive services should be concentrated on a small number of machines, and these machines should only be accessible via a minimal number of routes or check-points. The logic is straightforward: it is easier to secure these checkpoints than to secure all the sensitive machines against the entirety of the outside world. It is at this point that the usefulness of network filtering (including by firewalls) becomes apparent. This filtering can be implemented with dedicated hardware but a simpler and more flexible solution is to use a software firewall such as the one integrated in the Linux kernel.

7.2. Possible Security Measures

As the previous section explained, there is no single response to the question of how to secure Kali Linux. It all depends on how you use it and what you are trying to protect.

7.2.1. On a Server

If you run Kali Linux on a publicly accessible server, you most likely want to secure network services by changing any default passwords that might be configured (see section 7.3, "Securing Network Services" [page 153]) and possibly also by restricting their access with a firewall (see section 7.4, "Firewall or Packet Filtering" [page 153]).

If you hand out user accounts either directly on the server or on one of the services, you want to ensure that you set strong passwords (they should resist brute-force attacks). At the same time, you might want to setup *fail2ban*, which will make it much harder to brute-force passwords over the network (by filtering away IP addresses that exceed a limit of failed login attempts). Install *fail2ban* with `apt update` followed by `apt install fail2ban`.

If you run web services, you probably want to host them over HTTPS to prevent network intermediaries from sniffing your traffic (which might include authentication cookies).

7.2.2. On a Laptop

The laptop of a penetration tester is not subject to the same risks as a public server: for instance, you are less likely to be subject to random scans from script kiddies and even when you are, you probably won't have any network services enabled.

Real risk often arises when you travel from one customer to the next. For example, your laptop could be stolen while traveling or seized by customs. That is why you most likely want to use full disk encryption (see section 4.2.2, "Installation on a Fully Encrypted File System" [page 85]) and possibly also setup the "nuke" feature (see "Adding a Nuke Password for Extra Safety" [page 245]): the data that you have collected during your engagements are confidential and require the utmost protection.

You may also need firewall rules (see section 7.4, "Firewall or Packet Filtering" [page 153]) but not for the same purpose as on the server. You might want to forbid all outbound traffic except the traffic generated by your VPN access. This is meant as a safety net, so that when the VPN is down, you immediately notice it (instead of falling back to the local network access). That way, you do not divulge the IP addresses of your customers when you browse the web or do other online activities. In addition, if you are performing a local internal engagement, it is best to remain in control of all of your activity to reduce the noise you create on the network, which can alert the customer and their defense systems.

7.3. Securing Network Services

In general, it is a good idea to disable services that you do not use. Kali makes it easy to do this since most network services are disabled by default.

As long as services remain disabled, they do not pose any security threat. However, you must be careful when you enable them because:

- there is no firewall by default, so if they listen on all network interfaces, they are effectively publicly available.
- some services have no authentication credentials and let you set them on first use; others have default (and thus widely known) credentials preset. Make sure to (re)set any password to something that only you know.
- many services run as root with full administrator privileges, so the consequences of unauthorized access or a security breach are therefore usually severe.

Default Credentials

We won't list here all tools that come with default credentials, instead you should check the `README.Debian` file of the respective packages, as well as docs.kali.org[1] and tools.kali.org[2] to see if the service needs some special care to be secured.

If you run in live mode, the password of the root account is "*toor*." Thus you should not enable SSH before changing the password of the root account, or before having tweaked its configuration to disallow password-based logins.

Also note that the BeEF project (from the already-installed package *beef-xss*) is also known to have default credentials user "beef", password "beef") hardcoded in its default configuration file.

7.4. Firewall or Packet Filtering

A *firewall* is a piece of computer equipment with hardware, software, or both that parses the incoming or outgoing network packets (coming to or leaving from a local network) and only lets through those matching certain predefined conditions.

A filtering network gateway is a type of firewall that protects an entire network. It is usually installed on a dedicated machine configured as a gateway for the network so that it can parse all packets that pass in and out of the network. Alternatively, a local firewall is a software service that runs on one particular machine in order to filter or limit access to some services on that machine, or possibly to prevent outgoing connections by rogue software that a user could, willingly or not, have installed.

[1] `https://docs.kali.org`
[2] `https://tools.kali.org`

The Linux kernel embeds the *netfilter* firewall. There is no turn-key solution for configuring any firewall since network and user requirements differ. However, you can control *netfilter* from user space with the `iptables` and `ip6tables` commands. The difference between these two commands is that the former works for IPv4 networks, whereas the latter works on IPv6. Since both network protocol stacks will probably be around for many years, both tools will need to be used in parallel. You can also use the excellent GUI-based `fwbuilder` tool, which provides a graphical representation of the filtering rules.

However you decide to configure it, *netfilter* is Linux's firewall implementation, so let's take a closer look at how it works.

7.4.1. Netfilter Behavior

Netfilter uses four distinct tables, which store rules regulating three kinds of operations on packets:

- filter concerns filtering rules (accepting, refusing, or ignoring a packet);
- nat (Network Address Translation) concerns translation of source or destination addresses and ports of packets;
- mangle concerns other changes to the IP packets (including the ToS—*Type of Service*—field and options);
- raw allows other manual modifications on packets before they reach the connection tracking system.

Each table contains lists of rules called *chains*. The firewall uses standard chains to handle packets based on predefined circumstances. The administrator can create other chains, which will only be used when referred by one of the standard chains (either directly or indirectly).

The filter table has three standard chains:

- INPUT: concerns packets whose destination is the firewall itself;
- OUTPUT: concerns packets emitted by the firewall;
- FORWARD: concerns packets passing through the firewall (which is neither their source nor their destination).

The nat table also has three standard chains:

- PREROUTING: to modify packets as soon as they arrive;
- POSTROUTING: to modify packets when they are ready to go on their way;
- OUTPUT: to modify packets generated by the firewall itself.

These chains are illustrated in Figure 7.1, "How *Netfilter* Chains are Called" [page 155].

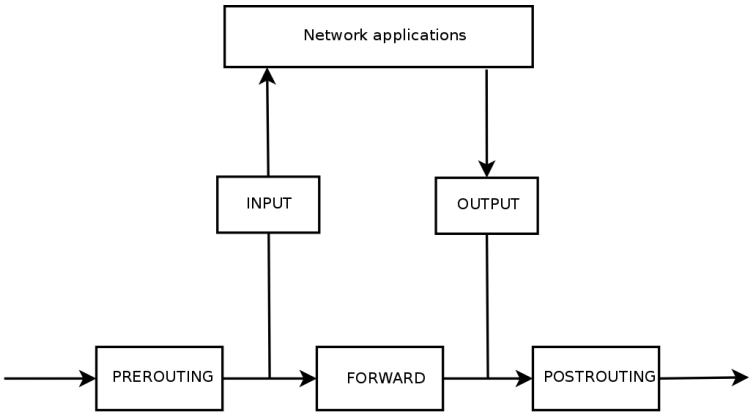


Figure 7.1 *How* Netfilter *Chains are Called*

Each chain is a list of rules; each rule is a set of conditions and an action to perform when the conditions are met. When processing a packet, the firewall scans the appropriate chain, one rule after another, and when the conditions for one rule are met, it jumps (hence the -j option in the commands) to the specified action to continue processing. The most common behaviors are standardized and dedicated actions exist for them. Taking one of these standard actions interrupts the processing of the chain, since the packets fate is already sealed (barring an exception mentioned below). Listed below are the *Netfilter* actions.

- ACCEPT: allow the packet to go on its way.
- REJECT: reject the packet with an Internet control message protocol (ICMP) error packet (the --reject-with *type* option of `iptables` determines the type of error to send).
- DROP: delete (ignore) the packet.
- LOG: log (via `syslogd`) a message with a description of the packet. Note that this action does not interrupt processing, and the execution of the chain continues at the next rule, which is why logging refused packets requires both a LOG and a REJECT/DROP rule. Common parameters associated with logging include:
  - --log-level, with default value warning, indicates the `syslog` severity level.
  - --log-prefix allows specifying a text prefix to differentiate between logged messages.
  - --log-tcp-sequence, --log-tcp-options, and --log-ip-options indicate extra data to be integrated into the message: respectively, the TCP sequence number, TCP options, and IP options.
- ULOG: log a message via `ulogd`, which can be better adapted and more efficient than `syslogd` for handling large numbers of messages; note that this action, like LOG, also returns processing to the next rule in the calling chain.
- *chain_name*: jump to the given chain and evaluate its rules.

- RETURN: interrupt processing of the current chain and return to the calling chain; in case the current chain is a standard one, there's no calling chain, so the default action (defined with the -P option to `iptables`) is executed instead.

- SNAT (only in the nat table): apply *Source Network Address Translation* (SNAT). Extra options describe the exact changes to apply, including the --to-source *address*:*port* option, which defines the new source IP address and/or port.

- DNAT (only in the nat table): apply *Destination Network Address Translation* (DNAT). Extra options describe the exact changes to apply, including the --to-destination *address*:*port* option, which defines the new destination IP address and/or port.

- MASQUERADE (only in the nat table): apply *masquerading* (a special case of *Source NAT*).

- REDIRECT (only in the nat table): transparently redirect a packet to a given port of the firewall itself; this can be used to set up a transparent web proxy that works with no configuration on the client side, since the client thinks it connects to the recipient whereas the communications actually go through the proxy. The --to-ports *port(s)* option indicates the port, or port range, where the packets should be redirected.

Other actions, particularly those concerning the mangle table, are outside the scope of this text. The `iptables(8)` and `ip6tables(8)` man pages have a comprehensive list.

What is ICMP? *Internet Control Message Protocol* (ICMP) is the protocol used to transmit ancillary information on communications. It tests network connectivity with the `ping` command, which sends an ICMP *echo request* message, which the recipient is meant to answer with an ICMP *echo reply* message. It signals a firewall rejecting a packet, indicates an overflow in a receive buffer, proposes a better route for the next packets in the connection, and so on. This protocol is defined by several RFC documents. RFC777 and RFC792 were the first, but many others extended and/or revised the protocol.

➨ `http://www.faqs.org/rfcs/rfc777.html`

➨ `http://www.faqs.org/rfcs/rfc792.html`

For reference, a receive buffer is a small memory zone storing data between the time it arrives from the network and the time the kernel handles it. If this zone is full, new data cannot be received and ICMP signals the problem so that the emitter can slow down its transfer rate (which should ideally reach an equilibrium after some time).

Note that although an IPv4 network can work without ICMP, ICMPv6 is strictly required for an IPv6 network, since it combines several functions that were, in the IPv4 world, spread across ICMPv4, *Internet Group Membership Protocol* (IGMP), and *Address Resolution Protocol* (ARP). ICMPv6 is defined in RFC4443.

➨ `http://www.faqs.org/rfcs/rfc4443.html`

7.4.2. Syntax of `iptables` and `ip6tables`

The `iptables` and `ip6tables` commands are used to manipulate tables, chains, and rules. Their -t *table* option indicates which table to operate on (by default, filter).

Commands

The major options for interacting with chains are listed below:

- -L *chain* lists the rules in the chain. This is commonly used with the -n option to disable name resolution (for example, `iptables -n -L INPUT` will display the rules related to incoming packets).
- -N *chain* creates a new chain. You can create new chains for a number of purposes, including testing a new network service or fending off a network attack.
- -X *chain* deletes an empty and unused chain (for example, `iptables -X ddos-attack`).
- -A *chain rule* adds a rule at the end of the given chain. Remember that rules are processed from top to bottom so be sure to keep this in mind when adding rules.
- -I *chain rule_num rule* inserts a rule before the rule number *rule_num*. As with the -A option, keep the processing order in mind when inserting new rules into a chain.
- -D *chain rule_num* (or -D *chain rule*) deletes a rule in a chain; the first syntax identifies the rule to be deleted by its number (`iptables -L --line-numbers` will display these numbers), while the latter identifies it by its contents.
- -F *chain* flushes a chain (deletes all its rules). For example, to delete all of the rules related to outgoing packets, you would run `iptables -F OUTPUT`. If no chain is mentioned, all the rules in the table are deleted.
- -P *chain action* defines the default action, or "policy" for a given chain; note that only standard chains can have such a policy. To drop all incoming traffic by default, you would run `iptables -P INPUT DROP`.

Rules

Each rule is expressed as *conditions* -j *action action_options*. If several conditions are described in the same rule, then the criterion is the conjunction (logical *AND*) of the conditions, which is at least as restrictive as each individual condition.

The -p *protocol* condition matches the protocol field of the IP packet. The most common values are tcp, udp, icmp, and icmpv6. This condition can be complemented with conditions on the TCP ports, with clauses such as --source-port *port* and --destination-port*port*.

Negating Conditions Prefixing a condition with an exclamation mark negates the condition. For example, negating a condition on the -p option matches "any packet with a different protocol than the one specified." This negation mechanism can be applied to all other conditions as well.

The -s *address* or -s *network/mask* condition matches the source address of the packet. Correspondingly, -d *address* or -d *network/mask* matches the destination address.

The -i *interface* condition selects packets coming from the given network interface. -o *interface* selects packets going out on a specific interface.

The --state *state* condition matches the state of a packet in a connection (this requires the `ipt_conntrack` kernel module, for connection tracking). The NEW state describes a packet starting a new connection, ESTABLISHED matches packets belonging to an already existing connection, and RELATED matches packets initiating a new connection related to an existing one (which is useful for the ftp-data connections in the "active" mode of the FTP protocol).

There are many available options for `iptables` and `ip6tables` and mastering them all requires a great deal of study and experience. However, one of the options you will use most often is the one to block malicious network traffic from a host or range of hosts. For example, to silently block incoming traffic from the IP address 10.0.1.5 and the 31.13.74.0/24 class C subnet:

```
# iptables -A INPUT -s 10.0.1.5 -j DROP
# iptables -A INPUT -s 31.13.74.0/24 -j DROP
# iptables -n -L INPUT
Chain INPUT (policy ACCEPT)
target     prot opt source               destination
DROP       all  --  10.0.1.5            0.0.0.0/0
DROP       all  --  31.13.74.0/24       0.0.0.0/0
```

Another commonly-used `iptables` command is to permit network traffic for a specific service or port. To allow users to connect to SSH, HTTP, and IMAP, you could run the following commands:

```
# iptables -A INPUT -m state --state NEW -p tcp --dport 22 -j ACCEPT
# iptables -A INPUT -m state --state NEW -p tcp --dport 80 -j ACCEPT
# iptables -A INPUT -m state --state NEW -p tcp --dport 143 -j ACCEPT
# iptables -n -L INPUT
Chain INPUT (policy ACCEPT)
target     prot opt source               destination
DROP       all  --  10.0.1.5            0.0.0.0/0
DROP       all  --  31.13.74.0/24       0.0.0.0/0
ACCEPT     tcp  --  0.0.0.0/0           0.0.0.0/0           state NEW tcp dpt:22
ACCEPT     tcp  --  0.0.0.0/0           0.0.0.0/0           state NEW tcp dpt:80
ACCEPT     tcp  --  0.0.0.0/0           0.0.0.0/0           state NEW tcp dpt:143
```

It is considered to be good computer *hygiene* to clean up old and unnecessary rules. The easiest way to delete `iptables` rules is to reference the rules by line number, which you can retrieve with

the --line-numbers option. Be wary though: dropping a rule will renumber all the rules appearing further down in the chain.

```
# iptables -n -L INPUT --line-numbers
Chain INPUT (policy ACCEPT)
num  target     prot opt source               destination
1    DROP       all  --  10.0.1.5             0.0.0.0/0
2    DROP       all  --  31.13.74.0/24        0.0.0.0/0
3    ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW tcp dpt:22
4    ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW tcp dpt:80
5    ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW tcp dpt:143
# iptables -D INPUT 2
# iptables -D INPUT 1
# iptables -n -L INPUT --line-numbers
Chain INPUT (policy ACCEPT)
num  target     prot opt source               destination
1    ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW tcp dpt:22
2    ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW tcp dpt:80
3    ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW tcp dpt:143
```

There are more specific conditions, depending on the generic conditions described above. For more information refer to `iptables(8)` and `ip6tables(8)`

7.4.3. Creating Rules

Each rule creation requires one invocation of `iptables` or `ip6tables`. Typing these commands manually can be tedious, so the calls are usually stored in a script so that the system is automatically configured the same way every time the machine boots. This script can be written by hand but it can also be interesting to prepare it with a high-level tool such as `fwbuilder`.

```
# apt install fwbuilder
```

The principle is simple. In the first step, describe all the elements that will be involved in the actual rules:

- The firewall itself, with its network interfaces
- The networks, with their corresponding IP ranges
- The servers
- The ports belonging to the services hosted on the servers

Next, create the rules with simple drag-and-drop actions on the objects as shown in Figure 7.2, “Fwbuilder’s Main Window” [page 160]. A few contextual menus can change the condition (negating it, for instance). Then the action needs to be chosen and configured.

As far as IPv6 is concerned, you can either create two distinct rulesets for IPv4 and IPv6, or create only one and let `fwbuilder` translate the rules according to the addresses assigned to the objects.

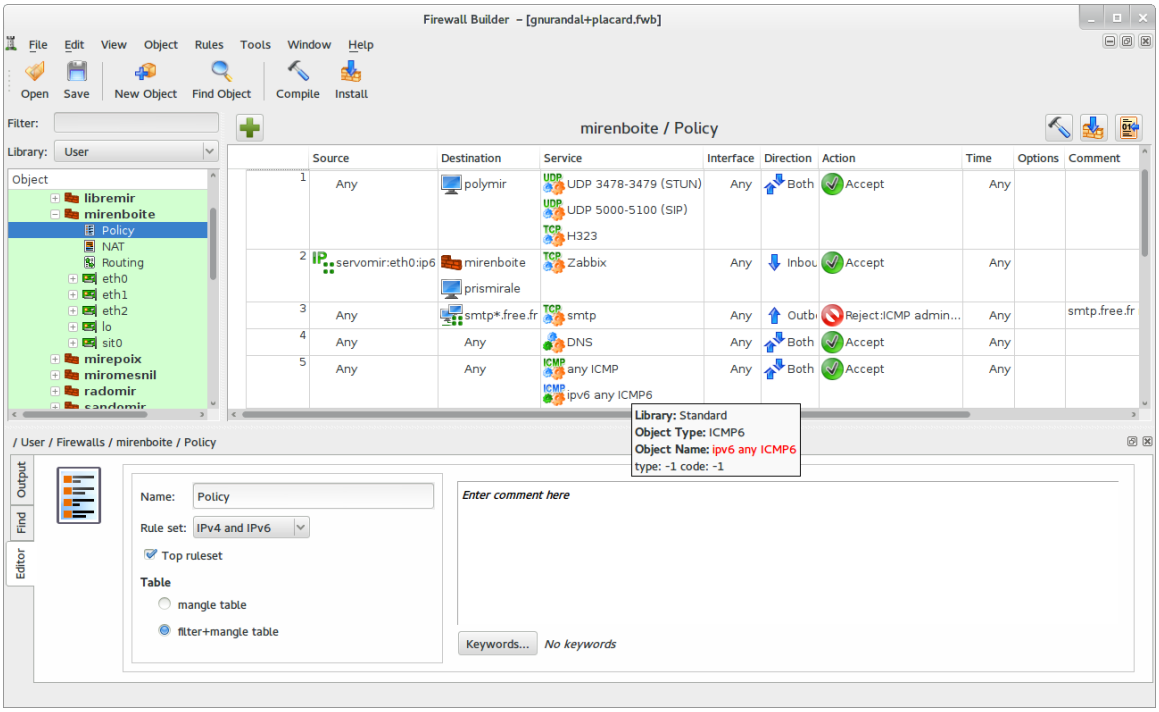


Figure 7.2 *Fwbuilder's Main Window*

`fwbuilder` will generate a script configuring the firewall according to the rules that you have defined. Its modular architecture gives it the ability to generate scripts targeting different systems including `iptables` for Linux, `ipf` for FreeBSD, and `pf` for OpenBSD.

7.4.4. Installing the Rules at Each Boot

In order to implement the firewall rules each time the machine is booted, you will need to register the configuration script in an `up` directive of the `/etc/network/interfaces` file. In the following example, the script is stored under `/usr/local/etc/arrakis.fw`.

```
auto eth0
iface eth0 inet static
    address 192.168.0.1
    network 192.168.0.0
    netmask 255.255.255.0
    broadcast 192.168.0.255
    up /usr/local/etc/arrakis.fw
```

This example assumes that you are using *ifupdown* to configure the network interfaces. If you are using something else (like *NetworkManager* or *systemd-networkd*), then refer to their respective documentation to find out ways to execute a script after the interface has been brought up.

7.5. Monitoring and Logging

Data confidentiality and protection is an important aspect of security but it is equally important to ensure availability of services. As an administrator and security practitioner, you must ensure that everything works as expected, and it is your responsibility to detect anomalous behavior and service degradation in a timely manner. Monitoring and logging software plays a key role in this aspect of security, providing insight into what is happening on the system and the network.

In this section, we will review some tools that can be used to monitor several aspects of a Kali system.

7.5.1. Monitoring Logs with `logcheck`

The `logcheck` program monitors log files every hour by default and sends unusual log messages in emails to the administrator for further analysis.

The list of monitored files is stored in `/etc/logcheck/logcheck.logfiles`. The default values work fine if the `/etc/rsyslog.conf` file has not been completely overhauled.

`logcheck` can report in various levels of detail: *paranoid*, *server*, and *workstation*. *paranoid* is *very* verbose and should probably be restricted to specific servers such as firewalls. *server* is the default mode and is recommended for most servers. *workstation* is obviously designed for workstations and is extremely terse, filtering out more messages than the other options.

In all three cases, `logcheck` should probably be customized to exclude some extra messages (depending on installed services), unless you really want to receive hourly batches of long uninteresting emails. Since the message selection mechanism is rather complex, `/usr/share/doc/logcheck-database/README.logcheck-database.gz` is a required—if challenging—read.

The applied rules can be split into several types:

- those that qualify a message as a cracking attempt (stored in a file in the `/etc/logcheck/cracking.d/` directory);
- ignored cracking attempts (`/etc/logcheck/cracking.ignore.d/`);
- those classifying a message as a security alert (`/etc/logcheck/violations.d/`);
- ignored security alerts (`/etc/logcheck/violations.ignore.d/`);
- finally, those applying to the remaining messages (considered as *system events*).

ignore.d files are used to (obviously) ignore messages. For example, a message tagged as a cracking attempt or a security alert (following a rule stored in a `/etc/logcheck/violations.d/myfile` file) can only be ignored by a rule in a `/etc/logcheck/violations.ignore.d/myfile` or `/etc/logcheck/violations.ignore.d/myfile-`*`extension`* file.

A system event is always signaled unless a rule in one of the `/etc/logcheck/ignore.d.{paranoid,server,workstation}/` directories states the event should be ignored. Of course, the only directories taken into account are those corresponding to verbosity levels equal or greater than the selected operation mode.

7.5.2. Monitoring Activity in Real Time

`top` is an interactive tool that displays a list of currently running processes. The default sorting is based on the current amount of processor use and can be obtained with the P key. Other sort orders include a sort by occupied memory (M key), by total processor time (T key), and by process identifier (N key). The k key kills a process by entering its process identifier. The r key changes the priority of a process.

When the system seems to be overloaded, `top` is a great tool to see which processes are competing for processor time or consuming too much memory. In particular, it is often interesting to check if the processes consuming resources match the real services that the machine is known to host. An unknown process running as the "www-data" user should really stand out and be investigated since it's probably an instance of software installed and executed on the system through a vulnerability in a web application.

`top` is a very flexible tool and its manual page gives details on how to customize its display and adapt it to your personal needs and habits.

The `gnome-system-monitor` graphical tool is similar to `top` and it provides roughly the same features.

7.5.3. Detecting Changes

Once a system is installed and configured, most system files should stay relatively static until the system is upgraded. Therefore, it is a good idea to monitor changes in system files since any unexpected change could be cause for alarm and should be investigated. This section presents a few of the most common tools used to monitor system files, detect changes, and optionally notify you as the administrator of the system.

Auditing Packages with `dpkg --verify`

`dpkg --verify` (or `dpkg -V`) is an interesting tool since it displays the system files that have been modified (potentially by an attacker), but this output should be taken with a grain of salt. To

do its job, `dpkg` relies on checksums stored in its own database which is stored on the hard disk (found in `/var/lib/dpkg/info/`*`package`*`.md5sums`). A thorough attacker will therefore modify these files so they contain the new checksums for the subverted files, or an advanced attacker will compromise the package on your Debian mirror. To protect against this class of attack, use APT's digital signature verification system (see section 8.3.6, "Validating Package Authenticity" [page 202]) to properly verify the packages.

What Is a File Fingerprint?

As a reminder: a fingerprint is a value, often a number (although in hexadecimal notation), that contains a kind of signature for the contents of a file. This signature is calculated with an algorithm (MD5 or SHA1 being well-known examples) that more or less guarantees that even the tiniest change in the file contents will result in a change of the fingerprint; this is known as the "avalanche effect". A simple numerical fingerprint then serves as a litmus test to check whether the contents of a file have been altered. These algorithms are not reversible; in other words, for most of them, knowing a fingerprint doesn't allow finding the corresponding contents. Recent mathematical advances seem to weaken the absoluteness of these principles but their use is not called into question so far, since creating different contents yielding the same fingerprint still seems to be quite a difficult task.

Running `dpkg -V` will verify all installed packages and will print out a line for each file that fails verification. Each character denotes a test on some specific meta-data. Unfortunately, `dpkg` does not store the meta-data needed for most tests and will thus output question marks for them. Currently only the checksum test can yield a 5 on the third character (when it fails).

```
# dpkg -V
??5??????   /lib/systemd/system/ssh.service
??5?????? c /etc/libvirt/qemu/networks/default.xml
??5?????? c /etc/lvm/lvm.conf
??5?????? c /etc/salt/roster
```

In the example above, dpkg reports a change to SSH's service file that the administrator made to the packaged file instead of using an appropriate `/etc/systemd/system/ssh.service` override (which would be stored below `/etc` like any configuration change should be). It also lists multiple configuration files (identified by the "c" letter on the second field) that had been legitimately modified.

Monitoring Files: AIDE

The Advanced Intrusion Detection Environment (AIDE) tool checks file integrity and detects any change against a previously-recorded image of the valid system. The image is stored as a database (`/var/lib/aide/aide.db`) containing the relevant information on all files of the system (fingerprints, permissions, timestamps, and so on).

You can install AIDE by running `apt update` followed by `apt install aide`. You will first initialize the database with `aideinit`; it will then run daily (via the `/etc/cron.daily/aide` script) to

check that nothing relevant changed. When changes are detected, AIDE records them in log files (`/var/log/aide/*.log`) and sends its findings to the administrator by email.

Protecting the Database

Since AIDE uses a local database to compare the states of the files, the validity of its results is directly linked to the validity of the database. If an attacker gets root permissions on a compromised system, they will be able to replace the database and cover their tracks. One way to prevent this subversion is to store the reference data on read-only storage media.

You can use options in `/etc/default/aide` to tweak the behavior of the *aide* package. The AIDE configuration proper is stored in `/etc/aide/aide.conf` and `/etc/aide/aide.conf.d/` (actually, these files are only used by `update-aide.conf` to generate `/var/lib/aide/aide.conf.autogenerated`). The configuration indicates which properties of which files need to be checked. For instance, the contents of log files changes routinely, and such changes can be ignored as long as the permissions of these files stay the same, but both contents and permissions of executable programs must be constant. Although not very complex, the configuration syntax is not fully intuitive and we recommend reading the `aide.conf(5)` manual page for more details.

A new version of the database is generated daily in `/var/lib/aide/aide.db.new`; if all recorded changes were legitimate, it can be used to replace the reference database.

Tripwire is very similar to AIDE; even the configuration file syntax is almost the same. The main addition provided by *tripwire* is a mechanism to sign the configuration file so that an attacker cannot make it point at a different version of the reference database.

Samhain also offers similar features as well as some functions to help detect rootkits (see the sidebar "The *checksecurity* and *chkrootkit*/*rkhunter* packages" [page 164]). It can also be deployed globally on a network and record its traces on a central server (with a signature).

The *checksecurity* and *chkrootkit*/*rkhunter* packages

checksecurity consists of several small scripts that perform basic checks on the system (searching for empty passwords, new setuid files, and so on) and warn you if these conditions are detected. Despite its explicit name, you should not rely solely on it to make sure a Linux system is secure.

The *chkrootkit* and *rkhunter* packages detect certain *rootkits* potentially installed on the system. As a reminder, these are pieces of software designed to hide the compromise of a system while discreetly keeping control of the machine. The tests are not 100 percent reliable but they can usually draw your attention to potential problems.

7.6. Summary

In this chapter, we took a look at the concept of security policies, highlighting various points to consider when defining such a policy and outlining some of the threats to your system and to you personally as a security professional. We discussed laptop and desktop security measures as well

as firewalls and packet filtering. Finally, we reviewed monitoring tools and strategies and showed how to best implement them to detect potential threats to your system.

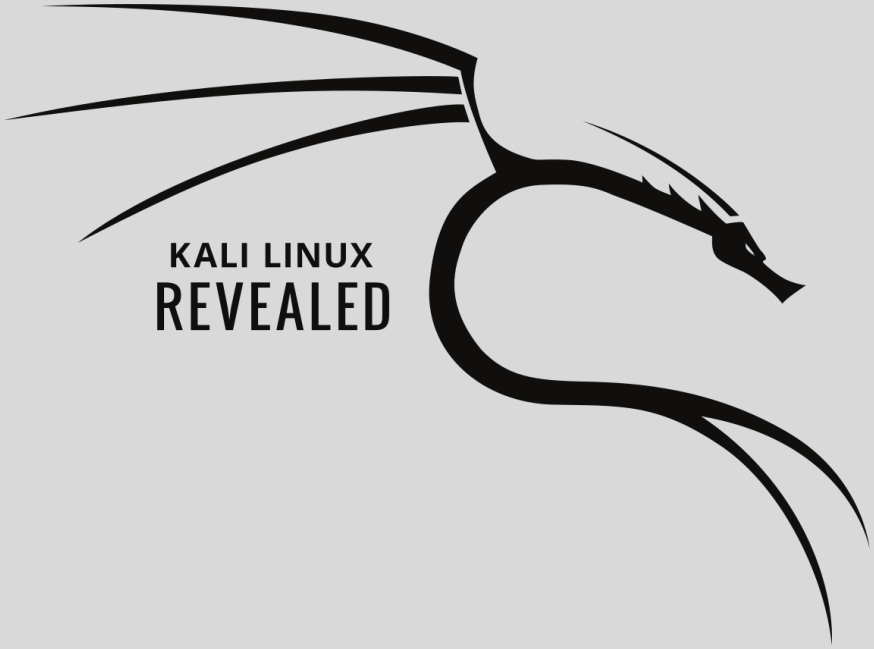
Summary Tips:

- Take time to define a comprehensive security policy.
- If you are running Kali on a publicly accessible server, change any default passwords for services that might be configured (see section 7.3, "Securing Network Services" [page 153]) and restrict their access with a firewall (see section 7.4, "Firewall or Packet Filtering" [page 153]) prior to launching them.
- Use *fail2ban* to detect and block password-guessing attacks and remote brute force password attacks.
- If you run web services, host them over HTTPS to prevent network intermediaries from sniffing your traffic (which might include authentication cookies).
- Real risk often arises when you travel from one customer to the next. For example, your laptop could be stolen while traveling or seized by customs. Prepare for these unfortunate possibilities by using full disk encryption (see section 4.2.2, "Installation on a Fully Encrypted File System" [page 85]) and consider the nuke feature (see "Adding a Nuke Password for Extra Safety" [page 245]) to protect your clients data.
- Implement firewall rules (see section 7.4, "Firewall or Packet Filtering" [page 153]) to forbid all outbound traffic except the traffic generated by your VPN access. This is meant as a safety net, so that when the VPN is down you immediately notice it (instead of falling back to the local network access).
- Disable services that you do not use. Kali makes it easy to do this since all external network services are disabled by default.
- The Linux kernel embeds the *netfilter* firewall. There is no turn-key solution for configuring any firewall, since network and user requirements differ. However, you can control *netfilter* from user space with the `iptables` and `ip6tables` commands.
- The `logcheck` program monitors log files every hour by default and sends unusual log messages in emails to the administrator for further analysis.
- `top` is an interactive tool that displays a list of currently running processes.
- `dpkg --verify` (or `dpkg -V`) displays the system files that have been modified (potentially by an attacker), but relies on checksums, which may be subverted by a clever attacker.
- The Advanced Intrusion Detection Environment (AIDE) tool checks file integrity and detects any changes against a previously-recorded image of the valid system.
- Tripwire is very similar to AIDE but uses a mechanism to sign the configuration file, so that an attacker cannot make it point at a different version of the reference database.
- Consider the use of `rkhunter`, `checksecurity`, and `chkrootkit` to help detect rootkits on your system.

In the next chapter, we are going to dig into Debian fundamentals and package management. You will quickly understand the power behind Kali's Debian roots and learn how the developers have harnessed that power. Be warned, the next chapter is fairly dense, but it is critical that you understand Debian basics and package management if you are going to be a Kali power user.

Keywords

dpkg
apt
sources.list
Upgrades
Package repositories



Chapter

8

Debian Package Management

Contents

After the basics of Linux, it is time to learn the package management system of a Debian-based distribution. In such distributions, including Kali, the Debian package is the canonical way to make software available to end-users. Understanding the package management system will give you a great deal of insight into how Kali is structured, enable you to more effectively troubleshoot issues, and help you quickly locate help and documentation for the wide array of tools and utilities included in Kali Linux.

In this chapter, we will introduce the Debian package management system and introduce `dpkg` and the APT suite of tools. One of the primary strengths of Kali Linux lies in the flexibility of its package management system, which leverages these tools to provide near-seamless installation, upgrades, removal, and manipulation of application software, and even of the base operating system itself. It is critical that you understand how this system works to get the most out of Kali and streamline your efforts. The days of painful compilations, disastrous upgrades, debugging `gcc`, `make`, and `configure` problems are long gone, however, the number of available applications has exploded and you need to understand the tools designed to take advantage of them. This is also a critical skill because there are a number of security tools that, due to licensing or other issues, cannot be included in Kali but have Debian packages available for download. It is important that you know how to process and install these packages and how they impact the system, especially when things do not go as expected.

We will begin with some basic overviews of APT, describe the structure and contents of binary and source packages, take a look at some basic tools and scenarios, and then dig deeper to help you wring every ounce of utility from this spectacular package system and suite of tools.

8.1. Introduction to APT

Let's begin with some basic definitions, an overview, and some history about Debian packages, starting with `dpkg` and APT.

8.1.1. Relationship between APT and `dpkg`

A Debian package is a compressed archive of a software application. A *binary package* (a `.deb` file) contains files that can be directly used (such as programs or documentation), while a *source package* contains the source code for the software and the instructions required for building a binary package. A Debian package contains the application's files as well as other *metadata* including the names of the dependencies the application needs, as well as scripts that enable the execution of commands at different stages in the package's lifecycle (installation, removal, and upgrades).

The `dpkg` tool was designed to process and install `.deb` packages, but if it encountered an unsatisfied dependency (like a missing library) that would prevent the package from installing, `dpkg` would simply list the missing dependency, because it had no awareness or built-in logic to find or process the packages that might satisfy those dependencies. The Advanced Package Tool (APT),

including `apt` and `apt-get`, were designed to address these shortcomings and could automatically resolve these issues. We will talk about both `dpkg` and the APT tools in this chapter.

