Using OpenBSD relayd(8) as an Application Layer Gateway

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Who's that guy?

User of a Terminal since late 90s.

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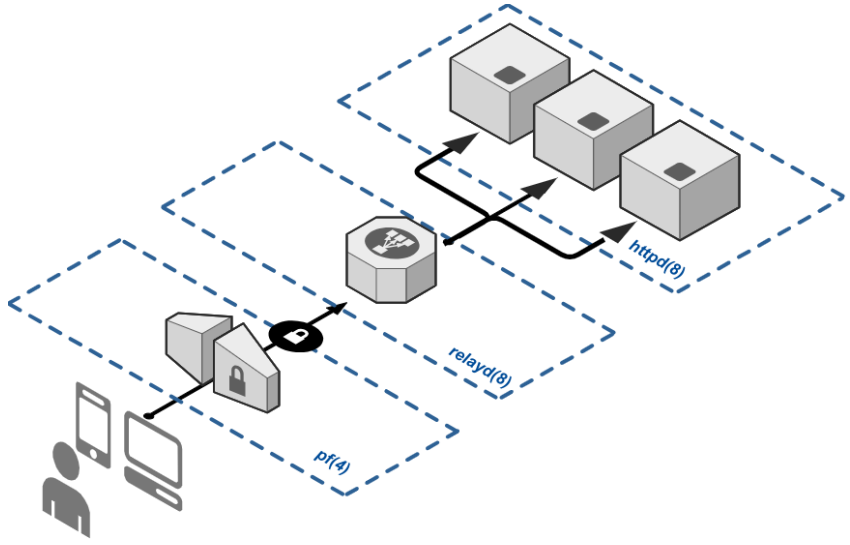
What is relayd(8)?

- Multi-purpose daemon available on OpenBSD since 4.3*:
  - load-balancer.
  - application layer gateway.
  - transparent proxy.
- Capable of monitoring groups of hosts for high-availability.
- Operates as:
  - Layer 3 redirection via communication with pf(4).
  - Layer 7 relaying with application level filtering via itself.



* relayd was known as hoststated in OpenBSD 4.1

How to manage relayd(8)?

- Read the man pages

```
# man relayd
# man relayd.conf
# man relayctl
```

- Configure the software

```
# more /etc/examples/relayd.conf
# vi /etc/relayd.conf
```

- Control the daemon

```
# relayd -dvn

# rcctl enable relayd
# rcctl start relayd
# rcctl stop relayd

# relayctl command [argument ...]
```

Terminology

- Macros: user-defined variables that can be used later on.
- Tables: host or a group of hosts defining traffic targets.
- Protocols: settings and filter rules for relays.
- Relays: layer 7 proxying instances.

Simplest HTTP relay

A simple **HTTP Reverse proxy**.

- Define an HTTP PROTOCOL section.
- Define a RELAY section.
  - Listen on address and port.
  - Use the defined HTTP protocol.
  - Forward HTTP traffic to the servers.

```
http protocol www {
    pass
}

relay www {
    listen on 203.0.113.1 port 80
    protocol www
    forward to 192.0.2.10 port 80
}
```

Better simple HTTP relay

A simple **HTTP Reverse proxy** providing **reusable** names in configuration and **logging** state changes and remote connections.

- Define and use MACROS.
- Configure GLOBAL CONFIGURATION.
  - Enable logging.
- Define and use TABLES.
- Update the PROTOCOL and RELAY sections.

```
# Macros ---------------------------------
ext_addr="203.0.113.1"
webhost1="192.0.2.10"

# Global configuration -------------------
log state changes
log connection

# Tables ---------------------------------
table <webhosts> { $webhost1 }

# Protocols & Relays ---------------------
http protocol www {
    pass
}

relay www {
    listen on $ext_addr port 80
    protocol www

    forward to <webhosts> port 80
}
```

Encrypt HTTP relay using Transport Layer Security (TLS)

Secure communication and data transfer between the client and the website using HTTPS.

- Acquire a TLS certificate*.
- Install the TLS certificate

  `/etc/ssl/private/relayd.example.key`

  `/etc/ssl/relayd.example.crt`

- Define TLS PROTOCOL and RELAY sections.

```
# Macros ---------------------------------
ext_addr="203.0.113.1"
webhost1="192.0.2.10"

# Global configuration -------------------
log state changes
log connection

# Tables ---------------------------------
table <webhosts> { $webhost1 }

# Protocols & Relays ---------------------
http protocol wwwtls {
    tls keypair relayd.example
}

relay wwwtls {
    listen on $ext_addr port 443 tls
    protocol wwwtls

    forward to <webhosts> port 80
}
```

*Out of relayd(8) scope. Use acme-client(1) and httpd(8).

