ModSecurity for Apache User Guide

Version 1.9.4 / (May 15, 2006)

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Introduction

ModSecurity(TM) is an open source intrusion detection and prevention engine for web applications. It can also be called an web application firewall. It operates embedded into the web server, acting as a powerful umbrella, shielding applications from attacks.

ModSecurity integrates with the web server, increasing your power to deal with web attacks. Some of its features worth mentioning are:

- Request filtering; incoming requests are analysed as they come in, and before they get handled by the web server or other modules. (Strictly speaking, some processing is done on the request before it reaches ModSecurity but that is unavoidable in the embedded mode of operation.)
- Anti-evasion techniques; paths and parameters are normalised before analysis takes place in order to fight evasion techniques.
- Understanding of the HTTP protocol; since the engine understands HTTP, it performs very specific and fine granulated filtering. For example, it is possible to look at individual parameters, or named cookie values.
- POST payload analysis; the engine will intercept the contents transmitted using the POST method, too.
- Audit logging; full details of every request (including POST) can be logged for forensic analysis later.
- HTTPS filtering; since the engine is embedded in the web server, it gets access to request data after decryption takes place.
- Compressed content filtering; same as above, the security engine has access to request data after decompression takes place.

ModSecurity can be used to detect attacks, or to detect and prevent attacks.

Licensing

ModSecurity is available under two licenses. Users can choose to use the software under the terms of the GNU General Public License (http://www.gnu.org/licenses/gpl.html), as an Open Source / Free Software product. Alternatively, a variety of commercial licenses is available: end-user licenses for individual or site-wide deployment, OEM licenses for closed-source distribution with applications, web servers, or security appliances. For more information on commercial licensing please contact Thinking Stone.

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Note

ModSecurity and mod_security are trademarks of Thinking Stone.

Acknowledgements

This module would not be possible without the fine people who have created the Apache Web server, and the fine people who have spent many hours building the Apache modules I used to learn Apache module programming from.

Contact

ModSecurity is developed by Ivan Ristic and Thinking Stone. Comments and feature requests are welcome. Please send your emails to <ivanr@webkreator.com>.

Note

Please do not send support requests to my personal email address. I do spend time responding to support queries but I don't respond privately any more. Doing so prevents other users from using mail archives to find answers for themselves. If you need answers quickly or you want guaranteed response times consider purchasing commercial support from Thinking Stone.

Installation

Before you begin with installation you will need to choose your preferred installation method. First you need to choose whether to install the latest version of ModSecurity directly from CVS (best features, but possibly unstable) or use the latest stable release (recommended). If you choose a stable release, it might be possible to install ModSecurity from binary. It is always possible to compile it from source code.

The following few pages will give you more information on benefits of choosing one method over another.

CVS Access

If you want to access the latest version of the module you need to get it from the CVS repository. The list of changes made since the last stable release is normally available on the web site (and in the file CHANGES). The CVS repository for ModSecurity is hosted by SourceForge (http://www.sf.net). You can access it directly or view if through web using this address: http://cvs.sourceforge.net/cgi-bin/viewcvs.cgi/mod-security/

To download the source code to your computer you need to execute the following two commands:

```
$ cvs -d:pserver:anonymous@cvs.sourceforge.net:/cvsroot/mod-security login
$ cvs -z3 -d:pserver:anonymous@cvs.sourceforge.net:/cvsroot/mod-security \
> co mod_security
```

The first line will log you in as an anonymous user, and the second will download all files available in the repository.

Nightly Snapshot Download

If you don't like CVS but you still want the latest version you can download the latest nightly tarball from the following address:

http://www.modsecurity.org/download/snapshot/mod_security-snapshot.tar.gz

New features are added to mod_security one by one, with regression tests being run after each change. This should ensure that the version available from CVS is always usable.

Stable Release Download

To download the stable release go to http://www.modsecurity.org/download/. Binary distributions are sometimes available. If they are, they are listed on the download page. If not download the source code distribution.

Installing from source

When installing from source you have two choices: to install the module into the web server itself, or to compile mod_security.c into a dynamic shared object (DSO).

DSO

Installing as DSO is easier, and the procedure is the same for both Apache branches. First unpack the distribution somewhere (anywhere will do), and compile the module with:

```
# <apache-home>/bin/apxs -cia mod_security.c
```

After this you only need to stop and then start Apache (if you try to restart it you may get a segfault):

```
# <apache-home>/bin/apachectl stop
# <apache-home>/bin/apachectl start
```

Note

I've had reports from people using platforms that do not have the apxs utility installed. In some Unix distribution this tool is distributed in a separate package. The problem arises when that package is not installed b default. To resolve this problem read the documentation from your vendor to discover how you can add your own custom Apache modules. (On some RedHat platforms you need to install the package `http-devel` to get access to the apxs utility).

Static installation with Apache 1.x

When a module is compiled statically, it gets embedded into the body of the web server. This method results in a slightly faster executable but the compilation method (and subsequent maintenance) is a bit more complicated.

```
$ cd <apache1-source>
$ cp <modsecurity-source>/apache1/mod_security.c ./src/modules/extra
$ ./configure \
> --activate-module=src/modules/extra/mod_security \
> -–enable-module=security
```

Compile, install, and start the web server as you normally do.

Static installation with Apache 2.x

To compile statically with Apache 2.x you only need to copy the module source code into the Apache source code tree and reconfigure Apache:

```
$ cd <apache2-source>
$ cp <modsecurity-source>/apache2/mod_security.c ./modules/proxy
$ ./configure \
> -enable-security \
> --with-module=proxy:mod_security.c
```

Integrating into the Apache 2.x build

You can also choose to integrate mod_security into the Apache 2.x build.

```
$ cd <modsecurity-source>/apache2
$ mkdir -r <apache2-source>/modules/security
$ cp mod_security.c Makefile.in config.m4 <apache2-source>/modules/security
$ cd <apache2-source>
$ ./buildconf
```

From this point on mod_security will appear to Apache as any other built-in module. It will not be compiled-in by default. To enable it do the following:

```
$ ./configure --enable-security
```

Compiling the Apache 1.x version against PCRE

By default ModSecurity relies on the regular expression library built into Apache for pattern matching. This works well with Apache 2.x but not so much with Apache 1.x. The Apache 1.x regular expression engine is several times slower. Since 1.9.2 it is possible to compile ModSecurity for Apache 1.x against an external regular expression library (PCRE, http://www.pcre.org, the same library used in Apache 2.x) and achieve significant performance increase. This is achieved with the `USE_PCRE` compile-time flag.

If you have PCRE already installed on your system it may be sufficient to compile ModSecurity like this:

```
# <apache1-home>/bin/apxs -DUSE_PCRE -cia mod_security.c
```

If you don't already have PCRE then you will have to download, configure, and compile it first. It is not necessary to install it.

```
$ cd <pcre-source>
$ ./configure && make
# cp ./.libs/libpcre.so <apache1-home>/libexec
```

Then compile and install ModSecurity:

```
# <apache1-home>/bin/apxs -I <pcre-source> -DUSE_PCRE -cia mod_security.c
```

Finally, tell Apache to load the PCRE library before ModSecurity. Add the following line before the line that loads ModSecurity (`LoadModule ...`):

```
LoadFile libexec/libpcre.so
```

Now you can stop then start Apache and observe the performance improvements.

Installing from binary

In some circumstances, you will want to install the module as a binary. At the moment I only make Windows binaries available for download. When installing from binary you are likely to have two DSO libraries in the distribution, one for each major Apache branch. Choose the file appropriate for the version you are using. Then proceed as described below:

Apache 1.x

Copy `mod_security.so` (on Unix) or `mod_security.dll` (on Windows) to `libexec/` (this folder is relative to the Apache installation, not the source tree). Then add the following line to `httpd.conf`:

```
LoadModule security_module    libexec/mod_security.so
```

Depending on your existing configuration (you may have chosen to configure module loading order explicitly) it may be necessary to activate the module using the `AddModule` directive:

```
AddModule mod_security.c
```

In most cases it is not important where you add the line. It is recommended (and, in fact, mandatory if you intend to use the internal chroot feature) to make `mod_security` execute last in the module chain. Read the section “Required module ordering for chroot support (Apache 1.x)” for more information.

Apache 2.x

Copy `mod_security.so` (on Unix) or `mod_security.dll` (on Windows) to `modules/` (this folder is relative to the Apache installation, not the source tree). Then add the following line to `httpd.conf`:

```
LoadModule security_module    modules/mod_security.so
```

Configuration

ModSecurity configuration directives are added to your configuration file (typically `httpd.conf`) directly. When it is not always certain whether module will be enabled or disabled on web server start it is customary to enclose its configuration directives in a <`IfModule`> container tag. This allows Apache to ignore the configuration directives when the module is not active.

```
<IfModule mod_security.c>
    # mod_security configuration directives
    # ...
</IfModule>
```

Since Apache allows configuration data to exist in more than one file it is possible to group ModSecurity configuration directives in a single file (e.g. `modsecurity.conf`) and include it from `httpd.conf` with the Include directive:

```
Include conf/modsecurity.conf
```

Turning filtering on and off

The filtering engine is disabled by default. To start monitoring requests add the following to your configuration file:

```
SecFilterEngine On
```

Supported parameter values for this parameter are:

- `On` – analyse every request
- `Off` – do nothing
- `DynamicOnly` – *deprecated as of 1.9.3* - read the discussion in "Choosing what to log".

POST scanning

Request body payload (or POST payload) scanning is disabled by default. To use it, you need to turn it on:

```
SecFilterScanPOST On
```

mod_security supports two encoding types for the request body:

- `application/x-www-form-urlencoded` - used to transfer form data
- `multipart/form-data` – used for file transfers

Other encodings are not used by most web applications. To make sure that only requests with these two encoding types are accepted by the web server, add the following line to your configuration file:

```
SecFilterSelective HTTP_Content-Type \
"!(^$|^application/x-www-form-urlencoded$|^multipart/form-data;)"
```

Turning buffering off dynamically

It is possible to turn POST payload scanning off on per-request basis. If ModSecurity sees that an environment variable MODSEC_NOPOSTBUFFERING is defined it will not perform POST payload buffering. For example, to turn POST payload buffering off for file uploads use the following:

```
SetEnvIfNoCase Content-Type \
"^multipart/form-data;" "MODSEC_NOPOSTBUFFERING=Do not buffer file uploads"
```

The value assigned to the MODSEC_NOPOSTBUFFERING variable will be written to the debug log, so you can put in there something that will tell you why was buffering turned off.