The base command for handling Debian packages on the system is `dpkg`, which performs installation or analysis of `.deb` packages and their contents. However, `dpkg` has only a partial view of the Debian universe: it knows what is installed on the system and whatever you provide on the command line, but knows nothing of the other available packages. As such, it will fail if a dependency is not met. APT addresses the limitations.

APT is a set of tools that help manage Debian packages, or applications on your Debian system. You can use APT to install and remove applications, update packages, and even upgrade your entire system. The magic of APT lies in the fact that it is a complete package management system that will not only install or remove a package, but will consider the requirements and dependencies of the packaged application (and even their requirements and dependencies) and attempt to satisfy them automatically. APT relies on `dpkg` but APT differs from `dpkg`, as the former installs the latest package from an online source and works to resolve dependencies while `dpkg` installs a package located on your local system and does not automatically resolve dependencies.

If you have been around long enough to remember compiling programs with `gcc` (even with the help of utilities such as `make` and `configure`), you likely remember that it was a painful process, especially if the application had several dependencies. By deciphering the various warnings and error messages, you may be able to determine which part of the code was failing and most often that failure was due to a missing library or other dependency. You would then track down that missing library or dependency, correct it, and try again. Then, if you were lucky, the compile would complete, but often the build would fail again, complaining about another broken dependency.

APT was designed to help alleviate that problem, collate program requirements and dependencies, and resolve them. This functionality works out-of-the-box on Kali Linux, but it isn't foolproof. It is important that you understand how Debian and Kali's packaging system works because you will need to install packages, update software, or troubleshoot problems with packages. You will use APT in your day-to-day work with Kali Linux and in this chapter, we will introduce you to APT and show you how to install, remove, upgrade, and manage packages, and even show you how to move packages between different Linux distributions. We will also talk about graphical tools that leverage APT, show you how to validate the authenticity of packages, and delve into the concept of a rolling distribution, a technique that brings daily updates to your Kali system.

Before we dig in and show you how to use `dpkg` and APT to install and manage packages, it is important that we delve into some of the inner workings of APT and discuss some terminology surrounding it.

Package Source and Source Package

The word *source* can be ambiguous. A source package—a package containing the source code of a program—should not be confused with a package source—a repository (website, FTP server, CD-ROM, local directory, etc.) that contains packages.

APT retrieves its packages from a repository, a package storage system or simply, "package source". The `/etc/apt/sources.list` file lists the different repositories (or sources) that publish Debian packages.

8.1.2. Understanding the `sources.list` File

The `sources.list` file is the key configuration file for defining package sources, and it is important to understand how it is laid out and how to configure it since APT will not function without a properly defined list of package sources. Let's discuss its syntax, take a look at the various repositories that are used by Kali Linux, and discuss mirrors and mirror redirection, then you will be ready to put APT to use.

Each active line of the `/etc/apt/sources.list` file (and of the `/etc/apt/sources.list.d/*.list` files) contains the description of a source, made of three parts separated by spaces. Commented lines begin with a # character:

```
# deb cdrom:[Debian GNU/Linux 2016.1 _Kali-rolling_ - Official Snapshot amd64 LIVE/
    ➥ INSTALL Binary 20160830-11:29]/ kali-rolling contrib main non-free

deb http://http.kali.org/kali kali-rolling main non-free contrib
```

Let's take a look at the syntax of this file. The first field indicates the source type:

- deb for binary packages,
- deb-src for source packages.

The second field gives the base URL of the source: this can consist of a Debian mirror or any other package archive set up by a third party. The URL can start with file:// to indicate a local source installed in the system's file hierarchy, with http:// to indicate a source accessible from a web server, or with ftp:// for a source available on an FTP server. The URL can also start with cdrom: for CD-ROM/DVD-ROM/Blu-ray disc-based installations, although this is less frequent since network-based installation methods are more and more common.

The cdrom entries describe the CD/DVD-ROMs you have. Contrary to other entries, a CD-ROM is not always available, since it has to be inserted into the drive and usually only one disc can be read at a time. For those reasons, these sources are managed in a slightly different way and need to be added with the `apt-cdrom` program, usually executed with the add parameter. The latter will then request the disc to be inserted in the drive and will browse its contents looking for `Packages` files. It will use these files to update its database of available packages (this operation is usually done by the `apt update` command). After that, APT will request the disc if it needs a package stored on it.

The syntax of the last field depends on the structure of the repository. In the simplest cases, you can simply indicate a subdirectory (with a required trailing slash) of the desired source (this is often a simple "`./`", which refers to the absence of a subdirectory—the packages are then directly

at the specified URL). But in the most common case, the repositories will be structured like a Debian mirror, with multiple distributions each having multiple components. In those cases, name the chosen distribution, then the components (or sections) to enable. Let's take a moment to introduce these sections.

Debian and Kali use three sections to differentiate packages according to the licenses chosen by the authors of each work.

Main contains all packages that fully comply with the Debian Free Software Guidelines[1].

The non-free archive is different because it contains software that does not (entirely) conform to these principles but which can nevertheless be distributed without restrictions.

Contrib (contributions) is a set of open source software that cannot function without some non-free elements. These elements may include software from the non-free section or non-free files such as game ROMs, BIOS of consoles, etc. Contrib also includes free software whose compilation requires proprietary elements, such as VirtualBox, which requires a non-free compiler to build some of its files.

Now, let's take a look at the standard Kali Linux package sources, or repositories.

8.1.3. Kali Repositories

A standard `sources.list` file for a system running Kali Linux refers to one repository (kali-rolling) and the three previously mentioned components: main, contrib, and non-free:

```
# Main Kali repository
deb http://http.kali.org/kali kali-rolling main contrib non-free
```

Let's take a look at the various Kali repositories.

The Kali-Rolling Repository

This is the main repository for end-users. It should always contain installable and recent packages. It is managed by a tool that merges Debian Testing and the Kali-specific packages in a way that ensures that each package's dependencies can be satisfied within kali-rolling. In other words, barring any bug in maintainer scripts, all packages should be installable.

Since Debian Testing evolves daily, so does Kali Rolling. The Kali-specific packages are also regularly updated as we monitor the upstream releases of the most important packages.

[1] `https://www.debian.org/social_contract#guidelines`

The Kali-Dev Repository

This repository is not for public use. It is a space where Kali developers resolve dependency problems arising from the merge of the Kali-specific packages into Debian Testing.

It is also the place where updated packages land first, so if you need an update that was released recently and that has not yet reached kali-rolling, you might be able to grab it from this repository. This is not recommended for regular users.

The Kali-Bleeding-Edge Repository

This repository contains packages automatically built out of the upstream Git (or Subversion) repository. The upside is that you immediately have access to the latest features and bug fixes less than 24 hours after they have been committed. This is an ideal way to verify if a bug that you reported upstream has been fixed.

The downside is that these packages have not been tested or vetted: if the upstream changes impacted the packaging (adding a new dependency), then that package might not work. Because of this, the repository is marked in such a way that APT does not automatically install packages from it, particularly during an upgrade.

You can register the repository either by editing `/etc/apt/sources.list` or by creating a new file under the `/etc/apt/sources.list.d` directory, which has the benefit of leaving the original system `sources.list` file un-altered. In this example, we opt to create a separate `/etc/apt/sources.list.d/kali-bleeding-edge.list` file like this:

```
# Kali Bleeding Edge repository
deb http://http.kali.org/kali kali-bleeding-edge main contrib non-free
```

The Kali Linux Mirrors

The `sources.list` extracts above refer to http.kali.org: this is a server running MirrorBrain[2], which will redirect your HTTP requests to an official mirror close to you. MirrorBrain monitors each mirror to ensure that they are working and up-to-date; it will always redirect you to a good mirror.

Debugging a Mirror Redirection

If you have a problem with the mirror (for instance because `apt update` fails), you can use `curl -sI` to see where you are being redirected:

```
$ curl -sI http://http.kali.org/README
HTTP/1.1 302 Found
Date: Mon, 11 Apr 2016 09:43:21 GMT
```

[2] `http://mirrorbrain.org`

```
Server: Apache/2.4.10 (Debian)
X-MirrorBrain-Mirror: ftp.free.fr
X-MirrorBrain-Realm: country
Link: <http://http.kali.org/README.meta4>; rel=describedby;
    ➥ type="application/metalink4+xml"
Link: <http://ftp.free.fr/pub/kali/README>; rel=duplicate;
    ➥ pri=1; geo=fr
Link: <http://de-rien.fr/kali/README>; rel=duplicate; pri=2;
    ➥ geo=fr
Link: <http://ftp.halifax.rwth-aachen.de/kali/README>; rel=
    ➥ duplicate; pri=3; geo=de
Link: <http://ftp.belnet.be/kali/kali/README>; rel=duplicate;
    ➥  pri=4; geo=be
Link: <http://ftp2.nluug.nl/os/Linux/distr/kali/README>; rel=
    ➥ duplicate; pri=5; geo=nl
Location: http://ftp.free.fr/pub/kali/README
Content-Type: text/html; charset=iso-8859-1
```

If the problem persists, you can edit `/etc/apt/sources.list` and hardcode the name of another known working mirror in place of (or before) the `http.kali.org` entry.

We also have a second MirrorBrain instance: where http.kali.org hosts the package repositories, cdimage.kali.org hosts the released ISO images.

➨ `http://cdimage.kali.org`

If you want to request a list of official Kali Linux Mirrors, you can add .mirrorlist to any valid URL pointing to http.kali.org or cdimage.kali.org.

➨ `http://http.kali.org/README.mirrorlist`

➨ `http://cdimage.kali.org/README.mirrorlist`

These lists are not exhaustive due to some MirrorBrain limitations (most notably mirrors restricted to some countries do not appear in the list unless you are in the given country). But they contain the best mirrors: they are well maintained and have large amounts of bandwidth available.

8.2. Basic Package Interaction

Armed with a basic understanding of the APT landscape, let's take a look at some basic package interactions including the initialization of APT; installation, removal, and purging of packages; and upgrading of the Kali Linux system. Then let's venture from the command line to take a look at some graphical APT tools.

8.2.1. Initializing APT

APT is a vast project and tool set, whose original plans included a graphical interface. From a client perspective, it is centered around the command-line tool `apt-get` as well as `apt`, which was later developed to overcome design flaws of `apt-get`.

There are graphical alternatives developed by third parties, including `synaptic` and `aptitude`, which we will discuss later. We tend to prefer `apt`, which we use in the examples that follow. We will, however, detail some of the major syntax differences between tools, as they arise.

When working with APT, you should first download the list of currently available packages with `apt update`. Depending on the speed of your connection, this can take some time because various packages' list, sources' list and translation files have grown in size alongside Debian development. Of course, CD/DVD installation sets install much more quickly, because they are local to your machine.

8.2.2. Installing Packages

Thanks to the thoughtful design of the Debian package system, you can install packages, with or without their dependencies, fairly easily. Let's take a look at package installation with `dpkg` and `apt`.

Installing Packages with dpkg

`dpkg` is the core tool that you will use (either directly or indirectly through APT) when you need to install a package. It is also a go-to choice if you are operating offline, since it doesn't require an Internet connection. Remember, `dpkg` will not install any dependencies that the package might require. To install a package with `dpkg`, simply provide the -i or --install option and the path to the `.deb`. This implies that you have previously downloaded (or obtained in some other way) the `.deb` file of the package to install.

```
# dpkg -i man-db_2.7.0.2-5_amd64.deb
(Reading database ... 86425 files and directories currently installed.)
Preparing to unpack man-db_2.7.0.2-5_amd64.deb ...
Unpacking man-db (2.7.0.2-5) over (2.7.0.2-4) ...
Setting up man-db (2.7.0.2-5) ...
Updating database of manual pages ...
Processing triggers for mime-support (3.58) ...
```

We can see the different steps performed by `dpkg` and can see at what point any error may have occurred. The -i or --install option performs two steps automatically: it unpacks the package and runs the configuration scripts. You can perform these two steps independently (as apt does behind the scenes) with the --unpack and --configure options, respectively:

```
# dpkg --unpack man-db_2.7.0.2-5_amd64.deb
(Reading database ... 86425 files and directories currently installed.)
Preparing to unpack man-db_2.7.0.2-5_amd64.deb ...
Unpacking man-db (2.7.0.2-5) over (2.7.0.2-5) ...
Processing triggers for mime-support (3.58) ...
# dpkg --configure man-db
Setting up man-db (2.7.0.2-5) ...
Updating database of manual pages ...
```

Note that the "Processing triggers" lines refer to code that is automatically executed whenever a package adds, removes, or modifies files in some monitored directories. For instance, the *mime-support* package monitors `/usr/lib/mime/packages` and executes the `update-mime` command whenever something changes in that directory (like `/usr/lib/mime/packages/man-db` in the specific case of man-db).

Sometimes `dpkg` will fail to install a package and return an error. However, you can order `dpkg` to ignore this and only issue a warning with various --force-* options. Issuing the `dpkg --force-help` command will display a complete list of these options. For example, you can use `dpkg` to forcibly install `zsh`:

```
$ dpkg -i --force-overwrite zsh_5.2-5+b1_amd64.deb
```

A frequent error, which you are bound to encounter sooner or later, is a file collision. When a package contains a file that is already installed by another package, `dpkg` will refuse to install it. The following types of messages will then appear:

```
Unpacking libgdm (from .../libgdm_3.8.3-2_amd64.deb) ...
dpkg: error processing /var/cache/apt/archives/libgdm_3.8.3-2_amd64.deb (--unpack):
    ➥ trying to overwrite '/usr/bin/gdmflexiserver', which is also in package gdm3
    ➥ 3.4.1-9
```

In this case, if you think that replacing this file is not a significant risk to the stability of your system (which is usually the case), you can use --force-overwrite to overwrite the file.

While there are many available --force-* options, only --force-overwrite is likely to be used regularly. These options exist for exceptional situations, and it is better to leave them alone as much as possible in order to respect the rules imposed by the packaging mechanism. Do not forget, these rules ensure the consistency and stability of your system.

Installing Packages with APT

Although APT is much more advanced than `dpkg` and does a lot more behind the scenes, you will find that interacting with packages is quite simple. You can add a package to the system with a simple `apt install` *`package`*. APT will automatically install the necessary dependencies:

```
# apt install kali-linux-gpu
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  oclgausscrack oclhashcat
The following NEW packages will be installed:
  kali-linux-gpu oclgausscrack oclhashcat
0 upgraded, 3 newly installed, 0 to remove and 416 not upgraded.
Need to get 2,494 kB of archives.
After this operation, 51.5 MB of additional disk space will be used.
Do you want to continue? [Y/n]
Get:1 http://archive-2.kali.org/kali kali-rolling/non-free amd64 oclhashcat amd64 2.01+
    ➥ git20160114-0kali2 [2,451 kB]
Get:2 http://archive-2.kali.org/kali kali-rolling/main amd64 oclgausscrack amd64 1.3-1
    ➥ kali2 [37.2 kB]
Get:3 http://archive-2.kali.org/kali kali-rolling/main amd64 kali-linux-gpu amd64
    ➥ 2016.3.2 [6,412 B]
Fetched 2,494 kB in 0s (3,060 kB/s)
Selecting previously unselected package oclhashcat.
(Reading database ... 317084 files and directories currently installed.)
Preparing to unpack .../0-oclhashcat_2.01+git20160114-0kali2_amd64.deb ...
Unpacking oclhashcat (2.01+git20160114-0kali2) ...
Selecting previously unselected package oclgausscrack.
Preparing to unpack .../1-oclgausscrack_1.3-1kali2_amd64.deb ...
Unpacking oclgausscrack (1.3-1kali2) ...
Selecting previously unselected package kali-linux-gpu.
Preparing to unpack .../2-kali-linux-gpu_2016.3.2_amd64.deb ...
Unpacking kali-linux-gpu (2016.3.2) ...
Setting up oclhashcat (2.01+git20160114-0kali2) ...
Setting up oclgausscrack (1.3-1kali2) ...
Setting up kali-linux-gpu (2016.3.2) ...
```

You can also use `apt-get install` *`package`*, or `aptitude install` *`package`*. For simple package installation, they do essentially the same thing. As you will see later, the differences are more meaningful for upgrades or when dependencies resolution do not have any perfect solution.

If `sources.list` lists several distributions, you can specify the package version with `apt install` *`package=version`*, but indicating its distribution of origin (kali-rolling, kali-dev, or kali-bleeding-edge) with `apt install` *`package/distribution`* is usually preferred.

As with `dpkg`, you can also instruct `apt` to forcibly install a package and overwrite files with --force-overwrite, but the syntax is a bit strange since you are passing the argument through to `dpkg`:

```
# apt -o Dpkg::Options::="--force-overwrite" install zsh
```

8.2.3. Upgrading Kali Linux

As a rolling distribution, Kali Linux has spectacular upgrade capabilities. In this section, we will take a look at how simple it is to upgrade Kali, and we will discuss strategies for planning your updates.

We recommend regular upgrades, because they will install the latest security updates. To upgrade, use `apt update` followed by either `apt upgrade`, `apt-get upgrade`, or `aptitude safe-upgrade`. These commands look for installed packages that can be upgraded without removing any packages. In other words, the goal is to ensure the least intrusive upgrade possible. The `apt-get` command line tool is slightly more demanding than `aptitude` or `apt` because it will refuse to install packages that were not installed beforehand.

The `apt` tool will generally select the most recent version number (except for packages from kali-bleeding-edge, which are ignored by default whatever their version number).

To tell `apt` to use a specific distribution when searching for upgraded packages, you need to use the -t or --target-release option, followed by the name of the distribution you want (for example: `apt -t kali-rolling upgrade`). To avoid specifying this option every time you use `apt`, you can add APT::Default-Release "kali-rolling"; in the file `/etc/apt/apt.conf.d/local`.

For more important upgrades, such as major version upgrades, use `apt full-upgrade`. With this instruction, `apt` will complete the upgrade even if it has to remove some obsolete packages or install new dependencies. This is also the command that you should use for regular upgrades of your Kali Rolling system. It is so simple that it hardly needs explanation: APT's reputation is based on this great functionality.

Unlike `apt` and `aptitude`, `apt-get` doesn't know the `full-upgrade` command. Instead, you should use `apt-get dist-upgrade` (distribution upgrade), a well-known command that `apt` and `aptitude` also accept for backwards compatibility.

Be Aware of Important Changes

To anticipate some of these problems, you can install the *apt-listchanges* package, which displays information about possible problems at the beginning of a package upgrade. This information is compiled by the package maintainers and put in `/usr/share/doc/`*`package`*`/NEWS.Debian` files for your benefit. Reading these files (possibly through *apt-listchanges*) should help you avoid nasty surprises.

Since becoming a rolling distribution, Kali can receive upgrades several times a day. However, that might not be the best strategy. So, how often should you upgrade Kali Linux? There is no hard rule but there are some guidelines that can help you. You should upgrade:

- When you are aware of a security issue that is fixed in an update
- When you suspect that an updated version might fix a bug that you are experiencing
- Before reporting a bug to make sure it is still present in the latest version that you have available

- Often enough to get the security fixes that you have not heard about

There are also cases where it is best to not upgrade. For example, it might not be a good idea to upgrade:

- If you can't afford any breakage (for example, because you go offline, or because you are about to give a presentation with your computer); it is best to do the upgrade later, when you have enough time to troubleshoot any issue introduced in the process.
- If a disruptive change happened recently (or is still ongoing) and you fear that all issues have not yet been discovered. For example, when a new GNOME version is released, not all packages are updated at the same time and you are likely to have a mix of packages with the old version and the new version. Most of the time this is fine and it helps everybody to release those updates progressively, but there are always exceptions and some applications might be broken due to such discrepancies.
- If the `apt full-upgrade` output tells you that it will remove packages that you consider important for your work. In those cases, you want to review the situation and try to understand why `apt` wants to remove them. Maybe the packages are currently broken and in this case you might want to wait until fixed versions are available, or they have been obsoleted and you should identify their replacements and then proceed with the full upgrade anyway.

In general, we recommend that you upgrade Kali at least once a week. You can certainly upgrade daily but it doesn't make sense to do it more often than that. Even if mirrors are synchronized four times a day, the updates coming from Debian usually land only once a day.

8.2.4. Removing and Purging Packages

Removing a package is even simpler than installing one. Let's take a look at how to remove a package with `dpkg` and `apt`.

To remove a package with `dpkg`, supply the -r or --remove option, followed by the name of a package. This removal is not, however, complete: all of the configuration files, maintainer scripts, log files (system logs), data generated by the daemon (such as the content of an LDAP server directory or the content of a database for an SQL server), and most other user data handled by the package remain intact. The remove option makes it easy to uninstall a program and later re-install it with the same configuration. Also remember that dependencies are not removed. Consider this example:

```
# dpkg --remove kali-linux-gpu
(Reading database ... 317681 files and directories currently installed.)
Removing kali-linux-gpu (2016.3.2) ...
```

You can also remove packages from the system with `apt remove` *`package`*. APT will automatically delete the packages that depend on the package that is being removed. Like the `dpkg` example, configuration files and user data will not be removed.

Through the addition of suffixes to package names, you can use `apt` (or `apt-get` and `aptitude`) to install certain packages and remove others on the same command line. With an `apt install` command, add "-" to the names of the packages you wish to remove. With an `apt remove` command, add "+" to the names of the packages you wish to install.

The next example shows two different ways to install *package1* and to remove *package2*.

```
# apt install package1 package2-
[...]
# apt remove package1+ package2
[...]
```

This can also be used to exclude packages that would otherwise be installed, for example due to a Recommends (discussed later). In general, the dependency solver will use that information as a hint to look for alternative solutions.

To remove all data associated with a package, you can purge the package with the `dpkg -P` *package*, or `apt purge` *package* commands. This will completely remove the package and all user data, and in the case of `apt`, will delete dependencies as well.

```
# dpkg -r debian-cd
(Reading database ... 97747 files and directories currently installed.)
Removing debian-cd (3.1.17) ...
# dpkg -P debian-cd
(Reading database ... 97401 files and directories currently installed.)
Removing debian-cd (3.1.17) ...
Purging configuration files for debian-cd (3.1.17) ...
```

Warning! Given the definitive nature of purge, do not execute it lightly. You will lose everything associated with that package.

8.2.5. Inspecting Packages

Next, let's take a look at some of the tools that can be used to inspect Debian packages. We will learn of `dpkg`, `apt`, and `apt-cache` commands that can be used to query and visualize the package database.

Querying dpkg's Database and Inspecting .deb Files

We will begin with several `dpkg` options that query the internal dpkg database. This database resides on the filesystem at `/var/lib/dpkg` and contains multiple sections including configuration scripts (`/var/lib/dpkg/info`), a list of files the package installed (`/var/lib/dpkg/info/*.list`), and the status of each package that has been installed (`/var/lib/dpkg/status`). You can use `dpkg` to interact with the files in this database. Note that most options are available in a long

version (one or more relevant words, preceded by a double dash) and a short version (a single letter, often the initial of one word from the long version, and preceded by a single dash). This convention is so common that it is a POSIX standard.

First, let's take a look at --listfiles *package* (or -L), which lists the files that were installed by the specified package:

```
$ dpkg -L base-passwd
/.
/usr
/usr/sbin
/usr/sbin/update-passwd
/usr/share
/usr/share/lintian
/usr/share/lintian/overrides
/usr/share/lintian/overrides/base-passwd
/usr/share/doc-base
/usr/share/doc-base/users-and-groups
/usr/share/base-passwd
/usr/share/base-passwd/group.master
/usr/share/base-passwd/passwd.master
/usr/share/man
/usr/share/man/pl
/usr/share/man/pl/man8
/usr/share/man/pl/man8/update-passwd.8.gz
[...]
/usr/share/doc
/usr/share/doc/base-passwd
/usr/share/doc/base-passwd/users-and-groups.txt.gz
/usr/share/doc/base-passwd/changelog.gz
/usr/share/doc/base-passwd/copyright
/usr/share/doc/base-passwd/README
/usr/share/doc/base-passwd/users-and-groups.html
```

Next, `dpkg --search` *`file`* (or -S), finds any packages containing the file or path passed in the argument. For example, to find the package containing `/bin/date`:

```
$ dpkg -S /bin/date
coreutils: /bin/date
```

The `dpkg --status` *`package`* (or -s) command displays the headers of an installed package. For example, to search the headers for the coreutils package:

```
$ dpkg -s coreutils
Package: coreutils
Essential: yes
Status: install ok installed
```

```
Priority: required
Section: utils
Installed-Size: 13855
Maintainer: Michael Stone <mstone@debian.org>
Architecture: amd64
Multi-Arch: foreign
Version: 8.23-3
Replaces: mktemp, realpath, timeout
Pre-Depends: libacl1 (>= 2.2.51-8), libattr1 (>= 1:2.4.46-8), libc6 (>= 2.17),
    ➥ libselinux1 (>= 2.1.13)
Conflicts: timeout
Description: GNU core utilities
This package contains the basic file, shell and text manipulation
utilities which are expected to exist on every operating system.
.
Specifically, this package includes:
arch base64 basename cat chcon chgrp chmod chown chroot cksum comm cp
csplit cut date dd df dir dircolors dirname du echo env expand expr
factor false flock fmt fold groups head hostid id install join link ln
logname ls md5sum mkdir mkfifo mknod mktemp mv nice nl nohup nproc numfmt
od paste pathchk pinky pr printenv printf ptx pwd readlink realpath rm
rmdir runcon sha*sum seq shred sleep sort split stat stty sum sync tac
tail tee test timeout touch tr true truncate tsort tty uname unexpand
uniq unlink users vdir wc who whoami yes
Homepage: http://gnu.org/software/coreutils
```

The `dpkg --list` (or -l) command displays the list of packages known to the system and their installation status. You can also use `grep` on the output to search for certain fields, or provide wildcards (such as b*) to search for packages that match a particular partial search string. This will show a summary of the packages. For example, to show a summary list of all packages that start with 'b':

```
$ dpkg -l 'b*'
Desired=Unknown/Install/Remove/Purge/Hold
| Status=Not/Inst/Conf-files/Unpacked/halF-conf/Half-inst/trig-aWait/Trig-pend
|/ Err?=(none)/Reinst-required (Status,Err: uppercase=bad)
||/ Name           Version      Architecture Description
+++-==============-============-============-=================================
ii  b43-fwcutter   1:019-3      amd64        utility for extracting Broadcom 4
ii  backdoor-facto 3.4.2-0kali1 all          Patch win32/64 binaries with shel
un  backupninja    <none>       <none>       (no description available)
un  backuppc       <none>       <none>       (no description available)
ii  baobab         3.22.1-1     amd64        GNOME disk usage analyzer
[...]
```

The `dpkg --contents file.deb` (or -c) command lists all the files in a particular `.deb` file:

```
$ dpkg -c /var/cache/apt/archives/gnupg_1.4.18-6_amd64.deb
drwxr-xr-x root/root         0 2014-12-04 23:03 ./
drwxr-xr-x root/root         0 2014-12-04 23:03 ./lib/
drwxr-xr-x root/root         0 2014-12-04 23:03 ./lib/udev/
drwxr-xr-x root/root         0 2014-12-04 23:03 ./lib/udev/rules.d/
-rw-r--r-- root/root      2711 2014-12-04 23:03 ./lib/udev/rules.d/60-gnupg.rules
drwxr-xr-x root/root         0 2014-12-04 23:03 ./usr/
drwxr-xr-x root/root         0 2014-12-04 23:03 ./usr/lib/
drwxr-xr-x root/root         0 2014-12-04 23:03 ./usr/lib/gnupg/
-rwxr-xr-x root/root     39328 2014-12-04 23:03 ./usr/lib/gnupg/gpgkeys_ldap
-rwxr-xr-x root/root     92872 2014-12-04 23:03 ./usr/lib/gnupg/gpgkeys_hkp
-rwxr-xr-x root/root     47576 2014-12-04 23:03 ./usr/lib/gnupg/gpgkeys_finger
-rwxr-xr-x root/root     84648 2014-12-04 23:03 ./usr/lib/gnupg/gpgkeys_curl
-rwxr-xr-x root/root      3499 2014-12-04 23:03 ./usr/lib/gnupg/gpgkeys_mailto
drwxr-xr-x root/root         0 2014-12-04 23:03 ./usr/bin/
-rwxr-xr-x root/root     60128 2014-12-04 23:03 ./usr/bin/gpgsplit
-rwxr-xr-x root/root   1012688 2014-12-04 23:03 ./usr/bin/gpg
[...]
```

The `dpkg --info file.deb` (or -I) command displays the headers of the specified `.deb` file:

```
$ dpkg -I /var/cache/apt/archives/gnupg_1.4.18-6_amd64.deb
 new debian package, version 2.0.
 size 1148362 bytes: control archive=3422 bytes.
    1264 bytes,    26 lines      control
    4521 bytes,    65 lines      md5sums
     479 bytes,    13 lines   *  postinst             #!/bin/sh
     473 bytes,    13 lines   *  preinst              #!/bin/sh
 Package: gnupg
 Version: 1.4.18-6
 Architecture: amd64
 Maintainer: Debian GnuPG-Maintainers <pkg-gnupg-maint@lists.alioth.debian.org>
 Installed-Size: 4888
 Depends: gpgv, libbz2-1.0, libc6 (>= 2.15), libreadline6 (>= 6.0), libusb-0.1-4 (>=
     ➥ 2:0.1.12), zlib1g (>= 1:1.1.4)
 Recommends: gnupg-curl, libldap-2.4-2 (>= 2.4.7)
 Suggests: gnupg-doc, libpcsclite1, parcimonie, xloadimage | imagemagick | eog
 Section: utils
 Priority: important
 Multi-Arch: foreign
 Homepage: http://www.gnupg.org
 Description: GNU privacy guard - a free PGP replacement
  GnuPG is GNU's tool for secure communication and data storage.
  It can be used to encrypt data and to create digital signatures.
  It includes an advanced key management facility and is compliant
```

```
  with the proposed OpenPGP Internet standard as described in RFC 4880.
[...]
```

You can also use `dpkg` to compare package version numbers with the `--compare-versions` option, which is often called by external programs, including configuration scripts executed by `dpkg` itself. This option requires three parameters: a version number, a comparison operator, and a second version number. The different possible operators are: `lt` (strictly less than), `le` (less than or equal to), `eq` (equal), `ne` (not equal), `ge` (greater than or equal to), and `gt` (strictly greater than). If the comparison is correct, `dpkg` returns 0 (success); if not, it gives a non-zero return value (indicating failure). Consider these comparisons:

```
$ dpkg --compare-versions 1.2-3 gt 1.1-4
$ echo $?
0
$ dpkg --compare-versions 1.2-3 lt 1.1-4
$ echo $?
1
$ dpkg --compare-versions 2.6.0pre3-1 lt 2.6.0-1
$ echo $?
1
```

Note the unexpected failure of the last comparison: for `dpkg`, the string "pre" (usually denoting a pre-release) has no particular meaning, and `dpkg` simply interprets it as a string, in which case "2.6.0pre3-1" is alphabetically greater than "2.6.0-1". When we want a package's version number to indicate that it is a pre-release, we use the tilde character, "~":

```
$ dpkg --compare-versions 2.6.0~pre3-1 lt 2.6.0-1
$ echo $?
0
```

Querying the Database of Available Packages with `apt-cache` and `apt`

The `apt-cache` command can display much of the information stored in APT's internal database. This information is a sort of cache since it is gathered from the different sources listed in the `sources.list` file. This happens during the `apt update` operation.

VOCABULARY

Cache

A cache is a temporary storage system used to speed up frequent data access when the usual access method is expensive (performance-wise). This concept can be applied in numerous situations and at different scales, from the core of microprocessors up to high-end storage systems.

In the case of APT, the reference `Packages` files are those located on Debian mirrors. That said, it would be very ineffective to push every search through the online package databases. That is why APT stores a copy of those files (in `/var/lib/apt/lists/`) and searches are done within those local files. Similarly, `/var/cache/apt/archives/` contains a cached copy of already downloaded packages to avoid downloading them again if you need to reinstall them.

To avoid excessive disk usage when you upgrade frequently, you should regularly sort through the `/var/cache/apt/archives/` directory. Two commands can be used for this: `apt clean` (or `apt-get clean`) entirely empties the directory; `apt autoclean` (`apt-get autoclean`) only removes packages that can no longer be downloaded because they have disappeared from the mirror and are therefore useless. Note that the configuration parameter `APT::Clean-Installed` can be used to prevent the removal of `.deb` files that are currently installed. Also, note that `apt` drops the downloaded files once they have been installed, so this matters mainly when you use other tools.

The `apt-cache` command can do keyword-based package searches with `apt-cache search` *`keyword`*. It can also display the headers of the package's available versions with `apt-cache show` *`package`*. This command provides the package's description, its dependencies, and the name of its maintainer. This feature is particularly useful in determining the packages that are installed via meta-packages, such as *kali-linux-wireless*, *kali-linux-web*, and *kali-linux-gpu*. Note that `apt search`, `apt show`, `aptitude search`, and `aptitude show` work in the same way.

An Alternative: `axi-cache`

`apt-cache search` is a very rudimentary tool, basically implementing `grep` on package's descriptions. It often returns too many results or none at all, when too many keywords are included.

`axi-cache search` *`term`*, on the other hand, provides better results, sorted by relevancy. It uses the *Xapian* search engine and is part of the *apt-xapian-index* package, which indexes all package information (and more, like the `.desktop` files from all Debian packages). It knows about tags and returns results in a matter of milliseconds.

```
$ axi-cache search forensics graphical
5 results found.
Results 1-5:
100% autopsy - graphical interface to SleuthKit
82% forensics-colorize - show differences between files using
    ➥  color graphics
73% dff - Powerful, efficient and modular digital forensic
    ➥ framework
53% gpart - Guess PC disk partition table, find lost
    ➥ partitions
46% testdisk - Partition scanner and disk recovery tool, and
    ➥ PhotoRec file recovery tool
```

```
More terms: colorize partitions file disklabel autopsy
    ➥ digital differences
More tags: admin::forensics security::forensics role::program
    ➥  admin::recovery interface::commandline admin::boot
    ➥ scope::utility
```

Some features are more rarely used. For instance, `apt-cache policy` displays the priorities of package sources as well as those of individual packages. Another example is `apt-cache dumpavail`, which displays the headers of all available versions of all packages. `apt-cache pkgnames` displays the list of all the packages that appear at least once in the cache.

8.2.6. Troubleshooting

Sooner or later, you will run into a problem when interacting with a package. In this section, we will outline some basic troubleshooting steps that you can take and provide some tools that will lead you closer to a potential solution.

Handling Problems after an Upgrade

In spite of the Kali/Debian maintainers' best efforts, a system upgrade isn't always as smooth as we would hope. New software versions may be incompatible with previous ones (for instance, their default behavior or their data format may have changed), or bugs may slip through the cracks despite the testing performed by package maintainers and Debian Unstable users.

Leveraging Bug Reports You might sometimes find that a new version of software doesn't work at all. This generally happens if the application isn't particularly popular and hasn't been tested enough. The first thing to do is to have a look at the Kali bug tracker[3] and at the Debian bug tracking system[4] at https://bugs.debian.org/*package* , and check whether the problem has already been reported. If it hasn't, you should report it yourself (see section 6.3, "Filing a Good Bug Report" [page 129] for detailed instructions). If it is already known, the bug report and the associated messages are usually an excellent source of information related to the bug. In some cases, a patch already exists and has been made available in the bug report itself; you can then recompile a fixed version of the broken package locally (see section 9.1, "Modifying Kali Packages" [page 222]). In other cases, users may have found a workaround for the problem and shared their insights about it in their replies to the report; those instructions may help you work around the problem until a fix or patch is released. In a best-case scenario, the package may have already been fixed and you may find details in the bug report.