Load balancing & Failover

Distribute incoming requests to several servers.

- Define a TABLE that references all the servers.
- Select a scheduling algorithms (aka MODE): hash, loadbalance, random, **roundrobin** source-hash.
- Select a health-checking method (aka CHECK):
  no check, code, icmp, host, path, script, send data expect pattern, tcp, tls

```
ext_addr="203.0.113.1"
whost1="192.0.2.11"
whost2="192.0.2.12"
whost3="192.0.2.13"
interval 5
table <webhosts> { $whost1, $whost2, $whost3 }

http protocol wwwtls {
   tls keypair relayd.example
}

relay wwwtls {
    listen on $ext_addr port 443 tls
    protocol wwwtls
    # l/b using roundrobin, no check
#   forward to <webhosts> port 80
    # l/b using source-IP, check HTTP return code
    forward to <webhosts> port 80  \
      mode loadbalance             \
      check "/health-check" code 200
}
```

Fallback server(s) - automatic switch

Automatic reaction on server(s) **outage**:

- Switch service to **secondary server pool**.
- Display an **incident status page** rather than HTTP/5xx error pages.
- Display a static **"be back soon"** page while performing maintenance.

- Define a TABLE for primary server(s).
- Define a TABLE for fallback server(s).
- Define a primary FORWARD directive. Use a CHECK method.
- Define a fallback FORWARD directive.

```
ext_addr="203.0.113.1"
whost1="192.0.2.11"
whost2="192.0.2.12"
whost3="192.0.2.13"
interval 5
table <webhosts> { $whost1, $whost2 }
table <fallback> { $whost3 }

http protocol wwwtls {
   tls keypair relayd.example
}

relay wwwtls {
  listen on $ext_addr port 443 tls
  protocol wwwtls

  # l/b using round-robin, check HTTP return code
   forward to <webhosts> port 80 mode roundrobin \
     check http "/" code 200
  # switch service if all previous checks fail
   forward to <fallback> port 80
}
```

Fallback server(s) - manual switch

Managed operations on server(s) **outage**:

- Same as automatic switch.
- As part of a **Business Continuity Plan**, switch to remote | mutualized | resources limited | staging servers...

- Define a TABLE for primary server(s).
- Define a TABLE for fallback server(s). Use the DISABLE attribute.
- Define a primary FORWARD directive. Use a CHECK method.
- Define a fallback FORWARD directive. Use a CHECK method.

```
ext_addr="203.0.113.1"
whost1="192.0.2.11"
whost2="192.0.2.12"
whost3="192.0.2.13"
whost4="192.0.2.14"
interval 5
table <webhosts>          { $whost1, $whost2 }
table <fallback> disable { $whost3, $whost4 }

http protocol wwwtls {
   tls keypair relayd.example
}

relay wwwtls {
  listen on $ext_addr port 443 tls
  protocol wwwtls

  # l/b using source-IP, check HTTP return code
   forward to <webhosts> port 80 mode loadbalance \
     check http "/" code 200
  # l/b using round-robin, check HTTP return code
   forward to <fallback> port 80 mode roundrobin \
     check http "/" code 200
}
```

Fallback server(s) - manual switch example

```
# relayctl show summary
Id      Type            Name                            Avlblty Status
1       relay           wwwtls                                  active
1       table           webhosts:80                             active (2 hosts)
1       host            192.0.2.11                      100.00% up
2       host            192.0.2.12                      100.00% up
2       table           fallback:80                             disabled
```

- Primary hosts are up and running.
- Secondary hosts are disabled.

☑ Service is UP.

Fallback server(s) - manual switch example

```
# relayctl show summary
Id      Type            Name                            Avlblty Status
1       relay           wwwtls                                  active
1       table           webhosts:80                             empty
1       host            192.0.2.11                      95.56%  down
2       host            192.0.2.12                      95.56%  down
2       table           fallback:80                             disabled
```

- Primary hosts are down.
- Secondary hosts are disabled.

❎ Service is DOWN.