Controlling ModSecurity dynamically

It is also possible to enable or disable ModSecurity on the per-request basis. This is done via the MODSEC_ENABLE environment variable, in combination with the SetEnvIf and SetEnvIfNoCase directives. If MODSEC_ENABLE is not set the configuration specified with SecFilterEngine will be used. If MODSEC_ENABLE is set the value of SecFilterEngine will be ignored. The possible values for MODSEC_ENABLE are the same as for the SecFilterEngine directive: On, and Off.

Chunked transfer encoding

The HTTP protocol supports a method of request transfer where the size of the payload is not known in advance. The body of the request is delivered in chunks. Hence the name chunked transfer encoding. ModSecurity does not support chunked requests at this time; when a request is made with chunked encoding it will ignore the body of the request. As far as I am aware no browser uses chunked encoding to send requests. Although Apache does support this encoding for some operations most modules (e.g. the PHP module with Apache 1.3.x) don't.

Left unattended this may present an opportunity for an attacker to sneak malicious payload. Add the following line to your configuration to prevent attackers to exploit this weakness:

```
SecFilterSelective HTTP_Transfer-Encoding "!^$"
```

This will not affect your ability to send responses using the chunked transfer encoding.

Default action list

Whenever a rule is matched against a request, one or more actions are performed. Individual filters can each have their own actions but it is easier to define a default set of actions for all filters. (You can always have per-rule actions if you want.) You define default actions with the configuration directive SecFil-

terDefaultAction. For example, the following will configure the engine to log each rule match, and reject the request with status code 404:

```
SecFilterDefaultAction "deny,log,status:404"
```

The SecFilterDefaultAction directive accepts only one parameter, a comma-separated list of actions separated. The actions you specify here will be performed on every filter match, except for rules that have their own action lists.

Note

As of 1.8.6, if you specify a non-fatal default action list (a list that will not cause the request to be rejected, for example log,pass) such action list will be ignored during the initialisation phase. The initialisation phase is designed to gather information about the request. Allowing non-fatal actions would cause some pieces of the request to be missing. Since this information is required for internal processing such actions cannot be allowed. If you want ModSecurity to operate in a "detect-only" mode you need to disable all implicit validations (URL encoding validation, Unicode encoding validation, cookie format validation, and byte range restrictions).

Note

Some actions cannot appear in the default list. These are: id, rev, skipnext, chain, chained.

Implicit validation

As of 1.8.6 implicit request validation (if configured) will be performed only at the beginning of request processing. Implicit validation consists of the checks of the request line, and the headers.

Note

As of 1.9dev4 Unicode encoding validation is not applied to the contents of the Referer header when part of the initial implicit request validation. This is because this header often contains information from other web sites, and their encoding usually differs from the encoding used on the protected web site.

Filter inheritance

Filters defined in parent folders are normally inherited by nested Apache configuration contexts. This is behaviour is acceptable (and required) in most cases, but not all the time. Sometimes you need to relax checks in some part of the site. By using the SecFilterInheritance directive:

```
SecFilterInheritance Off
```

you can instruct ModSecurity to disregard parent filters so that you can start with rules from the scratch. This directive affects rules only. The configuration is always inherited from the parent context but you can override it as you are pleased using the appropriate configuration directives.

Note

Configuration and rule inheritance is always enabled by default. If you have a configuration context beneath one that has had inheritance disabled you will have to explicitly disable inheritance again if that is what you need.

When you choose not to inherit the rules from the parent context you can either write new rules for the new context, or simply use the Include directive to include the same rules into many different contexts.

Sometimes only a small change to the rule set is required in the child context. In such cases you may choose to use the selective inheritance option. You can do this with the help of the following two directives:

- `SecFilterImport` – import a single rule from the parent context. This directive is useful when you want to start from scratch in the child context and only import selected rules from the parent context.
- `SecFilterRemove` – remove a rule from the current context. This directive is useful when you want to start with the same rule set as in the parent context, removing selected rules only.

The `SecFilterImport` and `SecFilterRemove` directives both accept a list rule IDs. The target rules must have IDs associated with them (this is done using the id action). The directives will be executed in the order they appear in the configuration file. Therefore, it is possible to remove a rule with `SecFilterRemove` and then add it again with `SecFilterImport`. Below you can find two examples that arrive at the same rule configuration, but take different routes to get there.

Note

If a target rule ID refers to a rule that is part of a chain, the import and remove directives will affect the whole chain, and not only the rule the ID refers to.

Example 1: the rules from the parent context are not inherited, but a single rule is imported.

```
SecFilter XXX id:1001
SecFilter YYY id:1002
SecFilter ZZZ id:1003

<Location /subcontext/>
    SecFilterInheritance Off
    SecFilterImport 1003
</Location>
```

Example 2: the rules from the parent context are inherited, with two rules removed.

```
SecFilter XXX id:1001
```

```
SecFilter YYY id:1002
SecFilter ZZZ id:1003

<Location /subcontext/>
    SecFilterRemove 1001 1002
</Location>
```

Note

The Apache web server supports many different types of context (e.g. `<Directory>`, `<Location>`, `<Files>`, ...). The order in which contexts are merged is significant. You should try not to mix inheritance and different-type contexts. If you have to, make sure you test the configuration to make sure it works as intended, and read the Apache context merging documentation carefully: http://httpd.apache.org/docs-2.0/sections.html#mergin.

Filter inheritance In multiuser environments

When you are deploying ModSecurity in multi-user environments, and your users are allowed to use the rules in their `.htaccess` files, you may not wish to allow them to not inherit the rules from the parent context. There are two ways to achieve this.

Note

If you do not trust your users (e.g. running in a web hosting environment) then you should never allow them access to ModSecurity. The `.htaccess` facility is useful for limited administration control decentralisation, keeping ModSecurity configuration with the application code. But it is not meant to be used in situations when the users may want to subvert the configuration. If you are running a hostile environment you should turn off the `.htaccess` facility completely by custom-compiling ModSecurity with the `-DDISABLE_HTACCESS_CONFIG` switch.

First, you can mark certain rules mandatory using the mandatory action. Such rules will always be inherited in the child context.

The other way is to use the `SecFilterInheritanceMandatory` directive to simply make all rules in the context mandatory for all child contexts.

```
SecFilterInheritanceMandatory On
```

Note

Just like `SecFilterInheritance` is always enabled in a context, `SecFilterInheritanceMandatory` is always disabled in a context, no matter of the value used in the parent context.

You may be wondering what happens in a situation like this one:

```
SecFilter XXX id:1001
SecFilterInheritanceMandatory On
<Location /subcontext/>
    SecFilterInheritance Off
    SecFilter YYY id:1002
    SecFilter ZZZ id:1003,mandatory
</Location>

<Location /subcontext/another/>
    SecFilterRemove 1001 1002 1003
    SecFilter QQQ id:1004
</Location>
```

Since rule inheritance is mandatory in the main context, the `/subcontext/` context will inherit rule 1001 in spite of an attempt not to (using `SecFilterInheritance Off`). This subcontext will first run rule 1001, followed by the rules 1002 and 1003.

The mandatory rule 1001 from the main context will also propagate to context `/subcontext/another/`, in spite of an attempt to remove it. This is also true for the rule 1003, which was made mandatory for inheritance using the mandatory action. The `SecFilterRemove` 1001 1002 1003 directive will, however, succeed in removing rule 1002 because inheritance was not mandatory in `/subcontext/`. This context will therefore first run rule 1001 and 1003, followed by the rule 1004.

Note

You should avoid importing and removing rules that makes use of the `skip` action. Unless you are very careful you may end up with a configuration that does something other than what you intended.

URL Encoding Validation

Special characters need to be encoded before they can be transmitted in the URL. Any character can be replaced using the three character combination %XY, where XY represents an hexadecimal character code (see http://www.rfc-editor.org/rfc/rfc1738.txt for more details). Hexadecimal numbers only allow letters A to F, but attackers sometimes use other letters in order to trick the decoding algorithm. ModSecurity checks all supplied encodings in order to verify they are valid.

You can turn URL encoding validation on with the following line:

```
SecFilterCheckURLEncoding On
```

Note

This directive does not check encoding in a `POST` payload when the `multipart/form-data` encoding (file upload) is used. It is not necessary to do so because URL encoding is not used for

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this encoding.

Unicode Encoding Validation

Like many other features Unicode encoding validation is disabled by default. You should turn it on if your application or the underlying operating system accept/understand Unicode.

Note

More information on Unicode and UTF-8 encoding can be found in RFC 2279 (http://www.ietf.org/rfc/rfc2279.txt [???]).

```
SecFilterCheckUnicodeEncoding On
```

This feature will assume UTF-8 encoding and check for three types of errors:

- Not enough bytes. UTF-8 supports two, three, four, five, and six byte encodings. ModSecurity will locate cases when a byte or more is missing.
- Invalid encoding. The two most significant bits in most characters are supposed to be fixed to 0x80. Attackers can use this to subvert Unicode decoders.
- Overlong characters. ASCII characters are mapped directly into the Unicode space and are thus represented with a single byte. However, most ASCII characters can also be encoded with two, three, four, five, and six characters thus tricking the decoder into thinking that the character is something else (and, presumably, avoiding the security check).

Byte range check

You can force requests to consist only of bytes from a certain byte range. This can be useful to avoid stack overflow attacks (since they usually contain "random" binary content). To only allow bytes from 32 to 126 (inclusive), use the following directive:

```
SecFilterForceByteRange 32 126
```

Default range values are 0 and 255, i.e. all byte values are allowed.

Note

This directive does not check byte range in a `POST` payload when `multipart/form-data` encoding (file upload) is used. Doing so would prevent binary files from being uploaded. However, after the parameters are extracted from such request they are checked for a valid range.

Allowing others to see ModSecurity

Prior to 1.9 ModSecurity supported the `SecServerResponseToken` directive. When used, this dir-

ective exposed the presence of the module (with the version) in the web server signature. This directive no longer works in 1.9. If used, it will emit a warning message to the error log.

Rules

When the filtering engine is enabled, every incoming request is intercepted and analysed before it is processed. The analysis begins with a series of built-in checks designed to validate the request format. These checks can be controlled using configuration directives. In the second stage, the request goes through a series of user-defined filters that are matched against the request. Whenever there is a positive match, certain actions are taken.

Simple filtering

The most simplest form of filtering is, well, simple. It looks like this:

```
SecFilter KEYWORD
```

For each simple filter like this, ModSecurity will look for the keyword in the request. The search is pretty broad; it will be applied to the first line of the request (the one that looks like this `GET /index.php?parameter=value HTTP/1.0`). In case of `POST` requests, the body of the request will be searched too (provided the request body buffering is enabled, of course).

Note

All pattern matches are case insensitive by default.

Path normalisation

Filters are not applied to raw request data, but on a normalised copy instead. We do this because attackers can (and do) apply various evasion techniques to avoid detection. For example, you might want to setup a filter that detects shell command execution:

```
SecFilter /bin/sh
```

But the attacker may use a `string /bin/./sh` (which has the same meaning) in order to avoid the filter.