[3] `http://bugs.kali.org`
[4] `https://bugs.debian.org`

Downgrading to a Working Version When the problem is a clear regression (where the former version worked), you can try to downgrade the package. In this case, you will need a copy of the old version. If you have access to the old version in one of the repositories configured in APT, you can use a simple one-liner command to downgrade (see section 8.2.2.2, "Installing Packages with APT" [page 177]). But with Kali's rolling release, you will usually only find a single version of each package at any one time.

You can still try to find the old `.deb` file and install it manually with `dpkg`. Old `.deb` files can be found in multiple places:

- in APT's cache in `/var/cache/apt/archives/`
- in the `pool` directory on your usual Kali mirror (removed and obsolete packages are kept for three to four days to avoid problems with users not having the latest package indices)
- in `http://snapshot.debian.org` if the affected package was provided by Debian and not by Kali; this service keeps historical versions of all Debian packages

Dealing with Broken Maintainer Scripts Sometimes the upgrade gets interrupted because one of the package maintainer scripts fails (usually, it is the `postinst`). In those cases, you can try to diagnose the problem, and possibly work around it, by editing the problematic script.

Here we rely on the fact that maintainer scripts are stored in `/var/lib/dpkg/info/` and that we can review and modify them.

Since maintainer scripts are usually simple shell scripts, it is possible to add a `set -x` line just after the shebang line and arrange them to be rerun (with `dpkg --configure -a` for `postinst`) to see precisely what is happening and where it is failing. This output can also nicely complement any bug report that you might file.

With this newly gained knowledge, you can either fix the underlying problem or transform the failing command into a working one (for example by adding `|| true` at the end of the line).

Note that this tip does not work for a failing `preinst` since that script is executed even before the package gets installed so it is not yet in its final location. It does work for `postrm` and `prerm` although you will need to execute a package removal (respectively upgrade) to trigger them.

The dpkg Log File

The `dpkg` tool keeps a log of all of its actions in `/var/log/dpkg.log`. This log is extremely verbose, since it details all the stages of each package. In addition to offering a way to track dpkg's behavior, it helps to keep a history of the development of the system: you can find the exact moment when each package has been installed or updated, and this information can be extremely useful in understanding a recent change in behavior. Additionally, with all versions being recorded, it is easy to cross-check the information with the `changelog.Debian.gz` for packages in question, or even with online bug reports.

```
# tail /var/log/dpkg.log
2016-12-22 09:04:05 status installed kali-linux-gpu:amd64 2016.3.2
2016-12-22 09:20:07 startup packages remove
2016-12-22 09:20:07 status installed kali-linux-gpu:amd64 2016.3.2
2016-12-22 09:20:07 remove kali-linux-gpu:amd64 2016.3.2 <none>
2016-12-22 09:20:07 status half-configured kali-linux-gpu:amd64 2016.3.2
2016-12-22 09:20:07 status half-installed kali-linux-gpu:amd64 2016.3.2
2016-12-22 09:20:07 status config-files kali-linux-gpu:amd64 2016.3.2
2016-12-22 09:20:07 status config-files kali-linux-gpu:amd64 2016.3.2
2016-12-22 09:20:07 status config-files kali-linux-gpu:amd64 2016.3.2
2016-12-22 09:20:07 status not-installed kali-linux-gpu:amd64 <none>
```

Reinstalling Packages with `apt --reinstall` and `aptitude reinstall`

When you mistakenly damage your system by removing or modifying certain files, the easiest way to restore them is to reinstall the affected package. Unfortunately, the packaging system finds that the package is already installed and politely refuses to reinstall it. To avoid this, use the `--reinstall` option of the `apt` and `apt-get` commands. The following command reinstalls *postfix* even if it is already present:

```
# apt --reinstall install postfix
```

The `aptitude` command line is slightly different but achieves the same result with `aptitude reinstall postfix`. The `dpkg` command does not prevent re-installation, but it is rarely called directly.

Do Not Use `apt --reinstall` to Recover from an Attack

Using `apt --reinstall` to restore packages modified during an attack will certainly not recover the system as it was.

After an attack, you can't rely on anything: `dpkg` and `apt` might have been replaced by malicious programs, not reinstalling the files as you would like them to. The attacker might also have altered or created files outside the control of `dpkg`.

Remember that you can specify a specific distribution with `apt` as well, which means you can roll back to an older version of a package (if for instance you know that it works well), provided that it is still available in one of the sources referenced by the `sources.list` file:

```
# apt install w3af/kali-rolling
```

Leveraging --force- to Repair Broken Dependencies*

If you are not careful, the use of a --force-* option or some other malfunction can lead to a system where the APT family of commands will refuse to function. In effect, some of these options allow

installation of a package when a dependency is not met, or when there is a conflict. The result is an inconsistent system from the point of view of dependencies, and the APT commands will refuse to execute any action except those that will bring the system back to a consistent state (this often consists of installing the missing dependency or removing a problematic package). This usually results in a message like this one, obtained after installing a new version of *rdesktop* while ignoring its dependency on a newer version of *libc6*:

```
# apt full-upgrade
[...]
You might want to run 'apt-get -f install' to correct these.
The following packages have unmet dependencies:
rdesktop: Depends: libc6 (>= 2.5) but 2.3.6.ds1-13etch7 is installed
E: Unmet dependencies. Try using -f.
```

If you are a courageous administrator who is certain of the correctness of your analysis, you may choose to ignore a dependency or conflict and use the corresponding --force-* option. In this case, if you want to be able to continue to use `apt` or `aptitude`, you must edit `/var/lib/dpkg/status` to delete or modify the dependency, or conflict, that you have chosen to override.

This manipulation is an ugly hack and should never be used, except in the most extreme case of necessity. Quite frequently, a more fitting solution is to recompile the package that is causing the problem or use a new version (potentially corrected) from a repository providing backports (backports are newer versions especially recompiled to work in an older environment).

8.2.7. Frontends: `aptitude` and `synaptic`

APT is a C++ program whose code mainly resides in the `libapt-pkg` shared library. Thanks to this shared library, it opened the door for the creation of user interfaces (front-ends), since the shared library code can easily be reused. Historically, `apt-get` was only designed as a test front-end for `libapt-pkg` but its success tends to obscure this fact.

Over time, despite the popularity of command line interfaces like `apt` and `apt-get`, various graphical interfaces were developed. We will take a look at two of those interfaces in this section: `aptitude` and `synaptic`.

Aptitude

Aptitude, shown in Figure 8.1, "The `aptitude` package manager" [page 191], is an interactive program that can be used in semi-graphical mode on the console. You can browse the list of installed and available packages, look up all the information, and select packages to install or remove. The program is designed specifically to be used by administrators so its default behavior is much more intelligent than APT's, and its interface much easier to understand.

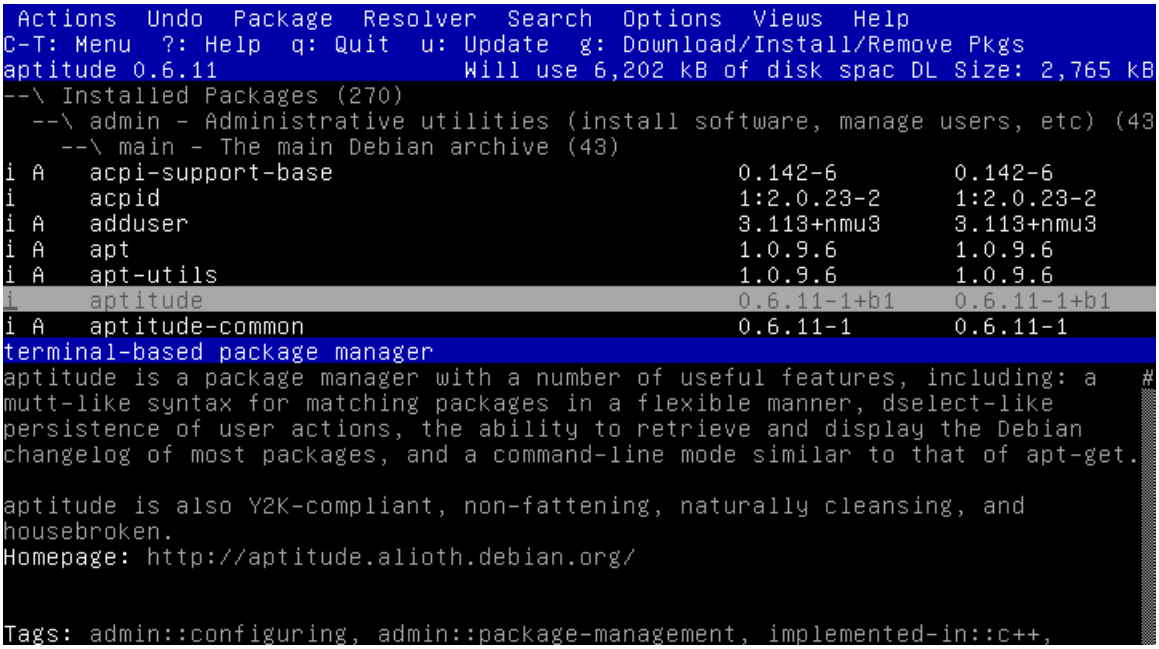


Figure 8.1 *The `aptitude` package manager*

When you run `aptitude`, you are shown a list of packages sorted by state (installed, not-installed, or installed but not available on the mirrors), while other sections display tasks, virtual packages, and new packages that appeared recently on mirrors. To facilitate thematic browsing, other views are available.

In all cases, `aptitude` displays a list combining categories and packages on the screen. Categories are organized through a tree structure, whose branches can respectively be unfolded or folded with the Enter, [, and] keys. The + key should be used to mark a package for installation, - to mark it for removal, and _ to purge it. Note that these keys can also be used for categories, in which case the corresponding actions will be applied to all the packages of the category. The u key updates the lists of available packages and Shift+u prepares a global system upgrade. The g key switches to a summary view of the requested changes (and typing g again will apply the changes), and q quits the current view. If you are in the initial view, this will close `aptitude`.

`aptitude`'s Documentation

This section does not cover the finer details of using `aptitude`, it rather focuses on giving you a user survival kit. `aptitude` is rather well documented and we advise you to use its complete manual available in the *aptitude-doc-en* package.

➨ `file:///usr/share/doc/aptitude/html/en/index.html`

To search for a package, you can type / followed by a search pattern. This pattern matches the name of the package but can also be applied to the description (if preceded by ~d), to the section

(with ~s), or to other characteristics detailed in the documentation. The same patterns can filter the list of displayed packages: type the l key (as in *limit*) and enter the pattern.

Managing the *automatic flag* of Debian packages (see section 8.3.4, "Tracking Automatically Installed Packages" [page 199]) is a breeze with `aptitude`. It is possible to browse the list of installed packages and mark packages as automatic with Shift+m or you can remove the mark with the m key. Automatic packages are displayed with an "A" in the list of packages. This feature also offers a simple way to visualize the packages in use on a machine, without all the libraries and dependencies that you don't really care about. The related pattern that can be used with l (to activate the filter mode) is ~i!~M. It specifies that you only want to see installed packages (~i) not marked as automatic (!~M).

Using `aptitude` on the Command-Line Interface

Most of Aptitude's features are accessible via the interactive interface as well as via the command-line. These command-lines will seem familiar to regular users of `apt-get` and `apt-cache`.

The advanced features of `aptitude` are also available on the command-line. You can use the same package search patterns as in the interactive version. For example, if you want to clean up the list of manually installed packages, and if you know that none of the locally installed programs require any particular libraries or Perl modules, you can mark the corresponding packages as automatic with a single command:

```
# aptitude markauto '~slibs|~sperl'
```

Here, you can clearly see the power of the search pattern system of `aptitude`, which enables the instant selection of all the packages in the `libs` and `perl` sections.

Beware, if some packages are marked as automatic and if no other package depends on them, they will be removed immediately (after a confirmation request).

Managing Recommendations, Suggestions, and Tasks Another interesting feature of `aptitude` is the fact that it respects recommendations between packages while still giving users the choice not to install them on a case-by-case basis. For example, the *gnome* package recommends *gdebi* (among others). When you select the former for installation, the latter will also be selected (and marked as automatic if not already installed on the system). Typing g will make it obvious: *gdebi* appears on the summary screen of pending actions in the list of packages installed automatically to satisfy dependencies. However, you can decide not to install it by deselecting it before confirming the operations.

Note that this recommendation tracking feature does not apply to upgrades. For instance, if a new version of *gnome* recommends a package that it did not recommend formerly, the package won't be marked for installation. However, it will be listed on the upgrade screen so that the administrator can still select it for installation.

Suggestions between packages are also taken into account, but in a manner adapted to their specific status. For example, since *gnome* suggests *dia-gnome*, the latter will be displayed on the sum-

mary screen of pending actions (in the section of packages suggested by other packages). This way, it is visible and the administrator can decide whether to take the suggestion into account or not. Since it is only a suggestion and not a dependency or a recommendation, the package will not be selected automatically—its selection requires manual intervention (thus, the package will not be marked as automatic).

In the same spirit, remember that `aptitude` makes intelligent use of the concept of tasks. Since tasks are displayed as categories in the screens of packages lists, you can either select a full task for installation or removal or browse the list of packages included in the task to select a smaller subset.

Better Solver Algorithms To conclude this section, let's note that `aptitude` has more elaborate algorithms compared to `apt` when it comes to resolving difficult situations. When a set of actions is requested and when these combined actions would lead to an incoherent system, `aptitude` evaluates several possible scenarios and presents them in order of decreasing relevance. However, these algorithms are not foolproof. Fortunately, there is always the possibility to manually select the actions to perform. When the currently selected actions lead to contradictions, the upper part of the screen indicates a number of broken packages (you can directly navigate to those packages by pressing b). Then you can manually build a solution. In particular, you can get access to the different available versions by selecting the package with Enter. If the selection of one of these versions solves the problem, you should not hesitate to use the function. When the number of broken packages gets down to zero, you can safely go to the summary screen of pending actions for a last check before you apply them.

Aptitude's Log Like `dpkg`, `aptitude` keeps a trace of executed actions in its logfile (`/var/log/aptitude`). However, since both commands work at a very different level, you cannot find the same information in their respective logfiles. While `dpkg` logs all the operations executed on individual packages step by step, `aptitude` gives a broader view of high-level operations like a system-wide upgrade.

Beware, this logfile only contains a summary of operations performed by `aptitude`. If other front-ends (or even `dpkg` itself) are occasionally used, then `aptitude`'s log will only contain a partial view of the operations, so you can't rely on it to build a trustworthy history of the system.

Synaptic

Synaptic is a graphical package manager that features a clean and efficient graphical interface (shown in Figure 8.2, "`synaptic` Package Manager" [page 194]) based on GTK+ and GNOME. Its many ready-to-use filters give fast access to newly available packages, installed packages, upgradable packages, obsolete packages, and so on. If you browse through these lists, you can select the operations to be done on the packages (install, upgrade, remove, purge); these operations are not performed immediately, but put into a task list. A single click on a button then validates the operations and they are performed in one go.

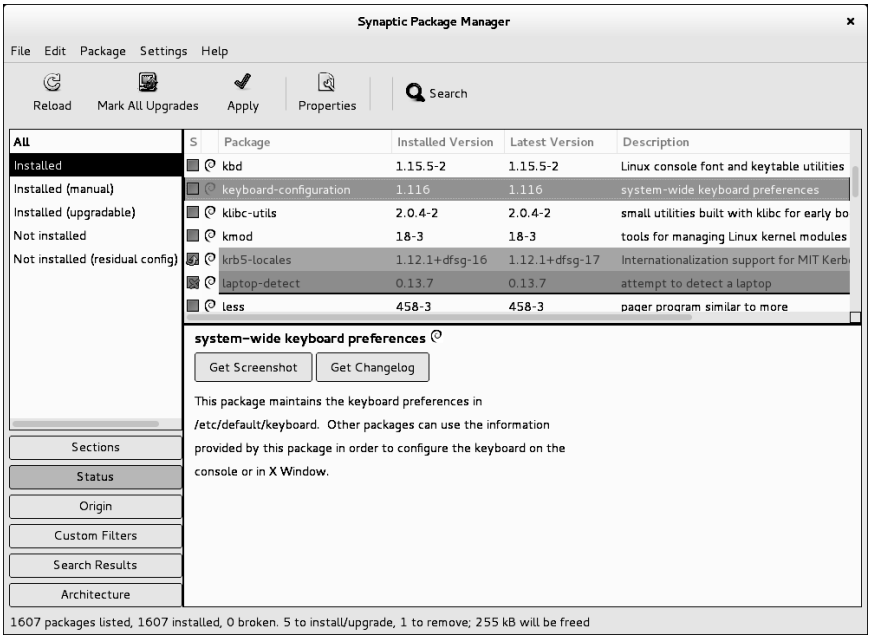


Figure 8.2 *`synaptic` Package Manager*

8.3. Advanced APT Configuration and Usage

Now it is time to dive into some more advanced topics. First, we will take a look at advanced configuration of APT, which will allow you to set more permanent options that will apply to APT tools. We will then show how package priorities can be manipulated, which opens the door for advanced fine-tuned, customized updates and upgrades. We will also show how to handle multiple distributions so that you can start experimenting with packages coming from other distributions. Next, we will take a look at how to track automatically installed packages, a capability that enables you to manage packages that are installed through dependencies. We will also explain how multiarch support opens the door for running packages built for various hardware architectures. Last

but not least, we will discuss the cryptographic protocols and utilities in place that will let you validate each package's authenticity.

8.3.1. Configuring APT

Before we dive into the configuration of APT, let's take a moment to discuss the configuration mechanism of the Debian system. Historically, configuration was handled by dedicated configuration files. However, in modern Linux systems like Debian and Kali, configuration directories with the `.d` suffix are becoming more commonly used. Each directory represents a configuration file that is split into multiple files. In this sense, all of the files in `/etc/apt/apt.conf.d/` are instructions for the configuration of APT. APT processes the files in alphabetical order, so that the later files can modify configuration elements defined in the earlier files.

This structure brings some flexibility to administrators and package maintainers, allowing them to make software configuration changes through file additions without having to change an existing file. This is especially helpful for package maintainers because they can use this approach to adapt the configuration of other software to ensure that it perfectly co-exists with theirs, without breaking the Debian policy that explicitly forbids modifying configuration files of other packages. Because of the `.d` configuration mechanism, you don't have to manually follow multiple package configuration instructions typically found in the package's `/usr/share/doc/`*`package`*`/README.Debian` file, since the installer can drop in configuration files.

Beware of Configuration Files Generated from `.d` Directories

While APT has native support of its `/etc/apt/apt.conf.d` directory, this is not always the case. For some applications (like exim, for example), the `.d` directory is a Debian-specific addition used as input to dynamically generate the canonical configuration file used by the application. In those cases, the packages provide an "update-*" command (for example: `update-exim4.conf`) that will concatenate the files from the `.d` directory and overwrite the main configuration file.

In those cases, you must not manually edit the main configuration file as your changes will be lost on the next execution of the `update-*` command, and you must also not forget to run the former command after having edited a file out of the `.d` directory (or your changes will not be used).

Armed with an understanding of the `.d` configuration mechanism, let's talk about how you can leverage it to configure APT. As we have discussed, you can alter APT's behavior through command-line arguments to `dpkg` like this example, which performs a forced overwrite install of `zsh`:

```
# apt -o Dpkg::Options::="--force-overwrite" install zsh
```

Obviously this is very cumbersome, especially if you use options frequently, but you can also use the `.d` directory configuration structure to configure certain aspects of APT by adding directives to a file in the `/etc/apt/apt.conf.d/` directory. For example, this (and any other) directive can

easily be added to a file in `/etc/apt/apt.conf.d/`. The name of this file is somewhat arbitrary, but a common convention is to use either `local` or `99local`:

```
$ cat /etc/apt/apt.conf.d/99local
Dpkg::Options {
   "--force-overwrite";
}
```

There are many other helpful configuration options and we certainly can't cover them all, but one we will touch on involves network connectivity. For example, if you can only access the web through a proxy, add a line like Acquire::http::proxy "http://*yourproxy*:3128". For an FTP proxy, use Acquire::ftp::proxy "ftp://*yourproxy*".

To discover more configuration options, read the `apt.conf(5)` manual page with the `man apt.conf` command (for details on manual pages, see section 6.1.1, "Manual Pages" [page 124]).

8.3.2. Managing Package Priorities

One of the most important aspects in the configuration of APT is the management of the priorities associated with each package source. For instance, you might want to extend your Kali Rolling system with one or two newer packages from Debian Unstable or Debian Experimental. It is possible to assign a priority to each available package (the same package can have several priorities depending on its version or the distribution providing it). These priorities will influence APT's behavior: for each package, it will always select the version with the highest priority (except if this version is older than the installed one and its priority is less than 1000).

APT defines several default priorities. Each installed package version has a priority of 100. A non-installed version has a priority of 500 by default but it can jump to 990 if it is part of the target release (defined with the -t command-line option or the APT::Default-Release configuration directive).

You can modify the priorities by adding entries in the `/etc/apt/preferences` file with the names of the affected packages, their version, their origin and their new priority.

APT will never install an older version of a package (that is, a package whose version number is lower than the one of the currently installed package) except when its priority is higher than 1000. APT will always install the highest priority package that follows this constraint. If two packages have the same priority, APT installs the newest one (whose version number is the highest). If two packages of same version have the same priority but differ in their content, APT installs the version that is not installed (this rule has been created to cover the case of a package update without the increment of the revision number, which is usually required).

In more concrete terms, a package whose priority is less than 0 will never be installed. A package with a priority ranging between 0 and 100 will only be installed if no other version of the package is already installed. With a priority between 100 and 500, the package will only be installed if there

is no other newer version installed or available in another distribution. A package of priority between 501 and 990 will only be installed if there is no newer version installed or available in the target distribution. With a priority between 990 and 1000, the package will be installed except if the installed version is newer. A priority greater than 1000 will always lead to the installation of the package even if it forces APT to downgrade to an older version.

When APT checks `/etc/apt/preferences`, it first takes into account the most specific entries (often those specifying the concerned package), then the more generic ones (including for example all the packages of a distribution). If several generic entries exist, the first match is used. The available selection criteria include the package's name and the source providing it. Every package source is identified by the information contained in a `Release` file that APT downloads together with the `Packages` files. These files specify the origin, usually "Kali" for the packages from Kali's official mirrors and "Debian" for the packages from Debian's official mirrors, but the origin can also be a person's or an organization's name for third-party repositories. The `Release` file also provides the name of the distribution together with its version. Let's have a look at its syntax through some realistic case studies of this mechanism.

Priority of Kali-Bleeding-Edge and Debian Experimental

If you listed kali-bleeding-edge or Debian experimental in your `sources.list` file, the corresponding packages will almost never be installed because their default APT priority is 1. This is of course a specific case, designed to keep users from installing bleeding edge packages by mistake. The packages can only be installed by typing `apt install` *`package`*`/kali-bleeding-edge`, assuming of course that you are aware of the risks and potential headaches of life on the edge. It is still possible (though *not* recommended) to treat packages of kali-bleeding-edge/experimental like those of other distributions by giving them a priority of 500. This is done with a specific entry in `/etc/apt/preferences`:

```
Package: *
Pin: release a=kali-bleeding-edge
Pin-Priority: 500
```

Let's suppose that you only want to use packages from Kali and that you only want Debian packages installed when explicitly requested. You could write the following entries in the `/etc/apt/preferences` file (or in any file in `/etc/apt/preferences.d/`):

```
Package: *
Pin: release o=Kali
Pin-Priority: 900

Package: *
Pin: release o=Debian
Pin-Priority: -10
```

In the last two examples, you have seen a=kali-bleeding-edge, which defines the name of the selected distribution and o=Kali and o=Debian, which limit the scope to packages whose origin are Kali and Debian, respectively.

Let's now assume that you have a server with several local programs depending on the version 5.22 of Perl and that you want to ensure that upgrades will not install another version of it. You could use this entry:

```
Package: perl
Pin: version 5.22*
Pin-Priority: 1001
```

The reference documentation for this configuration file is available in the manual page `apt_preferences(5)`, which you can display with `man apt_preferences`.

Adding Comments in `/etc/apt/preferences`

There is no official syntax for comments in `/etc/apt/preferences`, but some textual descriptions can be provided by prepending one or more `Explanation` fields into each entry:

```
Explanation: The package xserver-xorg-video-intel provided
Explanation: in experimental can be used safely
Package: xserver-xorg-video-intel
Pin: release a=experimental
Pin-Priority: 500
```

8.3.3. Working with Several Distributions

Given that `apt` is such a marvelous tool, you will likely want to dive in and start experimenting with packages coming from other distributions. For example, after installing a Kali Rolling system, you might want to try out a software package available in Kali Dev, Debian Unstable, or Debian Experimental without diverging too much from the system's initial state.

Even if you will occasionally encounter problems while mixing packages from different distributions, `apt` manages such coexistence very well and limits risks very effectively (provided that the package dependencies are accurate). First, list all distributions used in `/etc/apt/sources.list` and define your reference distribution with the APT::Default-Release parameter (see section 8.2.3, "Upgrading Kali Linux" [page 179]).

Let's suppose that Kali Rolling is your reference distribution but that Kali Dev and Debian Unstable are also listed in your `sources.list` file. In this case, you can use `apt install` *`package`*`/unstable` to install a package from Debian Unstable. If the installation fails due to some unsatisfiable dependencies, let it solve those dependencies within Unstable by adding the `-t unstable` parameter.

In this situation, upgrades (`upgrade` and `full-upgrade`) are done within Kali Rolling except for packages already upgraded to another distribution: those will follow updates available in the other distributions. We will explain this behavior with the help of the default priorities set by APT below. Do not hesitate to use `apt-cache policy` (see sidebar "Using `apt-cache policy`" [page 199]) to verify the given priorities.

Everything relies on the fact that APT only considers packages of higher or equal version than the installed package (assuming that `/etc/apt/preferences` has not been used to force priorities higher than 1000 for some packages).

Using `apt-cache policy` To gain a better understanding of the mechanism of priority, do not hesitate to execute `apt-cache policy` to display the default priority associated with each package source. You can also use `apt-cache policy` *package* to display the priorities of all available versions of a given package.

Let's assume that you have installed version 1 of a first package from *Kali Rolling* and that version 2 and 3 are available respectively in *Kali Dev* and *Debian Unstable*. The installed version has a priority of 100 but the version available in *Kali Rolling* (the very same) has a priority of 990 (because it is part of the target release). Packages in *Kali Dev* and *Debian Unstable* have a priority of 500 (the default priority of a non-installed version). The winner is thus version 1 with a priority of 990. The package stays in *Kali Rolling*.

Let's take the example of another package whose version 2 has been installed from *Kali Dev*. Version 1 is available in *Kali Rolling* and version 3 in *Debian Unstable*. Version 1 (of priority 990—thus lower than 1000) is discarded because it is lower than the installed version. This only leaves version 2 and 3, both of priority 500. Faced with this alternative, APT selects the newest version, the one from *Debian Unstable*. If you don't want a package installed from *Kali Dev* to migrate to *Debian Unstable*, you have to assign a priority lower than 500 (490 for example) to packages coming from *Debian Unstable*. You can modify `/etc/apt/preferences` to this effect:

```
Package: *
Pin: release a=unstable
Pin-Priority: 490
```

8.3.4. Tracking Automatically Installed Packages

One of the essential functionalities of `apt` is the tracking of packages installed only through dependencies. These packages are called *automatic* and often include libraries.

With this information, when packages are removed, the package managers can compute a list of automatic packages that are no longer needed (because there are no manually installed packages depending on them). The command `apt autoremove` will get rid of those packages. Aptitude does

not have this command because it removes them automatically as soon as they are identified. In all cases, the tools display a clear message listing the affected packages.

It is a good habit to mark as automatic any package that you don't need directly so that they are automatically removed when they aren't necessary anymore. You can use `apt-mark auto` *`package`* to mark the given package as automatic, whereas `apt-mark manual` *`package`* does the opposite. `aptitude markauto` and `aptitude unmarkauto` work in the same way, although they offer more features for marking many packages at once (see section 8.2.7.1, "Aptitude" [page 190]). The console-based interactive interface of `aptitude` also makes it easy to review the automatic flag on many packages.

You might want to know why an automatically installed package is present on the system. To get this information from the command line, you can use `aptitude why` *`package`* (`apt` and `apt-get` have no similar feature):

```
$ aptitude why python-debian
i   aptitude         Recommends apt-xapian-index
i A apt-xapian-index Depends    python-debian (>= 0.1.15)
```

8.3.5. Leveraging Multi-Arch Support

All Debian packages have an Architecture field in their control information. This field can contain either "all" (for packages that are architecture-independent) or the name of the architecture that it targets (like amd64, or armhf). In the latter case, by default, `dpkg` will only install the package if its architecture matches the host's architecture as returned by `dpkg --print-architecture`.

This restriction ensures that you do not end up with binaries compiled for an incorrect architecture. Everything would be perfect except that (some) computers can run binaries for multiple architectures, either natively (an amd64 system can run i386 binaries) or through emulators.

Enabling Multi-Arch

Multi-arch support for `dpkg` allows users to define foreign architectures that can be installed on the current system. This is easily done with `dpkg --add-architecture`, as in the example below where the i386 architecture needs to be added to the amd64 system in order to run Windows applications using Wine[5]. There is a corresponding `dpkg --remove-architecture` to drop support of a foreign architecture, but it can only be used when no packages of this architecture remain installed.

```
# dpkg --print-architecture
amd64
```

[5] `https://www.winehq.org/`

```
# wine
it looks like wine32 is missing, you should install it.
multiarch needs to be enabled first.  as root, please
execute "dpkg --add-architecture i386 & apt-get update &
apt-get install wine32"
Usage: wine PROGRAM [ARGUMENTS...]   Run the specified program
       wine --help                   Display this help and exit
       wine --version                Output version information and exit
# dpkg --add-architecture i386
# dpkg --print-foreign-architectures
i386
# apt update
[...]
# apt install wine32
[...]
Setting up libwine:i386 (1.8.6-5) ...
Setting up vdpau-driver-all:i386 (1.1.1-6) ...
Setting up wine32:i386 (1.8.6-5) ...
Setting up libasound2-plugins:i386 (1.1.1-1) ...
Processing triggers for libc-bin (2.24-9)
# wine
Usage: wine PROGRAM [ARGUMENTS...]   Run the specified program
     wine --help                   Display this help and exit
     wine --version                Output version information and exit
# dpkg --remove-architecture i386
dpkg: error: cannot remove architecture 'i386' currently in use by the database
# dpkg --print-foreign-architectures
i386
```

APT will automatically detect when dpkg has been configured to support foreign architectures and will start downloading the corresponding `Packages` files during its update process.

Foreign packages can then be installed with `apt install` *`package`*`:`*`architecture`*.

Using Proprietary i386 Binaries on amd64

There are multiple use cases for multi-arch, but the most popular one is the possibility to execute 32 bit binaries (i386) on 64 bit systems (amd64), in particular since several popular proprietary applications (like Skype) are only provided in 32 bit versions.

Multi-Arch Related Changes

To make multi-arch actually useful and usable, libraries had to be repackaged and moved to an architecture-specific directory so that multiple copies (targeting different architectures) can be installed alongside one another. Such updated packages contain the `Multi-Arch: same` header field to tell the packaging system that the various architectures of the package can be safely co-installed (and that those packages can only satisfy dependencies of packages of the same architecture).

```
$ dpkg -s libwine
dpkg-query: error: --status needs a valid package name but 'libwine' is not: ambiguous
    ➥ package name 'libwine' with more than one installed instance

Use --help for help about querying packages.
$ dpkg -s libwine:amd64 libwine:i386 | grep ^Multi
Multi-Arch: same
Multi-Arch: same
$ dpkg -L libgcc1:amd64 |grep .so
[...]
/usr/lib/x86_64-linux-gnu/wine/libwine.so.1
$ dpkg -S /usr/share/doc/libwine/copyright
libwine:amd64, libwine:i386: /usr/share/doc/libwine/copyright
```

It is worth noting that Multi-Arch: same packages must have their names qualified with their architecture to be unambiguously identifiable. These packages may also share files with other instances of the same package; `dpkg` ensures that all packages have bit-for-bit identical files when they are shared. Also, all instances of a package must have the same version, therefore they must be upgraded together.

Multi-Arch support also brings some interesting challenges in the way dependencies are handled. Satisfying a dependency requires either a package marked Multi-Arch: foreign or a package whose architecture matches the one of the package declaring the dependency (in this dependency resolution process, architecture-independent packages are assumed to be of the same architecture as the host). A dependency can also be weakened to allow any architecture to fulfill it, with the *package*:any syntax, but foreign packages can only satisfy such a dependency if they are marked Multi-Arch: allowed.

8.3.6. Validating Package Authenticity

System upgrades are very sensitive operations and you really want to ensure that you only install official packages from the Kali repositories. If the Kali mirror you are using has been compromised, a computer cracker could try to add malicious code to an otherwise legitimate package. Such a package, if installed, could do anything the cracker designed it to do including disclose passwords or confidential information. To circumvent this risk, Kali provides a tamper-proof seal to guarantee—at install time—that a package really comes from its official maintainer and hasn't been modified by a third party.

The seal works with a chain of cryptographic hashes and a signature. The signed file is the `Release` file, provided by the Kali mirrors. It contains a list of the `Packages` files (including their compressed forms, `Packages.gz` and `Packages.xz`, and the incremental versions), along with their MD5, SHA1, and SHA256 hashes, which ensures that the files haven't been tampered with. These

`Packages` files contain a list of the Debian packages available on the mirror along with their hashes, which ensures in turn that the contents of the packages themselves haven't been altered either.