Fallback server(s) - manual switch example

```
# relayctl table enable 2
command succeeded

# relayctl show summary
Id      Type            Name                            Avlblty Status
1       relay           wwwtls                                  active
1       table           webhosts:80                             empty
1       host            192.0.2.11                      76.79%  down
2       host            192.0.2.12                      76.79%  down
2       table           fallback:80                             active (2 hosts)
3       host            192.0.2.13                      100.00% up
4       host            192.0.2.14                      100.00% up
```

- Primary hosts are down.
- Secondary hosts are enabled.

✅ Service is UP.

Failback shall happen as soon as relayd detects a Primary host up.

Use `relayctl table disable 1` to prevent such an automatic failback.

Relaying multiple FQDNs*

Expose **multiple hostnames** using a **single IP**.

- Define a TABLE for each server pool.
- Reference every TLS server certificates enabling TLS Server Name Indication (SNI).
- Limit FQDNs using FILTER RULES.
- Define FORWARD directives to map FQDNs with TABLES.

```
(...)
table <blog>  { $whost1, $whost2 }
table <cloud> { $whost3 }

http protocol wwwtls {
  tls keypair blog.example
  tls keypair nextcloud.example

  block
  pass request header "Host" value "blog.example"  \
    forward to <blog>
  pass request header "Host" value "cloud.example" \
    forward to <cloud>
}

relay wwwtls {
  listen on $ext_addr port 443 tls
  protocol wwwtls
  forward to <blog>  port 80 mode roundrobin \
    check http "/" code 200
  forward to <cloud> port 80
}
```

*AKA Apache Virtual Host, AKA nginx server blocks.

Relaying multiple pathnames*

Design **reaction rules** (allow, deny, forward...) depending on **URL path**.

- Define a TABLE for each server pool.
- Limit pathnames using FILTER RULES.
- Define FORWARD directives to map pathnames with TABLES.

```
(...)
table <blog>  { $whost1, $whost2 }
table <cloud> { $whost3 }

http protocol wwwtls {
  tls keypair relayd.example

  block quick path "/cgi-bin*"
  block quick path "/wp-admin*"
  pass  quick path "/nextcloud/*" forward to <cloud>
  pass  request                   forward to <blog>
}

relay wwwtls {
  listen on $ext_addr port 443 tls
  protocol wwwtls

  forward to <blog> port 80 mode roundrobin \
    check http "/" code 200
  forward to <cloud> port 80
}
```

*AKA Apache location directive, AKA nginx location blocks.

Solving problems with HTTP headers

- 😡 Software like Baikal, Mastodon or SearxNG **refuse** to serve **unencrypted content**.
- 😇 Pass the *X-Forwarded-Proto* HTTP header to **confirm communication is secured** using TLS.

```
(...)
http protocol wwwtls {
  tls keypair blog.example
  tls keypair nextcloud.example

  block
  pass request header "Host" value "blog.example"  forward to <blog>
  pass request header "Host" value "cloud.example" forward to <cloud>

  match request header set "X-Forwarded-Proto" value "https"
}
(...)
```

Solving problems with HTTP headers

😡 Software add **too many information** in the HTTP headers.

🤓 Remove **leaking HTTP headers** from chatterbox software.

```
(...)
http protocol wwwtls {
  tls keypair relayd.example

  pass  quick path "/nextcloud/*" forward to <cloud>
  pass  request                   forward to <blog>

  match response header remove "X-Powered-By"
  match response header set "Server" value "Microsoft-IIS/8.5"
}
(...)
```

😈 Fool script kiddies or deal with buggy clients by replacing a existing HTTP header.

Solving problems with HTTP headers

- Software don't bother about **security and privacy**..
- Add HTTP headers that helps **protecting the user**.

```
(...)
http protocol wwwtls {
  tls keypair relayd.example

  pass  quick path "/nextcloud/*" forward to <cloud>
  pass  request                   forward to <blog>

  match response header set "X-XSS-Protection"       value "1; mode=block"
  match response header set "X-Content-Type-Options" value "nosniff"
  match response header set "Permissions-Policy"     value "accelerometer=(),
ambient-light-sensor=(),autoplay=(),camera=(),encrypted-media=(),
focus-without-user-activation=(),geolocation=(),gyroscope=(),
magnetometer=(),microphone=(),midi=(),payment=(),picture-in-picture=(),
speaker=(),sync-xhr=(),usb=(),vr=()"
}
(...)
```

- Check your Web application using tools like Mozilla Observatory or Nextcloud Security Scan.