ModSecurity automatically applies the following transformations:

- On Windows only, convert \ to /
- Reduce `/./` to /
- Reduce `//` to /
- Decode URL-encoded characters

You can choose whether to enable or disable the following checks:

- Verify URL encoding
- Allow only bytes from a certain range to be used

Null byte attack prevention

Null byte attacks try to confuse C/C++ based software and trick it into thinking that a string ends before it actually does. This type of an attack is typically rejected with a proper `SecFilterByteRange` filter. However, if you do not do this a null byte can interfere with ModSecurity processing. To fight this, ModSecurity looks for null bytes during the decoding phase and converts them into spaces. So, where before this filter:

```
SecFilter hidden
```

would not detect the word hidden in this request:

```
GET /one/two/three?p=visible%00hidden HTTP/1.0
```

it now works as expected.

Regular expressions

The simplest method of filtering I discussed earlier is actually slightly more complex. Its full syntax is as follows:

```
SecFilter KEYWORD [ACTIONS]
```

First of all, the keyword is not a simple text. It is an regular expression. A regular expression is a mini programming language designed to pattern matching in text. To make most out of this (now) powerful tool you need to understand regular expressions well. I recommend that you start with one of the following resources:

- Perl-compatible regular expressions man page, http://www.pcre.org/pcre.txt
- Perl Regular Expressions, http://www.perldoc.com/perl5.6/pod/perlre.html
- Mastering Regular Expressions, http://www.oreilly.com/catalog/regex/
- Google search on regular expressions, http://www.google.com/search?q=regular%20expressions
- Wikipedia entry, http://en.wikipedia.org/wiki/Regular_expression
- POSIX regular expressions, http://www.wellho.net/regex/posix.html

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Note

Two different regular expression engines are used in Apache 1.x and Apache 2.x. The Apache 1.x regular expression engine is POSIX compliant. The Apache 2.x regular engine is PCRE compliant. As a rule of thumb, regular expressions that work in Apache 1.x will work in Apache 2.x, but not the other way round. If you need to write rules that work on both major branches you will have to test them thoroughly. Since 1.9.2 it is possible to compile ModSecurity for Apache 1.x to use PCRE as an regular expression library.

The second parameter is an action list definition, which specifies what will happen if the filter matches.

Actions are explained later in this manual.

Inverted expressions

If exclamation mark is the first character of a regular expression, the filter will treat that regular expression as inverted. For example, the following:

```
SecFilter !php
```

will reject all requests that do not contain the word php.

Advanced filtering

While `SecFilter` allows you to start quickly, you will soon discover that the search it performs is too broad, and doesn't work very well. Another directive:

```
SecFilterSelective LOCATION KEYWORD [ACTIONS]
```

allows you to choose exactly where you want the search to be performed. The `KEYWORD` and the `ACTIONS` bits are the same as in `SecFilter`. The `LOCATION` bit requires further explanation.

The `LOCATION` parameter consist of a series of location identifiers separated with a pipe.

Examine the following example:

```
SecFilterSelective "REMOTE_ADDR|REMOTE_HOST" KEYWORD
```

It will apply the regular expression only the IP address of the client and the host name. The list of possible location identifiers includes all CGI variables, and some more. Here is the full list:

- `REMOTE_ADDR`
- `REMOTE_HOST`
- `REMOTE_USER`
- `REMOTE_IDENT`
- `REQUEST_METHOD`
- `SCRIPT_FILENAME`
- `PATH_INFO`
- `QUERY_STRING`
- `AUTH_TYPE`
- `DOCUMENT_ROOT`
- `SERVER_ADMIN`
- `SERVER_NAME`
- `SERVER_ADDR`
- `SERVER_PORT`

- SERVER_PROTOCOL
- SERVER_SOFTWARE
- TIME_YEAR
- TIME_MON
- TIME_DAY
- TIME_HOUR
- TIME_MIN
- TIME_SEC
- TIME_WDAY
- TIME
- API_VERSION
- THE_REQUEST
- REQUEST_URI
- REQUEST_FILENAME
- REQUEST_BASENAME
- IS_SUBREQ

There are some special locations:

- POST_PAYLOAD – filter the body of the POST request
- ARGS - filter arguments, the same as QUERY_STRING|POST_PAYLOAD
- ARGS_NAMES – variable/parameter names only
- ARGS_VALUES – variable/parameter values only
- COOKIES_NAMES - cookie names only
- COOKIES_VALUES - cookie values only
- SCRIPT_UID
- SCRIPT_GID
- SCRIPT_USERNAME
- SCRIPT_GROUPNAME
- SCRIPT_MODE
- SCRIPT_BASENAME
- ARGS_COUNT
- COOKIES_COUNT
- HEADERS
- HEADERS_COUNT
- HEADERS_NAMES
- HEADERS_VALUES
- FILES_COUNT

- FILES_NAMES
- FILES_SIZES

And even more special:

- HTTP_header – search request header "header" (HEADER_header also works as of 1.9)
- ENV_variable – search environment variable variable
- ARG_variable – search request variable/parameter variable
- COOKIE_name - search cookie with name name
- FILE_NAME_variable - search the filename of the file uploaded under the name variable.
- FILE_SIZE_variable - search the size of the file uploaded under the name variable

A limited number of output-specific variables are also available for Apache 2 (only when output buffering is enabled):

- OUTPUT - the complete response body
- OUTPUT_STATUS - response status code

Argument filtering exceptions

The ARG_variable location names support inverted usage when used together with the ARG location. For example:

```
SecFilterSelective "ARGS|!ARG_param" KEYWORD
```

will search all arguments except the one named param.

Cookies

ModSecurity provides full support for Cookies. By default cookies will be treated as if they were in version 0 format (Netscape-style cookies). However, version 1 cookies (as defined in RFC 2965) are also supported. To enable version 1 cookie support use the SecFilterCookieFormat directive:

```
# enable version 1 (RFC 2965) cookies
SecFilterCookieFormat 1
```

By default, ModSecurity will not try to normalise cookie names and values. However, since some applications and platforms (e.g. PHP) do encode cookie content you can choose to apply normalisation techniques to cookies. This is done using the SecFilterNormalizeCookies directive.

```
SecFilterNormalizeCookies On
```

Note

Prior to version 1.8.7 ModSecurity supported the `SecFilterCheckCookieFormat` directive. Due to recent changes in 1.8.7 this directive is now deprecated. It can still be used in the configuration but it does not do anything. The directive will be completely removed in the 1.9.x branch.

Output filtering

ModSecurity supports output filtering in the version for Apache 2. It is disabled by default so you need to enable it first:

```
SecFilterScanOutput On
```

After that, simply add selective filters using a special variable `OUTPUT`:

```
SecFilterSelective OUTPUT "credit card numbers"
```

Those who have perhaps followed my columns at http://www.webkreator.com/php/ know that I am somewhat obsessed with the inability of PHP to prevent fatal errors. I have gone to great lengths to prevent fatal errors from spilling to end users (see http://www.webkreator.com/php/configuration/handling-fatal-and-parse-errors.html) but now, finally, I don't have to worry any more about that. The following will catch PHP output error in the response body, replace the response with an error, and execute a custom PHP script (so that the application administrator can be notified):

```
SecFilterSelective OUTPUT "Fatal error:" deny,status:500
ErrorDocument 500 /php-fatal-error.html
```

You should note that although you can mix output filters with input filters, they are not executed at the same time. Input filters are executed before a request is processed by Apache, while the output filters are executed after Apache completes request processing.

Note

Actions `skipnext` and `chain` do not work with output filters.

Output filtering is only useful for plain text and HTML output. Applying regular expressions to binary content (for example images) will only slow down the server. By default ModSecurity will scan output in responses that have no content type, or whose content type is `text/plan` or `text/html`. You can change this using the `SecFilterOutputMimeTypes` directive:

```
SecFilterOutputMimeTypes "(null) text/html text/plain"
```

Configured as in example above ModSecurity will apply output filters to plain text files, HTML files, and

files where the mime type is not specified "(null)".

Note

Using output buffering will make ModSecurity keep the whole of the page output in memory, no matter how large it is. The memory consumption is over twice the size of the page length.

While output monitoring is a useful feature in some circumstances you should be aware that it isn't fool-proof. If an attacker is in a full control of request processing she can evade output monitoring in two ways:

1. Use a Content-Type that is not being monitored. (For performance reasons it is not feasible to monitor all content types.)
2. Encode the output in some way. Any simple encoding is likely to be enough to fool monitoring.

As of 1.9 another output variable is supported - `OUTPUT_STATUS`. This variable contains the status code of the response.

Actions

There are several types of actions:

- A primary action will make a decision whether to continue with the request or not. There can exist only one primary action. If you put several primary actions in the parameter, the last action to be seen will be executed. Primary actions are `deny`, `pass`, and `redirect`.
- Secondary actions will be performed on a filter match independently on the decision made by primary actions. There can be any number of secondary actions. For example, `exec` is one secondary action.
- Flow actions can change the flow of rules, causing the filtering engine to jump to another rule, or to skip one or several rules. Flow actions are `chain` and `skip`.
- Parameters are not really actions, but a method of attaching parameters to filters. Some of this parameters can be used by real actions. For example `status` supplies the response code to the primary action `deny`.

Specifying actions

There are three places where you can put actions. One is the `SecFilterDefaultAction` directive, where you define actions you want executed for the rules that follow the directive:

```
SecFilterDefaultAction "deny,log,status:500"
```

This example defines an action list that consists of three actions. Commas are used to separate actions in a list. The first two actions consist of a single word. But the third action requires a parameter. Use double colon to separate the parameter from the action name. Action parameters must not contain whitespace unless you surround them in single quotes (escape a single quote in the parameter with a backslash):

```
SecFilterDefaultAction "deny,log,status:'Hello World!'"
```

Note

As of 1.8.6, if you specify a non-fatal default action (such as `log,pass`) then it will be ignored during the initialisation phase. The initialisation phase is designed to gather information about the request, allowing non-fatal actions would cause some pieces of the request to be missing (for internal processing in ModSecurity). Therefore if you want ModSecurity to operate in a "detect-only" mode you should disable all implicit validations (check URL encoding, Unicode, cookie format, byte range).

Note

Meta-data actions (`id`, `rev`, `msg`, `severity`) and the actions that control the flow of rules (`skip`/`skipnext`, `chain`) cannot appear in the `SecFilterDefaultAction` directive.