The trusted keys are managed with the `apt-key` command found in the *apt* package. This program maintains a keyring of GnuPG public keys, which are used to verify signatures in the `Release.gpg` files available on the mirrors. It can be used to add new keys manually (when non-official mirrors are needed). Generally however, only the official Kali keys are needed. These keys are automatically kept up-to-date by the *kali-archive-keyring* package (which puts the corresponding keyrings in `/etc/apt/trusted.gpg.d`). However, the first installation of this particular package requires caution: even if the package is signed like any other, the signature cannot be verified externally. Cautious administrators should therefore check the fingerprints of imported keys before trusting them to install new packages:

```
# apt-key fingerprint
/etc/apt/trusted.gpg.d/debian-archive-jessie-automatic.gpg
-----------------------------------------------------------
pub   4096R/2B90D010 2014-11-21 [expires: 2022-11-19]
      Key fingerprint = 126C 0D24 BD8A 2942 CC7D  F8AC 7638 D044 2B90 D010
uid                  Debian Archive Automatic Signing Key (8/jessie) <ftpmaster@debian.org>

/etc/apt/trusted.gpg.d/debian-archive-jessie-security-automatic.gpg
-------------------------------------------------------------------
pub   4096R/C857C906 2014-11-21 [expires: 2022-11-19]
      Key fingerprint = D211 6914 1CEC D440 F2EB  8DDA 9D6D 8F6B C857 C906
uid                  Debian Security Archive Automatic Signing Key (8/jessie) <ftpmaster@debian.org>

/etc/apt/trusted.gpg.d/debian-archive-jessie-stable.gpg
-------------------------------------------------------
pub   4096R/518E17E1 2013-08-17 [expires: 2021-08-15]
      Key fingerprint = 75DD C3C4 A499 F1A1 8CB5  F3C8 CBF8 D6FD 518E 17E1
uid                  Jessie Stable Release Key <debian-release@lists.debian.org>

/etc/apt/trusted.gpg.d/debian-archive-squeeze-automatic.gpg
----------------------------------------------------------
pub   4096R/473041FA 2010-08-27 [expires: 2018-03-05]
      Key fingerprint = 9FED 2BCB DCD2 9CDF 7626  78CB AED4 B06F 4730 41FA
uid                  Debian Archive Automatic Signing Key (6.0/squeeze) <ftpmaster@debian.org>

/etc/apt/trusted.gpg.d/debian-archive-squeeze-stable.gpg
--------------------------------------------------------
pub   4096R/B98321F9 2010-08-07 [expires: 2017-08-05]
      Key fingerprint = 0E4E DE2C 7F3E 1FC0 D033  800E 6448 1591 B983 21F9
uid                  Squeeze Stable Release Key <debian-release@lists.debian.org>

/etc/apt/trusted.gpg.d/debian-archive-wheezy-automatic.gpg
----------------------------------------------------------
pub   4096R/46925553 2012-04-27 [expires: 2020-04-25]
      Key fingerprint = A1BD 8E9D 78F7 FE5C 3E65  D8AF 8B48 AD62 4692 5553
uid                  Debian Archive Automatic Signing Key (7.0/wheezy) <ftpmaster@debian.org>

/etc/apt/trusted.gpg.d/debian-archive-wheezy-stable.gpg
-------------------------------------------------------
pub   4096R/65FFB764 2012-05-08 [expires: 2019-05-07]
      Key fingerprint = ED6D 6527 1AAC F0FF 15D1  2303 6FB2 A1C2 65FF B764
uid                  Wheezy Stable Release Key <debian-release@lists.debian.org>
```

```
/etc/apt/trusted.gpg.d/kali-archive-keyring.gpg
------------------------------------------------
pub   4096R/7D8D0BF6 2012-03-05 [expires: 2018-02-02]
      Key fingerprint = 44C6 513A 8E4F B3D3 0875  F758 ED44 4FF0 7D8D 0BF6
uid                  Kali Linux Repository <devel@kali.org>
sub   4096R/FC0D0DCB 2012-03-05 [expires: 2018-02-02]
```

When a third-party package source is added to the `sources.list` file, APT needs to be told to trust the corresponding GPG authentication key (otherwise it will keep complaining that it can't ensure the authenticity of the packages coming from that repository). The first step is of course to get the public key. More often than not, the key will be provided as a small text file, which we will call `key.asc` in the following examples.

To add the key to the trusted keyring, the administrator can run `apt-key add < key.asc`. Another way is to use the `synaptic` graphical interface: its Authentication tab in the Settings → Repositories menu provides the ability to import a key from the `key.asc` file.

For people who prefer a dedicated application and more details on the trusted keys, it is possible to use `gui-apt-key` (in the package of the same name), a small graphical user interface that manages the trusted keyring.

Once the appropriate keys are in the keyring, APT will check the signatures before any risky operation, so that front-ends will display a warning if asked to install a package whose authenticity can't be ascertained.

8.4. Package Reference: Digging Deeper into the Debian Package System

Now it is time to dive really deep into Debian and Kali's package system. At this point, we are going to move beyond tools and syntax and focus more on the nuts and bolts of the packaging system. This behind-the-scenes view will help you understand how APT works at its foundation and will give you insight into how to seriously streamline and customize your Kali system. You may not necessarily memorize all the material in this section, but the walk-through and reference material will serve you well as you grow in your mastery of the Kali Linux system.

So far, you have interacted with APT's package data through the various tools designed to interface with it. Next, we will dig deeper and take a look inside the packages and look at the internal *meta-information* (or information about other information) used by the package management tools.

This combination of a file archive and of meta-information is directly visible in the structure of a `.deb` file, which is simply an ar archive, concatenating three files:

```
$ ar t /var/cache/apt/archives/apt_1.4~beta1_amd64.deb
debian-binary
control.tar.gz
data.tar.xz
```

The `debian-binary` file contains a single version number describing the format of the archive:

```
$ ar p /var/cache/apt/archives/apt_1.4~beta1_amd64.deb debian-binary
2.0
```

The `control.tar.gz` archive contains meta-information:

```
$ ar p /var/cache/apt/archives/apt_1.4~beta1_amd64.deb control.tar.gz | tar -tzf -
./
./conffiles
./control
./md5sums
./postinst
./postrm
./preinst
./prerm
./shlibs
./triggers
```

And finally, the `data.tar.xz` archive (the compression format might vary) contains the actual files to be installed on the file system:

```
$ ar p /var/cache/apt/archives/apt_1.4~beta1_amd64.deb data.tar.xz | tar -tJf -
./
./etc/
./etc/apt/
./etc/apt/apt.conf.d/
./etc/apt/apt.conf.d/01autoremove
./etc/apt/preferences.d/
./etc/apt/sources.list.d/
./etc/apt/trusted.gpg.d/
./etc/cron.daily/
./etc/cron.daily/apt-compat
./etc/kernel/
./etc/kernel/postinst.d/
./etc/kernel/postinst.d/apt-auto-removal
./etc/logrotate.d/
./etc/logrotate.d/apt
./lib/
./lib/systemd/
[...]
```

Note that in this example, you are viewing a `.deb` package in APT's archive cache and that your archive may contain files with different version numbers than what is shown.

In this section, we will introduce this meta-information contained in each package and show you how to leverage it.

8.4.1. The `control` File

We will begin by looking at the `control` file, which is contained in the `control.tar.gz` archive. The `control` file contains the most vital information about the package. It uses a structure similar to email headers and can be viewed with the `dpkg -I` command. For example, the `control` file for *apt* looks like this:

```
$ dpkg -I apt_1.4~beta1_amd64.deb control
Package: apt
Version: 1.4~beta1
Architecture: amd64
Maintainer: APT Development Team <deity@lists.debian.org>
Installed-Size: 3478
Depends: adduser, gpgv | gpgv2 | gpgv1, debian-archive-keyring, init-system-helpers (>=
    ➥  1.18~), libapt-pkg5.0 (>= 1.3~rc2), libc6 (>= 2.15), libgcc1 (>= 1:3.0),
    ➥ libstdc++6 (>= 5.2)
Recommends: gnupg | gnupg2 | gnupg1
Suggests: apt-doc, aptitude | synaptic | wajig, dpkg-dev (>= 1.17.2), powermgmt-base,
    ➥ python-apt
Breaks: apt-utils (<< 1.3~exp2~)
Replaces: apt-utils (<< 1.3~exp2~)
Section: admin
Priority: important
Description: commandline package manager
 This package provides commandline tools for searching and
 managing as well as querying information about packages
 as a low-level access to all features of the libapt-pkg library.
 .
 These include:
  * apt-get for retrieval of packages and information about them
    from authenticated sources and for installation, upgrade and
    removal of packages together with their dependencies
  * apt-cache for querying available information about installed
    as well as installable packages
  * apt-cdrom to use removable media as a source for packages
  * apt-config as an interface to the configuration settings
  * apt-key as an interface to manage authentication keys
```

In this section, we will walk you through the control file and explain the various fields. Each of these will give you a better understanding of the packaging system, give you more fine-tuned configuration control, and provide you with insight needed to troubleshoot problems that may occur.

Dependencies: the Depends Field

The package dependencies are defined in the Depends field in the package header. This is a list of conditions to be met for the package to work correctly—this information is used by tools such as `apt` in order to install the required libraries, in appropriate versions fulfilling the dependencies of the package to be installed. For each dependency, you can restrict the range of versions that meet that condition. In other words, it is possible to express the fact that you need the package *libc6* in a version equal to or greater than "2.15" (written "`libc6 (>= 2.15)`"). Version comparison operators are as follows:

- <<: less than;
- <=: less than or equal to;
- =: equal to (note that "2.6.1" is not equal to "2.6.1-1");
- >=: greater than or equal to;
- >>: greater than.

In a list of conditions to be met, the comma serves as a separator, interpreted as a logical "AND." In conditions, the vertical bar ("|") expresses a logical "OR" (it is an inclusive "OR," not an exclusive "either/or"). Carrying greater priority than "AND," you can use it as many times as necessary. Thus, the dependency "(A OR B) AND C" is written `A | B, C`. In contrast, the expression "A OR (B AND C)" should be written as "(A OR B) AND (A OR C)", since the Depends field does not tolerate parentheses that change the order of priorities between the logical operators "OR" and "AND". It would thus be written `A | B, A | C`. See `http://www.debian.org/doc/debian-policy/ch-relationships.html` for more information.

The dependencies system is a good mechanism for guaranteeing the operation of a program but it has another use with meta-packages. These are empty packages that only describe dependencies. They facilitate the installation of a consistent group of programs preselected by the meta-package maintainer; as such, `apt install` *`meta-package`* will automatically install all of these programs using the meta-package's dependencies. The *gnome*, *kde-full*, and *kali-linux-full* packages are examples of meta-packages.

Pre-Depends, a More Demanding Depends

Pre-dependencies, which are listed in the Pre-Depends field in the package headers, complete the normal dependencies; their syntax is identical. A normal dependency indicates that the package in question must be unpacked and configured before configuration of the package declaring the dependency. A pre-dependency stipulates that the package in question must be unpacked and configured before execution of the pre-installation script of the package declaring the pre-dependency, that is before its installation.

A pre-dependency is very demanding for `apt` because it adds a strict constraint on the ordering of the packages to install. As such, pre-dependencies are discouraged unless absolutely necessary. It is even recommended to consult other developers on debian-devel@lists.debian.org before adding a pre-dependency as it is generally possible to find another solution as a work-around.

Recommends, Suggests, and Enhances Fields

The Recommends and Suggests fields describe dependencies that are not compulsory. The recommended dependencies, the most important, considerably improve the functionality offered by the package but are not indispensable to its operation. The suggested dependencies, of secondary importance, indicate that certain packages may complement and increase their respective utility, but it is perfectly reasonable to install one without the others.

You should always install the recommended packages unless you know exactly why you do not need them. Conversely, it is not necessary to install suggested packages unless you know why you need them.

The Enhances field also describes a suggestion, but in a different context. It is indeed located in the suggested package, and not in the package that benefits from the suggestion. Its interest lies in that it is possible to add a suggestion without having to modify the package that is concerned. Thus, all add-ons, plug-ins, and other extensions of a program can then appear in the list of suggestions related to the software. Although it has existed for several years, this last field is still largely ignored by programs such as `apt` or `synaptic`. The original goal was to let a package like *xul-ext-adblock-plus* (a Firefox extension) declare Enhances: firefox, firefox-esr and thus appear in the list of suggested packages associated to *firefox* and *firefox-esr*.

Conflicts: the Conflicts Field

The Conflicts field indicates when a package cannot be installed simultaneously with another. The most common reasons for this are that both packages include a file of the same name, provide the same service on the same transmission control protocol (TCP) port, or would hinder each other's operation.

If it triggers a conflict with an already installed package, `dpkg` will refuse to install a package, except if the new package specifies that it will replace the installed package, in which case `dpkg` will choose to replace the old package with the new one. APT always follows your instructions: if you choose to install a new package, it will automatically offer to uninstall the package that poses a problem.

Incompatibilities: the Breaks Field

The Breaks field has an effect similar to that of the Conflicts field, but with a special meaning. It signals that the installation of a package will break another package (or particular versions of it). In general, this incompatibility between two packages is transitory and the Breaks relationship specifically refers to the incompatible versions.

When a package breaks an already installed package, `dpkg` will refuse to install it, and `apt` will try to resolve the problem by updating the package that would be broken to a newer version (which is assumed to be fixed and, thus, compatible again).

This type of situation may occur in the case of updates without backwards compatibility: this is the case if the new version no longer functions with the older version and causes a malfunction in another program without making special provisions. The Breaks field helps prevent these types of problems.

Provided Items: the Provides Field

This field introduces the very interesting concept of a *virtual package*. It has many roles, but two are of particular importance. The first role consists in using a virtual package to associate a generic service with it (the package provides the service). The second indicates that a package completely replaces another and that for this purpose, it can also satisfy the dependencies that the other would satisfy. It is thus possible to create a substitution package without having to use the same package name.

Meta-Package and Virtual Package

It is essential to clearly distinguish meta-packages from virtual packages. The former are real packages (including real `.deb` files), whose only purpose is to express dependencies.

Virtual packages, however, do not exist physically; they are only a means of identifying real packages based on common, logical criteria (for example, service provided, or compatibility with a standard program or a pre-existing package).

Providing a Service Let's discuss the first case in greater detail with an example: all mail servers, such as *postfix* or *sendmail* are said to provide the *mail-transport-agent* virtual package. Thus, any package that needs this service to be functional (e.g. a mailing list manager, such as *smartlist* or *sympa*) simply states in its dependencies that it requires a *mail-transport-agent* instead of specifying a large yet incomplete list of possible solutions. Furthermore, it is useless to install two mail servers on the same machine, which is why each of these packages declares a conflict with the *mail-transport-agent* virtual package. A conflict between a package and itself is ignored by the system, but this technique will prohibit the installation of two mail servers side by side.

Interchangeability with Another Package The Provides field is also interesting when the content of a package is included in a larger package. For example, the *libdigest-md5-perl* Perl module was an optional module in Perl 5.6, and has been integrated as standard in Perl 5.8. As such, the package *perl* has since version 5.8 declared Provides: libdigest-md5-perl so that the dependencies on this package are met if the system has Perl 5.8 (or newer). The *libdigest-md5-perl* package itself was deleted, since it no longer had any purpose when old Perl versions were removed.

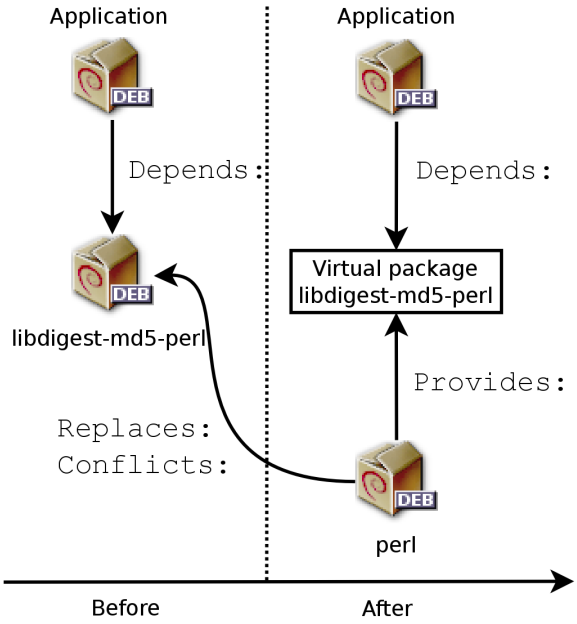


Figure 8.3 *Use of a Provides Field in Order to Not Break Dependencies*

This feature is very useful, since it is never possible to anticipate the vagaries of development and it is necessary to be able to adjust to renaming, and other automatic replacement, of obsolete software.

Replacing Files: The Replaces Field

The Replaces field indicates that the package contains files that are also present in another package, but that the package is legitimately entitled to replace them. Without this specification, `dpkg` fails, stating that it cannot overwrite the files of another package (technically, it is possible to force it to do so with the --force-overwrite option, but that is not considered standard operation). This allows identification of potential problems and requires the maintainer to study the matter prior to choosing whether to add such a field.

The use of this field is justified when package names change or when a package is included in another. This also happens when the maintainer decides to distribute files differently among various binary packages produced from the same source package: a replaced file no longer belongs to the old package, but only to the new one.

If all of the files in an installed package have been replaced, the package is considered to be removed. Finally, this field also encourages `dpkg` to remove the replaced package where there is a conflict.

8.4.2. Configuration Scripts

In addition to the `control` file, the `control.tar.gz` archive for each Debian package may contain a number of scripts (`postinst`, `postrm`, `preinst`, `prerm`) called by `dpkg` at different stages in the processing of a package. We can use `dpkg -I` to show these files as they reside in a `.deb` package archive:

```
$ dpkg -I /var/cache/apt/archives/zsh_5.3-1_amd64.deb | head
 new debian package, version 2.0.
 size 814486 bytes: control archive=2557 bytes.
     838 bytes,    20 lines      control
    3327 bytes,    43 lines      md5sums
     969 bytes,    41 lines   *  postinst            #!/bin/sh
     348 bytes,    20 lines   *  postrm              #!/bin/sh
     175 bytes,     5 lines   *  preinst             #!/bin/sh
     175 bytes,     5 lines   *  prerm               #!/bin/sh
 Package: zsh
 Version: 5.3-1
$ dpkg -I zsh_5.3-1_amd64.deb preinst
#!/bin/sh
set -e
# Automatically added by dh_installdeb
dpkg-maintscript-helper symlink_to_dir /usr/share/doc/zsh zsh-common 5.0.7-3 -- "$@"
# End automatically added section
```

The Debian Policy describes each of these files in detail, specifying the scripts called and the arguments they receive. These sequences may be complicated, since if one of the scripts fails, `dpkg` will try to return to a satisfactory state by canceling the installation or removal in progress (insofar as it is possible).

The dpkg Database

You can traverse the dpkg database on the filesystem at /var/lib/dpkg/. This directory contains a running record of all the packages that have been installed on the system. All of the configuration scripts for installed packages are stored in the /var/lib/dpkg/info/ directory, in the form of a file prefixed with the package's name:

```
$ ls /var/lib/dpkg/info/zsh.*
/var/lib/dpkg/info/zsh.list
/var/lib/dpkg/info/zsh.md5sums
/var/lib/dpkg/info/zsh.postinst
/var/lib/dpkg/info/zsh.postrm
/var/lib/dpkg/info/zsh.preinst
/var/lib/dpkg/info/zsh.prerm
```

This directory also includes a file with the .list extension for each package, containing the list of files that belong to that package:

```
$ head /var/lib/dpkg/info/zsh.list
/.
/bin
/bin/zsh
/bin/zsh5
/usr
/usr/lib
/usr/lib/x86_64-linux-gnu
/usr/lib/x86_64-linux-gnu/zsh
/usr/lib/x86_64-linux-gnu/zsh/5.2
/usr/lib/x86_64-linux-gnu/zsh/5.2/zsh
[...]
```

The /var/lib/dpkg/status file contains a series of data blocks (in the format of the famous mail headers request for comment, RFC 2822) describing the status of each package. The information from the control file of the installed packages is also replicated there.

```
$ more /var/lib/dpkg/status
Package: gnome-characters
Status: install ok installed
Priority: optional
Section: gnome
Installed-Size: 1785
Maintainer: Debian GNOME Maintainers <pkg-gnome-
    ➥ maintainers@lists.alioth.debian.org>
Architecture: amd64
Version: 3.20.1-1
[...]
```

Let's discuss the configuration files and see how they interact. In general, the `preinst` script is executed prior to installation of the package, while the `postinst` follows it. Likewise, `prerm` is invoked before removal of a package and `postrm` afterwards. An update of a package is equivalent to removal of the previous version and installation of the new one. It is not possible to describe in detail all the possible scenarios here but we will discuss the most common two: an installation/update and a removal.

These sequences can be quite confusing, but a visual representation may help. Manoj Srivastava made these diagrams explaining how the configuration scripts are called by `dpkg`. Similar diagrams have also been developed by the Debian Women project; they are a bit simpler to understand, but less complete.

➨ `https://people.debian.org/~srivasta/MaintainerScripts.html`

➨ `https://wiki.debian.org/MaintainerScripts`

CAUTION

Symbolic Names of the Scripts

The sequences described in this section call configuration scripts by specific names, such as `old-prerm` or `new-postinst`. They are, respectively, the `prerm` script contained in the old version of the package (installed before the update) and the `postinst` script contained in the new version (installed by the update).

Installation and Upgrade Script Sequence

Here is what happens during an installation (or an update):

1. For an update, `dpkg` calls the `old-prerm upgrade` *`new-version`*.
2. Still for an update, `dpkg` then executes `new-preinst upgrade` *`old-version`*; for a first installation, it executes `new-preinst install`. It may add the old version in the last parameter if the package has already been installed and removed (but not purged, the configuration files having been retained).
3. The new package files are then unpacked. If a file already exists, it is replaced, but a backup copy is made and temporarily stored.
4. For an update, `dpkg` executes `old-postrm upgrade` *`new-version`*.
5. `dpkg` updates all of the internal data (file list, configuration scripts, etc.) and removes the backups of the replaced files. This is the point of no return: `dpkg` no longer has access to all of the elements necessary to return to the previous state.
6. `dpkg` will update the configuration files, prompting you to decide if it is unable to automatically manage this task. The details of this procedure are discussed in section 8.4.3, "Checksums, Conffiles" [page 214].
7. Finally, `dpkg` configures the package by executing `new-postinst configure` *`last-version-configured`*.

Package Removal

Here is what happens during a package removal.

1. `dpkg` calls `prerm remove`.
2. `dpkg` removes all of the package's files, with the exception of the configuration files and configuration scripts.
3. `dpkg` executes `postrm remove`. All of the configuration scripts, except `postrm`, are removed. If you have not used the purge option, the process stops here.
4. For a complete purge of the package (command issued with `dpkg --purge` or `dpkg -P`), the configuration files are also deleted, as well as a certain number of copies (`*.dpkg-tmp`, `*.dpkg-old`, `*.dpkg-new`) and temporary files; `dpkg` then executes `postrm purge`.

In some cases, a package might use `debconf` to require configuration information from you: the four scripts detailed above are then complemented by a `config` script designed to acquire that information. During installation, this script defines in detail what questions `debconf` will ask. The responses are recorded in the `debconf` database for future reference. The script is generally executed by `apt` prior to installing packages one by one in order to group all the questions together at the beginning of the process. The pre- and post-installation scripts can then use this information to operate according to your wishes.

The `debconf` Tool

The `debconf` tool was created to resolve a recurring problem in Debian. All Debian packages unable to function without a minimum of configuration used to ask questions with calls to the `echo` and `read` commands in `postinst` shell scripts (and other similar scripts). This forced the installer to babysit large installations or updates in order to respond to various configuration queries as they arose. These manual interactions have now been almost entirely dispensed with, thanks to `debconf`.

The `debconf` tool has many interesting features: It requires the developer to specify user interaction; it allows localization of all the displayed strings (all translations are stored in the `templates` file describing the interactions); it provides different frontends for questions (text mode, graphical mode, non-interactive); and it allows creation of a central database of responses to share the same configuration with several computers. The most important feature is that all of the questions can be presented in a row, all at once, prior to starting a long installation or update process. Now, you can go about your business while the system handles the installation on its own, without having to stay there staring at the screen, waiting for questions to pop up.

8.4.3. Checksums, Conffiles

In addition to the maintainer scripts and control data already mentioned in the previous sections, the `control.tar.gz` archive of a Debian package may contain other interesting files:

```
# ar p /var/cache/apt/archives/bash_4.4-2_amd64.deb control.tar.gz | tar -tzf -
```

```
./
./conffiles
./control
./md5sums
./postinst
./postrm
./preinst
./prerm
```

The first—`md5sums`—contains the MD5 checksums for all of the package's files. Its main advantage is that it allows `dpkg --verify` to check if these files have been modified since their installation. Note that when this file doesn't exist, `dpkg` will generate it dynamically at installation time (and store it in the dpkg database just like other control files).

`conffiles` lists package files that must be handled as configuration files. Configuration files can be modified by the administrator, and `dpkg` will try to preserve those changes during a package update.

In effect, in this situation, `dpkg` behaves as intelligently as possible: if the standard configuration file has not changed between the two versions, it does nothing. If, however, the file has changed, it will try to update this file. Two cases are possible: either the administrator has not touched this configuration file, in which case `dpkg` automatically installs the new version; or the file has been modified, in which case `dpkg` asks the administrator which version they wish to use (the old one with modifications, or the new one provided with the package). To assist in making this decision, `dpkg` offers to display a `diff` that shows the difference between the two versions. If you choose to retain the old version, the new one will be stored in the same location in a file with the `.dpkg-dist` suffix. If you choose the new version, the old one is retained in a file with the `.dpkg-old` suffix. Another available action consists of momentarily interrupting `dpkg` to edit the file and attempt to reinstate the relevant modifications (previously identified with `diff`).

`dpkg` handles configuration file updates, but, while doing so, regularly interrupts its work to ask for input from the administrator. This can be time consuming and inconvenient. Fortunately, you can instruct `dpkg` to respond to these prompts automatically. The `--force-confold` option retains the old version of the file, while `--force-confnew` will use the new version. These choices are respected, even if the file has not been changed by the administrator, which only rarely has the desired effect. Adding the `--force-confdef` option tells `dpkg` to decide by itself when possible (in other words, when the original configuration file has not been touched), and only uses `--force-confnew` or `--force-confold` for other cases.

These options apply to `dpkg`, but most of the time the administrator will work directly with the `aptitude` or `apt` programs. It is, thus, necessary to know the syntax used to indicate the options to pass to the `dpkg` command (their command line interfaces are very similar).

```
# apt -o DPkg::options::="--force-confdef" -o DPkg::options::="--force-confold" full-
    ➥ upgrade
```

These options can be stored directly in `apt`'s configuration. To do so, simply write the following line in the `/etc/apt/apt.conf.d/local` file:

```
DPkg::options { "--force-confdef"; "--force-confold"; }
```

Including this option in the configuration file means that it will also be used in a graphical interface such as `aptitude`.

Conversely, you can also force `dpkg` to ask configuration file questions. The `--force-confask` option instructs `dpkg` to display the questions about the configuration files, even in cases where they would not normally be necessary. Thus, when reinstalling a package with this option, `dpkg` will ask the questions again for all of the configuration files modified by the administrator. This is very convenient, especially for reinstalling the original configuration file if it has been deleted and no other copy is available: a normal re-installation won't work, because `dpkg` considers removal as a form of legitimate modification, and, thus, doesn't install the desired configuration file.

8.5. Summary

In this section, we learned more about the Debian package system, discussed the Advanced Package Tool (APT) and `dpkg`, learned about basic package interaction, advanced APT configuration and usage, and dug deeper into the Debian package system with a brief reference of the `.deb` file format. We looked at the `control` file, configuration scripts, checksums, and the `conffiles` file.

Summary Tips:

A Debian package is a compressed archive of a software application. It contains the application's files as well as other metadata including the names of the dependencies that the application needs as well as scripts that enable the execution of commands at different stages in the package's lifecycle (installation, removal, upgrades).

The `dpkg` tool, contrary to `apt` and `apt-get` (of the APT family), has no knowledge of all the available packages that could be used to fulfill package dependencies. Thus, to manage Debian packages, you will likely use the latter tools as they are able to automatically resolve dependency issues.

You can use APT to install and remove applications, update packages, and even upgrade your entire system. Here are the key points that you should know about APT and its configuration:

- The `sources.list` file is the key configuration file for defining package sources (or repositories that contain packages).
- Debian and Kali use three sections to differentiate packages according to the licenses chosen by the authors of each work: `main` contains all packages that fully comply with the Debian Free Software Guidelines[6]; `non-free` contains software that does not (entirely) conform to the Free Software Guidelines but can nevertheless be distributed without restrictions; and

[6] `https://www.debian.org/social_contract#guidelines`

contrib (contributions) includes open source software that cannot function without some non-free elements.

- Kali maintains several repositories including: kali-rolling, which is the main repository for end-users and should always contain installable and recent packages; kali-dev, which is used by Kali developers and is not for public use; and kali-bleeding-edge, which often contains untested and un-vetted packages automatically built out of the upstream Git (or Subversion) repository less than twenty-four hours after they have been committed.
- When working with APT, you should first download the list of currently-available packages with `apt update`.
- You can add a package to the system with a simple `apt install` *`package`*. APT will automatically install the necessary dependencies.
- To remove a package use `apt remove` *`package`*. It will also remove the reverse dependencies of the package (i.e. packages that depend on the package to be removed).
- To remove all data associated with a package, you can "purge" the package with the `apt purge` *`package`* command. Unlike a removal, this will not only remove the package but also its configuration files and sometimes the associated user data.

We recommend regular upgrades to install the latest security updates. To upgrade, use `apt update` followed by either `apt upgrade`, `apt-get upgrade`, or `aptitude safe-upgrade`. These commands look for installed packages that can be upgraded without removing any packages.

For more important upgrades, such as major version upgrades, use `apt full-upgrade`. With this instruction, `apt` will complete the upgrade even if it has to remove some obsolete packages or install new dependencies. This is also the command that you should use for regular upgrades of your Kali Rolling system. Review the pros and cons of updates we outlined in this chapter.

Several tools can be used to inspect Debian packages:

- `dpkg --listfiles` *package* (or -L) lists the files that were installed by the specified package.
- `dpkg --search` *`file`* (or -S) finds any packages containing the file or path passed in the argument.
- `dpkg --list` (or -l) displays the list of packages known to the system and their installation status.
- `dpkg --contents` *`file.deb`* (or -c) lists all the files in a particular `.deb` file.
- `dpkg --info` *`file.deb`* (or -I) displays the headers of the specified `.deb` file.
- The various `apt-cache` subcommands display much of the information stored in APT's internal database.

To avoid excessive disk usage, you should regularly sort through `/var/cache/apt/archives/`. Two commands can be used for this: `apt clean` (or `apt-get clean`) entirely empties the direc-

tory; `apt autoclean` (`apt-get autoclean`) only removes packages that can no longer be downloaded because they have disappeared from the mirror and are therefore useless.

Aptitude is an interactive program that can be used in semi-graphical mode on the console. It is an extremely robust program that can help you install and troubleshoot packages.

`synaptic` is a graphical package manager that features a clean and efficient graphical interface.

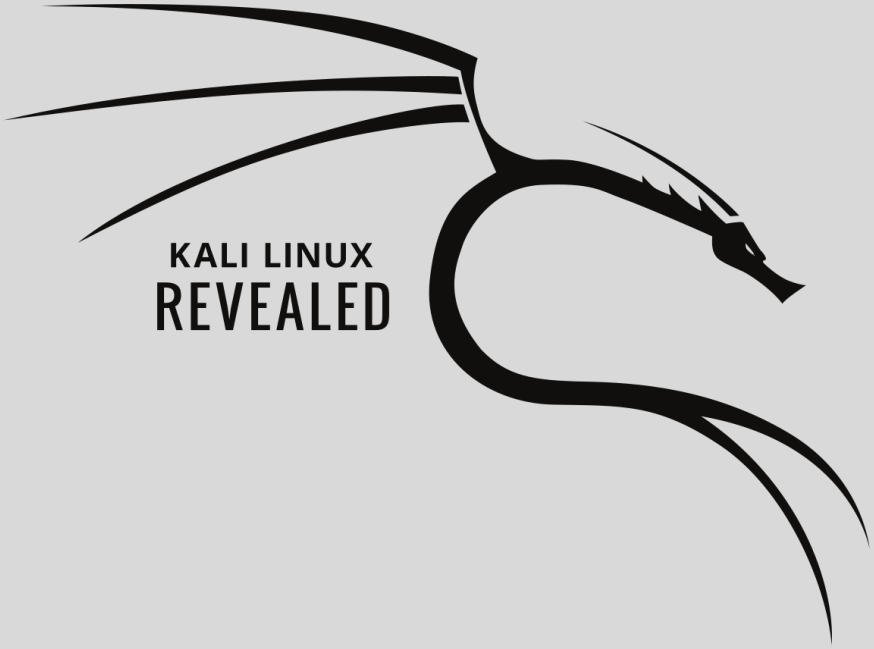
As an advanced user, you can create files in `/etc/apt/apt.conf.d/` to configure certain aspects of APT. You can also manage package priorities, track automatically installed packages, work with several distributions or architectures at once, use cryptographic signatures to validate packages, and upgrade files using the techniques outlined in this chapter.

In spite of the Kali/Debian maintainers' best efforts, a system upgrade isn't always as smooth as we would hope. When this happens, you can look at the Kali bug tracker[7] and at the Debian bug tracking system[8] at https://bugs.debian.org/*package* to check whether the problem has already been reported. You can also try to downgrade the package or to debug and repair a failed package maintainer script.

[7] `http://bugs.kali.org`
[8] `https://bugs.debian.org`

Keywords

Custom packages
Custom kernel
Custom images
live-build
Persistence



Chapter

9 Advanced Usage

Contents

Kali has been built as a highly modular and customizable penetration testing framework and allows for some fairly advanced customization and usage. Customizations can happen at multiple levels, beginning at the source code level. The sources of all Kali packages are publicly available. In this chapter, we will show how you can retrieve packages, modify them, and build your own customized packages out of them. The Linux kernel is somewhat of a special case and as such, it is covered in a dedicated section (section 9.2, "Recompiling the Linux Kernel" [page 232]), where we will discuss where to find sources, how to configure the kernel build, and finally how to compile it and how to build the associated kernel packages.

The second level of customization is in the process of building live ISO images. We will show how the `live-build` tool offers plenty of hooks and configuration options to customize the resulting ISO image, including the possibility to use custom Debian packages in place of the packages available on mirrors.

We will also discuss how you can create a persistent live ISO built onto a USB key that will preserve files and operating system changes between reboots.

9.1. Modifying Kali Packages

Modifying Kali packages is usually a task for Kali contributors and developers: they update packages with new upstream versions, they tweak the default configuration for a better integration in the distribution, or they fix bugs reported by users. But you might have specific needs not fulfilled by the official packages and knowing how to build a modified package can thus be very valuable.

You might wonder why you need to bother with the package at all. After all, if you have to modify a piece of software, you can always grab its source code (usually with `git`) and run the modified version directly from the source checkout. This is fine when it is possible and when you use your home directory for this purpose, but if your application requires a system-wide setup (for example, with a `make install` step) then it will pollute your file system with files unknown to `dpkg` and will soon create problems that cannot be caught by package dependencies. Furthermore, with proper packages you will be able to share your changes and deploy them on multiple computers much more easily or revert the changes after having discovered that they were not working as well as you hoped.

So when would you want to modify a package? Let's take a look at a few examples. First, we will assume that you are a heavy user of SET and you noticed a new upstream release but the Kali developers are all busy for a conference and you want to try it out immediately. You want to update the package yourself. In another case, we will assume that you are struggling to get your MIFARE NFC card working and you want to rebuild "libfreefare" to enable debug messages in order to have actionable data to provide in a bug report that you are currently preparing. In a last case, we will assume that the "pyrit" program fails with a cryptic error message. After a web search, you find a commit that you expect to fix your problem in the upstream GitHub repository and you want to rebuild the package with this fix applied.

We will go through all those samples in the following sections. We will try to generalize the explanations so that you can better apply the instructions to other cases but it is impossible to cover all situations that you might encounter. If you hit problems, apply your best judgment to find a solution or go seek help on the most appropriate forums (see chapter 6, "Helping Yourself and Getting Help" [page 124]).

Whatever change you want to make, the general process is always the same: grab the source package, extract it, make your changes, then build the package. But for each step, there are often multiple tools that can handle the task. We picked the most relevant and most popular tools, but our review is not exhaustive.

9.1.1. Getting the Sources

Rebuilding a Kali package starts with getting its source code. A source package is composed of multiple files: the main file is the `*.dsc` (*Debian Source Control*) file as it lists the other accompanying files, which can be `*.tar.`*`gz,bz2,xz`*, sometimes `*.diff.gz`, or `*.debian.tar.`*`gz,bz2,xz` files.