Log management

By **default**, relayd(8) logs

- are sent to **syslogd(8)**
- appear in `/var/log/{daemon,messages}`
- are not all debug friendly.

```
Sep 17 14:31:46 ebsdc relayd[75340]: startup
Sep 17 14:31:46 ebsdc relayd[87221]: adding 2 hosts from table blog:80
Sep 17 14:31:46 ebsdc relayd[87221]: adding 1 hosts from table cloud:80 (no check)
Sep 17 14:31:56 ebsdc relayd[87221]: relay wwwtls, session 1 (1 active), 0,
                                     203.0.113.1 -> 127.0.0.1:80, done, GET -> 127.0.0.1:80;
```

Log management

Get relayd(8) logs in a **dedicated log file** by configuring syslogd(8).

```
# touch /var/log/relayd

# vi /etc/syslog.conf
!!relayd
*.* /var/log/relayd
!*
(...)

# vi /etc/newsyslog.conf
(...)
/var/log/relayd root:_relayd 640 7 * $D0 ZB

# rcctl restart syslogd
```

Log management

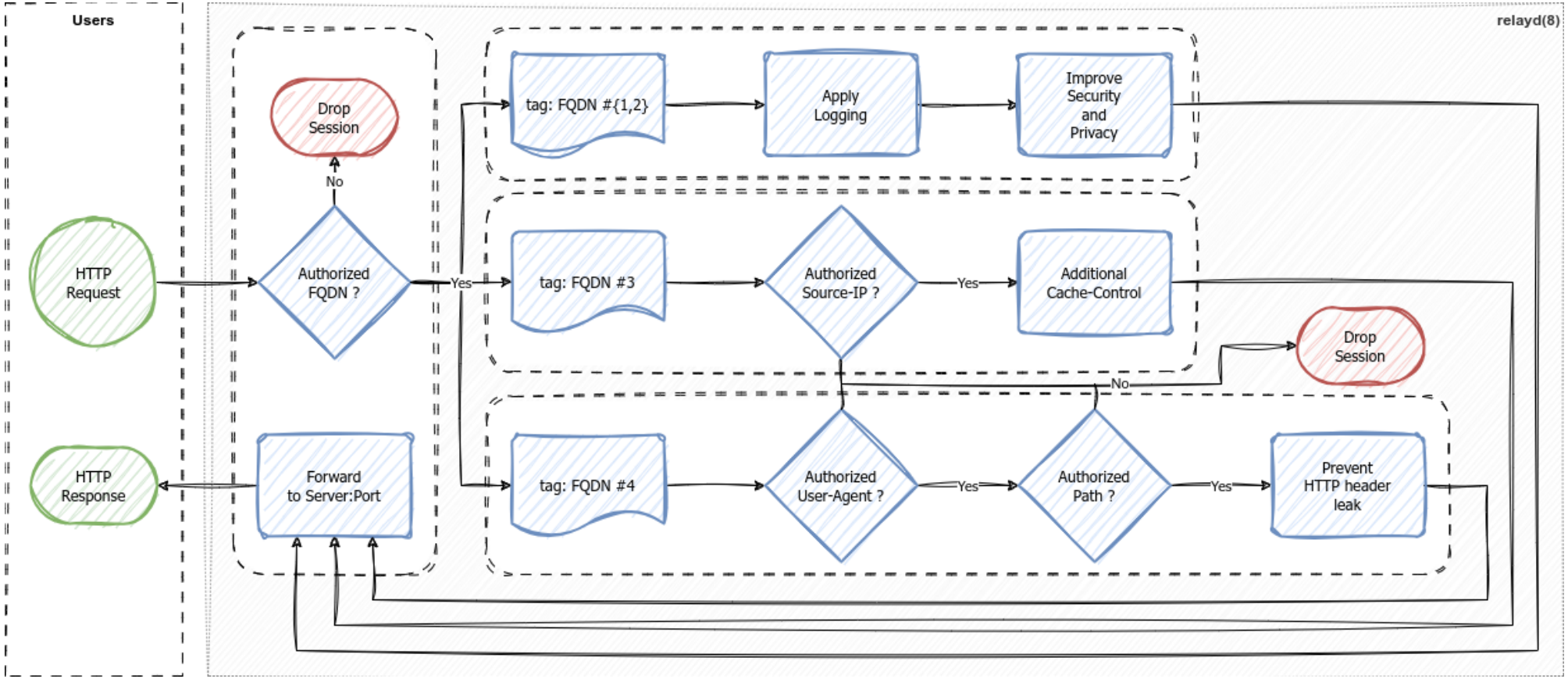
Get more **HTTP details** in relayd(8) logs by using FILTER RULES.

```
http protocol wwwtls {
  tls keypair relayd.example

  match url log
  match header log "Host"
  match header log "User-Agent"
  match response header log "Content-Type"
  match response header log "Content-Length"

  pass  quick path "/nextcloud/*" forward to <cloud>
  pass  request                   forward to <blog>
}
```

```
Sep 17 14:35:12 ebsdc relayd[34137]: relay wwwtls, session 1 (1 active), 0,
                                     203.0.113.1 -> 127.0.0.1:80, done,
                                     [blog.example/about] [Host: blog.example] [User-Agent: curl/8.2.0]
                                     GET -> 127.0.0.1:80 {Content-Type: text/html} {Content-Length: 41};
```