Per-rule actions

You can also specify per-filter actions. Both filtering directives (`SecFilter` and `SecFilterSelective`) accept a set of actions as an optional parameter. Per-rule actions are merged with the actions specified in the most recent `SecFilterSignatureAction` directive (the default value is `log,deny,status:403`). The following rules apply to the merging process:

1. Only one primary action is allowed per action list. A per-rule primary action will override the primary action in the default list.
2. The actions specified in the per-rule configuration will override the equivalent actions in the default action list.
3. When the restricted mode (see `SecFilterActionsRestricted`) is enabled only the meta-data actions can appear in the per-rule action list.
4. Rules can be merged at configuration-time (preferred, intuitive), or at run-time (not so intuitive). Read on to learn about the differences.

SecFilterSignatureAction

The `SecFilterSignatureAction` directive, available since 1.9RC1, makes it easier to maintain rule sets. Prior to 1.9RC1, if one wanted to use per-rule action lists, every action list had to be complete, e.g. specify a primary action, status codes etc. This made it very difficult to separate the rules (the logic to detect attacks) from configuration policy. The `SecFilterSignatureAction` directive can appear many times within a single configuration context and it applies to the rules that immediatelly follow it. Also note that, for consistency, the rules that do not contain custom actions will also inherit the action list from this directive. For example:

```
SecFilterDefaultAction log,deny,status:500

# The rule below will respond with actions
# specified in the context it is executed in.
# You should note that the context a rule is
# executed in is not necessarily the context
# that rule was created in. Through inheritance
# one rule can be executed in many different
# contexts.
SecFilter 000

# Warning rules
SecFilterSignatureAction log,pass
SecFilter 111 id:1
SecFilter 222 id:2

# Error rules
SecFilterSignatureAction log,deny,status:403
SecFilter 333 id:3
SecFilter 444 id:4
# Rule below, too, will reject with status 403
```

```
SecFilter 555
```

When used together with `SecFilterActionsRestricted`, this directive makes it easier to include third-party rule sets into the configuration.

Note

The value of the `SecFilterSignatureAction` directive will not be inherited in child contexts.

Restricting what can appear in the per-rule action list

Sometimes, when you want to include third-party rules in your configuration, you may want to appear what actions will be allowed to appear in them. You can do this with the help of the SecFilterActionsRestricted directive:

```
SecFilterSignatureAction log,deny,status:403
SecFilterActionsRestricted On
Include conf/third-party-rules.conf
```

The only actions allowed in the per-rule configuration when the restricted mode is enabled are the metadata rules `id`, `msg`, `rev`, and `severity`. Other rules will be silently ignored.

Built-in actions

pass

Allow request to continue on filter match. This action is useful when you want to log a match but otherwise do not want to take action.

```
SecFilter KEYWORD "log,pass"
```

allow

This is a stronger version of the previous filter. After this action is performed the request will be allowed through and no other filters will be tried:

```
# stop filter processing for request coming from
# the administrator's workstation
SecFilterSelective REMOTE_ADDR "^192\.168\.2\.99$" allow
```

deny

Interrupt request processing on a filter match. Unless the status action is used too, ModSecurity will immediately return a HTTP 500 error code. If a request is denied the header `mod_security-action`

will be added to the list of request headers. This header will contain the status code used.

status

Use the supplied HTTP status code when request is denied. The following rule:

```
SecFilter KEYWORD "deny,status:404"
```

will return a "Page not found" response when triggered. The Apache `ErrorDocument` directive will be triggered if present in the configuration. Therefore if you have previously defined a custom error page for a given status then it will be executed and its output presented to the user.

redirect

On filter match redirect the user to the given URL. For example:

```
SecFilter KEYWORD "redirect:http://www.modsecurity.org"
```

This configuration directive will always override HTTP status code, or the deny keyword. The URL must not contain a comma.

proxy

On filter match rewrite the request through the internal reverse proxy:

```
SecFilter KEYWORD "proxy:http://www.example.com"
```

For this action to work `mod_proxy` must be installed.

exec

Execute a binary on filter match. Full path to the binary is required:

```
SecFilter KEYWORD "exec:/home/ivanr/report-attack.pl"
```

This directive does not effect a primary action if it exists. This action will always call script with no parameters, but providing all information in the environment. All the usual CGI environment variables will be there.

You can have one binary executed per filter match. Execution will add the header `mod_security-executed` to the list of request headers.

Note

You should be aware that forking a threaded process results in all threads being replicated in the new process. Forking can therefore incur larger overhead in multithreaded operation.

Note

The script you execute must write something (anything) to `stdout`. If it doesn't ModSecurity will assume execution didn't work.

log

Log filter match to the Apache error log.

nolog

Do not log the filter match. This will also prevent the audit logging from taking place.

skipnext

This action allows you to skip over one or more rules. You will use this action when you establish that there is no need to perform some tests on a particular request. By default, the action will skip over the next rule. It can jump any number of rules provided you supply the optional parameter:

```
SecFilterSelective ARG_p value1 skipnext:2
SecFilterSelective ARG_p value2
SecFilterSelective ARG_p value3
```

chain

Rule chaining allows you to chain several rules into a bigger test. Only the last rule in the chain will affect the request but in order to reach it, all rules before it must be matched too. Here is an example of how you might use this feature.

I wanted to restrict the administration account to log in only from a certain IP address. However, the administration login panel was shared with other users and I couldn't use the standard Apache features for this. So I used these two rules:

```
SecFilterSelective ARG_username admin chain
SecFilterSelective REMOTE_ADDR "!^YOUR_IP_ADDRESS_HERE$"
```

The first rule matches only if there exists a parameter username and its value is admin. Only then will the second rule be executed and it will try to match the remote address of the request to the single IP address. If there is no match (note the exclamation mark at the beginning) the request is rejected.

pause

Pause for the specified amount of milliseconds before responding to a request. This is useful to slow down or completely confuse some web scanners. Some scanners will give up if the pause is too long.

Note

Be careful with this option as it comes at a cost. Every web server installation is configured with a limit, the maximal number of requests that may be served at any given time. Using a long delay time with this option may create a "voluntary" denial of service attack if the vulnerability scanner is executing requests in parallel (therefore many .

auditlog

Log the transaction information to the audit log.

noauditlog

Do not log transaction information to the audit log.

logparts

This action makes it possible to change what is logged (concurrent audit log only) on the per-request basis. It was specifically designed to allow request bodies and response bodies to be conditionally logged. For example, you may want to log the response bodies only of those transactions that may have suspicious content in them.

This action requires one parameter, the list of parts to be logged. However, it supports relative changes to the definition provided the first character of the parameter is either a plus `+` or a minus `-`. For example:

```
SecAuditLogType Concurrent
SecAuditLogParts ABCEFHZ
# ...

SecFilter 111 pass,logparts:ABCDFHZ
SecFilter 222 pass,logparts:+E
SecFilter 333 pass,logparts:-C
```

id, rev, msg, severity

These four actions all accept one parameter each, and then reproduce the parameters in every log message emitted by ModSecurity. The idea is to be able to classify problems and put more information in the error logs.

- `id` - unique rule ID
- `rev` - rule revision; if missing assumed to be "1"; whenever a rule is changed the revision value must be incremented
- `msg` - a text message that will appear in the error log
- `severity` - an integer value or a name, as defined by `syslog`. Publishers are advised to only use the following levels: 2 (high severity), 3 (medium severity), 4 (low severity) and 5 (normal but significant). Levels 0-1 and 5-7 should only be used by the end users for their own purposes.
  - 0 `EMERGENCY` - system is unusable
  - 1 `ALERT` - action must be taken immediately

- 2 `CRITICAL` - critical conditions
- 3 `ERROR` - error conditions
- 4 `WARNING` - warning conditions
- 5 `NOTICE` - normal but significant conditions
- 6 `INFO` - informational
- 7 `DEBUG` - debug-level messages

Note

These actions only be used on a standalone rule, or on a rule that is starting a chain.

Although the `id` action can contain any text, it is recommended to only use integers. There is no guarantee that, at some point in future, we will start to accept only integers as valid rule IDs. Unless you intend to publish rules to the public you should use the local range: 1-99,999. These are the reserved ranges:

- 1 – 99999; reserved for your internal needs, use as you see fit but don't publish them to others
- 100,000-199,999; reserved for internal use of the engine, to assign to rules that do not have explicit IDs
- 200,000-299,999; reserved for rules published at `modsecurity.org`
- 300,000-399,999; reserved for rules published at `gotroot.com`
- 400,000 and above; unreserved range.

Contact Ivan Ristic to reserve a range.

mandatory

You can use this action to mark a rule, or a chain or rules, for mandatory inheritance in subcontexts. Read the section on filter inheritance for more information.

Note

Action id can only used on a standalone rule, or on a rule that is starting a chain.

For example:

```
SecFilter 111 mandatory
```

or

```
SecFilter 111 mandatory,chain
SecFilter 222
```

setenv, setnote

These two actions will set or unset a named environment variable or an Apache. There are three formats you can use.

Choose the name and the value

```
SecFilter KEYWORD setenv:name=value
```

Choose just the name, a value "1" will be assumed:

```
SecFilter KEYWORD setenv:name
```

Delete an existing variable / note by placing an exclamation mark before the variable name:

```
SecFilter KEYWORD setenv:!name
```

Request headers added by mod_security

Wherever possible, ModSecurity will add information to the request headers, thus allowing your scripts to find and use them. Obviously, you will have to configure ModSecurity not to reject requests in order for your scripts to be executed at all. At a first glance it may be strange that I'm using the request headers for this purpose instead of, for example, environment variables. Although environment variables would be more elegant, input headers are always visible to scripts executed using an `ErrorDocument` directive (see below) while environment variables are not.

This is the list of headers added:

- `mod_security-executed`; with the path to the binary executed
- `mod_security-action`; with the status code returned
- `mod_security-message`; the message about the problem detected, the same as the message added to the error log

Logging the request body

ModSecurty will export a request body through the mod_security-body note. You can use this for logging:

```
LogFormat "%h %l %u %t \"%r\" %>s %{mod_security-body}n
```

Note

If the request is of multipart/request-data type (file upload) the real request body will be replaced with a simulated `application/x-www-form-urlencoded` content.

Handling rule matches using ErrorDocument

If your configuration returns a HTTP status code 500, and you configure Apache to execute a custom script whenever this code occurs (for example: `ErrorDocument 500 /error500.php`) you will be able to use your favourite scripting engine to respond to errors. The information on the error will be in

the environment variables `REDIRECT_*` and `HTTP_MOD_SECURITY_*` (as described here: http://httpd.apache.org/docs-2.0/custom-error.html).

Making ModSecurity talk to your firewall

In some cases, after detecting a particularly dangerous attack or a series of attacks you will want to prevent further attacks coming from the same source. You can do this by modifying the firewall to reject all traffic coming from a particular IP address (I have written a helper script that works with iptables, download it from here: http://www.apachesecurity.net).