The source packages are stored on Kali mirrors that are available over HTTP. You could use your web browser to download all the required files but the easiest way to accomplish this is to use the `apt source` *`source_package_name`* command. This command requires a deb-src line in the `/etc/apt/sources.list` file and up-to-date index files (accomplished by running `apt update`). By default, Kali doesn't add the required line as few Kali users actually need to retrieve source packages but you can easily add it (see sample file in section 8.1.3, "Kali Repositories" [page 173] and the associated explanations in section 8.1.2, "Understanding the `sources.list` File" [page 172]).

```
$ apt source libfreefare
Reading package lists... Done
NOTICE: 'libfreefare' packaging is maintained in the 'Git' version control system at:
git://anonscm.debian.org/collab-maint/libnfc.git
Please use:
git clone git://anonscm.debian.org/collab-maint/libnfc.git
to retrieve the latest (possibly unreleased) updates to the package.
Need to get 119 kB of source archives.
Get:1 http://archive-2.kali.org/kali kali-rolling/main libfreefare 0.4.0-2 (dsc) [2,090 B]
Get:2 http://archive-2.kali.org/kali kali-rolling/main libfreefare 0.4.0-2 (tar) [113 kB]
Get:3 http://archive-2.kali.org/kali kali-rolling/main libfreefare 0.4.0-2 (diff) [3,640 B]
Fetched 119 kB in 1s (63.4 kB/s)
gpgv: keyblock resource '/home/rhertzog/.gnupg/trustedkeys.gpg': file open error
gpgv: Signature made Tue 04 Mar 2014 06:57:36 PM EST using RSA key ID 40AD1FA6
gpgv: Can't check signature: public key not found
dpkg-source: warning: failed to verify signature on ./libfreefare_0.4.0-2.dsc
dpkg-source: info: extracting libfreefare in libfreefare-0.4.0
dpkg-source: info: unpacking libfreefare_0.4.0.orig.tar.gz
dpkg-source: info: unpacking libfreefare_0.4.0-2.debian.tar.xz
$ cd libfreefare-0.4.0
$ ls
AUTHORS    CMakeLists.txt  COPYING   HACKING            m4           README
ChangeLog  configure.ac    debian    libfreefare        Makefile.am  test
```

```
cmake      contrib         examples  libfreefare.pc.in  NEWS         TODO
$ ls debian
changelog  copyright               libfreefare-dev.install  rules
compat     libfreefare0.install    libfreefare-doc.install  source
control    libfreefare-bin.install  README.Source            watch
```

In this example, while we received the source package from a Kali mirror, the package is the same as in Debian since the version string doesn't contain "kali." This means that no kali-specific changes have been applied.

If you need a specific version of the source package, which is currently not available in the repositories listed in `/etc/apt/sources.list`, then the easiest way to download it is to find out the URL of its `.dsc` file by looking it up on `http://pkg.kali.org` and then handing that URL over to `dget` (from the *devscripts* package).

After having looked up the URL of the libreefare source package available in kali-bleeding-edge, you can download it with `dget`. It will first download the `.dsc` file, then parse it to know what other files are referenced, and then download those from the same location:

```
$ dget http://http.kali.org/pool/main/libf/libfreefare/libfreefare_0.4.0+0~
    ➥ git1439352548.ffde4d-1.dsc
dget: retrieving http://http.kali.org/pool/main/libf/libfreefare/libfreefare_0.4.0+0~
    ➥ git1439352548.ffde4d-1.dsc
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100   364  100   364    0     0    852      0 --:--:-- --:--:-- --:--:--   854
100  1935  100  1935    0     0   2650      0 --:--:-- --:--:-- --:--:-- 19948
dget: retrieving http://http.kali.org/pool/main/libf/libfreefare/libfreefare_0.4.0+0~
    ➥ git1439352548.ffde4d.orig.tar.gz
[...]
dget: retrieving http://http.kali.org/pool/main/libf/libfreefare/libfreefare_0.4.0+0~
    ➥ git1439352548.ffde4d-1.debian.tar.xz
[...]
libfreefare_0.4.0+0~git1439352548.ffde4d-1.dsc:
dscverify: libfreefare_0.4.0+0~git1439352548.ffde4d-1.dsc failed signature check:
gpg: Signature made Wed Aug 12 06:14:03 2015 CEST
gpg:                using RSA key 43EF73F4BD8096DA
gpg: Can't check signature: No public key
Validation FAILED!!
$ dpkg-source -x libfreefare_0.4.0+0~git1439352548.ffde4d-1.dsc
gpgv: Signature made Wed Aug 12 06:14:03 2015 CEST
gpgv:                using RSA key 43EF73F4BD8096DA
gpgv: Can't check signature: No public key
dpkg-source: warning: failed to verify signature on ./libfreefare_0.4.0+0~git1439352548
    ➥ .ffde4d-1.dsc
dpkg-source: info: extracting libfreefare in libfreefare-0.4.0+0~git1439352548.ffde4d
dpkg-source: info: unpacking libfreefare_0.4.0+0~git1439352548.ffde4d.orig.tar.gz
dpkg-source: info: unpacking libfreefare_0.4.0+0~git1439352548.ffde4d-1.debian.tar.xz
```

It is worth noting that `dget` did not automatically extract the source package because it could not verify the PGP signature on the source package. Thus we did that step manually with `dpkg-source -x` *`dsc-file`*. You can also force the source package extraction by passing the --allow-unauthenticated or -u option. Inversely, you can use --download-only to skip the source package extraction step.

Retrieving Sources from Git

You might have noticed that the `apt source` invocation tells you about a possible Git repository used to maintain the package. It might point to a Debian Git repository or to a Kali Git repository.

All Kali-specific packages are maintained in Git repositories hosted on git.kali.org[1]. You can retrieve the sources from those repositories with `git clone git://git.kali.org/packages/`*`source-package`*. If the operation doesn't yield the expected sources, try switching to the `kali/master` branch with `git checkout kali/master`.

Contrary to what you get with `apt source`, the obtained tree will not have patches automatically applied. Have a look at `debian/patches/` to learn about the possible changes made by Kali.

```
$ git clone git://git.kali.org/packages/kali-meta
Cloning into 'kali-meta'...
remote: Counting objects: 760, done.
remote: Compressing objects: 100% (614/614), done.
remote: Total 760 (delta 279), reused 0 (delta 0)
Receiving objects: 100% (760/760), 141.01 KiB | 0 bytes/s,
    ➥ done.
Resolving deltas: 100% (279/279), done.
Checking connectivity... done.
$ cd kali-meta
$ ls
debian
$ ls debian
changelog  compat  control  copyright  rules  source
```

You can use the git repositories as another way to retrieve the sources and thus (mostly) follow the other instructions from this section. But when Kali developers work with those repositories, they use another packaging workflow and use tools from the *git-buildpackage* package that we will not cover here. You can learn more about those tools here:

➨ `https://honk.sigxcpu.org/piki/projects/git-buildpackage/`

[1] `http://git.kali.org`

9.1.2. Installing Build Dependencies

Now that you have the sources, you still need to install build dependencies. They will be necessary to build the desired binary packages but are also likely required for partial builds that you might want to run to test the changes while you make them.

Each source package declares its build dependencies in the Build-Depends field of the `debian/control` file. Let's instruct `apt` to install those (assuming that you are in a directory containing an unpacked source package):

```
$ sudo apt build-dep ./
Note, using directory './' to get the build dependencies
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  autoconf automake autopoint autotools-dev debhelper dh-autoreconf
  dh-strip-nondeterminism gettext intltool-debian libarchive-zip-perl
  libfile-stripnondeterminism-perl libtool po-debconf
0 upgraded, 13 newly installed, 0 to remove and 0 not upgraded.
Need to get 4 456 kB of archives.
After this operation, 14,6 MB of additional disk space will be used.
Do you want to continue? [Y/n]
[…]
```

In this sample, all build dependencies can be satisfied with packages available to APT. This might not always be the case as the tool building kali-rolling does not ensure installability of build dependencies (only dependencies of binary packages are taken into account). In practice, binary dependencies and build dependencies are often tightly coupled and most packages will have their build dependencies satisfiable.

9.1.3. Making Changes

We can't cover all the possible changes that you might want to make to a given package in this section. This would amount to teaching you all the nitty gritty[2] details of Debian packaging. However, we will cover the three common use cases presented earlier and we will explain some of the unavoidable parts (like maintaining the `changelog` file).

The first thing to do is to change the package version number so that the rebuilt packages can be distinguished from the original packages provided by Kali or Debian. To achieve this, we usually add a suffix identifying the entity (person or company) applying the changes. Since `buxy` is my IRC nickname, I will use it as a suffix. Such a change is best effected with the `dch` command (*Debian CHangelog*) from the *devscripts* package, with a command such as `dch --local buxy`. This invokes

[2] `https://www.debian.org/doc/manuals/maint-guide/`

a text editor (`sensible-editor`, which runs the editor assigned in the `VISUAL` or `EDITOR` environment variables, or `/usr/bin/editor` otherwise), which allows you to document the differences introduced by this rebuild. This editor shows that `dch` really did change the `debian/changelog` file:

```
$ head -n 1 debian/changelog
libfreefare (0.4.0-2) unstable; urgency=low
$ dch --local buxy
[...]
$ head debian/changelog
libfreefare (0.4.0-2buxy1) UNRELEASED; urgency=medium

  * Enable --with-debug configure option.

 -- Raphael Hertzog <buxy@kali.org>  Fri, 22 Apr 2016 10:36:00 -0400

libfreefare (0.4.0-2) unstable; urgency=low

  *  Update debian/copyrtight.
     Fix license to LGPL3+.
```

If you do such changes regularly, you might want to set the DEBFULLNAME and DEBEMAIL environment variables to your full name and your email, respectively. Their values will be used by many packaging tools, including `dch`, which will embed them on the trailer line shown above (starting with " -- ").

Applying a Patch

In one of our use cases, we have downloaded the *pyrit* source package and we want to apply a patch that we found in the upstream git repository. This is a common operation and it should always be simple. Unfortunately, patches can be handled in different ways depending on the source package format and on the Git packaging workflow in use (when Git is used to maintain the package).

With an Unpacked Source Package You have run `apt source pyrit` and you have a `pyrit-0.4.0` directory. You can apply your patch directly with `patch -p1 < patch-file`:

```
$ apt source pyrit
[...]
$ cd pyrit-0.4.0
$ wget https://github.com/JPaulMora/Pyrit/commit/14
    ➥ ec997174b8e8fd20d22b6a97c57e19633f12a0.patch -O /tmp/pyrit-patch
[...]
$ patch -p1 </tmp/pyrit-patch
patching file cpyrit/pckttools.py
```

```
Hunk #1 succeeded at 53 (offset -1 lines).
$ dch --local buxy "Apply patch to work with scapy 2.3"
```

At this point, you have manually patched the source code and you can already build binary packages of your modified version (see section 9.1.4, "Starting the Build" [page 230]). But if you try to build an updated source package, it will fail, complaining about "unexpected upstream changes." This is because pyrit (like a majority of the source packages) uses the source format (see `debian/source/format` file) known as 3.0 (quilt), where changes to the upstream code must be recorded in separate patches stored in `debian/patches/` and where the `debian/patches/series` file indicates the order in which patches must be applied. You can register your changes in a new patch by running `dpkg-source --commit`:

```
$ dpkg-source --commit
dpkg-source: info: local changes detected, the modified files are:
 pyrit-0.4.0/cpyrit/pckttools.py
Enter the desired patch name: fix-for-scapy-2.3.patch
dpkg-source: info: local changes have been recorded in a new patch: pyrit-0.4.0/debian/
    ➥ patches/fix-for-scapy-2.3.patch
$ tail -n 1 debian/patches/series
fix-for-scapy-2.3.patch
```

Quilt Patch Series This patch management convention has been popularized by a tool named `quilt` and the "3.0 (quilt)" source package format is thus compatible with this tool—with the small deviation that it uses `debian/patches` instead of `patches`. This tool is available in the package of the same name and you can find a nice tutorial here:

➨ `https://raphaelhertzog.com/2012/08/08/how-to-use-quilt-to-manage-patches-in-debian-packages/`

If the source package uses the 1.0 or 3.0 (native) source format, then there is no requirement to register your upstream changes in a patch. They are automatically bundled in the resulting source package.

With a Git Repository If you have used Git to retrieve the source package, the situation is even more complicated. There are multiple Git workflows and associated tools, and obviously not all Debian packages are using the same workflows and tools. The distinction already explained about source format is still relevant but you must also check whether patches are pre-applied in the source tree or whether they are only stored in `debian/patches` (in this case, they are then applied at build time).

The most popular tool is *git-buildpackage*. It is what we use to manage all repositories on git.kali.org. When you use it, patches are not pre-applied in the source tree but they are stored in `debian/patches`. You can manually add patches in that directory and list them in `debian/patches/`

`series` but users of git-buildpackage tend to use `gbp pq` to edit the entire patch series as a single branch that you can extend or rebase to your liking. Check `gbp-pq(1)` to learn how to invoke it.

git-dpm (with associated command of the same name) is another git packaging tool that you can find in use. It records metadata in `debian/.git-dpm` and keeps patches applied in the source tree by merging a constantly-rebased branch that it builds out of the content of `debian/patches`.

Tweaking Build Options

You usually have to tweak build options when you want to enable an optional feature or behavior that is not activated in the official package, or when you want to customize parameters that are set at build time through a `./configure` option or through variables set in the build environment.

In those cases, the changes are usually limited to `debian/rules`, which drives the steps in the package build process. In the simplest cases, the lines concerning the initial configuration (./configure ...) or the actual build ($(MAKE) ... or make ...) are easy to spot. If these commands are not explicitly called, they are probably a side effect of another explicit command, in which case, please refer to their documentation to learn more about how to change the default behavior. With packages using `dh`, you might need to add an override for the `dh_auto_configure` or `dh_auto_build` commands (see their respective manual pages for explanations on how to achieve this).

To make those explanations more concrete, let's apply them to our sample use case. You decided to modify libfreefare to pass the --enable-debug option to the `./configure` script so that you could get a more verbose output from your near field communication (NFC) tools and file a better bug report about your non-recognized Mifare NFC card. Since the package uses `dh` to drive the build process, you add (or in this case modify) the override_dh_auto_configure target. Here is the corresponding extract of libfreefare's `debian/rules` file:

```
override_dh_auto_configure:
        dh_auto_configure -- --without-cutter --disable-silent-rules --enable-debug
```

Packaging a New Upstream Version

Let's take a look at an example at this point, as we discuss packaging upstream versions. Let's say you are a SET power-user and you noticed a new upstream release (7.4.5) that is not yet available in Kali (which only has version 7.4.4). You want to build an updated package and try it out. This is a minor version bump and you thus don't expect the update to require any change at the packaging level.

To update the source package, you extract the new source tarball next to the current source package and you copy the `debian` directory from the current source package to the new one. Then you bump the version in `debian/changelog`.

```
$ apt source set
Reading package lists... Done
NOTICE: 'set' packaging is maintained in the 'Git' version control system at:
git://git.kali.org/packages/set.git
Please use:
git clone git://git.kali.org/packages/set.git
to retrieve the latest (possibly unreleased) updates to the package.
Need to get 42.3 MB of source archives.
[...]
dpkg-source: warning: failed to verify signature on ./set_7.4.4-0kali1.dsc
dpkg-source: info: extracting set in set-7.4.4
dpkg-source: info: unpacking set_7.4.4.orig.tar.gz
dpkg-source: info: unpacking set_7.4.4-0kali1.debian.tar.xz
dpkg-source: info: applying edit-config-file
dpkg-source: info: applying fix-path-interpreter.patch
$ wget https://github.com/trustedsec/social-engineer-toolkit/archive/7.4.5.tar.gz -O
    ➥ set_7.4.5.orig.tar.gz
[...]
$ tar xvf set_7.4.5.orig.tar.gz
[...]
social-engineer-toolkit-7.4.5/src/wireless/wifiattack.py
$ cp -a set-7.4.4/debian social-engineer-toolkit-7.4.5/debian
$ cd social-engineer-toolkit-7.4.5
$ dch -v 7.4.5-0buxy1 "New upstream release"
```

That's it. You can now build the updated package.

Depending on the kind of changes that the new upstream version introduces, you may also need to change build dependencies and run-time dependencies, and install new files. Those are much more involved operations that are not covered by this book.

9.1.4. Starting the Build

When all the needed changes have been applied to the sources, you can start generating the actual binary package or `.deb` file. The whole process is managed by the `dpkg-buildpackage` command and it looks like this:

```
$ dpkg-buildpackage -us -uc -b
dpkg-buildpackage: source package libfreefare
dpkg-buildpackage: source version 0.4.0-2buxy1
dpkg-buildpackage: source distribution UNRELEASED
dpkg-buildpackage: source changed by Raphael Hertzog <buxy@kali.org>
dpkg-buildpackage: host architecture amd64
[...]
   dh_builddeb
dpkg-deb: building package 'libfreefare0-dbgsym' in '../libfreefare0-dbgsym_0.4.0-2buxy1_amd64.deb'.
dpkg-deb: building package 'libfreefare0' in '../libfreefare0_0.4.0-2buxy1_amd64.deb'.
dpkg-deb: building package 'libfreefare-dev' in '../libfreefare-dev_0.4.0-2buxy1_amd64.deb'.
dpkg-deb: building package 'libfreefare-bin-dbgsym' in '../libfreefare-bin-dbgsym_0.4.0-2buxy1_amd64.deb'.
```

```
dpkg-deb: building package 'libfreefare-bin' in '../libfreefare-bin_0.4.0-2buxy1_amd64.deb'.
dpkg-deb: building package 'libfreefare-doc' in '../libfreefare-doc_0.4.0-2buxy1_all.deb'.
 dpkg-genchanges -b >../libfreefare_0.4.0-2buxy1_amd64.changes
dpkg-genchanges: binary-only upload (no source code included)
 dpkg-source --after-build libfreefare-0.4.0
dpkg-buildpackage: binary-only upload (no source included)
```

The -us -uc options disable signatures on some of the generated files (`.dsc`, `.changes`) because this operation will fail if you do not have a GnuPG key associated with the identity you have put in the `changelog` file. The -b option asks for a "binary-only build." In this case, the source package (`.dsc`) will not be created, only the binary (`.deb`) packages will. Use this option to avoid failures during the source package build: if you haven't properly recorded your changes in the patch management system, it might complain and interrupt the build process.

As suggested by `dpkg-deb`'s messages, the generated binary packages are now available in the parent directory (the one that hosts the directory of the source package). You can install them with `dpkg -i` or `apt install`.

```
$ sudo apt install ../libfreefare0_0.4.0-2buxy1_amd64.deb \
  ../libfreefare-bin_0.4.0-2buxy1_amd64.deb
Reading package lists... Done
Building dependency tree
Reading state information... Done
Note, selecting 'libfreefare0' instead of '../libfreefare0_0.4.0-2buxy1_amd64.deb'
Note, selecting 'libfreefare-bin' instead of '../libfreefare-bin_0.4.0-2buxy1_amd64.deb'
The following packages will be upgraded:
  libfreefare-bin libfreefare0
2 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
Need to get 0 B/69,4 kB of archives.
After this operation, 2 048 B of additional disk space will be used.
[...]
```

We prefer `apt install` over `dpkg -i` as it will deal with missing dependencies gracefully. But not so long ago, you had to use `dpkg` as `apt` was not able to deal with `.deb` files outside of any repository.

`dpkg-buildpackage` wrappers

More often than not, Debian developers use a higher-level program such as `debuild`; this runs `dpkg-buildpackage` as usual, but it also adds an invocation of a program (`lintian`) that runs many checks to validate the generated package against the Debian policy[3]. This script also cleans up the environment so that local environment variables do not pollute the package build. The `debuild` command is one of the tools in the *devscripts* suite, which share some consistency and configuration to make the maintainers' task easier.

[3] `https://www.debian.org/doc/debian-policy/`

9.2. Recompiling the Linux Kernel

The kernels provided by Kali include the largest possible number of features, as well as the maximum number of drivers, in order to cover the broadest spectrum of existing hardware configurations. This is why some users prefer to recompile the kernel in order to include only what they specifically need. There are two reasons for this choice. First, it is a way to optimize memory consumption since all kernel code, even if it is never used, occupies physical memory. Because the statically compiled portions of the kernel are never moved to swap space, an overall decrease in system performance will result from having drivers and features built in that are never used. Second, reducing the number of drivers and kernel features reduces the risk of security problems since only a fraction of the available kernel code is being run.

> Important
>
> 
>
> If you choose to compile your own kernel, you must accept the consequences: Kali cannot ensure security updates for your custom kernel. By keeping the kernel provided by Kali, you benefit from updates prepared by the Debian Project.

Recompilation of the kernel is also necessary if you want to use certain features that are only available as patches (and not included in the standard kernel version).

The Debian Kernel Handbook

The Debian kernel team maintains the *Debian Kernel Handbook* (also available in the *debian-kernel-handbook* package) with comprehensive documentation about most kernel-related tasks and about how official Debian kernel packages are handled. This is the first place you should look into if you need more information than what is provided in this section.

➨ `http://kernel-handbook.alioth.debian.org`

9.2.1. Introduction and Prerequisites

Unsurprisingly, Debian and Kali manage the kernel in the form of a package, which is not how kernels have traditionally been compiled and installed. Since the kernel remains under the control of the packaging system, it can then be removed cleanly, or deployed on several machines. Furthermore, the scripts associated with these packages automate the interaction with the bootloader and the initrd generator.

The upstream Linux sources contain everything needed to build a Debian package of the kernel but you still need to install the *build-essential* package to ensure that you have the tools required to

build a Debian package. Furthermore, the configuration step for the kernel requires the *libncurses5-dev* package. Finally, the *fakeroot* package will enable creation of the Debian package without needing administrative privileges.

```
# apt install build-essential libncurses5-dev fakeroot
```

9.2.2. Getting the Sources

Since the Linux kernel sources are available as a package, you can retrieve them by installing the *linux-source*-version package. The `apt-cache search ^linux-source` command should list the latest kernel version packaged by Kali. Note that the source code contained in these packages does not correspond precisely with that published by Linus Torvalds and the kernel developers[4]; like all distributions, Debian and Kali apply a number of patches, which might (or might not) find their way into the upstream version of Linux. These modifications include backports of fixes/features/drivers from newer kernel versions, new features not yet (entirely) merged in the upstream Linux tree, and sometimes even Debian or Kali specific changes.

The remainder of this section focuses on the 4.9 version of the Linux kernel, but the examples can, of course, be adapted to the particular version of the kernel that you want.

In this example, we assume that the *linux-source-4.9* binary package has been installed. Note that we install a binary package containing the upstream sources but do not retrieve the Kali source package named *linux*.

```
# apt install linux-source-4.9
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  bc libreadline7
Suggested packages:
  libncurses-dev | ncurses-dev libqt4-dev
The following NEW packages will be installed:
  bc libreadline7 linux-source-4.9
0 upgraded, 3 newly installed, 0 to remove and 0 not upgraded.
Need to get 95.4 MB of archives.
After this operation, 95.8 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
[...]
# ls /usr/src
linux-config-4.9  linux-patch-4.9-rt.patch.xz  linux-source-4.9.tar.xz
```

Notice that the package contains `/usr/src/linux-source-4.9.tar.xz`, a compressed archive of the kernel sources. You must extract these files in a new directory (not directly under `/usr/src/`,

[4] `https://kernel.org/`

since there is no need for special permissions to compile a Linux kernel). Instead, `~/kernel/` is more appropriate.

```
$ mkdir ~/kernel; cd ~/kernel
$ tar -xaf /usr/src/linux-source-4.9.tar.xz
```

9.2.3. Configuring the Kernel

The next step consists of configuring the kernel according to your needs. The exact procedure depends on the goals.

The kernel build depends on a kernel configuration file. In most cases, you will most likely keep as close as possible to that proposed by Kali, which, like all Linux distributions, is installed in the `/boot` directory. In this case, rather than reconfiguring everything from scratch, it is sufficient to make a copy of the `/boot/config-`*`version`* file. (The version should be the same as that version of the kernel currently used, which can be found with the `uname -r` command.) Place the copy into a `.config` file in the directory containing the kernel sources.

```
$ cp /boot/config-4.9.0-kali1-amd64 ~/kernel/linux-source-4.9/.config
```

Alternatively, since the kernel provides default configurations in `arch/`*`arch`*`/configs/*_defconfig`, you can put your selected configuration in place with a command like `make x86_64_defconfig` (in the case of a 64-bit PC) or `make i386_defconfig` (in the case of a 32-bit PC).

Unless you need to change the configuration, you can stop here and skip to section 9.2.4, "Compiling and Building the Package" [page 235]. If you need to make changes or if you decide to reconfigure everything from scratch, you must take the time to configure your kernel. There are various dedicated interfaces in the kernel source directory that can be used by calling the `make` *`target`* command, where *target* is one of the values described below.

`make menuconfig` compiles and launches a text-mode kernel configuration interface (this is where the *libncurses5-dev* package is required), which allows navigating the many available kernel options in a hierarchical structure. Pressing the Space key changes the value of the selected option, and Enter validates the button selected at the bottom of the screen; Select returns to the selected sub-menu; Exit closes the current screen and moves back up in the hierarchy; Help will display more detailed information on the role of the selected option. The arrow keys allow moving within the list of options and buttons. To exit the configuration program, choose Exit from the main menu. The program then offers to save the changes that you have made; accept if you are satisfied with your choices.

Other interfaces have similar features but they work within more modern graphical interfaces, such as `make xconfig`, which uses a Qt graphical interface, and `make gconfig`, which uses GTK+. The former requires *libqt4-dev*, while the latter depends on *libglade2-dev* and *libgtk2.0-dev*.

Dealing with Outdated `.config` Files

When you provide a `.config` file that has been generated with another (usually older) kernel version, you will have to update it. You can do so with `make oldconfig`, which will interactively ask you the questions corresponding to the new configuration options. If you want to use the default answer to all those questions, you can use `make olddefconfig`. With `make oldnoconfig`, it will assume a negative answer to all questions.

9.2.4. Compiling and Building the Package

Clean Up Before Rebuilding

If you have already compiled a kernel in the directory and wish to rebuild everything from scratch (for example because you substantially changed the kernel configuration), you will have to run `make clean` to remove the compiled files. `make distclean` removes even more generated files, including your `.config` file, so make sure to back it up first.

Once the kernel configuration is ready, a simple `make deb-pkg` will generate up to five Debian packages in standard `.deb` format: *linux-image*-version, which contains the kernel image and the associated modules; *linux-headers*-version, which contains the header files required to build external modules; *linux-firmware-image*-version, which contains the firmware files needed by some drivers (this package might be missing when you build from the kernel sources provided by Debian or Kali); *linux-image*-version-*dbg*, which contains the debugging symbols for the kernel image and its modules; and *linux-libc-dev*, which contains headers relevant to some user-space libraries like GNU's C library (glibc).

The *version* is defined by the concatenation of the upstream version (as defined by the variables VERSION, PATCHLEVEL, SUBLEVEL, and EXTRAVERSION in the `Makefile`), of the LOCALVERSION configuration parameter, and of the LOCALVERSION environment variable. The package version reuses the same version string with an appended revision that is regularly incremented (and stored in `.version`), except if you override it with the KDEB_PKGVERSION environment variable.

```
$ make deb-pkg LOCALVERSION=-custom KDEB_PKGVERSION=$(make kernelversion)-1
[...]
$ ls ../*.deb
../linux-headers-4.9.0-kali1-custom_4.9.2-1_amd64.deb
../linux-image-4.9.0-kali1-custom_4.9.2-1_amd64.deb
../linux-image-4.9.0-kali1-custom-dbg_4.9.2-1_amd64.deb
../linux-libc-dev_4.9.2-1_amd64.deb
```

To actually use the built kernel, the only step left is to install the required packages with `dpkg -i` *`file.deb`*. The "linux-image" package is required; you only have to install the "linux-headers" package if you have some external kernel modules to build, which is the case if you have some

"*-dkms" packages installed (check with `dpkg -l "*-dkms" | grep ^ii`). The other packages are generally not needed (Unless you know why you need them!).

9.3. Building Custom Kali Live ISO Images

Kali Linux has a ton of functionality and flexibility right out of the box. Once Kali is installed, you can perform all sorts of amazing feats with a little guidance, creativity, patience, and practice. However, you can also customize a Kali build so that it contains specific files or packages (to scale up or scale down performance and features) and can perform certain functions automatically. For example, the Kali ISO of Doom[5] and the Kali Evil Wireless Access Point[6] are both excellent projects that rely on a custom-built implementation of Kali Linux. Let's take a look at the process of rolling a custom Kali Linux ISO image.

Official Kali ISO images are built with live-build[7], which is a set of scripts that allows for the complete automation and customization of all facets of ISO image creation. The *live-build* suite uses an entire directory structure as input for its configuration. We store this configuration and some associated helper scripts in a live-build-config Git repository. We will use this repository as a basis for building customized images.

Before going further, you must know that the commands shown in this section are meant to be run on an up-to-date Kali Linux system. They are very likely to fail if run on a non-Kali system or if the system is out of date.

9.3.1. Installing Pre-Requisites

The first step is to install the packages needed and to retrieve the Git repository with the Kali *live-build* configuration:

```
# apt install curl git live-build
[...]
# git clone git://git.kali.org/live-build-config.git
[...]
# cd live-build-config
# ls
auto  build_all.sh  build.sh  kali-config  README
```

At this point, you can already create an updated (but unmodified) Kali ISO image just by running `./build.sh --verbose`. The build will take a long time to complete as it will download all the packages to include. When finished, you will find the new ISO image in the `images` directory.

[5] `https://www.offensive-security.com/kali-linux/kali-linux-iso-of-doom`
[6] `https://www.offensive-security.com/kali-linux/kali-linux-evil-wireless-access-point/`
[7] `http://debian-live.alioth.debian.org/live-build/`

9.3.2. Building Live Images with Different Desktop Environments

The `build.sh` live-build wrapper that we provide is responsible for setting up the `config` directory that `live-build` expects to find. It can put in place different configurations depending on its --variant option.

The wrapper creates the `config` directory by combining files from `kali-config/common` and `kali-config/variant-X`, where *X* is the name of a variant given with the --variant parameter. When the option is not explicitly given, it uses default as the name of the variant.

The `kali-config` directory contains directories for the most common desktop environments:

- `e17` for Enlightenment;
- `gnome` for GNOME;
- `i3wm` for the corresponding window manager;
- `kde` for KDE;
- `lxde` for LXDE;
- `mate` for the Mate Desktop Environment;
- `xfce` for XFCE.

The `light` variant is a bit special; it is based on XFCE[8] and is used to generate the official "light" ISO images that contain a reduced set of applications.

You can easily create a Kali live image using KDE as desktop environment with this single command:

```
# ./build.sh --variant kde --verbose
```

This concept of *variant* allows for some high-level pre-defined customizations but if you take the time to read through the Debian Live System Manual[9], you will discover many other ways to customize the images, just by changing the content of the appropriate sub-directory of `kali-config`. The following sections will provide some examples.

9.3.3. Changing the Set of Installed Packages

Once launched, `live-build` installs all the packages listed in `package-lists/*.list.chroot` files. The default configuration that we provide includes a `package-lists/kali.list.chroot` file, which lists *kali-linux-full* (the main meta-package pulling all the Kali packages to include). You can comment out this package and put another meta-package of your choice or include a precise set of other packages. You can also combine both approaches by starting with a meta-package and adding supplementary packages of your choice.

[8] `https://www.xfce.org/`

[9] `http://debian-live.alioth.debian.org/live-manual/unstable/manual/html/live-manual.en.html`

With `package-lists`, you can only include packages that are already available in the official Kali repository. But if you have custom packages, you can include them in the live image by placing the `.deb` files in a `packages.chroot` directory (for example `kali-config/config-gnome/packages.chroot` if you build the GNOME variant).

Meta-packages are empty packages whose sole purpose is to have many dependencies on other packages. They make it easier to install sets of packages that you often want to install together. The kali-meta source package builds all the meta-packages provided by Kali Linux:

- kali-linux: the base system (it is pulled by all the other meta-packages)
- kali-linux-full:the default Kali Linux installation
- kali-linux-all: meta-package of all the meta-packages and other packages (almost everything that Kali provides so it is really huge!)
- kali-linux-sdr: Software Defined Radio (SDR) tools
- kali-linux-gpu: GPU-powered tools (tools making use of the computing power available in your graphical card)
- kali-linux-wireless: wireless assessment and analysis tools
- kali-linux-web: web applications assessment tools
- kali-linux-forensic: forensic tools (finding evidence of what happened)
- kali-linux-voip: Voice Over IP tools
- kali-linux-pwtools: password cracking tools
- kali-linux-top10: the ten most popular tools
- kali-linux-rfid: RFID tools

You can leverage these meta-packages when you create custom package lists for `live-build`. The full list of available meta-packages and the tools they include can be found at `http://tools.kali.org/kali-metapackages`

Debconf Preseeding of Installed Packages

You can provide Debconf preseed files (see section 4.3.2, "Creating a Preseed File" [page 93] for explanations) as `preseed/*.cfg` files. They will be used to configure the packages installed in the live file system.

9.3.4. Using Hooks to Tweak the Contents of the Image

`live-build` offers hooks that can be executed at different steps of the build process. Chroot hooks are executable scripts that you install as `hooks/live/*.chroot` files in your config tree and that are executed within the chroot. While `chroot` is the command that lets you temporarily changes the operating system's root directory to a directory of your choice, it is also used by extension to

designate a directory hosting a full (alternate) file system tree. This is the case here with `live-build`, where the chroot directory is the directory where the live file system is being prepared. Since applications started in a chroot can't see outside of that directory, the same goes with the chroot hooks: you can only use and modify anything available in that chroot environment. We rely on those hooks to perform multiple Kali specific customizations (see `kali-config/common/hooks/live/kali-hacks.chroot`).

Binary hooks (`hooks/live/*.binary`) are executed in the context of the build process (and not chrooted anywhere) at the end of the process. You can modify the content of the ISO image built but not of the live file system since at this point, it has already been generated. We use this feature in Kali to make some changes to the default isolinux configuration generated by live-build. For example, see `kali-config/common/hooks/live/persistence.binary` where we add the boot menu entries enabling persistence.

9.3.5. Adding Files in the ISO Image or in the Live Filesystem

Another very common customization is to add files either in the live file system or in the ISO image.

You can add files to the live file system by putting them at their expected location below the `includes.chroot` config directory. For example, we provide `kali-config/common/includes.chroot/usr/lib/live/config/0031-root-password`, which ends up as `/usr/lib/live/config/0031-root-password` in the live file system.

Live-Boot Hooks Scripts installed as `/lib/live/config/`*`XXXX-name`* are executed by the init script of the live-boot package. They reconfigure many aspects of the system to be suited for a live system. You can add scripts of your own to customize your live system at run-time: it's notably used to implement a custom boot parameter for example.

You can add files to the ISO image by putting them at their expected location below the `includes.binary` config directory. For example, we provide `kali-config/common/includes.binary/isolinux/splash.png` to override the background image used by the Isolinux bootloader (which is stored in `/isolinux/splash.png` in the filesystem of the ISO image).

9.4. Adding Persistence to the Live ISO with a USB Key

9.4.1. The Persistence Feature: Explanations

Next, we will discuss the steps required to add persistence to a Kali USB key. The nature of a live system is to be ephemeral. All data stored on the live system and all the changes made are lost when you reboot. To remedy this, you can use a feature of *live-boot* called persistence, which is enabled when the boot parameters include the persistence keyword.

Since modifying the boot menu is a non-trivial task, Kali includes two menu entries by default that enable persistence: Live USB Persistence and Live USB Encrypted Persistence, as shown in Figure 9.1, “Persistence Menu Entries” [page 240].

Figure 9.1 *Persistence Menu Entries*

When this feature is enabled, *live-boot* will scan all partitions looking for file systems labeled persistence (which can be overridden with the persistence-label=*value* boot parameter) and the installer will set up persistence of the directories which are listed in the `persistence.conf` file found in that partition (one directory per line). The special value “/ union” enables full persistence of all directories with a *union mount*, an overlay that stores only the changes when compared to the underlying file system. The data of the persisted directories are stored in the file system that contains the corresponding `persistence.conf` file.