Conditional filtering

Using TAGS and INCLUDES to perform **different computation and actions** depending on wether or not conditions **evaluate to true or false**.



Conditional filtering: `/etc/relayd-ssg.conf`

- Use TAG to **mark connections** matching filter rules.
- Use TAGGED to **match marked connections**.

```
# Mark using hostnames
match request header "Host" value "www.example"     tag "ssg"
match request header "Host" value "blog.example"    tag "ssg"

# Apply additionnal logging
match header log "Host"       tagged "ssg"
match header log "User-Agent" tagged "ssg"
match url    log              tagged "ssg"

# Improve Security and Privacy
match response tagged "ssg" header set \
  "Strict-Transport-Security" value "max-age=31536000; includeSubDomains; preload"
match response tagged "ssg" header set \
  "X-XSS-Protection" value "1; mode=block"
match response tagged "ssg" header set \
  "X-Content-Type-Options" value "nosniff"
```

Conditional filtering: `/etc/relayd-nextcloud.conf`

- Use TAG to **mark connections** matching filter rules.
- Use TAGGED to **match marked connections**.

```
# Mark using hostname
match request header "Host" value "cloud.example"   tag "nextcloud"

# Block User Agents
block request quick tagged "nextcloud" header "User-Agent" value "Googlebot/*"
block request quick tagged "nextcloud" header "User-Agent" value "YandexBot/*"

# Only allow "admin" path from specific subnet
match request                   url "cloud.example/admin/" tag "forbidden"
match request from 192.0.2.0/24 url "cloud.example/admin/" tag "nextcloud"

# Don't let version leak via HTTP header
match response tagged "nextcloud" header remove "Server"
```

Conditional filtering: `/etc/relayd-grafana.conf`

- Use TAG to **mark connections** matching filter rules.
- Use TAGGED to **match marked connections**.

```
# Mark using client source IP and path
match request from 192.0.2.0/24    url "metrics.example/" tag "grafana"
match request from 198.51.100.8/32 url "metrics.example/" tag "grafana"

# Overwrite caching
match request tagged "grafana" path "*.css" tag "g-cache"
match request tagged "grafana" path "*.js"  tag "g-cache"
match request tagged "grafana" path "*.png" tag "g-cache"

match response tagged "g-cache" header set "Cache-Control" value "max-age=86400"
```

Conditional filtering: `/etc/relayd.conf`

- Use INCLUDE to **dispatch** filter rules in dedicated configuration files.
- Use TAG to **mark connections** matching filter rules.
- Use TAGGED to **match marked connections**.

```
table <blog>    { $whost1, $whost2 }
table <cloud>   { $whost3 }
table <grafana> { $whost4 }

http protocol wwwtls {
  tls keypair www.example
  tls keypair cloud.example
  tls keypair metrics.example

  block

  include "/etc/relayd-ssg.conf"
  include "/etc/relayd-nextcloud.conf"
  include "/etc/relayd-grafana.conf"

  pass request tagged "ssg"       forward to <blog>
  pass request tagged "nextcloud" forward to <cloud>
  pass request tagged "grafana"   forward to <grafana>
  pass request tagged "g-cache"   forward to <grafana>
}
```

Thank you!

Any questions?

See you on  .