This method can be very dangerous since it can result in a denial of service (DOS) attack. For example, an attacker can use a proxy to launch attacks. Rejecting all requests from a proxy server can be very dangerous since all legitimate users will be affected too.

Since most proxies send information describing the original client (some information on this is available here http://www.webkreator.com/cms/view.php/1685.html [???], under the "`Stop hijacking`" header), we can try to be smart and find the real IP address. While this can work, consider the following scenario:

- The attacker is accessing the application directly but is pretending to be a proxy server, citing a random (or valid) IP address as the real source IP address. If we start rejecting requests based on that deducted information, the attacker will simply change the IP address and continue. As a result we might have banned legitimate users while the attacker is still free searching for application holes.

Therefore this method can be useful only if you do not allow access to the application through proxies, or allow access only through proxies that are well known and, more importantly, trusted.

If you still want to ban requests based on IP address (in spite of all our warnings), you will need to write a small script that will executed on a filter match. The script should extract the IP address of the attacker from environment variables, and then make a call to iptables or ipchains to ban the IP address. We will include a sample script doing this with a future version of mod_security.

Special Features

File upload support

ModSecurity is capable of intercepting files uploaded through `POST` requests and `multipart/form-data` encoding or (as of 1.9) through `PUT` requests.

Choosing where to upload files

ModSecurity will always upload files to a temporary directory. You can choose the directory using the `SecUploadDir` directive:

```
SecUploadDir /tmp
```

It is better to choose a private directory for file storage, somewhere only the web server user is allowed access. Otherwise, other server users may be able to access the files uploaded through the web server.

Verifying files

You can choose to execute an external script to verify a file before it is allowed to go through the web server to the application. The `SecUploadApproveScript` directive enables this function. Like in the following example:

```
SecUploadApproveScript /full/path/to/the/script.sh
```

The script will be given one parameter on the command line - the full path to the file being uploaded. It may do with the file whatever it likes. After processing it, it should write the response on the standard output. If the first character of the response is "1" the file will be accepted. Anything else, and the whole request will be rejected. Your script may use the rest of the line to write a more descriptive error message. This message will be stored to the debug log.

Storing uploaded files

You can choose to keep files uploaded through the web server. Simply add the following line to your configuration:

```
SecUploadKeepFiles On
```

Files will be stored at a path defined using the `SecUploadDir` directive. If you want to keep files selectively you can use

```
SecUploadKeepFiles RelevantOnly
```

This will keep only those files that belong to requests that are deemed relevant.

Interacting with other daemons

To allow for interaction with other daemons (for example `ClamAV`, as described later), as of 1.9dev1 files are created with relaxed permissions allowing group read. To do this assuming Apache runs as httpd and daemon as clamav:

```
# mkdir /tmp/webfiles
# chown httpd:clamav /tmp/webfiles
# chmod 2750 /tmp/webfiles
```

With this configuration in place, the user clamav will have access to the folder. The same goes for files, which will be created with group ownership clamav. Don't forget to use the `SecUploadDir` directive to store files in `/tmp/webfiles.`

Note

If you are keeping files around it might not be safe to leave them there owned by the web server user. For example, if you have PHP running as a module and untrusted users on the server they may be able to access the files. Consider implementing a cron script to make the files only readable by root, and possibly move them to a separate location altogether.

Integration with ClamAV

ModSecurity includes a utility script that allows the file approval mechanism to integrate with the ClamAV virus scanner. This is especially handy to prevent viruses and exploits from entering the web server through file upload.

```
#!/usr/bin/perl
#
# modsec-clamscan.pl
# mod_security, http://www.modsecurity.org
# Copyright (c) 2002-2004 Ivan Ristic <ivanr@webkreator.com>
#
# $Id: modsecurity-manual.xml,v 1.8.2.14 2006/05/15 08:39:07 ivanr Exp $
#
# This script is an interface between mod_security and its
# ability to intercept files being uploaded through the
# web server, and ClamAV

# by default use the command-line version of ClamAV,
# which is slower but more likely to work out of the
# box
$CLAMSCAN = "/usr/bin/clamscan";

# using ClamAV in daemon mode is faster since the
# anti-virus engine is already running, but you also
# need to configure file permissions to allow ClamAV,
```

```
# usually running as a user other than the one Apache
# is running as, to access the files
# $CLAMSCAN = "/usr/bin/clamdscan";

if (@ARGV != 1) {
    print "Usage: modsec-clamscan.pl <filename>\n";
    exit;
}

my ($FILE) = @ARGV;

$cmd = "$CLAMSCAN --stdout --disable-summary $FILE";
$input = `$cmd`;
$input =~ m/^(.+)/;
$error_message = $1;

$output = "0 Unable to parse clamscan output [$1]";

if ($error_message =~ m/: Empty file\.$/) {
    $output = "1 empty file";
}
elsif ($error_message =~ m/: (.+) ERROR$/) {
    $output = "0 clamscan: $1";
}
elsif ($error_message =~ m/: (.+) FOUND$/) {
    $output = "0 clamscan: $1";
}
elsif ($error_message =~ m/: OK$/) {
    $output = "1 clamscan: OK";
}

print "$output\n";
```

Upload memory limit

Apache 1.x does not offer a proper infrastructure for request interception. It is only possible to intercept requests storing them completely in the operating memory. With Apache 1.x there is a choice to analyse `multipart/form-data` (file upload) requests in memory or not analyse them at all (selectively turn `POST` processing off).

With Apache 2.x, however, you can define the amount of memory you want to spend parsing multipart/form-data requests in memory. When a request is larger than the memory you have allowed a temporary file will be used. The default value is 60 KB but the limit can be changed using the `SecUploadInMemoryLimit` directive:

```
SecUploadInMemoryLimit 125000
```

Server identity masking

One technique that often helps slow down and confuse attackers is the web server identity change. Web servers typically send their identity with every HTTP response in the Server header. Apache is particularly helpful here, not only sending its name and full version by default, but it also allows server modules to append their versions too.

To change the identity of the Apache web server you would have to go into the source code, find where the name "Apache" is hard-coded, change it, and recompile the server. The same effect can be achieved using the `SecServerSignature` directive:

```
SecServerSignature "Microsoft-IIS/5.0"
```

It should be noted that although this works quite well, skilled attackers (and tools) may use other techniques to "fingerprint" the web server. For example, default files, error message, ordering of the outgoing headers, the way the server responds to certain requests and similar - can all give away the true identity. I will look into further enhancing the support for identity masking in the future releases of mod_security.

If you change Apache signature but you are annoyed by the strange message in the error log (some modules are still visible - this only affects the error log, from the outside it still works as expected):

```
[Fri Jun 11 04:02:28 2004] [notice] Microsoft-IIS/5.0 mod_ssl/2.8.12 OpenSSL/0.9.6b \
configured -- resuming normal operations
```

Then you should re-arrange the modules loading order to allow mod_security to run last, exactly as explained for chrooting.

Note

In order for this directive to work you must leave/set `ServerTokens` to Full.

When the `SecServerSignature` directive is used to change the public server signature, ModSecurity will start writing the real signature to the error log, to allow you to identify the web server and the modules used.

```
[Fri Jun 11 04:02:28 2004] [notice] mod_security/1.9dev1 configured - Apache/2.0.52 \
(Unix) PHP/4.3.10 proxy_html/2.4
```

Chroot support

Standard approach

ModSecurity includes support for Apache filesystem isolation, or chrooting. Chrooting is a process of confining an application into a special part of the file system, sometimes called a "jail". Once the chroot (short for “change root”) operation is performed, the application can no longer access what lies outside the jail. Only the root user can escape the jail (in most cases, there are some circumstances when even

non-root users can escape too, but only on an improperly configured jail). A vital part of the chrooting process is not allowing anything root related (root processes or root suid binaries) inside the jail. The idea is that if an attacker manages to break in through the web server he won't have much to do because he, too, will be in jail, with no means to escape.

Applications do not have to support chrooting. Any application can be chrooted using the chroot binary. The following line:

```
chroot /chroot/apache /usr/local/web/bin/apachectl start
```

will start Apache but only after replacing the file system with what lies beneath `/chroot/apache`.

Unfortunately, things are not as simple as this. The problem is that applications typically require shared libraries, and various other files and binaries to function properly. So, to make them function you must make copies of required files and make them available inside the jail. This is not an easy task. (I covered the process in detail in my book, Apache Security. The chapter that covers chroot is available for free at http://www.apachesecurity.net).

The ModSecurity way

While I was chrooting an Apache the other day I realised that I was bored with the process and I started looking for ways to simplify it. As a result, I built the chrooting functionality into the `mod_security` module itself, making the whole process less complicated. With ModSecurity under your belt, you only need to add one line to the configuration file:

```
SecChrootDir /chroot/apache
```

and your web server will be chrooted successfully.

Note

The internal chroot functionality provided by ModSecurity works great for simple setups. One example of a simple setup is Apache serving static files only, or running scripts using modules. For more complex setups you should consider building a jail the old-fashioned way.

Note

The internal chroot feature should be treated as somewhat experimental. Due to the large number of default and third-party modules available for the Apache web server, it is not possible to verify the internal chroot works reliably with all of them. You are advised to think about your option and make your own decision. In particular, if you are using any of the modules that fork in the module initialisation phase (e.g. mod_fastcgi, mod_fcgid, mod_cgid), you are advised to examine each Apache process and observe its current working directory, process root, and the list of open files.

What follows is a list of facts about the internal chroot functionality for you to consider before making the decision:

1. Unlike external chrooting (mentioned previously) ModSecurity chrooting requires no additional files to exist in jail. The chroot call is made after web server initialisation but before forking. Because of this, all shared libraries are already loaded, all web server modules are initialised, and log files are opened. You only need your data files in the jail.
2. To create new processes from within jail your either need to use statically-compiled binaries or place shared libraries in the jail too.
3. With Apache 2.x, the default value for the `AcceptMutex` directive is `pthread`. Sometimes this setting prevents Apache from working when the chroot functionality is used. Set `AcceptMutex` to any other setting to overcome this problem (e.g. `posixsem`). If you configure chroot to leave log files outside the jail, Apache will have file descriptors pointing to files outside the jail. The chroot mechanism was not initially designed for security and some people fill uneasy about this.
4. If your Apache installation uses mod_ssl you will find that it is not possible to leave the logs directory outside the jail when a file-based SSL mutex is used. This is because `mod_ssl` creates a lock file in the logs directory immediately upon startup, but fails when it cannot find it later. This problem can be avoided by using some other mutex type, for example `SSLMutex sem`, or by telling `mod_ssl` to place its file-based mutex in a directory that is inside the jail (using `SSLMutex file://path/to/file`).
5. If you are trying to use the chroot feature with a multithreaded Apache installation you may get the folllowing message "libgcc_s.so.1 must be installed for pthread_cancel to work". Add `LoadFile /lib/libgcc_s.so.1` to your Apache configuration to fix this problem.
6. The files used by Apache for authentication must be inside the jail since these files are opened on every request.
7. Certain modules (e.g. `mod_fastcgi`, `mod_fcgi`, `mod_cgid`) fork in the module initialisation phase. If they fork before chroot takes place they create a process that lives outside jail. In this case ModSecurity must be configured to initialise after most modules but before the modules that fork. This is a manual process with Apache 1.3.x. It is an automated process with Apache 2.x since ModSecurity 1.9.3.

