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Linux Netfilter (iptables)

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Linux packet filter

- Linux kernels have had packet filtering since the 1.1 series
- Packet filtering is implemented by netfilter
- Netfilter is a general framework inside the Linux kernel which other things can plug into (such as the iptables module)
- The tool `iptables` talks to the kernel and tells it what packets to filter
  - **`iptables` inserts and deletes rules from the kernel's packet filtering table**
  - **`iptables` is a replacement for the old `ipfwadm` and `ipchains`**

Making rules permanent

- The current firewall setup stored in the kernel is lost on reboot
- There are two ways to restore a firewall setup:
  - **`iptables-save/iptables-restore`**
    - The `iptables-save` and `iptables-restore` scripts save it to, and restore it from a file
  - **using initialization scripts**
    - The other way is to put the commands required to set up the rules in an initialization script

Simple example of netfilter script

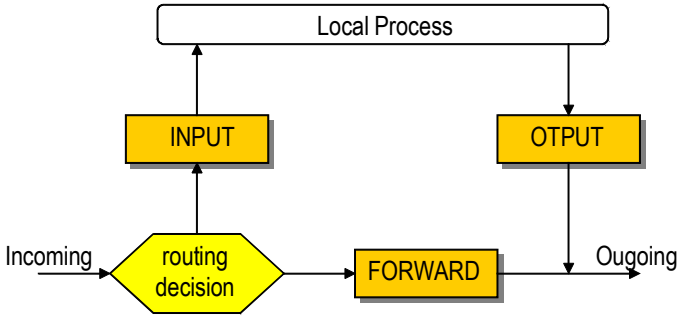
```
# Insert connection-tracking modules (not needed if built into kernel).
insmod ip_conntrack
insmod ip_conntrack_ftp

# Create chain which blocks new connections, except if coming from inside.
iptables -N block
iptables -A block -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A block -m state --state NEW -i ! ppp0 -j ACCEPT
iptables -A block -j DROP

# Jump to that chain from INPUT and FORWARD chains.
iptables -A INPUT -j block
iptables -A FORWARD -j block
```

Netfilter basic chains

- The kernel starts with three built-in lists of rules in the `filter' table
  - **These lists are called firewall chains or just chains**
  - **The three built-in chains are called INPUT, OUTPUT and FORWARD**
  - **The three chains can't be deleted**



Netfilter basic chains

- When a packet reaches a chain, that chain is examined to decide the fate of the packet
  - **If the chain says to DROP the packet, it is killed there, but**
  - **if the chain says to ACCEPT the packet, it continues traversing the diagram**
- A chain is a checklist of *rules*
  - **each rule says `if the packet header looks like this, then here's what to do with the packet'**
  - **if the rule doesn't match the packet, then the next rule in the chain is consulted**
  - **finally, if there are no more rules to consult, then the kernel looks at the chain policy to decide what to do**
  - **in a security- conscious system, this policy usually tells the kernel to DROP the packet**

`iptables` operations

- Operations to manage whole chains:
  - **Create a new chain (-N)**
  - **Delete an empty chain (-X)**
  - **Change the policy for a built-in chain. (-P)**
  - **List the rules in a chain (-L)**
  - **Flush the rules out of a chain (-F)**
  - **Zero the packet and byte counters on all rules in a chain (-Z)**
- Operations to manipulate rules inside a chain:
  - **Append a new rule to a chain (-A)**
  - **Insert a new rule at some position in a chain (-I)**
  - **Replace a rule at some position in a chain (-R)**
  - **Delete a rule at some position in a chain, or the first that matches (-D)**

Operations on a single rule

- Each rule specifies a set of conditions the packet must meet (matching condition),
  and what to do if it meets them ('target' or action)
- For example
  - **to drop all ICMP packets coming from the IP address 127.0.0.1**
    - the conditions are that the protocol must be ICMP and that the source address must be 127.0.0.1
    - the target is `DROP'
  - **to add the rule:**

```
iptables -A INPUT -s 127.0.0.1 -p icmp -j DROP
```