9.4.2. Setting Up Unencrypted Persistence on a USB Key

In this section, we assume that you have prepared a Kali Live USB Key by following the instructions at section 2.1.4, "Copying the Image on a DVD-ROM or USB Key" [page 19] and that you have used a USB key big enough to hold the ISO image (roughly 3 GB) and the data of the directories that you want to persist. We also assume that the USB key is recognized by Linux as /dev/sdb and that it only contains the two partitions that are part of the default ISO image (/dev/sdb1 and /dev/sdb2). Be very careful when performing this procedure. You can easily destroy important data if you re-partition the wrong drive.

To add a new partition, you must know the size of the image that you copied so that you can make the new partition start after the live image. Then use `parted` to actually create the partition. The commands below analyze the ISO image named `kali-linux-2016.1-amd64.iso`, which is assumed to be present on the USB key as well:

```
# parted /dev/sdb print
Model: SanDisk Cruzer Edge (scsi)
Disk /dev/sdb: 32,0GB
Sector size (logical/physical): 512B/512B
Partition Table: msdos
Disk Flags:

Number  Start   End     Size    Type     File system  Flags
 1      32,8kB  2852MB  2852MB  primary               boot, hidden
 2      2852MB  2945MB  93,4MB  primary
# start=$(du --block-size=1MB kali-linux-2016.1-amd64.iso | awk '{print $1}')
# echo "Size of image is $start MB"
Size of image is 2946 MB
# parted -a optimal /dev/sdb mkpart primary "${start}MB" 100%
Information: You may need to update /etc/fstab.

# parted /dev/sdb print
Model: SanDisk Cruzer Edge (scsi)
Disk /dev/sdb: 32,0GB
Sector size (logical/physical): 512B/512B
Partition Table: msdos
Disk Flags:

Number  Start   End     Size    Type     File system  Flags
 1      32,8kB  2852MB  2852MB  primary               boot, hidden
 2      2852MB  2945MB  93,4MB  primary
 3      2946MB  32,0GB  29,1GB  primary
```

With the new `/dev/sdb3` partition in place, format it with an ext4 filesystem labelled "persistence" with the help of the `mkfs.ext4` command (and its -L option to set the label). The partition is then mounted on the `/mnt` directory and you add the required `persistence.conf` configuration file. As

always, use caution when formatting any disk. You could lose valuable information if you format the wrong disk or partition.

```
# mkfs.ext4 -L persistence /dev/sdb3
mke2fs 1.43-WIP (15-Mar-2016)
Creating filesystem with 7096832 4k blocks and 1777664 inodes
Filesystem UUID: dede20c4-5239-479a-b115-96561ac857b6
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
        4096000

Allocating group tables: done
Writing inode tables: done
Creating journal (32768 blocks): done
Writing superblocks and filesystem accounting information: done
# mount /dev/sdb3 /mnt
# echo "/ union" >/mnt/persistence.conf
# ls -l /mnt
total 20
drwx------ 2 root root 16384 May 10 13:31 lost+found
-rw-r--r-- 1 root root     8 May 10 13:34 persistence.conf
# umount /mnt
```

The USB key is now ready and can be booted with the "Live USB Persistence" boot menu entry.

9.4.3. Setting Up Encrypted Persistence on a USB Key

`live-boot` is also able to handle persistence file systems on encrypted partitions. You can thus protect the data of your persistent directories by creating a LUKS encrypted partition holding the persistence data.

The initial steps are the same up to the creation of the partition but instead of formatting it with an ext4 file system, use `cryptsetup` to initialize it as a LUKS container. Then open that container and setup the ext4 file system in the same way as in the non-encrypted setup, but instead of using the `/dev/sdb3` partition, use the virtual partition created by `cryptsetup`. This virtual partition represents the decrypted content of the encrypted partition, which is available in `/dev/mapper` under the name that you assigned it. In the example below, we will use the name kali_persistence. Again, ensure that you are using the correct drive and partition.

```
# cryptsetup --verbose --verify-passphrase luksFormat /dev/sdb3

WARNING!
========
This will overwrite data on /dev/sdb3 irrevocably.

Are you sure? (Type uppercase yes): YES
```

```
Enter passphrase:
Verify passphrase:
Command successful.
# cryptsetup luksOpen /dev/sdb3 kali_persistence
Enter passphrase for /dev/sdb3:
# mkfs.ext4 -L persistence /dev/mapper/kali_persistence
mke2fs 1.43-WIP (15-Mar-2016)
Creating filesystem with 7096320 4k blocks and 1774192 inodes
Filesystem UUID: 287892c1-00bb-43cb-b513-81cc9e6fa72b
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
        4096000

Allocating group tables: done
Writing inode tables: done
Creating journal (32768 blocks): done
Writing superblocks and filesystem accounting information: done

# mount /dev/mapper/kali_persistence /mnt
# echo "/ union" >/mnt/persistence.conf
# umount /mnt
# cryptsetup luksClose /dev/mapper/kali_persistence
```

9.4.4. Using Multiple Persistence Stores

If you have multiple use-cases for your Kali live system, you can use multiple filesystems with different labels and indicate on the boot command line which (set of) filesystems should be used for the persistence feature: this is done with the help of the persistence-label=*label* boot parameter.

Let's assume that you are a professional pen-tester. When you work for a customer, you use an encrypted persistence partition to protect the confidentiality of your data in case the USB key is stolen or compromised. At the same time, you want to be able to showcase Kali and some promotional material stored in an unencrypted partition of the same USB key. Since you don't want to manually edit the boot parameters on each boot, you want to build a custom live image with dedicated boot menu entries.

The first step is to build the custom live ISO (following section 9.3, "Building Custom Kali Live ISO Images" [page 236] and in particular section 9.3.4, "Using Hooks to Tweak the Contents of the Image" [page 238]). The main customization is to modify `kali-config/common/hooks/live/persistence-menu.binary` to make it look like this (note the persistence-label parameters):

```
#!/bin/sh

if [ ! -d isolinux ]; then
    cd binary
```

```
fi

cat >>isolinux/live.cfg <<END

label live-demo
    menu label ^Live USB with Demo Data
    linux /live/vmlinuz
    initrd /live/initrd.img
    append boot=live username=root hostname=kali persistence-label=demo persistence

label live-work
    menu label ^Live USB with Work Data
    linux /live/vmlinuz
    initrd /live/initrd.img
    append boot=live username=root hostname=kali persistence-label=work persistence-
        ➥ encryption=luks persistence

END
```

Next, we will build our custom ISO and copy it to the USB key. Then we will create and initialize the two partitions and files ystems that will be used for persistence. The first partition is unencrypted (labeled "demo"), and the second is encrypted (labeled "work"). Assuming `/dev/sdb` is our USB key and the size of our custom ISO image is 3000 MB, it would look like this:

```
# parted /dev/sdb mkpart primary 3000 MB 55%
# parted /dev/sdb mkpart primary 55% 100%
# mkfs.ext4 -L demo /dev/sdb3
[...]
# mount /dev/sdb3 /mnt
# echo "/ union" >/mnt/persistence.conf
# umount /mnt
# cryptsetup --verbose --verify-passphrase luksFormat /dev/sdb4
[...]
# cryptsetup luksOpen /dev/sdb4 kali_persistence
[...]
# mkfs.ext4 -L work /dev/mapper/kali_persistence
[...]
# mount /dev/mapper/kali_persistence /mnt
# echo "/ union" >/mnt/persistence.conf
# umount /mnt
# cryptsetup luksClose /dev/mapper/kali_persistence
```

And that's all. You can now boot the USB key and select from the new boot menu entries as needed!

Adding a Nuke Password for Extra Safety

Kali has modified `cryptsetup` to implement a new feature: you can set a *nuke password* which—when used— will destroy all keys used to manage the encrypted partition.

This can be useful when you travel a lot and need a quick way to ensure your data cannot be recovered. When booting, just type the nuke password instead of the real one and it will then be impossible for anyone (including you) to access your data.

Before using that feature, it is thus wise to make a backup copy of your encryption keys and keep them at some secure place.

Following the example in this section, you could add a nuke password with this command:

```
# cryptsetup luksAddNuke /dev/sdb4
Enter any existing passphrase:
Enter new passphrase for key slot:
Verify passphrase:
```

More information about this feature can be found in the following tutorial:

➨ `https://www.kali.org/tutorials/nuke-kali-linux-luks/`

9.5. Summary

In this chapter, we learned about modifying Kali source packages, which are the basic building blocks of all applications shipped in Kali. We also discovered how to customize and install the Kali kernel. Then we discussed the live-build environment and discussed how to build a customized Kali Linux ISO. We also demonstrated how to create both encrypted and unencrypted Kali USB installs.

9.5.1. Summary Tips for Modifying Kali Packages

Modifying Kali packages is usually a task for Kali contributors and developers, but you might have specific needs not fulfilled by the official packages and knowing how to build a modified package can be very valuable, especially if you want to share your changes, deploy them internally, or cleanly roll the software back to a previous state.

When you need to modify a piece of software, it might be tempting to download the source, make the changes, and use the modified software. However, if your application requires a system-wide setup (e.g. with a `make install` step), then it will *pollute* your file system with files unknown to `dpkg` and will soon create problems that cannot be caught by package dependencies. In addition, this type of software modification is more tedious to share.

When creating a modified package, the general process is always the same: grab the source package, extract it, make your changes, and then build the package. For each step, there are often multiple tools that can handle each task.

To start rebuilding a Kali package, first download the source package, which is composed of a `*.dsc` (*Debian Source Control*) file and of additional files referenced from that control file.

Source packages are stored on HTTP-accessible mirrors. The most efficient way to obtain them is with `apt source` *`source-package-name`*, which requires that you add a deb-src line to the `/etc/apt/sources.list` file and update the index files with `apt update`.

Additionally, you can use `dget` (from the *devscripts* package) to download a `.dsc` file directly together with its accompanying files. For Kali-specific packages whose sources are hosted in a Git repository on git.kali.org[10], you can retrieve the sources with `git clone git://git.kali.org/packages/`*`source-package`* (if you don't see anything in your repository, try switching to the kali/master branch with `git checkout kali/master`).

After downloading sources, install the packages listed in the source package's build dependencies with `sudo apt build-dep ./`. This command must be run from the package's source directory.

Updates to a source package consist of a combination of some of the following steps:

- The required first step is changing the version number to distinguish your package from the original with `dch --local` *`version-identifier`*, or modify other package details with `dch`.
- Applying a patch with `patch -p1 <` *`patch-file`* or modifying `quilt`'s patch series.
- Tweaking build options, usually found in the package's `debian/rules` file, or other files in the `debian/` directory.

After modifying a source package, you can build the binary package with `dpkg-buildpackage -us -uc -b` from the source directory, which will generate an unsigned binary package. The package can then be installed with `dpkg -i` *`package-name_version_arch.deb`*.

9.5.2. Summary Tips for Recompiling the Linux Kernel

As an advanced user, you may wish to recompile the Kali kernel. You may want to slim down the standard Kali kernel, which is loaded with many features and drivers, add non-standard drivers or features, or apply kernel patches. Beware though: a misconfigured kernel may destabilize your system and you must be prepared to accept that Kali cannot ensure security updates for your custom kernel.

For most kernel modifications, you will need to install a few packages with `apt install build-essential libncurses5-dev fakeroot`.

[10] `http://git.kali.org`

The command `apt-cache search ^linux-source` should list the latest kernel version packaged by Kali, and `apt install linux-source-`*`version-number`* installs a compressed archive of the kernel source into `/usr/src`.

The source files should be extracted with `tar -xaf` into a directory other than `/usr/src` (such as `~/kernel`).

When the time comes to configure your kernel, keep these points in mind:

- Unless you are an advanced user, you should first populate a kernel configuration file. The preferred method is to borrow Kali's standard configuration by copying `/boot/config-`*`version-string`* to `~/kernel/linux-source-`*`version-number`*`/.config`. Alternatively, you can use `make `*`architecture`*`_defconfig` to get a reasonable configuration for the given architecture.
- The text-based `make menuconfig` kernel configuration tool will read the `.config` file and present you all the configuration items in a huge menu that you can navigate. Selecting an item shows you its documentation, its possible values, and permits you to enter a new value.

When run from your kernel source directory, `make clean` will remove previously-compiled files and `make deb-pkg` will generate up to five Debian packages. The *linux-image*-version `.deb` file contains the kernel image and the associated modules.

To actually use the built kernel, install the required packages with `dpkg -i `*`file.deb`*. The "linux-image" package is required; you only have to install the "linux-headers" package if you have some external kernel modules to build, which is the case if you have some "*-dkms" packages installed (check with `dpkg -l "*-dkms" | grep ^ii`). The other packages are generally not needed (unless you know why you need them!).

9.5.3. Summary Tips for Building Custom Kali Live ISO Images

Official Kali ISO images are built with live-build[11], which is a set of scripts that allows for the complete automation and customization of all facets of ISO image creation.

Your Kali system must be completely up-to-date before using live-build.

The Kali live-build configuration can be retrieved from Kali's Git repositories with two commands: `apt install curl git live-build` followed by `git clone git://git.kali.org/live-build-config.git`

To generate an updated but unmodified Kali ISO image, simply run `./build.sh --verbose`. The build will take a long time to complete as it will download all the packages to include. When finished, you will find the new ISO image in the `images` directory. If you add `--variant `*`variant`* to the command line, it will build the given variant of the Kali ISO image. The various variants

[11] `http://debian-live.alioth.debian.org/live-build/`

are defined by their configuration directories `kali-config/variant-*`. The main image is the gnome variant.

There are several ways to customize your ISO by modifying live-build's configuration directory:

- Packages can be added to (or removed from) a live ISO by modifying `package-lists/*.list.chroot` files.
- Custom packages can be included in the live image by placing the `.deb` files in a `packages.chroot` directory. Their installation can be preseeded with `preseed/*.cfg` files.
- You can add files to the live filesystem by putting them at their expected location below the `includes.chroot` config directory.
- You can execute scripts during the live system's chroot setup process by installing them as `hooks/live/*.chroot` files. You can also execute scripts at boot time of the generated live image: you must arrange for them to be installed in `/usr/lib/live/config/`*`XXXX`*`-`*`name`*, for example by relying on the `includes.chroot` config directory.
- The Debian Live Systems Manual[12] is an excellent reference for live-build configuration and testing.

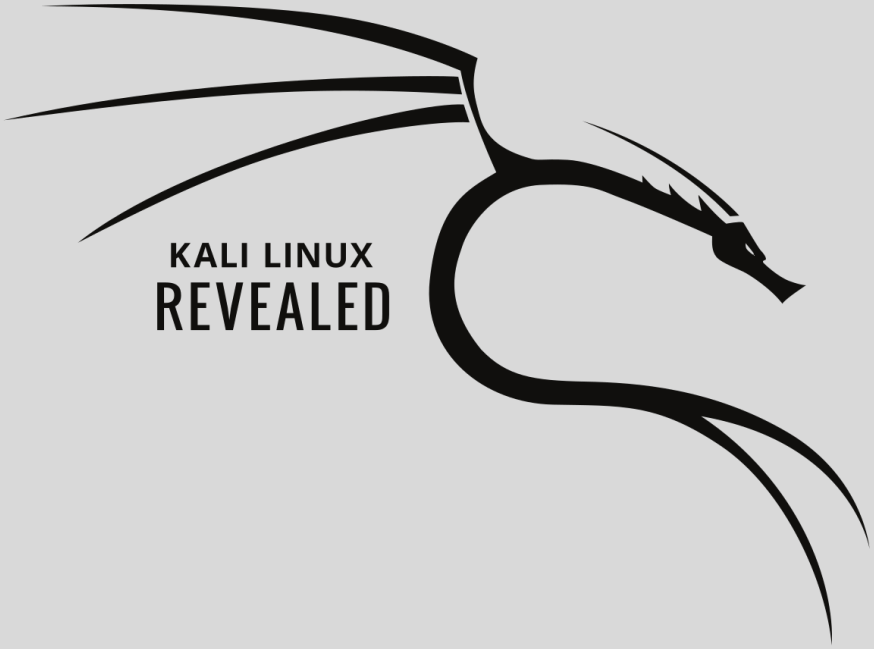
Setting up encrypted and unencrypted persistence on a USB key: it's fairly simple to create a standard Kali Live USB installation. Although the process may seem syntactically complex, it is relatively straight-forward to add both encrypted and unencrypted persistence to your portable installation to significantly extend its functionality.

In the next chapter, we will discuss how Kali scales to the enterprise. We will discuss configuration management and show you how to extend and customize Kali Linux in a way that is easy to deploy whether you have a pair of machines, or several thousand.

[12] `http://debian-live.alioth.debian.org/live-manual/unstable/manual/html/live-manual.en.html`

Keywords

PXE installation
Configuration management
Saltstack
Forking Kali packages
Configuration packages
Package repository



Chapter

10

Kali Linux in the Enterprise

Contents

So far, we have seen that Kali is an extremely capable and secure Debian derivative providing industrial-strength security and encryption features, advanced package management, multi-platform capability, and (what it is most-known for) an arsenal of world-class tools for the security professional. What might not be obvious is how Kali scales beyond the desktop to medium or large scale deployments and even to the enterprise level. In this chapter, we will show you how well Kali can scale beyond the desktop, providing centralized management and enterprise-level control over multiple Kali Linux installations. In short, after reading this chapter you will be able to quickly deploy highly secure Kali systems preconfigured for your specific needs and keep them synchronized thanks to Kali's (semi-automatic) installation of package updates.

This level of scale requires several steps, including initiating a PXE network boot, use of an advanced configuration management tool (SaltStack), the ability to fork and customize packages, and the deployment of a package repository. We will cover each step in detail, show you how to get the "heavy lifting" out of the way, and deploy, manage, and maintain multitudes of custom Kali Linux installations with relative ease. As if that were not enough, we will throw in a crowd of minions to assist you in running your empire.

10.1. Installing Kali Linux Over the Network (PXE Boot)

As we have seen in previous chapters, the basic Kali Linux installation process is straightforward once you know your way around. But if you have to install Kali on multiple machines, the standard setup can be quite tedious. Thankfully, you can start the Kali installation procedure by booting a computer over the network. This allows you to install Kali quickly and easily on many machines at a time.

First, you will need to boot your target machine from the network. This is facilitated by the Preboot eXecution Environment (PXE), a client/server interface designed to boot any networked machine from the network even if it does not have an operating system installed. Setting up PXE network boot requires that you configure at least a trivial file transfer protocol (TFTP) server and a DHCP/BOOTP server. You will also need a web server if you want to host a *debconf* preseeding file that will be automatically used in the installation process.

Fortunately, *dnsmasq* handles both DHCP and TFTP so that you can rely on a single service to set up everything you need. And the Apache web server is installed (but not enabled) by default on Kali systems.

Separate DHCP and TFTP daemons

For more complex setups, *dnsmasq*'s feature set might be too limited or you might want to enable PXE booting on your main network that already runs a DHCP daemon. In both cases, you will then have to configure separate DHCP and TFTP daemons.

The Debian installation manual covers the setup of *isc-dhcp-server* and *tftpd-hpa* for PXE booting.

➨ `https://www.debian.org/releases/stable/amd64/ch04s05.html`

In order to set up *dnsmasq*, you must first configure it through `/etc/dnsmasq.conf`. A basic configuration consists of only a few key lines:

```
# Network interface to handle
interface=eth0
# DHCP options
# IP range to allocate
dhcp-range=192.168.101.100,192.168.101.200,12h
# Gateway to announce to clients
dhcp-option=option:router,192.168.101.1
# DNS servers to announce to clients
dhcp-option=option:dns-server,8.8.8.8,8.8.4.4
# Boot file to announce to clients
dhcp-boot=pxelinux.0
# TFTP options
enable-tftp
# Directory hosting files to serve
tftp-root=/tftpboot/
```

With `/etc/dnsmasq.conf` configured, you will need to place the installation boot files in the `/tftpboot/` directory. Kali Linux provides a file archive dedicated to this purpose that can be directly unpacked into `/tftpboot/`. Simply select between 32-bit (i386) and 64-bit (amd64) and standard or graphical (gtk) install methods for your target machine and choose the appropriate archive:

➡ `http://http.kali.org/dists/kali-rolling/main/installer-amd64/current/images/netboot/gtk/netboot.tar.gz`

➡ `http://http.kali.org/dists/kali-rolling/main/installer-amd64/current/images/netboot/netboot.tar.gz`

➡ `http://http.kali.org/dists/kali-rolling/main/installer-i386/current/images/netboot/gtk/netboot.tar.gz`

➡ `http://http.kali.org/dists/kali-rolling/main/installer-i386/current/images/netboot/netboot.tar.gz`

Once you have selected the archive, create `/tftpboot/`, download the archive, and unpack it into that directory:

```
# mkdir /tftpboot
# cd /tftpboot
# wget http://http.kali.org/dists/kali-rolling/main/installer-amd64/current/images/
    ➥ netboot/netboot.tar.gz
# tar xf netboot.tar.gz
# ls -l
total 25896
drwxrwxr-x 3 root root     4096 May  6 04:43 debian-installer
```

```
lrwxrwxrwx 1 root root       47 May  6 04:43 ldlinux.c32 -> debian-installer/amd64/boot
    ➥ -screens/ldlinux.c32
-rw-r--r-- 1 root root 26507247 May  6 04:43 netboot.tar.gz
lrwxrwxrwx 1 root root       33 May  6 04:43 pxelinux.0 -> debian-installer/amd64/
    ➥ pxelinux.0
lrwxrwxrwx 1 root root       35 May  6 04:43 pxelinux.cfg -> debian-installer/amd64/
    ➥ pxelinux.cfg
-rw-rw-r-- 1 root root       71 May  6 04:43 version.info
```

The unpacked files include the *pxelinux* bootloader, which uses the same configuration files as *syslinux* and *isolinux*. Because of this, you can tweak the boot files in `debian-installer/amd64/boot-screens/` as you would when generating custom Kali Linux Live ISO images.

For example, assuming that you have picked the textual installer, you can add boot parameters to preseed the language, country, keymap, hostname, and domainname values. You can also point the installer to an external preseed URL and configure the timeout so that the boot happens automatically if no key is pressed within 5 seconds. To accomplish this, you would first modify the `debian-installer/amd64/txt.cfg` file:

```
label install
        menu label ^Install
        kernel debian-installer/amd64/linux
        append vga=788 initrd=debian-installer/amd64/initrd.gz --- quiet language=en
            ➥ country=US keymap=us hostname=kali domain= url=http://192.168.101.1/
            ➥ preseed.cfg
```

Then, you would modify the `debian-installer/amd64/syslinux.cfg` file to adjust the timeout:

```
# D-I config version 2.0
# search path for the c32 support libraries (libcom32, libutil etc.)
path debian-installer/amd64/boot-screens/
include debian-installer/amd64/boot-screens/menu.cfg
default debian-installer/amd64/boot-screens/vesamenu.c32
prompt 0
timeout 50
```

Armed with the ability to boot any machine from the network via PXE, you can take advantage of all the features outlined in section 4.3, "Unattended Installations" [page 91], enabling you to do full booting, preseeding, and unattended installation on multiple computers without physical boot media. Also, don't forget the flexibility of the boot parameter preseed/url=http://*server*/preseed.cfg (nor the use of the url alias), which allows you to set a network-based preseed file.

10.2. Leveraging Configuration Management

With the ability to install Kali on multiple computers very quickly, you will need some help in managing those machines post-installation. You can leverage configuration management tools to manage machines or configure replacement computers to any desired state.

Kali Linux contains many popular configuration management tools that you might want to use (*ansible*, *chef*, *puppet*, *saltstack*, etc.) but in this section, we will only cover *SaltStack*.

➨ `https://saltstack.com`

10.2.1. Setting Up SaltStack

SaltStack is a centralized configuration management service: a *salt master* manages many *salt minions*. You should install the *salt-master* package on a server that is reachable by all the hosts that you want to manage and *salt-minion* on the hosts that you wish to manage. Each minion must be told where to find their master. Simply edit `/etc/salt/minion` and set the `master` key to the DNS name (or IP address) of the Salt master. Note that Salt uses YAML as format for its configuration files.

```
minion# vim /etc/salt/minion
minion# grep ^master /etc/salt/minion
master: 192.168.122.105
```

Each minion has a unique identifier stored in `/etc/salt/minion_id`, which defaults to its hostname. This minion identifier will be used in the configuration rules and as such, it is important to set it properly before the minion opens its connection to the master:

```
minion# echo kali-scratch >/etc/salt/minion_id
minion# systemctl enable salt-minion
minion# systemctl start salt-minion
```

When the *salt-minion* service is running, it will try to connect to the Salt master to exchange some cryptographic keys. On the master side, you have to accept the key that the minion is using to identify itself to let the connection proceed. Subsequent connections will be automatic:

```
master# systemctl enable salt-master
master# systemctl start salt-master
master# salt-key --list all
Accepted Keys:
Denied Keys:
Unaccepted Keys:
kali-scratch
Rejected Keys:
master# salt-key --accept kali-scratch
The following keys are going to be accepted:
```

```
Unaccepted Keys:
kali-scratch
Proceed? [n/Y] y
Key for minion kali-scratch accepted.
```

10.2.2. Executing Commands on Minions

As soon as minions are connected, you can execute commands on them from the master:

```
master# salt '*' test.ping
kali-scratch:
    True
kali-master:
    True
```

This command asks all minions (the '*' is a wildcard targeting all minions) to execute the ping function from the test execution module. This function returns a True value on success and is a simple way to ensure that the connection is working between the master and the various minions.

You can also target a specific minion by giving its identifier in the first parameter, or possibly a subset of minions by using a less-generic wildcard (such as '*-scratch' or 'kali-*'). Here is an example of how to execute an arbitrary shell command on the kali-scratch minion:

```
master# salt kali-scratch cmd.shell 'uptime; uname -a'
kali-scratch:
     05:25:48 up 44 min,  2 users,  load average: 0.00, 0.01, 0.05
    Linux kali-scratch 4.5.0-kali1-amd64 #1 SMP Debian 4.5.3-2kali1 (2016-05-09) x86_64
        ➥ GNU/Linux
```

Salt Module Reference

There are many execution modules available for all sorts of use cases. We won't cover them all here, but the full list is available at `https://docs.saltstack.com/en/latest/ref/modules/all/index.html`. You can also obtain a description of all the execution modules and their available functions on a given minion with the `salt` *`minion`* `sys.doc` command. Running this command returns a very long list of functions, but you can filter the list by passing the name of a function or module prefixed by its parent module as a parameter:

```
master# salt kali-scratch sys.doc disk.usage
disk.usage:

    Return usage information for volumes mounted on this
        ➥ minion
```

One of the most useful modules is pkg, which is a package manager abstraction relying on the appropriate package manager for the system (`apt-get` for Debian and its derivatives like Kali).

The `pkg.refresh_db` command updates the package list (that is, it performs `apt-get update`) while `pkg.upgrade` installs all the available updates (it performs `apt-get upgrade` or `apt-get dist-upgrade`, depending on the options received). The `pkg.list_upgrades` command lists the pending upgrade operations (that would be performed by the `pkg.upgrade dist_upgrade=True` command).

The service module is an abstraction of the service manager (`systemd` in the case of Kali), which lets you perform all the usual `systemctl` operations: `service.enable`, `service.disable`, `service.start`, `service.stop`, `service.restart`, and `service.reload`:

```
master# salt '*' service.enable ssh
kali-scratch:
    True
kali-master:
    True
master# salt '*' service.start ssh
kali-master:
    True
kali-scratch:
    True
master# salt '*' pkg.refresh_db
kali-scratch:
    ----------
kali-master:
    ----------
master# salt '*' pkg.upgrade dist_upgrade=True
kali-scratch:
    ----------
    changes:
        ----------
        base-files:
            ----------
            new:
                1:2016.2.1
            old:
                1:2016.2.0
[...]
        zaproxy:
            ----------
            new:
                2.5.0-0kali1
            old:
                2.4.3-0kali3
    comment:
    result:
        True
```

As a more concrete sample, you could easily set up a distributed *Nmap* scan with *dnmap*. After having installed the package on all the minions, you start the server in a first terminal:

```
server# salt '*' pkg.install dnmap
[...]
server# vim dnmap.txt
server# dnmap_server -f dnmap.txt
```

Assuming that the server IP is 1.2.3.4, you can next tell all minions to start a client process that connects to the server:

```
server# salt '*' cmd.run_bg template=jinja 'dnmap_client -s 1.2.3.4 -a {{ grains.id }}'
kali-scratch:
    ----------
    pid:
        17137
[...]
```

Note that the example uses cmd.run_bg to run the `dnmap_client` command in the background. Don't wait until it finishes, since it is a long-running process. Unfortunately, it doesn't kill itself properly when you interrupt the server so you might have to clean it up:

```
server# salt '*' cmd.shell 'pkill -f dnmap_client'
```

10.2.3. Salt States and Other Features

While remote execution is an important building block, it is only a tiny fraction of what SaltStack can do.

When setting up a new machine, you often run many commands and tests to determine the details of the system prior to installation. These operations can be formalized in re-usable configuration templates called *state files*. The operations described in state files can then be performed with a single `state.apply` salt command.

To save some time, you can rely on many ready-to-use state files that have been created by the community and which are distributed in "Salt formulas":

➨ `https://docs.saltstack.com/en/latest/topics/development/conventions/formulas.html`

There are many other features that can be combined:

- Scheduled execution of actions
- Defining actions in response to events triggered by minions
- Collecting data out of minions

- Orchestration of a sequence of operations across multiple minions
- Applying states over SSH without installing the salt-minion service
- Provisioning systems on cloud infrastructures and bringing them under management
- And more

SaltStack is quite vast and we can't possibly cover all the features here. In fact, there are books dedicated entirely to SaltStack and the online documentation is very extensive as well. Check it out if you want to learn more about its features:

➨ `https://docs.saltstack.com/en/latest/`

If you manage a significant number of machines, you would be well advised to learn more about SaltStack as you can save a significant amount of time when deploying new machines and you will be able to maintain a coherent configuration throughout your network.

To give you a taste of what it looks like to work with state files, we will cover a simple example: how to enable the APT repository and install a package that you create in section 10.3.3, "Creating a Package Repository for APT" [page 269] and section 10.3.2, "Creating Configuration Packages" [page 263]. You will also register a SSH key in root's account so that you can login remotely in case of problems.

By default, state files are stored in `/srv/salt` on the master; they are YAML structured files with a `.sls` extension. Just like for running commands, applying a state relies on many state modules:

➨ `https://docs.saltstack.com/en/latest/topics/tutorials/starting_states.html`

➨ `https://docs.saltstack.com/en/latest/ref/states/all/`

Your `/srv/salt/offsec.sls` file will call three of those modules:

```
offsec_repository:
  pkgrepo.managed:
    - name: deb http://pkgrepo.offsec.com offsec-internal main
    - file: /etc/apt/sources.list.d/offsec.list
    - key_url: salt://offsec-apt-key.asc
    - require_in:
      - pkg: offsec-defaults

offsec-defaults:
  pkg.installed

ssh_key_for_root:
  ssh_auth.present:
    - user: root
    - name: ssh-rsa AAAAB3NzaC1yc2...89C4N rhertzog@kali
```

The offsec_repository state relies on the pkgrepo state module. The example uses the managed function in that state module to register a package repository. With the key_url attribute, you

let salt know that the (ASCII armored) GPG key required to verify the repository's signature can be fetched from `/srv/salt/offsec-apt-key.asc` on the salt master. The require_in attribute ensures that this state is processed before the offsec-defaults, since the latter needs the repository correctly configured to be able to install the package.

The offsec-defaults state installs the package of the same name. This shows that the name of the key is often an important value for states, although it can always be overridden with a name attribute (as done for the former state). For simple-cases like this one, this is both readable and concise.

The last state (ssh_key_for_root) adds the SSH key given in the name attribute to `/root/.ssh/authorized_keys` (the target user is set in the user attribute). Note that we have shortened the key for readability here, but you should put the full key in the name attribute.

This state file can next be applied to a given minion:

```
server# salt kali-scratch state.apply offsec
kali-scratch:
----------
          ID: offsec_repository
    Function: pkgrepo.managed
        Name: deb http://pkgrepo.offsec.com offsec-internal main
      Result: True
     Comment: Configured package repo 'deb http://pkgrepo.offsec.com offsec-internal
         ➥ main'
     Started: 06:00:15.767794
    Duration: 4707.35 ms
     Changes:
              ----------
              repo:
                  deb http://pkgrepo.offsec.com offsec-internal main
----------
          ID: offsec-defaults
    Function: pkg.installed
      Result: True
     Comment: The following packages were installed/updated: offsec-defaults
     Started: 06:00:21.325184
    Duration: 19246.041 ms
     Changes:
              ----------
              offsec-defaults:
                  ----------
                  new:
                      1.0
                  old:
----------
          ID: ssh_key_for_root
    Function: ssh_auth.present
```

```
        Name: ssh-rsa AAAAB3NzaC1yc2...89C4N rhertzog@kali
      Result: True
     Comment: The authorized host key AAAAB3NzaC1yc2...89C4N for user root was added
     Started: 06:00:40.582539
    Duration: 62.103 ms
     Changes:
              ----------
              AAAAB3NzaC1yc2...89C4N:
                  New

Summary for kali-scratch
------------
Succeeded: 3 (changed=3)
Failed:    0
------------
Total states run:     3
Total run time:  24.015 s
```

It can also be permanently associated to the minion by recording it in the `/srv/salt/top.sls` file, which is used by the state.highstate command to apply all relevant states in a single pass:

```
server# cat /srv/salt/top.sls
base:
  kali-scratch:
    - offsec
server# salt kali-scratch state.highstate
kali-scratch:
----------
          ID: offsec_repository
    Function: pkgrepo.managed
        Name: deb http://pkgrepo.offsec.com offsec-internal main
      Result: True
     Comment: Package repo 'deb http://pkgrepo.offsec.com offsec-internal main' already
         ➥  configured
     Started: 06:06:20.650053
    Duration: 62.805 ms
     Changes:
----------
          ID: offsec-defaults
    Function: pkg.installed
      Result: True
     Comment: Package offsec-defaults is already installed
     Started: 06:06:21.436193
    Duration: 385.092 ms
     Changes:
----------
          ID: ssh_key_for_root
```

```
    Function: ssh_auth.present
        Name: ssh-rsa AAAAB3NzaC1yc2...89C4N rhertzog@kali
      Result: True
     Comment: The authorized host key AAAAB3NzaC1yc2...89C4N is already present for
         ➥ user root
     Started: 06:06:21.821811
    Duration: 1.936 ms
     Changes:

Summary for kali-scratch
------------
Succeeded: 3
Failed:    0
------------
Total states run:     3
Total run time: 449.833 ms
```

10.3. Extending and Customizing Kali Linux

Sometimes you need to modify Kali Linux to make it fit your local needs. The best way to achieve this is to maintain your own package repository hosting the modified versions of the Kali packages that you had to fork, as well as supplementary packages providing custom configuration and extra software (not provided by Kali Linux).

10.3.1. Forking Kali Packages

Please refer to section 9.1, "Modifying Kali Packages" [page 222] for explanations about this topic.

All packages can be forked if you have a good reason but you must be aware that forking a package has a cost, since you have to update it every time that Kali publishes an update. Here are some reasons why you might want to fork a package:

- To add a patch to fix a bug or add a new feature. Although in most cases, you will want to submit that patch to the upstream developers so that the bug is fixed or the feature is added at the source.
- To compile it with different options (assuming that there are good reasons why Kali did not compile it with those options; otherwise it might be best to discuss this with Kali developers to see if they can enable the desired options).