Required module ordering for chroot support (Apache 1.x)

Note

This step should not be needed if you intend to leave the log files inside the jail.

As mentioned above, the chroot call must be performed at a specific moment in Apache initialisation, only after all other modules are initialised. This means that ModSecurity must be the first on the list of modules. To ensure that, you will probably need to make some changes to module ordering, using the following configuration directives:

```
ClearModuleList
AddModule mod_security.c
AddModule ...
```

```
AddModule ...
AddModule ...
```

The first directive clears the list. You must put ModSecurity next, followed by all other modules you intend to use (except http_core.c, which is always automatically added and you do not have to worry about it). You can find out the list of built-in modules by executing the httpd binary with the -l switch:

```
./httpd -l
```

Note

If you choose to put the Apache binary and the supporting files outside of jail, you won't be able to use the `apachectl graceful` and `apachectl restart` commands anymore. That would require Apache reaching out of the jail, which is not possible. With Apache 2, even the apachectl stop command may not work.

Required module ordering for chroot support (Apache 2.x)

Note

This step should not be needed if you intend to leave the log files inside the jail.

With Apache 2.x you shouldn't need to manually configure module ordering since Apache 2.x already includes support for module ordering internally. ModSecurity uses this feature to tell Apache 2.x when exactly to call it and chroot works (if you're having problems let me know).

There was a change in how the process is started in Apache2. The httpd binary itself now creates the pid file with the process number. Because of this you will need to put Apache in jail at the same folder as outside the jail. Assuming your Apache outside jail is in `/usr/local/web/apache` and you want jail to be at `/chroot` you must create a folder `/chroot/usr/local/web/apache/logs`.

When started, the Apache will create its pid file there (assuming you haven't changed the position of the pid file in the `httpd.conf` in which case you probably know what you're doing).

A step-by-step chroot guide

If you follow this step-by-step guide you won't even have to bother with the module ordering. First install Apache as you normally would. Here I will assume Apache was installed into `/usr/local/apache`. I will also assume the jail will be placed at `/chroot/apache`. It is always a good idea the installation was successful by starting the server and checking it works properly.

```
# mkdir -p /chroot/apache/usr/local
# cd /usr/local
# mv apache /chroot/apache/usr/local
# ln -s /chroot/apache/usr/local/apache
```

Now instruct ModSecurity to perform chroot upon startup:

```
SecChrootDir /chroot/apache
```

And start Apache:

```
/usr/local/apache/bin/apachectl startssl
```

Note

This procedure describes an approach where the Apache files are left inside the jail after chroot takes place. This is the recommended approach because it works every time, and because it is very easy to switch from a non-chrooted Apache to a chrooted one (simply by commenting the `SecChrootDir` line in the configuration file). It is perfectly possible, however, to create a jail where most of the files are outside. But this is also an option that is more difficult to get right. A good understanding of the chroot mechanism is needed to get it right.

Note

Since version 1.8, if ModSecurity fails to perform chroot for any reason it will prevent the server from starting. If it fails to detect chroot failure during the configuration phase and then detects it at runtime, it will write a message about that in the error log and exit the child. This may not be pretty but it is better than running without a protection of a chroot jail when you think such protection exists.

Performance measurement

In 1.9dev1 I introduced experimental support for performance measurement to the Apache 2 version of ModSecurity. Measuring script performance is sometimes difficult if the clients are on a slow link. Because the response is generated and sent to the client at the same time it is not possible to separate the two. The only way to measure performance is to withhold from sending the response in parts, and only send it when it is generated completely. This is exactly what ModSecurity does anyway (for security purposes) so it makes sense to use it for performance measurement. Three time measurements are performed and data stored the results in Apache notes. All times are given in microseconds relative to the start of request processing:

- `mod_security-time1` - ModSecurity initialisation completed. If the request contains a body the body will have been read by now (provided `POST` scanning is enabled).
- `mod_security-time2` - ModSecurity completes rule processing. Since we try to execute last, just before request is processed by a handler, this time is roughly the time just before processing begins.
- `mod_security-time3` - response has been generated and is about to be sent to the client.

To use these values in a custom log do this (again, this only works with Apache 2):

```
CustomLog logs/timer_log "%h %l %u %t \"%r\" %>s %b - %{UNIQUE_ID}e \
%<{mod_security-time1}n %<{mod_security-time2}n \
%<{mod_security-time3}n %D"
```

Each entry in the log will look something like this:

```
82.70.94.182 - - [19/Nov/2004:11:33:52 +0000] "GET /cgi-bin/modsec-test.pl HTTP/1.1" \
200 1418 - 532 1490 13115 14120
```

In the example above it took 532 microseconds for processing to reach ModSecurity. ModSecurity used 958 microseconds (1490 - 532) to execute the defined rules, the CGI script generated output in 11625 microseconds (13155 - 1490), and Apache took 965 microseconds to send the response to the client.

Logging

Debug Log

Use the `SecFilterDebugLog` directive to choose a file where debug output will be written. If the parameter does not start with a forward slash, Apache home path will be prepended to it.

```
SecFilterDebugLog logs/modsec_debug_log
```

You can control how detailed the debug log is with `SecFilterDebugLevel`:

```
SecFilterDebugLevel 4
```

Possible log values are:

- 0 - none (this value should always be used on production systems)
- 1 - significant events (these will also be reported in the error_log)
- 2 - info messages
- 3 - more detailed info messages

Note

ModSecurity uses log levels up until 9 internally but they are only useful for debugging purposes.

Audit logging

Standard Apache logging will not help much if you need to trace back steps of a particular user or an attacker. The problem is that only a very small subset of each request is written to a log file. This problem can be remedied with the audit logging feature of ModSecurity. These two directives:

```
SecAuditEngine On
SecAuditLog logs/audit_log
```

will let ModSecurity know that you want a full audit log stored into the log file audit log. Here is an example of how a request is logged:

```
============================================
Request: 192.168.0.2 - - [[18/May/2003:11:20:43 +0100]] "GET /cgi-bin/printenv?p1=666 \
HTTP/1.0" 406 822
Handler: cgi-script
--------------------------------------------
GET /cgi-bin/printenv?p1=666 HTTP/1.0
Host: wkx.dyndns.org:8080
User-Agent: mod_security regression test utility
Connection: Close
```

```
mod_security-message: Access denied with code 406. Pattern match "666" at \
ARGS_SELECTIVE
mod_security-action: 406

HTTP/1.0 406 Not Acceptable
=======================================
```

You can see that on the first line you get what you normally get from Apache. The second line contains the name of the handler that was supposed to handle the request. Full request (with additional mod_security headers) is given after the separator, and the response headers (in this case there is only one line) is given after one empty line.

When the `POST` filtering is on, the `POST` payload will always be included in the audit log. Actual response will never be included (at least not in this version).

Note

Take care when handling audit log data. The files may contain unfiltered binary data received over the network. Such data may be dangerous if not handled properly (e.g. it may contain terminal escape sequences.)

At this time, the audit logging part of the module will log Apache 1.x error messages, on the line below the `Handler`: line. The line will always begin with `Error:`. This functionality will be added to the Apache 2.x version of the module if possible.

Note

The audit log subsystem does not log request timeouts.

Note

The audit log entries do not contain the output headers `Date` and `Server`. This is because Apache is adding these response headers to the response at the very last moment in response processing making it impossible for a module to get to them.

Choosing what to log by response status code

As of 1.9 ModSecurity supports the `SecAuditLogRelevantStatus` directive, which is used to selectively log requests to audit log even if they did not cause a warning or an error. It is especially useful to establish a simple communication channel with the applications deployed on the web server. For example, if you know the application always responds with a HTTP status code 500 whenever an internal error or an attack occurs you can configure ModSecurity to log such requests in full:

```
SecAuditLogRelevantStatus ^5
```

This directive accepts one parameter, a regular expression that will be matched against the response status

code. If there is a match the transaction will be considered relevant, and logged.

Unique request identifiers

If you add mod_unique_id to the Apache configuration mod_security will detect it and use the environment variable it generates (`UNIQUE_ID`). Its value will be written to the audit log. You could write the unique ID in an error page to the user and use it later to track and fix a false positive.

Choosing what to log

The SecAuditEngine parameter accepts one of four values:

- `On` – log all requests
- `Off` – do not log requests at all
- `RelevantOnly` – only log relevant requests. Relevant requests are those requests that caused a filter match.
- `DynamicOrRelevant` – (*deprecated as of 1.9.3*) log dynamically generated or relevant requests. A request is considered dynamic if its handler is not null.

Note

It is sometimes difficult for ModSecurity to determine if a particular request is dynamic in nature or not. Since this logic relies on the internal (and not entirely documented) workings of Apache and on the chosen configuration it also makes it somewhat unpredictable. Because unpredictability is not a desired quality in a security device, *as of 1.9.3 dynamic request detection is deprecated*.

Getting ModSecurity to log dynamic requests can sometimes require a little bit of work depending on your configuration. In Apache theory, a response to a request is generated by a so-called handler. If there is a handler attached to a request it should be considered to be of a dynamic nature. In practise, however, Apache can be configured to serve dynamic pages without a handler (it then chooses the module based on the resource MIME type). This will happen, for example, if you configure PHP as instructed in the main distribution:

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

While this works, it isn't entirely correct. However, if you replace the above line with the following:

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

PHP will work just as well, Apache will have a handler assigned to the request, and audit logger will be able to log selectively.

As of 1.9 the audit logger takes the response code into account when deciding whether something is relevant or not. At the time response codes 4xx and 5xx are treated as relevant. This makes it easy to perform audit logging on request from (any) web application. If an error occurs just respond as you normally

would but just change the response code to (for example) 500.

New Audit Log Type

New audit log type was introduced in ModSecurity 1.9. The old audit log type remains useful for ad-hoc logging but *it is considered obsolete and it may be removed from ModSecurity 2.0*. The new audit log type was introduced to increase performance (one file per transaction is created, avoiding the need to synchronise writes between concurrent requests), increase the amount of information logged, and to allow for real-time audit log aggregation (a proof-of-concept piped logging script, `modsec-audit-log-collector.pl`, is included in the distribution). The new audit log type can log the response body too.

Note

For the new audit log type to work the `mod_unique_id` module must be active.