  - **to test:**

```
PING 127.0.0.1
```

  - **to delete the rule:**

```
iptables -D INPUT 1 ,or
iptables -D INPUT -s 127.0.0.1 -p icmp -j DROP
```

Filtering specifications

- Specifying Source and Destination IP Addresses
  - **source (`-s', `--source' or `--src') and destination (`-d', `--destination' or `--dst') IP addresses can be specified in four ways**
    - using the full name, such as `localhost' or `www.linuxhq.com'
    - specifying the IP address, such as `127.0.0.1'
    - specifying a group of IP addresses, such as `199.95.207.0/24'
    - or such as `199.95.207.0/255.255.255.0'
- Specifying Inversion
  - **many flags can have their arguments preceded by `!' (NOT) to invert (negate) the given matching condition**
    - e.g. `-s ! localhost' matches any packet not coming from localhost
- Specifying Protocol
  - **protocol can be specified with the `-p' (or `--protocol') flag**
  - **protocol can be a number or a name ('tcp', `udp' or `icmp')**

Filtering specifications

- Specifying an Interface
  - **the `-i' (or `--in-interface') and `-o' (or `--out-interface') options specify the name of an interface to match**
  - **INPUT chain don't have an output interface**
  - **OUTPUT chain don't have an input interface**
  - **Only FORWARD chain have both an input and output interface**
  - **an interface name ending with a `+' (wildcard) will match all interfaces which begin with that string**
- Specifying fragments
  - **Note: any filtering rule that asks for information that the packet doesn't have it will not match**
  - **this means that the first fragment is treated like any other packet, second and further fragments won't be**
  - **however, it is possible to specify a rule specifically for second and further fragments, using the `-f' (or `--fragment') flag**
  - **usually it is safe to let second and further fragments through**

Matching extensions

- TCP, UDP and ICMP protocols automatically offer new matching tests
  - **it is possible to specify the new match test on the command line after the `-p' option**
- Other extension can be loaded explicitly
  - **using the `-m' option followed by the match test**
  - **e.g. `-m mac --mac-source 45:e4:23:6b:82:a0`**

TCP/UDP extensions

- --tcp-flags
  - **allows the filtering on specific TCP flags**
  - **used with two parameters (strings of flags)**
    - the first string is the mask: a list of flags you want to examine
    - the second string of flags tells which one(s) should be set
  - **for example,**

```
iptables -A INPUT --protocol tcp --tcp-flags ALL
  SYN,ACK -j DROP
```

- --syn
  - **shorthand for `--tcp-flags SYN,RST,ACK SYN'**
- --source-port (--sport) and --destination-port (--dport)
  - **followed by either a single TCP/UDP port, or a range of ports**
  - **ranges are two port names separated by a `:'**
- --tcp-option
  - **followed by a TCP option**

Example on TCP extensions

- It is sometimes useful to allow TCP connections in one direction, but not the other
- The solution is to block only the packets used to request a connection
- By disallowing only these packets, we can stop attempted connections in their tracks
- For example, to specify TCP connection attempts from 192.168.1.1:

```
-p TCP -s 192.168.1.1 --syn
```


Other match extensions

- --icmp-type
  - **followed by an icmp type name (eg `host-unreachable'), or a numeric type (eg. `3'), or a numeric type and code separated by a `/' (eg. `3/3')**
- -m mac --mac-source (or `--match mac --mac-source ')
  - **followed by an ethernet address in colon-separated hexbyte notation, e.g.**

```
--mac-source 00:60:08:91:CC:B7
```


The state match

- The `state' extension interprets the connection-tracking analysis (of the `ip_conntrack' module)
- `-m state' allows an additional `--state' option, which is a comma-separated list of states to match
- These states are:
  - **NEW**
    - a packet which creates a new connection
  - **ESTABLISHED**
    - a packet which belongs to an existing connection
  - **RELATED**
    - a packet which is related to, but not part of, an existing connection (e.g. an ICMP error, or an ftp data connection)
  - **INVALID**
    - a packet which could not be identified for some reason