By contrast, here are some bad reasons to fork a package along with suggestions of how to handle your problem:

- To modify a configuration file. You have multiple, better options like using configuration management to automatically install a modified configuration file or installing a configuration package that will put a file in a configuration directory (when available) or that will divert the original configuration file.
- To update to a newer upstream version. Again, it is better to work with developers to update the package directly in Debian or Kali. With the rolling release model, updates are rather quick to reach end users.

Among all the available packages, there are some that are building blocks of Kali Linux and that could be interesting to fork in some situations:

- *kali-meta*: this source package builds all the kali-linux-* meta packages and notably *kali-linux-full*, which defines what packages are installed in the default Kali Linux ISO image.
- *desktop-base*: This source package contains various miscellaneous files that are used by default in desktop installations. Consider forking this package if you would like to show your organization's brand in the default background or change the theme of the desktop.
- *kali-menu*: this package defines the structure of the Kali menu and provides `.desktop` files for all applications that should be listed in the Kali menu.

10.3.2. Creating Configuration Packages

Now that we have touched on PXE booting and discussed configuration management with SaltStack as well as package forking, it is time to wrap these processes up into a practical example and extend the scenario by creating a custom configuration package to deploy a custom configuration to multiple machines semi-automatically.

In this example, you will create a custom package that sets up and utilizes your own package repository and GnuPG signing key, distributes a SaltStack configuration, pushes a custom background, and provides default desktop settings in a unified way to all your Kali installations.

This may seem like a daunting task (especially if you glance through the Debian New Maintainer Guide[1]) but fortunately for us, a configuration package is mainly a sophisticated file archive and turning it into a package is rather easy.

Looking into a Sample Package

If you want to look into a real package that is basically a configuration package, consider the *kali-defaults* package. It is not as simple as the sample in this section but it has all the relevant characteristics and even uses some advanced techniques (like `dpkg-divert`) to replace files already provided by other packages.

[1] `https://www.debian.org/doc/manuals/maint-guide/`

The *offsec-defaults* package will contain a few files:

- `/etc/apt/sources.list.d/offsec.list`: a `sources.list` entry for APT, enabling the company's internal package repository
- `/etc/apt/trusted.gpg.d/offsec.gpg`: the GnuPG key used to sign the company's internal package repository
- `/etc/salt/minion.d/offsec.conf`: a SaltStack configuration file to indicate where to find the Salt master
- `/usr/share/images/offsec/background.png`: a nice background image with the Offensive Security logo
- `/usr/share/glib-2.0/schemas/90_offsec-defaults.gschema.override`: a file providing alternate default settings for the GNOME desktop

First, create an `offsec-defaults-1.0` directory and put all the files in that directory. Then run `dh_make --native` (from the *dh-make* package) to add Debian packaging instructions, which will be stored in a `debian` sub-directory:

```
$ mkdir offsec-defaults-1.0; cd offsec-defaults-1.0
$ dh_make --native
Type of package: (single, indep, library, python)
[s/i/l/p]? i
Email-Address       : buxy@kali.org
License             : gpl3
Package Name        : offsec-defaults
Maintainer Name     : Raphaël Hertzog
Version             : 1.0
Package Type        : indep
Date                : Thu, 16 Jun 2016 18:04:21 +0200
Are the details correct? [Y/n/q] y
Currently there is not top level Makefile. This may require additional tuning
Done. Please edit the files in the debian/ subdirectory now.
```

First, you are prompted for a package type. In the example, we selected *indep*, which indicates that this source package will generate a single binary package that can be shared across all architectures (Architecture: all). *single* acts as a counterpart, and produces a single binary package that is dependent on the target architecture (Architecture: any). In this case, *indep* is more relevant, since the package only contains text files and no binary programs, so that it can be used similarly on computers of all architectures. The *library* type is useful for shared libraries, since they need to follow strict packaging rules. In a similar fashion, *python* should be restricted to Python modules.

Maintainer's Name and Email Address

Most of the programs involved in package maintenance will look for your name and email address in the `DEBFULLNAME` and `DEBEMAIL` or `EMAIL` environment variables. Defining them, once and for all, prevents re-typing them multiple times. If your usual shell is Bash, it is a simple matter of adding the following two lines in your `~/.bashrc` file. For example:

```
export EMAIL="buxy@kali.org"
export DEBFULLNAME="Raphael Hertzog"
```

The `dh_make` command created a `debian` subdirectory containing many files. Some are required, in particular `rules`, `control`, `changelog`, and `copyright`. Files with the `.ex` extension are example files that can be used by modifying them and removing the extension. When they are not needed, we recommend removing them. The `compat` file should be kept, since it is required for the correct functioning of the *debhelper* suite of programs (all beginning with the `dh_` prefix) used at various stages of the package build process.

The `copyright` file must contain information about the authors of the documents included in the package, and the related license. If the default license selected by `dh_make` does not suit you, then you must edit this file. Here is the modified version of the copyright file:

```
Format: https://www.debian.org/doc/packaging-manuals/copyright-format/1.0/
Upstream-Name: offsec-defaults

Files: *
Copyright: 2016 Offensive Security
License: GPL-3.0+

License: GPL-3.0+
 This program is free software: you can redistribute it and/or modify
 it under the terms of the GNU General Public License as published by
 the Free Software Foundation, either version 3 of the License, or
 (at your option) any later version.
 .
 This package is distributed in the hope that it will be useful,
 but WITHOUT ANY WARRANTY; without even the implied warranty of
 MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
 GNU General Public License for more details.
 .
 You should have received a copy of the GNU General Public License
 along with this program. If not, see <https://www.gnu.org/licenses/>.
 .
 On Debian systems, the complete text of the GNU General
 Public License version 3 can be found in "/usr/share/common-licenses/GPL-3".
```

The default `changelog` file is generally appropriate; replacing the "Initial release" with a more verbose explanation should be enough:

```
offsec-defaults (1.0) unstable; urgency=medium

  * Add salt minion's configuration file.
  * Add an APT's sources.list entry and an APT's trusted GPG key.
  * Override the gsettings schema defining the background picture.

 -- Raphaël Hertzog <buxy@kali.org>  Thu, 16 Jun 2016 18:04:21 +0200
```

In the example, we will make changes to the `control` file. We will change the Section field to *misc* and remove the Homepage, Vcs-Git, and Vcs-Browser fields. Lastly, we will fill in the Description field:

```
Source: offsec-defaults
Section: misc
Priority: optional
Maintainer: Raphaël Hertzog <buxy@kali.org>
Build-Depends: debhelper (>= 9)
Standards-Version: 3.9.8

Package: offsec-defaults
Architecture: all
Depends: ${misc:Depends}
Description: Default settings for Offensive Security
 This package contains multiple files to configure computers
 owned by Offensive Security.
 .
 It notably modifies:
  - APT's configuration
  - salt-minion's configuration
  - the default desktop settings
```

The `rules` file usually contains a set of rules used to configure, build, and install the software in a dedicated subdirectory (named after the generated binary package). The contents of this subdirectory are then archived within the Debian package as if it were the root of the filesystem. In this case, files will be installed in the `debian/offsec-defaults/` subdirectory. For example, to end up with a package installing `/etc/apt/sources.list.d/offsec.list`, install the file in `debian/offsec-defaults/etc/apt/sources.list.d/offsec.list`. The `rules` file is used as a `Makefile`, with a few standard targets (including clean and binary, used respectively to clean the source directory and generate the binary package).

What is a `Makefile` file? You may have noticed the message concerning the missing `Makefile` at the end of the `dh_make` output and the mention of its similarity to the `rules` file. A `Makefile` is a script file used by the `make` program; it describes rules for how to build a set of files from each other in a tree of dependencies. For instance, a program can be built from a set of source files. The `Makefile` file describes these rules in the following format:

```
target: source1 source2 ...
        command1
        command2
```

The interpretation of such a rule is as follows: if one of the `source*` files is more recent than the `target` file, then the target needs to be generated, using `command1` and `command2`.

Note that the command lines must start with a tab character; also note that when a command line starts with a dash character (`-`), failure of the command does not interrupt the whole process.

Although this file is the heart of the process, it contains only the bare minimum for running a standard set of commands provided by the `debhelper` tool. Such is the case for files generated by `dh_make`. To install most of your files, we recommend configuring the behavior of the `dh_install` command by creating the following `debian/offsec-defaults.install` file:

```
apt/offsec.list etc/apt/sources.list.d/
apt/offsec.gpg etc/apt/trusted.gpg.d/
salt/offsec.conf etc/salt/minion.d/
images/background.png usr/share/images/offsec/
```

You could also use this to install the gsettings override file but debhelper provides a dedicated tool for this (`dh_installgsettings`) so you can rely on it. First, put your settings in `debian/offsec-defaults.gsettings-override`:

```
[org.gnome.desktop.background]
picture-options='zoom'
picture-uri='file:///usr/share/images/offsec/background.png'
```

Next, override the `dh_installgsettings` call in `debian/rules` to increase the priority to the level expected for an organization override (which is 90 according to the manual page):

```
#!/usr/bin/make -f

%:
        dh $@

override_dh_installgsettings:
        dh_installgsettings --priority=90
```

At this point, the source package is ready. All that is left to do is to generate the binary package with the same method used previously for rebuilding packages: run the `dpkg-buildpackage -us -uc` command from within the `offsec-defaults-1.0` directory:

```
$ dpkg-buildpackage -us -uc
dpkg-buildpackage: info: source package offsec-defaults
dpkg-buildpackage: info: source version 1.0
dpkg-buildpackage: info: source distribution unstable
dpkg-buildpackage: info: source changed by Raphaël Hertzog <buxy@kali.org>
dpkg-buildpackage: info: host architecture amd64
 dpkg-source --before-build offsec-defaults-1.0
 fakeroot debian/rules clean
dh clean
   dh_testdir
   dh_auto_clean
   dh_clean
 dpkg-source -b offsec-defaults-1.0
dpkg-source: info: using source format '3.0 (native)'
dpkg-source: info: building offsec-defaults in offsec-defaults_1.0.tar.xz
dpkg-source: info: building offsec-defaults in offsec-defaults_1.0.dsc
 debian/rules build
dh build
   dh_testdir
   dh_update_autotools_config
   dh_auto_configure
   dh_auto_build
   dh_auto_test
 fakeroot debian/rules binary
dh binary
   dh_testroot
   dh_prep
   dh_auto_install
   dh_install
   dh_installdocs
   dh_installchangelogs
   debian/rules override_dh_installgsettings
make[1]: Entering directory '/home/rhertzog/kali/kali-book/samples/offsec-defaults-1.0'
dh_installgsettings --priority=90
make[1]: Leaving directory '/home/rhertzog/kali/kali-book/samples/offsec-defaults-1.0'
   dh_perl
   dh_link
   dh_strip_nondeterminism
   dh_compress
   dh_fixperms
   dh_installdeb
   dh_gencontrol
   dh_md5sums
```

```
   dh_builddeb
dpkg-deb: building package 'offsec-defaults' in '../offsec-defaults_1.0_all.deb'.
 dpkg-genchanges  >../offsec-defaults_1.0_amd64.changes
dpkg-genchanges: info: including full source code in upload
 dpkg-source --after-build offsec-defaults-1.0
dpkg-buildpackage: info: full upload; Debian-native package (full source is included)
```

10.3.3. Creating a Package Repository for APT

Now that you have a custom package, you can distribute it through an APT package repository. Use `reprepro` to create the desired repository and to fill it. This tool is rather powerful and its manual page is certainly worth reading.

A package repository is typically hosted on a server. To properly separate it from other services running on the server, it is best to create a user dedicated to this service. In the dedicated user account, you will be able to host the repository files and also the GnuPG key that will be used to sign the package repository:

```
# apt install reprepro gnupg
[...]
# adduser --system --group pkgrepo
Adding system user 'pkgrepo' (UID 136) ...
Adding new group 'pkgrepo' (GID 142) ...
Adding new user 'pkgrepo' (UID 136) with group 'pkgrepo' ...
Creating home directory '/home/pkgrepo' ...
# chown pkgrepo $(tty)
# su - -s /bin/bash pkgrepo
$ gpg --gen-key
gpg (GnuPG) 2.1.11; Copyright (C) 2016 Free Software Foundation, Inc.
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.

gpg: directory '/home/pkgrepo/.gnupg' created
gpg: new configuration file '/home/pkgrepo/.gnupg/dirmngr.conf' created
gpg: new configuration file '/home/pkgrepo/.gnupg/gpg.conf' created
gpg: keybox '/home/pkgrepo/.gnupg/pubring.kbx' created
Note: Use "gpg --full-gen-key" for a full featured key generation dialog.

GnuPG needs to construct a user ID to identify your key.

Real name: Offensive Security Repository Signing Key
Email address: repoadmin@offsec.com
You selected this USER-ID:
    "Offensive Security Repository Signing Key <repoadmin@offsec.com>"
```

```
Change (N)ame, (E)mail, or (O)kay/(Q)uit? o
We need to generate a lot of random bytes. It is a good idea to perform
some other action (type on the keyboard, move the mouse, utilize the
disks) during the prime generation; this gives the random number
generator a better chance to gain enough entropy.
[...]
gpg: /home/pkgrepo/.gnupg/trustdb.gpg: trustdb created
gpg: key B4EF2D0D marked as ultimately trusted
gpg: directory '/home/pkgrepo/.gnupg/openpgp-revocs.d' created
gpg: revocation certificate stored as '/home/pkgrepo/.gnupg/openpgp-revocs.d/
    ➥ F8FE22F74F1B714E38DA6181B27F74F7B4EF2D0D.rev'
public and secret key created and signed.

gpg: checking the trustdb
gpg: marginals needed: 3  completes needed: 1  trust model: PGP
gpg: depth: 0  valid:   1  signed:   0  trust: 0-, 0q, 0n, 0m, 0f, 1u
pub   rsa2048/B4EF2D0D 2016-06-17 [S]
      Key fingerprint = F8FE 22F7 4F1B 714E 38DA  6181 B27F 74F7 B4EF 2D0D
uid         [ultimate] Offensive Security Repository Signing Key <repoadmin@offsec.com>
sub   rsa2048/38035F38 2016-06-17 []
```

Note that when you are prompted for a passphrase, you should enter an empty value (and confirm that you don't want to protect your private key) as you want to be able to sign the repository non-interactively. Note also that `gpg` requires write access to the terminal to be able to securely prompt for a passphrase: that is why you changed the ownership of the virtual terminal (which is owned by root since you initially connected as that user) before starting a shell as pkgrepo.

Now you can start setting up the repository. A dedicated directory is necessary for `reprepro` and inside that directory you have to create a `conf/distributions` file documenting which distributions are available in the package repository:

```
$ mkdir -p reprepro/conf
$ cd reprepro
$ cat >conf/distributions <<END
Codename: offsec-internal
AlsoAcceptFor: unstable
Origin: Offensive Security
Description: Offsec's Internal packages
Architectures: source amd64 i386
Components: main
SignWith: F8FE22F74F1B714E38DA6181B27F74F7B4EF2D0D
END
```

The required fields are Codename, which gives the name of the distribution, Architectures, which indicates which architectures will be available in the distribution (and accepted on the input side), and Components, which indicates the various components available in the distribution (com-

ponents are a sort of sub-section of the distribution, which can be enabled separately in APT's sources.list). The Origin and Description fields are purely informative and they are copied as-is in the `Release` file. The SignWith field asks `reprepro` to sign the repository with the GnuPG key whose identifier is listed (put the full fingerprint here to ensure you use the correct key, and not another one colliding on the short identifier). The AlsoAcceptFor setting is not required but makes it possible to process `.changes` files whose Distribution field has a value listed here (without this, it would only accept the distribution's codename in that field).

With this basic setup in place, you can let `reprepro` generate an empty repository:

```
$ reprepro export
Exporting indices...
$ find .
.
./db
./db/version
./db/references.db
./db/contents.cache.db
./db/checksums.db
./db/packages.db
./db/release.caches.db
./conf
./conf/distributions
./dists
./dists/offsec-internal
./dists/offsec-internal/Release.gpg
./dists/offsec-internal/Release
./dists/offsec-internal/main
./dists/offsec-internal/main/source
./dists/offsec-internal/main/source/Release
./dists/offsec-internal/main/source/Sources.gz
./dists/offsec-internal/main/binary-amd64
./dists/offsec-internal/main/binary-amd64/Packages
./dists/offsec-internal/main/binary-amd64/Release
./dists/offsec-internal/main/binary-amd64/Packages.gz
./dists/offsec-internal/main/binary-i386
./dists/offsec-internal/main/binary-i386/Packages
./dists/offsec-internal/main/binary-i386/Release
./dists/offsec-internal/main/binary-i386/Packages.gz
./dists/offsec-internal/InRelease
```

As you can see, `reprepro` created the repository meta-information in a `dists` sub-directory. It also initialized an internal database in a `db` sub-directory.

It is now time to add your first package. First, copy the files generated by the build of the offsec-defaults package (`offsec-defaults_1.0.dsc`, `offsec-defaults_1.0.tar.xz`,

`offsec-defaults_1.0_all.deb`, and `offsec-defaults_1.0_amd64.changes`) into `/tmp` on the server hosting the package repository and ask `reprepro` to include the package:

```
$ reprepro include offsec-internal /tmp/offsec-defaults_1.0_amd64.changes
Exporting indices...
$ find pool
pool
pool/main
pool/main/o
pool/main/o/offsec-defaults
pool/main/o/offsec-defaults/offsec-defaults_1.0.dsc
pool/main/o/offsec-defaults/offsec-defaults_1.0.tar.xz
pool/main/o/offsec-defaults/offsec-defaults_1.0_all.deb
```

As you can see, it added the files into its own package pool in a `pool` sub-directory.

The `dists` and `pool` directories are the two directories that you need to make (publicly) available over HTTP to finish the setup of your APT repository. They contain all the files that APT will want to download.

Assuming that you want to host this on a virtual host named pkgrepo.offsec.com, you could create the following Apache configuration file, save it to `/etc/apache2/sites-available/pkgrepo.offsec.com.conf`, and enable it with `a2ensite pkgrepo.offsec.com`):

```
<VirtualHost *:80>
    ServerName pkgrepo.offsec.com
    ServerAdmin repoadmin@offsec.com

    ErrorLog /var/log/apache2/pkgrepo.offsec.com-error.log
    CustomLog /var/log/apache2/pkgrepo.offsec.com-access.log "%h %l %u %t \"%r\" %>s %O"

    DocumentRoot /home/pkgrepo/reprepro

    <Directory "/home/pkgrepo/reprepro">
        Options Indexes FollowSymLinks MultiViews
        Require all granted
        AllowOverride All
    </Directory>
</VirtualHost>
```

And the corresponding `sources.list` entry to add on machines that need packages from this repository would look like this:

```
deb http://pkgrepo.offsec.com offsec-internal main

# Enable next line if you want access to source packages too
# deb-src http://pkgrepo.offsec.com offsec-internal main
```

Your package is now published and should be available to your networked hosts.

Although this has been a lengthy setup, the "heavy lifting" is now completed. You can boot your networked machines via PXE, install a customized version of Kali Linux without interaction thanks to a network-delivered preseed, configure SaltStack to manage your configurations (and control minions!), create forked custom packages, and distribute those packages through your own package repository. This provides centralized management and enterprise-level control over multiple Kali Linux installations. In short, you can now quickly deploy highly secure Kali systems preconfigured for your specific needs and keep them synchronized thanks to Kali's (semi-automatic) installation of all package updates.

10.4. Summary

Kali Linux scales beyond the desktop to medium or large scale deployments and even to the enterprise level. In this chapter, we covered how to centralize management of multiple Kali installations with SaltStack, allowing you to quickly deploy highly secure Kali systems preconfigured for your specific needs. We also revealed how you can keep them synchronized thanks to Kali's (semi-automatic) installation of package updates.

We discussed package forking, which allows you to create your own customized distributable source packages.

In summary, let's review the major steps required to establish Salt masters and minions, which allow you remote control and configuration of remote hosts.

Summary Tips:

- Boot machine from the network with PXE, with at least a TFTP file server, a DHCP/BOOTP server (and a web server for debconf preseeding). *dnsmasq* handles both DHCP and TFTP, and the *apache2* web server comes pre-installed (but disabled) on Kali.
- The Debian installation manual covers the setup of *isc-dhcp-server* and *tftpd-hpa* for PXE booting:

  ➨ `https://www.debian.org/releases/stable/amd64/ch04s05.html`

- *dnsmasq* is configured through `/etc/dnsmasq.conf`. A basic configuration consists of only a few key lines:

```
# Network interface to handle
interface=eth0
# DHCP options
# IP range to allocate
dhcp-range=192.168.101.100,192.168.101.200,12h
# Gateway to announce to clients
dhcp-option=option:router,192.168.101.1
# DNS servers to announce to clients
dhcp-option=option:dns-server,8.8.8.8,8.8.4.4
# Boot file to announce to clients
```

```
dhcp-boot=pxelinux.0
# TFTP options
enable-tftp
# Directory hosting files to serve
tftp-root=/tftpboot/
```

- Unpack 32-bit (i386), 64-bit (amd64), standard or graphical (gtk) installation boot files from the Kali archive into `/tftpboot/`. The archives can be found here:

➡ `http://http.kali.org/dists/kali-rolling/main/installer-amd64/current/images/netboot/gtk/netboot.tar.gz`

➡ `http://http.kali.org/dists/kali-rolling/main/installer-amd64/current/images/netboot/netboot.tar.gz`

➡ `http://http.kali.org/dists/kali-rolling/main/installer-i386/current/images/netboot/gtk/netboot.tar.gz`

➡ `http://http.kali.org/dists/kali-rolling/main/installer-i386/current/images/netboot/netboot.tar.gz`

```
# mkdir /tftpboot
# cd /tftpboot
# wget http://http.kali.org/dists/kali-rolling/main/installer-amd64/current/
    ➥ images/netboot/netboot.tar.gz
# tar xf netboot.tar.gz
```

- Optionally modify `txt.cfg` to preseed parameters or custom timeouts. See section 4.3, "Unattended Installations" [page 91]. Next, you can leverage configuration management tools to manage machines or configure remote computers to any desired state.
- SaltStack is a centralized configuration management service: a Salt master manages many Salt minions. Install the *salt-master* package on a reachable server and *salt-minion* on managed hosts.
- Edit the `/etc/salt/minion` YAML-formatted config file and set the master key to the DNS name (or IP address) of the Salt master.
- Set minion's unique identifier in `/etc/salt/minion_id`:

```
minion# echo kali-scratch >/etc/salt/minion_id
minion# systemctl enable salt-minion
minion# systemctl start salt-minion
```

- Key exchange will follow. On the master, accept minion's identification key. Subsequent connections will be automatic:

```
master# systemctl enable salt-master
master# systemctl start salt-master
master# salt-key --list all
```

```
Accepted Keys:
Denied Keys:
Unaccepted Keys:
kali-scratch
Rejected Keys:
master# salt-key --accept kali-scratch
The following keys are going to be accepted:
Unaccepted Keys:
kali-scratch
Proceed? [n/Y] y
Key for minion kali-scratch accepted.
```

- Once minions are connected, you can execute commands on them from the master. Examples:

```
master# salt '*' test.ping
kali-scratch:
True
kali-master:
True
master# salt kali-scratch cmd.shell 'uptime; uname -a'
master# salt kali-scratch sys.doc'
master# salt '*' service.enable ssh
[...]
master# salt '*' service.start ssh
[...]
master# salt '*' pkg.refresh_db
[...]
master# salt '*' pkg.upgrade dist_upgrade=True
server# salt '*' cmd.shell 'pkill -f dnmap_client'
```

- The full list of execution modules can be found at `https://docs.saltstack.com/en/latest/ref/modules/all/index.html`.
- Use Salt state files (re-usable configuration templates) to schedule actions, collect data, orchestrate sequences of operations on multiple minions, provision cloud systems and bring them under management, and more. Save time with pre-defined Salt formulas:

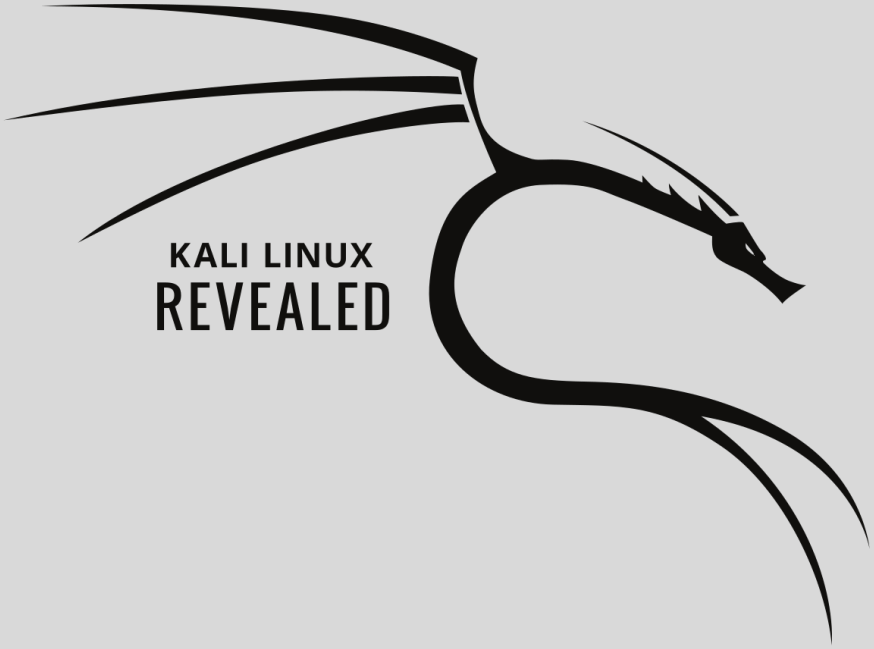
  ➨ `https://docs.saltstack.com/en/latest/topics/development/conventions/formulas.html`

- When it comes time to fork a package, first decide if it is a task that you need to tackle. There are significant advantages and disadvantages. Review them carefully. The *kali-meta*, *desktop-base*, and *kali-menu* packages are interesting, probable choices. The process of forking a package can be daunting and is difficult to summarize.

Now that we have covered all the bases in terms of installation, configuration, customization, and deployment of Kali Linux, let's turn towards the role of Kali Linux in the field of Information Security.

Keywords

Types of assessments
Vulnerability assessment
Compliance penetration test
Traditional penetration test
Application assessment
Types of attacks
Denial of service
Memory corruption
Web vulnerabilities
Password attacks
Client-side attacks



Chapter

11

Introduction to Security Assessments

Contents

We have covered many Kali Linux-specific features up to this point so you should have a strong understanding of what makes Kali special and how to accomplish a number of complex tasks.

Before putting Kali to use however, there are a few concepts relating to security assessments that you should understand. In this chapter, we will introduce these concepts to get you started and provide references that will help if you need to use Kali to perform a security assessment.

To start with, it is worth taking some time to explore exactly what "security" means when dealing with information systems. When attempting to secure an information system, you focus on three primary attributes of the system:

- *Confidentiality*: can actors who should not have access to the system or information access the system or information?
- *Integrity*: can the data or the system be modified in some way that is not intended?
- *Availability*: are the data or the system accessible when and how it is intended to be?

Together, these concepts make up the CIA (Confidentiality, Integrity, Availability) triad and in large part, are the primary items that you will focus on when securing a system as part of standard deployment, maintenance, or assessment.

It is also important to note that in some cases, you may be far more concerned with one aspect of the CIA triad than others. For instance, if you have a personal journal that contains your most secret thoughts, the confidentiality of the journal may be far more important to you than the integrity or the availability. In other words, you may not be as concerned about whether someone can write to the journal (as opposed to reading it) or whether or not the journal is always accessible. On the other hand, if you are securing a system that tracks medical prescriptions, the integrity of the data will be most critical. While it is important to prevent other people from reading what medications someone uses and it is important that you can access this list of medications, if someone were able to change the contents of the system (altering the integrity), it could lead to life-threatening results.

When you are securing a system and an issue is discovered, you will have to consider which of these three concepts, or which combination of them, the issue falls into. This helps you understand the problem in a more comprehensive manner and allows you to categorize the issues and respond accordingly. It is possible to identify vulnerabilities that impact a single, or multiple items from the CIA triad. To use a web application with a SQL injection vulnerability as an example:

- *Confidentiality*: a SQL injection vulnerability that allows an attacker to extract the full contents of the web application, allowing them to have full access to read all the data, but no ability to change the information or disable access to the database.
- *Integrity*: a SQL injection vulnerability that allows an attacker to change the existing information in the database. The attacker can't read the data or prevent others from accessing the database.

- *Availability*: a SQL injection vulnerability that initiates a long-running query, consuming a large amount of resources on the server. This query, when initiated multiple times, leads to a denial of service (DoS) situation. The attacker has no ability to access or change data but can prevent legitimate users from accessing the web application.
- *Multiple*: a SQL injection vulnerability leads to full interactive shell access to the host operating system running the web application. With this access, the attacker can breach the confidentiality of the system by accessing data as they please, compromise the integrity of the system by altering data, and if they so choose, destroy the web application, leading to a compromise of the availability of the system.

The concepts behind the CIA triad are not overly complicated, and realistically are items that you are working with intuitively, even if you don't recognize it. However, it is important to mindfully interact with the concept as it can help you recognize where to direct your efforts. This conceptual foundation will assist you with the identification of the critical components of your systems and the amount of effort and resources worth investing in correcting identified problems.

Another concept that we will address in detail is *risk*, and how it is made up of *threats* and *vulnerabilities*. These concepts are not too complex, but they are easy to get wrong. We will cover these concepts in detail later on, but at a high level, it is best to think of *risk* as what you are trying to prevent from happening, *threat* as who would do it to you, and *vulnerability* as what allows them to do it. Controls can be put in place to address the threat or vulnerability, with the goal of mitigating the risk.

For example, when visiting some parts of the world, you may be at substantial *risk* of catching malaria. This is because the *threat* of mosquitoes is very high in some areas, and you are almost certainly not immune to malaria. Fortunately, you can control the *vulnerability* with medication and attempt to control the *threat* with the use of bug repellent and mosquito nets. With controls in place addressing both the *threat* and the *vulnerability*, you can help ensure the *risk* does not actualize.

11.1. Kali Linux in an Assessment

When preparing to use Kali Linux in the field, you must first ensure you have a clean, working installation. A common mistake that many novice security professionals make is using a single installation across multiple assessments. This is a problem for two primary reasons:

- Over the course of an assessment, you will often manually install, tweak, or otherwise change your system. These one-off changes may get you up and running quickly or solve a particular problem, but they are difficult to keep track of; they make your system more difficult to maintain; and they complicate future configurations.
- Each security assessment is unique. Leaving behind notes, code, and other changes can lead to confusion, or worse — cross-contamination of client data.

That is why starting with a clean Kali installation is highly recommended and why having a pre-customized version of Kali Linux that is ready for automated installation quickly pays off. Be sure to refer back to section 9.3, "Building Custom Kali Live ISO Images" [page 236] and section 4.3, "Unattended Installations" [page 91] on how to do this, since the more you automate today, the less time you waste tomorrow.

Everyone has different requirements when it comes to how they like Kali Linux configured when they are in the field, but there are some universal recommendations that you really want to follow. First, consider using an encrypted installation as documented in section 4.2.2, "Installation on a Fully Encrypted File System" [page 85]. This will protect your data on the physical machine, which is a life-saver if your laptop is ever stolen.

For extra safety during travel, you might want to nuke the decryption key (see "Adding a Nuke Password for Extra Safety" [page 245]) after having sent an (encrypted) copy of the key to a co-worker in the office. That way, your data are secure until you get back to the office where you can restore the laptop with the decryption key.

Another item that you should double-check is the list of packages that you have installed. Consider what tools you might need for the work you are setting out to accomplish. For example, if you are embarking on a wireless security assessment, you may consider installing the *kali-linux-wireless* metapackage, which contains all of the wireless assessment tools available in Kali Linux, or if a web application assessment is coming up, you can install all of the available web application testing tools with the *kali-linux-web* metapackage. It is best to assume that you will not have easy access to the Internet while conducting a security assessment, so be sure to prepare as much as possible in advance.

For the same reason, you might want to review your network settings (see section 5.1, "Configuring the Network" [page 104] and section 7.3, "Securing Network Services" [page 153]). Double-check your DHCP settings and review the services that are listening on your assigned IP address. These settings might make a critical impact to your success. You can't assess what you can't see and excessive listening services might flag your system and get you shut down before you get started.

If your role involves investigating network intrusions, paying close attention to your network settings is even more important and you need to avoid altering the impacted systems. A customized version of Kali with the *kali-linux-forensic* metapackage booted up in forensics mode will not automatically mount disks or use a swap partition. In this way, you can help maintain the integrity of the system under analysis while making use of the many forensics tools available in Kali Linux.

It is critical that you properly prepare your Kali Linux installation for the job. You will find that a clean, efficient, and effective Kali environment will always make everything that follows much smoother.

11.2. Types of Assessments

Now that you have ensured that your Kali environment is ready, the next step is defining exactly what sort of assessment you are conducting. At the highest level, we may describe four types of assessments: a *vulnerability assessment*, a *compliance test*, a *traditional penetration test*, and an *application assessment*. An engagement may involve various elements of each type of assessment but it is worth describing them in some detail and explaining their relevance to your Kali Linux build and environment.

Before delving into the different types of assessments, it is important to first note the difference between a vulnerability and an exploit.

A *vulnerability* is defined as a flaw that, when taken advantage of, will compromise the confidentiality, integrity, or availability of an information system. There are many different types of vulnerabilities that can be encountered, including:

- File Inclusion: File inclusion vulnerabilities[1] in web applications allow you to *include* the contents of a local or remote file into the computation of a program. For example, a web application may have a "Message of the day" function that reads the contents of a file and includes it in the web page to display it to the user. When this type of feature is programmed incorrectly, it can allow an attacker to modify their web request to force the site to include the contents of a file of their choosing.
- SQL Injection: A SQL injection[2] attack is one where the input validation routines for the program are bypassed, allowing an attacker to provide SQL commands for the targeted program to execute. This is a form of command execution that can lead to potential security issues.
- Buffer Overflow: A buffer overflow[3] is a vulnerability that bypasses input validation routines to write data into a buffer's adjacent memory. In some cases, that adjacent memory location may be critical to the operation of the targeted program and control of code execution can be obtained through careful manipulation of the overwritten memory data.
- Race Conditions: A race condition[4] is a vulnerability that takes advantage of timing dependencies in a program. In some cases, the workflow of a program depends on a specific sequence of events to occur. If you can alter this sequence of events, that may lead to a vulnerability.

An *exploit*, on the other hand, is software that, when used, takes advantage of a specific vulnerability, although not all vulnerabilities are exploitable. Since an exploit must change a running process, forcing it to make an unintended action, exploit creation can be complex. Furthermore, there are a number of anti-exploit technologies in modern computing platforms that have been

[1] `https://en.wikipedia.org/wiki/File_inclusion_vulnerability`
[2] `https://en.wikipedia.org/wiki/SQL_injection`
[3] `https://en.wikipedia.org/wiki/Buffer_overflow`
[4] `https://en.wikipedia.org/wiki/Race_condition`

designed to make it harder to exploit vulnerabilities, such as Data Execution Prevention[5] (DEP) and Address Space Layout Randomization[6] (ASLR). However, just because there is no publicly-known exploit for a specific vulnerability, that does not mean that one does not exist (or that one can not be created). For example, many organizations sell commercialized exploits that are never made public, so all vulnerabilities must be treated as potentially exploitable.