Example configuration:

```
# Yes, we want to use the new format
SecAuditLogType Concurrent

# Directory where the files will be stored
# MUST NOT BE THE SAME AS THE APACHE LOGS FOLDER
SecAuditLogStorageDir /var/www/audit_log/data/

# The index of all files created
# YOU MUST NOT ALLOW NON-ROOT USERS TO WRITE
# TO THE BASE FOLDER
SecAuditLog /var/www/audit_log/index

# Choose what to log – everything (default is ABCFHZ)
SecAuditLogParts ABCDEFGHZ
```

For each audit log file created, an one-line entry will appear in the index file. Those who wish to implement real-time audit log aggregation should configure a script to receive information about audit log entries via the piped logging mechanism.

Note

You have probably heard that it is dangerous to allow non-`root` users to have write permissions in the Apache logs folder. In the same manner non-`root` users should not be allowed to have write permissions in the folder where you place the audit log index file. To be safe create a subdirectory beneath the main audit log folder and allow the `httpd` user to write there.

A typical audit log entry looks like this:

```
192.168.2.101 192.168.2.11 - - [15/Jul/2005:11:56:52 +0100] \
"POST /form.php HTTP/1.1" 403 3 "http://192.168.2.101:8080/form.php" \
```

```
"Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.7.8) Gecko/20050511 \
Firefox/1.0.4" G3yTd38AAAEAAAM7BLwAAAAA "-" \
/20050715/20050715-1156/20050715-115652-G3yTd38AAAEAAAM7BLwAAAAA 0 1031 \
md5:dc910f6d647d47b32ae6e47326f0ca42
```

The line begins with a "vcombined" log format, but it then adds the following fields:

- `unique_id`
- `session_id` (not used at this time)
- `filename`
- `offset`
- `size`
- hash of the audit log entry (`MD5` hash used at this time)

A typical audit log entry may look like this:

```
--67458b6b-A--
[15/Jul/2005:11:56:52 +0100] G3yTd38AAAEAAAM7BLwAAAAA \
192.168.2.11 4236 192.168.2.101 8080
--67458b6b-B--
POST /form.php HTTP/1.1
Host: 192.168.2.101:8080
User-Agent: Mozilla/5.0
Accept: */*
Accept-Language: en-us,en;q=0.5
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Referer: http://192.168.2.101:8080/form.php
Content-Type: application/x-www-form-urlencoded
Content-Length: 5

--67458b6b-C--
f=111
--67458b6b-E--
403 (Response body)
--67458b6b-F--
HTTP/1.1 403 Forbidden
Last-Modified: Fri, 08 Jul 2005 14:25:30 GMT
ETag: "decb4-3-34b96a80"
Accept-Ranges: bytes
Content-Length: 19
Keep-Alive: timeout=15, max=100
Connection: Keep-Alive
Content-Type: text/html

--67458b6b-H--
```

```
Message: Pattern match "111" at POST_PAYLOAD \
[id "1"] [rev "2"] [msg "3"] [severity "4"]
Apache-Handler: application/x-httpd-php
Stopwatch: 1126536042708000 11024 (7276* 7375 9842)

--67458b6b-Z--
```

Note

Take care when handling audit log data. The files may contain unfiltered binary data received over the network. Such data may be dangerous if not handled properly (e.g. it may contain raw terminal escape sequences.)

Available audit log parts:

- `A` – audit log header (mandatory)
- `B` – request headers
- `C` – request body (present only if the request body exists and ModSecurity is configured to intercept it)
- `D` - RESERVED for ntermediary response headers, not implemented yet.
- `E` – intermediary response body (present only if ModSecurity is configured to intercept response bodies, and if the audit log engine is configured to record it). Intermediary response body is the same as the actual response body unless ModSecurity intercepts the intermediary response body, in which case the actual response body will contain the error message (either the Apache default error message, or the ErrorDocument page).
- `F` – final response headers (excluding the Date and Server headers, which are always added by Apache in the late stage of content delivery).
- `G` – RESERVED for the actual response body, not implemented yet.
- `H` - audit log trailer
- `Z` – final boundary, signifies the end of the entry (mandatory)

Note

ModSecurity does not log response bodies of stock Apache responses (e.g. `404`).

Guardian log

Since 1.9 ModSecurity supports a new directive, `SecGuardianLog`, that is designed to send all access data to another program using the piped logging feature. Since Apache is typically deployed in a multi-process fashion, making information sharing difficult, the idea is to deploy a single external process to observe all requests in a stateful manner, providing additional protection.

Development of a state of the art external protection tool will be a focus of subsequent ModSecurity re-

leases. However, a fully functional tool is already available as part of the Apache httpd tools project (http://www.apachesecurity.net/tools/). The tool is called `httpd-guardian` and can be used to defend against Denial of Service attacks. It uses the blacklist tool (from the same project) to interact with an iptables-based (Linux) or pf-based (*BSD) firewall, dynamically blacklisting the offending IP addresses. It can also interact with SnortSam (http://www.snortsam.net). Assuming `httpd-guardian` is already configured (look into the source code for the detailed instructions) you only need to add one line to your Apache configuration to deploy it:

```
SecGuardianLog |/path/to/httpd-guardian
```

By default `httpd-guardian` will defend against clients that send more 120 requests in a minute, or more than 360 requests in five minutes.

Custom logging

Since 1.8 it is possible to use Apache custom logging to log only those requests where ModSecurity was involved. This is because ModSecurity now defines an environment variable mod_security-relevant whenever it performs an action. To use a custom log file, add the following (or similar) to your configuration:

```
CustomLog logs/modsec_custom_log \
"%h %l %u %t \"%r\" %>s %b %{mod_security-message}i" \
env=mod_security-relevant
```

Miscellaneous Topics

Impedance mismatch

Web application firewalls have a difficult job trying to make sense of data that passes by, without any knowledge of the application and its business logic. The protection they provide comes from having an independent layer of security on the outside. Because data validation is done twice, security can be increased without having to touch the application. In some cases, however, the fact that everything is done twice brings problems. Problems can arise in the areas where the communication protocols are not well specified, or where either the device or the application do things that are not in the specification.

The worst offender is the cookie specification. (Actually all four of them: http://wp.netscape.com/newsref/std/cookie_spec.html, http://www.ietf.org/rfc/rfc2109.txt, http://www.ietf.org/rfc/rfc2964.txt [<?xml version="1.0"?> <ns:clipboard xmlns:ns="http://www.xmlmind.com/xmleditor/namespace/clipboard" ><ulink url="???" >http://www.ietf.org/rfc/rfc2964.txt</ulink ></ns:clipboard >], http://www.ietf.org/rfc/rfc2965.txt.) For many of the cases, possible in real life, there is no mention in the specification - leaving the programmers to do what they think is appropriate. For the largest part this is not a problem when the cookies are well formed, as most of them are. The problem is also not evident because most applications parse cookies they themselves send. It becomes a problem when you think from a point of view of a web application firewall, and a determined adversary trying to get past it. In the 1.8.x branch and until 1.8.6, ModSecurity (changes were made to 1.8.7) used a v1 cookie parser. However, the differences between v0 and v1 formats could be exploited to make a v1 parser see one cookie where a v0 parser would see more. Consider the following:

```
Cookie: innocent="; nasty=payload; third="
```

A v0 parser does not understand double quotes. It typically only looks for semi-colons and splits the header accordingly. Such a parser sees cookies `innocent`, `nasty`, and `third`. A v1 parser, on the other hand, sees only one cookie - `innocent`.

How is the impedance mismatch affecting the web application firewall users and developers? It certainly makes our lives more difficult but that's all right - it's a part of the game. Developers will have to work to incorporate better and smarter parsing routines. For example, there are two cookie parsers in ModSecurity 1.8.7 and the user can choose which one to use. (A v0 format parser is now used by default.) But such improvements, since they cannot be automated, only make using the firewall more difficult - one more thing for the users to think about and configure.

On the other hand, the users, if they don't want to think about cookie parsers, can always fall back to use those parts of HTTP that are much better defined. Headers, for example. Instead of using `COOKIE_innocent` to target an individual cookie they can just use `HTTP_Cookie` to target the whole cookie header. Other variables, such as `ARGS`, will look at all variables at once no matter how hard adversaries try to mask them.

Testing

A small HTTP testing utility was developed as part of the ModSecurity effort. It provides a simple and easy way to send crafted HTTP requests to a server, and to determine whether the attack was successfully detected or not.

Calling the utility without parameters will result in its usage printed:

```
$ ./run-test.pl
Usage: ./run-test.pl host[:port] testfile1, testfile2, ...
```

First parameter is the host name of the server, with port being optional. All other parameters are filenames of files containing crafted HTTP requests.

To make your life a little bit easier, the utility will generate certain request headers automatically:

- Host: hostname
- User-Agent: mod_security regression testing utility
- Connection: Close

You can include them in the request if you need to. The utility will not add them if they are already there.

Here is how an HTTP request looks like:

```
# 01 Simple keyword filter
#
# mod_security is configured not to allow
# the "/cgi-bin/keyword" pattern
#
GET /cgi-bin/keyword HTTP/1.0
```

This request consists only of the first line, with no additional headers. You can create as complicated requests as you wish. Here is one example of a POST method usage:

```
# 10 Keyword in POST
#
POST /cgi-bin/printenv HTTP/1.0
Content-Type: application/x-www-form-urlencoded
Content-Length: 5

p=333
```

Lines that are at the beginning of the file and begin with # will be treated as comments. The first line is special, and it should contain the name of the test.

The utility expects status 200 as a result and will treat such responses as successes. If you want some other response you need to tell it by writing the expected response code on the first line (anywhere on the line). Like this:

```
# 14 Redirect action (requires 302)
```

```
GET /cgi-bin/test.cgi?p=xxx HTTP/1.0
```

The brackets and the "requires" keyword are not required but are recommended for better readability.

Solving Common Security Problems

As an example of ModSecurity capabilities we will demonstrate how you can use it to detect and prevent the most common security problems. We won't go into detail here about problems themselves but a very good description is available in the Open Web Application Security Project's guide, available at http://www.owasp.org [???].

Directory traversal

If your scripts are dealing with the file system then you need to pay attention to certain meta characters and constructs. For example, a character combination ../ in a path is a request to go up one directory level.

In normal operation there is no need for this character combination to occur in requests and you can forbid them with the following filter:

```
SecFilter "\.\./"
```

Cross site scripting attacks

Cross site scripting attacks (XSS) occur when an attacker injects HTML or/and JavaScript code into your Web pages and then that code gets executed by other users. This is usually done by adding HTML to places where you would not expect them. A successful XSS attack can result in the attacker obtaining the cookie of your session and gaining full access to the application!