The state match

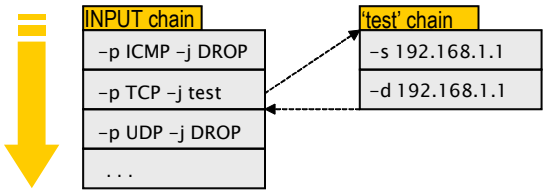
- Example of 'state' match extension:
  - `iptables -A FORWARD -i ppp0 -m state ! --state NEW -j DROP`
- This has an effect similar to:
  - `iptables -A FORWARD -i ppp0 -p tcp --syn -j DROP`

Target specifications

- Rule's target is what to do to the packets which match the rule
- There are two very simple built-in targets: `DROP` and `ACCEPT`
- There are two types of targets other than the built-in ones:
  - **extensions**
  - **user-defined chains**

User-defined chains

- It is possible to create new chains, in addition to the three built-in ones (INPUT, FORWARD and OUTPUT)
- When a packet matches a rule whose target is a user-defined chain
  - **the packet begins traversing the rules in that user-defined chain**
  - **if that chain doesn't decide the fate of the packet, then traversal resumes on the next rule in the current chain**



New targets

- The other types of targets are new extension targets
- There are several extensions in the default netfilter distribution:
  - **LOG**
    - this module provides kernel logging of matching packets
  - **REJECT**
    - has the same effect as `DROP', except that the sender is sent an ICMP `port unreachable' error message
- There are two special built-in targets: RETURN and QUEUE.
  - **RETURN**
    - has the same effect of falling off the end of a chain
  - **QUEUE**
    - is a special target, which queues the packet for userspace processing

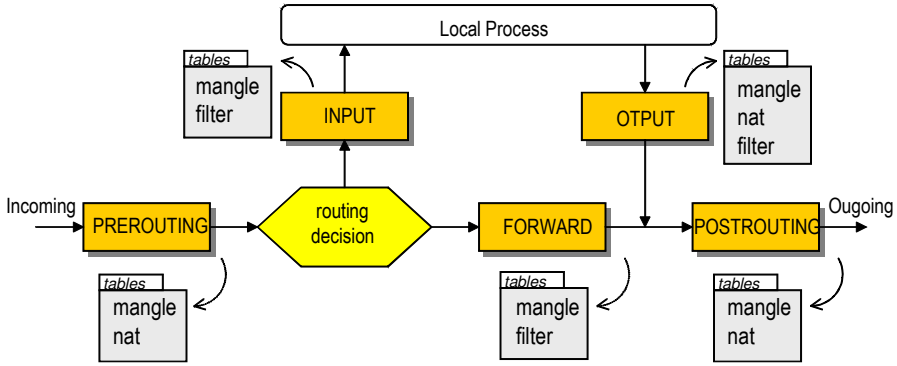
Operations on an entire chain

- Creating a New Chain
  - **using the `-N' (or `--new-chain') command**
  - **e.g. `iptables -N test`**
- Deleting a Chain
  - **using the `-X' (or `--delete-chain') command**
  - **e.g. `iptables -X test`**
- Flushing a Chain
  - **using the `-F' (or `--flush') command**
  - **e.g. `iptables -F FORWARD`**
- Listing a Chain
  - **using the `-L' (or `--list') command**
    - `-n' (numeric) option prevents iptables from to lookup the IP addr
    - `-v' options shows you all the details of the rules

Operations on an entire chain

- Setting Policy
  - **the policy of the chain determines the fate of the packet**
  - **only built-in chains (INPUT, OUTPUT and FORWARD) have policies**
  - **The policy can be either ACCEPT or DROP, for example:**
  - **e.g. `# iptables -P FORWARD DROP`**

The entire netfilter (including NAT)



References

[1] Rusty Russell, “Linux 2.4 Packet Filtering HOWTO”,
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[2] Oskar Andreasson, “Iptables Tutorial”,
http://iptables-tutorial.frozentux.net/

[3] Linux iptables man pages