11.2.1. Vulnerability Assessment

A *vulnerability* is considered a weakness that could be used in some manner to compromise the confidentiality, integrity, or availability of an information system. In a vulnerability assessment, your objective is to create a simple inventory of discovered vulnerabilities within the *target environment*. This concept of a target environment is extremely important. You must be sure to stay within the scope of your client's target network and required objectives. Creeping outside the scope of an assessment can cause an interruption of service, a breach of trust with your client, or legal action against you and your employer.

Due to its relative simplicity, a vulnerability test is often completed in more mature environments on a regular basis as part of demonstrating their due diligence. In most cases, an automated tool, such as the ones in the Vulnerability Analysis[7] and Web Applications[8] categories of the Kali Tools site and Kali desktop Applications menu, is used to discover live systems in a target environment, identify listening services, and enumerate them to discover as much information as possible such as the server software, version, platform, and so on.

This information is then checked for known signatures of potential issues or vulnerabilities. These signatures are made up of data point combinations that are intended to represent known issues. Multiple data points are used, because the more data points you use, the more accurate the identification. A very large number of potential data points exist, including but not limited to:

- Operating System Version: It is not uncommon for software to be vulnerable on one operating system version but not on another. Because of this, the scanner will attempt to determine, as accurately as possible, what operating system version is hosting the targeted application.
- Patch Level: Many times, patches for an operating system will be released that do not increase the version information, but still change the way a vulnerability will respond, or even eliminate the vulnerability entirely.
- Processor Architecture: Many software applications are available for multiple processor architectures such as Intel x86, Intel x64, multiple versions of ARM, UltraSPARC, and so on.

[5] `https://en.wikipedia.org/wiki/Executable_space_protection#Windows`
[6] `https://en.wikipedia.org/wiki/Address_space_layout_randomization`
[7] `http://tools.kali.org/category/vulnerability-analysis`
[8] `http://tools.kali.org/category/web-applications`

In some cases, a vulnerability will only exist on a specific architecture, so knowing this bit of information can be critical for an accurate signature.

- Software Version: The version of the targeted software is one of the basic items that needs to be captured to identify a vulnerability.

These, and many other data points, will be used to make up a signature as part of a vulnerability scan. As expected, the more data points that match, the more accurate the signature will be. When dealing with signature matches, you can have a few different potential results:

- True Positive: The signature is matched and it captures a true vulnerability. These results are the ones you will need to follow up on and correct, as these are the items that malicious individuals can take advantage of to hurt your organization (or your client's).
- False Positive: The signature is matched; however the detected issue is not a true vulnerability. In an assessment, these are often considered noise and can be quite frustrating. You never want to dismiss a true positive as a false positive without more extensive validation.
- True Negative: The signature is not matched and there is no vulnerability. This is the ideal scenario, verifying that a vulnerability does not exist on a target.
- False Negative: The signature is not matched but there is an existing vulnerability. As bad as a false positive is, a false negative is much worse. In this case, a problem exists but the scanner did not detect it, so you have no indication of its existence.

As you can imagine, the accuracy of the signatures is extremely important for accurate results. The more data that are provided, the greater the chance there is to have accurate results from an automated signature-based scan, which is why authenticated scans are often so popular.

With an authenticated scan, the scanning software will use provided credentials to authenticate to the target. This provides a deeper level of visibility into a target than would otherwise be possible. For instance, on a normal scan you may only detect information about the system that can be derived from listening services and the functionality they provide. This can be quite a bit of information sometimes but it can't compete with the level and depth of data that will be obtained if you authenticate to the system and comprehensively review all installed software, applied patches, running processes, and so on. This breadth of data is useful for detecting vulnerabilities that otherwise may not have been discovered.

A well-conducted vulnerability assessment presents a snapshot of potential problems in an organization and provides metrics to measure change over time. This is a fairly lightweight assessment, but even still, many organizations will regularly perform automated vulnerability scans in off-hours to avoid potential problems during the day when service availability and bandwidth are most critical.

As previously mentioned, a vulnerability scan will have to check many different data points in order to get an accurate result. All of these different checks can create load on the target system as well as consume bandwidth. Unfortunately, it is difficult to know exactly how many resources will be consumed on the target as it depends on the number of open services and the types of

checks that would be associated with those services. This is the cost of doing a scan; it is going to occupy system resources. Having a general idea of the resources that will be consumed and how much load the target system can take is important when running these tools.

Scanning Threads Most vulnerability scanners include an option to set *threads per scan*, which equates to the number of concurrent checks that occur at one time. Increasing this number will have a direct impact on the load on the assessment platform as well as the networks and targets you are interacting with. This is important to keep in mind as you use these scanners. It is tempting to increase the threads in order to complete scans faster but remember the substantial load increase associated with doing so.

When a vulnerability scan is finished, the discovered issues are typically linked back to industry standard identifiers such as CVE number[9], EDB-ID[10], and vendor advisories. This information, along with the vulnerabilities CVSS score[11], is used to determine a risk rating. Along with false negatives (and false positives), these arbitrary risk ratings are common issues that need to be considered when analyzing the scan results.

Since automated tools use a database of signatures to detect vulnerabilities, any slight deviation from a known signature can alter the result and likewise the validity of the perceived vulnerability. A false positive incorrectly flags a vulnerability that does not exist, while a false negative is effectively blind to a vulnerability and does not report it. Because of this, a scanner is often said to only be as good as its signature rule base. For this reason, many vendors provide multiple signature sets: one that might be free to home users and another fairly expensive set that is more comprehensive, which is generally sold to corporate customers.

The other issue that is often encountered with vulnerability scans is the validity of the suggested risk ratings. These risk ratings are defined on a generic basis, considering many different factors such as privilege level, type of software, and pre- or post-authentication. Depending on your environment, these ratings may or may not be applicable so they should not be accepted blindly. Only those well-versed in the systems and the vulnerabilities can properly validate risk ratings.

While there is no universally defined agreement on risk ratings, NIST Special publication 800-30[12] is recommended as a baseline for evaluation of risk ratings and their accuracy in your environment. NIST SP 800-30 defines the true risk of a discovered vulnerability as *a combination of the likelihood of occurrence and the potential impact*.

[9] `https://cve.mitre.org`
[10] `https://www.exploit-db.com/about/`
[11] `https://www.first.org/cvss`
[12] `http://csrc.nist.gov/publications/PubsSPs.html#800-30`

Likelihood of Occurrence

According to the National Institute of Standards and Technology (NIST), the likelihood of occurrence is based on the probability that a particular threat is capable of exploiting a particular vulnerability, with possible ratings of Low, Medium, or High.

- High: the potential adversary is highly skilled and motivated and the measures that have been put in place to protect against the vulnerability are insufficient.
- Medium: the potential adversary is motivated and skilled but the measures put in place to protect against the vulnerability may impede their success.
- Low: the potential adversary is unskilled or lacks motivation and there are measures in place to protect against the vulnerability that are partially or completely effective.

Impact

The level of impact is determined by evaluating the amount of harm that could occur if the vulnerability in question were exploited or otherwise taken advantage of.

- High: taking advantage of the vulnerability could result in very significant financial losses, serious harm to the mission or reputation of the organization, or even serious injury, including loss of life.
- Medium: taking advantage of the vulnerability could lead to financial losses, harm to the mission or reputation of the organization, or human injury.
- Low: taking advantage of the vulnerability could result in some degree of financial loss or impact to the mission and reputation of the organization.

Overall Risk

Once the likelihood of occurrence and impact have been determined, you can then determine the overall risk rating, which is defined as a function of the two ratings. The overall risk can be rated Low, Medium, or High, which provides guidance to those responsible for securing and maintaining the systems in question.

- High: There is a strong requirement for additional measures to be implemented to protect against the vulnerability. In some cases, the system may be allowed to continue operating but a plan must be designed and implemented as soon as possible.
- Medium: There is a requirement for additional measures to be implemented to protect against the vulnerability. A plan to implement the required measures must be done in a timely manner.

- Low: The owner of the system will determine whether to implement additional measures to protect against the vulnerability or they can opt to accept the risk instead and leave the system unchanged.

In Summary

With so many factors making up the true risk of a discovered vulnerability, the pre-defined risk ratings from tool output should only be used as a starting point to determine the true risk to the overall organization.

Competently-created reports from a vulnerability assessment, when analyzed by a professional, can provide an initial foundation for other assessments, such as compliance penetration tests. As such, it is important to understand how to get the best results possible from this initial assessment.

Kali makes an excellent platform for conducting a vulnerability assessment and does not need any special configuration. In the Kali Applications menu, you will find numerous tools for vulnerability assessments in the Information Gathering, Vulnerability Analysis, and Web Application Analysis categories. Several sites, including the aforementioned Kali Linux Tools Listing[13], The Kali Linux Official Documentation[14] site, and the free Metasploit Unleashed[15] course provide excellent resources for using Kali Linux during a vulnerability assessment.

11.2.2. Compliance Penetration Test

The next type of assessment in order of complexity is a compliance- based penetration test. These are the most common penetration tests as they are government- and industry-mandated requirements based on a compliance framework the entire organization operates under.

While there are many industry-specific compliance frameworks, the most common would likely be Payment Card Industry Data Security Standard[16] (PCI DSS), a framework dictated by payment card companies that retailers processing card-based payments must comply with. However, a number of other standards exist such as the Defense Information Systems Agency Security Technical Implementation Guides[17] (DISA STIG), Federal Risk and Authorization Management Program[18] (FedRAMP), Federal Information Security Management Act[19] (FISMA), and others. In some cases, a corporate client may request an assessment, or ask to see the results of the most recent assessment for various reasons. Whether ad-hoc or mandated, these sorts of assessments are collectively

[13] http://tools.kali.org/tools-listing
[14] http://docs.kali.org
[15] https://www.offensive-security.com/metasploit-unleashed/
[16] https://www.pcisecuritystandards.org/documents/Penetration_Testing_Guidance_March_2015.pdf
[17] http://iase.disa.mil/stigs/Pages/index.aspx
[18] https://www.fedramp.gov/about-us/about/
[19] http://csrc.nist.gov/groups/SMA/fisma/

called compliance-based penetration tests, or simply "compliance assessments" or "compliance checks".

A compliance test often begins with a vulnerability assessment. In the case of PCI compliance auditing[20], a vulnerability assessment, when performed properly, can satisfy several of the base requirements, including: "2. Do not use vendor-supplied defaults for system passwords and other security parameters" (for example, with tools from the Password Attacks menu category), "11. Regularly test security systems and processes" (with tools from the Database Assessment category) and others. Some requirements, such as "9. Restrict physical access to cardholder data" and "12. Maintain a policy that addresses information security for all personnel" don't seem to lend themselves to traditional tool-based vulnerability assessment and require additional creativity and testing.

Despite the fact that it might not seem straight-forward to use Kali Linux for some elements of a compliance test, the fact is that Kali is a perfect fit in this environment, not just because of the wide range of security-related tools, but because of the open-source Debian environment it is built on, allowing for the installation of a wide range of tools. Searching the package manager with carefully chosen keywords from whichever compliance framework you are using is almost certain to turn up multiple results. As it stands, many organizations use Kali Linux as the standard platform for these exact sorts of assessments.

11.2.3. Traditional Penetration Test

A traditional penetration test has become a difficult item to define, with many working from different definitions, depending on the space they operate in. Part of this market confusion is driven by the fact that the term "Penetration Test" has become more commonly used for the previously mentioned compliance-based penetration test (or even a vulnerability assessment) where, by design, you are not delving too deep into the assessment because that would go beyond the minimum requirements.

For the purposes of this section, we will side-step that debate and use this category to cover assessments that go beyond the minimum requirements; assessments that are designed to actually improve the overall security of the organization.

As opposed to the previously-discussed assessment types, penetration tests don't often start with a scope definition, but instead a goal such as, "simulate what would happen if an internal user is compromised" or, "identify what would happen if the organization came under focused attack by an external malicious party." A key differentiator of these sorts of assessments is that they don't just find and validate vulnerabilities, but instead leverage identified issues to uncover the worst-case scenario. Instead of relying solely on heavy vulnerability scanning toolsets, you must follow up with validation of the findings through the use of exploits or tests to eliminate false positives and do your best to detect hidden vulnerabilities or false negatives. This often involves exploiting

[20] `https://www.pcisecuritystandards.org/documents/PCIDSS_QRGv3_2.pdf`

vulnerabilities discovered initially, exploring the level of access the exploit provides, and using this increased access as leverage for additional attacks against the target.

This requires critical review of the target environment along with manual searching, creativity, and outside-the-box thinking to discover other avenues of potential vulnerability and ultimately using other tools and tests outside those found by the heavier vulnerability scanners. Once this is completed, it is often necessary to start the whole process over again multiple times to do a full and complete job.

Even with this approach, you will often find that many assessments are composed of different phases. Kali makes it easy to find programs for each phase by way of the Kali Menu:

- Information Gathering: In this phase, you focus on learning as much as possible about the target environment. Typically, this activity is non-invasive and will appear similar to standard user activity. These actions will make up the foundation of the rest of the assessment and therefore need to be as complete as possible. Kali's Information Gathering category has dozens of tools to uncover as much information as possible about the environment being assessed.
- Vulnerability Discovery: This will often be called "active information gathering", where you don't attack but engage in non-standard user behavior in an attempt to identify potential vulnerabilities in the target environment. This is where the previously-discussed vulnerability scanning will most often take place. The programs listed in the Vulnerability Analysis, Web Application Analysis, Database Assessment, and Reverse Engineering categories will be useful for this phase.
- Exploitation: With the potential vulnerabilities discovered, in this phase you try to exploit them to get a foothold into the target. Tools to assist you in this phase can be found in the Web Application Analysis, Database Assessment, Password Attacks, and Exploitation Tools categories.
- Pivoting and Exfiltration: Once the initial foothold is established, further steps have to be completed. These are often escalating privileges to a level adequate to accomplish your goals as an attacker, pivoting into other systems that may not have been previously accessible to you, and exfiltrating sensitive information from the targeted systems. Refer to the Password Attacks, Exploitation Tools, Sniffing & Spoofing, and Post Exploitation categories to help with this phase.
- Reporting: Once the active portion of the assessment is completed, you then have to document and report on the activities that were conducted. This phase is often not as technical as the previous phases, however it is highly important to ensure your client gets full value from the work completed. The Reporting Tools category contains a number of tools that have proven useful in the reporting phase.

In most cases, these assessments will be very unique in their design as every organization will operate with different threats and assets to protect. Kali Linux makes a very versatile base for

these sorts of assessments and this is where you can really take advantage of the many Kali Linux customization features. Many organizations that conduct these sorts of assessments will maintain highly customized versions of Kali Linux for internal use to speed up deployment of systems before a new assessment.

Customizations that organizations make to their Kali Linux installations will often include:

- Pre-installation of commercial packages with licensing information. For instance, you may have a package such as a commercial vulnerability scanner that you would like to use. To avoid having to install this package with each build, you can do it once[21] and have it show up in every Kali deployment you do.
- Pre-configured connect-back virtual private networks (VPN). These are very useful in leave-behind devices that allow you to conduct "remote internal" assessments. In most cases, these systems will connect back to an assessor-controlled system, creating a tunnel that the assessor can use to access internal systems. The Kali Linux ISO of Doom[22] is an example of this exact type of customization.
- Pre-installed internally-developed software and tools. Many organizations will have private toolsets, so setting these up once in a customized Kali install[23] saves time.
- Pre-configured OS configurations such as host mappings, desktop wallpaper, proxy settings, etc. Many Kali users have specific settings[24] they like to have tweaked just so. If you are going to do a re-deployment of Kali on a regular basis, capturing these changes makes a lot of sense.

11.2.4. Application Assessment

While most assessments have a broad scope, an application assessment is a specialty that is narrowly focused on a single application. These sorts of assessments are becoming more common due to the complexity of mission-critical applications that organizations use, many of which are built in-house. An application assessment is usually added on to a broader assessment, as required. Applications that may be assessed in this manner include, but are not limited to:

- Web applications: The most common externally-facing attack surface, web applications make great targets simply because they are accessible. Often, standard assessments will find basic problems in web applications, however a more focused review is often worth the time to identify issues relating to the workflow of the application. The *kali-linux-web* meta-package has a number of tools to help with these assessments.
- Compiled desktop applications: Server software is not the only target; desktop applications also make up a wonderful attack surface. In years past, many desktop applications such as

[21] `http://docs.kali.org/kali-dojo/02-mastering-live-build`
[22] `https://www.offensive-security.com/kali-linux/kali-rolling-iso-of-doom/`
[23] `http://docs.kali.org/development/live-build-a-custom-kali-iso`
[24] `https://www.offensive-security.com/kali-linux/kali-linux-recipes/`

PDF readers or web-based video programs were highly targeted, forcing them to mature. However, there are still a wide number of desktop applications that are a wealth of vulnerabilities when properly reviewed.

- Mobile applications: As mobile devices become more popular, mobile applications will become that much more of a standard attack surface in many assessments. This is a fast moving target and methodologies are still maturing in this area, leading to new developments practically every week. Tools related to the analysis of mobile applications can be found in the Reverse Engineering menu category.

Application assessments can be conducted in a variety of different ways. As a simple example, an application-specific automated tool can be run against the application in an attempt to identify potential issues. These tools will use application-specific logic in an attempt to identify unknown issues rather than just depending on a set of known signatures. These tools must have a built-in understanding of the application's behavior. A common example of this would be a web application vulnerability scanner such as Burp Suite[25], directed against an application that first identifies various input fields and then sends common SQL injection attacks to these fields while monitoring the application's response for indications of a successful attack.

In a more complex scenario, an application assessment can be conducted interactively in either a *black box* or *white box* manner.

- Black Box Assessment: The tool (or assessor) interacts with the application with no special knowledge or access beyond that of a standard user. For instance, in the case of a web application, the assessor may only have access to the functions and features that are available to a user that has not logged into the system. Any user accounts used would be ones where a general user can self-register the account. This would prevent the attacker from being able to review any functionality that is only available to users that need to be created by an administrator.

- White Box Assessment: The tool (or assessor) will often have full access to the source code, administrative access to the platform running the application, and so on. This ensures that a full and comprehensive review of all application functionality is completed, regardless of where that functionality lives in the application. The trade-off with this is that the assessment is in no way a simulation of actual malicious activity.

There are obviously shades of grey in between. Typically, the deciding factor is the goal of the assessment. If the goal is to identify what would happen in the event that the application came under a focused external attack, a black box assessment would likely be best. If the goal is to identify and eliminate as many security issues as possible in a relatively short time period, a white box approach may be more efficient.

[25] `https://portswigger.net/burp/`

In other cases, a hybrid approach may be taken where the assessor does not have full access to the application source code of the platform running the application, but user accounts are provisioned by an administrator to allow access to as much application functionality as possible.

Kali is an ideal platform for all manner of application assessments. On a default installation, a range of different application-specific scanners are available. For more advanced assessments, a range of tools, source editors, and scripting environments exist. You may find the Web Application[26] and Reverse Engineering[27] sections of the Kali Tools[28] website helpful.

11.3. Formalization of the Assessment

With your Kali environment ready and the type of assessment defined, you are almost ready to start working. Your last step is to formalize the work to be done. This is critically important, as this defines what the expectations for the work will be, and grants you permission to conduct what might otherwise be illegal activity. We will cover this at a high level, but this is a very complex and important step so you will likely want to check with your organization's legal representative for assistance.

As part of the formalization process, you will need to define the rules of engagement for the work. This covers items such as:

- What systems are you allowed to interact with? It is important to ensure you don't accidentally interfere with anything that is critical to business operations.
- What time of day and over what attack window is the assessment allowed to occur? Some organizations like to limit the times that the assessment work can be conducted.
- When you discover a potential vulnerability, are you allowed to exploit it? If not, what is the approval process? There are some organizations that take a very controlled approach to each exploitation attempt, whereas others would like a more realistic approach. It is best to define these expectations clearly before work begins.
- If a significant issue is discovered, how should it be handled? Sometimes, organizations want to be informed right away, otherwise it is typically addressed at the end of the assessment.
- In case of emergency, who should you contact? It is always important to know who to contact when a problem of any sort occurs.
- Who will know about the activity? How will it be communicated to them? In some cases, organizations will want to test their incident response and detection performance as part of the assessment. It is always a good idea to know this beforehand, so you know if you should take any degree of stealth in the approach to the assessment.

[26] `http://tools.kali.org/category/web-applications`
[27] `http://tools.kali.org/category/reverse-engineering`
[28] `http://tools.kali.org`

- What are the expectations at the end of the assessment? How will results be communicated? Know what all parties expect at the end of the assessment. Defining the deliverable is the best way to keep everyone happy after the work is completed.

While not complete, this listing gives you an idea of the details that should be covered. However, you should realize that there is no substitute for good legal representation. Once these items are defined, you need to acquire proper authorization to perform the assessment, since much of the activity that you will do in the course of an assessment may not be legal without proper authority from someone with the authority to give that permission.

With all that in place, there is still one last step you will want to take before starting work: validation. Never trust the scope that you are provided—always validate it. Use multiple information sources to confirm that the systems within scope are in fact owned by the client and that they are operated by the client as well. With the prevalence of cloud services, an organization may forget that they don't actually own the systems providing them service. You may find that you have to obtain special permission from a cloud service provider before starting work. In addition, always validate IP address blocks. Don't count on an organization's assumption that they own entire IP blocks, even if they sign off on them as viable targets. For example, we have seen examples of organizations that request an assessment of an entire class C network range when, in fact, they only owned a subset of those addresses. By attacking the entire class C address space, we would have ended up attacking the organization's network neighbors. The OSINT Analysis sub-category of the Information Gathering menu contains a number of tools that can assist you with this validation process.

11.4. Types of Attacks

Once the work is taking place, what are some of the specific sorts of attacks that you will be conducting? Each type of vulnerability[29] has its own associated exploitation techniques. This section will cover the various classes of vulnerabilities that you will interact with most often.

No matter what category of vulnerability you are looking at, Kali makes these tools and exploits easy to find. The Kali menu on your graphical user interface is divided up into categories to help make the right tool easier to find. In addition, the Kali Tools website[30] has comprehensive listings of the various tools available in Kali, organized by category and tagged for easy browsing. Each entry contains detailed information about the tool as well as example usage.

[29] `https://www.cvedetails.com/vulnerabilities-by-types.php`
[30] `http://tools.kali.org/tools-listing`

11.4.1. Denial of Service

Denial of service attacks leverage a vulnerability to create a loss of service, often by crashing the vulnerable process. The Stress Testing category of the Kali Linux menu contains a number of tools for this purpose.

When many people hear the term "denial of service attack", they immediately think of resource consumption attacks that are sent out from multiple sources at once against a single target. These would be a *distributed* denial of services attack, or DDoS. These sorts of attacks are rarely part of a professional security assessment.

Instead, a singular denial of service attack is most often the result of an improper attempt to exploit a vulnerability. If an exploit writer releases partially functional, or proof-of-concept (PoC) code and it is used in the field, this could create a denial of service condition. Even a properly-coded exploit may only work under very specific circumstances but cause a denial of service under lesser circumstances. It may seem that the solution is to only use safe and tested exploit code, or to write your own. Even with this solution, there are no guarantees and this severely limits the assessor, causing undue constraints, which results in a lesser assessment. Instead, the key is compromise. Avoid PoC code and untested exploits in the field and always make sure a lawyer has you covered for other mishaps.

Typically, denial of service attacks are not launched intentionally. Most automated vulnerability tools will declare denial of service vulnerabilities as lower risk due to the fact that while you can remove a service from operation, that service can't be exploited for code execution. However, it is important to remember that not all exploits are released publicly and a denial of service vulnerability may mask a deeper, more serious threat. A code execution exploit for a known denial of service may exist but not be public. The point is, pay attention to denial of service vulnerabilities and encourage your customer to get them patched regardless of their (often low) threat rating.

11.4.2. Memory Corruption

A memory corruption happens when a location within the memory space of a process is accidentally modified due to programming mistakes. Memory corruption bugs usually lead to unpredictable program behavior, however in many cases, these bugs allow process memory manipulation in such a way that the program execution flow can be controlled, allowing attacker-defined activity.

These attacks are typically referred to as buffer overflows, although this term is an oversimplification. The most common types of memory corruption are vastly different from one another and have their own tactics and techniques required for successful exploitation.

- Stack Buffer Overflow: When a program writes more data to a buffer on the stack than there is space available for it, adjacent memory can be corrupted, often causing the program to crash.

- Heap Corruption: Heap memory is allocated at run- time and usually contains data from the running program. Heap corruptions occur by manipulating the data to overwrite through the linked list of heap memory pointers.
- Integer Overflow: These overflows occur when an application tries to create a numeric value that can't be contained within its allocated storage space.
- Format String: When a program accepts user input and formats it without checking it, memory locations can be revealed or overwritten, depending on the format tokens that are used.

11.4.3. Web Vulnerabilities

Due to the fact that modern web sites are no longer static pages, but instead dynamically generated for the user, the average website is quite complex. Web vulnerabilities take advantage of this complexity in an effort to attack either the back end page generation logic or the presentation to the visitor of the site.

These sorts of attacks are extremely common, as many organizations have reached the point where they have very few externally facing services. Two of the most prevalent web application attack types[31] are SQL injection and cross-site scripting (XSS).

- SQL injection: These attacks take advantage of improperly-programmed applications that do not properly sanitize user input, leading to the ability to extract information from the database or even the complete takeover of the server.
- Cross-site scripting: As with SQL injection, XSS attacks result from improper sanitization of user input, allowing attackers to manipulate the user or site into executing code in the context of their own browser session.

Complex, rich, and complicated web applications are very common, presenting a welcome attack surface for malicious parties. You will find a large number of useful tools in the Web Application Analysis menu category and the *kali-linux-web* metapackage.

11.4.4. Password Attacks

Password attacks are attacks against the authentication system of a service. These attacks are often broken into online password attacks and offline password attacks, which you will find reflected in the Password Attacks menu category. In an online password attack, multiple passwords are attempted against a running system. In an offline password attack, the hashed or encrypted values of the passwords are obtained and the attacker attempts to obtain the clear text values. The protection against this sort of attack is the fact that it is computationally expensive to work through this process, limiting the number of attempts per second you can generate. However,

[31] `https://www.owasp.org/index.php/Top_10_2013-Top_10`

workarounds for this do exist, such as using graphic processor units (GPUs) to accelerate the number of attempts that can be made. The *kali-linux-gpu* metapackage contains a number of tools that tap into this power.

Most commonly, password attacks target vendor-supplied default passwords. As these are well-known values, attackers will scan for these default accounts, hoping to get lucky. Other common attacks include custom dictionary attacks where a wordlist is created that has been tailored to the target environment and then an online password attack against common, default, or known accounts is conducted where each word is attempted in sequence.

In an assessment, it is very important to understand the potential consequences of this sort of attack. First, they are often very noisy due to the repeated authentication attempts. Secondly, these attacks can often result in an account lock out situation after too many invalid attempts are performed against a single account. Finally, the performance of these attacks is often quite slow, resulting in difficulty when attempting to use a comprehensive wordlist.

11.4.5. Client-Side Attacks

Most attacks are conducted against servers, but as services have become harder to attack, easier targets have been selected. Client-side attacks are a result of this, where an attacker will target the various applications installed on the workstation of an employee within a target organization. The Social Engineering Tools menu category has a number of excellent applications that can help conduct these types of attacks.

This sort of attack is best exploited by the Flash, Acrobat Reader, and Java attacks that were very common in the early 2000s. In these cases, attackers would try to solicit a target to visit a malicious web page. These pages would contain specialized code that would trigger vulnerabilities in these client-side applications, resulting in the ability to run malicious code on the targets system.

Client-side attacks are incredibly difficult to prevent, requiring a great deal of user education, constant application updates, and network controls to effectively mitigate the risk.

11.5. Summary

In this chapter, we took a brief look at Kali's role in the field of information security. We discussed the importance of a clean, working installation and the use of encryption before heading out to the field in order to protect your client's information, and the importance of legal representation to protect you and your client's interests.

The components of the CIA (confidentiality, integrity, availability) triad are the primary items that you will focus on when securing a system as part of standard deployment, maintenance, or assessment. This conceptual foundation will assist you with the identification of the critical com-

ponents of your systems and the amount of effort and resources worth investing into correcting identified problems.

We discussed several types of vulnerabilities including file inclusion, SQL injection, buffer overflows, and race conditions.

The accuracy of the signatures is extremely important to get useful vulnerability assessment results. The more data that are provided, the higher chance there is to have accurate results from an automated signature-based scan, which is why authenticated scans are often so popular.

Since automated tools use a database of signatures to detect vulnerabilities, any slight deviation from a known signature can alter the result and likewise the validity of the perceived vulnerability.

We also discussed the four types of assessments: the *vulnerability assessment*, *compliance test*, *traditional penetration test*, and the *application assessment*. Even though each type of assessment leverages a core set of tools, many of the tools and techniques overlap.

The vulnerability assessment is relatively simple in comparison to the other assessment types and often consists of an automated inventory of discovered issues within a target environment. In this section, we discussed that a vulnerability is a flaw that, when exploited, will compromise the confidentiality, integrity, or availability of an information system. Since it is signature-based, this type of assessment relies on accurate signatures and can present false positives and negatives. You will find the core tools for this type of assessment in the Vulnerability Analysis and Exploitation Tools menu categories of Kali Linux.

Compliance tests are based on government- and industry-mandated requirements (such as PCI DSS, DISA STIG, and FISMA), which are in turn based on a compliance framework. This test usually begins with a vulnerability assessment.

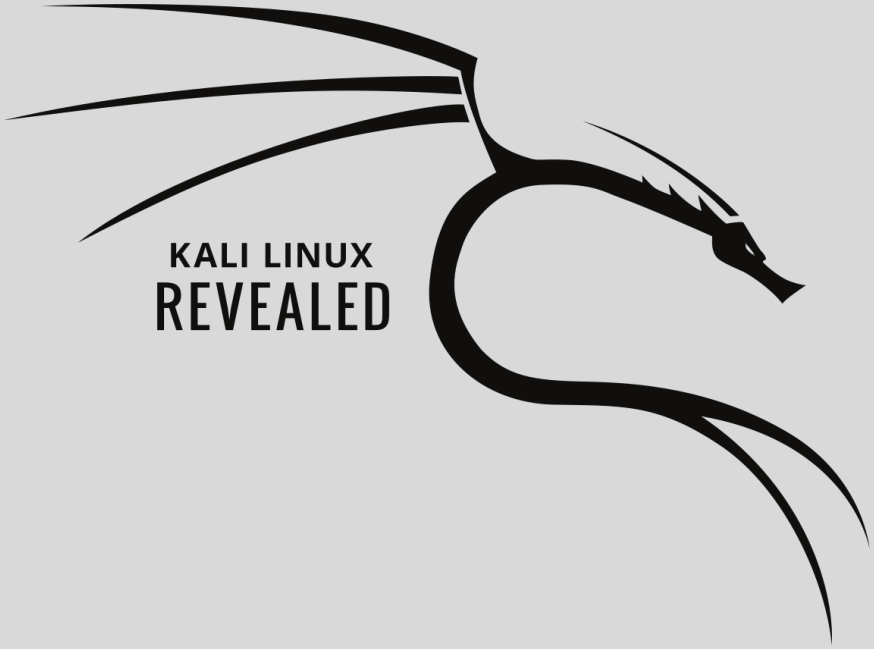
A traditional penetration test is a thorough security assessment that is designed to improve the overall security posture of an organization based on certain real-world threats. This type of test involves several steps (mirrored by the Kali Linux menu structure) and culminates in exploitation of vulnerabilities and pivoting access to other machines and networks within the target scope.

Application assessments (usually white- or black-box) focus on a single application and use specialized tools such as those found in the Web Application Analysis, Database Assessment, Reverse Engineering, and Exploitation Tools menu categories.

Several types of attacks were discussed including: denial of service, which breaks the behavior of an application and makes it inaccessible; memory corruption, which leads to manipulation of process memory, often allowing an attacker code execution; web attacks, which attack web services using techniques like SQL injection and XSS attacks; and password attacks, which often leverage password lists to attack service credentials.

Keywords

Constant changes
Certifications
Trainings



Chapter

12

Conclusion: The Road Ahead

Contents

Congratulations! Hopefully you should now be more familiar with your Kali Linux system and you should not be afraid of using it for any experiment that you can think of. You have discovered its most interesting features but you also know its limits and various ways to work around those limitations.

If you have not put all features into practice, keep this book around for reference purposes and refresh your memory when you are about to try a new feature. Remember that there is nothing better than practice (and perseverance) to develop new skills. Try Harder[1], as the Offensive Security trainers keep repeating.

12.1. Keeping Up with Changes

With a constantly-changing distribution like *kali-rolling*, some parts of the book will necessarily become obsolete. We will do our best to keep it up to date (at least for the online version) but for most parts we tried to provide generic explanations that should be useful for a long time to come.

That said, you should be ready to embrace changes and to find out solutions to any problem that might pop up. With the better understanding of Kali Linux and its relationship to Debian, you can rely on both the Kali and Debian communities and their numerous resources (bug trackers, forums, mailing lists, etc.) when you are getting stuck.

Don't be afraid to file bugs (see section 6.3, "Filing a Good Bug Report" [page 129])! If you are like me, by the time you have completed the steps involved in filing a good bug report (and it takes some time), you will have solved the problem or at least found a good work-around. And by actually filing the bug, you will be helping others who are affected by the issue.

12.2. Showing Off Your Newly Gained Knowledge

Are you proud of your new Kali Linux skills? Would you like to ensure that you remember the really important things? If you answer yes to one of those questions, then you should consider applying for the Kali Linux Certified Professional program.

It is a comprehensive certification that will ensure that you know how to deploy and use Kali Linux in many realistic use cases. It is a nice addition to your resume and it also proves that you are ready to go further.

12.3. Going Further

This book taught you a lot of things that any Kali Linux user should know, but we made some hard choices to keep it short, and there are many topics that were not covered.

[1] `https://www.offensive-security.com/offsec/say-try-harder/`

12.3.1. Towards System Administration

If you want to learn more about system administration, then we can only recommend that you check out the Debian Administrator's Handbook:

➨ `https://debian-handbook.info/get/`

You will find there many supplementary chapters covering common Unix services that we have entirely skipped in this book. And even for chapters that have been reused in the Kali book, you will find plenty of supplementary tips, notably on the packaging system (which is also covered more extensively at its lowest level).

The Debian book obviously presents more deeply the Debian community and the way it is organized. While this knowledge is not vital, it is really useful when you have to interact with Debian contributors, for example through bug reports.

12.3.2. Towards Penetration Testing

You probably noticed by now that this book did not teach you penetration testing. But the things you learned are still important. You are now ready to fully exploit the power of Kali Linux, the best penetration testing framework. And you have the basic Linux skills required to participate in Offensive Security's training.

If you feel that you are not yet ready for a paid course, you can start by following the Metasploit Unleashed[2] free online training. Metasploit is a very popular penetration testing tool and you have to know it if you are serious about your plans to learn penetration testing.

The next logical step would then be to follow the Penetration Testing with Kali Linux[3] online course leading the path to the famous "Offensive Security Certified Professional" certification. This online course can be followed at your own pace but the certification is actually a difficult, 24h long, real-word, hands-on penetration test which takes place in an isolated VPN network.

Are you up to the challenge?

[2] `https://www.offensive-security.com/metasploit-unleashed/`
[3] `https://www.offensive-security.com/information-security-training/`

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