Proper defense against this attack is parameter filtering (and thus removing the offending HTML/Javascript) but often you must protect existing applications without changing them. This can be done with one of the following filters:

```
SecFilter "<script"
SecFilter "<.+>"
```

The first filter will protect only against JavaScript injection with the <`script`> tag. The second filter is more general, and disallows any HTML code in parameters.

You need to be careful when applying filters like this since many application want HTML in parameters (e.g. CMS applications, forums, etc). You can this with selective filtering. For example, you can have the second filter from above as a general site-wide rule, but later relax rules for a particular script with the following code:

```
<Location /cms/article-update.php>
    SecFilterInheritance Off
    # other filters here ...
    SecFilterSelective "ARGS|!ARG_body" "<.+>"
```

```
</Location>
```

This code fragment will only accept HTML in a named parameter body. In reality you will probably add a few more named parameters to the list.

SQL/database attacks

Most Web applications nowadays rely heavily on databases for data manipulation. Unless great care is taken to perform database access safely, an attacker can inject arbitrary SQL commands directly into the database. This can result in the attacker reading sensitive data, changing it, or even deleting it from the database altogether.

Filters like:

```
SecFilter "delete[[:space:]]+from"
SecFilter "insert[[:space:]]+into"
SecFilter "select.+from"
```

can protect you from most SQL-related attacks. These are only examples, you need to craft your filters carefully depending on the actual database engine you use.

Operating system command execution

Web applications are sometimes written to execute operating system commands to perform operations. A persistent attacker may find a hole in the concept, allowing him to execute arbitrary commands on the system.

A filter like this:

```
SecFilterSelective ARGS "bin/"
```

will detect attempts to execute binaries residing in various folders on a Unix-related operating system.

Buffer overflow attacks

Buffer overflow is a technique of overflowing the execution stack of a program and adding assembly instructions in an attempt to get them executed. In some circumstances it may be possible to prevent these types of attack by using the line similar to:

```
SecFilterByteRange 32 126
```

as it will only accept requests that consists of bytes from this range. Whether you use this type of protection or not depends on your application and the used character encoding.

If you want to support multiple ranges, regular expressions come to rescue. You can use something like:

```
SecFilterSelective THE_REQUEST "!^[\x0a\x0d\x20-\x7f]+$"
```

PHP

PHP peculiarities

When writing ModSecurity rules that are meant to protect PHP applications one needs to have a list of PHP peculiarities in mind. It is often easy to design a rule that works when you are attacking yourself in one way but completely miss an attack variant. Below is a list of things I am aware about:

- When the register_globals is set to On request parameters become global variables. (In PHP 4.x it is even possible to override the GLOBALS array).
- Cookies are treated as request parameters.
- Whitespace at the beginning of parameters is ignored.
- The remaining whitespace (in parameter names) is converted to underscores.
- The order in which parameters are taken from the request and the environment is EGPCS (environment, get, post, cookies, built-in variables). This means that a `POST` parameter will overwrite the parameters transported on the request line (in `QUERY_STRING`).
- When the magic_quotes_gpc is set to On PHP will use backslash to escape the following characters: single quote, double quote, backslash, and NULL.
- If magic_quotes_sybase is set to On only the single quote will be escaped using another single quote. In this case the magic_quotes_gpc setting becomes irrelevant.

Preventing register_global problems

Nowadays it is widely accepted that using the register_globals feature of PHP leads to security problems, but it wasn't always like this (if you don't know what this feature is then you are probably not using it; but, hey, read on the discussion is informative). In fact, the register_globals feature was turned on by default until version 4.2.0. As a result of that, many applications that exist depend on this feature (for more details have a look at http://www.php.net/register_globals).

If you can choose, it is better to refactor and rewrite the code to not use this feature. But if you cannot afford to do that for some reason or another, you can use ModSecurity to protect an application from a known vulnerability. Problematic bits of code usually look like this:

```
<?php
// this is the beginning of the page
if ($authorised) {
    // do something protected
}
// the rest of the page here
?>
```

And the attacker would take advantage of this simply by adding an additional parameter to the URL. For example, http://www.modsecurity.org/examples/test.php?authorised=1

Rejecting all requests that explicitly supply the parameter in question will be sufficient to protect the application from all attackers:

```
<Location /vulnerable-application/>
    SecFilterSelective ARG_authorised "!^$"
    SecFilterSelective COOKIE_authorised "!^$"
</Location>
```

The filter above rejects all requests where the variable "authorised" is not empty. You can also see that we've added the <Location> container tag to limit filter only to those parts of the web server that really need it.

Performance

The protection provided by ModSecurity comes at a cost, but the cost is generally very low. Your web server becomes a little bit slower and uses more memory.

Speed

In my experience, the speed difference is not significant. Most regular expressions take only a couple of microseconds to complete. The performance impact is directly related to the complexity of the configuration. You can use the performance measurement improvements in the Apache 2 version of the module to measure exactly how much time ModSecurity spends working on each request. In my tests this was usually 2-4 milliseconds for a couple of hundred of rules (on a server with a 2 GHz processor).

Note

The debug log in the Apache 2 version of the module will show the time it took ModSecurity to process every request, and even individual rules.

Note

If you have the debug logging feature enabled the performance figures you get from ModSecurity will not be realistic. Debug logging is usually very extensive (especially on the higher levels) and also very slow. The best way to assess the speed of ModSecurity is to create a custom Apache log and log the performance notes as described earlier.

Memory consumption

In order to be able to analyse a request, ModSecurity stores the request data in memory. In most cases this is not a big deal since most requests are small. However, it can be a problem for parts of the web site where files are being uploaded. To avoid this problem you need to turn the request body buffering off for those parts of the web site. (This is only a problem in the Apache 1.x version. The Apache 2.x version will use a temporary file on disk for storage when a request is too large to be stored in memory.) In any case it is advisable to review and configure various limits in the Apache configuration (see http://httpd.apache.org/docs/mod/core.html#limitrequestbody for a description of `LimitRequestBody`, `LimitRequestsFields`, `LimitRequestFieldsize` and `LimitRequestLine` directives).

Other things to watch for

The debugging feature can be very useful but it writes large amounts of data to a file for every request. As such it creates a bottleneck for busy servers. There is no reason to use the debugging mode on production servers so keep it off.

The audit log feature is similar and also introduces a bottleneck for two reasons. First, large amounts of data are written to the disk, and second, access to the file must be synchronised. If you still want to use the audit log try to create many different audit logs, one for each application running on the server, to minimise the synchronisation overhead (this advice does not remove the overhead in the Apache 2.x version because synchronisation is performed via a central mutex).

Important notes

Please read the following notes:

- You should carefully consider the impact of every filtering rule you add to the configuration. You particularly don't want to deny access using very broad rules. Broad rules are often a cause of many false positives, which, in.
- Although ModSecurity can be used in `.htaccess` files (`AllowOverride Options` is required to do this), it should not be enabled for use by parties you do not trust. If you are very paranoid you can disable this feature by compiling ModSecurity with `-DDISABLE_HTACCESS_CONFIG` (as a parameter to the `apxs` utility).
- With so many Apache modules to choose from it is impossible to test every possible configuration. Always verify your configuration works as you want it to.

Changing the Apache hook at which mod_security runs

By default mod_security will try to run at the last possible moment in Apache request pre-processing, but just before the request is actually run (for example, processed by mod_php). I have chosen this approach because the most important function of mod_security is to protect the application. On the other hand by doing this we are leaving certain parts of Apache unprotected although there are things we could do about it. For those who wish to experiment, as of 1.9dev3 mod_security can be compiled to run at the earliest possible moment. Just compile it with `-DENABLE_EARLY_HOOK`. Bear in mind that this is an experimental feature. Some of the differences you will discover are:

- It should now be possible to detect invalid requests before Apache handles them.
- It should be possible to assess requests that would otherwise handled by Apache (e.g TRACE)
- Only server-wide rules will run. This is because at this point Apache hasn't mapped the request to the path yet.

Subsequent releases of ModSecurity are likely to allow rule processing to be split into two phases. One to run as early as possible, and another, to run as late as possible.

Examples

Parameter checking

Regular expressions can be pretty powerful. Here is how you can check whether a parameter is an integer between 0 and 99999:

```
SecFilterSelective ARG_parameter "!^[0-9]{1,5}$"
```

File upload

Forbid file upload for the application as a whole, but allow it in a subfolder:

```
# Reject requests with header "Content-Type" set
# to "multipart/form-data"
SecFilterSelective HTTP_CONTENT_TYPE multipart/form-data

# Only for the script that performs upload
<Location /upload.php>
    # Do not inherit filters from the parent folder
    SecFilterInheritance Off
</Location>
```

Securing FormMail

Earlier versions of FormMail could be abused to send email to any recipient (I've been told that there is a new version that can be secured properly).

```
# Only for the FormMail script
<Location /cgi-bin/FormMail>
    # Reject request where the value of parameter "recipient"
    # does not end with "@webkreator.com"
    SecFilterSelective ARG_recipient "![a-zA-Z0-9]+@webkreator\.com$">
</Location>
```

Appendix A: Recommended Configuration

Below is the recommended minimal `mod_security` configuration. It is only a starting point designed not to give you an instant headache. You should look into tightening the configuration where you can.

```
# Turn ModSecurity On
SecFilterEngine On

# Reject requests with status 403
SecFilterDefaultAction "deny,log,status:403"

# Some sane defaults
SecFilterScanPOST On
SecFilterCheckURLEncoding On
SecFilterCheckUnicodeEncoding Off

# Accept almost all byte values
SecFilterForceByteRange 1 255

# Server masking is optional
# SecServerSignature "Microsoft-IIS/5.0"

SecUploadDir /tmp
SecUploadKeepFiles Off

# Only record the interesting stuff
SecAuditEngine RelevantOnly
SecAuditLog logs/audit_log

# You normally won't need debug logging
SecFilterDebugLevel 0
SecFilterDebugLog logs/modsec_debug_log

# Only accept request encodings we know how to handle
# we exclude GET requests from this because some (automated)
# clients supply "text/html" as Content-Type
SecFilterSelective REQUEST_METHOD "!^(GET|HEAD)$" chain
SecFilterSelective HTTP_Content-Type \
"!(^application/x-www-form-urlencoded$|^multipart/form-data;)"

# Do not accept GET or HEAD requests with bodies
SecFilterSelective REQUEST_METHOD "^(GET|HEAD)$" chain
SecFilterSelective HTTP_Content-Length "!^$"

# Require Content-Length to be provided with
# every POST request
```

```
SecFilterSelective REQUEST_METHOD "^POST$" chain
SecFilterSelective HTTP_Content-Length "^$"

# Don't accept transfer encodings we know we don't handle
SecFilterSelective HTTP_Transfer-Encoding "!^$"
```